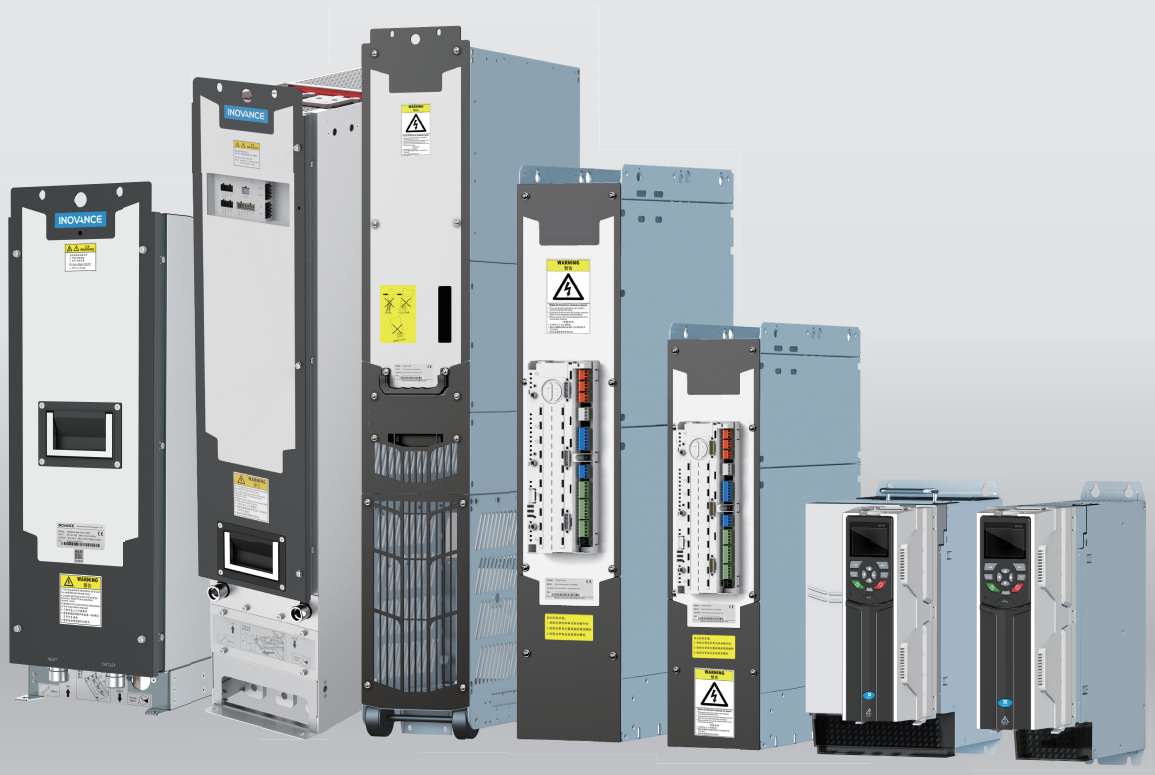
INOVANCE

FORWARD, ALWAYS PROGRESSING



MD880 Series AC Drive

Function Application Guide

(HCU-50S，HCU-51S，HCU-50S-CS，HCU-51S-CS)

Industrial Automation | Intelligent Elevator | New Energy Vehicle | Industrial Robot | Rail Transit

Data code PS00016196A02

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The storage, use, and disposal of this product (including optional accessories) must comply with local laws and regulations.

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The product/system described in this documentation may be operated only by personnel qualified for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel can identify the risks of the product/system and prevent possible dangers.

Proper Use of the Product

Proper transportation, storage, assembly, installation, commissioning, operation, and maintenance are required to ensure the safe operation of the product without any problems. The required ambient conditions must be met. All operations must follow the guidelines provided in this documentation.

Preface

Scope of application

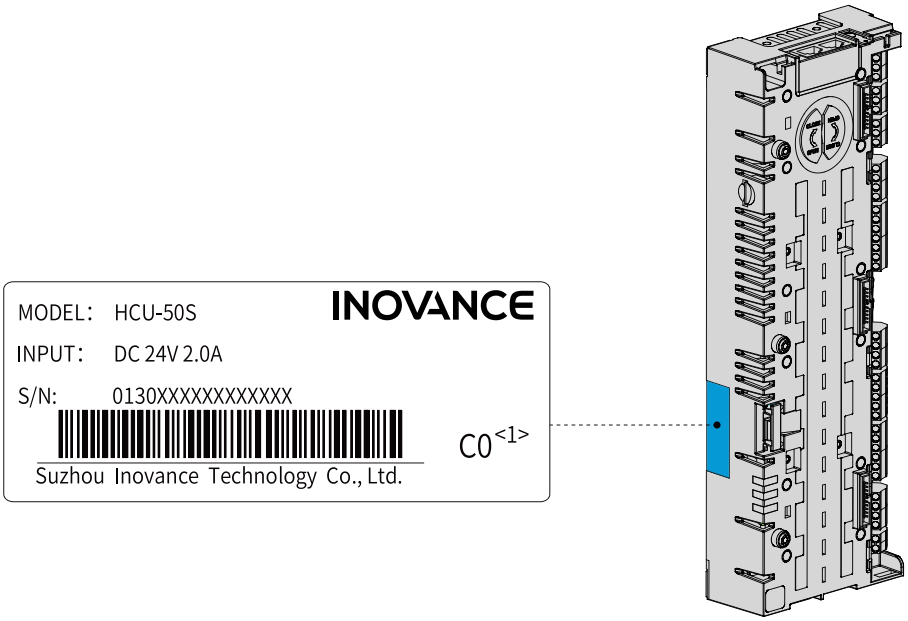


Figure -1 Nameplate

Note

- <1>: Indicates the version number B0, C0, or E0. E0 is the main version.
- The preceding nameplate is for reference only.
- This guide is applicable for HCU-50S (B0, C0, and E0), HCU-50S-CS (B0, C0, and E0), HCU-51S (B0, C0, and E0), and HCU-51S-CS (B0, C0, and E0).

Introduction

This product targets at high-end transmission applications and features high-performance speed and torque control, high reliability, flexible system integration, easy commissioning and maintenance, and high power density. The MD880 series products are divided into two topological structures, namely single-drive system and multi-drive system, which can be air-cooled and water-cooled. This product is applicable to a wide range of industries, including metallurgy, petroleum, paper making, cranes, vessels, shields, and test benches.

This guide describes function applications, and troubleshooting of the product. For complete information on parameters and fault codes, see *MD880 Series AC Drive Parameter Guide (HCU-50S, HCU-51S, HCU-50S-CS, and HCU-51S-CS).*

More data

Name	Code	Description
MD880 Series AC Drive Function Application Guide (HCU-50S, HCU-51S, HCU-50S-CS, and HCU-51S-CS)	19012581	Presents function applications and troubleshooting of the product.
MD880 Series AC Drive Communication Guide	19012451	Presents specifications, networking, and communication configuration of the product.

Name	Code	Description
MD880 Series AC Drive Parameter Guide (HCU-50S, HCU-51S, HCU-50S-CS, and HCU-51S-CS)	19012699	Presents parameters and fault codes.
MD880LC Series AC Drive (Multi-drive System) Hardware Guide	19012447	Presents the system structure, technical specifications, components, dimensions, options (including installation accessories, cables, and electrical peripherals), certifications, and standards.
MD880LC Series AC Drive (Multi-drive System) Installation and Maintenance Guide	19012448	Presents installation preparation, unpacking and transportation, mechanical installation, electrical installation, routine maintenance, and component replacement.
MD880-50 Series Inverter Hardware User Guide	19012698	Describes technical specifications, components, dimensions, preparations before installation, unpacking and transportation, mechanical installation, electrical installation, daily maintenance, and component replacement.

Revision history

Date	Version	Revision
July 2025	A02	Added: • *"5.2.6.5 Tracking Function of Ramp Function Generator" on page 187*. • *"8.1.6.4 Master-Slave Control Macro" on page 265*. • Added *"8.4.1 Overview of the Encoder" on page 340*. • Added *"8.6.10.4 Description of Position Synchronous Control Parameters" on page 401*. • Added *"8.7 Automatic Configuration of Position Control Parameters" on page 406*. • Added *"9.6 Motor Pre-heating" on page 434*. • Added *"9.7 Energy Conservation Statistics" on page 436*. • Added *"9.8 Statistics of Relay Service Life" on page 437*. • Added *"9.10 Carrier Frequency Adjusted with Speed" on page 453*. • *"9.13.13.1 Function of the Multi-timer Module" on page 495*. • Added *"9.15 Pre-overtemperature Action" on page 536*. • Added *"9.16 General Timer and Counter" on page 537*. • *"9.9.1 Function of the Interface Macro" on page 439* • *" Application macro" on page 366* • *"14.6.3.1 Synchronous Motor Runaway Protection in FVC Mode" on page 679*. Updated: • *"2.1 Commissioning Tool List" on page 37* and *"3.1.1 Overview" on page 77*. • *" Vector Control" on page 222*. • *"9.5.2.1 Vector Control" on page 425*. • *"9.13.5.4 Pulse Generator Module" on page 478*. • *"10.2 Related Parameters" on page 558*. • *"11.2.5.15 H330 - Additional Torque and Torque Limit Setting" on page 619*. • *"11.2.6.3 H412 - Speed controller" on page 623*, *"11.2.6.5 H422 - Torque limit and runaway prevention" on page 625*, *"11.2.6.6 H426 - Bus voltage control" on page 626*, *"11.2.6.7 H430 - Torque reference" on page 627*, and *"11.2.6.8 H432 - Torque/Current conversion" on page 628*. • *" Fault List" on page 681* Made minor corrections.

Date	Version	Revision
October 2024	A01	• Updated *"5.1.2 Emergency Stop Command" on page 144*. • Updated *"5.1.10.1 Status Word 1" on page 168*. • Updated *"8.1.6.2 Master PI+Slave P Control" on page 261*. • Updated *"8.6.4 Unit Calibration" on page 377*. • Updated *"8.6.6.6 Interrupt Positioning" on page 392*.
January 2024	A00	Initial release.

Access to the Guide

This guide is not delivered with the product. You can obtain the PDF version in the following ways

- Do keyword search under Service and Support at *www.inovance.com*.
- Scan the QR code on the product with your smart phone.
- Scan the QR code below to install My Inovance app, where you can search for and download user guides.



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For details, see Product Warranty Card.

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Fundamental Safety Instructions

Safety Precautions

- This chapter provides essential safety instructions for proper use of the equipment. Before operating the equipment, read through the guide and comprehend all the safety instructions. Failure to observe the safety instructions may result in death, personal injuries, or equipment damage.
- "DANGER", "WARNING", and "CAUTION" in this guide only indicate some of the precautions that need to be followed; they just supplement the safety precautions.
- Use this product according to designated environment requirements. Damage caused by improper use is not covered by warranty.
- Inovance shall take no responsibility for any personal injury or property damage caused by improper use.

Safety Levels and Definitions



Indicates that failure to comply with the notice can result in death or severe personal injury.



Indicates that failure to comply with the notice may result in severe personal injury or even death.



Indicates that failure to comply with the notice may result in minor or moderate personal injury or equipment damage.

General safety instructions

- Drawings in the guide are sometimes shown without covers or protective guards. Remember to install the covers or protective guards as specified first, and then perform operations in accordance with the instructions.
- The drawings in the guide are shown for illustration only and may be different from the product you purchased.
- Operators must take mechanical precautions to protect personal safety and wear protective equipment, such as anti-smashing shoes, safety clothing, safety glasses, protective gloves, and protective sleeves.

Unpacking



- Do not install the equipment if you find damage, rust, or signs of use on the equipment or accessories upon unpacking.
- Do not install the equipment if you find water seepage or missing or damaged components upon unpacking.
- Do not install the equipment if you find the packing list does not conform to the equipment you received.



- Check whether the packing is intact and whether there is damage, water seepage, dampness, and deformation before unpacking.
- Unpack the package in sequence. Do not hit the package violently.
- Check whether there is damage, rust, or signs of bumping on the surface of the equipment and equipment accessories before unpacking.
- Check whether the package contents are consistent with the packing list before unpacking.

Storage and transportation



- Large-scale or heavy equipment must be handled by qualified professionals using specialized hoisting equipment. Failure to comply may result in personal injury or equipment damage.
- Before hoisting the equipment, ensure that components such as the front cover and terminal blocks are secured firmly with screws. Loosely-connected components may fall off and result in personal injury or equipment damage.
- Never stand or stay below the equipment when the equipment is being hoisted by the hoisting equipment.
- When hoisting the equipment with a steel rope, ensure the equipment is hoisted at a constant speed without suffering from vibration or shock. Do not turn the equipment over or let the equipment stay hanging in the air. Failure to comply may result in personal injury or equipment damage.



- Handle the equipment with care during transportation and mind your steps to prevent personal injury or equipment damage.
- When carrying the equipment with bare hands, hold the equipment casing firmly with care to prevent parts from falling. Failure to comply may result in personal injury.
- Store and transport the equipment based on the storage and transportation requirements. Failure to comply may result in equipment damage.
- Avoid storing or transporting the equipment in environments with water splash, rain, direct sunlight, strong electric field, strong magnetic field, and strong vibration.
- Avoid storing the product for more than 3 months. When the product needs to be stored for an extended period, take more strict protection and necessary inspection.
- Pack the equipment strictly before transportation. Use a sealed box for long-distance transportation.
- Never transport the equipment with other equipment or materials that may harm or have negative impacts on the product.

Installation
DANGER • Installation must be carried out by skilled personnel who have undergone specialized electrical training and possess comprehensive electrical expertise. Non-professionals are not allowed to install the equipment.
WARNING • Read through the guide and safety precautions before installation. • Do not install the equipment in places with strong electric or magnetic fields. • Before installation, check that the mechanical strength of the installation site can bear the weight of the equipment. Failure to comply can result in mechanical hazards. • Do not wear loose clothes or accessories during installation. Failure to comply may result in electric shock. • When installing the equipment in a closed environment (such as a cabinet or casing), use a cooling device (such as a fan or air conditioner) to cool the environment down to the required temperature. Failure to comply may result in equipment over-temperature or a fire. • Do not retrofit the equipment. • Do not fiddle with the bolts used to fix equipment components or the bolts marked in red. • When the equipment is installed in a cabinet or final assembly, a fireproof enclosure providing both electrical and mechanical protections must be provided. The IP rating must meet IEC standards and local laws and regulations. • Before installing equipments with strong electromagnetic interference, such as a transformer, install a shielding equipment for the equipment to prevent malfunction. • Install the product on an incombustible object such as metal and do not contact or attach the product with combustible objects. Failure to comply can cause fires.
CAUTION • Cover the top of the equipment with a piece of cloth or paper during installation. This is to prevent unwanted objects such as metal chippings, oil, and water from falling into the equipment and causing faults. After installation, remove the cloth or paper to prevent over-temperature caused by poor ventilation due to blocked ventilation holes. • Resonance may occur when the equipment operating at a constant speed switches to variable speed operations. In this case, install the vibration-proof rubber under the motor frame or use the vibration suppression function to reduce resonance.

Wiring
 • Equipment installation, wiring, maintenance, inspection, or component replacement must be performed only by professionals. • Before wiring, disconnect all the power supplies of the equipment. Wait for at least the time designated on the equipment warning label before further operations because residual voltage still exists after power-off. Measure the DC voltage of the main circuit and make sure that it is below the safety voltage. Failure to comply can result in electric shock. • Do not perform wiring, remove the equipment cover, or touch the circuit board with power ON. Failure to comply can result in an electric shock. • Check that the equipment is grounded properly. Failure to comply can result in an electric shock.
 • Do not connect the input power supply to the output end of the equipment. Failure to comply can result in equipment damage or even a fire. • When connecting a drive to the motor, check that the phase sequences of the drive and motor terminals are consistent to prevent reverse motor rotation. • Cables used for wiring must meet cross sectional area and shielding requirements. The shield of the cable must be reliably grounded at one end. • Tighten the terminal screws with the tightening torque specified in the user guide. Improper tightening torque may result in overheat, damage to the connecting parts, or a fire. • After wiring is done, check that all cables are connected properly and no screws, washers or exposed cables are left inside the equipment. Failure to comply may result in electric shock or equipment damage.
 • During wiring, follow the proper electrostatic discharge (ESD) procedures, and wear an antistatic wrist strap. Failure to comply can result in damage to internal equipment circuits. • Use shielded twisted pairs for the control circuit. Connect the shield to the grounding terminal of the equipment for grounding purpose. Failure to comply can result in equipment malfunction.

Power-On
 • Before power-on, check that the equipment is installed properly with reliable wiring and the motor can be restarted. • Check that the power supply meets equipment requirements before powering on to prevent equipment damage or a fire. • When the equipment is powered on, do not open the cabinet door or protective cover, touch any wiring terminal, or disassemble any component of the equipment. Failure to comply can result in electric shock.
 • Perform a trial run after wiring and parameter setting to ensure that the equipment operates safely. Failure to comply may result in personal injury or equipment damage. • Before power-on, check that the rated voltage of the equipment is consistent with that of the power supply. Failure to comply may result in a fire. Failure to comply may result in fire accident. • Before power-on, check that no one is near the equipment, motor, or machine. Failure to comply may result in death or personal injury.

Operation
 • The equipment must be operated only by professionals. Failure to comply can result in death or personal injury. • During operation, do not touch any connecting terminals or disassemble any component of the equipment. Failure to comply can result in electric shock.
 • Do not touch the equipment enclosure, fan, or resistor with bare hands. Failure to comply may result in burns. • During operation, prevent metal or other objects from falling into the equipment. Failure to comply may result in fire or equipment damage.

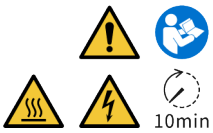
Maintenance
 • Equipment installation, wiring, maintenance, inspection, or component replacement must be performed only by professionals. • Do not maintain the equipment with power ON. Failure to comply can result in electric shock. • Before maintenance, disconnect all the power supplies of the equipment and wait for at least the time designated on the equipment warning label. • When a permanent magnet motor is used, do not touch the motor terminals immediately after power-off because the motor terminals can generate induced voltage during rotation even after the equipment is powered off. Failure to comply can result in electric shock.
 • Perform routine and regular inspection and maintenance on the equipment in accordance with maintenance requirements and keep a record.

Repair
 • Equipment installation, wiring, maintenance, inspection, or component replacement must be performed only by professionals. • Do not perform maintenance on the equipment with power on. Failure to comply can result in electric shock. • Before inspection and maintenance, disconnect all the power supplies of the equipment and wait for at least the time designated on the equipment warning label.
 • Submit a request for repair services in accordance with the product warranty agreement. • When the fuse is blown or the circuit breaker or earth leakage current breaker (ELCB) trips, wait for at least the time designated on the equipment warning label before power-on or further operations. Failure to comply may result in death, personal injury, or equipment damage. • Troubleshooting and repair must be performed by professionals in accordance with the repair instructions, with repair records kept properly. • Replace quick-wear parts of the equipment in accordance with the replacement instructions. • Do not use damaged equipment. Failure to comply may result in death, personal injury, or severe equipment damage. • After the equipment is replaced, check the wiring and set parameters again.

Disposal
 • Dispose of retired equipment in accordance with local regulations and standards. Failure to comply may result in death, personal injury, or property damage. • Recycle retired equipment in accordance with industry waste disposal standards to avoid environmental pollution.

Safety label

For safe operation and maintenance, comply with the safety labels on the equipment. Do not damage or remove the safety labels. The following table describes the meaning of the safety labels.

Safety Label	Description
	• Read through the safety instructions before operating the equipment. Failure to comply may result equipment damage, personal injury, or even death. • Do not touch the terminals or remove the cover with power ON or within 10 min after power-off. Failure to comply can result in an electric shock.

1 List of Terms

Function	Name	Description	Alias
Commissioning tool	MDKE-10	LED operating panel for the MD880	-
	SOP-20-880	Smart operating panel for the MD880	-
	InoDriveStudio	PC commissioning software for the MD880	-
	IDS	Abbreviation for InoDriveStudio	-
Control information	OFF1	Start/stop command, corresponding to bit0 of control word 1. The rising edge corresponds to the start command. When bit0 is set to 0 (low level), OFF1 is the stop command.	-
	OFF2	Emergency stop command, corresponding to bit1 of control word 1. The emergency stop command takes effect immediately in any state. Operation is allowed at high level and IGBT output is blocked at low level.	-
	OFF3	Fast stop command, corresponding to bit2 of control word 1. The fast stop command takes effect immediately in any state. Operation is allowed at high level. At low level, the device decelerates to zero speed according to the OFF3 stop time and then the IGBT output is blocked.	-
	Operation enable	Corresponds to bit3 of control word 1. Whether to enable the operation is determined after the OFF1 start command is valid. At high level, the device is allowed to enter the operational state and IGBT output is enabled. At low level, the device keeps in the ready-to-run state and IGBT output is blocked.	-
Reference source parameter	Reference source parameter	It is a special parameter. The value of the connector parameter can be read for control by the MD880 by setting the number of the connector parameter.	-
	Bit reference source parameter	A reference source parameter of one bit connector is read and one piece of bit data is output.	-
	Word reference source parameter	A reference source parameter of one word connector is read and an analog value is outputted.	-
Terminal start/ stop module	Terminal start/stop module	Used to start or stop the drive through terminals.	-

Function	Name	Description	Alias
Input/Output	DI	Digital input terminal	-
	AI	Analog input terminal	-
	HDI	High-speed digital input terminal	-
	DO	Digital output terminal	-
	AO	Analog output terminal	-
	HDO	High-speed digital output	-
	RO	Relay output terminal	-
Parameter macro	Custom application macro	Used to save some parameters as custom parameter sets to simplify the commissioning process.	-
	Interface Macros	The parameter set in the interface macro mainly applies to control interfaces such as digital input (DI), digital output (DO), and analog input (AI), facilitating commissioning on control interface parameters.	-
	Application macro	The application macro mainly applies to specific industrial applications, such as fans and water pumps, facilitating commissioning during application.	-
Process PID control	Process PID control	As a general process control method, PID process control is a closed-loop mechanism in which each controlled variable is stabilized at the target level. This is implemented through proportional, integral, and derivative calculation of the difference between the feedback signal and the target signal of the controlled variable and through adjustment of the AC drive output frequency.	-
	PID	Proportional Integral Derivative	-
Process PID control	Kp	Proportional coefficient	-
	Ti	Integral time	-
	Td	Derivative time	-
Acceleration/ Deceleration/ Jog	Ramp function generator (RFG)	Ramp function generator	-
	JOG1/2	Jog 1/2	-
Motorized potentiometer	Motorized potentiometer	Refers to the virtual potentiometer output by the software, which can be set through parameters in group C7.	-

Function	Name	Description	Alias
Connector	Connector	Read-only parameters that allow you to view the drive status and data or allow read and use by other parameters.	-
	Bit connector (B connector)	The bit connector is sourced from the bit, which can be 0 or 1 only. It can be used to monitor the digital signal status in the system or used as a binary signal source for certain functions.	-
	Word connector (K connector)	The word connector is divided into single-word connector and double-word connector. This connector can be used as the signal source of some functions or used to monitor the status word in the system.	-
Free function module	Free function module	Multiple status signals and control signals are used together to implement engineering control requirements. Such signals include logic operation, arithmetic function, word-bit conversion, data conversion, switch function, control function, multi-point curve, constant setting. You can set related parameters as needed to achieve simple logic operation.	-
Speed reference	Droop control	The operating frequency is automatically reduced when the load is heavy.	Softening control, speed drop
	Frequency hopping	The target frequency is automatically adjusted to skip the resonance point.	Dangerous speed, skip frequency, and skip speed
	Motor direction of rotation	Switches the motor operating direction without changing the positive and negative signs of the frequency reference.	Motor phase sequence switchover, motor phase sequence

Function	Name	Description	Alias
Vector control	Vector control	The three-phase UVW current is divided into id/iq to control the magnetic flux and torque respectively. Direct torque control, which can control speed and torque and features high accuracy and dynamic responsiveness (similar to DTC control)	-
	FVC/SVC	Feedback vector control/Sensorless vector control	-
	Acceleration torque feedforward	Used to calculate the acceleration/ deceleration torque and compensate for the speed change, which can greatly reduce the demand for speed loop Kp, Ti, and dynamic response of the loop.	-
	Kp	Indicates the proportional gain of the PI controller. The higher the Kp, the stronger the control effect can be, such as the Speed loop Kp in SVC mode.	-
	Ti	Indicates the integral time of the PI controller. The lower the Ti, the stronger the integral effect can be, such as the SVC speed loop Ti.	-
	Ki	Indicates the integral gain of the PI controller. The higher the Ki, the stronger the integral effect can be (Ki = Kp/Ti).	-
	I/F control	The reference speed is used as the frequency for the output current at speeds close to 0 rpm in SVC mode. The speed is not in closed-loop control. It improves the stability at zero speed in SVC mode.	Speed open loop control
	Electromechanical time constant	Indicates the time for the motor to drive the load at rated torque to reach rated speed.	Mechanical time constant, rated motor startup time
	Overspeed controller	The overspeed controller operates once motor overspeed occurs to prevent further acceleration.	Stall control
	V/f control	Indicates constant voltage/frequency ratio control, which features stable control and is insensitive to parameters. However, the dynamic responsiveness and accuracy of V/f control mode is not as high as other control modes.	Scalar control, V/f control
	DTC control	Indicates direct torque control, which can control the speed and torque and features high accuracy and dynamic responsiveness. This mode corresponds to the vector control mode.	-

Function	Name	Description	Alias
V/f control	Slip compensation	The rotor speed of the asynchronous motor is lower than the set speed after the load is applied. In slip compensation, the magnitude of the load is estimated and the reference frequency is boosted automatically to improve the speed accuracy.	V/F slip compensation gain
	Overcurrent suppression	When the output torque is high, the frequency is automatically adjusted to reduce the output current to prevent overcurrent during high load or acceleration/deceleration.	Overcurrent stall suppression
	Torque boost	Indicates low-speed compensation for the stator resistance voltage drop to ensure a constant air gap flux (voltage/ frequency) of the motor during operation in V/f mode, thus keeping a good load carrying capacity at low speed.	Torque compensation, voltage boost, IR compensation
	Oscillation suppression	In V/f control, the motor may oscillate during no-load operation. In this case, use the oscillation suppression function.	Resonance suppression

Function	Name	Description	Alias
Basic control	Active short circuit control	In synchronous motor control, the drive shorts the UVW output terminals together through IGBT control to form a braking torque. The higher the speed, the higher the braking torque. This function can prevent motor runaway, preventing the motor from rotating reversely at low speed or coasting for a long time.	Electronic motor stator shorting, internal armature short-circuit braking
	Carrier frequency	Indicates the frequency of the output pulse voltage.	Carrier frequency, pulse frequency, and switching frequency
	DPWM/PWM	DPWM indicates 5-segment discontinuous pulse width modulation and IGBT is switched on/off four times per one carrier cycle. CPWM indicates 7-segment continuous pulse width modulation and IGBT is switched on/off six times per one carrier cycle.	5-segment discontinuous pulse width modulation/7-segment continuous pulse width modulation
	Overmodulation	The output voltage in general control is low in the flux weakening range. Overmodulation can increase the output voltage by up to 5%, reducing the output current effectively under the same load. However, the output harmonics may be increased slightly.	Edge modulation, hexagon flux weakening control
	Carrier ratio	Indicates the ratio of effective carrier frequency to the output frequency. The carrier ratio indicates the number of pulses in a sinusoidal wave current cycle. If the carrier ratio is low, the pulse voltage is low, and the output current cannot be controlled properly, which may result in motor control error, overtemperature, and demagnetization.	Carrier frequency/Output frequency
	Random PWM	The carrier frequency changes randomly during operation, so that the sharp noise of the carrier frequency can be dispersed. After random PWM is enabled, the motor may generate rustling sound.	Pulse frequency modulation
	Overvoltage suppression	Used to prolong the motor deceleration time during regenerative braking, preventing overvoltage during quick deceleration.	Vdc_max, overvoltage stall suppression, overvoltage control
	Undervoltage suppression	Used to reduce the motor speed automatically upon power dip to prevent bus undervoltage. After the power grid is recovered, normal operation applies again. In long-term power failure, you can enable undervoltage suppression to allow the motor to stop properly, preventing the motor from coasting.	Instantaneous stop, power dip suppression, Vdc_min, undervoltage stall suppression, undervoltage control

Function	Name	Description	Alias
Basic control	Over-excitation	The excitation current is automatically increased during deceleration, which increases the energy loss. The overvoltage during deceleration can be reduced and the motor can decelerate faster.	Flux braking
	Speed tracking	In V/f and SVC control, a rotating motor can be started only after the motor speed is tracked before start. The speed tracking algorithm can estimate the motor speed upon start to allow bumpless start.	Flying start, rotating restart
	Energy-saving control	In energy-saving control of the asynchronous motor, the output voltage is adjusted automatically based on the magnitude of the load to achieve the energy-saving effect by reducing the output current.	Efficiency optimization
	Back EMF	When the motor is being driven to operate at rated speed without load, the effective voltage on the output cables (UV/VW/WU) is the rated back EMF of the motor.	-
	No-load current	During no-load operation in the non-flux weakening range of the asynchronous motor in V/f mode, the output excitation current is the no-load current.	-
	Mutual inductance	Indicates the main flux that can be generated per unit current and the conductivity of the magnetic circuit between the stator and the rotor.	-
	Moment of inertia ratio	Indicates the inertia reference value for internal calculation of the motor (Inertia ratio = Auto-tuned inertia/Inertia reference value).	-
	Number of motor pole pairs	Determined by the internal structure of the motor. The higher the number of poles, the higher the output torque, and the lower the mechanical speed can be.	-
	Rated motor slip	Indicates the deviation between the actual rotor frequency output and the reference frequency during operation of asynchronous motors with rated load.	-
	Current loop	Used to keep the feedback current be consistent with the current reference through different model control to ensure dynamic responsiveness.	-
	Speed loop	Used to keep the motor speed feedback be consistent with the speed reference to meet the requirements for speed control.	-

Function	Name	Description	Alias
Parameter auto-tuning	Parameter auto-tuning	Used to auto-tune motor parameters (such as motor resistance and inductance) in vector control to establish accurate mathematical model for calculating the magnetic flux, torque, and speed of the motor. Parameter auto-tuning must be performed for FVC/ SVC control. It is also recommended for V/f control to obtain better performance.	Auto-tuning, parameter auto-tuning, and motor data identification
	Static auto-tuning	In static auto-tuning, the motor does not need to rotate or disconnected from the load.	-
	Dynamic auto-tuning	In dynamic auto-tuning, the motor must rotate and be disconnected from the load.	-
	With-load auto-tuning	In with-load auto-tuning, the motor can be connected to the load and the motor may rotate during auto-tuning.	-
	Magnetic pole position auto-tuning	Before starting the motor, perform magnetic pole position auto-tuning because a motor that connected to the load can be started properly only with an accurate field position.	Phase searching and magnetic pole position identification
	Stator resistance, per-unit value of rotor resistance	The standard unit value is generally a percentage. The actual motor parameters can be calculated through the reference value. Per-unit reference value of the resistor = Rated motor voltage/(1.732 x Rated current) in Ω. Actual resistance value = Per-unit value of the resistor x Reference value of the resistor.	-
	Leakage inductance, mutual inductance, and Ld/Lq inductance per-unit value	The standard unit value is generally a percentage. The actual motor parameters can be calculated through the reference value. Per-unit reference value of inductance = Per-unit reference value of the resistor /(2 x pi x rated frequency) in H. Actual inductance value = Per-unit inductance x Reference value of the resistor.	-

Function	Name	Description	Alias
Encoder	Incremental encoder	The incremental encoder counts the pulse signal, indicating the displacement by the number of pulses.	-
	Absolute encoder	Each position of the absolute encoder corresponds to a digital code, which indicates the absolute position.	-
	Z signal	For incremental encoders, the signal corresponding to the Z pulse provides the relative zero point for the incremental encoders.	Zero pulse
	Zero point angle	For absolute encoders, the zero angle is the angle between the zero degree of the encoder and phase U. For incremental encoders, the zero angle is the angle between the Z signal and phase U.	Zero phase, commutation angle offset
	Dual encoder	Two types of encoder signals are obtained at the same time, in which one is used for speed control, and the other is used for position control.	-
	Speed control encoder	Indicates the encoder used for speed control.	-
	Position control encoder	Indicates the encoder used for position control.	-
	Input phase sequence of encoder	The positive direction of the encoder may be different from the forward direction of the motor. If the direction is the same, the input phase sequence of the encoder is forward, otherwise, it is reverse.	-
	Encoder resolution	The encoder resolution indicates the minimum position change that can be detected, which reflects the precision of the measurement system. The higher the resolution, the more accurate the position information obtained. For incremental encoders, the resolution is related to the number of pulses per revolution. For absolute encoders, the resolution is related to the number of single-turn bits.	-
	Number of resolver pole pairs	The magnetic pole pairs formed by the resolver winding structure affect the conversion relationship between the electrical signal and mechanical angle.	-
	Single-turn bits of communication-type encoder	Indicates the number of position information bits that can be outputted within a single revolution (one revolution of the rotor) of the encoder.	-
	Multi-turn bits of communication-type encoder	Indicates the number of rotor revolutions that can be recorded by the encoder.	-

Note

References to “words” and “bits” in this guide indicate the length of the data information, such as word connectors, bit connectors, and control words.

- “Bit” refers to the bit information and its value is 0 or 1.
- “Word” refers to a 16-bit message and its value range is 0 to 65535 as an unsigned number or -32768 to +32767 as a signed number.

2 Commissioning Tool

2.1 Commissioning Tool List

The MD880 series AC drives support the following commissioning tools.

- SOP-20-880 smart operating panel
- InoDriveStudio commissioning software

For the MD880 series AC drives, you can use the operating panel to modify and view parameters, perform simple commissioning and view operation status.

Note

You also need to confirm and record the operating waveform, perform visualized commissioning, view fault information and black box. It is recommended to use InoDriveStudio for commissioning.

2.2 Smart Operating Panel SOP-20-880

2.2.1 Overview

SOP-20-880 is a new-generation commissioning tool of Inovance that applicable to single-drive/multi-drive systems.

- It features a wide power supply range and LCD display.
- It provides rich functions, such as parameter setting, status monitoring, parameter copy, fault analysis and diagnosis, parameter upload and download, and USB relay/mass storage.

2.2.2 Components

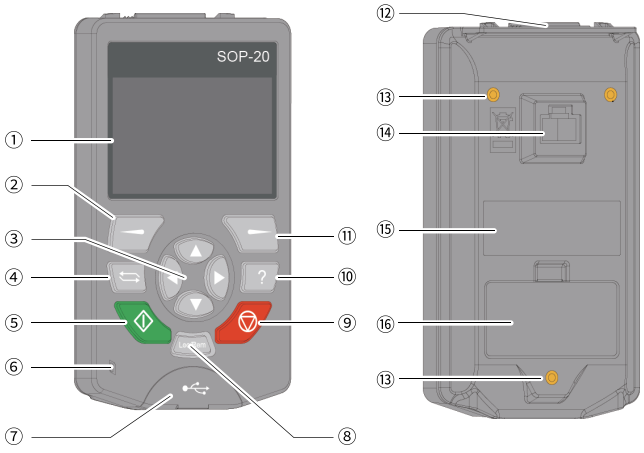


Figure 2-1 Appearance and keys of SOP-20-880

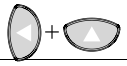
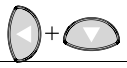
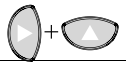
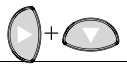
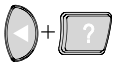
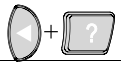
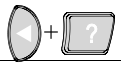
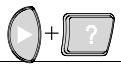
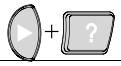
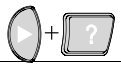
Table 2–1 SOP-20-880 components

No.	Name
①	Display
②	Left soft key
③	Arrow key
④	Shift key
⑤	Run key
⑥	Status indicator
⑦	USB port
⑧	LOC/REM switchover key
⑨	Stop/Reset key
⑩	Help key
□	Right soft key
□	Snap-fit joint
□	Fixing screw
□	RJ45 port
□	Nameplate
□	Battery cover

Table 2–2 Description of the keys

Key	Name	Description
	Left soft key	Used for exit or cancellation. This key locates on the left below the display. It corresponds to different functions in different situations. On the home page, pressing this key enters the device list.
	Right soft key	Used for enter or confirmation. This key locates on the right below the display. It corresponds to different functions in different situations. On the home page, pressing this key enters the menu page.
	Shift key	Used to quickly enter the device list. On pages that do not allow operations to be interrupted, quick device switchover is not allowed and this key is disabled.
	Help key	Used to open the help page. The content on the help page depends on the context, such as the current menu or page.
	Run key	Used in the local control mode to start the device.
	Stop/Reset key	Used in the local control mode to stop the device. When the device is in the fault state, use this key to reset the fault.
	LOC/REM switchover key	Used to switch the control permission of the device. Local: The device start/stop is controlled by SOP-20-880. Remote: The device start/stop is controlled by the parameters and functions of the device.
	Arrow key	The up and down keys are used to select options in a displayed menu and list, scroll up and down a text page, and adjust a value (such as setting time, entering a password, or changing a parameter value). The left and right keys are used to move the cursor left and right.

Table 2–3 Shortcuts

Shortcut	Illustration	Applicable Page	Function
Left+Up		All	Adjusts the backlight brightness.
Left+Down			
Right+Up		All	Adjusts the contrast ratio.
Right+Down			
Left+Help		Parameter list	Adds the parameter that the cursor is directed at to the quick commissioning page.
Left+Help		Quick commissioning	Deletes the parameter from the quick commissioning page.
Left+Help		Startup screen	Deletes the parameter from the startup screen.
Right+Help		Parameter list	Adds the parameter that the cursor is directed at to the startup screen.
Right+Help		Quick commissioning	Clears all parameters from the quick commissioning page.
Right+Help		Startup screen	Clears all parameters from the startup screen.

2.2.3 Operating Panel Display

SOP-20-880 adopts the monocolour LCD with white backlight and a resolution of 240x160 pixels.

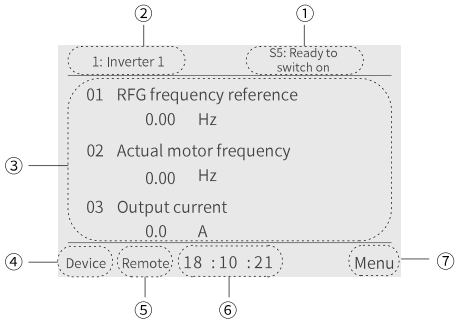


Figure 2-2 Homepage

Table 2–4 Descriptions of the homepage

No.	Display	Description
①	Device status and fault information	Displays information about the operating status of the device, including the state machine, fault, and alarm. When a fault occurs on the device, the fault information and operating status are displayed alternately.
②	Current device information	1: Current device station number Inverter 1: Current device name
③	Content	Real-time display of monitored information

No.	Display	Description
④	Device list	Displays the device list of the current network.
⑤	Local/remote	Local: The device is controlled by SOP-20-880 (local control). Remote: The device is controlled by I/O or bus (remote control). Blank: This function is unavailable on the equipment.
⑥	SOP-20-880 time	Displays the clock time in SOP-20-880.
⑦	Menu	Used to access the function menu of current device.

2.2.4 Viewing and Setting Parameters

Viewing parameters

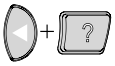
If a parameter group is selected, all the parameters under this group will be displayed. You can view or edit these parameters as needed. Press  to display the help information.

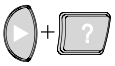
For read-only parameters, when the cursor points at this parameter, the right soft key  is invalid. In this case, the "Select" button is not displayed at the right bottom on the screen.

If "0x" is displayed before the parameter, the parameter setpoint is a hexadecimal value.

Parameter setting

Table 2–5 Description

Function	Button	Description
Viewing or modifying parameters	Key operations	Go to "Menu"→"Parameter setting"→select the parameter group to be changed→select the parameter to be changed→view or modify the parameter→click "Back" or "OK".
Adding or deleting quick commissioning parameters		• Adding a parameter to the quick commissioning interface:• In the parameter setting interface, enter any parameter group, move the cursor to the specific parameter, and press the Left key and Help key at the same time for more than 1.5 seconds to add the parameter to the quick commissioning interface. • Deleting a parameter from the quick commissioning interface:• In the quick commissioning interface, move the cursor to the parameter to be deleted, press  and  at the same time for more than 1.5 seconds to delete the parameter from the quick commissioning interface.

Function	Button	Description
Clearing parameters from the shortcut interface		Clearing parameters from the quick commissioning interface: In the quick commissioning interface, press  and  at the same time for more than 1.5s to clear all the parameters in the quick commissioning interface.
Viewing quick commissioning parameters	Key operations	-

Modifying parameters that used to set values

For example, to set C8-08 (namely, ramp 1 acceleration time) to 30.00s, do as follows:

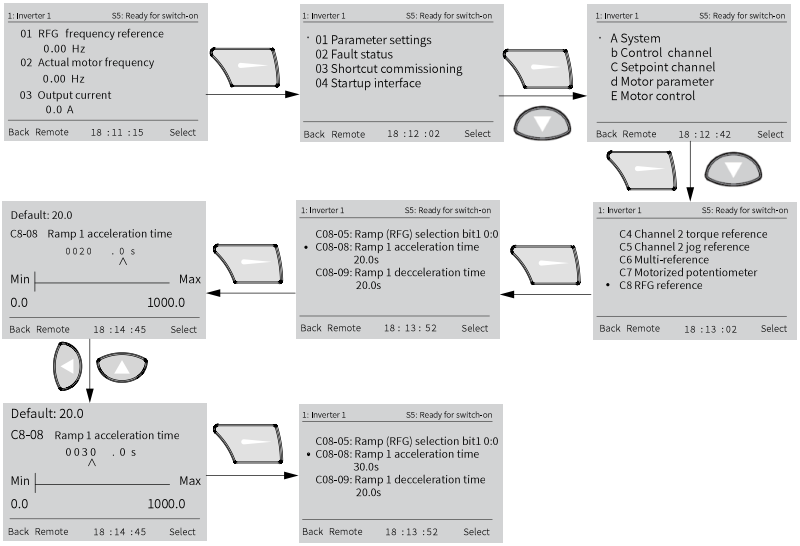


Figure 2-3 Modifying parameters that used to set values

After setting the parameter, press  to save the setting and exit or press  to quit and exit.

Press  and  at the same time for more than 1.5 seconds to restore the parameter to default value and then press  to activate the default value.

2.2.5 Status Indicator

The status indicator on SOP-20-880 is used to indicate whether a fault or alarm exists.

Table 2–6 Status indicator

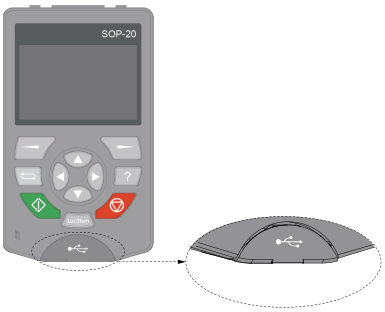
Indicator	Illustration	Meaning
Steady green		The device is running properly.
Flashing green		Data is being transmitted between the SOP-20-880 and PC with USB.

Indicator	Illustration	Meaning
Steady red		Communication between SOP-20-880 and device is proper, but the device is faulty.
Flashing red		Communication between SOP-20-880 and device has been interrupted.

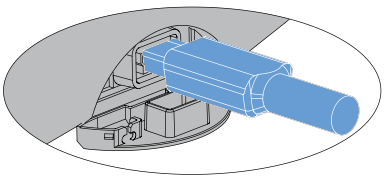
2.2.6 Connecting the Relay to PC

The B-type mini USB terminal on the lower part of SOP-20-880 is used to connect to PC. The connection cable cannot exceed 3 m. The USB2.0 communication protocol is used between the SOP-20-880 and the PC.

1. Open the USB terminal cover.

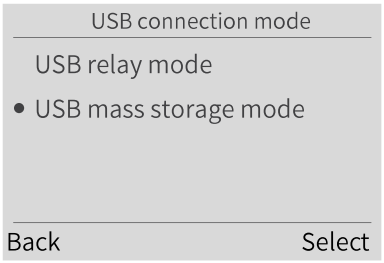


2. Insert the USB cable and connect the cable with ferrite core (recommended) to the PC.



3. After the SOP-20-880 is connected to the PC, you can select the USB relay mode or USB mass storage mode.

- When "USB relay mode" is selected, the SOP-20-880 can be used as a relay to enable communication between the device and the PC. To perform commissioning with InoDriveStudio, select "USB relay mode".
- In the “USB mass storage mode”, the SOP-20-880 can be used as a memory.



Note

For details, see *SOP-20-880 Series Smart Operating Panel User Guide*.

2.3 InoDriveStudio Commissioning Software

2.3.1 Overview

The InoDriveStudio (hereinafter referred to as IDS) is a commissioning software developed by Inovance for high-performance engineering drives. It can be used for commissioning, troubleshooting, and operation status monitoring of the drive.

The InoDriveStudio supports only the Windows operating systems, including but not limited to those listed below: WindowsXP Professional, Windows2003 Server, Windows Vista, Windows7, Windows8, and Windows10.

2.3.2 Installation

1. To download InoDriveStudio, do as follows:

   a. Log in to the official website of Inovance (*www.inovance.com*).
   b. Choose “Support” > “Download” > “Search”, and then enter InoDriveStudio.
   c. Click "Download".

2. Unzip the package downloaded.
3. Click to start installing InoDriveStudio.

2.3.3 Common Functions

2.3.3.1 Main Interface

Double-click 

to open InoDriveStudio, as shown below.

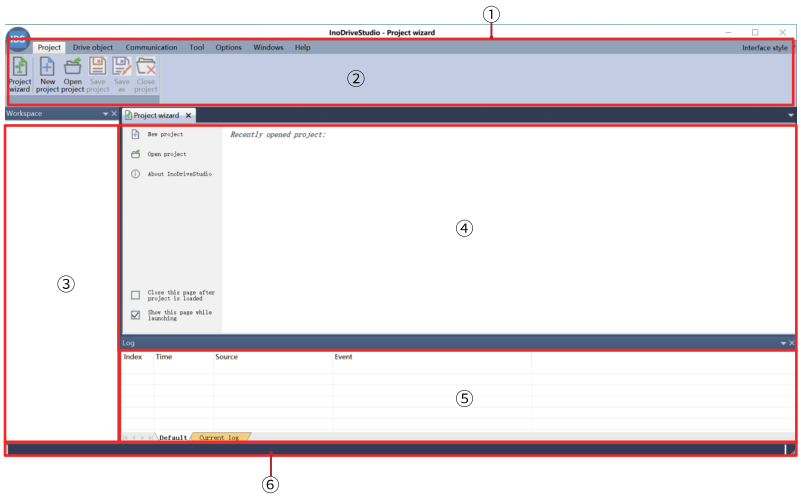


Figure 2-4 Start interface

No.	Name	Description
①	Title bar	Displays information such as window titles or files that are open.
②	Menu bar	Displays each functional module.

No.	Name	Description
③	Work area	Displays navigation information such as the current project.
④	Main workspace	Displays the specific content of an item specified in the navigation pane.
⑤	Multi-functional area	Displays the log pane, monitoring pane, control panel pane, fault pane, etc.
⑥	Status bar	Displays the current project status.

2.3.3.2 Creating a Project

1. Go to "Project" > "New project", as shown by *"Figure 2-6 Creating a project" on page 45* .

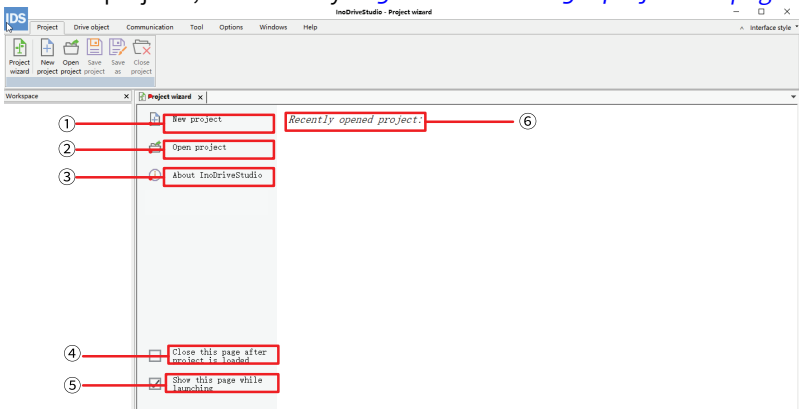


Figure 2-5 Homepage of the new project

No.	Name	Description
①	New project	Click "New project" to create a project in the displayed dialog box.
②	Open project	Click "Open project" to open a target project.
③	About InoDriveStudio	Click "About InoDriveStudio" to view information about the current InoDriveStudio version.
④	Close this page after project is loaded	If this option is selected, the project wizard is closed automatically when the project is loaded. If this option is cleared, the project wizard cannot be closed automatically when the project is loaded.
⑤	Show this page while launching	If this option is selected, the project wizard is opened automatically when the software is started. If this option is cleared, the project wizard cannot be opened automatically when the software is started. You can go to "Project" > "Project wizard" to open this page.
⑥	Recently opened project	You can view eight recently opened projects in the descending order of time. Double-click a file name to open the specified recent project. Move your cursor over the file name. The file name will be highlighted in light blue and  is displayed. Click the icon to hide the project from the recently opened project list.

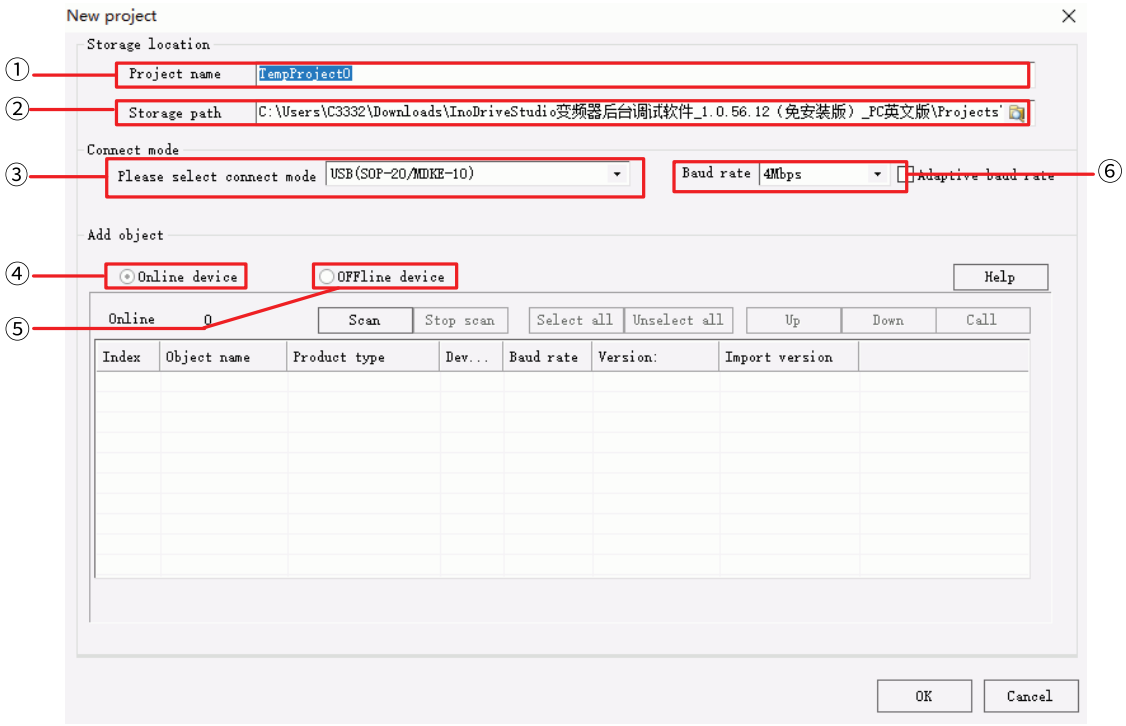


Figure 2-6 Creating a project

No.	Name	Description
①	Project name	Specifies the name of the project to be created.
②	Storage path	Specifies the path where the new project is saved.
③	Connect mode	Specifies the communication method and related parameters for the project to be created. Currently, USB, TCP/IP, and gateway communication methods are supported. After a project is loaded, you can go to "Communication" > "Project communication setting" to change the connection method. For details, see *"Figure 2-7 Modifying connection mode" on page 46*. The project is connected to the device using the set connection mode.
④	Online device	Specifies the online device to be added to the project. The online device can be displayed by scanning.
⑤	Offline device	Specifies the offline device to be added to the project. The offline device can be determined by information such as product type and version.
⑥	Adaptive baud rate	When selecting the USB communication method, you can choose whether to scan the device with an adaptive baud rate. If yes, devices whose baud rates are supported can be scanned; otherwise, only devices whose baud rate is the specified baud rate can be scanned.

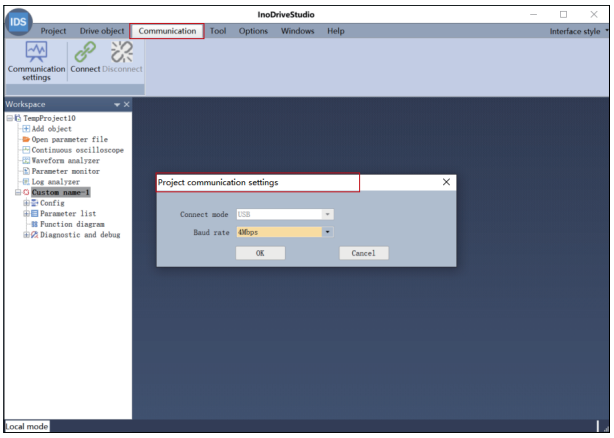


Figure 2-7 Modifying connection mode

Note

- When multiple devices are cascaded, ensure that the communication addresses of the devices are unique and the communication baud rates of the devices are consistent. Set the communication address through A10-03 and communication baud rate through A10-04.
- When multiple devices are cascaded, ensure that the device names are unique. Otherwise, the new project cannot be created.

2. Click "Scan".

- In the following figure, USB connection is selected.

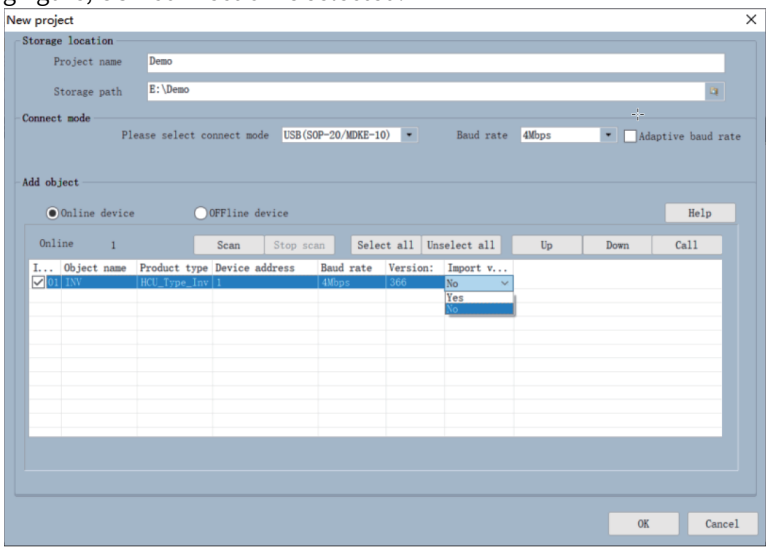


Figure 2-8 Scanning when USB connection is selected

Note

When you import the software tool configuration table for the first time, select "Yes" for the import version.

- In the following figure, TCP/IP (HETN-10) is selected.

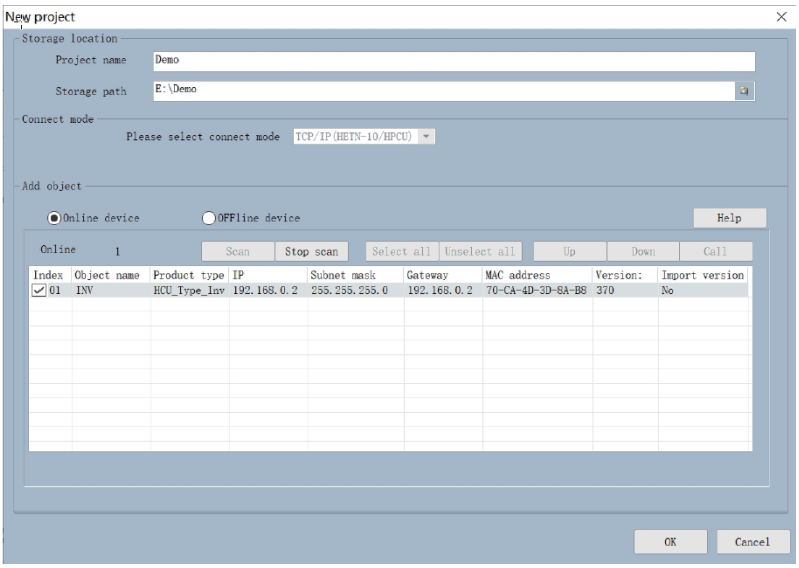


Figure 2-9 Scanning when TCP/IP (HETN-10) connection is selected

Note

For the settings of IP address, subnet mask, and gateway address, see *HETN-10 Ethernet Commissioning Module User Guide*.

- In the following figure, TCP/IP (HGW-10) is selected.

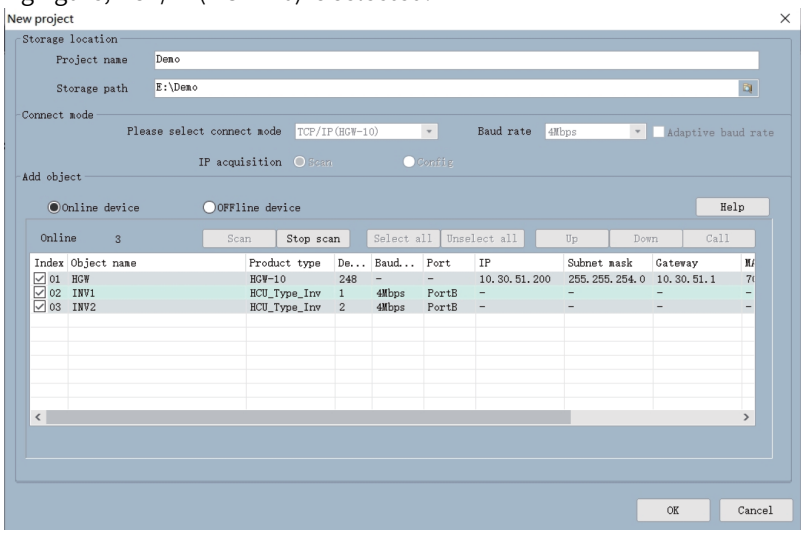


Figure 2-10 Scanning when TCP/IP (HGW-10) connection is selected

Note

As there are multiple gateways in the Ethernet network, when the IP is obtained through scanning, an excessive number of devices may be scanned. It is recommended to scan via configuration. After you click "IP config" or "Config", the IP configuration dialog box automatically pops up. You can add up to ten HGW-10 IP addresses manually. After you configure an IP, click "Scan" to display all devices under this IP in the list. When the check button is not checked, this IP address will not be scanned.

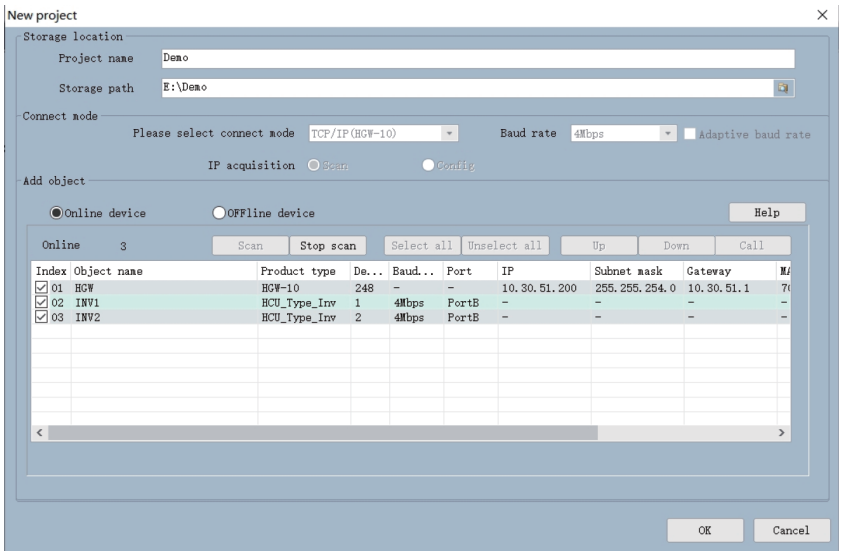


Figure 2-11 Manually configuring the IP dialog box

Note

For centralized commissioning and operation data acquisition of the gateway and MD880 series AC drives, see *HGW-10 Digital Gateway Commissioning and Monitoring Module User Guide*.

3. After you click "OK", the new project is created. The following *"Figure 2-12 Main interface" on page 48* interface appears, and you can perform related setup and commissioning.

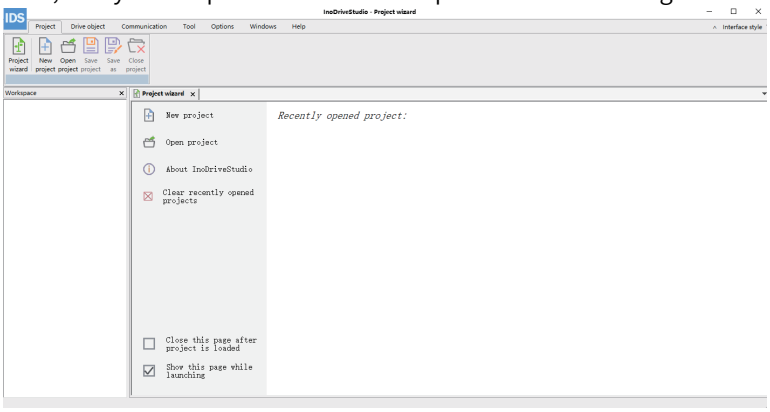


Figure 2-12 Main interface

2.3.3.3 Control Panel

You can use the control panel of InoDriveStudio to start and stop the drive, reset faults, and so on. Go to "INV" > "Diagnostic and debug" > "Debug" > "Control panel" to open the control panel, as shown in the following figure.

1. Click "Basic panel" to switch to the basic panel. In the basic panel, the device cannot be selected, the device name is displayed in the title bar, and an indicator icon is added.

- If the device is stopped, the indicator is gray.
- If the device encounters a fault, the indicator flashes in red.
- If the device encounters an alarm or minor fault, the indicator flashes in yellow.
- If the device is operating properly, the indicator flashes in green.

2. Click "Restore panel" to expand the control panel.

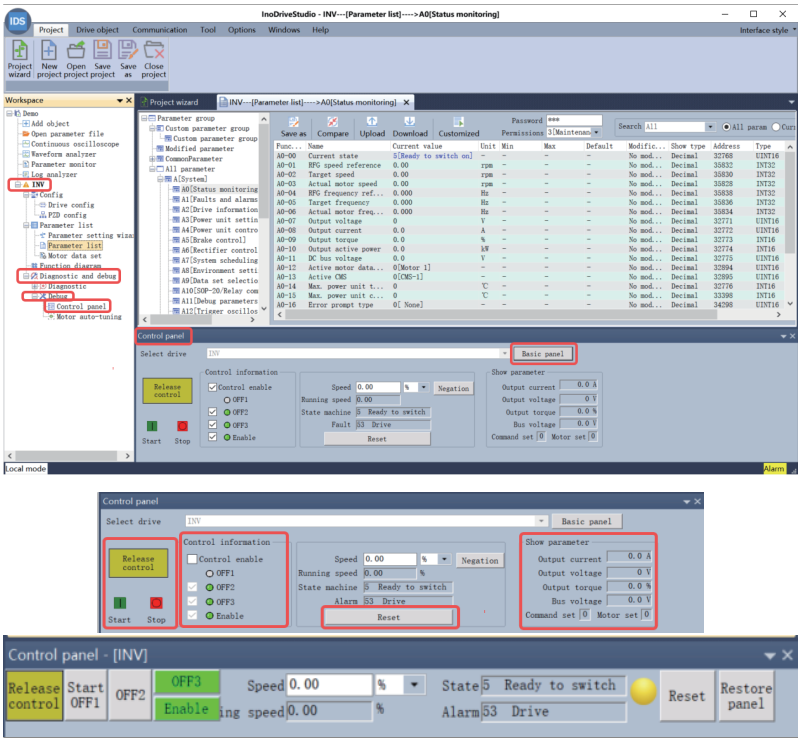


Figure 2-13 Control panel

- You can start or stop the device and monitor the device status on the control panel.
- Before controlling a device through the control panel, click "Request control" to gain control of the device.
- After you obtain control permission, you can click "Start" or "Stop" to start or stop the device.
- After the "Control enable" is checked, select "OFF1", "OFF2", "OFF3", and "Enable" to switch the control word directly, achieving the start/stop control of the device.
- Click "Reset" to reset the fault.
- Click the space key consecutively for three times to automatically trigger the OFF2 stop command.
- If the communication between HCU-50S/51S and InoDriveStudio fails after the device is started using the control panel, fault 52-1 (IDS communication fault) is reported.

2.3.3.4 Viewing Faults/Alarms

There are two ways to view faults through InoDriveStudio.

- Viewing active faults
  - Method 1: Go to "INV"→"Diagnostic and debug"→"Diagnostic"→"Faults and alarms" to open the alarm/fault list, as shown in the following figure.

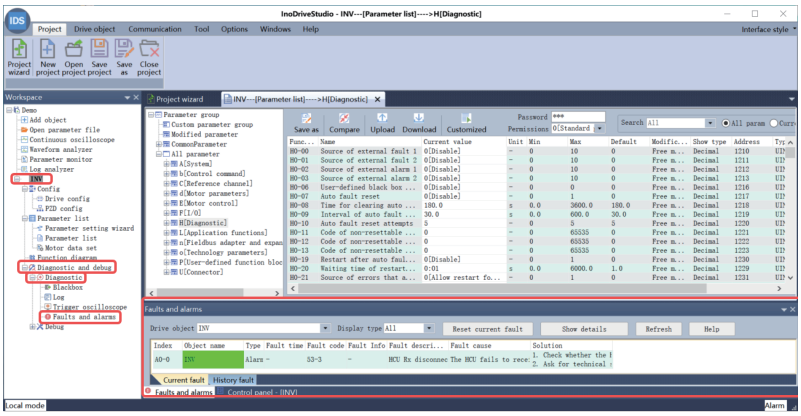


Figure 2-14 Fault List

- Method 2: Click parameters in group A1 to view current faults and alarms, as shown in the following figure.

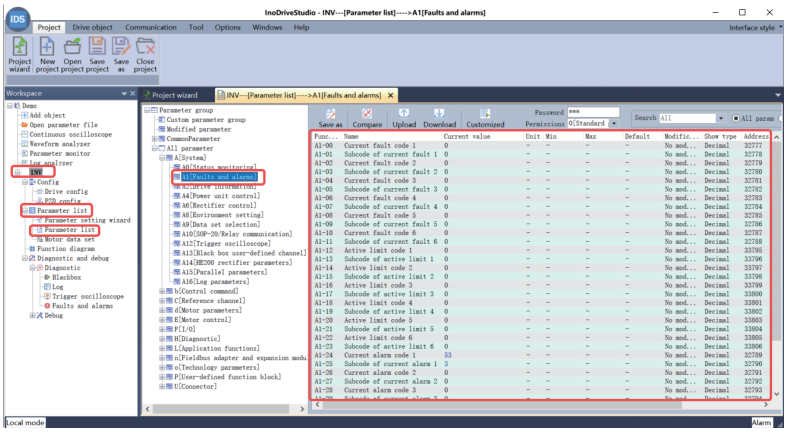


Figure 2-15 Viewing faults in group A1

- Viewing the previous fault information
  - Method 1: Go to "INV"→"Diagnostic and debug"→"Diagnostic"→"Faults and alarms" to open the alarm/fault list, as shown in the following figure.

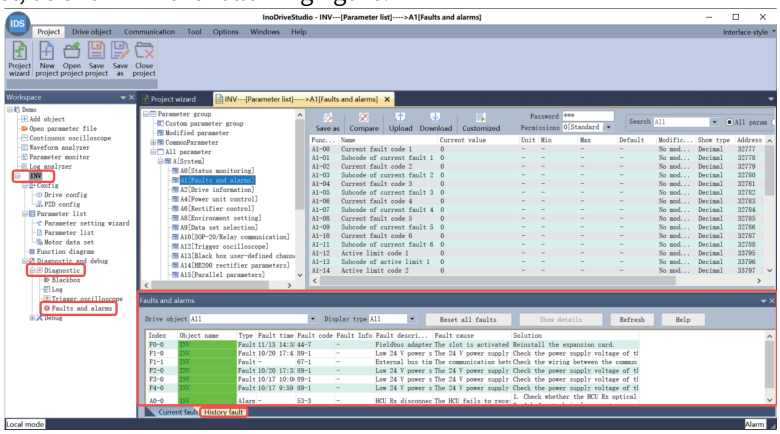


Figure 2-16 Historical fault list

  - Method 2: Click parameters in groups H2 to H7 to view previous faults and alarms, as shown below.

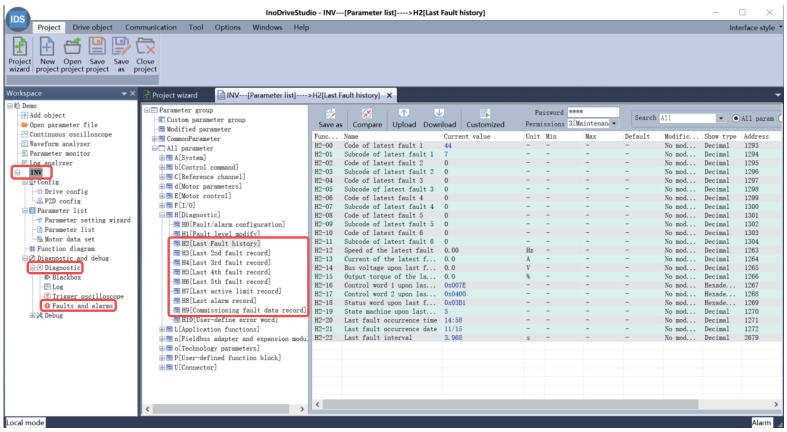


Figure 2-17 Viewing previous faults

2.3.3.5 Viewing and Modifying Parameters

You can view and modify parameters through InoDriveStudio. After the device is connected, go to "INV"→"Parameters"→"Parameter list" to display the parameter list of current device, as shown below.

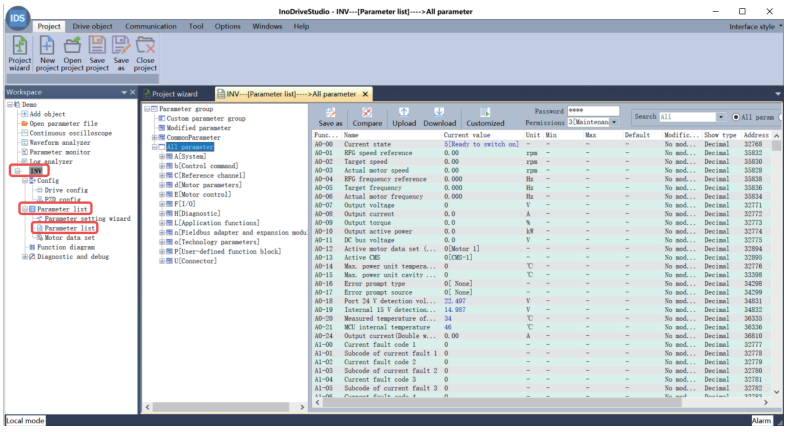


Figure 2-18 Parameter list

- Parameter groups are displayed on the left, and parameters in a selected parameter group are displayed on the right.
- You can view information such as the parameter name, present value, default value, unit, modification method, and communication address of a parameter.
- Modified parameters will be downloaded to the device.
- When the present value of a parameter does not match the default value, the present value is displayed in blue.
- When the parameter is changed to a value outside the allowable range, the modification does not take effect.
- During operation, if you change a parameter that should be modified at stop, the modification does not take effect.
- You can enter part of the parameter description in the filter to realize fuzzy match. For example, click "System group" to select all parameters, enter "Torque" in the filter, and press "Enter". All parameters containing "Torque" will be displayed.

2.3.3.6 Parameter Comparison

InoDriveStudio supports the comparison of parameters. You can access the comparison function in either of the following two ways.

- Go to “Drive object” > “Compare”.
- Click “Compare” in the parameter list interface.

The figure below shows two ways to access the comparison function.

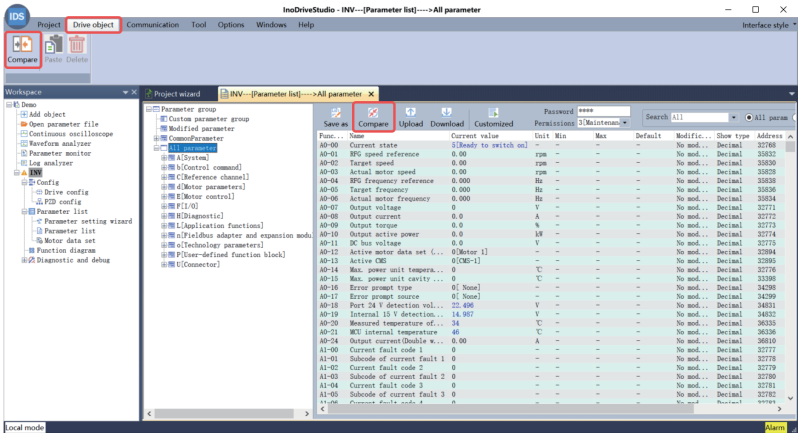


Figure 2-19 Accessing the comparison function

As shown in the following figure, you can compare two offline parameter files. Also, you can compare the current parameters and the default parameters of the inverter module. You can select to show the different parameters, the same parameters, or all parameters.

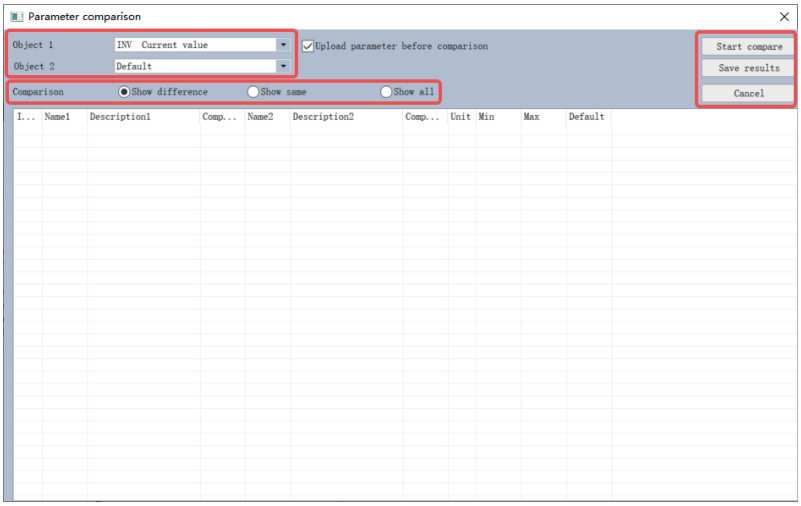


Figure 2-20 Comparison page

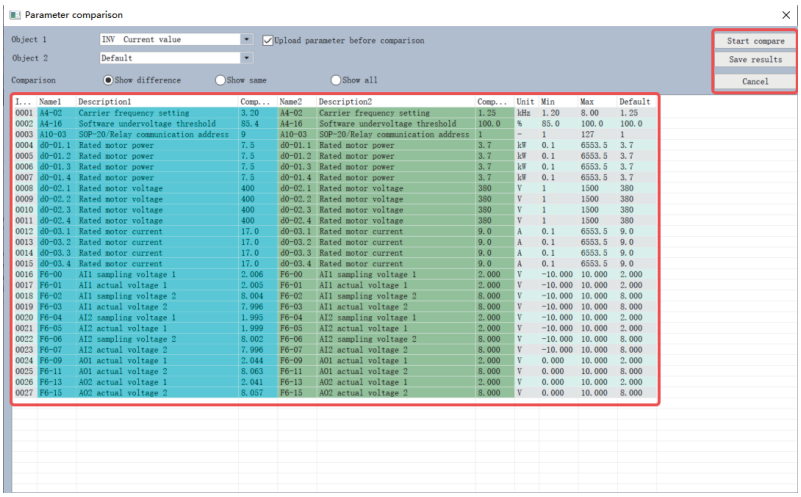


Figure 2-21 Example of comparison between present values and default values

2.3.3.7 Parameter Backup and Download

You can use InoDriveStudio to back up the parameters to the PC through the "Upload" or "Save as" function. Also, you can restore the backup parameters from the PC to the drive through the "Download" function.

- The following shows how to back up parameters through the "Upload" function. Go to "Parameter list"→"Upload"→enter the file name→select the save type as "Parameter file (*.inoprm)"→click "Save". Then wait for uploading to be done.

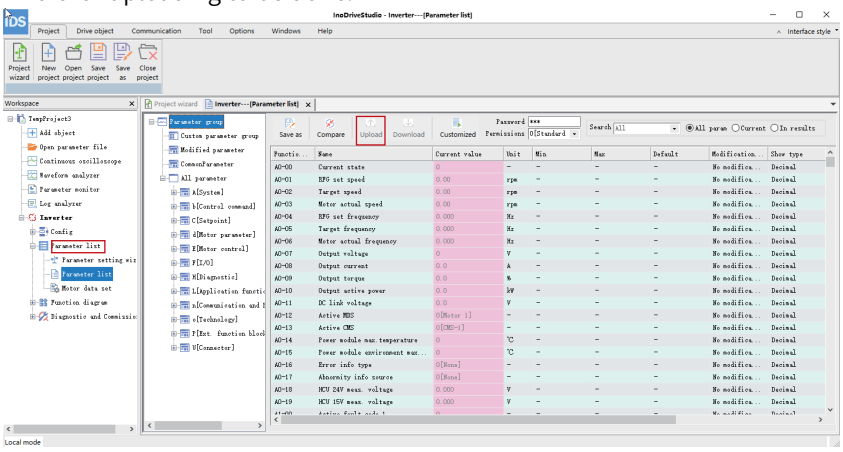


Figure 2-22 Parameter backup through the upload function

- The following shows how to back up parameters through the "Save as" function. Go to "Parameter list"→select the parameter group to be backed up→"Save as"→enter the file name to be saved→select the save type as "Parameter file (*.inoprm)"→check "Upload parameter before saving"→click "Save". Then wait for uploading to be done.

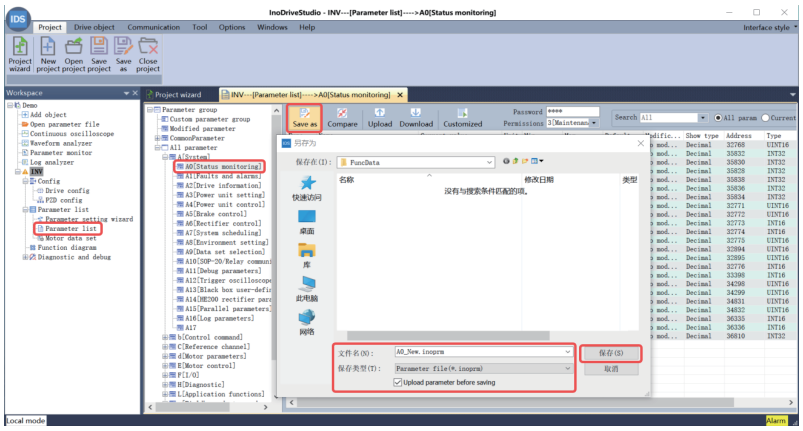


Figure 2-23 Parameter backup through the "Save as" function

Note

- When you click "Upload" to back up parameters, all parameters are backed up.
- When you need to back up custom parameters, see *"2.3.3.8 Custom Parameter Group" on page 55*.
- When you click "Save as" to back up parameters, select "Parameter file (*.inoprm)" as the file type and check "Upload parameters before saving".

- The following shows how to download parameters. Go to "Parameter list"→click "Download"→select the file to be downloaded→select the download mode→click "Open". Then, wait for the download to be done.

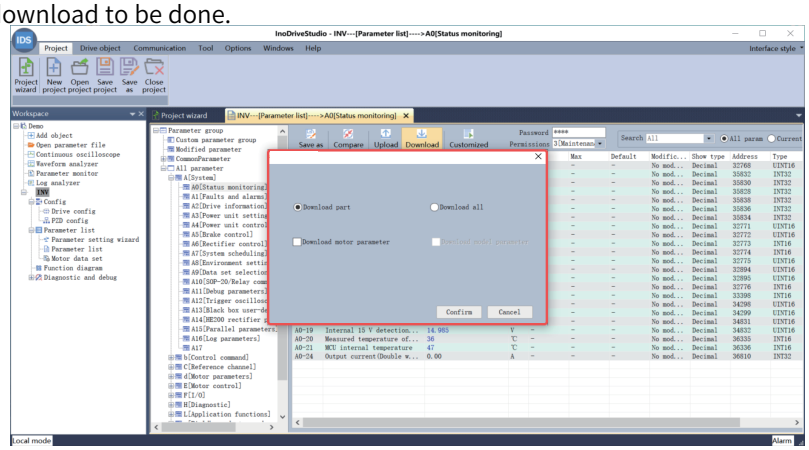


Figure 2-24 Parameter download

Download part/Download all: All the parameters are downloaded, except motor parameters (group d), model-related parameters, A10-04 (Communication rate of SOP-20-880), and A10-03 (Communication address). You can check "Download motor parameters" to download motor parameters. Model-related parameters cannot be downloaded either in the "Download part" mode or "Download all" mode.

Caution

Be cautious when downloading model parameters. Model parameters can be downloaded by professionals only.

2.3.3.8 Custom Parameter Group

InoDriveStudio allows you to form multiple parameters into a new group. You can save the custom parameter group as a parameter file or a configuration file.

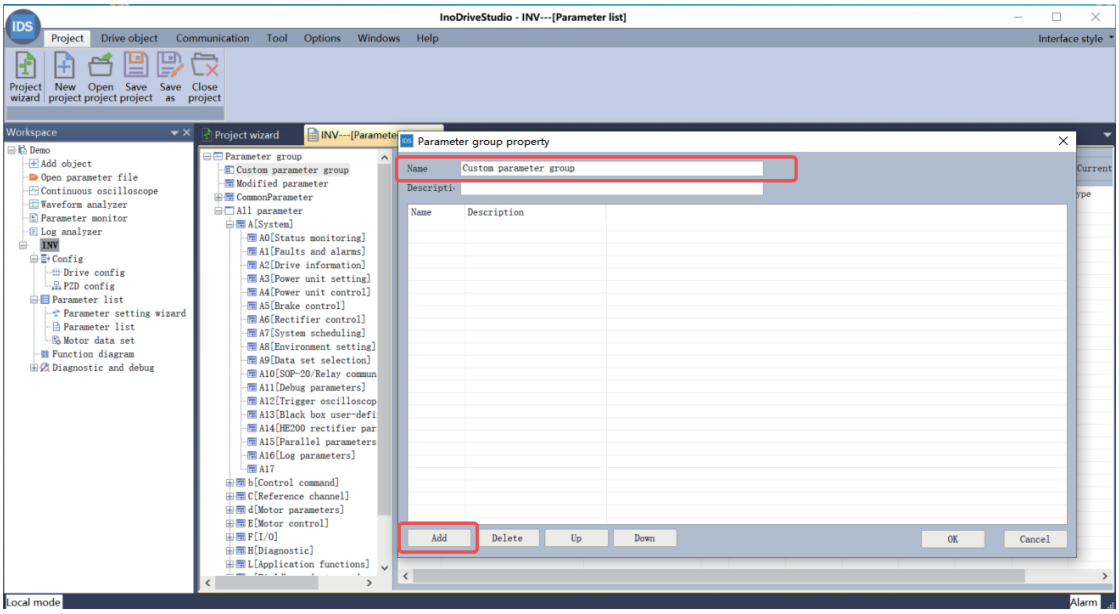


Figure 2-25 Entering the custom parameter group

- The following shows the procedure for customizing the parameter group.
  Click "Parameter list"→"Custom parameter group", then create or load the saved the custom group→set the custom group name→click "Add" button→add or delete the parameters need to be customized→click "OK" to generate custom parameter group.

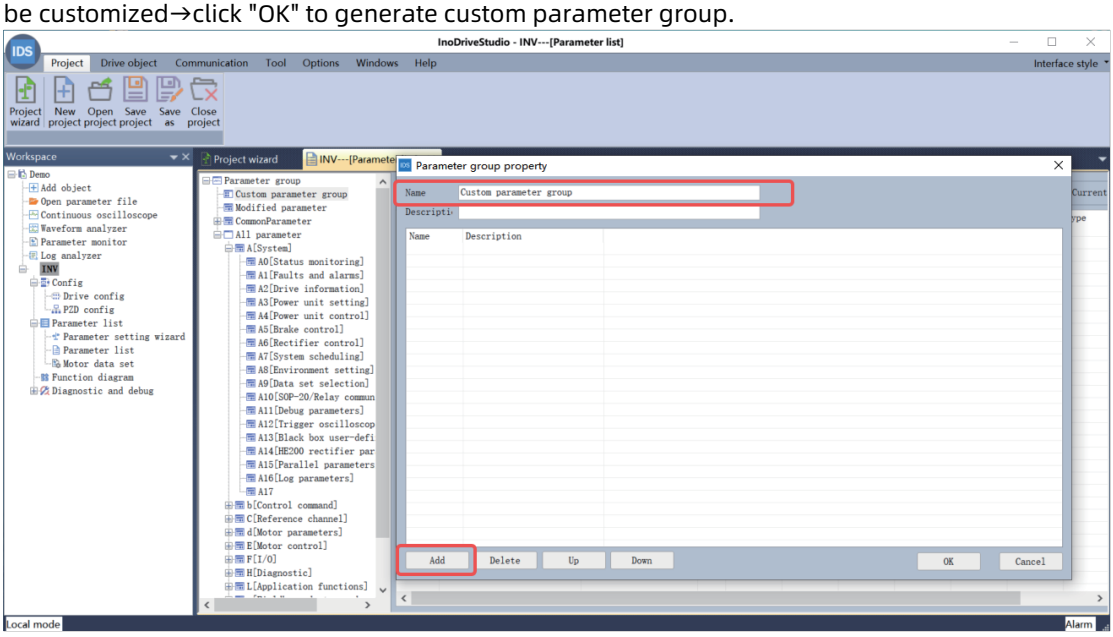


Figure 2-26 Custom parameter groups

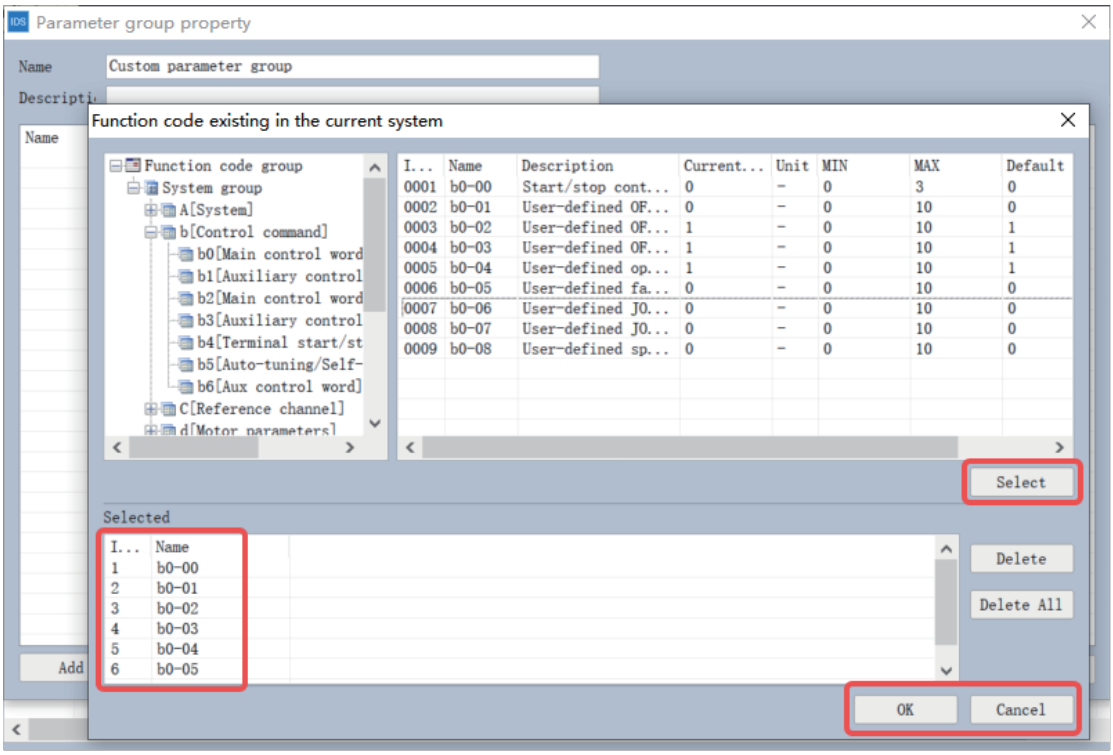


Figure 2-27 Custom configuration parameters

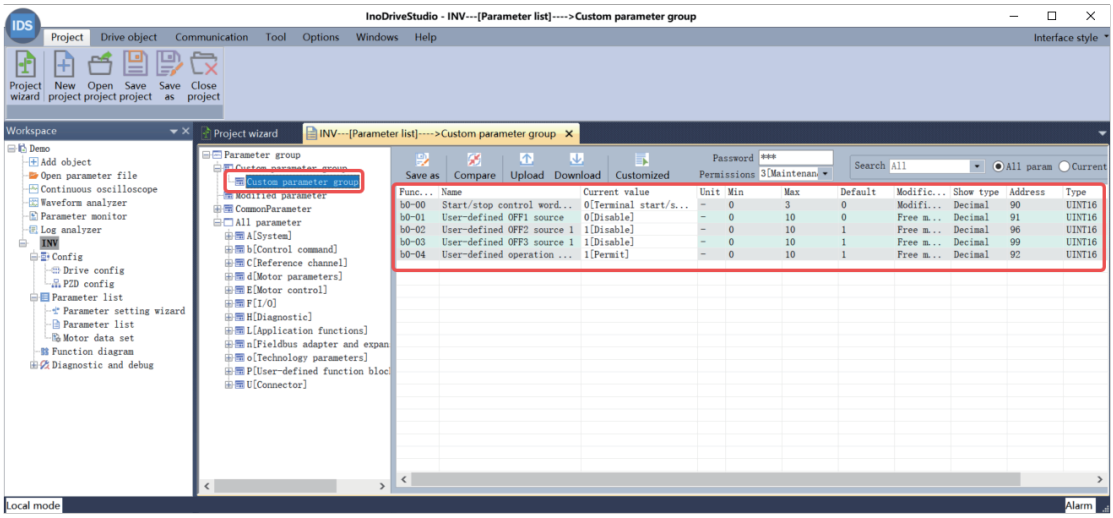


Figure 2-28 New custom parameter group file

Right-click a new custom parameter group and select "Delete custom group", "Edit custom group", "Load custom group", and "Save as" to perform related operations.

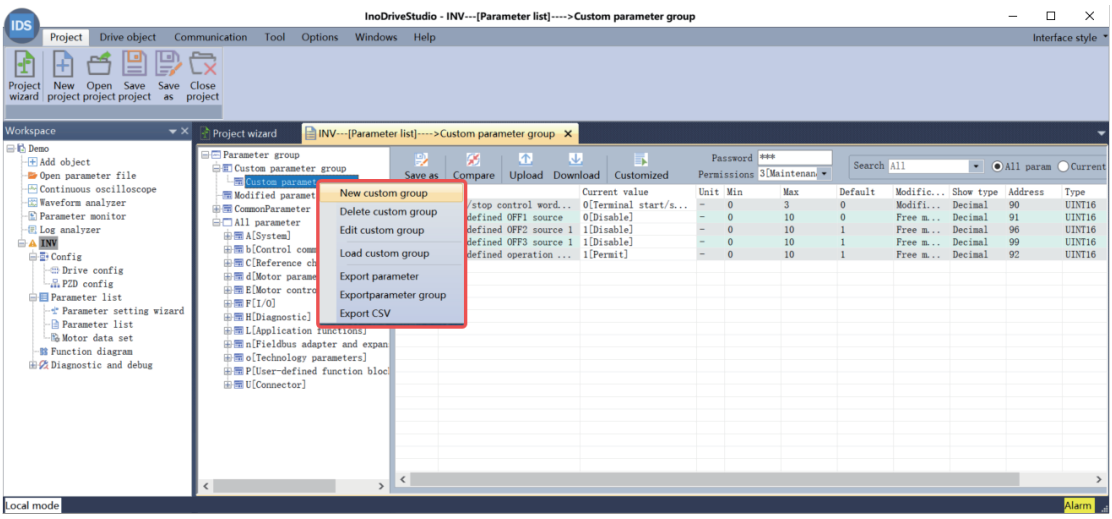


Figure 2-29 Operations on the custom parameter group

When saving a custom parameter group, you can select the following file types.

- Parameter file (*.inoprm): The "Save as" files support parameter download. The parameter values in the file can be downloaded to other device.
- Parameter group file (*.inogrp): The "Save as" file is the parameter group configuration file that only contains parameter group information, which can be re-loaded to the custom group.
- CSV file (*.csv): The "Save as" file can be opened and viewed directly.

2.3.3.9 Viewing Modified Parameters

The InoDriveStudio allows you to view parameters with default values changed. Go to "INV" > "Parameter list" > "Parameter group" > "Modified parameter". Double-click "Modified parameter". If parameters are in the process of uploading, modified parameters will be displayed after uploading is done.

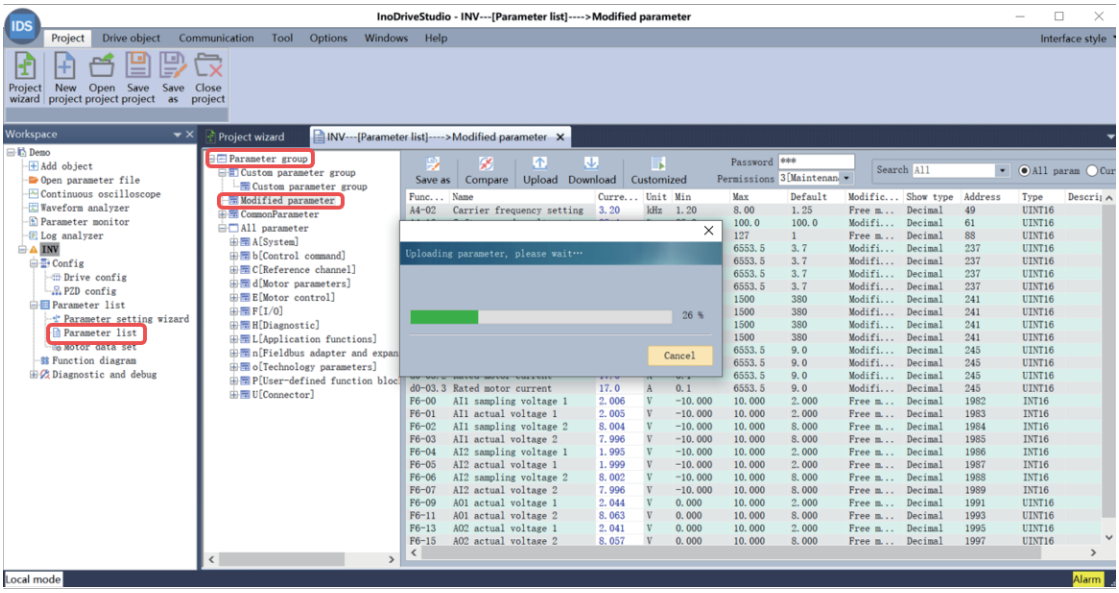


Figure 2-30 Double-clicking "Modified parameter"

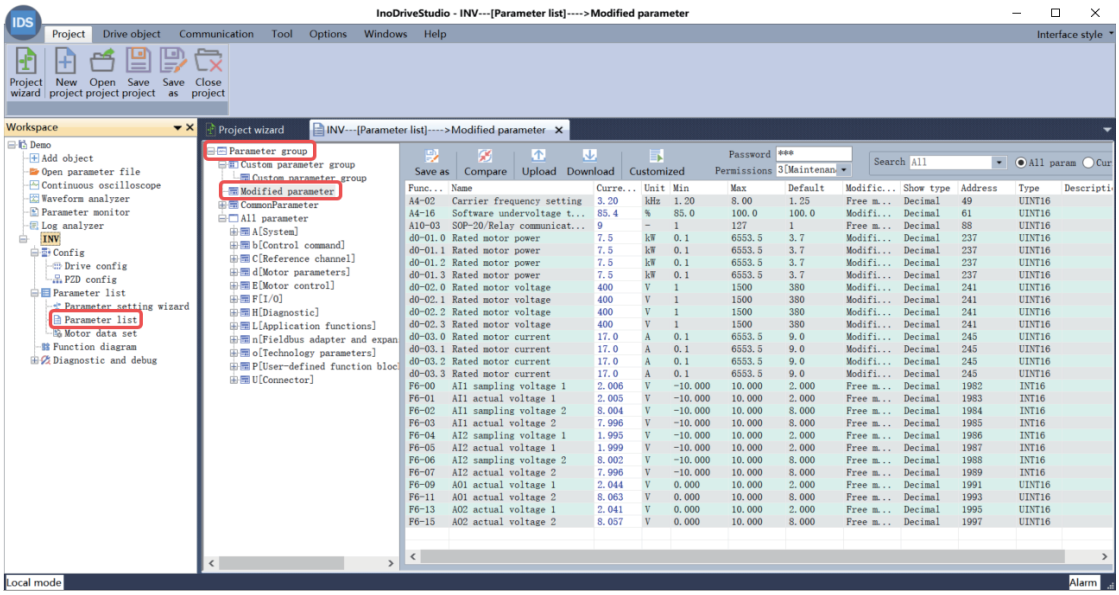
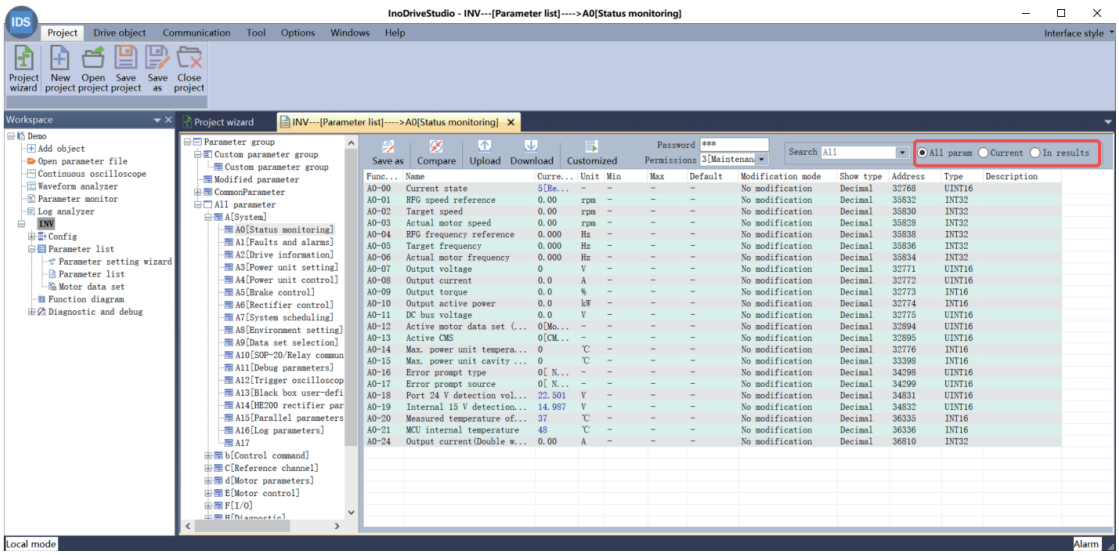


Figure 2-31 Modified parameters

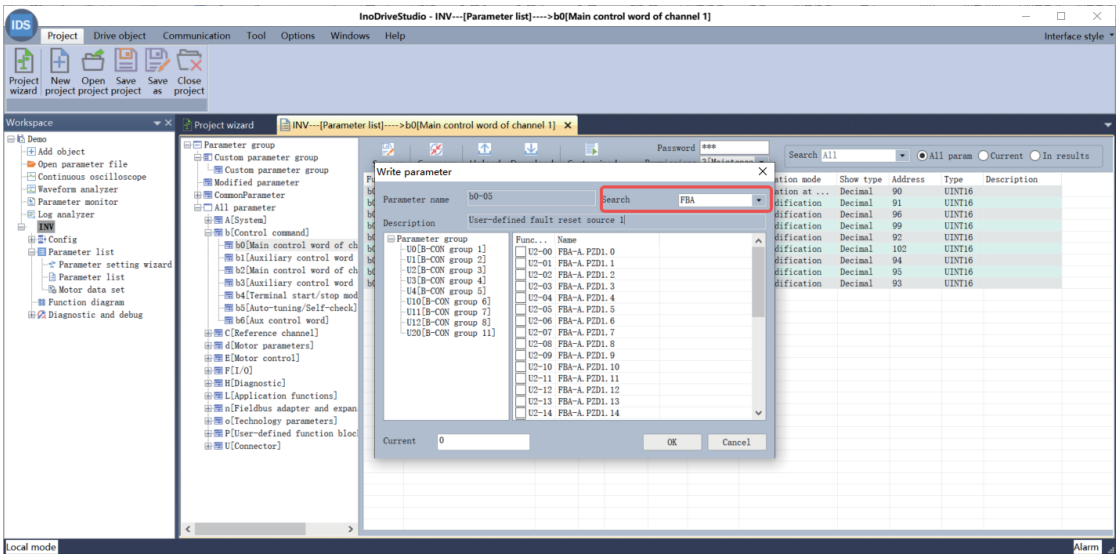
2.3.3.10 Search Function

The InoDriveStudio supports search for parameters and connectors. You can search for parameters and connectors by keywords in the following ways:

- "All parameters": Used to search for all parameters in the parameter list.
- "Current group": Used to search for parameters in the current parameter group.
- "Search the current results": Used to search for parameters in the current list.



When a parameter value is set to "Connector", you can search for the required connector quickly, as shown below.



2.3.3.11 Common Functions

You can use InoDriveStudio to back up the parameters to the PC through the "Upload" or "Save as" function. Also, you can restore the backup parameters from the PC to the drive through the "Download" function.

- The following shows how to back up parameters through the "Upload" function. Go to "Parameter list"→"Upload"→enter the file name→select the save type as "Parameter file (*.inoprm)"→click "Save". Then wait for uploading to be done.

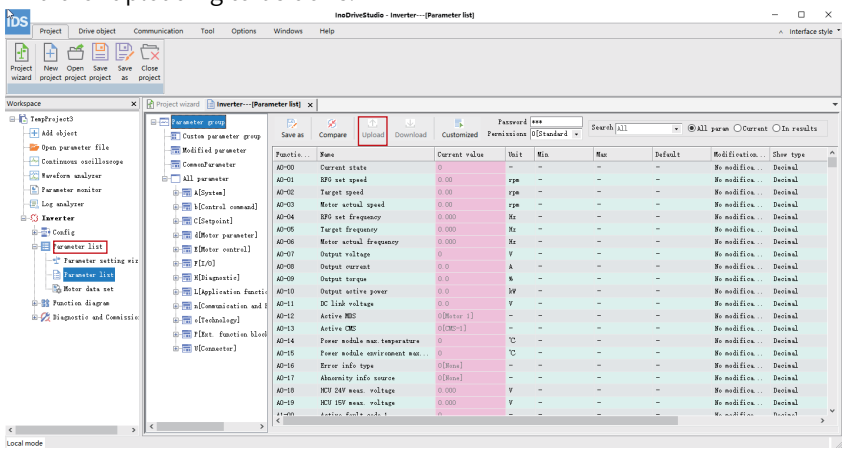


Figure 2-32 Parameter backup through the upload function

- The following shows how to back up parameters through the "Save as" function. Go to "Parameter list"→select the parameter group to be backed up→"Save as"→enter the file name to be saved→select the save type as "Parameter file (*.inoprm)"→check "Upload parameter before saving"→click "Save". Then wait for uploading to be done.

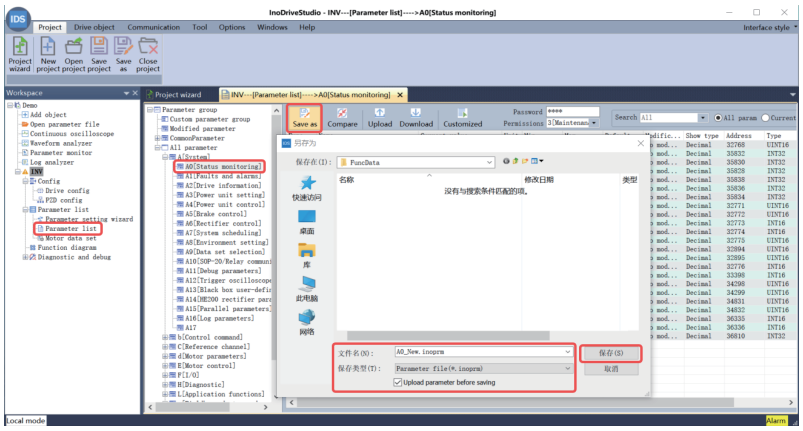


Figure 2-33 Parameter backup through the "Save as" function

Note

- When you click "Upload" to back up parameters, all parameters are backed up.
- When you need to back up custom parameters, see *"2.3.3.8 Custom Parameter Group" on page 55*.
- When you click "Save as" to back up parameters, select "Parameter file (*.inoprm)" as the file type and check "Upload parameters before saving".

- The following shows how to download parameters. Go to "Parameter list"→click "Download"→select the file to be downloaded→select the download mode→click "Open". Then, wait for the download to be done.

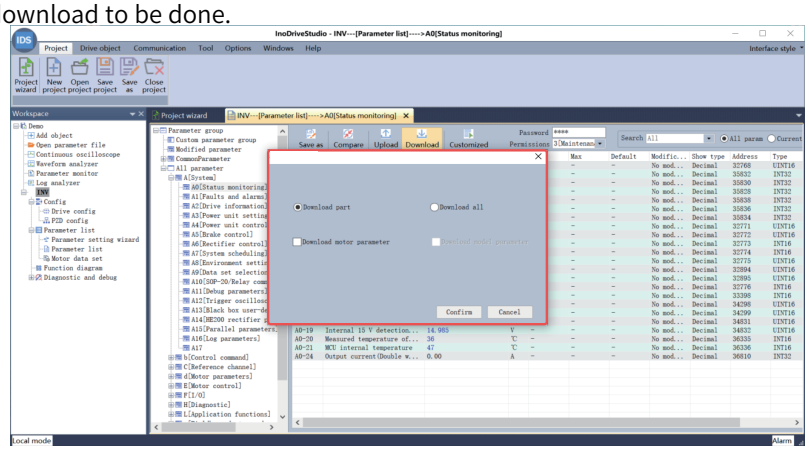


Figure 2-34 Parameter download

Download part/Download all: All the parameters are downloaded, except motor parameters (group d), model-related parameters, A10-04 (Communication rate of SOP-20-880), and A10-03 (Communication address). You can check "Download motor parameters" to download motor parameters. Model-related parameters cannot be downloaded either in the "Download part" mode or "Download all" mode.

Caution

Be cautious when downloading model parameters. Model parameters can be downloaded by professionals only.

2.3.4 Waveform Record and Analysis

Real-time analysis of data curves is key for the commissioning performance. InoDriveStudio provides three ways for online recording of data curves in real time, recording of conditional triggering events, and offline view of waveforms.

2.3.4.1 Continuous Oscilloscope

The operation status of the equipment needs to be monitored in real time during on-site commissioning. The continuous oscilloscopes in InoDriveStudio can be used to monitor and record related data or status of the equipment in real time. Click "Continuous Oscilloscope" in the workspace pane to open the oscilloscope. The oscilloscope consists of the channel selection area, waveform display area, waveform configuration area, and toolbar, as shown in the following figure.

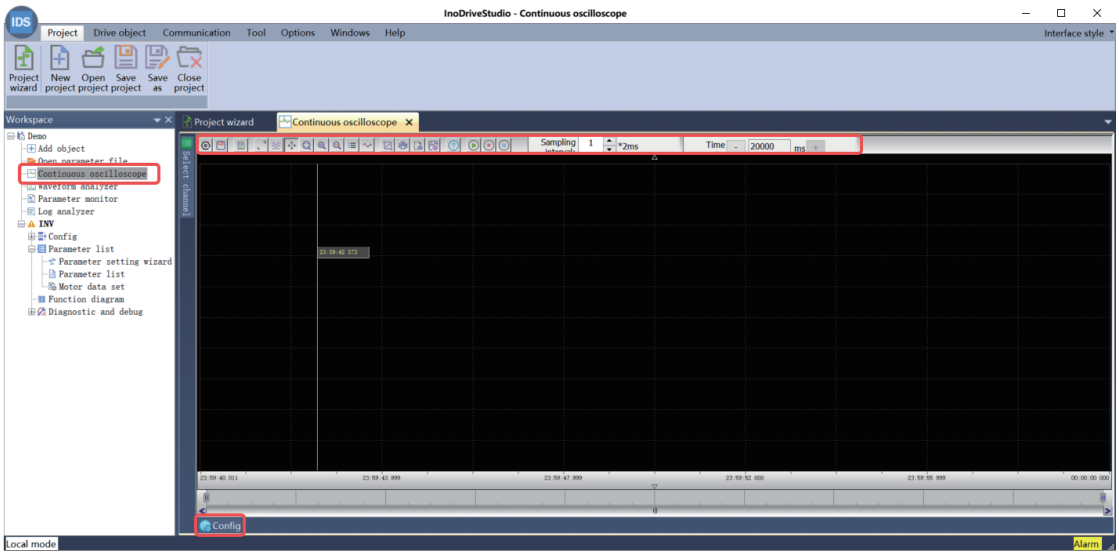


Figure 2-35 Opening the continuous oscilloscope

Only one continuous oscilloscope can be opened for each project. The oscilloscope is used to record and analyze waveforms of all equipment in the current project, as shown in the following figure.

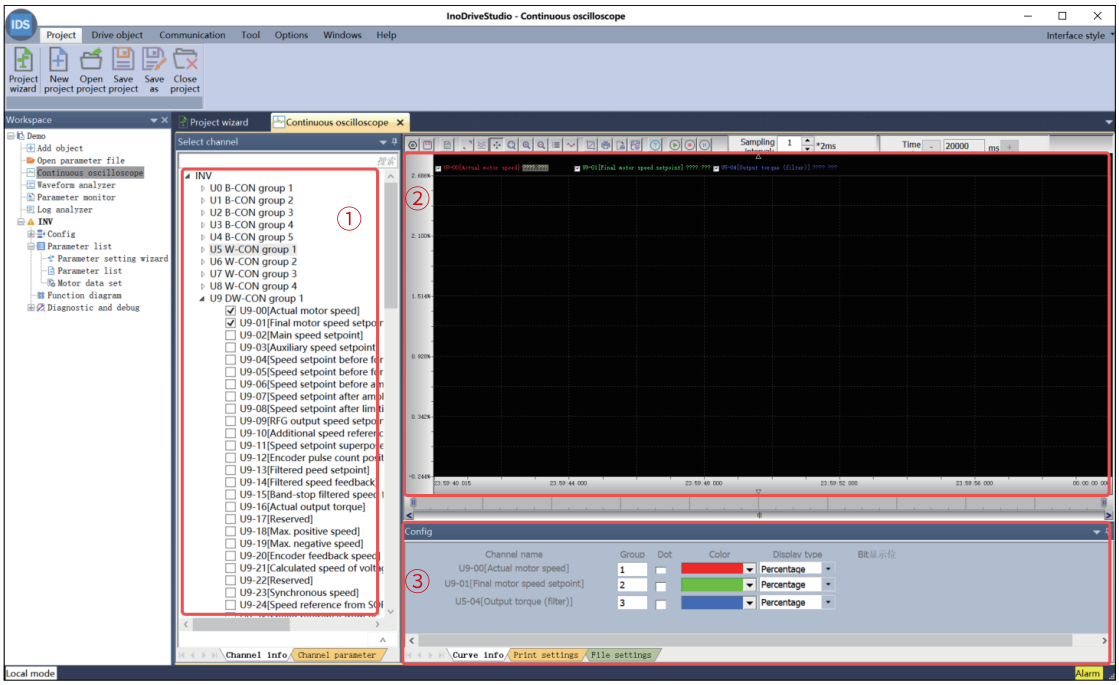


Figure 2-36 Continuous oscilloscope interface

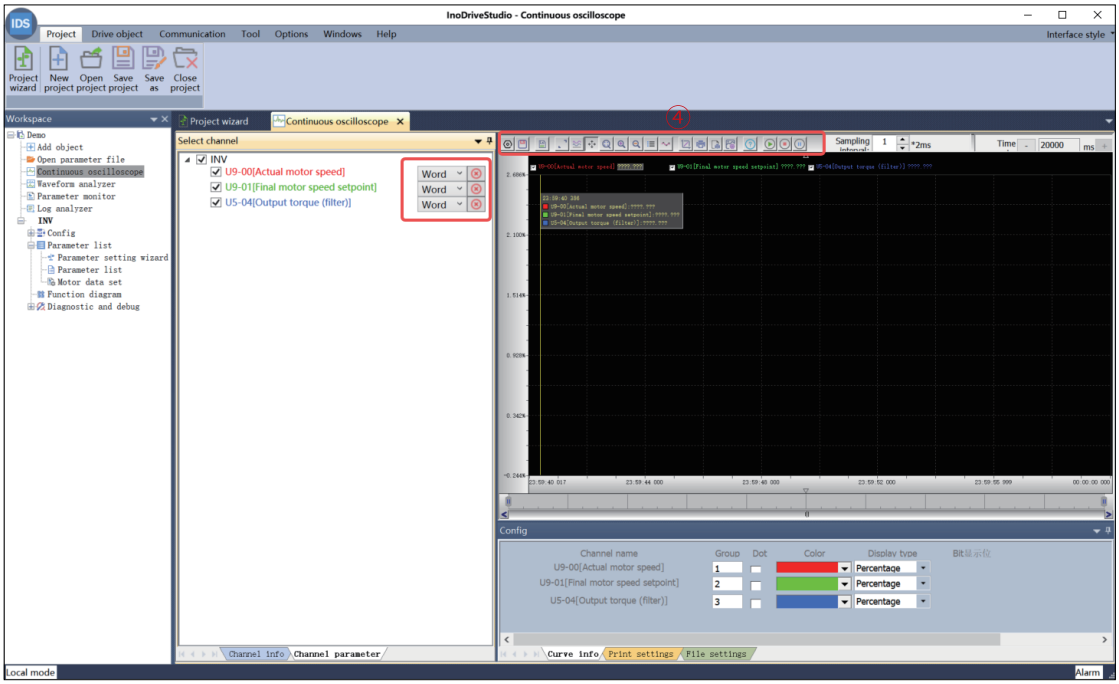


Figure 2-37 Deleting continuous oscilloscope channels

Table 2–7 Descriptions of continuous oscilloscope interface

No.	Name	Function
①	Channel selection	-
②	Main interface for waveform display	-

No.	Name	Function
③	Waveform configuration	When the same group number is set, connectors with the same physical quantity meaning are displayed in the same axis.
④	Toolbar	You can start, stop, pause, and zoom in/out the toolbar. To delete the selected channel, click the "Stop" button and then select "Channel Parameter".

In the "Select channel" pane, customize the data channel to be monitored. All parameters in group U can be used as the data source to record curves, in which:

- When U5 to U8 and U15 to U18 are used as the data source to record curves, each data occupies one recording channel.
- When U9, U19, and U29 are used as the data source to record curves by default, each data occupies one recording channel. To generate waveforms of higher accuracy, you can also modify the configuration to "double-word recording", with each data occupying two recording channels.
- U0 to U4, U10 to U14, and U20 are digital values, which can be used to record up to eight digital values in a device. All digital waveforms in a device only occupy one recording channel.

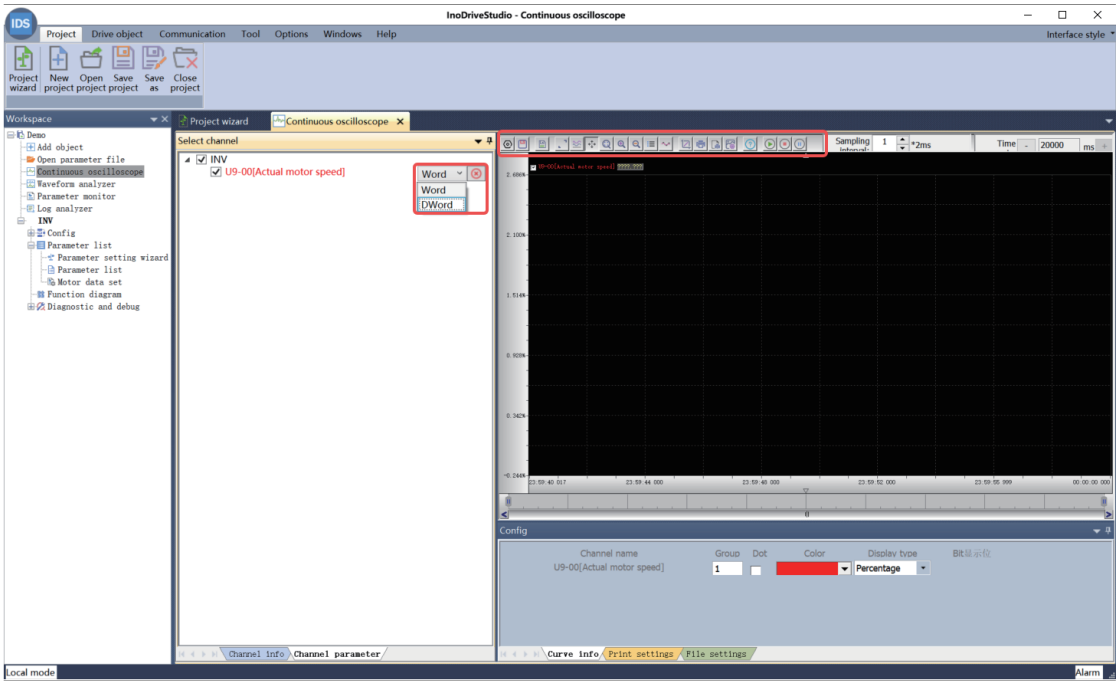


Figure 2-38 Word or double-word display of connectors

The number of channels is related to the communication baud rate and sampling interval, as shown in the following table.

Table 2–8 Relation between the baud rate and sampling interval

Baud rate	Sampling interval	Max. number of channels	Sampling interval	Max. number of channels	Sampling interval	Max. number of channels
115200 bps	2 ms	4	4 ms	7	> 4 ms	8
1 Mbps	2 ms	8	4 ms	8	> 4 ms	8
2 Mbps	2 ms	8	4 ms	8	> 4 ms	8
4 Mbps	2 ms	8	4 ms	8	> 4 ms	8

For details on waveform configuration and toolbar usage, see the help file of the InoDriveStudio software.

Button descriptions:

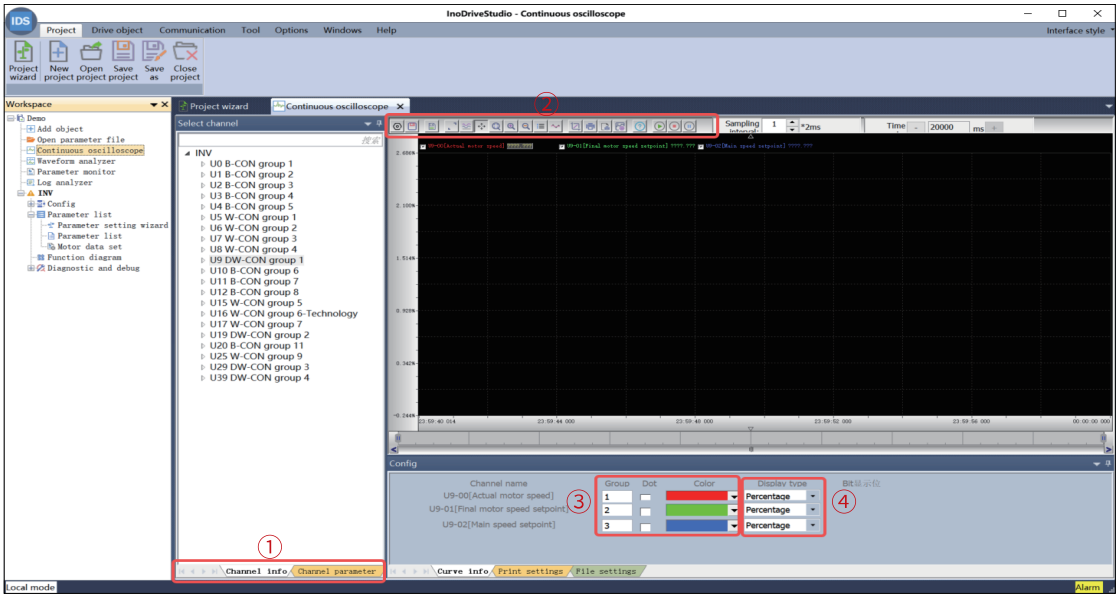


Figure 2-39 Continuous oscilloscope

① In the lower part of the "Select channel" pane, click the "Channel info" tab to select a device and configure the oscilloscope channel for the device. Click the "Channel Parameter" tab to show the current and configured oscilloscope channels. You can also select the recording accuracy of the 32-bit connector. Selecting Dword indicates higher accuracy, but occupies two oscilloscope channels.

② The following table describes buttons in the oscilloscope tool bar.

Button	Function
	Used to save the waveform. Waveforms are automatically saved in the project directory during operation of the continuous oscilloscope. However, the previous waveform is automatically deleted when the waveform file exceeds the limit. It is recommended that important waveforms be manually saved to another directory for backup.
	When you click this button, Y-axes of all curves are zoomed out automatically based on the displayed value range to ensure that all curve points are displayed.
	Used to pan the current curve by the left mouse button.
	When you click this button and select an area with the mouse, this area can be enlarged to cover the current screen. When the Y-axis range of the current curve changes, the time axes of all curves change simultaneously.
	Used to zoom in or zoom out step by step. When the Y-axis range of the current curve changes, the time axes of all curves change simultaneously.
	Used to show or hide the cursor. Measurement of curve data can be achieved using these two cursors.

Button	Function
	Used to capture the entire interface and save the file as the *.Bmp, *.jpg, or *.png files.
	Used to set the background. You can set the background color, axis color, font size, grid color, and cursor color of the oscilloscope. After setting, click "Save" to save the setting.

③ Modify the color of each curve in curve information. When you check the curve point, each sampling point of the curve will be bolded. When the group numbers of the two curves are set to the same value, these two curves share the same set of Y-axis, which are zoomed in/out simultaneously.

④ The display type of certain signals can be changed. For example, the speed can be displayed as the per unit value by percentage, frequency, or speed unit.

Table 2–9 Description of common shortcut keys

Shortcut key	Function
Right button of the mouse	Used to zoom in/out the X-axis and Y-axis of all the curves automatically.
Mouse wheel	Used to zoom in or out curves. In the waveform area, both the X-axis and Y-axis can be zoomed in/out simultaneously. In the axis area, only the specific axis can be zoomed in/out. When the Y-axis range of the current curve changes, the time axes of all curves change simultaneously.
Ctrl+mouse wheel	Used to pan the curve. In the waveform area, both the X-axis and Y-axis can be paned. In the axis area, only the specific axis can be paned. When the Y-axis range of the current curve changes, time axes of all the curves change simultaneously.
Up and down arrows (↑ ↓)	Used to pan the current curve upwards and downwards.
Alt	Used to shift all the curves forcibly. For example, pressing the Alt key+up arrow can move all curves up.
Shift	Used to zoom in/out the axes forcibly. For example, pressing the Shift key+up arrow can zoom in or out the Y-axis of current curve.
Ctrl	Used to pan the curve focibly. For example, pressing the Ctrl key+mouse wheel can pan the curve.

2.3.4.2 Black Box Function

The MD880 series AC drives are equipped with the built-in black box function. The black box function is enabled automatically upon power-on. The black box records the information generated when a fault occurs or when custom conditions are met.

When a fault occurs, the controller of MD880 series drives collects the data generated 1.5s before the fault and 0.5s after the fault. The data includes 16 entries of ADC internal interruption data, 48 entries of internal data collected at a cycle of 2 ms, and 16 entries of customized data collected at a cycle of 2 ms. The data collected are automatically saved to the SD card of the HCU-50S/51S. Up to 1000 groups of fault data can be saved.

- Automatic fault trigger condition: Once the inverter module enters the fault state, black box function is triggered automatically.
- Custom trigger condition: You can set H0-06 to trigger the black box once upon the rising edge. Related parameters are shown in the following table.

Table 2–10 Parameters related to custom trigger

Param.	Name	Value description
H0-06	Custom black box trigger command source	0: Inactive Others: B connector
H0-40	Exception detection selection 1	Ones-: OFF2/OFF3 activation alarm 0: Disable 1: Enable Tens-: HCU RTC battery voltage too low 0: Disable 1: Enable Hundreds-: Reserved 0: Disable 1: Enable Thousands: SD card offline/error alarm 0: Disable 1: Enable Ten thousands-: Condition to activate black box fault recording with SD card 0: Faults that occurred in operation 1: Faults that occurred at any time

To view the waveform recorded by the black box, do as follows:

1. Go to "INV"→"Diagnostic and debug"→"Diagnostic"→"Blackbox" to open the black box interface. Click "Refresh" to view the fault list and the occurrence time.

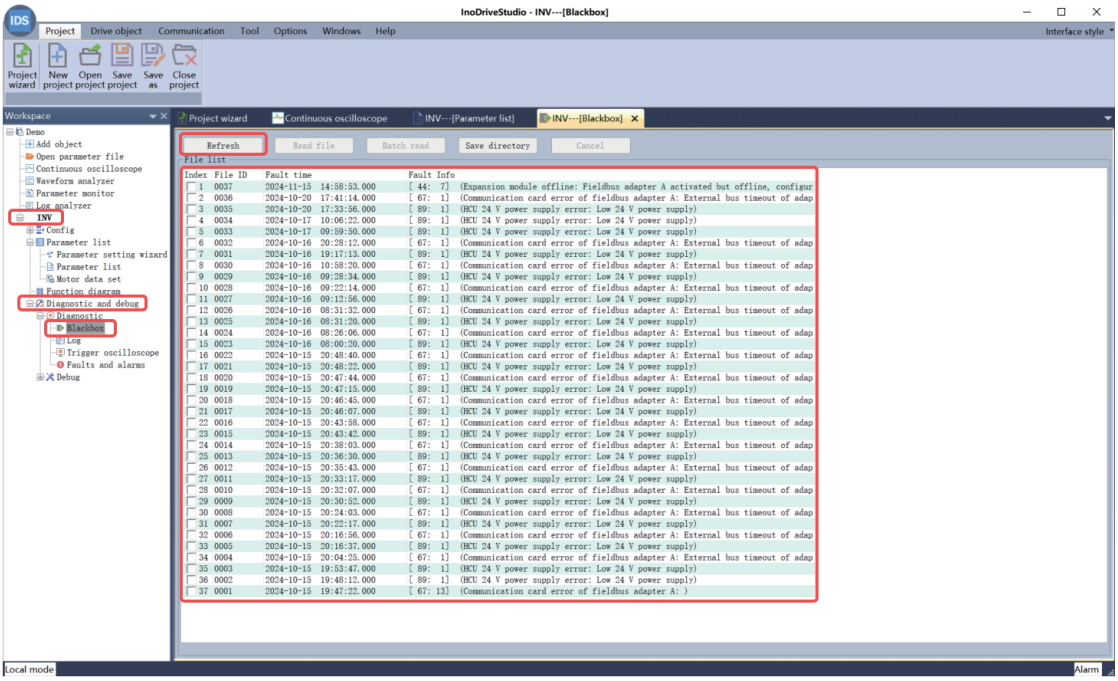


Figure 2-40 Black box interface

2. Select one of the faults, such as fault 2, select the file to be read, and save it.

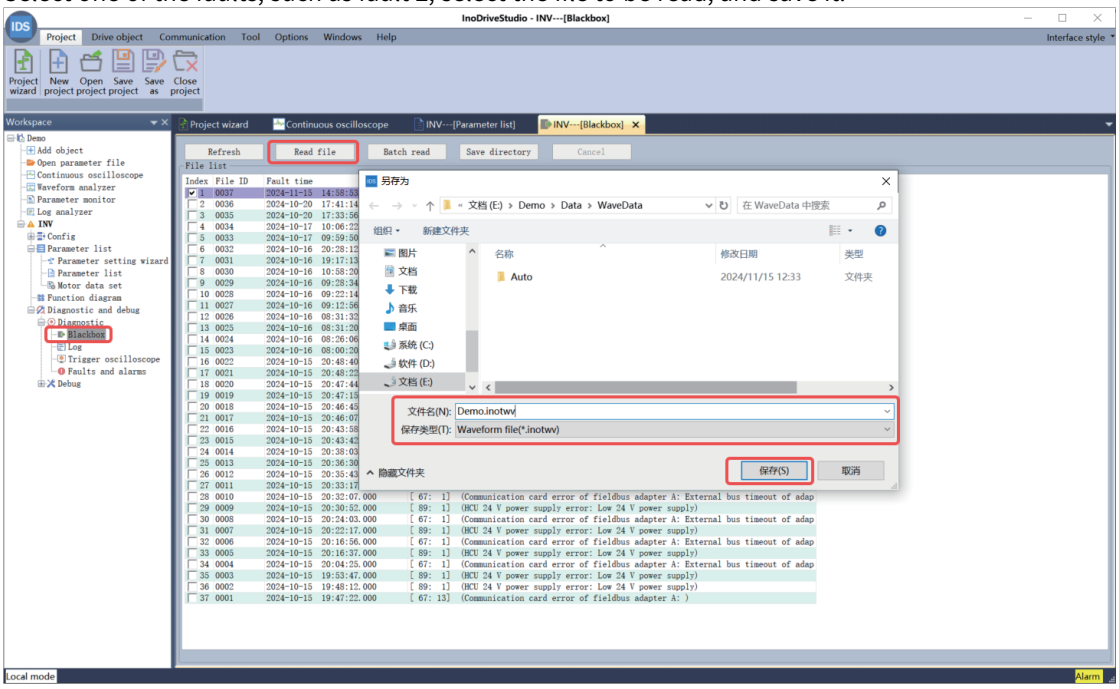


Figure 2-41 Saving interface of the black box

3. After you click "Save", InoDriveStudio automatically opens the waveform that has been saved. Select the channel to be viewed, and the corresponding waveform will be shown.

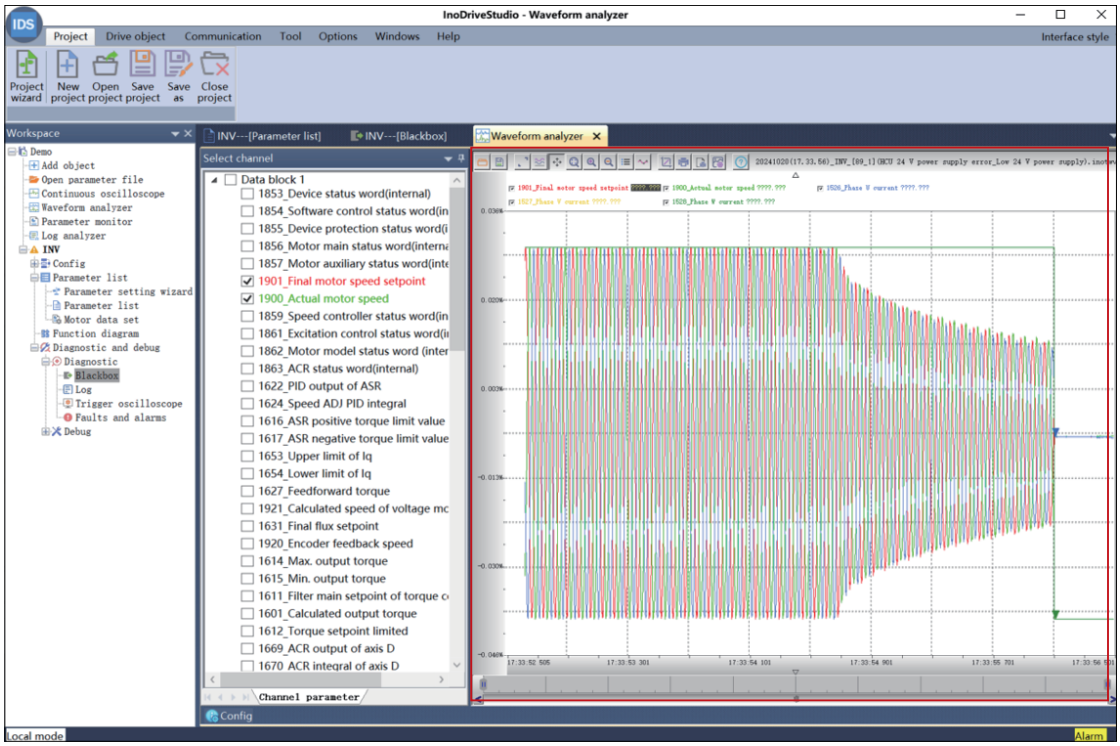


Figure 2-42 Black box waveform

Batch reading of black box files is supported, as shown in the following figure. Click "Batch read" and select the directory for saving the files. You can read multiple black box files consecutively.

Note

Note that the progress bar only represents the reading process of an individual black box file.

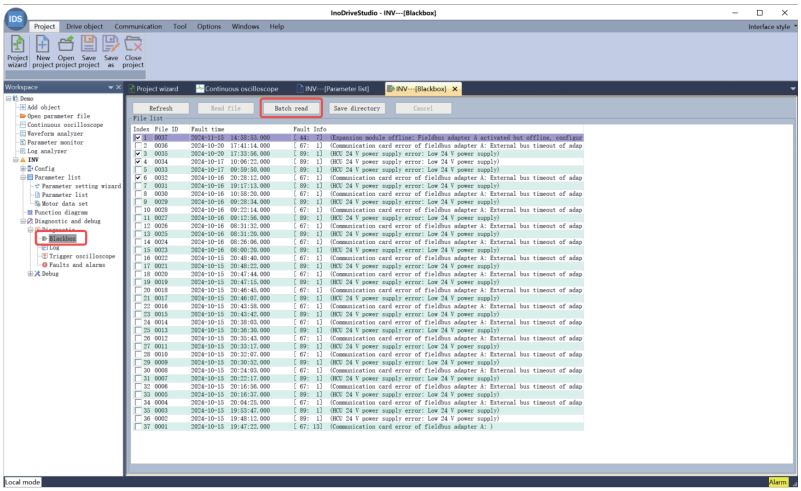


Figure 2-43 Batch reading of black box files

The following shows how to clear the black box records.

1. Set A8-00 to 4 to clear black box record.
2. Set A8-01 to 1 to acknowledge the operation defined by A8-00.

In this case, the parameter file backed up in the SD card of HCU-50S/51S is deleted, without affecting other parameters.

2.3.4.3 Log Function

The system log records information about the software, hardware, and system problems, including specific data and time of occurrence. You can monitor related events such as operation events, state changes, faults, minor faults, and alarms in the system. Users and manufacturers can locate the fault causes through the log for easy fault tracking and equipment maintenance. The log covers the changing process of critical system states (including power-on/power-off, state machine change, command setting, automatic fault reset) and operations to restore default setting.

The log function is enabled by default. You can disable this function through A16-00.

Reading the log

Connect InDriverStudio to HCU-50S/51S, as shown in the following figure. Go to "INV"→"Diagnostic and debug"→"Diagnostic"→"Log reading" to open the log interface. Click "Refresh" to view the log files and date of establishment.

The time in the following figure refers to the power-on time of HCU-50S/51S. You can see the time of each event only after the log is opened. After the HCU-50S/51S is powered on again, a log file will be created. You can make records in the new log file. All records are saved in the newly created log file during power-on. A log file will be created only after its memory is full occupied. The system can save up to 400 log files, with 1000 records saved in each file log.

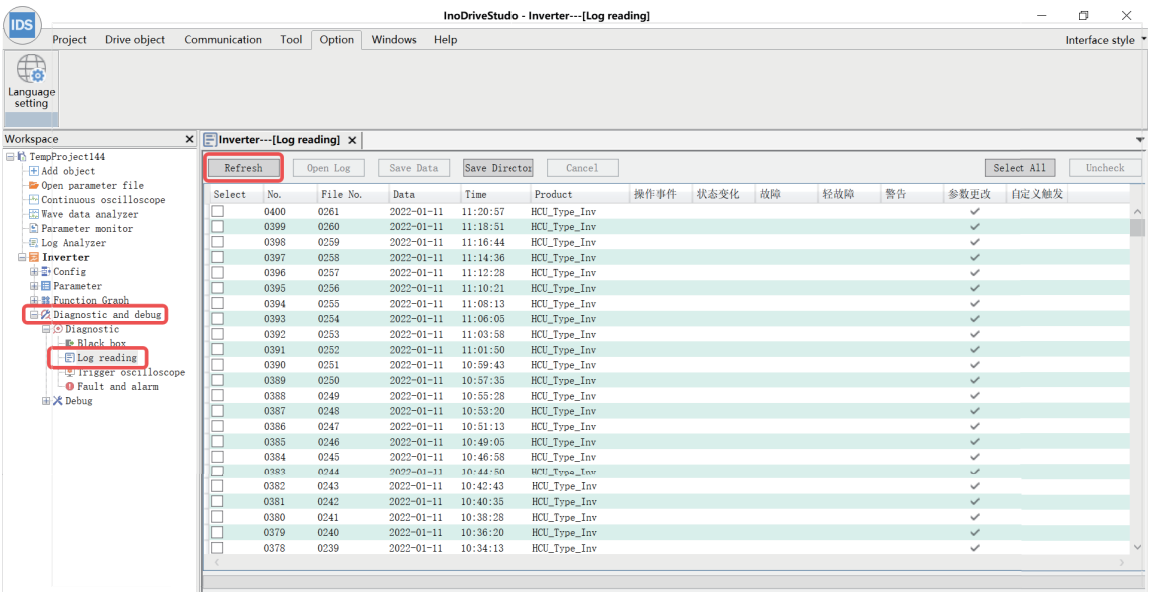
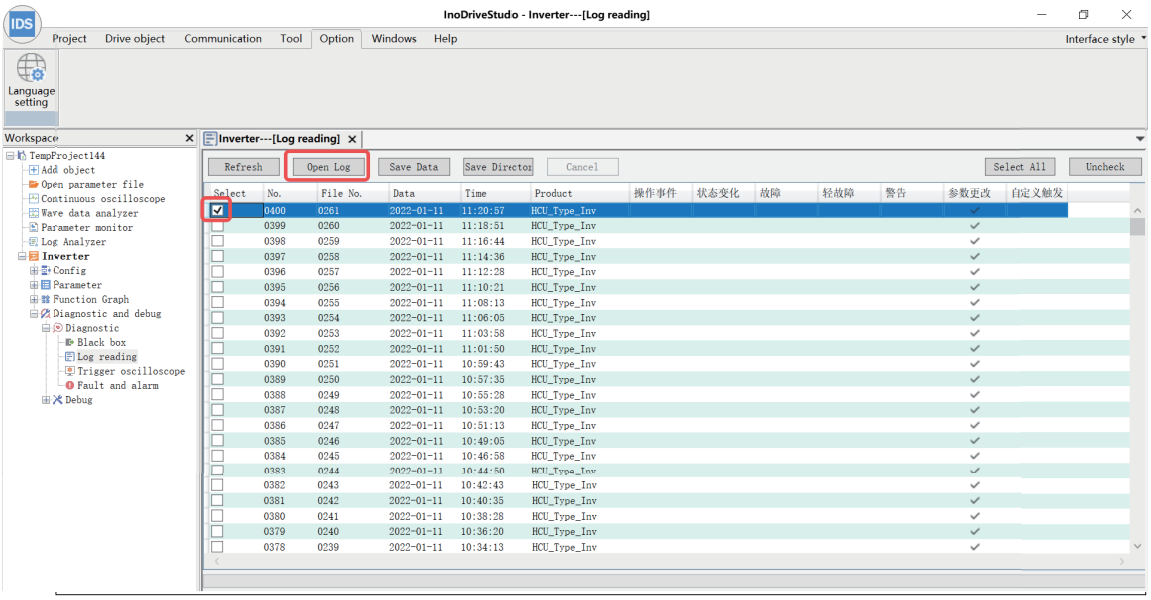
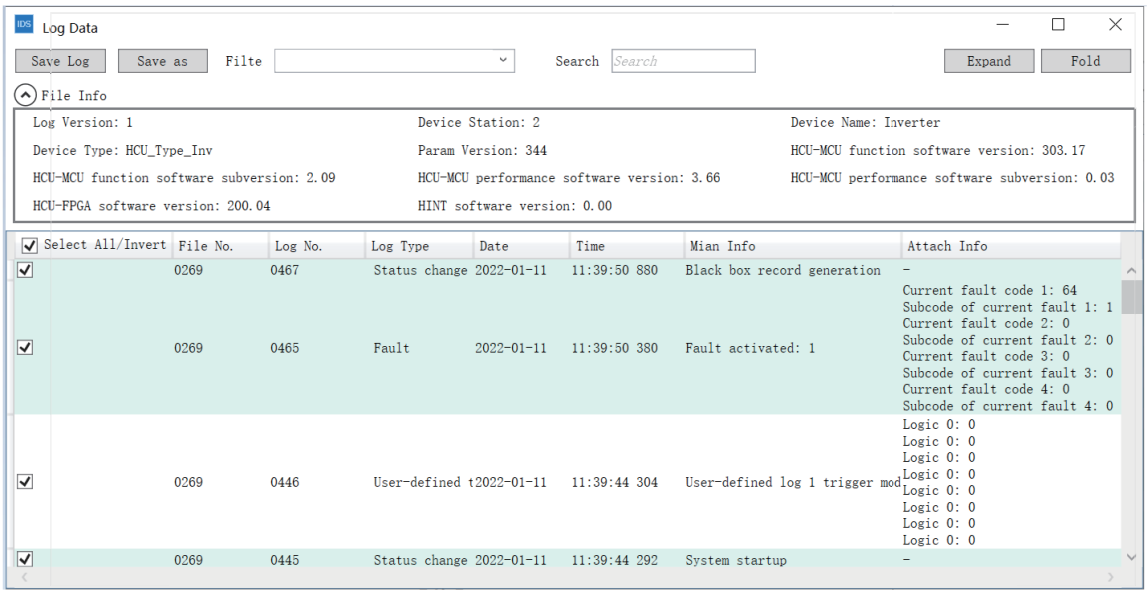


Figure 2-44 Reading InoDriverStudio log

The following figure shows the log after it is refreshed. Check the log as needed, and click "Open Log" to view the log file.



View the log type and time of occurrence in the log data, as shown in the following figure.



Clearing the log

Do as follows:

1. Set A8-00 to 5 to clear log.
2. Set A8-01 to 1 to acknowledge the operation defined by A8-00.

All the log records will be cleared.

Note

The log that has been cleared cannot be recovered again. Use this function with caution.

Custom log trigger

In custom log trigger, analog trigger and digital trigger are supported. When digital trigger is used, the log function is triggered once upon the edge of the digital signal. The edge signal type can be configured by parameters. When analog trigger is used, the log function triggered through comparison with the set source value. Four groups of custom log trigger are supported. The following table describes the related parameters, in which only parameters for custom log 1 are presented because configurations for custom logs 2, 3, and 4 are the same.

Table 2–11 Related parameters

Param.	Name	Setpoint	Remarks
A16-3	Custom log reset function	0: No action 1: Reset the number of custom log 1 triggers 2: Reset the number of custom log 2 triggers 3: Reset the number of custom log 3 triggers 4: Reset the number of custom log 4 triggers 5: Reset the number of all the custom log triggers 6: Restore custom log configuration parameters	-
A16-4	Acknowledgement of log custom reset	0: Cancel 1: OK	-
A16-5	Number of custom log 1 triggers	-	Displays the number of triggers, which cannot be written.
A16-15	Mode for triggering custom log 1	0: Inactive 1: Analog trigger 2: Digital trigger 3: Analog or digital trigger 4: Analog and digital trigger	When the setpoint is 3, a log record will be triggered when as long as one of the analog and digital trigger conditions is met. When the setpoint is 4, a log record will be triggered only when both of the analog and digital trigger conditions are met.
A16-16	Source for analog trigger of custom log 1	0: Inactive Others: K connector	-
A16-17	Comparison condition for analog trigger of custom log 1	0: > 1: < 2: = 3: ≥ 4: ≤	-
A16-18	Comparison value source for analog trigger of custom log 1	0: Inactive Others: K connector	-

Param.	Name	Setpoint	Remarks
A16-19	Source for digital trigger of custom log 1	0: Inactive Others: B connector	-
A16-20	Comparison condition for digital trigger of custom log 1	0: Rising edge (0->1) 1: Falling edge (1->0) 2: Edge (0->1 or 1->0)	-
A16-21	Channel 1 of custom log 1	0: 0 Others: K connector	Set the data value to be recorded when the log is triggered, and bind it through the connector.
A16-22	Channel 2 of custom log 1		
A16-23	Channel 3 of custom log 1		
A16-24	Channel 4 of custom log 1		
A16-25	Channel 5 of custom log 1		
A16-26	Channel 6 of custom log 1		
A16-27	Channel 7 of custom log 1		
A16-28	Channel 8 of custom log 1		

Enabling the log function

The log function can be clipped. You can set this function through parameters A16-85 to A16-91. You can disable or enable specific log functions to mask or open related event records. The following takes A16-85 as an example.

Table 2–12 Related parameters

Param.	Name	Setpoint
A16-85	Log function selection 1	Ones-: Brake released 0: Disable 1: Enable Tens-: Brake applied 0: Disable 1: Enable Hundreds-: AI1 open circuit 0: Disable 1: Enable Thousands-: AI2 open circuit 0: Disable 1: Enable Ten thousands-: Jog operation 0: Disable 1: Enable
A16-86	Log function selection 2	Ones-: Droop function 0: Disable 1: Enable Tens-: Low RTC battery voltage 0: Disable 1: Enable Hundreds-: Self-test selection 0: Disable 1: Enable Thousands-: Current state machine 0: Disable 1: Enable Ten thousands-: Parameter calculation 0: Disable 1: Enable

Param.	Name	Setpoint
A16-87	Log function selection 3	Ones-: Control channel switchover 0: Disable 1: Enable Tens-: Motor parameter group switchover 0: Disable 1: Enable Hundreds-: Reference channel switchover 0: Disable 1: Enable Thousands-: SOP-20 gets permission 0: Disable 1: Enable Ten thousands-: SOP-20 releases permission 0: Disable 1: Enable
A16-88	Log function selection 4	Ones-: IDS gets permission 0: Disable 1: Enable Tens-: IDS releases permission 0: Disable 1: Enable Hundreds-: Parameter access level modification 0: Disable 1: Enable Thousands-: Encoder open circuit 0: Disable 1: Enable Ten thousands-: Control method switchover 0: Disable 1: Enable

Param.	Name	Setpoint
A16-89	Log function selection 5	Ones-: Control mode switchover 0: Disable 1: Enable Tens-: Reserved 0: Disable 1: Enable Hundreds-: bit10 parity check failed in Profibus-DP 0: Disable 1: Enable Thousands-: Reserved 0: Disable 1: Enable Ten thousands-: Reserved 0: Disable 1: Enable
A16-90	Log function selection 6	Ones-: Inolink offline 0: Disable 1: Enable Tens-: Execution time synchronization 0: Disable 1: Enable Hundreds-: OFF1 state 0: Disable 1: Enable Thousands-: OFF2 state 0: Disable 1: Enable Ten thousands-: OFF3 state 0: Disable 1: Enable

Param.	Name	Setpoint
A16-91	Log function selection 7	Ones-: Operation permission state 0: Disable 1: Enable Tens-: Black box trigger records 0: Disable 1: Enable Hundreds-: Write Modbus mailbox data (reserved) 0: Disable 1: Enable Thousands-: Write non-Modbus mailbox data 0: Disable 1: Enable Ten thousands-: Reserved 0: Disable 1: Enable

3 Commissioning and Operation

3.1 Overview

3.1.1 Overview

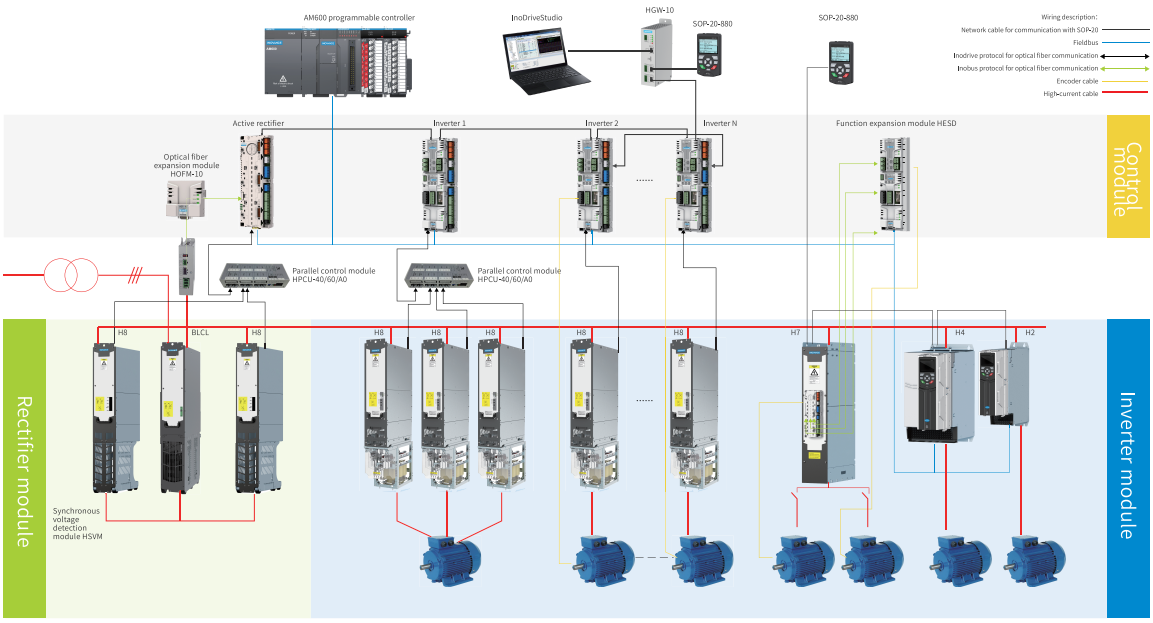


Figure 3-1 Typical topology of MD880

The typical topology of the MD880 series AC drive (multi-drive system) is shown in the preceding figure. It is mainly comprised of the rectifiers (basic rectifier, regenerative rectifier, and active rectifier) and the inverters. The rectifier module and the inverter module can be expanded through the HPCU. The HCUs for the rectifier module and the inverter module are connected to the PLC through fieldbus for centralized control. Centralized commissioning and monitoring of HCUs can be realized through the RS485 bus.

3.1.2 Description of Parallel Inverter Modules

Up to 10 MD880 inverter modules can be connected in parallel through the HPCU. The following shows the electrical diagram for parallel topology.

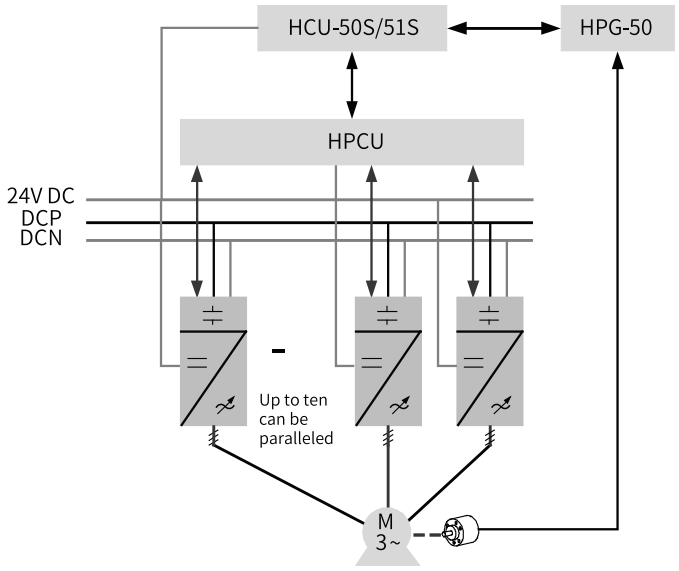


Figure 3-2 Topology for parallel inverter modules

The parallel inverter modules must be configured with an output reactor by default. It is recommended that each inverter module be connected to the motor terminal with dedicated cables. Alternatively, you can also short the output terminals of the inverter modules through a busbar first, and then connect the busbar to the motor. For wiring requirements, see*MD880LC Series Multi-drive AC Drive Hardware Guide*and*MD880–50 Series Inverter Module Hardware Guide*

You can view the module information through the parameters in the following table.

Table 3–1 Viewing the module information

Param.	Name	Description
A2-00	Product type	Displays the type of the current device. 0: Diode rectifier 1: Basic rectifier 2: Inverter 3: Regenerative rectifier 4: Three-phase braking 5: DC-DC
A2-01	Rated power of the module	Displays the rated power of the module.
A2-02	Rated voltage of the module	Displays the rated voltage of the module.
A2-03	Rated current of the module	Displays the rated current of the module.
A15-07	Number of online parallel modules	Displays the number of online parallel modules, which must be consistent with A15-04.
A15-12	Total rated power of the device	Displays the total rated power of the parallel module.
A15-13	Total rated current of the device	Displays the total rated current of the parallel module.

Note

When two 500 kW power modules are connected in parallel, the value of A2-01 is displayed as 500 kW, and the derating coefficient is 0.95. However, the actual power for two parallel 500 kW modules is 950 kW, which is the expected value of A15-12.

3.1.3 Description of the Control Module

3.1.3.1 Indicators

The HCU has three indicators from top to bottom, as shown in the following figure.

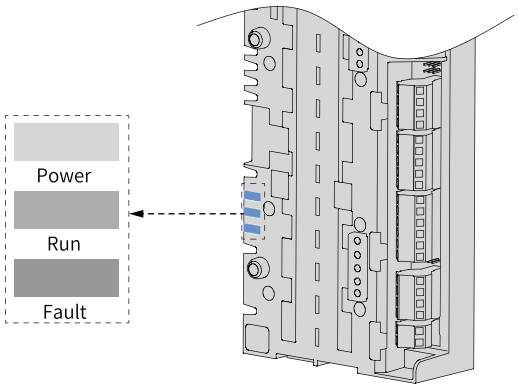


Table 3–2 Location and definition of the LED indicator

No.	Name	Status	Description
1	Power	Steady ON	The HCU power supply is normal.
		OFF	The HCU is not energized or the power supply is faulty.
2	Run	Steady ON	The power module is running.
		OFF	The power module is in the stop state.
3	Fault	Steady red	System fault
		Steady yellow	System alarm
		OFF	System OK
		Flashing red	HCU auxiliary power supply fault (Check whether 24 V power supply is short-circuited or overloaded.)
4	Fault, Run	Flashing yellow (FAULT) and green (RUN) simultaneously	This HCU is selected by the PC or SOP-20-880, which ends after 10s.
		Flashing red (FAULT) and green (RUN) alternately	The FPGA of the HCU is abnormal or the external expansion RAM is abnormal.

3.1.3.2 Standard Peripheral Terminals and Parameter Setting

For use of the standard peripheral terminals, see *HCU Control Module User Guide*. This section only describes terminals and related parameter groups, as shown in the following table.

Name	Parameter group	Remarks
RS485	A10	Used to set the communication rate and address.
DI	F0	Used to view the DI status and set switch-on/switch-off delay.
RO	F1	Used to select the output source, which is displayed in U0-21 to U0-23.
AI	F2	The final result is displayed in U5-18/U5-19.
AO	F3	Used to select the output source, which is displayed in U5-22/U5-23.
HDI	F4	Used to set the high-speed DI.

Name	Parameter group	Remarks
HDO	F5	Used to set the high-speed DO.
InoLink	n0	Used to transmit data between HCUs. U5-32 to U5-39 are used to display data of PZD1 to PZD8. U2-32 to U2-47 are used to display bit0 to bit15 of PZD1.

3.1.3.3 Descriptions for HCU Expansion Module

For details of the expansion module hardware, see the related user guides. Observe the following procedure when using the expansion module.

1. Confirm the module type.
2. Select the slot in which the module is located. For I/O modules or encoder detection modules, a maximum of three modules can be used simultaneously. Configure each module separately.
3. Configure other parameters of the module. For communication expansion modules, set parameters in n1/n2 fieldbus adapters. For details, see *MD880 Series AC Drive Communication Guide*.

Table 3–3 List of common expansion modules

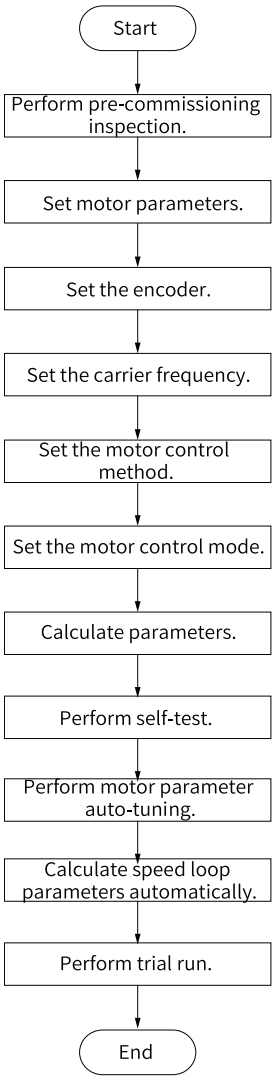
Model	Module name	Module type	Parameter group	Related parameter group
HPG-10	HTL incremental encoder signal detection module	Encoder detection module	n4/n5/n6	-
HPG-30	Sine-Cosine incremental encoder signal detection module		n4/n5/n6	-
HPG-40	Resolver signal detection module		n4/n5/n6	-
HPG-50	TTL Incremental encoder signal detection module		n4/n5/n6	-
HIO-10/20/30	Digital analog expansion module	I/O module	n7	n23/n24/n25
			n8	n26/n27/n28
			n9	n29/n30/n31
HMBA-10	Modbus-RTU fieldbus adapter module	Fieldbus module	n10	n1/n2/n3
HDP-10	PROFIBUS-DP fieldbus adapter module	PROFIBUS-DP module	n16	n1/n2/n3
HCAN-10	CANopen fieldbus adapter module	CAN bus module	n12	n1/n2/n3
HETC-10	EtherCAT industrial Ethernet module	Industrial Ethernet module	n14	n1/n2/n3
HPFN-10	PROFINET I/O industrial Ethernet module	PROFINET I/O module	n17	n1/n2/n3
HMBT-10	Modbus TCP industrial Ethernet module	Modbus TCP module	n18	n1/n2/n3
HETN-10	Ethernet commissioning module	Ethernet module	n13	n1/n2/n3
HSVM-10	Synchronous voltage detection module	Voltage detection module	n19	-
HOFR-50 series PLC	Optical fiber routing data exchange control module	Optical fiber routing control module	n22	-
HIBA-10	Data conversion module	Data conversion module	n18	n1/n2/n3

You can view the inserted communication expansion modules and their versions through parameters in group A2.

Table 3–4 Viewing the expansion module

Expansion slot	Module type parameter	Software version parameter	Expansion slot	Module type parameter	Software version parameter
SLOT1_1	A2-24	A2-25	SLOT2_1	A2-30	A2-31
SLOT1_2	A2-26	A2-27	SLOT2_2	A2-32	A2-33
SLOT1_3	A2-28	A2-29	SLOT2_3	A2-34	A2-35
SLOT3_1	A2-36	A2-37	-	-	-

3.2 Commissioning flowchart



3.3 Pre-commissioning Inspection

3.3.1 Wiring Inspection

Check the following items before powering on the control system.

Item	Action	Compliance
1	The power input of the main circuit is correctly connected based on terminal labels (R, S, T).	☐
2	The main circuit output terminals (U, V, W) and motor cables (U, V, W) are connected in correct phase sequence.	☐
3	The power supply input terminals (R, S, T) and output terminals (U, V, W) of the main circuit are connected properly. Note that the power supply input cables cannot be connected to the output end.	☐
4	The drive and motor are grounded properly.	☐
5	The encoder and shield are connected properly.	☐
6	The power supply input of the auxiliary circuit must be correctly connected based on terminal labels (L1, L2, L3, N).	☐
7	Communication cables are correctly connected.	☐
8	External interfaces such as I/O interfaces are correctly connected.	☐

Note

For how to handle the shield, see *"8.4.3.6 Encoder Interference" on page 361*.

3.3.2 Restoring Default Values

Restore default values first after the control circuit is powered on for the first time. Restore the default values in two steps. The related parameters are as follows.

1. Set A8-00 to 2 to restore all parameters to default.
2. Set A8-01 to 1 to acknowledge the action of restoring all parameters to default.

When the value of A8-00 changes to 0, the default values are restored.

- Restore all parameters to default
  Do as follows:

  1. Set A8-00 to 2 to restore all parameters to default.
  2. Set A8-01 to 1 to acknowledge the operation of A8-00.

  All parameters (including motor parameters in group d) are restored to default. The motor power and current are restored to values corresponding to the model.

- Restore some parameters (excluding motor parameters) to default.
  Do as follows:

  1. Set A8-00 to 1 to restore some parameters to default.
  2. Set A8-01 to 1 to confirm the operation of A8-00.

  Parameters excluding those in group d are restored to default.

Note

Parameters (such as carrier frequency A4-02) related to the power module model are restored to the default values of the model instead of the factory values. The record parameters in groups H2 to H7 or the device names are not restored.

3.3.3 Equipment Information Parameter Check

Check the following device information parameters.

Param.	Name	Description
A2-00	Product type	Displays the type of the current device. 2: Inverter
A2-01	Rated power of the module	Displays the rated power of the drive.
A2-02	Rated voltage of the module	Displays the rated voltage of the drive.
A2-03	Rated current of the module	Displays the rated current of the drive.
A2-08	HCU-MCU function software version	-
A2-09	Sub-version of HCU-MCU function software	-
A2-10	HCU-MCU performance software version	-
A2-11	Sub-version of HCU-MCU performance software	-

Note

If the rated power, voltage, and current of the power module do not match the module nameplate information, contact Inovance technical support engineers.

3.4 Setting Motor Parameters

3.4.1 Precautions

The motor parameters on the nameplate determine whether the parameter auto-tuning is successful or not. The parameter setting of asynchronous motors and synchronous motors is different. First, determine the motor type. In some cases, the motor type is not indicated on the nameplate. You can confirm the motor type by using the following two methods:

- The asynchronous motor has slip, and the synchronous motor has no slip. The rated slip of the motor = rated frequency x 60/rated pole pairs - rated speed.
- Short the UVW cable of the motor. The motor with obvious resistance when it is rotated manually is synchronous motor. Otherwise, the motor is an asynchronous motor. This method can be used to determine whether the reluctance motor is a synchronous reluctance motor with field strengthening. The resistance of a reluctance motor without field strengthening cannot increase.

It is recommended to check whether the motor connection method (Y-type or delta-type) is consistent with the motor nameplate. The wrong motor connection method can result in low torque output, low load capacity, and high output current.

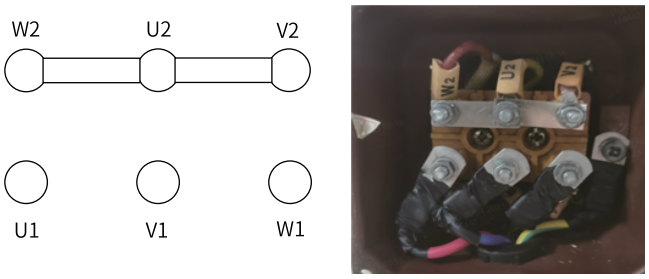


Figure 3-3 Y-type connection method

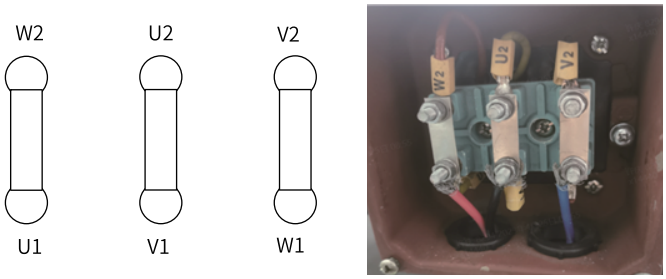
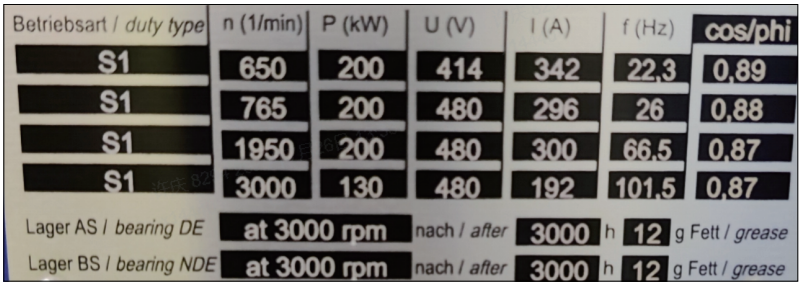


Figure 3-4 Delta-type connection method

Some motors may have multiple groups of parameters on the nameplates. As shown in the following figure, it is recommended to select the motor parameter group 1 as the rated parameters. The analysis is as follows.



The motor U/f is directly proportional to the flux. The U/f of motor parameter group 1 and motor parameter group 2 is about 18.5, which is the rated flux coefficient. The U/f of the parameter groups 3 and 4 are 7.2 and 4.7 respectively, which are flux weakening parameters. The maximum torque output reference can be reduced substantially if you set parameters in groups 3 and 4. Flux weakening parameters cannot be set for rated motor parameters in the drive. Failure to comply can result in insufficient motor torque output. Therefore, only group 1/2 parameters can be selected. The rated current reference of the drive is used as the output current limit. The rated current in group 2 is lower than that in group 1, so if parameters in group 2 are selected, the maximum torque output at low frequencies may not reach the requirements. You can set parameters in group 1.

The maximum output voltage is related to the bus voltage for the drive. If you set the parameters in group 1, the risk of insufficient output voltage cannot occur.

3.4.2 Setting Asynchronous Motor Parameters

When an asynchronous motor is used, set the motor parameters based on the motor nameplate, as shown below.

Param.	Name	Description	Mandatory
d0-00	Motor type selection	Set this parameter to 0. 0: Asynchronous motor 2: Permanent magnet synchronous motor 5: Electromagnetic coil	Yes
d0-01	Rated power of the motor	Defines the rated power of the motor. In applications where the AC drive is used to drive multiple motors of the same specifications, set the rated power of an individual motor and then set the number of parallel motors in d0-10.	Yes
d0-02	Rated voltage of the motor	Defines the rated motor voltage.	Yes
d0-03	Rated current of the motor	Defines the rated current of the motor. In applications where the AC drive is used to drive multiple motors, set the rated power of an individual motor and then set the number of parallel motors in d0-10.	Yes
d0-04	Rated frequency of the motor	Defines the rated frequency of the motor, which must correspond to the rated voltage of the motor.	Yes
d0-05	Rated speed of the motor	Defines the rated rotor speed of the motor, which is lower than the synchronous speed (rated frequency x 60/ number of pole pairs). Reserve a slip when setting the rated speed of the asynchronous motor. For motors whose nameplates do not indicate the rated speed or synchronous speed, set the rated speed based on the following references.	Yes
d0-06	Maximum motor speed	When the maximum speed is lower than the rated motor speed, the maximum motor speed is the rated motor speed. To set the speed limit, set the base value to d3-02 in group E2.	Optional
d0-07	Minimum motor speed	Defines the minimum motor speed. This parameter (d3-02 as the base value) is not needed for motors that do not allow low-speed operations.	Optional
d0-09	Number of motor pole pairs (number of poles/2)	For the motor whose number of pole pairs does not exceed 12, the default value 0 is used. The software calculates the accurate the number of pole pairs automatically. Note the difference between the number of poles and the number of pole pairs. Number of motor pole pairs = Number of poles/2 The number of pole pairs is usually marked on the motor nameplate. If not, you can calculate the number of pole pairs through the rated speed and rated frequency through the following formula: Number of pole pairs ≈ (Rated frequency (Hz) x 60)/Rated speed (rpm). The calculated number of pole pairs is not an integer. For example, if the rated frequency of the motor is 50 Hz and the rated speed is 1450 rpm, then the number of pole pairs is 2.07, in which the decimal value 0.07 the is slip value that can be ignored.	Optional

For motors whose nameplates do not indicate the rated speed or synchronous speed, calculate these values through the following formula: Rated speed = Rated frequency x 60/Number of pole pairs x (100% - Recommended slip rate).

Power (kW)	2.2	3.7	5.5	7.5	11	15	22	30	55
Recommended slip ratio	6%	5%	4%	4%	3.5%	3%	2.5%	2.5%	2%

Power (kW)	90	110	160	250	315	400	500	630
Recommended slip ratio	1.5%	1.5%	1%	1%	0.67%	0.67%	0.67%	0.67%

After motor parameters are set based on the nameplate, if the output current is excessively high during no-load operation in V/f mode, reduce the rated voltage properly and then perform parameter auto-tuning again to get better energy-saving performance.

3.4.3 Setting Synchronous Motor Parameters

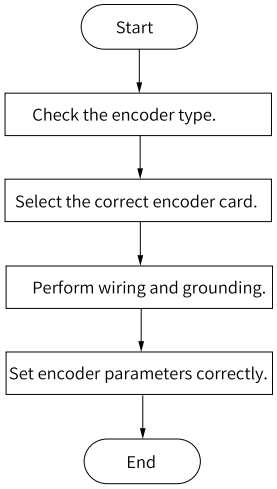
When a synchronous motor is used, set the motor parameters based on the motor nameplate, as shown below.

Param.	Name	Description	Mandatory
d0-00	Motor type selection	Defines the motor type (= 2/4/5) 0: Asynchronous motor 2: Permanent magnet synchronous motor - This option also applies to DC brushless motors. 5: Electromagnetic coil	Yes
d0-01	Rated power of the motor	Defines the rated power of the motor. The synchronous motor does not apply applications where one drive is used to drive multiple motors. For synchronous motors with damper winding, it is recommended to set it to "V/f operation of asynchronous motor".	Yes
d0-02	Rated voltage of the motor	Defines the rated voltage of the motor.	Yes
d0-03	Rated current of the motor	Defines the rated current of the motor.	Yes
d0-04	Rated frequency of the motor	Defines the rated frequency of the motor.	Yes
d0-05	Rated speed of the motor	Defines the rated speed of the motor. Check whether the rated speed is equal to the synchronous speed (rated frequency x 60/number of pole pairs), if not, the motor parameters are incorrect. In this case, parameter auto-tuning and operation errors can occur.	Yes
d0-06	Maximum motor speed	When the maximum speed is lower than the rated motor speed, the maximum motor speed is the rated motor speed. To set the speed limit, set the base value to d3-02 in group E2.	Optional
d0-07	Minimum motor speed	Defines the minimum motor speed. This parameter (d3-02 as the base value) is not needed for motors that do not allow low-speed operations.	Optional

Param.	Name	Description	Mandatory
d1-26	Back EMF voltage of synchronous motor	The back EMF refers to the back EMF (effective value of the line voltage) when the motor rotates at rated speed without load. It affects the performance in low-speed operation greatly. If no-load dynamic auto-tuning is not available for synchronous motors, check the motor nameplate or contact the motor manufacturer to get the accurate motor back EMF. d1-26 represents the back EMF in rated speed. If the effective back EMF marked on the nameplate is 120 V/krpm, the rated back EMF = d0-05/1000 x 120 V. If the back EMF is unknown, disconnect the motor from the load to perform no-load dynamic auto-tuning. The above procedure only need to be performed once for motors with the same specifications. After that, you can manually input the back EMF value.	Optional
d0-09	Number of motor pole pairs (number of poles/2)	For the motor whose number of pole pairs does not exceed 12, the default value 0 is used. The software calculates the accurate the number of pole pairs automatically. Note the difference between the number of poles and the number of pole pairs. Number of motor pole pairs = Number of poles/2 The number of pole pairs is usually marked on the motor nameplate. If not, you can calculate the number of pole pairs through the rated speed and rated frequency through the following formula: Number of pole pairs ≈ (Rated frequency (Hz) x 60)/Rated speed (rpm). The calculated number of pole pairs is not an integer. For example, if the rated frequency of the motor is 50 Hz and the rated speed is 1450 rpm, then the number of pole pairs is 2.07, in which the decimal value 0.07 the is slip value that can be ignored.	Optional

3.5 Setting the Encoder

The MD880 supports ABZ encoder/sine-cosine encoder/resolver/23-bit encoder/SSI encoder/ENDA encoder/sine-cosine+ENDA encoder. The commissioning procedure for the encoder is as follows.



The followings shows the encoder card specifications, supported encoder types, and wiring of the encoder card.

Encoder card	Encoder types supported	Signal types supported	Assignment
HPG-10	ABZ encoder	The differential HTL, single-ended HTL, OC (Open Collector), and OE (Open Emitter) are selected through four-channel DIP switches. Signal specification: Maximum signal frequency: 300 kHz Power supply specifications: 15 VDC±10%, 200 mA or 24 VDC±10%, 200 mA Differential HTL: The encoder A+/A-/B+/A-/Z +/Z- is connected to A+/A-/B+/A-/Z+/Z- of the encoder card. The encoder power supply (+) is connected to VCC_EN and the encoder power supply (-) is connected to the COM terminal of X31. Single-ended HTL/OC/OE: The encoder A+/B +/Z is connected to the encoder card A+/B+/Z +. The encoder power supply (+) is connected to VCC_EN, and the encoder power supply (-) is connected to the COM terminal of X31 and X32. The ABZ encoder differential signals are applicable to long-line applications. Check whether the MD580 single-ended signal PG card is connected to the negative terminal and the MD880 single-ended signal PG card is connected to the positive terminal. The encoder card supports open circuit detection and frequency division output. The metal shield of the encoder cable needs to be twisted into a strand to be connected to the SHELD terminal. It is not recommended to ground the shield on the encoder side.	See "HPG-10 differential signal wiring diagram" and "HPG-10 single-ended/OC/ OE signal wiring diagram".
HPG-30	Sine-cosine encoder, 23-bit encoder, SSI encoder, ENDAT encoder, and sin-cosine+ENDAT encoder	Supports sine-cosine incremental signals and absolute signal input of 23-bit encoders, SSI encoders, and ENDAT encoders, which is selected by two 4-bit DIP switches. Sine-cosine increment signal: Supports signals with a maximum frequency of 500 kHz and 0.6 VPP to 1.2 VPP Absolute signal: 23-bit encoders support a maximum communication rate of 8 Mbps, SSI encoders support a maximum communication rate of 2 Mbps, and ENDAT encoders support a maximum communication rate of 10 Mbps. When the encoder circuit is excessively long, the communication rate of the absolute encoder can be reduced properly.	See "HPG-30 sine-cosine encoder interface diagram" and "HPG-30 absolute encoder interface diagram".

Encoder card	Encoder types supported	Signal types supported	Assignment
HPG-40	Resolver signal	Supports 10/12/15/20 kHz excitation source, 7 Vp-p-0.5 transformation ratio, 7 Vrms-0.5 transformation ratio, 7 Vrms-0.286 transformation ratio, and 4 Vrms-0.3 transformation ratio feedback signals. The resolver outputs analog signals, which may easily be disturbed. Perform wiring as required and keep regular cables within 50 m. For applications requiring low disturbance, keep the longest cable within 100 m. The shield of the resolver signal cable must be crimped to the metal housing of DB9 terminal to ensure that the shield is grounded properly. The number of motor pole pairs must be an integer divisor of the number of resolver pole pairs. For example, for a motor with six pole pairs, select a resolver with 1/2/3/6 pole pairs. If you select a resolver with 4 pole pairs, operation can fail.	See "HPG-40 terminal diagram".
HPG-50	TTL differential signals	Power supply specifications: 5.2 VDC±5%, 200 mA or 15 VDC±10%, 200 mA or 24 VDC±10%, 200 mA Signal type: TTL differential, RS422, maximum signal frequency: 300 kHz Differential ABZ encoders are recommended for long cable applications. It is recommended to use the 24 V power supply as it features better disturbance resistance capability. In XB1 terminal, VCC_EN is the 5.1 V power supply, and the 24 V/15 V power supply is also available. Note that the power supply must match the voltage class of the encoder. Incorrect power cables (higher than the encoder voltage class) may damage the encoder. The metal shield of the encoder cable needs to be twisted into a strand to be connected to the SHELD terminal. It is not recommended to ground the shield on the encoder side.	See "HPG-40 terminal diagram".

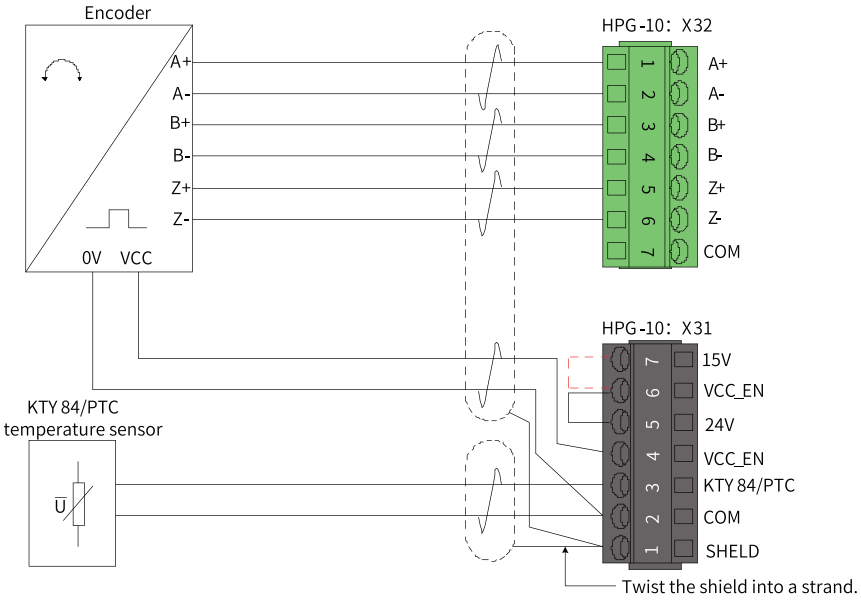


Figure 3-5 Wiring of HPG-10 differential signals

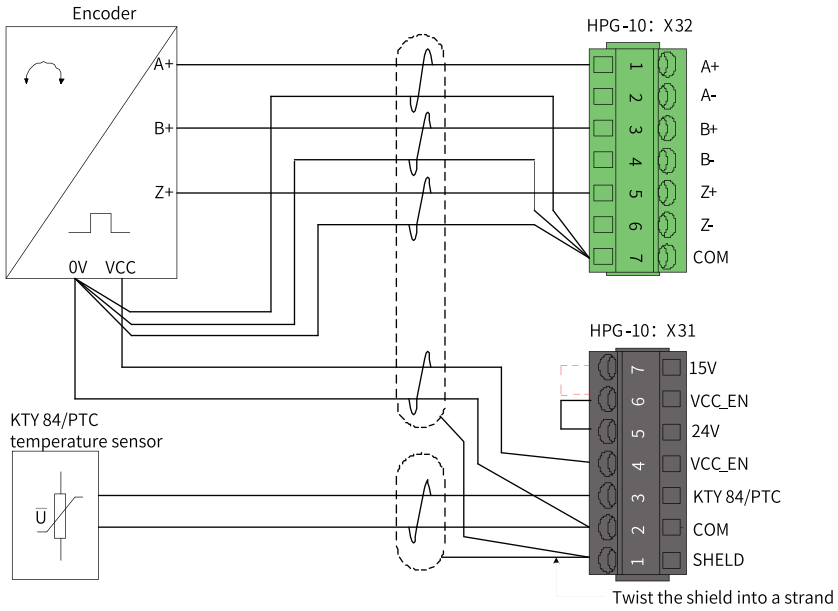


Figure 3-6 Wiring of HPG-10 single-ended/OC/OE signals

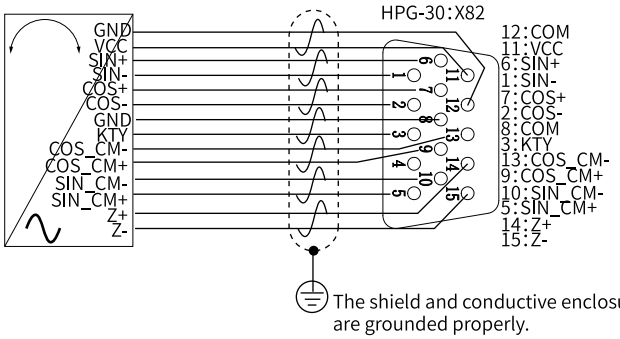


Figure 3-7 Wiring of HPG-30 sine-cosine encoder interfaces

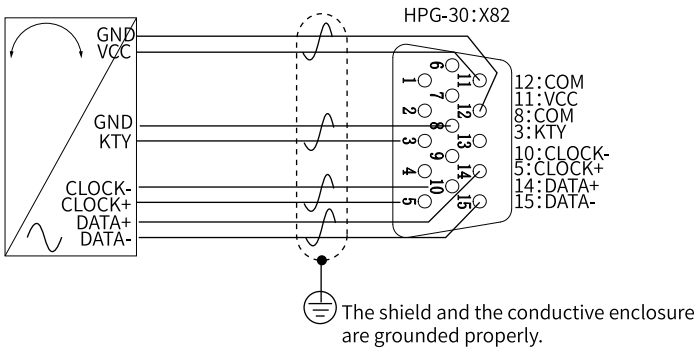


Figure 3-8 Terminal layout of HPG-30

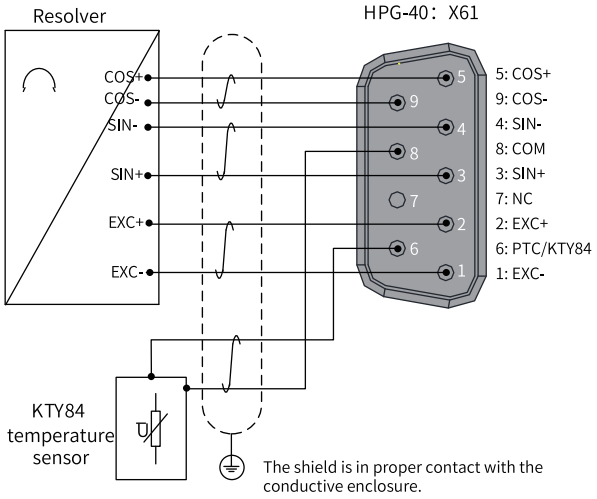


Figure 3-9 Terminal layout of HPG-40

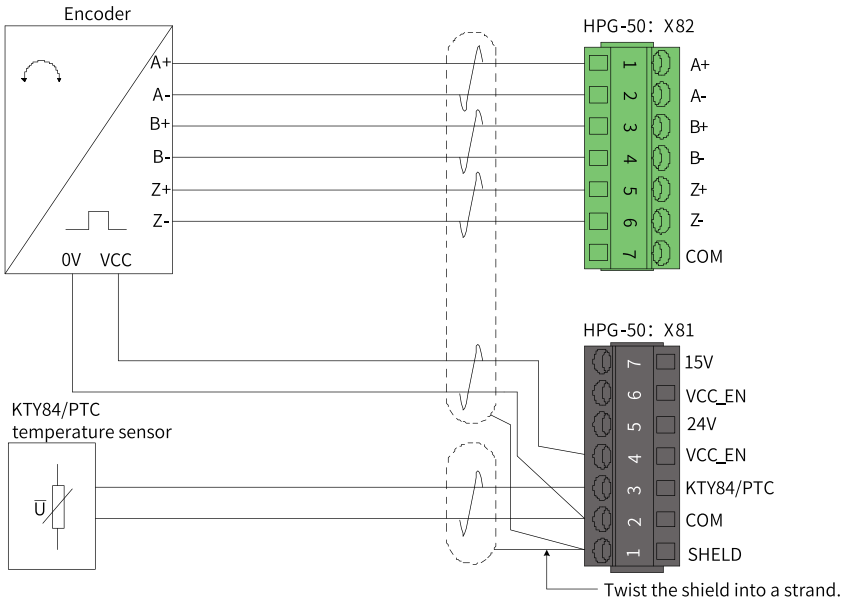


Figure 3-10 Terminal layout of HPG-50

Caution

Wiring precautions:

- Because the output voltage of the drive is pulse voltage and there is common mode voltage to ground, connect the PE terminal of the motor to the PE terminal of the drive in addition to the U/V/W power cables. Ensure that the grounding busbar of the electrical cabinet is grounded. Otherwise, common-mode voltage and leakage current interference may result in encoder signal interference caused by backflow from the encoder cable.
- Use encoder cables with braided shield to enhance the anti-interference capability. Connect the shield of HPG-10 and HPG-50 to the PE terminal, and solder the shield of other encoder cards to the enclosure of the DB terminal. Use twisted pair cables and connect them in pairs. For example, use twisted pairs for A+ and A, which can reduce common mode interference.
- Minimize consumption of encoder cable connectors because connectors can generate radiation interference.
- Avoid parallel routing of encoder cables and motor power cables to prevent power cables from disturbing encoder signal.
- For short encoder cables (within 10 m), it is recommended to perform grounding on both ends. For long encoder cables (above 10 m), it is recommended to perform grounding on the encoder card end only.

3.5.1 Setting the ABZ Encoder

Param.	Name	Description	Mandatory
n4/5/6-00	Expansion slot selection	By default, encoder detection module 1 is used as speed feedback. You can switch to other encoder detection module through d0-11. The expansion card slot selection acts as the software switch for the entire encoder function. When it is disabled, all parameters are inactive..	Yes
n4/5/6-02	Encoder type selection	Set the encoder type to 1 [Common ABZ encoder].	Yes
n4/5/6-07	Encoder resolution (pulses/ revolutions)	Set the encoder pulses accurately.	Yes

3.5.2 Setting the Sine-cosine Encoder

Param.	Name	Description	Mandatory
n4/5/6-00	Expansion slot selection	By default, encoder detection module 1 is used as speed feedback. You can switch to other encoder detection module through d0-11. The expansion card slot selection acts as the software switch for the entire encoder function. When it is disabled, all parameters are inactive.	Yes
n4/5/6-02	Encoder type selection	Set the encoder type to 2 [Sine-cosine encoder].	Yes
n4/5/6-07	Encoder resolution (pulses/ revolutions)	The number of sine wave cycles of the sine signal or cosine signals per revolution of the encoder indicates the number of encoder pulses.	Yes

3.5.3 Setting the Resolver

Param.	Name	Description	Mandatory
n4/5/6-00	Expansion slot selection	By default, encoder detection module 1 is used as speed feedback. You can switch to other encoder detection module through d0-11. The expansion card slot selection acts as the software switch for the entire encoder function. When it is disabled, all parameters are inactive.	Yes
n4/5/6-02	Encoder type selection	Set the encoder type to 3 [Resolver].	Yes
n4/5/6-15	Number of resolver pole pairs	Set the correct number of resolver pole pairs. The synchronous motor is equipped with a resolver. The number of motor pole pairs must be an integer divisor of the number of resolver pole pairs. For example, for a motor with six pole pairs, select a resolver with 1/2/3/6 pole pairs. If you select a resolver with 4 pole pairs, operation can fail.	Yes

3.5.4 Setting the 23-bit Encoder

Param.	Name	Description	Mandatory
n4/5/6-00	Expansion slot selection	By default, encoder detection module 1 is used as speed feedback. You can switch to other encoder detection module through d0-11. The expansion card slot selection acts as the software switch for the entire encoder function. When it is disabled, all parameters are inactive.	Yes
n4/5/6-02	Encoder type selection	Set the encoder type to 4 [23-bit encoder].	Yes
n4/5/6-84	23-bit encoder communication protocol	Set the communication rate of the 23-bit encoder properly. The 23-bit encoder communication protocol supports backward compatibility. If the communication protocol of the 23-bit encoder is the 2nd generation, you can set n4-84 to 0 [2 Mbps in the 1st generation] or 1 [4 Mbps in the 2nd generation].	Yes

3.5.5 Setting the SSI Encoder

Param.	Name	Description	Mandatory
n4/5/6-00	Expansion slot selection	By default, encoder detection module 1 is used as speed feedback. You can switch to other encoder detection module through d0-11. The expansion card slot selection acts as the software switch for the entire encoder function. When it is disabled, all parameters are inactive.	Yes
n4/5/6-02	Encoder type selection	Set the encoder type to 5 [SSI encoder].	Yes

Param.	Name	Description	Mandatory
n4/5/6-87	SSI encoder communication baud rate	0: 2 Mbps 1: 1.6 Mbps 2: 1 Mbps 3: 0.8 Mbps 4: 0.5 Mbps 5: 0.25 Mbps 6: 0.125 Mbps The default value is 2 [1 Mbps]. See the encoder user guide and set the communication frequency properly. The higher the communication frequency, the weaker the anti-interference capacity can be. If the encoder feedback signals are being disturbed frequently, reduce the communication frequency properly. Note that an excessively low communication frequency can affect the operating carrier frequency of the drive.	Optional
n4/5/6-87	SSI encoder configuration	Ones: Check mode • 0: No check • 1: Odd parity • 2: Even parity Tens: Encoder output code value • 0: Binary code • 1: Gray code The default value is 0 [No check], and the default encoder output code value is 0 [Binary code]. Set the correct check mode and encoder output code value according to the actual encoder type. Otherwise, open circuit or control errors can be reported.	Optional
n4/5/6-88	Number of SSI encoder status bits	The default number of status bits is 0. Set the correct check mode and encoder output value according to the actual encoder type. Otherwise, open circuit or control errors can be reported.	Mandatory for non-zero encoders
n4/5/6-89	Single-turn bits of communication-type encoder	Defines the number of single-turn bits of the encoder. For example, if the number of single-turn bits is 12, the resolution is $1/2^{12}$.	Yes
n4/5/6-90	Multi-turn bits of communication-type encoder	Set an accurate number of multi-turn bits for communication-type multi-turn encoder. Otherwise, operation errors can occur. The multi-turn encoder can be used to record the current encoder revolutions.	Mandatory for multi-turn absolute encoders

3.5.6 Setting the ENDAT Encoder

Param.	Name	Description	Mandatory
n4/5/6-00	Expansion slot selection	By default, encoder detection module 1 is used as speed feedback. You can switch to other encoder detection module through d0-11. The expansion card slot selection acts as the software switch for the entire encoder function. When it is disabled, all parameters are inactive.	Yes
n4/5/6-02	Encoder type selection	Set the encoder type to 6 [ENDAT encoder].	Yes

Param.	Name	Description	Mandatory
n4/5/6-92	ENDAT encoder communication baud rate	1: 1 Mbps 2: 2 Mbps 3: 4 Mbps 4: 5 Mbps 5: 8 Mbps 6: 10 Mbps The default is 4 Mbps to 5 Mbps. See the encoder user guide and set the communication frequency properly. The higher the communication frequency, the weaker the anti-interference capacity can be. If the encoder feedback signals are being disturbed frequently, reduce the communication frequency properly. Note that an excessively low communication frequency can affect the operating carrier frequency of the drive.	Optional
n4/5/6-89	Single-turn bits of communication-type encoder	Defines the number of single-turn bits of the encoder, that is, the accuracy of the encoder. For example, if the number of single-turn bits is 12, the resolution is $1/2^{12}$.	Yes
n4/5/6-90	Multi-turn bits of communication-type encoder	Set an accurate number of multi-turn bits for communication-type multi-turn encoder. Otherwise, operation errors can occur. The multi-turn encoder can be used to record the current encoder revolutions.	Mandatory for multi-turn absolute encoders

3.5.7 Setting the Sine-cosine+ENDAT Encoder

Param.	Name	Description	Mandatory
n4/5/6-00	Expansion slot selection	By default, encoder detection module 1 is used as speed feedback. You can switch to other encoder detection module through d0-11. The expansion card slot selection acts as the software switch for the entire encoder function. When it is disabled, all parameters are inactive.	Yes
n4/5/6-02	Encoder type selection	Set the encoder type to 7 [Sine-cosine+ENDAT encoder].	Yes
n4/5/6-07	Encoder resolution (pulses/ revolutions)	The number of sine wave cycles of the sine signal or cosine signals per revolution of the encoder indicates the number of encoder pulses.	Yes

Param.	Name	Description	Mandatory
n4/5/6-92	ENDAT encoder communication baud rate	1: 1 Mbps 2: 2 Mbps 3: 4 Mbps 4: 5 Mbps 5: 8 Mbps 6: 10 Mbps The default is 4 Mbps to 5 Mbps. See the encoder user guide and set the communication frequency properly. The higher the communication frequency, the weaker the anti-interference capacity can be. If the encoder feedback signals are being disturbed frequently, reduce the communication frequency properly. Note that an excessively low communication frequency can affect the operating carrier frequency of the drive.	Optional
n4/5/6-89	Single-turn bits of communication-type encoder	Defines the number of single-turn bits of the encoder, that is, the accuracy of the encoder. For example, if the number of single-turn bits is 12, the resolution is $1/2^{12}$.	Yes
n4/5/6-90	Multi-turn bits of communication-type encoder	Set an accurate number of multi-turn bits for communication-type multi-turn encoder. Otherwise, operation errors can occur. The multi-turn encoder can be used to record the current encoder revolutions.	Mandatory for multi-turn absolute encoders

3.6 Setting the Carrier Frequency

The carrier frequency of the drive is set by A4-02 [Carrier frequency reference]. The effective carrier frequency is limited by A4-02 [Frequency reference], A4-00 [Maximum carrier frequency of the drive], and the functions of "Carrier frequency adjusted with synchronous frequency" and "Random PWM". For details, see descriptions of A4-09 to A4-13.

Related parameters

Table 3–5 Carrier frequency parameter

Param.	Name	Default	Value range
A4-02	Carrier frequency reference	The default carrier frequency varies with the machine. The default carrier frequency for high-power machines or machines with high voltage class is low.	1.20 kHz to 12.00 kHz

Precautions

For high-speed motors, ensure that:

A4-02 [Carrier frequency reference] > [12 x Maximum output frequency]

For example, if the maximum output frequency is 200 Hz, the carrier frequency reference must be greater than 2.4 kHz. Otherwise, oscillation and overcurrent can occur due to insufficient high-speed control frequency. Low carrier frequency reference at high-speed operation can also result in large

harmonics of the output current. Long-term operation can cause the motor temperature to rise, which may damage the motor insulation or incur demagnetization of the synchronous motor.

3.7 Setting the Motor Control Mode

Param.	Name	Description	Application scenario
E0-00	Control mode	0: SVC (sensorless vector control)	Open loop vector control Advantages: The SVC mode features excellent dynamic responsiveness and requires less encoders, encoder cables, and encoder cards compared with the FVC mode. The fault rate of SVC mode is low during long-term operation. Disadvantage: Speed open loop applies by default at speeds lower than 2.5% of rated speed (E11-12), in which the current is in closed loop control and the speed is in open loop control. When E11-08 is set to 0, the control performance is good at low speed, but the speed cannot be set to 0 for a long time. Recommended application scenario: Applications requiring high accuracy/high dynamic response
		1: FVC (Feedback vector control)	Feedback vector control (FVC) Advantages: The FVC mode allows long-term stable operation at 0 Hz. It supports position control and has higher control precision in speed control compared with the SVC mode. When used together with a high-resolution encoder, high dynamic performance can be achieved in the FVC mode.. Disadvantages: The encoder feedback signal may be disturbed or damaged easily. More than 60% of faults in FVC mode are caused by the encoder. Recommended application scenario: Applications requiring ultra-high accuracy/ dynamic response, cranes, position control, and applications requiring high torque accuracy for long-term operation at zero speed
		2: V/f	Applicable to applications without strict load control requirements or where one drive is used to drive multiple asynchronous motors, such as fans and pumps.

3.8 Setting the Motor Control Mode

Param.	Name	Description	Default	Value range
E0-01	Control mode	0: Speed control 1: Torque control 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: HDI1 Others: B connector	0	0 to 8

The control mode can be switched through the DI terminal or the B connector.

Note

- In the V/F control mode, only the speed control mode is supported.
- If the torque control mode is applied under normal operating conditions, it is recommended to switch to the speed control mode during motor auto-tuning upon initial commissioning. This is to prevent speed control error caused by inadvertent start. After auto-tuning is done, adjust the operating direction properly and switch to the torque control mode again.

3.9 Self-test

It is recommended to perform system self-test before initial use to check whether the internal and external wiring is correct.

Do the following when the drive is in the "ready for switch-on" state:

1. Ensure that SOP-20-880 get local permissions.
2. Ensure that no fault occurs on the drive and the drive is in S5 (ready for switch-on) state.
3. Set b5-01 to 1 to enable the drive to enter the S16 (Ready for self-test) state.
4. After pressing the green RUN key (OFF1 is the drive start command, which changes from 0 to 1 after start), the drive enters the S17 (Self-test) state and generates current output. The drive enters the S4 (power-on blocked) state after self-check is done. After the operation command is canceled, the drive enters the S5 (ready for switch-on) state.

The state change process during self-test is as follows.



The self-test items include tests on IGBT short circuit, IGBT open circuit, output phase loss, current sensor error, phase-to-phase imbalance, ground short circuit, and output imbalance.

The self-test can be started in four ways:

- 1. Perform the self-test manually (b5-01 = 1). After self-test is done, the drive enters the stop state. The manual self-test is a complete self-test, in which all items are executed in about 10s.
- 2. Power self-test upon power-on, in which the drive executes self-test once upon power-on. The related parameters are E8-15/16/17/20/21. This function is not enabled by default, which can be enabled as needed.
- 3. Perform self-test before operation. The drive executes self-test once upon start. The related parameters are E8-15/16/17/20/21. It is not recommended to also enable current sensor self-test (E8-17) because current sensor self-test can take a long time. The duration of self-test before operation (E8-16/20/21) can be controlled to a value within 100 ms.
- Perform self-test before parameter auto-tuning. When b5-00 [Auto-tuning mode selection] is set to 1, 2, or 3, self-test is executed once by default before auto-tuning, which covers the test on IGBT short circuit, IGBT open circuit, output phase loss, and current sensor monitoring error. You can deactivate the self-test before auto-tuning through b5-07.

Note

- For low-power drives, the ground leakage current is high in long-line output, which can easily result in false fault during self-test.
- The synchronous motor generates back EMF during rotation, which can easily result in false fault during self-test.
- The IT grid does not have the current return path, so grounding short circuit cannot be detected during self-test.
- It is recommended to enable the self-test when the rated motor current is greater than 0.2 x rated current of the drive.
- The drive operates with a short circuit reactor connected at the output side, when the difference between d0-03 [Rated current of the motor] and A2-05 [Total current of the device] is excessive, self-test can fail.

The following figures show different types of grids.

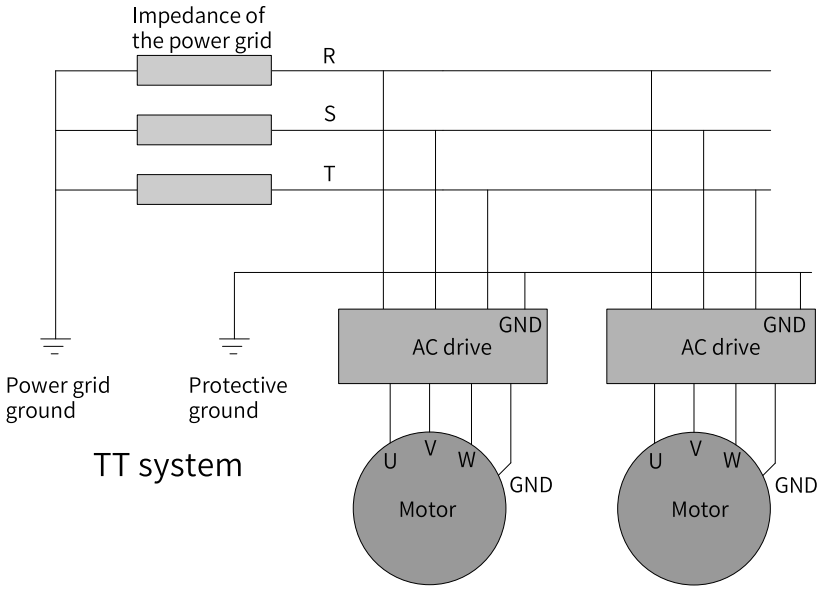


Figure 3-11 TT system

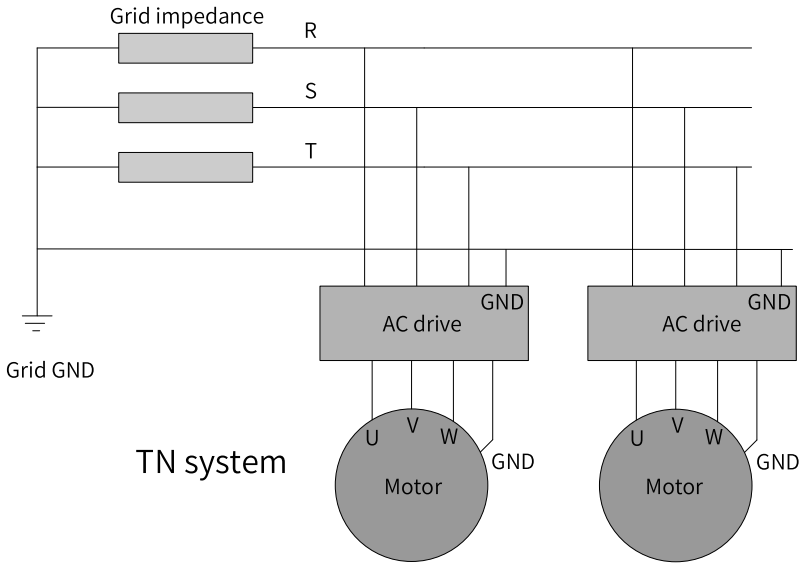


Figure 3-12 TN system

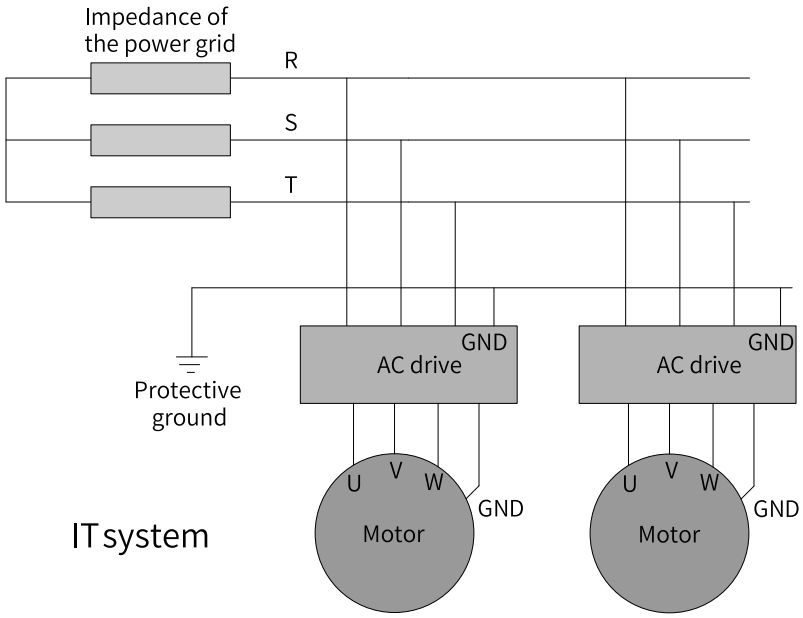


Figure 3-13 IT system

Table 3–6 Related parameters

Param.	Name	Setpoint
b5-01	Self-test request	0: None 1: Active
E8-15	VI detection mode	Ones-: Detection upon power-on 0: Inactive 1: Active Tens-: Detection before operation 0: Inactive 1: Active

Param.	Name	Setpoint
E8-16	Bridge arm detection mode	Ones-: Detection upon power-on 0: Inactive 1: Active Tens-: Detection before operation 0: Inactive 1: Active
E8-17	Output current sensor CM detection mode	Ones-: Detection upon power-on 0: Inactive 1: Active Tens-: Detection before operation 0: Inactive 1: Active
E8-20	Ground short circuit detection mode	Ones-: Detection upon power-on 0: Inactive 1: Active Tens-: Detection before operation 0: Inactive 1: Active
E8-21	Output phase loss detection mode	Ones-: Detection upon power-on 0: Inactive 1: Active Tens-: Detection before operation 0: Inactive 1: Active Hundreds-: Detection during operation 0: Inactive 1: Active
b5-07	Self-test before auto-tuning	0: Model dependent 1: Disable 2: Enable

Param.	Name	Setpoint
E8-48	Self-test (b5-01) mode	bit00: VI detection 0: Inactive 1: Active bit01: Bridge arm detection 0: Inactive 1: Active bit02: CM detection on output current sensor 0: Inactive 1: Active bit03: Braking transistor detection (reserved) 0: Inactive 1: Active
E8-48	Self-test (b5-01) mode	bit04: Bus capacitance detection (reserved) 0: Inactive 1: Active bit05: Ground short circuit detection 0: Inactive 1: Active bit06: Output phase loss detection 0: Inactive 1: Active bit07: Current output imbalance detection 0: Inactive 1: Active

3.10 Motor Parameter Auto-tuning

3.10.1 Auto-Tuning Procedure

Perform motor parameter auto-tuning before operation to match the drive to different motors. In what scenario is motor parameter auto-tuning required?

- Parameter auto-tuning is required in vector control.
- In V/f control of asynchronous motor, static parameter auto-tuning is required in flying start. It is also recommended to perform parameter auto-tuning in V/f control to obtain better performance.

The following shows the parameter auto-tuning procedure.

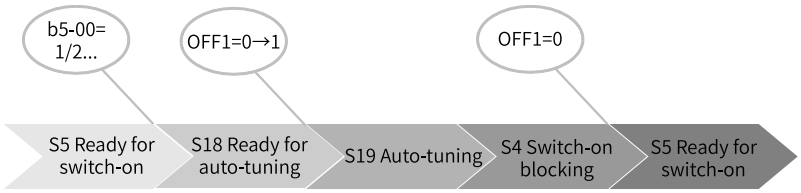


Figure 3-14 State change during auto-tuning

The status of S5/S18/S19/S4 state machine can be viewed through A0-00 or the control panel. OFF1 is the start command of the drive.

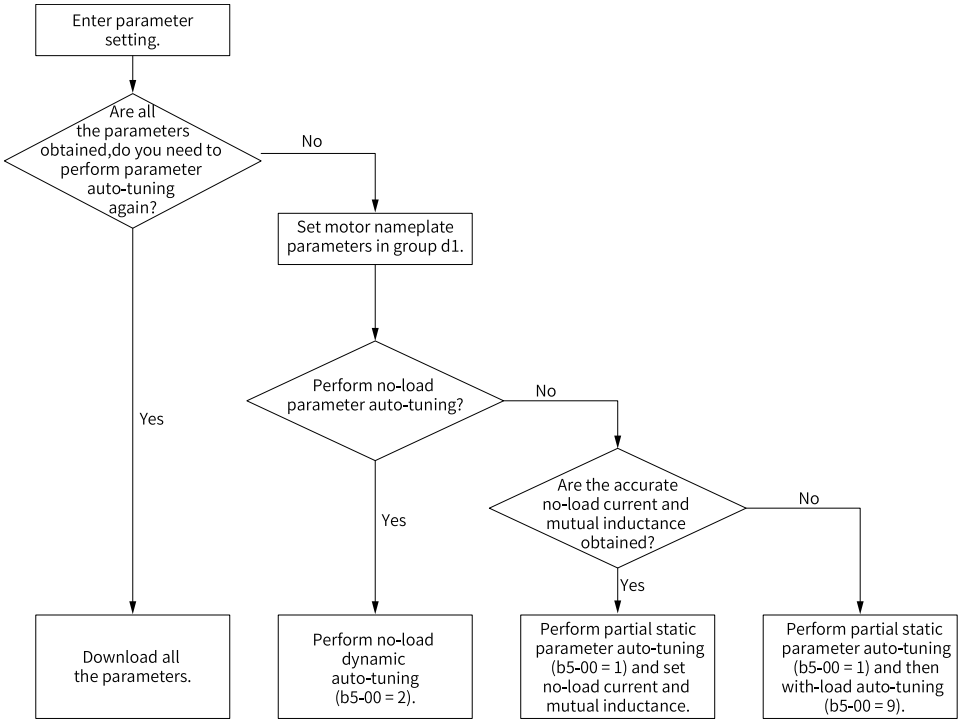
The following describes commonly-used auto-tuning items (b5-00).

Auto-tuning option	Description
0: No action	The default value is 0. After auto-tuning is done, the value is set to 0 again.
1: Static auto-tuning	Some motor parameters can be auto-tuned when the motor does not rotate. Dynamic auto-tuning or with-load auto-tuning is also required. In static partial auto-tuning of asynchronous motors, the no-load current and mutual inductance are estimated to prevent initial start failure. Note that the estimated values cannot be used as final control parameters. Dynamic auto-tuning or with-load auto-tuning is still needed for normal operation.
2: No-load complete auto-tuning	During motor auto-tuning, keep the motor in the no-load or low-load state and ensure that the motor can rotate freely. In no-load complete auto-tuning, all the motor parameters can be auto-tuned. The mechanical system with inertia load generates the output torque only during acceleration/deceleration. The steady-state load is low. Parameter auto-tuning is performed when the speed is steady and the output torque does not affect the auto-tuning accuracy, so no-load dynamic auto-tuning can be performed on the inertia load (such as rolling mills in metallurgy industry).
5: Moment of inertia auto-tuning	The moment of inertia and speed loop IP controller parameters can be auto-tuned. Inertia auto-tuning can also be applied on machines with load. For machines where the load changes with the speed, such as fans and water pumps, inertia auto-tuning is not available.
7: With-load complete auto-tuning of synchronous motor in FVC mode	This mode is applicable to cases where the motor cannot rotate freely in FVC control. Before auto-tuning, check that the encoder feedback speed direction matches the motor operating direction. The motor that equipped with an absolute encoder (resolver or SSI) does not rotate during auto-tuning. The motor that equipped with an incremental encoder (ABZ, sine-cosine encoder) rotates slightly during auto-tuning. You can set the auto-tuning speed through b5-11.
8: No-load dynamic auto-tuning	The no-load dynamic auto-tuning is used together with static auto-tuning to achieve no-load complete auto-tuning.
9: With-load dynamic auto-tuning of asynchronous motor	This is an online auto-tuning method which limits the maximum speed only. You can start the motor through a PLC or terminal. This method can be used together with dynamic auto-tuning for large machineries with travel limits or loads. The auto-tuning accuracy can also reach the same level as no-load dynamic auto-tuning.

3.10.2 Asynchronous Motor Parameter Auto-Tuning

The commissioning priority is as follows based on the usability and control performance: 1 > 2 > 3 > 4.

1. The auto-tuned value can be applied to motors and drives of the same model. You can download the parameter files that commissioned properly to a new drive through the software tool or SOP-20 operating panel.
2. For items that commissioned for the first time, if the motor can rotate freely, it is recommended to set b5-00 to 2 [No-load dynamic auto-tuning] to achieve the optimal control performance.
3. If dynamic auto-tuning is not available but the no-load current (d1-10) and mutual inductance (d1-08) of the motor are known, you can set b5-00 to 1 to perform static partial auto-tuning, and set the accurate no-load current and mutual inductance after auto-tuning is done.
4. If the motor cannot be disconnected from the load and the no-load current and mutual inductance are unknown, you can set b5-00 to 1 to perform static partial auto-tuning of asynchronous motor. After which, set b5-00 to 9 to perform with-load dynamic auto-tuning of asynchronous motor.



Param.	Name	b5-00 = 1: Static partial auto-tuning of asynchronous motor	b5-00 = 2: No-load dynamic auto-tuning of asynchronous motor	b5-00 = 9: Online with-load dynamic auto-tuning of asynchronous motor	b5-00 = 4: Inertia auto-tuning	Description
d1-02	Motor stator resistance	□	□	-	-	-
d1-04	Asynchronous motor rotor resistance	□	□	-	-	-

Param.	Name	b5-00 = 1: Static partial auto-tuning of asynchronous motor	b5-00 = 2: No-load dynamic auto-tuning of asynchronous motor	b5-00 = 9: Online with-load dynamic auto-tuning of asynchronous motor	b5-00 = 4: Inertia auto-tuning	Description
d1-06	Leakage inductance of motor	□	□	-	-	-
Group A3	Dead zone compensation curve	□	□	-	-	The dead zone compensation curve is critical to the low-speed performance in the SVC mode, which must be included during parameter file download or parameter setting.
d1-08/d1-10	Mutual inductance and no-load current of the motor	- (Calculated value, not for long-term use)	□	□	-	The no-load current and mutual inductance are critical to the low-speed performance of the asynchronous motor in SVC mode. The no-load dynamic auto-tuning is best. The mutual inductance and no-load current are estimated during static partial auto-tuning, which need to be supplemented through with-load auto-tuning.
d1-12 to d1-19	Magnetic field saturation flux curve of asynchronous motor	-	□	□	-	-
E4-02 to E4-05/ d2-02	Speed loop Kp/Ti and inertia ratio	-	□	-	□	The system with fixed inertia supports inertia auto-tuning to obtain accurate moment of inertia. Enabling acceleration torque feedforward can achieve good following performance during acceleration/deceleration. The auto-tuned speed loop Kp/Ti can improve the resistance to load disturbance.
n4-03/ABZ encoder n4-07/ Resolver n4-15/ Communication-type encoder n4-89	Encoder direction auto-tuning Verification on the encoder pulses of revolution	-	□	□	-	No-load dynamic auto-tuning or with-load auto-tuning can detect whether the direction and number of encoder pulses per revolution are set correctly and whether the encoder signal is normal.

With-load dynamic auto-tuning of asynchronous motor

When no-load dynamic auto-tuning is not enough but the equipment cannot be disconnected from the coupling, you can perform with-load dynamic auto-tuning to reduce the commissioning time greatly. b5-10 represents the maximum speed limit for with-load auto-tuning, which is set to 40% by default. The default speed reference and start/stop commands for with-load auto-tuning are set by the user. After b5-00 is set to 9 [With-load auto-tuning], the motor can be started by the PLC or terminal. Configure the peripheral brake and limit devices and start the motor with the maximum speed reference through the PLC. Ensure that the auto-tuning speed exceeds 25% of the starting speed of auto-tuning.

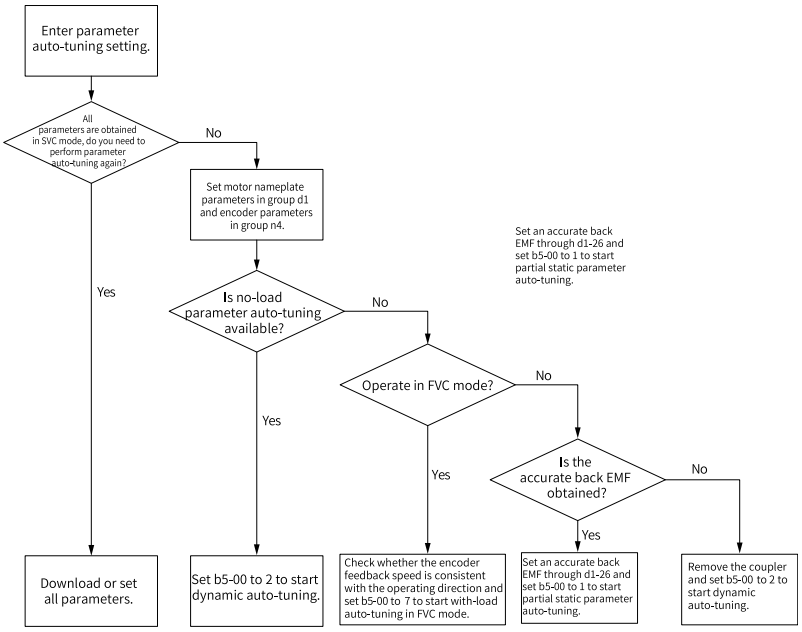
Caution

- After b5-00 is set to 9, start parameter auto-tuning through OFF1 as soon as possible. If parameter auto-tuning is not started within 10s, the auto-tuning option can be cleared.
- With-load dynamic auto-tuning is performed online, which requires users to set the speed through the PLC or control panel. If the speed reference during auto-tuning is 0 for a long time, a timeout fault can be reported.
- Set the auto-tuning speed to a value higher than 25%. Otherwise, the system cannot auto-tune the parameters online. It is also recommended to set the auto-tuning speed to a value lower than 80%.
- If the system is used with multiple motors acting as master and slaves, enable online auto-tuning on the master motor and set the tens of b5-08 to 1. When b5-08 is set to 1, the motor does not stop automatically after auto-tuning is done. You can stop the motor by sending an OFF1 command. Given system speeds are different, you can increase the speed limit (b5-10) to 100%. Note that the operating speed cannot exceed 80%. The auto-tuned values of d1-08/d1-10 can be manually set to other motors of the same specification.
- If the speed cannot be set through the PLC, you can set b5-09 to 1. The auto-tuning speed can be set automatically through the program. The auto-tuning speed is 40% by default.

3.10.3 Synchronous Motor Parameter Auto-tuning

The parameter auto-tuning process for synchronous motors is as follows.

The synchronous motor can be a permanent magnet synchronous motor, a synchronous reluctance motor with field strengthening, or a DC brushless motor.



After auto-tuning is done, the auto-tuned motor parameters are automatically saved to corresponding parameters. Parameters to be auto-tuned vary with the auto-tuning method, as shown in the following table.

Param.	Name	b5-00 = 1 (Static partial auto-tuning)	b5-00 = 2 (No-load complete auto-tuning)	b5-00 = 8 (No-load dynamic auto-tuning)	b5-00 = 7 (Complete auto-tuning of synchronous motor in FVC mode)	Description
d1-26	Back EMF voltage of synchronous motor	-	□	□	-	The back EMF refers to the back EMF (effective value of the line voltage) when the motor rotates at rated speed without load. It can affect the performance in low-speed operation. If no-load dynamic auto-tuning is not available for synchronous motors, check the motor nameplate or contact the motor manufacturer to get the accurate motor back EMF. d1-26 represents the back EMF in rated speed. If the effective back EMF marked on the nameplate is 120 V/krpm, the rated back EMF = d0-05/1000 x 120 V. The back EMF here is the effective value of the line voltage. If the back EMF is unknown, disconnect the motor from the load to perform no-load dynamic auto-tuning. The above procedure only need to be performed once for motors with the same specifications. After that, you can manually input the back EMF value.
d1-02	Motor stator resistance	□	□	-	□	-
d1-24/d1-25	D-axis/q-axis inductance of the motor	□	□	-	□	Inductance and saturation values are critical to SVC performance, which must be included during parameter file download or static auto-tuning.
Group A3	Dead zone compensation curve	□	□	-	□	The dead zone compensation curve is critical to the low-speed performance in the SVC mode, which must be included during parameter file download or parameter setting.

Param.	Name	b5-00 = 1 (Static partial auto-tuning)	b5-00 = 2 (No-load complete auto-tuning)	b5-00 = 8 (No-load dynamic auto-tuning)	b5-00 = 7 (Complete auto-tuning of synchronous motor in FVC mode)	Description
E4-02 to E4-05/ d2-02	Speed loop Kp in SVC mode/Ti, inertia ratio	-	□	-	-	The system with fixed inertia supports inertia auto-tuning to obtain accurate moment of inertia. Enabling acceleration torque feedforward can achieve good following performance during acceleration/deceleration. The auto-tuned speed loop Kp/Ti can improve the resistance to load disturbance.
n4-12	Encoder mounting position angle	-	□	□	□	If the synchronous motor is used in FVC mode, motor runaway can occur if the encoder installation angle is not auto-tuned. The encoder installation angle can be auto-tuned when b5-00 is set to 2 [Dynamic parameter auto-tuning] or 7 [With-load auto-tuning]. Check the encoder phase sequence (n4-03) before setting b5-00 to 7. Failure to comply may result in motor runaway.
n4-03	Input phase sequence of the encoder	-	□	□	-	The encoder input phase sequence can be auto-tuned through dynamic parameter auto-tuning. If dynamic auto-tuning is not available, set an accurate encoder input phase sequence first. After setting the control mode to SVC, run the motor to see whether the encoder feedback speed (U9-20) is consistent with the actual motor speed (U9-00). If not, modify n4-03.
ABZ encoder n4-07/Resolver n4-15/ Communication-type encoder n4-89	Verification on the encoder pulses of revolution	-	□	□	□	No-load dynamic auto-tuning or with-load auto-tuning can detect whether the direction and number of encoder pulses per revolution are set correctly and whether the encoder signal is normal.

Caution

Before performing with-load auto-tuning of synchronous motors in FVC mode (b5-00 = 7), check that the encoder phase sequence (n4-03) is correct. Incorrect phase sequence may result in motor runaway. To check the encoder phase sequence, set basic motor parameters and back EMF (if known) first, and then set b5-00 to 1 to perform static auto-tuning. Finally, set E0-00 to 0 to run in the SVC mode, and start the motor to observe whether U9-00 and U9-20 are consistent.

- If signs (+ or -) of U9-00 and U9-20 are different, change the encoder direction through n4-03.
- If values of U9-00 and U9-20 are different, adjust the encoder pulses per revolution for an ABZ encoder or adjust the number of pole pairs for a resolver.
- If the motor has rotates but the encoder feedback speed is 0, the causes may be the following: 1. The encoder may be wired improperly. 2. Encoder parameters may be set improperly. 3. The encoder may be damaged. 4. The signals do not match.

After U9-00 and U9-20 are consistent, set b5-00 to 7 to perform with-load auto-tuning of the synchronous motor in FVC mode.

3.11 Automatic Calculation of Speed Loop Parameters

In applications where the moment of inertia auto-tuning is not available, manually input the load moment of inertia. The control module calculates proper speed loop control parameters automatically. Perform speed loop parameter calculation according to the following steps:

1. Manually adjust d2-02 to obtain the correct moment of inertia through d2-00.
2. Set b5-02 to 2 to enable speed loop parameter calculation.
3. Set b5-03 to 1 to confirm speed loop parameter calculation (b5-02).

