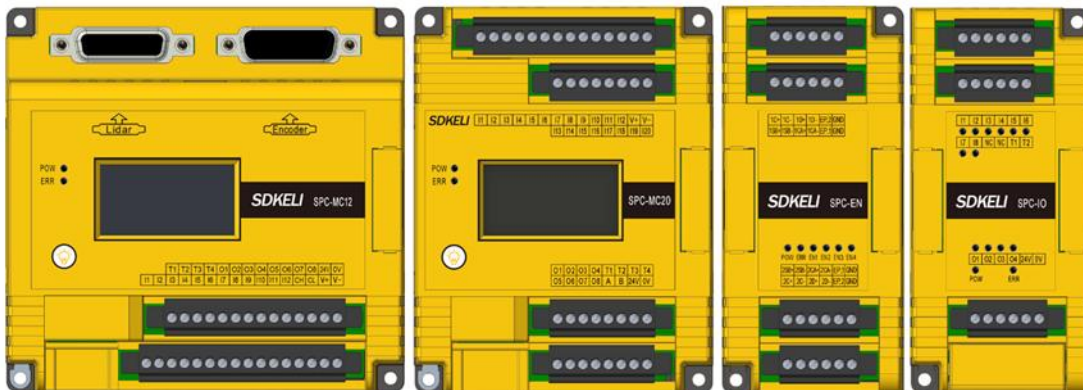




Safety Programmable Controller

Hardware instruction manual

(26004)



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1 Documentation description

This operating guide contains information necessary for the life cycle of the Safety Programmable Controller (SPC).

This operating guide should be used by all personnel using the Safety Programmable Controller.

1.1 Scope of application

This operating guide applies to all modules of the Safety Controller SPC.

This operating guide is used to guide the technicians of the machine builder or machine operator in safely installing, electrically installing, commissioning, and operating and maintaining the SPC.

This operating guide does not provide information regarding machine operation of the safety controller that has been/is to be integrated. Please refer to the machine operating guide for relevant information.

1.2 Information content

This operating guide mainly contains the following information about the safety controller:

- Complete machine installation
- Electrical installation
- Commissioning
- Maintenance
- Troubleshooting

In addition, professional technical knowledge not mentioned in this document is also required when planning and using Keli protective equipment.

In principle, the SPC should be operated in compliance with official and legal regulations.

For more information, Website: <http://www.sdkeli.com>.

1.3 Target groups

This operation guide is intended for project development (planning engineers, R&D personnel and operators), commissioning and maintenance personnel. The entire operating guide is very important for use according to regulations important.

Table 1-1: Target groups and selected chapters

Target group	Chapter
Project developers (planning engineers, R&D personnel, designers)	Chapter 6 Configuration Chapter 12 Technical parameters

Installer	Chapter 4 Complete machine installation
Safety professionals (e.g. CE Plenipotentiary, Compliance Specialist, and Application Inspection and Activation Personnel)	Chapter 6 Configuration Chapter 7 Commissioning Chapter 12 Technical data
Operator	Chapter 7 Commissioning Chapter 12 Troubleshooting
Maintenance personnel	Chapter 9 Maintenance Chapter 10 Troubleshooting

1.4 Icon and Document Specifications

This document uses the following icons and symbols:

 Warn
This is a safety warning sign, and the content of the sign is very important. Operators must strictly implement the safety information prompted by the signs to avoid possible personal injuries.

 Attention
This is a key information prompt sign, and the content of the sign is very important. Operators must understand and strictly implement the information requirements as much as possible to avoid possible legal disputes and product damage.

Action instructions

- Arrows indicate action instructions.
- 1. The order of action instructions is numbered.
- 2. Please execute the numbered action instructions in the given order.
- ✓ The hook symbol represents the result of the action instruction.

2 Safety information

This chapter contains general safety information about safety programmable controllers.

More safety information on specific usage scenarios of safety programmable controllers will be given in the corresponding sections.

2.1 Basic safety tips

Connection of products



Warn

If the product is incorrectly integrated, the product does not provide the expected protection.

- ▶ Product integration designed according to machine requirements (project planning).
- ▶ Product integration as per project plan.

Mechanical and Electrical Installation



Warn

Voltage and/or accidental start-up of the machine may cause death or serious injury

- ▶ Ensure that the machine is in and remains unpowered during mechanical and electrical installation.
- ▶ Ensure that the machine hazard status has been released and remains released.



Attention

Improper installation or use

If you don't pay attention, you can't achieve the required safety technology level.

- ▶ Comply with all applicable standards and instructions when assembling, installing and applying safety programmable controllers.
- ▶ Comply with domestic and international regulations when installing and using safety programmable controllers, commissioning and routine technical inspections.
- ▶ Manufacturers and operators of machines using safety programmable controllers must, under their own responsibility, consult with the competent authorities and comply with all applicable safety regulations/rules.
- ▶ Always follow the tips, especially the inspection instructions in this operating guide (e.g. related to use, assembly, installation or integration into the machine control system).
- ▶ Inspections must be performed by qualified security personnel or specially certified and authorized personnel and documented in a manner that is readily traceable by a third party.

Configuration



Attention

Incorrect configuration leads to the failure of protective equipment

If you don't pay attention, a dangerous state may not end or not end in time.

If you don't pay attention, you can't achieve the required safety technology level.

- ▶ Check whether the configured security application monitors the machine or equipment as expected and whether the configured application remains secure at all times. This must be guaranteed in all operating modes and in some applications. Record the inspection results.
- ▶ Re-check security features after each configuration change.
- ▶ Follow the inspection instructions in the Operating Guide for Connected Protective Equipment.

Repairs and alterations



Attention

Improper operation on product

The altered product may not provide the expected protection.

► The product must not be serviced, opened, tampered with, or otherwise altered except as described in this document.

2.2 Safety performance

The Safety Programmable Controller SPC is an adjustable controller suitable for safety applications.

It can be used according to the following criteria:

- IEC 61508 up to SIL 3
- IEC 62061 up to SIL 3
- ISO 13849-1 up to PL e, Cat.4

The safety level actually achieved depends on the external wiring, the implementation of the wiring, the setting of parameters, the selection of control switches and their arrangement on the machine.

Products can be used for safety features.

In any case, the product is only allowed to be used under the specified and given technical parameters and operating conditions.

The product is only suitable for use in industrial environments.



Attention

If the product is not used according to the regulations, improperly changed or tampered with, the company will not be responsible for the loss. In addition, the company does not assume any responsibility for the losses and joint and several losses caused therefrom.

UL, CSA applications

If the product is used according to UL 61010-1, 3rd Ed. Rev. June 06, 2023, CAN/CSA C22.2 No. 61010-1-12 (R2022) or UL 61010-2-201, 2nd Ed., May 14, 2018, CAN/CSA C22.2 No. 61010-2-201:18, the following additional conditions are required:

- According to UL 248 Requirements, a fuse with a maximum current of 4A and a minimum voltage of 30V DC is used to protect the 24V voltage supply of the equipment.
- Can only connect the screw terminals or spring terminals using copper conductors with a temperature resistance of at least 60 °C/75 °C and conductor cross section AWG30-20 or AWG24-16.
- Use 0.22 to 0.25 N·m torque tightening screw terminals.
- Use equipment only in environments that do not exceed contamination level 2.



Attention

Functional safety has not been assessed by UL. The certification complies with UL 61010-1, 3rd Ed. Rev. June 06, 2023, and CAN/CSA C22.2 No. 61010-1-12 (R2022) for general applications.

2.3 Qualified safety personnel

Products should only be planned, installed, connected, operated and maintained by qualified safety personnel.

Project planning

You need expertise to implement security features and choose the right product for it. You need expertise in relevant standards and specifications.

Mechanical installation, electrical installation and commissioning

You need the corresponding expertise and experience. You must be able to assess whether the machine is in a safe operating condition.

Configuration

You need the corresponding expertise and experience. You must be able to assess whether the machine is in a safe operation condition.

Operation and maintenance

You need the corresponding expertise and experience. You must be trained in operation by the machine operator. When performing maintenance, you must be able to assess whether the machine is in a safe operation condition.

2.4 Compliance with EU Directive Requirements

Extract

The Manufacturers Agent Signatory hereby declares that this product meets the requirements of the following EU Directive (including all relevant modifications) and is manufactured on the basis of the standards and/or technical specifications described in the EU Declaration of Compliance.

- RoHS DIRECTIVE 2011/65/EU
- EMC DIRECTIVE 2014/30/EU
- MACHINERY DIRECTIVE 2006/42/EC

2.5 Standard application precautions

The manual provides standards. Display regional standards with the same or similar content in the table. Not all standards are applicable to all products.

Table 2-1: Standard considerations

Serial number	Standard	Standard Region (China)
1	ISO 13849-1	GB/T 16855.1
2	IEC 61508	GB/T 20438
3	IEC 62061	GB 28526
4	IEC 61131-2	GB/T 15969.2

5	IEC 60204-1	GB/T 5226.1
6	IEC 60068-2-6	GB/T 2423.10
7	IEC 60068-2-27	GB/T 2423.5
8	IEC 60529	GB/T 4208
9	IEC 60825-1	GB 7247.1
10	IEC 61140	GB/T 17045
11	IEC 61496-1	GB/T 19436.1
12	IEC 61496-2	GB/T 19436.2
13	IEC 61496-3	GB 19436.3
14	ISO 13855	GB/T 19876

3 Product description

This chapter introduces the features, structure, and functions of safety programmable controllers.

3.1 System characteristics

The Safety Programmable Controller SPC can connect switching elements and sensors (such as emergency stop buttons, laser scanners, safety light curtains, photoelectric switches, encoders, etc.) and be logically combined with each other. By means of the output signal switching device of the safety controller, the relevant excitation element of the machine/plant can be safely turned off.

The SPC system has the following characteristics:

- Modular structure: The system adopts a combined structure of "main control module + expansion module". One main control module has up to 14 IO modules and 2 EN modules. Can be used for multi-master module communication.

- Safety inputs: up to 132, supporting digital and switching signal inputs.

- Safe outputs: up to 84, PNP transistor outputs.

- Function blocks: Use up to 255 basic logical operation blocks and specific function blocks. Wherein the basic logic operation block comprises AND, OR, NO, XOR, SO, RS trigger, delay function block. Specific functional blocks include Encoder monitoring, lidar monitoring, emergency stop monitoring, switch monitoring, reset, light curtain monitoring, two-hand monitoring, mode selection monitoring, EDM.

- Encoder interfaces: up to 12, interface support: A/B incremental encoder (frequency up to 500KHz), sine and cosine incremental encoder (frequency up to 500KHz) 120KHz, SSI encoder (highest baud rate 500KHz).

- Communication interface: Supports Ethernet, CAN, RS485, Type C

Configuration software SPCTool can be used to configure applications.



Attention

The range of available services for the SPC system depends on the configuration software used. Refer to "Versions and Compatibility" section.

3.2 Version and Compatibility

Different firmware versions or SPCTool configuration software versions provide different SPC product features. This section focuses on which firmware version is required and/or which SPCTool Configuration Software Version to implement specific functions/applications.

Table 3-1: Versions and Features/Applications

Serial number	Functions/Applications	Minimum firmware version	Minimum SPCTool version
1	Basic logic operation blocks and specific function blocks	V1.0. 0.0	V1.0.0
2	-	-	-
3	-	-	-



Attention

- Higher version modules are backward compatible, so each module can be replaced by a module with a higher firmware version.
- In order to make full use of all the functions of the higher firmware version module, the corresponding higher version configuration software may be required.
- Configuration software is not upward compatible. Opening a project created by a higher version with an older version of the configuration software may cause risks to occur.
- The hardware version of the SPC module can be viewed online from the hardware configuration of the configuration software.
- The firmware version of the SPC module can be found in the "Firmware Version" column of the module nameplate.
- The manufacturing date of the equipment can be viewed on the module production number label in the format "yyyymmdd-xxxxx" (yyyy = year, mm = month, dd = date, xxxxx = production serial number).
- Configure the software version to view under the "Information" column of the software menu bar.

3.3 Structure and Function

System Structure

The SPC system consists of the following modules:

- 1 main control module
- Up to 14 IO expansion modules
- Up to 2 EN expansion modules, with each EN expansion module connected reducing the maximum number of available IO expansion modules by 2.



Attention

Modules not mentioned here shall not be connected to the SPC system.

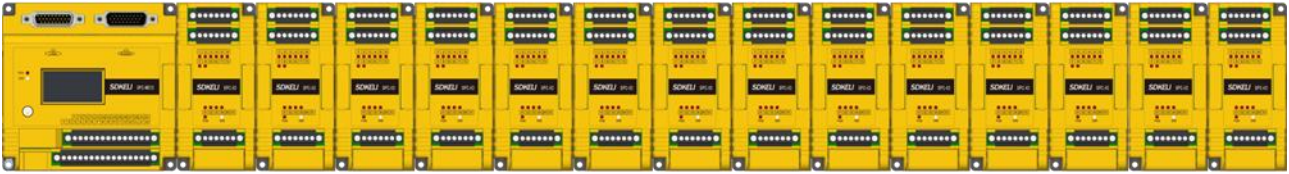


Figure 3-1: Maximum structure diagram of SPC system (MC12+14IO)

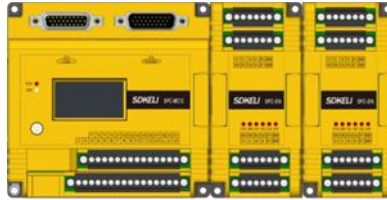


Figure 3-2: Maximum structure diagram of SPC system (MC12+2EN)

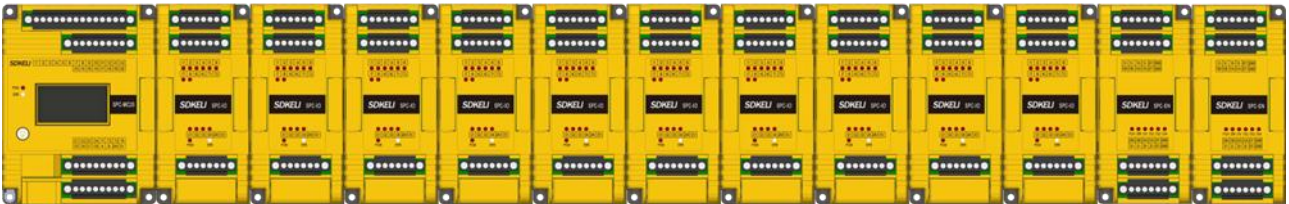


Figure 3-3: Maximum structure diagram of SPC system (MC20+10IO + 2EN)

Table 3-2: Module Overview

Model	Type	Input number/channel	Output number/channel	Communication	Maximum quantity
SPC-MC1284ALEC	Main control module	12	8	ETH、CAN、Type C	1
SPC-MC208400E4		20	8	ETH, RS485 Type C	1
SPC-IO08420000	Expansion module	8	4	-	14
SPC-EN0000S000		0	0	-	2

4 Complete machine installation

Module Arrangement

- The main control module is located on the far left.
- All other expansion modules can be installed in any order to the right of the main control module.

Voltage warning



Attention

There is a hazard of injury due to electric shock while connecting the device.

- Power off the entire device/machine.

Installation premises

- Protective measures must be taken to protect the safety controller from condensation and conductive dirt, such as installation in an IP54-rated electrical cabinet.
- Installation in accordance with EN 50274.
- Install on a 35mm rail with functional earth connected to the rail as per IEC 60715.
- Install vertically (rail horizontal prevention), as shown in Figure 4-1.
- To ensure air circulation, leave at least 30 mm of space above each module.
- Leave at least 50 mm of space in front and back of the module, depending on the interface selected, more space may be needed.
- Take appropriate measures to prevent foreign matter from entering the plug opening.
- Take appropriate ESD protection measures.

Installation tool

SPC supports two installation methods, one is rail snap mounting (see installation steps below) and the other is screw mounting. To ensure the reliability of installation, it is recommended to use cross-grooved pan-head screws, size: M3 x 12, cross-type screwdriver, VDE insulation, size: PH1 x 100 mm for screw installation.

After installation, the tools should be properly kept and maintained regularly to prevent rust or deformation, which will affect the installation quality.

Installation steps

1. Insert the module into the guide rail ①.
 2. Press the module onto the DIN rail in the direction of the arrow ②.
- ✓ The module clicks in and makes a click sound.

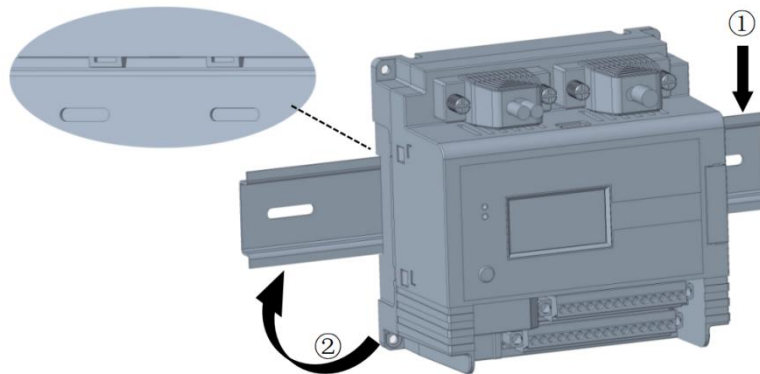


Figure 4-1: Installing module on DIN rail

3. Will extend the modules snap into the rails one by one in the direction of the arrows until the side plugs remain at a distance.

Supplementary Information

The connection of the expansion module requires a VBUS cable, and the user can choose the cable length according to the actual application distance.

5 Electrical installation

This chapter describes the electrical installation of the SPC system in the electrical cabinet.

5.1 Electrical installation requirements



Attention

Voltage warning

There is a hazard of injury due to electric shock while connecting the device.

- Power off the entire device/machine.



Attention

Equipment/machine start-up unexpectedly

The device/machine may start up unexpectedly while connecting the device.

- Power off the entire device/machine.



Attention

Violation of safety standards resulting in failure of protective equipment

If you are not careful, you may not achieve the required level of safety technology.

