PLC

Machinery Safety Basic

This course is intended for users to understand functional safety, which is technology that ensures safety with electronic devices, such as microcontrollers, used for safety devices.

L(NA)00266ENG

Introduction Purpose of the Course

This course is intended for first time users to understand functional safety, which is technology that ensures safety with electronic devices, such as microcontrollers, used for safety devices.
This course provides the knowledge, system introduction, future trends, and other information on the functional safety.

- Machinery Safety

Course Structure

The contents of this course are as follows.
We recommend that you start from Chapter 1.

Introduction

How to Use This e-Learning Tool

Go to the next page	>	Go to the next page.
Back to the previous page	<	Back to the previous page.
Move to the desired page	TOC	"Table of Contents" will be displayed, enabling you to navigate to the desired page.
Exit the learning	X	Exit the learning.

Cautions for Use

Safety precautions

When you learn based on using actual products, please carefully read the safety precautions in the corresponding manuals.

Chapter 1 Functional Safety

First of all, let's learn about the spread of functional safety.

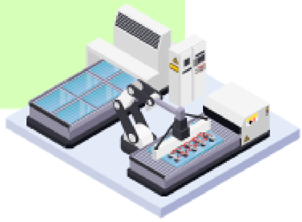
1.1 Functional Safety

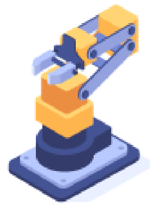
Functional safety is technology that ensures safety with electronic devices, such as microcontrollers, used for safety devices.
With the spread of computers in the control field, machines and equipment have become more sophisticated. The situation has become uncontrollable with only mechanical hardware circuits, and the problem of how to prove safety of embedded software has arisen.
Therefore, in 2000, the functional safety standard IEC 61508 was established to prove safety of electronic devices used for safety devices.
This standard has made it possible to use programmable controllers in the safety field, enabling complex control tailored to the system and facilitating both productivity and safety.
In this course, both "machinery safety" and "functional safety" have the same meaning.

Functional Safety Standard IEC 61508 (came into effect in 2000)

Technology to prove safety of electronic devices (including software) used for safety devices

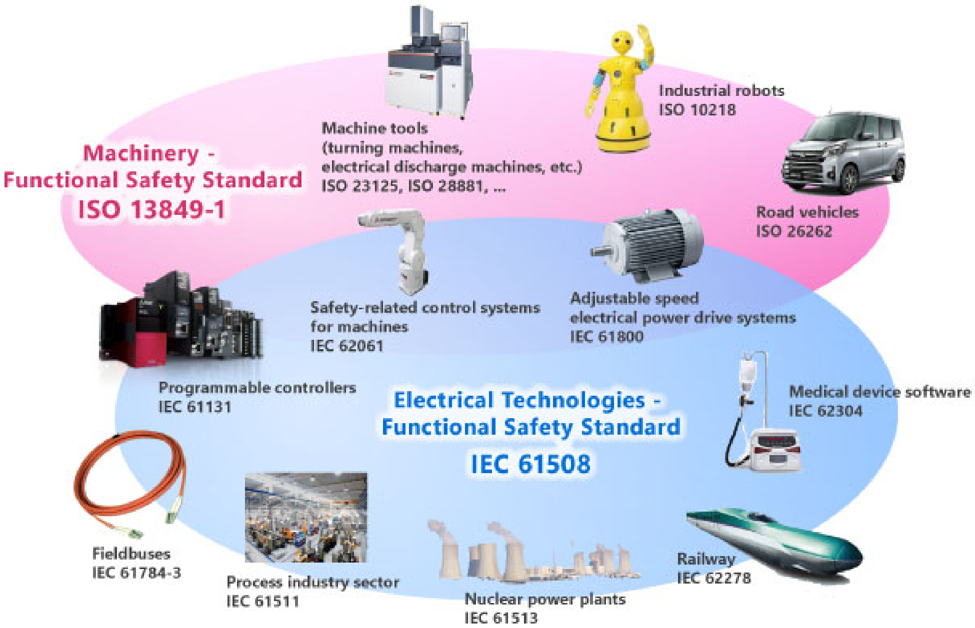
IEC61508	
-1	**General requirements**
-2	**Requirements for electrical/electronic/ programmable electronic safety-related systems**
-3	**Software requirements**
-4	**Definitions and abbreviations**
-5	**Examples of methods for the determination of safety integrity levels (SIL1 to 4)**
-6	**Guidelines on the application of IEC 61508-2 and IEC 61508-3**
-7	**Overview of techniques and measures**





1.2 Spread of Functional Safety (IEC 61508)

IEC 61508 is a standard for safety systems that use embedded software. IEC 61508 is the basis for standards in various fields and many functional safety standards have been established.
These standards are interrelated with IEC 61508.



1.3 Examples of Technology Used for Ensuring Safety

The following are examples of technology used for ensuring safety.
Functional safety is ensured through the technology.

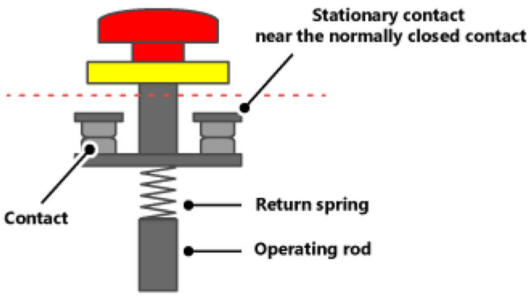
1) Interlock
An interlocking device refers to a mechanical or electrical device that was designed to prevent machines from operating unless certain conditions are met.

2) Off confirmation (falling edge signal processing)
The start switch signal is programmed so that the machine is started at the fall (on → off) of the signal.
This can prevent the machine from accidentally starting at the switch failure (such as contact welding and spring damage).

