MITSUBISHI ELECTRIC

Safety Programmable Controller

MELSEC QS series

Safety Application Guide

● SAFETY PRECAUTIONS ●

(Read these precautions before using this product.)

Before using the product, please read this manual, the relevant manuals introduced in this manual, standard programmable controller manuals, and the safety standards carefully and pay full attention to safety to handle the product correctly.

In this manual, the safety precautions are classified into two levels: " ⚠ WARNING" and " ⚠ CAUTION".

⚠ WARNING	Indicates that incorrect handling may cause hazardous conditions, resulting in death or severe injury.
⚠ CAUTION	Indicates that incorrect handling may cause hazardous conditions, resulting in minor or moderate injury or property damage.

Under some circumstances, failure to observe the precautions given under " ⚠ CAUTION" may lead to serious consequences.
Observe the precautions of both levels because they are important for personal and system safety.
Make sure that the end users read this manual and then keep the manual in a safe place for future reference.

[Design Precautions]

⚠WARNING

- When a safety programmable controller detects an error in an external power supply or a failure in programmable controller main module, it turns off all the outputs.
  Create an external circuit to securely stop the power of hazard by turning off the outputs.
  Incorrect configuration may result in an accident.
- Create short current protection for a safety relay, and a protection circuit such as a fuse, and breaker, outside a safety programmable controller.
- If load current more than the rating or overcurrent due to a short circuit in the load has flowed in the CC-Link Safety remote I/O module, the module defines it as a fault and turns off all the outputs.
  However, if overcurrent flows in the CC-Link Safety remote I/O module for a long time, it may cause smoke or a fire. To prevent it, create a safety circuit such as a fuse outside the module.
- When data/program change, or status control is performed from a PC to a running safety programmable controller, create an interlock circuit outside the sequence program and safety programmable controller to ensure that the whole system always operates safely.
  For the operations to a safety programmable controller, pay full attention to safety by reading the relevant manuals carefully, and establishing the operating procedure.
  Furthermore, for the online operations performed from a PC to a safety CPU module, the corrective actions against a communication error due to a cable connection fault, etc. should be predetermined as a system.
- All output signals from a safety CPU module to the CC-Link Safety master modules are prohibited to use.
  These signals can be found in the CC-Link Safety System Master Module User's Manual.
  Do not turn ON or OFF these signals by sequence program, since turning ON/OFF these output signals of the programmable controller system may cause malfunctions and safety operation cannot be guaranteed.
- All output signals from a safety CPU module to the CC-Link IE Field Network master/local modules (with safety functions) are prohibited to use.
  These signals can be found in the MELSEC-QS CC-Link IE Field Network Master/Local Module User's Manual.
  Do not turn ON or OFF these signals by sequence program, since turning ON/OFF these output signals of the programmable controller system may cause malfunctions and safety operation cannot be guaranteed.

[Design Precautions]

⚠WARNING

- When a CC-Link Safety remote I/O module has detected CC-Link Safety error, it turns off all the outputs.
  Note that the outputs in a sequence program are not automatically turned off.
  If CC-Link Safety or CC-Link IE Field Network error has been detected, create a sequence program that turns off the outputs in the program.
  If the CC-Link Safety or CC-Link IE Field Network is restored with the outputs on, it may suddenly operate and result in an accident.
- To inhibit restart without manual operation after safety functions was performed and outputs were turned OFF, create an interlock program which uses a reset button for restart.

[Design Precautions]

⚠CAUTION

- Do not bunch the wires of external devices or communication cables together with the main circuit or power lines, or install them close to each other.
  They should be installed 100mm or more from each other.
  Not doing so could result in noise that would cause malfunctions.
- Select the external devices to be connected to the CC-Link Safety remote I/O module, considering the maximum inrush current with reference to the CC-Link Safety System Remote I/O Module User's Manual.

[Installation Precautions]

⚠CAUTION

- Use a safety programmable controller in the environment that meets the general specifications described in the QSCPU User's Manual (Hardware Design, Maintenance and Inspection).
  Using this programmable controller in an environment outside the range of the general specifications could result in electric shock, fire, erroneous operation, and damage to or deterioration of the product.
- While pressing the installation lever located at the bottom of module, insert the module fixing tab into the fixing hole in the base unit until it stops. Then, securely mount the module with the fixing hole as a supporting point.
  Incorrect loading of the module can cause a failure or drop.
  Secure the module to the base unit with screws.
  Tighten the screw in the specified torque range.
  If the screws are too loose, it may cause a drop of the screw or module.
  Overtightening may cause a drop due to the damage of the screw or module.
- Make sure to fix the CC-Link Safety remote I/O module with a DIN rail or fixing screws and tighten the screws with the specified torque.
  If the screws are too loose, it may cause a drop of the screw or module.
  Overtightening may cause a drop due to the damage of the screw or module.
- Completely turn off the external supply power used in the system before mounting or removing the module.
  Not doing so could result in damage to the product.
- Do not directly touch the module's conductive parts or electronic components.
  Doing so may cause malfunctions or a failure.

[Wiring Precautions]

⚠WARNING

- Be sure to shut off all phases of the external supply power used by the system before wiring.
  Not completely turning off all power could result in electric shock or damage to the product.
- When energizing or operating the module after installation or wiring, be sure to close the attached terminal cover.
  Not doing so may result in electric shock.

[Wiring Precautions]

⚠CAUTION

- Ground the FG and LG terminals correctly.
  Not doing so could result in electric shock or malfunctions.
- Use a solderless terminal with insulation sleeve for wiring of a terminal block.
  Use up to two solderless terminals for a single terminal.
- Use applicable solderless terminals and tighten them with the specified torque. If any solderless spade terminal is used, it may be disconnected when the terminal screw comes loose, resulting in a failure.
- Wire the module correctly after confirming the rated voltage and terminal layout.
  Connecting a power supply of a different rated voltage or incorrect wiring may cause a fire or failure.
- Tighten a terminal block mounting screw, terminal screw, and module fixing screw within the specified torque range.
  If the terminal block mounting screw or terminal screw is too loose, it may cause a short circuit, fire, or malfunctions.
  If too tight, it may damage the screw and/or the module, resulting in a drop of the screw or module, a short circuit or malfunctions.
  If the module fixing screw is too loose, it may cause a drop of the screw or module.
  Overtightening the screw may cause a drop due to the damage of the screw or module.
- Be sure there are no foreign substances such as sawdust or wiring debris inside the module.
  Such debris could cause a fire, failure, or malfunctions.
- The module has an ingress prevention label on its top to prevent foreign matter, such as wire offcuts, from entering the module during wiring.
  Do not peel this label during wiring.
  Before starting system operation, be sure to peel this label because of heat dissipation.

[Wiring Precautions]

⚠CAUTION

- Be sure to fix the communication cables or power cables by ducts or clamps when connecting them to the module.
  Failure to do so may cause damage of the module or cables due to a wobble, unintentional shifting, or accidental pull of the cables, or malfunctions due to poor contact of the cable.
- When removing the connected communication cables or power cables, do not pull the cable with grasping the cable part.
  Remove the cable connected to the terminal block after loosening the terminal block screws.
  Pulling the cable connected to a module may result in malfunctions or damage of the module or cable.
- For the cables to be used in the CC-Link Safety, use the ones specified by the manufacturer.
  Otherwise, the performance of the CC-Link Safety is not guaranteed.
  As to the maximum overall cable length and station - to station cable length, follow the specifications described in the CC-Link Safety System Master Module User's Manual.
  If not following the specification, the normal data transmission is not guaranteed.
- For the cables to be used in CC-Link IE Field Network, use the ones specified by the manufacturer.
  Otherwise, the performance of CC-Link IE Field Network is not guaranteed.
  As to the maximum overall cable length and station - to station cable length, follow the specifications described in the MELSEC-QS CC-Link IE Field Network Master/Local Module User's Manual.
  If not following the specification, the normal data transmission is not guaranteed.
- Install our programmable controller in a control panel for use.
  Wire the main power supply to the power supply module installed in a control panel through a distribution terminal block.
  Furthermore, the wiring and replacement of a power supply module have to be performed by a maintenance worker who acquainted with shock protection.
  For the wiring methods, refer to the QSCPU User's Manual (Hardware Design, Maintenance and Inspection).

[Startup and Maintenance precautions]

⚠WARNING

- Do not touch the terminals while power is on.
  Doing so could result in electric shock.
- Correctly connect the battery connector.
  Also, do not charge, disassemble, heat, place in fire, short circuit, or solder the battery.
  Mishandling of battery can cause overheating, cracks, or ignition which could result in injury and fires.
- Turn off all phases of the external supply power used in the system when cleaning the module or retightening the terminal block mounting screws, terminal screws, or module fixing screws.
  Not doing so could result in electric shock.
  Tighten a terminal block mounting screw, terminal screw, and module fixing screw within the specified torque range.
  If the terminal block mounting screw or terminal screw is too loose, it may cause a short circuit, fire, or malfunctions.
  If too tight, it may damage the screw and/or the module, resulting in a drop of the screw or module, a short circuit or malfunctions.
  If the module fixing screw is too loose, it may cause a drop of the screw or module.
  Overtightening the screw may cause a drop due to the damage of the screw or module.

[Startup and Maintenance precautions]

⚠CAUTION

- The online operations performed from a PC to a running safety programmable controller (Program change when a safety CPU module is RUN, device test, and operating status change such as RUN-STOP switching) have to be executed after the manual has been carefully read and the safety has been ensured.
  Following the operating procedure predetermined at designing, the operation has to be performed by an instructed person.
  When changing a program while a safety CPU module is RUN (Write during RUN), it may cause a program breakdown in some operating conditions.
  Fully understand the precautions described in the GX Developer's manual before use.
- Do not disassemble or modify the modules.
  Doing so could cause a failure, malfunctions, injury, or fire.
  If the product is repaired or remodeled by other than the specified FA centers or us, the warranty is not covered.
- Use any radio communication device such as a cellular phone or a PHS phone more than 25cm away in all directions of safety programmable controller.
  Not doing so can cause malfunctions.

[Startup and Maintenance precautions]

⚠CAUTION
●Completely turn off the external supply power used in the system before mounting or removing the module. Not doing so may result in a failure or malfunctions of the module. ●Restrict the mounting/removal of a module, base unit, and terminal block up to 50 times (IEC 61131-2 compliant), after the first use of the product. Failure to do so may cause the module to malfunction due to poor contact of connector. ●Do not drop or give an impact to the battery mounted to the module. Doing so may damage the battery, causing the battery fluid to leak inside the battery. If the battery is dropped or given an impact, dispose of it without using. ●Before touching the module, always touch grounded metal, etc. to discharge static electricity from human body, etc. Not doing so may result in a failure or malfunctions of the module. ●Since the module case is made of resin, do not drop or apply any strong impact to the module. Doing so may damage the module. ●Shut off the external power supply (all phases) used in the system before installing or removing a module to/from a control panel. Not doing so may result in a failure or malfunctions of the module.

[Disposal Precautions]

⚠CAUTION
●When disposing of this product, treat it as industrial waste. When disposing of batteries, separate them from other wastes according to the local regulations. (For details of the Battery Directive in EU member states, refer to the QSCPU User's Manual (Hardware Design, Maintenance and Inspection).)

[Transportation Precautions]

⚠CAUTION
●When transporting lithium batteries, make sure to treat them based on the transport regulations. (For details of the controlled models, refer to the QSCPU User's Manual (Hardware Design, Maintenance and Inspection).)

●CONDITIONS OF USE FOR THE PRODUCT●

(1) Although MELCO has obtained the certification for Product's compliance to the international safety standards IEC61508, ISO13849-1 from TUV Rheinland, this fact does not guarantee that Product will be free from any malfunction or failure. The user of this Product shall comply with any and all applicable safety standard, regulation or law and take appropriate safety measures for the system in which the Product is installed or used and shall take the second or third safety measures other than the Product. MELCO is not liable for damages that could have been prevented by compliance with any applicable safety standard, regulation or law.

(2) MELCO prohibits the use of Products with or in any application involving, and MELCO shall not be liable for a default, a liability for defect warranty, a quality assurance, negligence or other tort and a product liability in these applications.
(a) power plants,
(b) trains, railway systems, airplanes, airline operations, other transportation systems,
(c) hospitals, medical care, dialysis and life support facilities or equipment,
(d) amusement equipments,
(e) incineration and fuel devices,
(f) handling of nuclear or hazardous materials or chemicals,
(g) mining and drilling,
(h) and other applications where the level of risk to human life, health or property are elevated.

REVISIONS

The manual number is given on the bottom left of the back cover.

Print date	Manual number	Revision
Sep., 2006	SH(NA)-080613ENG-A	First edition
Mar., 2007	SH(NA)-080613ENG-B	Partial correction CHAPTER1, Section 4.2, 5.5, 5.6.3, 5.6.4
Apr., 2008	SH(NA)-080613ENG-C	Partial correction Section 4.1, Appendix 1
Apr., 2009	SH(NA)-080613ENG-D	Change of a term "PLC" was changed to "programmable controller" . Partial correction SAFETY PRECAUTIONS, ABOUT MANUALS, HOW THIS MANUAL IS ORGANIZED, Section 5.1, 5.2.4, 5.3 to 5.6, 5.6.1 to 5.6.4, INDEX Addition Section 5.6.6 to 5.6.8 Section number changed Section 5.6.2 → 5.6.5
Jul., 2010	SH(NA)-080613ENG-E	Partial correction SAFETY PRECAUTIONS, Section 4.1 Addition CONDITIONS OF USE FOR THE PRODUCT
May, 2011	SH(NA)-080613ENG-F	Full revision
Dec., 2016	SH(NA)-080613ENG-G	Partial correction TERMINOLOGY
Nov., 2018	SH(NA)-080613ENG-H	Partial correction Section 4.1

Japanese Manual Version SH-080611-H

INTRODUCTION

Thank you for purchasing the Mitsubishi Electric safety programmable controller MELSEC-QS series. Before using the equipment, please read this manual carefully to develop full familiarity with the functions and performance of the QS series programmable controller you have purchased, so as to ensure correct use.

When applying the program examples introduced in this manual to the actual system, ensure the applicability and confirm that it will not cause system control problems.

CONTENTS

MANUAL

The manual related to this product is shown below. Please place an order as needed.

Related manuals

Manual name	Manual number (Model code)
Safety Guidelines Explains the specifications of the QSCPU, safety power supply module and safety base unit, etc. (Supplied with the product)	IB-0800424 (13JY84)
QSCPU User's Manual (Hardware Design, Maintenance and Inspection) Explains the specifications of the QSCPU, safety power supply module, safety base unit, etc. (Sold separately)	SH-080626ENG (13JR92)
QSCPU User's Manual (Function Explanation, Program Fundamentals) Explains the functions, programming methods, devices, etc. that are necessary to create programs with the QSCPU. (Sold separately)	SH-080627ENG (13JR93)
QSCPU Programming Manual (Common Instructions) Explains how to use the sequence instructions, basic instructions, application instructions, and QSCPU dedicated instructions. (Sold separately)	SH-080628ENG (13JW01)
QSCPU Programming Manual (Safety FB) Explains how to use safety function blocks. (Sold separately)	SH-080744ENG (13JW05)
CC-Link Safety System Master Module User's Manual Explains the specifications, procedures and settings up to operation, parameter settings and trouble shootings of the QS0J61BT12 type CC-Link Safety system master module. (Sold separately)	SH-080600ENG (13JP88)
CC-Link Safety System Remote I/O Module User's Manual Explains the specifications, procedures and settings up to operation, parameter settings and trouble shootings of the CC-Link Safety remote I/O module. (Sold separately)	SH-080612ENG (13JR89)
MELSEC-QS CC-Link IE Field Network Master/Local Module User's Manual Explains the overview of CC-Link IE Field Network, and specifications, procedures before operation, system configuration, installation, wiring, settings, functions, programming, and troubleshooting of the CC-Link IE Field Network master/local module (with safety functions). (Sold separately)	SH-080969ENG (13JZ53)
MELSEC-Q CC-Link IE Controller Network Reference Manual Explains the system configuration, performance specifications, functions, handling, wiring, and troubleshooting of the CC-Link IE Controller Network. (Sold separately)	SH-080668ENG (13JV16)
Q Corresponding MELSECNET/H Network System Reference Manual (PLC to PLC network) Explains the specifications for a MELSECNET/H network system for PLC to PLC network, the procedures and settings up to operation, parameter settings, programming and troubleshooting. (Sold separately)	SH-080049 (13JF92)
Q Corresponding Ethernet Interface Module User's Manual (Basic) Explains the specifications, procedures for data communication with external devices, line connection (open/close), fixed buffer communication, random access buffer communication, and troubleshooting of the Ethernet module. (Sold separately)	SH-080009 (13JL88)

Remark

If you would like to obtain a manual individually, printed materials are available separately. Order the manual by quoting the manual number on the table above (model code).

HOW THIS MANUAL IS ORGANIZED

The section in this manual or another relevant manual that can be referred to is shown as follows:

(☞ Section 3.5)

In addition, this manual provides the following explanations.

POINT

In addition to description of the page, notes or functions that require special attention are described here.

Remark

The reference related to the page or useful information are described here.

HOW TO USE THIS MANUAL

This manual describes the points to be concerned when configuring safety application that meets the safety standards using the safety programmable controller.
Although the safety application configuration example is shown in CHAPTER 5 and CHAPTER 6 of this manual, authentication is not obtained. The safety standards conformance approval must be obtained for the user with the entire safety-related system.

This manual is classified roughly into five chapters as shown below.

CHAPTER 1	Describes the outline of the safety programmable controller.
CHAPTER 2	Describes the safety application that is configured using the safety programmable controller.
CHAPTER 3	Describes the risk assessment, Category, and SIL.
CHAPTER 4	Describes the cautions for use of the safety programmable controller.
CHAPTER 5	Describes a safety application example (when a single safety programmable controller is used).
CHAPTER 6	Describes a safety application example (when several safety programmable controllers are used).

For the detailed specifications and functions of each module, refer to the related manuals.

GENERIC TERMS AND ABBREVIATIONS

Unless otherwise specified, this manual uses the following generic terms and abbreviations. When a clear indication of target model name is required, the module name is indicated.