- Comply with the corresponding safety standards (e.g. EN 62061) for all safety-related parts of the equipment (wiring, wired sensors and control switches, configuration, monitoring of external equipment).

Key points of electrical installation

- The SPC complies with the EMC requirements of the general standard EN 61000-6-2 for use in industrial areas.
- Industrial safety devices of KELI are only suitable for local DC applications. If a device is used in a voltage supply network, such as reference IEC 61326-3-1, additional protective measures shall be taken.
- Machines using safety devices must be in accordance with EN 62305-1 installed and designed according to lightning protection zones. The required level can be achieved through the use of external protective equipment. The over voltage protection device used must meet the requirements of EN 61643-11.
- Equipment must be protected against "common mode" interference in the frequency range of 0 Hz to 150 Hz per IEC 61000-4-16.
- To establish sufficient EMC safety, the DIN rail must be connected to functional ground (FE).
- According to EN 60204-1 and similar standards, the external voltage supply of the SPC module must be able to buffer short-term power outages of 20 ms.
- The voltage supply and all connected signals must comply with the low voltage regulations (SELV, PELV) for safe isolation according to EN 60664 and EN 50178 (electronic equipment for power supply facilities)
- According to the requirements of EN 1175, the battery-powered 24V power circuit is isolated from the circuit of the safety controller by a packaged DC-DC converter (for example, when used on AGV)
- If the Type-C interface on the main control module is used for communication, the maximum allowable cable length is 3 m.

- The GND of the Type-C interface is internally connected to the GND interface of the voltage supply of the main control module. Avoid the formation of a ground loop between the GND of the Type-C interface and the GND supplied by the voltage of the main control module.

- If Ethernet communication is used on the main control module, SPC with RJ45 interface, standard twisted pair Ethernet cable with shielding layer should be used, with a maximum transmission distance of 100 m, in compliance with EN 50173 standard requirements.

- If using RS485 communication on the main control module, pay attention to the selection and wiring of transmission cables. The transmission cable should be a shielded cable with twisted pair, and both ends of the shielding layer should be grounded. When the baud rate is 1Mbps, the maximum transmission distance is 200m.

- If using CAN communication on the main control module, pay attention to the selection and wiring of transmission cables. The transmission cable should be a shielded cable with twisted pair, terminated with a 120 ohm matching resistor, and both ends of the shielding layer should be grounded. When the baud rate is 1Mbps, the maximum transmission distance is 20m.

- Depending on external loads, especially inductive loads, additional external protection measures (such as varistors, RC components) may be required to protect the output. Refer to the section "Technical Parameters" regarding operating limits. It is important to note that response times may increase depending on the type of suppressor.

- When replacing the module, it is necessary to ensure that the terminal blocks are correctly allocated, such as by marking or laying the cables accordingly.

Installation tool

Multimeter, wire crimping pliers, screwdriver (One line shape, VDE insulation, dimensions: 0.4 x 2.5 x 80 mm), Ethernet cable (Super Category 5), USB to Type-C data cable, etc.

Installation tools should be properly kept to prevent damage or distortion, and electrical tools should be calibrated regularly.

Electrical installation

- Perform electrical installation in accordance with EN 60204-1.

- The shielding of the ETH, CAN, RS485 cables is directly connected to the functional earth (FE) on the device that introduces the cable into the electrical cabinet.

- Establish a star connection between the GND interface of the excitation element and the GND interface of the voltage supply at the O1 to O8 outputs. Otherwise, an excitation element, such as a relay, may accidentally turn on when the common GND cable is broken, at least one output is high and at least one excitation element output is low.

- Ensure that all modules, connecting equipment, and voltage supply of the SPC system are connected to the same ground port.



Attention

Reverse current when ground wire is broken causes unexpected high state at input terminal
If you don't pay attention, you can't achieve the required level of safety technology.

If you don't pay attention, the dangerous state may not end or end in time. If multiple safety inputs are connected in parallel:

- Check if this reverse current can unexpectedly lead to a high state, see "Data Parameters" section.

- Consider this possible failure source in risk analysis and risk reduction strategies.

5.2 Modules and interfaces

5.2.1 Main control module SPC-MC12

Overview

The main control module SPC-MC12 is the central processing unit of the whole system, which monitors all signals according to the configuration stored in the system and processes them logically. The processing result is the output of the switching system. The system internal bus VBUS acts as the system power and data interaction interface.

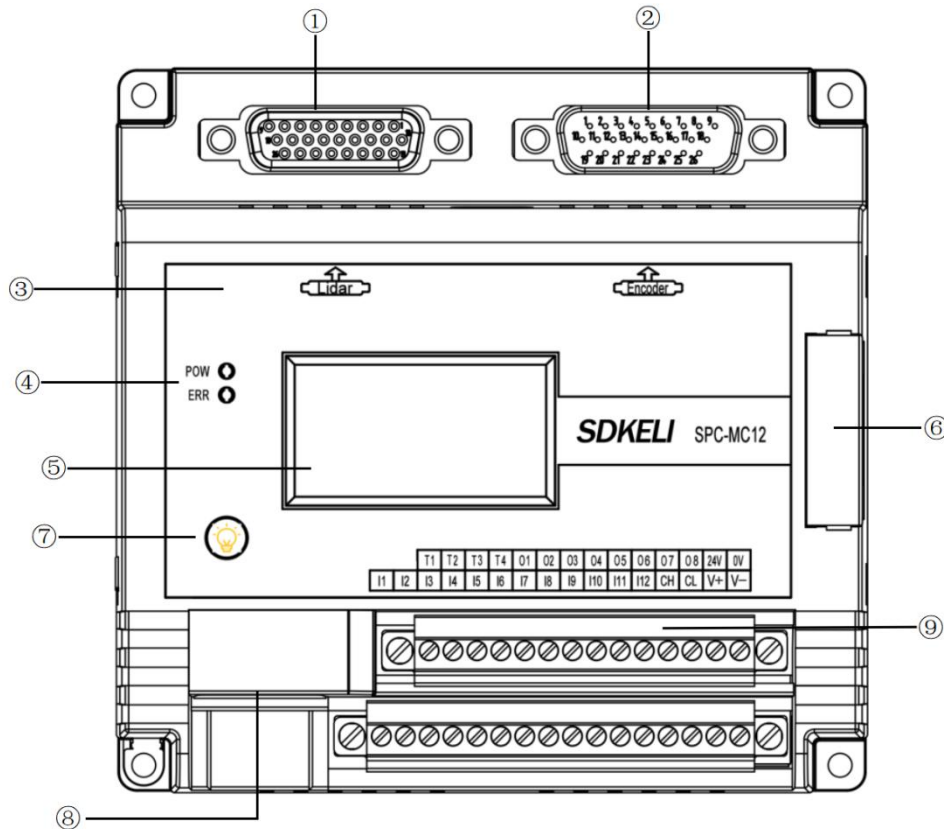


Figure 5-1: Master Control Module SPC-MC1284ALEC

- ①: Lidar interface
- ②: Encoder interface
- ③: Panel
- ④: Indicator light
- ⑤: OLED display
- ⑥: VBUS bus
- ⑦: Screen operation buttons
- ⑧: ETH interface
- ⑨: input/output/power terminal

Table 5-1: SPC-MC12 Input and Output Power Terminal Interface Allocation

Serial number	Terminal Block (Identification)	Pin allocation
1	TO1 to TO4	Test outputs 1 to 4
2	O1 to O8	Safety outputs 1 to 8
3	24V, 0V	Output power supply

4	I1 to I12	Input 1 to 12
5	CH, CL	CAN communication interface CH is connected to a high-level signal line CL is connected to a low-level signal line
6	V+, V-	System power interface V+ is connected to 24V V- is connected to 0V

Table 5-2: SPC-MC12 Lidar DB Allocation

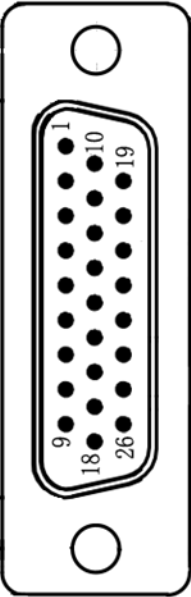
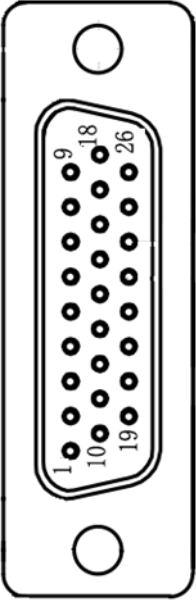
DB terminal	Serial Number/Pin	Terminal Block (Identification)	Element	Pin allocation
	7	R1IN2	Lidar 1	OSSD1. A
	6	R1IN1		OSSD1. B
	17	R1IO1/B1		General I/O 1
	18	R1IO2/A1		General I/O 2
	19	R1IO4/B2		General I/O 3
	9	R1IO3/A2		General I/O 4
	12	DC24V		Power Supply: DC24V
	11	GND		Power Supply: 0V
	5	R2IN2	Lidar 2	OSSD1. A
	8	R2IN1		OSSD1. B
	21	R2IO1/B1		General I/O 1
	4	R2IO2/A1		General I/O 2
	24	R2IO4/B2		General I/O 3
	26	R2IO3/A2		General I/O 4
	3	DC24V		Power Supply: DC24V
	2	GND		Power Supply: 0V
	10	ROUT1/C1	Lidar 1 and Lidar 2	Input 1
	20	ROUT2/C2		Input 2
	22	ROUT3/D1		Input 3
	14	ROUT4/D2		Input 4
	23	ROUT5/E1		Input 5
	15	ROUT6/E2		Input 6
	25	ROUT7/F1		Input 7
	16	ROUT8/F2		Input 8
	13	GND		PE
	1	GND		PE

Table 5-3: SPC-MC12 Encoder DB Allocation:

DB terminal	Serial Number/Pin	Terminal block (Identification)	Element	Pin allocation	
				AB increment	Sine and cosine
	26	+ 1CA	Encoder 1	A +	COS +
	17	-1CA		A-	COS-
	18	+1SB		B +	SIN +
	9	-1SB		B-	SIN-
	2	EN _ POW		Power supply of encoder 1: 24V	
	1	GND		Power supply of encoder 1: 0V	
	23	+ 2CA	Encoder 2	A +	COS +
	16	-2CA		A-	COS-
	24	+ 2SB		B +	SIN +
	25	-2SB		B-	SIN-
	4	EN _ POW		Power supply of encoder 2: 24V	
	3	GND		Power supply of encoder 2: 0V	
	21	+ 3CA	Encoder 3	A +	COS +
	12	-3CA		A-	COS-
	22	+ 3SB		B +	SIN +
	13	-3SB		B-	SIN-
	6	EN _ POW		Power supply of encoder 3: 24V	
	5	GND		Power supply of encoder 3: 0V	
	10	+ 4CA	Encoder 4	A +	COS +
	19	-4CA		A-	COS-
	11	+ 4SB		B +	SIN +
	20	-4SB		B-	SIN-
	8	EN _ POW		Power supply of encoder 4: 24V	
	7	GND		Power supply of encoder 4: 0V	
	14	no connect	-	-	-
	15	no connect	-	-	-



Attention

The main control module has two 26PIN DB ports for connecting up to two lidars or and four encoders.



Attention

Tighten each screw of the DB terminal alternately one turn at a time until a torque of 0.2 N·m is achieved.

5.2.2 Main control module SPC-MC20

Overview:

The main control module SPC-MC20 is the central processing unit of the whole system, which monitors all signals according to the configuration stored in the system and processes them logically. The processing result is the output of the switching system. The system internal bus VBUS acts as the system power and data interaction interface.

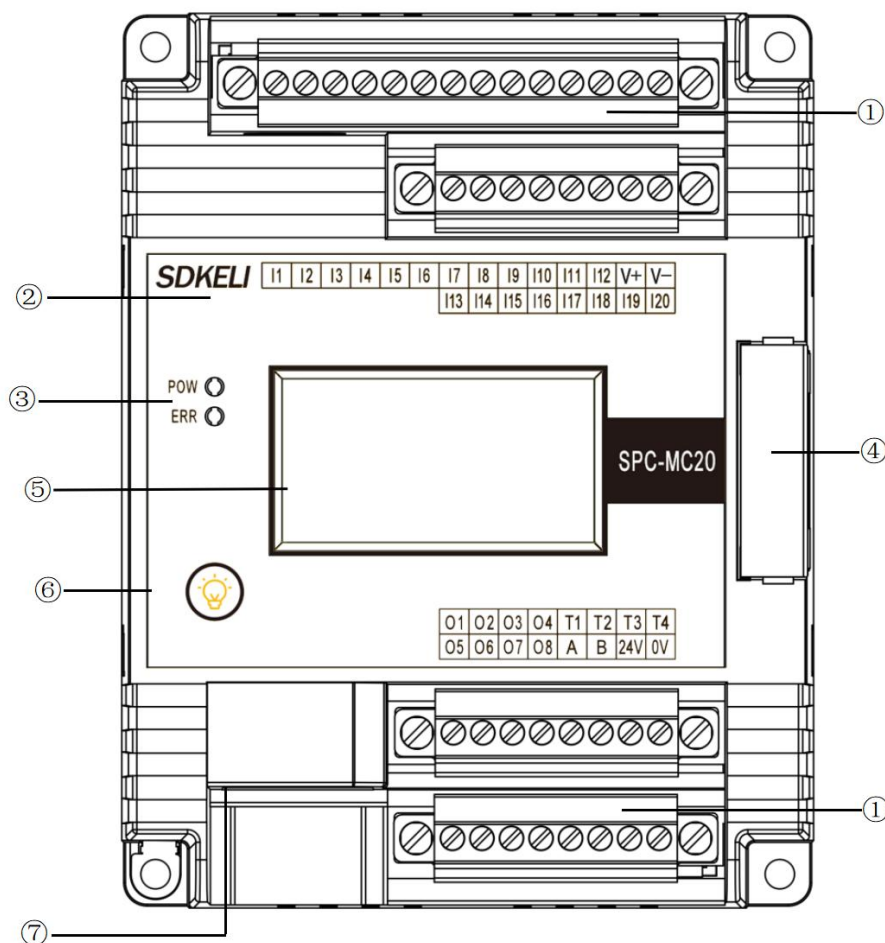


Figure 5-2: Master Control Module SPC-MC208400E4

- ①: Input/output/power terminal
- ②: Panel
- ③: Indicator lamp
- ④: VBUS bus
- ⑤: OLED display
- ⑥: Screen operation button
- ⑦: ETH interface

Table 5-4: SPC-MC20 Interface Assignment:

Serial number	Terminal Block (Identification)	Pin allocation
1	I1 to I12	Input 1 to 12
2	V+, V-	System power interface, V+ is connected to 24V, V- is connected to 0V
3	I13 to I20	Enter 13 to 20
4	O1 to O4	Safety outputs 1 to 4
5	T1 to T4	Test outputs 1 to 4
6	O5 to O8	Safety outputs 5 to 8
7	A, B	RS485 communication interface
8	24V, 0V	Output power supply

5.2.3 Expansion Module SPC-IO

Overview:

The expansion module SPC-IO has 8 safety inputs, 4 safety outputs and 2 test outputs, which is used to expand the number of input and output interfaces.

Extended features provided:

- Safety device for monitoring connection
- Pass the information on the I1 to I8 inputs to the main control module
- Enable/disable detection pulses on O1 to O4 outputs.



Attention

A short circuit between the unidentified test outputs causes the protective device to fail, and if you don't pay attention, the hazardous condition may not end or end in a timely manner.

- Configure the test output of the SPC-IO module with a test pulse width ≤ 4 ms and a test pulse interval ≥ 200 ms.

Working premise: This module can only run under the main control module.

The internal logic processing unit and the test output are supplied with voltage through the internal bus VBUS. The voltage supply to the O1 to O4 outputs must be supplied directly through the output power supply on the corresponding module.

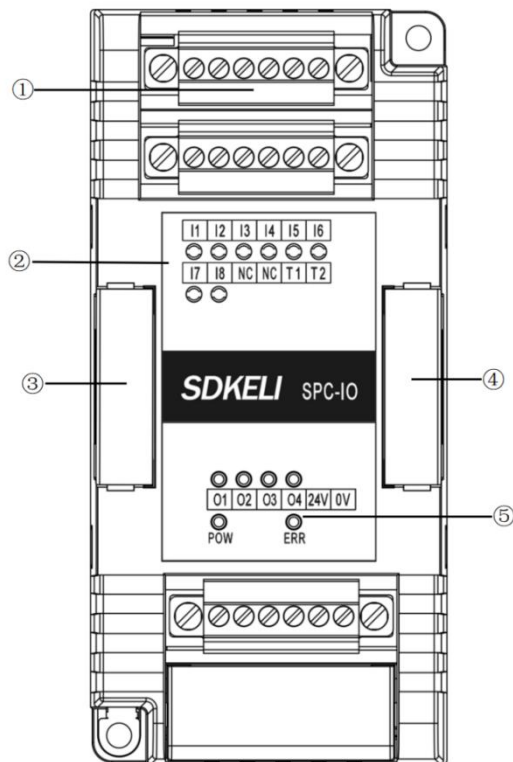


Figure 5-3: Expansion Module SPC-IO08420000

- ①: Input/output power supply terminal
- ②: Panel
- ③: VBUS bus-connect to the next module
- ④: VBUS bus-connect to the next module
- ⑤: Indicator lamp

Table 5-5: SPC-IO Interface Allocation:

Serial number	Terminal Block (Identification)	Pin allocation
1	I1 to I8	Enter 1 to 8
2	T1, T2	Test outputs 1, 2
3	O1 to O4	Safety outputs 1 to 4
4	24V, 0V	Output power supply
5	NC	Disconnect



Attention

Using test output:

The SPC-IO has 2 test outputs.

Each device to be tested must use the test output of the module to which it is connected.