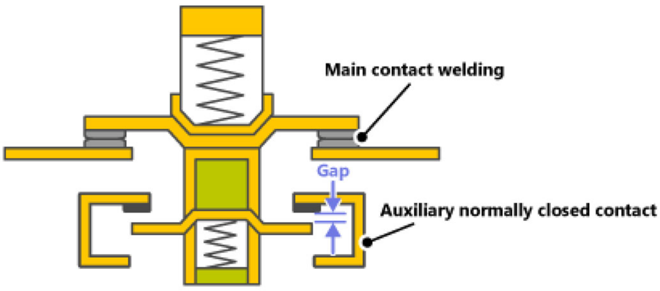
3) Dual input discrepancy detection
A contact is dual wired. If a mismatch between two operations occurs, contact welding or insufficient contact is assumed, and the machine is stopped to prevent dangerous situations.

4) Input/output dark test
Outputs test pulses to turn off the external input/output signals (X0 to X7, Y0 to Y7) that are on and diagnoses contacts including external devices for failure. Failures including circuit fixing and short-circuit faults can be detected.

5) Direct opening action, forcibly opened contacts
The welded contacts are mechanically forced apart by pressure from the actuator.



6) Direct opening mechanism
The normally open contact and the normally closed contact are not turned on simultaneously.



1.4 Summary

The contents of this chapter are:

- Functional Safety
- Spread of Functional Safety (IEC 61508)
- Examples of Technology Used for Ensuring Safety

Chapter 2 Safety Programmable Controller Functions

In this chapter, let's learn about the functions of the safety programmable controller.

2.1 What is "dual input discrepancy detection"?

Safety programmable controllers have the dual input discrepancy detection function that uses dual wiring for input signals. This function checks the dual input signals for discrepancies. If one of the dual input signals turns off due to a wiring failure such as disconnection, a dual discrepancy is detected, and the wiring failure can be detected immediately.

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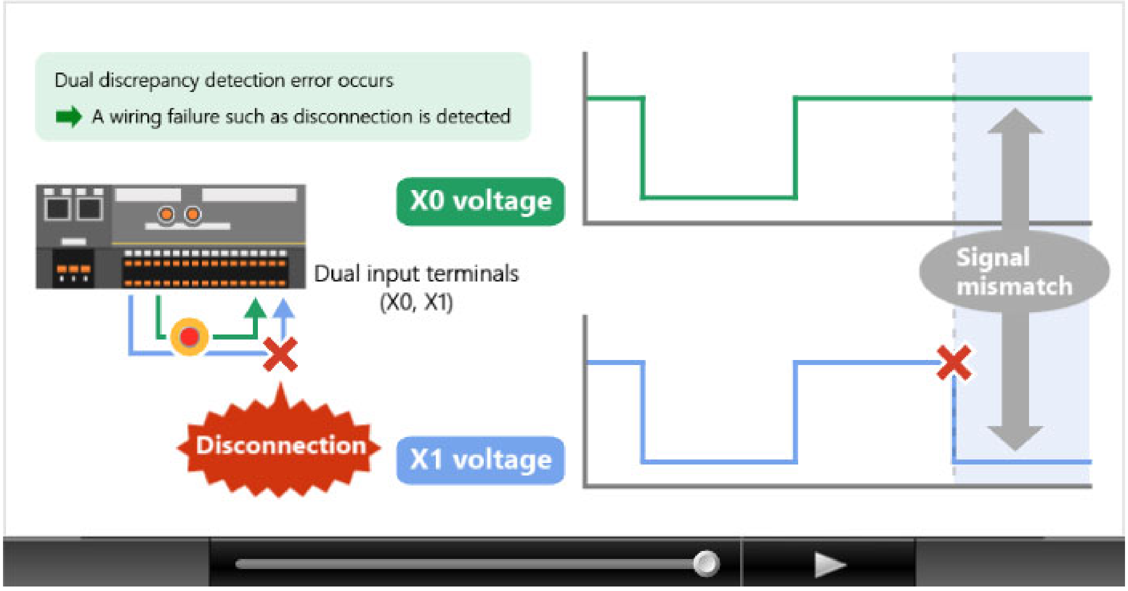

2.2 What is "input dark test"?

Safety programmable controllers have the input dark test function that outputs test pulses to the dual wiring used for input signals.
This function outputs test pulses (short off pulses) to the connected device and diagnoses whether an error such as a short circuit has occurred in the wiring by accurately receiving the returned test pulses.
The test pulses are output to each of the dual wiring at different timings.
Therefore, if a 24 V power supply short circuit occurs or the input signals come in contact with each other, the test pulses disappear and are not returned accurately. Thus, the wiring failure can be detected.

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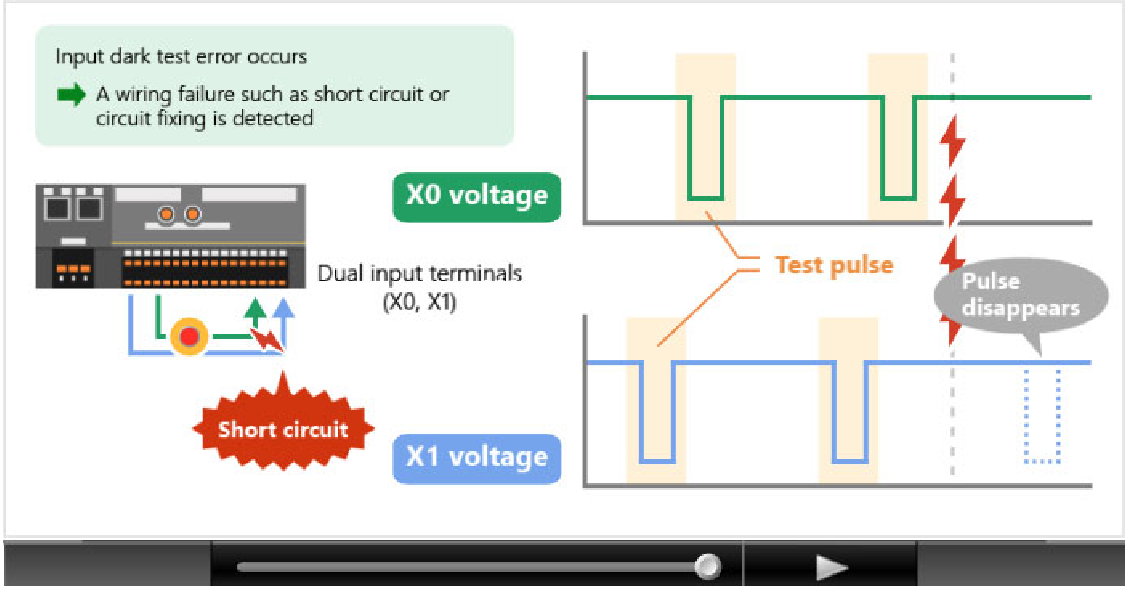


