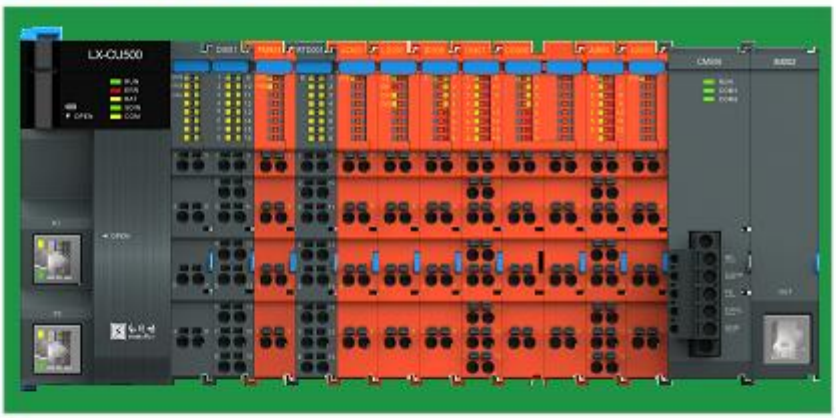
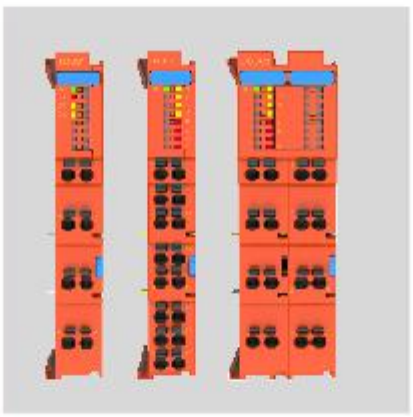
HollySys





LXS Control System
Module Manual

Version:2024.12

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Chapter 1 About this document

1.1 Document update

Version	Date	Description
1.0	2023.10	Newly created.
1.1	2024.02	Added module pictures, system response time, installation instructions, etc.
1.2	2024.06	According to TUV feedback suggestion, add fault exclusion instructions, optimize terminal connection methods, installation environment .etc chapter information.
1.3	2024.07	Add section 6.1.7, common sensor wiring instructions for digital quantities.
1.4	2024.07	1. Chapter 4.7.3 adds FSoE address verification and module indicator light flashing description; 2. Chapter 6.1.7 adds different types sensors should consider relevant standards.
1.5	2024.07	Chapter 6.8.3，"Fault exclusion" is modified to "trouble shooting".
1.6	2024.09	Add Chapter 6.8, instructions for using LX-DO908 module.
1.7	2024.10	Chapter 3.1.2, Explain the reason why the system power consumption does not include that of LX-DO908 module.
1.8	2024.12	1) Chapter 6.8.1，Add a fuse between the channel and the load in the schematic diagram； 2) Chapter 6.8.1，Modify notification content description； 3) Chapter 6.8.2，Add the processing time description； 4) Chapter 6.8.6，Add a fuse between the channel and the load in the wiring method diagram； 5) Add Chapter 6.8.7，LX-DO908 diagnostic description.

1.2 Purpose of the document

This document describes the use of all hardware modules within the LX series functional safety PLC system, including product introduction, module components, technical specifications, indicator lights, wiring instructions, and diagnostic information, etc. Please use this document in conjunction with other supporting product materials to gain a more comprehensive understanding of how to use the modules.

1.3 Intended readers

This manual is intended for engineers or technical personnel with expertise in automation and control systems.

1.4 Important information

This manual uses 5 types of symbols to differentiate and label key content, with each symbol meaning as follows:

This symbol indicates a dangerous situation that could cause death or injury if not avoided.

This symbol indicates a dangerous situation of electric shock if not avoided.

This symbol indicates a dangerous situation that could cause property or environment damage if not avoided.

This symbol indicates useful tips or recommendations for efficient operation.

This symbol indicates information for reference.

1.5 Illustrations

The illustrations in this manual can usually be displayed normally. If the illustration area shows ⊠, please press the F5 key to refresh.

1.6 Abbreviations

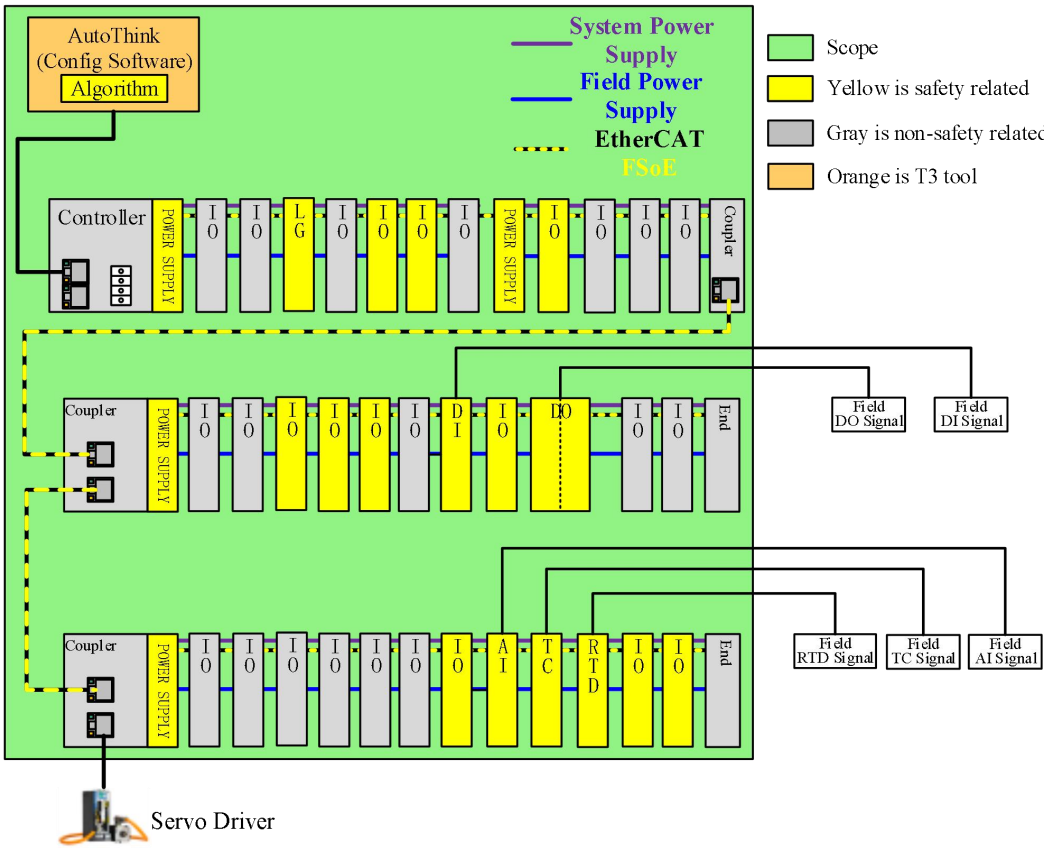
Abbreviation	Full name	Description
AI	Analog Input	Analog input
DI	Digital Input	Digital input
DO	Digital Output	Digital output
RTD	Resistance Temperature Detector	Resistance temperature detector
TC	Thermo Couple	Thermo couple

Abbreviation	Full name	Description
FSoE	Safety over EtherCAT	Safety communication protocol
ISAC	Industrial Smart Advanced Controller	Industrial smart advanced controller
PL	Performance Level	Performance level
SIL	Safety Integrity Level	Safety Integrity Level
LXS	LX series functional safety PLC system	LX series functional safety PLC system

Chapter 2 System overview

The LX series functional safety PLC (hereinafter referred to as "LXS") system is an enhancement of the LX PLC system with added safety function modules. The system features compactness, modularity, ease of use, quick fault response, and autonomy, making it suitable for applications requiring strict size constraints, flexible deployment, and functional safety. It is widely used in industries such as semiconductors, automotive manufacturing, new energy, logistics, intelligent equipment, and machinery manufacturing, etc.

The safety function modules, distinguished by their orange appearance, include safety logic, safety I/O, and safety power supply modules. Communication between the safety logic and safety I/O modules, and the controller is facilitated through the EtherCAT protocol, with the controller acting as the EtherCAT master station and the safety logic and safety I/O modules as EtherCAT slave stations. Furthermore, the safety logic and safety I/O modules communicate using the FSoE protocol, with the safety logic module serving as the FSoE master station and the safety I/O module as FSoE slave stations.



LXS system composition

The LXS system consists of a safety logic module, safety IO module, and configuration software. It accomplishes functions such as data acquisition, safety logic calculation, output execution, human-machine interaction, and data exchange, achieving automation, intelligence, and digitization. The hardware modules employ a card-type I/O design and support DIN35 rail-type installation, allowing cabinets and chassis to be flexibly installed and deployed according to application needs.

LXS layout diagram

2.1 System features

The system is compact and small, meeting the needs of users for medium and small-sized automation equipment and suitable for scenarios with strict size constraints and functional safety applications.

The system features a modular design, supports module expansion, precisely adapts to various occasions, and perfectly meets specific needs. The system can support up to 212 IO modules at most.

The system is safe and easy to use, including safety digital input/output modules and various signal safety analog input modules, allowing flexible configuration to meet various functional safety needs. The products comply with IEC61508 and ISO13849 standards, with the system capable of reaching up to SIL3 and PLe Cat.4.

The system is autonomously controllable, with both software and hardware developed independently, featuring fully autonomous programming software that is continuously iterated for ease of use, aligning with engineers' habits.

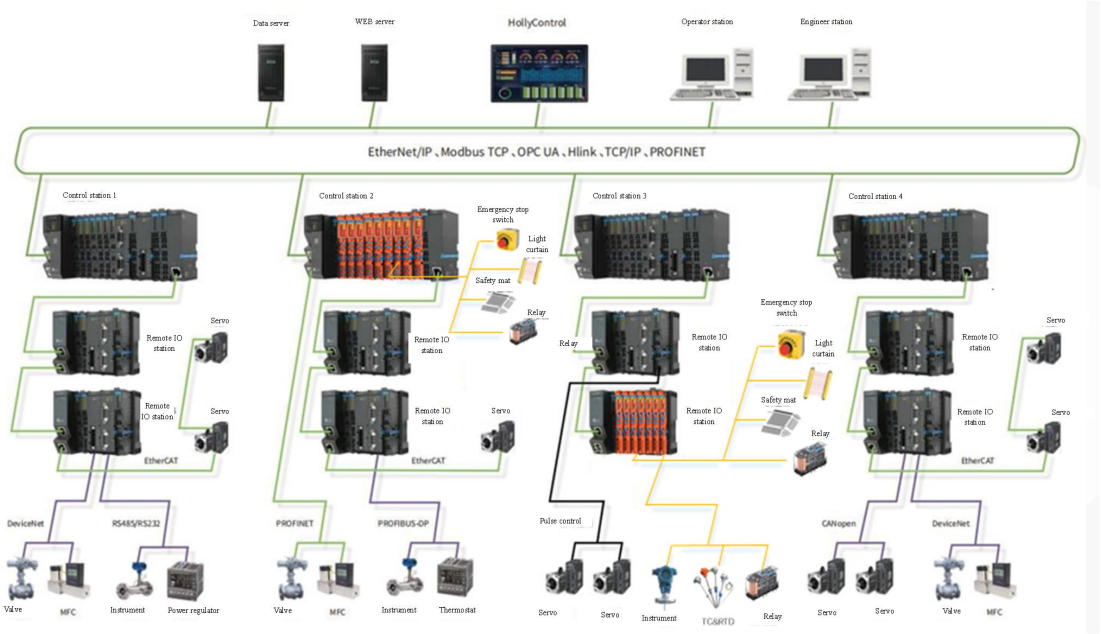
As a protection system, it is suitable for low demand, high demand, and continuous operation modes. The PFDavg and PFHavg caused by random hardware failures can be reduced to below 10% of the entire safety loop, facilitating the selection of other components in the safety loop.

The inter-module communication bus uses the EtherCAT bus with speed of 100Mbps, allowing for faster fault response, and the shortest response time is less than 20ms.

The configuration software complies with the requirements for T3 tools in IEC 61508-2010, and the configuration language supports FBD and LD.

2.2 System network composition

The following diagram shows the network composition of the LX system:



LX and LXS system configuration diagram

LXS modules can be placed either at the local control station or at remote I/O stations, and can be mixed with standard LX PLC modules.

2.3 System hardware

The LXS system, building upon the LX series PLC products with added functional safety modules, includes controllers, power relay modules, standard I/O modules, coupler modules, communication modules, safety logic modules, functional safety I/O modules, and safety isolation protection modules:

Controller: Possesses system logic processing and communication expansion capabilities, serving as the master station of the entire EtherCAT bus.

Communication module: Includes ModbusRTU serial modules, DeviceNet serial modules, CANopen communication modules, other communication protocol modules, and custom modules.

Coupler module: Used for EtherCAT communication expansion interface, supporting both field DC power and system DC power access through the coupler module.

Power relay module: Can be used for power relaying of the PLC controller module and I/O modules to the right of the coupler module.

Standard I/O module: Supports modules of DI, DO, AI, AO, RTD, TC, etc., converting field signals into digital signals.

Safety logic module: Used for safety input module collection, safety logic computation, and safety output module control functions, employing the FSoE protocol stack, and communicating with multiple functional safety I/O modules as the FSoE master station.

Functional safety I/O module: Used for functional safety input collection or output control, employing the FSoE protocol stack, communicating with the safety logic module as FSoE slave station, and supporting DI, DO, AI, RTD, and TC modules.

Safety isolation protection module: Used for functional safety I/O modules' isolation from standard modules, preventing standard module failures from damaging safety modules.

The specifications of functional safety modules of the LXS system are as follows:

S/N	Module model	Module name	Safety integrity level and system capability	Performance level and category
1	LX-LG901	Safety logic module	SIL3, SC3	PL e Cat.4
2	LX-DI906	4-channel safety DI module	SIL3, SC3	PL e Cat.4
3	LX-DI907	8-channel safety DI module	SIL3, SC3	PL e Cat.4
4	LX-DO906	4-channel safety DO module	SIL3, SC3	PL e Cat.4
5	LX-AI906	6-channel safety current AI module	SIL2, SC3	PL d Cat.3
6	LX-AI907	6-channel safety voltage AI module	SIL2, SC3	PL d Cat.3
7	LX-TC901	4-channel safety thermocouple module	SIL2, SC3	PL d Cat.3
8	LX-RTD901	4-channel safety RTD module	SIL2, SC3	PL d Cat.3
9	LX-PM903	Safety power relay module	SIL3, SC3	-
10	LX-AUX901	Safety isolation protection module	SIL3, SC3	-
11	LX-DO908	2-channel relay-type safety DO module	SIL3, SC3	PL e Cat.4

- The LX-AUX901 is an optional module that can prevent safety modules from being damaged by over-voltage of standard modules. The use of this module does not affect the system's safety level.
- In the LXS functional safety system, the power relay module can only use the safety power relay module LX-PM903 and cannot use the standard power relay module LX-PM003.

2.4 System software

The system software features offline configuration, compilation, installation, and online monitoring operations. It is a T3 tool related to functional safety, with the algorithm part of the configuration software being safety-related software.

The system software supports FBD and LD for safety configuration, and it offers flexible configuration options including support for custom function blocks. It allows for free configuration of safety logic and safety IO modules, automatic generation of EtherCAT slave station addresses and FSoE addresses, as well as software-based setting of FSoE addresses. The software also supports mapping between standard and safety data, and features such as online debugging, simulation, and user permission control.

Operating environment:

Operating system: Windows 7 Professional 32bits, Windows 7 Professional 64bits, Windows 10 Professional 64bits.

Software tools: Microsoft Office Excel 2003/2007/2010.

Key hardware configuration:

CPU: Intel Pentium 2.4GHz or above;

Memory: above 512MB, Hard disk: above10GB;

Graphics card: Resolution of 1280*720 or higher;

Network card: 100Mbps;

Monitor: Color CRT or LCD;

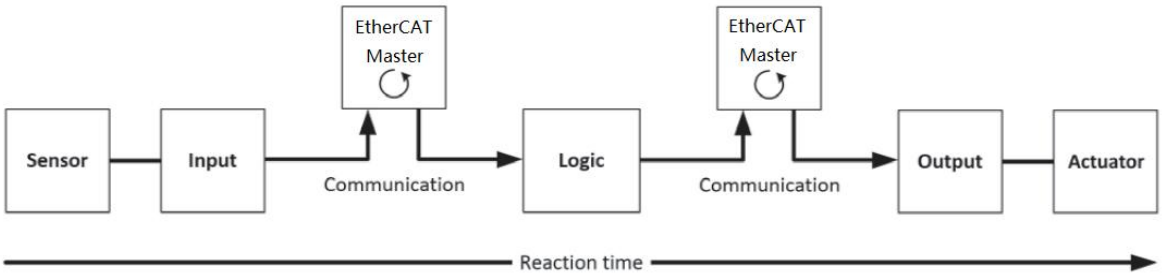
Input/output: Standard keyboard and mouse;

USB interface: At least one USB 2.0 port.

2.5 Estimation of system response time

The system response time is related to the configuration. The following formula can be used to estimate the maximum system response time: The system response time can be represented by the formula as below:

The maximum control cycle (response time) of the system = $T_{sensor}+2*T_{input} + T_{Filtering} + 6*T_{comm} + 2*T_{logic} + 6*T_{comm} + 2*T_{output}+T_{actuator}$.



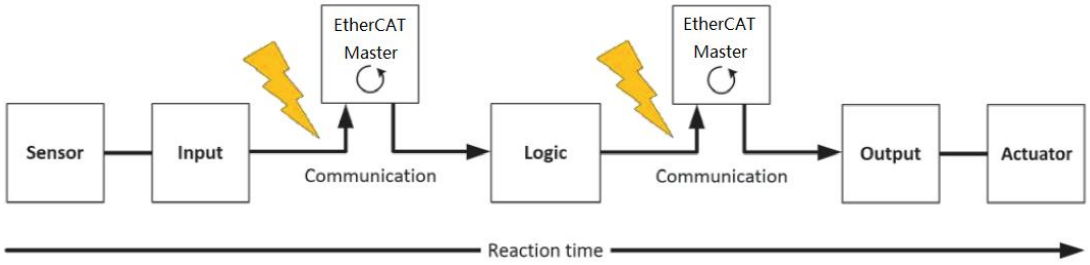
Logic diagram of LXS system response time

Definition	Description
T_{sensor}	The response time of the sensor, which needs to be obtained from the sensor manufacturer.
T_{input}	The response time of the safety input module. For LX-DI906/LX-DI907 modules, the maximum is 2ms; for LX-AI906/LX-AI907 modules, the maximum is 5ms; for LX-TC901

Definition	Description
	modules, the maximum is 260ms; and for LX-RTD901 modules, the maximum is 450ms.
$T_{Filtering}$	The signal filtering time of the safety input module, configurable on the FA AutoThink-Safety, varies among different input modules.
T_{comm}	EtherCAT communication cycle, configurable on the FA AutoThink, 1ms by default, ranges from 0.25 to 20ms.
T_{logic}	Safety logic IEC cycle, configurable, ranges from 1 to 1000ms.
T_{output}	The response time of the safety output module, the maximum response time for LX-DO906 modules is 2ms.
$T_{actuator}$	The response time of the actuator, which needs to be obtained from the actuator manufacturer.

When an EtherCAT or FSoE communication failure occurs, it will trigger the FSoE watchdog. After that, the worst-case failure response time is:

The maximum control cycle (response time) of the system= $T_{input\text{-}fsoe\_watchdog}+T_{output\text{-}fsoe\_watchdog}+T_{actuator}$



2.6 System certification

Certified by TÜV Rheinland Industrie Service GmbH, meeting the SC3 system capability level and SIL3 safety integrity level defined in IEC 61508, as well as the PLe Cat.4 performance level and category defined in ISO13849. According to the requirements of IEC 61508 /ISO13849, the LXS system can be applied to safety-related applications requiring a safety integrity level of SIL3, and a performance level and category of PLe Cat.4 or below.

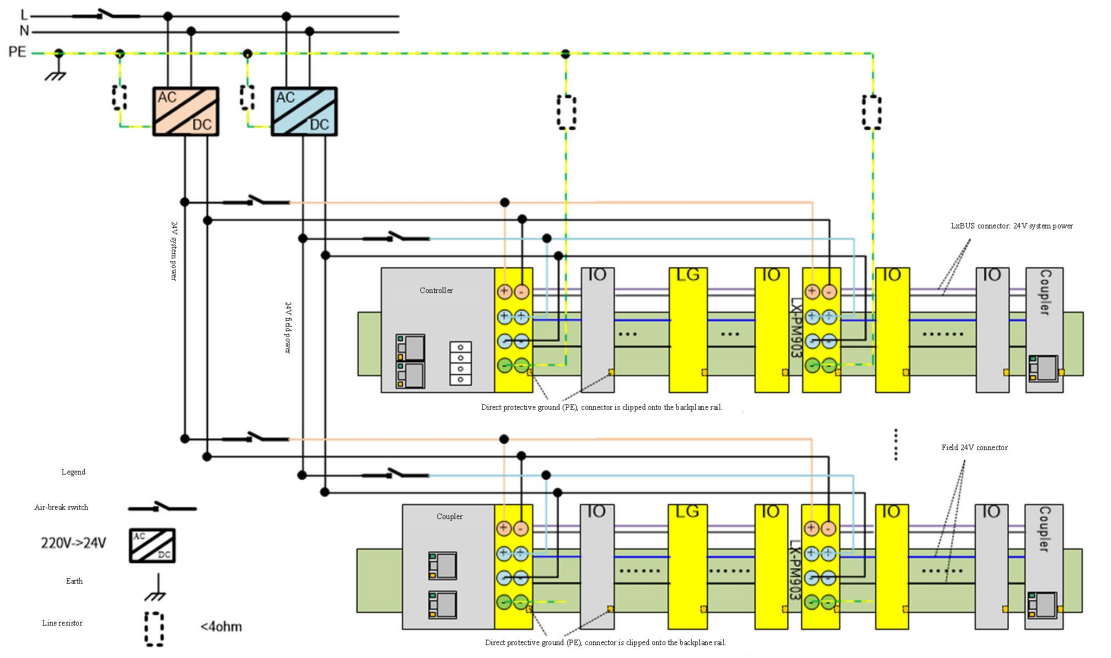
Complies with CE certification (including EMC, LVD, RoHS2.0).

Chapter 3 Power supply, grounding, and operating environment of the system

3.1 Power supply of the system

3.1.1 Topology of the system power supply

The system power supply is as shown in the figure below, with a 220V power source passing through a circuit breaker, then through two 220V/24V power supply modules, separately outputting a 24V power supply for the system side and the field side. Each then passes through an air-break switch, connecting to the system through the controller module and safety power relay module.



The protective ground of the LXS system must be well grounded, with a ground impedance of less than 4Ω.

3.1.2 Estimation of system power consumption

Total power consumption of safety modules = Number of safety logic modules * 1.5 + Number of safety DO modules * (1.5 + N * 30 * I) + Number of safety DI modules * (1.5 + N * 0.2) + Number of safety isolation protection modules * 0.5 + Other safety modules * 1.5.

System side power consumption = Number of safety logic modules * 1.5 + Number of safety IO modules * 1.5 + Number of safety isolation protection modules * 0.5 + Number of safety power boards (modules) * 0.5.

Field side power consumption = Number of DO modules * N * 24 * I + Number of DI modules * N * 0.2 + Number of safety power boards (modules) * 1.0.

N: Number of channels.

I: Output current of DO modules.

- The safety DO modules in this chapter do not include LX-DO908 (LX-DO908 is a passive module, the control terminal power supply of the LX-DO908 module comes from the field side of the LX-DO906 module) ;
- For standard modules (including controllers, IO modules, communication modules, couplers, etc.), please refer to the "Manual for LX Programmable Controller and IO Module".
- The power consumption unit is W. 1.5 and 0.5 in the system side power consumption represent the corresponding module power consumption/0.8, and 0.8 is considered for derating.

3.1.3 AC/DC power module

The system includes two types of AC/DC power modules with a power consumption of 240W, meeting SELV/PELV requirements. The power modules are TUV certified products, suitable for safety applications of SIL3 and PLe Cat.4. The two types of power modules are PRO MAX 240W 24V 10A and PIC240.241C, with specifications as shown in the table below.

Specifications of power module

Model	PRO MAX 240W 24V	PIC240.241C
Output	10A@24V	10A@24V
Voltage regulation range	22.5~29.5V	24~28V
Output voltage (rated)	24V	24V
Output current (rated)	10A	10A@24V, temperature<55°C 6.25A@24V, temperature<70°C 8.6A@28V, temperature<55°C 5.4A@28V, temperature <70°C Peak value: 13.5A (duration 5s)
Output power (rated)	240W	240W, temperature <55°C 150W, temperature <70°C Peak value: 320W (duration 5s)
AC input voltage	85~277VAC	200~240VAC
AC input frequency	45~65Hz	50~60Hz±6%
Power factor	>0.95@230VAC	>0.52@230VAC
Conversion efficiency	91.50%	91.40%
Power loss	22.3 W	22.6W
AC surge current	Maximum value 15 A	Maximum value 16A
Working temperature	-25℃~+70℃	-25℃~+70℃

Model	PRO MAX 240W 24V	PIC240.241C
Derating	> 60°C / 75% @ 70°C	6W/℃ +55℃~+70℃
Module dimensions (W*H*D)	60mm*130mm*125mm	49x124x124mm
MTBF (25℃ SN29500)	>500000h	>791000h
Connection method	Screw connection	Screw connection
Weight	1050g	550g

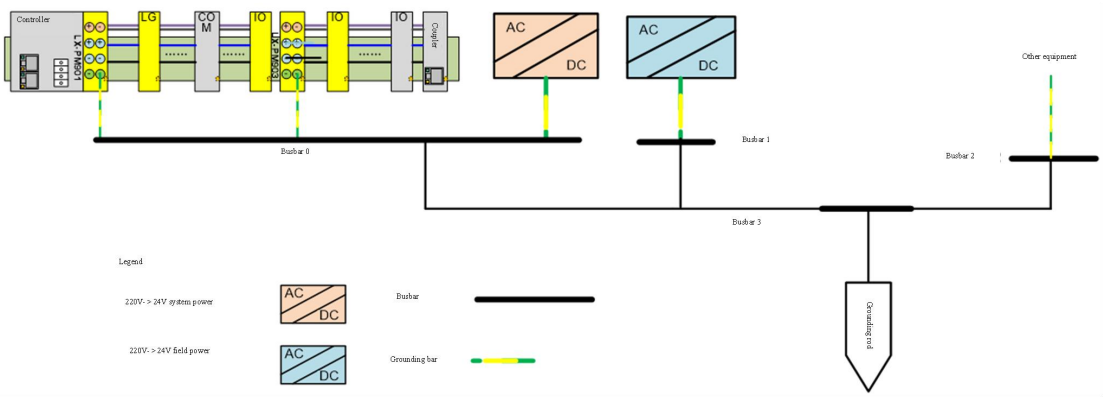
3.2 System earthing

The LXS system has three grounds: system ground (24V), shield (field) ground, and protective ground (enclosure);

Grounding method: The negative terminal of the system power supply is connected to an independent busbar, the negative terminal of the field power supply is connected to another busbar, and the third busbar is for protective ground. Inside the equipment, all busbars can be connected to an internal grounding plate or can be individually connected to outside of the equipment for unified grounding. Busbar 0 and Busbar 1 can be combined.

The grounding busbars inside each cabinet are made of copper bars with an area not less than 25mm×6mm;

Each grounding plate is connected to the copper grounding cable from the main grounding busbar, which has a cross-sectional area not less than 25mm^2 and is insulated. Finally, they are connected to the grounding electrode through a single point.



The safety logic,the safety isolation protection module and safety IO modules are connected with DIN35 rails through grounding spring clips (with contact impedance less than 1Ω), and the DIN35 rails are connected to the protective ground. No special grounding treatment is performed on the modules.

3.3 System insulation and withstand voltage

Isolation withstand voltage

The isolation withstand voltage between field ground and system ground, between channels and system ground, and between channels and protective ground is ≥1000VAC @1min@5mA; there is no isolation requirement between channels.

Insulation resistance

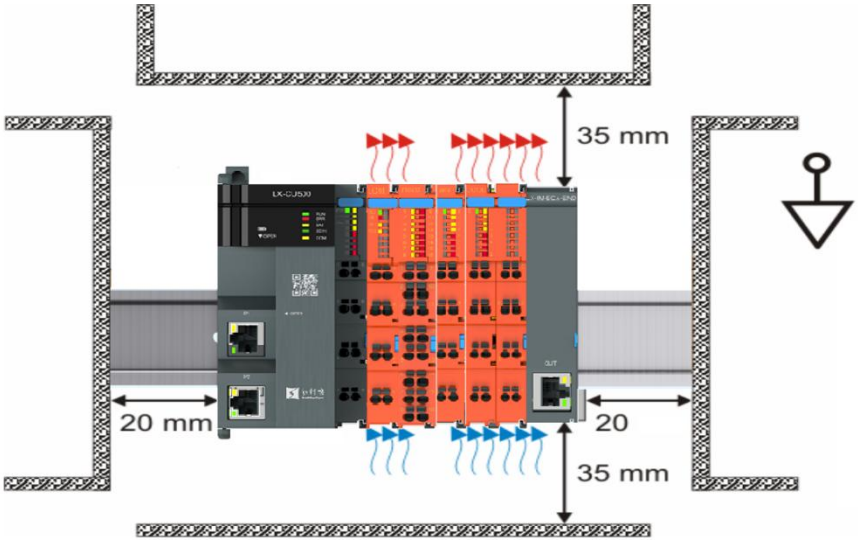
Under normal conditions, the insulation resistance between system ground, field ground, and protective ground is not less than 10MΩ @DC500V (temperature 25℃±2℃, relative humidity 30%±5%, non-condensing).

3.4 System operating environment

Hardware

Working temperature: -20℃~60℃.

The system is recommended to be placed horizontally. When placed horizontally, the operating temperature is -20℃~60℃; when placed vertically, the operating temperature is -20~50℃. In a sealed environment, it is recommended to meet the following requirements and add fans on both sides of the enclosure.



Standard modules adjacent to safety modules should preferably be those with low power consumption.

It is not recommended to place multiple safety DO modules together; the module adjacent to the right side of a safety DO module should not be equipped with LX-PM903 or standard potential distribution modules without EtherCAT slave station functionality.

Operating relative humidity: 10%~95%, non-condensing.

Operating altitude: Not higher than 2,000m (according to IEC61131-2 requirements, derating application restrictions for systems used at altitudes greater than 2,000m should be considered).

Software

The system adopts configuration software, utilizing HollySys's proprietary products, operating environment sees chapter 2.4 system software.

3.5 Hardware storage environment

Storage temperature: -40℃~70℃.

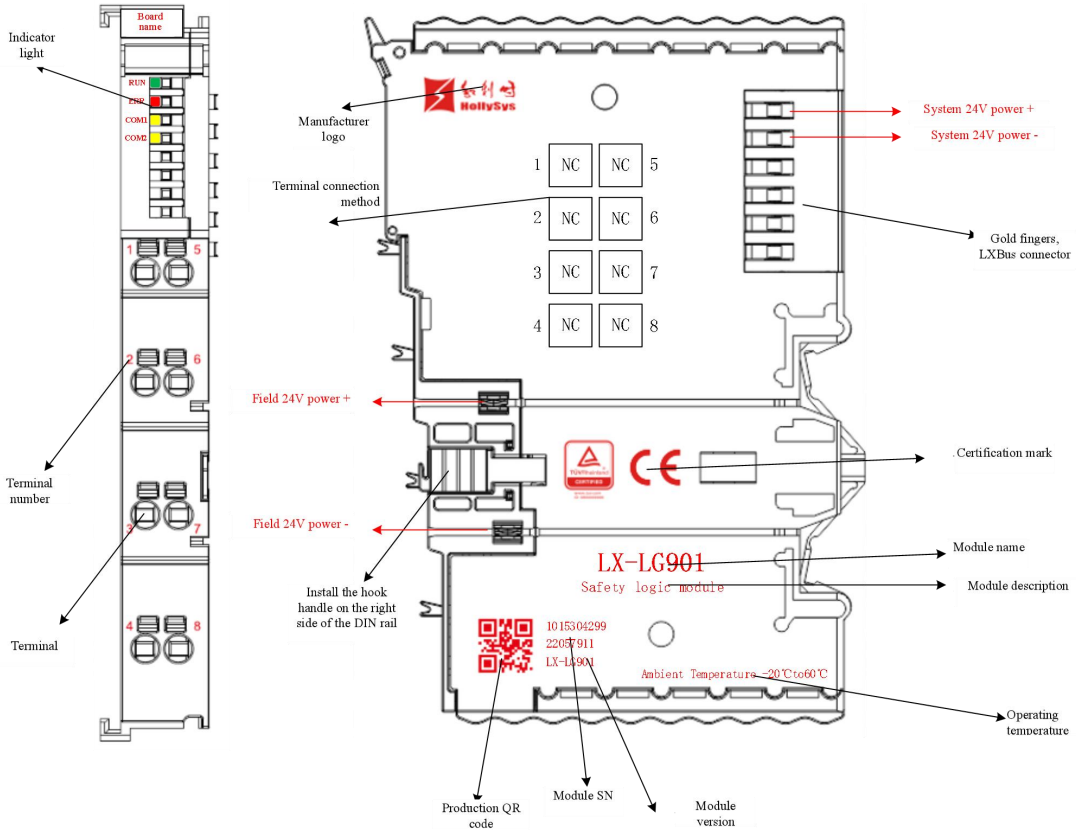
Relative humidity:10%~95%, non-condensing.