The speed loop parameter calculation can only be triggered in the stop state. After confirmation, parameters are calculated automatically, without the need to run the motor. After automatic calculation of speed loop parameters is done, the following parameters are updated.

Param.	Name
E4-02	Speed loop Kp in FVC mode
E4-03	Speed loop Ti in FVC mode
E4-04	Speed loop Kp in SVC mode
E4-05	Speed loop Ti in SVC mode

Note

- The parameter d2-00 indicates the motor moment of inertia J in kg·m^2. Note the difference between kg·m^2 and the flywheel torque GD^2. The conversion relationship between the motor moment of inertia and flywheel torque is: J = GD^2/4g.
- The parameter d2-05 indicates the commonly-used electromechanical time constant of the mechanical system. It identifies the time (s) required for the motor to accelerate from standstill to rated speed at rated torque. For the same motor, the proportional relationship between the electromechanical time constant and the moment of inertia can be set through d2-02.

3.12 Trial Run

3.12.1 Local Control and Default Terminal Startup Device

For initial trial operation, it is recommended to use the InoDriveStudio or SOP-20-880 operating panel for local control. For details, see *"2.3.1 Overview" on page 43* and SOP-20-880 Smart Operating Panel User Guide. Use the V/f control mode and speed control mode for trial run, with default speed references and ramps used. Before trial run, check parameters listed in the following table.

Table 3–7 Checking parameters through InoDriveStudio or SOP-20-880 operating panel

Param.	Name	Value (Default)	Value description
A9-00	Command source	0	Channel 1
A9-01	Source of motor data group selection 0	0	First group of motor parameters
A9-02	Source of motor data group selection 1	0	
E0-00	Control method	2	V/f control
E0-01	Control mode	0	Speed control
E1-00	Startup mode	0	Direct start
E1-14	OFF1 stop mode	1	Decelerate to stop
E3-00	V/f mode selection	0	V/f curve
E3-01	V/f curve selection	0	Linear V/f
C7-02	RFG ramp selection 1	0	RFG 1 acceleration/deceleration time
C7-03	RFG ramp selection 2	0	
C7-04	Ramp 1 acceleration time	20	Ramp 1 acceleration time (20s)
C7-05	Ramp 1 deceleration time	20	Ramp 1 deceleration time (20s)

When using the default terminal to start or stop the drive, check the following parameters in addition to the previous parameters.

Table 3–8 Parameters for start/stop by the default terminal

Param.	Name	Value	Value description
b0-00	Start/Stop control word source	0	Terminal start/stop module
b4-02	Terminal start/stop command 1/2 selection	0	Terminal start/stop command 1
b4-03	Terminal start/stop command 1 mode	1	IN1 start mode
b4-05	Terminal start/stop command 1 input	2	DI1 as the command source
C0-00	Main speed control reference	1	Multi-reference 1 as the speed reference
C6-05	Multi-reference 1	Defines the speed value.	-

When the DI1 state changes from 0 to 1 (rising edge), the drive starts and the motor accelerates from the standstill state to the speed set by C6-05.

3.12.2 Starting through DIs or AIs

You can use digital inputs as the command source to start and stop the device, analog inputs as the speed reference to start the device. For example, you can use DI1 as the start command, DI2 as the quick stop command, DI3 as the fault reset command, AI1 as the speed reference, and set parameters in *"Table 3-8 Parameters for start/stop by the default terminal" on page 110* on the basis of *"Table 3-7 Checking parameters through InoDriveStudio or SOP-20-880 operating panel" on page 110*.

Table 3–9 Example of AI/DI parameters for starting/stopping the device

Parameter	Name	Value	Value description
b0-00	Start/Stop control word source	3	Custom start/stop control word
b0-01	Custom OFF1 source 1	2	DI1 as the source of OFF1 command
b0-03	Custom OFF3 source 1	3	DI2 as the source of OFF3 command
b0-04	Custom operation permission source	1	Operation permitted
b0-05	Custom fault reset source 1	4	DI3 as the source of fault reset command
C0-00	Main reference selection in speed control mode	2	AI1 as the speed reference source

3.12.3 Starting Through the Fieldbus

This section describes how to start, stop, and reset the device through the fieldbus and how to set the reference source.

The device can be started through the fieldbus in the following two ways.

3.12.3.1 Starting Through Pre-configuration Mode

When the device is started through the pre-configuration mode and A9-00 is set to 0, set b0-00 (Start/Stop control word source of channel 1) to 1 or 2. When A9-00 is set to 1, set b2-00 (Start/Stop control word source of channel 2) to 1 or 2. In this case, fieldbus process data PZD1 is used as the command source for commands OFF1 and OFF2, as shown in the following table.

Table 3–10 Command source when starting through fieldbus pre-configuration mode

Command	Command source
OFF1	PZD1.0
OFF2	PZD1.1
OFF3	PZD1.2
Operation permission source	PZD1.3
Fault reset source	PZD1.7
Jog source 1	PZD1.8
Jog source 2	PZD1.9
Speed inversion source	PZD1.11

When pre-configuration mode is used, set the speed reference separately through multi-reference, analog values, or communication.

3.12.3.2 Starting Through Custom Mode

When the device is started through custom startup device defined by fieldbus communication, select a protocol for data interaction with the host controller and set parameters according to the protocol. The following takes the fieldbus adapter A as an example, in which the fieldbus A is configured as a startup device based on Profibus-DP bus.

Protocol for data interaction between HCU-50S/51S and the host controller:

Word No.	Meaning	Description
PZD1	Control word	For details, see *"Table 3-11 Control word definition" on page 112*.
PZD2	Speed reference	The speed ramp is determined by PLC. 4096 represents 100% of the motor rated frequency.

Table 3–11 Control word definition

Bit	Description
bit0	0: At stop 1: Start upon switch-on 0 → start upon rising edge
bit1	0: Coast to stop 1: Mandatory condition for operation
bit2	0: Quick stop 1: Mandatory condition for operation
bit3	0: Output blocked 1: Operation enabled
bit4	0: Ramp output inhibited 1: Ramp output enabled
bit5	0: Valid ramp pause 1: Invalid ramp pause
bit6	0: Action of setting ramp reference to 0 being valid 1: Action of setting ramp reference to 0 being invalid
bit7	0: Invalid 1: 0→1 fault reset valid
bit8 to bit9	Reserved
bit10	0: PZD data invalid 1: PZD data valid
bit11 to bit15	Reserved

The following table describes the data sent by HCU-50S/51S to the host controller.

Data	Meaning	Description
PZD1	Status word 1	For details, see the status word definition table.
PZD2	DC bus voltage	One decimal place. The value 1000 represents a voltage of 100.0 V.

Table 3–12 Status word definition

Bit	Description
bit0	0: Not ready for switch-on 1: Ready for switch-on
bit1	0: Not ready to run 1: Ready to run
bit2	0: Not in operation 1: In operation
bit3	0: No fault 1: Fault activated
bit4 to bit6	Reserved
bit7	0: No alarm 1: Alarm activated
bit8 to bit15	Reserved

Parameter configuration

- Bus adapter Porfibus-DP configuration:

Param.	Name	Value	Description
n1-00	Bus type of bus adapter	7	The bus adapter A is defined as the Profibus-DP type.
n1-01	Communication disconnection detection delay	1.00	A communication failure is reported one second after communication interruption.
n1-02	Bus adapter communication mode selection	0 (standard mode)	Errors and faults of the bus adapter communication card are detected by default.
n1-03	Continuous CRC error detection in communication	0	The CRC is not performed on the data received by the bus adapter.
n1-04	Process data output 1	U5-86 (1586)	Use the bit-to-word function module 1 to configure status words.
n1-05	Process data output 2	U5-05 (1505)	Indicates the DC bus voltage (100 ms filtering).
n1-20	Communication base value of process data output 1	0	Base value conversion is not required.
n1-21	Communication base value of process data output 2	0	Base value conversion is not required.
n1-36	Communication base value of process data input 1	0	Base value conversion is not required.
n1-37	Communication base value of process data input 2	0	Base value conversion is not required.
n16-00	Expansion slot	7	The Profibus-DP communication module is installed in expansion slot 3_1.
n16-02	Expansion card ID	45	Set the Profibus-DP address to 45.
n16-10	DP data check bit	0	Set the data check bit of Profibus-DP to bit10 of PZD1. When bit10 of the PZD1 received by HCU is set to 1, the communication data is valid.

- PZD 1 control word configuration

Param.	Name	Setpoint	Description
b0-00	Start/Stop control word source	3	Custom start/stop control word (through group b0)
b0-01	Custom OFF1 source	U2-00 (1200)	Select bit0 of PZD1 of bus adapter A as the OFF1 command source.
b0-02	Custom OFF2 source 1	U2-01 (1201)	Select bit1 of PZD1 of bus adapter A as the OFF2 command source.
b0-03	Custom OFF3 source 1	U2-02 (1202)	Select bit2 of PZD1 of bus adapter A as the OFF3 command source.
b0-04	Custom operation permission source	U2-03 (1203)	Select bit3 of PZD1 of bus adapter A as the operation permission command source.
b0-05	Custom fault reset source 1	U2-07 (1207)	Select bit7 of PZD1 of bus adapter A as the fault reset command source.
b1-06	Ramp function generator inhibition source	U2-04 (1204)	Select bit4 of PZD1 of bus adapter A as the command source for enabling ramp output.
b1-07	Ramp function generator pause source	U2-05 (1205)	Select bit5 of PZD1 of bus adapter A as the ramp pause command source.
b1-08	Source for setting Ramp function generator reference to 0	U2-06 (1206)	Select bit6 of PZD1 of bus adapter A as the source for setting ramp reference to 0.
n16-10	DP data check bit	0	Select bit10 of PZD1 for bus adapter A as the source of the DP data check bit.

- Speed reference configuration:

Parameter	Name	Setpoint	Description
A9-00	Reference channel source	0	Select reference channel 1.
C0-00	Main reference selection in speed control mode	U5-45 (1545)	Select PZD2 of bus adapter A as the speed reference source.

- Output of bit-to-word function 1 for status word:

Parameter	Name	Setpoint	Description
L0-10	Bit-to-word function 1 - bit0 selection	U1-00 (1100)	Ready to switch on
L0-11	Bit-to-word function 1 - bit1 selection	U1-01 (1101)	Ready to run
L0-12	Bit-to-word function 1 - bit2 selection	U1-02 (1102)	Running
L0-13	Bit-to-word function 1 - bit3 selection	U1-03 (1103)	Fault activated
L0-14	Bit-to-word function 1 - bit4 selection	0	-
L0-15	Bit-to-word function 1 - bit5 selection	0	-
L0-16	Bit-to-word function 1 - bit6 selection	0	-
L0-17	Bit-to-word function 1 - bit7 selection	U1-07 (1107)	Alarm/minor fault activated
L0-18	Bit-to-word function 1 - bit8 selection	0	-
L0-19	Bit-to-word function 1 - bit9 selection	0	-

Parameter	Name	Setpoint	Description
L0-20	Bit-to-word function 1 - bit10 selection	0	-
L0-21	Bit-to-word function 1 - bit11 selection	0	-
L0-22	Bit-to-word function 1 - bit12 selection	0	-
L0-23	Bit-to-word function 1 - bit13 selection	0	-
L0-24	Bit-to-word function 1 - bit14 selection	0	-
L0-25	Bit-to-word function 1 - bit15 selection	0	-

3.12.4 Control Through Modbus (Mailbox Data)

3.12.4.1 Control Through Continuous Address

The number of special communication addresses provided by HCU-50S/51S is limited, therefore the Modbus-RTU and Modbus TCP allow process data n1-68 to n1-83 (n2-68 to n2-83) to be written. After converted by communication base values of n1-36 to n1-51 (n2-36 to n2-51), the process data is updated to the corresponding connector U5-44 to U5-59 (U5-60 to U5-75).

Bus adapter A:

Comm. address	Parameter written	Name	Description
33807	n1-68	Data display of process data input 1	Written through Modbus, converted by the base value of n1-36, and updated to connector U5-44
33808	n1-69	Data display of process data input 2	Written through Modbus, converted by the base value of n1-37, and updated to connector U5-45
33809	n1-70	Data display of process data input 3	Written through Modbus, converted by the base value of n1-38, and updated to connector U5-46
33810	n1-71	Data display of process data input 4	Written through Modbus, converted by the base value of n1-39, and updated to connector U5-47
33811	n1-72	Data display of process data input 5	Written through Modbus, converted by the base value of n1-40, and updated to connector U5-48
33812	n1-73	Data display of process data input 6	Written through Modbus, converted by the base value of n1-41, and updated to connector U5-49
33813	n1-74	Data display of process data input 7	Written through Modbus, converted by the base value of n1-42, and updated to connector U5-50
33814	n1-75	Data display of process data input 8	Written through Modbus, converted by the base value of n1-43, and updated to connector U5-51
33815	n1-76	Data display of process data input 9	Written through Modbus, converted by the base value of n1-44, and updated to connector U5-52

Comm. address	Parameter written	Name	Description
33816	n1-77	Data display of process data input 10	Written through Modbus, converted by the base value of n1-45, and updated to connector U5-53
33817	n1-78	Data display of process data input 11	Written through Modbus, converted by the base value of n1-46, and updated to connector U5-54
33818	n1-79	Data display of process data input 12	Written through Modbus, converted by the base value of n1-47, and updated to connector U5-55
33819	n1-80	Data display of process data input 13	Written through Modbus, converted by the base value of n1-48, and updated to connector U5-56
33820	n1-81	Data display of process data input 14	Written through Modbus, converted by the base value of n1-49, and updated to connector U5-57
33821	n1-82	Data display of process data input 15	Written through Modbus, converted by the base value of n1-50, and updated to connector U5-58
33822	n1-83	Data display of process data input 16	Written through Modbus, converted by the base value of n1-51, and updated to connector U5-59

Bus adapter B

Comm. address	Parameter written	Name	Description
33839	n2-68	Data display of process data input 1	Written through Modbus, converted by the base value of n2-36, and updated to connector U5-60
33840	n2-69	Data display of process data input 2	Written through Modbus, converted by the base value of n2-37, and updated to connector U5-61
33841	n2-70	Data display of process data input 3	Written through Modbus, converted by the base value of n2-38, and updated to connector U5-62
33842	n2-71	Data display of process data input 4	Written through Modbus, converted by the base value of n2-39, and updated to connector U5-63
33843	n2-72	Data display of process data input 5	Written through Modbus, converted by the base value of n2-40, and updated to connector U5-64
33844	n2-73	Data display of process data input 6	Written through Modbus, converted by the base value of n2-41, and updated to connector U5-65
33845	n2-74	Data display of process data input 7	Written through Modbus, converted by the base value of n2-42, and updated to connector U5-66
33846	n2-75	Data display of process data input 8	Written through Modbus, converted by the base value of n2-43, and updated to connector U5-67
33847	n2-76	Data display of process data input 9	Written through Modbus, converted by the base value of n2-44, and updated to connector U5-68

Comm. address	Parameter written	Name	Description
33848	n2-77	Data display of process data input 10	Written through Modbus, converted by the base value of n2-45, and updated to connector U5-69
33849	n2-78	Data display of process data input 11	Written through Modbus, converted by the base value of n2-46, and updated to connector U5-70
33850	n2-79	Data display of process data input 12	Written through Modbus, converted by the base value of n2-47, and updated to connector U5-71
33851	n2-80	Data display of process data input 13	Written through Modbus, converted by the base value of n2-48, and updated to connector U5-72
33852	n2-81	Data display of process data input 14	Written through Modbus, converted by the base value of n2-49, and updated to connector U5-73
33853	n2-82	Data display of process data input 15	Written through Modbus, converted by the base value of n2-50, and updated to connector U5-74
33854	n2-83	Data display of process data input 16	Written through Modbus, converted by the base value of n2-51, and updated to connector U5-75

Use continuous addresses as the start, stop, and reset command sources of the drive through the Modbus. For details, see *"3.12.3.1 Starting Through Pre-configuration Mode" on page 111*.

3.12.4.2 Control Through Special Address

As specified by the Modbus communication protocol, parameters are read and written directly through the communication address, without generating process data. However, b0-01/b2-01 of the custom OFF1 source is not allowed to be set to 1 for start. A piece of connector data must be selected.

To start/stop through Modbus communication, the HCU-50S/51S provides several special communication addresses for accessing Modbus, and updates the data written to a specific connector to allow the reference source parameters to be read.

Add.	Written to connector	Name	Description
34196	U1-75	Start/Stop command from Modbus communication	The value ranges from 0 to 1, which can be used for custom OFF1 command.
34230	U5-40	Reference 1 set through modbus communication	The value ranges from -32768 to +32767, which can be used for speed setting.
34231	U5-41	Reference 2 set through modbus communication	
34232	U9-50	Double word reference set through Modbus communication	The value ranges from -2^{31} to $+2^{31}-1$, which can be used for high-precision speed setting. Write high 16 bits of the data to the communication address 34232. Write low 16 bits of the data to the communication address 34233.

Parameter configuration:

Param.	Name	Value	Description
n1-00	Bus type for fieldbus adapter	1	Select the Modbus RTU type for fieldbus adapter A.
n10-00	Expansion slot selection	7	The Modbus RTU module is installed in expansion slot 3_1.
n10-04	Modbus local address	4	Set the address of the Modbus RTU module to 4.
b0-00	Start/Stop control word source	3	Custom start/stop control word (through group b0)
b0-01	Custom OFF1 source	U1-75 (1175)	Select the start/stop command from Modbus communication as OFF1 command source.
C0-00	Main speed control reference	U5-40 (1540)	Use the reference 1 that set through Modbus communication as the speed reference source.

Write 0 to communication address 34196 through Modbus for stop and write 1 for operation control. Write data to communication address 34230 as the speed reference source. 4096 corresponds to 100% of the rated motor frequency, and -4096 corresponds to -100% of the rated motor frequency.

4 Basic System Concepts

4.1 Function Framework

The HCU-50S/51S control module adopts modular design. Each function module provides a specific sub-function. The modules are assembled with each other through the parameter interconnection system (see *"4.3.1 Connector Parameters" on page 120*).

The host controller exchanges data with the HCU-50S/51S through various communication protocols to control the motor. The HCU-50S/51S is supported by various types of process packages to achieve rapid application under specific scenarios.

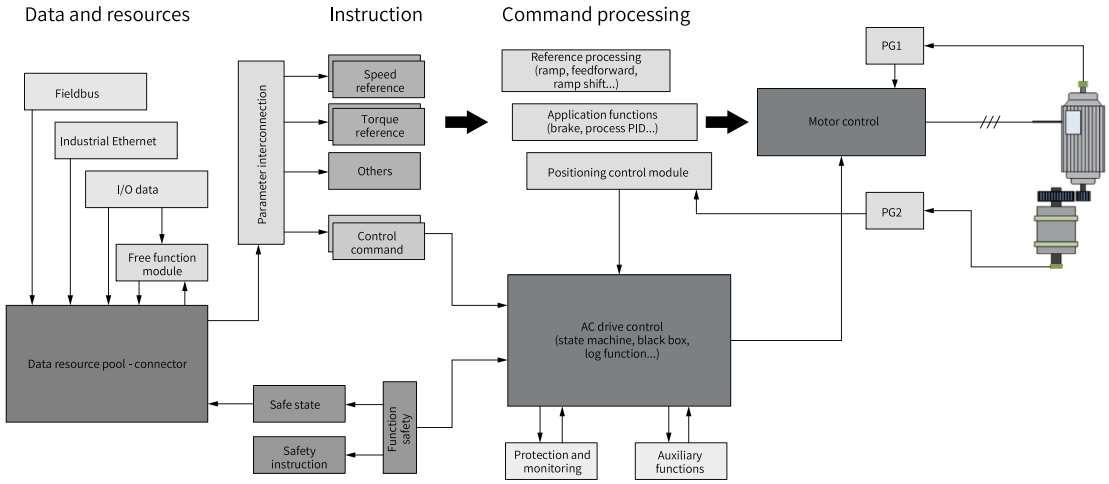
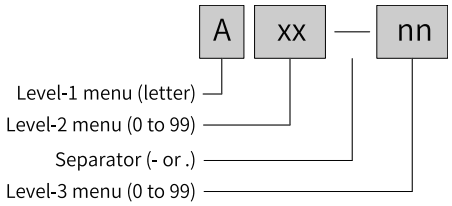


Figure 4-1 Functional framework diagram

4.2 Parameter Setpoints and Output Values

Parameters of HCU-50S/51S are represented by a three-level menu, as shown in the following figure.



Note

- The separators "-" and "." used in parameter menus represent the same meaning. For example, A0-00 is the same as A0.00. This guide uses A0-00, whereas the LED panel may display A0.00.
- Level-1 menus can contain the following letters: A, b, C, d, E, F, H, L, n, o, P, and U. The letters are case sensitive for the purpose of display on the LED panel.

The setpoint of a parameter is the value of the parameter set by the user.

The output value of a parameter is the value read by the HCU-50S/51S control module.

For most of parameters, the output value is equal to the setpoint. However, in HCU-50S/51S control modules, parameter setpoints of a certain type of reference source are taken from another parameter B and the output value of parameter A is equal to that of parameter B.

In this guide, the value of the parameter represents the setpoint, that is, the output value of this parameter, as shown below.

- U9-32 = 10%
- C0-00 = 1932
- [C0-00] = 10%

C0-00 represents main reference selection in speed control of channel 1, which is defined by the connector value in U9-32. When U9-32 is set to 10%, the actual output value of [C0-00] is 10%.

For reference source parameter C0-00, the setpoint 1932 only indicates that the setpoint source is the connector value in U9-32. In this case, [C0-00] represents the actual output value of the parameter, which is 10%.

4.3 Parameter Inter-connection System

4.3.1 Connector Parameters

Parameters in group U are read-only and store intermediate data from module operations during the AC drive running process. These parameters are called connector parameters and can be viewed by users or read or used by other parameters.

Connector parameters are divided into two categories based on signal types:

- Bit connector: includes DI, DO, a bit of a communication word, a bit of a control word or a status word, and status information of a hardware board or a fault. Parameter groups U0 to U4, U10 to U12, and U20 are bit connectors.
- Word connector: includes calculated values (speed, voltage, current, and torque) related to AC drive control, data received through communication, and AI and AO signals for hardware detection. Parameter groups U5 to U9, U15, U16, U17, U19, and U29 are word connectors. Groups U5 to U8, U15, U16, and U17 are single-word connectors. Groups U9, U19, and U29 are double-word connectors.

Note

Connector parameters are also needed by the continuous oscilloscope, trigger oscilloscope, and black box data recording functions of InoDriveStudio. Only the connector parameters can be used for continuous oscilloscope or black box data recording.

4.3.2 Reference Source Parameter

Parameters used to read connector parameters are reference source parameters, which are divided into two categories according to connector types.

- Bit reference source parameter: Set a parameter number for a bit connector and read the value of the bit connector as the reference source parameter output.
- Word reference source parameter: Set a parameter number for a word connector and read the value of the word connector as the reference source parameter output.

All parameters can be set by using numbers only. When setting reference sources, use 1000 to 1999 to indicate connectors U0-00 to U9-99 and 2000 to 3999 to indicate connectors U10-00 to U29-99.

One connector parameter can be read by multiple reference source parameters. However, one reference source parameter can read only one connector parameter at a time.

4.4 Per-unit System

In general circuit calculation, the units of current, voltage, power, and impedance are expressed as A, V, W, and Ω, respectively. This method of expressing physical quantities in actual named units is called the named unit system.

When the named unit system is used for calculation, even parameters for motors of the same type are completely different due to difference in capacities, causing inconvenience in parameter calculation. On that account, the per-unit value system is typically used in engineering to simplify calculation and facilitate analysis on physical status changes.

The per-unit value system is a common way to mark numerical values in engineering calculation, indicating relative values of physical quantities and parameters. A per-unit value is relative to a base value. For a given named value, per-unit values vary with base values. The conversion between per-unit values and named values is as follows:

Per-unit value = Named value/Base value

In motor control systems, the rated value of the motor is typically used as the base value of the per-unit system. For example, assume that the rated motor current is 100 A and the no-load current is 40 A. When the rated motor current 100 A is used as the base value, the per-unit value of the motor no-load current 40 A is 40%.

4.4.1 Per-Unit Base Value Selection

To facilitate motor control, the HCU-50S/51S control module uses rated motor parameters as the basis for converting detection and control values to per-unit values.

Name	Base Value
AC voltage	The base value is the RMS value (based on d0-02) of the motor line voltage. This parameter can be viewed through d3-00.
AC current	The base value is the RMS value (based on d0-03) of the motor current. This parameter can be viewed through d3-01. If the rated current of the AC drive under a heavy load is greater than 4 times the rated motor current, use 1/4 of the rated current of the AC drive under a heavy load as the base value.
Motor speed	The base value is the motor synchronous speed (calculated based on d0-04, rather than the rotor speed). This parameter can be viewed through d3-02.
Output frequency	The base value is the rated motor frequency (based on d0-04). This parameter can be viewed through d3-03.

Name	Base Value
Motor torque	The base value is the rated motor torque, which is automatically calculated based on the basic parameters input by users and does not need manual setting.
Motor power	The base value is the rated power of the motor (calculated based on d0-01, or based on d0-02 and d0-03 if the input deviation of d0-01 is large). This parameter can be viewed through d3-04.

4.4.2 Per-Unit Value Ranges

In the HCU-50S/51S control module, the range of values is the same for the 16-bit and 32-bit per-unit values, that is, –799.9% to +799.9%. However, 32-bit values have more valid digits, indicating numerical values with higher precision. The following table takes 123.45% as an example to illustrate the data errors of 16-bit and 32-bit per-unit values.

Value Mode	Stored Numerical Value	Per-Unit Value	Absolute Error	Relative Error
16-bit per-unit value	5056	123.4375%	-0.0125%	0.010126%
32-bit per-unit value	331383570	123.44999984%	-0.00000016%	< 0.0001%

4.4.3 Per-Unit Value Formats

The HCU-50S/51S control module displays parameters as integers with 16-bit or 32-bit precision. The following rules apply to expression of per-unit values.

- When the per-unit value is expressed in the 16-bit format, 4096 (hexadecimal 0x1000) indicates 100%, with the accuracy being 0.0244%, and the value range is –799.9% to +799.9%. Typically, this format is used for the per-unit value of current, voltage, and torque.
- When the per-unit value is expressed in the 32-bit format, hexadecimal 0x1000 0000 indicates 100%, with higher accuracy, and the value range is –799.99% to +799.99%. Typically, this format is used for the per-unit value of motor speed.

The 16-bit and 32-bit numerical values can be automatically converted to each other in the system. A 32-bit value can be used as a 16-bit value when its low-order 16 bits are removed. A 16-bit value can be used as a 32-bit value when 16 zeros are added to its low-order bits.

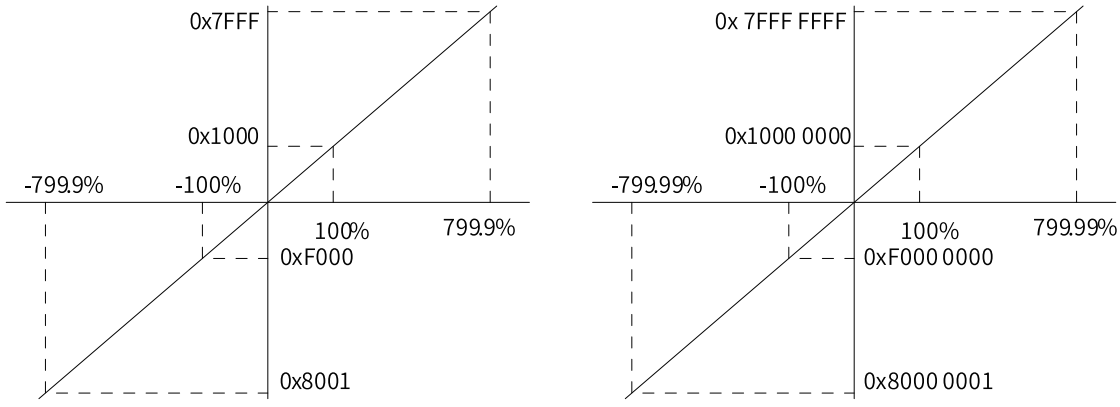


Figure 4-2 Per-unit value expressed in the 16-bit and 32-bit numerical value formats

4.5 Motor Data Sets

4.5.1 Switchover Between Multiple Motor Data Sets

The HCU-50S/51S control module can store up to four different motor data sets (MDSs). Each MDS contains motor parameters (group d) and corresponding motor control parameters (group E).

The A9-02 and A9-03 parameters are used for switchover between active MDSs. MDS switchover is allowed only in the stop state. MDS switchover during AC drive running does not take effect until the AC drive stops.

Parameter	Name	Description
A9-02 (bit 0)	MDS selection 0 source	Bit 1 bit 0: 00: MDS 1 01: MDS 2 10: MDS 3 11: MDS 4
A9-03 (bit 1)	MDS selection 1 source	

Parameter values of active MDSs can be viewed through group d and group E. Parameters of different MDSs have different communication addresses.

Parameters with the same function in MDS1 to MDS4 are assigned with ascending communication addresses. Communication addresses mentioned in this guide correspond to MDS1. Communication addresses corresponding to other MDSs need to be calculated manually. The following description takes the rated motor current as an example.

Parameter	Name	Current Range (A)	Change	Default	Correspondence Address
d0-03	Rated motor current	0.1 to 6553.5	At stop	9.0	245

According to the table:

- The communication address of the rated motor current parameter of motor 1 is 245.

Based on motor 1, the communication addresses of the rated motor current parameters of motors 2, 3, and 4 can be derived:

- The communication address of the rated motor current parameter of motor 2 is 246.
- The communication address of the rated motor current parameter of motor 3 is 247.
- The communication address of the rated motor current parameter of motor 4 is 248.

Note

- The MDS function allows an AC drive to run with different motors or a motor to run in different control modes.
- After MDS switchover, ensure that the motor control parameters match the motor parameters.
- If a drive unit drives different motors, perform parameter auto-tuning on every motor during commissioning.

4.5.1.1 Viewing and Setting Parameters with SOP-20-880

When using SOP-20-880 to view different motor data, you need to switch the currently activated motor data group through A9-01/A9-02. After switching, the parameters corresponding to the currently activated motor can be viewed in group d and group E.

4.5.1.2 Quick View Using InoDriveStudio

When using InoDriveStudio, you can view the currently active motor parameters in the same way as SOP-20-880. You can also view all motor parameters by choosing "Inverter > Parameter list > Motor data set".

As shown in the following figure, the list contains all parameters related to motor switchover. When users select different motors from the "Select data set" drop-down list, parameters displayed in the list are switched to those corresponding to the selected motor.

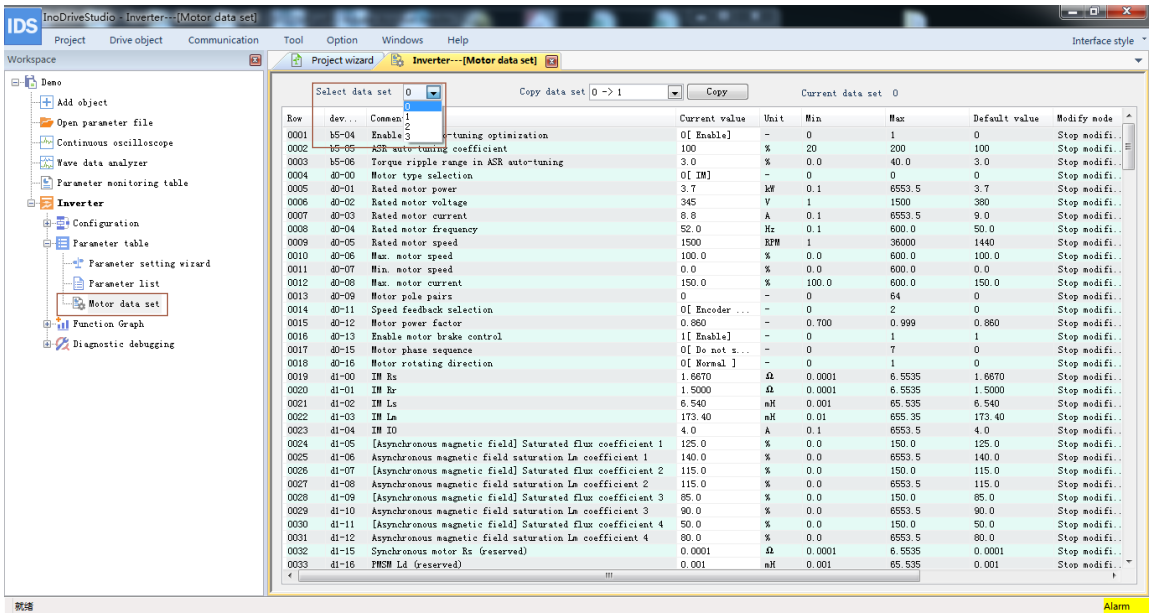


Figure 4-3 Quickly viewing motor parameters

4.5.1.3 Motor Data Set and Motor Control Data Set

The motor data set (group d) and the motor control data set (group E) each have four groups of communication addresses, which are switched based on the settings of A9-01 and A9-02. In actual use, group d and group E both can be considered as motor data sets.

Group d differs from group E in restoration to factory defaults. Specifically, when A8-00 is set to 1, parameters of group d are not restored while parameters of group E are restored.

4.5.1.4 Copying a Motor Data Set

If you need two groups of identical motor parameters, you can choose "Inverter > Parameter list > Motor data set" in InoDriveStudio to access the motor data set, select the copy mode through "Copy data set", and click the "Copy" button, as shown in the following figure.

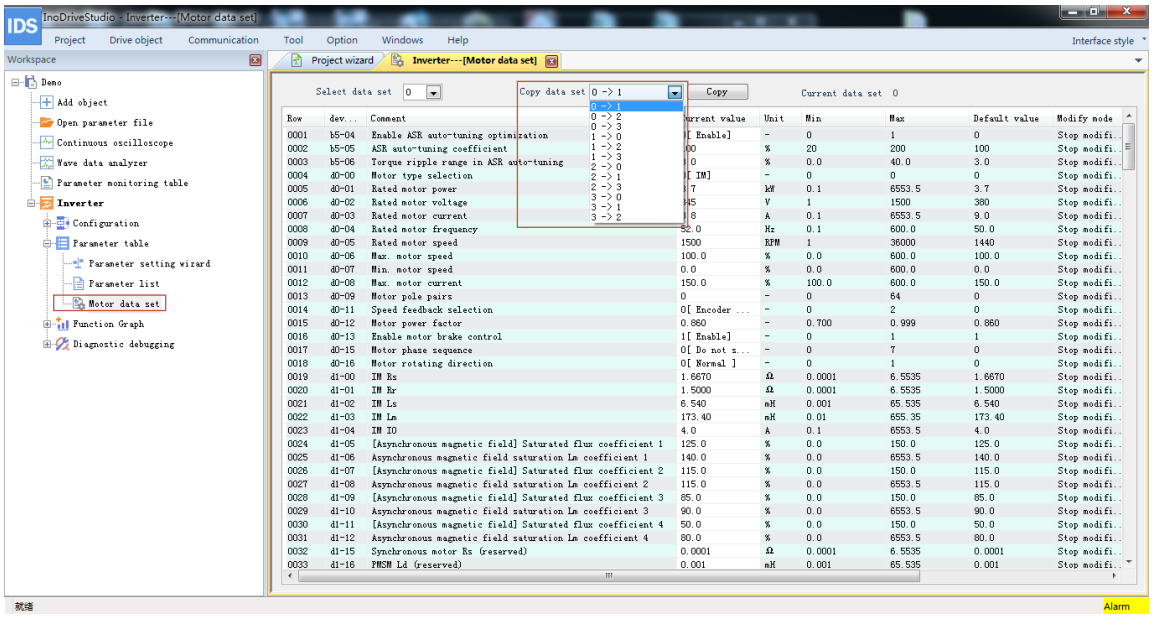


Figure 4-4 Copying a motor data set

Note

In the "Copy data set" drop-down list, digits 0 to 3 correspond to motor data sets 1 to 4, respectively.

4.6 Reference Channel and Local Control

4.6.1 Definitions of Local Control and Remote Control

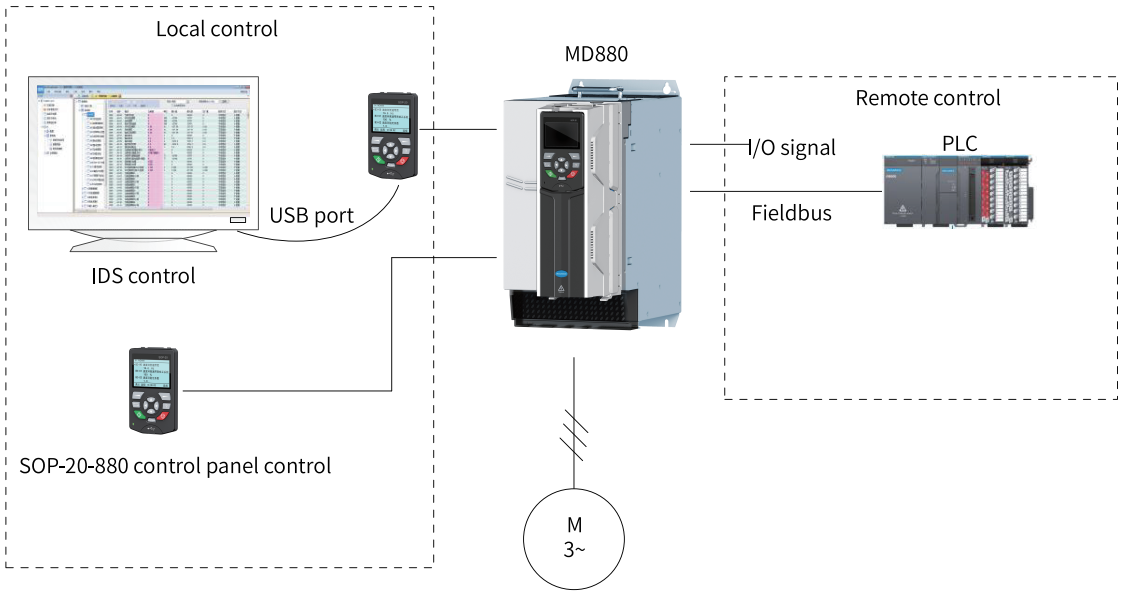


Figure 4-5 Diagram of local control and remote control

The terms "local" and "remote" in this guide are defined based on the HCU-50S/51S control module. Controlling device start/stop through the control channel is defined as "remote control", and controlling through SOP-20-880 or InoDriveStudio is defined as "local control".

Some cabinet manufacturers may add start/stop buttons and potentiometers on drive cabinet doors to implement operations with the cabinet doors, and define such control as local control and the PLC control as remote control. This is not the case in this guide. As for the HCU-50S/51S control module, "remote control" covers cabinet door, PLC and other host controller control. Two control channels are used for switching. The "LOC/REM" control button on the cabinet door should be connected to the HCU-50S/51S control module through a DI, which must be set as the source of A9-00 (control channel selection).

In some production sites, the operation cabinet beside the machine will be defined as local control, while PLC will be defined as centralized control or remote control, which is equivalent to switching between two control channels in HCU-50S/51S. Configure the I/O signals of the operation box and the PLC communication protocol into two control channels, and set A9-00 for switchover, implementing separate control.

4.6.2 Local Control and Remote Control

Controlling the start/stop of the inverter module through control channel is called remote control, which is the most commonly used mode. During commissioning, using SOP-20-880 or InoDriveStudio to control the start/stop of the inverter module is called local control. Local control mainly applies to commissioning and maintenance. When local control is enabled, the start/stop control word of control channel reference and the reference for the reference channel are inactive.

- The local control of InoDriveStudio has the highest commissioning priority. Once InoDriveStudio local control is enabled, the command channel and the SOP-20-880 control are disabled. Switchover between local control and remote control is allowed only in the stop state.
- The local/remote control status is indicated by U1-78. The value 0 indicates that local control is activated and the command channel is inactivated. The value 1 indicates that remote control is activated, that is, the command channel is activated.
- Command channel switchover is implemented by the A9-00 parameter, and the status is indicated by U0-26. The value 0 indicates that command channel 1 is active. The value 1 indicates that command channel 2 is active.

The following table lists the actually activated control sources and the connector states.

A9-00	SOP local/remote	IDS local/remote	U1-78	U0-26	Actual control source
0	0	0	1	0	Command channel 1
0	1	0	0	0	SOP-20-880
0	0	1	0	0	InoDriveStudio
0	1	1	0	0	InoDriveStudio
1	0	0	1	1	Command channel 2
1	1	0	0	1	SOP-20-880
1	0	1	0	1	InoDriveStudio
1	1	1	0	1	InoDriveStudio

4.6.2.1 Local Start Control Through SOP-20-880

After SOP-20-880 and HCU-50S/51S are properly connected, pressing Loc/Rem on SOP-20-880 can switch the control permission. The switchover is valid only when the AC drive is in the stop state. When Loc is displayed at the lower left corner of SOP-20-880, SOP-20-880 has obtained the control permission, and the start/stop control through control channels and reference through reference channels is inactive. To restore the control channel function, press Loc/Rem on SOP-20-880 again.

If the SOP-20-880 is disconnected from the HCU-50S/51S after obtaining the control permission, the control mode switches to remote control. After the SOP-20-880 is connected to the HCU-50S/51S again, press the Loc/Rem key of the SOP-20-880 to switch to local control. If you want the SOP-20-880 to keep the local control permission upon reconnection after power failure, set this function through parameter A10-09. Specifically, set parameter A10-09 to 1 [Retentive].

You can use parameter A10-00 to prevent SOP-20-880 from taking control. After local control is disabled, the Loc/Rem key of the SOP-20-880 is unavailable.

After SOP-20-880 obtains the local control permission, the start/stop command source can only be the keys of SOP-20-880, but the speed reference source can be set through the A10-01 parameter.

- When A10-01 is set to 0, the speed reference is controlled by group C4 (output of motor-driven potentiometer), and the increment/decrement command of the motor-driven potentiometer comes from the Up/Down key of SOP-20-880.
- When A10-01 is set to 1, the speed reference still comes from the speed reference channel.

When SOP-20-880 is used, you can start and stop the device with the "RUN" and "STOP" keys. For details about how to use the SOP-20-880, see *SOP-20-880 Smart Operating Panel User Guide*.

When SOP-20-880 obtains the local control permission, if you want to set the source of the start/stop command as remote control, such as terminal control or communication, and the source of the speed reference increment/decrement command as the Up/Down key of SOP-20-880, set the parameters as follows.

1. Switch to local control by using the Loc/Rem key of SOP-20.
2. Set A10-01 to 0 [motor-driven potentiometer] and A10-07 to 1 [control setting channel].

With settings in step 1 and step 2, you can remotely control the start/stop of the device through the terminal or communication. In addition, you can use the Up or Down key on the main interface of the SOP-20 as shown in *"Figure 4-6 Homepage" on page 128* to increase or decrease the speed.

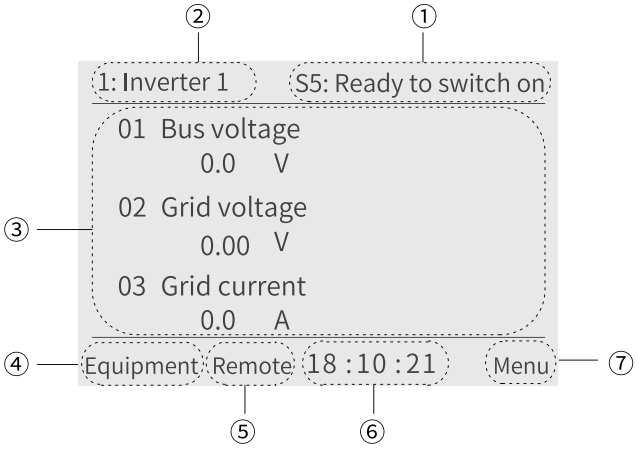


Figure 4-6 Homepage

Table 4–1 Main interface description

No.	Display Content	Description
①	Device status and fault information	Displays the running status of the current equipment, including the state machine, fault, and alarm information. When the device fails, fault information running status are displayed alternately.
②	Current device information	1: ID of the current device Inverter 1: Name of the current device
③	Content area	Displays monitoring data in real time.
④	Device list	Displays the list of devices in the current network.
⑤	Local/Remote switchover	Local: Indicates that the equipment is controlled by SOP-20-880. Remote: Indicates that the equipment is controlled remotely through I/O or the bus. No display: This function is unavailable on the equipment.
⑥	SOP-20-880 clock time	Displays the current clock time of SOP-20-880.
⑦	Menu	Accesses the function menu of the current device.

Hold down the Up or Down key on SOP-20-880 to adjust the value quickly to a range close to the target speed, and then keep pressing the key until the target speed value is reached. If the target frequency has decimal points, set the target frequency through parameters A10-10 to A10-13 as follows.

Assume that the speed per-unit base value d3-02 is 1560 rpm, the frequency per-unit base value d3-03 is 52 Hz.

- If A10-10 is set to 26.00 Hz, then U9-29 is 50.00%, A10-11 is 780 rpm, and A10-12 is 50.0%.
- If A10-11 is set to 780 rpm, then U9-29 is 50.00%, A10-10 is 26.00 Hz, and A10-12 is 50.0%.
- If A10-12 is set to 50.0%, then U9-29 is 50.00%, A10-10 is 26.00 Hz, and A10-11 is 780 rpm.

Note

When the drive unit is running, the Loc/Rem key is disabled and cannot be used to switch control permissions.

4.6.2.2 Local Start/Stop Control Through InoDriveStudio

For details of local start/stop control through the InoDriveStudio control panel, see the *MD880 Series AC Drive Parameter Guide (HCU-50S, HCU-51S, HCU-50S-CS, and HCU-51S-CS)*.

4.6.2.3 Start/Stop Control Through Control Channels

For details about the configuration, see *" Terminal Start/Stop Module" on page 173*.

4.6.3 Control Channel and Reference Channel

HCU-50S/51S has two command channels. Each channel contains a group of control channels and a group of reference channels.

- The control channels are used to set AC drive control instructions to start/stop the AC drive or implement other relevant control. Groups b0 and b1 are for control reference of channel 1, while groups b2 and b3 are for control reference of channel 2. The control reference mainly includes the start/stop control word reference and other control word reference.
- The reference channels are used to set the motor speed and torque references to change the running status of the motor. Groups C0 and C1 correspond to references of channel 1, while groups C2 and C3 correspond to references of channel 2.

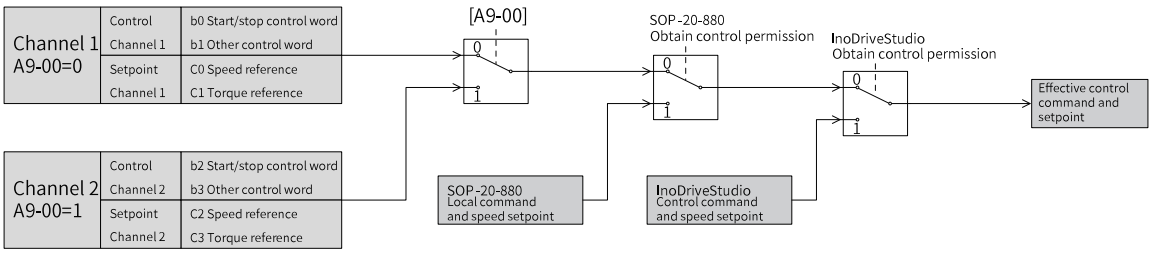


Figure 4-7 Control command data flow diagram

In remote control, set the control channel parameters to specify the start/stop command word and the speed and torque references.

You can select control channel 1 or 2 to switch between two different control modes, dynamically changing the RUN command source.

- For example, you can select channel 1 to use terminals to set start/stop control commands and analog speed references,
- or select channel 2 to use PLC communication to set speed references and start/stop commands.

Set A9-00 to enable the control channel you need. The parameters in groups b0, b1, C0, and C1 are enabled when channel 1 is selected. The parameters in groups b2, b3, C2, and C3 are enabled when channel 2 is selected. Other parameters in groups b and C are always enabled.

A9-00	b0-00	b0-01 to b0-08	Group b1	b2-00	b2-01 to b2-08	Group b3	Group b4	U5-44	U5-60
0	0	-	Enabled	-	-	-	Enabled	-	-
	1	-	Enabled	-	-	-	-	Enabled	-
	2	-	Enabled	-	-	-	-	-	Enabled
	3	Enabled	Enabled	-	-	-	-	-	-
1	-	-	-	0	-	Enabled	Enabled	-	-
	-	-	-	1	-	Enabled	-	Enabled	-
	-	-	-	2	-	Enabled	-	-	Enabled
	-	-	-	3	Enabled	Enabled	-	-	-

4.6.4 Control Channel Switchover

The switchover between local control and remote control is allowed only in the stop state.

The switchover between the two remote control channels is allowed in any state. After switchover, if the OFF1 command is 0, the device stops. If the OFF1 command is 1, the device remains in the status before the switchover. The following table lists the drive unit statuses after the control channel switchover.

Status Before Switchover	OFF1 Before Switchover	OFF1 After Switchover	Status After Switchover
Switch-on inhibited	1	0	Ready to switch on
Switch-on inhibited	1	1	Switch-on inhibited
Ready to switch on	0	0	Ready to switch on
Ready to switch on	0	1	Switch-on inhibited
Operation	1	0	Ready to switch on
Operation	1	1	Operation

Note

- If the state machine is ready-to-switch-on (OFF1 = 0) before control channel switchover and OFF1 is 1 after the switchover, the state machine becomes switch-on-inhibited. In this case, the state machine can return to the ready-to-switch-on state only after OFF1 is reset to 0.
- When the same DI signal is configured for A9-00 command channel selection and start/stop control commands, the DI signal is active and the state machine enters the switch-on-inhibited state (S4).
- The control channel switchover helps to implement the control permission switchover of two different control GNDs. For example, after the operation box channel DI on the field is started, devices can be switched to centralized control on the PLC, or the devices in centralized control on the PLC can be switched to the operation box on the field for manual operation.
- In the switch-on-inhibited state, the OFF1 start command is not accepted. The machine can be started only in the ready-to-switch-on state. For details about each status of the state machine, see *"5.1.11 State Machine" on page 170*.

4.7 Drive Object Configuration Information

4.7.1 Device ID and Baud Rate

When SOP-20-880 or InoDriveStudio is connected to the HCU, set the station number and communication rate correctly. When multiple HCUs are cascaded in the same network, the station number and communication rate of each HCU must be set separately through SOP-20-880 or InoDriveStudio. Before cascading, ensure that the communication rates of all devices in the same network are the same but the station numbers are different.

- Method 1: Connect the SOP-20-880 to the HCU, and set the communication rate and station number by choosing "Menu > 01 Parameter Setting > A System > A10 SOP-20/Relay Communication > A10-03 SOP-20/Relay Communication Address" and "A10-04 SOP-20/Relay Communication Rate".
- Method 2: Directly change the baud rate and device ID of a device after it is detected when you are creating a project in InoDriveStudio, as shown in the following figure.

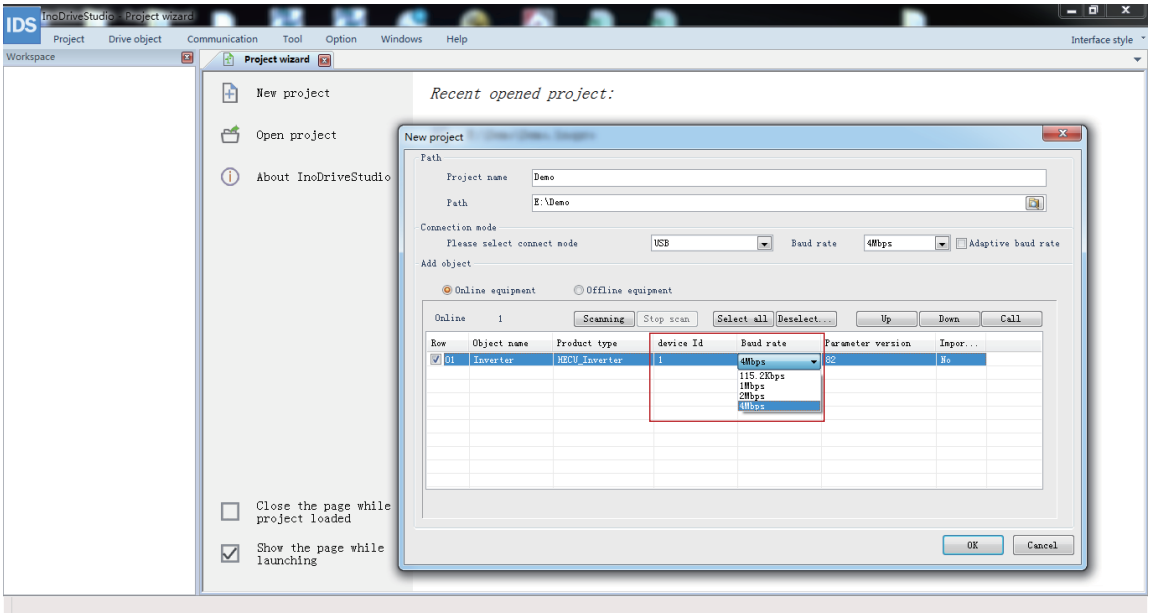


Figure 4-8 Changing the device ID and baud rate

Method 3: Connect InoDriveStudio to the device and then change the device ID (A10-03) and baud rate (A10-04) in the parameter list.

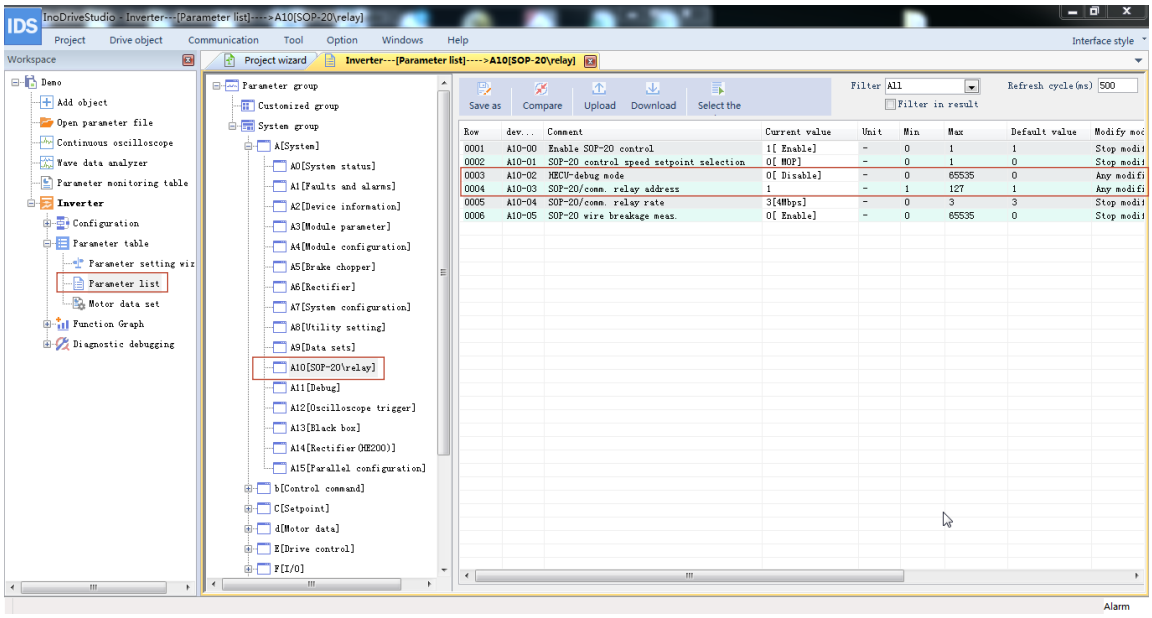


Figure 4-9 Changing the device ID and baud rate on the parameter list page

Method 4: On the drive object configuration page of InoDriveStudio, directly change the device ID and baud rate.

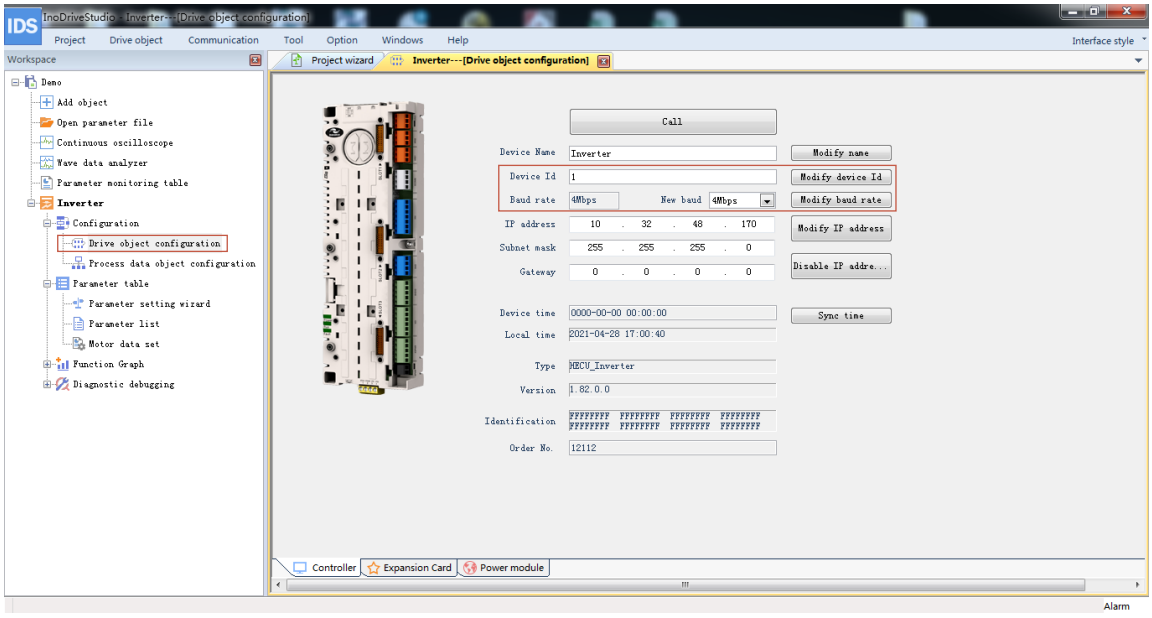


Figure 4-10 Changing the device ID and baud rate on the configuration page

4.7.2 Viewing System Date and Time Through Parameters

Access parameter group A2 to view the system date and time through parameters.

Parameter	Name
A2-44	Current year
A2-45	Current date
A2-46	Current time

4.7.3 System Time

The built-in RTC of HCU MCU supports recording of the system date and time. You can view and modify the system date and time through SOP-20-880 and InoDriveStudio.

4.7.3.1 Viewing and Changing System Date and Time Using SOP-20-880

- Method 1: Choose "Menu > 06 System settings > 04 Date/Time > 02 Device Time". On the page that appears, view and change the current system date and time.
- Method 2: Choose "Menu > 06 System settings > 04 Date/Time > 03 Sync Device Time". Then, synchronize the date/time of SOP-20-880 with that of HCU.

4.7.3.2 Viewing and Changing System Date and Time Using InoDriveStudio

In InoDriveStudio, choose "Configuration" > "Drive config" to view the HCU system time (object time) and PC time (local time). Click the "Sync time" button to synchronize the PC time to HCU.

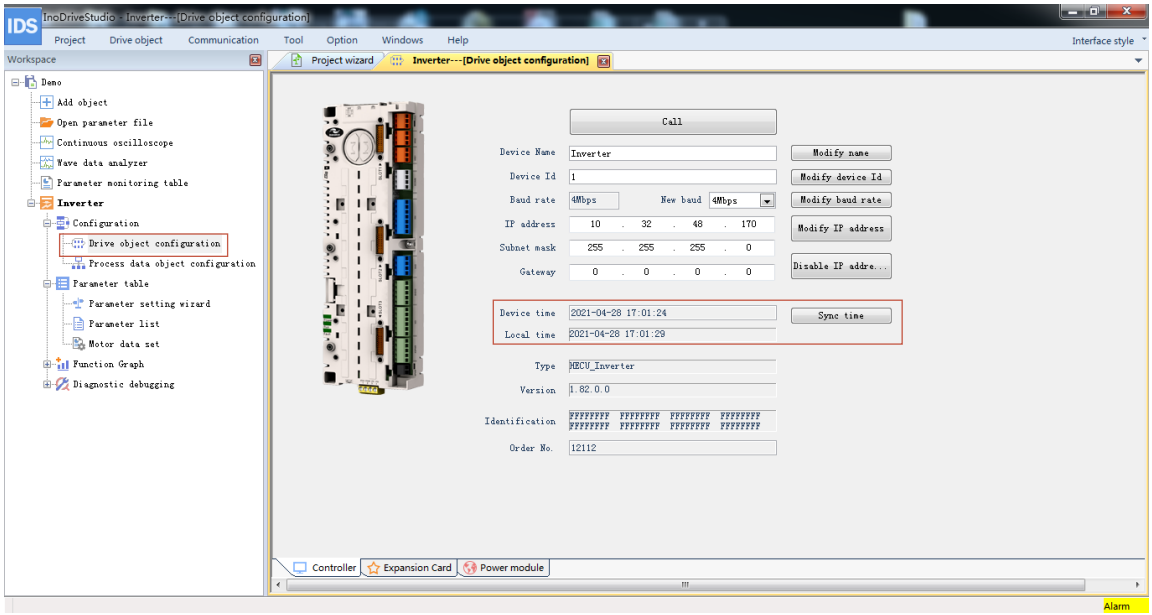


Figure 4-11 InoDriveStudio system time

4.7.3.3 Device Name

The HCU supports user-defined device names. A user-defined device name is retained at power failure. The device name is not reset when you restore partial parameters to factory settings (A8-00 set to 1), but is factory reset when you restore all parameters to factory settings (A8-00 set to 2). The HCU supports three methods of viewing and changing a device name.

Method 1: When creating a project on InoDriveStudio, after a device is scanned, change the device name, as shown in the following figure.

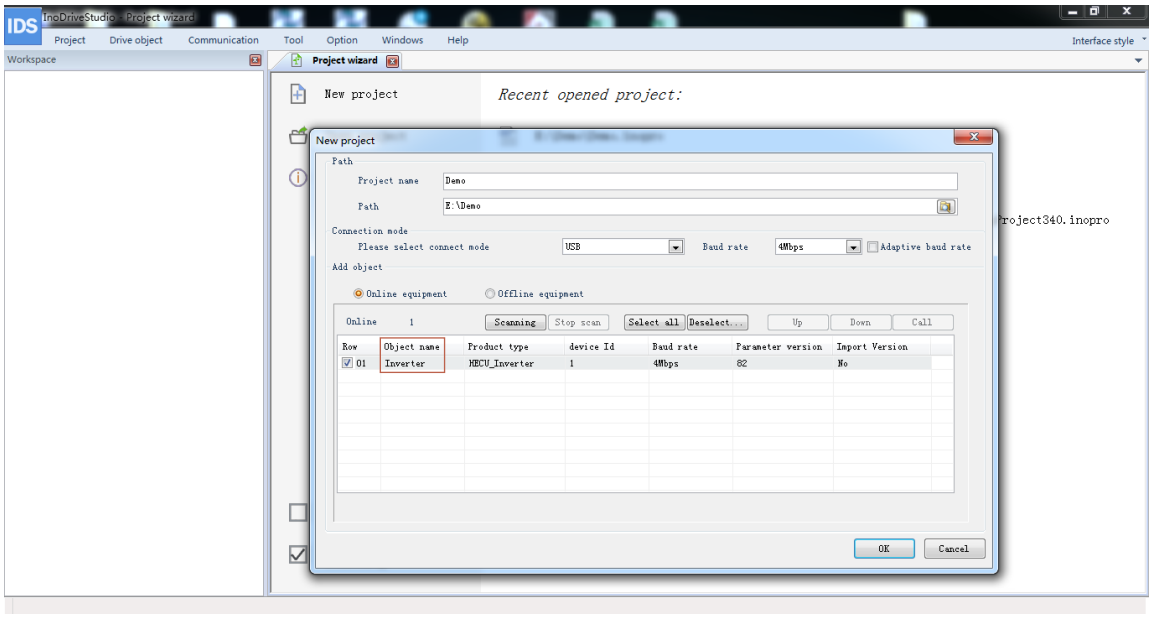


Figure 4-12 Directly changing the device name in InoDriveStudio

Method 2: In the work area of InoDriveStudio, right-click the device and choose "Rename" to change the device name.

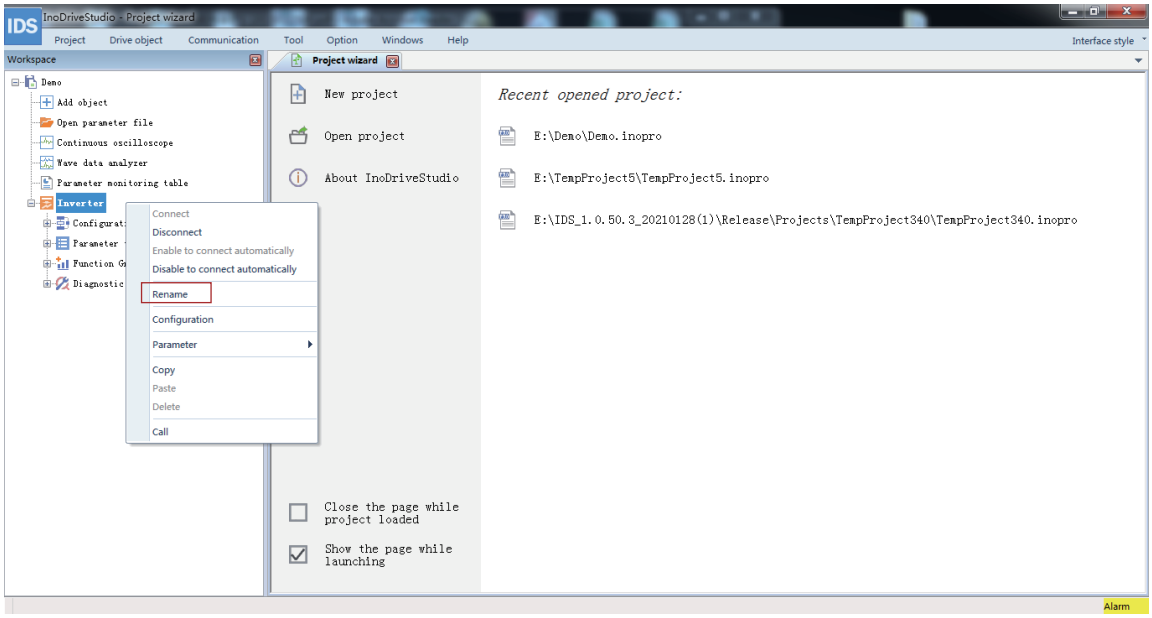


Figure 4-13 Changing the device name by right-clicking the device

Method 3: In InoDriveStudio, choose "Config > Drive config". On the "Inverter–[Motor data set]" tab page, change the device name, as shown in the following figure.

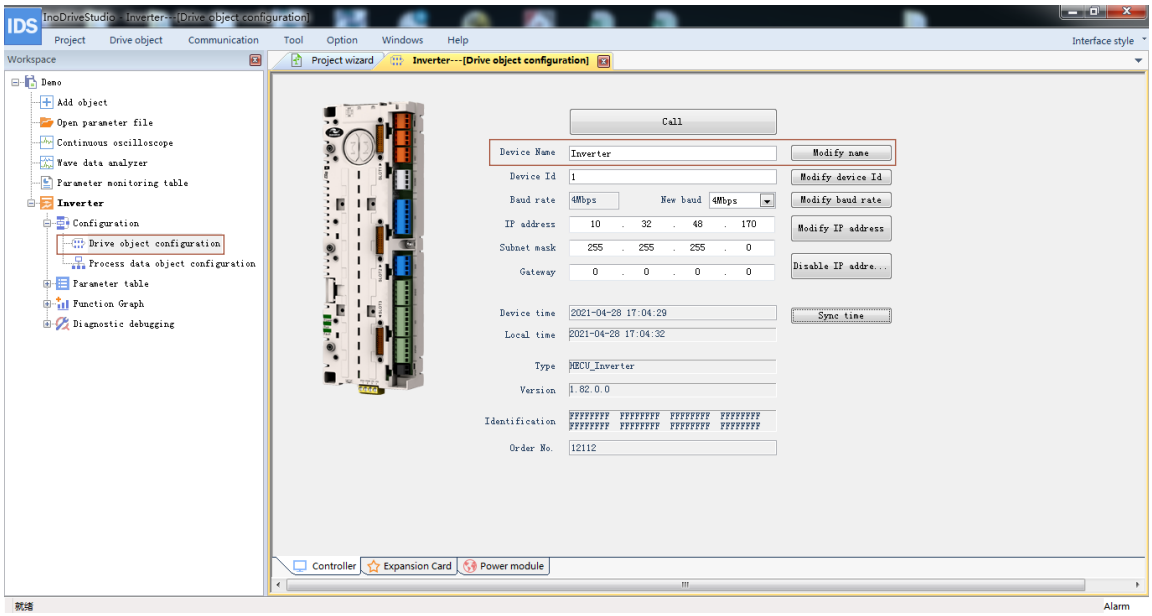


Figure 4-14 Changing the device name in InoDriveStudio

Note

When multiple devices are cascaded in one monitoring network by InoDriveStudio, ensure that each device name is unique.

4.8 Parameter Backup and Recovery

4.8.1 Default Data Reset

Parameters in group A8 (environment setting) are used to restore parameters to factory defaults as needed. For this purpose, select an operation through A8-00 and set A8-01 to confirm the selection.

4.8.1.1 All Parameters

Procedure:

1. Set A8-00 to 2 (restore all parameters to factory defaults).
2. Set A8-01 to 1 to confirm the operation specified in A8-00.

All parameters (including parameters of group d) are restored to factory defaults (parameters such as motor power and current are restored to the values corresponding to the model).

Note

Parameters related to the power module model will be restored to the default value instead of the factory value, such as carrier frequency reference A4-02. The record parameters of H1 to H8 parameter groups will not be restored.

4.8.1.2 Some Parameters (Motor Parameters Not Restored)

Procedure:

1. Set A8-00 to 1 (restore specified parameters to factory defaults). In this case, motor parameters in group d will remain unchanged.
2. Set A8-01 to 1 to confirm the operation specified in A8-00.

Parameters are restored to factory defaults, excluding parameters in group d.

Note

Parameters related to the power module model will be restored to the default value instead of the factory value, such as carrier frequency reference A4-02. The record parameters of H1 to H8 parameter groups will not be restored. The device name is not recoverable.

4.8.1.3 Record Parameters

Procedure:

1. Set A8-00 to 3 (clear fault records).
2. Set A8-01 to 1 to confirm the operation specified in A8-00.

Parameters in groups H1 to H8 are cleared, and other parameters are not affected.

4.8.1.4 Clearing Parameters in the SD Card of HCU-50S and HCU-51S

Procedure:

1. Set A8-00 to 4 (Clear black box records).
2. Set A8-01 to 1 to confirm the operation specified in A8-00.

The parameter file backed up on the SD card of HCU is deleted, and all parameters are not affected.

4.8.1.5 Clearing Time Statistics Information

Procedure:

1. Set A8-17 to select the time record information to be cleared.
2. Set A8-18 to 1 to confirm the operation specified in A8-17.

The selected time record information will be cleared.

4.8.2 Parameter Backup With SD Card of HCU-50S/HCU-51S

4.8.2.1 Backing up Parameters with SD Card of HCU-50S and HCU-51S

In the A8 group (environment setting) parameters, select the operation to be performed through A8-05 and set A8-06 to confirm the operation. Then the values of all parameters can be saved to the SD card or parameters saved in the SD card can be restored to the HCU.

4.8.2.2 Saving Parameters to the SD Card

Procedure:

1. Set A8-05 to 1 to back up all parameters of the HCU to the SD card.
2. Set A8-06 to 1 to confirm the operation specified in A8-05.
3. Parameters of HCU can be saved in the SD card, which is convenient for spare parts replacement. Only one backup parameter file is allowed. The backup record will be overwritten by the next backup.
4. If backup is successful, A8-07 will display status 2 "Parameter saved".

4.8.2.3 Restoring Parameters from SD Card to HCU-50S and HCU-51S

Procedure:

1. Set A8-05 to 2 to restore all HCU parameters from the backup file in the SD card.
2. Set A8-06 to 1 to confirm the operation specified in A8-05.
3. Use the parameters backed up in the SD card to overwrite the current parameters of the HCU. When using a new HCU, you can use this function to quickly restore the parameters from the SD card of the old HCU.
4. If the recovery is successful, you will see status 5 "Parameter recovery completed" in A8-07; otherwise, there may be no backup file in the SD card, or the SD card is currently being used by other processes.

4.8.2.4 Checking the Parameter File

Procedure:

1. Set A8-05 to 3 to select parameter verification.
2. Set A8-06 to 1 to confirm the operation specified in A8-05.

The program will check the parameters backed up in the SD card against the current parameters in the HCU. If the parameters are consistent, status 9 "Parameters are consistent" is displayed in A8-07. Otherwise, status 10 "Parameters are inconsistent" is displayed, indicating that the backup parameters in the SD card are different from those in the HCU.

4.8.2.5 Deleting Record Files on the SD Card of HCU-50S and HCU-51S

Procedure:

1. Set A8-00 to 4 (Clear black box records).
2. Set A8-01 to 1 to confirm the operation specified in A8-00.

The parameter file backed up on the SD card is deleted, without affecting any parameters.

4.8.3 Parameter Backup Through SOP-20-880

On the SOP-20-880 panel, select the desired device and log in to the system. Then, choose "07 System operations" > "01 Parameter copy" to back up or restore parameters.

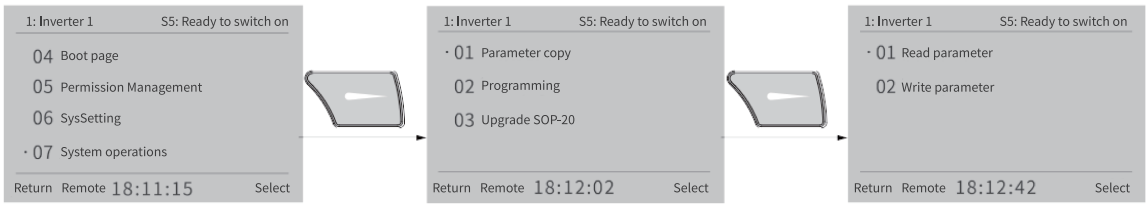


Figure 4-15 Entering the "Parameter copy" screen after login to the system

4.8.3.1 Saving Parameters to an SOP-20-880 File

To read all parameters of the device and save the parameters to a file in the SD card of SOP-20-880, select "Read parameters".

Then, set the user-defined part (five characters) of the parameter file name. Specifically, press the left or right arrow key to select a character, and press the up or down arrow key to set a value for the character. The value range is 0 to 9 and A to Z. The file name must follow the format of "Device name-Five-character user-defined name.ipv".

Example: Inverter 1-12ABC.ipv

Meaning: The device is inverter 1 and the user-defined name is 12ABC.

After setting the file name, press  to read parameters. After the parameters are read successfully, the screen prompts "Operation successful". If the operation fails, the screen prompts the cause of failure.

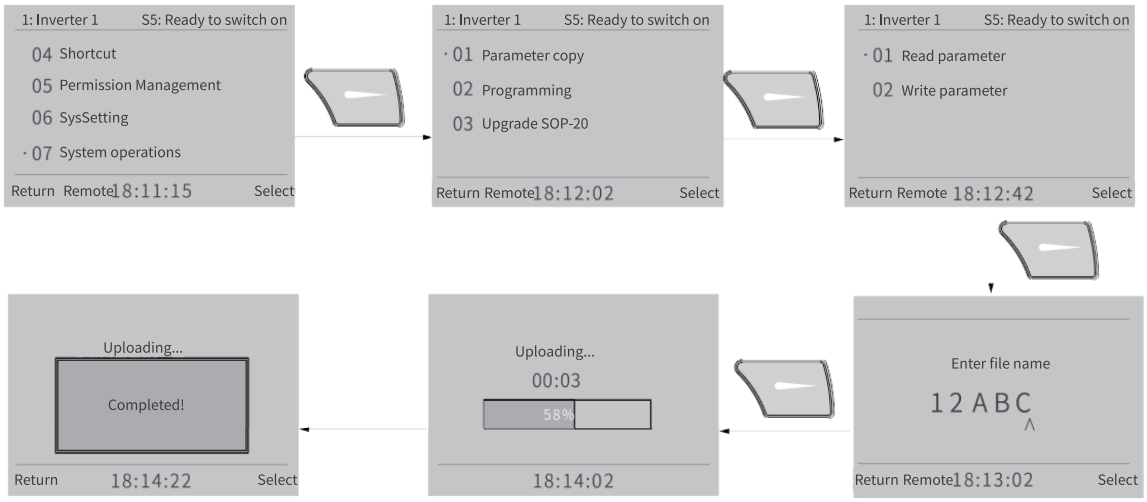


Figure 4-16 Example of reading parameters

4.8.3.2 Restoring Parameters from an SOP-20-880 File

To download parameters saved in an SOP-20-880 file to the HCU, select "Write parameter". Then, select a parameter file in the SD card, and select "Copy all" to restore all parameters in the HCU to those in the file.

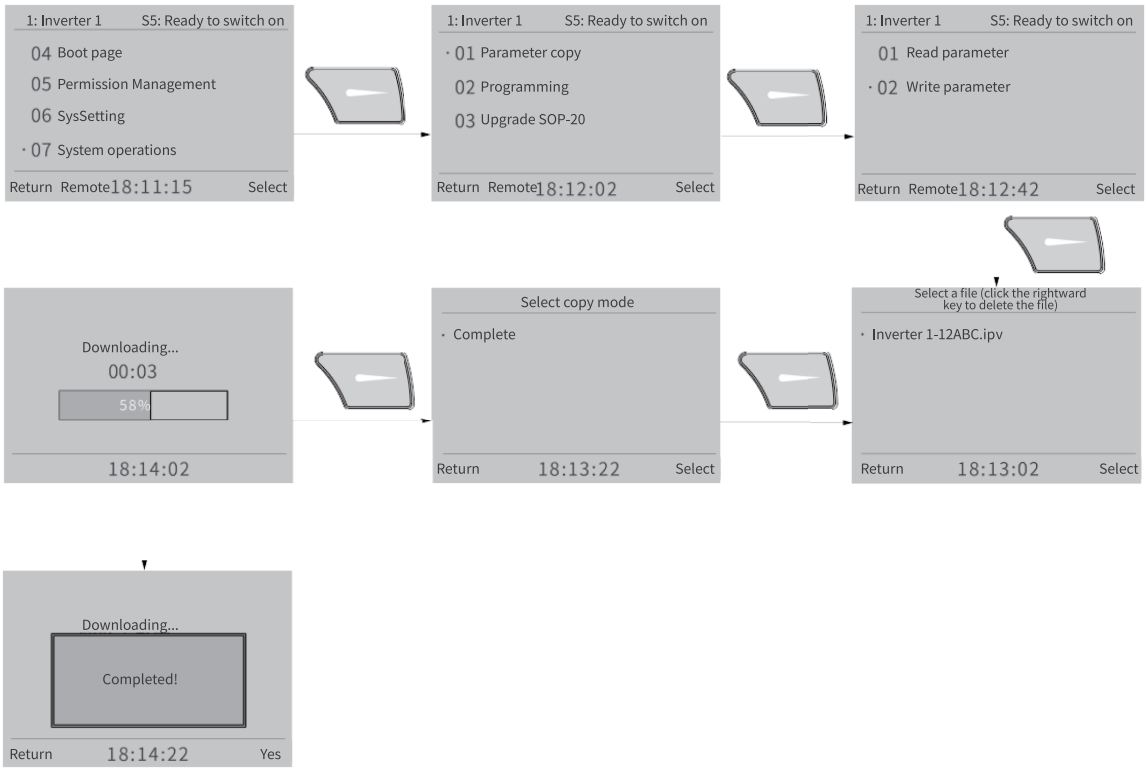


Figure 4-17 Example of writing parameters

Note

Files saved and read through the parameter copy function are stored in the SD card of SOP-20-880. Before using the parameter copy function, ensure that the SD card of SOP-20-880 is properly installed.

4.8.3.3 Backing up Parameters with InoDriveStudio

You can use InoDriveStudio to back up the parameters to your PC through the "Upload" function, or you can restore the backup parameters from your PC to the HCU through the "Download" function.

4.9 Parameter Lock

After field commissioning is completed, to protect parameters from accidental modification when they are viewed or to prevent unauthorized tampering with the AC drive parameters, set A8-30 to enable the parameter lock function. When this function is enabled, parameters can be viewed but cannot be modified. After the parameter locking password is set, only users who have the password can edit A8-30, preventing unauthorized tampering with the AC drive parameters.

4.9.1 Setting Parameter Locking Password

By default, no parameter locking password is set for the HCU controller, and all users can edit A8-30. After a parameter locking password is set, only users who have the password can edit A8-30.

When no parameter locking password is set, the password setting procedure is as follows:

1. Set A8-25 to 3, and A8-28 will display "20 Waiting for password input". The waiting time is 60 seconds. If no operation is performed within the 60 seconds, A8-28 will display "22 Password input timeout". In this case, you need to set A8-25 to 3 again if you still want to set a password.
2. Enter a password in A8-26, and A8-28 will display "21 Waiting for password input again".
3. Enter the password again in A8-27, which must be the same as that entered in A8-26. Otherwise, the password setting will fail. If the password setting fails, you need to try again from step 1.
4. Wait for A8-28 to display "28 Password set successfully", which indicates that the parameter locking password is set.

Table 4–2 Parameter locking password parameters

Parameter	Name	Reference
A8-25	Parameter locking password operation	0: No operation 1: Check password 2: Cancel password 3: Set password
A8-26	Entering parameter locking password	0 to 65535
A8-27	Re-entering password	0 to 65535
A8-28	Parameter locking password status	0: Password not set 1: Password set 20: Waiting for password input 21: Waiting for password input again 22: Password input timeout 23: Password check failed 24: Password check succeeded 25: Password cancellation failed 26: Password canceled successfully 27: Password setting failed 28: Password set successfully
A8-29	Parameter locking function status	0: A8-30 cannot be set by user 1: A8-30 can be set by user
A8-30	Enable parameter locking function	0: Disabled 1: Enabled

4.9.2 Modifying Parameter Locking Password

To change the set password, cancel the password first and then set a new one. Follow the steps below to cancel the password setting.

1. Set A8-25 to 2, and A8-28 will display "20 Waiting for password input". The waiting time is 60 seconds. If no operation is performed within the 60 seconds, A8-28 will display "22 Password input timeout". In this case, you need to set A8-25 to 2 again if you still want to set a password.
2. Enter the password in A8-26.
3. Wait for A8-28 to display "25 Password canceled", which indicates that the parameter locking password setting is completed.

4. Wait for 1s, and then set the parameter locking password as described in *"4.9.1 Setting Parameter Locking Password" on page 139*.

4.9.3 Enabling Parameter Writing by SDO

By default, parameters can be written by the SDO of adapter A and adapter B after the parameter locking function is enabled. For example, parameters are written through Modbus communication or PROFIBUS-DP communication. You can set parameter A8-31 to prevent the host controller from changing the AC drive parameters through the SDO. The following table describes parameter A8-31.

Parameter	Name	Reference
A8-31	Parameter setting after parameter locking	Bit 00: Device name 0: Can be set 1: Cannot be set Bit 01: Parameter written by adapter A SDO 0: Can be set 1: Cannot be set Bit 02: Parameter written by adapter B SDO 0: Can be set 1: Cannot be set Bit 03 to bit 15: Reserved

4.9.4 Specifying Unlocked Parameters

After the parameter locking function is enabled, you can specify some parameters as modifiable through A8-32 to A8-41. A total of 10 parameters can be specified. Fill in the communication address of the specified parameters in A8-32 to A8-41. For details of the communication address, see the section "Function Parameter Table". The following table describes parameters A8-32 to A8-41.

Table 4–3 Parameters used to specify unlocked parameters

Parameter	Name	Reference
A8-32	Specified unlocked parameter address 1	0 to 65535
A8-33	Specified unlocked parameter address 2	0 to 65535
A8-34	Specified unlocked parameter address 3	0 to 65535
A8-35	Specified unlocked parameter address 4	0 to 65535
A8-36	Specified unlocked parameter address 5	0 to 65535
A8-37	Specified unlocked parameter address 6	0 to 65535
A8-38	Specified unlocked parameter address 7	0 to 65535
A8-39	Specified unlocked parameter address 8	0 to 65535

Parameter	Name	Reference
A8-40	Specified unlocked parameter address 9	0 to 65535
A8-41	Specified unlocked parameter address 10	0 to 65535

5 Drive Configuration

5.1 Setting the Start/Stop Mode

5.1.1 Startup and Operation

HCU-50S/51S involves two commands related to motor start/stop control. The commands can be set by using start/stop control words.

5.1.1.1 OFF1 Command

When OFF1 is set to 0, the OFF2 and OFF3 commands are inactive, and no fault occurs, the system enters the ready-to-switch-on state (S5). In this case, if the OFF1 value is changed from 0 to 1, the start command is delivered, and the system enters the pre-charge state (S6). When the DC bus voltage is detected to be normal, the system enters the ready-to-run state (S7) and waits for the running permission command. After the running permission command is active, the system enters detection before operation (S9). If detection before operation is not selected in group E8, the S9 state is skipped. According to different start modes indicated by E1-00, the system enters pre-excitation (S10), flying start (S11), or DC injection braking (S15), and then enters the running state (S12).

If OFF1 is set to 0, the stop command is delivered. Then, the system exits the running state (S12) and enters OFF1 stopped state (S13). When the motor zero-speed conditions are met, the system enters the ready-to-switch-on state (S5).

5.1.1.2 Operation Permission Command

The operation permission command is used to trigger IGBT only, which is judged after execution of OFF1 switch-on command. If operation permission is inactive, IGBT cannot be triggered and stay in the ready-to-run state (S7) even upon the OFF1 switch-on command. In this case, wait until the operation permission signal is active before triggering IGBT.

Keep the operation permission command at a high level to perform start/stop operations through OFF1 command directly.

Both the OFF1 and operation permission commands are start/stop control words, which are affected by the switchover of command channels defined by A9-00. For details, see *“4.6.1 Definitions of Local Control and Remote Control” on page 125*.

Table 5–1 Start and operation permission command sources

Command Channel	Command Word Source	OFF1 Command Source	Running Permission Command Source
[A9-00] = 0	[b0-00] = 0	Terminal start/stop module	Always active
	[b0-00] = 1	bit0 (U2-00) of U5-44	bit3 (U2-03) of U5-44
	[b0-00] = 2	bit0 (U2-16) of U5-60	bit3 (U2-19) of U5-60
	[b0-00] = 3	b0-01	b0-04
	SOP control	SOP-20-880 local control	Always active
	IDS control	InoDriveStudio control panel	InoDriveStudio control panel
[A9-00] = 1	[b2-00] = 0	Terminal start/stop module	Always active
	[b2-00] = 1	bit0 (U2-00) of U5-44	bit3 (U2-03) of U5-44
	[b2-00] = 2	bit0 (U2-16) of U5-60	bit3 (U2-19) of U5-60
	[b2-00] = 3	b2-01	b2-04
	SOP control	SOP-20-880 local control	Always active
	IDS control	InoDriveStudio control panel	InoDriveStudio control panel

5.1.2 Emergency Stop Command

HCU-50S/51S has two emergency stop modes:

- OFF2 emergency stop: The IGBT output is inhibited unconditionally once the command is received.
- OFF3 quick stop: After the command is received, the device decelerates to 0 according to OFF3 stop time configured in E1-16/E1-15, and then IGBT output is inhibited.

The emergency stop command is enabled at low level. When the corresponding parameter is set to 0, emergency stop is executed. For more information about OFF3 stop, see *"5.1.6.1 Stop Modes for Different Stop Commands" on page 152*.

The OFF2 and OFF3 commands have multiple sources. The current active parameters vary with the settings of control channels. Taking OFF2 as an example, the following table lists the active parameters of the OFF2 command. OFF3 is activated in the similar way.

Table 5–2 OFF2 command sources

Command Channel	Command Word Source	OFF2 Command Source									
		b0-02	b1-00	b1-01	b2-02	b3-00	b3-01	U2-01	U2-17	SOP	IDS
[A9-00] = 0	[b0-00] = 0	X	Enabled	Enabled	X	X	X	X	X	X	X
	[b0-00] = 1	X	Enabled	Enabled	X	X	X	Enabled	X	X	X
	[b0-00] = 2	X	Enabled	Enabled	X	X	X	X	Enabled	X	X
	[b0-00] = 3	Enabled	Enabled	Enabled	X	X	X	X	X	X	X
	SOP control	X	Enabled	Enabled	X	X	X	X	X	X	X
	IDS control	X	Enabled	Enabled	X	X	X	X	X	X	Enabled
[A9-00] = 1	[b2-00] = 0	X	X	X	X	Enabled	Enabled	X	X	X	X
	[b2-00] = 1	X	X	X	X	Enabled	Enabled	Enabled	X	X	X
	[b2-00] = 2	X	X	X	X	Enabled	Enabled	X	Enabled	X	X
	[b2-00] = 3	X	X	X	Enabled	Enabled	Enabled	X	X	X	X
	SOP control	X	X	X	X	Enabled	Enabled	X	X	X	X
	IDS control	X	X	X	X	Enabled	Enabled	X	X	X	Enabled

Note

- "X" in the table indicates that the corresponding command source is disabled.
- U2-01 and U2-17 are activated together with parameters b1-00/b1-01/b3-00/b3-01 after being configured. This table only indicates whether they are active by default when they are not selected by these four parameters.
- When b0-00/b2-00 is set to 3, U2-01 and U2-17 are activated with parameters b0-02/b2-02 after being configured. This table only indicates whether they are active by default when they are not selected by these two parameters.

5.1.3 Control Mode

There are three motor control modes: V/f, sensorless vector control (SVC), and feedback vector control (FVC). Control modes can be set through E0 group parameters.

- In V/f control mode, the drive runs in open-loop control, without the need for speed feedback. With low dependence on motor parameters and high robustness, this mode is typically suitable for occasions with low dynamic requirements.
- SVC control and FVC control differ from each other. The feedback speed of FVC is measured by the encoder, while the feedback speed of SVC is calculated based on back EMF and output current. In the SVC mode, the motor speed cannot be accurately calculated during low-speed operation, so the control accuracy is lower than that of FVC.

The control modes and parameter settings of the motor are as follows:

Control mode setting source [E0-06]	Control mode [E0-00]	Control mode source 1 [E0-07]	Control mode source 2 [E0-08]	Current setting control mode [U8-38]
0	0	-	-	SVC
	1	-	-	FVC
	2	-	-	V/f
1	-	0	0	SVC
	-		1	FVC
	-	1	-	V/f

5.1.4 Start Mode

The MD880 series drive can be started in three modes: direct start, flying start, and start with DC braking. Set E1-00 to select a startup mode of the drive.

Param.	Name	Default	Value range	Description
E1-00	Startup mode	0	0: Direct start 1: Flying start 2: Start with DC braking	Defines the startup mode of the drive. Value description: 0: Direct start - The drive starts directly. 1: Flying start - Flying start applies when the motor operating at a high speed needs to be started again in non-FVC control modes. 2: Start with DC braking - In this mode, DC braking is applied on the motor before operation to make sure that the motor is at zero speed. Note: When the asynchronous motor is in SVC or FVC mode, the motor needs to enter the pre-excitation state before starting, so as to establish a rotor magnetic field to better control the output torque.

5.1.4.1 Flying Start

Application scenario

Set E1-00 [Start mode] to 1 [Flying start].

If a rotating motor is being started directly, overcurrent or overload may occur due to the inrush current at startup. In this case, you can set E1-00 to 1 to apply flying start, where the drive detects the motor speed and direct first and then start at the motor frequency tracked.

When E1-00 is not set to 1, you can also set b1-09/b3-09 [Forced speed tracking source] to "Active" to enable flying start once.

The speed tracking function applies to applications where a encoder-less motor needs to be started during rotation in V/f or SVC mode. If you do not use the flying start function in this case, overcurrent or overload may easily occur.

Operating principles

In this mode, the drive can automatically track the motor speed and direction and perform bumpless start of a rotating motor. As shown in the following figure, after startup, the drive tracks the motor synchronous frequency first before entering the normal operation mode.

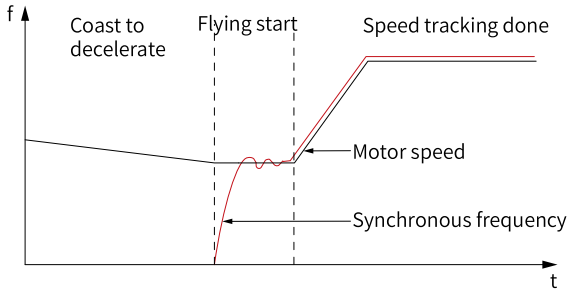


Figure 5-1 Flying start diagram

Note

When E7-20 is set to [Speed tracking in mode 0], it is recommended to connect the drive to the motor to perform parameter auto-tuning.

Related parameters

Param.	Name	Default	Value range	Description
E7-20	Speed tracking mode of the asynchronous motor	0	0: Mode 0 1: Mode 1	Defines the speed tracking mode of the asynchronous motor. Mode 0: Speed tracking is applicable to startup in the V/f or SVC mode. Mode 1: Speed tracking is only applicable to V/f control, especially where the drive output is equipped with LC filter and transformer.

Precautions

- When E7-20 [Speed tracking mode of the asynchronous motor] is set to 1 [Mode 1], the duration of speed tracking may be long. However, mode 1 does not require accurate motor parameters. It is recommended to perform parameter auto-tuning for better performance.
- For speed tracking of synchronous motors, set E1-00 to 1 [Flying start].
- Do not enable self-test upon power-on or before operation when flying start is enabled. If self-test is started during rotation of the motor, related faults may be reported if back EMF exists in the motor.

Application instance

- After the fan stops, the air inside the air duct can blow the fan blades, causing the motor to rotate.
- After the water pump stops, the water still flows, which can hit the impeller vane, causing the motor to rotate.
- The shutdown time of large equipment lasts for dozens of minutes, so coast-to-stop is usually used for timely stop. In this case, the motor may be still rotating upon next startup.

You need to enable flying start for a rotating motor. Set E1-00 [Start mode] to 1 [Flying start] and click Start. Then the drive observes current motor speed and starts the motor at the current motor speed.

The flying start mode is usually applied to fields including fans, water pumps, air conditioners, and air compressors. In addition, flying start also applies to quick restart of high-power or high-inertia motors with a long coast-to-stop time after fault reset. In this case set H0-27 to 1.

5.1.4.2 Direct Start of Asynchronous Motor (Pre-excitation Start)

Application scenario

E1-00 [Startup mode] = 0 [Direct start].

After receiving the start command, when the asynchronous motor is in SVC or FVC control, the motor needs to enter the pre-excitation state before being started. This is to establish the rotor magnetic field before acceleration. In V/f control, pre-excitation is not perform for asynchronous motors and acceleration is started directly. This startup mode is applicable to most of load applications.

Operating principles

Pre-excitation is not performed for asynchronous motors in V/f control. Set E1-00 [Start mode] to 0 [Direct start]. After receiving the start command, the motor speed reference is defined by RFG output.

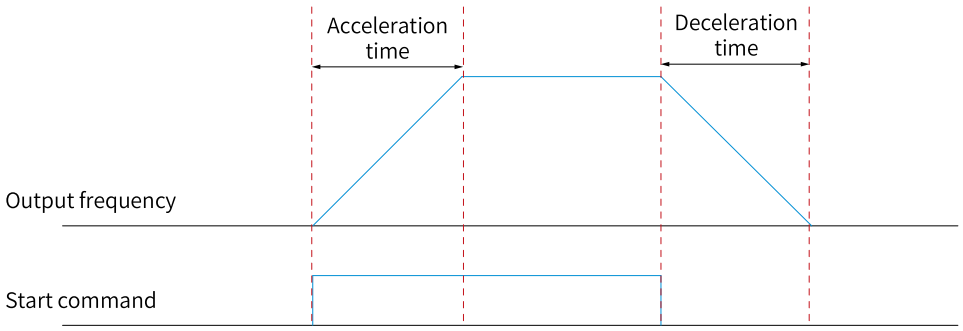


Figure 5-2 Direct start of the asynchronous motor in V/f mode

When the asynchronous motor operates in SVC or FVC mode, set E1-00 [Start mode] to 0 [Direct start], and set pre-excitation parameters. The motor needs to enter the pre-excitation state before being started, so that a rotor magnetic field can be established for better control of motor output torque. You can set the pre-excitation function through E1-01 (Pre-excitation mode) to E1-04 (Digital reference of pre-excitation current). The pre-excitation time (E1-02) is automatically updated after parameter auto-tuning.

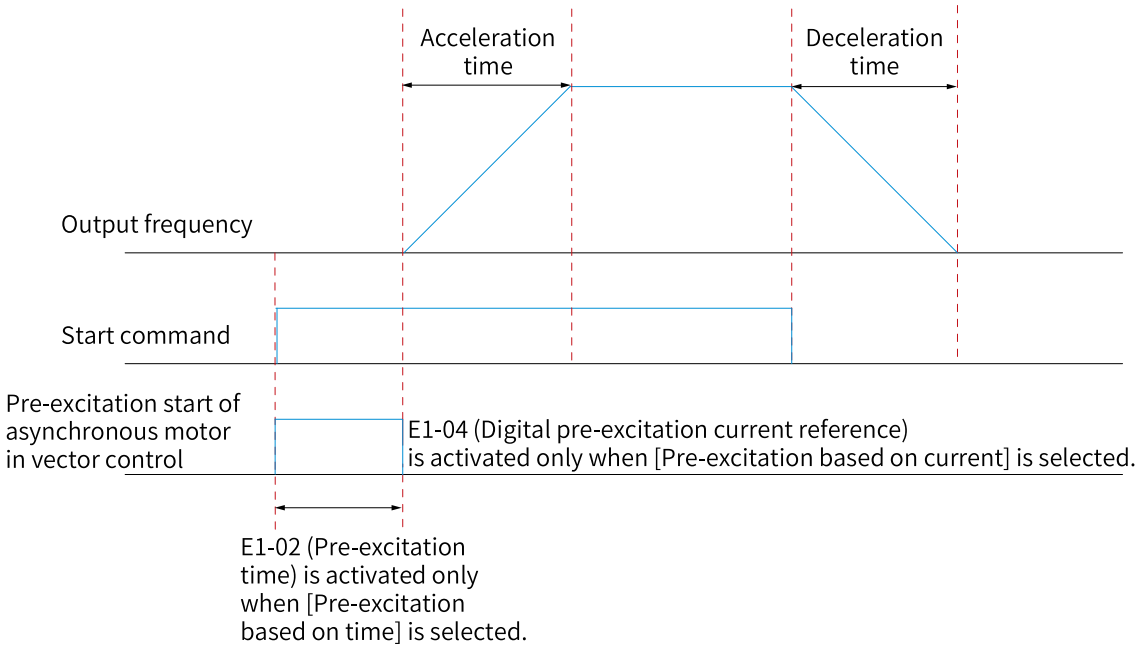


Figure 5-3 Pre-excitation of asynchronous motor

When multiple asynchronous motors need to be started at the same time, you can set the same pre-excitation time for motors by using the time-based pre-excitation function. For details, see the application instances.

Related parameters

Param.	Name	Default	Value range	Description
E1-01	Pre-excitation mode	0	0: Time-based pre-excitation 1: Current-based pre-excitation	Defines the pre-excitation mode of the asynchronous motor. Value description: 0: Time-based pre-excitation - The pre-excitation time is defined by E1-03. The excitation current is calculated dynamically based on the excitation time. After the excitation time is reached, pre-excitation is done. 1: Current-based pre-excitation - The excitation current is defined by E1-04 and E1-05. Pre-excitation is done when the motor magnetic field established exceeds the value of E6-03 [Minimum flux threshold upon start].
E1-02	Pre-excitation time	0.10	0.00s to 20.00s	Defines the pre-excitation time before the asynchronous motor starts. Note: Note that an excessively short time may result in insufficient motor flux.

Param.	Name	Default	Value range	Description
E1-03	Pre-excitation current reference source	0	0: Automatic 1: Digital reference	Defines the pre-excitation current reference source. Value description: 0: Automatic - The excitation time is shortened based on the maximum current output capacity. 1: Digital reference - The excitation current is defined by E1-04.
E1-04	Digital reference of pre-excitation current	100.0%	20.0% to 400.0%	Defines the excitation current of the asynchronous motor during pre-excitation.

Precautions

- Pre-excitation start is applicable only to the asynchronous motors in SVC and FVC modes.
- The excitation time is defined by E1-02 [Pre-excitation time] only when E1-01 [Pre-excitation mode] is set to 0 [Time-based pre-excitation]. The excitation current is calculated dynamically based on the excitation time. After the excitation time is reached, pre-excitation is done.
- The excitation current is defined by E1-04 [Digital reference of pre-excitation] only when E1-01 [Pre-excitation mode] is set to 1 [Current-based pre-excitation] and E1-03 [Pre-excitation current reference source] is set to 1 [Digital reference]. The excitation time changes dynamically.
- When pre-excitation start is enabled, the motor speed does not drop upon start. To achieve the same pre-excitation effect for asynchronous motors in V/f mode, apply DC braking start and set the DC braking startup time.

Application instance

Time-based pre-excitation start: For applications with multiple asynchronous motors and these motors are expected to be started simultaneously, set E1-01 to 0 [Time-based pre-excitation] and set same pre-excitation time in E1-02 to allow these motors to be started after pre-excitation is done. Ensure that the pre-excitation time for each motor is the same. Failure to comply can result in inconsistency in startup.

5.1.4.3 Direct Start of Synchronous Motor (Magnetic Pole Position Auto-tuning)

Application scenario

E1-00 [Startup mode] = 0 [Direct start].

The synchronous motor needs to get the rotor polarity before direct start for driving the motor in the correct direction, preventing overcurrent/overload or stuck upon startup.

Operating principles

Direct start of a synchronous motor in SVC mode involves magnetic pole position auto-tuning to obtain the rotor position of the synchronous motor, so that the motor can start running in the correct direction. Auto-tuning helps prevent startup issues such as reverse startup, oscillation, or step loss caused by excessive deviation between the initial pulsing phase angle and the actual position of the motor rotor.

In FVC control of a synchronous motor, if an incremental encoder is used, perform magnetic pole position auto-tuning upon initial power-on or initial startup upon fault. If an absolute encoder is used, magnetic pole position auto-tuning is not needed. The incremental encoders supported by MD880 are ABZ encoders and sine-cosine encoders. Absolute encoders supported are resolvers, 23-bit encoders, SSI encoders, ENDAT encoders, and sine-cosine+ENDAT encoders.

Synchronous motors can be divided into salient pole motors and surface-mounted motors. For a salient pole synchronous motor, the magnetic pole position auto-tuning takes about 250 ms. For a surface-mounted synchronous motor, the magnetic pole position auto-tuning takes about 50 ms. The drive switches the magnetic pole position auto-tuning mode based on the motor type detected.

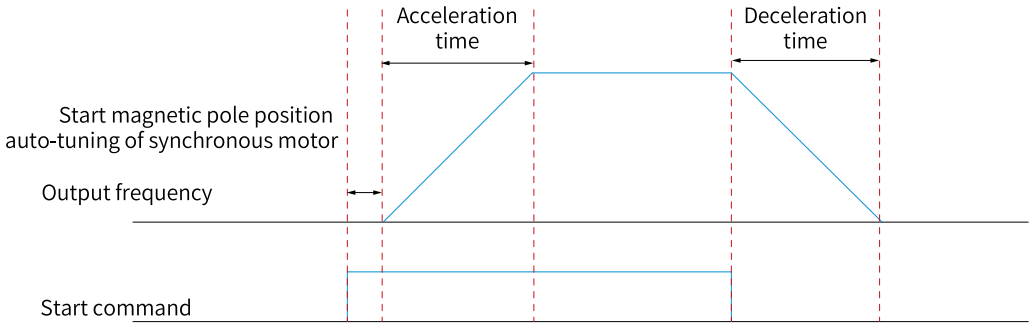


Figure 5-4 Pole position auto-tuning

Related parameters

Param.	Name	Default	Value range	Description
E11-39	Magnetic pole auto-tuning upon start of synchronous motor in SVC mode	2	0 to 2	Used to enable magnetic pole auto-tuning upon start of a synchronous motor in SVC mode.
E11-56	Magnetic pole auto-tuning mode for synchronous motor with incremental encoder in FVC mode	0	0 to 1	Defines the magnetic pole auto-tuning mode for a synchronous motor that equipped with an incremental encoder in FVC mode.

5.1.5 Zero Speed Judgment

Except for coast-to-stop, the other three stop modes require the motor speed to be reduced to zero before the IGBT output is blocked. The zero speed thresholds are divided into motor zero speed and zero speed reference.

Two parameters are involved in determining the motor zero speed. The zero speed condition is met only after the absolute value of the actual motor speed keeps lower than or equal to E1-11 for a period longer than the time defined by E1-12.

Note:

- If E1-12 is set to an excessively low value, the IGBT can be blocked before the motor speed reaches the zero speed threshold, which prolongs the time for a motor in the stop state to enter the standstill state. Increasing the value of E1-12 ensures that the IGBT is blocked after the motor is at a standstill.
- Setting E1-11 to an excessively low value may result in stop failure due to errors in the detected speed.
- Setting E1-11 to an excessively high value may make the motor enter the coast-to-stop state before it enters the standstill state.
- If brake control is enabled, even the zero speed condition is met, the IGBT can be blocked only after the brake is fully applied.

Therefore, set the zero speed threshold properly based on the actual operating requirements. Keep the value of E1-12 as high as possible to ensure the motor is at a standstill.

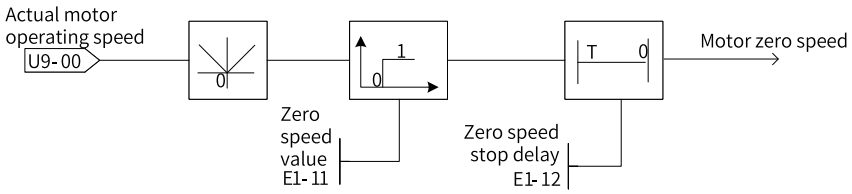


Figure 5-5 Condition for determining zero speed

5.1.6 Stop Mode

Stop commands are the command sources triggering stop, including OFF1, OFF2, OFF3, Running Permission, and faults. Stop modes specify the actions upon corresponding stop commands, including coast to stop, stop at maximum capability, OFF3 decelerate-to-stop, and OFF1 decelerate-to-stop.

For HCU-50S/51S, each stop command corresponds to at least one stop mode, which can be configured by parameter settings. Under the default parameter settings, the stop mode is usually consistent with the stop command, but there are exceptions. For example, the stop mode of V/f separation and torque control is coast to stop by default.

5.1.6.1 Stop Modes for Different Stop Commands

- The stop mode corresponding to the OFF1 stop command is as follows.

Control mode	E1-14 (Stop mode of OFF1)	E1-16 (Stop mode of OFF3)	E1-18 (Stop mode in torque control)	Stop mode
Speed control	0: Coast to stop	X	X	Coast to stop
	1: Decelerate to stop	X	X	Decelerate to stop for OFF1
	2: Stop at maximum capability	X	X	Stop at maximum capability
Torque control	0: Coast to stop	X	0: Stop mode of OFF1	Coast to stop
	1: Decelerate to stop	X		Decelerate to stop for OFF1
	2: Stop at maximum capability	X		Stop at maximum capability
	X	X	1: Stop mode of OFF2	Coast to stop
	X	0: Decelerate to stop	2: Stop mode of OFF3	Decelerate to stop for OFF3
	X	1: Stop at maximum capability		Stop at maximum capability
Decoupled V/f (E3-45 = 0)	X	X	X	Coast to stop
Decoupled V/f (E3-45 = 1)	0: Coast to stop	X	X	Coast to stop
	1: Decelerate to stop	X	X	Decelerate to stop for OFF1
	2: Stop at maximum capability	X	X	Stop at maximum capability

Note

In the torque control mode, the stop mode of the OFF1 stop command is related to E1-18.

- The stop mode corresponding to the OFF3 stop command is as follows.

Control Mode	E1-16 (Stop mode of OFF3)	Stop mode
Speed control	0: Decelerate to stop	Decelerate to stop for OFF3
	1: Stop at maximum capability	Stop at maximum capability
Torque control	0: Decelerate to stop	Decelerate to stop for OFF3
	1: Stop at maximum capability	Stop at maximum capability
Decoupled V/f (E3-45 = 0)	X	Coast to stop

Control Mode	E1-16 (Stop mode of OFF3)	Stop mode
Decoupled V/f (E3-45 = 1)	0: Decelerate to stop	Decelerate to stop for OFF3
	1: Stop at maximum capability	Stop at maximum capability

Note

When OFF3 is triggered in torque control, the drive switches to speed control and executes the decelerate-to-stop or stop-at-maximum-capability command for OFF3. In torque control mode, the stop mode for OFF3 is not related to E1-18.

- The stop mode corresponding to the operation permission command is as follows.

Control Mode	E1-14 (Stop mode of OFF1)	E1-16 (Stop mode of OFF3)	E1-17 (Stop mode for operation permission command)	Stop mode
Speed control	0: Coast to stop	X	X	Coast to stop
	1: Decelerate to stop	X	X	Decelerate to stop for OFF1
	2: Stop at maximum capability	X	X	Stop at maximum capability
	X	X	1: Stop mode of OFF2	Coast to stop
	X	0: Decelerate to stop	2: Stop mode of OFF3	Decelerate to stop for OFF3
	X	1: Stop at maximum capability		Stop at maximum capability
Torque control	0: Coast to stop	X	0: Stop mode of OFF1	Coast to stop
	1: Decelerate to stop	X		Decelerate to stop for OFF1
	2: Stop at maximum capability	X		Stop at maximum capability
	X	X	1: Stop mode of OFF2	Coast to stop
	X	0: Decelerate to stop	2: Stop mode of OFF3	Decelerate to stop for OFF3
	X	1: Stop at maximum capability		Stop at maximum capability
Decoupled V/f (E3-45 = 0)	X	X	X	Coast to stop

Control Mode	E1-14 (Stop mode of OFF1)	E1-16 (Stop mode of OFF3)	E1-17 (Stop mode for operation permission command)	Stop mode
Decoupled V/f (E3-45 = 1)	0: Coast to stop	X	0: Stop mode of OFF1	Coast to stop
	1: Decelerate to stop	X		Decelerate to stop for OFF1
	2: Stop at maximum capability	X		Stop at maximum capability
	X	X	1: Stop mode of OFF2	Coast to stop
	X	0: Decelerate to stop	2: Stop mode of OFF3	Decelerate to stop for OFF3
	X	1: Stop at maximum capability		Stop at maximum capability

Note

In the torque control mode, the stop mode for S24 (Run-enabled stop) is not related to E1-18.

- The stop mode between OFF2 and the fault is fixed to coast-to-stop.

5.1.6.2 Actions in Different Stop Modes

- Coast-to-stop
  In coast-to-stop, the IGBT output is blocked directly and the motor coasts to stop. For devices with high inertia, the duration is quite long. Coast-to-stop can be triggered upon most of the faults or OFF2 emergency stop.

  All the stop modes are fixed to coast-to-stop when E3-45 is set to 0 during operation in V/f mode.
- Decelerate-to-stop for OFF1
  This command is typically triggered by low level of OFF1 command. After it is activated, the speed reference of the motor is set to 0 forcibly, and the motor decelerates to zero speed based on the RFG deceleration time, together with pulses blocked or DC braking triggered upon reaching zero speed. For details, see *"5.1.5 Zero Speed Judgment" on page 151*.

  The stop mode for OFF1 can be set through E1-14. E1-14 is set to 1 [Decelerate to stop] by default.
- Decelerate-to-stop for OFF3
  After OFF3 (Decelerate to stop) mode is activated, the motor speed reference is set to 0 forcibly. No arc exists during deceleration and the IGBT is blocked after zero speed is reached.
- Stop-at-maximum-capability
  After this command is activated, the speed reference of the motor is set to 0 forcibly, and the motor decelerates to zero speed based on the maximum output capability. During deceleration, the motor torque or current may reach the limit.

  The motor may stop at the maximum capability during OFF1 or OFF3.

5.1.7 DC Braking

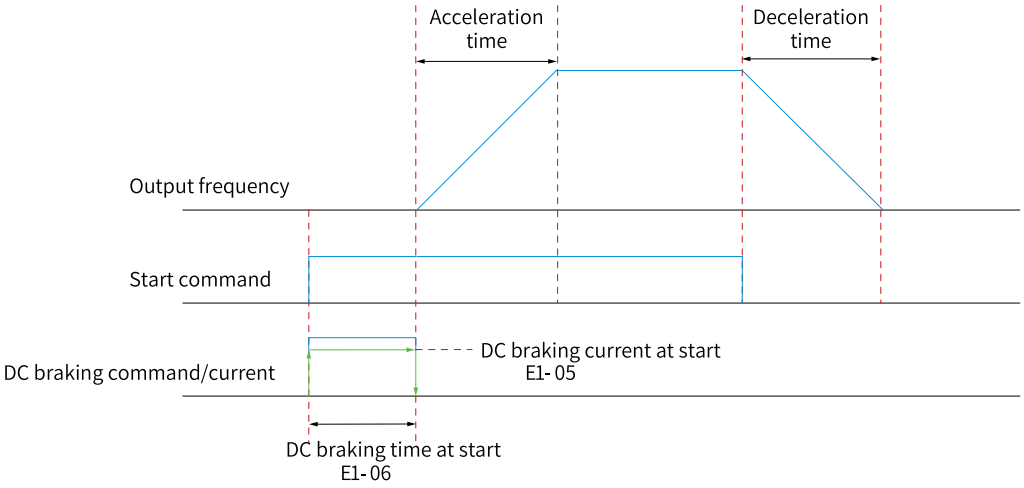
5.1.7.1 Start with DC Braking

Application scenario

E1-00 [Startup mode] = 2 [Start with DC braking].

This mode applies to applications where the motor may creep upon start.

When an asynchronous motor is started in the V/f mode, the DC braking functions in the same way as pre-excitation, which can increase the startup torque.



Operating principles

When DC braking is enabled, a DC current is applied to the motor stator winding to generate a braking force that brings the motor to a standstill. Set the DC braking function at start through E1-05 [DC braking current at start] and E1-06 [DC braking time at start].

Related parameters

Param.	Name	Default	Value range	Description
E1-05	DC braking current	100.0%	0.0% to 100.0%	Defines the current outputted during DC braking. The value 100% corresponds to the rated motor current.
E1-06	DC braking time at start	0.00	0.00s to 100.00s	Defines the duration of DC braking. Note: Long-term braking can keep the asynchronous motor at the zero speed but may result in motor overtemperature.

Precautions

- Note that the current and action time of DC braking must be lower than the overload limits of the motor and drive.

- Long-term braking can keep the asynchronous motor at the zero speed but may result in motor overtemperature.
- Do not use the DC braking function as a replacement of the brake function configured in the mechanical device.

Caution

Do not use DC braking on traction loads. Traction loads can cause the motor to rotate, which may result in personal injury or death.

Application instance

Abrupt acceleration is needed during operation in the V/f mode. The actual motor speed deviates greatly from the speed reference at start, which cannot meet the process requirements. You can apply DC braking at start to all the motors in the V/f mode to reduce the speed deviation upon start.

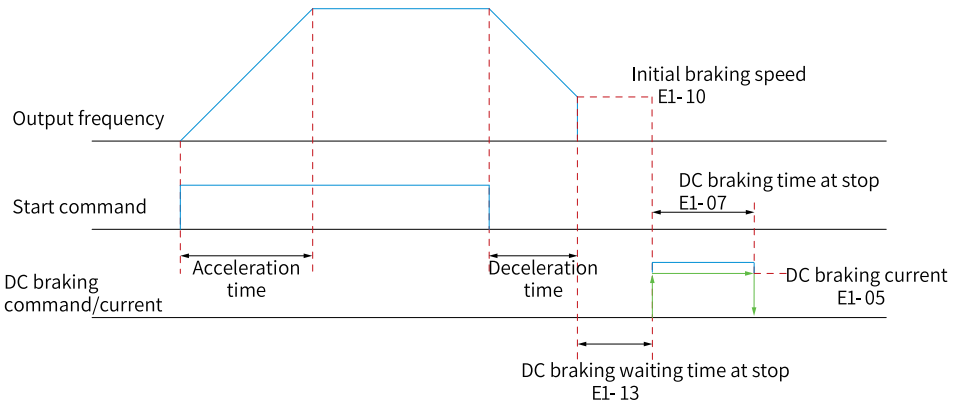
5.1.7.2 Stop with DC Braking

Application scenario

Set E1-07 to a value greater than 0 to enable stop with DC braking, which applies to applications where the motor may rotate. This function brakes the motor through direct current at stop, allowing the load to stop after the motor stops.

Operating principles

When DC braking is enabled, a DC current is applied to the motor stator winding to generate a braking force that brings the motor to a standstill. Set the DC braking function through E1-05 [DC braking current] and E1-07 [DC braking time at stop].



Related parameters

Param.	Name	Default	Value range	Description
E1-10	Starting speed of braking	30.0	0.0 rpm to 6000.0 rpm	Defines the starting frequency of DC braking at stop. Note: DC braking starts only when the speed in decelerating upon OFF1, the actual speed, and RFG speed reference are lower than this starting speed. If DC braking is started at high speed, the braking torque may be reduced.
E1-05	DC braking current	50.0%	0.0% to 100.0%	Defines the current outputted during DC braking. The value 100% corresponds to the rated motor current.
E1-07	Duration of DC braking at stop	0.00	0.00s to 100.00s	Defines the duration of DC braking at stop. Note: When this parameter is set to 0, the function of DC braking at stop is disabled, the motor stops based on the zero speed threshold value. When this parameter is not set to 0, the function of DC braking at stop is enabled, and this parameter defines the duration of braking.
E1-13	Demagnetization time (waiting time for DC braking at stop)	1.00s	0.01s to 100.00s	Defines the demagnetization time of the motor. The motor rotates freely during demagnetization. Note: If the demagnetization time is not zero and E1-10 [Starting speed for DC braking at stop] is greater than or equal to E1-11 [Threshold of motor zero speed], DC braking starts after IGBT is blocked and the demagnetization time elapses. Otherwise, DC braking starts directly.

Precautions

- The starting frequency for DC braking at stop cannot be set to an excessively high value. Otherwise, overcurrent may occur on the drive.
- For asynchronous motors, if the waiting time for DC braking at stop is set to an excessively low value, overcurrent may easily occur on the drive.
- Note that the current and action time of DC braking must be lower than the overload limits of the motor and drive.

5.1.8 Start/Stop Control Word

5.1.8.1 Start/Stop Control Word

Start/stop control words are equipotential commands controlling the running, stop, and fault reset of the drive. Drive control is performed to process start/stop control words according to the priority in the following function diagram.

Function diagram of start/stop control words

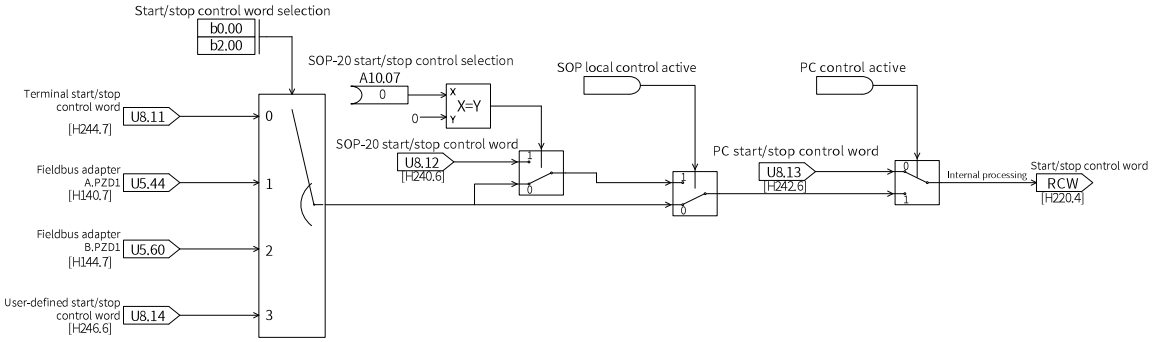


Figure 5-6 Function diagram of start/stop control words

As shown in the figure, InoDriveStudio, followed by SOP-20-880, has the highest priority, and when InoDriveStudio local control is active, other control sources will be ignored.

Only when local control is not enabled, a control channel is activated based on A9.00. There are four sources of control channels, and the corresponding configuration is activated according to the settings of b0.00/b2.00. No matter whether local control is enabled or not, the function of fault reset of SOP-20-880 and InoDriveStudio is enabled.

5.1.8.2 U8-11 Terminal Start/Stop Control

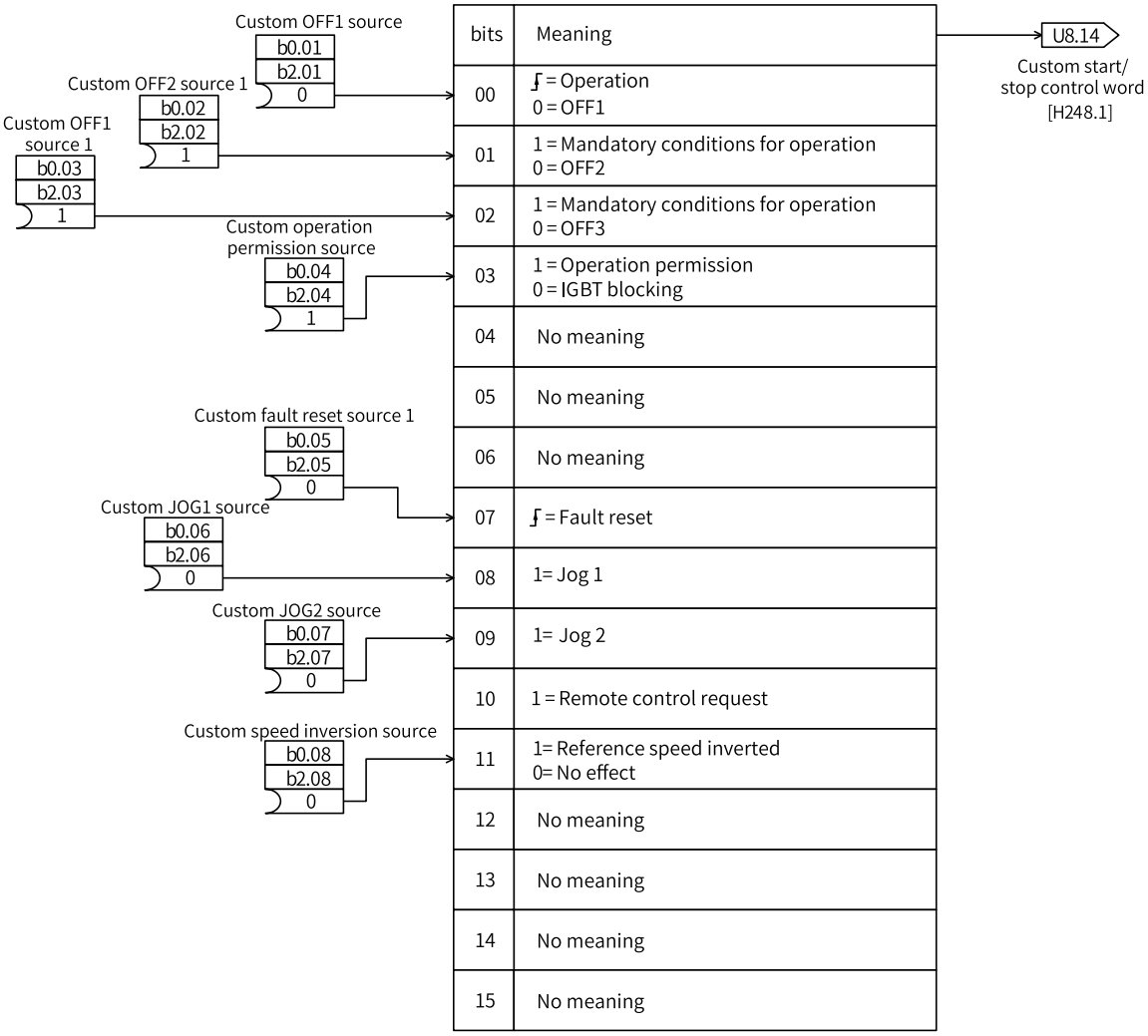
For details about configurations of U8-11 terminal start/stop control, see *" Terminal Start/Stop Module" on page 173*.

Bits	Meaning
00	∫= Operation 0 = OFF1
01	1 = Jog 1
02	1 = Jog 2
03	1 = Invert speed reference 0 = No operation
04	Reserved
05	Reserved
06	Reserved
07	Reserved
08	Reserved
09	Reserved
10	Reserved
11	Reserved
12	Reserved
13	Reserved
14	Reserved
15	Reserved

→ U8.11 Terminal start/stop control word [H248.1]

Figure 5-7 U8-11 terminal start/stop control

5.1.8.3 U8-14 Custom Start/Stop Control Word



5.1.8.4 Start/Stop Control Word from Fieldbus Adapter

When the source of the start/stop control word is the fieldbus adapter, the structure of the start/stop control word is basically the same as that of the user-defined start/stop control module, but each control bit no longer needs to be configured separately through the parameter, but is directly obtained from PZD1 of the process data by default.

- When the start/stop control module comes from fieldbus adapter A, U5-44 is used as the start/stop control word, and the corresponding bits are U2-00 to U2-15.
- When the start/stop control module comes from fieldbus adapter B, U5-60 is used as the start/stop control word, and the corresponding bits are U2-16 to U2-31.

Table 5–3 Start control word coming from the user-defined parameter setting equivalent to the field-bus adapter

Start/Stop Control Word Para of Channel 1	Start/Stop Control Word Para of Channel 2	Parameter	Equivalent Para Setting When from Fieldbus Adapter A	Equivalent Para Setting When from Fieldbus Adapter B
b0-01	b2-01	User-defined OFF1 source	U2-00	U2-16
b0-02	b2-02	User-defined OFF2 source 1	U2-01	U2-17
b0-03	b2-03	User-defined OFF3 source 1	U2-02	U2-18
b0-04	b2-04	User-defined running permission source	U2-03	U2-19
b0-05	b2-05	User-defined fault reset source 1	U2-07	U2-23
b0-06	b2-06	User-defined JOG1 source	U2-08	U2-24
b0-07	b2-07	User-defined JOG2 source	U2-09	U2-25
b0-08	b2-08	User-defined speed inversion source	U2-11	U2-27

5.1.8.5 Parameter Setting

The following table takes control channel 1 as an example.

Table 5–4 Control channel 1 parameter setting

Parameter	Name	Setting	Command Source
b0-01	Custom OFF1 source	Command source output: 0: Normal stop 0→1: Start	0: 0 1: Reserved 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: DIL 9: HDI1 10: HDI2 Others: B connector
b0-02	Custom OFF2 source 1	Command source output: 0: Enabled, IGBT inhibited, coast to stop 1: Disabled	0: 0 1: 1 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: DIL 9: HDI1 10: HDI2 Others: B connector
b0-03	Custom OFF3 source 1	Command source output: 0: Enabled 1: Disabled	

For example:

- b0-00 = 3: Custom (set in group b0).
- b0-01 = 2: DI1 is used as the command source of OFF1. When DI1 changes from 0 to 1, the equipment is started.
- b0-02 = 3: DI2 is used as the command source of OFF2. When DI2 becomes 0 (low level), the equipment coasts to stop.
- b0-03=4, DI3 is used as the command source of OFF3. When DI3 is 0 (low level), the device decelerates to stop.

5.1.8.6 Operation Permission and Fault Reset

Pulses triggered by IGBT can be sent only after the operation permission signal is activated, and only in this case can the device output current. If the drive is started but the operation permission signal is inactive, IGBT cannot be triggered. The following table lists the parameters of operation permission and fault reset.

Table 5–5 Parameters of operation permission and fault reset

Param.	Name	Description	Command source
b0-04/b2-04	Custom operation permission source	Command source output: 0: Disabled 1: Enabled	0: 0 1: Reserved 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: DIL 9: HDI1 10: HDI2 Others: B connector
b0-05/b2-05	Custom fault reset source 1	Command source output: 0: Disabled 0→1: Fault reset	

5.1.8.7 Parameter Settings for Jog, Ramp Function Generator (RFG), and Speed Regulator

For details on the ramp function generator and speed regulator function module, see *" Ramp Function Generator" on page 184*. The following shows parameters related to the control channel.

Table 5–6 Parameter settings for jog, ramp function generator, and speed regulator

Param.	Name	Description	Command source
b0-06/b2-06	Custom JOG1 source	The output of the command source is: 0: Invalid 1: Valid	0: 0 1: Reserved 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: DIL 9: HDI1 10: HDI2 Others: B connector
b0-07/b2-07	Source of custom JOG2	The output of the command source is: 0: Invalid 1: Valid	
b0-08/b2-08	Custom speed inversion source	The output of the command source is: 0: Invalid 1: Valid	0: 0 1: 1 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: DIL 9: HDI1 10: HDI2 Others: B connector
b1-06/b3-06	RFG inhibition source	The output of the command source is: 0: RFG is inhibited and RFG output is set to 0 forcibly. 1: RFG generates output normally.	
b1-07/b3-07	RFG pause source	The output of the command source is: 0: RFG pause is active, and RFG maintains the current output value. 1: RFG operates normally.	
b1-08/b3-08	Source of setting RFG reference to 0	The output of the command source is: 0: RFG input is set to 0 forcibly. 1: RFG gets the input normally.	
b1-11/b3-11	Speed regulator enable source	The output of the command source is: 0: Disable 1: Enable	

5.1.9 Control Word

A control word is a set of various control commands in the system, which is derived from the control channel parameter setting.

5.1.9.1 Control Word 1

Control word 1 can be viewed through U8-07. The following table lists bits of control word 1 and their corresponding parameters.

Bit	Name	Para.	Value	Description
0	Run/Stop (OFF1)	b0-01<1> b2-01<1>	0	Stop: The drive stops according to the OFF1 stop mode defined by E1-14 and enters the S5 ready-to-switch-on state.
			1	Running: At the rising edge, the drive state changes from "Ready to switch on" to "Pre-charge" and then to "Ready to run". You can select self-test (b5-01), auto-tuning (b5-00), or normal operation after the drive starts running.
1	Coast to stop (OFF2)	b0-02<2> b1-00/b1-01<2> b2-02<2> b3-00/b3-01<2>	0	IGBT is inhibited and the drive enters the S4 switch-on-inhibited state.
			1	Normal state
2	Quick stop (OFF3)	b0-03<2> b1-02/b1-03<2> b2-03<2> b3-02/b3-03<2>	0	The motor decelerates to 0 rpm according to the OFF3 stop mode defined in E1-16. Then, the IGBT is inhibited and the drive enters the S4 switch-on-inhibited state.
			1	Normal state
3	Running permission	b0-04<3> b2-04<3>	0	In the OFF1 active state, the motor enters the S7 ready-to-run state according to the stop mode defined in E1-17 and IGBT is inhibited.
			1	In the S7 ready-to-run state, the drive must receive the operation permission signal before entering the normal operation state.
4	Ramp output disabled	b1-06 b3-06	0	The output of the ramp function generator is set to 0 forcibly.
			1	Normal state
5	Ramp output retained	b1-07 b3-07	0	The last output of the ramp function generator is retained.
			1	Normal state
6	Ramp output being zero	b1-08 b3-08	0	The setpoint of the ramp function generator is set to 0 forcibly and the output decelerates to 0 according to the set time.
			1	Normal state
7	Fault reset	b0-05<4> b1-04/b1-05<4> b2-05<4> b3-04/b3-05<4>	0	Disabled
			0→1	If the current fault disappears, the state machine changes from the S3 faulty state to the S4 switch-on-inhibited state during operation. When OFF1 is set to 0, the state machine enters the S5 ready-to-switch-on state.
8	Jog 1 (JOG1)	b0-06 b2-06 b4-13c	0	Disabled
			1	1 .The state changes from ready-to-switch-on to jog and the [JOG1 setpoint] of C5-00 is used as the speed reference. 2 .The state can be changed to jog during operation and the current speed is the [JOG1 setpoint] of C5-00.
9	Jog 2 (JOG2)	b0-07 b2-07 b4-14	0	Disabled
			1	1 .The state changes from ready-to-switch-on to jog and the [JOG2 setpoint] of C5-01 is used as the speed reference. 2 .The state can be changed to jog during operation and the current speed is the [JOG2 setpoint] of C5-01.

Bit	Name	Para.	Value	Description
10	Remote control	-	0	Remote control disable
			1	Receives control word command set by channel 1 or channel 2.
11	Invert speed reference	b0-08<5> b2-08<5>	0	The speed reference is used.
			1	The speed reference is inverted and then used as the setpoint of the ramp function generator.
12	Motorized potentiometer up	C4-05	0	C4-06 and C4-05 selection 00: Disable, output value unchanged 01: Motorized potentiometer output increases at the predefined slope 10: Motorized potentiometer output decreases at the predefined slope 11: Disable, output value unchanged
			1	
13	Motorized potentiometer down	C4-06	0	
			1	
14	External fault 1	H0-00	0	Disabled
			1	External fault 1 is triggered.
15	External fault 2	H0-01	0	Disabled
			1	External fault 2 is triggered.

Note

- <1>: The OFF1 command may come from a terminal start/stop module, fieldbus adapter, or custom group setting. Parameters b0-01/b2-01 are only active when the custom start/stop control word is selected. See *"5.1.8.3 U8-14 Custom Start/Stop Control Word" on page 161* for details.
- <2>: The OFF2/OFF3 command can be set through the start/stop control word and other control words. The settings in other control words are always active and not affected by the sources of start/stop control words. See *"5.1.2 Emergency Stop Command" on page 144* for details.
- <3>: Parameters b0-04/b2-04 are only active when the custom start/stop control word is selected. When terminal start/stop is selected, the operation permission command is always active. When the fieldbus adapter is selected, the operation permission command corresponds to the state of bit 3 of PZD1.
- <4>: For details about reset upon fault, see *"14.1.3 Fault Reset Methods" on page 660*.
- <5>: Parameters b0-08/b2-08 are only active when the custom start/stop control word is selected. When terminal start/stop is selected, the speed reference inversion is determined by the configuration and input of the terminal start/stop module. When the fieldbus adapter is selected, the speed reference inversion corresponds to the state of bit 11 of PZD1.

5.1.9.2 Control Word 2

Control word 2 can be viewed by using parameter U8-08. The following table lists bits of control word 2 and their corresponding parameters.

Bit	Name	Para.	Value	Description
0	External alarm 1	H0-02	0	Disabled
			1	External alarm 1 is triggered.
1	External alarm 2	H0-03	0	Disabled
			1	External alarm 2 is triggered.
2 to 3	Motor selection	A9-01 A9-02	0 to 3	A maximum of four motor groups and related control parameters (groups d and E) can be stored. A9-01 and A9-02 selection The values 0 to 3 correspond to motor data sets 1 to 4 in the active state. The currently active motor data is displayed by the parameters of motor parameter (group d) and motor control (group E).

Bit	Name	Para.	Value	Description
4 to 7	Multi-reference data selection	C6-01 to C6-04	0	The values correspond to C6-01 to C6-04. One of the fixed values of C6-05 to C6-20 is selected as the multi-reference output value.
8	Channel selection	A9-00	0	Channel 1 is activated, and b0, b1, C0, and C1 are selected as the command source and reference source.
			1	Channel 2 is activated, and b2, b3, C2, and C3 are selected as the command source and reference source.
9	Forced flying start	b1-09 b3-09	0	E1-00 sets whether to enable flying start.
			1	Flying start is forcibly enabled.
10	Speed regulator enable	b1-11 b3-11	0	The speed regulator output is forced to be 0, and the motor can rotate freely.
			1	The speed regulator works properly and ensures the switch-on speed.
11	Reserved	-	-	-
12	Forced torque control	b1-10 b3-10	0	The control mode is determined by E0-01.
			1	Vector control is forced in torque control mode.
13 to 15	Reserved	-	-	-

5.1.10 Status Word

A status word is a set of bit codes for the running states of the drive. Check the status word to determine the system status.

5.1.10.1 Status Word 1

Status word 1 is displayed in U8-09. Status word 1 indicates the main operating states of the system. The following table lists bits of status word 1 and their corresponding bit connectors and meanings.

Bit	Name	Para.	Value	Description
0	Ready to switch on	U1-00	0	The drive is faulty or external conditions are not met. (See the description for "Switch-on inhibited".)
			1	Operation preparation is done. The value is 1 regardless of whether there is an operation (OFF1) command or not.
1	Ready to run	U1-01	0	There is no operation command.
			1	The drive receives an operation command and the bus voltage is established. The value is fixed to 1 regardless of whether the operation permission command is available.
2	Operation	U1-02	0	There is no operation permission signal.
			1	The value is 1 during normal operation.
3	Fault activation	U1-03	0	No fault
			1	A fault is activated.
4	Coast to stop activation (OFF2)	U1-04	0	Coast-to-stop is activated.
			1	Coast-to-stop is not activated.
5	Quick stop activation (OFF3)	U1-05	0	Quick stop is activated.
			1	Quick stop is not activated

Bit	Name	Para.	Value	Description
6	Switch-on prohibited	U1-06	0	Normal
			1	External conditions are not met (OFF2 or OFF3 activated) or a fault occurs.
7	Alarm/limit activation	U1-07	0	Normal
			1	An alarm or a limit is active.
8	No speed deviation	U1-08	0	The actual speed deviates from the speed reference.
			1	The actual speed follows the speed reference.
9	IDS control active	-	0	IDS control permission is active.
			1	IDS control permission is inactive.
10	Comparative speed achievement	U1-09	0	The actual speed is lower than the comparison value.
			1	The actual speed is higher than the comparison value.
11	Limit achievement	U1-10	0	The torque or current does not reach the limit.
			1	The torque or current reaches the limit.
12	Brake release	U1-11	0	The brake is applied.
			1	The brake is released.
13	Forward speed	U1-12	0	Reverse
			1	Forward
14	Current command channel	U0-26	0	Command channel 1 is active.
			1	Command channel 2 is active.
15	IGBT operation	U1-13	0	IGBT is blocked.
			1	IGBT is triggered.

5.1.10.2 Status Word 2

Status word 2 can be viewed through U8-10. Status word 2 indicates the auxiliary status of the system.

Bit	Name	Value	Description
0	Ramp enable	0	The RFG is disabled and the output is 0.
		1	The RFG works properly.
1	Ramp running	0	The last output of the RFG is retained.
		1	The RFG works properly.
2	Ramp bypass	0	The input and output of the RFG are the same. The ramp time is invalid.
		1	The RFG works properly.
3	Normal operation	0	The motor is not running or jogging.
		1	The AC drive starts running based on the RUN (OFF1) command.
4	Jogging	0	The motor is not running or jogging.
		1	The drive is started by the jog command.
5	Reserved	-	-
6	Parameter auto-tuning	0	Auto-tuning is not in progress.
		1	Motor parameter auto-tuning is in progress.
7	A limit is activated.	0	No limit is activated.
		1	A limit is activated.
8	An alarm is activated.	0	No alarm is activated.
		1	An alarm is activated.
9 to 10	Current motor selection	0 to 3	Indicates the motor data set that is currently activated.

Bit	Name	Value	Description
11	SOP-20-880 local control activation	0	SOP-20-880 local control is not activated.
		1	SOP-20-880 local control is activated using the Loc/Rem key of the SOP-20-880, which controls AC drive operation in replacement of the control channel.
12 to 15	Reserved	-	-

The status word indicates the working state of HCU. The main status bits change with the control word as shown in the following figure.

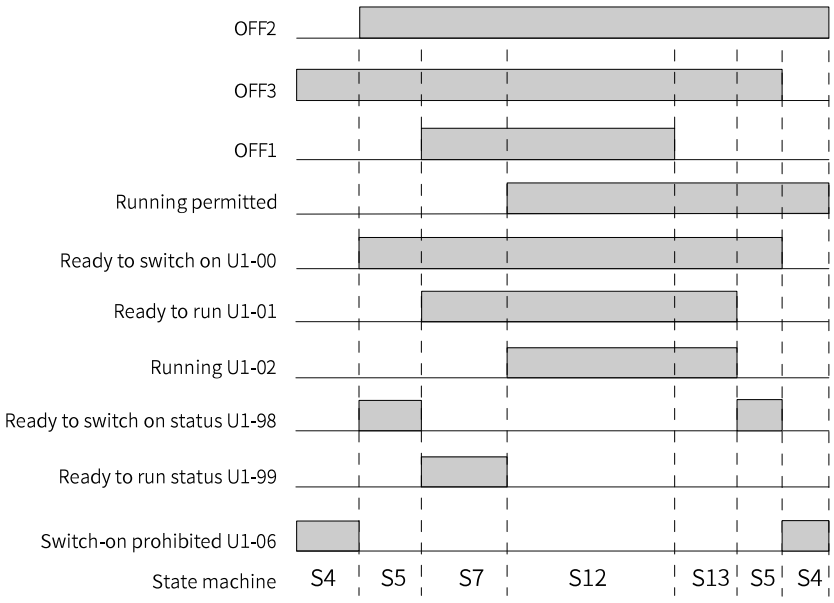


Figure 5-8 Status bit sequence diagram

5.1.11 State Machine

The following table describes different states of the state machine.

Status	Name	Description
S1	System initializing	The program is initialized and waits for the establishment of the control voltage. The system enters S2 when conditions are met.
S2	Power-on check	If you select power-on self-test items, the system performs self-test after the bus voltage is established and then enters S4. The system directly enters S4 if no power-on self-test item is selected.
S3	Fault	The state machine enters S3 when a fault occurs in any state. After the fault is reset, the state machine enters S4.
S4	Switch-on inhibited	The state machine enters S5 when no OFF2, OFF3, STO, or OFF1 signal is received. Otherwise, the state machine waits for the corresponding command in this state.
S5	Ready to switch on	The state machine waits for the run (OFF1) command and enters S6 at the rising edge of the command. The state machine enters S6 when the jog command is valid. The state machine enters S18 when the value of b5-00 is greater than 0. The state machine enters S16 when the value of b5-01 is greater than 0.

Status	Name	Description
S6	Pre-charging	The state machine waits for the establishment of the DC bus voltage and then enters S7. If [A6-00] is 0, the 64-1 pre-charge failure fault is reported if the bus voltage does not reach the normal level within 6 seconds, and the system enters S3. If [A6-00] is 1, and the bus voltage fails to become normal after the starting time set by [A6-01] has elapsed, the 64-1 pre-charge failure fault is reported, and the system enters S3. If the bus voltage is normal but HINT is not ready, the 64-2 pre-charge failure fault is reported and the system enters S3.
S7	Ready to run	The system enters S8 after receiving the running permitted signal.
S8	Waiting for demagnetiza-tion	When IGBT is inhibited for the first time, if the actual motor speed is greater than the zero speed threshold, the state machine has to wait until the interval is greater than the demagnetization time defined in E1-13. If the inhibition duration is longer than the demagnetization time, the state machine enters S9.
S9	Pre-operation check	The system executes the selected pre-running self-test items. If no item is selected, the system skips this state. The state machine enters S10, S11, or S15, depending on the startup mode.
S10	Pre-excitation	The state machine creates a magnetic field for the asynchronous motor and then enters S12.
S11	Flying start	The state machine searches for the current motor speed and then enters S12.
S12	Operational	The state machine runs normally and can accept speed or torque references. The system enters S13 after receiving the stop (OFF1) command. The system enters S14 after receiving the quick stop (OFF3) command. The state machine enters S4 when the OFF2 or STO signal is activated.
S13	OFF1 stop	The IGBT is inhibited when the speed is reduced to 0 within the deceleration time specified by the RFG. Then the system enters S5.
S14	OFF3 stop	The IGBT is inhibited when the speed is reduced to 0 within the OFF3 stop time. Then the system enters S4.
S15	Start with DC braking	Before startup, a direct current is supplied to the asynchronous motor to ensure the motor is braked to the zero speed. The state machine enters S12 after the braking time is reached.
S16	Self-test preparation	The system enters S17 on the rising edge of the RUN (OFF1) command.
S17	Self-test	The system enters S4 after completion.
S18	Ready for auto-tuning	The state machine enters S19 at the rising edge of the RUN (OFF1) command.
S19	Auto-tuning	The state machine auto-tunes the motor parameters and then enters S4.
S20	Parameter recovery	The state machine restores the motor parameters to defaults and then enters S4.
S21	Parameter download	The state machine downloads the motor parameters in batch in background and then enters S4.
S22	Jogging	The system enters S23 after the jog command is canceled.
S23	Jog stop	The system enters S4 after completion. The system returns to S22 after the jog command is restored.
S24	Run-enabled stop	This state applies when operation permission is canceled during operation, after which the S7 state applies.
S25	Stop with DC braking	A direct current is supplied to the asynchronous motor to stop it forcibly. After the time is reached, S4 state applies.

Status	Name	Description
S26	Waiting time for stop with DC braking	When the motor decelerates to a value lower than the threshold for a period of time, the state machine enters S25.
S27	Stop at fault	The system enters this state if a fault is activated, and then decelerates to zero speed based on the fault level or blocks the output directly. Then, it enters S3 state.

State diagram

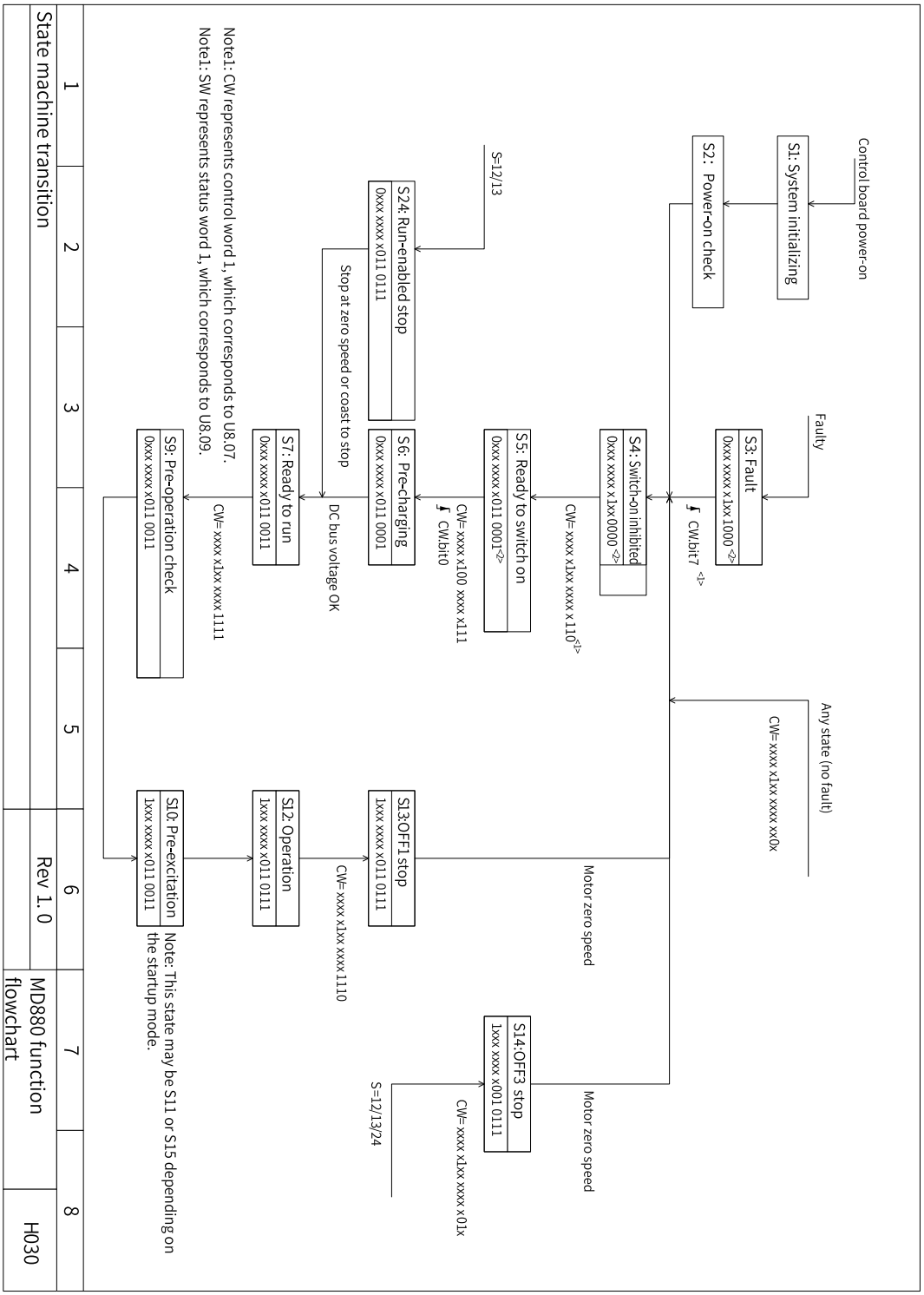


Figure 5-9 State conversion diagram of the state machine

5.1.12 Terminal Start/Stop

Six templates are available for controlling motor operations in the terminal control mode. Three terminals need to be configured at most, which are defined as IN1, IN2, and IN3.

You can configure two different terminal start/stop modes for the terminal start/stop module. Parameters are provided to enable terminal start/stop command 1 or 2. When command 1 is selected, b-03 to b4-07 are active. When command 2 is selected, b4-08 to b4-12 are active. The following table describes the input terminal parameters of the terminal start/stop module.

[b4-02] Selection of terminal start/stop command 1/2	IN1 active parameter	IN2 active parameter	IN3 active parameter
[0]: Terminal start/stop command 1	b4-05	b4-06	b4-07
[1]: Terminal start/stop command 2	b4-10	b4-11	b4-12

Check that parameters match the terminal wiring. For example, if terminal start/stop command 1 is active, b4-05 corresponds to DI1 (DI1 corresponds to b4-05, DI2 corresponds to b4-06, and DI3 corresponds to b4-07, unless otherwise specified in this manual). If terminal start/stop command 2 is active, set b4-10...b4-12 in sequence.

The following table lists six terminal start/stop modes defined by parameters (the suffix P indicates that the command is rising edge-triggered).

Param.	Name	Value range	Default	Unit	User setting	Remarks
b4-03/b4-08	Terminal start/stop mode	0: Inactive 1: IN1 for start 2: IN1 for start and IN2 for direction 3: IN1 for forward start and IN2 for reverse start 4: IN1P for start and IN2 for stop 5: IN1P for start, IN2 for stop, and IN3 for direction 6: IN1P for forward start, IN2P for reverse start, and IN3 for stop	b4-03 is set to 1 by default. b4-08 is set to 0 by default.	-	-	-

The relationship among the input and the start/stop command OFF1 and reference direction DIR is shown in the following table.

Terminal start/ stop mode	IN1 input	IN2 input	IN3 input	Start command OFF1	Reference direction DIR
0: Inactive	X	X	X	0 - Stop	0 - Forward
1: IN1 for start	0→1	X	X	1 - Run	0 - Forward
	0	X	X	0 - Stop	0 - Forward
2: IN1 for start and IN2 for direction	0	N	X	0 - Stop	N = IN2
	0→1	N	X	1 - Run	N = IN2

Terminal start/ stop mode	IN1 input	IN2 input	IN3 input	Start command OFF1	Reference direction DIR
3: IN1 for forward start and IN2 for reverse start	0	0	X	0 - Stop	Depends on the running direction before stop.
	0→1	0	X	1 - Run	0 - Forward
	0	0→1	X	1 - Run	1 - Reverse
	1	1	X	0 - Stop	Depends on the running direction before stop.
4: IN1P for start and IN2 for stop	X	0	X	0 - Stop	0 - Forward
	0→1	1	X	1 - Run	0 - Forward
5: IN1P for start, IN2 for stop, and IN3 for direction	X	0	N	0 - Stop	N = IN3
	0→1	1	N	1 - Run	N = IN3
6: IN1P for forward start, IN2P for reverse start, and IN3 for stop	X	X	0	0 - Stop	Depends on the running direction before stop.
	0→1	0	1	1 - Run	0 - Forward
	0	0→1	1	1 - Run	1 - Reverse

Note

1 indicates high level. 0 indicates low level. N indicates 0 or 1, namely, a certain state. X indicates that the bit does not affect the output.

In the following example, DI1, DI2, and DI3 are used as external terminals. That is, the functions of DI1, DI2, and DI3 are selected by b4-05 to b4-07/b4-10 to b4-12.

5.1.12.1 Terminal Start/Stop Mode 1

This is the most commonly used single-wire mode, in which DI1 is used to control the start/stop of a motor.

K1	Operation command
Close	Run
Open	Stop

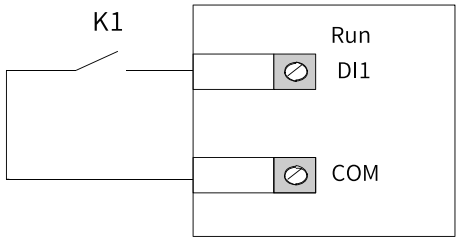


Figure 5-10 Terminal start/stop mode 1

As shown in the preceding figure, DI1 is used for terminal start/stop mode 1. The operation command is triggered upon the rising edge of DI1. When DI1 is set to 0, the motor stops.

5.1.12.2 Terminal Start/Stop Mode 2

In this mode, the DI1 terminal functions as the operation enable terminal, and the DI2 terminal determines the running direction.

K1	K2	Operation command
Close	Open	Forward
Close	Close	Reverse
Open	Open	Stop
Open	Close	Stop

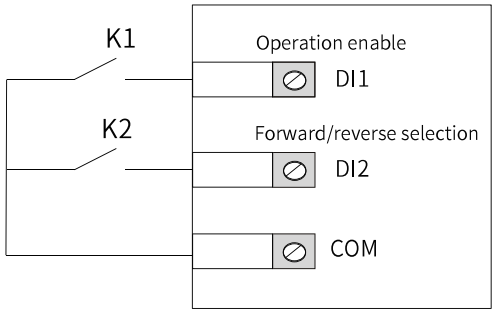


Figure 5-11 Terminal Start/Stop Mode 2

As shown in the preceding figure, two terminals, DI1 and DI2, are used for start/stop and direction control in terminal start/stop mode 2. The start/stop logic of DI1 control in this mode is the same as that in mode 1, but the speed reference is inverted when DI2 is 1.

5.1.12.3 Terminal Start/Stop Mode 3

K1	K2	Operation command
Close	Open	Forward
Open	Close	Reverse
Close	Close	Stop
Open	Open	Stop

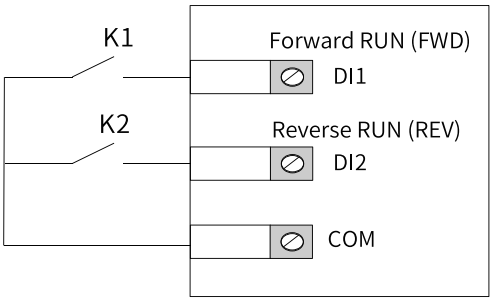


Figure 5-12 Terminal start/stop mode 3

As shown in the preceding figure, DI1 and DI2 are used to control start/stop and determine the running direction. An operation command can be triggered upon the rising edge of DI1 and the speed reference is used directly. An operation can also be triggered upon the rising edge of DI2 with the speed reference inverted. The motor is stopped when both DI1 and DI2 are 0 or 1.

5.1.12.4 Terminal Start/Stop Mode 4

SW1	K	Operation command
X	Open	Stop
Open→Close	Close	Run

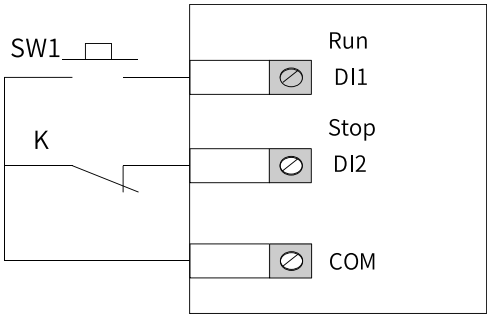


Figure 5-13 Terminal Start/Stop Mode 4

As shown in the preceding figure, two terminals are used for terminal start/stop mode 4, with one controlling start while the other controlling stop. DI2 is set to 1 and the DI1 rising edge triggers the operating command. When DI2 is set to 0, the device is stopped.

5.1.12.5 Terminal Start/Stop Mode 5

SW1	K1	K2	Operation command
X	Open	X	Stop
Open→Close	Close	Open	Forward
Open→Close	Close	Close	Reverse

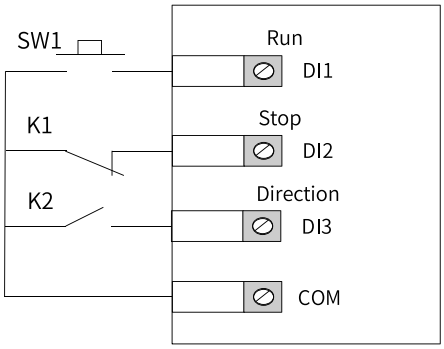


Figure 5-14 Terminal Start/Stop Mode 5

As shown in the preceding figure, three terminals are used for start/stop and direction control. The start/stop logic of DI1 and DI2 control in this mode is the same as that in mode 4, but the speed reference is inverted when DI3 is 1.

5.1.12.6 Terminal Start/Stop Mode 6

SW1	SW2	K	RUN Command
X	X	Open	Stop
Open →Close	Open	Close	Forward
Open	Open→Close	Close	Reverse

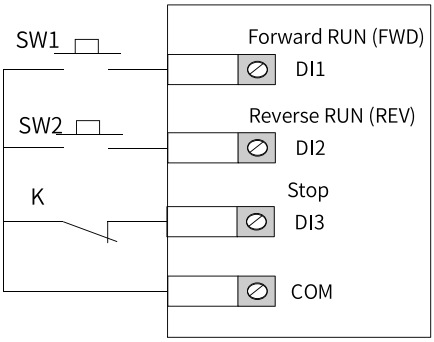


Figure 5-15 Terminal Start/Stop Mode 6

As shown in the preceding figures, three terminals are used to control the start and direction in terminal start/stop mode 6. When DI3 is set to 1, DI1 and DI2 start logic is the same as that of mode 3. However, a running device can stop only when DI3 is set to 0, which is irrelevant to DI1 and DI2 statuses.

5.2 Reference Setting Channel

5.2.1 Speed Reference

Speed reference can be set through two channels: the main reference channel and the auxiliary reference channel, as shown in the following figure.

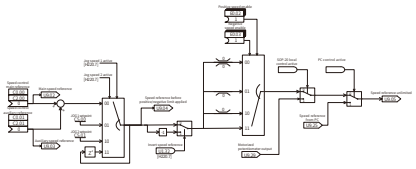


Figure 5-16 Function diagram of speed reference

The main reference and auxiliary reference are superimposed as the input of the ramp function generator and then processed with the acceleration/deceleration time to generate the actual speed reference.

Some processes need a speed regulation reference that is enabled directly without waiting after the acceleration/deceleration time. *"11.2.5.14 H328 - Additional Speed and Limit" on page 618* provides an additional speed reference, which is enabled only during operation and superimposed onto the RFG output speed once enabled. The additional speed is applicable only in FVC and SVC control modes.

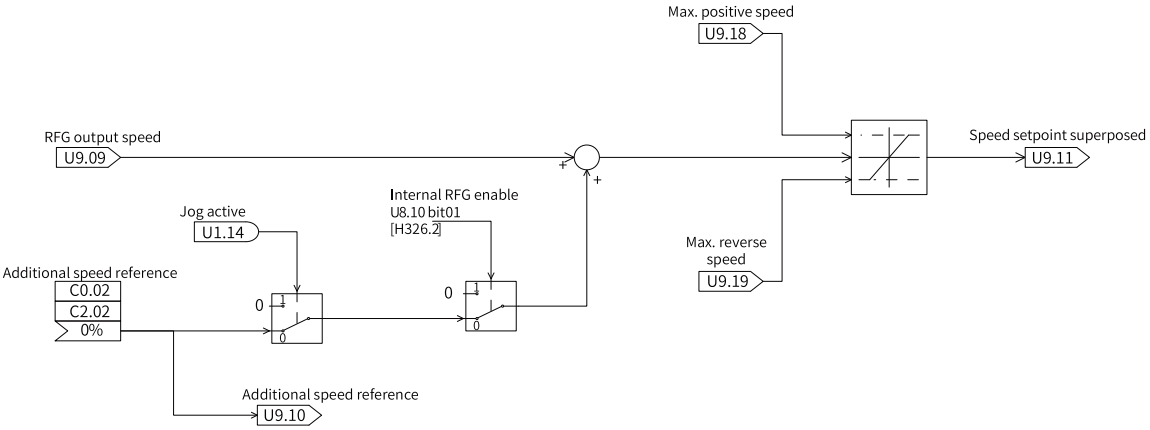


Figure 5-17 Additional speed reference function diagram

The speed reference source can be analog inputs, communication, and multi-reference values. The following description takes channel 1 as an example.

Param.	Name	Setpoint
C0-00	Main speed control reference	0: 0 1: Multi-reference 1 2: AI1 3: AI2 4: HDI1 5: HDI2 6: Multi-reference 7: Motorized potentiometer 8: Reserved 9: Process data 2 of fieldbus adapter A 10: Process data 2 of fieldbus adapter B Others: K connector
C0-01	Auxiliary speed control reference selection	
C0-02	Additional speed reference	

The speed reference is a percentage to the value defined by d3-02 (Per-unit speed).

5.2.2 Torque Reference

The torque reference is shown in the following figure. When torque control is active, the actual torque reference is generated based on the main reference after being filtered and processed with the ramp acceleration/deceleration time. The actual torque reference is then superimposed with the additional torque to generate the non-limited torque reference.

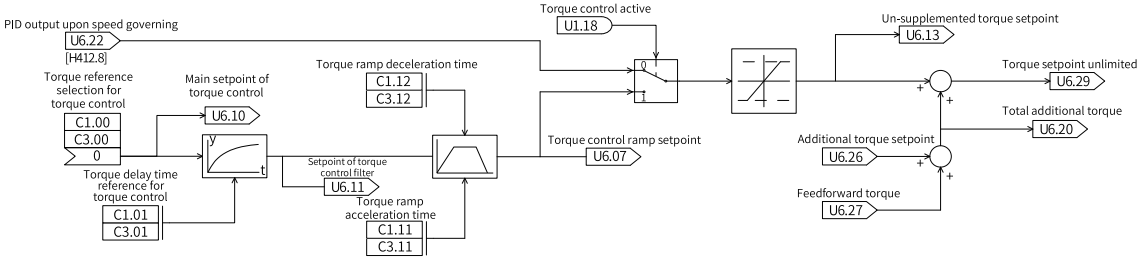


Figure 5-18 Torque setting channel in torque control

Two setting channels are available. The following parameters take channel 1 as an example.

Param.	Name	Setpoint
C1-00	Torque reference selection in torque control	0: 0 Mbit/s 1: Multi-reference 2 2: AI1 3: AI2 4: HDI1 5: HDI2 6: Multi-reference 7: Motorized potentiometer 8: Reserved 9: Process data 3 of bus adapter A 10: Process data 3 of bus adapter B Others: K connector
C1-01	Torque reference filter time in torque control	0.00s to 10.00s
C1-02<1>	Speed window in torque control	0: Invalid 1: Valid
C1-03<1>	Window speed selection in torque control	0: Channel 1 speed reference 1: Digital reference
C1-04<1>	Digital reference of the window speed in torque control	-600.0% to +600.0% The value 100.0% corresponds to the rated frequency of the motor.
C1-05<1>	Speed window width in torque control	0.0% to 30.0% The value 100.0% corresponds to the rated frequency of the motor.
C1-06	Selection of additional torque reference 1	0: 0 1: Digital reference Others: K connector
C1-07	Digital reference of additional torque reference 1	-400.0% to +400.0% The setpoint 100.0% corresponds to the rated torque of the motor.
C1-08	Additional torque reference 2	0: 0 Others: K connector
C1-09	Friction torque selection (additional torque reference 3)	0: 0 1: d2-03 Others: K connector
C1-10	RFG feedforward torque coefficient selection	0: 0% 1: 100% Others: K connector
C1-11<2>	Torque ramp-up time	0.000s to 60.000s
C1-12<3>	Torque ramp-down time	0.000s to 60.000s

Note

- <1>: For torque control with window, see *"8.1.5.3 Torque Control with Speed Window" on page 256*.
- <2> Acceleration time: Defines the time for the motor torque to increase from 0 to the rated torque.
- <3>: Deceleration time: Defines the time for the motor torque to decrease from rated motor torque to 0.

5.2.3 Multi-Reference

When multi-reference is enabled, multi-reference values 1 to 16 (U9-31 to U9-46) can be directly used as the reference. If multi-reference values 13 to 16 are used, the accuracy is higher. Alternatively, the multi-reference selection output (U9-30) can be used as the reference. In this case, C6-01 to C6-04 determine the actually enabled multi-reference values. The following table lists the parameter settings.

Parameter	Name	Reference
C6-01 to C6-04	Multi-reference selection 1/2/3/4	0: 0 1: 1 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: DIL 9: HDI1 10: HDI2 Other: B connector
C6-05 to C6-16	Multi-reference values 1 to 12	-600.0% to +600.0%
C6-17 to C6-20	Multi-reference values 13 to 16	-300.00% to +300.00%

0000 (binary) to 1111 (binary) corresponding to C6-01 to C6-04 correspond to multi-reference values 1 to 16. Multi-reference values are displayed in C6-00.

Multi-Reference Value	[C6-04] Bit 3	[C6-03] Bit 2	[C6-02] Bit 1	[C6-01] Bit 0	Valid Multi-Reference Value of U9-30	Connector Parameter Corresponding to Multi-Reference Value
Multi-reference value 1	0	0	0	0	C6-05	U9-31
Multi-reference value 2	0	0	0	1	C6-06	U9-32
Multi-reference value 3	0	0	1	0	C6-07	U9-33
Multi-reference value 4	0	0	1	1	C6-08	U9-34
Multi-reference value 5	0	1	0	0	C6-09	U9-35

Multi-Reference Value	[C6-04] Bit 3	[C6-03] Bit 2	[C6-02] Bit 1	[C6-01] Bit 0	Valid Multi-Reference Value of U9-30	Connector Parameter Corresponding to Multi-Reference Value
Multi-reference value 6	0	1	0	1	C6-10	U9-36
Multi-reference value 7	0	1	1	0	C6-11	U9-37
Multi-reference value 8	0	1	1	1	C6-12	U9-38
Multi-reference value 9	1	0	0	0	C6-13	U9-39
Multi-reference value 10	1	0	0	1	C6-14	U9-40
Multi-reference value 11	1	0	1	0	C6-15	U9-41
Multi-reference value 12	1	0	1	1	C6-16	U9-42
Multi-reference value 13	1	1	0	0	C6-17	U9-43
Multi-reference value 14	1	1	0	1	C6-18	U9-44
Multi-reference value 15	1	1	1	0	C6-19	U9-45
Multi-reference value 16	1	1	1	1	C6-20	U9-46

Multi-reference values 1 to 4 (U0-31 to U0-34) are determined by C6-01 to C6-04 [multi-reference selection parameters 1 to 4].

Multi-Reference Selection	Connector Parameter Corresponding to Multi-Reference Selection
Multi-reference selection 1 C6-01	U0-31
Multi-reference selection 2 C6-02	U0-32
Multi-reference selection 3 C6-03	U0-33
Multi-reference selection 4 C6-04	U0-34

5.2.4 Motorized Potentiometer

The motorized potentiometer function diagram H302 is shown below.

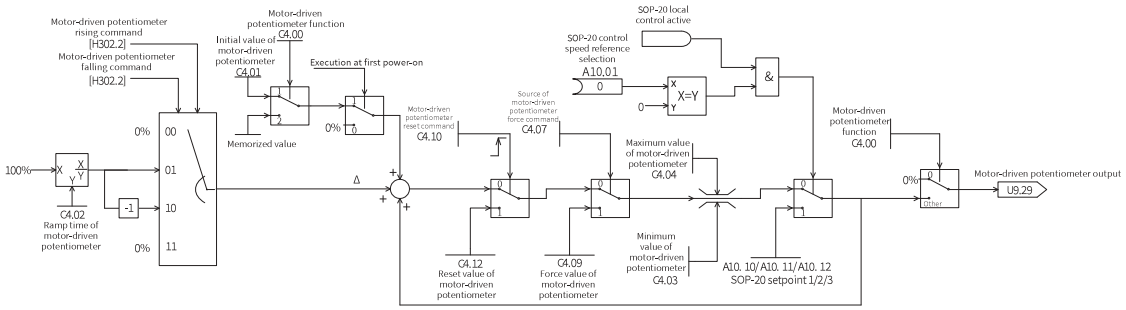


Figure 5-19 Function diagram of motorized potentiometer

When an SOP-20-880 is used to control the device, local control is active and A10-01 is set to 0. The speed reference is defined by the output of the motorized potentiometer, and the increase and decrease of the potentiometer is controlled by the SOP-20-880.

The following table lists the function parameters of the motorized potentiometer.

Parameter	Name	Description	Reference
C4-00	Motorized potentiometer function	0: Disabled 1: Restore the initial value at power-on 2: Restore the value retained at power-off	0: Disabled 1: Not retentive at power failure 2: Retentive at power failure
C4-01	Initial value setting of motorized potentiometer	Indicates the initial value after power-on.	-600.0% to +600.0%
C4-02	Ramp time of motorized potentiometer	Indicates the time for output to increase from 0% to 100% or decrease from 100% to 0%.	0.1s to 1000.0s
C4-03	Minimum value of motorized potentiometer	Indicates the lower limit of output value.	-600.0% to +600.0%
C4-04	Maximum value of motorized potentiometer	Indicates the upper limit of output value.	-600.0% to +600.0%
C4-05	Motorized potentiometer up command source	When the up or down command source is active, the output increases or decreases at the set rate. When both the up and down commands are active or inactive, the output value remains unchanged.	0: 0 1: 1 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: DIL 9: HDI1 10: HDI2 Others: B connector
C4-06	Motorized potentiometer down command source		
C4-07	Forced source of motorized potentiometer	When this parameter is set to 1, the motorized potentiometer output is set to the value defined by C4-08.	
C4-08	Forced value source of motorized potentiometer	Defines the source of the forced value.	0: 0 1: 100% 2: Digital setting Others: K connector

Parameter	Name	Description	Reference
C4-09	Forced value reference of motorized potentiometer	When C4-08 is set to 2, the forced value is defined by a digital reference.	-600.0% to +600.0%
C4-10	Reset command source of motorized potentiometer	The output value is reset once upon the rising edge of the reset command. The value defined by C4-11 is the reset value.	0: 0 1: 1 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: DIL 9: HDI1 10: HDI2 Others: B connector
C4-11	Reset value source of motorized potentiometer	Defines the source of the reset value.	0: 0 1: 100% 2: Digital setting Others: K connector
C4-12	Reset value reference of motorized potentiometer	Defines the reset value of digital reference when C4-11 is set to 2.	-600.0% to +600.0%

Note

When SOP-20-880 local control is active and A10.01 is set to 0 [Motorized potentiometer], you can use A10.10, A10.11, or A10.12 to set the output of the motorized potentiometer to a fixed value.

5.2.5 Jog Speed Reference

The following figure shows function diagram for the jog speed reference.

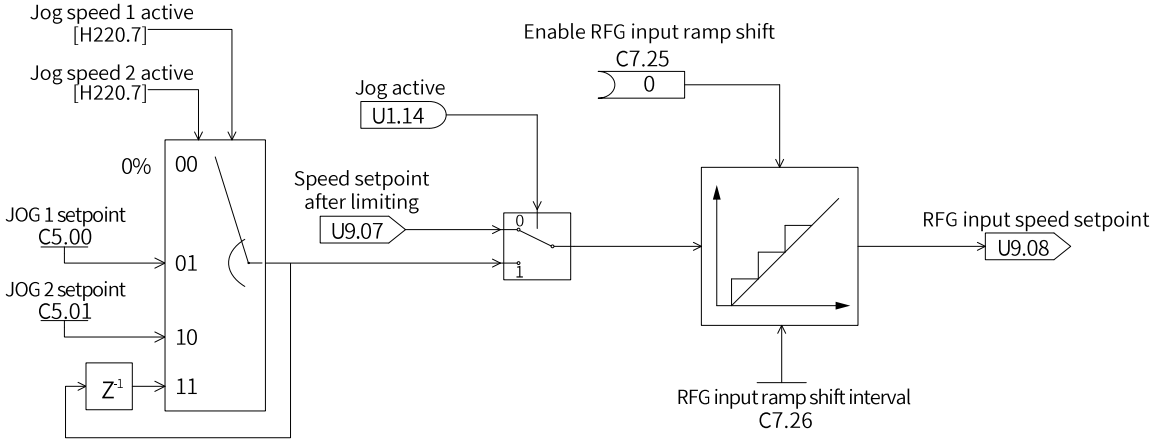


Figure 5-20 Function diagram for jog speed reference

Related parameters are shown below.

Param.	Name	Setpoint
C5-00	JOG1 reference	-50.0% to +50.0%
C5-01	JOG2 reference	-50.0% to +50.0%
C5-02	JOG acceleration time	0.1s to 1000.0s
C5-03	JOG deceleration time	0.1s to 1000.0s

For details about RFG ramp function, see *"8.1.3.4 Acceleration Torque Feedforward" on page 242*.

5.2.6 Ramp Function Generator

The ramp function generator has two groups of parameters. The acceleration and deceleration time source is either group C7 or group C8, which can be switched through parameter [C8-00]. When C8-00 is set to 0, group C7 ramp is enabled, and group C8 ramp is disabled. When C8-00 is set to 1, group C7 ramp is disabled, and group C8 ramp is enabled. The group C7 ramp function generator parameters are used by default. The major difference between group C7 and group C8 is the accuracy of acceleration and deceleration time. The acceleration and deceleration time of group C7 has only one decimal point, but that of group C8 has three decimal points.

The parameters of groups C7 and C8 are used to set the characteristics of the ramp function generator (RFG). For details, see function diagrams H322 and H326.

5.2.6.1 Acceleration/Deceleration Time Setting and Selection

The ramp function generator is used to control the acceleration and deceleration time of the motor. You can set four different sets of acceleration and deceleration time for group C7 and group C8 each and switch them using external commands. When the arc time is set to 0, linear acceleration/deceleration is followed.

- Acceleration time: indicates the time for a motor to accelerate from 0 to the speed indicated by d3-02 (per-unit speed base value).
- Deceleration time: indicates the time for a motor to decelerate from the speed indicated by d3-02 (per-unit speed base value) to 0.
- Start arc time: indicates the time for the acceleration rate to increase from 0 to the maximum acceleration rate (determined by acceleration/deceleration time) during motor acceleration (or deceleration).
- End arc time: indicates the time for the motor to transit from the maximum acceleration rate (determined by acceleration/deceleration time) to steady speed before approaching steady speed (during acceleration or deceleration).

When C8-00 is set to 0 (group C7 ramp enabled, and group C8 ramp disabled), you can select different acceleration/deceleration curves for C7 through different combinations of C7-02/C7-03, as shown in the following table.

Table 5–7 Group C7 acceleration/deceleration curve selection

RFG Ramp Selection C7-03	RFG Ramp Selection C7-02	Acceleration time	Deceleration time	Start Arc Time	End Arc Time
0	0	C7-04	C7-05	C7-12	C7-13
0	1	C7-06	C7-07	C7-14	C7-15
1	0	C7-08	C7-09	C7-16	C7-17
1	1	C7-10	C7-11	C7-18	C7-19

When C8-00 is set to 1 (group C7 ramp disabled, and group C8 ramp enabled), you can select different acceleration/deceleration curves for C8 through different combinations of C8-06/C8-07, as shown in the following table.

Table 5–8 Group C8 acceleration/deceleration curve selection

RFG Ramp Selection C8-06	RFG Ramp Selection C8-07	Acceleration time	Deceleration time	Start Arc Time	End Arc Time
0	0	C8-08	C8-09	C8-16	C8-17
0	1	C8-10	C8-11	C8-18	C8-19
1	0	C8-12	C8-13	C8-20	C8-21
1	1	C8-14	C8-15	C8-22	C8-23

5.2.6.2 Low-Speed Compensation Gain

When the V/f or SVC control mode is used, the control characteristics at a low speed are always low due to voltage drop of asynchronous motor stator resistance and parameter deviation, causing insufficient motor torque. However, the running is normal at a medium or high speed.

In case of a heavy load and a great acceleration rate, acceleration at a high speed is normal but locked-rotor occurs due to insufficient torque at a low speed. Alternatively, the acceleration rate is reduced to ensure stable running at a low speed, which causes longer acceleration time.

When C8-00 is set to 0 (group C7 ramp enabled, and group C8 ramp disabled), you can set a ratio for parameter C7-20 (low-speed acceleration time gain) and C7-21 (low-speed threshold). This allows the motor to accelerate at the low acceleration rate when running at a speed below C7-21, and accelerate at the normal acceleration rate when running at a speed above C7-21, as shown in the following figure.

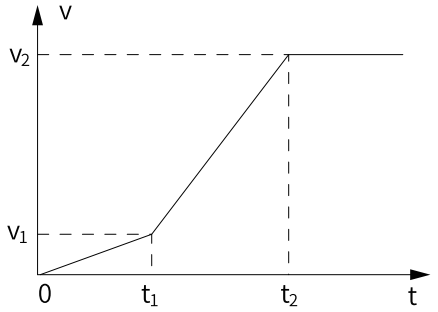


Figure 5-21 Low-speed compensation gain

In the preceding figure, v_1 indicates the speed indicated by C7-21. The motor accelerates from zero speed to v_1 within the acceleration time Ta' = [C7-20] x Ta, where Ta is the enabled acceleration time. The motor accelerates from v_1 to v_2 within the normal acceleration time Ta.

Note

The low-speed compensation gain is active only for acceleration. The motor decelerates according to the active deceleration time.

5.2.6.3 Arc Type Selection

In case of abrupt acceleration or deceleration, the output frequency of the ramp function generator is not smooth and the acceleration rate of the output frequency is discontinuous, which may cause motor torque oscillation and damage to mechanical gears.

- C7-27 = 0 (Continuous arc disabled): Input values are executed immediately after change.
- C7-27 = 1 (Continuous arc enabled): During acceleration, even if the input value suddenly decreases, the motor executes the end arc (overshoot incurred) before deceleration. During deceleration, even if the input value suddenly increases, the motor executes the end arc (overshoot incurred) before acceleration.

Take sudden deceleration during forward acceleration as an example. As shown in *"Figure 5-22 Arc type selection" on page 186*, the target frequency at t_0 is F_3 and the motor accelerates to frequency F_2 at t_1. At this time, the target frequency is set to F_1. The RFG output frequency changes with curve 3 rather than curve 2. This helps to rectify abrupt change of the acceleration rate a at t_1 and reduces impact of the abrupt change on the device.

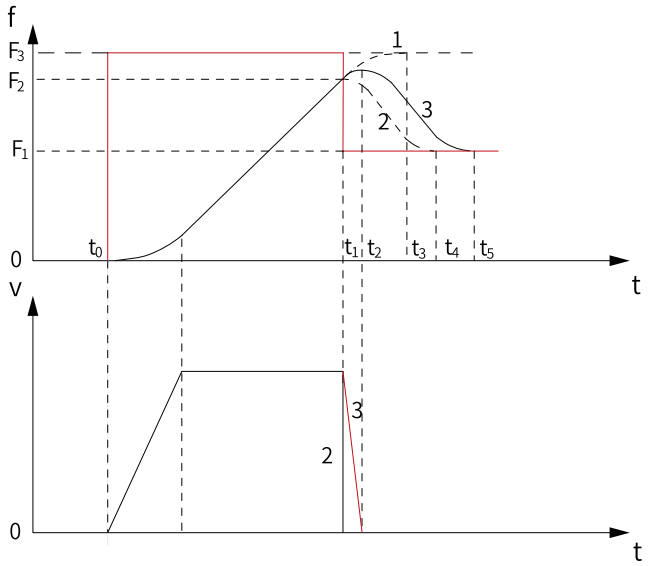


Figure 5-22 Arc type selection

5.2.6.4 Automatic Switchover Between Ramps 1 and 2

The ramp function generator in group C8 switches the acceleration/deceleration time at a certain speed threshold through C8-01...C8-05. This means that the acceleration/deceleration time 1 switches to acceleration/deceleration time 2 when a certain speed is reached, thus meeting the requirements of different acceleration/deceleration time at different speeds. Take forward acceleration/deceleration as an example, as shown in *"Figure 5-23 Automatic switchover of ramps 1/2" on page 187*. Set [C8-00] to 1, [C8-01] to 1, [C8-02] to 1, and [C8-04] to 1.

- Forward acceleration process: Run to V_2 at C8-08 [Acceleration time of ramp 1]. V_2 is the speed threshold defined by C8-03. Switch the acceleration time at V_2 and run to the target speed at C8-10 [Ramp 2 acceleration time].
- Forward deceleration process: Run to V_1 at C8-11 [Acceleration time of ramp 2]. V_1 is the value of C8-03 subtracted by C8-05. Switch the deceleration time at V_1 and run to the target speed at C8-09 [Ramp 1 deceleration time].

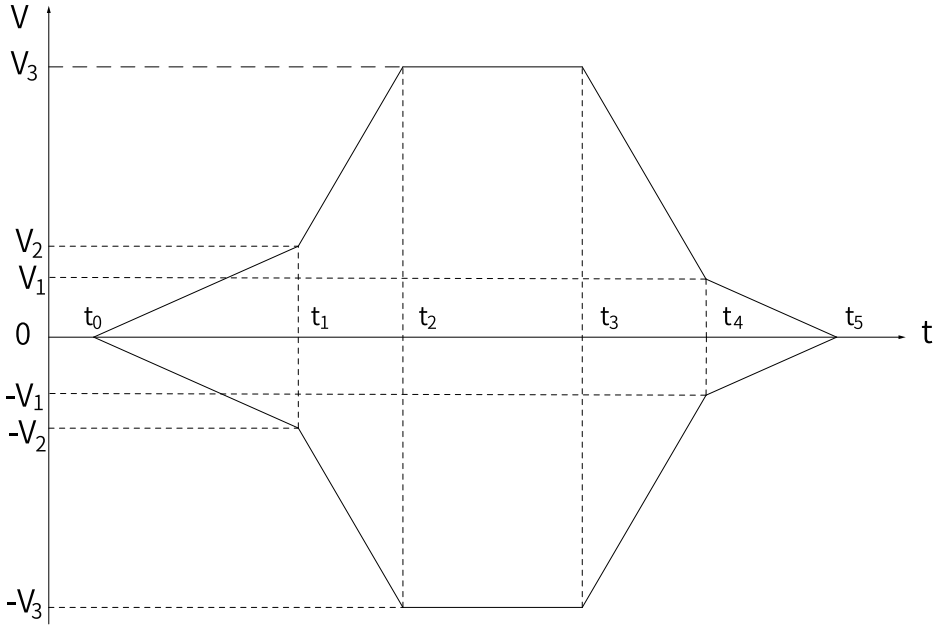


Figure 5-23 Automatic switchover of ramps 1/2

Parameter description:

Param.	Name	Setpoint
C8-01	Automatic switchover between ramps 1 and 2	0: Invalid 1: Valid Others: B connector
C8-02	Speed threshold source for automatic switchover between ramps 1 and 2	0: 0 1: C8-03 Others: K connector
C8-03	Digital reference of speed threshold for automatic switchover between ramps 1 and 2	0.0% to 600%
C8-04	Source of speed hysteresis value for automatic switchover between ramps 1 and 2	0: 0 1: C8-05 Others: K connector
C8-05	Digital reference of speed hysteresis value for automatic switchover between ramps 1 and 2	0.0% to 600%

5.2.6.5 Tracking Function of Ramp Function Generator

In certain operating conditions, such as material digging by electric shovel, the actual motor speed may not follow the speed outputted by the ramp function generator due to high load torque during

acceleration. When the crowd motor decelerates, deceleration may take a long time due to the large deviation between the speed outputted by the ramp function generator and the actual speed. As shown in the figure, the speed reference is n_2 at the moment of t_0, and then it is reduced from n_2 to n_1 at the moment of t_1, but the motor still accelerates to t_2. Though a deceleration command is sent at the moment of t_1, the motor starts decelerating after Δt (Δt = t_2 - t_1). When the tracking function of ramp function generator is enabled, the speed outputted by the ramp function generator actively follows the actual speed when the deviation between the output speed and the actual speed reaches the set error value.

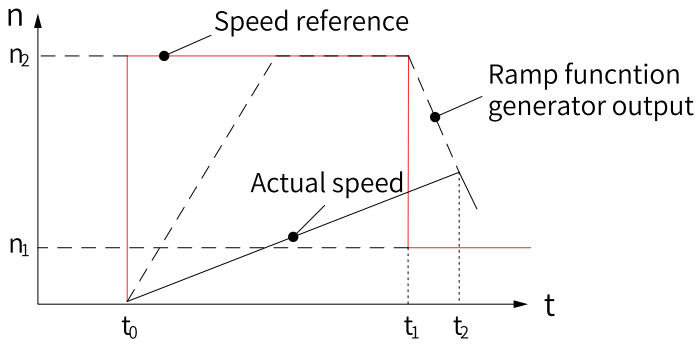


Figure 5-24 Speed outputted by the ramp function generator with tracking function

Related parameters are shown below.

Param.	Name	Setpoint	Default
C7-28	RFG tracking function	0: Disable 1: Enable 2: Torque/Current limit reached (U1-10) Others: B connector	0: Disable
C7-29	Ramp tracking error setting	0.0% to 300.0%	10.0%

When C7-28 is set to 1 [Enable], the tracking function of ramp function generator is activated when the actual speed is lower than the output speed of the ramp function generator by Δn (Δn can be set according to actual conditions). After which, the output speed of ramp function generator is kept at actual speed + Δn/-Δn forcibly. If the specified condition is not met, the tracking state is canceled.

When C7-28 is set to 2 [Torque/Current limit reached (U1-10)], the tracking function of ramp function generator can be activated only when the torque or current reaches the limit. The output speed of the ramp function generator is kept at actual speed + Δn/-Δn forcibly. If the specified condition is not met, the tracking state is canceled.

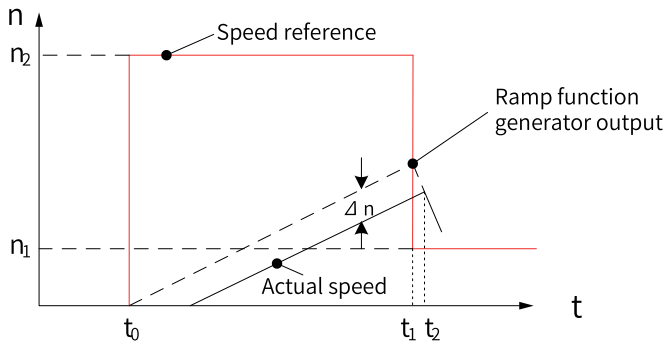


Figure 5-25 Output speed of ramp function generator with tracking function

6 Self-test and Auto-tuning

6.1 System Self-test

The self-test items include IGBT short circuit, IGBT open circuit, output phase loss, current sensor error detection, phase-to-phase unbalance, ground short circuit, and phase loss and output unbalance in parallel mode. It is recommended to perform system self-test before use to check whether the wiring is correct.

The self-test can be started in four ways:

- Manual self-test (b5-01 = 1). After self-test is done, the drive enters the stop state. The manual self-test is a complete self-test, in which all items are executed in about 10s.
- Self-test upon power-on: The drive executes self-test once upon power-on. The self-test upon power-on is not enabled by default. You can enable an individual self-test item through setting the ones of E8-15/16/17/20/21 to 1 respectively.
- Self-test before operation: The drive executes self-test once upon start. The related parameters are E8-15/16/17/20/21. The self-test before operation is not enabled by default. The duration of self-test before operation (E8-16/20/21) can be controlled to a value within 100 ms.

Note

- Flying start cannot be enabled when pre-start self-test is enabled.
- It takes about 10s for the current sensor to perform self-test. For scenarios with requirements on pre-start time, do not enable current sensor self-test in E8-17.
- It takes about 100 ms to complete self-test items other than current sensor self-test. After pre-start self-test is enabled, the startup delay will be increased.

- Self-test before motor parameter auto-tuning: When b5-00 is set to 1/2/3, self-test is executed once before auto-tuning. The self-test items include IGBT short circuit, IGBT open circuit, output phase loss, and current sensor detection errors. You can deactivate the self-test before auto-tuning through b5-07.

The state change process during self-test is as follows.



Note

- If the power of the motor is much lower than that of the drive, the self-test may fail. Therefore, it is recommended to enable the self-test function when the rated motor current is greater than 0.2 x rated current of the drive.
- Do not start the self-test during rotation of the motor because the motor back EMF can result in false fault in self-test.
- In applications where the output of the drive is connected to a short circuit reactor, if the difference between d0-03 [Rated motor current] and A2-05 [Total device current] is excessive, a self-test fault can also be reported.
- When the grid is an IT system, short circuit to ground cannot be detected during self-check. To enable this function, install an insulation monitor to the IT system.

The following figures show different types of grids.

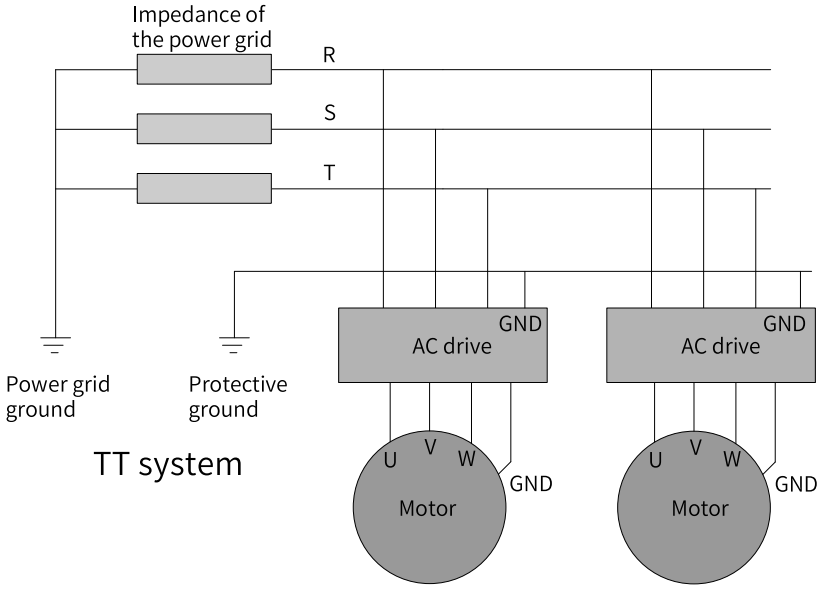


Figure 6-1 TT system

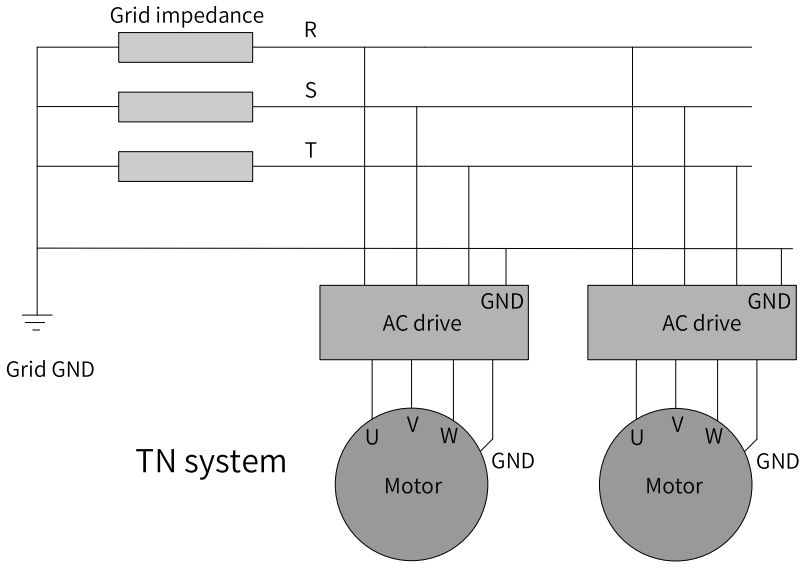


Figure 6-2 TN system

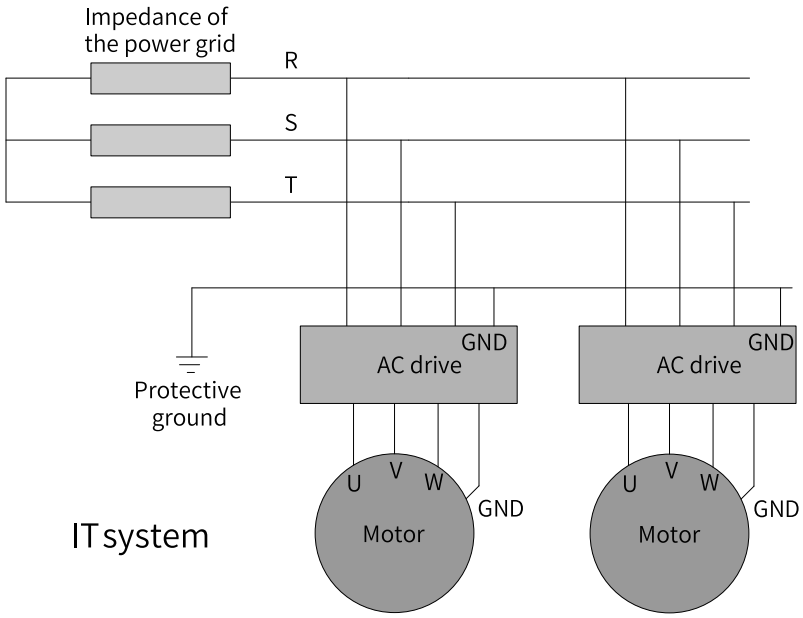


Figure 6-3 IT system

Related parameters

Param.	Name	Setpoint
b5-01	Self-test request	0: None 1: Enable After self-test is done, b5-01 is set to 0 automatically.
E8-15	VI detection mode	Ones: VI self-test before power-on Tens: VI self-test before operation
E8-16	Bridge arm detection mode	Ones: Bridge arm self-test before power-on Tens: Bridge arm self-test before operation
E8-17	Output current sensor CM detection mode	Ones: Current sensor self-test before power-on Tens: Current sensor self-test before operation
E8-20	Ground short circuit detection mode	Ones: Ground short circuit self-test before power-on Tens: Ground short circuit self-test before operation
E8-21	Output phase loss detection mode	Ones: Output phase loss self-test before power-on Tens: Output phase loss self-test before operation Hundreds: Output phase loss self-test during operation

Param.	Name	Setpoint
b5-07	Self-test before auto-tuning	0: Model dependent 1: Disable 2: Enable
E8-48	Self-test (b5-01) mode	bit00: VI detection 0: Invalid 1: Valid bit01: Bridge arm detection 0: Invalid 1: Valid bit02: Output current sensor CM detection 0: Invalid 1: Valid bit03: Reserved 0: Invalid 1: Valid bit04: Reserved 0: Invalid 1: Valid bit05: Ground short circuit detection 0: Invalid 1: Valid bit06: Output phase loss detection 0: Invalid 1: Valid bit07: Current output unbalance detection 0: Invalid 1: Valid bit08 to bit15: Reserved

6.2 Motor Auto-tuning

You can obtain parameters of the controlled motor through motor auto-tuning.

The methods for motor parameter auto-tuning include the following:

- Static auto-tuning (b5-00 = 1): This mode is suitable for asynchronous motors and permanent magnet synchronous motors. The motor does not rotate during auto-tuning and basic parameters of the motor can be auto-tuned. Static auto-tuning is only applicable to applications where a load is connected but the motor cannot rotate. For asynchronous motors, parameters such as mutual inductance, no-load current, mutual inductance characteristic curve, or inertia speed loop cannot be auto-tuned. For synchronous motors, parameters such as the encoder installation position angle, back EMF, and inertia speed loop cannot be auto-tuned. The accuracy of related parameter

is lower than those auto-tuned through no-load complete auto-tuning. If the asynchronous motor uses the SVC mode, it is recommended to set b5-00 to 2 or 3 for auto-tuning.

- When the synchronous motor uses the FVC mode, static auto-tuning is not enough. You need to set b5-00 to 2 or 7 to obtain the encoder mounting position angle. Failure to comply may result in motor runaway.
- When the synchronous motor uses the SVC mode, it is recommended to set b5-00 to 2 to obtain an accurate back EMF or consult the manufacturer to obtain the motor back EMF. Note that static auto-tuning is not enough. Do not input the accurate back EMF manually to start operation in the SVC mode.

- No-load complete auto-tuning (b5-00 = 2): This mode is applicable to asynchronous motors and permanent magnet synchronous motors. The motor rotates during auto-tuning. Therefore, before auto-tuning, ensure that the motor can rotate without causing personal injury or equipment damage. This method applies to the scenario where the motor is unloaded and can be rotate freely. By this method, the most accurate motor parameters can be obtained.
- Static complete auto-tuning of asynchronous motor (b5-00 = 3): This mode is applicable to asynchronous motors only. The motor does not rotate during auto-tuning, and most of the motor parameters can be auto-tuned. This mode applies only to applications where the motor is connected to the load but cannot rotate freely. Parameters such as mutual inductance, no-load current, mutual inductance characteristic curve and inertia speed loop cannot be auto-tuned. The accuracy of auto-tuned motor parameters is slightly lower than those auto-tuned through no-load complete auto-tuning. The auto-tuning performance of this mode is higher than static auto-tuning (b5-00 = 1).

No-load auto-tuning (b5-00 = 2) is recommended for motors that can be disconnected from the load and rotate freely.

The state change process during auto-tuning is as follows:

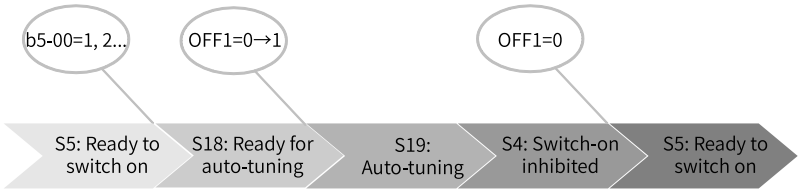


Figure 6-4 State change during auto-tuning

After auto-tuning is done, the auto-tuned motor parameters are automatically saved to corresponding parameters. Parameters to be auto-tuned vary with different auto-tuning modes, as shown in the following table.

Table 6–1 Auto-tuned parameters for asynchronous motors

Param.	Name	b5-00 = 1	b5-00 = 2	b5-00 = 3	b5-00 = 5 <2>	b5-00 = 8 <4>	b5-00 = 9 <5>
d1-02	Motor stator resistance	✓	✓	✓	-	-	-
d1-04	Asynchronous motor rotor resistance	✓	✓	✓	-	-	-
d1-06	Asynchronous motor leakage inductance	✓	✓	□	-	-	-

Param.	Name	b5-00 = 1	b5-00 = 2	b5-00 = 3	b5-00 = 5 <2>	b5-00 = 8 <4>	b5-00 = 9 <5>
d1-08	Asynchronous motor mutual inductance	□<3>	□	□<3>	-	□<3>	□<3>
d1-10	No-load current of asynchronous motor	□<3>	□	□<3>	-	□<3>	□<3>
d1-12	Magnetic field saturation flux coefficient 1 of asynchronous motor	-	□	-	-	□	□
d1-13	Magnetic field saturation mutual inductance coefficient 1 of asynchronous motor	-	□	-	-	□	□
d1-14	Magnetic field saturation flux coefficient 2 of asynchronous motor	-	□	-	-	□	□
d1-15	Magnetic field saturation mutual inductance coefficient 2 of asynchronous motor	-	□	-	-	□	□
d1-16	Magnetic field saturation flux coefficient 3 of asynchronous motor	-	□	-	-	□	□
d1-17	Magnetic field saturation mutual inductance coefficient 3 of asynchronous motor	-	□	-	-	□	□
d1-18	Magnetic field saturation flux coefficient 4 of asynchronous motor	-	□	-	-	□	□
d1-19	Magnetic field saturation mutual inductance coefficient 4 of asynchronous motor	-	□	-	-	□	□
n4-03 n5-03 <1> n6-03	Input A/B phase sequence	-	□	-	-	□	□
d2-02	Moment of inertia ratio	-	□	-	□	-	-
d2-00	Moment of inertia	-	□	-	□	-	-
d2-05	Rated motor startup time	-	□	-	□	-	-
d2-03	Friction torque	-	□	-	□	-	-
E1-02	Pre-excitation time	□	□	□	-	□	□
E1-13	Demagnetization time	□	□	□	-	□	□
E7-04	Speed tracking time	□	□	□	-	□	□

Param.	Name	b5-00 = 1	b5-00 = 2	b5-00 = 3	b5-00 = 5 <2>	b5-00 = 8 <4>	b5-00 = 9 <5>
E4-02	Speed loop Kp in FVC mode	-	□	-	□	-	-
E4-03	Speed loop Ti in FVC mode	-	□	-	□	-	-
E4-04	Speed loop Kp in SVC mode	-	□	-	□	-	-
E4-05	Speed loop Ti in SVC mode	-	□	-	□	-	-

Note

- <1>: If the encoder detection module corresponding to d0-11 is enabled, the corresponding encoder phase sequence is detected and the detection result is written to corresponding parameters of n4-03/n5-03/n6-03.
- <2>: Inertia auto-tuning is only performed in FVC or SVC. It is invalid in V/f control.
- <3>: Set b5-00 to 2 to perform no-load complete auto-tuning if possible. After b5-00 is set to 2 [Dynamic auto-tuning], accurate motor mutual inductance and no-load current can be auto-tuned. The magnetic field saturation coefficient of asynchronous motors can also be auto-tuned to improve the torque control accuracy. In applications where dynamic auto-tuning is not available, set b5-00 to 3 to auto-tune the mutual inductance and no-load current of the motor (the auto-tuning accuracy is lower than dynamic auto-tuning and the saturation coefficient cannot be auto-tuned).
- <4>: Only professionals are allowed to set b5-00 to 8, and b5-00 can be set to 8 only after static auto-tuning (b5-00 = 1) is done. The motor may rotate during auto-tuning.
- <5>: When the motor is connected to the load or the operating distance is limited, you can set b5-00 to 9 for high auto-tuning accuracy of asynchronous motors. For more information on with-load dynamic auto-tuning of asynchronous motors, see *"6.5 Asynchronous Motor With-load Auto-tuning" on page 198*.

Table 6–2 Auto-tuned parameters for synchronous motors

Param.	Name	b5-00 = 1	b5-00 = 2	b5-00 = 5 <2>	b5-00 = 7 <3>	b5-00 = 8 <4>
d1-22	Motor stator resistance	□	□	-	□	-
d1-24	d-axis inductance of synchronous motor	□	□	-	□	-
d1-25	q-axis inductance of synchronous motor	□	□	-	□	-
d1-26	Back EMF voltage of synchronous motor	□	□	-	□	□
n4-03 n5-03 <1> n6-03	Input A/B phase sequence	-	□	-	-	□
n4-12 n5-12 <1> n6-12	Encoder mounting position angle	-	□	-	□	□
d2-02	Moment of inertia ratio	-	□	□	-	-
d2-00	Moment of inertia	-	□	□	-	-
d2-05	Rated motor startup time	-	□	□	-	-
d2-03	Friction torque	-	□	□	-	-
E4-02	Speed loop Kp in FVC mode	-	□	□	-	-

Param.	Name	b5-00 = 1	b5-00 = 2	b5-00 = 5 <2>	b5-00 = 7 <3>	b5-00 = 8 <4>
E4-03	Speed loop Ti in FVC mode	-	□	□	-	-
E4-04	Speed loop Kp in SVC mode	-	□	□	-	-
E4-05	Speed loop Ti in SVC mode	-	□	□	-	-

Note

- <1>: If the encoder detection module corresponding to d0-11 is enabled, the corresponding encoder phase sequence can be detected. The detection result is written to corresponding parameters in n4-03/n5-03/n6-03. The encoder mounting position angle detected is written to corresponding parameters in n4-12/n5-12/n6-12.
- <2>: Inertia auto-tuning is only performed in FVC or SVC mode. It is invalid in V/f control.
- <3>: The with-load complete auto-tuning of synchronous motors in FVC mode is mainly used to auto-tune the encoder mounting position angle instead of the system moment of inertia. This auto-tuning mode applies only to the FVC mode with correct A/B phase sequence.
- <4>: Only professionals are allowed to set b5-00 to 8, and b5-00 can be set to 8 only after static auto-tuning (b5-00 = 1) is done. The motor may rotate during auto-tuning.

When b5-00 is set to 2 (No-load complete auto-tuning), the motor rotates at high speed. Check that mechanical conditions are safe before performing no-load complete auto-tuning. Besides, keep the load torque as close to the no-load torque as possible when the motor rotates at a constant speed. The lower the load, the more accurate the auto-tuned values can be. Heavy load may result in drive overload or overcurrent.

Note

In FVC control mode, before starting a synchronous motor, correctly set the installation position angle of the encoder or obtain it through auto-tuning. If the load cannot be detached and no-load auto-tuning on all parameters (b5-00 = 2) cannot be performed, set b5-00 to 7 to perform FVC with-load auto-tuning on all parameters of synchronous motors. For details, see *"6.4 Synchronous Motor With-Load Auto-Tuning of Encoder Position Angle" on page 198*.

6.3 Auto-Calculation of Speed Loop Parameters

When the moment of inertia cannot be auto-tuned, you can also manually input the inertia of the load, and the control module can automatically calculate the appropriate speed loop control parameters. The speed loop parameter calculation is performed in the following three steps:

1. Manually adjust d2-02 to obtain the correct inertia value in d2-00.
2. Set b5-02 to 2 to select speed loop parameter calculation.
3. Set b5-03 to 1 to confirm the selection of b5-02.

The calculation of speed loop parameters can only be triggered in the shutdown state. The parameters are automatically calculated upon confirmation and you do not need to run the motor. After automatic calculation of speed loop parameters is completed, the following parameters are updated.

Parameter	Name
E4-02	FVC speed loop Kp
E4-03	FVC speed loop Ti

Parameter	Name
E4-04	SVC speed loop Kp
E4-05	SVC speed loop Ti

Note

- d2-00 represents the moment of inertia J of the motor in kg·m², which should be distinguished from the flywheel torque GD² commonly used in engineering. The conversion relationship between them is J = GD²/4 g.
- d2-05 is the rated motor startup time of mechanical systems commonly used in engineering, which indicates the time required for a standstill motor to accelerate to rated speed at rated torque, in seconds. For the same motor, the rated motor startup time has a fixed proportional relationship with the moment of inertia, which can be adjusted by d2-02.

6.4 Synchronous Motor With-Load Auto-Tuning of Encoder Position Angle

If the synchronous motor is in FVC control mode, the encoder position angle must be auto-tuned. Complete auto-tuning (setting b5-00 to 2) is recommended. If complete auto-tuning cannot be performed because the synchronous motor has load, set b5-00 to 7 to perform with-load auto-tuning of all synchronous motor parameters in FVC mode.

When with-load auto-tuning of all synchronous motor parameters in FVC mode is performed for a resolver, the motor is completely standstill during auto-tuning. When an ABZ encoder is used, the motor needs to rotate several turns during auto-tuning of the encoder installation position angle. In this case, open the motor brake if any and then close the brake after auto-tuning is completed. Set the parameters for with-load auto-tuning of all synchronous motor parameters in FVC mode properly to avoid accidents during motor running.

With-load auto-tuning of all synchronous motor parameters can be performed only in FVC mode. Before performing auto-tuning, check whether the input A/B phase sequence of the encoder is correct; if not, the auto-tuned encoder installation position angle may be inaccurate. If the input A/B phase sequence of the encoder cannot be confirmed, after with-load auto-tuning of all synchronous motor parameters is completed in FVC mode, observe the motor running status. If motor locked-rotor or serious jitter during motor forward and reverse running occurs, change the encoder input AB phase sequence in n4-03/n5-03/n6-03 or change any phases of the power cable, and then perform with-load auto-tuning of all synchronous motor parameters in FVC mode again.

Parameter	Name
b5-11	[With-load auto-tuning of all synchronous motor parameters] Running speed
b5-12	[With-load auto-tuning of all synchronous motor parameters] Running direction
b5-15	[With-load auto-tuning of all synchronous motor parameters] Acceleration time
b5-16	[With-load auto-tuning of all synchronous motor parameters] Deceleration time

6.5 Asynchronous Motor With-load Auto-tuning

With-load dynamic auto-tuning

In no-load dynamic auto-tuning, the motor coupling needs to be removed first. However, production lines for metallurgy and paper-making, for example, are equipped with large motors which cannot be removed easily. In this case, asynchronous motor with-load dynamic auto-tuning can be performed without removing the coupling, which applies to applications of cranes, fans, water pumps, inertia loads (rollers), petrochemical and metallurgy.

- Asynchronous motor with-load dynamic auto-tuning does not require removal of the coupling. The parameter auto-tuning is related to the magnitude of the load. Dynamic auto-tuning can be performed in the motoring and generating states for loads that equal to or lower than 50% of rated load. In full load state, the mutual inductance, no-load current, and encoder error can be auto-tuned.

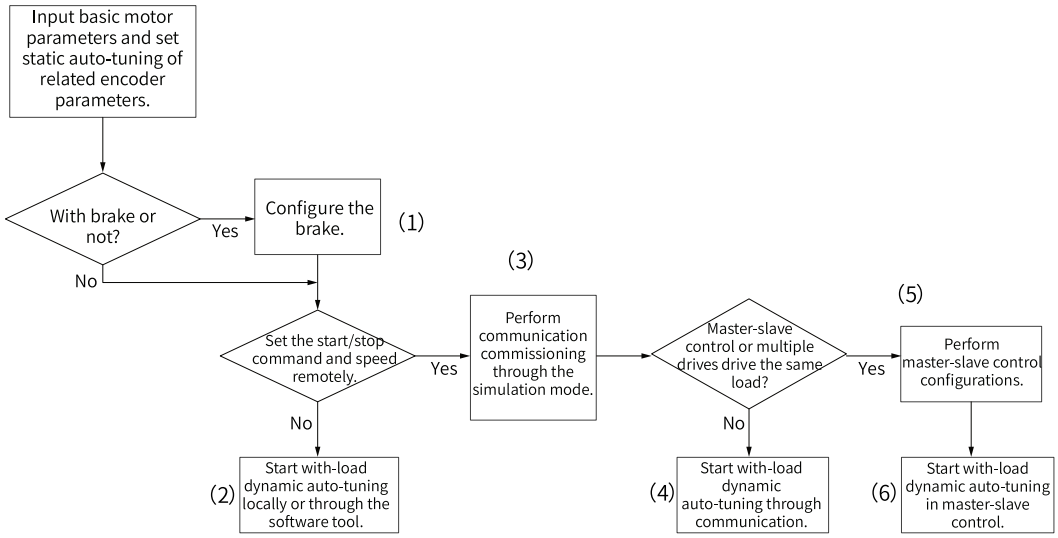
Auto-tuned content	Torque output below 50%	Torque output above 50%
Mutual inductance and no-load current	Active	Active
Mutual inductance saturation curve	Active	X
Encoder signal feedback, encoder pulses per revolution, automatic adjustment of reverse encoder direction, and encoder signal interference	Active	Active

- Auto-tuning can be achieved with a motor speed above 25% of rated speed. Auto-tuning at low speed reduces possible mechanical hazards and derates the auto-tuning load of fans and water pumps to be lower than 50% of rated load, ensuring successful dynamic auto-tuning.
- The auto-tuning frequency reference source can be set through the program or through operation and is suitable for applications with limit signals. You can shorten the auto-tuning time and adjust the auto-tuning speed as needed to reduce the auto-tuning travel.
- The use of with-load rotation auto-tuning can prevent oscillation in no-load rotation auto-tuning.
- In SVC mode, accurate no-load current and mutual inductive reactance are required to ensure satisfactory device performance. When the motor cannot be disconnected from the coupling, perform no-load dynamic auto-tuning. Otherwise, perform with-load dynamic auto-tuning if it is allowed by the motor. If the preceding two auto-tuning methods are not allowed, perform static complete auto-tuning.

Before asynchronous motor with-load rotation auto-tuning, perform the following operations:

- Enter the basic motor parameters of group d0 correctly. You do not need to enter the number of motor pole pairs if it is lower than 12 pairs. Enter the motor power factor (cosϕ) properly according to the motor nameplate. If a drive is connected to multiple motors of same models, enter the motor nameplate parameters and the number of paralleled motors (d0-10).
- If an encoder card is available, activate the encoder card and enter the correct encoder parameters. D0-11 is used to select the encoder detection module (encoder module 1 by default). The corresponding encoder slot is activated in group n4. Select the corresponding encoder type and set other corresponding parameters. For more details, see *" Encoder Speed Measurement" on page 414*.
- The stator resistance, rotor resistance, and leakage inductance are obtained through static auto-tuning.
- Minimize the load for auto-tuning. For example, avoid any heavy load for the crane or material feeding for the extruder to derate the load to be lower than 50% of rated load. However, inertia load with small friction force does not affect auto-tuning.
- If the motor is connected to a passive load without brake control, such as fans, water pumps, and rollers, you can perform with-load dynamic auto-tuning after static auto-tuning is done.

The following figure shows the steps that need to be confirmed before auto-tuning.



Brake configuration

The HCU-50S/51S controller is suitable for brake control. Configure RO3 (relay with long lifetime) to brake output. For details, see *" Brake Control" on page 422*.

Auto-tuning at the speed defined locally or defined by the software tool

In applications with position limits such as cranes, sufficient travel space must be reserved. Take the RTG hoist motor as an example, the asynchronous motor with-load dynamic auto-tuning lasts for about 40s (for 200 kW motors), with a speed set to 30% of rated hoisting speed (22 m/min). In that case, the hoisting speed should be 6.6 m/min during auto-tuning, with a hoisting/descending height of 4.4 m in 40s (calculated based on default acceleration/deceleration time). To reduce auto-tuning travel, set the value of acceleration/deceleration time as low as possible.

Set the target speed through the control panel or multi-references. The target speed must be greater than 25% and can be set as positive or negative. Set b5-00 to 9 (Asynchronous motor with-load dynamic auto-tuning). Start auto-tuning through the control panel or terminal. The motor stops automatically (as determined by tens of b5-08) by default after auto-tuning is done.

Communication commissioning during simulation

With-load dynamic auto-tuning is used in applications where the coupling cannot be removed easily and the motor cannot be started though the software tool. Ensure that the motor runs properly before performing auto-tuning through remote communication. Use the simulation mode to commission the operation commands and references. Perform the communication commissioning as follows.

1. Configure parameters of the communication card.
2. Confirm the communication state with PLC.
3. When there is no residual voltage left in the bus, set A8-22 to 1 (Simulation operation mode). In the simulation mode, the bus voltage must be lower than 48 V, with no IGBT output or brake action. Check the data for simulation when commissioning the communication with PLC.
4. In the simulation mode, you can check whether the motor starts/stops properly with normal speed through the software tool or PLC.

5. Ensure that the stop signal can be responded to normally. (During testing, set the emergency stop to OFF2. OFF3 is not used during test to prevent stop failure.)
6. Check that the motor runs properly in the simulation mode. Then, set A8-22 to 0 and switch on the power supply for the bus.

With-load dynamic auto-tuning

You can implement basic control of the motor through preceding communication and brake configurations. If the load is driven by a single motor without master-slave control or droop control, set b5-10 (Maximum speed for auto-tuning) properly. Set b5-00 to 9 (Asynchronous motor with-load dynamic auto-tuning) to start the motor. The target speed set by the user must be greater than 25%. Otherwise, auto-tuning can fail.

Master-slave control configuration in with-load dynamic auto-tuning

Remote master-slave control commissioning for with-load auto-tuning:

1. Start only one motor for auto-tuning and disconnect other motors if possible.
2. If multiple drives are expected to run at the same time, commission the master-slave control. Generally, for auto-tuning through master/slave control, only one motor is allowed to run in the auto-tuning state.
3. It is recommended to use the droop function for load distribution during auto-tuning. Set b5-10 to 100% to release the speed limit during auto-tuning. Set the speed to a value between 30% to 70%. Set E4-14 to 1 (Droop enable) to achieve motor load balance. Then, set the droop coefficient (E4-16). For example, when the rated frequency is 50 Hz, with a rated speed of 1460 r/min and 2 pole pairs, set E4-16 as shown in $\text{E4-16[Droop coefficient]} = \text{Rated slip} = 1 - \frac{\text{Rated speed x Number of pole pairs}}{\text{Rated frequency x 60}} = 2.6\%$.
4. After the master-slave control is configured properly, perform the auto-tuning through master-slave control.

With-load dynamic auto-tuning in master/slave control

- Set the motor parameters for each drive properly and perform static auto-tuning.
- Ensure that each drive is equipped with the brake and communication properly to receive commands and operate properly in the simulation mode.
- Enable only one drive during auto-tuning, while other AC drives run normally. If other motors are with encoders and operate in FVC mode, switch to SVC mode to prevent operation faults caused by signal reversal or improper connection of the encoder.
- Set b5-00 to 9 (Asynchronous motor with-load dynamic auto-tuning) for the drive to be auto-tuned. Set the tens of b5-08 (Stop mode of asynchronous motor with-load dynamic auto-tuning) to 1 (Manual stop). Run the motor for a while, and stop it after auto-tuning is done, that is, when the state machine (A0-00) enters from the auto-tuning state (19) to operational state (12).
- After auto-tuning is done, set the auto-tuned no-load current mutual inductance and saturation curve to other drives that are not auto-tuned (provided that all AC drives are connected to motors of the same model).

Param.	Name
d1-08	Asynchronous motor mutual inductance
d1-10	No-load current of asynchronous motor
d1-12	Magnetic field saturation flux coefficient 1 of asynchronous motor
d1-13	Magnetic field saturation mutual inductance coefficient 1 of asynchronous motor

Param.	Name
d1-14	Magnetic field saturation flux coefficient 2 of asynchronous motor
d1-15	Magnetic field saturation mutual inductance coefficient 2 of asynchronous motor
d1-16	Magnetic field saturation flux coefficient 3 of asynchronous motor
d1-17	Magnetic field saturation mutual inductance coefficient 3 of asynchronous motor
d1-18	Magnetic field saturation flux coefficient 4 of asynchronous motor
d1-19	Magnetic field saturation mutual inductance coefficient 4 of asynchronous motor
E1-02	Pre-excitation time

- Perform auto-tuning in the same way for encoders of other motors as required.

Parameters related to asynchronous motor with-load dynamic auto-tuning are as follows.

Param.	Name	Setpoint
b5-00	Auto-tuning request	9: Asynchronous motor with-load dynamic auto-tuning
b5-08	Auto-tuning switch selection	Tens: Stop mode of asynchronous motor with-load dynamic auto-tuning 0: Automatic stop 1: Manual stop, mainly used in auto-tuning through master-slave control to ensure that multiple motors stop at the same time
b5-09	Speed reference source of asynchronous motor with-load dynamic auto-tuning	0: User-defined. The speed reference is set through software tool, communication, or AI. 1: Internal reference. The speed is 40% by default. When the hundreds of b5-08 is set to 1 and b5-00 is set to 2, the speed is defined by internal reference by default.
b5-10	Speed limit of asynchronous motor with-load dynamic auto-tuning	The speed limit is 40% by default. The motor speed does not exceed this limit during auto-tuning.

Note

Release the torque limit during with-load dynamic auto-tuning. For example, if the limit value is 0 after the torque limit is configured through communication, the motor cannot accelerate during auto-tuning, which can result in auto-tuning failure.

7 Control Interface

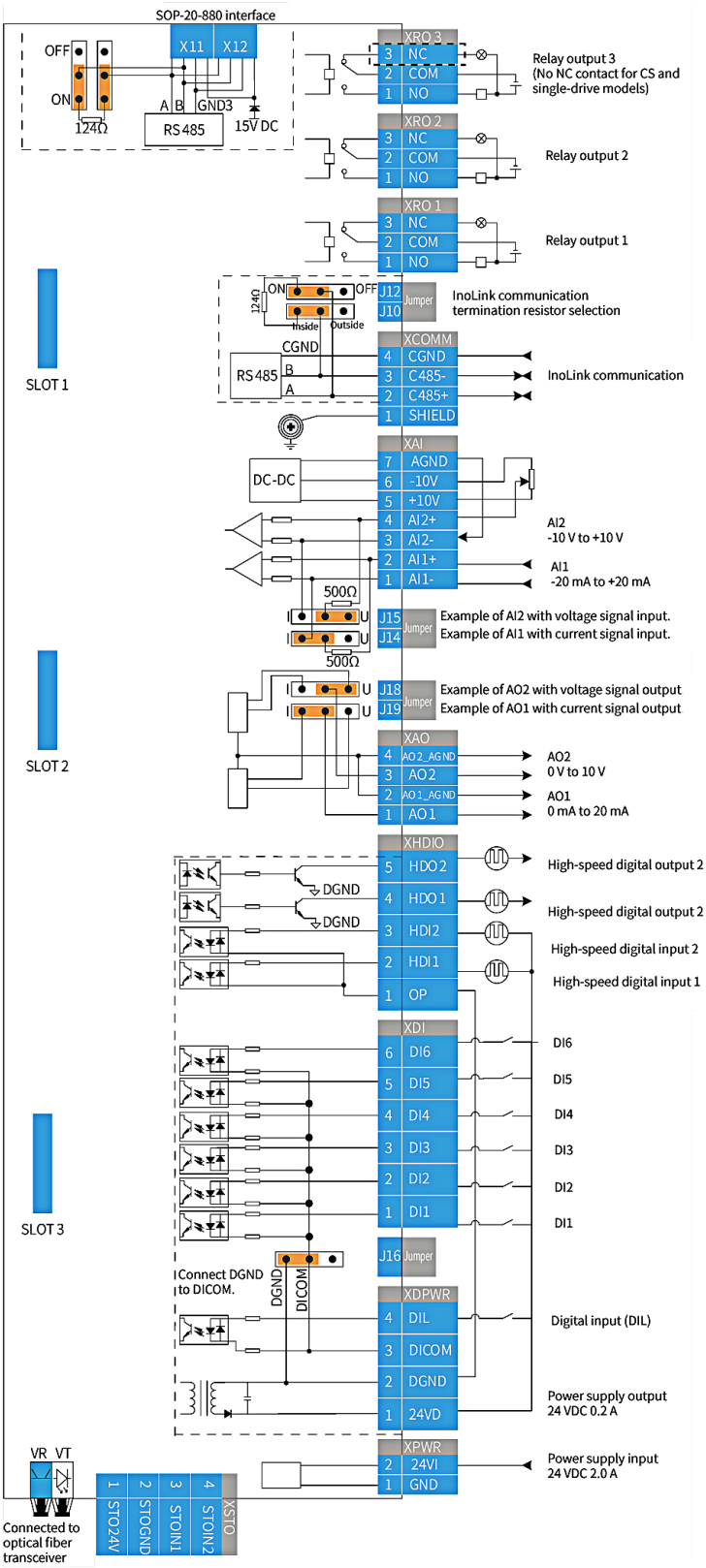


Figure 7-1 Overview of HCU interface circuits

The HCU-50S/51S controller comes standard with 7 DIs (DI1 to DI6 and DIL), 2 high-speed HDIs, 3 ROs, 2 high-speed HDOs, 2 AIs, and 2 AOs. The parameters to be set are in group F.

