Diamond Series Servo Drive

User Guide

Preface

Thank you for using Diamond Series Servo Drives!

Diamond series drive is a small power, high-performance compact low-voltage AC servo drive developed by our company, currently there are covering 0-750W power level.Support standard EtherCAT/CANopen/Modbus communication, equipped with intelligent ultimate tuning tools, with powerful functions such as full Chinese interface, one-click import of parameters and image-based tuning. Support multiple motor types (permanent magnet synchronous servo motor / DC brushless motor / linear motor / torque motor / voice coil motor / stepper motor) and rich feedback types (incremental / absolute / Hall).This series of servo takes up little space, has high precision, high performance, high reliability characteristics, suitable for electronic manufacturing, robotics, semiconductor, warehousing, transportation, logistics, medical, traditional manufacturing, etc.

This manual is the Diamond series drive manual, providing product introduction, installation and assembly line, parameter setting and commissioning, troubleshooting and troubleshooting and daily maintenance related notes, communication protocol introduction and case configuration, etc. For first-time users, please read this manual carefully, if you have doubts about the function and performance, please consult our technical staff for help.

When opening the box, please check carefully:

Confirmation Items	Description
Does the Model ordered match the one that arrived?	Please determine the drive Model from the drive nameplate.
Are the product accessories complete?	Please check the whole machine to confirm whether the driver terminals and connectors are complete (it is recommended to buy the manufacturer's recommended cables), and whether there is a manual.
Whether the product is damaged?	Please make sure that the product has not been damaged during transportation.
If there is a problem with any of the above, please contact your supplier or our company to solve.	

⚠ Product electrical safety use specification：

Greetings, Dear User! Before assembling and Tuningthe IISMC Servo Drive product, please read in detail the Servo Drive product safety use specification described below. Improper use of this product may result in personal injury or equipment damage. Be sure to strictly observe the relevant instructions and requirements.

1、Before powering up the equipment for operation, make sure that each system component of the equipment must be grounded to ensure electrical safety by means of a low impedance ground (protection class 1 according to EN/IEC 618005-1 standard). The motor should also be connected to a protective earth via a separate grounding conductor, the specification of which must not be lower than that of the motor power cable.

2、Only qualified technical personnel should perform the installation, operation, overhaul and maintenance procedures for this product. These qualified personnel must have sufficient technical training and knowledge to anticipate and identify potential hazards that may occur when using the product, modifying settings, and operating the mechanical, electrical, and electronic components of the entire machine system, setting emergency stop switches to ensure unforeseen operations that cause injury to persons or damage to property.

3、This product contains components sensitive to static electricity, incorrect placement can damage these components, please avoid this product contact with highly insulating materials (such as synthetic fibers, plastic films, etc.), should be placed on a conductive surface. The operator must pass the electrostatic hand loop before operation to discharge all possible static electricity.

4、In order to avoid serious personal injury or product damage during operation, please add protective cover when Tuningthe product and close all cabinet doors when Tuningthe equipment.

5、This manual uses the following identification terms to further explain what needs to be done to prevent injuries and damage to equipment. The labeling terms are used to distinguish the hazards and extent of damage that can occur when mishandled. The contents are important for safety and must be observed：

	**Danger signs** ● Please read the product manual carefully before powering up, make sure that the maximum supply voltage is not higher than the voltage range in the product specification, and that the actual use of the maximum current does not exceed the maximum peak current specified in the product. ● **Check the wiring before powering up, avoid any short circuit and abnormal connection between U\V\W\PE\DC+\DC-, otherwise burn the driver or even generate electric sparks causing personal injury or death.** ● **DC+/DC- reversal must be avoided, otherwise the driver will be burned or even generate electric sparks causing personal injury or death.** ● **In order to avoid arcing and other hazards to personnel and electrical contacts, it is forbidden to plug and unplug all cables of servo connectors with electricity when the servo is powered on.** ● Before wiring, inspection, maintenance and other operations, be sure to disconnect all power supply and confirm that the servo indicator is off and the voltage input on the DC side is 0 volts, otherwise there is a risk of damage to the drive or electric shock to personnel.
	**Warning Signs** ● In order to dissipate heat, the drivers should be kept at a certain distance from each other as required, and the working environment should meet the requirements of the product environmental standards, and the secondary heat sink should be added according to the actual situation. ● **USB does not support hot-swapping, otherwise there may be a voltage difference between the drive and the PC, resulting in damage to the drive or the PC, which must be powered off to plug and play.** ● **USB debug cable must be used with PE isolated data cable at both ends to avoid leakage of power from the device to damage the drive or computer.** ● **Please avoid using external power supply for the encoder 5V unless necessary, if external 5V power supply is used under special circumstances, please ensure that the 5V reference ground is common (i.e. avoid voltage difference), otherwise there is a risk of damaging the driver.** ● **When controlling the switching power supply to power on and off**

	the drive, be sure to do so on the AC input side of the switching power supply to avoid over-voltage damage to the drive caused by the transient spike voltage generated during the switching action. ● For products with STO function, please make sure the safe torque shutdown function is active before powering up and running. ● Make sure the drive is not higher than 1000m above sea level. ● In order to prevent the motor feeder state, resulting in bus over-voltage and damage to the drive hardware, the braking module should be added according to the actual working conditions. ● Before commissioning, please ensure that all safety measures have followed the installation procedures in this manual.
	**Anti-static Peugeot** ● This product is only applicable to the standard ESD operating environment, please ensure that the operating environment is free of abnormal electrostatic sources; ● **When operating manually with bare hands, the operator must pass the electrostatic hand loop to release possible static electricity and then wear anti-static gloves before touching the servo drive products and carrying out installation operations to avoid touching the components of the board.** ● Avoid contact with highly insulating materials (e.g. synthetic fibers, plastic films, etc.) and place the product on the surface of a conductive body.
	**Grounding mark** ● Product heat sink, housing and other system shielding ground must ensure a reliable connection with the earth, otherwise it may cause abnormal equipment, damage or other unpredictable danger.

The company reserves the right to make continuous improvements to the product without notice

Diamond drives are subjected to environmental testing, EMC testing, reliability testing, and life testing in strict accordance with IEC60068 standards to meet the requirements of the corresponding standard levels, ensuring that customers can apply reliable, stable, and low-noise in complex industrial environments.

Environmental Standards		
Storage temperature	IEC60068-2-1	-40 ˚C ~ +85 ˚C -70℃~+85℃
Working temperature	IEC60068-2-2	0: 0˚C ~ +50˚C 1: -40℃~+50℃ 2: -55℃~+50℃ 2: -70℃~+50℃
Humidity	IEC60068-2-78	95% (No condensation)

Vibration	IEC60068-2-6	• 2<f<9, 3.5 mm • 9<f<200, 5 g • 200<f<500, 5 g,10 min
Shock	IEC60068-2-27	15g 11ms half-sine pulse 3 times

EMC Standards		
Voltage fluctuation	IEC61000-4-29	±10%
Voltage dips / short interruption	IEC61000-4-29	Drop 100%/0.1s
Static electricity	IEC61000-4-2	• 4 KV contact discharge • 8KV air discharge
Fast transient	IEC61000-4-4	• 2 kV / 5 kHz power terminal • 1 kV / 5 kHz signal terminal
Electromagnetic conduction	IEC61000-4-6	0.15 MHz - 80 MHz, 10 V, 80% AM(1 kHz)
Electromagnetic radiation	IEC61000-4-3	80 MHz – 1000 MHz, 10 V/m, 80% AM(1 kHz)
Electromagnetic leakage	CISPR-16-1	C3/C4

Version Records

Date	Version	Details
2019-10	V1.0	Release 1st edition
2019-12	V1.1	Modify the preamble notes and add brake unit introduction and wiring
2020-03	V1.2	New AI description, modify part of the PID tuning instructions
2020-04	V1.3	Update product photos
2020-10	V1.4	Update some functions and fault descriptions, update DI definition and wiring
2021-11	V1.5	New support for stepper motor function, collision return to zero function, update naming
2022-02	V1.6	Update product naming
2022-07	V1.7	Revision of product electrical safety use specifications

Contents

Chapter 1 Product introduction

1.1 Product Overview

Diamond Series low voltage AC servo power range covers 0-750W servo applications.Communication Model support EtherCAT, CANopen two bus communication Model.Support 6 digital inputs and 4 digital outputs. Motor type support permanent magnet synchronous motor, brushless DC motor, hollow cup motor, linear motor, stepper motor, voice coil motor, stepper motor； Encoders support Tamagawa absolute encoder protocol, incremental encoders, and Hall sensors.

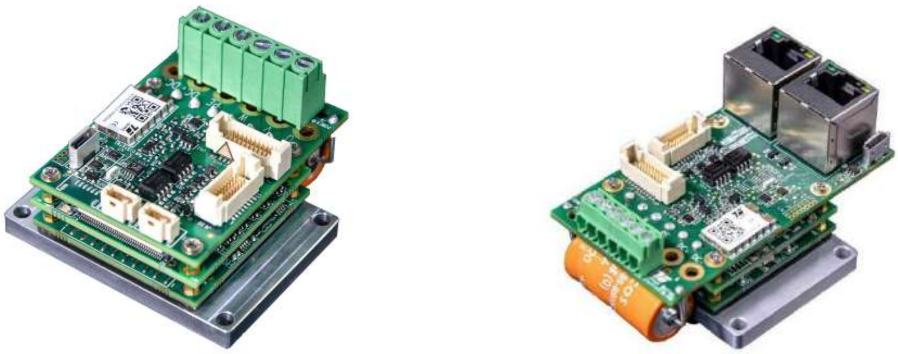


Figure 1-1 Servo driver appearance diagram

1.2 Model Introduction

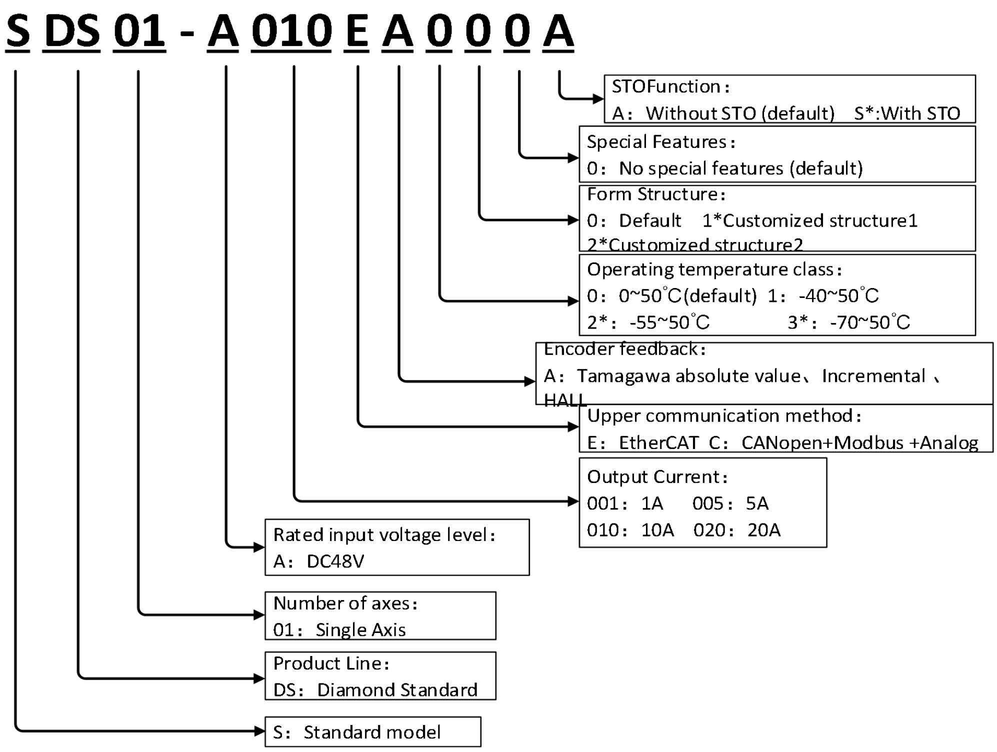


Figure 1-2 Servo Drive Composition

Note: 1: with * for customized version

2: Form factor: 0: default ---- high power terminals, large heat sink; 1*: custom 1 ---- high power terminals, small heat sink; 2*: custom 2 ---- small power terminals, large heat sink；

1.3 Product parameters

Table 1-1 Product parameters

Product Model		SDS01-A001	SDS01-A005	SDS01-A010	SDS01-A020
Output power	Power Rating（W）	0-50	0-200	0-400	0-750
	Rated current（A）	1	5	10	20
	Instantaneous peak current（A）	2.5	12.5	25	50
	Instantaneous peak current duration（s）	3	3	3	3
Input power	Rated input voltage（V）	12-60			
	Maximum input voltage（V）	72			
Communication method	Remote	EtherCAT\CANopen			
	Local	USB			
Motor Feedback	Absolute Encoders				
	Incremental Encoders				
	HALL				
Digital IO	Input	Isolated 6 way			
	Output	Isolated 4-way			
Simulation AI	Input	-10V~+10V 2-way 12-bit resolution			
Status display	Dual color LED, red and green				
Motor Control	Position, speed, current three-loop control, current loop 50us, position speed loop 200us				
Failsafe	Short circuit, over current, over temperature, over voltage, under voltage, over speed, encoder communication error, etc.				
Machinery	Size:CANopen：56mm*53mm*28mm EtherCAT：73mm*56mm*35mm				

1.4 Function Introduction

The product adopts advanced vector control algorithm, the system response speed is high

Table 1-2 Servo function introduction

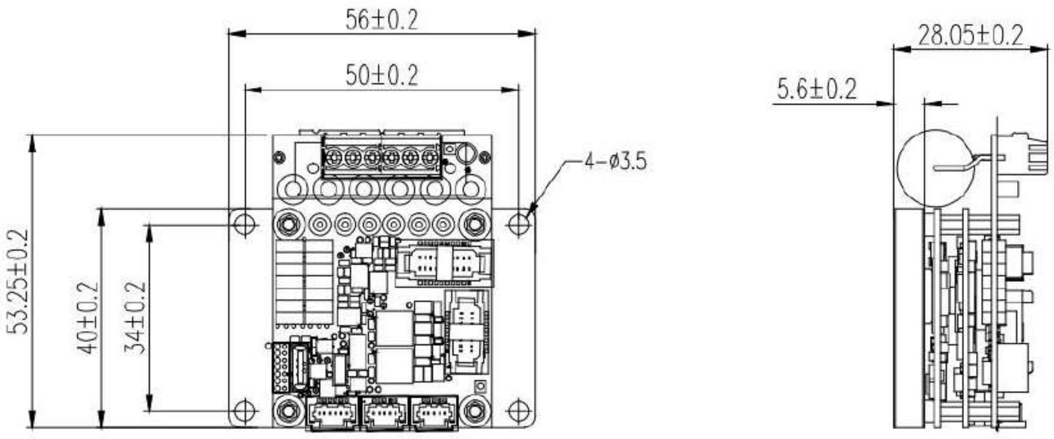
Function	Content
Servo Control	1. Current loop bandwidth 4.5kHz, current loop, speed loop and position loop sampling frequency 20kHz, 5kHz, 5kHz respectively. 2. Support three-loop control of position, speed and torque. 3. Support dynamic PID download. 4. Support filtering parameter tuning. 5. Support real-time reading of servo system parameters. 6. Deadband compensation support. 7. Support position angle compensation. 8. Position, speed and torque commands support full 32-bit data range. Position: -2×10^9 count~$+2\times10^9$ count Speed: -2×10^9 count/s ~$+2\times10^9$ count/s Acceleration: -2×10^9 count/s^2 ~$+2\times10^9$ count/s^2
Motion Control	1. Based on EtherCAT (COE) protocol, fully supports CIA402 position profile, speed profile, torque profile, zero return Model, cycle synchronization Model; 2. S-curve support; 3. Support position command fine interpolation; 4. Motion Instructions : Refer to "IISMC_Servo Drive EtherCAT Communication User Manual; 5. Top tools: Supports TwinCAT2.0 and TwinCAT3.0 software from Pepperl+Fuchs; 6. tuning tools: Refer to "IISMC_Servo Drive TuningSoftware User's Manual;
Feedback terminal	The following feedback methods are supported: 1. Absolute Encoders; Direct support for Tamagawa single loop 、 Multiturn absolute encoders. 2. Incremental Encoders; Orthogonal encoding support , Maximum supported frequency multiplier before 10M, 40M after multiplier. 3. Digital Hall Sensors; Phase change frequency up to 4kHz, supporting 5V logic level. 4. Incremental encoder + digital Hall sensor;

Communication	The following communication protocols are supported 1. EtherCAT slave; ■ CoE（CANopen over EtherCAT）; ■ Distributed clock support; ■ Support synchronization cycle Model, synchronization cycle 1~4ms; 2. USB 2.0; 3. Modbus 4.CAN Open;
Digital IO	1. DI can be configured with the following functions: ■ Positive and negative limit switches ■ Home switch ■ Enable ■ Motor overtemperature ■ Start ■ Normal/emergency stop ■ Forward/reverse jogging ■ Zero calibration ■ Clear faults ■ Reset soft start ■ External fault input 2. DO can be configured with the following features: ■ Remote DO ■ Fault output ■ Holding brake output ■ Target arrival ■ Servo enable output

Chapter 2 Installation Instructions

2.1 External mounting dimensions

CANopen Model:



EtherCAT Model:

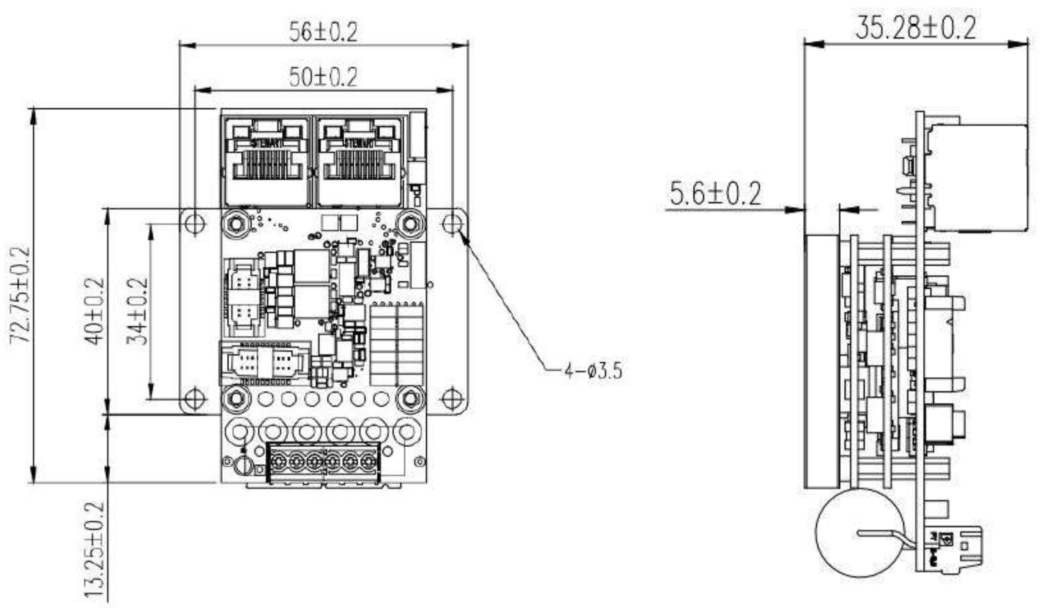


Figure 2-1 Drive mechanical dimension drawing Unit mm

2.2 Disassembly and assembly instructions

Before starting the installation, please make sure that the following materials are inside the package of the product:

1) Servo Controller;
2) The connector corresponding to the servo controller;
3) Servo controller manual (there is a QR code card in the individual package that can be

directly connected to the official website for download).In the process of disassembly and installation, note the following points:

1) Remove the box carefully;

2) Make sure there is no damage to the appearance of the equipment, if there is damage, please report it to the shipping personnel;

3) Read the product type signal on the servo controller housing to confirm that it is the product you expect;

4) Verify that the voltage rating of the equipment meets your specific requirements.

2.3 Mechanical installation

This servo is a pedestal type servo amplifier and will malfunction if installed in the wrong way.

2.3.1 Installation site

◆ Do not use this product in the vicinity of corrosive and flammable gases such as hydrogen sulfide, chlorine, ammonia, sulfur, chlorinated gases, acids, alkalis, salts, and combustible materials..

◆ Please do not install in high temperature, humid places and dusty, iron powder environment.

◆ Please do not use the servo in a closed environment, the closed environment will cause the servo high temperature and shorten the service life.

◆ 200W and below power consumption installation no special requirements, 400W installation need to ensure that the product installation of the secondary cooling installation surface temperature below 55 ℃; 750W operating conditions need to ensure that the maximum temperature of the product installation surface below 55 ℃, and to ensure that at least 3m / s of wind convection, wind direction along the horizontal direction of the PCB.

2.3.2 Environmental conditions

Table 2-1 Environmental conditions

Project	Description
Operating ambient temperature	0: 0 ℃~50 ℃; 1: -40℃~50℃; 2: -55℃~50℃;3: -70℃~50℃
Use of environmental humidity	Below 95%RH (no condensation)
Storage temperature	-40 ℃~+85 ℃ (no freezing)
Storage humidity	0%~95%RH (no condensation)
Vibration	5m/s2 or less

2.3.3 Cautions

◆ Installation method

① Panel Mount

1) Mark the Position of the screw hole on the back of the mounting plate, and refer to Figure 2-1 for the hole spacing, the heat sink hole specification is Φ3.5 through hole.
2) The tapped threads should provide better full contact according to the labeled tapping. Note: The metal surface of the mounting plate should not be coated or painted, and if so, please scrape it off. Otherwise electromagnetic compatibility will deteriorate.
3) Mount the servo drive vertically on the bacKplane. Note: Do not forget the mounting pitch and make sure the mounting surface is in good contact.

◆ Installation method

Driver installation on the wall should be placed vertically, M3 screws must be locked, 200W and below power consumption installation no special requirements, 400W installation need to ensure that the product installation of the secondary cooling installation surface temperature below 55 ℃; 750W working conditions use need to ensure that the maximum temperature of the product installation surface below 55 ℃, and to ensure that at least 3m / s of wind convection, wind direction along the horizontal direction of the PCB.

Chapter 3 System Wiring

3.1 Interface Definition

There are 9 interfaces on the drive interface. The 8 external interfaces are J2 SPI interface, J3-J4 CAN communication interface, J10-J11 EtherCAT communication interface, J5 USB communication interface, J6 input and output IO interface, J7 motor encoder feedback interface, and J9 power input and power electrical output interface. The pin definition of each port is shown in Figure 3-1.

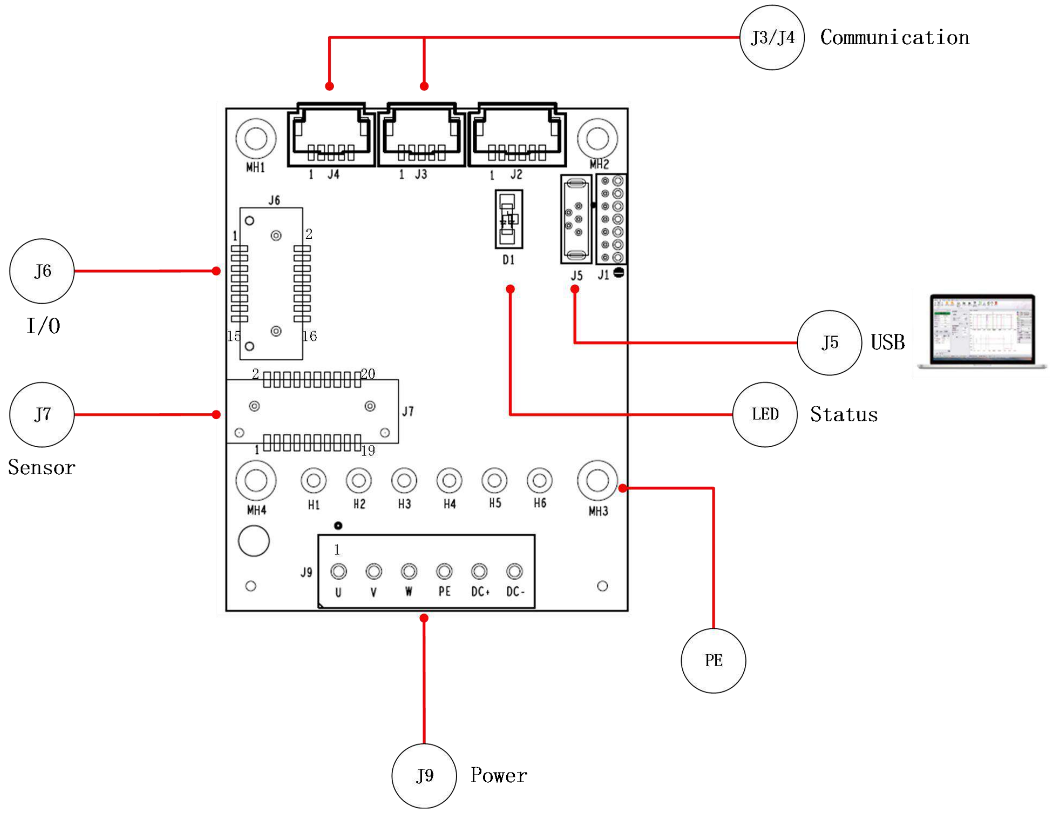


Figure 3-1 Driver Interface Definition

3.1.1 Bus communication interface pin definition

Table 3-1 Bus Interface Pin Definitions

Interface	Interface Pins	Pin Name
J10/J11-EtherCAT (J11-IN; J10-OUT)	1	TX+
	2	TX-
	3	RX+
	6	RX-
	Housing	PE
J3/J4-CANopen	1	NC
	2	GND
	3	CAN_L
	4	CAN_H

	5	PE

3.1.2 J5 USB debug interface

Customers can use the standard Micro-USB cable to communicate with the servo for parameter configuration and tuning

3.1.3 J6 IO interface pin definition

Table 3-2 J6 Interface Pin Definition (for Samtec type connector)

Interface	Interface Pins	Pin Name
J6-IO interface	1	+24V_OUT
	2	GND/STO_RET
	3	DO2_OUT
	4	DO3_OUT
	5	DO0_OUT
	6	DO1_OUT
	7	DI4_IN
	8	DI5_IN
	9	DI2_IN
	10	DI3_IN
	11	DI0_IN
	12	DI1_IN
	13	STO0
	14	STO1
	15	NC
	16	NC

J6 interface pin definition (for Molex type connector)

Interface	Interface Pins	Pin Name
J6-IO interface	1	+24V_OUT
	2	DO_GND
	3	DO2_OUT
	4	DO3_OUT
	5	DO0_OUT
	6	DO1_OUT
	7	DI4_IN
	8	DI5_IN
	9	DI2_IN
	10	DI3_IN
	11	DI0_IN
	12	DI1_IN
	13	STO0
	14	DI_COM

	15	STO1
	16	STO_RET
	17	NC
	18	NC
	19	NC
	20	NC

Note: Samtec connector and Molex connector Model IO definition is not the same, the specific connector Model see 3.5 description.

3.1.4 J7 Motor encoder interface pin definition

Table 3-3 J7 interface pin definition

Interface	Interface Pins	Pin Name				
		Absolute value	Incremental	Hall	Analog	Power supply
J7 motor encoder interface	1					PE
	2					GND
	3		INC_A+			
	4		INC_A-			
	5		INC_B+			
	6		INC_B-			
	7		INC_Z+			
	8		INC_Z-			
	9			HALL_U		
	10					5V
	11			HALL_W		
	12			HALL_V		
	13	RS485_A				
	14	RS485_B				
	15				AI1+	
	16				AI1-	
	17				AI2+	
	18				AI2-	
	19	ABS_DATA+				
	20	ABS_DATA-				

3.1.5 J9 power input and power output interface pin definition

Table 3-4 J9 interface pin definition

Interface	Interface Pins	Pin Name
J9-Power input and power electrical output	1	U
	2	V
	3	W
	4	PE
	5	DC+
	6	DC-

Attention.

1, voice coil, DC brush motor when the power line connected to the UV phase.

2, two-phase four-wire stepper motor, the power line A + \ B + respectively connected to the U \ W phase, A - and B - together with the V phase.

3.2 IO wiring instructions

The wiring of the driver is shown in Figure 3-2, the red font in the figure is the corresponding cable, which is described in detail in 3.3, and the wiring schematic of the driver IO is shown in Figure 3-2.

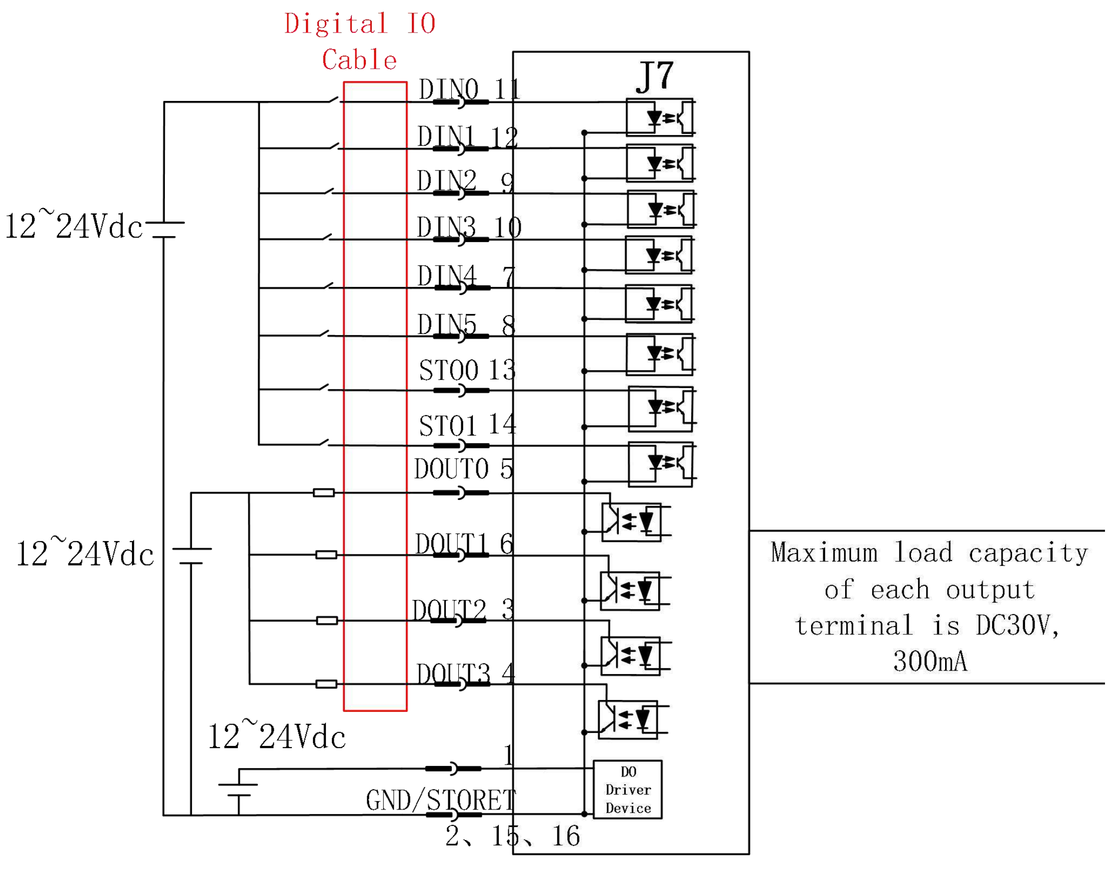


Figure 3-2 Interface Wiring

Note: 1. Red is the cable

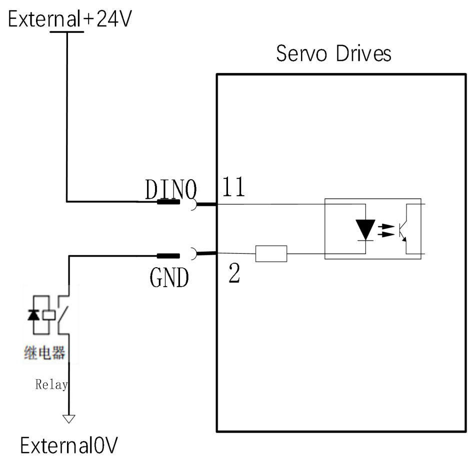
2. When connected to DI, pin 1 does not need to be connected; when connected to DO, it must be connected to power supply DC12~24V.

3. The three GNDs of digital IO (2,15,16) are connected together internally.

4. The product has no internal 24V power supply, DI and DO need external power supply.

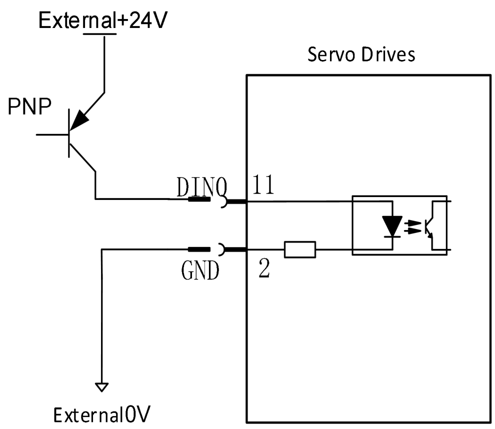
3.2.1 DI wiring method

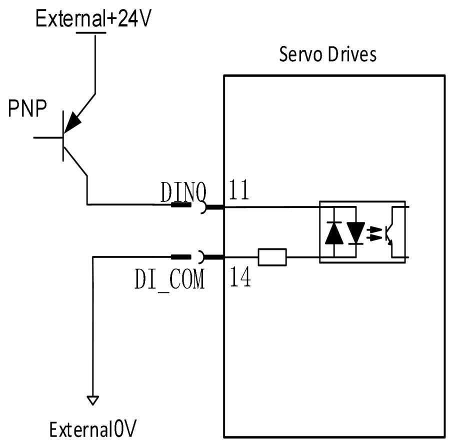
1) When the upper unit uses relay outputs (take DI0 as an example):



2) When the upper unit uses open collector output:

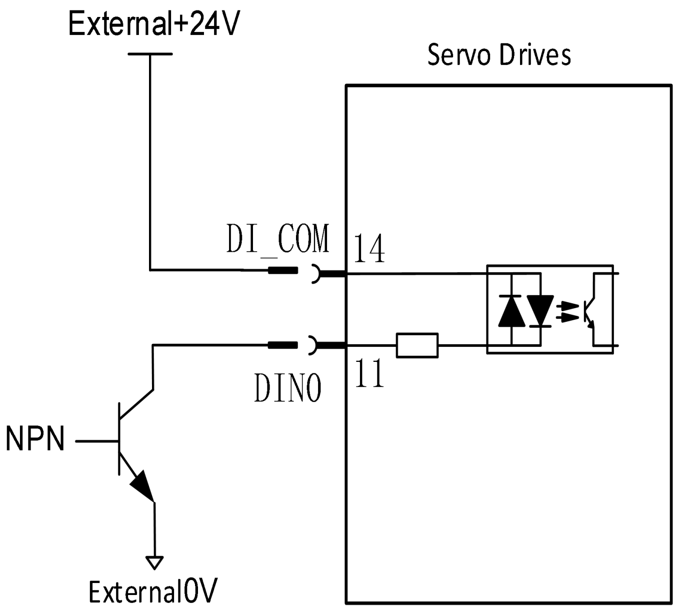
PNP connection:





(Samtec connector Model wiring diagram) (Molex connector Model wiring schematic)

NPN connection：



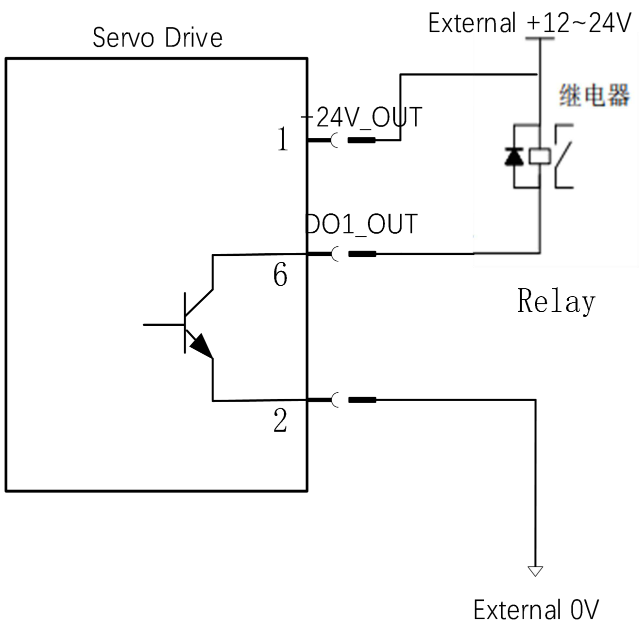
Attention.

1, Samtec connector Models only support PNP type sensor connection, Molex connector Models are compatible with PNP, NPN two types of connection.

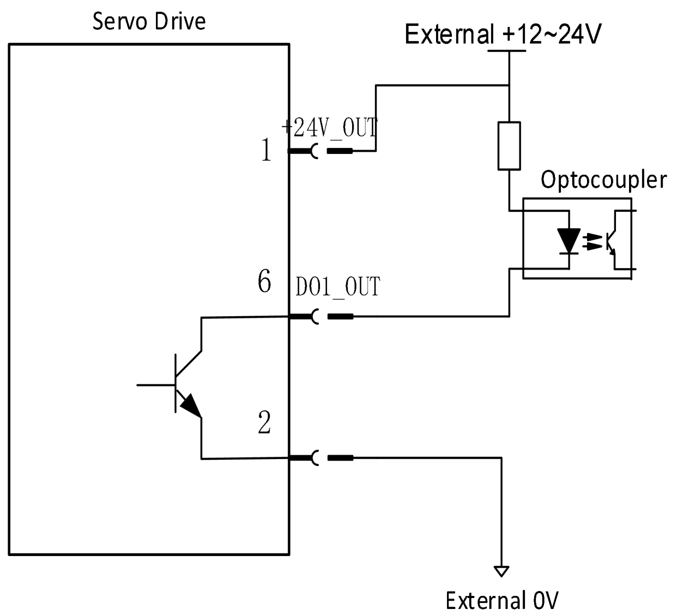
2, does not support PNP, NPN input mixed case.

3.2.2 DO wiring method

1）When the upper unit uses relay inputs (DO1 for example)：



2）When the upper unit uses an optocoupler input (DO1 for example)：



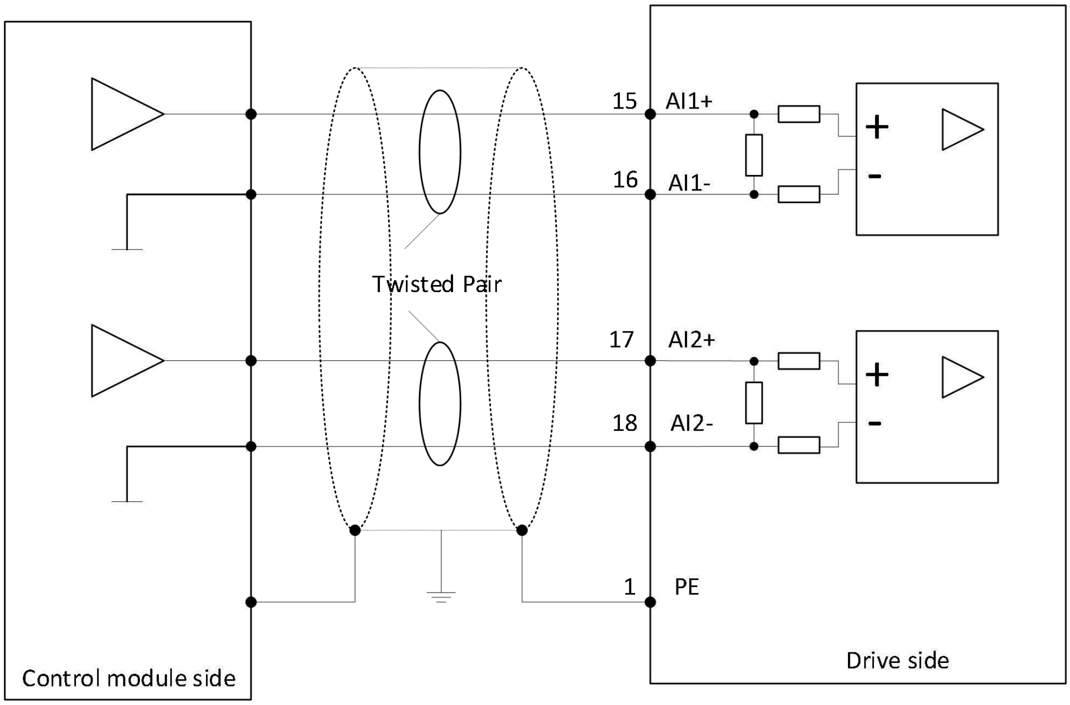
Note: 1, DO_OUT need to be pulled up to connect the current limiting resistor (need to be optional according to the specifications of the upper device optocoupler).

2, the maximum allowable voltage and current capacity of the driver internal optocoupler output are as follows.

① Voltage: DC30V (maximum)

② Current: DC400mA (maximum)

3.3 AI wiring instructions



1、 Notes.

2、 the driver has 2 analog input circuit, AI1 \ A12, input voltage range -10V ~ +10V, AD accuracy of 12 bits.

3、 the maximum input voltage range ± 12V, beyond the possibility of damage to the circuit.

4、 input impedance 3.74kΩ.

5、 The upper bit can read 0x2413(AI1),0x2414(AI2) values for external analog closed loop control.

3.4 Cable Introduction

Table 3-6 Cable Introduction

Cable Name	Cable Description	Cable length/m	Cable type
Set of power cables*1	Power cable between motor and driver with plug (with 5A and below servo system)	1	SP-075-010-A
		3	SP-075-030-A
		5	SP-075-050-A
		X(Non-standard)	SP-075-XXX-A
	Power cable between motor and driver with plug (with 10A servo system)	1	SP-150-010-A
		3	SP-150-030-A
		5	SP-150-050-A
		X(Non-standard)	SP-150-XXX-A
	Power cable between motor and driver with plug (with 20A servo system)	1	SP-250-010-A
		3	SP-250-030-A
		5	SP-250-050-A
		X(Non-standard)	SP-250-XXX-A
Set of encoder cables*1	Encoder signal cable between motor and drive, with plug, adapted to incremental definition	1	SDE15-010-A
		3	SDE15-030-A
		5	SDE15-050-A
		X(Non-standard)	SDE-15-XXX-A
	Encoder signal cable between motor and driver, with plug, with battery (3.6V, recommended to be replaced in 15~24 months), adapted to absolute definition	1	SDE08-010B-A
		3	SDE08-030B-A
		5	SDE08-050B-A
		X(Non-standard)	SDE08-XXXB-A
Set of digital I/O cables*1	Driver 6 in 4 out digital I/O cable, 2 way STO, with plug	1	SDD16-010
		3	SDD16-030
		5	SDD16-050
		X(Non-standard)	SDD16-XXX
Communication cable*2	CANopen communication line 1 (for the driver to connect to the upper PLC)	X	SDC0X0-CC
	CANopen communication line 2 (for serial connection between drives)	X	SDC0X0-CD

Notes.

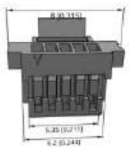
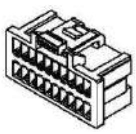
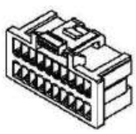
*1 If you buy complete sets of cables, you do not need to buy J3-J7 plugs. We suggest customers to buy complete sets of cables for direct use.

*2 Because the CAN communication interface is not standard RJ45 connector, so the bus communication cable is recommended to be configured as a set, and the USB cable can be purchased on its own (purchase the data cable with PE isolation on both ends of the USB cable) or requested to be given.

*3 Cable can be customized, other special needs can be communicated with the company business consulting.

3.5 Wiring accessories

Table 3-7 Introduction to accessory connectors

	Category	Connector Name	Fitting Needle
	CAN network port connector	ISS1-05-L (Samtec Inc.)	CC09M-01-GF
	Terminal resistance	SDC-TR	
	Encoder connector	ISD1-10 (Samtec Inc.)	CC09M-01-GF
	I/O connectors	ISD1-08 (Samtec Inc.)	CC09M-01-GF
	Encoder connector	501189-2010 (Molex.)	5011937000
	I/O connectors	501189-2010 (Molex.)	5011937000

Note: The recommended cable diameter for the connector pin is 28AWG.

3.6 Brake Module

3.6.1Brake Module Introduction

Servo motor in the acceleration, deceleration operation during the deceleration stop, in the vertical axis continuous decline in operation, in the power generation of three states, will generate regenerative energy, the braking module is used to consume the regenerative energy generated, play a role in protecting the equipment on the DC bus will not be damaged due to over-voltage.

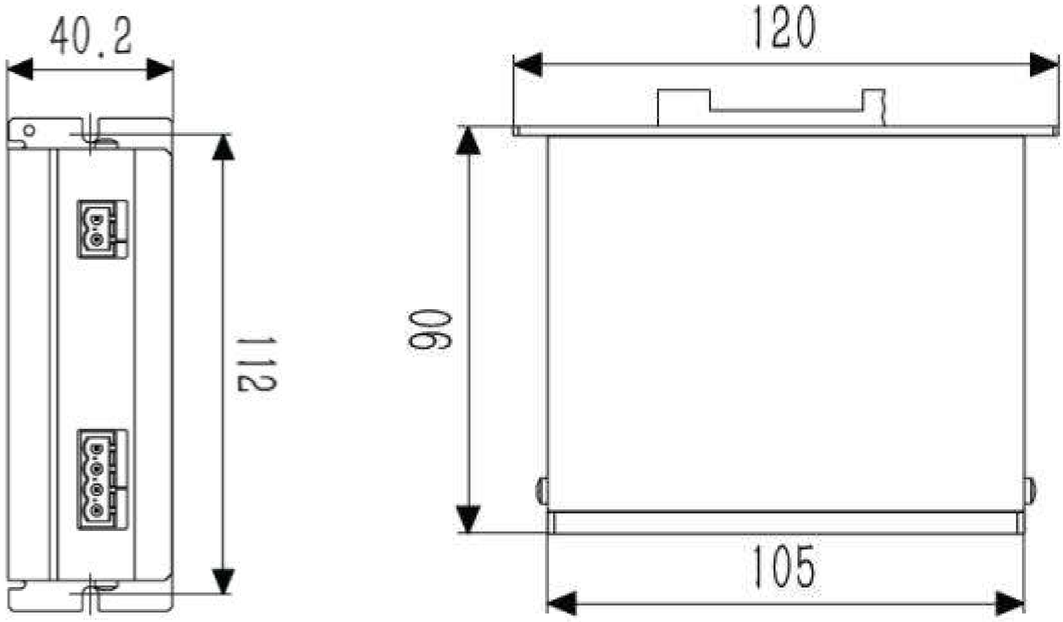


Figure 3-3 Dimensions of the brake module

3.6.2Brake Module Principle

The brake module mainly consists of a power consumption unit, a comparator unit, and a switching tube unit. DC bus 48V enters from DC power supply by J1 and outputs to the servo driver through J2. The comparator unit compares the bus voltage. When the bus voltage exceeds the upper threshold, the comparator unit outputs a high level to make the switching tube unit conductive, at which time the bus pump-up voltage is added to the unit and the power consumption unit consumes the excess energy on the bus. When the voltage drops back to the lower threshold of the normal voltage, the comparator unit outputs low to turn off the switching tube unit. The energy returned from the driver is not transferred to the DC power supply because a high power, low on-state voltage drop secondary is connected in series at the bus feed. The diode protects the DC power supply while also providing anti-reverse protection.

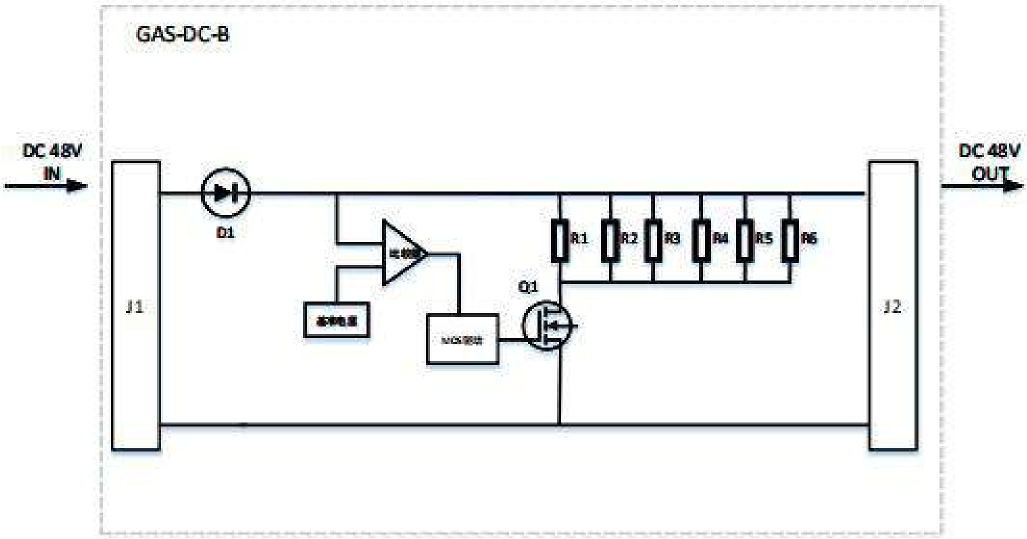


Figure 3-4 Brake Module Principle

A voltage comparator with hysteresis function is used in the comparator unit to avoid false operation due to signal interference. The set upper threshold value is 53V and the lower threshold value is 50V.

3.6.3 Brake Module Selection

In the position Model, the motor is controlled to move with a cycle of speed V. When braking, the kinetic energy is converted into electrical energy and fed back to the bus capacitor, and the single braking voltage exceeds the unloading braking voltage, the braking module will consume the excess energy.

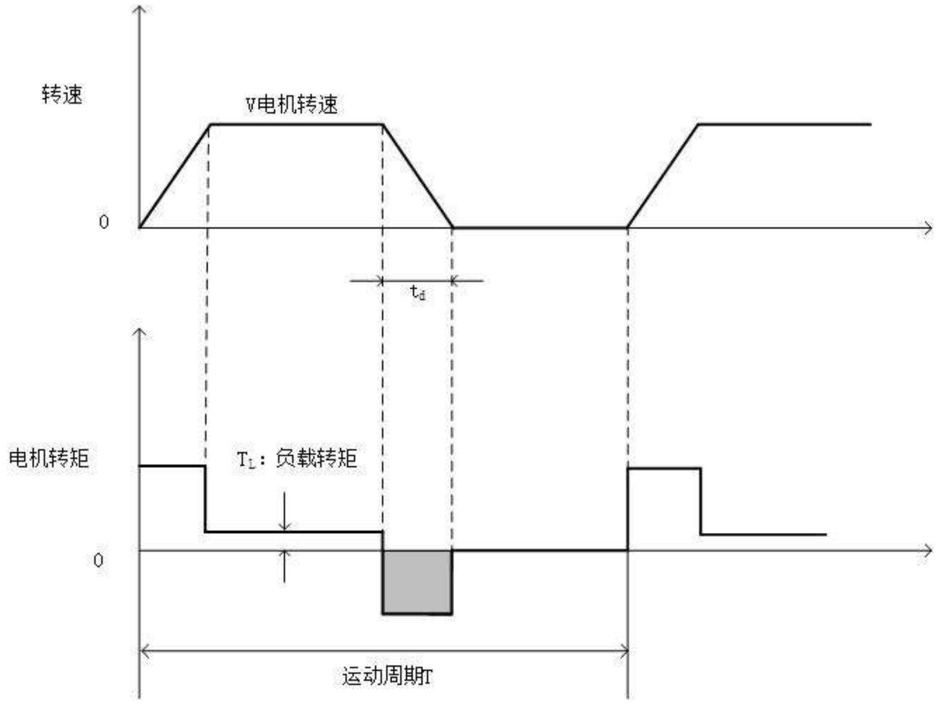


Figure 3-5 Schematic diagram of reciprocating operation

转速：Speed
电机转矩：Motor torque
电机转速：Motor speed
负载转矩：Load torque
运动周期：Period of motion

The specific calculation steps and methods are as follows:

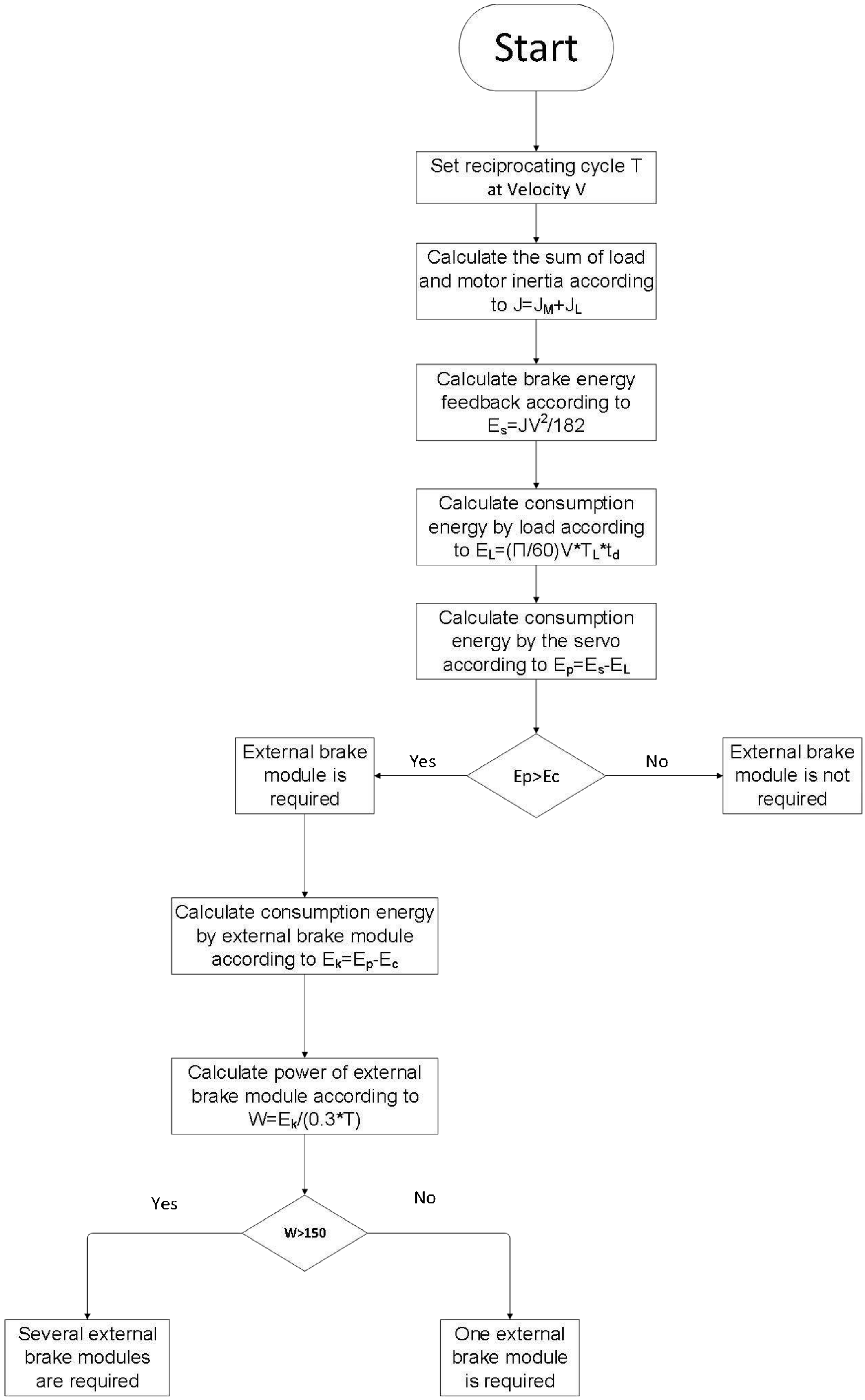


Figure 3-6 Calculation steps

Calculation content related instructions:

Step	Calculated items	Symbols	Formula
1	Total inertia of the servo system	J	$J=J_M+J_L$ Note: Inertia is the sum of motor inertia and load inertia.
2	Total braking energy of the servo system	E_s	$E_s=JV^2/182$
3	Energy consumed by the load system during deceleration	E_L	$E_L=(\pi/60)V*T_L*td$ Note: When the loss energy of the load system is not clear, please assume $E_L=0$
4	Energy required to regenerate to the servo	E_p	$E_p=E_s-E_L$
5	Absorbable energy by servo drive	E_c	See the table below for details of the energy that can be absorbed by products with different specifications.
6	Energy consumed by regenerative resistor	E_k	$E_k=E_p-E_c$
7	Capacity of regenerative resistor	W	$W=E_k/(0.3*T)$ Note: 0.3 is used when the load rate of regenerative resistance is 30%.