Altitude: ≤2,000m.

Chapter 4 Description for common part of module

4.1 Module appearance

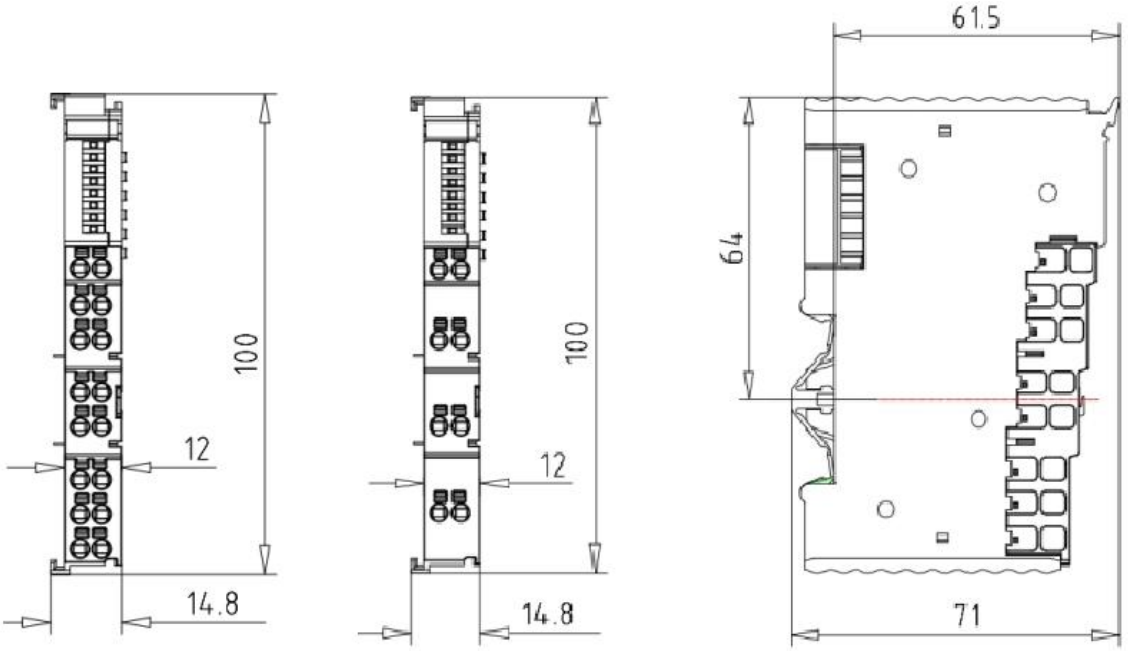
The appearance of the module is as shown in the following figure:



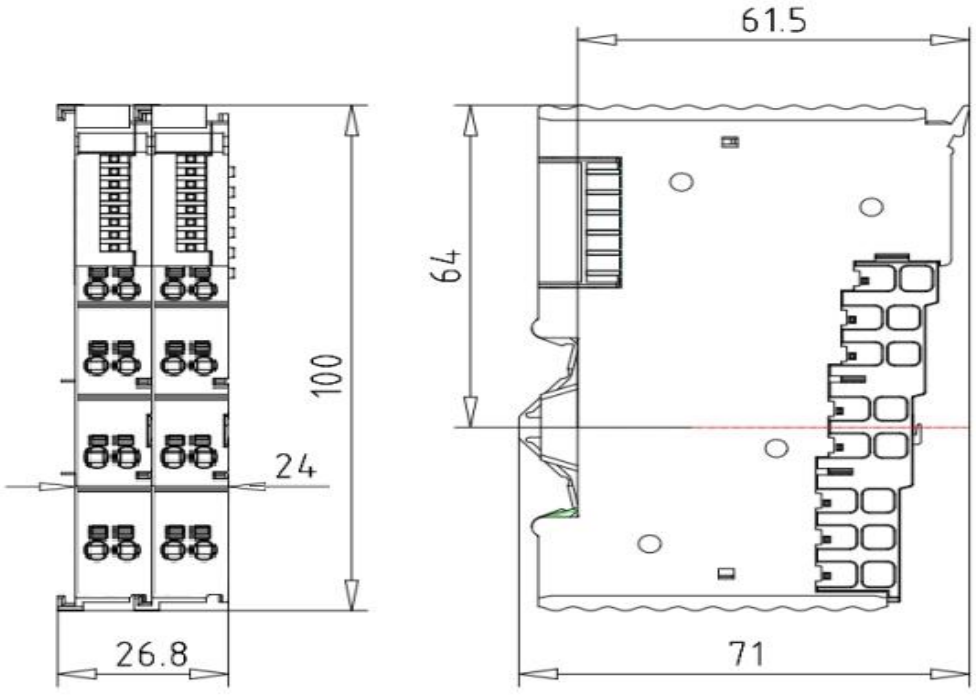
4.2 Module dimensions

Functional safety modules are orange in color and come in two sizes: 12mm*100mm*68mm and 24mm*100mm*68mm. The safety DO module LX-DO906 and LX-DO908 are 24mm*100mm*68mm, and other safety modules are 12mm*100mm*68mm.

1）The installation dimensions for the 12mm wide IO modules are shown in the following figure, in mm.



2）The installation dimensions for the 24mm wide IO modules are shown in the following figure, in mm.



4.3 Module power supply

Safety logic, safety isolation modules, and safety I/O modules on the system side are powered from the LX-bus connector, and the field side is powered from the through-board connector.

Parameters of power supply are as follows:

Power supply	
Power supply of the system	24VDC (±20%)
Field power	24VDC (±20%)
Mode of power supply	Powered through the LX-bus interface
Hot plugging	Not support

For power supply of the safety power relay module LX-PM903, refer to 7.4 LX-PM903 terminal description.

4.4 Communication interface and protocol

Safety logic modules, safety isolation modules, and safety I/O modules communicate via the LX-bus, realizing point-to-point connection through the LX-bus connector.

Safety logic and safety I/O modules act as EtherCAT slave station modules, communicating with the EtherCAT master station (general controller module) via the EtherCAT protocol; safety logic and safety I/O modules communicate with each other using the safety protocol FSoE, with safety logic module as the FSoE master station and safety I/O module as FSoE slave station.

Parameters related to communication are as follows:

Communication parameter	
Communication interface	LX-bus
Communication protocol	EtherCAT slave station protocol (safety logic and safety I/O modules) FSoE master station protocol (safety logic module) FSoE slave station protocol (safety I/O module)
Communication rate	100M bps
Number of communication ports	2
Safety communication address (FSoE address)	1-65535 (configurable)

4.5 Module information retrieval

Safety logic and safety I/O modules support retrieval of module model, software version number, hardware version number, module SN, and module control chip junction temperature.

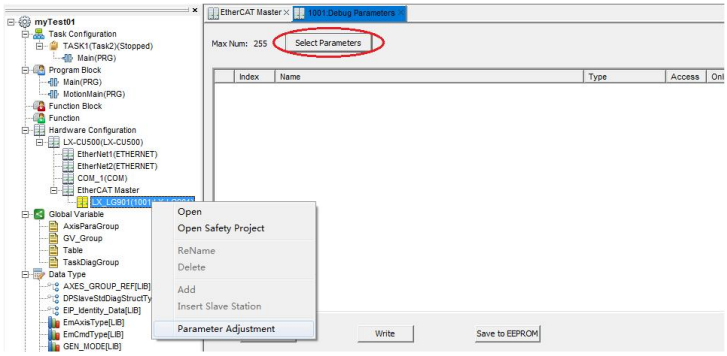
In the FA AutoThink, related information can be queried through the object dictionary.

S/N	Module information	Object dictionary	Description

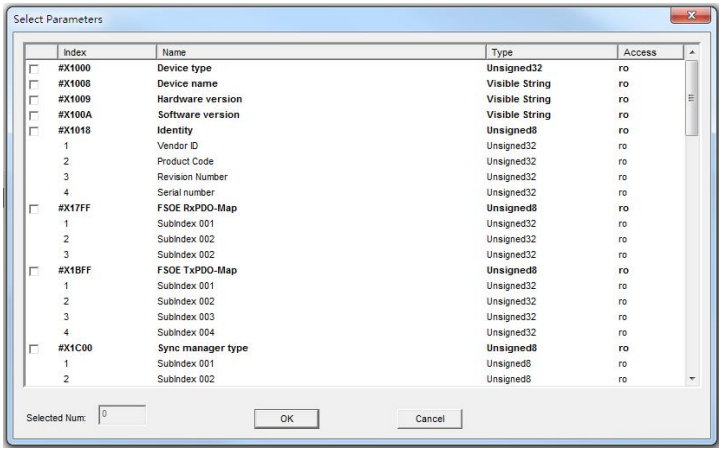
S/N	Module information	Object dictionary	Description
1	Equipment type	0x1000	
2	Module model	0x1008	For example, in the case of the AI current collection module, the online value is displayed as LX-AI906.
3	Hardware version number	0x1009	
4	Software version number	0x100A	
5	Serial number (SN)	0x1018	Index 4 under the object dictionary
6	Control chip junction temperature	0xA005	MPU and MCU junction temperature

4.6 Object dictionary retrieval

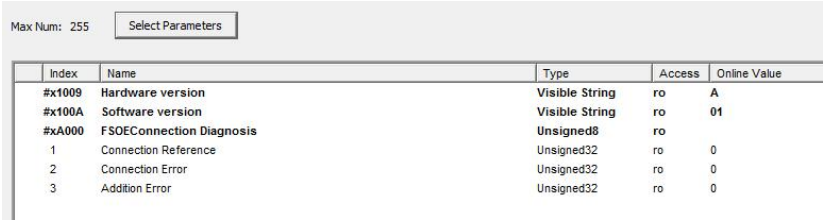
1）In the FA AutoThink engineering management area, right-click on the relevant module and select "Parameter Adjustment" from the pop-up menu;



2）Click the "Select Parameters" button within the red circle, and in the pop-up window, select the corresponding object dictionary based on the index number;



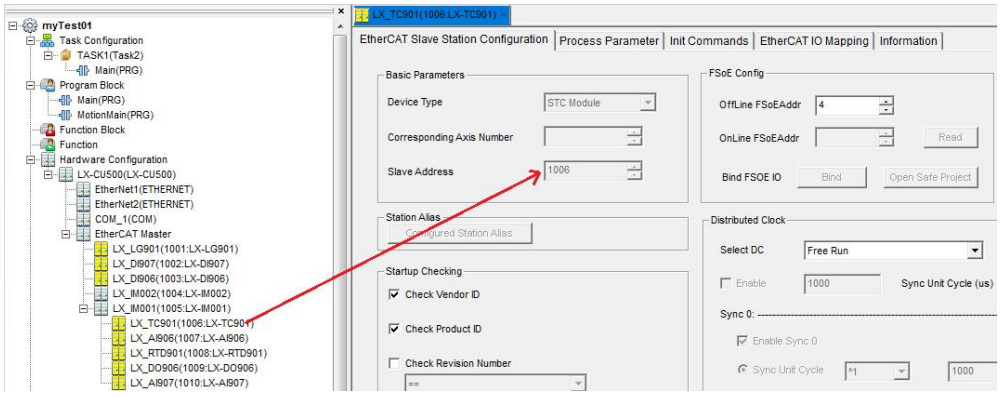
3）After selection, the content of the relevant object dictionary can be viewed in the FA AutoThink-Safety information output window.



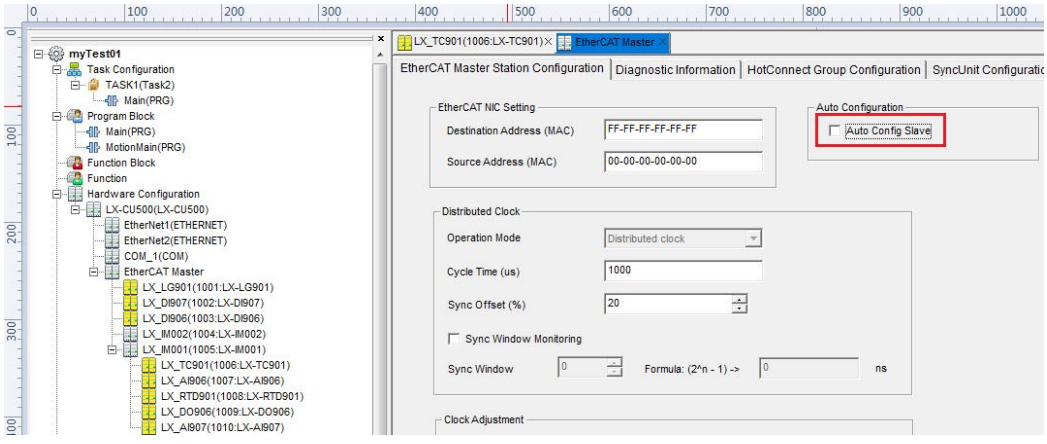
4.7 Module EtherCAT and FSoE Slave Address Configuration

4.7.1 EtherCAT slave address configuration

In FA AutoThink, according to the order of adding or scanning modules, the safety logic module and safety IO module will automatically generate EtherCAT slave addresses, as shown in the following figure:



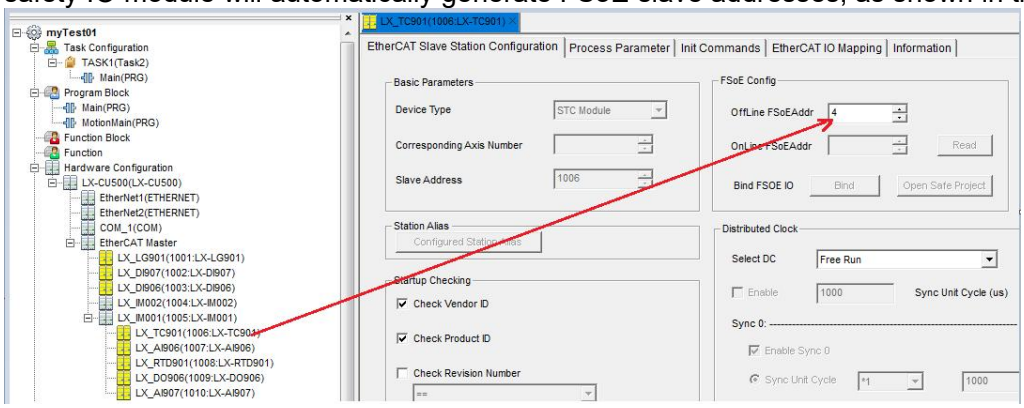
On the "EtherCAT Master" page, remove the automatic configuration the slave properties. Users can customize the address of the EtherCAT slave module, as shown in the following figure. If the "Auto Config Slave" is unchecked, the EtherCAT slave station address can be manually configured.



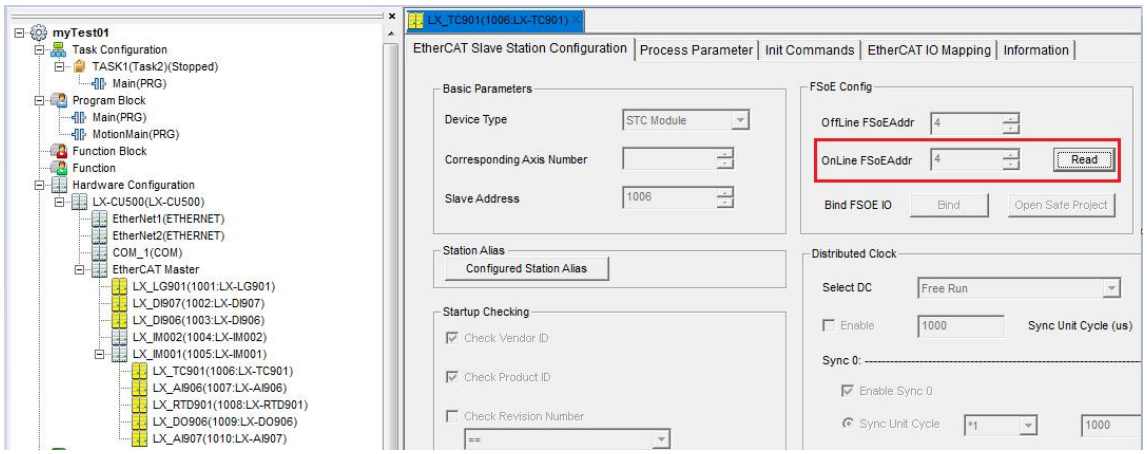
When manually configuring the EhterCAT slave address, if the configured slave address conflicts with an existing slave address, the automatically assigned address will remain unchanged.

4.7.2 FSoE slave address configuration

In FA AutoThink, according to the order of adding or scanning modules, the safety logic module and safety IO module will automatically generate FSoE slave addresses, as shown in the following figure:



In offline mode, users can customize the address of the FSoE slave module; When FA AutoThink is in monitoring mode, users can obtain the FSoE address of the module through the "Read" button.



When manually configuring the FSoE slave address, if the configured slave address conflicts with an existing slave address, the automatically assigned address will remain unchanged;

As the FSoE master station of the safety logic module, the FSoE address cannot be configured.

4.7.3 FSoE slave address verification

In FA AutoThink, under monitoring mode, users can obtain the "OnLine FSoEAddr" of the module through the "Read" button. By comparing it with the "OffLine FSoEAddr", users can confirm whether the FSoE address configuration is correct.

The FSoE address must be verified after configuration.

After configuring the FSoE address through the configuration interface on FA-AutoThink, users need to read back the configured FSoE address through FA-AutoThink. The address of the safety IO module is read back every time, the all LED indicator light of the safety IO module flashes about 3-5 second to indicate the current physical module position that is being read back, and to confirm the check between the FSoE address and the physical position of the module.

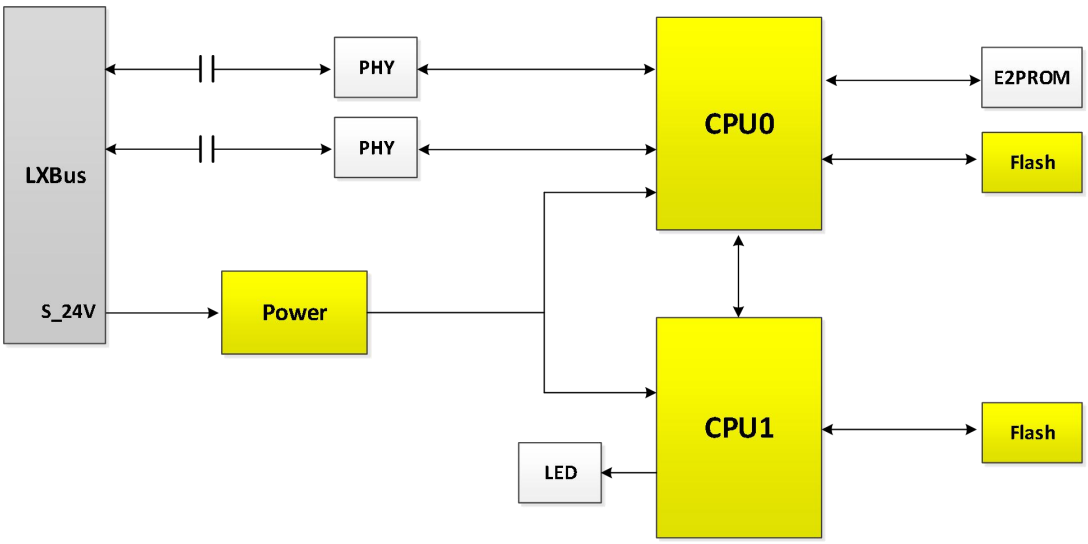
Chapter 5 LX-LG901 safety logic module

5.1 Product overview

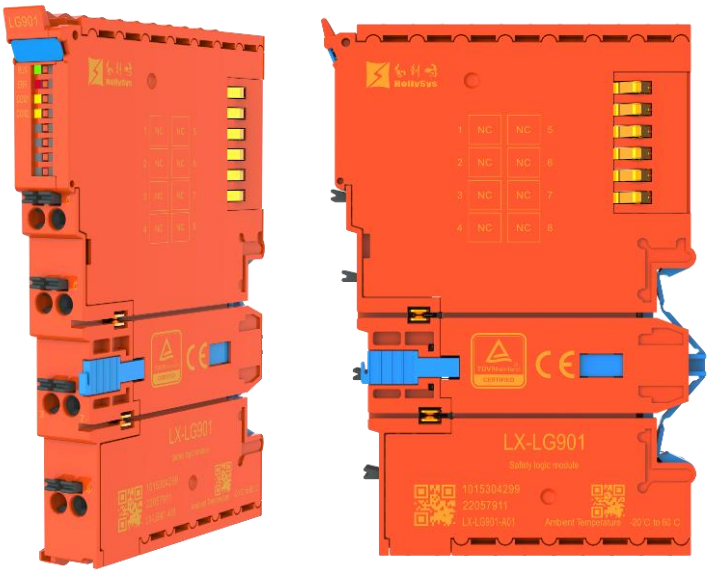
The LX-LG901 is designed for executing safety input module collection, safety logic operations, and safety output module control functions. It adopts the FSoE protocol stack, with the safety logic module acting as an FSoE master station and supporting communication with multiple functional safety I/O modules.

The LX-LG901 connects to the system via the LX-bus with no external interfaces. The LX-bus connector includes the communication bus and module system side input power.

The schematic diagram of the module is as follows:



The diagram of the module components is as follows:



5.2 Technical indicators

LX-LG901 safety logic module	
Function safety	
Safety Integrity Level	SIL3 (IEC61508) SC3 (IEC61508) SIL3 (IEC62061)
Performance level	PLe (ISO13849-1)
Safety category	Cat. 4 (ISO13849-1)
System modes	Low demand, high demand and continuous mode operation modes
Address of safety communication	1-65535 (configurable)
Reset	
Cold reset	Click the Cold Reset button on the configuration software FA AutoThink-Safety. After a cold reset, the user program does not need to be reloaded, data areas will be reinitialized.
Hot reset	Not support
Power-on reset time	≤10s
Module diagnosis	

LX-LG901 safety logic module	
Logic module fault information	Logic module normal/abnormal
EtherCAT communication status	EtherCAT communication normal/abnormal
FSoE communication status	FSoE communication normal/abnormal
Status of FSoE slave station	Status of each FSoE slave station module (communication status and channel status)
CPU temperature	Real-time value of the CPU internal junction temperature, °C
IEC operation information	IEC calculation time IEC scheduling interval
IEC operation status	RUN/STOP status Debug/Run mode
Technical indicators	
System scale	Supports up to 128 safety IO modules.
Control cycle	1~1000ms (configurable), with a setting step of 1ms, adaptive by default, jitter range ≤10%.
Task type	Periodic/Full-speed
Insulation resistance	Under normal condition, ≥10MΩ@DC500V (Temperature 25℃±2℃, relative humidity 30%±5%, non-condensing).
Typical power consumption	1.2W
Physical characteristics	
Module dimensions (W*H*D)	12mm *100mm*68mm
Degree of protection provided by enclosure	IP20 (IEC60529)
Installation mode	DIN35 rail mounting
Grounding method	Module connected to ground via DIN35 rail
Weight (excluding packaging)	≤60g

5.3 Indicator light status

After powering up the LX-LG901 module, the panel indicator lights display the current working and communication status.

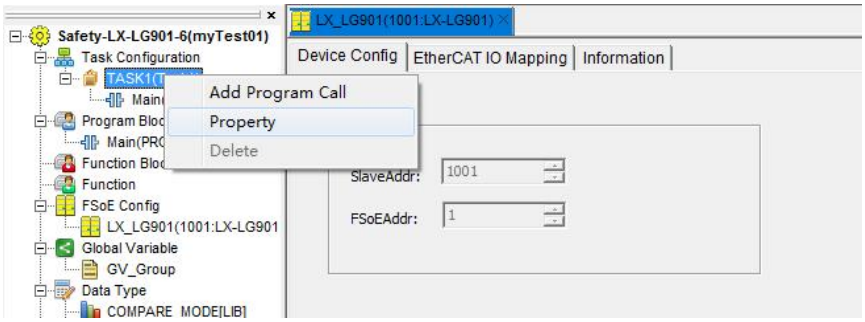
Name	Function	Color	Definition	
RUN	Status indicator	Green	On	Module operating normally, project in stop mode
			Flashing	Module operating normally, project in run mode
			Off	Module not powered or no user project
COM1	EtherCAT communication indicator	Yellow	On	EtherCAT communication normal
			Off	EtherCAT communication fault
COM2	FSoE communication indicator	Yellow	On	FSoE communication normal
			Flashing	At least one FSoE slave station communication abnormal
			Off	All FSoE communication fault
ERR	Module status indicator	Red	On	Module fault
			Off	No module fault
Note: When reading back the FSoE address, all indicator lights flash for about 5 seconds (at a frequency of 4Hz).				

5.4 Terminal description

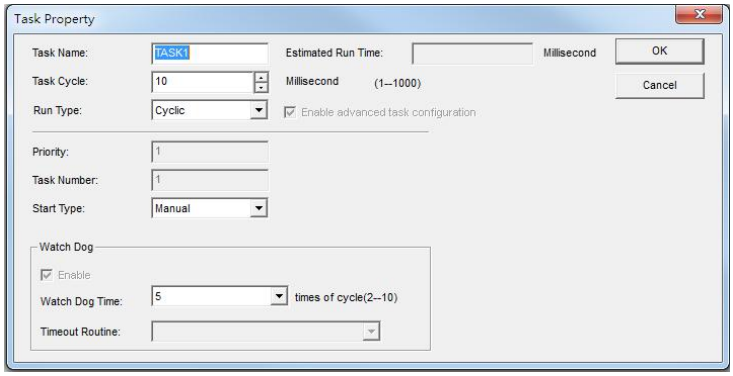
The LX-LG901 does not involve external wiring; no wire connection at the terminals.

5.5 Parameter Configuration

In the FA AutoThink-Safety interface, right-click on "Task Configuration ->TASK1 (Task1)" in the engineering management area, and select the "Property" option in the pop-up menu bar.



In the pop-up dialog box, you can modify parameters such as Task Name, Task Cycle (Tlogic), Run Type, Start Type, etc.



The startup type is configured as "Auto", and it is necessary to change "RUN" from "FALSE" to "True" on the "EtherCAT IO Mapping" tab page of the safety logic page on the FA AutoThink to ensure the normal operation of the safety engineering.

The startup type is configured as "manual", and the safety project can run by clicking on the "run" button on the FA AutoThink-Safety in order for the project to run normally;

When the running type is configured as "Cyclic", the task cycle is scheduled according to the configured value; When the running type is configured to "Full Speed", the task scheduling cycle will be adaptive according to the scale of the project, the adaptive task cycle is different when the scale of the project is different.

When safety applications, users can call the SF_STATS algorithm block to obtain the task cycle time; By calling the limit algorithm block SF_LIMIT and setting reasonable upper and lower limits, monitor whether the task cycle is normal.

Chapter 6 Safety I/O module

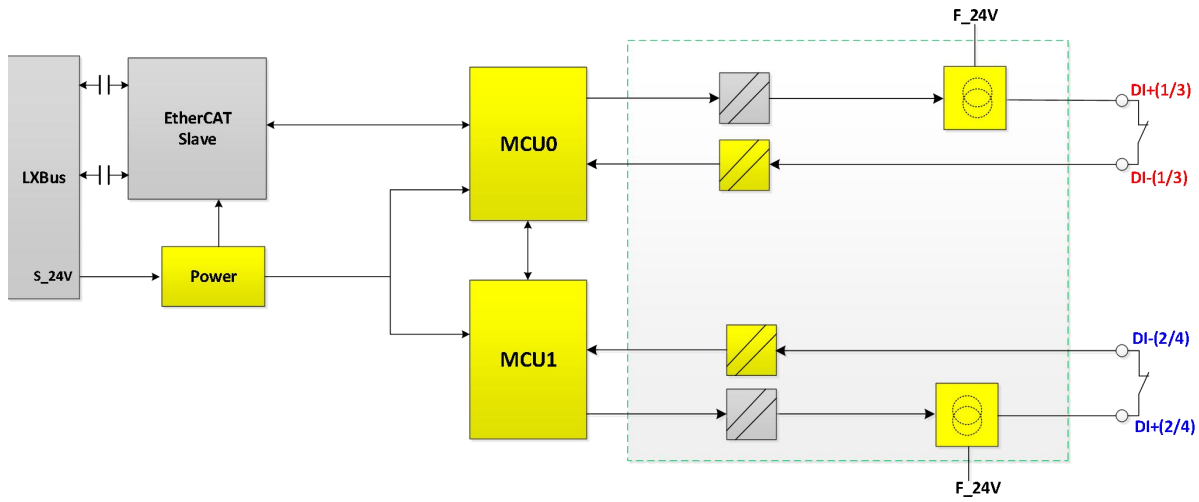
6.1 LX-DI906 4-channel safety digital input module

6.1.1 Product overview

The LX-DI906 is a safety digital input module for the LXS system, featuring a 1oo2 architecture design. It supports dry contact and PNP input signals, with digital signals acquired being transmitted to the safety logic module via the LX-bus. Adjacent odd and even channels (1/2, 3/4) form a safety loop, meeting SIL3 (IEC61508) and PLe Cat.4 (ISO13849).

The LX-DI906 connects to the system through the LX-bus, which includes the communication bus and module system side input power.

The schematic diagram of the module is as follows:



1. Basic features

The LX-DI906 module is designed for the acquisition of digital signals:

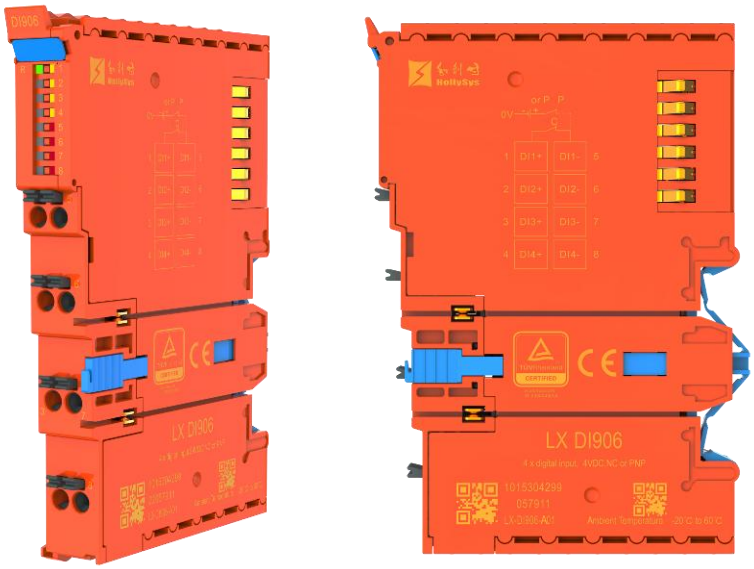
It supports dry contact and PNP signal acquisition, with channel working mode and filter parameters configurable;

Adjacent odd and even channels form a safety loop, meeting SIL3 and PLe Cat.4 requirements;

Indicator lights display module operational status, channel enable status, and fault status.

2. Module components

The diagram of the module components is as follows:



6.1.2 Technical indicators

LX-DI906 4-channel safety digital input module	
Function safety	
Safety Integrity Level	SIL3 (IEC61508) SC3 (IEC61508) SIL3 (IEC62061)
Performance level	PLe (ISO13849-1)
Safety category	Cat.4 (ISO13849-1)
System modes	Low demand, high demand and continuous mode operation modes
Address of safety communication	1~65535 (configurable)
Power-on reset time	≤5s
Module diagnosis	
FSoE communication status	FSoE communication status normal/abnormal
MCU diagnosis	MCU synchronization diagnosis, MCU self-diagnosis
MCU clock diagnosis	Support
MCU temperature	The junction temperature of MCU can be readed, unit is °C.

LX-DI906 4-channel safety digital input module	
Channel diagnosis	Support
Technical indicators	
Number of channels	4
Full channel scan time	2ms
Channel type	Supports dry contacts, PNP loads.
Sampling end level	Logic 1 signal (ON condition): 11~30VDC and ≥2mA Logic 0 signal (OFF condition): 0~5VDC and≤ 1mA
Over-voltage protection of channel	MAX.36VDC
Safety application requirements	When used for safety functions, adjacent odd and even channels must be used in pairs, such as channels 1/2 as a pair, 3/4 as a pair.
Response time	Logic 0 to 1: 0.5ms; Logic 1 to 0: 0.5ms
Safety value	ON/OFF configurable, OFF by default; When a channel fails, the DI module reports a safe value for the corresponding channel; When the module fails, the DI module reports a safe value for all channels; In the event of a communication failure, the safety logic module uses a safe substitute value.
Channel filtering (ms)	Configurable: 0(no filtering),0.5 (by default), 1,6, 10, 20, 50, 100, 200, 500, 1000, 1500.
Odd-even channel working mode	Single logic (same value NC input, NC+NO opposite value input), OSSD , safety mat.
Time difference of dual channel input values	Configurable
Channel diagnostic pulse enable	Configurable,default enable.
Diagnostic pulse width	100~2000us configurable, 300us by default.
Diagnostic pulse interval	1~200ms configurable, 10ms by default.
Cable length	Supports 100 meters (AWG16-22) for unshielded or shielded cables
Insulation resistance	Under normal condition, ≥10MΩ@DC500V (Temperature 25℃±2℃, relative humidity 30%±5%, non-condensing).

