

AX70-C-1608P CPU Module User Manual

Thanks for choosing AX series programmable controller (programmable controller for short). The programmable controller fully supports IEC61131-3 programming systems, EtherCAT real-time fieldbus, CANopen fieldbus (reserved), and high-speed I/O ports, and provides electronic cam, electronic gear, and interpolation functions.

The manual mainly describes the specifications, features, wiring, and use methods of the CPU module of the programmable controller. To ensure that you use the product safely and properly and bring it into full play, read the manual carefully before the installing. For details about the user program development environments and user program design methods, see *AX Series Programmable Controller Hardware User Manual* and *AX Series Programmable Controller Software User Manual* that we issue.

The manual is subject to change without prior notice. Please visit www.invt.com to download the latest manual version.

1 Safety precautions

1.1 Warning signs

Sign	Name	Description	Abbreviation
	Danger	Serious physical injury or even death may occur if related requirements are not followed.	
	Warning	Physical injury or device damage may occur if related requirements are not followed.	

1.2 Delivery and installation

- Only trained and qualified electricians are allowed to install, wire, maintain, and inspect the programmable controller.
- Do not install the programmable controller on inflammables. In addition, prevent the programmable controller from contacting or adhering to inflammables.
- Install the programmable controller in a lockable control cabinet of at least IP20, which prevents the personnel without electrical equipment related knowledge from touching by mistake, since the mistake may result in device damage or electric shock. Only personnel who have received related electrical knowledge and equipment operation training can operate the control cabinet.
- Do not run the programmable controller if it is damaged or incomplete.
- Do not contact the programmable controller with damp objects or body parts. Otherwise, electric shock may result.

1.3 Wiring

- Only trained and qualified electricians are allowed to install, wire, maintain, and inspect the programmable controller.
- Fully understand the interface types, specifications, and related requirements before wiring. Otherwise, incorrect wiring will cause abnormal running.
- Cut off all power supplies connected to the programmable controller before performing wiring.
- Before power-on for running, ensure that the module terminal cover is properly installed in place after the installation and wiring are completed. This prevents the live terminal from being touched. Otherwise, physical injury, device fault or misoperation may result.
- Install proper protection components or devices when using external power supplies for the programmable controller. This prevents the controller from being damaged due to external power supply faults, overvoltage, overcurrent, or other exceptions.

1.4 Commissioning and running

- Before power-on for running, ensure that the working environment of the programmable controller meets the requirements, the wiring is correct, the input power specifications meet the requirements, and a protection circuit has been designed to protect the controller so that the controller can run safely even if an external device fault occurs.
- For modules or terminals requiring external power supply, configure external safety devices such as fuses or circuit breakers to prevent damage caused due to external power supply or device faults.

1.5 Maintenance and component replacement

- Only trained and qualified electricians are allowed to perform maintenance, inspection, and component replacement for the programmable controller.
- Cut off all power supplies connected to the programmable controller before wiring programmable controller terminals.
- During maintenance and component replacement, take measures to prevent conductive materials such as screws and cables from falling into the internal of the programmable controller.

1.6 Disposal

- The programmable controller contains heavy metals. Dispose of a scrap product as industrial waste.
- Dispose of a scrap product separately at an appropriate collection point but not place it in the normal waste stream.

2 Product introduction

2.1 Model and nameplate

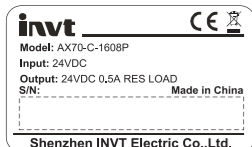


Figure 2.1 Product nameplate

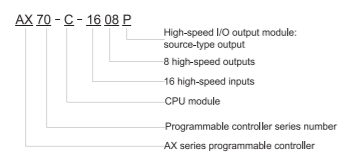


Figure 2.2 Product model

2.2 Function overview

As the main control module of the programmable controller, AX70-C-1608P CPU module (CPU module for short) has the following functions:

- Realizes the control, monitoring, data processing, and networking communication for the system running of the programmable controller.
- Supports the IL, ST, FBD, LD, CFC, and SFC programming languages compliant with IEC61131-3 standards by using CODESYS (V3.5.9.5) launched by Smart Software Solution GmbH (3S) for programming.
- Supports 16 local expansion modules (such as the I/O, temperature, and analog modules).
- Uses EtherCAT or CANopen bus (reserved) to connect slave modules, each of which supports 16 expansion modules (such as the I/O, temperature, and analog modules).
- Supports Modbus TCP master/slave protocol.
- Integrates two RS485 interfaces, supporting Modbus RTU master/slave protocol.
- Supports high-speed I/O, 16 high-speed inputs and 8 high-speed outputs.
- Supports EtherCAT fieldbus motion control on a maximum of 32 axes with synchronization time of 1ms, 2ms, 4ms, or 8ms.
- Supports pulse single- or multi-axis motion control, including 2–4 axis linear interpolation, 2 axis arc interpolation, and 3 axis spiral interpolation (reserved).
- Supports real-time clock.
- Supports power-failure protection.

2.3 Structural dimensions

The structural dimensions (unit: mm) of the CPU module are shown in the following figure.

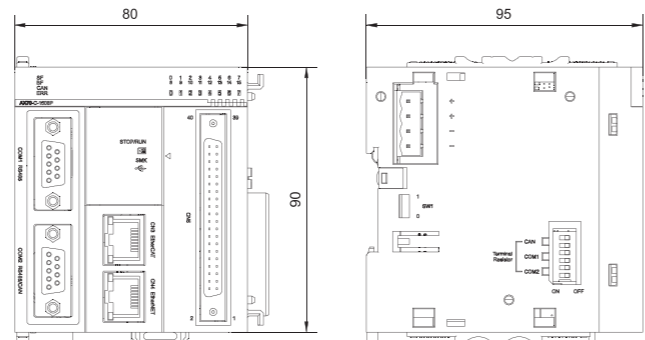


Figure 2.3 Structural dimensions

3 Interfaces

3.1 Interface description

3.1.1 Interface distribution

Figure 3.1 shows the interface distribution of the CPU module. For each interface, a respective silk screen description is provided nearby, facilitating wiring, operation and check.

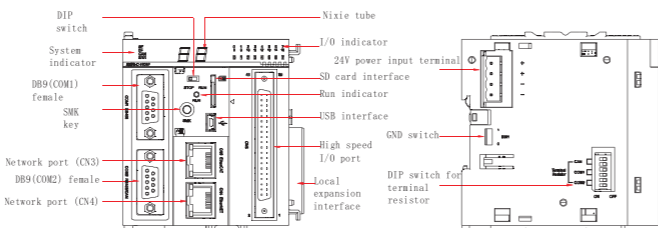


Figure 3.1 Interface distribution

Interface	Function
DIP switch	RUN/STOP DIP switch.
System indicator	SF: System fault indicator. BF: Bus fault indicator. CAN: CAN bus fault indicator. ERR: Module fault indicator.
DB9 (COM1) female	One RS485 interface, supporting Modbus RTU master/slave protocol.
SMK key	SMK smart key.
Network port (CN3)	EtherCAT interface.
DB9 (COM2) female	One interface supporting Modbus RTU master/slave protocol and the other interface supporting CANopen master/slave protocol (reserved).
Network port (CN4)	Supports Modbus TCP, standard Ethernet functions, and user program download and debug (only with IPv4).
Nixie tube	Displays alarms and replies to SMK key pressing.
I/O indicator	Indicates whether the signals of 16 inputs and 8 outputs are valid.
SD card interface	Used to store user programs and data (reserved).
RUN indicator	CPU module running indicator.
USB interface	Used to download and debug programs (reserved).
High-speed I/O	16 high-speed inputs and 8 high-speed outputs.
Local expansion interface	Supports the expansion of 16 I/O modules, disallowing hot swapping.
24V power input terminal	DC 24V voltage input, adapting to AX70 series power module.
Grounding switch	Connection switch between the system internal digital ground and housing ground. It is disconnected by default (SW1 is set to 0). It is used only in special scenarios where the system internal digital ground is taken as the reference plane. Exercise caution before operating it. Otherwise, system stability is impacted.
DIP switch of terminal resistor	ON indicates terminal resistor connection (it is OFF by default). 1 and 2 correspond to COM1 (RS485-1), 3 and 4 correspond to COM2 (RS485-2), 5 and 6 correspond to COM2 (CAN).