Servo unit capacitor can absorb the maximum energy table:

Product Line	Specification	**Max Absorbable Energy (Ec/J)**
Diamond	SD-A010CA SD-A010EA	0.084
	SD-A020CA SD-A020EA	0.2
Sapphire	SS-A010CA SS-A010EA	0.142

The power braking module is composed of six 25W 120Ω cement resistors connected in parallel.Thus a single brake module can consume 150W of brake return energy.The brake module supports one with multiple servo drives when the braking energy of the multiple servo drives is less than or equal to 150w.When the energy of braking all servo drives in the system is greater than 150W, multiple braking modules should be equipped and the servo drives should be evenly distributed to the braking modules.

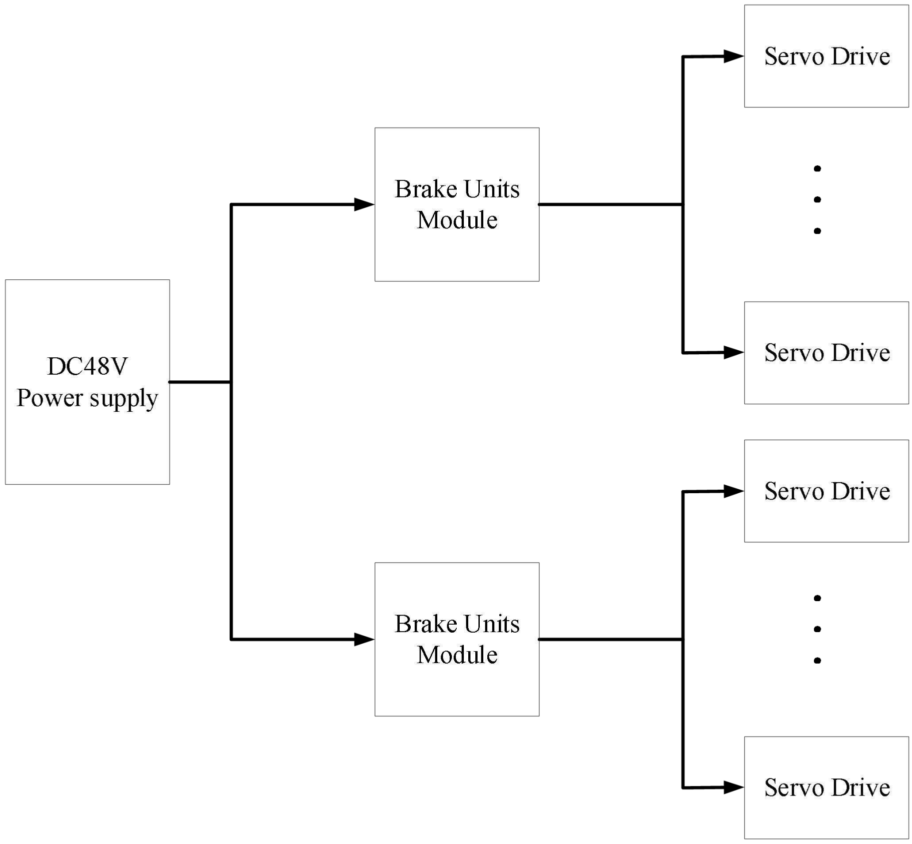


Figure 3-7 Diagram of brake die wiring

3.6.4 Brake module interface definition

Figure 3-8 Interface Definition

<table>
<tr><th>J1 power inlet</th><th>Pin No.</th><th>Definition</th></tr>
<tr><td rowspan="2"></td><td>1</td><td>48V IN+</td></tr>
<tr><td>2</td><td>GND</td></tr>
<tr><td colspan="3">Board End Connectors: 1954919 (Phoenix Contact material number)
Wire End Connectors: 1754568 is suitable for 14-24AWG or 0.2-1.5mm2 wire</td></tr>
</table>

<table>
<tr><th>J2 power outlet</th><th>Pin No.</th><th>Definition</th></tr>
<tr><td rowspan="2"></td><td>1, 2</td><td>48V OUT+</td></tr>
<tr><td>3, 4</td><td>GND</td></tr>
<tr><td colspan="3">Board End Connectors: 1954919 (Phoenix Contact material number)
Wire End Connectors: 1754584 for 14-24AWG or 0.2-1.5mm2 wire</td></tr>
</table>

3.6.5 Brake Module Wiring

When the motor is working in a situation where braking is required, the braking module should be connected in series between the DC power supply and the power feed of the servo drive.

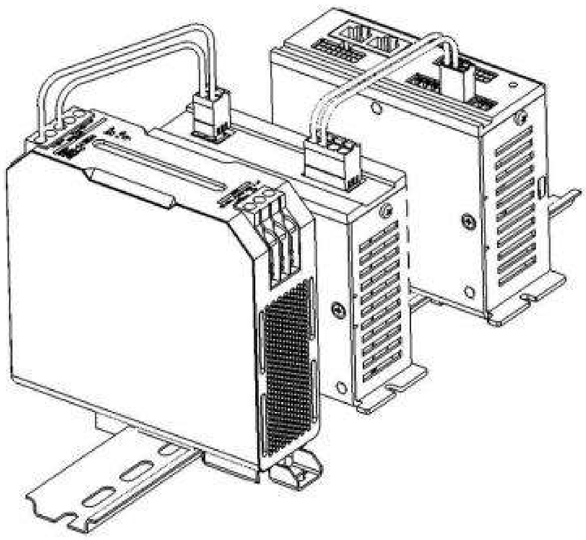


Figure 3-9 Brake Module Wiring

Chapter 4 Trial Run and Debugging

The Tuningof the trial run uses ISMC Tuningtool, please refer to the "Servo TuningSoftware ISMC User Manual" for details.

tuning steps:

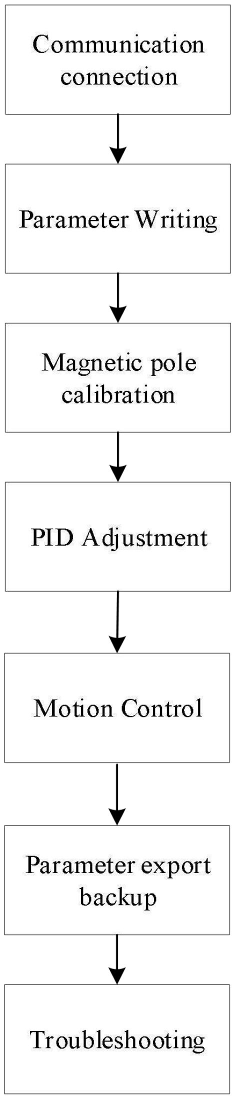


Figure 4-1 Parameter tuning steps

4.1 Communication connection

1) Installation of servo host software and USB driver.

2) Use a USB data cable (Mirco Type B) to connect the host computer to the drive.

3) Double click to open the ISMC program, enter the interface, click the "**Connect**" icon on the main menu bar.

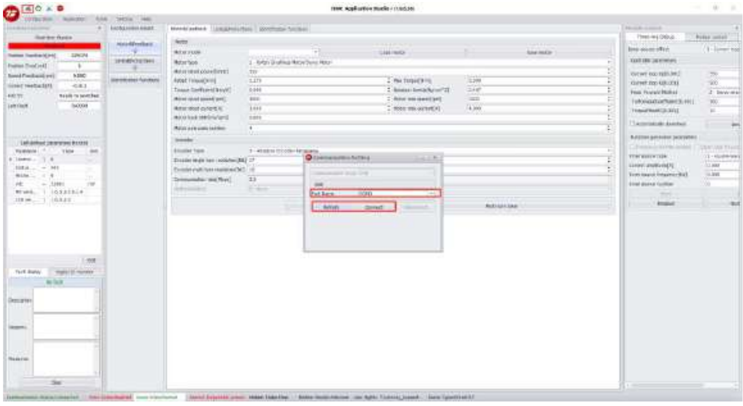


Figure 4-2 Open communication interface

4）Click the "**Connect**" icon to bring up the port and select the port number, as shown in Figure 4-2.

5）Click the "**Connect**" button to complete the communication connection, as shown in Figure 4-3.

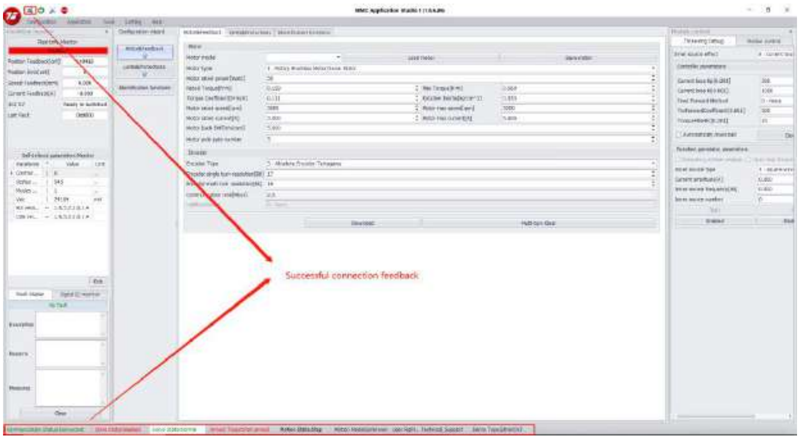


Figure 4-3 Establishing communication connection successfully

4.2 Parameter setting

Parameter writing includes parameter configuration, limit protection, user units.

4.2.1 Motor parameter

In the "**Configuration**" submenu, click on "**Parameter Configuration**", in the middle interactive area you can configure the motor parameters.

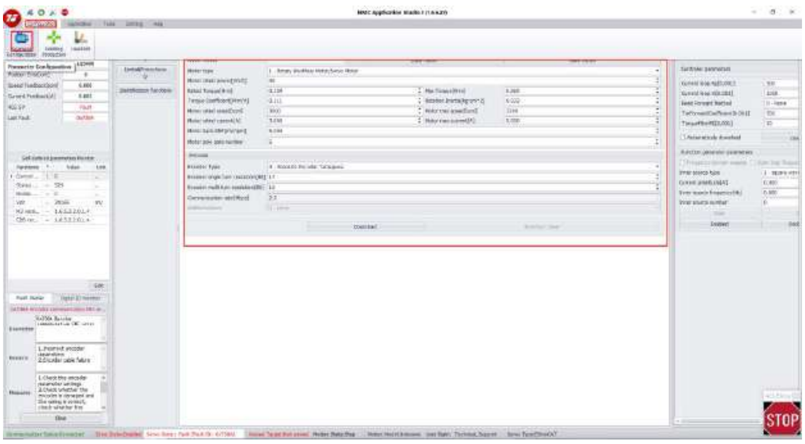


Figure 4-4 Parameter Configuration

4.2.1 Parameter Configuration

The parameter configuration includes motor and feedback, limit protection, and recognition function. Select "Motor and Feedback" in the "Configuration" submenu to set the motor parameters and encoder parameters, and click "Download" after the settings are completed.

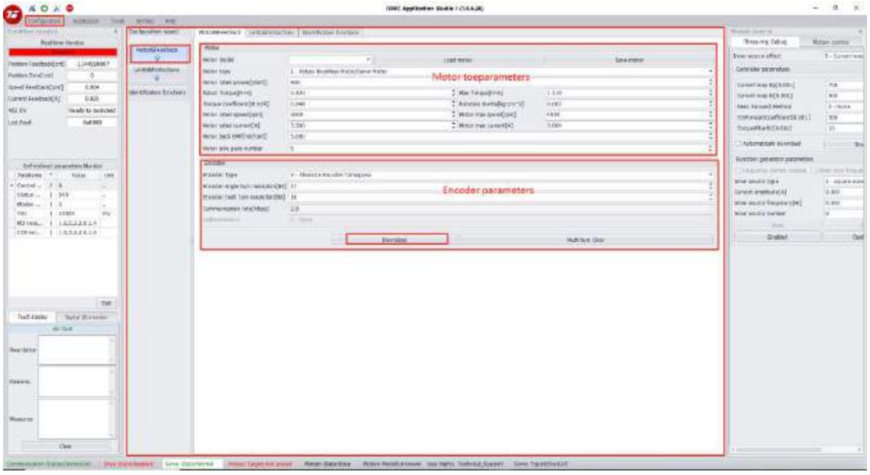


Figure 4-5 Motor and feedback parameter setting

Note: Power off and restart the servo after successful saving, and retry the communication connection after the restart is completed.

1） Motor parameters

①In order to facilitate the configuration of motor parameters, ISMC provides the function of motor database. It is possible to call the parameters of known motor Models in the database, and also to save the parameters of new Model motors to the database after setting them. However, the database only saves and loads the motor feedback parameters, "import from file" and "export from file" are to import or export all the servo parameters, and **it is necessary to power off and restart after writing motor parameters or importing drive parameters.**

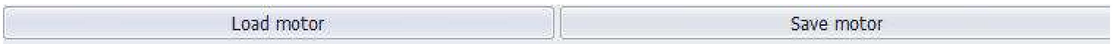


Figure 4-6 Motor parameters I

②According to the motor nameplate and the motor parameters manual provided by the motor manufacturer, fill in the motor parameters to be set into the software motor parameters interface, as shown in Figure 4-7.

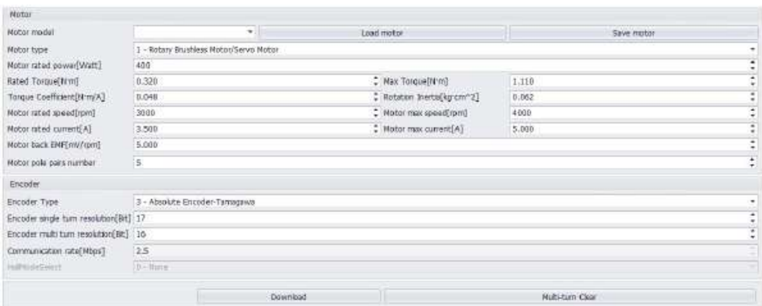


Figure 4-7 Motor parameters II

③Motor types include rotary brushless motors, linear brushless motors, rotary DC brush, voice coil motors, which require configuration parameters and units that vary according to the motor type.

Note: Be sure to pay attention to the units of each parameter when writing!

2） Encoder parameters

Depending on the actual encoder type, select the encoder type and write the resolution in the Encoder Parameters screen.The Diamond Series Servo Drives currently support incremental, Tamagawa absolute, and Nikon absolute encoders (of which Nikon absolute encoders require the use of a protocol conversion board).

Rotary Encoder

Sine-cosine Encoder

Figure 4-8 Motor parameters III

The encoder parameters are described in Table 4-1.

Table 4-1 Encoder parameters introduction

Name	Unit	Definition
Absolute single-turn resolution	Bit	The pulse value output by one rotation of the encoder
Absolute multi-turn resolution	Bit	Maximum number of turns recorded by the encoder
Zeroing of encoder multi-turn values		Zeroing out absolute encoder multi-turn values
Resolution	counts/revolution (Rotary type) counts/nm、um、mm(Linear type)	The pulse value output by one rotation of the encoder Pulse value per unit distance of optical scale output
Communication Rate	M	Clock frequency for sending or receiving data to or from the encoder

4.2.2 Limit protection

Current, voltage, speed and position are limited in the limit protection.

Current: The peak current is set at 2.4 times the corresponding 1, 5, 10, 20A of the drive. If it exceeds 2, 4 times of the rated current corresponding to the drive it will alarm. The continuous current is the rated current.

Voltage: You can set the DC bus voltage under voltage and over voltage thresholds.

Speed: You can set the threshold value of the speed tracking error and the determination time, that is, the given speed and feedback speed exceeds a certain value and exceeds the specified time will alarm.

Figure 4-9 Limiting protection parameters

4.2.3 User Units

In the submenu of "Configuration", select "User Units" to set unified motion control parameter units, including position units and speed units, as well as configure mechanical ratio parameters, as shown in Figure 4-9. After the settings are completed, click "Apply" to indicate the successful conversion of units to take effect, and the units used in the subsequent TuningModel and motion Model will be consistent with the units set.

Figure 4-10 User Units

The user units are configured with different position and speed units depending on the load type selection, as described in Table 4-2.

Table 4-2 Introduction of user units

Load Type / Movement units	Linear		Rotation	
Position Unit	cnt	Pulse count	cnt	Pulse count
	um	Micron	deg	Angle

	mm	Millimeter	rad	Curvature
	cm	centimeter	rev	Turn
	uu	Customization	uu	Customization
Speed unit	cnt/s	Number of pulses/sec	cnt/s	Number of pulses/sec
	um/s	micron/sec	deg/s	Angle/sec
	mm/s	mm/sec	rad/s	Arc/sec
	cm/s	Centimeters/second	rpm	Revolutions per minute
	uu	Customization	rps	Rev/sec
			uu	Customization

4.3 Identification functions

4.3.1 Current loop auto-tuning

Click "**Current loop auto-tuning**" in the identification function, you can identify the electrical identification, pole pair identification, phase sequence steering identification, Hall identification, electrical angle identification and other functions in order to identify. Current loop self-adjustment can adjust the resistance inductance through electrical identification: phase sequence identification needs to confirm the direction of rotation of the motor to determine whether the motor is forward or reverse, and a dialog box will pop up whether the motor is forward or not. If you select "**Yes**", the phase sequence will remain unchanged; if you select "**No**", the phase sequence will be reversed.

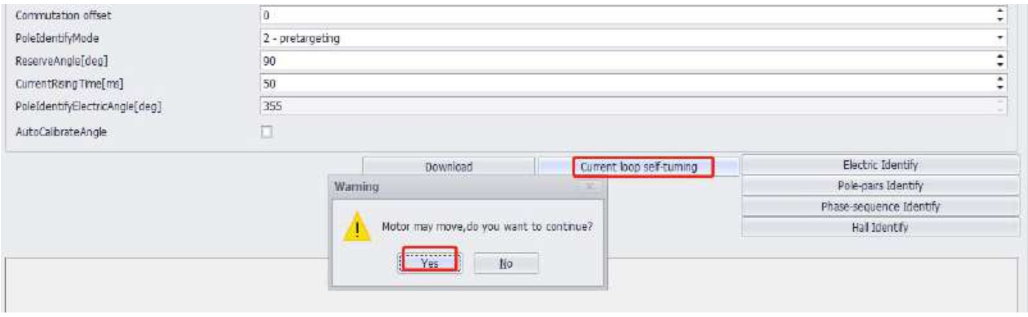
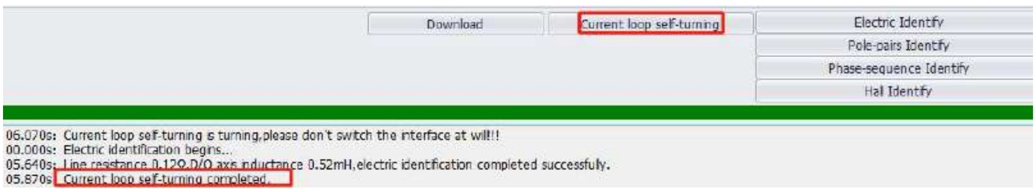
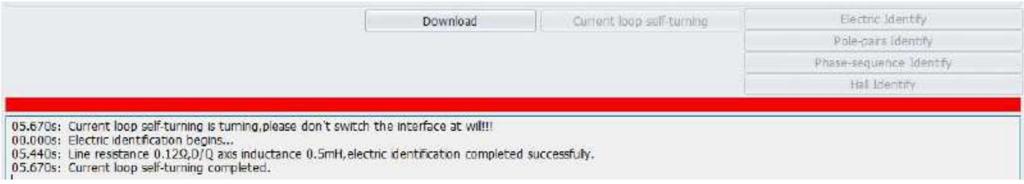


Figure 4-11 Current loop auto-tuning completion

When all items are identified, a pop-up message will appear indicating that the Current loop auto-tuning is complete, and a green stripe will appear accordingly. If the calibration fails, it will indicate that the Current loop auto-tuning has failed, and a red stripe will appear accordingly.



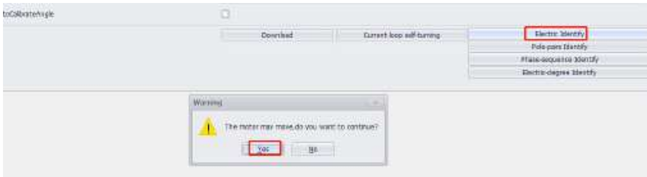


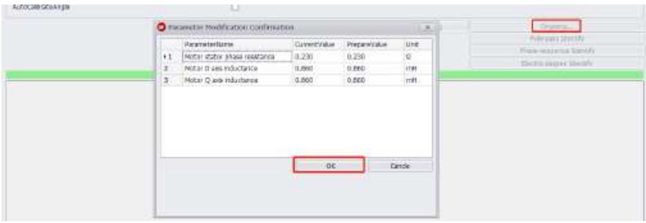
Note: Identification failure needs to be modified for the problem item.

4.3.2 Identify type

①Electric Identify

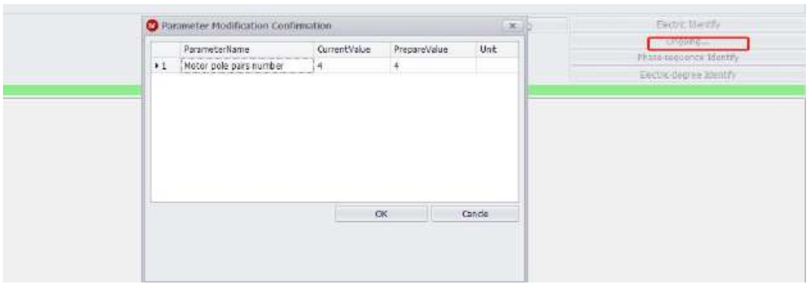
Click "**Electric Identify**" in the identification function to adjust the resistance inductance. The figure below shows.





②Pole- pairs Identify

You can correct the logarithm by clicking "**Pole- pairs Identify**".

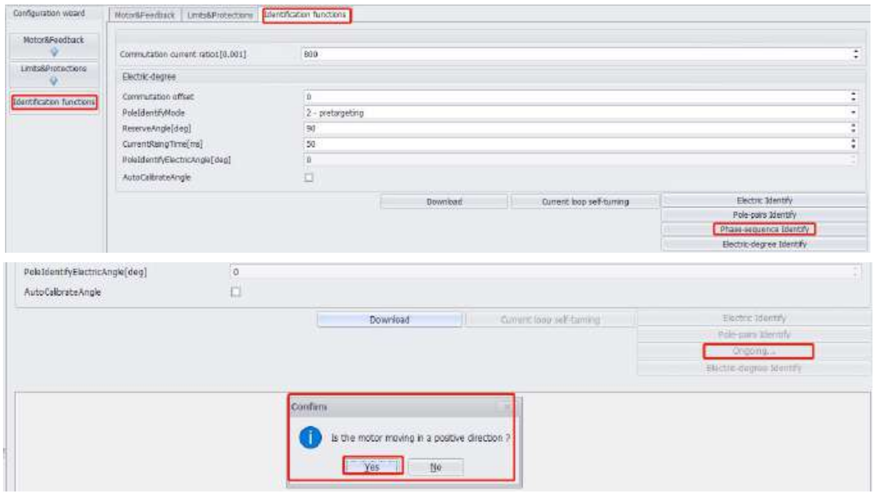


③Phase-sequence Identify

Before the motion control, the motor needs to be tested and calibrated, calibration is completed before the normal motion control, otherwise the motor will appear flying, at the same time before calibration need to confirm the motor UVW wiring phase sequence is correct, incorrect calibration will lead to calibration failure, when enabling or start the movement, motion monitoring to observe the current feedback value is very large, the motor blocking, may be the phase line is connected to the reverse, can be set in the "parameter editor - PID parameters" 2002 to 1 for phase sequence switching.

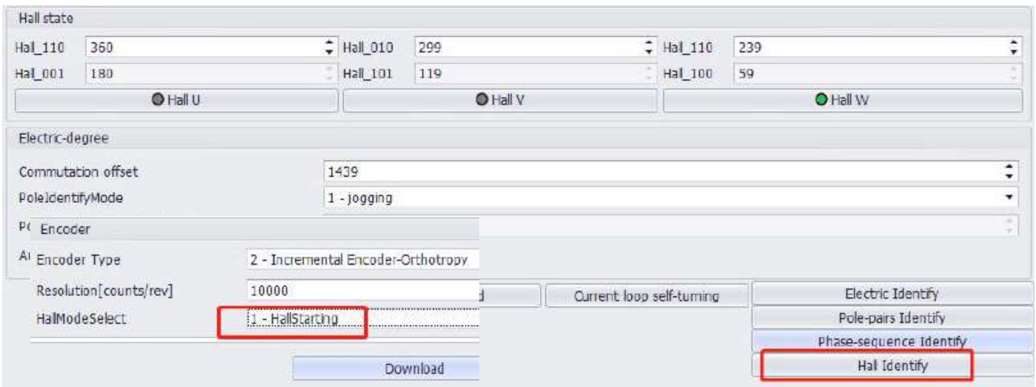
Parameter	Description
2002 Three Phase Seq Switch Enable	Three-phase sequence switching function, 0-no switching, 1-switching

Phase sequence identification can also be performed by selecting phase sequence steering identification in the identification function. during the identification process, the motor rotation is observed and the direction of rotation is selected according to the direction of rotation. When you click "**Phase sequence and steering identification**", you need to confirm the rotation direction of the motor to determine whether the motor is forward or reverse, and a dialog box will pop up whether the motor is forward or not. Select "**Yes**" to keep the phase sequence unchanged, select "**No**" to switch the phase sequence.

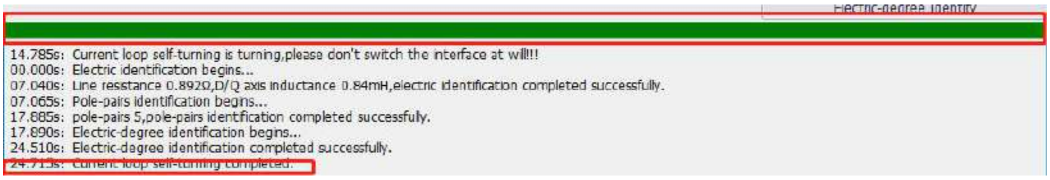


④Hall Identify

1）Hall Identify steps are as follows: Hall sensor is not used to do commutation, other values when doing Hall detection. To turn on Hall recognition, you need to select the encoder in the motor and feedback to use Hall sensor.



2） Wait about 5~15s after clicking the button for each test, and the corresponding operation status parameter will be shown in green, as shown in the figure below, then the test is completed.



Note: 1. If the control motor encoder type is absolute encoder, the initial adaptation of the servo needs to be accurately calibrated once, the servo re-energized without the need for zero point calibration, the power can be directly on the motion control.

2.If the control motor encoder type is incremental encoder (without Hall signal), the servo needs to perform a magnetic pole calibration on the motor every time it is powered on in order to perform motor control, either by sending calibration and enable commands (see Note 4 for logic details) or manually clicking on the commutation bias automatic detection for calibration, do not perform other motion control related operations during calibration, the servo driver will report the corresponding error;At the same time, the servo comes with power-on automatic calibration function, if you open this function, you need to configure 0x2120 as 1, save and restart after power off, the servo will automatically calibrate every time the servo is powered off and re-powered, after the calibration is completed, the servo is disabled, and then output the calibration completion flag 0x2121 set to 1.

3.If the control motor encoder type is incremental encoder (with Hall signal), the first time to adapt servo need to configure Hall Model Select (0x2103 = 1), at the same time, input the HALL starting electrical angle 0x210F given by the motor factory, save to EEPROM, the subsequent power can be directly on the motion control.

4.Calibration current setting: calibration current default 800 (80% of rated current), if in the occasion of larger load can be appropriately increased current ratio for calibration.

Note:

1、No-load condition: motors with small inertia or small cogging torque only need to be calibrated in the 2105d axis calibration current Model;

2、Under load: large inertia motors or motors with high frictional resistance need to be calibrated in combination with 0x2402 calibration current2。

3、If the calibration current is not adjusted properly or the load of motor shaft is too large, the calibration will fail. For the error handling, please refer to **Chapter 5 Tuning and Motion**.

4、After 0x6060 (control Model) is set to 0, 0x2101 is written to 1, 0x6040 (control word) is executed according to the enable logic of 6 -> 7 -> 15, the servo enters calibration status. When 0x2101 turns to 0, it means the calibration process is completed.

Commutation bias-related parameters and description

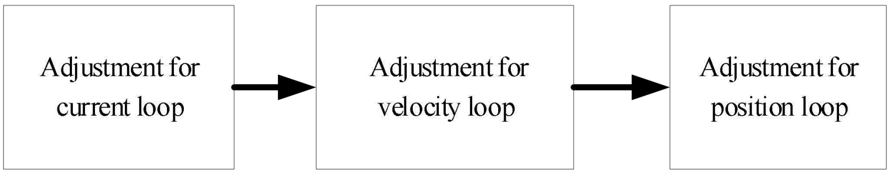
parameter	Description
2101 Calibrate commutation offset	The sign of manual zero calibration enable.
2102 Commutation offset	The value of zero calibration.
2103 Hall Model Select	Hall Model selection. 0: disable Hall;1: enable Hall.
2105 Commutation current ratio_1	D-axis calibration current amplitude = 2105 / 1000 * Rate current. Frequency: constant value
213E Hall_Angle	Hall calibration angle.
2120 Auto Calibrate Angle	Automatic calibration after power-on. 0-OFF; 1-ON.
2121 Auto Calibrate Angle Finish	The sign whether automatic calibration after power-on is completed. 0-Incomplete; 1-Complete.
2402 Commutation current ratio_2	Q-axis calibration current amplitude = 2402 / 1000 * 2105 Frequency: high frequency

4.4 PID Adjustment

If PID parameters are not set properly, the motor may vibrate or make abnormal noise. Thus, to achieve a better control effect, it is necessary to adjust PID parameters before controlling the motor.

The upper software ISMC provides a function generator, which can output the given Model, wave form and step signal, and capture the given waveform and the feedback waveform for response analysis with an oscilloscope.

Three loop Tuningsteps:



4.4.1 Current loop

The first loop of three-loop tuning is current loop, click "**three-loop tuning**" in the control area of the module, select "**current loop**", and the tuning interface of current loop appears, as shown in Figure 4-12.

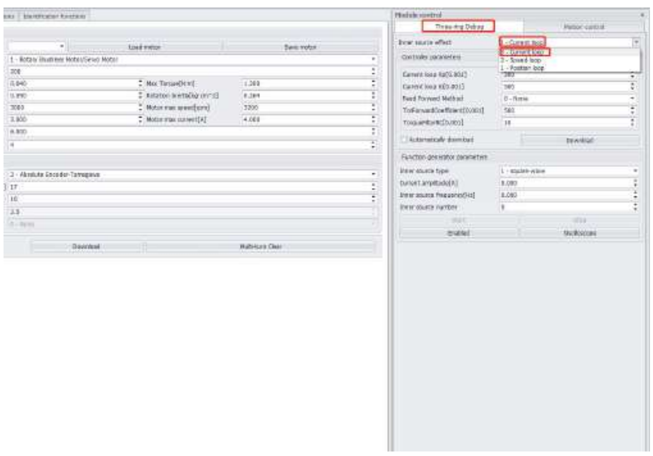


Figure 4-12 Current loop tuning interface

The current loop Tuningsteps are as follows:

1、Kp tuning

①First, Set Ki is 0, Kp is 100, click "**Download**" (generally only need to be near the factory default value of the servo for fine-tuning).

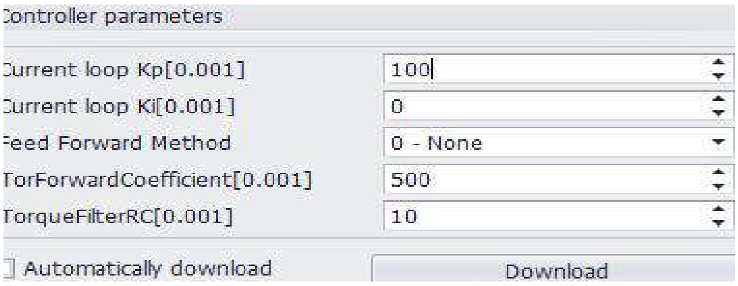


Figure 4-13 Current loop control parameters

②Then set the function generator function type for the sine wave signal, the current amplitude is 25% of the rated motor current (under the 1A for example), the frequency is 1500Hz.

Figure 4-14 Current loop function generator parameters

③Then open the oscilloscope, set the sampling channel for Id reference (current given value) and Id feedback (current feedback value), select the sampling period of 50us, check the continuous acquisition.

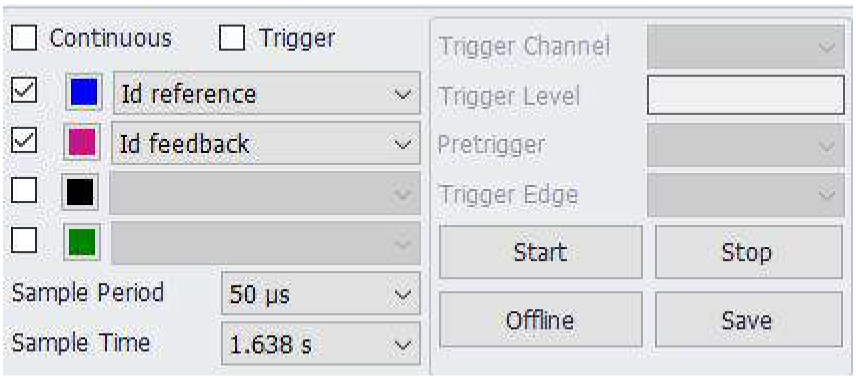


Figure 4-15 Current loop oscilloscope sampling parameters settings

④Put the servo "**enable**", then "start" the function generator, and then click the oscilloscope "**start** ".

⑤Keep increasing Kp until the amplitude of Id feedback is between (0.707~1) of Id reference amplitude and the phase lag does not exceed 90°. The following figure shows the tuning ok:

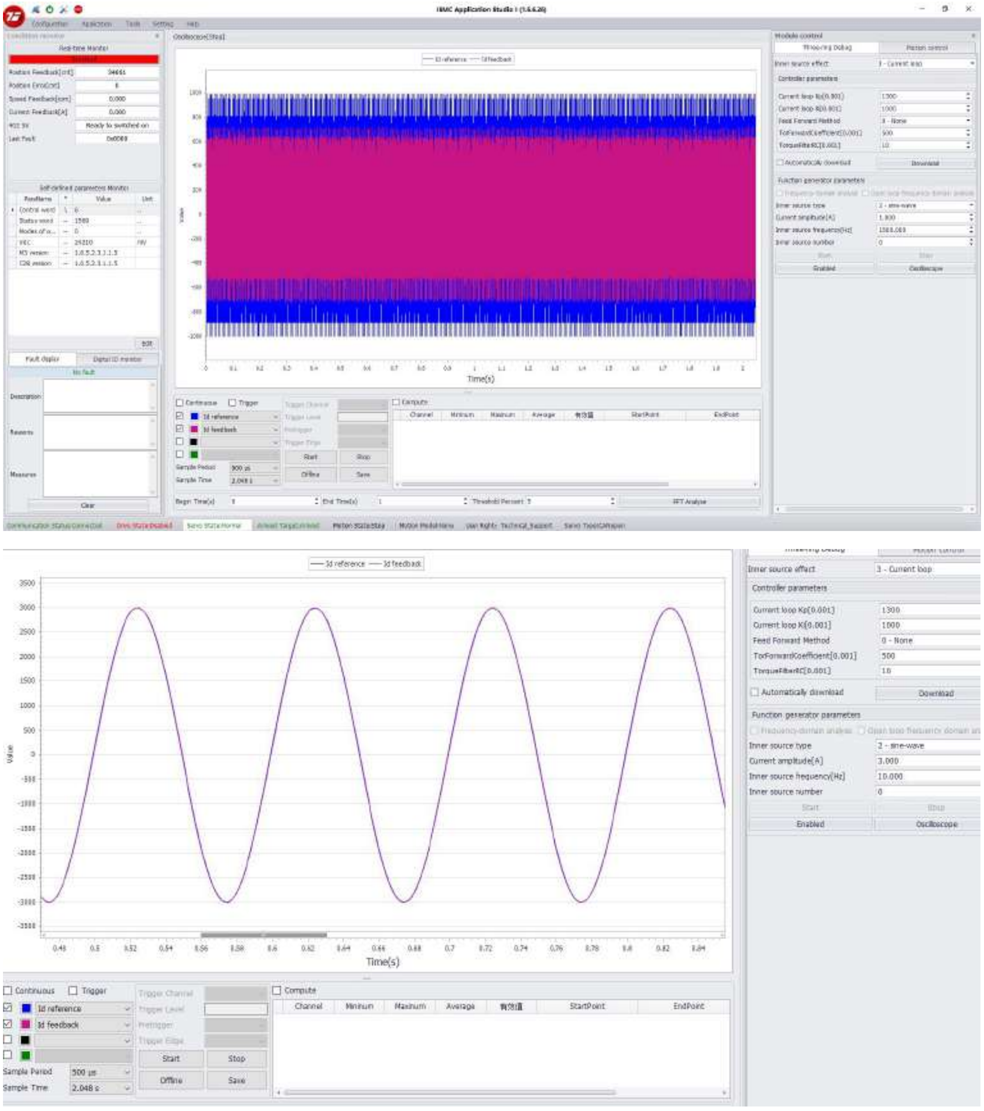


Figure 4-16 Adjusting Kp to complete the current sampling waveform

Current loop Kp main role： It is the bandwidth that increases with the increase of Kp. If Kp is too large, the motor whistles, if Kp is too small, the bandwidth decreases.

2、Ki tuning

①The function generator will be selected as a square wave, the current amplitude is 25% of the rated motor current (under 1A for example), the frequency is 10Hz.

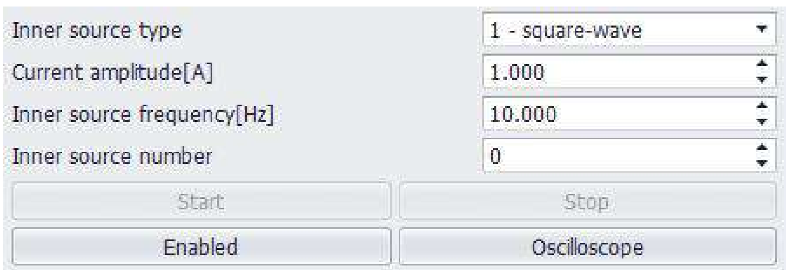


Figure 4-17 Current loop function generator parameters

②Current loop Ki tuning: gradually increase the ki, generally by 100 orders of magnitude, while selecting the oscilloscope settings as in steps ③ and ④ above. Until the steady-state error is eliminated, the waveform of Id/Iq feedback and Id/Iq reference waveform basically coincide, and the overshoot is within 5%, the current loop tuning is OK, as shown below:

Figure 4-18 Adjusting Ki to complete the current sampling waveform

Current loopKi main role: Eliminates steady-state errors, which can lead to overshoot and motor whine when too large.

Note: When the current loop commissioning, when the Tuning motor is a rotary brushless/linear motor, the Tuning current selects id for commissioning; when the Tuning motor is a DC brush/voice coil motor, the Tuning current selects iq for commissioning.

4.4.2 Speed loop

The second loop of the three-loop tuning is the speed loop, select "speed loop", and the tuning interface of the speed loop appears, as shown in Figure4-19.

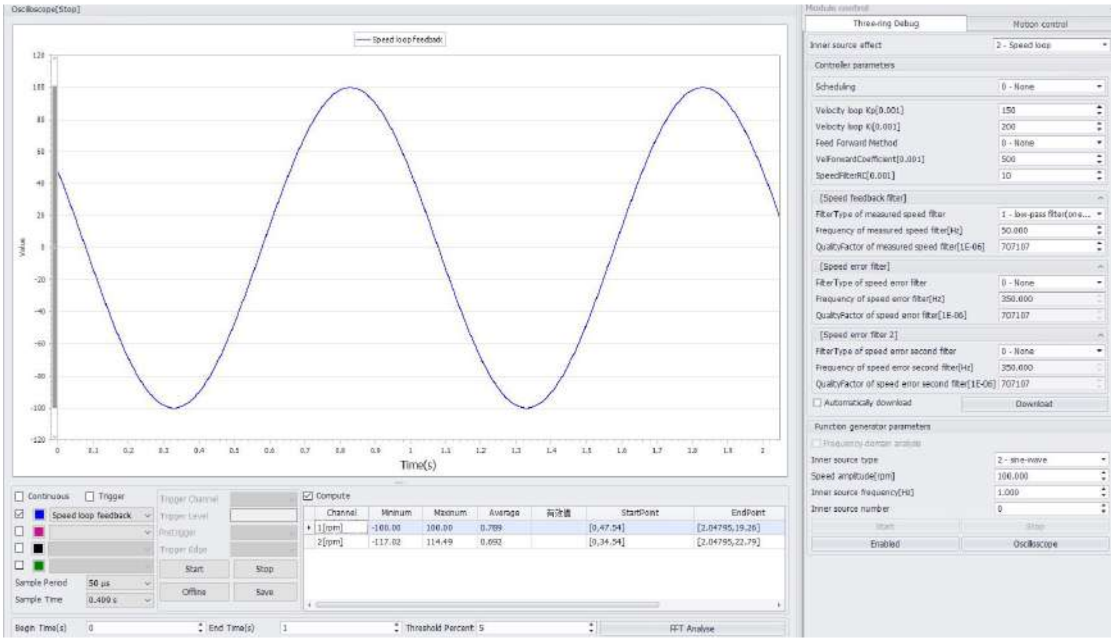


Figure 4-19 Speed loop tuning interface

Speed loop Tuning steps：

①Preparation：

1） Set the correct inertia ratio 0X2422.

2） 0x2020:01Filter Type of measured speed, 0x2021:01 Filter Type of speed error filterSet to 0 ， 2022:01 Filter Type of speed error second filterSet to 0， Set 2006 Feed Forward Method to 0.

First, given Ki is 0 and Kp is 10, click "**Download**".

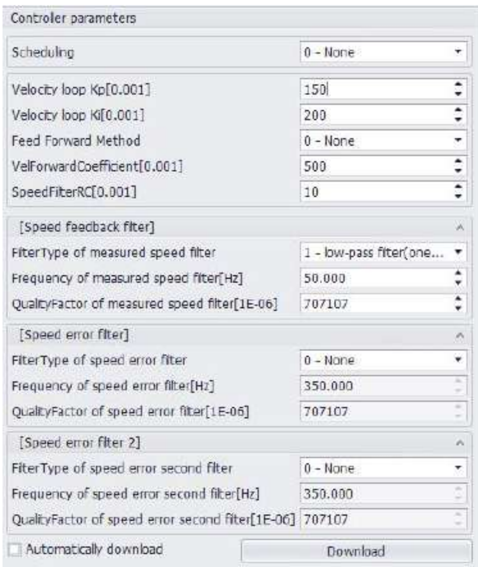


Figure 4-20 Speed loop control parameters

②Then set the function generator function type as step signal, for example, the speed amplitude is 300rpm, and set the duration according to the equipment limit running distance, for example, set 500ms.

Figure 4-21 Velocity loop function generator parameters

③Open the oscilloscope again, set the sampling channel to speed loop reference and speed loop feedback, select the appropriate sampling period of 200us, check the trigger acquisition, set the trigger edge to rising edge, select the speed loop reference for the trigger channel, and set the trigger level to 10rpm. The trigger level is 10rpm, and the pre-trigger setting is 20%.

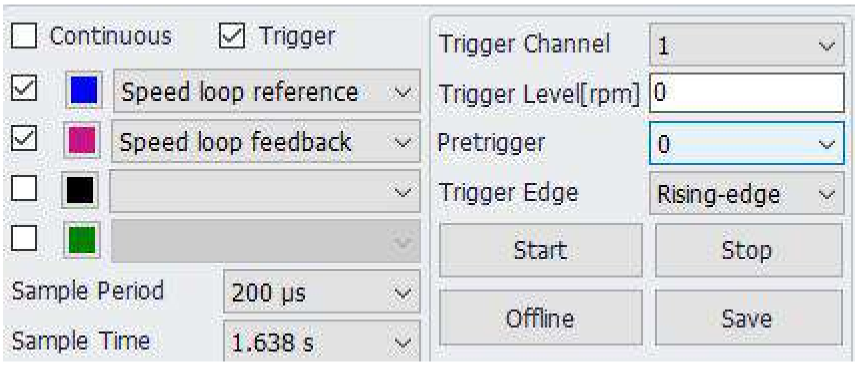


Figure 4-22 Speed loop oscilloscope sampling parameters settings

④Put the servo "**enable**", "start" the function generator, and then click the oscilloscope to "**start acquisition**". When the function type is step signal, there will be a delay time of 4~5s after clicking Start to ensure that there is enough time for the oscilloscope to start acquisition.

⑤Gradually increase Kp (generally by 10-bit order of magnitude) and observe the waveforms displayed on the oscilloscope for speed loop reference and speed loop feedback until a critical oscillation in the speed waveform occurs:

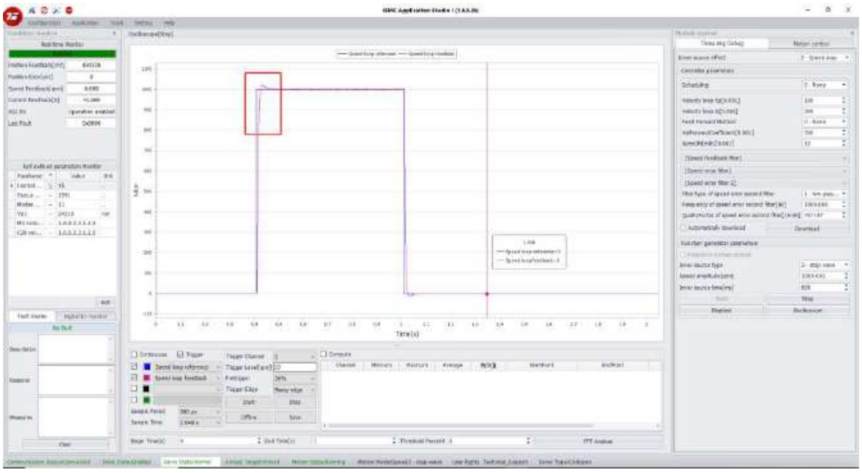


Figure 4-23 Adjusting Kp to critical oscillation speed sampling waveform

⑥Then take 70%~80% of Kp value at this time, stop the oscilloscope acquisition and stop the function generator. Gradually increase Ki, and repeat steps 3 and 4, and wait until the speed loop feedback (speed feedback value) of the following steady-state error is all eliminated, and the overshoot does not exceed 30% speed loop tuning is completed.

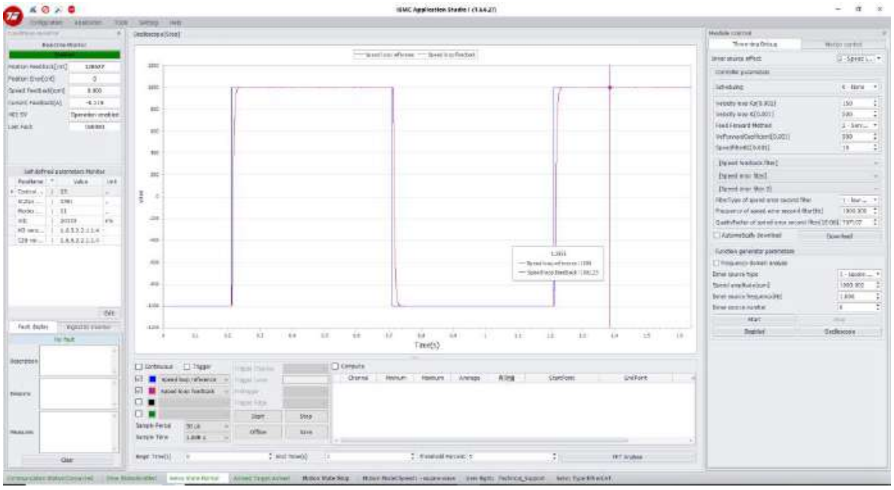


Figure 4-24 Speed sampling waveform after Ki adjustment is completed

To reduce the speed deviation value during acceleration, torque feed forward tuning can be performed by setting 2006 to 2 and turning on the feed forward function. When adjusting, set 2019 torque feed forward time constant as a fixed value, and then increase 2016 speed feed forward coefficient continuously until the speed feed forward achieves effect under a certain setting value. When commissioning, 2019 and 2016 values should be adjusted repeatedly to find a well-balanced setting, and improper Tuning can lead to system oscillation (generally not recommended to add).

If oscillation or mechanical resonance occurs during the Tuning process, you can set the speed trap filter 0x2021/0x2022 to eliminate the oscillation frequency：

参数	说明

200C:01 Measured speed filter	Feedback speed filter value
200F:01 Speed error filter	Speed deviation filter value
2010:01 Speed error second filter	Speed deviation filter value2
2020:01 FilterType of measured speed filter	Feedback speed filtering type
2020:02 Frequency of measured speed filter	Feedback speed filter frequency
2020:03 QualityFactor of measured speed filter	Feedback speed filter quality factor
2021:01 FilterType of speed error filter	Feedback speed filtering type 1
2021:02 Frequency of speed errror filter	Feedback speed filter frequency 1
2021:03 QualityFactor of speed errror second filter	Feedback speed filter quality factor 1
2022:01 FilterType of speed error filter	Feedback speed filtering type 2
2022:02 Frequency of speed errror filter	Feedback speed filter frequency 2
2022:03 QualityFactor of speed errror second filter	Feedback speed filter quality factor 2
2421 Velocity Average Filtering	Speed-averaged filtering, internally using

4.4.3 Position Loop

The third loop of the three-loop Tuning is the position ring, select "**Position Loop** ", the Tuning interface of the position loop appears, as shown in Figure 4-25.

Figure 4-25 Position loop Tuninginterface

Compared with the current and position loops, the parameters only need to determine a Kp scale factor, and the position loop Tuningsteps：

①It is recommended to follow the default parameter 10 when tuning other loops and revise Kp according to the situation after capturing the position curve.

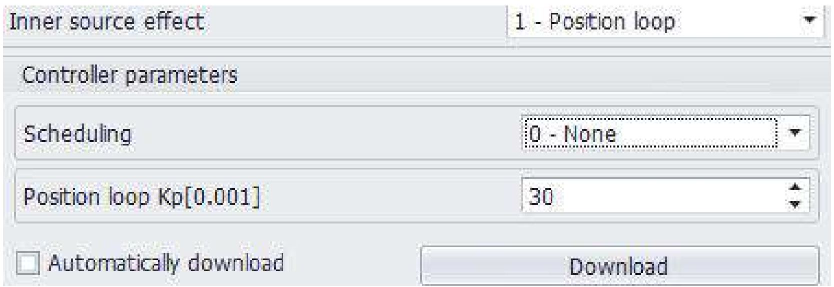


Figure 4-26 Position loop control parameters

②Set the function generator function type for the square wave signal, position amplitude of 1000cnt (with the current position as the zero point, the movement amplitude of 1000cnt, the position looptuning pay attention to the mechanical end travel), the signal frequency of 5Hz.

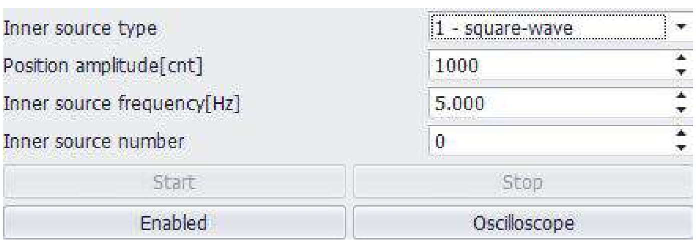


Figure 4-27 Position loop function generator parameters

③Open the oscilloscope, set the sampling channel to position loop reference and position loop feedback, select the appropriate sampling period and sampling time, and check the continuous acquisition.

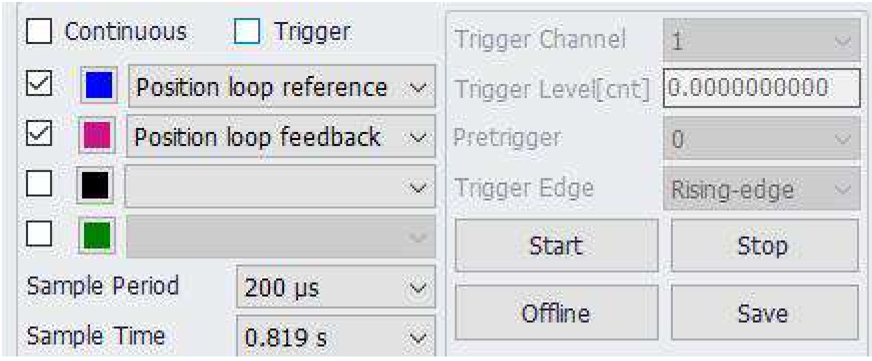


Figure 4-28 Position loop oscilloscope sampling parameters settings

④Adjust the position Kp and observe the waveforms displayed on the oscilloscope for position loop reference and position loop feedback.

⑤The Kp can be increased when the position following error is large or the response is slow, and reduced when the position overshoots or jitter occurs, until the waveform follows well, while ensuring that the current does not saturate and the position loop tuning is completed.

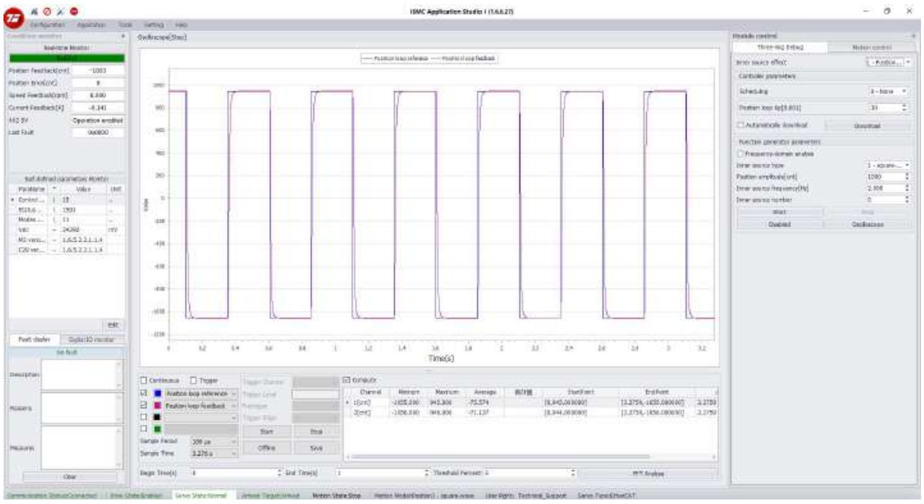


Figure 4-29 Position sampling waveform after adjusting Kp

If the position following error is not satisfied in the actual application, the feedforward function can be turned on for torque and speed feedforward tuning by setting 0x2006 to 2 and turning on the feedforward function.When adjusting, set 0x2019 torque feedforward time constant as a fixed value, and then increase the 2016 speed feedforward coefficient until the speed feedforward achieves effect at a certain setting value.When tuning, the 0x2019 and 0x2016 values should be adjusted repeatedly to find the setting with good balance.