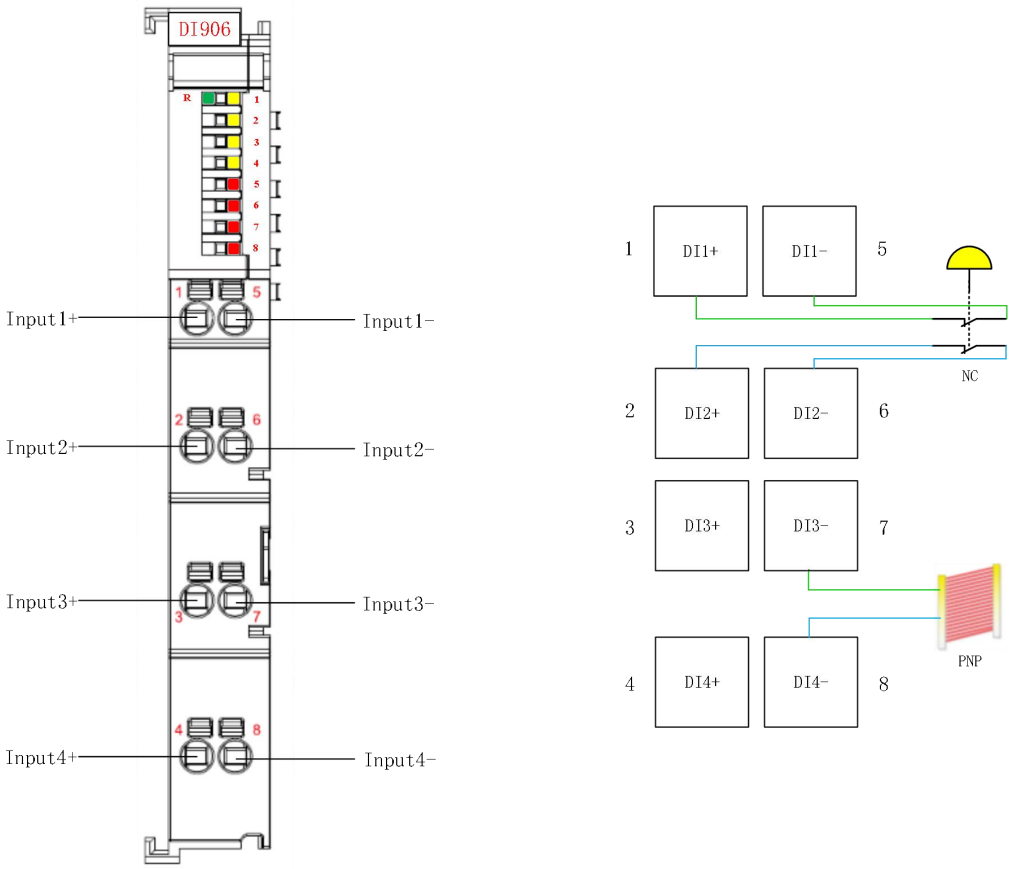
LX-DI906 4-channel safety digital input module	
Isolation withstand voltage	1000VAC@1min@5mA
Typical power consumption	System side: 1W; Field side: 0.3W
Physical characteristics	
Module dimensions (W*H*D)	12mm *100mm*68mm
Degree of protection provided by enclosure	IP20 (IEC60529)
Installation mode	DIN35 rail mounting
Grounding method	Module connected to ground via DIN35 rail
Weight (excluding packaging)	≤65g

6.1.3 Indicator light status

After powering up the LX-DI906 module, the panel's indicator lights display the current working and communication status.

Name	Function	Color	Definition	
RUN	Module status indicator	Green	On	Module status normal
			Flashing	Module offline
			Off	Module not powered
CH1~4	Channel status indicator	Yellow	On	Channel enabled and input signal normal
			Off	Channel not enabled or no signal input
ERR1~4	Channel fault indicator	Red	On	Channel fault
			Off	Channel normal
Note: When reading back the FSoE address, all indicator lights flash for about 5 seconds (at a frequency of 4Hz).				

6.1.4 Terminal description



LX-DI906 terminal wiring diagram

The signal descriptions are as follows:

Terminal identifier	Description of signal	Terminal identifier	Description of signal
1	NC: Channel 1 input signal PNP: Not connected	5	NC: Channel 1 input signal PNP: Channel 1 input signal
2	NC: Channel 2 input signal PNP: Not connected	6	NC: Channel 2 input signal PNP: Channel 2 input signal
3	NC: Channel 3 input signal PNP: Not connected	7	NC: Channel 3 input signal PNP: Channel 3 input signal
4	NC: Channel 4 input signal PNP: Not connected	8	NC: Channel 4 input signal PNP: Channel 4 input signal

PNP signal (such as OSSD signal) is only connected to the DIn- terminal, leaving the DIn+ terminal unconnected;

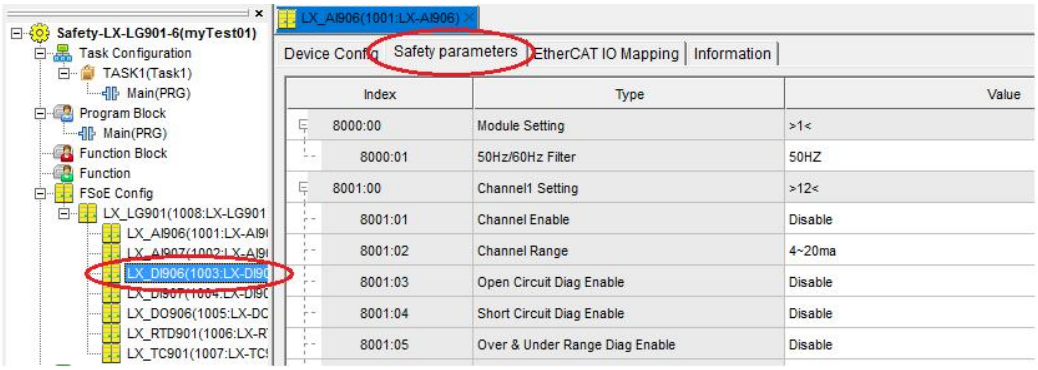
The module supports two safety loops, with adjacent odd and even channels forming a safety loop, i.e., Channel 1/Channel 2 and Channel 3/Channel 4 constitute two safety loops;

The same DI module does not support simultaneous connection of safety mat type signals and OSSD signals; connecting both simultaneously will prevent the module from going online.

6.1.5 Parameter Configuration

For safety related application, the diagnostic is not allowed to disable any diagnosis.

In the FA AutoThink-Safety interface, select the module you want to modify safety parameters in the engineering management area, double-click the module, and select the "Safety parameters" tab page in the pop-up interface.



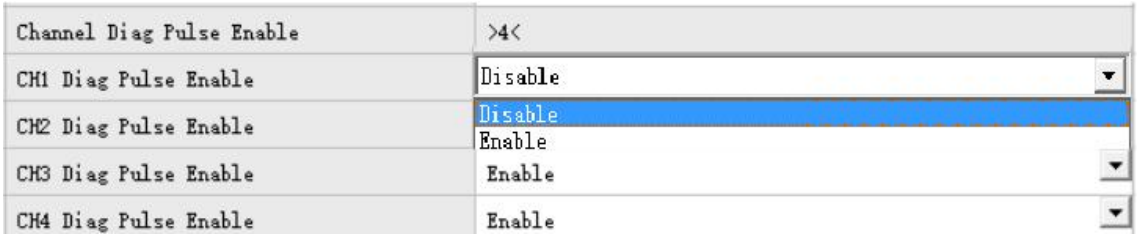
- Channel enable configuration

In the safety parameter interface, the default channel enable value is "Enable", which may select "Enable" or "Disable" by the drop-down menu.

Unused channels should be disabled, that is, the channel enable value should be selected as "Disabled" to avoid fault alarms caused by sensors not connected outside the channel, leading to system shutdown.

- Channel diag pulse enable configuration

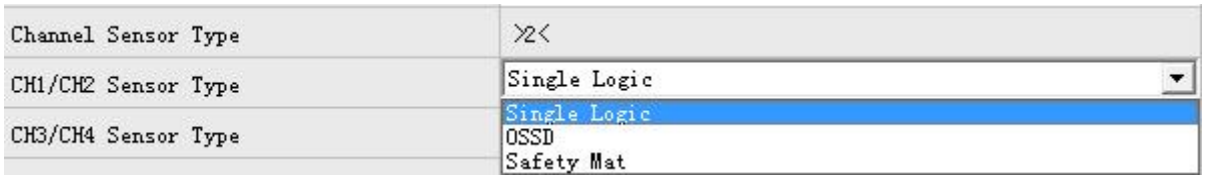
In the safety parameter interface, the default enable value of the channel diagnostic pulse is "Enable", which may select "Enable" or "Disable" by the drop-down menu.



After configuring the diag pulse enable value of any channel to "Disabled", the diagnostic function of the channel will be turned off, and the module's safety level cannot reach SIL3 or PLe Cat. 4 levels.

- Channel sensor type configuration

In the safety parameter interface, the default value for the channel sensor type is "Single Logic", which may select "Single Logic", "OSSD", or "Safety" by the drop-down menu.

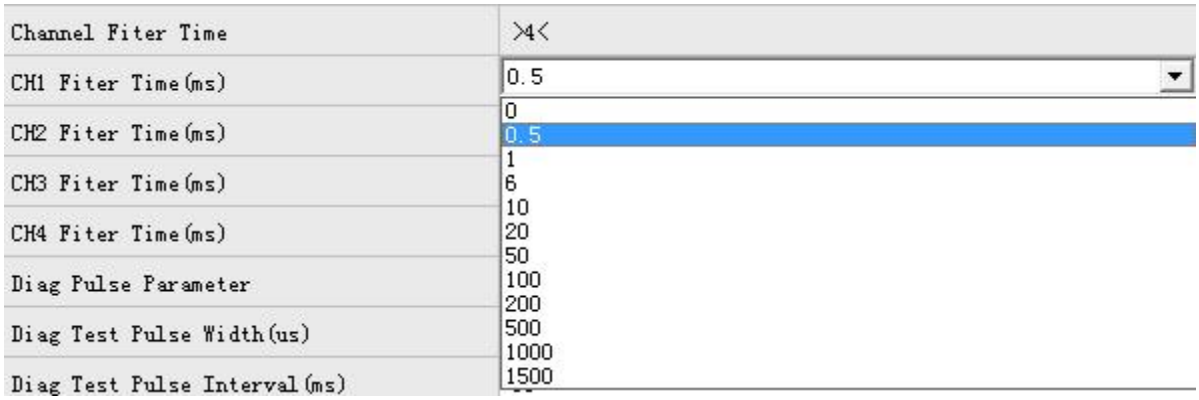


For PNP type signals with diagnostic pulses, select "OSSD" as the type value; For those without diagnostic pulses, the channel diagnostic pulse enable is configured as "Disabled", and the type value can be selected as "Single Logic" or "OSSD";

If the type value is configured as "Safety Mat", the DI module can only support "Safety Mat" type sensors. If "Safety Mat" is mixed with "Single Logic" or "OSSD", the module will go offline.

- Channel filter configuration

In the safety parameter interface, the channel filtering unit is ms, and the default configuration value is "0.5". It can be configured through the drop-down menu. When configured to "0", the channel has no filtering.

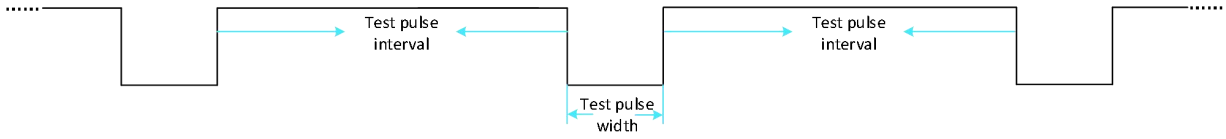


- Diag pulse parameter configuration

The diag pulse parameters include two parameters: diagnostic test pulse width and diagnostic test pulse interval. The diagnostic test pulse width unit is us, with a range of 100-2000us; The diagnostic test pulse interval unit is ms, with a range of 1~200ms.

Diag Pulse Parameter	>2<
Diag Test Pulse Width(us)	300
Diag Test Pulse Interval(ms)	10

The diagnostic test pulse width and diagnostic test pulse interval are shown in the following figure.



When the sensor type is configured as "Safety Mat", the configuration of diagnostic test pulse width and diagnostic test pulse interval does not take effect on "Safety Mat".

6.1.6 Sensor introduction

The DI module supports two types of physical signals, dry contact type and PNP type signals. According to practical application scenarios, sensor signals are divided into three types: Single Logic, OSSD, and Safety Mat. On the FA AutoThink-Safety, on the safety parameters tab of the DI module, select the type of input sensor by configuring the "Channel Sensor Type" parameter.

The types of common sensor signals and contact types are shown in the table below: (Due to the different technical means used by sensors, the signal type/contact type of the same sensor's type may also be different. The table below is for reference only. The actual signal type/contact type of sensors should be based on the sensor manual.)

Sensor	Signal type	Contact type	Remark
Emergency stop	Single Logic	Dry contact，NC or NO	The emergency stop button should have at least one NC contact, multiple NC contacts, NC and NO mixed contacts. Typical emergency stop button application scenarios can achieve safety level: NC+NO type contacts: ISO 13849 Cat 3 PL d. NC+NC type contacts: ISO 13849 Cat 4 PL e.
Contact type safety door	Single Logic	Dry contact，NC or NO	Typical contact type safety door application scenarios can achieve safety level:

			NC+NO type contacts: ISO 13849 Cat 3 PL d. NC+NC type contacts: ISO 13849 Cat 4 PL e.
Non-contact type safety door	OSSD	PNP Note1	The function of the safety door is achieved through light induction, magnetic induction, etc. The typical application scenario of non-contact safety doors can achieve safety level: ISO 13849 Cat 3 PL d.
Safety limit switch	Single Logic	Dry contact，NC or NO	Products generally include contact forms such as NO+NC (single or multiple), NC+NC (single or multiple), etc. Typical contact type safety limit switch application scenarios can achieve safety level: NC+NO type contacts: ISO 13849 Cat 3 PL d. NC+NC type contacts: ISO 13849 Cat 4 PL e.
Two handed operation button	Single Logic	Dry contact，NC or NO	Usually NC+NO. Typical contact type two handed operation button application scenarios can achieve safety level: NC+NO type contacts: ISO 13849 Cat 3 PL d.
Safety light curtain	OSSD	PNP	The detection and monitoring function is achieved through light induction to detect and monitor whether there are objects, people, etc. which passing through a certain plane. The typical application scenario of

			safety light curtain can achieve safety level: ISO 13849 Cat 4 PL e.
Safety laser scanner	OSSD	PNP	Used for intrusion monitoring on production sites, capable of regional monitoring. The typical application scenario of safety laser scanner can achieve safety level: ISO 13849 Cat 3 PL d.
Safety Mat	Safety Matnote2	Dry contact,NC+NC	It can be simply understood as two metal sheets on top and bottom, which come into contact when subjected to pressure. The typical application scenario of safety mat can achieve safety level: ISO 13849 Cat 3 PL d.
Safety bumper	Safety Mat	Dry contact,NC+NC	Safety bumper are installed on moving parts such as doors and fences of mechanical equipment, which can prevent the impact of moving parts. Danger, or shut down the entire system when contact with people or objects is detected. The typical application scenario of safety bumber can achieve safety level: ISO 13849 Cat 3 PL d.

1. For PNP type signals, the sensor must have its own diagnostic pulse, and the ground of the sensor must be equipotential with the field ground of the system;

2. After the DI module is connected to the safety mat type signal, it cannot connect to other types of signals (Single Logic or OSSD signals)；

3.For external device(e.g., E-STOP button, safety door, and Safety limit switch,etc.)with HFT=1,which cannot be detected by online automated diagnostics technically, the following diagnosis interval shall be considered according to the recommendation of Vertical Group 11:

- the input contacts have to switched at least once a month for SIL 3, PL e / category 4.

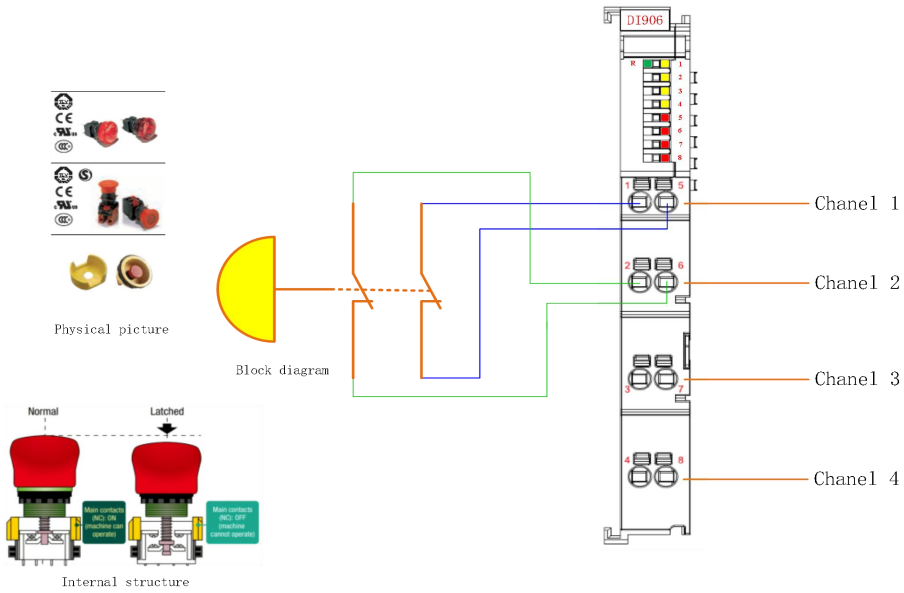
- the input contacts have to switched at least once a year for SIL 2, PL d /

category 3.

6.1.7 Common Sensor Wiring Instructions

6.1.7.1 Emergency stop

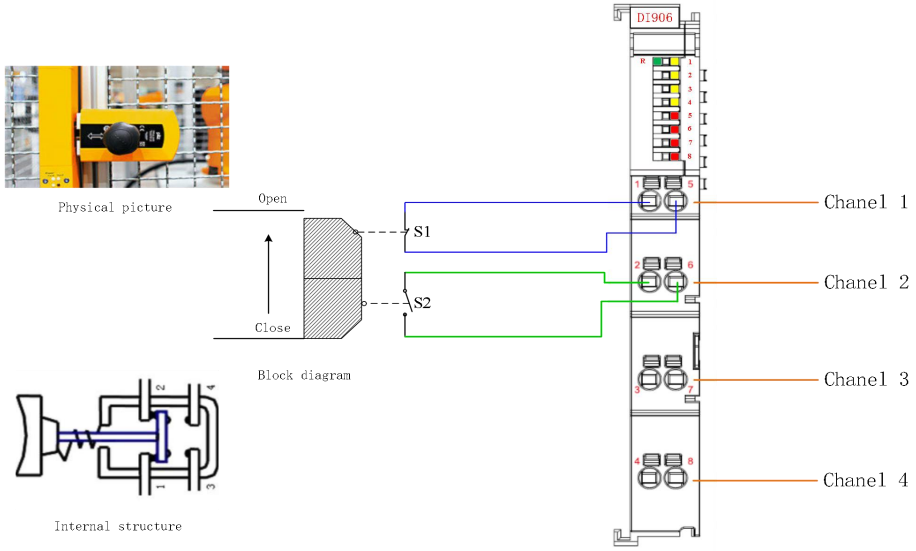
As shown in the figure below, the two NC contacts of emergency stop button need to be connected to the adjacent odd and even channels of the DI module (channels 1 and 2, or channels 3 and 4), with the channel sensor type configured as "Single Logic".



When selecting emergency stop button, relevant standards need be met, such as EN 60947-5-1, EN 60947-5-5 standards, UL508 standards, or GB14048.5 standards.

6.1.7.2 Contact type safety door

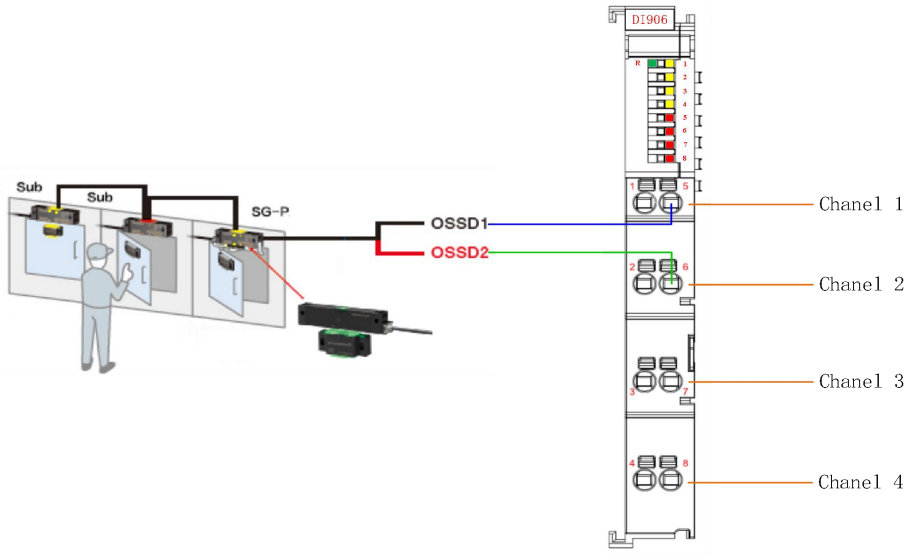
As shown in the figure below, the two contacts of contact type safety door need to be connected to the adjacent odd and even channels of the DI module (channels 1 and 2, or channels 3 and 4), with the channel sensor type configured as "Single Logic".



When selecting contact type safety door, relevant standards need be met, such as EN 60947-5-1 standards, UL508 standards, or GB14048.5 standards.

6.1.7.3 Non-contact type safety door

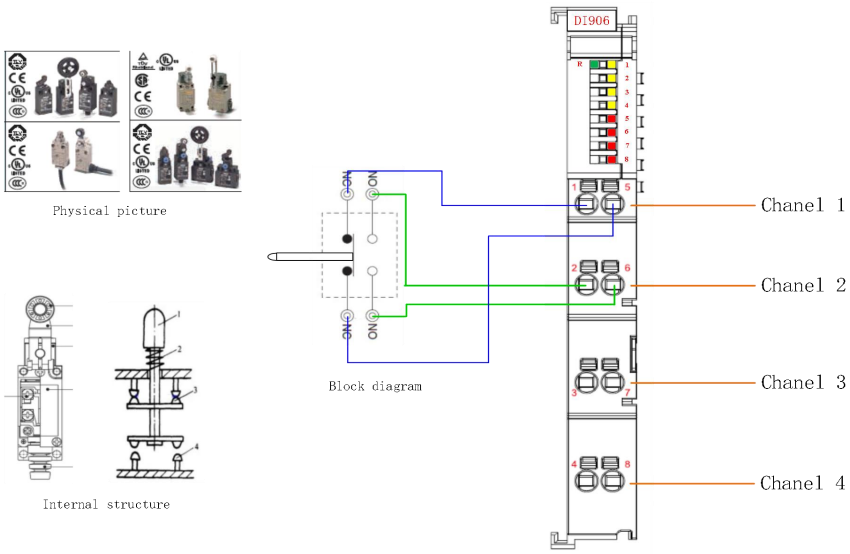
As shown in the figure below, the two OSSD signals of non-contact safety door need to be connected to the negative terminals(DI -) of the adjacent odd and even channels (channels 1 and 2, or channels 3 and 4) of the DI module, and the channel sensor type configured as "OSSD".



When selecting non-contact type safety door, relevant standards need be met, such as EN 60947-5-1, EN 60947-5-5 standards, UL508 standards, GB14048.5 ,or ISO 13849 standards.

6.1.7.4 Safety limit switch

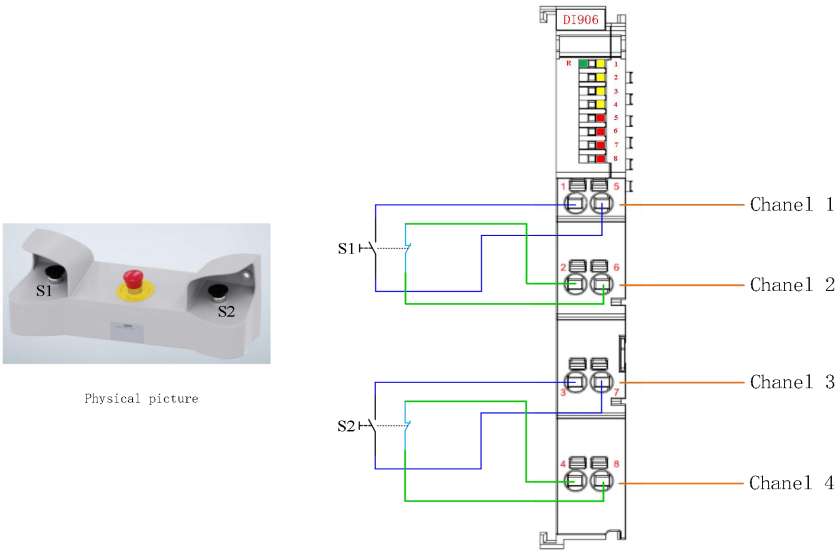
As shown in the figure below, the two contacts of safety limit switch need to be connected to the adjacent odd and even channels of the DI module (channels 1 and 2, or channels 3 and 4), and the channel sensor type should be configured as "Single Logic".



When selecting safety limit switch, relevant standards need be met, such as EN 60947-5-1standards, UL508 standards, CSA C22.2 No.14, or GB14048.5 standards.

6.1.7.5 Two handed operation button

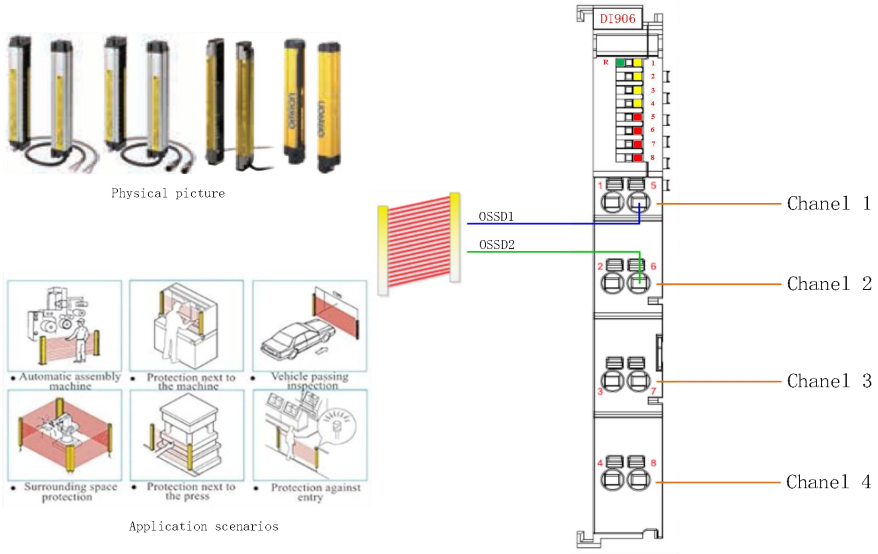
As shown in the figure below, the two switches for two handed operation button, the two contacts of S1 and S2 need to be respectively connected to the adjacent odd and even channels of the DI module, and the channel sensor type should be configured as "Single Logic".



When selecting two handed operation button, relevant standards need be met, such as EN 60947-5-1/5, or ISO 13850/1 standards.

6.1.7.6 Safety light curtain

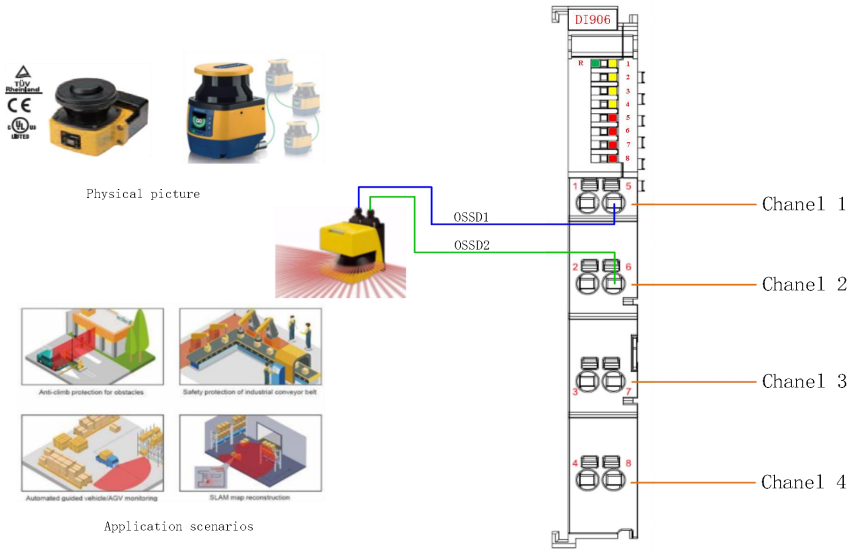
As shown in the figure below, the two OSSD signals of safety light curtain need to be connected to the negative terminals (DI -) of the adjacent odd and even channels (channels 1 and 2, or channels 3 and 4) of the DI module, and the channel sensor type configured as "OSSD".



When selecting safety light curtain, relevant standards need be met, such as EN 61946-1/-3 standards, IEC 61946-1 standards, UL508 standards, ISO 13849-1 standards, or GB4584 standards.

6.1.7.7 Safety laser scanner

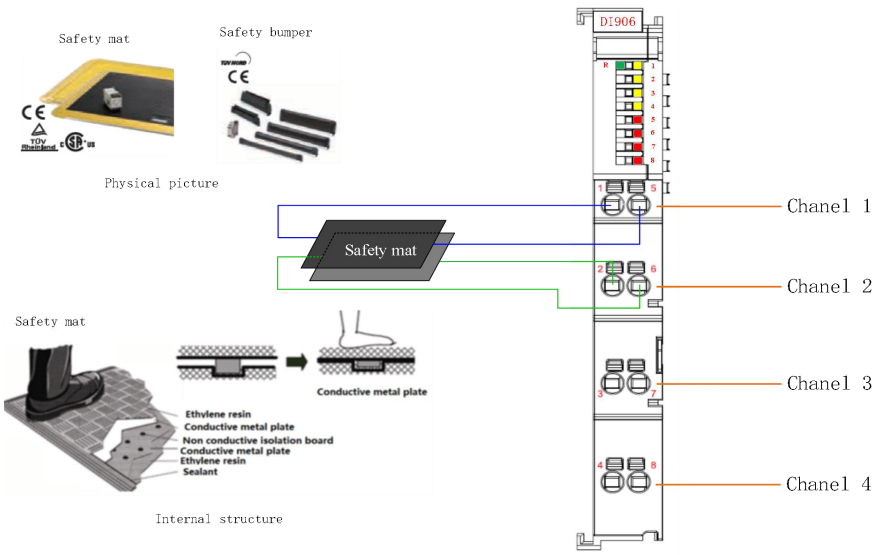
As shown in the figure below, the two OSSD signals of safety laster scanner need to be connected to the negative terminals (DI -) of the adjacent odd and even channels (channels 1 and 2, or channels 3 and 4) of the DI module, and the channel sensor type configured as "OSSD".



When selecting safety laser scanner, relevant standards need be met, such as EN 61946-1/-3 standards, IEC 61946-1 standards, UL508 standards, ISO 13849-1 standards, or GB4584 standards.

6.1.7.8 Safety Mat / bumper

As shown in the figure below, the two contacts of safety mat/bumper need to be connected to the adjacent odd and even channels of the DI module (channels 1 and 2, or channels 3 and 4), and the channel sensor type configured as "Safety mat".



When selecting safety mat/bumper, relevant standards need be met, such as EN 1760-1/-2，ISO 13849-1、GB/T 17454-1/-2 standards.

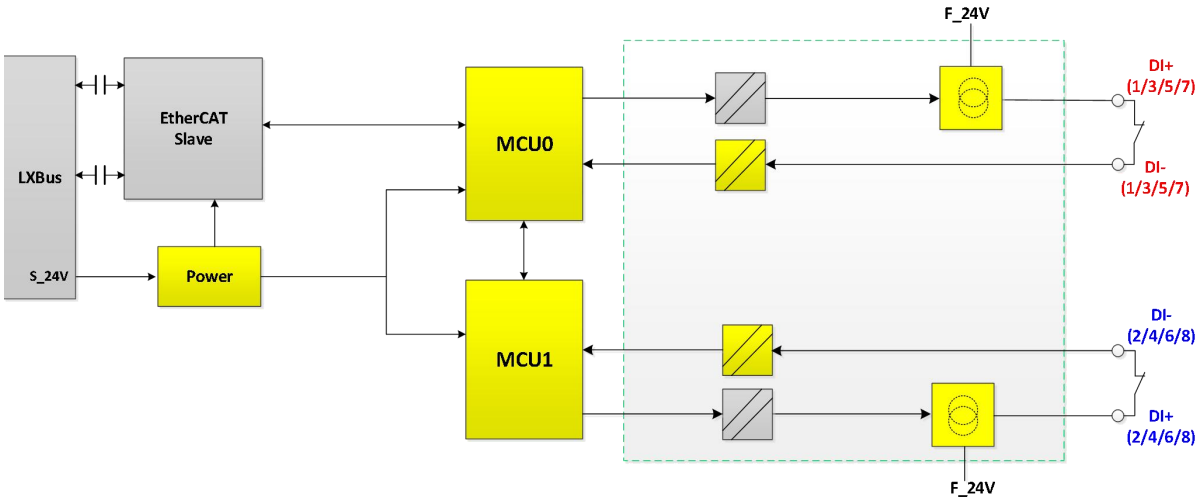
6.2 LX-DI907 8-channel safety digital input module

6.2.1 Product overview

The LX-DI907 is a safety digital input module for the LXS system, featuring a 1oo2 architecture design. It supports dry contact and PNP input signals, with digital signals acquired being transmitted to the safety logic module via the LX-bus. Adjacent odd and even channels (1/2, 3/4, 5/6, 7/8) form a safety loop, meeting SIL3 (IEC61508) and PLe Cat.4 (ISO13849).