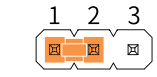
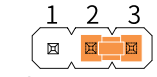
The AI and AO combination can be used to measure the motor temperature. For details, see *"9.1.2 Motor Temperature Detection with AI/AO" on page 413*.

HCU-50S/51S supports the simultaneous use of up to 3 HIO modules to expand the input and output interfaces of HCU control modules. The HIO-10 module includes 2 DIOs, 2 AIs, 2 AOs, and 1 RO; the HIO-20 module includes 5 DIOs and 2 ROs; the HIO-30 module includes 6 DIs, 6 DIOs, 4 ROs, 3 AOs, and 3 AIs.

7.1 Digital Input (DI)

The HCU-50S/51S control module comes standard with 7 DIs and 2 HDIs, which can be configured as DIs. The corresponding function diagrams are H110 and H114. Before using DI terminals, configure the DI internal and external power supply selection jumper J16 (DICOM or DGND) based on the actual hardware connection.

Table 7–1 DI internal and external power supply selection jumper

Jumper J16: power supply selection	
	By shorting DGND and DICOM, DI is powered by the 24 VDC internal power supply.
	When DGND is disconnected from DICOM, DI is powered by the external power supply.

7.1.1 Forced DI

The DI state can be set forcibly. F0-02 is used to select the DI to be set forcibly, and F0-03 is used to set the status of the forced DI. One bit corresponds to the status of one DI. bit0 to bit5 correspond to DI1 to DI6, bit 6 corresponds to DIL, bit 7 corresponds to HDI1, and bit 8 corresponds to HDI2, as shown below.

F0-02		DI1 (U0-02)	DI2 (U0-03)	DI3 (U0-04)	DI4 (U0-05)	DI5 (U0-06)	DI6 (U0-07)	DIL (U0-08)	HDI1 (U0-09)	HDI2 (U0-10)
bit0	0	Hard-ware DI1	x	x	x	x	x	x	x	x
	1	F0-03 (bit0)	x	x	x	x	x	x	x	x
bit1	0	x	Hard-ware DI2	x	x	x	x	x	x	x
	1	x	F0-03 (bit1)	x	x	x	x	x	x	x

F0-02		DI1 (U0-02)	DI2 (U0-03)	DI3 (U0-04)	DI4 (U0-05)	DI5 (U0-06)	DI6 (U0-07)	DIL (U0-08)	HDI1 (U0-09)	HDI2 (U0-10)
bit2	0	x	x	Hard-ware DI3	x	x	x	x	x	x
	1	x	x	F0-03 (bit2)	x	x	x	x	x	x
bit3	0	x	x	x	Hard-ware DI4	x	x	x	x	x
	1	x	x	x	F0-03 (bit3)	x	x	x	x	x
bit4	0	x	x	x	x	Hard-ware DI5	x	x	x	x
	1	x	x	x	x	F0-03 (bit4)	x	x	x	x
bit5	0	x	x	x	x	x	Hard-ware DI6	x	x	x
	1	x	x	x	x	x	F0-03 (bit5)	x	x	x
bit6	0	x	x	x	x	x	x	Hard-ware DIL	x	x
	1	x	x	x	x	x	x	F0-03 (bit6)	x	x
bit7	0	x	x	x	x	x	x	x	Hard-ware HDI1	x
	1	x	x	x	x	x	x	x	F0-03 (bit7)	x
bit8	0	x	x	x	x	x	x	x	x	Hard-ware HDI2
	1	x	x	x	x	x	x	x	x	F0-03 (bit8)
bit9 to bit15	x	x	x	x	x	x	x	x	x	x

7.1.2 DI Delay

Each DI of HCU-50S/51S can be set with a ON delay and OFF delay separately. As shown by *"Figure 7-2 Sequence diagram of DI ON/OFF delay" on page 206*, both the ON delay and OFF delay can be filtered. When the hold time of DI signal state is shorter than the set time, the DI state remains in the original state. Set the ON delay and OFF delay for each DI through F0-04 to F0-21.

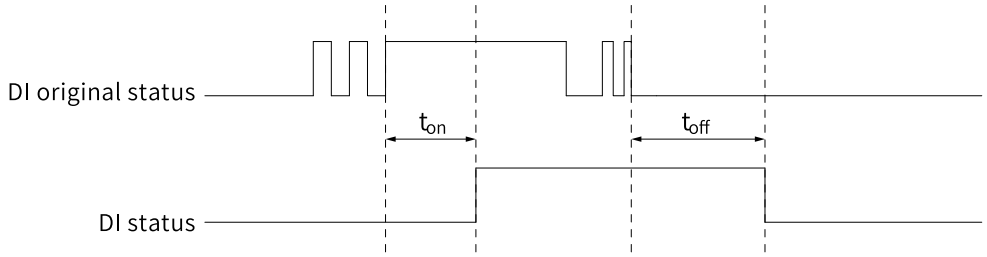


Figure 7-2 Sequence diagram of DI ON/OFF delay

In ON delay, high-level pulses with the period shorter than t_{on} can be filtered out. Therefore, the first two pulses of the signal source are filtered out. The third pulse of the signal source rises and changes to high level after the t_{on} delay elapses.

The OFF delay is t_{off}, during which the low level that shorter than t_{off} time can be filtered out, as shown in the preceding figure. The ON/OFF delay can be used to filter out interference or control logic delay. The related parameters include F0-04 to F0-21.

7.1.3 DI Connector

When DI is used in controlling the drive or other purposes, correlate corresponding parameters to the DI connector. Two groups of bit connectors are available for DI status.

Param.	Description	Param.	Description
U0-02	DI1 status	U0-12	DI1 status inverted
U0-03	DI2 status	U0-13	DI2 status inverted
U0-04	DI3 status	U0-14	DI3 status inverted
U0-05	DI4 status	U0-15	DI4 status inverted
U0-06	DI5 status	U0-16	DI5 status inverted
U0-07	DI6 status	U0-17	DI6 status inverted
U0-08	DIL status	U0-18	DIL status inverted
U0-09	HDI1 status	U0-19	HDI1 status inverted
U0-10	HDI2 status	U0-20	HDI2 status inverted

7.2 Digital Output (DO)

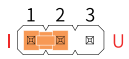
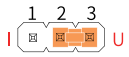
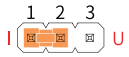
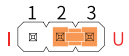
HCU-50S/51S supports 3 ROs, and 2 HDOs, which can also be used as DOs. The DO function is configured according to the function diagrams H112 and H116. The three ROs and two HDOs (as DOs) support independent setting of switch-on delay and switch-off delay. They also support negative logic (set through F1-17).

When the negative logic is enabled, logic 0 indicates that the output (normally open) is enabled, and logic 1 indicates that the output (normally open) is disabled.

F1-00 indicates the DO source signal status. F1-01 indicates the status after delay logic and negative logic processing.

7.3 Analog Input (AI)

The HCU-50S/51S supports two AI inputs (current signal input or voltage signal input). Before using AI, check whether the external signal is a current signal or voltage signal and then set jumpers J14 and J15 properly. Then, set F2-04 and F2-05 properly.

Jumper J14: Current or voltage signal input selection for AI1
 Current signal input applies for AI1 when pins 1 and 2 are shorted.
 Voltage signal input applies for AI1 when pins 2 and 3 are shorted.
Jumper J15: Current and voltage signal selection for AI2
 Current signal input applies for AI2 when pins 1 and 2 are shorted.
 Voltage signal input applies for AI2 when pins 2 and 3 are shorted.

For implementation of AI functions, see H120. For details, see the following table.

Param.	Name	Description
F2-00	AI1 input value	Displays AI1 input value in V or mA as defined by F2-04.
F2-01	AI1 input scaling	Displays the percentage corresponding to AI1 input, which is the final output after being processed by the AI module.
F2-02	AI2 input value	Displays AI2 input value in V or mA as defined by F2-05.
F2-03	AI2 input scaling	Displays the percentage corresponding to AI2 input, which is the final output after being processed by the AI module.
F2-04	AI1 type	Defines the input signal type of AI1 or AI2. Connect jumpers properly on the HCU end based on the signal type. 0: -10 V to +10 V; 1: 0 V to 10 V; 2: -20 mA to +20 mA; 3: 0 mA to 20 mA; 4: 4 mA to 20 mA
F2-05	AI2 type	
F2-06	Minimum input value of AI1 curve	Used to calibrate AI1. F2-06 and F2-08 also limit the range of AI1 input (the unit is V or mA as defined by F2-04). Within the value range, the output percentage is converted linearly. When the input value is lower than F2-06, the default output is [F2-07], or you can set the output to 0.0% through the ones of F2-14 [Selection when AI value lower than minimum input value].
F2-07	Minimum input scaling of AI1 curve	
F2-08	Maximum input value of AI1 curve	
F2-09	Maximum input scaling of AI1 curve	
F2-10	Minimum input value of AI2 curve	Used to calibrate AI2. F2-10 and F2-12 also limit the range of AI2 input (the unit is V or mA as defined by F2-05). Within the value range, the output percentage is converted linearly. When the input value is lower than F2-10, the default output is [F2-11], or you can set the output to 0.0% through the tens of F2-14 [Selection when AI value lower than minimum input value].
F2-11	Minimum input scaling of AI2 curve	
F2-12	Maximum input value of AI2 curve	
F2-13	Maximum input scaling of AI2 curve	

Param.	Name	Description
F2-14	Selection of AI lower than the minimum input setting	Ones: Selection when AI1 value lower than the minimum input value - 0: Minimum input scaling; 1: 0.0% Tens: Selection when AI2 value lower than the minimum input value - 0: Minimum input scaling; 1: 0.0%
F2-15	AI1 filter time	Defines the AI filter time, which can remove interference and generate a delay effect.
F2-16	AI2 filter time	
F2-17	AI1 de-noising threshold	Defines the de-noising threshold. When the AI input fluctuation is lower than the set threshold, the AI input scaling remains unchanged.
F2-18	AI2 de-noising threshold	
F2-19	Zero-crossing threshold of AI setting	When the AI input value is lower than the threshold, the AI input value is 0.
F2-20	AI1 selection	Used to enable or disable AI1. When this parameter is disabled, AI1 is set to 0 forcibly.
F2-21	AI2	Used to enable or disable AI2. When this parameter is disabled, AI2 is set to 0 forcibly.
F2-26	AI open circuit monitoring	Used to enable or disable open circuit monitoring, which is active only when the signal type is 4 mA to 20 mA. When the AI input value is lower than the open circuit threshold for a period of time longer than the open circuit monitoring delay, AI is disconnected. Ones: AI1 open circuit monitoring 0: Inhibited 1: Enabled Tens: AI2 open circuit monitoring 0: Inhibited 1: Enabled
F2-22	AI1 open circuit monitoring threshold	0.000 mA to 4.000 mA
F2-23	AI2 open circuit monitoring threshold	0.000 mA to 4.000 mA
F2-24	AI1 open circuit monitoring delay	0.00s to 10.00s
F2-25	AI2 open circuit monitoring delay	0.00s to 10.00s

Note

When AI1 is assigned with the function of motor temperature measurement by E8-22. When AI2 is assigned with the function of motor temperature measurement by E8-22, the setting on AI2 is invalid.

In some applications, the AI signal is used as the speed reference. You can use the AI monitoring function to monitor the actual value of AI in real time and trigger protective actions once the AI exceeds the limit. After this function is enabled, the minimum and maximum values of AI monitoring need to be set. When the actual value of AI input exceeds the minimum or maximum values, the corresponding protective action can be triggered. The following five modes of action are included.

- No action
- Fault reported
- Alarm reported and operating at the end speed
- Alarm reported and operating at safe speed

- Alarm reported only

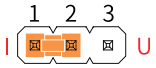
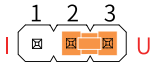
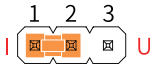
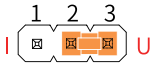
See the following table for the related parameters and descriptions.

Param.	Name	Description
F2-28	Minimum reference value monitored by AI1	Defines the minimum value monitored by AI1.
F2-30	Maximum reference value monitored by AI1	Defines the maximum value monitored by AI1.
F2-32	Minimum reference value monitored by AI2	Defines the minimum value monitored by AI2.
F2-34	Maximum reference value monitored by AI2	Defines the maximum value monitored by AI2.
F2-35	Hysteresis value monitored by AI	Defines the hysteresis value monitored by AI. For example, the maximum value is set to 8, the minimum value is set to 2, and the default hysteresis value monitored by AI is 0.2, then AI monitoring is activated when the AI input is higher than 8.2 V or lower than 1.8 V in voltage mode. The activation flag is cleared when the AI input is restored to a value between 2 V and 8 V.
F2-36	AI monitoring function	Used as the switch for enabling the AI monitoring function.
F2-37	AI monitoring activation condition	Used to set the activation conditions for AI monitoring. You can configure multiple conditions at a time. bit00: AI1 value < Minimum value of AI1 bit01: AI1 value > Maximum value of AI1 bit02: AI2 value < Minimum value of AI2 bit03: AI2 value > Maximum value of AI2
F2-38	AI monitoring control channel selection	Specifies the control channel under which AI monitoring can be activated. Multiple channels can be configured at a time. bit00: Activating AI1 monitoring through remote setting channel 1 bit01: Activating AI1 monitoring through remote setting channel 2 bit02: Activating AI1 monitoring through local operating panel bit03: Activating AI2 monitoring through remote setting channel 1 bit04: Activating AI2 monitoring through remote setting channel 2 bit05: Activating AI2 monitoring through local operating panel
F2-39	Protection class triggered during AI monitoring	Defines the protective actions of the drive when AI monitoring is activated. 0: No action 1: Fault reported 2: Alarm reported and operating at the end speed 3: Alarm reported and operating at safe operating speed 4: Alarm reported only
F2-40	Safe operating speed triggered during AI monitoring	The setpoint 3 in F2-39 represents the safe operating speed.

7.4 Analog Output (AO)

The HCU-50S/51S control module provides two AOs and supports two signal types: voltage and current. Before using AO, set jumpers J18 and J19, and configure parameters F3-06 and F3-07.

Table 7–2 AO output signal selection jumper

Jumper J19: AO1 current and voltage signal selection
 AO1 current signal output applies when 1 and 2 are shorted.
 AO1 voltage signal output applies when 2 and 3 are shorted.
Jumper J18: AO2 current and voltage signal selection
 AO2 current signal output applies when 1 and 2 are shorted.
 AO2 voltage signal output applies when 2 and 3 are shorted.

For the use of the AOs, see function diagram H122. The function parameters are shown in the following table.

Param.	Name	Description
F3-00	AO1 output value	Shows the AO1 output value, which is set through F3-06, in V or mA.
F3-01	AO1 output scaling	Shows the percentage of AO1 output, corresponding to [F3-04].
F3-02	AO2 output value	Shows the AO2 output value, which is set through F3-07, in V or mA.
F3-03	AO2 output scaling	Shows the percentage of AO2 output, corresponding to [F3-05].
F3-04	AO1 signal source	Defines the signal source of AO1 output.
F3-05	AO2 signal source	Defines the signal source of AO2 output.
F3-06	AO1 type	Defines the signal type output by AO1 or AO2, which requires proper wiring. See *HCU Control Unit Hardware User Guide* for details. 0: 0 V to 10 V 1: 0 mA to 20 mA 2: 4 mA to 20 mA
F3-07	AO2 type	
F3-08	[AO1 curve] Minimum output scaling	Defines the calibration factor for AO1. F3-08 and F3-10 also limit the range of AO1 output percentage. Within the range, the output value is obtained by linear conversion (unit: V or mA, depending on F3-06).
F3-09	[AO1 curve] Minimum output value	
F3-10	[AO1 curve] Maximum output scaling	
F3-11	[AO1 curve] Maximum output value	

Param.	Name	Description
F3-12	[AO2 curve] Minimum output scaling	Defines the calibration factor of AO2. F3-12 and F3-14 also limit the range of AO2 output percentage. Within the range, the output value is obtained by linear conversion (unit: V or mA, depending on F3-07).
F3-13	[AO2 curve] Minimum output value	
F3-14	[AO2 curve] Maximum output scaling	
F3-15	[AO2 curve] Maximum output value	

Note

- When the motor temperature is measured through AI1 as defined by E8-22, the setting of AO1 is invalid.
- When the motor temperature is measured through AI2 as defined by E8-22, the setting of AO2 is invalid.

7.5 High-Speed Digital Input (HDI)

The HCU-50S/51S control module supports two HDI signals, which are described in detail in the HCU Control Unit Hardware Guide. For software functions, see function diagram H114.

- HDI can be used as DI. For details about relevant parameter settings in this case, see *" Digital Input (DI)" on page 204*.
- HDI1 is forced to be used as DI, and is used as the reactor over-temperature detection signals.

7.6 High-Speed Digital Output (HDO)

HCU-50S/51S supports two HDOs. The HDOs require external pull-up resistors. For details about the HDOs, see the HCU Control Unit User Guide. For software functions, see function diagram H116.

Note

HDO can be used as DO. For details of relevant parameter settings in this case, see *"7.2 Digital Output (DO)" on page 206*.

7.7 Input/Output Function Module (HIO)

- Parameter groups n7, n8, and n9 provide HIO module enable selection and status display.
- Parameter groups n23, n26, and n29 are used to configure DIO, RO, AI, and AO of the HIO-10 module.
- Parameter groups n24, n27, and n30 are used to configure DIO and RO of the HIO-20 module.
- Parameter groups n25, n28, and n31 are used to configure DI, DIO, RO, AI, and AO of the HIO-30 module.

The relationship is shown in the following table.

Param.	Description
n7-02	0: Disabled 1: HIO-10, group n23 activated, and groups n24 and n25 hidden 2: HIO-20, group n24 activated, and groups n23 and n25 hidden 3: HIO-30, group n25 activated, and groups n23 and n24 hidden
n8-02	0: Disabled 1: HIO-10, group n26 activated, and groups n27 and n28 hidden 2: HIO-20, group n27 activated, and groups n26 and n28 hidden 3: HIO-30, group n28 activated, and groups n26 and n27 hidden
n9-02	0: Disabled 1: HIO-10, group n29 activated, and groups n30 and n31 hidden 2: HIO-20, group n30 activated, and groups n29 and n31 hidden 3: HIO-30, group n31 activated, and groups n29 and n30 hidden

Parameters of the HIO-10 module are described in the following table.

Param.	Description
n7-00 (n8-00, n9-00)	Defines the position of the HIO module extension slot.
n7-02 (n8-02, n9-02)	Module type selection: 0: Disabled 1: HIO-10 2: HIO-20 3: HIO-30
n7-01 (n8-01, n9-01)	Displays HIO module online status.
n7-10 (n8-10, n9-10)	Displays DIO configuration status.
n7-11 to n7-14 (n8-11 to n8-14, n9-11 to n9-14)	Displays DI, DIO, RO input and output status.
n7-15 (n8-15, n9-15)	Displays AI input status.
n7-20 to n7-25 (n8-20 to n8-25, n9-20 to n9-25)	Displays AI input value and AI input scaling.
n7-30 to n7-35 (n8-30 to n8-35, n9-30 to n9-35)	Displays AO output scaling and AO output actual value.
n23-00 (n26-00, n29-00)	Defines DI/DIO input filter time.
n23-09 to n23-15 (n26-09 to n26-15, n29-09 to n29-15)	Define the positive and negative logic, signal source, switch-on time, and switch-off time of DIO.
n23-20 to n23-23 (n26-20 to n26-23, n29-20 to n29-23)	Define positive and negative logic, signal source, switch-on delay, and switch-off delay of RO.
n23-35 to n23-37 (n26-35 to n26-37, n29-35 to n29-37)	Define the action for the AI that lower than the minimum input setting, AI disconnection monitoring, and zero-crossing threshold of AI setting.
n23-40 to n23-59 (n26-40 to n26-59, n29-40 to n29-59)	Define the AI enable state, AI type <1>, AI curve parameter, AI filter time, AI denoising threshold, AI disconnection monitoring threshold, and AI disconnection monitoring delay.
n23-70 to n23-85 (n26-70 to n26-85, n29-70 to n29-85)	Define AO signal source, AO type <1> and AO curve parameters.

Note

<1>: The function selection of AI type and AO type is consistent with the hardware DIP switch (jumper).

7.7.1 Digital Input (DI or DIO)

Before using the DIOs, see *HIO-10 I/O Function Module User Guide* for HIO power supply selection and peripheral circuit wiring.

Take the HIO-10 as an example. When n7-00 and n7-02 are both set to 1, configure DIO1 and DIO2 as DIs or DOs through n23-10 and n23-13. The following figure shows the DIO software functions of HIO. When DI is selected through n23-10/n23-13, the DI signals is processed with the input filter, switch-on delay, switch-off delay, and positive/negative logic. When B connector is selected through n23-10/n23-13, configure the DIO as DO and set n23-10/n23-13 as the DO signal source of DIO1/DIO2. The DO signal is processed with the switch-on delay, switch-off delay, and positive/ negative logic. When B connector is of low level, low level is outputted. When B connector is of high level, high level is outputted.

The HIO-30 module provides six DIs. Signal processing of DIs is the same as that of DIO used as a DI.

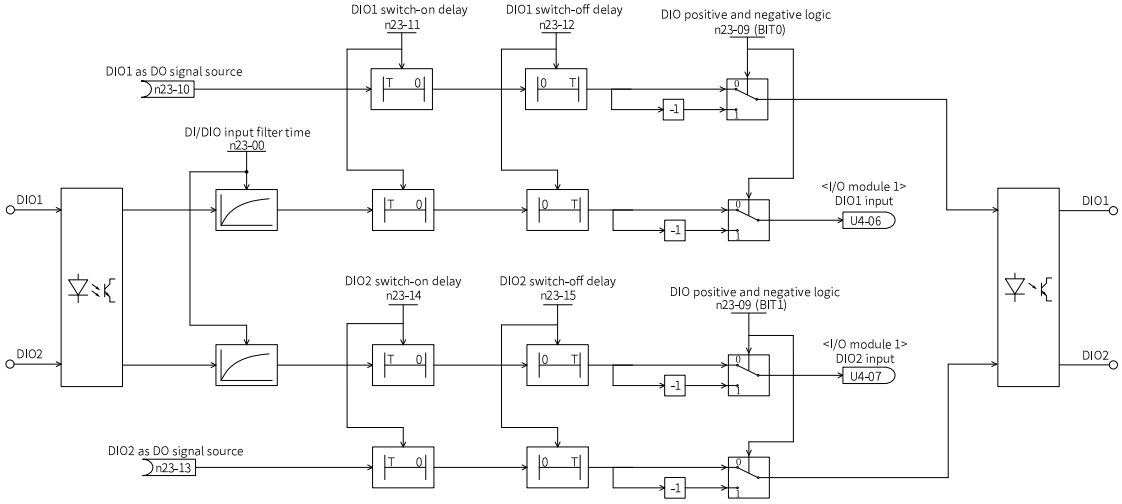


Figure 7-3 DIO software functions of HIO

DIO function parameters are listed in the following table.

Param.	Name	Description
n7-10/n8-10/n9-10	Configuration for the DIO that used as digital output	The HIO module provides a maximum of six DIOs. DIO1 to DOI6 correspond to bit00 to bit05 of n7-10 respectively. 0: DIO used as DI 1: DIO used as DO
n7-11/n8-11/n9-11	Original status of DI/DIO input	Displays the initial state of DI or the DIO that used as DI. bit00 to bit05 display the initial state of the DIO that used as DI. bit08 to bit13 display the initial state of DI input.
n7-12/n8-12/n9-12	Final state of DI/DIO input	Displays the final input state of DI or DIO that used as DI after being processed with the filter, delay, and positive/negative logic. bit0 to bit5 display the final state of the DIO that used as DI. bit8 to bit13 display the final state of DI input.

Param.	Name	Description
n7-13/n8-13/n9-13	RO/DIO output setting state	Displays the setting state of the RO or DIO that used as DO. bit0 to bit5 display the setting state of the DIO that used as DO. bit8 to bit13 display the setting state of RO.
n7-14/n8-14/n9-14	Final state of RO/DIO	Displays the final output state of RO or DIO that used as DO after being processed with the filter and positive/negative logic. bit0 to bit5 display the final state of DIO that used as DO. bit8 to bit13 display the final state of RO.
n23-10/n26-10/n29-10	DIO1 as DO signal source	DIO1 is used as a DI by default. When n23-10 is configured as B connector, DIO1 is used as DO. 0: Used as DI Others: B connector
n23-13/n26-13/n29-13	DIO2 as DO signal source	DIO2 is used as a DI by default. When n23-13 is configured as B connector, DIO1 is used as DO. 0: Used as DI Others: B connector
n23-00/n26-00/n29-00	Filter time of DI/DIO input	0.000s to 1.000s
n23-11/n26-11/n29-11	DIO1 switch-on delay	0.00s to 360.00s
n23-14/n26-14/n29-14	DIO2 switch-on delay	0.00s to 360.00s
n23-12/n26-12/n29-12	DIO1 switch-off delay	0.00s to 360.00s
n23-15/n26-15/n29-15	DIO2 switch-off delay	0.00s to 360.00s
n23-09/n26-09/n29-09	DIO positive/negative logic	bit0: DIO1 positive and negative logic 0: Logic 1 corresponds to high level. 1: Logic 1 corresponds to low level. bit1: DIO2 positive and negative logic 0: Logic 1 corresponds to high level. 1: Logic 1 corresponds to low level. bit2: DIO3 positive and negative logic 0: Logic 1 corresponds to high level. 1: Logic 1 corresponds to low level. bit3: DIO4 positive and negative logic 0: Logic 1 corresponds to high level. 1: Logic 1 corresponds to low level. bit4: DIO5 positive and negative logic 0: Logic 1 corresponds to high level. 1: Logic 1 corresponds to low level. bit5: DIO6 positive and negative logic 0: Logic 1 corresponds to high level. 1: Logic 1 corresponds to low level.

The following table describes parameters of the DI/DIO connector.

Param.	Description	Param.	Description	Param.	Description
U4-00	<I/O module 1> DI1 input	U4-12	<I/O module 2> DI1 input	U4-24	<I/O module 3> DI1 input
U4-01	<I/O module 1> DI2 input	U4-13	<I/O module 2> DI2 input	U4-25	<I/O module 3> DI2 input
U4-02	<I/O module 1> DI3 input	U4-14	<I/O module 2> DI3 input	U4-26	<I/O module 3> DI3 input
U4-03	<I/O module 1> DI4 input	U4-15	<I/O module 2> DI4 input	U4-27	<I/O module 3> DI4 input
U4-04	<I/O module 1> DI5 input	U4-16	<I/O module 2> DI5 input	U4-28	<I/O module 3> DI5 input
U4-05	<I/O module 1> DI6 input	U4-17	<I/O module 2> DI6 input	U4-29	<I/O module 3> DI6 input
U4-06	<I/O module 1> DIO1 input	U4-18	<I/O module 2> DIO1 input	U4-30	<I/O module 3> DIO1 input
U4-07	<I/O module 1> DIO2 input	U4-19	<I/O module 2> DIO2 input	U4-31	<I/O module 3> DIO2 input
U4-08	<I/O module 1> DIO3 input	U4-20	<I/O module 2> DIO3 input	U4-32	<I/O module 3> DIO3 input
U4-09	<I/O module 1> DIO4 input	U4-21	<I/O module 2> DIO4 input	U4-33	<I/O module 3> DIO4 input
U4-10	<I/O module 1> DIO5 input	U4-22	<I/O module 2> DIO5 input	U4-34	<I/O module 3> DIO5 input
U4-11	<I/O module 1> DIO6 input	U4-23	<I/O module 2> DIO6 input	U4-35	<I/O module 3> DIO6 input

Note

For the DIO and DI configuration of the HIO-20 and HIO-30 modules, see that of the HIO-10 module in the preceding description.

7.7.2 Analog Input (AI)

This section takes HIO-10 as an example. HIO-10 provides two AIs and supports current and voltage signals. Before using AI, check whether external signals are of voltage type or current type, and select the DIP switch accordingly. When you set n7-00 and n7-02 to 1, perform configuration through n23-41/n23-51. The AI function is achieved as shown in the following function diagram.

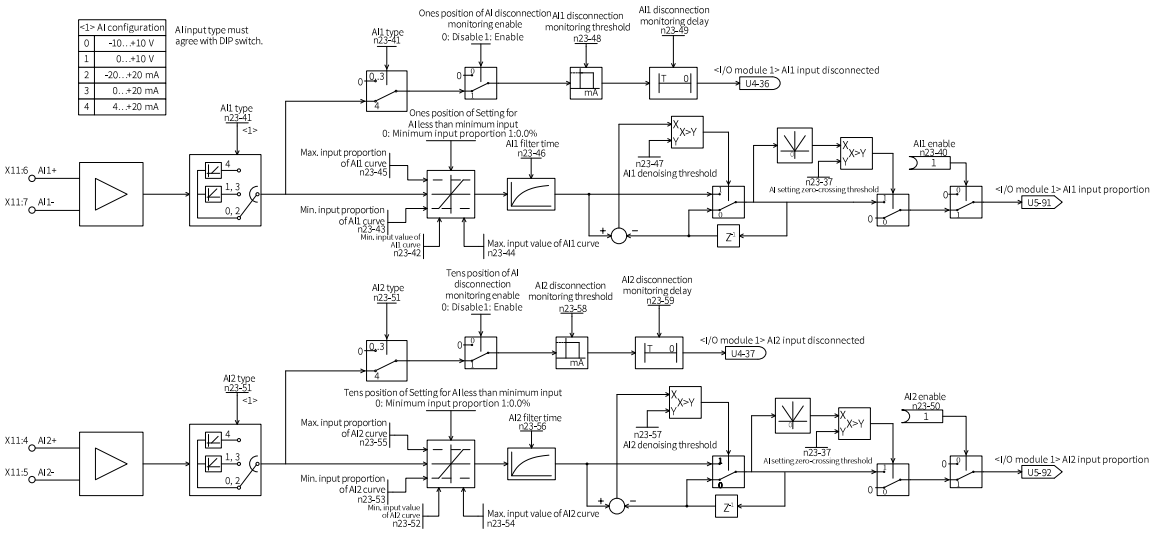


Figure 7-4 AI software function diagram of HIO

AI function parameters are as follows.

Param.	Name	Description
n7-20/n8-20/n9-20	AI1 input value	Displays AI1 input value in V or mA according to the selection of n23-41.
n7-21/n8-21/n9-21	AI1 input scaling	Displays the percentage corresponding to AI1 input, which is the final output after AI module processing.
n7-22/n8-22/n9-22	AI2 input value	Displays AI2 input value in V or mA according to the selection of n23-51.
n7-23/n8-23/n9-23	AI2 input scaling	Displays the percentage corresponding to AI2 input, which is the final output after AI module processing.
n23-41/n26-41/n29-41	AI1 type	Defines the input signal type of AI1 or AI2. Different signal types require different settings of the HIO AI DIP switch. 0: -10 V to +10 V 1: 0 V to 10 V 2: -20 mA to +20 mA 3: 0 mA to 20 mA 4: 4 mA to 20 mA
n23-51/n26-51/n29-51	AI2 type	
n23-42/n26-42/n29-42	Minimum input value of AI1 curve	Calibrates AI1. n23-42 and n23-44 together define the input range of AI1 (the unit is V or mA based on the setting of n23-41). Within the value range, convert the input into a value in percentage to output according to a straight line. When the input is less than n23-42: The default output is n23-43, or the output can be set to 0.0% according to the ones position of n23-35.
n23-43/n26-43/n29-43	Minimum input scaling of AI1 curve	
n23-44/n26-44/n29-44	Maximum input value of AI1 curve	
n23-45/n26-45/n29-45	Maximum input scaling of AI1 curve	

Param.	Name	Description
n23-52/n26-52/n29-52	Minimum input value of AI2 curve	Calibrates AI2. n23-52 and n23-54 together define the input range of AI2 (the unit is V or mA based on the setting of n23-51). Within the value range, convert the input into a value in percentage to output according to a straight line. When the input is less than n23-52: The default output is n23-53, or the output can be set to 0.0% according to the tens position of n23-35.
n23-53/n26-53/n29-53	Minimum input scaling of AI2 curve	
n23-54/n26-54/n29-54	Maximum input value of AI2 curve	
n23-55/n26-55/n29-55	Maximum input scaling of AI2 curve	
n23-35/n26-35/n29-35	Reference for AI that lower than the minimum input	Ones: Setting for AI1 that lower than the minimum input 0: Minimum input scaling 1: 0.0% Tens: Setting for AI2 that lower than the minimum input 0: Minimum input scaling 1: 0.0%
n23-46/n26-46/n29-46	AI1 filter time	Defines the AI filter time, which will produce a delay effect while removing the interference.
n23-56/n26-56/n29-56	AI2 filter time	
n23-47/n26-47/n29-47	AI1 denoising threshold	Defines the denoising threshold. When the AI input fluctuation is less than the threshold, the AI scaling remains unchanged.
n23-57/n26-57/n29-57	AI2 denoising threshold	
n23-37/n26-37/n29-37	AI reference zero-crossing threshold	When the AI value is smaller than the threshold, the AI value is 0%.
n23-40/n26-40/n29-40	AI1 enable	Enables or disables AI1. When AI1 is disabled, its value is forced to be 0.
n23-50/n26-50/n29-50	AI2 enable	Enables or disables AI2. When AI2 is disabled, its value is forced to be 0.
n23-36/n26-36/n29-36	AI disconnection monitoring enable	Enables or disables disconnection monitoring. Monitoring is only enabled when the signal type is 4 mA to 20 mA. When the AI input value is smaller than the disconnection monitoring threshold and the monitoring delay is maintained, disconnection occurs. Ones: AI1 disconnection monitoring enable 0: Disabled 1: Enabled Tens: AI2 disconnection monitoring enable 0: Disabled 1: Enabled Hundreds: AI3 disconnection monitoring enable 0: Disabled 1: Enabled
n23-48/n26-48/n29-48	AI1 disconnection monitoring threshold	0.000 mA to 4.000 mA
n23-58/n26-58/n29-58	AI2 disconnection monitoring threshold	0.000 mA to 4.000 mA

Param.	Name	Description
n23-49/n26-49/n29-49	AI1 disconnection monitoring delay	0.00s to 10.00s
n23-59/n26-59/n29-59	AI2 disconnection monitoring delay	0.00s to 10.00s

AI connector parameters are as follows.

Param.	Description	Param.	Description
U4-36	<I/O module 1> AI1 input disconnection	U5-91	<I/O module 1> AI1 input scaling
U4-37	<I/O module 1> AI2 input disconnection	U5-92	<I/O module 1> AI2 input scaling
U4-38	<I/O module 1> AI3 input disconnection	U5-93	<I/O module 1> AI3 input scaling
U4-39	<I/O module 2> AI1 input disconnection	U5-94	<I/O module 2> AI1 input scaling
U4-40	<I/O module 2> AI2 input disconnection	U5-95	<I/O module 2> AI2 input scaling
U4-41	<I/O module 2> AI3 input disconnection	U5-96	<I/O module 2> AI3 input scaling
U4-42	<I/O module 3> AI1 input disconnection	U5-97	<I/O module 3> AI1 input scaling
U4-43	<I/O module 3> AI2 input disconnection	U5-98	<I/O module 3> AI2 input scaling
U4-44	<I/O module 3> AI3 input disconnection	U5-99	<I/O module 3> AI3 input scaling

Note

For the AI configuration of the HIO-30 module, see that of the HIO-10 module in the preceding description.

7.7.3 Analog Output (AO)

This section takes HIO-10 as an example. HIO-10 provides two AO outputs and supports current and voltage signal types. Before using AO, set the corresponding hardware jumper (see the *HIO-10 I/O Function Module User Guide*). If n7-00 and n7-02 are set to 1, configuration is carried out through parameters n23-71 and n23-81. The AO function is implemented as shown in the following function diagram.

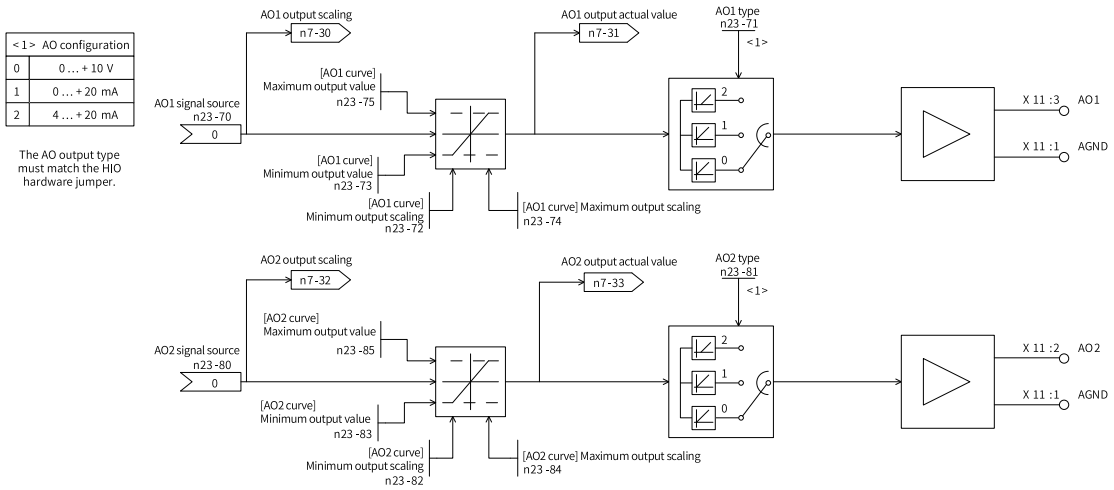


Figure 7-5 AO software function diagram of HIO

AO function parameters are as follows:

Parameter	Name	Description
n7-30/n8-30/n9-30	AO1 output proportion	Displays the AO1 output value in V or mA according to the setting of n23-71.
n7-31/n8-31/n9-31	AO1 output actual value	Displays AO1 output in percentage corresponding to n23-70.
n7-32/n8-32/n9-32	AO2 output proportion	Displays the AO2 output value in V or mA according to the setting of n23-81.
n7-33/n8-33/n9-33	AO2 output actual value	Displays AO2 output in percentage corresponding to n23-80.
n23-70/n26-70/n29-70	AO1 signal source	Sets the signal source of AO1 output.
n23-80/n26-80/n29-80	AO2 signal source	Sets the signal source of AO2 output.
n23-71/n26-71/n29-71	AO1 type	Sets the signal type of AO1 or AO2. The wiring mode must be configured reasonably. For details, see the *HIO-10 I/O Function Module User Guide*. 0: 0 V to 10 V 1: 0 mA to 20 mA 2: 4 mA to 20 mA
n23-81/n26-81/n29-81	AO2 type	
n23-73/n26-73/n29-73	[AO1 curve] Minimum output value	Sets the calibration factor of AO1. n23-73 and n23-75 also limit the range of AO1 output percentage. Within the value range, the output value is obtained by linear conversion (unit: V or mA, depending on n23-71).
N23-72/n26-72/n29-72	[AO1 curve] Minimum output proportion	
n23-75/n26-75/n29-75	[AO1 curve] Maximum output value	
n23-74/n26-74/n29-74	[AO1 curve] Maximum output proportion	
n23-83/n26-83/n29-83	[AO2 curve] Minimum output value	Sets the calibration factor of AO2. n23-83 and n23-85 also limit the range of AO2 output percentage. Within the value range, the output value is obtained by linear conversion (unit: V or mA, depending on n23-81).
N23-82/n26-82/n29-82	[AO2 curve] Minimum output proportion	
n23-85/n26-85/n29-85	[AO2 curve] Maximum output value	
n23-84/n26-84/n29-84	[AO2 curve] Maximum output proportion	

Note

For the AO configuration of the HIO-30 module, see that of the HIO-10 module in the preceding description.

7.7.4 Relay Output (RO)

This section takes HIO-10 as an example. HIO-10 provides one RO. The RO function is achieved as shown in the following function diagram.

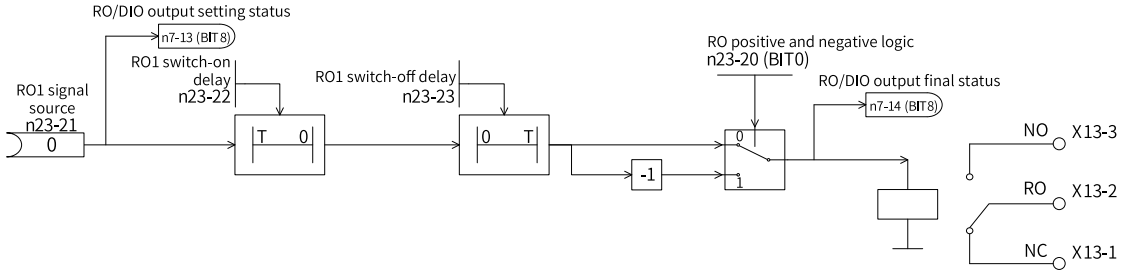


Figure 7-6 RO software function diagram of HIO

RO function parameters are as follows:

Parameter	Name	Description
n7-13/n8-13/n9-13	RO/DIO output setting status	Displays the output setting status of RO or DIO as DO. Bit 00 to bit 05 display the output setting status of DIO as DO. Bit 08 to bit 13 display the output setting status of RO.
n7-14/n8-14/n9-14	RO/DIO output final status	Displays the final output status of RO or DIO as DO after delay and positive and negative logic processing. Bit 00 to bit 05 display the final status of DIO as DO. Bit 08 to bit 13 display the final status of RO.
n23-21/n26-21/n29-21	RO1 signal source	0: Low level 1: High level Other: B connector
n23-22/n26-22/n29-22	RO1 switch-on delay	0.00s to 360.00s

Parameter	Name	Description
n23-23/n26-23/n29-23	RO1 switch-off delay	0.00s to 360.00s
n23-20/n26-20/n29-20	RO positive and negative logic	Bit 00: RO1 positive and negative logic 0: Logic 1 outputs high level. 1: Logic 1 outputs low level. Bit 01: RO2 positive and negative logic 0: Logic 1 outputs high level. 1: Logic 1 outputs low level. Bit 02: RO3 positive and negative logic 0: Logic 1 outputs high level. 1: Logic 1 outputs low level. Bit 03: RO4 positive and negative logic 0: Logic 1 outputs high level. 1: Logic 1 outputs low level.

Note

For the RO configuration of HIO-20 and HIO-30 modules, see that of the HIO-10 module in the preceding description.

8 Motor Control

8.1 Vector Control

Vector control features high dynamic response and high precision, which can be used to adjust the output torque. Vector control includes sensorless vector control (SVC) and feedback vector control (FVC), which can be selected through [E0-00].

Param.	Name	Default	Value range	Description
E0-00	Control mode	2	0 to 2	Defines the control mode of the drive. Value description: 0: SVC (Sensorless vector control) - Sensorless field-oriented vector control This mode features excellent dynamic performance and steady-state accuracy, but it is highly dependent on parameters and needs prior auto-tuning of motor parameters. 1: FVC (Feedback vector control) - The speed is fed back by the encoder to reach the optimal control performance. 2: V/f - It is the open-loop control with the constant voltage-to-frequency ratio. The dynamic performance of this mode is not as good as the SVC mode. Note: It is recommended to install an encoder to run in FVC mode for a long time at zero speed with active load. If SVC mode must be used under such conditions, enable the SVC speed open loop control function (E11-08 = 1).

Control mode	Advantage	Disadvantage	Common application scenarios
SVC	The SVC mode features excellent dynamic responsiveness and requires less encoders, encoder cables, and encoder cards compared with the FVC mode. The fault rate of SVC mode is low during long-term operation. However, the operational stability in the SVC mode at speeds lower than 2.5% of rated speed is not as good as that in the FVC mode.	The back EMF is low during low-speed operation (E11-12 = 2.5% of rated speed), so long-term operation is not available. During long-term operation at low speed, I/F control applies. In this case, only the speed can be controlled. Fluctuation can occur at speeds close to zero in the torque control mode.	SVC control applies to most of applications except for applications where FVC is a must. The SVC mode applies to industries including fans, water pumps, air conditioners, steam turbines, turbines, roughing mills, furnace rollers, tensioners, travel and trolley of cranes, flywheels, and jack-up legs of offshore platforms.
FVC	The FVC mode allows long-term stable operation at zero speed. It supports position control and has higher control precision in speed control compared with the SVC mode. When used together with a high-resolution encoder, high dynamic performance can be achieved in the FVC mode.	However, the FVC mode requires more encoder cards and encoder cables compared with SVC mode. In FVC mode, encoder feedback signals may be easily disturbed.	The FVC mode applies to hoists, zero speed tension control (winding/unwinding, loop), position control, and applications requiring ultra-high precision and dynamic responsiveness (such as new energy vehicle test benches, high-speed finishing mills, and flying shears).
V/f	The V/f mode features easy control and commissioning.	However, the dynamic responsiveness and control precision in V/f mode are low. Only the speed can be controlled in the V/f mode. For high-power motors, it is recommended to switch to the SVC mode for parameter adjustment. Only asynchronous motors support V/f control.	The V/f mode applies to applications with low precision requirements, such as fans and water pumps.

8.1.1 FVC Control

Application scenario

The difference between FVC (E0-00 = 1) and SVC is that the feedback speed in FVC is measured by the encoder, while the feedback speed in SVC is calculated by the back EMF and output current. The back EMF is low at low speed. Therefore, the dynamic performance of the control accuracy during low-speed operation in SVC mode is not as good as that in the FVC mode. FVC must be used in the following scenarios.

- It is recommended to use FVC for loads such as cranes and hoists because the risks of stuck or faults may be present in the SVC mode under high load.

- It is recommended to use FVC for the position control type of loads. The position estimated by SVC at low speed may be deviated, and large position deviation can be cumulated during long-term operation.
- It is recommended to use FVC for zero speed tension control. Torque limit is required for a long time at zero speed. The speed open loop is enabled by default during low speed operation in SVC mode (E11-08 = 1). In this state, torque control cannot be implemented, which may cause speed cycle fluctuation. In this case, turning off the speed open loop (E11-08 = 0) can stabilize the operation for only a short period of time.
- It is recommended to use FVC for applications requiring ultra-high dynamic response and ultra-high precision. For example, the power system test bench for an electric vehicle requires ultra-high dynamic responses.

Operating principles

The following figure shows the FVC control block diagram.

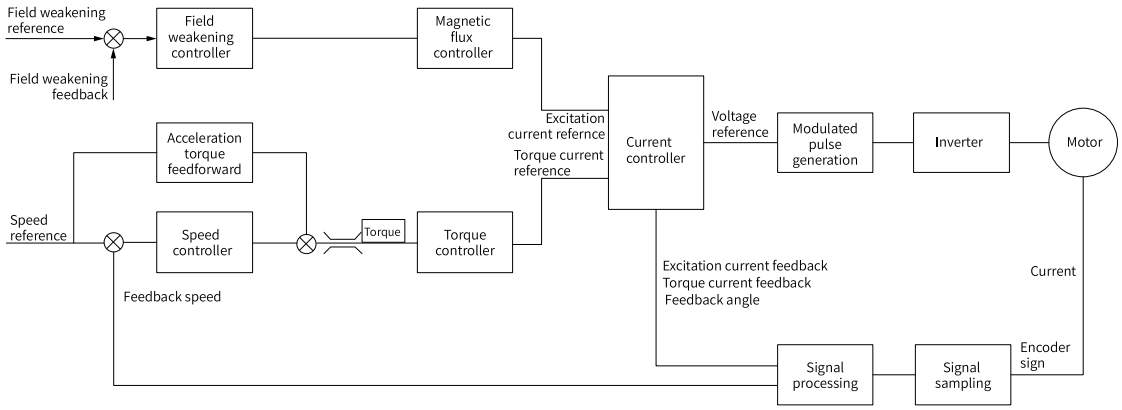


Figure 8-1 Block diagram for feedback vector control (FVC)

High-speed and low-speed model switchover of asynchronous motor in FVC mode

The high speed and low speed models have different features.

Model	Advantage	Disadvantage
Low-speed model	Simple and stable; Operation allowed in the whole speed range	Serious encoder interference compared with the high-speed model; Torque accuracy affected by rotor resistance due to significant motor temperature rise
High-speed model	High torque precision and low impact of motor temperature rise;	More motor parameters involved compared with the low-speed model, affecting precision in low-speed operation; Operation stability affected by model fluctuation due to excessive motor harmonics

Typical troubleshooting scenarios:

- The motor harmonics affect the speed and torque fluctuation of the high-speed model. You can set E11-00 and E11-01 to values higher than the maximum operating speed to make the motor run in the low-speed model, thus improving the steady state performance.

- If the motor temperature rises significantly and high torque accuracy is required, reduce the values of E11-00 and E11-01 to cover the range commonly used by high-speed model. It is recommended to set the model speed in high-speed range to a value not lower than 5% of the rated speed. You can also refer to the motor temperature model parameter setting to reduce the impact of temperature rise on motor control.

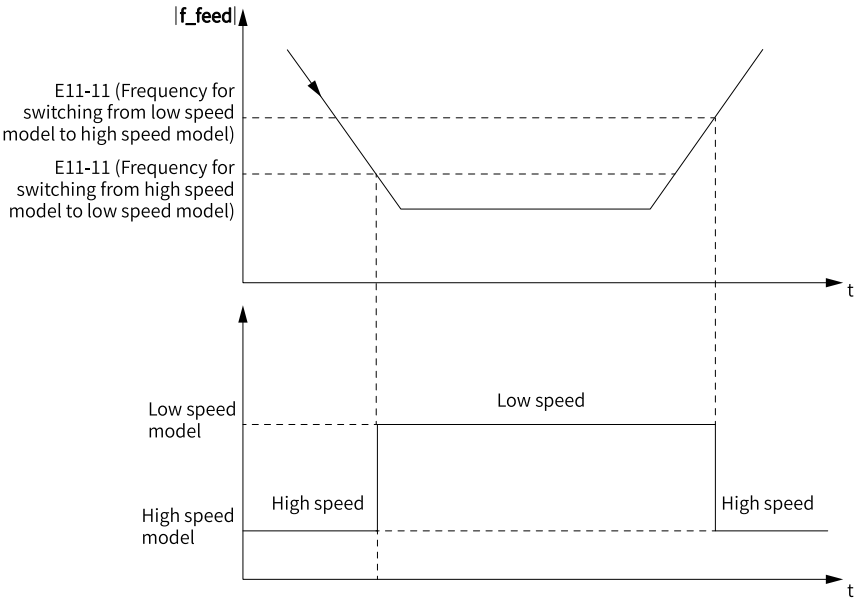


Figure 8-2 High-speed and low-speed model switchover of the asynchronous motor in FVC mode

Switching from FVC to SVC upon encoder error

If open circuit occurs on the encoder frequently during operation in FVC mode, you can set E8-51 to 1 [Alarm and continue running in SVC] to ensure continuous operation of the motor after the encoder fault occurs.

If the encoder feedback speed fluctuation is low in low-speed operation but high in high-speed operation, set E11-04 [Switching from FVC to SVC actively] to 1 [Enable]. Use FVC mode during low-speed operation and switch to SVC mode during high-speed operation to ensure normal operation of the motor upon unusual fluctuation of the encoder feedback during high-speed operation. There is a hysteresis band during switchover between FVC mode and SVC mode, as shown below.

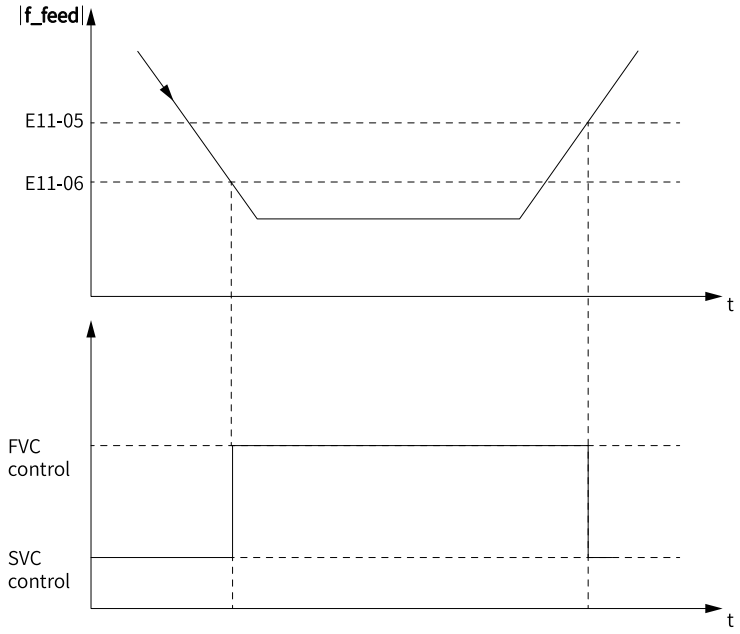


Figure 8-3 Switching between FVC and SVC

Related parameters

Param.	Name	Default	Value range	Description
E8-51	Handling mode for encoder faults	0	0 to 1	Defines the handling mode for encoder faults. Value description: 0: Stop as defined by E8-51 1: Alarm and continue operating in SVC mode Others: B connector
E8-52	Stop mode upon encoder fault	0	0 to 2	Defines the stop mode upon an encoder fault.
E8-53	Minimum operating speed upon encoder fault (SVC)	3.0%	0.0% to 100.0%	Defines the minimum operating speed in SVC mode after encoder fault occurs. Note: When E8-51 is set to 1, the drive switches from FVC mode to SVC mode after an encoder fault occurs, without interrupting the operation. A fault is reported until a stop command is sent or the operating speed is lower than E8-53.
E11-00	Frequency for the motor to switch from low-speed mode to high-speed model	20%	0% to 600%	Defines the threshold for the motor to switch from low-speed model to high-speed model.
E11-01	Frequency for the motor to switch from high-speed model to low-speed model	10%	0% to 600%	Defines the threshold for the motor to switch from high-speed model to low-speed model.

Param.	Name	Default	Value range	Description
E11-04	Active switchover from FVC to SVC	0	0 to 1	Used to enable active switchover from FVC to SVC. Value description: 0: Disable 1: Enable
E11-05	Upper limit frequency for switching from FVC to SVC actively	25%	0% to 100%	Defines the upper limit frequency for switching from FVC to SVC actively. Note: When E11-04 is set to 1 and the value of U9-00 [Absolute value of actual motor speed] is higher than the value of this parameter, the drive switches from FVC mode to SVC mode.
E11-06	Lower limit frequency for switching from FVC to SVC actively	15%	0% to 100%	Defines the lower limit frequency for switching from FVC to SVC actively. Note: When E11-04 is set to 1 and the value of U9-00 [Absolute value of actual motor speed] is higher than the value of this parameter, the drive switches from SVC mode to FVC mode.

Application instance

- Switching to SVC mode upon encoder fault
  The continuous production line of a metallurgical rolling mill is running with multiple AC drives. If the encoder of a motor is disconnected or being disturbed, one of the drives may report a fault and stop. This can cause the entire production line to stop, resulting in severe property loss. To avoid this, set E8-51 [Handling mode upon encoder fault] to 1 [Alarm and continue operating in SVC mode] to ensure that the motor can run normally when the encoder is faulty. The fault is reported only after the motor decelerates to an ultra-low speed.
- Switching to SVC at high-speed operation upon encoder fluctuation
  The encoder is installed with improper alignment, which can operate normally at low speed. During high-speed operation, large speed fluctuation can occur. In cases where the rial runout of the encoder cannot be calibrated, set E11-04 to 1 [Switching from FVC to SVC actively] to ensure that the motor operation is not affected by encoder speed fluctuation.

8.1.2 SVC Control

Application scenario

The sensorless vector control (SVC) mode is used in applications without a encoder. To enable the SVC mode, set [E0-00] to 0 [Sensorless vector control].

SVC mode applies to applications including fans, water pumps, air compressors, air conditioners, and crushers.

Operating principles

The following figure shows the control block diagram of sensorless vector control (SVC).

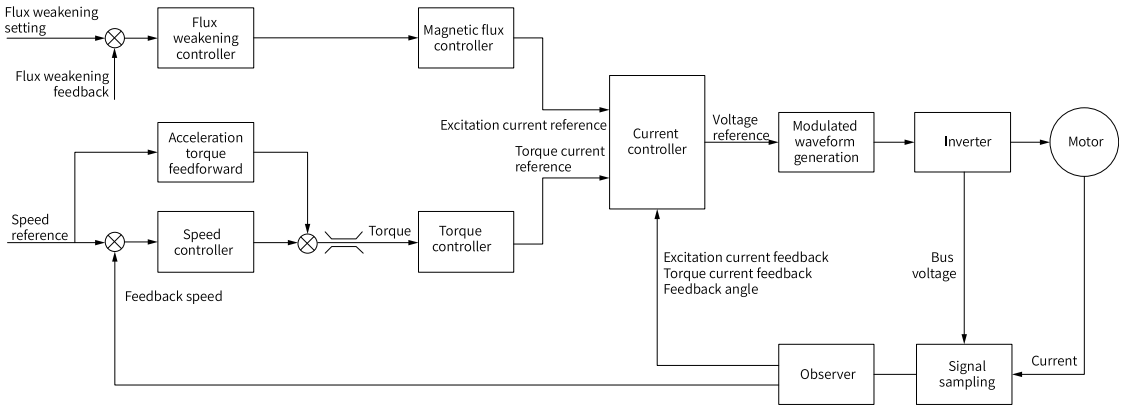


Figure 8-4 Control block diagram of sensorless vector control (SVC)

In SVC mode, the feedback speed and angle needed in vector control are estimated through the motor model and output current by the observer module. The SVC control is estimated based on motor voltage, current, and motor parameters. Therefore, complete motor parameters are required for SVC control. It is recommended to perform dynamic auto-tuning before operation. Failure to perform dynamic auto-tuning may result in oscillation or overcurrent due to inaccurate motor parameters.

High/Low speed model switchover in SVC

During low-speed operation, the motor speed and angle cannot be accurately calculated, affecting the control accuracy. To prevent the motor from getting stuck or operating improperly during long-term operation at low speed, the speed open loop (E11-08) is enabled by default. If the motor keeps at a low speed for a period longer than E11-15 [Waiting time of speed open loop], the speed open loop applies automatically because the switchover threshold of speed loop is low (below 2.5% of rated frequency), which does not affect most of applications such as fans and pumps. The I/F control parameters do not need to be adjusted.

In I/F control, the motor operates at the current and frequency reference set by users. The current reference is set to 50% of torque current by default. When the passive load is higher than the current, the system adjusts the output current automatically. To prevent motor runaway accidents. For active loads, the current must be set based on the maximum torque needed by the load, which can result in excessive current in the low frequency range in speed open loop control. The drive also derates at low frequencies, which requires a drive of higher power rating.

When the speed open loop function is disabled (E11-08 = 0), the SVC mode applies to all the speed ranges and an accurate torque can be outputted even at zero speed. In this case, do not keep the motor running at zero speed for a long term.

When the motor runs to A low speed, the drive switches to open loop speed control and outputs the current set by E11-09/10. The drive switches to SVC mode during high-speed operation. There is a hysteresis band during switchover between the speed open loop I/F control and SVC mode. The switchover process is shown in the following figure.

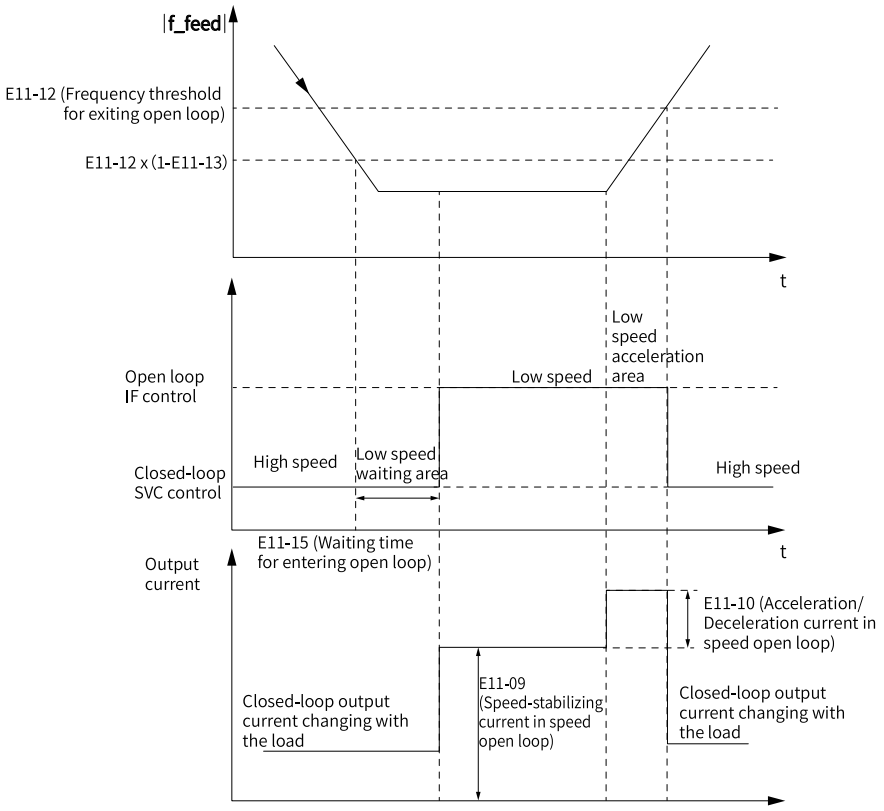


Figure 8-5 Switching between open loop control and closed-loop control

High-frequency output in SVC mode

A high carrier frequency is needed during high-speed operation in SVC mode. An excessively low carrier frequency can easily result in motor overtemperature or even demagnetization during long-term operation of synchronous motors. Carrier ratio = Carrier frequency/Operating frequency. For medium- to high-speed applications, it is recommended to set the carrier ratio to a value higher than 12. To run at 400 Hz, set the carrier frequency to a value greater than or equal to 4.8 kHz.

Related parameters

Param.	Name	Default	Value range	Description
E11-08	Speed open loop in SVC mode	1	0 to 1	Used to enable speed open loop in SVC mode. Note: It is recommended to install an encoder to run in FVC mode for a long time at zero speed with active load. If SVC mode must be used under such conditions, enable the SVC speed open loop control function (E11-08 = 1).
E11-09	Steady speed current in speed open loop control in SVC	50%	0% to 400%	Defines the steady-state current in speed open loop control. Set this parameter to a value higher than 20% of the load.

Param.	Name	Default	Value range	Description
E11-10	Acceleration current in speed open loop control in SVC	0%	0% to 400%	Defines the acceleration current in speed open loop control in SVC mode.
E11-12	Frequency threshold for exiting speed open loop control in SVC	2.5%	0% to 100%	Defines the frequency for exiting speed open loop, which is a percentage to the rated frequency. If the percentage of the operating frequency to the rated frequency is higher than E11-12, the drive switches to closed loop control. The default value is 2.5% of the rated frequency based on the low-speed operation band of speed open loop.
E11-13	Hysteresis range in speed open loop control in SVC	50%	0% to 99%	Defines the speed open loop switchover hysteresis, which is a percentage to the rated frequency. If the percentage of the operating frequency to the rated frequency is lower than "E11-12 x (1 - E11-13)", the drive switches to speed closed-loop control in SVC. The default value is 50% of the rated frequency according to the hysteresis band needed.
E11-15	Waiting time in speed open loop control in SVC	0.5s	0s to 10s	Defines the waiting time in speed open loop control in SVC. Do not set the waiting time to an excessively low value. Otherwise, switchover to speed open loop control may fail. Note: This parameter is active when E11-14 is set to 1.

Application instance

- Example 1
  A film winding/winding device is operating without encoder. During tension control, the drive that controls unwinding must keep the unwinding device running at zero speed. When SVC mode is used, long-term stable operation at zero speed is not available. In this case, you need to set speed open loop I/F as follows.
  - Set [E11-08] to 1 to enable speed open loop function.
  - Observe the torque corresponding to the tension, which should be about 50% during normal operation. Therefore, set E11-09 to 70%.
  - During normal acceleration/deceleration, for precise control and rapid response, you can set the switchover frequency to a low value (E11-12 = 2%, E11-13 = 30%).
- Example 2
  The torque limit is controlled by SVC speed to maintain the tension. Cyclic fluctuation occurs during low-speed operation. In this case, the material tension is higher than the set tension. This is because the torque limit is no longer active when I/F control mode applies, and the motor operates only at the set speed. The torque that can be outputted in I/F mode is higher than the torque reference. The material can be broken in severe cases.

- In this case, try changing [E11-08] to 0 to disable the speed open loop function. Observe whether the fault can be rectified.
- If not, try setting [E11-08] to 1 and reduce the I/F switchover frequency [E11-12] properly.
- If none of the above measures work, install an encoder and use FVC control.

8.1.3 Speed Control

8.1.3.1 Speed Control

Application scenario

Most of applications require the motor speed to be controlled. In vector control, the speed can be controlled accurately.

Operating principles

The following figure shows the typical speed control diagram. The speed reference is outputted to the motor only after being processed with the speed limit, ramp function generator (RFG), speed controller, additional torque, torque limit, and current controller (ACR).

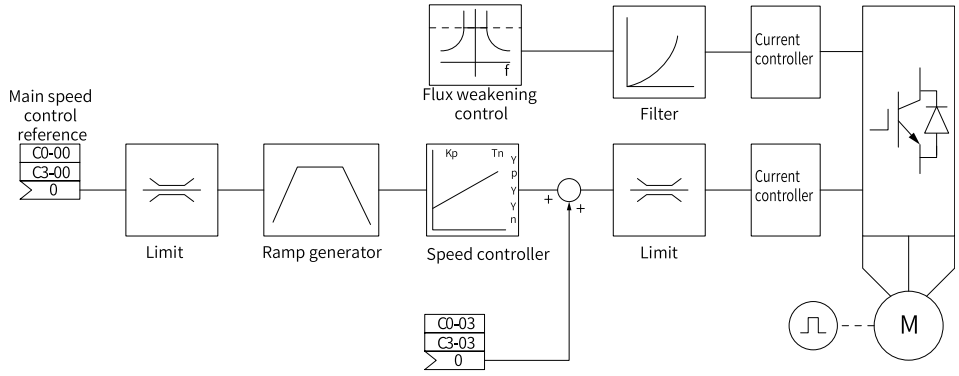


Figure 8-6 Typical block diagram of speed control

In speed control, the speed reference is converted to the actual speed reference only after being processed with a series of limits, ramp function generator, and additional speed reference.

Related parameters

Param.	Name	Default	Value range	Description
E0-01	Control mode	0	0: Speed control 1: Torque control 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: HDI1 Others: B connector	Defines the motor control target. Value description: 0: Speed control - The speed is being controlled. 1: Torque control - The torque is being controlled. 2 to 7, 8: DI1 to DI6, HDI1 - Depends on the final terminal state of DI and HDI (0: Speed mode; 1: Torque mode). Others: B connector - Depends on the status of B connector (0: Speed mode; 1: Torque mode). Note: The torque control mode is invalid in V/f mode.

8.1.3.2 Speed Controller (Speed Loop)

Operating principles

The speed controller receives the speed reference from the setting channel and the feedback speed values from the feedback channel (the feedback speed is measured by the encoder in the FVC mode or measured through motor model calculation in the SVC mode). The deviation between the speed reference and feedback value is generated as the torque reference after being adjusted by the PI regulator, and then transmitted to the current controller. The most important parameters of the speed controller are Kp and Ti of the PI regulator.

The following figure shows the function diagram of the speed controller.

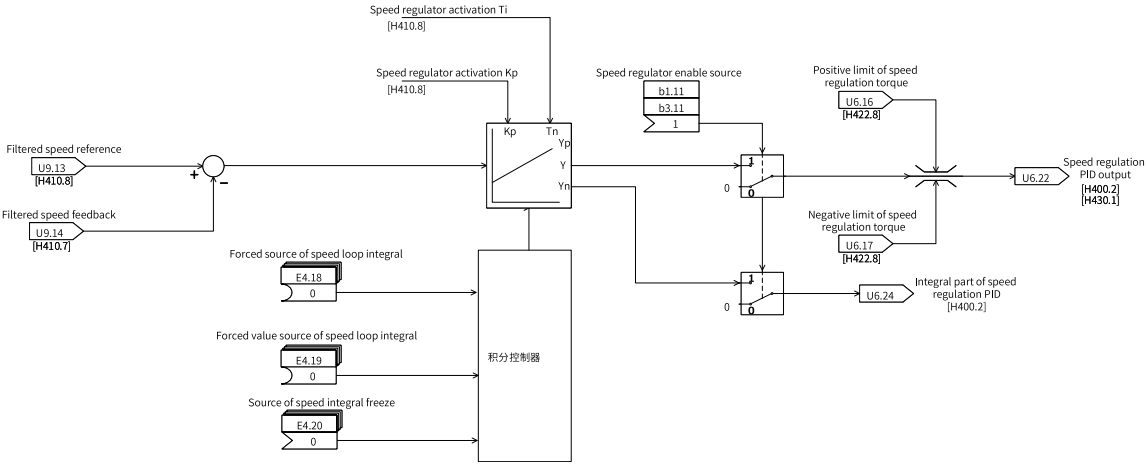


Figure 8-7 Function diagram of the speed controller

The dynamic response in the FVC mode differs from that in the SVC mode, so different regulator parameters (Kp and Ti) are used. In FVC mode, regulator parameters are E4-02 and E4-03. In SVC mode, regulator parameters are E4-04 and E4-05.

In SVC control, the speed controller can be adjusted by parameters E4-04 (Speed loop Kp in SVC mode) and E4-05 (Speed loop Ti in SVC mode). The relationship between the speed controller output and Kp and Ti is shown in the following table.

$$Out = Kp\Delta f + \int \frac{Kp}{Ti}\Delta f dt$$

The torque reference is shown in the following figure. For the speed deviation with a magnitude of Δf, the torque reference outputted by the proportional term is KpΔf. After Ti time elapses, the torque reference outputted by the integral term is KpΔf.

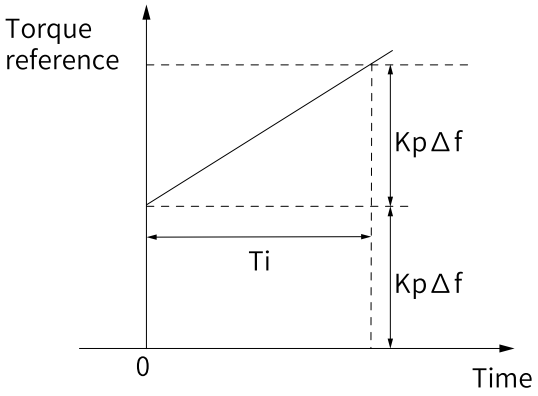


Figure 8-8 Torque reference diagram

Kp and Ki of PI regulator of the speed loop can be optimized through complete no-load auto-tuning (b5-00 = 2). If the moment of inertia is known, you can set d2-02 [Moment of inertia ratio] directly, and then set b5-02 to 2 and b5-03 to 1 to calculate speed loop parameters.

If the feedback speed is still oscillating after optimization, you need to manually optimize the controller parameters. When Kp is low, the feedback speed overshoot is high. Increasing Kp can quicken the adjustment process and reduce overshoot. Note that an excessively high Kp can result in oscillation of the output torque and feedback speed. Decreasing Ti can quicken the adjustment process. Note that an excessively low Ti can result in oscillation of the output torque and feedback speed.

Special handling of the speed loop regulator may be required for process application with the PLC, which has the following three functions.

- The speed loop regulator is enabled by b1-11 or b3-11. b1-11 and b3-11 are bit reference source parameters. You can obtain data of the bit connector to control the regulator. Once the speed loop regulator is inhibited, the speed loop output and the torque reference change to 0.
- Set E4-20 to freeze the speed loop integral. In this case, the integral output value is fixed to the value of the last cycle.
- Set E4-18 to enable the integral forcibly. E4-19 defines the forced value of the integral. After the integral is enabled forcibly, the integral output value is set to the word connector value defined by E4-19 forcibly.

Related parameters

Param.	Name	Default	Value range	Description
E4-02	Speed loop Kp in FVC mode	3	0 to 200	Defines the speed loop Kp in FVC mode. Note: 1. Kp and Ki of PI regulator of the speed loop can be optimized through complete no-load auto-tuning (b5-00 = 2). If the moment of inertia is known, you can set d2-02 [Moment of inertia ratio] directly, and then set b5-02 to 2 and b5-03 to 1 to calculate speed loop parameters. 2. If the feedback speed is still oscillating after optimization, you need to manually optimize the controller parameters.
E4-03	Speed loop Ti in FVC mode	500 ms	1 ms to 10000 ms	Defines the speed loop Ti in FVC mode. Note: 1. Kp and Ki of PI regulator of the speed loop can be optimized through complete no-load auto-tuning (b5-00 = 2). If the moment of inertia is known, you can set d2-02 [Moment of inertia ratio] directly, and then set b5-02 to 2 and b5-03 to 1 to calculate speed loop parameters. 2. If the feedback speed is still oscillating after optimization, you need to manually optimize the controller parameters.
E4-04	Speed loop Kp in SVC mode	3	0 to 200	Defines the speed loop Kp in SVC mode. Note: 1. Kp and Ki of PI regulator of the speed loop can be optimized through complete no-load auto-tuning (b5-00 = 2). If the moment of inertia is known, you can set d2-02 [Moment of inertia ratio] directly, and then set b5-02 to 2 and b5-03 to 1 to calculate speed loop parameters. 2. If the feedback speed is still oscillating after optimization, you need to manually optimize the controller parameters.
E4-05	Speed loop Ti in SVC mode	500 ms	1 ms to 10000 ms	Defines the speed loop Ti in SVC mode. Note: 1. Kp and Ki of PI regulator of the speed loop can be optimized through complete no-load auto-tuning (b5-00 = 2). If the moment of inertia is known, you can set d2-02 [Moment of inertia ratio] directly, and then set b5-02 to 2 and b5-03 to 1 to calculate speed loop parameters. 2. If the feedback speed is still oscillating after optimization, you need to manually optimize the controller parameters.

Param.	Name	Default	Value range	Description
b1-11/b3-11	Speed regulator enable source	1	0 to 1	Defines the source for enabling the speed regulator of control channels 1/2. Value description: 0: Disable - The speed regulator is inactive and the drive no longer controls the motor speed. 1: Enable - The speed regulator operates properly to ensure the speed is in closed-loop control. Others: B connector - Whether the speed regulator is active or depends on the connector.
E4-18	Source of forced speed loop integral	0	0 to 8	Defines whether to set the speed loop integral value forcibly. Value description: 0: Inhibited 1: Enabled - When this function is enabled, the integral term output of the speed loop is determined by E4-19 [Forced value source of speed loop integral] and E4-20 [Source for speed loop integral freeze]. 2 to 7 and 8: DI1 to DI6 and HDI1 - Depends on the final terminal state of DI and HDI (0: Inhibited; 1: Enabled). Others: B connector - The value of B connector determines whether to enable forced speed loop integral.

Param.	Name	Default	Value range	Description
E4-19	Source of forced speed loop integral value	0	0 to 0	Defines the source of forced integral value of speed loop. Value description: 0: The integral value is set to 0 forcibly. Others: K connector - The value of K connector determines the forced integral value of the speed loop. Note: When E4-18 is enabled, the forced integral value set by E4-19 is active.
E4-20	Source of speed loop integral freeze	0	0 to 8	Defines the source for freezing the speed loop integral. Value description: 0: Operating - Integral freeze is disabled. 1: Freeze - After this function is enabled, the speed loop integral value is fixed. 2 to 7, 8: DI1 to DI6, HDI1 - Depends on the final terminal state of DI and HDI (0: Operating; 1: Freeze). Others: B connector - The value of B connector determines whether to enable speed loop integral freeze. Note: After integral freeze is enabled, the integral output value is fixed to the value of the previous cycle.

Application instance

For details, see *"6.3 Auto-Calculation of Speed Loop Parameters" on page 197*.

8.1.3.3 Speed Controller Adapter

Application scenario

The speed controller adapter automatically adjusts the speed loop parameters to suppress overshoot or oscillation of the speed controller.

Operating principles

The adapter includes speed adaption and adaptive adaption.

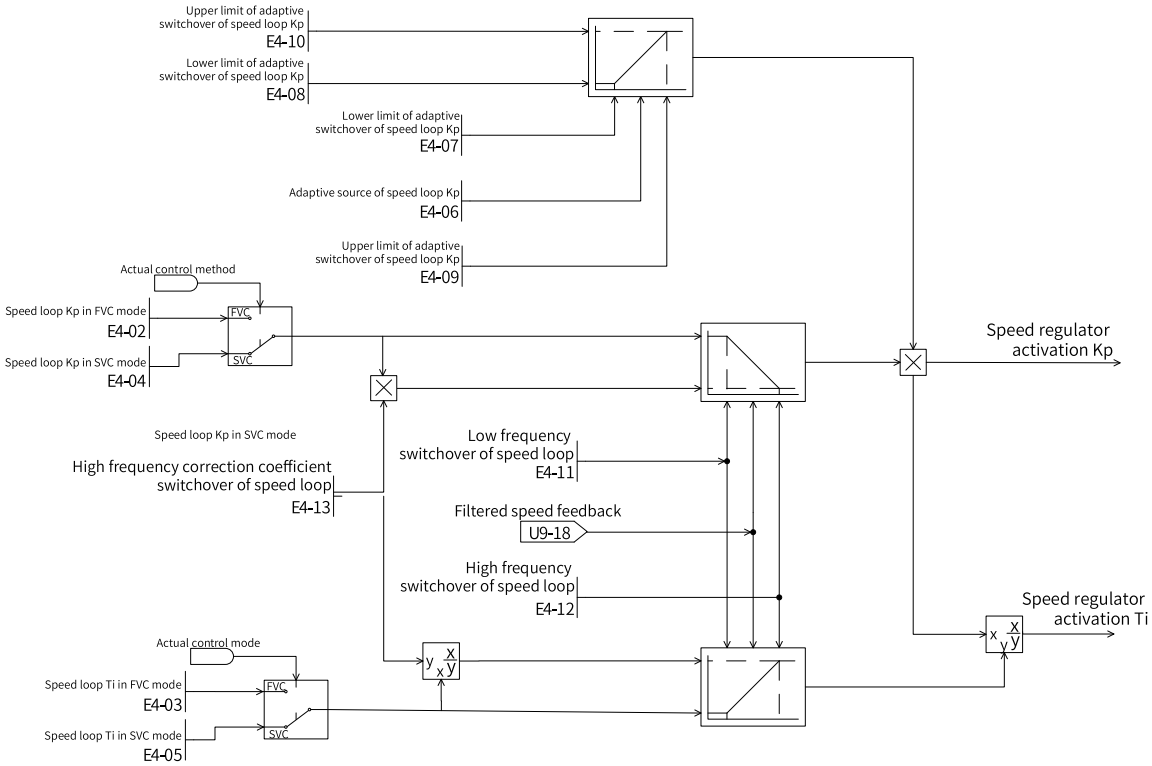


Figure 8-9 Speed controller adapter

- When U9-17 [Filtered speed reference] is lower than E4-42 [Kp switchover starting speed at 0 rpm], the speed loop is adjusted according to the "Zero speed adaption" rule.
- When U9-17 [Filtered speed reference] is higher than E4-42 (Kp switchover starting speed at 0 rpm), the speed loop is adjusted according to the "Low-High speed adaption" rule.

Zero speed adaption: The speed loop is adjusted based on the frequency reference at 0 rpm based on the following rules.

When U9-17 (Filtered speed reference) is lower than E4-43 (Kp switchover completion speed at 0 rpm), the effective speed loop parameters are adjusted based on the original speed loop parameters through E4-41 [Kp coefficient at 0 rpm]. When U9-17 [Filtered speed reference] is higher than E4-42 [Kp switchover starting speed at 0 rpm], the original speed loop parameters are not modified. That is, the Kp coefficient at 0 rpm is 100%. When U9-17 [Filtered speed reference] is between E4-42 [Kp switchover starting speed at 0 rpm] and E4-43 [Kp switchover completion speed at 0 rpm], the adjustment coefficient changes linearly between E4-41 (Kp coefficient at 0 rpm) and 100%.

Low-High speed adaption: The speed loop is adjusted based on the feedback speed. During operation at high speed, current control capacity is weakened, resulting in decrease of the speed loop bandwidth. In this case, adjust the effective Kp and Ti parameters in real time based on the feedback speed. The adjustment rules are as follows.

- When U9-00 [Motor actual speed] is higher than E4-12 [Threshold for high frequency switchover of speed loop), make adjustment through E4-13 [Correction coefficient for high frequency switchover of speed loop] based on the original speed loop parameters E4-02 [FVC speed loop Kp], E4-03 [FVC speed loop Ti], E4-04 [Speed loop Kp in SVC mode], and E4-05 [SVC speed loop Ti].

- When U9-00 [Motor actual speed] is lower than E4-11 [Frequency for low frequency switchover of speed loop], the speed loop parameters are not modified.
- The speed loop correction coefficient changes linearly when U9-00 [Motor actual speed] is between low speed and high speed.

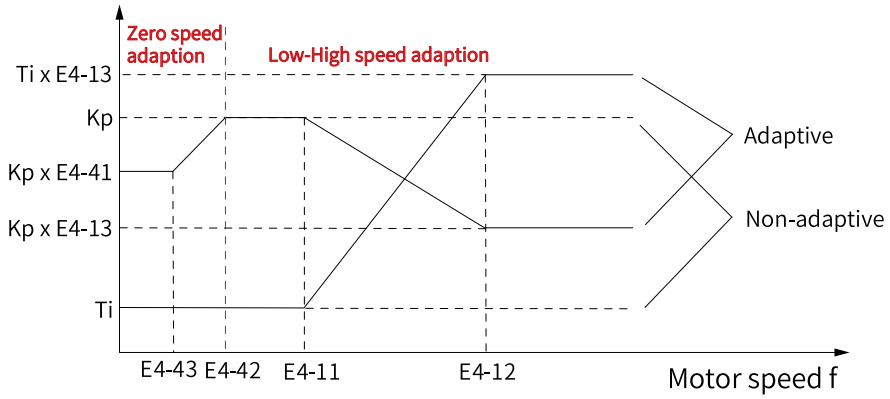


Figure 8-10 Speed controller adapter

Adaptive adaption: The principle of adaptive adaptation is the same as that of speed adaptation, but the adjustment reference value range for adaptive adaption is wider. For example, if the speed loop controller needs to be modified when the roll diameter changes during winding and unwinding, the roll diameter can be used as the adjustment reference. The adaptive adapter outputs an adjustment coefficient, which acts on Kp of the speed adaptation output.

The adjustment rules for adaptive adaption are as follows.

- When E4-06 [Speed loop Kp adaptive source] is lower than E4-07 [Lower limit of speed loop adaptive switchover], the speed loop Kp is corrected with E4-08 [Upper limit of speed loop adaptive correction]. When E4-06 is higher than E4-10 [Upper limit of speed loop adaptive switchover], the Kp of the speed loop is corrected with E4-08 [Lower limit of speed loop adaptive correction]. When E4-06 is between E4-07 and E4-09, the Kp correction coefficient also changes linearly between E4-10 and E4-08.

The adaptive correction coefficient is calculated as follows.

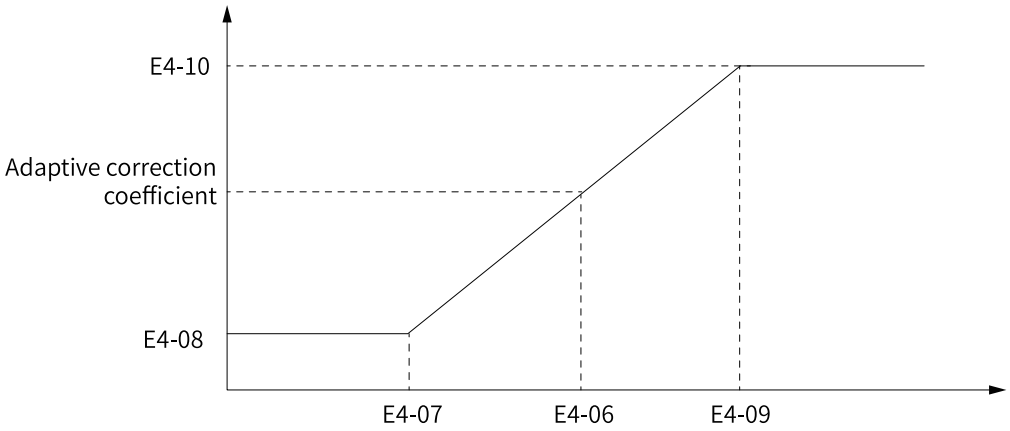


Figure 8-11 Adaptive adapter

The final active Kp and Ti are calculated as follows:

Final effective value of Kp = Speed loop Kp (E4-02 [FVC speed loop Kp] or E4-04 [Speed loop Kp in SVC mode]) x Proportional coefficient (speed adapter) x Adaptive correction coefficient

Final effective value of Ti = Speed loop Ti (E4-03 [FVC speed loop Ti] or E4-05 [SVC speed loop Ti]) x Integral coefficient (speed adapter)

Related parameters

Param.	Name	Default	Value range	Description
E4-02	Speed loop Kp in FVC mode	3	0 to 200	Defines the speed loop Kp in FVC mode. Note: 1. Kp and Ti of PI regulator of the speed loop can be optimized through complete no-load auto-tuning (b5-00 = 2). If the moment of inertia is known, you can set d2-02 and set b5-02 to 2, and then set b5-03 to 1. 2. If the feedback speed is still oscillating after optimization, manually optimize the controller parameters.
E4-03	Speed loop Ti in FVC mode	500 ms	1 ms to 10000 ms	Defines the speed loop Ti in FVC mode. Note: 1. Kp and Ti of PI regulator of the speed loop can be optimized through complete no-load auto-tuning (b5-00 = 2). If the moment of inertia is known, you can set d2-02 and set b5-02 to 2, and then set b5-03 to 1. 2. If the feedback speed is still oscillating after optimization, manually optimize the controller parameters.
E4-04	Speed loop Kp in SVC mode	3	0 to 200	Defines the speed loop Kp in SVC mode. Note: 1. Kp and Ti of PI regulator of the speed loop can be optimized through complete no-load auto-tuning (b5-00 = 2). If the moment of inertia is known, you can set d2-02 and set b5-02 to 2, and then set b5-03 to 1. 2. If the feedback speed is still oscillating after optimization, you need to manually optimize the controller parameters.

Param.	Name	Default	Value range	Description
E4-05	Speed loop Ti in SVC mode	500 ms	1 ms to 10000 ms	Defines the speed loop Ti in SVC mode. Note: 1. Kp and Ti of PI regulator of the speed loop can be optimized through complete no-load auto-tuning (b5-00 = 2). If the moment of inertia is known, you can set d2-02 and set b5-02 to 2, and then set b5-03 to 1. 2. If the feedback speed is still oscillating after optimization, you need to manually optimize the controller parameters.
E4-06	Adaptive source of speed loop Kp	0	0 to 0	Defines the adaptive source of speed loop Kp. Value description: 0: Disable Others: K connector
E4-07	Lower limit of adaptive switchover of speed loop Kp	25%	0% to 400%	Defines the adaptive switchover lower limit of the speed loop Kp.
E4-08	Adaptive correction lower limit of speed loop Kp	25%	0% to 400%	Defines the adaptive correction lower limit of speed loop Kp.
E4-09	Adaptive switchover upper limit of speed loop Kp	100%	0% to 400%	Defines the adaptive switchover upper limit of speed loop Kp.
E4-10	Adaptive correction upper limit of speed loop Kp	100%	0% to 400%	Defines the adaptive correction upper limit of speed loop Kp.
E4-11	Threshold for low frequency switchover of speed loop	50%	0% to 400%	Defines the threshold for low frequency switchover of the speed loop.
E4-12	Threshold for high frequency switchover of speed loop	100%	0% to 400%	Defines the threshold for high frequency switchover of speed loop.
E4-13	Correction coefficient for high frequency switchover of speed loop	50%	0% to 1600%	Defines the correction coefficient for high frequency switchover of speed loop. Note: When the operating frequency of the motor is higher than E4-12, the speed loop parameter is the current effective parameter x E4-13.

Param.	Name	Default	Value range	Description
E4-41	Kp coefficient at zero speed	70%	0% to 600%	Defines the Kp coefficient at zero speed. Note: At low speed, the speed loop proportional coefficient Kp must be multiplied by the low speed conversion coefficient Coff as the final effective Kp. The low-speed conversion coefficient Coff is calculated as follows: When the speed is lower than E4-43, Coff = E4-41. When the speed is higher than E4-42, Coff = 100%. When the speed is between E4-42 and E4-43, the coff changes linearly.
E4-42	Starting speed of Kp switchover at zero speed	3%	1% to 600%	Defines the starting speed of Kp switchover at zero speed. Note: At low speed, the speed loop proportional coefficient Kp must be multiplied by the low speed conversion coefficient Coff as the final effective Kp. The low-speed conversion coefficient Coff is calculated as follows: When the speed is lower than E4-43, Coff = E4-41. When the speed is higher than E4-42, Coff = 100%. When the speed is between E4-42 and E4-43, the coff changes linearly.
E4-43	Kp switchover completion speed at zero speed	1%	0% to 3%	Defines the speed for completing Kp switchover at zero speed. Note: At low speed, the speed loop proportional coefficient Kp must be multiplied by the low speed conversion coefficient Coff as the final effective Kp. The low-speed conversion coefficient Coff is calculated as follows: When the speed is lower than E4-43, Coff = E4-41. When the speed is higher than E4-42, Coff = 100%. When the speed is between E4-42 and E4-43, the coff changes linearly.

Application instance

- Example 1
  In the application of a wire drawing machine, the improper mechanical installation results in mechanical vibration of the stand. The higher the speed, The more obvious the vibration is.

  On-site commissioning reveals that the speed loop parameters needs to be increased at low speed to suppress speed fluctuation, or decreased at high speed to reduce vibration.

Based on the actual commissioning, the speed loop parameters can be adjusted automatically by using the high-low speed loop adaptive function.

The following shows the detailed procedure.

1. Set the threshold for low-speed speed loop switchover (E4-11 = 10%) based on the on-site commissioning results.
2. Decrease speed loop parameters at high speed and set the threshold for high-speed speed loop switchover (E4-12 = 30%).
3. Based on the commissioning results, decrease high-speed speed loop parameter (E4-13 = 30%).

- Example 2
  In high load applications, due to the saturation effect, speed oscillation may occur during motor operation. You can adjust the control parameters in real time through the speed loop adaption function. This effectively suppresses speed fluctuation. The following shows detailed procedure.

  1. Calculate the absolute value of the speed deviation through the absolute module and set the input of the absolute value module A (L13-00) to U6-09 [Speed deviation].
  2. Set the absolute value of the speed deviation to the speed loop Kp adaptive source and set E4-06 to U19-28 (Absolute module A output).
  3. Set the lower limit of adaptive switchover to 1%: E4-07 = 1%, and the lower limit of adaptive switchover to 3%: E4-09 = 3%.
  4. Set the lower limit of the adaptive correction to 100%: E4-08 = 100%, and the upper limit of the adaptive correction to 200%: E4-10 = 200%.

  After the above settings are done, the speed loop control intensity can be adjusted adaptively according to the speed deviation. When the speed deviation exceeds the lower limit of the adaptive switchover, the actual effective proportional coefficient is increased to 200% of the original value. The above parameters can be adjusted according to the actual working conditions.

8.1.3.4 Acceleration Torque Feedforward

The motor motion equation is as follows.

$$T_e - T_L = J\frac{d\omega}{dt}$$

In the preceding formula, T_e represents the electromagnetic torque of the motor.

T_L represents the load torque and friction torque.

J represents the moment of inertia, which is displayed in d2-00 after auto-tuning. The per-unit value is equal to the electromechanical time constant (d2-05).

$\frac{d\omega}{dt}$ represents the speed change rate of the motor.

To allow the motor to accelerate/decelerate based on the set RFG curve, set a proper acceleration torque for the motor (Ta = Te - TL) instead of using the speed regulator only, preventing overshoot at the end of acceleration and speed lag at the start of acceleration.

In this case, you can use acceleration torque compensation to calculate the acceleration torque required through the auto-tuned moment of inertia and expected acceleration. Then superimpose the acceleration torque to the output of the speed regulator (function diagram H430) to improve the speed following characteristics.

The output acceleration of RFG is used during acceleration torque calculation. When the set speed curve is generated only by RFG, you can get an accurate acceleration torque through this method. Take the control channel 1 as an example. After setting E4-22 to 1, c1-10 to 1, and E4-23 to 100%, you can get an accurate acceleration torque after the filter time defined by C1-14 elapses. You can view current acceleration torque through U6-25/U6-27/U25-61.

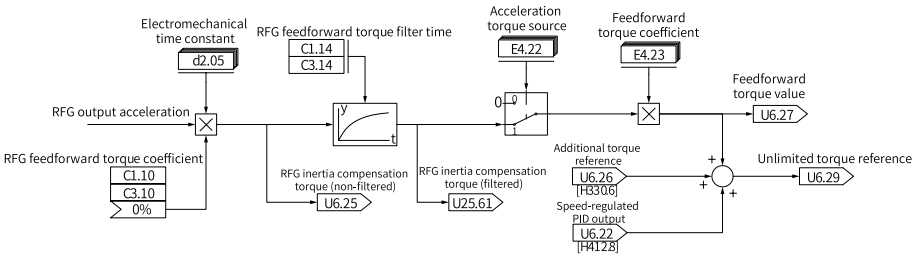


Figure 8-12 Feedforward torque

8.1.4 Speed Control Optimization

Poor speed following performance or speed fluctuation can easily occur during commissioning. Increasing or decreasing the speed loop PI parameters can only solve part of the problems. For example, it is difficult to adjust the PI parameters to solve the problem of speed tracking difference in high-inertia systems and fast acceleration/deceleration. In addition, there are certain techniques for adjusting the PI parameters of the speed loop. Incorrect parameter setting can result in improper system operations.

To optimize speed control, speed performance are classified into two categories: speed following performance and load disturbance immunity. The commissioning sequence is to optimize the performance of the speed following first, and then optimize the load disturbance immunity.

The speed control performance in vector control is classified into the following two types:

- Speed following performance
  Speed following performance indicates the ability to follow the speed reference, which is usually a challenge during acceleration/deceleration, as shown in the following figure.

  Acceleration feedforward is mainly used to improve the speed following capability. When the speed following performance is affected by acceleration/deceleration, commission the acceleration feedforward first.

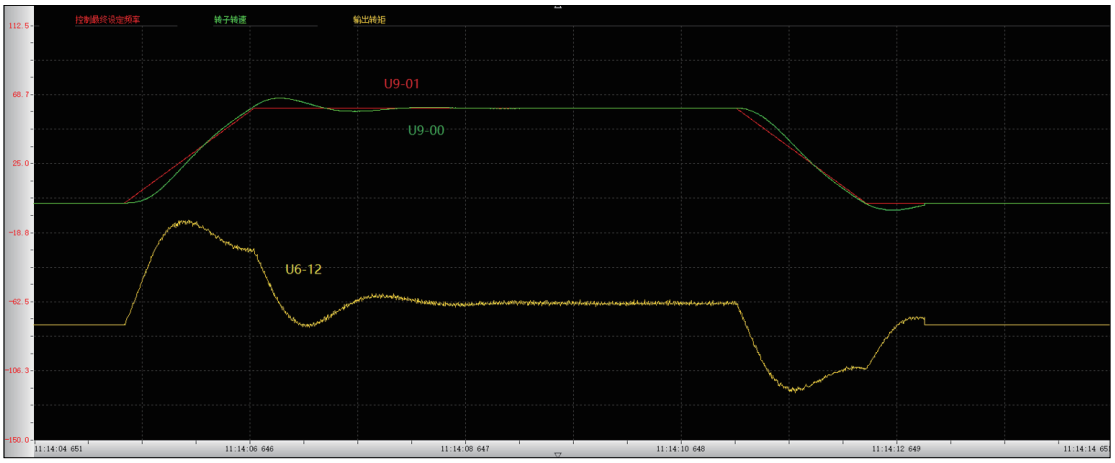


Figure 8-13 Poor speed following performance

- Load disturbance immunity
  Load disturbance immunity indicates the ability to keep the speed stable when the load changes, which is usually a challenge when the load changes, as shown in the following figure.

  The speed loop PID is mainly used to improve the load disturbance immunity. When the speed following performance is disturbed by the load, optimize speed loop PID parameters first.

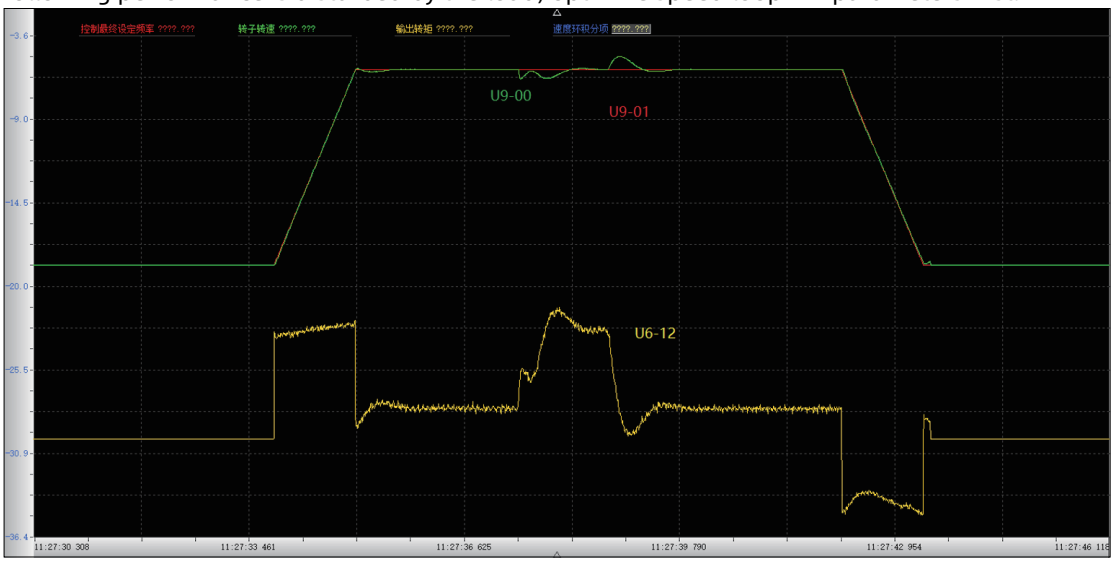


Figure 8-14 Poor load disturbance immunity

8.1.4.1 Optimizing Speed Reference Following Performance

During acceleration/deceleration, the actual speed may fail to follow the speed reference closely, resulting in excessive overshoot or repeated oscillation after the speed is reached. To optimize speed control, first adjust the speed loop to a low value. For example, set speed loop Kp to 5 (E4-02/04 = 5) and Ti to 2000 ms (E4-03/05 = 2000 ms). Then adjust the acceleration torque feedforward to greatly improve the speed following performance.

Acceleration torque feedforward calculation formula: $T_e = J \times a$.

- T_e: Motor output acceleration torque
- J: Moment of inertia. This is a system parameter that needs to be auto-tuned or manually tested.
- A: Acceleration rate, indicating the acceleration/deceleration time

As shown in the preceding formula, the acceleration/deceleration time a is known. You only need to get the value of inertia J for calculating the feedforward torque accurately, which can be auto-tuned through inertia auto-tuning. If auto-tuning fails, adjust E4-23 [Inertia feedforward coefficient] manually to get the accurate inertia compensation.

If dynamic inertia auto-tuning is available, see the commissioning process for acceleration feedforward in the following diagram.

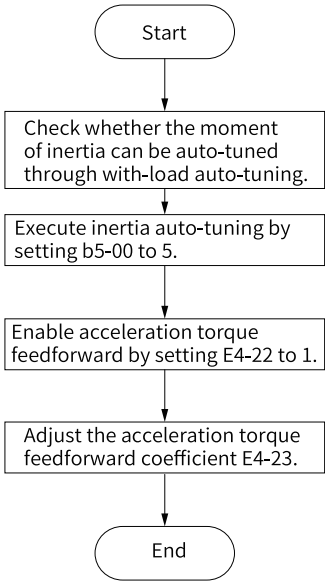


Figure 8-15 Commissioning for acceleration feedforward based on inertia auto-tuning

Caution

The moment of inertia is an important parameter for acceleration feedforward. Precautions for inertia auto-tuning are shown below.

- Systems with fixed inertia such as inertia disks and rollers.
- Do not perform inertia auto-tuning on systems with travel limit. Perform partial inertia compensation (acceleration feedforward compensation) on systems with variable inertia, then adjust the PI parameters.
- Do not perform inertia auto-tuning on systems with variable inertia, such as winding/unwinding and reciprocating cam slider mechanisms.
- Do not perform inertia auto-tuning for systems with significant load changes, such as fans and water pumps.

If dynamic inertia auto-tuning is not available, see the commissioning process for acceleration feedforward in the following diagram.

If inertia auto-tuning is not performed, the system assigns a moment of inertia by default and adjusts d3-39 [Acceleration torque feedforward coefficient] directly during operation to done the commissioning on acceleration feedforward torque. Set the speed loop Kp to 5 [E4-02/04 = 5] and Ti to 2.0s [E4-03/05 = 2.0s], and then adjust the feedforward torque. The commissioning process is as follows.

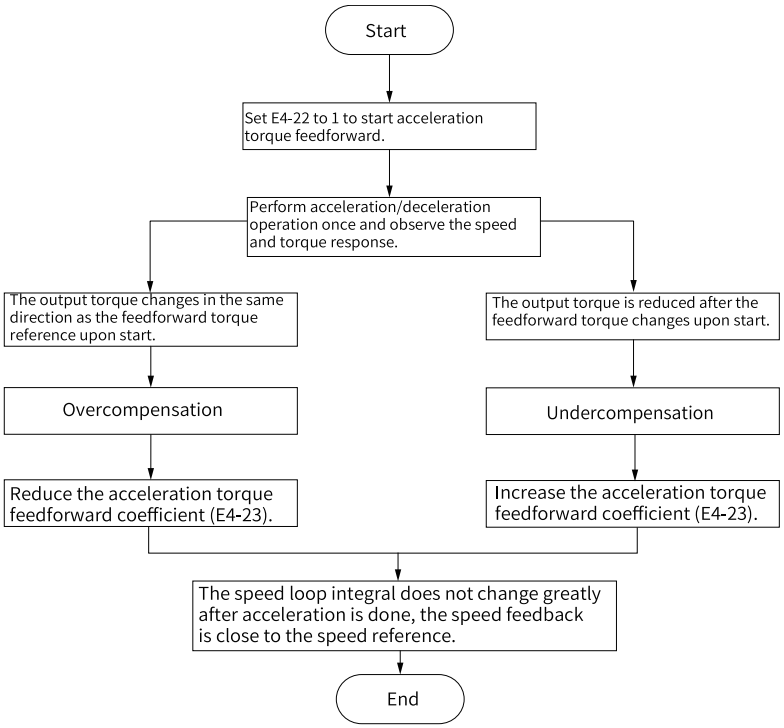


Figure 8-16 Commissioning process for acceleration feedforward without inertia auto-tuning

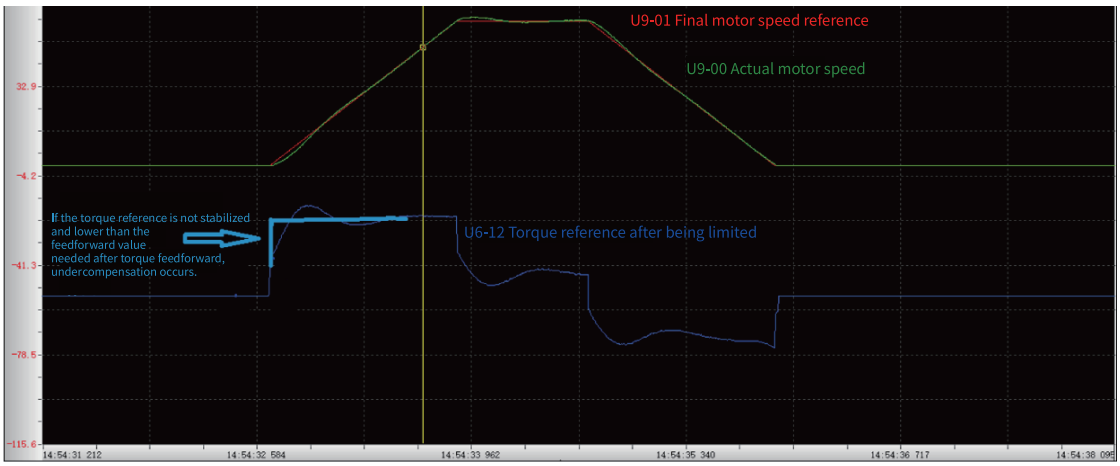


Figure 8-17 Acceleration torque feedforward undercompensation

Feedforward undercompensation: The feedforward torque step change does not reach the required level at the start of acceleration/deceleration or speed arrival. The speed loop integral value changes significantly after the speed is reached. For undercompensation, the compensation coefficient (E4-23) needs to be increased.

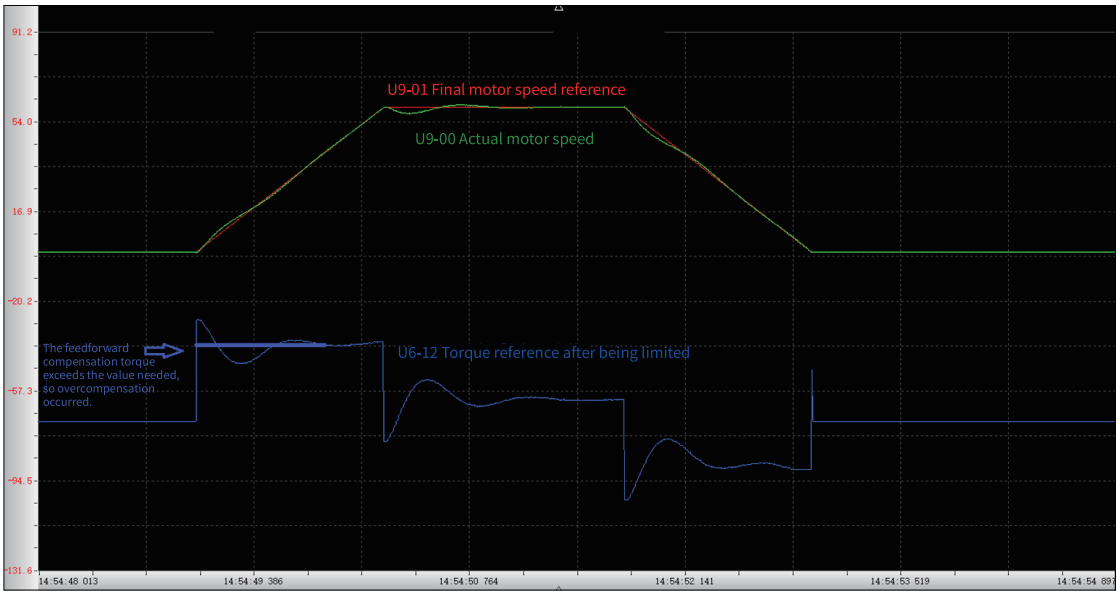


Figure 8-18 Acceleration torque feedforward overcompensation

Feedforward overcompensation: When the feedforward torque step change exceeds the required level at the start of acceleration/deceleration start and speed arrival, the speed loop integral value changes significantly after the speed is reached. For overcompensation, reduce the compensation coefficient (E4-23).

As shown in the following figure, the feedforward is close to the required torque. The actual speed follows the speed reference closely when the speed reference changes.

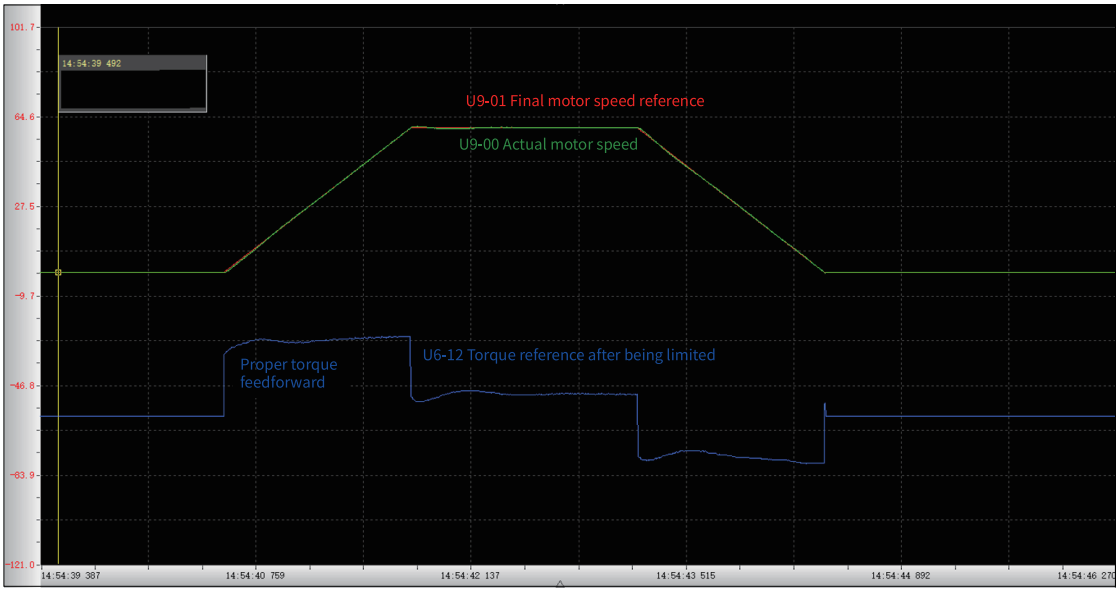


Figure 8-19 Normal effect of acceleration torque feedforward

For flexible loads, a sudden change in the feedforward torque cam cause acceleration transient, resulting in mechanical oscillation or unusual noise. In this case, you can set a ramp arc, and set C7-12/C7-13 to 10% of the acceleration time (C7-04). For example, if C7-04 is set to 20s, you can set C7-12/C7-13 to 2s to make the torque change linearly, thus alleviating torque transient greatly and reducing mechanical oscillation.

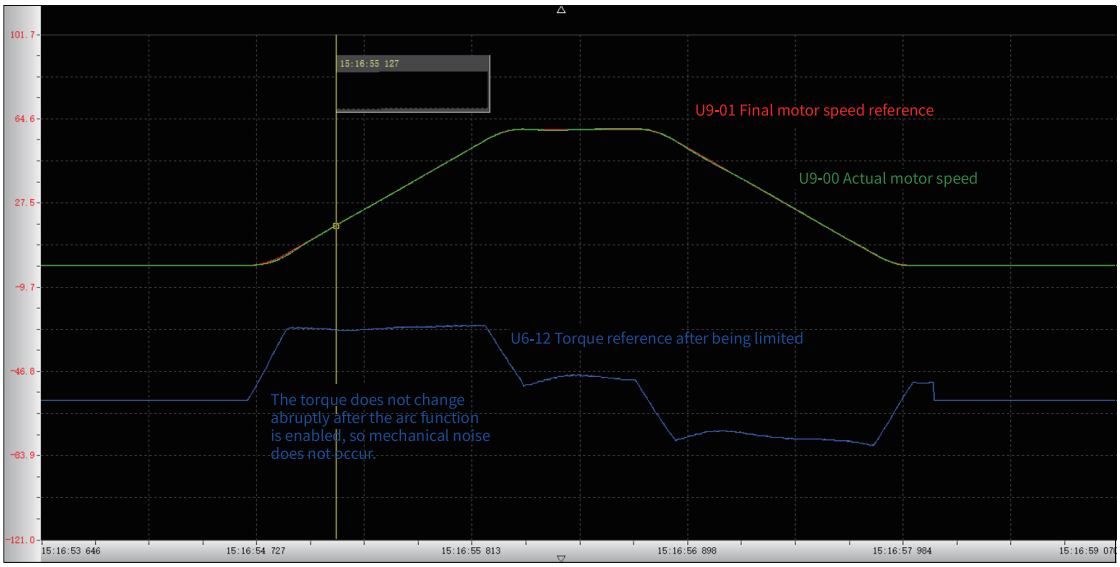


Figure 8-20 Normal effect of acceleration torque feedforward after S-curve enabled

If the PLC writes the reference speed at a slow cycle, for example, if the speed is set once every 100 ms, a stepwise change can occur on the speed feedback, resulting in excessive fluctuation in the output torque. This phenomenon is widely present in industries where speed references are set through PLCs, such as the metallurgy, papermaking, test bench, chemical, and textile industries. In this case, you can enable the ramp function (C8-48), and define the PLC setting cycle for speed references through C8-49 (measure the interval time through the oscilloscope in the software tool). The ramp function can effectively reduce the torque ripple during acceleration/deceleration.

8.1.4.2 Load Disturbance Immunity

The load change can cause speed fluctuation. For example, obvious speed drop can occur upon high loads in the crushers or upon the moment of steel biting and ejection in metallurgical bar/wire rod/wide heavy plate rolling mill and sudden torque increase in the new energy vehicle powertrain test benches. Inadequate speed following performance may occur upon excessive friction between the travel and trolley in port RTG and STS cranes. For low-inertia systems, torque oscillation and mechanical noise can occur when default speed loop parameter values are high. In this case, you can set speed loop PI parameters to rectify these problems.

See the following procedure for PI parameter adjustment.

1. Set speed loop Kp to 5 (E4-02/04 = 5) and Ti to 2.0s (E4-03/05 = 2.0s). To prevent operation oscillation caused by excessively high PI parameters, set speed loop parameters to low values first. For motors with high torque output, such as direct-drive motors, set the speed loop Kp to a value lower than 5.
2. Increase the value of E4-02/04 gradually for the speed loop, and observe U9-00 (Speed feedback waveform) and U6-41 (Torque current reference). Generally, fluctuation o f U9-00 should be lower than 0.3%, and U6-41 should be lower than 3%.
3. When increasing the value of Kp, note that fluctuation of U6-41 cannot exceed 3%. After changing the value of Kp, run at different speeds to check whether torque current fluctuation increases.
4. When the torque current reference fluctuates by 3%, decrease Kp by 1/3.

5. Reduce the speed loop integral time Ti (E4-03/05) gradually as needed by the load. Keep the integral time high than 0.5s in general applications. In applications with high dynamic responses, keep the integral value higher than 0.1s.
6. The band width of large equipment or mechanical systems with high inertia ratio or is low, which may easily incur repeated speed fluctuation upon sudden unloading after loading, resulting in bus voltage rise and over-temperature/overload of the braking transistor IGBT and braking resistor. It is recommended to set the integral time for large equipment or mechanical systems with high inertia ratio to 2s. The integral time should be set to a high value.

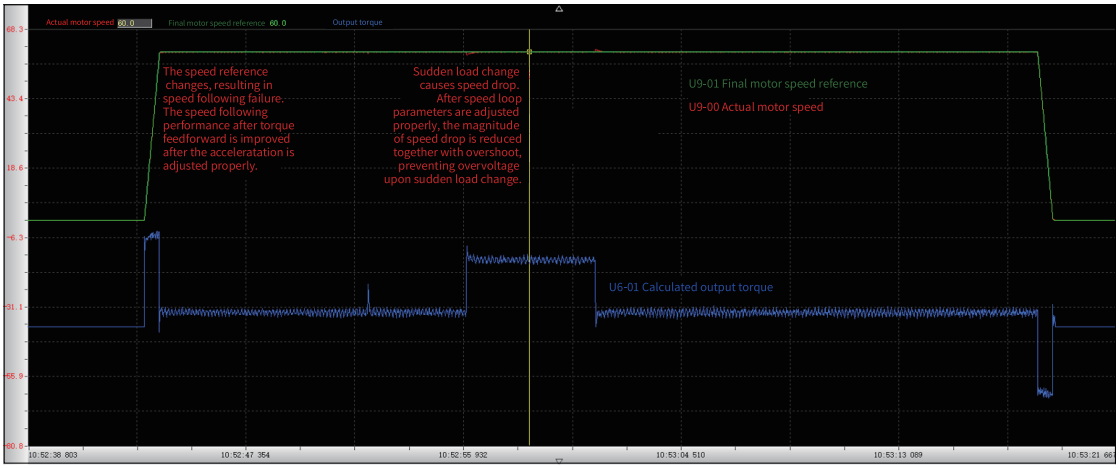


Figure 8-21 Waveform of sudden loading/unloading after commissioning is done

8.1.5 Torque Control

This section describes torque reference setting and speed window in the torque mode.

8.1.5.1 Torque Control

Application scenario

Torque control applies to applications where a constant torque output is required. Torque control ensures that the motor output torque follows the torque reference.

If torque control is used, you need to parameters related to torque references, including the torque reference source, reference value, and the filter and ramp acceleration/deceleration. Generally, the output torque in torque control is not affected by the actual operating speed of the motor.

The function of torque control speed window allows the motor to run within the set speed range and output the set torque. After the motor speed exceeds the set range, the drive switches to speed control to keep the motor speed within the set range. To use this function, you need to set the window center speed source, window center speed, and window width.

Operating principles

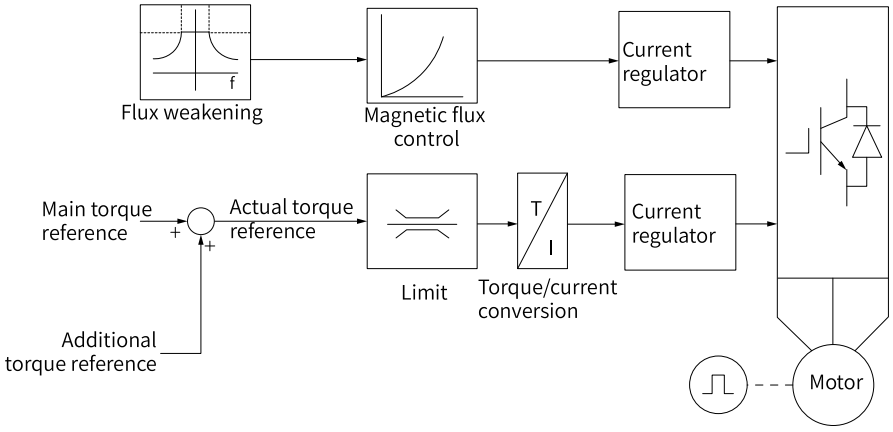


Figure 8-22 Block diagram for torque control mode

The following figure shows the typical block diagram of torque control. The sum of the torque reference and additional torque reference is used as the current reference input of the current loop after being limited and converted. When the motor output torque is lower than the load torque, the motor speed is determined by the load. The actual output torque strictly follows the reference. When the motor output torque is higher than the load torque, the motor accelerates to run. To prevent motor overspeed, use the following methods.

1. For details on applying the overspeed control function, see *"8.1.7.2 Overspeed Limit" on page 277*.
2. For details , see *"8.1.5.3 Torque Control with Speed Window" on page 256*.

Related parameters

Param.	Name	Default	Value range	Description
E0-01	Control mode	0	0: Speed control 1: Torque control 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: DIL 9: HDI1 10: HDI2 Others: B connector	Defines the control mode of the drive. The torque control mode is invalid in V/f mode. Value description: 0: Speed control - The speed is being controlled. 1: Torque control - The torque is being controlled. 2 to 7: DI1 to DI6 - Depends on the final terminal state of the DI (0: Speed control; 1: Torque control). 8: DI1 to DI5 - Depends on the final terminal state of the DIL (0: Speed control; 1: Torque control). 9 to 10: HDI1 to HDI2 - Depends on the final terminal state of the HDI (0: Speed control; 1: Torque control). Others: B connector - Depends on the status of B connector (0: Speed control; 1: Torque control).

Application case

In the automotive test bench industry, the torque control mode enables the auxiliary test motor to output constant torque, which is used to test the torque output condition and external characteristics of the test motor.

8.1.5.2 Torque Reference

Application scenario

In torque control, the torque reference directly determines the magnitude and form of the motor torque output. Adjusting the torque reference can change the operating state of the motor during torque control.

The torque reference includes the main torque reference and the additional torque reference. The main torque reference is generally set to the expected torque output of the motor, which is usually a fixed value under steady state conditions. The actual torque output during operation can deviate from the main torque reference due to friction or inertia. The additional torque can be used to eliminate the impact caused by other mechanical factors on the motor output torque. For example, set the known friction torque or inertia compensation torque to the additional torque. The additional torque is superimposed on the main torque reference to be used as the actual torque reference output, which ensures that the actual motor torque output is equal to the main torque reference.

Operating principles

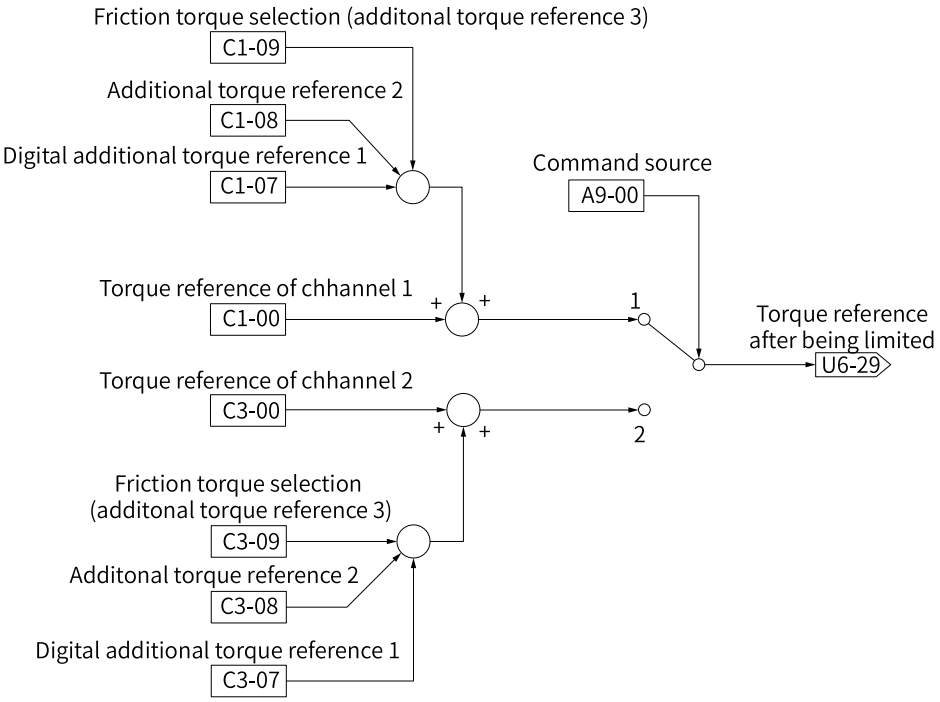


Figure 8-23 Typical block diagram for torque reference

The typical block diagram for torque reference is shown in the preceding figure. There are two channels for setting the motor torque. The structure of each channel is the same. Group C1 corresponds to channel 1, and group C3 corresponds to channel 2. The active channel can be

selected through A9-00 [Setting channel selection]. When the setting channel 1 is selected, parameters in group C1 are activated. In this case, the torque reference is set by parameters in group C1. When the setting channel 2 is selected, parameters in group C3 are activated. In this case, the torque reference is defined by parameters in group C3.

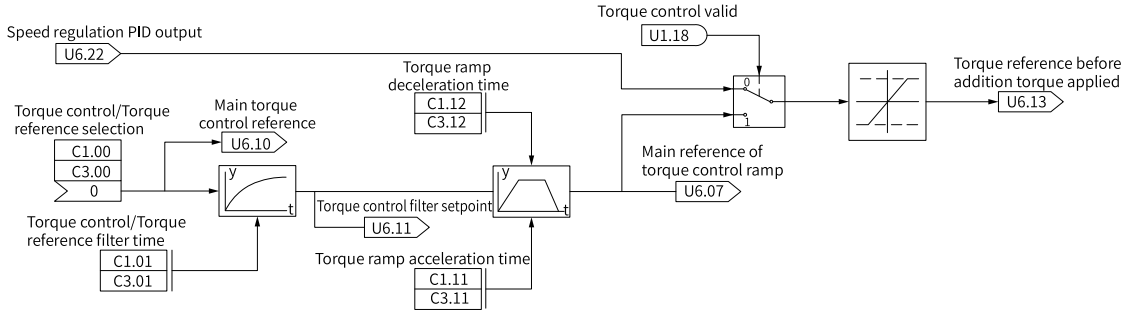


Figure 8-24 Typical block diagram of main torque reference

In torque control, the difference between the actual output torque of the motor and the load torque determines the speed change rate of the motor and load. When the speed change rate is large, the motor speed changes quickly, which can easily result in noise or excessive mechanical stress. You can smooth the motor speed change by setting the torque control filter and acceleration/deceleration time. The torque acceleration/deceleration time corresponds to the time for the torque to increase from 0 to the rated motor torque. The typical block diagram for main torque reference is shown in the preceding figure. Take the torque reference channel 1 as an example. You can set the torque reference filter, acceleration time, and deceleration time through C1-01, C1-11, and C1-12 respectively.

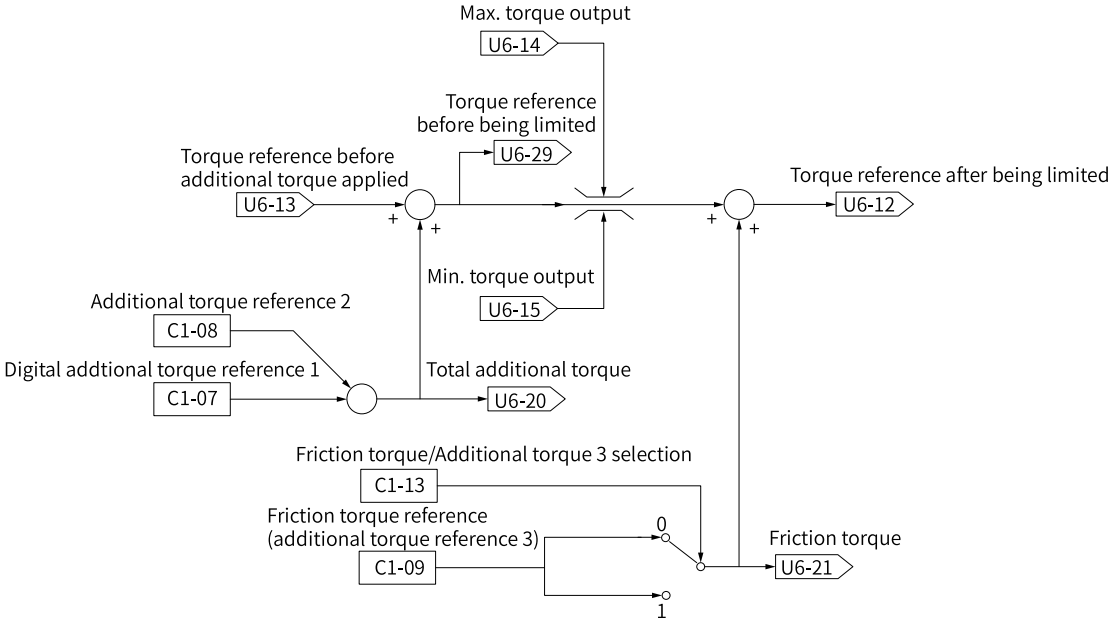


Figure 8-25 Typical block diagram of additional torque reference

The preceding figure shows the typical block diagram of the additional torque reference. The additional torque 1 can be set by digits or transmitted through the connector. Additional torque 2 can only be transmitted through the connector. Additional torque 3 can be selected through C1-13. If additional torque 3 is selected, it is transmitted through the connector similar to that of additional

torque 2. If friction torque is selected, the sign of the friction torque is determined by the motor operating direction. The main reference value that superimposed with additional torque 1 and additional torque 2 are used as the general additional torque after being limited. After being limited again, the additional torque 1 and additional torque 2 are added to the friction torque (additional torque reference 3) to be used as the final torque reference. Take torque reference channel 1 as an example. You can set additional torque reference 1, additional torque 2, and friction torque reference through C1-07, C1-08, and C1-09.

Related parameters

Take torque control channel 1 as an example. The parameters are described as follows.

Param.	Name	Default	Value range	Description
C1-00	Torque reference selection in torque control	0	0: [0] 1: Multi-reference 2 2: AI1 3: AI2 4: HDI1 5: HDI2 6: Multi-reference 7: Reserved 8: Process data 3 of bus adapter A 9: Process data 3 of bus adapter B 10: Reserved Others: K connector	Defines the torque reference source of channel 1 in torque control mode. Value description: 0: 0 1: Depends on the value of multi-reference 2. 2 to 3: AI1 to AI2 - Depends on the final state of AI. 4 to 5: HDI1 to HDI2 - Depends on the final state of HDI. 6: Multi-reference 7: Reserved 8: Depends on process data 3 of bus adapter A. 9: Depends on process data 3 of bus adapter B. 10: Reserved Others: K connector - Depends on the K connector. Note: When torque control is active, the actual torque reference is generated based on the main reference after being filtered and processed with the ramp acceleration/deceleration time. The actual torque reference is then superimposed with the additional torque to generate the unlimited torque reference.
C1-01	Torque reference filter time in torque control	0.0%	0.00% to 10.00%	Defines the filter time of the torque reference of setting channel 1, which is used to filter out disturbance caused by the torque reference. Set this parameter according to the actual reference signal quality. The higher the setpoint, the better the filtering effect, but the longer the torque reference delay can be.
C1-06	Selection of additional torque reference 1	0 ms	0: [0] 1: Digital reference Others: K connector	Used to select the additional torque reference 1. 0: [0] - Null 1: Digital setting - The source of additional torque reference 1 is C1-07. Others: K connector - Depends on the K connector.

Param.	Name	Default	Value range	Description
C1-07	Digital reference of additional torque reference 1	0.000s	-400.0s to +400.0s	Defines the digital setting of additional torque reference 1. Note: This parameter is valid when C1-06 is set to 1.
C1-08	Additional torque reference 2	0.000s	0: [0] Others: K connector	Used to set the additional torque reference 2. 0: [0] - Null Others: K connector - Depends on the K connector.
C1-09	Friction torque selection (additional torque reference 3)	0	0: [0] 1: d2-03 Others: K connector	Used to select friction torque (additional torque reference 3). 0: [0] - Null 1: d2-03 Others: K connector - Depends on the K connector.
C1-11	Torque ramp-up time	0.000s	0.000s to 60.000s	Defines the torque-up time. Note: This parameter defines the time for the motor torque to increase from 0 to the rated torque.
C1-12	Torque ramp-down time	0.000s	0.000s to 60.000s	Defines the torque ramp-down time. Note: This parameter defines the time for the motor torque to decrease from rated torque to 0.
C1-13	Friction torque/ Additional torque 3 selection	0	0: Friction torque (compensation torque sign determined by speed direction) 1: Additional torque 3 (compensation torque sign determined by the reference value)	Used to set the direction of additional torque reference 3. 0: Friction torque (compensation torque sign determined by speed direction) 1: Additional torque 3 (compensation torque sign determined by the reference value)

Application case

When two motors are rigidly coupled to drive the same load, master-slave control is usually used for even load distribution, in which the slave adopts torque control and the master adopts speed control generally. The actual output torque of the master is used as the torque reference of the slave. In this case, the slave torque needs to follow the master quickly. You can select torque reference channel 1. The acceleration/deceleration time for torque control of the slave is 0.000s. The filter time must be set to 0.000s. If the friction torque of the two motors is known, friction torque compensation can be achieved by sending the friction torque to additional torque reference 3 from the host controller through a connector.

8.1.5.3 Torque Control with Speed Window

Application scenario

In torque control, when the motor output torque is higher than the load torque, the motor speed increases continuously until the speed limit is exceeded. In this case, you can enable the torque control speed window to prevent overspeed. Determine the speed range through parameters. When the motor speed deviation is outside the speed range, torque control applies and the motor generates torque output based on the setting. When the motor speed is within the speed range, speed control applies to ensure that the actual speed does not exceed the speed limit.

Operating principles

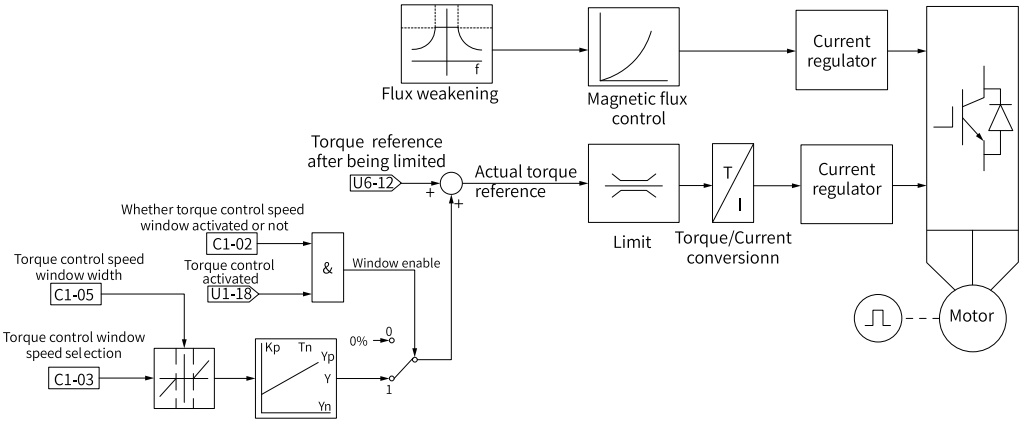


Figure 8-26 Typical block diagram for torque control with speed window

The typical block diagram for torque control with speed window is shown in the preceding figure. Take torque control channel 1 as an example. The window width H is set by C1-05. The center speed W of the window can be set in two ways.

1. The center speed is determined by the speed reference channel in speed control and activated after being processed by the reference frequency generator. (Set C1-03 to 0 [Channel 1 speed reference].)
2. The speed value is set by C1-04, which is activated after being processed by the reference frequency generator. (Set C1-03 to 1 [Digital reference].)

The window control is determined by the center speed W and width H of the window. The actual active window is [W - H, W + H]. When the actual speed is lower than W - H or higher than W + H, torque control applies. When the speed deviation is within the window, speed control applies.

The window width must be set properly to ensure that the speed during normal operation is always within the window range. Otherwise, the drive can switch between speed control and torque control, resulting in motor speed fluctuation.

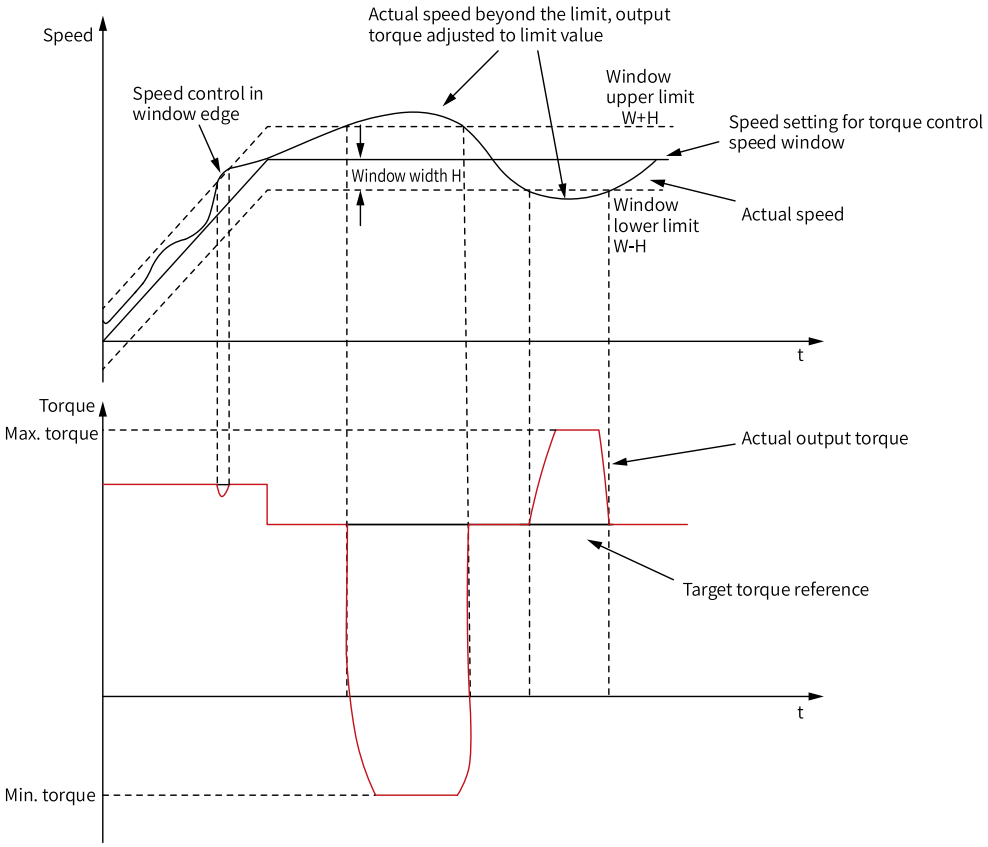


Figure 8-27 Typical block diagram for torque control with speed window

Related parameters

Take torque control channel 1 as an example. The parameters are described as follows.

Param.	Name	Default	Value range	Description
C1-02	Speed window in torque control	0	0: Invalid 1: Valid	Used to activate the speed window in torque control. Value description: 0: Invalid - Speed window inactive 1: Active - Speed window active
C1-03	Window speed selection in torque control	1	0: Channel 1 speed reference 1: Digital reference	Defines the center speed source of the speed window in torque control. Value description: 0: Channel 1 speed reference - The center speed is determined by the speed reference channel in speed control, which is activated after being processed by reference frequency generator. 1: Digital reference - The center speed is determined by C1-04, which is activated after being processed by reference frequency generator.

Param.	Name	Default	Value range	Description
C1-04	Digital reference of the window speed in torque control	0.0%	-600.0% to +600.0%	Defines digital reference value of the window speed in torque control. The window speed setpoint is a percentage to the rated speed of the motor. The setpoint 600.0% indicates that the maximum digital reference of window speed is 6 x rated speed of the motor.
C1-05	Speed window width in torque control	0.0%	0.0% to 30.0%	Defines the speed window width in torque control. The actual effective width of the speed window in torque control is determined by C1-04 and C1-05.

8.1.6 Master-slave Control

Application scenario

The mechanical coupling mode of the motor can be divided into rigid connection and flexible connection.

Rigid connection usually means that multiple motors are connected coaxially or connected through gear meshing. and the speed is closely synchronized between each motor. If each motor is cascaded to be driven by one drive, the drive power may not meet the requirements and the torque output of motors may not be evenly distributed, which may easily result in mechanical damage. Flexible connection usually refers to the indirect connection between the motors through a medium, such as a belt in belt transmission or a roller-conveyed steel strip in a cold rolling processing line. Speeds of motors connected flexibly may are not synchronized, so relative motion is present. Softening control (see *"8.1.12 Softening (Droop) Control" on page 300*) is applicable to synchronous control of motors connected flexibly, without the need for communication or interaction between control modules. However, the speed control accuracy and dynamic responsiveness are low.

In this case, you can use master-slave control. In master-slave control, select one drive as the master to control one motor, and the other drives are used as slaves to control other motors. In this way, even torque output can be achieved in motors connected rigidly or the speed control accuracy and dynamic responsiveness can be improved in motors connected flexibly. Depending on the application scenarios and requirements, master-slave control can be implemented in different ways.

Operating principles

Master-slave control requires a quick network for data transmission between drives. In MD880, the InoLink communication network is used to enable data exchange between up to eight drives in one network. The InoLink communication network is used as an example for parameter setting in this section.

In MD880 master-slave control, the master and slave are not related to the node numbers of the InoLink network. You can configure any one of the drive as the master once the InoLink communication network and data exchange are established. In the following example, the InoLink communication network contains #1 and #2 nodes, in which #1 node controls the master and #2 node controls the slave.

The following three master-slave control solutions apply typically.

1. Master speed+Slave torque control
2. Master PI+Slave P control
3. Slave speed deviation+Torque limit

8.1.6.1 Master Speed+Slave Torque Control

Application scenario

Motors between the master and slave must be connected rigidly through coaxial connection or meshing with the gear chamber.

In aluminum foil rolling mill applications in the metallurgy industry, two coaxial motors are generally used to control the winding/unwinding of rollers. The application of master speed+slave torque control on both motors ensures that the load torque is evenly distributed between the two motors, so that the heat-generating conditions of the drive are the same as those of the motor during long-term operation.

Operating principles

The following figure shows the typical control block diagram of master speed+slave torque control. The master adopts speed control. The slave speed is always consistent with the master due to the rigid connection. The slave adopts torque control and the torque reference is sent by the master to the slave through InoLink communication. This ensures that the output torque at the shaft end is evenly distributed between the master and the slave.

In this master/slave control scheme, the slave torque always follows the master torque. The whole system runs according to the speed loop of the master and features fast dynamic response. However, when the mechanical connection between the motors driven by the master and slave is disconnected, the speed of the slave can be out of control and reach the speed upper limit. In this case, you can enable the torque control speed window or the overspeed controller on the slave to limit the speed of the slave. If the torque control frequency window is enabled on the slave, the master needs to send the actual motor speed to the slave through InoLink communication and ensures that the acceleration/deceleration time of the master is the same as that of the slave.

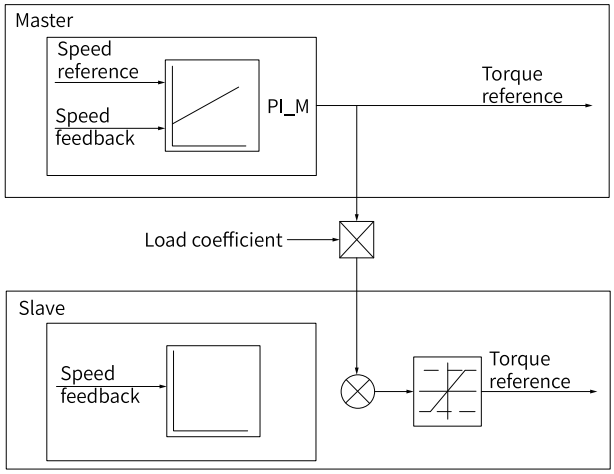


Figure 8-28 Typical control block diagram of master speed+slave torque

Related parameters

Take control channel 1 setting as an example. Parameters required for typical master speed+slave torque control are as follows.

Param.	Name	Master configuration	Slave configuration
E0-00	Control mode	0: SVC (Sensorless vector control) 1: FVC (Feedback vector control)	0: SVC (Sensorless vector control) 1: FVC (Feedback vector control)
E0-01	Control mode	0: Speed control	1: Torque control
b1-10	Forced torque control source	0: Invalid	1: Valid
b0-00	Start/Stop control word source	3: Custom (set in group b0)	3: Custom (set in group b0)
b0-01	Source of custom OFF1	Others: B connector -U2-00: PZD1.0 of bus adapter A	Others: B connector -U2-32: PZD1.0 of InoLink
C0-00	Main speed source in speed control	Others: K connector -U5-45: PZD2 of bus adapter A	-
C1-00	Torque reference selection in torque control	-	Others: K connector -U6-01: Calculated value of output torque
n0-00	InoLink communication startup selection	1: Start	1: Start
n0-02	Local node address	1: #1 node	2: #2 node
n0-40	Source node of received data 1	-	1: #1 node
n0-41	Data selection for received data 1	-	1: Data 1
n0-42	Source node of received data 2	-	1: #1 node
n0-43	Data selection for received data 2	-	2: Data 2
n0-20	Selection of transmission data 1	Others: K connector -U5-44: PZD1 of bus adapter A	-
n0-21	Selection of transmission data 2	Others: K connector -U6-01: Calculated value of output torque	-

Where:

1. Both E0-01 (Control mode) and b1-10 (Forced torque control) must be set to 0 in speed control, and the torque control mode applies when either E0-01 or b1-10 is set to 1.
2. By supposition, the control command word source is PZD1 of bus adapter A and the speed reference source is PZD2 of bus adapter A.
3. The slave command word can be from the master or the bus adapter.
4. To allow the master to detect the fault state of the slave, make the slave send its own status word to be judged by the master.

5. For torque control with speed window, set parameters in *"8.1.5.3 Torque Control with Speed Window" on page 256*.

8.1.6.2 Master PI+Slave P Control

Application scenario

Motors between the master and slave can be connected rigidly or flexibly.

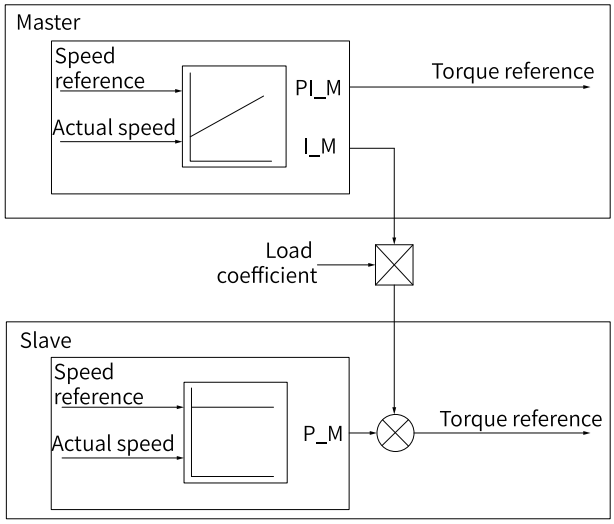
In crane applications in the port industry, two AC drives are used to drive two motors to control the action of one hook. If the master speed+slave torque control is used when the master fails, the slave speed can be out of control, causing the heavy load to fall quickly, which incurs high risk of personal injury. In this case, use master PI+slave P control to control the slave speed, preventing the risk of personal injury.

Master PI+Slave P control is recommended for most of applications.

Operating principles

Figure 6-2 shows the typical control block diagram of the master PI+slave P. The master and slave operate in speed control mode and receive the same speed reference. The PI controller is used for the master speed regulator, and the P controller is used for the slave speed regulator. Meanwhile, the integral term of the master speed regulator is sent to the slave and superposed to the output of the slave speed regulator, achieving torque assignment in the steady state.

In this master-slave control scheme, the output of the slave speed regulator is basically the same as that of the master, and the control performance is similar to that of the master speed control+slave torque control when applied to devices connected rigidly. On the other hand, the slave is capable of adjusting the speed independently, preventing the slave speed from running out of control upon disconnection of rigid connection, without the need to enable other functions.



Related parameters

Take the control channel 1 setting as an example. Parameters required for typical master PI+slave P control are as follows.

Param.	Name	Master configuration	Slave configuration
E0-00	Control mode	0: SVC (Sensorless vector control) 1: FVC (Feedback vector control)	0: SVC (Sensorless vector control) 1: FVC (Feedback vector control)
E0-01	Control mode	0: Speed control	0: Speed control
b1-10	Forced torque control source	0: Invalid	0: Invalid
b0-00	Start/Stop control word source	3: Custom (set in group b0)	3: Custom (set in group b0)
b0-01	Source of custom OFF1	Others: B connector -U2-00: PZD1.0 of bus adapter A	Others: B connector -U2-32: PZD1.0 of InoLink
C0-00	Main speed source in speed control	Others: K connector -U5-45: PZD2 of bus adapter A	Others: K connector -U5-45: PZD2 of bus adapter A
E4-18	Source of forced speed loop integral	0: Inhibited	1: Enabled
E4-19	Source of forced speed loop integral value	-	U15-01: PZD2 of InoLink
n0-00	InoLink communication startup selection	1: Start	1: Start
n0-03	Local node address	1: #1 node	2: #2 node
n0-40	Source node of received data 1	-	1: #1 node
n0-41	Data selection for received data 1	-	1: Data 1
n0-42	Source node of received data 2	-	1: #1 node
n0-43	Data selection for received data 2	-	1: Data 2
n0-20	Selection of transmission data 1	Others: K connector -U5-44: PZD1 of bus adapter A	-
n0-21	Selection of transmission data 2	Others: K connector -U6-24: Speed regulation PID integral term	-

Where:

1. Other settings of the master and slave must be consistent, such as the start time, acceleration/ deceleration time, acceleration torque compensation, and speed loop parameters.
2. By supposition, the control command word source is PZD1 of bus adapter A and the speed reference source is PZD2 of bus adapter A.
3. The slave command word and speed reference can be from the master or the bus adapter.
4. To allow the master to detect the fault state of the slave, make the slave send its own status word to be judged by the master.

8.1.6.3 Slave Speed Deviation+Torque Limit

Application scenario

When the master and slave motors are connected flexibly, the control effect can be better than that of the first two master and slave control schemes.

In conveyor belt applications in the logistics industry, a conveyor belt is usually driven by two motors at the head and end. During startup, the slave speed deviation+torque limit control mode can be used to tighten the belt to ensure normal delivery of the load. After the belt is tightened and normal operation applies, the output torque of the two motors is the same due to the torque limit.

Operating principles

Both the master and slave operate in the speed control mode, and the speed regulator uses the PI controller. The difference is that the slave speed reference is superimposed with a speed deviation based on the master reference, and the output torque of the master is transmitted to the slave through InoLink communication as the torque limit. The speed deviation that superimposed to the slave speed reference is set to 5%...10% generally depending on the actual operating conditions. The additional speed and torque limit direction are related to the operating direction.

As the slave is equipped with a speed regulator, the slave speed can be controlled (deviation kept 5% to 10% from the speed reference) even when devices are disconnected from each other. The slave accelerates and tightens the flexible connection at startup due to the additional speed. Then the torque limit takes effect when the speed regulator is saturated, which limits the slave torque to the same value as the master, allowing an even torque distribution.

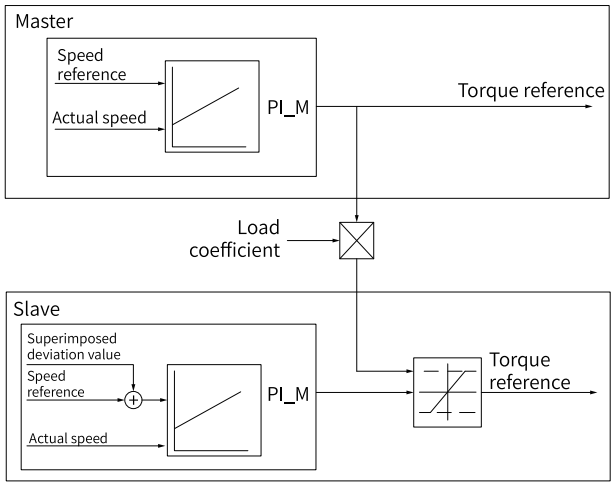


Figure 8-29 Typical control block diagram for master speed + slave speed deviation and torque limit

Related parameters

Take control channel 1 setting as an example. Parameters required for typical master speed+slave torque control are as follows.

Param.	Name	Master configuration	Slave configuration
E0-00	Control mode	0: SVC (Sensorless vector control) 1: FVC (Feedback vector control)	0: SVC (Sensorless vector control) 1: FVC (Feedback vector control)
E0-01	Control mode	0: Speed control	0: Speed control
b1-10	Forced torque control source	0: Invalid	0: Invalid
b0-00	Start/Stop control word source	3: Custom (set in group b0)	3: Custom (set in group b0)
b0-01	Source of custom OFF1	Others: B connector -U2-00: PZD1.0 of bus adapter A	Others: B connector -U2-32: PZD1.0 of InoLink
C0-00	Main speed source in speed control	Others: K connector -U5-45: PZD2 of bus adapter A	Others: K connector -U5-45: PZD2 of bus adapter A
C0-02	Additional speed reference	-	Others: K connector -U9-31: Multi-reference 1
E2-10	Torque upper limit reference selection	1: 400%	Others: K connector -U5-33: InoLink.PZD2
E4-18	Source of forced speed loop integral	0: Inhibited	0: Inhibited
E4-19	Source of forced speed loop integral value	-	-
n0-00	InoLink communication startup selection	1: Start	1: Start
n0-02	Local node address	1: #1 node	2: #2 node
n0-40	Source node of received data 1	-	1: #1 node
n0-41	Data selection for received data 1	-	1: Data 1
n0-42	Source node of received data 2	-	1: #1 node
n0-43	Data selection for received data 2	-	1: Data 2
n0-20	Selection of transmission data 1	Others: K connector -U5-44: PZD1 of bus adapter A	-
n0-21	Selection of transmission data 2	Others: K connector -U6-12: Torque reference after being limited	-

Where:

1. Other settings of the master and slave must be consistent, such as the start time, acceleration/ deceleration time, acceleration torque compensation, and speed loop parameters.
2. By supposition, the control command word source is PZD1 of bus adapter A and the speed reference source is PZD2 of bus adapter A.
3. The slave command word and speed reference source can be the master or the bus adapter.
4. The additional speed of the slave is set by the multi-speed reference 1.

5. In forward rotation, an additional 5% positive speed reference and torque upper limit are needed. In reverse rotation, an additional -5% negative speed reference and torque lower limit are needed.

8.1.6.4 Master-Slave Control Macro

Parameters for master-slave control can be configured through master-slave control macro with one key, which requires user to confirm the role of the controller first, namely whether the controller acts as a master or slave. Then set A8-51 to select related functions.

Related parameters:

Param.	Name	Value range	Description
A8-51	Master-slave control application selection	0: No operation 1: Master speed control 2: Slave torque control 3: Slave speed control (proportional control) 4: Slave speed deviation + Torque limit	In the three master and slave control modes, set A8-51 to 1 [Master speed control] when the controller acts as a master. When the controller acts as a slave, set A8-51 to 2 [Slave torque control] if master speed+slave torque control is needed. When the controller acts as a slave, set A8-51 to 3 [Slave speed control (proportional control)] if master PI +slave P control is needed. When the controller acts as a slave, set A8-51 to 4 [Slave speed deviation+Torque limit] if slave speed deviation+torque limit control is needed.
A8-52	Master-slave control application confirmation	0: Cancel 1: OK	After A8-51 is set to 1, one-key configuration of the parameter is triggered only when A8-52 is set to 1.
A8-53	Master-slave control application currently in effect	0: Invalid 1: Master-speed control 2: Slave torque control 3: Slave speed control (proportional control) 4: Slave speed deviation + Torque limit	Read-only parameter that displays the master-slave application macro currently in effect.

The one-key configuration of master-slave control parameters are based on one-master and one-slave applications.

When the controller acts as a master, set A8-51 to 1 [Master speed control] and A8-52 to 1 [OK] to trigger one-key configuration of parameters.

Param.	Name	Default	Written value
A9-00	Command source selection	0 [Reference channel 1]	0 [Reference channel 1]
A9-02	Source of motor data set selection 0	0 [0]	0 [0]
A9-03	Source of motor data set selection 1	0 [0]	0 [0]
d0-11	Speed feedback selection	0 [Encoder detection module 1]	0 [Encoder detection module 1]
E0-00	Control mode	2 [V/f]	1 [FVC]

Param.	Name	Default	Written value
E0-01	Control mode	0 [Speed control]	0 [Speed control]
E1-00	Startup mode	0 [Direct start]	0 [Direct start]
E1-14	OFF1 stop mode	1 [Decelerate to stop]	1 [Decelerate to stop]
C7-02	RFG ramp selection 1	0 [0]	0 [0]
C7-03	RFG ramp selection 2	0 [0]	0 [0]
C7-04	Ramp 1 acceleration time	20.0s	20.0s
C7-05	Ramp 1 deceleration time	20.0s	20.0s
E2-08	Digital reference of torque upper limit	150.0%	150.0%
E2-09	Digital reference of torque lower limit	-150.0%	-150.0%
E2-10	Torque upper limit reference selection	1 [400.0%]	1 [400.0%]
E2-11	Torque lower limit reference selection	1 [-400.0%]	1 [-400.0%]
E4-18	Source of forced speed loop integral	0 [Inhibited]	0 [Inhibited]
E4-19	Source of forced speed loop integral value	0 [0]	0 [0]
E4-20	Source of speed loop integral freeze	0 [Operation]	0 [Operation]
b0-00	Start/Stop control word source	0 [Terminal start/stop module]	1 [Custom setting]
b0-01	Source of custom OFF1	0 [Inactive]	U2-00 [bit00 of input PZD1 of bus adapter A]
b0-02	Source 1 of custom OFF2	1 [Inactive]	U2-01 [bit01 of input PZD1 of bus adapter A]
b0-03	Source 1 of custom OFF3	1 [Inactive]	U2-02 [bit02 of input PZD1 of bus adapter A]
b0-04	Custom operation permission source	1 [Operation allowed]	U2-03 [bit03 of input PZD1 of bus adapter A]
b0-05	Custom fault reset source 1	0 [Inactive]	U2-07 [bit07 of input PZD1 of bus adapter A]
b0-08	Custom speed inversion source	0 [Inactive]	U2-11 [bit11 of input PZD1 of bus adapter A]
C0-00	Main speed source in speed control	0 [Digital reference]	U5-45 [PZD2 of bus adapter A]
n1-00	Applicable bus type of bus adapter	0 [None]	7 [Profibus-DP module]
n1-01	Open circuit detection delay of bus adapter A	0.1s	0.1s
n1-02	Communication mode selection of bus adapter A	0 [standard mode]	0 [standard mode]
n1-03	Continuous CRC error detection setting in communication	0	0
n1-04	Process data output 1	0 [0]	U8-09 [Internal status word 1]
n1-05	Process data output 2	0 [0]	U5-00 [Actual motor speed (filtered)]

Param.	Name	Default	Written value
n1-06	Process data output 3	0 [0]	U6-01 [Calculated output torque (filtered)]
n1-20	Communication base value of process data output 1	0	0
n1-21	Communication base value of process data output 2	0	0
n1-22	Communication base value of process data output 3	0	0
n1-36	Communication base value of process data input 1	0	0
n1-37	Communication base value of process data input 2	0	0
n16-00	Expansion slot selection	0 [Disable]	1 [Expansion slot 1_1]
n16-02	Expansion card station number	1	1
n16-09	Feature code	0 [Default]	0 [Default]
n16-10	DP data check bit	0 [bit10 of PZD1 by default]	0 [bit10 of PZD1 by default]
n0-00	InoLink communication startup selection	0 [Inactive]	1 [Start]
n0-02	Local node address	0	1
n0-03	InoLink fault mode selection	0 [Standard mode]	0 [Standard mode]
n0-04	InoLink node restart judgment time	0.100s	0.100s
n0-06	InoLink communication mode selection	0 [Standard mode]	0 [Standard mode]
n0-08	Custom InoLink communication mode configuration	00350	00350
n0-19	InoLink auxiliary function setting	00000	00000
n0-20	Selection of transmission data 1	0	U6-12 [Limited torque reference]
n0-21	Selection of transmission data 2	0	U6-24 [Speed regulation PID integral term]

When the controller acts as a slave, use the master speed+slave torque control mode and set A8-51 to 2 [Slave torque control] and A8-52 to 1 [OK] to trigger one-key configuration. Parameters configured are as follows.

Param.	Name	Default	Macro-configured value
A9-00	Control channel selection	0 [Control channel 1]	0 [Control channel 1]
A9-02	Source of motor data set selection 0	0 [0]	0 [0]
A9-03	Source of motor data set selection 1	0 [0]	0 [0]

Param.	Name	Default	Macro-configured value
d0-11	Speed feedback selection	0 [Encoder detection module 1]	0 [Encoder detection module 1]
E0-00	Control mode	2 [V/f]	1 [FVC]
E0-01	Control mode	0 [Speed control]	1 [Torque control]
C1-00	Torque control reference selection	0 [0]	U5-32 [Data 1 received via Inolink]
E1-00	Startup mode	0 [Direct start]	0 [Direct start]
E1-14	OFF1 stop mode	1 [Decelerate to stop]	1 [Decelerate to stop]
C7-02	RFG ramp selection 1	0 [0]	0 [0]
C7-03	RFG ramp selection 2	0 [0]	0 [0]
C7-04	Ramp 1 acceleration time	20.0s	20.0s
C7-05	Ramp 1 deceleration time	20.0s	20.0s
b0-00	Start/Stop control word source	0 [Terminal start/stop module]	3 [Custom setting]
b0-01	Source of custom OFF1	0 [Inactive]	U2-00 [bit00 of input PZD1 of bus adapter A]
b0-02	Source 1 of custom OFF2	1 [Inactive]	U2-01 [bit01 of input PZD1 of bus adapter A]
b0-03	Source 1 of custom OFF3	1 [Inactive]	U2-02 [bit02 of input PZD1 of bus adapter A]
b0-04	Custom operation permission source	1 [Operation allowed]	U2-03 [bit03 of input PZD1 of bus adapter A]
b0-05	Custom fault reset source 1	0 [Invalid]	U2-07 [bit07 of input PZD1 of bus adapter A]
b0-08	Custom speed inversion source	0 [Invalid]	U2-11 [bit11 of input PZD1 of bus adapter A]
n1-00	Applicable bus type of bus adapter	0 [None]	7 [Profibus-DP module]
n1-01	Open circuit detection delay of bus adapter A	0.1s	0.1s
n1-02	Communication mode selection of bus adapter A	0 [Standard mode]	0 [Standard mode]
n1-03	Continuous CRC error detection setting in communication	0	0
n1-04	Process data output 1	0 [0]	U8-09 [Status word 1]
n1-05	Process data output 2	0 [0]	U5-00 [Actual motor speed (filtered)]
n1-06	Process data output 3	0 [0]	U6-01 [Calculated output torque (filtered)]
n1-20	Communication base value of process data output 1	0	0
n1-21	Communication base value of process data output 2	0	0
n1-21	Communication base value of process data output 3	0	0

Param.	Name	Default	Macro-configured value
n1-36	Communication base value of process data input 1	0	0
n1-37	Communication base value of process data input 2	0	0
n16-00	Expansion slot selection	0 [Disable]	1 [Expansion slot 1_1]
n16-02	Expansion card station number	1	2
n16-09	Feature code	0 [Default]	0 [Default]
n16-10	DP data check bit	0 [bit10 of PZD1 by default]	0 [bit10 of PZD1 by default]
n0-00	InoLink communication startup selection	0 [Invalid]	1 [Start]
n0-02	Local node address	0	2
n0-03	InoLink fault mode selection	0 [Standard mode]	0 [Standard mode]
n0-04	InoLink node restart judgment time	0.100s	0.100s
n0-06	InoLink communication mode selection	0 [Standard mode]	0 [Standard mode]
n0-08	Custom InoLink communication mode configuration	00350	00350
n0-19	InoLink auxiliary function setting	00000	00000
n0-40	Source node of received data 1	0 [Invalid]	1 [Node 1]
n0-41	Data selection for received data 1	1 [Data 1]	1 [Data 1]
n0-42	Source node of received data 2	0 [Invalid]	1 [Node 1]
n0-43	Data selection for received data 2	1 [Data 1]	2 [Data 2]
n0-70	Proportional setting of received data 1	1.000	1.000
n0-71	Proportional setting of received data 2	1.000	1.000

When the controller acts as a slave and the master PI+slave P control mode is used, set A8-51 to 3 [Slave speed control (proportional control)] and A8-52 to 1 [OK] to trigger one-key configuration. Parameters configured are as follows.

Param.	Name	Default	Macro-configured value
A9-00	Control channel selection	0 [Control channel 1]	0 [Control channel 1]
A9-02	Source of motor data set selection 0	0 [0]	0 [0]
A9-03	Source of motor data set selection 1	0 [0]	0 [0]
d0-11	Speed feedback selection	0 [Encoder detection module 1]	0 [Encoder detection module 1]
E0-00	Control mode	2 [V/f]	1 [FVC]

Param.	Name	Default	Macro-configured value
E0-01	Control mode	0 [Speed control]	0 [Speed control]
E1-00	Startup mode	0 [Direct start]	0 [Direct start]
E1-14	OFF1 stop mode	1 [Decelerate to stop]	1 [Decelerate to stop]
E2-08	Digital reference of torque upper limit	150.0%	150.0%
E2-09	Digital reference of torque lower limit	-150.0%	-150.0%
E2-10	Torque upper limit reference selection	1 [400.0%]	1 [400.0%]
E2-11	Torque lower limit reference selection	1 [-400.0%]	1 [-400.0%]
E4-18	Source of forced speed loop integral	0 [Invalid]	1 [Enable]
E4-19	Source of forced speed loop integral value	0 [0]	U5-33 [Data 2 received through Inolink]
E4-20	Source of speed loop integral freeze	0 [Operation]	0 [Operation]
C7-02	RFG ramp selection 1	0 [0]	0 [0]
C7-03	RFG ramp selection 2	0 [0]	0 [0]
C7-04	Ramp 1 acceleration time	20.0s	20.0s
C7-05	Ramp 1 deceleration time	20.0s	20.0s
b0-00	Start/Stop control word source	0 [Terminal start/stop module]	1 [Custom setting]
b0-01	Source of custom OFF1	0 [Invalid]	U2-00 [bit00 of input PZD1 of bus adapter A]
b0-02	Source 1 of custom OFF2	1 [Inactive]	U2-01 [bit01 of input PZD1 of bus adapter A]
b0-03	Source 1 of custom OFF3	1 [Inactive]	U2-02 [bit02 of input PZD1 of bus adapter A]
b0-04	Custom operation permission source	1 [Operation allowed]	U2-03 [bit03 of input PZD1 of bus adapter A]
b0-05	Custom fault reset source 1	0 [Inactive]	U2-07 [bit07 of input PZD1 of bus adapter A]
b0-08	Custom speed inversion source	0 [Inactive]	U2-11 [bit11 of input PZD1 of bus adapter A]
C0-00	Main reference selection in speed control	0 [0]	U5-45 [Bus Adapter A. PZD2]
n1-00	Applicable bus type of bus adapter	0 [None]	7 [Profibus-DP module]
n1-01	Open circuit detection delay of bus adapter A	0.1s	0.1s
n1-02	Communication mode selection of bus adapter A	0 [Standard mode]	0 [Standard mode]
n1-03	Continuous CRC error detection setting in communication	0	0
n1-04	Process data output 1	0 [0]	U8-09 [Status word 1]
n1-05	Process data output 2	0 [0]	U5-00 [Actual motor speed (filtered)]
n1-06	Process data output 3	0 [0]	U6-01 [Calculated output torque (filtered)]

Param.	Name	Default	Macro-configured value
n1-20	Communication base value of process data output 1	0	0
n1-21	Communication base value of process data output 2	0	0
n1-21	Communication base value of process data output 3	0	0
n1-36	Communication base value of process data input 1	0	0
n1-37	Communication base value of process data input 2	0	0
n16-00	Expansion slot selection	0 [Disable]	1 [Expansion slot 1_1]
n16-02	Expansion card station number	1	2
n16-09	Feature code	0 [Default]	0 [Default]
n16-10	DP data check bit	0 [bit10 of PZD1 by default]	0 [bit10 of PZD1 by default]
n0-00	InoLink communication startup selection	0 [Inactive]	1 [Start]
n0-02	Local node address	0	2
n0-03	InoLink fault mode selection	0 [Standard mode]	0 [Standard mode]
n0-04	InoLink node restart judgment time	0.100s	0.100s
n0-06	InoLink communication mode selection	0 [Standard mode]	0 [Standard mode]
n0-08	Custom InoLink communication mode configuration	00350	00350
n0-19	InoLink auxiliary function setting	00000	00000
n0-40	Source node of received data 1	0 [Inactive]	1 [Node 1]
n0-41	Data selection for received data 1	1 [Data 1]	1 [Data 1]
n0-42	Source node of received data 2	0 [Inactive]	1 [Node 1]
n0-43	Data selection of received data 2	1 [Data 1]	2 [Data 2]
n0-70	Proportional setting of received data 1	1.000	1.000
n0-71	Proportional setting of received data 2	1.000	1.000

When the controller acts as a slave and slave speed deviation+torque limit control mode is used, set A8-51 to 4 [Slave speed deviation+Torque limit] and A8-52 to 1 [OK] to trigger one-key configuration. Parameters configured are as follows.

Param.	Name	Default	Macro-configured value
A9-00	Control channel selection	0 [Control channel 1]	0 [Control channel 1]
A9-02	Source of motor data set selection 0	0 [0]	0 [0]
A9-03	Source of motor data set selection 1	0 [0]	0 [0]
d0-11	Speed feedback selection	0 [Encoder detection module 1]	0 [Encoder detection module 1]
E0-00	Control mode	2 [V/f]	1 [FVC]
E0-01	Control mode	0 [Speed control]	0 [Speed control]
E1-00	Startup mode	0 [Direct start]	0 [Direct start]
E1-14	OFF1 stop mode	1 [Decelerate to stop]	1 [Decelerate to stop]
L7-00	Input of absolute value module A	0 [Inactive]	U5-32 [InoLink.PZD1]
L7-01	Input of absolute value module B	0 [Inactive]	U9-02 [Main speed reference]
L7-20	Input of multiplication/ division module A (multiplication)	0 [Module inhibited]	U9-73 [Output of absolute module A]
L7-21	Input of multiplication/ division module A (multiplication)	0 [Not involved in calculation]	U7-47 [Output of constant reference 1]
L7-22	Input of multiplication/ division module A (division)	0 [Not involved in calculation]	U7-48 [Output of constant reference 2]
L9-00	Constant reference 1	0.0%	-100.0%
L9-01	Constant reference 2	0.0%	100.0%
C6-07	Multi-reference 3	0.0%	5.0%
C6-08	Multi-reference 4	0.0%	-5.0%
L5-20	Input selection of digital multiplexer module A	0 [Input 1]	U3-31 [Negative number input flag of absolute module B]
L5-21	Input 1 of digital multiplexer module A	0 [Inactive]	U9-33 [Multi-reference 3]
L5-22	Input 2 of digital multiplexer module A	0 [Inactive]	U9-34 [Multi-reference 4]
E2-08	Digital reference of torque upper limit	150.0%	150.0%
E2-09	Digital reference of torque lower limit	-150.0%	-150.0%
E2-10	Torque upper limit reference selection	1 [400.0%]	U9-73 [Output of absolute module A]
E2-11	Torque lower limit reference selection	1 [-400.0%]	U9-81 [Output of multiplication/division module A]
C0-02	Additional speed reference	0 [0]	U9-67 [Output of digital multiplexer module A]
E4-18	Source of forced speed loop integral	0 [Inhibited]	0 [Inhibited]
E4-19	Source of forced speed loop integral value	0 [0]	0 [0]
E4-20	Source of speed loop integral freeze	0 [Operation]	0 [Operation]

Param.	Name	Default	Macro-configured value
C7-02	RFG ramp selection 1	0 [0]	0 [0]
C7-03	RFG ramp selection 2	0 [0]	0 [0]
C7-04	Ramp 1 acceleration time	20.0s	20.0s
C7-05	Ramp 1 deceleration time	20.0s	20.0s
b0-00	Start/Stop control word source	0 [Terminal start/stop module]	1 [Custom setting]
b0-01	Source of custom OFF1	0 [Inactive]	U2-00 [bit00 of input PZD1 of bus adapter A]
b0-02	Source 1 of custom OFF2	1 [Inactive]	U2-01 [bit01 of input PZD1 of bus adapter A]
b0-03	Source 1 of custom OFF3	1 [Inactive]	U2-02 [bit02 of input PZD1 of bus adapter A]
b0-04	Custom operation permission source	1 [Operation allowed]	U2-03 [bit03 of input PZD1 of bus adapter A]
b0-05	Custom fault reset source 1	0 [Inactive]	U2-07 [bit07 of input PZD1 of bus adapter A]
b0-08	Custom speed inversion source	0 [Inactive]	U2-11 [bit11 of input PZD1 of bus adapter A]
C0-00	Main reference selection in speed control	0 [0]	U5-45 [Bus Adapter A. PZD2]
n1-00	Applicable bus type of bus adapter	0 [None]	7 [Profibus-DP module]
n1-01	Open circuit detection delay of bus adapter A	0.1s	0.1s
n1-02	Communication mode selection of bus adapter A	0 [Standard mode]	0 [Standard mode]
n1-03	Continuous CRC error detection setting in communication	0	0
n1-04	Process data output 1	0 [0]	U8-09 [Status word 1]
n1-05	Process data output 2	0 [0]	U5-00 [Actual motor speed (filtered)]
n1-06	Process data output 3	0 [0]	U6-01 [Calculated output torque (filtered)]
n1-20	Communication base value of process data output 1	0	0
n1-21	Communication base value of process data output 2	0	0
n1-21	Communication base value of process data output 3	0	0
n1-36	Communication base value of process data input 1	0	0
n1-37	Communication base value of process data input 2	0	0
n16-00	Expansion slot selection	0 [Disable]	1 [Expansion slot 1_1]

Param.	Name	Default	Macro-configured value
n16-02	Expansion card station number	1	2
n16-09	Feature code	0 [Default]	0 [Default]
n16-10	DP data check bit	0 [bit10 of PZD1 by default]	0 [bit10 of PZD1 by default]
n0-00	InoLink communication startup selection	0 [Inactive]	1 [Start]
n0-02	Local node address	0	2
n0-03	InoLink fault mode selection	0 [Standard mode]	0 [Standard mode]
n0-04	InoLink node restart judgment time	0.100s	0.100s
n0-06	InoLink communication mode selection	0 [Standard mode]	0 [Standard mode]
n0-08	Custom InoLink communication mode configuration	00350	00350
n0-19	InoLink auxiliary function setting	00000	00000
n0-40	Source node of received data 1	0 [Inactive]	1 [Node 1]
n0-41	Data selection for received data 1	1 [Data 1]	1 [Data 1]
n0-42	Source node of received data 2	0 [Inactive]	1 [Node 1]
n0-43	Data selection of received data 2	1 [Data 1]	2 [Data 2]
n0-70	Proportional setting of received data 1	1.000	1.000
n0-71	Proportional setting of received data 2	1.000	1.000

8.1.7 Limits

8.1.7.1 Speed Limit

Application scenario

This function is used to limit the motor speed range by setting a speed limit to prevent the motor from running above or below a certain speed.

Operating principles

The speed upper limit limits the maximum positive speed of the motor. Set the speed upper limit to a value not lower than 0. The speed lower limit limits the maximum negative speed of the motor. Set the speed lower limit to a value not higher than 0. The following figure shows the relationship among speed limits.

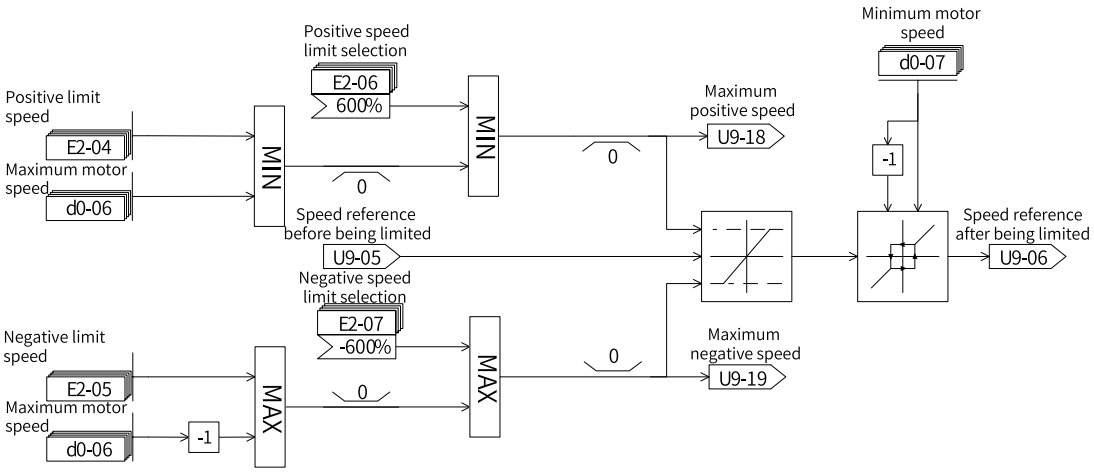


Figure 8-30 Relationship among speed limits

Related parameters

See the following table for speed limit parameters.

Param.	Name	Default	Value range	Description
d0-06	Maximum motor speed	100.0%	0.0% to 600.0%	The value of d0-06 cannot be exceeded in both forward and reverse directions. The setpoint 100% corresponds to the base value of the per-unit speed (d3-02).
E2-04	Positive speed limit	600.0%	0.0% to 600.0%	Defines the maximum speed in forward direction. The setpoint 100% corresponds to the base value of the per-unit speed (d3-02).
E2-05	Negative speed limit	-600.0%	-600.0% to 0.0%	Defines the maximum speed in reverse direction. The setpoint -100% corresponds to the base value of the per-unit speed (d3-02).

Param.	Name	Default	Value range	Description
E2-06	Positive speed limit selection	1	0: 0.0% 1: 600.0% 2: AI1 3: AI2 4: HDI1 5: HDI2 Others: K connector	Defines the speed limit during forward operation. The setpoint 100% corresponds to the base value of the per-unit speed (d3-02). Value description: 0: 0.0% - The positive torque limit is set to 0.0%. 1: 600.0% - The positive torque limit is set to 600.0%. 2: AI1 - The positive speed limit is input by using current or voltage signals from AI1. The upper limit is calculated according to the preset AI curve. 3: AI2 - The positive speed limit is input by using current or voltage signals from AI2. The upper limit is calculated according to the preset AI curve. 4: HDI1 - The positive torque limit is set through the pulse frequency of HDI1. The corresponding upper limit is calculated based on the curve of the relationship between the pulse frequency and the speed reference. 5: HDI2 - The positive torque limit is set through the pulse frequency of HDI2. The corresponding upper limit is calculated based on the curve of the relationship between the pulse frequency and the speed reference. Others: K connector - The positive speed limit depends on the value of the selected K connector. Note: The active positive speed limit is the lower value between E2-13 and E2-15.

Param.	Name	Default	Value range	Description
E2-07	Negative speed limit selection	1	0: 0.0% 1: -600.0% 2: AI1 3: AI2 4: HDI1 5: HDI2 Others: K connector	Defines the speed limit of the motor in reverse direction. The setpoint 100% corresponds to the base value of the per-unit speed (d3-02). Value description: 0: 0.0% - The negative speed limit is 0.0%. 1: -600.0% - The negative speed limit is -600.0%. 2: AI1 - The negative speed limit is input by using current or voltage signals from AI1. The upper limit is calculated according to the preset AI curve. 3: AI2 - The negative speed limit is input by using current or voltage signals from AI2. The upper limit is calculated according to the preset AI curve. 4: HDI1 - The negative torque limit is set through the pulse frequency of HDI1. The corresponding upper limit is calculated based on the curve of the relationship between the pulse frequency and the speed reference. 5: HDI2 - The positive torque limit is set through the pulse frequency of HDI2. The corresponding upper limit is calculated based on the curve of the relationship between the pulse frequency and the speed reference. Others: K connector - The negative speed limit depends on the value of the selected K connector. Note: The effective negative speed limit is the higher value between E2-14 and E2-16.

8.1.7.2 Overspeed Limit

Application scenario

In the torque control mode, if the load torque is lower than the output torque of the motor, the motor speed keeps increasing. Therefore, the motor speed (that is, the frequency upper limit) must be restricted to prevent accidents such as runaway.

Operating principles

Overspeed control is used to protect against overspeed in torque control. It defines the positive overspeed limit as the maximum positive speed (U9-18) + 4% of the rated motor speed, and the negative overspeed limit as the negative maximum speed (U9-19) - 4% of the rated motor speed. When the motor runs at a speed greater than the overspeed limit, overspeed control takes effect. In

this case, the motor torque is limited by the overspeed adjustment torque and cannot generate output according to the torque reference. When the speed is recovered to a value within the speed limit range, the output torque recovers to the set torque. The overspeed adjustment torque is shown in the following figure.

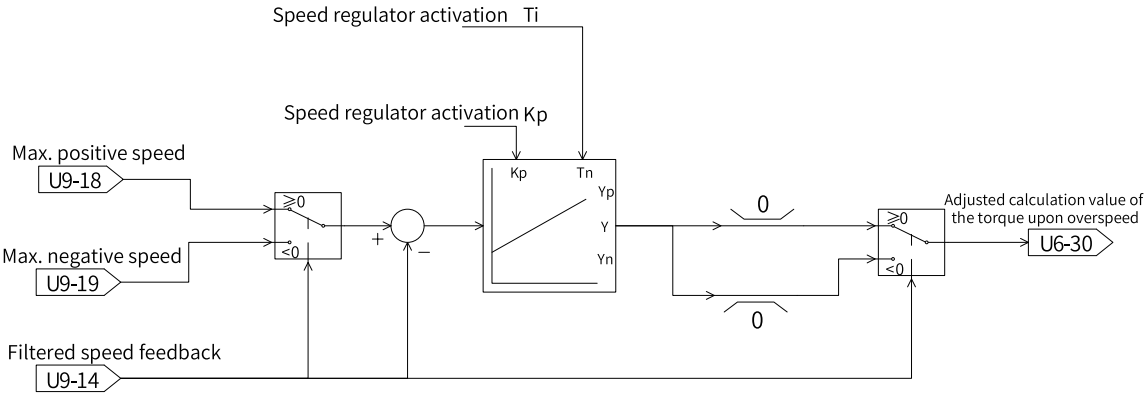


Figure 8-31 Overspeed controller

8.1.7.3 Current Limit

Application scenario

If you need to limit the motor operating current in FVC or SVC mode, set the maximum current of the motor (d0-08) so that the current during normal operation does not exceed the value of d0-08. The maximum current during operation is also affected by the maximum current of the drive, which is determined by the drive model.

Operating principles

The current regulator automatically controls the current, ensuring that the total current output does not exceed the limit value.

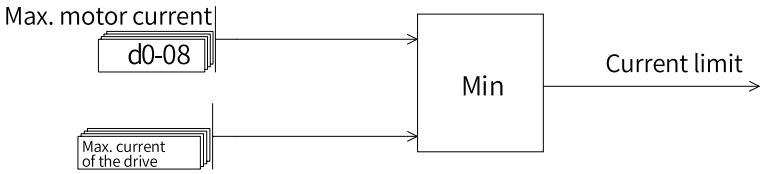


Figure 8-32 Effective current limit diagram

Related parameters

Param.	Name	Default	Value range	Description
d0-08	Maximum motor current	150.0%	0 to 600	Set the maximum value to limit the motor current. The value 100% corresponds to the rated motor current.

Precautions

- Limiting the maximum current of the motor may affect the overload capacity of the motor and reduce the motor torque output.

- The current limit of the motor is valid only in vector control. In V/f mode, the overcurrent suppression function needs to be enabled to ensure that the current is lower than the maximum current.

8.1.7.4 Torque Limit

Application scenario

In some process applications, the motor output torque needs to be limited in the FVC or SVC mode. In some cases, the motor torque limit needs to be adjusted to achieve torque control while the motor runs in the speed mode.

Operating principles

The torque limit can be achieved by limiting the output of the speed loop. The following figure shows the effective value of torque reference limit.

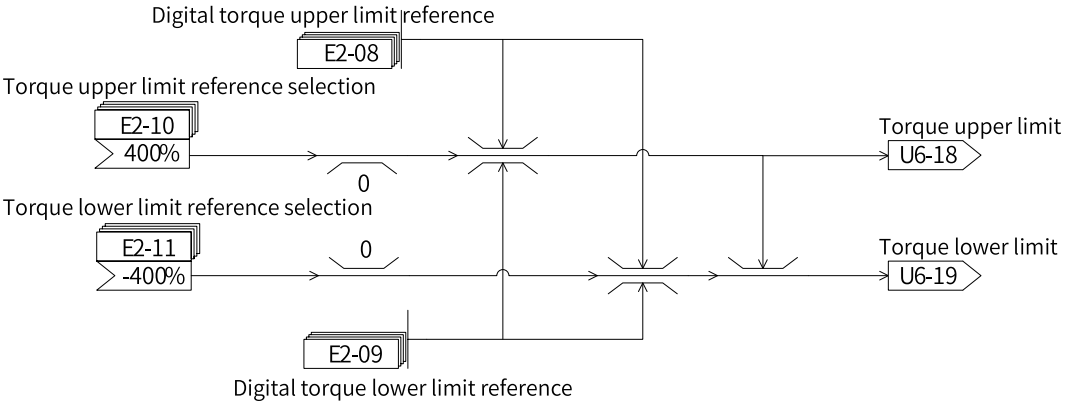


Figure 8-33 Torque limit diagram

The following figure shows the effective torque limit position.

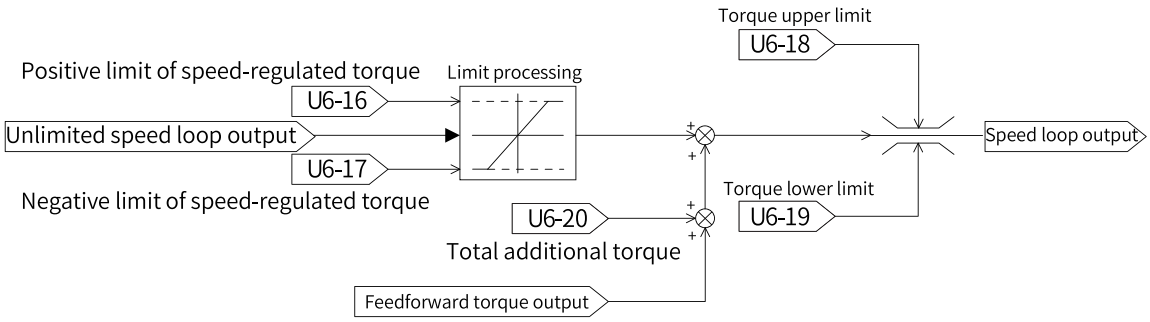


Figure 8-34 Speed loop with output torque limit

Related parameters

Param.	Name	Default	Value Range	Description
E2-08	Digital reference of torque upper limit	150.0%	0.0% to 400.0%	Used to limit the maximum positive output torque. The value 100% corresponds to the rated torque of the motor. Note: The effective positive torque limit is the lower one between E2-23 and E2-25.
E2-10	Torque upper limit reference selection	1	0: 0% 1: 400.0% 2: AI1 3: AI2 4: HDI1 5: HDI2 Others: K connector	Defines the positive torque limit source. The value 100% corresponds to the rated torque of the motor. Value description: 0: 0% - The positive torque limit is set to 0%. 1: 400% - The positive torque limit is set to 400%. 2: AI1 - The positive torque limit is input by current or voltage signal through AI1 and the corresponding per-unit value is calculated according to the preset AI curve. 3: AI2 - The positive torque limit is input by current or voltage signal through AI2 and the corresponding per-unit value is calculated according to the preset AI curve. 4: HDI1 - The positive torque limit is set through the pulse frequency of the DI terminal. The corresponding per-unit value is calculated based on the curve of the relationship between the pulse frequency and the frequency reference. 5: HDI2 - The positive torque limit is set through the pulse frequency of the DI terminal. The corresponding per-unit value is calculated based on the curve of the relationship between the pulse frequency and the frequency reference. Others: K connector - The positive torque limit depends on the value of the selected K connector. Note: The effective positive torque limit is the lower one between E2-23 and E2-25.

Param.	Name	Default	Value Range	Description
E2-09	Digital reference of torque lower limit	-150.0%	-400.0% to 0.0%	This parameter limits the negative maximum output torque. The value 100% corresponds to the rated motor torque. Note: The effective negative torque limit is the higher one between E2-24 and E2-26.
E2-11	Torque lower limit reference selection	1	0: 0% 1: -400.0% 2: AI1 3: AI2 4: HDI1 5: HDI2 Others: K connector	Defines the negative torque limit source. The value 100% corresponds to the rated motor torque. Value description: 0: 0% - Set the negative torque limit to 0%. 1: -400% - Set the negative torque limit to -400%. 2: AI1 - The negative torque limit is input by current or voltage signal through AI1 and the corresponding per-unit value is calculated according to the preset AI curve. 3: AI2 - The negative torque limit is input by current or voltage signal through AI2 and the corresponding per-unit value is calculated according to the preset AI curve. 4: HDI1 - The negative torque limit is set through the pulse frequency of the DI terminal. The corresponding per-unit value is calculated based on the curve of the relationship between the pulse frequency and the frequency reference. 5: HDI2 - The positive torque limit is set through the pulse frequency of the DI terminal. The corresponding per-unit value is calculated based on the curve of the relationship between the pulse frequency and the frequency reference. Others: K connector – The negative torque limit depends on the value of the selected K connector. Note: The effective negative torque limit is the higher one between E2-24 and E2-26.

Precautions

- The motor torque limit is active only in vector control modes. It is inactive in V/f mode.
- The actual torque limit of the motor is affected by the current limit, torque limit, and power limit. The preceding figure takes the motoring condition as an example to describe the impact of the three limits on the actual torque limit. Among all the limits, the one with the most severe restriction

is effect. In the figure, the effective torque limit is slightly moved down for easy comparison. In actual applications, the torque reference limit overlap with the minimum torque limit.

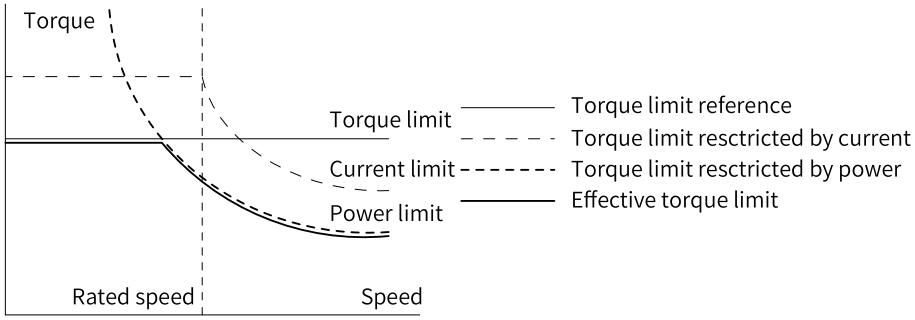


Figure 8-35 Torque limit diagram

8.1.7.5 Power Limit

Application scenario

In FVC or SVC control, the power limit can limit the total power output of the motor, which is applicable to process applications where the output power of the motor needs to be limited separately.

Operating principles

The power limit is converted to the torque limit internally. As the motor speed increases, the output torque limit decreases due to the power limit.

The following figure describes the difference between the generating power and the motoring power. When the motor speed direction and torque direction are both positive or negative, that is, when the speed direction and torque direction are consistent, the motor is in the motoring state and is limited by the motoring power limit. When the motor speed direction is positive and the torque direction is negative, or the speed direction is negative and the torque direction is positive, that is, the speed direction is opposite to the torque direction, the motor is in the generating state and is subject to the generating torque limit.

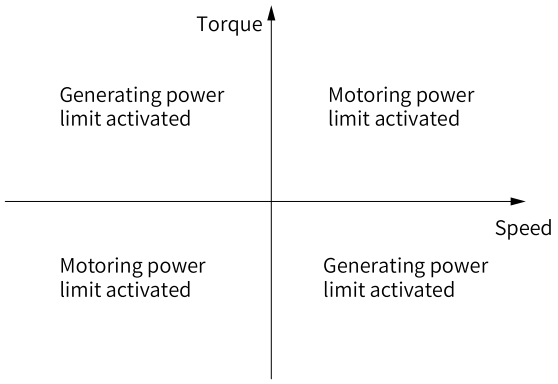


Figure 8-36 Effective range of different power limits

The motoring power limit is defined by E2-15 [Motoring power limit] and E2-19 [Motoring power limit coefficient].

Whether E2-19 [Motoring power limit coefficient] is active or not is determined by E2-18 [Motoring power limit coefficient].

If E2-18 [Motoring power limit coefficient enable] is set to 0 [Disable], E2-19 [Motoring power limit coefficient] is inactive.

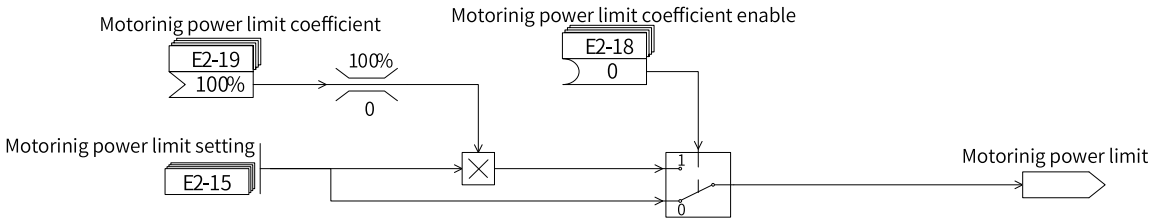


Figure 8-37 Diagram of motoring power limit

The generating power limit is defined by E2-14 [Generating power limit] and E2-17 [Generating power limit coefficient].

Whether E2-17 [Generating power limit coefficient] is active or not is determined by E2-16 [Generating power limit coefficient].

If E2-16 [Generating power limit coefficient enable] is set to 0 [Disable], E2-17 [Generating power limit coefficient] is inactive.

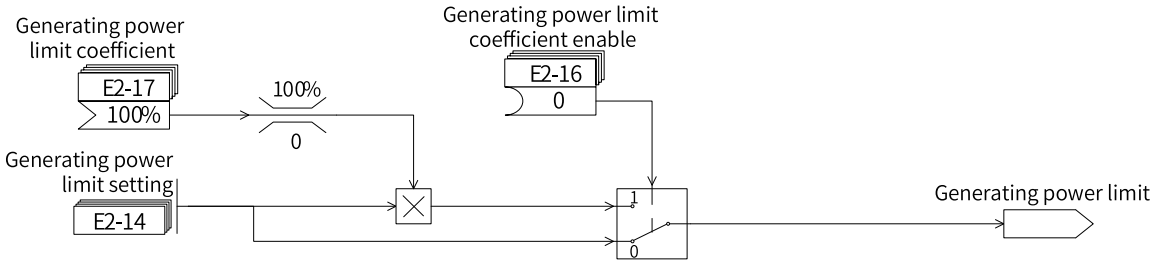


Figure 8-38 Diagram of generating power limit

Related parameters

Param.	Name	Default	Value range	Description
E2-14	Generating power limit	200.0%	0.0% to 400.0%	This parameter limits the output power of the motor in the generating state. The value 100% corresponds to the rated power of the motor.
E2-16	Generating power limit coefficient enable	0	0: Disable 1: Enable 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: DIL 9: HDI1 10: HDI2 Others: B connector	Defines whether the generating power limit coefficient is active. When enabled, the active generating power limit is E2-17 x E2-14. When disabled, the active generating power limit is E2-14.
E2-17	Generating power limit coefficient	0	0: 100.0% Others: K connector	Defines the coefficient of generating power limit. When E2-16 is enabled, the active generating power limit is E2-17 × E2-14. When disabled, the active generating power limit is E2-14.
E2-15	Motoring power limit	200.0%	0.0% to 400.0%	Used to limit the output power of the motor in the motoring state. The value 100% corresponds to the rated power of the motor.
E2-18	Motoring power limit coefficient enable	0	0: Disable 1: Enable 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: DIL 9: HDI1 10: HDI2 Others: B connector	Defines whether the motoring power limit coefficient is active. When E2-18 is enabled, the active motoring power limit is E2-19 x E2-15. When E2-18 is disabled, the active motoring power limit is E2-15.
E2-19	Motoring power limit coefficient	0	0: 100.0% Others: K connector	Defines the coefficient of the motoring power limit. When E2-18 is enabled, the active motoring power limit is E2-19 x E2-15. When E2-18 is disabled, the effective motorized power limit is E2-15.

Precautions

The motor power limit is active only in vector control. It is inactive in V/f mode.

8.1.7.6 Output Voltage Limit

Application scenario

If you need to limit the output voltage of the motor during motor control, you can change the output voltage limit setting in E2-20 so that the output voltage of the motor does not exceed the value of E2-20 during normal operation.

Related parameters

Param.	Name	Default	Value range	Description
E2-20	Output voltage limit	800.0%	0.0% to 800.0%	Used to limit the maximum motor output voltage. The value 100% corresponds to the rated motor voltage.

8.1.7.7 Gear Backlash Elimination

Application scenario

In applications involving gear transmission, you can enable backlash elimination to limit the output torque in the gear backlash, reducing shock on the machine.

Operating principles

The drive limits the output torque in the position with gear backlash to prevent excessive shock between adjacent gears. In the figure, the output torque is moved slightly downward for easy view. The actual output torque overlaps with the torque limit.

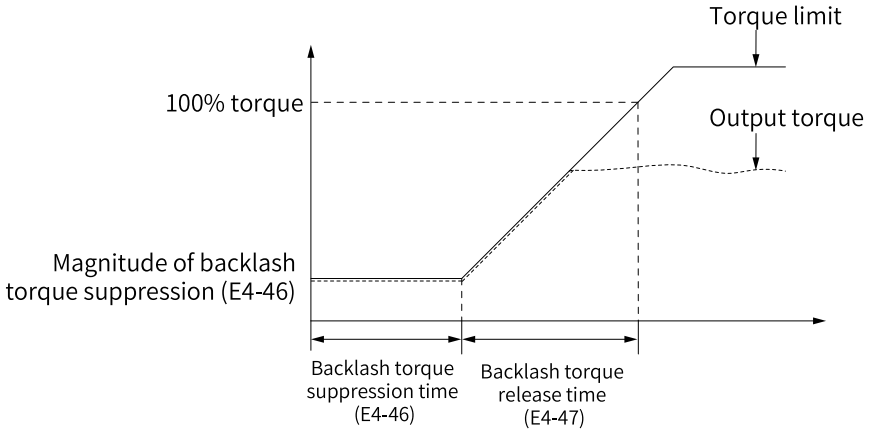


Figure 8-39 Logic of gear backlash elimination

Related parameters

Param.	Name	Default	Value range	Description
E4-44	Gear backlash elimination	0	0: Disable 1: Enable	Used to enable/disable the gear backlash elimination function.
E4-45	Gear backlash torque suppression time	0.200s	0.000s to 6.000s	The output torque is limited within the time defined by E4-45.
E4-46	Magnitude of gear backlash torque suppression	10.0%	0.0% to 50.0%	The absolute value of the motor output torque is limited to the value of E4-46 within the gear backlash torque suppression time defined by E4-45. The value 100% corresponds to the per-unit torque base value.
E4-47	Gear backlash torque release time	0.300s	0.000s to 6.000s	Defines the time for the output torque to recover from E4-46 to the rated torque of the motor after the time defined by E4-45 [Gear backlash torque suppression time] elapses.
E4-48	Gear backlash filter time	0 ms	0 ms to 50 ms	Defines the gear backlash torque filter time.

8.1.8 VDC Control in Vector Control

8.1.8.1 Overvoltage Suppression (Vector)

Application scenario

In high inertia or rapid deceleration applications, overvoltage may occur during deceleration. Because the motor is in the generating state during deceleration, which causes the DC bus voltage to rise. In FVC or SVC control, you can enable overvoltage suppression to suppress the rise of the DC bus voltage.

Operating principles

When overvoltage suppression is enabled, the actual deceleration speed of the motor is limited by PID control of the bus voltage after the bus voltage exceeds the VDC_max activation voltage, so as to prevent overvoltage caused by DC bus voltage rise. In this case, the deceleration time can be longer than the set time.

The following figure shows the overvoltage suppression control process.

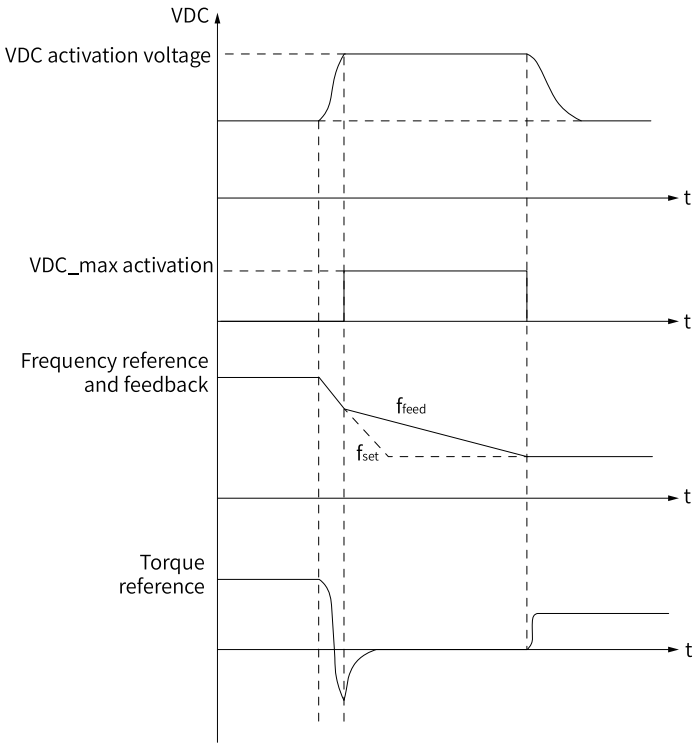


Figure 8-40 Overvoltage suppression control process

Related parameters

Param.	Name	Default	Value range	Description
E9-00	Automatic calculation of VDC activation voltage in vector control	1	0 to 1	Defines the calculation mode of VDC activation voltage in vector control. Value description: 0: Set by parameter - The VDC activation voltage is set through E9-02 and E9-05. 1: Calculated automatically - The VDC activation voltage is obtained through calculation of the bus undervoltage threshold and bus overvoltage threshold: VDC_min activation voltage = bus undervoltage threshold + 50 V; VDC_max activation voltage = bus overvoltage threshold - 70 V.
E9-01	VDC_max control switch in vector control	0	0 to 1	Defines VDC_max control switch in vector control mode. Value description: 0: Disable 1: Enable
E9-02	VDC_max activation voltage in vector control	115%	110% to 140%	Defines VDC_max activation voltage in vector control mode. Note: A2-02 is used as the reference for VDC_max activation voltage in vector control. When A2-02 is set to 400 V, VDC_max activation voltage is calculated as follows by default. VDC_max activation voltage = E9-02 x A2-02 x 1.414 = 650 V

Precautions

- Set the VDC_max activation voltage to a high value upon excessively high grid voltage fluctuation. This is to prevent overvoltage control from being triggered inadvertently. It is recommended to verify the trigger voltage during application.
- Use the overvoltage suppression function only when the power supply lacks the regenerative capability.
- When using a braking resistor, set the braking voltage to a value lower than the overvoltage suppression activation voltage or disable overvoltage suppression.
- In the case of common bus, enable overvoltage suppression function on only one inverter, typically the inverter with the highest inertia, and disable this function on other inverters.
- In the torque control mode, take cautions when enabling overvoltage suppression. If the torque cannot adjust the system bus voltage, the torque may be adjusted to the limit value.
- In the case of active loads, such as lifting loads, do not enable overvoltage suppression because overvoltage suppression can limit the generating torque, which may cause motor runaway accidents and result in serious damage.

Application instance

In the case of short deceleration time and high motor inertia, an overvoltage fault may occur during deceleration or speed overshoot.

Overvoltage suppression is enabled by default to suppress bus voltage rise through reducing generating torque. However, the bus voltage is kept near the actual effective value of VDC_max activation voltage in vector control during suppression. You can reduce the activation voltage through E9-02 [VDC_max activation voltage in vector control].

8.1.8.2 Undervoltage Suppression (Vector)

Application scenario

When the power supply or DC bus encounters instantaneous power failure in FVC or SVC control, undervoltage can occur if the fault is not handled in time, causing coast to stop. After the undervoltage suppression function is enabled, undervoltage can be suppressed in a short period of time, preventing stop upon instantaneous power failure. When the power supply or DC bus encounters long-term power failure, you need to enable the undervoltage suppression function to compensate for bus energy loss until all motors stop reliably.

Operating principles

After the bus voltage falls below the undervoltage suppression threshold, the PID control of the bus voltage makes the motor decelerate and enter the generating state to compensate for energy loss to stabilize the voltage in the DC bus.

The following figure shows the undervoltage suppression process.

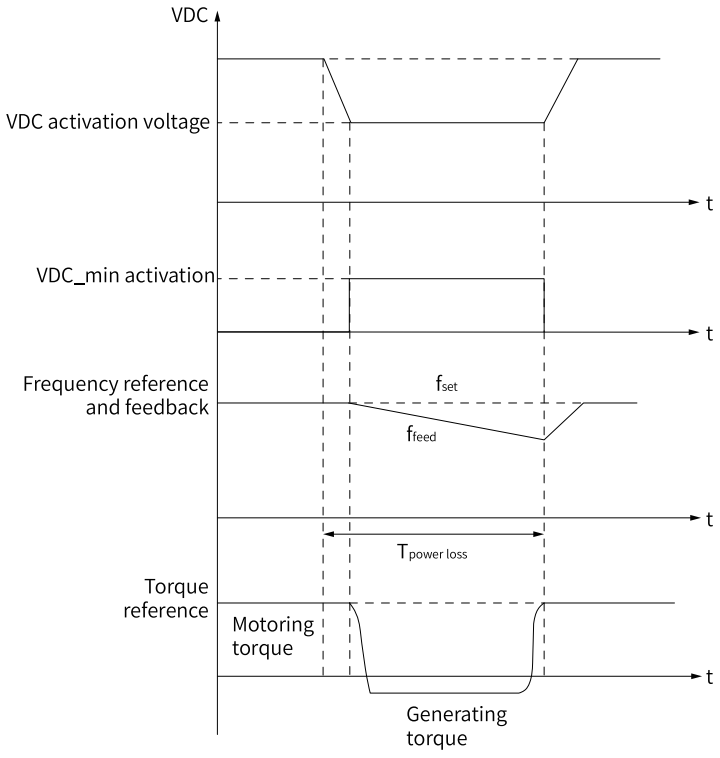


Figure 8-41 Undervoltage suppression control

Related parameters

Param.	Name	Default	Value range	Description
E9-00	Automatic calculation of Vdc activation voltage in vector control	1	0 to 1	Defines the calculation mode of Vdc activation voltage in vector control. Value description: 0: Set by parameter - The VDC activation voltage is set through E9-02 and E9-05. 1: Calculated automatically - The Vdc activation voltage is obtained by calculating the bus undervoltage/ overvoltage threshold: Vdc_min activation voltage = bus undervoltage threshold + 50 V; Vdc_max activation voltage = bus overvoltage threshold - 70 V.
E9-03	Vdc_min control switch in vector control	0	0 to 1	Defines Vdc_min control switch in vector control. Value description: 0: Disable -Vdc_min control disabled 1: Enable - Vdc_min control enabled
E9-04	Vdc_min control cut-off frequency in vector control	2.0 Hz	0.0 Hz to 50.0 Hz	Cut-off frequency of Vdc_min control in vector control Note: This parameter indicates that the system exits Vdc_min control when the operating frequency is lower than the value of E9-04.
E9-05	Vdc_min activation voltage in vector control	80.0%	60.0% to 90.0%	Defines the Vdc_min activation voltage in vector control. Note: A2-02 is used as the reference for Vdc_ min activation voltage in vector control. When A2-02 is set to 400 V, the Vdc_min activation voltage is calculated as follows by default. Vdc_min activation voltage = E9-05 x A2-02 x 1.414 = 452.4 V
E9-06	Gain tuning coefficient of Vdc control in vector control	100%	1% to 1500%	Defines the gain tuning coefficient of Vdc control in vector control. Note: E9-06 is used to adjust controller performance dynamically. Vdc_max control and Vdc_min control use the same PI controller. The controller parameter gain is calculated automatically. When the number of parallel inverters connected to the bus increases, you can adjust E9-06 based on the power proportion.

Param.	Name	Default	Value range	Description
E9-07	Bus capacitance ratio	100%	100% to 1500%	Defines the bus capacitance ratio. Note: The controller performance is affected by the number of capacitors connected to the bus when multiple drives share the same bus. The capacitance of the inverter module connected to the bus is typically proportional to the power of the inverter module. The aggregate power of all inverters connected to the bus is 2000 kW if the power of the inverter module is 500 kW. In this case, set this parameter to 400%.
E9-08	Speed deviation threshold for exiting speed tracking in Vdc_min control	1.0%	0.0% to 10.0%	Defines the speed deviation threshold for exiting speed tracking in Vdc_min control. Note: This parameter is inactive when the speed deviation is within the range of E9-08 upon exiting Vdc_min control.

Precautions

Set Vdc-min activation voltage to a low value upon excessively high grid voltage fluctuation. This is to prevent undervoltage control from being triggered inadvertently. It is recommended to verify the trigger voltage during application.

Application instance

When the grid voltage is unstable, undervoltage that causes stop may easily occur, leading to process faults. In this case, enable undervoltage suppression through E9-03 to decelerate the motor, thus stabilizing the bus voltage.

When undervoltage suppression is active, the drive enters the deceleration (generating) state and keeps the bus at the actual effective value of Vdc_min activation voltage. If the bus needs to keep a relatively high voltage, you can increase E9-05 (Vdc_min activation voltage in vector control).

8.1.9 Magnetic Flux Control

8.1.9.1 Flux Weakening Control of Asynchronous Motor

Application scenario

In FVC or SVC control, flux weakening control of the asynchronous motor is triggered when the acceleration process of the motor requires a voltage output capacity higher than the maximum value or the bus voltage is insufficient to support current operating speed.

Operating principles

When the motor operating speed increases, the back EMF increases accordingly. When the back EMF exceeds the maximum output voltage, the drive loses its ability to adjust the current, which means the motor is out of control. In this case, you can reduce the magnetic flux to reduce the back EMF and prevent motor runaway, so that the motor speed can be increased further.

The maximum available voltage is calculated based on the bus voltage, and a voltage margin [E6-02] is provided to ensure the current regulation capability. The maximum output voltage is calculated as follows.

$$V_{max} = \frac{\text{Bus voltage}}{\sqrt{2}} (100\% - [E6\text{-}02])$$

When the output voltage capacity in insufficient, you can adjust E6-02 [Voltage margin reserved] manually.

When the voltage reaches the maximum output voltage and the output frequency increases, the flux weakening range is entered. In this case, the back EMF is reduced based on the set magnetic flux according to the built-in curve, preventing motor runway during high-speed operation.

When the output frequency enters the weak magnetic range, set the flux according to the following curve to reduce the back EMF, preventing motor runway during high-speed operation.

$$\psi_{set} = \begin{cases} \psi_N & \cdots\cdots f_{syn} < f_N \\ \psi_N \dfrac{f_N}{f_{syn}} & \cdots\cdots f_{syn} \geqslant f_N \end{cases}$$

Ψ_N, Ψ_{set}: Rated flux and flux reference

F_N, f_{syn}: Rated frequency and output frequency

As shown in the following figure, the output voltage (Vout) has reached the maximum limit (Vmax). If the motor continues accelerating in this case, it will enter the flux weakening range where the flux starts to decrease the the output voltage (Vout) stops increasing. The reserved voltage margin (E6-02) cannot be set to an excessively high value. Otherwise, the load-carrying capacity of the motor at high speed can be affected.

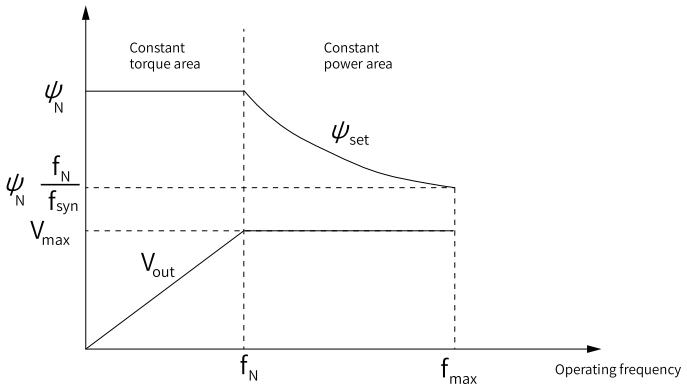


Figure 8-42 Flux and voltage output during operation of asynchronous motor

The final flux setting process in the flux weakening phase after the maximum output voltage is obtained is shown in the following figure.

Rated motor flux x Flux speed coefficient = Actual motor flux

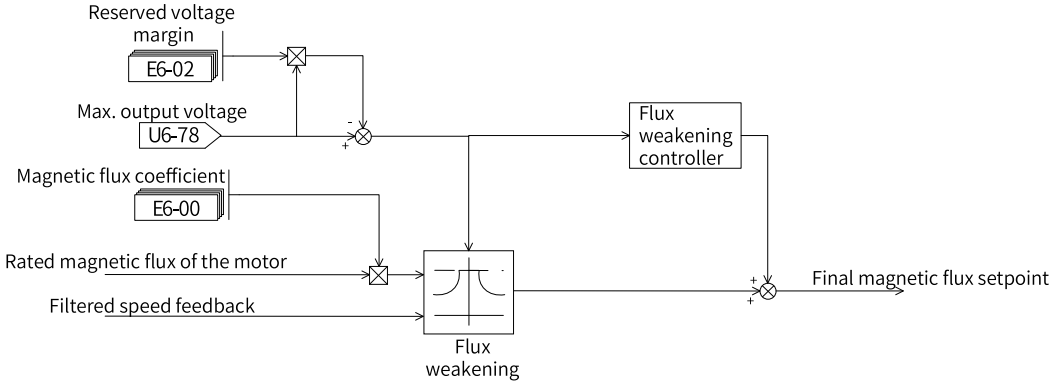


Figure 8-43 Calculation process for final flux setting

Related parameters

Param.	Name	Default	Value range	Description
E6-02	Reserved voltage margin	3.0%	0.0% to 50.0%	Defines the voltage margin. Note: Decreasing the setpoint improves voltage utilization, allowing lower current at the same load in the flux weakening range. Note that an excessively low setpoint can affect dynamic performance.
E6-00	Flux setting coefficient	100.0%	50.0% to 200.0%	Used to adjust the magnetic flux of the asynchronous motor. The value 100% corresponds to the rated magnetic flux of the motor. Note: This parameter adjusts the operation flux of the asynchronous motor. Decreasing the setpoint of this parameter can cause the motor to enter the under-excitation state. Increasing the setpoint can cause the motor to enter the over-excitation state.

Precautions

The reserved voltage margin (E6-02) cannot be set to an excessively high value. Otherwise, the load-carrying capacity of the motor at high speed can be affected.

8.1.9.2 Synchronous Motor Flux Weakening Control

Application scenario

In FVC or SVC control, flux weakening control of the synchronous motor is triggered when the acceleration process of the motor requires a voltage output capacity higher than the maximum value or the bus voltage is insufficient to support current operating speed.

Operating principles

The motor back EMF increases with the operating speed of the motor. When the back EMF exceeds the maximum voltage that can be output by the drive, the synchronous motor enters flux weakening control. In the flux weakening control mode, the synchronous motor reduces the flux linkage of the motor stator through increasing the demagnetization current, which also reduces the motor back EMF voltage. Increasing the demagnetization current of the synchronous motor can result in an increase in the motor output current. The higher the motor speed, the higher the demagnetization current can be. For details, see *"8.1.9.1 Flux Weakening Control of Asynchronous Motor" on page 291*.

Related parameters

Param.	Name	Default	Value range	Description
E6-02	Reserved voltage margin	3.0%	0.0% to 50.0%	Defines the voltage margin. Note: Decreasing the setpoint improves voltage utilization, allowing lower current at the same load in the flux weakening range. Note that an excessively low setpoint can affect dynamic performance.
E6-13	Maximum demagnetization current limit of synchronous motor	150.0%	0.0% to 200.0%	This parameter is used to limit the demagnetization current of synchronous motors to prevent faults such as overload. The value 100% corresponds to the rated motor current.

8.1.10 Energy Conservation

8.1.10.1 MTPA Control of Synchronous Motor

Application scenario

In applications involving a built-in permanent magnet synchronous motor and requiring high energy conversation, you can enable the MTPA function to use the motor reluctance torque effectively, minimizing the motor energy consumption under the same torque requirements.

Operating principles

The motor stator current can be vectorially decomposed into excitation current (id) and torque current (iq), the amplitudes of which are limited by d0-08. When MTPA control is enabled, the motor can output the limit torque within the maximum current range, which improves the current utilization and system efficiency effectively.

The following figure shows the schematic diagram of MTPA control of the synchronous motor.

The solid line indicates the relationship between excitation current and torque current when the motor outputs a constant torque. The dotted line indicates the area in which the excitation current and torque current can be adjusted when the motor is limited by the maximum output current. If the traditional vector control is used (id = 0), the torque corresponding to point B is the maximum torque

that the motor can output. After MTPA control is enabled, the system searches for the torque limit within the maximum output current range, that is, the torque corresponding to point A in the figure.

If the system load is constant, after MTPA is enabled, the system searches for the best combination of id and iq, that is, a point on the constant torque curve where the distance to the home is minimized, thereby reducing the motor energy consumption through reducing the motor output current.

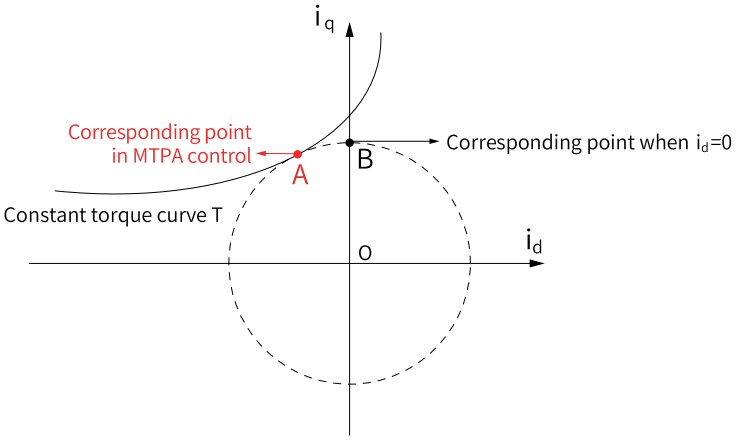


Figure 8-44 MTPA control principle of synchronous motor

Related parameters

Param.	Name	Default	Value range	Description
E11-41	Synchronous motor MTPA control enable	1	0 to 1	Used to enable synchronous motor MTPA control. Value description: 0: Disable - Disable MTPA control of the synchronous motor. 1: Enable - Enable MTPA control of the synchronous motor.

8.1.10.2 Energy-saving Control of Asynchronous Motor (Vector)

Application scenario

In applications requiring high energy conservation, you can enable energy-saving control function of the asynchronous motor to reduce the energy consumption during no-load or low-load operation of the motor.

Operating principles

Energy consumption during no-load and low-load operation of the asynchronous motor can be reduced through reducing the excitation current of the motor.

The following figure shows the energy-saving control function.

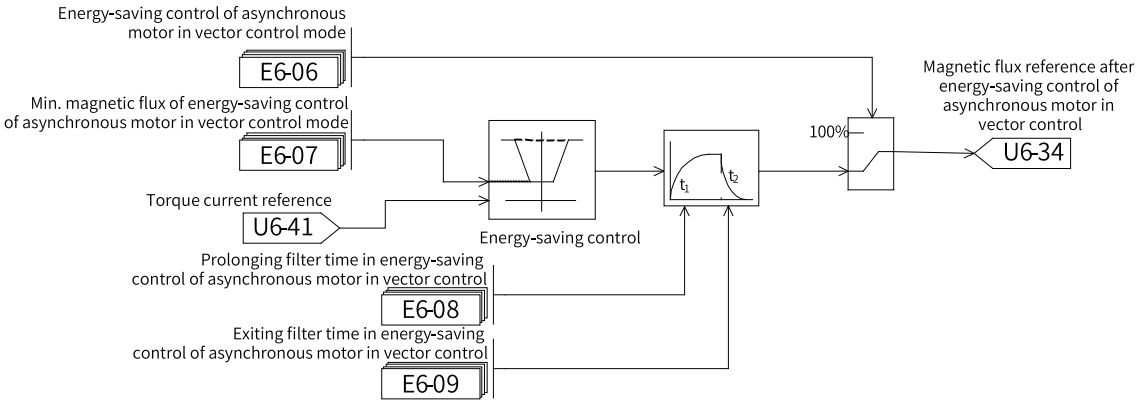


Figure 8-45 Energy-saving control (vector) of the asynchronous motor

Related parameters

Param.	Name	Default	Value range	Description
E6-06	Asynchronous motor energy-saving control (vector)	0	0 to 1	Used to enable the energy-saving control function of the asynchronous motor. Value description: 0: Disable - Disable energy-saving control. 1: Enable - Enable energy-saving control. After energy-saving control is enabled, the current in no-load or low-load mode can be reduced.
E6-07	Minimum flux in energy-saving control of the asynchronous motor (vector)	70.0%	25.0% to 100.0%	Defines the minimum flux in energy-saving control of the asynchronous motor (vector). Note: When energy-saving control is enabled (E6-06 = 1), the lower the setpoint, the more energy can be saved at no load operation. However, a low setpoint can affect the dynamic responsiveness after loading.

Param.	Name	Default	Value range	Description
E6-08	Filter increase time in energy-saving control of asynchronous motor (vector)	4 ms	0 ms to 10000 ms	Defines the filter increase time in energy-saving control. Note: When energy-saving control of the asynchronous motor is active (E6-06 = 1), decreasing this value improves the dynamic responsiveness and prevents excessive speed drop caused by sudden loading. When the output current fluctuates greatly, increase this value.
E6-09	Filter time for exiting energy-saving control of asynchronous motor (vector)	20 ms	0 ms to 10000 ms	Defines the filter time for exiting energy-saving control. Note: When energy-saving control of the asynchronous motor is active (E6-06 = 1), decreasing this value reduces the output current quickly after load reduction. When the output current fluctuates greatly, increase this value.

Precautions

The function is applicable to application with stable loads. In applications where the sudden loading/unloading occurs frequently, enable this function with caution.

8.1.11 Current Loop

Application scenario

In the FVC or SVC control mode, the current loop acts as the regulator of the inner loop, which serves to make the output current follow the reference current closely. The reference current is the output value of the outer loop regulator. Ensure that the maximum allowable current is obtained during dynamic speed change to accelerate dynamic response.