Generic term/ abbreviation	Description
GX Developer	Generic product name for models SWnD5C-GPPW, SWnD5C-GPPW-A, SWnD5C-GPPW-V, and SWnD5C-GPPW-VA
RWr	Remote register (Read area for CC-Link Safety and CC-Link IE Field Network)
RWw	Remote register (Write area for CC-Link Safety and CC-Link IE Field Network)
RX	Remote input (for CC-Link Safety and CC-Link IE Field Network)
RY	Remote output (for CC-Link Safety and CC-Link IE Field Network)
SB	Link special relay (for CC-Link Safety and CC-Link IE Field Network)
SW	Link special register (for CC-Link Safety and CC-Link IE Field Network)
Safety master station on CC-Link Safety	Station that controls CC-Link Safety. One station is required in a system.
Remote station on CC-Link Safety	Generic term for a safety remote I/O station, a standard remote I/O station, and a remote device station on CC-Link Safety. This station is controlled by the safety master station on CC-Link Safety.
Safety remote I/O station on CC-Link Safety	Remote station on CC-Link Safety, which exchanges only bit data. Compatible with the safety-related system.
Standard remote I/O station on CC-Link Safety	Remote station on CC-Link Safety, which exchanges only bit data. Not compatible with the safety-related system.
Remote I/O station on CC-Link Safety	Generic term for a safety remote I/O station and a standard remote I/O station on CC-Link Safety
Remote device station on CC-Link Safety	Remote station on CC-Link Safety, which exchanges bit data and word data. Not compatible with the safety-related system.
Safety station on CC-Link Safety	Generic term for stations on CC-Link Safety, which perform safety communication
Master station (safety station) on CC-Link IE Field Network	Station that controls the entire CC-Link IE Field Network. Only one station can be used in a network. This station can perform cyclic transmission and transient transmission with all stations on CC-Link IE Field Network. The station can also perform safety communication with another safety station on the same network.
Local station (safety station) on CC-Link IE Field Network	This station can perform cyclic transmission and transient transmission with the master station and other local stations on CC-Link IE Field Network. The station can also perform safety communication with another safety station on the same network. The station is controlled by programs in the CPU module or other equivalent modules on the station.
Slave station on CC-Link IE Field Network	Generic term for stations other than a master station on CC-Link IE Field Network: local station, remote I/O station, remote device station, and intelligent device station
Safety station on CC-Link IE Field Network	Generic term for stations on CC-Link IE Field Network, which perform safety communication and standard communication
CC-Link Safety master module	Abbreviation for the QS0J61BT12 CC-link Safety system master module
CC-Link Safety remote I/O module	Abbreviation for the QS0J65BTS2-8D, QS0J65BTS2-4T and QS0J65BTB2-12DT CC-Link Safety system remote I/O module
CC-Link IE Field Network master/local module (with safety functions)	Abbreviation for the QS0J71GF11-T2 CC-Link IE Field Network master/local module
Safety main base unit	Abbreviation for the QS034B(-E) type safety main base unit

Generic term/ abbreviation	Description
Safety CPU module	Abbreviation for the QS001CPU type safety CPU module
Safety power supply module	Abbreviation for the QS061P-A1 and QS061P-A2 type safety power supply modules
Safety programmable controller	Generic term for a safety CPU module, a safety power supply module, a safety main base unit, a CC-Link Safety master module, CC-Link Safety remote I/O modules, and a CC-Link IE Field Network master/local module (with safety functions)
Standard programmable controller	Generic term for MELSEC-Q series, MELSEC-L series, MELSEC-QnA series, MELSEC-A series, and MELSEC-FX series modules (This term is used to distinguish a programmable controller that uses these modules from a safety programmable controller.)
Safety input	Generic term for the signals that are input to the safety programmable controller for realizing the safety functions
Safety output	Generic term for the signals that are output from the safety programmable controller for realizing the safety functions
Safety communication	Function to exchange safety data between safety stations on the same network
Safety application	Generic term for the applications that are operated using the safety programmable controller for realizing the safety functions

TERMINOLOGY

Term	Description
Safety component	Equipment such as the safety compatible sensor and actuator
Safety-related system	System executing a safety functions to be required
Safety functions	Functions to be realized for protecting a human from machinery hazards
Safety measure	Measure for reducing the risk
Category	Safety level standardized in EN954-1. The safety level is classified into 5 levels of B and 1 to 4.
PL (performance level)	Safety level specified in ISO13849-1:2015. The safety level is classified into five levels of "a" to "e".
SIL	Safety level which is standardized in IEC61508. The safety level is classified into 4 levels of SIL1 to SIL4.
Risk	Degree of hazards, which is the combination of the occurrence probability and degree of an injury and a health problem
Risk assessment	To clarify hazards in machinery and assess the degree of the hazards
Link ID	Unique network identifier which is given to each network of the CC-Link Safety
Target failure measure	Target value of reliability for each SIL level standardized in IEC61508. There are PFD and PFH depending on the operation frequency of the safety functions.
NC	Abbreviation for normal close contact which is normally closed, but opened when a switch or other function is operated
NO	Abbreviation for normal open contact which is normally opened, but closed when a switch or other function is operated
Close contact	Same as NC
Open contact	Same as NO
Dark test	Outputs a pulse to turn off the input/output when it is on, and performs the failure diagnostics to contacts including external equipment

CHAPTER 1 OVERVIEW

This chapter describes the overview of the safety programmable controller.
The safety programmable controller has acquired certification of the highest safety level (SIL3 of IEC 61508, Category 4 of EN 654-1, and Category 4 performance level "e" of EN ISO 13849-1) applicable to programmable controllers.

The safety programmable controller can be used to construct a safety system meeting requirements of these safety standards.
The system configuration diagram of the safety programmable controller is shown in Figure 1.1.

- Mount a safety power supply module, a safety CPU module, and a CC-Link Safety master module on the safety main base unit.
- Connect the CC-Link Safety master module and a CC-Link Safety remote I/O module to a network.
- When performing safety communication, mount a CC-Link IE Field Network master/local module (with safety functions) on the safety main base unit, and connect it to a network.
- Connect a personal computer with GX Developer installed to the safety CPU module via USB when setting programs and parameters.

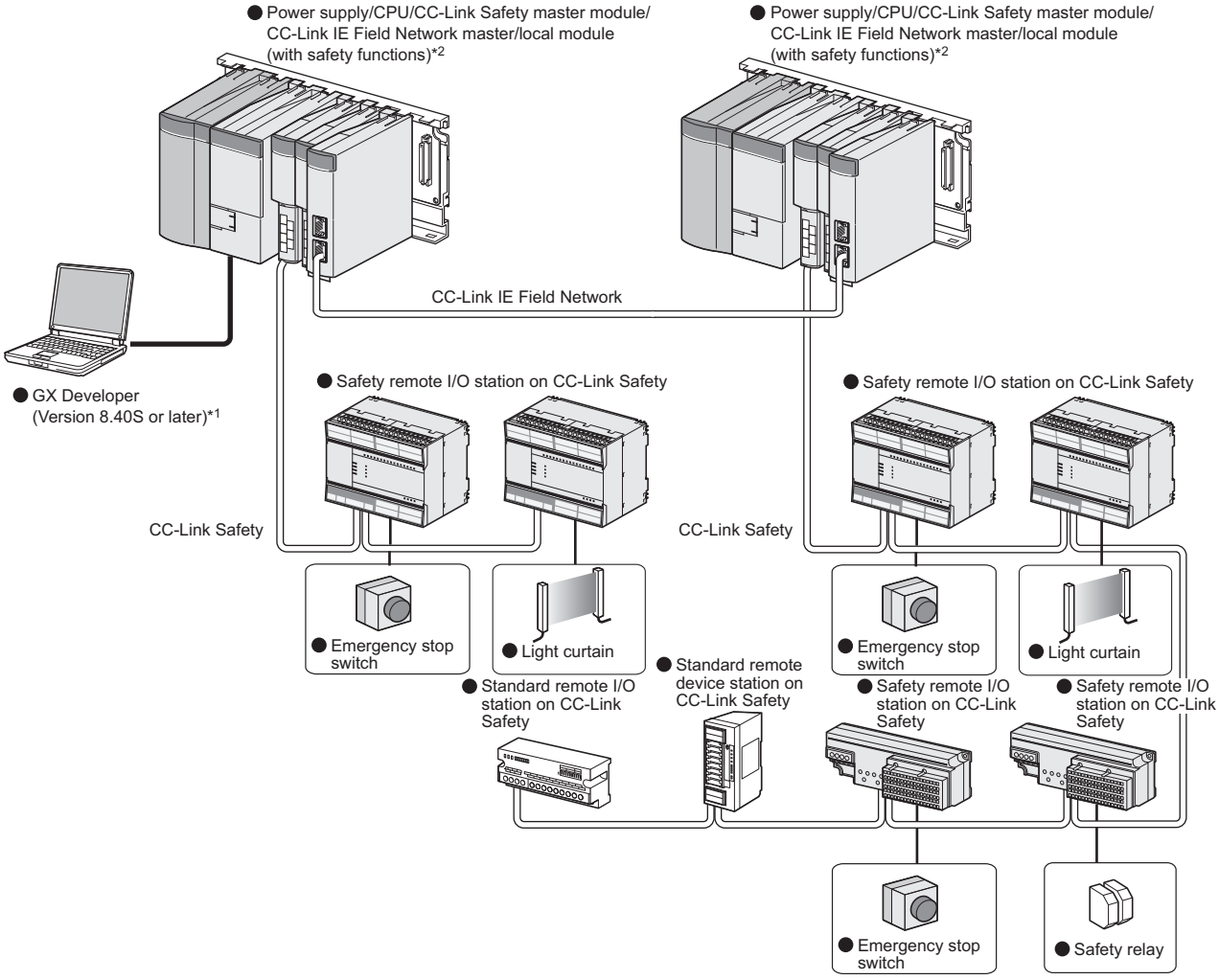


Figure 1.1 System configuration of safety programmable controller

* 1 : The available functions vary depending on the version. For details, refer to the following.

☞ QSCPU User's Manual (Function Explanation, Program Fundamentals)

* 2 : For details on a CC-Link IE Field Network master/local module (with safety functions), refer to the following.

☞ MELSEC-QS CC-Link IE Field Network Master/Local Module User's Manual

CHAPTER 2 APPLICATION EXAMPLE

(1) When performing safety control for the entire line using a single safety programmable controller

The application image for the car welding line is shown as an application example of the safety programmable controller in Figure 2.1.

A safety application operated by the safety programmable controller is configured for the following purposes:

- When safety is ensured using the safe state signal, power is supplied to robots.
- When safety is not ensured using the safe state signal, the power is cut off.
- The safe state signal can be checked using an emergency stop switch or a light curtain.

The safety programmable controller operates as follows:

- Connect a safe state signal to the CC-Link Safety remote I/O module.
- The CC-Link Safety remote I/O module sends the safe state signal to the safety CPU module. The safety CPU module processes the received signal in the sequence program, and sends a safety output to the CC-Link Safety remote I/O module.
- The safety output cuts off the power to the robots.

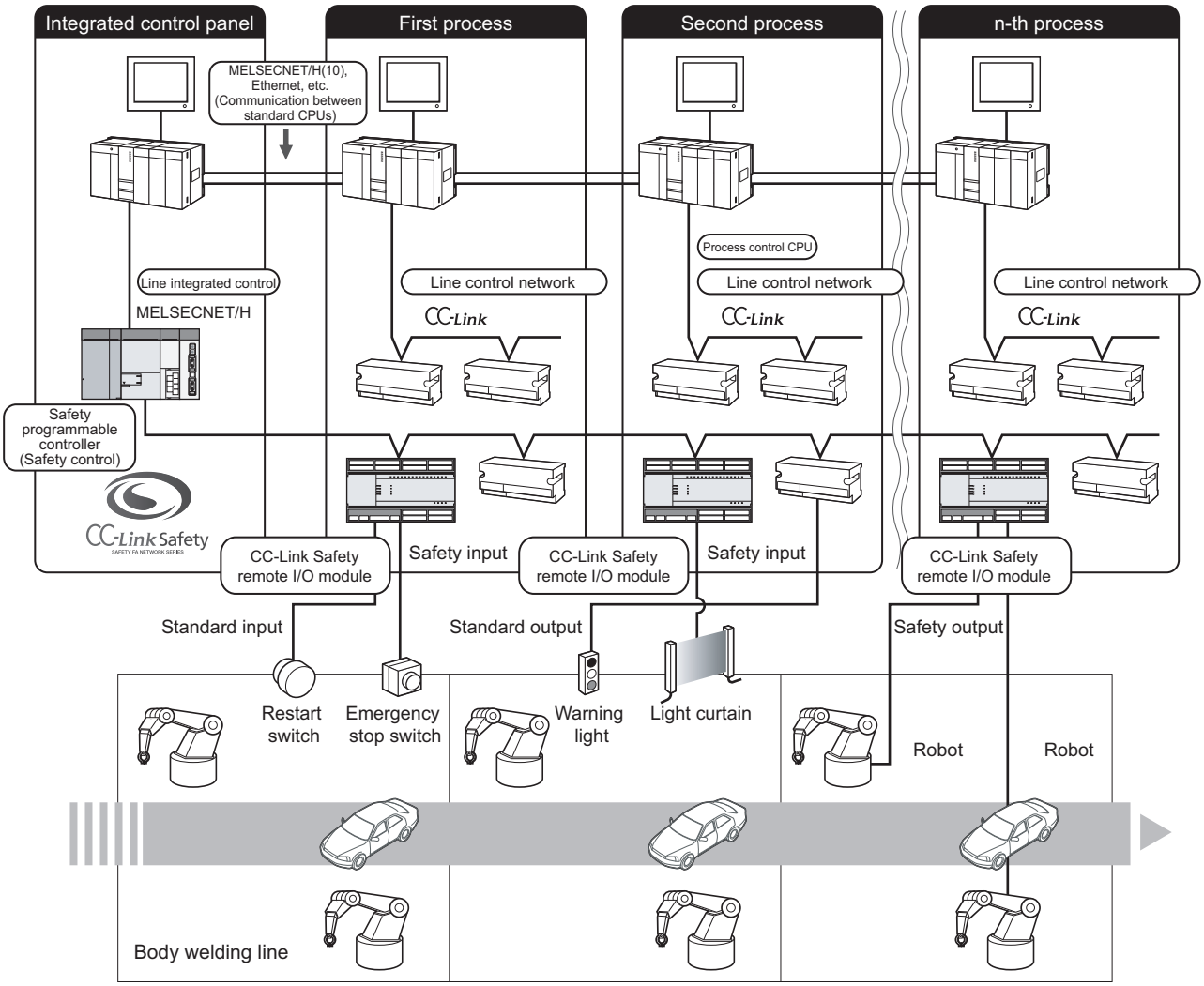


Figure 2.1 Safety control for the entire line using a single safety programmable controller

(2) When performing safety control for the entire line using several safety programmable controllers

Figure 2.2 shows an application of safety control interfacing with control processes.

A safety application operated by safety programmable controllers is configured for the following purposes:

- When safety is ensured using the safe state signal, power is supplied to robots.
- When safety is not ensured using the safe state signal, the power is cut off.
- The safe state signal can be checked using an emergency stop switch or a light curtain.
- Using safety communication, safety programmable controllers on CC-Link IE Field Network can perform safety control interfacing some processes or the entire process.

The safety programmable controller in each process operates as follows:

- Connect a safe state signal to the CC-Link Safety remote I/O module.
- Connect safety programmable controllers in all processes through CC-Link IE Field Network.
- The CC-Link Safety remote I/O module sends the safety state signal to the safety CPU module.
- To perform emergency stop for consecutive processes or the entire line, perform safety communication in CC-Link IE Field Network using sequence program. An emergency stop request is sent to the safety programmable controllers in the consecutive processes or in the entire line.
- The safety CPU module processes the safe state signal received from the CC-Link Safety remote I/O module and an emergency stop request received by safety communication through CC-Link IE Field Network using the sequence program, and sends a safety output to the CC-Link Safety remote I/O module.
- The safety output cuts off the power to the robots.

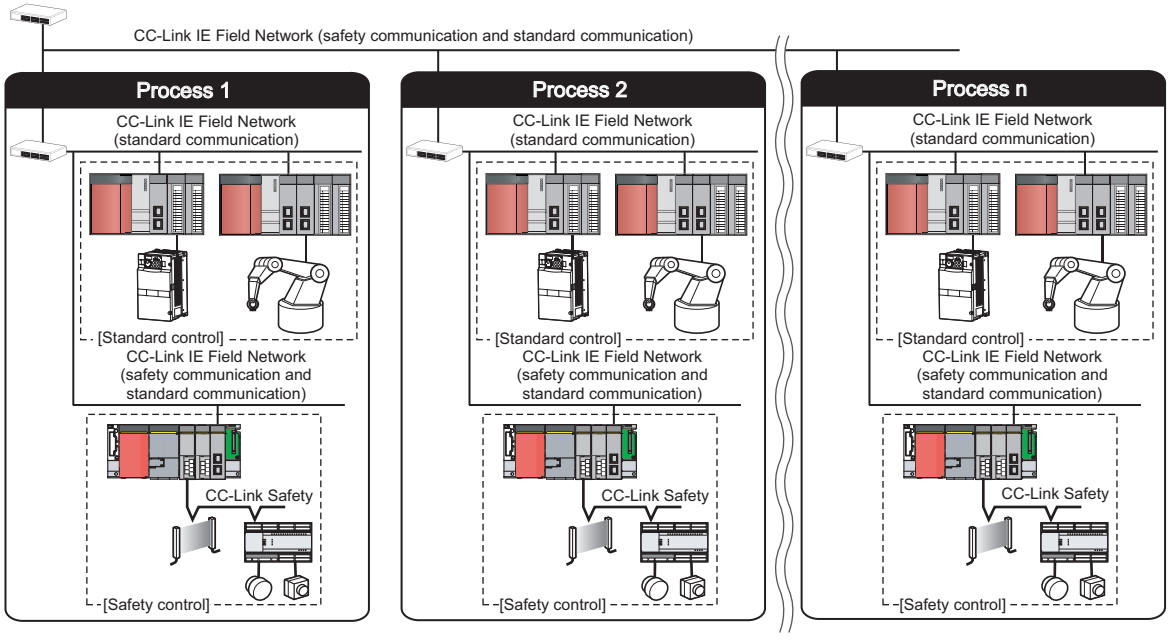


Figure 2.2 Safety control interfacing with control processes

CHAPTER 3 RISK ASSESSMENT AND SAFETY LEVEL

Conforming to EN954-1, ISO13849-1, and IEC61508, select the risk assessment, safety category, PL, and SIL to reduce the risk.
This chapter briefly describes the risk assessment, risk reduction and safety category, PL, and SIL.
For details, refer to each standard.

3.1 Risk Assessment

The risk assessment is to clarify hazards in a machine and assess the degree of the hazards.
The risk assessment procedure is shown in Figure 3.1. This procedure is standardized in ISO12100 and 14121.

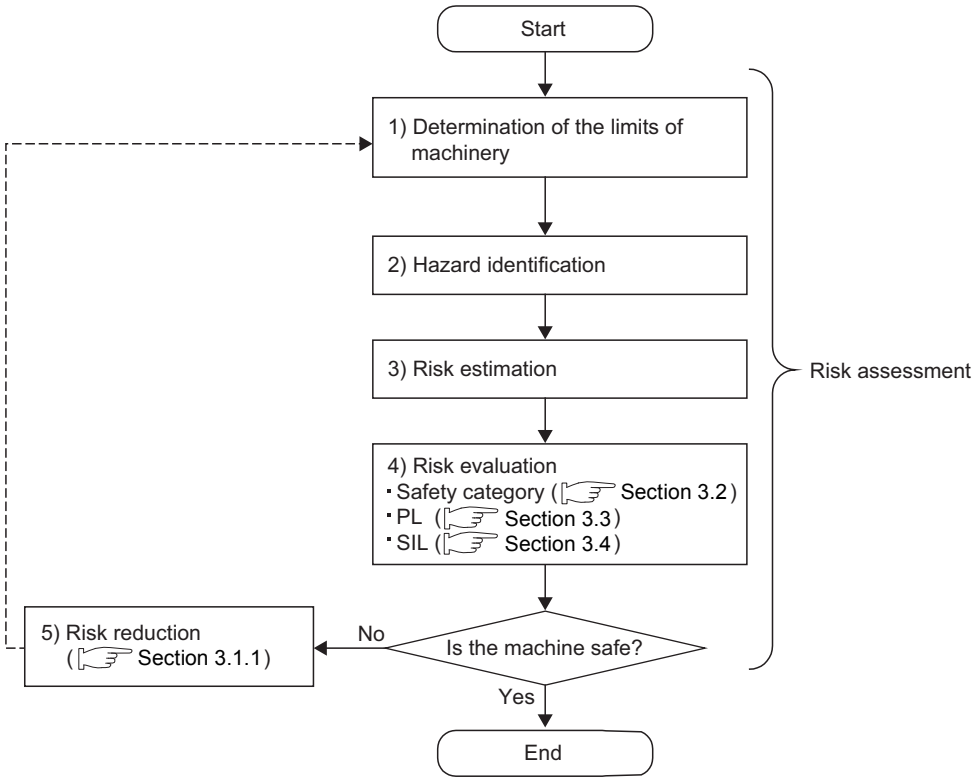


Figure 3.1 Risk assessment procedure

(Referred to ISO12100.)

3.1.1 Risk reduction

As a result of the risk assessment, when the machinery is judged as unsafe, the risk reduction must be performed.
The measures for the risk reduction are standardized in ISO12100 and ISO14121 as shown in Figure 3.2.