3.1.2 SMK key description

The main function of the SMK key is to reset the CPU module IP address, which is 192.168.1.10 by default. If you want to restore the default address from a modified IP address, you can press and hold the SMK key for restoring. The operation method is as follows:

Set the CPU module to the STOP state. If you press and hold the SMK key, the nixie tube displays "rP" and turns off alternately, indicating IP address reset. The reset operation succeeds if the nixie tube is steady on. If you release the SMK key, the nixie tube displays "00".

Note: If you release the SMK key when the nixie tube displays "rP" and turns off alternately, the IP address reset operation is cancelled, and the nixie tube displays "00".

3.1.3 Nixie tube display

If a program has no fault after being downloaded and run, the nixie tube displays "00" steadily.

If the program encounters a fault, the nixie tube displays the fault information in blinking way. For example, if only fault 19 occurs, the nixie tube displays "19" and turns off alternately; if fault 19 and fault 29 occur simultaneously, the nixie tube displays "19", turns off, displays "29", and turns off alternately; if more faults occur simultaneously, the display way is similar.

3.2 Terminals

3.2.1 COM1 and COM2 terminals

COM1 and COM2 of the CPU module are RS485 communication terminal and RS485/CAN communication terminal, both of which use a DB9 connector for data transmission.

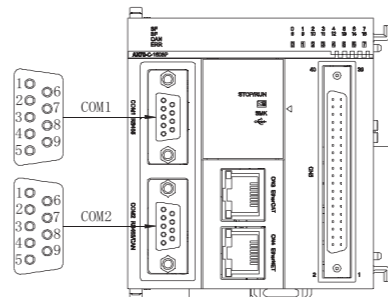


Figure 3.2 COM1/COM2 terminal layout diagram

The following table lists the pins of COM1 and COM2.

Port	Distribution	Pin	Definition	Function
COM1 (RS485)		1	/	/
		2	/	/
		3	/	/
		4	RS485A	RS485 differential signal +
		5	RS485B	RS485 differential signal -
		6	/	/
		7	/	/
		8	/	/
		9	GND_RS485	RS485 power ground
COM2 (RS485/CAN)		1	/	/
		2	CAN L	CAN differential signal -
		3	/	/
		4	RS485A	RS485 differential signal +
		5	RS485B	RS485 differential signal -
		6	GND_CAN	CAN power ground
		7	CAN H	CAN differential signal +
		8	/	/
		9	GND_RS485	RS485 power ground

3.2.2 High-speed I/O terminals

The high speed I/O port of the CPU module has 16 high-speed inputs and 8 high-speed outputs.