Safety input and test output circuit

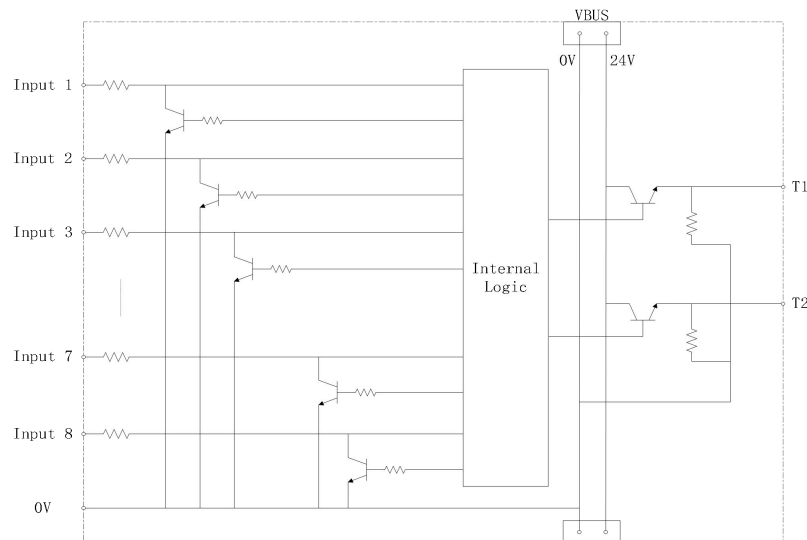


Figure 5-4 Safety input and test output internal circuits

Safety output circuit

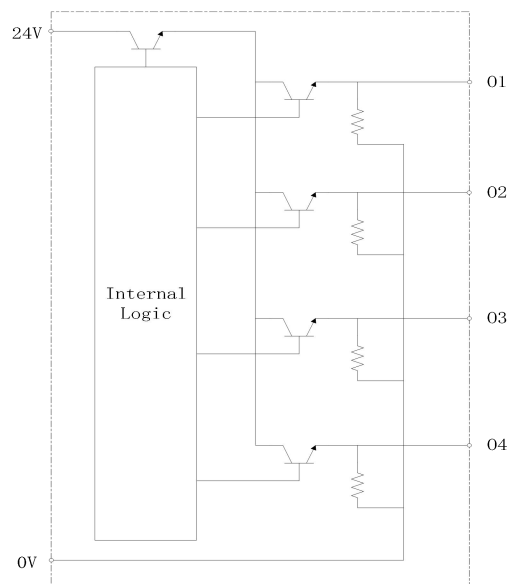


Figure 5-5 Safety Output Internal Circuit

5.2.4 Expansion Module SPC-EN

Overview

The expansion module SPC-EN is used to monitor the motion status of the drive system, including speed, deceleration, resting position and other information. The module has four encoder interfaces, which can be connected to A/B incremental encoder, sine and cosine encoder, and SSI encoder.

Extended features provided:

- Connect encoders for monitoring shaft movement: A/B incremental encoders HTL24V, TTL5V, maximum frequency 500KHz; Sine and cosine encoder 1Vss, 2.5VRef, maximum frequency 120KHz; SSI encoder, RS422, maximum baud rate 500kHz.
- Stationary monitoring
- Speed monitoring

- Direction monitoring
- Pass the information of the internal logic unit to the main control module

Working premise: This module can only run under the main control module.

The internal logic processing unit and the encoder power supply are supplied via the internal bus VBUS.

Encoder selection:


Attention

Selecting an inappropriate encoder causes protective equipment to fail.

If you are not careful, you may not achieve the required level of safety technology. Choose the right encoder.

► Take appropriate measures to prevent system failure or common cause failure of the encoder.

The correct selection of encoders is important to achieve the required Security Integrity Level (CCF) and Performance Level (PL). At the same time, attention should be paid to the systematic failure and common cause failure of the control system. Refer to 10.4 for details.

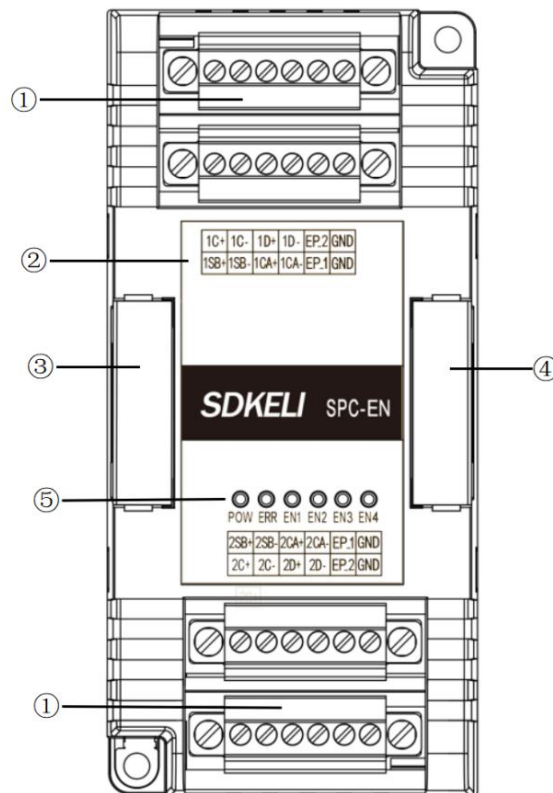


Figure 5-6: Expansion Module SPC-EN0000S000

- ①: Encoder input terminal
- ②: Panel
- ③: VBUS bus-connect to the previous module
- ④: VBUS bus-connect to the next module
- ⑤: Indicator lamp

Table 5-6: SPC-EN Interface Assignment:

Serial number	Terminal block (Identification)	Element	Pin allocation		
			AB increment	sin and cos	SSI
1	1C +	SSI Encoder 1	-	-	clock +
2	1C-		-	-	clock-
3	1D +		-	-	data +
4	1D-		-	-	data-
5	EP_2, GND		-	-	Encoder power supply interface
6	1SB +	Incremental/Sine and Cosine Encoder 1	B +	SIN +	-
7	1SB-		B- (GND)	SIN- (Sin_ Ref)	-
8	1CA +		A +	COS +	-
9	1CA-		A- (GND)	COS- (Cos_ Ref)	-
10	EP_1, GND		Encoder power supply interface		-
11	2SB +	Incremental/Sine and Cosine Encoder 2	B +	SIN +	-
12	2SB-		B- (GND)	SIN- (Sin_ Ref)	-
13	2CA +		A +	COS +	-
14	2CA-		A- (GND)	COS- (Cos_ Ref)	-
15	EP_1, GND		Encoder power supply interface		-
16	2C +	SSI Encoder 2	-	-	clock +
17	2C-		-	-	clock-
18	2D +		-	-	data +
19	2D-		-	-	data-
20	EP_2, GND		-	-	Encoder power supply interface

5.3 Voltage supply

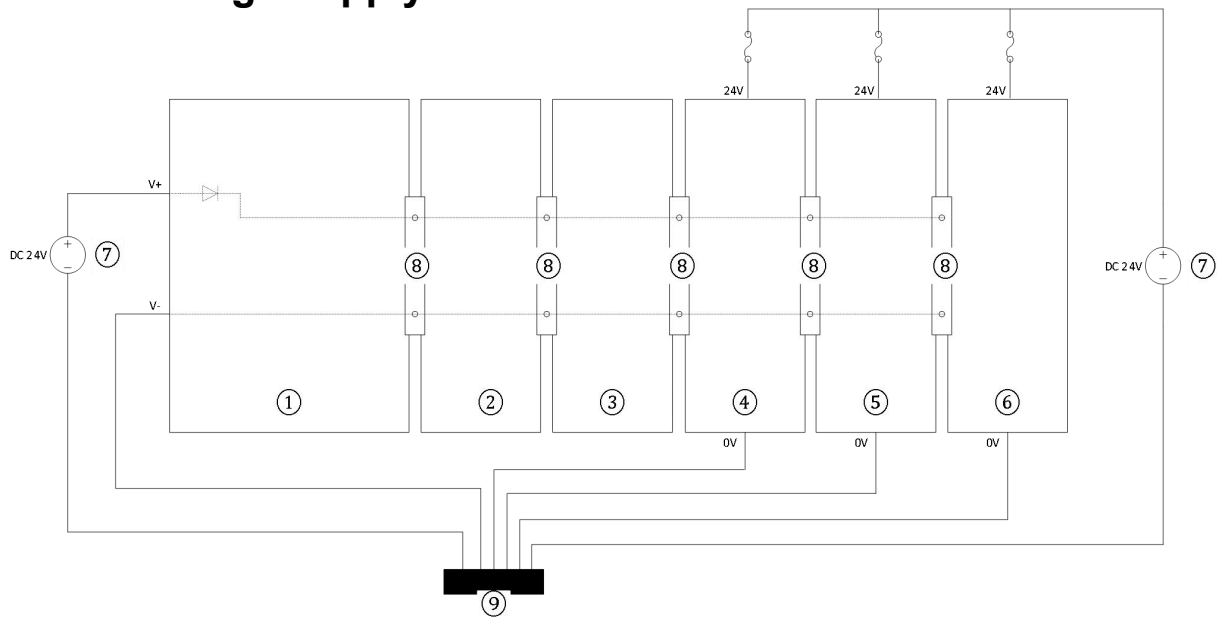


Figure 5-7: Voltage Supply Line for SPC System

- ①: Main control module
- ②: EN Expansion Module 1
- ③: EN Expansion Module 2
- ④: IO Expansion Module 1
- ⑤: IO Expansion Module 2
- ⑥: IO Expansion Module n
- ⑦: DC power supply
- ⑧: VBUS
- ⑨: Common Grounding Point

5.4 Peripheral connections

This section describes the connection of safety and non-safety sensors, excitation elements, and switching elements on the SPC system and provides installation instructions for selected functions.

Sensor



Attention

Failure to recognize the switch signal of the safety sensor resulted in the failure of the protective equipment. If not careful, the dangerous state may not end or may not end in a timely manner.

► The selection of the minimum shutdown time for connected sensors should be greater than the system scanning cycle of the SPC system, and attention should be paid to the minimum shutdown time information in the sensor technical parameters.

► Follow the safety tips and functional descriptions of the connected sensors, and contact the device manufacturer promptly if you have any questions.

► Follow the instructions for debugging and daily inspection in the operation manual for connecting sensors.

Single channel input



Attention

Unexpected pulses or delayed falling edges on single-channel inputs can cause protective equipment to fail.

If you don't pay attention, the dangerous state may not end or end in time.

If you don't pay attention, you can't achieve the required level of safety technology.

- ▶ Prevent short circuit of single-channel input or crossover circuit.
- ▶ Ensure that the signal line cable is laid without protection (due to crossover circuit with other signal lines)
- ▶ There is no short circuit detection, i.e. no test output is connected.

On a previously low single-channel input with test pulses, a short circuit to high may be treated as a pulse by the logic unit for fault identification. A short circuit to high causes the signal to go high first, and then to go low after a false identification time. Therefore, single-channel signals with test pulses require attention:

- If there is a short circuit to high on a single channel input with a test pulse that was previously high, the signal is regarded by the logic unit as a delayed falling signal edge.
- If an unexpected pulse or delayed falling edge on a single channel input may cause a dangerous condition, specific measures must be taken.

Pay special attention to the following inputs:

- Reset input on reset function blocks
- Restart input on the Restart function blocks
- Mask override inputs on function blocks
- Reset to 0 input and set to initial value input on the counter function blocks

Test Output



Attention

Failure of protective equipment due to incorrect test output connection

If you don't pay attention, you can't achieve the required level of safety technology.

- ▶ For each device to be tested, the test output of the device connection module is used.
- ▶ Follow the tips on the use of test pulses in the appropriate sections of this operating guide.
(Main Control Module Section 5.2. 1, 5.2. 2, Extension Module Section 5.2. 3)

5.4.1 Safety command devices and safety switches

5.4.1.1 Emergency stop button

Table 5-7: Emergency Stop Button Connection

Electrical connection: e.g. to SPC-IO	
Single channel, connection 24V	Contact between 24V and I1

Single channel, connected test output	Contact between T1 and I2
Dual channel, 24 V connection	Channel 1: Contact between 24V and I3 Channel 2: Contact between 24V and I4
Dual channel, connected test output	Channel 1: Contact between T2 and I5 Channel 2: Contact between T3 and I6

A dual channel emergency stop button with equivalent switch contacts is pre-configured in the configuration software. In order to achieve single-channel and dual-channel emergency stop control, you can find the corresponding component in the window interface by **Components-Inputs -Control Devices**.

Table 5-8: Functional characteristics using emergency stop button

Function	Description
Testing	Feasible
Series/Cascade	If the emergency stop buttons are connected in series, the maximum resistance of the cable shall not exceed 100 Ω (see section "Technical parameters")
Differential time	See Configuration Software Report for details



Attention

For more information, please refer to the operation guide of the emergency stop button

5.4.1.2 Safety switches

Table 5-9: Safety Switch Connections

Electrical connection: e.g. to SPC-IO	
Single channel, connection 24V	Contact between 24V and I1
Single channel, connected test output	Contact between T1 and I2
Dual channel, 24 V connection	Channel 1: Contact between 24V and I3 Channel 2: Contact between 24V and I4
Dual channel, connected test output	Channel 1: Contact between T2 and I5 Channel 2: Contact between T3 and I6

In order to achieve single-channel and dual-channel switch control, you can find the corresponding component in the window interface by **Component-Input-Safety Switch**.

Table 5-10: Safety Switch Connection with Locking

Electrical connection: e.g. to SPC-IO	
Single channel, connection 24V	Contact between 24V and I1 Coil on O1
Single channel, connected test output	Contact between T1 and I2 Coil on O1

Dual channel, 24 V connection	Channel 1: Contact between 24V and I3 Channel 2: Contact between 24V and I4 Coil on O1
Dual channel, connected test output	Channel 1: Contact between T2 and I5 Channel 2: Contact between T3 and I6 Coil on O1

Table 5-11: Functional Characteristics of Using Safety Switches

Function	Description
Testing	Feasible
Series/Cascade	If the safety switches are connected in series, the maximum resistance of the cable shall not exceed 100 Ω (see section "Technical parameters")
Differential time	See Configuration Software Report for details



Attention

For more information, please refer to the operating guide of the safety switch.

5.4.1.3 Enable switch

Table 5-12: Enable switch connections

Electrical connection: e.g. to SPC-IO	
2 positions, connection 24V	Channel 1 (NC): Contact between 24V and I1 Channel 2 (NC): Contact between 24V and I2
2 positions, connect test output	Channel 1 (NC): Contact between 24V and I3 Channel 2 (NC): Contact between 24V and I4
3 positions, 24V connection	Channel 1 (NC): Contact between 24V and I1 Channel 2 (NC): Contact between 24V and I2 Channel 3 (NO): Contact between 24V and I3 Channel 4 (NO): Contact between 24V and I4
3 positions, connect test output	Channel 1 (NC): Contact between T1 and I5
	Channel 2 (NC): Contact between T2 and I6 Channel 3 (NO): Contact between T3 and I7 Channel 4 (NO): Contact between T4 and I8

In order to achieve 2-position, 3-position switch control, you can find the corresponding alternative switching element in the window interface by **Component-Input-Safety Switch**.

Table 5-13: Functional characteristics using the enable switch

Function	Description
Testing	Feasible
Tandem	Not feasible
Differential time	See Configuration Software Report for details



Attention

Please refer to the operating guide of the enable switch for more information.

5.4.1.4 Two-handed buttons

Table 5-14: Two-handed button connections

Electrical connection: e.g. to SPC-IO	
Type IIIA, connection 24V	Channel 1 (NO): Contact between 24V and I1 Channel 2 (NO): Contact between 24V and I2
Type IIIC, connection 24V	Channel 1 (NO): Contact between 24V and I5 Channel 2 (NC): Contact between 24V and I6 Channel 3 (NO): Contact between 24V and I7 Channel 4 (NC): Contact between 24V and I8

In order to realize Type IIIA, Type IIIC two-handed button control, you can find the corresponding component in the window interface by **Components-Input-Two-Hand Control**.

For Type IIIA two-handed buttons, the system monitors two equivalent inputs (NO contacts for both manual buttons).

A valid input signal will only be generated if within 0.5 seconds both inputs become ON (high) (synchronous change, both manual buttons have been activated) and both inputs were previously OFF (low).

Table 5-15: Functional features using Type IIIA two-handed buttons

Function	Description
Testing	Feasible
Series/Cascade	Not feasible
Differential time	Fixed value: 500 ms, please refer to the configuration software report for details

For Type IIIC two-handed buttons, the system monitors two pairs of equivalent inputs (NC/NO contact pairs for both manual buttons).

A valid input signal will only be generated if both inputs become ON (high/low) within 0.5 seconds (synchronous change, both manual buttons have been activated) and both were previously OFF (low/high).

Table 5-16: Functional features using Type IIIC two-handed buttons

Function	Description
Testing	Feasible
Series/Cascade	Not feasible
Differential time	Value range: 0-500ms, please refer to the configuration software report for details
Synchronization time	Fixed value: 500 ms, please refer to the configuration software report for details



Attention

For more information, please refer to the operation guide of the two-handed button.

5.4.1.5 Mode selector switch

Table 5-17: Mode Select Switch Connections

Electrical connection: e.g. to SPC-IO	
Mode select switch (1 of 2), connect 24V	Channel 1: Contact between 24V and I1 Channel 2: Contact between 24V and I2
Mode select switch (1 out of 2), connect test output	Channel 1: Contact between T1 and I3 Channel 2: Contact between T2 and I4

To implement the mode selection switch function, you can find the corresponding component in the window interface by **Component-Input-Mode Selection**.

Table 5-18: Functional characteristics of the use mode selection switch

Function	Description
Testing	Feasible



Attention

The mode selection switch provides a total of 2-4 operating modes.

The function block can provide a mode selection switch with reset function. For details, see Configuration Software Instructions for use.

Refer to the operating guide of the mode select switch for more information.

5.4.1.6 Potentialess contacts

Configure the software in **Component-Input-Safety Switch** window provides a range of potential free contacts that can be used to design contact elements "freely". Users can choose with or without test output to achieve different NO/NC combinations. For example, it is used to design and implement start button, reset button, and external device monitoring (EDM).