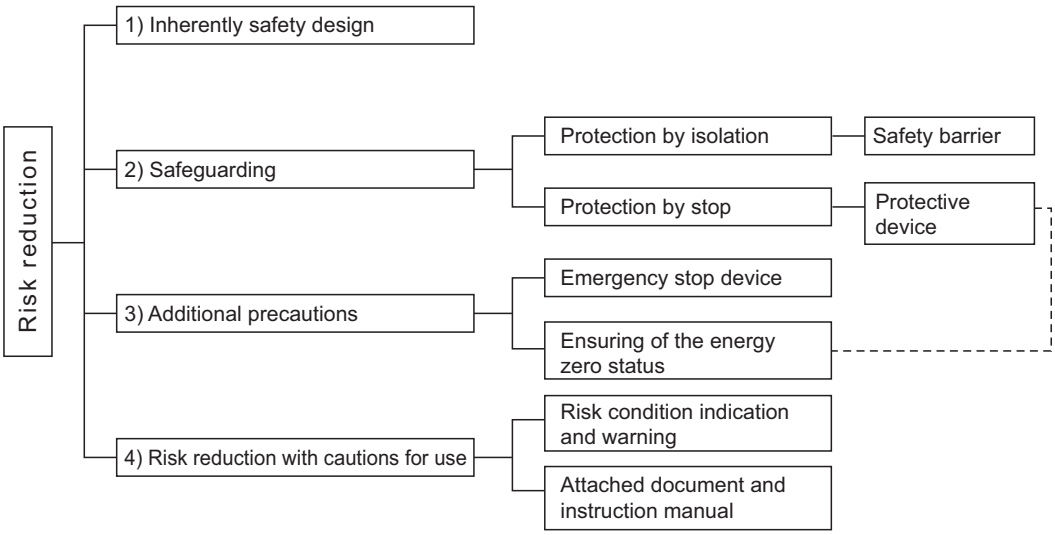


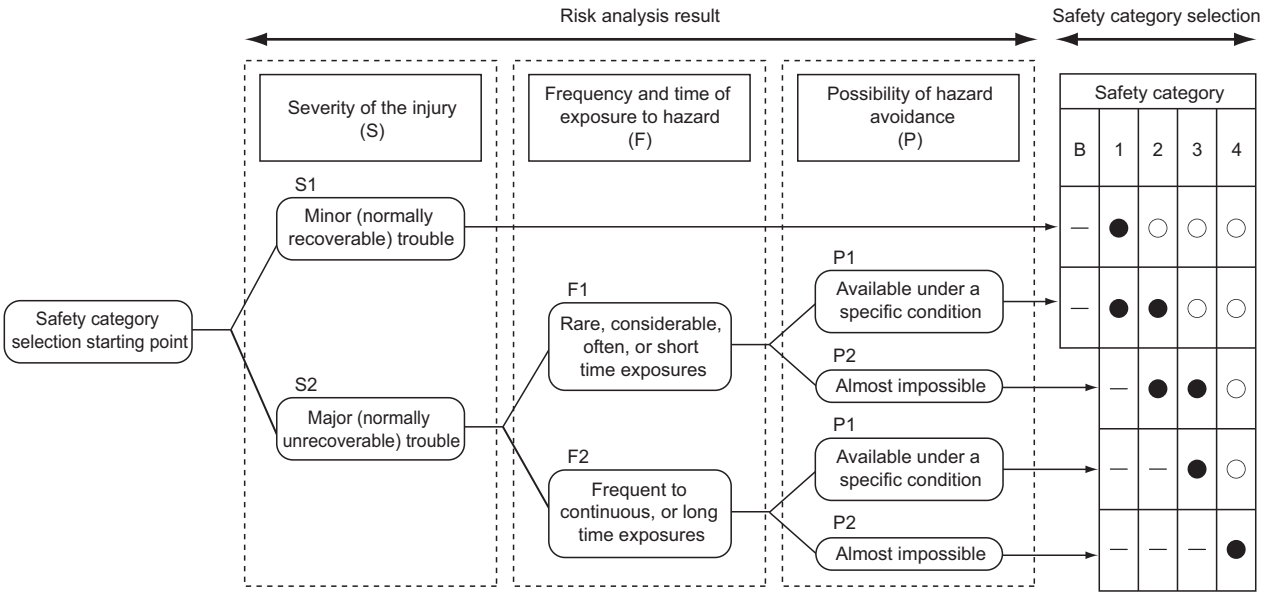
Figure 3.2 Risk reduction

(Referred to ISO12100 and 14121.)

According to the procedure of Figure 3.1, combine and execute the several risk reduction measures until the machine is safe.

3.2 Safety Category

The safety category is standardized in EN954-1.
The risk graph to be used for the safety category selection is shown in Figure 3.3.



Definition of symbols:

Symbol	Definition
●	Safety category which is desirable as a reference point
○	Safety category which may be over-specification
—	Insufficient safety category

Figure 3.3 Safety category selection relevant to safety related sections of control system

(Referred to EN954-1.)

The requirements of standards for the safety category are shown in Table 3.1.

Table 3.1 Summary of safety category requirements

Category*1	Summary of requirements	System behavior*2	Principles to achieve safety
B	Safety-related parts of control systems and/or their protective equipment, as well as their components, shall be designed, constructed, selected, assembled and combined in accordance with relevant standards so that they can withstand the expected influence.	The occurrence of a fault can lead to loss of the safety function.	Mainly characterized by selection of components
1	Requirements of B shall apply. Well-tried components and well-tried safety principles shall be used.	The occurrence of a fault can lead to loss of the safety function, but the probability of occurrence is lower than for category B.	
2	Requirements of B and the use of well-tried safety principles shall apply. Safety function shall be checked at suitable intervals by the machine control system.	-- The occurrence of a fault can lead to loss of the safety function between the checks. -- The loss of safety function is detected by the check.	Mainly characterized by structure
3	Requirements of B and the use of well-tried safety principles shall apply. -- a single fault in any of these parts does not lead to loss of the safety function, and -- whenever reasonably practicable the single fault is detected.	-- When a single fault occurs, the safety function is always performed. -- Some but not all faults will be detected. -- Accumulation of undetected faults can lead to loss of the safety function.	
4	Requirements of B and the use of well-tried safety principles shall apply. -- a single fault in any of these parts does not lead to loss of the safety function, and -- the single fault is detected at or before the next demand upon the safety function. If this is not possible, then an accumulation of faults shall not lead to loss of the safety function.	-- When the faults occur the safety function is always performed. -- The faults will be detected in time to prevent loss of the safety function.	

* 1: The categories are not intended to be used in any given order or in any given hierarchy in respect of safety requirements.

* 2: The risk assessment will indicate whether the total or partial loss of the safety function(s) arising from faults is acceptable.

(Referred to EN954-1.)

3.3 PL

The PL is specified in ISO13849-1.
Determine a required performance level (PLr). The PLr refers to a performance level required for safety functions to achieve required risk reduction.
Figure 3.4 is a risk graph used to determine a PLr.

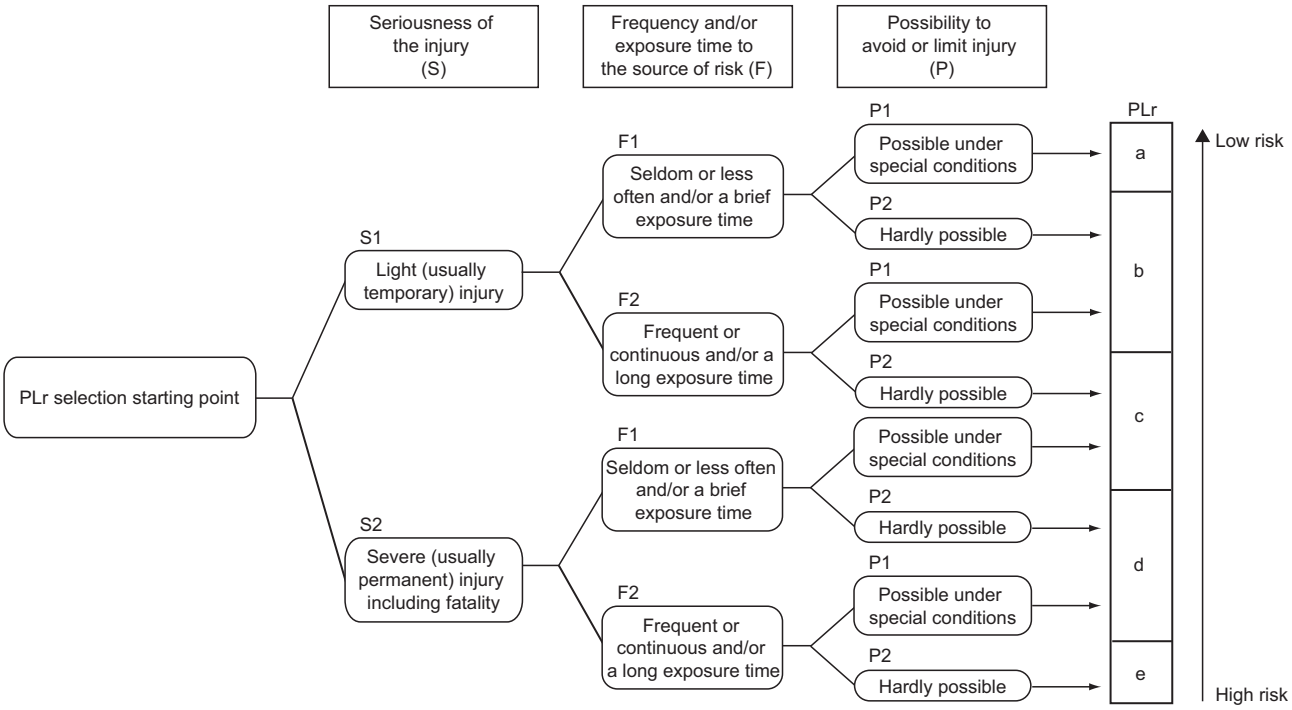


Figure 3.4 Risk graph

(Referred to ISO13849-1.)

Figure 3.5 shows relationship between Category, DCavg (average diagnostic coverage), and MTTFd (mean time to dangerous failure) of each channel and the resulting PL.

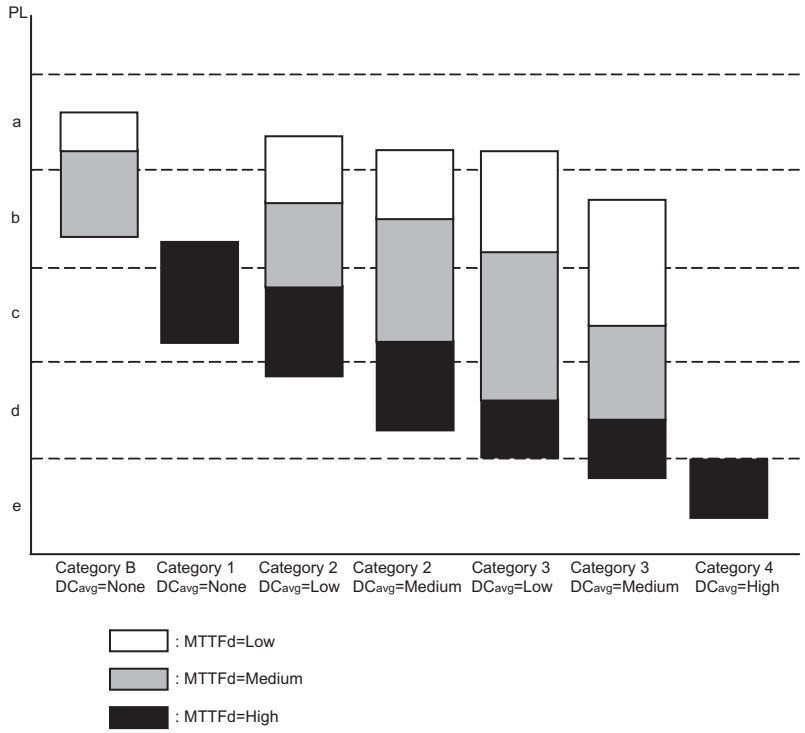


Figure 3.5 Relationship between Category, DCavg, and MTTFd of each channel and the resulting PL
(Referred to ISO13849-1.)

Refer to the following summary of safety category requirements.

Table 3.2 MTTFd (mean time to dangerous failure)

Level	Range
Low	3 years≦ MTTFd ＜10 years
Medium	10 years ≦ MTTFd ＜30 years
High	30 years ≦ MTTFd ≦100 years

Table 3.3 DCavg (average diagnostic coverage)

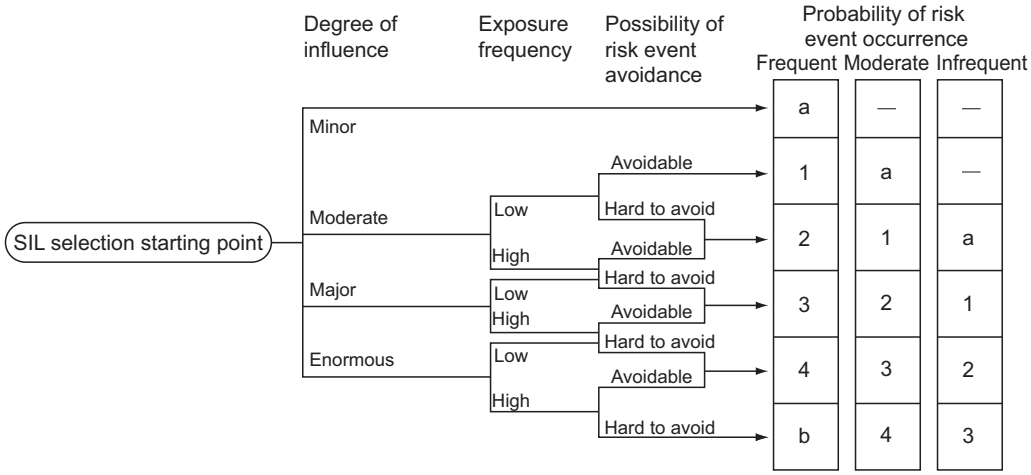
Level	Range
None	DCavg ＜60%
Low	60%≦ DCavg ＜90%
Medium	90%≦ DCavg ＜99%
High	99%≦ DCavg

The PL of a safety-related part in control system must be higher than or equal to the PLr of the safety function.

PL ≧ PLr

3.4 SIL

SIL is standardized in IEC61508.
The risk graph to be used for the SIL selection is shown in Figure 3.6.



Definition of symbols:

Symbol	Definition
—, a	No safety requirements.
b	Not sufficient with a single safety-related system.
1,2,3,4	Safety integrity level Stands for SIL1, SIL2, SIL3 and SIL4 respectively.

Figure 3.6 SIL risk graph

(Referred to IEC61508-5.)

In SIL, the following target failure measure is defined according to the level.

Table 3.4 Target failure measure (PFD,PFH)

SIL	Low demand mode of operation*1	High demand mode of operation*1
4	$10^{-5} \leqq PFD < 10^{-4}$	$10^{-9} \leqq PFH < 10^{-8}$
3	$10^{-4} \leqq PFD < 10^{-3}$	$10^{-8} \leqq PFH < 10^{-7}$
2	$10^{-3} \leqq PFD < 10^{-2}$	$10^{-7} \leqq PFH < 10^{-6}$
1	$10^{-2} \leqq PFD < 10^{-1}$	$10^{-6} \leqq PFH < 10^{-5}$

* 1: For the low and high demand modes of operation, refer to IEC61508.

(Referred to IEC61508-1.)

CHAPTER 4 PRECAUTIONS FOR USE OF SAFETY PROGRAMMABLE CONTROLLER

The safety standards conformance approval must be made by the user for the entire safety-related system.
The safety system inspection is made for the entire safety-related system including safety components and a sequence program.
The sample program is shown in CHAPTER 5 and CHAPTER 6. However, the safety standards approval is not obtained.
And all work for safety-related system construction (e.g. design, installation, operation, maintenance) has to be handled by the person who has an enough education concerning safety standards, safety devices, and safety programmable controller.

4.1 Precautions for Designing Safety Application

(1) Response time

The response time is a time from the safety input off to the safety output off using the safety programmable controller.
The response time is needed for determining the safety distance for a safety-related system.
Calculate the response time of a system to be configured with referring to Appendix 1 and Appendix 2.

POINT

For the safety programmable controller, connecting GX Developer makes the response time longer. Do not constantly connect GX Developer during the safety-related system operation.

(2) Target failure measure (PFD/PFH) calculation

Target failure measure (PFD/PFH) is the target value of reliability for each SIL level standardized in IEC61508.(☞ Section 3.4)
Calculate the target failure measure (PFD/PFH) with the following formula for each safety function.

PFD/PFH = A + B + C + D ⋯ Calculation formula of PFD/PFH

Table 4.1 Definition of each variable

Variable	Definition
A	PFD/PFH of safety CPU module, safety power supply module, safety main base unit, CC-Link Safety master module, and CC-Link IE Field Network master/local module (with safety functions)
B	PFD/PFH of the CC-Link Safety remote I/O module (1) The safety input device and safety output device are connected to the same CC-Link Safety remote I/O module: B = B1 (2) The safety input device and safety output device are connected to the different CC-Link Safety remote I/O modules: B = B1 + B2
B1	PFD/PFH of the CC-Link Safety remote I/O module to which the safety input device is connected

Variable	Definition
B2	PFD/PFH of the CC-Link Safety remote I/O module to which the safety output device is connected
C*1	PFD/PFH of safety input equipment
D*1	PFD/PFH of safety output equipment

* 1: For PFD/PFH of C and D, refer to the manuals, etc. of the used safety components.

PFD/PFH of the safety programmable controller is listed in Table 4.2.

Table 4.2 PFD/PFH of safety programmable controller

Module/unit		PFD	PFH
PFD/PFH of safety CPU module		4.10×10^{-5} *2	9.20×10^{-10} *2
PFD/PFH of safety power supply module	QS061P-A1	8.75×10^{-5} *3	3.85×10^{-9} *3
	QS061P-A2	8.75×10^{-5} *4	3.85×10^{-9} *4
PFD/PFH of safety main base unit*1		–	–
PFD/PFH of CC-Link Safety master module*1		–	–
PFD/PFH of CC-Link Safety remote I/O module	QS0J65BTB2-12DT (DC input transistor output combined module)	2.57×10^{-5}	1.15×10^{-9}
	QS0J65BTS2-8D (DC input module)	1.68×10^{-5}	7.46×10^{-10}
	QS0J65BTS2-4T (transistor output module)	1.68×10^{-5}	7.46×10^{-10}
PFD/PFH of CC-Link IE Field Network master/local module (with safety functions)*1		–	–

* 1: PFD and PFH are not required for the following modules:
  - Safety main base unit
  - CC-Link Safety master module
  - CC-Link IE Field Network master/local module (with safety functions)
* 2: For the safety CPU module with the serial number "12□□□3" or earlier (first six digits), the PFD and PFH values are as follows: PFD = 5.22×10^{-5} and PFH = 1.15×10^{-9}. (□□□ contains any figure.)
* 3: For the QS061P-A1 with the serial number "12□□□5" or earlier (first six digits), the PFD and PFH values are as follows: PFD = 8.67×10^{-5} and PFH = 3.80×10^{-9}. (□□□ contains any figure.)
* 4: For the QS061P-A2 with the serial number "12□□□9" or earlier (first six digits), the PFD and PFH values are as follows: PFD = 8.67×10^{-5} and PFH = 3.80×10^{-9}. (□□□ contains any figure.)