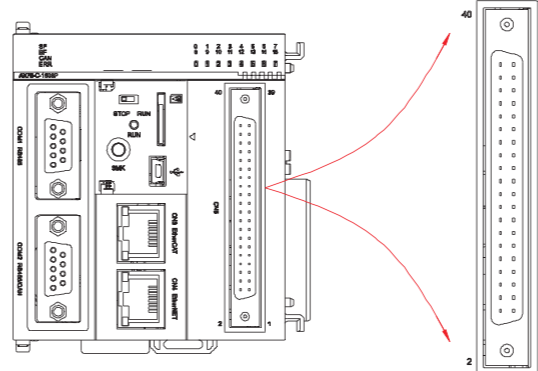


Figure 3.3 High-speed I/O port terminal layout

Port	External circuit	CN5 pin		Internal circuit	Signal	
		Line B	Line A		Line B	Line A
Input		40	39		HSD 24V input (IN0-24V)	HSD 24V input (IN1-24V)
		38	37		HSD differential input (IN0-DIFF)	HSD differential input (IN1-DIFF)
		36	35		HSD input common terminal (IN0-COM)	HSD input common terminal (IN1-COM)
		34	33		HSD 24V input (IN2-24V)	HSD 24V input (IN3-24V)
		32	31		HSD differential input (IN2-DIFF)	HSD differential input (IN3-DIFF)
		30	29		HSD input common terminal (IN2-COM)	HSD input common terminal (IN3-COM)
		28	27		HSD 24V input (IN4-24V)	HSD 24V input (IN5-24V)
		26	25		HSD differential input (IN4-DIFF)	HSD differential input (IN5-DIFF)
		24	23		HSD input common terminal (IN4-COM)	HSD input common terminal (IN5-COM)

Port	External circuit	CN5 pin		Internal circuit	Signal	
		Line B	Line A		Line B	Line A
Input		22	21		Input common terminal SS1	Input common terminal SS2
		20	19		Standard input (IN6)	Standard input (IN7)
		18	17		Standard input (IN8)	Standard input (IN9)
		16	15		Standard input (IN10)	Standard input (IN11)
		14	13		Standard input (IN12)	Standard input (IN13)
		12	11		Standard input (IN14)	Standard input (IN15)
Output		10	9		Output (OUT0)	Output (OUT1)
		8	7		Output (OUT2)	Output (OUT3)
		6	5		Output (OUT4)	Output (OUT5)
		4	3		Output (OUT6)	Output (OUT7)
		2	1		Common output terminal (COM1)	Common output terminal (COM2)

Note:

- HSD is short for high speed. All 16 input channels of the CPU module allow high-speed input, but the first 6 channels support 24V single-end or differential input, and the last 10 channels support 24V single-end input.
- The connection from each I/O point to the internal circuit is isolated by using an optocoupler.
- The total length of high-speed I/O port connection cable cannot exceed 3 meters.
- Do not bend the cables when fastening the cables.
- During cable routing, separate the connection cables from high-power cables that cause strong interference but not bind the connection cables with the latter together. In addition, avoid long-distance parallel routing.

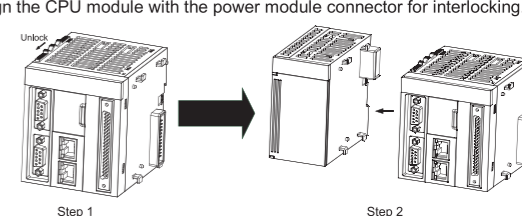
3.3 Module installation

Using modular design, the programmable controller is easy to install and maintain. As for the CPU module, the main connection objects are the power module and expansion modules.

The modules are connected by using the module-provided connection interfaces and snap-fits.

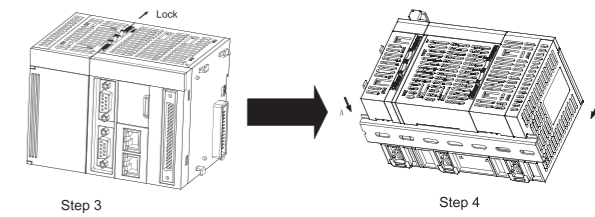
Installation procedure

Step 1 Slide the snap-fit on the CPU module in the direction shown in following figure (using power module connection for example)



Step 3 Slide the snap-fit in the direction shown in the following figure to connect and lock the two modules.

Step 4 As for standard DIN rail installation, hook the respective module into the standard installation rail until the snap-fit clicks into place.