After adjusting the position loop gain, the motor emits low-frequency audible noise in the enable state without starting the running state, which can reduce the speed loop Kp or current loop Kp. if the position loop Kp is set too low, the rigidity is weaker.

4.4.4 Grouping gain

For the application of variable inertia load, when a set of fixed gain parameters of speed loop and position loop cannot meet the high, medium and low speed, the group gain can be set. Same as the single group gain setting method, the principle of group gain setting is as follows：

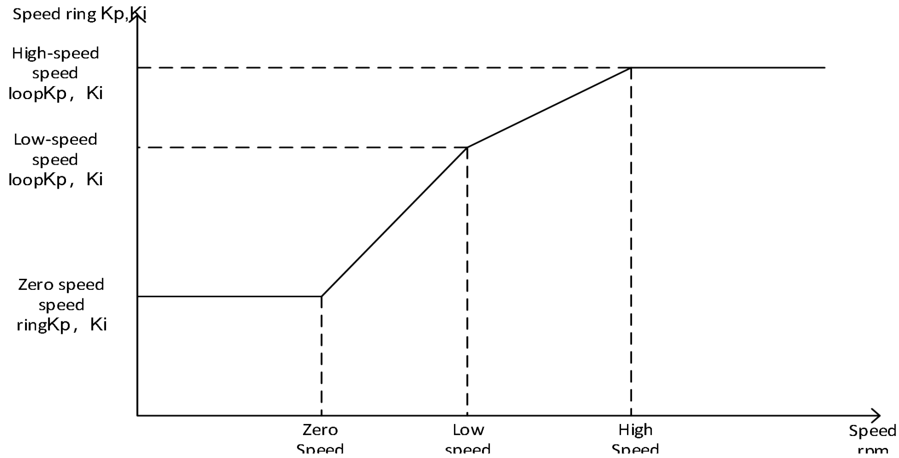


Figure 4-30 Grouping gain principle

Take the speed loop as an example: when setting the group gain, the actual speed or the given speed can be set.

Actual speed or given speed：

1）In the 0-zero speed range, the gain parameters are fixed settings of zero speed Kp, Ki；

2）In the zero-speed-low-speed range, the gain parameter increases with speed according to the slope (low-speed Kp, Ki-zero-speed Kp, Ki)/(low-speed-zero-speed). Kp increases according to the slope (low-speed Kp-zero-speed Kp)/(low-speed-zero-speed) and Ki increases according to the slope (low-speed Ki-zero-speed Ki)/(low-speed-zero-speed).

3）In the low-speed-high-speed range, the gain parameter increases with speed according to the slope (high-speed Kp, Ki-low-speed Kp, Ki)/(high-speed-low-speed). Kp increases according to the slope (high-speed Kp-low-speed Kp)/(high-speed-low-speed), and Ki increases according to the slope (high-speed Ki-low-speed Ki)/(high-speed-low-speed).

4）In the greater than high speed range, the gain parameters are fixed settings of high speed Kp, Ki；

4.5 Motion Control

After the motor parameters, encoder parameters and control parameters are configured, the motor can be driven in a simple way. The upper computer software control servo driver drive motor mainly has the following Models, including speed Model, position Model, Homing Model, torque Model.

4.5.1 Position control Model

Select "**Motion Model**" in the module control, click "**Position Model**" to open the position Model motion control interface, as shown in Figure 4-31.

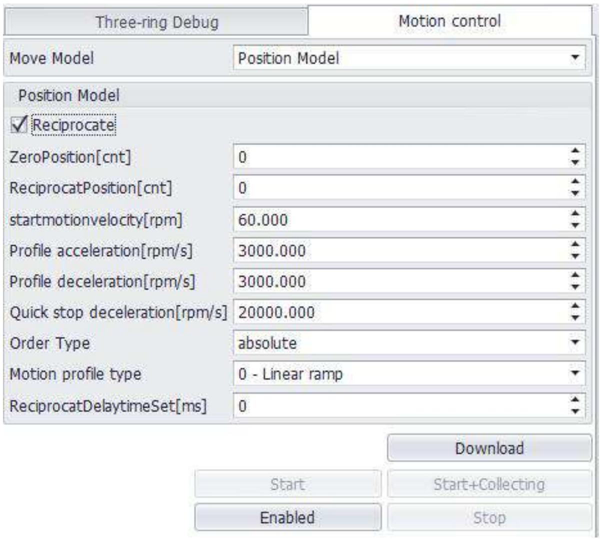


Figure 4-31 Position Model motion control interface

The position Model motion control steps are as follows:

①Configure position Model motion parameters.

- Reciprocating motion: configure the position motion as a one-way motion or reciprocating motion.
- Target position: Controls the distance the motor moves. When configured for reciprocating motion, two target positions need to be set.
- Speed: The speed of motor movement.
- Acceleration: Acceleration of the motor starting motion.
- Deceleration: the deceleration of the motor stop motion.
- Fast stop deceleration: the deceleration of the motor stop when the energy is directly prohibited.
- Command type: Absolute, movement from the encoder zero point; Relative, movement from the encoder's current position as the zero point. Reciprocal motion can only be "absolute".
- Curve types: There are two types of curve planning: Linear ramp (straight line) and Jerk-limited ramp (S-curve).

■ Waiting time: When configured for reciprocal motion, you can configure the target position arrival waiting delay time.

■ Number of cycles: When configured as reciprocal motion, the number of reciprocal cycles can be configured, and when infinite cycle is checked, it will run an infinite number of cycles.

②Enable the servo driver. Click "**Enable**" to switch the servo driver to the enable state.

③"Start" to begin position Model motion control.

④"Start + Start Acquisition" to start position Model motion control, then start acquiring the oscilloscope.

4.5.2 Speed Model

Select "**Motion Model**" in the module control area, click "**Speed Model**" to open the speed Model motion control interface, as shown in Figure 4-32.

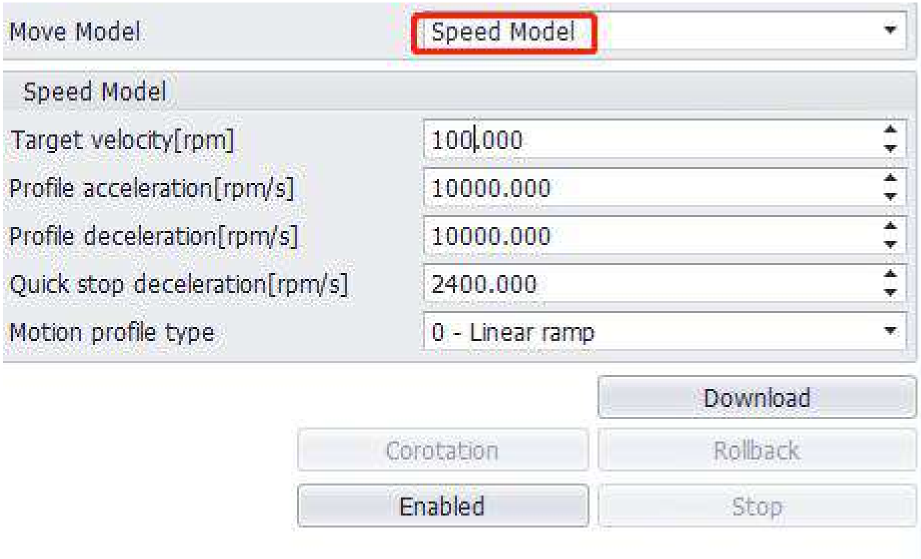


Figure 4-32 Speed Model motion control interface

The speed Model motion control steps are as follows:

①Configure speed Model motion parameters.

■ Target speed: the speed of motor movement.

■ Acceleration: Acceleration of the motor starting motion

■ Deceleration: the deceleration of the motor stop motion.

■ Fast stop deceleration: the deceleration of the motor stop when the energy is directly prohibited.

②Enable the servo driver. Click "**Enable**", and the motion monitoring window will switch to "**Servo Enable**" after successful enablement.

③Forward/reverse rotation. Forward rotation, control the motor to move in the positive direction; reverse rotation, control the motor to move in the opposite direction.

4.5.3 Homing Model

Select "**Motion**" in the main menu, click "**homing Model**" to open the Homing Model motion control interface, as shown in Figure 4-33.

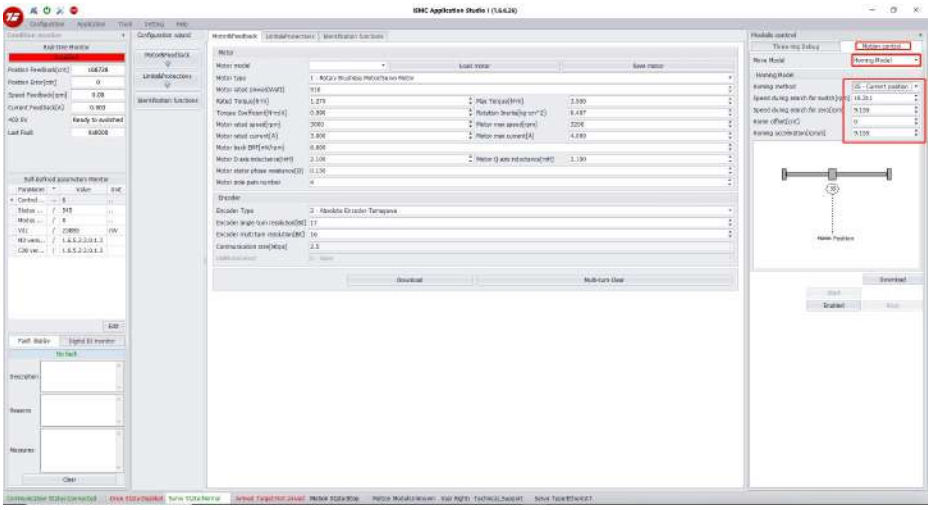


Figure 4-33 Homing Model motion control interface

The steps of the Homing Model motion control are as follows:

①Configure Homing Model movement parameters.

■ Zeroing method: There are 35 types of zero-seeking methods, when starting, the motor moves according to the selected zero-seeking method.

■ Zero Search Highway: When starting, the motor starts to find the zero point at high speed

■ Zero-seeking low speed: When starting, the motor finds the zero point and then moves to the zero point at low speed.

■ Zero Offset: After setting the zero offset, the motor finally stops at the position after the offset.

■ Zero-seeking plus or minus speed: At startup, finding zero and finding zero plus or minus speed

②Servo Drive Enable: Click "Enable", and the motion monitoring window will be switched to "Servo Enable" state after successful enablement.

③Start/Stop: Tap the "**Start**" button, the motor will move according to the set Homing Model; tap the "**Stop**" button, the motor will stop.

Back to the original way to introduce:

1) Back to the original way to use

When the incremental encoder is used, the power-up servo does not know the motor position, and the return operation is required for each power-up.

When using absolute encoders or incremental + Hall signals, only the first power-up is required for the return operation.

Note: Difference with zero point correction. Zero point correction is the initial angle identification of the motor. If the initial angle identification is not performed, the motor may reverse or even fly. Similarly when incremental encoder is used, zero point correction is required for each power up. When using absolute encoders or incremental + Hall signals, zero point correction is only required for the first power-up.

2）Introduction of related concepts

①Origin and zero point

Origin：Mechanical home position, can indicate home switch or motor Z signal.

Zero Point：Locate the target point, i.e., back to the original final stopping position.

During the return process, the motor stops at the home position, or at the zero point if the position deviation 607C is set.

The relationship between the two is: zero = origin + 607C (position deviation) as in Figure 4-34：

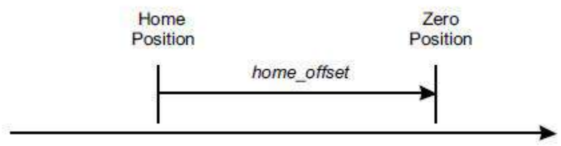


Figure 4-34 Relationship between the origin and the zero point

②Speed

High Speed：Find the limit switch (different depending on the origin method) during the speed is high speed.（6099-01h）.

Low speed：The speed of the home position finding process after finding the limit switch is low（6099-02h）.

Acceleration and deceleration：Acceleration and deceleration in the return process（609A）.

③Direction

The encoder value increases in the positive direction and decreases in the negative direction.

3）Method 1: Homing on negative limit switch (falling edge) and index pulse

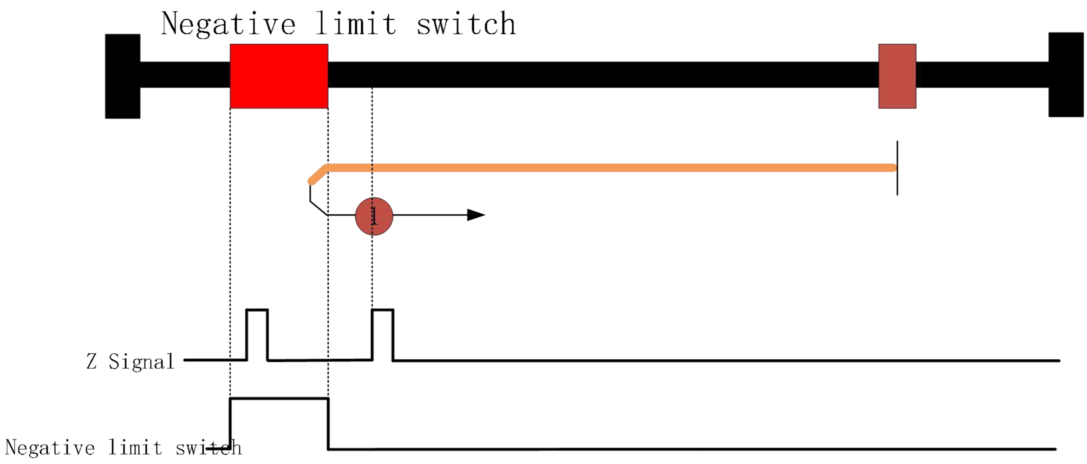


Figure 4-35 Method 1

When homing starts, the motor moves at a high speed (6099-01) in the negative direction. When the negative limit switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), moves in the positive direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the positive direction at the low speed. After the negative limit switch signal becomes low level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

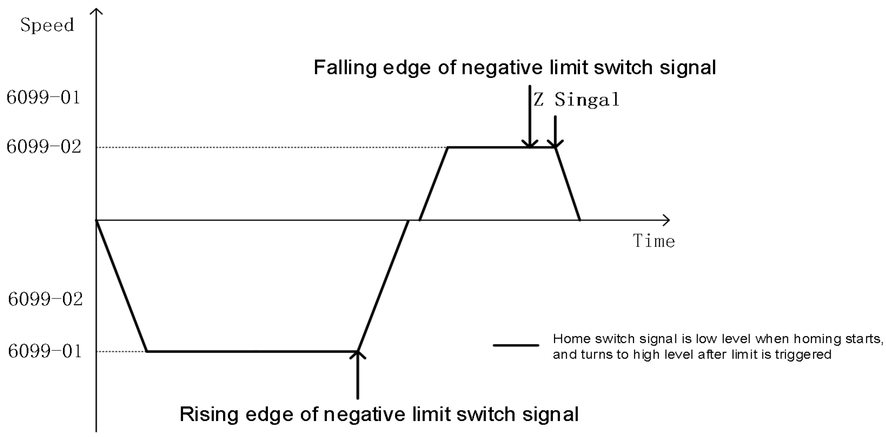


Figure 4-36 Speed-time curve of method 1

Method 2: Homing on positive limit switch (falling edge) and index pulse

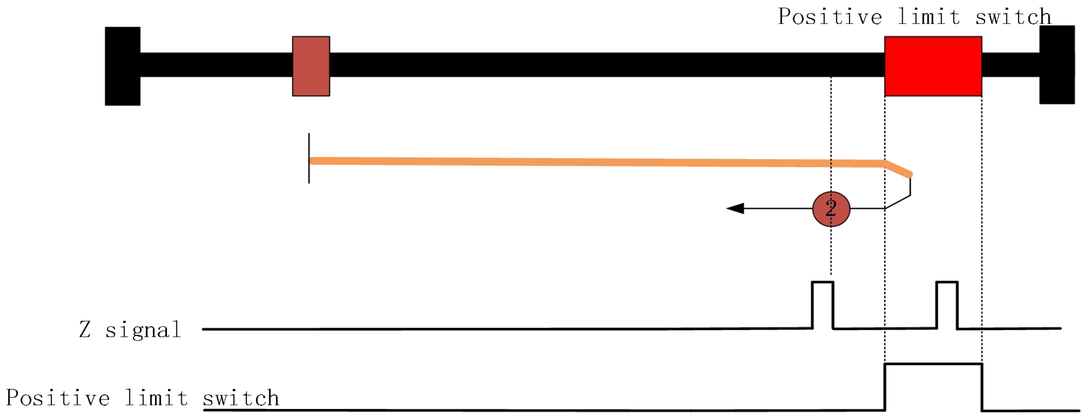


Figure 4-37 Method 2

When homing starts, the motor moves at a high speed (6099-01) in the positive direction. When the positive limit switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), moves in the negative direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the negative direction at the low speed. After the positive limit switch signal becomes low level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

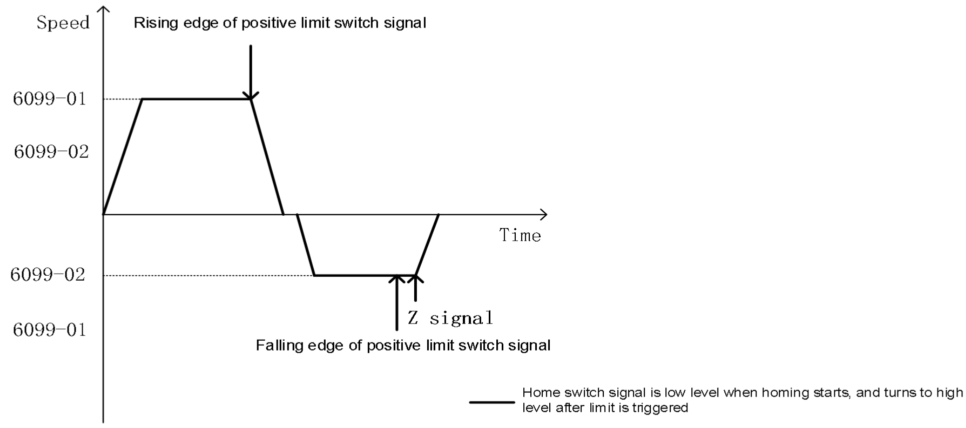


Figure 4-38 Speed-time curve of method 2

Method 3: Homing on positive home switch (falling edge) and index pulse

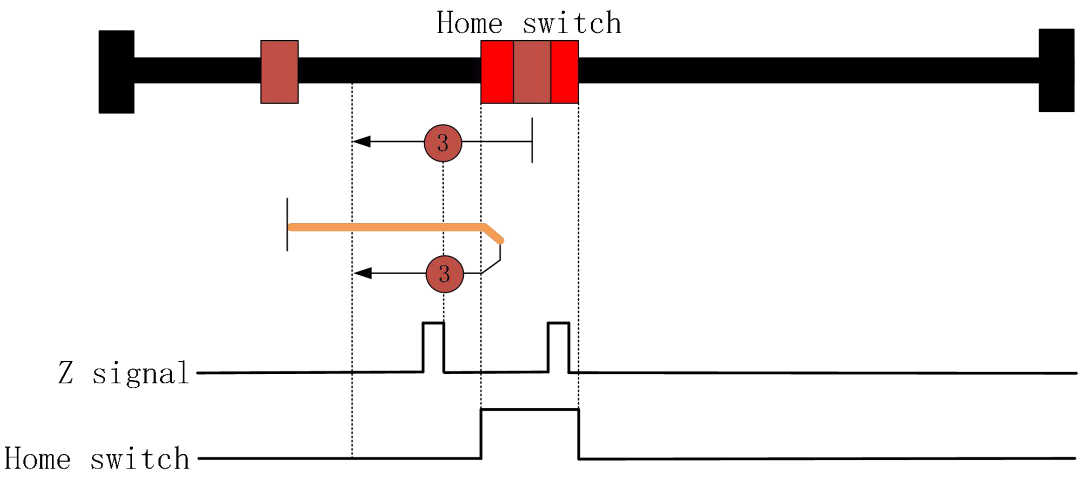


Figure 4-39 Method 3

- **When homing starts, if the home switch signal is low level,** the motor moves at a high speed (6099-01) in the positive direction. After the home switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the negative direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the negative direction at the low speed. After the positive home switch signal becomes low level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
- **When homing starts, if the home switch signal is high level,** the motor moves at a low speed (6099-02) in the negative direction. After the home switch signal becomes low level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

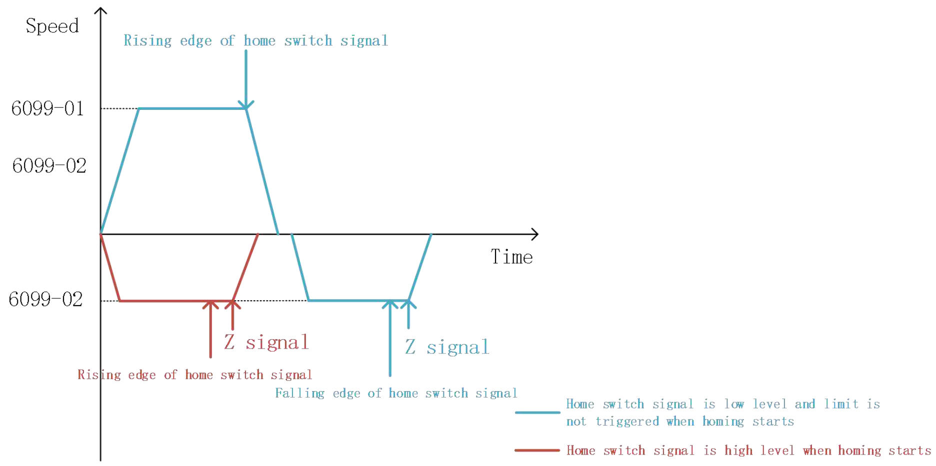


Figure 4-40 Speed-time curve of method 3

Method 4: Homing on positive home switch (rising edge) and index pulse

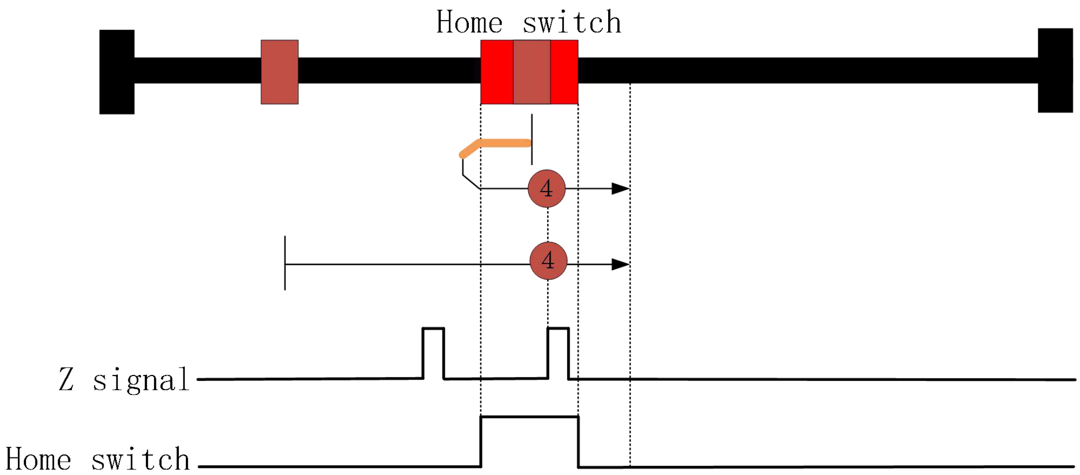


Figure 4-41 Method 4

原点开关：Home switch
Z 信号：Z signal

- **When homing starts, if the home switch signal is low level,** the motor moves at a low speed (6099-02) in the positive direction. After the home switch signal becomes high level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A) and finally return to the Z pulse latch position. The status word Target reached is set to 1 when the motor stops.
- **When homing starts, if the home switch signal is high level,** the motor moves at a high speed (6099-01) in the negative direction. After the home switch signal becomes low level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the positive direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the positive direction at the low speed. After the home switch signal becomes high level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A) and finally return to the Z pulse latch position. The status word Target reached is set to 1 when the motor stops.

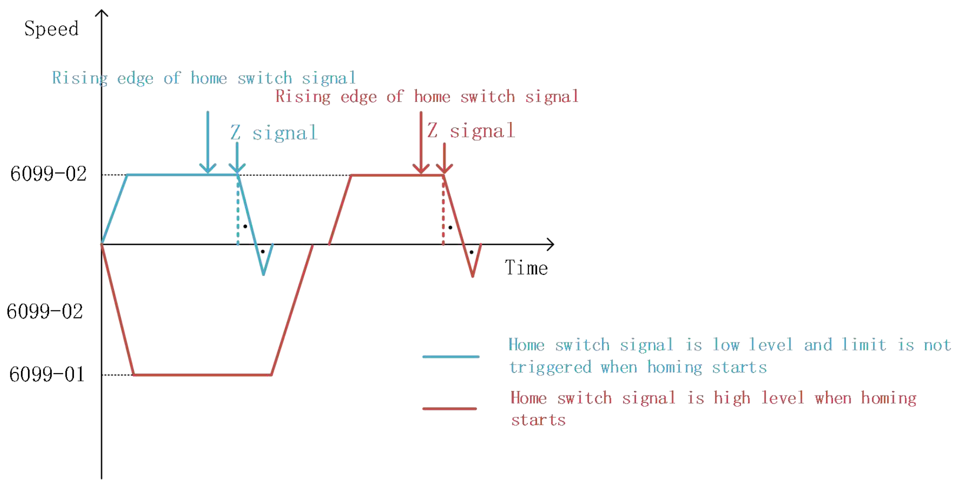


Figure 4-42 Speed-time curve of method 4

Method 5: Homing on negative home switch (falling edge) and index pulse

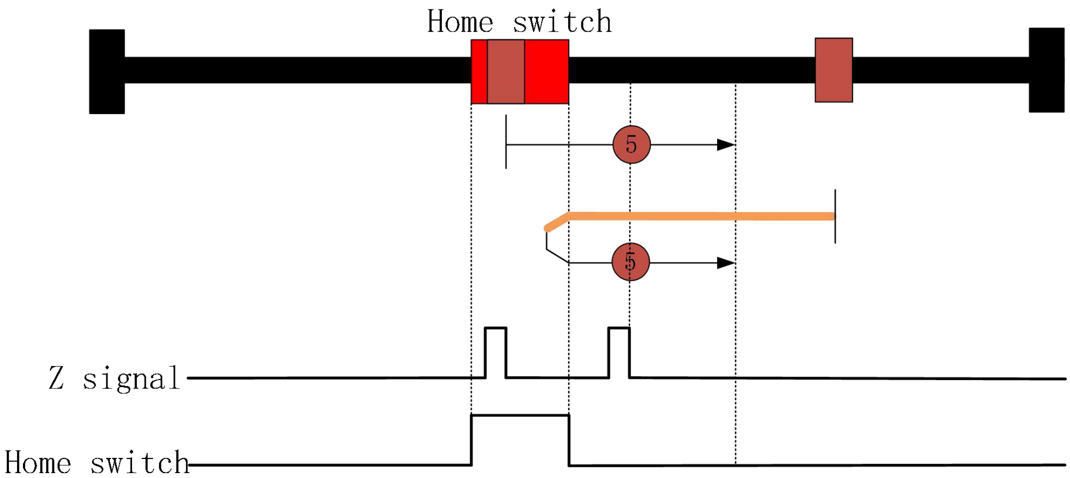


Figure 4-43 Method 5

- **When homing starts, if the home switch signal is low level,** the motor moves at a high speed (6099-01) in the negative direction. After the home switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the positive direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the positive direction at the low speed. After the home switch signal becomes low level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A) and finally returns to the Z pulse latch position. The status word Target reached is set to 1 when the motor stops.
- **When homing starts, if the home switch signal is high level,** the motor moves at a low speed (6099-02) in the positive direction. After the home switch signal becomes low level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A) and finally returns to the Z pulse latch position. The status word Target reached is set to 1 when the motor stops.

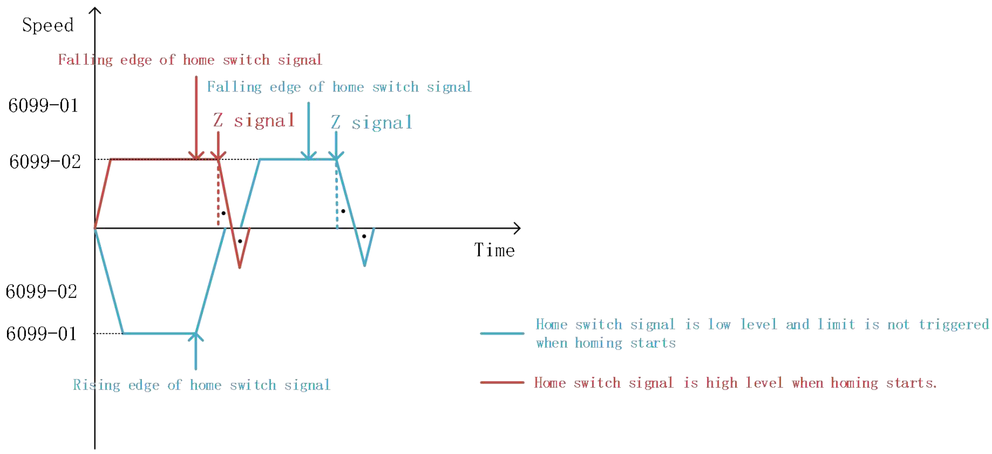


Figure 4-44 Speed-time curve of method 5

Method 6: Homing on negative home switch (rising edge) and index pulse

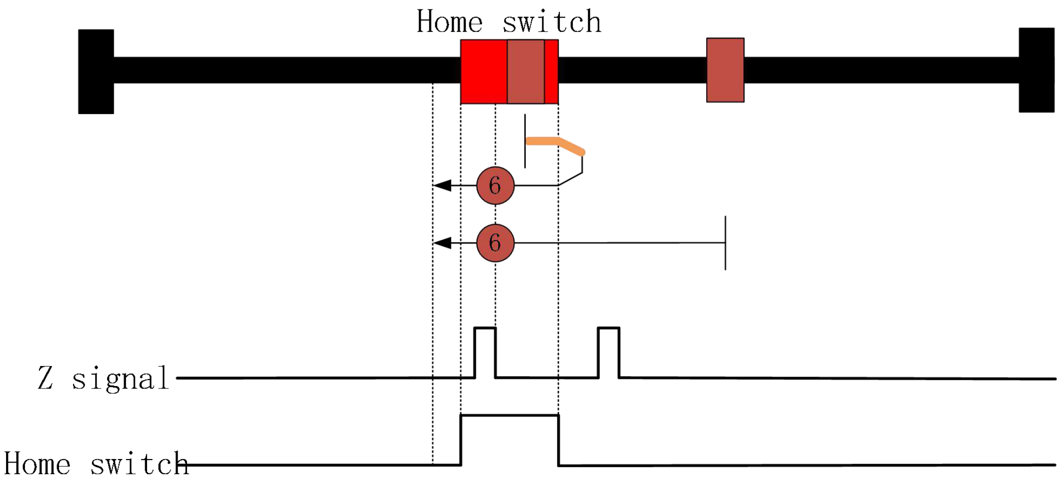


Figure 4-45 Method 6

- **When homing starts, if the home switch signal is low level,** the motor moves at a low speed (6099-02) in the negative direction. After the home switch signal becomes high level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
- **When homing starts, if the home switch signal is high level,** the motor moves at a high speed (6099-01) in the positive direction. After the home switch signal becomes low level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the negative direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the negative direction at the low speed. After the home switch signal becomes high level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

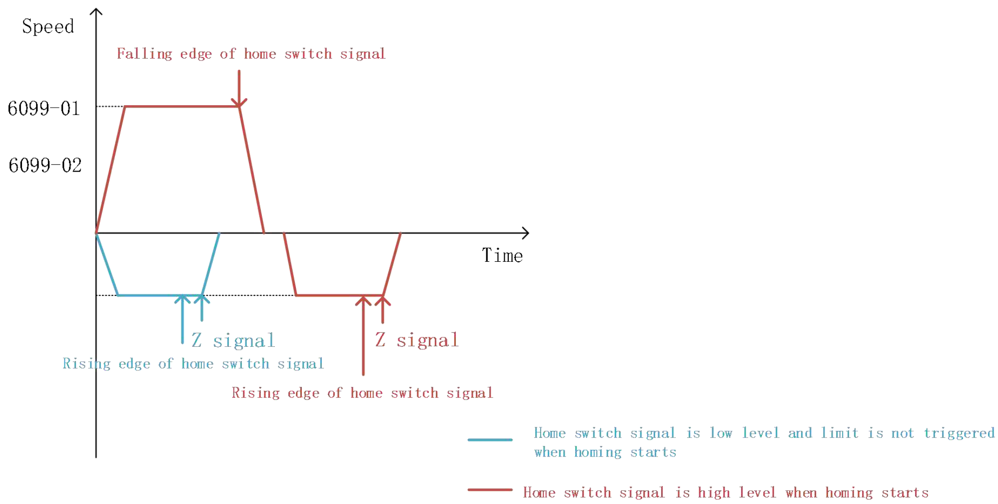


Figure 4-46 Speed-time curve of method 6

Method 7: Homing on negative home switch (falling edge) and index pulse-positive limit switch detection

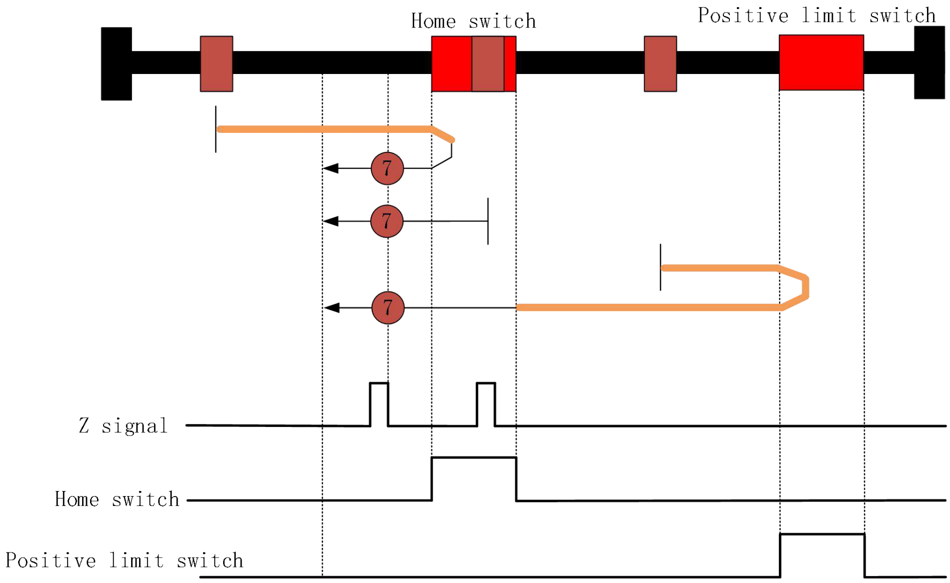


Figure 4-47 Method 7

- **When homing starts, if the home switch signal is low level,** the motor moves at a high speed in the positive direction.
  - ✓ After the home switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the negative direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the negative direction at the low speed. After the home switch signal becomes low level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
  - ✓ After the positive limit switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the negative direction with the homing acceleration (609A) to accelerate to a high speed (6099-01), and keeps moving in the negative direction at the high speed. After the home switch signal becomes high level, the motor decelerates with homing deceleration (609A) to a low speed (6099-02), and keeps moving in the negative direction at the low speed. After the home switch signal becomes low level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

- **When homing starts, if the home switch signal is high level,** the motor moves at a low speed (6099-02) in the negative direction. After the home switch signal becomes low level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

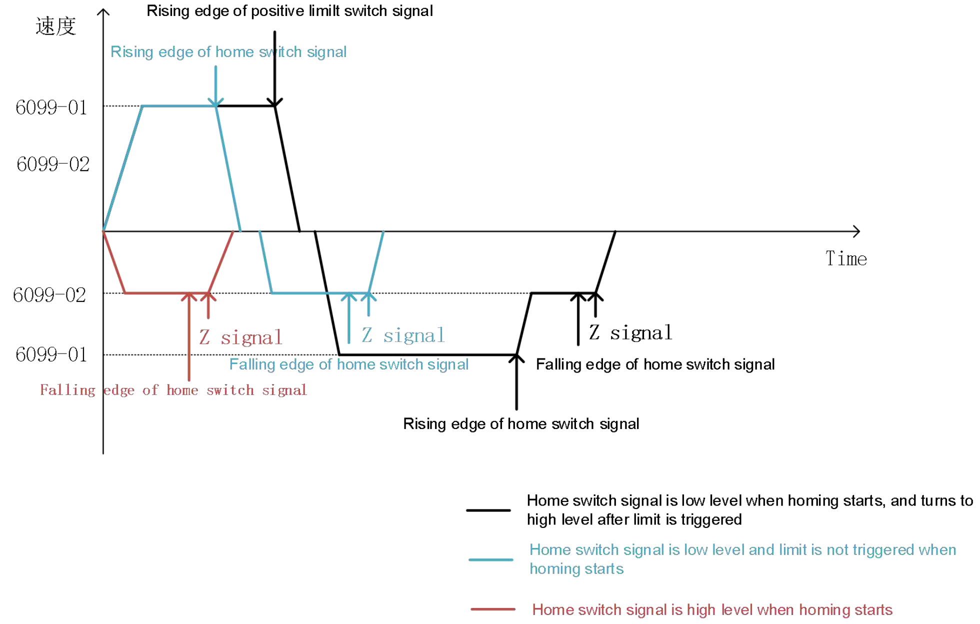


Figure 4-48 Speed-time curve of method 7

Method 8: Homing on positive home switch (rising edge) and index pulse-positive limit switch detection

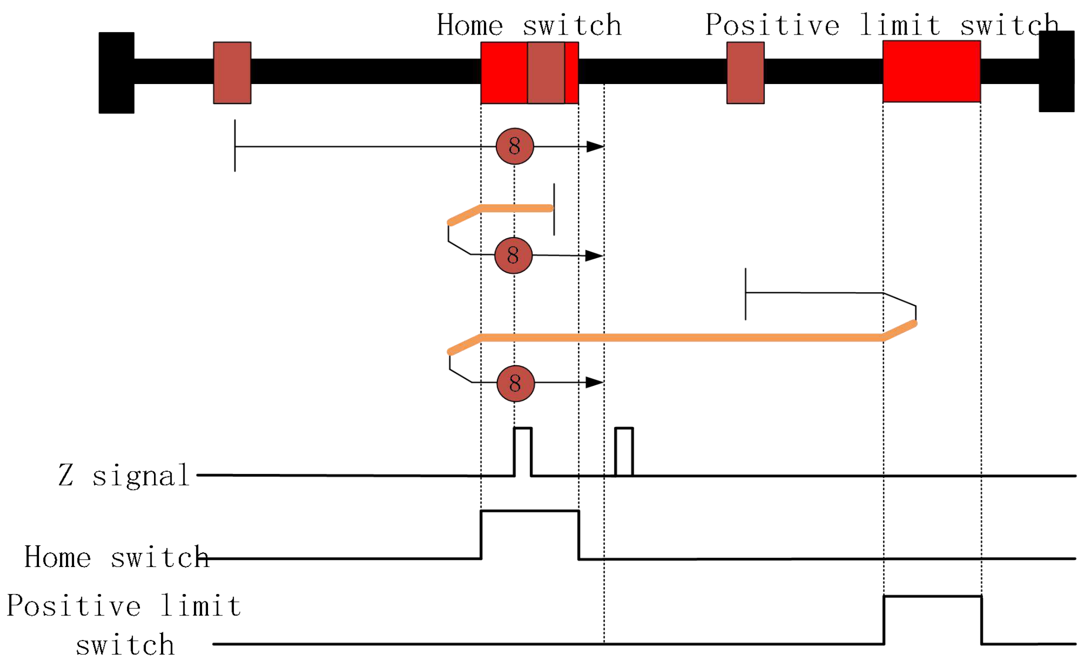


Figure 4-49 Method 8

- **When homing starts, if the home switch signal is low level,** the motor moves at a low speed (6099-02) in the positive direction.
  - ✓ After the home switch signal becomes high level, the motor keeps moving at a low speed (6099-02) in the positive direction. After the home switch signal becomes high level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
  - ✓ After the positive limit switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the negative direction with the homing acceleration (609A) to accelerate to a high speed (6099-01), and keeps moving in the negative direction at the high speed. After the home switch signal becomes low level, the motor decelerates to 0 with the homing deceleration (609A), move in the positive direction to accelerate to a low speed (6099-02) with the homing acceleration (609A), and keeps moving in the positive direction at the low speed. After the home switch signal becomes high level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
- **When homing starts, if the home switch signal is high level,** the motor moves at a high speed (6099-01) in the negative direction. After the home switch signal becomes low level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the positive direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the positive direction at the low speed. After the home switch signal becomes high level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

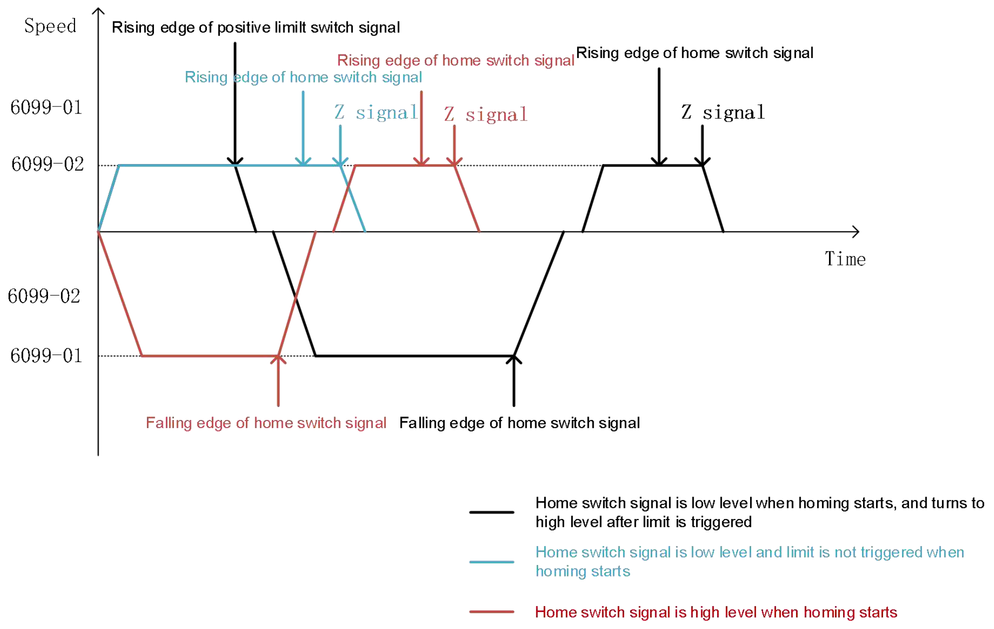


Figure 4-50 Speed-time curve of method 8

Method 9: Homing on negative home switch (rising edge) and index pulse-positive limit switch detection

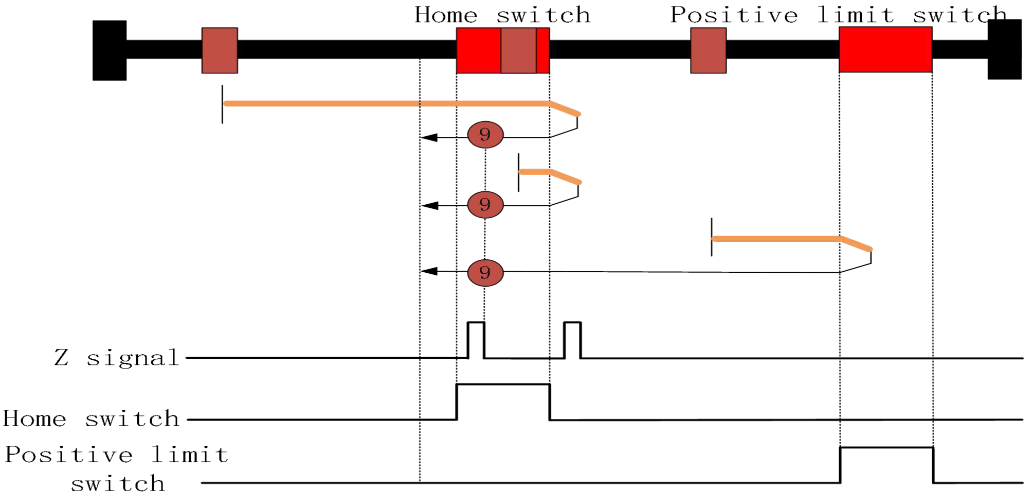


Figure 4-51 Method 9

- **When homing starts, if the home switch signal is low level,** the motor moves at a high speed (6099-01) in the positive direction.
  - ✓ After the home switch signal becomes high level, the motor keeps moving at a high speed (6099-01) in the positive direction. After the home switch signal becomes low level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the negative direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the negative direction at the low speed. After the home switch signal changes from low level to high level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
  - ✓ After the positive limit switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the negative direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the negative direction at the low speed. After the home switch signal becomes high level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

- **When homing starts, if the home switch signal is high level,** the motor moves at a high speed (6099-01) in the positive direction. After the home switch signal becomes low level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the negative direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the negative direction at the low speed. After the home switch signal becomes high level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

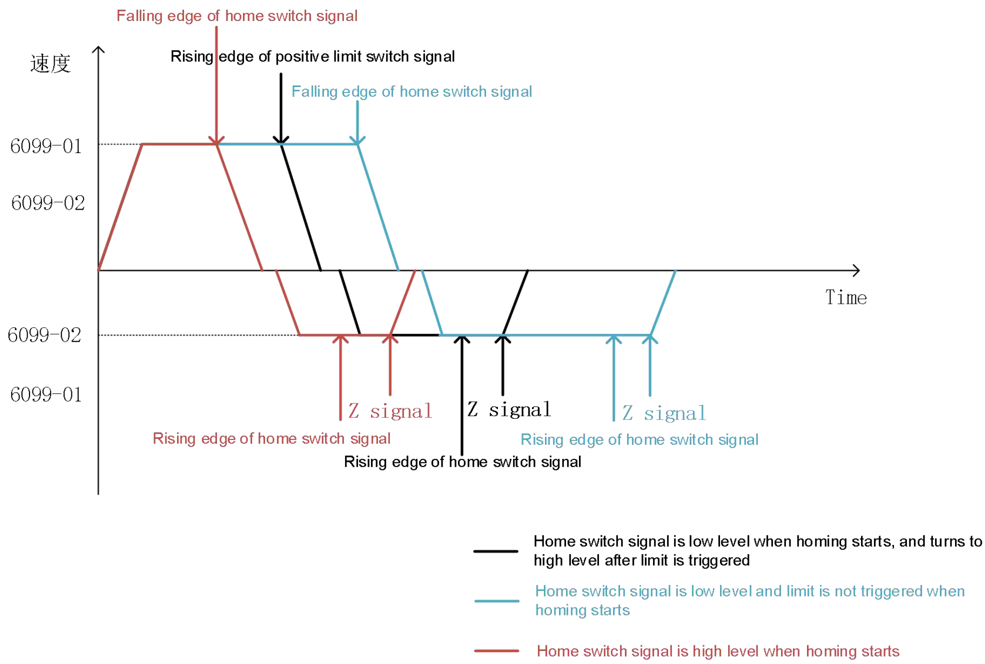


Figure 4-52 Speed-time curve of method 9

Method 10: Homing on positive home switch (falling edge) and index pulse-positive limit switch detection

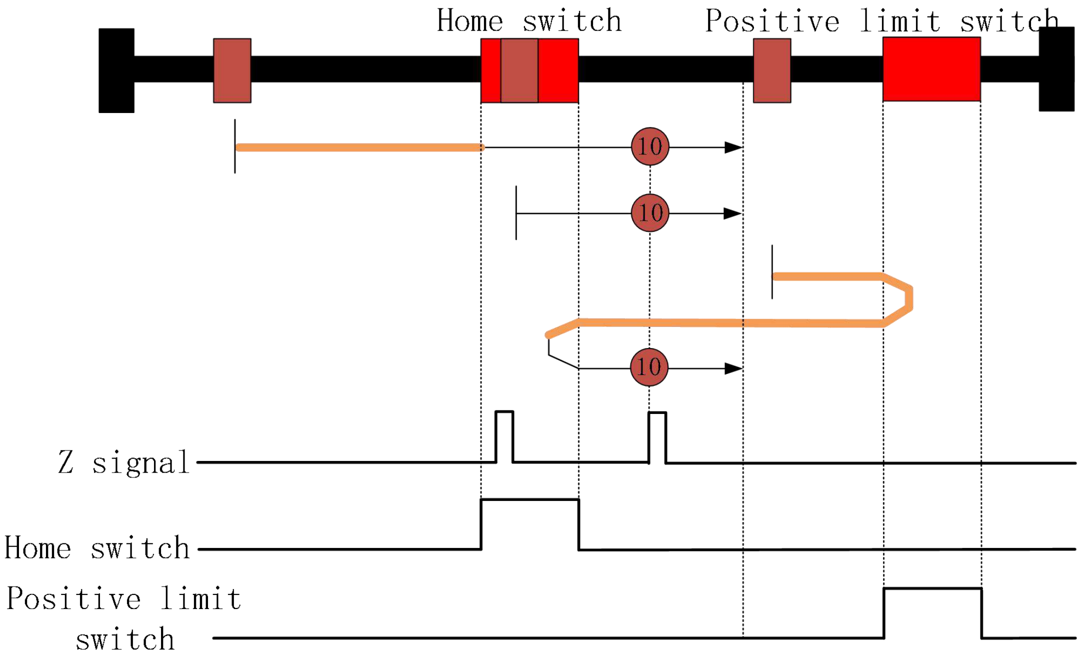


Figure 4-53 Method 10

- **When homing starts, if the home switch signal is low level,** the motor moves at a high speed (6099-01) in the positive direction.
  - ✓ After the home switch signal becomes high level, the motor moves with the homing deceleration (609A) to decelerate to a low speed (6099-02), and keeps moving at the low speed in the positive direction. After the home switch signal becomes low level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
  - ✓ After the positive limit switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the negative direction with the homing acceleration (609A) to accelerate to a high speed (6099-01), and keeps moving in the negative direction at the high speed. After the home switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), move in the positive direction to accelerate to a low speed (6099-02) with the homing acceleration (609A), and keeps moving in the positive direction at the low speed. After the home switch signal becomes low level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

- **When homing starts, if the home switch signal is high level,** the motor moves at a low speed (6099-02) in the positive direction. After the home switch signal becomes low level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

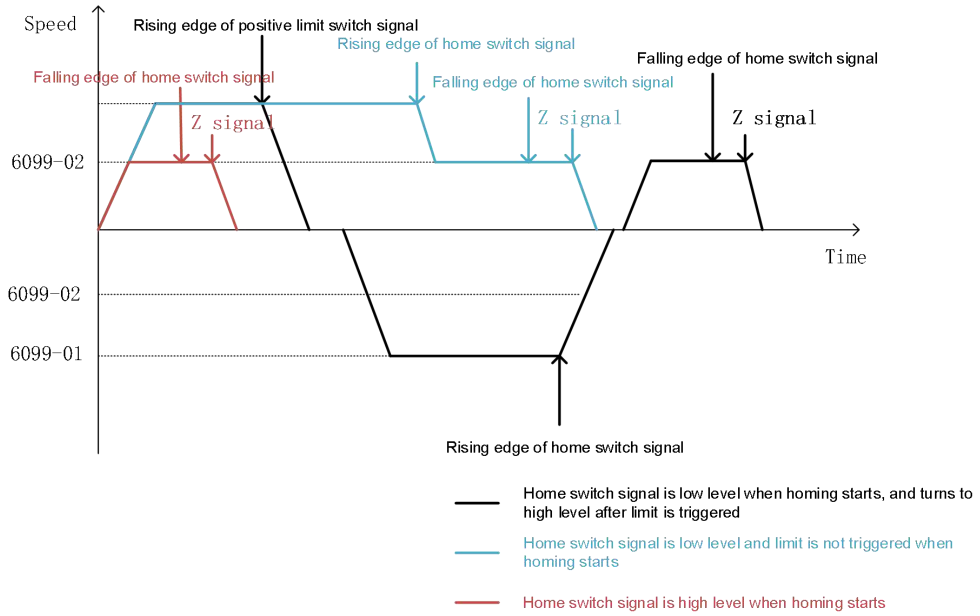


Figure 4-54 Speed-time curve of method 10

Method 11: Homing on positive home switch (falling edge) and index pulse-negative limit switch detection

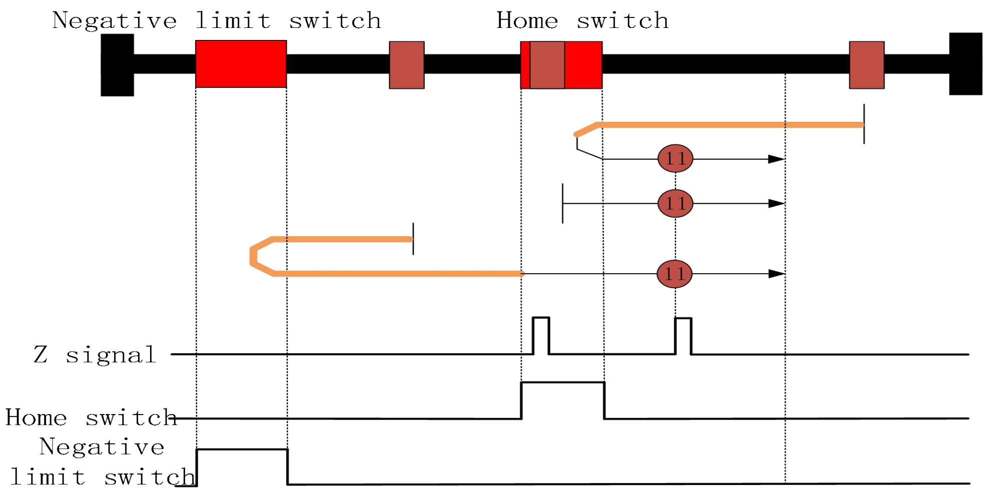


Figure 4-55 Method 11

- **When homing starts, if the home switch signal is low level,** the motor moves at a high speed (6099-01) in the negative direction.
  - ✓ After the home switch signal becomes high level, the motor moves with the homing deceleration (609A) to decelerate to 0, and moves in the positive direction to accelerate to a low speed (6099-02) with the homing acceleration (609A), and keeps moving at the low speed in the positive direction. After the home switch signal becomes low level and

the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

✓ After the negative limit switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the positive direction with the homing acceleration (609A) to accelerate to a high speed (6099-01), and keeps moving in the positive direction at the high speed. After the home switch signal becomes high level, the motor decelerates to a low speed (6099-02) with the homing deceleration (609A), and keeps moving in the positive direction at the low speed. After the home switch signal becomes low level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