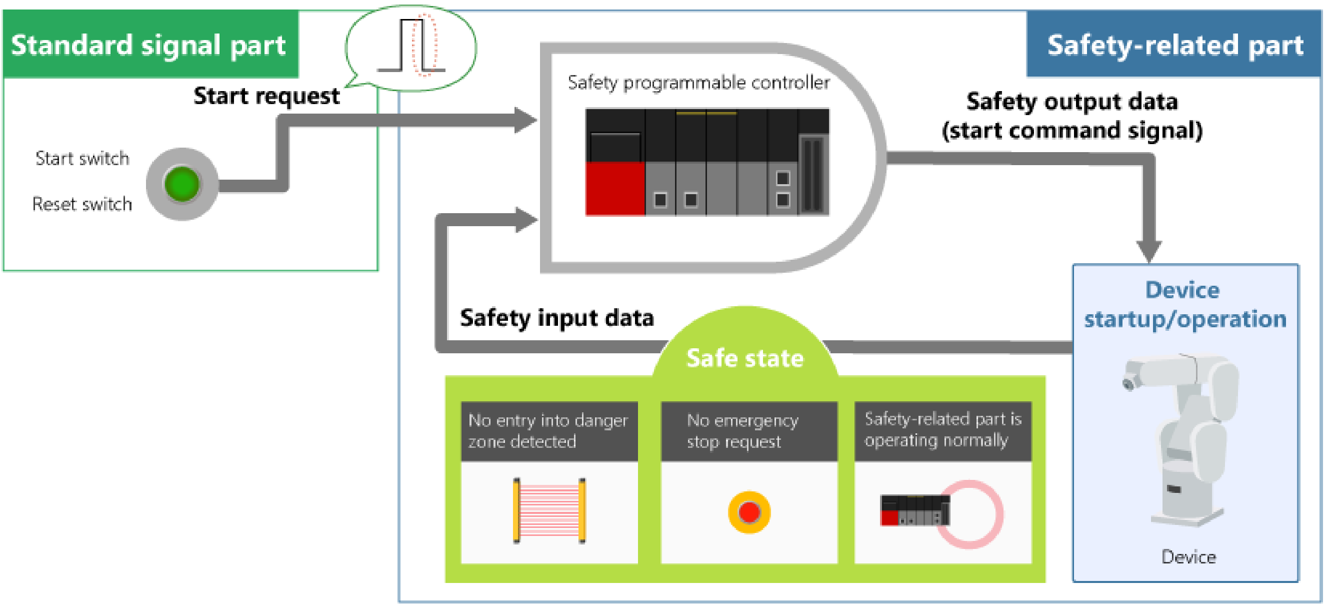
2.3 Precautions on Programming for the Safety System

The following are the precautions on programming for the safety system.

1) Program the safety system so that a machine is stopped if the safe state cannot be confirmed.

2) Program the safety system so that a machine is started only when the safe state is confirmed at the time the operation command (start switch) is pressed.
In addition, program the safety system so that a machine is started at the fall (on → off) of the start switch signal. This prevents the machine from accidentally starting at the start switch failure (such as contact welding, spring damage).

3) Create an interlock program that uses a reset switch for restart to ensure that the safety system does not restart automatically after executing safety functions and turning off outputs.



2.4 Wiring Methods for Safety Devices

The mainstream method for wiring safety devices is PNP connection, not NPN connection.
For NPN connection and PNP connection, the device operation is largely different when a grounding fault occurs to the wiring on the device side due to a failure.
With NPN connection, a voltage is applied to the safety device when a grounding fault occurs, so it is erroneously detected as a safe state.
On the other hand, with PNP connection, the load voltage application is stopped if a grounding fault occurs, so it is detected as a hazardous state, and the device is stopped.
PNP connection is used in safety devices because the emergency stop can reliably be executed as required.