Operating principles

The PID output of the speed loop is the input of the current loop. The output current of the drive is the inputted as negative feedback. The difference between the input and feedback is inputted to the PI controller of the current loop to adjust the final voltage output, thus achieving current control to improve current stability and system performance.

Current loop parameters are auto-tuned without the need of modification.

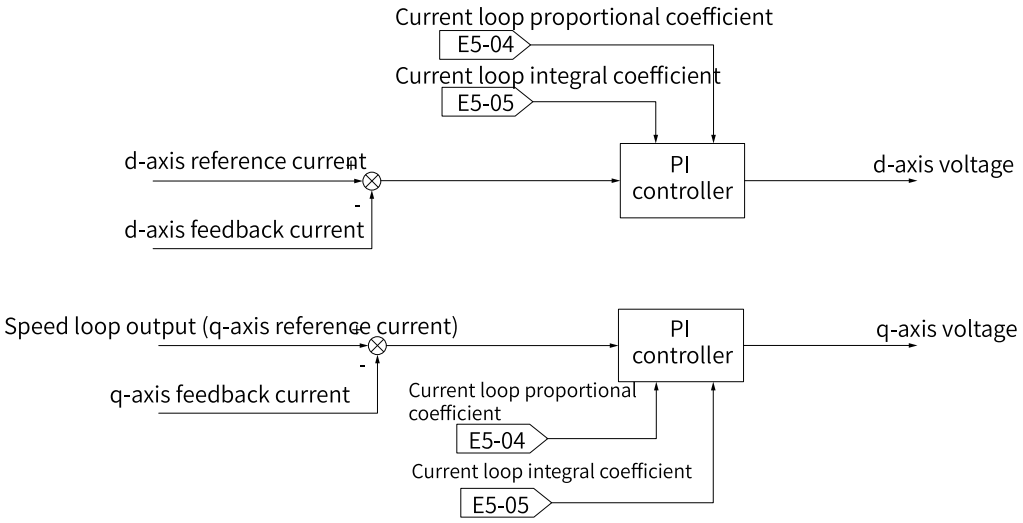


Figure 8-46 Current loop diagram

The adaptive PI parameters of current loop can be enabled or disabled through E5-06 (Adaptive current loop proportional enable). It is applicable to the adaptive adjustment of current loop parameters under heavy load.

When the current exceeds E5-07 [Proportional adaptive current lower limit of current loop] but lower than E5-08 [Proportional adaptive current upper limit of current loop], the actual effective Kp coefficient of d-axis and Kp coefficient of q-axis in the current loop are obtained through calculation. Calculation method: The adaptive coefficient is calculated linearly based on the actual current. The adaptive coefficient is multiplied by the set Kp coefficient (E5-04) to be the actual effective Kp coefficient.

When the current exceeds E5-08 [Proportional adaptive current upper limit of current loop], the actual effective Kp coefficient of the current loop is kept at E5-04 [Current loop proportional coefficient] x E5-09 [Proportional adaptive upper limit coefficient of current loop].

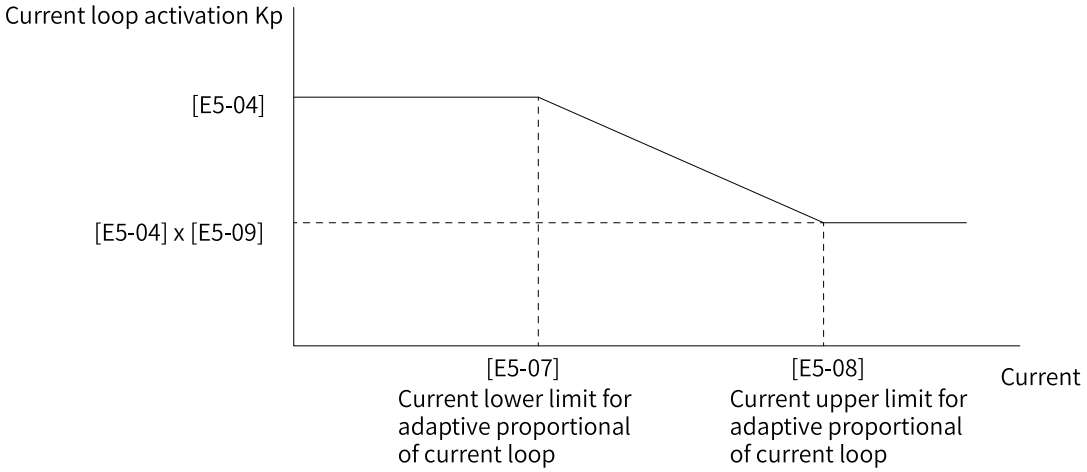


Figure 8-47 Adaptive Kp of current loop

Related parameters

Param.	Name	Default	Value range	Description
E5-04	Current loop proportional coefficient	50%	1% to 1000%	Defines the current loop proportional coefficient. Note: This parameter is used to adjust the effective proportional coefficient Kp of the current loop.
E5-05	Integral coefficient of current loop	100%	1% to 1000%	Defines the integral coefficient of current loop. Note: This parameter is used to adjust the effective integral coefficient Ki of the current loop.
E5-06	Adaptive proportion of current loop	0	0 to 1	Used to enable adaptive proportion of the current loop. Value description: 0: Disabled - The adaptive proportional coefficient is inactive. 1: Enabled - The adaptive current loop proportional coefficient is enabled.
E5-07	Adaptive proportional current lower limit of current loop	100%	1% to 1000%	Defines the adaptive current lower limit of proportional coefficient in the current loop.
E5-08	Adaptive proportional current upper limit of current loop	100%	1% to 1000%	Defines the adaptive current upper limit of proportional coefficient in the current loop.
E5-09	Adaptive proportional upper limit coefficient of current loop	100%	1% to 1000%	Defines the adaptive proportional coefficient of current loop.

Application instance

In high-load applications, the motor is affected by the saturation effect and current oscillation may occur. You can restore stable operation of the current loop by weakening the current loop control properly.

See the procedure below.

1. Enable adaptive proportional of current loop (E5-06 = 1).
2. Set the upper limit of the adaptive current to 50% (E5-08 = 50%), and the lower limit of the adaptive current to 100% (E5-07 = 100%). When the motor output current is greater than 50%, the adaptive control of the current loop proportional parameter can be achieved.
3. Set the adaptive upper limit coefficient to 50% (E5-09 = 50%). When the current exceeds E5-07, the actual effective proportional parameter is the current loop proportional coefficient (E5-04) × 50% (E5-09). This can reduce the current loop control intensity properly when the upon sever saturation.

In actual applications, adjust the current loop proportional adaptive current upper/lower limit and adaptive upper limit coefficient according to the actual application conditions.

8.1.12 Softening (Droop) Control

Application scenario

In applications such as belt conveyors, roller conveyors, or continuous casting machines, the load may be driven by multiple motors. Slight deviation can exist among motors at the same speed reference due to different mechanical characteristics, which may result in significant difference in the output torque or even inter-motor dragging.

Droop control can be applied to all motors to enable automatic even load distribution between motors, requiring no communication between motors. The motor with a higher speed carries more torque. The speed reference of the motor is reduced automatically through negative feedback, achieving torque distribution to other motors.

Characteristics of softening (droop) control

The softening (droop) control has the following features.

- Simple application without need for communication between motor controllers
- Multiple motors can be connected rigidly or flexibly to drive the same load.
- When redundant operation is needed in the case of multiple motors, the faulty device can be stopped easily without affecting operation of other devices.
- The speed regulation range is usually not greater than the rated slip of the motor.
- The speed cannot be followed accurately. The steady-state error is present between the actual speed and speed reference. The difference value is in proportion to the load.
- Accurate load distribution is not available during dynamic process.

Operating principles

Droop (softening) control is a control method that uses the output torque of the motor to generate negative feedback, thus reducing the motor speed reference. See the block diagram below.

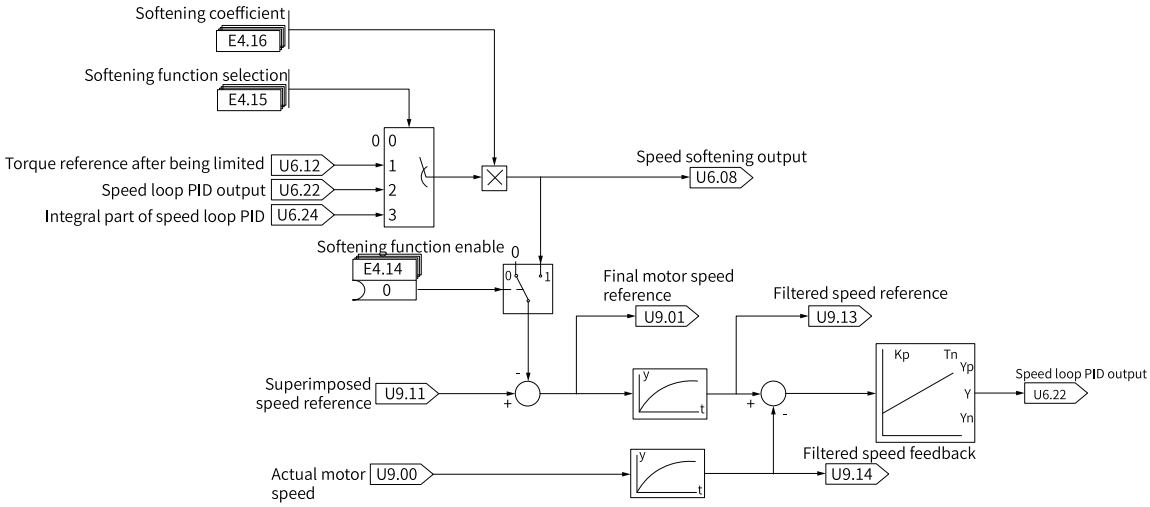


Figure 8-48 Block diagram of softening control

Three droop sources (general torque reference, speed regulation output, and speed regulation integral term) are available for softening control (droop), which can be set through E4-15. The relationship among the three droop sources is shown in the following figure.

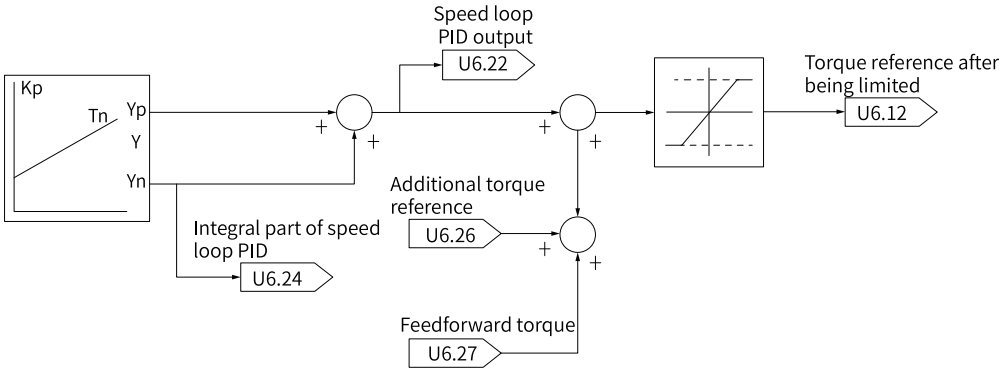


Figure 8-49 Three softening sources

Related parameters

Param.	Name	Default	Value range	Description
E4-14	Softening function enable	0	0 to 8	Used to enable the softening function. Value description: 0: Disable - Disable the softening function. 1: Enable - Enable the softening function. 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: DIL 9: HDI1 10: HDI2 Others: B connector Note: Softening (droop) control is a control method that uses the output torque of the motor to generate negative feedback, thus reducing the motor speed. It features low control accuracy but high stability and simple application. This function is widely used in belt conveyors, roller conveyors or continuous casting machines.
E4-15	Softening function	0	0 to 3	Used to select the input value for softening calculation. Value description: 0: Inactive - The softening function is disabled. 1: General torque reference - Corresponds to U6-12 [Torque reference after being limited]. 2: Speed regulator output - Corresponds to U6-22 [Speed regulator PID output]. 3: Speed regulation integral term - Corresponds to U6-24 [Speed regulation PID integral term].

Param.	Name	Default	Value range	Description
E4-16	Softening coefficient	0.0%	0.0% to 50.0%	Defines the softening coefficient. Note: Speed softening output (U6-08) = E4-16 x E4-15 x Rated motor frequency When E4-15 is set to 10%, the speed is reduced by E4-16 x 0.1 x rated motor frequency.
E4-17	Softening gain source	1	1 to 1	Defines the softening gain source. Value description: 1: 100% Others: K connector

Application case

In a marine elevating platform, 12 motors are connected to the same rack through the gearbox (reduction ratio 80:1), and the rack is welded to the jack-up leg. The host controller uses the PLC to set different speeds to raise the jack-up leg. Difference in the manufacturing of the gearbox and rack can result in the situation where some motors are connected tightly but some motors need to run for a certain period of time to come into contact with the rack.

In general speed control mode, the motor output with good contact is in overload state, and the motor with poor contact is in no-output state or the load is being driven in the reverse direction. The motor reducer that runs under heavy load for a long time may be easily damaged, leading to a fault.

In this application case, the output speed accuracy and dynamic response requirements are not high. However, the system must be reliable if the motor or AC drive is damaged. This can be achieved by using the droop function.

See the procedure below.

Step 1: Enable the softening function for all drives by setting E4-14 to 1.

Step 2: Set E4-16 to a value that represents rated motor slip.

8.2 V/f Control of Asynchronous Motor

8.2.1 Control Mode

Application scenario

The V/f control mode is applicable to asynchronous motor control applications. If you set V/f mode for a synchronous motor, the drive operates in the SVC mode.

Operating principles

The set frequency curve is regulated through droop control algorithm based on the user-defined speed reference curve. This curve, after being regulated through overcurrent suppression, overcurrent suppression, undervoltage suppression, and slip compensation, generates the final output frequency. This output frequency, after being regulated through the V/f curve, generates the

output voltage reference. The final voltage magnitude is outputted after being regulated through energy-saving control and over-excitation control. The output frequency, after being regulated through oscillation suppression, is converted to the final frequency reference. The final frequency reference is then regulated through the integral action to generate the voltage phase angle to be outputted to the drive.

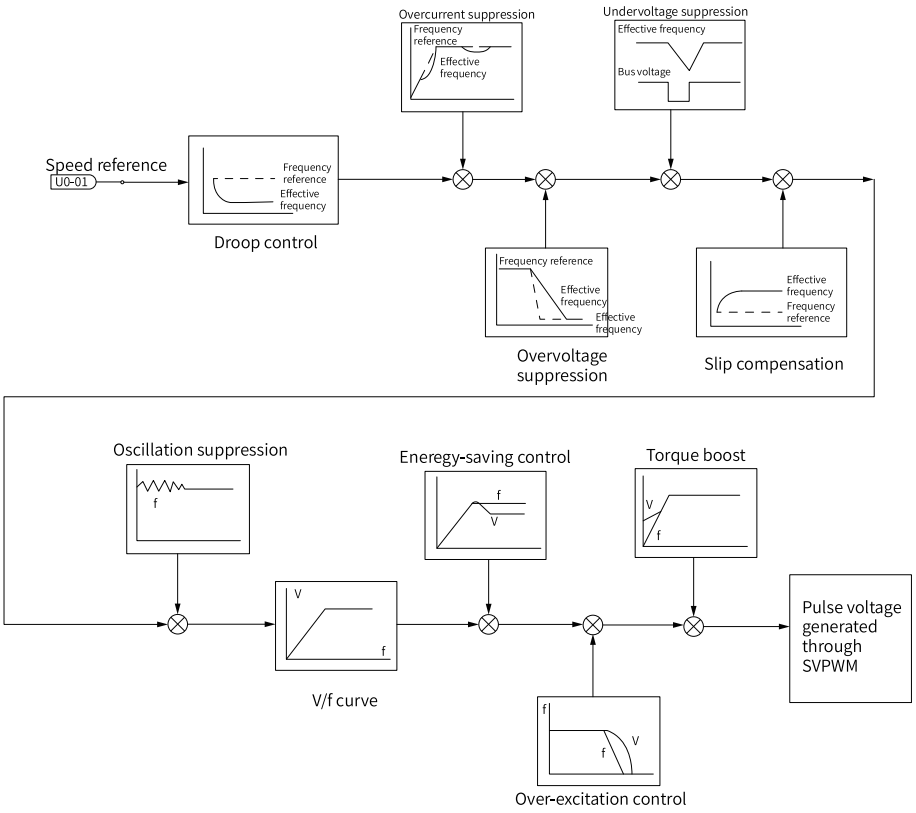


Figure 8-50 Schematic diagram of V/f control mode

8.2.2 V/f Curve Selection

Application scenario

There are two control modes for V/f, V/f curve mode and V/f decoupling mode. The following options are available for V/f curve mode.

0: Linear V/f curve: When the motor runs at frequencies lower than the rated frequency, a linear relationship is kept between the output voltage and the frequency. It is applicable to common constant torque load.

1: Multi-point V/f curve: It is applicable to special loads such as dehydrators and centrifuges. The relationship between the voltage and frequency points can be set based on the motor characteristics.

2: Square V/f curve: Applicable to centrifugal loads such as fans and water pumps. The voltage is proportional to the square of the frequency.

3/6/8: 1.2-power V/f curve/1.6-power V/f curve/1.8-power V/f curve: The voltage changes with the frequency by 1.2-, 1.6-, and 1.8-power.

The V/f decoupling mode is generally used in induction heating, inverter power supply, and torque motor control. In this mode, the output voltage of the drive is independent of the frequency. The output frequency is determined by the frequency source.

Operating principles

- Linear V/f curve: When the motor runs at frequencies lower than the rated frequency, a linear relationship is kept between the output voltage and the frequency.
- Multi-point V/f curve: You can set E3-02 to E3-07 to define the V/f curve frequency and voltage points. The multi-point V/f curve needs to be set according to the motor load characteristics. The three voltage and frequency points should meet the following conditions: V1 ⩽ V2 ⩽ V3 and f1 < f2 < f3. Different voltage and frequency points are connected by a polyline.
- Square V/f curve: Applicable to centrifugal loads such as fans and water pumps. The voltage is proportional to the square of the frequency.
- 1.2-power V/f curve/1.6-power V/f curve/1.8-power V/f curve: The voltage changes with the frequency by 1.2-, 1.6-, and 1.8-power.
- Decoupled V/f mode: The output frequency is determined by the frequency source, and the output voltage is set by the E3-46 (V/f decoupling voltage). If the set decoupling voltage changes, you can set the V/f decoupling voltage acceleration/deceleration time through E3-47/E3-48 to prevent sudden voltage change.

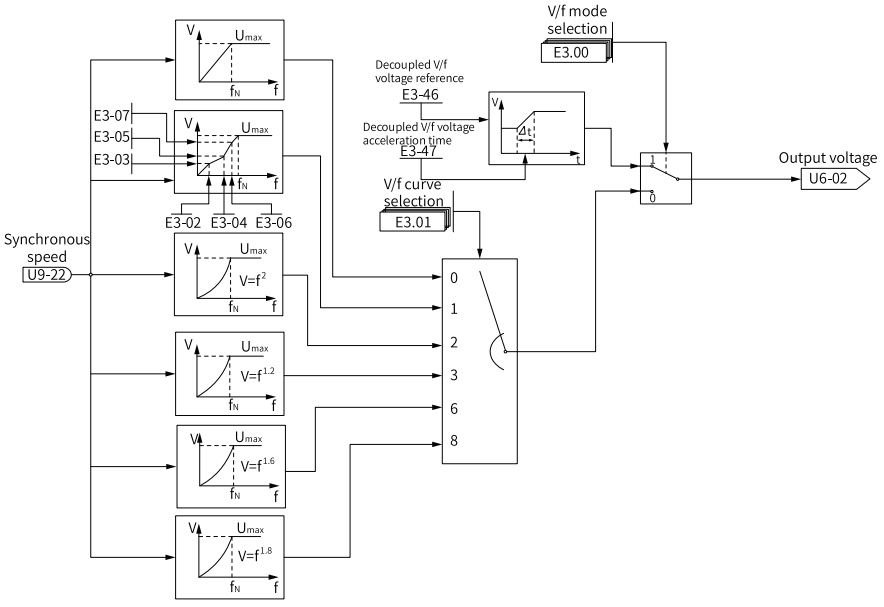


Figure 8-51 Operating principles of V/f curve

F_N indicates the set frequency, and U_{max} indicates the maximum output voltage.

Related parameters

Param.	Name	Default	Value range	Description
E3-00	V/f mode selection	0	0 to 1	Defines the control mode of V/f control. Value description: 0: V/f curve - The V/f control is performed based on the curve selected by E3-01. 1: Decoupled V/f - The output voltage of the drive is independent of the frequency. The output frequency is determined by the frequency source. The output voltage source is set by E3-46. If the set decoupling voltage changes, you can set the V/f decoupling voltage acceleration/deceleration time through E3-46/E3-48 to prevent sudden voltage change.
E3-01	V/f curve selection	0	0: Linear V/f curve 1: Multi-point V/f curve 2: Square V/f curve 3: 1.2-power V/f curve 6: 1.6-power V/f curve 8: 1.8-power V/f curve	Defines the curve selection when V/f curve is used. This parameter is active when E3-00 is set to 0. Value description: 0: Linear V/f - When the motor runs at frequencies lower than the rated frequency, a linear relationship is kept between the output voltage and the frequency. It is applicable to common constant torque load. 1: Multi-point V/f - It is applicable to special loads such as dehydrators and centrifuges. You can set custom frequency/voltage point for the V/f curve through E3-02 to E3-07. The multi-point V/f curve is set based on the motor load characteristics. The relationship among the eight voltage points and frequency points must be as follows: V1≤V2≤V3≤V4≤V5≤V6≤V7≤V8, F1<F2<F3<F4<F5<F6<F7<F8. 2: Square V/f curve - Applicable to centrifugal loads such as fans and water pumps. The voltage is proportional to the square of the frequency. 3, 6, and 8: The voltage changes with the frequency by 1.2-, 1.6-, and 1.8-power.

Param.	Name	Default	Value range	Description
E3-02	Frequency point 1 of multi-point V/f curve	0.0	0.0% to 100.0%	This parameter is active when E3-00 is set to 0 and E3-01 is set to 1. Note: You can set custom frequency/voltage point for the V/f curve through E3-02 to E3-07. The multi-point V/f curve is set based on the motor load characteristics. The relationship among the eight voltage points and frequency points must be as follows: V1≤V2≤V3≤V4≤V5≤V6≤V7≤V8, F1<F2<F3<F4<F5<F6<F7<F8.
E3-03	Voltage point 1 of multi-point V/f curve	0.0	0.0% to 100.0%	This parameter is active when E3-00 is set to 0 and E3-01 is set to 1. Note: You can set custom frequency/voltage point for the V/f curve through E3-02 to E3-07. The multi-point V/f curve is set based on the motor load characteristics. The relationship among the eight voltage points and frequency points must be as follows: V1≤V2≤V3≤V4≤V5≤V6≤V7≤V8, F1<F2<F3<F4<F5<F6<F7<F8.
E3-04	Frequency point 2 of multi-point V/f curve	0.0	0.0% to 100.0%	This parameter is active when E3-00 is set to 0 and E3-01 is set to 2. Note: You can set custom frequency/voltage point for the V/f curve through E3-02 to E3-07. The multi-point V/f curve is set based on the motor load characteristics. The relationship among the eight voltage points and frequency points must be as follows: V1≤V2≤V3≤V4≤V5≤V6≤V7≤V8, F1<F2<F3<F4<F5<F6<F7<F8.
E3-05	Voltage point 2 of multi-point V/f curve	0.0	0.0% to 100.0%	This parameter is active when E3-00 is set to 0 and E3-01 is set to 1. Note: You can set custom frequency/voltage point for the V/f curve through E3-02 to E3-07. The multi-point V/f curve is set based on the motor load characteristics. The relationship among the eight voltage points and frequency points must be as follows: V1≤V2≤V3≤V4≤V5≤V6≤V7≤V8, F1<F2<F3<F4<F5<F6<F7<F8.

Param.	Name	Default	Value range	Description
E3-06	Frequency point 3 of multi-point V/f curve	0.0	0.0% to 100.0%	This parameter is active when E3-00 is set to 0 and E3-01 is set to 3. Note: You can set custom frequency/voltage point for the V/f curve through E3-02 to E3-07. The multi-point V/f curve is set based on the motor load characteristics. The relationship among the eight voltage points and frequency points must be as follows: V1≤V2≤V3≤V4≤V5≤V6≤V7≤V8, F1<F2<F3<F4<F5<F6<F7<F8.
E3-07	Voltage point 3 of multi-point V/f curve	0.0	0.0% to 100.0%	This parameter is active when E3-00 is set to 0 and E3-01 is set to 1. Note: You can set custom frequency/voltage point for the V/f curve through E3-02 to E3-07. The multi-point V/f curve is set based on the motor load characteristics. The relationship among the eight voltage points and frequency points must be as follows: V1≤V2≤V3≤V4≤V5≤V6≤V7≤V8, F1<F2<F3<F4<F5<F6<F7<F8.
E3-46	Decoupled V/f voltage reference	0	0: 0 1: 100.0% 2: AI1 3: AI2 4: HDI1 Others: K connector	Defines the voltage source for decoupled V/f. You can set the voltage acceleration/deceleration time through E3-47 and E3-48 to prevent sudden voltage change.
E3-47	Voltage acceleration time in decoupled V/f	0.0s	0s to 1000.0s	Defines the voltage increase time during decoupled V/f. This is the time required for the motor output voltage to increase from 0 V to the base value per-unit voltage (d3-02).
E3-48	Voltage deceleration time in decoupled V/f	0.0s	0s to 1000.0s	Defines the voltage decrease time during decoupled V/f. This is the time required for the motor output voltage to decrease from d3-02 to 0 V.

Precautions

In decoupled V/f and multi-point V/f control, note that the ratio of V/f cannot be excessively high. Otherwise, overcurrent may occur. For example, if voltage is set without frequency reference, overcurrent may easily occur.

8.2.3 V/f Overvoltage Suppression

Application scenario

When the motor is in the deceleration (generating) state, if the power supply does not have the regenerative capacity, energy will be fed into the bus, causing the DC bus voltage to rise. This is especially true with high motor inertia and short deceleration time.

If overvoltage exists in the DC bus in V/f control, enable V/f overvoltage suppression.

Operating principles

When E3-30 [Overvoltage suppression in V/f control] is set to 1 [Enable] and the bus voltage rises to the setpoint (A4-48 [Effective value of software overvoltage threshold] to E3-31 [VDC_max voltage margin in V/f control], the drive stabilizes the bus voltage through adjusting the output frequency to suppress voltage rise.

After this function is enabled, the actual deceleration time is prolonged automatically. If the actual deceleration time cannot meet the requirements, increase the value of E3-24 [Over-excitation gain in V/f control] properly.

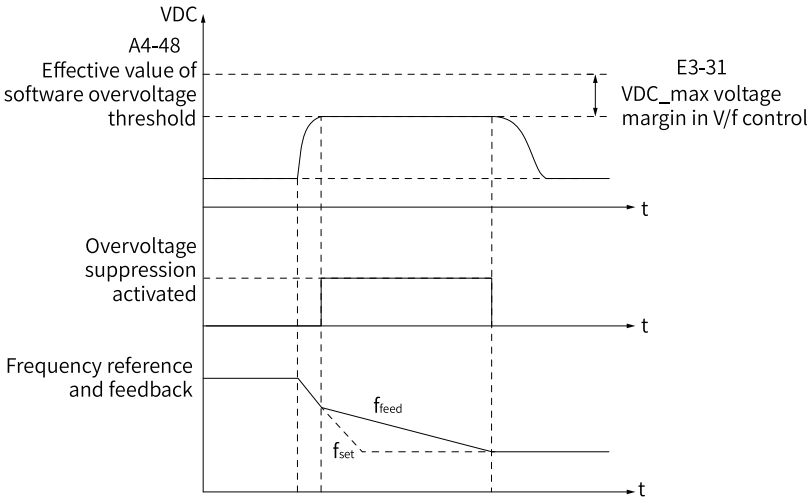


Figure 8-52 Operating principles of overvoltage suppression in V/f mode

F_{feed} : Feedback frequency; f_{set} : Frequency reference

Related parameters

Param.	Name	Default	Value range	Description
A4-48	Actual effective value of software overvoltage threshold	-	-	Displays the active DC bus overvoltage threshold at present.
E3-30	VDC_max control switch in V/f mode	0	0: Disable 1: Enable	Defines whether to enable VDC_max control in V/f mode. When VDC_max function is enabled through E3-30 and the bus voltage rises to the setpoint (bus overvoltage threshold - E3-31 [VDC_max voltage margin]), the drive stabilizes the bus voltage through adjusting the output frequency to suppress voltage rise.
E3-31	VDC_max voltage margin in V/f mode	100.0V	20.0 V to 300.0 V	Defines the VDC_max voltage margin in V/f mode. Note: When VDC_max function is enabled through E3-30 and the bus voltage rises to the setpoint (bus overvoltage threshold - E3-31 [VDC_max voltage margin]), the drive stabilizes the bus voltage through adjusting the output frequency to suppress voltage rise.
E3-28	Frequency regulation proportional coefficient for VDC control in V/f mode	30	1 to 100	Defines the frequency regulation proportional coefficient for VDC control in V/f mode. Note: The VDC_max control and VDC_min control use a common PI controller. The PI controller parameter gain is calculated automatically. The internal PI parameters can be modified through E3-28 and E3-29 based on the default values. In the case of excessive overshoot during bus voltage regulation, increase the value of E3-28.
E3-29	Frequency regulation integral coefficient for VDC control in V/f mode	250	10 to 8000	Defines the frequency regulation integral coefficient for VDC control in V/f mode.

Precautions

- Use the overvoltage suppression function only when the power supply is lack of the regenerative capability.

- When a braking resistor is used, set the braking voltage to a value lower than the braking voltage threshold because a margin must be reserved to prevent overvoltage suppression from being triggered by bus voltage fluctuation or being disabled during braking resistor control.
- In the case of common bus, enable overvoltage suppression function on one inverter only, typically the inverter with the highest inertia, and disable this function on other inverters.
- Overvoltage suppression cannot be enabled for lifting active loads. When the load drops, the motor is in the power generation state. Overvoltage suppression limits the power generation, which can prevent the motor from carrying the load effectively, leading to continuous acceleration. There is a risk of motor stall.
- If the number of parallel motors is large, increase the frequency regulation proportional coefficient for VDC control in V/f mode, or decrease the frequency regulation proportional coefficient for VDC control in V/f mode.

Application case

When a braking resistor is not connected, set E3-30 to 1 [Enable]. Set E3-31 according to the actual bus voltage. Set other values according to the default. When decelerate-to-stop is needed, you can enable overvoltage suppression to prevent the bus voltage from rising to an excessively high value.

8.2.4 V/f Undervoltage Suppression

Application scenario

This function is mainly applicable to unstable power grid, preventing system stop due to undervoltage caused by transient voltage dip. It can also be used to prevent coast-to-stop of the mechanism due to power failure, thus avoiding machining materials from be damaged, such as yarn breakage in the textile industry.

Undervoltage suppression is used to set the motor to the generating state when the bus voltage detected is lower than the sum of A4-21 [Base value of effective undervoltage] + E3-38 [VDC_min voltage margin in V/f control], so as to compensate the energy loss to stabilize the DC bus voltage. When the power supply or DC bus encounters instantaneous power failure, undervoltage can occur if the fault is not handled in time, resulting in coast-to-stop.

Operating principles

When undervoltage suppression is enabled (E3-36 = 1), the undervoltage fault can be suppressed for a short period of time to allow power dip ride-through. When the power supply or DC bus is powered off for a long time, the drive keeps the bus voltage stable and suppresses the voltage by adjusting the output frequency. Enabling the undervoltage suppression function can compensate for the power loss of the bus until each motor stops reliably.

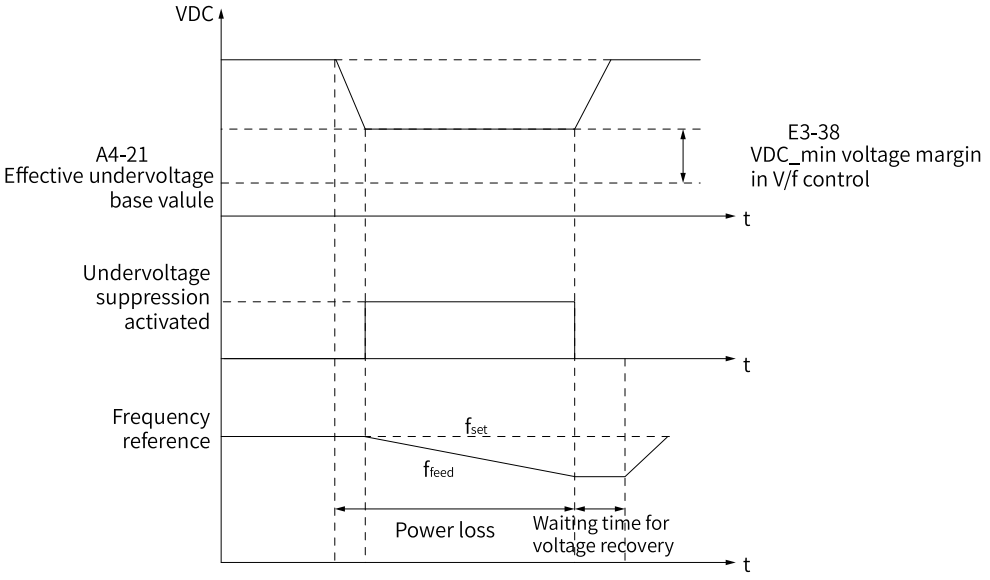


Figure 8-53 Schematic diagram of undervoltage suppression in V/f mode

F_{feed} : Feedback frequency, f_{set} : Frequency reference

Related parameters

Param.	Name	Default	Value range	Description
A4-21	Active base value for undervoltage	-	-	Displays the active DC bus undervoltage threshold at present.
E3-36	VDC_min control switch in V/f mode	0	0: Disable 1: Enable	Used to set the VDC_min control switch in V/f mode. Note: When VDC_min function is enabled, the undervoltage fault can be suppressed for a short period of time to allow power dip ride-through. When the power supply or DC bus powers down for a long time, you can enable VDC_min function to compensate the energy loss of the bus until each motor stops properly.
E3-38	VDC_min voltage margin in V/f mode	50.0V	20.0 V to 300.0 V	Defines the VDC_min voltage margin in V/f mode. Note: The VDC_min function is used to set the motor to the generating state when the bus voltage detected is lower than the sum of A4-21 [Base value of effective undervoltage] + E3-38 [VDC_min voltage margin in V/f control], so as to compensate the energy loss to stabilize the DC bus voltage.

Param.	Name	Default	Value range	Description
E3-28	Frequency regulation proportional coefficient for VDC control in V/f mode	30	1 to 100	Defines the frequency regulation proportional coefficient for VDC control in V/f mode. Note: The VDC_max control and VDC_min control use a common PI controller. The PI controller parameter gain is calculated automatically. The internal PI parameters can be modified through E3-28 and E3-29 based on the default values. In the case of excessive overshoot during bus voltage regulation, increase the value of E3-28.
E3-29	Frequency regulation integral coefficient for VDC control in V/f mode	250	10 to 8000	Defines the frequency regulation integral coefficient for VDC control in V/f mode.

Application case

The textile industry requires high yarn continuity. If the power grid is disconnected, the entire machine coasts to stop. In this case, all yarns are broken, making it difficult to restart production. Undervoltage suppression can effectively prevent yarn breakage caused by free rotation due to power failure. When power failure occurs for a short period of time, the machine enters undervoltage suppression state and maintains production at a low speed and resumes normal production after the power grid is recovered.

Configuration for this application case is as follows.

1. Connect the buses of the drive together and use a drive of high power to provide power supply for other drives.
2. Select a motor with a high inertia and enable undervoltage suppression in V/f mode (E3-36 = 1).
3. During power failure, the motor with undervoltage suppression enabled is used as the master. The PLC calculates the matching speed of other motors, and the master motor decelerates to stop.

8.2.5 V/f Overcurrent Suppression

Application scenario

In the case of rapid acceleration, deceleration, or overload, the current can easily exceed the limit, resulting in overcurrent. The overcurrent suppression function can prevent the from exceeding the overcurrent threshold.

Operating principles

The overcurrent suppression threshold is d0-08 [Maximum motor current]. After overcurrent suppression is enabled, if the output current of the drive reaches the motor overcurrent suppression threshold during motor current rise, the output frequency of the drive changes to reduce the motor

output current until the current falls below the overcurrent threshold where the frequency changes to the target frequency again. The actual acceleration time is automatically prolonged during rapid acceleration. The deceleration time is prolonged during rapid deceleration. The motor output frequency drops when heavy load occurs suddenly during steady-state operation.

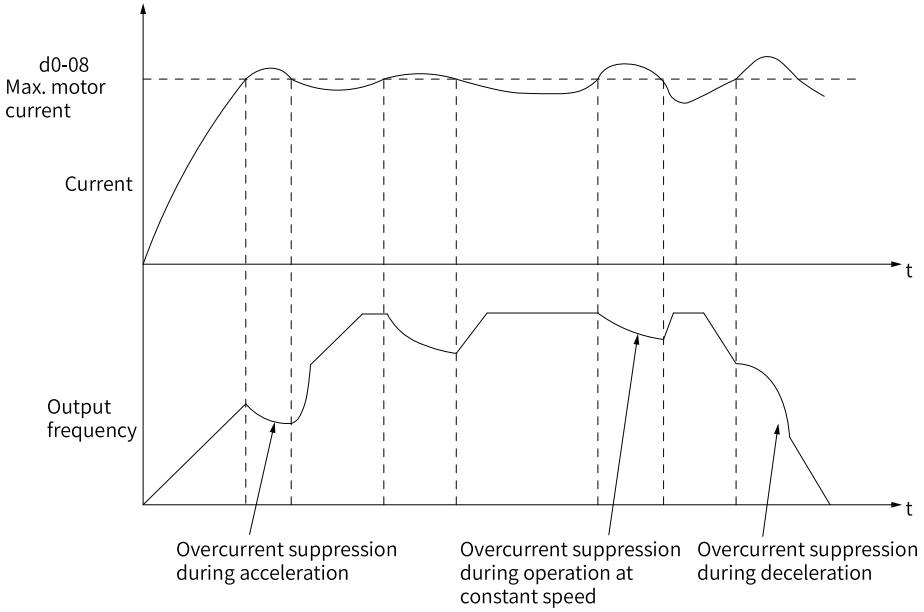


Figure 8-54 Schematic diagram of the overcurrent suppression control function

Related parameters

Param.	Name	Default	Value range	Description
E3-10	Imax control	0	0 to 1	Defines whether to enable Imax control. Note: After Imax control is enabled, if the output current of the drive reaches the motor overcurrent suppression threshold during motor acceleration, the output frequency of the drive starts to decrease until the current falls below the overcurrent suppression threshold where the frequency accelerates to the target frequency again. Therefore, the actual acceleration time is prolonged automatically. If the actual acceleration time cannot meet the requirements, increase the value of E3-11 properly.
E3-11	Frequency regulation proportional coefficient in Imax control	20	0 to 100	Defines the frequency regulation proportional coefficient in Imax control.
E3-12	Flux weakening coefficient in Imax control	100	0 to 200	Defines the flux weakening coefficient in Imax control, which is activated when E3-11 is enabled. Note: When the current oscillates in the flux weakening range, decrease this parameter properly.

Precautions

The current in V/f overcurrent suppression is high, so the motor decelerates upon high loads. When the output frequency is lower than 5 Hz, the drive may derate at low frequencies, triggering the overload fault easily. If overload may easily occur at low speed during overcurrent suppression, check whether the load is proper. Otherwise, select a drive with a higher rated power.

Application case

Enable overcurrent suppression through E3-10 and set d0-08 [Maximum motor current] based on the operating conditions on site to ensure that the overcurrent suppression threshold is higher than the current applied in normal operating conditions. For other values, keep the default values.

8.2.6 V/f Oscillation Suppression

Application scenario

During motor operation, system oscillation may occur due to mechanical resonance. In this case, you can enable oscillation suppression.

Operating principles

You can enable oscillation suppression by setting E3-20 to 1 to improve the control effect. E3-21 represents the V/f oscillation suppression gain, which must be as low as possible to minimize the impact on operation, provided that the oscillation can be effectively suppressed. Increase this gain only upon obvious oscillation. The higher the gain, the better the suppression effect can be.

Related parameters

Param.	Name	Default	Value range	Description
E3-20	Oscillation suppression in V/f mode	1	0 to 1	Defines the V/f oscillation suppression mode. Note: 1. During operation of the motor, system oscillation that caused by mechanical resonance can be suppressed through E3-20. 2. When oscillation suppression function is enabled, the rated current and no-load current of the motor must be as accurate as possible to ensure the V/f oscillation suppression effect. 3. If oscillation cannot be suppressed effectively after this function is enabled, ensure that the cut-off frequency (E3-23) is lower than the motor oscillation frequency.
E3-21	Oscillation suppression gain in V/f mode	20%	0.0% to 2000%	Defines the oscillation suppression gain in V/f mode. Note: E3-21 represents the oscillation suppression gain in V/f mode, which must be as low as possible to minimize the impact on operation, provided that the oscillation can be effectively suppressed. Increase this gain only upon obvious oscillation. The higher the gain, the better the suppression effect can be.
E3-23	Cut-off frequency of oscillation suppression in V/f mode	2.0 Hz	0.5 Hz to 50.0 Hz	Defines the cut-off frequency of oscillation suppression in V/f mode. Note: When the effective frequency of oscillation suppression is lower than this frequency, the suppression is active; otherwise, it is inactive.

Precautions

When oscillation suppression is enabled, the rated current and no-load current of the motor must be as accurate as possible to ensure the V/f oscillation suppression effect. If oscillation cannot be suppressed effectively after this function is enabled, ensure that the cut-off frequency (E3-23) is lower than the motor oscillation frequency.

Application case

Motor oscillation caused by mechanical structure can be reduced by setting E3-20 [Oscillation suppression in V/f mode] to 1 [Enable].

8.2.7 V/f Torque Boost

Application scenario

When the motor adopts V/f control, the voltage drop on the stator resistor can lead to low motor output torque, and even low load-carrying capacity of the motor during low-speed operation. In this case, you can compensate the voltage loss on the stator resistor through the torque boost function to improve the load-carrying capacity of the motor during low-speed operation. If torque boost is not enabled during start with high-load in V/f mode, overload may easily occur.

Operating principles

Setting E3-13 to enable this function and select the torque boost mode. In the case of manual torque boost, you can set the voltage that compensated by torque boost through E3-14. When the load is heavy and the starting torque of the motor is insufficient, increase the value of E3-14. Note that an excessively high setpoint can easily result in motor overtemperature and drive overcurrent.

To further improve the acceleration capability of the motor at low speed, the voltage boost during motor acceleration can be set through E3-15. This part of the boost voltage takes effect only during acceleration.

E3-16 defines the cut-off frequency of torque boost. If the frequency is lower than this value, the boost is enabled; otherwise, it is disabled. The following figure shows the V/f curve after manual torque boost.

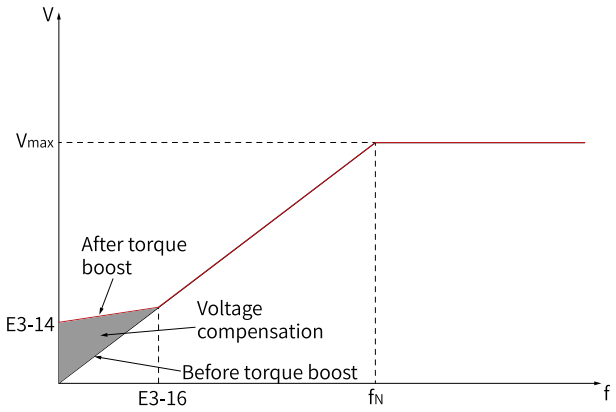


Figure 8-55 Schematic diagram of torque boost in V/f mode

F_N indicates the frequency reference, and V_{max} indicates the maximum output voltage.

When automatic torque boost is enabled, the drive automatically calculates the voltage compensation value according to the motor parameters, without the need for setting E3-14 or E3-16. Note that before using this function, ensure that the motor parameter auto-tuning function is used to guarantee the motor parameter accuracy.

Related parameters

Param.	Name	Default	Value range	Description
E3-13	V/f torque boost mode	0	0 to 2	Defines the V/f torque boost mode to increase the load-carrying capacity at low speed in V/f control. 0: Disable 1: Manual - The voltage boost value and frequency range for active torque boost are set manually through E3-14...E3-16. The boost value is active when the output frequency is lower than E3-16. Otherwise, it is inactive. 2: Automatic - The drive automatically calculates the voltage compensation value based on motor parameters. Note that before using this function, ensure that motor parameter auto-tuning is performed to guarantee the motor parameter accuracy. Note: 1. You can enable this function through E3-13 and select the torque boost mode. 2. In decoupled V/f and multi-point V/f modes, the torque boost is inactive.
E3-14	Manual torque boost at constant speed in V/f mode	1.0%	0.0% to 25.0%	Defines the manual torque boost at constant speed in V/f mode. Note: In the case of manual torque boost, the voltage can be compensated by torque boost defined by E3-14. When the load is heavy and the starting torque of the motor is insufficient, increase the value of E3-14. Note that an excessively high setpoint can easily result in motor overtemperature and drive overcurrent.
E3-15	Manual torque boost at acceleration in V/f mode	0	0% to 20%	Defines the manual torque boost at acceleration in V/f mode. Note: To further improve the acceleration capability of the motor at low speed, you can set the voltage boost value during motor acceleration through E3-15. This part of the boost voltage takes effect only during acceleration.
E3-16	Cut-off frequency of torque boost in V/f mode	100.0%	0.0% to 100.0%	Defines the cut-off frequency of torque boost in V/f mode. Note: E3-16 defines the cut-off frequency of torque boost. If the frequency is lower than this value, the torque boost is active. Otherwise, it is inactive.

Application case

After startup, operation errors occur to high load. The value of E3-14 [Manual torque boost at acceleration in V/f mode] needs to be increased in the stop state. Increase the value continuously until the motor can be started properly.

8.2.8 V/f Slip Compensation

Application scenario

V/f slip compensation can compensate the decrease of speed of an asynchronous motor when the load increases, so that the motor speed can remain unchanged when the load changes, improving the speed control precision in V/f mode.

Operating principles

When E3-17 [Slip compensation coefficient in V/f mode] is set to 100%, the slip compensated is the rated slip of the motor when the motor is connected to a rated load. When the coefficient is set to 0, the slip compensation function is disabled. When adjusting the slip compensation gain in V/f mode, check that the motor speed under the rated load is the same as the target motor speed. If they are different, fine-tune this parameter.

E3-18 defines the slip compensation filter time in V/f mode. The lower the setpoint, the faster the response speed of slip compensation, but an excessively low setpoint can also result in oscillation or instability in the dynamic process of the motor.

E3-19 defines the starting frequency for slip compensation in V/f mode. When the operating frequency is higher than this frequency, the slip compensation is active. Otherwise, it is inactive.

Related parameters

Param.	Name	Default	Value range	Description
E3-17	V/f slip compensation coefficient	0	0.0% to 300.0%	Adjust the compensation frequency through E3-17. Note: 1. When the coefficient is set to 100%, the slip compensated is the rated slip of the motor when the motor is connected to a rated load. 2. When the coefficient is set to 0, the slip compensation function is disabled. When adjusting the slip compensation gain in V/f mode, check that the motor speed under the rated load is the same as the target motor speed. If they are different, fine-tune this parameter.
E3-18	Slip compensation filter time in V/f mode	0.500s	0.000s to 2.000s	Defines the slip compensation filter time in V/f mode. Note: The lower the setpoint, the faster the slip compensation response can be, but an excessively low setpoint can cause oscillation or instability during dynamic process.
E3-19	Starting frequency of slip compensation in V/f mode	2.0 Hz	0 Hz to 50.0 Hz	Defines the starting frequency of slip compensation in V/f mode. Note: When the operating frequency is higher than this frequency, the slip compensation is active; otherwise, it is inactive.

Precautions

The slip compensation in V/f mode can improve the dynamic accuracy but features slow dynamic response. For applications required high dynamic response, use vector control.

Application case

In textile applications, the asynchronous motor runs stably in V/f control mode. The heavier the load, the lower the output speed on the motor shaft end can be compared with the speed reference. In the actual process, the speed must be as accurate as possible to match motors of different mechanisms.

If E3-17 (V/f slip compensation coefficient) is not set to 0, the slip compensation mode is enabled to improve the speed accuracy. The actual speed accuracy during operation can meet the process requirements. If slip compensation is too fast, increase E3-18 [Slip compensation filter time in V/f mode].

8.2.9 V/f Energy-saving Control

Application scenario

Energy-saving control is applicable to applications where the motor load does not change. It can be also used in light-load applications to reduce output current automatically to achieve energy conservation. It can be used in applications where the load changes slowly, such as fans, water pumps, and air compressors.

Operating principles

After this function is enabled through E3-48, when the motor runs with low load, the drive reduces the output voltage continuously to lower the exciting current to reduce energy consumption. Enabling the energy-saving mode does not affect the motor speed. When the motor load increases, the drive recovers the original output voltage and automatically exits the energy-saving mode.

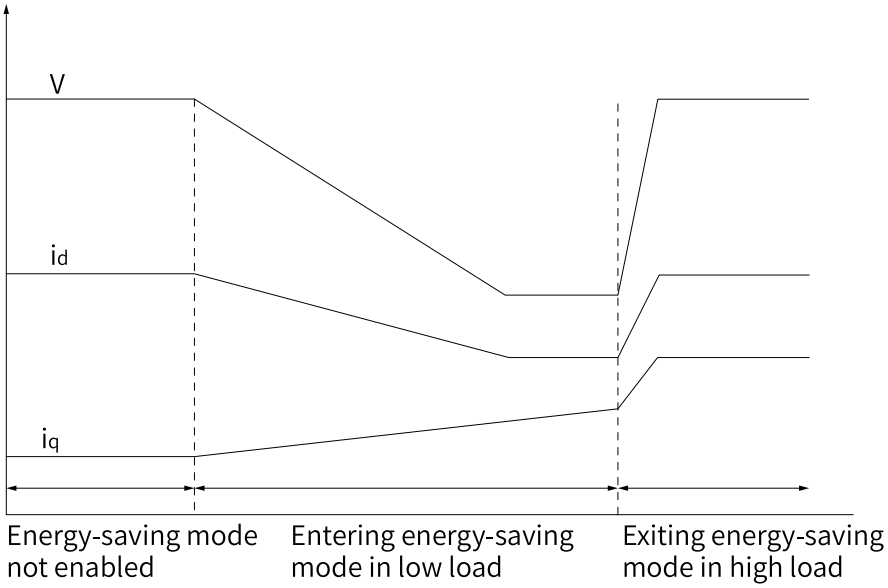


Figure 8-56 Energy-saving control in V/f mode

Related parameters

Param.	Name	Default	Value range	Description
E3-25	Energy-saving control in V/f mode	0	0 to 1	Used to enable/disable energy-saving control in V/f mode. Note: Energy-saving control is applicable to applications where the motor is in light-load operation for a long time. After this function is enabled through E3-25, when the motor runs with low load, the drive reduces the output voltage continuously to lower the exciting current to reduce energy consumption.

Application case

In low-load applications, you can enable V/f energy-saving control through E3-25 to reduce the current and output power.

8.2.10 V/f Droop Control

Application scenario

The droop control function applies to applications where the load is driven by multiple motors, slight deviation can exist among motors at the same speed reference due to different mechanical characteristics, which may result in significant difference in the output torque or even inter-motor dragging.

The droop control function is widely used in applications involving belt conveyors, roller conveyors, or continuous casting machines. This function is easy to use. Multiple motors can be connected rigidly or flexibly to drive the same load without communication between motor controllers, allowing redundant operation of multiple motors where the faulty device can be switched off without affecting other devices.

Operating principles

The droop (softening) control function is used to generate negative feedback based on the motor output torque to reduce the motor reference speed. Droop control features good stability and simple application though low control accuracy. It can be applied to all motors to enable even load distribution between motors without communication. The motor with a higher speed carries more torque. The speed reference of the motor is reduced automatically through negative feedback, achieving torque distribution to other motors.

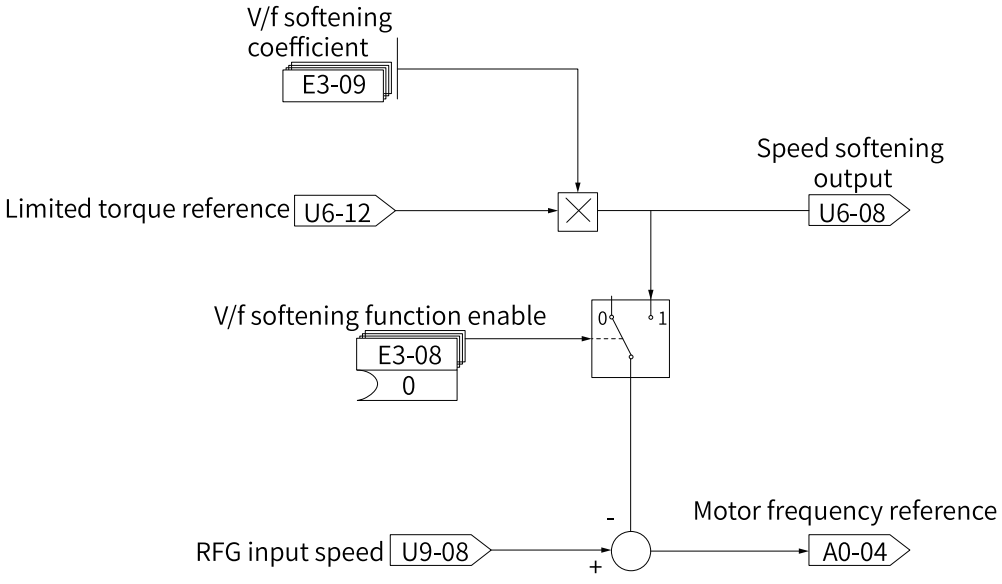


Figure 8-57 Schematic diagram of droop control in V/f mode

Related parameters

Param.	Name	Default	Value range	Description
E3-08	V/f droop function	0	0: Disable 1: Enable 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: HDI1 Others: B connector	Used to enable/disable the V/f droop function to solve the problem of load distribution among motors. Note: 1. When multiple motors are used to drive the same load, the motor and drive with higher speed carry higher load due to speed difference. In this case, you can enable the V/f droop function to allow the drive to fine-tune the frequency references based on the magnitude of the motor load, achieving even load distribution by softening the mechanical characteristics of the motor. 2. The V/f softening coefficient can be set through E3-09.
E3-09	V/f softening coefficient	0.0	0.0% to 50.0%	Defines the V/f softening coefficient. This function is enabled when E3-08 is enabled. Note: The frequency of V/f softening is proportional to the softening coefficient and the motor load torque.

Precautions

- The speed adjustment range is normally equal to or lower than the rated slip of the motor.
- The actual speed may not follow the speed reference accurately, where a steady difference exists between the actual speed and reference speed. The difference is proportional to the load.
- Accurate load distribution cannot be ensured during the dynamic process.

Application case

When multiple motors are connected with a belt, enable the droop function and set the droop coefficient to adjust the droop speed to the rated slip, thus achieving a balanced load during operation of the motor to prevent the motor from entering the generating state.

In this application case, the system must be able to operate properly even the motor or drive is damaged. Given that accurate output speed or high dynamic response is not needed in this application case, you can enable the droop function for all the drives (E3-08 = 1), and set E3-09 to [Rated frequency x 60/Number of pole pairs - Rated speed]/Rated speed.

8.2.11 V/f Over-excitation

Application scenario

During rapid deceleration, the bus voltage increases. When the bus voltage is close to the overvoltage threshold, increase the motor excitation current to increase the loss and reduce the deceleration time.

Operating principles

Set the over-excitation gain through E3-47 when the motor is decelerating and the bus voltage is approaching the overvoltage threshold in asynchronous motor V/f control mode. When entering the over-excitation state, the drive increases the output voltage to increase the motor exciting current, thus increasing the loss and reducing the motor deceleration time. The higher the over-excitation gain, the better the suppression effect will be.

Related parameters

Param.	Name	Default	Value range	Description
E3-24	V/f over-excitation gain	0	0 to 200	Defines the over-excitation gain in V/f mode.

Application case

In the ceramic industry, a large number of mechanisms on the ceramic tile production line need to be started and stopped quickly. The bus voltage rises generally during deceleration, triggering overvoltage suppression and prolonging the deceleration time. For devices that requires quick start and stop, increase E3-24 [V/f over-excitation gain] properly to allow faster consumption of the bus voltage, reducing the deceleration time significantly.

8.3 Basic Control

8.3.1 Random PWM

Application scenario

When the drive drives a motor, a sharp noise may be caused by the switching frequency. In noise-sensitive applications, you can enable the random PWM function to improve the user experience.

Operating principles

After random PWM is enabled, the active carrier frequency changes randomly near the set carrier frequency, changing the sharp noise to a soft rustling sound.

Related parameters

Param.	Name	Default	Value range	Description
A4-08	Random PWM depth	0	0 to 10	The random PWM can turn the sharp electromagnetic noise of the motor caused by the carrier frequency into a soft rustling sound. Setting this parameter to 0 disables this function. The higher the setpoint, the better the noise reduction performance can be.

Precautions

- The higher the random PWM depth, the better the noise reduction performance can be. Note that an excessively high value may increase current harmonics. Therefore, it is recommended to increase the default value gradually during actual commissioning.
- When the carrier ratio (ratio of carrier frequency to output frequency) is lower than 10, it is recommended that random PWM cannot be turned on. When the carrier ratio is low, enabling the random PWM can result in insufficient control frequency and excessive motor speed fluctuation.
- The random PWM depth is affected by the carrier frequency range. When the active carrier frequency range reaches the minimum carrier frequency 1.2 kHz or the maximum carrier frequency limited by the model, increasing the random PWM depth doe not change the carrier frequency change range.
- Both vector control and V/f control support random PWM. It is recommended to set the random PWM depth in vector control to a value lower than or equal to 5.

8.3.2 Overmodulation

Application scenario

In applications with high requirements on the output current and energy efficiency, increasing the voltage overmodulation coefficient can enhance the output capacity of the voltage and effectively improve the load capacity of the motor in the flux weakening range.

Operating principles

Under the same loads, increasing the output voltage can reduce the output current and the heat generated by the motor, cable, and inverter. The output voltage is related to the grid voltage/grid capacity, rectifier, and inverter. In summary, the power grid and rectifier determine the output voltage base. A low power grid capacity can result in excessive voltage drop at high loads. The maximum base voltage is determined after the bus voltage is obtained through rectifying the grid voltage. In the SVPWM linear modulation range, the relationship between the bus voltage and the maximum output voltage of the drive is as follows.

$$V_{\text{max. output voltage}} = \frac{1}{\sqrt{2}} U_{dc}$$

For control stability, reserve a voltage margin of 3% (E6-02) to stabilize the output voltage at a value calculated through the following formula.

$$V_{\text{max. output voltage}} = \frac{1 - (E6\text{-}02)}{\sqrt{2}} U_{dc} = \frac{0.97}{\sqrt{2}} U_{dc}$$

In some sites, the bus voltage is low due to low input voltage. The output voltage can be increased by overmodulation. Overmodulation is not enabled by the inverter software by default. You can set A4-07 to 1 to enable overmodulation and set the overmodulation coefficient through A4-32. Take A4-32 = 106% as an example. If the output voltage is not enabled, the overmodulation coefficient can be increased by 6% (in the case of low harmonics during stable operation). After overmodulation is enabled, the conversion relationship between the effective value of the maximum output line voltage and the bus voltage of the drive is as follows.

$$V_{\text{Effective value of max. output voltage}} = \frac{U_{dc}}{\sqrt{2}} \times (A4\text{-}10) \times \{1 - (E6\text{-}02)\}$$

Related parameters

Param.	Name	Default	Value range	Description
A4-07	PWM modulation mode	0	0: No overmodulation 1: With overmodulation	Defines whether overmodulation is enabled.
A4-32	Overmodulation depth	103	100 to 110	Defines the overmodulation depth. Note: The higher the overmodulation depth, the greater the voltage output capacity and the stronger the load capacity in the flux weakening range can be. However, the output current distortion can also increase.

Precautions

- The higher the overmodulation coefficient, the greater the output voltage distortion and current fluctuation can be. Excessive fluctuation can easily result in pulse-by-pulse current limit or overcurrent. Therefore, take the fluctuation rise into account when increasing the overmodulation coefficient.
- The output voltage reserves a voltage margin of 3% to meet the dynamic current response. Therefore, a overmodulation coefficient of 103% is equal to 100% of the maximum output voltage, which means there is no overmodulation effect. It is recommended to set the overmodulation coefficient to a value lower than or equal to 108%. Otherwise, excessive harmonic current can occur, resulting in a decrease in the system efficiency.

8.3.3 Carrier Frequency and Pulse Generation

Application scenario

The carrier frequency of the drive is set by A4-02. The actual carrier frequency is limited by A4-02 [Carrier frequency reference], the maximum carrier frequency of the drive, and functions such as "Carrier frequency adjusted with synchronous frequency" and "Random PWM". For details, see description of A4-36 to A4-40 and A4-08.

Related parameters

Param.	Name	Default	Value range	Description
A4-01	Actual effective carrier frequency	-	-	Displays the effective carrier frequency of the drive. Note: The actual effective carrier frequency of the drive is also affected by functions such as "Carrier frequency adjusted with synchronous frequency", "Carrier frequency adjusted with temperature", and "random PWM".
A4-02	Carrier frequency reference	Model dependent	1.20 kHz to 8.00 kHz	Defines the carrier frequency of the drive. This function is used to adjust the carrier frequency of the drive. It helps reduce the motor noise, avoid the resonance point of the mechanical system, and reduce the ground leakage current and interference generated by the drive. Note: When parameters are restored to default values through A8-00 and A8-01, the default value will match the default carrier frequency of the model. The higher the setpoint, the lower the motor noise and the lower the current ripple can be. However, an excessively high carrier frequency can derate the drive, resulting in frequent overload faults. When the carrier frequency is low, high harmonics of the output current and power loss, as well as temperature rise of the motor can increase.

Precautions

Increasing the carrier frequency generally improves the control performance, current harmonics, and noise of the motor, but it can incur problems such as drive temperature rise, as described below.

Item	Problem
Carrier frequency	Low → High
Motor noise	High → Low
Current harmonics	Bad → Good
Motor temperature rise	High → Low
AC drive temperature rise	Low → High
Leakage current	Low → High
External radiation interference	Low → High

The default carrier frequency varies with the drive power. When modifying the carrier frequency, note that if the set carrier frequency is higher than the default value, temperature rise can occur on

the heatsink of the drive. In this case, you need to derate the drive. Otherwise, the overtemperature alarm can be triggered.

The MD880 series AC drive adopts 7-segment continuous pulse width modulation. The equivalent 5-segment discontinuous pulse width modulation under the same switching times is A4-02 x 1.5. Compared with 5-segment discontinuous pulse width modulation, 7-segment continuous pulse width modulation can effectively reduce current harmonics, torque ripple, and noise, and provide better control performance at the same carrier frequency.

In long-line applications, keep the carrier frequency as low as possible as a high carrier frequency can shorten the motor service life.

8.3.4 Simulation Mode

Application scenario

The simulation mode allows you to simulate application conditions with mechanical characteristics such as friction, torque, and inertia. It is mainly used for commissioning optimization, system test, and fault diagnosis to effectively shorten the commissioning time and reduce the risk of equipment damage. In certain applications where installation is complicated or the risk of motor faults exists, you can perform electrical commissioning through simulation mode to verify the logic of the PLC control system and effectively test the external terminal control logic (such as start/stop, forward/reverse rotation, and fault reset), the communication command response (such as I/O status read, frequency reference), and collaborative operation of multiple drives. The motor control parameters can also be set in the simulation mode to simulate actual operations such as motor parameter calculation, commissioning, observation of control feedback, and fault logic verification.

Related parameters

Param.	Name	Description	Default	Value range
A8-22	Simulation mode	Used to enable the simulation mode. Value description: 0: Inhibited - Normal operation The setpoint reverts to 0 each time after power-on. 1: Allowed - Start simulation. If simulation conditions are not met, the setpoint automatically reverts to 0. Note: 1. When A8-22 is set to 1, the dive generates a virtual bus voltage and alarm 46-3, indicating that the simulation mode applies currently. 2. During simulation, ensure that the actual bus voltage is lower than 48 V. Once the bus voltage exceeds 48 V, fault 5-3 is triggered and A8-23 is cleared. If the bus voltage is higher than 48 V during non-simulation operation, A8-22 cannot be set to 1.	0	0 to 1
A8-23	Load torque for simulation	Defines the load torque for simulation. Note: During simulation, a virtual load torque can be generated.	0.0%	-3276.7% to +3276.7%

Param.	Name	Description	Default	Value range
d2-02	Moment of inertia ratio	Defines the motor moment of inertia ratio. Note: During simulation, you can set the moment of inertia ratio based on the actual motor inertia to simulate the actual inertia during operation of the motor.	100%	0% to 65535%
d2-03	Friction torque	Defines the motor friction torque. Note: During simulation, a virtual mechanical torque equal to the actual friction torque of the motor can be generated.	0.0%	0.0% to 100.0%

Precautions

- The simulation mode is only applicable to analog asynchronous motors.
- The simulation mode can start commissioning only when the main circuit of the drive is switched off.
- After starting simulation, you can simulate normal operation of the drive and adjust motor control parameters.

Application case

With-load dynamic auto-tuning applies when the motor coupling cannot be removed easily or the motor can be started by professionals only instead of being started though the software tool. Ensure that the motor runs properly before performing auto-tuning through remote communication. Use the simulation mode to commission operation commands and references. Perform the communication commissioning as follows.

1. Configure parameters of the communication card.

2. Confirm the communication state with PLC.

3. After the bus is powered off, set A8-22 to 1 to enable simulation. In the simulation mode, the bus voltage must be lower than 48 V, with no IGBT output or brake action. Check the data for simulation when commissioning communication with PLC.

4. In the simulation mode, you can check whether the motor starts/stops properly at normal speed through the software tool or PLC.

5. Ensure that emergency stop signals can be responded to properly. During the test, set emergency stop to OFF2. OFF3 is not used during the test to prevent stop failure.

6. Check that the motor runs properly in the simulation mode. Then, set A8-22 to 0 to disable simulation and switch on the bus.

8.3.5 DC Voltage Regulation Control Mode

Application scenario

The DC voltage regulation control mode is generally used in power generation applications to keep a constant bus voltage and output electrical energy to the outside through the bus. In such applications, the speed of the unit is generally controlled by the original motor. The generator starts running only after a certain speed is achieved. Therefore, set the startup mode (E1-00) to flying start and the stop mode to coast-to-stop.

Operating principles

The DC voltage regulation control mode does not support V/f control. When this function is enabled, the motor is in the generating mode and E0-01 (Speed/torque mode) is no longer active. In this case, the controller implements closed-loop control based on the bus voltage, keeping the bus voltage constant through controlling the generating torque to output electrical energy to the outside.

Related parameters

Param.	Name	Default	Value range	Description
E9-10	DC voltage regulation control	0	0: Disable 1: Enable Others: B connector	Used to enable DC voltage regulation control. Value description: 0: Disabled - DC voltage regulation control is disabled. 1: Enable - DC voltage regulation control is enabled. Others: B connector - Determine whether DC voltage regulation control is activated based on the value of the connector.
E9-11	DC voltage regulation control voltage loop	1	0: Disable 1: Enable Others: B connector	Used to enable the DC voltage regulation control voltage loop. Value description: 0: Disable - The bus voltage loop is disabled. 1: Enabled - The bus voltage loop is enabled. Others: B connector: Determine whether the bus voltage loop is enabled by DC voltage regulation control based on the value of the connector.

Param.	Name	Default	Value range	Description
E9-14	Voltage reference source in DC voltage regulation mode	0	0: E9-15 Others: K connector	Defines the voltage in DC voltage regulation mode. Value description: 0: E9-15 - DC voltage regulation mode is set to the value of E9-15. Others: K connector - DC voltage regulation mode is the value set by K connector.
E9-15	Digital setting of the voltage in DC voltage regulation mode	600.0V	410.0 V to 1200.0 V	Bus voltage reference in DC voltage regulation mode
E9-16	Digital setting of voltage upper limit in DC voltage regulation mode	120.0%	60.0% to 150%	Defines the upper limit of bus reference in DC voltage regulation mode, which is a percentage to the bus voltage base value<1>.
E9-17	Source of voltage upper limit in DC voltage regulation mode	0	0: Invalid Others: K connector	The upper limit of the bus reference in the DC voltage regulation mode is the lower value between this parameter and E9-16. Value description: 0: Invalid – E9-17 is invalid. Others: K connector – The upper limit of the bus reference in DC voltage regulation mode depends on the value of K connector.
E9-18	Digital setting of voltage lower limit in DC voltage regulation mode	75%	60.0% to 150%	Defines the lower limit of bus reference in DC voltage regulation mode, which is a percentage to the bus voltage base value [1].
E9-19	Source of voltage lower limit in DC voltage regulation mode	0	0: Invalid Others: K connector	The lower limit of the bus reference in the DC voltage regulation mode is higher value between this parameter and E9-18. Value description: 0: Inactive - E9-19 is inactive. Others: K connector – The upper limit of the bus reference in DC voltage regulation mode depends on the value of K connector.
E9-20	Voltage upper limit in DC voltage regulation mode	-	-	Displays the upper limit of the effective bus voltage reference.
E9-21	Voltage lower limit in DC voltage regulation mode	-	-	Defines the voltage lower limit in DC voltage regulation mode.
E9-22	Base time for voltage reference change	5.0s	0.0s to 2000.0s	Defines the ramp time of bus voltage reference to change from 0 V to the base value of bus voltage.

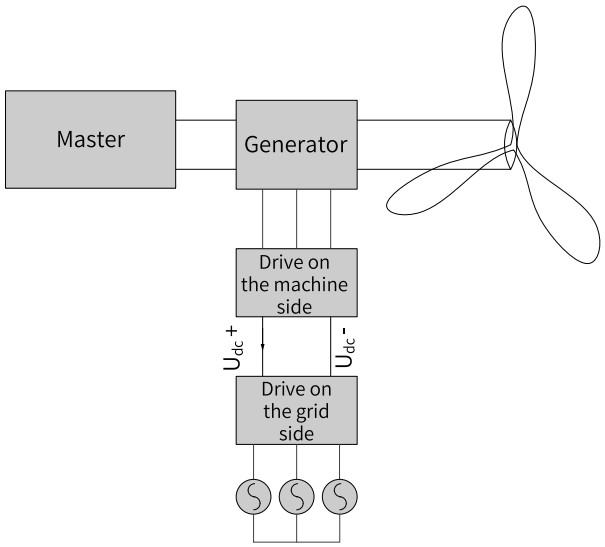
Param.	Name	Default	Value range	Description
E9-26	Minimum operating frequency in DC voltage regulation mode	10.0%	0.0% to 200.0%	If the motor speed is lower than this frequency, the bus voltage loop no longer works and the torque reference is kept at zero.
E9-27	Kp tuning coefficient of DC voltage regulation loop	100.0%	1.0% to 1000.0%	Used to adjust the Kp coefficient of the bus voltage loop in DC voltage regulation mode.
E9-28	Ki tuning coefficient of DC voltage regulation loop	100.0%	1.0% to 1000.0%	Used to adjust the Ki coefficient of the bus voltage loop in DC voltage regulation mode.
E9-29	Dynamic Kp tuning in DC voltage regulation mode	100.0%	10.0% to 1000.0%	When the deviation between the bus voltage in DC voltage regulation mode and the reference value exceeds E9-30, you can increase the voltage loop Kp through this coefficient to achieve better dynamic and load-resistant disturbance performance.
E9-30	Dynamic Kp activation threshold in DC voltage regulation mode	25.0V	5.0 V to 100.0 V	If the deviation between the bus voltage and the reference value in the DC voltage regulation mode exceeds the value of this parameter, you can adjust the Kp value of the voltage loop dynamically to achieve higher dynamic and load-resistant disturbance performance.
E9-31	Softening function of DC voltage regulation mode	0	0: Disable 1: Enable	Used to enable softening control function in the DC voltage regulation mode.
E9-32	Softening source in the DC voltage regulation mode	0	0: Invalid 1: Generating torque 2: Generating power 3: Absolute value of operating speed	Defines the softening source in the DC voltage regulation mode.
E9-33	Softening coefficient (V/ 100%) in DC voltage regulation mode	0.0	0.0 to 1000.0	Defines the softening coefficient (V/ 100%) in DC voltage regulation mode.
E9-34	Softening source filter in DC voltage stabilization mode	200 ms	0 ms to 5000 ms	Defines the filter time of the softening source selected by E9-32.
E9-35	Additional voltage (100 V as base value) in DC voltage regulation mode	0	0: 0 Others: K connector	Defines the additional voltage in DC voltage regulation mode. 0: 0 - The additional voltage is 0. Others: K connector - The percentage of the additional voltage in DC voltage regulation mode depends on the value of K connector.

Note

[1] The bus voltage base value is determined based on the voltage class of the model, which is 540 V for 400 V models and 975 V for 690 V models.

Application instance

- Typical application 1: A shaft generator system (SGS) is a power generation device that utilizes surplus power from the ship's main propulsion engine to drive a generator, thereby supplying electrical energy to the vessel's power grid. The following figure shows the system topology. The ship's main engine provides prime power to both the propulsion system and generators. The drive on the engine side operates in constant DC bus voltage control mode, and the drive on the grid-side inverts the electrical energy from the DC bus and feeds the inverted energy into the shipboard power grid.



The drive on the engine side can start running only after the bus voltage is higher than the undervoltage threshold. The bus voltage can be established in the following ways.
Provide the bus voltage through the uncontrolled rectification of motor back EMF. (This solution requires that the motor must be a permanent magnet synchronous motor.) The prime mover drives the generator to rotate. The generator's back-EMF is rectified through the drive's uncontrolled rectifier stage, naturally establishing bus voltage. When rotational speed reaches the threshold where bus voltage exceeds the undervoltage setpoint, system startup is achieved.

Provide the bus voltage through an external device. When the back EMF of the PMSM is low or the speed does not meet the requirement, sufficient bus voltage cannot be established through the back EMF. Before the asynchronous motor runs, there is no excitation and no back EMF to establish bus voltage. In this case, external devices are required to provide bus voltage to meet the startup conditions. For example, in this example, you can make the inverter on the grid side work in the rectification mode first to provide the bus voltage, and then enter the grid-connected mode after the drive on the engine side is done starting. As the asynchronous motor requires pre-excitation at startup, the active power is extracted from the bus during this process. Therefore, the capacity of the external device needs to be larger than the power lost by the asynchronous motor's stator resistor, with a certain margin left. Failure to comply may result in undervoltage or damage to the external device during pre-excitation. After startup, the bus

voltage is supported by the generating energy of the generator, and the external device is no longer needed.

The DC voltage regulation mode supports switchover to the speed mode during operation. When operating in the speed mode, enable E9-10 [DC voltage regulation mode] to make the motor enter the generating mode without surge. Similarly, when this function is disabled during DC voltage regulation, the set speed switches to the speed mode from the current speed to achieve switchover between the motoring and generating modes. Generally, it can be used in applications such as starting and generating application of internal combustion engines and charging/discharging of flywheel energy storage devices.

- Typical application 2: The flywheel energy storage device is a device that drives high-inertia flywheel through a motor to rotate at high speed and store the mechanical energy, and then converts mechanical energy to electrical energy when needed. To charge the flywheel, the motor needs to run in the motoring speed mode to increase the mechanical energy through acceleration. When energy needs to be released, enable DC voltage regulation control through E9-10. In this case, the motor switches from the speed mode to the constant bus voltage mode to provide power supply for the outside.
  Starting and generating application: A common generator set consists of the internal combustion engine as the original motor and the generator responsible as the output source of electrical energy. The internal combustion engine generally does not have the self-starting capability, requiring an external force to be driven to a certain speed for start. After start, the internal combustion engine outputs energy to the outside. Therefore, you can first use the speed mode to make the generator operate in the motoring state to assist the internal combustion engine to start. After the internal combustion engine is started, switch to constant bus voltage mode to for power generation.

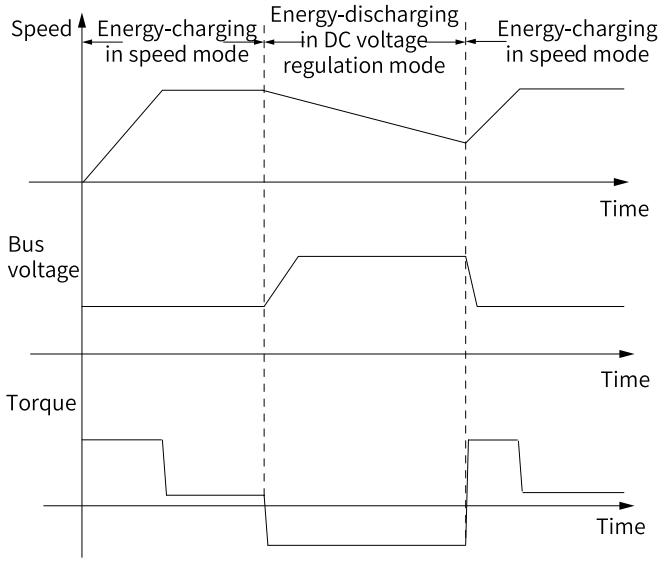


Figure 8-58 Switchover between constant bus voltage control and speed mode

8.3.6 Motor Temperature Model Adaption

Application scenario

The motor stator resistance, rotor resistance, and back EMF can change greatly due to overtemperature or ambient temperature change of the motor, leading to deviation in the model, which may affect applications requiring high control precision. In this case, you can enable motor temperature model adaption to compensate for the temperature change.

Operating principles

The MD580S model can compensate for temperature change in the following two ways.

- Compensation based on temperature sensor detection:
  Get the accurate motor temperature through the temperature sensor. Set the motor temperature sensor as the motor thermal model temperature source (E11-29). You can adjust the motor model through the temperature sensor to adapt to changes in the motor temperature. Note that abnormal feedback from the temperature sensor (such as disturbed signals) may result in incorrect temperature, resulting in motor model error.

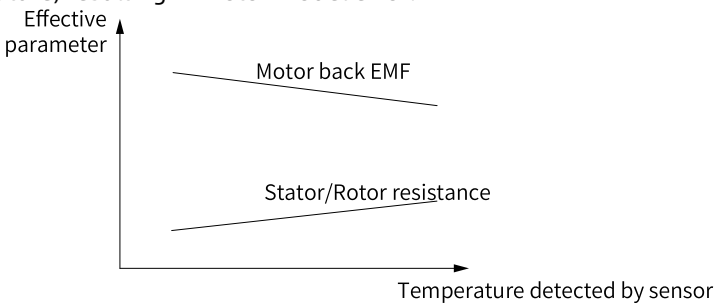


Figure 8-59 Motor parameters changing with temperature

- Compensation based on temperature model estimation:
  If the temperature sensor is not available and the motor temperature varies greatly, to get accurate motor model, you can select estimation model in E11-29 and temperature model 1 in E11-30, and set parameters E11-31 to E11-36. Accurate model parameters can improve the control precision. For the temperature estimation model, E11-35 and E11-36 are important parameters that can be estimated based on experiment or experience.

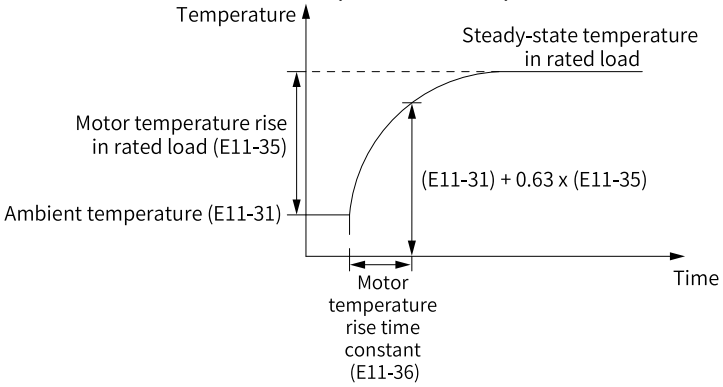


Figure 8-60 Temperature rise and related parameters under rated load

For cooling with shaft-mounted fan, parameters E11-32 to E11-34 can also significantly affect the temperature model results. The following figure shows the load that can be carried at different speeds to reach the same temperature rise.

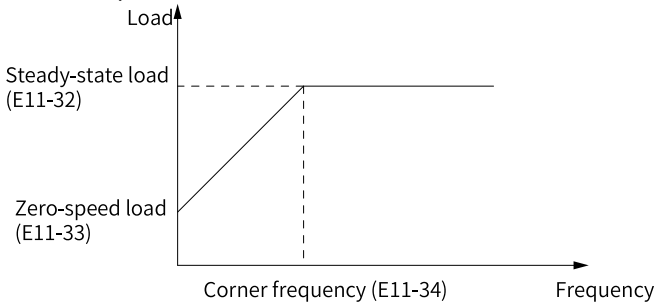


Figure 8-61 Temperature for reaching the same temperature rise at different speeds

Precautions

- When temperature sensor is used for temperature model compensation, configure the temperature sensor first, and perform parameter auto-tuning after obtaining the correct temperature.
- The MD580S can also compensate for the temperature change by setting E11-45 [Stator resistance optimization]. The stator resistance is auto-tuned upon start after the stator resistance is enabled, so that the stator resistance can be calibrated upon temperature change, keeping the stator resistance error within the allowable range. Enabling this function can improve the load-carrying performance during low-speed operation in SVC mode. This function can be used in the following conditions.
  - Frequent motor start/stop and significant motor temperature change
  - Significant ambient temperature change and low motor temperature rise
- It takes some time to start stator resistance auto-tuning. If the pre-excitation time is set to an excessively low value, auto-tuning can fail.

Related parameters

Param.	Name	Default	Value range	Description
E11-29	Motor thermal model temperature source	0	0: Estimation 1: Motor temperature sensor 1 (U5-10) 2: Motor temperature sensor 2 (U5-11) 3: Motor temperature sensor 3 (U5-12)	Defines the motor thermal model temperature source. Value description: 0: The motor temperature is estimated through the motor temperature model. 1: The motor temperature is obtained through motor temperature sensor 1. 2: The motor temperature is obtained through motor temperature sensor 2. 3: The motor temperature is obtained through motor temperature sensor 3.
E11-30	Motor thermal model type	0	0: Not estimated 1: Temperature model 1	Defines the motor temperature model type. Value description: 0: Not estimated 1: Temperature model 1

Param.	Name	Default	Value range	Description
E11-31	Ambient temperature	20.0℃	-50.0℃ to +100.0℃	Ambient temperature of the motor
E11-32	Steady-state load	100.0%	0.0% to 800.0%	Defines the temperature rise coefficient basis under the rated load, which is 100% by default.
E11-33	Zero speed load	100.0%	0.0% to 800.0%	Indicates the load required to generate the same temperature rise as the steady-state load at zero speed. When the motor adopts forced air cooling or water cooling, the coefficient can be set to 100%. If the temperature rise is faster at low speed when the shaft-mounted fan is used for heat dissipation, and the load corresponding to the same temperature rise per unit is lower, you can set the coefficient to 50%.
E11-34	Corner frequency	20.0 Hz	0.0 Hz to 100.0 Hz	Defines the corner frequency between zero speed and steady state of the load required by temperature rise per unit.
E11-35	Motor temperature rise under rated load	80.0℃	0.0℃ to 200.0℃	Defines the temperature change of the motor during changing from ambient temperature to steady-state temperature under rated load.
E11-36	Motor temperature rise time constant	1000s	0s to 20000s	Defines the time required for the temperature to rise to 63% of E11-35.

8.3.7 Electromagnetic Coil

Application scenario

In the electromagnetic coil, a stable rotating magnetic field is formed through the coil current, which can achieve stirring and removal of metallurgical impurities in the electromagnetic stirring stations for metallurgical continuous casting. Electromagnetic stirring can significantly improve product quality and production efficiency in various industries, especially in clean production and precision manufacturing.

Operating principles

The drive controls the frequency and intensity of electromagnetic stirring through adjusting the frequency and magnitude of the rotating magnetic field generated by the electromagnetic coil based on the output coil current according to parameter setting.

Related parameters

Param.	Name	Default	Value range	Description
E3-60	Coil I/F control enable	0	0: Disable 1: Enable Others: B connector	Used to enable/disable the coil I/F function.
E3-61	Coil I/F mode selection	0	0: Frequency/ Current accelerated separately based on the ramp and decelerated without ramp 1: Frequency/ Current accelerated/ decelerated separately based on the ramp	When the reference is 0, the current acceleration time in decoupled I/F mode is defined by E3-90, the current deceleration time in decoupled coil I/F mode is 0, the frequency acceleration time is RFG acceleration time, and the frequency deceleration time is 0. When the reference is 1, the acceleration/deceleration time of the decoupled coil I/F mode is defined by E3-90/E3-91 respectively, and the frequency acceleration/deceleration time is the RFG acceleration/deceleration time.
E3-62	Current reference in decoupled coil I/F mode	0	0: [0] 1: E3-86 digital reference 1 (physical) 2: E3-87 digital reference 2 (per-unit) 3: AI1 4: AI2 5: HDI1 Others: K connector	Defines the current reference in decoupled I/F mode.
E3-63	Digital current reference 1 in decoupled coil I/F mode (physical)	0.0 A	0.0 A to 6553.5 A	When E3-85 is set to 1, the effective current reference is the value of E3-86.
E3-64	Digital current reference 2 in decoupled coil I/F mode (per-unit)	0.0%	0.0% to 600.0%	When E3-85 is set to 2, the effective current reference is the value of E3-87. The value 100% corresponds to the rated current of the motor.
E3-65	Maximum current in decoupled coil I/F mode	0.0%	0.0% to 600.0%	Defines the maximum current in decoupled coil I/F mode.
E3-67	Current acceleration time in decoupled coil I/F mode	0.000s	0.000s to 65.535s	Defines the time for the current to rise from 0 to the rated value in the decoupled coil I/F mode.
E3-68	Current deceleration time in decoupled coil I/F mode	0.000s	0.000s to 65.535s	Defines the time for the current to drop from the rated value to 0 in the decoupled coil I/F mode.

8.4 Encoder

8.4.1 Overview of the Encoder

The MD880 series drive supports multiple types of encoders. Different types of encoders require different types of encoder cards (hereafter referred to as PG cards) for signal processing. Up to three PG cards can be inserted at the same time, corresponding to three encoder detection modules.

The following table lists the encoder signal types supported by different PG cards.

Encoder card model	Encoder signals supported	Type of the encoder connected
HPG-10	HTL differential, HTL single-ended, OC and OE	HTL differential, HTL single-ended, OC and OE type ABZ encoders
HPG-30	Sine-cosine increment signal, absolute signal (23-bit, SSI, ENDAT)	Sine-cosine encoder 23-bit encoder SSI encoder ENDAT encoder Sine-cosine and ENDAT encoder
HPG-40	Resolver	Resolver
HPG-50	TTL	TTL type ABZ encoder

Parameters in groups n4/n5/n6 are used to set detection signals of the three encoders. The encoder speed feedback (d0-11) can be used to select the encoder signal for speed control. o15-10 can be used to select the encoder signal used for position control.

8.4.2 Encoder Connection and Basic Setting

The following shows the wiring and parameter setting for the encoder.

8.4.2.1 ABZ Encoder

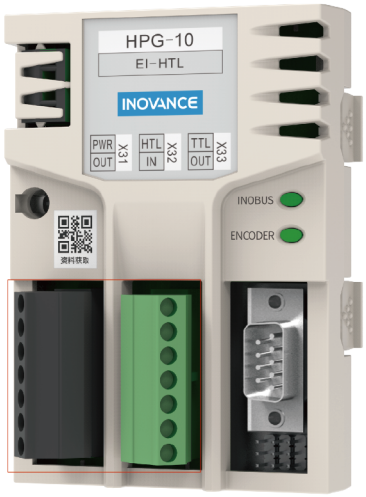
8.4.2.1.1 Wiring of the Encoder

HPG-10 (HTL/OC/OE) or HPG-50 (TTL) can be used based on different signal types of the ABZ encoder.

[HPG-10]:

Differential HTL input: The encoder A+/A-/B+/A-/Z+/Z- is connected to A+/A-/B+/A-/Z+/Z- of the encoder card. The encoder power supply (+) is connected to VCC_EN, and the encoder power supply (-) is connected to the COM terminal of X31.

Single-ended HTL/OC/OE input: Encoder A+/B+/Z is connected to the encoder card A+/B+/Z+, encoder power supply (+) is connected to VCC_EN, and encoder power supply (-) is connected to the COM terminal of X31 and X32.



[HPG-50]:

TTL differential input: The encoder A+/A-/B+/A-/Z+/Z- is connected to A+/A-/B+/A-/Z+/Z- of the encoder card. The wiring diagram is shown in the following figure.

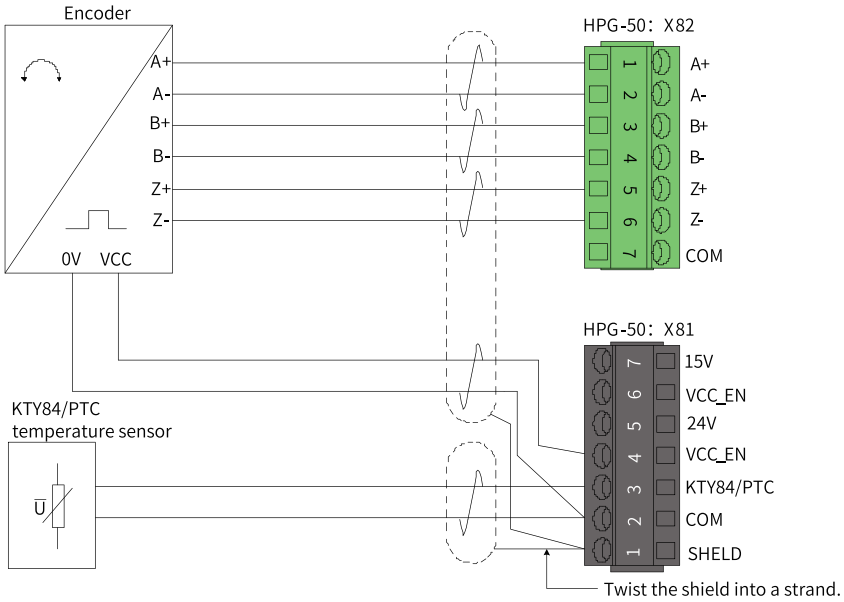


Figure 8-62 Wiring of HPG-50 differential input TTL signal

8.4.2.1.2 Basic Software Setting

Take d0-11 = 0 [Encoder detection module 1] as an example. For the ABZ encoder, set as follows.

1. Setting the expansion slot: Set n4-00 to the correct expansion slot module based on the expansion slot connected to the PG card.
2. Setting the encoder type: Set n4-02 to 1 [Common ABZ encoder].
3. Setting the resolution (PPR) of the sine-cosine encoder: The nameplate of the ABZ encoder is marked with the number of pulses per revolution. If a 1024-PPR encoder is used, set n4-07 to 1024.

After the preceding steps are done, n4-01 should indicate "Online", with the PG card indicator turned green.

Param.	Name	Description
n4-00/n5-00/n6-00	Expansion slot selection	0: Disable 1: Expansion slot 1_1 2: Expansion slot 1_2 3: Expansion slot 1_3 4: Extension slot 2_1 5: Expansion slot 2_2 6: Expansion slot 2_3 7: Extension slot 3_1 Set this parameter based on the expansion slot connected to the PG card.
n4-02/n5-02/n6-02	Encoder type	1: Regular ABZ encoder Set this parameter to 1.
n4-07/n5-07/n6-07	Encoder resolution (pulses/ revolutions)	This parameter is marked on the nameplate of the encoder, indicating the number of pulses per revolution.

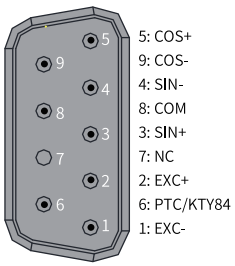
Note

- For synchronous motors, the encoder Z signal must be connected. For details, see *"8.4.3.3 Synchronous Motor Angle Correction" on page 356*.
- For asynchronous motors, the motor can be used without Z signal.

8.4.2.2 Resolver

8.4.2.2.1 Wiring of the Encoder

For resolvers, you can use HPG-40, which supports frequency-division signal output. The following table describes the input terminals of the encoder signal.

Name	Function	Pin No.	Terminal
EXC-	Resolver excitation (-)	1	HPG-40：X61 
EXC+	Resolver excitation (+)	2	
SIN+	Resolver signal input SIN+	3	
SIN-	Resolver signal input SIN-	4	
COS+	Resolver signal input COS +	5	
PTC/KTY84	Temperature sensor input	6	
NC	Unconnected internally	7	
COM	Reference ground of temperature sensor	8	
COS-	Resolver signal input COS-	9	

Note

HPG-40 supports resolvers with 10/12/15/20 kHz excitation source, 7 Vp-p-0.5 transformation ratio, 7 Vrms-0.5 transformation ratio, 7 Vrms-0.286 transformation ratio, and 4 Vrms-0.3 transformation ratio.

8.4.2.2.2 Basic Software Setting

Take d0-11 = 0 [Encoder detection module 1] as an example. For a resolver, set as follows.

1. Setting the expansion slot: Set n4-00 to the correct expansion slot module based on the expansion slot connected to the PG card.
2. Setting the encoder type: Set n4-02 to 3 [Resolver].
3. Setting the number of pole pairs: Set the number of pole pairs according to the nameplate or manual of the resolver. For one pair of poles, set n4-15 to 1.

After the preceding steps are done, n4-01 should indicate "Online", with the PG card indicator turned green.

Param.	Name	Description
n4-00/n5-00/n6-00	Expansion slot selection	0: Disable 1: Expansion slot 1_1 2: Expansion slot 1_2 3: Expansion slot 1_3 4: Extension slot 2_1 5: Expansion slot 2_2 6: Expansion slot 2_3 7: Extension slot 3_1 Set this parameter based on the expansion slot connected to the PG card.
n4-02/n5-02/n6-02	Encoder type	3: Resolver Set this parameter to 3 for a resolver.
n4-15/n5-15/n6-15	Number of resolver pole pairs	Set the number of pole pairs of the resolver according to the nameplate or manual.

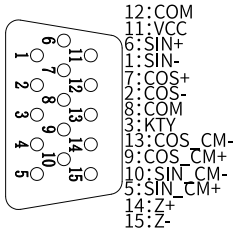
Note

- For synchronous motors equipped with a resolver, the following two conditions must be met:
  - Number of motor pole pairs ≥ Number of resolver pole pairs
  - The number of motor pole pairs must be an integer multiple of the number of resolver pole pairs.
- This rule does not apply to asynchronous motors.

8.4.2.3 Sine-Cosine Encoder

8.4.2.3.1 Wiring of the Encoder

HPG-30 can be used for sine-cosine encoders. For hardware wiring, see the following table.

Name	Function	Pin No.	Terminal
SIN-	SIN signal of the incremental encoder (-)	1	
COS-	COS signal of the incremental encoder (-)	2	HPG-30:X82  12:COM 11:VCC 6:SIN+ 1:SIN- 7:COS+ 2:COS- 8:COM 3:KTY 13:COS_CM- 9:COS_CM+ 10:SIN_CM- 5:SIN_CM+ 14:Z+ 15:Z-
SIN+	SIN signal of the incremental encoder (+)	6	
COS+	COS signal of the incremental encoder (+)	7	
COM	Encoder power supply ground	8, 12	
VCC	Encoder power supply	11	
Z+	Z signal of the incremental encoder (+)	14	
Z-	Z signal of the incremental encoder (-)	15	

8.4.2.3.2 Basic Software Setting

Take d0-11 = 0 [Encoder detection module 1] as an example. For the sine-cosine encoder, set as follows.

1. Setting the expansion slot: Set n4-00 to the correct expansion slot module based on the expansion slot connected to the PG card.
2. Setting the encoder type: Set n4-02 to 2 [Sine-cosine encoders].
3. Setting the resolution (PPR) of the sine-cosine encoder: The nameplate of the encoder is marked with the number of pulses per revolution. If a 1024-PPR encoder is used, set n4-07 to 1024.

After the preceding steps are done, n4-01 should indicate "Online", with the PG card indicator turned green.

Param.	Name	Description
n4-00/n5-00/n6-00	Expansion slot selection	0: Disable 1: Expansion slot 1_1 2: Expansion slot 1_2 3: Expansion slot 1_3 4: Extension slot 2_1 5: Expansion slot 2_2 6: Expansion slot 2_3 7: Extension slot 3_1 Set this parameter based on the expansion slot connected to the PG card.
n4-02/n5-02/n6-02	Encoder type	2: Sin-cos encoder Set this parameter to 2.
n4-07/n5-07/n6-07	Encoder resolution (pulses/ revolutions)	This parameter is marked on the nameplate of the encoder, indicating the number of pulses per revolution.

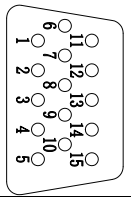
Note

- For synchronous motors, the encoder Z signal (R signal) must be connected. The MD880 series drive does not support correction of the sine/cosine encoders through the C/D signal.
- For asynchronous motors, the motor can be used without Z signal.

8.4.2.4 23-bit Encoder

8.4.2.4.1 Wiring of the Encoder

HPG-30 can be used for the 23-bit encoder. For the input interface of the 23-bit encoder signal, see the following table.

Name	Function	Pin No.	Terminal
COM	Encoder power supply ground	8, 12	HPG-30:X82 
VCC	Encoder power supply	11	
DATA+	23-bit encoder DATA signal (+)	14	
DATA-	23-bit encoder DATA signal (-)	15	

8.4.2.4.2 Basic Software Setting

Take d0-11 = 0 [Encoder detection module 1] as an example. For the 23-bit encoder, set as follows.

1. Setting the expansion slot: Set n4-00 to the correct expansion slot module based on the expansion slot connected to the PG card.
2. Setting the encoder type: Set n4-02 to 4 [23-bit encoder].
3. Setting the 23-bit encoder communication protocol: Set the communication protocol according to the protocol supported and cable length. The 23-bit encoder communication protocol supports backward compatibility. If the communication protocol of the 23-bit encoder is the 2nd generation (4 M communication rate), you can set n4-84 to 0 [2 Mbps in the 1st generation] or 1 [4 Mbps in the 2nd generation].

After the preceding steps are done, n4-01 should indicate "Online", with the PG card indicator turned green.

Param.	Name	Description
n4-00/n5-00/n6-00	Expansion slot selection	0: Disable 1: Expansion slot 1_1 2: Expansion slot 1_2 3: Expansion slot 1_3 4: Extension slot 2_1 5: Expansion slot 2_2 6: Expansion slot 2_3 7: Extension slot 3_1 Set this parameter based on the expansion slot connected to the PG card.
n4-02/n5-02/n6-02	Encoder type	4: 23-bit encoder Set this parameter to 4 based on the PG card connected actually.
n4-84/n5-84/n6-84	23-bit encoder communication protocol	0 [2 Mbps in the 1st generation] 1 [4 Mbps in the 2nd generation] 2 [8 Mbps in the 3rd generation] Set the communication protocol according to the actual encoder information or manual.

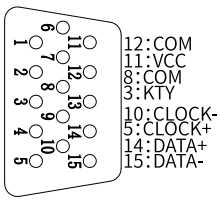
Note

The 23-bit encoder communication protocol can be compatible with earlier versions. For example, if the encoder cable is excessively long, you can select a low communication rate.

8.4.2.5 SSI Encoder

8.4.2.5.1 Wiring of the Encoder

HPG-30 can be used for the SSI encoder. For the input terminals of the SSI signal, see the following table.

Name	Function	Pin No.	Terminal
CLOCK+	CLOCK signal of the SSI encoder (+)	5	HPG-30:X82 
COM	Encoder power supply ground	8, 12	
VCC	Encoder power supply	11	
CLOCK -	CLOCK signal of the SSI encoder (-)	10	
DATA+	DATA signal of the SSI encoder (+)	14	
DATA-	DATA signal of the SSI encoder (-)	15	

8.4.2.5.2 Basic Software Setting

Take setting d0-11 to 0 [Encoder detection module 1] as an example, for SSI, set as follows.

1. Setting the expansion slot: Set n4-00 to the correct expansion slot module based on the expansion slot connected to the PG card.
2. Setting the encoder type: Set n4-02 to 5 [SSI encoder].
3. Setting the SSI encoder communication baud rate: Set the clock frequency based on the encoder cable length. N4-85 [SSI encoder clock frequency] is set to 2 [1 Mbps] by default.
4. Setting the SSI encoder data format: Set the encoder parameters according to the actual data format of the encoder, including the check mode, output code value, number of single-turn bits, number of multi-turn bits, and status bits. The following example does not involve the check mode or status bit, with 13-bit single-turn resolution and 12-bit multi-turn resolution used.
   Ones of n4-87 [Check mode] = 1 [No check]; Tens of n4-87 [Output code value of the encoder] = 1 [Gray code]; n4-88 [Number of SSI encoder status bits] = 0; n4-89 [Single-turn bits of communication-type encoder] = 13; n4-90 [Multi-turn bits of communication-type encoder] = 12.

Param.	Name	Description
n4-00/n5-00/n6-00	Expansion slot selection	0: Disable 1: Expansion slot 1_1 2: Expansion slot 1_2 3: Expansion slot 1_3 4: Extension slot 2_1 5: Expansion slot 2_2 6: Expansion slot 2_3 7: Extension slot 3_1 Set this parameter based on the expansion slot connected to the PG card.
n4-02/n5-02/n6-02	Encoder type	5: SSI encoder Set this parameter to 5 based on the PG card connected.
n4-85/n5-85/n6-85	SSI encoder communication baud rate	0: 2 Mbps 1: 1.6 Mbps 2: 1 Mbps 3: 0.8 Mbps 4: 0.5 Mbps 5: 0.25 Mbps 6: 0.125 Mbps Set the encoder communication baud rate based on the actual communication rate supported by the encoder and actual cable length.
n4-87/n5-87/n6-87	SSI encoder configuration	Ones - Check mode: 0 [No check] 1 [Odd check] 2 [Even check] Tens - Encoder output code value 0 [Binary code] 1 [Gray code] Set the check mode and output code values according to the actual encoder nameplate information or manual.

Param.	Name	Description
n4-88/n5-88/n6-88	Number of SSI encoder status bits	Set the number of encoder status bits according to the actual encoder nameplate information or the manual.
n4-89/n5-89/n6-89	Single-turn bits of communication-type encoder	Set the single-turn bits of the encoder based on the actual encoder nameplate or the manual.
n4-90/n5-90/n6-90	Multi-turn bits of communication-type encoder	Set the multi-turn bits of the encoder based on the actual encoder nameplate or the manual.

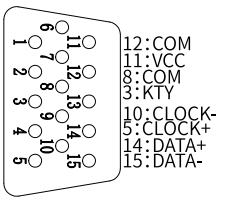
Note

The number of multi-turn bits and single-turn bits in SSI data must be lower than 32 bits. The maximum number of status bits is 8 bits.

8.4.2.6 ENDAT Encoder

8.4.2.6.1 Wiring of the Encoder

HPG-30 can be used for the ENDAT encoder. For the input terminals of the ENDAT signal, see the following table.

Name	Function	Pin No.	Terminal
CLOCK+	CLOCK signal of the ENDAT encoder (+)	5	HPG-30:X82 
COM	Encoder power supply ground	8, 12	
CLOCK -	CLOCK signal of the ENDAT encoder (-)	10	
VCC	Encoder power supply	11	
DATA+	DATA signal of the ENDAT encoder (+)	14	
DATA-	DATA signal of the ENDAT encoder (-)	15	

8.4.2.6.2 Basic Software Setting

Take d0-11 = 0 [Encoder detection module 1] as an example. For the ENDAT encoder, set as follows.

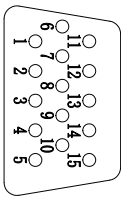
1. Setting the expansion slot: Set n4-00 to the correct expansion slot module based on the expansion slot connected to the PG card.
2. Setting the encoder type: Set n4-02 to 6 [ENDAT encoder].
3. Setting the ENDAT encoder communication baud rate: Set the clock frequency based on the encoder cable length. n4-92 [Communication-type encoder clock frequency] is set to 4 [5 Mbps] by default.
4. Setting the ENDAT encoder data format: Set the encoder parameters according to the actual data format of the encoder, including the single-turn bits and multi-turn bits. The following takes 13-bit single-turn resolution and 12-bit multi-turn resolution as example.
   Set n4-89 [Single-turn bits of the communication-type encoder] to 13 and n4-90 [Multi-turn bits of the communication-type encoder] to 12.

Param.	Name	Description
n4-00/n5-00/n6-00	Expansion slot selection	0: Disable 1: Expansion slot 1_1 2: Expansion slot 1_2 3: Expansion slot 1_3 4: Extension slot 2_1 5: Expansion slot 2_2 6: Expansion slot 2_3 7: Extension slot 3_1 Set this parameter based on the expansion slot connected to the PG card.
n4-02/n5-02/n6-02	Encoder type	6: ENDAT encoder Set this parameter to 6 based on the PG card connected actually.
n4-92/n5-92/n6-92	ENDAT encoder communication baud rate	1: 1 M 2: 2 M 3: 4 M 4: 5 M 5: 8 M 6: 10 M Set the encoder communication baud rate based on the actual communication rate supported by the encoder and actual cable length.
n4-89/n5-89/n6-89	Single-turn bits of communication-type encoder	Set the single-turn bits of the encoder based on the actual encoder nameplate or the manual.
n4-90/n5-90/n6-90	Multi-turn bits of communication-type encoder	Set the multi-turn bits of the encoder based on the actual encoder nameplate or the manual.

8.4.2.7 Sine-Cosine Encoder+ENDAT Encoder Setting

8.4.2.7.1 Wiring of the Encoder

HPG-30 can be used for the sin-cosine+ENDAT encoder. When the encoder type is selected as the sin-cosine+ENDAT encoder, only the sin-cosine signals and ENDAT signals without the Z signal are supported. For the input interface of the sin-cosine+ENDAT signals, see the following table.

Name	Function	Pin No.	Terminal
SIN-	SIN signal of the incremental encoder (-)	1	HPG-30:X82 
COS-	COS signal of the incremental encoder (-)	2	
CLOCK+	CLOCK signal of the ENDAT encoder (+)	5	
SIN+	SIN signal of the incremental encoder (+)	6	
COS+	COS signal of the incremental encoder (+)	7	
COM	Encoder power supply ground	8, 12	
CLOCK -	CLOCK signal of the ENDAT encoder (-)	10	
VCC	Encoder power supply	11	
COM	Encoder power supply ground	8, 12	
DATA+	DATA signal of the ENDAT encoder (+)	14	
DATA-	DATA signal of the ENDAT encoder (-)	15	

8.4.2.7.2 Basic Software Setting

In the following example, d0-11 is set to 0 [Encoder detection module 1]. For sine-cosine+ENDAT encoders, set as follows.

1. Setting the expansion slot: Set n4-00 to the correct expansion slot module based on the expansion slot connected to the PG card.
2. Setting the encoder type: Set n4-02 to 7 [Sine-cosine+ ENDAT encoders].
3. Setting the resolution (PPR) of the sine-cosine encoder: The nameplate of the encoder is marked with the number of pulses per revolution. If a 1024-PPR encoder is used, set n4-07 to 1024.
4. Setting the ENDAT encoder communication baud rate: Set the clock frequency based on the encoder cable length. n4-92 [Communication-type encoder clock frequency] is set to 4 [5 Mbps] by default.
5. Setting the ENDAT encoder data format: Set the encoder parameters according to the actual data format of the encoder, including the single-turn bits and multi-turn bits. The following takes 13-bit single-turn resolution and 12-bit multi-turn resolution as example.
   Set n4-89 [Single-turn bits of the communication-type encoder] to 13 and n4-90 [Multi-turn bits of the communication-type encoder] to 12.

After the preceding steps are done, n4-01 should indicate "Online", with the PG card indicator turned green.

Param.	Name	Description
n4-00/n5-00/n6-00	Expansion slot selection	0: Disable 1: Expansion slot 1_1 2: Expansion slot 1_2 3: Expansion slot 1_3 4: Extension slot 2_1 5: Expansion slot 2_2 6: Expansion slot 2_3 7: Extension slot 3_1 Set this parameter based on the expansion slot connected to the PG card.
n4-02/n5-02/n6-02	Encoder type	7: Sine-cosine+ENDAT encoders Set this parameter to 7 based on the PG card connected actually.
n4-07/n5-07/n6-07	Encoder resolution (pulses/ revolutions)	This parameter is marked on the nameplate of the encoder, indicating the number of pulses per revolution.
n4-92/n5-92/n6-92	ENDAT encoder communication baud rate	1: 1 M 2: 2 M 3: 4 M 4: 5 M 5: 8 M 6: 10 M Set the encoder communication baud rate based on the actual communication rate supported by the encoder and actual cable length.
n4-89/n5-89/n6-89	Single-turn bits of communication-type encoder	Set the single-turn bits of the encoder based on the actual encoder nameplate or the manual.
n4-90/n5-90/n6-90	Multi-turn bits of communication-type encoder	Set the multi-turn bits of the encoder based on the actual encoder nameplate or the manual.

8.4.2.7.3 Speed Measurement of Sine-cosine+ENDAT Encoder

The sine-cosine+ENDAT encoder supports speed measurement with sine/cosine signals and speed measurement with ENDAT absolute signals, which can be selected through n4-93/n5-93/n6-93. The sine-cosine signals are used for speed measurement by default. In addition, if the sine-cosine signal is disconnected, set n4-93/n5-93/n6-93 to 0 [Speed measurement with ENDAT signals] to ensure normal operation of the motor. If the ENDAT signal is disconnected, repair or replace the encoder.

Param.	Name	Description
n4-93/n5-93/n6-93	Speed measurement mode selection	0: Speed measurement with ENDAT signals 1: Speed measurement with sine-cosine signals Select a proper speed measurement mode based on the actual application conditions of the encoder.

8.4.2.7.4 Sine-Cosine+ENDAT Encoder Direction Setting

To ensure stable operation of the system, first ensure that the counting direction of the encoder signal is consistent with the motor operating direction. The correct direction of the encoder signal can be obtained through direction auto-tuning or manual setting.

- Parameters n4-03, n5-03, and n6-03 correspond to the directions of the ENDAT signal.
- Parameters n4-91/n5-91/n6-91 correspond to the directions of the sine/cosine signal.

[Auto-tuning direction]

If the motor can rotate freely, it is recommended to use no-load complete auto-tuning or no-load dynamic auto-tuning to auto-tune the signal direction of the sine-cosine+ENDAT encoder (set b5-00 to 2 [No-load complete auto-tuning] or 8 [No-load dynamic auto-tuning]). Accurate encoder direction can be auto-tuned through no-load complete auto-tuning or no-load dynamic auto-tuning.

[Manual direction setting]

If no-load complete auto-tuning is not possible, manually set the encoder direction.

Set the ENDAT signal direction:

1. Switch the control mode to SVC control, and set a speed of 1 rpm.
2. Enable the encoder and set the encoder speed measurement mode to [ENDAT signal speed measurement]. Set parameters n4-93/n5-93/n6-93 to 0 [ENDAT signal speed measurement].
3. Observe U9-00 [Actual motor speed] and U9-20 [Encoder feedback speed] through the oscilloscope in the software tool.

- If U9-00 and U9-20 are in the same direction, the ENDAT signal direction is correct.
- If U9-00 and U9-20 are in different directions, the ENDAT signal is reversed. In this case, you need to manually modify n4-03 to another value.
  - If the original setpoint is 0 [Forward], change it to 1 [Reverse].
  - If the original setpoint is 1 [Reverse], change it to 0 [Forward].

Set the sine-cosine signal direction.

1. Set the control mode to "SVC" and set a speed of 1 rpm.
2. Enable the encoder and set the encoder speed measurement mode to [Sine-cosine signal speed measurement]. Set parameters n4-93/n5-93/n6-93 to 1 [Sine-cosine signal speed measurement].
3. Observe U9-00 [Actual motor speed] and U9-20 [Encoder feedback speed] through the oscilloscope in the software tool. Check whether the directions of U9-00 and U9-20 are consistent, if not, change n4-91 to the correct value.

8.4.2.7.5 Selecting the Encoder for Speed Feedback and Position Feedback

d0-11 [Encoder speed feedback] can be used to select which encoder is used for speed control. The default value is 0 [Encoder detection module 1]. In this case, the corresponding encoder parameter group is group n4 - Encoder detection module 1 configuration. You can modify d0-11 to 1 [Encoder detection module 2]. In this case, the corresponding encoder parameter group is group n5 - Encoder

detection module 2 configuration. When you changing d0-11 to 2 [Encoder detection module 3], the corresponding encoder parameter group is group n6 - Encoder detection module 3 configuration.

O15-10 [Position detection feedback source] can be used to select which encoder signal is used for position control. The default value is 0 [Encoder in current motor group].

8.4.2.8 Parameter Setting Fault

8.4.2.8.1 Description

For the MD880 series drives, the control board communicates with the PG card through Inobus communication. Therefore, you can check whether the PG card is online through the communication protocol. Different faults or alarms can be reported in different parameter settings and control modes.

8.4.2.8.2 Speed Control Encoder

Take d0-11 = 0 [Encoder detection module 1] as an example. The encoder parameter group used for speed feedback is encoder detection module 1 in group n4.

- In the SVC or V/f control mode, no fault is reported.
- In FVC control mode:
  - When a PG card is not connected, if n4-00 is set to 0 [Disable], no fault can be reported. Otherwise, [E44.01 - Encoder detection module 1 activated but offline] can be reported.
  - When the encoder type is set improperly, the PG card connected does not support the encoder type set by n4-02. If PG10, PG40, or PG50 is connected, an incorrect encoder type can trigger [E44.01 - Encoder detection module 1 activated but offline]. If PG30 is connected and n4-02 set to an encoder type not supported by PG30 (n4-02 = 1, 2, or 3), the fault [E44.01 - Encoder detection module 1 activated but offline] can be reported. Otherwise, the corresponding encoder open circuit fault can be reported (when n4-02 is set to 7 [Sine-cosine+ENDAT encoder], the fault [E20.14 - Sine-cosine encoder open circuit (hardware detection) and [E20.15 - ENDAT encoder open circuit (hardware detection)] can be reported. For others, the fault [E20.01 - Encoder open circuit (hardware detection)] is reported).
  - When the encoder hardware is disconnected and n4-10 [Encoder hardware open circuit detection] is set to 1 [Enable], and the PG card connected actually matches the encoder type set by n4-02, a corresponding open circuit fault can be reported.
  - When the expansion slot is disabled (n4-00 = 0), the fault [E20.04 - Operating in FVC without encoder] can be reported if you try running the motor.

For detailed fault causes and solutions, see Chapter *14 Troubleshooting*.

8.4.2.8.3 Position Control Encoder

- When position control is not enabled, no fault is reported.
- When position is enabled and [Position detection feedback source] is set to [Custom], no fault can be reported.
- In the following example, position control is enabled and [Position detection feedback source] is set to [Encoder] (o15-10 = 1 [Encoder 1]).

- When a PG card is not connected, if n4-00 is set to 0 [Disable], no fault can be reported. Otherwise, [E44.01 - Encoder detection module 1 activated but offline] can be reported.
- When a wrong encoder type is set, the PG card connected actually does not support the encoder type defined by n4-02. If PG10, PG40, or PG50 is connected, an incorrect encoder type can trigger [E44.01 - Encoder detection module 1 activated but offline]. If PG30 is connected and n4-02 set to an encoder type not supported by PG30 (n4-02 = 1, 2, or 3), the fault [E44.01 - Encoder detection module 1 activated but offline] can be reported. Otherwise, the fault [E187.04 - Position feedback encoder open circuit] can be reported.
- When the encoder hardware is disconnected, the fault [E187.04 - Position feedback encoder open circuit] can be reported if n4-10 [Encoder hardware open circuit detection] is set to 1 [Enable] and the PG card connected actually matches the encoder type defined by n4-02.

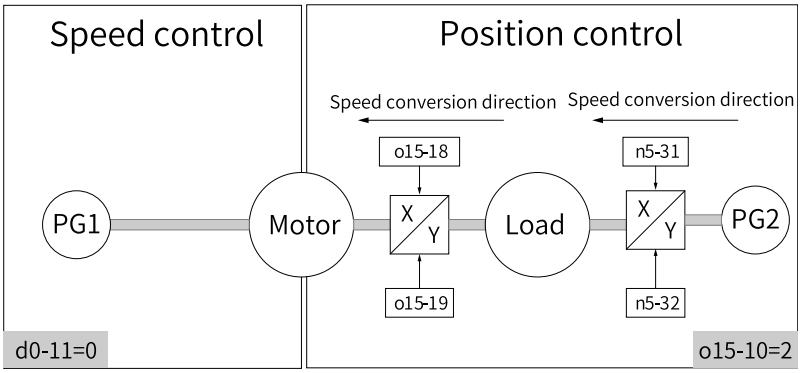
For detailed fault causes and solutions, see Chapter *14 Troubleshooting*.

8.4.3 Encoder Function

8.4.3.1 Transmission Ratio

A transmission ratio is allowed among the motor, encoder, and load. In position control, up to two encoder signals can be connected at the same time, both of which can be used for speed control or position control.

Take d0-11 = 0 and o15-10 = 2 as an example. In this case, encoder 1 (PG1) is used for speed control and encoder 2 (PG2) is used for position control. The following figure shows the speed conversion relationship.



The transmission ratio between the motor and the load is defined by o15-18 and o15-19. The speed ratio is shown in the following figure.

$$\frac{\text{Motor speed}}{\text{Load speed}}=\frac{\text{o15-18}}{\text{o15-19}}$$

n5-32 and n5-33 are used to define the transmission ratio between the load and encoder (encoder 2), as shown in the following figure.

$$\frac{\text{Load speed}}{\text{Encoder 2 speed}}=\frac{\text{n5-32}}{\text{n5-33}}$$

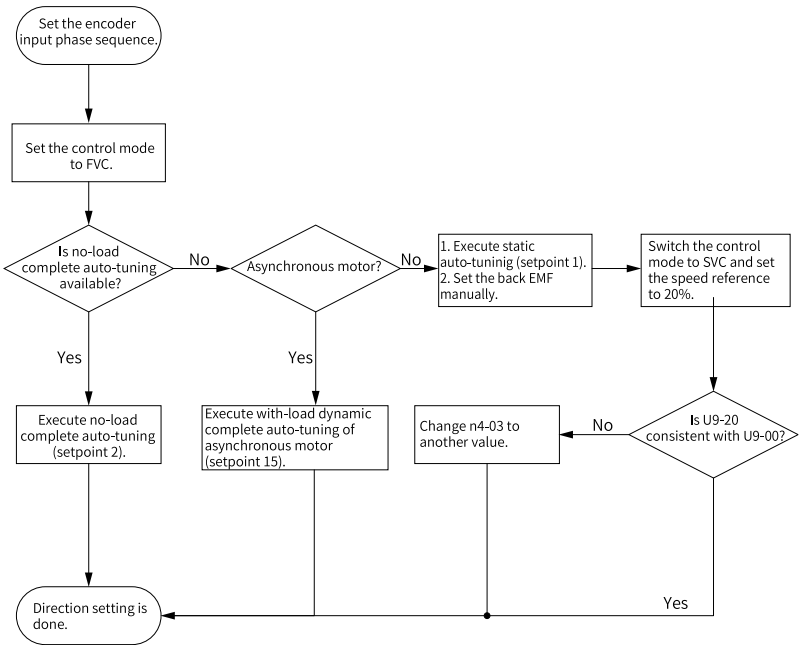
Param.	Name	Default	Value range	Description
n4-32/n5-32/ n6-32	Numerator of motor-to-encoder transmission ratio	1	1 to 65535	Defines the transmission ratio between the motor and encoder.
n4-33/n5-33/ n6-33	Denominator of motor-to-encoder transmission ratio	1	1 to 65535	Defines the transmission ratio between the motor and encoder.
o15-18	Nameplate method - Number of motor revolutions for motor-to-load ratio	1	1 to 65535	Defines the transmission ratio between the motor and load.
o15-19	Nameplate method - Number of load revolutions for motor-to-load ratio	1	1 to 65535	Defines the transmission ratio between the motor and load.

8.4.3.2 Input Phase Sequence of Encoder

Parameters n4-03/n5-03/n6-03 [Input A/B phase sequence] indicates whether the encoder speed and motor speed direction are consistent. If the parameter is set improperly, such a error where the motor rotate forwardly but the encoder speed is negative may occur.

Input phase sequence setting process

Take d0-11 = 0 [Encoder detection module 1] as an example. See the following flowchart for encoder direction setting.



Auto-tuning direction

If the motor can rotate freely without load, it is recommended to use the no-load complete auto-tuning function to auto-tune the encoder direction.

Before auto-tuning, set the control mode to FVC.

Asynchronous motor with-load auto-tuning direction

If an asynchronous motor is connected to the load, the encoder direction can be auto-tuned through complete with-load dynamic auto-tuning. For details on complete with-load dynamic auto-tuning, see *"3.10.2 Asynchronous Motor Parameter Auto-Tuning" on page 104*.

Before auto-tuning, set the control mode to FVC.

Manual direction setting

For synchronous motors, the correct encoder direction can be obtained through static auto-tuning +operation in SVC mode.

Step 1: Execute static auto-tuning.

Step 2: Consult the manufacturer for the back EMF value and set the motor back EMF manually.

Step 3: Switch the control mode to SVC and set a speed reference of 20%. Observe U9-00 [Actual motor speed] and U9-20 [Encoder feedback speed] through the oscilloscope in the software tool.

- If U9-00 and U9-20 are in the same direction, the encoder direction is correct.
- If U9-00 and U9-20 are in different directions, the encoder direction is reversed. In this case, you need to manually modify n4-03 to another value.
  - If the original setpoint is 0 [Forward], change it to 1 [Reverse].
  - If the original setpoint is 1 [Reverse], change it to 0 [Forward].

Note

- For a synchronous motor, the encoder rotation direction and accurate encoder mounting position angle must be known for operation in FVC mode. Otherwise, runaway accidents may occur. See detailed procedure in *"8.4.3.3 Synchronous Motor Angle Correction" on page 356*.
- For an asynchronous motor, only the encoder phase sequence needs to be known for operation in the FVC mode.
- The auto-tuning mentioned in the preceding procedure can be performed only when E0-00 [Control mode] is set to 1 [FVC (feedback vector control)].

Param.	Name	Default	Value range	Description
n4-03/n5-03	Input phase sequence of encoder	0	0: Forward 1: Reverse	Describes whether the encoder speed and motor speed directions are consistent.

8.4.3.3 Synchronous Motor Angle Correction

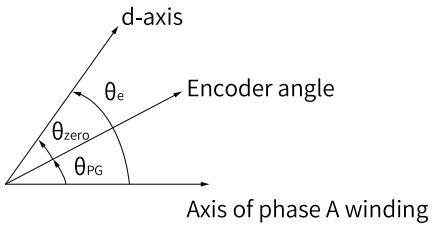
Description of encoder mounting position angle

When the synchronous motor adopts FVC mode, the drive controls the motor based on the accurate permanent magnet angle (d-axis). Therefore, the deviation between the encoder angle and

permanent magnet angle must be obtained through n4-12/n5-12/n6-12 [Encoder mounting position angle].

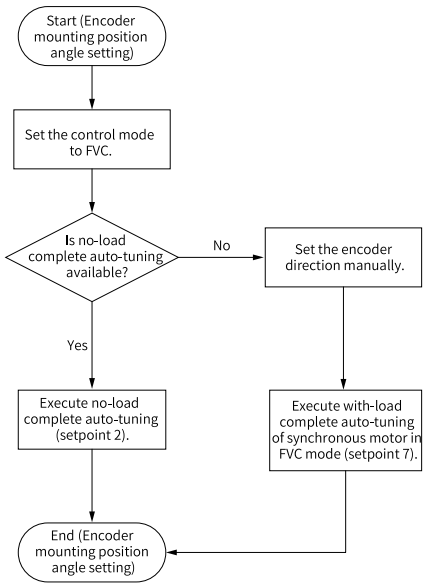
- For incremental encoders, the encoder mounting position angle represents the angle between the Z-phase signal and the A-phase winding axis.
- For incremental encoders, the encoder mounting position angle represents the angle between the encoder zero degree and A-phase winding axis of the motor.

The following figure shows the relationship among the encoder angle (θ_{PG}), d-axis angle (θ_e), the encoder mounting position angle (θ_{zero}), and the motor A-phase winding axis.



Method for getting the encoder mounting position angle

The encoder mounting position angle can be auto-tuned through n4-12/n5-12/n6-12.



- For motors that can rotate freely, it is recommended to perform no-load complete auto-tuning. The input signal phase sequence and mounting position angle of the encoder can be auto-tuned through this auto-tuning mode.
- If no-load complete auto-tuning is not available, you can manually set the encoder direction and perform with-load auto-tuning to get the encoder mounting position angle, as shown below.

  1. Get the accurate encoder input phase sequence through n4-03/n5-03 as described in *“8.4.3.2 Input Phase Sequence of Encoder” on page 355*.
  2. After getting the encoder phase sequence, perform with-load complete auto-tuning for synchronous motor in FVC mode to get the encoder mounting position angle.

Note

1. The encoder input phase sequence is not auto-tuned when the setpoint 7 [With-load complete auto-tuning of synchronous motor in FVC mode] applies. If an incorrect encoder phase sequence is used during with-load complete auto-tuning of synchronous motor in FVC mode, an incorrect encoder mounting position angle can be auto-tuned.
2. The synchronous motor must get an accurate encoder mounting position angle in FVC mode. Otherwise, runway may occur.
3. When a synchronous motor equipped with an incremental encoder (such as HT, TTL, or sine-cosine encoders) operates in FVC mode, Z signal must be provided to prevent operation failure. Runway accidents can occur without a Z signal.

Param.	Name	Default	Value range	Description
ne-12/n5-12/ n6-12	Encoder mounting position angle	0.0°	0.0° to 359.9°	Defines the difference between the encoder angle and permanent magnet angle.

8.4.3.4 Speed Measurement Fluctuation Caused by Improper Encoder Installation

High-performance applications (such as test benches) requires low fluctuation in the motor speed controlled by the drive. In this case, proper installation of the encoder is critical. Improper installation can affect system performance or even result in faults. Radial runout frequently occurs during encoder installation, which are further divided into the following three situations.

- Connection shaft not vertical to the end face: The connection shaft is not vertical to the encoder end face, leading to encoder shaft misalignment.
- Encoder connection shaft not aligned with motor shaft: The encoder shaft is not aligned with the motor shaft, leading to radial runout during operation.
- Manufacturing problems: For example, the motor bearing is damaged or the motor is severely unbalanced (rarely occurred).

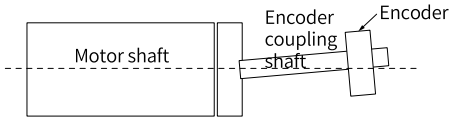


Figure 8-63 Connection shaft not vertical to end face

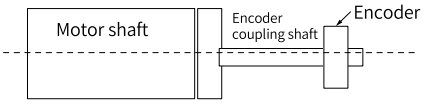


Figure 8-64 Encoder connection shaft not aligned with motor shaft

Problems caused by radial runout

The radial runout of the encoder can affect the system in the following aspects.

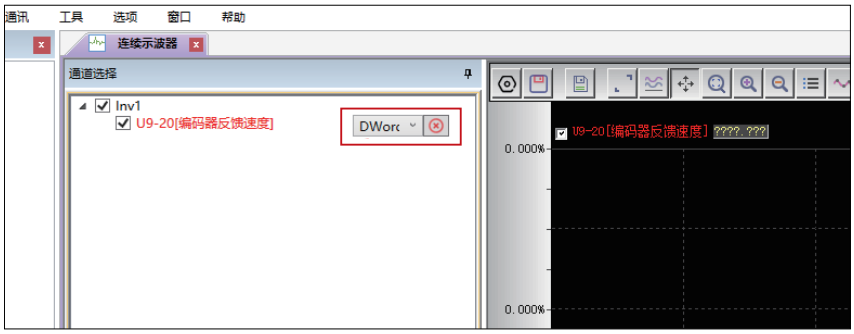
- Feedback speed fluctuation: Torque fluctuation and shock may occur, leading to unusual noise of the machine, which is especially true during high-speed operation. This can affect the service life of the machine.
- Control error: In high-speed operation with a high-gain speed loop, overcurrent and overvoltage may occur.
- Mechanical fatigue: The radial runout of the encoder increases the fatigue stress at the connection parts, leading to spring breakage on the encoder base or encoder coupling breakage.

Troubleshooting

Radial runout in the encoder shaft can result in encoder feedback speed jitter along with the mechanical frequency. You can use the following two methods to determine whether a fault occurs:

Method 1: Coast to stop

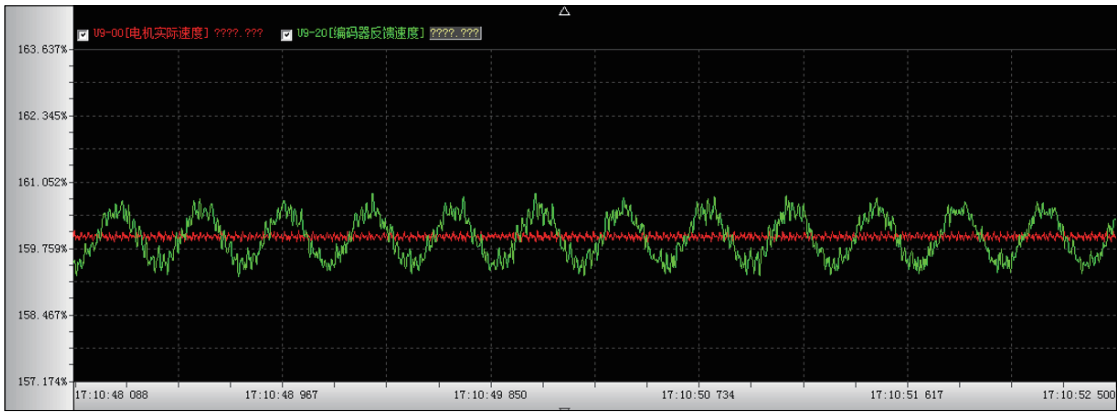
1. Select any control mode (such as V/f/SVC/FVC) and set the stop mode to coast-to-stop.
2. Start the motor and run it to a certain speed (for example, 50% of the rated speed).
3. Record the encoder feedback speed (U9-20) through the oscilloscope in the software tool. "Word" (16-bit) is displayed by default. Modify the channel property to "DWord" (32-bit) to improve the measurement accuracy.



4. Observe the waveform. After coast-to-stop, the feedback speed of the encoder can jitter along with the mechanical frequency. For example, if the operating frequency of the motor with two pairs of poles is 62.99 Hz, the mechanical frequency is 31.25 Hz. If the waveform shows that fluctuation that close to the mechanical frequency (such as 31.25 Hz) is present in the encoder speed feedback, the radial runout of the encoder is abnormal.

Method 2: Comparison between SVC speed and encoder speed

1. Set the control mode to SVC.
2. Observe the actual motor speed (U9-00) and feedback speed of the encoder (U9-20) through the oscilloscope in the software tool.
3. If U9-00 (Actual motor speed) is stable without fluctuation, but mechanical frequency fluctuation is present in U9-20 (Encoder feedback speed), the encoder is installed improperly.

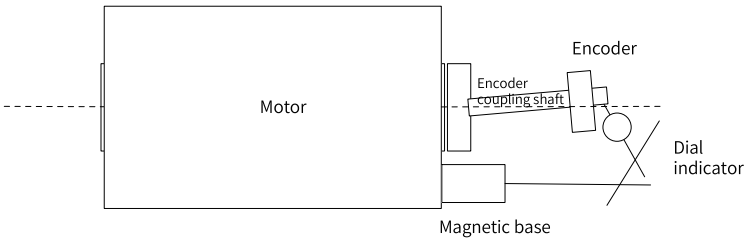


Encoder concentricity judgment

If you suspect that the encoder is installed improperly, you can calibrate the stand with a dial indicator to measure the radial runout of the encoder. See the following procedure.

1. Fix the dial indicator to the magnetic base and align the dial indicator head to the encoder shaft.
2. After zero calibration, rotate the motor shaft slowly to read the radial runout value of the encoder.
3. Acceptance criteria: The radial runout range of the encoder is lower than 0.03 mm. During operation in SVC mode, the encoder runs at the rated speed.

For applications requiring low speed fluctuation, install the encoder as required. For retrofit commissioning on site, measure and evaluate the radial runout value of the encoder to ensure installation quality.



Recommended method for installing the stand

The following measures are recommended to ensure system stability and reliability during encoder installation.

1. Coupling selection: Do not use rigid couplings. The rigid coupling may expose the encoder bearing to additional stress during operation, which increases the risk of damage. It is recommended to select a flexible coupling to reduce vibration and shock.
2. Reinforcement of the fixing screws: Install spring washers to the encoder fixing screws. The spring washers prevent loosening of screws due to vibration during operation, thus preventing the encoder from jitter and ensuring stable installation.
3. Avoid use of long shaft: Avoid using long shafts for the shaft system of the stand. In long shafts, the torsional stiffness decreases and the system deflection and vibration increases. When connected to the load, the shaft system may oscillate, affecting the overall control performance.

The above measures can effectively improve the installation quality of the encoder, reduce system faults caused by improper installation, and ensure stable operation of the equipment for a long time.

8.4.3.5 Encoder Slip

If the coupling between the motor and the encoder is not connected tightly, relative slip may occur between the encoder and the motor.

- For asynchronous motors, the motor can operate normally with slight slip.
- For synchronous motors, the mounting position angle of the encoder changes due to encoder slip. In this case, the load-carrying capacity of the motor is affected, and in severe cases, motor runaway may occur.

When you suspect that the encoder slips, you can verify whether the encoder slips by using the following two methods.

Method 1: Software method

You can check whether the encoder slips through encoder mounting angle auto-tuning again. This method is applicable to any operating condition.

See the procedure below.

1. First, record the current values of n4-12/n5-12/n6-12 [Encoder mounting bit position angle].
2. For motors without load and can rotate freely, perform no-load complete auto-tuning. For motors connected to a load, perform with-load complete auto-tuning in FVC mode to auto-tune the encoder mounting position angle again.
3. Compare the previously recorded encoder mounting position angle with the auto-tuned encoder mounting position angle. The deviation between them cannot exceed 20°. If the deviation exceeds 20°, the encoder slips.

Method 2: Physical method

The physical method applies when the encoder and motor are connected through a coupling and the encoder shaft is exposed. This method is not applicable when the motor is integrated into the encoder.

1. Draw a straight line among the encoder-coupling-motor axis.
2. Switch the control mode to SVC, start the motor, set a low speed such as 30%, and run for a period of time.
3. Stop the motor and observe whether the line drawn earlier is misaligned. If the line is misaligned, the encoder slips and needs to be re-tightened. After the encoder is tightened, auto-tune the zero point angle again. See the diagram below.

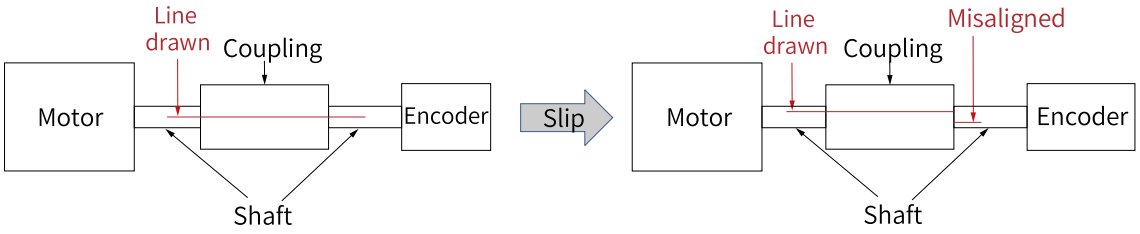
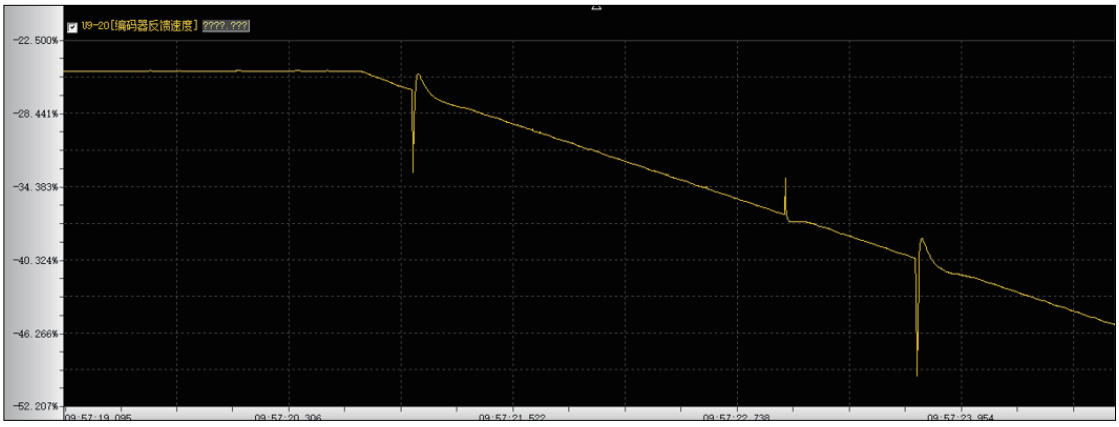


Figure 8-65 Encoder slip

8.4.3.6 Encoder Interference

The motor generates electromagnetic interference during operation, which can disturb encoder signals, incurring burrs in the angle or speed. The following figure shows the waveform of a disturbed encoder.



Interference source analysis

Common interference types and sources are as follows.

- Electrostatic interference: Indicates electrostatic discharge or high impedance circuit from the surface of the device.
- Magnetic field interference: Indicates electromagnetic field from the motor, AC drive, or power cable.
- High-frequency interference: Indicates radiation from external electromagnetic waves or reflection of signal lines.
- Low-frequency interference: Indicates inductive coupling or power supply noise from the signal cable.

Anti-interference measures

1. Selection and routing of signal cables

   - Twisted pair cables: Twisted pair cables are recommended. The signal cables are transmitted in pairs (including A+A-, B+B-, power supply+ and -, and Data+Data-) to reduce interference.
   - Shield: Use a braided shield with high shielding performance to enhance the shielding effect.
   - Cable thickness: The signal cable cannot be excessively thick. However, the 0 V power cable must be as thick as possible to form a high inter-conductor capacitance with the shield, dissipating high-frequency disturbing signals away from 0 V cables. Spare conductors can be that are not used in the cable can be combined into the 0 V cable. The recommended thickness ratio between the signal cable and power cable is 1:3.5. The cross sectional area of the signal cable and 0 V cable is 0.14 square meters and 0.5 square meters respectively.
   - Avoid winding: Keep the signal cable as straight as possible to prevent signal distortion caused by inductance characteristics.
   - Avoid re-connection of the separate cables: It is recommended to use only one cable from encoder signal generation to signal reception. The more the cable joints, the more the radiation sources, and the more signal burrs and distortion can be generated.
   - Avoid parallel power cables: Long encoder cables must be routed through special metal duct to avoid sharing the same duct with power cables. This is to prevent encoder signals from being disturbed by power cables.

2. Grounding and shielding

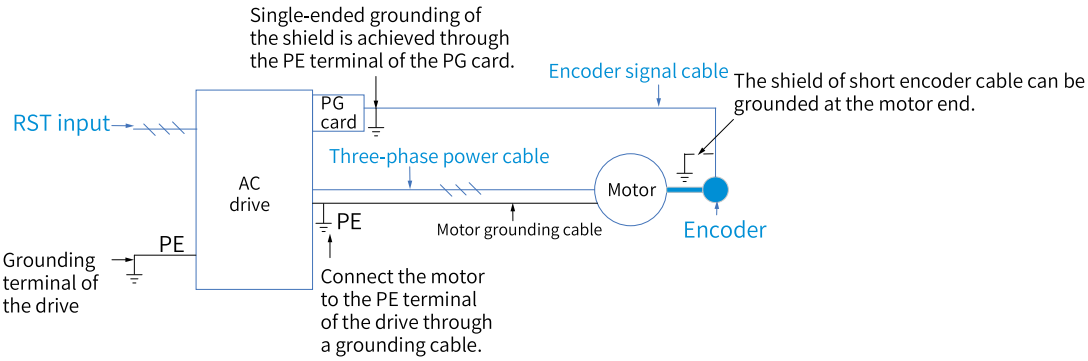
   Proper grounding and shielding is the key to reducing interference. A closed loop must be formed from the source to grounding of the encoder signal cable feedback.

   - Grounding of the drive: The drive must be connected to the grounding cable of the power supply through the PE terminal of the drive to ensure that the drive is grounded properly.
   - Grounding of the motor: The motor enclosure is connected to the PE terminal of the drive through the grounding cable to ensure that the motor is grounded properly.
   - Grounding of the encoder signal cable shield: Single-ended grounding and double-ended grounding are available for the shield.
     - Single-ended grounding: Indicates grounding at the PG card end of the drive only. When the encoder cable is long (50 m), it is recommended to perform single-ended grounding. In single-ended grounding, connect the encoder signal cable shield to the PE terminal of the PG card. If

the terminal is a DB interface, ensure that the cable shield is soldered to the metal housing of the DB terminal.

- Double-ended grounding: Indicates grounding at both ends of the drive and encoder. When the encoder cable is short, try double-ended grounding.

- Connection between 0 V of power supply and PE: Normally, the PE is not connected to 0 V of the power supply unless the PE signal is free from disturbance. After the PE is connected to 0 V of the power supply, the high-frequency signals of the filter can be absorbed by PE quickly, reducing encoder signal interference. Check whether the PE is connected to 0 V.
- Insulated shaft sleeve: The encoder with insulated shaft sleeve or rubber shaft sleeve can prevent shaft voltage interference.



Parameter filtering

If interference on the encoder speed feedback cannot be eliminated, in applications with low requirements on motor control performance, try increasing the filter time of the encoder feedback speed.

Param.	Name	Default	Value range	Description
n4-17/n5-17/n6-17	Filter time of encoder speed measurement	4.00 ms	0.00 ms to 100.00 ms	Defines the filter time for encoder speed feedback.

Note

Increasing the filter can seriously reduce the control performance of the drive. If the filter time is set to an excessively high value, oscillation may occur.

8.4.3.7 Encoder Open Circuit Detection and SVC Switchover

Encoder open circuit detected by hardware

The detection by hardware refers to the open circuit detection through the encoder card. All types of encoders support hardware open circuit detection.

When a hardware open circuit signal is detected and this signal lasts for the time defined by n4-11 [Hardware detection time for encoder open circuit], a fault [20-1 - Encoder open circuit (detected by hardware)] can be reported.

Param.	Name	Description	Default	Value range
n4-10/n5-10/n6-10	Detection on encoder open circuit by hardware	Used to enable encoder open circuit detection by hardware.	1	0: Disable 1: Enable
n4-11/n5-11/n6-11	Hardware detection time for encoder open circuit	Defines the time for detecting encoder open circuit by hardware. When the hardware open circuit signal keeps active for the time defined by n4-11, a hardware open circuit detection fault can be reported.	0.5s	0.001s to 10.000s

Encoder open circuit detected by software

Only the ABZ encoder supports open circuit detection by software. This function is not supported by other types of encoders. The open circuit detection by software is not enabled by default.

A detection threshold is set in the software, which can be adjusted through n4-21. If the software detects an error that exceeds the number of cycles set by n4-23 and software detection is enabled, a fault [20-5 - Encoder open circuit (detected by software)] can be reported.

Param.	Name	Description	Default	Value range
n4-20/n5-20/n6-20	Encoder open circuit detection by software	Used to enable the encoder open circuit detection by software.	0	0: Disable 1: Enable
n4-21/n5-21/n6-21	Coefficient for encoder signal error detection by software	Used to adjust the threshold.	100%	0.0% to 800.0%
n4-23/n5-23/n6-23	Threshold of encoder signal error count	Defines the number of cycles for fault detection.	5	1 to 100

Solutions to open circuit

You can set E8-50...E8-52 to define how the drive acts upon encoder open circuit.

- Open circuit judgment
  The encoder open circuit is handled in the same way as encoder faults. The following two types of encoder open circuit detection are available.
  - Open circuit detection by hardware
  - After n4-28 is enabled for ABZ encoders, the software detects open circuit.
- Logic for stop at encoder open circuit
  E8-50 defines the encoder fault handling mode. The stop mode defined by E8-51 applies by default. E8-51 is set to 0 [OFF2 stop] by default.

Setpoint of E8-51	Description	Action
0	OFF2 stop	Coast to stop upon fault
1	OFF3 stop	After the fault occurs, the drive stops according to the OFF1 stop mode defined by E1-27. If the OFF1 stop mode is not coast-to-stop, the drive switches from FVC to SVC mode and stops.
2	OFF1 stop	After the fault occurs, the drive stops according to the OFF3 stop mode defined by E1-29. If the OFF3 stop mode is not coast-to-stop, the drive switches from FVC to SVC mode and stops.

- Switching to SVC upon encoder open circuit
  When E8-50 is set to 1 [Alarm and continue operating in SVC mode], the drive switches from FVC to SVC upon encoder fault and continues operating. A fault is reported only after the drive receives a stop command or the operating speed is lower than E8-52.

  The value of E8-52 [Minimum operating speed upon encoder fault (SVC)] is 3% by default. When an encoder fault occurs, a fault can be reported if the operating frequency is lower than 3% after the drive switches from FVC mode to SVC mode. If E8-52 is set to 0%, the drive operates in SVC mode until receiving a stop command.

Caution

If the active load (E8-52) is set to 0%, the risk of operational divergence may occur.

Note

If E11-04 [Active switchover from FVC to SVC] is enabled, but the encoder is disconnected after the drive switches from FVC mode to SVC mode, the actions defined by E8-50 [Actions upon encoder fault] are not responded to no matter whether the disconnection is rectified or not.

Param.	Name	Description	Default	Value range
E8-50	Handling mode for encoder faults	Describes how the drive acts upon encoder open circuit. Coast-to-stop applies by default.	0	0: Stop as defined by E8-51 1: Alarm and continue operating in SVC mode Others: B connector
E8-51	Stop mode upon encoder fault	Describes the stop mode for switching to SVC.	0	0: OFF2 stop mode 1: OFF3 stop mode 2: OFF1 stop mode
E8-52	Minimum operating speed upon encoder fault (SVC)	Describes the minimum operating speed after switching to SVC mode.	3.0%	0.0% to 100.0%

8.4.3.8 Encoder Switching From FVC To SVC

If encoder signals are subject to unavoidable interference during high-speed operation, you can switch from FVC to SVC mode during high-speed operation and switch back to FVC mode at low-speed operation to prevent divergence during low-speed operation.

This function is disabled by default. It can be enabled by E11-04. You can adjust the speed of switching from FVC to SVC by setting E11-05 and E11-06.

Param.	Name	Description	Default	Value range
E11-04	Active switchover from FVC to SVC	Used to enable/disable active switchover from FVC to SVC.	0	0: Disable 1: Enable
E11-05	Frequency for switching from FVC to SVC actively	Defines the threshold for switching from FVC to SVC. When acceleration exceeds this frequency during low-speed operation, the control mode is switched to SVC.	25%	0.0% to 100.0%
E11-06	Frequency for switching from SVC to FVC actively	Defines the threshold for switching from SVC to FVC. When deceleration exceeds this frequency during high-speed operation, the control mode is switched to FVC.	15%	0.0% to 100.0%

8.5 Application Macro

8.5.1 Function of the Application Macro

For special applications, you can set application macro parameters to meet special needs, such as high dynamic response, flying start, high-inertia load, and high energy conservation. The application macro can greatly simplify the configuration process, improving the working efficiency.

8.5.2 Selecting the Application Macro

You can set the application macro needed through A8-42 and A8-43.

1. Set A8-42 [Application macro selection] to the application macro needed.
2. Set A8-43 [Application macro acknowledgment] to 1 [OK].
3. The active application macro is displayed in A8-44.

When multiple application macros are set, no error is reported and the selected application macro is active. In this case, A8-47 only displays the interface macro acknowledged last. If the same parameters are present in the application macro, the parameters in the macro activated last can be overwritten.

8.5.3 Definition of the Application Macro

The application macro can be configured with a set of parameters according to the application scenario. Application macros supported are "High dynamic response configuration", "Fan and water pump", and "High-inertia load", and "Electromagnetic coil".

8.5.3.1 High Dynamic Response Configuration

Application scenario

For applications requiring enhanced dynamic response, such as the test bench, set A8-42 to 1 [High dynamic response configuration].

- When the encoder is enabled, the macro optimizes the control performance by optimizing the speed measurement mode and reducing the filter time.
- Meanwhile, the system control performance is improved through enhancement in the speed loop, current loop, and feedforward control, thus improving the dynamic response of the system effectively.

Related parameters

Param.	Name	Default	Macro-configured value
C7-25	RFG input ramp enable	0 [Disable]	1 [Enable]
C7-26	RFG input ramp interval time	50 ms	100 ms
E4-02	Speed loop Kp in FVC mode	3	Regular ABZ encoder - 30 Sine-cosine encoder - 30 Resolver - 20 23-bit encoder - 20 SSI encoder - 20 ENDAT encoder - 20 Sine-cosine + ENDAT encoder - ENDAT speed measurement (n4/n5/n6-93 = 0) - 20 Sine-cosine + ENDAT encoder - Sine-cosine speed measurement (n4/n5/n6-93 = 1) - 30
E4-03	Speed loop Ti in FVC mode	500 ms	Regular ABZ encoder - 80 ms Sine-cosine encoder - 80 ms Resolver - 100 ms 23-bit encoder - 100 ms SSI encoder - 100 ms ENDAT encoder - 100 ms Sine-cosine + ENDAT encoder - ENDAT speed measurement (n4/n5/n6-93 = 0) - 100 ms Sine-cosine + ENDAT encoder - Sine-cosine speed measurement (n4/n5/n6-93 = 1) - 80 ms

Param.	Name	Default	Macro-configured value
E4-04	Speed loop Kp in SVC mode	3	10
E4-05	Speed loop Ti in SVC mode	500 ms	120 ms
E4-13	Correction coefficient for high frequency switchover of speed loop	50.0%	100.0%
E4-22	Acceleration torque source	0 [Disable]	1 [RFG feedforward]
E4-23	Feedforward torque coefficient	100%	100%
E4-41	Kp coefficient at zero speed	70.0%	30.0%
E5-04	Current loop proportional coefficient	50%	130%
E5-05	Integral coefficient of current loop	500%	130%
E8-04	Overspeed detection value	20.0%	5%
E8-05	Overspeed detection time	0.5s	0s
E8-41	Additional time of overspeed detection	0.05s	0.01s
E8-54	Synchronous motor runaway protection time in FVC mode	0.1s	0.05s
E8-55	Synchronous motor runaway protection threshold in FVC mode	50.0%	5.0%
E11-07	SVC speed estimation filter time	15 ms	10 ms
n4/n5/n6-04	Speed measurement mode	1 [Fundamental frequency]	Regular ABZ encoder - 2 [Fast speed measurement] Sine-cosine encoder - 1 [Fundamental frequency] Resolver - 1 [Fundamental frequency] Sine-Cosine + ENDAT encoder - Sine-cosine speed measurement (n4/n5/n6-93 = 1) - 1 [Fundamental frequency]

Param.	Name	Default	Macro-configured value
n4/n5/n6-17	Filter time of encoder speed measurement	4 ms	0 ms
n4/n5/n6-55	Additional speed filter of the encoder	0 ms	Regular ABZ encoder - 1 ms Sine-cosine encoder - 1 ms Resolver - 4 ms 23-bit encoder - 4 ms SSI encoder - 4 ms ENDAT encoder - 4 ms Sine-cosine + ENDAT encoder - ENDAT speed measurement (n4/n5/n6-93 = 0) - 4 ms Sine-cosine + ENDAT encoder - Sine-cosine speed measurement (n4/n5/n6-93 = 1) - 1 ms

8.5.3.2 Fan and Water Pump

Application scenario

When the MD880 is used in fans and water pumps, set A8-42 to 2 [Fan/Water pump].

- Flying start may needed in fan/water pump applications. After the application macro is enabled, the startup mode is set to flying start automatically (HSVM sampling card needed). If the preceding configurations are not available, try setting E10-37 [Flying start of synchronous motor] to 1 [Model method] and set the stop mode to coast-to-stop.
- To reduce the fault rate, enable the following functions after enabling fan/water pump application macro.

  1. To prevent overvoltage caused by high inertia during deceleration, enable overvoltage suppression function.
  2. To prevent undervoltage after grid power failure, enable undervoltage suppression function to improve the resistance to power dip.
  3. Enable automatic restart upon fault.

- To improve the voltage output capability, enable overmodulation and increase the overmodulation coefficient.

Related parameters

Param.	Name	Default	Macro-configured value
A4-07	PWM modulation mode	0 [No overmodulation]	1 [Overmodulation]
A4-32	Overmodulation depth	103.0%	107.0%
C7-12	Ramp 1 start arc	0.0s	0.5s
C7-13	Ramp 1 end arc	0.0s	0.5s
C7-28	RFG tracking function	0 [Disable]	1 [Enable]
C7-29	Ramp tracking error setting	10.0%	3.0%

Param.	Name	Default	Macro-configured value
d0-08	Maximum current	150.0%	120.0%
E0-00	Control mode	2 [V/f]	0 [SVC]
E1-00	Startup mode	0 [Direct start]	1 [Flying start]
E1-14	OFF1 stop mode	1 [Decelerate to stop]	0 [Coast to stop]
E4-04	Speed loop Kp in SVC mode	3	12
E4-05	Speed loop Ti in SVC mode	500 ms	2000 ms
E6-06	Efficiency optimization	0 [Inhibited]	1 [Enable]
E9-01	VDC_max control switch in vector control	0 [Inhibited]	1 [Enable]
E9-03	VDC_min control switch in vector control	0 [Inhibited]	1 [Enable]
H0-07	Automatic fault reset	0 [Inactive]	1 [Active]
H0-08	Time for resetting the number of fault resets	180.0s	600.0s
H0-09	Automatic fault reset interval	30.0s	10.0s
H0-10	Number of fault resets	5	3
H0-19	Restart after automatic reset	0 [Inactive]	1 [Active]
H0-27	Startup mode after automatic reset	0 [Normal]	1 [Flying start]

8.5.3.3 High-Inertia Load

Application scenario

When the MD880 series drive is used in high-inertia applications, set A8-42 to 3 [High-inertia load].

- For high-inertia equipment, overvoltage may easily occur upon speed fluctuation. This application macro enables overvoltage suppression by default to suppress excessive speed fluctuation and prevent overvoltage during operation.
- For high-inertia loads, you can perform inertia auto-tuning if possible. This application macro enables inertia feedforward. You can enable RFG input ramp function to allow continuous feedforward, reducing speed loop overshoot effectively.

Related parameters

Param.	Name	Default	Macro-configured value
A4-07	PWM modulation mode	0 [No overmodulation]	1 [Overmodulation]
A4-32	Overmodulation depth	103.0%	105.0%
C7-12	Ramp 1 start arc	0.0s	0.5s
C7-13	Ramp 1 end arc	0.0s	0.5s
C7-25	RFG input ramp enable	0 [Disable]	1 [Enable]
C7-26	RFG input ramp interval	50 ms	100 ms

Param.	Name	Default	Macro-configured value
n4/n5/n6-17	Filter time of encoder speed measurement	4 ms	10 ms
E4-02	Speed loop Kp in FVC mode	3	12
E4-03	Speed loop Ti in FVC mode	500 ms	1000 ms
E4-04	Speed loop Kp in SVC mode	3	12
E4-05	Speed loop Ti in SVC mode	500 ms	1000 ms
E4-22	Acceleration torque source	0 [Disable]	1 [RFG feedforward]
E4-23	Feedforward torque coefficient	0	100%
E9-01	VDC_max control switch in vector control	0 [Inhibited]	1 [Enabled]

8.5.3.4 Electromagnetic Coil

Application scenario

When the application scenario is electromagnetic coil, set A8-42 to 4 [Electromagnetic coil].

The startup time at zero speed during SVC startup is too long, which may result in zero-speed divergence. This application macro is used to enable coil I/F control.

Related parameters

Param.	Name	Default	Macro-configured value
A4-09	Dead zone compensation enable	1 [Enable]	0 [Inhibited]
C0-00	Main reference selection in speed control	0 [0]	1 [Multi-reference value 1]
d0-00	Motor type	0 [Induction motor]	5 [Electromagnetic coil]
E0-00	Control mode	2 [V/f]	0 [SVC]
E3-60	Coil I/F control enable	0 [Inhibited]	1 [Enable]
E11-12	Frequency threshold for exiting speed open loop control in SVC	2.5%	100.0%
E11-39	Magnetic pole position auto-tuning upon start of synchronous motor in SVC mode	2 [Detected every time before start]	0 [Disable]

8.6 Position Control

8.6.1 Function Overview

Position control enables fast and accurate positioning of the load axes. The position control function can be configured flexibly for asynchronous/synchronous motors to drive rotary axes or linear axes. Both incremental positioning and absolute positioning are supported.

It is recommended to commission the position control function through InoDriveStudio, which allows parameter setting, commissioning, and status monitoring.

Similar to torque control and speed control, the position control function is mainly used to control the position of the motor axis or load axis. The drive controls the movement of the transmission device in accordance with the position reference. The position control function consists of the following parts.

- Positioning control
- Synchronous control
- Position controller
- Homing
- Multi-position reference
- Limit function

The logic block diagram of position control is as follows.

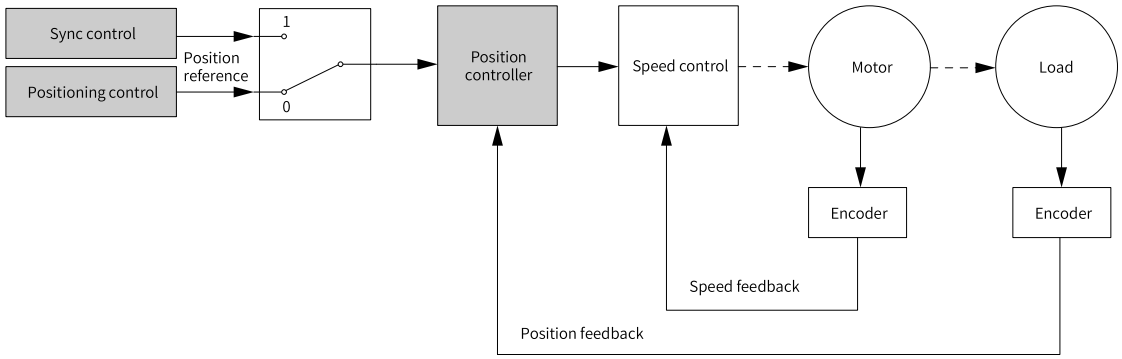


Figure 8-66 Logic block diagram of position control

8.6.2 Positioning Control

During positioning control, the controller receives a position reference or encoder pulse and generates a real-time motion curve based on the limits of acceleration/deceleration time and limit speed, making the motor axis follow the position curve and the load reach the target position.

The positioning function is activated after o15-01 is set to 1 and o15-03 is set to 0.

According to the actual application, positioning control is further divided into linear axis and rotary axis, which can be selected through o15-05.

Linear axis means that the load generally moves back and forth linearly, such as the lifting platform. The following figure is the schematic diagram of the linear axis positioning control.

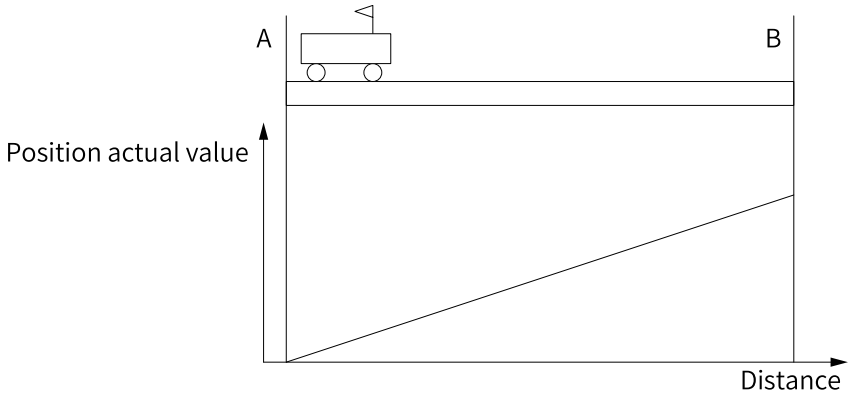


Figure 8-67 Linear axis positioning control

Rotary axis means that the load generally moves back and forth circularly, such as the rotary table. The setting range of rotary axis can be set through o15-06. *"Figure 8-68 Rotary axis positioning control" on page 373* shows the schematic diagram of rotary axis positioning control.

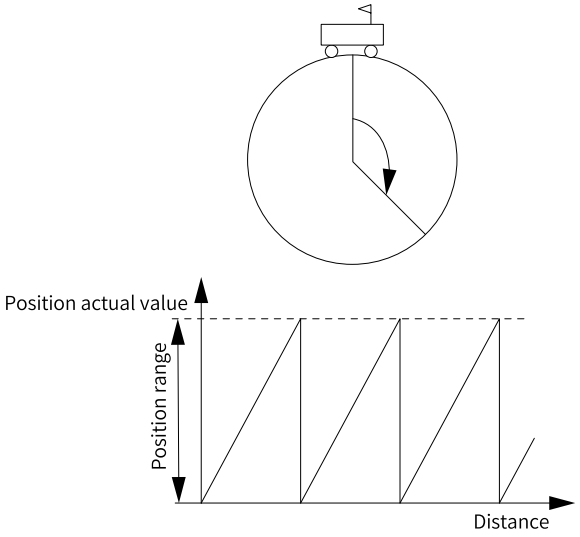


Figure 8-68 Rotary axis positioning control

The following figure shows the flowchart of positioning function commissioning.

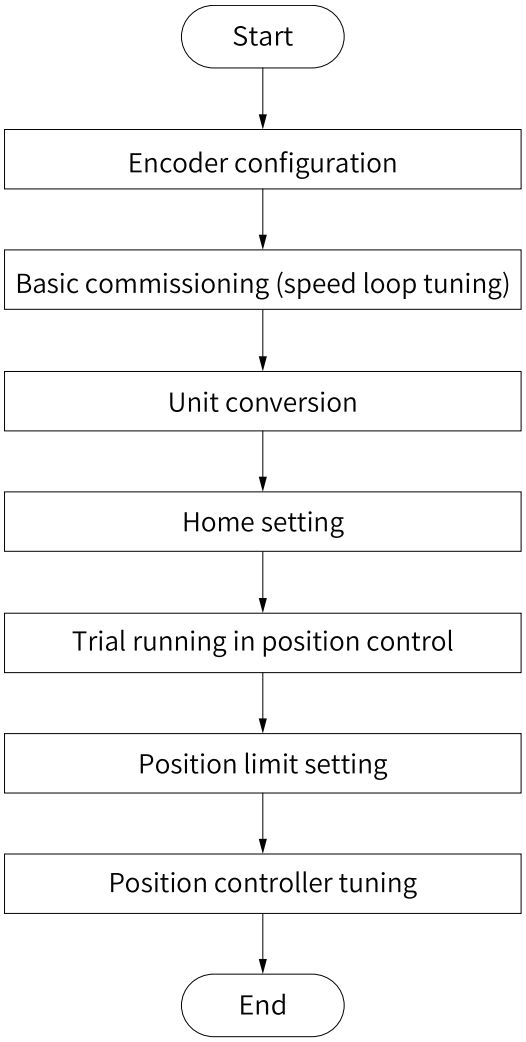


Figure 8-69 Positioning function commissioning flowchart

Table 8–1 Parameters related to activation of position control

Parameter	Name	Reference	Remarks
o15-01	Enable position control	0: Disabled 1: Enabled 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: DIL 9: HDI1 10: HDI2 Others: B connector	-
o15-02	Position control pause source	0: Disabled 1: Reserved 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: DIL 9: HDI1 10: HDI2 Others: B connector	-
o15-03	Position control type	0: Positioning control 1: Synchronization control Others: B connector	-
o15-05	Position control load axis type	0: Linear axis 1: Rotary axis	-
o15-06	Rotary axis position range setting	1 to 2147483647	-

8.6.3 Configuring the Encoder

The dynamic response and control accuracy of position control is subject to the speed loop and current loop of the inner loop. The best control performance can be provided only when the inner loop is tuned to the optimum and the feedback vector control mode is used (E0-00 = 1). The dynamic response and accuracy can be reduced in SVC mode (E0-00 = 0) or V/f mode (E0-00 = 2) in position control.

Position control must be implemented with an encoder. The HCU-50S/51S controller supports up to three encoder detection modules at the same time. You can set the three encoders through

parameters in groups n4, n5, and n6 respectively. The following table shows the encoder types supported in position control.

Table 8–2 Encoder types supported in position control

Encoder type	Encoder detection module model	Remarks
HTL level incremental encoder	HPG-10	-
Sine-cosine incremental encoder	HPG-30	-
Inovance 23-bit optical encoder	HPG-30	-
EnData2.2 bidirectional-interface absolute encoder	HPG-30	-
SSI serial-interface absolute encoder	HPG-30	-
Resolver	HPG-40	-
TTL level incremental encoder	HPG-50	-

- For an ABZ incremental encoder, you can set the encoder pulses per revolution through n4-07 [Encoder resolution (pulses/revolution)]. When the motor is connected coaxially with the encoder, the position value per rotation of the motor corresponds to the quadruple frequency of the encoder pulses per revolution. For example, for a 2500-PPR encoder, the position value increases by 10000 per revolution in the forward direction.
- For Inovance motors equipped with 23-bit optical encoder, you can set the matching communication protocol through n4-84 [23-bit encoder communication protocol]. When the motor is connected coaxially to the encoder, the corresponding position value per revolution is 2^23.
- For a resolver, if n4-15 [Number of pole pairs of the resolver] is set to 1, the position value per revolution increases by 4096 by default. If the number of resolver pole pairs is not 1, the position value per revolution increases by 4096 x number of pole pairs.
- For absolute encoders, you can set n4-89 [Single-turn bits of communication encoder] and n4-90 [Multi-turn bits of communication-type encoder]. If the number of single-turn bits is set to 12, when the motor is connected coaxially to the encoder, the corresponding position value per revolution is 2^12.

Note

Before commissioning the positioning function, run the drive in the speed control mode first to check whether the absolute position value (U29-00) increases during forward run and decreases during reverse run. If not, you can modify parameters n4/5/6-19.

The MD880 series drive supports fully closed-loop position control and up to three encoder detection modules. The logic diagram of fully closed-loop position control is as follows.

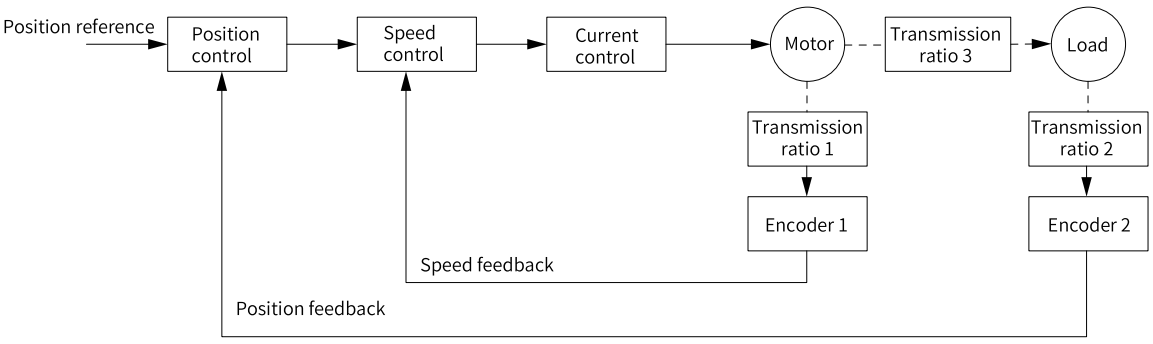


Figure 8-70 Fully closed-loop position control

The two encoders for fully closed-loop position control provide speed feedback and position feedback respectively. Their feedback sources can be configured through the following parameters.

Table 8–3 Speed feedback and position feedback parameters

Param.	Name	Setpoint	Remarks
d0-11	Speed feedback selection	0: Encoder detection module 1 1: Encoder detection module 2 2: Encoder detection module 3	-
o15-10	Position detection feedback source	0: Encoder of the current motor group 1: Encoder 1 2: Encoder 2 3: Encoder 3 4: Custom	-
o15-11	Custom position feedback source	0: 0 Others: K connector	-
o15-12	Numerator of custom feedback conversion coefficient	1 LU to 2147483647 LU	-
o15-13	Denominator of custom feedback conversion coefficient	1 to 2147483647	-

When the position feedback value is sent by the host controller through communication, o15-10 [Position feedback source] can be set to 4 [Custom]. When neither o15-20 [Position feedback average filter time] nor o15-21 [Position feedback first-order filter time] is set to 0, the position feedback value will be filtered.

8.6.4 Unit Calibration

The units of position reference and feedback position may be different in different application scenarios, and may be different even in the same application scenario. Therefore, unify the unit of the reference value and feedback value before activating position control so that the positioning system can operate normally. The following figure shows the logic diagram of position control dimension conversion, which contains the calibration relationship among the user-defined reference unit (UU) of the host controller, internal logical operation unit (LU) of position control, and the load position feedback unit (FU).

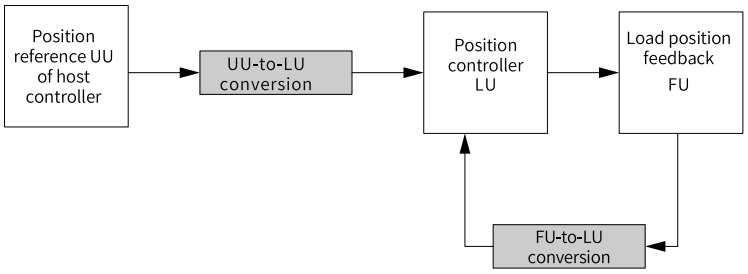


Figure 8-71 Logic diagram of position control unit conversion

Note

- User-defined reference unit (UU): Indicates the unit of the position references that sent from the host controller.
- Position feedback unit (FU): Indicates the unit of load position feedback.
- Internal logical operation unit (LU): Indicates the unit specified for internal calculation of the controller.

Therefore, when applying position control, check the positioning accuracy needed, the reference unit (UU) sent by the host controller, and the position feedback unit (FU).

Based on the above information, determine the logical unit (LU) for internal calculation by the controller. LU can be 1 p, 1 mm, or 0.1°.

Here is an example of the unit calibration.

1. In a linear axis application, the accuracy required is about 1 mm, the motor-to-load ratio is 1:1, a 2500-PPR encoder is used for position feedback, and 1 pulse (1 p) represents 0.01 mm. In addition, the unit sent by the user is 1 m.
2. Based on the preceding information, it can be determined that UU is 1 m, LU is 1 mm, and FU is 1 p.
3. Confirm the ratio of UU to LU. That is, 1 UU = 1000 LU. When the host controller sends 1 UU, the position set internally is 1000 LU. The setpoints of the related parameters are shown in the following table.

Table 8–4 UU -> LU conversion parameters

Param.	Name	Unit	Remarks
o17-05	Numerator of reference unit conversion factor	LU	Fill in 1000 based on the preceding example.
o17-06	Denominator of reference unit conversion factor	UU	Fill in 1 based on the preceding example.

4. Confirm the ratio between the position feedback unit (FU) and the internal logical operation unit (LU). Two methods are provided for calibrating the position feedback: incremental calibration and nameplate calibration, both of which support position feedback calibration in any positioning modes. When the on-site transmission ratio is unclear or high accuracy is required and the drive mechanism can move, it is recommended to use incremental calibration. During commissioning, the load can be moved manually for a certain distance and the ratio of FU to LU can be obtained by averaging results of several tests. Parameters related to incremental calibration are as follows.

Table 8–5 FU→LU incremental calibration parameters

Param.	Name	Unit	Remarks
o15-14	Position feedback calibration method selection	-	Select "0: Incremental calibration method".
o15-15	Incremental calibration - Operating distance increment on the load side	LU	Fill in 1 based on the preceding example.
o15-16	Incremental calibration - Position feedback encoder pulse increment	-	Fill in 100 based on the preceding example.

When the drive mechanism on site cannot move, you can use nameplate calibration based on available information. Parameters related to nameplate calibration are as follows.

Table 8–6 FU-> LU nameplate calibration parameters

Param.	Name	Unit	Remarks
o15-14	Position feedback calibration method selection	-	Select "1: Nameplate calibration method".
o15-17	Nameplate calibration - LU/ Revolution setting on the load side	LU	Fill in 100 based on the preceding example.
o15-18	Nameplate calibration - Motor speed in motor-to-load ratio	-	Fill in 1 based on the preceding example.
o15-19	Nameplate calibration - Load speed in motor-to-load ratio	-	Fill in 1 based on the preceding example.

5. Unit calibration is done.

Note

A high position control accuracy requires a high resolution of LU. However, the resolution of LU cannot exceed the resolution of FU. For example, 1 pulse (1p) of the encoder corresponds to 0.1 mm of linear operation of the load, that is, FU = 0.1 mm. In this case, the LU setting range must be greater than or equal to 0.1 mm.

8.6.5 Homing

After the drive is powered on again, execute homing once before starting positioning. Otherwise, when the positioning start command is triggered, o17-00 (Valid state of positioner) alerts "5: Home invalid".

After the homing command is triggered, set the current position as the home through parameter to let the motor search for the home actively. Parameter o19-03 (homing type) has four options.

- Current position as the reference point
- Current position as reference point (position control not required)
- Proximity switch 1 as the reference point
- Proximity switch 2 as the reference point

- When the current position is used as the reference point, the motor does not rotate. As long as the homing command is triggered, current position is used as the home immediately, The source and reference of the current position are determined by o19-03 (Source of current position) and o19-04 (Digital reference of current position).

- When proximity switches 1 or 2 is used as the reference point, the motor runs and returns to the home actively, which usually involves use of mechanical switches such as proximity switches or photoelectric sensors. Because the motor runs in this case, you must set the limit switches at both ends properly to prevent the motor from running beyond the limit and crashing the mechanical devices. The homing operation is executed in three steps.

  1. The motor starts to run in the direction defined by o19-02 (Homing direction) and follows the set motion profile defined by o19-15...o19-18 to search for the home switch signal.
  2. When the switch signal is detected, the position where the switch signal is detected will be recorded and the deceleration process starts. The source and activation mode of the switch signals can be set through o19-06 and o19-07 or o19-10 and o19-11.
  3. After the motor decelerates to 0, positioning is triggered once, with the home position detected in step 2 used as the target position. After reaching the home position, change the current absolute position to the position reference defined by o19-09 or o19-13. Homing is done now.

The schematic diagram of home position deviation compensation is shown below.

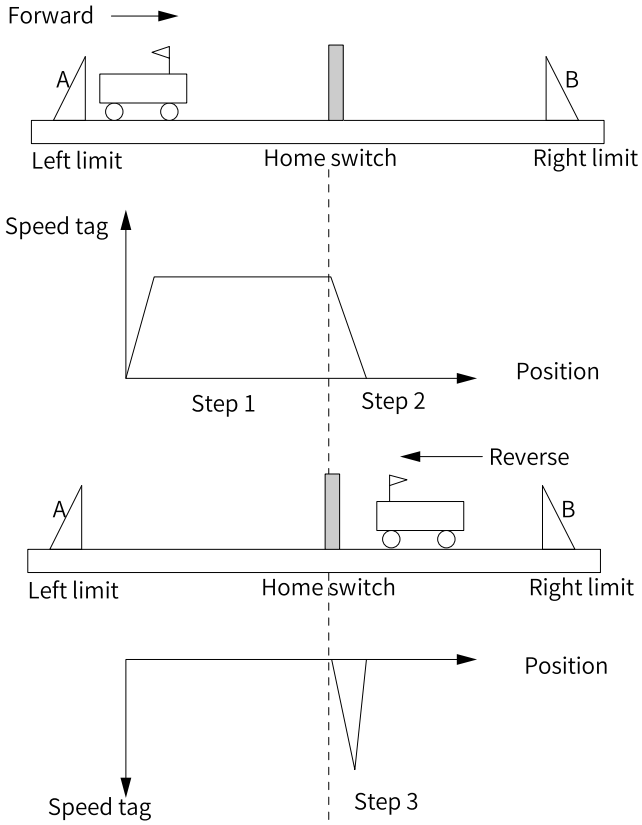


Figure 8-72 Homing diagram

After homing is completed, the bit connector U20-22 (position control home active) flag bit will be set to 1 and U29-00 (current absolute position value) will be changed to the home position reference. When the homing execution time exceeds the time set by o19-21 (home search timeout), a fault indicating home-searching timeout can be reported.

Cumulative position deviation during long-term operation can be corrected by the home switch because the position of the home switch is definite. The related parameters are o19-22 to o19-25.

Table 8–7 Home position correction parameters

Param.	Name	Unit	Remarks
o19-22	Position correction activation	-	-
o19-23	Minimum value of position deviation correction	UU	-
o19-24	Maximum value of position deviation correction	UU	-
o19-25	Position correction linear change time	ms	-

The schematic diagram of home position deviation compensation is shown below.

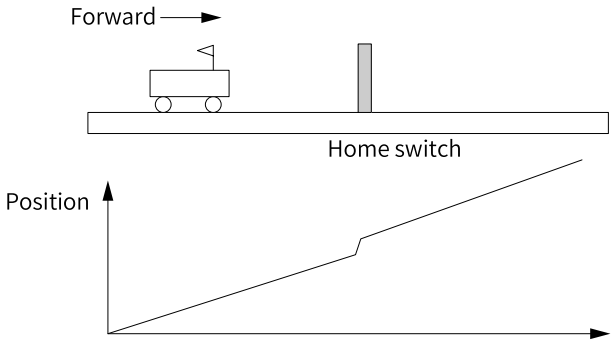


Figure 8-73 Home position deviation compensation

If the motor position does not change upon power-off, the drive can record the absolute value of current position through the home retention function. After the drive is powered on again, it directly reads the absolute position value recorded upon the last power failure to ensure that the home is valid.

8.6.6 Position Reference

The positioner reference channels include main reference and auxiliary reference. The final position reference is determined by the sum of these two references. The main reference source is set by o17-01, which provide options include multi-position references and custom references. Multi-position references refer to optional internal position references of the controller. Custom references refer to references set through external communication.

8.6.6.1 Multi-Position Reference

When o17-01 is set to 0 [Multi-position reference], the positioning control reference source is the active multi-position reference.

The controller provides 32 multi-position references, the value and property of which can be set through parameter group o18. You can also set the execution mode through o18-02 [Multi-position operation mode].

- Fixed (defined by o18-03)
- Multi-position switchover (defined by o18-17 to o18-21)
- Individual sequential operation (defined by o18-04 and o18-05)
- Cyclic operation (defined by o18-04 and o18-05)

Table 8–8 Multi-position reference parameters

Parameter	Name	Reference	Remarks
o18-02	Multi-position operation mode	0: Fixed [Digital reference of multi-position reference] 1: Multi-position switchover 2: Individual sequential operation 3. Cyclic operation	0: Fixed (defined by o18-03) 1: Multi-position switchover (defined by o18-17 to o18-21) 2: Individual sequential operation (defined by o18-04 and o18-05) 3: Cyclic operation (defined by o18-04 and o18-05)
o18-03	Digital setting of multi-position reference	1 to 32	-
o18-04	Start position of multi-position reference	1 to 32	-
o18-05	End position of multi-position reference	1 to 32	-
o18-06	Multi-position operation recovery	0: Continue to execute unfinished segments 1: Start from the starting segment	-
o18-17	Multi-position selection input 1	0: Disabled 1: Enabled Others: B connector	-
o18-18	Multi-position selection input 2		-
o18-19	Multi-position selection input 3		-
o18-20	Multi-position selection input 4		-
o18-21	Multi-position selection input 5		-

Parameter	Name	Reference	Remarks
o18-22 to o18-84	Multi-position references 1 to 32	-2147483648 to +2147483647	-
o18-23 to o18-85	Property of multi-position references 1 to 32	Ones: Acceleration/ Deceleration time 0: Positioner acceleration/ deceleration time 1 1: Positioner acceleration/ deceleration time 2 2: Positioner acceleration/ deceleration time 3 3: Positioner acceleration/ deceleration time 4 Tens: Forward/Reverse speed limit 0: Positioner forward/reverse speed limit 1 1: Positioner forward/reverse speed limit 2 2: Positioner forward/reverse speed limit 3 3: Positioner forward/reverse speed limit 4 Hundreds: Waiting time for positioning completion 0: No waiting 1: Waiting time 1 for positioning completion 2: Waiting time 2 for positioning completion 3: Waiting time 3 for positioning completion 4: Waiting time 4 for positioning completion Thousands: Positioner command output filter time 0: No filter 1: Filter time 1 2: Filter time 2 3: Filter time 3 4: Filter time 4 Ten thousands: Travel type 0: Absolute 1: Incremental	-

Positioner property parameters, such as the acceleration/deceleration time and FWD/REV speed limit, can affect the operation characteristics of the positioner. By default, the controller executes positioning control according to the following curves.

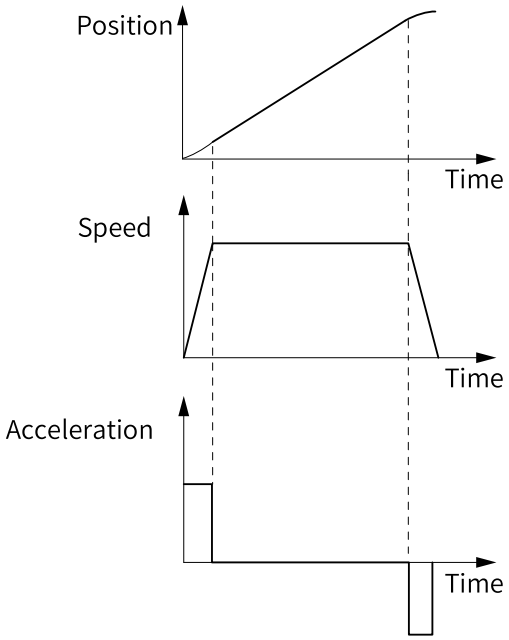


Figure 8-74 Position-speed-acceleration curves in positioning control

The current positioning control curve contains the acceleration section, constant speed section, and deceleration section. The acceleration time of the positioner indicates the time taken for accelerating from 0% to 100%, which affects the acceleration in motion. Similarly, the deceleration time of the positioner indicates the time taken for decelerating from 100% to 0%. The following figure shows the impact of positioning acceleration/deceleration time on the curve under the same position reference.

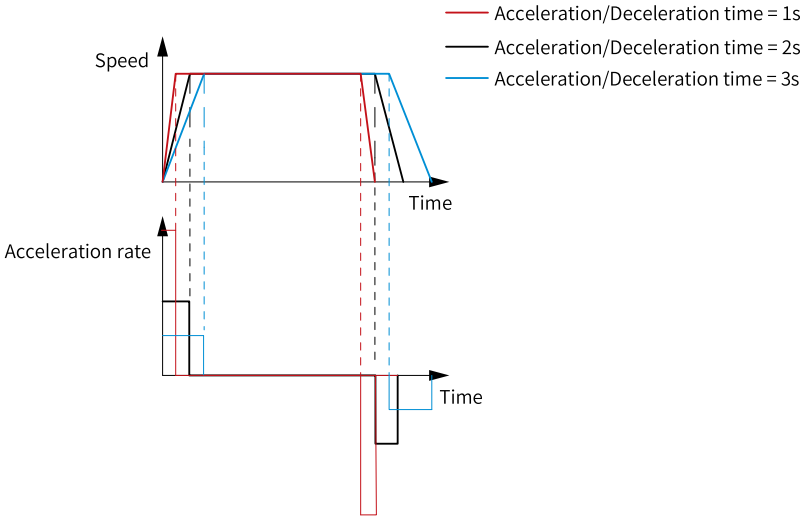


Figure 8-75 Impact of positioning acceleration/deceleration time on the curve

The positive/negative speed limit of the positioner indicates the maximum speed reached after the acceleration phase, and such a speed is used as the constant speed for subsequent operation. Note that o17-15 [Curve profile limit speed margin] is set to 3% by default, that is, when the positive limit is 100%, the active positive speed limit is 97% (100% - 3%). The following figure shows the impact of the FWD/REV speed limit on the curve under the same position reference.

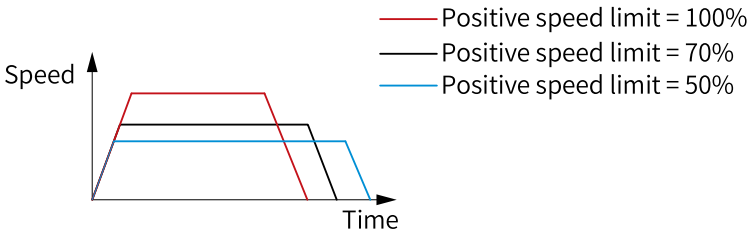


Figure 8-76 Impact of the positive/negative speed limit on the curve

The waiting time for positioning completion refers to the interval for starting the next section of positioning after the completion of an individual sequential operation or an individual section in cyclic operation. During the waiting period, the flag bit of U2-06 [Waiting for positioning completion] can be set. After the waiting time elapses, the flag bit of U2-06 [Waiting for positioning completion] can be cleared and the flag bit of U20-04 [Positioning completed] can be set.

The positioner reference output filter time indicates the first-order low-pass filter time of the position reference. A longer filter time means a smoother curve but a longer execution time. The following figure shows the impact of filter time on the curve under the same position reference.

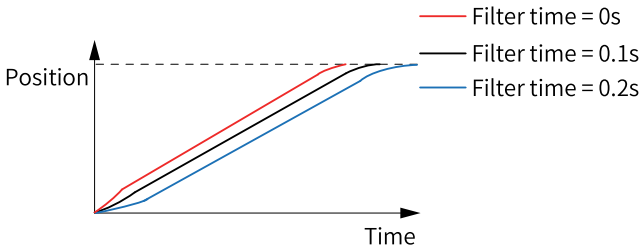


Figure 8-77 Impact of positioner filter time on the curve

There are two travel types: incremental positioning and absolute positioning. Their difference lies in the reference points for positioning. Incremental positioning uses the current point at the start of each positioning signal as the reference point, and the position reference is based on the increments of this reference point. The schematic diagram of incremental positioning is shown below.

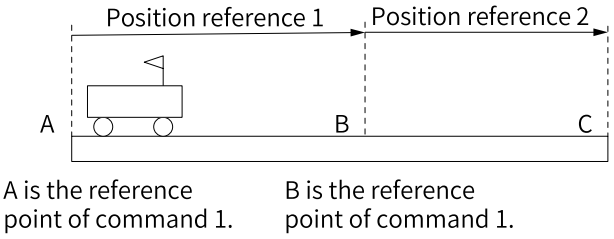


Figure 8-78 Incremental positioning

Absolute positioning uses the home as the reference point for each start after the home is confirmed to be valid.

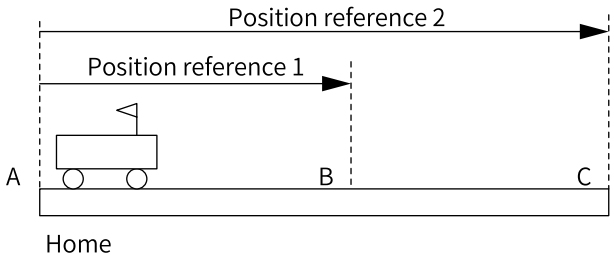


Figure 8-79 Absolute positioning

8.6.6.2 Custom Reference

When o17-01 [Main reference source of positioner] is set to 1 [Custom], the positioning control reference source is o17-02 [Custom reference source].

For example, you can send the position reference through communication and set o17-02 to other connectors to bind to the process data.

Note

The communication process data is a single word. If the position reference sent by the host controller is double-word data, you need to configure parameter groups n33 (Doubleword input of process data of adapter A) or n35 (Doubleword input of process data of adapter B). For communication-related configuration, see the*MD880 Series AC Drive Communication Guide*.

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o17-03 [Custom reference property] can also be used to configure the operation characteristics of the custom position reference.

Table 8–9 Parameters related to custom references

Param.	Name	Setpoint
o17-01	Main reference source of positioner	0: Multi-position reference 1: Custom
o17-02	Custom reference source	0: 0 Others: K connector
o17-03	Custom reference property	Ones-: Acceleration/Deceleration time 0: Acceleration/Deceleration time 1 of positioner 1: Acceleration/Deceleration time 2 of positioner 2: Acceleration/Deceleration time 3 of positioner 3: Acceleration/Deceleration time 4 of positioner Tens-: Positive/Negative speed limit 0: Positive/Negative speed limit 1 of positioner 1: Positive/Negative speed limit 2 of positioner 2: Positive/Negative speed limit 3 of positioner 3: Positive/Negative speed limit 4 of positioner Hundreds-: Waiting time for positioning completion 0: No waiting 1: Waiting time 1 for positioning completion 2: Waiting time 2 for positioning completion 3: Waiting time 3 for positioning completion 4: Waiting time 4 for positioning completion Thousands-: Reference output filter time of positioner 0: No filter 1: Filter time 1 2: Filter time 2 3: Filter time 3 4: Filter time 4 Ten thousands-: Stroke type 0: Absolute 1: Incremental

8.6.6.3 Positioning Start and Position Direction

You can set parameter o17-07 [positioning start signal source] to DI terminal or bit connector and set the command to be active at the rising edge. Parameter o15-00 [position control state] displays the current position control state. The flowchart of position control state switching during positioning start is shown below.

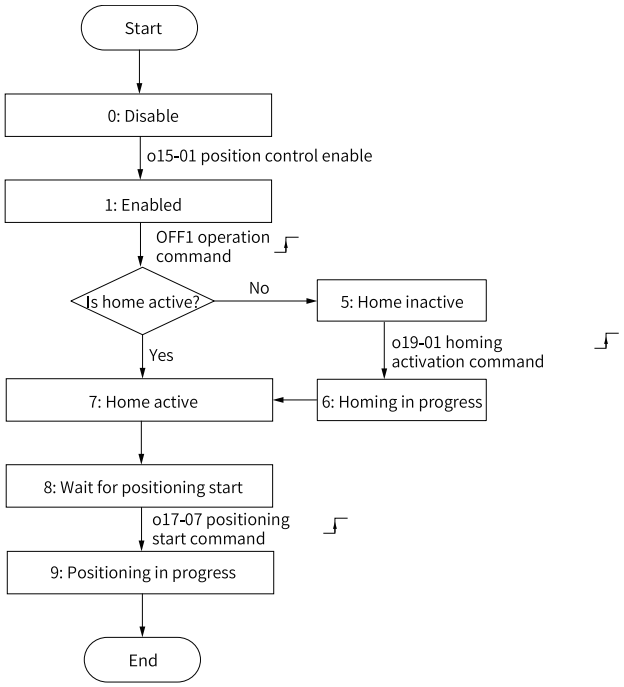


Figure 8-80 Position control state change during positioning start

Note

When o17-01 [main reference source of positioner] is set to multi-position reference and o18-02 [multi-position running mode] is set to loop execution, the position reference will be cyclically executed once the positioning start command is triggered. To stop the execution, cancel the OFF1 running reference.

During positioning operation, when the user retriggers the positioning start command or expects to change the position reference, different activation modes can be configured through the parameters. See o17-09 and o17-10 for details.

Table 8–10 Positioning start parameters

Parameter	Name	Reference	Remarks
o15-00	Position control status	0: Disabled 1: Enabled 2: Initializing 3: Waiting for position synchronization 4: Synchronizing position 5: Home inactive 6: Homing in progress 7: Home active 8: Wait for positioning start 9: Positioning in progress 10: Positioning holding 11: Interrupt positioning in progress 12: Position control paused	Status display, read-only
o17-07	Positioner start signal source	0: Disabled 1: Reserved 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: DIL 9: HDI1 10: HDI2 Others: B connector	-
o17-09	Positioner function selection	Ones position: Start of positioning when incremental positioning is not completed 0: The start command is invalid. 1: Perform positioning again based on the current position. 2: Add to the unfinished stroke and perform positioning again. Tens position: Start of positioning when incremental positioning is completed 0: Add the current error to the stroke upon startup. 1: Clear the error upon startup. Hundreds position: Reserved Thousands position: Reserved Ten thousands position: Reserved	-

Parameter	Name	Reference	Remarks
o17-10	Position reference activation method	0: Activated for a single time when the start command is triggered 1: Continuously activated (absolute positioning) 2: Continuously activated before positioning is completed (absolute positioning)	-
o17-16	Running direction of rotary axis	0: Forward direction 1: Reverse direction 2: Nearby positioning	-
o17-17	Inverse linear axis target position command	0: Disabled 1: Enabled Others: B connector	-

During the commissioning of a linear axis application, if the user-given position direction is opposite to the expected operation, use parameter o17-17 [invert linear axis target position] to reverse the target position.

During the commissioning of a rotary axis application, if the user expects the axis to run in the forward or reverse direction all the time or to turn to the target position in the nearest direction, set parameter o17-16 [rotary axis running direction] accordingly.

8.6.6.4 Backlash Compensation

Backlash may be present in positioning applications such as gear meshing or screwing. The motor and encoder are installed coaxially. When the motor and the load accelerate or run at a constant speed in one direction, the motor shaft is tightly attached to the load. However, when the motor decelerates or changes direction, the movement of the motor shaft will lag behind the load. In this case, the impact of backlash should be considered. The following figure illustrates the backlash.

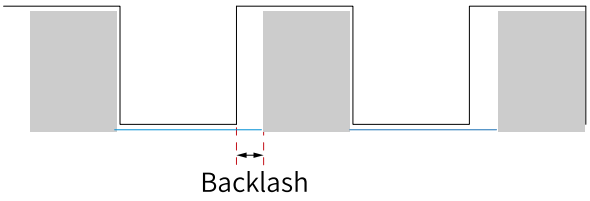
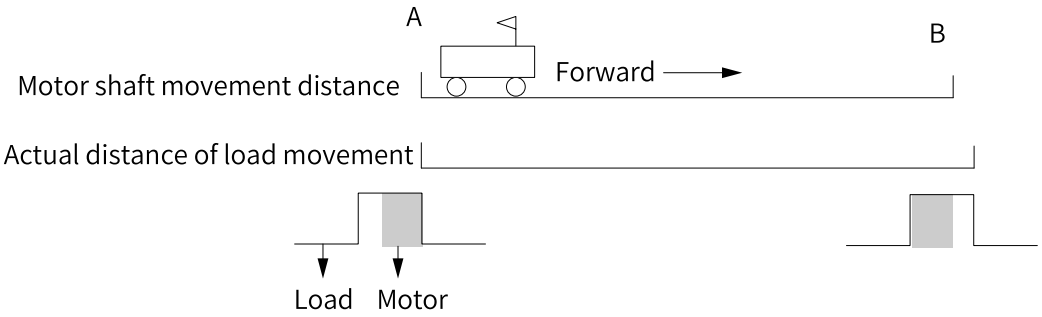


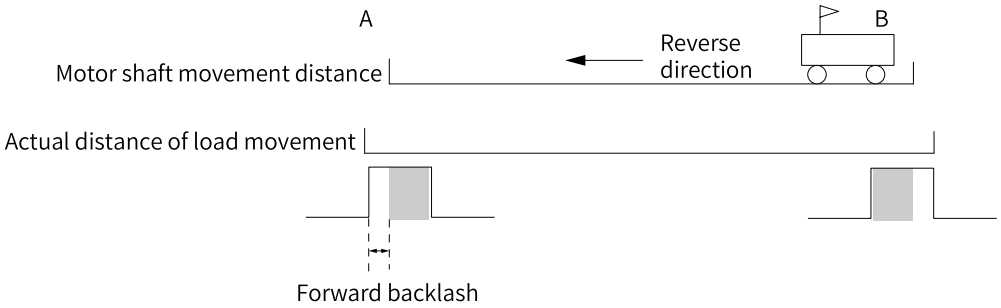
Figure 8-81 Backlash

The following figure shows the backlash measurement method.

1. The motor moves from point A in the forward direction over a given distance to point B. The relative position of the load and the motor is shown in the diagram. In practical on-site applications, the focus is often on the position of the load.



2. After reaching point B, the load continues to run in the reverse direction. The given distance remains unchanged. However, the load cannot return to point A due to the backlash, resulting in an inadequate final position.



If the load is expected to reach point A accurately, subtract the backlash from the positioning distance in advance in case of reverse operation. With the backlash subtracted, the load can reach the set position accurately. After the backlash measurement is completed, compensation can be made through parameters o17-11 [forward backlash] and o17-12 [reverse backlash].

8.6.6.5 Position Control Pause

Configure the triggering source for the position control pause command through o15-02 [Position control pause source]. When this function is triggered upon active signal, the speed is reduced to 0 based on the active deceleration time for the ramp function generator, and the current positioning is ended. After the pause command is canceled, positioning can be started again only after a positioning start command is triggered again. The position control state change flowchart for pause triggered during positioning is shown below.

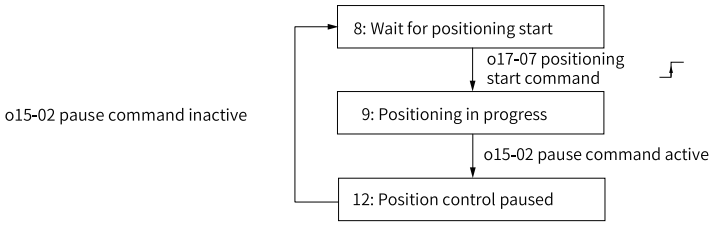


Figure 8-82 Position control pause state change flowchart

The following figure shows the position and speed curves when position control is paused.

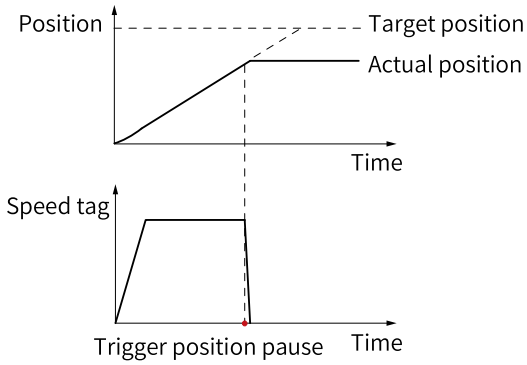


Figure 8-83 Position and speed curves for position control pause

8.6.6.6 Interrupt Positioning

After the interrupt positioning command is triggered with position control enabled, the current operation state is interrupted (regardless of whether the current state is waiting for positioning or positioning in progress) and the position command set by interrupt positioning can be executed. The flowchart of position control state change during interrupt positioning is shown below.

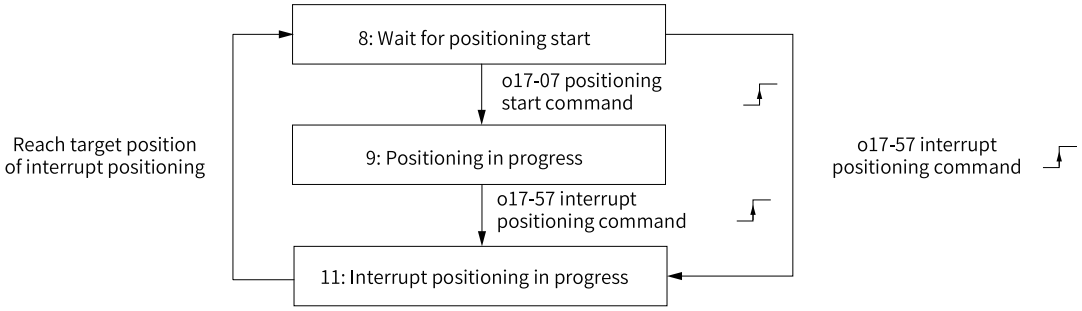


Figure 8-84 Flowchart of position control state change during interrupt positioning

o17-57 [Interrupt positioning signal source] is used to configure the trigger command source. o17-59 [Position reference source of interrupt positioning] can be set directly by o17-60 or the connector. o17-58 [Interrupt positioning property configuration] can be used to configure the operating characteristics of the position reference in interrupt positioning.

Table 8–11 Interrupt positioning parameters

Param.	Name	Reference
o17-57	Interrupt positioning signal source	0: Disabled 1: Reserved 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: DIL 9: HDI1 10: HDI2 Others: B connector
o17-58	Interrupt positioning attribute setting	Ones: Acceleration/Deceleration time 0: Positioner acceleration/deceleration time 1 1: Positioner acceleration/deceleration time 2 2: Positioner acceleration/deceleration time 3 3: Positioner acceleration/deceleration time 4 Tens: Positive/Negative speed limit 0: Positioner positive/negative speed limit 1 1: Positioner positive/negative speed limit 2 2: Positioner positive/negative speed limit 3 3: Positioner positive/negative speed limit 4 Hundreds: Waiting time for positioning completion 0: No waiting 1: Waiting time 1 for positioning completion 2: Waiting time 2 for positioning completion 3: Waiting time 3 for positioning completion 4: Waiting time 4 for positioning completion Thousands: Positioner command output filter time 0: No filter 1: Filter time 1 2: Filter time 2 3: Filter time 3 4: Filter time 4 Ten thousands: Travel type 0: Absolute 1: Incremental
o17-59	Position reference source in interrupt positioning	0: Position reference in interrupt positioning Others: K connector
o17-60	Position reference in interrupt positioning	–2147483648 UU to +2147483647 UU

8.6.7 Position Controller

Before optimizing the position controller, ensure that the drive speed control has been optimized. The following figure shows the internal position controller of the drive.

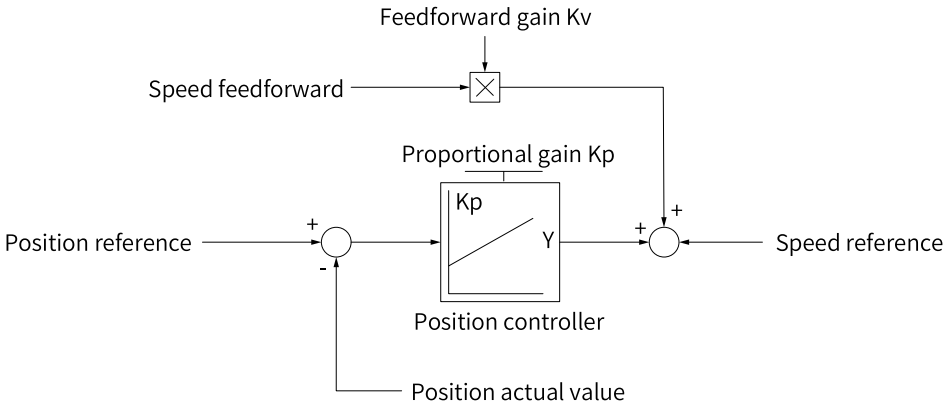


Figure 8-85 Position controller

The drive provides two sets of position loop parameters, as shown in the following table. Position loop 1 or position loop 2 can be activated through parameters or switched based on deviation. Position loop 1 is activated by default.

Table 8–12 Position loop parameters

Parameter	Name	Reference
o15-27	Position loop switchover function selection	0: Set through o15-28 1: Switched based on position deviation
o15-28	Position loop selection setting	0: Position loop 1 1: Position loop 2 Others: B connector
o15-29	Position loop switchover position deviation 1	0 LU to 65535 LU
o15-30	Position loop switchover position deviation 2	0 LU to 65535 LU
o15-31	Position loop Kp 1	0.00 to 100.00
o15-32	Position loop Kp 2	0.00 to 100.00

The proportional gains of the two position loops can be adjusted through o15-31 and o15-32, respectively. Increasing the proportional gain Kp of the position loop can improve the dynamic response of the position controller. However, for equipment with low stiffness, the increase in gain may lead to vibration of the mechanical equipment.

Similarly, increasing the speed feedforward gain Kv can also improve the dynamic response, but it may lead to overshoot or equipment vibration. Therefore, adjust the feedforward gain gradually.

For most field applications, the default value of the preceding parameters can meet the requirements. However, if the default value fails to meet the field application requirements, you can manually optimize the parameters based on the real-time position deviation and other characteristics.

8.6.8 Limit Functions

For applications with fixed travel (such as lifting), the operating range must be limited to prevent the device from running out of range or hitting equipment on either end, which can damage the device. The controller provides hardware limit and software limit. When the travel distance exceeds the limit, the corresponding action can be taken, with a fault or alarm reported. The following figure shows the limit application which ensures the movement between the left and right limits.

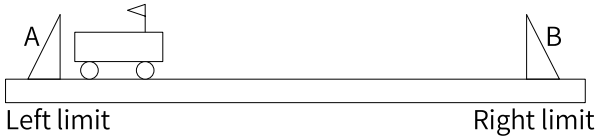


Figure 8-86 Limit application

8.6.8.1 Hardware Limit

A limit switch is placed in the limit position and the digital switch signal fed back by the limit switch is connected to the controller. Parameters L13-00 to L13-03 provide two groups of positive and negative hardware limit functions. You can configure it based on actual conditions. The limit function is triggered by the rising edge.

When the limit switch is exceeded during operation, the limit status can be activated with alarm 189 reported. In this case, the controller decelerates to stops as defined by L13-04 and L13-05, as detailed below.

- Coast to stop (The output is blocked immediately, but the shaft continues running for some distance due to inertia.)
- Decelerate to stop (Decelerate to zero speed and stop based on the deceleration time of the active ramp function generator.)
- Stop mode of OFF3 (Stop as defined by E1-16.)
- Decelerate to zero speed and run at zero speed (Decelerate to zero speed and run at zero speed based on the deceleration time defined by L13-07.)

Note

When a limit is activated, the drive must run reversely into the hardware limit switch range to reset the limit activation status.

Param.	Name	Setpoint
L13-00	Source of positive hardware limit 1	0: Invalid 1: Reserved 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: DIL 9: HDI1 10: HDI2 Others: B connector
L13-01	Source of negative hardware limit 1	
L13-02	Source of positive hardware limit 2	
L13-03	Source of negative hardware limit 2	
L13-04	Action for hardware limit 1	0: Coast to stop 1: Decelerate to stop 2: Stop mode of OFF3 3: Decelerate to zero speed and run at zero speed
L13-05	Action for hardware limit 2	

8.6.8.2 Software Limit

- When the home is confirmed to be valid, the system compares the real-time position feedback of the controller with the limits and takes corresponding action if the actual position exceeds the limit. The prerequisite for applying the software limit is that the home has been confirmed through homing.
- The software limit function can be enabled or disabled through o17-61. The limits are set by parameters o17-62 and o17-63. The unit is consistent with the position reference UU sent by the host controller.
- The action mode of the software limit is set by L13-06. The optional action modes are the same as the four hardware limit actions mentioned in *"8.6.8.1 Hardware Limit" on page 395*.

The following table compares the hardware limit with the software limit.

Table 8–13 Comparison between hardware limit and software limit

Hardware Limit		Software Limit	
1	Only linear operation and single-turn rotary movement are supported.	1	In addition to linear operation, single-turn and multi-turn rotary applications are supported.
2	External mechanical limit switch is required.	2	Hardware wiring is not required, eliminating malfunction due to poor cable contact.
3	Mechanical slip cannot be detected.	3	Mechanical slip and relevant abnormal actions can be detected through internal position comparison.

Table 8–14 Software limit parameters

Param.	Name	Value	Remarks
L13-06	Software limit action	0: Coast to stop 1: Decelerate to stop 2: Stop at the stop mode for OFF3 3: Decelerate to run at zero speed	-
L13-07	Limit deceleration time	0.0 to 1000.0	Unit: s

8.6.9 Status Monitoring

8.6.9.1 Proximity

The proximity flag bit indicates that the current position is near the target position. This flag bit can be viewed through connector U20-18 [Proximity]. The threshold and time of the judgment can be set through the following parameters.

Table 8–15 Proximity parameters

Param.	Name	Value	Default
o17-66	Proximity judgment threshold	0 LU to 21474836470 LU	500 LU
o17-67	Proximity judgment time	0 ms to 60000 ms	10 ms

8.6.9.2 Positioning Completed

The positioning completion flag bit indicates that the current position has reached the target position. This flag bit can be viewed through connector U20-19 [Positioning completed]. The threshold and time of the judgment can be set through the following parameters. The timing for positioning completion timeout starts from the moment when the motion profile planning is done. For systems with high following performance, the positioning process is done once the motion profile planning is done. Once the timeout threshold is exceeded, a corresponding fault can be reported.

Table 8–16 Positioning completion parameters

Param.	Name	Value	Default
o15-52	Threshold of positioning completion	0 LU to 2147483647 LU	10 LU
o15-53	Positioning completion judgment time	0 ms to 60000 ms	4 ms
o15-54	Positioning completion timeout	0s to 600.00s	5.00s

8.6.9.3 Excessive Position Deviation

The excessive position deviation flag bit indicates that the deviation between the reference and the feedback of the position controller is excessive. The flag bit can be viewed through connector U20-

20 [Excessive position deviation]. A fault can be reported if the position deviation exceeds the deviation threshold and lasts for a period longer than the judgment time. The following figure shows the position deviation.

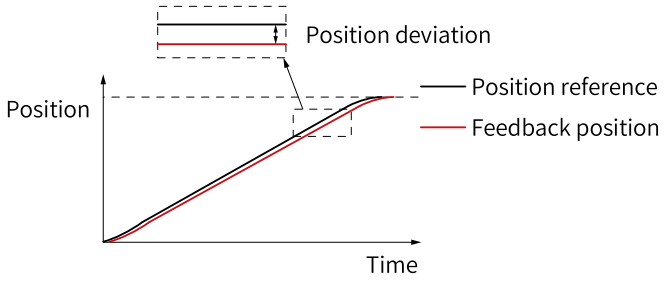


Figure 8-87 Position deviation

Solution to excessive position deviation:

- Check whether the encoder operating direction is consistent with the direction of U29-00.
- Adjust the gain of the position controller to improve the dynamic response of the position controller.
- Set position reference filter.
- Increase the position deviation detection threshold.

The related parameters are as follows.

Table 8–17 Excessive position deviation parameters

Param.	Name	Value	Default
o15-49	Detection threshold for excessive position deviation	0 LU to 2147483647 LU	600 LU
o15-50	Detection time for excessive position deviation	0s to 600.00s	0.50s

8.6.9.4 Position Compensation

There are two types of position compensation: absolute position compensation and position deviation compensation. The related parameters are as follows.

Table 8–18 Position compensation parameters for positioning control

Param.	Name	Reference
o17-18	Position compensation input type	0: Position deviation value 1: Absolute position value
o17-19	Position compensation input source	0: 0 Others: K connector

Param.	Name	Reference
o17-20	Position compensation trigger command	0: Disabled 1: Reserved 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: DIL 9: HDI1 10: HDI2 Others: B connector
o17-21	Trigger command source transmission delay	0 ms to 128 ms
o17-22	Numerator of position deviation compensation conversion coefficient	1 LU to 65535 LU
o17-23	Denominator of position deviation compensation conversion coefficient	1 to 65535
o17-24	Position deviation compensation linear change time	0 ms to 65000 ms

Absolute position value compensation: The signal from the proximity switch is detected during operation. The position of the proximity switch is measured in advance and fixed to an absolute position value. The current absolute position value is corrected and compensated once if the proximity switch is reached during movement. The following figure shows the absolute position compensation. For example, the absolute position of the proximity switch is defined as 10000 LU, that is, the value of the position compensation input source is 10000 LU. If the current absolute position is 9900 LU, then 10 LU will be compensated to the current absolute position at the proximity switch.

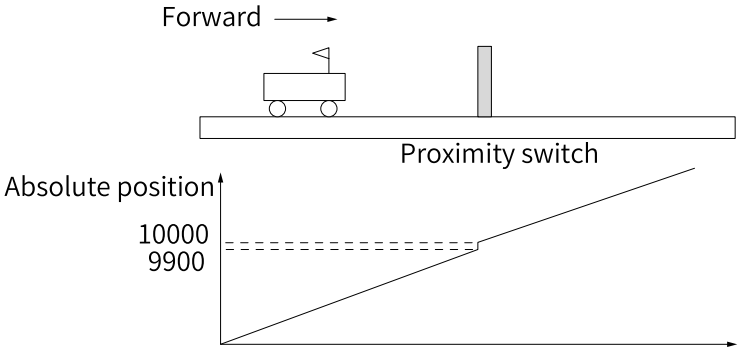


Figure 8-88 Absolute position compensation

Position deviation compensation is used to compensate the difference between the reference and the feedback in the position controller. Note that a longer linear change time of position deviation compensation means a smaller actual speed fluctuation during the change time, because the total deviation compensation value compensates the deviation evenly during the change time.

8.6.10 Synchronous Control

Two controllers control two axes respectively. The master controller transmits the position reference or encoder pulse sequence to the slave controller to make the slave axis follow the operation status of the master axis. The following figure shows synchronization control.

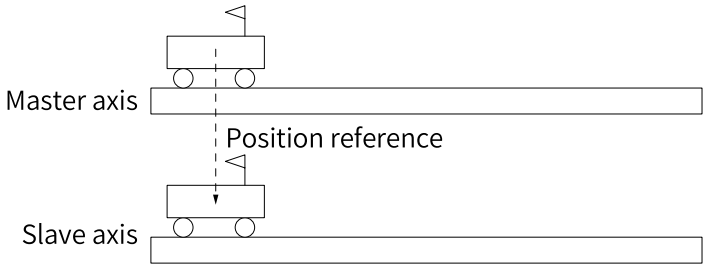


Figure 8-89 Sync control

8.6.10.1 Position Reference and Unit Calibration

The position reference source for synchronization control can be any one of the three encoder detection modules. It can also be sent through communication and then implemented by the connector selected. Units of position reference can be converted through the following parameters.

Table 8–19 UU-to-LU conversion parameters

Param.	Name	Value	Remarks
o16-02	Synchronous control reference source	0: Encoder 1 1: Encoder 2 2: Encoder 3 Others: K connector	-
o16-03	Numerator of reference unit conversion coefficient	1 LU to 65535 LU	Unit: LU
o16-04	Denominator of reference unit conversion coefficient	1 to 65535	-

The settings of position feedback and unit calibration for synchronization control are the same as those for position control.

8.6.10.2 Position Reference Filter

In the case of high-frequency noise interference or unsmooth signals in the position reference, use the position reference filter function. Average filter and first-order low-pass filter are available. The related parameters are as follows.

Table 8–20 Position reference filter parameters

Param.	Name	Value	Remarks
o16-05	Reference average filter time	0 ms to 128 ms	Unit: ms
o16-06	Reference first-order filter time	0 ms to 65535 ms	Unit: ms

A higher filter time value means a better filter effect and smoother curve. However, the curve lags behind the actual reference, so set the final filter time while balancing the smoothness and stability as needed.

8.6.10.3 Position Compensation

There are two types of position compensation: absolute position compensation and position deviation compensation. The related parameters are as follows.

Table 8–21 Position compensation parameters for synchronization control

Param.	Name	Value	Remarks
o16-07	Position compensation input type	0: Position deviation value 1: Absolute position value	-
o16-08	Position compensation input source	0: 0 Other: K connector	-
o16-09	Position compensation trigger command	0: Disabled 1: Reserved 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: DIL 9: HDI1 10: HDI2 Others: B connector	-
o16-10	Trigger command source transmission delay	0 ms to 128 ms	-
o16-11	Numerator of deviation compensation conversion coefficient	1 LU to 65535 LU	-
o16-12	Denominator of deviation compensation conversion coefficient	1 to 65535	-
o16-13	Deviation compensation linear change time	0 ms to 65000 ms	-

8.6.10.4 Description of Position Synchronous Control Parameters

Synchronous control is used to adjust the motor speed and position through the drive to achieve accurate position alignment between multiple devices or axes. It combines variable frequency speed regulation, closed-loop feedback, and synchronization algorithms, and is widely used in industrial scenarios requiring high-precision and collaborative motion. MD880 synchronous control is used to control the synchronous operation of multiple motors, which can be implemented through the encoder frequency division function. If the encoder frequency division is not available, you can configure position synchronous control based on Inolink communication, as shown below.

Description

Master configuration parameters

Table 8–22 Master configuration parameters

Name	Meaning	Association with other parameters
o16-32 [Macro configuration (synchronous control)]	Configure parameters related to synchronous control with one key.	When o16-32 is set to 1 [Master configuration], the master speed selection function (o16-34) is enabled.
o16-34 [Master speed selection]	Select the speed sent by the master to the slave as needed. You can select between 0 [Motor reference speed] and 1 [Motor actual speed].	Set o16-32 to 1 to activate this parameter. The selected motor speed can be monitored through U25-36 and U25-37.

Slave configuration parameters

Table 8–23 Slave configuration parameters

Name	Meaning	Association with other parameters
o16-31 [Master encoder resolution (synchronous control)]	Defines the encoder resolution for master position feedback.	-
o16-32 [Macro configuration (synchronous control)]	Configure parameters related to slave synchronous control with one key.	When o16-32 is set to 2 [Slave configuration], the position/speed compensation (o16-33) and feedforward speed conversion (o16-35/o16-36) are enabled.
o16-33 [Position/Speed compensation enable]	Used to enable compensation calculation for the speed and position sent by the master. After speed or position compensation is enabled, the speed position received by InoLink is calculated for compensation. If compensation is not enabled, the speed and position values received by InoLink are outputted directly.	The feedforward speed and reference position in synchronous control are monitored through U25-32 and U39-30.
o16-35 [Numerator of feedforward speed conversion factor]	Given that the speed information sent by the master to the slave is proportional to the speed of the slave motor due to the motor-to-load transmission ratio of the master and slave, you can use this parameter to change U25-32 [Feedforward speed (synchronous control)] based on the slave motor speed.	Used in conjunction with o16-36.
o16-36 [Denominator of feedforward speed conversion coefficient]	See o16-35.	Used in conjunction with o16-35.

o16-32 [Macro configuration (synchronous control)]

	Param.	Effective value
Master	n0-02 [Local address]	1
	n0-19 [InoLink auxiliary function setting]	1
	n0-20 [Selection of transmission data 1]	U25-81 [Master FPGA cycle (synchronous control)]
	n0-21 [Selection of transmission data 2]	U25-82 [High word of master position (synchronous control)]
	n0-22 [Selection of transmission data 3]	U25-83 [Low word of master position (synchronous control)]
	n0-23 [Selection of transmission data 4]	U25-84 [Master speed (synchronous control)]
	n0-24 [Selection of transmission data 5]	U25-85 [Master acceleration (synchronous control)]
Slave	n0-19 [InoLink auxiliary function setting]	1
	n0-40/n0-42/n0-44/n0-46/n0-48 Data reception source node	1 [Node 1]
	n0-40/n0-42/n0-44/n0-46/n0-48 Data reception selection	[Data 1] to [Data 5]
	o15-33 [Position loop speed feedforward source]	U25-80 [Feedforward speed (synchronous control)]
	o16-02 [Synchronous control reference source]	U39-50 [Position reference (synchronous control)]

Parameter configuration example

To configure high-precision position synchronous control, do as follows.

1. Control mode configuration: Configure the master as speed control or position control as needed, and set the corresponding control mode and reference value.
   If the master is configured as speed control, the following parameters need to be configured for control channel 1.

Param.	Name	Setting
E0-00	Control mode	1 - FVC <1>
E0-01	Control mode	0 - Speed control
b0-00	Start/Stop control word source	0 - Terminal start/stop module
C0-00	Main reference selection in speed control	6 - Multi-reference <2>

Note

<1>: Set the control mode according to the actual application needs.

<2>: Set the main reference source in speed control based on actual application needs.

If the master is configured as positioning control, the following parameters need to be configured for control channel 1.

Param.	Name	Setting
o15-01	Position control	1 - Enable
o15-03	Position control type	0 - Positioning control
o15-10	Position feedback detection source	0 - Encoder in current motor group
o17-01	Main reference source of positioner	0 - Multi-position reference

2. The delay compensation configuration for the position synchronous control module is as follows.

Param.	Name	Master configuration	Slave configuration
n0-00	InoLink communication startup selection	1 - Start	1 - Start
n0-02	Local node address	1	n<1>
n0-06	InoLink communication mode selection	0 - Standard mode <2>	0 - Standard mode <2>
o16-31	Master encoder resolution (synchronous control)	-	Set this parameter according to actual conditions.
o16-32	Macro configuration (synchronization control)	1 - Master configuration	2 - Slave configuration
o16-33	Position/Speed compensation enable	-	3 - Compensation position and speed <3>
o16-34	Master speed selection	Set this parameter according to actual conditions. <4>	-
o16-35	Numerator of feedforward speed conversion coefficient	-	Set this parameter according to actual conditions.
o16-36	Numerator of feedforward speed conversion coefficient	-	Set this parameter according to actual conditions.
o15-01	Position control	-	1 - Enable<5>
o16-03	Numerator of reference unit conversion factor	-	Set this parameter according to actual conditions. <6>
o16-04	Denominator of reference unit conversion factor	-	Set this parameter according to actual conditions.

Note

<1>: The slave starts InoLink communication (n0-00 = 1). The communication mode matches the master configuration. Set the slave node address according to actual applications. Do not set the slave node address to 1.

<2>: The master and slave start InoLink communication. Configure the InoLink communication mode according to actual applications: total number of nodes, magnitude of data exchange, and exchange cycle.

<3>: To improve synchronization control accuracy, it is recommended to set o16-33 [Position/Speed compensation enable] to 3 [Enable].

<4>: The master sets o16-32 [Macro configuration (synchronous control)] to 1 [Master configuration] and o16-35 [Master speed selection] to 0 [Motor reference speed] or 1 [Motor actual speed].

<5>: The slave is configured to position control mode and o15-01 is set to 1 [Enable]. Change o15-05 [Position control load axis type] according to actual requirements and set the position detection feedback source. Select a proper position feedback calibration method.