3.4 Cable connection and specifications

3.4.1 EtherCAT bus connection

EtherCAT bus specifications

Item	Specifications
Communication protocol	EtherCAT protocol
Supported service	COE (PDO/SDO)
16-axis min. synchronization interval	1ms
Max. synchronization shake	Less than 1ms
Synchronization method	DC
Physical layer	100BASE-TX
Baud rate	100Mbps
Duplex mode	Full duplex
Topology structure	Serial connection
Transmission media	Network cable (see <i>Cable selection</i>)
Transmission distance	Distance between two nodes less than 100 meters
Slave number	125 at most
EtherCAT frame length	44 bytes–1498 bytes
Process data	Up to 1486 bytes per frame

Cable selection

The CPU module can implement EtherCAT bus communication through the CN3 port. INVT AX70 optional cables are recommended.

Option	Model	Specifications
Shielded cable for communication	AX-L3-20	Shielded cable for EtherCAT communication, two meters

Option	Model	Specifications
Shielded cable for communication	AX-L3-50	Shielded cable for EtherCAT communication, five meters

EtherCAT communication cable requirements

If you make the communication cables by yourself, ensure the cables meet the following requirements:

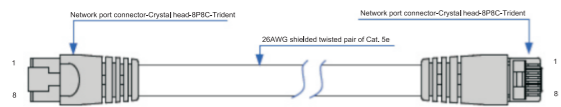


Figure 3.4 Self-made network cable requirements

- Note:**
- The communication cables you use must pass the conductivity test 100%, without short circuit, opened circuit, dislocation or poor contact.
 - To ensure communication quality, the EtherCAT communication cable length cannot exceed 100 meters.
 - You are recommended to make the communication cables by using the shielded twisted pairs in category 5e, compliant with EIA/TIA568A, EN50173, ISO/IEC11801, EIA/TIA bulletin TSB, and EIA/TIA SB40-A&TSB36.

3.4.2 CANopen cable connection (Reserved)

Topology

The CAN bus connection topology structure is shown in the Figure 3.5. It is recommended that the shielded twisted pair be used as the CAN bus, each end of which connects a 120Ω terminal resistor to prevent signal reflection. In most cases, the shield layer uses single-point grounding.

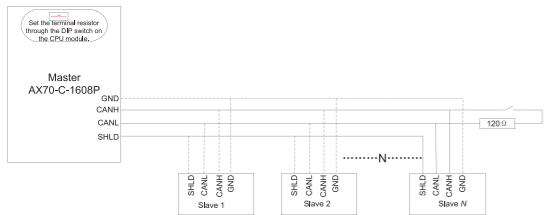


Figure 3.5 CAN bus connection diagram

Cable selection

The same terminal is used for both CANopen communication and RS485 communication, both of which use a DB9 connector for data transmission. The pins in the DB9 connector have been described earlier. INVT AX70 optional cables are recommended. If you make the communication cables by yourself, make the cables according to the pin description and ensure the manufacturing process and technical parameters meet communication requirements.

Option	Model	Specifications
RS485/CAN communication cable	AX-L2-20	RS485/CAN communication cable (DB9 male & terminal), two meters
RS485/CAN communication cable	AX-L2-30	RS485/CAN communication cable (DB9 male & terminal), three meters
RS485/CAN communication cable	AX-L2-50	RS485/CAN communication cable (DB9 male & terminal), five meters

- Note:**
- To enhance cable anti-interference capability, you are recommended to use aluminum foil shielding and aluminum-magnesium braid shielding techniques when making the cables.
 - Use the twisted-pair winding technique for the differential cable.

3.4.3 Serial RS485 communication connection

The CPU module provides two channels of RS485 communication, COM1 and COM2, both of which use a DB9 connector for data transmission. The pins in the DB9 connector have been described earlier. INVT AX70 optional cables are recommended. If you make the communication cables by yourself, make the cables according to the pin description and ensure the manufacturing process and technical parameters meet communication requirements.