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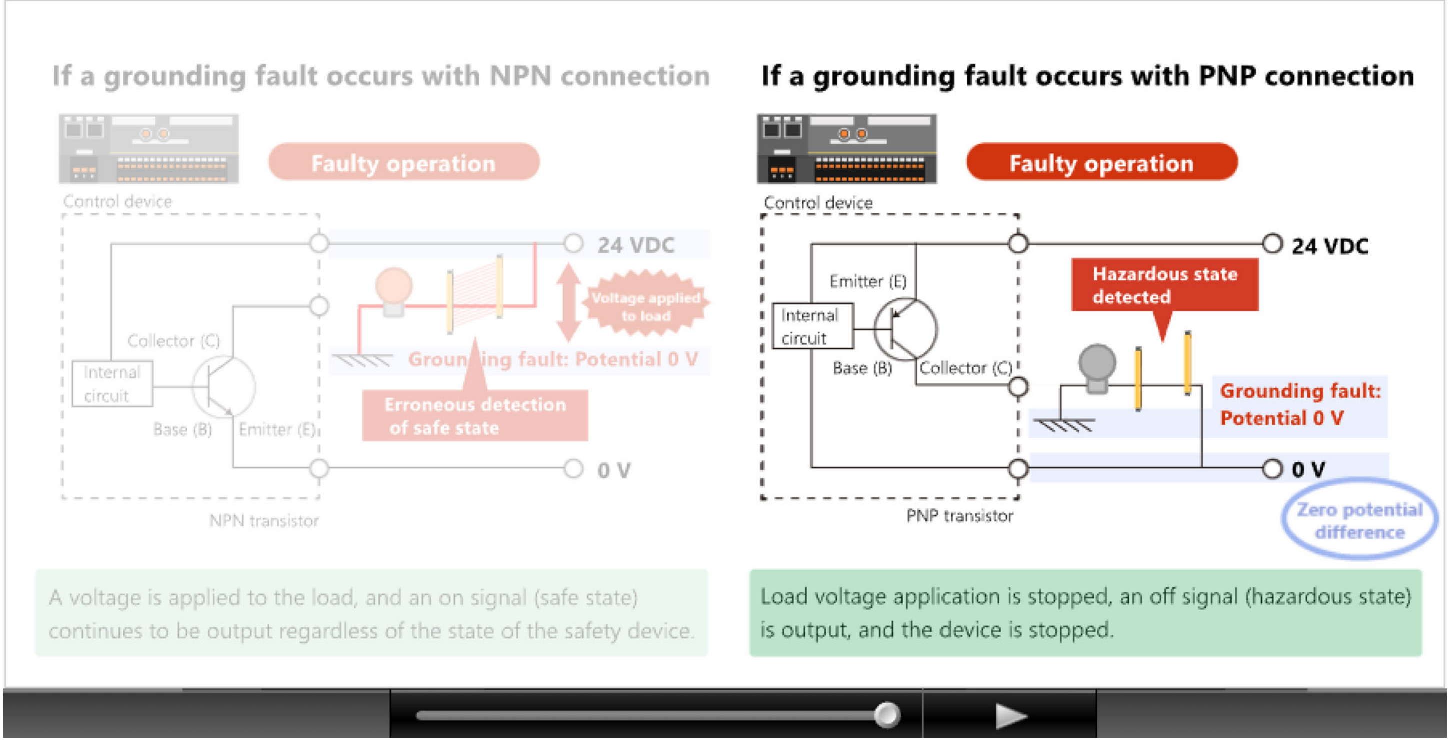
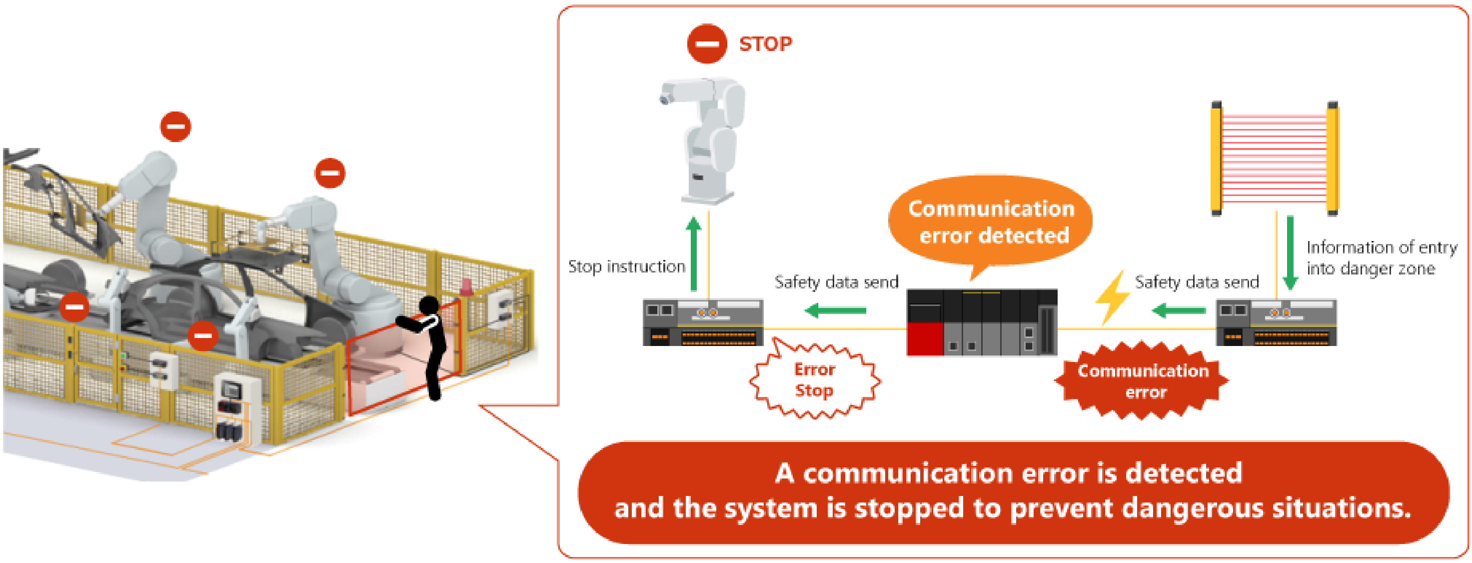


2.5 Safety Communications

Data communications performed in the safety system are called "safety communications".
The safety communications technology is standardized in IEC 61784-3, which incorporates the concept of IEC 61508. IEC 61784-3 defines the communications that can check whether safety data, such as emergency stop requests involving human life, is correctly delivered to the communication destination. Also, it defines that communication errors, such as safety data corruption or loss on the network, can be detected.



2.6 Summary

The contents of this chapter are:

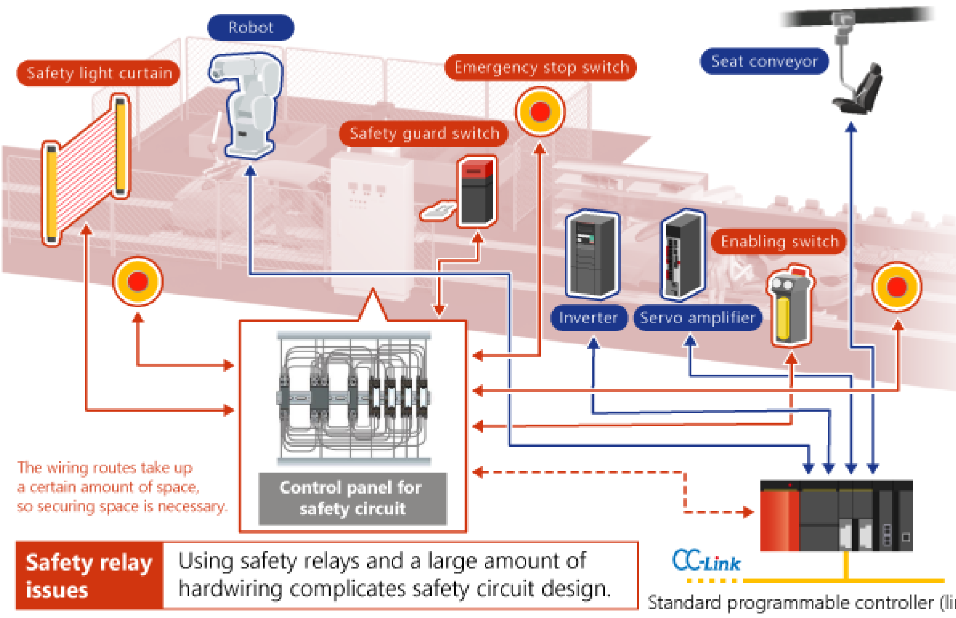
- What is "dual input discrepancy detection"?
- What is "input dark test"?
- Precautions on Programming for the Safety System
- Wiring Methods for Safety Devices
- Safety Communications

Chapter 3 Future Trends of Machinery Safety

In this chapter, let's learn about the future trends of functional safety.