<6>: Configure o16-32 [Macro configuration (synchronous control)] to 2 [Slave configuration]. Set o16-31 based on the master position encoder resolution. Set o16-33 [Position/Speed compensation enable] to 3 [Enable]. Set o16-03/o16-04 [Reference unit conversion coefficient] and o16-35/o16-36 [Feedforward speed conversion coefficient] based on the actual installation position of the master/slave encoder and the motor-to-load transmission ratio.

3. The following describes the setting methods for fully closed-loop positioning control of the master and fully closed-loop synchronous control of the slave.

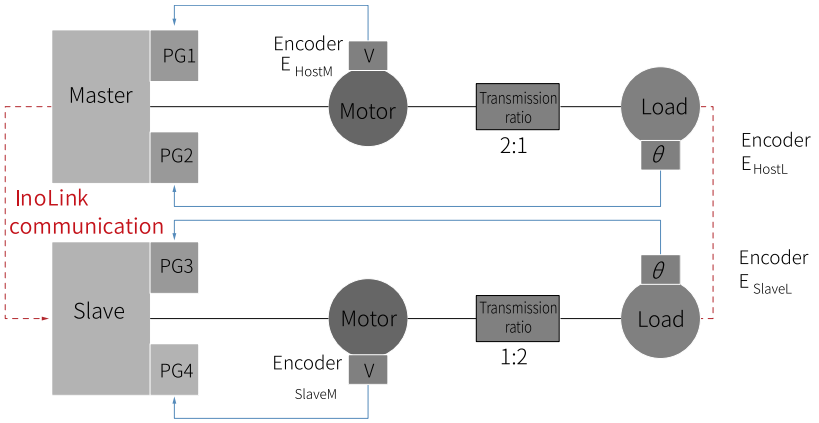


Figure 8-90 Application scenario

The fully closed-loop positioning control mode applies on the master side, in which the encoder on the load side generates position control feedback and the encoder on the motor side generates speed feedback. The resolution of two encoders is 1024. The motor-to-load transmission ratio of the master is 2:1.

The fully closed-loop synchronous control mode applies on the slave side, in which the encoder on the load side generates position control feedback and the encoder on the motor side generates speed feedback. The resolution of two encoders is 2500. The motor-to-load transmission ratio of the slave is 1:2.

The master and slave encoders are installed on the load side to keep synchronous operation of the master and slave on the load side. Given the difference in the encoder resolution of the master and slave, the pulse position value (quadruple frequency) increases by 4096 per forward revolution of the master or increases by 10000 per forward revolution of the slave. If the FU->LU ratio on the slave side is set to 1:1 in this case, set o16-03 and o16-04 to 2500 and 1024 respectively.

The value of U25-84 [Master speed (synchronous control)] sent by the master is the speed information on the load side. Given the motor-to-load transmission ratio of the slave is 1:2, the value of U25-84 is twice the slave motor speed. Therefore set o16-38 and o16-39 to 1 and 2 respectively. The parameters are set as follows.

Param.	Name	Unit	Value
o15-14	Position feedback calibration method	-	0 [Incremental calibration]
o15-15	Incremental calibration method - Operating distance increment on the load side	LU	1
o15-16	Incremental calibration method - Position feedback encoder pulse increment	p	1
o16-03	Numerator of reference unit conversion factor	LU	2500
o16-04	Denominator of reference unit conversion factor	UU	1024
o16-35	Numerator of feedforward speed conversion coefficient	-	1
o16-36	Denominator of feedforward speed conversion coefficient	-	2

8.7 Automatic Configuration of Position Control Parameters

The position control parameters can be configured quickly through o15-80.

Param.	Name	Value range
o15-80	Triggering automatic configuration of position control parameters	0: No action 1: Positioning control (single closed loop) 2: Positioning control (fully closed loop)

When o15-80 is set to 1, automatic parameter configuration is triggered once. Parameters configured are shown below.

Param.	Name	Default	Macro-configured value
A9-00	Control channel selection	0 [Control channel 1]	0 [Control channel 1]
A9-02	Source of motor data set selection 0	0 [0]	0 [0]
A9-03	Source of motor data set selection 1	0 [0]	0 [0]
E0-00	Control mode	2 [V/f]	1 [FVC]
E0-01	Control mode	0 [Speed control]	0 [Speed control]
E1-00	Startup mode	0 [Direct start]	0 [Direct start]
E1-14	OFF1 stop mode	1 [Decelerate to stop]	1 [Decelerate to stop]
C7-02	RFG ramp selection 1	0 [0]	0 [0]
C7-03	RFG ramp selection 2	0 [0]	0 [0]
C7-04	Ramp 1 acceleration time	20.0s	20.0s
C7-05	Ramp 1 deceleration time	20.0s	20.0s
d0-11	Speed feedback selection	0 [Encoder detection module 1]	0 [Encoder detection module 1]
b0-00	Start/Stop control word source	0 [Terminal start/stop module]	3 [Custom (group bo)]
b0-01	Source of custom OFF1	0 [Invalid]	2 [DI1]
b0-02	Source 1 of custom OFF2	1 [Inactive]	1 [Inactive]
b0-03	Source 1 of custom OFF3	1 [Inactive]	1 [Inactive]
b0-04	Custom operation permission source	1 [Operation allowed]	1 [Operation allowed]
b0-05	Custom fault reset source 1	0 [Inactive]	0 [Inactive]
b0-08	Custom speed inversion source	0 [Inactive]	0 [Inactive]
o15-01	Position control enable	0 [Inhibited]	1 [Enabled]
o15-02	Position control pause source	0 [Inactive]	0 [Inactive]
o15-03	Position control type selection	0 [Positioning control]	0 [Positioning control]
o15-05	Position control load axis type	0 [Linear axis]	0 [Linear axis]
o15-10	Position detection feedback source	0 [Encoder of current motor group]	0 [Encoder of current motor group]
o15-11	Custom position feedback source	0 [0]	0 [0]
o15-14	Position feedback calibration method	0 [Incremental calibration method]	1 [Nameplate setting method]

Param.	Name	Default	Macro-configured value
o15-17	Nameplate method - Lu/ Revolution setting on the load side	1	1
o15-18	Nameplate method - Number of motor revolutions for motor-to-load ratio	1	1
o15-19	Nameplate method - Number of load revolutions for motor-to-load ratio	1	1
o17-01	Main reference source of positioner	0 [Multi-position reference]	0 [Multi-position reference]
o17-05	Numerator of reference unit conversion factor	1	1
o17-06	Denominator of reference unit conversion factor	1	1
o17-07	Positioning start signal source	0 [Inactive]	3 [DI2]
o17-10	Position reference activation mode	0 [Activated once when start command triggered]	0 [Activated once when start command triggered]
o18-02	Multi-position operation mode	0 [Digital setting of multi-position reference]	0 [Digital setting of multi-position reference]
o18-03	Digital setting of multi-position reference	1	1
o18-22	Multi-position 1 reference	0	0
o18-23	Multi-position 1 property	0	0
o19-00	Homing trigger mode	0	0 [Triggered by activation command]
o19-01	Homing activation command source	0	4 [DI3]
o19-03	Homing type	0 [Current position as reference point]	0 [Current position as reference point]
L3-25	Base value coefficient for double word-to-word conversion	0	0
L3-26	Selection of double word-to-word 1	0 [Inactive]	U29-00 [Current absolute position]
L3-27	Base value of double word-to-word 1	0	0
L3-28	Selection of double word-to-word 2	0 [Inactive]	U29-02 [Set target position]
L3-29	Base value of double word-to-word 2	0	0
L3-30	Selection of double word-to-word 3	0 [Inactive]	U29-03 [Effective target position]
L3-31	Base value of double word-to-word 3	0	0
A13-00	Selection of black box custom channel 1	U6-93 [Z signal position]	U5-76 High word of the output of [double word-to-word 1]
A13-01	Selection of black box custom channel 2	U15-90 [Corresponding angle of Z signal]	U5-77 Low word of the output of [double word-to-word 1]

Param.	Name	Default	Macro-configured value
A13-02	Selection of black box custom channel 3	U8-33 [Motor phase sequence switchover state]	U5-78 High word of the output of [double word-to-word 2]
A13-03	Selection of black box custom channel 4	U7-80 [DI/DO state of HINT module]	U5-79 Low word of the output of [double word-to-word 2]
A13-04	Selection of black box custom channel 5	U5-44 [Bus adapter A.PZD1]	U5-80 High word of the output of [double word-to-word 3]
A13-05	Selection of black box custom channel 6	U5-60 [Bus adapter B.PZD1]	U5-81 Low word of the output of [double word-to-word 3]
A13-06	Selection of black box custom channel 7	U9-09 [RFG output speed reference]	U17-20 [Real-time position deviation]
A13-07	Selection of black box custom channel 8	U15-23 [24 V detection voltage at HCU control board terminal]	U17-01 [Position controller status word 1]
A13-08	Selection of black box custom channel 9	U15-22 [14 V detection voltage at HCU control board terminal]	U17-02 [Position controller status word 2]
A13-09	Selection of black box custom channel 10	U8-77 [Original value of the number of encoder pulses (FPGA-quadruple frequency)]	U17-03 [Position controller command word 1]
A13-10	Selection of black box custom channel 11	U7-97 [Online module with activated STO]	U17-04 [Position controller command word 2]
A13-11	Selection of black box custom channel 12	U8-39 [HINT status word 1 in single mode/General fault word 1 in parallel mode]	U17-05 [Positioning controller status word 1]
A13-12	Selection of black box custom channel 13	U8-40 [HINT status word 2 in single mode/General fault word 2 in parallel mode]	U17-06 [Positioning controller status word 2]
A13-13	Selection of black box custom channel 14	U8-74 [Status word of FPGA operation status control]	U17-07 [Positioning control command word 1]
A13-14	Selection of black box custom channel 15	U8-75 [Fault word 1 of FPGA operation status control]	U17-08 [Positioning control command word 2]
A13-15	Selection of black box custom channel 16	U8-76 [Fault word 2 of FPGA operation status control]	U9-09 [RFG output speed reference]

Set o15-80 to 2 [Positioning control (fully closed loop)] to trigger automatic parameter configuration once. Parameters configured are shown below.

Param.	Name	Default	Macro-configured value
A9-00	Control channel selection	0 [Control channel 1]	0 [Control channel 1]
A9-02	Source of motor data set selection 0	0 [0]	0 [0]
A9-03	Source of motor data set selection 1	0 [0]	0 [0]
E0-00	Control mode	2 [V/f]	1 [FVC]
E0-01	Control mode	0 [Speed control]	0 [Speed control]

Param.	Name	Default	Macro-configured value
E1-00	Startup mode	0 [Direct start]	0 [Direct start]
E1-14	OFF1 stop mode	1 [Decelerate to stop]	1 [Decelerate to stop]
C7-02	RFG ramp selection 1	0 [0]	0 [0]
C7-03	RFG ramp selection 2	0 [0]	0 [0]
C7-04	Ramp 1 acceleration time	20.0s	20.0s
C7-05	Ramp 1 deceleration time	20.0s	20.0s
d0-11	Speed feedback selection	0 [Encoder detection module 1]	0 [Encoder detection module 1]
b0-00	Start/Stop control word source	0 [Terminal start/stop module]	3 [Custom (group bo)]
b0-01	Source of custom OFF1	0 [Inactive]	2 [DI1]
b0-02	Source 1 of custom OFF2	1 [Inactive]	1 [Inactive]
b0-03	Source 1 of custom OFF3	1 [Inactive]	1 [Inactive]
b0-04	Custom operation permission source	1 [Operation allowed]	1 [Operation allowed]
b0-05	Custom fault reset source 1	0 [Inactive]	0 [Inactive]
b0-08	Custom speed inversion source	0 [Inactive]	0 [Inactive]
o15-01	Position control	0 [Inhibited]	1 [Enable]
o15-02	Position control pause source	0 [Inactive]	0 [Inactive]
o15-03	Position control type	0 [Positioning control]	0 [Positioning control]
o15-05	Position control load axis type	0 [Linear axis]	0 [Linear axis]
o15-10	Position detection feedback source	0 [Encoder of current motor group]	2 [Encoder detection module 2]
o15-11	Custom position feedback source	0 [0]	0 [0]
o15-14	Position feedback calibration method	0 [Incremental calibration method]	1 [Nameplate setting method]
o15-17	Nameplate method - Lu/ Revolution setting on the load side	1	1
o15-18	Nameplate method - Number of motor revolutions for motor-to-load ratio	1	1
o15-19	Nameplate method - Number of load revolutions for motor-to-load ratio	1	1
o17-01	Main reference source of positioner	0 [Multi-position reference]	0 [Multi-position reference]
o17-05	Numerator of reference unit conversion factor	1	1
o17-06	Denominator of reference unit conversion factor	1	1
o17-07	Positioning start signal source	0 [Inactive]	3 [DI2]
o17-10	Position reference activation mode	0 [Activated once when start command triggered]	0 [Activated once when start command triggered]

Param.	Name	Default	Macro-configured value
o18-02	Multi-position operation mode	0 [Digital setting of multi-position reference]	0 [Digital setting of multi-position reference]
o18-03	Digital setting of multi-position reference	1	1
o18-22	Multi-position 1 reference	0	0
o18-23	Multi-position 1 property	0	0
o19-00	Homing trigger mode	0	0 [Triggered by activation command]
o19-01	Homing activation command source	0	4 [DI3]
o19-03	Homing type	0 [Current position as reference point]	0 [Current position as reference point]
L3-25	Base value coefficient for double word-to-word conversion	0	0
L3-26	Selection of double word-to-word 1	0 [Inactive]	U29-00 [Current absolute position]
L3-27	Base value of double word-to-word 1	0	0
L3-28	Selection of double word-to-word 2	0 [Inactive]	U29-02 [Set target position]
L3-29	Base value of double word-to-word 2	0	0
L3-30	Selection of double word-to-word 3	0 [Inactive]	U29-03 [Effective target position]
L3-31	Base value of double word-to-word 3	0	0
A13-00	Selection of black box custom channel 1	U6-93 [Z signal position]	U5-76 High word of the output of [double word-to-word 1]
A13-01	Selection of black box custom channel 2	U15-90 [Corresponding angle of Z signal]	U5-77 Low word of the output of [double word-to-word 1]
A13-02	Selection of black box custom channel 3	U8-33 [Motor phase sequence switchover state]	U5-78 High word of the output of [double word-to-word 2]
A13-03	Selection of black box custom channel 4	U7-80 [DI/DO state of HINT module]	U5-79 Low word of the output of [double word-to-word 2]
A13-04	Selection of black box custom channel 5	U5-44 [Bus adapter A.PZD1]	U5-80 High word of the output of [double word-to-word 3]
A13-05	Selection of black box custom channel 6	U5-60 [Bus adapter B.PZD1]	U5-81 Low word of the output of [double word-to-word 3]
A13-06	Selection of black box custom channel 7	U9-09 [RFG output speed reference]	U17-20 [Real-time position deviation]
A13-07	Selection of black box custom channel 8	U15-23 [24 V detection voltage at HCU control board terminal]	U17-01 [Position controller status word 1]

Param.	Name	Default	Macro-configured value
A13-08	Selection of black box custom channel 9	U15-22 [14 V detection voltage at HCU control board terminal]	U17-02 [Position controller status word 2]
A13-09	Selection of black box custom channel 10	U8-77 [Original value of the number of encoder pulses (FPGA-quadruple frequency)]	U17-03 [Position controller command word 1]
A13-10	Selection of black box custom channel 11	U7-97 [Online module with activated STO]	U17-04 [Position controller command word 2]
A13-11	Selection of black box custom channel 12	U8-39 [HINT status word 1 in single mode/General fault word 1 in parallel mode]	U17-05 [Positioning controller status word 1]
A13-12	Selection of black box custom channel 13	U8-40 [HINT status word 2 in single mode/General fault word 2 in parallel mode]	U17-06 [Positioning controller status word 2]
A13-13	Selection of black box custom channel 14	U8-74 [Status word of FPGA operation status control]	U17-07 [Positioning control command word 1]
A13-14	Selection of black box custom channel 15	U8-75 [Fault word 1 of FPGA operation status control]	U17-08 [Positioning control command word 2]
A13-15	Selection of black box custom channel 16	U8-76 [Fault word 2 of FPGA operation status control]	U9-09 [RFG output speed reference]

9 Function Application

9.1 Motor Temperature Detection

The motor temperature can be detected through simple wiring and parameter setting. Temperature sensors KTY84, PT100, PT1000, and PTC are supported. PG cards or AI/AO support motor temperature detection in various ways. You can select a detection mode through E8-22, and set the motor over-temperature threshold and warning threshold through E8-23 and E8-24, respectively. The detected motor temperature can be viewed through U5-06.

When connector is selected in E8-22, the temperature unit is ℃ and is used for obtaining the motor temperature through communication. For example, when E8-22 is set to U5-53, the received PZD represents the motor temperature. If U5-53 is 100, it represents the current motor temperature of 10.0℃.

The related parameters are as follows.

Parameter	Name	Description
U5-06	Detected motor temperature	The measured temperature is displayed based on the temperature measurement mode selected in E8-22. Unit: ℃ Actual temperature cannot be obtained during PTC measurement.
E8-22	Motor temperature detection mode	When the encoder module is selected (determined by d0-11), KTY84 and PTC are supported. When AI1/AO1 or AI2/AO2 is selected, KTY84, PTC, PT100 and PT1000 are supported. For HCU-50S/51S jumper, the AO jumper must be set to the current mode output and the AI jumper to the voltage mode input.
d0-11	Current motor selection	When temperature measurement by encoder module is selected in E8-22, the activated encoder module is determined by d0-11.
E8-23	Motor over-temperature protection value	If the detected temperature U5-06 is greater than E8-23, a fault is triggered and the motor coasts to stop. If the detected temperature U5-06 is greater than E8-24, only an alarm is triggered.
E8-24	Motor over-temperature alarm value	

9.1.1 Motor Temperature Detection with PG Card

HPG-10 or HPG-50 has a temperature sampling module, which can realize motor temperature detection in KTY84 and PTC modes. No matter which encoder signal type is used, the wiring of the motor temperature detection part is the same<1>. Take the HPG-10 HTL incremental encoder as an example:

Connect the temperature sensors (thermistors) in series to pins 2 and 3 of the X31 terminal. According to the sampling value detected inside the module, the resistance value of the thermistor at this time can be obtained through conversion. Further, the motor temperature value at this time can be obtained by looking up the "Resistance-Temperature" table. The wiring diagram is as follows:

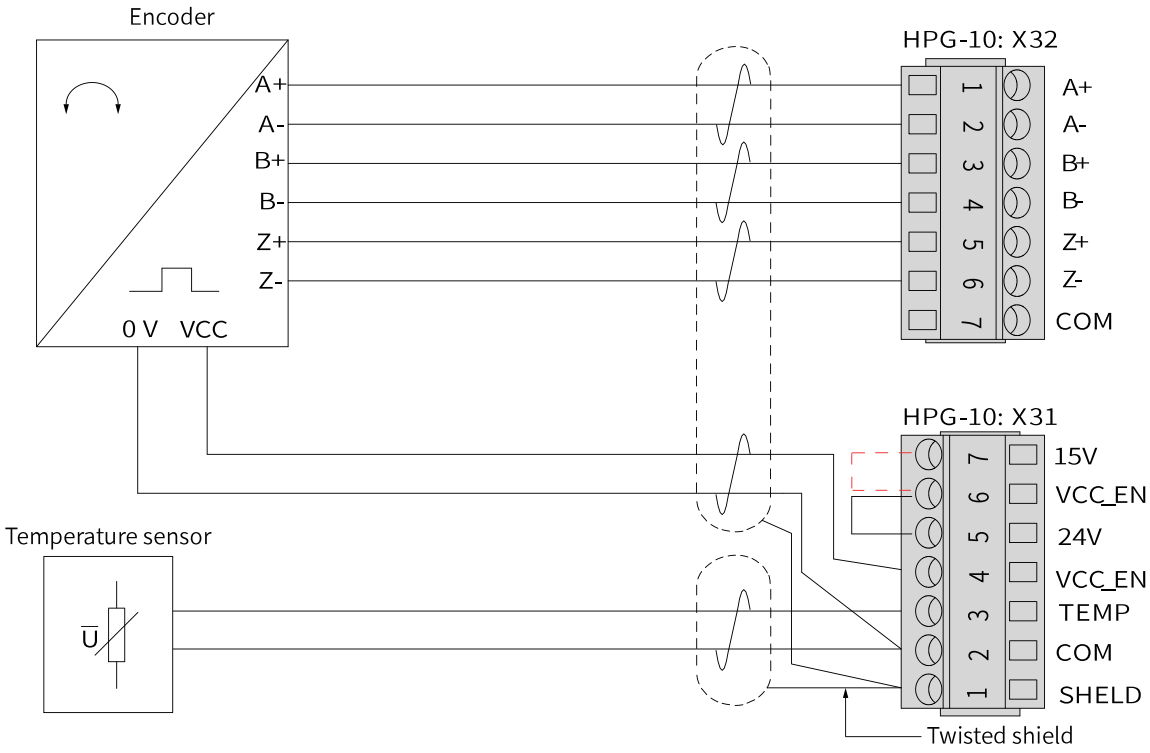


Figure 9-1 Push-pull output HTL encoder interfaces

When HPG-10 is used to detect the motor temperature, the PG module must be inserted into the specified expansion slot and must be configured correctly. Select the encoder detection module to be used in the motor parameter group d0-11 (default is 1). After selection, select the expansion slot and encoder type in the corresponding expansion module group (n4). When the module status is online, the PG card is activated. Then, the motor temperature detection can be easily achieved by selecting the corresponding motor temperature detection mode through E8-22.

Note

<1>: For detailed introduction of the PG module, see *HPG-10 HTL Incremental Encoder Detection Module User Guide* and *HPG-50 TTL Incremental Encoder Detection Module User Guide*.

9.1.2 Motor Temperature Detection with AI/AO

To measure motor temperature with analog quantity, AI/AO<1> are required. The supported detection methods include KTY84, PT100, PT100×2, PT100×3, PT1000, and PTC. AI1 can only be used with AO1 and AI2 can only be used with AO2. This section takes AI1/AO1 as an example.

When you use AI1/AO1 to measure motor temperature, AI1 must be switched to voltage output mode and AO1 to current output mode with the jumper. According to the detection mode selected by E8-22, AO1 outputs a fixed current value<2>, as shown in the following table:

Detection Mode (E8-22)	KTY84	PT100	PT100×2	PT100×3	PT1000	PTC
AO output value (F3-00)	2 mA	5 mA	5 mA	5 mA	2 mA	2 mA

The temperature sensors (thermistors) are connected in series to both ends of AO1. By measuring the voltage at both ends of AO1, the resistance value of the thermistor at this time can be obtained according to Ohm's law. Further, the motor temperature value at this time can be obtained by looking up the "Resistance-Temperature" table. Connecting both ends of AO1 to AI1 respectively can achieve automatic measurement of AO voltage value<3>. Then, the AI1 input value displayed in F2-00 is the voltage at both ends of AO1. After the wiring is completed, select the motor temperature detection mode through E8-22. Then, the motor temperature can be detected easily. The wiring diagram is as follows:

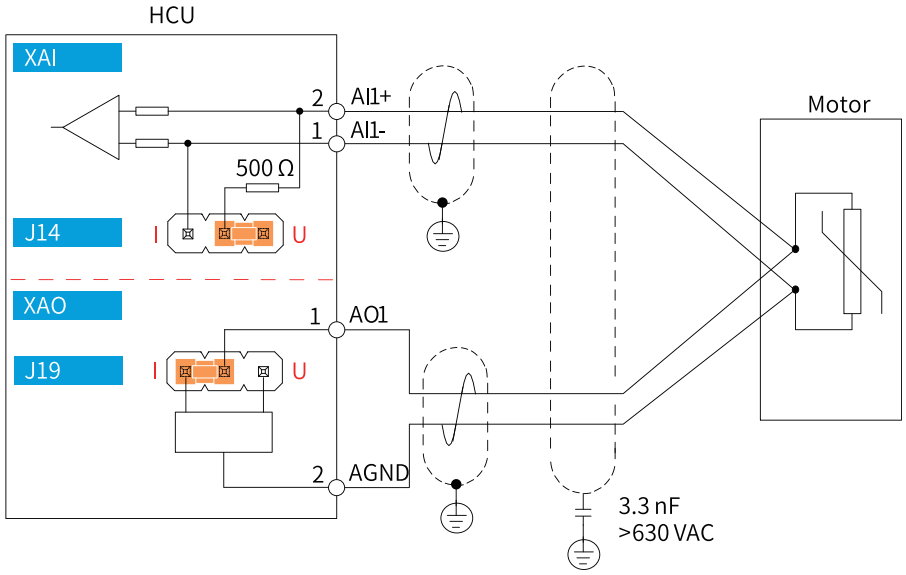


Figure 9-2 Temperature detection wiring with AI1 and AO1

Note

- <1>: To improve detection accuracy, it is recommended to correct AI and AO in advance.
- <2>: When AI1/AO1 is used to detect the motor temperature, the setting of F3-04 (AO1 signal source) can fail.
- Do not directly ground both ends of the cable shield. Ground one end and keep the other end unconnected, or ground one end directly and ground the other end through a capacitor in series.

9.2 Speed Measurement by Encoder

The HCU-50S/51S supports up to three encoder detection modules. Parameters in groups n4/n5/n6 correspond to the parameters of the three encoder detection modules. Set corresponding parameters according to d0-11. In motor parameters, d0-11 is set to 0 [Encoder detection module 1] by default.

9.2.1 Encoder Parameter Setting

9.2.1.1 Incremental Encoder Setting

HCU-50S/51S supports incremental encoders with HTL and TTL levels, and the corresponding encoder detection module models are HPG-10 and HPG-50 respectively. The software configuration

methods of the two are exactly the same. Take encoder detection module 1 (d0-11 set to 0) as an example:

Parameter	Name	Description
n4-00	Expansion slot selection	According to the actual slot position of the encoder detection module in HCU-50S/51S. When enabling two encoder detection modules, specify each module separately.
n4-02	Encoder type	0: Invalid type, encoder function off 1: Common ABZ encoder, supports HPG-10 and HPG-50 HPG-10 is an HTL ABZ encoder detection module. It supports incremental encoders from 12 V to 24 V and supports differential, single-ended, and OC input. HPG-50 is a TTL ABZ encoder detection module. It corresponds to 5 V incremental encoders and does not support OC input.
n4-01	Module online status	After n4-00 and n4-02 are configured correctly, the status should be displayed as "online".
n4-03	Input A/B phase sequence	If the encoder speed measurement is opposite to the selected motor direction, modify this parameter to adjust the speed measurement direction.
n4-04	Speed measurement mode	0: Quadruple frequency. This mode enables faster response at low speed, and will cause larger speed fluctuation when the encoder signal duty cycle is not 50% or the A/B signal orthogonality is not good. 1: Pulse A. The speed measurement response at extremely low speed is slightly poor, but relatively stable.
n4-07	Encoder resolution (number of pulses/revolutions)	The nameplate parameter of the incremental encoder, which identifies how many pulses are generated per revolution.

9.2.1.2 Resolver Setting

The model of the resolver detection module is HPG-40. The following description takes encoder detection module 1 (d0-11 set to 0) as an example to describe the parameter settings.

Parameter	Name	Description
n4-00	Expansion slot selection	According to the actual slot position of the encoder detection module in HCU-50S/51S. When enabling two encoder detection modules, specify each module separately.
n4-02	Encoder type	0: Invalid type, encoder function off 3: Resolver
n4-01	Module online status	After n4-00 and n4-02 are configured correctly, the status should be displayed as "online".
n4-03	Input A/B phase sequence	If the encoder speed measurement is opposite to the selected motor direction, modify this parameter to adjust the speed measurement direction.
n4-12	Encoder installation position angle	When a synchronous motor is used, the resolver installation position angle must be set correctly; otherwise, motor runaway will occur during running. The installation position angle can be auto-tuned (b5-00 set to 2 or b5-00 set to 7), and must be auto-tuned each time after the encoder is replaced for the parameter settings are restored to factory defaults. When an asynchronous motor is used, the installation position angle is not required.

Parameter	Name	Description
n4-25	Resolver type	0: 7 Vp-p, ratio 0.5 1: 7 Vrms, ratio 0.5 2: 7 Vrms, ratio 0.286 3: 4 Vrms, ratio 0.3
n4-26	Resolver excitation signal frequency	0: 10 kHz 1: 12 kHz 2: 15 kHz 3: 20 kHz

9.2.2 Anti-Interference and Frequency-Division Output

Parameter	Name	Description
n4-08	Enable PG quadrature interlock	It is enabled by default and can increase the suppression of interference signals.
n4-17	Filter time of encoder speed test	The detected feedback speed is filtered to smooth burr.
n4-09	Pulse frequency-division output coefficient	The encoder input signal is divided and then output. When 1 is selected, the frequency of the output signal is the same as that of the original signal; When n is selected, the output signal frequency is 1/n of the input signal frequency.
n4-05	Output A/B phase sequence	0: Forward, the A signal of frequency division output is ahead of B. 1: Reverse, the A signal of frequency division output lags behind B.
n4-06	Output Z phase sequence	0: Maintain the polarity of input Z signal. 1: Output Z signal after reversing the polarity.

9.2.3 Open Circuit Detection

9.2.3.1 Encoder Open Circuit Fault and Fault Response Setting

E8-50 is used to set the encoder fault processing mode, which is the stop mode defined by E8-51 by default. Description of E8-51 is as follows.

Value	Meaning	Action
0	OFF2 stop	The device coasts to stop after a fault occurs.
1	OFF3 stop (SVC)	After a fault occurs, the drive switches from FVC to SVC and stops in the emergency stop mode.
2	OFF1 stop (SVC)	After a fault occurs, the drive switches from FVC to SVC and decelerates to stop.

If E8-50 is set to “Alarm and continue operating in SVC mode”, the drive switches from FVC to SVC and continues operating until it is stopped by the user or the operating speed is lower than the value of E8-52.

The default minimum speed in SVC mode after encoder open circuit occurs is 3%. After the drive switches from FVC to SVC upon an encoder fault, if the synchronous frequency during operation is

lower than 3%, a fault can be reported. When E8-52 is set to 0%, the drive operates a any speed after switching from FVC to SVC mode until it is stopped by the user. For active loads, you can set E8-52 to 0% to prevent operation divergence.

Note

If E11-04 [Active switchover from FVC to SVC] is enabled, but the encoder is disconnected after the drive switches from FVC mode to SVC mode, the actions defined by E8-50 [Actions upon encoder fault] are not responded to no matter whether the disconnection fault is rectified or not.

9.2.3.2 Incremental Encoder Hardware Open Circuit Detection

Parameter	Name	Description
n4-10	Open circuit detection mode for ABZ encoder	The encoder detection module monitors the connection status of the encoder signal cables. It reports a fault once open circuit is detected. 0: Disable 1: ABZ differential signal, A+/A-, B+/B-, and Z+/Z- detected 2: AB differential signal, A+/A- and B+/B- detected 3: ABZ single-ended positive signal, A+, B+ and Z+ detected. Note that only these three cables can be used during wiring; otherwise the encoder open circuit fault can be reported. 4: AB single-ended signal (+), A+ and B+ detected only. Note that only these two cables can be used during wiring; otherwise the encoder open circuit fault can be reported.
n4-11	Speed feedback PG open circuit detection time	When the encoder open circuit duration exceeds the set detection time, an open circuit fault is reported. Increase the detection time in the case of false alarms. When this parameter is set to 0, the open circuit detection function is disabled.

9.2.3.3 Resolver Open Circuit Detection

Parameter	Name	Description
n4-27	Resolver open circuit detection time	When the encoder open circuit duration exceeds the detection time, an open circuit fault is reported. Increase the detection time in the case of false alarms. Due to characteristics of the resolver, if the resolver stops at a certain angle, open circuit can be detected after the resolver runs. When this parameter is set to 0, the open circuit detection function is disabled.

9.2.4 Encoder Signal Error Software Detection Setting

Encoder signals can be disturbed when encoder signal cables are routed or shielded improperly, resulting in excessive fluctuation in the speed measured. In this case, you can enable software open circuit detection to detect such errors. When the encoder mounting shaft is loosened, encoder software open circuit fault can also be triggered.

Parameter	Name	Description
n4-20	Software detection of encoder signal error	0: Disabled 1: Enabled
n4-21	Encoder signal error software detection coefficient	This threshold is automatically set during auto-tuning. Invalid threshold is displayed in n4-22. If the deviation of the encoder detection speed exceeds this threshold, the measured value is abnormal.
n4-22	Software detection threshold of encoder signal error	
n4-23	Threshold of encoder signal error count	When an incremental encoder is enabled, the value of n4-23 is the threshold. When a resolver is enabled, the value of n4-31 is the threshold. When the encoder detection signal fluctuation keeps exceeding the threshold specified in n4-22 for a period longer than n4-23/n4-31, the encoder software open circuit fault is triggered. Abnormal signals before the count is reached are eliminated to ensure smooth speed detection.
n4-31	Threshold of abnormal resolver signals	
n4-28	Burr removal for speed measured by encoder	Even if n4-20 is set to 0, you can set n4-28 to remove abnormal encoder detection signals.

9.2.5 Pulse Counting and Encoder Angle Simulation

Depending on the internal operation function of HCU-50S/51S, not only incremental encoder can be used to measure speed, but also pulses can be counted to simulate absolute encoder to realize position measurement. You can change the current count value to correct the home position.

Parameter	Name	Description
U29-40	Encoder 1 pulse position value (4-frequency multiplication)	Displays the pulse position accumulation of the encoder 1/2/3. The position increases upon forward running and decreases upon reverse running. The pulse position increases by 4 x [n4-07] for one forward revolution of the motor.
U29-41	Encoder 2 pulse position value (4-frequency multiplication)	
U29-42	Encoder 3 pulse position value (4-frequency multiplication)	
U9-12	Encoder pulse position value (4-frequency multiplication)	Displays the pulse position accumulation of the activated encoder module (d0-11). If d0-11 is set to 0, the value of U29-40 is displayed.
n4-36	Retention of encoder pulses upon power failure	1: Save pulse number. The current position value of U29-40 is retained before HCU is powered off. The counting starts from the last position upon the next power-on. Ensure that the encoder and device have no displacement after HCU power failure. 0: U29-40 counts from 0 upon each power-on.
n4-38	Encoder position setting switch	When n4-38 is set to 1, the value of U29-40 is forced to be the connector selected in n4-39. If n4-39 is set to 0, the setting is cleared. When n4-38 is set to 0, the value of U29-40 increases or decreases with encoder rotating.
n4-39	Encoder position setpoint	

The position value of the encoder can be converted into the rotor rotation angle and turns based on the encoder pulses per revolution. The following table lists the parameters.

Parameter	Name	Description
U8-77	Encoder pulse count	Displays the number of incremental input pulses counted by the current encoder module. Corresponds to the quadruple frequency of the input pulse: that is, when a 1024 PPR encoder rotates one revolution, the count increases by 4096.
U16-94	Encoder 1 measuring angle	Simulates the absolute encoder to convert the number of encoder pulses into the angle. The angle increases upon forward running and decreases upon reverse running. Values 0 to 65535 correspond to angles 0° to 360°. U16-95 and U16-94 can be used together to simulate a multi-turn absolute encoder.
U16-95	Measured revolutions of encoder 1	
U16-96	Encoder 2 measuring angle	Corresponds to encoder module detection in group n5. See U16-94/U16-95.
U16-97	Measured revolutions of encoder 2	
U16-98	Encoder 3 measuring angle	Corresponds to encoder module detection in group n6. See U16-94/U16-95.
U16-99	Measured revolutions of encoder 3	
U5-11	Encoder measuring angle	Displays the revolutions and angle of the activated encoder module (d0-11). If d0-11 is set to 0, the values of U16-94 and U16-95 are displayed.
U5-12	Encoder revolutions	
n4-18	Encoder initial angle trigger reference	Sets U16-94 and U16-95 when the set connector numerical value changes. If the connector is single-word, the changed value will be set to the value of U16-94. If the connector is double-word, the low-order byte of the changed value will be set to the value of U16-94 and the high-order byte to the value of U16-95.

9.3 Module Fan Operation Control

The fan speed regulation of the MD880 inverter module can be set in A4-30.

Parameter	Name	Description
A4-30	Module fan operation control	0: Operating at full speed during operation of the system. The fan runs at full speed when the inverter is running. 1: Operating at full speed after power-on. The fan runs at full speed when the DC bus is connected. 2: Fan speed regulated automatically during operation. After the inverter runs, the fan is controlled based on the internal temperature/duty cycle curve. The minimum duty cycle for multi-drive system fans is 50%, and that for single-drive system is 40%.

This mode is supported only by some models as listed in the following table. For models not supporting fan speed regulation, if A4-30 is set to 2, the fan runs at full speed after the inverter runs.

Structure	Model
400 V multi-drive system	
H8	MD880-50M-0757-4
H8	MD880-50M-0900-4
500 V multi-drive system	
H8	MD880-50M-0617-5

Structure	Model
H8	MD880-50M-0810-5
690 V multi-drive system	
H8	MD880-50M-0530-7
H8	MD880-50M-0600-7
H8	MD880-50M-0650-7
H8	MD880-50M-0721-7
690 V single-drive system	
H8	MD880-01S-0600-7-SG
H8	MD880-01S-0650-7-SG
H8	MD880-01S-0721-7-SG

Note

- When the maximum power unit temperature set in A0-14 exceeds 50℃, the fan is started forcibly. When the temperature is lower than 45℃, the fan stops.
- The fan stops one minute after the inverter stops.

9.4 Process PID Module

In industrial control application, closed-loop control mode is usually used to control the speed, pressure, temperature, or current of the controlled objects and maintain a stable output. The proportional control (P), integral control (I), and differential control (D) are used together to keep the feedback value consistent with the reference.

- The output of P control is proportional to the deviation. There is a steady-state error in the output of the system when only proportional control is used.
- The output of I control is proportional to the integral of the deviation. The static error of the system can be eliminated by introducing "integral term".
- The output of D control is proportional to the differential of the deviation. The "differential term" can predict the variation trend of deviation, thus optimizing the dynamic response of the controlled object with large inertia or strong lag.

Set parameters in group L4 as needed and adjust PID parameters for proper control on controlled variables. PID function and PID operation are enabled by L4-00 and L4-01, respectively, and the execution cycle of PID controller is defined by L4-03.

9.4.1 PID Input

Set L4-04 and L4-08 to the target value and actual value of the controlled variables, which are used as the reference source and feedback source of the controller. Filter the reference and feedback (L4-07 and L4-09) as required. For reverse characteristic load, set the PID action direction (L4-02) as the reverse direction, so that when the input value is positive, the PID output is reduced. The input deviation (U9-60) is superimposed to the additional reference (L4-10) to be used as the final PID input (U9-61). When reference freezing (L4-06) is enabled, the reference does not change, as shown below.

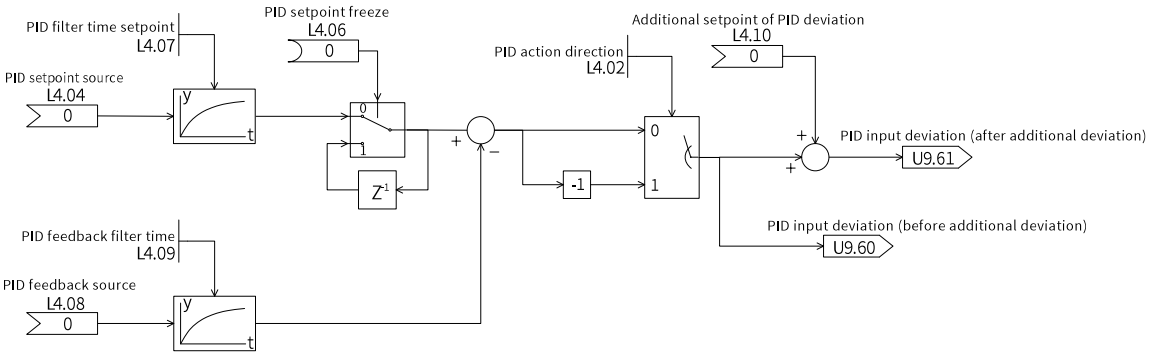


Figure 9-3 PID input

9.4.2 PID Output

When the input deviation is outside the set dead zone, the PID controller starts to work. When the controller input is not 0, the control volume continues to increase or decrease under the PID function until the output limit is reached. Adjust the proportional gain Kp and integral time Ti to ensure the dynamic response and steady accuracy of PID output, as shown below.

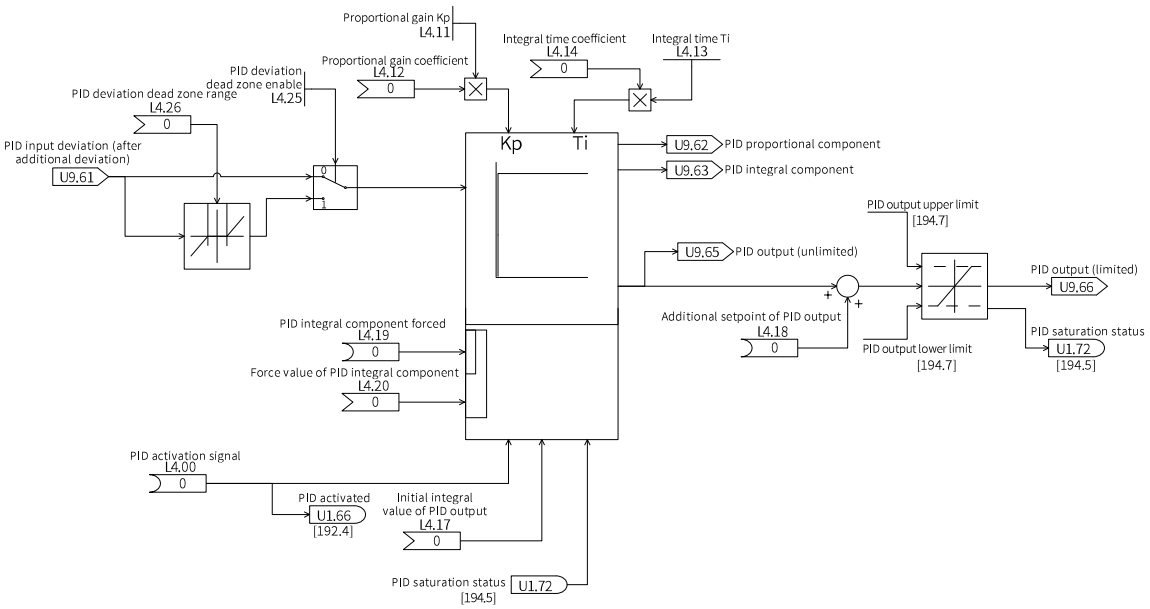


Figure 9-4 PID Output

9.4.3 PID Limit

Set the upper and lower limits and the rise and fall time to limit the PID output, ensuring that the controller output is within the controllable range. See the following figure.

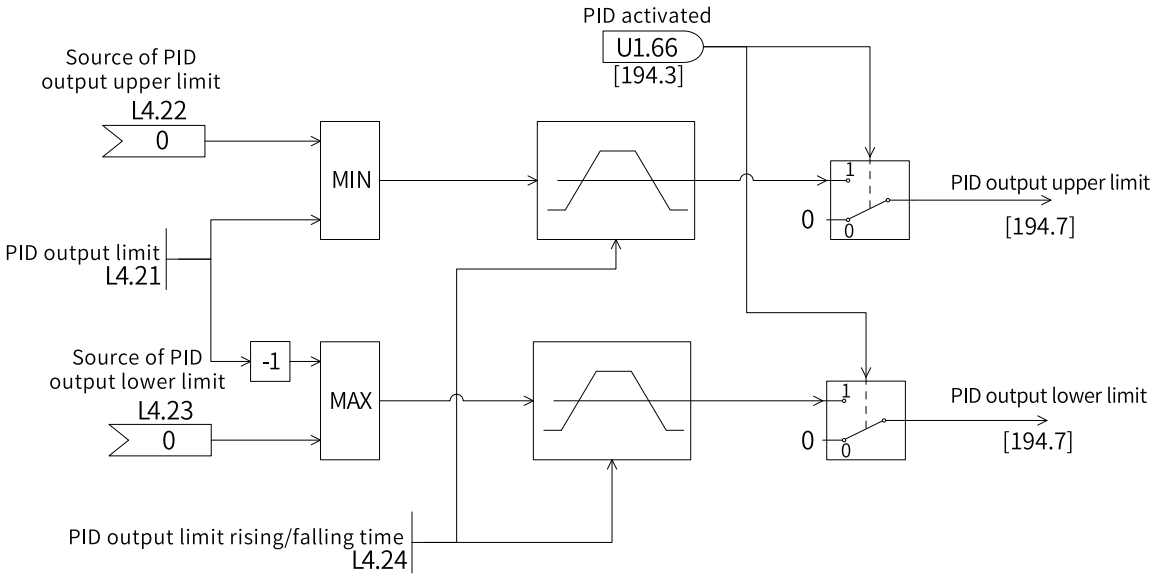


Figure 9-5 PID limit

9.4.4 PID Feedback Loss Detection

When the absolute value of PID feedback keeps lower than L4-27 [PID feedback loss detection value] for a period longer than L4-28 [PID feedback loss detection time], the PID feedback has lost, with fault code 31 reported to alert users to sensor or wiring errors.

9.5 Brake Control

Parameters in group L1 are used to set brake control logic conditions. For function diagrams of brake control, see *"11.2.8.2 H630 - Brake Release and Brake Apply" on page 638* and *"11.2.8.3 H632 - Brake Status Detection" on page 639*.

In the control module of HCU-50S-CS, the RO3 relay is optimized for brake control in crane applications. It is recommended to use RO3 relay for brake control output.

The motor and the device being driven are kept at zero speed through the mechanical brake when the drive unit is not running. You can determine whether to enable brake control and whether brake feedback detection is enabled through L1-00. When brake control is enabled, set related parameters based on the actual working conditions of the equipment and load for effective control by the brake logic to achieve operation safety.

If L1-00 is set to 2, the brake with feedback is selected and the system detects the brake feedback status defined by L1-15. If the brake release feedback signal is not obtained within 2s, the fault 84-1 can be reported, indicating that brake release fails.

If L1-00 is set to 1, the brake is controlled based on the set time only and the actual status will not detected. L1-23, L1-24, and L1-25 can be used to set the brake release conditions. For example, you can set the brake to be released only when the output torque is greater than a specified value. This ensures that the gravity load does not slip at the moment of brake release. Note that the system speed loop neither works or generates torque output before the brake is released. Therefore, after

setting the brake release conditions, set a starting torque through L1-06 to meet the brake release conditions. For details on the brake control process, see *"9.5.2.1 Vector Control" on page 425*.

9.5.1 Typical Brake Configuration

When using the brake, you can configure the parameters according to the following templates (group L1 parameters listed in the table remain the default values).

- The brake does not generate feedback and needs to be configured with a starting torque only to prevent unintended movement of the motor upon brake release.

Param.	Name	Value
L1-00	Brake function selection	1: Enable brake without detection information
L1-01	Brake release time	Set the parameter according to the actual brake release time.
L1-02	Brake apply action time	Set the parameter according to the actual brake close time.
L1-06	Starting torque source in vector control	2: L1-07
L1-07	Digital reference of starting torque	Set the parameter according to the estimated load weight.

- The brake does not generate feedback and needs to use the retentive torque as the starting torque and keeps outputting excitation current for 10s after the brake applies.

Param.	Name	Value
L1-00	Brake function selection	1: Enable brake without detection information
L1-01	Brake release time	Set the parameter according to the actual brake release time.
L1-02	Brake apply action time	10s or actual brake apply time +10s After the brake applies, it keeps generating the output current for 10s.
L1-06	Starting torque source in vector control	1: Automatic torque retention
L1-07	Digital reference of starting torque	This torque value is used as the retentive torque during initial start, which can be set based on the estimated load weight.
L1-08	Automatic torque retention gain coefficient	Set this parameter to 100% in normal scenarios. To adjust the proportion of the retentive torque, set this parameter.
L1-09	Upper limit of starting torque	Used to limit the retentive torque to avoid retentive torque errors caused by brake apply errors. If L1-10 is set to 10% and L1-09 is set to 80%, the starting torque can be limited to a positive value between 10% and 80%.
L1-10	Lower limit of starting torque	
L1-22	Brake release command source	Defines the condition for controlling the brake through external control signals.When this parameter is set to 0, the brake cannot be released. When the brake is released, setting L1-22 to 0 does not cause the brake to apply.

Param.	Name	Value
L1-23	Comparison value source of brake release	Defines the additional condition for determining brake release. If L1-23 is set to 0, the condition is invalid. After the option connector is selected by L1-23, the brake release state can be applied only when the connector keeps higher than the threshold for a period defined by L1-25 during judgment of brake release conditions.
L1-24	Comparison threshold of brake release	
L1-25	Brake release delay	

- The brake can be released only when the brake generates feedback and the output torque is 35% of the rated torque.

Param.	Name	Value
L1-00	Brake function selection	2: Enable brake with detection information
L1-01	Brake release time	Set the parameter according to the actual brake release time.
L1-02	Brake apply action time	Set the parameter according to the actual brake close time.
L1-03	Brake feedback point source	4: DI3 (When the brake feedback is set to DI3, the value 1 indicates brake release and 0 indicates brake apply.)
L1-06	Starting torque source in vector control	2: L1-07
L1-07	Digital reference of starting torque	40% (It must be a value higher than 35%.)
L1-23	Comparison value source of brake release	U6-01 (Calculated value of output torque)
L1-24	Comparison threshold of brake release	35%
L1-25	Brake release delay	0.5s (You can decrease this value to accelerate brake release and avoid fluctuation of the detected value.)

9.5.2 Sequence Diagram

9.5.2.1 Vector Control

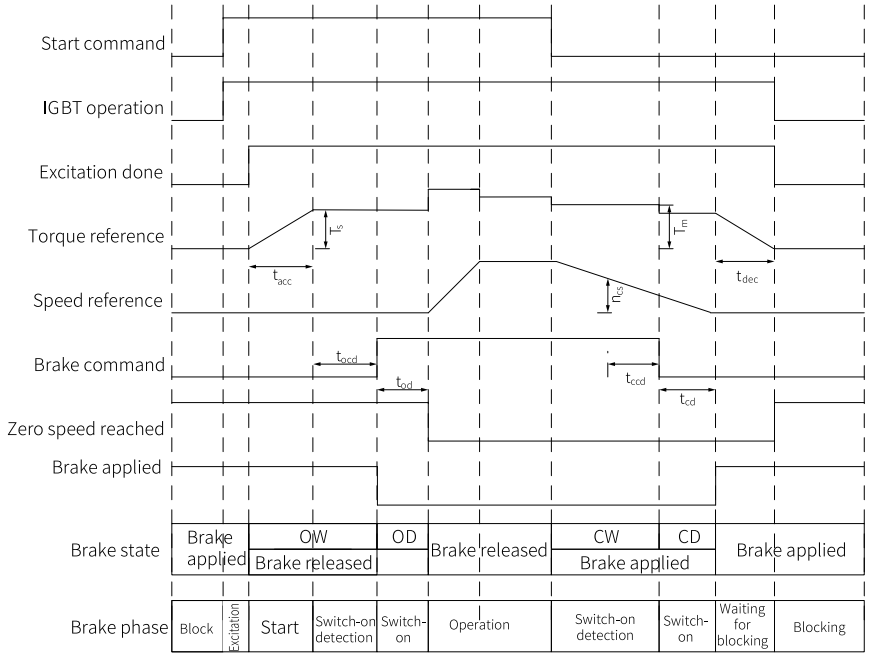


Figure 9-6 Brake sequence diagram in vector control

T_s : Starting torque upon brake release

n_{cs} : Speed threshold upon brake apply

t_{acc} : Torque ramp-up time upon start of the brake

t_{ocd} : Comparison delay upon brake release

t_{od} : Brake release action time

t_{ccd} : Brake apply delay

t_{cd} : Brake apply action time

t_{dec} : Brake torque ramp-down time

OW: Waiting for brake release

OD: Brake release delay

CW: Waiting for brake apply

CD: Brake apply delay

9.5.2.2 V/f Control

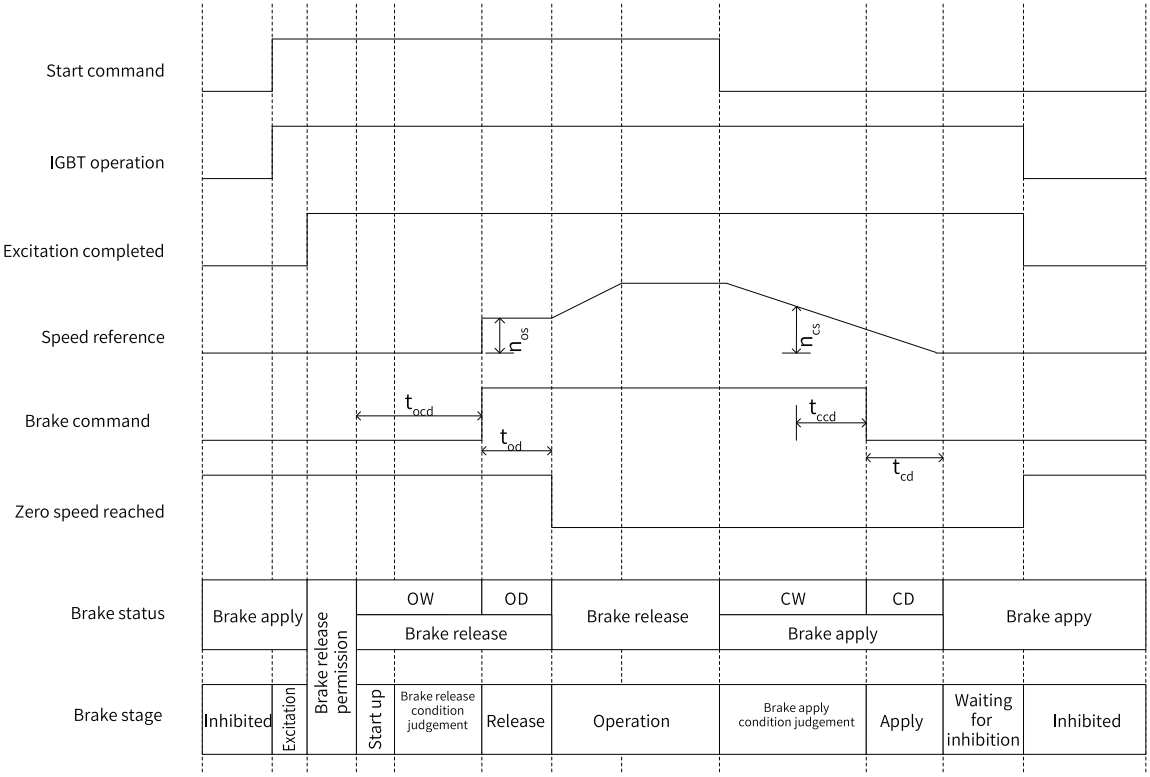


Figure 9-7 V/f control brake sequence diagram

n_s : Starting speed upon brake opening

n_{cs} : Speed threshold upon brake closing

t_s : Acceleration time reference upon brake opening

t_{ocd} : Comparison delay upon brake opening

t_{od} : Brake open action time

t_{ccd} : Brake close delay

t_{cd} : Brake close action time

OW: Brake open waiting time

OD: Brake open delay

CW: Brake close waiting time

CD: Brake close delay

9.5.3 Description of the Brake Phase

Brake actions can be performed only after the operation command is received and the motor is ready. For the asynchronous motor, it is ready when pre-excitation is done. For the synchronous motor, it is ready when the magnetic pole angle is obtained.

When a fault occurs or an emergency stop command is received during brake release, the brake applies immediately, with a brake apply command outputted.

The brake apply/release actions are generally triggered by operation commands. When L1-14 is set to 1 and RFG input speed (U9-08) is set to 0, the brake cannot be released even if an operation command is received. After the brake is released, the brake apply command is triggered when L1-14 and U9-08 is set to 1 and 0 respectively. You can set L1-14 to 0 to disable this characteristic.

The brake module outputs the brake apply signal (U1-11 = 0) whenever OFF2 emergency stop or faults that cause coast-to-stop occurred or when L1-15 is set to 1.

Parameter	Name	Description
L1-14	Source for brake apply command upon zero speed	0: Invalid 1: The brake apply command is triggered automatically when U9-08 is set to 0.
L1-15	Source for forced brake apply command	0: Invalid 1: The brake apply signal (U1-11 = 0) is outputted immediately.

9.5.3.1 Braking Force Test

The braking force test is optional and can be skipped if not activated.

The braking force may decrease after the brake is used for a long time. To check whether the detection braking force of the internal logic function is satisfactory, set L1-30 to 1 to enable braking force test before startup.

This function is active only when E0-00 is set to 1 (FVC). During the test, the drive continues to output the torque according to the setting of L1-32 and checks whether the feedback torque is normal. If the feedback torque is too low or the motor rotates, the braking force is insufficient and the fault 84-3 or 84-4 can be triggered.

Parameter	Name	Description
L1-30	Enable brake self-test	You can use the connector to enable or disable self-test. When this parameter is set to 1, the test is performed before brake release after excitation is done.
L1-31	Brake test hold time	Defines the test duration.
L1-32	Maximum verification torque for brake test	During the test, the output torque increases gradually but the maximum torque cannot exceed the torque specified by this parameter.
L1-33	Torque direction for brake test	Defines the torque direction, which can be modified in the connector. The torque is outputted and tested in the forward direction by default.
L1-34	Slip speed threshold for brake test	During the brake test, if the motor speed exceeds the value of L1-34 for a period longer than that specified in L1-35, the motor rotates.
L1-35	Slip speed duration for brake test	

9.5.3.2 Brake Release Preparation Phase

Brake release preparation includes three phases: starting torque setup, brake release condition judgment, and brake release.

- Starting torque setup: This phase is active only in vector control mode. To prevent the load from moving upon brake release due to gravity load, the torque is outputted based on the setting of L1-

06. Before brake release, the speed loop does not work. If L1-06 is set to 0, no torque is outputted before brake release.

- Brake release condition judgement: After the starting torque is established, you can set L1-22 and L1-25 to add two sets of additional start conditions. By default, the additional condition does not apply. After the starting torque is established, the brake release action starts.
- Brake release: The brake release signal (U1-11 = 1) is outputted in this phase. In addition, the ramp function generator (RFG) is enabled. If the setting of L1-11 is active, the RFG starts to accelerate from the speed defined by L1-12. If L1-11 is inactive, the RFG starts to accelerate from 0.

Parameter	Name	Description
L1-06	Starting torque source in the vector control mode	Defines the torque to be outputted before brake release.
L1-07	Digital reference of starting torque	Active when L1-06 is set to 2.
L1-08	Automatic retentive torque gain coefficient	Active when L1-06 is set to 1. It is used to adjust the retentive torque value.
L1-09	Upper limit of starting torque	Active when L1-06 is not set to 0. If L1-10 is set to 10% and L1-09 is set to 80%, the starting torque is limited to a positive value within the range of 10% to 80%.
L1-10	Lower limit of starting torque	
L1-11	Enable starting speed	L1-11 = 0: After the brake is released, the device accelerates from 0. L1-11 = 1: After the brake is released, the device accelerates from the speed defined by L1-12.
L1-12	Digital reference of starting speed	
L1-22	Brake release command source	Defines the condition for external control of the brake. When it is set to 0, the brake cannot be released. When the brake has been released, the brake does not apply when you set L1-22 to 0.
L1-23	Comparison value source of brake release	Define the additional judgment conditions for brake release. If L1-23 is set to 0, the condition is inactive. If L1-23 is set to “Connector”, the brake release state applies only when the connector keeps higher than the threshold for a period longer than L1-25 after entering the brake release condition judgment phase.
L1-24	Comparison threshold of brake release	
L1-25	Brake release delay	

9.5.3.3 Brake Release Phase

The brake release phase includes “brake release detection” and “brake released”.

- Brake release detection: When the value of U1-11 is set to 1, the RFG output does not change and waits until the brake is released. If L1-00 is set to 1, the brake release detection phase is exited after the time defined by L1-01 elapses. If L1-00 is set to 2, whether the feedback point of L1–03 is at high level can be detected at this phase. If it is at high level, this phase ends. If the delay time defined by L1-01 is reached but the feedback point of L1-03 is kept at low level, a brake detection error can be triggered. When this error lasts for a period longer than the time defined by L1-04, the fault ERR84-1 (Brake cannot be released) is triggered.
- Brake released: When RFG is enabled, the RFG output speed is allowed to increase based on the set time. The brake release signal remains active unless a stop or brake apply command is received. If L1-00 is set to 2, whether the feedback indicated of L1-03 is at high level is detected continuously.

9.5.3.4 Brake Apply Preparation Phase

When the brake apply command is received, the brake output does not change immediately, instead, the brake apply preparation phase applies.

- Brake apply condition judgement: When the actual speed keeps lower than the value of L1-16 for a period longer than L1-17, the brake apply conditions are met, the retentive torque and brake apply signal output starts.
- Automatic retentive torque: When L1-06 is set to 1, the torque before brake apply is recorded, which is used as the torque output for the next startup.
- Brake apply: In this phase, the brake apply signal (U1-11 = 0) is outputted and brake apply starts.

9.5.3.5 Brake Apply Phase

The brake apply phase includes “brake apply detection” and “brake applied”.

- Brake apply detection: When the value of U1-11 is set to 0, current output is kept before the brake is applied to prevent the motor from moving. If L1-00 is set to 1, this phase is exited after the time defined by L1-02 elapses. If L1-00 is set to 2, whether the feedback point of L1-03 is at low level can be detected in this phase. If it is at low level, this phase ends. If the delay time defined by L1-02 is reached but the feedback of L1-03 is kept at high level, a brake detection error can be triggered. When this error lasts for a period longer than the time defined by L1-04, the fault ERR84-2 (Brake cannot be applied) is triggered.
- Brake applied: The brake apply signal output is kept unless an operation and brake release command is received. If L1-00 is set to 2, whether the feedback of L1-03 is at low level can be detected continuously.

9.5.3.6 Waiting for Inhibition

The waiting phase starts from the moment when the brake apply command is activated to the moment when the motor reaches zero speed.

When the motor feedback speed keeps lower than the zero speed defined by E1-11 for a period defined by E1-12, the motor reaches zero speed and U1-65 is set to block PWM output. Increasing the value of E1-12 prolongs the excitation time, removing the needs for excitation at next brake release.

9.5.4 Troubleshooting

9.5.4.1 Automatic Memory of Starting Torque

When L1-06 is set to 1, the internal torque memory function of the AC drive is activated. Upon each stop, the torque before brake closing is recorded and will be used as the starting torque output upon next startup, reducing load drop during brake opening. The automatic torque memory function can well adapt to load changes during operation.

When the function is used, a torque fault may occur during the stop process due to external brake faults. In this case, you can set the upper and lower limits of starting torque in L1-09/L1-10 to avoid impact of the torque upon stop due to error on the next startup.

When the automatic torque memory function is activated for the first time, the initial value of the torque memory is sourced from L1-07.

The L1-08 parameter can be set to adjust the coefficient for automatic torque memory. If L1-08 is set to 80% and the memory torque during the stop process is 50%, the starting torque to be established is 40%.

9.5.4.2 Delayed Excitation OFF

To improve the efficiency of the operation, the asynchronous motor needs to generating exciting current for a period of time after the brake applies during stop. In this way, when you start the motor again within a short period of time, the brake can run directly without motor excitation (excitation time for some motors may take 3s to 5s).

When the motor feedback speed keeps lower than the zero speed threshold set by E1-11 for a period longer than E1-12, zero speed is reached. In this case, U1-65 is set and the PWM output is blocked. Therefore, if the value of E1-12 increases, excitation can last longer after the motor reaches the zero speed, eliminating the need for excitation upon next brake release.

In addition, if the brake close action time set by L1-02 is increased, the brake module can force the brake to output current, keeping excitation for a period after stop.

Param.	Name	Description
E1-12	Delay of stop at zero speed	When the actual speed keeps lower than E1-11 for a period longer than E1-12, the PWM output can be blocked.
L1-02	Brake apply action time	After the brake apply signal (U1-11 = 0) is outputted, the PWM output can be blocked only after the time defined by L1-02 elapses.

9.5.4.3 Excitation upon Stop

To improve the working efficiency of asynchronous motors, you may want to keep continuous output of motor exciting current even if the brake is closed during the stop process. In this way, when you start motors again, the brake can directly run without the need of motor excitation (excitation time for some motors may take 3s to 5s).

To enable excitation upon stop, you can enable both RFG input reset and brake zero-speed closing force.

Parameter	Name	Description
b0-00	Start/Stop control word source	3: User-defined
b0-01	User-defined OFF1 source	Connect the PLC excitation command. The value 1 means excitation is enabled.
b1-08	Source of setting RFG reference to 0	Connect the PLC running permission command. The value 1 means running is permitted.
L1-14	Brake zero-speed closing command source	U1-47 [RFG speed reference invalid]

The preceding table takes the running control of channel 1 as an example. After parameters are set according to the preceding table, if b0-01 is set to 1 and b1-08 is set to 0, the AC drive performs pre-excitation for asynchronous motors. After excitation, since b1-08 is set to 0, the RFG speed reference is forced to 0, and U1-47 is 1, the brake module is closed. If b0-01 and b1-08 are set to 1, since U1-47

changes to 0 (associated with b1-08), the brake opening command is automatically generated. During normal operation, when b1-08 is 0, RFG output decelerates. Since U1-47 is set to 1, the brake is automatically closed when the feedback speed reaches 0.

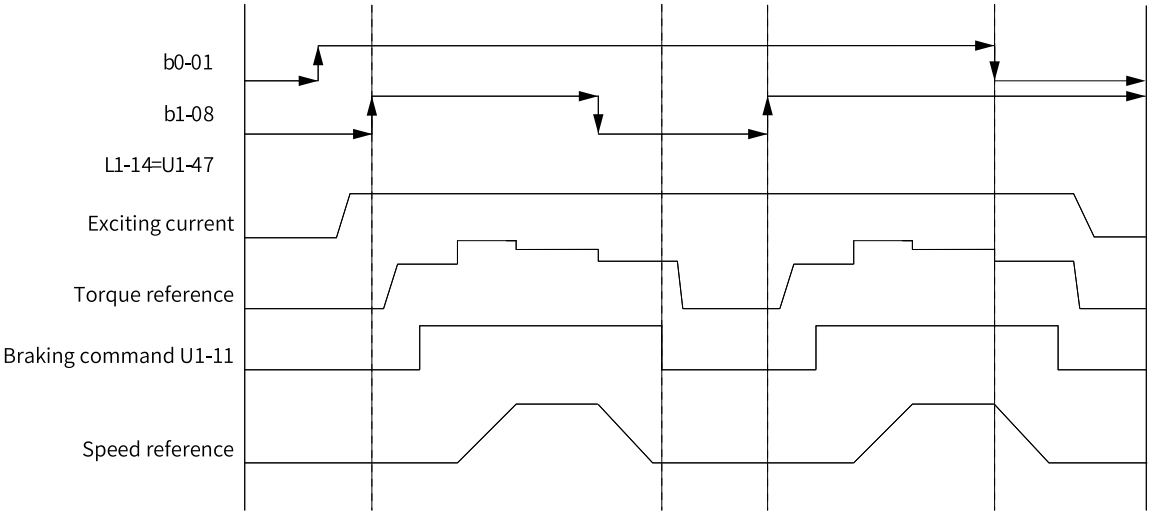


Figure 9-8 Excitation upon stop

9.5.4.4 Starting Torque Restriction

In some lifting load scenarios, the brake can open only when the load torque is greater than the threshold for security reasons. The speed loop does not act before the brake opens. Therefore, the torque cannot be output even if the speed is specified. In this case, set L1-06 for the starting torque. The torque can be measured by using two methods:

- Method 1: Use the comparison function of L1-24 for AC drive torque detection. Set L1-23 to the braking opening comparison value indicated by U6-01, set L1-24 to the comparison threshold, and set L1-25 to a delay time. When the absolute value of L1-23 is greater than L1-24 and the duration exceeds the value indicated by L1-25, the AC drive enters the brake opening state.
- Method 2: The torque is detected on the PLC side. After the conditions are met, the PLC transmits a status bit to the AC drive through communication. Set L1-06 to a starting torque higher than the threshold indicated in L1-24, and then set L1-22 to the received PLC status bit. After the running command is received, the AC drive does not enter the brake opening state until the bit is 1. When the brake is open, setting L1-22 to 0 will not close the brake.

9.5.5 Auto-restart Function upon Brake Failure

In hoisting applications, the brake may wear during long-term operation, resulting in insufficient braking force, which may result in falling of heavy objects even if the brake has applied, leading to safety accidents. After the auto-restart function upon brake failure is enabled, when brake failure is detected, the drive starts automatically to pull the load and operates in zero speed while triggering alarm 84.5. The auto-start function upon brake failure is only active in FVC mode (E0-00 = 1).

Related parameters are shown in the following table.

Param.	Name	Value range	Description
L1-36	Auto-start activation upon brake test failure	0: Inhibited 1: Enabled	When this parameter is set to 1, auto-start can be activated when insufficient braking force is detected in the braking force test stage.
L1-37	Auto-start upon brake failure	0: Inhibited 1: Enabled	The auto-start function upon brake failure is active only in the FVC mode (E0-00 = 1).
L1-38	Brake failure protection detection scheme	0: Scheme 1 1: Scheme 2 2: Activated when conditions for either scheme 1 or scheme 2 are met	In scheme 1, whether the brake fails is determined by detection on the encoder rotation angle. In scheme 1, whether the brake fails is determined by detection on the encoder pulses. If the encoder pulses keeps changing in a fixed direction for a period longer than the time defined by L1-40, the brake fails.
L1-39	Angle threshold of brake failure protection scheme 1	1° to 360°	Take the 1024-PPR encoder as an example, when the angle threshold is set to 60° and the encoder pulses change by 1024x60/360=170 (pulses) at the fundamental frequency, the brake fails.
L1-40	Detection count threshold of brake failure protection scheme 2	10 ms to 250ms	Defines the duration in which the encoder pulses change continuously.
L1-41	Deceleration time for brake failure protection	0s to 600s	Defines the time needed for decelerating from 100% to 0%.

Note

1. During auto-start upon brake failure, the drive operates at zero speed and can start again in positive or negative speed through OFF1 to ensure that the heavy object can be laid down.
2. During auto-start upon brake failure, the drive does not stop upon OFF1 stop command, instead, it decelerates to zero speed based on the ramp-down time and keeps operating at zero speed. The drive stops only upon power-off or upon receiving the emergency stop command (OFF2/OFF3) or encountering faults that can cause stop.
3. The encoder pulse change is detected only when the drive is in the stop state. The stop state refers to when U7-12 [State machine] is in S5 (Ready to start), S6 (pre-drive), and S7 (run preparation). S8 (demagnetization waiting) and S10 (pre-excitation) state. In other state machines, auto-start cannot be triggered even if the encoder pulse change detected reaches the threshold. The OFF2 and OFF3 emergency stop commands can cause the drive to be in the S4 (Switch-on blocked) state, which disables auto-start of the drive.

9.5.6 Configuring Brake Parameters Automatically

Parameters related to brake control can be configured by L1-05. See the following table for related parameters.

Param.	Name	Value range
L1-05	Trigger automatic configuration of brake parameters	0: No action 1: Enable brake without detection information 2: Enable brake with detection information

When L1-05 is set to 1 [Enable brake without detection information], automatic parameter configuration is triggered once. Parameters configured are shown below.

Param.	Name	Default	Macro-configured value
L1-00	Brake function selection	0 [Disable brake]	1 [Enable brake without detection information]
L1-01	Brake release action time	0.2s	0.5s
L1-02	Brake apply action time	0.2s	0.5s
L1-03	Brake feedback point source	0 [Applied]	0 [Applied]
L1-06	Starting torque source in vector control	0 [0]	2 [Digital reference]
L1-07	Digital reference of starting torque	0.0%	50.0%
L1.09	Upper limit of starting torque	200.0%	200.0%
L1-10	Lower limit of starting torque	-200.0%	-200.0%
L1-11	Starting speed enable	0 [Inhibited]	0 [Inhibited]
L1-14	Source for brake apply command at zero speed	0 [Inactive]	0 [Inactive]
L1-15	Forced brake apply command source	0 [Inactive]	0 [Inactive]
L1-16	Speed threshold upon brake apply	3.0%	3.0%
L1-17	Brake apply delay	0.02s	0.02s
L1.18	Brake torque ramp-up time	0.04s	0.04s
L1.19	Brake torque ramp-down time	0.20s	0.20s
L1-22	Brake release command source	1 [Active]	1 [Active]
L1-23	Comparison value source of brake release	0 [0]	0 [0]
L1-30	Brake self-test enable	0 [Inhibited]	0 [Inhibited]
L1-37	Automatic start upon brake failure	0 [Inhibited]	0 [Inhibited]
F1-02	RO1 signal source	0 [Low level]	U1-03 [Fault]
F1-04	RO3 signal source	0 [Low level]	U1-11 [Brake release in progress]

When L1-05 is set to 2 [Enable brake with detection information], automatic parameter configuration is triggered once. Parameters configured are shown below.

Param.	Name	Default	Macro-configured value
L1-00	Brake function selection	0 [Disable brake]	2 [Enable brake with detection information]
L1-01	Brake release action time	0.2s	2.00s
L1-02	Brake apply action time	0.2s	2.00s
L1-03	Brake feedback point source	0 [Applied]	4 [DI3]
L1-06	Starting torque source in vector control	0 [0]	2 [Digital reference]
L1-07	Digital reference of starting torque	0.0%	50.0%
L1.09	Upper limit of starting torque	200.0%	200.0%
L1.10	Lower limit of starting torque	-200.0%	-200.0%
L1-11	Starting speed enable	0 [Inhibited]	0 [Inhibited]
L1-14	Source for brake apply command at zero speed	0 [Inactive]	0 [Inactive]
L1-15	Forced brake apply command source	0 [Inactive]	0 [Inactive]
L1-16	Speed threshold upon brake apply	3.0%	3.0%
L1.17	Brake apply delay	0.02s	0.02s
L1-18	Brake torque ramp-up time	0.04s	0.04s
L1.19	Brake torque ramp-down time	0.20s	0.20s
L1-22	Brake release command source	1 [Active]	1 [Active]
L1-23	Comparison value source of brake release	0 [0]	0 [0]
L1-30	Brake self-test enable	0 [Inhibited]	0 [Inhibited]
L1-37	Automatic start upon brake failure	0 [Inhibited]	0 [Inhibited]
F1-02	RO1 signal source	0 [Low level]	U1-03 [Fault]
F1-04	RO3 signal source	0 [Low level]	U1-11 [Brake release in progress]

9.6 Motor Pre-heating

When the motor is in a high-humidity environment, condensation may easily occur when the motor temperature is low during stop, which may corrode the metal components of the motor, affecting the service life of the motor, or even result in short circuit or explosion. The motor pre-heating function can be used to heat up the motor in the stop state to eliminate condensation. In the pre-heating mode, the drive feeds the DC current to the motor stator winding to achieve the purpose of heating.

Related parameters are as follows.

Param.	Name	Setpoint	Description
o13-21	Motor pre-heating mode enable	0: Disable 1: Enable 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: DIL 9: HDI1 10: HDI2 Others: B connector	In SVC and FVC modes, this signal is active only when the drive is in S3, S4, S5, S6, or S7 state.
o13-22	Motor pre-heating completion signal	0: Inactive 1: Active 2: DI1 3: DI2 4: DI3 5: DI4 6: DI5 7: DI6 8: DIL 9: HDI1 10: HDI2 Others: B connector	When the motor is in the pre-heating state, if the motor pre-heating completion signal is active, the drive immediately triggers a stop command. This signal is level-triggered.
o13-23	Action upon motor pre-heating completion	0: No alert 1: Alarm 2: Fault	When this parameter is set to 1 [Alarm] or 2 [Fault], an alarm or fault is triggered if the motor pre-heating time is reached or the motor pre-heating completion signal is active.
o13-24	Maximum motor pre-heating time	0s to 3000s	The pre-heating function is inactive when this parameter is set to 0. In the pre-heating state, timing starts from the moment the drive enters S12 state machine. When the timing reaches the setpoint, the drive triggers a stop command internally.
o13-25	Motor pre-heating current	0% to 30%	The magnitude of pre-heating current is a percentage to d3-01.

The following table shows the connectors related to motor pre-heating.

Param.	Name	Description
U12-90	Motor pre-heating	This flag is set to 1 when the drive is running in the pre-heating mode.
U12-91	Motor pre-heating mode activation	This flag is set to 1 when the pre-heating mode is activated. The speed, torque, or position modes cannot apply when the pre-heating mode is activated. You need to exit the pre-heating mode first before applying speed, torque, or position control.
U12-92	Motor pre-heating completion flag	In the pre-heating state, this flag is set to 1 when the pre-heating time reaches the time set by o13-24 or set to 1 when the pre-heating completion signal (o13-22) is active. When U12-90 is set to 1 during motor pre-heating, the flag is cleared. This flag is cleared when the pre-heating mode does not apply.

Motor pre-heating mode activation:

When the drive is in the stop state, the pre-heating mode is activated when o13-21 (Signal source reference) is active. When the pre-heating mode is activated, the drive enters the motor pre-heating state upon receiving an OFF command. When the pre-heating mode is activated, the value of U12-91 connector is set to 1.

Exiting motor pre-heating mode:

When the drive is in the pre-heating state (U12-90 = 1), it does not exit the pre-heating mode if o13-21 [Signal source reference] is inactive. The drive can exit the pre-heating mode only when the drive is in the stop state and o13-21 [Signal source reference] is inactive. When the drive exits the pre-heating mode, the value of U12-91 connector is set to 0. Speed control or torque control can be applied only after the drive exits the pre-heating mode and receives and OFF1 command.

Note

- In the pre-heating state of the motor, the internal stop command can be triggered upon pre-heating time arrival or pre-heating completion signal, or upon the OFF2/OFF3/ run-enabled stop signals.
- The motor pre-heating function is supported only in SVC and FVC modes.

9.7 Energy Conservation Statistics

The energy conservation statistics function can be used to record the power output and the power saved over a period of time, as well as the amount saved during this period. When the output power of the drive is lower than the set reference power, energy conservation is achieved. Therefore, set an accurate reference power to improve the accuracy of power statistics. Reference power is usually set dynamically by the user.

The following table shows the related parameters.

Param.	Name	Description
L18-60	Start year of energy conservation	These read-only parameters are used t indicate the start time of energy conservation. L18-81 and L18-82 can be used to update the current time to L18-60 to L18-62.
L18-61	Start date of energy conservation	
L18-62	Start time of energy conservation	
L18-63	Output power during energy conservation	This parameter is read-only and retentive upon power failure. It indicates the cumulative power outputted since the moment when statistics starts.
L18-64	Power saved during energy conservation	This parameter is read-only and retentive upon power failure. It indicates the cumulative power saved since the moment when statistics starts.
L18-65	Amount saved (x 1000000) during energy conservation	This parameter is read-only and retentive upon power failure. It indicates the cumulative amount saved since the moment when statistics starts.
L18-66	Amount saved (x 1000) during energy conservation	
L18-67	Amount saved (x 1) during energy conservation	
L18-75	Effective reference power	This read-only parameter indicates the effective reference power.
L18-76	Reference power source	The motor power is used as the source of reference power by default.
L18-77	Digital reference of the reference power	When L18-76 is set to 1, the reference power can be set by L18-77.
L18-78	Price 1 of power per kWh	L18-80 can be used to select between price 1 and price 2 for calculating the amount saved.
L18-79	Price 2 of power per kWh	
L18-80	Price source	
L18-81	Energy conservation statistics reset	During reset, set L18-81 to 1 [Energy statistics reset] and L18-82 to 1 [OK]. In this case, L18-60 to L18-62 are restored to the current time. L18-63 to L18-67 are cleared.
L18-82	Acknowledgment of energy conservation statistics reset	

9.8 Statistics of Relay Service Life

The relay service life statistics function records the number of operations of the RO1, RO2, and RO3 relays on the HCU. If the action upon expiration of the service life is set in L18-00, an or fault can be reported when the residual service life reaches the set alarm/fault threshold, alerting users to replacement of the relay, preventing safety risks caused by use of a relay that should have been retired.

Related parameters are shown in the following table.

Param.	Name	Description
L18-00	Action when relay (RO1/ RO2/RO3) service life reached	The default value is 0, that is, no alarm or fault is reported when the residual service life of the relay reaches the alarm or fault threshold. Action types of the three relays can be set separately. Take RO1 as an example, if L18-00 is set to 001, an alarm is reported when the residual service life of RO1 reaches the alarm/fault threshold defined by L18-02. When L18-00 is set to 002, a fault is reported when the residual service life of RO1 reaches the fault threshold defined by L18-03. When the alarm threshold defined by L18-02 is reached, no alarm or fault is reported. When L18-00 is set to 003, an alarm is reported when the residual service life of RO1 reaches the alarm threshold defined by L18-02, or a fault is reported when the fault threshold defined by L18-03 is reached.
L18-02	Threshold of relay (RO1) residual service life alarm	Defines the residual service life alarm threshold of RO1 in percentages. The value 100.0% corresponds to 50000 operations.
L18-03	Threshold of relay (RO1) residual service life fault	Defines the residual service life fault threshold of RO1 in percentages. The value 100.0% corresponds to 50000 operations.
L18-05	Displayed value of residual service life of the relay (RO1)	This is a read-only parameter that displays the residual service life of RO1 in percentages. The value 100.0% corresponds to 50000 operations.
L18-08	Threshold of relay (RO2) residual service life alarm	Defines the residual service life alarm threshold of RO2 in percentages. The value 100.0% corresponds to 50000 operations.
L18-09	Threshold of relay (RO2) residual service life fault	Defines the residual service life fault threshold of RO2 in percentages. The value 100.0% corresponds to 50000 operations.
L18-11	Displayed value of residual service life of the relay (RO2)	This is a read-only parameter that displays the residual service life of RO2 in percentages. The value 100.0% corresponds to 50000 operations.
L18-14	Threshold of relay (RO3) residual service life alarm	Defines the residual service life alarm threshold of RO3 in percentages. The value 100.0% corresponds to 50000 operations generally. For crane-specific HCUs, the value 100.0% corresponds to 100000 operations.
L18-15	Threshold of relay (RO3) residual service life fault	Defines the residual service life fault threshold of RO3 in percentages. The value 100.0% corresponds to 50000 operations generally. For crane-specific HCUs, the value 100.0% corresponds to 100000 operations.
L18-17	Displayed value of residual service life of the relay (RO3)	This is a read-only parameter that displays the residual service life of RO3 in percentages. The value 100.0% corresponds to 50000 operations generally. For crane-specific HCUs, the value 100.0% corresponds to 100000 operations.
A8-13	Reset service life count	Used to reset the service life count of the relay, which can be executed separately on each relay. Select the relay to be reset through A8-13 and set A8-14 to 1 [OK].
A8-14	Acknowledgment on reset of the service life count	

Note

Only professionals are allowed to reset the service life of the relay. Failure to comply may result in safety risks.

9.9 Interface Macro

9.9.1 Function of the Interface Macro

The interface macro has been predefined by the manufacturer and is connected to the hardware of the control board. Perform wiring according to the wiring diagram of each interface macro, and then select the corresponding interface macro through parameters, so that corresponding interface macro parameters can be assigned automatically. If the wiring is not consistent with the predefined interface macro, you can change the wiring or modify the related parameters. It is recommended to change the wiring.

9.9.2 Interface Macro Selection

You can set the interface macro needed through A8-45 and A8-46, as shown below.

1. Set A8-45 to the interface macro needed. The definition of the interface macro is described in the related section.
2. Set A8-46 to 1 [OK].
3. After the interface macro is activated, A8-47 displays the active interface macro.

No error can be reported when you set multiple interface macros and all the macros selected are active. A8-47 only displays the last acknowledged interface macro. If the interface macro contains the same parameters, the last active parameter overrides the previous parameter.

Param.	Name	Setpoint
A8-45	Interface macro selection	0: No action 1: Parameter setting for start/stop control by operating panel 2: Controlling fixed speeds through two-wire mode 3: Controlling analog speed regulation through two-wire mode 4: Controlling fixed speeds through three-wire mode 5: Controlling analog speed regulation through three-wire mode 6: Parameter setting for start/stop control by fieldbus adapter 7: Dual-channel switchover parameter setting
A8-46	Interface macro acknowledgment	0: Cancel 1: OK
A8-47	Active interface macro	0: No action 1: Parameter setting for start/stop control by operating panel 2: Controlling fixed speeds through two-wire mode 3: Controlling analog speed regulation through two-wire mode 4: Controlling fixed speeds through three-wire mode 5: Controlling analog speed regulation through three-wire mode 6: Parameter setting for start/stop control by fieldbus adapter 7: Dual-channel switchover parameter setting

When you need to reset the interface macro parameters, set A8-00 [Parameter operation mode] to 1 or 2 [Restore some/all parameters to default], and then set A8-01 [Parameter operation acknowledgment] to 1 [OK]. After parameters are reset, A8-47 [Active interface macro] displays 0 [Inactive].

Param.	Name	Setpoint
A8-00	Parameter operation mode	0: Invalid 1: Restore some parameters to default 2: Restore all parameters to default 3: Clear fault records 4: Clear black box records 5: Clear log records
A8-01	Parameter operation acknowledgment	0: Cancel 1: OK

9.9.3 Definition of Interface Macro

9.9.3.1 Parameter Setting for Start/Stop Control with Operating Panel

Interface macro setting: Set A8-45 to 1 [Parameters for start/stop control by operating panel] and A8-46 to 1 [OK] to activate this interface macro.

Description: In this mode, the start command and speed of the drive are set by SOP-20. If communication between the operating panel and the drive is disconnected after the drive starts, a fault can be reported.

Fault output: RO1

Speed output: AO1

Param.	Name	Default	Macro-configured value
A9-02	Source of motor data set selection 0	0 [0]	0 [0]
A9-03	Source of motor data set selection 1	0 [0]	0 [0]
E0-00	Control mode	2 [V/f]	2 [V/f]
E0-01	Control mode	0 [Speed control]	0 [Speed control]
E1-00	Startup mode	0 [Direct start]	0 [Direct start]
E1-14	OFF1 stop mode	1 [Decelerate to stop]	1 [Decelerate to stop]
E3-00	V/f mode	0 [V/f curve]	0 [V/f curve]
E3-01	V/f curve selection	0 [Linear V/f]	0 [Linear V/f]
A10-00	Operating panel control permission	1 [Allowed]	1 [Allowed]
A10-01	Speed reference in operating panel control	0 [Motorized potentiometer]	0 [Motorized potentiometer]
A10-05	Operating panel open circuit detection selection	0 [Enable]	0 [Enable]
A10-06	Detection time of operating panel disconnection	3.0	3.0s
A10-07	Start/Stop control by SOP-20	0 [SOP-20 active]	0 [SOP-20 active]
A10-09	Retention of SOP-20 local/remote state upon power failure	0 [Non-retentive]	0 [Non-retentive]
F1-02	RO1 signal source	0 [Low level]	U1-03 [Stop-at-fault in progress]
F3-04	AO1 signal source	0 [0]	U5-00 [Actual motor speed (filtered)]
F3-06	AO1 type	0 [0 V to 10 V]	0 [0 V to 10 V]
F3-08	Minimum output scaling of AO1 curve	0.0%	0.0%
F3-09	Minimum output value of AO1 curve	0.000 V	0.000 V
F3-10	Maximum output scaling of AO1 curve	100.0%	100.0%
F3-11	Maximum output value of AO1 curve	10.000 V	10.000 V

9.9.3.2 Controlling Fixed Speeds Through Two-Wire Mode

Interface macro setting: Set A8-45 to 2 [Controlling fixed speeds through two-wire mode] and set A8-46 to 1 [OK] to activate the interface macro.

Description:

Start/Stop control: DI1 - Started upon rising edge, stopped upon OFF; DI2 - Switching between forward/reverse run

Fault reset: DI6

Speed adjustment: DI4 to DI5 - References for fixed speeds. Set multi-speed references 1 to 4 through C6-05 to C6-08.

Fault output: RO1

Speed output: AO1

Param.	Name	Default	Macro-configured value
A9-00	Control channel selection	0 [Reference channel 1]	0 [Reference channel 1]
A9-02	Source of motor data set selection 0	0 [0]	0 [0]
A9-03	Source of motor data set selection 1	0 [0]	0 [0]
E0-00	Control mode	2 [V/f]	2 [V/f]
E0-01	Control mode	0 [Speed control]	0 [Speed control]
E1-00	Startup mode	0 [Direct start]	0 [Direct start]
E1-14	OFF1 stop mode	1 [Decelerate to stop]	1 [Decelerate to stop]
E3-00	V/f mode	0 [V/f curve]	0 [V/f curve]
E3-01	V/f curve selection	0 [Linear V/f]	0 [Linear V/f]
C7-02	bit0 of RFG ramp selection	0 [0]	0 [0]
C7-03	bit1 of RFG ramp selection	0 [0]	0 [0]
C7-04	Ramp 1 acceleration time	20.0s	20.0s
C7-05	Ramp 1 deceleration time	20.0s	20.0s
b0-00	Start/Stop control word source	0 [Terminal start/stop mode]	0 [Terminal start/stop mode]
b4-02	Selection of terminal start/stop module 1/2	0 [Terminal start/stop command 1]	0 [Terminal start/stop command 1]
b4-03	Mode of terminal start/stop command 1	1 [IN1 for start]	2 [IN1 for start, IN2 for direction]
b4-05	Input 1 of terminal start/stop command 1	2 [DI1]	U0-02 [DI1]
b4-06	Input 2 of terminal start/stop command 1	3 [DI2]	U0-03 [DI2]
b4-07	Input 3 of terminal start/stop command 1	0 [Inactive]	0 [Inactive]
b1-04	Fault reset source 2	0 [Inactive]	U0-07 [DI6]
C0-00	Main speed source in speed control	0 [0]	U9-30 [Multi-reference selection output]
C6-01	Multi-reference selection bit0	0 [0]	U0-05 [DI4]
C6-02	Multi-reference selection bit1	0 [0]	U0-06 [DI5]
C6-03	Multi-reference selection bit2	0 [0]	0 [0]
C6-04	Multi-reference selection bit3	0 [0]	0 [0]

Param.	Name	Default	Macro-configured value
C6-05	Multi-reference 1	10.0%	20.0%
C6-06	Multi-reference 2	10.0%	30.0%
C6-07	Multi-reference 3	0.0%	40.0%
C6-08	Multi-reference 4	0.0%	50.0%
F1-02	RO1 signal source	0 [Low level]	U1-03 [Fault]
F3-04	AO1 signal source	0 [0]	U5-00 [Actual motor speed (filtered)]
F3-06	AO1 type	0 [0 V to 10 V]	0 [0 V to 10 V]
F3-08	Minimum output scaling of AO1 curve	0.0%	0.0%
F3-09	Minimum output value of AO1 curve	0.000 V	0.000 V
F3-10	Maximum output scaling of AO1 curve	100.0%	100.0%
F3-11	Maximum output value of AO1 curve	10.000 V	10.000 V

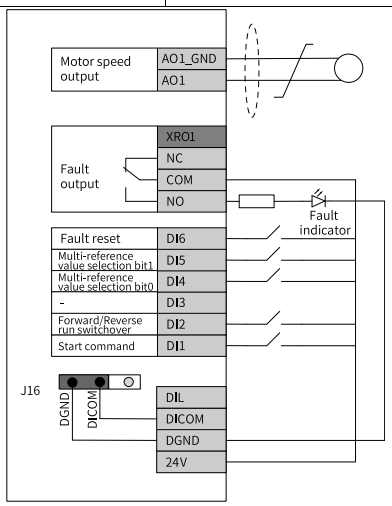


Figure 9-9 Controlling fixed speeds through two-wire mode

9.9.3.3 Controlling Analog Speed Adjustment Through Two-Wire Mode

Interface macro setting: Set A8-45 to 3 [Controlling analog speed adjustment through two-wire mode] and A8-46 to 1 [OK] to activate this interface macro.

Description:

Start/Stop control: DI1 - Started upon rising edge, stopped upon OFF; DI2 - Switching between forward/reverse run

Fault reset: DI6

Speed adjustment: The speed is set through AI1. Voltage input (0 V to 10 V) applies to AI1 by default.

Fault output: RO1

Speed output: AO1

Param.	Name	Default	Macro-configured value
A9-00	Control channel selection	0 [Reference channel 1]	0 [Reference channel 1]
A9-02	Source of motor data set selection 0	0 [0]	0 [0]
A9-03	Source of motor data set selection 1	0 [0]	0 [0]
E0-00	Control mode	2 [V/f]	2 [V/f]
E0-01	Control mode	0 [Speed control]	0 [Speed control]
E1-00	Startup mode	0 [Direct start]	0 [Direct start]
E1-14	OFF1 stop mode	1 [Decelerate to stop]	1 [Decelerate to stop]
E3-00	V/f mode	0 [V/f curve]	0 [V/f curve]
E3-01	V/f curve	0 [Linear V/f]	0 [Linear V/f]
C7-02	RFG ramp selection 1	0 [0]	0 [0]
C7-03	RFG ramp selection 2	0 [0]	0 [0]
C7-04	Ramp 1 acceleration time	20.0s	20.0s
C7-05	Ramp 1 deceleration time	20.0s	20.0s
b0-00	Start/Stop control word source	0 [Terminal start/stop mode]	0 [Terminal start/stop mode]
b4-02	Selection of terminal start/stop command 1/2	0 [Terminal start/stop command 1]	0 [Terminal start/stop command 1]
b4-03	Mode of terminal start/ stop command 1	1 [IN1 for start]	2 [IN1 for start, IN2 for direction]
b4-05	Input 1 of terminal start/ stop command 1	2 [DI1]	U0-02 [DI1]
b4-06	Input 2 of terminal start/ stop command 1	3 [DI2]	U0-03 [DI2]
b4-07	Input 3 of terminal start/ stop command 1	0 [Inactive]	0 [Inactive]
b1-04	Fault reset source 2	0 [Inactive]	U0-07 [DI6]
C0-00	Main speed source in speed control	0 [0]	U5-18 [AI1 input scaling]
F2-04	AI1 type	0 [–10 V to +10 V]	1 [0 V to 10 V]
F2-06	Minimum input value of AI1 curve	0.000 V	0.000 V
F2-07	Minimum input scaling of AI1 curve	0.0%	0.0%
F2-08	Maximum input value of AI1 curve	10.000 V	10.000 V
F2-09	Maximum input scaling of AI1 curve	100.0%	100.0%
F2-20	AI1 selection	1 [Enable]	1 [Enable]
F1-02	RO1 signal source	0 [Low level]	U1-03 [Fault]
F3-04	AO1 signal source	0 [0]	U5-00 [Actual motor speed (filtered)]
F3-06	AO1 type	0 [0 V to 10 V]	0 [0 V to 10 V]
F3-08	Minimum output scaling of AO1 curve	0.0%	0.0%
F3-09	Minimum output value of AO1 curve	0.000 V	0.000 V

Param.	Name	Default	Macro-configured value
F3-10	Maximum output scaling of AO1 curve	100.0%	100.0%
F3-11	Maximum output value of AO1 curve	10.000 V	10.000 V

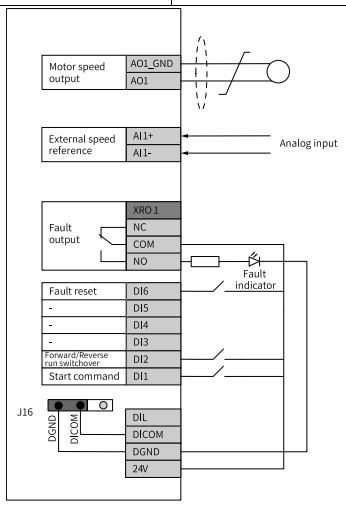


Figure 9-10 Controlling analog speed adjustment through two-wire mode

9.9.3.4 Controlling Fixed Speeds Through Three-Wire Mode

Interface macro setting: Set A8-45 to 4 [Three-wire control for multiple fixed speeds], and set A8-46 to 1 [OK] to activate the interface macro.

Description:

Start/Stop control: DI1- Forward run upon rising edge; DI2 - Reverse run upon rising edge; DI3- Stop upon OFF

Fault reset: DI6

Speed adjustment: DI4 to DI5 - References for fixed speeds. Set multi-speed references 1 to 4 through C6-05 to C6-08.

Fault output: RO1

Speed output: AO1

Param.	Name	Default	Macro-configured value
A9-00	Control channel selection	0 [Reference channel 1]	0 [Reference channel 1]
A9-02	Source of motor data set selection 0	0 [0]	0 [0]
A9-03	Source of motor data set selection 1	0 [0]	0 [0]
E0-00	Control mode	2 [V/f]	2 [V/f]
E0-01	Control mode	0 [Speed control]	0 [Speed control]
E1-00	Startup mode	0 [Direct start]	0 [Direct start]
E1-14	OFF1 stop mode	1 [Decelerate to stop]	1 [Decelerate to stop]
E3-00	V/f mode	0 [V/f curve]	0 [V/f curve]
E3-01	V/f curve	0 [Linear V/f]	0 [Linear V/f]
C7-02	RFG ramp selection 1	0 [0]	0 [0]

Param.	Name	Default	Macro-configured value
C7-03	RFG ramp selection 2	0 [0]	0 [0]
C7-04	Ramp 1 acceleration time	20.0s	20.0s
C7-05	Ramp 1 deceleration time	20.0s	20.0s
b0-00	Start/Stop control word source	0 [Terminal start/stop mode]	0 [Terminal start/stop mode]
b4-02	Selection of terminal start/stop module 1/2	0 [Terminal start/stop command 1]	0 [Terminal start/stop command 1]
b4-03	Mode of terminal start/ stop command 1	1 [I1N for start]	6 [IN1P for forward start, IN2P for reverse start, IN3 for stop]
b4-05	Input 1 of terminal start/stop command 1	2 [DI1]	U0-02 [DI1]
b4-06	Input 2 of terminal start/stop command 1	3 [DI2]	U0-03 [DI2]
b4-07	Input 3 of terminal start/stop command 1	0 [Inactive]	U0-04 [DI3]
b1-04	Fault reset source 2	0 [Inactive]	U0-07 [DI6]
C0-00	Main speed source in speed control	0 [0]	U9-30 [Multi-reference selection output]
C6-01	Multi-reference selection bit0	0 [0]	U0-05 [DI4]
C6-02	Multi-reference selection bit1	0 [0]	U0-06 [DI5]
C6-03	Multi-reference selection bit2	0 [0]	0 [0]
C6-04	Multi-reference selection bit3	0 [0]	0 [0]
C6-05	Multi-reference 1	10.0%	20.0%
C6-06	Multi-reference 2	10.0%	30.0%
C6-07	Multi-reference 3	0.0%	40.0%
C6-08	Multi-reference 4	0.0%	50.0%
F1-02	RO1 signal source	0 [Low level]	U1-03 [Fault]
F3-04	AO1 signal source	0 [0]	U5-00 [Actual motor speed (filtered)]
F3-06	AO1 type	0 [0 V to 10 V]	0 [0 V to 10 V]
F3-08	Minimum output scaling of AO1 curve	0.0%	0.0%
F3-09	Minimum output value of AO1 curve	0.000 V	0.000 V
F3-10	Maximum output scaling of AO1 curve	100.0%	100.0%
F3-11	Maximum output value of AO1 curve	10.000 V	10.000 V

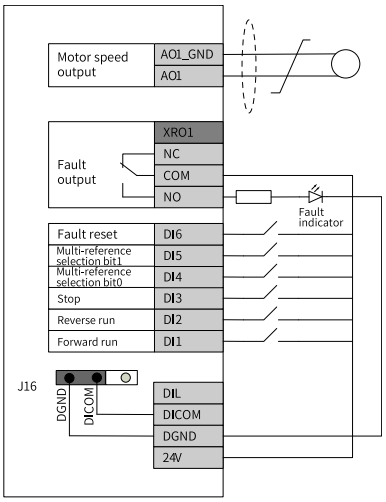


Figure 9-11 Controlling fixed speeds through three-wire mode

9.9.3.5 Controlling Analog Adjustment Through Three-Wire Mode

Interface macro setting: Set A8-45 to 5 [Controlling analog adjustment through three-wire mode] and A8-46 to 1 [OK] to activate this interface macro.

Description:

Start/Stop control: DI1- Forward run upon rising edge; DI2 - Reverse run upon rising edge; DI3- Stop upon OFF

Fault reset: DI6

Speed adjustment: The speed is set through AI1. Voltage input (0 V to 10 V) applies to AI1 by default.

Fault output: RO1

Speed output: AO1

Param.	Name	Default	Macro-configured value
A9-00	Control channel selection	0 [Reference channel 1]	0 [Reference channel 1]
A9-02	Source of motor data set selection 0	0 [0]	0 [0]
A9-03	Source of motor data set selection 1	0 [0]	0 [0]
E0-00	Control mode	2 [V/f]	2 [V/f]
E0-01	Control mode	0 [Speed control]	0 [Speed control]
E1-00	Startup mode	0 [Direct start]	0 [Direct start]
E1-14	OFF1 stop mode	1 [Decelerate to stop]	1 [Decelerate to stop]
E3-00	V/f mode	0 [V/f curve]	0 [V/f curve]
E3-01	V/f curve	0 [Linear V/f]	0 [Linear V/f]
C7-02	RFG ramp selection 1	0 [0]	0 [0]
C7-03	RFG ramp selection 2	0 [0]	0 [0]
C7-04	Ramp 1 acceleration time	20.0s	20.0s
C7-05	Ramp 1 deceleration time	20.0s	20.0s

Param.	Name	Default	Macro-configured value
b0-00	Start/Stop control word source	0 [Terminal start/stop mode]	0 [Terminal start/stop mode]
b4-02	Selection of terminal start/stop module 1/2	0 [Terminal start/stop command 1]	0 [Terminal start/stop command 1]
b4-03	Mode of terminal start/ stop command 1	1 [IN1 for start]	6 [IN1P for forward start, IN2P for reverse start, IN3 for stop]
b4-05	Input 1 of terminal start/stop command 1	2 [DI1]	U0-02 [DI1]
b4-06	Input 2 of terminal start/stop command 1	3 [DI2]	U0-03 [DI2]
b4-07	Input 3 of terminal start/stop command 1	0 [Inactive]	U0-04 [DI3]
b1-04	Fault reset source 2	0 [Inactive]	U0-07 [DI6]
C0-00	Main speed source in speed control	0 [0]	U5-18 [AI1 input scaling]
F2-04	AI1 type	0 [-10 V to +10 V]	1 [0 V to 10 V]
F2-06	Minimum input value of AI1 curve	0.000 V	0.000 V
F2-07	Minimum input scaling of AI1 curve	0.0%	0.0%
F2-08	Maximum input value of AI1 curve	10.000 V	10.000 V
F2-09	Maximum input scaling of AI1 curve	100.0%	100.0%
F2-20	AI1 selection	1 [Enable]	1 [Enable]
F1-02	RO1 signal source	0 [Low level]	U1-03 [Fault]
F3-04	AO1 signal source	0 [0]	U5-00 [Actual motor speed (filtered)]
F3-06	AO1 type	0 [0 V to 10 V]	0 [0 V to 10 V]
F3-08	Minimum output scaling of AO1 curve	0.0%	0.0%
F3-09	Minimum output value of AO1 curve	0.000 V	0.000 V
F3-10	Maximum output scaling of AO1 curve	100.0%	100.0%
F3-11	Maximum output value of AO1 curve	10.000 V	10.000 V

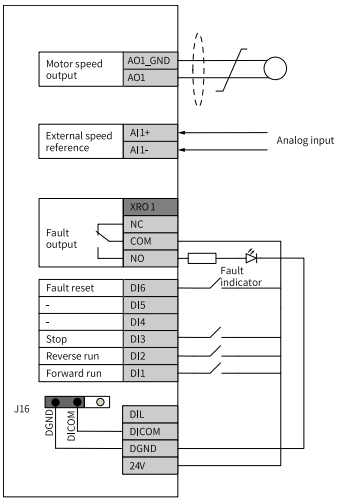


Figure 9-12 Controlling analog adjustment through three-wire mode

9.9.3.6 Controlling Start/Stop Parameters Through Fieldbus Adapter

Interface macro setting: Set A8-45 to 6 [Fieldbus adapter control start/stop parameter setting], and set A8-46 to 1 [OK] to activate the interface macro.

Description: The default configuration is DP communication.

Commands received by the drive: PZD1 as the control word and PZD2 as the speed reference

Drive feedback state: PZD1 as status word 1 and PZD2 as the actual motor speed

Fault output: RO1

Speed output: AO1

Param.	Name	Default	Macro-configured value
A9-00	Control channel	0 [Reference channel 1]	0 [Reference channel 1]
A9-02	Source of motor data set selection 0	0 [0]	0 [0]
A9-03	Source of motor data set selection 1	0 [0]	0 [0]
E0-00	Control mode	2 [V/f]	2 [V/f]
E0-01	Control mode	0 [Speed control]	0 [Speed control]
E1-00	Startup mode	0 [Direct start]	0 [Direct start]
E1-14	OFF1 stop mode	1 [Decelerate to stop]	1 [Decelerate to stop]
E3-00	V/f mode	0 [V/f curve]	0 [V/f curve]
E3-01	V/f curve	0 [Linear V/f]	0 [Linear V/f]
C7-02	RFG ramp selection 1	0 [0]	0 [0]
C7-03	RFG ramp selection 2	0 [0]	0 [0]
C7-04	Ramp 1 acceleration time	20.0s	20.0s
C7-05	Ramp 1 deceleration time	20.0s	20.0s
b0-00	Start/Stop control word source	0 [Terminal start/stop module]	3 [Custom setting]
b0-01	Source of custom OFF1	0 [Inactive]	U2-00 [bit00 of input PZD1 of bus adapter A]

Param.	Name	Default	Macro-configured value
b0-02	Source 1 of custom OFF2	1 [Inactive]	U2-01 [bit01 of input PZD1 of bus adapter A]
b0-03	Source 1 of custom OFF3	1 [Inactive]	U2-02 [bit02 of input PZD1 of bus adapter A]
b0-04	Custom operation permission source	1 [Operation allowed]	U2-03 [bit03 of input PZD1 of bus adapter A]
b0-05	Custom fault reset source 1	0 [Inactive]	U2-07 [bit07 of input PZD1 of bus adapter A]
b0-08	Custom speed inversion source	0 [Inactive]	U2-11 [bit11 of input PZD1 of bus adapter A]
C0-00	Main speed source in speed control	0 [Digital reference]	U5-45 [PZD2 of bus adapter A]
n1-00	Applicable bus type of bus adapter	0 [None]	7 [Profibus-DP module]
n1-01	Open circuit detection delay of bus adapter A	0.1s	0.1s
n1-02	Communication mode selection of bus adapter A	0 [Standard mode]	0
n1-03	Continuous CRC error detection setting in communication	0	0
n1-04	Process data output 1	0 [0]	U8-09 [Status word 1]
n1-05	Process data output 2	0 [0]	U5-00 [Actual motor speed (filtered)]
n1-20	Communication base value of process data output 1	0	0
n1-22	Communication base value of process data output 2	0	0
n1-36	Communication base value of process data input 1	0	0
n1-37	Communication base value of process data input 2	0	0
n16-00	Expansion slot selection	0 [Disable]	1 [Expansion slot 1_1]
n16-02	Expansion card station number	1	1
n16-09	Feature code	0 [Default]	0 [Default]
n16-10	DP data check bit	0 [bit10 of PZD1 by default]	0 [bit10 of PZD1 by default]
F1-02	RO1 signal source	0 [Low level]	U1-03 [Stop-at-fault in progress]
F3-04	AO1 signal source	0 [0]	U5-00 [Actual motor speed (filtered)]
F3-06	AO1 type	0 [0 V to 10 V]	0 [0 V to 10 V]
F3-08	Minimum output scaling of AO1 curve	0.0%	0.0%
F3-09	Minimum output value of AO1 curve	0.000 V	0.000 V

Param.	Name	Default	Macro-configured value
F3-10	Maximum output scaling of AO1 curve	100.0%	100.0%
F3-11	Maximum output value of AO1 curve	10.000 V	10.000 V

9.9.3.7 Dual-channel Switchover Parameters

Interface macro setting: Set A8-45 to 7 [Dual channel parameter switchover setting] and A8-46 is set to 1 [OK].

Description: Switch the start/stop command of dual channels through A9-00.

1. Command channel 1: Control the start/stop parameter setting through the fieldbus adapter, see details in *"9.9.3.6 Controlling Start/Stop Parameters Through Fieldbus Adapter" on page 449*.
2. Command channel 2: Control the analog speed regulation through the two-wire control mode. See details in *"9.9.3.3 Controlling Analog Speed Adjustment Through Two-Wire Mode" on page 443*.
   Start/stop control: DI1 - Start upon rising edge start, stop upon OFF; DI2 - Switchover between forward and reverse directions

   Fault reset: DI3

   Speed adjustment: AI1 is inputted through AI1. Voltage (0 V to 10 V) input mode is used for AI1 by default.
3. DI4 is used for switchover between channel 1 and channel 2.

Fault output: RO1

Speed output: AO1

Param.	Name	Default	Macro-configured value
A9-00	Control channel selection	0 [Reference channel 1]	U0-05 [DI4]
A9-02	Source of motor data set selection 0	0 [0]	0 [0]
A9-03	Source of motor data set selection 1	0 [0]	0 [0]
E0-00	Control mode	2 [V/f]	2 [V/f]
E0-01	Control mode	0 [Speed control]	0 [Speed control]
E1-00	Startup mode	0 [Direct start]	0 [Direct start]
E1-14	OFF1 stop mode	1 [Decelerate to stop]	1 [Decelerate to stop]
E3-00	V/f mode	0 [V/f curve]	0 [V/f curve]
E3-01	V/f curve selection	0 [Linear V/f]	0 [Linear V/f]
C7-02	RFG ramp selection 1	0 [0]	0 [0]
C7-03	RFG ramp selection 2	0 [0]	0 [0]
C7-04	Ramp 1 acceleration time	20.0s	20.0s
C7-05	Ramp 1 deceleration time	20.0s	20.0s
b0-00	Start/Stop control word source	0 [Terminal start/stop module]	3 [Custom setting]
b0-01	Source of custom OFF1	0 [Inactive]	U2-00 [bit00 of input PZD1 of bus adapter A]

Param.	Name	Default	Macro-configured value
b0-02	Source 1 of custom OFF2	1 [Inactive]	U2-01 [bit01 of input PZD1 of bus adapter A]
b0-03	Source 1 of custom OFF3	1 [Inactive]	U2-02 [bit02 of input PZD1 of bus adapter A]
b0-04	Custom operation permission source	1 [Operation allowed]	U2-03 [bit03 of input PZD1 of bus adapter A]
b0-05	Custom fault reset source 1	0 [Inactive]	U2-07 [bit07 of input PZD1 of bus adapter A]
b0-08	Custom speed inversion source	0 [Inactive]	U2-11 [bit011 of input PZD1 of bus adapter A]
C0-00	Source of main speed in speed control	0 [Digital reference]	U5-45 [PZD2 of bus adapter A]
n1-00	Bus type of bus adapter A	0 [None]	7 [PROFIBUS-DP module]
n1-01	Open circuit detection delay of bus adapter A	0.1s	0.1s
n1-02	Communication mode selection of bus adapter A	0 [Standard mode]	0
n1-03	Continuous CRC error detection setting in communication	0	0
n1-04	Process data output 1	0 [0]	U8-09 [Internal status word 1]
n1-05	Process data output 2	0 [0]	U5-00 [Actual motor speed (filtered)]
n1-20	Communication base value of process data output 1	0	0
n1-21	Communication base value of process data output 2	0	0
n1-36	Communication base value of process data input 1	0	0
n1-37	Communication base value of process data input 2	0	0
n16-00	Expansion slot selection	0 [Disable]	1 [Expansion slot 1_1]
n16-02	Expansion card station number	1	1
n16-09	Feature code	0 [Default]	0 [Default]
n16-10	DP data check bit	0 [bit10 of PZD1 by default]	0 [bit10 of PZD1 by default]
b2-00	Start/Stop control word source	0 [Terminal start/stop mode]	0 [Terminal start/stop mode]
b4-02	Selection of terminal start/stop command 1/2	0 [Terminal start/stop command 1]	0 [Terminal start/stop command 1]
b4-03	Mode of terminal start/stop command 1	1 [IN1 for start]	2 [IN1 for start, IN2 for direction]
b4-05	Input 1 of terminal start/stop command 1	2 [DI1]	U0-02 [DI1]

Param.	Name	Default	Macro-configured value
b4-06	Input 2 of terminal start/stop command 1	3 [DI2]	U0-03 [DI2]
b4-07	Input 3 of terminal start/stop command 1	0 [Inactive]	0 [Inactive]
b3-04	Fault reset source 2	0 [Inactive]	U0-07 [DI6]
C2-00	Main speed source in speed control	0 [0]	U5-18 [AI1 input scaling]
F2-04	AI1 type	0 [–10 V to +10 V]	1 [0 V to 10 V]
F2-06	Minimum input value of AI1 curve	0.000 V	0.000 V
F2-07	Minimum input scaling of AI1 curve	0.0%	0.0%
F2-08	Maximum input value of AI1 curve	10.000 V	10.000 V
F2-09	Maximum input scaling of AI1 curve	100.0%	100.0%
F2-20	AI1 selection	1 [Enable]	1 [Enable]
F1-02	RO1 signal source	0 [Low level]	U1-03 [Stop-at-fault in progress]
F3-04	AO1 signal source	0 [0]	U5-00 [Actual motor speed (filtered)]
F3-06	AO1 type	0 [0 V to 10 V]	0 [0 V to 10 V]
F3-08	Minimum output scaling of AO1 curve	0.0%	0.0%
F3-09	Minimum output value of AO1 curve	0.000 V	0.000 V
F3-10	Maximum output scaling of AO1 curve	100.0%	100.0%
F3-11	Maximum output value of AO1 curve	10.000 V	10.000 V

9.10 Carrier Frequency Adjusted with Speed

The drive operates at a fixed preset carrier frequency throughout the entire output frequency range by default. However, for high-frequency motors, the current during low-speed operation reaches nearly three times of that during high-speed operation. If high carrier frequency applies during low-speed operation, the power rating of the drive needs to be multiplied by 3 as well, which is a challenge for drive model selection. In this case, you can apply linear change on the output frequency of the set carrier frequency, allow low carrier frequency at low-speed operation and high carrier frequency at high-speed operation to achieve derating of the carrier frequency.

Related parameters are shown below.

Param.	Name	Setpoint	Description
A4-36	Carrier frequency adjusted with speed	0: Inhibited 1: Enabled	When set to 0 [Inhibited], the carrier frequency is fixed to the value of A4-02. When set to 1 [Enable], the carrier frequency changes with the speed.
A4-37	Carrier frequency adjustment	0.10 kHz to 1.00 kHz	Increment of carrier frequency adjustment

Param.	Name	Setpoint	Description
A4-38	Lower limit of carrier frequency adjustment	1.25 kHz to 10.00 kHz	Carrier frequency lower limit during adjustment
A4-40	Upper limit of carrier frequency adjustment	4.00 kHz to 12.00 kHz	Carrier frequency upper limit during adjustment
A4-41	Carrier frequency ratio	10.00 kHz to 24.00 kHz	Defines the ratio of carrier frequency to output frequency (K), which equals to carrier frequency/output frequency.

Set A4-36 to 1 [Enable] to enable the carrier frequency to be adjusted with the speed, as shown below.

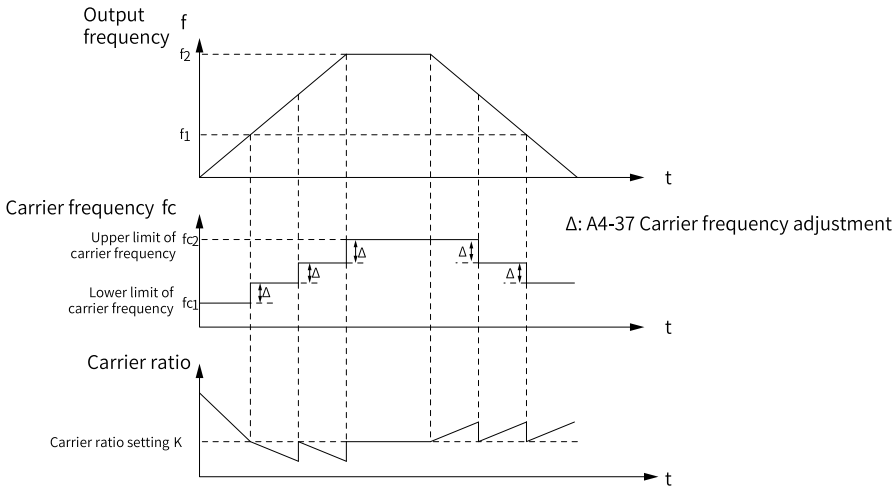


Figure 9-13 Carrier frequency adjusted with speed

Note

Set A4-38 [Lower limit adjustment of carrier frequency] to a value lower than A4-40 [Upper limit adjustment of carrier frequency]. Otherwise, the carrier frequency cannot be adjusted with the speed even if A4-36 [Carrier frequency adjusted with speed] is set to 1 [Enable].

9.11 Process Parameter Module

9.11.1 Switching Process Parameter Group

The HCU-50S/51S control module supports up to four groups of process parameters, and each group includes a process setting parameter group and a process controller parameter group. You can switch the active process setting parameter group and process controller parameter group through A9-04 and A9-05.

Parameter	Name	Description
A9-04	Process parameter group selection 0 source	A9-04/A9-05: 00: o0 (process setting parameter group 1) o1 (process controller parameter group 1) 01: o2 (process setting parameter group 2) o3 (process controller parameter group 2) 10: o4 (process setting parameter group 3) o5 (process controller parameter group 3) 11: o6 (process setting parameter group 4) o7 (process controller parameter group 4)
A9-05	Process parameter group selection 1 source	

9.11.2 Execution Sequence

To use group o (Process parameters) and group P (User-defined function blocks), define the execution sequence first. The execution sequence value ranges from 0 to 65535, and the function block with a lower execution sequence value is calculated first. For example, setting P9-04 to 1 indicates that the execution sequence of process setting word parameter 1 is 1 and setting P9-05 to 2 indicates that the execution sequence of process setting word parameter 2 is 2. Process setting word parameter 1 is calculated before 2.

When the execution sequences of two free function blocks are the same, P9-00 to P9-03 display the type and group of the two conflict blocks so that they can be located. For example, if P9-04 is set to 1 and P9-05 is also set to 1, P9-00 to P9-03 display as follows.

Param.	Name	Current value
P9-00	Type of execution sequence conflict module 1	27 [process setting word parameter in group P9]
P9-01	Group of execution sequence conflict module 1	1
P9-02	Type of execution sequence conflict module 2	27 [process setting word parameter in group P9]
P9-03	Group of execution sequence conflict module 2	2
P9-04	Execution sequence of process setting word parameter 1	1
P9-05	Execution sequence of process setting word parameter 2	1

Note

For individual process parameters and user-defined function blocks, you need to enable a user-defined function block in A8-15 and set its execution sequence.

9.11.3 Process Setting Parameter Group

There are four process setting parameter groups, which can be switched with A9-04 and A9-05.

Similar to constant setting modules 6 to 10 (with two decimal points), the parameters and connector parameters corresponding to process setting word parameters 1 to 14 are shown in the following table.

Process Setting Word Parameter	Process Setting Parameter Group 1		Process Setting Parameter Group 2		Process Setting Parameter Group 3		Process Setting Parameter Group 4	
	Input	Output	Input	Output	Input	Output	Input	Output
	I	O	I	O	I	O	I	O
1	o0-00	U19-67	o2-00	U19-67	o4-00	U19-67	o6-00	U19-67
2	o0-01	U19-68	o2-01	U19-68	o4-01	U19-68	o6-01	U19-68
3	o0-02	U19-69	o2-02	U19-69	o4-02	U19-69	o6-02	U19-69
4	o0-03	U19-70	o2-03	U19-70	o4-03	U19-70	o6-03	U19-70
5	o0-04	U19-71	o2-04	U19-71	o4-04	U19-71	o6-04	U19-71
6	o0-05	U19-72	o2-05	U19-72	o4-05	U19-72	o6-05	U19-72
7	o0-06	U19-73	o2-06	U19-73	o4-06	U19-73	o6-06	U19-73
8	o0-07	U19-74	o2-07	U19-74	o4-07	U19-74	o6-07	U19-74
9	o0-08	U19-75	o2-08	U19-75	o4-08	U19-75	o6-08	U19-75
10	o0-09	U19-76	o2-09	U19-76	o4-09	U19-76	o6-09	U19-76
11	o0-10	U19-77	o2-10	U19-77	o4-10	U19-77	o6-10	U19-77
12	o0-11	U19-78	o2-11	U19-78	o4-11	U19-78	o6-11	U19-78
13	o0-12	U19-79	o2-12	U19-79	o4-12	U19-79	o6-12	U19-79
14	o0-13	U19-80	o2-13	U19-80	o4-13	U19-80	o6-13	U19-80

Define the execution sequence of the technology setpoint bit parameter block, activate the corresponding block, and its output bit is equal to the input bit. The parameters and connector parameters corresponding to process setting bit parameters 1 to 6 are shown in the following table.

Process Setting Bit Parameter	Process Setting Parameter Group 1		Process Setting Parameter Group 2		Process Setting Parameter Group 3		Process Setting Parameter Group 4	
	Input	Output	Input	Output	Input	Output	Input	Output
	I	O	I	O	I	O	I	O
1	o0-14	U11-64	o2-14	U11-64	o4-14	U11-64	o6-14	U11-64
2	o0-15	U11-65	o2-15	U11-65	o4-15	U11-65	o6-15	U11-65
3	o0-16	U11-66	o2-16	U11-66	o4-16	U11-66	o6-16	U11-66
4	o0-17	U11-67	o2-17	U11-67	o4-17	U11-67	o6-17	U11-67
5	o0-18	U11-68	o2-18	U11-68	o4-18	U11-68	o6-18	U11-68
6	o0-19	U11-69	o2-19	U11-69	o4-19	U11-69	o6-19	U11-69

9.11.4 Process Controller Parameter Group

There are four process controller parameter groups, which can be switched with A9-04 and A9-05.

The process controller consists of reference, supplementation, feedback, differential operation, droop, Kp adaptation, proportional operation, integral operation, output limit, and output proportion. To control an object, you need to set related parameters in groups o1, o3, o5, and o7 and adjust PID parameters. You can set the process controller execution sequence in P9-24, which is applicable for process controller parameter groups selected in A9-04 and A9-05.

9.11.4.1 Input of Process Controller

This section takes process controller parameter group 1 as an example. Set the reference source and feedback source of the process controller through o1-02 to o1-05 and o1-09 to o1-12. Set the supplementary reference through o1-06 and o1-07. You can filter the reference and feedback (o1-08 and o1-13) as needed. Select the type of differential control using the hundreds position of parameter o1-01. Finally, obtain the controller differential component U19-83 and deviation U19-86.

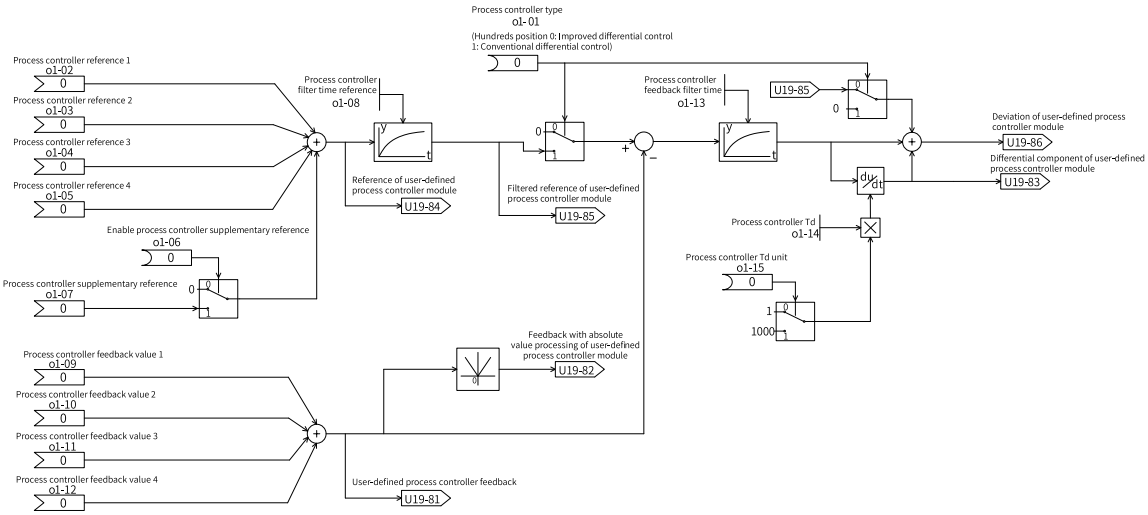


Figure 9-14 Input of process controller

9.11.4.2 Output of Process Controller

Enable the controller through parameter o1-00. Enable or disable integral or proportional control and set the calculation direction through parameter o1-01 (process controller type). Set the negative feedback to achieve the droop function through parameters o1-16 to o1-19. Set the Kp adaptive function through parameters o1-20 to o1-25. Set the output limit of the controller through parameters o1-30 to o1-33. Finally, set output scaling-up through parameters o1-34 and o1-35.

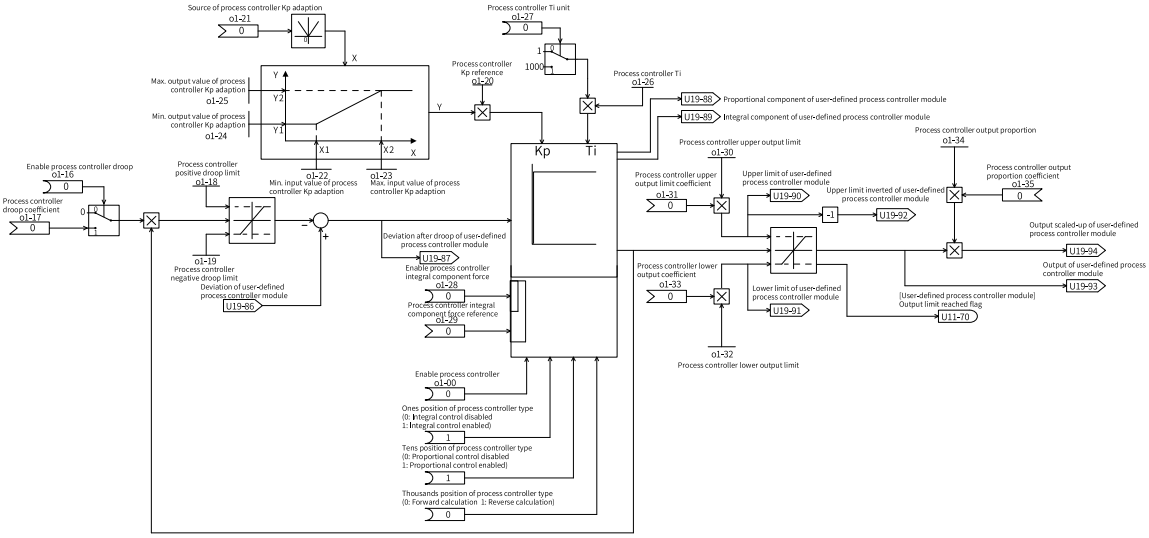


Figure 9-15 Output of process controller

9.12 Communication Module

9.12.1 Fieldbus Adapters

Fieldbus adapters of HCU-50S/51S are used for communication between the fieldbus and the drive control unit. Currently, three fieldbus adapters are supported, with two used independently and the remaining one used for redundancy.

The redundant fieldbus adapter C must be selected for fieldbus adapters A and B. The system automatically switches to the redundant fieldbus adapter C for receiving and sending data when fieldbus adapters A and B fail due to an error. Each fieldbus adapter supports a maximum of 16 pieces of 16-bit process data. The following figure shows how the fieldbus adapter works.

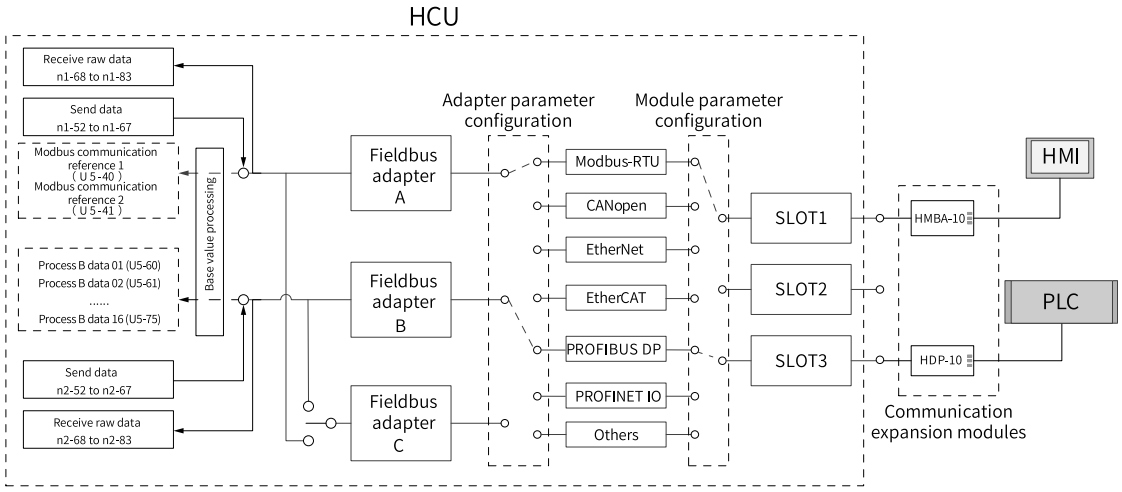


Figure 9-16 Working principle of fieldbus adapter

Table 9–1 Fieldbus adapter A/B setting

Item	Fieldbus Adapter A	Fieldbus Adapter B	Setting Description
1	n1-00	n2-00	Defines the required bus protocol type. 0: No fieldbus is selected.
2	n1-01	n2-01	Enables or disables communication timeout detection. 0.00: Communication timeout fault is not detected.
3	n1-02	n2-02	Enables or disables communication fault detection. 0: Enabled 1: Disabled
4	n1-03	n2-03	Enables or disables communication CRC error verification. 0: CRC fault detection is disabled.
5	n1-04 to n1-19	n2-04 to n2-19	Defines the output source of the process data of fieldbus adapters.
6	n1-20 to n1-35	n2-20 to n2-35	Defines the base value for the output process data. The calculation formula is as follows: Sent data = Selected data x (n1-20 to n1-35)/4096. The value 0 equals 4096.
7	n1-36 to n1-51	n2-36 to n2-51	Defines the base value for the input process data. The calculation formula is as follows: Used data = Received data x 4096/4 (n1-36 to n1-51). The value 0 equals 4096.
8	n1-90	n2-90	Defines whether to save written parameters to EEPROM.
9	n1-91	n2-91	Defines whether to upload the current fault information of devices to the host controller.

Table 9–2 Fieldbus adapter C setting

Item	Fieldbus Adapter C setting	Setting Description
1	n3-00	Used to bind the Ethernet commissioning module forcibly.
2	n3-03	Used to set whether to save written parameters to EEPROM.

Data of fieldbus adapters includes SDO and PDO.

- Mailbox data is used for parameter read and write, start/stop, fault reset, status monitoring, and command delivery, which is non-periodically delivered.
- Process data is used for command reference, status interaction, speed reference, and torque reference, which is subject to periodical data exchange.

9.12.2 Process Data Configuration

When the communication expansion module works normally, the process data can be configured.

Note

For more details about configuring the fieldbus adapter, see communication examples in the *MD880 Series AC Drive Communication Guide*.

9.12.3 Communication Module Expansion

Fieldbus adapters currently support 9 communication modules: Modbus RTU fieldbus module, CANopen fieldbus module, EtherCAT industrial Ethernet module, PROFIBUS-DP fieldbus module, PROFINET IO industrial Ethernet module, and other customized communication modules.

Table 9–3 Communication module expansion

Item	Expansion Module	Description
1	Modbus RTU module	Used by the Modbus communication protocol, which is a standard communication protocol. For details, see the communication extension card user guide. Parameters of this module are set in group n10.
2	CANopen module	Used by the CANopen communication protocol. For details, see the communication extension module user guide. The CANopen extension card supports seven communication speeds. Parameters of this module are set in group n12.
3	Ethernet module	Used by the Ethernet communication protocol. For details, see the communication extension Module user guide. The Ethernet communication extension card supports automatic IP address assignment. Parameters of this module are set in group n13.
4	EtherCAT module	Used by the EtherCAT communication protocol. For details, see the communication extension module user guide. Parameters of this module are set in group n14.
5	PROFIBUS-DP module	Used by the PROFIBUS-DP communication protocol. For details, see the communication extension module user guide. Parameters of this module are set in group n16.

Item	Expansion Module	Description
6	PROFINET IO module	Used by the PROFINET communication protocol. For details, see the communication extension module user guide. Parameters of this module are set in group n17.
7	Customized communication module	Used by the communication protocol customized for a specific manufacturer or application. For details, see the communication extension module user guide. Parameters of this module are set in group n18.

9.12.4 InoLink Communication Network

InoLink is used for master/slave communication among multiple drive units. Master/slave communication means that the logic master station in a network sends information such as control bit or setpoints to logic slave stations. InoLink supports eight 16-bit data entries for communication.

Currently, the InoLink communication network supports a maximum of 16 controllers. The controller with device ID 1 is the master controller that initiates InoLink communication, and the controllers numbered from 2 to 16 are slave controllers. The master controller initiates master/slave communication, and then the slave controllers respond in sequence. Data information sent by each controller is saved by other controllers in the network.

The master station in InoLink communication is not necessarily a logic master station. The logic master station sends data to logic slave stations (other controllers than the master controller), which then use the received data for control purposes. Each logic slave station can be configured with a data source, which can be one or more logic master stations.

One InoLink communication network can consist of one or more master/slave networks. A master/slave network is a communication network consisting of logic master and slave stations.

Currently, the InoLink communication baud rate is equal to 5 Mbps, and the communication cycle is 2 ms. All controllers in the InoLink communication network exchange data once during each 2-ms cycle.

If a controller receives no data from any other controller within 2 seconds, it reports an offline error. If the controller receives no data from the logic master station, it reports a master station offline error. If the device ID of a new controller is the same as that of an existing controller, the new controller reports an address conflict error.

Table 9–4 InoLink communication settings

Item	InoLink Communication Settings	Setting Description
1	n0-00	Enables an InoLink communication node.
2	n0-01	Sets the address of an InoLink communication node.
3	n0-02	Sets the InoLink communication mode.
4	n0-03, n0-05, n0-07, n0-09, n0-11, n0-13, n0-15, and n0-17	Sets the logic master station for a node, that is, from which node other than the current node on the network the current node has to receive data.
5	n0-04, n0-06, n0-08, n0-10, n0-12, n0-14, n0-16, and n0-18	Sets which data entry sent by the logic master station the node has to use. That is, which data entry sent by nodes other than the current node in the network the current node has to use.

Item	InoLink Communication Settings	Setting Description
6	n0-19 to n0-26	Sets the proportional coefficient of the received data, that is, the data finally used by this node is the data sent by the logical master station multiplied by the coefficient.
7	n0-27 to n0-34	Sets the data to be sent by the current node.

9.12.5 HOFR Optical Fiber Routing Network

The purpose of optical fiber synchronization is similar to InoLink communication network, that is, to realize data interaction between multiple drive devices, but the implementation is different. Optical fiber synchronization is achieved through the optical fiber synchronization expansion module. All HCU-50S/51S devices are connected to the optical fiber synchronization expansion module through an HOFM optical fiber module. The optical fiber synchronization expansion module resembles a data switch which allows data interaction between multiple drive devices. In addition, optical fiber synchronization does not involve any host, but a data switch.

The whole data network supports 11 nodes at most, and each node can send and receive 8 pieces of data. A node can select the data 1 to 8 of any other 3 nodes to form PZD1 to PZD8, thus further realizing various control operations. In addition, you can also customize the proportion of each received data, ranging from -8.000 to +8.000, which can meet the requirements of different applications.

Table 9–5 OF Sync Communication Setting

Item	OF Sync Communication Setting	Setting Description
1	n22-00, n22-01, n22-05	Enables the communication node and the communication interruption judgment time, and sets the address of the node.
2	n22-02, n22-03	Sets the slot connected to the optical fiber synchronization extension module and whether it is online.
3	n22-04	Displays the online nodes in the communication network. It is convenient to set its own node bit 0 to bit 10 corresponding to the node address 1 to the node address 11 respectively.
4	n22-06 to n22-08	Sets the 3 nodes that need to receive data.
5	n22-09 to n22-16	Sets which data (any one of data 1 to data 8) sent from which node (any one of the 3 nodes) is selected.
6	n22-17 to n22-24	Sets the proportional coefficient of received data. The data used by nodes is the received data multiplied by the coefficient.
7	n22-25 to n22-32	Sets the data to be sent by the current node.

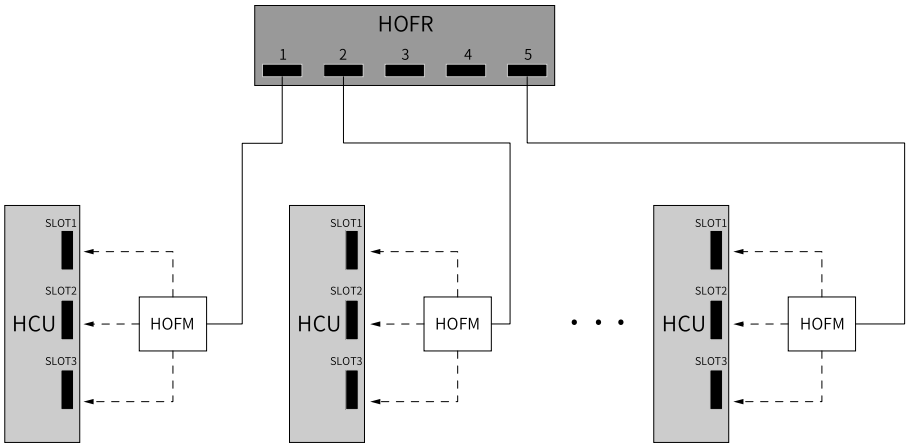


Figure 9-17 Connection diagram

9.12.6 Fieldbus Adapter Slot Configuration

Before using an expansion module, configure the expansion slot for the expansion module.

For example, when installing a PROFIBUS-DP module in the SLOT3, set n16-00 to 7 to select the expansion slot 3_1. The following table describes the configuration of the PROFIBUS-DP module expansion slot.

Parameter	Name	Value Range
n16-00	Expansion slot selection	0: Disabled 1: Expansion slot 1_1 2: Expansion slot 1_2 3: Expansion slot 1_3 4: Expansion slot 2_1 5: Expansion slot 2_2 6: Expansion slot 2_3 7: Expansion slot 3_1

The HCU provides three expansion slots, as shown in the following figure.

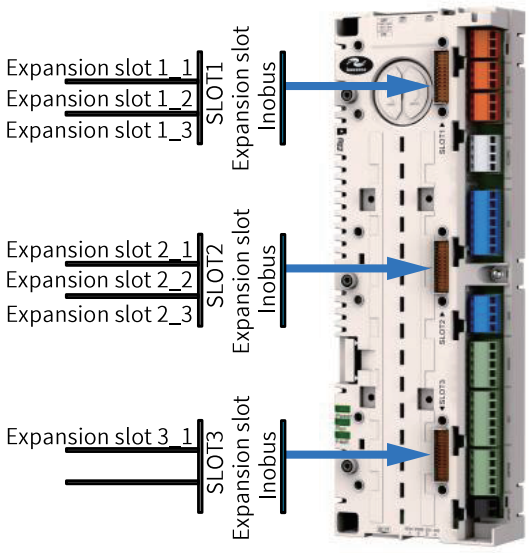


Figure 9-18 Expansion slots

HCU has only three slots. When more function modules are needed, use the HESD-10 function module expansion unit. Each slot can extend three function modules (except SLOT3) and needs to be used with the HOFM module.

SLOT1 and SLOT2 of the HCU each can be connected to an HOFM optical fiber expansion module, allowing expansion of up to six pairs of optical fibers. One HCU control module can expand a maximum of six function modules when used with HOFM and HESD. The expansion principle is shown in the following figure.

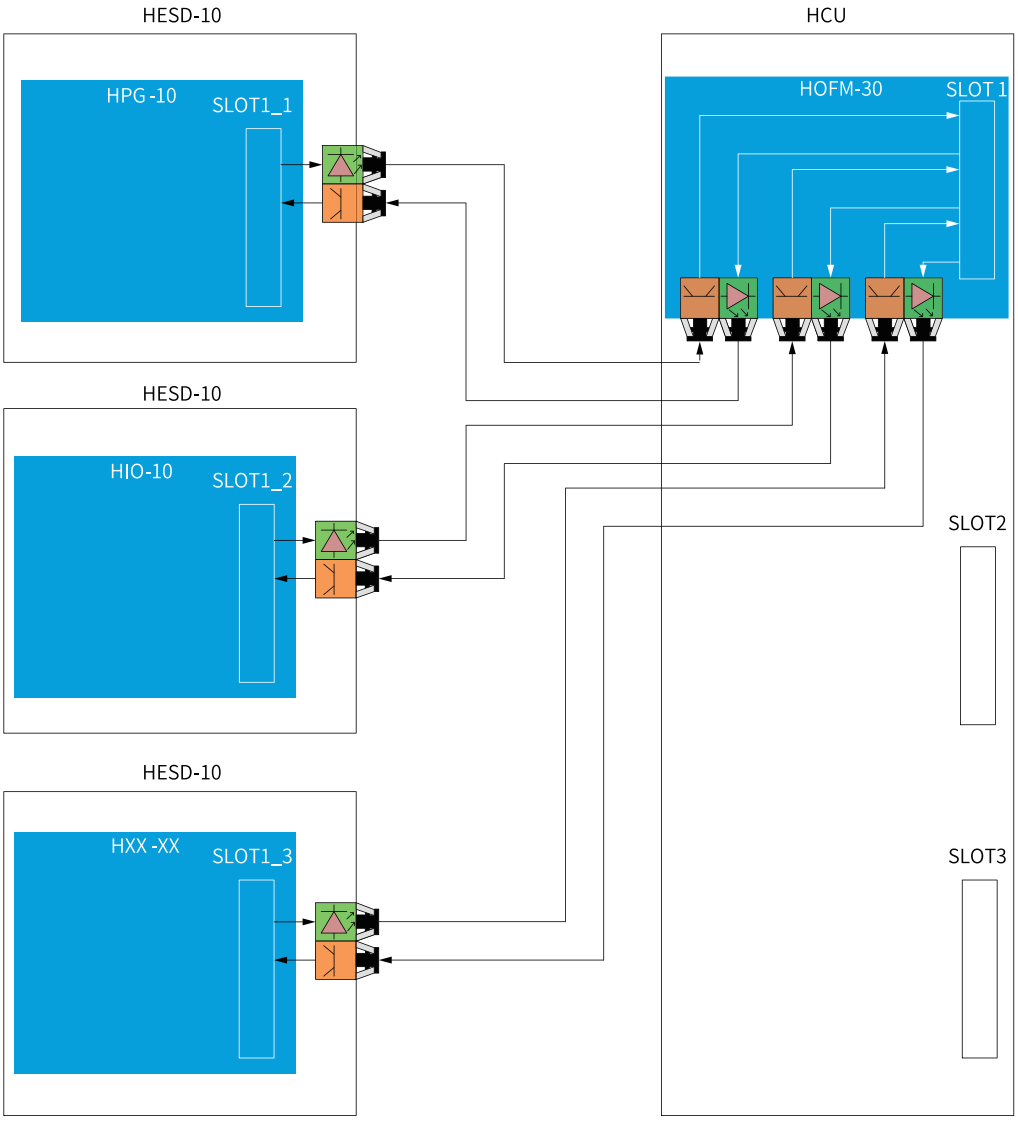


Figure 9-19 HSED wiring example

When installing function modules in the three slots, abide by the following principles:

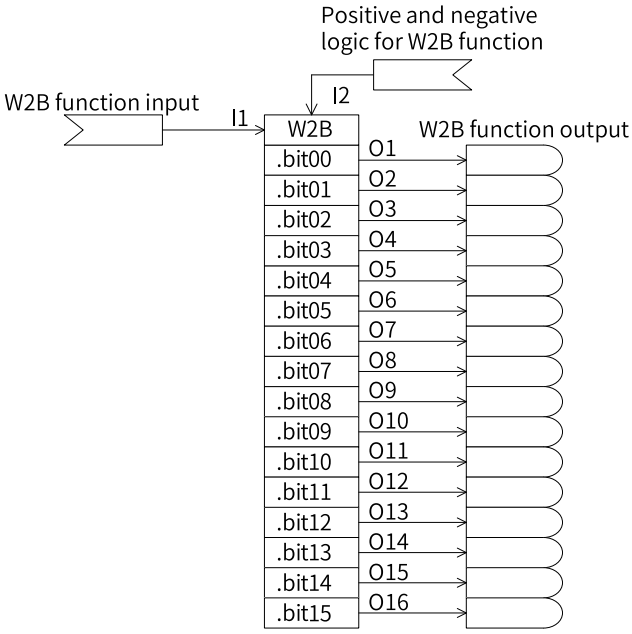
- Function modules can be directly installed in SLOT1, SLOT2, and SLOT3, and the addresses are SLOT1_1, SLOT2_1, and SLOT3_1.
- SLOT1 and SLOT2 each can work with the HOFM-30 module to expand up to three slots, that is, SLOT1_1, SLOT1_2, and SLOT1_3, or SLOT2_1, SLOT2_2, and SLOT2_3, respectively.
- The SLOT3 slot cannot be expanded.
- The HOFM optical fiber expansion module cannot be installed on the HESD module for further expansion.

9.13 Application Function

9.13.1 Word-to-Bit Function

9.13.1.1 Word-to-Bit (W2B) Module (1 to 4)

Diagram



Operation

When input I1 is single-word input, outputs O1 to O16 correspond to bit 00 to bit 15 of input I1. When input I1 is double-word input, outputs O1 to O16 correspond to bit 00 to bit 15 of the high-order 16 bits of input I1. When the bit of I2 is 0, the value is not inverted. When the bit is 1, the value is inverted.

Connection

Input I1 is a signed number.

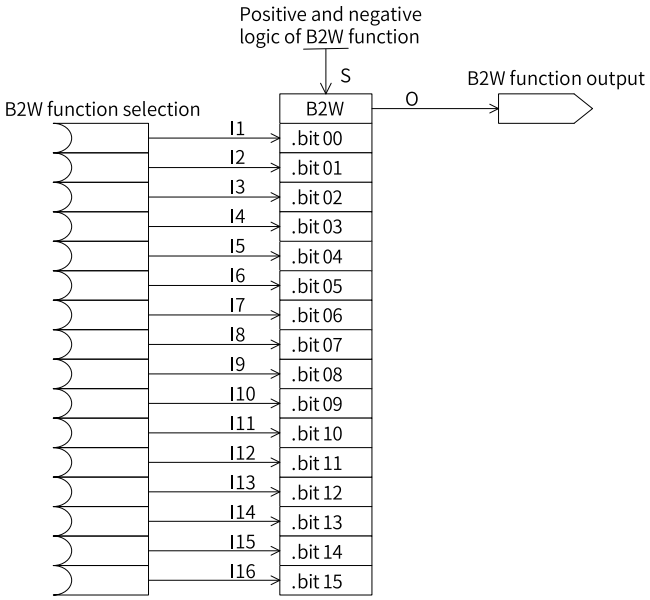
Input I2 is an unsigned number.

Outputs O1 to O16 are binary numbers.

Word-to-Bit (W2B) Module		1	2	3	4
Input	I1	L0-00	L0-01	L0-02	L0-03
	I2	L0-74	L0-75	L0-76	L0-77
Output	O1 (bit 00)	U2-48	U2-64	U2-80	U4-76
	O2 (bit 01)	U2-49	U2-65	U2-81	U4-77
	O3 (bit 02)	U2-50	U2-66	U2-82	U4-78
	O4 (bit 03)	U2-51	U2-67	U2-83	U4-79
	O5 (bit 04)	U2-52	U2-68	U2-84	U4-80
	O6 (bit 05)	U2-53	U2-69	U2-85	U4-81
	O7 (bit 06)	U2-54	U2-70	U2-86	U4-82
	O8 (bit 07)	U2-55	U2-71	U2-87	U4-83
	O9 (bit 08)	U2-56	U2-72	U2-88	U4-84
	O10 (bit 09)	U2-57	U2-73	U2-89	U4-85
	O11 (bit 10)	U2-58	U2-74	U2-90	U4-86
	O12 (bit 11)	U2-59	U2-75	U2-91	U4-87
	O13 (bit 12)	U2-60	U2-76	U2-92	U4-88
	O14 (bit 13)	U2-61	U2-77	U2-93	U4-89
	O15 (bit 14)	U2-62	U2-78	U2-94	U4-90
	O16 (bit 15)	U2-63	U2-79	U2-95	U4-91

9.13.1.2 Bit-to-Word (B2W) Module (1 to 4)

Diagram



Operation

Bit 00 to bit 16 of output O correspond to inputs I1 to I16. When the bit of I is 0, the value is not inverted. When the bit is 1, the value is inverted.

Connection

Input I is an unsigned number.

Inputs I1 to I16 are binary numbers.

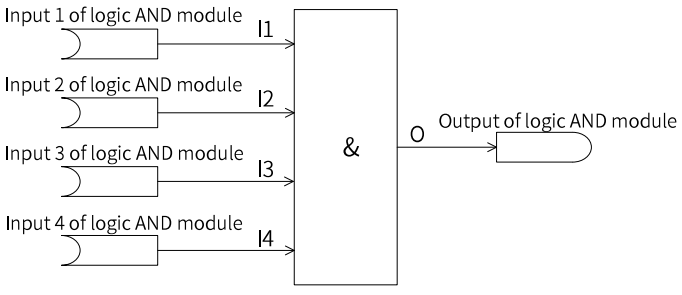
Output O is a signed number.

Bit-to-Word (B2W) Module		1	2	3	4
Input	I1 (bit 00)	L0-10	L0-26	L0-42	L0-58
	I2 (bit 01)	L0-11	L0-27	L0-43	L0-59
	I3 (bit 02)	L0-12	L0-28	L0-44	L0-60
	I4 (bit 03)	L0-13	L0-29	L0-45	L0-61
	I5 (bit 04)	L0-14	L0-30	L0-46	L0-62
	I6 (bit 05)	L0-15	L0-31	L0-47	L0-63
	I7 (bit 06)	L0-16	L0-32	L0-48	L0-64
	I8 (bit 07)	L0-17	L0-33	L0-49	L0-65
	I9 (bit 08)	L0-18	L0-34	L0-50	L0-66
	I10 (bit 09)	L0-19	L0-35	L0-51	L0-67
	I11 (bit 10)	L0-20	L0-36	L0-52	L0-68
	I12 (bit 11)	L0-21	L0-37	L0-53	L0-69
	I13 (bit 12)	L0-22	L0-38	L0-54	L0-70
	I14 (bit 13)	L0-23	L0-39	L0-55	L0-71
	I15 (bit 14)	L0-24	L0-40	L0-56	L0-72
	I16 (bit 15)	L0-25	L0-41	L0-57	L0-73
	I	L0-78	L0-79	L0-80	L0-81
Output	O	U5-86	U5-87	U5-88	U5-89

9.13.2 Logic Operation Function

9.13.2.1 Logic AND Module (A to D)

Diagram



Operation

O=I1&I2&I3&I4

Only if inputs I1, I2, I3, and I4 are all true, output O is true. Otherwise, output O is false. The truth table is as follows.

Input				Output
I1	I2	I3	I4	O
0	x	x	x	0
x	0	x	x	0
x	x	0	x	0
x	x	x	0	0
1	1	1	1	1

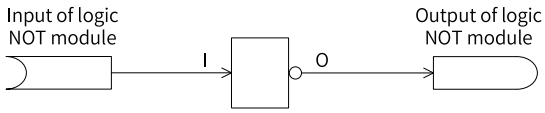
Connection Inputs I1, I2, I3, and I4 are binary numbers.

Output O is a binary number.

Logic AND Module	Input				Output
	I1	I2	I3	I4	O
A	L2-00	L2-01	L2-02	L2-03	U3-00
B	L2-04	L2-05	L2-06	L2-07	U3-01
C	L2-08	L2-09	L2-10	L2-11	U3-02
D	L2-12	L2-13	L2-14	L2-15	U3-03

9.13.2.2 Logic NOT Module (A to H)

Diagram



Operation

$$O=\bar{I}$$

Input	Output
I	O
0	1
1	0

Connection

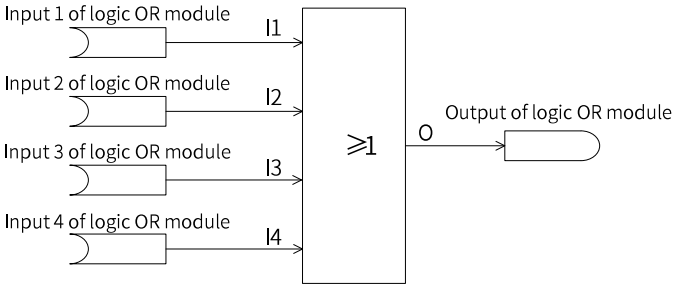
Input I is a binary number.

Output O is a binary number.

Logic NOT Module	Input	Output
	I	O
A	L2-16	U3-04
B	L2-17	U3-05
C	L2-18	U3-06
D	L2-19	U3-07
E	L2-20	U3-08
F	L2-21	U3-09
G	L2-22	U3-10
H	L2-23	U3-11

9.13.2.3 Logic OR Module (A to D)

Diagram



Operation

O=I1|I2|I3|I4

If any of inputs I1, I2, I3, and I4 is true, the output is also true. The truth table is as follows.

Input				Output
I1	I2	I3	I4	O
0	0	0	0	0
1	x	x	x	1
x	1	x	x	1
x	x	1	x	1
x	x	x	1	1

Connection

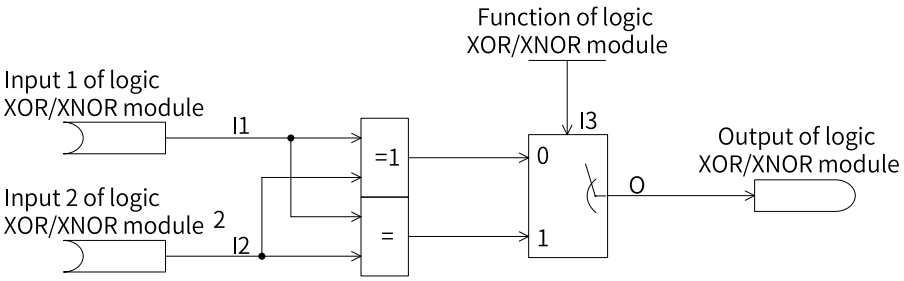
Inputs I1, I2, I3, and I4 are binary numbers.

Output O is a binary number.

Logic OR Module	Input				Output
	I1	I2	I3	I4	O
A	L2-24	L2-25	L2-26	L2-27	U3-12
B	L2-28	L2-29	L2-30	L2-31	U3-13
C	L2-32	L2-33	L2-34	L2-35	U3-14
D	L2-36	L2-37	L2-38	L2-39	U3-15

9.13.2.4 Logic XOR/XNOR Module (A to D)

Diagram



Operation

When I3 (logic XOR/XNOR module function) is set to 0, logic XOR is enabled, and $O=\overline{I1}I2+I1\overline{I2}$.

When input I1 and I2 are the same, output O is 0. When input I1 and I2 are different, output O is 1. The truth table is as follows.

Input		Output
I1	I2	O
0	0	0
1	0	1
0	1	1
1	1	0

When I3 (logic XOR/XNOR module function) is set to 1, logic XNOR is enabled, and $O=I1I2+\overline{I1}\,\overline{I2}$.

When input I1 and I2 are the same, output O is 1. When input I1 and I2 are different, output O is 0. The truth table is as follows.

Input		Output
I1	I2	O
0	0	1
1	0	0
0	1	0
1	1	1

Connection

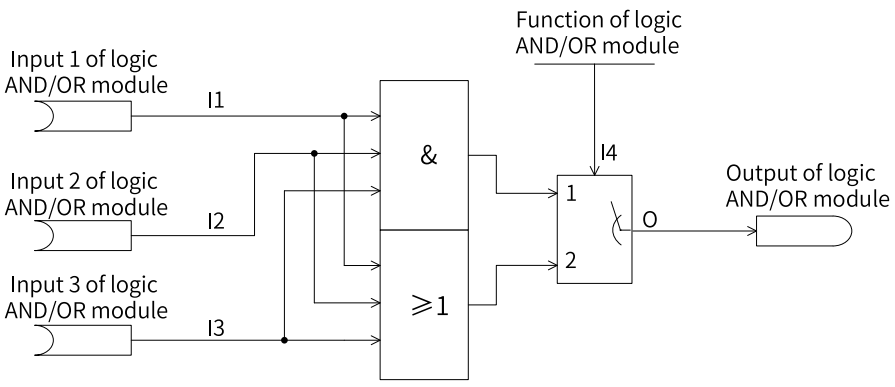
Inputs I1, I2, and I3 are binary numbers.

Output O is a binary number.

Logic XOR/XNOR Module	Input			Output
	I1	I2	I3	O
A	L2-41	L2-42	L2-40	U3-16
B	L2-44	L2-45	L2-43	U3-17
C	L2-47	L2-48	L2-46	U3-18
D	L2-50	L2-51	L2-49	U3-19

9.13.2.5 Logic AND/OR Module (A to H)

Diagram



Operation

When I4 for enabling logic AND/OR module is set to 1, the logic AND module is valid, as shown in $O=I1\&I2\&I3$.

Only when I1, I2, and I3 are all true, the output (O) can be true; otherwise, the output (O) is false. The output of the truth table is as follows.

Input			Output
I1	I2	I3	O
0	0	0	0
1	0	0	0
0	1	0	0
1	1	0	0
0	0	1	0
1	0	1	0
0	1	1	0
1	1	1	1

When I4 for enabling the logic AND/OR module is set to 2, the logic OR is valid, as shown in $O=I1|I2|I3$.

If any one of the inputs I1, I2, and I3 is true, the output is true. The output of the truth table is as follows.

Input			Output
I1	I2	I3	O
0	0	0	0
1	0	0	1
0	1	0	1
1	1	0	1
0	0	1	1
1	0	1	1
0	1	1	1
1	1	1	1

Connection

Input I1, I2, I3, and I4: Binary number

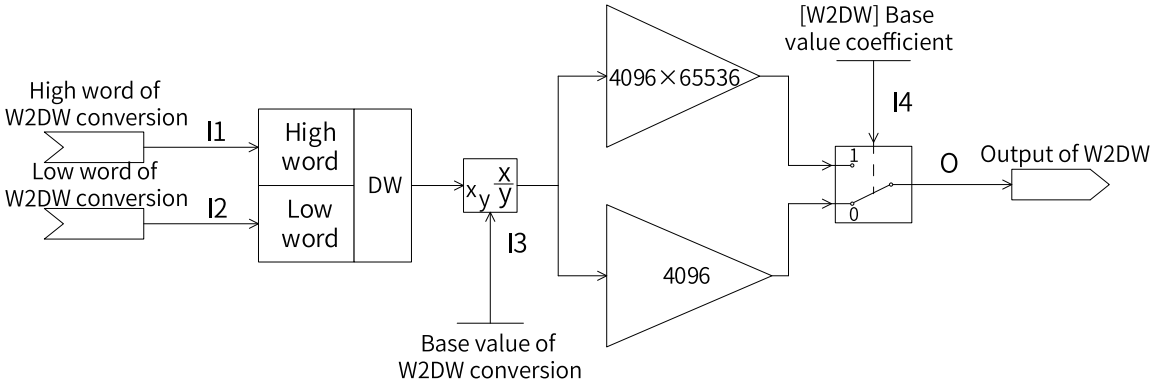
Output O: Binary number

Logic AND/OR module	Input				Output
	I1	I2	I3	I4	O
A	L2-61	L2-62	L2-63	L2-60	U4-92
B	L2-65	L2-66	L2-67	L2-64	U4-93
C	L2-69	L2-70	L2-71	L2-68	U4-94
D	L2-73	L2-74	L2-75	L2-72	U4-95
E	L2-77	L2-78	L2-79	L2-76	U4-96
F	L2-81	L2-82	L2-83	L2-80	U4-97
G	L2-85	L2-86	L2-87	L2-84	U4-98
H	L2-89	L2-90	L2-91	L2-88	U4-99

9.13.3 Word-to-Double Word Function

9.13.3.1 W2DW Conversion (1 to 5)

Diagram



Operation

$$O=\begin{cases}\frac{I1\times65536+I2}{I3}\times4096\times65536, I4=1\\ \frac{I1\times65536+I2}{I3}\times4096, I4=0\end{cases}$$

The output equals I1 (high-order 16 bits) or I2 (low-order 16 bits) double word divided by base value I3 and then multiplied by the base value coefficient (specified by I4). When the input value is a double word, the high-order 16 bits are used.

When I3 is set to 0, the output value equals the input value without base value conversion.

Connection

Inputs I1 and I2 are signed numbers.

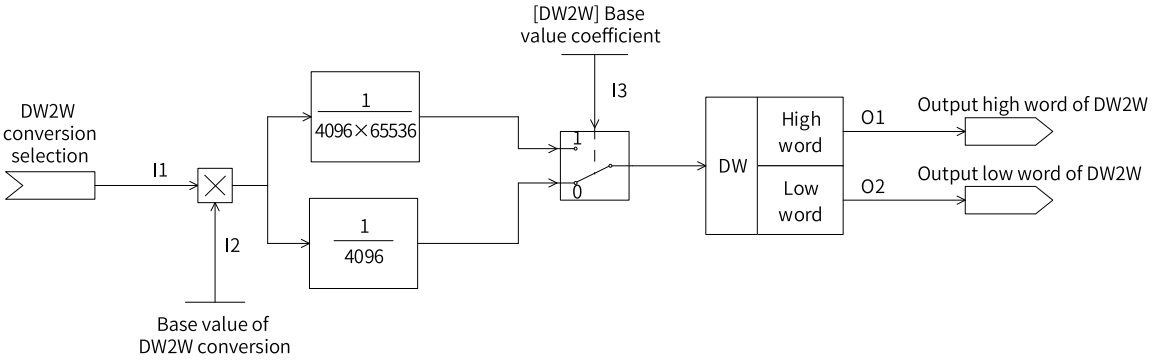
Input I3 is an unsigned number.

Output O is a signed number.

W2DW Conversion	Input				Output
	I1	I2	I3	I4	O
1	L3-01	L3-02	L3-03	L3-00 (bit 0)	U9-47
2	L3-04	L3-05	L3-06	L3-00 (bit 1)	U9-48
3	L3-07	L3-08	L3-09	L3-00 (bit 2)	U9-49
4	L3-10	L3-11	L3-12	L3-00 (bit 3)	U9-26
5	L3-13	L3-14	L3-15	L3-00 (bit 4)	U9-27

9.13.3.2 DW2W Conversion (1 to 5)

Diagram



Operation

$$O1=\begin{cases}\left(\frac{I1\cdot I2}{4096\times 65536}>>16\right)\&0xFFFF, I3=1\\ \left(\frac{I1\cdot I2}{4096}>>16\right)\&0xFFFF, I3=0\end{cases}$$

$$O2=\begin{cases}\left(\frac{I1\cdot I2}{4096\times 65536}\right)\&0xFFFF, I3=1\\ \left(\frac{I1\cdot I2}{4096}\right)\&0xFFFF, I3=0\end{cases}$$

The output high word equals to the high-order 16 bits of I1 multiplied by the base value I2 and divided by the base value coefficient (specified by I3). The output low word equals to the low-order 16 bits of I1 multiplied by the base value I2 and divided by the base value coefficient (specified by I3).

When I2 is set to 0, the output high word is the input high word while the output low word is the input low word, without base value conversion.

Connection

Input I1 is a signed number.

Input I2 is an unsigned number.

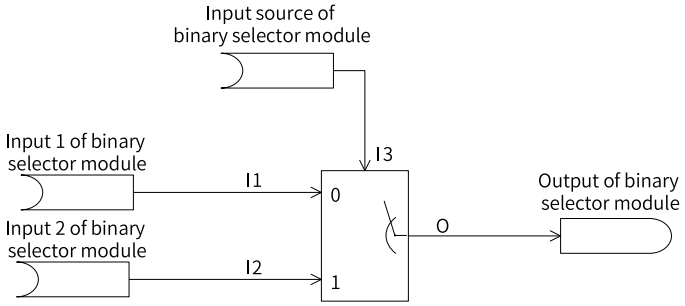
Outputs O1 and O2 are signed numbers.

DW2W Conversion	Input			Output	
	I1	I2	I3	O1	O2
1	L3-26	L3-27	L3-25 (bit 0)	U5-76	U5-77
2	L3-28	L3-29	L3-25 (bit 1)	U5-78	U5-79
3	L3-30	L3-31	L3-25 (bit 2)	U5-80	U5-81
4	L3-32	L3-33	L3-25 (bit 3)	U5-82	U5-83
5	L3-34	L3-35	L3-25 (bit 4)	U5-84	U5-85

9.13.4 Switch Function Block

9.13.4.1 Binary Selector Module (A to E)

Diagram



Operation

$$O=\begin{cases} I1, I3=0 \\ I2, I3=1 \end{cases}$$

When I3 (binary selector module input) is set to 0, output O equals I1 (bit). When I3 (binary selector module input) is set to 1, output O equals I2 (bit).

Connection

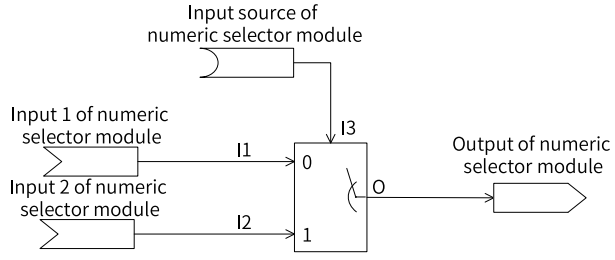
Inputs I1, I2, and I3 are binary numbers.

Output O is a binary number.

Binary Selector Module	Input			Output
	I1	I2	I3	O
A	L5-01	L5-02	L5-00	U3-20
B	L5-04	L5-05	L5-03	U3-21
C	L5-07	L5-08	L5-06	U3-97
D	L5-10	L5-11	L5-09	U3-98
E	L5-13	L5-14	L5-12	U3-99

9.13.4.2 Numeric Switch Module (A to E)

Diagram



Operation

$$O=\begin{cases} I1, I3=0 \\ I2, I3=1 \end{cases}$$

When I3 (numeric switch module input) is set to 0, output O equals I1 (word). When I3 (numeric switch module input) is set to 1, output O equals I2 (word).

Connection

Inputs I1 and I2 are signed numbers.

Input I3 is a binary number.

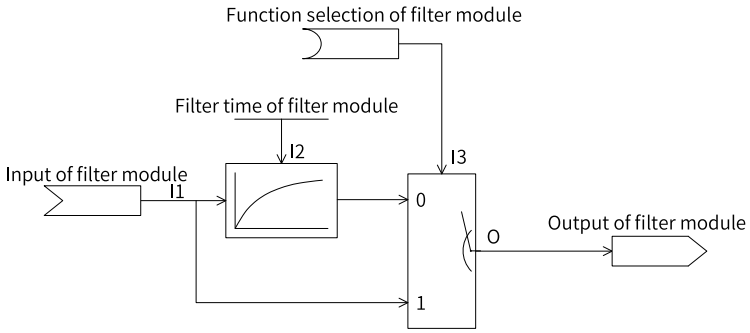
Output O is a signed number.

Numeric Switch Module	Input			Output
	I1	I2	I3	O
A	L5-21	L5-22	L5-20	U9-67
B	L5-24	L5-25	L5-23	U9-68
C	L5-27	L5-28	L5-26	U9-87
D	L5-30	L5-31	L5-29	U9-88
E	L5-33	L5-34	L5-32	U9-89

9.13.5 Control Function Block

9.13.5.1 Filter Module (A to D)

Diagram



Operation

When I3 (filter module function) is set to 0, output O equals to the filter value of input I1. When I3 (filter module function) is set to 1, output O equals to input I1.

Connection

Input I1 is a signed number.

Input I2 is an unsigned number.

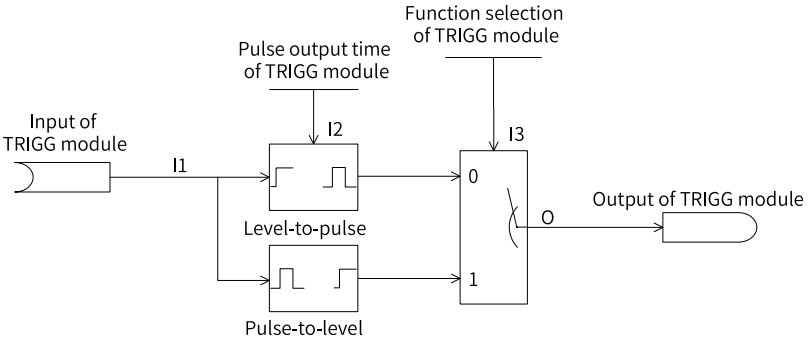
Input I3 is a binary number.

Output O is a signed number.

Filter Module	Input			Output
	I1	I2	I3	O
A	L6-01	L6-02	L6-00	U9-69
B	L6-04	L6-05	L6-03	U9-70
C	L6-07	L6-08	L6-06	U9-71
D	L6-10	L6-11	L6-09	U9-72

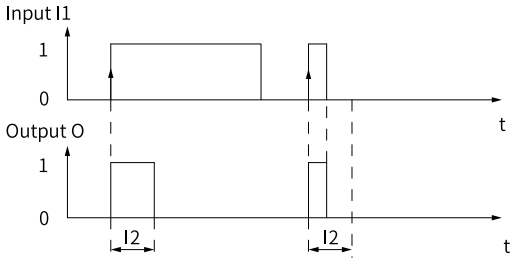
9.13.5.2 P_L Conversion Module (A to D)

Diagram

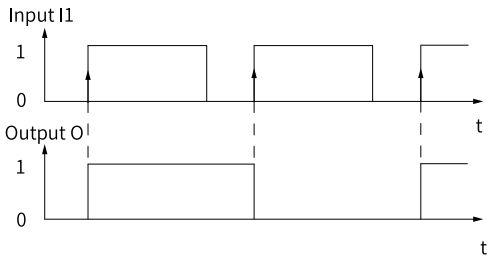


Operation

When the level-pulse (P_L) conversion module function (I3) is set to 0, level-to-pulse conversion is active. In this case, the output becomes high on the rising edge of input I1 within the pulse output time indicated by I2. If input I1 is set to 0, the output immediately changes to 0, regardless of whether the pulse duration is reached.



When the level-pulse (P_L) conversion module function is set to 1, pulse-to-level conversion is active. In this case, the output becomes high on the first rising edge of input I1, and becomes low on the second rising edge of input I1, and so on. That is, the pulse output of odd numbers is at a high level, while the pulse output of even numbers is at a low level.



Connection

Inputs I1 and I3 are binary numbers.

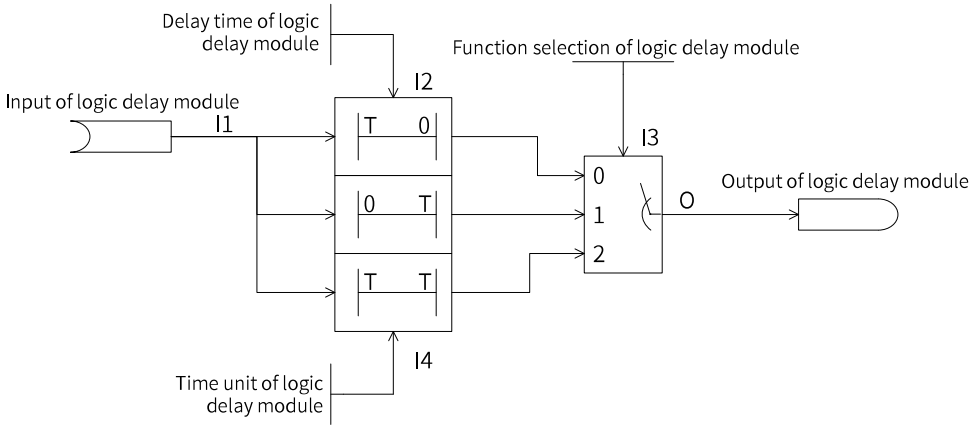
Input I2 is an unsigned number.

Output O is a binary number.

P_L Conversion Module	Input			Output
	I1	I2	I3	O
A	L6-13	L6-14	L6-12	U3-22
B	L6-16	L6-17	L6-15	U3-23
C	L6-19	L6-20	L6-18	U3-24
D	L6-22	L6-23	L6-21	U3-25

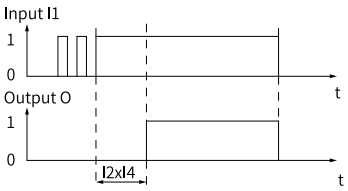
9.13.5.3 Logic Delay Module (A to D)

Diagram

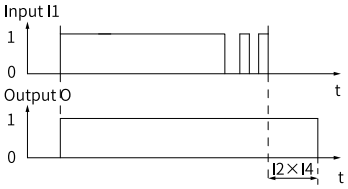


Operation

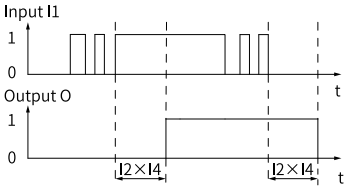
When logic delay module function selection I3 is 0, switch-on delay becomes active when input changes from 0 to 1, and the delay time is determined by I2 and I4 (time unit). After switch-on delay is enabled, high-level pulses lasting less than (I2 x I4) will be filtered out, as shown in the following figure.



When logic delay module function selection I3 is 1, switch-off delay becomes active when input changes from 1 to 0, and the delay time is determined by I2 and I4 (time unit). After switch-off delay is enabled, low-level pulses lasting less than (I2 x l4) will be filtered out, as shown in the following figure.



When logic switch delay block function selection I3 is 2, switch-on delay becomes active when input changes from 0 to 1 or from 1 to 0, and the delay time is determined by I2 and I4 (time unit). Both switch-on and switch-off delays will filter the pulses, as shown in the following figure.



Connection

Input I1 is a binary number.

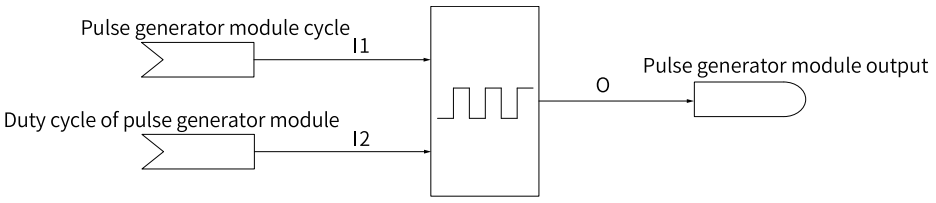
Inputs I2 and I3 are unsigned numbers.

Output O is a binary number.

Logic Delay Module	Input				Output
	I1	I2	I3	I4	O
A	L6-24	L6-26	L6-25	L6-27	U3-26
B	L6-28	L6-30	L6-29	L6-31	U3-27
C	L6-32	L6-34	L6-33	L6-35	U3-28
D	L6-36	L6-38	L6-37	L6-39	U3-29

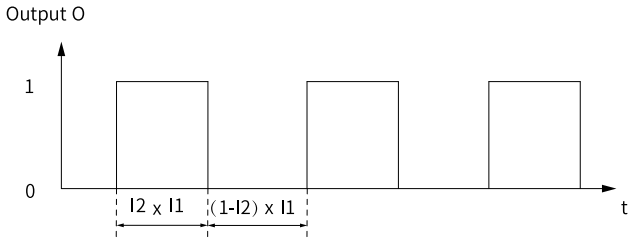
9.13.5.4 Pulse Generator Module

Diagram



Operation

When the pulse generator module period input is 0, the module keeps outputting low level. If the input I is not 0, the module outputs square-wave signals.



Connection

Input I: Unsigned number

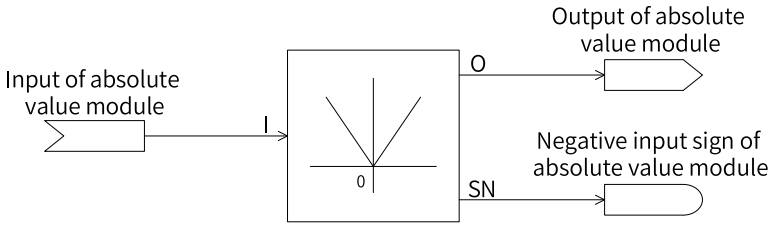
Output O: Binary number

Pulse generator module	Input		Output
	I1	I2	O
1	L6-45	L6-48	U4-45
2	L6-46	L6-49	U4-46
3	L6-47	L6-50	U4-47

9.13.6 Arithmetic Functional Block

9.13.6.1 Absolute Value Module (A to D)

Diagram



Operation

$O=|I|$

$SN=\begin{cases}1, I<0\\0, I\geqslant 0\end{cases}$

The output equals the absolute value of input I. When the input value is negative, the flag bit SN is 1. Otherwise, the flag bit is 0.

Connection

Input I is a signed number.

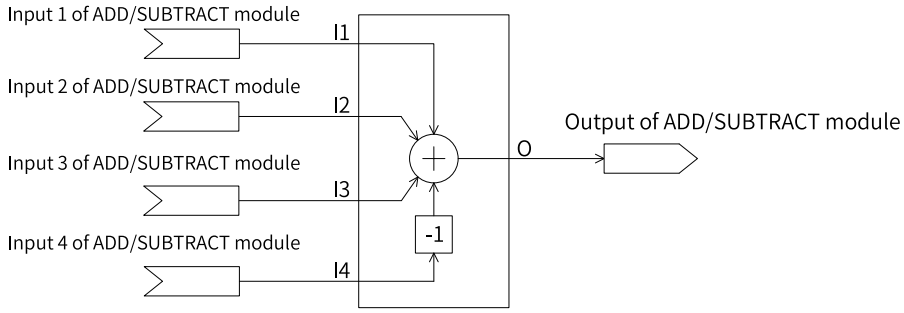
Output O is a signed number.

The output SN is a binary number.

Absolute Value Module	Input	Output	
	I	SN	O
A	L7-00	U3-30	U9-73
B	L7-01	U3-31	U9-74
C	L7-02	U3-32	U9-75
D	L7-03	U3-33	U9-76

9.13.6.2 ADD_SUB Module (A to D)

Diagram



Operation

O=I1+I2+I3-I4

The value of output O equals the sum of I1, I2, and I3 minus I4.

Connection

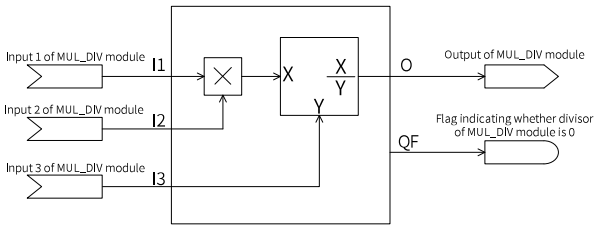
Inputs I1, I2, I3, and I4 are signed numbers.

Output O is a signed number.

ADD_SUB Module	Input				Output
	I1	I2	I3	I4	O
A	L7-04	L7-05	L7-06	L7-07	U9-77
B	L7-08	L7-09	L7-10	L7-11	U9-78
C	L7-12	L7-13	L7-14	L7-15	U9-79
D	L7-16	L7-17	L7-18	L7-19	U9-80

9.13.6.3 MUL_DIV Module (A to D)

Diagram



Operation

$$O=(I1 \cdot I2)/I3$$

$$QF=\begin{cases}1, I3=0\\0, I3\neq 0\end{cases}$$

Connection

Inputs I1, I2, and I3 are signed numbers.

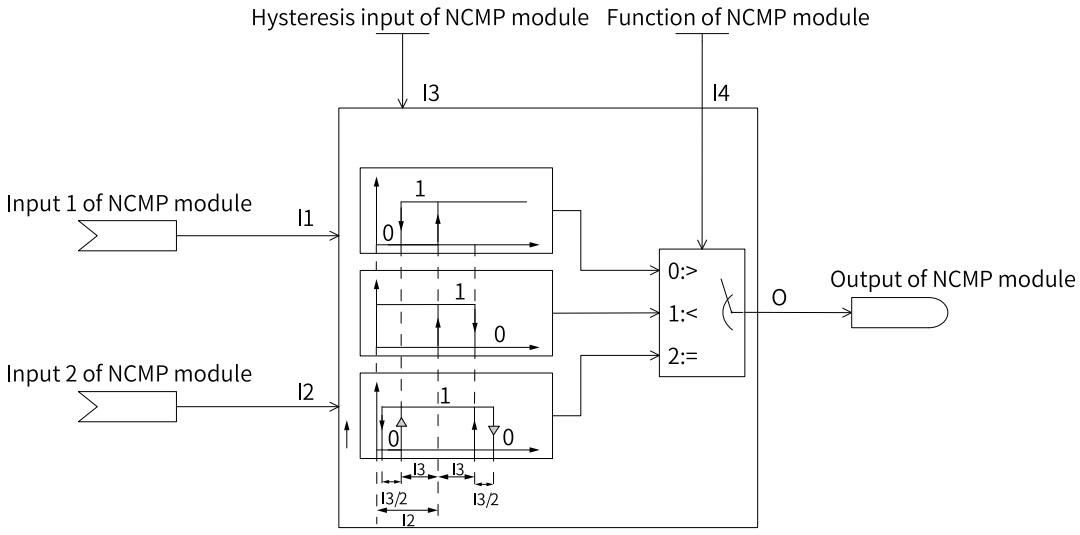
Output O is a signed number.

Output QF is a binary number.

MUL_DIV Module	Input			Output	
	I1	I2	I3	QF	O
A	L7-20	L7-21	L7-22	U3-34	U9-81
B	L7-23	L7-24	L7-25	U3-35	U9-82
C	L7-26	L7-27	L7-28	U3-36	U9-83
D	L7-29	L7-30	L7-31	U3-37	U9-84

9.13.6.4 NCMP Module (A to E)

Diagram



Operation

- If the comparison (NCMP) module function (I4) is set to 1, output O remains at a low level before I1 increases to I2 from 0 in the forward direction. When I1 exceeds I2, output O changes to a high level. If I1 further increases, output O remains at the high level. If I1 decreases but is still greater than I2 minus I3, output O still remains at the high level. Output O changes to the low level only when I1 becomes less than I2 minus I3.
- If the NCMP module function (I4) is set to 1, output O remains at a high level before I1 increases to I2 plus I3 from 0 in the forward direction. When I1 becomes greater than I2 plus I3, output O changes to a low level. If I1 further increases, output O remains at the low level. If I1 decreases but is still greater than I2, output O still remains at the low level. Output O changes to the high level only when I1 becomes less than I2.
- If the NCMP module function (I4) is set to 2, output O remains at a low level before I1 increases to I2 minus I3 from 0 in the forward direction. When I1 becomes greater than I2 minus I3 but less than I2 plus I3, output O changes to a high level. If I1 further increases to become greater than I2 plus I3 multiplied by 1.5, output O changes to the low level. If I1 decreases, output O still remains at the low level when I1 is less than I2 plus I3. Output O changes to the high level when I1 becomes less than I2 plus I3 but greater than I2 minus I3 multiplied by 1.5. Output O changes to the low level when I1 becomes less than I2 minus I3 multiplied by 1.5.
- Hysteresis input I3 suppresses frequent connection and disconnection.

Connection

Inputs I1 and I2 are signed numbers.

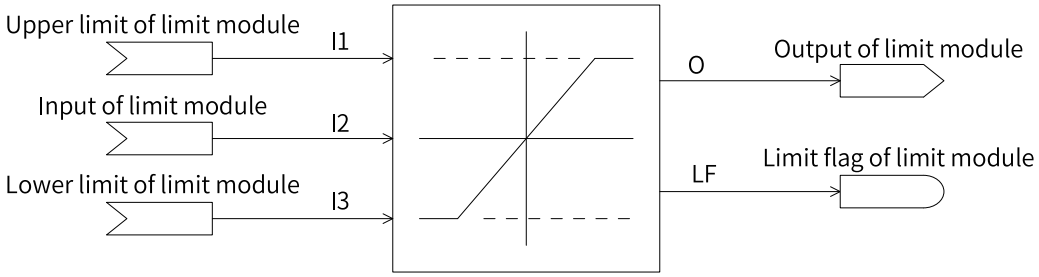
Inputs I3 and I4 are unsigned numbers.

Output O is a binary number.

NCMP module	Input				Output
	I1	I2	I3	I4	O
A	L7-33	L7-34	L7-35	L7-32	U3-38
B	L7-37	L7-38	L7-39	L7-36	U3-39
C	L7-41	L7-42	L7-43	L7-40	U4-69
D	L7-45	L7-46	L7-47	L7-44	U4-70
E	L7-49	L7-50	L7-51	L7-48	U4-71

9.13.6.5 Limiting Module (A to D)

Diagram



Operation

$$O=\begin{cases} I1, & I2>I1 \\ I2, & I3\leqslant I2\leqslant I1 \\ I3, & I2<I3 \end{cases}$$

$$LF=\begin{cases} 1.\ I2>I1 \text{ or } I2<I3 \\ 0.\ I3\leqslant I2\leqslant I1 \end{cases}$$

When input I2 is higher than the upper limit I1, the output O is equal to I1. When input I2 is lower than the lower limit I3, the output O is equal to I3. When input l2 is within the range of the lower limit to the upper limit, the output is equal to the input. When input I2 is higher than the upper limit I1 or lower than the lower limit I3, the limit flag position is set to 1.

Connection

Input I1, I2, and I3: signed number

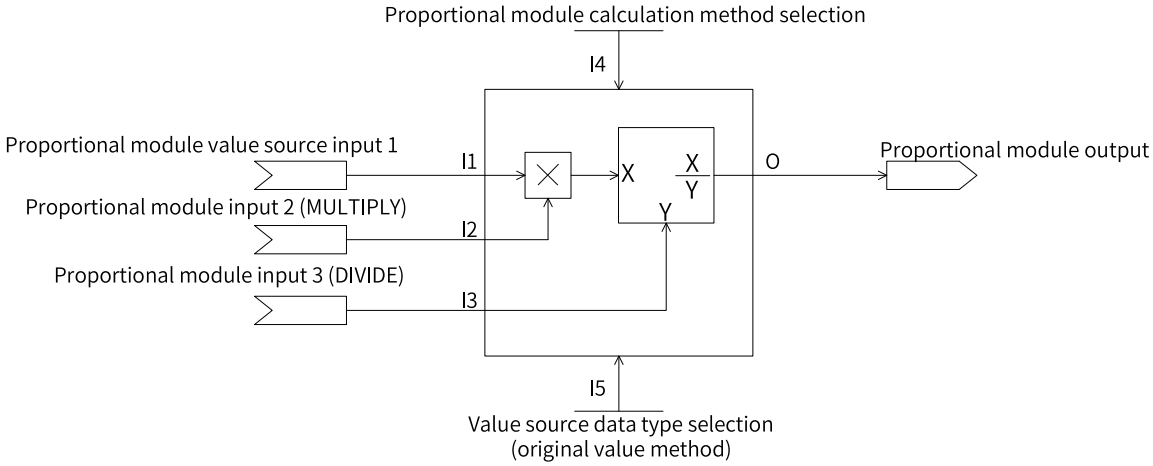
Output O: signed number

Output LF: binary number

Limiting module	Input			Output	
	I1	I2	I3	LF	O
A	L7-61	L7-60	L7-62	U4-72	U9-90
B	L7-64	L7-63	L7-65	U4-73	U9-91
C	L7-67	L7-66	L7-68	U4-74	U9-92
D	L7-70	L7-69	L7-71	U4-75	U9-93

9.13.6.6 Proportion Module (1 to 15)

Diagram



Operation

The operation of the proportion module is similar to that of the multiplication and division module. However, the calculation method and data type for I1 can be selected as required. 4096 corresponds to 100% for single-word connectors, and 4096 x 65536 corresponds to 100% for double-word connectors. Proportion modules 1 to 10 are used for single-word connector operation, and proportion modules 11 to 15 are used for double-word connector operation.

Connection

Inputs I1, I3, I4, and I5 are unsigned numbers.

Input I2 is a signed number.

Output O is a signed number.

Proportion Module	Input					Output
	I1	I2	I3	I4	I5	O
1	L11-02	L11-03	L11-04	L11-00 (bit 0)	L11-01 (bit 0)	U15-10
2	L11-05	L11-06	L11-07	L11-00 (bit 1)	L11-01 (bit 1)	U15-11
3	L11-08	L11-09	L11-10	L11-00 (bit 2)	L11-01 (bit 2)	U15-12
4	L11-11	L11-12	L11-13	L11-00 (bit 3)	L11-01 (bit 3)	U15-13
5	L11-14	L11-15	L11-16	L11-00 (bit 4)	L11-01 (bit 4)	U15-14
6	L11-17	L11-18	L11-19	L11-00 (bit 5)	L11-01 (bit 5)	U15-15
7	L11-20	L11-21	L11-22	L11-00 (bit 6)	L11-01 (bit 6)	U15-16
8	L11-23	L11-24	L11-25	L11-00 (bit 7)	L11-01 (bit 7)	U15-17
9	L11-26	L11-27	L11-28	L11-00 (bit 8)	L11-01 (bit 8)	U15-18
10	L11-29	L11-30	L11-31	L11-00 (bit 9)	L11-01 (bit 9)	U15-19
11	L11-32	L11-33	L11-34	L11-00 (bit 10)	L11-01 (bit 10)	U19-95
12	L11-35	L11-36	L11-37	L11-00 (bit 11)	L11-01 (bit 11)	U19-96
13	L11-38	L11-39	L11-40	L11-00 (bit 12)	L11-01 (bit 12)	U19-97

Proportion Module	Input					Output
	I1	I2	I3	I4	I5	O
14	L11-41	L11-42	L11-43	L11-00 (bit 13)	L11-01 (bit 13)	U19-98
15	L11-44	L11-45	L11-46	L11-00 (bit 14)	L11-01 (bit 14)	U19-99

Example:

- Single-word connector U7-47 uses the proportion module 1 for multiplication and division.
  Numerical value source input 1 of proportion module 1 is set by connector U7-47, and input 2 of proportion module 1 (MULTIPLY) and input 3 of proportion module 1 (DIVIDE) are both set to 1.

Parameter	Name	Reference
L11-02	[Proportion module 1] Numerical value source input 1	U7-47 [constant setpoint 1 output]
L11-03	Input 2 of proportion module 1 (MULTIPLY)	1
L11-04	Input 3 of proportion module 1 (DIVIDE)	1

  The following table lists the proportion module output values upon different calculation methods and data types when the constant reference 1 (single word) is ±10.0%.

[L9-00]	[L11-00] Bit 0	[L11-01] Bit 0	[U15-10]
10.0	0 (Raw value)	0 (Signed number)	10%
	0	1 (Unsigned number)	10%
	1 (Per-unit value)	-	10%
-10.0	0	0	-10%
	0	1	800%<1>
	1	-	-10%

Note

If -10.0% is treated as an unsigned number, the output value can reach the positive limit as a result.

- The multiplication and division operation is performed on the double-word connector U9-51 by using proportion module 11.
  Numerical value source input 1 of proportion module 11 is set by connector U9-51, and input 2 of proportion module 11 (MULTIPLY) and input 3 of proportion module 11 (DIVIDE) are both set to 1.

Parameter	Name	Reference
L11-32	[Proportion module 11] Numerical value source input 1	U9-51 [constant setpoint 6 output]
L11-33	Input 2 of proportion module 11 (MULTIPLY)	1
L11-34	Input 3 of proportion module 11 (DIVIDE)	1

  The following table lists the proportion module output values upon different calculation methods and data types when the constant reference 6 (double word) is ±10.00%.

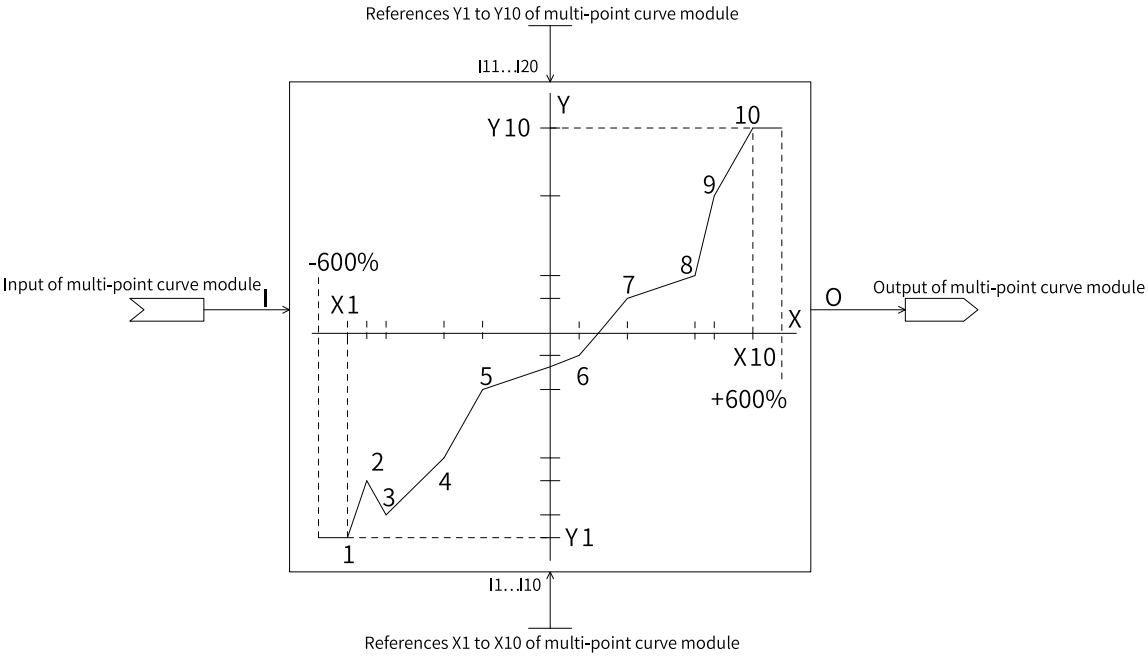
[L9-05]	[L11-00] Bit 10	[L11-01] Bit 10	[U19-95]
10.00%	0 (Raw value)	0 (Signed number)	10%
	0	1 (Unsigned number)	10%
	1 (Per-unit value)	-	10%
-10.00%	0	0	-10%
	0	1	800%<1>
	1	-	-10

Note

If -10.0% is treated as an unsigned number, the output value can reach the positive limit as a result.

9.13.7 Multi-Point Curve Module

Diagram



Operation

Only when the X1 < X2 <... condition is met, the set coordinate points are enabled. When the input is out of the enabled coordinate points, the output equals the ordinate value of the adjacent enabled coordinate points. When the input is within the enabled coordinate points, the ordinate value corresponding to the output can be calculated according to the curve.

Connection

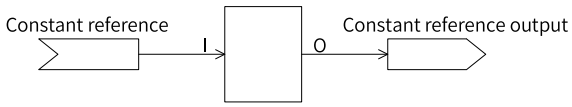
Inputs I and I1 to I20 are signed numbers.

Output O is a signed number.

Multi-Point Curve Module		A	B
Input	I	L8-00	L8-21
	I1 (X1)	L8-01	L8-22
	I2 (X2)	L8-03	L8-24
	I3 (X3)	L8-05	L8-26
	I4 (X4)	L8-07	L8-28
	I5 (X5)	L8-09	L8-30
	I6 (X6)	L8-11	L8-32
	I7 (X7)	L8-13	L8-34
	I8 (X8)	L8-15	L8-36
	I9 (X9)	L8-17	L8-38
	I10 (X10)	L8-19	L8-40
	I11 (Y1)	L8-02	L8-23
	I12 (Y2)	L8-04	L8-25
	I13 (Y3)	L8-06	L8-27
	I14 (Y4)	L8-08	L8-29
	I15 (Y5)	L8-10	L8-31
	I16 (Y6)	L8-12	L8-33
	I17 (Y7)	L8-14	L8-35
	I18 (Y8)	L8-16	L8-37
	I19 (Y9)	L8-18	L8-39
	I20 (Y10)	L8-20	L8-41
Output	O	U9-85	U9-86

9.13.8 Constant Setting Module

Diagram



Operation

O = I

Output O equals to input I. Constant setting modules 1 to 5 contain one decimal place, and constant setting modules 6 to 10 contain two decimal places, with higher accuracy.

Connection

Input I is a signed number.

Output O is a signed number.

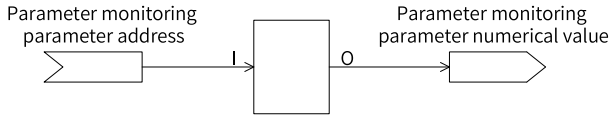
Constant Setting Module	Input	Output
	I	O
1	L9-00	U7-47
2	L9-01	U7-48
3	L9-02	U7-49

Constant Setting Module	Input	Output
	I	O
4	L9-03	U7-50
5	L9-04	U7-51
6	L9-05	U9-51
7	L9-06	U9-52
8	L9-07	U9-53
9	L9-08	U9-54
10	L9-09	U9-55

9.13.9 Parameter Monitoring and Modification

9.13.9.1 Parameter Monitoring (1 to 10)

Diagram



Operation

Output O of the parameter monitoring modules corresponds to the setpoint of the parameter monitoring parameter address I. The parameter monitoring modules 1 to 4 can monitor the parameters in the range of 0 to 65535, and the parameter monitoring modules 5 to 10 can monitor the parameters in the range of –32768 to +32767.

Connection

Input I is an unsigned number.

Output O of modules 1 to 4 is an unsigned number, and that of modules 5 to 10 is a signed number.

Parameter Monitoring Module	Input	Output
	I	O
1	L10-00	U7-65
2	L10-01	U7-66
3	L10-02	U7-67
4	L10-03	U7-68
5	L10-04	U7-69
6	L10-05	U7-70
7	L10-06	U7-71
8	L10-07	U7-72
9	L10-08	U7-73
10	L10-09	U7-74

Example:

Use parameter monitoring modules 1 and 5 to monitor constant setpoint 1.

Both parameter monitoring modules 1 and 5 are set to 3429, which corresponds to the address of constant setpoint 1 of L9-00.

Parameter	Name	Reference
L10-00	Parameter monitoring parameter address 1	3429
L10-04	Parameter monitoring parameter address 5	3429

The following table lists the output values of parameter monitoring modules 1 and 5 when the constant reference 1 of L9-00 is set to ±10.0%.

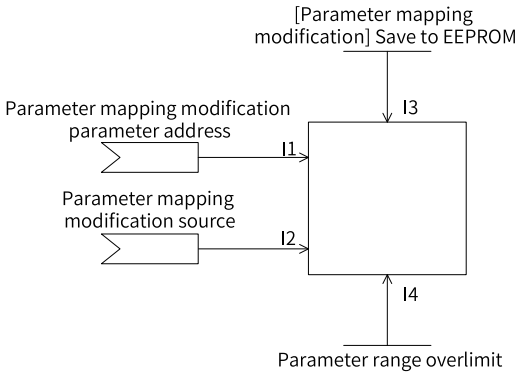
[L9-00]	[U7-65]	[U7-69]
10.0	100	100
-10.0	65436<1>	-100

Note

<1>: The output data types of parameter monitoring modules 1 to 4 are 16-bit unsigned numbers. The 16-bit unsigned number corresponding to the complement of –100 is 65436. Therefore, parameter monitoring modules 5 to 10 are required to monitor signed parameter values.

9.13.9.2 Parameter Mapping (1 to 16)

Diagram



Operation

For a modified value of I2 written to a parameter indicated by address I1, you can set I3 to determine whether to retain the modified parameter indicated by I1 at power failure, and set I4 to determine whether to apply limits if the modified value of I2 exceeds the upper limit/lower limit of I1.

Connection

Inputs I1, I2, I3, and I4 are unsigned numbers.

Parameter Mapping Module	Input			Output
	I1	I2	I3	I4
1	L10-18	L10-19	L10-16 (bit 0)	L10-17 (bit 0)
2	L10-20	L10-21	L10-16 (bit 1)	L10-17 (bit 1)
3	L10-22	L10-23	L10-16 (bit 2)	L10-17 (bit 2)
4	L10-24	L10-25	L10-16 (bit 3)	L10-17 (bit 3)
5	L10-26	L10-27	L10-16 (bit 4)	L10-17 (bit 4)
6	L10-28	L10-29	L10-16 (bit 5)	L10-17 (bit 5)

Parameter Mapping Module	Input			Output
	I1	I2	I3	I4
7	L10-30	L10-31	L10-16 (bit 6)	L10-17 (bit 6)
8	L10-32	L10-33	L10-16 (bit 7)	L10-17 (bit 7)
9	L10-34	L10-35	L10-16 (bit 8)	L10-17 (bit 8)
10	L10-36	L10-37	L10-16 (bit 9)	L10-17 (bit 9)
11	L10-38	L10-39	L10-16 (bit 10)	L10-17 (bit 10)
12	L10-40	L10-41	L10-16 (bit 11)	L10-17 (bit 11)
13	L10-42	L10-43	L10-16 (bit 12)	L10-17 (bit 12)
14	L10-44	L10-45	L10-16 (bit 13)	L10-17 (bit 13)
15	L10-46	L10-47	L10-16 (bit 14)	L10-17 (bit 14)
16	L10-48	L10-49	L10-16 (bit 15)	L10-17 (bit 15)

Example:

Connector U7-47 (output of constant setpoint 1) modifies C6-05 (multi-reference value 1) using the parameter mapping module 1.

L10-18 is set to 191, which is the address of C6-05 (multi-reference value 1). L10-19 is set to U7-47, which is the output of constant setpoint 1.

Parameter	Name	Reference
L10-18	Parameter mapping modification parameter address 1	191
L10-19	[Parameter mapping modification] Value source 1	U7-47 [constant setpoint 1 output]

The following table lists the reference of C6-05 when the constant reference 1 of L9-00 is set to ±10.0% or ±150.0%.

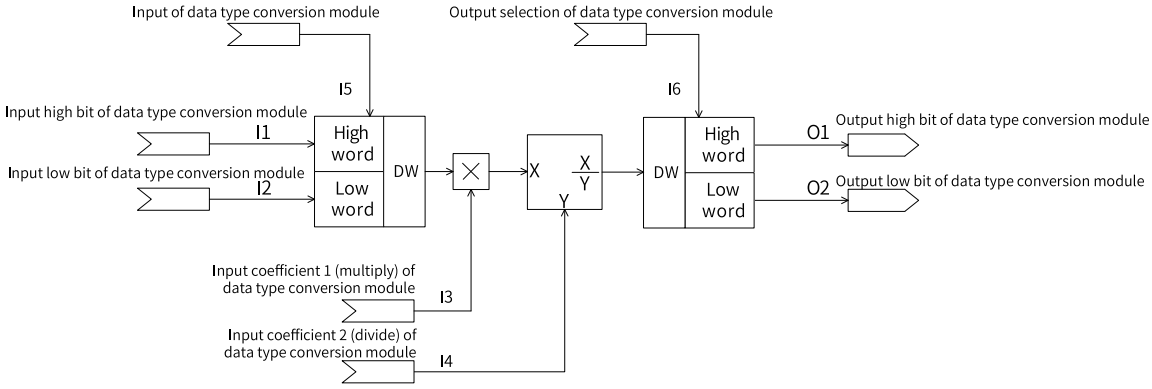
[L9-00]	[L10-17] bit 0	[C6-05]
10.0	-	41.0<1>
-10.0	-	-41.0
150.0	0: No action	Disabled
	1 (upper or lower limit)	600.0<2>
-150.0	0: No action	Disabled
	1 (upper or lower limit)	-600.0<2>

Note

- <1>: 4096 corresponds to 100% for single-word connectors according to *" Per-Unit Value System" on page 121*. [U7-47] is 10.00%, the per-unit value of 10% corresponds to the raw value 410, and C6-05 has a decimal point, so [C6-05] is 41.0.
- <2>: The raw value corresponding to ±150.0% per-unit value exceeds the upper limit/lower limit of C6-05. When the modification range overrun handling is effective, C6-05 is limited to the maximum value/minimum value.

9.13.10 Data Type Conversion Module

Diagram



Operation

I5 determines the input data type of I1 and I2. The input is multiplied by I3 and divided by I4 and then the output data type of O1 and O2 is determined by I6.

Connection

Inputs I1 to I3 are signed numbers.

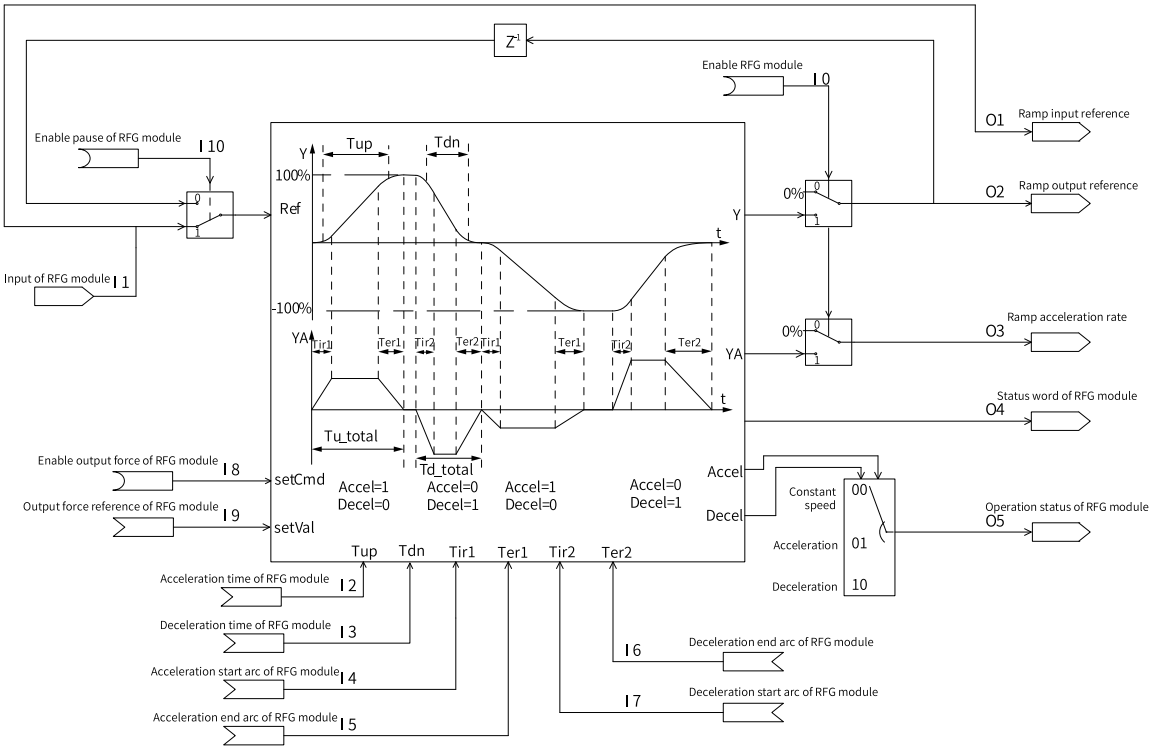
Input I4 to I6 are unsigned numbers.

Outputs O1 and O2 are signed numbers.

Data Type Conversion Module	Input						Output	
	I1	I2	I3	I4	I5	I6	O1	O2
1	L12-02	L12-03	L12-04	L12-05	L12-00	L12-01	U15-55	U15-56
2	L12-08	L12-09	L12-10	L12-11	L12-06	L12-07	U15-57	U15-58
3	L12-14	L12-15	L12-16	L12-17	L12-12	L12-13	U15-59	U15-60
4	L12-20	L12-21	L12-22	L12-23	L12-18	L12-19	U15-61	U15-62
5	L12-26	L12-27	L12-28	L12-29	L12-24	L12-25	U15-63	U15-64
6	L12-32	L12-33	L12-34	L12-35	L12-30	L12-31	U15-65	U15-66
7	L12-38	L12-39	L12-40	L12-41	L12-36	L12-37	U15-67	U15-68
8	L12-44	L12-45	L12-46	L12-47	L12-42	L12-43	U15-69	U15-70
9	L12-50	L12-51	L12-52	L12-53	L12-48	L12-49	U15-71	U15-72
10	L12-56	L12-57	L12-58	L12-59	L12-54	L12-55	U15-73	U15-74
11	L12-62	L12-63	L12-64	L12-65	L12-60	L12-61	U15-75	U15-76
12	L12-68	L12-69	L12-70	L12-71	L12-66	L12-67	U15-77	U15-78
13	L12-74	L12-75	L12-76	L12-77	L12-72	L12-73	U15-79	U15-80
14	L12-80	L12-81	L12-82	L12-83	L12-78	L12-79	U15-81	U15-82
15	L12-86	L12-87	L12-88	L12-89	L12-84	L12-85	U15-83	U15-84
16	L12-92	L12-93	L12-94	L12-95	L12-90	L12-91	U15-85	U15-86

9.13.11 Ramp Function Generator Module

Diagram



Operation

I2 acceleration time is the time for the speed to increase from 0 to +100% or to -100%, and I3 deceleration time is the time for the speed to decrease from +100% or -100% to 0.

I4 acceleration start arc time is the time for the acceleration rate to increase from 0 to the maximum acceleration rate (determined by the acceleration time). I5 acceleration end arc time is the time for the acceleration rate to decrease from the maximum acceleration rate (determined by the acceleration time) to 0.

I7 deceleration start arc time is the time for the acceleration rate to increase from 0 to the maximum acceleration rate (determined by the deceleration time). I6 deceleration end arc time is the time for the acceleration rate to decrease from the maximum acceleration rate (determined by the deceleration time) to 0.

The priority of I8 forcing is higher than that of I10 pause.

Definitions of status words of O4 RFG module:

Bit	Meaning	Description
Bit 0 to bit 1	Operation status of RFG module	0: Constant speed 1: Accelerate 2: Decelerate
Bit 2	RFG module enable	0: Disabled 1: Enabled
Bit 3	Reserved	-

Bit	Meaning	Description
Bit 4	Force enable	0: Disabled 1: Enabled
Bit 5	Pause enable	0: Disabled 1: Enabled
Bit 6 to bit 7	Reserved	-
Bit 8	Ramp acceleration rate positive	0: No 1: Yes
Bit 9	Ramp acceleration rate negative	0: No 1: Yes
Bit 10 to bit 15	Reserved	-

Connection

Inputs I0, I8, and I10 are binary numbers.

Inputs I1 and I9 are signed numbers.

Input I2 to I7 are unsigned numbers.

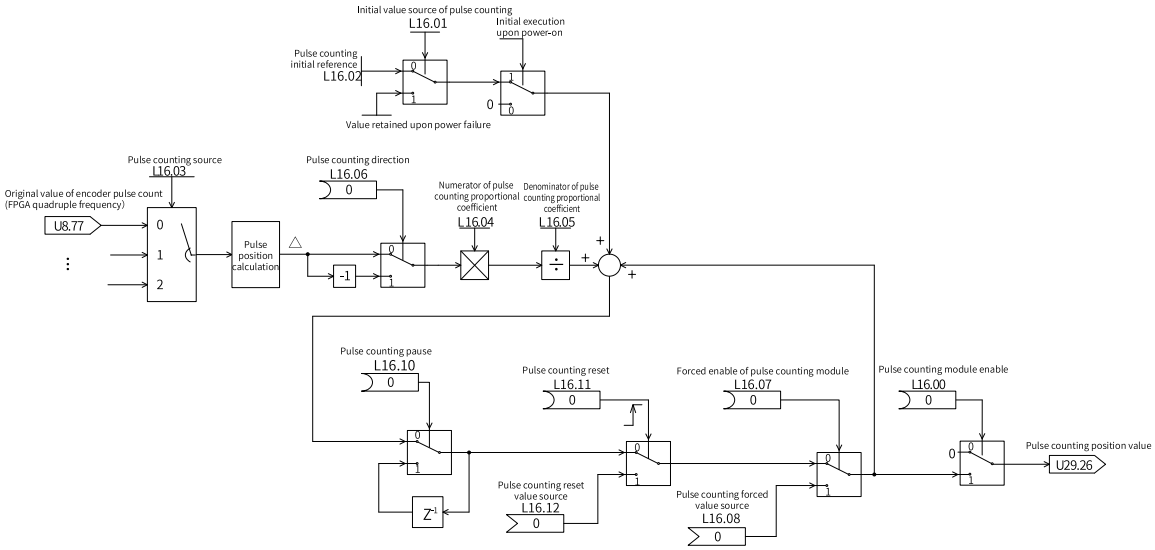
Outputs O1, O2, and O3 are signed numbers.

Outputs O4 and O5 are unsigned numbers.

Ramp Function Generator Module		A	B
Input	I0	L14-00	L14-00
	I1	L14-01	L14-11
	I2	L14-02	L14-12
	I3	L14-03	L14-13
	I4	L14-04	L14-14
	I5	L14-05	L14-15
	I6	L14-06	L14-16
	I7	L14-07	L14-17
	I8	L14-08	L14-18
	I9	L14-09	L14-19
	I10	L14-10	L14-20
Output	O1	U29-50	U29-53
	O2	U29-51	U29-54
	O3	U29-52	U29-55
	O4	U15-50	U15-52
	O5	U15-25	U15-51

9.13.12 Pulse Counting Module

The pulse counting module is used to convert pulse values of the encoder into position values, which are then placed in connectors. The host controller can read the connector values through communication for simple position control. The pulse counting module can be enabled by setting [L16-00] to 1.



The pulse counting module parameters are as follows.

Parameter	Name	Reference
L16-00	Enable pulse counting module	0: Disabled 1: Enabled Others: B connector
L16-01	Initial value source of pulse counting	0: L16-02 1: Value retained upon power failure
L16-02	Pulse counting initial value	-2147483648 to +2147483647
L16-03	Pulse counting source	0: Encoder detection module 1 1: Encoder detection module 2 2: Encoder detection module 3
L16-04	Numerator of pulse counting proportional coefficient	1 to 65535
L16-05	Denominator of pulse counting proportional coefficient	1 to 65535
L16-06	Pulse counting direction	0: Forward 1: Reverse Others: B connector
L16-07	Forced enable of pulse counting	0: Disabled 1: Enabled Others: B connector
L16-08	Forced value source of pulse counting	0: 0 1: Set by L16-09 Other: K connector
L16-09	Forced value setting of pulse counting	-2147483648 to +2147483647
L16-10	Pulse counting pause	0: Disabled 1: Enabled Others: B connector
L16-11	Pulse counting reset	0: Disabled 1: Enabled Others: B connector

Parameter	Name	Reference
L16-12	Pulse counting reset value source	0: 0 1: Set by L16-13 Other: K connector
L16-13	Pulse counting reset value setting	-2147483648 to +2147483647
U16-92	Pulse counting value	-
U29-26	Pulse counting position value	-

9.13.13 Multi-timer Module

9.13.13.1 Function of the Multi-timer Module

The multi-timer module can be used to implement simple PLC logic. It is generally used in applications with multi-speed requirements.

Example:

Step 1: Make the motor run at a speed of 50% for 30s.

Step 2: Make the motor run at a speed of 100% for 15s.

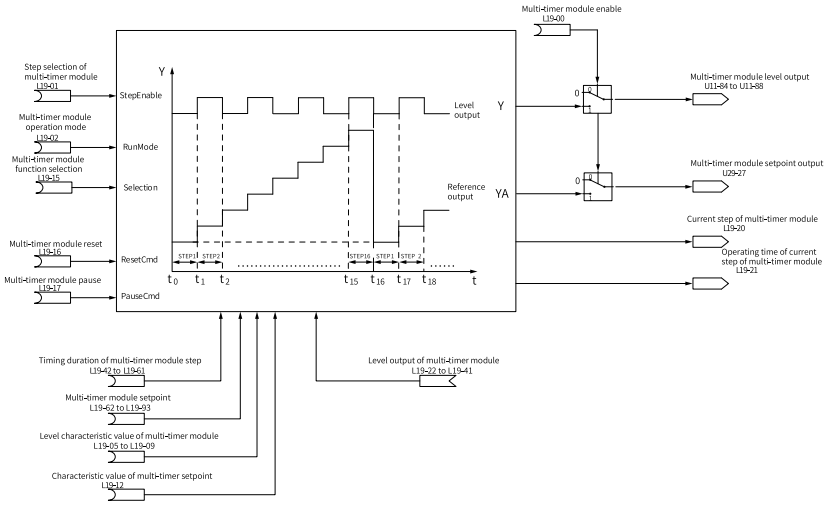
Step 3: Stop for 15s.

Step 4: Make the motor run at a speed of 10% for 30s.

Step 5: Make the motor run at a speed of 30% for 100s.

……

Up to 16 steps are supported. Run from step 1 to step 16 and then run from step 1 again, and repeat this process.



9.13.13.2 Description of Multi-timing Module Parameters

STEP setting of multi-timer module

Parameters related to STEP selection of multi-timer module are shown below.

Param.	Name	Value range	Default
L19-01	STEP selection of multi-timer module	bit00 to bit15: STEP1 to STEP16 0: Inhibited 1: Enabled	0xFFFF

The start and end steps are defined as follows.

Start step: Based on the setting of L19-01, the searching process starts from STEP1. The first enabled step searched is used as the start step.

End step: Based on the setting of L19-01, the searching process starts from STEP16 and ends if the first enabled step is found.

Example 1: If L19-01 = 0xFFFF, then the start step is SETP1 and the end step is SETP16.

Example 2: If L19-01 = 0x3FFC, then the start step is SETP3 and the end step is SETP14.

Example 3: If L19-01 = 0x0001, then the start step is SETP1 and the end step is SETP1.

The multi-timer module executes in sequence from the start step to the end step, which forms a complete cycle. Non-enabled steps between the start step and end step are skipped directly.

Operation mode of the multi-timer module

Parameters related to the operation mode of the multi-timer module are as follows.

Param.	Name	Value range	Default
L19-02	Operation mode of multi-timer module	0: Keep STEP1 output after operating for one cycle 1: Keep STEP16 output after operating for one cycle 2: Operate cyclically 3: Output specified feature values after operating for one cycle	2: Operate cyclically

Four modes of operation are available for the multi-timer module, which can be configured through L19-02.

- 0 [Keep STEP1 output after operating for one cycle]: Stay at STEP1 after one cycle of operation from the start step to the end step, even if STEP1 is not enabled. The five level signals are outputted according to the STEP1 values defined by L19-22...L19-41. The setpoints are outputted according to the STEP1 values defined by L19-62...L19-93.
- 1 [Keep STEP16 output after operating for one cycle]: Stay at STEP16 after one cycle of operation from the start step to the end step, even if STEP16 is not enabled. The five level signals are outputted according to the STEP16 values defined by L19-22...L19-41. The setpoints are outputted according to the STEP16 values defined by L19-62...L19-93.
- 2 [Operate cyclically]: Operate cyclically and repeatedly from the start step to the end step. The five level signals are outputted according to the values defined by L19-22...L19-41. The setpoints are outputted according to the values defined by L19-62...L19-93.
- 3 [Output specified feature values after operating for one cycle]: After one cycle of operation from the start step to the end step is done, the five level signals are outputted according to the values defined by L19-05...L19-09. The setpoints are outputted according to the values defined by L19-12.

Multi-timer module time setting

The time of each STEP in the multi-timer module can be set separately. Take STEP1 as an example, to achieve a timing of 10s in STEP1, set L19-46 to 1000 when the ones of L19-42 is set to 0 (time unit: 0.01s). Timing parameters for the multi-timer module are shown below.

Param.	Name	Value range	Default
L19-42	Timing unit in STEP1 to STEP4 of multi-timer module	Ones-: STEP1 timing unit selection 0: 0.01s 1: 0.1s 2: 1s 3: 1 min Tens-: STEP2 timing unit selection 0: 0.01s 1: 0.1s 2: 1s 3: 1 min Hundreds-: STEP3 timing unit selection 0: 0.01s 1: 0.1s 2: 1s 3: 1 min Thousands-: STEP4 timing unit selection 0: 0.01s 1: 0.1s 2: 1s 3: 1 min	0

Param.	Name	Value range	Default
L19-43	Timing unit in STEP5 to STEP8 of multi-timer module	Ones-: STEP5 timing unit selection 0: 0.01s 1: 0.1s 2: 1s 3: 1 min Tens-: STEP6 timing unit selection 0: 0.01s 1: 0.1s 2: 1s 3: 1 min Hundreds-: STEP7 timing unit selection 0: 0.01s 1: 0.1s 2: 1s 3: 1 min Thousands-: STEP8 timing unit selection 0: 0.01s 1: 0.1s 2: 1s 3: 1 min	0

Param.	Name	Value range	Default
L19-44	Timing unit in STEP9 to STEP12 of multi-timer module	Ones-: STEP9 timing unit selection 0: 0.01s 1: 0.1s 2: 1s 3: 1 min Tens-: STEP10 timing unit selection 0: 0.01s 1: 0.1s 2: 1s 3: 1 min Hundreds-: STEP11 timing unit selection 0: 0.01s 1: 0.1s 2: 1s 3: 1 min Thousands-: STEP12 timing unit selection 0: 0.01s 1: 0.1s 2: 1s 3: 1 min	0

Param.	Name	Value range	Default
L19-45	Timing unit in STEP13 to STEP16 of multi-timer module	Ones-: STEP13 timing unit selection 0: 0.01s 1: 0.1s 2: 1s 3: 1 min Tens-: STEP14 timing unit selection 0: 0.01s 1: 0.1s 2: 1s 3: 1 min Hundreds-: STEP15 timing unit selection 0: 0.01s 1: 0.1s 2: 1s 3: 1 min Thousands-: STEP16 timing unit selection 0: 0.01s 1: 0.1s 2: 1s 3: 1 min	0
L19-46 to L19-61	STEP 1 timing to STEP16 timing of multi-timer module	0 to 65535	0

Level output setting of multi-timer module

Parameters related to level output of multi-timer module are shown below.