The LX-DI907 connects to the system through the LX-bus, which includes the communication bus and module system side input power.

The schematic diagram of the module is as follows:



1. Basic features

The LX-DI907 module is designed for the acquisition of digital signals:

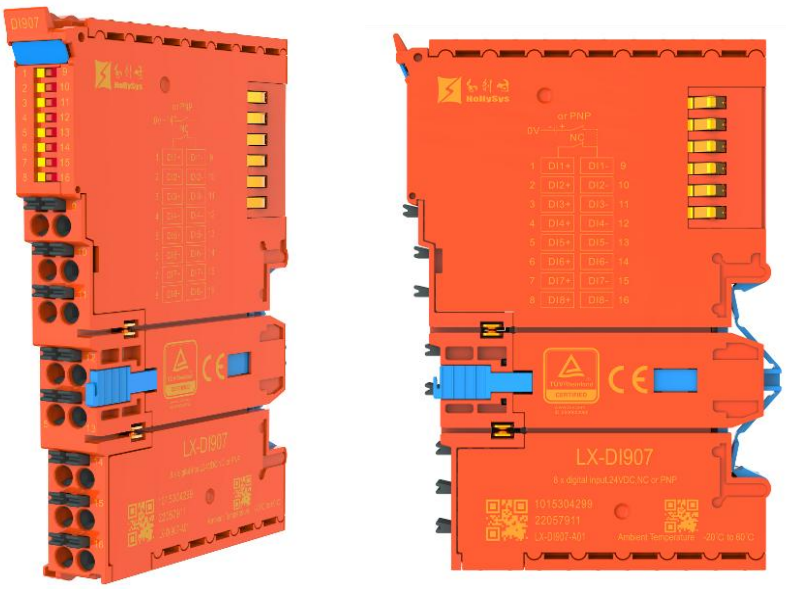
It supports dry contact and PNP signal acquisition, with channel working mode and filter parameters configurable;

Adjacent odd and even channels form a safety loop, meeting SIL3 and PLe Cat.4 requirements;

Indicator lights display module operational status, channel enable status, and fault status.

2. Module components

The diagram of the module components is as follows:



6.2.2 Technical indicators

LX-DI907 8-channel safety digital input module	
Function safety	
Safety Integrity Level	SIL3 (IEC61508) SC3 (IEC61508) SIL3 (IEC62061)
Performance level	PLe (ISO13849-1)
Safety category	Cat.4 (ISO13849-1)
System modes	Low demand, high demand and continuous mode operation modes
Address of safety communication	1~65535 (configurable)
Power-on reset time	≤5s
Module diagnosis	
FSoE communication status	FSoE communication status normal/abnormal
MCU diagnosis	MCU synchronization diagnosis, MCU self-diagnosis
MCU clock diagnosis	Support
MCU temperature	The junction temperature of MCU can be readed, unit is °C.

LX-DI907 8-channel safety digital input module	
Channel diagnosis	Support
Technical indicators	
Number of channels	8
Full channel scan time	2ms
Channel type	Supports dry contacts, PNP loads.
Sampling end level	Logic 1 signal (ON condition): 11~30VDC and ≥2mA Logic 0 signal (OFF condition): 0~5VDC and≤ 1mA
Over-voltage protection of channel	MAX.36VDC
Safety application requirements	When used for safety functions, adjacent odd and even channels must be used in pairs, such as Channel 1/2 as a pair, 3/4 as a pair, 5/6 as a pair, and 7/8 as a pair.
Response time	Logic 0 to 1: 0.5ms; Logic 1 to 0: 0.5ms
Safety value	ON/OFF configurable, OFF by default; When a channel fails, the DI module reports a safe value for the corresponding channel; When the module fails, the DI module reports a safe value for all channels; In the event of a communication failure, the safety logic module uses a safe substitute value.
Channel filtering (ms)	Configurable: 0(no filtering),0.5 (by default), 1,6, 10, 20, 50, 100, 200, 500, 1000, 1500.
Odd-even channel working mode	Single logic (same value NC input, NC+NO opposite value input), OSSD, safety mat.
Time difference of dual channel input values	Configurable
Channel diagnostic pulse enable	Configurable,default enable.
Diagnostic pulse width	100~2000us configurable, 300us by default.
Diagnostic pulse interval	1~200ms configurable, 10ms by default.
Cable length	Supports 100 meters (AWG16-22) for unshielded or shielded cables
Insulation resistance	Under normal condition, ≥10MΩ@DC500V (Temperature 25℃±2℃, relative humidity 30%±5%, non-condensing).

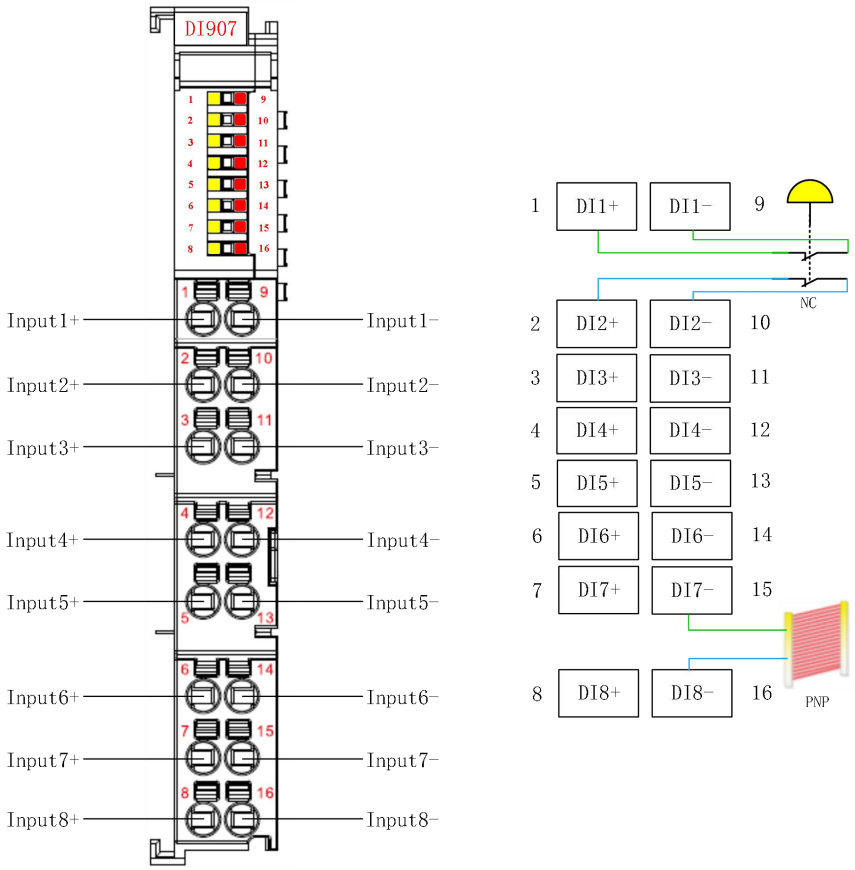
LX-DI907 8-channel safety digital input module	
Isolation withstand voltage	1000VAC@1min@5mA
Typical power consumption	System side: 1W; Field side: 0.6W
Physical characteristics	
Module dimensions (W*H*D)	12mm *100mm*68mm
Degree of protection provided by enclosure	IP20 (IEC60529)
Installation mode	DIN35 rail mounting
Grounding method	Module connected to ground via DIN35 rail
Weight (excluding packaging)	≤70g

6.2.3 Indicator light status

After the LX-DI907 module is powered on, the indicator lights on the panel display the current working and communication status.

Name	Function	Color	Definition	
CH1~8	Channel status indicator	Yellow	On	Channel enabled and input signal normal
			Off	Channel not enabled or no signal input
ERR1~8	Channel fault indicator	Red	On	Channel fault
			Off	Channel normal
Note: When reading back the FSoE address, all indicator lights flash for about 5 seconds (at a frequency of 4Hz).				

6.2.4 Terminal wiring



LX-DI907 terminal wiring diagram

The signal descriptions are as follows:

Terminal identifier	Description of signal	Terminal identifier	Description of signal
1	NC: Channel 1 input signal PNP: Not connected	9	NC: Channel 1 input signal PNP: Channel 1 input signal
2	NC: Channel 2 input signal PNP: Not connected	10	NC: Channel 2 input signal PNP: Channel 2 input signal
3	NC: Channel 3 input signal PNP: Not connected	11	NC: Channel 3 input signal PNP: Channel 3 input signal
4	NC: Channel 4 input signal PNP: Not connected	12	NC: Channel 4 input signal PNP: Channel 4 input signal
5	NC: Channel 5 input signal PNP: Not connected	13	NC: Channel 5 input signal PNP: Channel 5 input signal
6	NC: Channel 6 input signal PNP: Not connected	14	NC: Channel 6 input signal PNP: Channel 6 input signal

Terminal identifier	Description of signal	Terminal identifier	Description of signal
7	NC: Channel 7 input signal PNP: Not connected	15	NC: Channel 7 input signal PNP: Channel 7 input signal
8	NC: Channel 8 input signal PNP: Not connected	16	NC: Channel 8 input signal PNP: Channel 8 input signal

PNP signal (such as OSSD signal) is only connected to the DIn- terminal, leaving the DIn+ terminal unconnected;

The module supports four safety loops, with adjacent odd and even channels forming one safety loop, namely channels 1/2, 3/4, 5/6, and 7/8 form four safety loops;

The same DI module does not support simultaneous connection of safety mat type signals and OSSD signals; connecting both simultaneously will prevent the module from going online.

6.2.5 Parameter Configuration

Refer to section 6.1.5 parameter configuration instructions.

6.2.6 Sensor introduction

Refer to section 6.1.6 sensor instruction.

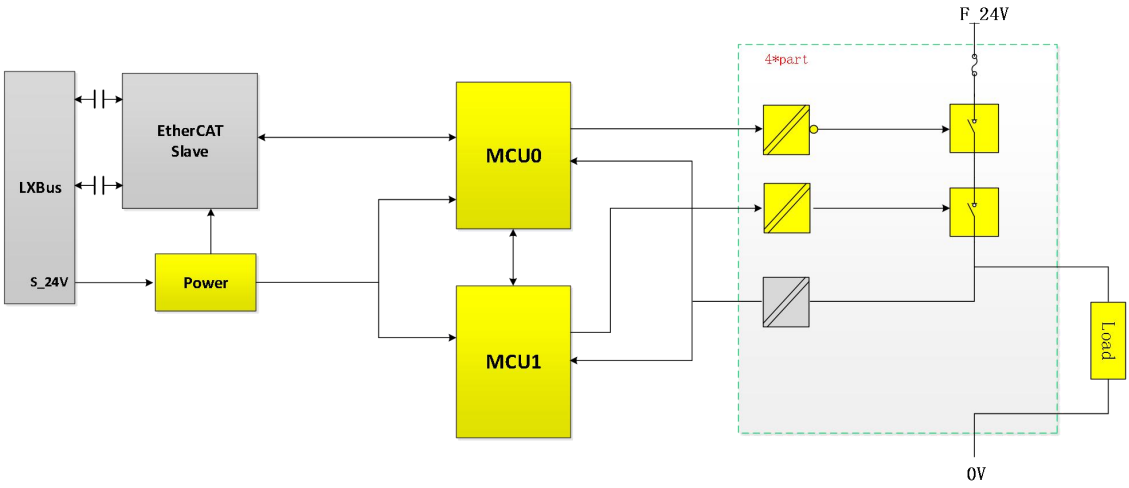
6.3 LX-DO906 4-channel safety digital output module

6.3.1 Product overview

The LX-DO906 is a safety digital output module for the LXS system, featuring a 1oo2 architecture design, supporting resistive and inductive loads, with a maximum load current of 0.5A. The module receives the results of logical operations from the safety logic module through the LX-bus and performs the corresponding safety operations. A single channel can serve as a safety loop, with support for up to four safety loops, meeting SIL3 (IEC61508) and PLe Cat.4 (ISO13849).

The LX-DO906 connects to the system through the LX-bus, which includes the communication bus and module system side input power.

The schematic diagram of the module is as follows:



1. Basic features

The LX-DO906 module completes the output of digital signals:

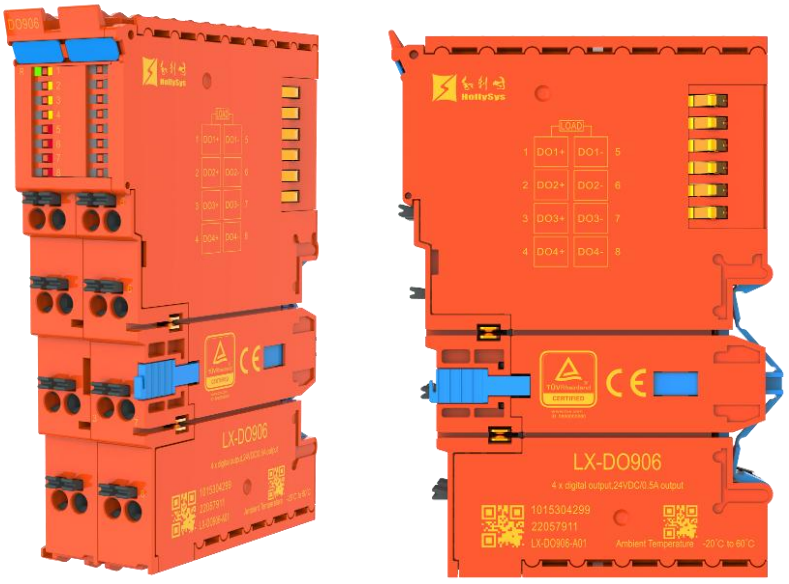
Supports resistive and inductive loads, with a maximum current of 0.5A per channel, and a total maximum module output current of 2A. It also supports short-circuit and open-circuit detection;

A single channel can serve as a safety loop, with support for up to four safety loops, meeting SIL3 (IEC61508) and PLe Cat.4 (ISO13849);

Indicator lights display module operational status, channel enable status, and fault status.

2. Module components

The diagram of the module components is as follows:



It is not recommended to place modules such as LX-PM903 or potential distribution modules, which only transmit signals through gold fingers, adjacent to the right side of the module (in such modules, the EtherCAT signal is only transmitted without

being driven).

6.3.2 Technical indicators

LX-DO906 4-channel safety digital output module	
Function safety	
Safety Integrity Level	SIL3 (IEC61508) SC3 (IEC61508) SIL3 (IEC62061)
Performance level	PLe (ISO13849-1)
Safety type	Cat.4 (ISO13849-1)
System modes	Low demand, high demand and continuous mode operation modes
Address of safety communication	1~65535 (configurable)
Power-on reset time	≤5s
Module diagnosis	
FSoE communication status	FSoE communication status normal/abnormal
MCU diagnosis	MCU synchronization diagnosis, MCU self-diagnosis
MCU clock diagnosis	Support
MCU temperature	The junction temperature of MCU can be readed, unit is °C.
Channel diagnosis	Support
Technical indicators	
Number of channels	4
Full-channel assignment time	2ms
Load current	20~500mA/channel (less than 20mA for light load, more than 500mA for overcurrent), 2A/module.
Maximum switching frequency	Resistive load: 30Hz, inductive load: 0.1Hz, asymmetrical output waveform.
Signal type	Voltage level

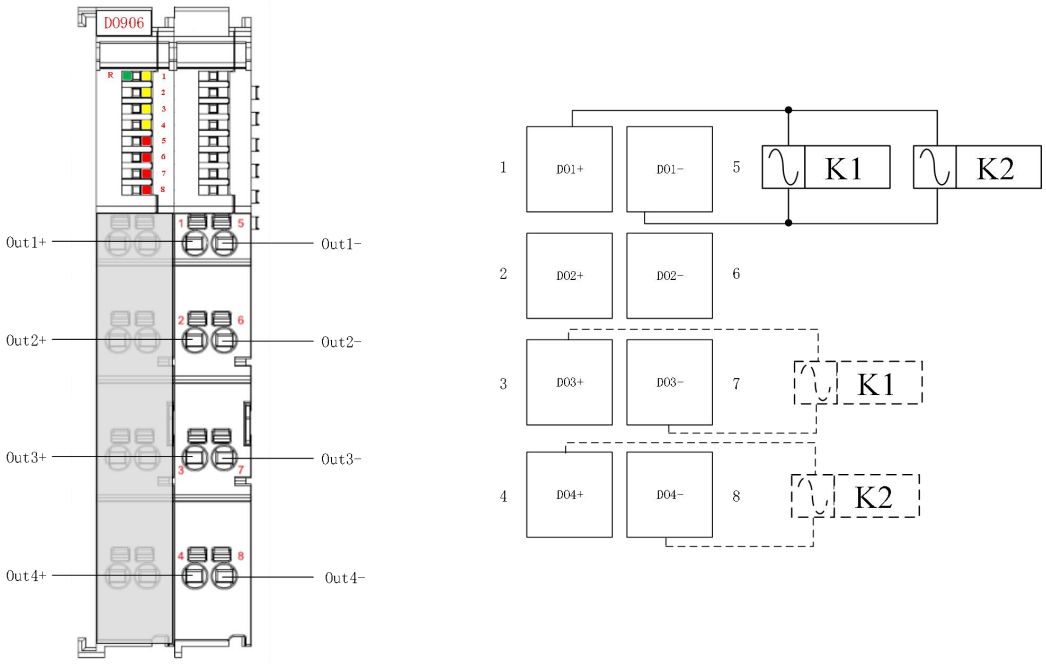
LX-DO906 4-channel safety digital output module	
Load voltage	24VDC
Over-voltage protection of channel	MAX.36VDC
Safety application requirements	For safety functions, a single channel can serve as a safety loop, controlling two actuators in parallel; alternatively, two channels can form one safety loop, with each channel controlling one actuator.
Safety value	OFF state, level < 2.4V
Channel operating mode	Single channel as one safety loop
Channel diagnostic pulse enable	Enable/disable configurable,default enable.
Configuration mode	1bit channel output data
Diagnostic pulse width	500~2000us configurable, 800us by default.
Diagnostic pulse interval	100~1000ms configurable, 200ms by default.
Cable length	Supports 100 meters (AWG16-22) for unshielded or shielded cables
Insulation resistance	Under normal condition, ≥10MΩ@DC500V (Temperature 25℃±2℃, relative humidity 30%±5%, non-condensing).
Isolation withstand voltage	1000VAC@1min@5mA
Typical power consumption	2W
Physical characteristics	
Module dimensions (W*H*D)	12mm *100mm*68mm
Degree of protection provided by enclosure	IP20 (IEC60529)
Installation mode	DIN35 rail mounting
Grounding method	Module connected to ground via DIN35 rail
Weight (excluding packaging)	≤105g

6.3.3 Indicator light status

After powering on the LX-DO906 module, the indicator lights on the panel display the current working and communication status.

Name	Function	Color	Definition	
RUN	Module status indicator	Green	On	Module status normal
			Flashing	Module offline
			Off	Module not powered
CH1~4	Channel status indicator	Yellow	On	Channel enabled and channel output ON
			Off	Channel not enabled or channel output OFF
ERR1~4	Channel fault indicator	Red	On	Channel fault
			Off	Channel normal
Note: When reading back the FSoE address, all indicator lights flash for about 5 seconds (at a frequency of 4Hz).				

6.3.4 Terminal wiring



LX-DO906 terminal wiring diagram

The signal descriptions are as follows:

Terminal identifier	Description of signal	Terminal identifier	Description of signal
1	Channel 1 digital signal output terminal	5	Channel 1 digital signal return terminal

Terminal identifier	Description of signal	Terminal identifier	Description of signal
2	Channel 2 digital signal output terminal	6	Channel 2 digital signal return terminal
3	Channel 3 digital signal output terminal	7	Channel 3 digital signal return terminal
4	Channel 4 digital signal output terminal	8	Channel 4 digital signal return terminal

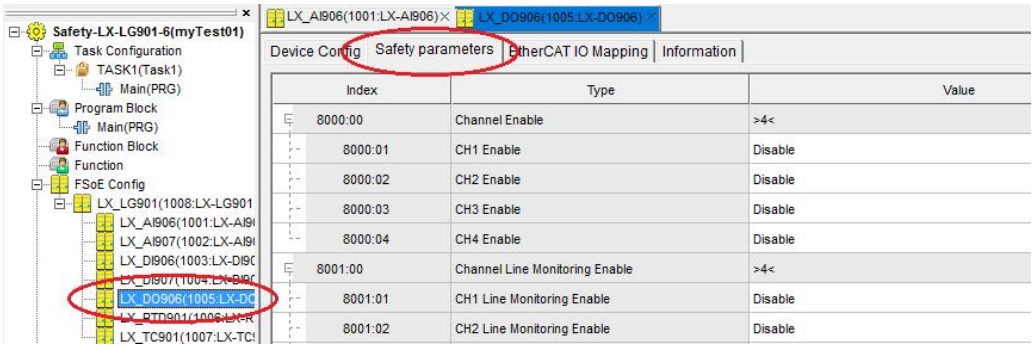
The module channel wiring is on the 8 terminals on the right side of the module, with the 8 terminals on the left side in shadow being left unconnected;

One channel of module can achieve a safety loop (as in the wiring method for Channel 1), or two channels form a safety loop (as in the wiring method for Channels 3 and 4).

6.3.5 Parameter Configuration

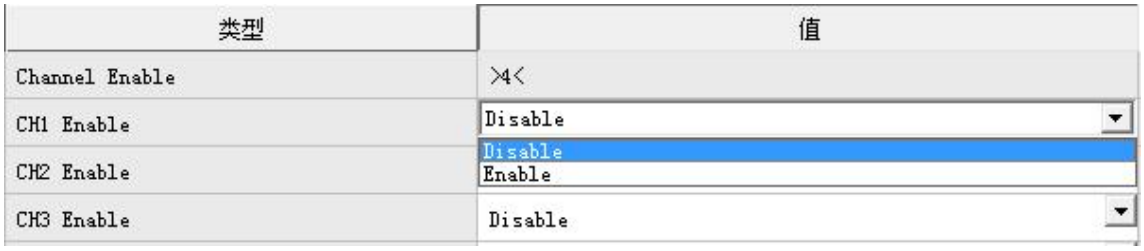
For safety related application, the diagnostic is not allowed to disable any diagnosis.

In the FA AutoThink-Safety interface, select the module you want to modify safety parameters in the engineering management area, double-click the module, and select the "Safety parameters" tab page in the pop-up interface.



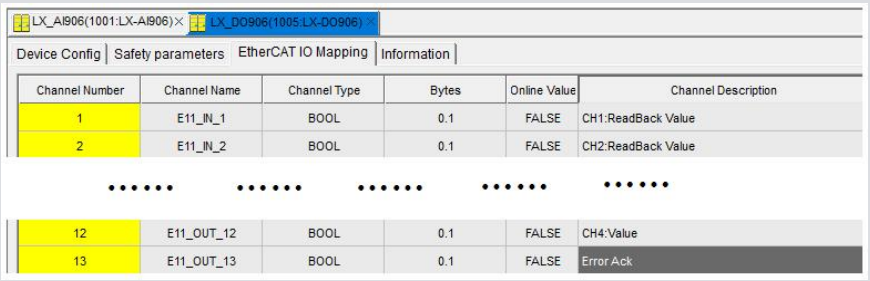
- Channel enable configuration

In the safety parameter interface, the default channel enable value is "Enable", which may select "Enable" or "Disable" by the drop-down menu.



Unused channels should be disabled, that is, the channel enable value should be selected as "Disabled" to avoid module diagnosis not being disabled and generating alarms;

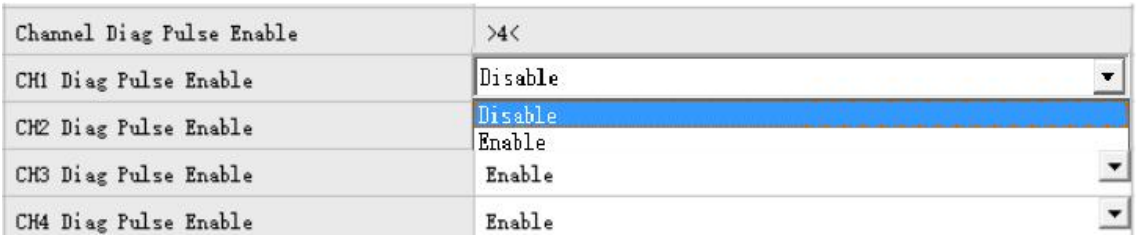
Channel enable and diagnostic enable. After channel failure and troubleshooting, the Error ACK signal should be set from "False" to "True" on the FA AutoThink-Safety;



Channel enable and diagnostic enable. After a channel failure, the channel will be disabled and the project will be reinstalled. The fault will not be eliminated and after setting the Error ACK, the fault can be cleared.

- Channel diag pulse enable configuration

In the safety parameter interface, the default enable value of the channel diagnostic pulse is "Enable", which may select "Enable" or "Disable" by the drop-down menu.

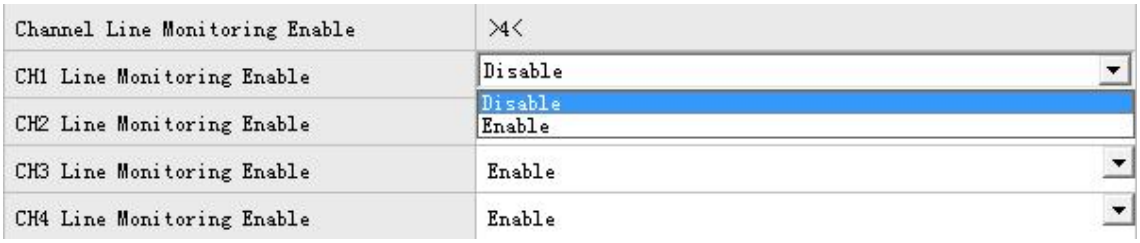


After configuring the diag pulse enable value of any channel to "Disabled", the diagnostic function of the channel will be turned off, and the module's safety level cannot reach SIL3 or PLe Cat. 4 levels.

- Channel line monitoring configuration

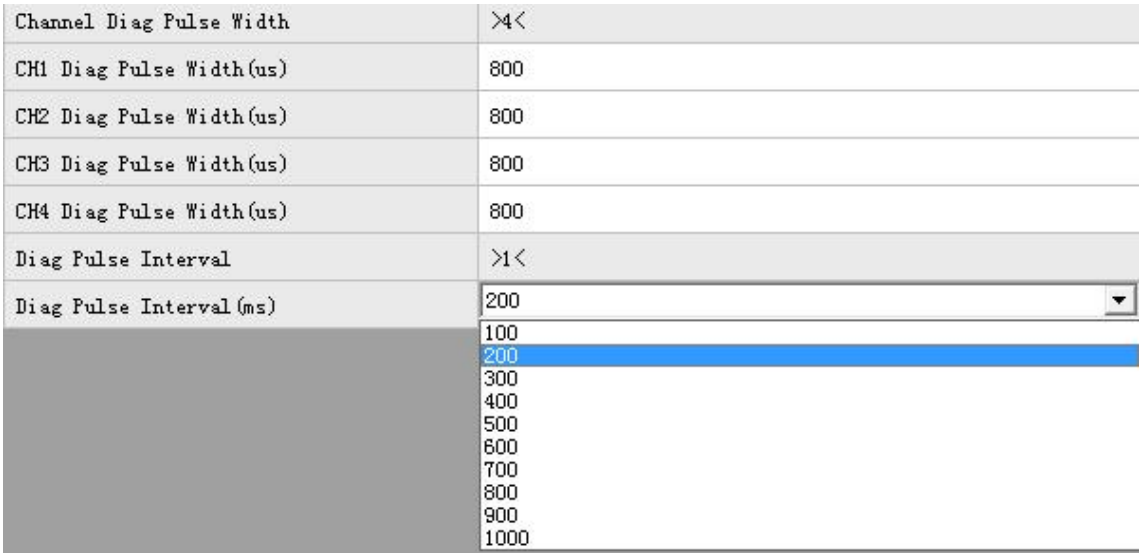
After configuring the channel line monitoring, it can diagnose light-load (open circuit) and over-load (short circuit) faults.

In the safety parameter interface, the default enable value of the channel diagnostic pulse is "Enable", which may select "Enable" or "Disable" by the drop-down menu.

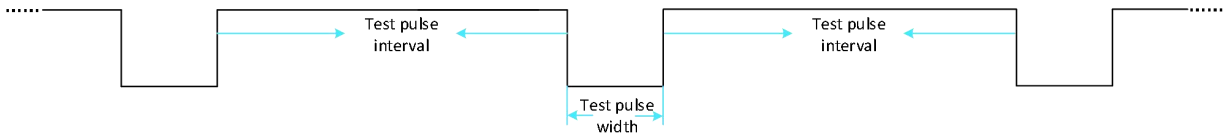


- Diag pulse parameter configuration

The diag pulse parameters include two parameters: diagnostic test pulse width and diagnostic test pulse interval. The diagnostic test pulse width unit is us, with a range of 500-2000us; The diagnostic test pulse interval unit is ms.



The diagnostic test pulse width and diagnostic test pulse interval are shown in the following figure.

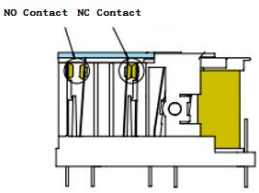
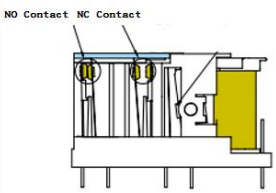
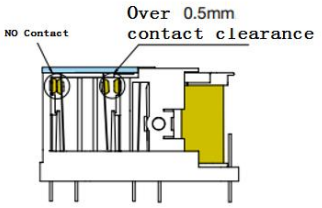


6.3.6 Sensor introduction

The safety DO module is mainly used to control the sensors of safety relays on/off, STO (current or level driven), indicator lights on/off, valve on/off, and other switch quantities. By controlling the sensors, it achieves protection and alarm for the production site.

Force-guided relay:

Being able to detect faults caused by contact fusion, damage, etc., helps to build safe circuits. The NO (Normal Open) and NC (Normal Close) contacts of the forced directional relay are isolated and can be insulated. In addition, the NO and NC contacts are mechanically connected through a linkage mechanism (guiding device), and act together based on the presence or absence of coil voltage. The main feature of a forced directional relay is that through a linkage mechanism (guiding device), when the NO contact is welded in a closed state, the NC contact remains open.

Coil Voltage	OFF Unexcited(Normal)	ON Excitation(Normal)	OFF Unexcited(Abnormal)
Safety Relay Status			
NO Contact (Control Power)	open(Machine stop)	Close (Machine running)	Close (Machine running)
NC Contact (Monitoring)	Close(Confirm [Machine stop])	Open(Confirm [Machine no stop])	Open(Confirm [Machine no stop])
SRP/CS Status	Normal	Normal	Abnormal(detectable fault)

As shown above, a safety relay with forced guidance includes at least 1NO+1NC contacts, where the NO contact is used for the control circuit of the safety loop, and the NC contact is used for EDM monitoring.

When the machinery is operating normally, the DO channel of the safety PLC system outputs 24V, the relay coil side is given excitation, the NO contact is closed, the NC contact is disconnected, and the external mechanical equipment is powered on and operates normally. When a danger occurs on site, the DO channel of the safety PLC system outputs 0V, the excitation is cut off on the relay coil side, the NO contact is disconnected, the NC contact is closed, and the external mechanical equipment loses power and stops working. The safety PLC system can diagnose whether the relay has NO contact fusion by reading whether the NC contact is closed. If the NO contact fusion occurs at this time, the safety PLC system reads back that the NC contact is in the open state, and generates a corresponding fault alarm.

STO: Safe Torque Off

The STO function is a special function that, when activated, prevents the stationary motor from accidentally starting if it is in a stationary state. If the motor is rotating, it will rely on inertia to continue rotating until it comes to a standstill. If the motor is equipped with a brake, the brake will immediately close and the motor will stop rotating to avoid safety accidents.

The safe DO module can provide a driving current of no more than 0.5A, with a typical high level value of 24V (minimum 15V). If the specified current and level are exceeded, STO will not be able to drive reliably.

Only force-guided contact can be used in safety related application;

When selecting safety relay, relevant standards must be met, such as EN 61810-3 standard, EN 50205 standard, UL508 standard, or GB14048 standard.

For external electromechanical (e.g., safety relay)with HFT=1,which cannot be detected by online automated diagnostics technically, the following diagnosis interval shall be considered according to the recommendation of Vertical Group 11:

- the input contacts have to switched at least once a month for *SIL* 3, PL e / category 4.

- the input contacts have to switched at least once a year for *SIL* 2, PL d / category 3.

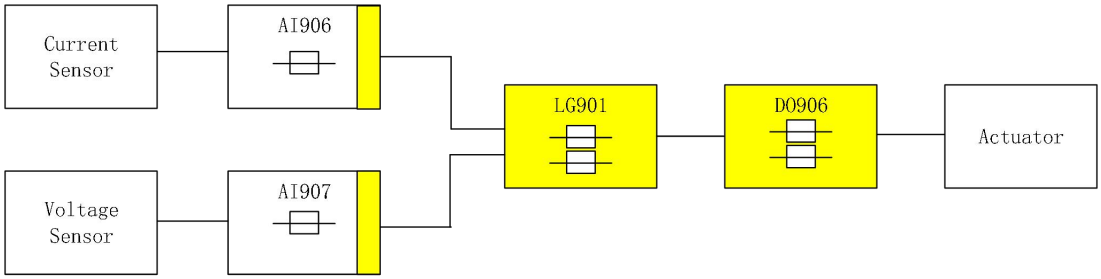
6.4 LX-AI906 6-channel safety current analog input module

6.4.1 Product overview

The LX-AI906 is an AI module for the LXS system, functioning as a current analog input module. This module acquires 0~20mA and 4~20mA current signals and converts them into digital signals, which are then reported to the safety logic module via the LX-bus. In addition, the module performs diagnostic functions based on the data converted from each channel to diagnose the current status of the channels.