3.1 Difference Between Safety Relays and Safety Programmable Controllers

Safety relays and safety programmable controllers are used for different purposes depending on a scale.
Systems using safety relays can easily build safety control for small-scale equipment, without safety programs or monitor wiring.
However, there are issues and problems, such as complicated wiring and troubleshooting that takes time.



Advantages

- Smaller control panel
- Can be controlled without a program
- Systems can be constructed at low cost

Disadvantages

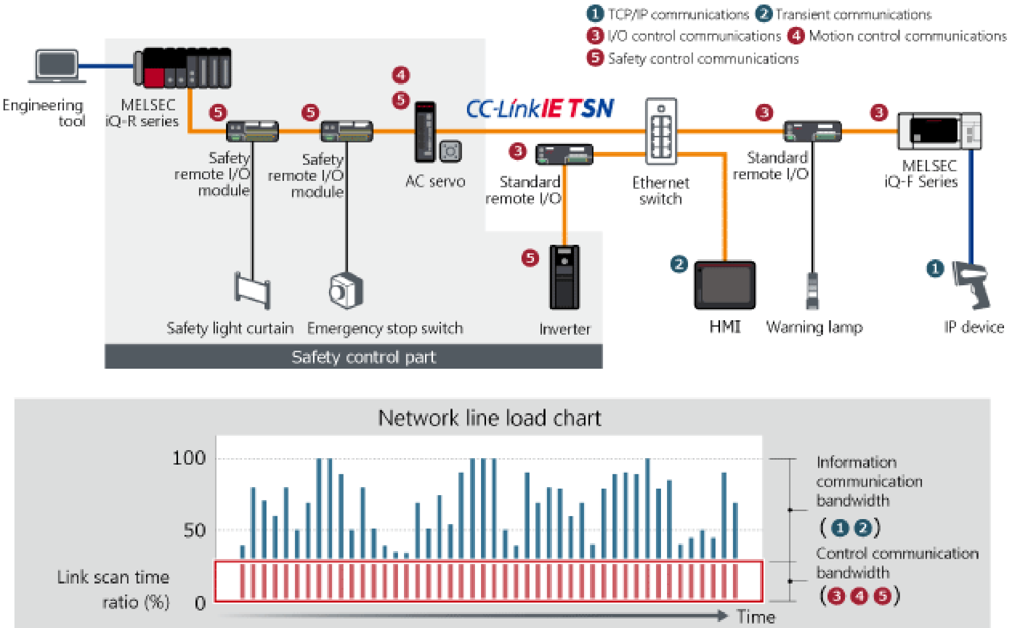
- Complex control not possible
- Information linkage not possible
- Difficult changeover

Application

Small-scale systems

3.2 Systems Using Safety Programmable Controllers

With the MELSEC iQ-R Series safety programmable controller, standard control and safety control can be integrated into one system.
The Safety CPU can be used as a module for standard control on the same base unit, thereby saving space. The power supply module, base unit, and network module can be used as a module for both standard control and safety control, thereby reducing costs.
Furthermore, in CC-Link IE TSN, both standard communications and safety communications can be used together, and various drive system devices can be connected. Therefore, safety functions can be used throughout the network. In addition, even if TCP/IP communications are also used together, the constant periodicity of cyclic transmissions can be guaranteed. Therefore, general-purpose IP devices can be used without impacting system control, enabling construction of a flexible IoT system.



Advantages

- Complex control possible
- Easy information linkage
- Easy changeover and program change