Table 5-19: Functional characteristics using potentieless contacts

Function	Description
Testing	Feasible
Tandem	Feasible

Differential time	See Configuration Software Report for details
-------------------	---

5.4.1.7 Safe carpet/edge touch

Table 5-20: Safe carpet/touch edge connection

Electrical connections: such as those to the SPC-MC12	
Dual-channel, connecting test output	Channel 1: Contact between T1 and I1 Channel 2: Contact between T2 and I2

SPC only supports four-wire safety carpet/edge touch, contact with test output to enable dual-channel detection. You can find the corresponding component in the **Components-Input-Safety Carpet/Edge touch** window interface.

Connection method: Each channel features a normally closed contact, connecting to one test output and one input respectively. For instance, in a safety carpet system, black and white wires form one channel, while blue and brown wires constitute another channel. Specifically, the black wire connects to T1, the white wire to I1, the blue wire to T2, and the brown wire to I2. Similarly, if the two white lines at the safety touch edge form one channel and the two red lines form another channel, then T1 and I1 are connected to the white lines respectively, while T2 and I2 are connected to the red lines respectively.

5.4.2 Contactless sensors

5.4.2.1 Magnetic safety switch

Table 5-20: Magnetic safety switch connection with dual channel equivalent input

Electrical connection: e.g. to SPC-IO	
Connect test output	Channel 1: Contact between T1 and I1 Channel 2: Contact between T2 and I2

Table 5-21: Magnetic safety switch connection with dual channel complementary input

Electrical connection: e.g. to SPC-IO	
Connect test output	Channel 1 (NC): Contact between T3 and I3 Channel 2 (NO): Contact between T4 and I4

Table 5-22: Functional characteristics using magnetic safety switches

Function	Description
Testing	Feasible
Series/Cascade	Feasible, pay attention to 100 Ω maximum cable resistance and correctly set test pulse time



Attention

Refer to the operating guide of the magnetic safety switch for more information.

5.4.2.2 Inductive safety switches

Table 5-23: With inductive safety switch connection

Electrical connection: e.g. to SPC-IO	
Inductive switch (with test output)	Test input TE connected to T1 Output connected to I1
Inductive switch (with OSSD)	OSSD1 to I2 OSSD2 to I3

Table 5-24: Functional characteristics using inductive safety switches

Function	Description
Testing	Inductive switch (with test output) required
Series/Cascade	Inductive switches (with test output) support cascading Maximum power-off/power-on delay of the cascade: 10 ms (test gap cannot cause shutdown), pay attention to the maximum cable resistance of 100 Ω and set the test pulse time correctly. Inductive switches (with OSSD) do not support cascading



Attention

For more information, please refer to the operating instructions of the inductive safety switch.

5.4.3 Testable single-beam safety gratings

5.4.3.1 Testable Type 2 Single Beam Safety Grating

Table 5-25: Testable Type 2 Single Beam Safety Grating Connection

Electrical connection: e.g. to SPC-IO	
Type 2 single beam safety grating	Test input TE (transmitter) connected to T1 Output (receiver) connected to I1



Attention

Crossover Circuits Affect Fault Identification

The dangerous state may not end or end in time if not taken care of

► Crossover circuits connecting from the test output of the SPC to the test input of the transmitter and from the output of the receiver to the input of the SPC are excluded by protected or separate cable laying.

Table 5-26: Functional characteristics of testable Type 2 single-beam safety gratings

Function	Description
Testing	Feasible
Series/Cascade	Feasible, depending on the type of safety grating used, pay attention to the correct setting of test pulse time: Maximum power-off/power-on delay of cascade: 10 ms (test gap cannot cause shutdown) Note that the maximum line resistance is 100 Ω



Attention

Further information can be found in the Operating Guide for Testable Type 2 Single Beam Safety Gratings.

5.4.3.2 Testable Type 4 Single Beam Safety Grating

Table 5-27: Testable Type 4 Single Beam Safety Grating Connection

Electrical connection: e.g. to SPC-IO	
Type 4 single beam safety grating	Test input TE (transmitter) connected to T1 Output (receiver) connected to I1



Attention

Crossover Circuits Affect Fault Identification

The dangerous state may not end or end in time if not taken care of

► Crossover circuits connecting from the test output of the SPC to the test input of the transmitter and from the output of the receiver to the input of the SPC are excluded by protected or separate cable laying.

Table 5-28: Functional characteristics of testable Type 4 single-beam safety gratings

Function	Description
Testing	Constraint
Series/Cascade	Feasible, depending on the type of safety grating used, pay attention to the correct setting of test pulse time: the maximum power-off/power-on delay of cascades is related to the number of cascades, but it is necessary to ensure that the test gap does not cause shutdown. Note that the maximum line resistance is 100 Ω



Attention

Further information can be found in the Operating Guide for the Testable Type 4 Single Beam Safety Grating.

5.4.3.3 Instructions for installation of testable single-beam safety gratings



Attention

Improper installation or illegal use can lead to failure of protective equipment

If you don't pay attention, the dangerous state may not end or end in time.

If you don't pay attention, you can't achieve the required level of safety technology.

► Single-beam safety gratings can only be used to comply with Access protection according to EN ISO 13855.

► Single beam safety gratings cannot be used for finger and palm protection.

► Minimum distance from the reflective surface is observed.

► Be sure to observe the safe distance between the beam required for channel access protection and the hazard point of the operation.

► Follow the operating guidelines for the respective sensors.

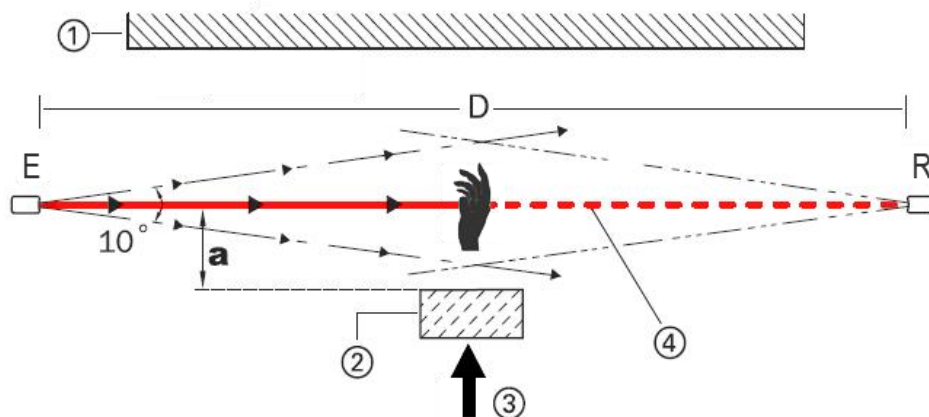


Figure 5-8 Installation and calibration schematic diagram

E: Emitter

R: Receiver

D: Transmitter-receiver distance

a: Minimum distance from reflective surface

①: Hazard zone limits

②: Reflective surface

③: Direction of entering the danger zone

④: Optical axis

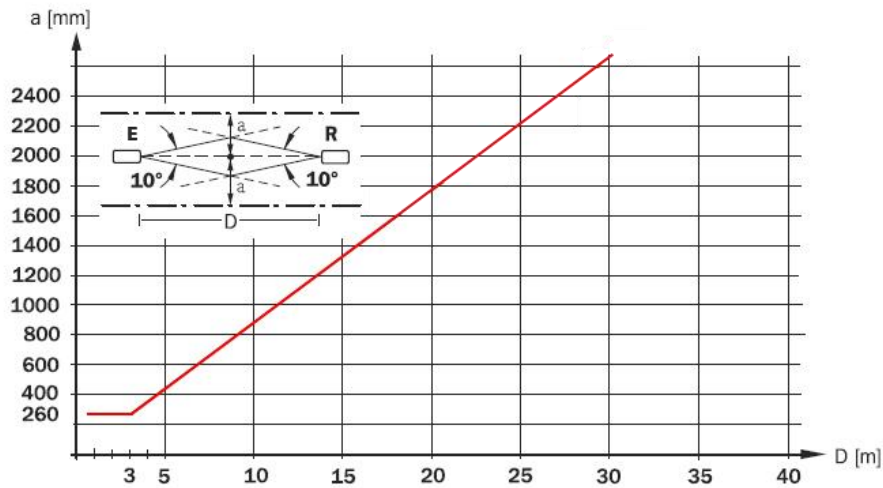


Figure 5-9 Relationship between minimum distance a and distance D of testable single-beam safety grating (opening angle is 10°)



Attention

Mutual light interference may cause protective equipment to fail

If using a multiple control single beam safety grating:

Pay attention to the aperture angle of the sensors to eliminate optical interference with each other

Ensure that the light beam of each transmitter is projected only to the relevant receiver, for which it may be necessary to install transmitters and receivers alternately.

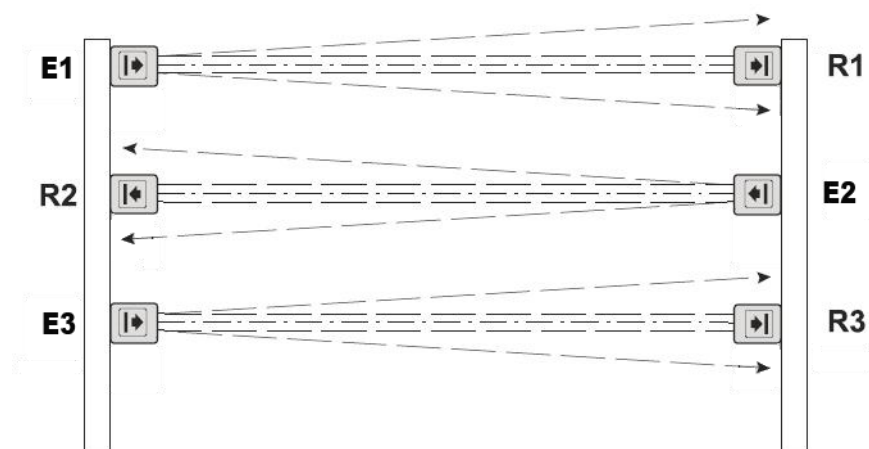


Figure 5-10: Schematic diagram of alternating installation (to avoid mutual light interference)

5.4.4 Electro Sensitive Protective Equipment (ESPE)

Table 5-29: Electro Sensitive Protective Equipment (ESPE) Connection

Electrical connection: e.g. to SPC-IO	
Electro Sensitive Protective Equipment (ESPE)	OSSD1 to I1 OSSD2 to I2



Attention

Refer to the Operating Guide for Electro Sensitive Protective Equipment (ESPE) for more information.

5.4.5 Safety output



Attention

Failure of protective equipment caused by accidental switching on of excitation element

If you don't pay attention, the dangerous state may not end or end in time.

► A star connection is established between the GND interface of the excitation element on the safety output and the GND interface of the voltage supply.



Attention

Output rating exceeded

If not taken care of, the equipment may be damaged.

Do not connect loads exceeding the safe output output rating.

Examples of SPC-MC12, SPC-MC20, SPC-IO modules connected to safety relays: The following example illustrates how to achieve SIL 3 with a single channel output and protected wiring.

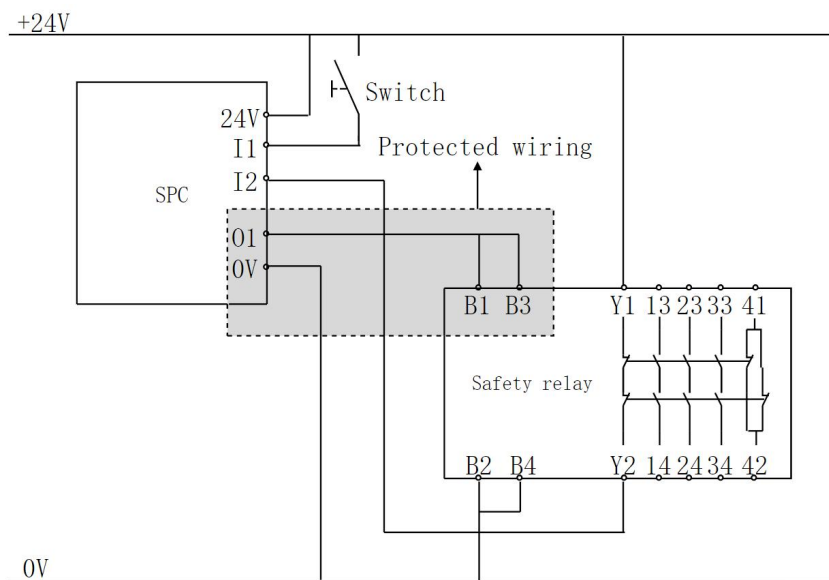


Figure 5-11 Module connection safety relay

5.4.6 Encoder

The following types of encoders can be connected to the SPC system:

- A/B incremental encoder HTL24V, TTL5V, maximum frequency 500KHz.
- A/B incremental encoder RS422, maximum frequency 500KHz.
- Sine and cosine encoder 1Vss, 2.5 VRef, maximum frequency 120KHz.
- SSI encoder, RS422, maximum baud rate 500Kbps.



Attention

Improper encoder selection leads to failure of protective equipment

If you don't pay attention, you can't achieve the required level of safety technology. ► Choose the right encoder.

► Take appropriate measures to prevent system failure or common cause failure of the encoder.

See 10.4.

Choosing the right encoder is critical to achieving the required Safety Integrity Level (SIL) and Performance Level (PL). At the same time, it is especially necessary to control systemic failures and common cause failures.

The relationship between encoder usage and PL/SIL ratings:

Use of Encoder	Number of monitoring axes	achievable safety level	Diagnostic measures for detecting encoder faults
1 safety encoder (incremental AB, sin/cos signals)	1	Cat.3, PL d, SIL 2	Power diagnosis, AB power loss detection, dual-channel comparison, reference via motion signal
2 standard or safety encoders (incremental AB, sine/cos signals)	1	Cat.4, PL e, SIL 3	Power diagnosis, AB power loss detection, dual-channel comparison

For more information on encoder selection and common cause failure prevention, see 5.2.1, 5.2.4, 10.4.



Attention

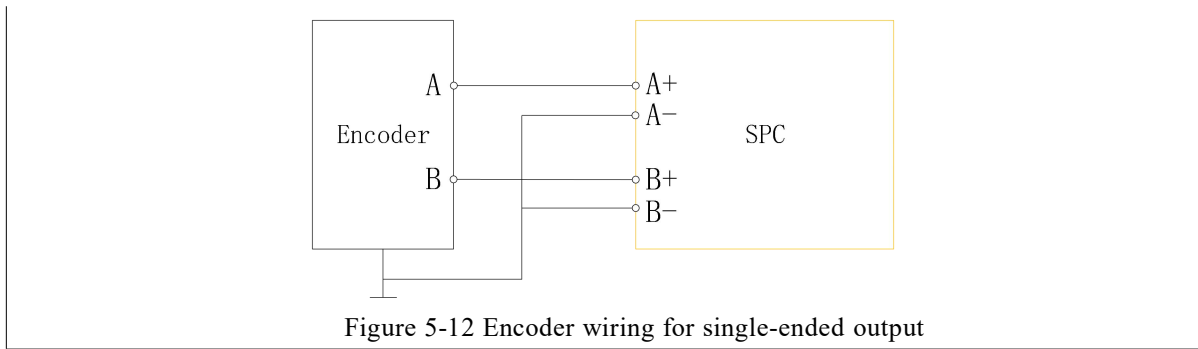
Note the selection of the encoder connection type in the configuration software.



Attention

If the encoder has a single output, the A-and B-inputs of the SPC must not remain suspended and need to be connected to 0V. At the same time, the connection point must be as close as possible to the vicinity of 0V of the encoder.

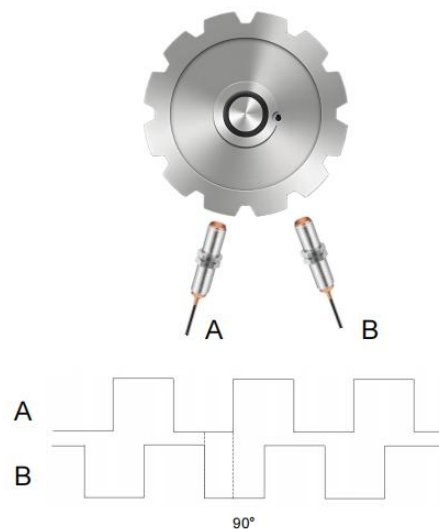
Note: The AB incremental single output encoder can only reach a maximum frequency of 120KHz.



Application of proximity switch to replace encoder:

The "two proximity switches + cam" configuration can be used as an alternative to a single-ended incremental encoder, provided it meets the following requirements:

- The sensor output is PNP type and provides essential failure parameters.
- The user selects the number of cams, their mechanical structure, and installation positions based on detection accuracy requirements, ensuring that the square wave signals from the two proximity switches have a specific phase difference (ideally 90 degrees).
- The proximity switch signal is directly connected through the encoder interface.



注意

When electromagnetic interference is present at the application site, enable the second or fourth frequency to ensure accurate readings.
Accurate reading of encoder is an important prerequisite for safe motion monitoring.

5.5 Special interface- SPC Line

SPC Line can securely connect up to 16 main control modules with SPC Line. Defined a unified data mapping to transmit security information in bit form to any main control module.

- The physical interface of SPC Line is multiplexed with the RS485 interface of MC20.

- Up to 16 main control modules with SPC Line can be connected.
- Each main control module can send up to 8 bits of information externally.
- The longest cable length is 1,000 meters.

Note 1: The polling method is used to exchange security information module by module, but each main control module does not perform logical execution simultaneously, and there may be a time difference in synchronizing information.

Note 2: The update rate of data is affected by the baud rate. The higher the baud rate, the faster the update rate. It is recommended to use the highest possible baud rate to reduce communication time.

Note 3: Twisted shielded wires must be used to reduce the risk of EMC interference.

6 Configuration



Attention

Failure of protective equipment caused by misconfiguration

If you don't pay attention, the dangerous state may not end or end in time.

► Check that the configured security application monitors the machine or equipment as expected, and that the configured application remains secure at all times. This must be guaranteed in all operating modes and in some applications. Record the inspection results.

► Re-check security features after each configuration change.

► Follow the inspection instructions in the Operating Guide for Connected Protective Equipment.