- **When homing starts, if the home switch signal is high level,** the motor moves at a low speed (6099-02) in the positive direction. After the home switch signal becomes low level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

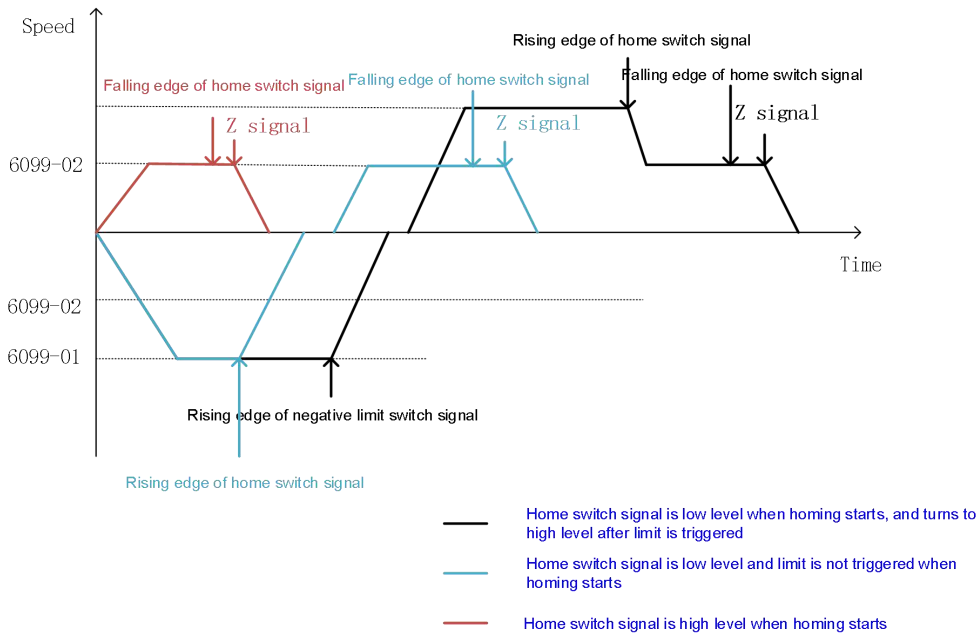


Figure 4-56 Speed-time curve of method 11

Method 12: Homing on negative home switch (rising edge) and index pulse-negative limit switch detection

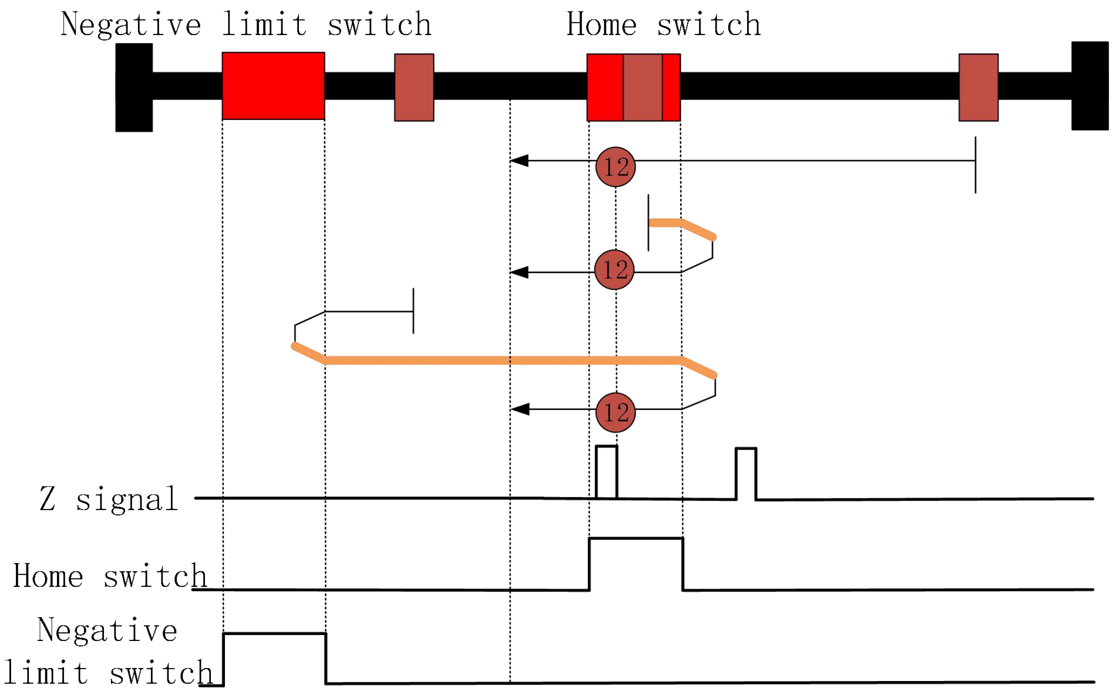


Figure 4-57 Method 12

- **When homing starts, if the home switch signal is low level,** the motor moves at a low speed (6099-02) in the negative direction.
  - ✓ After the home switch signal becomes high level, the motor keeps moving in the negative direction at a low speed (6099-02). After the home switch signal becomes high level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
  - ✓ After the negative limit switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the positive direction with the homing acceleration (609A) to accelerate to a high speed (6099-01), and keeps moving in the positive direction at the high speed. After the home switch signal becomes low level, the motor decelerates to 0 with the homing deceleration (609A), moves in the negative direction to accelerate to a low speed (6099-02) with the homing acceleration (609A), and keeps moving in the negative direction at the low speed. After the home switch signal becomes high level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

- **When homing starts, if the home switch signal is high level,** the motor moves at a high speed (6099-01) in the positive direction. After the home switch signal becomes low level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the negative direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the negative direction at the low speed. After the home switch signal becomes high level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

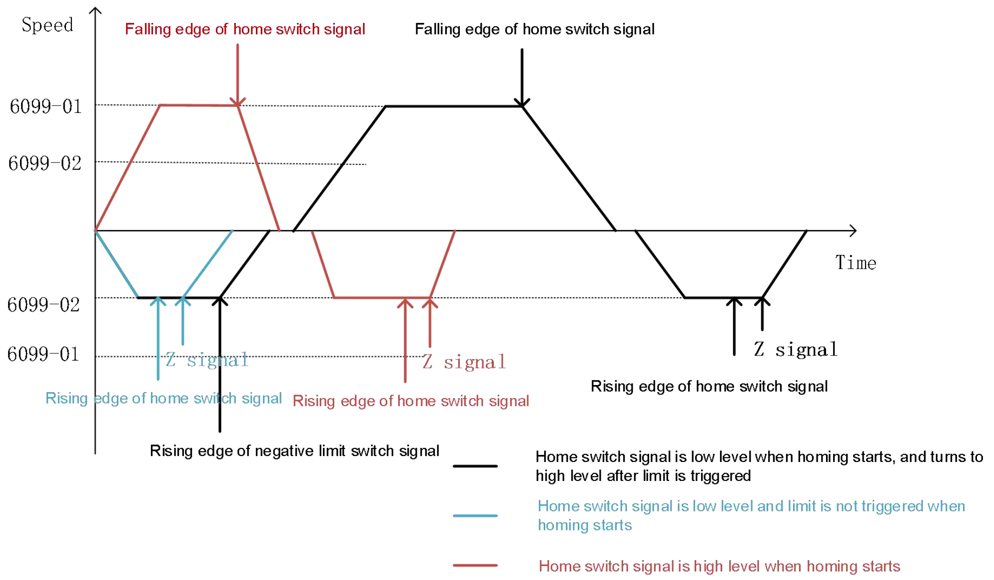


Figure 4-58 Speed-time curve of method 12

Method 13: Homing on positive home switch (rising edge) and index pulse-negative limit switch detection

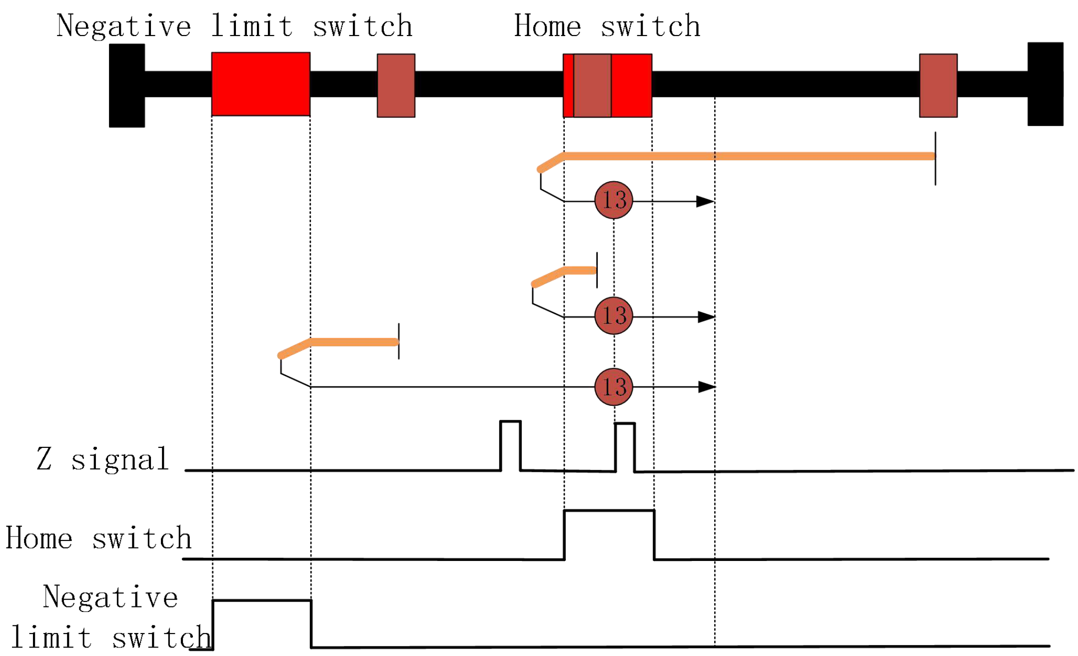


Figure 4-59 Method 13

- **When homing starts, if the home switch signal is low level,** the motor moves at a high speed (6099-01) in the negative direction.

- ✓ After the home switch signal becomes high level, the motor keeps moving in the negative direction at the high speed. After the home switch signal becomes low level, the motor moves with the homing deceleration (609A) to decelerate to 0, and moves in the positive direction to accelerate to a low speed (6099-02) with the homing acceleration (609A), and keeps moving at the low speed in the positive direction. After the home switch signal becomes high level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
- ✓ After the negative limit switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the positive direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the positive direction at the low speed. After the home switch signal becomes high level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

- **When homing starts, if the home switch signal is high level,** the motor moves at a high speed (6099-01) in the negative direction. After the home switch signal becomes low level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the positive direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the positive direction at the low speed. After the home switch signal becomes high level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

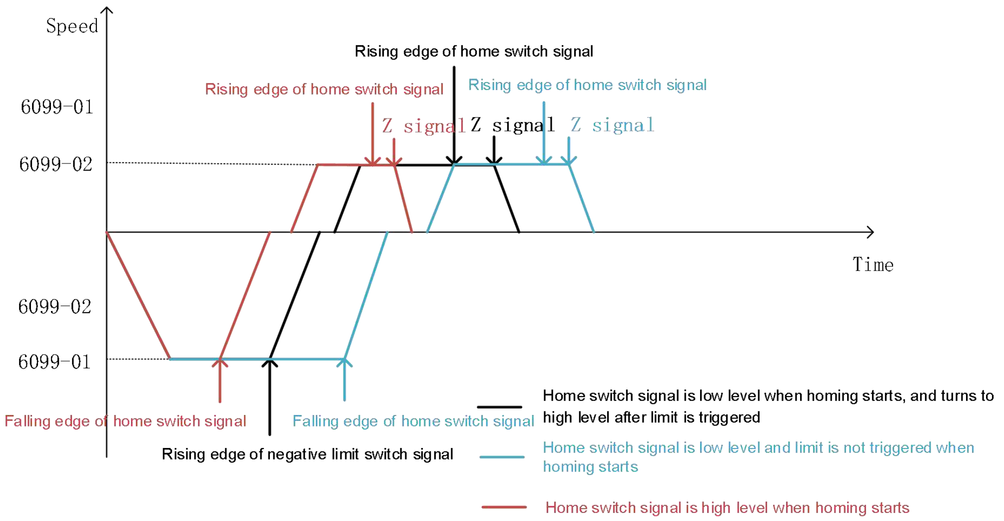


Figure 4-60 Speed-time curve of method 13

Method 14: Homing on negative home switch (falling edge) and index pulse-negative limit switch detection

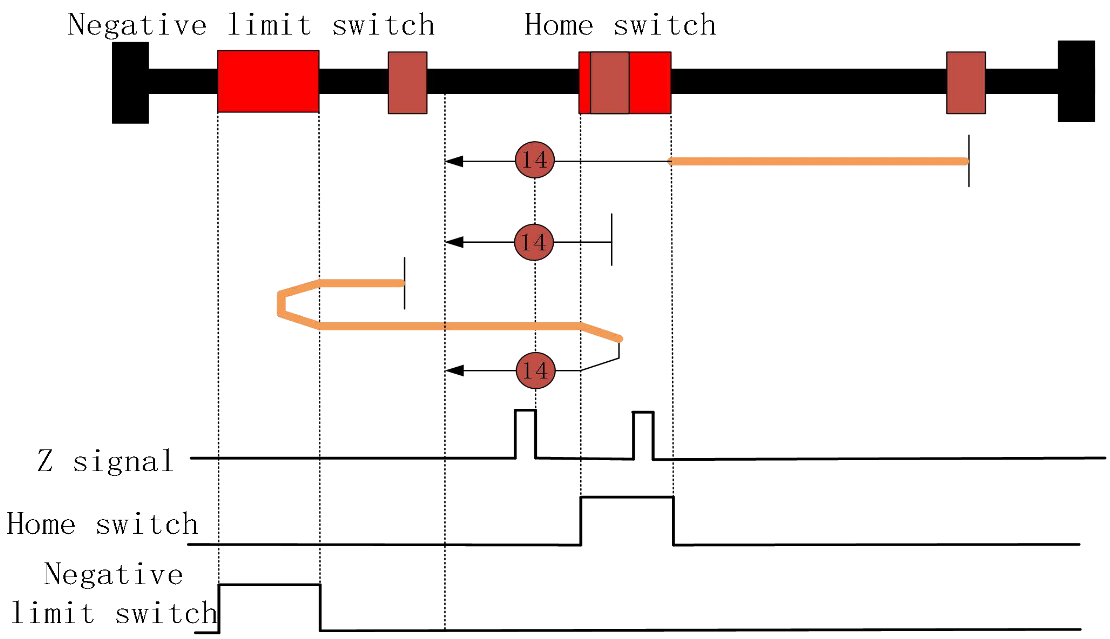


Figure 4-61 Method 14

- **When homing starts, if the home switch signal is low level,** the motor moves at a high speed (6099-02) in the negative direction.
  - ✓ After the home switch signal becomes high level, the motor moves with the homing deceleration (609A) to decelerate to a low speed (6099-02), and keeps moving in the negative direction at a low speed. After the home switch signal becomes low level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
  - ✓ After the negative limit switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the positive direction with the homing acceleration (609A) to accelerate to a high speed (6099-01), and keeps moving in the positive direction at the high speed. After the home switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), moves in the negative direction to accelerate to a low speed (6099-02) with the homing acceleration (609A), and keeps moving in the negative direction at the low speed. After the home switch signal becomes low level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
- **When homing starts, if the home switch signal is high level,** the motor moves at a low speed (6099-01) in the negative direction. After the home switch signal becomes low level and the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

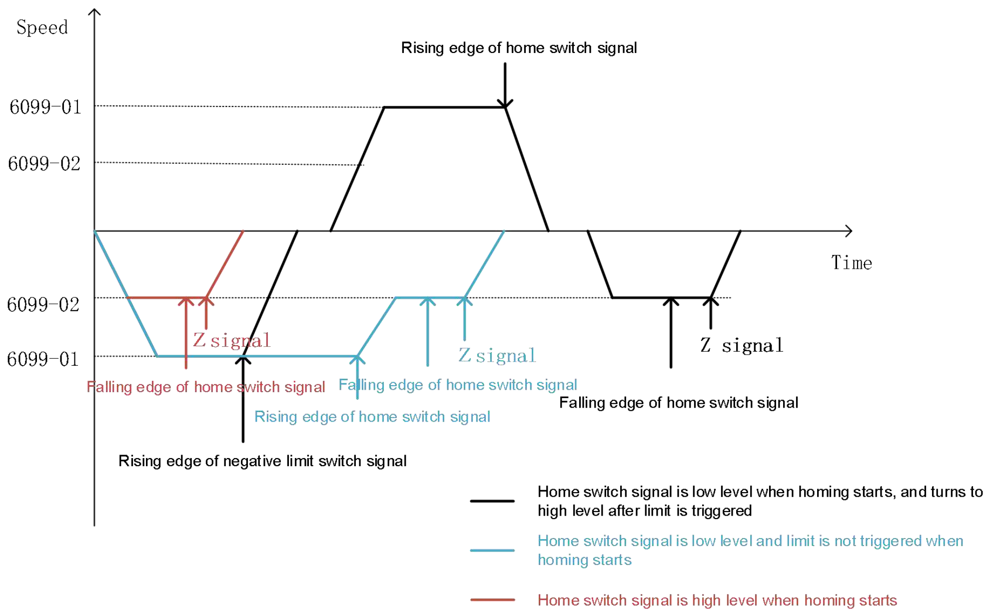


Figure 4-62 Speed-time curve of method 14

Method 15: Reserved

Method 16: Reserved

Method 17: Homing on negative limit switch (falling edge)

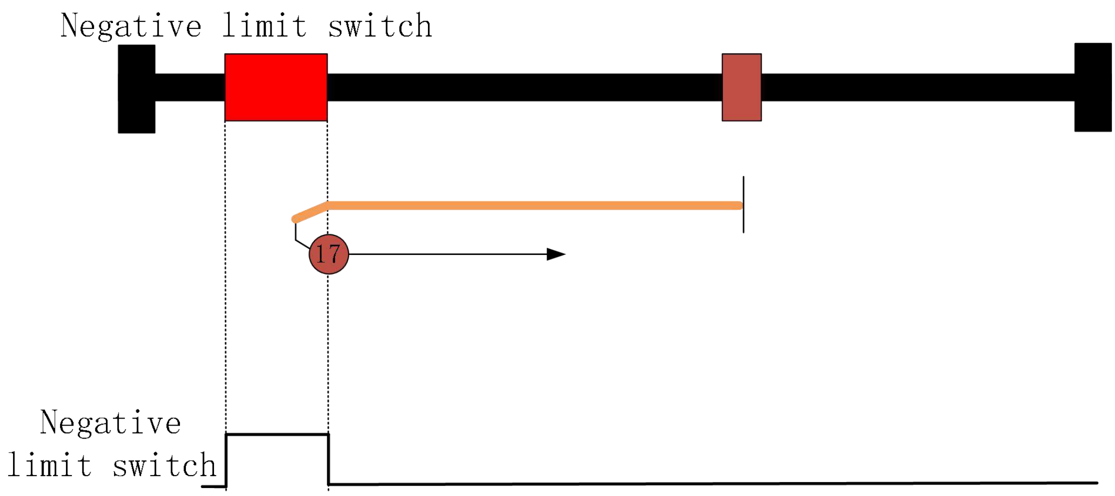


Figure 4-63 Method 17

When homing starts, the motor moves at a high speed (6099-01) in the negative direction. When the negative limit switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), moves in the positive direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the positive direction at the low speed. After the negative limit switch signal becomes low level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

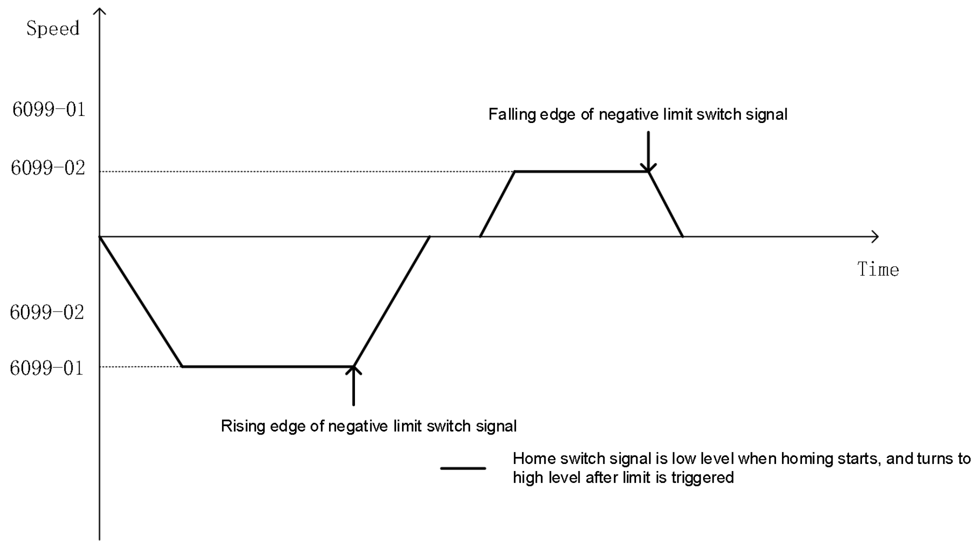


Figure 4-64 Speed-time curve of method 17

Method 18: Homing on positive limit switch (falling edge)

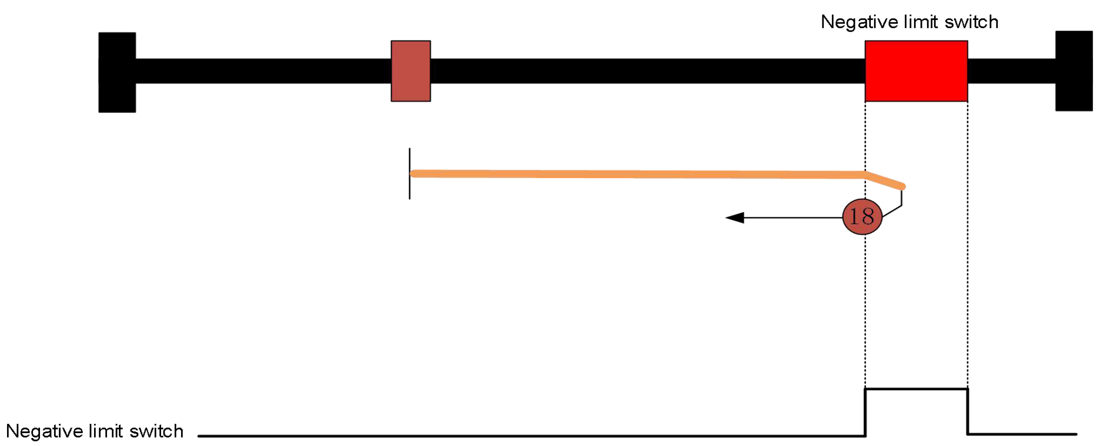


Figure 4-65 Method 18

When homing starts, the motor moves at a high speed (6099-01) in the positive direction. When the positive limit switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), moves in the negative direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the negative direction at the low speed. After the positive limit switch signal becomes low level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

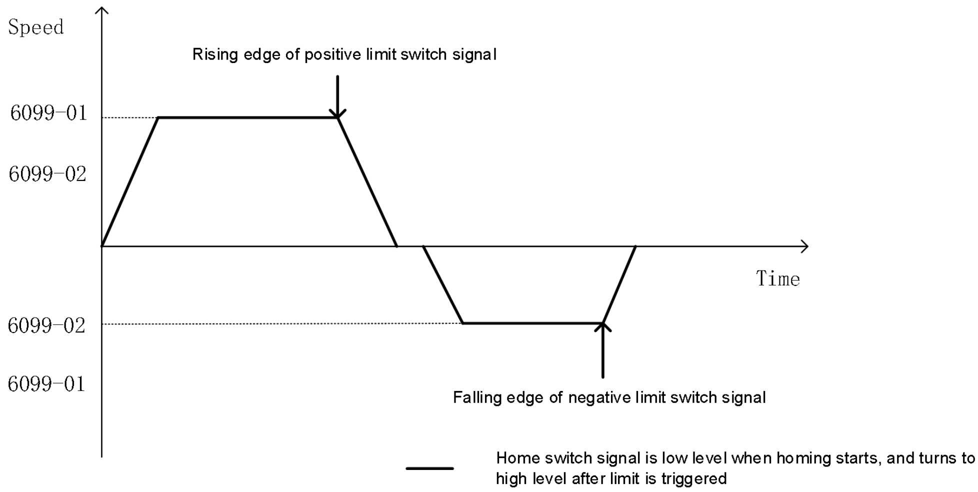


Figure 4-66 Speed-time curve of method 18

Method 19: Homing on negative home switch (falling edge)

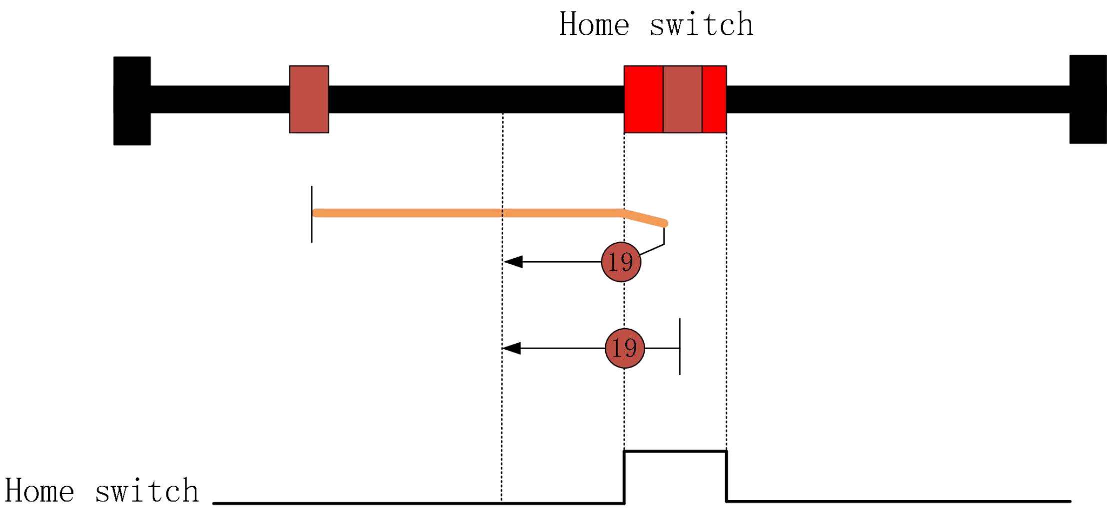


Figure 4-67 Method 19

- **When homing starts, if the home switch signal is low level,** the motor moves at a high speed (6099-01) in the positive direction. After the positive home switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the negative direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the negative direction at the low speed. After the positive home switch signal becomes low level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
- **When homing starts, if the home switch signal is high level,** the motor moves at a low speed (6099-02) in the negative direction. After the home switch signal becomes low level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

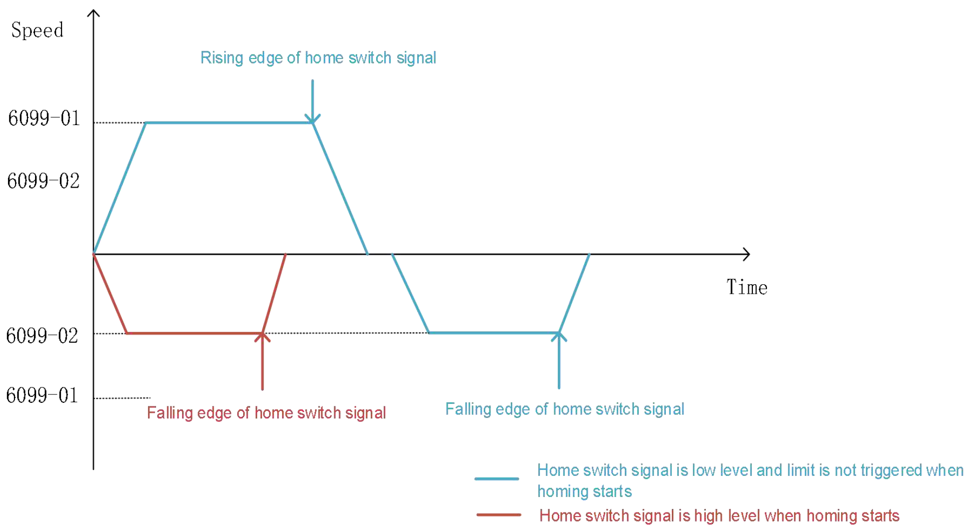


Figure 4-68 Speed-time curve of method 19

Method 20: Homing on positive limit switch (rising edge)

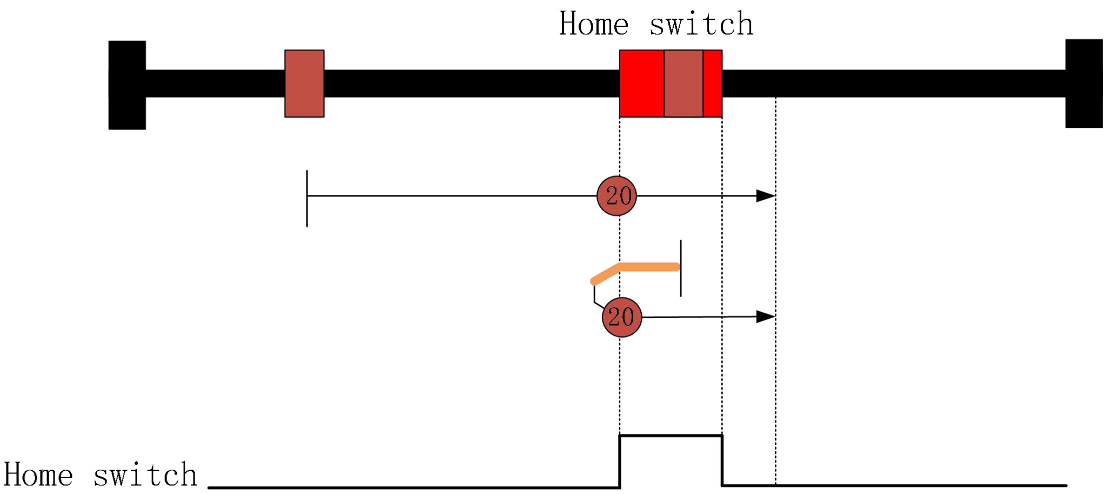


Figure 4-69 Method 20

- **When homing starts, if the positive home switch signal is low level,** the motor moves at a low speed (6099-02) in the positive direction. After the positive home switch signal becomes high level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
- **When homing starts, if the positive home switch signal is high level,** the motor moves at a high speed (6099-01) in the negative direction. After the positive home switch signal becomes low level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the positive direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the positive direction at the low speed. After the positive home switch signal becomes high level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

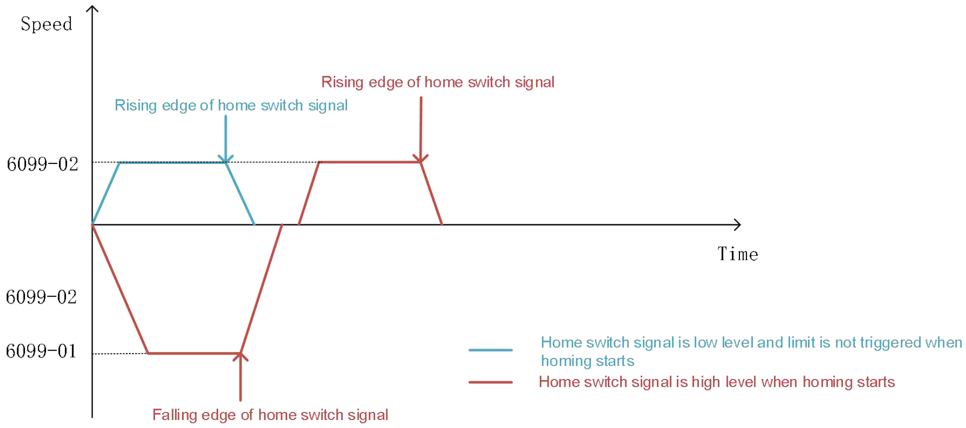


Figure 4-70 Speed-time curve of method 20

Method 21: Homing on negative home switch (falling edge)

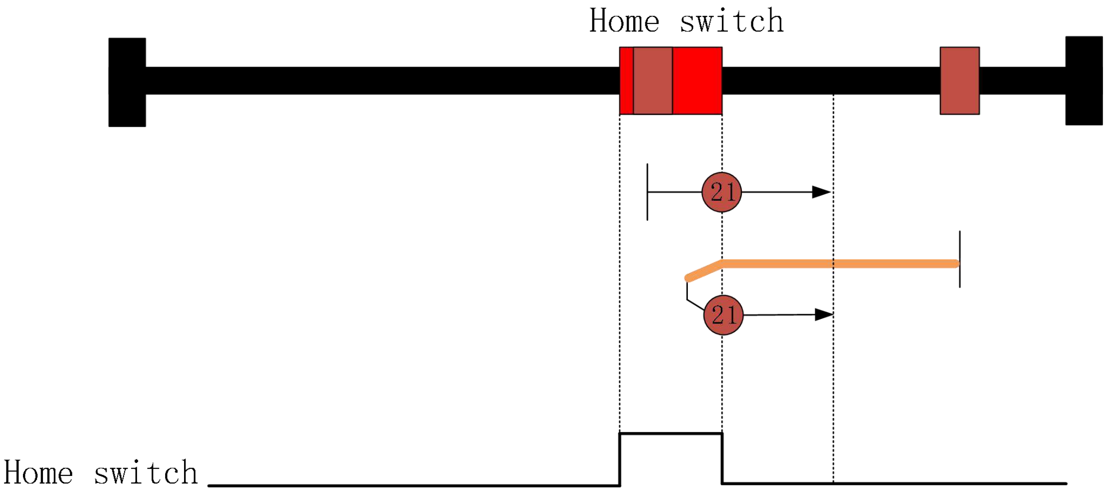


Figure 4-71 Method 21

- **When homing starts, if the home switch signal is low level,** the motor moves at a high speed (6099-01) in the negative direction. After the home switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the positive direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the positive direction at the low speed. After the home switch signal becomes low level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
- **When homing starts, if the home switch signal is high level,** the motor moves at a low speed (6099-02) in the positive direction. After the home switch signal becomes low level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

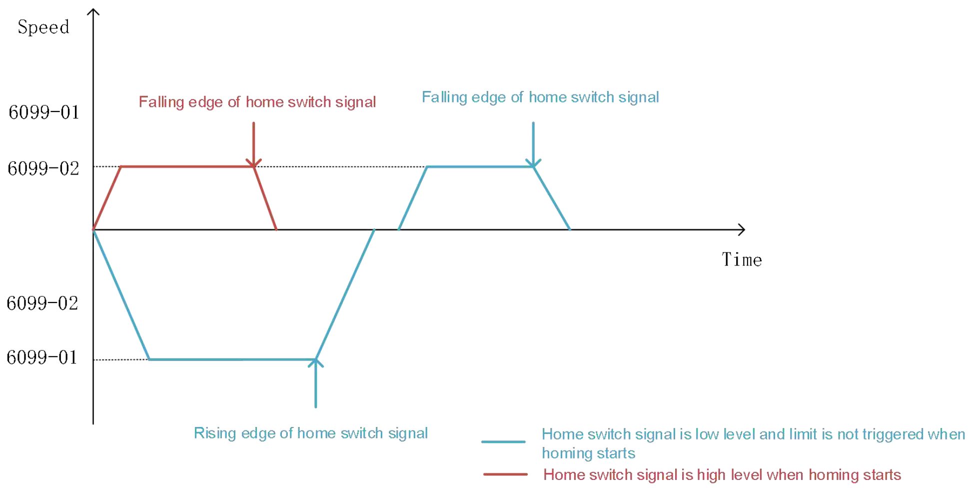


Figure 4-72 Speed-time curve of method 21

Method 22: Homing on negative home switch (rising edge)

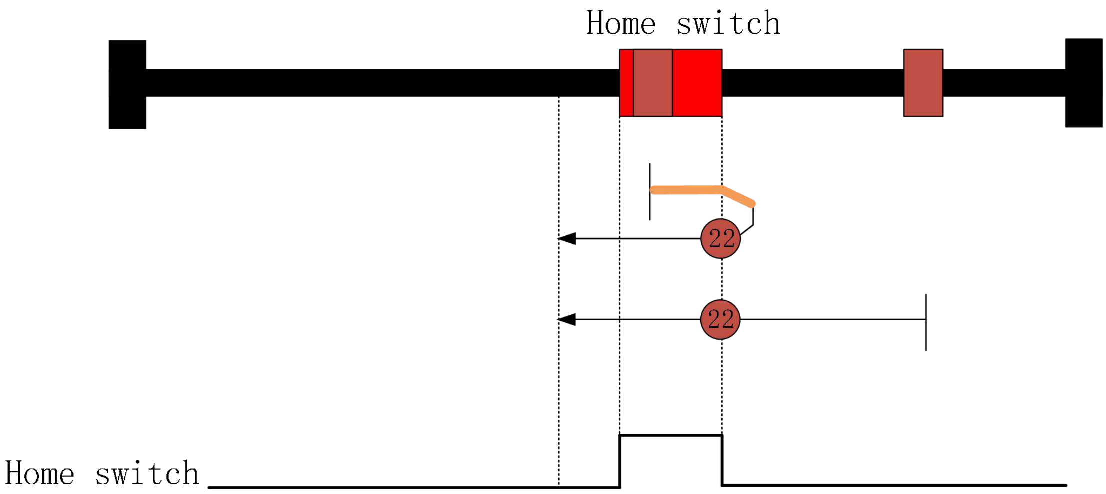


Figure 4-73 Method 22

- **When homing starts, if the home switch signal is low level,** the motor moves at a low speed (6099-02) in the negative direction. After the home switch signal becomes high level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
- **When homing starts, if the home switch signal is high level,** the motor moves at a high speed (6099-01) in the positive direction. After the home switch signal becomes low level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the negative direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the negative direction at the low speed. After the home switch signal becomes high level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

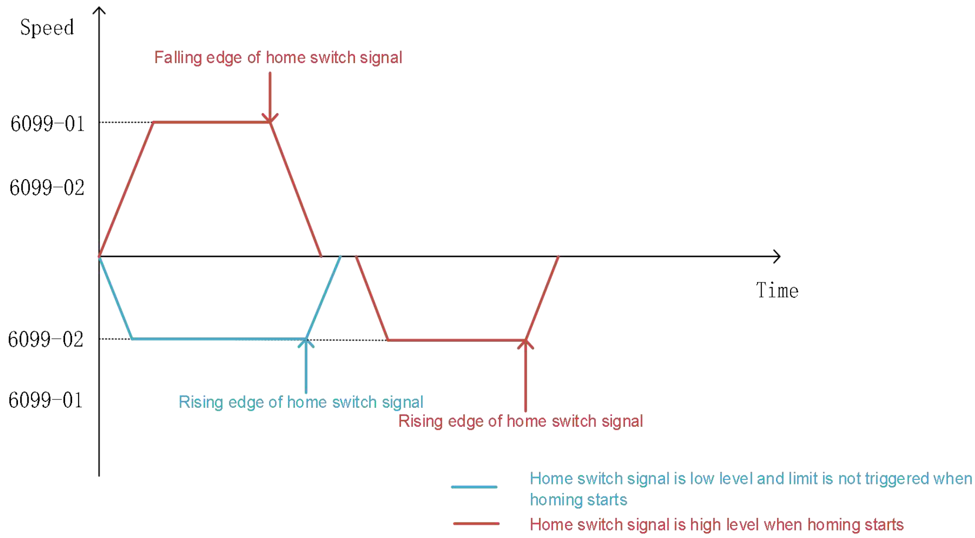


Figure 4-74 Speed-time curve of method 22

Method 23: Homing on negative home switch (falling edge) -positive limit switch detection

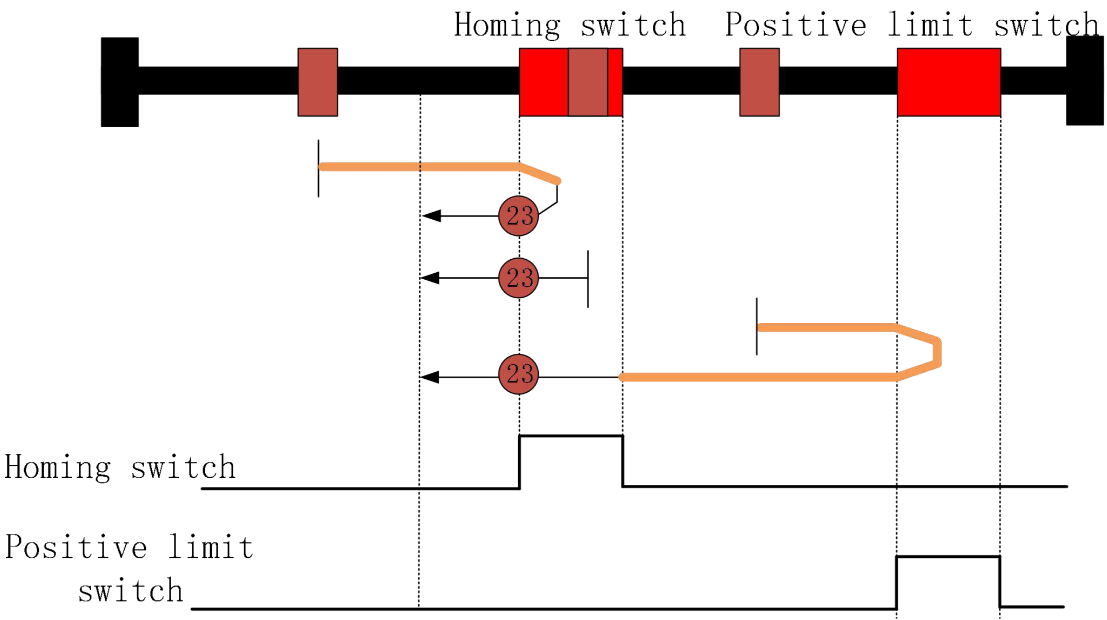


Figure 4-75 Method 23

- **When homing starts, if the home switch signal is low level,** the motor moves at a high speed (6099-01) in the positive direction.
  - ✓ After the home switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the negative direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the negative direction at the low speed. After the home switch signal becomes low level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor

stops.

✓ After the positive limit switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the negative direction with the homing acceleration (609A) to accelerate to a high speed (6099-01), and keeps moving in the negative direction at the high speed. After the home switch signal becomes high level, the motor decelerates to a low speed (6099-01) with the homing deceleration (609A), and keeps moving in the negative direction at the low speed. After the home switch becomes low level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

- **When homing starts, if the home switch signal is high level,** the motor moves at a low speed (6099-02) in the negative direction. After the home switch signal becomes low level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

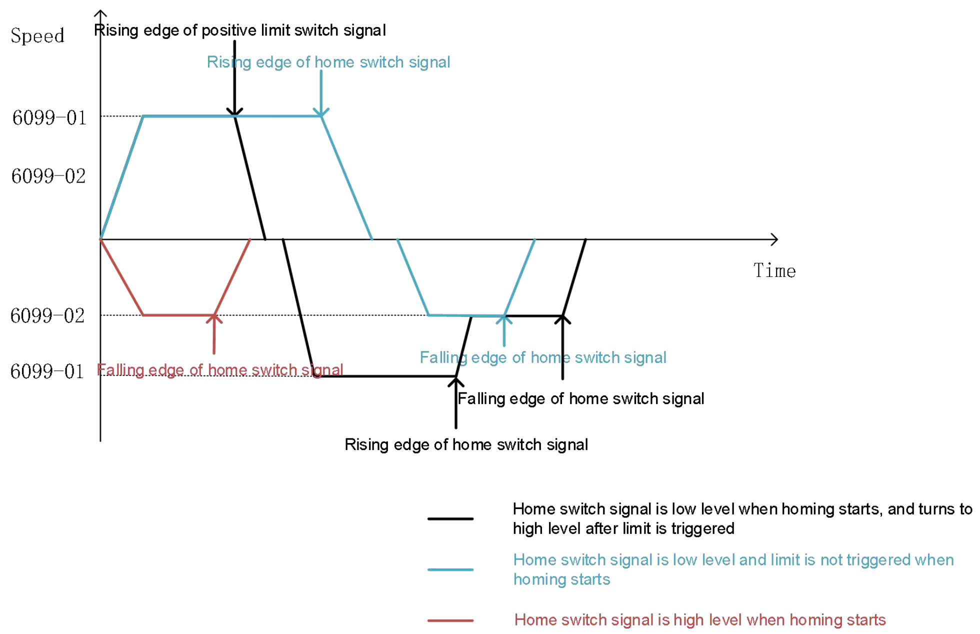


Figure 4-76 Speed-time curve of method 23

Method 24: Homing on positive home switch (rising edge)-positive limit switch detection

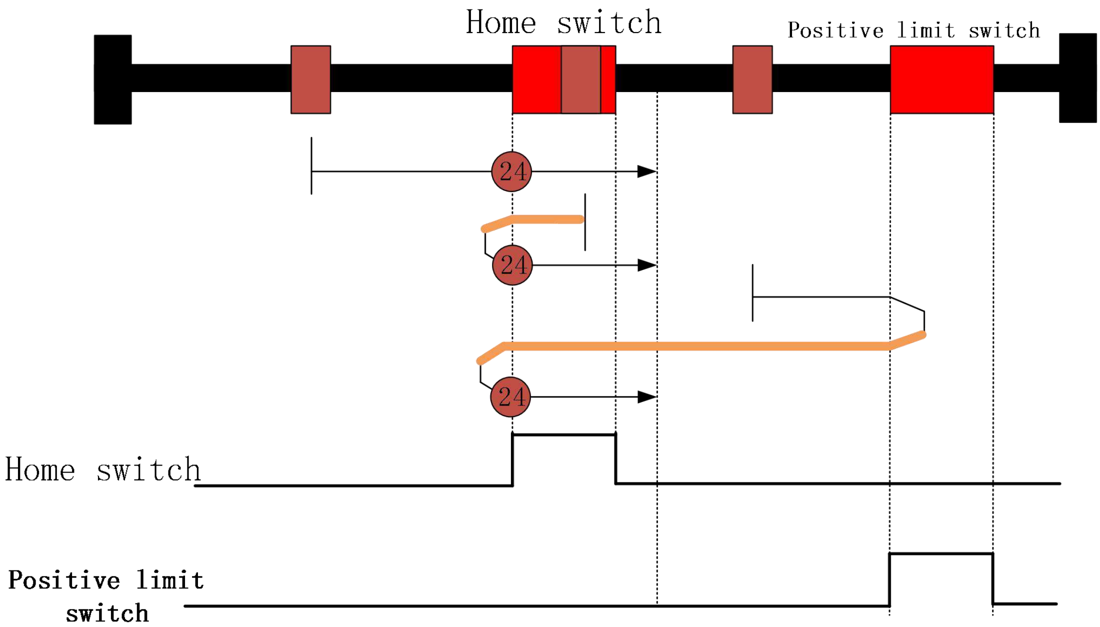


Figure 4-77 Method 24

- **When homing starts, if the home switch signal is low level,** the motor moves at a low speed (6099-02) in the positive direction.
  - ✓ After the home switch signal becomes high level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
  - ✓ After the positive limit switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the negative direction with the homing acceleration (609A) to accelerate to a high speed (6099-01), and keeps moving in the negative direction at the high speed. After the home switch signal becomes low level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the positive direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the positive direction at the low speed. After the home switch signal becomes high level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
- **When homing starts, if the home switch signal is high level,** the motor moves at a high speed (6099-01) in the negative direction. After the home switch signal becomes low level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the positive direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the positive direction at the low speed. After the home switch signal becomes high level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

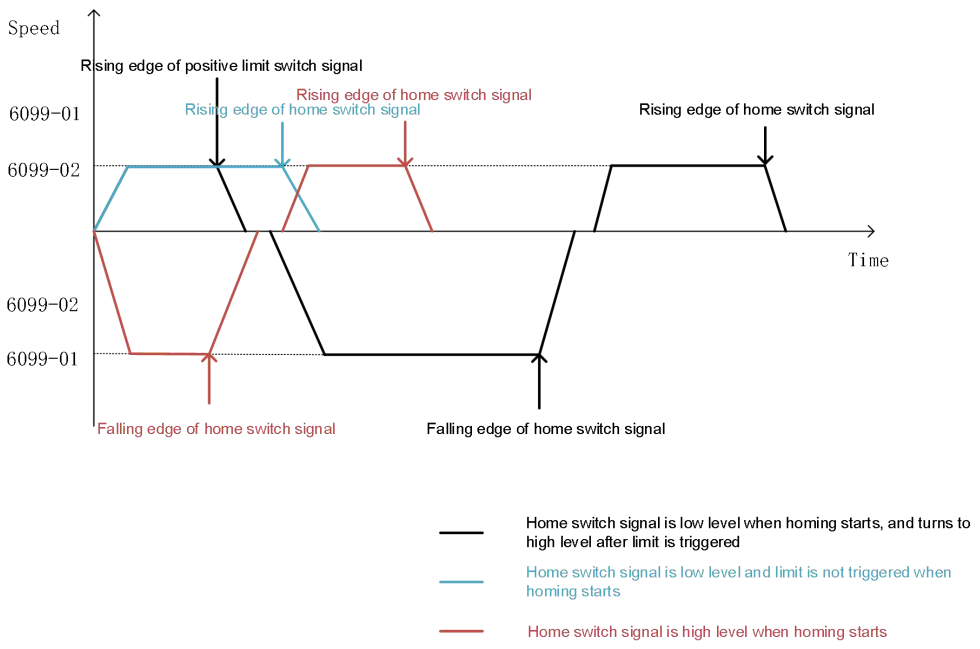


Figure 4-78 Speed-time curve of method 24

Method 25: Homing on negative home switch (rising edge)-positive limit switch detection

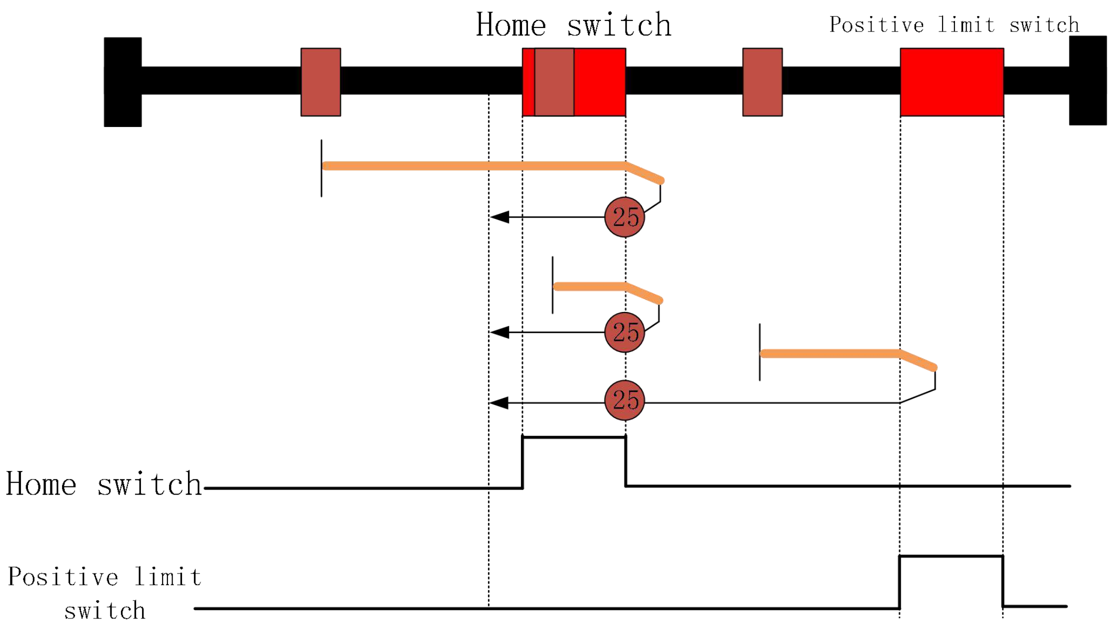


Figure 4-79 Method 25

Regardless of the high level or low level of the home switch signal, the motor moves in the positive direction.