(a) When using one QS0J65BTB2-12DT

PFD = (PFD of A) + (PFD of B) + (PFD of C) + (PFD of D)

= $(4.10 \times 10^{-5} + 8.75 \times 10^{-5}) + (2.57 \times 10^{-5})$ + (PFD of C) + (PFD of D)

= (1.54×10^{-4}) + (PFD of C) + (PFD of D)

PFH = (PFH of A) + (PFH of B) + (PFH of C) + (PFH of D)

= $(9.20 \times 10^{-10} + 3.85 \times 10^{-9}) + (1.15 \times 10^{-9})$ + (PFH of C) + (PFH of D)

= (5.92×10^{-9}) + (PFH of C) + (PFH of D)

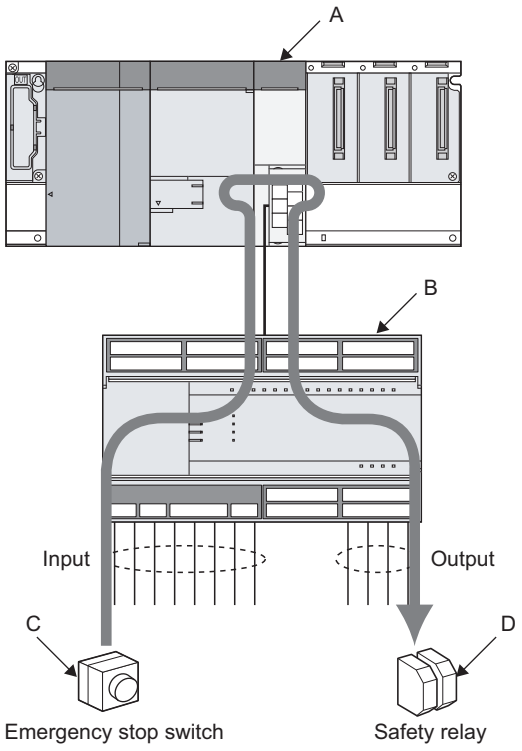


Figure 4.1 Example when one QS0J65BTB2-12DT is used

(b) When using one QS0J65BTS2-8D and one QS0J65BTS2-4T

PFD = (PFD of A) + (PFD of B) + (PFD of C) + (PFD of D)

= (4.10 $\times 10^{-5}$ + 8.75 $\times 10^{-5}$) + (1.68 $\times 10^{-5}$ + 1.68 $\times 10^{-5}$) + (PFD of C) + (PFD of D)

= (1.62 $\times 10^{-4}$) + (PFD of C) + (PFD of D)

PFH = (PFH of A) + (PFH of B) + (PFH of C) + (PFH of D)

= (9.20 $\times 10^{-10}$ + 3.85 $\times 10^{-9}$) + (7.46 $\times 10^{-10}$ + 7.46 $\times 10^{-10}$) + (PFH of C) + (PFH of D)

= (6.26 $\times 10^{-9}$) + (PFH of C) + (PFH of D)

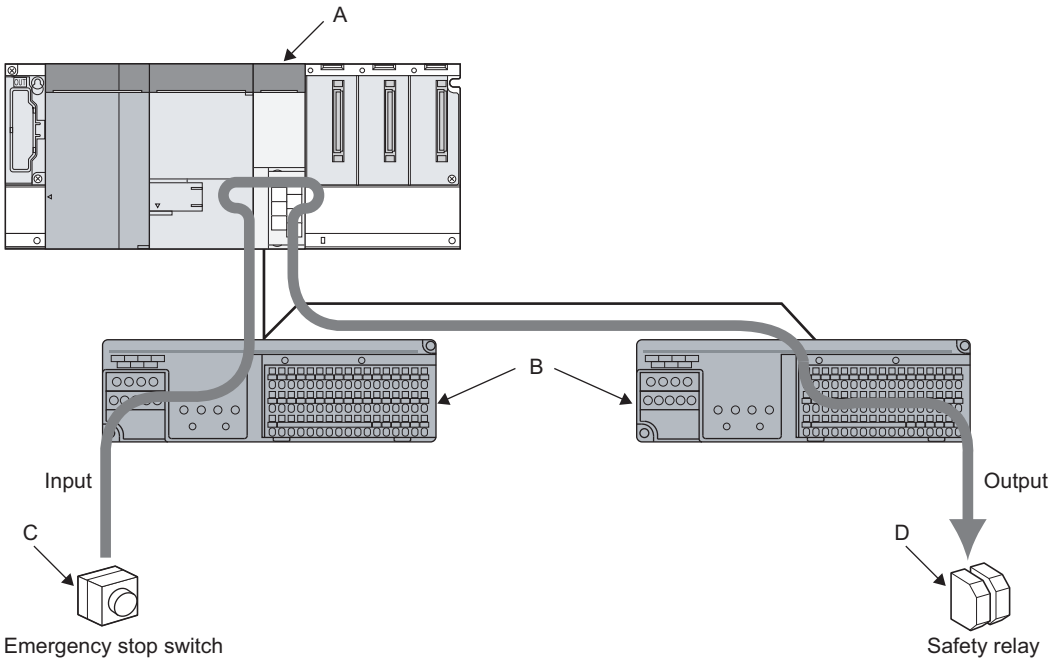


Figure 4.2 Example when one QS0J65BTS2-8D and one QS0J65BTS2-4T are used

(c) When using CC-Link IE Field Network between safety programmable controllers

PFD = (PFD of input side A) + (PFD of input side B) + (PFD of C) + (PFD of output side A) + (PFD of output side B) + (PFD of D)

$= (4.10 \times 10^{-5} + 8.75 \times 10^{-5}) + (2.57 \times 10^{-5}) + (\text{PFD of C}) + (4.10 \times 10^{-5} + 8.75 \times 10^{-5}) + (2.57 \times 10^{-5}) + (\text{PFD of D})$

$= (3.08 \times 10^{-4}) + (\text{PFD of C}) + (\text{PFD of D})$

PFH = (PFH of input side A) + (PFH of input side B) + (PFH of C) + (PFH of output side A) + (PFH of output side B) + (PFH of D)

$= (9.20 \times 10^{-10} + 3.85 \times 10^{-9}) + (1.15 \times 10^{-9}) + (\text{PFH of C}) + (9.20 \times 10^{-10} + 3.85 \times 10^{-9}) + (1.15 \times 10^{-9}) + (\text{PFH of D})$

$= (1.18 \times 10^{-8}) + (\text{PFH of C}) + (\text{PFH of D})$

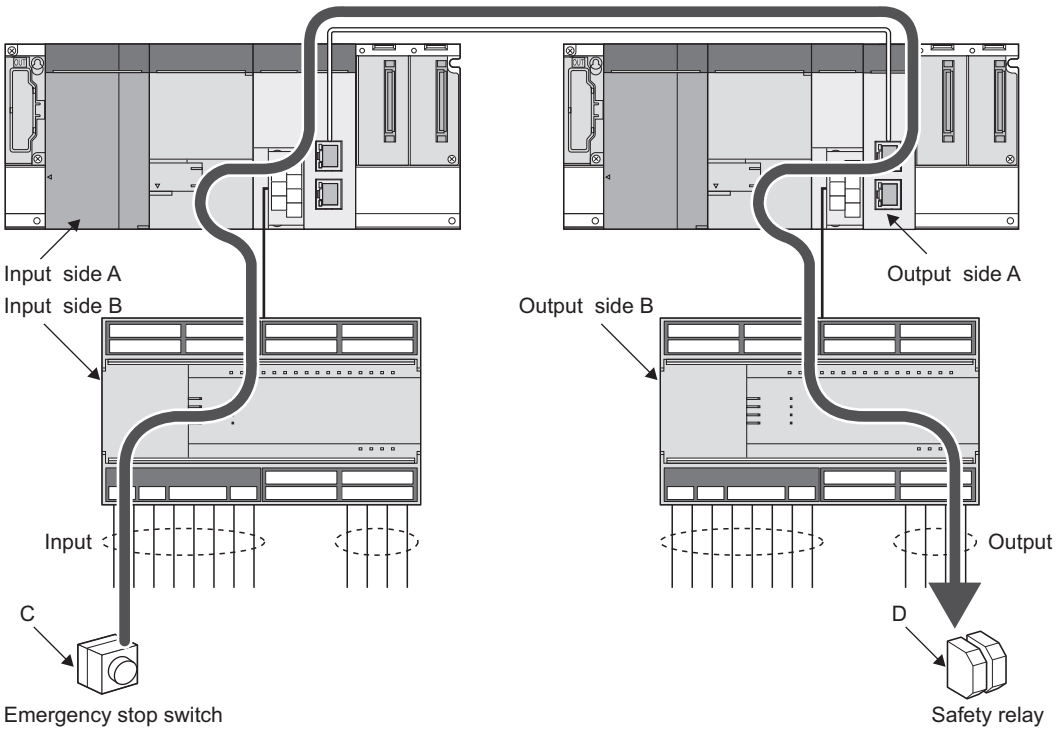


Figure 4.3 Example when CC-Link IE Field Network are used

(d) When using CC-Link IE Field Network between safety programmable controllers (multiple output points)

PFD = (PFD of A1) + (PFD of B1) + (PFD of C1) + (PFD of D1)
+ (PFD of A2) + (PFD of B2) + (PFD of D2)
= $(4.10 \times 10^{-5} + 8.75 \times 10^{-5}) + (2.57 \times 10^{-5})$ + (PFD of C1) + (PFD of D1)
+ $(4.10 \times 10^{-5} + 8.75 \times 10^{-5}) + (2.57 \times 10^{-5})$ + (PFD of D2)
= (3.08×10^{-4}) + (PFD of C1) + (PFD of D1) + (PFD of D2)

PFH = (PFH of A1) + (PFH of B1) + (PFH of C1) + (PFH of D1)
+ (PFH of A2) + (PFH of B2) + (PFH of D2)
= $(9.20 \times 10^{-10} + 3.85 \times 10^{-9}) + (1.15 \times 10^{-9})$ + (PFH of C1) + (PFH of D1)
+ $(9.20 \times 10^{-10} + 3.85 \times 10^{-9}) + (1.15 \times 10^{-9})$ + (PFH of D2)
= (1.18×10^{-8}) + (PFH of C1) + (PFH of D1) + (PFH of D2)

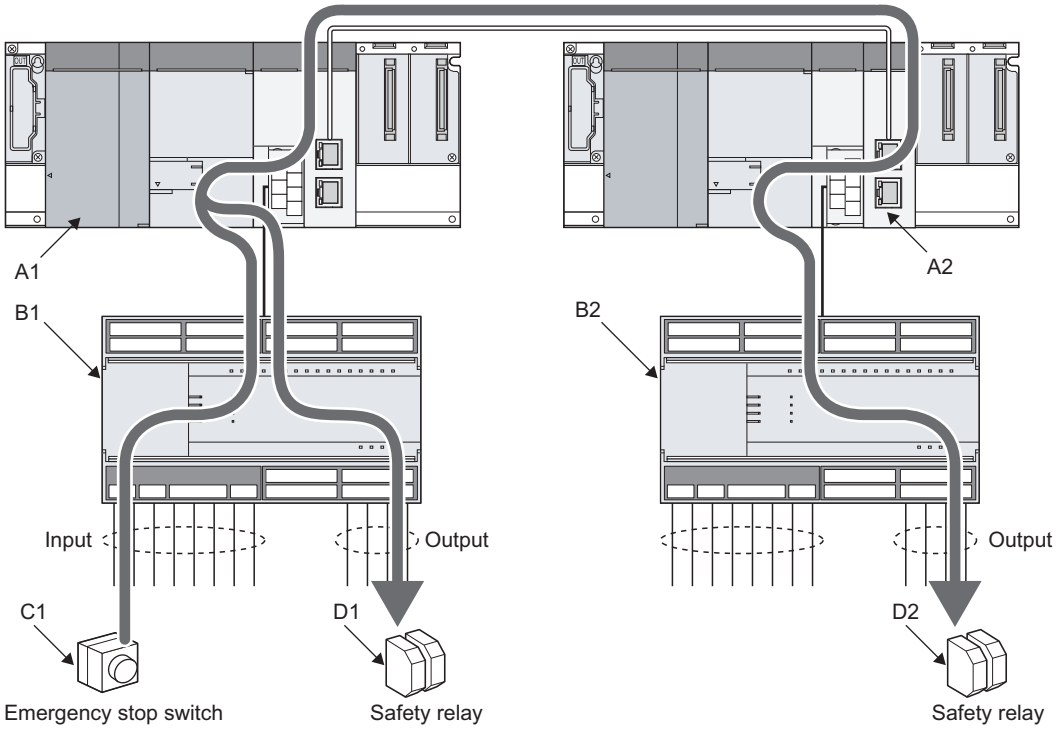


Figure 4.4 Example when CC-Link IE Field Network are used (multiple output points)

(3) Connecting safety components

Connect safety components according to the safety level by dual wiring and single wiring as shown in Figure 4.5.

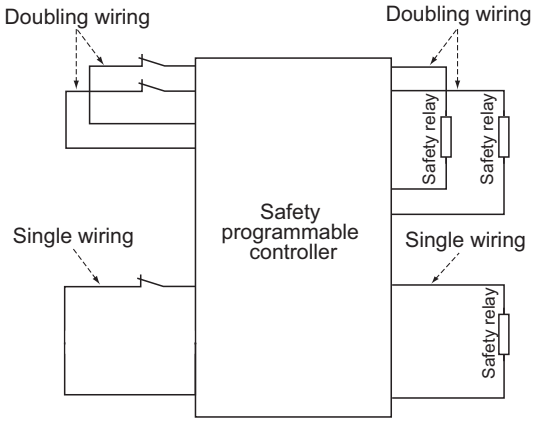


Figure 4.5 Wiring of safety components

POINT

Use the doubling input signal to the CC-Link Safety remote I/O module with the following combinations of input terminals.
For combinations other than the followings, an error is detected by doubling input discrepancy detection.
{X00, X01}, {X02, X03}, {X04, X05}, {X06, X07}
{X08, X09}, {X0A, X0B}, {X0C, X0D}, {X0E, X0F}

To execute the Input dark test function, connect the safety components using a test pulse terminal.

POINT

To execute the Input dark test function, use the test pulse terminals and input terminals of the CC-Link Safety remote I/O module with the following combinations.
Connecting to the incorrect test pulse terminal is identified as a wire break and causes an error.
Correct combination
{X00, X02, X04, X06, X08, X0A, X0C, X0E} and T0
{X01, X03, X05, X07, X09, X0B, X0D, X0F} and T1

When not performing input dark test, the COM+ terminal can be used.

For wiring and setting methods, refer to CHAPTER 5 and CHAPTER 6.
For details on dual wiring, single wiring, and input dark test, refer to the following.
☞ CC-Link Safety System Remote I/O Module User's Manual

(4) Using the monitor data of GX Developer

The monitor data of GX Developer should not be used for the operation related to the safety.

(For example, the operations for the safety such as starting a machine or resetting the stop status should not be performed with checking the monitor data of GX Developer.)

4.2 Precautions for Programming

(1) Basic programming

Configure a program for realizing safety functions with attention to the following points.

- Program so that a machine is started only when safe state can be confirmed at the time the start switch is pressed.
- Program so that a machine is stopped if the safe state is not confirmed.
- Program so that a machine is started at the fall (on→off) of the signal of the start switch.
  The programming can prevent a machine from accidentally starting at the switch failure (such as contact welding, spring damage).
- To inhibit restart without manual operation after safety functions were performed and outputs were turned off, create an interlock program which uses a reset button for restart.

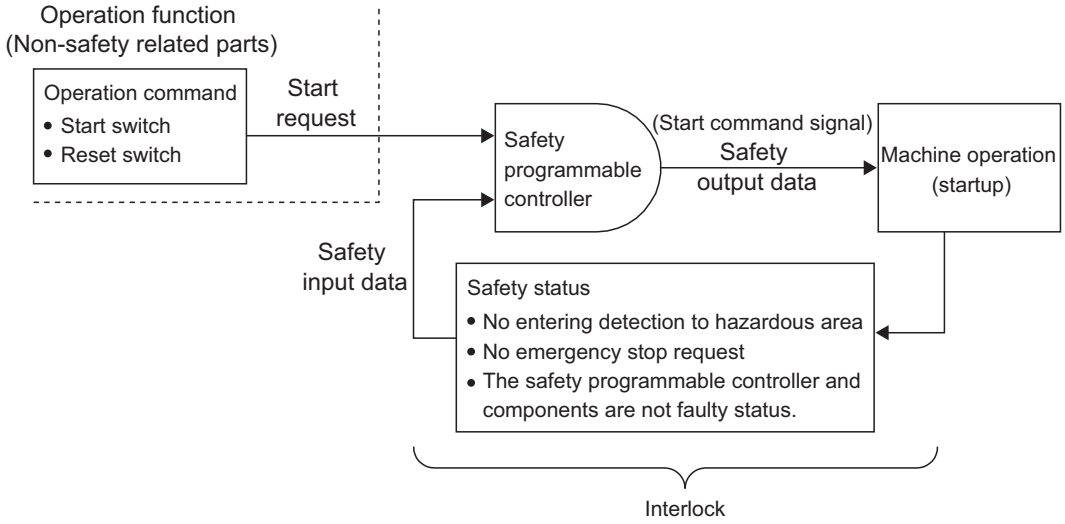


Figure 4.6 Configuration example of safety-related system

For program examples, refer to CHAPTER 5 and CHAPTER 6.

(2) Devices used in a program for realizing the safety functions

Data can be used as safety I/O data are the following safety refresh devices. Use the safety refresh devices to create a program for realizing the safety functions.

(a) Safety refresh device

- Internal device data refreshed by communication with safety remote I/O stations on CC-Link Safety

  Safety data is refreshed by communication with safety remote I/O stations on CC-Link Safety.

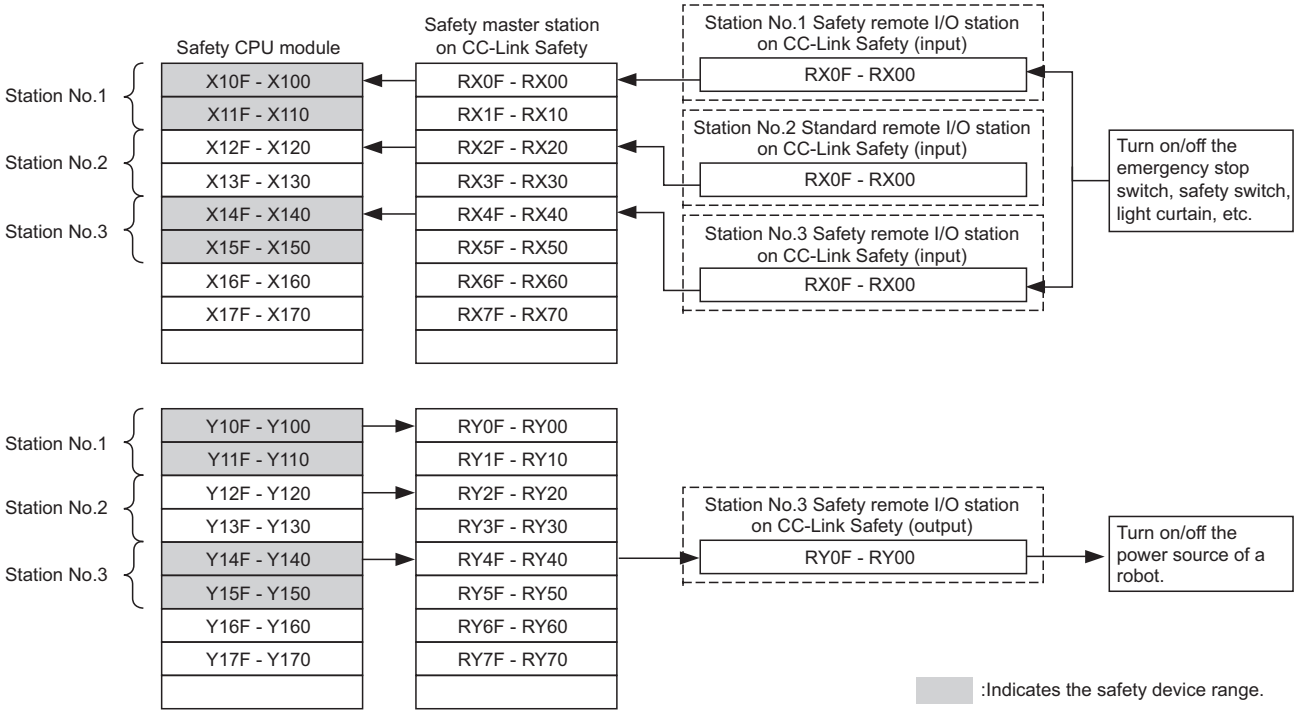


Figure 4.7 I/O data of safety remote I/O stations on CC-Link Safety*1

* 1: Figure 4.7 shows a case where X100 and Y100 are set with the auto refresh parameter.
The following device ranges actually not input/output to the safety remote I/O stations on CC-Link Safety are included.
Station No. 1: X110 to X11F, Y110 to Y11F, Station No. 3: X150 to X15F, Y150 to Y15F

- Device data transferred between safety stations on CC-Link IE Field Network

  Safety data are transferred between safety stations on CC-Link IE Field Network.

  For details, refer to the MELSEC-QS CC-Link IE Field Network Master/Local Module User's Manual.

(b) Special relay (SM), special register (SD)

Only the following devices can be used in a program that can perform safety functions.

- CC-Link Safety-related devices, SM1000 to SM1299 and SD1000 to SD1299
- CC-Link IE Field Network-related devices, SM1400 to SM1799 and SD1400 to SD1799

(3) Detecting errors in CC-Link Safety

Errors occurred in CC-Link Safety can be detected using safety refresh communication status shown in Table 4.3.

Create a program using safety refresh communication status, which turns off safety outputs in case of an error.

(a) Safety refresh communication status

Table 4.3 shows special registers to check safety refresh communication status.

Table 4.3 Special register names and numbers

<table>
<tr><th rowspan="3">Name</th><th rowspan="3">No.</th><th>Description</th></tr>
<tr><th>Description of bits of the following table
0: Normal communication, reserved station, unused station, standard remote station on CC-Link Safety
1: Safety station communication error</th></tr>
<tr><td></td><td></td></tr>
<tr><td>Safety refresh communication status of each safety remote station
(CC-Link Safety master module 1)</td><td>SD1004
to
SD1007</td><td>
<table>
<tr><th></th><th>b15</th><th>b14</th><th>to</th><th>b1</th><th>b0</th></tr>
<tr><td>SD1004</td><td>16</td><td>15</td><td>to</td><td>2</td><td>1</td></tr>
<tr><td>SD1005</td><td>32</td><td>31</td><td>to</td><td>18</td><td>17</td></tr>
<tr><td>SD1006</td><td>48</td><td>47</td><td>to</td><td>34</td><td>33</td></tr>
<tr><td>SD1007</td><td>64</td><td>63</td><td>to</td><td>50</td><td>49</td></tr>
</table>
1 to 64 in the table indicate the station numbers.
</td></tr>
<tr><td>Safety refresh communication status of each safety remote station
(CC-Link Safety master module 2)</td><td>SD1204
to
SD1207</td><td>
<table>
<tr><th></th><th>b15</th><th>b14</th><th>to</th><th>b1</th><th>b0</th></tr>
<tr><td>SD1204</td><td>16</td><td>15</td><td>to</td><td>2</td><td>1</td></tr>
<tr><td>SD1205</td><td>32</td><td>31</td><td>to</td><td>18</td><td>17</td></tr>
<tr><td>SD1206</td><td>48</td><td>47</td><td>to</td><td>34</td><td>33</td></tr>
<tr><td>SD1207</td><td>64</td><td>63</td><td>to</td><td>50</td><td>49</td></tr>
</table>
1 to 64 in the table indicate the station numbers.
</td></tr>
</table>

For details, refer to the following.