Disadvantages

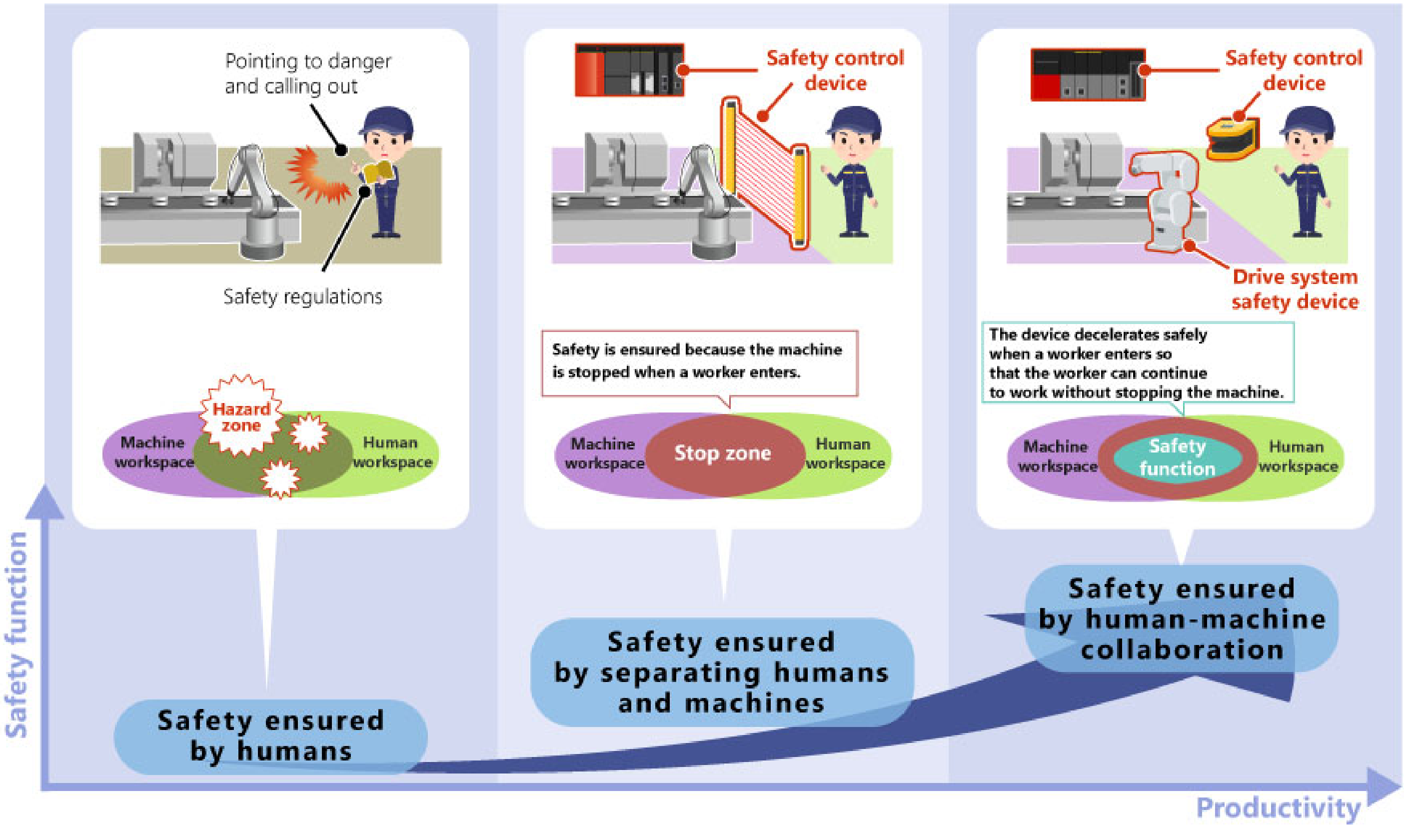
- Larger control panel
- Program required

Application

- Large-scale systems
- Distributed systems

3.3 Trends of Safety Devices

Occupational safety is changing from humans ensuring their safety, to the separation of human and machine workspace, and then to cooperative safety between humans and machines.
By linking a drive system safety device and the safety programmable controller, safety can be ensured while work continues, without stopping the machine, even if a worker approaches the machine.



3.4 Introduction to Drive System Safety

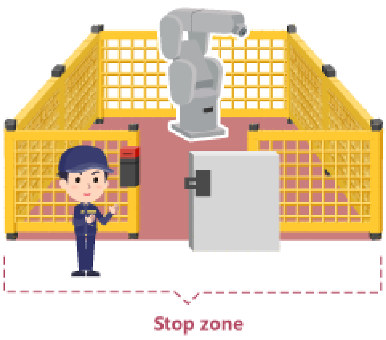
This section describes an application example of a drive system safety device.
In the past, stopping the machine to ensure safety reduced productivity. However, linking area sensors and a drive system safety device ensures safety by decelerating the motor when a worker approaches the machine, avoids frequent machine stops, and leads to higher productivity.
In addition, this measure eliminates the need for safety guards, thereby cost reduction and downsizing of equipment (space saving).

Before

Separation of human and machine workspace

Secure safe zone with
safety doors and safety guards

Safety is ensured by
stopping the machine

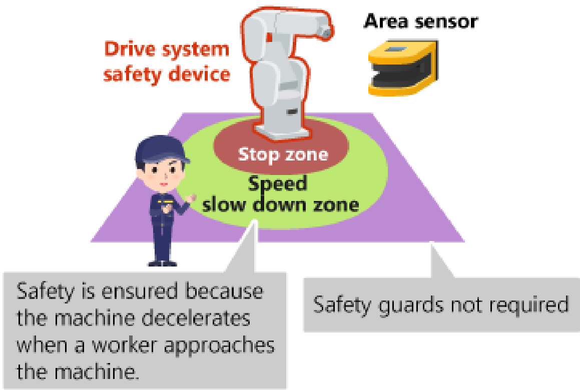


After

Safe zone control

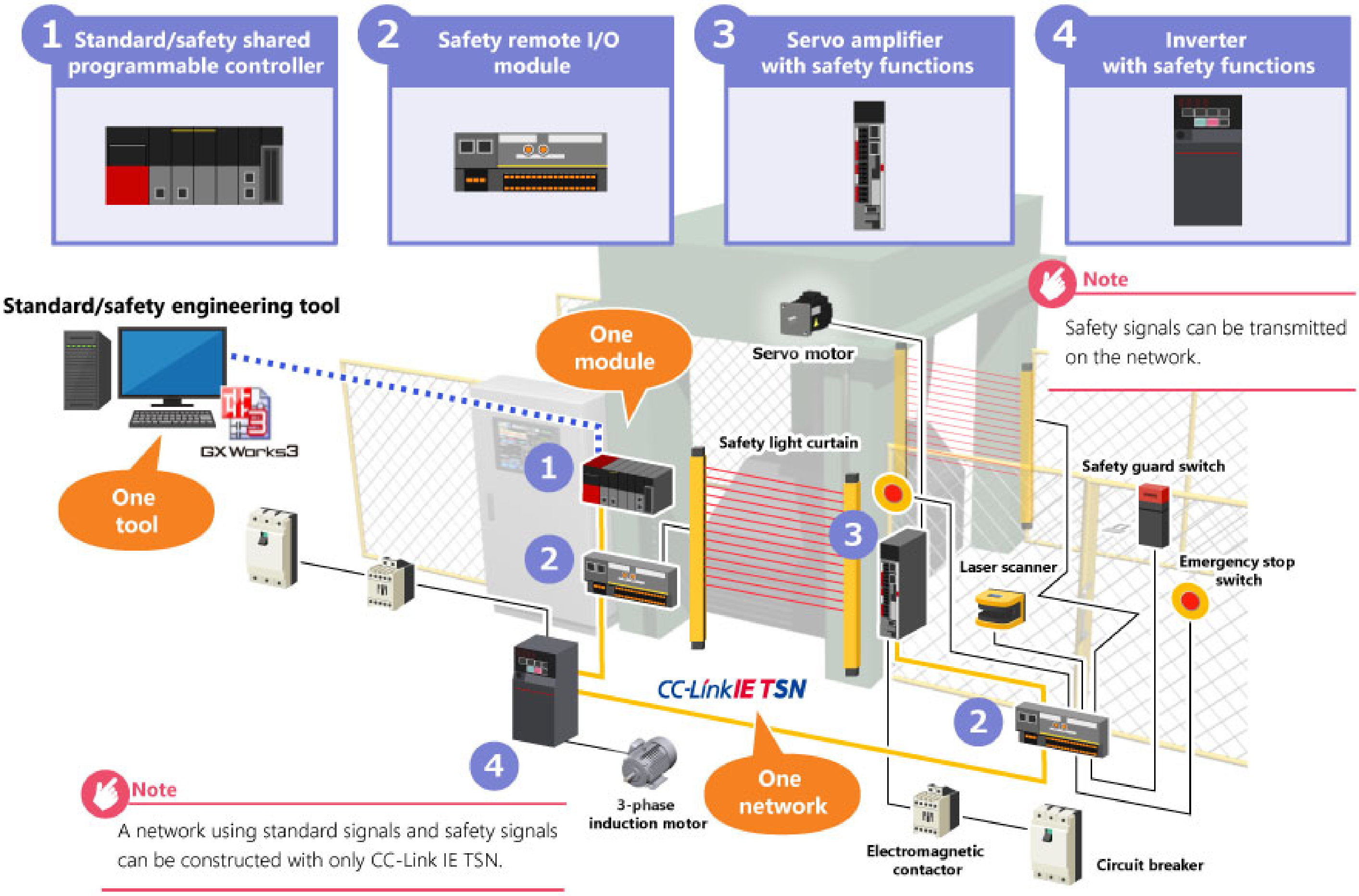
Secure safe zone with
area sensors and drive system safety device