Configuration of connected devices

Generally speaking, devices connected to the SPC cannot be configured and verified through the SPC configuration software. These devices have their own configuration and authentication mechanisms. Refer to the operating guide of the corresponding equipment for this information.

Configuration confirmation

When the configuration information of external devices and functions (blocks) connected to the SPC is sent to the SPC by the configuration software, the user needs to confirm the configuration first, and then the final configuration can be completed. Please refer to the configuration software instruction manual for details.

7 Debugging



Attention

Improper debugging

If you don't pay attention, the dangerous state may not end or end in time.

- ▶ Ensure that equipment/machines using SPC are inspected, approved and documented by qualified safety personnel prior to initial commissioning.
- ▶ Prevent personnel from entering hazardous areas (by erecting warning signs, placing barriers, etc.).
- ▶ Ensure that no one stays in the dangerous area before commissioning.
- ▶ Comply with relevant laws and local regulations.

7.1 Overall acceptance of the application

Only after passing the overall acceptance can the equipment be debugged.

Only the overall acceptance is allowed by the corresponding trained professionals.

The overall acceptance includes the following inspection items:

- ▶ Check all safety-related parts of the equipment (wiring, connected sensors and control switches, configuration) for compliance with the appropriate safety standards (e.g. IEC 62061 or ISO 13849).
- ▶ Inspect the equipment connected to the safety controller according to the inspection instructions in the relevant operating guide.
- ▶ Clearly and unambiguously mark all connecting cables and plug connectors on the safety controller to avoid confusion.
- ▶ Check the signal path and correct integration into the upper-level controller.
- ▶ Check whether the data transmission to and from the security controller is correct.
- ▶ Check the logic program of the safety controller.
- ▶ Adequate verification of safety features (e.g. failure simulation). Pay attention to response time.
- ▶ Completely record the configuration of equipment, individual devices and safety inspection results.
- ▶ To prevent accidental overwriting of the configuration, write protection of the configuration can be enabled.

7.2 Inspection before the first commissioning

Overview

Before commissioning a machine, it is essential to check that safety features meet their intended objectives and that personnel are adequately protected.

Prerequisites

- Please ensure that the equipment/machinery has been inspected and approved in writing by the appropriate qualified safety personnel before the initial commissioning.
- Ensure that no one stays in the dangerous area before commissioning.
- Prevent people from entering dangerous areas (by erecting warning signs, placing barriers, etc.).

Inspection before initial commissioning

Please inspect the protective equipment according to the following requirements and according to the appropriate standards and regulations:

- Check the validity of the safety features on the machine in all operating modes and functions that the machine can set.
- Ensure that qualified safety personnel employed by the machine operator instruct the operator of the machine protected by the safety controller before they start work, and that the machine user assumes the responsibility for guidance.

8 Run

8.1 Status Message of Master Control Module SPC-MC12

See Section 5.2.1 for the location of the OLED display and LED indicators on the main control module SPC-MC12.

Power LED (yellow)

Indicator lamp status	Meaning	Description
Bright	System power supply normal	Power via V+, V-
Destroy	There is no power supply to the system or abnormal power supply to the system	Check whether the power wiring is normal; Check whether the power supply is normal

System LED (Red)

Indicator lamp status	Meaning	Description
-----------------------	---------	-------------

Bright	Internal system failure	Check the system connection and troubleshoot connection problems; By checking the OLED screen or enabling the diagnostic function of the configuration software, check the fault code and troubleshoot the fault code indication; Reconfiguring application logic; Ensuring that the voltage supply is not interrupted until the end of the configuration application logic; Restart the system after a power failure. If the fault cannot be troubleshooted after several retries, you may need to replace the module.
Destroy	System failure-free	-

OLED screen display

Page	CONTENT	Status	Meaning	Description
Interface	Safety input	"X"	Port not enabled	Interface Happen In case of failure, The fault information is in the system state Page display See Figure 8-1 Fault information for details
		"Number", bright	The corresponding port to the number is enabled and the input is high	
		"Number", flashing	The corresponding port to the number is enabled and the input is low	
	Safety output	"X"	Port not enabled	
		"Number", bright	The corresponding port to the number is enabled and the output is high.	
		"Number", flashing	The corresponding port to the number is enabled and the output is low.	
Encoder	Encoder states 1~4	"XXXXXX"	The current encoder is not enabled	
		"Numerical value"	The current number of pulses per second of the encoder	

Radar	lidar 1 ~ 2 states	"X"	This signal is not enabled	For special display, please refer to the introduction section of lidar information display
		"1"	The signal is enabled and the output is 1	
		"0"	The signal is enabled and the output is 0	
System	System Information	normal	System normal	
		abnormal	Fault detected	

OLED Screen

System after powering on, start self-test and initialization. After the initialization is successful, the screen begins to display system data, as shown in Figure 8-1. If system failure the screen will display an error message, as shown in Figure 8-2.

When the system is working normally, the user can through the screen operation button turn the page to view the detailed information of each functional module, click the button to turn the page down, double-click the button to turn the page up, and press and hold the button to turn the page down continuously.

To extend the lifespan of the screen, if no button operation is performed for 60 consecutive seconds, the screen will enter a shutdown state. In the off screen state, pressing the screen operation button can wake up the screen.

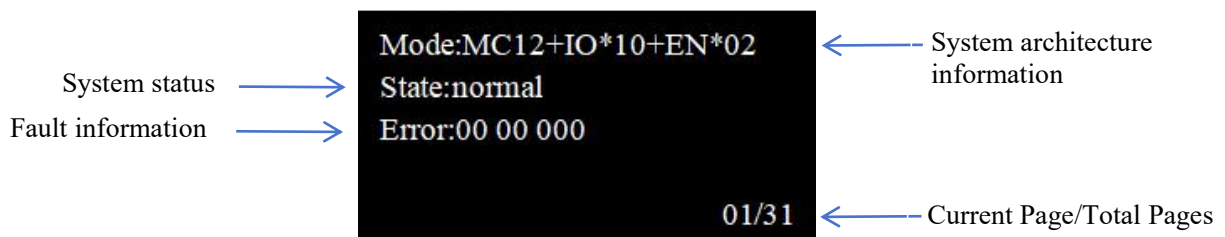


Figure 8-1 The system displays when normal

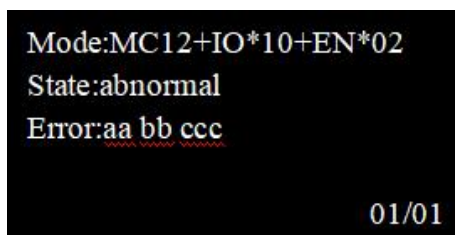


Figure 8-2 The system displays when the system is abnormal

Note: aa is the faulty module serial number, bb is the total fault code, and ccc is the detailed fault code, which is displayed in decimal system

 pay attention to

Unsuitable operations may cause device damage or shorten the screen life

Special case system display page

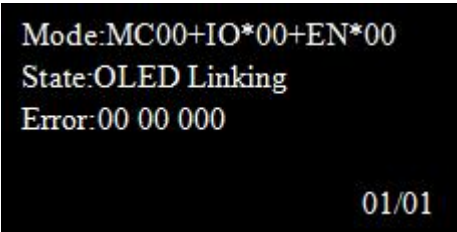


Figure 8-3OLEDWhen the connection is abnormal The system displays the page

When the OLED connection with the SPC host is abnormal, the OLED cleans up the system structure information and fault information, and the fault status shows the OLED Linking.

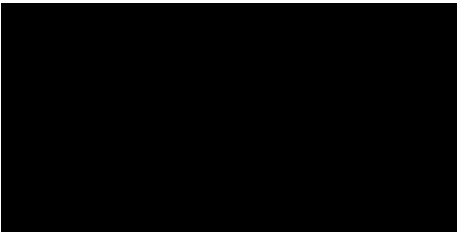


Figure 8-4OLED firmware upgrade time The system displays the page

When the OLED firmware is upgraded, clear all displays and turn to normal after the upgrade is successful.

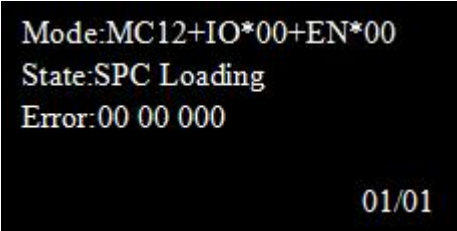


Figure 8-5Host firmware upgrade time The system displays the page

When the SPC host performs the firmware upgrade, OLED only retains the main module system structure information, cleans up the module system structure information and fault information, and the fault status displays SPC Loading.

IO information display

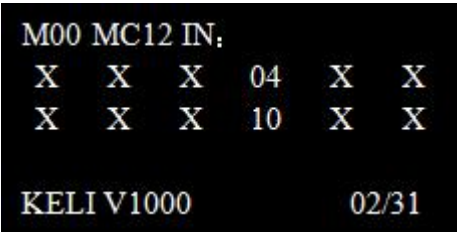


Figure 8-6 Enter information to display

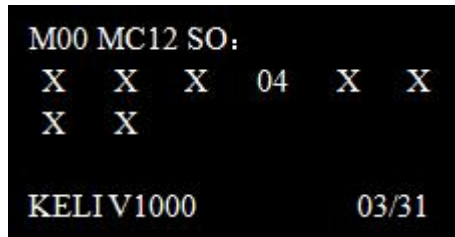


Figure 8-7 The output information is displayed The first row shows the data type:

- M00: The currentModule serial number, starting from 00.
- MC12: Current module type, including MC12, MC20, IOxx, and ENxx four kinds of, where xx represents the current number of extension modules, starting from 00.

- IN/SO: IN-input, SO-Safe output.

The second line and the third line represent the status of the corresponding input port:

- "X": Port not enabled
- "Number": For example, 04 indicates that input port 4 is enabled, a number always bright indicates that the input of this port is high, and a flashing number indicates that the input of this port is low.

The fourth line displays the company name, version number and page number

- KELI: Business Name.
- V1.0: Product version number.
- 03/32: Current Pages/Total Pages

Encoder information display

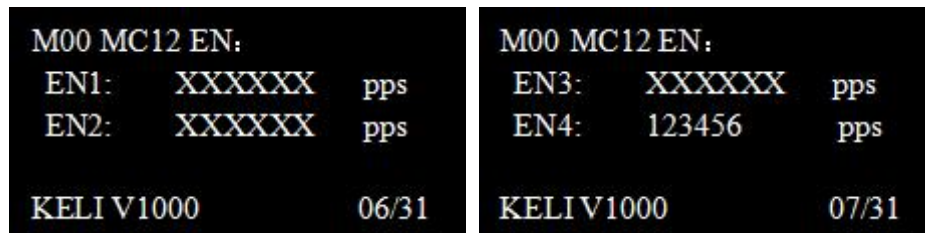


Figure 8-8Encoder information display

The MC12 and EN modules each have four encoders and are displayed on two pages.

- "XXXX XX": Indicates that the current encoder is not enabled.
- "1234 56": indicates the current encoder pulses per second.

Lidar information display

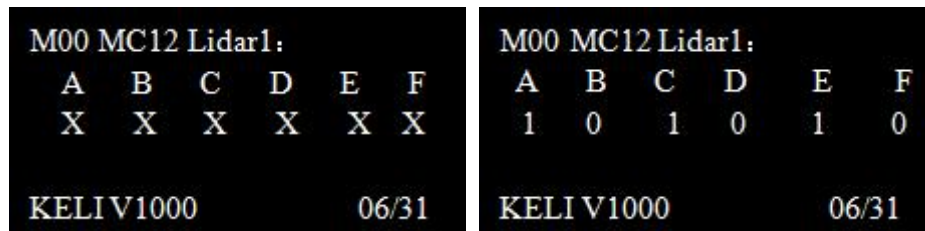


Figure 8-9 lidar information display

A, B, C, D, E, F represent the defense zone respectively (Group) Switching signal.

- "X": represents The signal is not enabled.
- "1": indicates the signal is enabled and the output is 1.
- "0": indicates the signal is enabled and the output is 0.



Attention

According to the operational requirements of the lidar, A and B are configurable signals.

When AB is configured as a zone handover signal, it is displayed according to the above rules;
When AB is configured as a zone status signal, it is displayed as follows:

If configured as an Alarm signal, it displays "X 1", as shown in the figure 8-10 shown;

If configured as OSSD, it displays "1 X", as shown in the figure 8-11 shown.

```

M00 MC12 Lidar1:
A  B  C  D  E  F
X  1  1  1  1  1

KELI V1000      06/31
  
```

Figure 8-10 AB is configured as Alarm signal

```

M00 MC12 Lidar1:
A  B  C  D  E  F
1  X  1  1  1  1

KELI V1000      06/31
  
```

Figure 8-11 The AB is configured for the OSSD signal

8.2 Status message of the master module SPC-MC20

See Section 5.2.2 for the OLED display and LED indicator position on the master module SPC-MC20.

Power supply indicator lamp (yellow)

Indicator lamp status	Meaning	Explain
bright	System power supply is normal	Power supply via V+ and V-
off	The system has no power supply or abnormal system power supply	Check whether the power supply wiring is normal; Check whether the power supply is normal

System indicator light (red)

Indicator lamp status	Meaning	Explain
bright	Internal fault of the system	Check the system connection to eliminate the connection problems; By viewing the OLED screen or enabling the diagnosis function of the configuration software, check the fault code and troubleshoot the fault code indication; Reconfigure the application logic; Ensure that the voltage supply is not interrupted until the end of the configuration application logic;

		Restart the system after the power failure. If the fault cannot be eliminated after multiple retests, the module may need to be replaced.
off	The system is not faulty	-

Display of the OLED screen

Page	Content	State	Meaning	Explain
port	Safe input	“X”	The port is not enabled	When an interface failure occurs, the fault information is displayed on the system status page.
		"Numbers", bright	Numbers correspond to port enabled and input high	
		"Number", flashing	Numbers correspond to port enabled and input low	
	Safe output	“X”	The port is not enabled	
		"Numbers", s bright	The port corresponding to the number is enabled and the output is high	
		"Number", flashing	The port corresponding to the number is enabled and the output is low	
system	System Information	normal	System normal	
		abnormal	Fault detected	

SPC Line Information Display

When the SPC Line function (also known as multi master mode) is enabled in MC20, the system display page will show the current master module serial number. Hm represents the mth host at that time, counting from 0.

```

Mode:MC20+IO*00+EN*00
State:normal           Hm
Error:aa bb ccc

01/04

```

Figure 8-12 System display page when the multi master mode system is normal

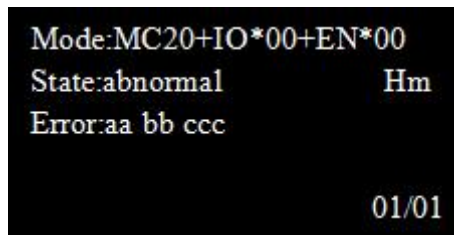


Figure 8-13 System Display Page When Multiple Main Mode System is Abnormal

Note: When configuring multiple master modes, if aa bb displays 00 14, ccc indicates the serial number of the faulty master control module, which is displayed in decimal.

8.3 Status Messages for Expansion Module SPC-IO

See Section 5.2.3 for the LED indicator location on the expansion module SPC-IO.

Power LED (Yellow)

Indicator lamp status	Meaning	Description
Bright	System power is normal	The module is connected with the main control module and the output power supply at the same time
Off	The main control module is not connected or the power supply is abnormal	Check whether the wiring is normal; Check whether the power supply is normal

System LED (Red)

Indicator lamp status	Meaning	Description
Bright	System failure detected	Check the system connection and troubleshoot connection problems; By checking the OLED screen or enabling the diagnostic function of the configuration software, check the fault code and troubleshoot the fault code indication; Reconfiguring application logic; Ensuring that the voltage supply is not interrupted until the end of the configuration application logic; Restart the system after a power failure. If the fault cannot be troubleshooted after several retries, you may need to replace the module.
Off	System failure-free	-

Safety output indicator (Green)

Indicator lamp status	Meaning	Description
-----------------------	---------	-------------

Bright	Output ON state	-
Off	Output OFF status or fault	-

Safety input indicator (Yellow)

Indicator lamp status	Meaning	Description
Bright	The corresponding input is ON state	-
Off	The corresponding input is OFF state or fault	-

8.4 Status Messages for Expansion Module SPC-EN

See Section 5.2.4 for the LED indicator location on the expansion module SPC-EN.

Power LED (Yellow)

Indicator lamp status	Meaning	Description
Bright	Connect to the main control module	-
Off	Not connect master module	Check whether the wiring is normal; Check whether the power supply is normal

System LED (Red)

Indicator lamp status	Meaning	Description
Bright	Detected system failure	Check the system connection and troubleshoot connection problems; By checking the OLED screen or enabling the diagnostic function of the configuration software, check the fault code and troubleshoot the fault code indication; Reconfiguring application logic; Ensuring that the voltage supply is not interrupted until the end of the configuration application logic; Restart the system after a power failure. If the fault cannot be troubleshooted after several retries, you may need to replace the module.
Off	System failure-free	-

Encoder LED (yellow)

Indicator lamp status	Meaning	Description
Bright	Enable encoder	-
Destroy	Unenable encoded	-

9 Maintenance

This section describes the periodic inspection and replacement of SPC.

Do not attempt to remove, repair or modify the SPC module as failure of the safety features may occur.

The tools used during maintenance are the same as those used during installation.

9.1 Periodic inspection of safety functions by qualified safety personnel

► Inspect the equipment within the required period according to the applicable regulations in the country. This ensures that changes on the machine or tampering on the protective equipment are detected after the first commissioning.

► Each safety application must be checked at defined intervals. The effectiveness of the safety features must be checked by an authorized and qualified person.

► If changes have been made to the machine or safety functions, or if the safety controller has been modified or repaired (e.g. by replacing the module), check the equipment again according to the checklist in the appendix.

► Perform periodic checks to keep the system in optimal operating condition.

► Check that the implementation of each module complies with all technical parameters.

► Check the installation conditions and whether the wiring of each module is still correct.

► Regularly verify that safety functions meet application requirements and all applicable regulations and standards (e.g. periodic inspections) to ensure the reliability of safety functions.