☞ QSCPU User's Manual (Function Explanation, Program Fundamentals)

(b) Program example

The program for handling the error detection of CC-Link Safety is shown in Figure 4.8.

Figure 4.8 shows the program used when outputting from the safety remote I/O station of station No.1 on CC-Link Safety connected to the first module of the CC-Link Safety master module using SD1004.0.

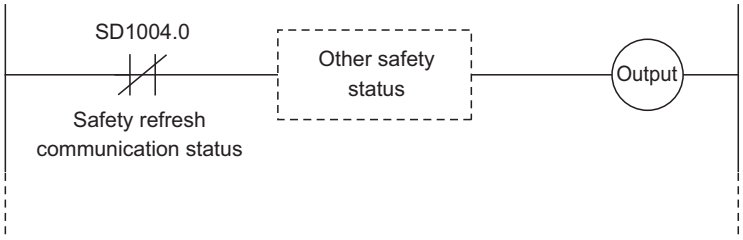


Figure 4.8 Program example for handling error detection of CC-Link Safety

(4) Resetting error status of CC-Link Safety

If an error occurs in CC-Link Safety, the safety station interlock status shown in Table 4.4 turns on.

To restart communication on CC-Link Safety, turn on the safety station interlock cancel request.

Create a program in which an safety station interlock cancel request is manually turned on (e.g. reset button).

Table 4.4 Special register names and numbers

<table>
<tr><th>Name</th><th>No.</th><th>Definition for bits special register (Safety station interlock status)</th></tr>
<tr><td>Safety station interlock status
(CC-Link Safety master module 1)</td><td>SD1072
to
SD1075</td><td>0: Does not interlocked.
1: During interlock
<table><tr><td></td><td>b15</td><td>b14</td><td>to</td><td>b1</td><td>b0</td></tr><tr><td>SD1072</td><td>16</td><td>15</td><td>to</td><td>2</td><td>1</td></tr><tr><td>SD1073</td><td>32</td><td>31</td><td>to</td><td>18</td><td>17</td></tr><tr><td>SD1074</td><td>48</td><td>47</td><td>to</td><td>34</td><td>33</td></tr><tr><td>SD1075</td><td>64</td><td>63</td><td>to</td><td>50</td><td>49</td></tr></table>1 to 64 in the table indicate the station numbers.</td></tr>
<tr><td>Safety station interlock cancel request
(CC-Link Safety master module 1)</td><td>SD1076
to
SD1079</td><td>0: I/O interlock of safety station on CC-Link Safety not released
1: I/O interlock of safety station on CC-Link Safety released
<table><tr><td></td><td>b15</td><td>b14</td><td>to</td><td>b1</td><td>b0</td></tr><tr><td>SD1076</td><td>16</td><td>15</td><td>to</td><td>2</td><td>1</td></tr><tr><td>SD1077</td><td>32</td><td>31</td><td>to</td><td>18</td><td>17</td></tr><tr><td>SD1078</td><td>48</td><td>47</td><td>to</td><td>34</td><td>33</td></tr><tr><td>SD1079</td><td>64</td><td>63</td><td>to</td><td>50</td><td>49</td></tr></table>1 to 64 in the table indicate the station numbers.</td></tr>
<tr><td>Safety station interlock status
(CC-Link Safety master module 2)</td><td>SD1272
to
SD1275</td><td>0: Does not interlocked.
1: During interlock
<table><tr><td></td><td>b15</td><td>b14</td><td>to</td><td>b1</td><td>b0</td></tr><tr><td>SD1272</td><td>16</td><td>15</td><td>to</td><td>2</td><td>1</td></tr><tr><td>SD1273</td><td>32</td><td>31</td><td>to</td><td>18</td><td>17</td></tr><tr><td>SD1274</td><td>48</td><td>47</td><td>to</td><td>34</td><td>33</td></tr><tr><td>SD1275</td><td>64</td><td>63</td><td>to</td><td>50</td><td>49</td></tr></table>1 to 64 in the table indicate the station numbers.</td></tr>
<tr><td>Safety station interlock cancel request
(CC-Link Safety master module 2)</td><td>SD1276
to
SD1279</td><td>0: I/O interlock of safety station on CC-Link Safety not released
1: I/O interlock of safety station on CC-Link Safety released
<table><tr><td></td><td>b15</td><td>b14</td><td>to</td><td>b1</td><td>b0</td></tr><tr><td>SD1276</td><td>16</td><td>15</td><td>to</td><td>2</td><td>1</td></tr><tr><td>SD1277</td><td>32</td><td>31</td><td>to</td><td>18</td><td>17</td></tr><tr><td>SD1278</td><td>48</td><td>47</td><td>to</td><td>34</td><td>33</td></tr><tr><td>SD1279</td><td>64</td><td>63</td><td>to</td><td>50</td><td>49</td></tr></table>1 to 64 in the table indicate the station numbers.</td></tr>
</table>

For details, refer to the following.

☞QSCPU User's Manual (Function Explanation, Program Fundamentals)

(a) Program example

Figure 4.9 shows the program when the interlock for the safety remote I/O station of station No. 1 on CC-Link Safety, connected to the first CC-Link Safety master module is cleared.

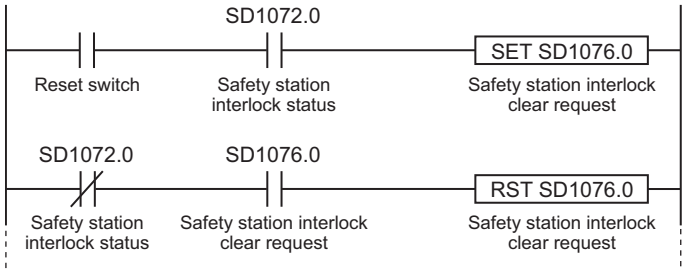


Figure 4.9 Program example to release interlock of CC-LInk Safety

(5) Detecting errors in CC-Link IE Field Network

Errors occurred in CC-Link IE Field Network can be detected using safety refresh communication status shown in Table 4.5.

Create a program using safety refresh communication status, which turns off safety outputs in case of an error.

(a) Safety refresh communication status

Table 4.5 shows the special relay and special registers to check the status of safety refresh communication between the own station and safety stations.

Table 4.5 Names and numbers of the special relay and special registers

<table>
<tr><th>Name</th><th>No.</th><th>Description</th></tr>
<tr><td>Safety refresh communication status of safety master station</td><td>SM1421</td><td>0: Normal or safety communication with master station on CC-Link IE Field Network not set
1: Safety refresh communication error</td></tr>
<tr><td>Safety refresh communication status of each safety station</td><td>SD1420 to SD1427</td><td>Description of bits of the following table
0: Normal communication, reserved station, unused station, standard station on CC-Link IE Field Network, or own station
1: Communication error of safety station on CC-Link IE Field Network

<table>
<tr><th></th><th>b15</th><th>to</th><th>b8</th><th>b7</th><th>to</th><th>b0</th></tr>
<tr><td>SD1420</td><td>16</td><td>to</td><td>9</td><td>8</td><td>to</td><td>1</td></tr>
<tr><td>SD1421</td><td>32</td><td>to</td><td>25</td><td>24</td><td>to</td><td>17</td></tr>
<tr><td>SD1422</td><td>48</td><td>to</td><td>41</td><td>40</td><td>to</td><td>33</td></tr>
<tr><td>SD1423</td><td>64</td><td>to</td><td>57</td><td>56</td><td>to</td><td>49</td></tr>
<tr><td>SD1424</td><td>80</td><td>to</td><td>73</td><td>72</td><td>to</td><td>65</td></tr>
<tr><td>SD1425</td><td>96</td><td>to</td><td>89</td><td>88</td><td>to</td><td>81</td></tr>
<tr><td>SD1426</td><td>112</td><td>to</td><td>105</td><td>104</td><td>to</td><td>97</td></tr>
<tr><td>SD1427</td><td>-</td><td>to</td><td>-</td><td>120</td><td>to</td><td>113</td></tr>
</table>
1 to 120 in the table indicate station numbers.
-: Fixed to "0".</td></tr>
</table>

For details, refer to the following.

☞QSCPU User's Manual (Function Explanation, Program Fundamentals)

(b) Program example

• When communicating with station No. 0

Figure 4.10 shows the program that handles an error occurred in CC-Link IE Field Network during communication with station No. 0.

Status of safety refresh communication with station No. 0 can be checked using SM1421, and the information is output to station No. 0.

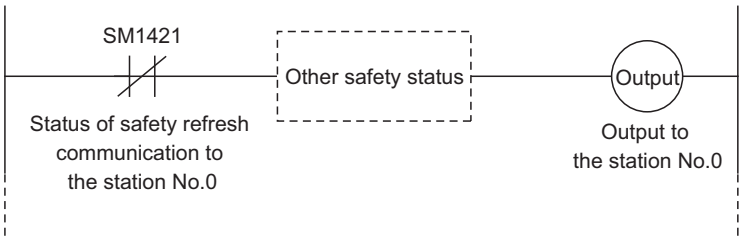


Figure 4.10 Example of the program that handles an error occurred in CC-Link IE Field Network during communication with station No. 0

• When communicating with any of station No. 1 to station No. 120

Figure 4.11 shows the program that handles an error occurred in CC-Link IE Field Network during communication with any of station No. 1 to station No. 120.

Status of safety refresh communication with station No. 1 can be checked using SD1420.0, and the information is output to station No. 1.

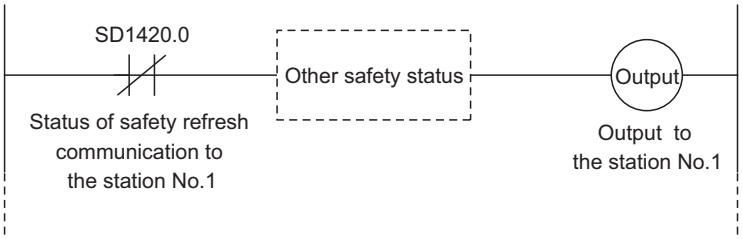


Figure 4.11 Example of the program that handles an error occurred in CC-Link IE Field Network during communication with any of station No. 1 to station No. 120

(6) Resetting error status of CC-Link IE Field Network

If an error occurs in CC-Link IE Field Network, the safety station interlock status shown in Table 4.6 turns on.

To restart communication on CC-Link IE Field Network, turn on the safety station interlock release request.

Create a program in which an safety station interlock release request is manually turned on (e.g. reset button).

Table 4.6 Names and numbers of special relays and special registers

<table>
<tr><th>Name</th><th>Number</th><th>Description</th></tr>
<tr><td>Safety master station interlock status</td><td>SM1700</td><td>0: Not interlocked
1: Interlocked</td></tr>
<tr><td>Safety station interlock status</td><td>SD1700 to SD1707</td><td>0: Not interlocked
1: Interlocked

<table>
<tr><th></th><th>b15</th><th>to</th><th>b8</th><th>b7</th><th>to</th><th>b0</th></tr>
<tr><td>SD1700</td><td>16</td><td>to</td><td>9</td><td>8</td><td>to</td><td>1</td></tr>
<tr><td>SD1701</td><td>32</td><td>to</td><td>25</td><td>24</td><td>to</td><td>17</td></tr>
<tr><td>SD1702</td><td>48</td><td>to</td><td>41</td><td>40</td><td>to</td><td>33</td></tr>
<tr><td>SD1703</td><td>64</td><td>to</td><td>57</td><td>56</td><td>to</td><td>49</td></tr>
<tr><td>SD1704</td><td>80</td><td>to</td><td>73</td><td>72</td><td>to</td><td>65</td></tr>
<tr><td>SD1705</td><td>96</td><td>to</td><td>89</td><td>88</td><td>to</td><td>81</td></tr>
<tr><td>SD1706</td><td>112</td><td>to</td><td>105</td><td>104</td><td>to</td><td>97</td></tr>
<tr><td>SD1707</td><td>-</td><td>to</td><td>-</td><td>120</td><td>to</td><td>113</td></tr>
</table>
1 to 120 in the table indicate station numbers.
- Fixed to "0".</td></tr>
<tr><td>Safety master station interlock release request</td><td>SM1720</td><td>0: I/O interlock of safety station on CC-Link IE Field Network not released
1: I/O interlock of safety station on CC-Link IE Field Network released</td></tr>
<tr><td>Safety station interlock release request</td><td>SD1720 to SD1727</td><td>0: I/O interlock of safety station on CC-Link IE Field Network not released
1: I/O interlock of safety station on CC-Link IE Field Network released

<table>
<tr><th></th><th>b15</th><th>to</th><th>b8</th><th>b7</th><th>to</th><th>b0</th></tr>
<tr><td>SD1720</td><td>16</td><td>to</td><td>9</td><td>8</td><td>to</td><td>1</td></tr>
<tr><td>SD1721</td><td>32</td><td>to</td><td>25</td><td>24</td><td>to</td><td>17</td></tr>
<tr><td>SD1722</td><td>48</td><td>to</td><td>41</td><td>40</td><td>to</td><td>33</td></tr>
<tr><td>SD1723</td><td>64</td><td>to</td><td>57</td><td>56</td><td>to</td><td>49</td></tr>
<tr><td>SD1724</td><td>80</td><td>to</td><td>73</td><td>72</td><td>to</td><td>65</td></tr>
<tr><td>SD1725</td><td>96</td><td>to</td><td>89</td><td>88</td><td>to</td><td>81</td></tr>
<tr><td>SD1726</td><td>112</td><td>to</td><td>105</td><td>104</td><td>to</td><td>97</td></tr>
<tr><td>SD1727</td><td>-</td><td>to</td><td>-</td><td>120</td><td>to</td><td>113</td></tr>
</table>
1 to 120 in the table indicate station numbers.
-: Fixed to "0".</td></tr>
</table>

For details, refer to the following.

☞ QSCPU User's Manual (Function Explanation, Program Fundamentals)

(a) Program example

• When communicating with station No. 0

Figure 4.12 shows the program that releases interlock of CC-Link IE Field Network during communication with station No. 0.

Status of safety station interlock with station No. 0 can be checked using SM1700, and safety station interlock for station No. 0 is released.

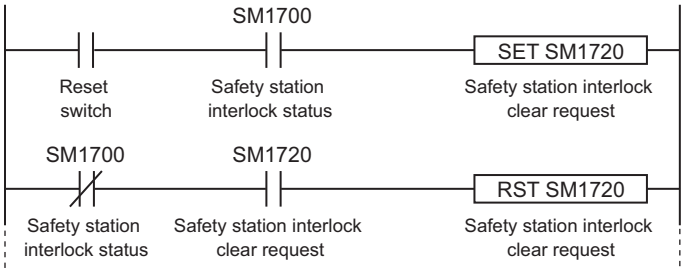


Figure 4.12 Example of the program that releases interlock of CC-Link IE Field Network during communication with station No. 0

• When communicating with any of station No. 1 to station No. 120

Figure 4.13 shows the program that releases interlock of CC-Link IE Field Network during communication with any of station No. 1 to station No. 120.

Status of safety station interlock with station No. 1 can be checked using SD1700.0, and safety station interlock for station No. 1 is released.

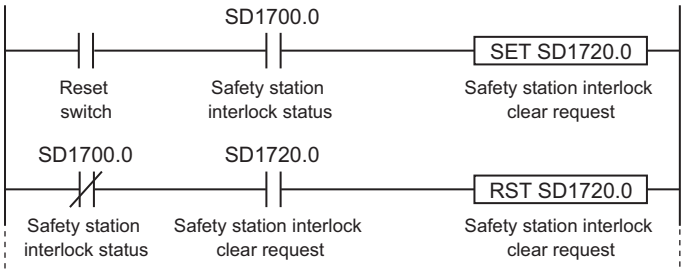


Figure 4.13 Example of the program that releases interlock of CC-Link IE Field Network during communication with any of station No. 1 to station No. 120

(7) Version management of GX Developer project file

Fill in the created date and author at the top of sequence program using the statement function of GX Developer.

When modifying a program, write the date modified, your name, and description of the modification at the modified location using the statement function.

And manage the data which was downloaded to the programmable controller by storing the hard disk of personal computer or CD.

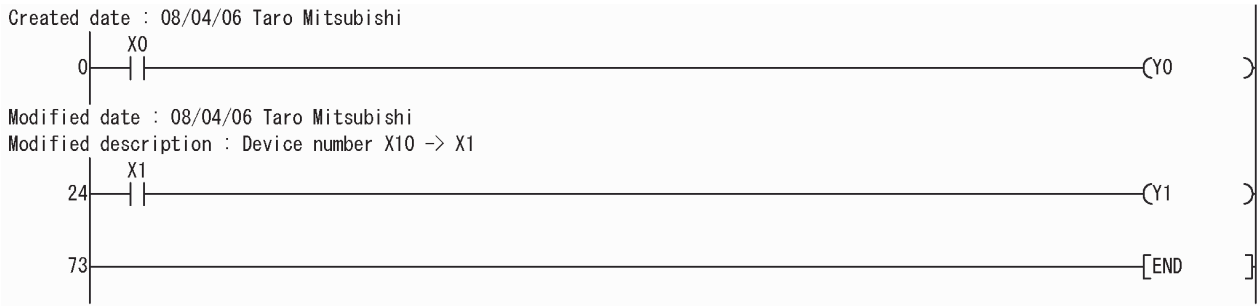


Figure 4.14 Version management of GX Developer project file

(8) User registration

Define the user who handles the corresponding project, then register the user information and authorization required for the login authentication in the project.
For the user registration, refer to the following.

☞GX Developer Version 8 Operating Manual (Safety Programmable Controller)

4.3 Precautions for Startup

When new safety-related system will be started up or existing safety-related system will be changed, confirm the below points.

(1) Confirmation of network connection configuration

Confirm that the CC-Link Safety remote I/O module used is set as designed.
The confirmation items are shown below.

1) Link ID
2) Station No.
3) Transmission speed

For the switch settings of the safety remote I/O station on CC-Link Safety, refer to the following.

☞ CC-Link Safety System Remote I/O Module User's Manual

(2) Confirmation before writing parameters and program

Confirm the parameters and program to be written are as designed before writing them to a programmable controller.
For parameter settings using GX Developer, refer to the following.

☞ GX Developer Version 8 Operating Manual (Safety Programmable Controller)

For definitions and setting ranges of parameter settings using GX Developer, refer to the following.

☞ CC-Link Safety System Master Module User's Manual
☞ MELSEC-QS CC-Link IE Field Network Master/Local Module User's Manual

(3) Usage of a checklist

Before operation, check if the safety-related system is correctly configured with the checklist in Appendix 3.

4.4 Precautions for Safety Functions Maintenance

(1) Periodic inspection

To confirm whether the emergency stop switch, safety sensor, etc. are not faulty, execute a periodic inspection every one year for meeting Category 3, every six months for meeting Category 4.

As well as diagnostics of the safety programmable controller, perform a test from the emergency stop

request to machine stop as safety functions.

(2) Module/unit replacement

For the safety programmable controller, execute the module/unit replacement according to the replacement cycle in Table 4.7.

Table 4.7 Module/unit replacement period

Module/unit	Module/unit replacement cycle
Safety power supply module	5 years
Safety CPU module	10 years
Safety main base unit	10 years
CC-Link Safety master module	10 years
CC-Link Safety remote I/O module	5 years
CC-Link IE Field Network master/local module (with safety functions)	10 years

(3) Safety CPU operation mode while a safety programmable controller is in operation

Set the safety CPU operation mode of the safety programmable controller to SAFETY MODE when the programmable controller is in operation.

(4) ROM information management of a safety CPU module

Confirm the ROM information at regular intervals whether the programs and parameters in the safety CPU module are illegally rewritten.

1) When writing a project file to ROM, check the ROM information using GX Developer, and separately save the information.
2) With reference to the ROM information of GX Developer at regular intervals, confirm whether the information is illegally rewritten.
3) When the information is illegally rewritten, stop the operation. Then, recover the project using the backup project file.

For checking ROM information, refer to the following.

☞ GX Developer Version 8 Operating Manual (Safety Programmable Controller)

(5) Password management

The project files for GX Developer and safety CPU module are protected by password.

Manage the registered password properly and do not leak the password except authorized person in order to prevent the unauthorized access.

CHAPTER 5 SAFETY APPLICATION CONFIGURATION EXAMPLE (USING A SINGLE SAFETY PROGRAMMABLE CONTROLLER)

This chapter describes a configuration example of a safety application using a single safety programmable controller.

5.1 System Configuration

This chapter describes a safety application using the system configuration shown in Figure 5.1.