By using the **safety monitoring function,** frequent **machine stops can be avoided and production can be continued.**



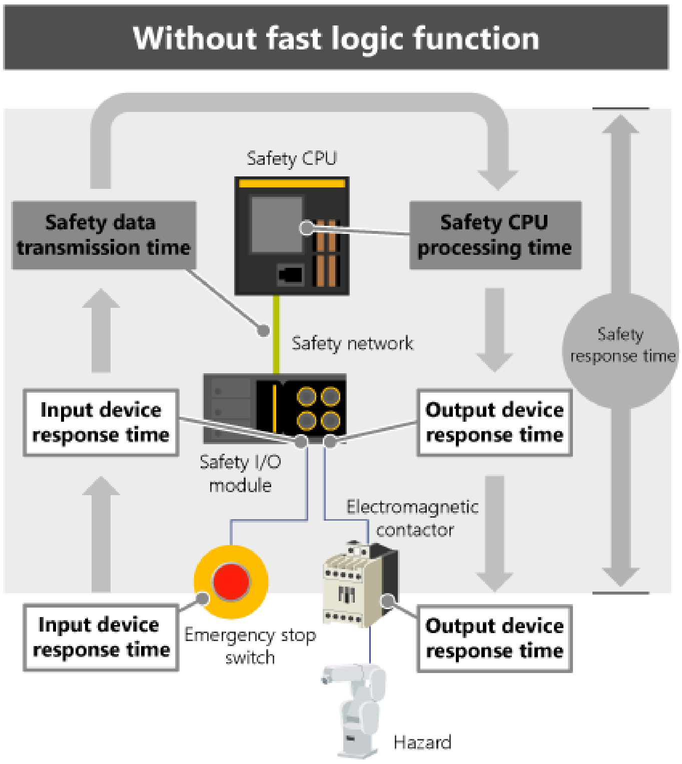
3.5 Introduction to Mitsubishi Electric Drive System Safety Devices

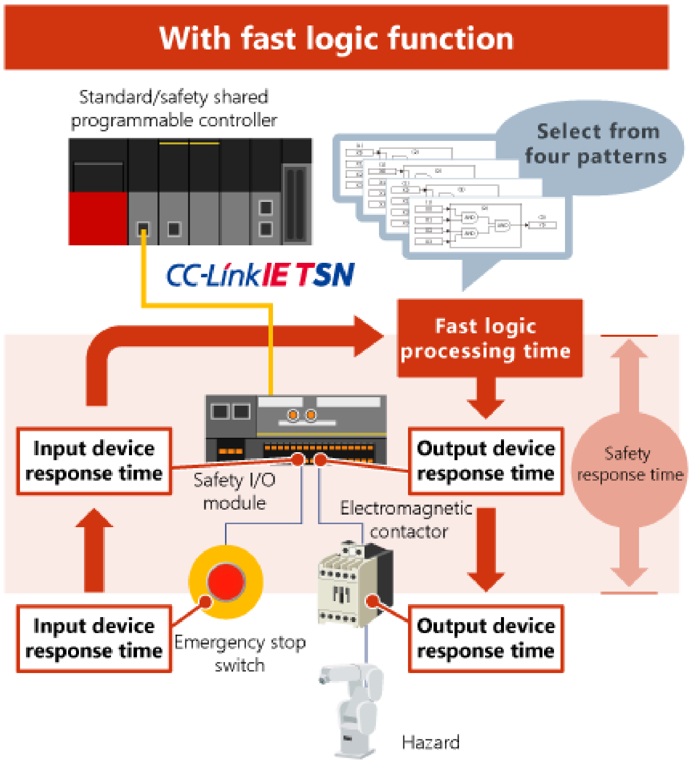
This section describes application examples of safety solutions on press machines.
By using the MELSEC iQ-R Series safety programmable controller and drive system safety devices as shown below, the general/safety shared system, which reduces wiring time and saves space and man-hour, can be constructed with one module, one tool, and one network.



3.6 Fast Logic

Mitsubishi Electric CC-Link IE TSN-compatible safety I/O modules support the fast logic function that turns off safety outputs without going through the safety programmable controller.
This function tuns off outputs to a device at high speed in response to inputs that demand urgency, such as pressing an emergency stop switch, thus greatly reducing the safety response time at an emergency stop.