9.2 Equipment Replacement

Overview

Critical errors within the SPC module will affect the overall system operation. Therefore, equipment with serious errors must be repaired or replaced quickly. It is recommended that standby equipment of the SPC module be prepared so that it can be restored to operation as soon as possible.



Attention

Equipment replacement causes protective equipment to fail

If you don't pay attention, the dangerous state may not end or not end in time.

► After replacing the equipment, make sure that there will be no failure with the new SPC module.

► Before debugging the standby module, use it for functional testing.

► After replacing a module with an encoder interface, such as SPC-EN, it may be necessary to re-reference or teach.

If the SPC module needs to be sent for repair, first generate a system diagnostic message report with the help of the configuration software, and send the module and report, detailed problem description and other relevant information to KELI.

Prerequisites

- The SPC module must not be disassembled or repaired.
- Replace the equipment only when the voltage supply is turned off.

Treatment method

- ▶ Remove the damaged module
- ▶ Install new modules
- ▶ Return the device to a safe state
- ▶ In order to continue to use the system configuration, please check the following points:
 - Whether the new module is of the same type and there is no error in the new module after replacement;
 - Whether the new module has been plugged into the location where the replaced module was once;
 - Whether all plug connectors are reconnected to the correct location;
- ▶ Otherwise the system must be completely reconfigured and commissioned, including performing all necessary checks.

10 Troubleshooting (Diagnostics)

10.1 Measures to be taken in case of failure



Attention

Protective equipment failure

If you don't pay attention, the dangerous state may not end or end in time.

- ▶ If it cannot be clearly classified and troubleshooted safely, shut down the equipment/machine.
- ▶ After troubleshooting, perform an impact analysis and check all affected safety features.

10.2 Error status

When there is a configuration error or functional failure, SPC will enter a safe state. Each module of the system displays the corresponding error status through LED or OLED screens.

SPC error types are mainly divided into system faults, configuration faults, and external faults.

System failure

- ▶ The fault light is constantly on.
- ▶ OLED displays fault codes.
- ▶ Zero all safety process data and non safety data.
- ▶ All outputs are turned off.

Allocation failures

- ▶ The fault light is constantly on.
- ▶ OLED displays fault codes.
- ▶ Zero all safety process data and non-safety data.
- ▶ All outputs are turned off.

External fault

- ▶ The main module fault light is always on, and the corresponding module fault light is always on.
- ▶ OLED displays fault codes.
- ▶ At least all safety process data should be reset to zero.
- ▶ All safety outputs are turned off.

Redebug

▶ Troubleshooting should be carried out according to the causes of errors displayed on LED and OLED screens.

▶ If it is a self-test error, disconnect the system's voltage supply for at least 3 seconds and then power it back on.

10.3 Fault Display, Possible Causes and Troubleshooting Measures

This section lists some important fault codes, possible causes, and troubleshooting measures. After the SPC system is connected to the configuration software, these error messages can be displayed by the diagnostic function of the system



Attention

Information on how to perform system diagnostics can be found in the configuration software-related documentation (instructions, operating manual).

For error display and error troubleshooting of the module, see the corresponding section of Chapter 8.

For external faults, after the fault disappears, it will be switched from the safe state to the normal operation state.

Table 10-1: System Fault Codes/Error Messages, Possible Causes, and Troubleshooting

Fault classification	Name of fault	Fault code	The fault subcode	Failure recovery
system failure	initialization error	1		a. Restart the system; b. Ensure that the system power supply equipment can buffer voltage interruptions for up to 20 ms during the initialization process; c. Ensure the load capacity of the power supply equipment; d. Check the voltage supply wiring; Check the equipment (DIN rail and FE connection of electrical cabinet), star grounding of voltage supply, and isolation of load and control components from an EMC perspective.
	Bus Error	3		a. Eliminate EMC interference; b. Check the wiring of the master-slave module c. Reconfigure the empty configuration file;
	Internal detection error	4		a. Restart the system
	Bus communication timeout	9		a. Eliminate EMC interference; b. Check the wiring of the master-slave module; c. Reconfigure the empty configuration file; d. Confirm software version
	Over temperature	10		a. Measure whether the ambient temperature exceeds the limit; b. Cooling down
	Temperature too low	11		a. Measure whether the ambient temperature exceeds the limit; b. Heating up
	Compatibility error	12		a. Check if the module version is compatible
	Multi host communication timeout	14		a. Check the communication connection status; b. Check the host version and model; c. Restart the system
	Multiple host frame errors	15		a. Check the communication connection status; b. Check the host version and model; c. Restart the system
	Dual channel preparation timeout	16		a. Check the bus connection status; b. Check the version and model of master and slave modules;

				c. Restart the system
	The dual-channel output comparison is inconsistent	17		a. Check the bus connection status; b. Check the version and model of master and slave modules; c. Restart the system
	Encoder sampling difference error	29	1-12	a. Eliminate EMC interference; b. Replace this module
allocation failures	configuration error	2		a. Retransmit configuration; b. Replace the main control module
	Function block error	5		a. Resend configuration
	Module mismatch	6		a. Reconfigure
	Inconsistent program information between master and slave modules	7		a. Check the version and model of the master-slave module; b. Reconfigure
	Program effectiveness	8		a. Retransmit configuration;
External fault	Input short 24V or incorrect test output wiring	22	1-20	a. wire inspection b. Replace this module
	Output short 24V	23	1-8	Output interface error: a. Check the connection of the output power supply; b. Check if the equipment is affected by EMC; c. Check the wiring of the relevant outputs; d. Check for capacitive and inductive loads; e. Replace this module
	Output short 0V or the output power supply is disconnected	24	1-8	
	lidar defense zone switching output short 24V	25	1-16	
	lidar defense zone switching output short 0V	26	1-16	
	Output cross error	27	1-4	
	Input dual channel component difference error	28	1-10	Input interface error: a. Eliminate external wiring issues and restart the system; b. Check the wiring of the relevant inputs, and if the test output is connected, also check the wiring of the test output; c. Check the switching ability of the two contacts/outputs on the connected device; d. Replace testable sensors; e. Check the mechanical dependency of the two switches; f. Replace the switch/sensor for hardware installation; g. Check the configuration of the input interface, including the ON-OFF and OFF-ON filtering configurations.
	Inconsistent error in dual-channel sampling of encoder	29	1-12	The input signal frequency of the encoder is inconsistent: a. Excluding external wiring problems, restart the system; b. Check whether the encoder power supply is normal; c. Check the wiring of relevant inputs to eliminate the possibility of interference
	Encoder power failure	30		a. Check encoder power wiring; b. Check whether the power supply voltage of the encoder is within the range
	SSI fault code	31	1-2	a. Excluding external wiring problems, restart the system; b. Check the wiring of relevant inputs to eliminate the possibility of interference; c. The shield of the encoder cable is grounded

Note: For fault codes not displayed in the table above, please contact the manufacturer for confirmation.

10.4 Measures to Avoid Common Cause Failure

Overview

The following considerations apply to all modules with encoder interfaces.

Measures to Avoid Common Cause Failure

If two encoders are used to redundantly monitor an axis, the following possibilities should be considered:

- Since the 4 encoders on the SPC system share the connection cable, the common GND connection may be disconnected.
- The operating voltage of the encoder may be too low or completely disconnected.
- The operating voltage shared by the encoders may be too high, causing encoder damage. If PELV/SELV voltage supply is used without protection in the vicinity, it is usually necessary to assume that the voltage will rise to 60V.
- The encoder connection of the SPC system may be completely interrupted.

The SPC system detects faults within the encoder system in the following ways:

- If an AB incremental encoder is used, the fault cannot be found directly based on the encoder signal.
- In some cases, motion control logic can be combined to use another signal during the process to check the authenticity of the encoder signal, such as using the "drive run/stop run" signal.
 - Use an SSI encoder with error bits. If a fault occurs, such as a disconnected encoder cable, the SSI data must contain bits in the reverse state.
 - By comparing the readings from two encoders monitoring the same axis, determine if an encoder is faulty based on consistency.

If the occurrence of the fault cannot be monitored by monitoring measures, the following measures can be taken to control the voltage increase within the limits of the PELV/SELV voltage supply:

- ▶ Power the encoder separately.
- ▶ Use an encoder that withstands high voltages.
- ▶ The voltage of the SPC module is supplied to the encoder directly or via an encoder/motor feedback system, and if the supply voltage of the SPC module exceeds 35.8V, the system will switch to a safe state. In this way, a safe shutdown in the application can be ensured when the voltage rises, but in this case the encoder may be damaged.

10.5 Technical Support

If the information in the relevant operation guide cannot be ruled out, please contact the responsible branch office in your area.

11 Deactivation

11.1 Disassembly

Processing method

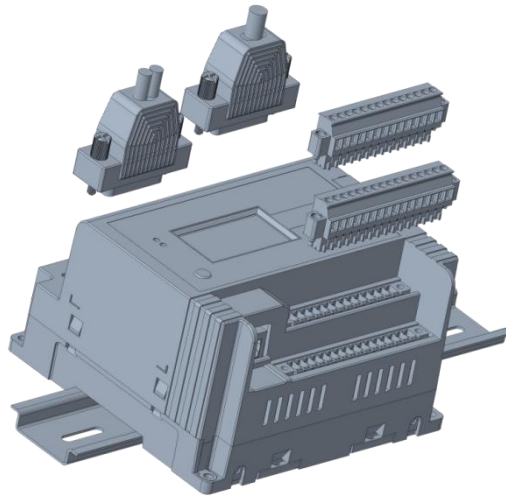


Figure 11-1: Unplug the wiring terminals and DB plug

1. Remove the pluggable terminal block and DB plug together with the wiring.

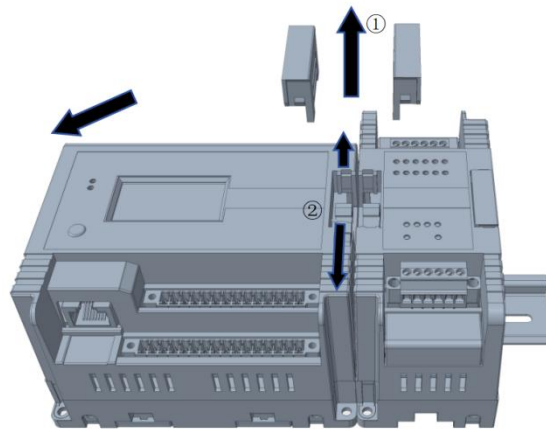


Figure 11-2: Separate the main module and expansion module connection cables

2. Use a small flat screwdriver (2 mm) to pry open the bus interface cover, remove it in the direction of arrow ①, open the horn plug in the direction indicated by arrow ②, and remove the connecting cable.

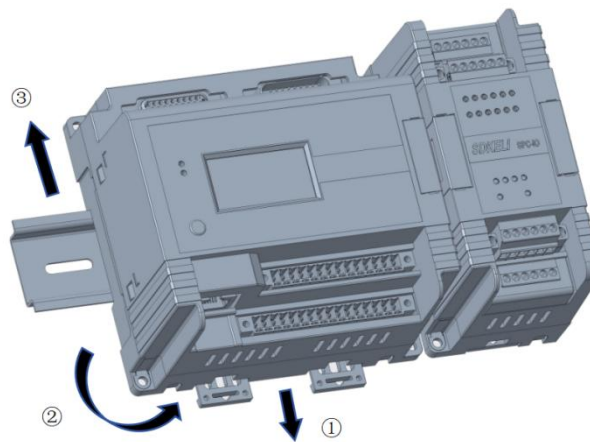


Figure 11-3: Removing the module from the DIN rail

3. Pry out the guide rail clip in the direction of arrow ①, then disengage one side of the module from the electrical guide rail in the direction of arrow ②, and finally remove it from the guide rail along arrow ③.

11.2 Disposal

Treatment method

- Dispose of unusable equipment in accordance with country-specific waste disposal regulations.

Supplementary Information

Our company can assist with the disposal of these devices according to your request.

12 Technical parameters

12.1 Minimum Shutdown Time

The minimum shutdown time refers to the minimum time that a shutdown condition must exist in order to be monitored by the SPC system.

Requirements for minimum shutdown time:

- It must be greater than the system scanning cycle + 1 ms. And:
- When the device is connected to the SPC test output, it must be greater than the test gap + maximum power-off/power-on delay (provided the test gap is > 1 ms). And:
- It must be greater than the test cycle (i.e. the higher of the two test outputs used) + the maximum power-off/power-on delay (provided a protective pad or bumper is used).

The minimum turn-off time of the sensor is usually given in the technical parameters of the sensor.

12.2 Response time

To calculate the response time within the SPC system, all paths must be taken into consideration, and each output response time should be calculated separately. For forming a secure communication network through SPC Line, further consideration needs to be given to communication time.

$$\text{Communication time} = N \times (\text{transmission cycle time}) + 4 \text{ ms}$$

Note 1: N=Number of nodes participating in SPC Line -1.

Logical execution time

The minimum logic execution time of the SPC system is always 4 ms, and it cannot be further reduced through optimization. Changing the logic execution time may require modifying the configuration of functional blocks based on logic execution time. For more information on optimizing logic execution time, please refer to the configuration software documentation.

Response time calculation

System scanning cycle=input and processing time+logic processing time+bus communication time+output and processing time.

SPC minimum response time=system scan cycle+delay time.

SPC maximum response time = (2 * system scan cycle) + delay time.

Maximum response time of safety circuit = sensor response time + SPC response time + actuator response time

System scanning cycle

Content	Subtype	Time
Input and processing time	+N SSI absolute encoder (if enabled)	N*1ms
Logical time	Logical execution time	4ms
Bus communication time	+M from modules (if enabled)	M*1ms
Output and processing time	-	-

Note 1: The logic execution time is stepped according to the logic complexity, with a step unit of 4 ms.

Note 2: For each additional expansion module, the bus communication time increases by 1 ms, with an additional 1 ms for MC12 bus communication time.

Note 3: If filtering is applied to the input, the filtering time needs to be increased.

Delay time

Content	Subtype	Time
Input time	+On/off filter time (if enabled)	8ms
	+A/B incremental encoder, sine/cosine encoder (if enabled)	6ms
Logical time	+ Logic delay function block (if enabled)	Depending on the block delay time
Output and processing time	Internal errors cause a delay in closing the output	Depending on the fault diagnosis and fault redundancy delay time

Note 1: The delay function block itself has a tolerance and needs to consider the current system scanning cycle.

Note 2: The + A/B incremental encoder and sine cosine encoder adopt a period of 4 ms.

Example 1:

Main control module SPC-MC208400E4 and an extended SPC-IO08420000 connection.

Table 12-5 Connection Description

Digital input	Two safety light screens are mounted on the SPSC-IO (e.g., I1/I2, I3/I4)
Digital output	Dual-channel output with two safety relays on the SPC-IO (e.g., O1/O2, O3/O4)
Logical function configuration	For I1/I2, the light curtain is directly output and the output is connected to O1/O2 For the light curtain of I3/I4, 8ms On/Off filter is added and then the output is connected to O3/O4

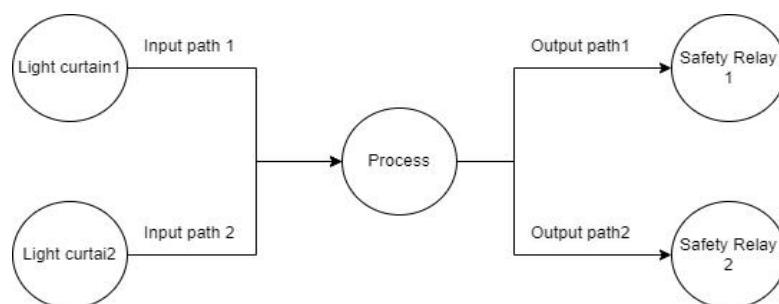


Figure 12-1: Path diagram of Example 1

The two paths need to be calculated separately:

Table 12-6 Response time of Path 1

Time type	Subtype	Value
System scan cycle	+N SSI absolute value encoder	0ms
	Logical processing time	4ms
	+M from modules (if enabled)	1ms
	-	0ms
Delay time	+On/off filter time (if enabled)	0ms
	+A/B incremental encoder, sine/cosine encoder (if enabled)	0ms
	+ Logic delay function block (if enabled)	0ms
Summation	(2* system scan cycle) + delay time	10ms

Table 12-7 Response time of Path

Time type	Subtype	Value
System scan cycle	+N SSI absolute value encoder	0ms
	Logical processing time	4ms
	+M from modules (if enabled)	1ms
	-	0ms
Delay time	+On/off filter time (if enabled)	8ms
	+A/B incremental encoder, sine/cosine encoder (if enabled)	0ms
	+ Logic delay function block (if enabled)	0ms
Summation	(2* system scan cycle) + delay time	18ms

Table 12-8 Maximum response time of the safety circuit for Path 1

Time type	Value	Instruction
Sensor response time	10ms	assume
SPC maximum response time	10ms	
Maximum response time of the actuator	2ms	assume
summation	22ms	

Table 12-9 Maximum response time of the safety circuit for Path 2

Time type	Value	Instruction
Sensor response time	10ms	assume
SPC maximum response time	18ms	
Maximum response time of the actuator	2ms	assume
summation	30ms	

Example 2:

The main control module SPC-MC208400E4 is connected to an extended SPC-EN0000S000.