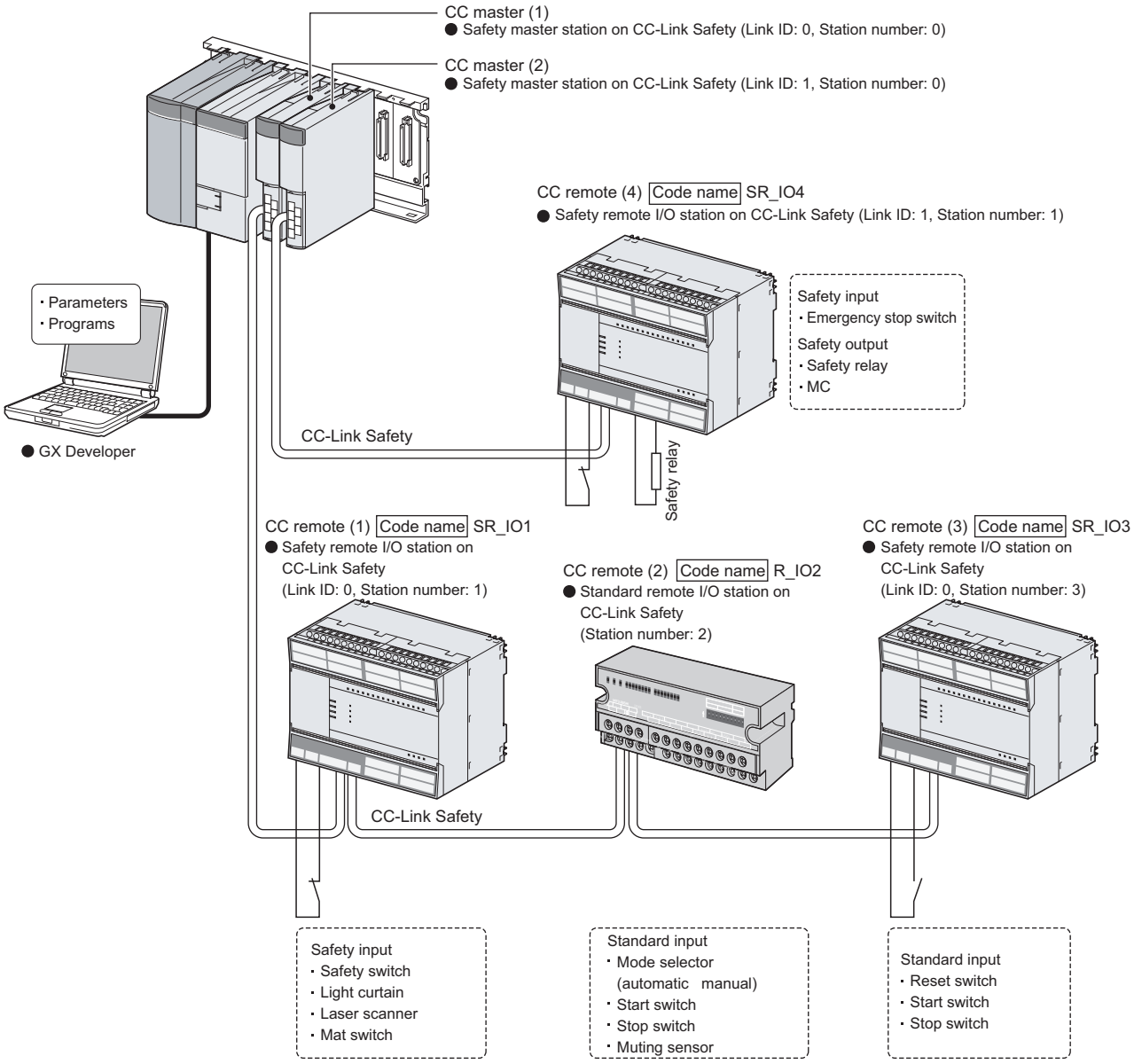


Figure 5.1 System configuration

Remark

In this chapter, the following abbreviations are used for each module.

Abbreviation	Module name
CC master (1)	CC-Link Safety master module (link ID = 0, station number 0)
CC master (2)	CC-Link Safety master module (link ID = 1, station number 0)
CC remote (1)	CC-Link Safety remote I/O module (link ID = 0, station number 1)
CC remote (2)	Standard remote I/O module on CC-Link Safety (station number 2)
CC remote (3)	CC-Link Safety remote I/O module (link ID = 0, station number 3)
CC remote (4)	CC-Link Safety remote I/O module (link ID = 1, station number 1)

5.2 Network-Related Switch Settings of Module

Set module switches as described below.

5.2.1 Safety power supply module

The safety power supply module does not have switches.

5.2.2 Safety CPU module

The safety CPU module does not have network-related switches.

5.2.3 CC-Link Safety master module

The CC-Link Safety master module does not have switches.

5.2.4 CC-Link Safety remote I/O module

Set the link ID setting switch, station number setting switch, and transmission speed setting switch.

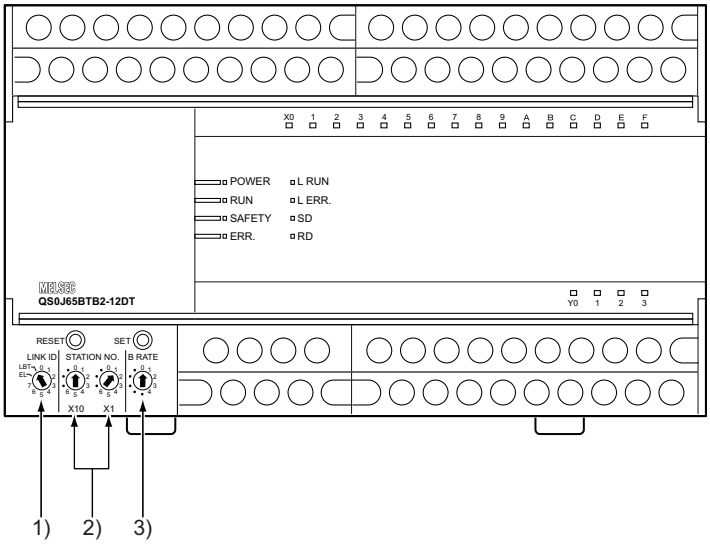


Figure 5.2 Positions of CC-Link Safety remote I/O module's switches

Table 5.1 Settings of CC-Link Safety remote I/O module's switches

Switch number	Remote I/O module number	CC remote (1) SR_I01	CC remote (3) SR_I03	CC remote (4) SR_I04
1)	Link ID setting switch	0	0	1
2)	Station number setting switch	1	3	1
3)	Transmission speed setting switch	2 (2.5Mbps)	2 (2.5Mbps)	2 (2.5Mbps)

POINT

For the procedure to validate the switch settings of the CC-Link Safety remote I/O module, refer to the following.

☞ CC-Link Safety System Remote I/O Module User's Manual

5.3 Parameter Settings of CC-Link Safety

Set the following values to the network parameters.
For descriptions and setting ranges of the parameters, refer to the following.

☞ CC-Link Safety System Master Module User's Manual

Table 5.2 Setting example of network parameters

Module		CC master (1)	CC master (2)
Start I/O No.		0000H	0020H
Operational setting	Case of CPU STOP setting*1	Clears compulsorily	Clears compulsorily
Mode		Safety remote net (Ver. 1 mode)	Safety remote net (Ver. 1 mode)
Transmission speed		2.5Mbps	2.5Mbps
Safety refresh monitoring time		50ms	50ms
Safety data monitoring time		80ms	80ms
Link ID		0	1
All connect count		3	1
Remote input (RX)		X100	X200
Remote output (RY)		Y100	Y200
Remote register (RWr)		–	–
Remote register (RWw)		–	–
Special relay (SB)		SB0	SB200
Special relay (SW)		SW0	SW200
Retry count		3	3
Automatic reconnection station count		1	1
Scan mode setting		Synchronous	Synchronous
Station information setting	Station information	☞ Section 5.3.1	
	Safety remote station settings	☞ Section 5.3.2	
Remote device station initial setting		None	None

* 1: Fixed at "Clears compulsorily" when the safety CPU operation mode is set to SAFETY MODE.

POINT

Set the link ID and transmission speed values of the network parameter and those of the switches of the connected CC-Link Safety remote I/O module so that they may be the same.

5.3.1 Station information setting

Set station information as follows.

Table 5.3 Example of station information setting

Module	Station No.	Station type	Exclusive station count	Reserve station count
CC master (1)	1/1	Safety remote I/O station	Exclusive station 1	No setting
	2/2	Standard remote I/O station	Exclusive station 1	No setting
	3/3	Safety remote I/O station	Exclusive station 1	No setting
CC master (2)	1/1	Safety remote I/O station	Exclusive station 1	No setting

5.3.2 Safety remote station settings

Set the safety remote station settings as follows.

Table 5.4 Safety remote station settings

Module	CC remote (1)	CC remote (3)	CC remote (4)
	SR_IO1	SR_IO3	SR_IO4
Model name	QS0J65BTB2-12DT	QS0J65BTB2-12DT	QS0J65BTB2-12DT
Module technical version*1	D	D	D
Specify production information to find module	Yes (check)	Yes (check)	Yes (check)
Production information*2	110000000000001	110000000000003	110000000000002
Parameter	Indicated in each case example of Section 5.6 or later.		

* 1: Check the module technical version on the rating plate located on the side of the module that is mounted on the corresponding safety remote I/O station on CC-Link Safety.
Depending on module combination, the station cannot be connected. For details, refer to the following.
☞ CC-Link Safety System Remote I/O Module User's Manual

* 2: Enter the production information referring to the serial number printed on the rating plate located on the side of the module that is mounted on the corresponding safety remote I/O station on CC-Link Safety. For details, refer to the following.
☞ CC-Link Safety System Remote I/O Module User's Manual
The production information is useful to maintain functions after the module is changed and to detect a setting error such as station number duplication of safety remote I/O stations on CC-Link Safety. Check the production information to use the safety programmable controllers properly and safely.

5.4 Relationship Between Safety CPU Module Devices and Remote Inputs/Outputs

The following shows the relationship between safety CPU module devices and inputs/outputs of remote I/O stations on CC-Link Safety with the settings described in Table 5.2. Use devices in shaded areas in the sequence program.

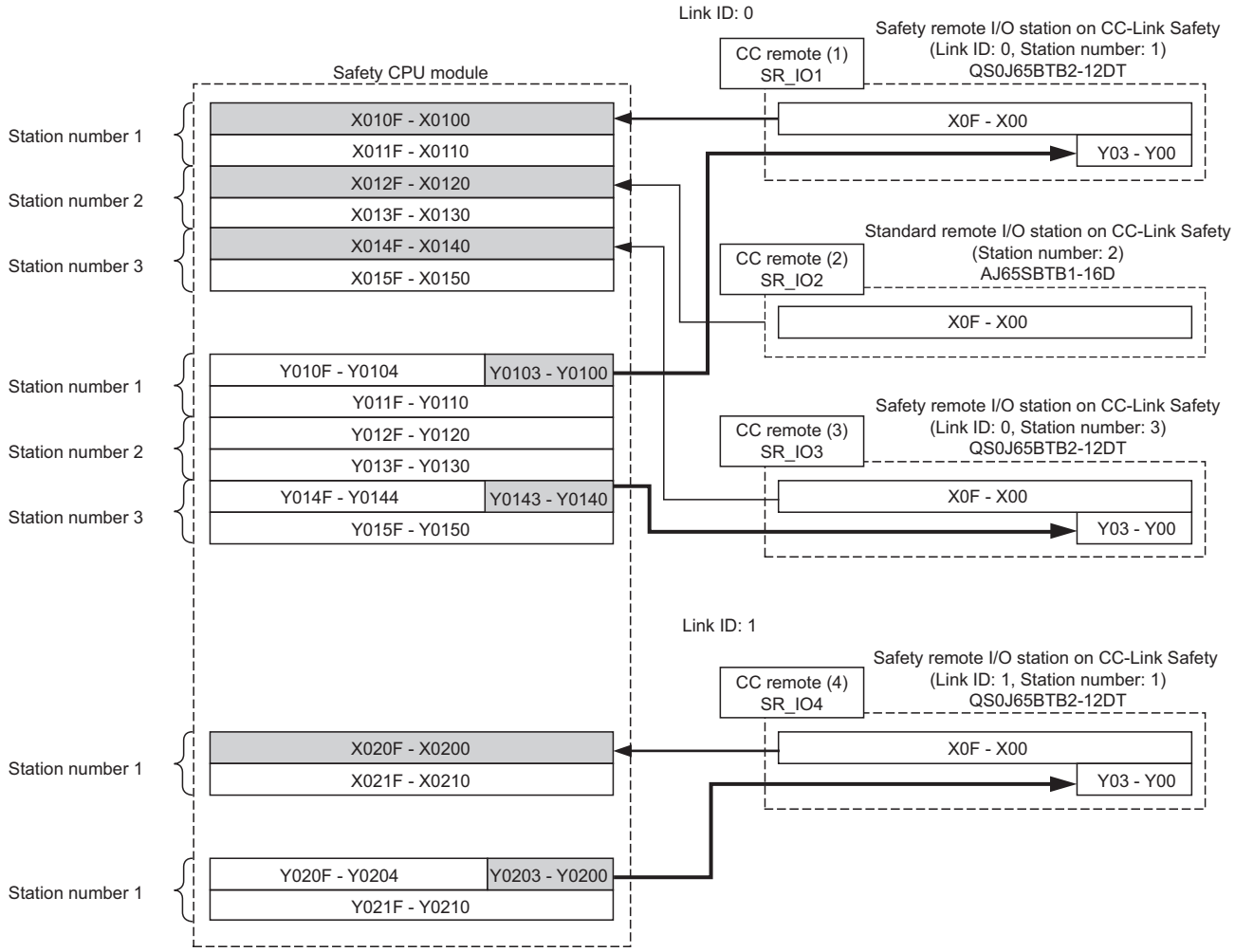


Figure 5.3 Relationship between safety CPU module devices and remote inputs/outputs

5.5 Wiring Diagram and Parameter Setting of Standard Input

(1) Using the QS0J65BTB2-12DT of module technical version D or later

• Wiring example of a reset switch, start switch, and stop switch*1

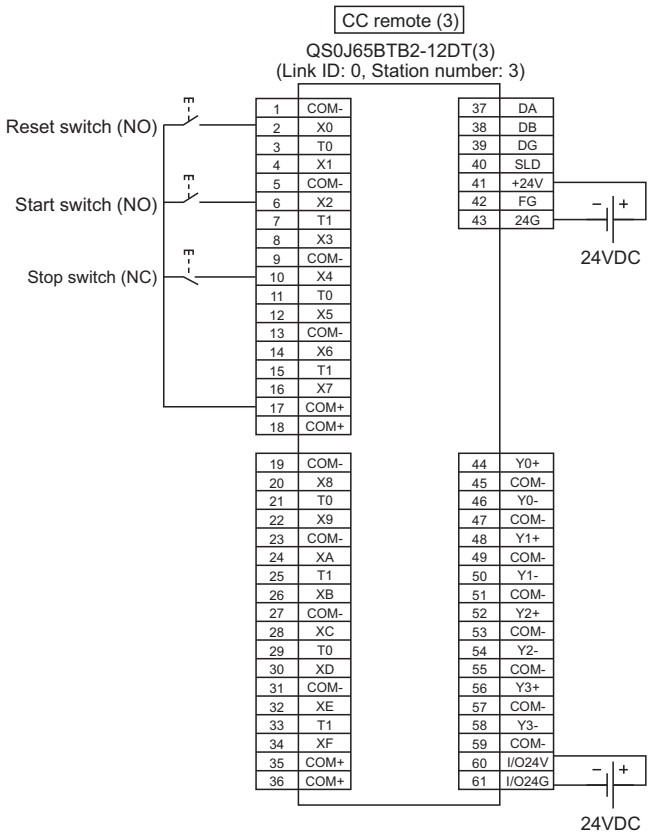


Figure 5.4 CC remote (3) SR_IO3 standard input wiring

*1: The switches can be wired to X0, X1, and X2 terminals.

• Parameter setting example

Table 5.5 CC remote (3) SR_IO3 parameter settings

Item	Option*3*4
1. Time of noise removal filter X0, 1*1	"1ms"
2. Time of noise removal filter X2, 3*1	"1ms"
3. Time of noise removal filter X4, 5*1	"1ms"
9. Doubling input discrepancy detection time X0, 1*2	"Do not detect"
10. Doubling input discrepancy detection time X2, 3*2	"Do not detect"
11. Doubling input discrepancy detection time X4, 5*2	"Do not detect"
17. Input dark test selection X0, 1	"Not execute"
18. Input dark test selection X2, 3	"Not execute"
19. Input dark test selection X4, 5	"Not execute"
25. Input dark test pulse OFF time*1	"400μs"
38. Doubling/single input selection X0, 1	"X0: Single input, X1: No Use"
39. Doubling/single input selection X2, 3	"X2: Single input, X3: No Use"
40. Doubling/single input selection X4, 5	"X4: Single input, X5: No Use"
46. Auto RTN Func to detect doubling input mismatch	"Invalid"

*1: Adjust the values of Time of noise removal filter and Input dark test pulse OFF time according to the installation environment and wiring length.

*2: Set Doubling input discrepancy detection time to 100ms for the mechanical switch and 20ms for the sensor input as a standard.

*3: For setting range, refer to the following.

☞ CC-Link Safety System Remote I/O Module User's Manual

*4: Always set the enclosed option for this case example.

(2) Using the QS0J65BTB2-12DT of module technical version C or earlier

• Wiring example of a reset switch, start switch, and stop switch

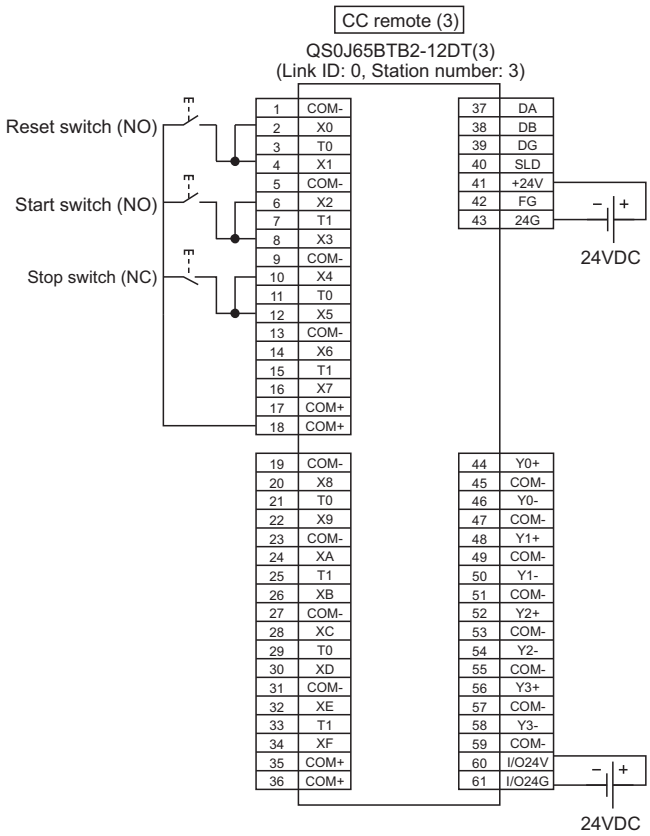


Figure 5.5 CC remote (3) SR_IO3 standard input wiring

• Parameter setting example

Table 5.6 CC remote (3) SR_IO3 parameter settings

Item	Setting*3 *4
1. Time of noise removal filter X0, 1*1	"1ms"
2. Time of noise removal filter X2, 3*1	"1ms"
3. Time of noise removal filter X4, 5*1	"1ms"
9. Doubling input discrepancy detection time X0, 1*2	"100ms"
10. Doubling input discrepancy detection time X2, 3*2	"100ms"
11. Doubling input discrepancy detection time X4, 5*2	"100ms"
17. Input dark test selection X0, 1	"Not execute"
18. Input dark test selection X2, 3	"Not execute"
19. Input dark test selection X4, 5	"Not execute"
25. Input dark test pulse OFF time*1	"400 μs"

*1: Adjust the values of Time of noise removal filter and Input dark test pulse OFF time according to the installation environment and wiring length.

*2: Set Doubling input discrepancy detection time to 100ms for the mechanical switch and 20ms for the sensor input as a standard.

*3: For setting range, refer to the following.

☞ CC-Link Safety System Remote I/O Module User's Manual

*4: Always set the enclosed option for this case example.

5.6 Case Examples

5.6.1 Emergency stop circuit

(1) Application overview

The emergency stop circuit is the safety application that turns off the power source of a robot with the emergency stop switch.
The application controls the start and stop of a robot by turning on or off the main contact of the contactor which opens and closes the power source of a robot at the safety relay contact.