Param.	Name	Value range	Default
L19-05	Feature value of level output 1	0: Low level 1: High level Others: B connector	0: Low level
L19-06	Feature value of level output 2	0: Low level 1: High level Others: B connector	0: Low level
L19-07	Feature value of level output 3	0: Low level 1: High level Others: B connector	0: Low level
L19-08	Feature value of level output 4	0: Low level 1: High level Others: B connector	0: Low level

Param.	Name	Value range	Default
L19-09	Feature value of level output 5	0: Low level 1: High level Others: B connector	0: Low level
L19-22	Multi-timer module level output 1	bit00 to bit15: STEP1 level to STEP16 level 0: Low level 1: High level	0x0000
L19-23	Multi-timer module level output 2	Same as above	0x0000
L19-24	Multi-timer module level output 3	Same as above	0x0000
L19-25	Multi-timer module level output 4	Same as above	0x0000
L19-26 to L19-41	Multi-timer module level output 5 - STEP1 to STEP16	0: Low level 1: High level Others: B connector	0: Low level

Application example of multi-timer module level output:

The multi-timer module has five level output signals, each corresponding to a connector. The following parameters apply to cyclic operation of the multi-timer module.

Table 9–6 Parameter configuration for multi-timer module level output

Param.	Name	Setpoint
L19-00	Multi-timer module enable	1 [Enable]
L19-01	STEP selection of multi-timer module	0xFFFF
L19-02	Operation mode of multi-timer module	2 [Operate cyclically]
L19-22	Multi-timer module level output 1	0xAAAA
L19-23	Multi-timer module level output 2	0xAAAA
L19-24	Multi-timer module level output 3	0xAAAA
L19-25	Multi-timer module level output 4	0xAAAA
L19-26 to L19-41	Multi-timer module level output 5 - STEP1 to STEP16	STEP1 is low level, STEP2 is high level, and STEP3 is low level... STEP16 is high level.

The following figure shows the level output after preceding configurations are done.

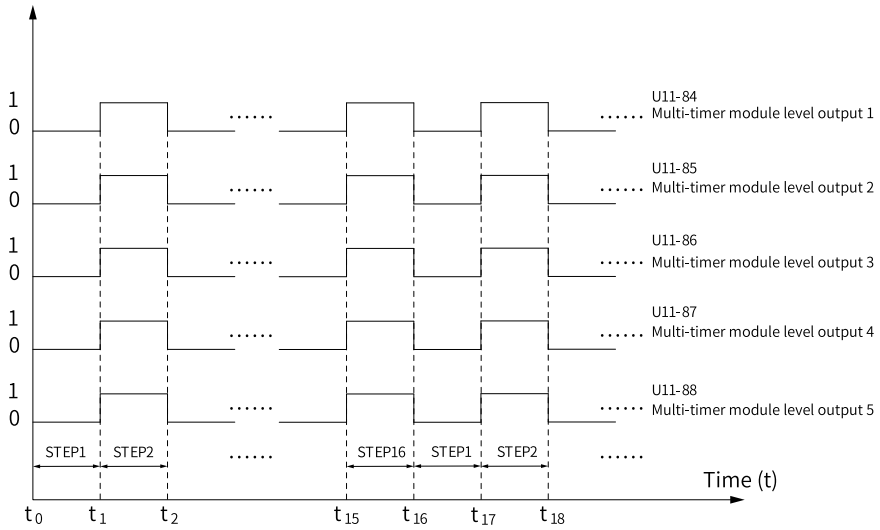


Figure 9-20 Multi-timer module level output

Multi-timer module reference output setting

Multi-timer module reference parameters are shown below.

Param.	Name	Value range	Default
L19-12	Feature value of reference output	-600.0% to +600.0%	0.0%
L19-62	STEP1 reference selection of multi-timer module	0: Set by L19-63 Others: K connector	0: Set by L19-63
L19-63	STEP1 reference of multi-timer module	-600.0% to +600.0%	0.0%
L19-64	STEP2 reference selection of multi-timer module	0: Set by L19-65 Others: K connector	0: Set by L19-65
L19-65	STEP2 reference of multi-timer module	-600.0% to +600.0%	0.0%
L19-66	STEP3 reference selection of multi-timer module	0: Set by L19-67 Others: K connector	0: Set by L19-67
L19-67	Multi-timer module STEP3 reference	-600.0% to +600.0%	0.0%
L19-68	STEP4 reference selection of multi-timer module	0: Set by L19-69 Others: K connector	0: Set by L19-69
L19-69	STEP4 reference of multi-timer module	-600.0% to +600.0%	0.0%
L19-70	STEP5 reference selection of multi-timer module	0: Set by L19-71 Others: K connector	0: Set by L19-71
L19-71	Multi-timer module STEP5 reference	-600.0% to +600.0%	0.0%
L19-72	STEP6 reference selection of multi-timer module	0: Set by L19-73 Others: K connector	0: Set by L19-73
L19-73	Multi-timer module STEP6 reference	-600.0% to +600.0%	0.0%
L19-74	STEP7 reference selection of multi-timer module	0: Set by L19-75 Others: K connector	0: Set by L19-75

Param.	Name	Value range	Default
L19-75	Multi-timer module STEP7 reference	-600.0% to +600.0%	0.0%
L19-76	STEP8 reference selection of multi-timer module	0: Set by L19-77 Others: K connector	0: Set by L19-77
L19-77	Multi-timer module STEP8 reference	-600.0% to +600.0%	0.0%
L19-78	STEP9 reference selection of multi-timer module	0: Set by L19-79 Others: K connector	0: Set by L19-79
L19-79	Multi-timer module STEP9 reference	-600.0% to +600.0%	0.0%
L19-80	STEP10 reference selection of multi-timer module	0: Set by L19-81 Others: K connector	0: Set by L19-81
L19-81	Multi-timer module STEP10 reference	-600.0% to +600.0%	0.0%
L19-82	STEP11 reference selection of multi-timer module	0: Set by L19-83 Others: K connector	0: Set by L19-83
L19-83	Multi-timer module STEP11 reference	-600.0% to +600.0%	0.0%
L19-84	STEP12 reference selection of multi-timer module	0: Set by L19-85 Others: K connector	0: Set by L19-85
L19-85	Multi-timer module STEP12 reference	-600.0% to +600.0%	0.0%
L19-86	STEP13 reference selection of multi-timer module	0: Set by L19-87 Others: K connector	0: Set by L19-87
L19-87	Multi-timer module STEP13 reference	-300.00% to +300.00%	0.0%
L19-88	STEP14 reference selection of multi-timer module	0: Set by L19-89 Others: K connector	0: Set by L19-89
L19-89	Multi-timer module STEP14 reference	-300.00% to +300.00%	0.0%
L19-90	STEP15 reference selection of multi-timer module	0: Set by L19-91 Others: K connector	0: Set by L19-91
L19-91	Multi-timer module STEP15 reference	-300.00% to +300.00%	0.0%
L19-92	STEP16 reference selection of multi-timer module	0: Set by L19-93 Others: K connector	0: Set by L19-93
L19-93	Multi-timer module STEP16 reference	-300.00% to +300.00%	0.0%

The reference of the multi-timer module corresponds to connector U29-27. The reference of each STEP can be set through parameters. The following diagram applies to cyclic operation of multi-timer module.

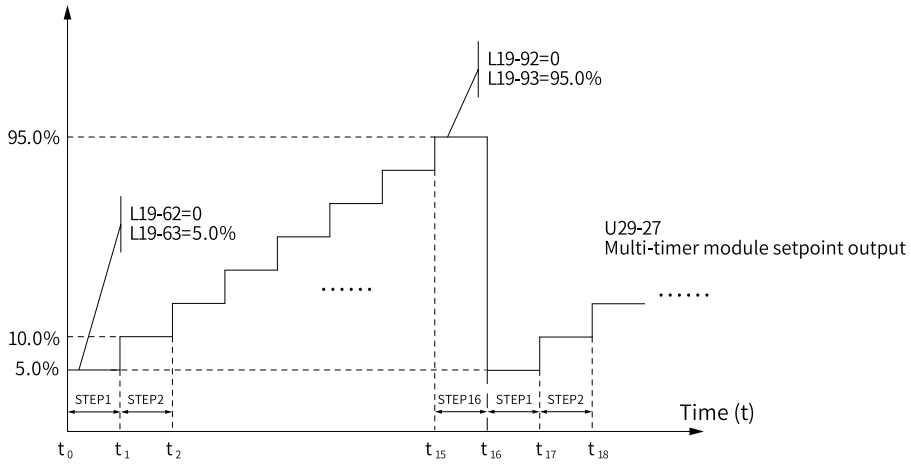


Figure 9-21 Reference output of multi-timer module

Retention function setting of multi-timer module

Parameters related to retention function of the multi-timer module are shown below.

Param.	Name	Value range	Default
L19-15	Multi-timer module function selection	0: Neither the STEP nor operating time retentive upon power failure 1: Only the STEP retentive upon power failure 2: Only the operating time retentive upon power failure 3: Both the STEP and operating time retentive upon power failure	0: Neither the STEP nor operating time retentive upon power failure

The retention function upon power failure is used to record the STEP and operating time upon power failure, allowing the device to continue operating at the recorded values. You can set the retention mode upon power failure through L19-15.

Setting the reset and pause functions of the multi-timer module

Parameters related to reset and pause functions of the multi-timer module are shown below.

Param.	Name	Value range	Default
L19-16	Multi-timer module reset enable	0: Inhibited 1: Enabled Others: B connector	0: Inhibited
L19-17	Multi-timer module pause enable	0: Invalid 1: Valid Others: B connector	0: Invalid

The reset command of the multi-timer module is rising edge-triggered. When a reset command is generated, the operation starts from the start step immediately. The reset command of the multi-timer module is configured through L19-16.

The pause command level of the multi-timer module is level-triggered. When the pause command is active, the timing stops, and therefore the operation stops at the current step. The pause command of the multi-timer module is configured through L19-17.

Note: The priority of the reset command is higher than the pause command.

9.13.13.3 Application Example of Multi-timer Module

You can implement the following logic through the multi-timer module.

Step 1: Keep the motor running at 100% speed for 30s.

Step 2: Stop the motor for 15s.

Step 3: Keep the motor running at 20% speed for 100s.

Step 4: Stop the motor for 30s.

Repeat steps 1 to 4.

For parameter configuration, see the following table.

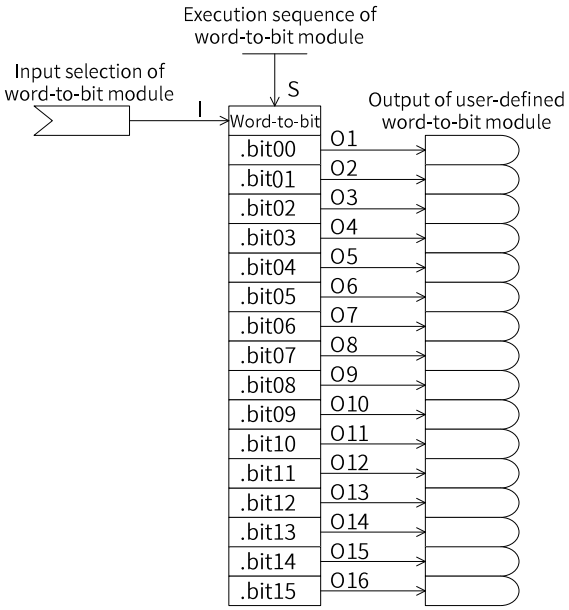
Param.	Name	Setpoint
L19-00	Multi-timer module enable	1 [Enable]
L19-01	STEP selection of multi-timer module	0x000F
L19-02	Multi-timer module operation mode	2 [Operate cyclically]
L19-15	Multi-timer module function selection	0 [STEP and operating time non-retentive before power failure]
L19-16	Multi-timer module reset enable	0 [Inhibited]
L19-17	Multi-timer module pause	0 [Inactive]
L19-22	Multi-timer module level output 1	0x0005
L19-42	Timer unit of multi-timer module STEP1 to STEP4	2222
L19-46	Timer duration of multi-timer module STEP1	30
L19-47	Timer duration of multi-timer module STEP2	15
L19-48	Timer duration of multi-timer module STEP3	100
L19-49	Timer duration of multi-timer module STEP4	30
L19-62	STEP1 reference selection of multi-timer module	0
L19-63	Multi-timer module STEP1 reference	100.0%
L19-66	STEP3 reference selection of multi-timer module	0
L19-67	Multi-timer module STEP3 reference	20.0%
A9-00	Command source	0 [Reference channel 1]
E0-00	Control mode	2 [V/f]
E0-01	Control mode	0 [Speed control]
b0-00	Start/Stop control word source	3 [Custom (set in group b0)]
b0-01	Source of custom OFF1	U11-84 [Multi-timer module level output 1]
C0-00	Main reference selection in speed control	U29-27 [Multi-timer module reference output]

9.13.14 Custom Function Block

9.13.14.1 User-Defined Conversion Function Block

1) Word-to-Bit (W2B) Module (1 to 3)

Diagram



Operation

When the input I is a single word, outputs O1 to O16 correspond to bit 00 to bit 15 of input I. When the input I is a double word, outputs O1 to O16 correspond to bit 00 to bit 15 of the high 16 bits of input I.

Connection

Input I is a signed number.

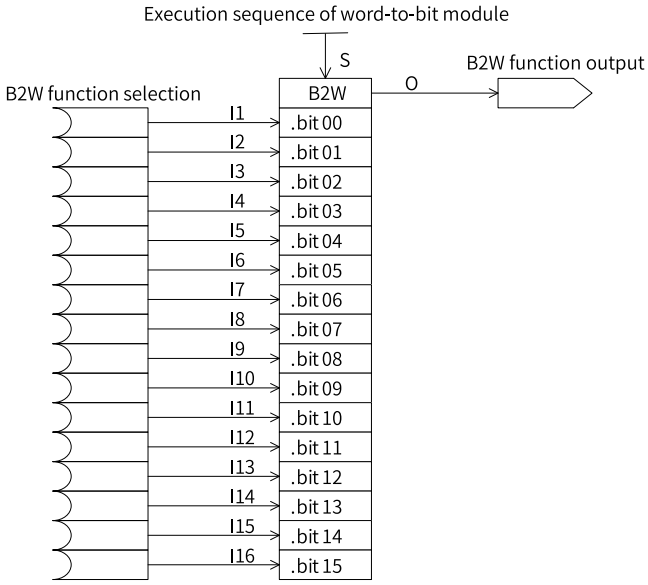
Outputs O1 to O16 are binary numbers.

Word-to-Bit (W2B) Module		1	2	3
Input	S	P0-00	P0-02	P0-04
	I	P0-01	P0-03	P0-05

Output	O1 (bit 00)	U10-00	U10-16	U10-32
	O2 (bit 01)	U10-01	U10-17	U10-33
	O3 (bit 02)	U10-02	U10-18	U10-34
	O4 (bit 03)	U10-03	U10-19	U10-35
	O5 (bit 04)	U10-04	U10-20	U10-36
	O6 (bit 05)	U10-05	U10-21	U10-37
	O7 (bit 06)	U10-06	U10-22	U10-38
	O8 (bit 07)	U10-07	U10-23	U10-39
	O9 (bit 08)	U10-08	U10-24	U10-40
	O10 (bit 09)	U10-09	U10-25	U10-41
	O11 (bit 10)	U10-10	U10-26	U10-42
	O12 (bit 11)	U10-11	U10-27	U10-43
	O13 (bit 12)	U10-12	U10-28	U10-44
	O14 (bit 13)	U10-13	U10-29	U10-45
	O15 (bit 14)	U10-14	U10-30	U10-46
	O16 (bit 15)	U10-15	U10-31	U10-47

2) Bit-to-Word (B2W) Module (1 to 4)

Diagram



Operation

Bit 00 to bit 16 of output O correspond to inputs I1 to I16.

Connection

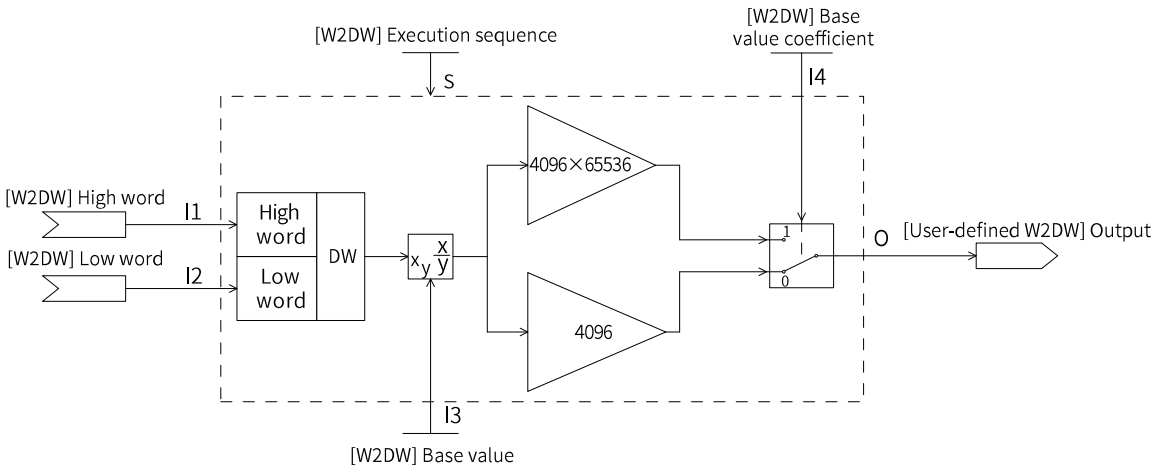
Inputs I1 to I16 are binary numbers.

Output O is a signed number.

Bit-to-Word (B2W) Module		1	2	3	4
Input	S	P0-06	P0-23	P0-40	P0-57
	I1 (bit 00)	P0-07	P0-24	P0-41	P0-58
	I2 (bit 01)	P0-08	P0-25	P0-42	P0-59
	I3 (bit 02)	P0-09	P0-26	P0-43	P0-60
	I4 (bit 03)	P0-10	P0-27	P0-44	P0-61
	I5 (bit 04)	P0-11	P0-28	P0-45	P0-62
	I6 (bit 05)	P0-12	P0-29	P0-46	P0-63
	I7 (bit 06)	P0-13	P0-30	P0-47	P0-64
	I8 (bit 07)	P0-14	P0-31	P0-48	P0-65
	I9 (bit 08)	P0-15	P0-32	P0-49	P0-66
	I10 (bit 09)	P0-16	P0-33	P0-50	P0-67
	I11 (bit 10)	P0-17	P0-34	P0-51	P0-68
	I12 (bit 11)	P0-18	P0-35	P0-52	P0-69
	I13 (bit 12)	P0-19	P0-36	P0-53	P0-70
	I14 (bit 13)	P0-20	P0-37	P0-54	P0-71
	I15 (bit 14)	P0-21	P0-38	P0-55	P0-72
	I16 (bit 15)	P0-22	P0-39	P0-56	P0-73
Output	O	U15-00	U15-01	U15-02	U15-03

3) W2DW Conversion (1 to 3)

Diagram



Operation

$$O=\begin{cases}\frac{I1\times65536+I2}{I3}\times4096\times65536, & I4=1\\ \frac{I1\times65536+I2}{I3}\times4096, & I4=0\end{cases}$$

The output equals I1 (high-order 16 bits) or I2 (low-order 16 bits) double word divided by base value I3 and then multiplied by the base value coefficient (specified by I4). When the input value is a double word, the high-order 16 bits are used.

When I3 is set to 0, the output value equals the input value without base value conversion.

Connection

Inputs I1 and I2 are signed numbers.

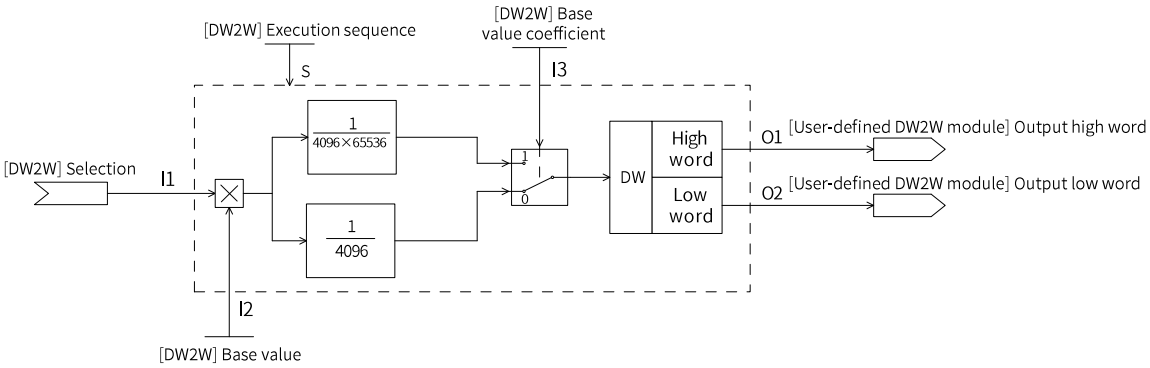
Input I3 is an unsigned number.

Output O is a signed number.

W2DW Conversion	Input					Output
	S	I1	I2	I3	I4	O
1	P0-75	P0-76	P0-77	P0-78	P0-74 (bit 0)	U19-00
2	P0-79	P0-80	P0-81	P0-82	P0-74 (bit 1)	U19-01
3	P0-83	P0-84	P0-85	P0-86	P0-74 (bit 2)	U19-02

4) DW2W Conversion (1 to 3)

Diagram



Operation

$$O1=\begin{cases}\left(\frac{I1\times I2}{4096\times 65536}>>16\right)\&0xFFFF, I3=1\\ \left(\frac{I1\times I2}{4096}>>16\right)\&0xFFFF, I3=0\end{cases}$$

$$O2=\begin{cases}\left(\frac{I1\times I2}{4096\times 65536}\right)\&0xFFFF, I3=1\\ \left(\frac{I1\times I2}{4096}\right)\&0xFFFF, I3=0\end{cases}$$

The output high word equals to the high-order 16 bits of I1 multiplied by the base value I2 and divided by the base value coefficient (specified by I3). The output low word equals to the low-order 16 bits of I1 multiplied by the base value I2 and divided by the base value coefficient (specified by I3).

When I2 is set to 0, the output high word is the input high word while the output low word is the input low word, without base value conversion.

Connection

Input I1 is a signed number.

Input I2 is an unsigned number.

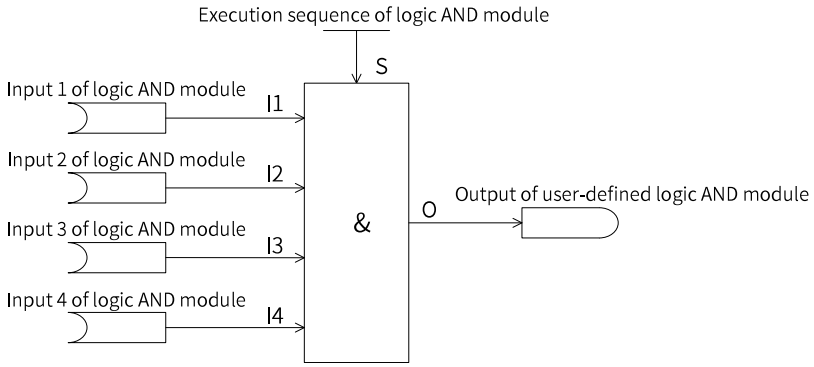
Outputs O1 and O2 are signed numbers.

DW2W Conversion	Input				Output	
	S	I1	I2	I3	O1	O2
1	P0-88	P0-89	P0-90	P0-87 (bit 0)	U15-04	U15-05
2	P0-91	P0-92	P0-93	P0-87 (bit 1)	U15-06	U15-07
3	P0-94	P0-95	P0-96	P0-87 (bit 2)	U15-08	U15-09

9.13.14.2 User-Defined Logic Function Block

1) Logic AND module (1 to 16)

Diagram



Operation

O = I1 & I2 & I3 & I4

Only if inputs I1, I2, I3, and I4 are all true, output O is true. Otherwise, output O is false. The truth table is as follows.

Input				Output
I1	I2	I3	I4	O
0	x	x	x	0
x	0	x	x	0
x	x	0	x	0
x	x	x	0	0
1	1	1	1	1

Connection

Inputs I1, I2, I3, and I4 are binary numbers.

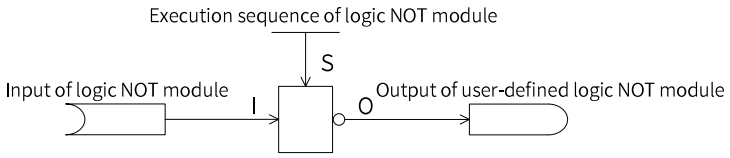
Output O is a binary number.

Logic AND Module		Input				Output
	S	I1	I2	I3	I4	O
1	P1-00	P1-01	P1-02	P1-03	P1-04	U10-48
2	P1-05	P1-06	P1-07	P1-08	P1-09	U10-49
3	P1-10	P1-11	P1-12	P1-13	P1-14	U10-50
4	P1-15	P1-16	P1-17	P1-18	P1-19	U10-51
5	P1-20	P1-21	P1-22	P1-23	P1-24	U10-52

Logic AND Module		Input				Output
	S	I1	I2	I3	I4	O
6	P1-25	P1-26	P1-27	P1-28	P1-29	U10-53
7	P1-30	P1-31	P1-32	P1-33	P1-34	U10-54
8	P1-35	P1-36	P1-37	P1-38	P1-39	U10-55
9	P1-40	P1-41	P1-42	P1-43	P1-44	U10-56
10	P1-45	P1-46	P1-47	P1-48	P1-49	U10-57
11	P1-50	P1-51	P1-52	P1-53	P1-54	U10-58
12	P1-55	P1-56	P1-57	P1-58	P1-59	U10-59
13	P1-60	P1-61	P1-62	P1-63	P1-64	U10-60
14	P1-65	P1-66	P1-67	P1-68	P1-69	U10-61
15	P1-70	P1-71	P1-72	P1-73	P1-74	U10-62
16	P1-75	P1-76	P1-77	P1-78	P1-79	U10-63

2) Logic NOT module (1 to 8)

Diagram



Operation

$O = \overline{I}$

The output is the inversion of input I. The truth table is as follows.

Input	Output
I	O
0	1
1	0

Connection

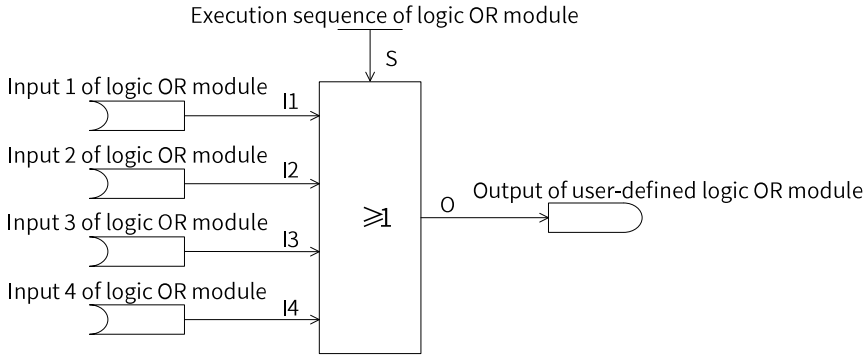
Input I is a binary number.

Output O is a binary number.

Logic NOT Module	Input		Output
	S	I	O
1	P1-80	P1-81	U10-64
2	P1-82	P1-83	U10-65
3	P1-84	P1-85	U10-66
4	P1-86	P1-87	U10-67
5	P1-88	P1-89	U10-68
6	P1-90	P1-91	U10-69
7	P1-92	P1-93	U10-70
8	P1-94	P1-95	U10-71

3) Logic OR module (1 to 12)

Diagram



Operation

O=I1|I2|I3|I4

If any of inputs I1, I2, I3, and I4 is true, the output is also true. The truth table is as follows.

Input				Output
I1	I2	I3	I4	O
0	0	0	0	0
1	x	x	x	1
x	1	x	x	1
x	x	1	x	1
x	x	x	1	1

Connection

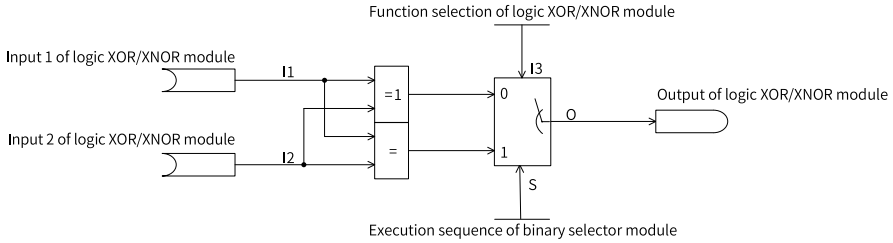
Inputs I1, I2, I3, and I4 are binary numbers.

Output O is a binary number.

Logic OR Module	Input					Output
	S	I1	I2	I3	I4	O
1	P2-00	P2-01	P2-02	P2-03	P2-04	U10-72
2	P2-05	P2-06	P2-07	P2-08	P2-09	U10-73
3	P2-10	P2-11	P2-12	P2-13	P2-14	U10-74
4	P2-15	P2-16	P2-17	P2-18	P2-19	U10-75
5	P2-20	P2-21	P2-22	P2-23	P2-24	U10-76
6	P2-25	P2-26	P2-27	P2-28	P2-29	U10-77
7	P2-30	P2-31	P2-32	P2-33	P2-34	U10-78
8	P2-35	P2-36	P2-37	P2-38	P2-39	U10-79
9	P2-40	P2-41	P2-42	P2-43	P2-44	U10-80
10	P2-45	P2-46	P2-47	P2-48	P2-49	U10-81
11	P2-50	P2-51	P2-52	P2-53	P2-54	U10-82
12	P2-55	P2-56	P2-57	P2-58	P2-59	U10-83

4) Logic XOR/XNOR module (1 to 4)

Diagram



Operation

When I3 (logic XOR/XNOR module function) is set to 0, logic XOR is enabled, and $O = \overline{I1}\, I2 + I1\, \overline{I2}$.

When input I1 and I2 are the same, output O is 0. When input I1 and I2 are different, output O is 1. The truth table is as follows.

Input		Output
I1	I2	O
0	0	0
1	0	1
0	1	1
1	1	0

When I3 (Logic XOR/XNOR module function) is set to 1, logic XNOR is enabled, and $O = I1\, I2 + \overline{I1}\, \overline{I2}$.

When input I1 and I2 are the same, output O is 1. When input I1 and I2 are different, output O is 0. The truth table is as follows.

Input		Output
I1	I2	O
0	0	1
1	0	0
0	1	0
1	1	1

Connection

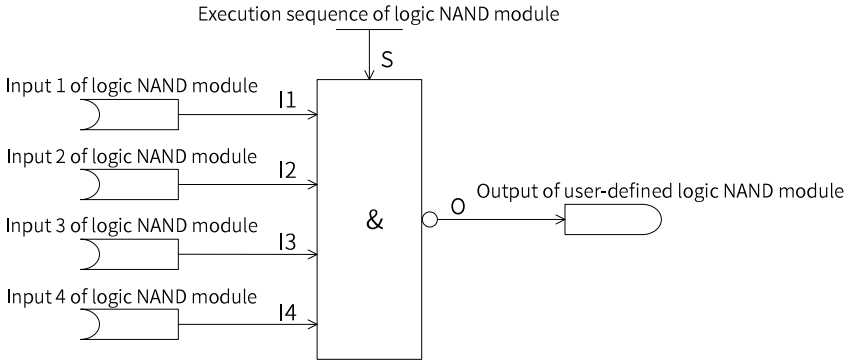
Inputs I1, I2, and I3 are binary numbers.

Output O is a binary number.

Logic XOR/XNOR Module	Input				Output
	S	I1	I2	I3	O
1	P2-60	P2-62	P2-63	P2-61	U10-84
2	P2-64	P2-66	P2-67	P2-65	U10-85
3	P2-68	P2-70	P2-71	P2-69	U10-86
4	P2-72	P2-74	P2-75	P2-73	U10-87

5) Logic NAND module (1 to 4)

Diagram



Operation

$O = \overline{I1 \& I2 \& I3 \& I4}$

If the inputs I1, I2, I3 and I4 are all true, the output O is false; otherwise the output O is true. The truth table is as follows.

Input				Output
I1	I2	I3	I4	O
0	0	0	0	1
1	0	0	0	1
0	1	0	0	1
1	1	0	0	1
0	0	1	0	1
1	0	1	0	1
0	1	1	0	1
1	1	1	0	1
0	0	0	1	1
1	0	0	1	1
0	1	0	1	1
1	1	0	1	1
0	0	1	1	1
1	0	1	1	1
0	1	1	1	1
1	1	1	1	0

Connection

Inputs I1, I2, I3, and I4 are binary numbers.

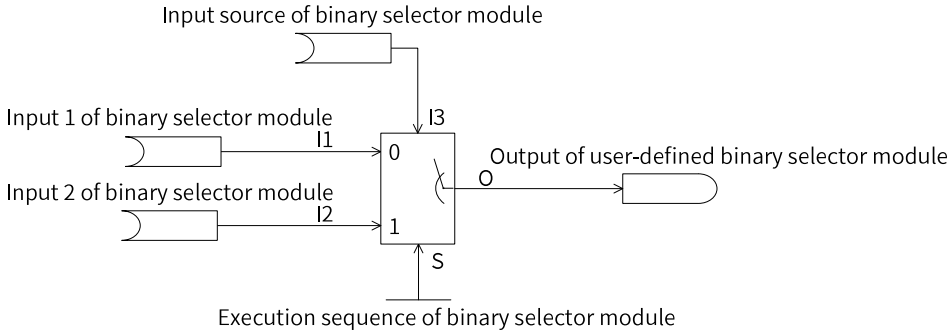
Output O is a binary number.

Logic NAND Module	Input					Output
	S	I1	I2	I3	I4	O
1	P2-76	P2-77	P2-78	P2-79	P2-80	U10-88
2	P2-81	P2-82	P2-83	P2-84	P2-85	U10-89
3	P2-86	P2-87	P2-88	P2-89	P2-90	U10-90
4	P2-91	P2-92	P2-93	P2-94	P2-95	U10-91

9.13.14.3 User-Defined Switch Function Block

1) Binary selector module (1 to 8)

Diagram



Operation

$$O = \begin{cases} I1, I3=0 \\ I2, I3=1 \end{cases}$$

Connection

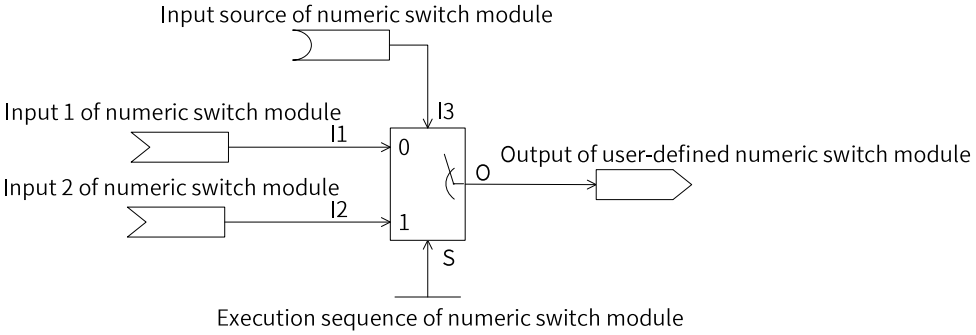
Inputs I1, I2, and I3 are binary numbers.

Output O is a binary number.

Binary Selector Module	Input				Output
	S	I1	I2	I3	O
1	P3-00	P3-02	P3-03	P3-01	U10-92
2	P3-04	P3-06	P3-07	P3-05	U10-93
3	P3-08	P3-10	P3-11	P3-09	U10-94
4	P3-12	P3-14	P3-15	P3-13	U10-95
5	P3-16	P3-18	P3-19	P3-17	U10-96
6	P3-20	P3-22	P3-23	P3-21	U10-97
7	P3-24	P3-26	P3-27	P3-25	U10-98
8	P3-28	P3-30	P3-31	P3-29	U10-99

2) Numeric switch module (1 to 12)

Diagram



Operation

$$O = \begin{cases} I1, I3=0 \\ I2, I3=1 \end{cases}$$

When I3 (numeric switch module input) is set to 0, output O equals I1 (word). When I3 (numeric switch module input) is set to 1, output O equals I2 (word).

Connection

Inputs I1 and I2 are signed numbers.

Input I3 is a binary number.

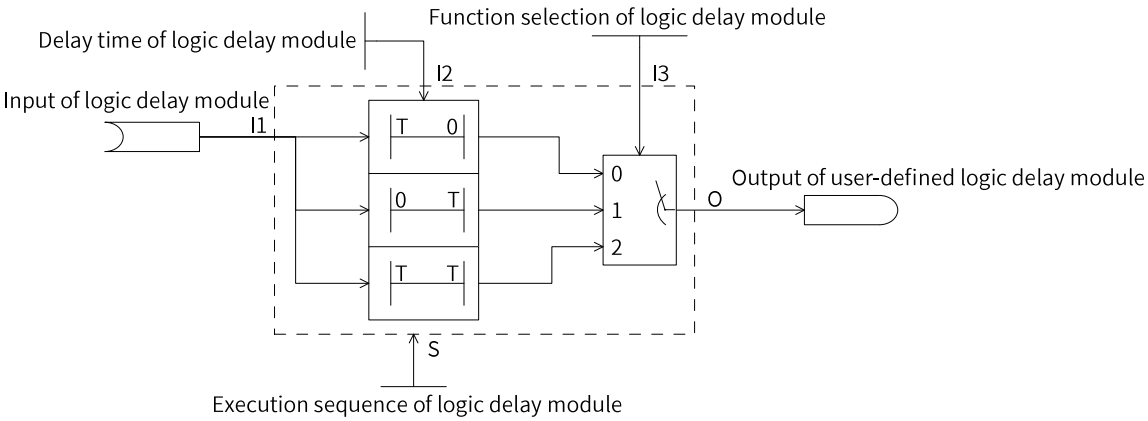
Output O is a signed number.

Numeric Switch Module	Input				Output
	S	I1	I2	I3	O
1	P3-32	P3-34	P3-35	P3-33	U19-03
2	P3-36	P3-38	P3-39	P3-37	U19-04
3	P3-40	P3-42	P3-43	P3-41	U19-05
4	P3-44	P3-46	P3-47	P3-45	U19-06
5	P3-48	P3-50	P3-51	P3-49	U19-07
6	P3-52	P3-54	P3-55	P3-53	U19-08
7	P3-56	P3-58	P3-59	P3-57	U19-09
8	P3-60	P3-62	P3-63	P3-61	U19-10
9	P3-64	P3-66	P3-67	P3-65	U19-11
10	P3-68	P3-70	P3-71	P3-69	U19-12
11	P3-72	P3-74	P3-75	P3-73	U19-13
12	P3-76	P3-78	P3-79	P3-77	U19-14

9.13.14.4 User-Defined Control Function Block

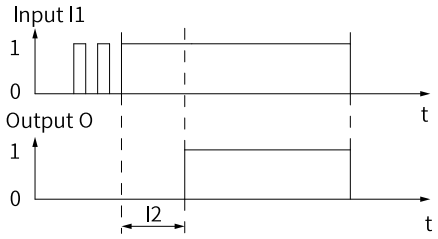
1) Logic delay module (1 to 4)

Diagram

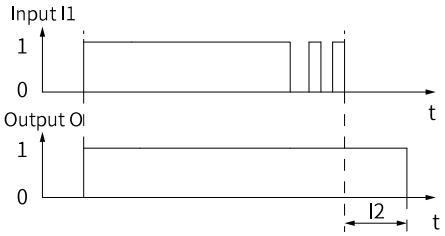


Operation

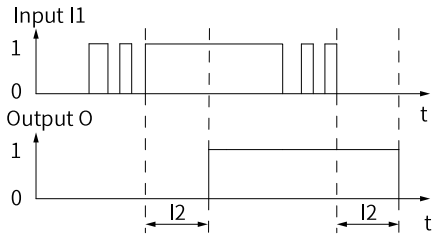
After the logic delay module function I3 is set to 0, switch-on delay becomes active when input changes from 0 to 1, and the delay time is determined by I2. After switch-on delay is enabled, high-level pulses lasting less than I2 will be filtered out, as shown in the following figure.



After the logic delay module function I3 is set to 1, switch-off delay becomes active when input changes from 1 to 0, and the delay time is determined by I2. After switch-off delay is enabled, low-level pulses lasting less than I2 will be filtered out, as shown in the following figure.



After the logic delay module function I3 is set to 2, switch-on delay becomes active when input changes from 0 to 1 or from 1 to 0, and the delay time is determined by I2. Both switch-on and switch-off delays will filter the pulses, as shown in the following figure.



Connection

Input I1 is a binary number.

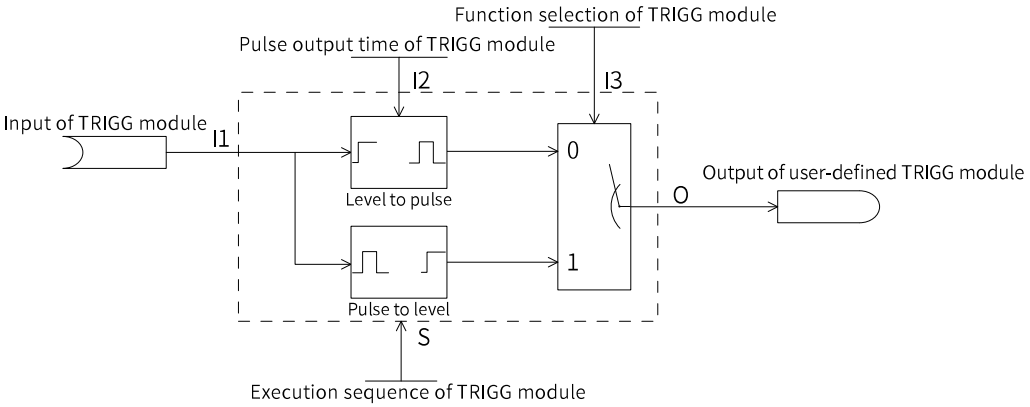
Inputs I2 and I3 are unsigned numbers.

Output O is a binary number.

Logic Delay Module	Input				Output
	S	I1	I2	I3	O
1	P4-00	P4-01	P4-03	P4-02	U11-00
2	P4-04	P4-05	P4-07	P4-06	U11-01
3	P4-08	P4-09	P4-11	P4-10	U11-02
4	P4-12	P4-13	P4-15	P4-14	U11-03

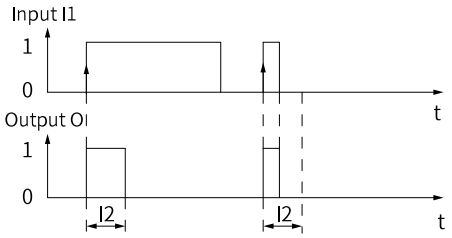
2) P_L conversion module (1 to 4)

Diagram

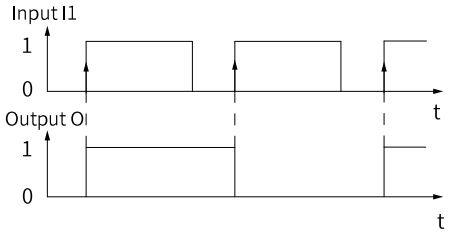


Operation

When the level-pulse (P_L) conversion module function (I3) is set to 0, level-to-pulse conversion is active. In this case, the output becomes high on the rising edge of input I1 within the pulse output time indicated by I2. If input I1 is set to 0, the output immediately changes to 0, regardless of whether the pulse duration is reached.



When the level-pulse (P_L) conversion module function is set to 1, pulse-to-level conversion is active. In this case, the output becomes high on the first rising edge of input I1, and becomes low on the second rising edge of input I1, and so on. That is, the pulse output of odd numbers is at a high level, while the pulse output of even numbers is at a low level.



Connection

Inputs I1 and I3 are binary numbers.

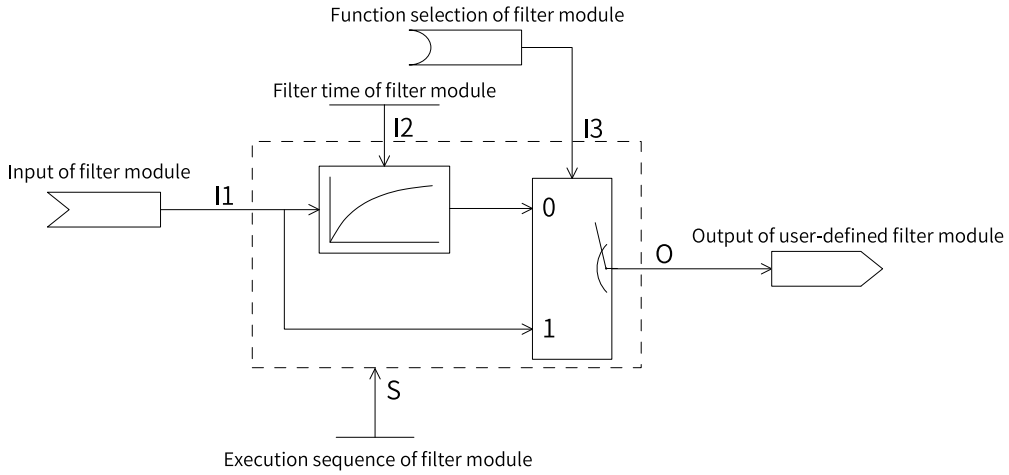
Input I2 is an unsigned number.

Output O is a binary number.

P_L Conversion Module	Input				Output
	S	I1	I2	I3	O
1	P4-16	P4-18	P4-19	P4-17	U11-04
2	P4-20	P4-22	P4-23	P4-21	U11-05
3	P4-24	P4-26	P4-27	P4-25	U11-06
4	P4-28	P4-30	P4-31	P4-29	U11-07

3) Filter module (1 to 8)

Diagram



Operation

When I3 (filter module function) is set to 0, output O equals to the filter value of input I1. When I3 (filter module function) is set to 1, output O equals to input I1.

Connection

Input I1 is a signed number.

Input I2 is an unsigned number.

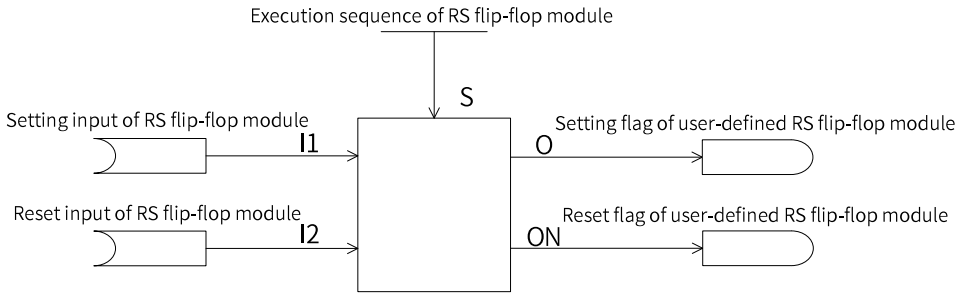
Input I3 is a binary number.

Output O is a signed number.

Filter Module	Input				Output
	S	I1	I2	I3	O
1	P4-32	P4-34	P4-35	P4-33	U19-15
2	P4-36	P4-38	P4-39	P4-37	U19-16
3	P4-40	P4-42	P4-43	P4-41	U19-17
4	P4-44	P4-46	P4-47	P4-45	U19-18
5	P4-48	P4-50	P4-51	P4-49	U19-19
6	P4-52	P4-54	P4-55	P4-53	U19-20
7	P4-56	P4-58	P4-59	P4-57	U19-21
8	P4-60	P4-62	P4-63	P4-61	U19-22

4) RS flip-flop module (1 to 4)

Diagram



Operation

If both inputs I1 and I2 are set to 0, output O remains at the current value. If input I1 is set to 1 and input I2 is set to 0, output O is 1. If input I2 is set to 1, output O is 0. If both inputs I1 and I2 are set to 1, output O is 0. Output ON is always opposite to the value of O. The truth table is as follows.

Input		Output	
I1	I2	O	ON
0	0	Unchanged	Unchanged
1	0	1	0
0	1	0	1
1	1	0	1

Connection

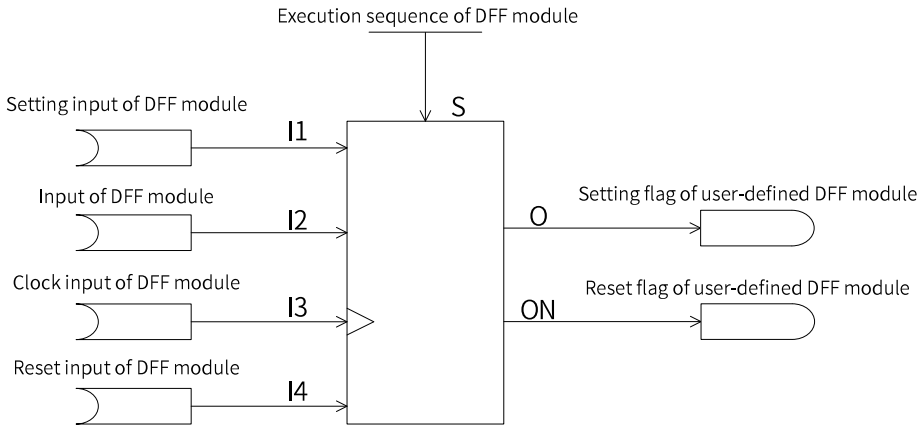
Inputs I1 and I2 are binary numbers.

Outputs O and ON are binary numbers.

RS Flip-Flop Module	Input			Output	
	S	I1	I2	O	ON
1	P4-64	P4-65	P4-66	U11-08	U11-09
2	P4-67	P4-68	P4-69	U11-10	U11-11
3	P4-70	P4-71	P4-72	U11-12	U11-13
4	P4-73	P4-74	P4-75	U11-14	U11-15

5) DLL module (1 to 4)

Diagram

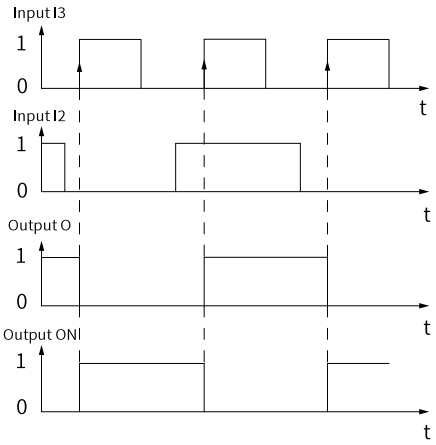


Operation

If the inputs I1 and I4 are both set to 0, output O is equal to input I2 on the rising edge of input I3. If input I1 is set to 1, output O is 1. If input I4 is set to 1, output O is 0.

If both inputs I1 and I4 are set to 0 and input I3 has no rising edge, output O remains at the current value. If both inputs I1 and I4 are set to 1, output O is 0. Output ON is always opposite to the value of output O.

When I1 = I4 = 0, the timing diagrams of output O, output ON, input I2, and clock I3 are as follows:



Connection

Inputs I1, I2, I3, and I4 are binary numbers.

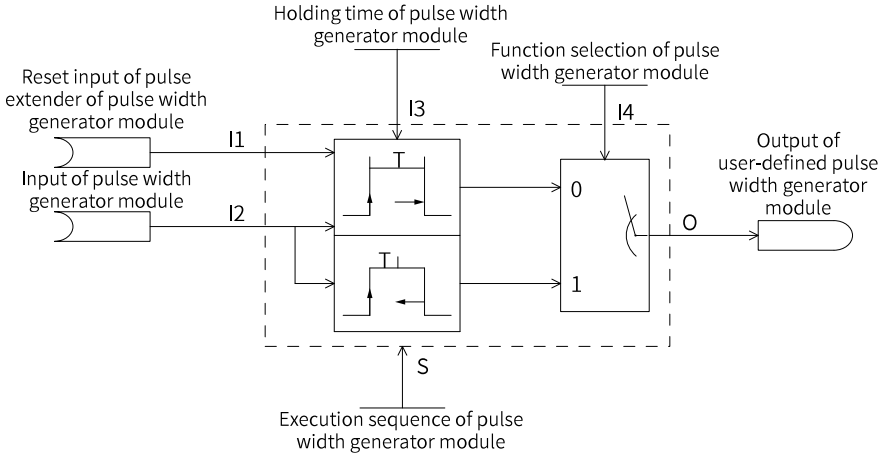
Outputs O and ON are binary numbers.

DLL Module	Input					Output	
	S	I1	I2	I3	I4	O	ON
1	P4-76	P4-79	P4-77	P4-80	P4-78	U11-16	U11-17
2	P4-81	P4-84	P4-82	P4-85	P4-83	U11-18	U11-19

DLL Module	Input					Output	
	S	I1	I2	I3	I4	O	ON
3	P4-86	P4-89	P4-87	P4-90	P4-88	U11-20	U11-21
4	P4-91	P4-94	P4-92	P4-95	P4-93	U11-22	U11-23

6) Pulse width generator module (1 to 8)

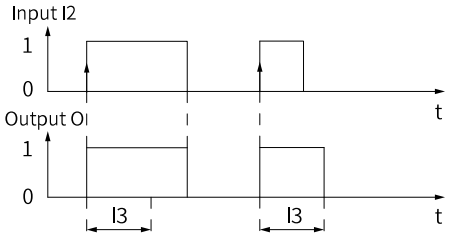
Diagram



Operation

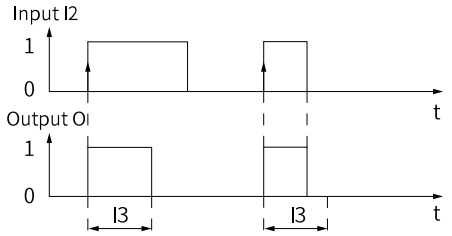
When pulse width generator module function selection I4 is 0, the pulse extension is active, and the output is set to 1 on the rising edge of input I2. When input I2 is 0 and the pulse duration reaches I3, output O is set to 0, and the output is set to 0 at any time by resetting the input I1 to 1.

When I1 is 0, the output O and input I2 timing diagrams are:



When pulse width generator module function selection I4 is 1, the pulse shortening is active. The output is set to 1 at the rising edge of input I2, and the output O is set to 0 when input I2 is 0 or the pulse duration reaches I3.

The timing diagram of output O and Input I2 is:



Connection

Inputs I1, I2, and I4 are binary numbers.

Input I3 is an unsigned number.

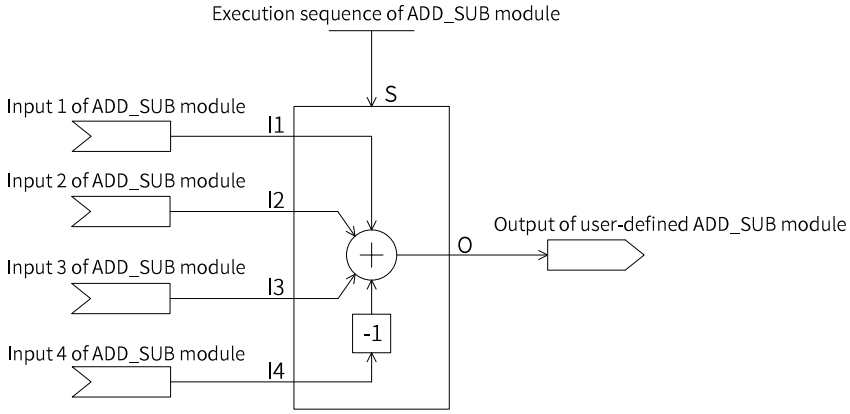
Output O is a binary number.

Pulse Width Generator Module	Input					Output
	S	I1	I2	I3	I4	O
1	P5-00	P5-04	P5-22	P5-23	P5-01	U11-24
2	P5-05	P5-09	P5-27	P5-28	P5-06	U11-25
3	P5-10	P5-14	P5-32	P5-33	P5-11	U11-26
4	P5-15	P5-19	P5-37	P5-38	P5-16	U11-27
5	P5-20	P5-24	P5-42	P5-43	P5-21	U11-28
6	P5-25	P5-29	P5-47	P5-48	P5-26	U11-29
7	P5-30	P5-34	P5-52	P5-53	P5-31	U11-30
8	P5-35	P5-39	P5-57	P5-58	P5-36	U11-31

9.13.14.5 User-Defined Arithmetic Function Block

1) ADD_SUB module (1 to 8)

Diagram



Operation

O=I1+I2+I3-I4

The value of output O equals the sum of I1, I2, and I3 minus I4.

Connection

Inputs I1, I2, I3, and I4 are signed numbers.

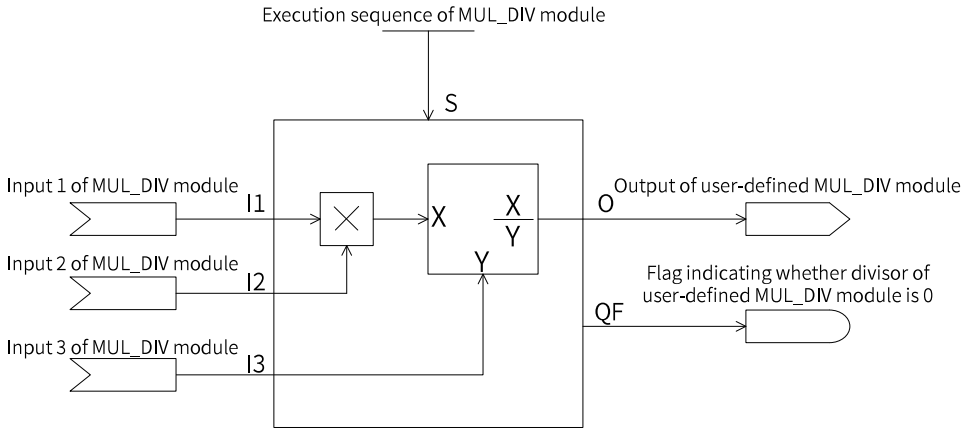
Output O is a signed number.

ADD_SUB Module	Input					Output
	S	I1	I2	I3	I4	O
1	P6-00	P6-01	P6-02	P6-03	P6-04	U19-23
2	P6-05	P6-06	P6-07	P6-08	P6-09	U19-24

ADD_SUB Module	Input					Output
	S	I1	I2	I3	I4	O
3	P6-10	P6-11	P6-12	P6-13	P6-14	U19-25
4	P6-15	P6-16	P6-17	P6-18	P6-19	U19-26
5	P6-20	P6-21	P6-22	P6-23	P6-24	U19-27
6	P6-25	P6-26	P6-27	P6-28	P6-29	U19-28
7	P6-30	P6-31	P6-32	P6-33	P6-34	U19-29
8	P6-35	P6-36	P6-37	P6-38	P6-39	U19-30

2) MUL_DIV module (1 to 8)

Diagram



Operation

$$O=(I1\cdot I2)/I3$$

$$QF=\begin{cases}1, I3=0\\0, I3\neq 0\end{cases}$$

Connection

Inputs I1, I2, and I3 are signed numbers.

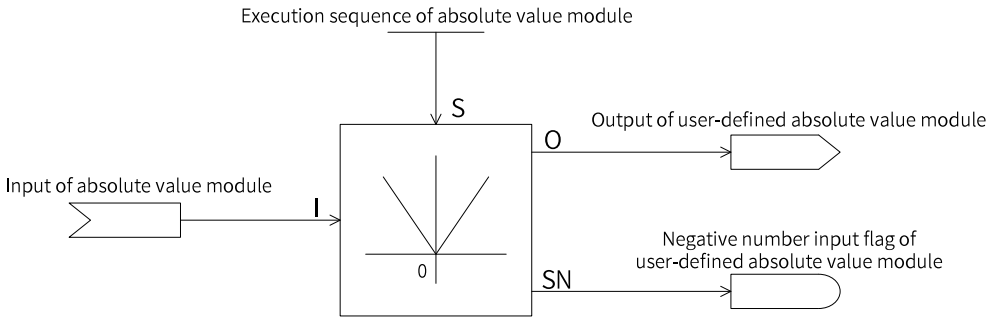
Output O is a signed number.

Output QF is a binary number.

MUL_DIV Module	Input				Output	
	S	I1	I2	I3	QF	O
1	P6-40	P6-41	P6-42	P6-43	U11-32	U19-31
2	P6-44	P6-45	P6-46	P6-47	U11-33	U19-32
3	P6-48	P6-49	P6-50	P6-51	U11-34	U19-33
4	P6-52	P6-53	P6-54	P6-55	U11-35	U19-34
5	P6-56	P6-57	P6-58	P6-59	U11-36	U19-35
6	P6-60	P6-61	P6-62	P6-63	U11-37	U19-36
7	P6-64	P6-65	P6-66	P6-67	U11-38	U19-37
8	P6-68	P6-69	P6-70	P6-71	U11-39	U19-38

3) Absolute value module (1 to 4)

Diagram



Operation

$O = |I|$

The output equals the absolute value of input I. When the input value is negative, the flag bit SN is 1. Otherwise, the flag bit is 0.

Connection

Input I is a signed number.

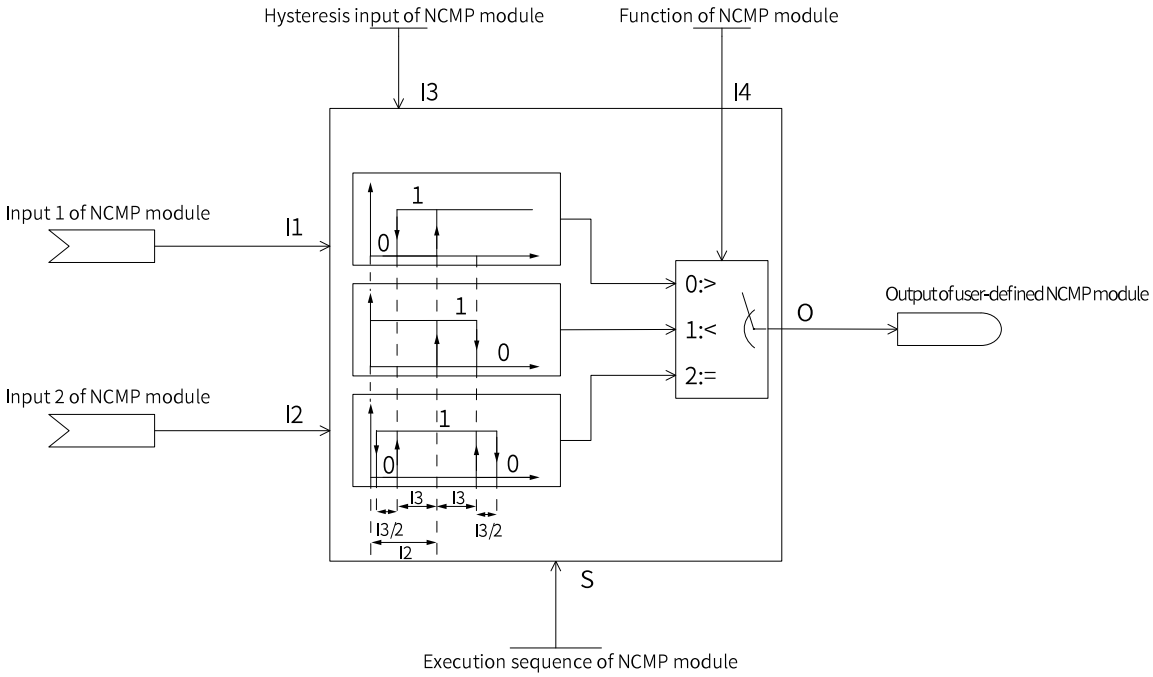
Output O is a signed number.

The output SN is a binary number.

Absolute Value Module	Input		Output	
	S	I	SN	O
1	P6-72	P6-73	U11-40	U19-39
2	P6-74	P6-75	U11-41	U19-40
3	P6-76	P6-77	U11-42	U19-41
4	P6-78	P6-79	U11-43	U19-42

4) NCMP module (1 to 4)

Diagram



Operation

- If the comparison (NCMP) module function (I4) is set to 1, output O remains at a low level before I1 increases to I2 from 0 in the forward direction. When I1 exceeds I2, output O changes to a high level. If I1 further increases, output O remains at the high level. If I1 decreases but is still greater than I2 minus I3, output O still remains at the high level. Output O changes to the low level only when I1 becomes less than I2 minus I3.
- If the NCMP module function (I4) is set to 1, output O remains at a high level before I1 increases to I2 plus I3 from 0 in the forward direction. When I1 becomes greater than I2 plus I3, output O changes to a low level. If I1 further increases, output O remains at the low level. If I1 decreases but is still greater than I2, output O still remains at the low level. Output O changes to the high level only when I1 becomes less than I2.
- If the NCMP module function (I4) is set to 2, output O remains at a low level before I1 increases to I2 minus I3 from 0 in the forward direction. When I1 becomes greater than I2 minus I3 but less than I2 plus I3, output O changes to a high level. If I1 further increases to become greater than I2 plus I3 multiplied by 1.5, output O changes to the low level. If I1 decreases, output O still remains at the low level when I1 is less than I2 plus I3. Output O changes to the high level when I1 becomes less than I2 plus I3 but greater than I2 minus I3 multiplied by 1.5. Output O changes to the low level when I1 becomes less than I2 minus I3 multiplied by 1.5.
- Hysteresis input I3 suppresses frequent connection and disconnection.

Connection

Inputs I1 and I2 are signed numbers.

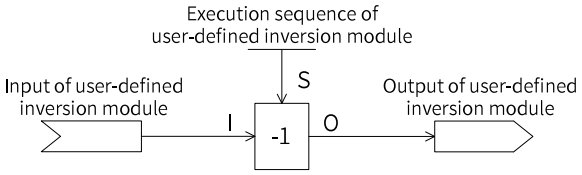
Inputs I3 and I4 are unsigned numbers.

Output O is a binary number.

NCMP Module	Input					Output
	S	I1	I2	I3	I4	O
1	P6-80	P6-82	P6-83	P6-84	P6-81	U11-44
2	P6-85	P6-87	P6-88	P6-89	P6-86	U11-45
3	P6-90	P6-92	P6-93	P6-94	P6-91	U11-46
4	P6-95	P6-97	P6-98	P6-99	P6-96	U11-47

5) Inversion module (1 to 8)

Diagram



Operation

O = - I

Output O equals inverted input I.

Connection

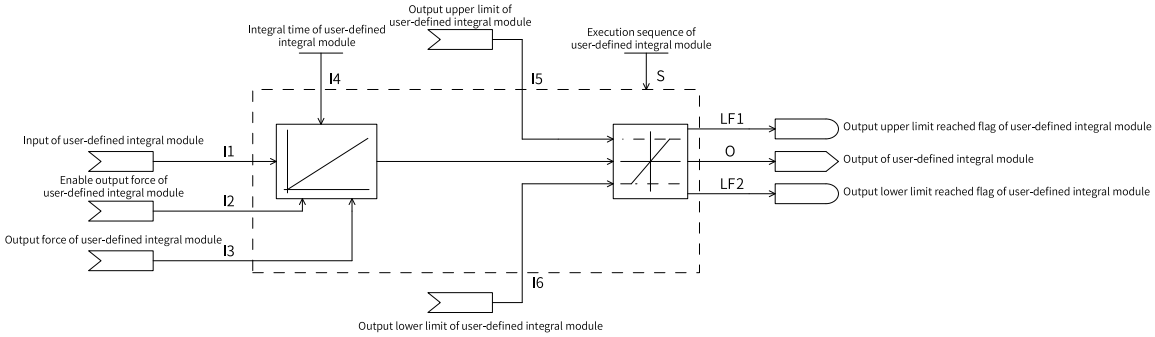
Input I is a signed number.

Output O is a signed number.

Inversion Module	Input		Output
	S	I	O
1	P7-00	P7-01	U19-43
2	P7-02	P7-03	U19-44
3	P7-04	P7-05	U19-45
4	P7-06	P7-07	U19-46
5	P7-08	P7-09	U19-47
6	P7-10	P7-11	U19-48
7	P7-12	P7-13	U19-49
8	P7-14	P7-15	U19-50

6) Integral module (1 to 4)

Diagram



Operation

$Y_n=Y_{n-1}+X_n/T_i$

Y_n is the output value, Y_{n-1} is the last beat value of the output Y_n, X_n is the input value, and T_i is the integral time.

The change of output value is proportional to the input value and inversely proportional to the integral time.

The output of the integrator is limited by I5 and I6. If the output reaches the upper or lower limit, the corresponding output limit flag bit is set to 1, and if I5 is smaller than or equal to I6, the output O equals to I5.

If I2 is forced to 1, output O equals to I3.

Connection

Inputs I1, I3, I5, and I6 are signed numbers.

Input I4 is an unsigned number.

Input I2 is a binary number.

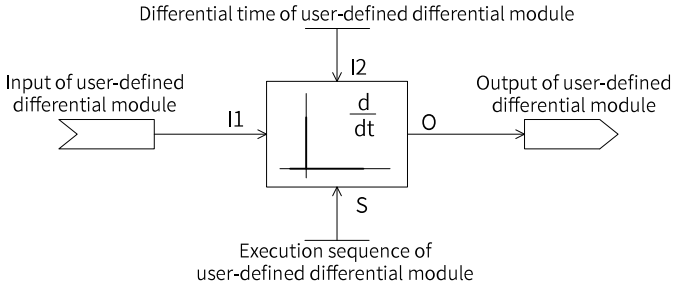
Outputs LF1 and LF2 are binary numbers.

Output O is a signed number.

Integral Module	Input							Output		
	S	I1	I2	I3	I4	I5	I6	LF1	LF2	O
1	P7-16	P7-17	P7-20	P7-21	P7-22	P7-18	P7-19	U11-48	U11-49	U19-51
2	P7-23	P7-24	P7-27	P7-28	P7-29	P7-25	P7-26	U11-50	U11-51	U19-52
3	P7-30	P7-31	P7-34	P7-35	P7-36	P7-32	P7-33	U11-52	U11-53	U19-53
4	P7-37	P7-38	P7-41	P7-42	P7-43	P7-39	P7-40	U11-54	U11-55	U19-54

7) Differential module (1 to 4)

Diagram



Operation

$Y_n=(X_n-X_{n-1})\cdot T_d$

Y_n is the output value, X_n is the input value, X_{n-1} is the last beat value of the input X_n, and T_d is the differential time.

The output Y is proportional to the input deviation and the differential time.

Connection

Input I1 is a signed number.

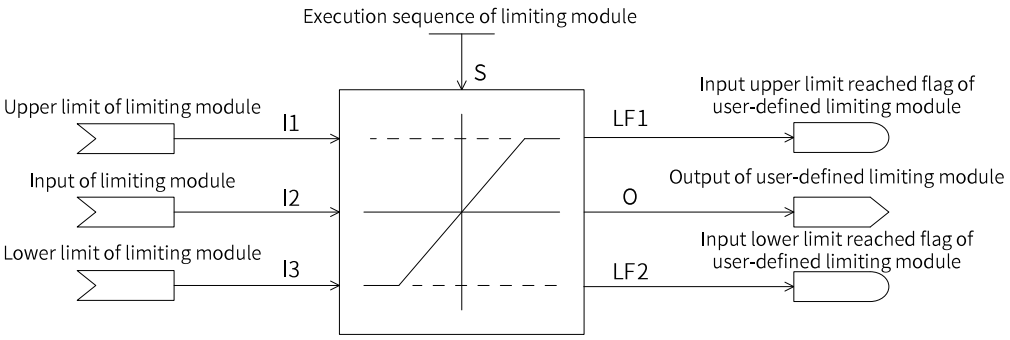
Input I2 is an unsigned number.

Output O is a signed number.

Differential Module	Input			Output
	S	I1	I2	O
1	P7-44	P7-45	P7-46	U19-55
2	P7-47	P7-48	P7-49	U19-56
3	P7-50	P7-51	P7-52	U19-57
4	P7-53	P-54	P7-55	U19-58

8) Limit module (1 to 4)

Diagram



Operation

$$O=\begin{cases} I1, & I1>I2 \\ I2, & I3\leqslant I2\leqslant I1 \\ I3, & I2<I3 \end{cases}$$

When the input I2 is greater than the upper limit I1, the output O is equal to I1, and the upper limit flag position LF1 is 1. When the input I2 is less than the lower limit I3, the output O is equal to I3, and the lower limit flag position LF2 is 1.

When input I2 is within the upper and lower limits, the output is equal to the input value.

Connection

Inputs I1, I2, and I3 are signed numbers.

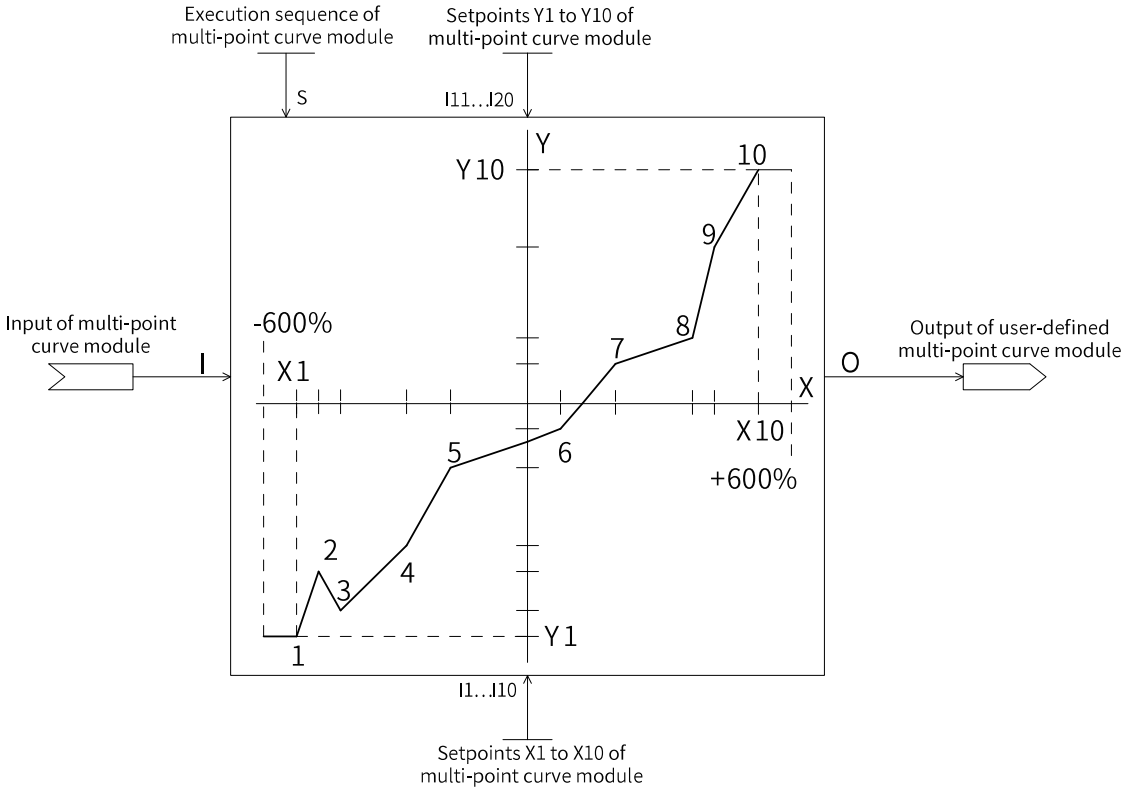
Output O is a signed number.

Outputs LF1 and LF2 are binary numbers.

Limit Module	Input				Output		
	S	I1	I2	I3	LF1	LF2	O
1	P7-56	P7-58	P7-57	P7-59	U11-56	U11-57	U19-59
2	P7-60	P7-62	P7-61	P7-63	U11-58	U11-59	U19-60
3	P7-64	P7-66	P7-65	P7-67	U11-60	U11-61	U19-62
4	P7-68	P7-70	P7-69	P7-71	U11-62	U11-63	U19-63

9.13.14.6 User-Defined Multi-Point Operation Function Block

Diagram



Operation

Only when the X1 < X2 <... condition is met, the set coordinate points are enabled. When the input is out of the enabled coordinate points, the output equals the ordinate value of the adjacent enabled coordinate points. When the input is within the enabled coordinate points, the ordinate value corresponding to the output can be calculated according to the curve.

Connection

Inputs I and I1 to I20 are signed numbers.

Output O is a signed number.

Multi-Point Curve Module		1	2	3	4
Input	S	P8-00	P8-22	P8-44	P8-66
	I	P8-01	P8-23	P8-45	P8-67
	I1 (X1)	P8-02	P8-24	P8-46	P8-68
	I2 (X2)	P8-04	P8-26	P8-48	P8-70
	I3 (X3)	P8-06	P8-28	P8-50	P8-72
	I4 (X4)	P8-08	P8-30	P8-52	P8-74
	I5 (X5)	P8-10	P8-32	P8-54	P8-76
	I6 (X6)	P8-12	P8-34	P8-56	P8-78
	I7 (X7)	P8-14	P8-36	P8-58	P8-80
	I8 (X8)	P8-16	P8-38	P8-60	P8-82
	I9 (X9)	P8-18	P8-40	P8-62	P8-84
	I10 (X10)	P8-20	P8-42	P8-64	P8-86
	I11 (Y1)	P8-03	P8-25	P8-47	P8-69
	I12 (Y2)	P8-05	P8-27	P8-49	P8-71
	I13 (Y3)	P8-07	P8-29	P8-51	P8-73
	I14 (Y4)	P8-09	P8-31	P8-53	P8-75
	I15 (Y5)	P8-11	P8-33	P8-55	P8-77
	I16 (Y6)	P8-13	P8-35	P8-57	P8-79
	I17 (Y7)	P8-15	P8-37	P8-59	P8-81
	I18 (Y8)	P8-17	P8-39	P8-61	P8-83
	I19 (Y9)	P8-19	P8-41	P8-63	P8-85
	I20 (Y10)	P8-21	P8-43	P8-65	P8-87
Output	O	U19-63	U19-64	U19-65	U19-66

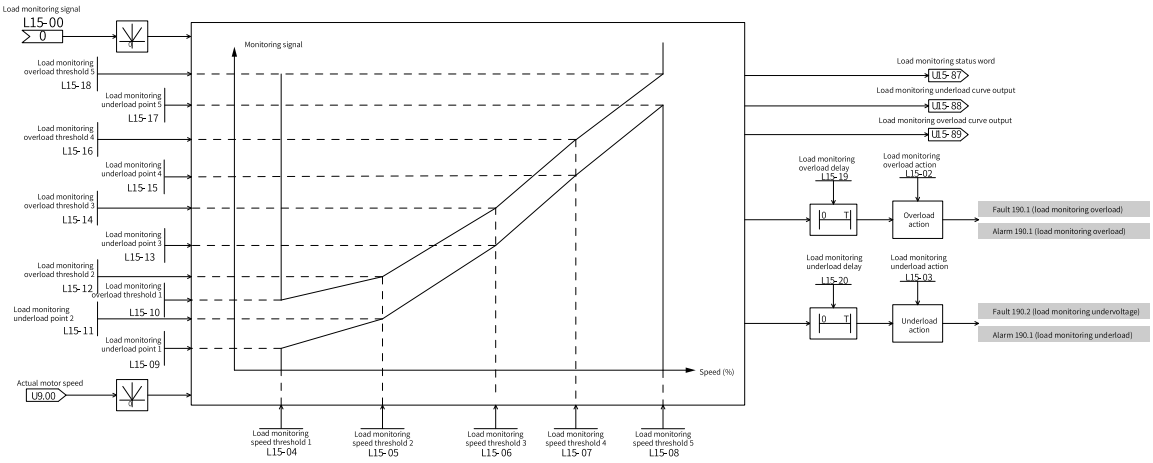
9.14 Load Monitoring Module

The load monitoring module is used to monitor input signals (such as output current, output torque, and output power) related to the output speed of the drive. This function includes underload monitoring and overload monitoring. Underload monitoring can be used for load loss detection (such as conveyor belt breakage and mechanical shaft breakage). Overload monitoring can be used to detect whether the drive load is blocked (such as motor stall).

During load monitoring, the current speed/monitoring signal is compared with the speed/overload or speed/underload threshold set by the user. If the current speed exceeds the threshold set by the user, a fault or an alarm is reported based on the setpoint of L15-02/L15-03 after the delay set by L15-19/L15-20 elapses.

The conditions for activating the load monitoring module to be active include the following.

- L15-00 [Load monitoring signal] is not set to 0.
- The speed at each point on the load monitoring curve increases incrementally (L15-04 < L15-05 < L15-06 < L15-07 < L15-08).
- The actual motor speed is within the range of L15-04 to L15-08.
- The overload threshold is higher than the underload threshold at the same speed point in the load monitoring curve.



Param.	Name	Value range	Default	Note
L15-00	Load monitoring signal	0: Monitoring disabled 1: Output current 2: Output torque 3: Output power Others: K connector	0	The output current/torque/ power can be used as monitoring variables. Set this parameter according to actual applications.
L15-01	Load monitoring state	0: Inactive 1: Active	-	Displays whether the load monitoring module is active.
L15-02	Action when overload is monitored	0: No alarm/No fault 1: Alarm 2: Fault 3: Alarm/fault	0	[No alarm/No fault]: No alarm/fault is reported. [Alarm]: Overload/Underload alarm is reported. [Fault]: Overload/Underload fault is reported. [Alarm/Fault]: Overload alarm 191-1 is reported when the monitoring signal is higher than the set overload curve for a period longer than half of the time set by L15-19. Overload fault 190-1 is reported when the monitoring signal is higher than the set overload curve for a period longer than the time set by L15-19. Overload alarm 191-2 is reported when the monitoring signal is higher than the set overload curve for a period longer than half of the time set by L15-20. Overload fault 190-2 is reported when the monitoring signal is higher than the set overload curve for a period longer than the time set by L15-20.
L15-03	Action when underload is monitored	0: No alarm/No fault 1: Alarm 2: Fault 3: Alarm/Fault	0	

Param.	Name	Value range	Default	Note
L15-04	Load monitoring speed point 1	0.0% to 600.0%	10.0%	Defines the first speed point on the x-coordinate in load monitoring state. The speed point is valid symmetrically in the negative direction.
L15-05	Speed point 2 in load monitoring state	0.0% to 600.0%	50.0%	Defines the second speed point on the x-coordinate in load monitoring state.
L15-06	Speed point 3 in load monitoring state	0.0% to 600.0%	86.0%	Defines the third speed point on the x-coordinate in load monitoring state.
L15-07	Speed point 4 in load monitoring state	0.0% to 600.0%	100.0%	Defines the fourth speed point on the x-coordinate in load monitoring state.
L15-08	Speed point 5 in load monitoring state	0.0% to 600.0%	120.0%	Defines the fifth speed point on the x-coordinate in load monitoring state.
L15-09	Underload point 1 in load monitoring state	0.0% to 400.0%	10.0%	Defines the first underload point in the load monitoring state.
L15-10	Overload point 1 in load monitoring state	0.0% to 400.0%	100.0%	Defines the first overload point in the load monitoring state.
L15-11	Underload point 2 in load monitoring state	0.0% to 400.0%	15.0%	Defines the second underload point in the load monitoring state.
L15-12	Overload point 2 in load monitoring state	0.0% to 400.0%	100.0%	Defines the second overload point in the load monitoring state.
L15-13	Underload point 3 in load monitoring state	0.0% to 400.0%	25.0%	Defines the third underload point in the load monitoring state.
L15-14	Overload point 3 in load monitoring state	0.0% to 400.0%	100.0%	Defines the third overload point in the load monitoring state.
L15-15	Underload point 4 in load monitoring state	0.0% to 400.0%	35.0%	Defines the fourth underload point in the load monitoring state.
L15-16	Overload point 4 in load monitoring state	0.0% to 400.0%	100.0%	Defines the fourth overload point in the load monitoring state.
L15-17	Underload point 5 in load monitoring state	0.0% to 400.0%	50.0%	Defines the underload point 5 in the load monitoring state.
L15-18	Overload point 5 in load monitoring state	0.0% to 400.0%	100.0%	Defines the overload point 5 in the load monitoring state.
L15-19	Overload delay in load monitoring state	0.0s to 1000.0s	10.0s	Defines the delay time for the action defined by L15-02.
L15-20	Underload delay in load monitoring state	0.0s to 1000.0s	10.0s	Defines the delay time for the action defined by L15-03.

Param.	Name	Value range	Default	Note
U15-87	Status word in load monitoring state	bit00: Underload limit 0: Normal 1: L5-00 monitoring signal lower than the underload curve bit01: Overload limit 0: Normal 1: L5-00 monitoring signal higher than the underload curve bit02: Unload fault/ alarm exception 0: No error occurred 1: Exception occurred bit03: Overload fault/ alarm exception 0: No error occurred 1: Exception occurred bit04 to bit15: Reserved	-	bit00/bit01 is independent of the monitoring action and monitoring delay defined by L15-02, L15-03, L15-19, and L15-20. bit02/bit03 is determined by the monitoring action and monitoring delay set in L15-02, L15-03, L15-19, and L15-20.
U15-88	Underload curve output in load monitoring state	-	-	Custom speed/underload curve
U15-89	Overload curve output in load monitoring state	-	-	Custom speed/overload curve

9.15 Pre-overtemperature Action

The pre-overtemperature action is used when the drive temperature keeps rising during operation to prevent the drive from stopping at overtemperature. To suppress drive temperature rise, reduce the switching frequency and output current because these two are the major causes for temperature rise.

Param.	Name	Setpoint
H1-80[1]	Pre-overtemperature action selection	0: No action 1: Reduce the carrier frequency. 2: Limit the maximum output current when the carrier frequency cannot be adjusted to a normal value 3: Limit the maximum speed when the carrier frequency cannot be adjusted to a normal value
H1-81[2]	Pre-overtemperature current limit	Defines the upper limit of the maximum current, which is active when H1-80 is set to 2.

Param.	Name	Setpoint
H1-82	Positive speed limit in pre-over-temperature	Defines the upper limit of the maximum positive speed, which is active when H1-80 is set to 3.
H1-83	Negative speed limit in pre-over-temperature	Defines the upper limit of the maximum negative speed, which is active when H1-80 is set to 3.
H1-84[3]	Threshold for exiting pre-overtemperature action	Defines the threshold for exiting the pre-overtemperature action.

Note

[1]: For loads with constant torque or constant power, it is recommended to set H1-80 [Pre-overtemperature action] to 1. Loads with constant torque include the conveyor belt, mixer, extruder, and hoist. Loads with constant power (high starting torque) include the machine tool spindle, rolling mill, paper machine, and traction motor. For quadratic torque loads such as the fan, water pump, and oil pump, it is recommended to set H1-80 [Pre-overtemperature action] to 2.

[2]: Setting H1-81 [Pre-overtemperature current limit] to an excessively low value may result in motor stall.

[3]: H1-84 [Threshold for exiting pre-overtemperature] affects the temperature for exiting pre-overtemperature. The exit temperature = A4-33 [Power unit overtemperature threshold (IGBT)] - A4-27 [Module pre-overtemperature threshold] - H1-84 [Threshold for exiting pre-overtemperature].

9.16 General Timer and Counter

The HCU-50S/51S has two groups of real-time timers and two groups of edge counters. They can be used to monitor the operating duration or number of actions of key vulnerable components and trigger preventive maintenance prompts.

Real-time timer: Enables the timing of digital signals in the continuous high/low state. (For example, the operating time of the fan and cumulative operation time of the IGBT)

Edge counter: Enables the counting of digital signals when they jump from 0 → 1/1 → 0 (for example, ON/OFF count of the relay, and start/stop count of the fan).

Timer/Counter reset mode

Param.	Name	Setpoint	Remarks
L20-02	Timer (counter) reset	0: No action 1: Clear real-time timer 1 2: Clear real-time timer 2 5: Clear edge counter 1 6: Clear edge counter 2 101: Clear all real-time timers 102: Clear all edge counters 103: Clear all timers (counters)	Used to reset the timer/counter (clear actual values L20-06/20/34/49). Procedure: 1. Set the clear mode through L20-02. 2. Check that L20-03 is set to 1.
L20-03	Acknowledgment for resetting the timer (counter)	0: Cancel 1: OK	Used to confirm the reset action.

Timer related parameters

Param.	Name	Setpoint	Remarks
L20-05	[Real-time timer 1] monitoring signal	0: Disable 101: DC bus powered on 102: IGBT operating 103: Control module powered on 104: Fan operating Others: B connector	The selected monitoring signal is timed according to the monitoring level defined by L20-08/22.
L20-19	[Real-time timer 2] monitoring signal		
L20-07	[Real-time timer 1] timing threshold	0s to 4294967295s	When the actual value (L20-06/20) reaches the set threshold, the alarm action defined by L20-14/28 is triggered. When the timing threshold is 0, the alarm action is inactive.
L20-21	[Real-time timer 2] timing threshold	0.00s to 42949672.95s	
L20-08	[Real-time timer 1] function selection	Ones: Timing mode 0: Cyclic timing 1: Continuous timing Tens: Monitoring level 0: Low level 1: High level Hundreds-: Storage mode of actual values 0: Non-retentive upon power failure 1: Retentive upon power failure	1. Timing mode selection: Cyclic timing: When the actual value (L20-06/20) is higher than or equal to the timing threshold defined by (L20-07/21), the actual value is cleared and cyclic timing applies. Continuous timing: When the actual value (L20-06/20) is higher than or equal to the timing threshold defined by L20-07/21, the actual value is not cleared and timing continues. 2. Monitoring level selection: Low level: When the monitoring signal (L20-05/19) is low level, the timer starts and stops at high level. High level: When the monitoring signal (L20-05/19) is high level, the timer starts and stops at low level. 3. Storage mode of actual values: Non-retentive upon power failure: The actual value (L20-06/20) is cleared upon power failure of HCU. Retentive upon power failure: The actual value (L20-06/20) is saved upon power failure of HCU.
L20-22	[Real-time timer 2] function selection		

Param.	Name	Setpoint	Remarks
L20-09	[Real-time timer 1] hold time of cyclic timing state setting	0s to 4294967295s	When L20-08/22 is set to "cyclic timing", the real-time timer status setting remains at the set time whenever the actual value (L20-06/20) reaches the timing threshold defined by L20-07/21.
L20-23	[Real-time timer 2] hold time of cyclic timing state setting		
L20-10	[Real-time timer 1] cyclic alarm/minor fault hold time		When L20-08/22 is set to "cyclic timing" and L20-14/28 (Alarm action) is set to "alarm/minor fault", automatic reset applies when the alarm/minor fault A118-1/119-1 that triggered when the actual value (L20-06/20) reaches the value defined by L20-07/21 lasts for the time set by this parameter.
L20-24	[Real-time timer 2] cyclic alarm/minor fault hold time		
L20-14	[Real-time timer 1] pre-alarm action	0: Coast to stop 1: Emergency stop 2: Stop according to the stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Used to set the pre-alarm action.
L20-28	[Real-time timer 2] pre-alarm action		

Counter-related parameters

Param.	Name	Setpoint	Remarks
L20-33	[Edge counter 1] monitoring signal	0: Disable 101: DC bus powered on 102: IGBT operating 103: Control module powered on 104: Fan operating Others: B connector	The selected monitoring signal is counted according to the counting edge set by L20-36/51.
L20-48	[Edge counter 2] monitoring signal		
L20-35	[Edge counter 1] counting threshold	0 to 4294967295	When the actual value (L20-34/49) reaches the set threshold, the pre-alarm action defined by L20-43/58 is triggered. When the counting threshold is the default value 0, the pre-alarm action is inactive.
L20-50	[Edge counter 2] counting threshold		

Param.	Name	Setpoint	Remarks
L20-36	[Edge counter 1] function selection	Ones-: Counting mode 0: Cyclic counting 1: Continuous counting Tens-: Counting edge 0: Falling edge 1: Rising edge 2: Falling edge or rising edge Hundreds-: Storage mode of actual values 0: Non-retentive upon power failure 1: Retentive upon power failure	1. Counting mode selection: Cyclic counting: When the actual value (L20-34/49) is higher than or equal to the counting threshold defined by L20-35/50, the actual value is cleared and cyclic counting applies. Continuous timing: When the actual value (L20-34/49) is higher than or equal to the timing threshold defined by L20-35/50, the actual value is not cleared and timing continues. 2. Counting edge selection: Rising edge: Capture monitoring signals (L20-33/48) to generate rising edge signal count. Falling edge: Capture monitoring signals (L20-33/48) to generate falling edge signal count. Rising edge or falling edge: Capture monitoring signals (L20-33/48) to generate falling edge and rising edge signal count. 3. Storage mode of actual values: Non-retentive upon power failure: The actual value (L20-34/49) is cleared upon power failure of HCU. Retentive upon power failure: The actual value (L20-34/49) is saved upon power failure of HCU.
L20-51	[Edge counter 2] function selection		

Param.	Name	Setpoint	Remarks
L20-37	[Edge counter 1] hold time of cyclic counting state setting	0s to 4294967295s	When L20-36/51 is set to "cyclic timing", the edge counter status setting remains at the set time whenever the actual value (L20-34/49) reaches the timing threshold defined by L20-35/50.
L20-52	[Edge counter 2] hold time of cyclic counting state setting		
L20-38	[Edge counter 1] cyclic count alarm/minor fault hold time		When L20-36/51 is set to "cyclic count" and L20-43/58 (Pre-alarm action) is set to" alarm/minor fault", automatic reset applies when the alarm/minor fault A122-1/123-1 that triggered when the actual value (L20-34/49) reaches the value defined by L20-35/50 lasts for the time set by this parameter.
L20-53	[Edge counter 2] cyclic count alarm/minor fault hold time		
L20-39	[Edge counter 1] proportional coefficient numerator	1 to 4294967295	L20-34/49 Proportional conversion of actual values
L20-54	[Edge counter 2] proportional coefficient numerator		
L20-40	[Edge counter 1] proportional coefficient denominator		
L20-55	[Edge counter 2] proportional coefficient denominator		
L20-43	[Edge counter 1] pre-alarm action	0: Coast to stop 1: Emergency stop 2: Stop according to the stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Used to set the pre-alarm action.
L20-58	[Edge counter 2] pre-alarm action		

Timer/Counter state display

Timer/Counter	Param.	Name	Description
Real-time timer	L20-00	Real-time timer status word	When the actual value (L20-06/20) is higher than or equal to the timing threshold defined by 20-07/21, the corresponding bit of the status word is set (bit0: Real-time timer 1 status bit; bit1: Real-time timer 2 status bit).
	L20-06	[Real-time timer 1] actual value	Cumulative timing value (unit: 1s)
	L20-20	[Real-time timer 2] actual value	Cumulative timing value (unit: 0.01s)
	U20-34	Real-time timer 1 status	The real-time timer 1/2 state is set when the actual value (L20-06/20) is higher than or equal to L20-07/21.
	U20-35	Real-time timer 2 status	
	U20-42	Real-time timer 1 pre-alarm action triggered	Pre-alarm action trigger flag
	U20-43	Real-time timer 2 pre-alarm action triggered	
Edge counter	L20-01	Edge counter status word	When the actual value (L20-34/49) is higher than or equal to the timing threshold defined by L20-35/50, the corresponding bit of the status word is set (bit0: Edge counter 1 status bit; bit1: Edge counter 2 status bit).
	L20-34	[Edge counter 1] actual value	Cumulative count value
	L20-49	[Edge counter 2] actual value	
	U20-38	Edge counter 1 status	The edge counter 1/2 state is set when the actual value (L20-34/49) is higher than or equal to the timing threshold defined by L20-35/50.
	U20-39	Edge counter 2 status	
	U20-46	Pre-alarm action of edge counter 1 triggered	Pre-alarm action trigger flag
	U20-47	Pre-alarm action of edge counter 2 triggered	

Typical applications

Scenario 1: Monitoring the cumulative operating time of the fan

Logic: The cumulative operating time of the fan reaches 50,000 hours, and an alarm is triggered to remind users of fan maintenance.

Parameter setting:

Param.	Setpoint	Remarks
L20-05 [Real-time timer 1] monitoring signal	104	Used as the fan start/stop signal. The fan operates at high level and stops at low level.
L20-07 [Real-time timer 1] timing threshold	180000000s	Converted to hours: 180000000/ 3600h = 50000 hours
L20-08 [Real-time timer 1] function selection	111	Timing mode: Continuous timing Monitoring level: High level Storage mode of actual values: Retentive upon power failure
L20-14 [Real-time timer 1] pre-alarm action	6	Displaying the alarm only

Status display for 500 hours of cumulative operating time of the fan:

Param.	Display value	Remarks
L20-00 Real-time timer status word	0x01	L20-06 ≥ 180000000 (cumulative operating time of the fan reaching 50000 hours) The HCU-50S/51S reports A118-1 based on the pre-alarm action configuration.
U20-34 Real-time timer 1 status	1	
U20-42 Real-time timer 1 pre-alarm action triggered	1	

Scenario 2: Monitoring of cumulative relay action count

Logic: A fault that cause stop can be reported when the relay action count exceeds 50000, reminding users of the risk of relay fault.

Parameter setting:

Param.	Setpoint	Remarks
L20-33 [Edge counter 1] monitoring signal	10	RO1 edge signal
L20-35 [Edge counter 1] timing threshold	50000	-
L20-36 [Edge counter 1] function selection	111	Counting mode: Continuous counting Counting edge: Rising edge Storage mode of actual values: Retentive upon power failure
L20-39 [Edge counter 1] proportional coefficient numerator	1	L20-34 = L20-34 x L20-39/L20-40
L20-40 [Edge counter 1] proportional coefficient denominator	1	
L20-43 [Edge counter 1] pre-alarm action	0	Coast to stop

Display when relay action count exceeding 50000:

Param.	Display value	Remarks
L20-01 Edge counter status word	0x01	L20-34 ≥ 50000 (relay action count exceeding 50000) HCU-50S/51S indicates F122-1 based on the pre-alarm action configuration.
U20-38 Edge counter 1 status	1	
U20-46 Edge counter 1 pre-alarm action triggered	1	

9.17 Crane Anti-Sway Function

Introduction

The drive is built-in with the anti-sway function to eliminate more than 95% of sway. This function features easy commissioning and high usability.

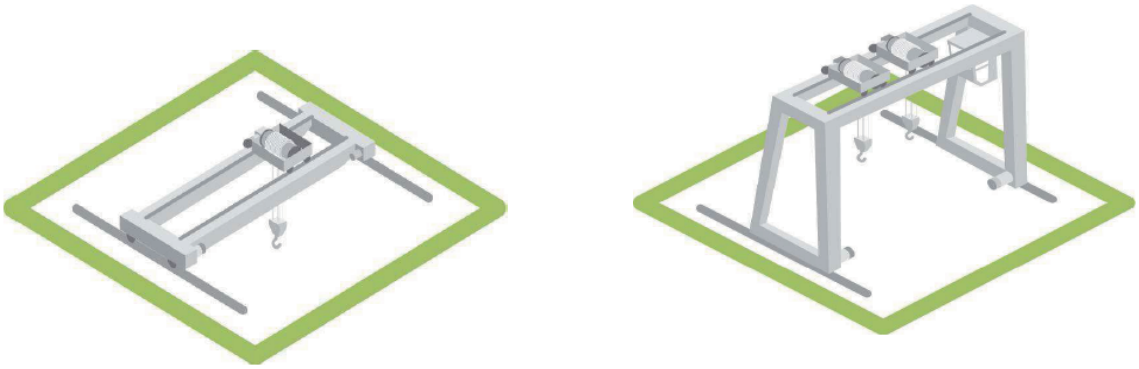


Figure 9-22 Overhead crane (left) Door crane (right)

Applicable scenario

The anti-sway system of MD880-50S-CS does not require an external sway angle detection signal. The anti-sway system has built a mathematical model for the crane. You only need to input the rated linear speed and current sway length of the trolley for operation.

This anti-sway function is applicable to indoor cranes. It can suppress unnecessary sway during operation of the load. In outdoor applications, the anti-sway function can be affected by the wind.

Before operating the travel and trolley, check that the heavy object is off the ground and the steel rope is laid vertically at a standstill without risks of swaying.

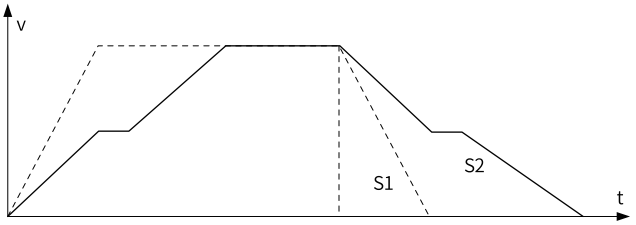
Anti-sway parameters in open loop

Table 9–7

Param.	Name	Value range	Default	Note
o11-00	Anti-sway function	0: Disable 1: Use the traditional model 2: Use the optimized model 3: Use the swing feedback closed loop	0: Disable	Set this parameter to 1 to enable the swing angle observation function. Only o11-02 and o11-03 are used for calculation.
o11-01	Anti-sway control selection	0: Observe only 1: Observe and suppress Others: B connector	0: Observe only	The setpoint 0 does not involve anti-sway function. The setpoint 1 involves the anti-sway function. You can also define the anti-sway control function by selecting communication bits through B connector.
o11-02	Rated linear speed of translation	0.00 to 655.00	0.00 m/min	Corresponds to the linear speed of the trolley during operating at the speed defined by d0-05. The model converts the motor speed into the trolley speed based on this parameter.
o11-03	Source of anti-sway height	0: o11-04 1: Improving the pendulum length feedback (InoLink) Others: K connector	0: o11-04	Select the current pendulum length through the connector. For example, you can receive the pendulum length sent from the PLC through communication. The connector unit must be cm, that is, the pendulum length corresponding to the value 500 is 5.00 m.
o11-04	Anti-sway height	0.00 to 200.00	0 m	Used to set the current pendulum length when o11-03 is set to 0. This parameter is used during system commissioning.

References set in the original reference channel are not affected after the anti-sway module is enabled.

However, the system acceleration/deceleration time can be prolonged after anti-sway control is enabled, as shown below.



S1 indicates the stop distance without anti-sway control. S2 indicates the additional stop distance with anti-sway control. In the case of stop, the stop command must be set in advance by taking into account the deceleration distance of the speed reference ramp and the deceleration distance after anti-sway control is enabled. For decelerating to stop at current speed v0, the running distance of the trolley is calculated based on the following formula.

$$s_e = \frac{v_0}{2}\left(\frac{v_0}{v_n}t_{dec} + \sqrt{L}\right)$$

L represents current pendulum length.

The deceleration time of the trolley is calculated based on the following formula:

$$t_e = \frac{v_0}{v_n}t_{dec} + \sqrt{L}$$

Stop judgment

The anti-sway suppression is executed continuously after the anti-sway function is enabled. Even upon receiving an OFF1 stop command, swing suppression is executed first to reduce the swing magnitude to a value below the threshold, and then the OFF1 stop command is executed.

If OFF2 or OFF3 is activated, the system exits anti-sway control immediately and stops without anti-sway control.

Param.	Name	Value range	Default	Description
o11-15	Anti-sway stop swing threshold	0 to 500	50 mm	After receiving the OFF1 stop command, the brake can be applied and the system can stop only after the anti-sway module determines that the maximum pendulum amplitude is lower than o11-15 and lasts for a period longer than o11-16. Otherwise, the system does not stop.
o11-16	Anti-sway stop delay	0.00 to 10.00	0.20s	

Pendulum length estimation

During commissioning, you can quickly estimate the current pendulum length by using the swing method, as shown below.

1. Set o11-01 to 0 to disable anti-sway control.
2. Run the trolley in one direction to a high speed and then stop (ensure that the lifting attachment swings significantly).
3. Measure the pendulum period (t) of the lifting attachment with a stopwatch. To improve the test accuracy, you can take the average value of four to five pendulum periods.
4. Calculate the pendulum length based on the following formula: $L = t^2/4$.

9.18 High-Speed Operation at Low Load

Applicable scenario

In port crane applications, the crane is expected to quickly accelerate to the maximum speed after grabbing the target load and move the target load to the destination at a high speed, and then returns without load quickly. To ensure the maximum handling efficiency, no stop is allowed during acceleration, constant speed, or deceleration. During acceleration upon lifting, the load must be calculated quickly to calculate the maximum speed the drive can accelerate to.

Auto-tuning for high-speed operation at low load

The load weight of the crane needs to be calculated for use of the corresponding function module. The load weight can be measured only when the gravitational torque, friction torque, gearbox inertia coefficient, and load acceleration torque coefficient are known. If these values are known, you can directly enter them through parameters. If not, you need to identify these values through "low load commissioning" and "high load commissioning".

Before performing auto-tuning for high-speed operation at low load, ensure that auto-tuning conditions are met and related parameters are set correctly. To ensure operational safety, perform a no-load motor test to ensure that motor parameters and communication parameters are set correctly, and then perform a no-load lifting/descending test to ensure that mechanical parts such as couplings and pulley blocks operate properly. Finally, perform low-load auto-tuning logic test to check whether the lifting/descending stroke and parameter configuration meet the requirements. As shown in the following figure, in low-load commissioning logic test and low-load commissioning, the hook lifts the clamp only

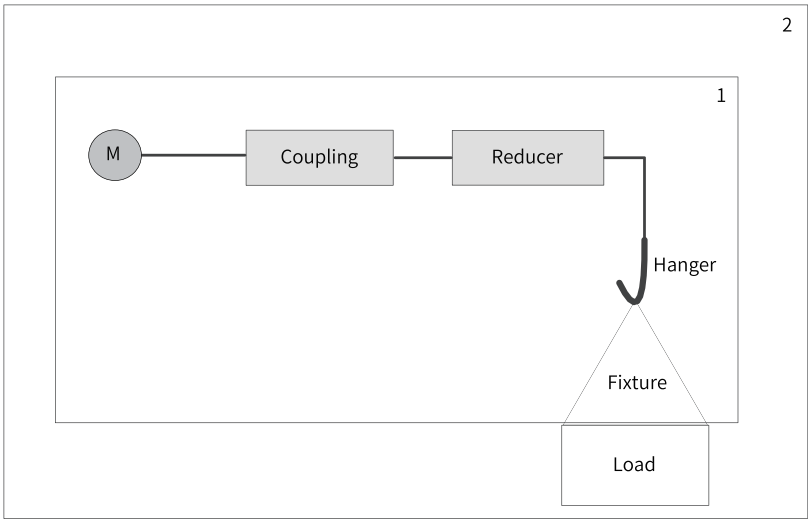


Figure 9-23 Load driven by the crane motor

- The low-load commissioning logic test involves the motor, gearbox, hook, and clamp, as shown by part 1 in the preceding figure. The following parameters need to be set.

Param.	Name	Value range	Setpoint	Note
o12-00	Load measurement enable	0: Inhibited 1: Enabled	1: Enabled	Used to enable the load measurement function.
o12-04	Starting speed of load measurement	5% to 40%	10%	Initial speed at start of auto-tuning
o12-05	Stop speed of load measurement	40% to 100%	50%	Defines the speed when auto-tuning stops.
o12-20	Load commissioning control	0: Commissioning inhibited 1: Low-load commissioning 2: High-load commissioning	1: Low-load commissioning	Set this parameter to 1 first. After low load commissioning is done, the setpoint changes to 0 automatically.

- After the setting is done, the state of o12-23 changes to [1: Low-load commissioning in progress].

Param.	Name	Value range	Display value	Description
o12-23	Load commissioning sub-state	0: Non-commissioning state 1: Low-load commissioning in progress 2: Low-load commissioning failed 3: Low-load commissioning done 4: High-load commissioning in progress 5: High-load commissioning failed 6: High-load commissioning done	1: Low-load commissioning in progress	Displays the state during commissioning.

- Set the acceleration time and deceleration time to the same value (3s or 5s for example).

Param.	Name	Value range	Setpoint	Description
C7-04	Ramp 1 acceleration time	0.0 to 1000.0	3s	-
C7-05	Ramp 1 deceleration time	0.0 to 1000.0	3s	-

Operate the crane for a complete cycle based on the V-t curve in the following figure through the control level in the cab. V1 and V2 in the V-t curve are set through o12-04/o12-05.

- **Forward motion process**
  Vmax1 is the maximum speed for acceleration. To improve the accuracy of the auto-tuning values, ensure that Vmax 1 > (V2 + 5%).
- **Reverse motion process**
  The conditions required in operation at constant speed are the same as those required in forward motion, namely the operating time during reverse motion at constant speed (t8 - t7) must be higher than 3s. To improve the accuracy of auto-tuning values, ensure that |Vmax 2| > (V2 + 5%).

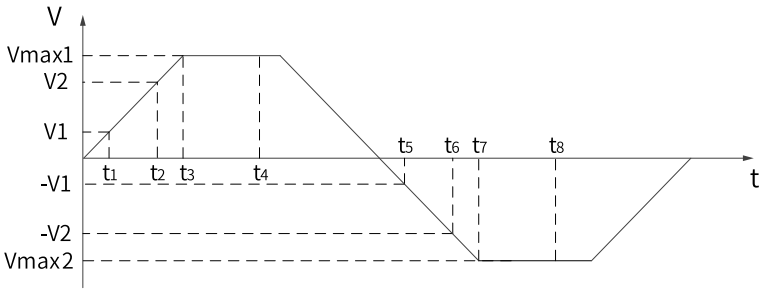


Figure 9-24 V-t curve for low-load commissioning

After preceding operations are done, if the load commissioning control (o12-20) changes from "low-load commissioning" to "commissioning inhibited" and the load commissioning sub-state (o12-23) changes from "low-load commissioning in progress" to "low-load commissioning done", the low-load commissioning logic is correct. The final auto-tuned values are displayed in o12-27 to o12-29.

Param.	Name	Setpoint	Display value	Description
o12-27	Friction torque	0.00 to 100.00	-	If these parameters are known, you can set through parameters directly. If not, perform low-load auto-tuning to get the values of these parameters.
o12-28	Gravitational torque of the clamp	0.00 to 100.00	-	
o12-29	Moment of inertia coefficient of the gearbox	0 to 65535	-	

Note

During low-load commissioning with, to ensure the accuracy of the auto-tuned values, o12-23 indicates "Low-load commissioning failed" and o12-24 indicates "Excessive speed deviation" when |Motor speed reference - Feedback speed| > 5% (o12-24 displays the speed deviation status in real time). In this case, you need to perform low-load auto-tuning again (excessive speed deviation detection also applies to high-load auto-tuning).

See the following table for parameters related to low-load commissioning logic test.

Param.	Name	Value range	Default
o12-00	Load measurement enable	0: Inhibited 1: Enabled	0: Inhibited
o12-04	Starting speed of load measurement	5% to 40%	10%
o12-05	Stop speed of load measurement	40% to 100%	50%
o12-20	Load commissioning control	0: Commissioning inhibited 1: Low-load commissioning 2: High-load commissioning	0: Commissioning inhibited

Param.	Name	Value range	Default
o12-23	Load commissioning sub-state	0: Non-commissioning state 1: Low-load commissioning in progress 2: Low-load commissioning failed 3: Low-load commissioning done 4: High-load commissioning in progress 5: High-load commissioning failed 6: High-load commissioning done	0: Non-commissioning state
o12-24	Speed deviation status	0: Excessive speed deviation 1: Speed reference reached without deviation	-
o12-27	Friction torque	0.00% to 100.00%	0%
o12-28	Gravitational torque of the clamp	0.00% to 100.00%	0%
o12-29	Moment of inertia coefficient of the gearbox	0% to 65535%	0%

Low-load commissioning

After checking that the low-load commissioning logic test is correct, you can proceed to low-load commissioning. The low-load commissioning process is the same as the low-load commissioning logic test. The following shows detailed procedure.

1. Ensure that the crane load is removed and the clamp is hung by the hook.
2. On the basis of the low-load commissioning logic test, set o12-20 [Load commissioning control] to 1 [Low-load commissioning]. In this case, the state of o12-23 [Load commissioning sub-state] changes to "Low-load commissioning in progress". Other parameters are consistent with the low-load commissioning logic test.
3. Make the crane operate for a complete cycle based on V-t motion curve in low-load commissioning. Check the low-load commissioning state through o12-23. The auto-tuned values are displayed in o12-27 to o12-29. After the low-load commissioning is done, the state of "o12-20" changes to "Commissioning inhibited".

Parameters related to low-load commissioning are the same as those in the low-load commissioning logic test.

The deviation between the set motor speed and feedback speed during commissioning must be within 5%.

High-load commissioning

After the low-load commissioning is done, you need to perform the high-load commissioning. Parameters obtained during low-load commissioning are also used during high-load

commissioning. Therefore, the values obtained during high-load commissioning may be incorrect if those obtained during low-load commissioning are inaccurate. If parameters related to low-load commissioning are known, you can manually enter the parameters related to low-load commissioning (o12-27 to o12-29) and perform the high-load commissioning directly.

The following auto-tuning conditions must be met to ensure that accurate load measurement parameters are obtained through complete high-load commissioning.

- It is recommended that the crane be loaded with a rated load.
- V1 and V2 are set through o12-04/o12-05. Vmax1 is the maximum speed for acceleration. To improve the accuracy of the auto-tuning values, ensure that Vmax 1 > (V2 + 5%).
  During high-load commissioning, after the speed is accelerated to Vmax1, keep operating at a constant speed for at least 3s, namely (t4 - t3) > 3s in the figure. Then, start decelerating at the same acceleration rate to perform reverse accelerated motion. Conditions for constant-speed operation during reverse motion are the same as those during forward motion, namely the reverse operating time at a constant speed (t8 - t7) > 3s and |Vmax 2| > (V2 + 5%).

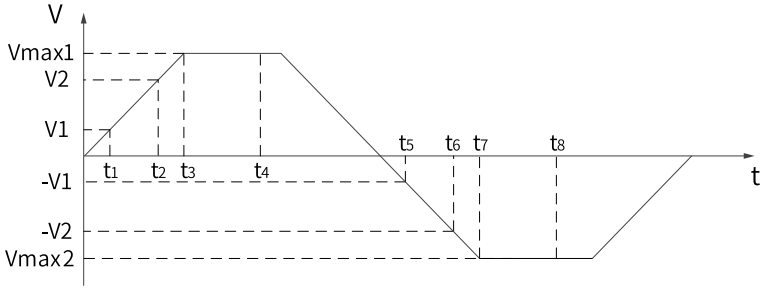


Figure 9-25 V-t curve for high-load commissioning

- The preceding steps 1 and 2 ensure that external conditions are met for on-site high-load commissioning of the crane, and then set the related parameters. On the basis of low-load commissioning, set o12-20 [Load commissioning control] to 2 [High-load commissioning]. In this case, the state of o12-23 [Load commissioning sub-state] changes to "High-load commissioning in progress", and then enter the load commissioning mass to o12-22. Other parameters needs no change.

Param.	Name	Value range	Setpoint	Description
o12-20	Load commissioning control	0: Commissioning inhibited 1: Low-load commissioning 2: High-load commissioning	2: High-load commissioning	Set this parameter to 2 first. After high load commissioning is done, the setpoint changes to 0 automatically.
o12-22	Load commissioning mass	0 to 65535	-	Defines the load mass of the clamp in t.

- Make the crane operate for a complete cycle based on V-t in high-load commissioning. Check the high-load commissioning state through o12-23. The auto-tuned values are displayed in o12-30/o12-31. After the high-load commissioning is done, the state of o12-01 (General state of load commissioning) changes to "Commissioning done".

Param.	Name	Value range	Display value	Description
o12-01	General state of load commissioning	0: Commissioning not done 1: Commissioning done	1: Commissioning done	After the high-load commissioning is done, the state of o12-01 (General state of load commissioning) changes to "Commissioning done".
o12-30	Load acceleration torque coefficient	0 to 65535	-	If these parameters are known, you can set through parameters directly. If not, perform high-load auto-tuning to get the values of these parameters.
o12-31	Mass/Torque	0 to 65535	-	

- The deviation between the set motor speed and feedback speed during high-load commissioning must be within 5%, as is the case with low-load commissioning. Otherwise, o12-23 displays "High-load commissioning failed".
- The default value of o12-26 is 30%. When the load torque obtained during heavy-load commissioning is lower than o1-26, o12-25 indicates "Load torque too low". o12-23 displays "High-load commissioning failed", and o12-01 displays "Commissioning not done". In this case, replace with a higher load and perform auto-tuning again. The purpose of setting o12-26 is to obtain more accurate auto-tuning values (o12-25/o12-26 requires maintenance parameters to be enabled).

Param.	Name	Value range	Default	Description
o12-25	Load torque state of high-load commissioning	0: The load torque is normal. 1: The load torque is too low.	0: The load torque is normal.	o12-26 is the minimum load torque set for high-load commissioning. If the auto-tuned load torque is lower than this threshold, o12-25 indicates that the load torque is too low.
o12-26	Load torque threshold for high-load commissioning	0.0% to 100.0%	30.0%	

Parameters related to high-load commissioning are shown below.

Param.	Name	Value range	Default
o12-00	Load measurement enable	0: Inhibited 1: Enabled	0: Inhibited
o12-01	General state of load commissioning	0: Commissioning not done 1: Commissioning done	0: Commissioning not done
o12-04	Starting speed of load measurement	5% to 40%	10%
o12-05	Stop speed of load measurement	40% to 100%	50%

Param.	Name	Value range	Default
o12-20	Load commissioning control	0: Commissioning inhibited 1: Low-load commissioning 2: High-load commissioning	0: Commissioning inhibited
o12-22	Load commissioning mass	0.00 to 655.35	0
o12-23	Load commissioning sub-state	0: Non-commissioning state 1: Low-load commissioning in progress 2: Low-load commissioning failed 3: Low-load commissioning done 4: High-load commissioning in progress 5: High-load commissioning failed 6: High-load commissioning done	0: Non-commissioning state
o12-25	Load torque state of high-load commissioning	0: The load torque is normal. 1: The load torque is too low.	-
o12-26	Load torque threshold for high-load commissioning	0.0% to 100.0%	30.0%
o12-30	Load acceleration torque coefficient	0.00% to 655.35%	0.00%
o12-31	Mass/Torque	0.00 to 655.35	0.00

Calibration on the measured load mass

Parameters required for crane load measurement have been obtained during low-load auto-tuning and with-load auto-tuning. The load mass can be measured during acceleration of the crane. Friction force is used in load calculation. If the friction force is obtained during low-load auto-tuning, the measured load mass may be inaccurate as the friction torque varies with the speed. In this case, you can calibrate the load mass through friction torque calibration coefficient (o12-07).

Check whether the load measurement results are normal by changing the load mass. If the deviation is large, calibrate the load mass through the friction torque correction coefficient (o12-07).

Param.	Name	Value range	Default	Description
o12-07	Friction torque correction coefficient	0% to 300%	100%	Used to calibrate friction force deviation during load measurement.

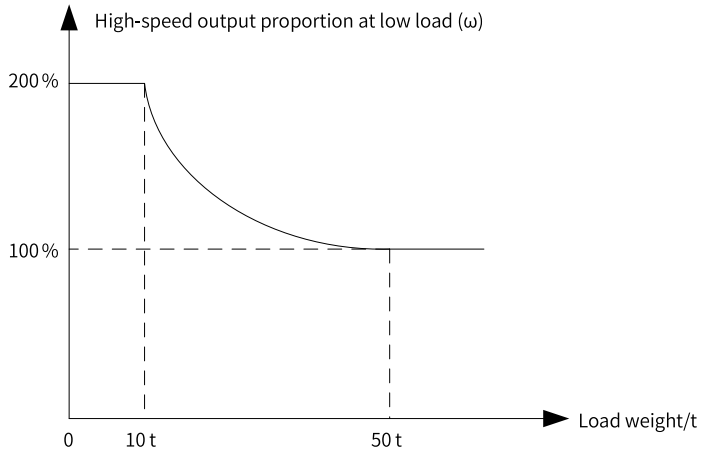
High-speed curve at low load

Parameters required in high-speed operation at low load can be obtained during low-load auto-tuning and high-load auto-tuning. The function of high-speed operation at low load is in the bypass state by default. You can set related parameters to introduce the corresponding function module to the control system. High-speed curves at low load include load mass curve and power limit curve. The following figure shows how to introduce the function module for high-speed operation at low load to the control system, with AI input as the speed source.

- **Load mass curve**

  1. Enable the load measurement function by setting o12-00 to 1.
  2. The starting/stop speed of the load measurement is set through o12-04/o12-05.
  3. Select the friction force source through o12-06. The friction force can be obtained from the friction force obtained during low-load commissioning or from the connector. The friction force is related to speed, so deviation may exist. In this case, you can calibrate the friction force through o12-07.
  4. Set the load speed curve parameters o12-13 to o12-16.
  5. Enable the function of high-speed operation at low load by setting o12-08 to 1.
  6. Set o12-09 [High-speed curve at low load] to 0 [Load mass-based curve].
  7. Select the input speed of the corresponding function module through o12-10, and set AI input as speed input through the connector.
  8. The speed output of the function module is displayed in connector U16-01. You can introduce the function of high-speed operation at low load to the control system by selecting U16-01 as the main speed source of the system (C0-00/C2-00) through the connector.

  Example:



The mathematical expression is as follows.

$$\omega = \frac{A}{m} + B$$

Where:

A and B are constant.

W is the high-speed output ratio at low load (o12-12).

M is the measured load mass+clamp mass+friction mass, where the friction mass is the value of the friction torque converted through o12-31.

Assume that the clamp weight is 5 t and the friction mass is 5 t. The load speed curve entered by the user is as follows:

o12-13 = 0 t, o12-14 = 200%

o12-15 = 40 t, o12-16 = 100%

Assume that the crane lifting line speed is 22 m/min when the function module is bypassed, then after being processed by the function module:

the crane lifting line speed is 44 m/min at 0.00 t.

the crane lifting line speed is 22 m/min at 40.00 t.

Different high-speed output speeds at low load can be obtained upon different loads.

Measure the mass	High-speed output ratio at low load (o12-11)	Crane line speed (m/min)
10 t	137.5%	30.3
20 t	116.6%	25.6
30 t	106.2%	23.4

During on-site commissioning, you can verify the correctness of the load mass curve by replacing loads of different weights and comparing the theoretical calculation result with the value of o12-12.

Power limit curve

When the power limit curve is used, set steps 4 and 6 in the load mass curve again. The other steps are consistent.

In step 4, set the power limit curve parameters o12-14, o12-16, and o12-17.

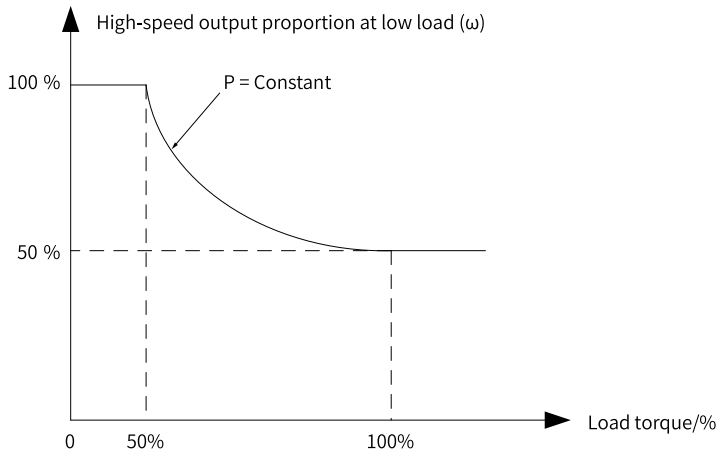
In step 6, set o12-09 [High-speed curve at low load] to 1 [Power limit-based curve].

See the following table for parameters related to high-speed operation at low load.

Param.	Name	Value range	Default	Description
o12-08	High-speed operation at low load	0: Inhibited 1: Enabled Others: B connector	0: Inhibited	Defines whether to enable high-speed operation at low load.
o12-09	Speed curve selection for high-speed operation at low load	0: Load mass-based curve 1: Power limit-based curve	0: Load mass-based curve	Used to select the high-speed curve for high-speed operation at low load.
o12-10	Input speed for high-speed operation at low load	0: [0] Others: K connector	0: [0]	Input speed for high-speed operation at low load
o12-13	Load 1 of load speed curve	0.00 to 655.35	0.00	Defines the load 1 of load speed curve.
o12-14	Speed 1 of load speed curve	10% to 400%	100%	Defines the speed 1 of load speed curve.

Param.	Name	Value range	Default	Description
o12-15	Load 2 of load speed curve	0.00 to 655.35	0.00	Defines the load 2 of load speed curve.
o12-16	Speed 2 of load speed curve	10% to 400%	100%	Defines the speed 2 of load speed curve.
o12-17	Power limit setpoint of load speed curve	0.0% to 400.0%	100.0%	Defines the power limit setpoint of load speed curve.
U16-00	Output ratio in high-speed operation at low load	-	-	Displays the output ratio in high-speed operation at low load.
U16-01	Output speed in high-speed operation at low load.	-	-	Displays the output speed in high-speed operation at low load.

Example:



The mathematical expression is as follows.

$$\omega = \frac{P}{T}$$

Where:

T is the measured load torque+clamp torque+friction torque, and P is the power constant.

W is the high-speed output ratio at low load (o12-12).

Assume that both the clamp mass and friction mass are 5%, then the power speed curve input by the user is as follows.

o12-17 = 50%

o12-14 = 100%

o12-16 = 50%

Assume that the crane lifting line speed is 22 m/min when the function module is bypassed, then after being processed by the function module:

the crane lifting line speed is 18.26 m/min when the load torque is 50%.

the crane lifting line speed is 12.32 m/min when the load torque is 80%.

Different high-speed output speeds at low load can be obtained upon different loads.

Load torque	High-speed output ratio at low load (o12-11)	Crane line speed (m/min)
70%	62.5%	13.75
90%	50.0%	11

During on-site commissioning, you can verify the correctness of the power limit curve by replacing loads of different weights and comparing the theoretical calculation result with the value of o12-12.

10 Safe Torque Off (STO) Function

10.1 Description

The Safe Torque Off (STO) function immediately blocks the motor torque or power output in electronic mode according to input signals STO1 and STO2 from external devices. This function complies with stop category 0 in EN 60204-1.

If the motor is still rotating when the STO function is enabled, the motor will coast to a standstill.

10.2 Related Parameters

Parameters related to the safety function module are shown as follows.

Param.	Name	Value range	Default
H0-32	STO terminal wiring mode	0: Powered up by the built-in 24 V power supply of the power module 1: Powered up by the external 24 V power supply	1: Powered up by the external 24 V power supply
H0-33	STO signal filter time	0 ms to 15 ms	4 ms
H0-34	STO signal inconsistency detection delay	15 ms to 2000 ms	50 ms
H0-35	STO alarm state reset mode	0: Manual reset 1: Automatic reset	0: Manual reset
H0-36	STO alarm state detection enable	0: Not detected upon bus undervoltage 1: Detected upon bus undervoltage	0: Not detected upon bus undervoltage

10.3 Function Triggering

To correctly use the input signals of the safety module, ensure that the system is correctly connected. If either the STO1 signal or STO2 signal is disconnected, the system enters the safe state.

Table 10–1 STO Function List

STO2 Input	STO1 Input	PWM Status	System Status	Reset
H	H	Normal	Normal	-
H	L	Inhibited	STO1 input activated (47-1)	Manual reset
L	H	Inhibited	STO2 input activated (47-2)	Manual reset
L	L	Inhibited	STO1 and STO2 input activated (147-3)	Automatic or manual reset, depending on the value of H0-35

Note

- H (1): Corresponding input connected to 24 V voltage
- L (0): Corresponding input disconnected from 24 V voltage

10.4 Sequence Diagram

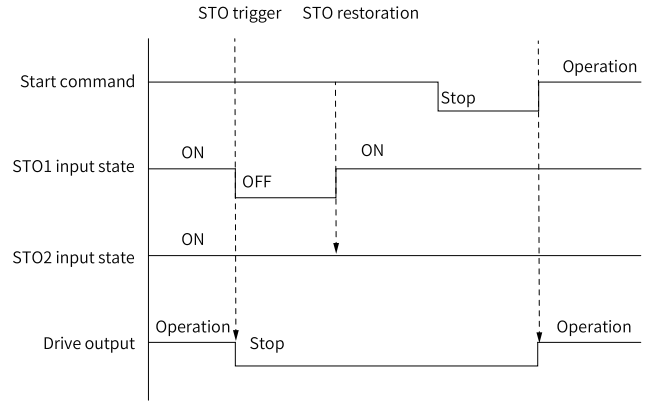


Figure 10-1 Safety function (STO1 trigger changed to OFF)

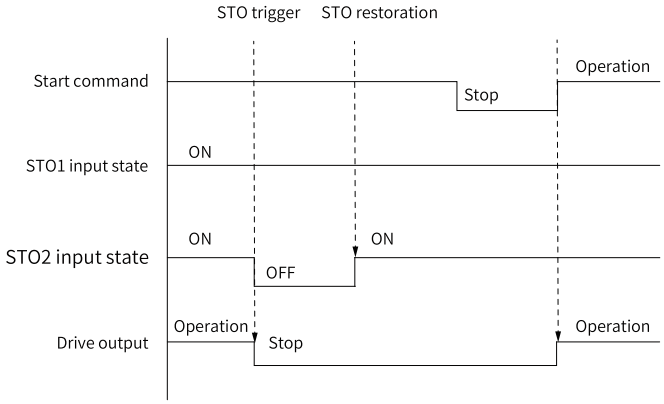


Figure 10-2 Safety function (STO2 trigger changed to OFF)

Safe Torque Off (STO) is a safety function that complies with IEC 61800-5-2:2016. This product is integrated with the STO function. After the STO function is triggered, the drive switches off the ready (RDY) signal and enters the safe state. At the same time, the drive control signal of the power semiconductor is blocked and the input motor current is cut off to prevent the AC drive from generating any torque at the motor shaft, to make the motor stop operating.

The STO function blocks the output of PWM signals to the power layer of the AC drive through external redundant hardware terminals STO1 and STO2, preventing the movement of the motor. The +24 VDC signals of the two terminals must be both active (high level) to enable normal operation of the AC drive. If either or both of them are set to low level, the PWM signal will be blocked.

11 Function Diagram

11.1 Function Diagram Information View

Function	Description	Page
Function diagram description		
-	Legend 1	"11.2.1.1 H010 - Diagram Illustration 1" on page 564
	Legend 2	"11.2.1.2 H011 - Legend 2" on page 565
State machine		
-	State machine overview	"11.2.2.1 H030 - State Machine Overview" on page 566
Input/Output		
Input/Output terminal	Digital input (DI)	"11.2.3.1 H110 - Digital Input" on page 567
	Relay output DO	"11.2.3.2 H112 - Relay Output" on page 568
	High-speed digital input (HDI)	"11.2.3.3 H114 - High-Speed Digital Input" on page 569
	High-speed digital output (HDO)	"11.2.3.4 H116 - High-Speed Digital Output" on page 570
	Analog input (AI)	"11.2.3.5 H120 - Analog input" on page 571
	Analog output (AO)	"11.2.3.6 H122 - Analog Output" on page 572
InoLink communication	InoLink communication data receiving	"11.2.3.7 H130 InoLink Network - Process Data Receiving" on page 573
	InoLink communication data transmitting	"11.2.3.8 H134 InoLink Network - Process Data Transmitting" on page 573
Bus adapter A	Process data reception	"11.2.3.9 H140 Fieldbus Adapter A - Process Data Receiving" on page 574
	Process data transmission	"11.2.3.10 H142 Fieldbus Adapter A - Process Data Transmitting" on page 574
	Dual word configuration of process data input	"11.2.3.13 H150 bus adapter A - Doubleword configuration of process data input" on page 577
	Dual word configuration of process data output	"11.2.3.14 H152 Bus adapter A - Doubleword configuration of process data output" on page 578
Bus adapter B	Process data reception	"11.2.3.11 H144 Fieldbus Adapter B - Process Data Receiving" on page 575
	Process data transmission	"11.2.3.12 H146 Fieldbus Adapter B - Process Data Transmitting" on page 576
	Dual word configuration of process data input	"11.2.3.15 H154 Fieldbus Adapter B - Process Data Input Double-Word Configuration" on page 579
	Dual word configuration of process data output	"11.2.3.16 H156 Fieldbus Adapter B - Process Data Output Double-Word Configuration" on page 580
Application function		

Function	Description	Page
Conversion function	Word-to-bit function	*"11.2.4.1 H160 - Word-to-Bit Function" on page 581*
	Bit-to-word function	*"11.2.4.2 H162 - Bit-to-Word Function" on page 582*
	Word/Doubleword conversion function	*"11.2.4.3 H164 - W2DW and DW2W" on page 583*
	Data type conversion	*"11.2.4.4 H166 - Data Type Conversion Module" on page 584*
Logic processing	Logic AND/OR	*"11.2.4.5 H170 - Logic AND and Logic NOT" on page 585*
	Logic OR	*"11.2.4.6 H172 - Logic OR" on page 586*
	Logic AND/OR	*"11.2.4.7 H173 - Logic AND and Logic OR" on page 587*
	Logic delay	*"11.2.4.8 H174 - Logic Delay Module" on page 588*
	XOR, XNOR	*"11.2.4.9 H176 - Logic XOR/XNOR" on page 589*
	Switch switchover function	*"11.2.4.10 H178 - Switch function block" on page 590*
	Level/Pulse conversion	*"11.2.4.12 H182 - Control Function Block - P_L Conversion Submodule" on page 592*
Mathematical operation	Absolute value operation	*"11.2.4.13 H184 - Arithmetic Function Block - Absolute Value Submodule" on page 593*
	Addition/Subtraction operation	*"11.2.4.14 H186 - Arithmetic Function Block - Addition_Subtraction Submodule" on page 594*
	Multiplication/Division operation	*"11.2.4.15 H188 - Arithmetic Function Block - Multiplication_Division Submodule" on page 595*
	Comparison module	*"11.2.4.16 H190 - Arithmetic Function Block - Comparison Submodule" on page 596*
Control function block	Filter module	*"11.2.4.11 H180 - Control Function Block - Filter Submodule" on page 591*
	Process PID - Input and Limit	*"11.2.4.17 H192 - Process PID Controller - Input and Limit" on page 597*
	Process PID - Operation	*"11.2.4.18 H194 - Process PID Controller - Operation" on page 598*
	Multi-point curve	*"11.2.4.19 H196 - Multi-Point Curve" on page 599*
	Ramp module A	*"11.2.4.20 H198 - RFG Module A" on page 600*
	Ramp module B	*"11.2.4.21 H200 - RFG Module B" on page 601*
	Load monitoring module	*"11.2.4.22 H202 - Load Monitoring Module" on page 602*
	High-frequency pulse detection module	*"11.2.4.23 H204 - High-Speed Pulse Detection Module" on page 603*
	Pulse counting module	*"11.2.4.24 H205 - Pulse Counting Module" on page 604*
Command and setting		

Function	Description	Page
Control channel	Control word 1	*"11.2.5.1 H220 - Control Word 1" on page 605*
	Status word 1	*"11.2.5.2 H230 - Status Word 1" on page 606*
	SOP-20 start/stop control word	*"11.2.5.3 H240 - SOP-20 Start/Stop Control Word" on page 607*
	PC start/stop control word	*"11.2.5.4 H242 - PC Start/Stop Control Word" on page 608*
	Terminal start/stop control word	*"11.2.5.5 H244 - Terminal Start/Stop Control Word" on page 609*
	Custom start/stop control word	*"11.2.5.6 H246 - User-Defined Start/Stop Control Word" on page 610*
	Start/Stop control word selection	*"11.2.5.7 H248 - Start/Stop control word selection" on page 611*
Reference channel	Motorized potentiometer	*"11.2.5.8 H302 - Motorized potentiometer" on page 612*
	Regular speed setting source	*"11.2.5.9 H310 - Regular speed reference source" on page 613*
	Speed limit	*"11.2.5.10 H312 - Speed Limit" on page 614*
	Jog speed setting	*"11.2.5.11 H314 - Jog Speed Setting" on page 615*
	RFG - Acceleration/ Deceleration time selection	*"11.2.5.12 H322 - Acceleration/Deceleration Time Selection" on page 616*
	RFG - Ramp function generator	*"11.2.5.13 H326 - Ramp Function Generator" on page 617*
	Additional speed and limit	*"11.2.5.14 H328 - Additional Speed and Limit" on page 618*
	Additional torque and torque limit setting	*"11.2.5.15 H330 - Additional Torque and Torque Limit Setting" on page 619*
	Power limit setting	*"11.2.5.16 H332 - Power Limit Setting" on page 620*
Vector control		
Speed regulator	Speed setting and feedback	*"11.2.6.1 H400 - Speed Setting" on page 621*
	ASR - Parameter adaption	*" " on page*
	ASR - PI regulator	*"11.2.6.3 H412 - Speed controller" on page 623*
	Torque reference and additional torque	*"11.2.6.7 H430 - Torque reference" on page 627*
	Torque current conversion	*"11.2.6.8 H432 - Torque/Current conversion" on page 628*
Torque limit	Torque/Current limit calculation	*"11.2.6.4 H420 - Torque Current Limit Value Calculation" on page 624*
	Torque limit and runaway prevention	*"11.2.6.5 H422 - Torque limit and runaway prevention" on page 625*
	Bus voltage control	*"11.2.6.6 H426 - Bus voltage control" on page 626*

Function	Description	Page
Flux control	Flux setting and flux weakening control	"11.2.6.9 H440 - Flux Setting and Flux Weakening Control of Asynchronous Motors" on page 629
	Flux current setting	"11.2.6.10 H442 - Exciting Current Setting" on page 630
Current control	Current regulator	"11.2.6.11 H540 - Current Regulator" on page 631
	Output voltage conversion	"11.2.6.12 H550 - Output Voltage Conversion" on page 632
	Power unit interface	"11.2.6.13 H560 - Power Unit Interface" on page 633
V/f control		
V/f control	V/f control reference voltage	"11.2.7.1 H460 - Reference Voltage in V/f Control" on page 634
	V/f control reference frequency	"11.2.7.2 H461 - Reference Frequency in V/f Control" on page 635
	Vdc control in V/f mode	"11.2.7.3 H462 - Vdc Control in V/f Mode" on page 636
Auxiliary function		
Speed judgment	Speed judgment	"11.2.8.1 H620 - Speed Determination" on page 637
Brake control	Brake release/apply control	"11.2.8.2 H630 - Brake Release and Brake Apply" on page 638
	Brake state monitoring	"11.2.8.3 H632 - Brake Status Detection" on page 639
	Brake verification	"11.2.8.4 H634 - Brake Verification" on page 640
Auxiliary control	Pulse suppression and motor fan control	"11.2.8.5 H640 - Pulse Inhibition and Motor Fan Control" on page 641
Position control		
Position control	Synchronous control	"11.2.9.1 H700 - Synchronization Control" on page 642
	Positioning control	"11.2.9.2 H710 - Positioning Control" on page 643
	Position controller	"11.2.9.3 H720 - Position Controller" on page 644

11.2 Data Flow Diagram

11.2.1 Description of Function Diagrams

11.2.1.1 H010 - Diagram Illustration 1

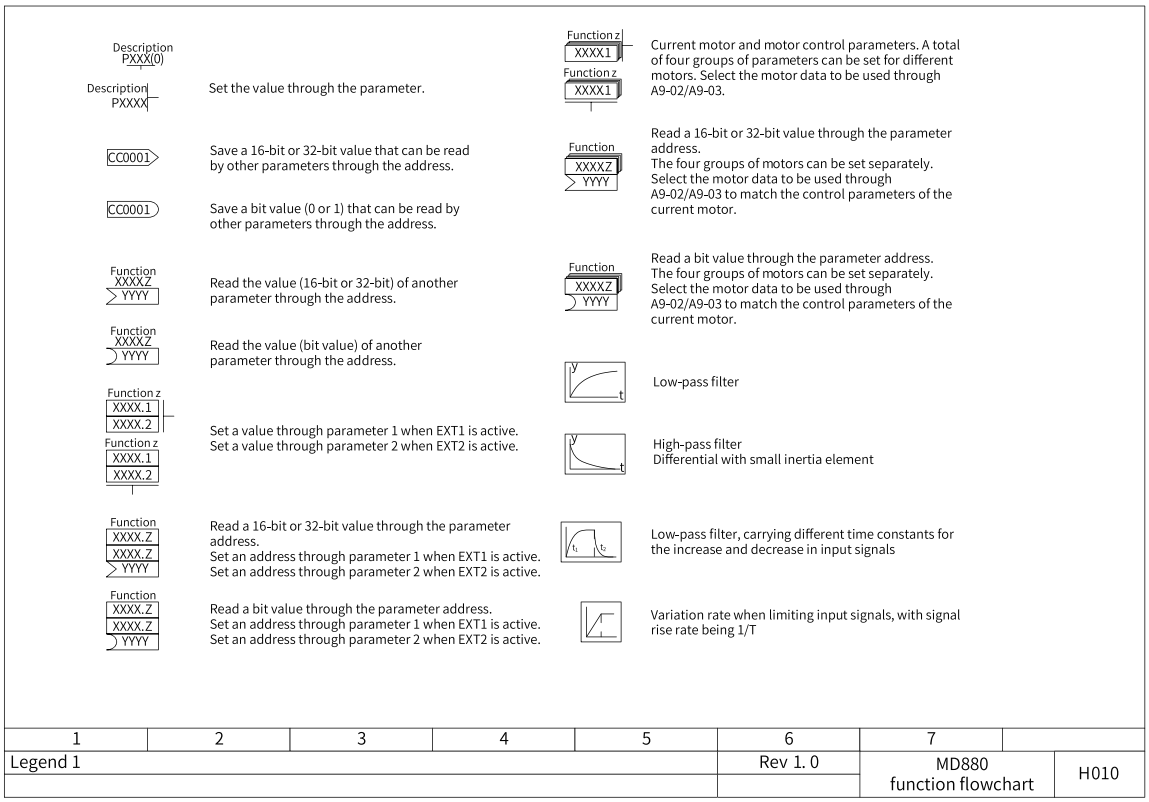
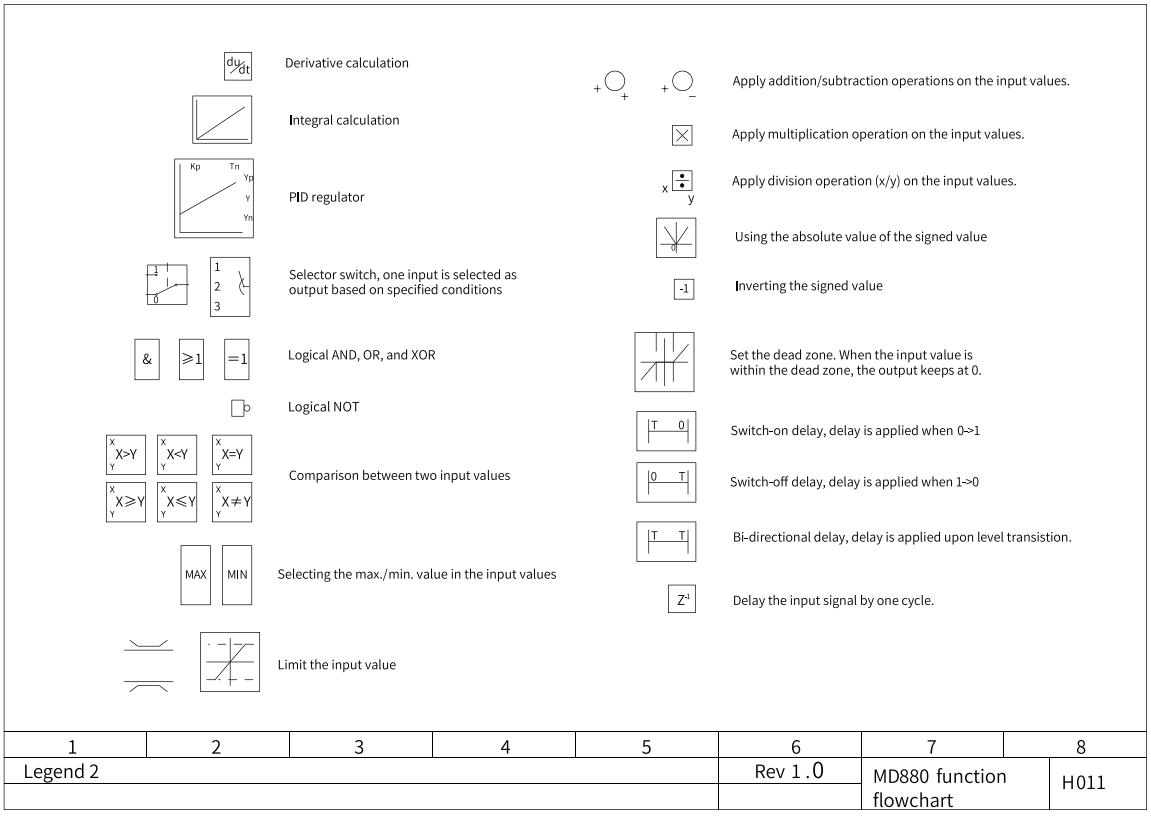


Figure 11-1 H010 - Diagram Illustration 1

11.2.1.2 H011 - Legend 2



1	2	3	4	5	6	7	8
Legend 2					Rev 1.0	MD880 function flowchart	H011

Figure 11-2 H011 - Legend 2

11.2.2 State Machine

11.2.2.1 H030 - State Machine Overview

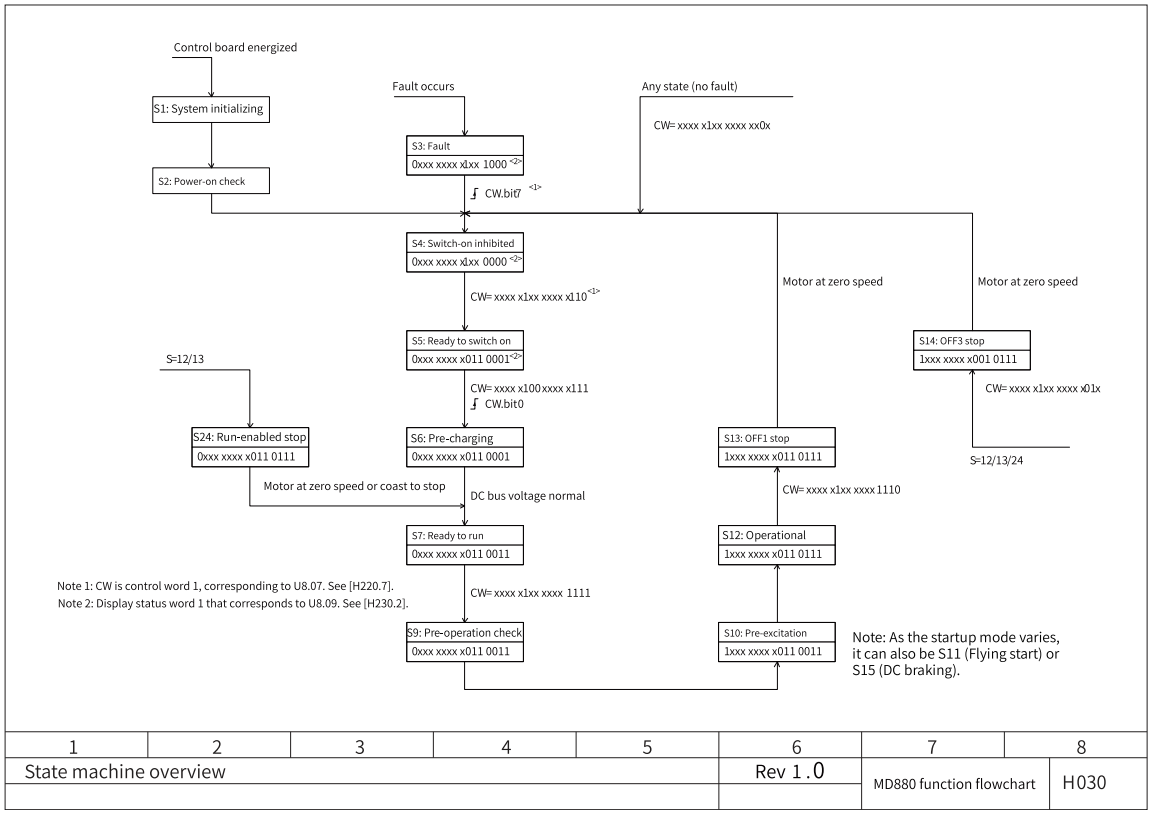
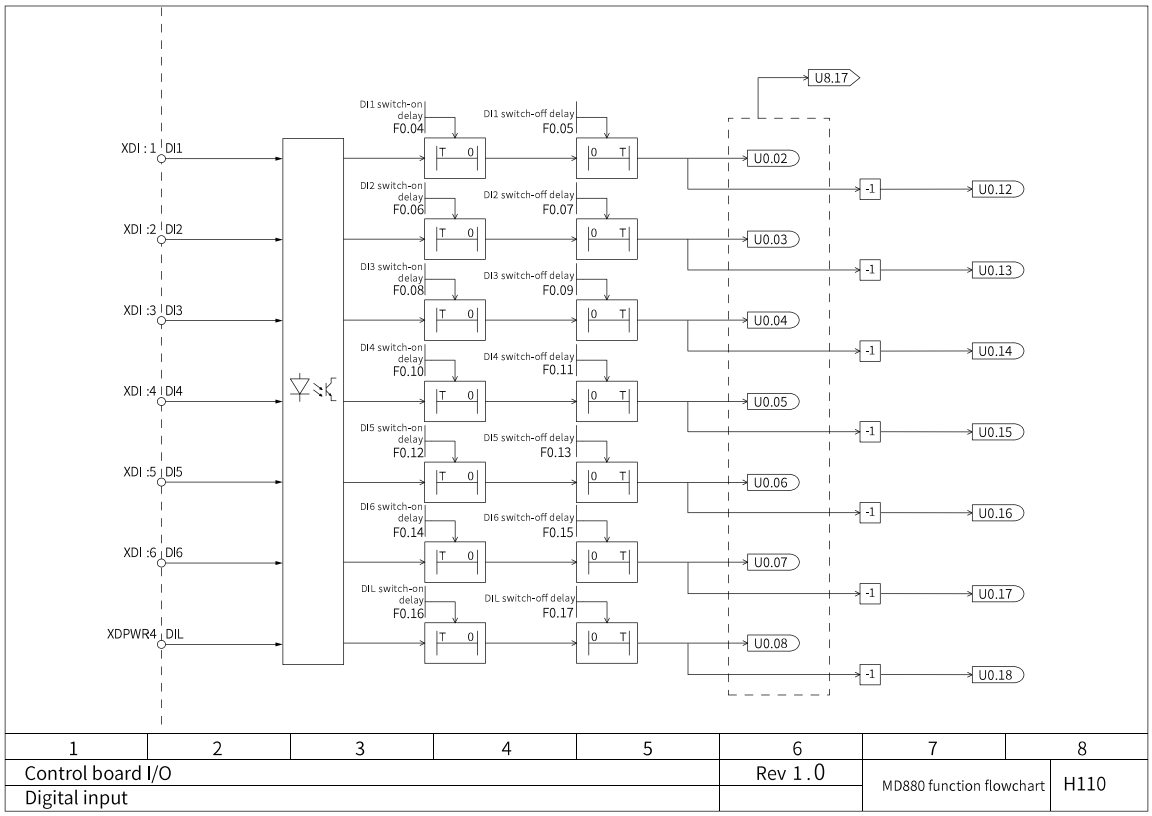


Figure 11-3 H030 - State Machine Overview

11.2.3 Input and Output

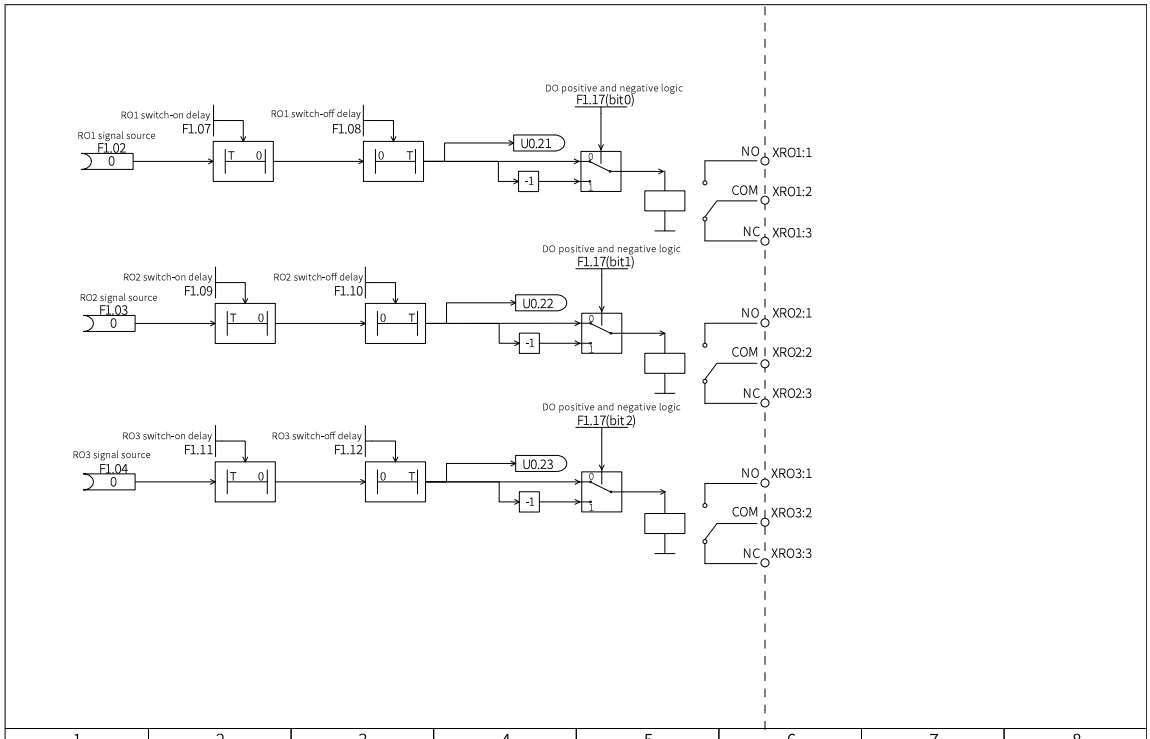
11.2.3.1 H110 - Digital Input



1	2	3	4	5	6	7	8
Control board I/O					Rev 1.0	MD880 function flowchart	H110
Digital input							

Figure 11-4 H110 - Digital Input

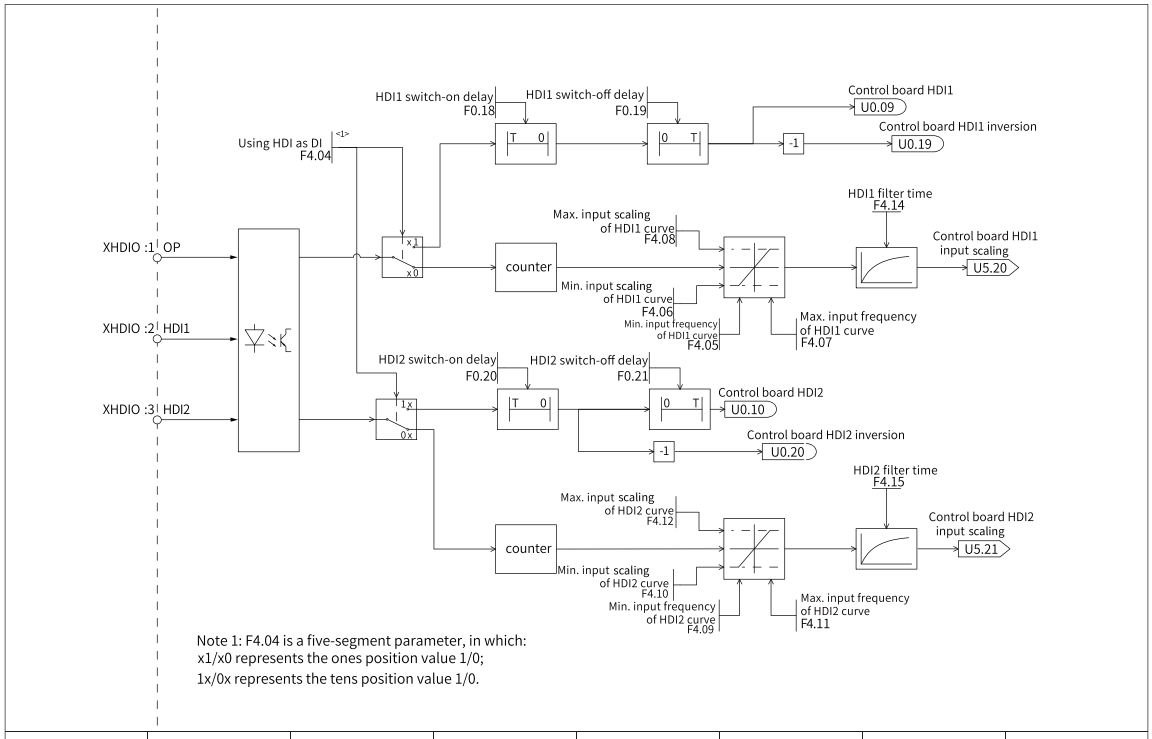
11.2.3.2 H112 - Relay Output



1	2	3	4	5	6	7	8
Control board I/O					Rev 1. 03	MD880 function flowchart	H112
Relay output							

Figure 11-5 H112 - Relay Output

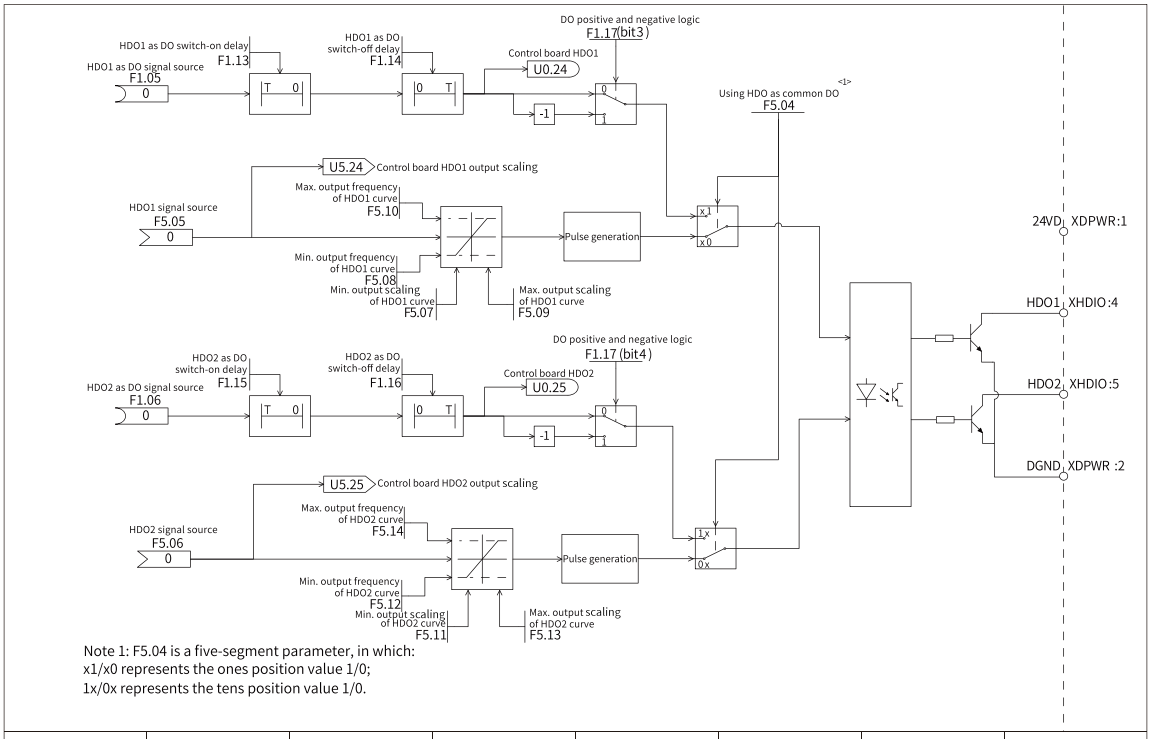
11.2.3.3 H114 - High-Speed Digital Input



1	2	3	4	5	6	7	8
Control board I/O					Rev 1 .03	MD880 function flowchart	H114
High-speed digital input							

Figure 11-6 H114 - High-Speed Digital Input

11.2.3.4 H116 - High-Speed Digital Output



1	2	3	4	5	6	7	8
Control board I/O					Rev 1.03	MD880 function flowchart	H116
High-speed digital output							

Figure 11-7 H116 - High-Speed Digital Output

11.2.3.5 H120 - Analog input

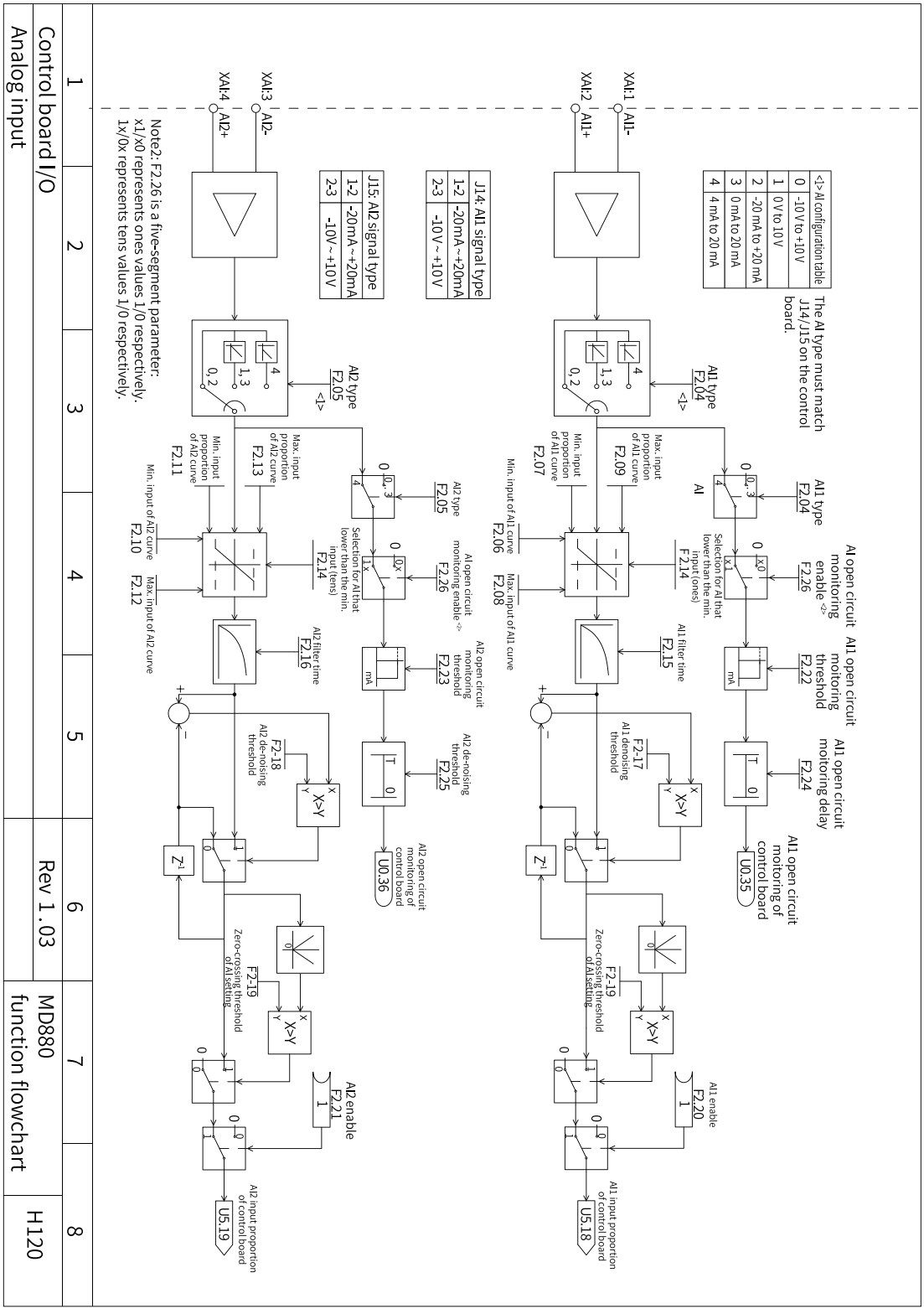


Figure 11-8 H120 - Analog input

11.2.3.6 H122 - Analog Output

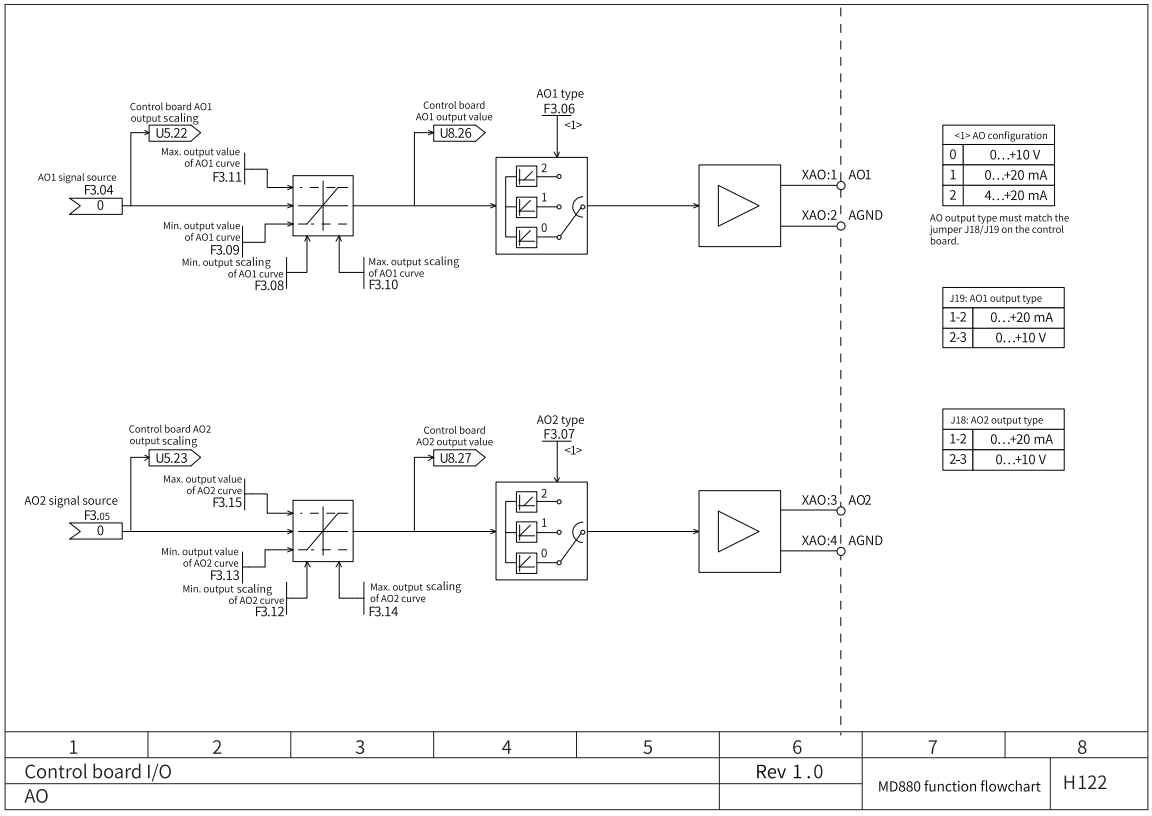


Figure 11-9 H122 - Analog Output

11.2.3.7 H130 InoLink Network - Process Data Receiving

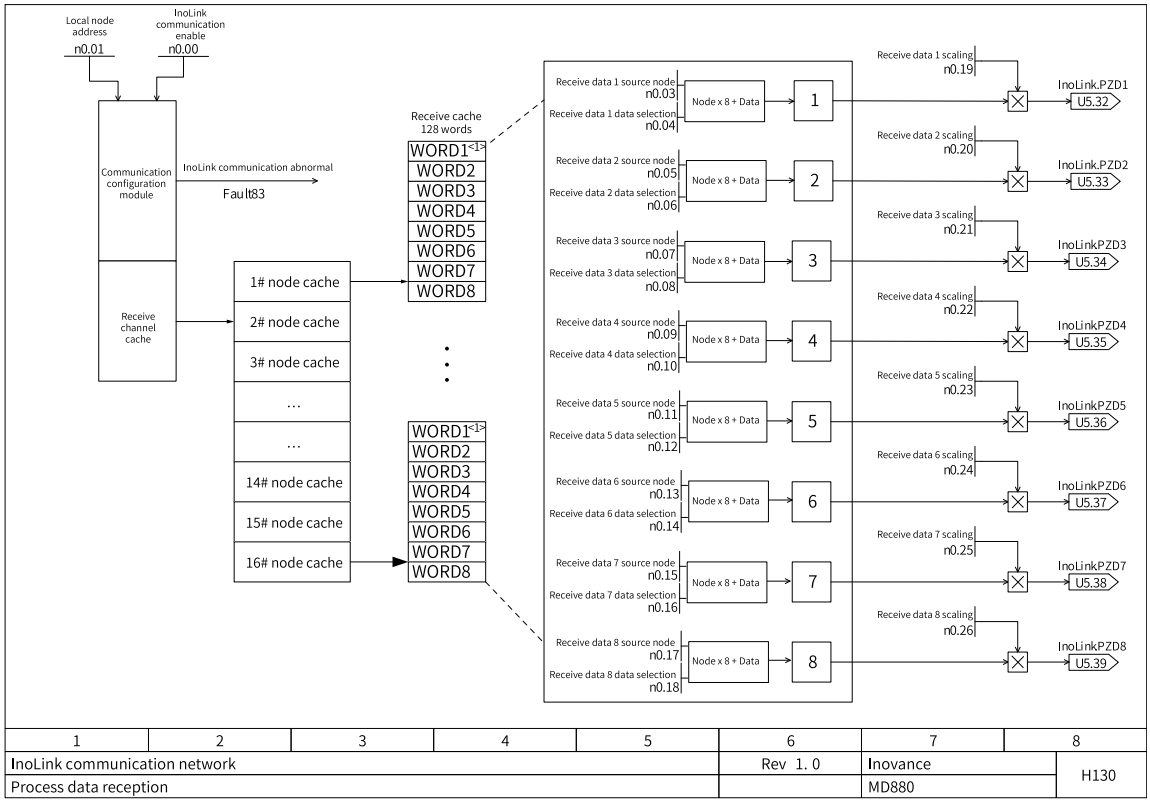


Figure 11-10 H130 InoLink Network - Process Data Receiving

11.2.3.8 H134 InoLink Network - Process Data Transmitting

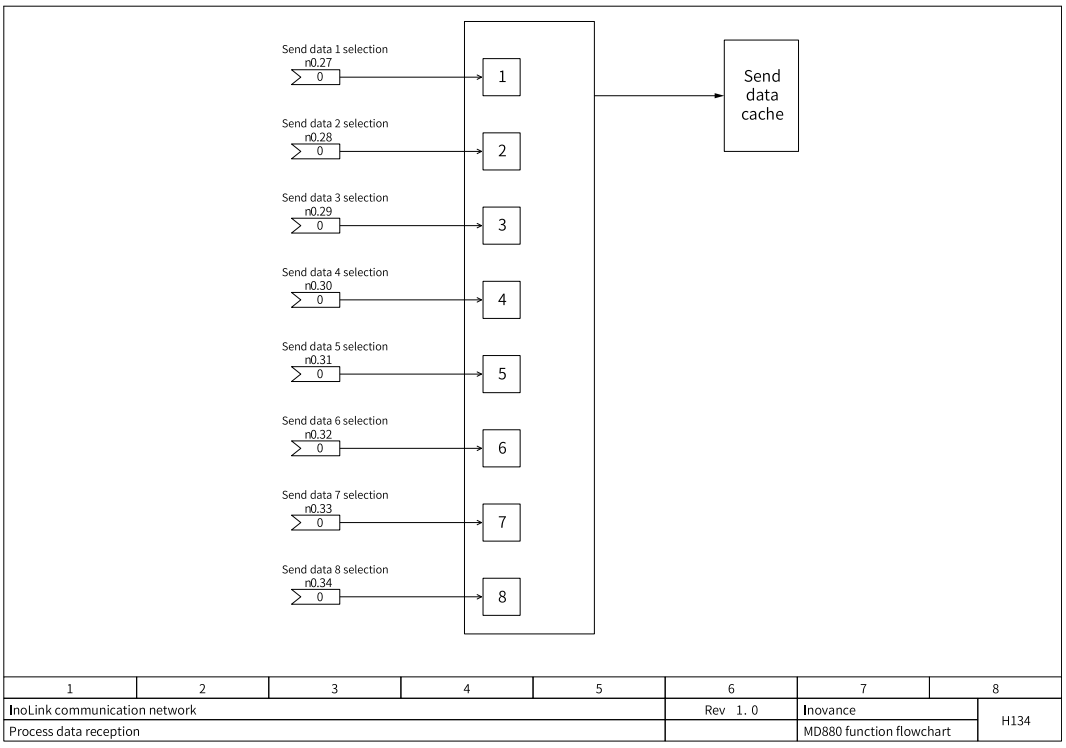
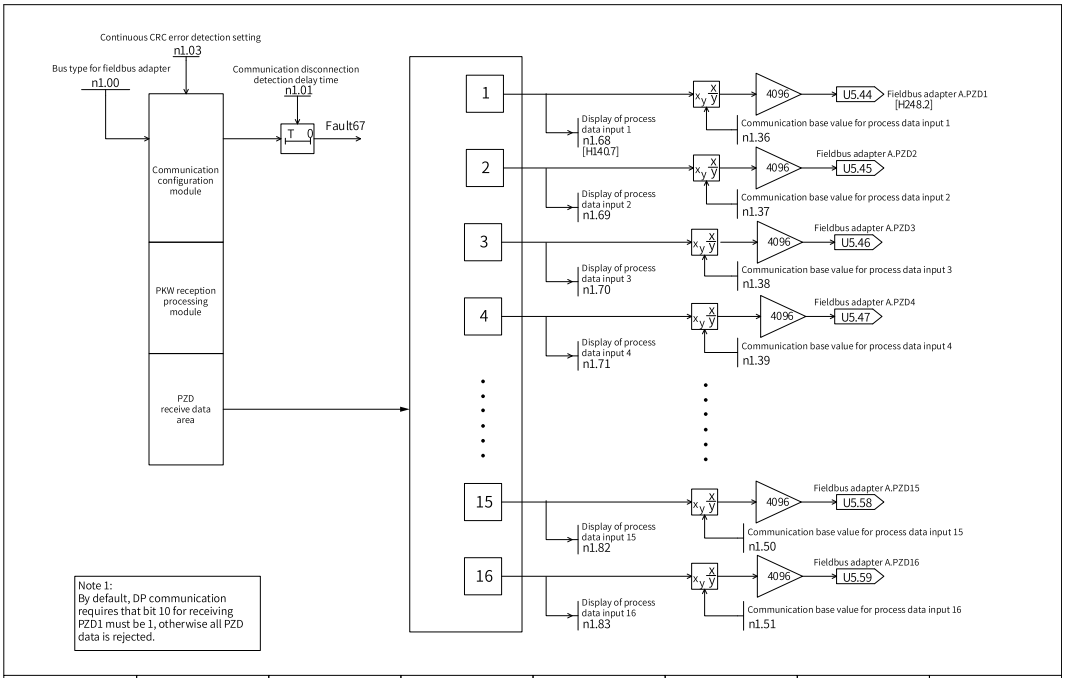


Figure 11-11 H134 InoLink Network - Process Data Transmitting

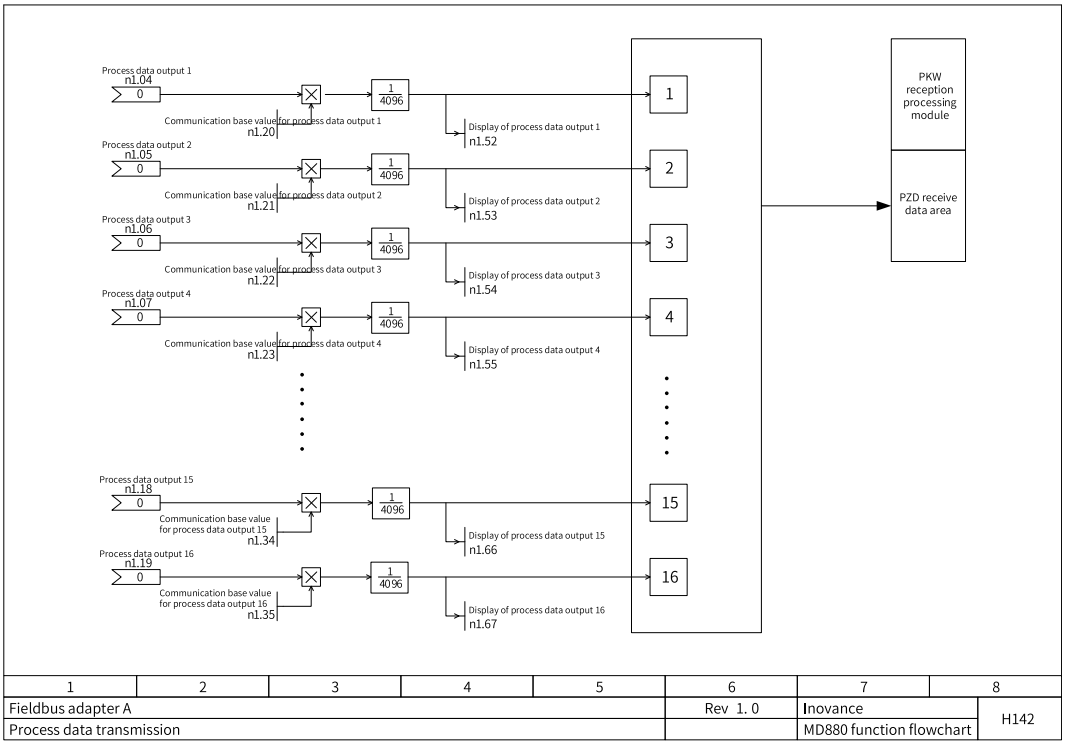
11.2.3.9 H140 Fieldbus Adapter A - Process Data Receiving



1	2	3	4	5	6	7	8
Fieldbus adapter A					Rev 1.0	Inovance	H140
Process data reception						MD880 function flowchart	

Figure 11-12 H140 Fieldbus Adapter A - Process Data Receiving

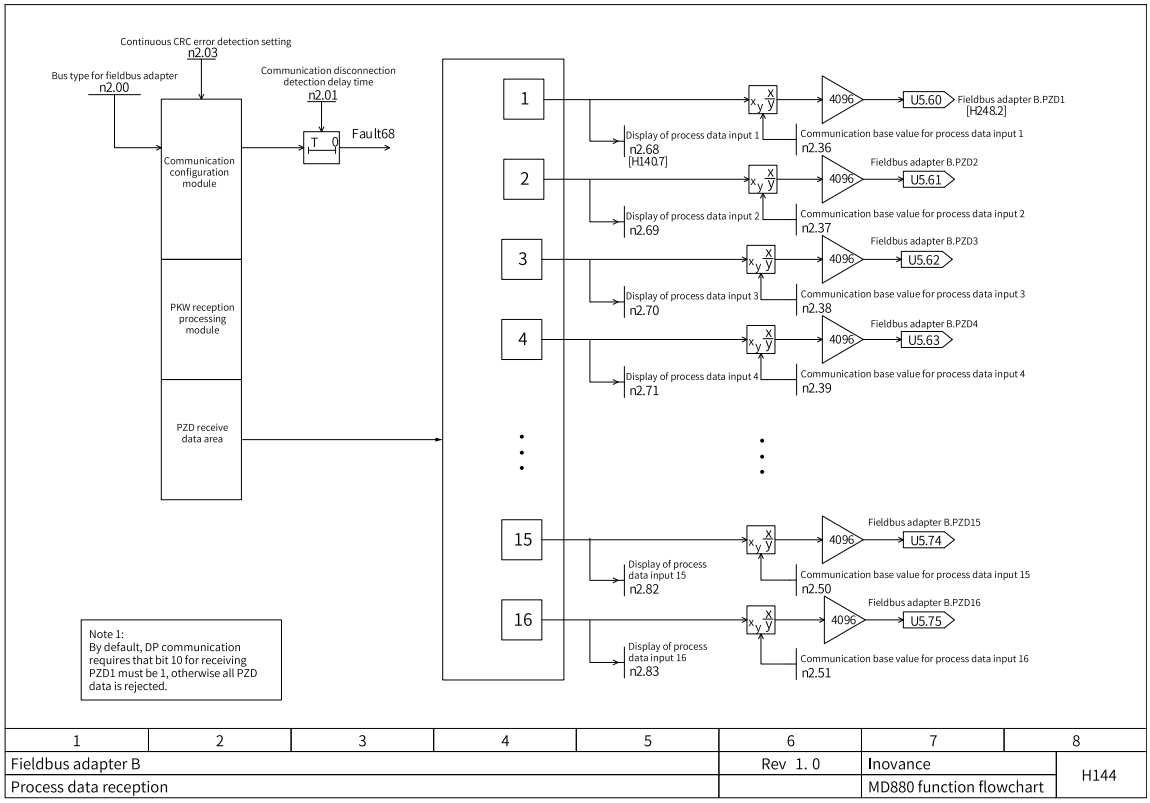
11.2.3.10 H142 Fieldbus Adapter A - Process Data Transmitting



1	2	3	4	5	6	7	8
Fieldbus adapter A					Rev 1.0	Inovance	H142
Process data transmission						MD880 function flowchart	

Figure 11-13 H142 Fieldbus Adapter A - Process Data Transmitting

11.2.3.11 H144 Fieldbus Adapter B - Process Data Receiving



1	2	3	4	5	6	7	8
Fieldbus adapter B					Rev 1.0	Inovance	H144
Process data reception						MD880 function flowchart	

Figure 11-14 H144 Fieldbus Adapter B - Process Data Receiving

11.2.3.12 H146 Fieldbus Adapter B - Process Data Transmitting

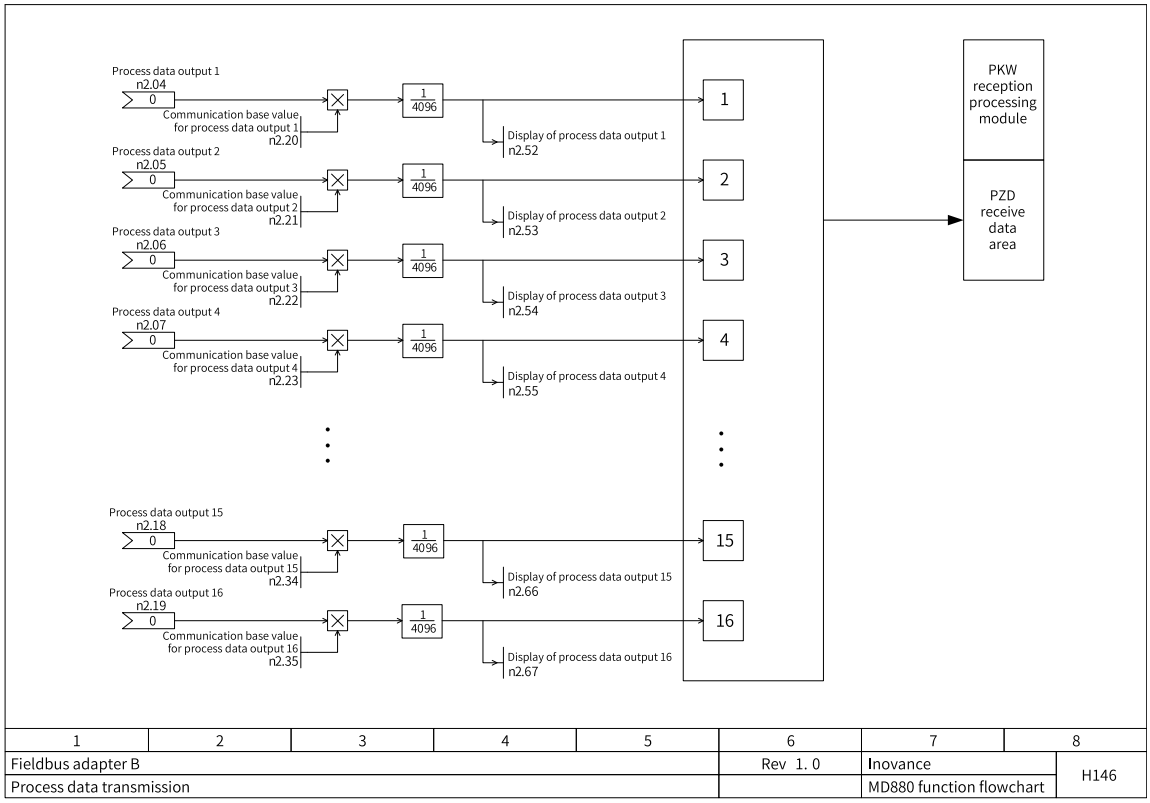


Figure 11-15 H146 Fieldbus Adapter B - Process Data Transmitting

11.2.3.13 H150 bus adapter A - Doubleword configuration of process data input

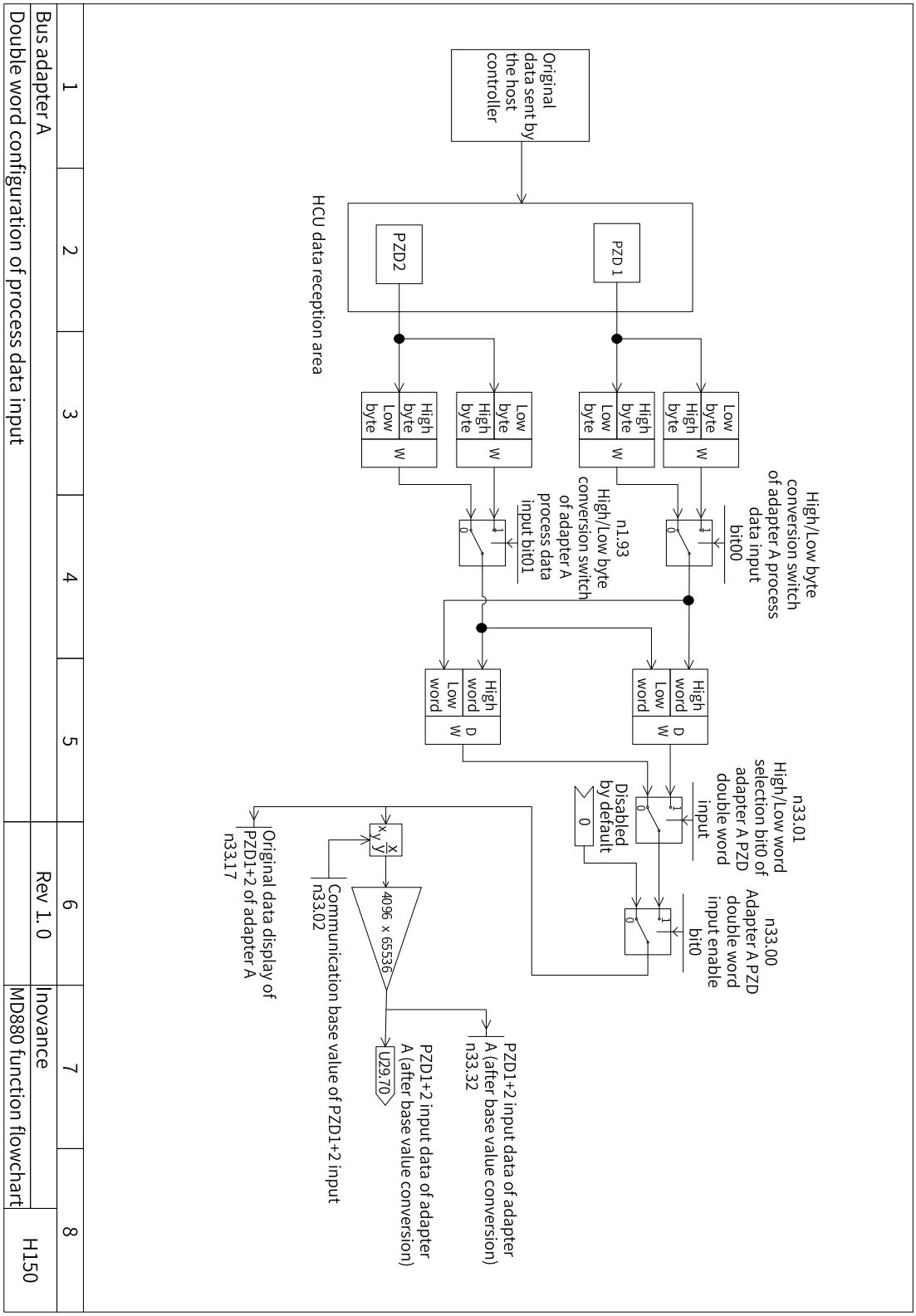


Figure 11-16 H150 bus adapter A - Doubleword configuration of process data input

11.2.3.14 H152 Bus adapter A - Doubleword configuration of process data output

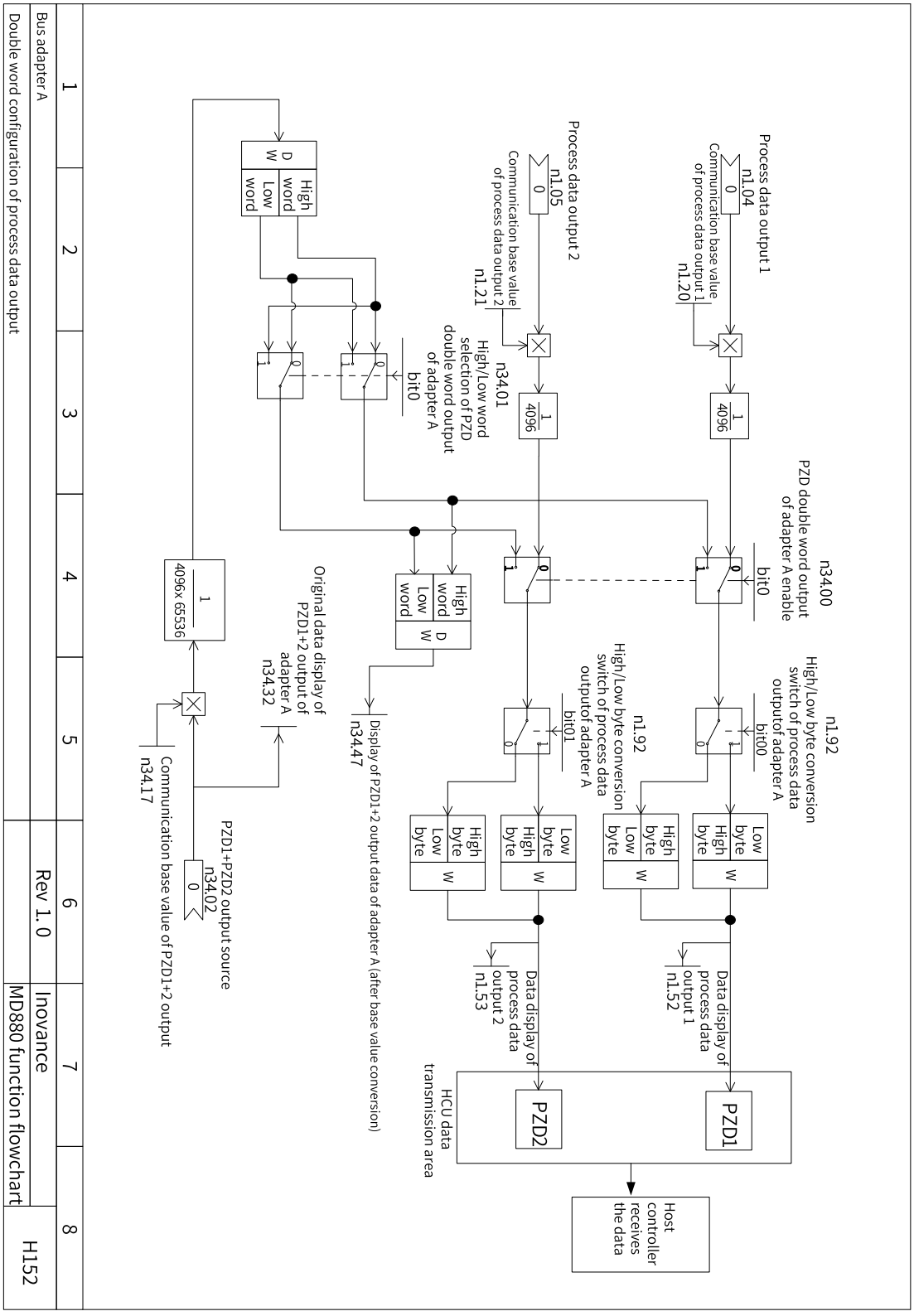
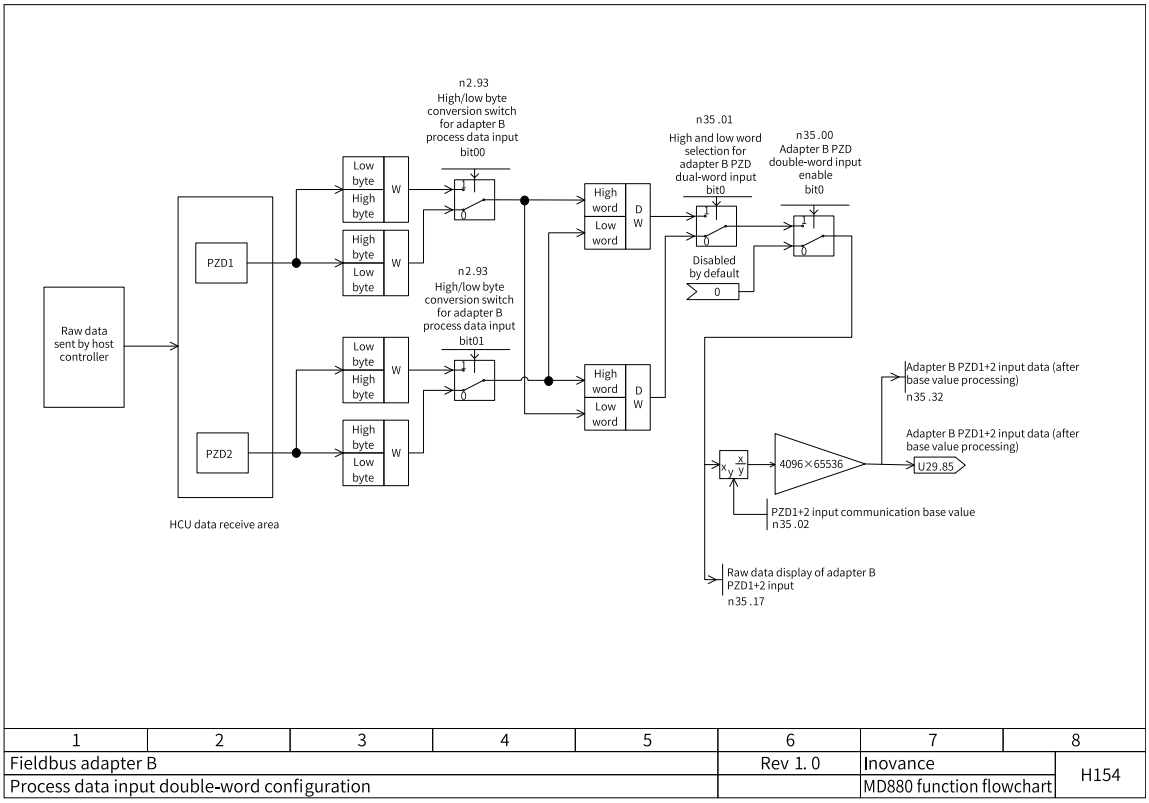


Figure 11-17 H152 Bus adapter A - Doubleword configuration of process data output

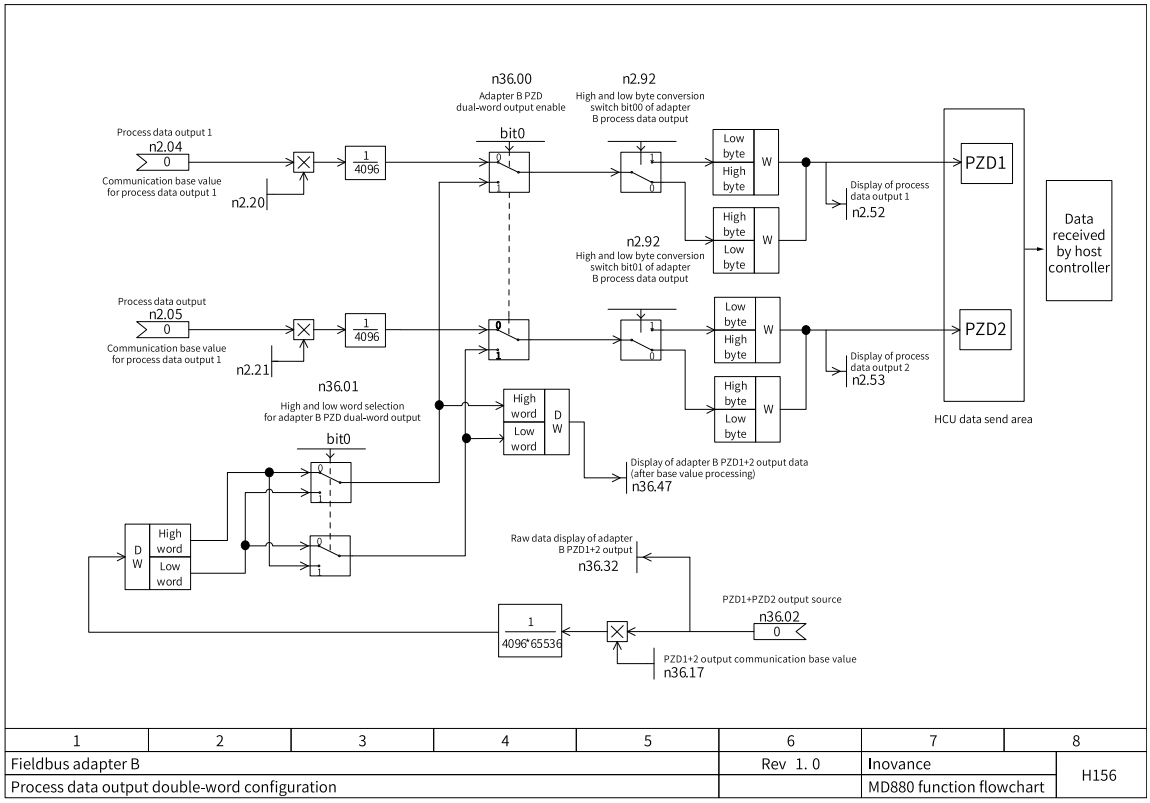
11.2.3.15 H154 Fieldbus Adapter B - Process Data Input Double-Word Configuration



1	2	3	4	5	6	7	8
Fieldbus adapter B					Rev 1. 0	Inovance	H154
Process data input double-word configuration						MD880 function flowchart	

Figure 11-18 H154 Fieldbus Adapter B - Process Data Input Double-Word Configuration

11.2.3.16 H156 Fieldbus Adapter B - Process Data Output Double-Word Configuration



1	2	3	4	5	6	7	8
Fieldbus adapter B					Rev 1.0	Inovance	H156
Process data output double-word configuration						MD880 function flowchart	

Figure 11-19 H156 Fieldbus Adapter B - Process Data Output Double-Word Configuration

11.2.4 Free Function Block

11.2.4.1 H160 - Word-to-Bit Function

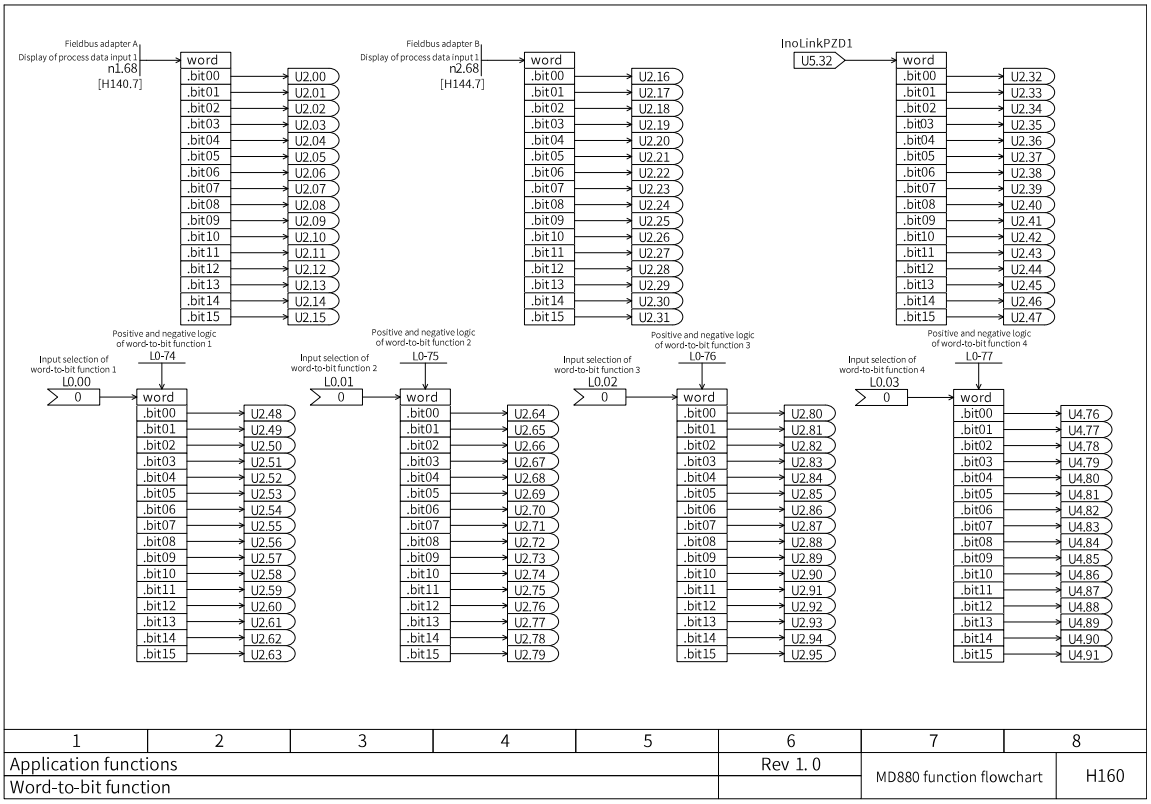
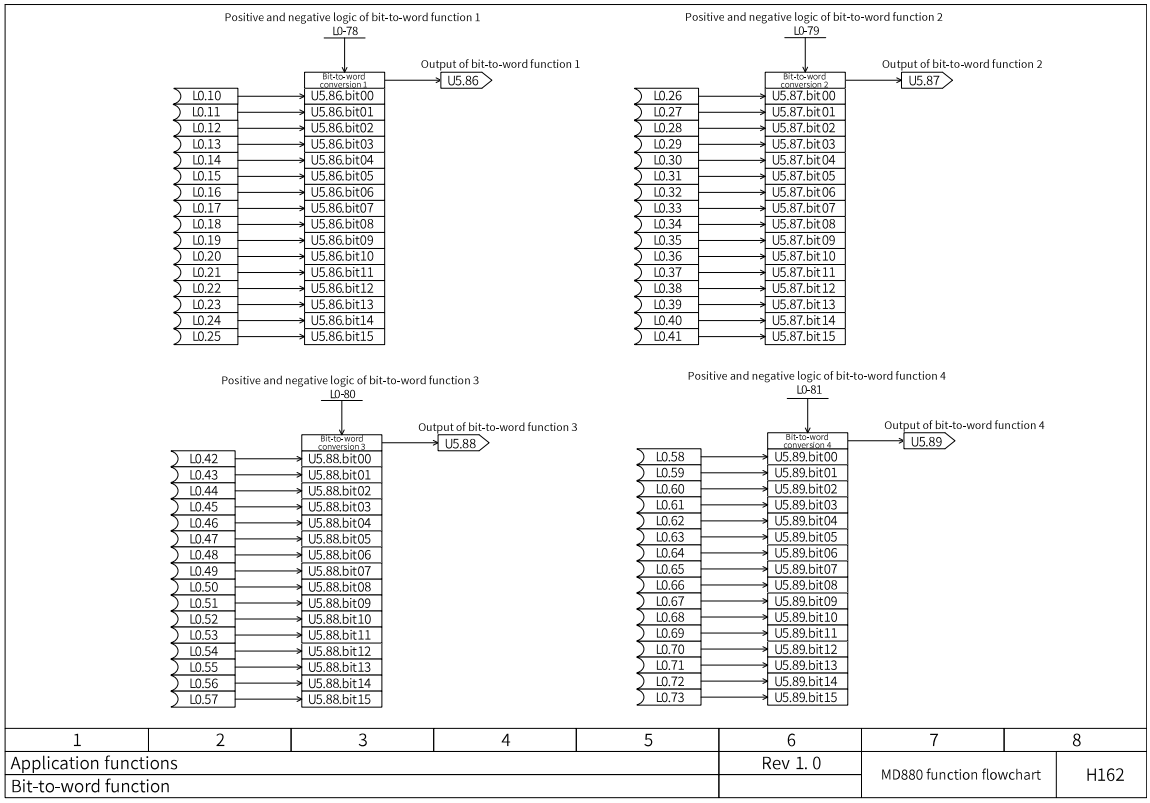


Figure 11-20 H160 - Word-to-bit function

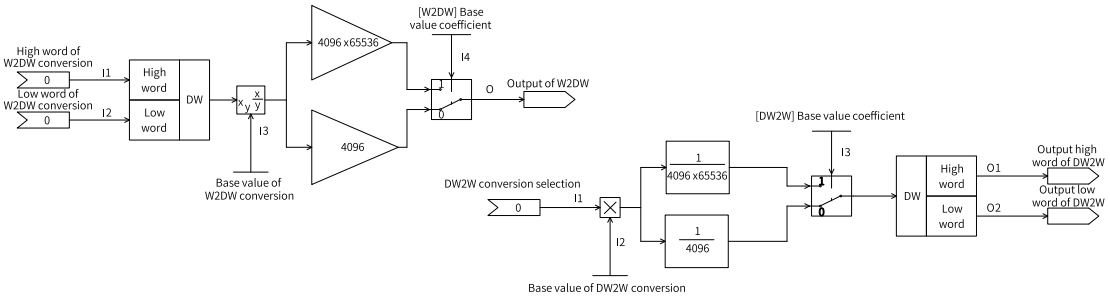
11.2.4.2 H162 - Bit-to-Word Function



1	2	3	4	5	6	7	8
Application functions					Rev 1. 0	MD880 function flowchart	H162
Bit-to-word function							

Figure 11-21 H162 - Bit-to-Word Function

11.2.4.3 H164 - W2DW and DW2W



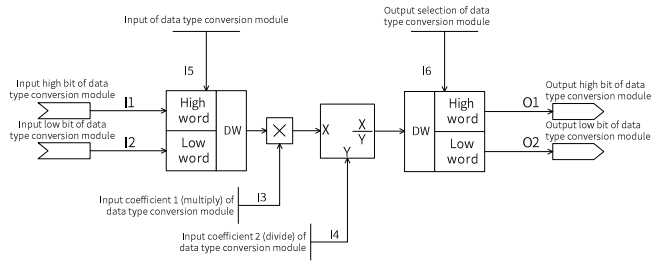
W2DW	Input				Output
Module	I1	I2	I3	I4	O
1	L3-01	L3-02	L3-03	L3-00 (bit0)	U9-47
2	L3-04	L3-05	L3-06	L3-00 (bit1)	U9-48
3	L3-07	L3-08	L3-09	L3-00 (bit2)	U9-49
4	L3-10	L3-11	L3-12	L3-00 (bit3)	U0-26
5	L3-13	L3-14	L3-15	L3-00 (bit4)	U9-27

DW2W	Input				Output
Module	I1	I2	I3	O1	O2
1	L3-26	L3-27	L3-25 (bit0)	U5-76	U5-77
2	L3-28	L3-29	L3-25 (bit1)	U5-78	U5-79
3	L3-30	L3-31	L3-25 (bit2)	U5-80	U5-81
4	L3-32	L3-33	L3-25 (bit3)	U5-82	U5-83
5	L3-34	L3-35	L3-25 (bit4)	U5-85	U5-85

1	2	3	4	5	6	7	8
Application functions					Rev 1. 0	Inovance	H164
W2DW, DW2W						MD880 function flowchart	

Figure 11-22 H164 - W2DW and DW2W

11.2.4.4 H166 - Data Type Conversion Module



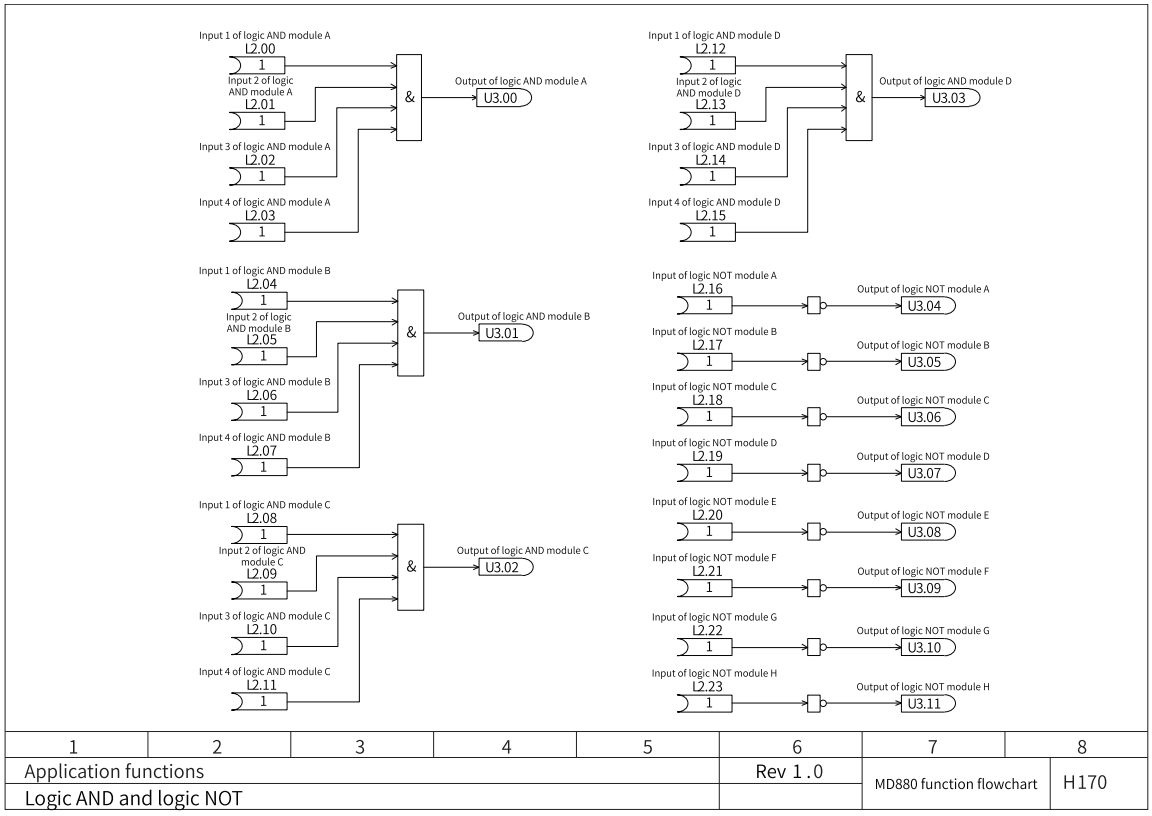
Data type conversion module	Input						Output	
	I1	I2	I3	I4	I5	I6	O1	O2
1	L12-02	L12-03	L12-04	L12-05	L12-06	L12-07	U15-55	U15-56
2	L12-08	L12-09	L12-10	L12-11	L12-12	L12-13	U15-57	U15-58
3	L12-14	L12-15	L12-16	L12-17	L12-18	L12-19	U15-59	U15-60
4	L12-20	L12-21	L12-22	L12-23	L12-24	L12-25	U15-61	U15-62
5	L12-26	L12-27	L12-28	L12-29	L12-30	L12-31	U15-63	U15-64
6	L12-32	L12-33	L12-34	L12-35	L12-36	L12-37	U15-65	U15-66
7	L12-38	L12-39	L12-40	L12-41	L12-42	L12-43	U15-67	U15-68
8	L12-44	L12-45	L12-46	L12-47	L12-48	L12-49	U15-69	U15-70

Data type conversion module	Input						Output	
	I1	I2	I3	I4	I5	I6	O1	O2
1	L12-50	L12-51	L12-52	L12-53	L12-54	L12-55	U15-71	U15-72
2	L12-56	L12-57	L12-58	L12-59	L12-60	L12-61	U15-73	U15-74
3	L12-62	L12-63	L12-64	L12-65	L12-66	L12-67	U15-75	U15-76
4	L12-68	L12-69	L12-70	L12-71	L12-72	L12-73	U15-77	U15-78
5	L12-74	L12-75	L12-76	L12-77	L12-78	L12-79	U15-79	U15-80
6	L12-80	L12-81	L12-82	L12-83	L12-84	L12-85	U15-81	U15-82
7	L12-86	L12-87	L12-88	L12-89	L12-90	L12-91	U15-83	U15-84
8	L12-92	L12-93	L12-94	L12-95	L12-96	L12-97	U15-85	U15-86

1	2	3	4	5	6	7	8
Application functions					Rev 1. 0	MD880 function flowchart	H166
Data type conversion function							

Figure 11-23 H166 - Data Type Conversion Module

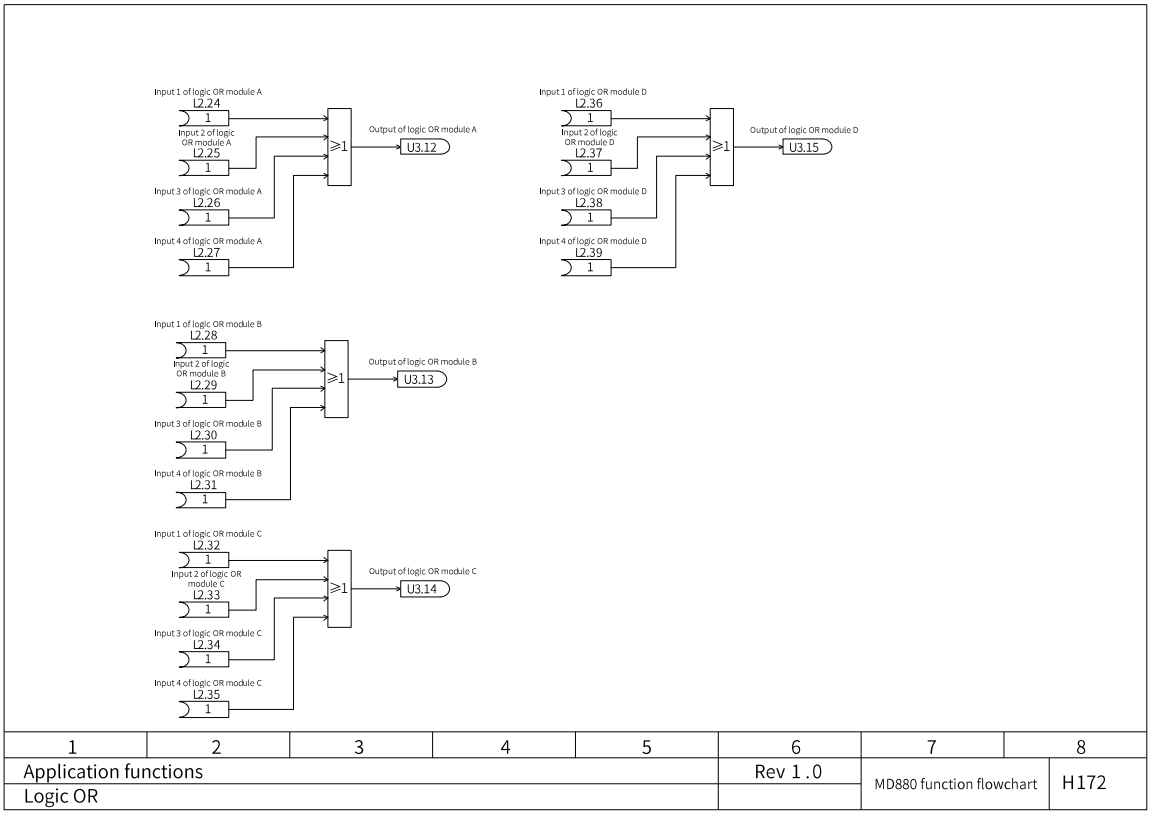
11.2.4.5 H170 - Logic AND and Logic NOT



1	2	3	4	5	6	7	8
Application functions					Rev 1.0	MD880 function flowchart	H170
Logic AND and logic NOT							

Figure 11-24 H170 - Logic AND and Logic NOT

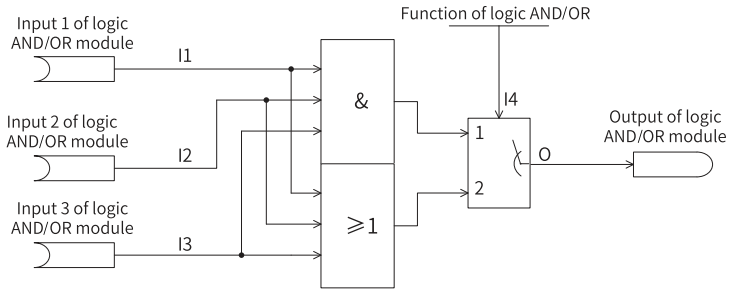
11.2.4.6 H172 - Logic OR



1	2	3	4	5	6	7	8
Application functions					Rev 1.0	MD880 function flowchart	H172
Logic OR							

Figure 11-25 H172 - Logic OR

11.2.4.7 H173 - Logic AND and Logic OR

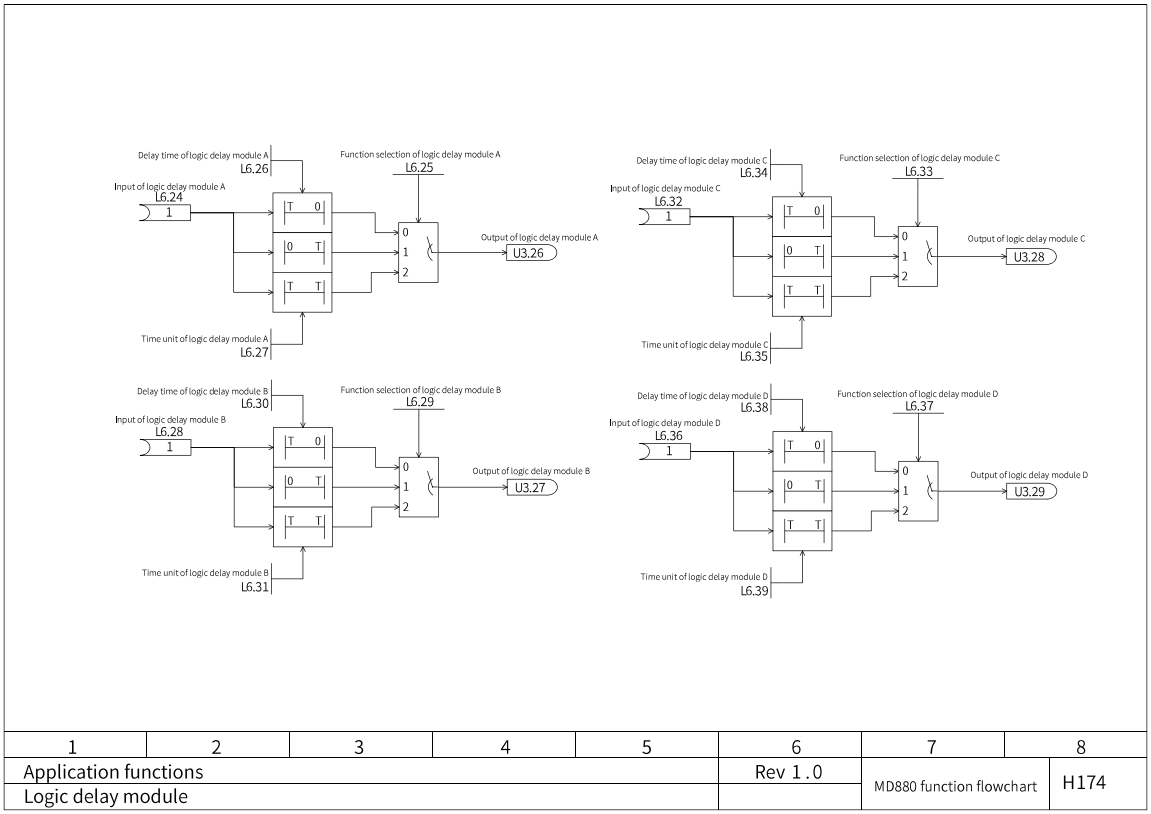


Logic AND/OR Module	Input				Output
	I1	I2	I3	I4	O
A	L2-61	L2-62	L2-63	L2-60	U4-92
B	L2-65	L2-66	L2-67	L2-64	U4-93
C	L2-69	L2-70	L2-71	L2-68	U4-94
D	L2-73	L2-74	L2-75	L2-72	U4-95
E	L2-77	L2-78	L2-79	L2-76	U4-96
F	L2-81	L2-82	L2-83	L2-80	U4-97
G	L2-85	L2-86	L2-87	L2-84	U4-98
H	L2-89	L2-90	L2-91	L2-88	U4-99

1	2	3	4	5	6	7	8
Application functions					Rev 1.0	MD880 function flowchart	H173
Logic AND/OR							

Figure 11-26 H173 - Logic AND and Logic OR

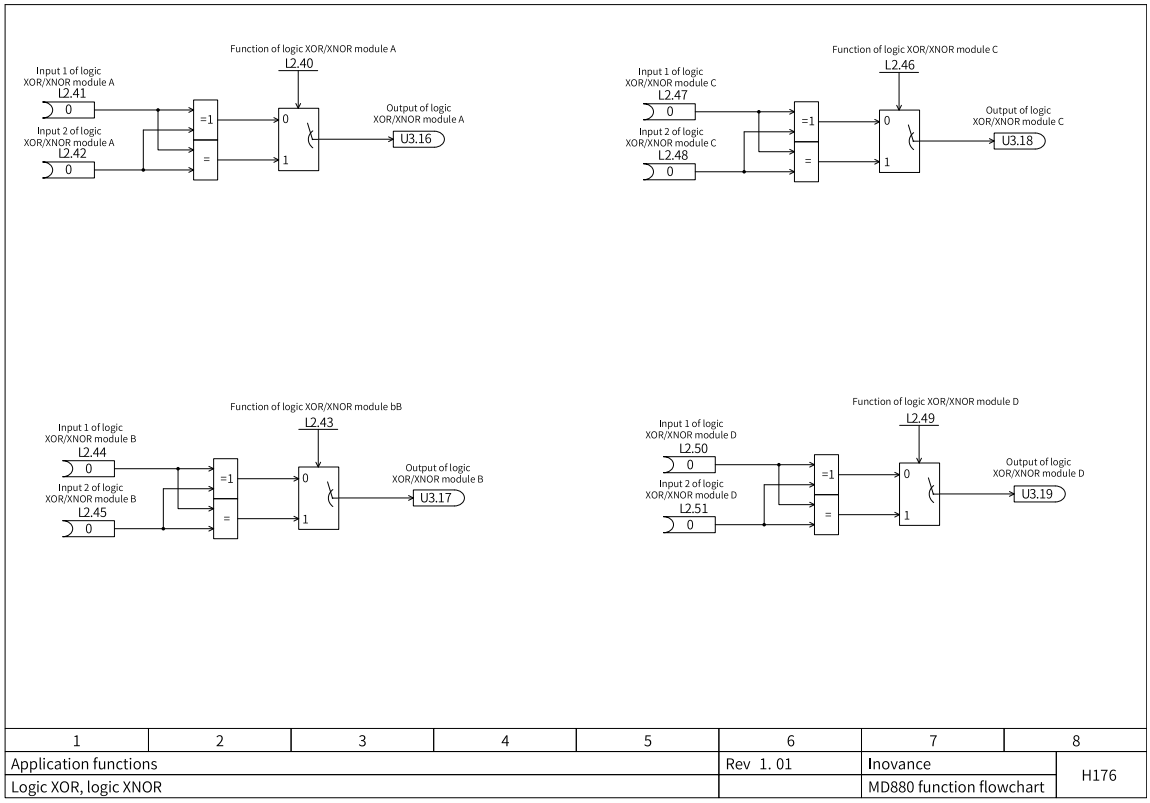
11.2.4.8 H174 - Logic Delay Module



1	2	3	4	5	6	7	8
Application functions					Rev 1.0	MD880 function flowchart	H174
Logic delay module							

Figure 11-27 H174 - Logic delay module

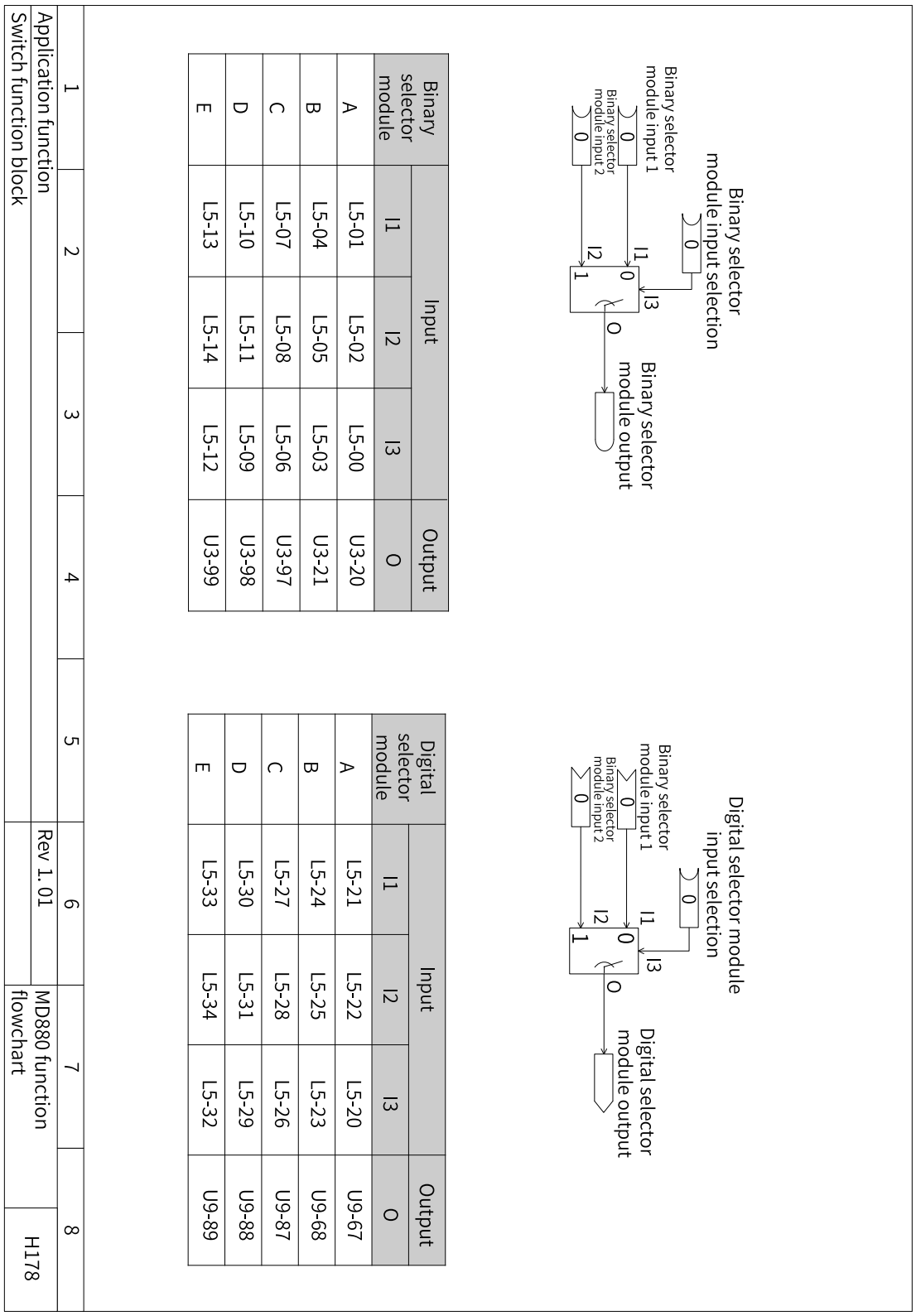
11.2.4.9 H176 - Logic XOR/XNOR



1	2	3	4	5	6	7	8
Application functions					Rev 1. 01	Inovance	H176
Logic XOR, logic XNOR						MD880 function flowchart	

Figure 11-28 H176 - Logic XOR/XNOR

11.2.4.10 H178 - Switch function block



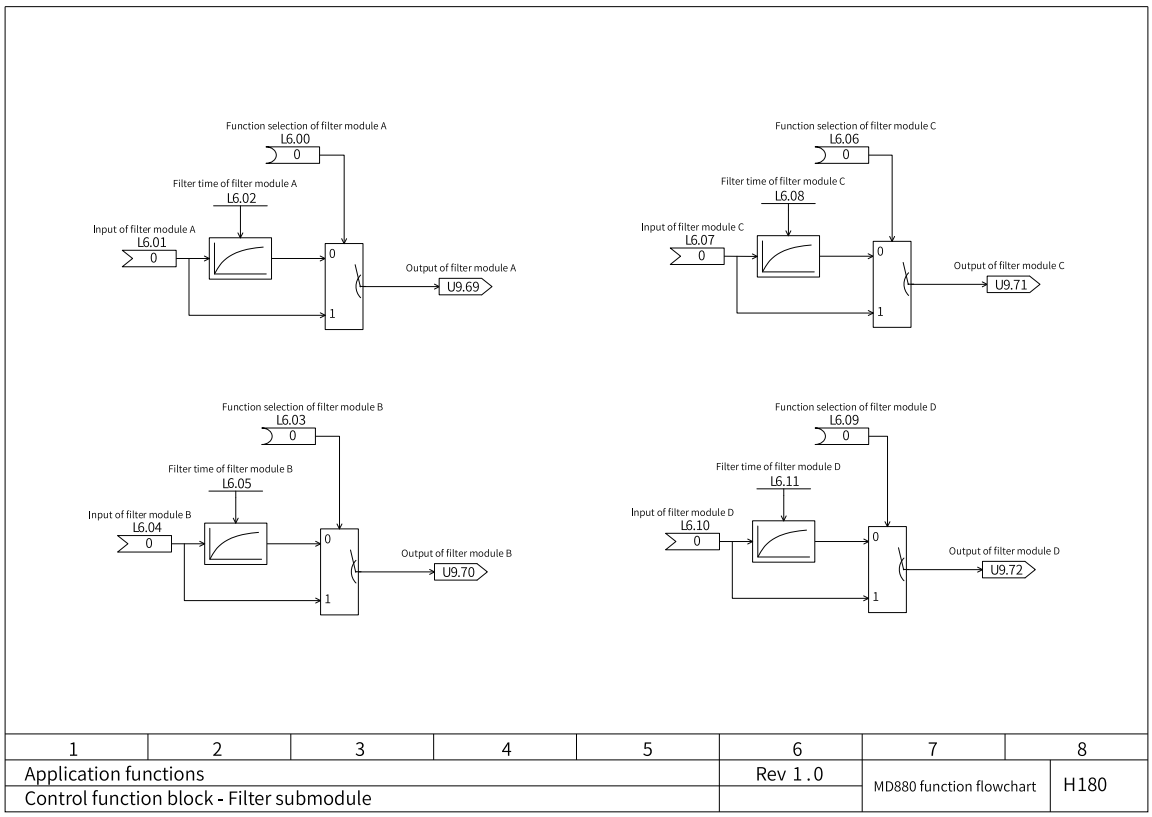
Binary selector module	Input			Output
	I1	I2	I3	O
A	L5-01	L5-02	L5-00	U3-20
B	L5-04	L5-05	L5-03	U3-21
C	L5-07	L5-08	L5-06	U3-97
D	L5-10	L5-11	L5-09	U3-98
E	L5-13	L5-14	L5-12	U3-99

Digital selector module	Input			Output
	I1	I2	I3	O
A	L5-21	L5-22	L5-20	U9-67
B	L5-24	L5-25	L5-23	U9-68
C	L5-27	L5-28	L5-26	U9-87
D	L5-30	L5-31	L5-29	U9-88
E	L5-33	L5-34	L5-32	U9-89

1	2	3	4	5	6	7	8
Application function					Rev 1. 01	MD880 function flowchart	H178
Switch function block							

Figure 11-29 H178 - Switch function block

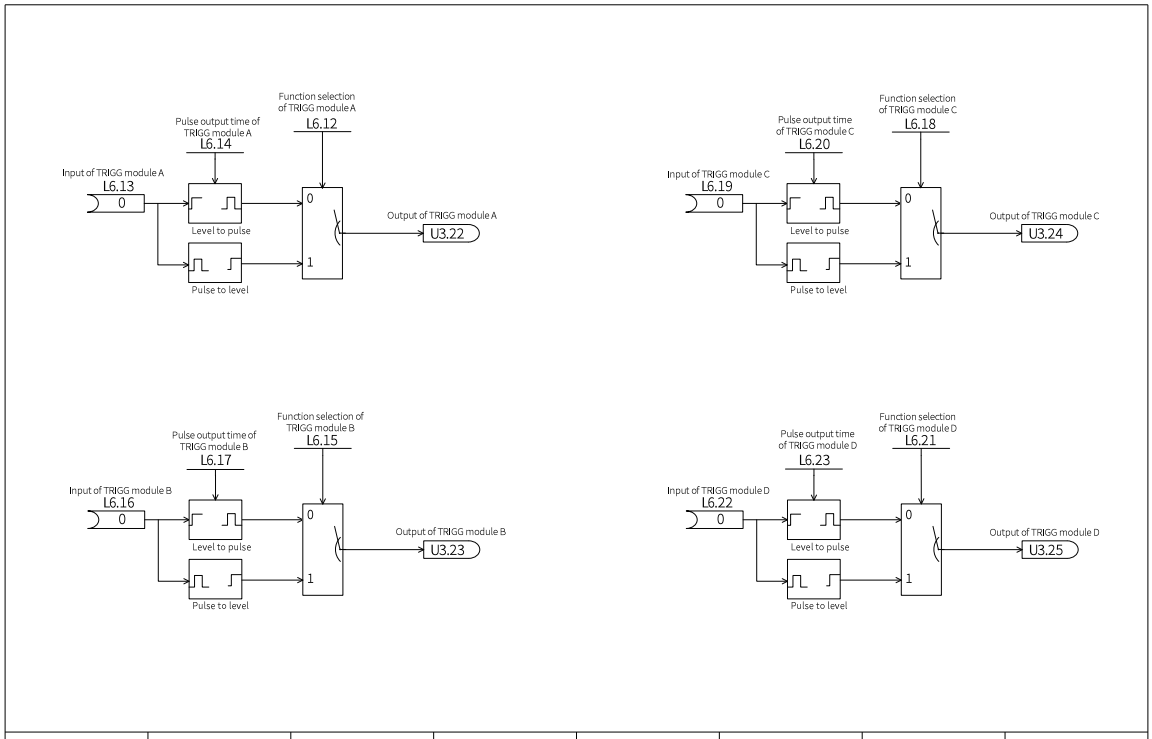
11.2.4.11 H180 - Control Function Block - Filter Submodule



1	2	3	4	5	6	7	8
Application functions					Rev 1.0	MD880 function flowchart	H180
Control function block - Filter submodule							

Figure 11-30 H180 - Control function block - Filter submodule

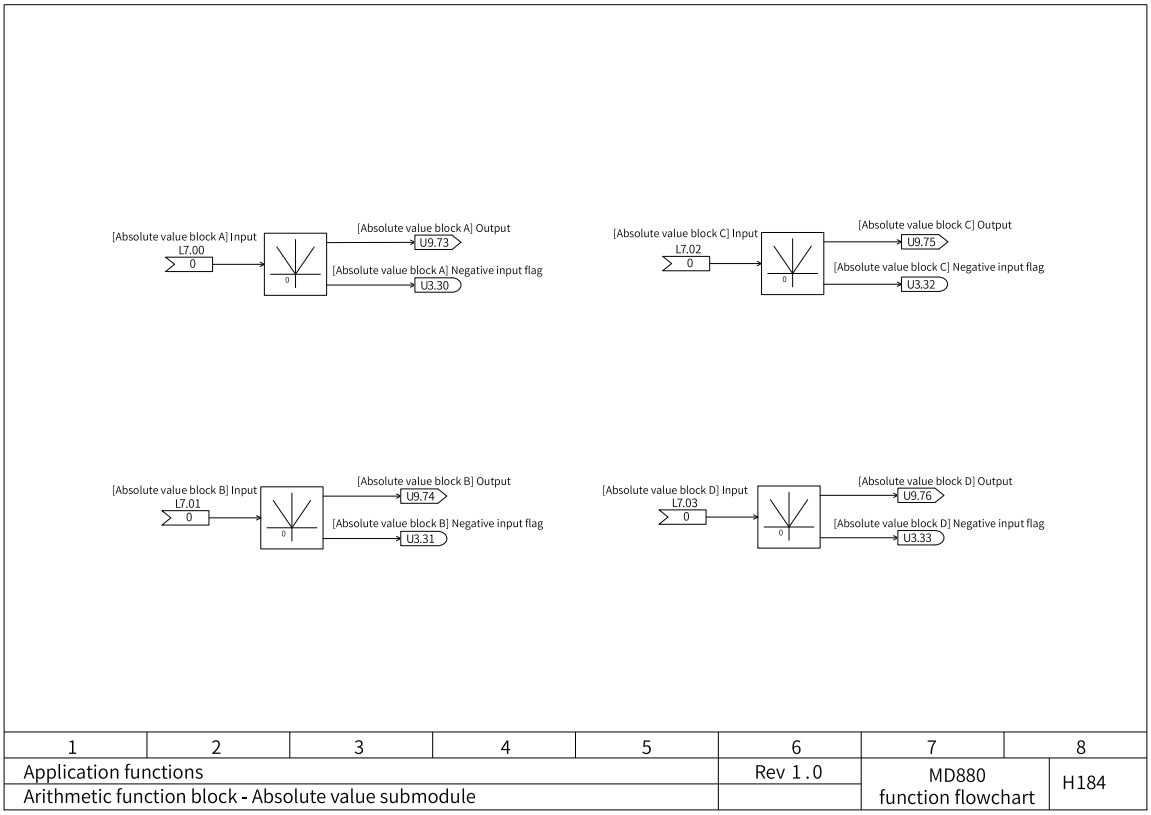
11.2.4.12 H182 - Control Function Block - P_L Conversion Submodule



1	2	3	4	5	6	7	8
Application functions					Rev 1.0	MD880 function flowchart	H182
Control function block - P_L conversion submodule							

Figure 11-31 H182 - Control function block - P_L conversion submodule

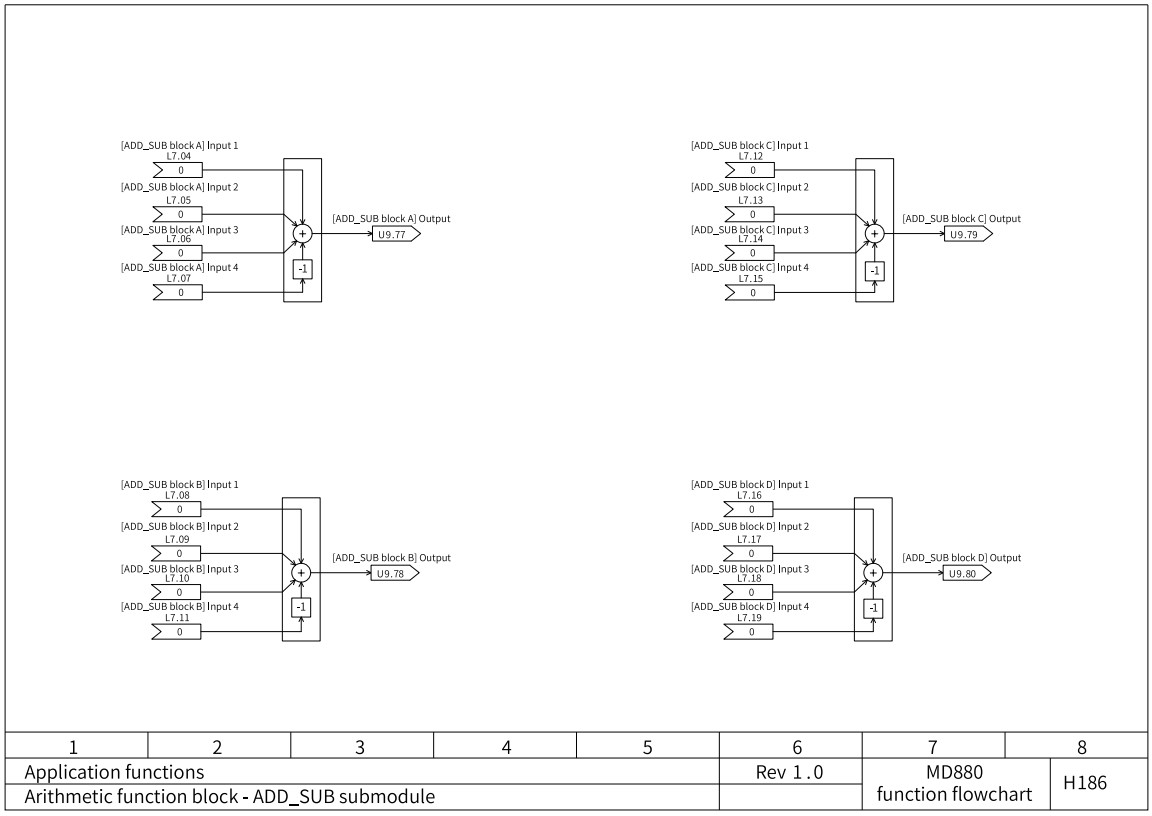
11.2.4.13 H184 - Arithmetic Function Block - Absolute Value Submodule



1	2	3	4	5	6	7	8
Application functions					Rev 1.0	MD880 function flowchart	H184
Arithmetic function block - Absolute value submodule							

Figure 11-32 H184 - Arithmetic function block - Absolute value submodule

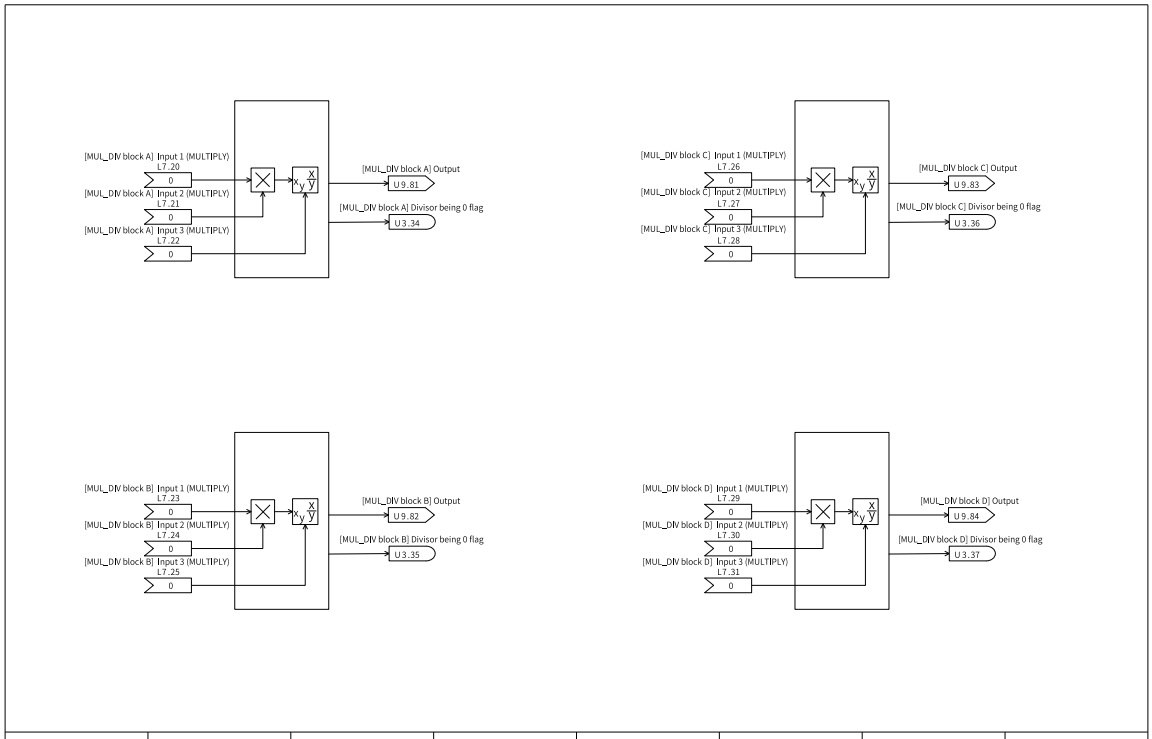
11.2.4.14 H186 - Arithmetic Function Block - Addition_Subtraction Submodule



1	2	3	4	5	6	7	8
Application functions					Rev 1.0	MD880 function flowchart	H186
Arithmetic function block - ADD_SUB submodule							

Figure 11-33 H186 - Arithmetic function block - Addition_Subtraction submodule

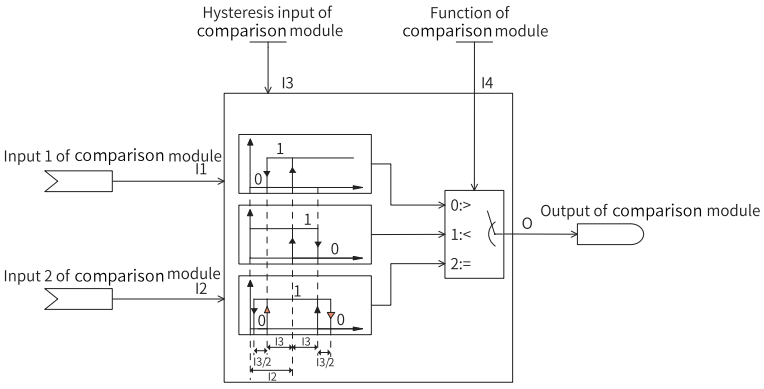
11.2.4.15 H188 - Arithmetic Function Block - Multiplication_Division Submodule



1	2	3	4	5	6	7	8
Application functions					Rev 1.0	MD880 function flowchart	H188
Arithmetic function block - MUL_DIV submodule							

Figure 11-34 H188 - Arithmetic function block - Multiplication_Division submodule

11.2.4.16 H190 - Arithmetic Function Block - Comparison Submodule



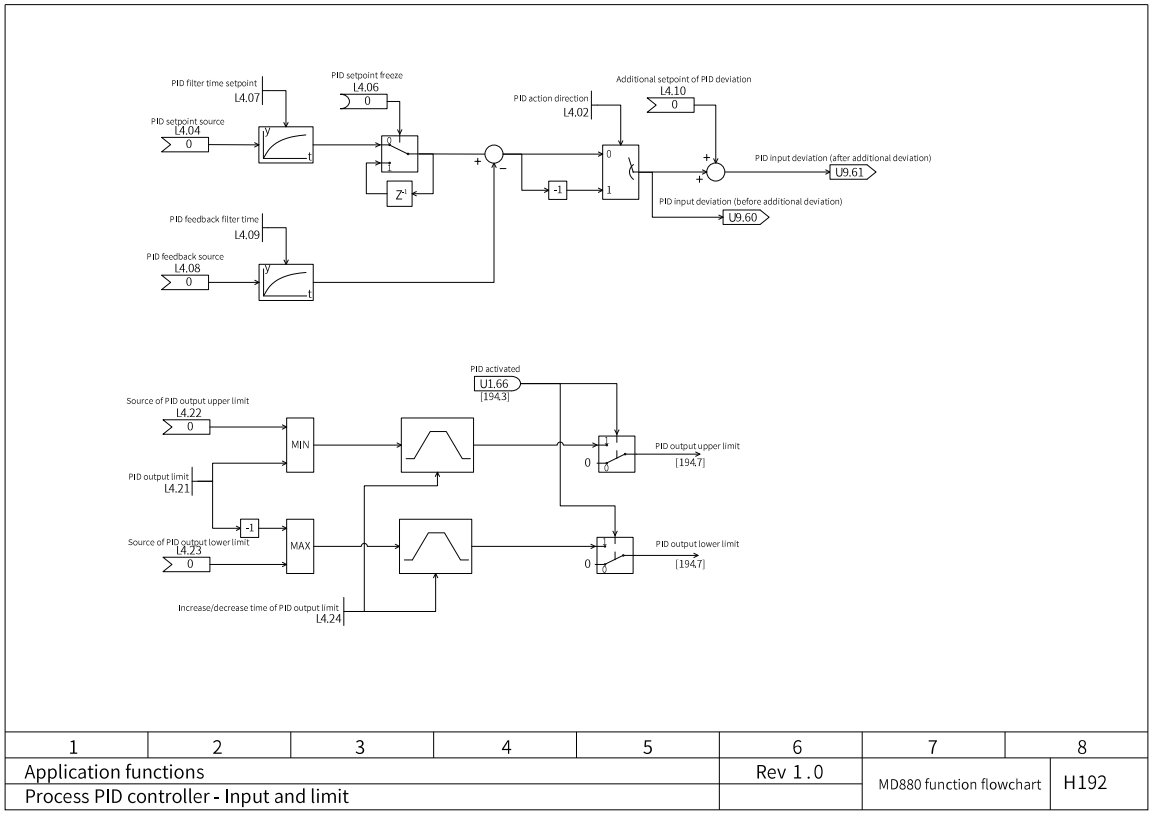
Comparison Module	Input				Output
	I1	I2	I3	I4	O
A	L7-33	L7-34	L7-35	L7-32	U3-38
B	L7-37	L7-38	L7-39	L7-36	U3-39
C	L7-41	L7-42	L7-43	L7-40	U4-69
D	L7-45	L7-46	L7-47	L7-44	U4-70
E	L7-49	L7-50	L7-51	L7-48	U4-71

Note: The symbol ">" represents input 1 > input 2.
The symbol "<" represents input 1 < input 2.
The symbol "=" represents input 1 = input 2.