Option	Model	Specifications
RS485/CAN communication cable	AX-L2-20	RS485/CAN communication cable (DB9 male & terminal), two meters
RS485/CAN communication cable	AX-L2-30	RS485/CAN communication cable (DB9 male & terminal), three meters
RS485/CAN communication cable	AX-L2-50	RS485/CAN communication cable (DB9 male & terminal), five meters

3.4.4 Ethernet connection

Networking

The Ethernet port of the CPU module is CN4, which can connect to another device such as a computer or HMI device by using a network cable in the point-to-point mode.

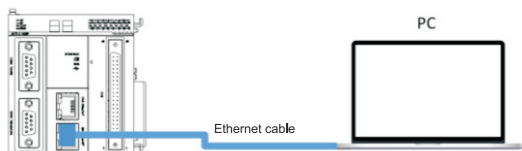


Figure 3.6 Ethernet connection diagram

You can also connect the Ethernet port to a hub or switch by using a network cable, implementing multi-point connection.

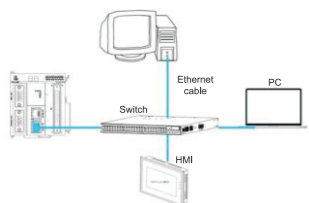


Figure 3.7 Ethernet networking diagram

Option	Model	Specifications
Shielded cable for communication	AX-L3-20	Shielded cable for EtherCAT communication, two meters
Shielded cable for communication	AX-L3-50	Shielded cable for EtherCAT communication, five meters

4 Use instructions

4.1 Technical parameters

4.1.1 General specifications of the CPU module

Item	Specifications																											
Input voltage	24VDC																											
Power consumption	Lower than 15W																											
Power-failure protection time	300ms (no protection within 20 seconds after power-on)																											
Backup battery of the real-time clock	Included																											
Backplane bus power supply	5V/2.5A																											
Programming method	IEC 61131-3 programming languages (LD, FBD, IL, ST, SFC, and CFC)																											
Program execution method	Local online																											
User program storage space	10MB																											
Flash memory space for power failure protection	512KB																											
SD card specifications	32G MicroSD																											
Soft elements and characteristics	<table border="1"> <thead> <tr> <th rowspan="2">Element</th> <th rowspan="2">Name</th> <th rowspan="2">Count</th> <th colspan="3">Storage characteristics</th> </tr> <tr> <th>Default</th> <th>Writable</th> <th>Remarks</th> </tr> </thead> <tbody> <tr> <td>I</td> <td>Input relay</td> <td>64KWord</td> <td>Not save</td> <td>No</td> <td>X: 1 bit B: 8 bits</td> </tr> <tr> <td>Q</td> <td>Output relay</td> <td>64KWord</td> <td>Not save</td> <td>No</td> <td>W: 16 bits D: 32 bits</td> </tr> <tr> <td>M</td> <td>Auxiliary relay</td> <td>256KWord</td> <td>Save</td> <td>Yes</td> <td>L: 64 bits</td> </tr> </tbody> </table>	Element	Name	Count	Storage characteristics			Default	Writable	Remarks	I	Input relay	64KWord	Not save	No	X: 1 bit B: 8 bits	Q	Output relay	64KWord	Not save	No	W: 16 bits D: 32 bits	M	Auxiliary relay	256KWord	Save	Yes	L: 64 bits
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M	Auxiliary relay	256KWord	Save	Yes	L: 64 bits																							
Program retention method upon power failure	Retention by the internal flash																											
Interruption mode	The high-speed DI signal of the CPU module can be set as interruption input, allowing up to eight points of input, and the rising edge and falling edge interruption modes can be set.																											

4.1.2 High-speed I/O specifications

Item	Specifications		
	High-speed input (Differential or single-end) (IN0-IN5)		High-speed input (Single-end) (IN6-IN15)
Signal	24V input	Differential input	24V input
Rated input voltage	24VDC (+20%~-15%, with the pulse within 5%)	EIA standard RS-422-A differential line driver level (equivalent to AM26LS31)	24VDC (+20%~-15%, with the pulse within 5%)
Rated input current	5.25mA (Typical value) (at 24VDC)		5.7mA (Typical value) (at 24VDC)
ON current	Greater than 2mA		Greater than 2mA
OFF current	Less than 1mA		Less than 1mA
Input resistor	4.58kΩ		4.2kΩ
Max. counting speed	800K Pulse/s (2PH fourfold frequency), 200kHz (single channel of input)		
2PH input duty ratio	40%: 60%		
Common terminal	Two groups of common terminal	--	Every five points use one common terminal.