Connect the emergency stop switch and safety relays to a safety programmable controller.
The safety programmable controller turns on/off the contacts of the safety relays with sequence program.
When the safety programmable controller detects an error by self-diagnostics, outputs to the safety relays turn off independent of the sequence program.
In this case, the outputs remain off until the safety CPU module or CC-Link Safety remote I/O module is reset independent of the sequence program.

Configure the sequence program so that the following functions can be achieved.

1) After ensuring safety (The emergency stop signal is on.), activating the reset switch and then the start switch turns on the safety relays.
2) When the contacts of the safety relays are welded, do not start the robot. Input the auxiliary relays (normally closed contacts) to the safety programmable controller to check for welding.
3) The reset switch and start switch become valid only when turned off to avoid operation at contact welding or short-circuit.
4) The safety relay outputs are turned off when the emergency stop switch input is turned off or an error is detected in the safety remote I/O station on CC-Link Safety after the operation is started.

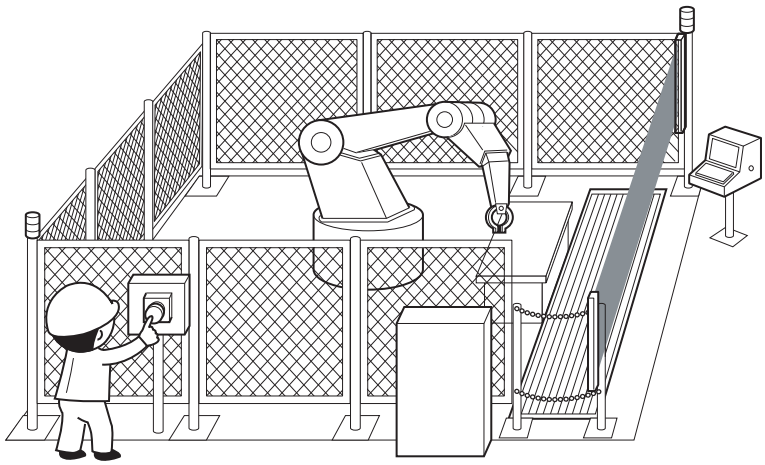


Figure 5.6 Emergency stop switch
(Partially quoted from "Safety Guide Book - the safety measures of machinery in the workplace"
: Nippon Electric Control Equipment Industries Association.)

(2) Connection of safety devices

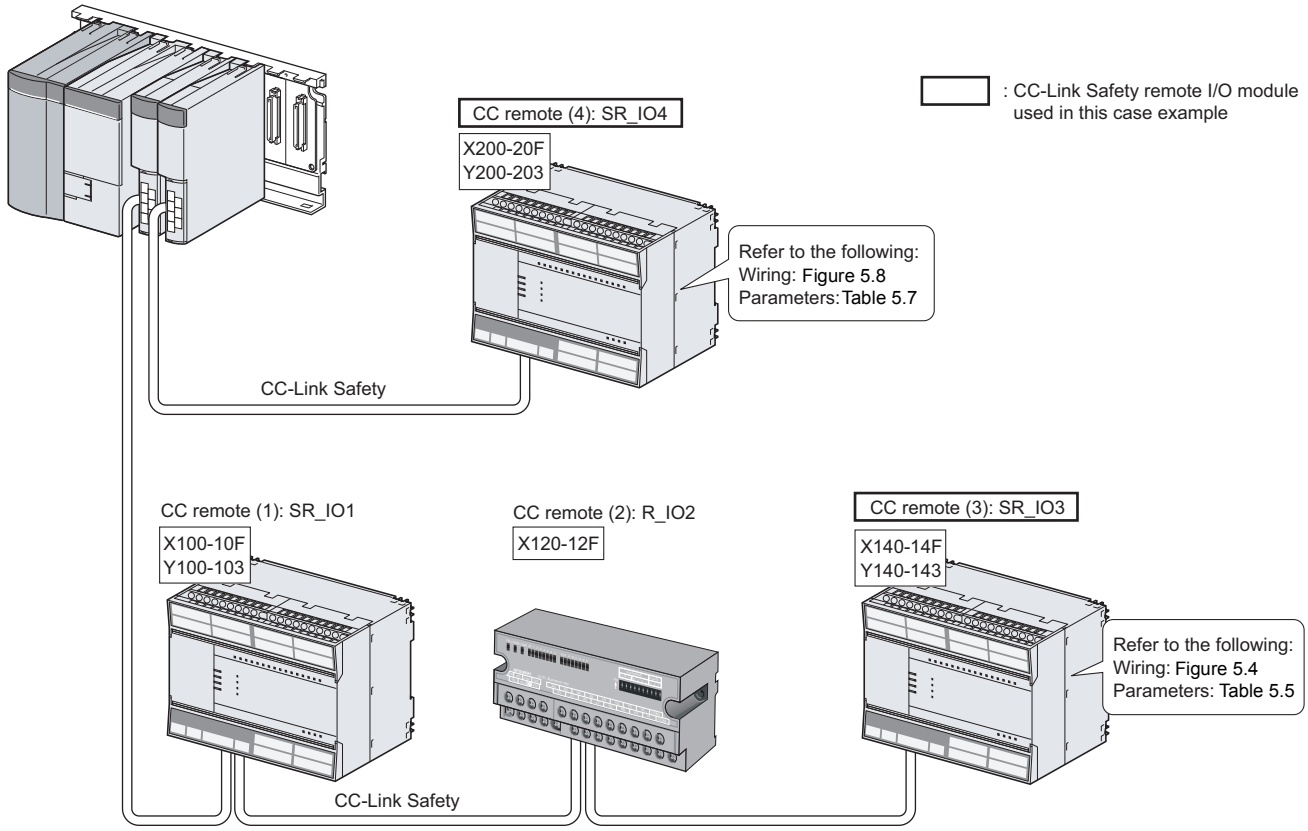


Figure 5.7 Safety device connection diagram

(3) Wiring diagram and parameter settings

Wire the emergency stop switch and safety relays to the CC-Link Safety remote I/O module as follows.

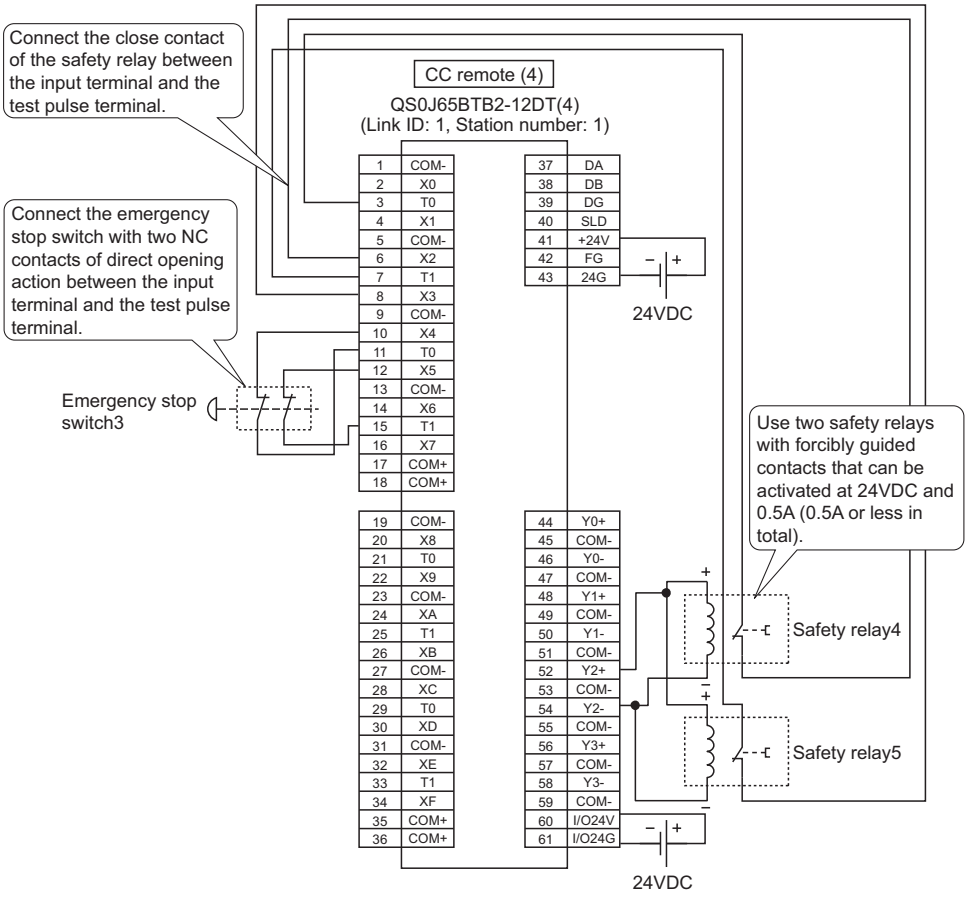


Figure 5.8 CC remote (4) SR_IO4 wiring

For the emergency stop switch and the safety relays, set the parameters as follows.

Table 5.7 CC remote (4) SR_IO4 parameter settings

Item	Setting*4*5
2. Time of noise removal filter X2, 3*1	"1ms"
3. Time of noise removal filter X4, 5*1	"1ms"
10. Doubling input discrepancy detection time X2, 3*2	"100ms"
11. Doubling input discrepancy detection time X4, 5*2	"100ms"
18. Input dark test selection X2, 3	"Execute"
19. Input dark test selection X4, 5	"Execute"
25. Input dark test pulse OFF time*1	"400μs"
28. Method of wiring of output Y2	"Doubling wiring (Source+Sink)"
32. Output dark test selection Y2	"Execute"
36. Output dark test pulse OFF time Y2*1	"1ms"
39. Doubling/single input selection X2, 3*3	"Doubling input"
40. Doubling/single input selection X4, 5*3	"Doubling input"
46. Auto RTN Func to detect doubling input mismatch*3	"Invalid"

*1: Adjust the values of Time of noise removal filter, Input dark test pulse OFF time, and Output dark test pulse OFF time according to the installation environment and wiring length.

*2: Set Doubling input discrepancy detection time to 100ms for the mechanical switch and 20ms for the sensor input as a standard.

*3: The parameter is added to the QS0J65BTB2-12DT of technical version D.
When a module of technical version C or earlier is used, the parameter is not available.

*4: For setting range, refer to the following.
☞ CC-Link Safety System Remote I/O Module User's Manual

*5: Always set the enclosed option for this case example.

(4) Device numbers to be used

The following device numbers are used in the sequence program.

Table 5.8 Device numbers to be used

Safety/Standard	External device	Device number
Safety	Emergency stop switch	X204 or X205
Safety	Safety relay	Y202
Safety	Safety relay (check for welding)	X202 or X203
Standard	Start switch	X142
Standard	Reset switch	X140

(5) Sequence program

The sequence program performs the following processing.

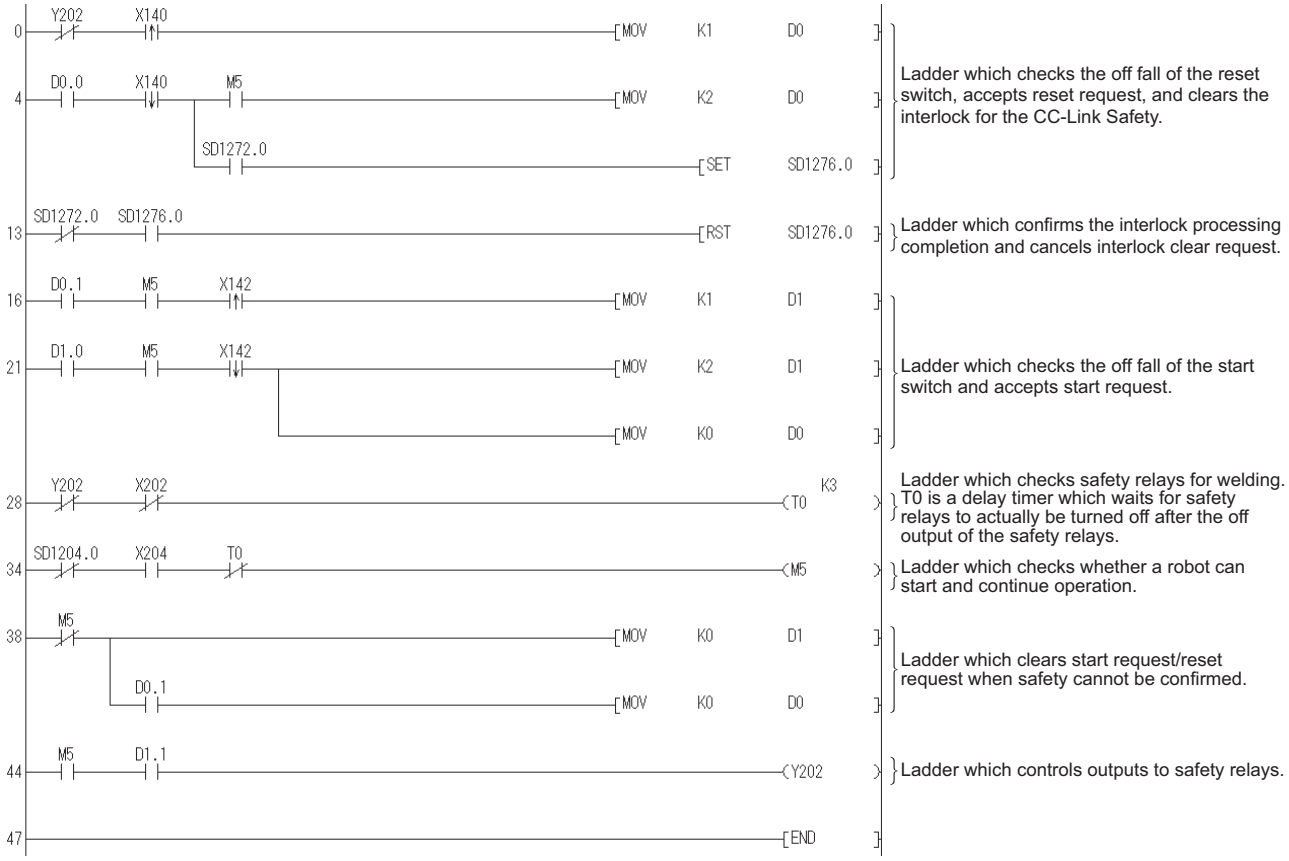


Figure 5.9 Sequence program

The following shows the constant and internal devices used in the program.

(a) Way of using the constant

K☐ indicates decimal number.

Example) K1 = 1 of decimal number

(b) Way of using the internal devices

Table 5.9 Way of using the internal devices

Internal device	Description
T0	Timer device Times out after a lapse of the time specified at K ☐.
D0	Word device Used as restart status in this program. (1) D0 = 0: Initial status or start processing completed (2) D0 = 1 (D0.0: on): Reset switch activated (3) D0 = 2 (D0.1: on): Restart processing completed (Reset switch released after activated in (2))
D1	Word device Used as start status in this program. (1) D1 = 0: Initial status or safety not confirmed (2) D1 = 1 (D1.0: on): Start switch activated (3) D1 = 2 (D1.1: on): Start processing completed (Start switch released after activated in (2))

(c) Way of using word device bit specification

D☐☐.⬚ indicates the ⬚th bit data of word device D ☐☐.

Example) D0.0 = 0 bits in D0

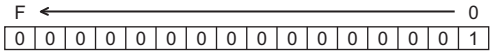


Figure 5.10 Word device bit specification

(6) Timing chart

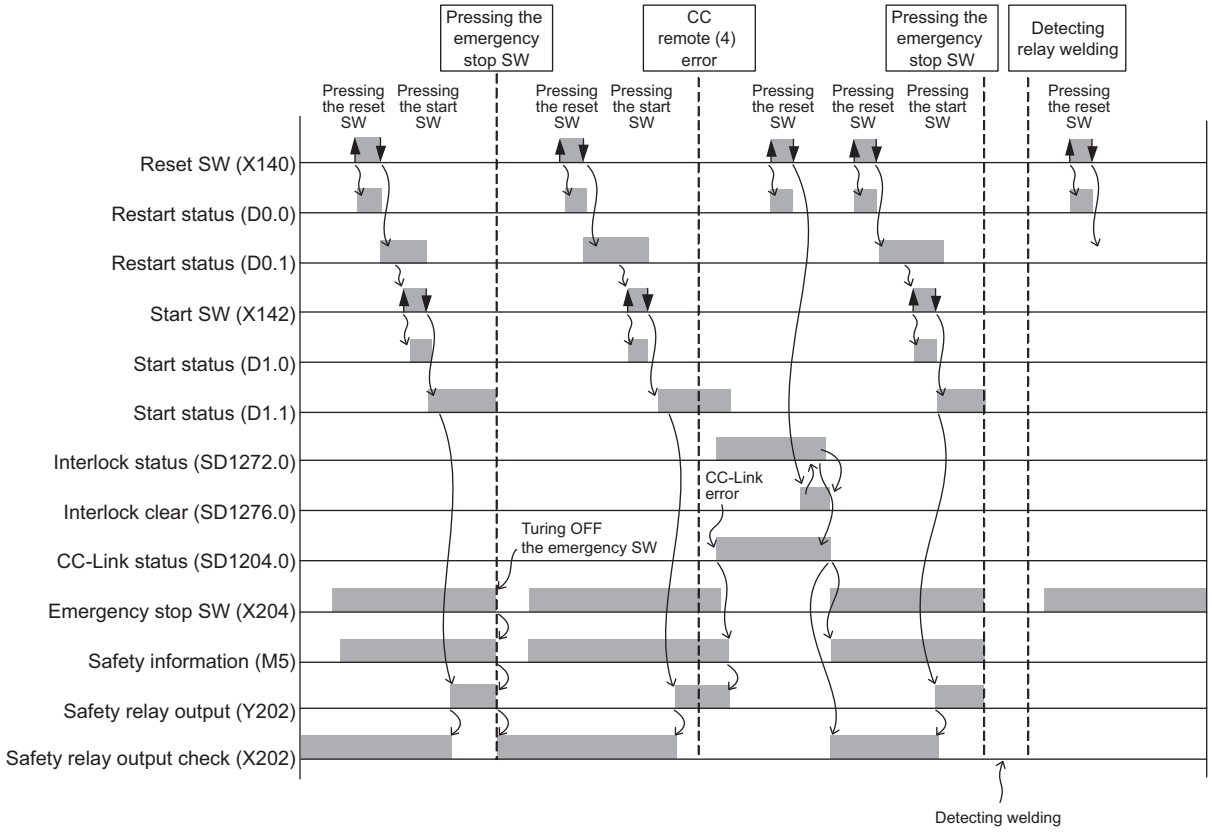


Figure 5.11 Timing chart

(7) Program using safety FB

Table 5.10 Safety FBs to be used

FB name	Function	Description
F+EDM	External device monitor	This FB monitors safety equipment such as an actuator and a contactor and controls a safety output.
F+ESTOP	Emergency stop	This FB is a safety-related FB for monitoring an emergency stop button. This FB can be used for emergency switch off functionality (stop category 0).

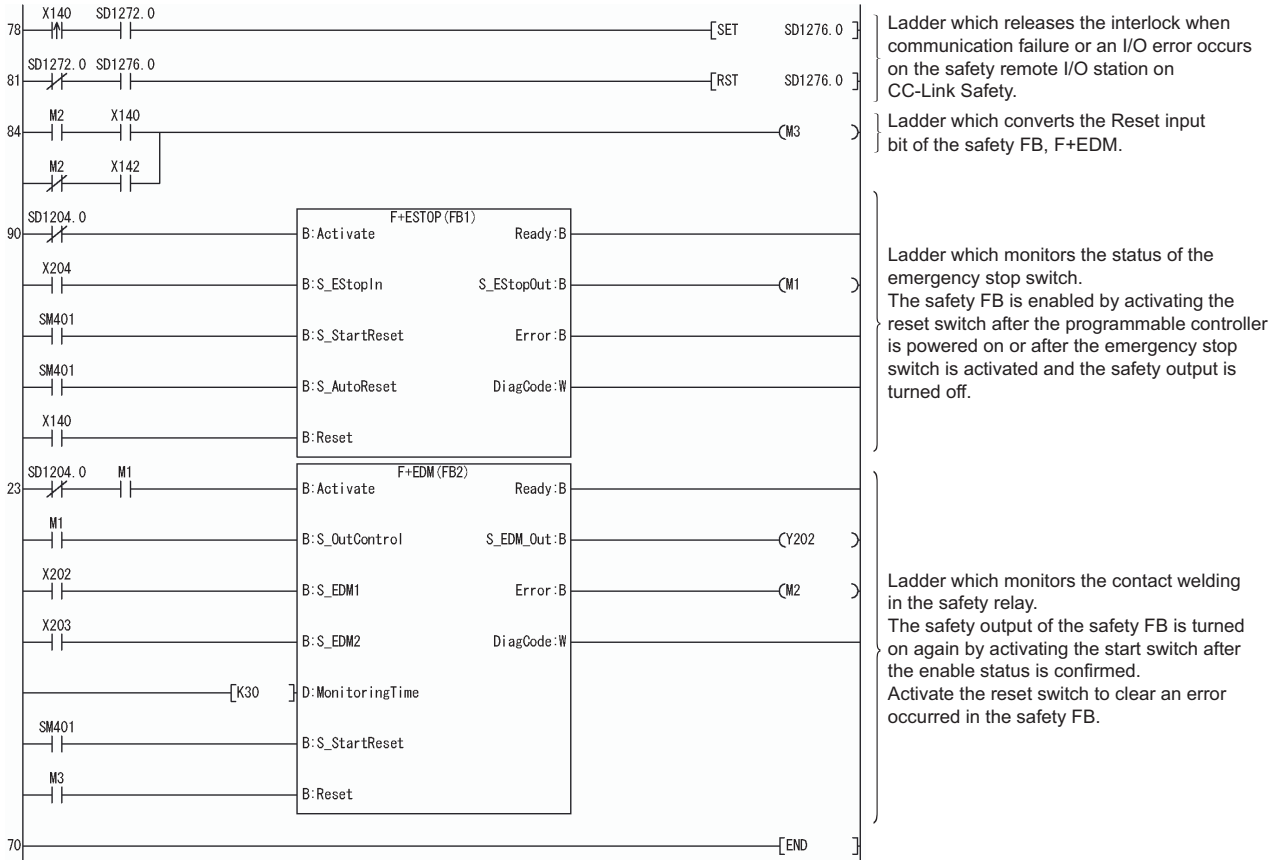


Figure 5.12 Program using safety FB

For details on the safety FBs, F+ESTOP, and F+EDM, refer to the following.