Safety response time comparison

3.7 Summary

The contents of this chapter are:

- Difference Between Safety Relays and Safety Programmable Controllers
- Systems Using Safety Programmable Controllers
- Trends of Safety Devices
- Introduction to Drive System Safety
- Introduction to Mitsubishi Electric Drive System Safety Devices
- Fast Logic

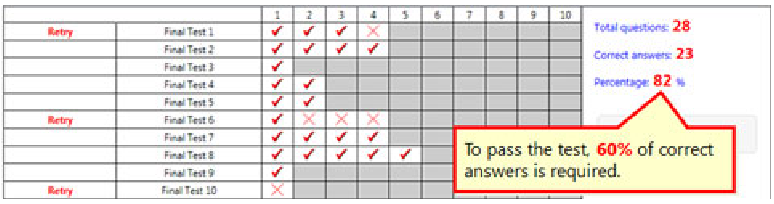
Now that you have completed all of the lessons of the **Machinery Safety Basic** course, you are ready to take the final test. If you are unclear on any of the topics covered, please take this opportunity to review those topics.

There are a total of 4 questions (14 items) in this Final Test.

You can take the final test as many times as you like.

Score results

The number of correct answers, the number of questions, the percentage of correct answers, and the pass/fail result will appear on the score page.



Test | **Final Test 1**

The following statements describe what "functional safety" is. Fill in the blanks with appropriate terms.

Functional safety is technology that ensures safety with electronic devices, such as microcontrollers, used for safety devices.

With the spread of computers in the control field, machines and equipment have become more sophisticated. The situation has become uncontrollable with only **(Q1)** , and the problem of how to prove safety of **(Q2)** has arisen.

Q1 mechanical hardware circuits

Q2 embedded software

Q3 electronic devices used for safety devices

Test | # Final Test 2

The following statements describe precautions on programming for the safety system. Fill in the blanks with appropriate terms.

The following are the precautions on programming for the safety system.

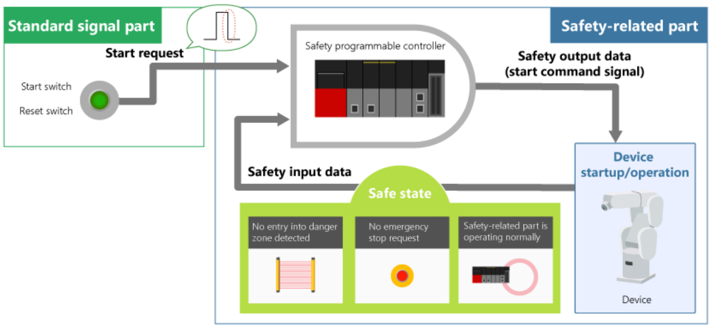
1) Program the safety system so that a machine is stopped if the **(Q1)** cannot be confirmed.

Q1 safe state

Q2 operation command (start switch)

Q3 fall (on → off)

Q4 the safety system does not restart automati...



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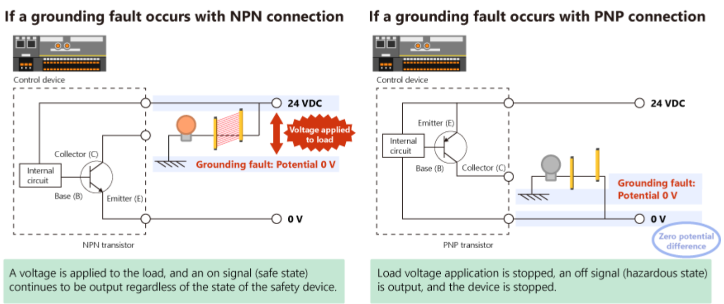
Test Final Test 3

The following statements describe the wiring methods for safety devices. Fill in the blanks with appropriate terms.

The mainstream method for wiring safety devices is **(Q2)** , not **(Q1)** .

For NPN connection and PNP connection, the device operation is largely different when a grounding fault occurs to the wiring on the device side due to a failure

Q1	NPN connection
Q2	PNP connection
Q3	voltage is applied
Q4	voltage application is stopped



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Test | Final Test 4

The following statements describe an application example of a drive system safety device. Fill in the blanks with appropriate terms.

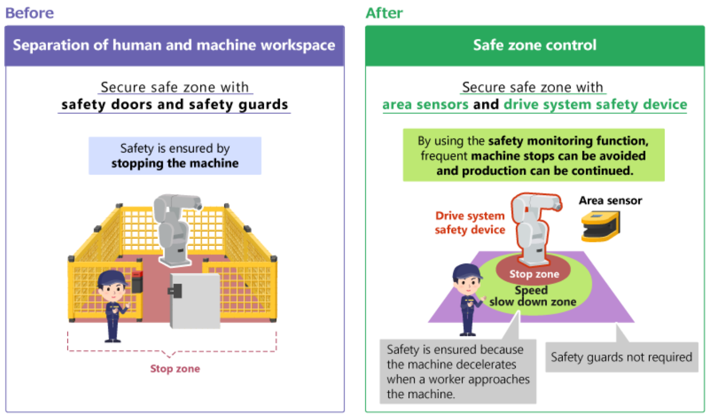
The following describes an application example of a drive system safety device.

In the past, **(Q1)** the machine to ensure safety reduced productivity. However, linking area sensors and a drive system safety device ensures safety by **(Q2)** the motor when a worker approaches the machine, avoids frequent machine

Q1 stopping

Q2 decelerating

Q3 stops



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Test **Test Score**

You have completed the Final Test. You results area as follows.
To end the Final Test, proceed to the next page

		1	2	3	4	5	6	7	8	9	10
	Final Test 1	✓	✓	✓							
	Final Test 2	✓	✓	✓	✓						
	Final Test 3	✓	✓	✓	✓						
	Final Test 4	✓	✓	✓							

Total questions: **14**

Correct answers: **14**

Percentage: **100** %

Clear

You have completed the Machinery Safety Basic course.

Thank you for taking this course.

We hope you enjoyed the lessons and the information you acquired in this course will be useful in the future.

You can review the course as many times as you want.

Review

Close