1	2	3	4	5	6	7	8
Application functions					Rev 1 . 0	MD880 function flowchart	H190
Arithmetic function block - Comparison submodule							

Figure 11-35 H190 - Arithmetic function block - Comparison submodule

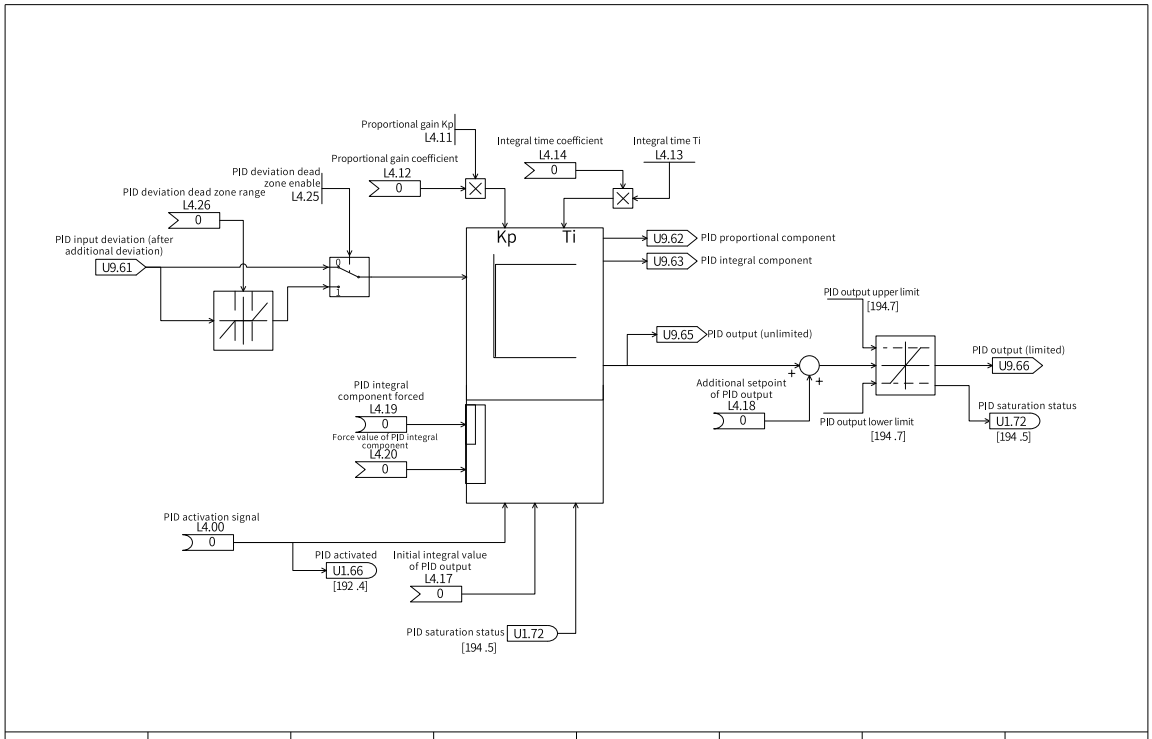
11.2.4.17 H192 - Process PID Controller - Input and Limit



1	2	3	4	5	6	7	8
Application functions					Rev 1.0	MD880 function flowchart	H192
Process PID controller - Input and limit							

Figure 11-36 H192 - Process PID controller - Input and limit

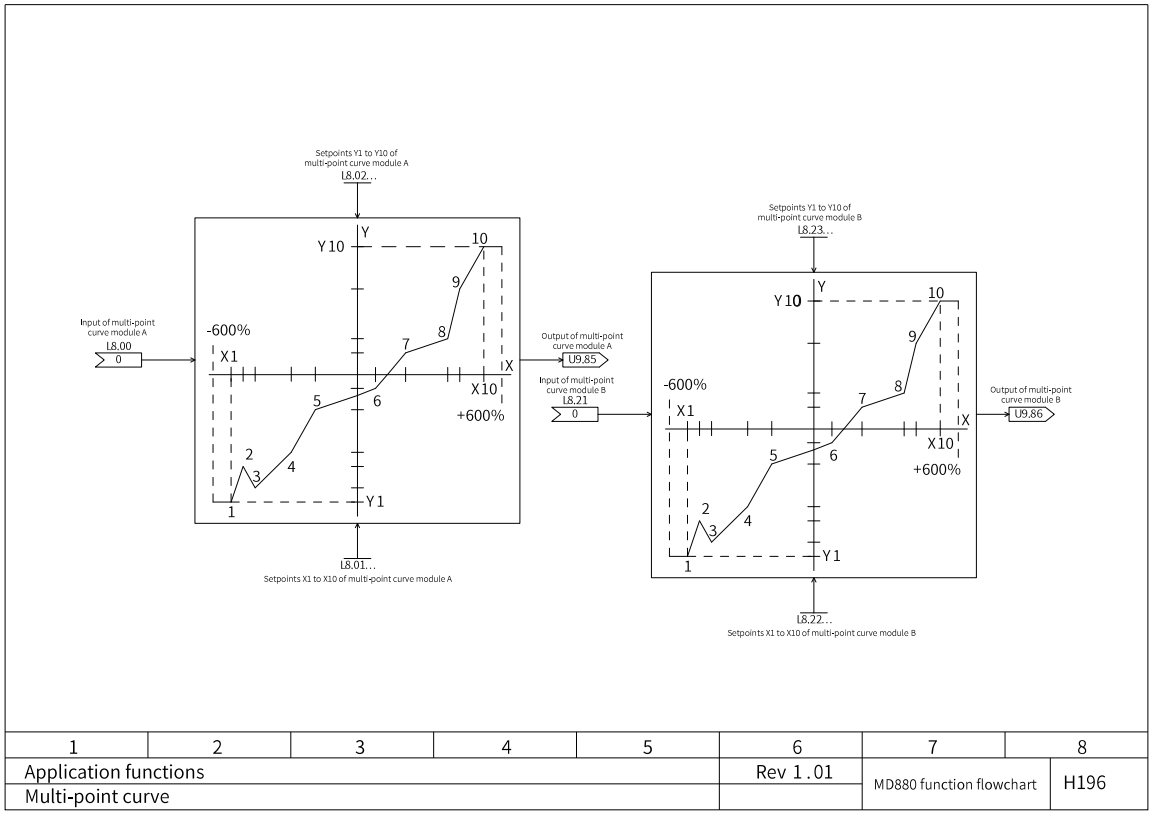
11.2.4.18 H194 - Process PID Controller - Operation



1	2	3	4	5	6	7	8
Application functions					Rev 1 . 0	MD880 function flowchart	H194
Process PID controller - Operation							

Figure 11-37 H194 - Process PID controller - Operation

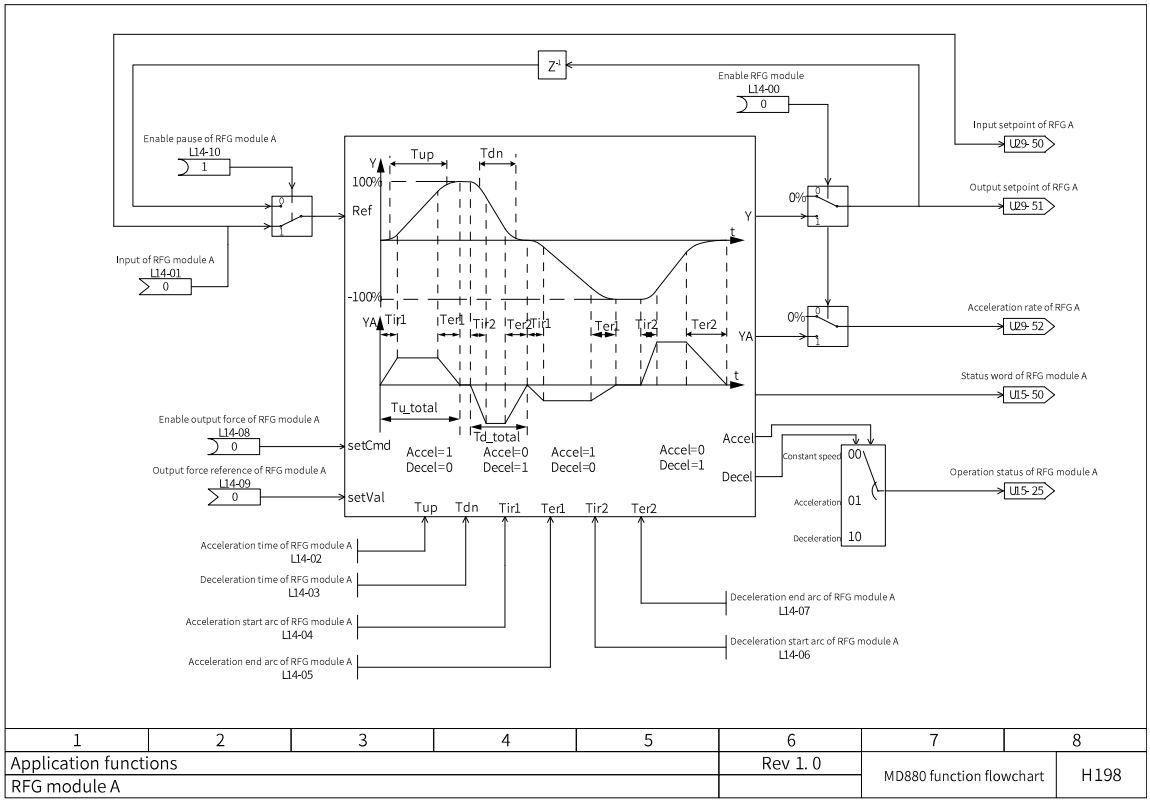
11.2.4.19 H196 - Multi-Point Curve



1	2	3	4	5	6	7	8
Application functions					Rev 1.01	MD880 function flowchart	H196
Multi-point curve							

Figure 11-38 H196 - Multi-Point Curve

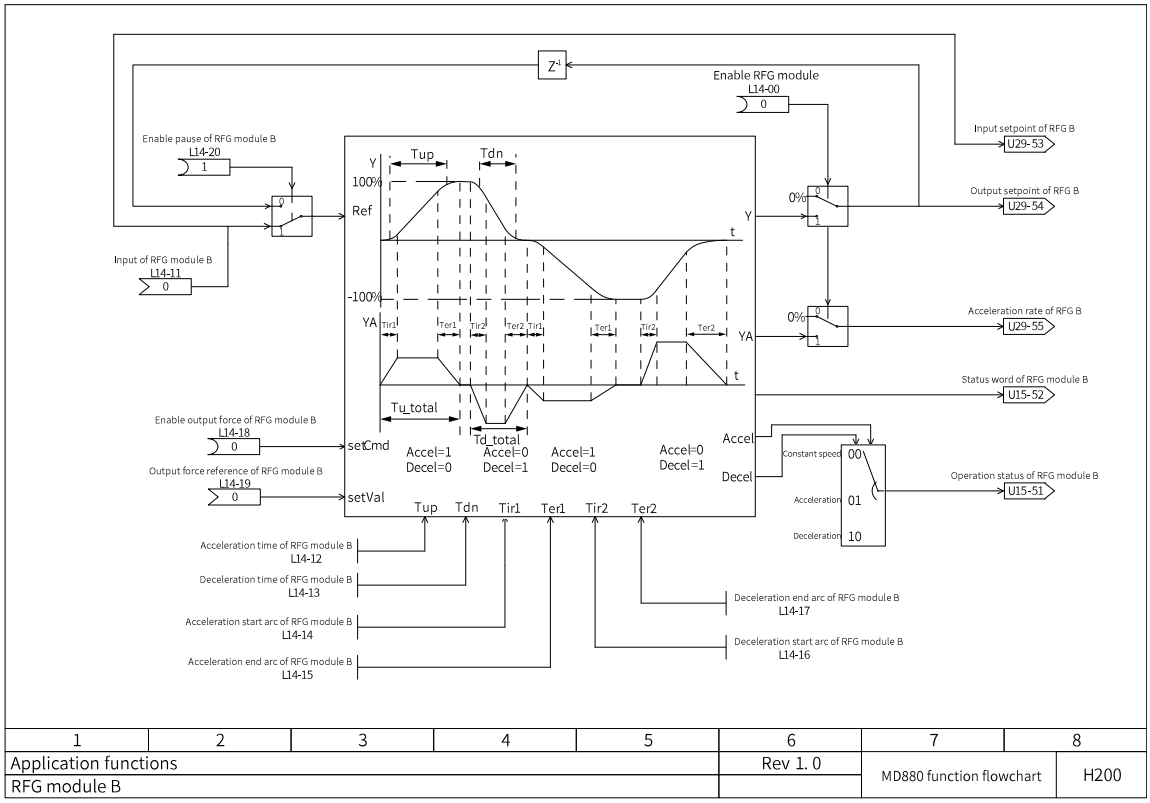
11.2.4.20 H198 - RFG Module A



1	2	3	4	5	6	7	8
Application functions					Rev 1. 0	MD880 function flowchart	H198
RFG module A							

Figure 11-39 H198 - RFG Module A

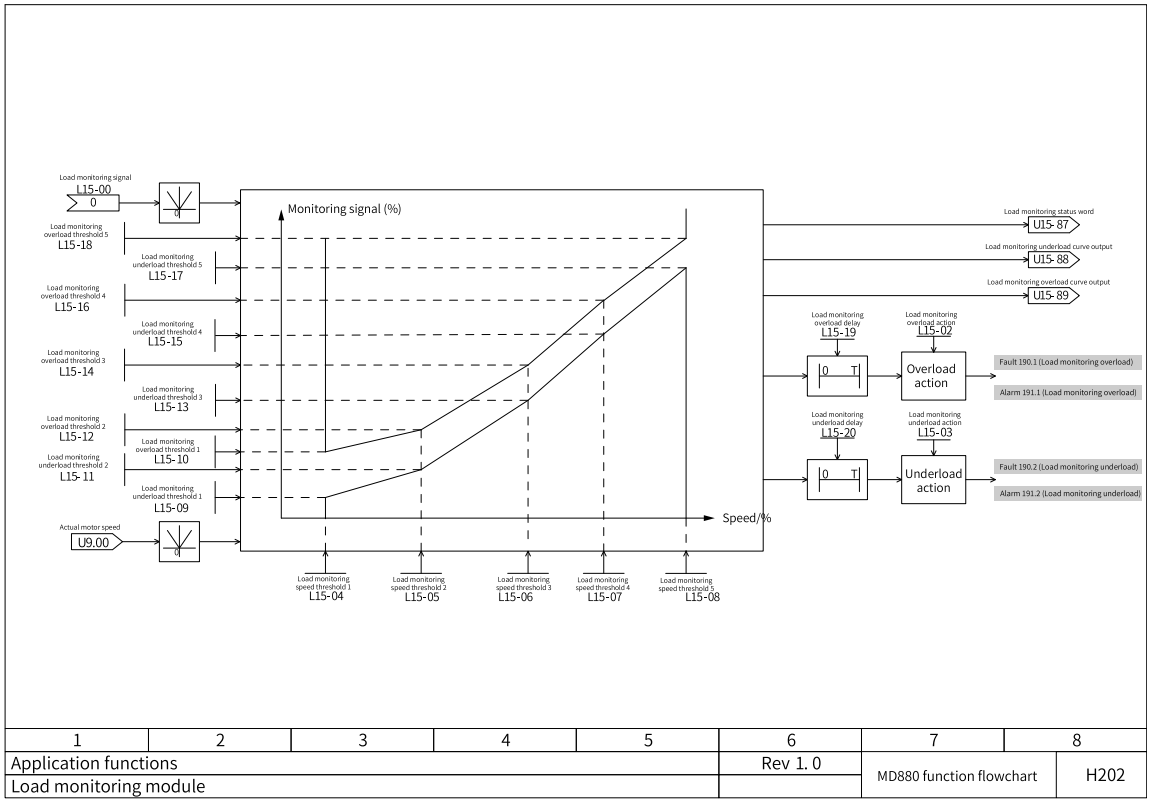
11.2.4.21 H200 - RFG Module B



1	2	3	4	5	6	7	8
Application functions RFG module B					Rev 1. 0	MD880 function flowchart	H200

Figure 11-40 H200 - RFG Module B

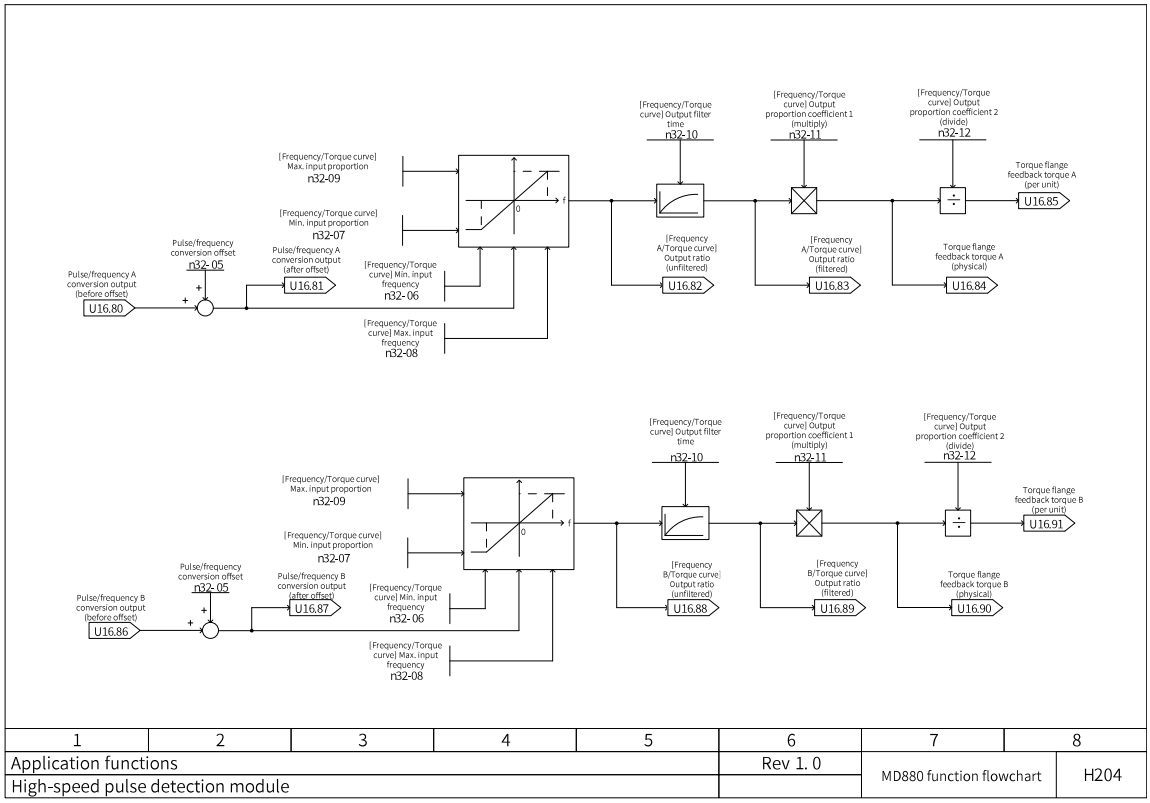
11.2.4.22 H202 - Load Monitoring Module



1	2	3	4	5	6	7	8
Application functions					Rev 1. 0	MD880 function flowchart	H202
Load monitoring module							

Figure 11-41 H202 - Load Monitoring Module

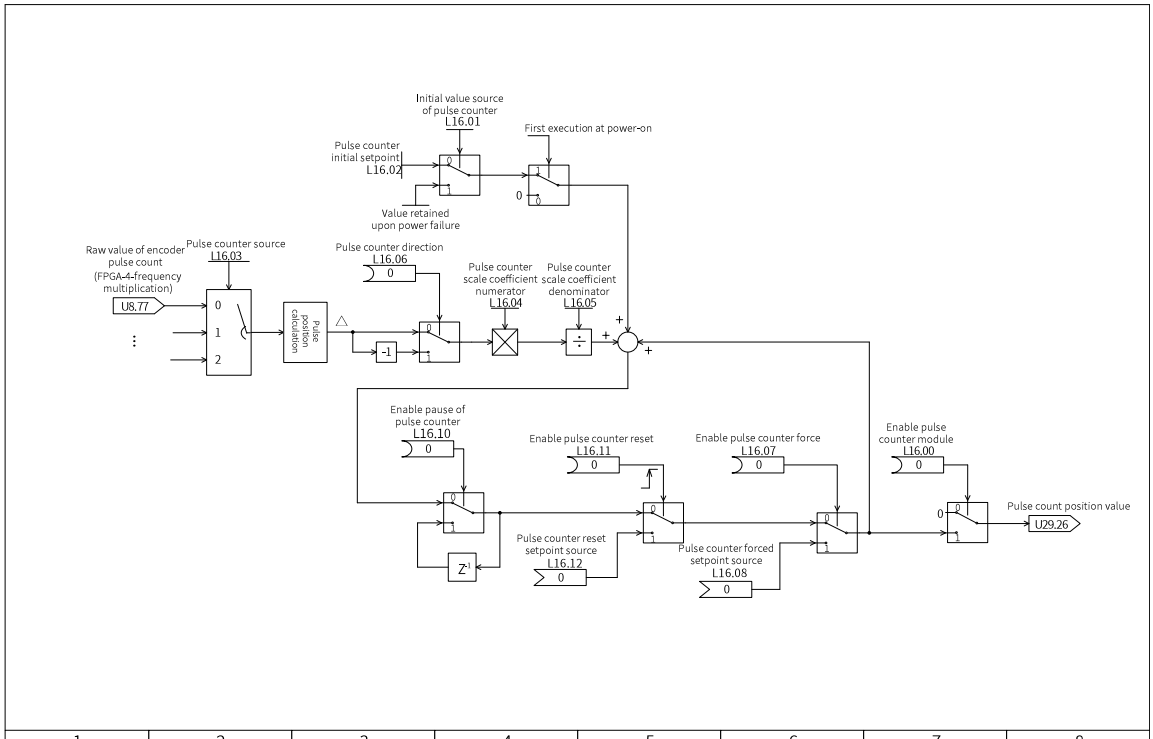
11.2.4.23 H204 - High-Speed Pulse Detection Module



1	2	3	4	5	6	7	8
Application functions					Rev 1. 0	MD880 function flowchart	H204
High-speed pulse detection module							

Figure 11-42 H204 - High-Speed Pulse Detection Module

11.2.4.24 H205 - Pulse Counting Module

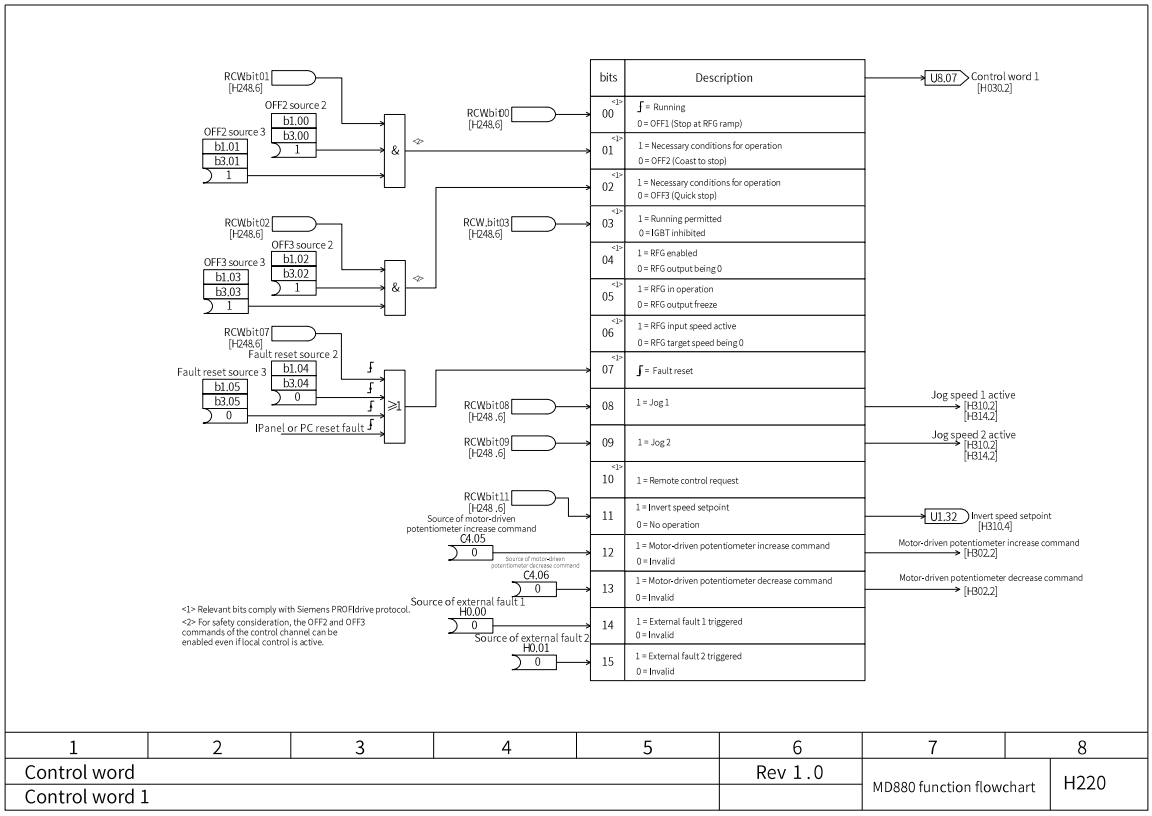


1	2	3	4	5	6	7	8
Application functions					Rev 1. 0	MD880 function flowchart	H205
Pulse calculation module							

Figure 11-43 H205 - Pulse Counting Module

11.2.5 Command and Setting

11.2.5.1 H220 - Control Word 1



1	2	3	4	5	6	7	8
Control word					Rev 1.0	MD880 function flowchart	H220
Control word 1							

Figure 11-44 H220 - Control Word 1

11.2.5.2 H230 - Status Word 1

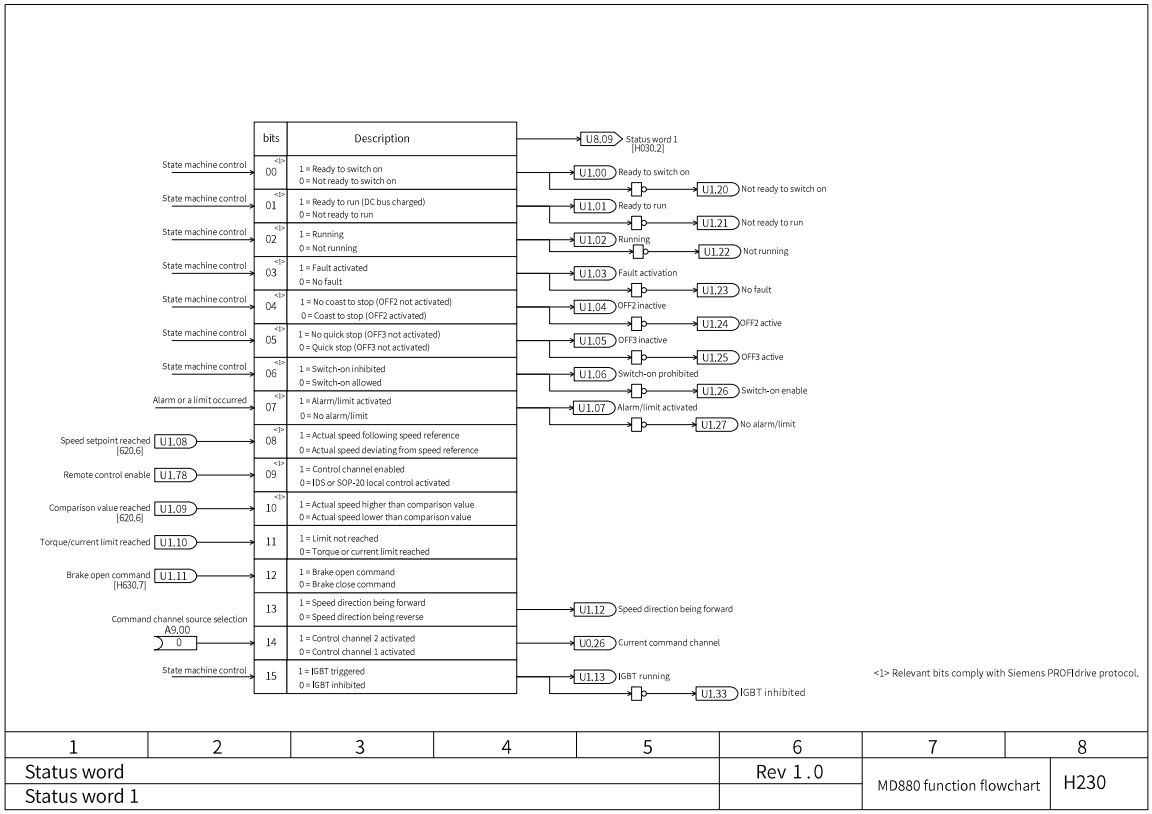
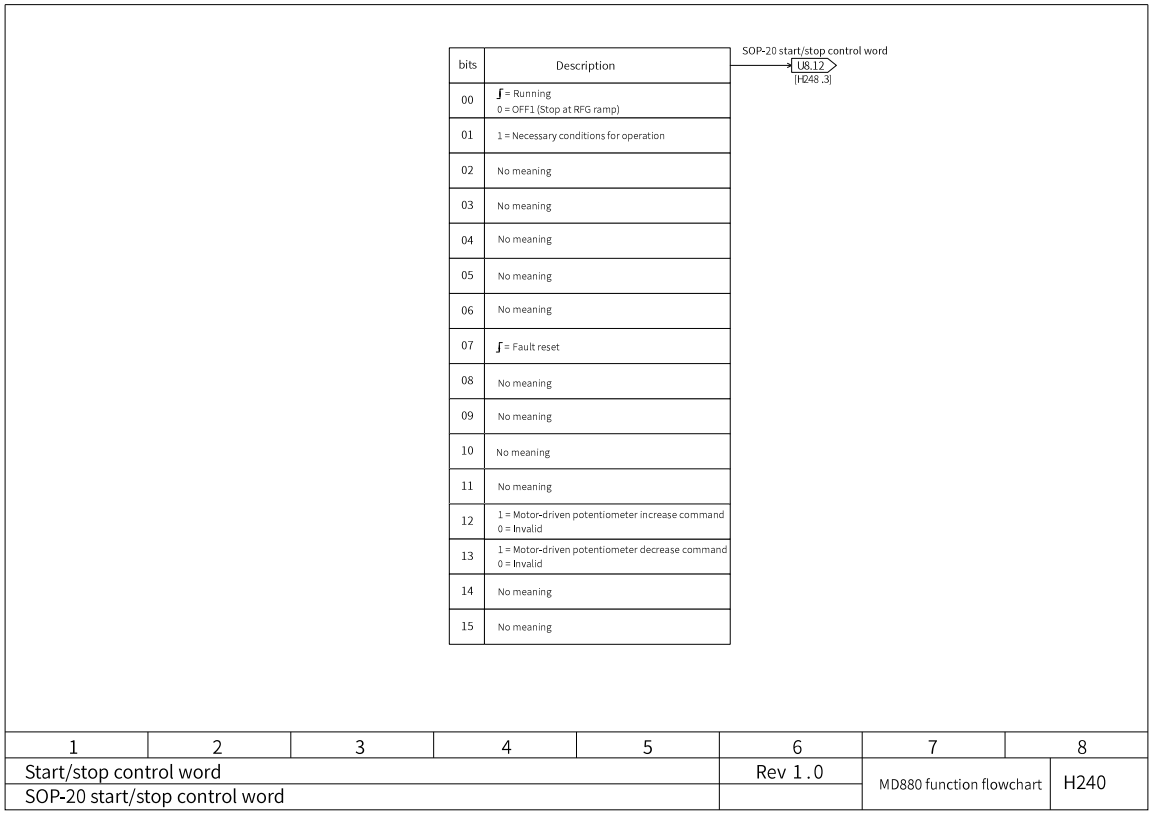


Figure 11-45 H230 - Status Word 1

11.2.5.3 H240 - SOP-20 Start/Stop Control Word

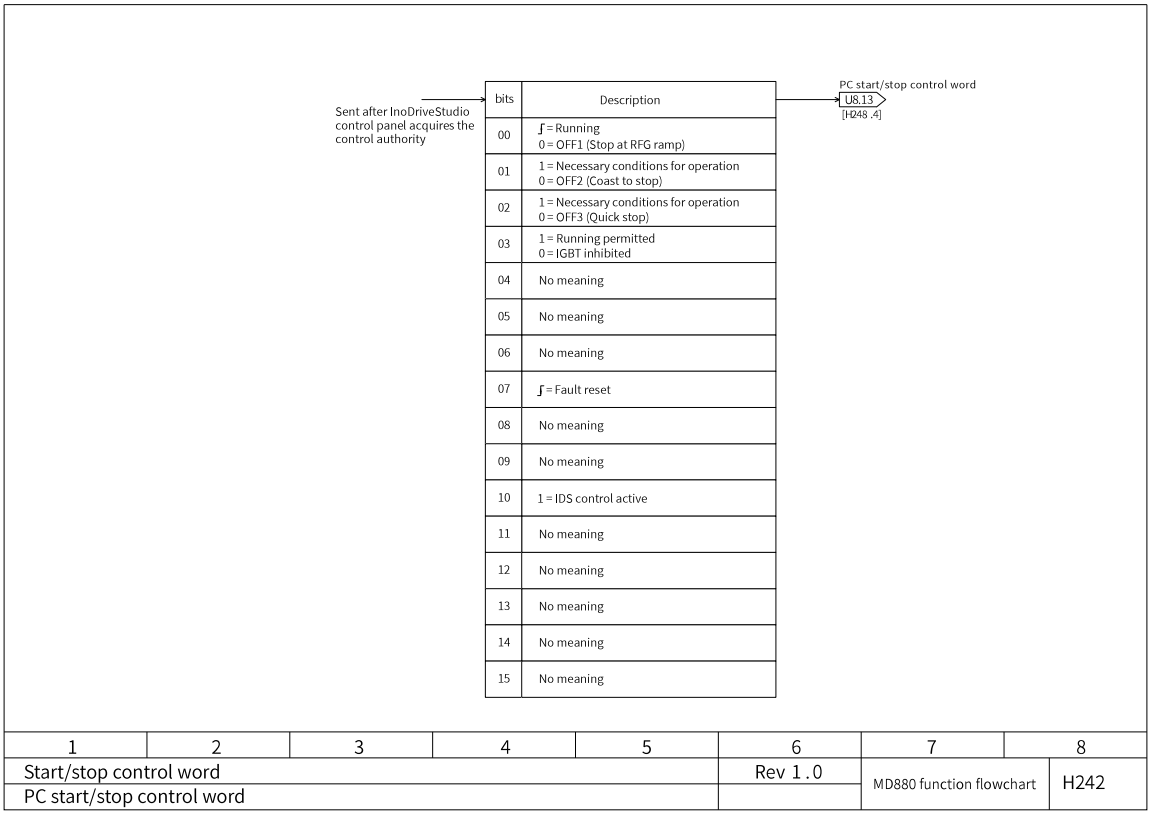


bits	Description
00	∫ = Running 0 = OFF1 (Stop at RFG ramp)
01	1 = Necessary conditions for operation
02	No meaning
03	No meaning
04	No meaning
05	No meaning
06	No meaning
07	∫ = Fault reset
08	No meaning
09	No meaning
10	No meaning
11	No meaning
12	1 = Motor-driven potentiometer increase command 0 = Invalid
13	1 = Motor-driven potentiometer decrease command 0 = Invalid
14	No meaning
15	No meaning

1	2	3	4	5	6	7	8
Start/stop control word					Rev 1.0	MD880 function flowchart	H240
SOP-20 start/stop control word							

Figure 11-46 H240 - SOP-20 Start/Stop Control Word

11.2.5.4 H242 - PC Start/Stop Control Word



bits	Description
00	∫ = Running 0 = OFF1 (Stop at RFG ramp)
01	1 = Necessary conditions for operation 0 = OFF2 (Coast to stop)
02	1 = Necessary conditions for operation 0 = OFF3 (Quick stop)
03	1 = Running permitted 0 = IGBT inhibited
04	No meaning
05	No meaning
06	No meaning
07	∫ = Fault reset
08	No meaning
09	No meaning
10	1 = IDS control active
11	No meaning
12	No meaning
13	No meaning
14	No meaning
15	No meaning

1	2	3	4	5	6	7	8
Start/stop control word					Rev 1.0	MD880 function flowchart	H242
PC start/stop control word							

Figure 11-47 H242 - PC Start/Stop Control Word

11.2.5.5 H244 - Terminal Start/Stop Control Word

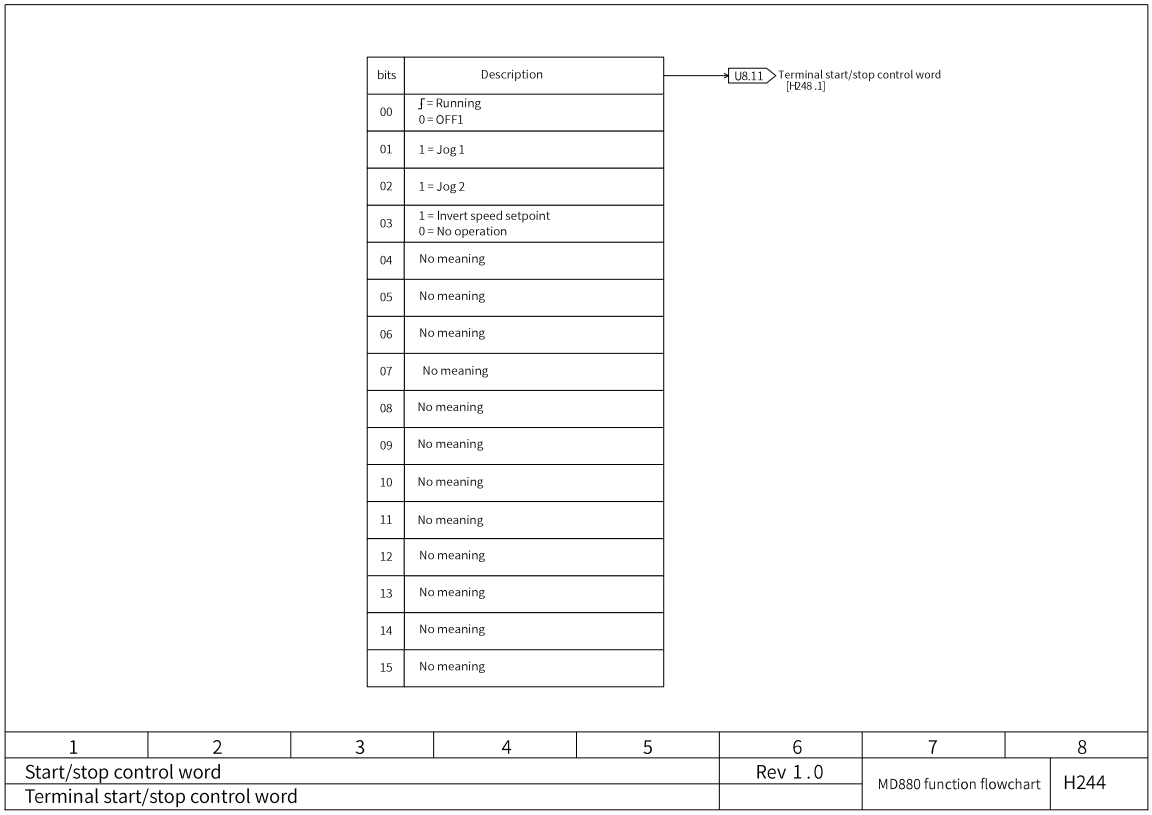
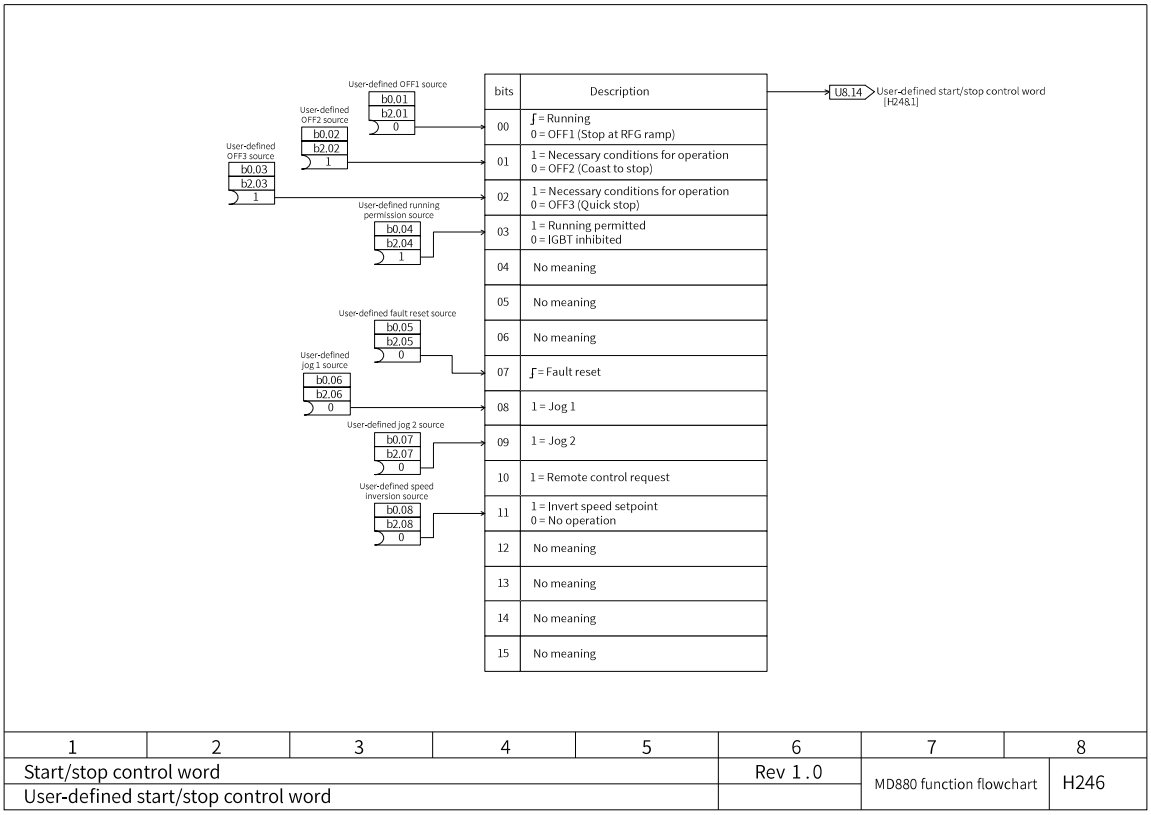


Figure 11-48 H244 - Terminal Start/Stop Control Word

11.2.5.6 H246 - User-Defined Start/Stop Control Word



1	2	3	4	5	6	7	8
Start/stop control word					Rev 1.0	MD880 function flowchart	H246
User-defined start/stop control word							

Figure 11-49 H246 - User-Defined Start/Stop Control Word

11.2.5.7 H248 - Start/Stop control word selection

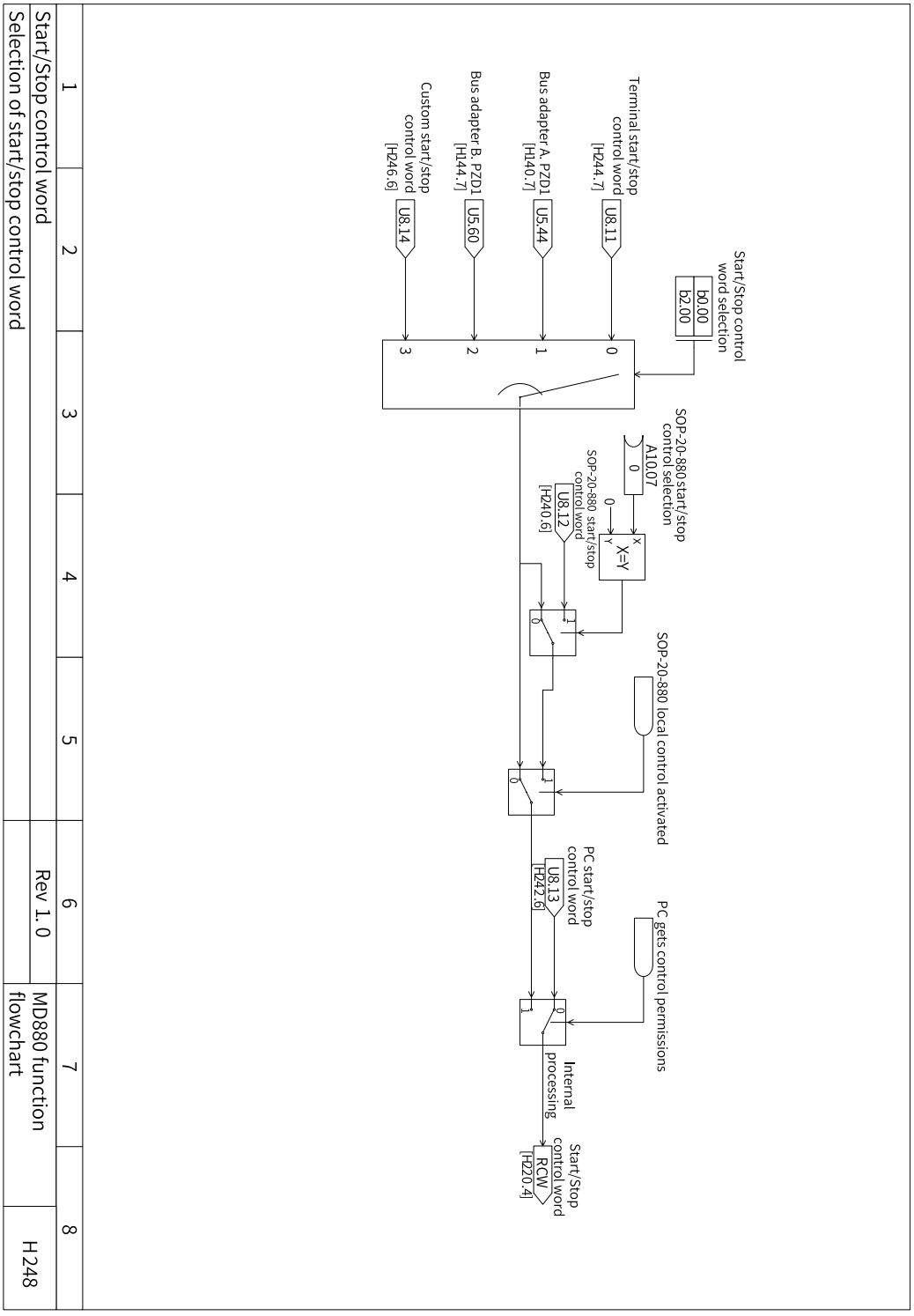
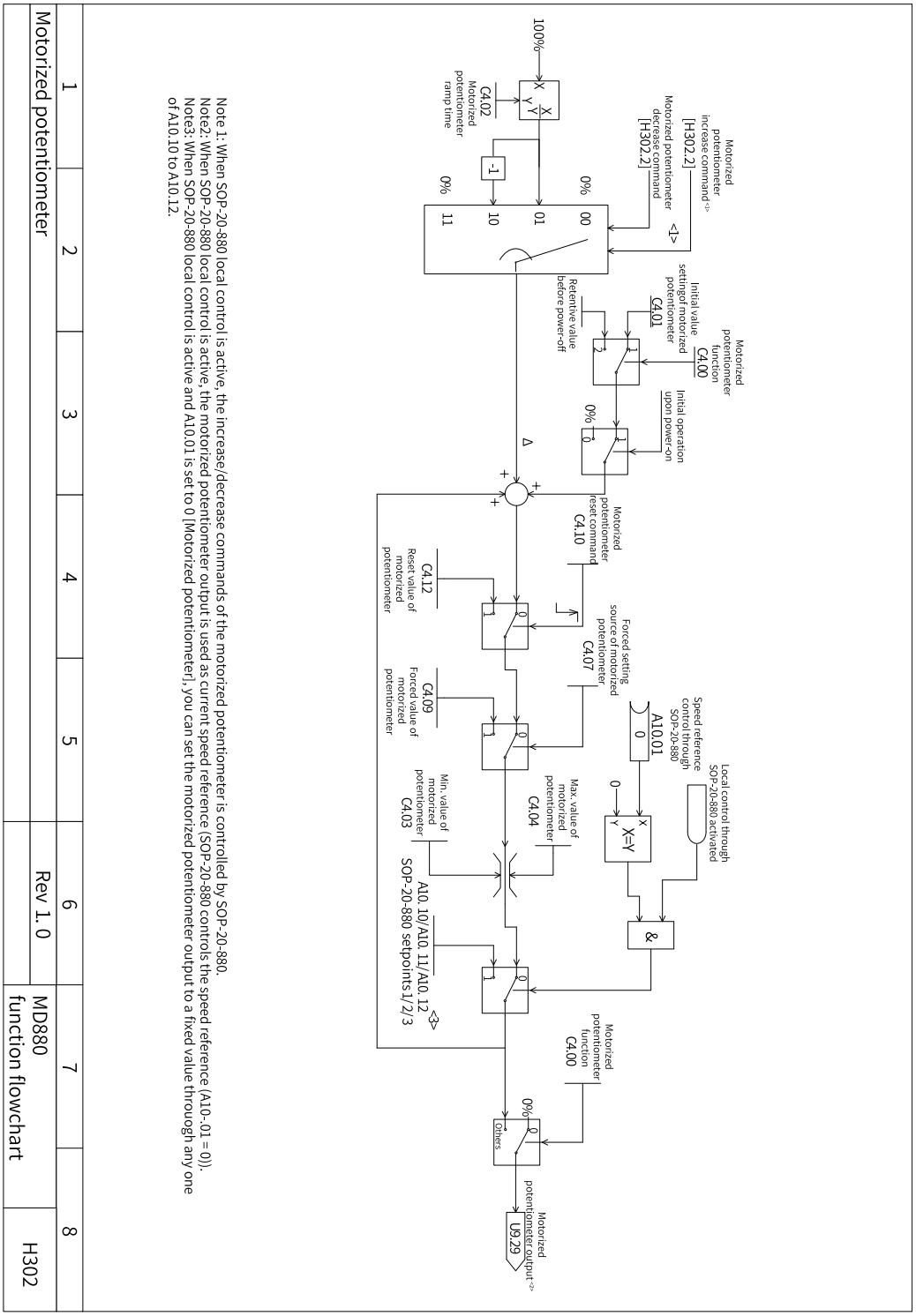


Figure 11-50 H248 - Start/Stop control word selection

11.2.5.8 H302 - Motorized potentiometer



Note 1: When SOP-20-880 local control is active, the increase/decrease commands of the motorized potentiometer is controlled by SOP-20-880.
Note2: When SOP-20-880 local control is active, the motorized potentiometer output is used as current speed reference (SOP-20-880 controls the speed reference (A10-.01 = 0)).
Note3: When SOP-20-880 local control is active and A10.01 is set to 0 [Motorized potentiometer], you can set the motorized potentiometer output to a fixed value through any one of A10.10 to A10.12.

1	2	3	4	5	6	7	8
Motorized potentiometer					Rev 1. 0	MD880 function flowchart	H302

Figure 11-51 H302 - Motorized potentiometer

11.2.5.9 H310 - Regular speed reference source

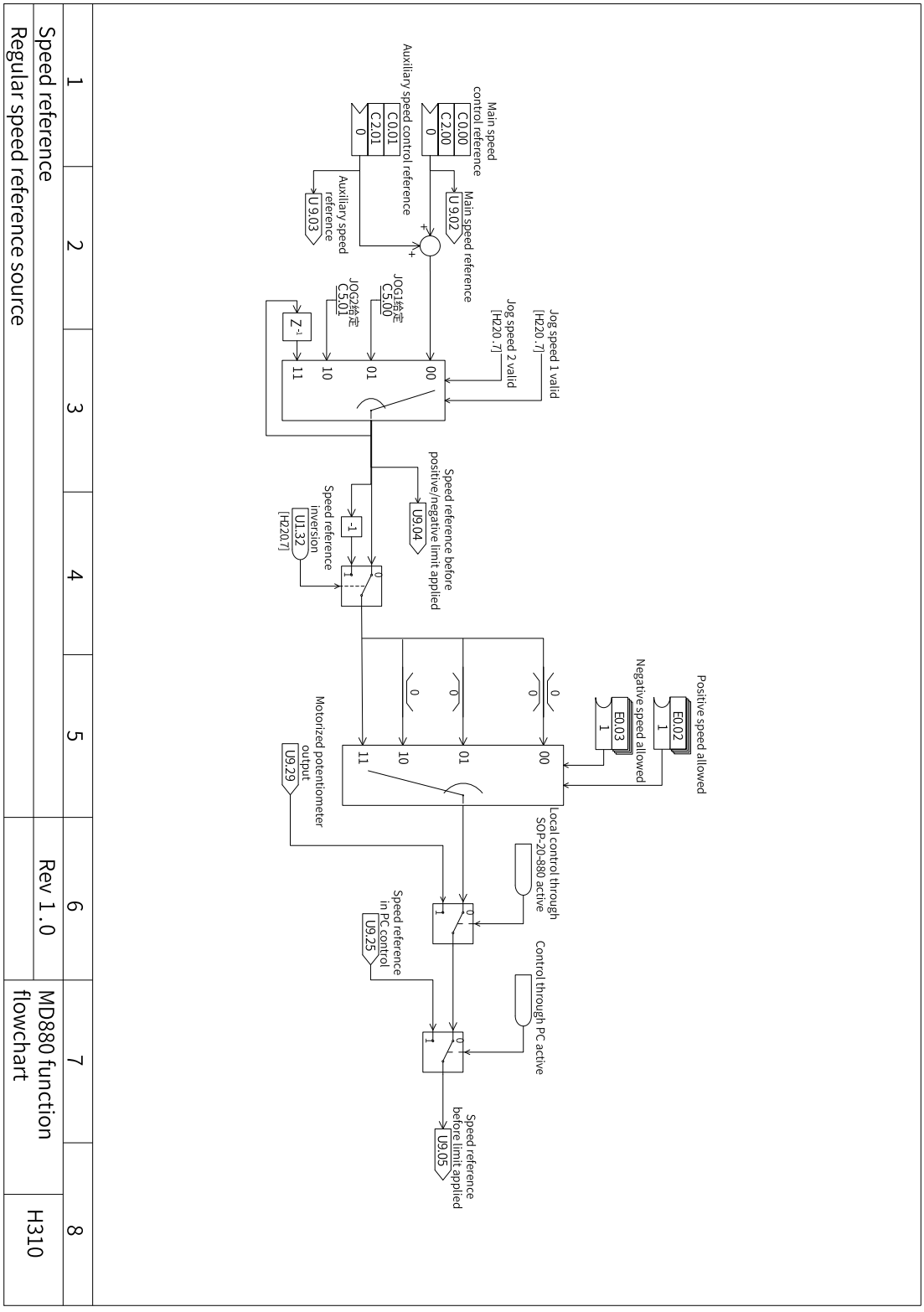
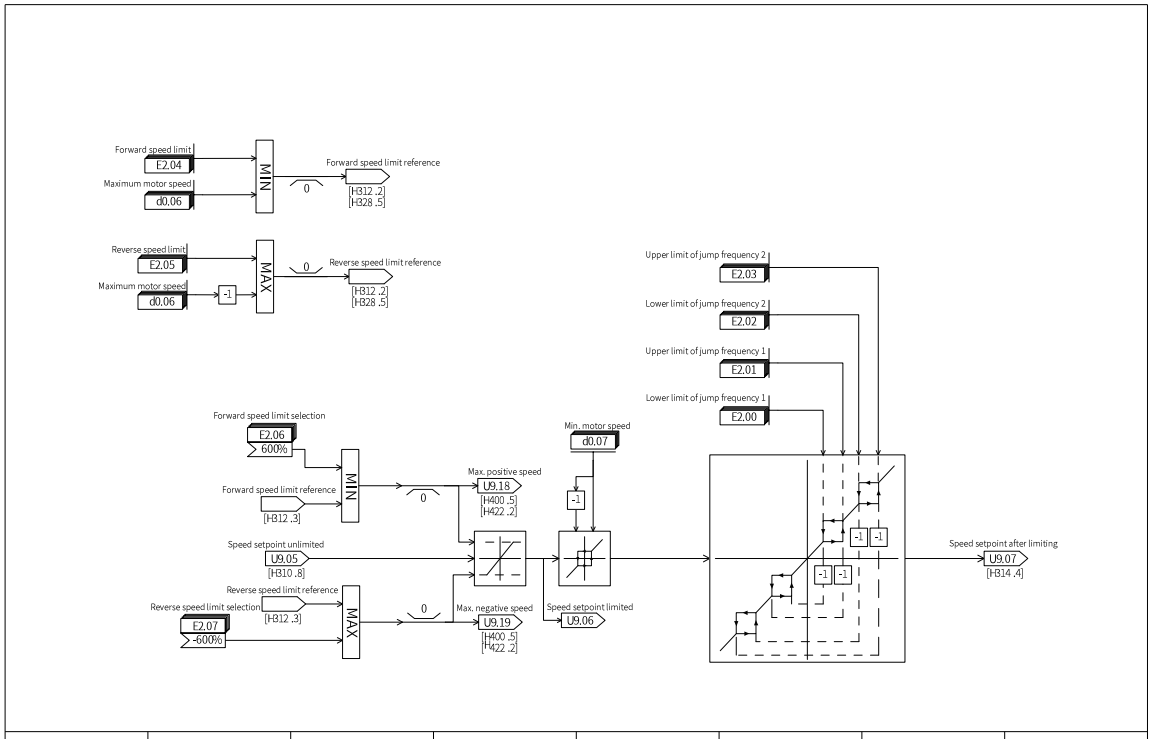


Figure 11-52 H310 - Regular speed reference source

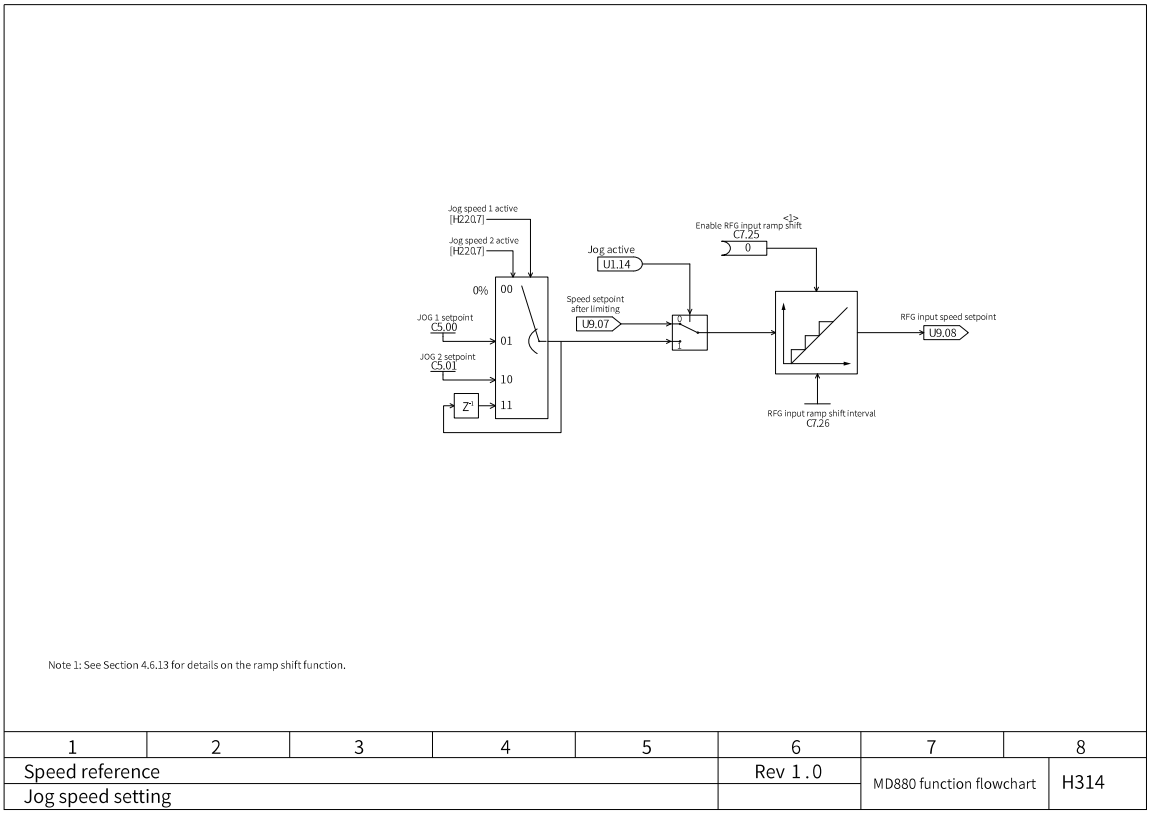
11.2.5.10 H312 - Speed Limit



1	2	3	4	5	6	7	8
Speed reference					Rev 1.0	MD880 function flowchart	H312
Speed limit							

Figure 11-53 H312 - Speed Limit

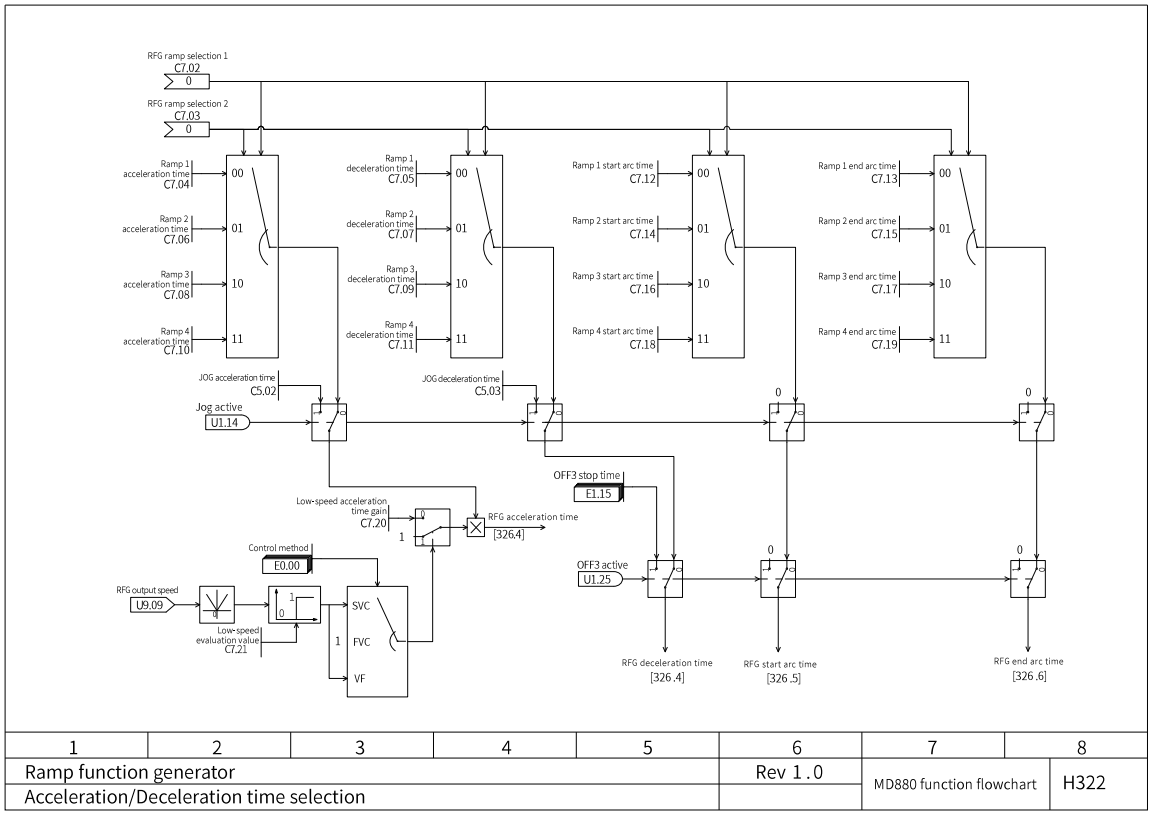
11.2.5.11 H314 - Jog Speed Setting



1	2	3	4	5	6	7	8
Speed reference					Rev 1.0	MD880 function flowchart	H314
Jog speed setting							

Figure 11-54 H314 - Jog Speed Setting

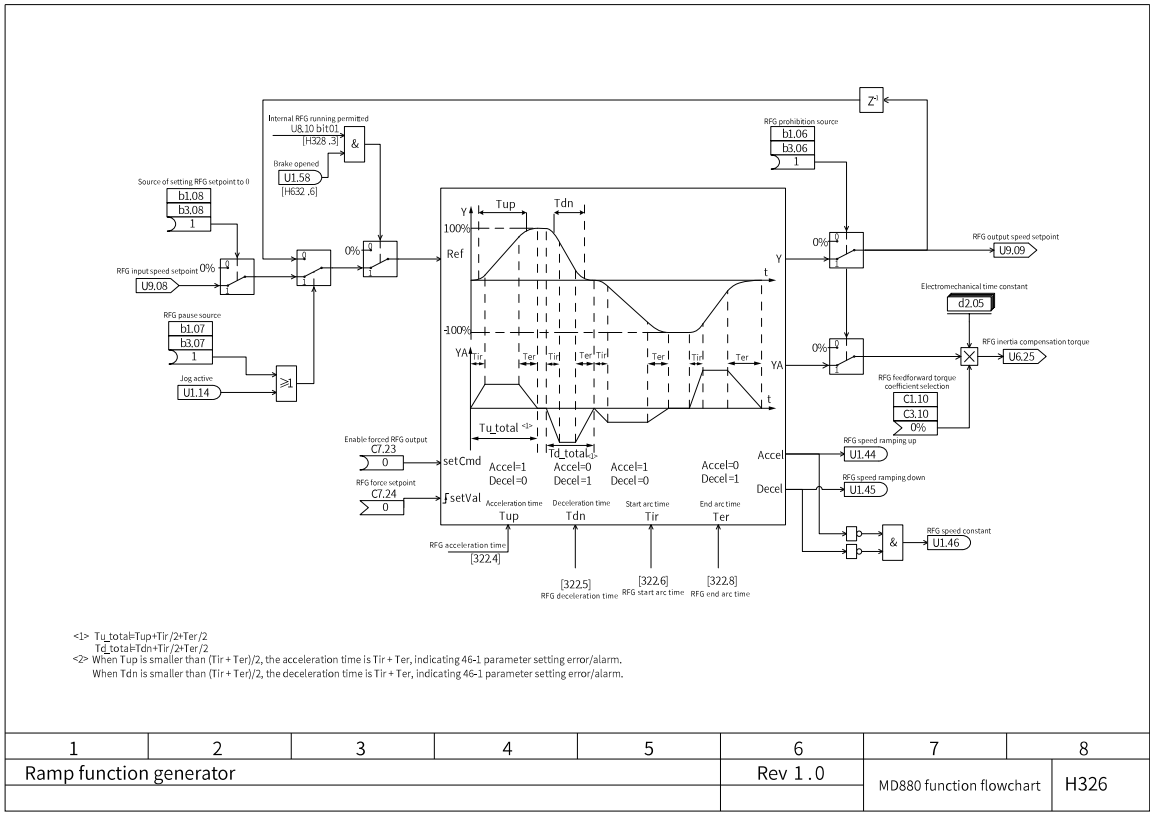
11.2.5.12 H322 - Acceleration/Deceleration Time Selection



1	2	3	4	5	6	7	8
Ramp function generator					Rev 1.0	MD880 function flowchart	H322
Acceleration/Deceleration time selection							

Figure 11-55 H322 - Acceleration/Deceleration Time Selection

11.2.5.13 H326 - Ramp Function Generator

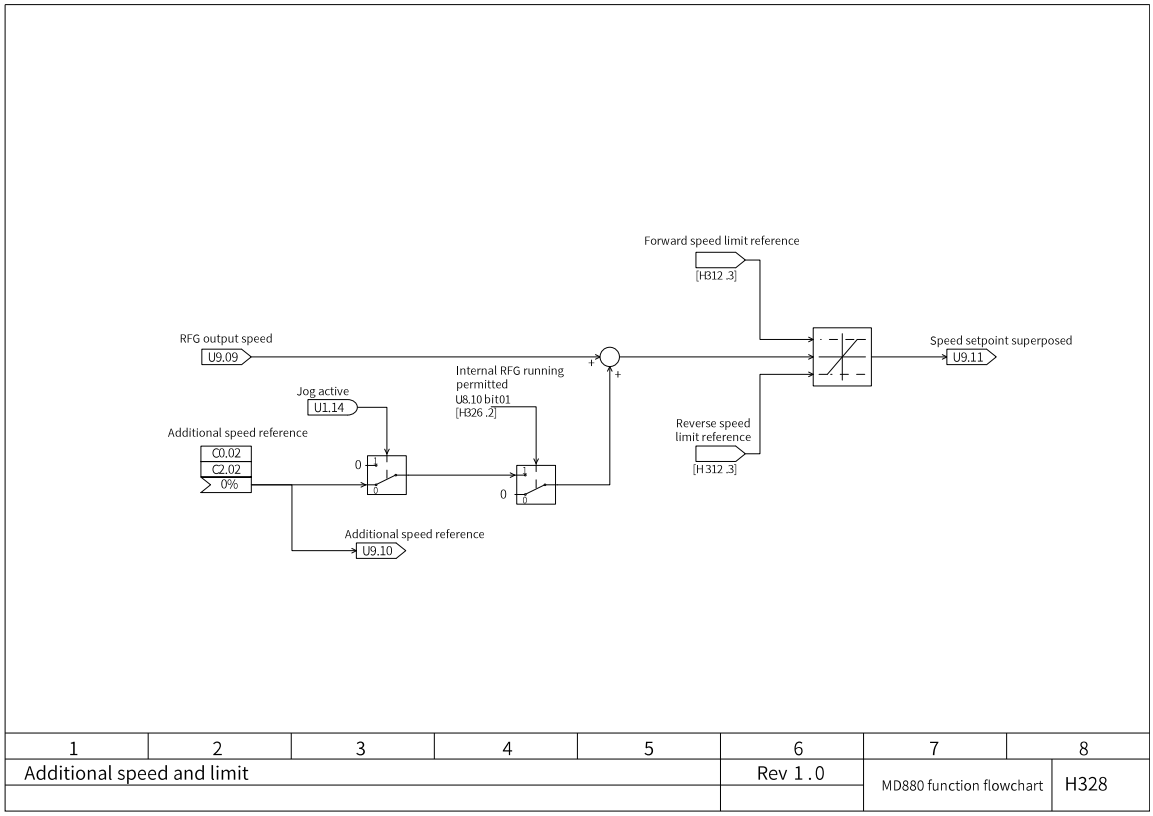


<1> Tu_total=Tup+Tir/2+Ter/2
Td_total=Tdn+Tir/2+Ter/2
<2> When Tup is smaller than (Tir + Ter)/2, the acceleration time is Tir + Ter, indicating 46-1 parameter setting error/alarm.
When Tdn is smaller than (Tir + Ter)/2, the deceleration time is Tir + Ter, indicating 46-1 parameter setting error/alarm.

1	2	3	4	5	6	7	8
Ramp function generator					Rev 1 .0	MD880 function flowchart	H326

Figure 11-56 H326 - Ramp Function Generator

11.2.5.14 H328 - Additional Speed and Limit



1	2	3	4	5	6	7	8
Additional speed and limit					Rev 1 . 0	MD880 function flowchart	H328

Figure 11-57 H328 - Additional speed and limit

11.2.5.15 H330 - Additional Torque and Torque Limit Setting

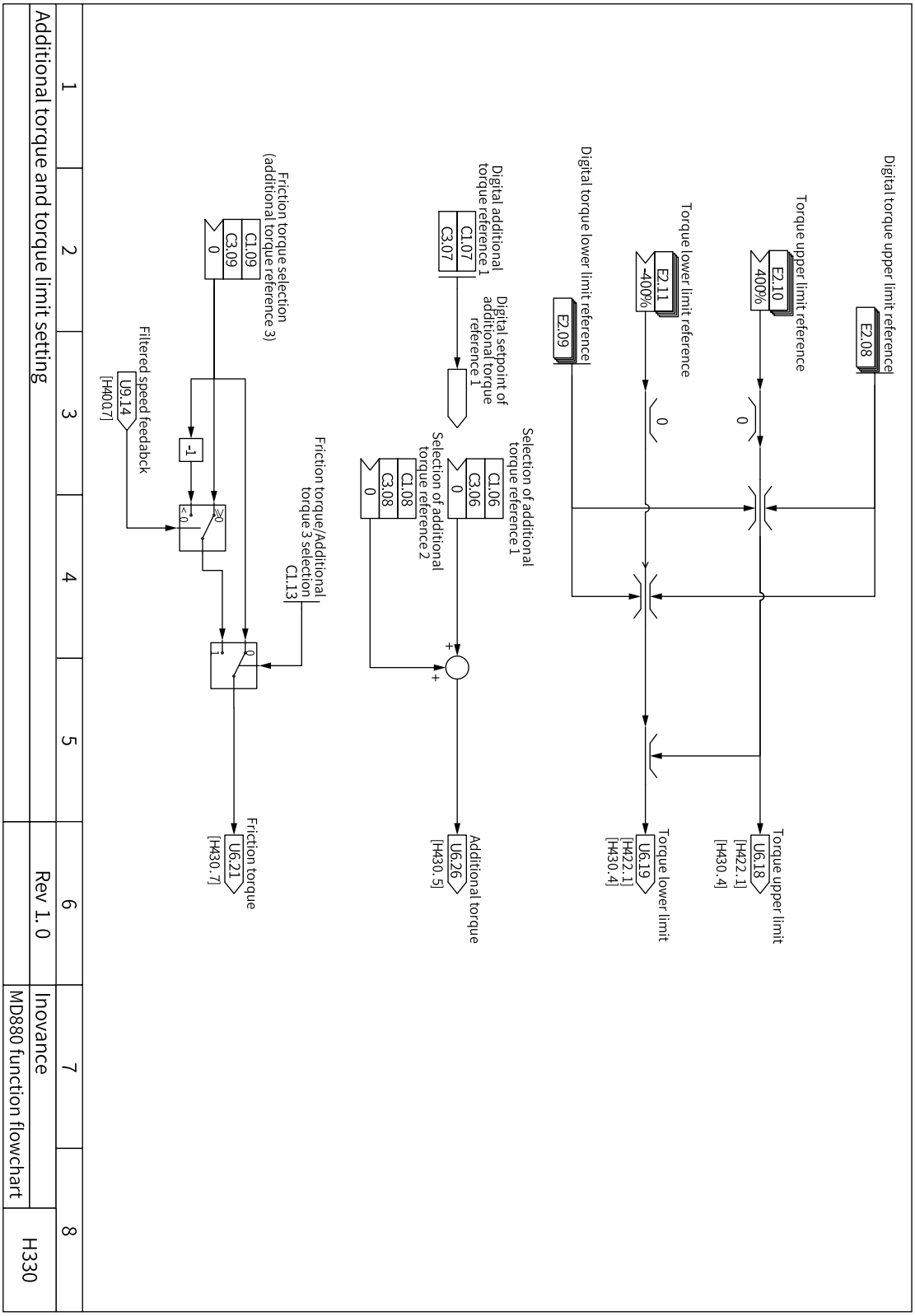
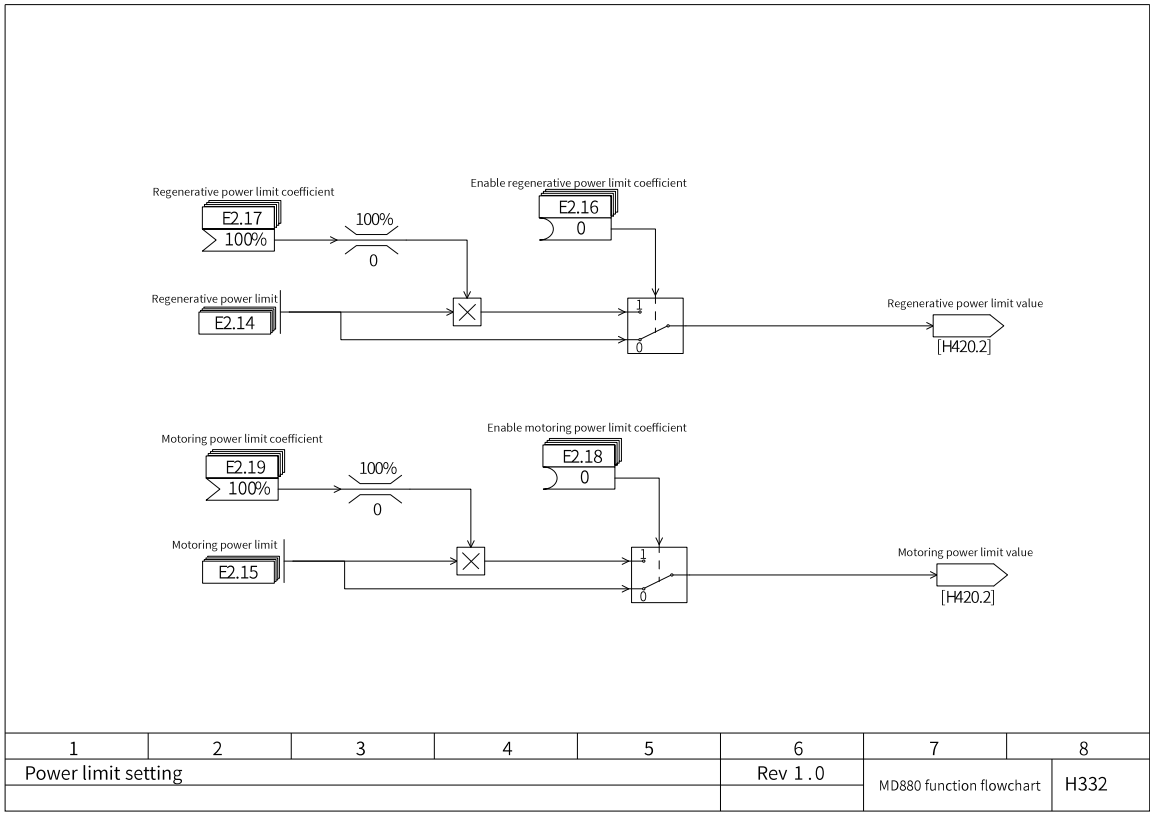


Figure 11-58 H330 - Additional torque and torque limit setting

11.2.5.16 H332 - Power Limit Setting

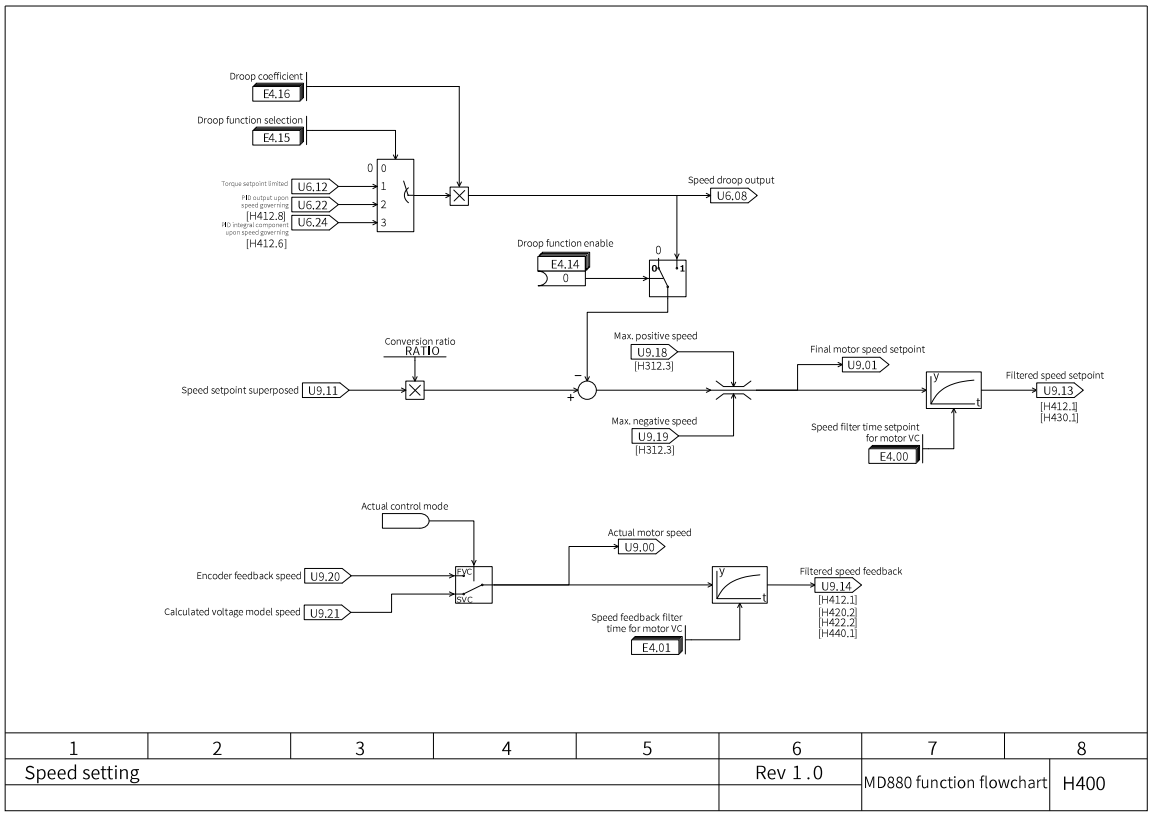


1	2	3	4	5	6	7	8
Power limit setting					Rev 1 . 0	MD880 function flowchart	H332

Figure 11-59 H332 - Power Limit Setting

11.2.6 Vector Control

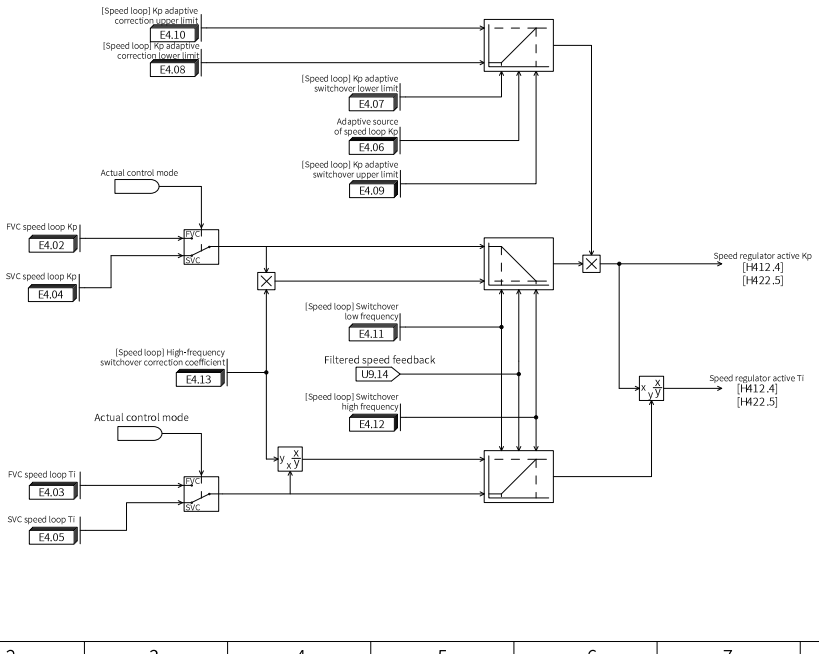
11.2.6.1 H400 - Speed Setting



1	2	3	4	5	6	7	8
Speed setting					Rev 1.0	MD880 function flowchart	H400

Figure 11-60 H400 - Speed Setting

11.2.6.2 H410 - Parameter Configuration



1	2	3	4	5	6	7	8
Speed controller					Rev 1 .0	MD880 function flowchart	H410
Parameter adaptation							

Figure 11-61 H410 - Parameter Configuration

11.2.6.3 H412 - Speed controller

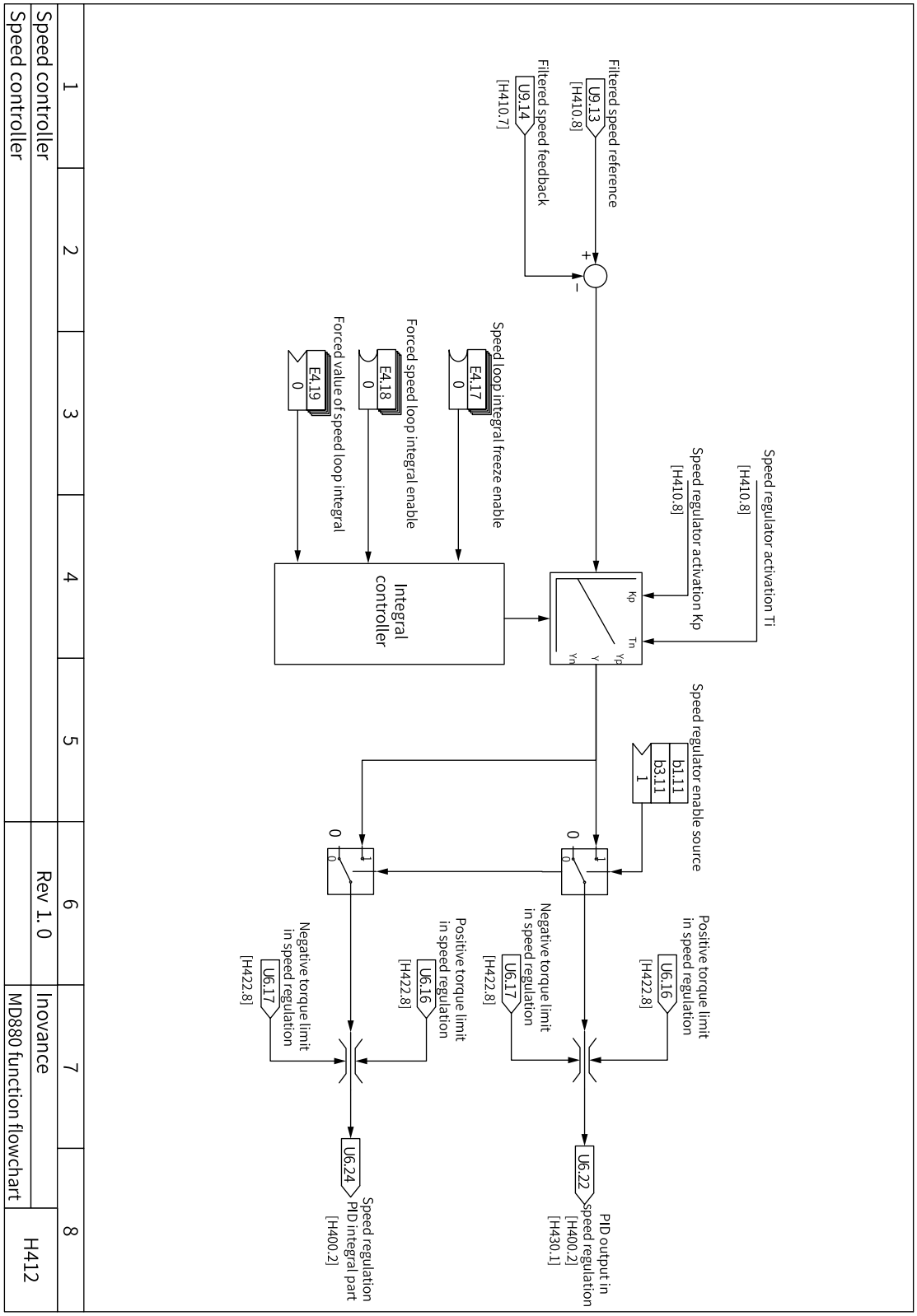
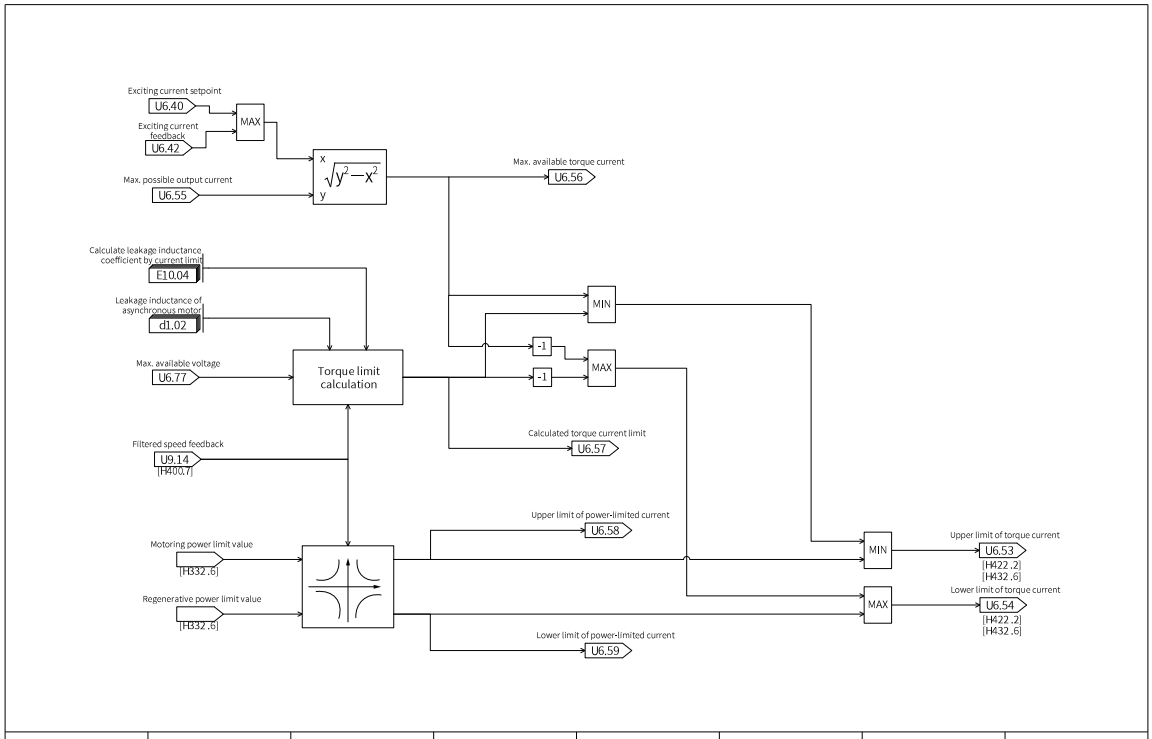


Figure 11-62 H412 - Speed controller

11.2.6.4 H420 - Torque Current Limit Value Calculation



1	2	3	4	5	6	7	8
Torque limit					Rev 1.0	MD880 function flowchart	H420
Torque current limit value calculation							

Figure 11-63 H420 - Torque Current Limit Value Calculation

11.2.6.5 H422 - Torque limit and runaway prevention

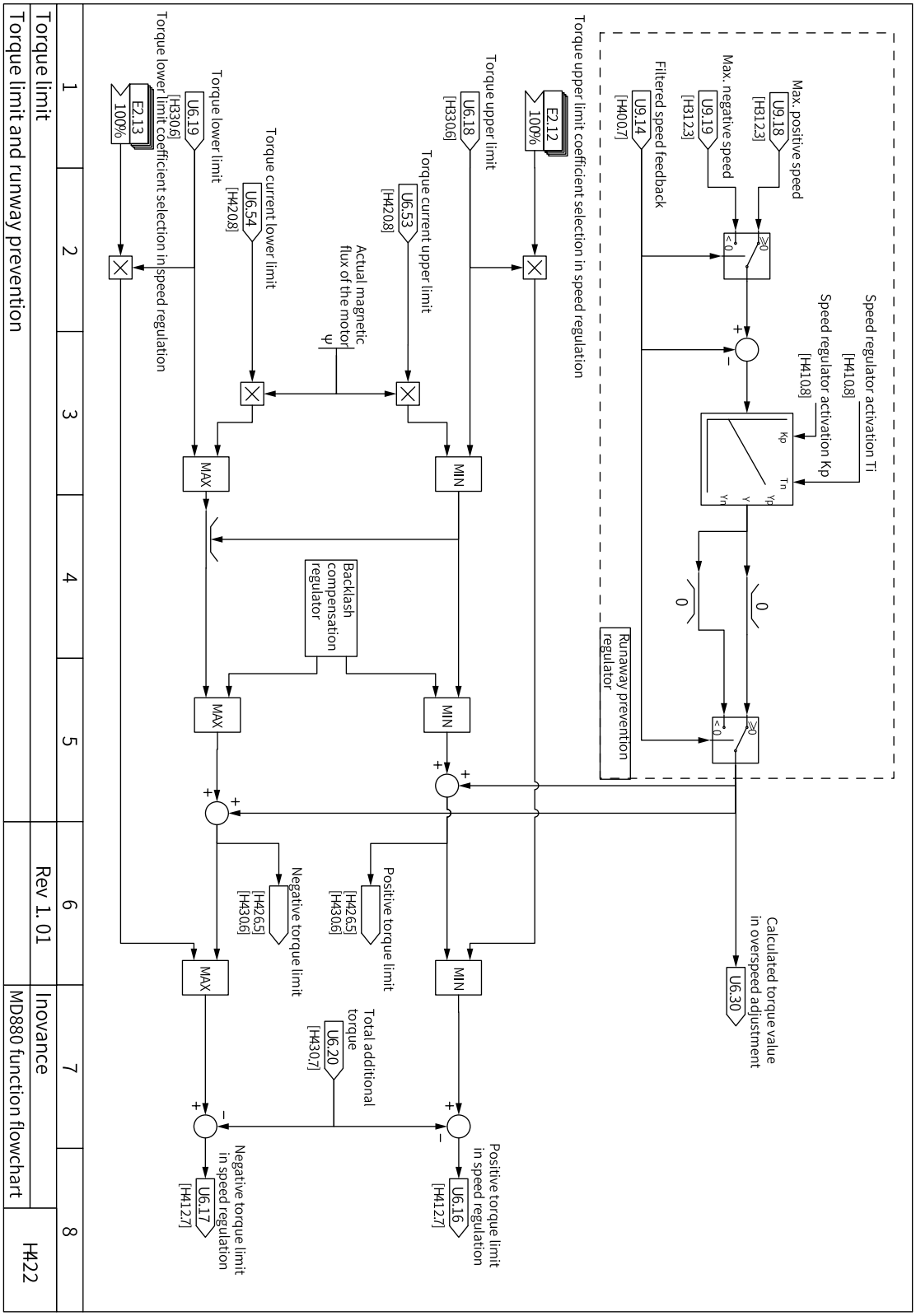


Figure 11-64 H422 - Torque limit and runaway prevention

11.2.6.6 H426 - Bus voltage control

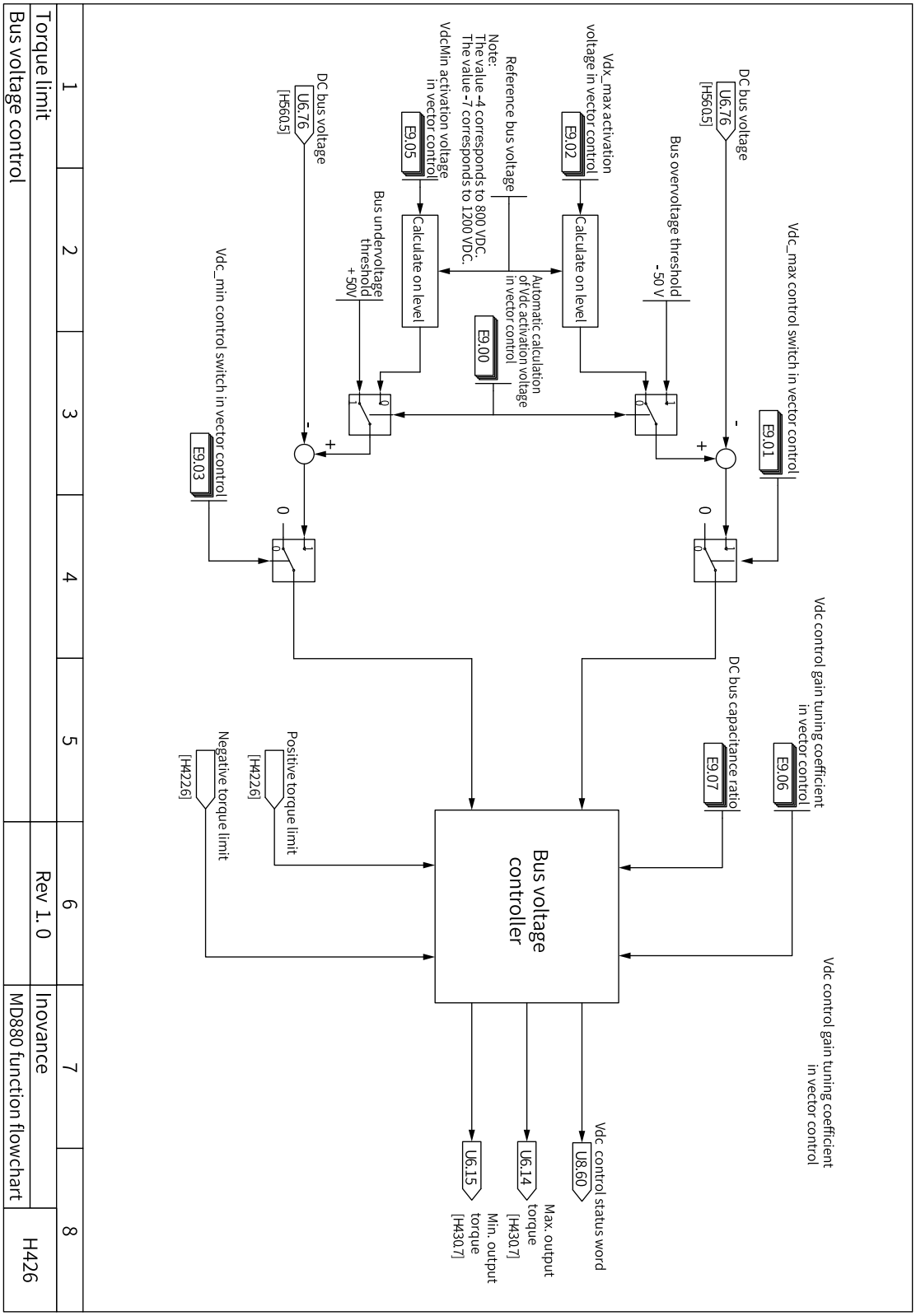


Figure 11-65 H426 - Bus voltage control

11.2.6.7 H430 - Torque reference

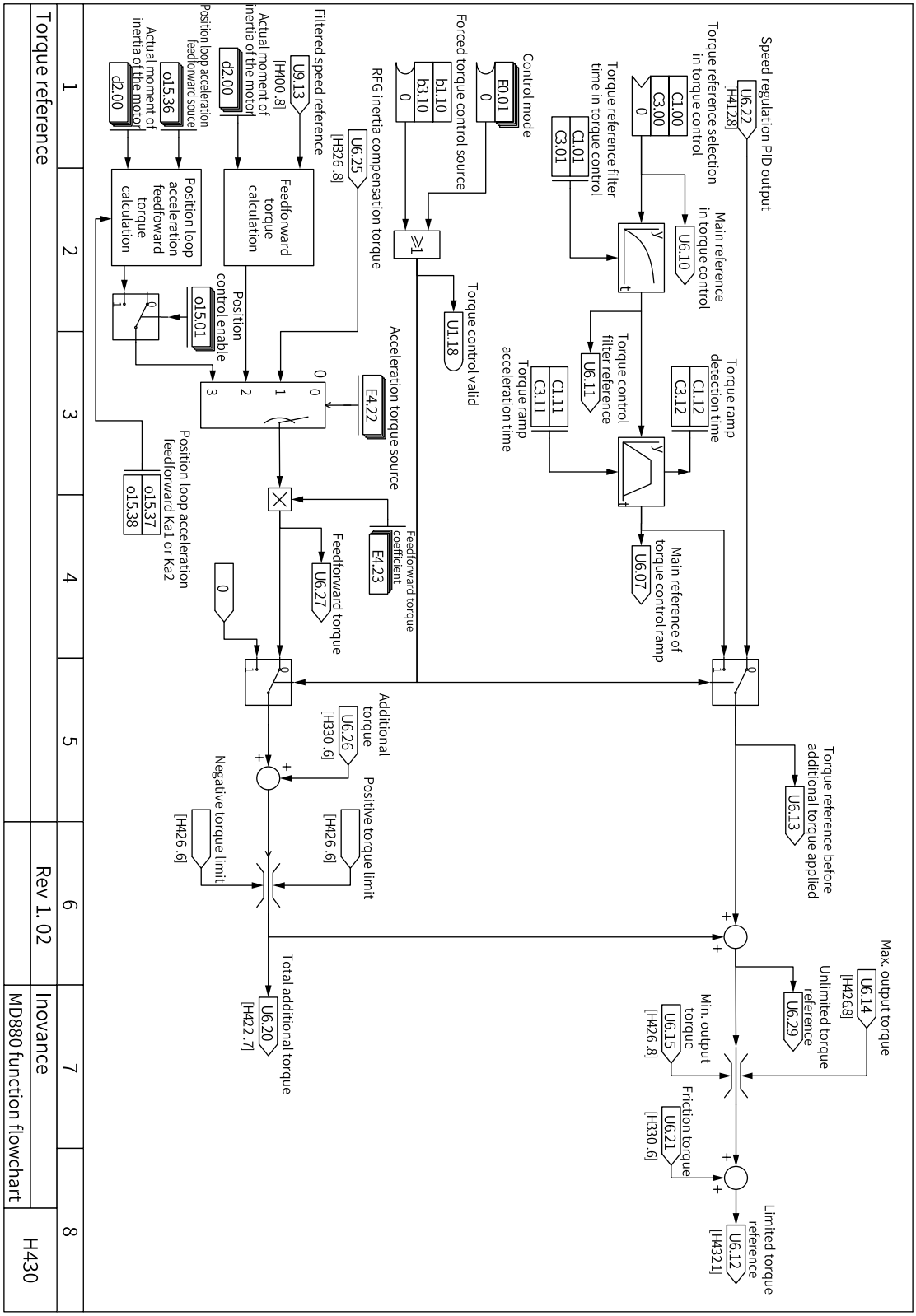


Figure 11-66 H430 - Torque reference

11.2.6.8 H432 - Torque/Current conversion

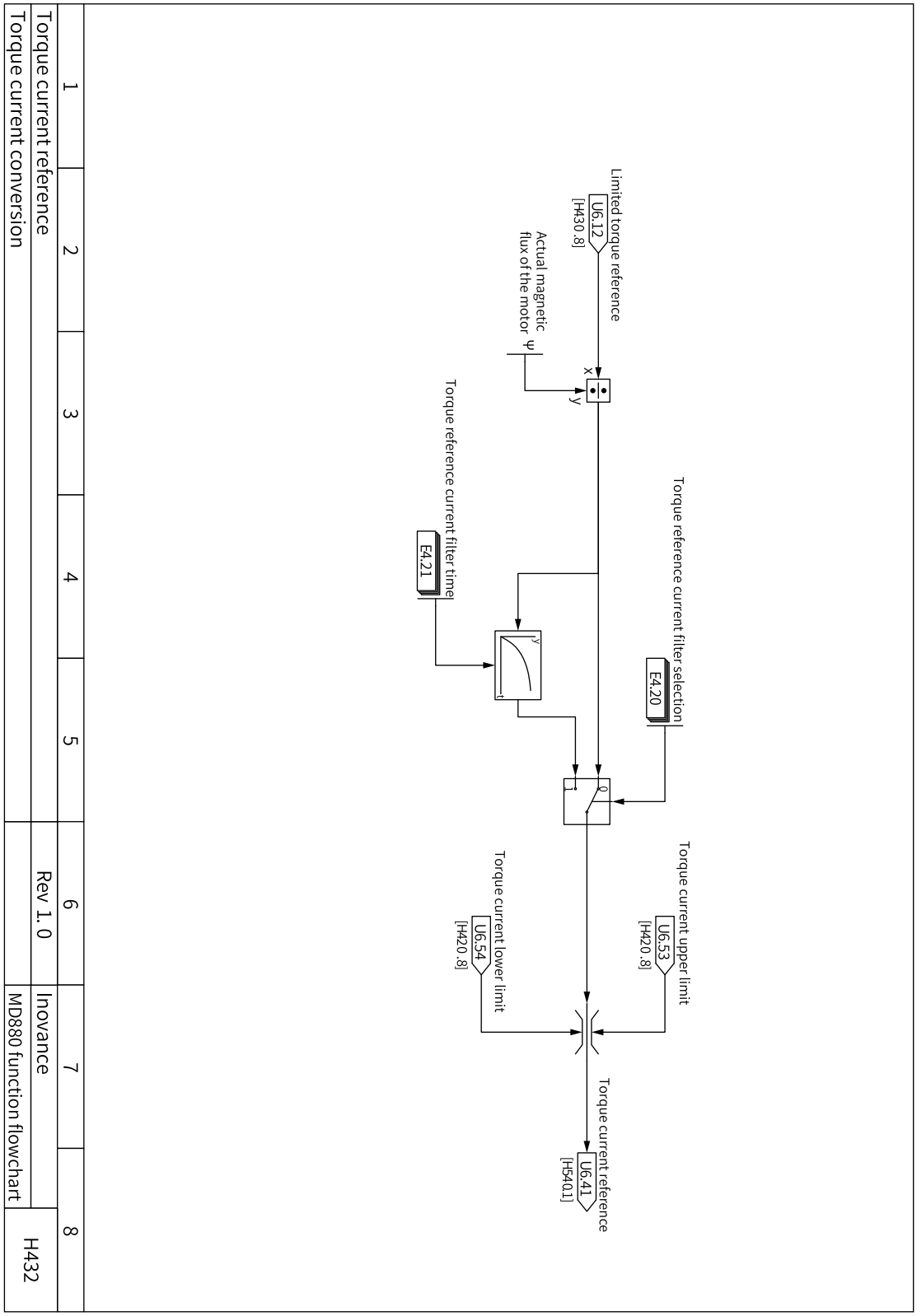
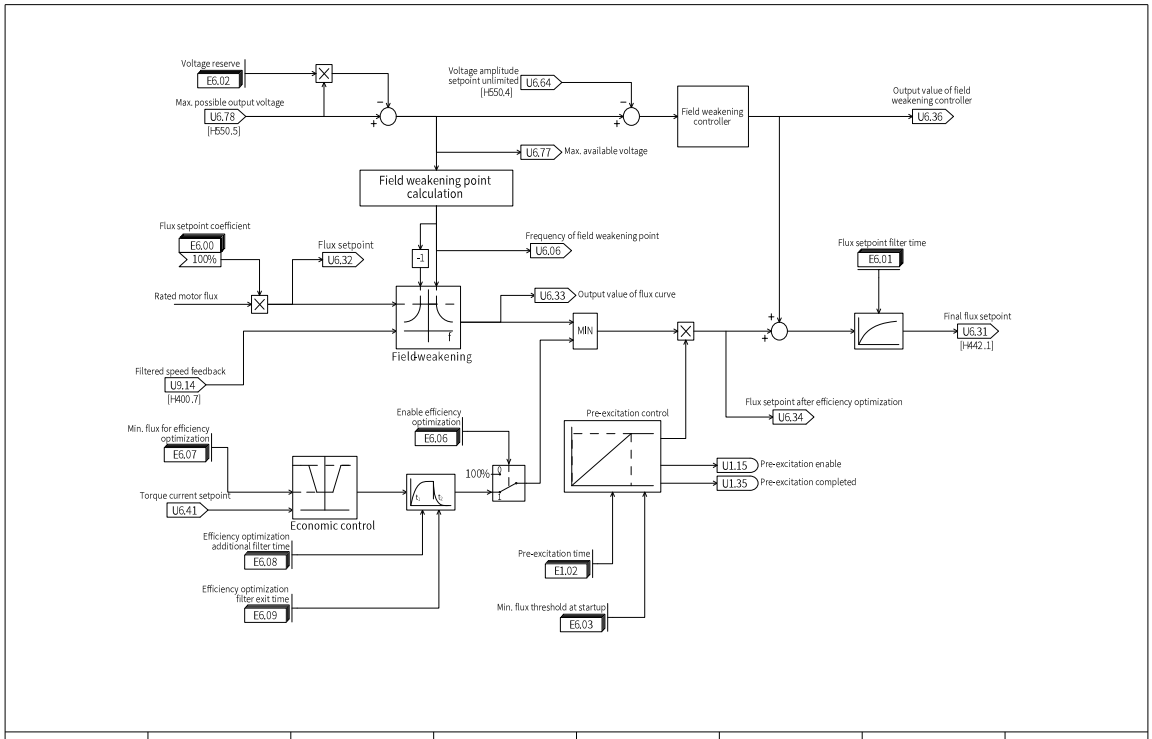


Figure 11-67 H432 - Torque/Current conversion

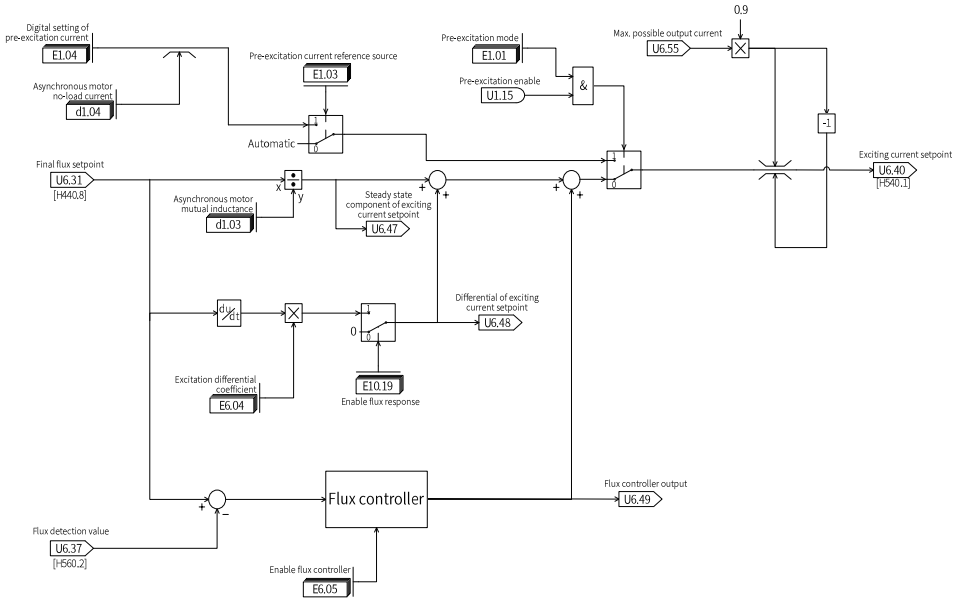
11.2.6.9 H440 - Flux Setting and Flux Weakening Control of Asynchronous Motors



1	2	3	4	5	6	7	8
Flux setting					Rev 1.0	MD880 function flowchart	H440
Flux setting and field weakening control							

Figure 11-68 H440 - Flux setting and flux weakening control of asynchronous motor

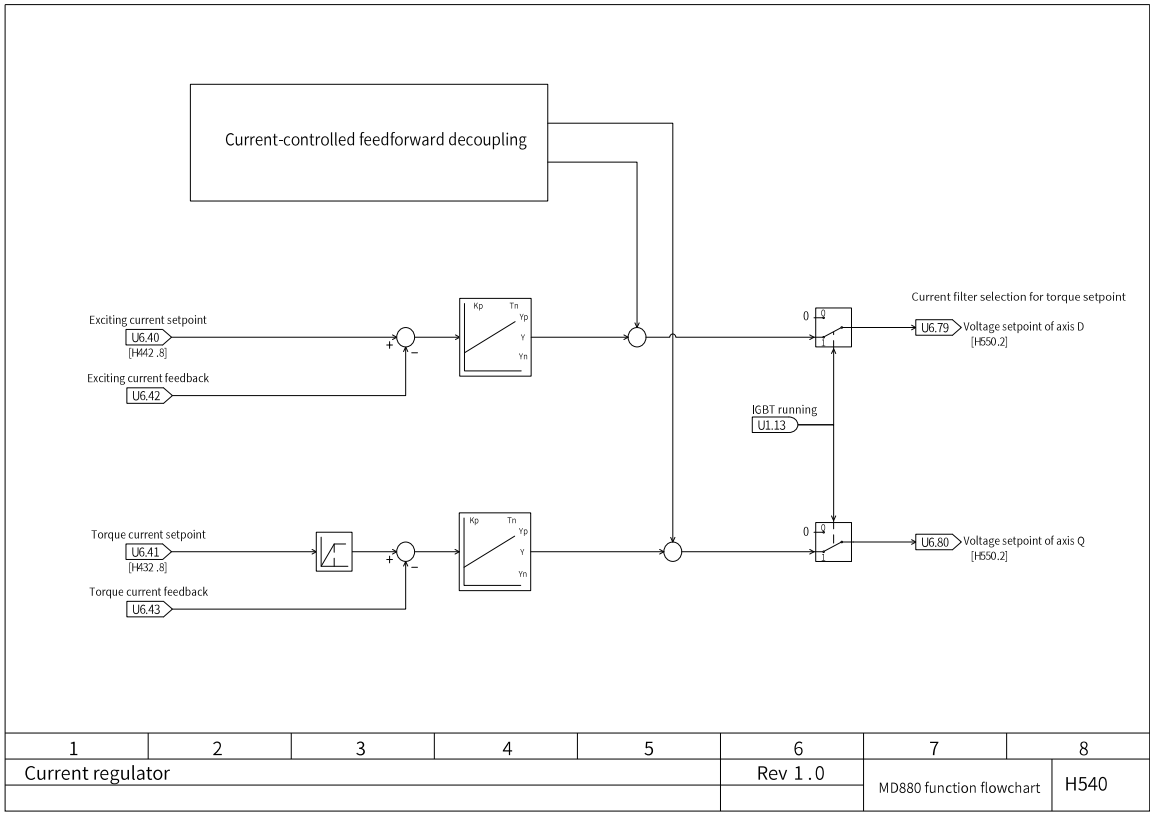
11.2.6.10 H442 - Exciting Current Setting



1	2	3	4	5	6	7	8
Exciting current setpoint					Rev 1.0	MD880 function flowchart	H442
Exciting current setpoint							

Figure 11-69 H442 - Exciting Current Setting

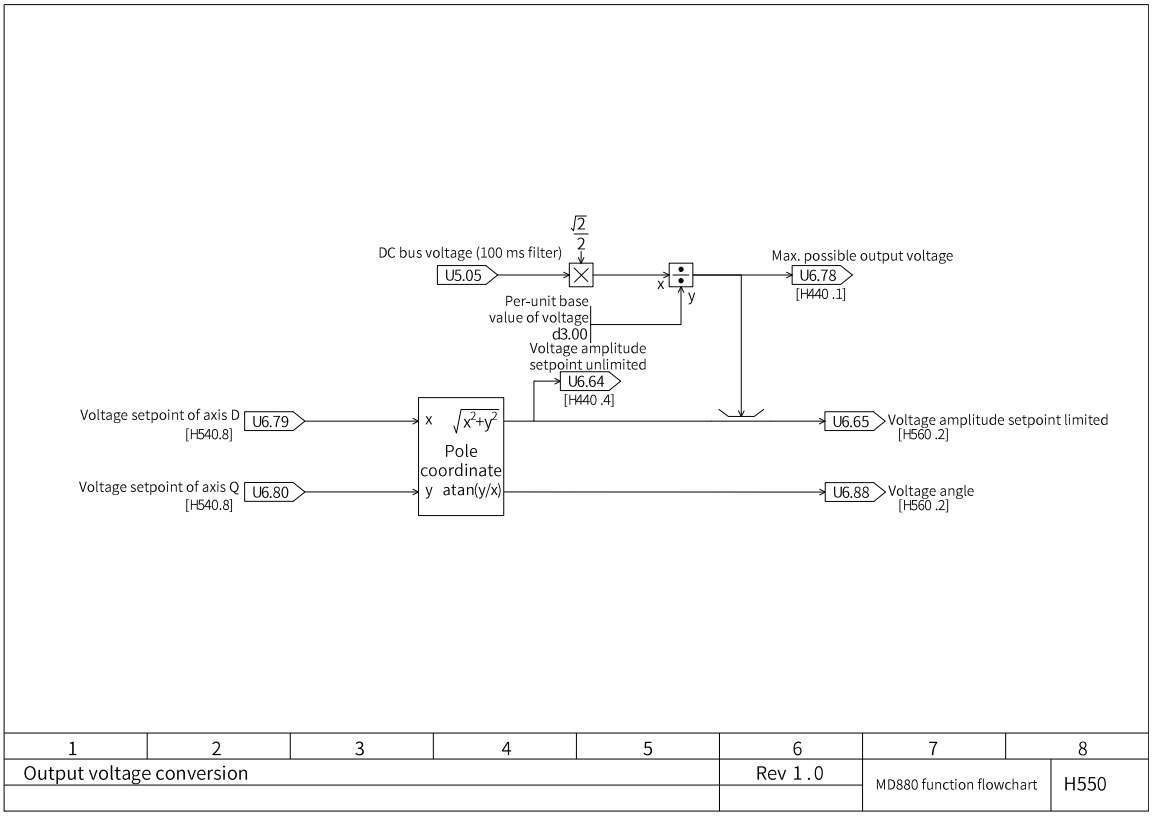
11.2.6.11 H540 - Current Regulator



1	2	3	4	5	6	7	8
Current regulator					Rev 1.0	MD880 function flowchart	H540

Figure 11-70 H540 - Current Regulator

11.2.6.12 H550 - Output Voltage Conversion



1	2	3	4	5	6	7	8
Output voltage conversion					Rev 1 . 0	MD880 function flowchart	H550

Figure 11-71 H550 - Output Voltage Conversion

11.2.6.13 H560 - Power Unit Interface

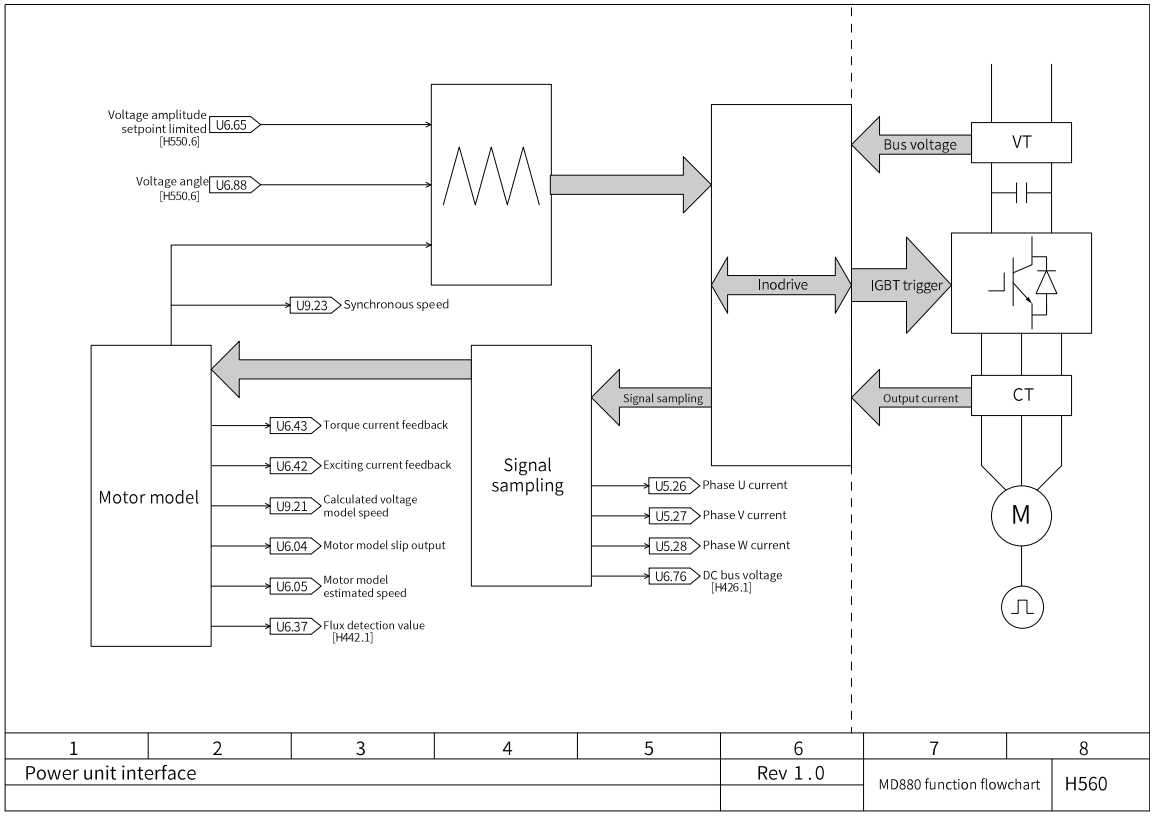
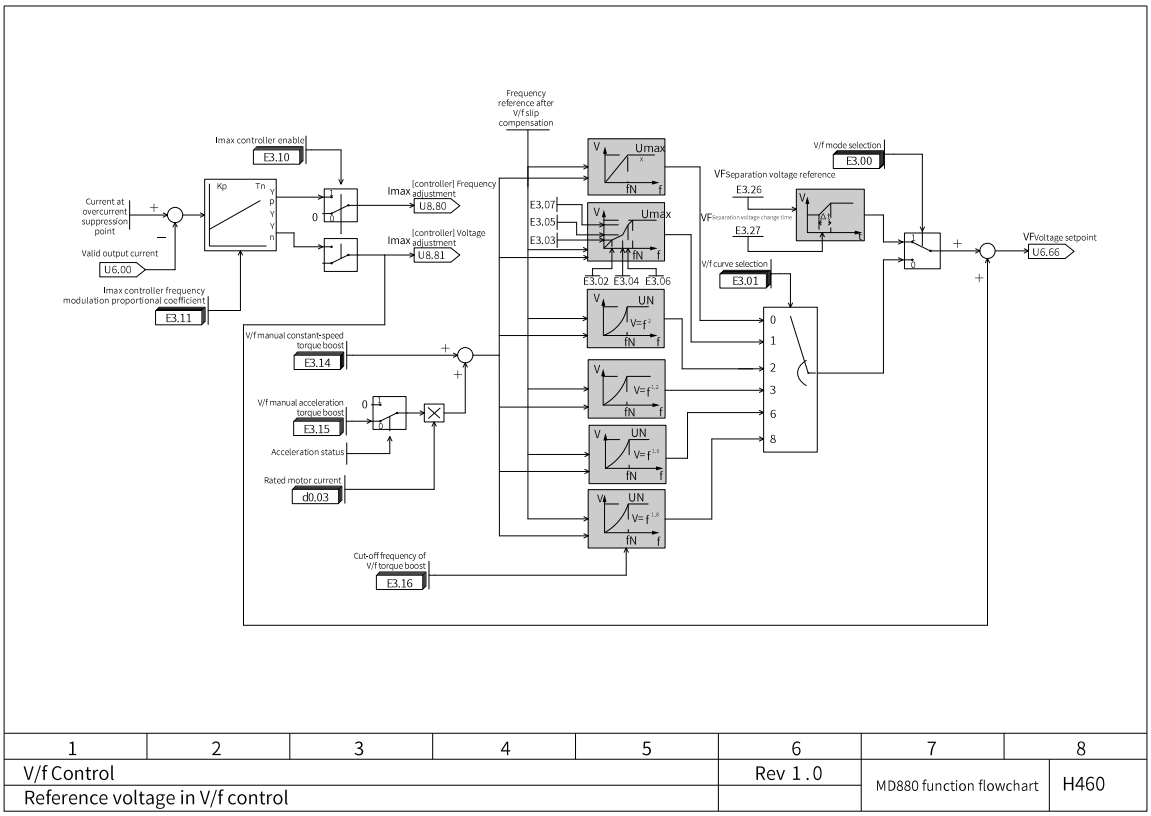


Figure 11-72 H560 - Power Unit Interface

11.2.7 V/f Control

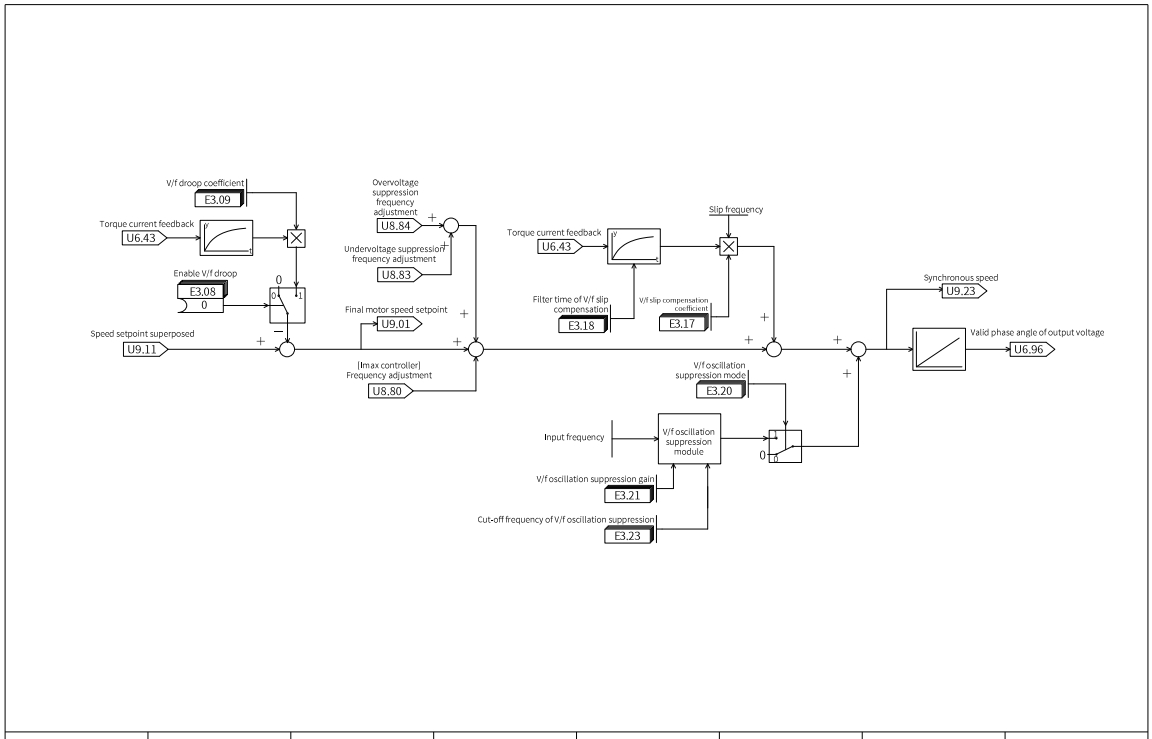
11.2.7.1 H460 - Reference Voltage in V/f Control



1	2	3	4	5	6	7	8
V/f Control					Rev 1.0	MD880 function flowchart	H460
Reference voltage in V/f control							

Figure 11-73 H460 - Reference Voltage in V/f Control

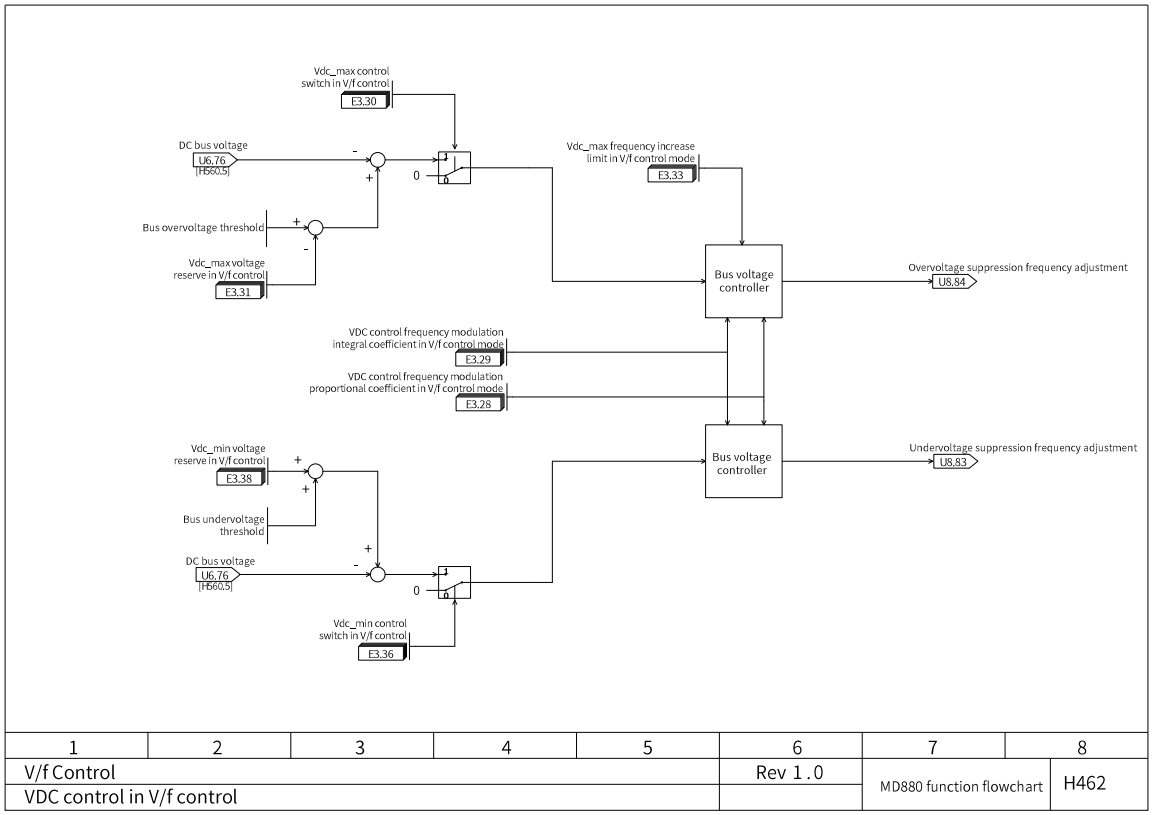
11.2.7.2 H461 - Reference Frequency in V/f Control



1	2	3	4	5	6	7	8
V/f Control					Rev 1.0	MD880 function flowchart	H461
Reference frequency in V/f control							

Figure 11-74 H461 - Reference Frequency in V/f Control

11.2.7.3 H462 - Vdc Control in V/f Mode

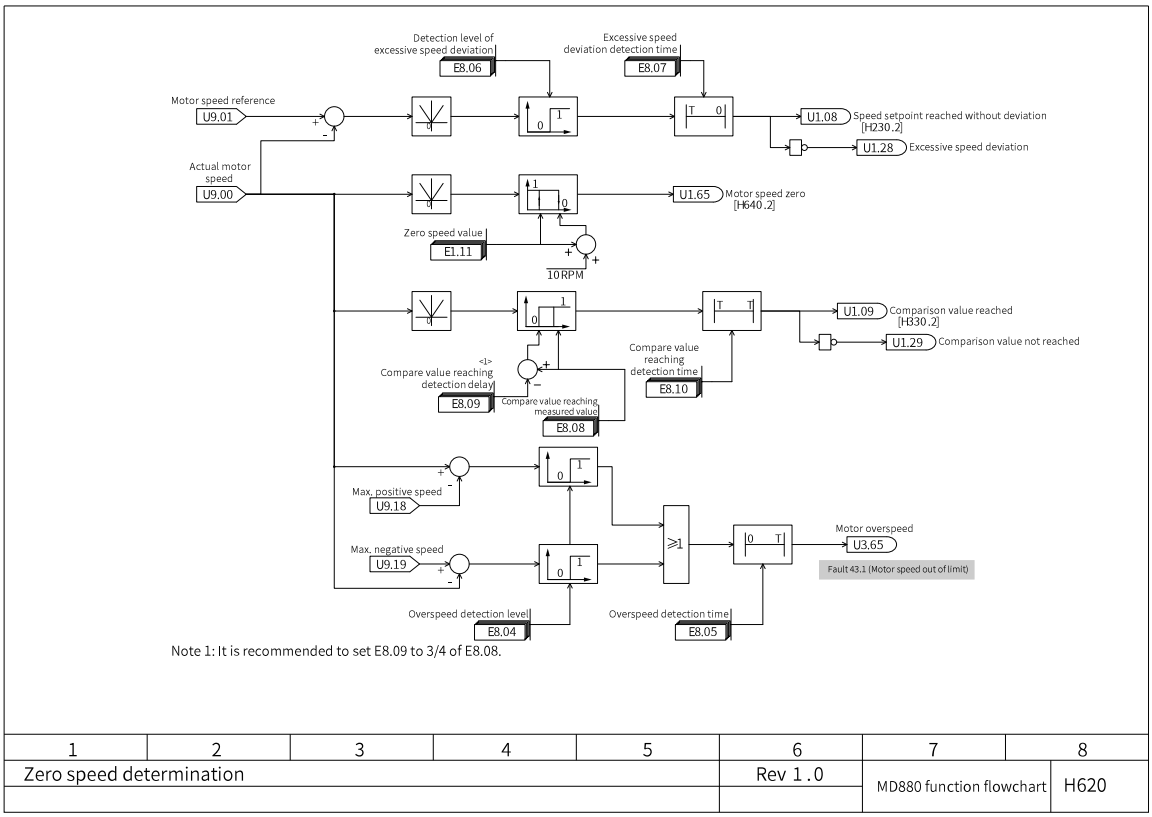


1	2	3	4	5	6	7	8
V/f Control					Rev 1.0	MD880 function flowchart	H462
VDC control in V/f control							

Figure 11-75 H462 - Vdc Control in V/f Mode

11.2.8 Auxiliary Functions

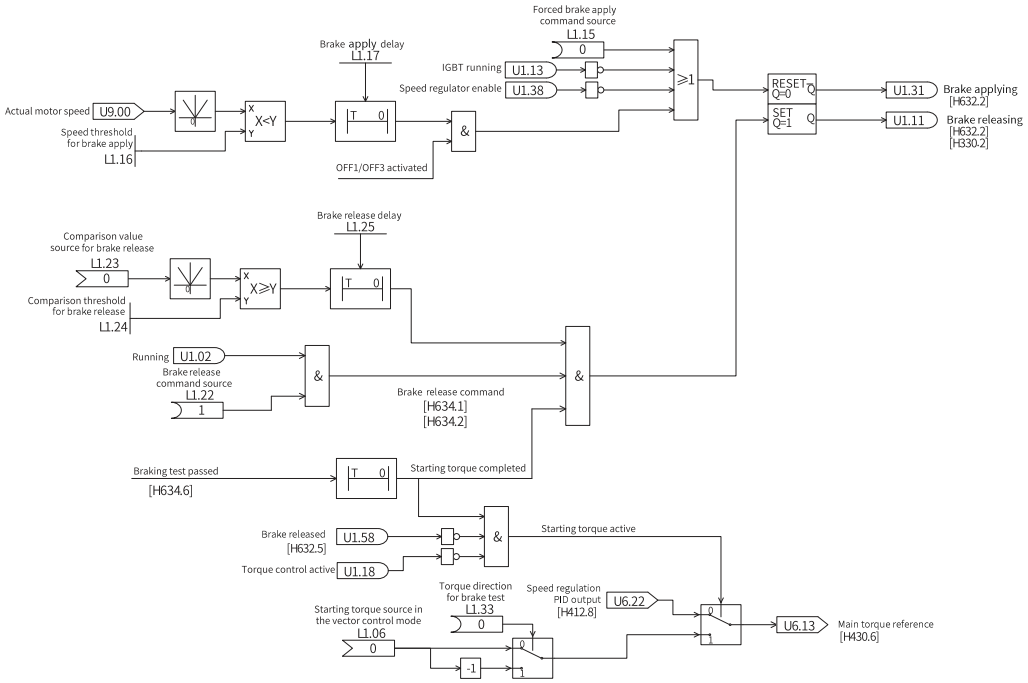
11.2.8.1 H620 - Speed Determination



1	2	3	4	5	6	7	8
Zero speed determination					Rev 1.0	MD880 function flowchart	H620

Figure 11-76 H620 - Speed Determination

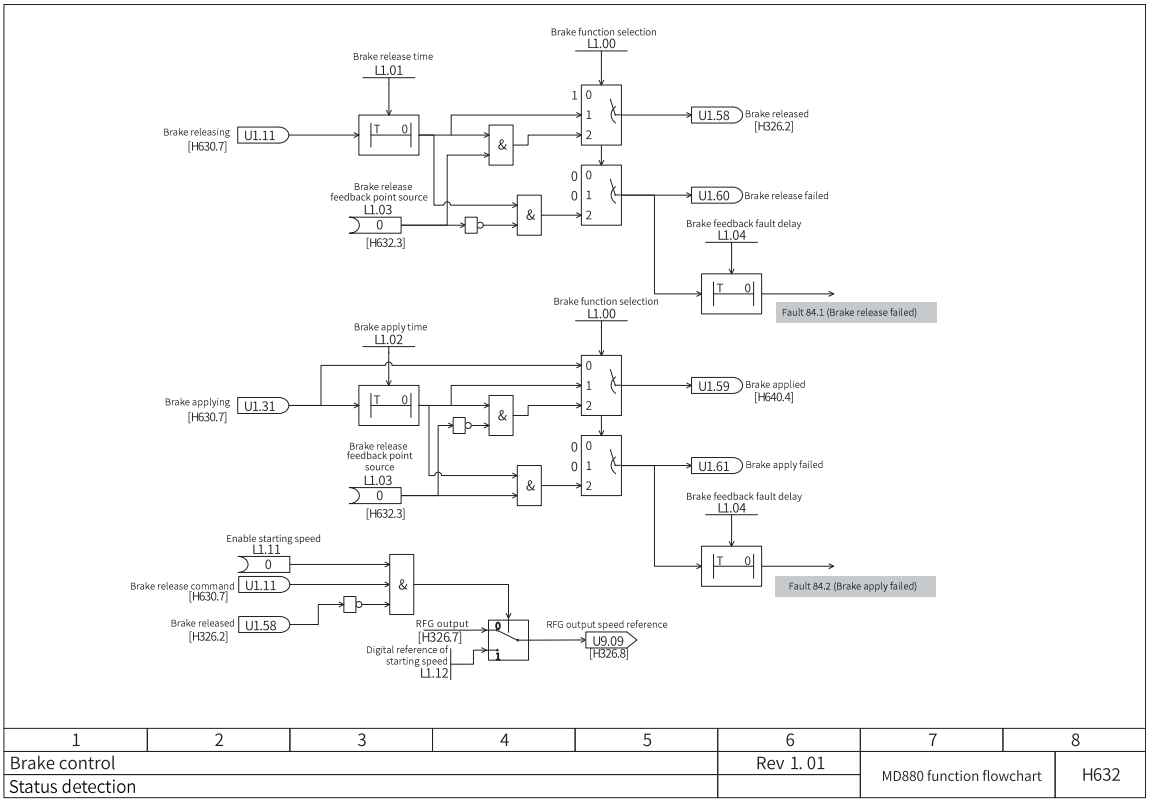
11.2.8.2 H630 - Brake Release and Brake Apply



1	2	3	4	5	6	7	8
Brake control					Rev 1. 01	MD880 function flowchart	H630
Apply/Release							

Figure 11-77 H630 - Brake release and brake apply

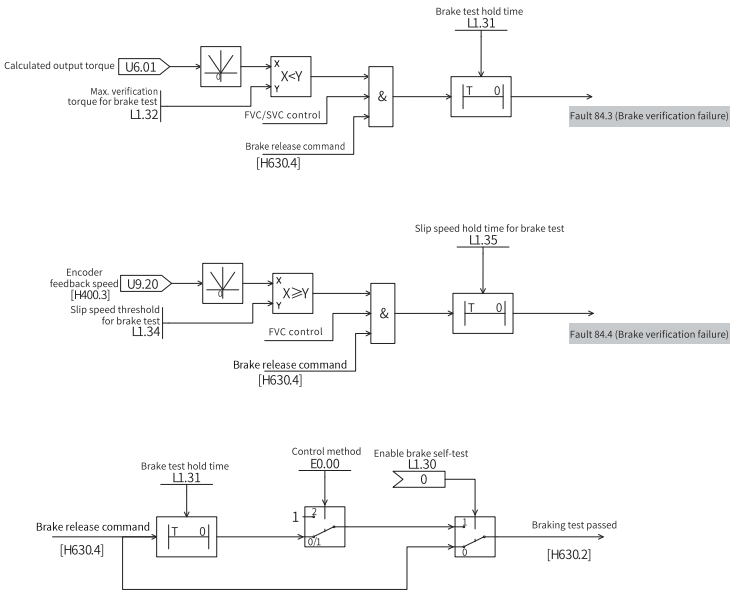
11.2.8.3 H632 - Brake Status Detection



1	2	3	4	5	6	7	8
Brake control					Rev 1. 01	MD880 function flowchart	H632
Status detection							

Figure 11-78 H632 - Brake Status Detection

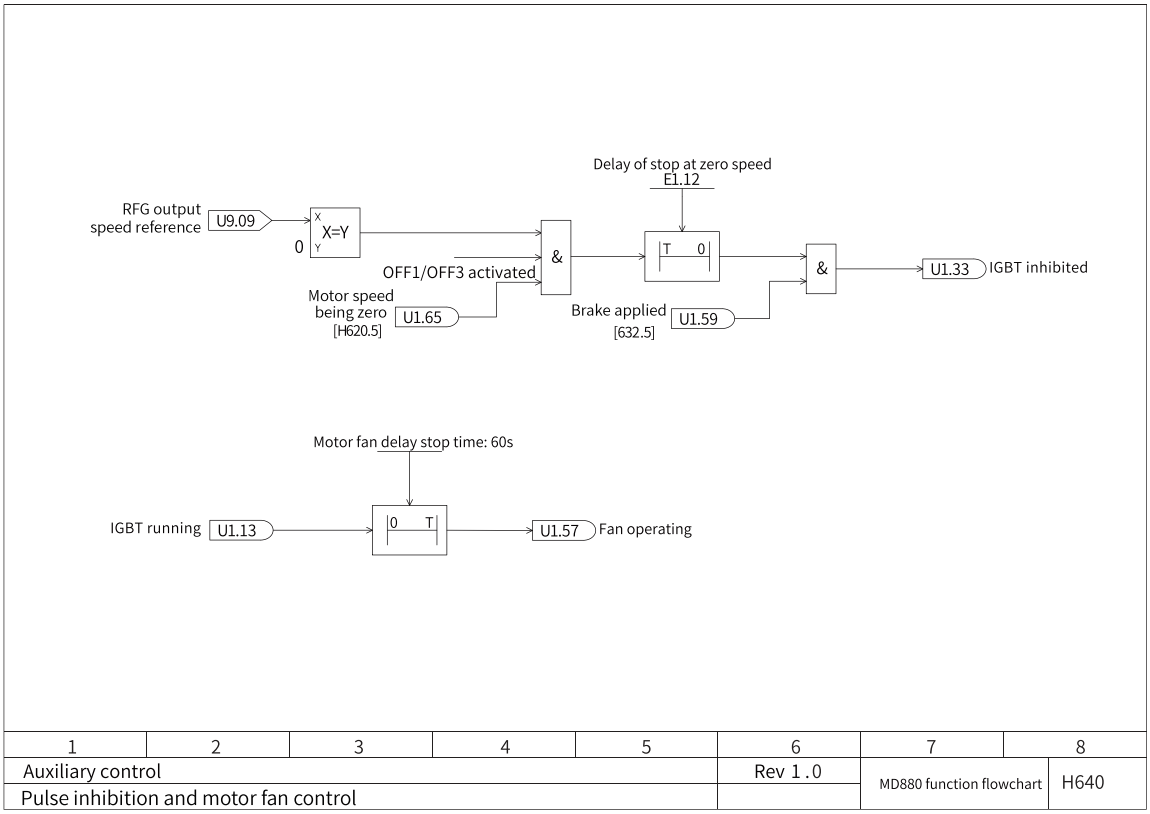
11.2.8.4 H634 - Brake Verification



1	2	3	4	5	6	7	8
Brake control					Rev 1. 03	MD880 function flowchart	H634
Brake verification							

Figure 11-79 H634 - Brake Verification

11.2.8.5 H640 - Pulse Inhibition and Motor Fan Control

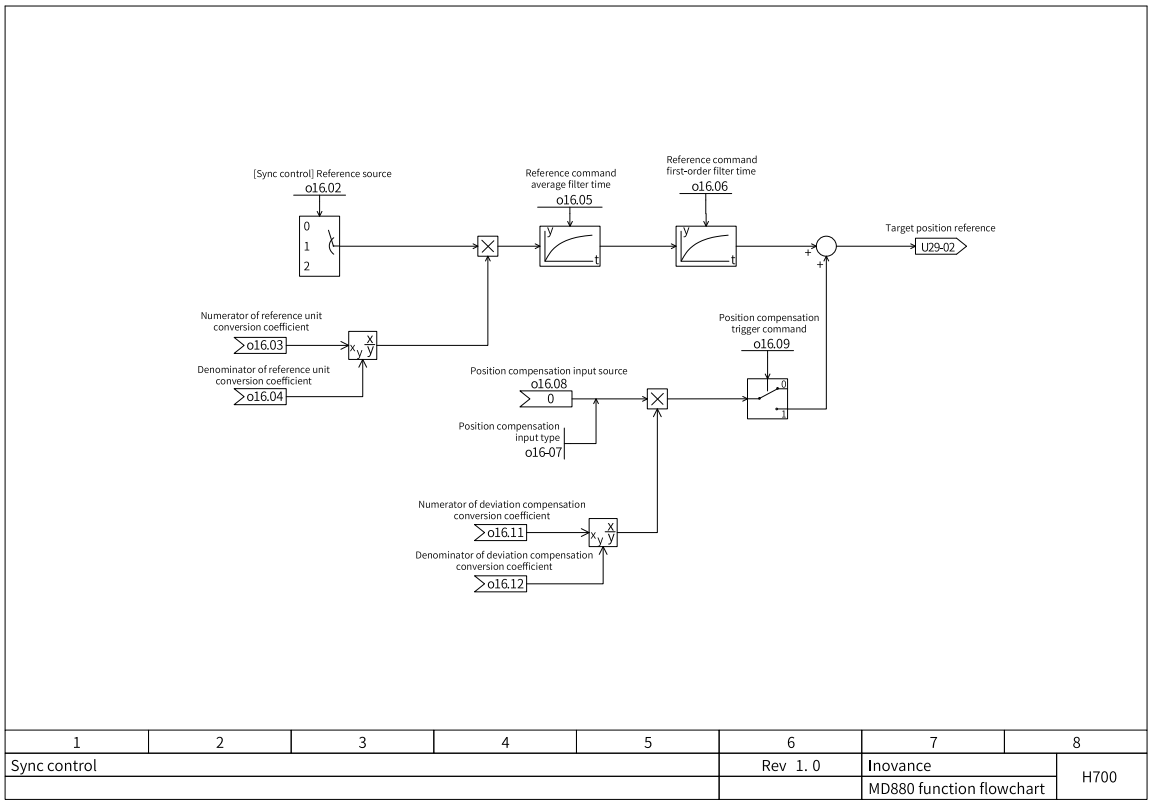


1	2	3	4	5	6	7	8
Auxiliary control					Rev 1.0	MD880 function flowchart	H640
Pulse inhibition and motor fan control							

Figure 11-80 H640 - Pulse inhibition and motor fan control

11.2.9 Position Control

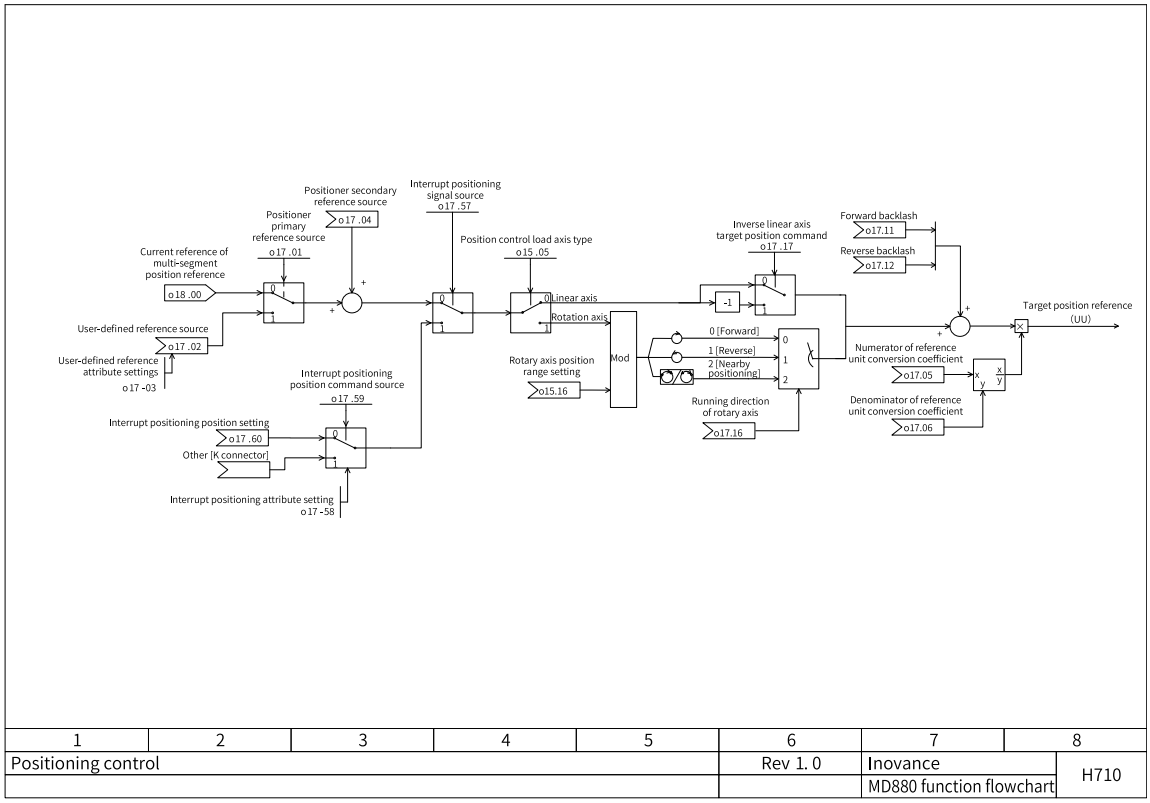
11.2.9.1 H700 - Synchronization Control



1	2	3	4	5	6	7	8
Sync control					Rev 1. 0	Inovance	H700
						MD880 function flowchart	

Figure 11-81 H700 - Synchronization Control

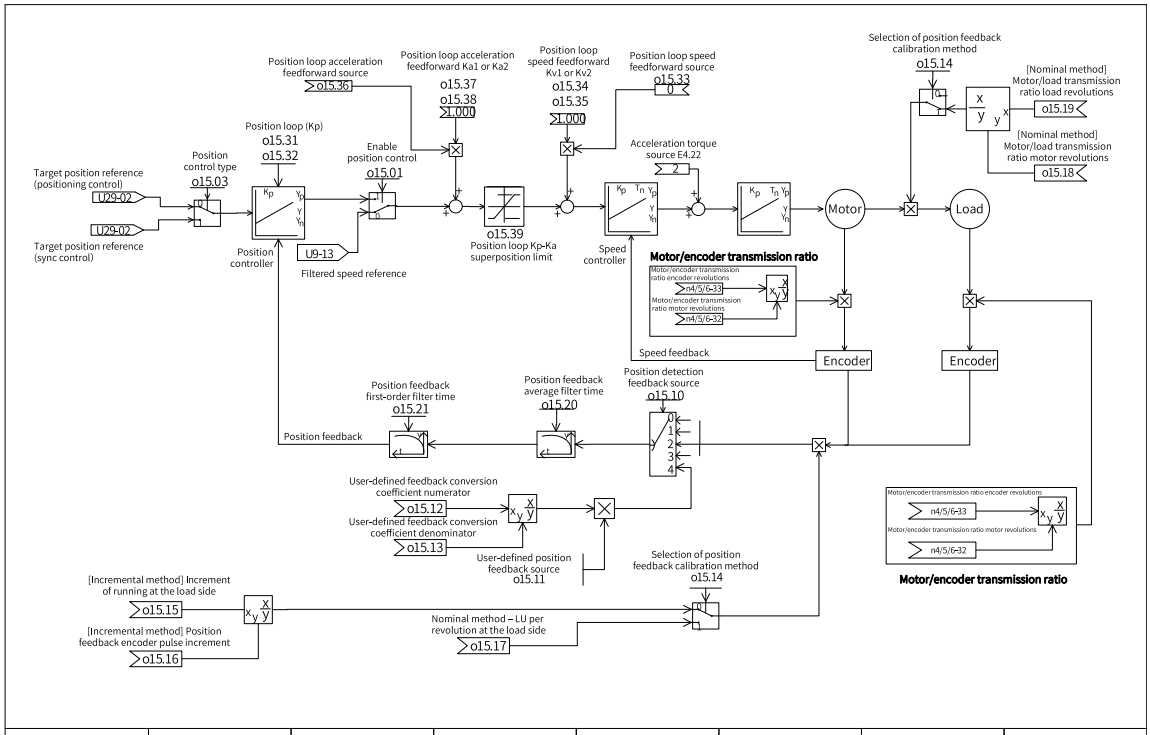
11.2.9.2 H710 - Positioning Control



1	2	3	4	5	6	7	8
Positioning control					Rev 1. 0	Inovance	H710
						MD880 function flowchart	

Figure 11-82 H710 - Positioning Control

11.2.9.3 H720 - Position Controller



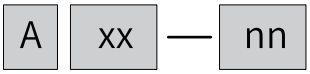
1	2	3	4	5	6	7	8
Position controller					Rev 1.0	Inovance	H720
						MD880 function flowchart	

Figure 11-83 H720 - Position Controller

12 Parameter List

12.1 Parameter Categories

Parameters of HCU are grouped by function and displayed in three levels of menus, as shown below:



- "A" indicates a level-1 menu, which is represented by one letter and corresponds to a group of complete functions.
- "xx" indicates the number of the level-2 menu, which is represented by one or two digits. It combines with the level-1 menu to indicate a group of specific functions.
- "nn" indicates the number of the level-3 menu, which is represented by two digits. It combines with the level-1 or level-2 menu to indicate a specific parameter.

The level-2 menu code and the level-3 menu code are separated by "-" in communication or by "." in display on LEDs. Axx-nn and Axx.nn indicate the same parameter.

The following table shows the menu classification of parameters.

Level-1 Menu	Level-1 Menu Name	Level-2 Menu	Level-2 Menu Name	Remarks
A	System	A0	Status monitoring	Contains common variables for monitoring the motor running status.
		A1	Faults and alarms	Displays the currently activated fault and alarm codes.
		A2	Drive information	Displays rated module parameters, indicating the types and software versions of the HCU, HINT, HPCU, and expansion modules.
		A4	Power unit control	Defines the carrier frequency or dead zone compensation, enable the power-on buffer detection or parallel module detection, or select the load mode or fan running control mode.
		A6	Rectifier control	-
		A8	Environment setting	Used to reset, back up, and restore parameters, and set the parameter access level.
		A9	Data set selection	Used to switch the command channels, motor data sets, and process parameter groups.
		A10	SOP-20/Relay communication	Defines communication parameters for SOP-20-880 (including using a repeater to connect InoDriveStudio).
		A12	Trigger oscilloscope	Used together with the trigger oscilloscope function page of InoDriveStudio.
		A13	Custom black box channels	Defines additional data to be recorded upon fault.
		A15	Parallel configuration	Defines the parallel parameters and view the status of parallel modules when using HPCU for parallel control.
		A16	Log configuration	Used to configure log functions. The log can monitor events occurring in the system, such as operational events, status changes, faults, active limits, and alarms.
b	Control channels	b0	Start/Stop control word reference of channel 1	Defines the start/stop control word when channel 1 is active. See function diagram H246.
		b1	Other control word reference of channel 1	Defines the control word when channel 1 is active. See function diagram H220/H326.
b	Control channels	b2	Start/Stop control word reference of channel 2	Defines the start/stop control word when channel 2 is active. See function diagram H246.
		b3	Other control word reference of channel 2	Defines the control word when channel 2 is active. See function diagram H220/H326.
		b4	Terminal start/stop module	Defines the start/stop mode in the DI terminal control mode.
		b5	Auto-tuning/Self-test	Defines the self-test or auto-tuning request.
		b6	Auxiliary control word setting	For 690 V single-drive cabinet, HDI1 is used as DI forcibly and as the reactor over-temperature detection signal.
C	Reference channel	C0	Speed reference for channel 1	Used to control the main and auxiliary speed control reference and additional speed reference when channel 1 is active. See function diagram H310.

Level-1 Menu	Level-1 Menu Name	Level-2 Menu	Level-2 Menu Name	Remarks
C	Reference channel	C1	Torque reference for channel 1	Used to control the torque control reference, window control reference, additional torque reference, and torque ramp time reference when channel 1 is active. See function diagrams H430 and H330.
		C2	Speed reference for channel 2	Used to control the main and auxiliary speed control reference and additional speed reference when channel 2 is active. See function diagram H310.
		C3	Torque reference for channel 2	Used to control the torque control reference, window control reference, additional torque reference, and torque ramp time reference when channel 2 is active. See function diagrams H430 and H330.
		C4	Motorized potentiometer	Defines the function parameters of the motorized potentiometer.
		C5	Jog reference	Defines the jog speed and jog time.
		C6	Multi-reference	Defines the 16 fixed references.
		C7	Ramp function generator basic parameter	Defines the function parameters of the ramp function generator.
		C8	Ramp function generator advanced parameter	Defines the function parameters of the ramp function generator.
d	Motor parameters	d0	Basic motor parameters	Defines the rated motor parameters.
		d1	Basic auto-tuning parameters	Used to auto-tune basic motor parameters.
		d2	Additional auto-tuning parameters	Contains parameters related to motor mechanical characteristics.
		d3	Base value information	Defines the base values used for system per-unit values.
E	Motor control	E0	Control reference	-
		E1	Start/Stop control	-
		E2	Limit	-
		E3	V/f control	-
		E4	Speed regulator	-
		E5	Current regulator	-
		E6	Excitation control	-
		E7	Flying start	-
		E8	Protection	-
		E9	Vdc control	-
		E11	Motor model	-
F	Input and output	F0	DI	-
		F1	DO	-
		F2	AI	-
		F3	AO	-
		F4	HDI	-
		F5	HDO	-
		F6	AI/AO factory correction parameters	

Level-1 Menu	Level-1 Menu Name	Level-2 Menu	Level-2 Menu Name	Remarks
H	Protection and auxiliary	H0	Troubleshooting	-
		H1	Fault data records	-
		H2	Latest fault code record	-
		H3	Second latest fault code record	-
		H4	Third latest fault code record	-
		H5	Fourth latest fault code record	-
		H6	Fifth latest fault code record	-
		H7	Latest limit code record	-
		H8	Latest alarm code record	-
		H10	User-defined error words	-
L	Application functions	L0	W2B and B2W conversion functions	-
		L1	Brake control	-
		L2	Logic operation functions	-
		L3	W2DW and DW2W conversion functions	-
		L4	Process PID	-
		L5	Switch function blocks	-
		L6	Control function blocks	-
		L7	Arithmetic function block 1	-
		L8	Multi-point curve modules	-
		L9	Constant setting module	-
		L10	Parameter monitoring and modification	-
		L11	Arithmetic function block 2	-
		L12	Data type conversion module	-
		L14	Ramp function generator module	-
		L15	Load monitoring module	-
		L16	Pulse counting module	-

Level-1 Menu	Level-1 Menu Name	Level-2 Menu	Level-2 Menu Name	Remarks
n	Fieldbus adapters and expansion modules	n0	InoLink communication	Used to achieve peer-to-peer communication between HCUs or load distribution or master-slave control.
		n1	Fieldbus adapter A	Defines the reception and transmission of communication data.
		n2	Fieldbus adapter B	
		n3	Fieldbus adapter C	Used to bind the EtherNET commissioning module forcibly.
		n4	Encoder detection module 1	Defines the encoder and measure the motor speed.
		n5	Encoder detection module 2	
		n6	Encoder detection module 3	
		n7	Configuration of HIO module 1	Used to select the HIO module type and monitor parameters.
		n8	Configuration of HIO module 2	
		n9	Configuration of HIO module 3	
		n10	Modbus RTU module	Defines the slot and inherent parameters for the communication module.
		n12	CANopen module	
		n13	EtherNET module	
		n14	EtherCAT module	
		n15	HDVN module	
		n16	PROFIBUS-DP module	
		n17	PROFINET I/O module	
		n18	Custom communication module	Other communication modules use this parameter group for setting.
		n19	Synchronous voltage detection module 1	Used to detect the voltage and phase.
		n20	Grid voltage detection module	Used to detect the grid voltage and phase.
		n22	Optical fiber routing control module	Defines parameters of the HOFR module for data exchange between multiple HCUs.
		n23	Parameter settings of HIO module 1 (HIO-10)	Parameter configuration of the HIO module 1 in group n7. n23 corresponds to n7-02 = HIO-10, n24 corresponds to n7-02 = HIO-20, and n25 corresponds to n7-02 = HIO-30.
		n24	Parameter settings of HIO module 1 (HIO-20)	
		n25	Parameter settings of HIO module 1 (HIO-30)	

Level-1 Menu	Level-1 Menu Name	Level-2 Menu	Level-2 Menu Name	Remarks
n	Fieldbus adapters and expansion modules	n26	Parameter settings of HIO module 2 (HIO-10)	Parameter configuration of the HIO module 2 in group n8. n26 corresponds to n8-02 = HIO-10, n27 corresponds to n8-02 = HIO-20, and n28 corresponds to n8-02 = HIO-30.
		n27	Parameter settings of HIO module 2 (HIO-20)	
		n28	Parameter settings of HIO module 2 (HIO-30)	
		n29	Parameter settings of HIO module 3 (HIO-10)	Parameter configuration of the HIO module 3 in group n9. n29 corresponds to n9-02 = HIO-10, n30 corresponds to n9-02 = HIO-20, and n31 corresponds to n9-02 = HIO-30.
		n30	Parameter settings of HIO module 3 (HIO-20)	
		n31	Parameter settings of HIO module 3 (HIO-30)	
		n32	High-speed pulse detection module	Used to calculate the actual output torque based on the detected output pulse of the torque sensor.
		n33	Adapter A process data double-word input	Used to combine single-word process data sent from the host controller into double-word data.
		n34	Adapter A process data double-word output	Used to split each piece of double-word data of the HCU into two pieces of single-word process data and send the single-word process data to the host controller.
		n35	Adapter B process data double-word input	Used to combine single-word process data sent from the host controller into double-word data.
		n36	Adapter B process data double-word output	Used to split each piece of double-word data of the HCU into two pieces of single-word process data and send the single-word process data to the host controller.

Level-1 Menu	Level-1 Menu Name	Level-2 Menu	Level-2 Menu Name	Remarks
o	Process parameters	o0	Process setting parameter group 1	-
		o1	Process controller parameter group 1	-
		o2	Process setting parameter group 2	-
		o3	Process controller parameter group 2	-
		o4	Process setting parameter group 3	-
		o5	Process controller parameter group 3	-
		o6	Process setting parameter group 4	-
		o7	Process controller parameter group 4	-
		o10	Rotary control process	-
		o15	Position controller	
		o16	Sync control	
		o17	Positioning control	
		o18	Multi-position reference	
		o19	Homing	
P	User-Defined Function Block	P0	User-defined conversion function block	-
		P1	User-defined logic function block 1	-
		P2	User-defined logic function block 2	-
		P3	User-defined switch function block	-
		P4	User-defined control function block 1	
		P5	User-defined control function block 2	-
		P6	User-defined arithmetic function block 1	-
		P7	User-defined arithmetic function block 2	-
		P8	User-defined multi-point operation function block	-
		P9	User-defined process control function block	-

Level-1 Menu	Level-1 Menu Name	Level-2 Menu	Level-2 Menu Name	Remarks
U	Connector	U0 to U11/ U15/ U16/ U17/ U19/ U20/U29	-	Read-only parameters, which can be used to view the status of inputs, outputs, and program execution, or used as inputs for reference source parameters

13 Connector Resources

13.1 Description of Common Connectors

Connectors are indicated by parameters in group U and store and display intermediate variables of system control. Connectors are divided into bit connectors (U0-00 to U4-99, U10-00 to U12-99, and U20-00 to U20-99) and word connectors (U5-00 to U9-99, U15-00 to U19-99, and U29-00 to U29-99) based on data types.

Word connectors are divided into single-word connectors (16 bits, occupying one storage address, corresponding to U5-00 to U8-99 and U15-00 to U16-99) and double-word connectors (32 bits, occupying two storage addresses, corresponding to U9-00 to U9-99, U19-00 to U19-99, and U29-00 to U29-99) based on data types. A double-word connector can indicate more valid digits, improving the numerical value accuracy.

Word connectors are divided into three categories based on units: per-unit value (expressed as percentage of a base value, indicating the speed, torque, and current), actual value (with meaningful units of V, A, and kW), and unitless numerical value (for example, communication data received, which is displayed as the original value, without actual meaning determined).

The per-unit value system is expressed based on the following rules:

- For single-word connectors, 0x1000 (decimal 4096) indicates 100%, which can be displayed as Value (actual value) or Percent (per-unit value). The conversion formula is as follows: Percent = Value/4096.
- For double-word connectors, 0x1000 0000 (4096 x 65536) indicates 100%, which can be displayed as Value (actual value) or Percent (per-unit value). The conversion formula is as follows: Percent = Value/4096/65536.
- Per-unit values expressed by single-word indicators and double-word indicators both range from –800.00% to +799.99%.
- Single-word indicators and double-word indicators can be converted to each other. When a single-word connector is granted to a double-word connector, the low word is 0 and the high word is the value of the single-word connector. When a double-word connector is granted to a single-word connector, the low word is discarded and the high word is granted to the single-word connector, indicating that the number of valid bits for the numerical value is reduced but the value range does not change.

13.1.1 Speed and Frequency

Parameter	Name	Description
U5-00	Actual motor speed (100 ms filter)	The value 100% corresponds to the rated motor speed processed by 100 ms filtering.
U9-00	Actual motor speed	The value 100% corresponds to the rated motor speed without filtering.
U9-01	Final motor speed reference	The value 100% corresponds to the rated motor speed, which is the speed before being processed by speed regulation PID filter.
U9-13	Filtered speed reference	The value 100% corresponds to the rated motor speed, which is the speed after being processed by speed regulation PID filter.

Parameter	Name	Description
U9-14	Filtered speed feedback	The value 100% corresponds to the rated motor speed, which is the feedback speed after being processed by speed regulation PID filter.
U9-20	Encoder feedback speed	The value 100% corresponds to the rated motor speed, which is sthe speed detected by the encoder.

13.1.2 Current and Voltage

Parameter	Name	Description
U5-01	Output voltage (100 ms filter)	The value 100% corresponds to the rated motor voltage processed with 100 ms filtering.
U5-02	Output current (100 ms filter)	The value 100% corresponds to the rated motor current processed with 100 ms filtering.
U5-05	DC bus voltage (100 ms filter)	Defines the actual value of the bus voltag in 0.1 V, with 100 ms filtering.
U5-26	U-phase current	U-phase current can be switched to the per-unit value, actual value, or unitless numerical value through display property switchover. The value 100% corresponds to the rated motor current.
U5-27	V phase current	V-phase current can be switched to the per-unit value, actual value, or unitless numerical value through display property switchover. The value 100% corresponds to the rated motor current.
U5-28	W phase current	W-phase current can be switched to the per-unit value, actual value, or unitless numerical value through display property switchover. The value 100% corresponds to the rated motor current.

13.1.3 Torque

Parameter	Name	Description
U5-04	Output torque (100 ms filter)	The value 100% corresponds to the rated motor torque (Rated power (kW) x 9550/Rated speed (RPM)) processed with 100 ms filtering.
U6-07	Main reference of torque control ramp	Indicates the torque reference of U6-11 after being processed with torque ramp acceleration/deceleration time. The value 100% corresponds to the rated motor torque.
U6-10	Main reference of torque control	Indicates the main reference of the setpoint channel in torque control. The value of 100% corresponds to the rated motor torque.
U6-11	Filtered main reference in torque control	Indicates the torque reference of U6-10 after being filtered by C1-01/C3-01. The value 100% corresponds to the rated motor torque.
U6-12	Torque reference after being limited	Indicates the active torque reference after being processed with torque reference limit, power limit, and VDC control. The value 100% corresponds to the rated motor torque.
U6-13	Torque reference before additional torque applied	Indicates the torque reference before being processed with the total additional torque (U6-20). The value 100% corresponds to the rated motor torque.
U6-14	Maximum output torque	Indicates the upper limit of the active torque reference of the speed regulation module after being processed with the power limit and VDC control. The value 100% corresponds to the rated motor torque.

Parameter	Name	Description
U6-15	Minimum output torque	Indicates the lower limit of the active torque reference of the speed regulation module after being processed with the power limit and VDC control. The value 100% corresponds to the rated motor torque.
U6-16	Positive torque limit	Indicates the positive torque limit outputted after being processed with the speed regulation PID, which is limited by the torque upper limit U6-18 and anti-runaway regulator. The value 100% corresponds to the rated motor torque.
U6-17	Negative torque limit	Indicates the negative torque limit outputted after being processed with the speed regulation PID, which is limited by the torque lower limit U6-19 and anti-runaway regulator. The value 100% corresponds to the rated motor torque.
U6-18	Torque upper limit	The lower value between E2-08 and E2-10 is used as the torque upper limit. The value 100% corresponds to the rated motor torque.
U6-19	Torque lower limit	The lower value between E2-09 and E2-11 is used as the torque upper limit. The value 100% corresponds to the rated motor torque.
U6-20	Total additional torque	Indicates the torque reference generated after torque feedforward torque (U6-27) is superimposed to the additional torque (U6-26). The value 100% corresponds to the rated motor torque.
U6-21	Friction torque	Depends on the friction torque defined by C1-09/C3-09 (additional torque reference 3).
U6-22	Speed regulation PID output	Indicates the speed regulation PID output value. The value 100% corresponds to the rated motor torque.
U6-23	Automatic retentive torque	Indicates the speed regulation PID output (U6-22) before the brake applies.
U6-24	Integral term of speed regulation PID	Indicates the integral term of speed regulation PID output. The value 100% corresponds to the rated motor torque.
U6-25	RFG inertia compensation torque	Indicates the compensation torque calculated based on the rated motor startup time and RFG output acceleration rate. The value 100% corresponds to the rated motor torque.
U6-26	Additional torque	Indicates the torque reference generated after the additional torque reference 1 is superimposed to additional torque reference 2. The value 100% corresponds to the rated motor torque.
U6-27	Feedforward torque	Indicates the feedforward torque calculate based on the RFG feedforward or speed derivative. The value 100% corresponds to the rated motor torque.
U6-28	Calculated load and friction torque	Depends on the friction torque defined by C1-09/C3-09 (Additional torque reference 3).
U6-29	Torque reference before being limited	Indicates the active torque reference after being processed with VDC control and limits defined by U6-18/U6-19. The value 100% corresponds to the rated motor torque.
U6-30	Calculated torque for overspeed adjustment	Indicates the output of the maximum positive speed or maximum negative speed and the filtered speed feedback after being processed with the speed regulator. The value 100% corresponds to the rated motor torque.
U6-39	Load observer output torque	Indicates the torque outputted by the load observer module. The value 100% corresponds to the rated motor torque.

13.1.4 Other Word Connectors

Parameter	Name	Description
U8-00	Current state machine	Indicates the current status of the system.
U8-07	Control word 1	Indicates a word composed of bit0 to bit15 of control word 1.
U8-08	Control word 2	Indicates a word composed of bit0 to bit15 of control word 2.
U8-09	Status word 1	Indicates a word composed of bit0 to bit15 of status word 1.
U8-10	Status word 2	Indicates a word composed of bit0 to bit15 of status word 2.
U5-40	Modbus communication reference 1	Writing data to address 34230 through Modbus can change the value of U5-40, which is used for speed setting.
U5-41	Modbus communication reference 2	Writing data to address 34231 through Modbus can change the value of U5-41, which is used for speed setting.
U9-50	Modbus communication doubleword reference	Writing data to address 34232 through Modbus can change the value of high 16 bits of U9-50. Writing data to address 34233 through Modbus can change the value of low 16 bits of U9-50. It can be used to set a 32-bit speed reference.

13.1.5 Common Bit Connectors

Parameter	Name	Description
U0-00	Logic 0	Constant 0
U0-01	Logic 1	Constant 1
U0-02/U0-12	DI1/DI1 inversion	Status of DI terminals after processing according to parameter settings in group F0
U0-03/U0-13	DI2/DI2 inversion	
U0-04/U0-14	DI3/DI3 inversion	
U0-05/U0-15	DI4/DI4 inversion	
U0-06/U0-16	DI5/DI5 inversion	
U0-07/U0-17	DI6/DI6 inversion	
U0-08/U0-18	DIL/DIL inversion	
U0-09/U0-19	HDI1/HDI1 inversion	Status of HDI terminals as DI terminals after processing according to parameter settings in group F0
U0-10/U0-20	HDI2/HDI2 inversion	
U1-00	Ready to switch on	bit0 of status word 1, indicating that no emergency stop or fault occurs in the system
U1-01	Ready to run	bit1 of status word 1, indicating that the system receives the OFF1 command, without the running permission signal, and that the bus voltage has been build-up
U1-02	Operation	bit2 of status word 1, indicating the normal running state
U1-98	Ready to switch on	Ready to switch on, with [U1-00] being 1 and [U1-01] being 0
U1-99	Ready to run	Ready to run, with [U1-01] being 1 and [U1-02] being 0
U1-03	Fault activation	bit3 of status word 1, indicating that a fault is active
U1-04	OFF2 inactive	bit4 of status word 1, where value 0 indicates that the emergency stop command OFF2 is active
U1-05	OFF3	bit5 of status word 1, where value 0 indicates that the quick stop command OFF3 is active

Parameter	Name	Description
U1-06	Switch-on inhibited	bit6 of status word 1, indicating that the system cannot become ready to switch on and cannot receive the OFF1 command. Typically, this is due to emergency stop or fault activation.
U1-07	Alarm/limit activation	bit7 of status word 1, indicating that an alarm or a limit is active
U1-08	Speed reference reached without deviation	bit8 of status word 1, where value 1 indicates that the feedback speed follows the speed reference
U1-09	Comparison value reached	bit10 of status word 1, where value 1 indicates that the feedback speed is greater than the value of E8-08
U1-10	Torque/current limit reached	bit11 of status word 1, where value 1 indicates that the torque or current has reached the limit
U1-11	Brake release	bit12 of status word 1, where value 1 indicates braking release. For the brake control module, see group L1.
U1-12	Forward speed	bit13 of status word 1, where value 1 indicates that the speed is forward
U1-64	DC bus energized	1: DC bus voltage built-up
U1-65	Motor speed being zero	1 = Absolute value of feedback speed smaller than E1-11
U1-75	Start/Stop command (Modbus)	Writing 0 or 1 to the address 34196 through Modbus changes the value of U1-75. This parameter can be used for the user-defined OFF1 command.
U1-78	Remote control enable	1 = Normal control channel enabled 0 = IDS or SOP-20 local control activated
U2-00 to U2-15	Fieldbus adapter A.PZD1.0 to fieldbus adapter A.PZD1.15	Corresponding to each bit of connector U5-44 and typically used for control channel setting
U2-16 to U2-31	Fieldbus adapter B.PZD1.0 to fieldbus adapter B.PZD1.15	Corresponding to each bit of connector U5-60 and typically used for control channel setting
U2-32 to U2-47	InoLink.PZD1.0 to InoLink.PZD1.15	Corresponding to each bit of connector U5-32 and can be used for control channel setting

14 Troubleshooting

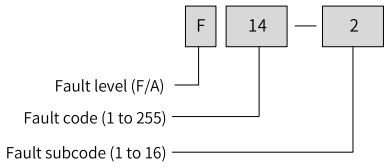
14.1 Classification and Display of Fault Levels

14.1.1 Fault Levels

Faults are divided into the following three levels based on severity:

- Fault: The system encounters major faults or errors and immediately stops running, waiting for troubleshooting.
- Minor fault (Limit): The system encounters faults but still can run after derating. The actual operation may deviate from the setting. When a minor fault occurs, the following modes are supported: run at limited current, run at limited speed, and run at limited torque.
- Alarm: The system reports the alarm without interrupting operation. Alarms can be handled by users as needed.

A fault code consists of three parts. The letter F indicates a fault, the letter L indicates a minor fault, and A indicates an alarm, as shown in the following figure.



14.1.2 Viewing Fault Information

Faults are represented by fault codes and subcodes, which indicate fault classifications and specific faults, respectively. For example, in 14-2, the fault code 14 indicates the drive overtemperature fault; the fault subcode 2 indicates phase-V module overtemperature fault.

Active fault

The HCU can record up to six faults that occurred at the same time, which can be viewed in group A1.

Active fault		Active minor fault		Active alarm	
Fault code	Fault subcode	Fault code	Fault subcode	Fault code	Fault subcode
A1-00	A1-01	A1-12	A1-13	A1-24	A1-25
A1-02	A1-03	A1-14	A1-15	A1-26	A1-27
A1-04	A1-05	A1-16	A1-17	A1-28	A1-29
A1-06	A1-07	A1-18	A1-19	A1-30	A1-31
A1-08	A1-09	A1-20	A1-21	A1-32	A1-33
A1-10	A1-11	A1-22	A1-23	A1-34	A1-35

Previous faults

The HCU can record five latest faults, one latest minor fault, and one latest alarm.

Latest fault		Second latest fault		Third latest fault		Fourth latest fault	
Fault code	Fault subcode	Fault code	Fault subcode	Fault code	Fault subcode	Fault code	Fault subcode
H2-00	H2-01	H3-00	H3-01	H4-00	H4-01	H5-00	H5-01
H2-02	H2-03	H3-02	H3-03	H4-02	H4-03	H5-02	H5-03
H2-04	H2-05	H3-04	H3-05	H4-04	H4-05	H5-04	H5-05
H2-06	H2-07	H3-06	H3-07	H4-06	H4-07	H5-06	H5-07
H2-08	H2-09	H3-08	H3-09	H4-08	H4-09	H5-08	H5-09
H2-10	H2-11	H3-10	H3-11	H4-10	H4-11	H5-10	H5-11

Fifth latest fault		Latest minor fault		Latest alarm	
Fault code	Fault subcode	Fault code	Fault subcode	Fault code	Fault subcode
H6-00	H6-01	H7-00	H7-01	H8-00	H8-01
H6-02	H6-03	H7-02	H7-03	H8-02	H8-03
H6-04	H6-05	H7-04	H7-05	H8-04	H8-05
H6-06	H6-07	H7-06	H7-07	H8-06	H8-07
H6-08	H6-09	H7-08	H7-09	H8-08	H8-09
H6-10	H6-11	H7-10	H7-11	H8-10	H8-11

Fault data records

HCU can also record the data generated upon fault when recording the fault.

Item	Data of latest fault	Data of second latest fault	Data of third latest fault	Data of fourth latest fault	Data of fifth latest fault
Speed upon fault	H2-12	H3-12	H4-12	H5-12	H6-12
Current upon fault	H2-13	H3-13	H4-13	H5-13	H6-13
Bus voltage upon fault	H2-14	H3-14	H4-14	H5-14	H6-14
Output torque upon fault	H2-15	H3-15	H4-15	H5-15	H6-15
Control word 1 upon fault	H2-16	H3-16	H4-16	H5-16	H6-16
Control word 2 upon fault	H2-17	H3-17	H4-17	H5-17	H6-17
Status word upon fault	H2-18	H3-18	H4-18	H5-18	H6-18
State machine upon the latest fault	H2-19	H3-19	H4-19	H5-19	H6-19
Latest fault occurrence time	H2-20	H3-20	H4-20	H5-20	H6-20
Latest fault occurrence date	H2-21	H3-21	H4-21	H5-21	H6-21

Viewing faults through SOP-20-880

SOP-20-880 allows you to directly view fault information using the above-mentioned parameters or view fault information in the fault menu.

Function	Button	Description
View the active fault	Key operations	Choose Menu > Fault Status > Active Fault.
View the active minor fault	Key operations	Choose Menu > Fault Status> Active Limit.
View the active alarm	Key operations	Choose Menu > Fault Status > Current alarm.
View fault-related help information		Select a fault and press this key, and the help information related to the fault will be displayed.
View previous faults	Key operations	Choose Menu > Fault Status > History Faults.

It is recommended to use the fault menu to view fault information. The fault menu presents all the recorded faults with fault descriptions and help information in text.

14.1.3 Fault Reset Methods

Faults can be reset through SOP-20-880, InoDriveStudio, control channels, parameter setting (auto reset), and power cycling.

Mode	Description
Reset through SOP-20-880	Press "STOP" on any screen to reset upon fault.
Reset through InoDriveStudio	Click the reset button on the control panel to reset faults.
Reset through control channel	Reset upon fault by parameter settings. For details, see the following table.
Auto reset through parameter setting	Set H0-07 to 1 and set the fault reset time properly to allow automatic fault reset.
Reset through power cycling	Power off and on the HCU again to reset the fault.

Reset commands have multiple sources. The reset command corresponding to the selected command source is active, while others are inactive. The following table lists the relationship between the reset command sources and the control channels (In the table, SOP indicates the reset by key pressing on SOP-20-880, and IDS indicates the reset command sent by InoDriveStudio).

Active Control Channel	Command Word Source	Reset Command Source									
		b0-05	b1-04	b1-05	b2-05	b3-04	b3-05	U2-07	U2-23	SOP	IDS
A9-00 = 0	b0-00 = 0	X	0→1	0→1	X	X	X	X	X	0→1	0→1
	b0-00 = 1	X	0→1	0→1	X	X	X	0→1	X	0→1	0→1
	b0-00 = 2	X	0→1	0→1	X	X	X	X	0→1	0→1	0→1
	b0-00 = 3	0→1	0→1	0→1	X	X	X	X	X	0→1	0→1
	SOP control	X	0→1	0→1	X	X	X	X	X	0→1	0→1
	IDS control	X	0→1	0→1	X	X	X	X	X	0→1	0→1
A9-00 = 1	b0-00 = 0	X	X	X	X	0→1	0→1	X	X	0→1	0→1
	b0-00 = 1	X	X	X	X	0→1	0→1	0→1	X	0→1	0→1
	b0-00 = 2	X	X	X	X	0→1	0→1	X	0→1	0→1	0→1
	b0-00 = 3	X	X	X	0→1	0→1	0→1	X	X	0→1	0→1
	SOP control	X	X	X	X	0→1	0→1	X	X	0→1	0→1
	IDS control	X	X	X	X	0→1	0→1	X	X	0→1	0→1

Note

- "X" in the table indicates that the command source is invalid. The reset command is active only upon the rising edge. Do not keep it at high level for a long time.
- U2-07 and U2-23 can be activated after being configured by parameters b1-04/b1-05/b3-04/b3-05. This table only shows whether U2-07 and U2-23 are active by default when they are not selected by these four parameters.
- When b0-00 is set to 3, U2-07 and U2-23 can be activated after being configured by parameters b0-05/b2-05. This table only shows whether U2-07 and U2-23 are active by default when they are not selected by these two parameters.
- The reset commands of SOP-20-880 and InoDriveStudio are always active after being connected, regardless of the control source.

14.1.4 Fault Level Change and Automatic Reset

Fault level change

Faults are classified into faults, minor faults, and alarms, which is further divided into seven levels to fit different fault conditions. Up to 10 fault levels can be set, as shown below.

Param.	Value
Fault codes 1 to 10 for changing fault level in H1-00	Fault display code
Fault codes 1 to 10 for changing fault level in H1-02	0: Coast to stop 1: Emergency stop 2: Stop according to the stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action

Fault level	Meaning	Remarks
0: Coast to stop	Output blocked directly	Fault
1: Emergency stop	Stop according to the maximum capacity of the system and restart not allowed	
2: Stop according to the stop mode	Stop based on the set stop mode and restart not allowed	
3: Operating at limited current	Operating normally within the limit range	Minor fault
4: Operating at limited speed		
5: Operating at limited torque		
6: Displaying this alarm only	The alarm itself does not affect normal operation.	Alarm
7: No action	No alert	No error

Note

- Fault display code: fault code displayed when the system is abnormal, such as 15 (external fault 1).
- Fault level change is not applicable to every fault. The system automatically determines the allowed maximum value according to different fault levels.

List of faults with fault levels changeable

Fault code	Default level	Highest	Lowest
11: Motor overload	0: Coast to stop	0: Coast to stop	6: Displaying this alarm only
13: Output phase loss	0: Coast to stop	0: Coast to stop	6: Displaying this alarm only
15: External fault	0: Coast to stop	0: Coast to stop	6: Displaying this alarm only
31: PID feedback loss	0: Coast to stop	0: Coast to stop	6: Displaying this alarm only
32: Inverter fan fault 2	6: Displaying this alarm only	0: Coast to stop	7: No action
44: Expansion module offline	0: Coast to stop	0: Coast to stop	6: Displaying this alarm only
45: Expansion module slot address conflict	0: Coast to stop	0: Coast to stop	6: Displaying this alarm only
46: Parameter setting alarm	6: Displaying this alarm only	6: Displaying this alarm only	7: No action

Fault code	Default level	Highest	Lowest
48: Motor temperature error	0: Coast to stop	0: Coast to stop	6: Displaying this alarm only
50: SD card error	6: Displaying this alarm only	6: Displaying this alarm only	7: No action
51: RTC error	6: Displaying this alarm only	6: Displaying this alarm only	7: No action
59: Module temperature too low	0: Coast to stop	0: Coast to stop	6: Displaying this alarm only
66: Leakage current fault	0: Coast to stop	0: Coast to stop	6: Displaying this alarm only
67: Communication card error of bus adapter A	0: Coast to stop	0: Coast to stop	6: Displaying this alarm only
68: Communication card error of bus adapter B	0: Coast to stop	0: Coast to stop	6: Displaying this alarm only
70: Inverter fan fault	0: Coast to stop	0: Coast to stop	6: Displaying this alarm only
74: Rectifier braking unit fault	0: Coast to stop	0: Coast to stop	6: Displaying this alarm only
77: Reactor temperature error	0: Coast to stop	0: Coast to stop	6: Displaying this alarm only
83: Master-slave communication error	0: Coast to stop	0: Coast to stop	6: Displaying this alarm only
84: Brake control error	0: Coast to stop	0: Coast to stop	6: Displaying this alarm only
91: Parallel error	0: Coast to stop	0: Coast to stop	6: Displaying this alarm only
93: Motor control error	0: Coast to stop	0: Coast to stop	6: Displaying this alarm only
114: Input phase loss	0: Coast to stop	0: Coast to stop	6: Displaying this alarm only
148: Motor temperature error	6: Displaying this alarm only	6: Displaying this alarm only	7: No action
170: I/O expansion module wiring error	6: Displaying this alarm only	0: Coast to stop	6: Displaying this alarm only
173: Synchronous voltage detection module fault	0: Coast to stop	0: Coast to stop	6: Displaying this alarm only

Automatic reset

In certain applications, a limited number of automatic fault resets can be set to ensure continuous operation when a fault occurs. The system can set the fault reset interval (Tr), number of fault resets (ResetNum), reset time of the number of fault resets (Ts), and three non-resettable fault codes.

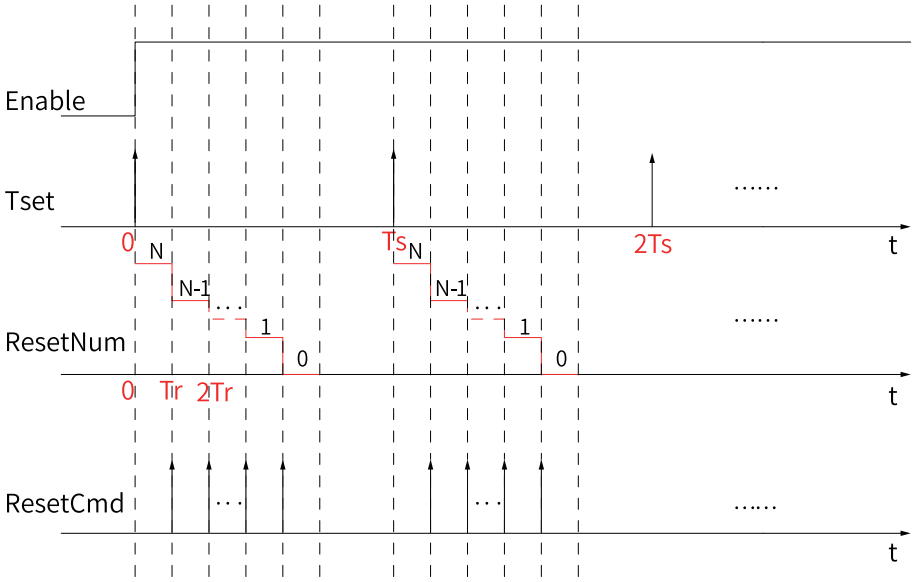
Tr: The reset command ResetCmd is generated every Tr time when a fault occurs.

ResetNum: Indicates the number of automatic resets. The remaining number of automatic resets is reduced by 1 every time a reset command ResetCmd is generated. When the remaining number of automatic resets is 0, the automatic fault reset function is inactive.

Ts: Indicates the time for resetting the number of fault resets. When the remaining number of automatic resets is 0 and the Ts time elapses, the remaining number of fault resets are restored to the number set previously (RestNum).

Non-resettable fault code: When the non-resettable fault code is included in the current system fault list, the system does not generate an automatic reset command, which means the fault can only be reset manually. See the following table for detailed setting.

Param.	Name	Value	Remarks
H0-07	Automatic fault reset	0: Invalid 1: Valid	Enable
H0-08	Time for resetting the number of fault resets	0.0s to 3600.0s	Ts
H0-09	Automatic fault reset interval	0.0s to 600.0s	Tr
H0-10	Number of fault resets	0 to 5	ResetNum
H0-11	Non-resettable fault code 1	Fault display code	-
H0-12	Non-resettable fault code 2	Fault display code	-
H0-13	Non-resettable fault code 3	Fault display code	-



Note

- The Enable signal is valid when the auto fault reset function is enabled and ResetNum is set to a value other than 0.
- This function is invalid if the fault reset interval time exceeds the time for resetting the number of faults.

14.2 Fault Reset

The current fault code can be viewed through connector U17-67. In some applications, the host controller needs to read the connector through communication to obtain the fault status of the AC

drive. In this case, the fault code expression mode can be modified to align with the data of the host controller.

By default, the high-order byte of the U17-67 word connector represents the fault code and the low-order byte represents the fault subcode. Fault codes can be expressed in three ways, which can be selected through H0-28.

For fault F15-1 as an example, the hexadecimal value 0x0F01 is displayed by U17-67 by default.

- If [H0-28] is set to 1 (low-order byte represents code, high-order byte represents subcode), [U17-67] is 0x010F.
- If [H0-28] is set to 2 (Code x 100 + Subcode), [U17-67] is 0x05DD.

Parameter description:

Parameter	Name	Reference
H0-28	Fault code/subcode expression mode	0: High-order byte represents code, and low-order byte represents subcode 1: Low-order byte represents code, and high-order byte represents subcode 2: Code x 100 + Subcode
U17-67	Active fault code (main code and subcode)	-

14.3 Description of Troubleshooting

14.3.1 S4 (Switch-on Inhibition) and S7 (Ready to Run)

- Switch-on-inhibition and ready-to-run are two state machines in the system, named S4 and S7 respectively.
- When the system is in the switch-on-inhibition or ready-to-run state for a long time, it is generally because signal states such as OFF1, OFF2, OFF3, or running permission are not normal. For example, the activation of OFF2 and OFF3 signals brings the system into the switch-on-inhibited state.
- Troubleshooting: Check A0-16 and A0-17 to quickly find the fault causes. See the following table for details.

Parameter	Value	Description	Remarks
A0-16 error info type	0	None	Normal state
	1	OFF1/JOG/Start-Stop command is not reset, leading to the switch-on-inhibition state.	Switch-on inhibition: The corresponding command of the active control channel is activated.
	2	OFF2 is activated, leading to the switch-on-inhibition state.	
	3	OFF3 is activated, leading to the switch-on-inhibition state.	
	4	Operation cannot be activated, causing the ready-to-run state.	Ready to run: The corresponding command of the active control channel is activated.
	9	STO activated	-
	10	DP bus data privilege is released but PZD1.10 is not set to 1.	The start/stop control source is bus adapter but bit 10 of data received by adapter (PZD1) is not 1.
	11	User-defined function block enable switchover causes switch-on inhibited.	-
	12	Three-phase brake A5-01 activates OFF2, resulting in switch-on inhibited.	
A0-17 error	0	None	Normal state
	1	The parameter is set to normally active. Check group b parameters.	The corresponding channel command of group b is set to a constant value of 1.
	2	DI1	The terminal signal is active.
	3	DI2	
	4	DI3	
	5	DI4	
	6	DI5	
	7	DI6	
	8	DIL	
	9	HDI1	
	10	HDI2	

Parameter	Value	Description	Remarks
A0-17 error	11	Fieldbus adapter A.PZD0.0	The start/stop control source is adapter A and the corresponding bit is active.
	12	Fieldbus adapter A.PZD0.1	
	13	Fieldbus adapter A.PZD0.2	
	14	Fieldbus adapter A.PZD0.3	
	15	Fieldbus adapter A.PZD0.8	
	16	Fieldbus adapter A.PZD0.9	
	17	Fieldbus adapter B.PZD0.0	The start/stop control source is adapter B and the corresponding bit is active.
	18	Fieldbus adapter B.PZD0.1	
	19	Fieldbus adapter B.PZD0.2	
	20	Fieldbus adapter B.PZD0.3	
	21	Fieldbus adapter B.PZD0.8	
	22	Fieldbus adapter B.PZD0.9	
	23	PC background control bit active	The software has acquired control permission and the corresponding bit is active.
	24	Fieldbus adapter A.PZD1 check bit	The start/stop control source is adapter A and received PZD1.bit 10 is not 1.
	25	Fieldbus adapter B.PZD1 parity bit	The start/stop control source is adapter B and received PZD1.bit 10 is not 1.
	26	User-defined function block enable is changed, but HCU is not powered on again.	-
	27	Three-phase braking setting A5-00 is set to 0.	-
	28	HINT is not ready due to, for example, a model parameter error.	-
	29	The STO action signal is active.	-
	Others	B connector	The corresponding command of the active control channel is set to a B connector and the B connector is active.

Note

The system may encounter various errors from different sources at the same time. Locate and resolve the errors one by one as prompted.

14.3.2 System Initialization Faults

Symptom	Solution
After the control power supply of HCU-50S/51S is switched on, the state machine (A0-00) stays at "0: System initializing".	Check whether the 24 VDC power supply voltage of HCU-50S/51S is excessively low.
	Check whether the detection circuits of the 24 VDC and 15 VDC power supplies of the HCU-50S/51S are abnormal.
	Check whether EEPROM of HCU-50S/51S functions improperly.
	Contact Inovance technical support.

14.3.3 Motor Stall Faults

The fault 93-1 (Motor stall fault) is a protective measure used to determine motor control errors, preventing the motor from being stopped due to failure of the motor output torque in withstanding the load torque.