When homing starts, the motor moves in the positive direction at a high speed (6099-01). After the home switch signal becomes low level or the positive limit switch becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the negative direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the negative direction at the low speed. After the home switch signal becomes high level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

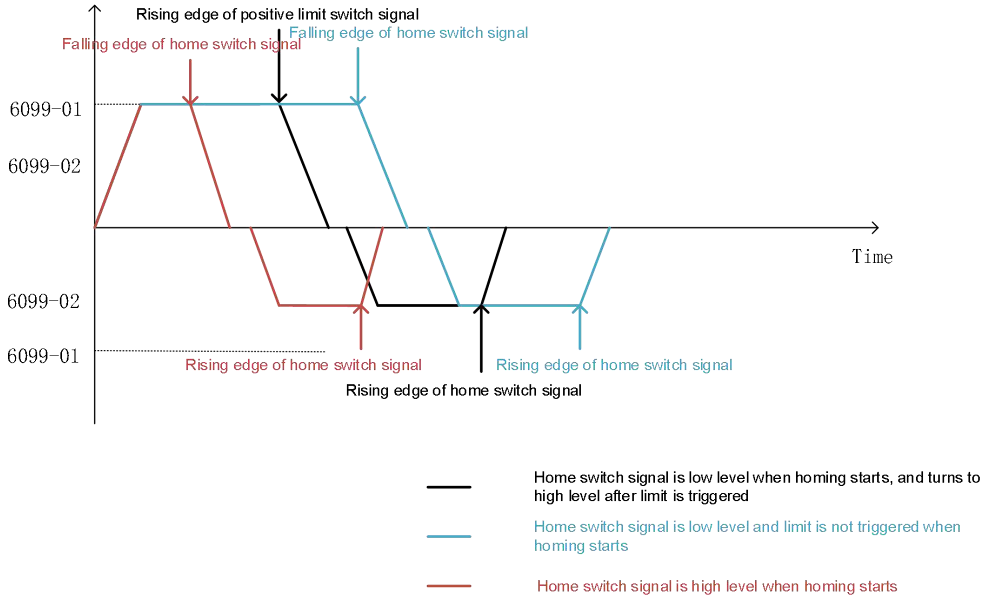


Figure 4-80 Speed-time curve of method 25

Method 26: Homing on positive home switch (falling edge)-positive limit switch detection

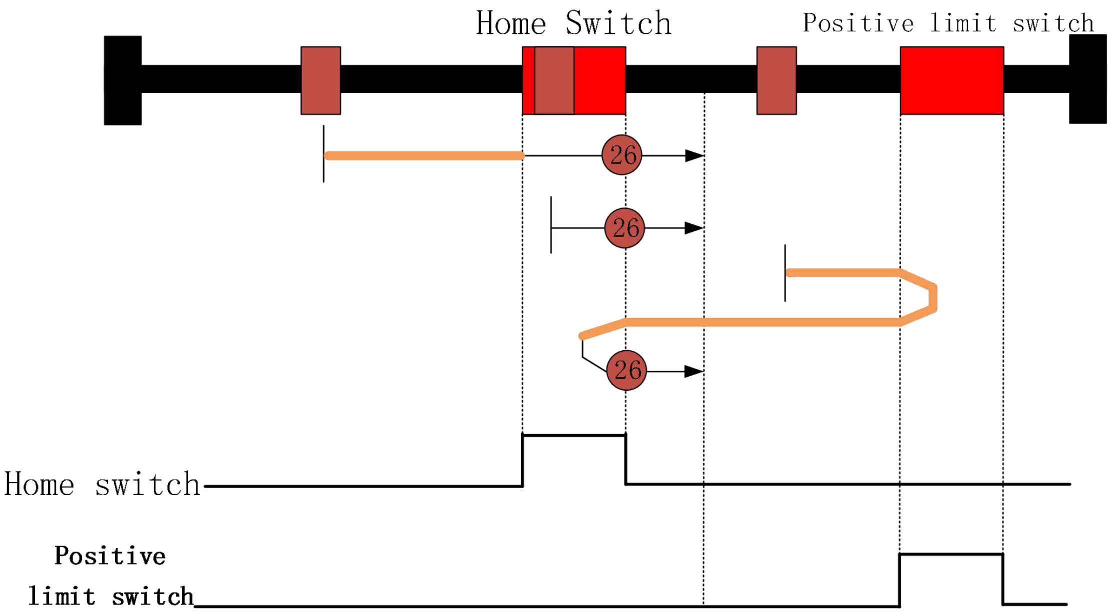


Figure 4-81 Method 26

- **When homing starts, if the home switch signal is low level,** the motor moves at a high speed (6099-01) in the positive direction.
  - ✓ After the home switch signal becomes high level, the motor decelerates to a low speed (6099-02) with the homing deceleration (609A), and keeps moving in the positive

direction at the low speed (6099-02). After the home switch signal becomes low level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

✓ After the positive limit switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the negative direction with the homing acceleration (609A) to accelerate to a high speed (6099-01), and keeps moving in the negative direction at the high speed. After the home switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the positive direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the positive direction at the low speed. After the home switch signal becomes low level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

- **When homing starts, if the home switch signal is high level,** the motor moves at a low speed (6099-02) in the positive direction. After the home switch signal becomes low level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

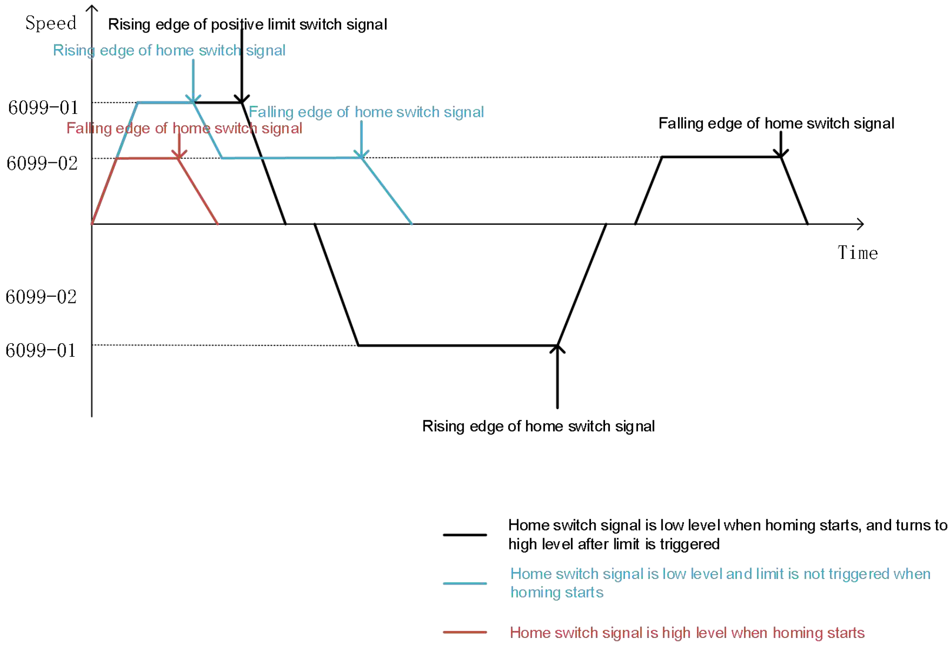


Figure 4-82 Speed-time curve of method 26

Method 27: Homing on positive home switch (falling edge)-negative limit switch detection

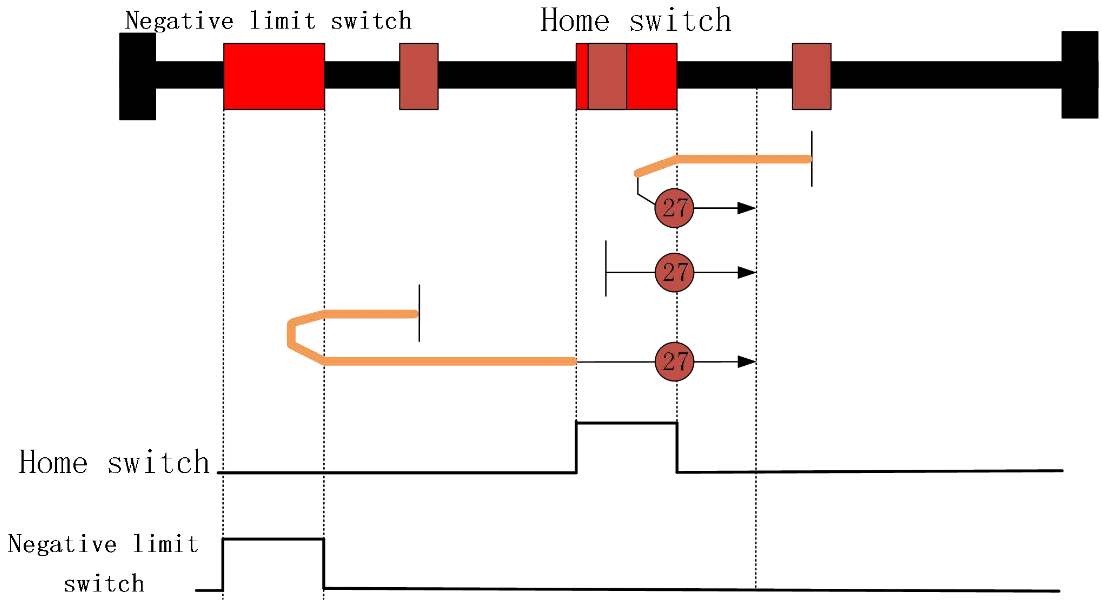


Figure 4-83 Method 27

- **When homing starts, if the home switch signal is low level,** the motor moves at a high speed (6099-01) in the negative direction.
  - ✓ After the home switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), moves in the positive direction with the homing acceleration to accelerate to a low speed (6099-02), and keeps moving in the positive direction at the low speed (6099-02). After the home switch signal becomes low level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
  - ✓ After the negative limit switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the positive direction with the homing acceleration (609A) to accelerate to a high speed (6099-01), and keeps moving in the positive direction at the high speed. After the home switch signal becomes high level, the motor moves in the positive direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the positive direction at the low speed. After the home switch signal becomes low level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
- **When homing starts, if the home switch signal is high level,** the motor moves at a low speed (6099-02) in the positive direction. After the home switch signal becomes low level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

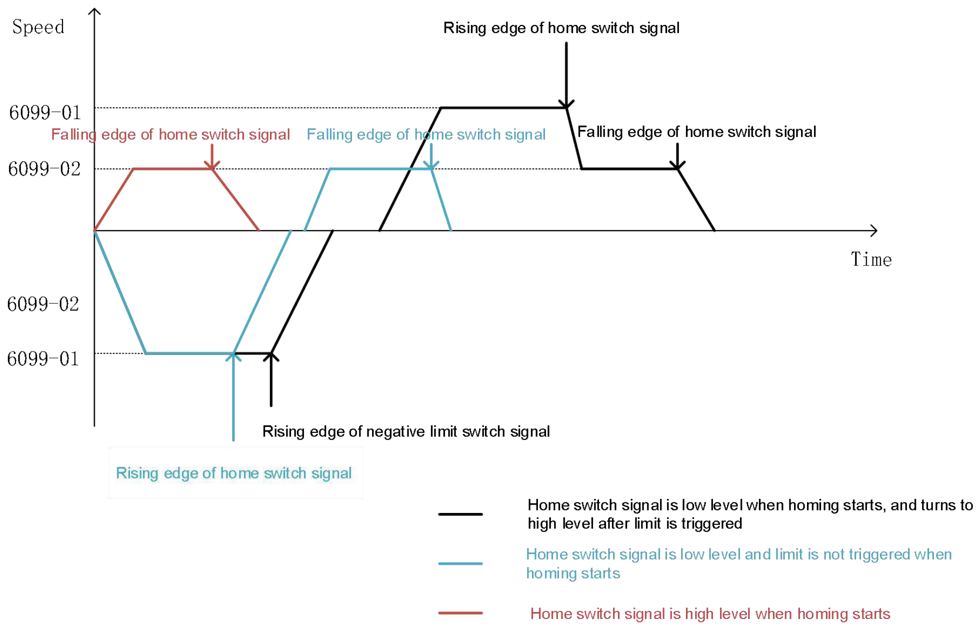


Figure 4-84 Speed-time curve of method 27

Method 28: Homing on negative home switch(rising edge)-negative limit switch detection

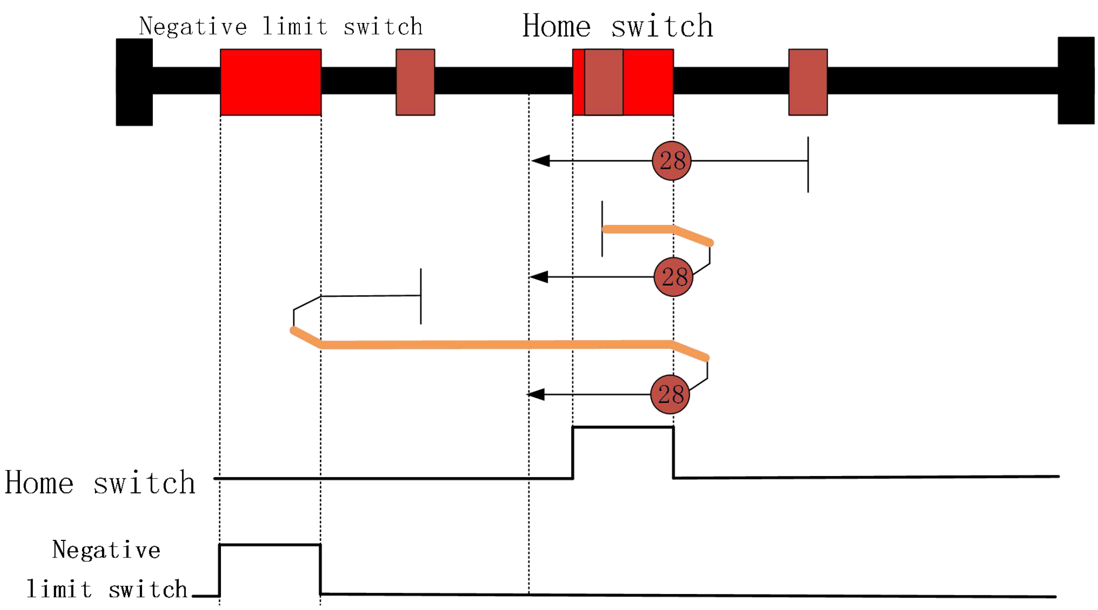


Figure 4-85 Method 28

- **When homing starts, if the home switch signal is low level,** the motor moves at a low speed (6099-02) in the negative direction.
  - ✓ After the home switch signal becomes high level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
  - ✓ After the negative limit switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the positive direction with the homing acceleration (609A) to accelerate to a high speed (6099-01), and keeps moving

in the positive direction at the high speed. After the home switch signal becomes low level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the negative direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the negative direction at the low speed. After the home switch signal becomes high level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

- **When homing starts, if the home switch signal is high level,** the motor moves at a high speed (6099-01) in the positive direction. After the home switch signal becomes low level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the negative direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the negative direction at the low speed. After the home switch signal becomes high level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

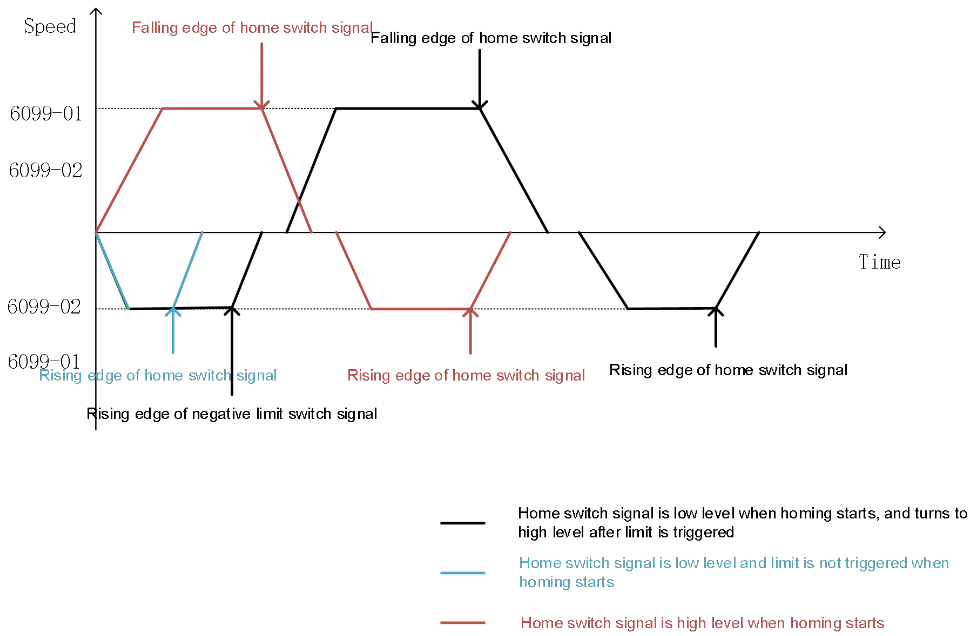


Figure 4-86 Speed-time curve of method 28

Method 29: Homing on positive home switch(rising edge)-negative limit switch detection

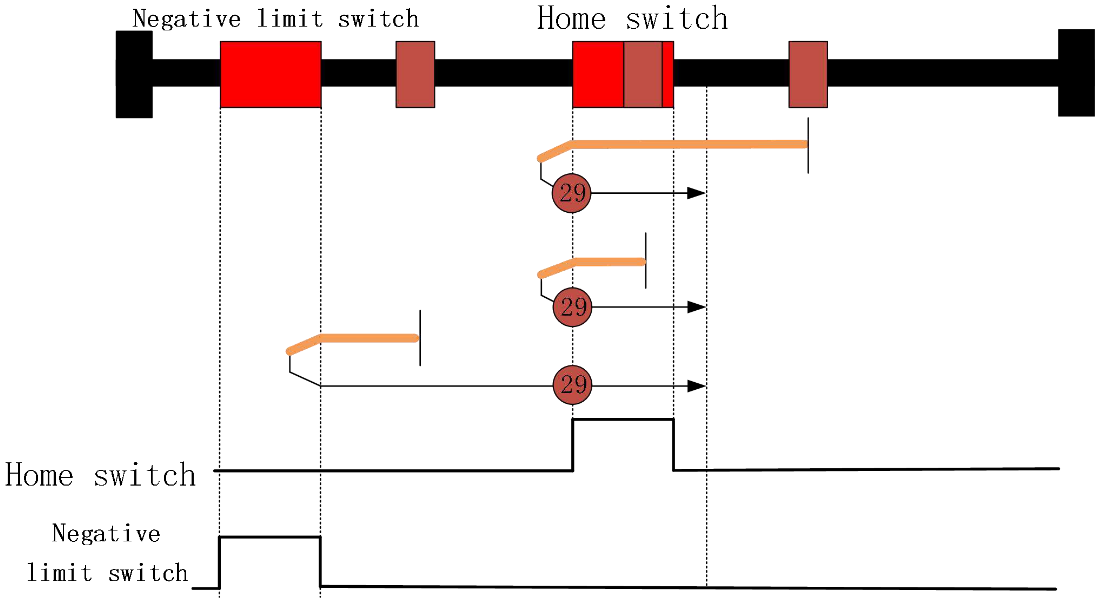


Figure 4-87 Method 29

Regardless of the high level or low level of the home switch signal, the motor moves in the negative direction.

When homing starts, the motor moves in the negative direction at a high speed (6099-01). After the home switch signal becomes low level or the negative limit switch becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the positive direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the positive direction at the low speed. After the home switch signal becomes high level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

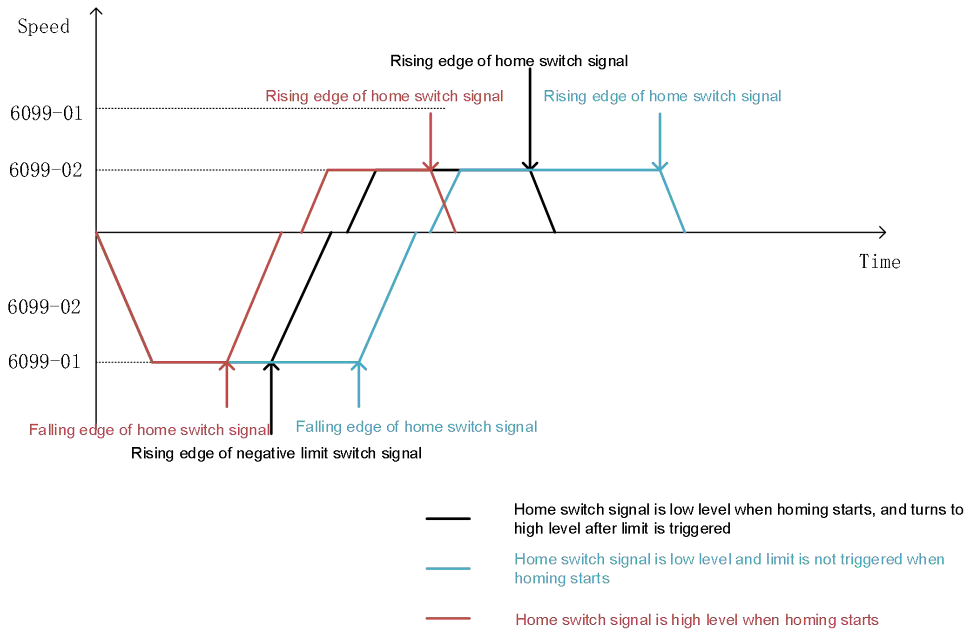


Figure 4-88 Speed-time curve of method 29

Method 30: Homing on negative home switch (falling edge)-negative limit switch detection

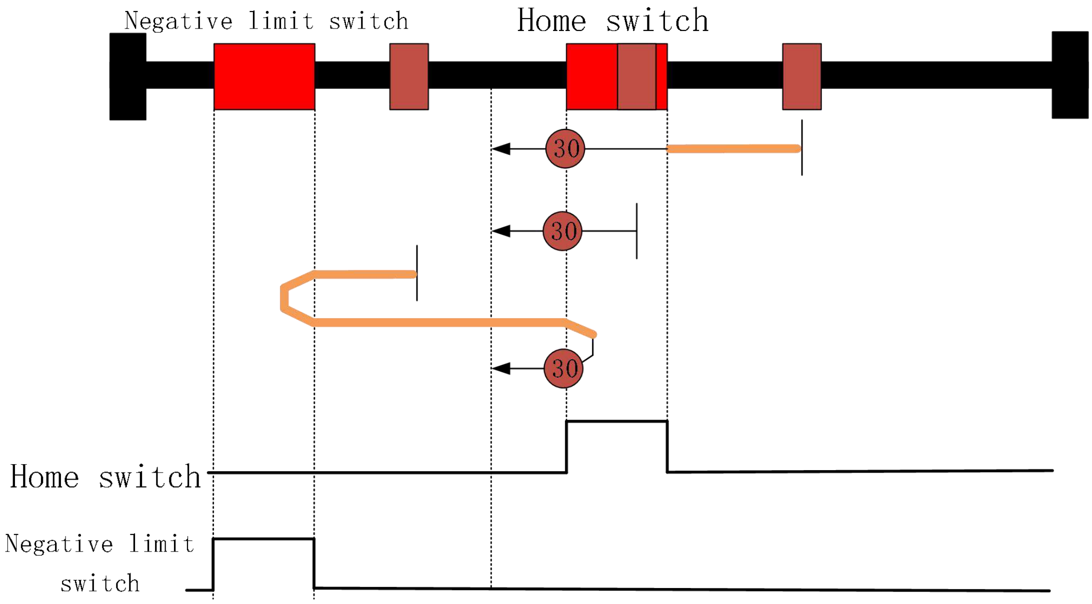


Figure 4-89 Method 30

- **When homing starts, if the home switch signal is low level,** the motor moves at a high speed (6099-01) in the negative direction.
  - ✓ After the home switch signal becomes high level, the motor moves with the homing deceleration (609A) to decelerate to a low speed (6099-02), and keeps moving in the negative direction at the high speed. After the home switch signal becomes low level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
  - ✓ After the negative limit switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the positive direction with the homing acceleration (609A) to accelerate to a high speed (6099-01), and keeps moving in the positive direction at the high speed. After the home switch signal becomes high level, the motor decelerates to 0 with the homing deceleration (609A), and moves in the negative direction with the homing acceleration (609A) to accelerate to a low speed (6099-02), and keeps moving in the negative direction at the low speed. After the home switch signal becomes low level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.
- **When homing starts, if the home switch signal is high level,** the motor moves at a low speed (6099-02) in the negative direction. After the home switch signal becomes low level, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

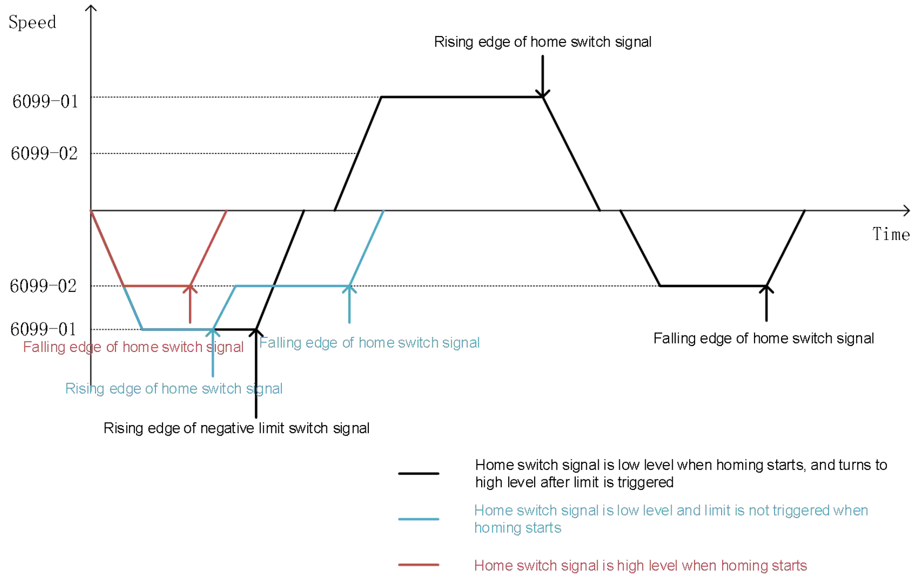


Figure 4-90 Speed-time curve of method 30

Method 31: Reserved

Method 32: Reserved

Method 33: Homing on index pulse in negative direction

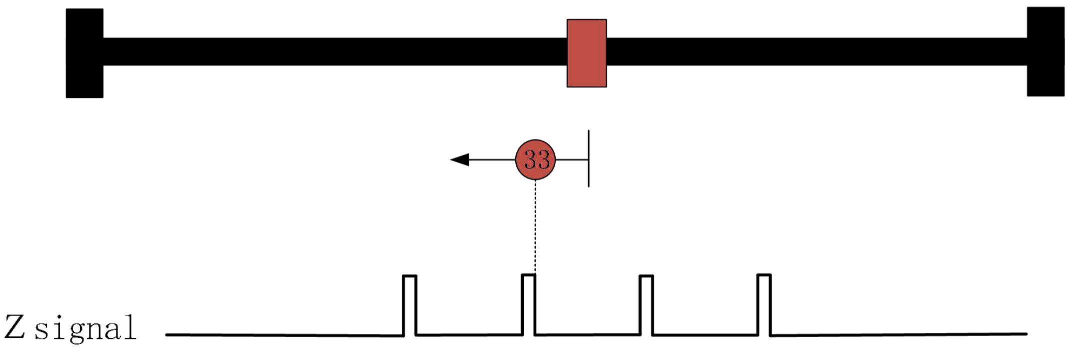


Figure 4-91 Method 33

When homing starts, the motor moves at a low speed (6099-02) in the negative direction. After the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

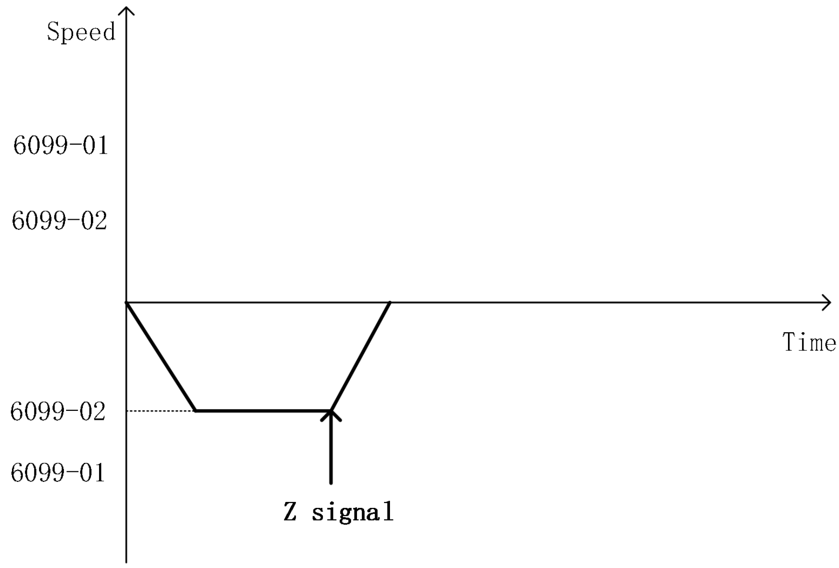


Figure 4-92 Speed-time curve of method 33

Method 34: Homing in index pulse in positive direction

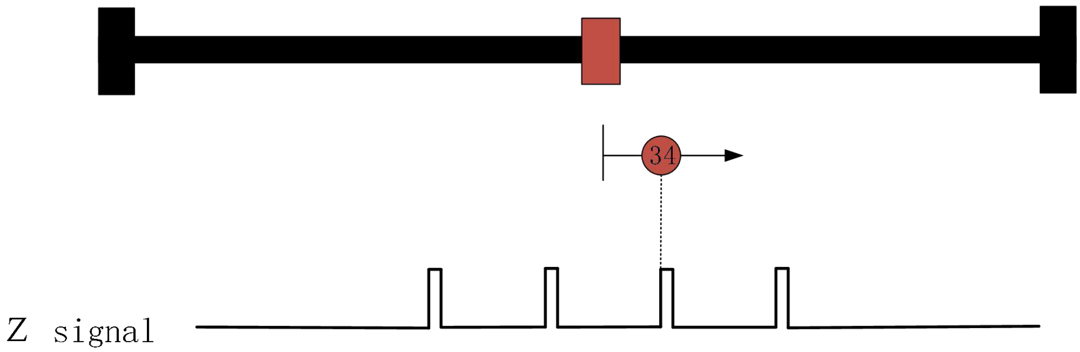


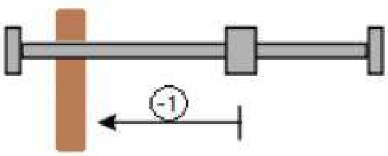
Figure 4-93 Method 34

When homing starts, the motor moves at a low speed (6099-02) in the positive direction. After the first Z signal shows, the status word Homing attained is set to 1, and the motor starts to decelerate with the homing deceleration (609A). The status word Target reached is set to 1 when the motor stops.

Method 35: Current position

In this method, the current position shall be taken to the home position.

Method -1: Guard position as home point in negative direction

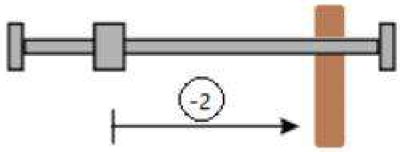


When homing starts, the motor moves in the negative direction, and the locked rotor torque reaches the set value of 0x2138 when the guard is touched. The motor stops after the time set by 0x2137:

- ✓ If the retraction distance is not set, the current position is set as the home point.

- ✓ If the retraction distance is set, the motor will retract the corresponding distance and set the current position as the home point.

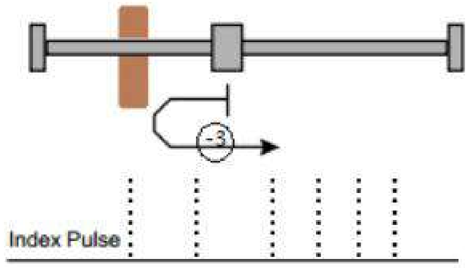
Method -2: Guard position as home point in positive direction



When homing starts, the motor moves in the positive direction, and the locked rotor torque reaches the set value of 0x2138 when the guard is touched. The motor stops after the time set by 0x2137:

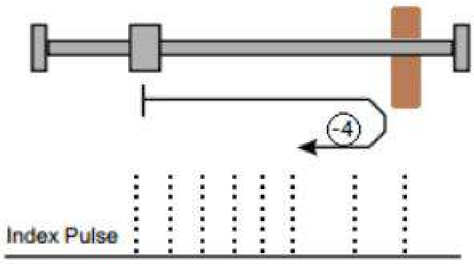
- ✓ If the retraction distance is not set, the current position is set as the home point.
- ✓ If the retraction distance is set, the motor will retract the corresponding distance and set the current position as the home point.

Method -3: C pulse as home point after guard is touched in negative direction



When homing starts, the motor moves in the negative direction, and the locked rotor torque reaches the set value of 0x2138 when the guard is touched. After the time set by 0x2137, the motor moves in the positive direction. The first C pulse is home point.

Method -4: C pulse as home point after guard is touched in positive direction



When homing starts, the motor moves in the positive direction, and the locked rotor torque reaches the set value of 0x2138 when the guard is touched. After the time set by 0x2137, the motor moves in the negative direction. The first C pulse is home point

4.5.4 Torque control Model

Click "**Motion Model**" in the module control area, click "**Torque Model**" to open the torque Model motion control interface, as shown in Figure 4-96.

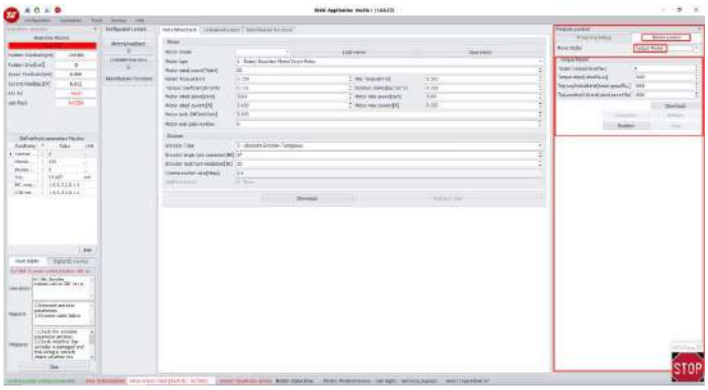


Figure 4-94 Torque Model motion control interface

Torque Model is generally used for servo loading, torque Model motion control steps are as follows：

①Configure torque Model motion parameters.

- Target torque: The amount of torque output by the motor. (The target torque unit is the rated torque in thousandths)
- Torque ramp: The acceleration at which the motor starts to output torque. (Torque ramp unit is rated torque in thousandths of a second)

②The ISMC installation process is as follows.

③Forward/reverse: forward, control the motor to move with positive given torque; reverse, control the motor to move with negative given torque.

4.6 Troubleshooting

If a fault alarm occurs in the Servo Drive during the Tuningprocess, please follow the fault description, possible causes of the fault, and troubleshooting methods displayed in the software of the host computer, as shown in Figure 4-98. After the fault is successfully investigated, click "Clear Alarm" in the toolbar, and the system will indicate that there is no fault before you can continue the commissioning.

Figure 4- 96 Fault display

Note: If you have questions during the tuning process, please contact the professional staff to provide technical support! Please do not modify the setting parameters at will, so as not to cause accidents to personnel and property safety!

Chapter 5 Troubleshooting

When a Diamond servo fails, the LED on the servo panel will flash red on a beat-by-beat basis.After connecting to the upper control software tool, a fault code based on the CiA402 standard will be displayed in the troubleshooting screen.

In case of servo alarm, please refer to the following table to check the servo and follow the corresponding strategy to solve the servo failure.

Table 5-1 Fault description

Error Code	Name	Cause	Solution
0x2230	Bus overcurrent	1. DC bus with excessive voltage. 2. Short circuit at periphery. 3. Encoder failure. 4. Internal components of the servo are damaged.	1. Check power supply and whether high inertia loads leads to rapid stop without dynamic braking. 2. Check whether the servo and the output wiring are short circuit, whether earthing is short circuit, and whether the braking resistor is short circuit. 3. Check whether the encoder is damaged or the wiring is correct; check whether the shielding layer of the encoder cable is well grounded, and whether there is strong interference near the cable.
0x2310	U-phase overcurrent	1. U-phase output is short circuit. 2. High load. 3. Cable insulation is damaged. 4. Poor motor insulation. 5. Failure of U-phase current detecting circuit.	1. Check U-phase wiring. 2. Lower the load. 3. Check U-phase cable and replace it if necessary. 4. Measure the motor insulation, repair and replace it if necessary; 5. Repair or replace the drive.
0x2311	V-phase overcurrent	1. V-phase output is short circuit; 2. High load. 3. Cable insulation is damaged. 4. Poor motor insulation. 5. Failure of V-phase current detecting circuit.	1. Check V-phase wiring. 2. Lower the load. 3. Check V-phase cable and replace it if necessary. 4. Measure the motor insulation, repair and replace it if necessary. 5. Repair or replace the drive.

Error Code	Name	Cause	Solution
0x2320	Hardware short circuit	1. DC bus with excessive voltage. 2. Short circuit at periphery. 3. Encoder failure. 4. Internal components of the servo are damaged.	1. Check power supply and whether high inertia loads leads to rapid stop without dynamic braking. 2. Check whether the servo and the output wiring are short circuit, whether earthing is short circuit, and whether the braking resistor is short circuit. 3. Check whether the encoder is damaged or the wiring is correct; check whether the shielding layer of the encoder cable is well grounded, and whether there is strong interference near the cable.
0x3220	Servo undervoltage	1. Low input voltage of the power circuit. 2. Poor insulation of DC bus. 3. High load. 4. Poor insulation of the driver cable. 5. Failure of DC bus undervoltage detecting circuit. 6. Basic power module failure.	1. Check the power circuit. 2. Check the DC bus insulation. 3. Lower the load. 4. Check the drive cable. 5. Repair or replace the drive. 6. Repair or replace the basic power module.
0x3210	Servo overvoltage	1. Insufficient capacity of brake circuit. 2. Insufficient capacity of braking resistor. 3. Basic power module failure	1. Reduce the start-stop frequency; increase the acceleration/deceleration time constant; lower the load inertia; increase the drive and motor capacity. 2. Increase the power of the braking resistor. 3. Repair or replace the basic power module;
0x4110	Ambient temperature overheating	1. High ambient temperature. 2. Abnormal cooling system. 3. Temperature detecting circuit failure.	1. Lower the ambient temperature and strengthen ventilation and heat dissipation. 2. Check the cooling fan speed and air volume. If they are abnormal, replace the fan with the same Model. 3. Check whether the servo cooling channel is blocked by foreign objects.
0x4120	Ambient temperature underheating	1. Low ambient temperature. 2. Temperature	1. Check whether the ambient temperature is too low; 2. Check the value of parameter minimum

Error Code	Name	Cause	Solution
		detecting circuit failure.	ambient temperature.
0x4310	Power module overheating	1. High ambient temperature. 2. Abnormal cooling system. 3. Temperature detecting circuit failure.	1. Lower the ambient temperature and strengthen ventilation and heat dissipation. 2. Check the cooling fan speed and air volume. If they are abnormal, replace the fan with the same Model. 3. Check whether the servo cooling channel is blocked by foreign objects.
0x8482	Exceed maximum speed	1. Motor run away. 2. Wrong encoder parameters. 3. Encoder failure 4. Instruction error 5. Load mutation	1. Check the phase sequence of the motor power cable. 2. Check the settings of encoder parameter. 3. Check whether the encoder is damaged or the wiring is correct; check whether the shielding layer of the encoder cable is well grounded, and whether there is strong interference near the cable. 4. Check the position / speed / torque command. 5. Check whether the load is mutated and related cause. 6. Correct the phase zero again. 7. Adjust PID parameters.
0x8483	Large speed tracking error	1. The encoder wiring is wrong or the connector is in poor contact. 2. The gain does not match. 3. Large external load fluctuations or interference.	1. Check the encoder wiring; 2. Adjust the servo gain again. 3. Increase anti-interference measures.
0x8611	Large position deviation	1. The encoder wiring is wrong or the connector is in poor contact. 2. The gain does not match. 3. Large external load fluctuations or interference.	1. Check the encoder wiring; 2. Adjust the servo gain again. 3. Increase anti-interference measures.
0x7380	Encoder	1. Wrong encoder	1. Check the settings of encoder parameters.

Error Code	Name	Cause	Solution
	connection error	parameters. 2. Encoder cable failure. 3. The encoder cable is not connected. 4. The internal components of the servo are damaged.	2. Check the line sequence of encoder cable. 3. Connect the encoder cable.
0x7383	Encoder multi-turn info error	Internal encoder error.	Power off and restart the servo. If the fault cannot be cleared, replace the encoder.
0x7385	Encoder count error	Internal encoder error.	Power off and restart the servo. If the fault cannot be cleared, replace the encoder.
0x7389	Encoder count overflow error	Internal encoder error.	Clear the encoder multi-turn value, power off and restart the servo. If the fault cannot be cleared, replace the encoder.
0x738A	Encoder communication CRC error	1. Wrong encoder parameters. 2. Encoder cable failure.	1. Check the settings of encoder parameters. 2. Check whether the encoder is damaged or the wiring is correct; check whether the shielding layer of the encoder cable is well grounded, and whether there is strong interference near the cable.
0x738B	Encoder delimiter error	Internal encoder error.	Power off and restart the servo. If the fault cannot be cleared, replace the encoder.
0x3221	PWM drive abnormal	PWM drive +15 V undervoltage.	Check whether the control power +24V is connected properly.
0x8612	Exceed position limit	Given position or actual position exceeds position limit.	1.Check the setting of limit position. 2.Check the settings of given position. 3.Check whether the limit switch is triggered.
0x7384	Encoder overheating	The working temperature of the encoder exceeds 95℃.	1. Test again after the motor has cooled down. 2. Improve the heat dissipation conditions and check whether the motor overheats during running. 3. Internal encoder error.
0x6280	Wrong profile value	There is a zero value in the set value of the profile track, which makes the planned track unsuccessful.	1. Make sure the set speed is not zero. 2. Make sure the set acceleration is not zero.

Error Code	Name	Cause	Solution
0x6281	Termination speed setting error	The termination speed is greater than the profile speed, which makes the planned track unsuccessful.	1. The set termination speed must be less than or equal to the profile speed.
0x6282	Termination speed setting error	The target position is too close to the current position to reach the termination speed.	1. Check whether the set termination speed is too large.
0x6283	Software limit setting error	When the minimum / maximum software limit is not set to 0, the minimum value is greater than or equal to the maximum value; or exceed the position limit.	1. Set the minimum value greater than the maximum when the minimum / maximum software limit is not set to 0. 2. Check whether the maximum value is too large. 3. Check whether the minimum value is too small.
0x6284	Wrong position limit	When the minimum / maximum position limit is not set to 0, the minimum value is greater than or equal to the maximum value.	1. Set the minimum value greater than the maximum when the minimum / maximum position limit is not set to 0.
0x6285	Wrong planned curve type	The set planned curve type is not supported.	1. Set the planned curve type to 0 (Linear ramp)
0x6286	Wrong planned curve type	The set planned curve type is not supported.	1. Set the planned curve type to 0 (Linear ramp) or 3 (Jerk-limited ramp).
0x6287	Wrong planned torque curve	The set planned torque type is not supported.	1. Set the planned torque curve type to 0 (Linear ramp).
0x6288	Wrong homing method	The limit switch was accidentally triggered.	1. Start homing again after setting a suitable homing method.
0x6289	Wrong homing method	The set homing method is not supported.	1. Start homing again after setting a suitable homing method.

Error Code	Name	Cause	Solution
0x628B	Homing process timed out	The zero point was not found during homing.	1.Check the lower limit switch or the origin switch. 2.Set a suitable homing method.
0x628C	Initial speed not zero when planning Jerk-limited ramp	When the planned curve type is Jerk-limited ramp, the initial speed is not zero.	1. Make sure the motor is still before enabling the curve planning of the Jerk-limited ramp.
0x6180	Execution time of planned curve less than 0	The settings of position, speed, or acceleration / deceleration are incorrect.	Reset position, speed, acceleration and deceleration.
0x6181	Stop speed greater than initial speed	Stop speed is not set to 0	Set stop speed to 0.
0x6182	Position, speed, acceleration and deceleration not set for continuous motion of multiple points	The position, speed, acceleration and deceleration are not set for continuous motion of multiple points	Reset the target position, speed, acceleration and deceleration.

Error Code	Name	Cause	Solution
0x6184	Internal state transition error in homing	Jump exception of the internal homing state.	Execute homing again.
0x7124	Motor overtheating	The motor temperature is detected by the external temperature sensor and then connected to the servo through the DI port, and its upper limit is determined by the external temperature sensor.	1. High load. 2. Lack of phase. 3. Fault related to motor machinery, including lack of lubricating grease, improper assembly of bearings and end caps, eccentricity of inner holes, etc.
0x3130	Lack of phase	UVW phases have open circuit.	Check the wiring of UVW phases.
0x8700	Sync error	Bus synchronization error.	Restart the servo.
0x738C	Hall error	Hall signal is disconnected.	Check the wring of Hall.
0x6551	Wrong target speed	The target speed is 0 in position control.	Check the value of 0x6081 and make sure it is not 0.
0x6552	Wrong acceleration and deceleration in position and velocity control	The track planning is unsuccessful when acceleration and deceleration is set to 0.	Make sure acceleration or deceleration is not 0.
0x6553	Wrong position track planning period	The position track planning is set to 0.	Make sure the set period is not 0.
0x7320	Z pulse repetition positioning	The difference of adjacent Z pulses exceeds 0x2001.	1. Check the scale installation or accuracy. 2. Check the Z pulse positioning deviation.

Error Code	Name	Cause	Solution
	position error		
0x8620	Failed to enable auto calibration	Failed to enable automatic calibration.	1. Check whether the motion control Model is 0. 2. Check whether the device is stuck, the frictional resistance increases or the load is abnormal, etc. 3. Check whether there is an open circuit or short circuit in the three-phase wiring. 4. Check whether the settings of 0x2105 and 0x2402 are proper. 5 Check whether the phase sequence of the UVW wiring and the setting of 0x2002 are correct. 6. Check the encoder wiring.
0x6542	Planned deceleration or quick stop deceleration in the position Model is 0	The planned deceleration or quick stop deceleration in the position Model is 0.	Check the deceleration or quick stop deceleration and make sure it is not 0.
0x6572	Planned deceleration or quick stop deceleration in the position Model is 0	The planned deceleration or quick stop deceleration in the position Model is 0.	Check the deceleration or quick stop deceleration and make sure it is not 0.
0x9100	DI external input alarm	DI external input condition triggers an alarm.	Check the external input conditions.
0x8900	I2T protection alarm	Exceed the I2T setting threshold	1. Adjust limiter protection peak current. 2. Adjust limiter protection peak current duration. Note: The alarm takes effect when 0x2017 bit1 is set to 1.
0x8901	Alarm of no calibration	Operation is enabled without performing angle identification.	Enable operation after If Hall is connected and angle identification is finished.
0xB010	Position feedback jitter during angle identification	Wrong encoder wiring. Abnormal load or external disturbance.	Check the encoder wiring. Check the load or external disturbance.
0xB020	Rotor not	Parameter settings	Set appropriate parameter values.

Error Code	Name	Cause	Solution
	moving during angle identification	such as current are incorrect. High load. The machine is stuck, or the wiring is wrong.	Check device, load and wiring.
0xB030	Large action of angle identification	Large setting of current. Fault, including device, load, wiring (phase sequence), etc.	Set appropriate parameter values. Check device, load and wiring (phase sequence).
0xB040	Angle identification timed out	Software exception	Check the upper computer software, M3 and C28. Check each parameter setting. Check device, load and wiring.
0xB102	Motor hardly rotates during phase sequence detection	Wrong encoder wiring. High load or friction. Problem with current loop configuration The commutation current ratio 1 is too small.	Check the encoder wiring. Increase commutation current ratio 1.
0xB104	Hall status feedback abnormal	Wrong wiring of Hall sensor. Wrong Hall Model.	Check the wring of Hall Sensor. Make sure 0x2103 is set to 0.

Chapter 6 tuning software ISMC

Stone Motion Control (IISMC) is a servo tuning software independently developed by our company. Through USB serial communication, you can configure and modify servo parameters, debug controller parameters, realize motion control, monitor system status in real time, diagnose faults, check error logs, and realize update and maintenance.
This chapter only focuses on software download and setup. For software operations, please refer to "***Servo tuning Software IISMC User Manual***".

6.1 Software Download

6.1.1 System Requirements

System environment requirements:

- Memory: 1 GB or more (1.5 GB or more for running on a virtual machine)
- Display: above 800x600
- System type: 32-bit or 64-bit Windows 7 / Windows 8 / Windows 10
- Processor: above 1.6 GHz

6.1.2 Software Installation

The setup process of ISMC is as follows:

1. Download the setup package from the official website.
2. Double click the .exe application file, and wait for the decompression. After decompression, the setup wizard pops up, as shown in Figure 6-1.

Figure 6-1 ISMC installation wizard

3. Click "**Next**". The agreement dialog box pops up, as shown in Figure 6-2.

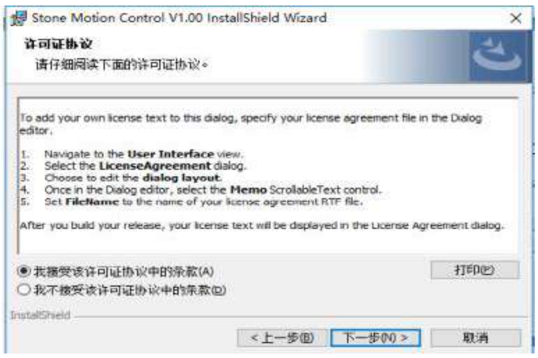


Figure 6- 2 Installation agreement

4. Select “**I Agree**”, click "**Next**" and enter the user information, as shown in Figure 6-3.

Figure 6-3 User information

5. Click "**Next**", and select the setup type, as shown in Figure 6-4.
   Generally, please use the default type.

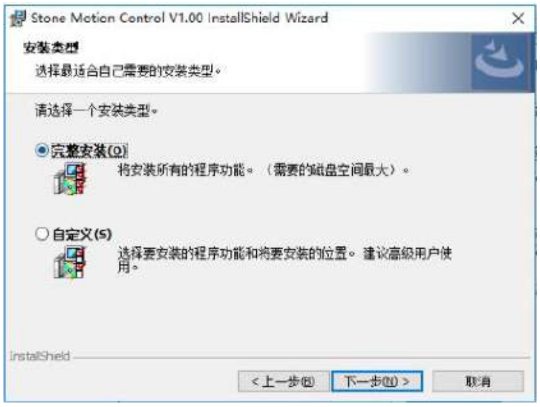


Figure 6-4 Setup type

6. Click “**Next**”, and click "**Finish**" after the setup is finished to exit the setup interface and complete the setup, as shown in Figure 6-5.

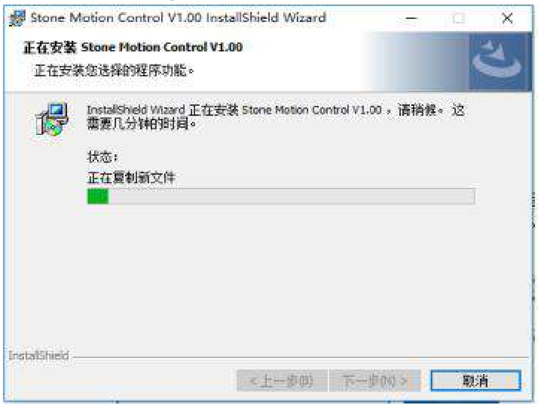


Figure 6-5 Installing

7. After setup, check the shortcut of ISMC software by accessing "**Desktop**" → "**Start**" →"**All Programs**" on your computer, as shown in Figure 6-6.

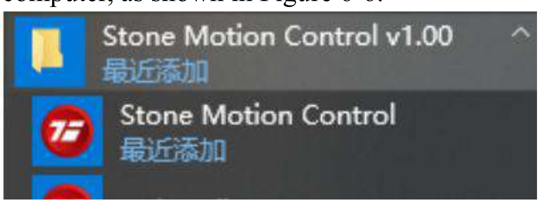


Figure 6-6 Start menu

6.2 Driver Installation

When using USB communication for the first time, you need to install the USB driver.

Note: The driver will be automatically installed on Windows 10 after connecting the USB data cable.

Taking Windows 7 as an example, the process of driver installation is as follows:

1. Connect the upper computer and the servo drive via the USB data cable. A prompt that the driver cannot be installed automatically, as shown in Figure 6-7.

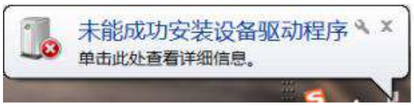


Figure 6-7 Failed to install the driver

2. Open the Windows main menu, and right click "**Computer**".

Figure 6-8 Windows main menu

3. To open the computer management, click "**Manage**":

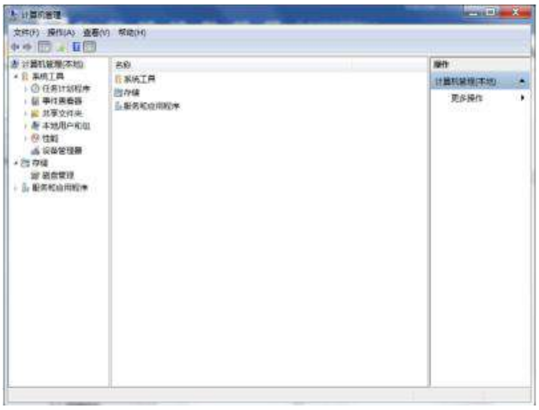


Figure 6-9 Computer management window

4. Select "**Device Manager**" → "**Others**", and find the unrecognized device **Virtual COM Port**.

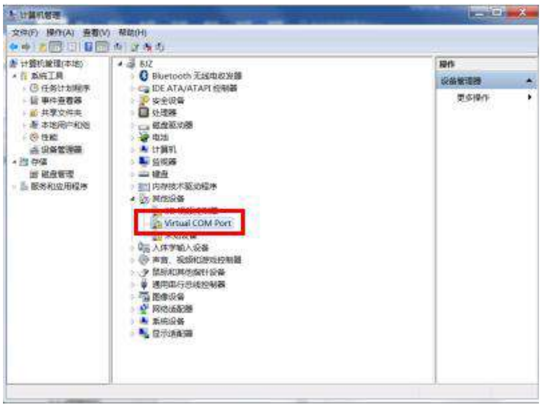


Figure 6-10 Device manager

5. Right click "**Virtual COM Port**", and select **"Update Driver Software**".

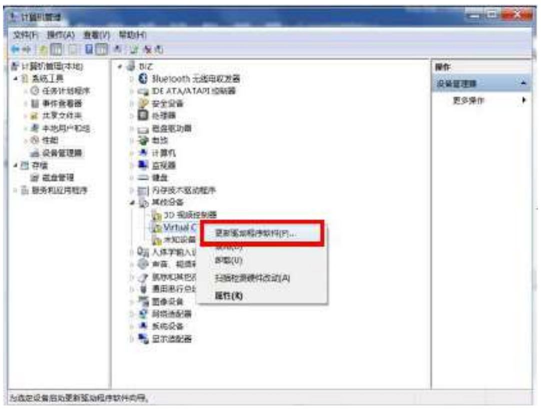


Figure 6-11 Update driver software

6. Select "**Browse my computer for driver software**".

Figure 6-12 Find driver software

7. Click **"Browse"**, find and select the driver folder "**windows_drivers**" in the ISMC installation directory.
   Default path: C:\Program Files(x86)\ISMC\Files\windows_drivers.

Figure 6-13 Browse the driver installation path

8. Click **"Next"** to start installation, and select "**Always install this driver software**" in the pop-up security warning window.

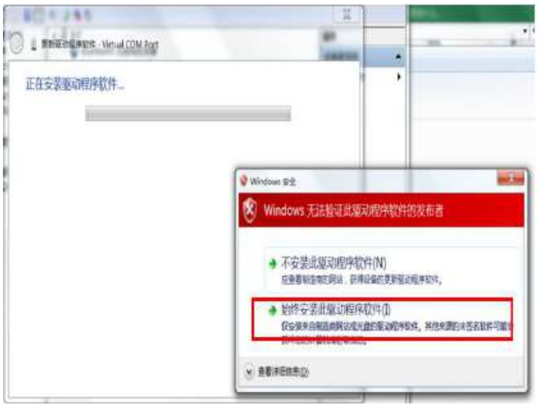


Figure 6-14 Security warning pop-up

9. Finish driver installation.

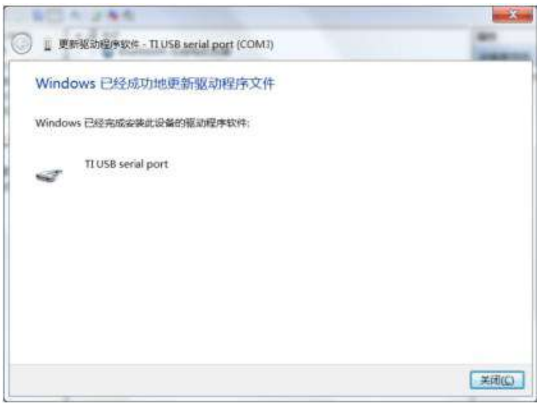


Figure 6-15 Finish driver installation

Note: If the driver fails to be installed successfully, please contact the technician.

6.3Firmware Upgrade

You can burn and upgrade the M3 and C28 files in the servo through ISMC.

The process of firmware upgrade is as follows:

1. Select **"Help"** in the main menu, and click **"Firmware Upgrade"** to open the firmware upgrade interface, as shown in Figure 6-16.

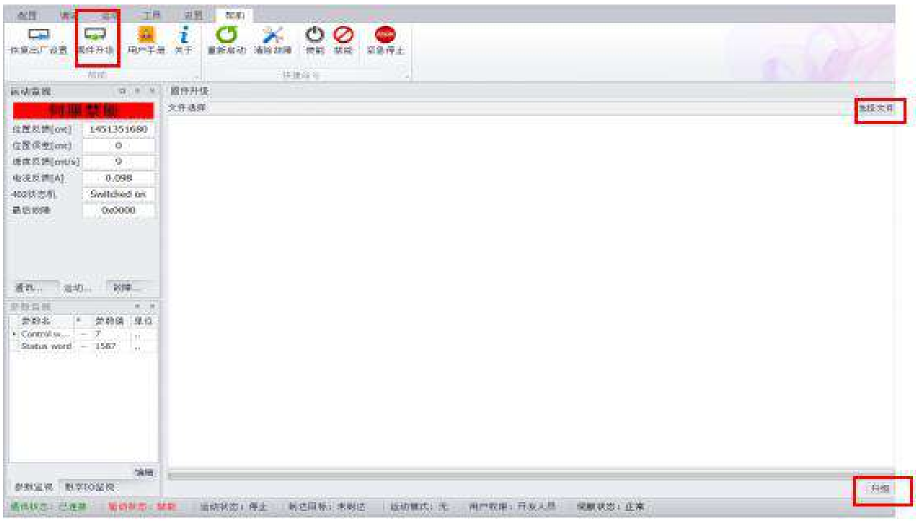


Figure 6-16 Firmware upgrade

2. Click **"Select File"** to open the folder and select the M3 or C28 file to be upgraded.
3. Click **"Upgrade"** to start upgrading. After the upgrade is successful, ISMC software and the servo are restarted.
4. After reconnecting, repeat the above steps to upgrade the next program until all programs are upgraded.