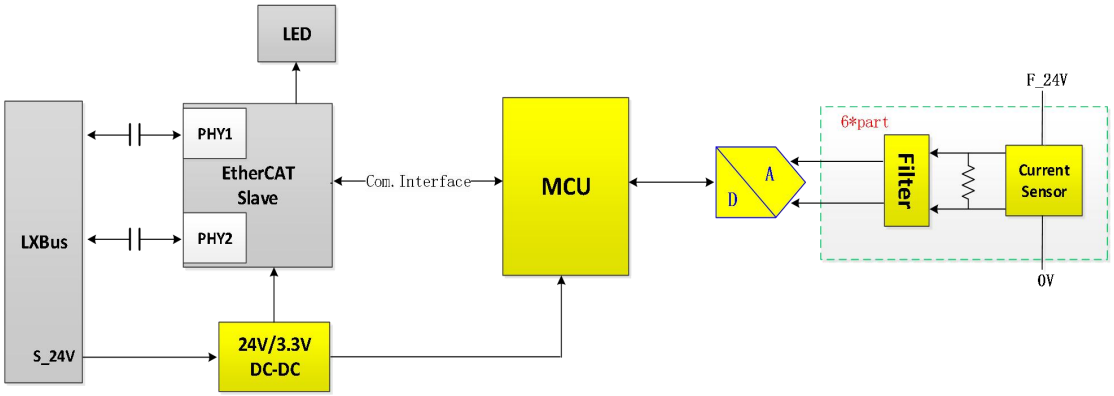
The LX-AI906 connects to the system through the LX-bus, which includes the communication bus and module system side input power.

A safety loop can be formed by one channel of a safety AI module (including LX-RTD901, LX-TC901, LX-AI906, and LX-AI907) and another channel from a different safety AI module, meeting SIL2 (IEC61508) and PLd Cat.3 (ISO13849). The safety loop is shown in the figure below:



Schematic diagram of the AI module safety loop

The schematic diagram of the module is as follows:



1. Basic features

The LX-AI906 module is designed for the acquisition of current analog signals:

Supports acquisition of 0~20mA and 4~20mA current signals, with a maximum of 6 channels for analog signal acquisition;

Supports power frequency filtering, which can be enabled or disabled; supports data collection filtering with filtering parameters configurable;

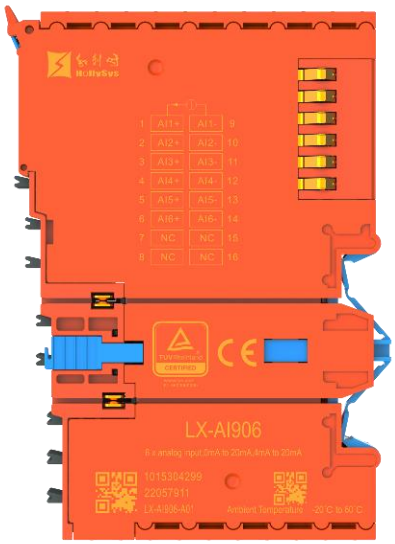
Supports diagnostics for wire break, short circuit, over-limit, and under-limit conditions, with over-limit and under-limit thresholds configurable;

Supports reporting of safety values, which can be configured;

Indicator lights display module operational status, channel enable status, and fault status.

2. Module components

The diagram of the module components is as follows:



6.4.2 Technical indicators

LX-AI906 6-channel current analog input module	
Function safety	
Safety Integrity Level	SIL2 (IEC61508) SC3 (IEC61508) SIL2 (IEC62061)
Performance level	PLd (ISO 13849-1)
Safety category	Cat.3 (ISO13849-1)
System modes	Low demand, high demand and continuous operation modes.
Address of safety communication	1-65535 (configurable)
Safety value	Configurable in range, 0 by default.
Power-on reset time	≤5s
Module diagnosis	

LX-AI906 6-channel current analog input module		
FSoE communication status	FSoE communication status normal/abnormal	
MCU temperature	The junction temperature of MCU can be readed, unit is °C.	
Module status	Module normal/abnormal	
Channel status	Real-time status of each channel (wire break, short circuit, over-limit and under-limit)	
Technical indicators		
Number of channels	6	
Full channel scan time	5ms (without filtering)	
Input type	Differential/single-end input	
Load type	Supports 2/4-wire	
Resolution	24bit	
Measuring range	0~22mA	0~21.6mA
Signal input range	0~20mA	4~20mA
Accuracy	±0.3%FS (@-20℃~60℃) ±0.2%FS (@25℃)	
Safety accuracy	Safety accuracy is configurable; parameters for the corresponding algorithm block can be configured in AutoThink software.	
Channel conversion time	330us/ channel	
Common mode rejection ratio	70dB	
Differential mode rejection ratio	60dB	
Input impedance	250Ω	
Maximum channel input signal	25mA	
Cable length	Max. 100m for shielded cables (AWG 16~22)	
Configuration mode	2byte channel data + 1byte channel quality bit Reported code value 0~32767 (0~22mA) Reported code value 0~32767 (4~21.6mA)	
Software filter	Configurable, filter points can be selected.	

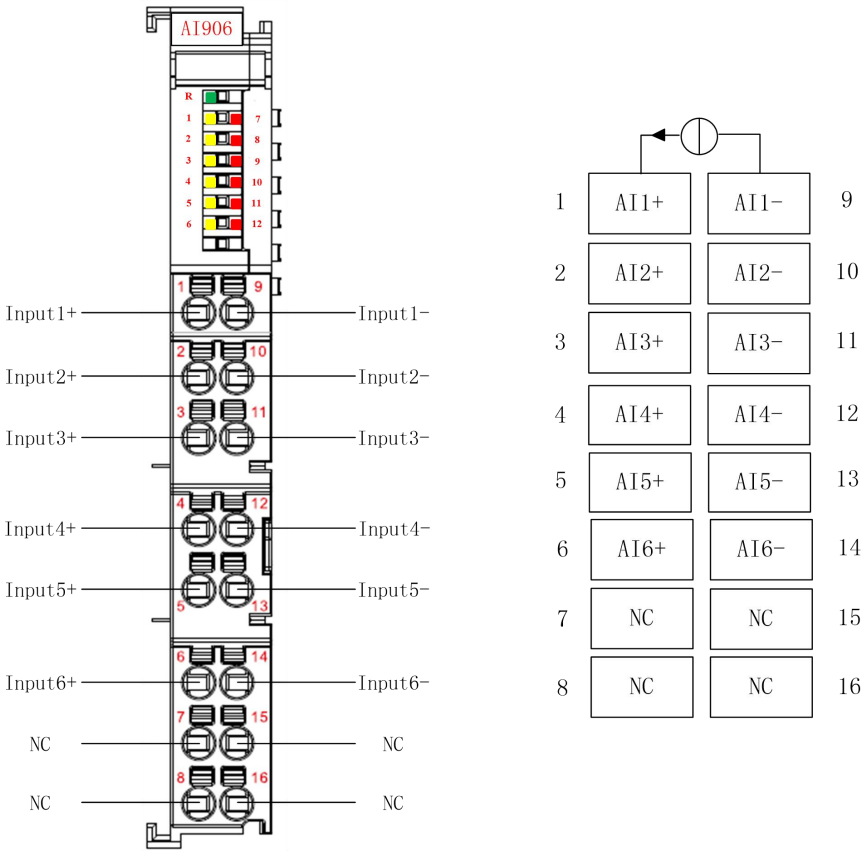
LX-AI906 6-channel current analog input module	
50/60Hz power frequency filtering	Configurable enable/disable, default enable
Over/Under-range diagnostic enable	Configurable enable/disable, default enable.
Over/Under-range threshold	Range:4~20mA Under-range threshold:3.6mA Over-range threshold:21mA Range:0~20mA Under-range threshold:0mA Over-range threshold:21mA
Safety value	Configurable In case of channel fault, the AI module reports a safety value for the corresponding channel; In case of module fault, the AI module reports a safety value for all channels. In the event of a communication failure, the safety logic module uses a safe substitute value.
Wire break diagnosis enable	Configurable enable/disable, default enable.
Short circuit diagnosis enable	Configurable enable/disable, default enable.
Over-limit diagnosis enable	Configurable enable/disable, default enable.
Over-limit threshold	Configurable
Under-limit diagnosis enable	Configurable enable/disable, default enable.
Under-limit threshold	Configurable
Insulation resistance	Under normal condition, ≥10MΩ@DC500V (Temperature 25℃±2℃, relative humidity 30%±5%, non-condensing).
Isolation withstand voltage	1000VAC@1min@5mA
Typical power consumption	1.5W
Physical characteristics	
Module dimensions (W*H*D)	12mm *100mm*68mm
Degree of protection provided by enclosure	IP20 (IEC60529)
Installation mode	DIN35 rail mounting
Grounding method	Module connected to ground via DIN35 rail
Weight (excluding packaging)	≤65g

6.4.3 Indicator light status

After the LX-AI906 module is powered on, the indicator lights on the panel display the current working and communication status.

Name	Function	Color	Definition	
RUN	Module status indicator	Green	On	Module working normally
			Flashing	Module offline
			Off	Module not powered
CH1~6	Channel status indicator	Yellow	On	Channel enable
			Off	Channel not enabled
ERR1~6	Channel fault indicator	Red	On	Channel fault
			Off	Channel normal
Note: When reading back the FSoE address, all indicator lights flash for about 5 seconds (at a frequency of 4Hz).				

6.4.4 Terminal wiring



LX-AI906 terminal wiring diagram

The signal descriptions are as follows:

Terminal identifier	Description of signal	Terminal identifier	Description of signal
1	Channel 1 differential input signal positive terminal	9	Channel 1 differential input signal negative terminal
2	Channel 2 differential input signal positive terminal	10	Channel 2 differential input signal negative terminal
3	Channel 3 differential input signal positive terminal	11	Channel 3 differential input signal negative terminal
4	Channel 4 differential input signal positive terminal	12	Channel 4 differential input signal negative terminal
5	Channel 5 differential input signal positive terminal	13	Channel 5 differential input signal negative terminal
6	Channel 6 differential input signal positive terminal	14	Channel 6 differential input signal negative terminal
7	Terminals are left unconnected and not connected to any external signal	15	Terminals are left unconnected and not connected to any external signal

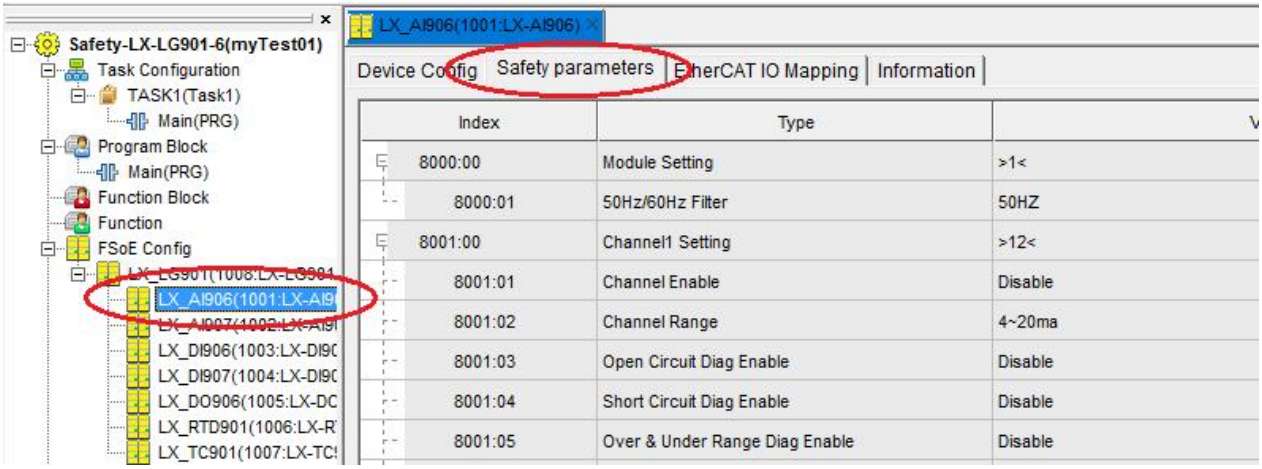
Terminal identifier	Description of signal	Terminal identifier	Description of signal
8	Terminals are left unconnected and not connected to any external signal	16	Terminals are left unconnected and not connected to any external signal

Terminals 7, 8, 15, and 16 are left unconnected and not connected to any external signal;

A single module cannot fulfill safety functions. Safety loops must be implemented through two channels across two modules, each channel is independently connected to a sensor, meeting SIL2 (IEC61508) and PLd Cat.3 (ISO13849).

6.4.5 Parameter Configuration

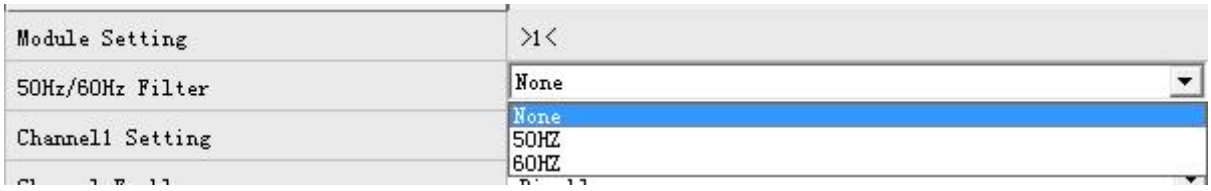
In the FA AutoThink-Safety interface, select the module you want to modify safety parameters in the engineering management area, double-click the module, and select the "Safety parameters" tab page in the pop-up interface.



For safety related application, the diagnostic is not allowed to disable any diagnosis.

- 50Hz/60Hz filter configuration

In the safety parameter interface, the 50Hz/60Hz filter configuration can be selected through the drop-down menu. When selecting "None", there is no filter.



➢ Channel parameter configuration

In the safety parameter interface：

- Channel enable,which may select "enable" or "disable" by the dropdown menu;
- Channel range,which may select "4~20ma" or "0~20ma" by the dropdown menu;
- Open circuit,short circuit,over/under range,upper/lower limit,which may select "enable" or "disable" by the dropdown menu;
- Channel filter, the number of filtering points can be selected through the drop-down menu;
- The value of upper and lower limits can be configured within the range;
- The channel safety value can be configured by users according to their actual needs, with a default value of "0".

Channel1 Setting	>12<
Channel Enable	Enable
Channel Range	4~20ma
Open Circuit Diag Enable	Disable
Short Circuit Diag Enable	Disable
Over & Under Range Diag Enable	Disable
Upper Limit Diag Enable	Disable
Lower Limit Diag Enable	Disable
Channel filter	4 Points
Upper Limit value	0 Points 4 Points 8 Points 16 Points 32 Points
Lower Limit value	
Channel Safety value	0

The channel safety value is reported to the FA AutoThink-Safety instead of the sample value when a fault is diagnosed, and the user sets the channel safety value according to actual needs.

➢ Parameter configuration note

After switching the range, if the diagnosis is enabled for the upper and lower limits, the threshold for the upper and lower limits must be within the range, and the threshold for the upper limit must be greater than the threshold for the lower limit.

6.4.6 Code value and current value conversion

When the range is 0-22mA, the corresponding channel sample code value is 0-32767, and the conversion relationship is as follows:

Current value=22 * Channel sample code value/32767mA

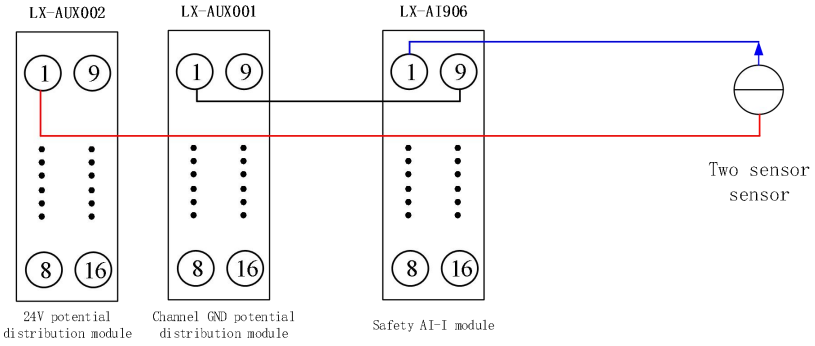
When the range is 4~21.6mA, the corresponding channel sample code value is 0~32767, and the conversion relationship is as follows:

Current value=4+17.6 * Channel sample code value/32767mA

6.4.7 Two wire and four wire connection methods

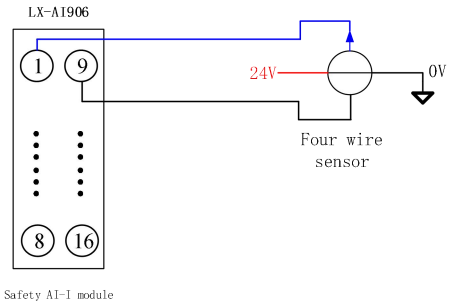
- Two wire

When the user uses a two wire sensor, they need to output 24V power from the 24V potential distribution module LX-AUX002 to the two wire sensor. Then, the current signal output by the two wire sensor is connected to the positive terminal of the channel input signal of the LX-AI906 module, and the negative terminal of the channel input signal of the LX-AI906 module is connected to the terminal of the channel GND potential distribution module.



- Four wire

A four wire sensor is powered separately, and the positive and negative signals of the sensor are respectively connected to the positive and negative terminals of the input signals of the LX-AI906 module channel.



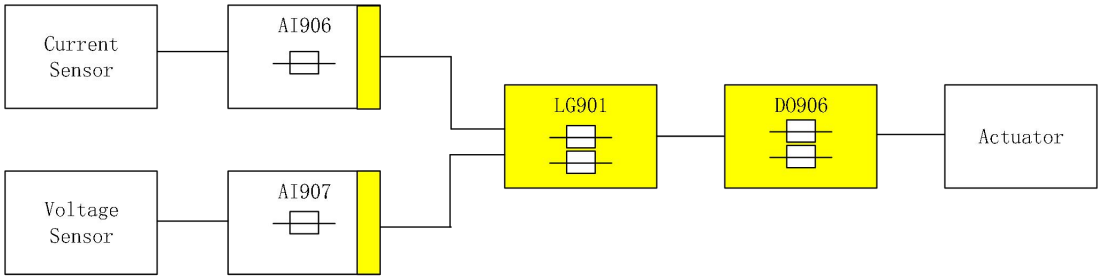
6.5 LX-AI907 6-channel safety voltage analog input module

6.5.1 Product overview

The LX-AI907 is an AI module for the LXS system, functioning as a voltage analog input module. This module acquires -10~+10V and 0~+10V voltage signals and converts them into digital signals, which are then reported to the safety logic module via the LX-bus. In addition, the module performs diagnostic functions based on the data converted from each channel to diagnose the current status of the channels.

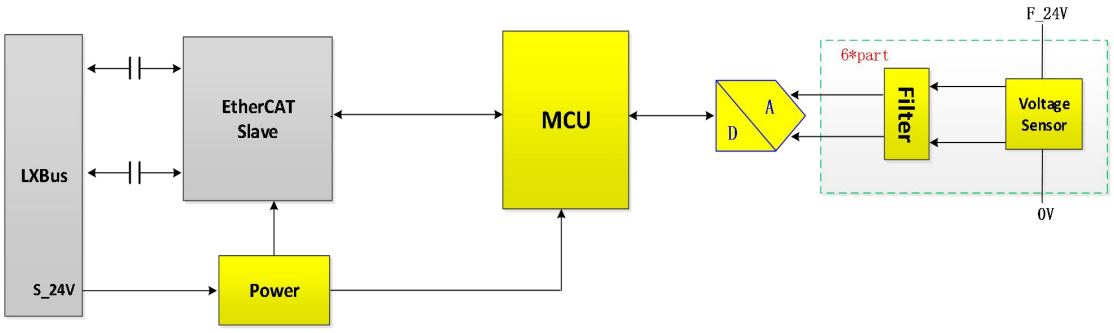
The LX-AI907 connects to the system through the LX-bus, which includes the communication bus and module system side input power.

A safety loop can be formed by one channel of a safety AI module (including LX-RTD901, LX-TC901, LX-AI906, and LX-AI907) and another channel from a different safety AI module, meeting SIL2 (IEC61508) and PLd Cat.3 (ISO13849). The safety loop is shown in the figure below:



Schematic diagram of the AI module safety loop

The schematic diagram of the module is as follows:



1. Basic features

The LX-AI907 module is designed for the acquisition of voltage analog signals:

It supports the acquisition of 0~10V and -10~+10V voltage signals, with a maximum capacity for 6 channels of analog signal;

Supports power frequency filtering, which can be enabled or disabled; supports data collection filtering with filtering parameters configurable;

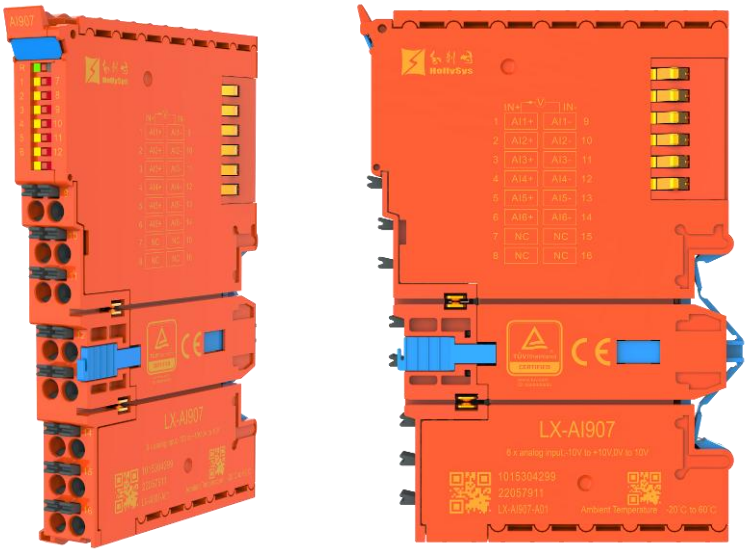
Supports diagnostics for over&under range,over-limit, and under-limit conditions, with over-limit and under-limit thresholds configurable;

Supports reporting of safety values, which can be configured;

Indicator lights display module operational status, channel enable status, and fault status.

2. Module components

The diagram of the module components is as follows:



6.5.2 Technical indicators

LX-AI907 6-channel safety voltage analog input module	
Function safety	
Safety Integrity Level	SIL2 (IEC61508) SC3 (IEC61508) SIL2 (IEC62061)
Performance level	PLd (ISO 13849-1)
Safety category	Cat.3 (ISO13849-1)
System modes	Low demand, high demand and continuous operation modes.
Safety communication address	1-65535 (configurable)
Safety value	Configurable in range, 0 by default.
Power-on reset time	≤5s
Module diagnosis	

LX-AI907 6-channel safety voltage analog input module	
FSoE communication status	FSoE communication status normal/abnormal
MCU temperature	The junction temperature of MCU can be readed, unit is °C.
Module status	Module normal/abnormal
Channel status	Real-time status of each channel (under-range, over-range, over-limit, and under-limit)
Technical indicators	
Number of channels	6
Full channel scan time	5ms (without filtering)
Input type	Differential
Resolution	24bit
Measuring range	-11V~11V
Signal input range	0~10V, -10~10V
Accuracy	±0.3%FS (@-20℃~60℃) ±0.2%FS (@25℃)
Safety accuracy	Safety accuracy is configurable; parameters for the corresponding algorithm block can be configured in AutoThink software.
Channel conversion time	330us/ channel
Common mode rejection ratio	70dB
Input impedance	≥200kΩ
Channel withstand voltage	Maximum 10V (signal line to GND/0V) Maximum 30V (between differential input signals)
Cable length	Max. 100m for shielded cables (AWG 16~22)
Configuration mode	2byte channel data + 1byte channel quality bit Reported code value: -32768~32767 (±11V) Reported code value: 0~32767 (0-11V)
Software filter	Configurable, filter points can be selected.
50/60Hz power frequency filtering	Configurable enable/disable, default enable
Over/Under-range diagnostic	Configurable enable/disable, default enable.

LX-AI907 6-channel safety voltage analog input module	
enable	
Over/Under-range threshold	Range:0~10V Under-range threshold:-0.35V Over-range threshold:10.35V Range:-10~10V Under-range threshold:-10.35V Over-range threshold:10.35V
Over-limit diagnosis enable	Configurable enable/disable, default enable.
Over-limit threshold	Configurable
Under-limit diagnosis enable	Configurable enable/disable, default enable.
Under-limit threshold	Configurable
Insulation resistance	Under normal condition, ≥10MΩ@DC500V (Temperature 25℃±2℃, relative humidity 30%±5%, non-condensing).
Isolation withstand voltage	1000VAC@1min@5mA
Typical power consumption	1.2W
Physical characteristics	
Module dimensions (W*H*D)	12mm *100mm*68mm
Degree of protection provided by enclosure	IP20 (IEC60529)
Installation mode	DIN35 rail mounting
Grounding method	Module connected to ground via DIN35 rail
Weight (excluding packaging)	≤65g

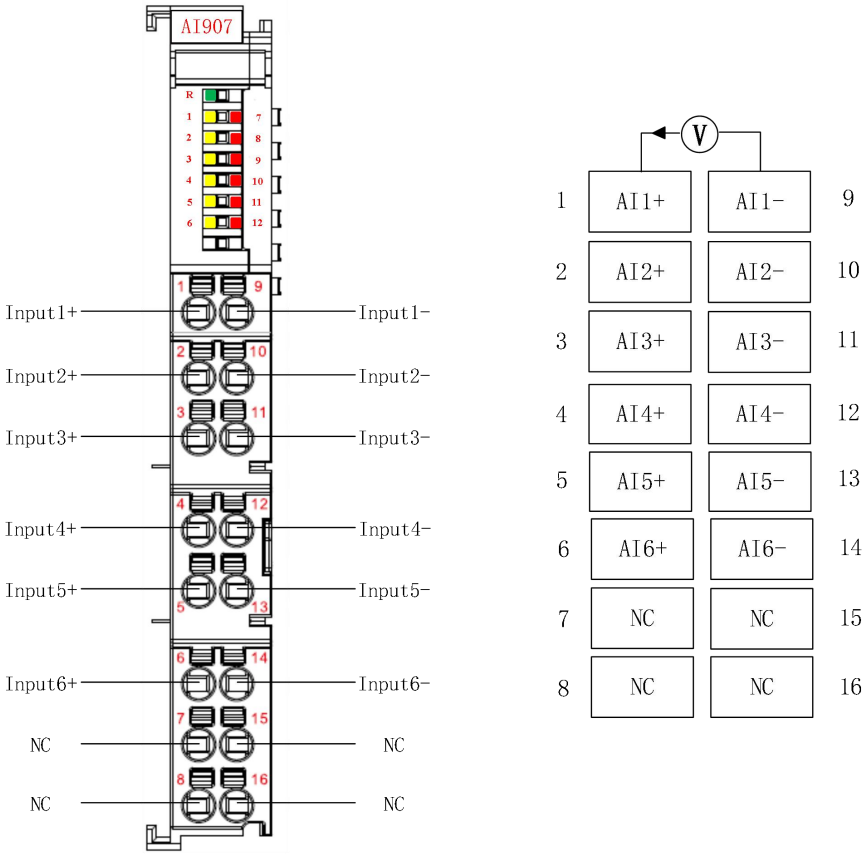
6.5.3 Indicator light status

After the LX-AI907 module is powered on, the indicator lights on the panel display the current working and communication status.

Name	Function	Color	Definition	
RUN	Module status indicator	Green	On	Module working normally
			Flashing	Module offline
			Off	Module not powered

Name	Function	Color	Definition	
CH1~6	Channel status indicator	Yellow	On	Channel enable
			Off	Channel not enabled
ERR1~6	Channel fault indicator	Red	On	Channel fault
			Off	Channel normal
Note: When reading back the FSoE address, all indicator lights flash for about 5 seconds (at a frequency of 4Hz).				

6.5.4 Terminal wiring



LX-AI907 terminal wiring diagram

The signal descriptions are as follows:

Terminal identifier	Description of signal	Terminal identifier	Description of signal
1	Channel 1 differential input signal positive terminal	9	Channel 1 differential input signal negative terminal

Terminal identifier	Description of signal	Terminal identifier	Description of signal
2	Channel 2 differential input signal positive terminal	10	Channel 2 differential input signal negative terminal
3	Channel 3 differential input signal positive terminal	11	Channel 3 differential input signal negative terminal
4	Channel 4 differential input signal positive terminal	12	Channel 4 differential input signal negative terminal
5	Channel 5 differential input signal positive terminal	13	Channel 5 differential input signal negative terminal
6	Channel 6 differential input signal positive terminal	14	Channel 6 differential input signal negative terminal
7	Terminals are left unconnected and not connected to any external signal	15	Terminals are left unconnected and not connected to any external signal
8	Terminals are left unconnected and not connected to any external signal	16	Terminals are left unconnected and not connected to any external signal

Terminals 7, 8, 15, and 16 are left unconnected and not connected to any external signal;

A single module cannot achieve safety functions. Safety loops must be realized through two channels of two modules, each channel is independently connected to a sensor, meeting SIL2 (IEC61508) and PLd Cat.3 (ISO13849).

6.5.5 Parameter configuration

The parameter configuration of LX-AI907 module can refer to section 6.4.5 for configuration.

6.5.6 Code value and voltage value conversion

When the range is -10~10V, the conversion relationship is as follows:

Voltage value=22 * Channel sample code value/65534V

When the range is 0~10V, the sample relationship is as follows:

Voltage value=11 * Channel sample code value/32767V

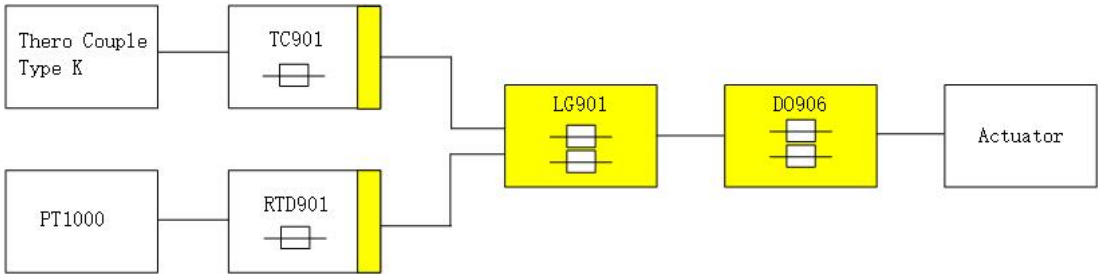
6.6 LX-TC901 4-channel safety thermocouple input module

6.6.1 Product overview

The LX-TC901 is an AI module of LXS system, functioning as the thermocouple analog input module. It converts temperature signals from the field side into digital signals and reports them to the safety logic module via the LX-bus. The module features four channels capable of acquiring signals from B, C, E, J, K, N, R, S, and T type thermocouples, as well as -75mV ~75mV voltage signals, with internally integrated cold junction compensation. It also performs diagnostic functions based on channel data collected to diagnose the current status of each channel.

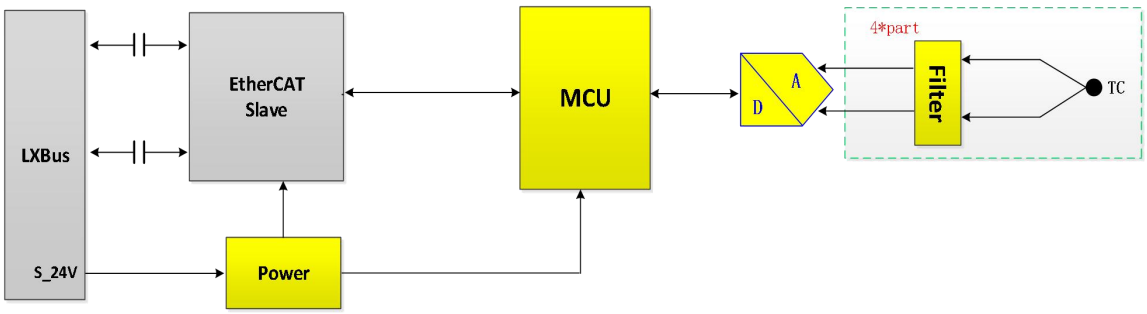
The LX-TC901 connects to the system through the LX-bus, which includes the communication bus and module system side input power.