High-speed output specifications

Item	Specifications
Signal	Output (OUT0-OUT7)
Output polarity	Source output (High-end output)
Control circuit voltage	DC 5V~24V
Rated load current	100mA/point, 0.5A/COM
Max. voltage drop at ON	0.2V (Typical value)
Leakage current at OFF	Less than 0.1mA
Output frequency	200kHz (The output of 200kHz requires the externally connect equivalent load must be greater than 12mA.)
Common terminal	Every four points use one common terminal.

- Note:**
- The high-speed I/O ports have restrictions on the allowed frequency. If the input or output frequency exceeds the allowed value, control and identification may be abnormal. Arrange the I/O ports properly.
 - The high-speed differential input interface does not accept the single-end input level of greater than 15V. Otherwise, the input circuit may be damaged.

4.2 Programming tool

The programmable controller uses the CODESYS (V3.5.9.5) platform. The CODESYS platform is a powerful software programming tool, which supports six programming languages compliant with IEC61131-3 standards, IL, St, FBD, LD, CFC and SFC. You can obtain CODESYS from the website www.codesys.com or from the local INVT dealer.

You can install CODESYS on a desktop or portable computer, of which the operating system is at least Windows 7, memory space is at least 2GB, free hardware space is at least 10GB, and the CPU main frequency is higher than 2GHz. Then you can connect your computer to the CPU module of the programmable controller through a network cable so that you can download and debug user programs.

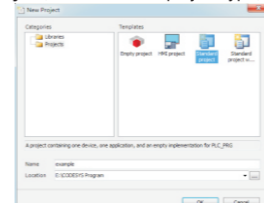
5 Programming instance

The following uses an instance to describe how to perform programming.

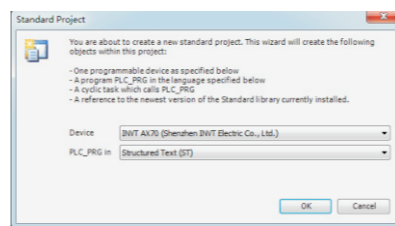
First of all, connect all the modules of the programmable controller, including connecting the power supply to the CPU module, connecting the CPU module to the computer where CODESYS has been installed and to the required expansion module, and connecting the

EtherCAT bus to the motor drive.

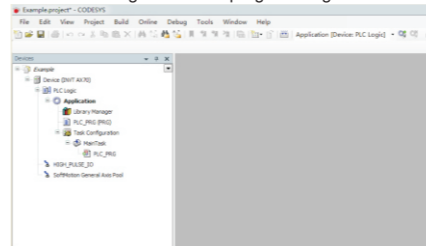
Start CODESYS to create a project and perform programming configuration.
Step 1 Choose **File > New Project**, and select the project type, saving location, and name.



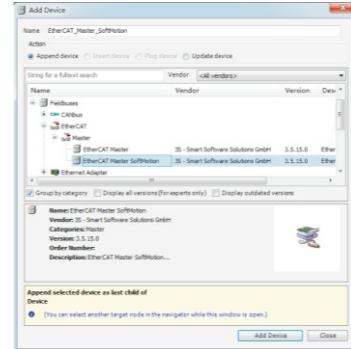
Step 2 Click **OK**. Then select a device type and programming language in the standard project configuration window that appears.