The motor stall detection enable signal comes from U1-28 [Excessive speed deviation] by default. When U1-28 is enabled, the motor stall detection is activated. In some applications, the motor needs to continue operating in the stall mode. In applications where torque control needs to be achieved through motor torque limit adjustment on a motor that operates in the speed control mode, you can set E8-25 to 0 to manually disable motor stall detection.

For example, the take-up machines on cold rolling lines typically need to work in torque mode. In this case, the output torque can be controlled through speed control and torque limit. However, typically, the actual motor speed is not equal to the speed reference. The actual motor speed may even be 0 during tension build-up. In this case, disable motor stall detection or set E8-26 (Motor stall speed reference) to a high value.

14.3.4 Rectifying Parameter Setting Errors

If there is a conflict between user-defined parameters, HCU-50S/51S limits the setpoints internally to ensure normal operation. In this case, alarm 46-1 is also reported, indicating that the parameter inputted is incorrect. The operating state of the system may be different from expected.

See U8-44 to find out the cause of the parameter setting error. When no error occurs, [U8-44] is 0. If the set maximum motor speed is lower than the minimum motor speed, [U8-44] is 11 and the motor speed is set to the minimum speed forcibly at the maximum speed threshold. See details of U8-44 in the following table.

Setpoint	Definition
0	No parameter setting error
1	Pulse-by-pulse current limit count conflict
2	Conflict between minimum and maximum values of motorized potentiometer
3	Conflict between RFG arc time 1 and acceleration time 1
4	Conflict between RFG arc time 1 and deceleration time 1
5	Conflict between RFG arc time 2 and acceleration time 2
6	Conflict between RFG arc time 2 and deceleration time 2
7	Conflict between RFG arc time 3 and acceleration time 3
8	Conflict between RFG arc time 3 and deceleration time 3
9	Conflict between RFG arc time 4 and acceleration time 4
10	Conflict between RFG arc time 4 and deceleration time 4
11	Conflict between the maximum motor speed and the minimum speed
12	Conflict between the lower limit and upper limit of jump frequency 1
13	Conflict between the lower limit and upper limit of jump frequency 2
14	Conflict between the lower limit and upper limit of the digital torque limit reference
15	Conflict between lower limit and upper limit of adaptive switchover of speed loop Kp
16	Conflict between low frequency and high frequency switchover of speed loop
17	Conflict between lower limit and upper limit of proportional adaptive current of the current loop
18	Conflict between the lower frequency and upper frequency of model switchover

Setpoint	Definition
19	Conflict between lower frequency and upper frequency for FVC-to-SVC
20	Conflict between minimum and maximum input values of AI1 curve
21	Conflict between minimum and maximum input values of AI2 curve
22	Conflict between minimum and maximum output ratios of AO1 curve
23	Conflict between minimum and maximum output ratios of AO2 curve
24	Conflict between minimum and maximum input frequencies of HDI1 curve
25	Conflict between minimum and maximum input frequencies of HDI2 curve
26	Conflict between minimum and maximum output ratios of HDO1 curve
27	Conflict between minimum and maximum output ratios of HDO2 curve
28	Slot number of the communication card selected for fieldbus adapter A not set
29	Slot number of the communication card selected for fieldbus adapter B not set
30	Nominal rated current of the drive higher than 6 x rated current of the motor
31	Fault reset interval time exceeding the time for resetting the number of fault resets
32	Encoder module slot setting conflict
33	I/O expansion module slot setting conflict
34	Fault handling level setting conflict
35	Linear V/f curve frequency point setting conflict
36	Incremental setting not applied to X points of multi-point curve module A
37	Incremental setting not applied to X points of multi-point curve module B
38	Brake apply threshold setting error
39	Number of trigger oscilloscope channels (A12-20) exceeding 8 during carrier cycle
40	Conflict between selected AO1 signal source and motor temperature detection
41	Conflict between selected AO2 signal source and motor temperature detection
42	Custom function block execution sequence conflict (See P9-00 to P9-03 for details.)
43	Incremental setting not applied to X points of custom multi-point curve module
44	Brake fully-apply threshold setting error
45	Start/Stop control word being bus adapter but bit10 not used as DP data check bit (n16-10)
46	Parallel function enabled (A15-00) but the number of modules enabled being 0
47	Parameter setting conflict of I/O expansion module 1 (The minimum input of AI curve is higher than the maximum input value or the minimum output ratio of AO curve is higher than the maximum output ratio.)
48	Parameter setting conflict of I/O expansion module 2 (The minimum input of AI curve is higher than the maximum input value or the minimum output ratio of AO curve is higher than the maximum output ratio.)
49	Parameter setting conflict of I/O expansion module 3 (The minimum input of AI curve is higher than the maximum input value or the minimum output ratio of AO curve is higher than the maximum output ratio.)
50	Charging limit curve setting error (The voltage points or current points are not set incrementally).
51	Current feedforward function on the low-voltage side inactive (The current sampling channel is not configured, but the corresponding current feedforward function is enabled.)
52	Voltage detection source on the low-voltage side not configured
53	HSVM module for voltage detection source on the low-voltage side not configured
54	HSVM module for pre-charge feedback voltage measurement source on the low-voltage side not configured
55	HSVM module of current detection source at low voltage side not configured
56	HSVM module for HVS current measurement source not configured

Setpoint	Definition
57	Voltage points for undervoltage/overvoltage protection on the low voltage side not set incrementally
60	Voltage points of regulator functions on the medium-voltage side not set incrementally
61	Conflict between the lower limit and upper limit of buck mode of reference channel 1
62	Conflict between the lower limit and upper limit of boost mode of reference channel 1
63	Conflict between the lower limit and upper limit of buck mode of reference channel 2
64	Conflict between the lower limit and upper limit of boost mode of reference channel 2
65	Current feedforward function on the medium-voltage side invalid (The current sampling channel is not configured but the corresponding current feedforward function is enabled, or the sampling card does not support current feedforward function on the medium-voltage side.)
66	Conflict between voltage detection source on the low-voltage side and pre-charge feedback voltage detection source on the low voltage side
67	Conflict between the current detection source on the low voltage side and current detection source on the medium-voltage side
68	Read index setting conflict of address mapping adapter A
69	Write index setting conflict of address mapping adapter A
70	Write mapped internal address setting conflict of address mapping adapter A
71	Read index setting conflict of address mapping adapter B
72	Write index setting conflict of address mapping adapter B
73	Write mapped internal address setting conflict of address mapping adapter B
74	Write mapped internal address setting conflict between address mapping adapters A and B
75	I/O quantity of DeviceNet module exceeding the maximum value
76	Number of parallel motors set incorrectly: The number of permanent magnet synchronous motor can only be 1.
77	Card type setting incorrect of custom communication card
78	The back EMF corresponding to the maximum speed of the synchronous motor is excessively high. Inhibiting pulse generation during operating at high speed may damage the drive. If protective measures are set, you can set H0-41 to turn off the alarm.
79	The set maximum motor speed (d0-06) exceeds the maximum permissible output of the current carrier frequency. Increase the carrier frequency (A4-02) or A4-40 (when A4-36 = 1) or decrease the minimum carrier frequency ratio (A4-41).
80	The minimum carrier frequency ratio limit (A4-41) is lower than the minimum value allowed by the system.
81	Conflict between minimum and maximum input frequencies of frequency/torque curve in group n32
82	When d0-00 is set to synchronous motor and E0-00 is set to V/f control, the actual synchronous motor runs in SVC control mode.
83	Conflict between A4-36 [Carrier frequency adjusted with speed] and H1-80 [Pre-overtemperature action selection] (A4-36 is enabled but H1-80 is not enabled.)
89	Position correction setting parameter conflict (o19-23 is greater than or equal to o19-24.)
90	The position synchronization control reference (o16-02) is the same as the feedback source (o15-10).
91	Start position of multi-position reference > end position
92	Position reference exceeding the maximum range
93	Position feedback exceeding the maximum range
94	Negative software limit > Positive software limit
95	The speed of load monitoring curve points in group L15 is not set incrementally.

Setpoint	Definition
96	The underload threshold of load monitoring curve in group L15 is higher than or equal to overload point.
97	Excessive InoLink data exchange
98	Conflict between upper and lower limits of limit module A
99	Conflict between upper and lower limits of limit module B
100	Conflict between upper and lower limits of limit module C
101	Conflict between upper and lower limits of limit module D
102	Conflict between RFG arc time 1 and acceleration time 1 in group C8
103	Conflict between RFG arc time 1 and deceleration time 1 in group C8
104	Conflict between RFG arc time 2 and acceleration time 2 in group C8
105	Conflict between RFG arc time 2 and deceleration time 2 in group C8
106	Conflict between RFG arc time 3 and acceleration time 3 in group C8
107	Conflict between RFG arc time 3 and deceleration time 3 in group C8
108	Conflict between RFG arc time 4 and acceleration time 4 in group C8
109	Conflict between RFG arc time 4 and deceleration time 4 in group C8
110	Conflict between the setting of n34-00 or n34-47 (adjacent PZD double-word output enabled)
111	Conflict between the setting of n36-00 or n36-47 (adjacent PZD double-word output enabled)
112	Process data output setting of n1-04 to n1-19/n37-05 to n37-20 not matching the active process data displayed by n1-84/n37-87
113	Process data output setting of n2-04 to n2-19/n38-05 to n38-20 not matching the active process data displayed by n2-84/n38-87
114	Parameter mapping 1 is set incorrectly (possible causes: source of the modified value exceeds the upper and lower limits of the parameter value to be modified; the parameter is read-only; and the address of the parameter to be modified is incorrect).
115	Parameter mapping 2 is set incorrectly (possible causes: source of the modified value exceeds the upper and lower limits of the parameter value to be modified; the parameter is read-only; and the address of the parameter to be modified is incorrect).
116	Parameter mapping 3 is set incorrectly (possible causes: source of the modified value exceeds the upper and lower limits of the parameter value to be modified; the parameter is read-only; and the address of the parameter to be modified is incorrect).
117	Parameter mapping 4 is set incorrectly (possible causes: source of the modified value exceeds the upper and lower limits of the parameter value to be modified; the parameter is read-only; and the address of the parameter to be modified is incorrect).
118	Parameter mapping 5 is set incorrectly (possible causes: source of the modified value exceeds the upper and lower limits of the parameter value to be modified; the parameter is read-only; and the address of the parameter to be modified is incorrect).
119	Parameter mapping 6 is set incorrectly (possible causes: source of the modified value exceeds the upper and lower limits of the parameter value to be modified; the parameter is read-only; and the address of the parameter to be modified is incorrect).
120	Parameter mapping 7 is set incorrectly (possible causes: source of the modified value exceeds the upper and lower limits of the parameter value to be modified; the parameter is read-only; and the address of the parameter to be modified is incorrect).
121	Parameter mapping 8 is set incorrectly (possible causes: source of the modified value exceeds the upper and lower limits of the parameter value to be modified; the parameter is read-only; and the address of the parameter to be modified is incorrect).
122	Parameter mapping 9 is set incorrectly (possible causes: source of the modified value exceeds the upper and lower limits of the parameter value to be modified; the parameter is read-only; and the address of the parameter to be modified is incorrect).

Setpoint	Definition
123	Parameter mapping 10 is set incorrectly (possible causes: source of the modified value exceeds the upper and lower limits of the parameter value to be modified; the parameter is read-only; and the address of the parameter to be modified is incorrect).
124	Parameter mapping 11 is set incorrectly (possible causes: source of the modified value exceeds the upper and lower limits of the parameter value to be modified; the parameter is read-only; and the address of the parameter to be modified is incorrect).
125	Parameter mapping 12 is set incorrectly (possible causes: source of the modified value exceeds the upper and lower limits of the parameter value to be modified; the parameter is read-only; and the address of the parameter to be modified is incorrect).
126	Parameter mapping 13 is set incorrectly (possible causes: source of the modified value exceeds the upper and lower limits of the parameter value to be modified; the parameter is read-only; and the address of the parameter to be modified is incorrect).
127	Parameter mapping 14 is set incorrectly (possible causes: source of the modified value exceeds the upper and lower limits of the parameter value to be modified; the parameter is read-only; and the address of the parameter to be modified is incorrect).
128	Parameter mapping 15 is set incorrectly (possible causes: source of the modified value exceeds the upper and lower limits of the parameter value to be modified; the parameter is read-only; and the address of the parameter to be modified is incorrect).
129	Parameter mapping 16 is set incorrectly (possible causes: source of the modified value exceeds the upper and lower limits of the parameter value to be modified; the parameter is read-only; and the address of the parameter to be modified is incorrect).
130	Parameter modification conflict of parameter mapping 1 to 16 (different source values are written to the same address)
140	E3-60 [Coil I/F control] is active but d0-00 is not set to [5: Solenoid].
141	d0-00 is set to [5 solenoid], but E3-60 [I/F control of the coil] is not enabled.
142	When L1-42 is set to "Inhibited" and L1-23 [Brake release comparison value source] is set to "torque", brake release may fail upon OFF1 start command after the brake failure auto-start is activated.
143	The random PWM parameter is set improperly. Adjust the carrier frequency [A4-02] or the random PWM depth [A4-08] to ensure that the random carrier frequency is between 1.2 kHz to (U8-31 - 0.4 kHz).
501	The number of motor pole pairs is set incorrectly.
502	The motor nameplate parameters are set incorrectly. Check whether the rated voltage, current, and power are set correctly.
503	The no-load current of the asynchronous motor is too large. Please check the motor parameters and perform complete auto-tuning.
504	The rated magnetic flux is incorrect. Check whether the mutual inductance or no-load current is correct.
505	The rotor resistance of the asynchronous motor is abnormal or the rated speed is set incorrectly (d0-05 or d0-04 are set improperly).
506	The weak magnetic curve of the asynchronous motor is abnormal.
507	The number of resolver pole pairs does not match that of the motor. The number of motor pole pairs needs to be an integer multiple of the number of resolver pole pairs.

14.3.5 Pre-Charge Faults

When the state machine is in the S6 (Pre-charging) state during inverter startup and a low bus voltage is detected, the pre-charge fault (64-1) can be reported.

- When A6-00 (Rectifier control) is not enabled, the pre-charge time is 6s, which cannot be changed.

- When A6-00 (Rectifier control) is enabled, the pre-charge time depends on the rectifier control startup time (A6-01).

Therefore, ensure that the bus voltage is within the normal value range during pre-charging.

14.4 Custom External Faults and Alarms

External fault

H0-00 and H0-01 provide two ways to trigger custom external faults and inhibit drive output upon faults. You can select a bit connector from U0-00 to U4-99 as the source for triggering custom faults. A status bit of 0 indicates that the system is working normally, and a status bit of 1 triggers external fault 15-1 or 15-2.

External alarm

H0-02 and H0-03 provide two ways to trigger custom external alarms. When an alarm is triggered, the drive continues running. You can select a bit connector from U0-00 to U4-99 as the source for triggering custom external alarms. A status bit of 0 indicates that the system is working normally, and a status bit of 1 triggers external fault 63-1 or 63-2.

14.5 Custom Error Words

Group H10 contains two sets of custom fault words, including fault word 1 from H10-02 to H10-33 and fault word 2 from H10-34 to H10-65. Group H10 can be set by the user with a fault code and a fault subcode. When the fault occurred on the AC drive is consistent with the fault code and subcode set by the user, the error word bit corresponding to H10-00 to H10-01 is set to high. If the error subcode of a bit is set to 0 [all error subcodes], when a fault matches the corresponding custom fault code, the bit is set to high level.

For example, if [H10-02] is set to 15 and [H10-03] is set to 1, bit00 of [H10-00] indicates the fault state of ERR15-1 (External fault 1). If [H0-00] is set to 1 and ERR15-1 is triggered manually, H10-00 displayed 0x0001. Next, set [H0-00] to 0 to cancel the source for triggering ERR15-1. In this case, H10-00 still displays 0x0001. H10-00 can display 0x0000 only after the fault has been reset.

Parameter	Name	Description	Reference
H10-00	Custom error word 1	Error code corresponding to fault word 1	-
H10-01	Custom error word 2	Error code corresponding to fault word 2	-
H10-02	Fault word 1 - bit00 error code	Fault code that can be set by users	0 to 65535

Parameter	Name	Description	Reference
H10-03	Fault word 1 - bit00 error subcode	Error subcode that can be set by users, which corresponds to the code in H10-02	0: All error subcodes 1: Error subcode 1 2: Error subcode 2 3: Error subcode 3 4: Error subcode 4 5: Error subcode 5 6: Error subcode 6 7: Error subcode 7 8: Error subcode 8 9: Error subcode 9 10: Error subcode 10 11: Error subcode 11 12: Error subcode 12 13: Error subcode 13 14: Error subcode 14 15: Error subcode 15 16: Error subcode 16
...	...	...	...
H10-32	Fault word 1 - bit15 error code	Fault code that can be set by users	0 to 65535
H10-33	Fault word 1 - bit15 error subcode	Error subcode that can be set by users, which corresponds to the code in H10-32	Same as H10-03
H10-34	Fault word 2 - bit00 error code	Fault code that can be set by users	0 to 65535
H10-35	Fault word 2 - bit00 error subcode	Error subcode that can be set by users, which corresponds to the code in H10-34	Same as H10-03
...	...	...	...
H10-64	Fault word 2 - bit15 error code	Fault code that can be set by users	0 to 65535
H10-65	Fault word 2 - bit15 error subcode	Error subcode that can be set by users, which corresponds to the code in H10-64	Same as H10-03
U8-20	Custom error word 1	Corresponding to H10-00	-
U8-21	Custom error word 2	Corresponding to H10-01	-

14.6 Faults and Maintenance

14.6.1 Motor Control Error

14.6.1.1 Motor Stall

Parameter	Name	Value
E8-25	Motor stall detection	0: Disabled 1: Enabled Others: B connector
E8-26	Motor stall speed reference	0.0% to 100.0%
E8-27	Motor stall detection time	0.00s to 65.00s

When [E8-25] is set to 1, if the torque reaches the torque limit and the feedback speed remains lower than the threshold specified in E8-26 for a period of time longer than the time specified by E8-27, the motor stall fault (93-1) is triggered.

For possible causes and solutions, see the following table.

Possible cause	Solution
The torque limit is active and the operating speed is low.	Disable motor stall detection.
The torque limit is improper.	Check whether E2-08 to E2-13 are set correctly, especially when references are set through communication.
The load is excessive.	Check the motor load.
Motor parameters are set incorrectly.	Check whether the motor parameters are set correctly.
The encoder operates improperly.	1. Check whether the encoder is connected properly. 2. Check whether the encoder is damaged. 3. Check whether the encoder parameters are set correctly.
Motor auto-tuning is not performed.	Set motor parameters correctly, and perform motor parameter auto-tuning.
Output phase loss or output open circuit occurs.	1. Check whether the motor is wired properly. 2. Check whether the contactor on the motor side is disconnected.
The motor is started when it is still rotating or an incorrect speed is detected upon flying start.	Set the startup mode to flying start and adjust the flying start parameters.
Other causes lead to the fault.	Contact Inovance technical support.

14.6.1.2 Motor Step Loss

Parameter	Name	Reference
E8-28	Enable motor step loss detection	0: Disabled 1: Enabled
E8-29	Motor step loss detection threshold	10.0% to 80.0%
E8-30	Motor step loss detection time	0.00s to 10.00s

In FVC control mode, when [E8-28] is set to 1 and the speed deviation keeps exceeding the motor step loss detection threshold defined by E8-29 for a period longer than the time defined by E8-30, the fault 93-2 (Motor step loss) can be triggered.

For possible causes and troubleshooting, see the following table.

Possible cause	Solution
The load is excessive during high-speed operation.	Check the motor load.
A spinning motor is being started directly, which brings the motor to the generating state and leads to bus overvoltage.	Set E1-00 (Startup mode) to flying start (auto-tuning needed) or start the motor when it is at a standstill.
Motor parameters are set incorrectly.	Check whether the motor parameters are set correctly.
The encoder operates improperly.	1. Check whether the encoder is connected properly. 2. Check whether the encoder is damaged. 3. Check whether the encoder parameters are set correctly.
The motor parameter deviation is excessive.	Set motor parameters correctly and perform motor parameter auto-tuning.
Output phase loss or output open circuit occurs.	1. Check whether the motor is wired properly. 2. Check whether the contactor on the motor side is disconnected.
Other causes lead to the fault.	Contact Inovance for technical support.

14.6.1.3 Current Control Error

Parameter	Name	Reference
E8-31	Current control error detection	0: Disabled 1: Enabled
E8-32	Current control error detection threshold	10.0% to 80.0%
E8-33	Current control error detection time	0 ms to 500 ms

When [E8-31] is 1, if the deviation between the feedback and reference of torque current or exciting current exceeds the current error detection threshold (E8-32) for a period longer than the time specified by E8-33, the current control error (93-3) is triggered.

For possible causes and solutions, see the following table.

Possible cause	Solution
Open circuit occurs on the motor side.	1. Check whether a phase of the motor is disconnected. 2. Check whether the contactor on the motor side is connected properly.
The encoder is disconnected or the encoder signal is being disturbed.	Check the wiring of the encoder and handle the encoder interference.
The motor parameters are set improperly.	Set the motor parameters correctly and perform auto-tuning on all motor parameters.
Other causes lead to the fault	Contact Inovance for technical support.

14.6.1.4 Speed Open Loop Stall in SVC Mode

Parameter	Name	Reference
E8-38	Speed open loop stall detection time in SVC mode	0.000s to 65.000s

When the speed open loop is enabled in SVC mode and the motor is stalled, the fault 93-5 (Speed open loop fault in SVC mode) can be triggered.

For possible causes and solutions, see the following table.

Possible cause	Solution
The load is excessive.	Check the motor load.
Motor parameters are set incorrectly.	Check whether the motor parameters are set correctly.
Motor auto-tuning is not performed.	Set motor parameters correctly, and perform motor parameter auto-tuning.
Output phase loss or output open circuit occurs.	1. Check whether the motor is wired properly. 2. Check whether the contactor on the motor side is disconnected.
Other causes lead to the fault	Contact Inovance technical support.

14.6.2 Motor Overload Protection

Parameter	Name	Reference
E8-00	Motor overload software protection selection	0: Disabled 1: Enabled
E8-01	Motor overload software protection gain	20% to 1000%
E8-02	Motor overload pre-alarm coefficient	50% to 100%

E8-00 = 0: The motor overload protection function is disabled. The motor may be damaged due to overtemperature. Therefore, it is recommended to install a thermal relay between the drive and the motor.

E8-00 = 1: Check whether the motor is overloaded according to the inverse time-lag curve of motor overload protection. The following figure shows the default inverse time delay curve of the motor.

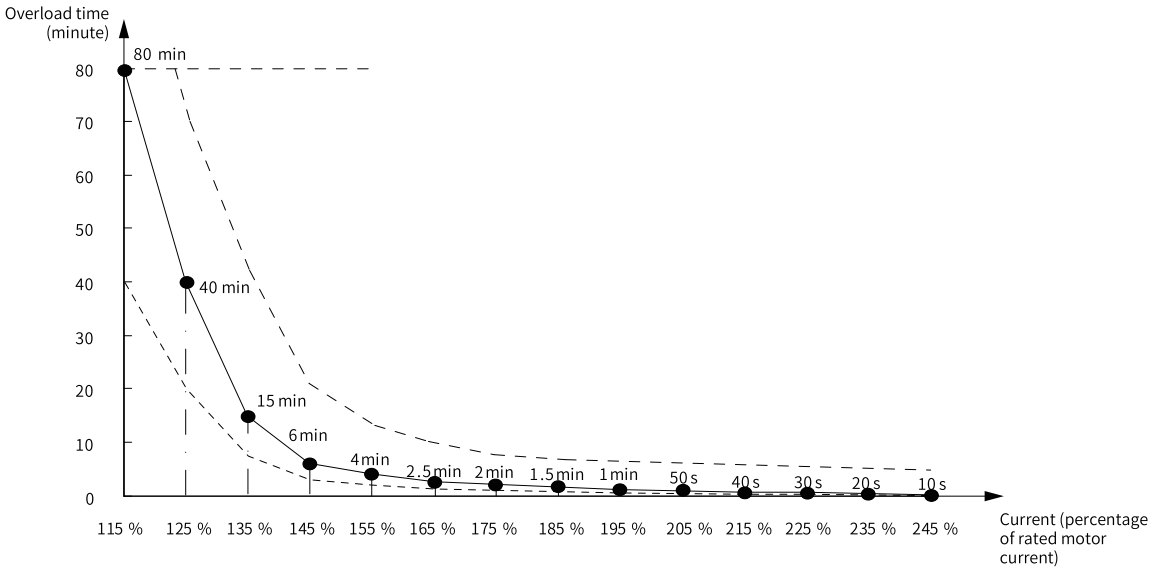


Figure 14-1 Inverse time delay curve of motor overload protection

The upper time limit for motor overload protection is 80 minutes, and the lower limit is 10s. However, the default motor overload curve may not match the actual motor overload characteristics. Set E8-01 (Motor overload software protection gain) to adjust the overload curve. As shown in the preceding figure, at the same current, the actual overload protection time is the time on the default curve multiplied by the motor overload software protection gain.

For example, to ensure that the motor reports overload after running 22 minutes at 130% current, the calculation method is as follows:

According to the motor overload curve, the overload time for motor current 125% and 135% is 40 minutes and 15 minutes, respectively. Therefore, 27.5 minutes of overload at 130% of rated motor current is calculated as follows:

$$40 + (40 - 15)/(125\% - 135\%) \times (130\% - 125\%) = 27.5 \text{ minutes}$$

To allow the overload fault to be reported 22 minutes after operating at 130% of rated current, the motor overload software protection gain needed is as follows.

$$E8\text{-}01 = 22/27.5 = 80\%$$

Note

Properly set E8-01 based on the actual overload capacity of motors. An excessively large value of the parameter may prevent the drive from reporting the error code 11-1 in time, causing damage to motors due to over-temperature.

The motor overload pre-alarm coefficient is used by the drive to provide the alarm signal in advance before the motor overload fault occurs. A lower coefficient means earlier triggering of the alarm signal. If the coefficient is 100%, the pre-overload alarm is reported at the same time as the overload fault.

For example, to allow the motor to report the overload fault 22 minutes after operating at 130% of rated current, it can be known from the above formula that E8-01 is 80%. If E8-02 is set to 80% under

this condition, when the motor operates continuously for 17.6 min (80% x 22 min) under 130% of rated current, the pre-overload state of the motor (U1-62) is set to 1.

14.6.3 Motor Runaway Protection

14.6.3.1 Synchronous Motor Runaway Protection in FVC Mode

Param.	Name	Setpoint
E8-53	Synchronous motor runaway detection in FVC mode	0: Inhibited 1: Enabled
E8-54	Synchronous motor runaway protection time in FVC mode	0.05s to 60.00s
E8-55	Synchronous motor runaway protection threshold in FVC mode	5.0% to 600.0%

When [E8-53] is set to 1, synchronous motor runaway detection protection is enabled in the FVC mode. If the feedback speed is in the same direction as the speed reference and the absolute value of the feedback speed is higher than the sum of the absolute value of the speed reference and the runaway protection threshold defined by E8-55, or if the feedback speed is in the opposite direction to the speed reference and the absolute value of feedback speed is higher than the runaway protection threshold defined by E8-55 for a period longer than the time defined by E8-54 [Runaway protection time], the fault 93-7 [Synchronous motor runaway fault] can be triggered.

The possible fault causes are listed below.

Possible cause	Solution
Check whether the zero point angle changes due to improper connection of the encoder.	Perform dynamic auto-tuning again. Check n4-12 and connect the encoder properly. Check whether the encoder shaft is locked in place.
Zero point angle auto-tuning is not performed in the FVC mode.	Check whether the value of n4-12 is normal. Set b5-00 to 2 [No-load dynamic auto-tuning] or 7 [Synchronous motor with-load dynamic auto-tuning in FVC mode].
Z signal errors occur due to encoder interference.	Check the encoder wiring to remove the interference source or replace the encoder.
The speed cannot be traced due to torque or current limit.	Check the limit values and if necessary, disable synchronous motor stall protection through E8-53.
The Kp value of the speed loop is excessively low, resulting in large speed deviation, such as speed overshoot upon brake release or acceleration.	Increase the Kp and Ti values of the speed loop.
Other causes lead to the fault.	Contact Inovance for technical support.

14.6.3.2 Asynchronous Motor Runaway Protection in SVC

Param.	Name	Setpoint
E8-61	Asynchronous motor runaway protection in SVC mode	0: Disable 1: Enable
E8-62	Asynchronous motor runaway protection threshold in SVC mode	0.0% to 50.0%
E8-63	Asynchronous motor runaway protection time in SVC mode	20 ms to 500ms

When [E8-61] is set to 1, if the detected speed deviation exceeds the threshold defined by E8-62 for a period longer than the time defined by E8-63, Then, the fault 93-9 [Asynchronous motor runaway fault in SVC mode] can be triggered.

The possible fault causes are listed below.

Possible cause	Solution
The SVC speed open loop is enabled, the load is excessive, and current reference set for speed open loop is exceeded.	If the fault is reported during acceleration, increase E11-10 [Speed open loop acceleration current]. If the fault is reported during steady-state operation, increase E11-09 [Speed open-loop current]. Ensure that the sum of E11-10 and E11-09 is higher than the torque required by the load and acceleration.
The SVC speed open loop is enabled, and a restart is performed when the motor is in coasting state.	Set E1-00 [Startup mode] to flying start.
The SVC speed open loop is not enabled and basic motor auto-tuning parameters are abnormal, which result in SVC model errors.	Check whether the basic motor auto-tuning parameters in group d1 are correct. If not, set b5-00 to 2 [No-load complete auto-tuning] in no-load conditions to perform auto-tuning again. In loaded conditions, set b5-00 to 9 [With-load dynamic auto-tuning of asynchronous motor] to perform auto-tuning again. Note that the speed reference must be kept at 35% to 80% when b5-00 is set to 9.
Other causes lead to the fault.	If an encoder can be installed, switch to FVC mode or contact Inovance technical support.

14.7 Fault List

Fault code	Name	Fault level range	Reset mode	Cause	Solution
1-1	Current detection circuit error	0: Coast to stop	Next power-on	Zero drift of the three-phase output current is excessively high.	1. In the stop state, check the three-phase output UVW current and check whether the current fluctuation exceeds 10% of the rated current. 2. Replace the power module. 3. Contact Inovance for technical support.
				The Hall sensor is disconnected.	1. Check the wiring of the three-phase output Hall sensor. 2. Replace the power module. 3. Contact Inovance for technical support.
				Zero drift of one or multiple parallel modules is excessively high.	Set A15-02 and A15-03 to enable one unit at a time to check whether the fault occurs again. In this way, you can locate the fault of a specific unit module.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
1-2	15 V power supply error	0: Coast to stop	Next power-on	The 24 V control circuit power supply of HCU is abnormal.	Replace the HCU control power supply.
				The 24 V output is short-circuited.	Rectify the 24 V power supply fault or replace the HCU control power supply.
				The 15 V output on the SOP-20-880 is short-circuited.	Replace the cable or SOP-20-880.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
1-3	EEPROM error	0: Coast to stop	Next power-on	The EEPROM chip is damaged.	1. Replace the control board. 2. Contact Inovance for technical support.
				The peripheral circuit of EEPROM is abnormal.	1. Replace the control board. 2. Contact Inovance for technical support.
1-4	Model download failure	0: Coast to stop	Next power-on	The HINT is abnormal.	Replace the HINT board.
				Strong interference exists.	Remove the interference source.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
1-5	HCU-FPGA or SRAM error	0: Coast to stop	Next power-on	The FPGA on HCU does not have software.	Contact technical support to download the correct HCU-FPGA software.
				Other fault causes lead to the fault.	1. Replace the control board. 2. Contact Inovance for technical support.
1 to 6	HINT-FPGA software update failure	0: Coast to stop	Next power-on	The FPGA on HINT does not have software.	Contact technical support to download the correct HCU-FPGA software.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
1-8	EEPROM parameter-read timeout	0: Coast to stop	Next power-on	The EEPROM chip is damaged.	1. Replace the control board. 2. Contact Inovance for technical support.
				The peripheral circuit of EEPROM is abnormal.	1. Replace the control board. 2. Contact Inovance for technical support.
1-9	EEPROM parameter saving timeout	0: Coast to stop	Next power-on	The EEPROM chip is damaged.	1. Replace the control board. 2. Contact Inovance for technical support.
				The peripheral circuit of EEPROM is abnormal.	1. Replace the control board. 2. Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
2-1	Hardware overcurrent	0: Coast to stop	Manual reset	The acceleration/deceleration time is too short.	Set the acceleration/deceleration time properly.
				The power rating of the drive is low.	Select a drive with proper power rating.
				A grounding fault or short circuit occurs on the output circuit of the drive.	Rectify peripheral faults and ensure that short circuit does not occur on the motor, output contactor, or braking resistor.
				The control mode is FVC or SVC, and the motor is started without parameter auto-tuning.	Set motor parameters correctly according to the motor nameplate, and start the motor after auto-tuning of the motor parameters is done.
				In fast acceleration/deceleration conditions, the acceleration/ deceleration time is too short.	Set the acceleration/deceleration time properly.
				The manual torque boost or V/f curve is improper.	1. Set the torque boost parameters properly. 2. Set the V/f curve correctly.
				A rotating motor is being started.	Set E1-00 to "Flying start" (parameter auto-tuning needed) or wait until the motor stops before start.
				The encoder feedback signal in FVC mode is abnormal.	Check whether external interference source exists around the encoder. Replace the encoder or encoder output cable.
				The motor cable is excessively long.	Install an output reactor or reduce the length of the motor cable.
				The DC bus voltage is excessively low.	Adjust the DC bus voltage to a value within the normal range.
				Motor parameters are set improperly.	Set the motor parameters correctly.
				The Hall circuit is abnormal.	1. Change the wiring of the Hall device. 2. Replace the Hall power supply. 3. Replace the Hall sensor.
				Peripheral devices are faulty.	View the historical fault records. If the current upon fault does not reach the overcurrent threshold, check the interference source.
				A current sampling DIP switch error occurs after the power board is replaced.	1. See the DIP switch of the power board before replacement. 2. Contact Inovance for technical support.
				Other causes: 1. Connect the capacitive load to the output. 2. Connect the output to a transformer or filter.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
2-2	Software overcurrent	0: Coast to stop	Manual reset	A4-20 [Software overcurrent threshold] is set to an excessively low value.	Set A4-20 properly (The value 100% is recommended to disable software overcurrent detection).
				A grounding fault or short circuit occurs on the output circuit of the drive.	Rectify peripheral faults, and check whether short circuit occurs on the motor or motor cables.
				The control mode is FVC or SVC, and the motor is started without parameter auto-tuning.	Set motor parameters correctly according to the motor nameplate, and start the motor after auto-tuning of the motor parameters is done.
				In fast acceleration/deceleration conditions, the acceleration/ deceleration time is too short.	Set the acceleration/deceleration time properly.
				The manual torque boost or V/f curve is improper.	1. Set the torque boost parameters properly. 2. Set the V/f curve correctly.
				A rotating motor is being started.	Enable flying start or start the motor after it stops.
				The encoder feedback signal in FVC mode is abnormal.	Check whether the encoder feedback signal is normal. Eliminate external interference sources or replace the encoder cable.
				The power rating of the drive is low.	Select a drive with proper power rating.
				The DC bus voltage is low.	Adjust the DC bus voltage to a value within the normal range.
				Motor parameters are set improperly.	Set the motor parameters correctly.
				Peripheral devices are faulty.	1. Check the fault log. If the current upon fault is far below the overcurrent threshold, check for interference sources. 2. If no external interference source exists, the driver board or the HALL device may be faulty. In this case, replace the driver board or Hall device.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
2-6	Phase U hardware overcurrent	0: Coast to stop	Manual reset	The power rating of the drive is low.	Select a drive with proper power rating.
				A grounding fault or short circuit occurs on the output circuit of the drive.	Rectify peripheral faults, and check whether short circuit occurs on the motor or motor cables.
				The control mode is FVC or SVC, and the motor is started without parameter auto-tuning.	Set motor parameters correctly according to the motor nameplate, and start the motor after auto-tuning of the motor parameters is done.
				In fast acceleration/deceleration conditions, the acceleration/ deceleration time is too short.	Set the acceleration/deceleration time properly.
				The manual torque boost or V/f curve is improper.	1. Set the torque boost parameters properly. 2. Set the V/f curve correctly.
				A rotating motor is being started.	Set E1-00 to "Flying start" (parameter auto-tuning needed) or wait until the motor stops before start.
				The encoder feedback signal in FVC mode is abnormal.	Check whether the encoder feedback signal is normal. Eliminate external interference sources or replace the encoder cable.
				The motor cable is too long.	Install an output reactor or reduce the length of the motor cable.
				The DC bus voltage is low.	Adjust the DC bus voltage to a value within the normal range.
				Motor parameters are set improperly.	Set the motor parameters correctly.
				The Hall circuit is abnormal.	1. Change the wiring of the Hall device. 2. Replace the Hall power supply. 3. Replace the faulty Hall sensor.
				Peripheral devices are faulty.	View the historical fault records. If the current upon fault does not reach the overcurrent threshold, check the interference source.
				A current sampling DIP switch error occurs after power board replacement.	1. See the DIP switch of the power board before replacement. 2. Contact Inovance for technical support.
				Other causes: 1. Connect the output to the capacitive load. 2. Connect the output to a transformer or filter.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
2-7	Phase V hardware overcurrent	0: Coast to stop	Manual reset	The power rating of the drive is low.	Select a drive with proper power rating.
				A grounding fault or short circuit occurs on the output circuit of the drive.	Rectify peripheral faults, and check whether short circuit occurs on the motor or motor cables.
				The control mode is FVC or SVC, and the motor is started without parameter auto-tuning.	Set motor parameters correctly according to the motor nameplate, and start the motor after auto-tuning of the motor parameters is done.
				In fast acceleration/deceleration conditions, the acceleration/ deceleration time is too short.	Set the acceleration/deceleration time properly.
				The manual torque boost or V/f curve is improper.	1. Set the torque boost parameters properly. 2. Set the V/f curve correctly.
				A rotating motor is being started.	Set E1-00 to "Flying start" (parameter auto-tuning needed) or wait until the motor stops before start.
				The encoder feedback signal in FVC mode is abnormal.	Check whether the encoder feedback signal is normal. Eliminate external interference sources or replace the encoder cable.
				The motor cable is too long.	Install an output reactor or reduce the length of the motor cable.
				The DC bus voltage is low.	Adjust the DC bus voltage to a value within the normal range.
				Motor parameters are set improperly.	Set the motor parameters correctly.
				The Hall circuit is abnormal.	1. Change the wiring of the Hall device. 2. Replace the Hall power supply. 3. Replace the Hall sensor.
				Peripheral devices are faulty.	View the historical fault records. If the current upon fault does not reach the overcurrent threshold, check the interference source.
				A current sampling DIP switch error occurs after power board replacement.	1. See the DIP switch of the power board before replacement. 2. Contact Inovance for technical support.
				Other causes: 1. Connect the output to the capacitive load. 2. Connect the output to a transformer or filter.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
2-8	Phase W hardware overcurrent	0: Coast to stop	Manual reset	The power rating of the drive is low.	Select a drive with proper power rating.
				A grounding fault or short circuit occurs on the output circuit of the drive.	Rectify peripheral faults, and check whether short circuit occurs on the motor or motor cables.
				The manual torque boost or V/f curve is improper.	1. Set the torque boost parameters properly. 2. Set the V/f curve correctly.
				A rotating motor is being started.	Set E1-00 to "Flying start" (parameter auto-tuning needed) or wait until the motor stops before start.
				The encoder feedback signal in FVC mode is abnormal.	Check whether the encoder feedback signal is normal, rectify external interference source or replace the encoder cable.
				The motor cable is too long.	Install an output reactor or reduce the length of the motor cable.
				The DC bus voltage is low.	Adjust the DC bus voltage to a value within the normal range.
				Motor parameters are set improperly.	Set the motor parameters correctly.
				The Hall circuit is abnormal.	1. Change the wiring of the Hall device. 2. Replace the Hall power supply. 3. Replace the faulty Hall sensor.
				Peripheral devices are faulty.	View the historical fault records. If the current upon fault does not reach the overcurrent threshold, check the interference source.
				A current sampling DIP switch error occurs after the power board is replaced.	1. See the DIP switch of the power board before replacement. 2. Contact Inovance for technical support.
				Other causes: 1. Connect the capacitive load to the output. 2. Connect the output to a transformer or filter.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
2-10	Instantaneous overcurrent of synchronous motor	0: Coast to stop	Manual reset	1. The load is excessive. Reduce the output power.	Contact Inovance for technical support.
				2. Check whether the threshold for demagnetization protection is set properly.	Contact Inovance for technical support.
				3. The control mode is FVC or SVC, but the motor is started without parameter auto-tuning.	Set motor parameters correctly according to the motor nameplate, and start the motor after auto-tuning of the motor parameters is done.
				In fast acceleration/deceleration conditions, the acceleration/ deceleration time is too short.	Set the acceleration/deceleration time properly.
				5. The motor saturation characteristics are not obvious, leading to incorrect magnetic polarity auto-tuning.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
5-1	DC overvoltage	0: Coast to stop	Manual reset	The DC bus voltage is excessively high.	1. Increase the DC bus voltage to a value within the normal range. 2. Enable the Vdc_max overvoltage suppression algorithm, adjust parameters in group E9 in vector control, and adjust parameters in group E3 in V/f control. 3. Optimize Vdc_max overvoltage suppression parameters, adjust parameters in group E9 in vector control, and adjust parameters in group E3 in V/f control. 4. Increase the acceleration/deceleration time.
				The DC bus overvoltage threshold is set improperly.	Check whether A4-15 is set properly.
				The starting voltage of the braking unit is excessively high.	Reduce the starting voltage of the braking unit.
				In generating state, the braking unit is not installed or the braking resistor model is improper.	Install a braking unit or select a proper braking resistor.
				The voltage class of the drive is improper.	Select a drive model with the proper voltage class.
				The drive model is incorrect.	Contact Inovance for technical support.
				Overvoltage suppression parameters are set improperly.	1. In V/f control mode, check whether the overvoltage suppression (E3-30) is enabled. If it is enabled, set E3-31...E3-35 properly. 2. In vector control mode, check whether E9-01 is enabled. If so, set E9-02 properly.
				The correction factor of the DC bus voltage is set improperly.	Set the DC voltage sampling gain (A3-09) properly.
				In the vector control mode, speed loop parameters are set improperly.	Excessively low speed loop parameter values can cause power generation during recovery from speed overshoot. Excessively high speed loop parameter values or excessively high speed feedback fluctuation can result in high frequency oscillation and overvoltage during high-speed operation. In this case, set speed loop parameters properly.
				The motor is still rotating. Starting a rotating motor can change the motor to power generation state, resulting in bus overvoltage.	Set E1-00 to "Flying start" (parameter auto-tuning needed) or wait until the motor stops before start.
				A ground fault occurs.	If the output end is short-circuited to ground, overvoltage may occur during operation. Check whether the insulation on the output end is normal with a megger.
				Check whether the model parameters are modified. Check A2-01/A2-03.	Modify model parameters.
				Other causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
5-3	The bus voltage is high during simulation.	0: Coast to stop	Manual reset	Simulation applies when the bus voltage is higher than 48 V.	Switch off the bus voltage before entering the simulation mode.
9-1	DC undervoltage	0: Coast to stop	Manual reset	The input voltage is abnormal.	1. Check whether the input voltage is excessively low. 2. Check whether input phase loss or open circuit occurs. 3. Enable Vdc_min undervoltage suppression if the load and process allow.
				The DC bus undervoltage threshold is set improperly.	1. Check whether the preset DC bus undervoltage threshold (A4-18) is excessively high. 2. Adjust the effective value of the undervoltage threshold through A4-16 and A4-17.
				The voltage class of the drive is incorrect. Check the rated voltage through A2-02.	Select a drive model with the proper voltage class.
				The undervoltage suppression has been set but parameters are set improperly.	1. Check whether E9-03 is enabled in vector control and set E9-04 to E9-06 properly. 2. Enable E3-36 in V/f control and adjust E3-37...E3-40 properly.
				The displayed DC bus voltage is abnormal.	1. Set the DC voltage sampling gain (A3-09) properly. 2. The hardware sampling circuit is abnormal. 3. Contact Inovance for technical support.
				The pre-charge resistor is not disconnected properly.	Check whether the pre-charge resistor is disconnected.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
9-2	Low voltage fault	0: Coast to stop	Manual reset	The excessively low input voltage lasts for a long time.	Ensure that the input voltage is correct.
				The load inertia is excessively low to maintain the DC bus voltage.	-
				The set frequency threshold is excessively high.	1. Set the frequency threshold (E9-04) properly in vector control. 2. Set the frequency threshold (E3-37) properly in V/f control.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
10-1	Drive overload	0: Coast to stop	Manual reset	The load is excessive.	1. Reduce the load. 2. Select the drive with a proper power rating.
				Parameter auto-tuning is not performed in vector control.	Set motor parameters correctly and perform parameter auto-tuning before operation.
				The torque boost parameter is set to an excessively high value in V/f control.	1. E3-14 and E3-15 are set to excessively high values during manual torque boost. 2. During automatic torque boost, perform operation after static auto-tuning is done.
				The motor is stalled.	Check the motor and mechanical conditions.
				The drive operates with high load at low speed for a long term.	The derating coefficient must be taken into account when the drive runs at low frequency for a long time. Increase the power of the drive properly.
				Derating occurs due to excessively high carrier frequency.	Reduce the carrier frequency by setting A4-02.
				Speed tracking fails.	The speed tracked is inconsistent with the actual motor speed. After operation, the drive is overloaded due to excessively high current. During high-speed tracking, increase the value of E7-02 (Speed tracking filter cutoff frequency).
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
10-2	Pulse-by-pulse current limit fault	0: Coast to stop	Manual reset	The acceleration/deceleration time is too short.	Set the acceleration/deceleration time properly.
				The power rating of the drive is low.	Select a drive with proper power rating.
				A grounding fault or short circuit occurs on the output circuit of the drive.	Rectify peripheral faults, and check whether short circuit occurs on the motor or motor cables.
				The control mode is FVC or SVC, and the motor is started without parameter auto-tuning.	Set motor parameters correctly according to the motor nameplate, and start the motor after auto-tuning of the motor parameters is done.
				In fast acceleration/deceleration conditions, the acceleration/ deceleration time is too short.	Set the acceleration/deceleration time properly.
				The manual torque boost or V/f curve is improper.	1. Set the torque boost parameters properly. 2. Set the V/f curve correctly.
				A rotating motor is being started.	Set E1-00 to “Flying start” (parameter auto-tuning needed) or wait until the motor stops before start.
				The encoder feedback signal in FVC mode is abnormal.	Check whether the encoder feedback signal is normal, rectify external interference source or replace the encoder cable.
				The motor cable is too long.	Install an output reactor or reduce the length of the motor cable.
				The DC bus voltage is low.	Adjust the DC bus voltage to a value within the normal range.
				Motor parameters are set improperly.	Set the motor parameters correctly.
				The Hall circuit is abnormal.	1. Change the wiring of the Hall device. 2. Replace the Hall power supply. 3. Replace the Hall sensor.
				Peripheral devices are faulty.	View the historical fault records. If the current upon fault does not reach the overcurrent threshold, check the interference source.
				A current sampling DIP switch error occurs after power board replacement.	1. See the DIP switch of the power board before replacement. 2. Contact Inovance for technical support.
				Other causes: 1. Connect the output to the capacitive load. 2. Connect the output to the transformer or filter.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
11-1	Motor overload	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The load is excessive.	1. Reduce the load or replace with a motor with a higher power rating. 2. Eliminate the excessive external mechanical load.
				Parameter auto-tuning is not performed in vector control.	Set motor parameters correctly and perform parameter auto-tuning before operation.
				The torque boost parameter is set to an excessively high value in V/f control.	1. E3-14 and E3-15 are set to excessively high values during manual torque boost. 2. During automatic torque boost, perform operation after static auto-tuning is done.
				The motor overload protection gain is set improperly.	Ensure that E8-01 is set to an excessively low value.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
13-1	Phase U loss	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The motor phase U cable is disconnected or connected improperly.	Replace motor U/V/W cables.
				The output contactor is not closed or is abnormal.	Ensure that the output contactor is closed properly.
				The motor three-phase winding is abnormal.	Replace the motor.
				The hardware current detected is abnormal.	1. Rectify the hardware current detection circuit fault. 2. Replace the power board or Hall.
				The driver board is abnormal.	1. Ensure that the drive circuit cable is connected properly. 2. Replace the power board.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
13-2	Phase V loss	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The motor V cable is disconnected or connected improperly.	Replace motor U/V/W cables.
				The output contactor is not closed or is abnormal.	Ensure that the output contactor is closed properly.
				The motor three-phase winding is abnormal.	Replace the motor.
				The hardware current detected is abnormal.	1. Rectify the hardware current detection circuit fault. 2. Replace the power board or Hall.
				The driver board is abnormal.	1. Ensure that the drive circuit cable is connected properly. 2. Replace the power board.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
13-3	Phase W loss	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The motor phase W cable is disconnected or connected properly.	Replace motor U/V/W cables.
				The output contactor is not closed or is abnormal.	Ensure that the output contactor is closed properly.
				The motor three-phase winding is abnormal.	Replace the motor.
				The hardware current detected is abnormal.	1. Rectify the hardware current detection circuit fault. 2. Replace the power board or Hall.
				The driver board is abnormal.	1. Ensure that the drive circuit cable is connected properly. 2. Replace the power board.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
13-4	Two- or three-phase loss	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The motor cables are disconnected or connected improperly.	Replace motor U/V/W cables.
				The output contactor is not closed or is abnormal.	Ensure that the output contactor is closed properly.
				The motor three-phase winding is abnormal.	Replace the motor.
				The driver board is abnormal.	1. Ensure that the drive circuit cable is connected properly. 2. Replace the power board.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
14-1	Phase U module overtemperature	0: Coast to stop	Manual reset	The ambient temperature is high.	Reduce the ambient temperature to ensure that the air inlet temperature does not exceed 40°C.
				The load is excessive.	Reduce the load.
				The air duct is blocked.	Clean the air duct.
				The fan operates improperly. 1. The fan stops or the speed is low. 2. The power supply board is abnormal.	1. Replace the damaged fan. 2. Replace the power supply board of the fan.
				Thermistor of the module is abnormal.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
14-2	Phase V module overtemperature	0: Coast to stop	Manual reset	The ambient temperature is high.	Reduce the ambient temperature to ensure that the air inlet temperature does not exceed 40°C.
				The load is excessive.	Reduce the load.
				The air duct is blocked.	Clean the air duct.
				The fan operates improperly. 1. The fan stopped or the speed is low. 2. The fan power supply board is abnormal.	1. Replace the damaged fan. 2. Replace the power supply board of the fan.
				Thermistor of the module is abnormal.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
14-3	Phase W module overtemperature	0: Coast to stop	Manual reset	The ambient temperature is high.	Reduce the ambient temperature to ensure that the air inlet temperature does not exceed 40°C.
				The load is excessive.	Reduce the load.
				The air duct is blocked.	Clean the air duct.
				The fan operates improperly. 1. The fan stops or the speed is low. 2. The fan power supply board is abnormal.	1. Replace the damaged fan. 2. Replace the power supply board of the fan.
				Thermistor of the module is abnormal.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
14-4	Temperature switch fault	0: Coast to stop	Manual reset	The ambient temperature is high.	Reduce the ambient temperature to ensure that the air inlet temperature does not exceed 40°C.
				The load is excessive.	Reduce the load.
				The air duct is blocked.	Clean the air duct.
				The fan operates improperly. 1. The fan stops or the speed is low. 2. The fan rotates in reverse direction.	1. Replace the damaged fan. 2. Replace the power supply board of the fan.
				The module temperature switch is abnormal.	1. Check whether the wiring circuit of the temperature switch is disconnected. 2. Check whether the temperature switch is normal.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
14-5	Rectifier module overtemperature	0: Coast to stop	Manual reset	The ambient temperature is high.	Reduce the ambient temperature to ensure that the air inlet temperature does not exceed 40°C.
				The load is excessive.	Reduce the load.
				The air duct is blocked.	Clean the air duct.
				The fan operates improperly. 1. The fan stops or the speed is low. 2. The fan power supply board is abnormal.	1. Replace the damaged fan. 2. Replace the power supply board of the fan.
				Thermistor of the module is abnormal.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
14-7	Control chamber overtemperature	0: Coast to stop	Manual reset	The ambient temperature is high.	Reduce the ambient temperature to ensure that the air inlet temperature does not exceed 40°C.
				The load is excessive.	Reduce the load.
				The air duct is blocked.	Clean the air duct.
				The fan operates improperly. 1. The fan stops or the speed is low. 2. The fan power supply board is abnormal.	1. Replace the damaged fan. 2. Replace the power supply board of the fan.
				Thermistor of the module is abnormal.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
15-1	External fault 1	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The setting source of H0-00 is active.	Check whether the setting source is active.
				H0-00 is set improperly.	1. Set H0-00 to 0. 2. Set H0-00 correctly.
15-2	External fault 2	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The setting source of H0-01 is active.	Check whether the setting source is active.
				H0-01 is set improperly.	1. Set H0-01 to 0. 2. Set H0-01 correctly.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
15-3	Motor overtemperature	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The cooling fan of the motor is stalled or abnormal.	Rectify exceptions of the cooling fan and air outlet of the motor.
				The motor is overloaded.	Prevent the motor from being overloaded for a long time.
				The temperature detection circuit is abnormal.	Ensure that the temperature detection circuit is connected properly.
				The motor temperature detection mode [E8-22] is set incorrectly.	1. Check the motor temperature detection mode. 2. Check the signal source: PG card or AI terminal. 3. Check whether the sensor type is selected correctly.
				The motor overtemperature protection threshold [E8-23] is set improperly.	Check whether the motor overtemperature protection threshold is set to an excessively low value.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
19-1	Auto-tuning of UV/UVW sampling proportional gain failed	0: Coast to stop	Manual reset	The motor is not connected.	1. Ensure that the motor is connected properly. 2. Ensure that the output contactor is connected properly.
				Output phase loss occurs.	1. Ensure that the motor is connected properly. 2. Ensure that the output contactor is connected properly. 3. See the description for F13-1.
				Motor basic parameters are set incorrectly.	Set motor basic parameters correctly according to the motor nameplate.
				The power rating of the drive is low.	Select the drive with a proper power rating.
				Other fault causes lead to the fault.	1. Check whether the module is normal by setting b5-01 to 1. 2. Contact Inovance for technical support.
19-2	Auto-tuned current too low	0: Coast to stop	Manual reset	The motor is not connected or the motor wiring is abnormal.	1. Replace the motor cables. 2. Contact Inovance for technical support.
19-3	Auto-tuning of rotor resistance and leakage inductance failed	0: Coast to stop	Manual reset	The auto-tuning process has been interrupted.	Ensure that the start/stop control word during motor auto-tuning is normal.
				A fault occurs during auto-tuning.	Rectify the fault reported by the controller.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
19-4	No-load auto-tuning of no-load current and mutual inductance failed	0: Coast to stop	Manual reset	Set the motor speed upper limit to a value lower than 75%.	Modify the motor speed upper limit to a value higher than 75%.
				Deviation of the auto-tuned values is excessive.	1. Check whether motor nameplate parameters are set properly. 2. Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
19-5	With-load auto-tuning of asynchronous motor no-load current and mutual inductance failed	0: Coast to stop	Manual reset	The motor parameters are set incorrectly or the drive model is set improperly.	Set basic parameters of the motor properly. Ensure that the power and current of the motor and drive match each other and motor cables are connected properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
19-6	Auto-tuning of motor and load inertia failed	0: Coast to stop	Manual reset	Set the motor speed upper limit to a value lower than 75%.	Modify the motor speed upper limit to a value higher than 75%.
				The auto-tuning process lasts for a long time.	1. Set parameters in group E4 according to the parameter guide. 2. Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
19-7	Dead zone auto-tuning failure	0: Coast to stop	Manual reset	Motor basic parameters are set improperly.	Set the motor parameters according to the motor nameplate and perform motor parameter auto-tuning.
				The bus voltage fluctuates.	Contact Inovance for technical support.
				The motor rotates.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
19-8	Auto-tuned rotor resistance beyond the limit	0: Coast to stop	Manual reset	The rated speed of the asynchronous motor is set incorrectly, and motor nameplate parameters are set to values inconsistent with actual values.	Set the motor parameters according to the motor nameplate and perform motor parameter auto-tuning.
				The power of the drive deviates greatly from that of the motor.	Select the module model properly.
				The motor is rotating during static auto-tuning.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
19-9	With-load auto-tuning of asynchronous motor failed	0: Coast to stop	Manual reset	The torque limit is not released.	Release the torque limit to a proper value.
				The speed reference is excessively low.	Improve the speed reference for with-load auto-tuning. It is recommended to use the default value.
				Motor basic parameters are set incorrectly.	Set motor basic parameters correctly according to the motor nameplate.
				Static auto-tuning [b5-00 =1] or complete static auto-tuning [b5-00=3] is not performed.	Perform static auto-tuning before performing with-load auto-tuning.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
19-10	Synchronous motor pole auto-tuning failure	0: Coast to stop	Manual reset	Absence of magnetic saturation in motor results in auto-tuning failure.	1. Check whether motor parameters are set properly. 2. Check whether the motor model is correct.
				Motor basic parameters are set incorrectly.	Set motor basic parameters correctly according to the motor nameplate.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
19-11	Current searching failure in magnetic pole auto-tuning of synchronous motor	0: Coast to stop	Manual reset	Check the motor for phase loss or open circuit.	Ensure that motor cables are connected properly.
19-12	Failure to obtain the Z signal during synchronous motor auto-tuning	0: Coast to stop	Manual reset	Z signal is connected improperly.	Ensure that the Z signal is connected properly.
19-13	Synchronous motor with-load auto-tuning failure	0: Coast to stop	Manual reset	The encoder phase sequence is connected reversely.	1. Ensure that the encoder cable is connected properly. 2. Invert the values of n4/5/6-03 and perform auto-tuning again. 3. Contact Inovance for technical support.
19-14	High-frequency injection auto-tuning fault	0: Coast to stop	Manual reset	Motor saturation characteristics are not obvious.	Set E11-57 to 0.
19-15	Auto-tuning failure	0: Coast to stop	Manual reset	Auto-tuning is not done.	Perform auto-tuning again. If auto-tuning fails, contact technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
19-16	Auto-tuning interrupted	0: Coast to stop	Manual reset	The auto-tuning process has been interrupted.	Ensure that the start/stop control word is normal during motor auto-tuning.
				A fault occurs during auto-tuning.	Rectify the fault reported.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
20-1	Encoder open circuit (hardware detection)	0: Coast to stop	Manual reset	The encoder is damaged.	Replace the encoder.
				The encoder power supply is abnormal.	Ensure that the encoder power supply is connected properly and that the encoder power supply voltage is consistent with the PG card power supply voltage.
				The encoder cable is wired improperly.	Ensure that the encoder cable is connected properly.
				The encoder open circuit detection method is set improperly.	Check whether n4-10/n5-10/n6-10 is set incorrectly. For example, if this parameter is set to 4 for AB single-ended signals, a fault can be reported if this parameter is set to the default value 2.
				The encoder signal is being disturbed seriously.	1. Check that the encoder shield is grounded properly. 2. Route the signal cable and power cable of the encoder through different routes.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
20-2	Incorrect encoder parameter setting (which is detected only during auto-tuning) (reserved)	0: Coast to stop	Manual reset	Parameters are set improperly.	1. Set the encoder pulses per revolution correctly. 2. Set motor parameters (rated motor speed, frequency, and number of pole pairs) correctly.
				The encoder is faulty.	1. Install the encoder properly. 2. Ensure that the encoder cable is wired properly. 3. Ensure that the encoder feedback signal and power supply are normal. 4. Replace the encoder.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
20-4	FVC operation applied without an encoder	0: Coast to stop	Manual reset	The PG card is offline or not installed.	1. Check that the PG card is installed properly. 2. Check that the PG card is online (n4-01).
				The PG card module is connected loosely.	Re-install or fix the PG card module.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
20-5	Encoder speed measurement fluctuation or pulse feedback fluctuation outside the permissible range	0: Coast to stop	Manual reset	The encoder is installed improperly.	Install the encoder properly.
				The encoder signal is being disturbed.	1. Ground the encoder shield. 2. Route the signal cable and power cable of the encoder through different routes. 3. If emergency operation is needed, increase the value of n4-21 or n4-23 properly, or set n4-20 to 0 to turn off software open circuit detection.
				The encoder power supply is abnormal.	Ensure the encoder is powered properly.
				The encoder is disconnected.	Replace the encoder signal cable.
				The motor gets stuck suddenly.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
20-6	Switching from FVC to SVC activated	0: Coast to stop	Manual reset	The encoder is installed improperly.	Install the encoder properly.
				The encoder signal is being disturbed.	1. Ground the encoder shield. 2. Route the signal cable and power cable of the encoder through different routes. 3. If emergency operation is needed, increase the value of n4-21 or n4-23 properly, or set n4-20 to 0 to turn off software open circuit detection.
				The encoder power supply is abnormal.	Ensure the encoder is powered properly.
				The encoder is disconnected.	Replace the encoder signal cable.
				The motor gets stuck suddenly.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
20-8	Z signal interference fault	0: Coast to stop	Manual reset	The Z signal is being disturbed when the synchronous motor equipped with an ABZ encoder operates in the closed-loop control mode.	Install the encoder properly.
20-9	Z signal loss fault	0: Coast to stop	Manual reset	The Z signal is lost when the synchronous motor equipped with an ABZ encoder operates in closed-loop control mode.	Contact Inovance for technical support.
20-10	The software version of the encoder signal detection module is too early.	0: Coast to stop	Manual reset	The software version of the encoder signal detection module does not support permanent magnet synchronous motor control.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
20-11	The software version of the encoder signal detection module does not match.	0: Coast to stop	Manual reset	The PG module does not support speed measurement at the current carrier frequency.	Contact Inovance for technical support.
20-12	Absolute position encoder angle error	0: Coast to stop	Manual reset	1. The encoder rotor slips. 2. The accurate zero angle is not auto-tuned by the encoder. 3. Other fault causes lead to the fault.	Install the position encoder correctly and auto-tune its zero angle.
20-14	Sine-cosine encoder open circuit (hardware detection)	0: Coast to stop	Manual reset	Open circuit is detected on the sine-cosine encoder.	Check the encoder and cabling. Switch to ENDAT speed measurement or SVC for operation.
20-15	ENDAT encoder open circuit (hardware detection)	0: Coast to stop	Manual reset	Open circuit is detected on the ENDAT encoder.	Check the encoder and cabling. Switch to SVC for operation.
22-1	Encoder not connected	0: Coast to stop	Manual reset	The encoder is installed improperly.	Install the encoder properly.
				Parameters are set improperly.	1. Check whether encoder related parameters are set correctly and match the encoder type (Set parameters in groups n4/n5/n6 based on the setpoint of d0-11). 2. If the control mode is SVC or V/f and an encoder is not needed, disable the encoder module. (Set n4.00/n5.00/n6.00 to 0 according to the selection of d0-11.)
				The encoder cable is connected improperly.	Replace the encoder signal cable.
				The encoder power supply is abnormal.	Ensure the encoder is powered properly.
				The motor gets stuck.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
22-2	Incorrect encoder pulses per revolution	0: Coast to stop	Manual reset	Parameters are set incorrectly.	1. Set the encoder pulses per revolution correctly. 2. Set motor parameters (rated motor speed, frequency, and number of pole pairs) correctly.
				The encoder is faulty.	1. Check whether the encoder is installed properly. 2. Check whether the encoder is wired properly. 3. Check whether the encoder feedback signal and power supply are normal. 4. Replace the encoder.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
22-3	Position detection error (reserved)	0: Coast to stop	Manual reset	Other fault causes lead to the fault.	Contact Inovance for technical support.
22-4	Incorrect basic motor parameters	0: Coast to stop	Manual reset	Motor basic parameters are set incorrectly.	Set motor basic parameters correctly according to the motor nameplate.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
22-5	Incorrect motor expansion parameters	0: Coast to stop	Manual reset	Motor basic parameters are set incorrectly.	Set motor basic parameters correctly according to the motor nameplate.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
22-14	Encoder Z signal being disturbed	1: Coast to stop	Manual reset	The number of pulses between Z signals does not always meet the number of encoder pulses.	1. Check the encoder wiring and pulses per revolution. 2. Contact Inovance for technical support.
22-15	Encoder signal being disturbed	0: Coast to stop	Manual reset	The encoder signal speed measurement fluctuation is excessively high.	Ensure that the encoder is installed properly, the related signal cable is connected properly, and the shield is connected as required.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
22-16	Magnetic field saturation coefficient of asynchronous motor not auto-tuned	0: Coast to stop	Manual reset	The magnetic field saturation coefficient auto-tuning is canceled due to excessive load.	Reduce the load and perform auto-tuning again.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
23-1	Output ground fault	0: Coast to stop	Manual reset	Contact Inovance for technical support.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
31-1	PID feedback loss	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The PID feedback value is abnormal or is set incorrectly.	1. Ensure that the PID feedback source is normal. 2. Properly increase the PID feedback error detection threshold (L4-28).
				The PID feedback error detection value is set improperly.	Set the feedback error detection threshold (L4-27) properly.
				The PID feedback fluctuates greatly, and the detection time for PID feedback error is too short.	1. Check whether the PID feedback fluctuates greatly. Check the feedback signal for interference, and rectify feedback signal source errors. 2. Properly increase the PID feedback error detection threshold (L4-28).
				Other fault causes lead to the fault.	Contact Inovance for technical support.
32-1	Fan status fault	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The phase sequence of the fan is incorrect.	Ensure that the fan phase sequence and wiring are normal.
				An error or phase loss occurs on the phase sequence detection circuit.	Ensure that the input power of the phase sequence detector is normal.
				The fan phase sequence detector is damaged.	Replace the fan phase sequence detector.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
32-2	MD880 inverter fan status error	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The phase sequence of the fan is incorrect.	Ensure that the fan phase sequence and wiring are normal.
				An error or phase loss occurs on the phase sequence detection circuit.	Ensure that the input power of the phase sequence detector is normal.
				The fan phase sequence detector is damaged.	Replace the fan phase sequence detector.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
42-1	Excessive speed deviation of motor	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Automatic reset	The acceleration/deceleration time is too short. The motor cannot follow the set speed.	1. Set the acceleration/deceleration time properly. 2. Perform acceleration feedforward compensation.
				The load is excessive or the motor is stalled.	1. Reduce the load or select an appropriate drive. 2. Ensure that the motor and drive are normal.
				The detection threshold for excessive deviation (E8-06) or the detection time for excessive deviation (E8-07) is set to excessively low values.	Set E8-06 and E8-07 properly.
				The speed loop PI parameter value is excessively low in the vector control mode.	Increase the value of speed loop PI parameters.
				The encoder parameters are set incorrectly.	Set the encoder parameters correctly.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
43-1	Motor speed beyond the limit	0: Coast to stop	Manual reset	The motor is driven by an external force.	Check the actual motor load.
				In excessive load conditions, the torque limit is set improperly and the load is being accelerated by its own gravity.	Set the torque limit properly.
				In excessive load conditions, the power rating of the drive is too low to drive the load.	Select a drive with the proper power rating.
				The motor control is abnormal.	Contact Inovance for technical support.
44-1	Encoder detection module 1 activated but offline	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The slot is set improperly.	Set the slot properly.
				The expansion module slot is loosened.	Re-tighten the screws that secure the expansion module slot.
				The expansion module type is incorrect.	Check that the encoder type (n4-02) is the same as the expansion module inserted in the corresponding slot defined by n4-00 (Expansion slot selection).
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
44-2	Encoder detection module 2 activated but offline	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The slot is set improperly.	Set the slot properly.
				The expansion module slot is loosened.	Re-tighten the screws that secure the expansion module slot.
				The expansion module type is incorrect.	Check that the encoder type (n5-02) is the same as the expansion module inserted in the corresponding slot defined by n5-00 (Expansion slot selection).
				Other fault causes lead to the fault.	Contact Inovance for technical support.
44-3	Encoder detection module 3 activated but offline	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The slot is set improperly.	Set the slot properly.
				The expansion module slot is loosened.	Re-tighten the screws that secure the expansion module slot.
				The expansion module type is incorrect.	Check that the encoder type (n6-02) is the same as the expansion module inserted in the corresponding slot defined by n6-00 (Expansion slot selection).
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
44-4	I/O module 1 activated but offline	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The slot is set improperly.	Set the slot properly.
				The expansion module slot is loosened.	Check whether the expansion module slot is loosened, re-tighten the fixing screws of the expansion module slot.
				The expansion module type is incorrect.	1. Check that the expansion module inserted is I/O module. 2. Check the I/O module type through n7-02.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
44-5	I/O module 2 activated but offline	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The slot is set improperly.	Set the slot properly.
				The expansion module slot is loosened.	Check whether the expansion module slot is loosened, re-tighten the fixing screws of the expansion module slot.
				The expansion module type is incorrect.	1. Check that the expansion module inserted is I/O module. 2. Check the I/O module type through n8-02.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
44-6	I/O module 3 activated but offline	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The slot is set improperly.	Set the slot properly.
				The expansion module slot is loosened.	Check whether the expansion module slot is loosened, re-tighten the fixing screws of the expansion module slot.
				The expansion module type is incorrect.	1. Check that the expansion module inserted is I/O module. 2. Check the I/O module type through n9-02.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
44-7	Bus adapter A activated but offline, configured communication card offline	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The slot is set improperly.	Set the slot properly.
				The expansion module slot is loosened.	Check whether the expansion module slot is loosened, re-tighten the fixing screws of the expansion module slot.
				The expansion module type is incorrect.	Check that the expansion module inserted matches the bus type configured by the bus adapter (n1-00).
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
44-8	Bus adapter B activated but offline, configured communication card offline	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The slot is set improperly.	Set the slot properly.
				The expansion module slot is loosened.	Check whether the expansion module slot is loosened, re-tighten the fixing screws of the expansion module slot.
				The expansion module type is incorrect.	Check that the expansion module inserted matches the bus type configured by the bus adapter (n2-00).
				Other fault causes lead to the fault.	Contact Inovance for technical support.
44-9	Bus adapter C activated but offline, configured communication card offline	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The slot is set improperly.	Set the slot properly.
				The expansion module slot is loosened.	Check whether the expansion module slot is loosened, re-tighten the fixing screws of the expansion module slot.
				The expansion module type is incorrect.	Check that the expansion module inserted matches the bus type configured by the bus adapter (n3-00).
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
44-10	Synchronous voltage detection module activated but offline	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The slot is set improperly.	Set the slot properly.
				The expansion module slot is loosened.	Check whether the expansion module slot is loosened, re-tighten the fixing screws of the expansion module slot.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
44-11	Dual-port RAM card activated but offline	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The slot is set improperly.	Set the slot properly.
				The expansion module slot is loosened.	Check whether the expansion module slot is loosened, re-tighten the fixing screws of the expansion module slot.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
44-12	Synchronous voltage detection module activated but offline	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The slot is set improperly.	Set the slot properly.
				The expansion module slot is loosened.	Check whether the expansion module slot is loosened, re-tighten the fixing screws of the expansion module slot.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
44-13	Grid voltage detection module activated but offline	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The slot is set improperly.	Set the slot properly.
				The expansion module slot is loosened.	Check whether the expansion module slot is loosened, re-tighten the fixing screws of the expansion module slot.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
44-15	HSTM-10 module activated but offline	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The slot is set improperly.	Set the slot properly.
				The expansion module slot is loosened.	Check whether the expansion module slot is loosened, re-tighten the fixing screws of the expansion module slot.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
45-1	Slot address conflict between encoder detection modules 1 and 2	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	n4-00 (Encoder detection module 1 slot selection) is set to the same as n5-00 (Encoder detection module 2 slot selection).	Set n4-00 and n5-00 correctly.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
45-2	Slot address conflict between encoder detection modules 1 and 3	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	n4-00 (Encoder detection module 1 slot selection) is set to the same as n6-00 (Encoder detection module 3 slot selection).	Set n4-00 and n6-00 correctly.
45-3	Slot address conflict between encoder detection modules 2 and 3	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	n5-00 (Encoder detection module 2 slot selection) is set to the same as n6-00 (Encoder detection module 3 slot selection).	Set n5-00 and n6-00 correctly.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
45-4	Slot address conflict between I/O modules 1 and 2	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	n7-00 (I/O module 1 slot selection) is set to the same as n8-00 (I/O module 2 slot selection).	Set n7-00 and n8-00 correctly.
45-5	Slot address conflict between I/O modules 1 and 3	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	n7-00 (I/O module 1 slot selection) is set to the same as n9-00 (I/O module 3 slot selection).	Set n7-00 and n9-00 correctly.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
45-6	Slot address conflict between I/O modules 2 and 3	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	n8-00 (I/O module 2 slot selection) is set to the same as n9-00 (I/O module 3 slot selection).	Set n8-00 and n9-00 correctly.
45-7	Slot address range conflict between bus adapters A and B	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	An address range conflict occurs between the bus type (n1-00) configured by bus adapter and the communication module configured by bus adapter (n2-00).	1. Set the slot position of the corresponding communication module correctly. 2. Install the slot of the corresponding communication module correctly.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
45-8	Slot address range conflict between bus adapters A and C	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	An address range conflict occurs between the bus type configured by bus adapter (n1-00) and the communication module configured by the redundant bus adapter (n3-00).	1. Set the slot position of the corresponding communication module correctly. 2. Install the slot of the corresponding communication module correctly.
45-9	Slot address range conflict between bus adapters B and C	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	An address range conflict occurs between the bus type configured by bus adapter (n2-00) and the communication module configured by the redundant bus adapter (n3-00).	1. Set the slot position of the corresponding communication module correctly. 2. Install the slot of the corresponding communication module correctly.
46-1	Incorrect parameter setting (for details, see U8-44)	6: Displaying this alarm only 7: No action	Automatic reset	You can check the details through U8-44.	Set parameters properly.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
46-3	Simulation mode activation	6: Displaying this alarm only 7: No action	Automatic reset	-	-
47-1	STO1 input activation	0: Coast to stop	Auto reset/ Manual reset	STO1 is activated.	Check the wiring and power supply of STO1 input circuit. Ensure that the positive and negative poles of STO1 24 VDC are connected correctly.
				The hardware does not support STO function.	If the STO function is not available, disable the detection through H0-04.
				The module is faulty.	Contact Inovance for technical support.
47-2	STO2 input activation	0: Coast to stop	Auto reset/ Manual reset	STO2 is activated.	Check the wiring and power supply of STO2 input circuit. Ensure that the positive and negative poles of STO2 24 VDC are connected correctly.
				The hardware does not support STO function.	If the STO function is not available, disable the detection through H0-04.
				The module is faulty.	Contact Inovance for technical support.
47-4	STO power supply fault	0: Coast to stop	Auto reset/ Manual reset	The STO-5 V power supply is faulty.	Ensure that the STO input circuit is connected properly with proper power supply.
				The module is faulty.	Contact Inovance for technical support.
47-5	STO1 pulse auto-test error	0: Coast to stop	Auto reset/ Manual reset	An STO1 input circuit detection error occurs.	Ensure that the STO input circuit is connected properly with proper power supply.
				The module is faulty.	Contact Inovance for technical support.
47-6	STO2 pulse auto-test error	0: Coast to stop	Auto reset/ Manual reset	An STO2 input circuit detection error occurs.	Ensure that the STO input circuit is connected properly with proper power supply.
				The module is faulty.	Contact Inovance for technical support.
47-7	STO1 buffer error	0: Coast to stop	Auto reset/ Manual reset	An STO1 logic circuit detection error occurs.	Ensure that wiring of the logic circuit and power supply of STO1 are proper.
				The module is faulty.	Contact Inovance for technical support.
47-8	STO2 buffer error	0: Coast to stop	Auto reset/ Manual reset	An STO2 logic circuit detection error occurs.	Ensure that wiring of the logic circuit and power supply of STO2 are proper.
				The module is faulty.	Contact Inovance for technical support.
47-9	STO input activated	0: Coast to stop	Auto reset/ Manual reset	The STO is activated.	1. Ensure that the wiring of input circuit and power supply of STO1 and STO2 are proper. 2. Ensure that the positive and negative poles of the 24 VDC input of STO1 and STOP2 are connected properly.
				The module is faulty.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
48-1	Motor overtemperature	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The actual temperature of the motor is high, and Thermal dissipation of the motor is abnormal.	Take measures for better dissipation of the motor.
				After the motor temperature detection is enabled, the temperature sensor type is incorrect.	Set the temperature sensor type correctly.
				After the motor temperature detection is enabled, the temperature sensor is disconnected.	Check that the temperature sensor is wired properly.
				The motor overtemperature threshold is too low.	Set the motor overtemperature threshold properly.
				The temperature detection module is abnormal.	Contact Inovance for technical support.
50-1	No SD card is detected.	6: Displaying this alarm only 7: No action	Automatic reset	The SD card is not installed or is installed improperly.	Re-install the SD card.
				The SD card is damaged.	Replace the SD card.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
50-2	SD card error	6: Displaying this alarm only 7: No action	Automatic reset	The SD card is connected loosely.	Re-install the SD card.
				The SD card is damaged.	Replace the SD card.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
51-1	Insufficient power supply for HCU-RTC unit	6: Displaying this alarm only 7: No action	Automatic reset	The RTC battery voltage is lower than 2.2 V.	Replace the RTC battery.
				The module is faulty.	Contact Inovance for technical support.
51-2	HCU-RTC read-write timeout	6: Displaying this alarm only 7: No action	Next power-on	The RTC clock chip is abnormal.	Contact Inovance for technical support.
				The peripheral circuit of RTC is abnormal.	Contact Inovance for technical support.
52-1	IDS communication fault	0: Coast to stop	Manual reset	The SOP-20-880 operating panel is disconnected from the PC.	Ensure the wiring is correct.
				The SOP-20-880 operating panel is disconnected from the drive or connected improperly.	Ensure the wiring is correct.
				Interference exists.	Eliminate external interference. You can enhance the anti-interference capability through installing a magnetic ring.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
52-2	SOP-20-880 communication fault	0: Coast to stop	Manual reset	Multiple devices are cascaded through the SOP-20-880 operating panel. In this case, when you start one device through SOP-20-880, the system may switch to another device.	1. When the SOP-20-880 operating panel gets the local control permission of the current device, switchover to other devices is not allowed. 2. Set [A10-05] to 1 to inhibit detection on communication disconnection of SOP-20-880.
				The SOP-20-880 operating panel is disconnected from the drive or connected improperly.	Ensure the wiring is correct.
				Interference exists.	Eliminate external interference. You can enhance the anti-interference capability through installing a magnetic ring.
53-1	CRC check error in the data received by HINT	0: Coast to stop	Manual reset	H8 model: The optical fiber is in poor contact or loosened.	Re-connect or replace the optical fiber.
				H8 model: The optical fiber connector is polluted by dust.	Clean or replace the optical fiber.
				H1 to H7 models: The DB15 terminal and the flat cable between the HCU and HINT are in poor contact or loose.	Check whether DB15 terminals and flat cables between HCU and HINT are connected properly. If not, rectify the fault.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
53-2	HINT ID authentication error	0: Coast to stop	Manual reset	Software versions of HCU and HINT do not match.	Check whether the MCU software type is consistent with the HINT board software type.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
53-3	Data reception failure of HCU	0: Coast to stop	Manual reset	The HINT or HPCU board is not connected or the control power supply is not switched on.	1. Connect the HINT board or the parallel board. 2. Check whether the HINT or parallel board power supply is normal.
				H8 model: The optical fiber is in poor contact or loosened.	Re-connect or replace the optical fiber.
				H8 model: The optical fiber connector is polluted by dust.	Clean or replace the optical fiber.
				H1 to H7 models: The DB15 terminal and the flat cable between the HCU and HINT are in poor contact or loose.	Check whether DB15 terminals and flat cables of the HCU and HINT are connected properly. If not, rectify the fault.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
53-4	CRC check error in the data received by HCU	0: Coast to stop	Manual reset	H8 model: The optical fiber is in poor contact or loosened.	Re-connect or replace the optical fiber.
				H8 model: The optical fiber connector is polluted by dust.	Clean or replace the optical fiber.
				H1 to H7 models: The DB15 terminal and the flat cable between the HCU and HINT are in poor contact or loose.	Check whether DB15 terminals and flat cables of the HCU and HINT are connected properly. If not, rectify the fault.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
53-5	HINT sync fault	0: Coast to stop	Manual reset	Communication errors occur.	1. H8 model: Check whether the optical fiber is loose. H1 to H7 models: Check whether DB15 terminals and flat cables of the HCU and HINT are connected properly. If not, rectify the fault. 2. Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
53-6	PWM data-write timeout	0: Coast to stop	Manual reset	The execution time of DSP is insufficient.	1. Reduce the carrier frequency. 2. Reduce the number of sampling points. 3. Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
53-7	Data reception failure of HINT	0: Coast to stop	Manual reset	H8 model: The optical fiber is in poor contact or loosened.	Re-connect or replace the optical fiber.
				H8 model: The optical fiber connector is polluted by dust.	Clean or replace the optical fiber.
				H1 to H7 models: The DB15 terminal and the flat cable between the HCU and HINT are in poor contact or loose.	Check whether DB15 terminals and flat cables of the HCU and HINT are connected properly. If not, rectify the fault.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
53-8	CRC error in the HCU data received by HPCU	0: Coast to stop	Manual reset	The optical fiber is in poor contact or loosened.	Re-connect or replace the optical fiber.
				The optical fiber connector is polluted by dust.	Clean or replace the optical fiber.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
53-9	HCU data reception failure of HPCU	0: Coast to stop	Manual reset	The optical fiber is in poor contact or loosened.	Re-connect or replace the optical fiber.
				The optical fiber connector is polluted by dust.	Clean or replace the optical fiber.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
53-10	CRC error in the HINT data received by HPCU	0: Coast to stop	Manual reset	The optical fiber is in poor contact or loosened.	Re-connect or replace the optical fiber.
				The optical fiber connector is polluted by dust.	Clean or replace the optical fiber.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
53-11	HINT data reception failure of HPCU	0: Coast to stop	Manual reset	The HINT is not powered on or the optical fiber is disconnected.	1. Check whether the HINT power supply is normal. 2. Check whether the optical fiber loop is normal.
				The optical fiber is in poor contact or loosened.	Re-connect or replace the optical fiber.
				The optical fiber connector is polluted by dust.	Clean or replace the optical fiber.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
53-12	HPCU synchronization error	0: Coast to stop	Manual reset	Communication errors occur.	Install the optical fiber properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
53-13	HINT not ready	0: Coast to stop	Manual reset	Power-on has not been completed but an operation command has been received.	Wait until HINT is powered on and then run again.
				The control power supply of HINT is abnormal.	Check whether the HINT control power is normal. If not, ensure that the control power supply is normal.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
57-1	Phase U upper bridge fault	0: Coast to stop	Manual reset	A grounding fault or short circuit occurs on the output circuit of the drive.	Rectify peripheral faults, and check whether short circuit occurs on the motor or motor cables.
				The IGBT is damaged.	Contact Inovance for technical support.
				The power board is damaged.	Replace the power board.
				The flat cable between the interface board and the power board is connected improperly.	Check that the wiring is correct.
				The flat cable between the power board and the gate driver board is connected improperly.	Check that the wiring is correct.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
57-2	Phase U lower bridge fault	0: Coast to stop	Manual reset	A grounding fault or short circuit occurs on the output circuit of the drive.	Rectify peripheral faults, and check whether short circuit occurs on the motor or motor cables.
				The IGBT is damaged.	Contact Inovance for technical support.
				The power board is damaged.	Replace the power board.
				The flat cable between the interface board and the power board is connected improperly.	Check that the wiring is correct.
				The flat cable between the power board and the gate driver board is connected improperly.	Check that the wiring is correct.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
57-3	Phase-V upper bridge fault	0: Coast to stop	Manual reset	A grounding fault or short circuit occurs on the output circuit of the drive.	Rectify peripheral faults, and check whether short circuit occurs on the motor or motor cables.
				The IGBT is damaged.	Contact Inovance for technical support.
				The power board is damaged.	Replace the power board.
				The flat cable between the interface board and the power board is connected improperly.	Check that the wiring is correct.
				The flat cable between the power board and the gate driver board is connected improperly.	Check that the wiring is correct.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
57-4	Phase V lower bridge fault	0: Coast to stop	Manual reset	A grounding fault or short circuit occurs on the output circuit of the drive.	Rectify peripheral faults, and check whether short circuit occurs on the motor or motor cables.
				The IGBT is damaged.	Contact Inovance for technical support.
				The power board is damaged.	Replace the power board.
				The flat cable between the interface board and the power board is connected improperly.	Check that the wiring is correct.
				The flat cable between the power board and the gate driver board is connected improperly.	Check that the wiring is correct.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
57-5	Phase W upper bridge fault	0: Coast to stop	Manual reset	A grounding fault or short circuit occurs on the output circuit of the drive.	Rectify peripheral faults, and check whether short circuit occurs on the motor or motor cables.
				The IGBT is damaged.	Contact Inovance for technical support.
				The power board is damaged.	Replace the power board.
				The flat cable between the interface board and the power board is connected improperly.	Check that the wiring is correct.
				The flat cable between the power board and the gate driver board is connected improperly.	Check that the wiring is correct.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
57-6	Phase W lower bridge fault	0: Coast to stop	Manual reset	A grounding fault or short circuit occurs on the output circuit of the drive.	Rectify peripheral faults, and check whether short circuit occurs on the motor or motor cables.
				The IGBT is damaged.	Contact Inovance for technical support.
				The power board is damaged.	Replace the power board.
				The flat cable between the interface board and the power board is connected improperly.	Check that the wiring is correct.
				The flat cable between the power board and the gate driver board is connected improperly.	Check that the wiring is correct.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
57-7	IGBT module fault	0: Coast to stop	Manual reset	A grounding fault or short circuit occurs on the output circuit of the drive.	Rectify peripheral faults, and check whether short circuit occurs on the motor or motor cables.
				The IGBT is damaged.	Contact Inovance for technical support.
				The power board is damaged.	Replace the power board.
				The flat cable between the interface board and the power board is connected improperly.	Check that the wiring is correct.
				The flat cable between the power board and the gate driver board is connected improperly.	Check that the wiring is correct.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
58-1	IGBT module short-circuited	0: Coast to stop	Manual reset	The IGBT module is short-circuited.	Replace the IGBT.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
58-2	Output end of the drive short-circuited	0: Coast to stop	Manual reset	Check whether short circuit occurs on the output phases.	Detect with a megger.
				Check whether the output end is short-circuited to ground.	Detect with a megger.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
58-3	AC drive output phase loss	0: Coast to stop	Manual reset	Output phase loss occurs.	Check wiring of the motor.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
58-4	Sensor detection error	0: Coast to stop	Manual reset	The Hall power supply is abnormal.	Check the Hall power supply.
				The Hall device is disconnected.	The Hall cable is loose or in poor contact.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
58-5	Sensor installed reversely	0: Coast to stop	Manual reset	The sensor is installed reversely.	Correct the sensor installation direction.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
58-6	Ground fault	0: Coast to stop	Manual reset	The output end is short-circuited to ground.	Check the insulation of the output terminal.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
58-7	Three-phase current unbalance	0: Coast to stop	Manual reset	The load at the output end is unbalanced.	Check whether the load is normal.
				Inconsistency occurs on current or Hall sensors.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
58-8	Two-phase current unbalance	0: Coast to stop	Manual reset	The load at the output end is unbalanced.	Check whether the load is normal.
				Inconsistency occurs on current or Hall sensors.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
58-16	Self-test interrupted	0: Coast to stop	Manual reset	The self-test process has been interrupted.	Ensure that the start/stop control word is normal during self-test.
				A fault occurs during self-test.	Rectify the fault reported.
				The drive stops during self-test.	Reset the fault.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
59-1	Phase U module temperature too low	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The ambient temperature is too low.	Increase the ambient temperature (turn on the air conditioner or heater).
				The temperature sampling circuit is connected improperly.	Check whether the temperature sampling circuit is connected properly. If not, rectify the fault.
				Thermistor of the module is abnormal.	Contact Inovance for technical support.
				The low temperature alarm threshold (A4-22) is set to an excessively high value.	Set the low temperature detection threshold (A4-22) properly.
59-2	Phase V module temperature too low	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The ambient temperature is too low.	Increase the ambient temperature (turn on the air conditioner or heater).
				The temperature sampling circuit is connected improperly.	Check whether the temperature sampling circuit is connected properly. If not, rectify the fault.
				Thermistor of the module is abnormal.	Contact Inovance for technical support.
				The low temperature alarm threshold (A4-22) is set to an excessively high value.	Set the low temperature detection threshold (A4-22) properly.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
59-3	Phase W module temperature too low	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The ambient temperature is too low.	Increase the ambient temperature (turn on the air conditioner or heater).
				The temperature sampling circuit is connected improperly.	Check whether the temperature sampling circuit is connected properly. If not, rectify the fault.
				Thermistor of the module is abnormal.	Contact Inovance for technical support.
				The low temperature alarm threshold (A4-22) is set to an excessively high value.	Set the low temperature detection threshold (A4-22) properly.
59-4	Rectifier module temperature too low	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The ambient temperature is too low.	Increase the ambient temperature (turn on the air conditioner or heater).
				The temperature sampling circuit is connected improperly.	Check whether the temperature sampling circuit is connected properly. If not, rectify the fault.
				Thermistor of the module is abnormal.	Contact Inovance for technical support.
				The low temperature alarm threshold (A4-22) is set to an excessively high value.	Set the low temperature detection threshold (A4-22) properly.
60-1	Ambient temperature too high	6: Displaying this alarm only	Automatic reset	The ambient temperature is high.	Lower down the ambient temperature.
				The fan is damaged.	Replace the damaged fan.
				Thermistor of the module is abnormal.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
61-1	Speed tracking current excessively high	0: Coast to stop	Manual reset	Speed tracking starts immediately after stop. The residual magnetism in the motor cause operation errors.	Increase the demagnetization time (E1-13) properly.
				Motor parameter auto-tuning is not performed.	Perform motor parameter auto-tuning again.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
61-2	Speed tracking time too long	0: Coast to stop	Manual reset	The set speed tracking time is short.	Increase the value of E7-04 (Speed tracking time).
				Set motor parameters properly.	Set motor basic parameters correctly and perform motor parameter auto-tuning again.
				Speed tracking errors occur.	Contact Inovance for technical support.
61-5	HSVM card not connected or not enabled	0: Coast to stop	Manual reset	The HSVM card is not enabled or connected when HSVM is used for synchronous motor speed tracking in SVC mode.	Install and enable the HSVM card properly.
63-1	External alarm 1	6: Displaying this alarm only	Automatic reset	The setting source of H0-02 is active.	Check whether the setting source is active.
				H0-02 is set improperly.	1. Set H0-02 to 0. 2. Set H0-02 correctly.
63-2	External alarm 2	6: Displaying this alarm only	Automatic reset	The setting source of H0-03 is active.	Check whether the setting source is active.
				H0-03 is set improperly.	1. Set H0-02 to 0. 2. Set H0-02 correctly.
63-3	Motor overtemperature alarm	6: Displaying this alarm only	Automatic reset	The cooling fan of the motor is stalled or abnormal.	Check whether the cooling fan and air outlet of the motor are normal. If not, replace the cooling fan and clean the air outlet.
				The motor is overloaded.	Avoid long-term overload operation of the motor. If unavoidable, contact Inovance technical support.
				The temperature detection circuit is abnormal.	Check the wiring of the temperature detection circuit.
				The motor temperature detection mode [E8-22] is set incorrectly.	Re-check motor temperature detection mode: 1. Check the signal source: PG card or AI terminal. 2. Check whether the sensor type is selected correctly.
				The motor overtemperature alarm threshold [E8-24] is set improperly.	Check whether the motor overtemperature protection threshold is set to an excessively low value.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
63-4	OFF2/OFF3 stop	6: Displaying this alarm only	Automatic reset	When the control channel is used to start/stop the drive, OFF2 or OFF3 of the selected control channel is activated.	Check whether OFF2 or OFF3 is activated in the start/stop control word and other control words.
				1. The other control words of the control channel are OFF. 2. The OFF2 source is activated. 3. The OFF3 source 2 or OFF3 source 3 is activated.	1. The OFF2 source of other control words of the selected control channel is activated. 2. The OFF2 source is activated. 3. The OFF3 source 2 or OFF3 source 3 is activated.
				OFF2 or OFF3 on the control panel of InoDriveStudio is not selected.	Select OFF2 and OFF3 on the control panel of InoDriveStudio.
64-1	Pre-charge failure 1	0: Coast to stop	Manual reset	The DC bus is not powered on or the voltage is low.	Increase the DC bus voltage to a value within the normal range.
				The voltage class of the drive is improper.	Select a drive model with the proper voltage class.
				The drive model is incorrect.	Contact Inovance for technical support.
				The drive is started when pre-charging of the DC bus voltage is not done.	Start the drive after the DC bus voltage is normal.
				The correction factor of the DC bus voltage is set improperly.	Set the DC voltage sampling gain properly.
				The pre-charge resistor, driver board, or control board is abnormal.	Contact Inovance for technical support.
				The displayed DC bus voltage is abnormal.	Contact Inovance for technical support.
64-2	Pre-charge failure 2	0: Coast to stop	Manual reset	The interface board is abnormal.	Contact Inovance for technical support.
65-1	Parameter reset interrupted unexpectedly	0: Coast to stop	Manual reset	Power failure occurs during parameter reset or fault log reset.	Perform parameter reset to rectify the fault.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
65-2	Parameter download interrupted unexpectedly (recovered from the SD card/SOP-20-880)	0: Coast to stop	Manual reset	The controller power supply fails unexpectedly during parameter download.	Find the cause of power failure, and perform parameter download at next power-on.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
65-3	Parameter cache capacity exceeded	0: Coast to stop	Manual reset	A massive number of parameters are being written.	Do not write parameters repetitively.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
65-4	Parameter storage timeout during parameter download	0: Coast to stop	Manual reset	The SD card is abnormal.	Replace the SD card.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
66-2	Excessive leakage current (software detection)	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The leakage current detection threshold (E8-12) is too low.	Set the leakage current detection threshold (E8-12) properly.
				The positive/negative bus is grounded improperly.	Check whether the positive/negative bus is grounded properly.
				The current detection circuit is abnormal.	Check whether the current detection circuit is normal.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
67-1	External bus timeout of adapter A	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The external bus is disconnected.	1. Ensure that the external bus is connected properly. 2. Check that the master PLC operates properly.
				The wiring is incorrect.	Ensure that the wiring is correct.
				The termination resistor is improper.	Set the termination DIP switch or resistance of the termination resistor properly.
				Check bit errors occur during PROFIBUS-DP communication.	Set the PROFIBUS-DP data check bit [n16-10] properly.
				Parameters are set improperly.	Ensure that the communication baud rates of the master and slave are the same and the communication station number is set properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
67-2	Incorrect setting of communication parameters (address or baud rate) for adapter A	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The station number or baud rate is set improperly.	Set the baud rate and station number properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
67-3	Bus address conflict of adapter A	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The slave addresses come into conflict with each other.	Set the slave addresses again.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
67-4	PZD1 data check error in PROFIBUS-DP communication of adapter A	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The check bit (n16-10) of input PZD1 is set improperly.	Set the check bit of input PZD1 properly.
				The host controller does not send the PZD1 check bit properly.	Correct the host controller program to ensure that the PZD1 check bit is normal.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
67-5	Ethernet/IP hardware error of adapter A	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
67-7	EtherCAT EEPROM loading error of adapter A	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	An EEPROM loading error occurs on the EtherCAT card.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
67-8	Communication card initialization error of adapter A	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	Communication initialization parameters are set improperly.	Set the baud rate and station number properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
67-9	EtherCAT master switchover error of adapter A	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	A master status switchover error occurs.	Configure master/slave communication correctly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
67-10	Synchronization signal error of adapter A	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The number of synchronization signal loss events exceeds the limit.	Set n4-00 and n5-00 properly. Contact the technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
67-11	PDI synchronization signal error of adapter A	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The number of PDI synchronization signal loss events exceeds the limit.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
67-12	Adapter A Ethernet/IP not programmed with MAC	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The adapter A Ethernet/IP is not programmed with MAC.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
67-13	Ethernet/IP IP conflict of adapter A	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	Ethernet/IP IP conflict occurs on adapter A.	Set the EtherNet/IP IP of adapter A properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
67-14	Ethernet/IP link loss of adapter A	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	Ethernet/IP Link loss occurs on adapter A.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
67-15	Reception data check error in the communication card of adapter A	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	Interference exists in the circuit.	1. Ensure that the shield of the cable is grounded properly. 2. Increase the value of n1-03 properly.
				The termination resistor is improper.	Set the termination DIP switch or resistance of the termination resistor properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
67-16	Transmission data check error in the communication card of adapter A	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	Interference exists in the circuit.	1. Ensure that the shield of the cable is grounded properly. 2. Remove external interference sources.
				n1-03 is set to an excessively low value.	Set n1-03 properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
68-1	External bus timeout of adapter B	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The external bus is disconnected.	1. Ensure that the external bus is connected properly. 2. Check whether the master PLC operates properly.
				The wiring is incorrect.	Ensure that the wiring is correct.
				The termination resistor is improper.	Set the termination DIP switch or resistance of the termination resistor properly.
				Check bit errors occur during PROFIBUS-DP communication.	Set the PROFIBUS-DP data check bit [n16-10] properly.
				Parameters are set improperly.	Ensure that the communication baud rates of the master and slave are the same and the communication station number is set properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
68-2	Incorrect setting of communication parameters (address or baud rate) for adapter B	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The station number or baud rate is set improperly.	Set the baud rate and station number properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
68-3	Bus address conflict of adapter B	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The slave addresses come into conflict with each other.	Set the slave addresses again.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
68-4	PZD1 data check error in PROFIBUS-DP communication of adapter B	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The check bit (n16-10) of input PZD1 is set improperly.	Set the check bit of input PZD1 properly.
				The host controller does not send the PZD1 check bit properly.	Correct the host controller program to ensure that the PZD1 check bit is normal.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
68-5	Adapter B Ethernet/IP hardware error	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	Other fault causes lead to the fault.	Contact Inovance for technical support.
68-7	EtherCAT EEPROM loading error of adapter B	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	An EEPROM loading error occurs on the EtherCAT card.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
68-8	Communication card initialization error of adapter B	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	Communication initialization parameters are set improperly.	Set the baud rate and station number properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
68-9	EtherCAT master switchover error of adapter B	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	A master status switchover error occurs.	Configure master/slave communication correctly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
68-10	Synchronization signal error of adapter B	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The number of synchronization signal loss events exceeds the limit.	Set n4-00 and n5-00 properly. Contact the technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
68-11	PDI synchronization signal error of adapter B	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The number of PDI synchronization signal loss events exceeds the limit.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
68-12	Adapter B Ethernet/IP not programmed with MAC	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The adapter B Ethernet/IP is not programmed with MAC.	Contact Inovance for technical support.
68-13	Adapter B Ethernet/IP IP conflict	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	Ethernet/IP IP conflict occurs on adapter B.	Set the IP of EtherNet/IP of adapter B properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
68-14	Adapter B Ethernet/IP link loss	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	Ethernet/IP link loss occurs on adapter B.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
68-15	CRC error in the data received by communication card of adapter B	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	Interference exists in the circuit.	1. Ensure that the shield of the cable is grounded properly. 2. Remove external interference sources.
				n2-03 is set to an excessively low value.	Set n2-03 properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
68-16	Transmission data check error in the communication card of adapter B	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	Interference exists in the circuit.	1. Ensure that the shield of the cable is grounded properly. 2. Remove external interference sources.
				n2-03 is set to an excessively low value.	Set n2-03 properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
69-1	External bus timeout of adapter C	0: Coast to stop	Manual reset	The external bus is disconnected.	1. Check that the external bus is connected properly. 2. Check that the master PLC operates properly.
				The wiring is incorrect.	Ensure that the wiring is correct.
				The termination resistor is improper.	Set the termination DIP switch or resistance of the termination resistor properly.
				Check bit errors occur during PROFIBUS-DP communication.	Set the PROFIBUS-DP data check bit [n16-10] properly.
				Parameters are set improperly.	Ensure that the communication baud rates of the master and slave are the same and the communication station number is set properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
69-2	Incorrect communication parameter setting (address or baud rate) of adapter C	0: Coast to stop	Manual reset	The station number or baud rate is set improperly.	Set the baud rate and station number properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
69-3	Bus address conflict of adapter C	0: Coast to stop	Manual reset	The slave addresses come into conflict with each other.	Set the slave addresses again.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
69-4	PZD1 data check error in PROFIBUS-DP communication of adapter C	0: Coast to stop	Manual reset	The check bit (n16-10) of input PZD1 is set improperly.	Set the check bit of input PZD1 properly.
				The host controller does not send the PZD1 check bit properly.	Correct the host controller program to ensure that the PZD1 check bit is normal.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
69-7	EtherCAT EEPROM loading error of adapter C	0: Coast to stop	Manual reset	An EEPROM loading error occurs on the EtherCAT card.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
69-8	EtherCAT initialization error of adapter C	0: Coast to stop	Manual reset	Communication initialization parameters are set improperly.	Set the baud rate and station number properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
69-9	EtherCAT master switchover error of adapter C	0: Coast to stop	Manual reset	A master status switchover error occurs.	Configure master/slave communication correctly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
69-15	Reception data check error in the communication card of adapter C	0: Coast to stop	Manual reset	Interference exists in the circuit.	1. Ensure that the shield of the cable is grounded properly. 2. Remove external interference sources.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
69-16	Transmission data check error in the communication card of adapter C	0: Coast to stop	Manual reset	Interference exists in the circuit.	1. Ensure that the shield of the cable is grounded properly. 2. Remove external interference sources.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
70-1	Incorrect HE inverter fan phase sequence	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The phase sequence of the fan is incorrect.	Adjust the phase sequence of the fan.
				An error or phase loss occurs on the phase sequence detection circuit.	Ensure that the input power supply of the phase sequence detector is normal.
				The fan phase sequence detector is damaged.	Replace the fan phase sequence detector.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
70-2	HE inverter fan overtemperature	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	Fan overtemperature	1. Check whether the fan is stalled. 2. Check whether phase loss occurs on the fan.
				The DI feedback circuit is abnormal.	Check whether the fan feedback DI signal is connected loosely or disconnected.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
71-1	Rectifier braking self-test fault	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The braking resistor is improper.	Select a proper braking resistor based on the operating conditions.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
72-1	Soft start timeout	0: Coast to stop	Manual reset	Other fault causes lead to the fault.	Contact Inovance for technical support.
72-2	Soft start timeout of the basic rectifier	0: Coast to stop	Manual reset	The bus voltage of the 400 V system or 690 V system does not reach 350 V or 600 V five seconds after soft start.	Ensure that the main contactor feedback signal is normal.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
72-4	Rectifier unit not started	0: Coast to stop	Manual reset	Other fault causes lead to the fault.	Contact Inovance for technical support.
73-1	Main breaker feedback error	0: Coast to stop	Manual reset	The main breaker feedback state does not match the control signal.	Contact Inovance for technical support.
73-2	Power board undervoltage (HE200-D2)	0: Coast to stop	Manual reset	Other fault causes lead to the fault.	Contact Inovance for technical support.
73-3	Pre-charge contactor feedback error (single-drive)	0: Coast to stop	Manual reset	The feedback signal of the single-drive pre-charge contactor is abnormal.	Ensure that the auxiliary contactor feedback signal is connected properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
73-4	Rectifier bridge error (single-drive)	0: Coast to stop	Manual reset	The pre-charge resistor is overloaded due to the rectifier bridge fault.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
74-1	Braking transistor overcurrent	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The braking current is excessively high during braking.	Ensure that the braking resistor selected is proper. Ensure that the braking side is not short-circuited.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
74-2	Braking transistor overtemperature	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The ambient temperature is high.	Reduce the ambient temperature to ensure that the air inlet temperature does not exceed 40°C.
				The air duct is blocked.	Clean the air duct.
				The fan operates improperly. 1. The fan stops or the speed is low. 2. The fan power supply board is abnormal.	1. Replace the damaged fan. 2. Replace the power supply board of the fan.
				Thermistor of the module is abnormal.	Contact Inovance for technical support.
				The braking action is performed frequently.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
74-3	Braking IGBT - Vce fault	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The braking IGBT is damaged or the braking resistor is short-circuited.	Ensure that the braking resistor circuit is normal (short circuit/open circuit). Ensure that the braking IGBT is not faulty.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
74-4	Braking IGBT short-circuited	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The braking IGBT is damaged or the braking resistor is short-circuited.	1. The braking transistor is not damaged. 2. Ensure that the braking IGBT is not short-circuited.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
74-5	The temperature of the braking transistor is too low or NTC is not connected.	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The ambient temperature is too low.	Increase the ambient temperature (turn on the air conditioner or heater).
				The temperature sampling circuit is connected improperly.	Check whether the temperature sampling circuit is connected properly. If not, rectify the fault.
				Thermistor of the module is abnormal.	Contact Inovance for technical support.
				The low temperature pre-alarm threshold (A4-22) is excessively high.	Set the low temperature pre-alarm threshold (A4-22) properly.
75-1	Rectifier fan error	6: Displaying this alarm only	Automatic reset	The phase sequence of the fan is incorrect.	Adjust the phase sequence of the fan.
				An error or phase loss occurs on the phase sequence detection circuit.	Ensure that the input power supply of the phase sequence detector is normal.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
76-1	Rectifier module 1 overtemperature	0: Coast to stop	Manual reset	The ambient temperature is high.	Reduce the ambient temperature to ensure that the air inlet temperature does not exceed 40°C.
				The load is excessive.	Reduce the load.
				The air duct is blocked.	Clean the air duct.
				The fan operates improperly. 1. The fan stops or the speed is low. 2. The fan power supply board is abnormal.	1. Replace the damaged fan. 2. Replace the power supply board of the fan.
				Thermistor of the module is abnormal.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
76-2	Rectifier module 2 overtemperature	0: Coast to stop	Manual reset	The ambient temperature is high.	Reduce the ambient temperature to ensure that the air inlet temperature does not exceed 40°C.
				The load is excessive.	Reduce the load.
				The air duct is blocked.	Clean the air duct.
				The fan operates improperly. 1. The fan stops or the speed is low. 2. The fan power supply board is abnormal.	1. Replace the damaged fan. 2. Replace the power supply board of the fan.
				Thermistor of the module is abnormal.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
76-3	Rectifier module 3 overtemperature	0: Coast to stop	Manual reset	The ambient temperature is high.	Reduce the ambient temperature to ensure that the air inlet temperature does not exceed 40°C.
				The load is excessive.	Reduce the load.
				The air duct is blocked.	Clean the air duct.
				The fan operates improperly. 1. The fan stops or the speed is low. 2. The fan power supply board is abnormal.	1. Replace the damaged fan. 2. Replace the power supply board of the fan.
				Thermistor of the module is abnormal.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
76-4	Rectifier module 1 temperature too low or NTC not connected	0: Coast to stop	Manual reset	The ambient temperature is high.	Reduce the ambient temperature to ensure that the air inlet temperature does not exceed 40°C.
				The load is excessive.	Reduce the load.
				The air duct is blocked.	Clean the air duct.
				The fan operates improperly. 1. The fan stops or the speed is low. 2. The fan power supply board is abnormal.	1. Replace the damaged fan. 2. Replace the power supply board of the fan.
				Thermistor of the module is abnormal.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
76-5	Rectifier module 2 temperature too low or NTC not connected	0: Coast to stop	Manual reset	The ambient temperature is high.	Reduce the ambient temperature to ensure that the air inlet temperature does not exceed 40°C.
				The load is excessive.	Reduce the load.
				The air duct is blocked.	Clean the air duct.
				The fan operates improperly. 1. The fan stops or the speed is low. 2. The fan power supply board is abnormal.	1. Replace the damaged fan. 2. Replace the power supply board of the fan.
				Thermistor of the module is abnormal.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
76-6	Rectifier module 3 temperature too low or NTC not connected	0: Coast to stop	Manual reset	The ambient temperature is high.	Reduce the ambient temperature to ensure that the air inlet temperature does not exceed 40°C.
				The load is excessive.	Reduce the load.
				The air duct is blocked.	Clean the air duct.
				The fan operates improperly. 1. The fan stops or the speed is low. 2. The fan power supply board is abnormal.	1. Replace the damaged fan. 2. Replace the power supply board of the fan.
				Thermistor of the module is abnormal.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
77-1	Reactor overtemperature (HE200)	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The load is excessive.	Reduce the load.
				The fan is damaged.	Replace the fan.
				The temperature detection circuit or temperature switch is abnormal.	Replace the temperature detection circuit or the temperature switch.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
77-4	Reactor overtemperature inside the drive cabinet	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The drive does not receive the overtemperature detection signal configured by b6-04. When the output reactor is equipped with a temperature detection switch (A3-54 = 1) in the standard cabinet, the source of b6-04 is set to "HDI1" forcibly.	1. Ensure that the temperature switch signal is connected correctly. 2. The ambient temperature is too high. Reduce the ambient temperature.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
77-7	Internal current-balancing reactor overtemperature	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The actual temperature of the internal current-balancing reactor is high. Heat dissipation of the internal current-balancing reactor is abnormal.	1. Take proper heat dissipation measures inside the cabinet. 2. Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
78-1	Temperature excessively high	6: Displaying this alarm only	Manual reset	The load is excessive.	Reduce the load.
				The air duct is blocked.	Clean the air duct.
				The fan is damaged.	Replace the fan.
				The temperature detection circuit is abnormal.	Replace the temperature detection circuit.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
78-2	Temperature excessively low or NTC not connected	6: Displaying this alarm only	Manual reset	The ambient temperature is excessively low.	Increase the ambient temperature.
				The temperature detection circuit is abnormal.	Replace the temperature detection circuit.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
79-2	Voltage excessively high	0: Coast to stop	Manual reset	Check whether the input voltage is excessively high.	Reduce the input voltage.
				In generating state, the braking unit is not installed or the braking resistor model is improper.	Install a braking unit or select a proper braking resistor.
				The voltage class of the drive is improper.	Select a drive model with the proper voltage class.
				The drive model is incorrect.	Contact Inovance for technical support.
				Overvoltage suppression parameters are set improperly.	1. In the V/f control mode, check whether overvoltage suppression (E3-30) is enabled and whether E3-31 to E3-35 are set properly. 2. In the vector control mode, check whether E9-01 is enabled and whether E9-02 is set to an excessively high value.
				The correction factor of the DC bus voltage is set improperly.	Set the DC voltage sampling gain properly.
				In the vector control mode, speed loop parameters are set improperly.	Use IDS to check whether overshoot of the actual motor speed during acceleration is large and whether generating overvoltage occurs during speed callback. Set the speed loop parameters properly to reduce the overshoot.
				Other causes lead to the fault.	Contact Inovance for technical support.
79-3	Voltage excessively low	0: Coast to stop	Manual reset	The input voltage is excessively low.	Adjust the voltage until it is within the normal range.
				The voltage class of the drive is improper.	Select a drive model with the proper voltage class.
				The drive model is incorrect.	Contact Inovance for technical support.
				Undervoltage suppression parameter are set improperly.	Check whether E9-03 is enabled and whether E9-04 to E9-06 are set properly.
				The correction factor of the DC bus voltage is set improperly.	Set the DC voltage sampling gain properly.
				The pre-charge resistor, driver board, or control board is abnormal.	Contact Inovance for technical support.
				The displayed DC bus voltage is abnormal.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
80-1	HE200 - Rectifier unit 1 offline	0: Coast to stop	Manual reset	The card slot is incorrect.	Check whether the expansion card slot of A14-37 (Rectifier unit 1) is selected correctly.
				The rectifier HINT is not powered on.	Replace the HINT power supply circuit of the rectifier.
				The optical fiber circuit is connected improperly.	Replace the optical fiber circuit.
				The optical fiber is damaged.	Replace the optical fiber.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
80-2	HE200 - Rectifier unit 2 offline	0: Coast to stop	Manual reset	The card slot is incorrect.	Check whether the expansion card slot of A14-38 (Rectifier unit 2) is selected correctly.
				The rectifier HINT is not powered on.	Replace the HINT power supply circuit of the rectifier.
				The optical fiber circuit is connected improperly.	Replace the optical fiber circuit.
				The optical fiber is damaged.	Replace the optical fiber.
				Other causes lead to the fault.	Contact Inovance for technical support.
80-3	Expansion card setting conflict of HE200 rectifier unit	0: Coast to stop	Manual reset	The expansion slot setting of A14-37 comes into conflict with A14-38.	Set the expansion card slot properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
81-1	Grid voltage too high	0: Coast to stop	Manual reset	The input grid voltage is too high.	Adjust the input grid voltage to a value within the normal range.
				The voltage class of the model is set incorrectly.	Set the voltage class of the model correctly.
				The overvoltage threshold of the grid voltage is set improperly.	Set A14-54 properly.
				The grid voltage sampling is abnormal.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
81-2	Grid voltage too low	0: Coast to stop	Manual reset	The input grid voltage is too low.	Adjust the input grid voltage to a value within the normal range.
				The voltage class of the model is set incorrectly.	Set the voltage class of the model correctly.
				The undervoltage threshold of the grid voltage is set improperly.	Set A14-55 properly.
				Phase loss occurs on the power grid.	Ensure that the input wiring is correct.
				The grid voltage sampling is abnormal.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
81-7	Phase R loss	0: Coast to stop	Manual reset	The grid voltage sampling is abnormal.	Ensure that the input wiring is correct.
				Phase loss occurs on phase R of the power grid.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
81-8	Phase S loss	0: Coast to stop	Manual reset	The grid voltage sampling is abnormal.	Ensure that the input wiring is correct.
				Phase loss occurs on phase S of the power grid.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
81-9	Phase T loss	0: Coast to stop	Manual reset	The grid voltage sampling is abnormal.	Ensure that the input wiring is correct.
				Phase T loss occurs on the power grid.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
82-1	DC pre-charge error	0: Coast to stop	Manual reset	The multi-drive system is not configured with a DC pre-charge unit but pre-charge resistor detection is enabled (A4-11 = 1).	Set A4-11 to 0 to disable the pre-charge resistor detection function.
				The feedback signal detection circuit of the DC pre-charge unit is abnormal.	1. Ensure that the feedback signal of the DC pre-charge unit is normal. 2. If the H4, H6, or H7 unit is used, ensure that the external 24 V power supply is normal.
				The pre-charge unit is damaged.	Replace the DC pre-charge unit.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
83-1	InoLink: Address conflict	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	Duplicate node addresses exist in the InoLink network.	Set a unique address to each node in the InoLink network.
81-2	InoLink: Communication offline	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	InoLink is connected improperly or disconnected.	Ensure that InoLink is connected properly.
				The termination resistor is improper.	Check whether the DIP switch of the termination resistor is set correctly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
81-3	InoLink: Receiver offline	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The specified node is offline.	Ensure that the wiring is correct.
				The specified node address does not exist.	Set a unique address to each node.
				The termination resistor is improper.	Check whether the DIP switch of the termination resistor is set correctly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
83-5	Optical fiber synchronization expansion module: Node address conflict	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The node address already exists.	Set a unique address to each node.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
83-6	Optical fiber synchronization expansion module: Data of the data reception node A interrupted	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The HCU corresponding to node A is disconnected from the network.	1. Check whether the HCU power supply corresponding to node A is normal. 2. Check whether the HOFR power supply is normal. 3. Check whether the communication of node A is configured properly.
				The optical fiber circuit is abnormal.	Check the wiring of the corresponding address of the data reception node A.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
83-7	Optical fiber synchronization expansion module: Data of the data reception node B interrupted	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The optical fiber circuit is abnormal.	Check the wiring of the corresponding address of the data reception node B.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
83-8	Optical fiber synchronization expansion module: Data of the data reception node C interrupted	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The optical fiber circuit is abnormal.	Check the wiring of the corresponding address of the data reception node C.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
83-9	Optical fiber synchronization expansion module: Module offline	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The optical fiber circuit is abnormal.	Ensure that the optical fiber circuit is connected properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
83-10	Optical fiber synchronization expansion module: Data reception error	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The transmission and reception circuits between modules are wired improperly.	Ensure that the optical fiber circuit is connected properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
84-1	Brake cannot be released	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The brake feedback wiring is incorrect or disconnected.	Ensure that the brake feedback circuit is normal and external interference sources are removed.
				The brake function is selected improperly.	When there is no brake feedback signal, set L1-00 to 1.
				The brake release feedback signal source is set incorrectly.	Ensure that L1-15 is set correctly.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
84-2	Brake cannot be applied	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The brake feedback wiring is incorrect or disconnected.	Ensure that the brake feedback circuit is normal and external interference sources are removed.
				The brake function is selected improperly.	When there is no brake feedback signal, set L1-00 to 1.
				The brake release feedback signal source is set incorrectly.	Ensure that L1-15 is set correctly.
84-3	Brake verification failure	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The brake is not applied properly.	Ensure that the brake can be applied properly.
				The brake is excessively worn.	Replace the brake mechanism.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
84-4	Brake verification failure	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The brake is not applied properly.	Ensure that the brake can be applied properly.
				The brake is excessively worn.	Replace the brake mechanism.
84-5	Auto-start upon brake failure for protection	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	This function is enabled mistakenly because L1-37 is configured improperly.	Disable L1-37.
				The brake is excessively worn.	Replace the brake mechanism.
85-1	HCU internal data exchange error	0: Coast to stop	Manual reset	Other fault causes lead to the fault.	Contact Inovance for technical support.
85-3	State machine out-of-bounds	0: Coast to stop	Manual reset	Other fault causes lead to the fault.	Contact Inovance for technical support.
85-4	Interrupt generated unexpectedly	0: Coast to stop	Manual reset	Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
85-5	HCU internal data synchronization error	0: Coast to stop	Manual reset	DSP or FPGA software programming is performed.	Fault reset
				Other fault causes lead to the fault.	Contact Inovance for technical support.
88-1	Model code not exist	0: Coast to stop	Manual reset	The model set by [A3-00] does not exist.	Check whether the model is set correctly.
				The model saved on HINT does not exist.	Reset the model and download the model setting to the HINT board.
				The HINT is abnormal.	Power on again or replace the HINT board.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
88-2	Model parameter/ Software undervoltage threshold changed	0: Coast to stop	Manual reset	The model parameters ([A3-00] to [A3-11]) are changed but not downloaded.	Download the parameters to be modified.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
88-3	Model parameter/ Software undervoltage threshold not match	0: Coast to stop	Manual reset	The HCU has been replaced.	Ensure that the ratings of the A2 module match the power unit.
				The power unit has been replaced.	Ensure that the ratings of the A2 module match the power unit.
				Only the HINT has been replaced.	Contact Inovance technical support to set the model and calibration parameters properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
88-4	Inconsistent model code	0: Coast to stop	Manual reset	In the parallel mode, not all the power module models are consistent.	Ensure that the nameplate parameters of all modules are consistent.
				Only the HINT has been replaced.	Contact Inovance technical support to set the model and calibration parameters properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
88-6	Mismatch between the model and software	0: Coast to stop	Manual reset	The power unit type does not match the HCU software type.	Ensure that the power unit type matches the HCU software type.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
88-7	Unknown model code/Software undervoltage threshold limit violated	0: Coast to stop	Manual reset	Different types of power modules are connected to the HCU.	1. Check whether the power module and HCU type match each other. 2. Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
88-8	Unknown model code	0: Coast to stop	Manual reset	The model set by [A3-00] does not exist.	Set [A3-00] correctly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
88-9	Calibration coefficient out-of-range	0: Coast to stop	Manual reset	The HINT calibration coefficient is abnormal.	Set the calibration coefficient properly and download the calibration parameters.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
88-11	Software undervoltage thresholds inconsistent	0: Coast to stop	Manual reset	The HCU has been replaced.	When the HINT undervoltage thresholds of the modules are consistent but different from the undervoltage threshold defined by the software, [A4-16] can be updated to the undervoltage threshold of HINT.
				Only the HINT has been replaced.	1. Select the unit module through [A3-12] in the parallel mode and read the command through [A3-14]. The undervoltage threshold of the corresponding module is displayed in [A3-47]. 2. Set A4-16 [Software undervoltage threshold] correctly and download the setting to the corresponding HINT module.
				Different types of power modules are connected to the HCU.	1. Check whether the power module and HCU type match each other. 2. Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
88-16	Mismatch between model setting and function parameter	0: Coast to stop	Manual reset	Parameters are set improperly.	Set A14-39 properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
89-1	24 V power supply excessively low	6: Displaying this alarm only	Automatic/Manual reset	The 24 V control circuit power supply of HCU is abnormal.	Check whether the HCU control circuit voltage is within 24 V±10%.
				The 24 V output is short-circuited.	Check whether the 24 V output (J11 on the HCU) is short-circuited.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
91-1	Mode setting conflict	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	A15-00 is set to 0 but the HCU is connected to the HPCU.	When the HCU is connected to the HPCU, set A15-00 to 1.
				A15-00 is set to 1 but the HCU is directly connected to HINT.	When the HCU is directly connected to HINT, set A15-00 to 0.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
91-2	Mismatch between enabled modules and online modules	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	A15-02 and A15-03 are set incorrectly.	Set A15-02 and A15-03 properly according to the module connected.
				The unit optical fiber circuit is abnormal.	Check the connection circuit of the offline module according to the online display information of A15-05 and A15-06.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
91-4	HPCU offline	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The HPCU power supply is abnormal.	Ensure that the HPCU power supply is normal.
				The optical fiber is connected improperly.	Ensure that the HPCU and HCU optical fibers are connected properly.
				The model of the HPCU module is incorrect.	Check whether the HPCU nameplate information is correct.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
92-2	Phase U loss in parallel mode	0: Coast to stop	Manual reset	Phase U of a parallel module is disconnected or connected improperly.	Ensure that phase U is wired properly.
				The phase U current of a parallel module is detected to be abnormal.	1. Replace the corresponding Hall sensor. 2. Replace the corresponding power module.
				The IGBT of phase U of a parallel module is faulty.	Replace the corresponding power module.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
92-3	Phase V loss in parallel mode	0: Coast to stop	Manual reset	Phase V of a parallel module is disconnected or connected improperly.	Ensure that phase V is wired properly.
				The phase V current of a parallel module is detected to be abnormal.	1. Replace the corresponding Hall sensor. 2. Replace the corresponding power module.
				The IGBT of phase V of a parallel module is faulty.	Replace the corresponding power module.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
92-4	Phase W loss in parallel mode	0: Coast to stop	Manual reset	Phase W of a parallel module is disconnected or connected improperly.	Ensure that phase W is wired properly.
				The phase W current of a parallel module is detected to be abnormal.	1. Replace the corresponding Hall sensor. 2. Replace the corresponding power module.
				The IGBT of phase W of a parallel module is faulty.	Replace the corresponding power module.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
92-5	Bus voltage detection error in parallel mode	0: Coast to stop	Manual reset	The quick-acting fuse of the DC bus is damaged.	Replace the quick-acting fuse of the DC bus.
				The DC bus of the module is not connected.	Re-connect the DC bus.
				The DC bus voltage sampling is not calibrated or calibration is incorrect.	Calibrate the DC current bus voltage again.
				The hardware sampling circuit is abnormal.	Check whether the hardware sampling circuit is abnormal.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
93-1	Motor stall	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The torque limit is active and the operating speed is excessively low when used together with the process.	Disable the motor stall fault.
				Check whether the torque limit is set properly.	Check whether the settings of E2-10 to E2-13 are proper, especially when communication reference is configured.
				The load is excessive.	Check the motor load to avoid excessive mechanical load.
				Set motor parameters properly.	Ensure that the motor parameters are set properly.
				The encoder is abnormal.	1. Ensure that the encoder is connected properly. 2. Ensure that the encoder is normal. 3. Ensure that the encoder parameters are configured correctly.
				Motor parameter auto-tuning is not performed.	Set motor parameters correctly and perform auto-tuning on motor parameters.
				Output phase loss occurs or the output is disconnected.	Ensure that the motor wiring is connected properly and the contactor on the motor side is not disconnected.
				The motor also starts directly during rotation or the wrong speed is tracked.	Set the start mode to flying start and adjust the speed tracking parameters.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
93-2	Motor step loss	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The load during high-speed operation is excessive.	Check the motor load to avoid excessive mechanical load.
				The motor is still rotating. Starting a rotating motor can change the motor to power generation state, resulting in bus overvoltage.	Set E1-00 to "Flying start" (parameter auto-tuning needed) or wait until the motor stops before start.
				Set motor parameters properly.	Ensure that the motor parameters are set properly.
				The encoder is faulty.	1. Ensure that the encoder is connected properly. 2. Ensure that the encoder is normal. 3. Ensure that the encoder parameters are configured correctly.
				The motor parameter deviation is large.	Set motor parameters correctly and perform auto-tuning on motor parameters.
				Output phase loss occurs or the output is disconnected.	Ensure that the motor wiring is connected reliably and the contactor on the motor side is not disconnected.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
93-3	Current control error	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The motor side is disconnected.	1. Check whether a phase of the motor is disconnected. 2. Check whether the contactor on the motor side is connected properly.
				The encoder is disconnected or the encoder signal is being disturbed severely.	Check the encoder wiring and handle the encoder interference.
				The motor parameters are set incorrectly.	Set motor parameters correctly and perform complete motor parameter auto-tuning.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
93-4	Two- or three-phase loss	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The motor U/V/W cable is disconnected or connected improperly.	Check whether the motor U/V/W cables are connected properly.
				The output contactor is not closed or is abnormal.	Ensure that the output contactor is closed properly.
				The motor three-phase winding is abnormal.	Replace the motor.
				The motor parameters are set incorrectly.	Set motor parameters correctly and perform complete motor parameter auto-tuning.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
93-5	Motor stall upon speed open loop in SVC mode	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The motor is stalled when speed open loop is enabled in SVC mode.	1. Increase the value of E4-04 and E4-05. 2. Set [E8-38] to a value lower than 5s to hide this fault.
				The load is excessive.	Check the motor load to avoid excessive mechanical load.
				Set motor parameters properly.	Ensure that the motor parameters are set properly.
				Output phase loss occurs or the output is disconnected.	Ensure that the motor wiring is connected reliably and the contactor on the motor side is not disconnected.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
93-6	SVC control error	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The SVC model is abnormal during low-speed operation.	1. Increase the minimum operating frequency of the motor. 2. If an encoder can be installed, apply FVC operation mode. 3. For non-gravitational loads, enable open loop control through E11-08.
				The motor parameters are set incorrectly.	Set motor parameters correctly and perform complete motor parameter auto-tuning.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
93-7	Synchronous motor runaway	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	1. The zero angle is incorrect due to loosened encoder. Perform dynamic auto-tuning again and check whether n4-12 changes. 2. Zero angle auto-tuning is not performed in the FVC mode. Check whether the value of n4-12 is normal. 3. The z signal is abnormal due to encoder interference. Enable signal interference detection through n4-30. 4. The speed cannot be tracked due to torque or current limit. 5. The speed loop kp is excessively low, resulting in excessive speed deviation. For example, speed overshoot occurs the moment upon brake release or during acceleration.	1. Install the encoder properly. Check whether the encoder shaft is tightened properly. 2. Set b5-00 to 2 (No-load dynamic auto-tuning) or 7 (Synchronous motor with-load dynamic auto-tuning in FVC mode). 3. Optimize the encoder signal interference, wiring, or replace the encoder. 4. Check the limit. You can disable synchronous motor stall protection through E8-53 as needed. 5. Increase the values of speed loop Kp and Ti.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
93-8	Overspeed during magnetic pole position auto-tuning	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The FVC encoder can detect the actual motor speed. The magnetic pole position auto-tuning starts at speeds higher than 5 rpm. If the motor cannot decelerate to speeds lower than 5 rpm for a long time, a fault can be reported. This prevents the motor from rotating after the magnetic pole angle is auto-tuned during operation, thus avoiding angle errors.	1. Start the motor only after it stops rotating. 2. If a motor equipped with an ABZ or sine-cosine encoder keeps rotating without stop, set E11-37 to 1 to start operation through Z signal.
93-9	Asynchronous motor runaway in SVC mode	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	1. The speed open loop (SVC) mode is enabled and the load is excessively high. The current set for speed open loop is exceeded. 2. The speed open loop (SVC) mode is enabled and a rotating motor has been restarted. 3. The speed open loop (SVC) mode is not enabled, the basic motor auto-tuning parameters are abnormal, resulting in SVC model error.	1. If a fault is reported during acceleration, increase the speed open-loop acceleration current [E11-10]. If a fault is reported during steady-state operation, increase the speed open-loop current [E11-09]. Ensure that the sum of E11-10 and E11-09 is higher than the sum of the acceleration torque required for load and the acceleration torque. 2. Change the start mode [E1-00] to "Flying start". 3. Check whether the basic motor auto-tuning parameters in group d1 are correct. If not, set [b5-00] to 2 (No-load complete auto-tuning) to perform auto-tuning again without load. If a load is connected, set [b5-00] to 9 (With-load dynamic auto-tuning of asynchronous motor) to perform auto-tuning again. Note that the speed reference must be between 35% to 80% when b5-00 is set to 9. 4. If an encoder can be installed, apply the FVC operation mode. 5. Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
99-1	Phase U current unbalance of parallel modules	6: Displaying this alarm only	Automatic reset	The output cable length varies greatly.	Ensure that the cable length of each phase is consistent.
				The current-balancing inductance outputted by each phase varies greatly.	Ensure that the output inductance of each phase is consistent.
				The detected current of a parallel unit is abnormal.	Replace the current sensor.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
99-2	Phase V current unbalanced of parallel modules	6: Displaying this alarm only	Automatic reset	The output cable length varies greatly.	Ensure that the cable length of each phase is consistent.
				The current-balancing inductance outputted by each phase varies greatly.	Ensure that the output inductance of each phase is consistent.
				The detected current of a parallel unit is abnormal.	Replace the current sensor.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
99-3	Phase W current unbalance of parallel modules	6: Displaying this alarm only	Automatic reset	The output cable length varies greatly.	Ensure that the cable length of each phase is consistent.
				The current-balancing inductance outputted by each phase varies greatly.	Ensure that the output inductance of each phase is consistent.
				The detected current of a parallel unit is abnormal.	Replace the current sensor.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
100-1	Abnormal fault information generated	0: Coast to stop	Manual reset	Other fault causes lead to the fault.	Contact Inovance for technical support.
100-2	Subcode error	0: Coast to stop	Manual reset	Other fault causes lead to the fault.	Contact Inovance for technical support.
100-3	Main fault code error	0: Coast to stop	Manual reset	Other fault causes lead to the fault.	Contact Inovance for technical support.
100-4	Data exchange error	0: Coast to stop	Manual reset	Other fault causes lead to the fault.	Contact Inovance for technical support.
100-14	The length of the signal interaction sheets is inconsistent.	1: Coast to stop	Manual reset	Other fault causes lead to the fault.	Contact Inovance for technical support.
101-1	HINT type not matching HCU	0: Coast to stop	Manual reset	The power unit type does not match the HCU software type.	Ensure that the power unit type matches the HCU software type.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
101-2	HINT software version not match	0: Coast to stop	Manual reset	In the parallel mode, the software versions of HINT modules do not match each other.	1. Check whether the HINT plate replaced is the same as before. 2. Update the HINT software version to ensure version consistency.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
101-3	STO function not match	0: Coast to stop	Manual reset	The HINT board has been replaced by an incorrect one.	1. Check whether the HINT plate replaced is the same as before. 2. Update the HINT software version to ensure version consistency.
				The hardware does not support the STO function but STO detection is enabled.	Disable the STO detection by H0-04.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
101-4	Mismatch between HINT function and setting	0: Coast to stop	Manual reset	The HINT board has been replaced by an incorrect one.	1. Check whether the HINT plate replaced is the same as before. 2. Update the HINT software version to ensure version consistency.
				The motor type is set improperly.	Set the motor type properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
102-1	HINT model parameter check not completed	6: Displaying this alarm only	Automatic reset	The attempt to read model parameters times out.	1. Power on the HCU control circuit power supply again. 2. Power on the HINT power supply again. 3. Set model-related parameter and perform a download.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
102-2	Mismatch between HINT current sampling function and setting	6: Displaying this alarm only	Automatic reset	The HINT has been replaced by an incorrect one.	1. Confirm the version again and replace with a new HINT. 2. Update the HINT software.
				A3-23 is set to 4, but HINT does not support N-point sampling.	Set A3-23 properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
114-1	Input phase loss	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	One of the RST power input cables is disconnected or connected improperly.	Ensure that the RST input cables are connected properly.
				The thyristor drive cable is connected improperly (for 690 V single-drive models).	Ensure that the thyristor drive cable is connected securely.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
117-1	Drive pre-overload	6: Displaying this alarm only	Automatic reset	The load is excessive.	1. Reduce the load. 2. Select a drive with a proper power rating.
				Parameter auto-tuning is not performed in vector control.	Set motor parameters correctly and perform parameter auto-tuning before operation.
				The torque boost parameter is set to an excessively high value in V/f control.	1. E3-14 and E3-15 are set to excessively high values during manual torque boost. 2. During automatic torque boost, perform operation after static auto-tuning is done.
				The motor is stalled.	Check the motor and mechanical conditions.
				The drive operates with high load at low speed for a long term.	The derating coefficient must be taken into account when the drive runs at low frequency for a long time. Increase the power of the drive properly.
				Derating occurs due to excessively high carrier frequency.	Reduce the carrier frequency through A4-02.
				Speed tracking fails.	The speed tracked is inconsistent with the actual motor speed. After operation, the drive is overloaded due to excessively high current. During high-speed tracking, increase the value of E7-02 (Speed tracking filter cutoff frequency).
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
118-1	Real-time timer 1 threshold reached	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Manual reset	The actual value of [real-time timer 1] (L20-06) is greater than or equal to the timing threshold of [real-time timer 1] (L20-07).	Modify L20-02 timer (count) to 1 [Real-time timer 1 clear] or 101 [All real-time timers clear] or 103 [All timer (count) clear], and change L20-03 timer (count) to 1 [OK].
119-1	Real-time timer 2 threshold reached	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Manual reset	The actual value of [real-time timer 2] (L20-20) is greater than or equal to the timing threshold of [real-time timer 2] (L20-21).	Modify L20-02 (Timer (count) reset) to 2 [Real-time timer 2 cleared] or 101 [All real-time timers cleared] or 103 [All timers (count) cleared], and change L20-03 (Timer (count) reset) to 1 [OK].

Fault code	Name	Fault level range	Reset mode	Cause	Solution
122-1	Threshold of edge counter 1 reached	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Manual reset	The actual value of [Edge counter 1] (L20-34) is greater than or equal to the counting threshold of [edge counter 1] (L20-35).	Modify L20-02 (Timer (count) reset) to 5 [Edge counter 1 cleared] or 102 [All edge counters cleared] or 103 [All timers (count) cleared], and change L20-03 (Timer (count) reset) to 1 [OK].
123-1	Threshold of edge counter 2 reached	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Manual reset	The actual value of [Edge counter 2] (L20-49) is greater than or equal to the counting threshold of [edge counter 2] (L20-50).	Modify L20-02 (Timer (count) reset) to 6 [Edge counter 2 cleared] or 102 [All edge counters cleared] or 103 [All timers (count) cleared], and change L20-03 (Timer (count) reset) to 1 [OK].

Fault code	Name	Fault level range	Reset mode	Cause	Solution
147-3	STO1 and STO2 input activated	6: Displaying this alarm only	Auto reset/ Manual reset	STO1 and STO2 are activated.	Ensure that STO1 and STO2 input circuit wiring and power supply are normal. Connect positive and negative poles of 24 VDC input of STO1 and STO2 properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
148-2	Motor overtemperature pre-alarm	6: Displaying this alarm only 7: No action	Manual reset	The actual temperature of the motor is high, and heat dissipation of the motor is abnormal.	Take measures to improve heat dissipation of the motor.
				The motor temperature detection is enabled but the temperature sensor type is incorrect.	Set the temperature sensor type correctly.
				Motor temperature detection is enabled but the temperature sensor is connected improperly.	Check that the temperature sensor is wired properly.
				The motor overtemperature threshold is excessively low.	Set the motor overtemperature threshold properly.
				The temperature detection module is abnormal.	Contact Inovance for technical support.
156-1	Communication error between fieldbus adapter A and host controller	6: Displaying this alarm only 7: No action	Automatic reset	The external bus is disconnected.	1. Check that the external bus is connected properly. 2. Check that the master PLC operates properly.
				The wiring is incorrect.	Ensure that the circuit is wired properly.
				The termination resistor is improper.	Set the termination DIP switch or resistance of the termination resistor properly.
				Check bit errors occur during PROFIBUS-DP communication.	Set the PROFIBUS-DP data check bit [n16-10] properly.
				Parameters are set improperly.	Ensure that the communication baud rates of the master and slave are the same and the communication station number is set properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
156-2	Communication error between bus adapter B and host controller	6: Displaying this alarm only 7: No action	Automatic reset	The external bus is disconnected.	1. Check that the external bus is connected properly. 2. Check that the master PLC operates properly.
				The wiring is incorrect.	Ensure that the wiring is correct.
				The termination resistor is improper.	Set the termination DIP switch or resistance of the termination resistor properly.
				Check bit errors occur during PROFIBUS-DP communication.	Set the PROFIBUS-DP data check bit [n16-10] properly.
				Parameters are set improperly.	Ensure that the communication baud rates of the master and slave are the same and the communication station number is set properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
156-3	Communication error between bus adapter C and host controller	6: Displaying this alarm only 7: No action	Automatic reset	The external bus is disconnected.	1. Ensure that the external bus is connected properly. 2. Check whether the master PLC operates properly.
				The wiring is incorrect.	Ensure that the wiring is correct.
				The termination resistor is improper.	Set the termination DIP switch or resistance of the termination resistor properly.
				Check bit errors occur during PROFIBUS-DP communication.	Set the PROFIBUS-DP data check bit [n16-10] properly.
				Parameters are set improperly.	Ensure that the communication baud rates of the master and slave are the same and the communication station number is set properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
156-4	Bus adapter A data check error	6: Displaying this alarm only 7: No action	Automatic reset	The communication circuit has been disturbed.	Ensure that the circuit is connected properly and the shield is grounded properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
156-5	Bus adapter B data check error	6: Displaying this alarm only 7: No action	Automatic reset	The communication circuit has been disturbed.	Ensure that the circuit is connected properly and the shield is grounded properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
156-6	Bus adapter C data check error	6: Displaying this alarm only 7: No action	Automatic reset	The communication circuit has been disturbed.	Ensure that the circuit is connected properly and the shield is grounded properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
158-1	VI self-test: Lower bridge IGBT of phase U short-circuited upon switch-on	0: Coast to stop	Manual reset	The lower bridge IGBT of phase U is short-circuited.	Ensure that the lower bridge IGBT of phase U is connected properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
158-2	VI self-test: Upper bridge IGBT of phase U short-circuited upon switch-on	0: Coast to stop	Manual reset	The upper bridge IGBT of phase U is short-circuited.	Ensure that the upper bridge IGBT of phase U is connected properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
158-3	VI self-test: Lower bridge IGBT of phase V short-circuited upon switch-on	0: Coast to stop	Manual reset	The lower bridge IGBT of phase V is short-circuited.	Ensure that the lower bridge IGBT of phase V is connected properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
158-4	VI self-test: Upper bridge IGBT of phase V short-circuited upon switch-on	0: Coast to stop	Manual reset	The upper bridge IGBT of phase V is short-circuited.	Ensure that the upper bridge IGBT of phase V is connected properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
158-5	VI self-test: Lower bridge IGBT of phase W short-circuited upon switch-on	0: Coast to stop	Manual reset	The lower bridge IGBT of phase W is short-circuited.	Ensure that the lower bridge IGBT of phase W is connected properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
158-6	VI self-test: Upper bridge IGBT of phase W short-circuited upon switch-on	0: Coast to stop	Manual reset	The upper bridge IGBT of phase W is short-circuited.	Ensure that the upper bridge IGBT of phase W is connected properly.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
158-7	Output ground fault	0: Coast to stop	Manual reset	A grounding fault or short circuit occurs on the output circuit of the drive.	Rectify peripheral faults and ensure that short circuit does not occur on the motor or output contactor.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
158-8	Bridge arm self-test: Short circuit occurred upon pulse generation by IGBT U+V-W-	0: Coast to stop	Manual reset	The UV or UW output terminals are short-circuited.	1. Ensure that short circuit does not occur on the VU or VW terminals of the drive. 2. Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
158-9	Bridge arm self-test: Short circuit occurred upon pulse generation by IGBT U-V+W+	0: Coast to stop	Manual reset	The UV or UW output terminals are short-circuited.	1. Ensure that short circuit does not occur on the VU or VW terminals of the drive. 2. Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
158-10	Bridge arm self-test: Short circuit occurred upon pulse generation by IGBT V+U-W-	0: Coast to stop	Manual reset	The VU or VW output terminals are short-circuited.	1. Ensure that short circuit does not occur on the VU or VW terminals of the drive. 2. Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
158-11	Bridge arm self-test: Short circuit occurred upon pulse generation by IGBT V-U+W+	0: Coast to stop	Manual reset	The VU or VW output terminals are short-circuited.	1. Ensure that short circuit does not occur on the VU or VW terminals of the drive. 2. Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
158-12	Bridge arm self-test: Short circuit occurred upon pulse generation by IGBT W+U-V-	0: Coast to stop	Manual reset	The WU or WV output terminals are short-circuited.	1. Ensure that short circuit does not occur on the WU or WV terminals of the drive. 2. Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
158-13	Bridge arm self-test: Short circuit occurred upon pulse generation by IGBT W-U+V+	0: Coast to stop	Manual reset	The WU or WV output terminals are short-circuited.	1. Ensure that short circuit does not occur on the WU or WV terminals of the drive. 2. Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
158-14	Phase U or phase V lost in system output	0: Coast to stop	Manual reset	The phase U or phase V output is not connected.	Perform wiring again.
				The current sensor of phase U or phase V is abnormal.	Replace the current sensor of phase U or phase V.
				Self-test is performed during rotation of the motor.	Wait until the motor is at a standstill before self-test.
				Other fault causes lead to the fault.	1. Ensure that the motor winding is connected properly. 2. Contact Inovance for technical support.
158-15	Phase W or phase V lost in system output	0: Coast to stop	Manual reset	Phase V or phase W is not connected.	Perform wiring again.
				The current sensor of phase V or phase W is abnormal.	Replace the current sensor of phase V or phase W.
				Self-test is performed during rotation of the motor.	Wait until the motor is at a standstill before self-test.
				Other fault causes lead to the fault.	1. Ensure that the motor winding is connected properly. 2. Contact Inovance for technical support.
158-16	Phase U or phase W lost in system output	0: Coast to stop	Manual reset	Phase W or phase U is not connected.	Perform wiring again.
				The current sensor of phase W or phase U is abnormal.	Replace the current sensor of phase W or phase U.
				Self-test is performed during rotation of the motor.	Wait until the motor is at a standstill before self-test.
				Other fault causes lead to the fault.	1. Ensure that the motor winding is connected properly. 2. Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
159-1	Abnormal detection value of phase U current sensor	0: Coast to stop	Manual reset	The current sensor of phase U is abnormal.	1. Ensure that the power cable and signal cable of the phase U current sensor are connected properly. 2. Replace the phase U current sensor.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
159-2	Abnormal detection value of phase V current sensor	0: Coast to stop	Manual reset	The phase V current sensor is abnormal.	1. Ensure that the power cable and signal cable of the phase V current sensor are connected properly. 2. Replace the phase V current sensor.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
159-3	Abnormal detection value of phase W current sensor	0: Coast to stop	Manual reset	The phase W current sensor is abnormal.	1. Ensure that the power cable and signal cable of the phase W current sensor are connected properly. 2. Replace the phase W current sensor.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
159-4	Phase U current sensor installed reversely	0: Coast to stop	Manual reset	The phase U current sensor is installed reversely.	Confirm the direction and adjust it again.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
159-5	Phase V current sensor installed reversely	0: Coast to stop	Manual reset	The phase V current sensor is installed reversely.	Confirm the direction and adjust it again.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
159-6	Phase W current sensor installed reversely	0: Coast to stop	Manual reset	The phase W current sensor is installed reversely.	Confirm the direction and adjust it again.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
159-7	Output phase loss in phase U or open circuit in lower bridge IGBT	0: Coast to stop	Manual reset	Phase U is lost on the output end of the module.	If phase U is not connected, ensure that phase U of the module is connected properly.
				Open circuit is detected in the lower bridge IGBT in this phase.	Ensure that the lower bridge IGBT is normal.
				The motor phase U winding is disconnected.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
159-8	Output phase loss in phase V or open circuit in lower bridge IGBT	0: Coast to stop	Manual reset	Phase V is lost on the output end of the module.	If the phase V is not connected, ensure that the phase V of the module is connected properly.
				Open circuit is detected in the lower bridge IGBT in this phase.	Ensure that the lower bridge IGBT is normal.
				The motor phase V winding is disconnected.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
159-9	Output phase loss in phase W or open circuit in lower bridge IGBT	0: Coast to stop	Manual reset	Phase W is lost on the output end of the module.	If the phase W is not connected, ensure that the phase W of the module is connected properly.
				Open circuit is detected in the lower bridge IGBT in this phase.	Ensure that the lower bridge IGBT is normal.
				The motor phase W winding is disconnected.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
159-10	Phase U/V sensor connected incorrectly	0: Coast to stop	Manual reset	The phase U/V sensor feedback cables of the module are connected reversely.	Check the feedback cable connection and adjust the connection.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
159-11	Phase U/W sensor connected incorrectly	0: Coast to stop	Manual reset	The phase U/W sensor feedback cables of the module are connected reversely.	Check the feedback cable connection and adjust the connection.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
159-12	Phase V/W sensor connected incorrectly	0: Coast to stop	Manual reset	The phase V/W sensor feedback cables of the module are connected reversely.	Check the feedback cable connection and adjust the connection.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
159-13	Output phase loss in phase U or open circuit in upper bridge IGBT	0: Coast to stop	Manual reset	Phase U is lost on the output end of the module.	Connect phase U properly.
				Open circuit occurs on the upper bridge IGBT of this phase.	Ensure that the upper bridge IGBT is normal.
				The motor phase U winding is disconnected.	If the phase U is disconnected, contact the technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
159-14	Output phase loss in phase V or open circuit in upper bridge IGBT	0: Coast to stop	Manual reset	Phase V is lost on the output end of the module.	Connect phase V.
				Open circuit occurs on the upper bridge IGBT of this phase.	Measure whether the upper bridge IGBT is abnormal. If yes, contact technical support.
				The motor phase V winding is disconnected.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
159-15	Output phase loss in phase W or open circuit in upper bridge IGBT	0: Coast to stop	Manual reset	Phase W is lost on the output end of the module.	If the phase W is not connected, ensure that the phase W of the module is connected properly.
				Open circuit occurs on the upper bridge IGBT of this phase.	Measure whether the upper bridge IGBT is abnormal. If yes, contact technical support.
				The motor phase W winding is disconnected.	If the phase W is disconnected, contact technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
159-16	Self-test interrupted	0: Coast to stop	Manual reset	The self-test is interrupted when a stop or emergency stop command is received halfway.	Reset the fault and perform self-test again.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
160-1	Three-phase current unbalance	0: Coast to stop	Manual reset	The current-balancing inductance outputted by each phase varies greatly.	Ensure that the output inductance of each phase is consistent.
				The output cable length varies greatly.	Ensure that the cable length of each phase is consistent.
				The current of a phase is detected to be abnormal.	Ensure that the Hall device is wired properly.
				Other fault causes lead to the fault.	1. The motor operates improperly. 2. Contact Inovance for technical support.
160-2	Excessive phase V/W sampling deviation	0: Coast to stop	Manual reset	The motor is rotating during self-test.	Wait until the motor stops before self-test.
				The output cable length varies greatly.	Ensure that the cable length of each phase is consistent.
				The Hall sampling is abnormal.	Replace the Hall sensor.
				Other fault causes lead to the fault.	1. The motor operates improperly. 2. Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
160-3	Excessive phase U/W sampling deviation	0: Coast to stop	Manual reset	The motor is rotating during self-test.	Wait until the motor stops before self-test.
				The output cable length varies greatly.	Ensure that the cable length of each phase is consistent.
				The Hall sampling is abnormal.	Replace the Hall sensor.
				Other fault causes lead to the fault.	1. The motor operates improperly. 2. Contact Inovance for technical support.
160-4	Excessive phase U/V sampling deviation	0: Coast to stop	Manual reset	The motor is rotating during self-test.	Wait until the motor stops before self-test.
				The output cable length varies greatly.	Ensure that the cable length of each phase is consistent.
				The Hall sampling is abnormal.	Replace the Hall sensor.
				Other fault causes lead to the fault.	1. The motor operates improperly. 2. Contact Inovance for technical support.
160-5	Phase U current unbalance	0: Coast to stop	Manual reset	The cables used for parallel operation are inconsistent.	Check that the cables of each parallel unit are consistent.
				The Hall sampling is abnormal.	Replace the Hall sensor.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
160-6	Phase V current unbalance	0: Coast to stop	Manual reset	The cables used for parallel operation are inconsistent.	Check that the cables of each parallel unit are consistent.
				The Hall sampling is abnormal.	Replace the Hall sensor.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
160-7	Phase W current unbalance	0: Coast to stop	Manual reset	The cables used for parallel operation are inconsistent.	Check that the cables of each parallel unit are consistent.
				The Hall sampling is abnormal.	Replace the Hall sensor.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
160-8	Phase U upper bridge or phase V lower bridge IGBT cannot be switched on	0: Coast to stop	Manual reset	The IGBT cannot be switched on.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
160-9	Phase U lower bridge or phase V upper bridge IGBT cannot be switched on	0: Coast to stop	Manual reset	The IGBT cannot be switched on.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
160-10	Phase V upper bridge or phase W lower bridge IGBT cannot be switched on	0: Coast to stop	Manual reset	The IGBT cannot be switched on.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
160-11	Phase V lower bridge or phase W upper bridge IGBT cannot be switched on	0: Coast to stop	Manual reset	The IGBT cannot be switched on.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
160-12	Phase W upper bridge or phase U lower bridge IGBT cannot be switched on	0: Coast to stop	Manual reset	The IGBT cannot be switched on.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
160-13	Phase W lower bridge or phase U upper bridge IGBT cannot be switched on	0: Coast to stop	Manual reset	The IGBT cannot be switched on.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
14	Self-test overcurrent	0: Coast to stop	Manual reset	The output transient current is higher than 1.5 x rated current of the motor or drive.	Contact Inovance for technical support.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
170-1	<I/O expansion module 1> DIO output wiring short-circuited	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Automatic reset	When DIO is used for output, the output circuit is short-circuited.	Ensure that the output circuit is not short-circuited when DIO is used as output.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
170-2	<I/O expansion module 2> DIO output circuit short-circuited	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Automatic reset	When DIO is used for output, the output circuit is short-circuited.	Ensure that the output circuit is not short-circuited when DIO is used as output.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
170-3	<I/O expansion module 3> DIO output circuit short-circuited	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Automatic reset	When DIO is used for output, the output circuit is short-circuited.	Ensure that the output circuit is not short-circuited when DIO is used as output.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
170-4	<I/O expansion module 1> AI input disconnected	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Automatic reset	The AI type is set improperly.	Set the AI type (input voltage/current) of the I/O expansion module properly.
				The AI open circuit monitoring threshold is excessively low or the open circuit monitoring delay is excessively short.	1. Re-adjust the value of n25-48 [AI1 open circuit monitoring threshold]. 2. Re-adjust the value of n25-49 [AI open circuit monitoring delay].
				Other fault causes lead to the fault.	Contact Inovance for technical support.
170-5	<I/O expansion module 2> AI input disconnected	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Automatic reset	The AI type is set improperly.	Set the AI type (input voltage/current) of the I/O expansion module properly.
				The AI open circuit monitoring threshold is excessively low or the open circuit monitoring delay is excessively short.	1. Re-adjust the value of n28-48 [AI1 open circuit monitoring threshold]. 2. Re-adjust the value of n28-49 [AI open circuit monitoring delay].
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
170-6	<I/O expansion module 3> AI input disconnected	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Automatic reset	The AI type is set improperly.	Set the AI type (input voltage/current) of the I/O expansion module properly.
				The AI open circuit monitoring threshold is excessively low or the open circuit monitoring delay is excessively short.	1. Re-adjust the value of n31-48 [AI1 open circuit monitoring threshold]. 2. Re-adjust the value of n31-49 [AI open circuit monitoring delay].
				Other fault causes lead to the fault.	Contact Inovance for technical support.
170-7	<I/O expansion module 1> EEPROM operation error	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Automatic reset	EEPROM fault	1. Re-write calibration parameters. 2. Replace the I/O expansion module.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
170-8	<I/O expansion module 2> EEPROM operation error	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Automatic reset	EEPROM fault	1. Re-write calibration parameters. 2. Replace the I/O expansion module.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
170-9	<I/O expansion module 3> EEPROM operation error	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Automatic reset	EEPROM fault	1. Re-write calibration parameters. 2. Replace the I/O expansion module.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
170-10	<I/O expansion module 1> calibration factor error	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Automatic reset	The default calibration parameters for AI or AO are abnormal and n7-39 is set to "Calibration inhibited".	Check the feedback status of the expansion module through n7-15 and modify the calibration factor of the abnormal channel.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
170-11	<I/O expansion module 2> calibration factor error	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Automatic reset	The default calibration parameters for AI or AO are abnormal and n8-39 is set to "Calibration inhibited".	Check the feedback status of the expansion module through n8-15 and modify the calibration factor of the abnormal channel.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
170-12	<I/O expansion module 3> calibration factor error	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Automatic reset	The default calibration parameters for AI or AO are abnormal and n9-39 is set to "Calibration inhibited".	Check the feedback status of the expansion module through n9-15 and modify the calibration factor of the abnormal channel.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
172-1	Phase U module pre-overtemperature	6: Displaying this alarm only	Automatic reset	The air duct is blocked.	Clean the air duct.
				The fan operates properly.	If the fan is faulty, replace the fan.
				The ambient temperature is high.	Lower down the ambient temperature.
				The pre-overtemperature alarm threshold is set to an excessively high value.	Set A4-27 properly.
				The module is faulty.	Contact Inovance for technical support.
172-2	Phase V module pre-overtemperature	6: Displaying this alarm only	Automatic reset	The air duct is blocked.	Clean the air duct.
				The fan operates properly.	If the fan is faulty, replace the fan.
				The ambient temperature is high.	Lower down the ambient temperature.
				The pre-overtemperature alarm threshold is set to an excessively high value.	Set A4-27 properly.
				The module is faulty.	Contact Inovance for technical support.
172-3	Phase W module pre-overtemperature	6: Displaying this alarm only	Automatic reset	The air duct is blocked.	Clean the air duct.
				The fan operates properly.	If the fan is faulty, replace the fan.
				The ambient temperature is high.	Lower down the ambient temperature.
				The pre-overtemperature alarm threshold is set to an excessively high value.	Set A4-27 properly.
				The module is faulty.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
172-7	Control chamber temperature error	6: Displaying this alarm only	Automatic reset	The air duct is blocked.	Clean the air duct.
				The fan operates properly.	If the fan is faulty, replace the fan.
				The ambient temperature is high.	Lower down the ambient temperature.
				The pre-overtemperature alarm threshold is set to an excessively high value.	Set A4-27 properly.
				The module is faulty.	Contact Inovance for technical support.
173-7	< Synchronous voltage detection module 1> version incompatibility	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Manual reset	The software version is not supported. Update the software version.	Update the HSVM software to the latest version.
174-13	HSVM wiring phase sequence error	0: Coast to stop	Manual reset	The HSVM wiring phase sequence is incorrect: VWU or UWV.	Ensure that the UVW phase sequence is correct.
174-14	HSVM sampling cable disconnected or not connected	0: Coast to stop	Manual reset	The HSVM sampling cable is disconnected or not connected.	Ensure that the HSVM module is connected properly.
183-4	InoLink communication: The local address is the node address for data reception.	6: Displaying this alarm only	Automatic reset	The specified node address for receiving data is set improperly.	Set the node address for receiving data correctly.
				The local address is set incorrectly.	Set the local address correctly.
183-5	Optical fiber synchronous communication module: node address conflict	6: Displaying this alarm only	Automatic reset	The node address already exists.	Set a unique address to each node.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
183-6	Optical fiber synchronous communication module: data reception node A not started	6: Displaying this alarm only	Automatic reset	The optical fiber circuit is abnormal.	Check that the wiring of the corresponding address of the data reception node A is correct.
				The node A address is not started.	Ensure that the node A source address has been started.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
183-7	Optical fiber synchronous communication module: data reception node B not started	6: Displaying this alarm only	Automatic reset	The optical fiber circuit is abnormal.	Check that the wiring of the corresponding address of the data reception node B is correct.
				The node address B is not started.	Ensure that the source address of node B is started.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
183-8	Optical fiber synchronous communication module: data reception node C not started	6: Displaying this alarm only	Automatic reset	The optical fiber circuit is abnormal.	Check that the wiring of the corresponding address of the data reception node C is correct.
				The node address C is not started.	Ensure that the node C source address has been started.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
183-9	Optical fiber synchronous communication module: local node address not set	6: Displaying this alarm only	Automatic reset	The local node address is not set.	Reset n22-05 (Local address).
				Other fault causes lead to the fault.	Contact Inovance for technical support.
183-10	Optical fiber synchronous communication module: local address used for data reception	6: Displaying this alarm only	Automatic reset	The data reception source node set by 22-06, n22-07, or n22-08 is the local address.	Reset the data source set by n22-06, n22-07, or n22-08.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
183-11	Optical fiber synchronous communication module not activated	6: Displaying this alarm only	Automatic reset	The communication network is started, but the slot (n22-02) is not set for the optical fiber synchronous communication module.	Set the card slot (n22-02).
				Other fault causes lead to the fault.	Contact Inovance for technical support.
183-12	Optical fiber synchronous communication module: data reception node A not in the network	6: Displaying this alarm only	Automatic reset	The node address set by n22-06 does not exist.	Reset n22-06 properly.
				The optical fiber of the node address loop set by n22-06 is abnormal.	Check the optical fiber of the loop.
				Other fault causes lead to the fault.	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
183-13	Optical fiber synchronous communication module: data reception node B not in the network	6: Displaying this alarm only	Automatic reset	The node address set by node B (n22-07) does not exist.	Reset n22-07 properly.
				The optical fiber of the node address loop set by node B (n22-07) is abnormal.	Check the optical fiber of the loop.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
183-14	Optical fiber synchronous communication module: data reception node C not in the network	6: Displaying this alarm only	Automatic reset	The node address set by node C (n22-08) does not exist.	Reset n22-08 properly.
				The optical fiber of the node address loop set by node C (n22-08) is abnormal.	Check the optical fiber of the loop.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
187-1	Excessive position deviation	0: Coast to stop	Manual reset	The difference between the feedback position and the position reference exceeds the error threshold set by software.	Modify the corresponding parameters, such as the deviation threshold or detection time.
187-2	Home searching timeout	0: Coast to stop	Manual reset	The duration of home searching exceeds the time defined by o19-21.	Set parameters related to homing in group o19 properly.
187-3	Positioning completion timeout	0: Coast to stop	Manual reset	The position reference does not change, but the actual position is out of the allowable range after the time defined by o15-54 elapses.	Set parameters related to positioning control in group o17.
187-4	Position feedback encoder open circuit	0: Coast to stop	Manual reset	In the position control mode, encoder open circuit is detected by the hardware.	Ensure that the position feedback encoder is connected properly.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
188-1	Home invalid during operation in the positioning control mode	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The home is invalid during operation in the positioning control mode.	Perform homing to ensure that the home is valid.
188-2	Home invalid during interrupt positioning	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The home is invalid during interrupt positioning.	Perform homing to ensure that the home is valid.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
188-3	Proximity switches 1 and 2 activated at the same time	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	Proximity switches 1 and 2 are too close to each other and activated simultaneously.	Keep a certain distance between proximity switches 1 and 2 to prevent them from being activated simultaneously.
188-4	Proximity switch 1 signal loss	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The proximity switch 1 signal is lost, which is not detected during operation.	Check that the position and signal circuit of the proximity switch are proper.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
188-5	Proximity switch 2 signal loss	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The proximity switch 2 signal is lost, which is not detected during operation.	Check that the position and signal circuit of the proximity switch are proper.
188-6	Proximity switch 1 position deviation too large	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The deviation between the detection position of proximity switch 1 and the position reference exceeds the set range.	Check that the position and signal circuit of the proximity switch are proper.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
188-7	Proximity switch 2 position deviation too large	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The deviation between the detection position of proximity switch 2 and the position reference exceeds the set range.	Check that the position and signal circuit of the proximity switch are proper.
188-8	Position reference limit violated	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The position reference in positioning control is out of the positive/negative software limit range.	Reset o17-62 and o17-63 properly.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
189-1	Positive hardware limit switch 1 activated	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The positive limit switch signal 1 is activated.	Ensure that the limit switch signal is normal. Set L13-00 correctly or run in the opposite direction.
189-2	Negative hardware limit switch 1 activated	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The negative limit switch signal 1 is activated.	Ensure that the limit switch signal is normal. Set L13-01 correctly or run in the opposite direction.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
189-3	Positive software limit switch activated	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The current position value (U29-00) is greater than the positive software limit setpoint (o17-62).	Set the positive software limit (o17-62) properly.
189-4	Negative software limit switch activated	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The current position (U29-00) is lower than the negative software limit setpoint (o17-63).	Set the negative software limit (o17-63) properly.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
189-5	Positive hardware limit switch 2 activated	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The positive limit switch signal 2 is activated.	Ensure that the limit switch signal is normal. Set L13-02 correctly or run in the opposite direction.
189-6	Negative hardware limit switch 2 activated	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The negative limit switch signal 2 is activated.	Ensure that the limit switch signal is normal. Set L13-03 correctly or run in the opposite direction.
190-1	Overload monitored	0: Coast to stop	Manual reset	The actual load characteristic curve exceeds the set overload curve point.	Set the overload curve properly.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
190-2	Underload monitored	0: Coast to stop	Manual reset	The actual load characteristic curve exceeds the set underload curve point.	Set the underload curve properly.
191-1	Overload monitored	6: Displaying this alarm only	Automatic reset	The actual load characteristic curve exceeds the set overload curve point.	Set the overload curve properly.
191-2	Underload monitored	6: Displaying this alarm only	Automatic reset	The actual load characteristic curve exceeds the set underload curve point.	Set the underload curve properly.
192-1	Variable frequency output contactor feedback error	0: Coast to stop	Manual reset	The control signal and feedback signal of the variable frequency contactor do not match.	1. Ensure that RO1 is wired properly. 2. Ensure that DI1 is wired properly. 3. Ensure that the control circuit of the variable frequency contactor is not powered off.
192-2	Grid contactor feedback error	0: Coast to stop	Manual reset	The control signal and feedback signal of the grid contactor do not match.	1. Ensure that RO1 is wired properly. 2. Ensure that DI1 is wired properly. 3. Ensure that the control circuit of the variable frequency contactor is not powered off.
193-1	Variable frequency output contactor feedback error	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Automatic reset	The control signal and feedback signal of the variable frequency contactor do not match.	1. Ensure that RO1 is wired properly. 2. Ensure that DI1 is wired properly. 3. Ensure that the control circuit of the variable frequency contactor is not powered off.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
193-2	Grid contactor feedback error	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only	Automatic reset	The control signal and feedback signal of the grid contactor do not match.	1. Ensure that RO1 is wired properly. 2. Ensure that DI1 is wired properly. 3. Ensure that the control circuit of the variable frequency contactor is not powered off.
194-1	Grid frequency error	0: Coast to stop	Manual reset	1. The grid frequency differs greatly from the rated motor frequency. 2. The grid frequency fluctuates greatly.	Check that the motor parameters are set properly, the rated motor parameters match the grid, and the HSVM detection module is wired properly.
194-2	Grid voltage error - Reserved	0: Coast to stop	Manual reset	The grid voltage fluctuates greatly.	Ensure that the grid voltage does not fluctuate unexpectedly and the HSVM detection module is wired properly.
194-3	Grid voltage deviating greatly from the motor rated voltage	0: Coast to stop	Manual reset	The grid voltage deviates greatly from the motor rated voltage.	Ensure that the motor parameters are normal and rated motor parameters match the grid. Calibrate the HSVM voltage sampling.
194-4	Grid phase synchronization timeout	0: Coast to stop	Manual reset	1. Grid phase synchronization is not done within 10 seconds. 2. The grid frequency fluctuates excessively. 3. The grid voltage is abnormal. 4. The grid synchronization tuning parameters are set improperly.	Ensure that the grid frequency fluctuates normally and the grid phase synchronization tuning parameters of the drive are not modified unexpectedly. In addition, you can contact Inovance technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
195-1	Pump marking selected repetitively	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The pump marking is the same as other pumps in the communication network.	Change the marking of current pump or other pumps in the network.
195-2	Communication disconnected during operation	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	No data is received during operation, and communication is disconnected.	Ensure that the communication wiring between the master and slave is normal.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
195-3	Sensor signal lost during operation	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The pump pulse sensor output signal is not received during operation.	Ensure that the sensor is wired properly and o20-08 is configured properly.
195-4	Number of cylinders (piston) of the pump inconsistent	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The number of cylinders (piston) of the pump is inconsistent with that of other pumps in the communication network.	Check the actual conditions on the site. Select the correct number of cylinders (piston) through o20-05.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
196-1	HSTM-10 module disconnected (hardware detection)	0: Coast to stop	Manual reset	The HSTM-10 module is damaged.	Replace the module.
				The module power supply is faulty.	The power supply of the module is normal.
				The module is wired improperly.	Ensure that the module is wired properly.
				The signal cable of the module is being disturbed seriously.	1. Check that the shield of the module is grounded properly. 2. Route the signal cable and power cable of the module through different routes.
				Other fault causes lead to the fault.	Contact Inovance for technical support.
197-1	EX-FLASH 1 read/ write error	6: Displaying this alarm only	Automatic reset	An error occurred during reading/writing data in EX-FLASH 1.	1. Power on the HCU control power supply again. 2. Clear the log through A8-00.
				EX-FLASH1 hardware error	Disable the EX-FLASH error alarm through H0-40 (the log function error is not reported when this alarm is disabled).
				Other fault causes lead to the fault.	Contact Inovance for technical support.
198-1	The quick stop function of the HPCU upon IGBT fault does not match the setting.	6: Displaying this alarm only	Automatic reset	The current HPCU does not support quick stop upon IGBT fault but A4-59 (Quick stop upon IGBT fault) is enabled.	1. Update the HPCU program. 2. A4-59 is set to "Disable". 3. Contact Inovance for technical support.
201-1	RO1 service life reached	6: Displaying this alarm only	Automatic reset	The number of RO1 actions (o13-10) reaches the RO1 service life alarm threshold (o13-08).	Contact Inovance for technical support.
201-2	RO2 service life reached	6: Displaying this alarm only	Automatic reset	The number of RO2 actions (o13-16) reaches the RO2 service life alarm threshold (o13-14).	Contact Inovance for technical support.
201-3	RO3 service life reached	6: Displaying this alarm only	Automatic reset	The number of RO3 actions (o13-22) reaches the RO3 service life alarm threshold (o13-20).	Contact Inovance for technical support.
201-4	Module fan service life reached	6: Displaying this alarm only	Automatic reset	The actual operating time of the fan reaches the service life alarm threshold of the fan.	Contact Inovance for technical support.
215-1	RO1 service life reached	0: Coast to stop	Manual reset	The number of RO1 actions (o13-10) reaches the RO1 service life fault threshold (o13-09).	Contact Inovance for technical support.
215-2	RO2 service life reached	0: Coast to stop	Manual reset	The number of RO2 actions (o13-16) reaches the RO2 service life fault threshold (o13-15).	Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
215-3	RO3 service life reached	0: Coast to stop	Manual reset	The number of RO3 actions (o13-22) reaches the RO3 service life fault threshold (o13-21).	Contact Inovance for technical support.
215-4	Module fan service life reached	0: Coast to stop	Manual reset	The actual operating time of the fan reaches the threshold of fan service life fault.	Contact Inovance for technical support.
220-1	AI1 input value limit exceeded	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The input value of AI1 (F2-00) is lower than F2-28 or greater than F2-30.	Ensure that the actual input value does not exceed the limit values defined by F2-28 and F2-30.
				The AI monitoring function (F2-36) is enabled.	If you do not want to enable detection on this fault, set F2-36 (AI monitoring function) to 0 (Disable).
				The AI1-related judgment conditions are activated through F2-37 (AI monitoring activation condition selection) and F2-38 (AI monitoring control channel selection).	1. Set F2-37 "AI monitoring activation condition selection" and F2-38 "AI monitoring control channel selection" properly. 2. Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
215-2	AI2 input value limit exceeded	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The input value of AI2 (F2-02) is lower than F2-32 or greater than F2-34.	Ensure that the actual input value does not exceed the limit.
				The AI monitoring function (F2-36) is enabled.	If you do not want to enable detection on this fault, set F2-36 (AI monitoring function) to 0 (Disable).
				The AI1-related judgment conditions are activated through F2-37 (AI monitoring activation condition selection) and F2-38 (AI monitoring control channel selection).	1. Set F2-37 "AI monitoring activation condition selection" and F2-38 "AI monitoring control channel selection" properly. 2. Contact Inovance for technical support.
222-1	Local contactor fault in redundancy switchover function	1: Coast to stop	Manual reset	The control signal and feedback signal of the local contactor do not match.	1. Check that wiring is correct. 2. Check that wiring is correct. 3. Check whether the control circuit of the local contactor is powered off. 4. Contact Inovance for technical support.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
227-1	Motor pre-heating completed	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	1. This fault is triggered when the motor pre-heating completion signal (o13-22) is activated. 2. This fault is triggered when the motor pre-heating time is reached.	Set o13-23 to 0 [No prompt] to ignore this fault/ alarm.
228-1	Capacitor leakage	1: Coast to stop	Manual reset	The bus voltage fluctuates violently due to bus capacitance leakage.	Contact Inovance for technical support.
229-1	Synchronous motor Back EMF parameter error	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	There is no accurate back EMF for permanent magnet synchronous motors in vector control mode. Parameters d1-26 is set improperly. The possible causes are as follows. 1. No-load complete dynamic auto-tuning is not performed. 2. No-load complete dynamic auto-tuning fails, resulting in the back EMF update failure.	To obtain an accurate back EMF, do as follows. 1. Set b5-00 to 2 to perform no-load complete dynamic auto-tuning. 2. If no-load dynamic auto-tuning is not available for synchronous motors, check the motor nameplate or contact the motor manufacturer to get the accurate motor back EMF. d1-26 represents the back EMF in rated speed. If the effective back EMF marked on the nameplate is 120 V/krpm, the rated back EMF = [d0-05]/1000 x 120 V. The back EMF of this product is the effective value of the line voltage. 3. If neither complete no-load dynamic auto-tuning nor accurate back EMF is available, you can estimate a back EMF by setting b5-02 to 3 in FVC mode. The motor can run during estimation of the back EMF in FVC mode, but the output torque may be inaccurate. The back EMF must be obtained by method 1 or 2 of SVC control.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
230-1	Auto-tuning of stator resistance and transistor voltage drop failed	1: Coast to stop	Manual reset	1. Each independent auto-tuning step is defined with a maximum time, beyond which this fault can be reported. 2. The performance software detects whether current auto-tuning step is abnormal and reports a fault.	Ensure that basic motor parameters are set correctly, the power and rated current of the motor match those of the drive, and the motor is wired properly.
230-2	Auto-tuning of rotor resistance and leakage inductance failed	1: Coast to stop	Manual reset	1. Each independent auto-tuning step is defined with a maximum time, beyond which this fault can be reported. 2. The performance software detects whether current auto-tuning step is abnormal and reports a fault.	Ensure that basic motor parameters are set correctly, the power and rated current of the motor match those of the drive, and the motor is wired properly.
230-3	No-load auto-tuning failure of no-load current and mutual inductance	1: Coast to stop	Manual reset	1. For safety reasons, this step is not allowed when the brake function is enabled. 2. Set the motor speed upper limit to a value lower than 75%. 3. Each independent auto-tuning step is defined with a maximum time, beyond which this fault can be reported. 4. The performance software detects whether the current auto-tuning step is abnormal and reports a fault. 5. The DC bus voltage is excessively low.	1. Disable the brake function through d0-13 or L1-00. Remove the potential energy load and manually release the brake without affecting personal safety, and then perform auto-tuning. 2. Modify the motor speed upper limit to a value higher than 75%. 3. Check whether basic motor parameters are set correctly and whether the power and rated currents of the motor match that of the drive. 4. Ensure that the motor is not in the stall state. 5. Set encoder parameters correctly when the PG card is online. 6. Increase the DC bus voltage or decrease the no-load dynamic auto-tuning speed [b5-19].
230-4	Rotor resistance and leakage inductance auto-tuning timeout	1: Coast to stop	Manual reset	1. Each independent auto-tuning step is defined with a maximum time, beyond which this fault can be reported. 2. The performance software detects whether current auto-tuning step is abnormal and reports a fault.	Ensure that basic motor parameters are set correctly, the power and rated current of the motor match those of the drive, and the motor is wired properly.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
230-5	With-load auto-tuning of asynchronous motor no-load current and mutual inductance failed	1: Coast to stop	Manual reset	1. Each independent auto-tuning step is defined with a maximum time, beyond which this fault can be reported. 2. The performance software detects whether current auto-tuning step is abnormal and reports a fault.	Ensure that basic motor parameters are set correctly, the power and rated current of the motor match those of the drive, and the motor is wired properly.
230-6	Auto-tuning of UV/UVW sampling proportional gain failed	1: Coast to stop	Manual reset	1. Each independent auto-tuning step is defined with a maximum time, beyond which this fault can be reported. 2. The performance software detects whether current auto-tuning step is abnormal and reports a fault.	Ensure that basic motor parameters are set correctly, the power and rated current of the motor match those of the drive, and the motor is wired properly.
230-7	Speed loop parameter calculation timeout	1: Coast to stop	Manual reset	1. Each independent auto-tuning step is defined with a maximum time, beyond which this fault can be reported. 2. The performance software detects whether current auto-tuning step is abnormal and reports a fault.	Ensure that basic motor parameters are set correctly, the power and rated current of the motor match those of the drive, and the motor is wired properly.
230-8	Dead zone auto-tuning failure	1: Coast to stop	Manual reset	Auto-tuning cannot be done.	Ensure that basic motor parameters are set correctly, the power and rated current of the motor match those of the drive, and the motor is wired properly.
230-9	Asynchronous motor with-load auto-tuning failure	1: Coast to stop	Manual reset	The with-load auto-tuning of asynchronous motor cannot be done.	1. Set motor parameters according to the motor nameplate. 2. Set the speed reference to a value between 35% and 80%, or set b5-09 to 1 to define the speed reference internally. 3. Contact Inovance for technical support.
230-10	Synchronous motor pole auto-tuning failure	1: Coast to stop	Manual reset	Absence of magnetic saturation in the motor results in auto-tuning failure.	1. Check that motor parameters are set properly. 2. Check that the motor model is correct. 3. Ensure phase loss does not occur on the motor.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
230-11	Back EMF auto-tuning of synchronous motor timeout	1: Coast to stop	Manual reset	1. Each independent auto-tuning step is defined with a maximum time, beyond which this fault can be reported. 2. The performance software detects whether current auto-tuning step is abnormal and reports a fault.	Ensure that basic motor parameters are set correctly, the power and rated current of the motor match those of the drive, and the motor is wired properly.
230-12	No-load auto-tuning of zero position timeout	1: Coast to stop	Manual reset	1. Each independent auto-tuning step is defined with a maximum time, beyond which this fault can be reported. 2. The performance software detects whether current auto-tuning step is abnormal and reports a fault.	Ensure that basic motor parameters are set correctly, the power and rated current of the motor match those of the drive, and the motor is wired properly.
230-13	With-load auto-tuning of zero position timeout	1: Coast to stop	Manual reset	1. Each independent auto-tuning step is defined with a maximum time, beyond which this fault can be reported. 2. The performance software detects whether current auto-tuning step is abnormal and reports a fault.	Ensure that basic motor parameters are set correctly, the power and rated current of the motor match those of the drive, and the motor is wired properly.
230-14	Auto-tuning of synchronous motor magnetic pole position timeout	1: Coast to stop	Manual reset	1. Each independent auto-tuning step is defined with a maximum time, beyond which this fault can be reported. 2. The performance software detects whether current auto-tuning step is abnormal and reports a fault.	Ensure that basic motor parameters are set correctly, the power and rated current of the motor match those of the drive, and the motor is wired properly.
230-15	Synchronous motor auto-tuning timeout	1: Coast to stop	Manual reset	1. Each independent auto-tuning step is defined with a maximum time, beyond which this fault can be reported. 2. The performance software detects whether current auto-tuning step is abnormal and reports a fault.	Ensure that basic motor parameters are set correctly, the power and rated current of the motor match those of the drive, and the motor is wired properly.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
230-16	Auto-tuning of motor and load inertia failed	1: Coast to stop	Manual reset	1. For safety reasons, this step is not allowed when the brake function is enabled. 2. Set the motor speed upper limit to a value lower than 75%. 3. Each independent auto-tuning step is defined with a maximum time, beyond which this fault can be reported. 4. The performance software detects whether the current auto-tuning step is abnormal and reports a fault.	1. Disable the brake function through d0-13 or L1-00. Remove the potential energy load and manually release the brake without affecting personal safety, and then perform auto-tuning. 2. Modify the motor speed upper limit to a value higher than 75%. 3. Check whether basic motor parameters are set correctly and whether the power and rated currents of the motor match that of the drive. 4. Ensure that the motor is not in the stall state. 5. Set encoder parameters correctly when the PG card is online.
231-1	Speed loop parameter calculation timeout	1: Coast to stop	Manual reset	1. For safety reasons, this step is not allowed when the brake function is enabled. 2. Set the motor speed upper limit to a value lower than 75%. 3. Each independent auto-tuning step is defined with a maximum time, beyond which this fault can be reported. 4. The performance software detects whether the current auto-tuning step is abnormal and reports a fault.	1. Check whether basic motor parameters are set properly. 2. Check whether the power and rated current of the motor match those of the drive. 3. Check the motor wiring.
231-2	Motor parameter calculation timeout	1: Coast to stop	Manual reset	1. Each independent auto-tuning step is defined with a maximum time, beyond which this fault can be reported. 2. The performance software detects whether current auto-tuning step is abnormal and reports a fault.	1. Check whether basic motor parameters are set properly. 2. Check whether the power and rated current of the motor match those of the drive. 3. Check the motor wiring.
231-3	Rotor resistance and leakage inductance auto-tuning timeout	1: Coast to stop	Manual reset	1. Each independent auto-tuning step is defined with a maximum time, beyond which this fault can be reported. 2. The performance software detects whether current auto-tuning step is abnormal and reports a fault.	1. Check whether basic motor parameters are set properly. 2. Check whether the power and rated current of the motor match those of the drive. 3. Check the motor wiring.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
231-4	Synchronous motor model auto-tuning timeout	1: Coast to stop	Manual reset	1. Each independent auto-tuning step is defined with a maximum time, beyond which this fault can be reported. 2. The performance software detects whether current auto-tuning step is abnormal and reports a fault.	1. Check whether basic motor parameters are set properly. 2. Check whether the power and rated current of the motor match those of the drive. 3. Check the motor wiring.
231-5	Back EMF parameter calculation of synchronous motor timeout	1: Coast to stop	Manual reset	1. Each independent auto-tuning step is defined with a maximum time, beyond which this fault can be reported. 2. The performance software detects whether current auto-tuning step is abnormal and reports a fault.	1. Check whether basic motor parameters are set properly. 2. Check whether the power and rated current of the motor match those of the drive. 3. Check the motor wiring.
231-6	Back EMF 2 auto-tuning timeout	1: Coast to stop	Manual reset	1. Each independent auto-tuning step is defined with a maximum time, beyond which this fault can be reported. 2. The performance software detects whether current auto-tuning step is abnormal and reports a fault.	1. Check whether basic motor parameters are set properly. 2. Check whether the power and rated current of the motor match those of the drive. 3. Check the motor wiring.
232-1	Back EMF auto-tuning error	1: Coast to stop	Manual reset	1. The acceleration process fails. 2. Overcurrent occurs during magnetic pole position auto-tuning.	1. Check that motor cables are connected properly. If the motor is connected to the load, disconnect the motor from the load before no-load complete auto-tuning. If the motor cannot be disconnected from the load, perform with-load complete auto-tuning. 2. Set motor parameters properly and perform no-load complete auto-tuning again.
232-2	Auto-tuned back EMF error	1: Coast to stop	Manual reset	The auto-tuned back EMF is not within the range of 5% to 120% of the rated motor voltage.	Check that basic motor parameters are set properly and perform no-load complete auto-tuning again.
232-3	Auto-tuned no-load current outside the limit	1: Coast to stop	Manual reset	The no-load current deviation is excessive. The no-load current of the motor within 2.2 kW exceeds the range of 0.125 to 1.5 x the rated current. The no-load current of the motor above 2.2 kW exceeds the range of 0.125 to 0.875 x the rated current.	Check whether the output current is excessively high or low in V/f mode. Check whether basic motor parameters are set properly. If motor parameters are accurate but the output current is still excessively high, you can decrease the rated voltage and perform auto-tuning again.

Fault code	Name	Fault level range	Reset mode	Cause	Solution
233-1	Communication time too long	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The response time of the communication encoder is excessively long, leading to failure in getting the encoder data within the set carrier cycle.	1. Set n4-92 or n4-85 to increase the encoder communication baud rate. 2. Replace the encoder.
233-2	Communication time not meeting the requirement of double pulse generation	0: Coast to stop 1: Emergency stop 2: Stop based on the set stop mode 3: Operating at limited current 4: Operating at limited speed 5: Operating at limited torque 6: Displaying this alarm only 7: No action	Automatic reset	The encoder communication time is excessively long, which cannot meet the double pulse generation requirements at 6.8 kHz carrier frequency. Therefore, the single/double pulse generation switchover threshold is reduced automatically.	Set n4-92 or n4-85 to increase the encoder communication baud rate.
255-1	Custom black box trigger command activated	7: No action	Automatic reset	The custom black box trigger command is activated.	-
255-2	FVC switched to SVC passively	7: No action	Automatic reset	The FVC mode is switched to SVC mode passively.	-

Fault code	Name	Fault level range	Reset mode	Cause	Solution
255-3	Black box triggered forcibly	7: No action	Automatic reset	The black box is triggered forcibly.	-
255-9	Z signal lost	7: No action	Automatic reset	The Z signal is lost.	-

14.8 Common Faults

Common faults on the power grid side

Symptom	Fault cause	Verification method	Solution
Input power factor on the grid side excessively low	The absence of a line reactor and a DC reactor can result in high harmonic current on the grid side, which can in turn cause a low power factor.	Check whether the model selected matches the requirements.	If a specific power factor is required on the network side, select a model with an reactor. If reactor is not available, install an external input reactor. There is no obvious correlation between the rectification power factor and efficiency. Common diode rectifiers have low power factors but high efficiency.
The input current measured by the multimeter deviates greatly from the theoretical value.	The grid-side current harmonics are excessively high, and the current waveform is not a standard sine wave. Therefore, measuring the input current directly using a multimeter can result in significant deviation.	Check whether the rectifier of the drive is AFE (active front end). If not, this fault can occur.	1. Measure the RMS value with an oscilloscope and current clamp. 2. Use a power quality analyzer.
The input current on the three-phase grid side is unbalanced.	The impedance on the grid side is unbalanced, leading to 100 Hz frequency fluctuation. This further results in different magnitudes of current.	1. Observe whether the bus voltage fluctuates at 100 Hz. 2. Check whether input phase loss occurs.	A three-phase reactor is used on the input end.
	Check whether the rectifier diodes are working properly. The bus voltage fluctuates at 50 Hz when one diode is inoperative.	Set the multimeter to the diode test mode. Connect the red probe to R/S/T and the black probe to the bus (+) terminal to measure the upper bridge of the rectifier. Connect the black probe to R/S/T and the red probe to the bus (-) terminal to measure the lower bridge of the rectifier. A consistent voltage drop indicates that the diode is normal.	Contact Inovance for technical support.

Symptom	Fault cause	Verification method	Solution
The input grid voltage measured at stop is normal. However, the output voltage is excessively low and the output current is excessively high during with-load operation.	1. The power grid is a weak power grid. 2. A reactor is installed on the input end and the voltage drop across the reactor is significant.	The grid voltage is inputted at stop but the grid voltage is excessively low during high-speed operation with high load.	1. Enable A4-07 (Overmodulation) and increase A4-32 (Overmodulation coefficient) to 107% to increase the output voltage properly. 2. Pay attention to the reactor model. The inductance can be reduced properly if it is excessively high. 3. Increase the mains voltage. If the transformer tap is changed, you can increase the grid voltage by 5%. Generally, a tap that allows slight grid voltage boost is reserved in the transformer, but not all transformers are reserved with such a tap.

Output measurement and display

Symptom	Fault cause	Verification method	Solution
The output current/ voltage fluctuates greatly.	1. The magnitude of the output data filter varies. 2. The motor output values fluctuate.	1. Check the output current filter. Only when the filter time is the same, the comparison is meaningful. 2. See the following table for actual speed fluctuation.	Observe the filtered output current and set the filter time accordingly. Set the display filter in group U5 through A11-85.
The low-speed output current measured by the clamp meter and oscilloscope + current clamp is excessively low with waveform distortion.	The measurement of both the clamp meter and the oscilloscope current clamp are based on the AC inductance principle. The AC magnetic field generated by low-frequency output current is weak, resulting in measurement deviation and waveform distortion.	1. Increase the output frequency and check whether the waveform and magnitude of the output current are correct. 2. After the speed is reduced, check whether the output current of the drive fluctuates significantly.	1. Use a DC current probe. 2. The low-frequency current output waveform is based on the software waveform of the drive because the drive can get the accurate the DC current through sampling.

V/f control

Symptom	Fault cause	Verification method	Solution
The drive vibrates during stop.	The acceleration abruptly changes during stop, resulting in torque impact.	1. Increase the deceleration time and check whether the vibration is alleviated. 2. Set C8-17 (Arc end time of ramp 1) properly to check whether the vibration is alleviated.	1. Set C8-17 (Arc end time of ramp 1) properly. If the deceleration time is short, you also need to set C8-16 (Arc start time of ramp 1). 2. Increase the speed loop Ti (E4-03/05) and the speed loop Kp (E4-02/04).
When the motor decelerates to stop according to the DI stop signal, the stop position of the motor exceeds the limit.	1. There is a delay in the transmission of the stop signal to the drive. 2. The drive filters command signals like DI. 3. The deceleration time does not match the actual mechanical requirements, such as the deceleration time base value. 4. Power generation results in overvoltage or overcurrent suppression. 5. The deceleration capacity is insufficient, with torque or current reaching the limit.	1. Check whether there is a delay in the transmission of the signal through the PLC, such as the delay in the PLC scan cycle. 2. Check the DI input filter (F0-06). If the deceleration time is very short, set the DI filter time to 0. 3. Check the actual deceleration time. The default base value for acceleration and deceleration time corresponds to the time at the maximum frequency. 4. Monitor the waveform. Power generation can occur during deceleration. If the bus voltage reaches the overvoltage suppression threshold (Overvoltage threshold - E3-21), the deceleration time is prolonged once overvoltage suppression applies, which can result in position overshoot. In this case, you can disable overvoltage suppression by setting E3-30 to 0 and observe whether overvoltage occurs during operation. 5. Monitor whether the output current reaches the overcurrent suppression threshold.	1. To improve the response, connect the DI that assigned with the decelerate-to-stop function directly to the drive without passing PLC. 2. Check whether the DI input filter (F0-22) is 0. 3. If the deceleration time is insufficient, increase the deceleration time (C7-05). 4. Try to increase the over-excitation coefficient (E3-24) and increase the deceleration time properly if the process allows. If the fault persists, connect a braking resistor. 5. Enable Imax control (E3-10).

Symptom	Fault cause	Verification method	Solution
The output current is excessively high.	1. Check whether the load is excessive. 2. Check whether the torque boost is excessively high. 3. Energy-saving control can be enabled for loads such as fans and water pumps. 4. If the output current is high only during high-speed flux weakening operation, this fault may be caused by low grid voltage.	1. Perform mechanical inspection. If the output current increases when drives of the same power rating are exchanged, the individual drive is faulty. Otherwise, this fault may be caused by mechanical reasons. 2. The output current at low frequency in V/f mode can be excessively high when the torque boost is lower than 50%. 3. You can enable energy-saving control to allow loads such as fans and pumps to output lower current in non-full load conditions. 4. In the high-speed flux weakening range, low output grid voltage at high load may result in excessively high output current. 5. Check whether basic motor parameters are set properly. If the output current of the motor is high during no-load operation in V/f mode, the rated motor parameters may be set improperly.	1. If this fault is caused by mechanical reasons, optimize the mechanical design and assembly. If the fault persists, replace with a motor of higher power rating. 2. Increase the torque boost factor (E3-14) properly. Note that an excessively high torque boost factor can result in excessively high output current. 3. Enable energy-saving control (E3-25) in V/f mode. 4. Enable A4-07 (Overmodulation) and increase A4-32 (Overmodulation coefficient) to 107%. Observe whether the output current decreases. 5. Check the rated motor parameters to ensure that V/f operation is normal.
The output voltage is lower than other machines during flux weakening operation.	The grid voltage is low or grid voltage loss occurs when the grid is connected to a low load.	Check whether the bus voltage drops significantly during operation with high load.	1. Enable A4-07 (Overmodulation) and increase A4-32 (Overmodulation coefficient) to 107%. Observe whether the output current decreases. 2. Change the transformer tap to increase the input voltage properly.

Symptom	Fault cause	Verification method	Solution
Insufficient speed accuracy in V/f control	During loaded operation in V/f control mode, there is a deviation (slip) between the rotor speed of the asynchronous motor and the frequency reference. Without slip compensation, a deviation can be generated between the rotor output speed and the speed reference..	Use a frequency sweeper to check whether the actual motor speed deviates significantly from the speed reference.	Try to increase the V/f slip compensation coefficient (E3-17).
Slow start occurs during quick start of acceleration.	1. Check whether the start command has been delayed. 2. The torque boost in V/f mode is set improperly, resulting in insufficient starting torque. 3. The output current limit is low, resulting in a deviation between the output acceleration frequency and the reference. 4. Check whether DC braking at start is enabled or the DC braking current and time at start are set.	1. Start/Stop control is applied too fast. Check the DI input value is filtered. 2. Increase the torque boost properly and check whether the startup delay is alleviated. 3. Release the current limit and torque limit properly. 4. Check the startup mode. Check the DC braking current and time at start.	1. Check whether the DI input filter (F0-22) is 0. 2. Increase the torque boost factor (E3-14) properly. 3. Increase the maximum motor current (d0-08) properly. Increase the positive and negative torque limit (E2-08/E2-09) properly. 4. Set the startup mode (E1-00) to de-select DC braking at start. Set the DC braking current (E1-05) to 0. Set the DC braking time at start (E1-06) to 0.
When multiple drives are used to drive the same load, the output current among drives is unbalanced.	When multiple drives are used to drive the same load, the minor mechanical errors between drives can result in high deviation between loads. In this case, perform master-slave control or droop control to balance the current among drives.	Load balance control is required when multiple drives are used to drive the same load. Independent speed control can easily result in this fault.	When multiple drives are used to drive the same load, perform master-slave control or droop control to balance the output torque.

Common faults in FVC and SVC control

Symptom	Fault cause	Verification method	Solution
The motor operates in reverse direction during decelerating to stop.	1. The Ti integral time and Kp proportional gain of the speed loop are excessively low. The integral overshoot occurs and the motor running speed is reversed. 2. When the motor stops suddenly, the output torque drops to 0 and elastic mechanical parts rebound, resulting in shaking at the mechanical end.	1. Increase E4-03/E4-05 of speed loop to 0.5s for regular models and 1.0 s for large inertia models. Then gradually increase E4-02/E4-04 to check whether the speed overshoot decreases. 2. Try apply arc transition to release the elastic torque gradually, thus reducing the shock caused by sudden acceleration change.	1. Increase E4-03/E4-05 of speed loop to 0.5s for regular models and 1.0 s for large inertia models. Then gradually increase E4-02/E4-04 to check whether the speed overshoot decreases. 2. Set C7-13 (Deceleration end arc of ramp 1) to reduce the elastic deformation caused by sudden change of the output torque to discharge the elastic energy gradually.

Symptom	Fault cause	Verification method	Solution
The output current is excessively high.	1. The load is excessive. 2. Energy-saving control is not enabled for loads such as fans and pumps, which can result in excessively high output current. 3. If the operating current is high during high-speed flux weakening operation, this fault may be caused by low grid voltage. 4. If rated motor parameters are set improperly or the Y-type or delta-type wiring of the motor is incorrect, motor operation errors can occur. 5. When the output current is high, this fault may be caused by current sampling deviation. 6. Dynamic parameter auto-tuning is not performed. This fault is usually caused by absence of dynamic parameter auto-tuning. 7. When overmodulation is enabled in vector control mode, the output current of the asynchronous motor is slightly high in the no-load flux weakening range. 8. The output current is excessively high during normal operation. 9. The synchronous motor is demagnetized.	1. Compare the output current of two drives with the same power rating. If only one drive shows a high output current, the drive may be faulty. 2. Check whether energy-saving control is enabled for loads such as fans and water pumps. 3. Check whether the grid voltage is excessively low. If so, increase the overmodulation depth. 4. Check whether basic motor parameters are set improperly. If the output current of the motor is still high during operation in V/f mode, the rated motor parameters may be set improperly. 5. A deviation of 1% may exist in the output current sampling of the drive. Use the same current clamp to test whether the high output current is caused by sampling deviation. 6. It is recommended to perform complete dynamic parameter auto-tuning in vector control. For initial commissioning in batch applications, it is recommended to perform no-load complete auto-tuning. Download the complete parameter file during batch copy. 7. During high-speed no-load operation of the asynchronous motor, the flux weakening depth of the motor decreases. During loaded operation, the output current decreases. 8. The excessively high current may be incurred by multiple causes. 9. Record the current back EMF (d1-26) and perform no-load complete auto-tuning again. Compare whether the newly auto-tuned back EMF is lower than the initial auto-tuned value. If the back EMF decreases significantly, wait for the motor to cool down and record the auto-tuned back EMF again.	1. If this fault is caused by mechanical issues, optimize the mechanical design and assembly. If the fault persists, replace with a motor of higher power rating. 2. Under steady-state loads such as the fans and pumps, it is recommended to activate E6-06 to reduce energy consumption. 3. In the high-speed flux weakening range, try to enable overmodulation (A4-09) and increase the overmodulation coefficient (A4-32) to improve the voltage utilization and reduce the output current. 4. Set the rated motor parameters correctly. Some motor nameplates list multiple sets of motor parameters, make sure that the correct motor parameter group is selected. If motor parameters are set correctly but the output current is still high, decrease the rated motor voltage. 5. Use the same current clamp for output current measurement and sampling. 6. Performing dynamic auto-tuning or downloading all parameters after dynamic auto-tuning can partially address the issue of high output current. 7. This is a normal phenomenon that requires no action. 8. Contact Inovance for technical support. 9. If the back EMF drops by more than 15% at the same temperature, the motor is demagnetized.

Symptom	Fault cause	Verification method	Solution
The deceleration time for large inertia models is excessively long.	1. The set deceleration time does not match the deceleration time needed. 2. The braking resistor is not installed, the motor enters the generating state during deceleration, which causes the bus voltage to rise above the overvoltage suppression threshold, slowing down the motor deceleration process. 3. The generating power limit is low.	1. Observe whether the actual motor speed (U9-00) follows the final motor speed setpoint (U9-01) through the oscilloscope. If the feedback speed can follow the set speed but the deceleration time is long, the set deceleration time is improper. 2. Check whether the DC bus voltage (U6-76) rises above the overvoltage suppression threshold (E9-02 x A2-02 x 1.414) and the feedback speed deviates from the set speed. If so, the fault is caused by overvoltage suppression. 3. Enable E2-16 (Generating power limit coefficient enable) and increase E2-17 (Generating power limit coefficient). Observe whether the deceleration is quickened.	1. Install a braking resistor. Note that the braking resistor model must match the operating conditions. Set the starting voltage (A5-12) properly. 2. If the fault persists, it is recommended to install a braking resistor. 3. Enable E2-16 and increase E2-17 properly. After increasing the generating power limit, check whether the braking resistor consumes energy in time in case of rapid power generation and whether the risk of overvoltage occurs.
The speed fluctuates greatly during high-speed flux weakening operation.	The flux weakening control bandwidth is insufficient, resulting in motor resonance.	Motor resonance occurs after the motor enters the flux weakening range. The point where the output voltage stops changing with the speed is the threshold for entering flux weakening range.	Increase the reserved voltage margin (E6-02) by a value of 2 in sequence and restart the operation.
Speed deviation occurs during high-speed flux weakening operation.	1. The torque has been limited. 2. The output is limited by the torque limit.	1. Check whether the output torque (U6-01) reaches the torque limit (E2-08/E2-09). 2. Increase the reverse torque coefficient and check whether the actual speed matches the set speed.	1. Release the torque limit (E2-08/E2-09) properly. 2. Contact Inovance for technical support.
The motor torque output is unstable and the motor generates unusual noise during quick acceleration/ deceleration.	The acceleration/ deceleration is too fast, resulting in deviations between the feedback current and the current reference. In this case, adjust loop parameters.	Check the fluctuation of the torque current reference (U6-41) and torque current feedback value (U6-43) through the oscilloscope. If the torque current reference fluctuates, speed loop parameters need to be adjusted. If the torque current reference does not fluctuate and the torque current feedback value fluctuates, current loop parameters need to be adjusted.	If the torque current reference fluctuates, decrease the speed loop Kp (E4-02/E4-04) and increase the speed loop Ti (E4-03/E4-05). If the torque current reference does not fluctuate but the torque current feedback value fluctuates, decrease the current loop Kp (E5-04) and increase the current loop Ti (E5-05).

Symptom	Fault cause	Verification method	Solution
The motor starts in reverse direction.	1. The auto-tuned magnetic pole position of the synchronous motor deviates from the actual value. 2. The SVC control in low speed is unstable. 3. Check whether there is an additional torque in the reverse direction. 4. For motors with active loads, when the output torque is lower than the load during startup, the motor operates in reverse direction. This usually occurs in applications with a brake.	1. Keep the motor in the stopped state. Check whether the flux angle is stable upon several times of quick start/stop at zero speed. 2. Check whether the feedback speed fluctuates greatly and whether the output torque is excessively high. 3. Check whether additional torque is set. If yes, unusual impact can occur during start of the motor. 4. Active loads are mainly hoisting loads or elastic loads. During startup, release of gravity or elastic potential energy can cause the motor to operate in reverse direction.	1. Increase the magnetic pole position auto-tuning current. 2. Contact Inovance for technical support. 3. Set C1-06 (Selection of additional torque reference 1), C1-08 (Additional torque reference 2), and C1-09 (Friction torque selection) to 0. 4. Increase the speed loop Kp (E4-02/E4-04) properly to improve speed response.
The operating speed overshoot is high.	In vector control mode, the integral action of the speed loop parameters is too strong and the proportional action is too weak, resulting in slow integral reset and output overshoot.	Increase the speed loop Kp and Ti to check whether the overshoot is alleviated.	1. Increase the speed loop Kp (E4-02/E4-04) and Ti (E4-03/E4-05). 2. Enable feedforward control. For details, see the user guide.
The acceleration of high inertia models is slow.	1. The output torque limit is low, resulting in low average output torque during acceleration. 2. The speed loop parameter values are low, resulting in a long time to reach the maximum torque.	1. Increase the output torque limit properly and check whether acceleration is quickened. 2. Increase the speed loop Kp properly and check whether acceleration is quickened.	1. Release the torque limit (E2-08/E2-09) properly. 2. Increase the speed loop Kp (E4-02/E4-04) properly.
There is a significant delay in the actual operation of the motor after the start key is pressed.	1. Pre-excitation delay is started for the asynchronous motor. 2. The DC braking start time and starting frequency are set.	1. Observe through an oscilloscope whether acceleration starts after the set time elapses upon an operation command and whether the feedback speed is consistent with the speed reference during acceleration. 2. Check whether the DC braking start time or starting frequency is not 0.	1. Reduce the pre-excitation time (E1-02) to quicken the startup process. 2. Set the DC braking current (E1-05) and the DC braking time at start (E1-06) to 0.

Symptom	Fault cause	Verification method	Solution
Multiple asynchronous motors receive the start command at the same time but motors does not start at the same time.	Asynchronous motors vary in size and pre-excitation completion time. Therefore, even if the start command is sent at the same time, acceleration is not started at the same time	The motor size and specifications are different. Generally, the startup time is not consistent.	Set E1-01 (Pre-excitation mode) to 0 (Pre-excitation based on time) for all drives and then set the pre-excitation time (E1-02) of the drives to the same value.
The motor does not start upon receiving an operation command in vector control mode.	1. The start command may be inactive or the set speed may be inactive. 2. The speed reference has been limited. 3. The output torque limit is low and the motor cannot be started.	1. Check whether the state machine is in the operational state after startup and whether U9-05 is equal to the set value. 2. The operating state is normal. The limited speed reference (U9-06) is 0. 3. Check the output torque limit and current limit.	1. Set the start/stop mode and reference channel. For details, see "5.1 Setting Start/Stop Mode" and "5.2 Setting the Reference Channel". 2. Check whether the speed limit is set in E2-04/05/06/07 and d0-06. 3. Increase the maximum motor current (d0-08) and the positive torque limit (E2-08/09) properly.
The torque accuracy is deviated.	1. The motor temperature changes, resulting in parameter deviation. 2. Friction torque can cause torque deviation in the output on the shaft end. 3. The acceleration/ deceleration torque is consumed during acceleration/ deceleration. 4. The motor auto-tuning parameters are deviated. 5. Current and voltage sampling is deviated.	1. Check whether the torque accuracy in the motor cold state is accurate. 2. U9-16 is the actual output torque in Nm. The output torque is recorded during no-load operation. In the motoring state, the output torque on the shaft end is obtained by subtracting the friction torque. In the generating state, the output torque on the shaft end is obtained by adding the friction torque. Check whether the output torque is close to the actual value. 3. The torque deviation between U9-16 and the shaft end sensor during acceleration/ deceleration is large, and the torque deviation during steady speed is small. This is because some of the torque is consumed by acceleration and deceleration of the motor rotor. 4. Check whether complete dynamic parameter auto-tuning is performed. 5. Contact Inovance for technical support.	1. Enable adaptive torque (E10-67 = 1). The torque accuracy cannot be optimized automatically at low speed and light load. 2. The friction torque can be set through C1-09. You can make the torque on the shaft end be close to the set torque in the torque mode. The actual output torque displayed in U9-16 is obtained by subtracting the friction torque in the motoring state or by adding the friction torque in the generating state. 3. You can set the acceleration torque source (E4-22) to "RFG feedforward" to make the shaft end torque be close to the set torque. For applications such as winding and unwinding, the inertia torque must be compensated strictly. Otherwise, tension fluctuation can occur, resulting in material breakage in severe cases. 4. If accurate torque accuracy is needed, perform complete dynamic parameter auto-tuning. 5. Contact Inovance for technical support.

Symptom	Fault cause	Verification method	Solution
Operating normally at low speed, speed drop during operation at high speed	1. Check whether the output torque and output current reach the limit. 2. Check whether the load during high-speed operation exceeds the maximum permissible limit of the motor. 3. Whether the set speed has been limited and whether U9-01 (Final speed reference) reaches the expected value. 4. The bus voltage is low, the motor is in the flux weakening state, and the maximum output torque capacity is insufficient.	1. Check whether the output torque reaches E2-08/09, and whether the output current reaches the limit defined by d0-08. 2. Whether the output torque in the high-speed steady state is continuously greater than the rated torque of the motor and whether the output power is greater than the rated power. 3. Check whether the set speed is limited and whether the speed limit defined by d0-06/E2-04/05/06/07 is lower than the expected value. 4. The grid voltage decreases or is distorted after connected to the load, resulting in bus voltage drop, insufficient torque output capacity, and high output current.	1. Increase the output torque limit (E2-08/09) and the current limit (d0-08). 2. If the motor is in overload operation for a long time, the motor temperature rise can be quickened. High temperature may affect the service life of the motor. In this case, use a motor with higher power rating. 3. Release the maximum speed limit (d0-06.E2-04/05/06/07). 4. Enable A4-07 (Overmodulation) to increase the maximum output torque effectively. If the fault persists, try to increase the grid voltage.
The motor speed is unstable during operation at low speed.	1. The motor speed is affected by the cogging torque. 2. The carrier frequency during low-speed operation is excessive, resulting in high harmonics in the output voltage. 3. The back EMF of the motor is excessive.	1. Current ripple frequency per cycle of the phase current - Number of motor slots/Number of poles±1. Torque ripple frequency = Number of motor slots/Number of poles. 2. A4-05 is set to an excessively low value and A4-02 is set to an excessively high value. Reduce A4-02 and increase A4-05 to see whether the jitter is alleviated significantly. 3. The common motor harmonics are 5th and 7th harmonics, which means 6th-order torque ripple.	1. Speed ripple that caused by cogging torque is mainly generated during low-speed operation. The motor should be designed with skewed slots or skewed poles to optimize the shape of magnetic poles and reduce the stator slot opening. Decrease the value of low-speed speed loop Kp to suppress vibration. 2. Decrease A4-02 and increase A4-05 properly. 3. Reduce the speed loop parameter values properly to prevent resonance.

SVC-specific control faults

Symptom	Fault cause	Verification method	Solution
The output current is excessively high.	The output current of synchronous motor during low-speed operation in SVC mode is high. The back EMF of the synchronous motor is inaccurate, resulting in inaccurate SVC model.	1. Inject current to low-speed synchronous motors in SVC mode to ensure current stability. 2. After setting the back EMF correctly, observe whether the SVC operation is optimized.	1. This is a normal phenomenon that requires no action. 2. Get the accurate back EMF of the synchronous motor from the motor manufacturer or perform no-load dynamic auto-tuning.
The motor starts in reverse direction.	1. The auto-tuned magnetic pole position of the synchronous motor deviates from the actual value. 2. The SVC control during low-speed operation is unstable. 3. Check whether reverse additional torque exists. 4. For motors with active loads, when the output torque is less than the load during startup, the motor operates in reverse direction. This usually occurs in situations with a brake.	1. Keep the motor in the stopped state. Check whether the flux angle is stable upon several times of quick start/stop at zero speed. 2. Check whether the feedback speed fluctuates greatly and whether the output torque is excessively high. 3. Check whether additional torque is set. If yes, unusual impact can occur during start of the motor. 4. Active loads are mainly hoisting loads or elastic loads. During startup, release of gravity or elastic potential energy can cause the motor to operate in reverse direction.	1. Increase the magnetic pole position auto-tuning current. 2. Contact Inovance for technical support. 3. Set C1-06, C1-08, and C1-09 to the default value 0. 4. Increase the speed loop Kp properly to improve the response.

Symptom	Fault cause	Verification method	Solution
The torque output in SVC mode is insufficient, and the output torque is much higher than the actual load.	1. The motor inductance is incorrect. 2. An inaccurate back EMF or stator resistance of the synchronous motor can affect the torque output capacity during low-speed operation in SVC mode. 3. The model parameters of the drive does not match the actual model, which results parameter auto-tuning error and motor operation error.	1. Check whether complete parameter auto-tuning has been performed. 2. Disconnect the motor from the load and perform no-load complete auto-tuning to get accurate motor parameters. 3. Check whether model parameters match those on the nameplate.	1. It is recommended to perform complete parameter auto-tuning. Values recommended by the motor manufacturer may differ from the auto-tuned values, and the latter shall prevail. 2. Disconnect the motor from the load and perform no-load complete auto-tuning to get accurate motor parameters. 3. Check whether model parameters (A2-01 to A2-03) match those on the nameplate.
The motor creeps at 0 rpm in SVC mode, which may result in overcurrent occasionally.	1. The motor model parameters are inaccurate. 2. The acceleration time in SVC mode is too long, which causes the motor to operate near 0 rpm for too long, resulting in occasional divergence. 3. The speed loop parameters at 0 rpm are too low, resulting in slow output torque rise and divergence when the motor operates at 0 rpm for too long. 4. The auto-tuned magnetic pole position is inaccurate, resulting in insufficient load-carrying capacity during startup.	1. It is recommended to perform a complete dynamic parameter auto-tuning to check whether the condition improves and whether the drive model setting is correct. 2. Shorten the acceleration time to check whether the motor still gets stuck during startup in SVC mode. 3. Increase the value of E4-41 and adjust E4-42 and E4-43 properly to check whether the motor still gets stuck during startup in SVC mode. 4. Increase the magnetic pole position auto-tuning current of the synchronous motor and observe whether the motor still gets stuck.	1. Ensure that the AC drive model is accurate and the motor auto-tuning parameters are accurate. It is recommended to perform no-load complete dynamic auto-tuning. If no-load complete auto-tuning is not available, input the correct back EMP and perform static auto-tuning. 2. If the system is not sensitive to acceleration, reduce C8-08 to quicken the acceleration process of the drive during low-speed operation. 3. Increase the value of E4-41 and adjust E4-42 and E4-43 properly to improve the speed loop intensity during operation at speeds near 0 rpm. 4. Increase the magnetic pole position auto-tuning current of the synchronous motor.

FVC-specific control faults

Symptom	Fault cause	Verification method	Solution
The motor is stalled during operation in FVC mode.	1. The encoder slips. 2. The encoder signal is being disturbed seriously.	1. In the SVC mode, observe whether the speed deviation between U9-00 (actual motor speed) and U9-20 (Speed feedback by encoder) occurs during acceleration/deceleration and high-speed operation, in which U9-00 is normal but U9-20 deviates greatly. If yes, the encoder slips. 2. In the SVC mode, observe whether obvious burrs exist in the encoder feedback speed. Be aware that even single burrs that occur occasionally need to be handled properly.	1. Ensure the encoder is installed securely and perform parameter auto-tuning again on the synchronous motor. Set b5-00 to 7 to perform with-load complete auto-tuning of synchronous motor in FVC mode. 2. The encoder shield is grounded on the encoder card. The motor grounding terminal and the input end of the drive need to be grounded. If disturbance persists, contact technical support.

Symptom	Fault cause	Verification method	Solution
Startup is not available in the FVC mode.	The encoder has no feedback signal, which may be caused by the following. 1. The encoder is wired improperly. 2. The encoder power supply voltage does not match. 3. The resolver signal type does not match. 4. The encoder cable is too long. 5. The communication encoder data format is incorrect and data check errors occur. The encoder generates speed feedback during operation in the SVC mode, which may be caused by the following. 1. The encoder pulses per revolution is incorrect. 2. The encoder direction is incorrect. This fault may also be caused by the following when a synchronous motor operates in the FVC mode. 1. For absolute encoders (resolver, SSI, Endat, and 23-bit encoders), the encoder mounting angle (n4-12) is set improperly. 2. For incremental encoders such as ABZ and sine-cosine encoders, if errors occur during initial operation, the auto-tuned magnetic pole position may be inaccurate.	If the encoder does not generate feedback signals. Check the following. Check whether the encoder wiring, voltage class, signal type, cable length, communication data formate, and data check method are proper. The encoder generates speed feedback during operation in the SVC mode, which may be caused by the following. 1. Check whether the values of U9-20 (Encoder feedback speed) and U9-00 are the same. 2. Check whether the signs of U9-20 (Encoder feedback speed) and U9-00 are the same. This fault may also be caused by the following when a synchronous motor operates in the FVC mode. 1. Check whether zero point angle auto-tuning is performed on absolute encoders (resolver, SSI, Endat, and 23-bit encoders) and whether the value of n4-12 has been updated. 2. For incremental encoders such as ABZ and sine-cosine encoders, set E11-57 to 0 or 1. If the fault is rectified in this way, the magnetic pole position auto-tuning error is the root cause for this fault.	If the encoder does not generate feedback signals. Check the following. Check whether the encoder wiring, voltage class, signal type, cable length, communication data formate, and data check method are proper. The encoder generates speed feedback during operation in the SVC mode, which may be caused by the following. 1. Rectify the encoder pulses per revolution and set U9-20 and U9-00 to the same value. 2. Change the encoder phase sequence (n4-03) to see whether the encoder feedback speed (U9-20) is the same as the positive and negative sign of U9-00. This fault may also be caused by the following when a synchronous motor operates in the FVC mode. 1. The absolute encoder (resolver, SSI, Endat, and 23-bit encoders) performs the zero point angle auto-tuning again. 2. For incremental encoders such as ABZ and sine-cosine encoders, set E11-57 to 0 or 1.

Symptom	Fault cause	Verification method	Solution
The ABZ encoder of the synchronous motor generates unusual noise once the motor rotates.	1. The AB pulse of the synchronous motor is subject to severe interference, resulting in pulse loss or surplus pulses in every revolution. 2. The number of encoder pulses per revolution is incorrect and close to the correct value, resulting in angle calibration every time upon reaching Z signal.	1. Observe the Z signal position (U6-93) in a continuous oscilloscope and check whether the subtraction value between two Z signals is equal to 4 x number of encoder pulses per revolution. If significant deviation exists, speed fluctuation and noise can occur due to sudden calibration position signal change upon reaching Z signal. 2. Check whether the number of encoder pulses per revolution is correct.	1. Select the correct encoder cable type to ensure proper wiring, especially wiring of the grounding cable. 2. Set the number of encoder pulses per revolution correctly.
The output current in FVC mode is excessive.	1. Deviation occurs in the zero point angle (n4-12) of synchronous motor in FVC mode. 2. The ABZ encoder of the synchronous motor is subject to continuous interference, resulting in pulse loss or surplus pulse in FVC mode.	1. Check whether the encoder rotor and coupling are installed securely and whether no-load dynamic auto-tuning is performed. 2. Switch to SVC mode and observe whether burrs and irregular disturbance occur on the speed fed back by the encoder during operation.	1. Ensure that the encoder is installed securely and perform dynamic auto-tuning. 2. Ground the encoder cable and motor enclosure properly.
The motor operates properly at low speed but is stalled with speed loss at high speed.	1. The encoder feedback signal is being disturbed at high speed 2. The encoder is installed improperly.	1. Check whether interference exists in the encoder feedback signal through the oscilloscope. 2. Use a dial gauge to confirm the radial runout of the encoder shaft end. In applications requiring high speed accuracy, the radial runout must be within 0.03 mm.	1. Check whether the shielded encoder cable is connected properly and remove the interference source. 2. Calibrate the encoder installation. Ensure that the misalignment error between the coupling and encoder rotor shaft is within 0.03 mm. Reduce the length of the encoder mounting shaft to effectively reduce speed fluctuation. If the fault persists, set E11-04 to 1, and set E11-05 and E11-06 properly to switch to SVC control at high speed.

Common motor faults

Symptom	Fault cause	Verification method	Solution
Electric corrosion occurs on the motor bearing.	Electric corrosion is usually caused by improper grounding and non-insulated bearing in the non-drive end bearing of the motor.	The inner and outer rings of the bearing and the bearing ball	Make sure that proper grounding is applied between the motor and drive, and the grounding terminal of the drive and the ground. The non-drive end of the motor must be equipped with an insulated bearing.
The synchronous motor is demagnetized.	1. The carrier frequency is set improperly, resulting in excessive current harmonics and abnormal motor temperature rise. 2. The motor oscillates and generates excessive heat during operation. 3. The motor back EMF harmonics are excessive and the coercivity is low, which may easily incur demagnetization.	1. Check whether the total harmonic distortion of current waveforms of phases U, V, and W are within the proper range. 2. Check whether the carrier frequency is set to a value higher than the carrier frequency ratio by at least 12. 3. Measure whether the motor temperature rise during operation is normal. 4. For high-speed motors and motors with low inductance, select a proper reactor or LC filter.	1. Perform complete parameter auto-tuning. 2. Set the carrier frequency to a value higher than the maximum output frequency x 12. 3. Take external heat dissipation measures. For example, improve the cooling conditions, increase the flow of the water-cooled motor to reduce the water temperature, and prevent the hot air from entering the fan of an air-cooled motor. Check whether the air duct is blocked. 4. For high-speed motors and motors with low inductance, select a proper reactor or LC filter. Observe whether the excitation current, torque current, and rotor speed fluctuate greatly (higher than 6%) during operation.

Symptom	Fault cause	Verification method	Solution
The system efficiency is not good.	The process does not match the pump's optimal efficiency point in terms of head, flow rate, and velocity.The process mismatch leads to poor efficiency, mismatch between the forward flow rate and the actual optimal efficiency point of the pump, energy loss due to improper piping design, and large pressure flow fluctuation due to improper process parameters.	1. Check whether the operating speed of the drive fluctuates dramatically and regularly. 2. Check whether there is a large difference between the actual efficiency and the design efficiency.	Contact Inovance for technical support.
	Misalignment in installation of the motor output shaft results in energy loss.	1. Measure the installation alignment accuracy of the motor with an alignment tool. 2. Measure the radial runout with a micrometer.	Ensure that the misalignment error between the coupling and encoder rotor shaft is within 0.03 mm. Check that installation alignment is proper and perform measurement again.
	The commissioning parameters of the AC drive are set improperly, resulting in poor system efficiency.	After checking that mechanical conditions are proper, observe whether the motor speed fluctuates cyclically.	Perform commissioning again according to the procedure. If the fault persists, contact the Inovance for technical support.
The noise is excessive.	1. The excessive noise may be caused by mechanical noise, improper mechanical installation alignment, and mechanical damage. 2. The electromagnetic noise is excessive.	1. For mechanical noise, increase the operating speed and then perform a coast-to-stop to check whether the noise is cleared. 2. For electromagnetic noise, change the carrier frequency and check whether the noise is cleared.	1. Optimize the mechanical connection. 2. Increase the carrier frequency (A4-02) properly. Set the random PWM (A4-08) to 1. If the fault persists, add by 1 in sequence.

Symptom	Fault cause	Verification method	Solution
The motor vibration is excessive.	1. Jitter occurs in the speed control. 2. The motor installation is misaligned, resulting in jitter. 3. Excessive vibration occurs during operation of the motor due to jitter on the load end. 4. The motor cogging torque fluctuation results in speed fluctuation.	1. Observe whether the output torque and output speed oscillates through waveforms in the software tool. 2. Disassemble the coupling and observe whether jitter is cleared. 3. Increase the operating speed and then perform a coast-to-stop after the drive stops to check whether vibration is cleared. 4. Obvious torque fluctuation occurs during no-load operation of the motor, especially during operation at low speed. The fluctuation is significantly reduced after the speed is increased.	1. Adjust the AC drive control. If the fault persists, contact Inovance for technical support. 2. Ensure that the motor shaft is correctly aligned. 3. Analyze the mechanical causes. 4. Contact Inovance for technical support.
Motor temperature rise is excessive.	1. The output current is high and the load is excessive. 2. The heat dissipation conditions of the motor is improper. 3. The carrier frequency is low and the current harmonics are excessive. 4. The input voltage is high, resulting in excessive current harmonics. 5. The current harmonics in long-line applications is excessive.	1. Check whether the motor load is excessive. 2. Check whether the cooling fan of the motor works properly, whether the air duct is blocked, and whether the cooling water temperature and flow of the water-cooled motor meet the requirements. 3. Check whether the carrier frequency of the drive meets the control requirements and whether the carrier frequency ratio is greater than 12. 4. Check whether the grid voltage is excessively high (higher than 420 V for example). 5. Ground capacitance exists in long-line applications, which can result in excessive current harmonics due to natural reflection. The higher the carrier frequency, the higher the current harmonics and the higher the temperature rise can be.	1. Reduce the load properly. 2. Ensure that the fan works properly, the air duct is not blocked, and the cooling water temperature and flow meet the requirements. 3. Check whether the carrier frequency ratio is greater than 12 and whether the carrier frequency meets the motor requirements. 4. If the motor temperature increases due to high grid voltage, increase A4-02 properly. 5. In long-line applications, reduce the carrier frequency properly to effective reduce motor temperature rise and the voltage overshoot caused by voltage reflection.

Symptom	Fault cause	Verification method	Solution
The motor generates noise upon start and the noise disappears during operation.	1. Asynchronous motor: By default, the motor starts with current excitation. Some motors may generate excitation noise when the pre-excitation current is high. 2. Synchronous motor: A bumping sound can be generated when magnetic pole position auto-tuning is performed through the pulse method.	1. For asynchronous motors, you can change the pre-excitation method to time-based excitation. 2. For synchronous motors, you can modify the magnetic pole position auto-tuning method.	1. Asynchronous motor: Set the pre-excitation mode E1-01 to 0 to enable time-based excitation and increase E1-02 (Pre-excitation time) properly. 2. Synchronous motor: Contact Inovance for technical support.
Motor resonance occurs.	An inherent oscillation frequency is present in the machine. When the motor runs to this frequency, resonance can occur between the motor and the machine.	In motor resonance, obvious current/torque oscillation occurs at a specific speed point. Operations at speeds lower than or higher than this specific point are normal without resonance.	1. Set frequency hopping to prevent the set speed/target speed from being equal to the resonance frequency, thus avoiding the machine from running in the resonance state for a long time. 2. Reduce the speed loop Kp (E2-02/E2-04) and increase the speed loop Ti (E2-03/E2-05) properly. 3. Set the torque reference filter time (C1-01) to a low value in torque control. The preceding measures can alleviate resonance. Resonance can be rectified thoroughly only through the mechanical end.

Service and Support

Should you encounter a safety accident during the use or operation of the product, or face challenges in operating and maintaining the equipment, which remain unresolved after the relevant documentation is consulted, we provide multiple channels to ensure prompt resolution:

- Channel #1: Contact service@inovance.com.
- Channel #2: Visit https://www.inovance.com/global to access document downloads, after-sales support, spare parts ordering, repair applications, and authenticity verification services.
- Channel #3: Download My Inovance app (https://zshc-eu.inovance.com/download-pc/) where you can access products info and documentation, and query product parameters.

We are committed to providing you with quick and professional technical support, and we look forward to your satisfaction and trust.

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