A safety loop can be formed by one channel of a safety AI module (including LX-RTD901, LX-TC901, LX-AI906, and LX-AI907) and another channel from a different safety AI module, meeting SIL2 (IEC61508) and PLd Cat.3 (ISO13849). The safety loop is shown in the figure below:



TC/RTD module safety loop diagram

The schematic diagram of the module is as follows:



1. Basic features

The LX-TC901 module is designed for the acquisition of thermocouple analog signals:

Supports temperature acquisition from B, C, E, J, K, N, R, S, and T type thermocouples and signal acquisition from voltage range -75mV~75mV, with a maximum support for 4 channels of analog signal acquisition;

Supports power frequency filtering, which can be enabled or disabled; supports data collection filtering with filtering parameters configurable;

Supports diagnostics for wire break, over-limit, under-limit, over-range, and under-range, with configurable thresholds for over and under-limits;

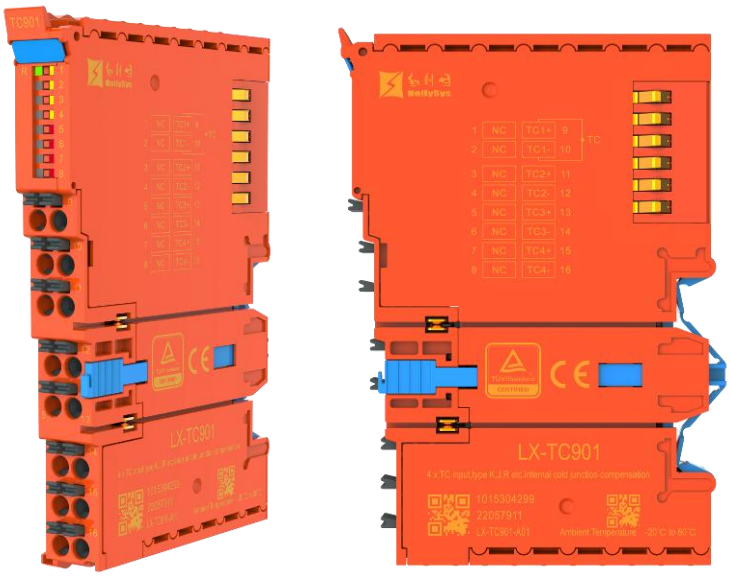
Supports reporting of safety values, which can be configured;

The module integrates cold junction compensation internally for thermocouple signal acquisition.

Indicator lights display module operational status, channel enable status, and fault status.

2. Module components

The diagram of the module components is as follows:



6.6.2 Technical indicators

LX-TC901 4-channel safety thermocouple input module	
Function safety	
Safety Integrity Level	SIL2 (IEC61508) SC3 (IEC61508) SIL2 (IEC62061)
Performance indicator	PLd (ISO13849-1)
Safety category	Cat. 3 (ISO13849-1)
System modes	Low demand, high demand and continuous operation modes.
Address of safety communication	1~65535 (configurable)

LX-TC901 4-channel safety thermocouple input module	
Safety value	Configurable in range, 0 by default.
Power-on reset time	≤5s
Module diagnosis	
FSoE communication status	FSoE communication status normal/abnormal
MCU temperature	The junction temperature of MCU can be readed, unit is °C.
Module status	Module normal/abnormal
Channel status	Real-time status of each channel (wire break, over&under range, over-limit, and under-limit)
Technical indicators	
Number of channels	4
Full channel scan time	260ms (without filtering)
Input type	Differential signal
Input impedance	≥10MΩ
RTD type	mV voltage: ±30/±60/±75 mV display voltage value Types B, C, E, J, K, N, R, S, and T: Display temperature value
Channel filter	Configurable, filter points can be selected.
Resolution	≥16bit
Measuring range	mV voltage: ±30/±60/±75 mV Type B: 200 ~ +1820℃ Type C: 0 ~+2320 ℃ Type E: -100 ~ +1000℃ Type J: -100 ~+1200 ℃ Type k: -270~ +1370℃ (default) Type N: -100 ~ +1300 ℃ Type R: -50 ~+1767 ℃ Type S: -50 ~+1760 ℃ Type T: -200 ~+400 ℃

LX-TC901 4-channel safety thermocouple input module	
Accuracy	mV voltage (Full temperature range): ±0.1%F.S.; RTD, measurement error when using internal cold-junction compensation at room temperature: Type B: ±8.5℃ Type C: ±6.2℃ Type E: ±2.5℃ Type J: ±2.7℃ Type K: ±3℃ Type N: ±3℃ Type R: ±6.7℃ Type S: ±7.1℃ Type T: ±2.9℃
Safety accuracy	Safety accuracy is configurable; parameters for the corresponding algorithm block can be configured in AutoThink software.
Configuration mode	4byte channel data + 1byte channel quality bit
Software filter	Configurable, filter points can be selected.
50/60Hz power frequency filtering	Configurable, no filtering by default
Common mode rejection ratio	≥90dB
Differential mode rejection ratio	≥60dB
Channel withstand voltage	10V (signal line to GND), 2V (between differential input signals)
Channel enable	Any channel can be configured, all channels enabled by default.
Channel signal type	Any channel can be configured, all channels set to Type K thermocouple by default.
Cable length	30m for cold junction compensation wire
Cold junction compensation method	Internal cold junction compensation
Cold junction compensation temperature range	-20～80℃
Cold junction compensation	Enabled/disabled, enabled by default.
Cold junction compensation fault handling	Configurable default value/safety value, default safety value. Note:1)Selected default value, cold junction compensation value uses default value 2)Selected safety value,channel value uses safety value.

LX-TC901 4-channel safety thermocouple input module	
Wire break diagnosis enable	Configurable enable/disable, default enable.
Over-range diagnostic enable	Configurable enable/disable, default enable.
Over-limit diagnosis enable	Configurable enable/disable, default enable.
Over-limit threshold	Configurable
Under-limit diagnosis enable	Configurable enable/disable, default enable.
Under-limit threshold	Configurable
Insulation resistance	Under normal condition, ≥10MΩ@DC500V (Temperature 25℃±2℃, relative humidity 30%±5%, non-condensing).
Isolation withstand voltage	1000VAC@1min@5mA
Typical power consumption	1.2W
Physical characteristics	
Module dimensions (W*H*D)	12mm *100mm*68mm
Degree of protection provided by enclosure	IP20 (IEC60529)
Installation mode	DIN35 rail mounting
Grounding method	Module connected to ground via DIN35 rail
Weight (excluding packaging)	≤65g

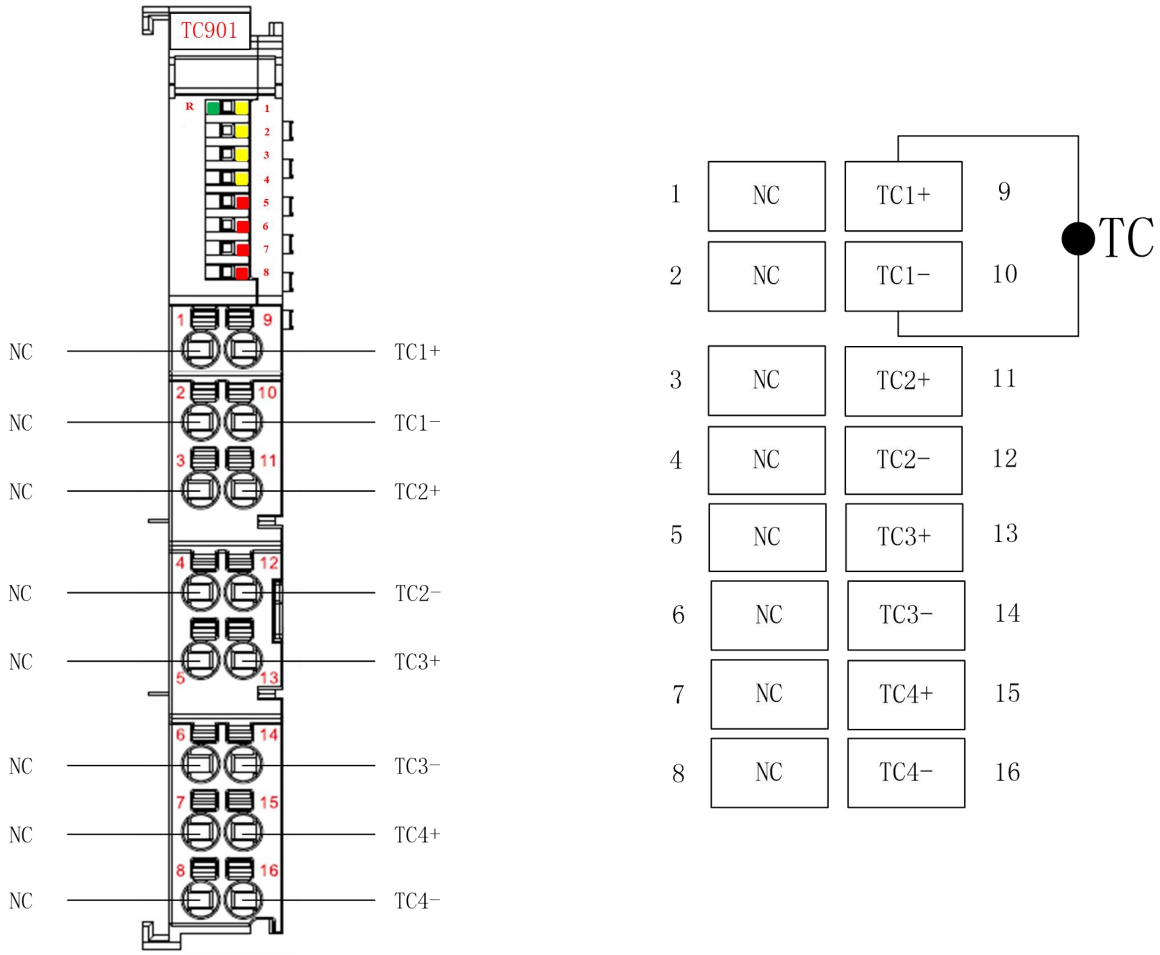
6.6.3 Indicator light status

After the LX-TC901 module is powered on, the indicator lights on the panel display the current working and communication status.

Name	Function	Color	Definition	
RUN	Module status indicator	Green	On	Module status normal
			Flashing	Module offline
			Off	Module not powered
CH1~4	Channel status indicator	Yellow	On	Channel enable

Name	Function	Color	Definition	
			Off	Channel not enabled
ERR1~4	Channel fault indicator	Red	On	Channel fault
			Off	Channel normal
Note: 1. When reading back the FSoE address, all indicator lights flash for about 5 seconds (at a frequency of 4Hz); 2. In Boot operation mode, the RUN light flashes continuously, with a flashing frequency of 2Hz.				

6.6.4 Terminal wiring



LX-TC901 terminal wiring diagram

The signal descriptions are as follows:

Terminal identifier	Description of signal	Terminal identifier	Description of signal

Terminal identifier	Description of signal	Terminal identifier	Description of signal
1	Terminals are left unconnected and not connected to any external signal	9	Channel 1 input signal positive terminal
2	Terminals are left unconnected and not connected to any external signal	10	Channel 1 input signal negative terminal
3	Terminals are left unconnected and not connected to any external signal	11	Channel 2 input signal positive terminal
4	Terminals are left unconnected and not connected to any external signal	12	Channel 2 input signal negative terminal
5	Terminals are left unconnected and not connected to any external signal	13	Channel 3 input signal positive terminal
6	Terminals are left unconnected and not connected to any external signal	14	Channel 3 input signal negative terminal
7	Terminals are left unconnected and not connected to any external signal	15	Channel 4 input signal positive terminal
8	Terminals are left unconnected and not connected to any external signal	16	Channel 4 input signal negative terminal

Terminals 1~8 are unconnected and not connected to any external signal;

A single module cannot fulfill safety functions. Safety loops must be implemented through two channels across two modules, each channel is independently connected to a sensor, meeting SIL2 (IEC61508) and PLd Cat.3 (ISO13849);

The wiring method for Type B to Type T thermocouple sensors is the same.

6.6.5 Parameter configuration

In addition to load type configuration and cold junction compensation related configuration, other parameter configurations of LX-TC901 module can refer to Chapter 6.4.5 for configuration.

For safety related application, the diagnostic is not allowed to disable any diagnosis.

Cold junction compensation configuration:

- Cold junction compensation can be configured by selecting "Enable" or "Disable" from the drop-down menu;
- After the cold junction compensation fault, there are two options:

  1） Configure as "Safety Value", and report the channel safety value to the FA AutoThink-Safety instead of the sample value;

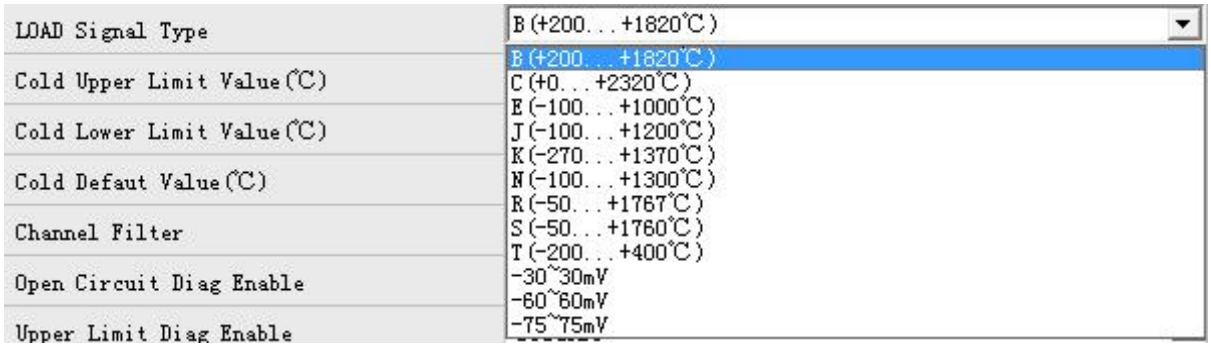
2） Set to "Default Value", the cold junction compensation will be compensated using the value set by "Cold Default Value".

- The upper and lower limits of the cold junction, as well as the default compensation values after a fault, can be set.

Cold Junction Compensation Enable	Enable
Cold Junction Compensation Fault	Safety Value
LOAD Signal Type	K(-270...+1370℃)
Cold Upper Limit Value(℃)	8000
Cold Lower Limit Value(℃)	-2000
Cold Defaut Value(℃)	2500

- Load signal type configuration

The load signal configuration type can be selected through the drop-down menu.



- Notes on parameter configuration

1) For channels that are not used, it is recommended to configure them as "Disabled" for channel enable. Even if the channel related diagnostic enableis enabled, the "Disabled" channel will not undergo diagnosis;

2) When the diagnostic configuration for the upper and lower limits is set to "Enable", the threshold for the upper and lower limits should be within the corresponding sensor type range based on the load signal type, and the threshold for the upper limit should be greater than the threshold for exceeding the lower limit。

For load signals of thermocouple type, the configured diagnostic threshold for the upper/lower limit is the actual temperature value * 100. If the threshold is 100 ℃, the parameter for the upper limit threshold on FA AutoThink-Safety is configured to 10000;

For load signals of voltage type, the configured diagnostic threshold for the upper/lower limit is the actual voltage value * 1000. If the threshold is 30mv, the parameter for the upper limit threshold on FA AutoThink-Safety is configured to 30000;

When configuring the upper and lower limits, they cannot be set at the boundary value. If set at the boundary, diagnostic discrimination cannot be performed and must be within the boundary, such as -100℃ -1000℃, and the FA AutoThink-Safety configuration is -9999-99999.

6.6.6 Conversion of code value and temperature value

The load signal is of thermocouple type:

Temperature value=channel sample code value/100

The load signal is of voltage type:

Voltage value=channel sample code value/1000

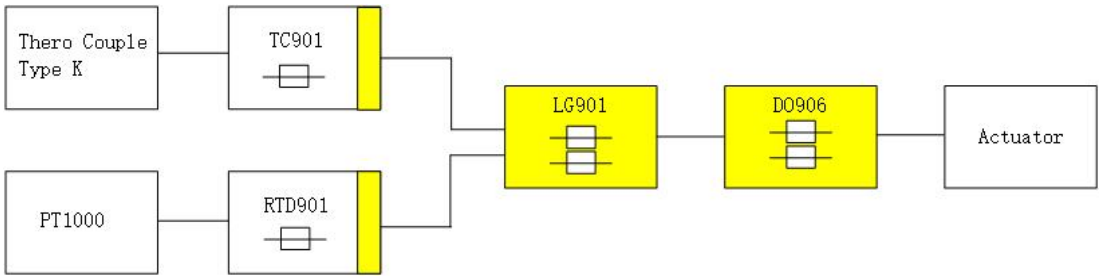
6.7 LX-RTD901 4-channel safety RTD input module

6.7.1 Product overview

The LX-RTD901 is an AI module of the LXS system, serving as a Resistance Temperature Detector (RTD) analog input module. It converts temperature signals from the field side into digital signals and reports them to the safety logic module via the LX-bus. This module features four RTD channels, enabling the collection of ambient temperatures through external RTDs of various ranges. It also performs diagnostic functions based on channel data collection to diagnose the current status of each channel.

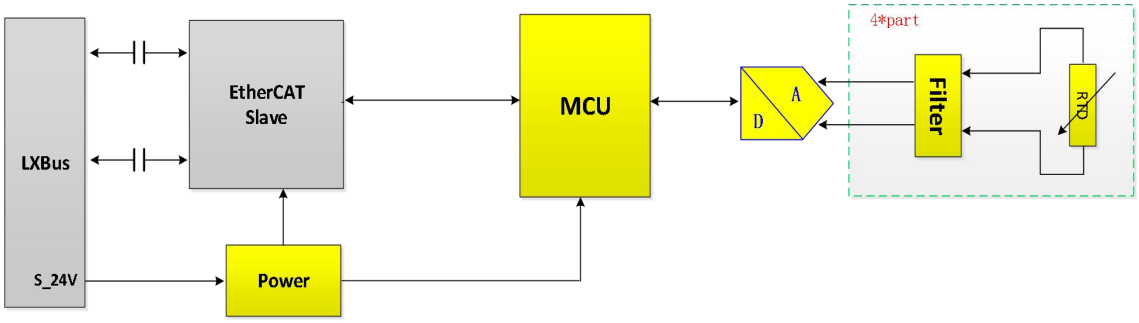
The LX-RTD901 connects to the system through the LX-bus, which includes the communication bus and module system side input power.

A safety loop can be formed by one channel of a safety AI module (including LX-RTD901, LX-TC901, LX-AI906, and LX-AI907) and another channel from a different safety AI module, meeting SIL2 (IEC61508) and PLe Cat.3 (ISO13849). The safety loop is shown in the figure below:



TC/RTD module safety loop diagram

The schematic diagram of the module is as follows:



1. Basic features

The LX-RTD901 module is designed for the acquisition of RTD analog signals:

Supports Pt, Ni, and resistance signal acquisition, with a maximum of 4 channels for analog signal acquisition;

Supports 2-wire and 3-wire RTD signal, and resistance signal inputs;

Supports power frequency filtering, which can be enabled or disabled; supports data collection filtering with filtering parameters configurable;

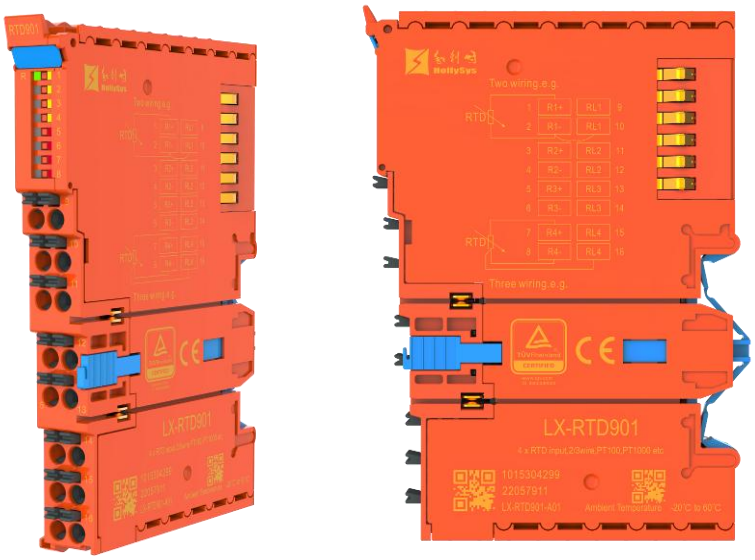
Supports diagnostics for wire break, over-limit, under-limit, over-range, and under-range, with configurable thresholds for over and under-limits;

Supports reporting of safety values, which can be configured;

Indicator lights display module operational status, channel enable status, and fault status.

2. Module components

The diagram of the module components is as follows:



6.7.2 Technical indicators

LX-RTD901 4-channel safety RTD input module	
Function safety	
Safety Integrity Level	SIL2 (IEC61508) SC3 (IEC61508) SIL2 (IEC62061)
Performance indicator	PLd (ISO13849-1)
Safety category	Cat.3 (ISO13849-1)
System modes	Low demand, high demand and continuous mode operation modes
Address of safety communication	1~65535 (configurable)
Safety value	Configurable in range, 0 by default.
Power-on reset time	≤5s
Module diagnosis	
FSoE communication status	FSoE communication status normal/abnormal
MCU temperature	The junction temperature of MCU can be readed, unit is °C.
Module status	Module normal/abnormal
Channel status	Real-time status for each channel (wire break, Over&under range, over-

LX-RTD901 4-channel safety RTD input module	
	limit, and under-limit)
Technical indicators	
Number of channels	4
Full channel scan time	450ms (without filtering)
Input type	2/3-wire resistance input 2/3-wire RTD signal input
RTD type	Pt100-385 Pt100-3916 Pt200-385 Pt200-3916 Pt500-385 Pt500-3916 Pt1000-385 Pt1000-3916 Ni100-618 Ni120-618 Resistance 10Ω-4KΩ
Resolution	≥16bit
Measuring range	-200~+630℃(Pt3916) -200~+870℃ (Pt385) -60~+250℃ (Ni) 10Ω~4KΩ
Accuracy (across full temperature range)	< ±0.5°C (Pt, 3-wire) ＜±0.9℃ (Ni) < 1°C (Pt, 2-wire @ cable impedance ≤0.38Ω)
Safety accuracy	Safety accuracy is configurable; parameters for the corresponding algorithm block can be configured in AutoThink software.
Configuration mode	4byte channel data + 1byte channel quality bit
Common mode rejection ratio	≥100dB
Differential mode rejection ratio	≥60dB
Channel withstand voltage	10V (signal line to GND) 2V (between differential input signals)
Cable length	Max. 100m for shielded cables (AWG 16~22)

LX-RTD901 4-channel safety RTD input module	
Dual comparison diagnostic thresholds	Configurable
Channel signal type	Configurable
Software filter	Configurable, filter points can be selected.
50/60Hz power frequency filtering	Configurable enable/disable, default enable
Wire break diagnosis enable	Configurable enable/disable, default enable.
Over-range diagnostic enable	Configurable enable/disable, default enable.
Over-limit diagnosis enable	Configurable enable/disable, default enable.
Over-limit threshold	Configurable
Under-limit diagnosis enable	Configurable enable/disable, default enable.
Under-limit threshold	Configurable
Insulation resistance	Under normal condition, ≥10MΩ@DC500V (Temperature 25℃±2℃, relative humidity 30%±5%, non-condensing).
Isolation withstand voltage	1000VAC@1min@5mA
Typical power consumption	1.2W
Physical characteristics	
Module dimensions (W*H*D)	12mm *100mm*68mm
Degree of protection provided by enclosure	IP20 (IEC60529)
Installation mode	DIN35 rail mounting
Grounding method	Module connected to ground via DIN35 rail
Weight (excluding packaging)	≤65g

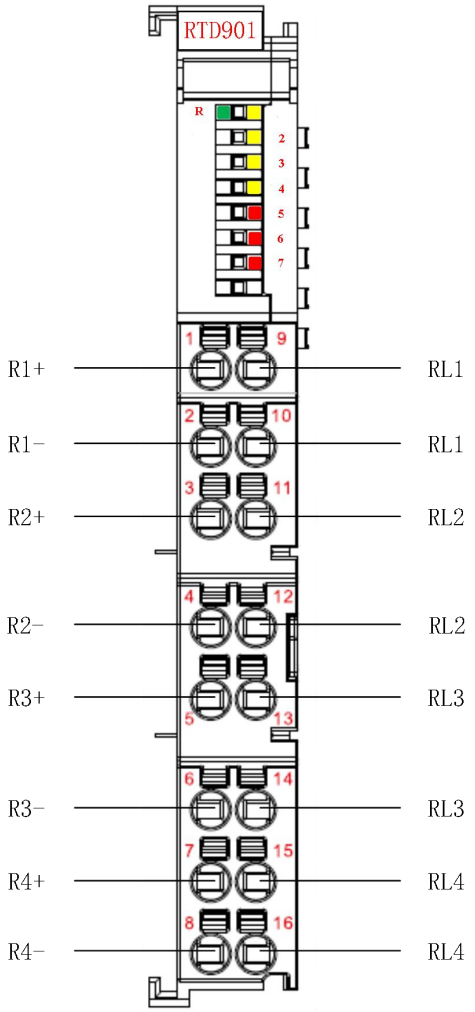
6.7.3 Indicator light status

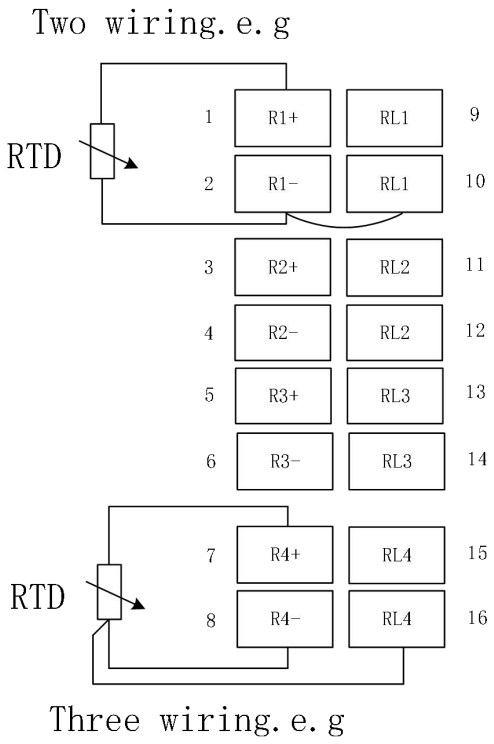
After powering on the LX-RTD901 module, the indicator lights on the panel display the current working and communication status.

Name	Function	Color	Definition

Name	Function	Color	Definition	
RUN	Module status indicator	Green	On	Module status normal
			Flashing	Module offline
			Off	Module not powered
CH1~4	Channel status indicator	Yellow	On	Channel enable
			Off	Channel not enabled
ERR1~4	Channel fault indicator	Red	On	Channel fault
			Off	Channel normal
Note: When reading back the FSoE address, all indicator lights flash for about 5 seconds (at a frequency of 4Hz).				

6.7.4 Terminal wiring





LX-RTD901 terminal wiring diagram

The signal descriptions are as follows:

Terminal identifier	Description of signal	Terminal identifier	Description of signal
1	Channel 1 input signal positive terminal	9	Channel 1 common terminal
2	Channel 1 input signal negative terminal	10	Channel 1 common terminal
3	Channel 2 input signal positive terminal	11	Channel 2 common terminal
4	Channel 2 input signal negative terminal	12	Channel 2 common terminal
5	Channel 3 input signal positive terminal	13	Channel 3 common terminal

Terminal identifier	Description of signal	Terminal identifier	Description of signal
6	Channel 3 input signal negative terminal	14	Channel 3 common terminal
7	Channel 4 input signal positive terminal	15	Channel 4 common terminal
8	Channel 4 input signal negative terminal	16	Channel 4 common terminal

The RTD module supports both 2-wire and 3-wire signal inputs, with the 3-wire method offering higher acquisition accuracy;

A single module cannot fulfill safety functions. Safety loops must be implemented through two channels across two modules, each channel is independently connected to a sensor, meeting SIL2 (IEC61508) and PLd Cat.3 (ISO13849).

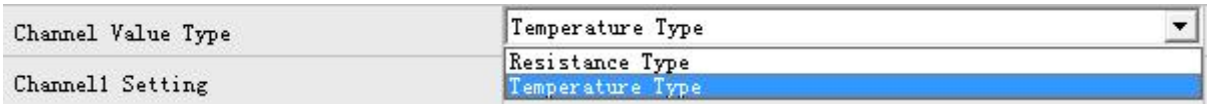
6.7.5 Parameter configuration

In addition to channel value type configuration and sensor type configuration, other parameter configurations of LX-RTD901 module can refer to Chapter 6.4.5 for configuration.

For safety related application, the diagnostic is not allowed to disable any diagnosis.

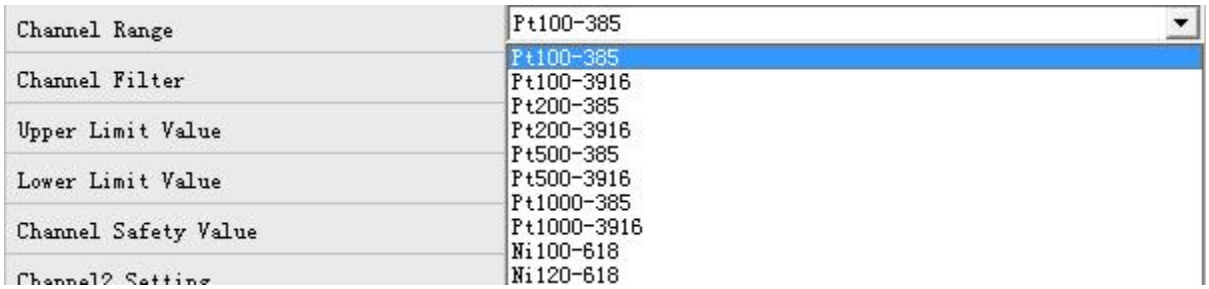
- Channel value type configuration

The channel value types are divided into resistance value and temperature value, which can be selected through the drop-down menu. The resistance value displayed on FA AutoThink-Safety is the resistance value, the temperature value is selected, and the temperature value is displayed on FA AutoThink-Safety.



- Sensor type configuration

The sensor type configuration (Channel Range) can be selected through the dropdown menu, selecting Pt type and Ni type RTD thermistors with different range ranges.



- Parameter configuration note

1) For channels that are not used, it is recommended to configure them as "Disabled" for channel enable. Even if the channel related diagnostic enable is enabled, the "Disabled" channel will not undergo diagnosis;

2) When the diagnostic configuration for the upper and lower limits is set to "Enable", the threshold for the upper and lower limits should be within the corresponding sensor type range based on the channel value type (resistance, temperature), and the threshold for exceeding the upper limit should be greater than the threshold for the lower limit.

The configured diagnostic threshold for the upper/lower limit should be rounded to two decimal places, which is the actual temperature value or resistance value * 100; If the upper limit threshold is 100.254 ℃, the parameter for the upper limit threshold on FA AutoThink-Safety is configured as 10025.

RTD type	Temperature(℃)		Resistance（Ω）	
	Min.	Max.	Min.	Max.
PT100-385	-200	870	18.52	396.31
PT100-3916	-200	630	16.99	327.74
PT200-385	-200	870	37.04	792.62
PT200-3916	-200	630	33.98	655.48
PT500-385	-200	870	92.60	1981.55
PT500-3916	-200	630	84.95	1638.70
PT1000-385	-200	870	185.20	3963.10
PT1000-3916	-200	630	169.90	3277.40
NI100-618	-60	250	69.52	343.58
NI120-618	-60	250	83.42	412.29

6.7.6 Conversion of code value and temperature value

Temperature value=channel sample code value/100

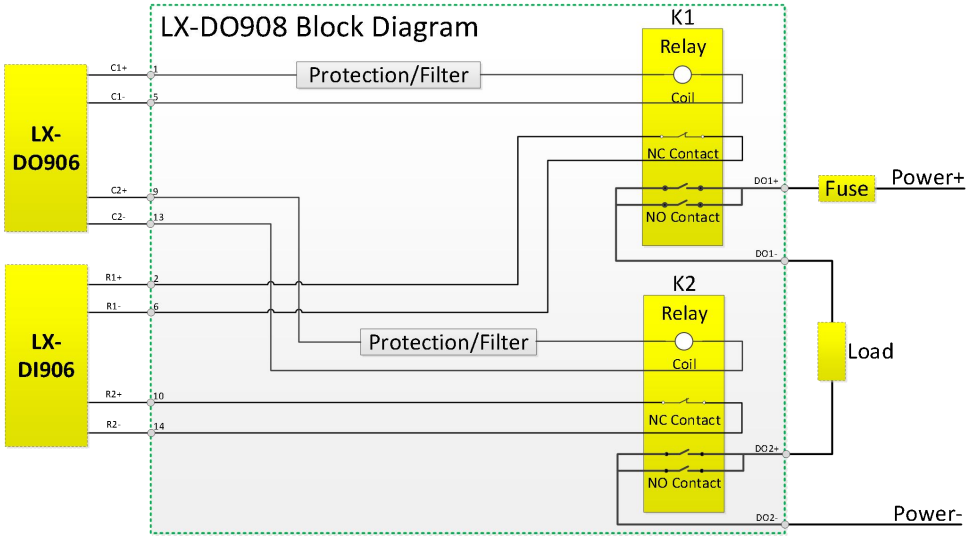
6.8 LX-DO908 2-channel relay-type safety digital output module

6.8.1 Product overview

The LX-DO908 is the relay-type safety digital output module of the LXS system, the module contains two channels, each channel is used alone, no safety level, the two channels can form a safety loop, the safety loop can reach SIL 3(IEC 61508), Cat. 4 PL e (ISO 13849) safety level.

The LX-DO908 module is a passive module and needs to be used with the driver module. To achieve SIL 3(IEC 61508), Cat. 4 PL e (ISO 13849) safety level, the read-back module is also required to monitor feedback signal status. The drive module can be LX-DO906, and the read-back module can be LX-DI906 or LX-DI907.