Note:

1. For firmware upgrade, please contact our technical team.
2. Servo DC+/DC- power supply is required when upgrading, and 24 V power supply is recommended.
3. The names of the upgraded files are fixed, i.e. C28-APP.bin and M3-APP.bin.

   For the first time, please flash M3-APP.bin first, and then flash C28-APP.bin.

Chapter 7 Communication Descriptions and Cases

The Stone servo drive supports both CANopen and EtherCAT. This chapter introduces the principles, usage and cases of these two communication Models. For details, please refer to "**User Manual of Stone Servo Drive (CANopen)**" and "**User Manual of Stone Servo Drive (EtherCAT)**".

7.1 CANopen Communication

7.1.1CANopen Protocol

CANopen is a high-level communication protocol and device profile specification that is based on the CAN (Controller Area Network) protocol, following the ISO/OSI standard Model. Different devices in the communication network exchange data with each other through the object dictionary, wherein the master node can access or modify the data in the object dictionary list of other nodes through process data object (PDO) or service data object (SDO).

Object Dictionary

The object dictionary is an ordered set of parameters and variables, including all parameters of the device description and device network status. A set of objects can be accessed through a network in an ordered and predefined manner.

The CANopen protocol uses an object dictionary, identified with a 16-bit index and an 8-bit subindex. The structure of the object dictionary is shown in Table 7-1.

Table 7-1 Object dictionary structure

Index	Object
0x0001-0x0FFF	Data type definition
0x1000-0x1029	Communication parameter object (such as CiA-301 protocol parameter)
0x1200-0x12FF	SDO object
0x1400-0x15FF	RPDO object
0x1600-0x17FF	RPDO mapping
0x1800-0x19FF	TPDO object
0x1A00-0x1BFF	TPDO mapping
0x1C00-0x1FFF	Other communication parameters
0x2000-0x5FFF	Manufacturer specific sub-protocol object
0x6000-0x9FFF	Standard device sub-protocol object (such as DSP-402 protocol parameter)
0xA000-0xFFFF	Reserved

7.1.2 CANopen Communication Object

Network Management (NMT)

The network management system (NMT) is responsible for initializing, starting and stopping the network and the devices in the network, and belongs to the master-slave system. There is only one NMT master in the CANopen network, which can configure the CANopen network including itauto. Network management objects include Boot-up messages, Heartbeat protocols and NMT messages. Based on the master-slave communication Model, NMT is used to manage and monitor each node in the network, mainly including node status control, error control and node startup.

1. NMT service

CANopen performs conversion according to the state machine specified by the protocol. Among them, some are internal automatic conversions, and some must be converted by NMT messages sent by the NMT master. Conversion by the state machine is as shown in Figure 2-2.

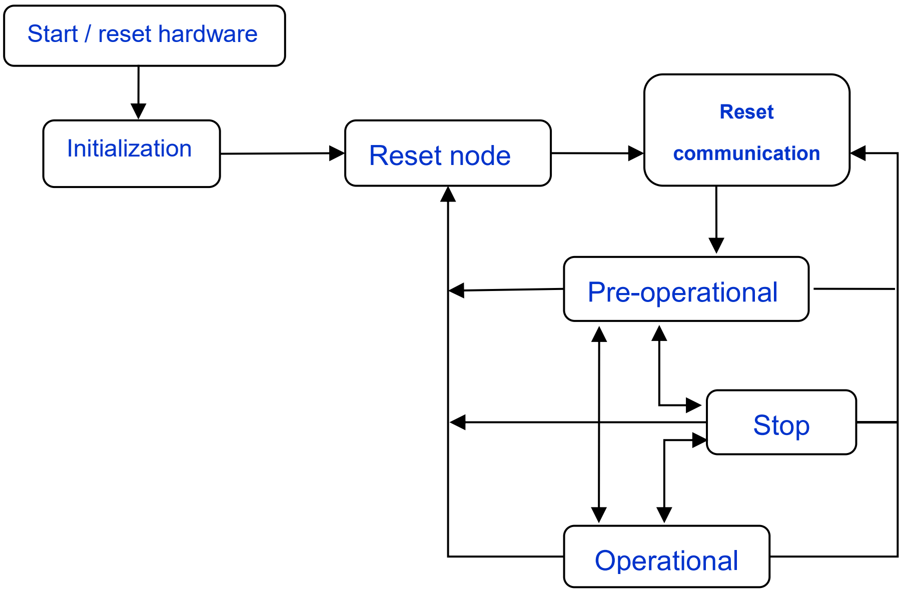


Figure 7-1 Working of NMT state machine

Part of the conversion in Figure 7-1 is achieved by NMT messages, and only the NMT master can send NMT messages. The message format is shown in Table 7-2.

Table 7-2 NMT module ControlNMT message format

COB-ID	RTR	Data/byte	
		0	1
0x000	0	Command word	Node_ID

COB-ID is fixed to "**0X000**".

The data consists of two bytes:

- Command word: indicating the control function of the frame, as shown in Table 7-3.
- CANopen node address: when Data1 is 0, this message is broadcast to all slaves in the network.

Table 7-3 Command word of NMT Module ControlNMT message

Command word	Jump state	Description
0X01	Pre-operational -> Operational	Start remote node
0X02	Operational/Pre-operational -> Stop	Stop remote node
0X80	Operational -> Pre-operational	Enter pre-operation state
0X81	Operational -> Reset node	Reset node
0X82	Operational -> Reset communication	Reset communication

After the device is powered on, it will automatically enter the initialization state, including the following:

- Initializing: During Initializing, the device starts up and initializes its internal parameters.
- Reset node: During Reset Application all parameters in the object dictionary range from 2000_h to $9FFF_h$ are set to the power-on or default values.
- Reset communication: the parameters of the communication profile (Index range $1xxx_h$) are set to their power-on/default values.

After the device initialization is finished, the device automatically transits to pre-operational state and indicates this transition by transferring the boot-up message. After the configuration, the node needs the NMT master to send NMT messages to enter the operational state in which each module should work normally.

When the NMT master sends a stop node message, the device enters the stopped state, and only the NMT module works normally in CANopen communication.

The CANopen services supported in various NMT states are shown in Table 7-4.

Table 7-4 Services supported by various NMT states

Serve	Pre-operational	Operational	stop
Process Data Object (PDO)	No	Yes	No
Service Data Object (SDO)	Yes	Yes	No
Synchronization Object (SYNC)	Yes	Yes	No
Emergency message (EMCY)	Yes	Yes	No
Network Management (NMT)	Yes	Yes	Yes
Error control	Yes	Yes	Yes

- **NMT error control protocols**

  Error control protocols enable the monitoring of a CANopen network. They comprise the Heartbeat-, Node-/Life-Guarding-, as well as the Boot-up protocol.

  a. Node-/Life guarding

  Node guarding is used to monitor the non-central peripheral modules, while they themselves can use Life Guarding to detect the failure of the guarding master. Guarding involves the master transferring remote frames (remote transmit requests) to the guarding identifier of the slaves that are to be monitored. These reply with the guarding message. This contains the slave's status code and a toggle bit that has to change after every message. If either the status or the toggle bit do not agree with that expected by the NMT master, or if there is no answer at all, the master assumes that there is a slave fault.

  The objects related to node-/life guarding are guard time 100Ch and live time factor 100Dh. 100Ch is the remote frame interval of node guarding (unit: ms). Object 100Ch multiplied by object 100Dh determines the latest time for master query. Generally, node guarding can be achieved. Lifetime guarding is activated when 100Ch and 100D are both non-zero and a node guarding request frame is received.

  The master station sends a node guarding remote frame every 100Ch. The slave station must respond, otherwise it assumes that the slave station has failed; If the slave fails to receive a message request from the master within the time of 100Ch X 100Dh, it assumes that the master station has failed.

  The format of remote frames is as shown in Table 7-5 below.

Table 7 - 5 Remote frame format

COB-ID	RTR
0x700+Node_ID	1

The response message returned by NMT node is a one-byte status word, as shown in Table 7-6 below.

Table 7-6 Response message

COB-ID	RTR	Data
0x700+Node_ID	0	status word

Bits of the status word are shown in Table 7-7 below.

Table 7-7 Bits of status word

Data bits	Description
bit7	It must be alternately set to "0" or "1" each time
Bit6 - bit0	4-Stopped state 5-Operational state 127 - Pre-operational state

b. Heartbeat protocol

With heatbeat messages, nodes can be configured as heartbeat producers or heartbeat consumers. The CANopen device can send heartbeat messages according to 1017h Producer heartbeat time (unit: ms). The node with the consumer heartbeat function in the network monitors the producer according to 1016h Consumer time. If a consumer does not see an expected heartbeat within its expected time, it signals an error.

After configuring 1017h Producer heartbeat time, the node heartbeat function is activated and starts to send heartbeat messages. After configuring 1016h Consumer heartbeat, the monitoring will start after receiving a frame of heartbeat sent by the corresponding node.

The master sends a heartbeat message according to the producer heartbeat time, and if the slave monitoring the master does not receive a heartbeat message within the consumer time, it assumes that the master has failed. The slave sends a heartbeat message every 1017h. If the master monitoring the salve does not receive a heartbeat message within the consumer time, it assumes that the slave has failed.

The format of the heartbeat message is shown in Table 7-8. The data segment has only one byte, the highest bit is fixed at 0, and the rest are the same as the node guarding response message.

Table 7-8 Heartbeat message format

COB-ID	RTR	Data
0x700+Node_ID	0	status word

Service Data Object (SDO)

It includes receiving SDO-SDO (Rx) and transferring SDO-SDO (Tx). Through indexes and sub-indexes, SDO enables access to all entries of a CANopen object dictionary. SDO is implemented through the CMS object of the multi-field in the CAL, allowing transmitting data of any length, and splitting it into several messages when the data is out of 4 bytes. This is a confirmed communication service that generates a reply for each message. SDO request and response messages always contain 8 bytes.

1. SDO transfer framework

   With an SDO, a peer-to-peer client-server communication between two CANopen devices can be established on the broadcast medium CAN. The owner of the accessed object dictionary acts as a SDO server. The device that accesses the object dictionary of the other device is the SDO client. Therefore, the data exchange between SDOs requires at least two CAN messages.

2. SDO transfer message

   SDO transfer is divided into transfer not greater than 4 bytes (expedited SDO transfer) and transfer greater than 4 bytes (segmented SDO transfer).

SDO transfer message consists of COB-ID and data segment, as shown in Table 7-9 below.

Table 7-9 Format of SDO transfer message

COB-ID	Data							
580h+Node_ID/ 600h+Node_ID	0	1	2	3	4	5	6	7
	command code	index		sub-index	data			

Among them, command code indicates the transfer type and transfer data length, index and sub-index indicate object position in the list, and data is the value of the object.

Expedited SDO transfer (write)

If there is 4 bytes or less than, the transfer can be expedited and all the data sent within the command or response message. Due to different read and write methods and data length, the transfer messages are different, as shown in Table 7-10.

Table 7-10 Format of expedited SDO transfer (write)

Transfer		COB-ID	0	1	2	3	4	5	6	7
Client		600h+Node_ID	23h	index		sub-index	data			
			27h				data			-
			2bh				data		-	-
			2fh				data	-	-	-
Server	Normal	580h+Node_ID	60h	index		Sub-index	-	-	-	-
	Abnormal		80h				abort code			

"-" indicates that there is data but it is not considered, it is recommended to write 0 when writing data, the same below.

Example:

The station number of the slave is 2, the write value of 60FFh-00 in expedited SDO transfer is 1000, that is 0x3E8, and the message sent by the master is as follows. (all in hexadecimal)

Table 7-11 Examples of message sent by the master

COB-ID	0	1	2	3	4	5	6	7
602	23	FF	60	00	E8	03	00	00

Table 7-12 Example of the message returned by the slave

COB-ID	0	1	2	3	4	5	6	7
582	60	FF	60	00	00	00	00	00

If the write data type does not match, the error code 0x06070010 will appear, and the message is as follows:

Table 7-13 Example of message when write data type mismatches

COB-ID	0	1	2	3	4	5	6	7
582	80	FF	60	00	10	00	07	06

Expedited SDO transfer (read)

If there is 4 bytes or less than, the transfer can be expedited and all the data sent within the command or response message. The expedited SDO transfer (read) is as shown in Table 7-10.

Table 7-14 SDO Format of expedited SDO transfer (read)

Transfer	COB-ID	0	1	2	3	4	5	6	7

Client		600h+Node_ID	40h	index	sub-index	-	-	-	-
Server	Normal	580h+Node_ID	43h	index	sub-index	data			
			47h			data			-
			4bh			data		-	-
			4fh			data	-	-	-
	Abnormal		80h			abort code			

Example:

The station number of the slave is 2, the read value of 6061h-00 in expedited SDO transfer is 3, that is 0x03, and the message sent by the master is as follows. (all in hexadecimal)

Table 7-15 Examples of message sent by the master

COB-ID	0	1	2	3	4	5	6	7
602	40	61	60	00	00	00	00	00

Table 7-1 6 Examples of message returned by the slave

COB-ID	0	1	2	3	4	5	6	7
582	4f	61	60	00	03	00	00	00

If the write data type does not match, the error code 0x05040001 will appear, and the message is as follows:

Table 7-17 Example of message when read data type mismatches

COB-ID	0	1	2	3	4	5	6	7
582	80	61	60	00	01	00	04	05

Segmented SDO transfer (read)

If more than 4 bytes of data is required to be transferred, a segmented transfer is used. Its message and initial transfer frame is the same with the expedited transfer.

Table 7-18 Format of initial transfer message

Transfer		**COB-ID**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Client		600h+Node_ID	40h	index		sub-index	-	-	-	-
Server	Normal	580h+Node_ID	41h	index		sub-index	Data length			
	Abnormal		80h				abort code			

The trigger bit (bit6) alternately sends 0 and 1 during transfer process. The format of the process message is shown in Table 7-19.

Table 7-19 Format of process message

Transfer		**COB-ID**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Client		600h+Node_ID	60h			-	-	-	-	-
Server	normal	580h+Node_ID	00h	Data length						
	abnormal		80h	index		sub-index	abort code			
Client		600h+Node_ID	70h	-	-	-	-	-	-	-
Server	normal	580h+Node_ID	10h	Data length						
	abnormal		80h	index		sub-index	abort code			

The end frame includes the end frame marker and the valid data length. Its format is shown in

Table 7-20.

Table 7-20 Format of end message

<table>
<tr><th colspan="2">Transfer</th><th>COB-ID</th><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th></tr>
<tr><td colspan="2">Client</td><td>600h+Node_ID</td><td>60h/0X70h</td><td colspan="2">index</td><td>sub-index</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td rowspan="8">Server</td><td rowspan="7">normal</td><td rowspan="8">580h+Node_ID</td><td>01h/11h</td><td colspan="7">data</td></tr>
<tr><td>03h/13h</td><td colspan="6">data</td><td></td></tr>
<tr><td>05h/15h</td><td colspan="5">data</td><td></td><td></td></tr>
<tr><td>07h/17h</td><td colspan="4">data</td><td></td><td></td><td></td></tr>
<tr><td>09h/19h</td><td colspan="3">data</td><td></td><td></td><td></td><td></td></tr>
<tr><td>0Bh/1Bh</td><td colspan="2">data</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>0Dh/1Dh</td><td>data</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>abnormal</td><td>80h</td><td colspan="2">index</td><td>sub-index</td><td></td><td></td><td></td><td></td></tr>
</table>

Process Data Object (PDO)

PDO includes receive PDO (RPDO) and transmit PDO (TPDO), which is used to transmit real-time data and is the most important data transmission method in CANopen. Data is passed from a creator to one or more receivers. Since PDO transmission does not require a response, and the PDO length can be less than 8 bytes, the transmission speed is fast. Each CANopen device contains 8 default PDO channels (4 transmit PDO channels and 4 receive PDO channels). PDO includes two transmission Models, synchronous and asynchronous, which are determined by PDO communication parameters. The content of the PDO message is predefined and determined by the PDO mapping parameters.

1. PDO object

According to the difference between receive and transmit, PDO can be divided into RPDO and TPDO. The final transmission method and content of PDO is determined by communication parameters and mapping parameters. The servo drive can use at most 4 groups of RxPDO and 4 groups of TxPDO to realize PDO transmission. The related object list is as shown in table 7-21.

Table 7-21 Format of PDO message

Name		COB-ID	Communication Object	Mapping Object
RxPDO	1	200h+Node_ID	1400h	1600h
	2	300h+Node_ID	1401h	1601h
	3	400h+Node_ID	1402h	1602h
	4	500h+Node_ID	1403h	1603h
TxPDO	1	180h+Node_ID	1800h	1A00h
	2	280h+Node_ID	1801h	1A01h
	3	380h+Node_ID	1802h	1A02h
	4	480h+Node_ID	1803h	1A03h

2. PDO communication parameters

CAN identifier

The CAN identifier (also known as COB-ID) includes control bit and identification data, and determines the CAN priority.

.COB-ID is located on sub-index 01 of communication parameters (RxPDO: 1400h~1403h and TxPDO: 1800h~1803h), and the highest bit determines whether the PDO is valid.

Transmission type

The transmission type is located on sub-index 02 of communication parameters (RxPDO: 1400h~1403h and TxPDO: 1800h~1803h), which determines which transmission method the PDO follows. Transmission Type represents different transmission types, and defines the method for triggering TxPDO transmitt or RxPDO receive, as shown in Table 7-22.

Table 7-22 PDO communication type

Communication Type	**Synchronous**		**Asynchronous**
	Cyclic	**Acyclic**	
0		√	
1~240	√		
241~253	-		
254, 255			√

- When the transmission type of TxPDO is 0, if the mapping data changes and a synchronization frame is received, TxPDO is transmitted.
- When the transmission type of TxPDO is 1~240, TxPDO is transmitted when a corresponding number of synchronization frames are received.
- When the transmission type of the TxPDO is 254 or 255, TxPDO is transmitted when the event timer is triggered.
- When the transmission type of RxPDO is 0~240, as long as one synchronization frame is received, the latest data of RxPDO is applied.
- When the transmission type of RxPDO is 254 or 255, the received data is directly applied.

Inhibit time

The inhibit time (unit: 100us) is set for TxPDO, which is located on sub-index 03 of communication parameters (1800h~1803h) to prevent the CAN network from being continuously occupied by PDO with lower priority. The transmission interval of the same TxPDO shall not be less than the inhibit time.

Event timer

For asynchronous TxPDO, an event timer is defined, which is located on sub-index 05 of communication parameters (1800h~1803h).

PDO mapping parameters

PDO mapping refers to mapping of the application objects (real time data) from the object directory to the process data objects, including index, sub-index and object length. The data length of each PDO can be up to 8 bytes, and one or more objects can be mapped at the same time. The sub-index 0 records the number of objects mapped by the PDO, and the sub-index 1~8 is the mapping content, as shown in table 7-23.

Table 7-23 PDO mapping parameters

Bit	31	......	16	15	......	8	7	......	0
Definition	index			sub-index			object length		

The index and sub-index jointly determine the position of the object in the object dictionary, and the object length indicates the specific bit length, expressed in hexadecimal.

Table 7-24 Relationship between object length and bit length

Object Length	Bit Length
08h	8 bits
10h	16 bit
20h	32 bit

SYNC Object

A synchronization (SYNC) object provides synchronous communication on a CANopen network. You can configure devices to transmit synchronous PDOs when these devices receive an SYNC message.

SYNC object is a special mechanism that controls the coordination and synchronization between transmit and receive of multiple nodes. Its transmission follows producer-consumer Model. An SYNC producer broadcasts SYNC messages in the network periodically and all other nodes in the CAN network can receive the synchronization frames as consumers without feedback. Only one synchronization generator is allowed in the same CAN network.

The relationship of synchronous PDOs and synchronization frame is as follows:

- For synchronous RxPDO, as long as the PDO is received, the received RxPDO will be applied at the next SYNC.
- For synchronous TxPDO, it can be divided into the following:
  - Cyclic synchronous: when the PDO transmission type is 1~240, and only when the SYNC specified by the transmission type is reached, no matter whether the data has changed or not, this TxPDO needs to be sent.
  - Acyclic synchronous: when the PDO transmission type is 0 and the content of the PDO mapping object changes, this TxPDO needs to be sent at the next SYNC.

Emergency (EMCY) Object Service

A CANopen device generates an emergency (EMCY) message when a device-internal error occurs. The EMCY message follows the producer-consumer Model. After it is sent, other nodes in the CAN network can choose to handle it.

When a node fails, regardless of whether the EMCY object is activated, the error registers and predefined error fields need to be updated. The format of the EMCY message is as follows:

Table 7-25 Format of EMCY message

COB-ID	0	1	2	3	4	5	6	7
80h+Node_ID	error code		error register	Reserved	auxiliary byte			

For the definition of error codes and auxiliary bytes, please refer to”.

CANopen frame COB-ID

CANopen 2.0A defines 11-bit CAN-ID, the first 4 bits equal a function code and the next 7 bits contain the node ID.

To facilitate the networking between devices on the bus, CANopen defines communication object identifier (COB-ID) according to CAN-ID: specifies the priority of the object during communication and the identification of the communication object. The COB-ID corresponds to the CAN-ID. The 11-bit COB-ID consists of two parts, which are 4-bit object function and 7-bit node ID.

Table 7 - 26 COB-ID and CAN-ID

10	9	8	7	6	5	4	3	2	1	0
Function Code				Node-ID						

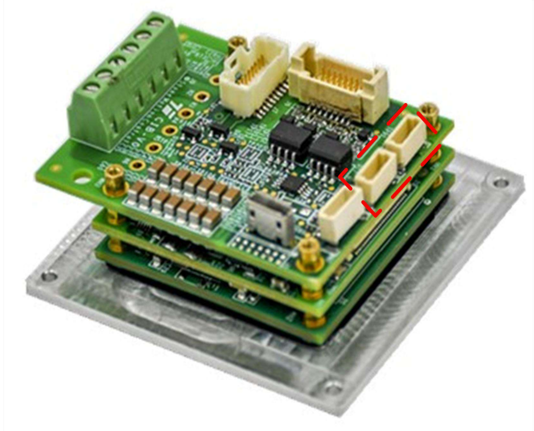
Each communication object of CANopen has a default COB-ID, to identify the devices and communication objects on the bus. The smaller the function code, the higher the priority of the communication object. The communication objects and their COB-IDs are shown in Table 7-27.

Table 7 - 27 Communication objects and their COB-IDs

Communication Object	COB-ID(hex)	Function Code	Related communication parameters in object dictionary
NMT Network Control (Broadcast)	000	0000b	-
Sync object (broadcast)	080	0001b	0x1005, 0x1006, 0x1007
EMCY object	080+Node-ID	0001b	0x1014, 0x1015
TPDO1	180+Node-ID	0011b	0x1800
RPDO1	200+Node-ID	0100b	0x1400
TPDO2	280+Node-ID	0101b	0x1801
RPDO2	300+Node-ID	0110b	0x1401
TPDO3	380+Node-ID	0111b	0x1802
RPDO3	400+Node-ID	1000b	0x1402
TPDO4	480+Node-ID	1001b	0x1803
RPDO4	500+Node-ID	1010b	0x1403
SDO(Tx)	580+Node-ID	1011b	0x1200
SDO(Rx)	600+Node-ID	1100b	0x1200
NMT Network Error Control	700+Node-ID	1110b	0x1016, 0x1017

7.1.3 CANopen usage

Communication Interface



Pin	Definition
1	NC
2	GND
3	CAN_L
4	CAN_H
5	PE

Figure 7-2 Definition of communication interface

Communication wiring

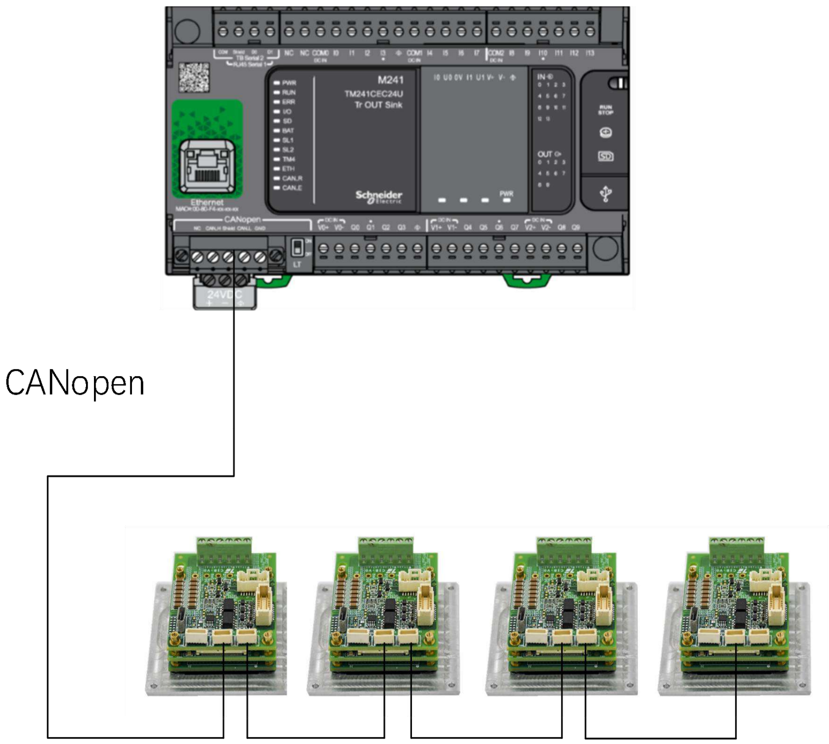


Figure 7-3 CANopen communication wiring

Software settings

The whole process to start communication is as follows:

1. In the upper computer software, import the EDS file.
2. Scan the Stone servo.
3. Set the communication parameters.

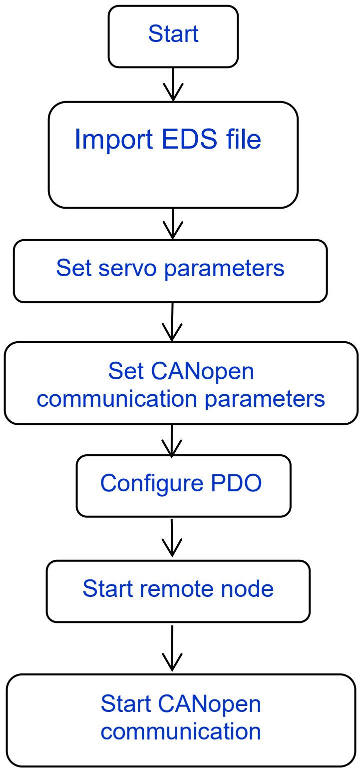


Figure 7-4 Software Settings

Before using the CANopen servo drive, please set the following parameters:

Note: The two parameters are effective after the servo restarts. After modifying them, please power on again or "restart" the servo in the ISMC software.

1. To set the baud rate of CAN communication, modify parameter 0x2004 CAN baud rate via the ISMC software.

   The baud rate of the master and slave must be same. Otherwise, communication fails.

   The relationship between the value of baud rate and the length of the bus communication cable is as shown in Tables 7-28.

Table 7-28 Relationship between baud rate and communication cable length

Baud Rate (bit/s)	Communication Cable Length (m)
1000000	25
500000	100
250000	250
125000	500
50000	1000
20000	1000

2. To set communication node ID of each slave, modify parameter 0x2401 Node ID via the ISMC software.

   The node ID of each servo slave cannot be the same with CNC or PLC of the master. And the node ID of each servo slave cannot be the same as well.

7.1.4Communication with Schneider PLC

1. **Connect hardware and check configuration**

   Refer to 7.1.2 and complete the hardware and basic configuration between the servo and PLC.

2. **Create a project**

   a. Run Schneider SoMachine software, and create a new blank project named test_CAN. The following takes software version 4.3 as an example:

Figure 7-5 Run SoMachine software

   b. Double-click "**Delete and Add Devices**" to add the master, and click "OK". Here takes deviceTM241CEC2U as an example:

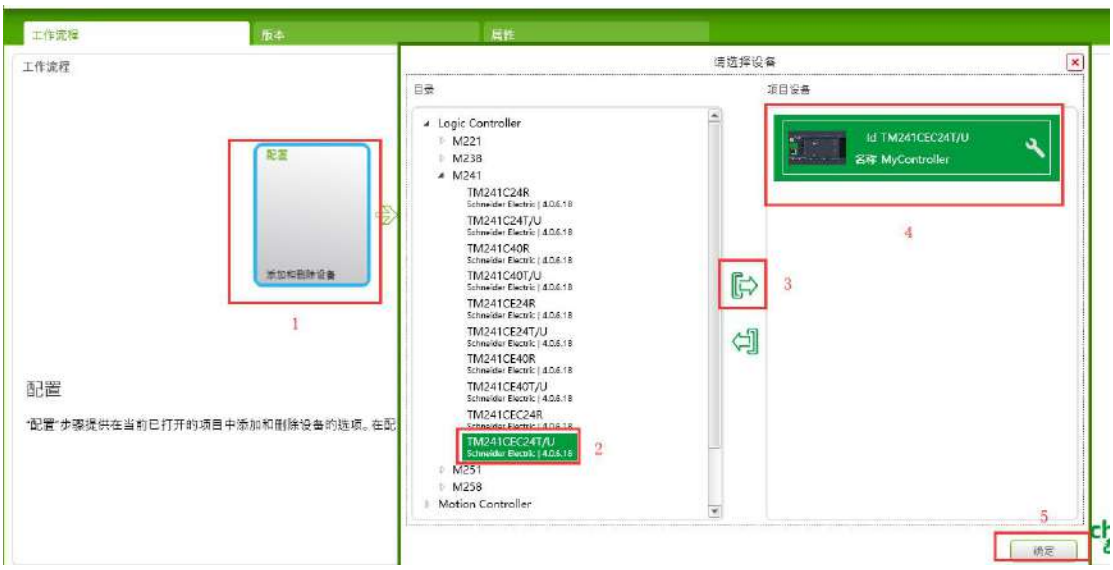


Figure 7-6 Add a master in SoMachine

c. Double click “**Controller**”, and add the app design:

Figure 7-7 Create a project in SoMachine

3. Import the EDS file of the slave

a. In the menu bar, click “**Tool**” --> “**Device Library**”.

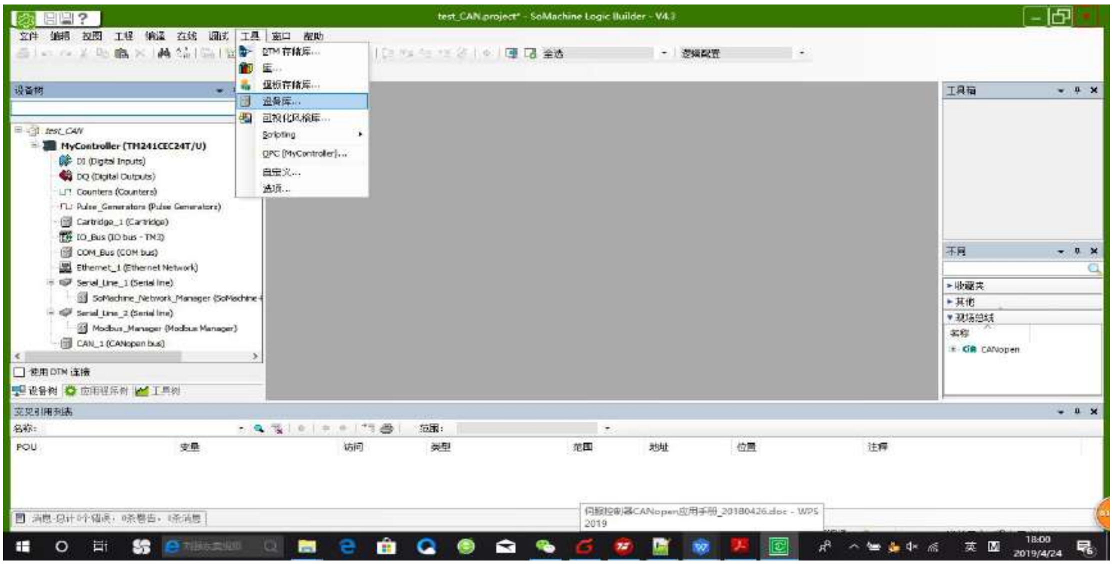


Figure 7-8 Open Device Library in SoMachine

b. Click “**Install**”, select the EDS file "**Stone.eds**" in the target path, and click “**Open**”.

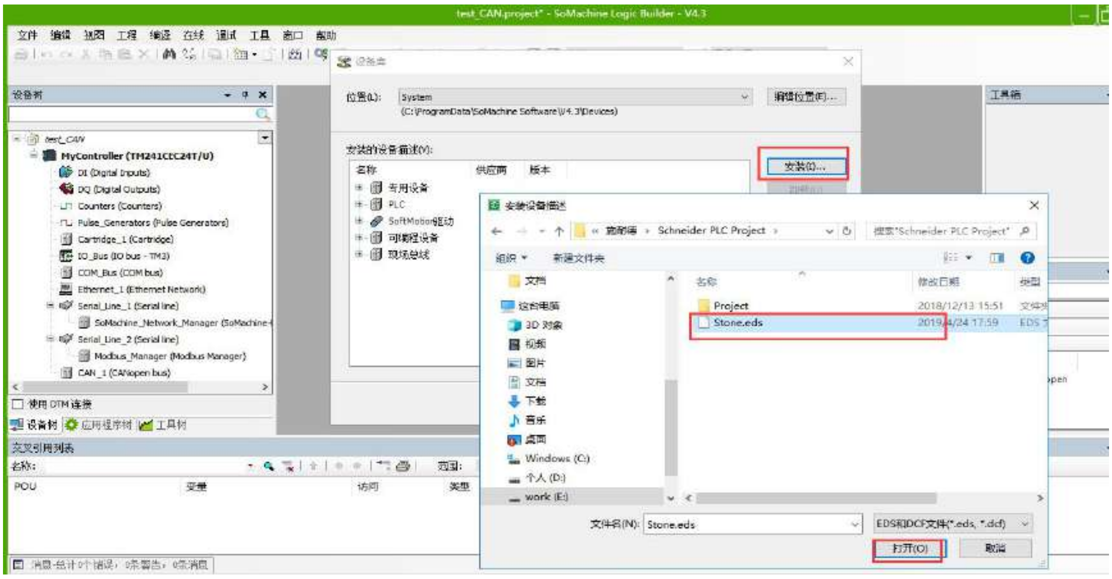


Figure 7-9 Import EDS file into SoMachine

4. Add CANopen gateway and slave

a. To add a device, click "+" under the device tree "**CANopen bus**", select "**Schneider Electric**" as the supplier, select "**CANopen Performance**", and click "**Add**".

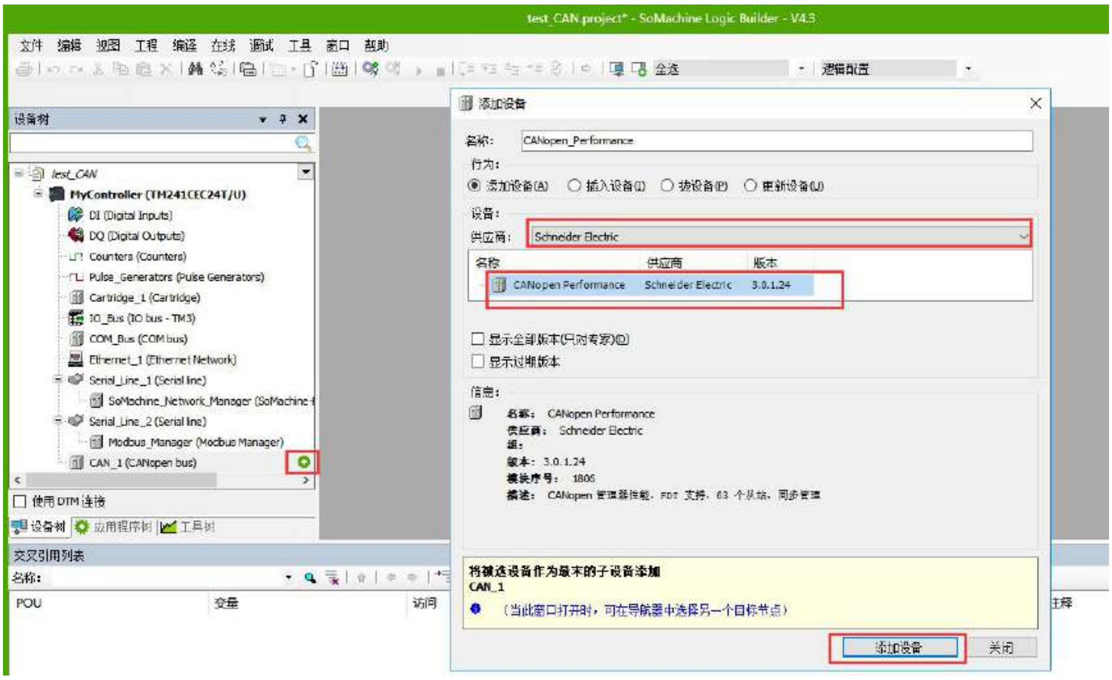


Figure 7-10 Add CANopen to SoMachine

b. Right click "**CANopen_Performance**" to add a slave, select "**Stone Motion Control**" as the supplier and "**Diamond Plus**" as the device name.

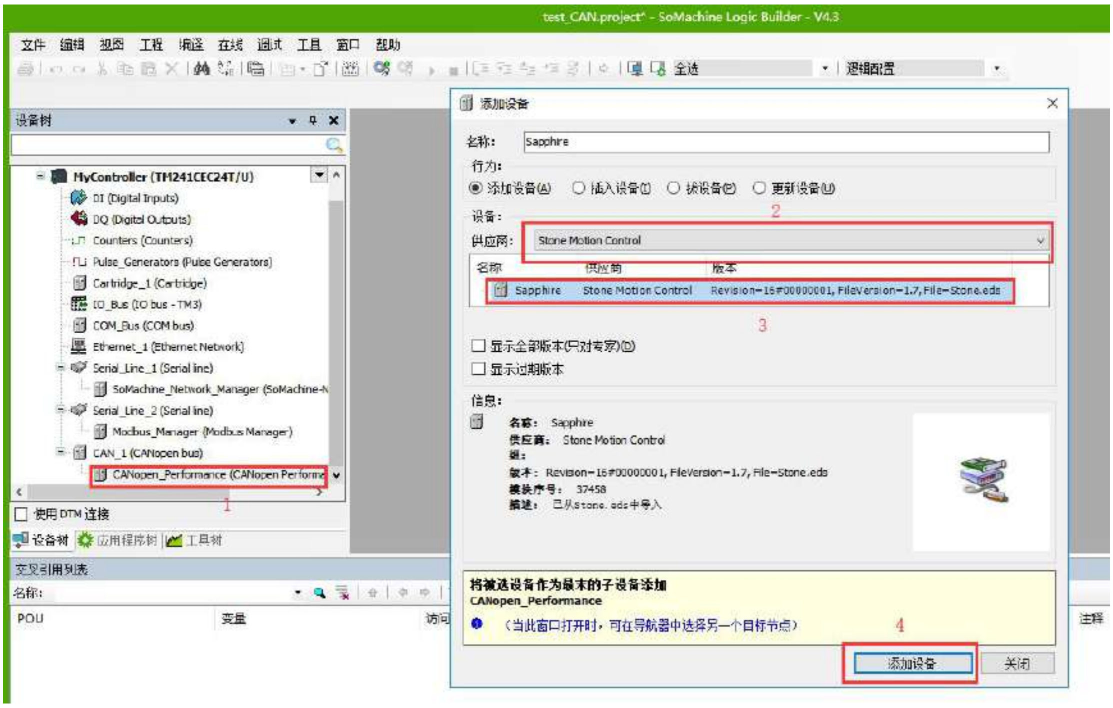


Figure 7-11 Add CANopen slave to SoMachine

5. Configure CANopen for master and slave

a. Set the CAN baud rate of the master to 1 M/s.

The default baud rate of the servo is 1 M/s.

You can also change the value according to requirements. But please make sure that the baud rate of the servo is the same as that of the master.

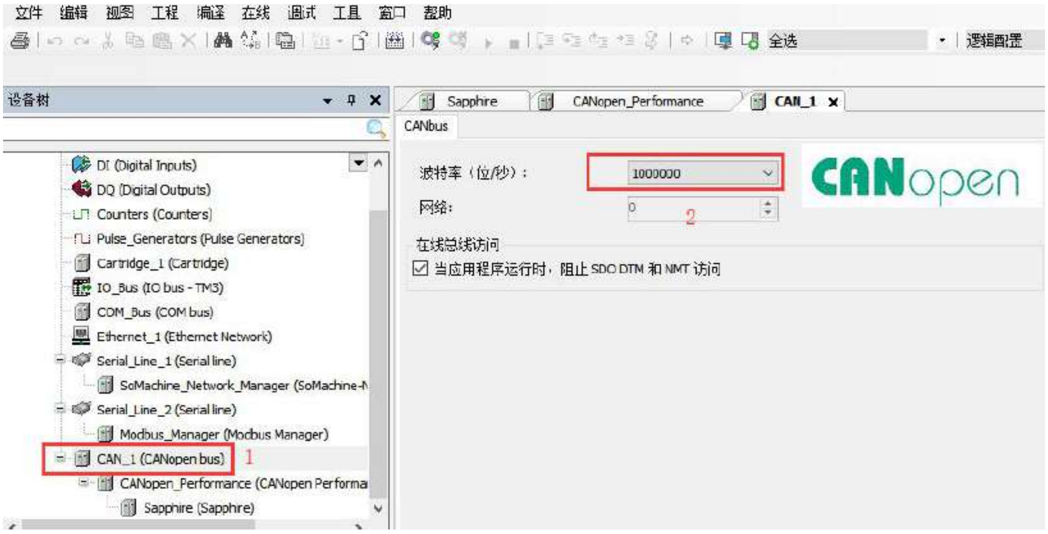


Figure 7-12 Set baud rate of master in SoMachine

b. Set the node ID of the slave to 1

The default node ID of the servo to 1.

You can also change the value according to requirements. But please make sure that the node ID of the servo is the same as that of the master.

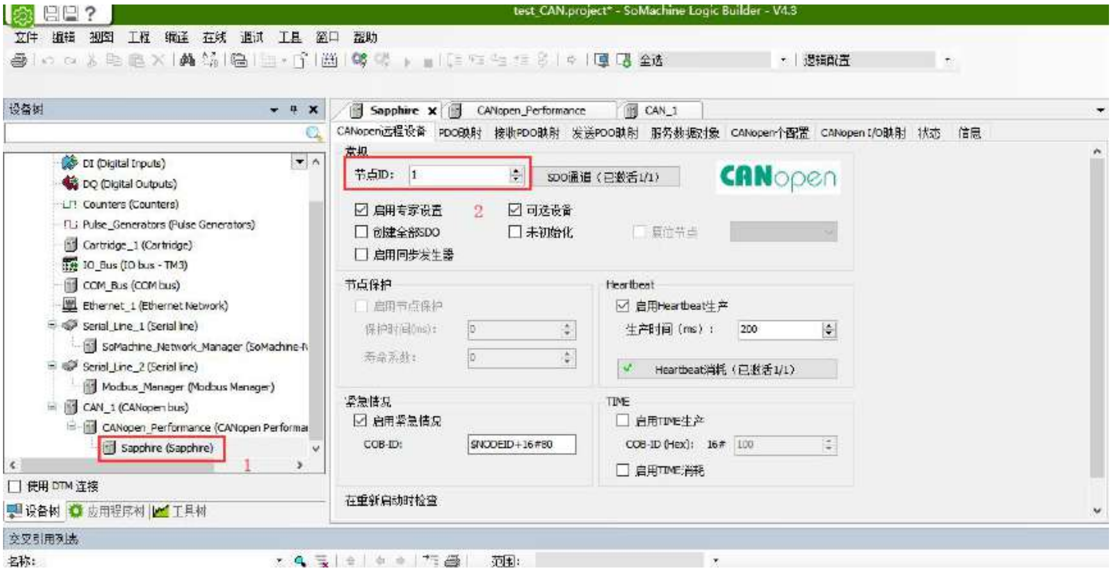


Figure 7-13 Set node ID of slave in SoMachine

c. To set the baud rate of CAN communication, modify parameter 0x2004 CAN baud rate via the ISMC software.

The baud rate of the master and slave must be same. Otherwise, communication fails.

The relationship between the value of baud rate and the length of the bus communication cable is as shown in Tables 7-29.

Table 7-29 Relationship between baud rate and communication cable length

Baud rate (bit/s)	Communication cable length (m)
1000000	25
500000	100

250000	250
125000	500
50000	1000
20000	1000

d. To set communication node ID of each slave, modify parameter 0x2401 Node ID via the ISMC software.

The node ID of each servo slave cannot be the same with CNC or PLC of the master. And the node ID of each servo slave cannot be the same as well.

Note: 0x2004 and 0x2401 are effective after the servo restarts. After modifying them, please power on again or "restart" the servo in the ISMC software.

6. Configure PDO mapping and SDO

Here takes position Model as an example, for details, please refer to "Stone Servo Drive CANopen Application Manual". In the position Model, PDO configuration is as follows.

Table 7-30 PDO configuration in position Model

PDO	Object	Meaning	Bit length
RPDO1	6040h-00h	Control word	16
	6060h-00h	Control Model	8
	607Ah-00h	Target position	32
RPDO2	6081h-00h	Planned speed	32
TPDO1	6041h-00h	Status word	16
	6061h-00h	Control Model display	8
	6064h-00h	Position feedback	32
TPDO2	606Ch-00h	Velocity feedback	32
	6078h-00h	Current feedback	16

a. Add PDO mapping:

Start expert setup, configure PDO mapping, and select 2 groups to receive PDOs, and 2 groups to send PDOs.

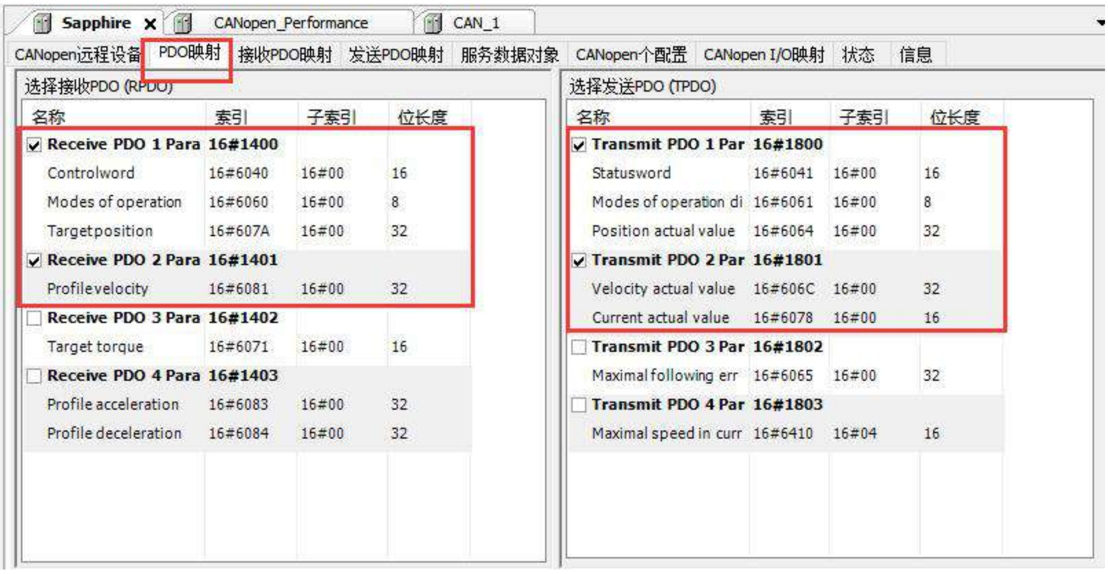


Figure 7-14 Add RPDO and TPDO mapping

When the default RPDO and TPDO do not contain a control word, please separately add PDO mapping as follows:

1) Set mapping parameters for receiving PDO1 and PDO2 as follows, and set the transmission type to 255 Asynchronous Model.

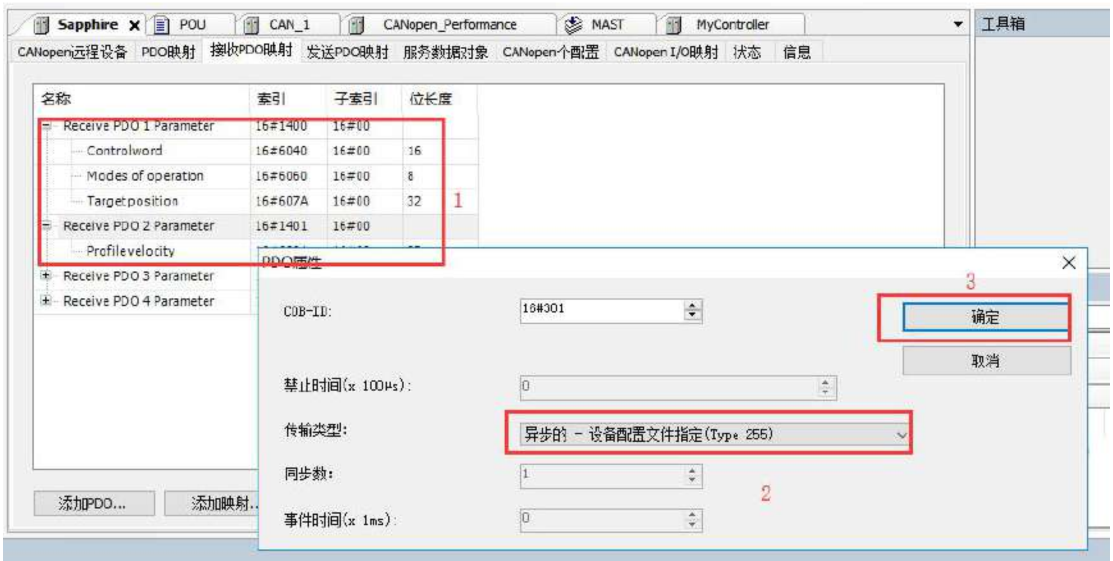


Figure 7-15 Add RPDO mapping

2) Set mapping parameters for transferring PDO1 and PDO2 as follows, and set the transmission type to 255 asynchronous Model.

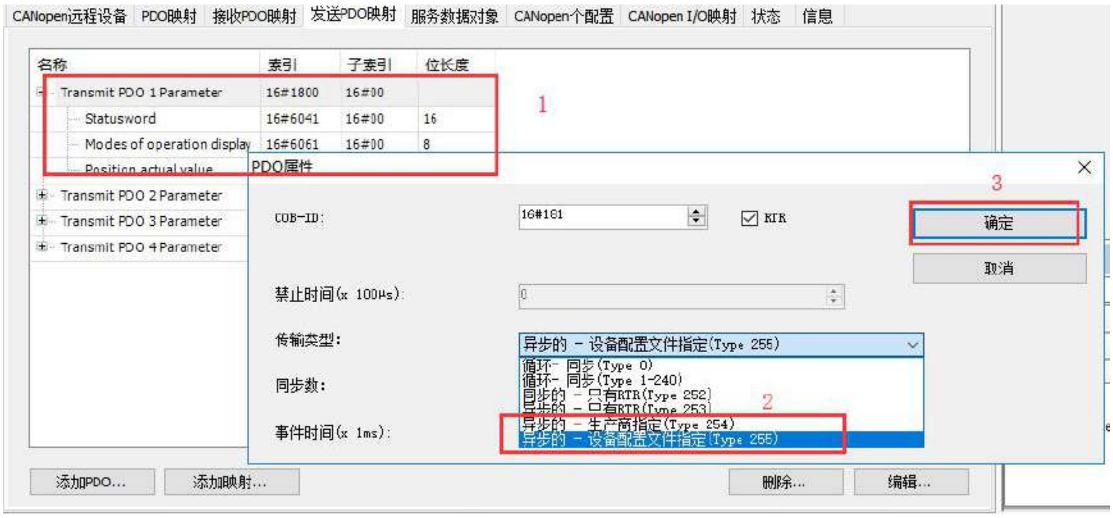


Figure 7-16 Add TPDO mapping

b. Configure SDO data: use SDO to configure acceleration 6083h and deceleration in position Model.

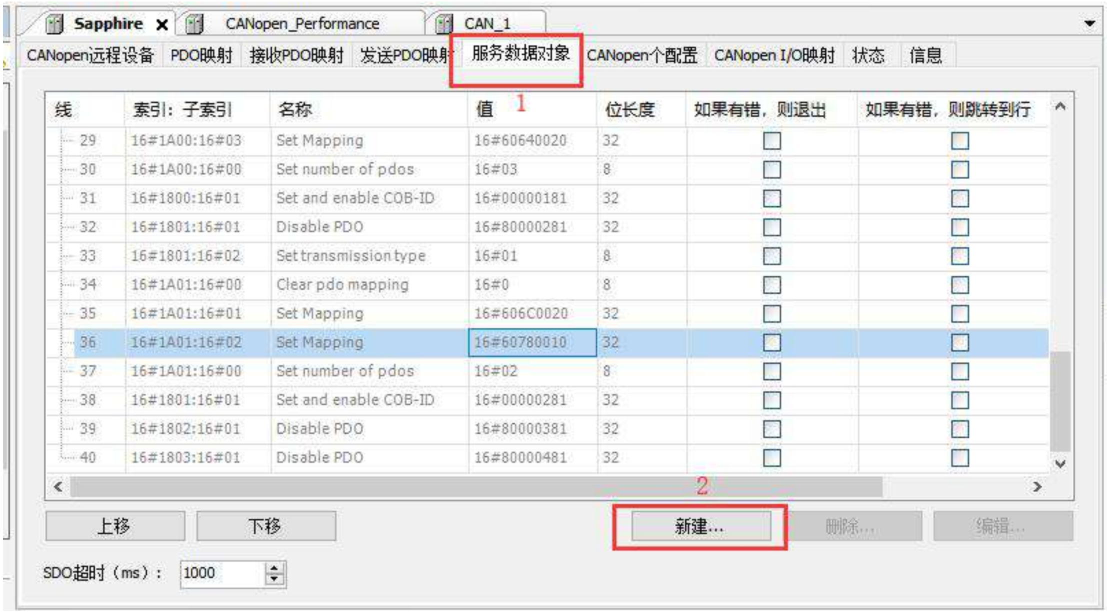


Figure 7-17 Add SDO (1)

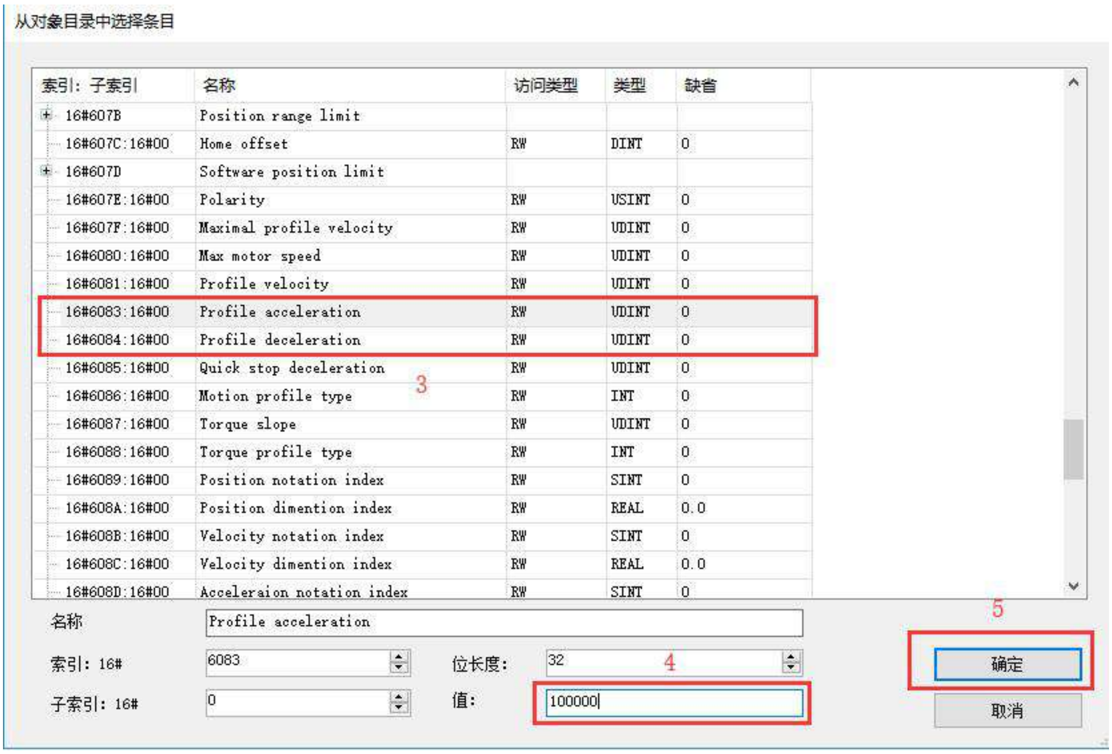


Figure 7-18 Add SDO (2)

7. Create a POU program

a. Under the application device tree, select "**Application**", add a POU program, select the program language, and click "**Add**".