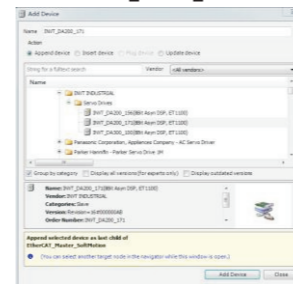
Step 3 Access the CODESYS configuration and programming interface.



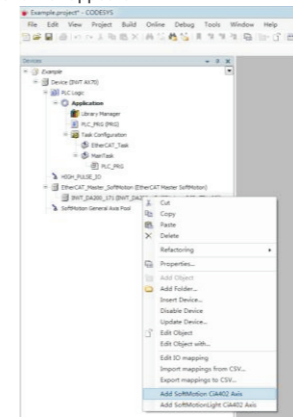
Step 4 Right-click **Device** in the left pane, choose **Add Device** in the shortcut menu that appears, and then choose **EtherCAT Master SoftMotion** shown in the following figure.



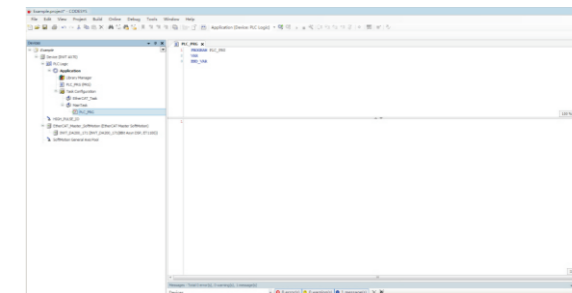
Step 5 Right-click **EtherCAT_Master** in the left pane, choose **Add Device** in the shortcut menu that appears, and then choose **INVT_DA200_171** shown in the following figure.



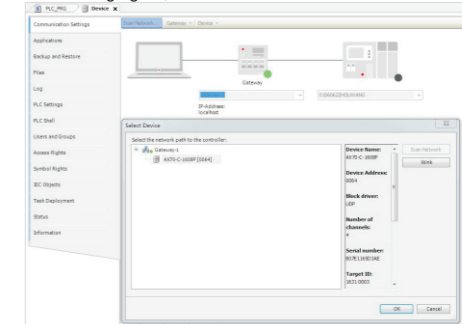
Step 6 Right-click **INVT_DA200_171** in the left pane and choose **Add SoftMotion CiA402 Axis** from the shortcut menu that appears.



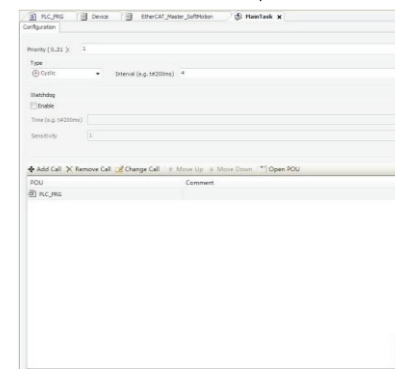
Step 7 Double-click **PLC_PRG** and write programs according to control processes.



Step 8 Double-click **Device** in the left pane, click **Scan Network**, choose **AX70-C-1608P[0064]** shown in the following figure, and click **OK**.



Step 9 Double-click **MainTask** under **Task Configuration** in the left pane. Set task priorities and execution intervals based on task real-time requirements.



In CODESYS, you can click to compile programs, and you can check for errors according to logs. After confirming the compilation is fully correct, you can click to log in to the programmable controller and download user programs to the programmable controller and you can perform simulation debugging.

6 Pre-startup check and preventive maintenance

6.1 Pre-startup check

If you have completed the wiring, ensure the following before starting the module to work:

- The module output cables meet requirements.
- The expansion interfaces at any levels are reliably connected.
- The application programs use the correct operation methods and parameter settings.

6.2 Preventive maintenance

Perform preventive maintenance as follows:

- Clean the programmable controller regularly, prevent foreign matters falling into the controller, and ensure good ventilation and heat dissipation conditions for the controller.
- Formulate maintenance instructions and regularly test the controller.
- Regularly check the wiring and terminals to ensure that they are securely fastened.

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