The schematic diagram of the module is as follows:



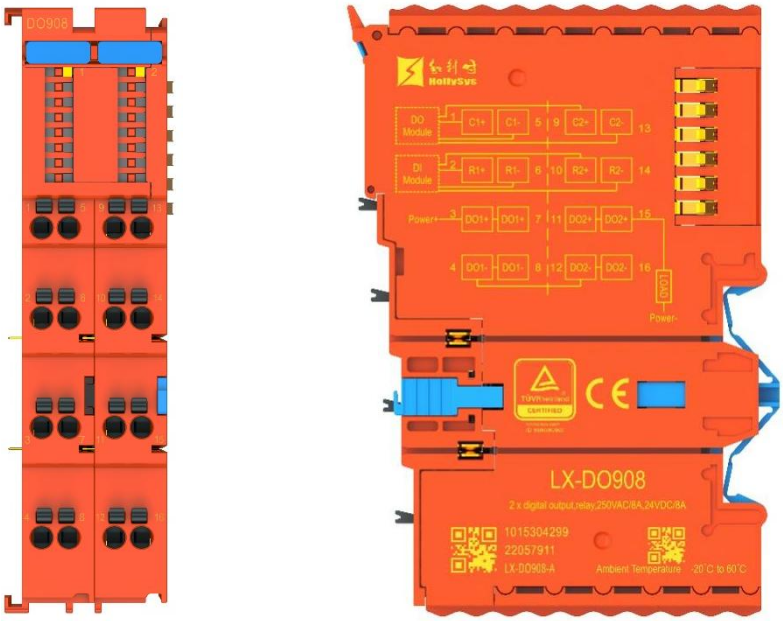
1. Basic features

The LX-DO908 module completes 2 channel relay-type safety digital output signal:

- The module contains two channels, supporting resistive load, inductive load, and single channel supports maximum resistive load AC250V/8A or DC24V/8A, maximum inductive load AC230V/3A or DC24V/4A;
- The dual channels can achieve SIL3 (IEC 61508) and Cat. 4 PL e (ISO 13849) safety level as a safety loop;
- The indicator light can indicate the channel status of the module.

2. Module components

The diagram of the module components is as follows:



- LX-DO908 module is strictly prohibited from being mixed and inserted between other modules. It can be arranged behind the end coupler, or at the end of the system, or separately from the system.
- When using the DO908 module for safety applications, it is highly recommended that 67% de-rating of the maximum current.
- When using the DO908 module for safety applications, an appropriated fuse must be installed between the load and the channels.

6.8.2 Technical indicators

LX-DO908 2-channel relay-type safety digital output module	
Function safety	
Safety Integrity Level	SIL2 (IEC61508) SC3 (IEC61508) SIL2 (IEC62061)
Performance indicator	PLe (ISO13849-1)
Safety category	Cat.4 (ISO13849-1)
System modes	high demand and continuous operation modes
Technical indicators	
Number of channels	2

LX-DO908 2-channel relay-type safety digital output module	
Load type	Resistive load，inductive load
Output terminal parameter(DO1+/-,DO2+/-)	
AC1	250V
Min. current	10mA
Max. current	8A
Max. power	2000VA
DC1	24 V
Min. current	10 mA
Max. current	8A
Max. power	192 W
AC15	230V
Max. current	3A（1s on 9s off）
DC13	24V
Max. current	4A（1s on 9s off）
Control terminal parameter	
Input resistance	1150Ω±10%
Operating voltage	≤16.8V
Operating current	Typ. 20.8mA, @operating voltage 24V, input resistance 1150Ω
Release voltage (control terminal) i.e.The relay output contact must be opened (i.e. de-energized state), when the voltage at input terminal (i.e. relay coil power supply) is less than 2.4 VDC.	≥2.4V
Max. processing time for relay output when signal changes	120 ms

LX-DO908 2-channel relay-type safety digital output module	
from "1" to "0" (Note: The maximum processing time includes the relay contact open jitter time)	
Typ. processing time of relay output when signal changes from "0" to "1" (Note: The typical processing time includes the relay contact close jitter time)	20 ~ 60 ms
Other parameter	
Channel operation mode	In safety applications, the two channels form a safety loop, i.e. the two channels must be used in series. In non safety applications, it can be used in series or parallel
Relay removable	Not supported
Isolation withstand voltage	1500VAC@1min@5mA
Relay mechanical endurance	>4x10^7 cycles
Relay electrical durability	>5x10^4 cycles (1NO: 85 ℃, 1s on 9s off, 8A 250VAC, resistive load)
Physical characteristics	
Module dimensions (W*H*D)	24mm *100mm*68mm
Degree of protection provided by enclosure	IP20 (IEC 60529)
Installation mode	DIN35 rail mounting
Grounding method	Module connected to ground via DIN35 rail
Weight (excluding packaging)	≤300g

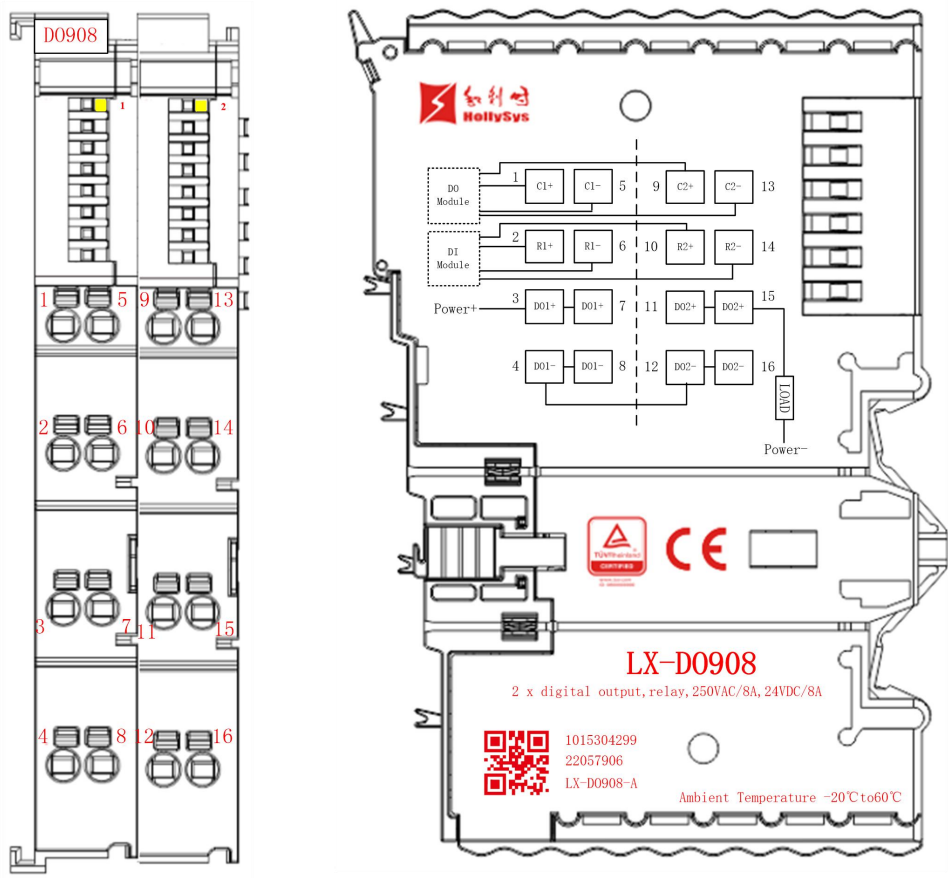
6.8.3 Indicator light status

The LX-DO908 module indicators are described as follows:

Name	Function	Color	Definition	
CH1~2	Channel status indicator	Yellow	On	Channel close
			Off	Channel open

6.8.4 Terminal wiring

C*+/C*- is the relay coil control contact, R*+/R*- is the relay read-back feedback contact, DO*+/DO*- is the relay output contact. When the C*+/C*- control contact is 0V, the R*+/R*- feedback contact is NC，DO*+/DO*- output contact is NO. When the C*+/C*- control contact is 24V, the R*+/R*- feedback contact is open and the DO*+/DO*- output contacts is close.



LX-DO908 terminal wiring diagram

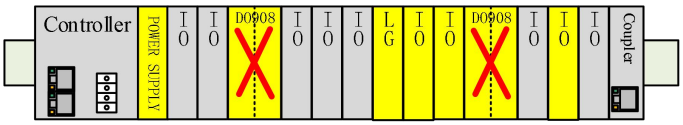
The signal descriptions are as follows:

Terminal identifier	Description of signal	Terminal identifier	Description of signal
1	DO channel 1 control signal positive terminal	5	DO channel 1 control signal negative terminal
2	DO channel 1 feedback signal positive terminal	6	DO channel 1 feedback signal negative terminal
3	DO channel 1 positive terminal	7	DO channel 1 positive terminal
4	DO channel 1 negative terminal	8	DO channel 1 negative terminal
9	DO channel 2 control signal positive terminal	13	DO channel 2 control signal negative terminal
10	DO channel 2 feedback signal	14	DO channel 2 feedback signal

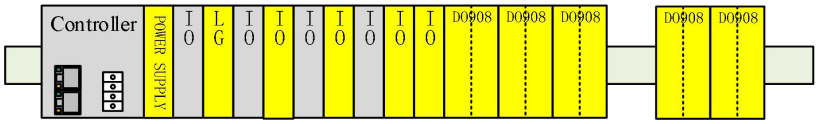
Terminal identifier	Description of signal	Terminal identifier	Description of signal
	positive terminal		negative terminal
11	DO channel 2 positive terminal	15	DO channel 2 positive terminal
12	DO channel 2 negative terminal	16	DO channel 2 negative terminal

6.8.5 Install description

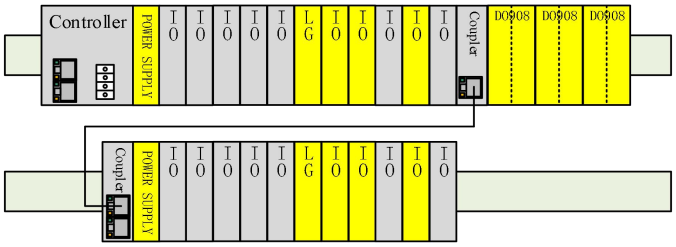
- The LX-DO908 modules is strictly prohibited from being mixed and inserted between other modules;



- The LX-DO908 module can be laid out at the end of the system or placed separately from the system;



- The LX-DO908 module can also be laid out on the back end of the coupler.

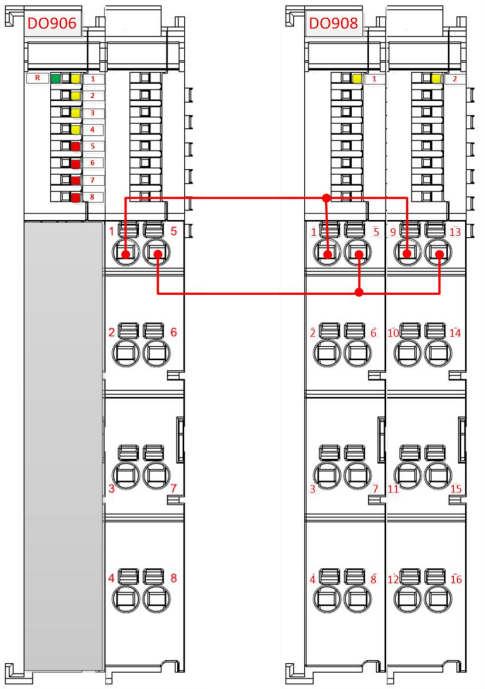


6.8.6 Application description

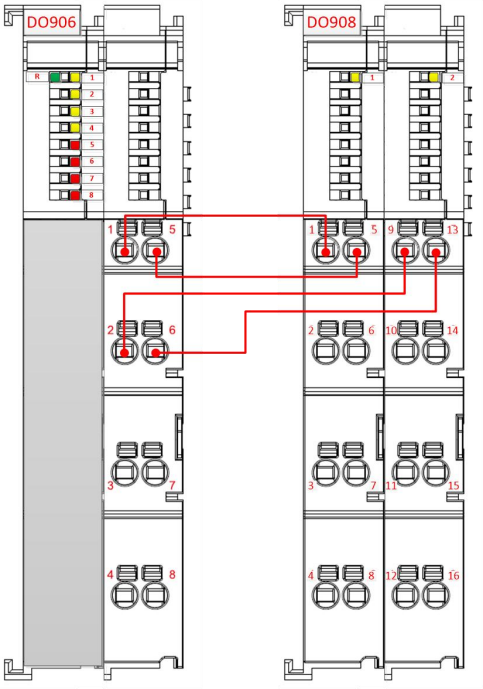
The LX-DO908 module is a passive module and needs to be used with the driver module. To achieve SIL 3(IEC 61508), Cat. 4 PL e (ISO 13849) safety level, the read-back module is also required to monitor feedback signal status. The drive module can be LX-DO906, and the read-back module can be LX-DI906 or LX-DI907.

When the driver module is LX-DO906 module, there are the following two wiring methods:

The control signal of the two channels of the LX-DO908 module can be controlled by the output of the two channels of the LX-DO906 module respectively (wiring mode 2), or by the output of one channel of the LX-DO906 module (wiring mode 1). When wiring mode 1 is used, the two channel outputs of LX-DO908 will operate simultaneously; When wiring mode 2 is used, the two channel outputs of the LX-DO908 can be operated separately.



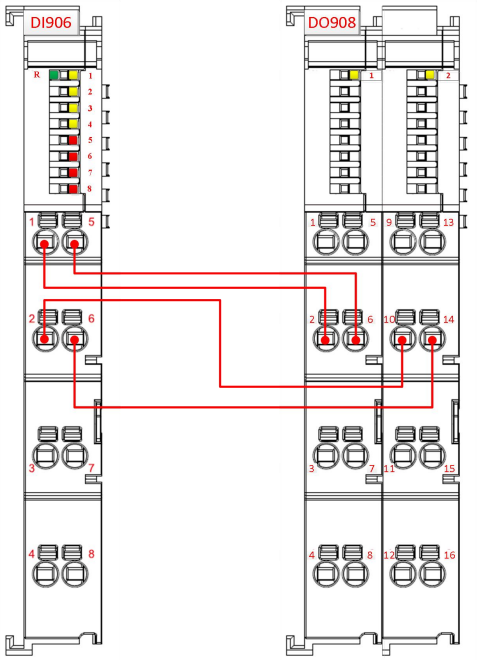
Wiring method 1:
LX-DO906 one channel output controls LX-DO908 two channels



Wiring method 2:
LX-DO906 one channel controls LX-DO908 one channel

When the LX-DI906 module is used as the read-back module, the following connection mode is available:

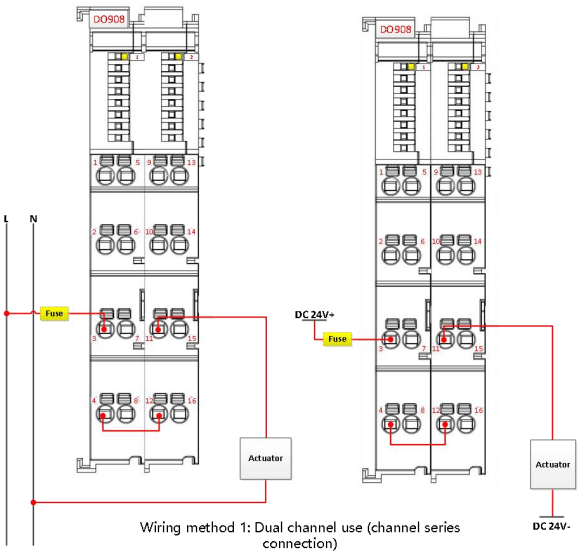
The feedback signals of the two channels of the LX-DO908 module can be connected to the two channels of the LX-DI906 module respectively.



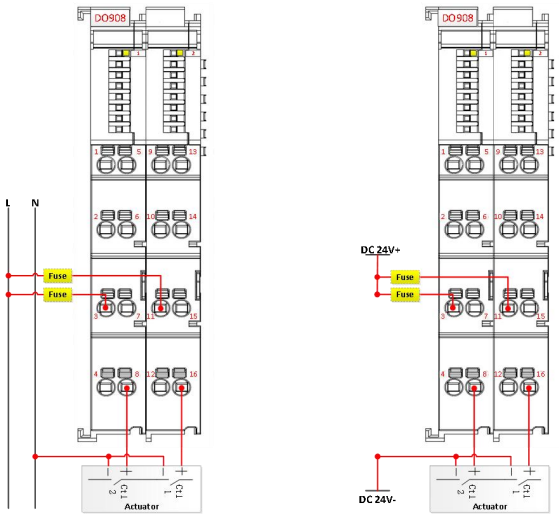
Wiring method:
The feedback signals are independently connected to the DI module

The two output channels of the LX-DO908 module can be used separately, and there is no safety level; Two output channels can also form a safety loop, which can reach the safety level of SIL3 (IEC 61508), Cat.4 PL e (ISO 13849), the wiring methods shown in the figure below can achieve this safety level.

The two output channels DO*- of the DO908 module are connected in series through external wiring, DO+ of one channel is connected to the power supply positive, while the DO+ of the other channel is connected to one end of the load, and the other end of the load is connected to the power supply negative (wiring method 1); the two output channels DO*+ of the DO908 module are connected to the power supply positive, DO*- is connected to one end of the load, and the other end of the load is connected to the power supply negative and the two switches inside the load are connected in series (wiring method 2).



Wiring method 1: Dual channel use (channel series connection)



Wiring method 2: Dual channel use (parallel connection of channels)

6.8.7 LX-DO908 diagnostic description

The diagnosis of the LX-DO908 module is achieved by collecting the status of the feedback terminal contacts through the LX-DI906 or LX-DI907 module, and determining whether the NO contacts of the LX-DO908 module are welded. The SF-EDM function block can be used to compare the output channel values of the LX-DO906 with the channel values collected by the DI module to determine if they are consistent with expectations for diagnosis. If the LX-DO906 channel output value is TRUE and the DI module acquisition channel value is False, or if the LX-DO906 module output channel value is False and the DI module acquisition channel value is TRUE, the SF-EDM function block will not malfunction or alarm, indicating a safe state. At this time, the LX-DO908 module is functioning normally. When the output channel value of LX-DO906 is false and the DI module's acquisition channel value is also false, the SF-EDM function block triggers a fault alarm and enters a fault state. At this time, it is considered that the normally open contact of LX-DO908 module has been welded. After the fault occurs, the output channel of LX-DO906 must be linked with other function blocks using the value of the SF-EDM function block output variable Error to cut off the external safety circuit of LX-DO908 module. Alternatively, another channel output by LX-DO906 can be set to false on the EtherCAT IO mapping tab page of LX-DO906 to ensure that the system is in a safe state in the event of a fault.

DO906 module channel output	DI module channel acquisition	SF_EDM function block error output	DO908 module status
TRUE	FALSE	FALSE	Normal
TRUE	TRUE	TRUE	NO contact is opened, safe state
FALSE	TRUE	FALSE	Normal
FALSE	FALSE	TRUE	Welding of NO contact

- Diagnostics on the LX-DO908 need to be implemented by the user through the application.

Each single NC contact of the relay must be readback by a single channel of LX-DI906 or LX-DI907 to check whether it is as expected or not by the user application program, in order to detect individually the switch off capability of each single NO contact of LX-DO908.

- Each single NO contact of LX-DO908 have to change its status (switch on and then switch off) at least once a month for the SIL 3, PL e / category 4 safety applications.

6.9 IO Module diagnostic alarm and trouble shooting description

6.9.1 Module level faults

By viewing the object dictionary, module faults can be viewed, including MCU faults, inter MCU communication faults, synchronization faults, etc.

Fault type	Object dictionary	Related Modules
MCU fault	0xA003	All IO module
Communication fault between MCU	0xA006	DI、DO module
Parameter configuration fault	0xA007	DI module
Synchronous interrupt fault	0xA003	DI、DO module
ADC fault	0xA004	AI、TC、RTD module

6.9.2 Channel fault

The DO and DI modules can obtain channel module fault information by querying the object dictionary 0xA004;

Bit bit of the certain channel	3	2	1	0
DI	0	0	0	Channel crosstalk fault
DO	Light load/ overload fault	Channel crosstalk fault	Switch fixed open	Switch fixed closed
Note: 0 represents no fault, 1 represents fault				

AI, TC, RTD modules, channel faults can be directly queried on FA AutoThink-Safety without the need to view object dictionaries. Monitor in the safety FA AutoThink-Safety and view relevant

diagnostic information on the EtherCAT IO mapping tab page of the corresponding module. The following figure shows the channel diagnostic information of the LX-AI906 module.

6.9.3 Trouble shooting

1.For the DI module, the external faults below cannot be diagnosed and need to be resolved by the user:

For NC type contact signals, the input terminals+(DI+)and –(DI-) of the DI module are short circuited together;

Trouble shooting: Operate the sensor to change the contact from NC to NO, and observe whether the collected values of the channel are consistent with the contact state on the safety configuration software FA AutoThink-Safety.

2.For the DO module, the external fault below cannot be diagnosed and needs to be resolved by the user:

The negative end of the actuator is not connected to DO -, it is connected to ground and cannot be diagnosed.

Trouble shooting: Enable channel line monitoring, disconnect the wiring of DO -, observe the status of the channel fault indicator light, connect correctly, the fault indicator light is on, connect incorrectly, and the fault indicator light is off.

3.For the AI module, the external faults below cannot be diagnosed and require the user to exclude:

1) LX-AI907 module does not support external wire break diagnosis, and wire break cannot be diagnosed;

Trouble shooting: Sensor output voltage, measure the voltage on the module terminal side, and If the voltage is 0, it indicates a broken wire.

2) There is a short circuit in the external cables of two channels of the same safety loop.

Trouble shooting:Disconnect any sensor,and in the safety loop,if the sampled value of one channel is 0 and another is normal , there is no short circuit; If the sampled values of two channels are consistent (considering channel sampled errors), there may be a short circuit in the external cable.

4.For the RTD module, the external fault below cannot be diagnosed and needs to be resolved by the user:

1) The two wire and three wire systems are connected incorrectly and cannot be diagnosed;

Trouble shooting:Observe whether the module terminals R * - and R * L have wiring, with wiring is two wire method and no wiring is three wire method .

2) There is a short circuit in the external cables of two channels of the same safety loop.

Trouble shooting:Disconnect any sensor,and in the safety loop,if the sampled value of one channel is 0 and another is normal , there is no short circuit; If the sampled values of two channels are consistent (considering channel sampled errors), there may be a short circuit in the external cable.

5.For the TC module, the external faults below cannot be diagnosed and require the user to exclude:

There is a short circuit in the external cables of two channels of the same safety loop.

Trouble shooting:Disconnect any sensor,and in the safety loop,if the sampled value of one channel is 0 and another is normal , there is no short circuit; If the sampled values of two channels are consistent (considering channel sampled errors), there may be a short circuit in the external cable.

6.For the PM module, the external faults below cannot be diagnosed and require the user to exclude:

The system power supply and on-site power supply are reversed. The system power supply is connected to the on-site power terminal, and the on-site power supply is connected to the system power terminal.

Trouble shooting: Disconnect the system power and field power respectively, and observe whether the system and field power indicator lights on the PM module are consistent with the power status.

Chapter 7 LX-PM903 safety power relay module

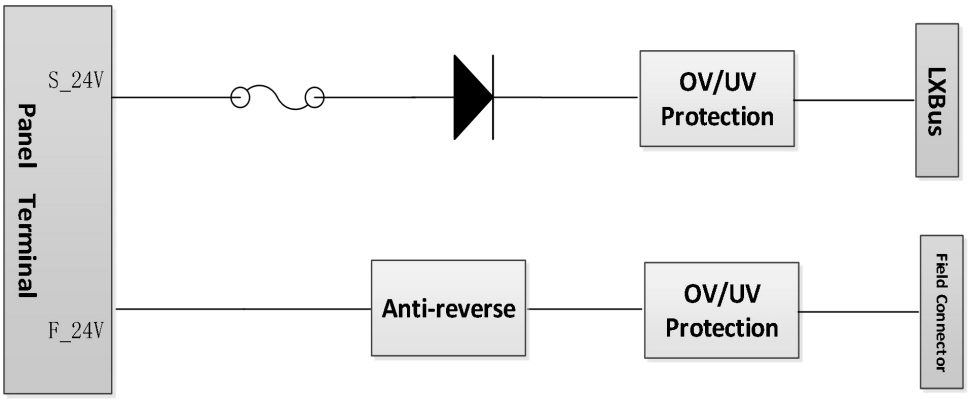
7.1 Product overview

The LX-PM903 is a safety power relay module within the LXS system hardware products. It facilitates system side and field side power conditioning, supporting protection, filtering, soft start, under/over-voltage monitoring, and shutdown functions.

The LX-PM903 safety power relay module connects externally via an LX-bus connector to other modules, which includes a communication bus and module system side output power.

The panel connector of LX-PM903 module accesses to system power and field power, requiring power cables with a system side current capacity greater than 2A and a field side current capacity greater than 10A.

The schematic diagram of the module is as follows:



1. Basic features

The LX-PM903 module is designed for system and field power supply functions:

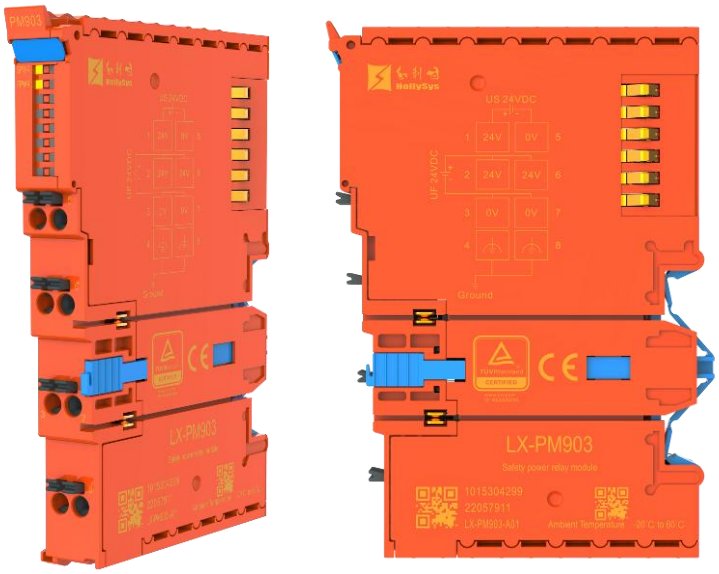
It provides system power to the right-side IO modules, up to a maximum of 16 modules;

It supplies field power to the right-side IO modules, up to a maximum of 10A (it is recommended to derate by 80% for actual usage);

It utilizes indicator lights for basic human-machine interaction.

2. Module components

The diagram of the module components is as follows:



7.2 Technical indicators

LX-PM903 safety power relay module	
Power supply	
System input/output	24VDC (±20%)
Field input/output	24VDC (±20%)
Mode of power supply	Input: The front-end terminal introduces a 24V power input. Output: The system side LX-bus connector outputs power to the IO modules; The panel side field power connector cascades to subsequent modules.
System side typical power consumption	1W
Field side typical power consumption	1.5W
Hot plugging	Not support
Reverse polarity protection	MAX 30V
Function safety	
Safety Integrity Level	SIL3 (IEC61508) SC3 (IEC61508) SIL3 (IEC62061)

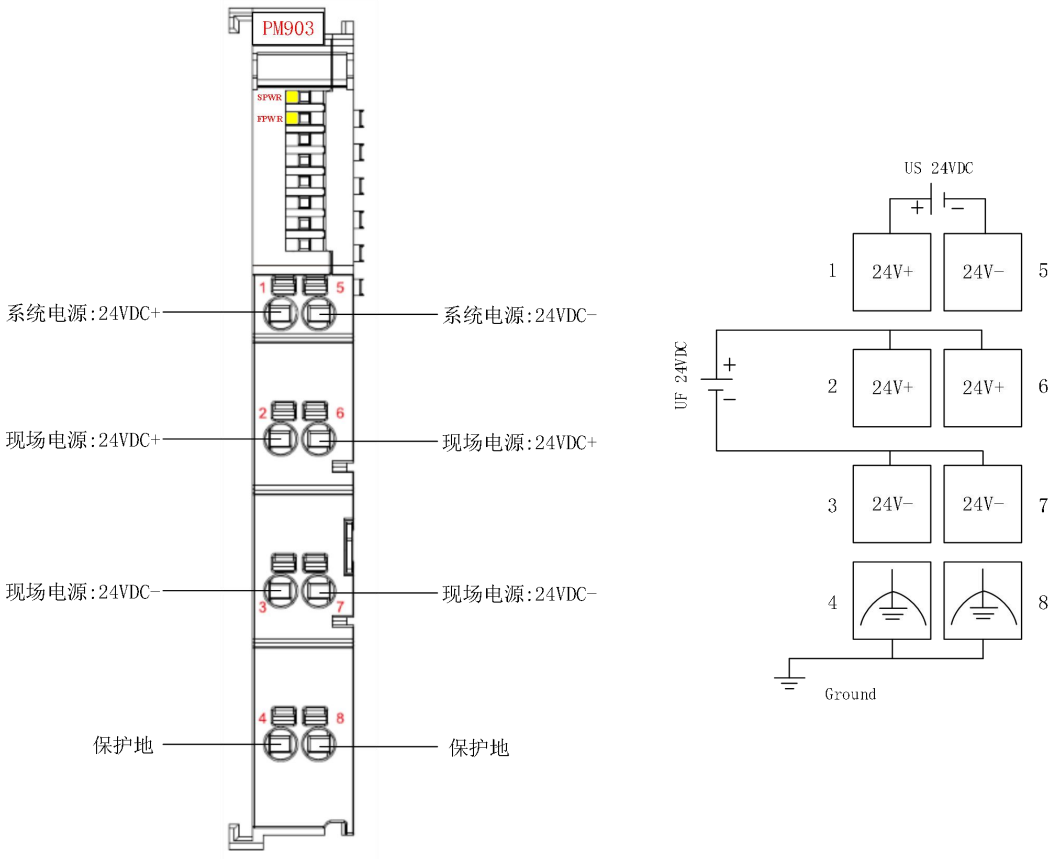
LX-PM903 safety power relay module	
Performance level	PLe (ISO13849-1)
Safety type	Cat.4 (ISO13849-1)
System modes	Low demand, high demand and continuous mode operation modes
Technical indicators	
Isolation withstand voltage	Field to system: 1000VAC @ 1 minute @ 5mA
Insulation resistance	Under normal condition, ≥10MΩ@DC500V (Temperature 25℃±2℃, relative humidity 30%±5%, non-condensing).
Physical characteristics	
Module dimensions (W*H*D)	12mm *100mm*68mm
Degree of protection provided by enclosure	IP20 (IEC60529)
Installation mode	DIN35 rail mounting
Grounding method	Module connected to ground via DIN35 rail
Weight (excluding packaging)	≤40g

7.3 Indicator light status

After the LX-PM903 module is powered on, the indicator lights on the panel display the current working status.

Name	Function	Color	Definition	
SPWR	System power indicator	Yellow	On	Power normal
			Off	Power failure
FPWR	Field power indicator	Yellow	On	Power normal
			Off	Power failure

7.4 Terminal description



LX-PM903 terminal wiring diagram

The signal descriptions are as follows:

Terminal identifier	Description of signal	Terminal identifier	Description of signal
1	System side power 24V+	5	System side power 24V-
2	Field side power 24V+	6	Field side power 24V+
3	Field side power 24V-	7	Field side power 24V-
4	PE, protective ground	8	PE, protective ground

7.5 Others

The protective ground must be reliably grounded. It is recommended to use multicore copper wire with a sectional area of not less than 2.5mm² and the grounding impedance less than 4Ω;

The system side can support up to 16 modules. If more than 16 modules are used, an LX-PM903 module should be added;

The maximum current on the field side is 10A, and 80% derating is recommended in use;

Due to the long EtherCAT link of the 24mm module, the LX-PM903 cannot be placed adjacent to the right side of the LX-DO906 module;

The AC-DC/24V external power supply must meet the requirements of SELV/PELV;

The input 24V maximum withstand voltage of the power relay module is 60V , the overvoltage threshold is 30V, and the undervoltage threshold is 15V. After overvoltage or undervoltage, the module no longer outputs 24V power.

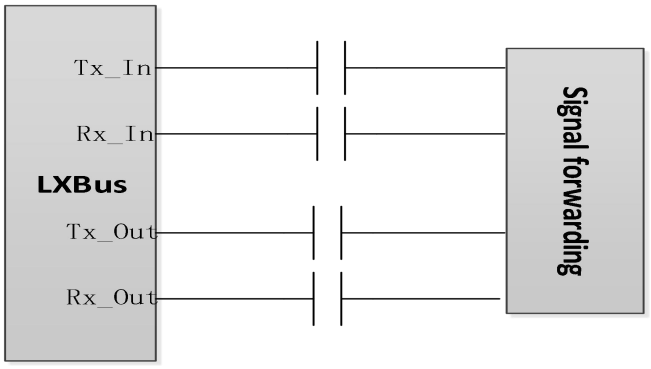
Chapter 8 LX-AUX901 safety isolation protection module

8.1 Product overview

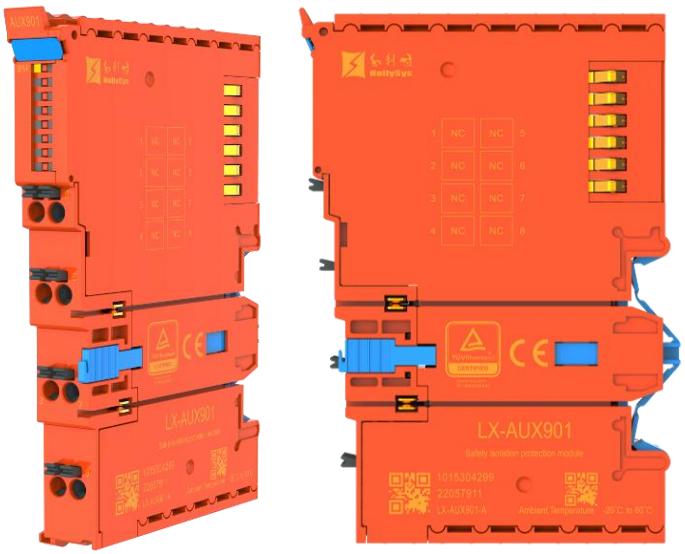
LX-AUX901 is a safety isolation protection module within the LXS system hardware products. The safety isolation protection module is used to isolate safety modules from standard modules, preventing the spread of power overvoltage faults within standard modules to safety modules through the LX-bus.