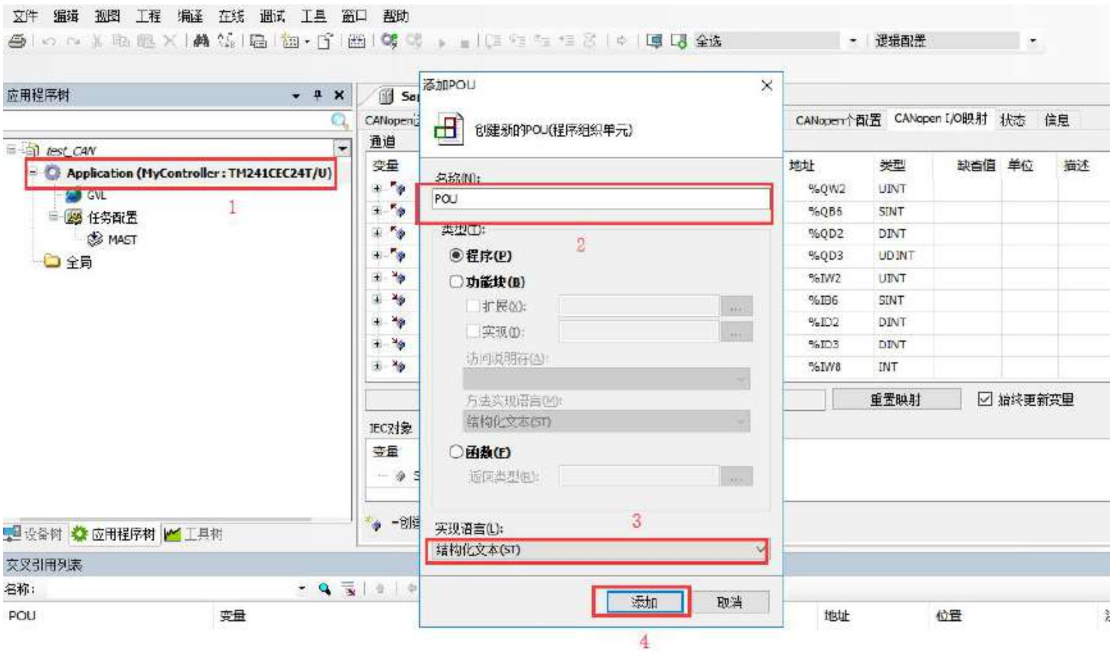


Figure 7-19 Create a POU

b. Double click "**POU**", define the variable in area 2, write the logic program in 3 area, click "**Compile**", confirm that there is no error, and proceed to the next step, as shown in Figure 7-20.

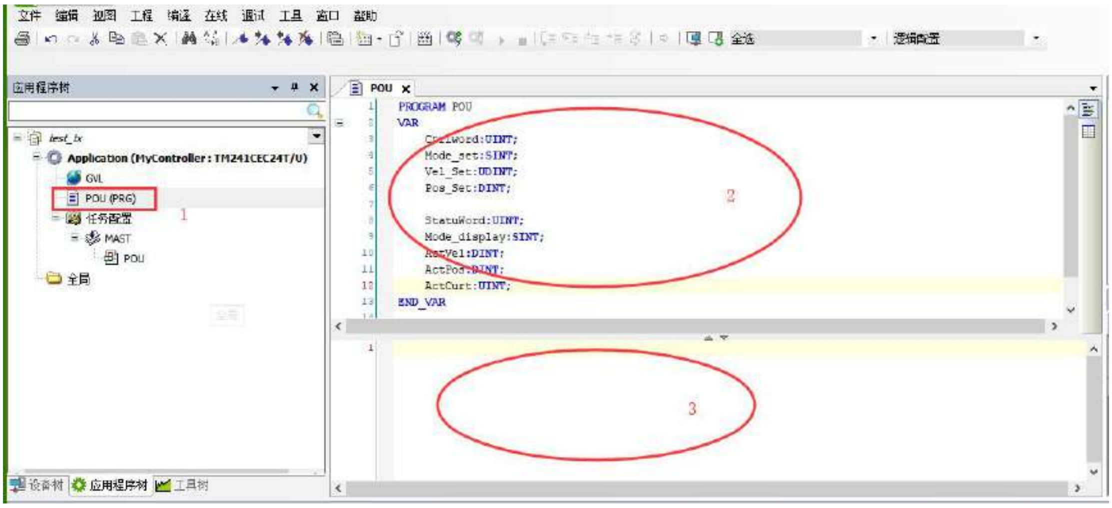


Figure 7-20 Write POU program

c. Double click "**Master**", and set the program cycle.

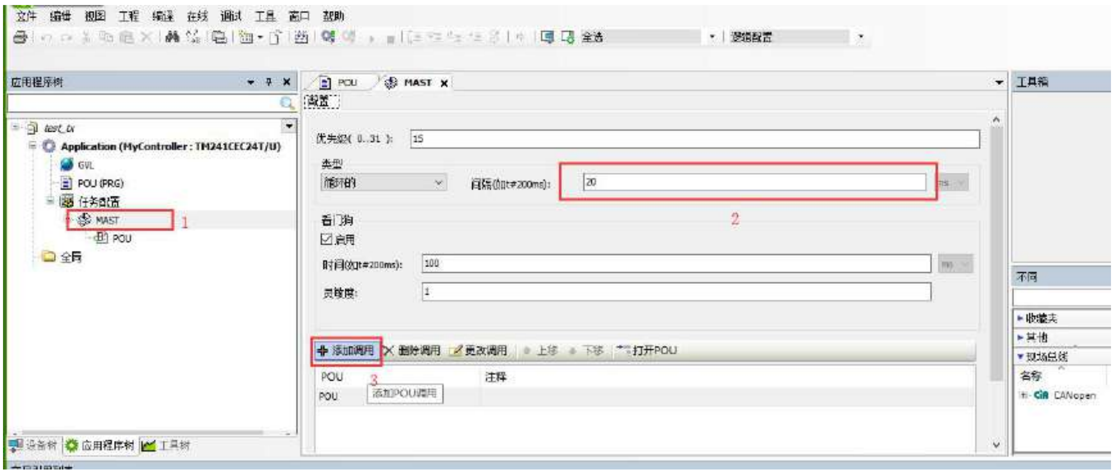


Figure 7-21 Set program cycle

d. Double click "**Master**", and add a POU call.

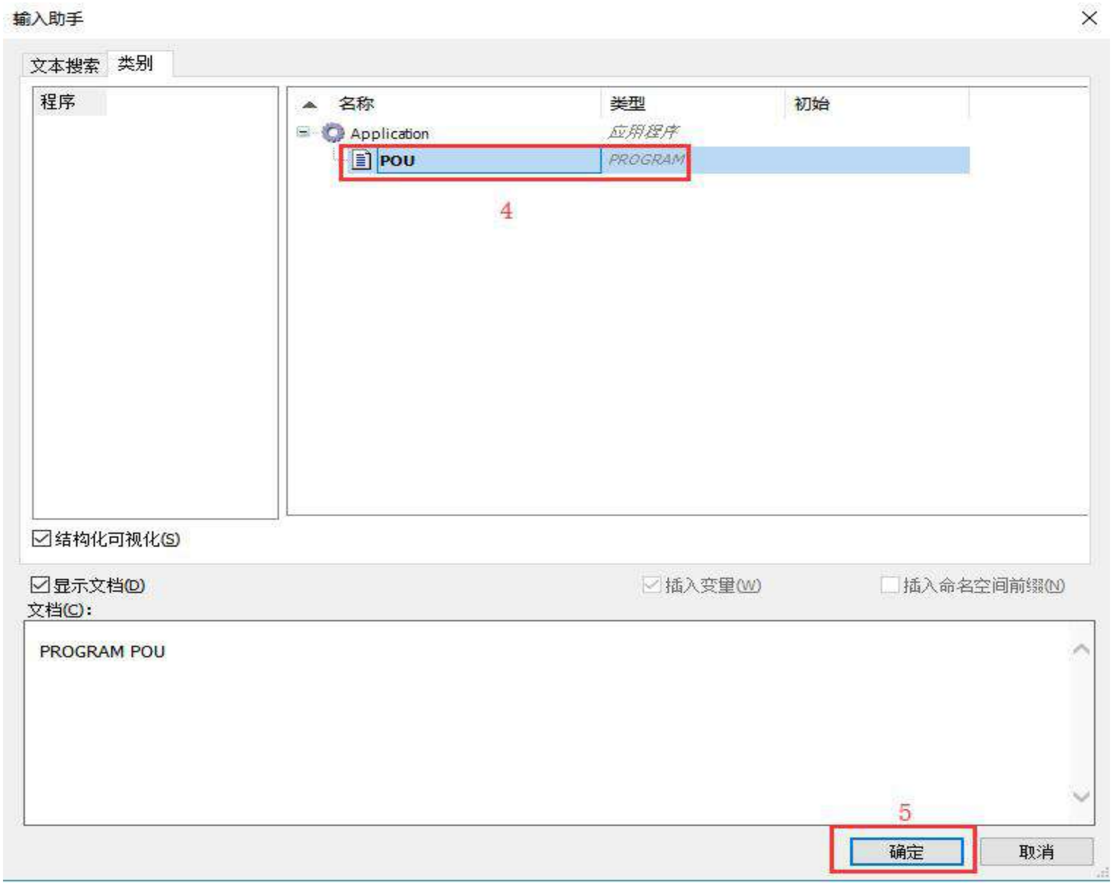


Figure 7-22 Add a POU call

8. Link CANopen I/O mapping to POU variable.

a. Select "**Diamond Plus**", click "**CANopen I/O Mapping**", and link POU variables to PDO parameters.

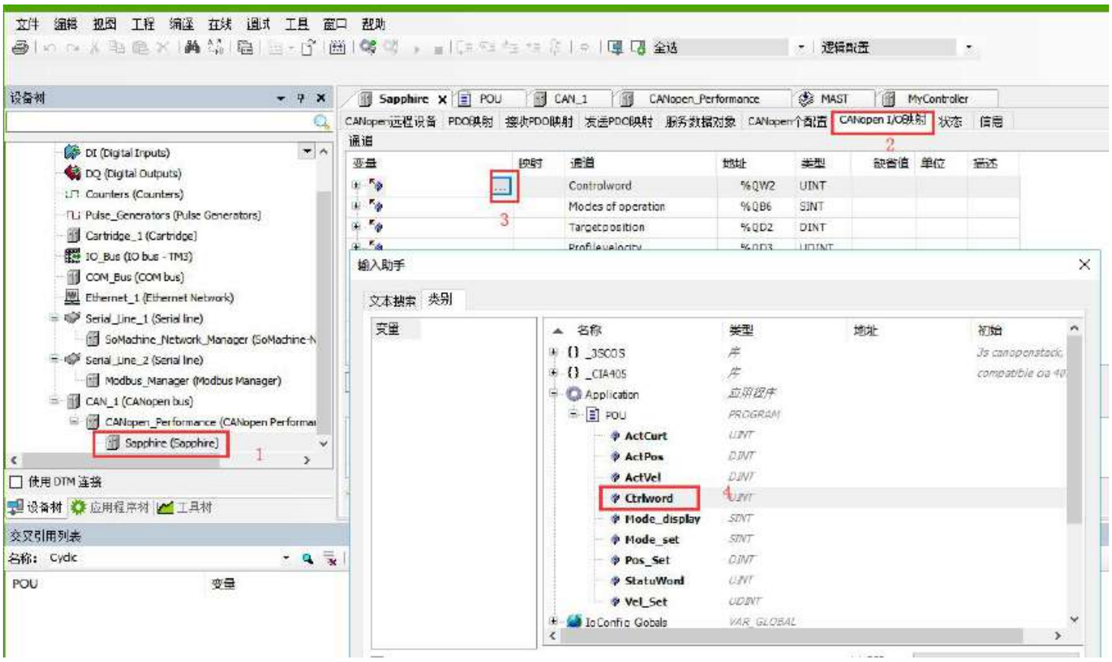


Figure 7-23 CANopen I/O Mapping

b. Link all variables in turn.

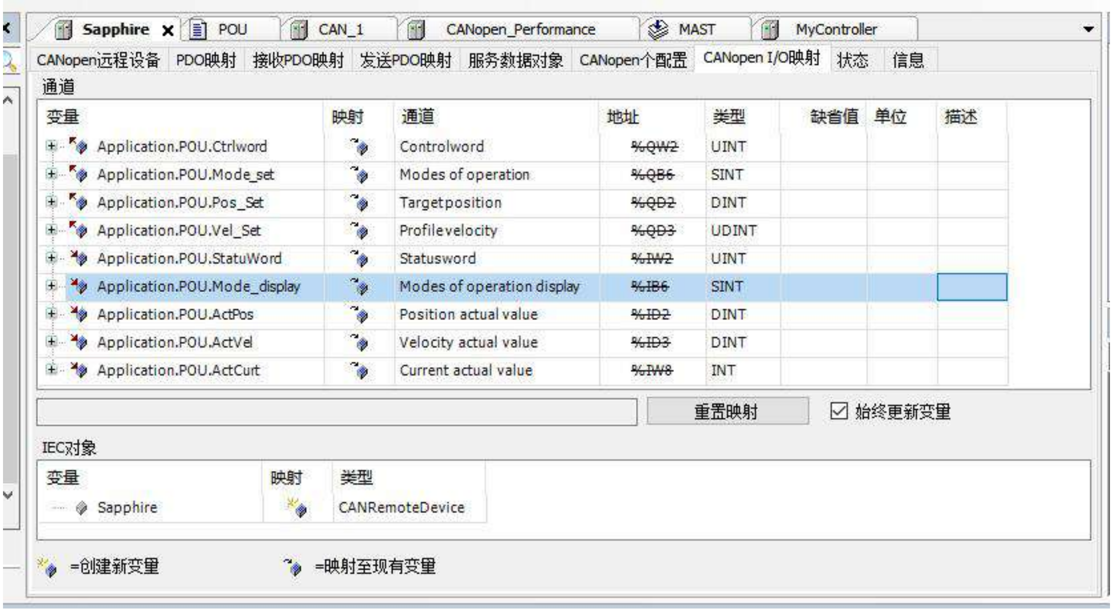


Figure 7-24 Link POU variables to PDO parameters

9. Log in and do tuning

a. Click the login button  or press "**Alt**” and “**F8**" to log in PLC. The following dialog box pops up as shown in 7-25.

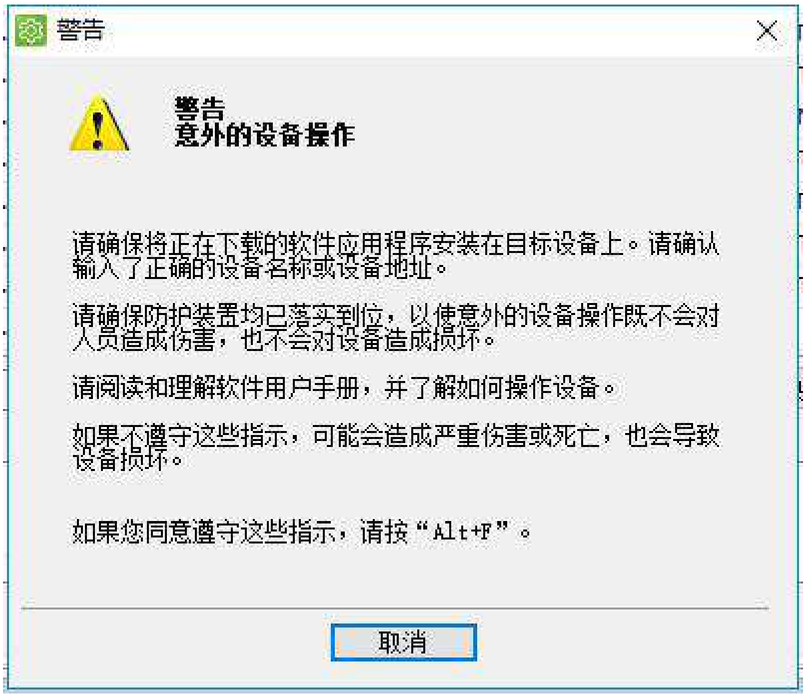


Figure 7-25 After clicking login button

b. Press "**Alt**" and "**7**", and click "**Yes**" to complete PLC login and download.

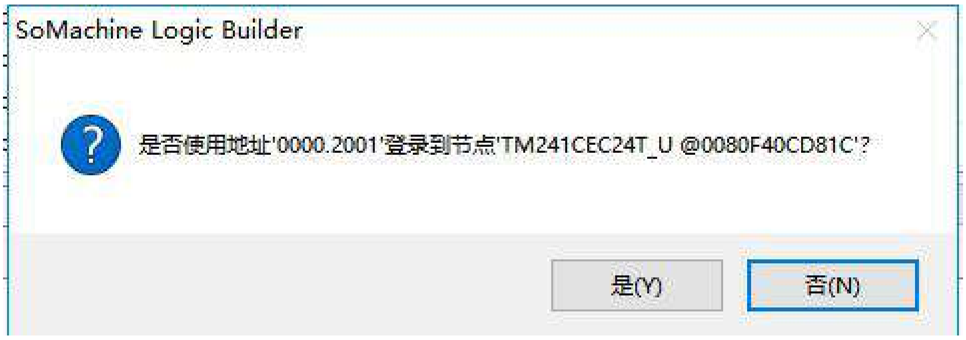


Figure 7-26 Confirm PLC login

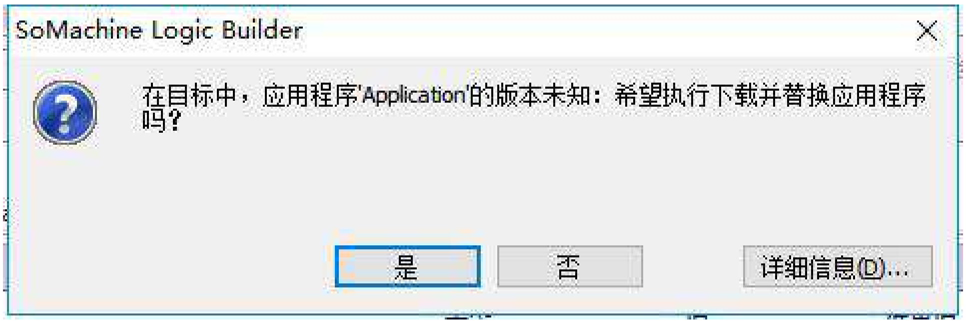


Figure 7-27 Confirm program download

c. Start PLC.

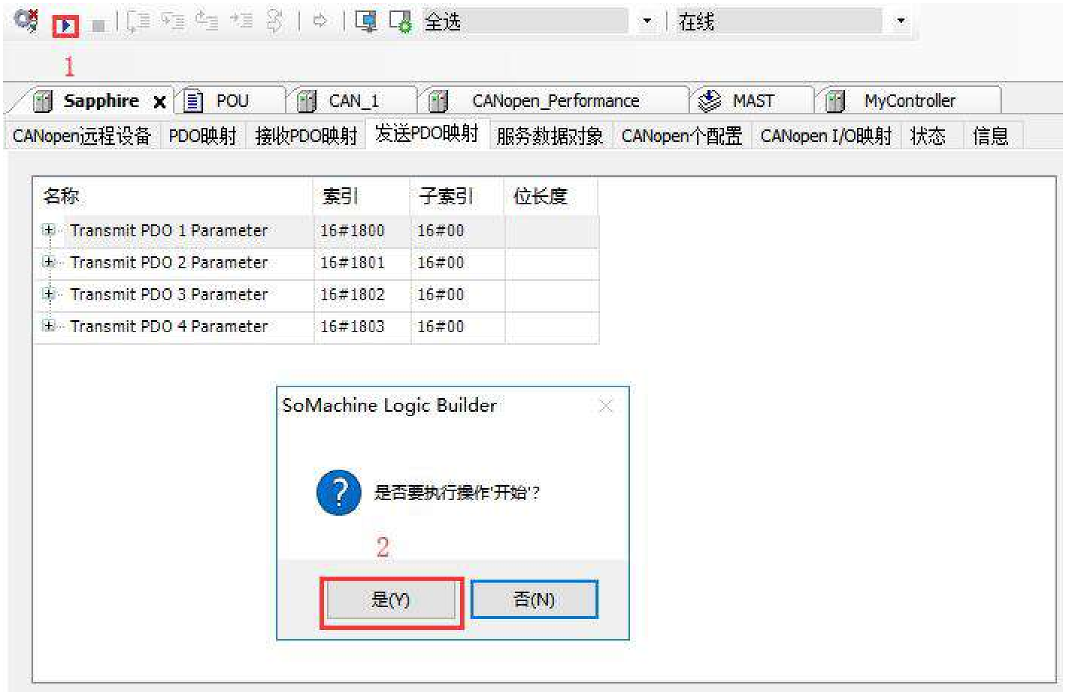


Figure 7-28 Start PLC

d. Do tuning

Forcibly configure the following parameters, and press F7 to force writing

e.g. Run the relative posit ion for 10 turns: to control the motor to run, set the control Model to "1", the target position to 100000 cnt, the planned speed to 1000000cnt/s, and the control word to 0x06 -> 0x07 -> 0x4F -> 0x5F.

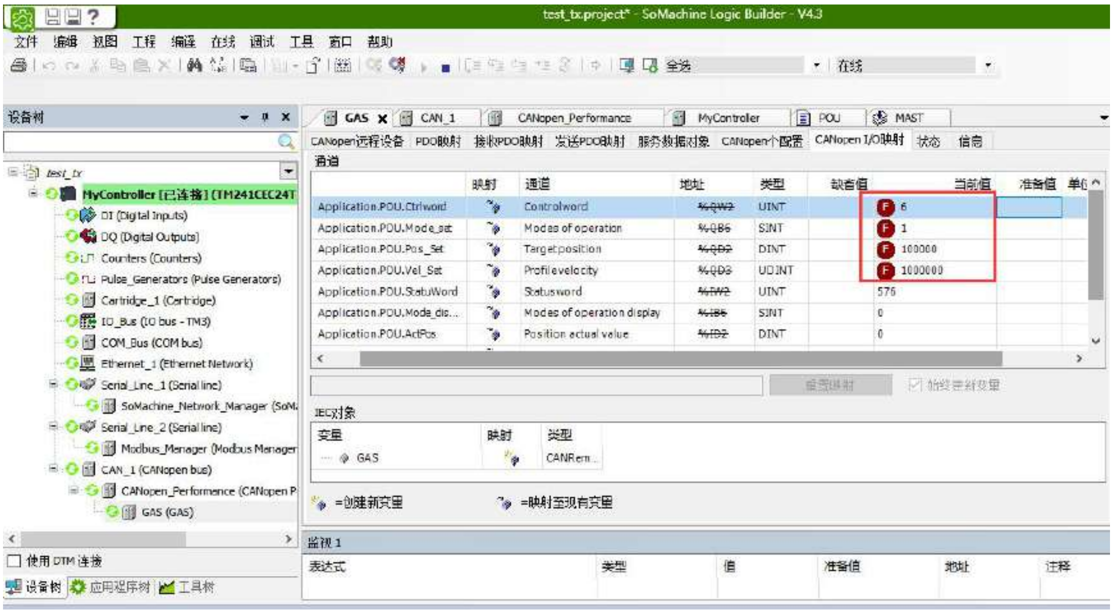


Figure 7-29 Program tuning

7.2 EtherCAT Communication

7.2.1Principle

CoE reference Model

The internal CANopen over EtherCAT (CoE) network Model of Stone servo is shown in Figure 7-30.

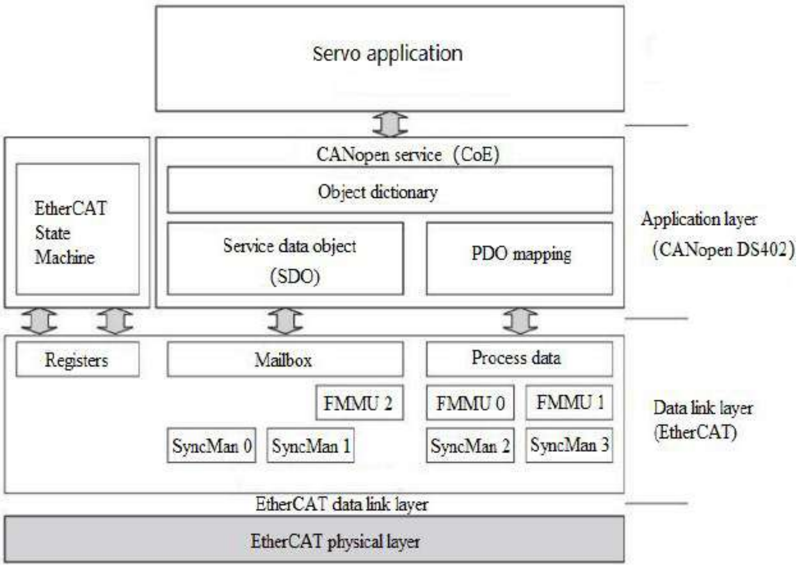


Figure 7-30 COE reference Model

The EtherCAT (CoE) network Model consists of two parts:

- Data link: mainly responsible for EtherCAT communication protocol
- Application: it embeds the CANopen drive Profile (DS402) communication protocol.

The object dictionary in CoE includes parameters, application data, and PDO mapping information.

Process data object (PDO) consists of objects in the object dictionary that can do PDO mapping, and the content in PDO data is defined by PDO mapping. The read and write of PDO data is periodic with no need to look up the object dictionary; while the mailbox communication (SDO) is non-periodic communication with a need to look up the object dictionary.

EtherCAT slave information

The EtherCAT slave information file (XML file) is read by the master and used to construct the configuration of the master and slave. The XML file contains the necessary information for EtherCAT communication. STONE provides the "Stone_E XML.xml" file for the servo drive to construct the configuration of the master and slave.

EtherCAT State Machine

It is used to describe the states and state changes of the slave. The state change request is usually initiated by the master and the slave responds. The details is shown in Figure 7-31.

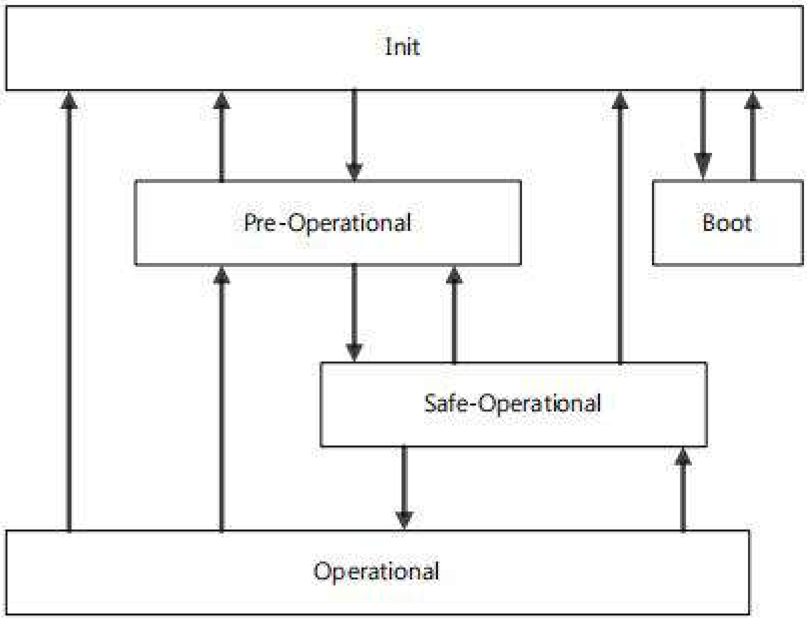


Figure 7-31 EtherCAT state machine

The status of state machine is shown in Table 7-31.

Table 7-31 Status

Status	Description
Boot	◆ Firmware update. ◆ Drive can transit to Init state.
Init	◆ Initialize the communication. ◆ Unable to communicate with SDO and PDO.
Init->Pre-OP	◆ The master configures the link address and SM channel to start mailbox communication. ◆ The master initializes DC clock synchronization. ◆ The master requests a transition to the Pre-Op state. ◆ The master sets the AL control register. ◆ The slave checks if mailbox is normally initialized.
Pre-OP	◆ Mailbox communication is activated. ◆ Unable to communicate with PDO.
Pre-OP->Safe-OP	◆ The master configures the Sync Manager channel and FMMU channel for PDO. ◆ The master configures PDO data mapping and Sync Manager PDO parameters through SDO. ◆ The master requests transition to Safe-Op state. ◆ The slave checks if the Sync Manager responsible for the PDO data is correctly configured, and check the distributed clock when the slave sends a request to start synchronization.
Safe-OP	◆ The slave application will transfer the actual input data and will not respond to the output. ◆ Output is set to "safe state".
Safe-OP->OP	◆ The master sends valid output data. ◆ The master requests a transition to the Op state.
OP	◆ Mailbox communication is available. ◆ PDO communication is available.

PDO mapping

STONE servo has 4 configurable PDOs, including 2 RxPDOs (0x1600 and 0x1601) and 2 TxPDOs (0x1A00 and 0x1A01). When you need to change the default PDO mapping, you can change the xml file and configure it into the servo.

Note: When using EtherCAT communication, it is necessary to set the communication cycle of the upper computer to be the same as that of the lower servo (default: 4 ms).

The default PDO mapping of STONE servo is as follows:

RxPDO

Table 7-32 RxPDO

(sub) index	Name	Object Type	Default
0x1600	1st Receive PDO	REC Data type -	-
0x00	Number of mapped objects	UINT8	10
0x01	Mapped object 1	UINT 16	0x6040 Control word
0x02	Mapped object 2	UINT32	0x607A Target position
0x03	Mapped object 3	UINT32	0x60B1 Velocity offset
0x04	Mapped object 4	UINT 16	0x60B2 Torque offset
0x05	Mapped object 5	UINT32	0x60FF Target velocity
0x06	Mapped object 6	UINT 16	0x6071 Target torque
0x07	Mapped object 7	UINT 8	0x6060 Models of operation
0x08	Mapped object 8	UINT 8	0x0000
0x09	Mapped object 9	UINT32	0x0000
0x0A	Mapped object 10	UINT32	0x0000

Table 7-33 RxPDO

(sub) index	Name	Object Type	Default
0x1601	2st Receive PDO	REC Data type -	-
0x00	Number of mapped objects	UINT8	12
0x01	Mapped object 1	UINT32	0x0000
		UINT32	0x0000
0x0C	Mapped object 12	UINT32	0x0000

TxPDO

Table 7-34 TxPDO

(sub) index	Name	Object Type	Default
0x1A00	1st Transmit PDO	REC Data type -	-
0x00	Number of mapped objects	UINT8	12
0x01	Mapped object 1	UINT 16	0x6041 Statusword
0x02	Mapped object 2	UINT32	0x6064 Position actual value
0x03	Mapped object 3	UINT32	0x 606C Velocity actual value
0x04	Mapped object 4	UINT 16	0x 6077 Torque actual value
0x05	Mapped object 5	UINT 8	0x 6061 Models of operation display

(sub) index	Name	Object Type	Default
0x06	Mapped object 6	UINT 8	0x0000
0x07	Mapped object 7	UINT32	0x0000
0x08	Mapped object 8	UINT32	0x 0000
0x09	Mapped object 9	UINT32	0x0000
0x0A	Mapped object 10	UINT32	0x 0000
0x0B	Mapped object 11	UINT32	0x0000
0x0C	Mapped object 12	UINT32	0x0000

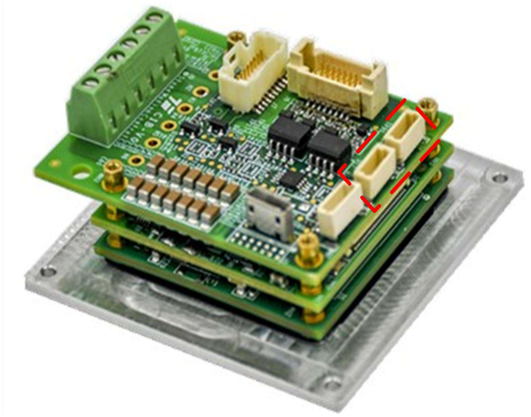
Table 7-35 TxPDO

(sub) index	Name	Object Type	Default
0x1A01	2 st Receive PDO	REC Data type -	-
0x00	Number of mapped objects	UINT8	12
0x01	Mapped object 1	UINT32	0x0000
⋮		UINT32	0x0000
0x0C	Mapped object 12	UINT32	0x0000

Note: You can query detailed PDO mapping information in the xml file.

7.2.2 EtherCAT

Communication Interface



Pin	Name	Definition	Direction
1	TX+	Send data+	Output
2	TX-	Send data-	Output
3	RX+	Receive data+	Input
4	RX-	Receive data-	Input
5	PE	Shield	-

Figure 7-32 Definition of EtherCAT communication interface

Communication Wiring

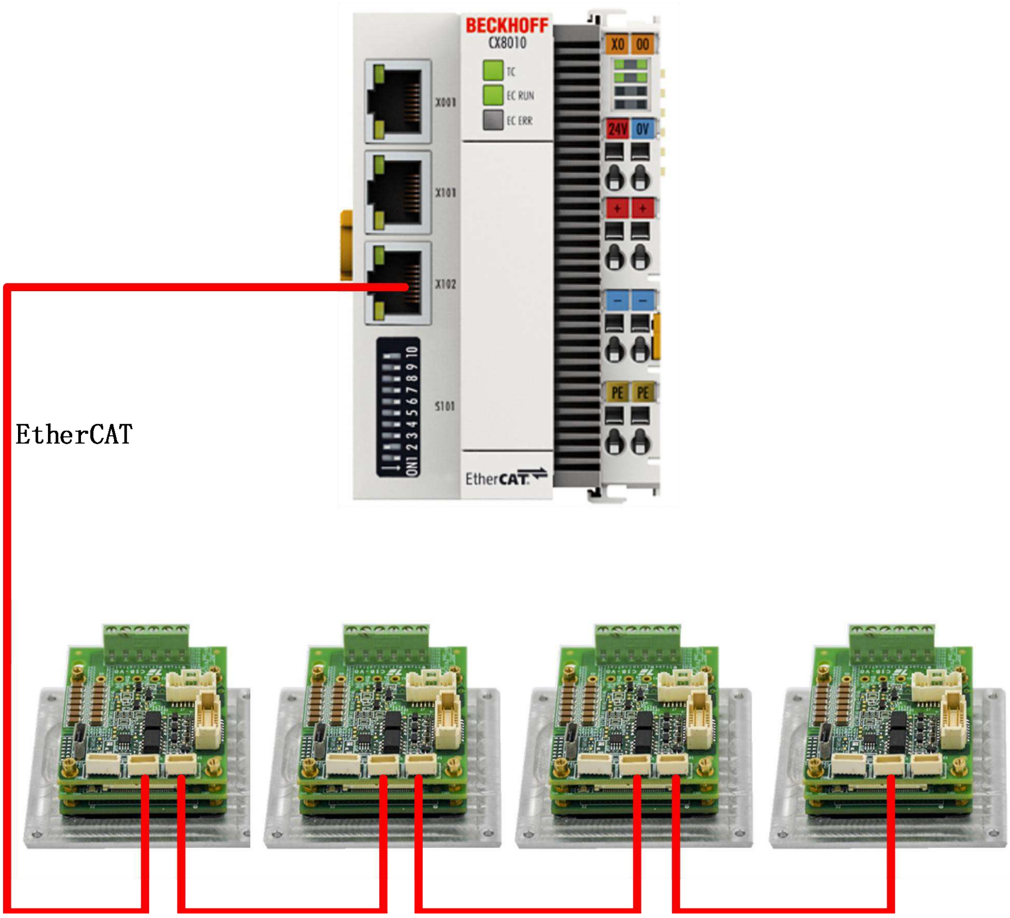


Figure 7-33 Communication wiring

Software Settings

1. Configure the motor parameters, and make sure that the servo motor can be operated normally with the IISMC software.
   For the trial run, please refer to "***Diamond Plus Servo User Manual***".
2. Select master type (0x2005):
   ✓ 0: support the 402 state machine of most masters, including Beckhoff.

✓ 1: specially support the 6061 state machine of Omron PLC.

3. Set servo communication cycle, set 0x60C2 to 01.

   Communication cycle range is within 1 - 4 ms (default value: 4 ms).

   The communication cycle of controller and servo should be the same. Otherwise, a synchronization error will occur during running.

The master triggers DC Model in the CSP Model. Otherwise, it will not operate normally.

Note:

1. The transferring and receiving PDOs can be dynamically configured by the master, but the maximum number for each PDO parameter is 10. If the range is exceeded, the slave will be unable to enter the op state.
2. The sequence of network cables is IN → OUT. Otherwise, some nodes may be unable to enter the op state.

7.2.3 Communication with Beckhoff PLC

1. Connect hardware and check configuration

Refer to chapter 1 and 2 and complete the hardware and basic configuration between the servo and PLC.

2. Place the configuration file

Place file Stone_E XML.xml under the TwinCAT directory as follows:

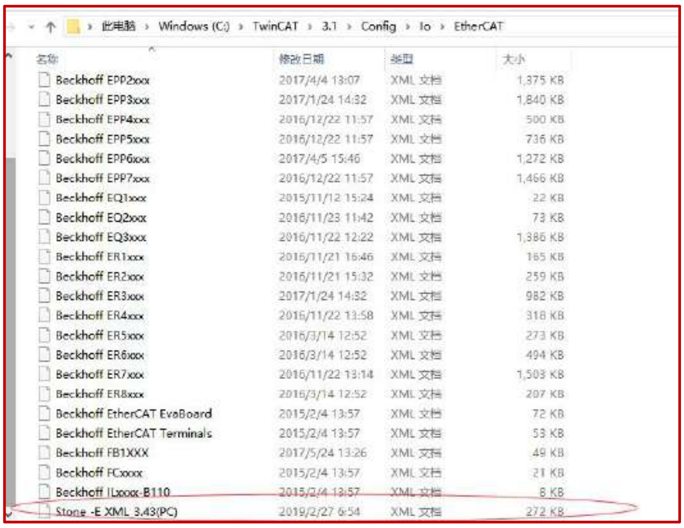


Figure 7-34 Directory of file Stone_E XML.xml

3. Establish project and connection

Run TwinCAT software, create a project, modify the IP address of the computer and the controller in the same local area network, and select the target system to be connected:

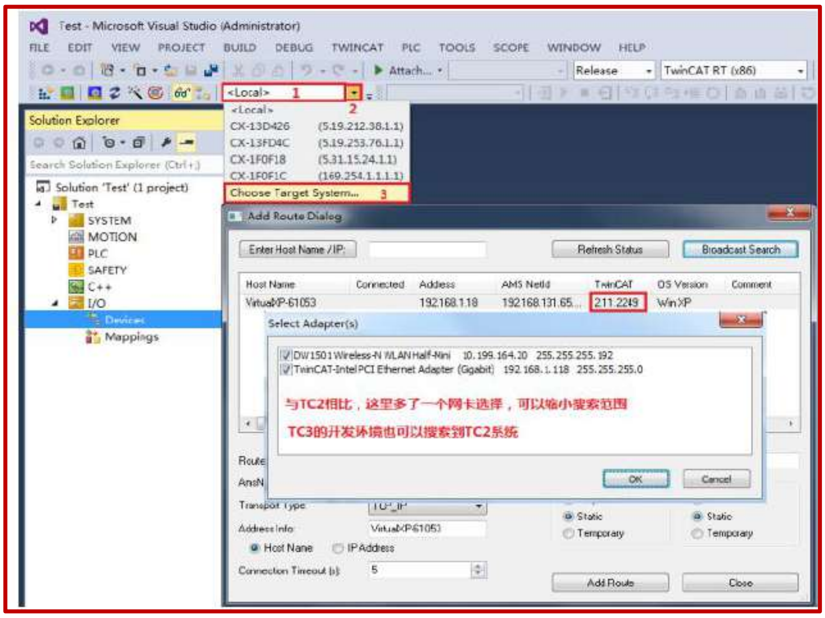


Figure 7-35 Modify IP address in TwinCAT

4. Scan the slave and automatically configure NC axis

Right click on "**I/O**", select "**Scan**", scan EtherCAT slave, click "**Scan boxes**" after scanning the slave, and click "**Automatically add NC axis**".

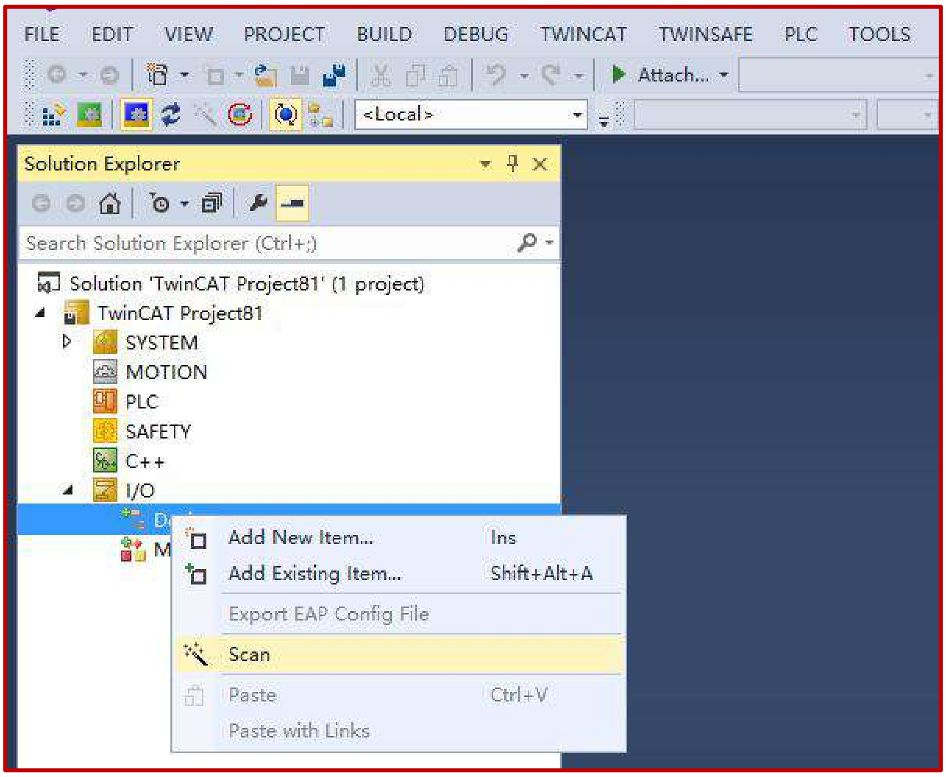


Figure 7-36 Automatic scanning and configuration of slaves in TwinCAT

After scanning is successful, icon StoneLOGO appears as shown in the below, and the servo status is in the OP state.

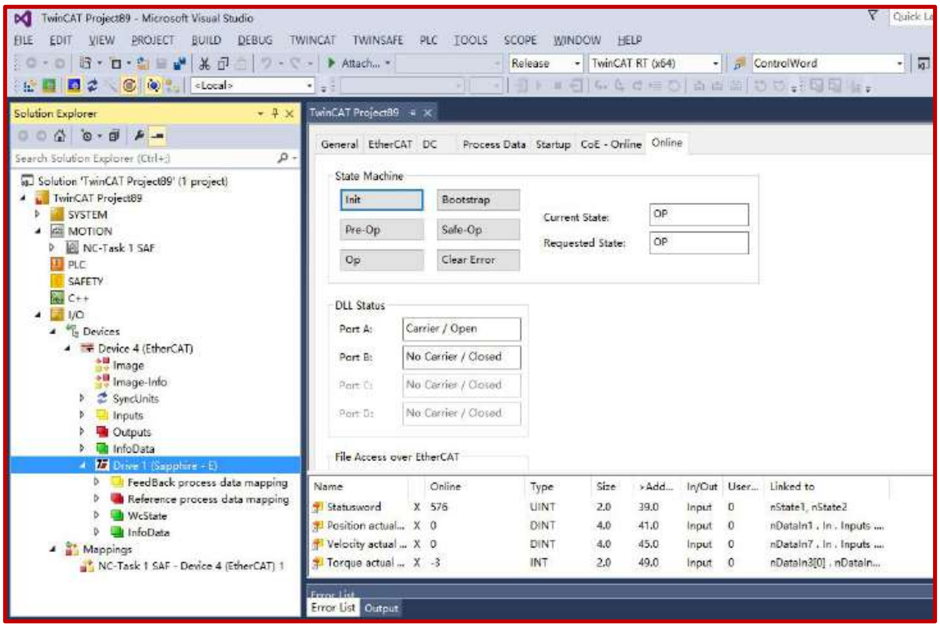


Figure 7-37 Successfully scan stone servo

Note: When scanning slave, please make sure TwinCat is in Config Model.

5. **Read COE data from Stone servo**

As shown in Figure 7-39, you can read and write the data of the servo slave through SDO. Or you can call the COE command function module through the EtherCAT function library in the PLC program (Please refer to “TwinCat User Manual” for details).

Note: If the data is configured as PDO, write is invalid.

To check if read and write are successful, you can monitor and compare data through the ISMC software.

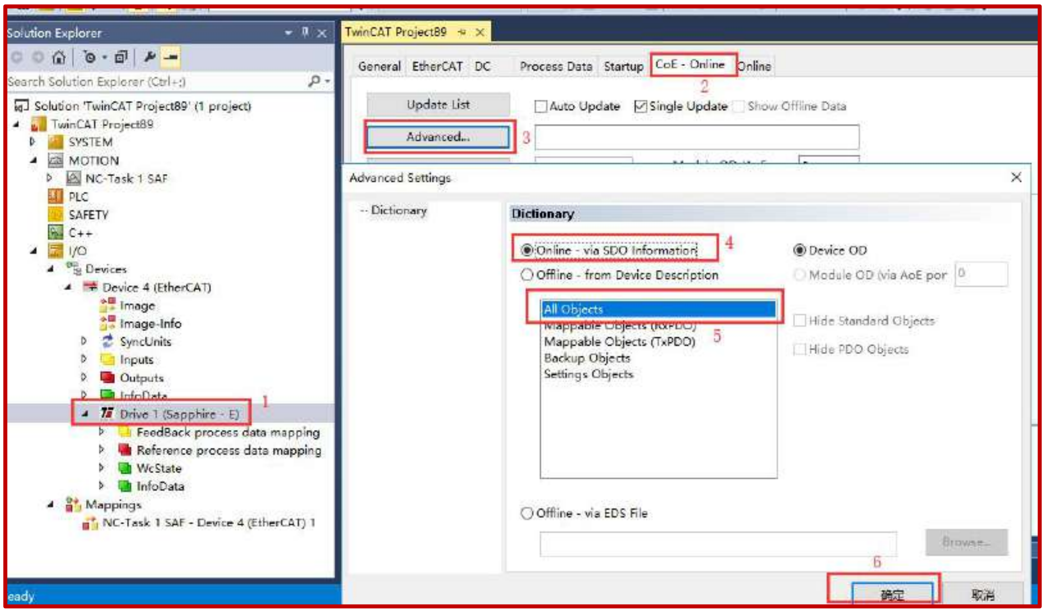


Figure 7-39 Configure SDO in TwinCAT

6. **Read and configure PDO mapping**

TwinCAT will automatically read the default PDO configuration of the lower computer when scanning the XML file of the slave. The default PDO mapping object and configuration are shown in Figure 7-40.

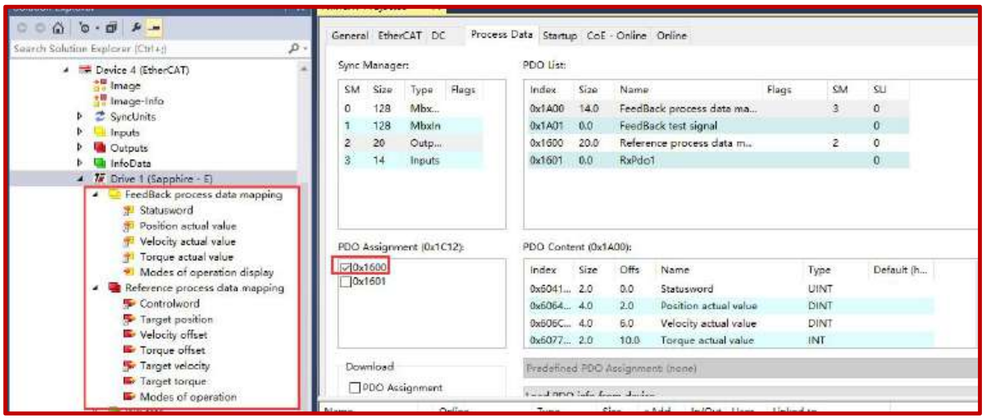


Figure 7-40 Configure PDO in TwinCAT

If the target PDO parameter is not in the default PDO configuration, you can add PDO parameter mapping through TWinCAT. For example, if you would like to add DI (0X2701) status when transferring PDO (1600):

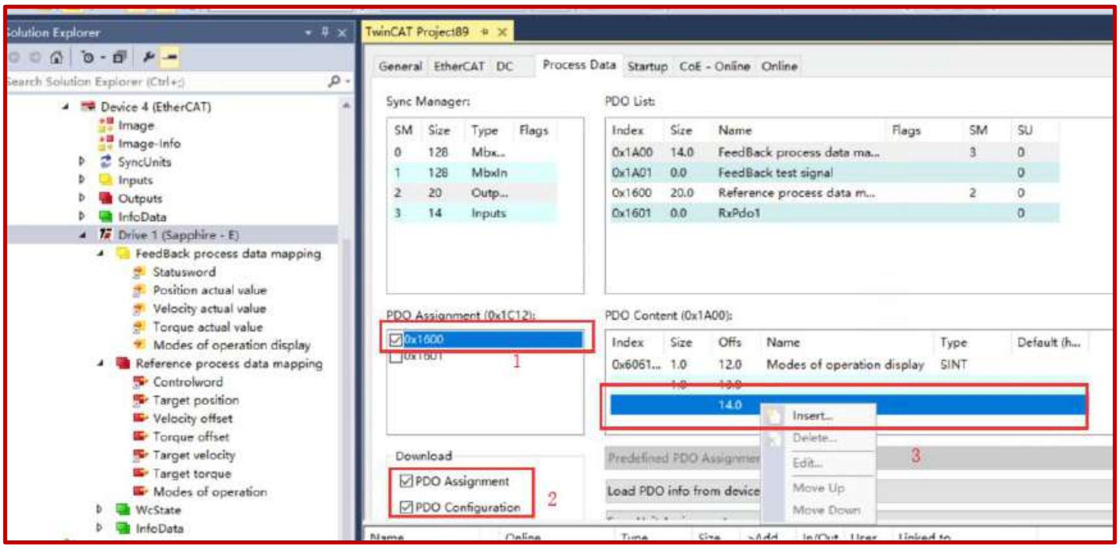


Figure 7-41 Add PDO parameters in TwinCAT

7. **Configure NC control**

a. Configure NC TASK cycle: set “Cycle ticks” in NC-Task 1 SAF to “4” (unit: ms).
NC determines generation and calculation of position, velocity, acceleration and the direction.

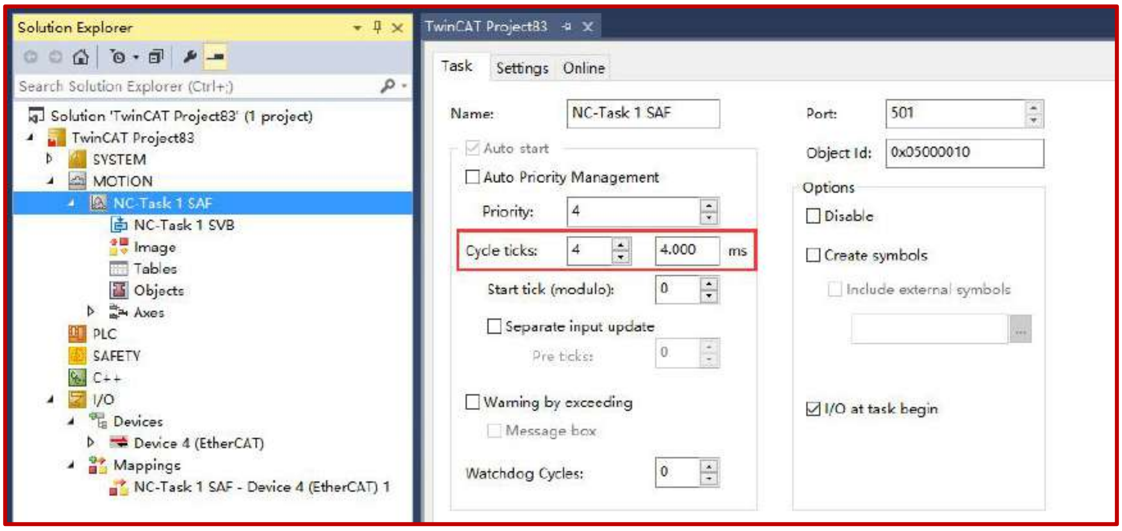


Figure 7-42 a. Configure NC TASK cycle in TwinCAT

b. Configure the synchronization clock: enable distributed clock.
Please note that the setting of Cycle Time should be the same with the synchronization period (4 ms) of the servo drive. Otherwise, the servo may vibrates during running.