Table 12-10 Connection Description

Digital input	The SPSC-EN is equipped with a safety encoder in the form of a sine and cosine encoder
Digital output	Dual-channel output with one safety relay on the MC20 (e.g. at O1/O2)
Logical function configuration	The speed value is judged. When the threshold is exceeded, the output is turned off and the output is connected to O1/O2

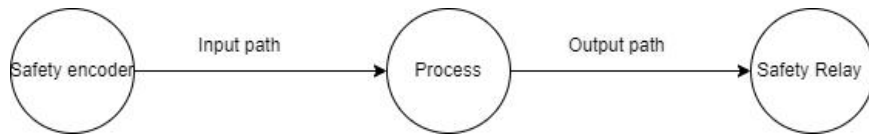


Figure 12-2 shows an example of path 2

Table 12-11 Response time of the path

Time type	Subtype	Value
System scan cycle	+N SSI absolute value encoder	0ms
	Logical processing time	4ms
	+M from modules (if enabled)	1ms
	-	0ms
Delay time	+On/off filter time (if enabled)	0ms
	+A/B incremental encoder, sine/cosine encoder (if enabled)	6ms
	+ Logic delay function block (if enabled)	0ms
Summation	(2* system scan cycle) + delay time	16ms

Table 12-12 Maximum response time of the safety circuit of the path

Time type	Value	Instruction
Sensor response time	0ms	assume
SPC maximum response time	16ms	
Maximum response time of the actuator	2ms	assume
Summation	18ms	

12.3 Data Sheet

12.3.1 Main Control Module SPC-MC12

Safety parameters

Table 12-1: SPC-MC12 safety technical parameters

Project	Parameter
Safety Integrity (IEC 61508) Safety Integrity (IEC 62061)	SIL 3
Performance Class (ISO 13849)	PL e
Category (ISO 13849)	
All safety outputs have enabled single channel outputs for detection pulses (O1-O8)	Cat.4 ¹
Dual channel outputs (O1-O8) with or without disabled detection pulses on this safety output or any other safety output	Cat.4
PFH	5.45×10^{-10}
TM (Continuous Run Time, ISO 13849)	20 years

Note 1: It is necessary to apply the fault exclusion clause for cables between safety outputs and external devices (output devices) in accordance with Table D.4 of ISO13849-2:2012. For example, installing SPC and external devices in a chassis (control cabinet, etc.) that complies with IEC60204-1, and using protected or separate cable laying for this safety output.

Electrical parameters

Table 12-2: SPC-MC12 electrical parameters

Project	Parameter
Operating voltage	24V DC (70%—125%)
UL/CSA application Operating voltage	24V DC
Operating voltage type	PELV/SELV The operating current of the module must be limited externally to a maximum of 4 A-through the power supply or fuse used
Over voltage category	II (EN 61131-2)
Power consumption (no load)	≤5.5W
Connection mode	Screw terminal
Cross-sectional area of power conductor	Single wire or thin wire: 0.2~1.5 mm ² AWG according to UL/CUL: 24~14
Cross-sectional area of signal port conductor	Single wire or thin wire: 0.14~1.5 mm ² Thin wire with core end sleeve: With plastic sleeve up to 0.75 mm ² No plastic sleeve up to 1.5 mm ² AWG according to UL/CUL: 24-16
Level of protection	III (IEC 61140)
Immunity	EN 61000-6-2
Electromagnetic Compatibility (EMC)	IEC 61131-2
Safety input	
Enter quantity	12
High input voltage	13 ~ 28V
Low input voltage	0 ~ 5V
Reverse current on input when ground wire is open	Max 20 mA 2.2 KΩ equivalent resistance from voltage supply to input
Input capacitance	1nF
Safety output	
Output quantity	8
Output Type	PNP transistor, short circuit protection
High output voltage	Output power supply voltage - 2V
Low output voltage	≤ 1V
Leakage current (low)	≤ 0.5 mA
Output current	300mA
Total Current	≤ 1.2A
Detection pulse width	0~1000us
Detection Pulse Period	<200ms
Load capacitance	≤0.9uF
Cable impedance	Up to 5 Ω (e.g. 100 m × 1.5 mm ² = 1.2 Ω)
Response time	Depending on the logic configuration

Safe output synchronization	< 1 ms
Test Output	
Output quantity	4
Output Type	PNP transistor, short circuit protection, short circuit monitoring
High output voltage	Output supply voltage-2 V
Output current	100mA
Total Current	200mA
Test pulse width	4ms
Test Pulse Period	200ms
Load capacitance	≤1uF
Cable resistance	< 100 Ω

Note 1: The detection pulse on the safety output is configured through the upper computer software SPC Tool, and the width of the detection pulse directly affects the capacitive load capacity of the safety output.

Environmental parameters

Table 12-3: SPC-MC12 environmental parameters

Project	Parameter
Protection level (IEC 60529)	IP20
Operating ambient temperature (UL/CSA: ambient air temperature)	-25 ... + 60 °C
Storage Temperature	-25... + 70 °C
Air humidity	10% ~ 95% without condensation
Running height	Not more than 2,000 m above sea level (80 kPa)
Vibration resistance	5Hz~8.4Hz, 3.5mm displacement, constant amplitude, 8.4Hz~150Hz, 1g acceleration, constant amplitude
Impact resistant, continuous	15 g, 11 ms (EN 60068-2-27)

Mechanical parameters

Table 12-4: SPC-MC12 mechanical parameters

Project	Parameter
Dimensions (L × W × H)	110 mm × 106 mm × 64 mm
Weight	337 g (± 5%)

12.3.2 Main Control Module SPC-MC20

Safety parameters

Table 12-5: SPC-MC20 safety technical parameters

Project	Parameter
---------	-----------

Safety Integrity (IEC 61508) Safety Integrity (IEC 62061)	SIL 3
Performance Class (ISO 13849)	PL e
Category (ISO 13849)	
All safety outputs have enabled single channel outputs for detection pulses (O1-O8)	Cat.4 ¹
Dual channel outputs (O1-O8) with or without disabled detection pulses on this safety output or any other safety output	Cat.4
PFH	2.23×10 ⁻¹⁰
TM (Continuous Run Time, ISO 13849)	20 years

Note 1: It is necessary to apply the fault exclusion clause for cables between safety outputs and external devices (output devices) in accordance with Table D.4 of ISO13849-2:2012. For example, installing SPC and external devices in a chassis (control cabinet, etc.) that complies with IEC60204-1, and using protected or separate cable laying for this safety output.

Electrical parameters

Table 12-6: SPC-MC20 electrical parameters

Project	Parameter
Operating voltage	24V DC (70%—125%)
UL/CSA application operating voltage	24V DC
Operating voltage type	PELV/SELV The operating current of the module must be limited externally to a maximum of 4 A-through the power supply or fuse used
Over voltage category	II (EN 61131-2)
Power consumption (no load)	≤3.5W
Connection mode	Screw terminal block/spring terminal block
Cross-sectional area of power conductor	Single wire or thin wire: 0.14 ~ 2.5 mm ² AWG according to UL/CUL: 24~14
Cross-sectional area of signal port conductor	Single wire or thin wire: 0.2 ~ 1.5 mm ² Thin wire with core end sleeve: With plastic sleeve up to 0.75 mm ² No plastic sleeve up to 0.75 mm ² AWG according to UL/CUL: 24~16
Protection level (IEC 61140)	III
Immunity	EN 61000-6-2
Electromagnetic Compatibility (EMC)	IEC 61131-2
Safety input	

Enter quantity	20
High input voltage	13 ~ 28V
Low input voltage	0 ~ 5V
Reverse current on input when ground wire is open	Max 20 mA 2.2K Ω equivalent resistance from voltage supply to input
Input capacitance	1nF
Safety output	
Output quantity	8
Output Type	PNP transistor, short circuit protection
High output voltage	Output supply voltage-2 V
Low output voltage	$\leq 1V$
Leakage current (low)	$\leq 0.5 \text{ mA}$
Output current	300mA
Total Current	$\leq 1.2A$
Detection pulse width	0~1000us
Detection Pulse Period	<200ms
Load capacitance	$\leq 0.9\mu F$
Cable impedance	Up to 5 Ω (e.g. 100 m $\times$ 1.5 mm ² = 1.2 Ω)
Response time	Depending on the logic configuration
Safe output synchronization	< 1 ms
Test Output	
Output quantity	4
Output Type	PNP transistor, short circuit protection, short circuit monitoring
High output voltage	Output supply voltage-2 V
Output current	100mA
Total Current	200mA
Test pulse width	4ms
Test Pulse Period	200ms
Load capacitance	$\leq 1\mu F$
Cable resistance	< 100 Ω

Note 1: The detection pulse on the safety output is configured through the upper computer software SPC Tool, and the width of the detection pulse directly affects the capacitive load capacity of the safety output.

Environmental parameters

Table 12-7: SPC-MC20 environmental parameters

Project	Parameter
Protection level (IEC 60529)	IP20
Operating ambient temperature (UL/CSA: ambient air temperature)	-25 ... + 60 °C
Storage Temperature	-25... + 70 °C
Air humidity	10% ~ 95% without condensation
Running height	Not more than 2,000 m above sea level (80 kPa)

Vibration resistance	5Hz~8.4Hz, 3.5mm displacement, constant amplitude, 8.4Hz~150Hz, 1g acceleration, constant amplitude
Impact resistant, continuous	15 g, 11 ms (EN 60068-2-27)

Mechanical parameters

Table 12-8: SPC-20 mechanical parameters

Project	Parameter
Dimensions (L × W × H)	82 mm × 106 mm × 64 mm
Weight	282 g (± 5%)

12.3.3 Expansion Module SPC-IO

Safety parameters

Table 12-9: SPC-IO safety technical parameters

Project	Parameter
Safety Integrity (IEC 61508) Safety Integrity (IEC 62061)	SIL 3
Performance Class (ISO 13849)	PL e
Category (ISO 13849)	
All safety outputs have enabled single channel outputs for detection pulses (O1-O8)	Cat.4 ¹
Dual channel outputs (O1-O8) with or without disabled detection pulses on this safety output or any other safety output	Cat.4
PFH	1.10×10^{-10}
TM (Continuous Run Time, ISO 13849)	20 years

Note 1: It is necessary to apply the fault exclusion clause for cables between safety outputs and external devices (output devices) in accordance with Table D.4 of ISO13849-2:2012. For example, installing SPC and external devices in a chassis (control cabinet, etc.) that complies with IEC60204-1, and using protected or separate cable laying for this safety output.

Electrical parameters

Table 12-10: SPC-IO electrical parameters

Project	Parameter
Operating voltage	24V DC (70%—125%)
UL/CSA application operating voltage	24V DC
Operating voltage type	PELV/SELV The operating current of the module must be limited externally to a maximum of 4 A-through the power supply or fuse used
Over voltage category	II (EN 61131-2)

Power consumption (no load)	≤2.5W
Connection mode	Screw terminal block/spring terminal block
Cross-sectional area of power conductor	Single wire or thin.: 0.14 ~ 2.5 mm ² AWG according to UL/CUL: 24~14
Cross-sectional area of signal port conductor	Single wire or thin wire: 0.2 ~ 1.5 mm ² Thin wire with core end sleeve: With plastic sleeve up to 0.75 mm ² No plastic sleeve up to 0.75 mm ² AWG according to UL/CUL: 26-16
Protection level (IEC 61140)	III
Immunity	EN 61000-6-2
Electromagnetic Compatibility (EMC)	IEC 61131-2
Safety input	
Enter quantity	8
High input voltage	13 ~ 28V
Low input voltage	0 ~ 5V
Reverse current on input when ground wire is open	Max 20 mA 2.2 K Ω equivalent resistance from voltage supply to input
Input capacitance	1nF
Safety output	
Output quantity	4
Output Type	PNP transistor, short circuit protection
High output voltage	Output supply voltage-2 V
Low output voltage	≤ 1V
Leakage current (low)	≤ 0.5 mA
Output current	300mA
Total Current	≤ 1.2A
Detection pulse width	0~1000us
Detection Pulse Period	<200ms
Load capacitance	≤0.9uF
Cable impedance	Up to 5 Ω (e.g. 100 m × 1.5 mm ² = 1.2 Ω)
Response time	Depending on the logic configuration
Safe output synchronization	< 1 ms
Test Output	
Output quantity	2
Output Type	PNP transistor, short circuit protection, short circuit monitoring
High output voltage	Output supply voltage-2 V
Output impedance	
Output current	100mA
Total Current	200mA
Test pulse width	4ms
Test Pulse Period	200ms
Load capacitance	≤1uF
Cable resistance	<100 Ω

Note 1: The detection pulse on the safety output is configured through the upper computer software SPC Tool, and the width of the detection pulse directly affects the capacitive load capacity of the safety output.

Environmental parameters

Table 12-11: SPC-IO environmental parameters

Project	Parameter
Protection level (IEC 60529)	IP20
Operating ambient temperature (UL/CSA: ambient air temperature)	-25 ... + 60 °C
Storage Temperature	-25... + 70 °C
Air humidity	10% ~ 95% without condensation
Running height	Not more than 2,000 m above sea level (80 kPa)
Vibration resistance	5Hz~8.4Hz, 3.5mm displacement, constant amplitude, 8.4Hz~150Hz, 1g acceleration, constant amplitude
Impact resistant, continuous	15 g, 11 ms (EN 60068-2-27)

Mechanical parameters

Table 12-12: SPC-IO mechanical parameters

Project	Parameter
Dimensions (L × W × H)	50 mm × 106 mm × 64 mm
Weight	172 g (± 5%)

12.3.4 Expansion Module SPC-EN

Safety parameters

Table 12-13: SPC-EN safety technical parameters

Project	Parameter
Safety Integrity (IEC 61508) Safety Integrity (IEC 62061)	SIL 3
Category (ISO 13849)	Cat.4
Performance Class (ISO 13849)	PL e
PFH	1.63×10^{-10}
TM (Continuous Run Time, ISO 13849)	20 years

Electrical parameters

Table 12-14: SPC-EN electrical parameters

Project	Parameter
Operating voltage	24V DC (70%—125%)

UL/CSA application operating voltage	24V DC
Operating voltage type	PELV/SELV The operating current of the module must be limited externally to a maximum of 4 A-through the power supply or fuse used
Over voltage category	II (EN 61131-2)
Power consumption (no load)	≤ 3W
Connection mode	Screw terminal
Cross-sectional area of conductor	Single wire or thin line: 0.14 ~ 2.5 mm ² AWG according to UL/CUL: 26-14
Protection level (IEC 61140)	III
Immunity	EN 61000-6-2
Electromagnetic Compatibility (EMC)	IEC 61131-2

Environmental parameters

Table 12-15: SPC-EN environmental parameters

Project	Parameter
Protection level (IEC 60529)	IP20
Operating ambient temperature (UL/CSA: ambient air temperature)	-25 ... + 60 °C
Storage Temperature	-25... + 70 °C
Air humidity	10% ~ 95% without condensation
Running height	Not more than 2,000 m above sea level (80 kPa)
Vibration resistance	5Hz~8.4Hz, 3.5mm displacement, constant amplitude, 8.4Hz~150Hz, 1g acceleration, constant amplitude
Impact resistant, continuous	15 g, 11 ms (EN 60068-2-27)

Mechanical parameters

Table 12-16: SPC-EN mechanical parameters

Project	Parameter
Dimensions (L × W × H)	50 mm × 106 mm × 64 mm
Weight	178g (± 5%)

12.4 Structural dimensions

Main control module SPC-MC12

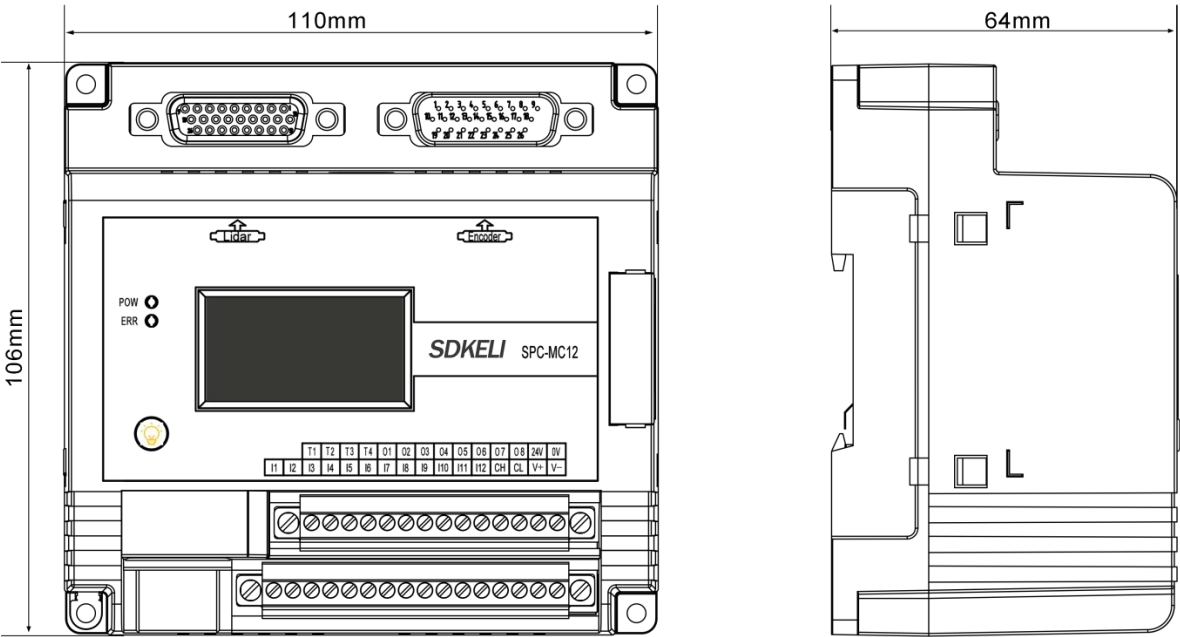


Figure 12-2 Dimensions of main control module SPC-MC12

Main control module SPC-MC20

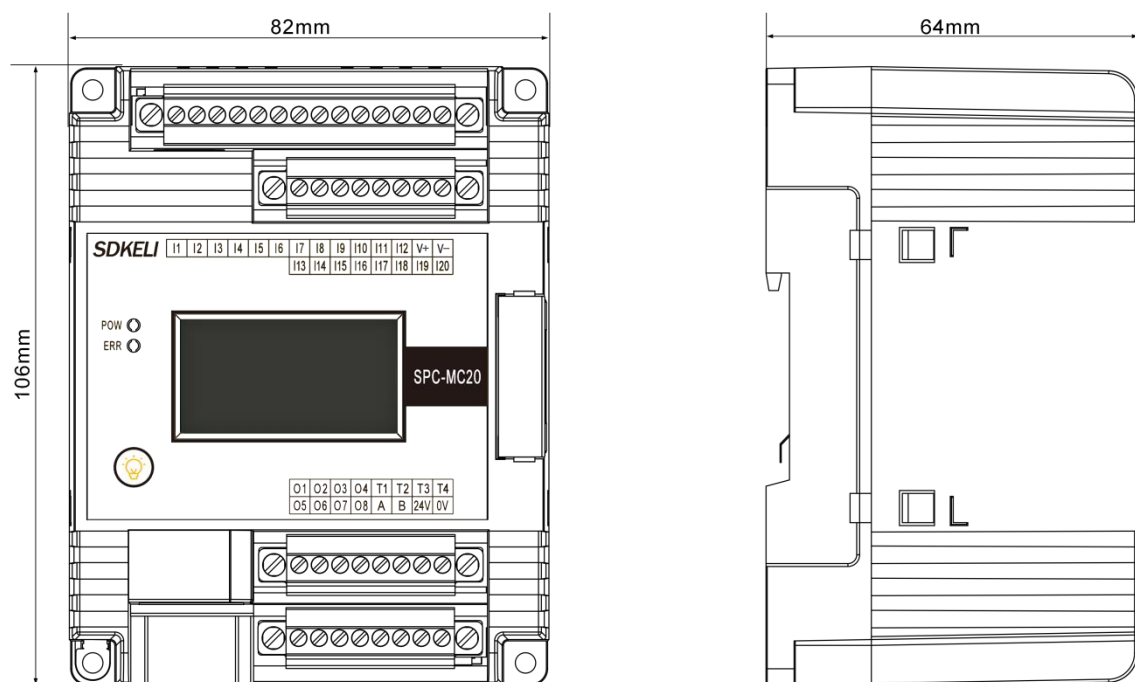


Figure 12-3 Dimensions of main control module SPC-MC20

Expansion module SPC-IO



Figure 12-4 Expansion Module SPC-IO Dimensions

Expansion module SPC-EN



Figure 12-5 Expansion Module SPC-EN Dimensions

13 Application checklist

Checklist for Manufacturers/Equipment Merchants to Install Products

Instructions for the following points must be available at least at the time of initial commissioning, but depending on the application, the manufacturer/equipment manufacturer must check their requirements.