The LX-AUX901 connects to the system via the LX-bus with no external interfaces. The LX-bus connector includes the communication bus and module system side input power.

The schematic diagram of the module is as follows:



The diagram of the module components is as follows:



8.2 Technical indicators

LX-AUX901 safety isolation protection module	
Function safety	
Safety Integrity Level	SIL3 (IEC61508) SC3 (IEC61508) SIL3 (IEC62061)
System modes	Low demand, high demand and continuous mode operation modes
Technical indicators	
Safety isolation protection	Supports isolation of overvoltage faults on the LX-bus, capable of isolating overvoltage faults up to 50V.
Insulation resistance	Under normal condition, ≥10MΩ@DC500V (Temperature 25℃±2℃, relative humidity 30%±5%, non-condensing).
Isolation withstand voltage	1000VAC@1min@5mA
Typical power consumption	0.5W
Physical characteristics	
Module dimensions (W*H*D)	12mm *100mm*68mm
Degree of protection provided by enclosure	IP20 (IEC60529)

LX-AUX901 safety isolation protection module	
Installation mode	DIN35 rail mounting
Grounding method	Module connected to ground via DIN35 rail
Weight (excluding packaging)	≤60g

8.3 Indicator light status

After the LX-AUX901 module is powered on, the indicator lights on the panel display the current working status.

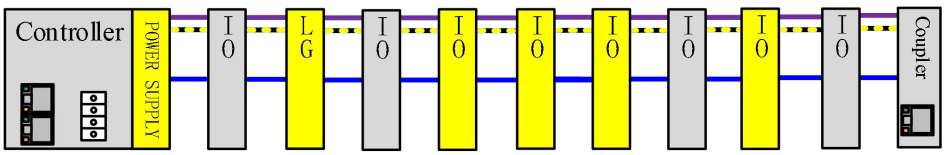
Name	Function	Color	Definition	
SPWR	System power indicator	Yellow	On	System power normal
			Off	System power failure

8.4 Terminal description

The LX-AUX901 does not involve external wiring; no wire connection is performed at the terminals.

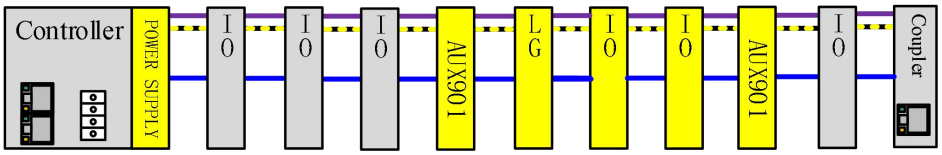
8.5 Others

The LX-AUX901 is an optional module and used to protect the safety modules. Safety modules between LX-AUX901 modules can avoid damage from overvoltage faults of standard modules. Configuring this module will not affect the system's safety integrity level. When not using LX-AUX901, the standard modules and the safety modules can be installed in combination, which will not affect the system's safety integrity level.

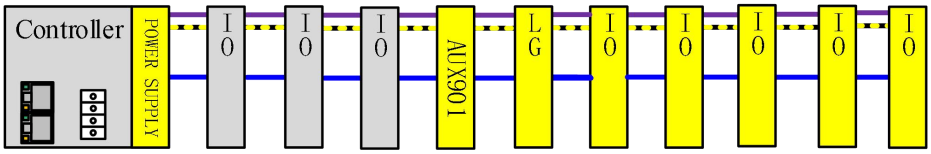


To avoid damage from overvoltage faults of standard modules, LX-AUX901 can be added.

1. When there are standard modules on both sides of a safety module, an LX-AUX901 module must be added to both sides of the safety module.



2. When the right side of the LX-AUX901 module is provided with all safety modules, only one LX-AUX901 module can be used, and no further LX-AUX901 modules can be placed at the end.



Chapter 9 Installation guide

9.1 Installation principles

- It is not recommended to place multiple safety DO modules together. It is advised against placing an LX-PM903 or potential distribution module adjacent to the right side of a safety DO module.
- For standard modules adjacent to safety IO modules, it is preferable to choose modules with low power consumption and good heat dissipation.
- There must be a module on the right side of the LX-AUX901 module, and it cannot be a power relay, potential distribution, or other modules without an EtherCAT slave station.
- Pay attention to the power module's load power consumption; the maximum load should not exceed 16 IO modules.
- LX-DO908 module is strictly prohibited from being mixed and inserted between other modules. It can be arranged behind the coupler, at the end of the system, or placed separately from the system.

9.2 Installation environment

When using the LXS series PLC, consider operability, maintainability, and environmental resistance. Please strictly follow the requirements below during installation:

The operating temperature for the LXS series PLC is -10℃ ~60℃. It is preferred to place it horizontally. If placed vertically, derating is necessary.

For the impact of installation methods on the system operating temperature, refer to Precautions for operating temperature in 3.4 System operating environment.

When positioning, ensure that vents are not obstructed by any objects;

The dust-proof and waterproof level of the cabinet where the LXS system is IP54 or above;

The length of the user cable connected to the IO module must meet the specifications of the IO module user cable length, and the cable must be reliably fixed;

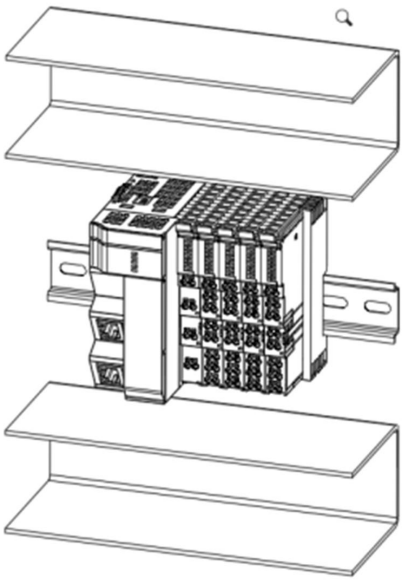
The wiring length from the AC-DC power module to the controller/coupler safety power board or safety power relay can not exceed 10m;

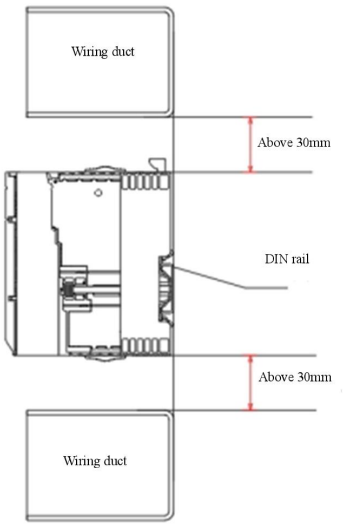
The power cables and user cables should be wired separately and cannot cross each other; It is recommended to choose cables with shielding layers for user cables and power cables;

For modules adjacent to safety modules, prioritize standard ones with lower power consumption. It is not recommended to cluster multiple safety DO modules; instead, it is advised to intersperse them with a standard AUX cooling module every 2 to 3 safety modules;

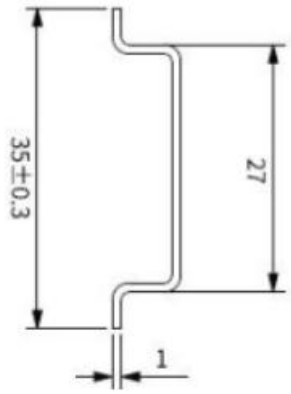
For the adjacent modules to the right side of safety DO modules, it is not recommended to place LX-PM903, standard potential distribution modules, or standard AUX cooling modules;

Considering ventilation and unit replacement, maintain a distance of more than 30mm between the CPU device and surrounding structures such as wire ducts, other equipment, structural components, and other parts, as shown in the diagram below:

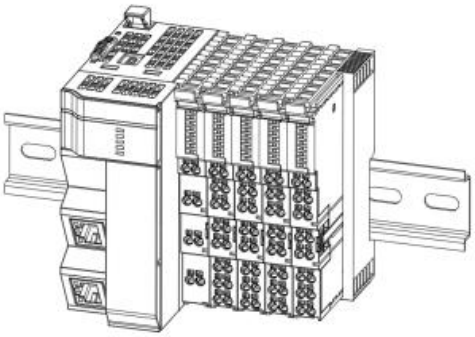




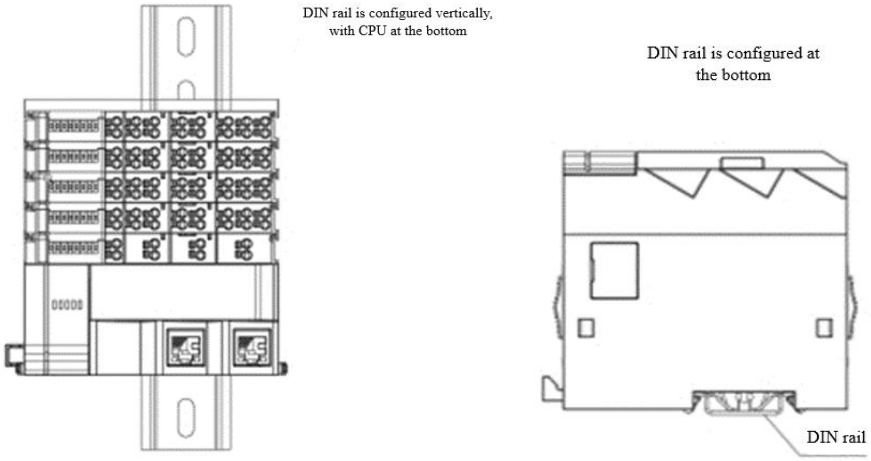
LX series PLCs utilize DIN rail for mounting, which should comply with the EN60715 standard (35mm wide, 1mm thick), as depicted in the diagram below with dimensions in mm;



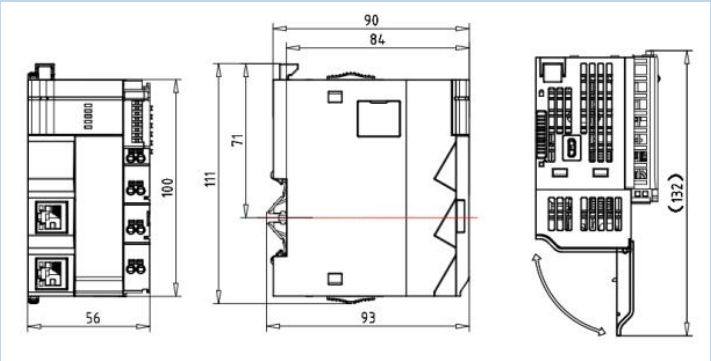
For necessary heat dissipation, install the instrument in the direction shown in the diagram below;

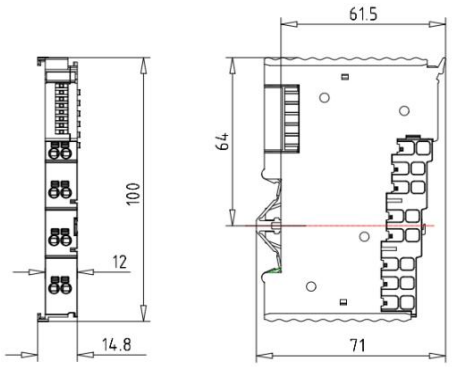
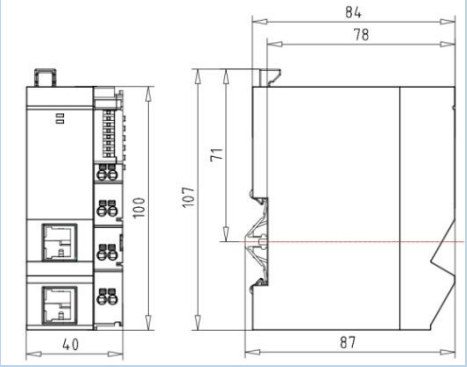
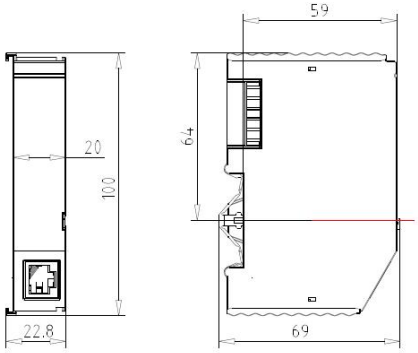


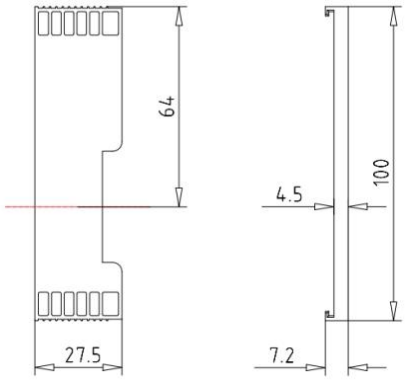
If special requirements necessitate the installation direction shown in the diagram below, a fan or air conditioning must be installed.



9.3 Installation dimensions

Model	Dimensions (mm)	Schematic diagram (in mm)
Controller	W*H*D: 56*100*93	

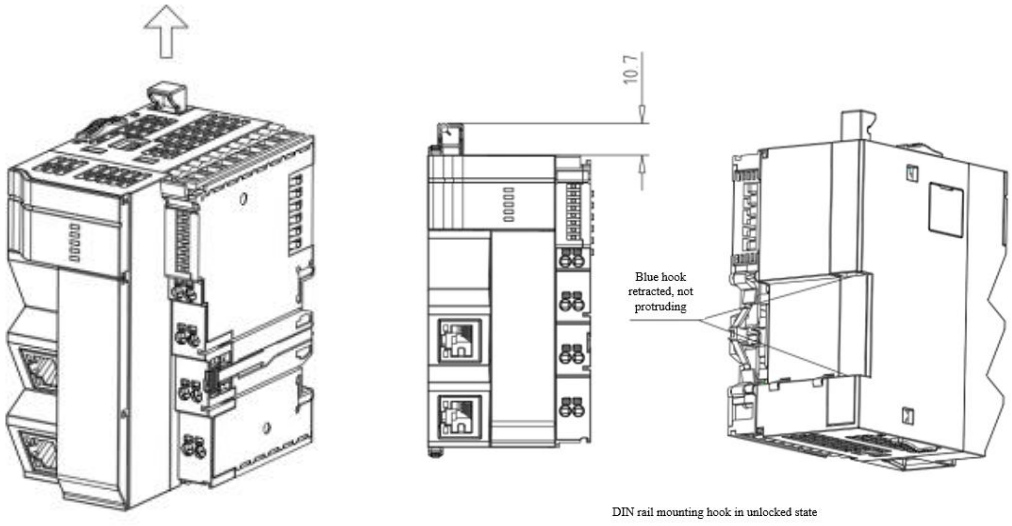
Model	Dimensions (mm)	Schematic diagram (in mm)
LX-PM903 LX-AUX001 LX-AUX002	W*H*D: 14.8*100*71	 Note: The LX-PM903 is used here as an example for illustration.
Starting coupler LX-IM001	W*H*D: 40*100*87	
End coupler LX-IM002	W*H*D: 22.8*100*69	
Safety logic and safety IO modules	Refer to 4.2 Module dimensions description.	

Model	Dimensions (mm)	Schematic diagram (in mm)
End cover plate	W*H*D: 27.5*100*7.2	

9.4 Assembly and disassembly

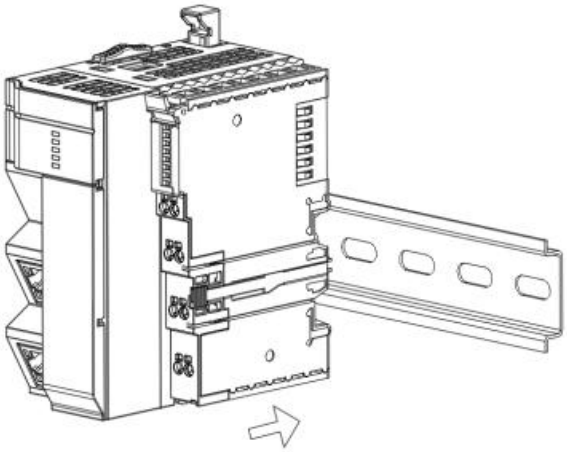
9.4.1 Installation of CPU module

Installation steps:
Step 1: Pull the top of the DIN rail mounting hook forcefully until you hear a click sound, the left side DIN rail mounting hook will be in an unlocked state.



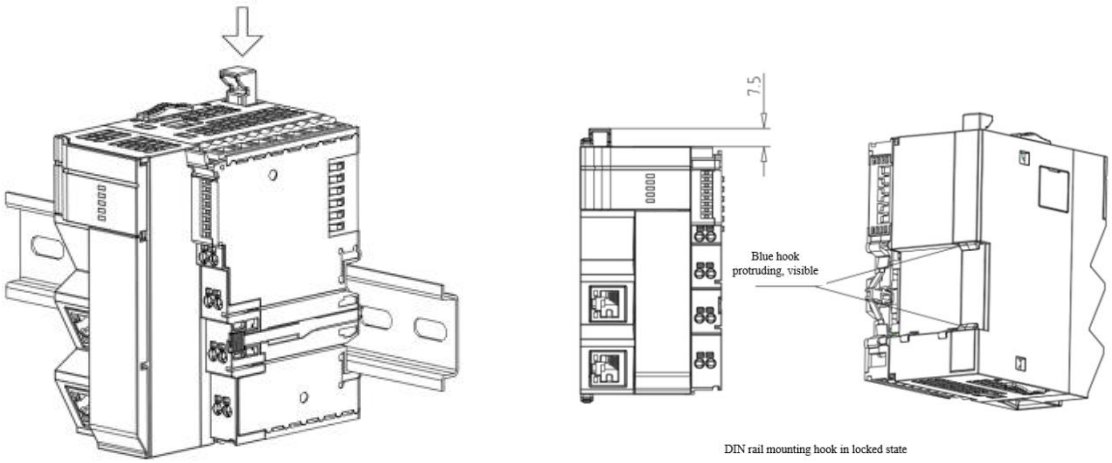
Setting to unlocked state

Step 2: Push the CPU module straight onto the DIN rail until you hear a click sound, the right side DIN rail mounting hook will be automatically locked.



Locking right side mounting hook

Step 3: Press down forcefully on the top of the DIN rail mounting hook until you hear a click sound, the left side DIN rail mounting hook is set to a locked state.

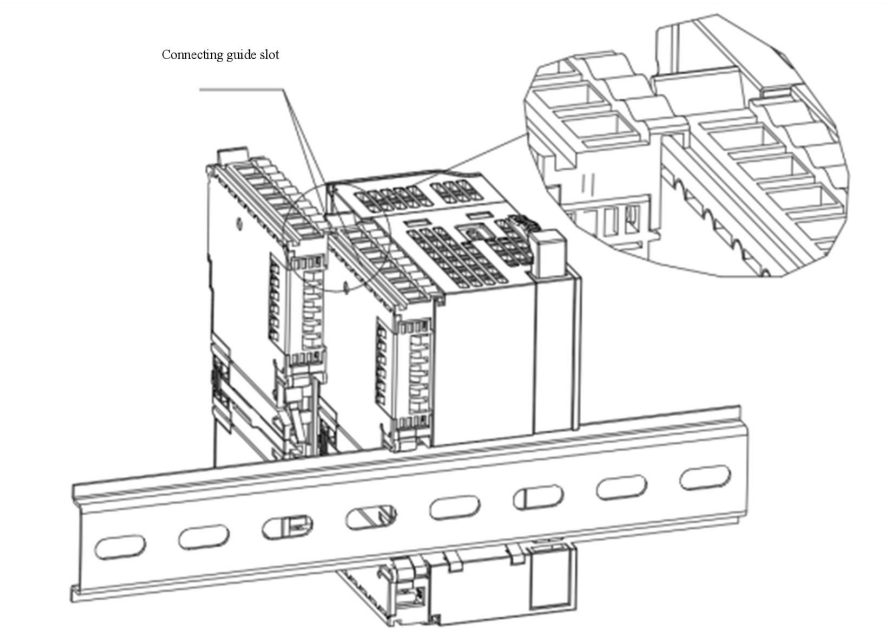


Locking left side mounting hook

9.4.2 Installation between modules

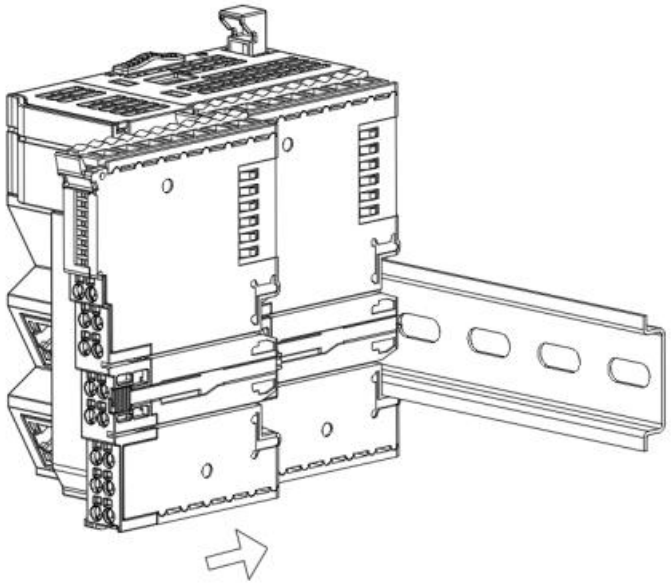
Here, the installation of an IO module onto a CPU module is used as an example.

Installation steps:
Step 1: Interlock the mounting module with the connecting guide slot of the module on the left from the front.



Interlock of connecting guide slots

Step 2: Slide the mounting module along the guide slot from front to back, push the module straight onto the DIN rail until you hear a click sound, the right side DIN rail mounting hook will be automatically locked.

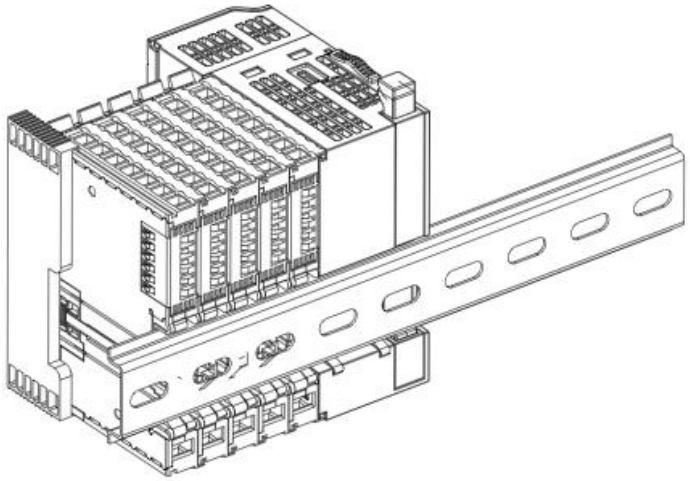


Mounting module onto rail

9.4.3 Installation of the end cover

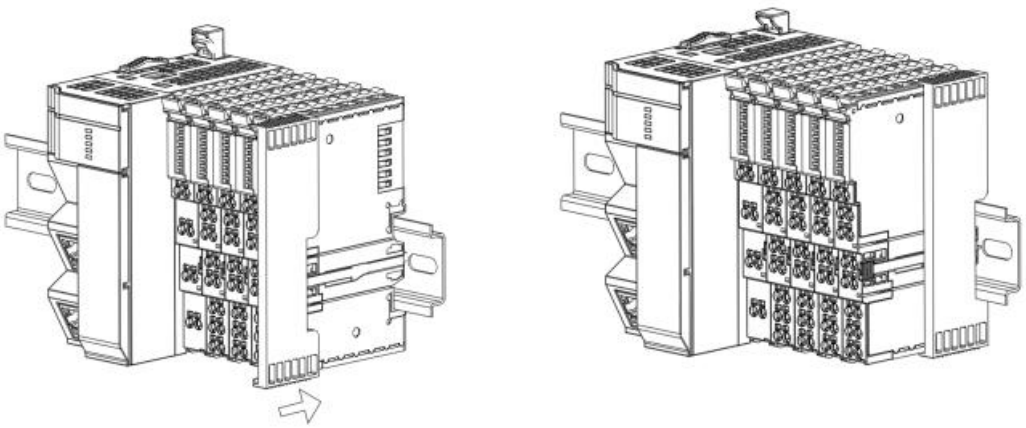
If the last module installed is not an end coupler, it is essential to install an end cover (LX-EBK) on the end of the last module.

Installation steps:
Step 1: Interlock the end cover with the connecting guide slot of the module on the left from the front.



Interlock of connecting guide slots

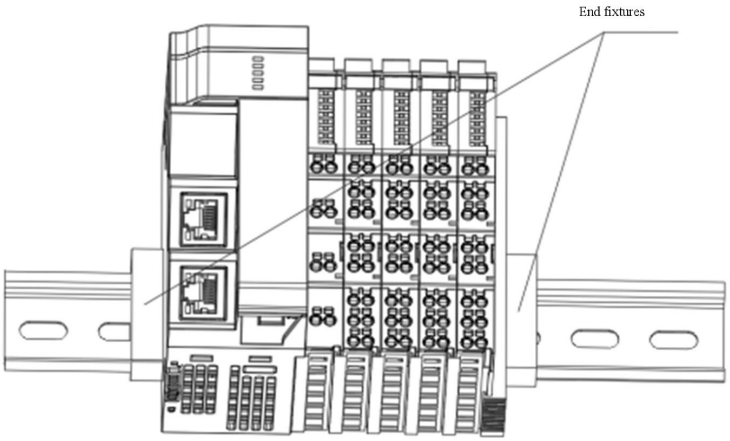
Step 2: Slide the end cover along the guide slot from front to back, push the end cover straight onto the DIN rail until the cover touches the rail.



Mounting end cover onto rail

9.4.4 Installation of end fixtures

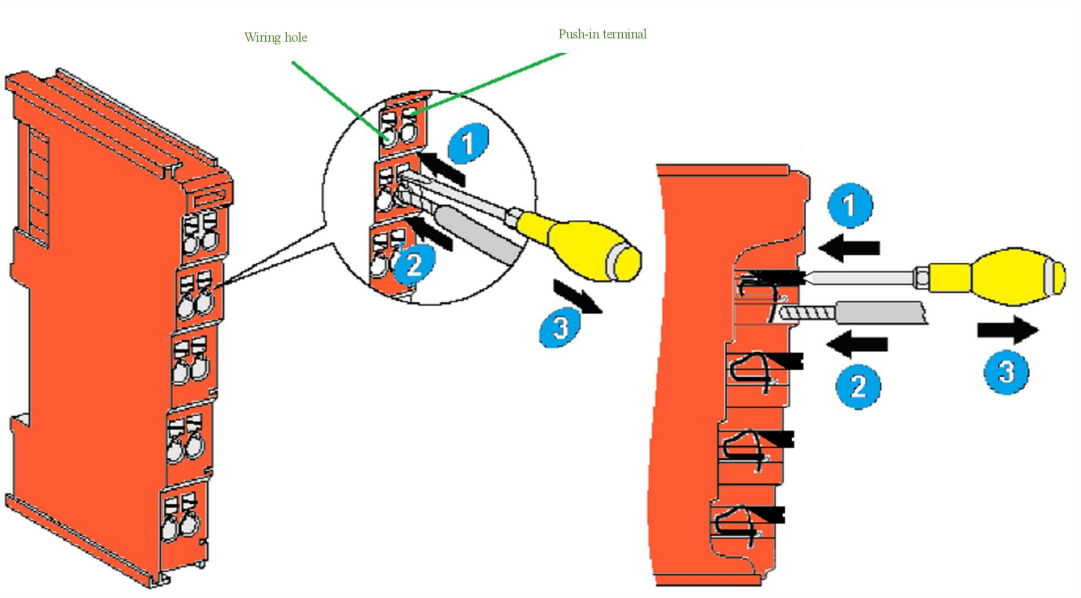
After all modules are mounted on the rail, rail positioning clips need to be installed on both sides to prevent sliding.



Installation diagram

9.5 Cable connection

The diagram below shows how to connect a cable to a terminal on the module panel.



The terminals on the panel utilize spring force technology, allowing cables to be easily connected to the wiring holes by push-in terminals. Connect cables as follows:

Step 1: By directly pressing the screwdriver against the push-in terminal, apply force to press down the push-in terminal (do not rotate the screwdriver or move it back and forth, and do not toggle it).

Step 2: While the push-in terminal is pressed down, insert the wire into the circular terminal opening;

Step 3: When the pressure on the push-in terminal is released, the terminal will automatically close, thereby securing the wire safely and permanently.

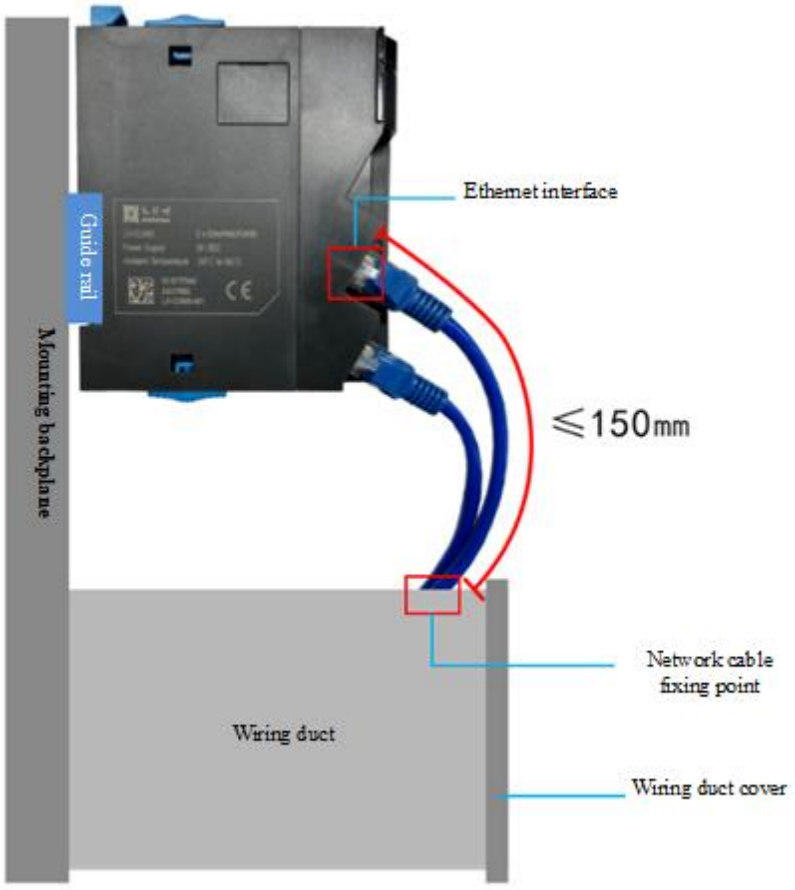
Cable diameter AWG16-22.

9.6 Precautions

9.6.1 Precautions for routing network cables

The length of the Ethernet cable between the controller module, coupler module, and other Ethernet interfaces and the fixed point should not exceed 150mm, as excess length may lead to unstable Ethernet communication in strong vibration environments.

The routing diagram is shown below:



Side view

9.6.2 Module installation precautions

When installing modules, apply pressure from the front until you hear a click sound, then ensure there are no visible gaps between the modules after mounting on the rail, and the front faces of the modules are basically flush, without obvious steps.

9.6.3 Rail selection precautions

The locking mechanism of terminal modules and couplers extends to the contour of the mounting rail. During installation, the locking mechanism of the components must not conflict with the fixed bolts of the mounting rail.

A 15mm high rail is recommended. If a 7.5mm high rail is selected, use flat mounting connections (such as countersunk screws or blind rivets).

Chapter 10 Module selection principles

10.1 Power relay/potential distribution module configuration principles

The following principles should be noted when using the LX series safety power relay module LX-PM903 and potential distribution modules LX-AUX001/LX-AUX002:

LX series ~~12mm~~ modules (LX-AI001, LX-AI002, LX-AI003, LX-AO003, LX-AO002, LX-DI001, LX-DI002, LX-DI005, LX-DO002, LX-DO003, LX-DO005, LX-CM001, and LX-CM003), LX~~S~~ series safety ~~12mm~~ modules (LX-LG901, LX-DI906, LX-DI907, LX-DO906, LX-AI906, LX-AI907, LX-TC901, and LX-RTD901, LX-AUX901) should avoid having three or more power relay/potential distribution modules adjacent to each other;

When potential distribution modules are used next to IM002, CM002, CM004, CM005, CM006, ECI001, PO001, SSI001, and PM903 modules, only one is allowed;

Potential distribution modules and power relay modules should not be used adjacent to CU500 and IM001 (as CU500 and IM001 modules come with their own power relay modules). If it's necessary to use potential distribution modules or power relay modules, they should be used with spacing between other modules.

10.2 System module quantity configuration principles

After the safety power relay module LX-PM903, it is recommended to assemble no more than 16 LX or LXS series IO modules. If the number of modules exceeds 16, an additional LX-PM903 module should be added.

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