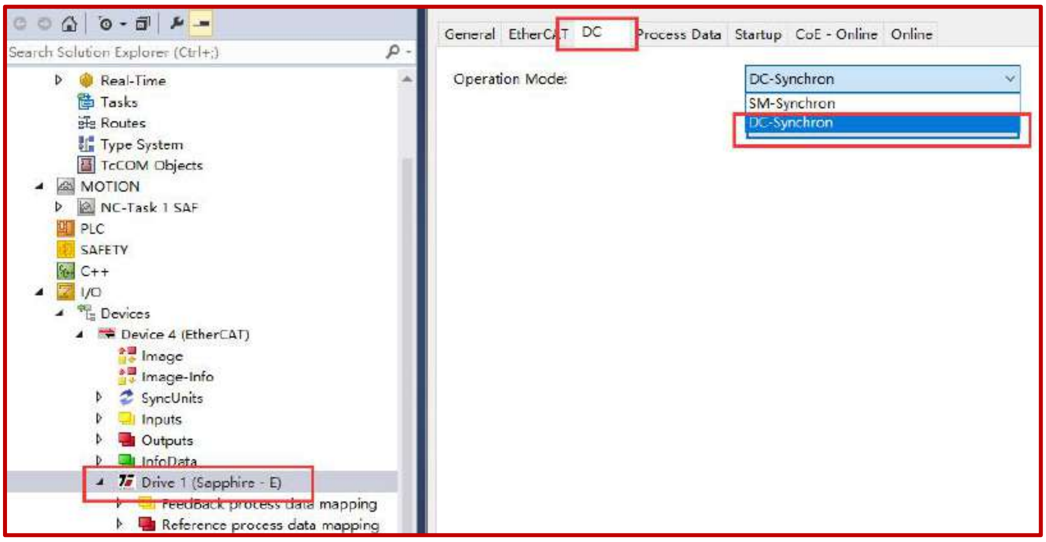


Figure 7-43 Check synchronization clock in TwinCAT

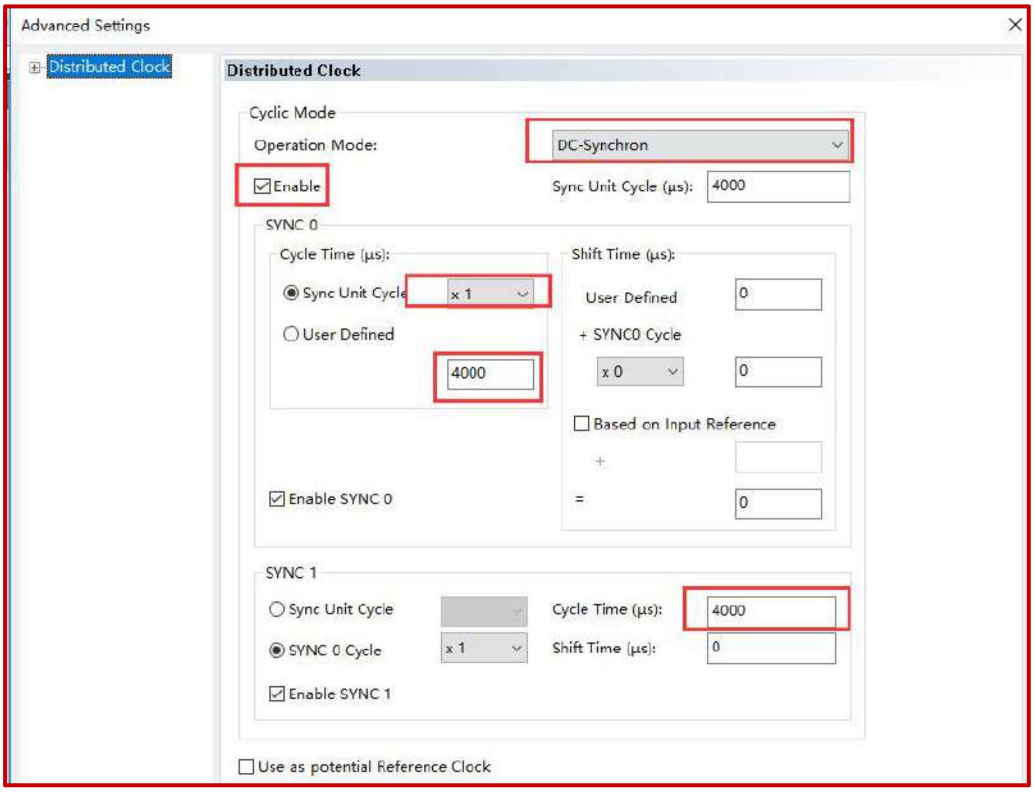


Figure 7-44 Set cycle time in TwinCAT

c. Set the following in the NC axis:

- Set Scaling Factor: the distance corresponding to the encoder pulse of each position feedback.

  e.g. If one turn of the servo motor is 10000 pulses, and each turn is 1 mm, the scaling factor should be set to 1/10000 = 0.0001 mm/Inc; if the target position increases by 10 mm, the actual servo position should increase by 100000 INC. Generally,

- Set the speed of NC control.

  Otherwise, an alarm will occur.

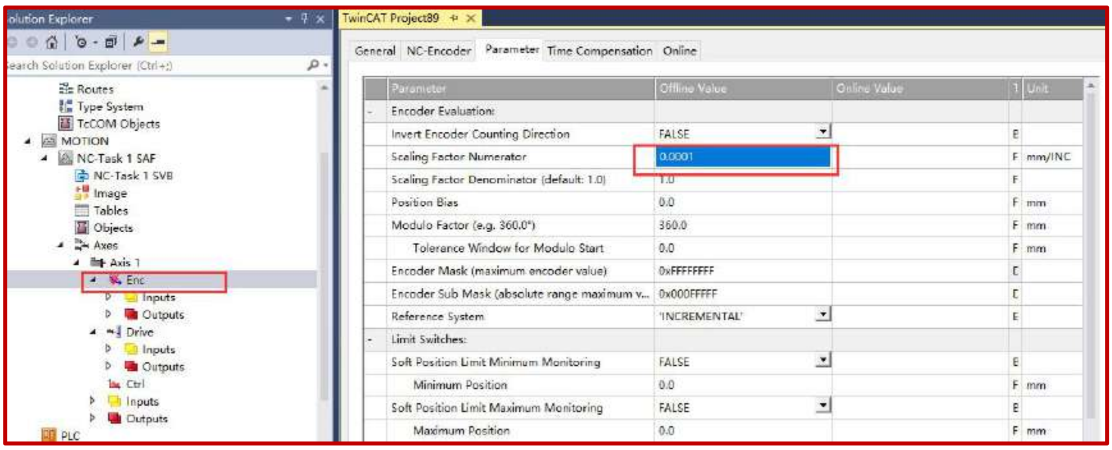


Figure 7-45 Set scaling factor in TwinCAT

d. To prevent the PLC from reporting a following error, set "**Following Error Calculation**" to "**Extern**".

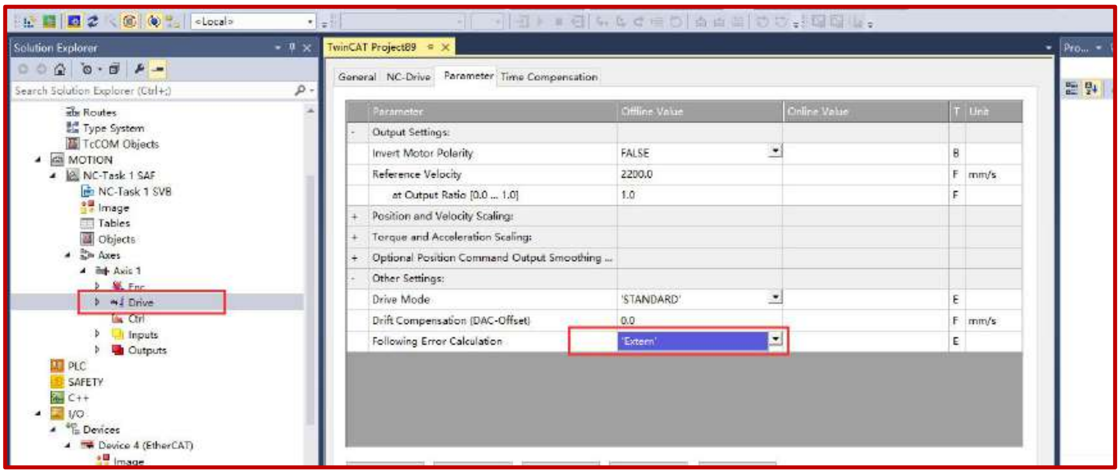


Figure 7-46 Set following error calculation in TwinCAT

e. To reverse the motor control polarity, set "**Invert Encoder Counting Directio**n" to "**TRUE**" and "**Invert Motor Polarity**" to "**TRUE**".

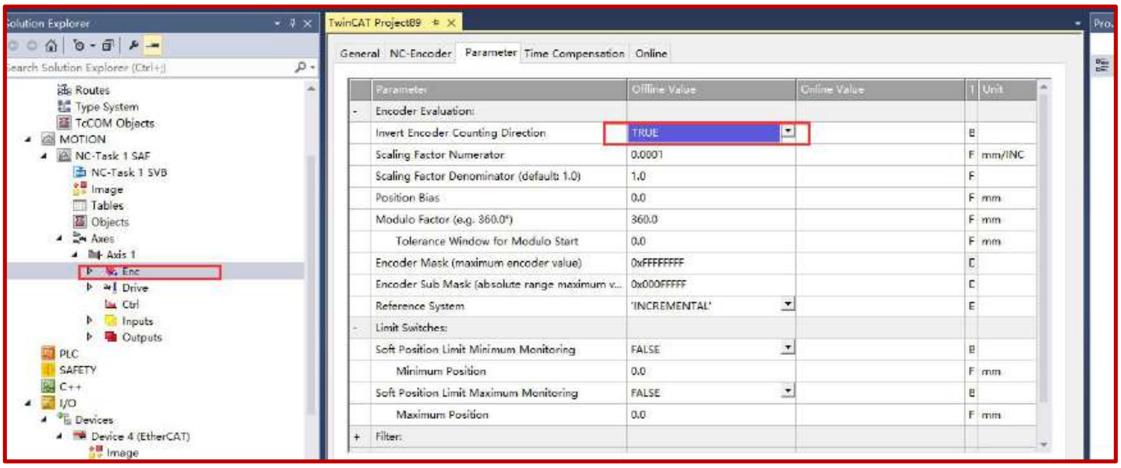


Figure 7-47 Set invert encoder counting direction in TwinCAT

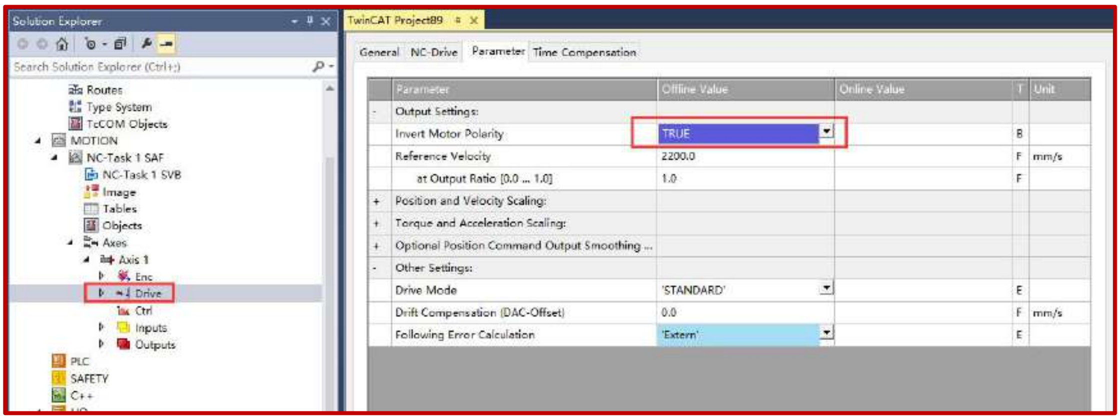


Figure 7-48 Set invert motor polarity in TwinCAT

f. Activate the configuration, control the servo working via the NC tuning interface, use Online function to simulate the servo working in the running Model (Make the servo lock the shaft, and click the button to make the servo run).

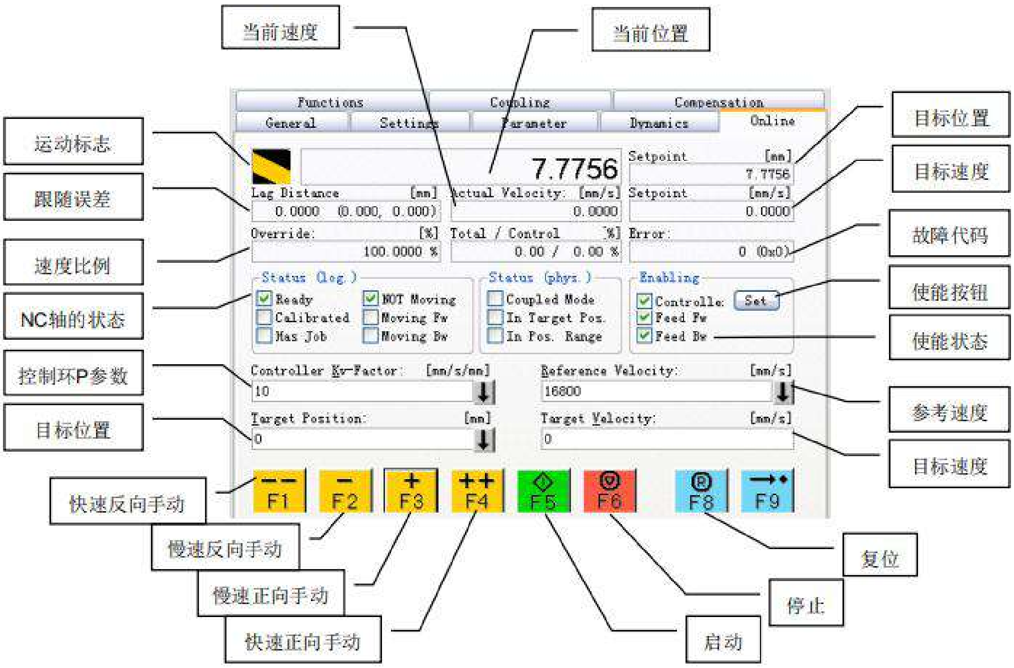


Figure 7-49 NC tuning interface in TwinCAT

当前速度：Current speed
当前位置：Current position
目标位置：Target position
目标速度：Target speed
故障代码：Error code
使能按钮：Enable button
使能状态：Enable status
参考速度：Reference speed
目标速度：Target speed
复位：Reset
停止：Stop
启动：Start
快速正向手动：Fast positive tuning
慢速正向手动：Slow positive tuning
慢速反向手动：Slow negative tuning
快速反向手动：Fast negative tuning
目标位置：Target position
控制环 P 参数：Control loop P parameter
NC 轴的状态：NC axis Status
速度比例：Speed rate
跟随误差：Follow-up error
运动标志：Movement sign

8. Create a PLC project

a. Create a new PLC project.

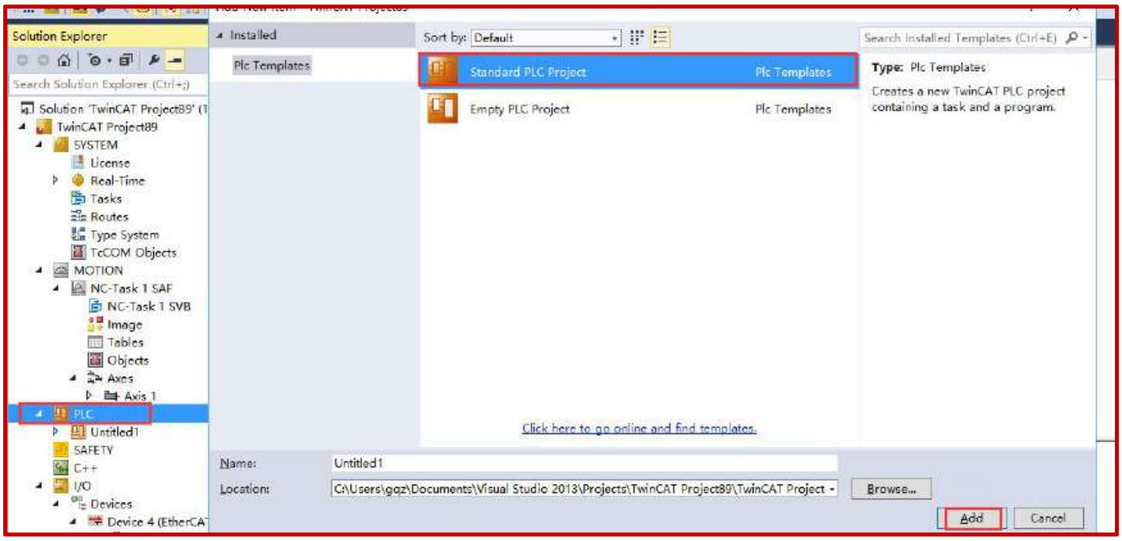


Figure 7-50 Create a new PLC project in TwinCAT

b. Set "**Cycle ticks**" of PLC Task to 4 ms.

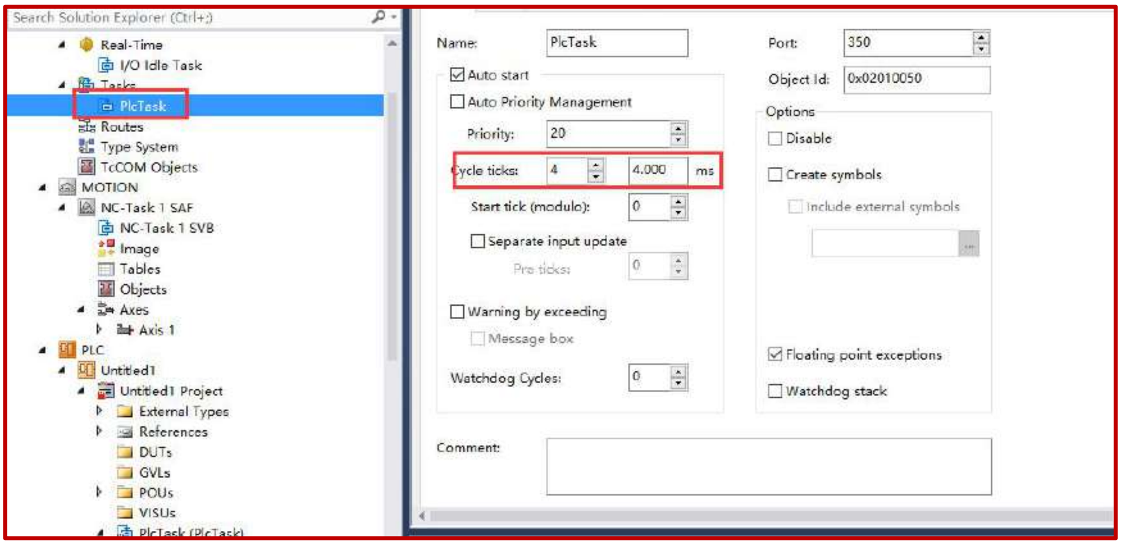


Figure 7-51 Set cycle ticks of PLC task in TwinCAT

9. Use of CoeSDO

CoeSDO is similar to SDO in CANOPEN. It can be used to read and write some objects whose exchange is not frequent or that are not supported by PDO communication. The steps are as follows:

a. Add "**Tc2_EtherCAT.lib**" in TwinCAT PLC library manager.

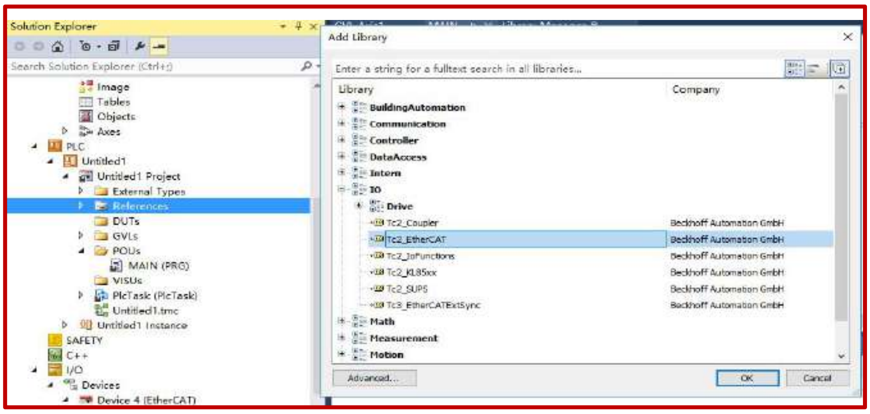


Figure 7-52 Add "Tc2_EtherCAT.lib" to the TwinCAT PLC library manager

b. After adding, declare the CoeSDO read and write in the program.

Taking read of status word 60410010 and write of homing Model 60980008 as examples, both of which have no symbols.

```
PROGRAM MAIN
VAR
    sNetId      : T_AmsNetId := '169.254.110.127.5.1';
    bExecute    : BOOL:=FALSE;
    bExe    : BOOL:=FALSE;
    nSlaveAddr  : UINT := 1001;
    nIndex      : WORD := 16#6041;
    nSubIndex   : BYTE :=0;
    nIndex1      : WORD := 16#6098;
    nSubIndex1   : BYTE :=0;
    bError      : BOOL;
    nErrId      : UDINT;
    fbSdoRead   : FB_EcCoESdoRead;
    fbSdoWrite  : FB_EcCoESdoWrite;
    statuword: UINT;
    Homing_mode: INT:= 7;

END_VAR
```

Figure 7-53 Add CoeSDO function to program in TwinCAT

c. Set the T_AmsNetId of the EtherCAT master.

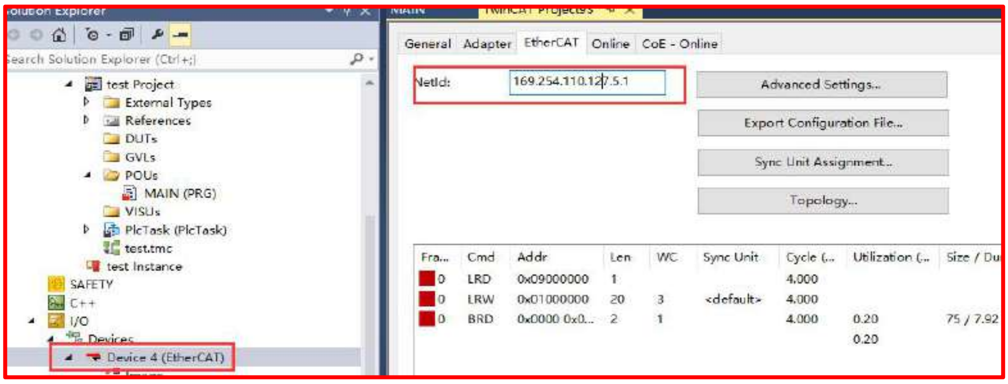


Figure 7-54 Set T_AmsNetId of EtherCAT master in TwinCAT

d. Set the slave's address SlaveAddr.

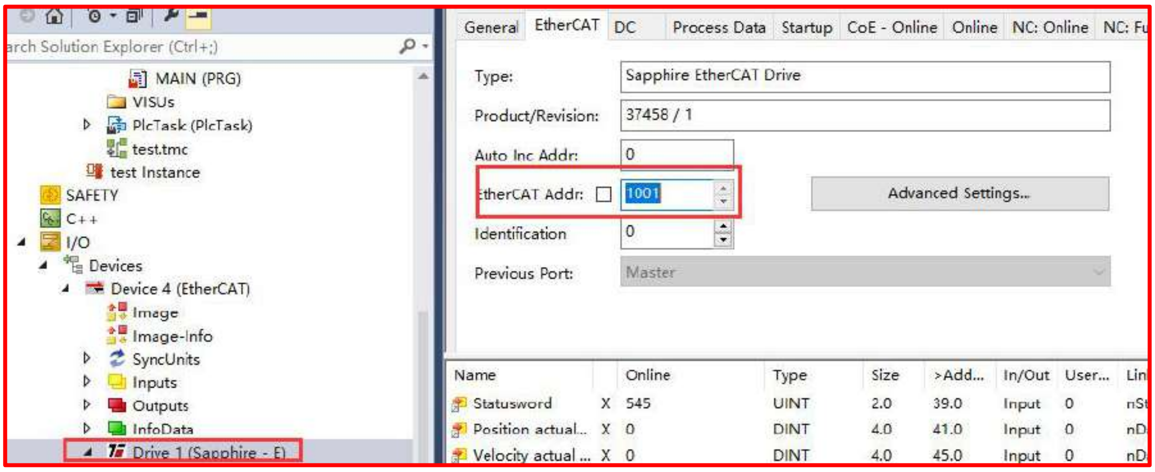


Figure 7-55 Set slave's address SlaveAddr in TwinCAT

e. Call the read and write function in the program, e.g. trigger read 0X6041 status word as 545, and write homing Model 0X6098 as 7.

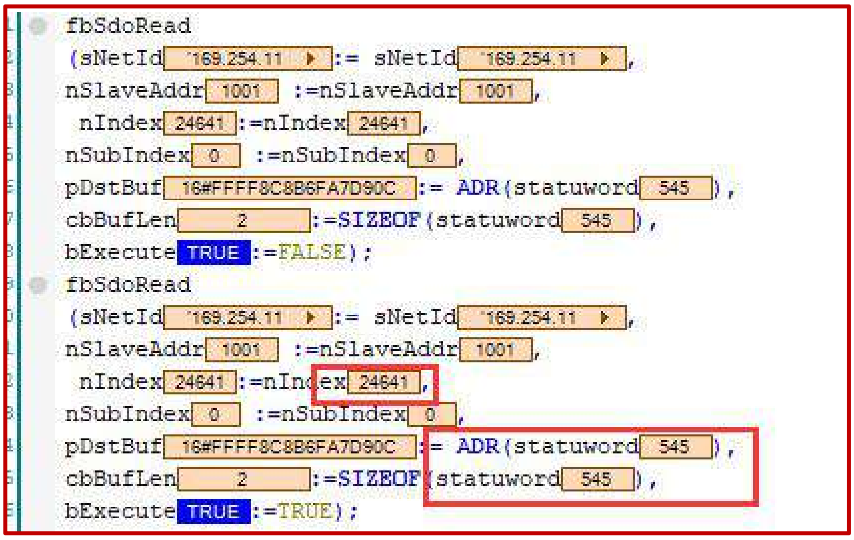
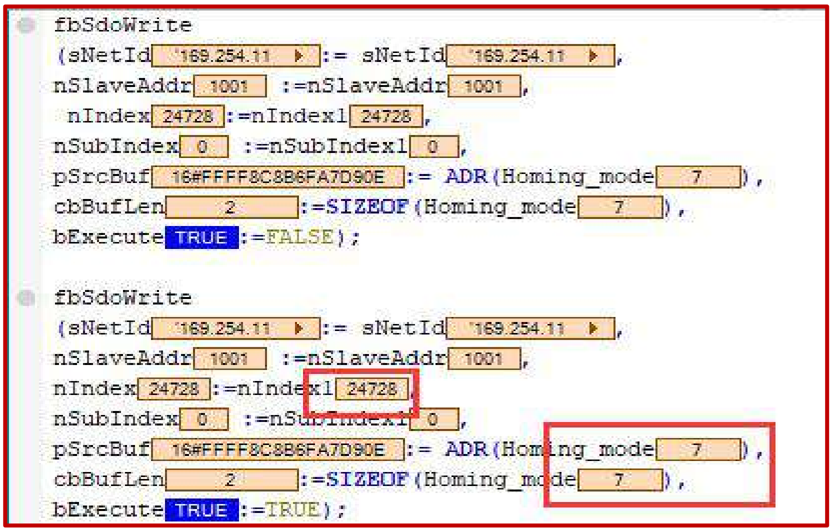


Figure 7-56 Trigger read of 0X6041 as 545 in TwinCAT



```
fbSdoWrite
(sNetId '169.254.11 := sNetId '169.254.11 ,
nSlaveAddr 1001 :=nSlaveAddr 1001 ,
 nIndex 24728 :=nIndex1 24728 ,
nSubIndex 0 :=nSubIndex1 0 ,
pSrcBuf 16#FFFF8C8B6FA7D90E := ADR(Homing_mode 7 ),
cbBufLen 2 :=SIZEOF(Homing_mode 7 ),
bExecute TRUE :=FALSE);

fbSdoWrite
(sNetId '169.254.11 := sNetId '169.254.11 ,
nSlaveAddr 1001 :=nSlaveAddr 1001 ,
nIndex 24728 :=nIndex1 24728 ,
nSubIndex 0 :=nSubIndex1 0 ,
pSrcBuf 16#FFFF8C8B6FA7D90E := ADR(Homing_mode 7 ),
cbBufLen 2 :=SIZEOF(Homing_mode 7 ),
bExecute TRUE :=TRUE);
```

Figure 7-57 Trigger write of homing Model 0X6098 as 7 in TwinCAT

7.2.4 Communication with Omron PLC

1. Connect hardware

Please refer to 7.22 for the hardware connection diagram.

2. Establish communication

a. Communication between PC and PLC

The PC and PLC are connected in a 1:1 manner with no need to specify an IP address and a connected device.

Click "Online" in Sysmac Studio to judge whether the communication is on by observing the status of the controller:

✓ The first green light indicates that communication between PC and PLC is established.

✓ The second green light indicates that the communication between PLC and the servo drive is established.

Figure 7-59 Controller status

b. Communication between PLC and the servo drive

Import an XML file

Right click “**EtherCAT**” under Sysmac Studio “Configuration and Settings, and click “**Show ESI Library**”, place file Store Stone -E XML_3.43 (PC).XML in this path.

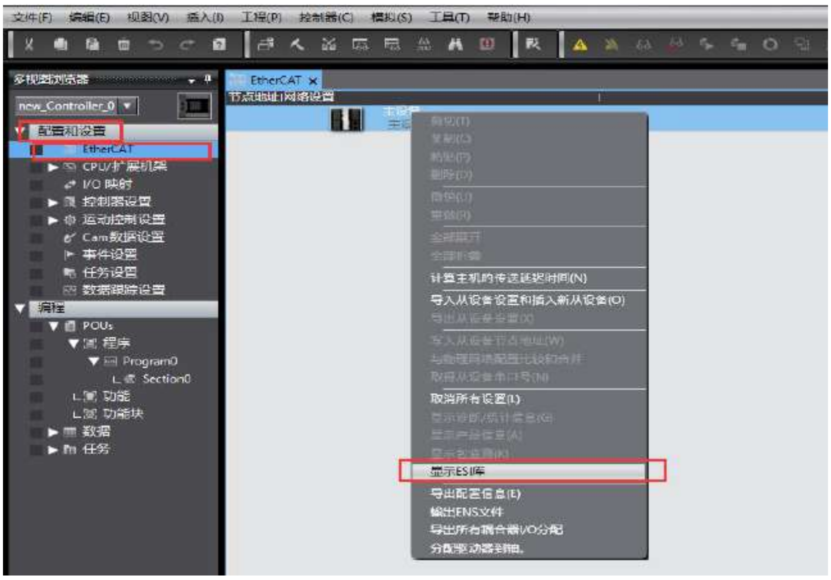


Figure 7-60 Import an XML file

Assign node

1) Create a project in Sysmac Studio, and log in online after compiling.
The default node address of the servo drive is 0.
Before establishing communication or when the device is replaced to merge the physical network and the application, the following warning shows, and node assignment is required.

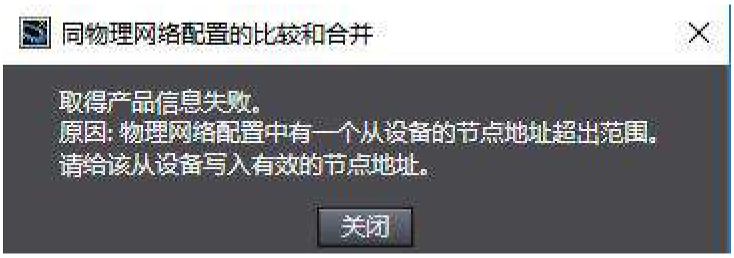


Figure 7-61 Node address out of range

2) In the left tree window, select "**Configuration and Settings-EtherCAT"**, right click the master, select "**Write slave node address"**, modify it to an address greater than 1 in the following interface, press "**Enter**" to write, Press "**Write**" after writing**,** and restart the servo drive.
The node address of different servo drives cannot be the same.

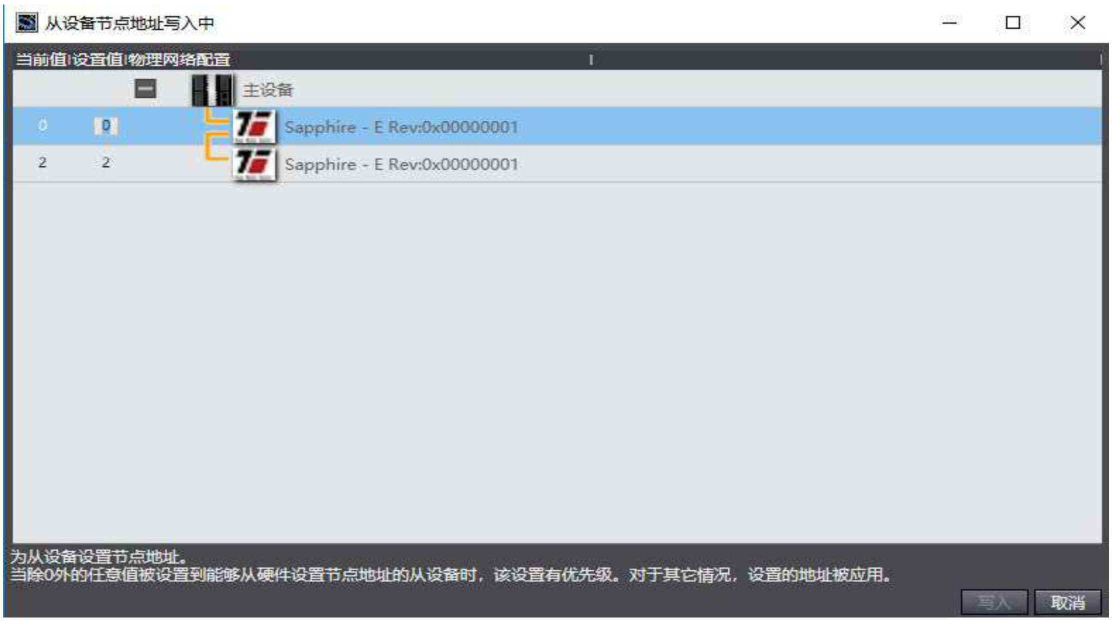


Figure 7-62 Modify node address

Establish communication

1) In the left tree window, select "**Configuration and Settings-EtherCAT"**, right click the master, and select "**Compare and Merge with Physical Network Configuration**".

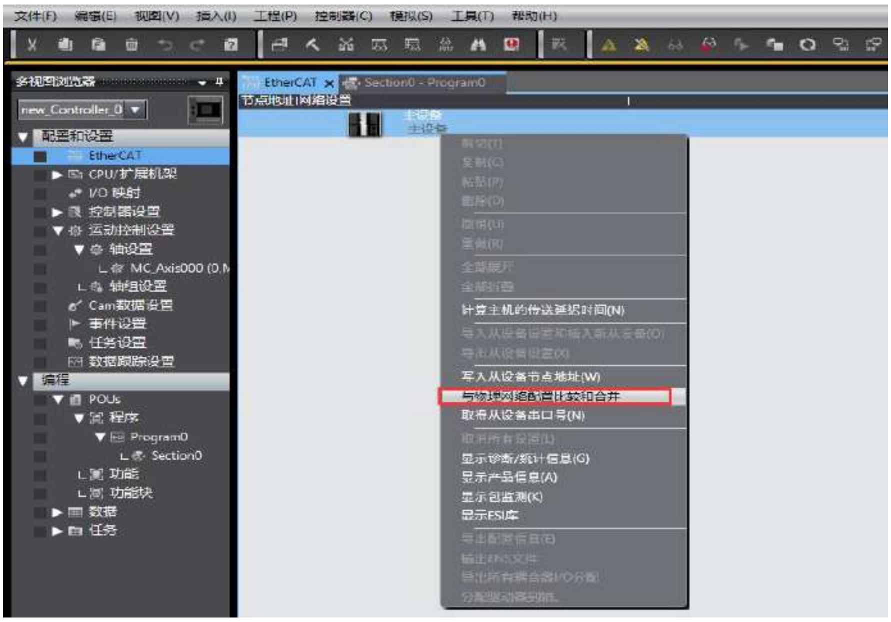


Figure 7-63 Compare and merge interface with physical network configuration

2) Click "**Apply physical network configuration**" in the pop-up to complete the communication between the PLC and the servo drive.

3) Click to download the program to the PLC.
The two yellow lights of the servo network port are on and the green lights are flashing, indicating that the communication between the PLC and the drive is successful.

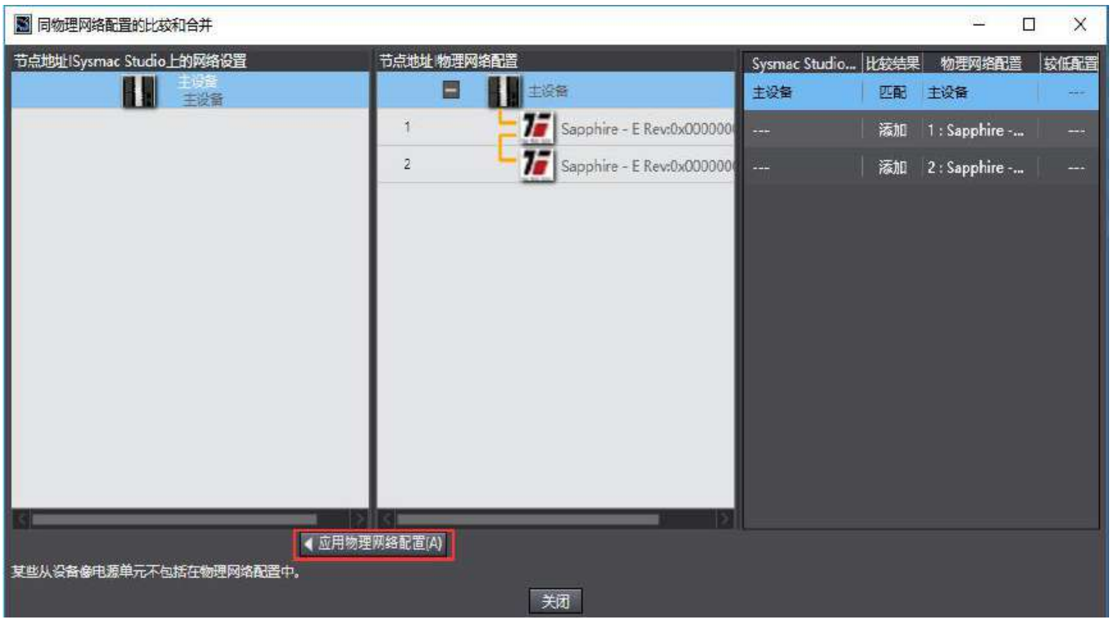


Figure 7-64 Apply physical network configuration

3. Configure communication

a. Configure the servo drive

In the left tree window, select "**Configuration and Settings-EtherCAT"**, click "Drive", and configure the servo drive.

Settings of PDO mapping and distributed clock settings are required.

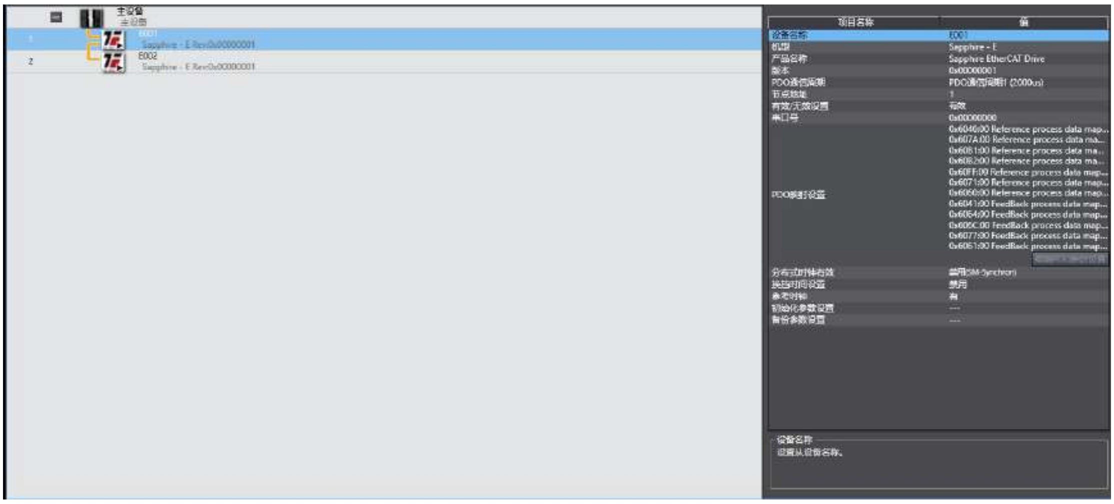


Figure 7-65 Modify PDO and distributed clock

PDO mapping: use default settings.

Distributed clock: please enable DC distributed clock. Otherwise the program cannot run normally.

b. Configure axis

To add a control axis, in menu "**Motion Control Settings**", right click "**Axis Settings**" → "**Add**" → "**Motion Control Axis**".

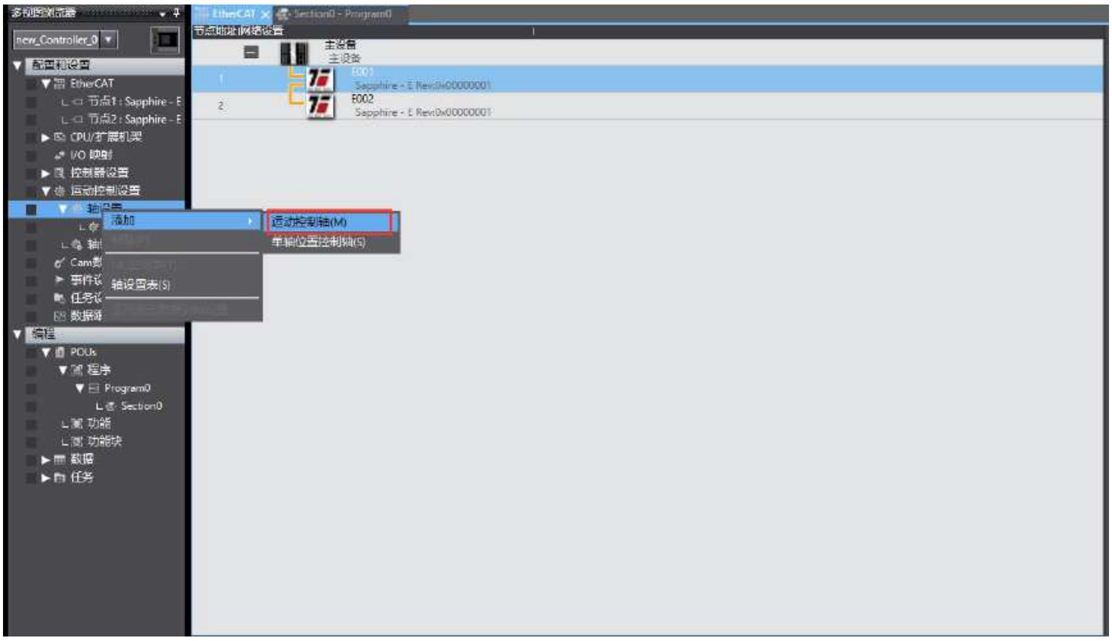


Figure 7-66 Add a motion control axis

Basic settings of axis

✓ Axis Use: the axis to use.

✓ Axis type: servo axis.

✓ Output device 1: to select the servo drive of the corresponding node.

✓ Detailed settings: set PDO for axes. Each axis configures the corresponding PDO according to the used function. If there is a digital input, please set it.

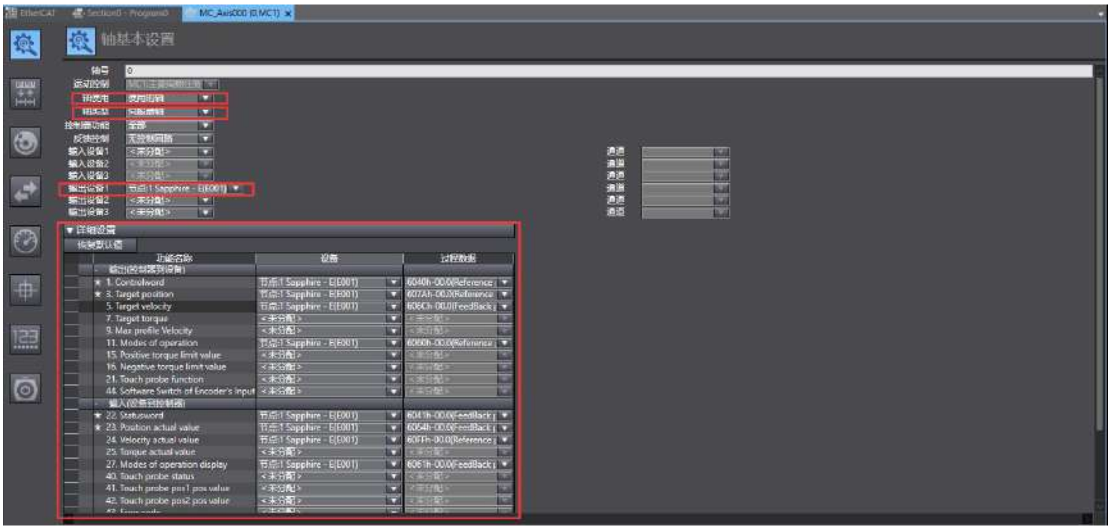


Figure 7-67 Basic axis settings

Unit settings

Unit: set the required unit according to actual needs.

Stroke distance:

- The number of command pulses in one revolution of the motor: please set it as the resolution of the encoder.
- To determine whether to use the gearbox according to whether there is a reducer.
- The stroke of the motor for one revolution: please set it according to the actual load movement distance for one revolution of the motor.

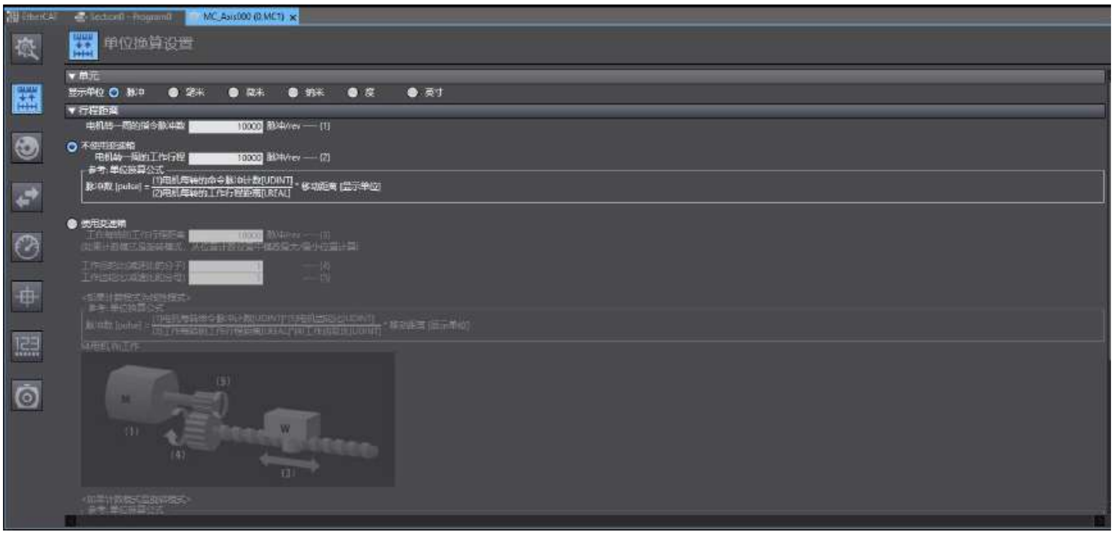


Figure 7-68 Set unit

Homing setting

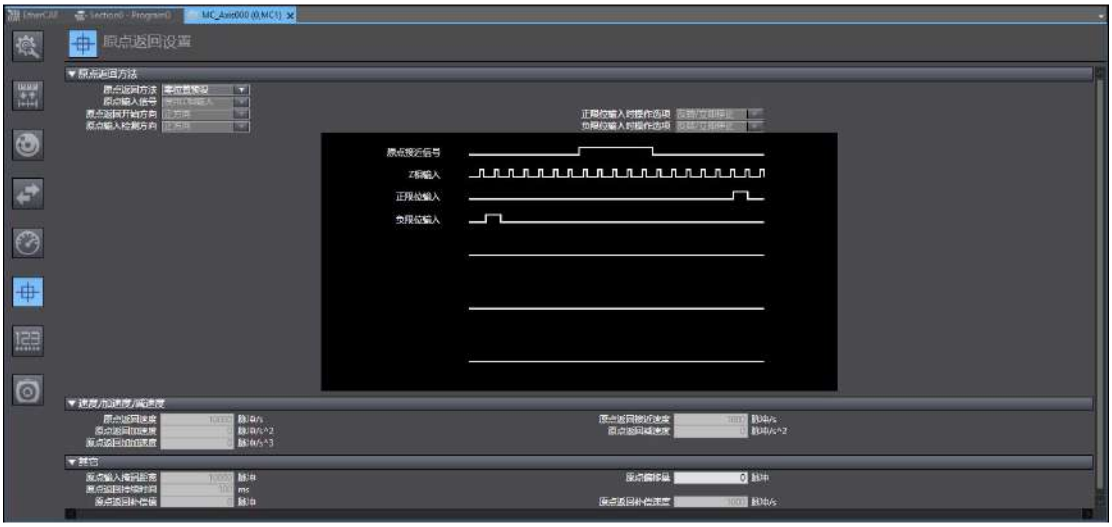


Figure 7-69 Zero return setting

Please select an appropriate homing method as required.

If you choose to use the external origin input, please connect the origin input signal to the digital input of the servo, and configure it in “**Axis-basic settings**” → “**Details**” → “**Digital Input**”.

Figure 7-70 Configure digital input

- Home switch: Home approaching signal of servo input.
- Positive limit switch: positive limit signal of servo input
- Negative limit switch: negative limit signal of servo input

Other settings

Note: it is the unit of the actuator. Units are important and set in the unit settings.

- Set the maximum acceleration.

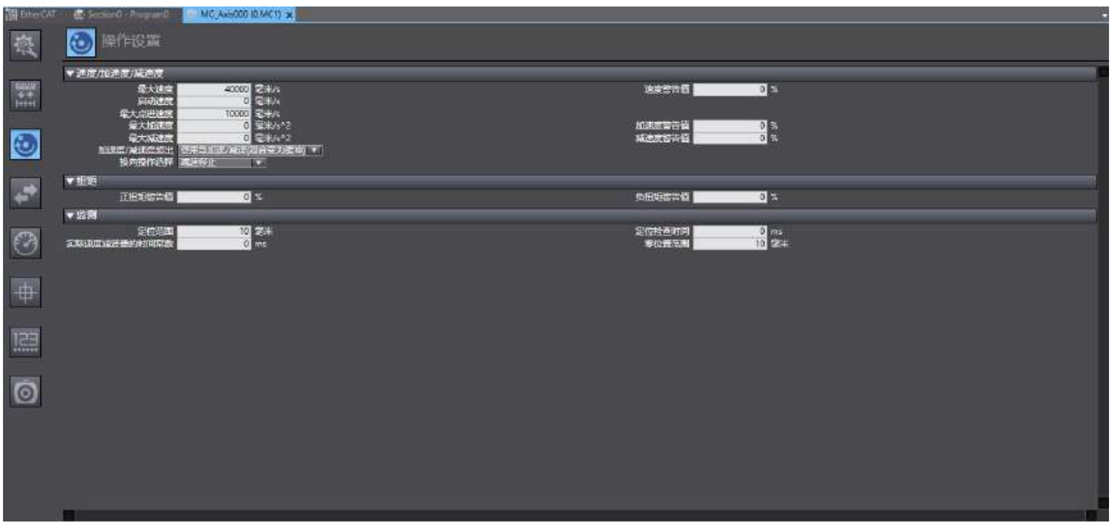


Figure 7-71 Set the maximum acceleration

- Set the maximum torque

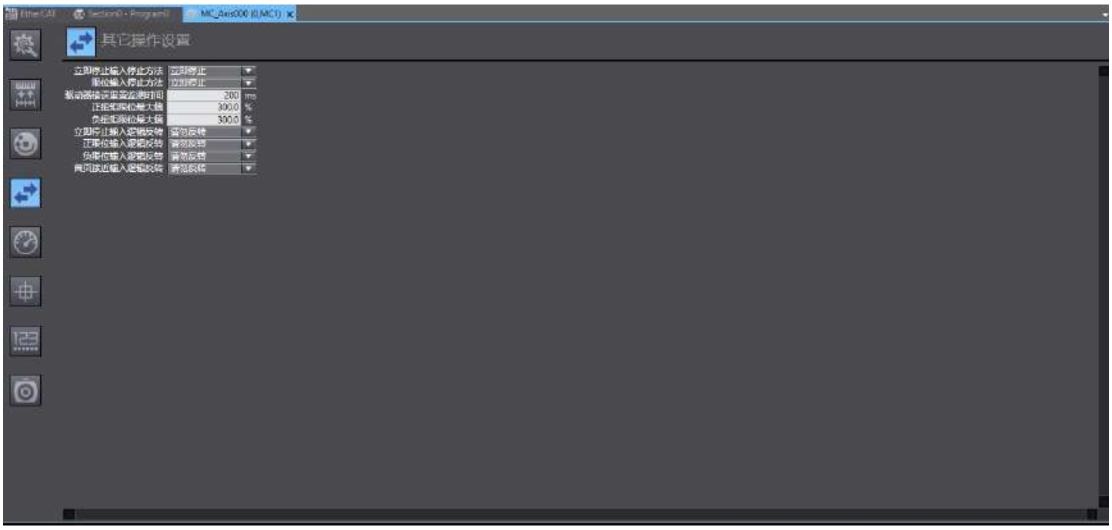


Figure 7-72 Set the maximum torque

- Set other settings.

c. Set task cycle to 4 ms (default value)

It should be the same with synchronization cycle of the lower computer.

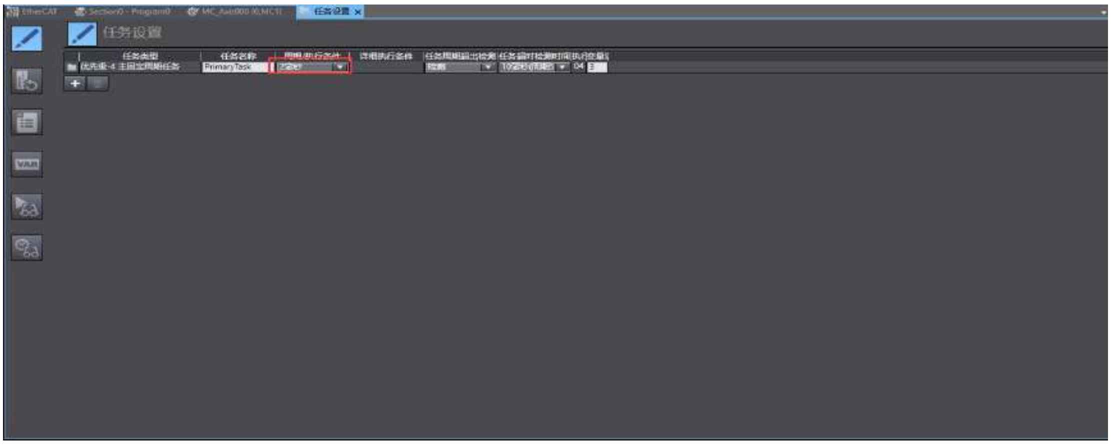


Figure 7-72 Set task cycle

IISMC (China)

Addr: Room 1008, Block A, No. 418, Guiping Road, Xuhui District, Shanghai, China
Hotline: 021-64030375
Email: sales@istomemc.com
Web: www.istomemc.com