This checklist should be properly kept and recorded in the machine data so that it can be used as a reference in regular inspections.

This checklist is irreplaceable and is performed by qualified safety personnel for initial commissioning as well as periodic inspections.

Have the relevant safety provisions of the directives and standards applicable to machines been taken as the basis?	Yes[] No[]
Have the application directives and standards been included in the declaration of conformity?	Yes[] No[]
Does the protection device meet the PL/SIL and PFHd required by ISO 13849/IEC 62061 and the Type grade required by IEC 61496?	Yes[] No[]
Are the required electric shock protection measures (protection levels) implemented?	Yes[] No[]
Are safety features checked according to the inspection instructions in this document?	Yes[] No[]
Have you ensured that the safety features are completely checked after any changes to the configuration of the product?	Yes[] No[]

14 Appendix: Terminology and Abbreviations

14.1 Terminology

Terminology	Definition
SPC	Safety Programmable Controller, product name designed in this project
Main control module	The main processing unit of the SPC system is the basis of the operation of the whole system and can run independently. Different main control module models carry different numbers of IO ports, lidar ports and encoder ports
Expansion module	The expansion processing unit of SPC is used to expand the interface and function of the system, and can only be used with the main control module. It includes two types: IO expansion module and motion expansion module
KLM	KLM is a lidar certified by Keli, which is certified by SIL 2 and PL d security level, which can cooperate with SPC to provide safety solutions for the AGV industry. KLM has rich interface configurations and can realize the switching of up to 64 defense zone groups. For details, please refer to the KLM manual
Safety status	Status of controlled equipment when safety is reached
Safety output	Outputs performed or related to safety functions
Standard output	Outputs that perform non-safety functions or are not related to safety functions
Test Output	The test output provides the drive source signal for the passive contact (such as the normally closed contact of the emergency stop button), and the "test output-passive contact-safety input" is connected in series to form a detection loop for monitoring the status of the passive contact.
Safety function	The portion of overall safety related to controlled equipment and

	controlled equipment control systems, which depends on the correct implementation of electrical/electronic/programmable electronic safety related systems and other risk reduction measures
Security integrity	The average probability of successfully implementing the required safety function within a specified time and under all specified conditions.
Security Integrity Level (SIL)	A set of grading numbers that determine the techniques and measures that must be adopted to reduce residual software failures to an appropriate level. The higher the safety integrity level value, the higher the safety level.
Availability	Assuming that the required external resources can be met, the ability of the product to complete the required functions under the specified conditions, at the specified time or within a given time interval.
Reliability	The possibility that the required functions of the system can be met under given conditions and within a given time.
Maintainability	The possibility of actively completing maintenance activities under assumed use conditions, within a certain time interval, under certain conditions, after certain procedures and using certain resources.

14.2 Abbreviations

Abbreviation	English Description	Chinese description
SIL	Safety Integrity Level	Security integrity level
PL	Performance Level	Performance level
Cat.	Category	Category
EDM	External Device Monitoring	External Device Monitoring
OSSD	Output signal switching device	Output signal switching device
MTTFd	Mean Time to Dangerous Failure	Mean Time to Dangerous Failure
PFHd	Probability of a dangerous failure per Hour	Probability of hazardous failure per hour
SILCL	Safety Integrity Level Claim Limit	Security Integrity Level Limits

14.3 Communication protocol

14.3.1 Internal register address definition-external output

Name	Register address (16 bits)			Function
	Address (Decimal)	Address (Hexadecimal)	Length (Bytes)	
Master module input	8192	2000	2	Each bit represents one input, with the lower bit representing a low physical position input. The MC12 is a 12-bit input and the MC20 is a 20-bit input.
	8193	2001	2	
IO Module 1 input	8194	2002	2	Each bit represents one input, with the lower bits representing low physical position inputs
IO Module 2 input				
IO Module 3 input	8195	2003	2	
IO Module 4 input				
IO Module 5 input	8196	2004	2	
IO module 6 input				
IO Module 7 input	8197	2005	2	
IO Module 8 input				
IO Module 9 input	8198	2006	2	
IO Module 10 input				
IO Module 11 input	8199	2007	2	
IO Module 12 input				
IO Module 13 input	8200	2008	2	
IO module 14 input				

Output from the master module	8392	20C8	2	Each bit represents one output, with the lower bits representing low physical position outputs
IO Module 1 output	8393	20C9	2	Each bit represents one output, with the lower bits representing low physical position outputs
IO Module 2 output				
IO Module 3 output	8394	20CA	2	
IO Module 4 output				
IO Module 5 output	8395	20CB	2	
IO module 6 output				
IO Module 7 output	8396	20CC	2	
IO Module 8 output				
IO Module 9 outputs	8397	20CD	2	
IO Module 10 output				
IO module 11 output	8398	20CE	2	
IO module 12 output				

IO module 13 output	8399	20CF	2	
IO module 14 output				

system mode	8592	2190	2	System running status. 0 is normal, 1 is fault
Status of the master module				Module running status. 0 is normal, 1 is fault
From module 1 status	8593	2191	2	
From module 2 status				
From module 3 status	8594	2192	2	
From module 4 status				
From module 5 status	8595	2193	2	
From module 6 status				
From module 7 status	8596	2194	2	
From module 8 status				
From module 9 status	8597	2195	2	
From module 10 status				
From module 11 status	8598	2196	2	
From module 12 status				
From module 13 status	8599	2197	2	
From module 14 status				

System checksum	8792	2258	2	System configuration identifier
	8793	2259	2	
Software checksum	8794	225A	2	Software configuration identification
	8795	225B	2	
Logical result 0	8796	225C	2	Each one represents a logical point
Logical result 1				
Logical result 2	8797	225D	2	
Logical result 3				
~	~	~	~	
Logical result 58	8799	2279	2	
Logical result 59				

Encoder 1 speed	8992	2320	4	MC12 master control module encoder 1 speed
Encoder 2 speed	8994	2322	4	MC12 master control module encoder 2 speed
Encoder 3 speed	8996	2324	4	MC12 master control module encoder 3 speed
Encoder 4 speed	8998	2326	4	MC12 master control module encoder 4 speed

Encoder 5 speed	9000	2328	4	EN module 1 encoder 1 speed
Encoder 6 speed	9002	232A	4	EN module 1 encoder 2 speed
Encoder 7 speed	9004	232C	4	EN module 1 encoder 3 speed
Encoder 8 speed	9006	232E	4	EN module 1 encoder 4 speed
Encoder 9 speed	9008	2330	4	EN module 2 encoder 1 speed
Encoder 10 speed	9010	2332	4	EN module 2 encoder 2 speed
Encoder 11 speed	9012	2334	4	EN module 2 encoder 3 speed
Encoder 12 speed	9014	2336	4	EN module 2 encoder 4 speed
lidar 1	9016	2338	2	MC12 main control module lidar 1 Low 8 bits: bit0~bit5 are OSSD1A, OSSD1B, IO2, IO3, IO1, IO4; High 8 bits: bit0~bit7: static switching signal output 1~8
lidar 2	9017	2339	2	MC12 main control module lidar 2 Low 8 bits: bit0~bit5 are OSSD1A, OSSD1B, IO2, IO3, IO1, IO4; High 8 bits: bit0~bit7: static switching signal output 1~8

Note 1: The index of the manufacturer-specific sub-protocol area in the CAN interface CanOpen object dictionary is consistent with the table above.

Note 2: All query register data is in little-endian order.

Canopen PDO1	Run Result 0	16384	4000	1	Each bit represents one input, with the lower bit representing a low physical position input
	Run Result 1	16384	4000	2	
	Run Result 2	16384	4000	3	
	Run Result 3	16384	4000	4	
	Run Result 4	16384	4000	5	
	Run Result 5	16384	4000	6	
	Run Result 6	16384	4000	7	
	Run Result 7	16384	4000	8	
Canopen PDO2	Run Result 8	16384	4000	9	
	Run Result 9	16384	4000	10	
	Run Result 10	16384	4000	11	
	Run Result 11	16384	4000	12	
	Run Result 12	16384	4000	13	
	Run Result 13	16384	4000	14	
	Run Result 14	16384	4000	15	
	Run Result 15	16384	4000	16	
Canopen PDO3	Run Result 16	16384	4000	17	Each bit represents one output, with the lower bits representing low physical position outputs
	Run Result 17	16384	4000	18	
	Run Result 18	16384	4000	19	
	Run Result 19	16384	4000	20	
	Run Result 20	16384	4000	21	
	Run Result 21	16384	4000	22	
	Run Result 22	16384	4000	23	
	Run Result 23	16384	4000	24	
Canopen PDO4	Run Result 24	16384	4000	25	Each one represents a logical point
	Run Result 25	16384	4000	26	

	Run Result 26	16384	4000	27	
	Run Result 27	16384	4000	28	
	Run Result 28	16384	4000	29	
	Run Result 29	16384	4000	30	
	Run Result 30	16384	4000	31	
	Run Result 31	16384	4000	32	

14.3.2 Internal Register Address Definition-Internal input

Name	Register address (16 bits)			Function
	Address (Decimal)	Address (Hexadecimal)	Length (Bytes)	
Modbus TCP holds register 1	40001	9C41	2	For Modbus TCP write, corresponding to 10 instructions.
Modbus TCP holds register 2	40002	9C42	2	
Modbus TCP holds register 3	40003	9C43	2	
Modbus TCP holds register 4	40004	9C44	2	
Modbus TCP holds register 5	40005	9C45	2	
Modbus TCP holds register 6	40006	9C46	2	

Modbus RTU keeps register 1	40100	9CA4	2	For Modbus RTU write, corresponding to 10 instructions.
Modbus RTU keeps register 2	40101	9CA5	2	
Modbus RTU keeps register 3	40102	9CA6	2	
Modbus RTU keeps register 4	40103	9CA7	2	
Modbus RTU keeps register 5	40104	9CA8	2	
Modbus RTU keeps register 6	40105	9CA9	2	

Canopen RPDO1	12288	3000	1	Write to Canopen
Canopen RPDO1	12288	3000	2	
Canopen RPDO1	12288	3000	3	
Canopen RPDO1	12288	3000	4	
Canopen RPDO1	12288	3000	5	
Canopen RPDO1	12288	3000	6	
Canopen RPDO1	12288	3000	7	

Canopen RPDO1	12288	3000	8
Canopen RPDO2	12288	3000	9
Canopen RPDO2	12288	3000	10
Canopen RPDO2	12288	3000	11
Canopen RPDO2	12288	3000	12

14.3.3 RS485 interface communication protocol

The RS485 communication data consists of: 8-bit data bits, 1-stop bit, and no parity check.

Query the frame format

address	FC	start address	Query the number of registers	check code
1Byte	1Byte	2Byte	2Byte	2Byte
SPC address	0x03	Internal register address	The number of registers to be queried	CRC16

Response frame format

address	FC	DL	data	check code
1Byte	1Byte	1Byte	nByte	2Byte
SPC address	0x03	The length of the data queried	valid data	CRC16

Incorrect frame format

address	FC	Error code	check code
1Byte	1Byte	1Byte	2Byte
SPC address	0x83	01: Illegal function; 02: Illegal address; 03: Illegal data;	CRC16

Default baud rate: 115200 bits/s

14.3.4 Ethernet interface communication protocol

Query the frame format

Transaction processing identifier	protocol identifier	length	element ID	FC	start address	Query the number of registers
2Byte	2Byte	2Byte	1Byte	1Byte	2Byte	2Byte
0x00 0x00	0x00 0x00	Length of the following byte	0x00	0x03	Internal register address	The number of registers to be queried

Response frame format

Transaction processing identifier	protocol identifier	length	element ID	FC	DL	data
2Byte	2Byte	2Byte	1Byte	1Byte	1Byte	nByte
0x00 0x00	0x00 0x00	Length of the following byte	0x00	0x03	The length of the data queried	valid data

Incorrect frame format

Transaction ID	protocol identifier	length	element ID	FC	Error code
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2Byte	2Byte	2Byte	1Byte	1Byte	1Byte
0x00 0x00	0x00 0x00	Length of the following byte	0x00	0x83	01: Illegal function; 02: Illegal address; 03: Illegal data;

14.3.5 Type C interface communication protocol

Query the frame format

Frame header	FC	start address	Query the number of registers	check code
1Byte	1Byte	2Byte	2Byte	2Byte
0x00	0x03	Internal register address	The number of registers to be queried	Modbus CRC16

Response frame format

Frame header	FC	DL	data	check code
1Byte	1Byte	1Byte	nByte	2Byte
0x00	0x03	The length of the data queried	valid data	Modbus CRC16

Default baud rate: 230400 bits/s

14.3.6 CAN interface communication protocol

Start SDO upload (CAN-ID is 0x600 + Node-ID)

CS designator	index of matrix	subindex	Not used
1Byte	2Byte	1Byte	4Byte
Read 0x40	Object dictionary manufacturer specific subprotocol zone index, little-end format	Object dictionary manufacturer specific sub-protocol zone sub-index	zero padding

Upload response (CAN-ID 0x580 + Node-ID)

CS designator	index of matrix	subindex	data
1Byte	2Byte	1Byte	4Byte
0x4F reads a response of 1 byte 0x4B reads the response in 2 bytes 0x47 Reads the response in three bytes 0x43 Reads the response in 4 bytes	Object dictionary manufacturer specific subprotocol zone index, little end format	Object dictionary manufacturer specific subprotocol zone sub-index	Small end format

Start the asynchronous PDO timer driver (CAN-ID 0x600 + Node-ID)

CS designator	index of matrix	subindex	data
1Byte	2Byte	1Byte	4Byte
0x2B	Object dictionary manufacturer specific subprotocol zone index, little end format	Object dictionary manufacturer specific sub-protocol zone sub-index	Timer time, in ms, little-endian format

Stop the asynchronous PDO timer driver (CAN-ID 0x600 + Node-ID)

CS designator	index of matrix	subindex	data
1Byte	2Byte	1Byte	4Byte
0x2B	Object dictionary manufacturer specific subprotocol zone index, little-end format	Object dictionary manufacturer specific sub-protocol zone sub-index	zero padding

Start synchronous PDO (CAN-ID is 0x600 + Node-ID)

CS designator	index of matrix	subindex	data
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1Byte	2Byte	1Byte	4Byte
0x2F	Object dictionary manufacturer specific subprotocol zone index, little end format	Object dictionary manufacturer specific sub-protocol zone sub-index	Fixed 0x01 0x00 0x00 0x00

Stop synchronous PDO (CAN-ID is 0x600 + Node-ID)

CS designator	index of matrix	subindex	data
1Byte	2Byte	1Byte	4Byte
0x2F	Object dictionary manufacturer specific subprotocol zone index in little-endian format	Object dictionary manufacturer specific sub-protocol zone sub-index	zero padding

PDO parameters are saved (CAN-ID is 0x600 + Node-ID)

CS designator	index of matrix	subindex	data
1Byte	2Byte	1Byte	4Byte
0x23	Object dictionary manufacturer specific subprotocol zone index in little-endian format	Object dictionary manufacturer specific sub-protocol zone sub-index	Fixed 0x73 0x61 0x76 0x65

PDO parameter reading (CAN-ID is 0x600 + Node-ID)

CS designator	index of matrix	subindex	data
1Byte	2Byte	1Byte	4Byte
0x40	Object dictionary manufacturer specific subprotocol zone index, little-end format	Object dictionary manufacturer specific subprotocol zone sub-index	zero padding

PDO parameter reset (CAN-ID 0x600 + Node-ID)

CS designator	index of matrix	subindex	data
1Byte	2Byte	1Byte	4Byte
0x23	Object dictionary manufacturer specific subprotocol zone index, little-end format	Object dictionary manufacturer specific sub-protocol zone sub-index	Fixed 0x6C 0x6F 0x61 0x64

Write RPDO1 (CAN-ID 0x200 + Node-ID)

data
8Byte
The internal input nodes 1-8, each of which represents a logical point

Write RPDO2 (CAN-ID 0x300 + Node-ID)

data	data
4Byte	4Byte
The input nodes 9-12 on the inside represent a logical point for each bit	Retain, zero fill

Default baud rate: 125,000 bits/s