☞ QSCPU Programming Manual (Safety FB)

(8) Timing chart

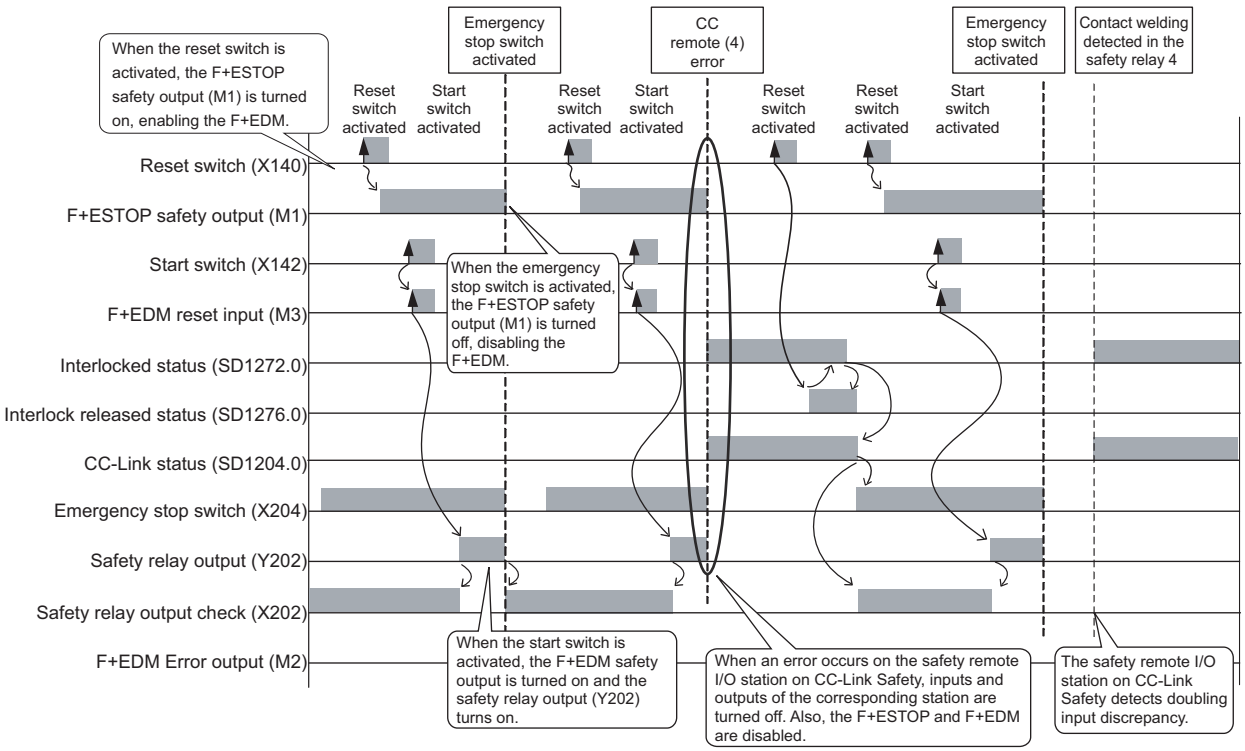


Figure 5.13 Timing chart

Safety relay contact welding detection in this example (The same applies to other examples in this manual.)

F+EDM is a safety FB that checks the contact welding of safety relays or safety contactors connected to the safety outputs of the safety remote I/O station on CC-Link Safety. The safety remote I/O station on CC-Link Safety has the doubling input discrepancy detection function. Therefore, when either contact of a safety relay or a safety contactor is welded, an error is detected both by the safety remote I/O station on CC-Link Safety and by F+EDM.

If either auxiliary relay (normally closed contact) is welded when S_EDM_Out (output of F+EDM) turns on, F+EDM does not detect the error while the safety remote I/O station on CC-Link Safety does.

Accordingly, the program is created using the safety station refresh communication status (SD1004 to SD1007 and SD1204 to SD1207) of the safety remote I/O station on CC-Link Safety to which the auxiliary relay (normally closed contact) is connected so that Activate may turn off to turn off the safety output of F+EDM.

(For SD1004 to SD1007 and SD1204 to SD1207, refer to Section 4.2 (3) Detecting errors in CC-Link Safety.)

5.6.2 Door monitor circuit

(1) Application overview

This application de-energizes a robot with the safety switch on the door of a safety barrier when the door is opened.
The robot cannot be started while the door on the safety barrier is open.

The application controls the start and stop of a robot by turning on or off the main contact of the contactor which opens and closes the power source of a robot at the safety relay contact.

Connect the safety switch and safety relays to a safety programmable controller.
The safety programmable controller turns on/off the contacts of the safety relays with sequence program.
When the safety programmable controller detects an error by self-diagnostics, outputs to the safety relays turn off independent of the sequence program.
In this case, the outputs remain off until the safety CPU module or CC-Link Safety remote I/O module is reset independent of the sequence program.

Configure the sequence program so that the following functions can be achieved.

1) After ensuring safety (The safety switch is on.), activating the reset switch and then the start switch turns on the safety relays.
2) When the contacts of the safety relays are welded, do not start the robot. Input the auxiliary relays (normally closed contacts) to the safety programmable controller to check for welding.
3) The reset switch and start switch become valid only when turned off to avoid operation at contact welding or short-circuit.
4) When the safety barrier door is opened and the safety switch is turned off or the stop switch is activated, outputs to the safety relays turn off.
5) When an error is detected in the safety remote I/O station on CC-Link Safety after operation, outputs to the safety relays turn off.

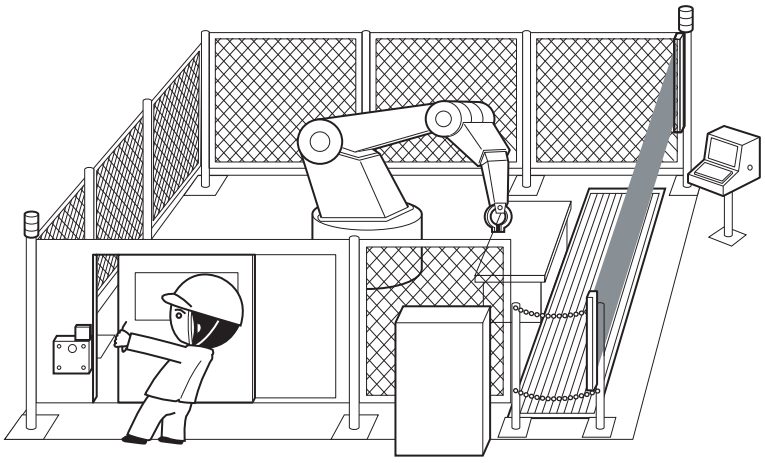


Figure 5.14 Door monitor circuit
(Partially quoted from "Safety Guide Book - the safety measures of machinery in the workplace" : Nippon Electric Control Equipment Industries Association.)

(2) Connection of safety devices

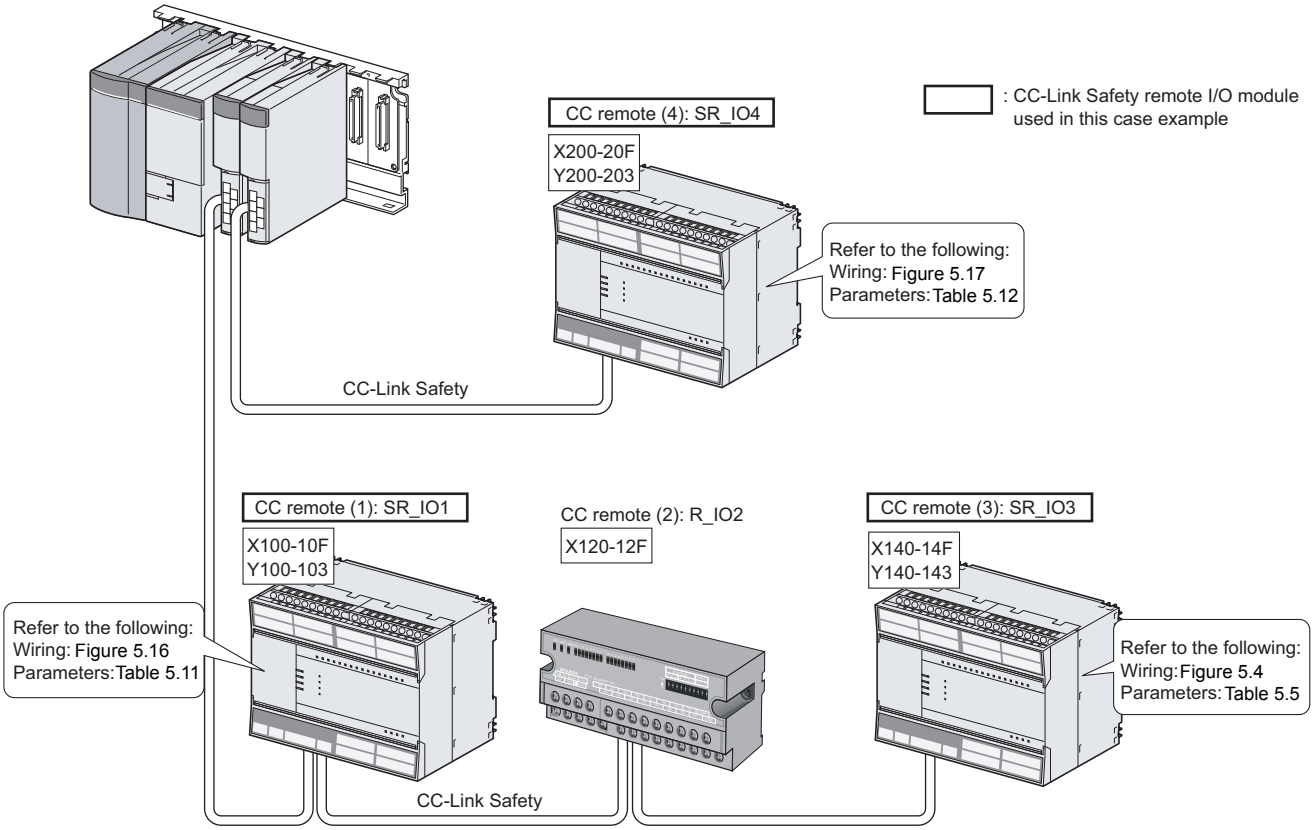


Figure 5.15 Safety device connection diagram

(3) Wiring diagram and parameter settings

(a) CC remote (1): SR_IO1

Wire the safety switch to the CC-Link Safety remote I/O module as follows.

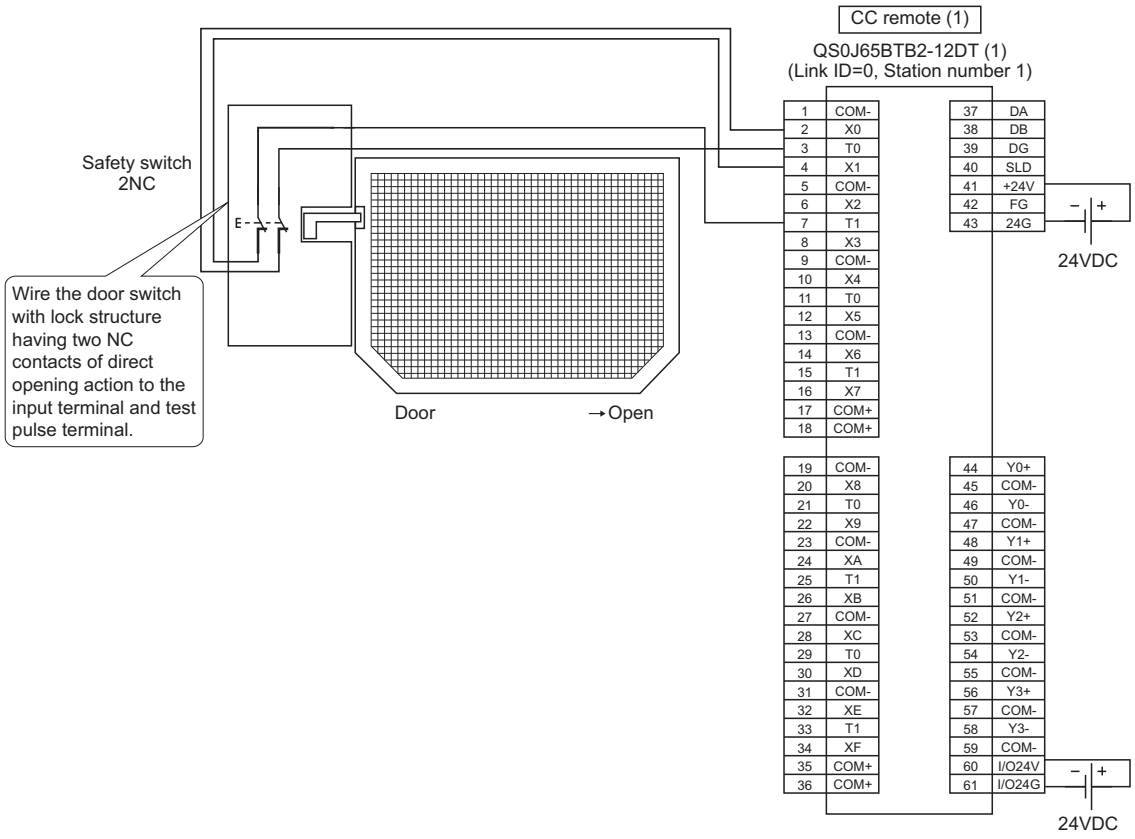


Figure 5.16 CC remote (1) SR_IO1 wiring

For the safety switch, set the parameters as follows.

Table 5.11 CC remote (1) SR_IO1 parameter settings

Item	Setting*4*5
1. Time of noise removal filter X0. 1*1	"1ms"
9. Doubling input discrepancy detection time X0, 1*2	"100ms"
17. Input dark test selection X0, 1	"Execute"
25. Input dark test pulse OFF time*1	"400μs"
38. Doubling/single input selection X0, 1*3	"Doubling input"
46. Auto RTN Func to detect doubling input mismatch*3	"Invalid"

*1 Adjust the values of Time of noise removal filter and Input dark test pulse OFF time according to the installation environment and wiring length.

*2: Set Doubling input discrepancy detection time to 100ms for the mechanical switch and 20ms for the sensor input as a standard.

*3: The parameter is added to the QS0J65BTB2-12DT of technical version D.
When a module of technical version C or earlier is used, the parameter is not available.

*4: For setting range, refer to the following.

☞ CC-Link Safety System Remote I/O Module User's Manual

*5: Always set the enclosed option for this case example.

(b) CC remote (4): SR_IO4

Wire the relay with forcibly guided (mechanically linked) contacts to the CC-Link Safety remote I/O module as follows.

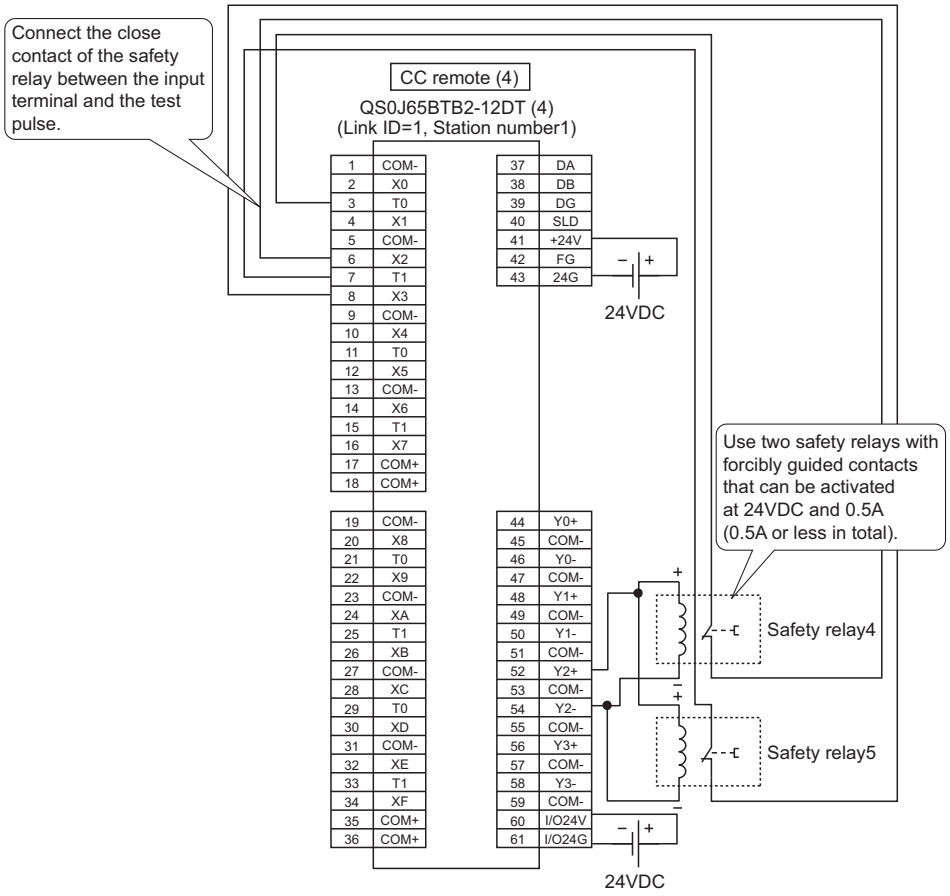


Figure 5.17 CC remote (4) SR_IO4 wiring

For the relay with forcibly guided (mechanically linked) relays, set the parameters as follows.

Table 5.12 CC remote (4) SR_IO4 parameter settings

Item	Setting*4*5
2. Time of noise removal filter X2, 3*1	"1ms"
10. Doubling input discrepancy detection time X2, 3*2	"100ms"
18. Input dark test selection X2, 3	"Execute"
25. Input dark test pulse OFF time*1	"400μs"
28. Method of wiring of output Y2	"Doubling wiring (Source+Sink)"
32. Output dark test selection Y2	"Execute"
36. Output dark test pulse OFF time Y2*1	"1ms"
39. Doubling/single input selection X2, 3*3	"Doubling input"
46. Auto RTN Func to detect doubling input mismatch*3	"Invalid"

*1: Adjust the values of Time of noise removal filter, Input dark test pulse OFF time, and Output dark test pulse OFF time according to the installation environment and wiring length.

*2: Set Doubling input discrepancy detection time to 100ms for the mechanical switch and 20ms for the sensor input as a standard.

*3: The parameter is added to the QS0J65BTB2-12DT of technical version D.
When a module of technical version C or earlier is used, the parameter is not available.

*4: For setting range, refer to the following.

☞ CC-Link Safety System Remote I/O Module User's Manual

*5: Always set the enclosed option for this case example.

(4) Device numbers to be used

The following device numbers are used in the sequence program.

Table 5.13 Device numbers to be used

Safety/standard	External device	Device number
Safety	Safety switch	X100 or X101
Safety	Safety relay	Y202
Safety	Safety relay (check for welding)	X202 or X203
Standard	Reset switch	X140
Standard	Start switch	X142
Standard	Stop switch	X144

(5) Sequence program

The sequence program performs the following processing.

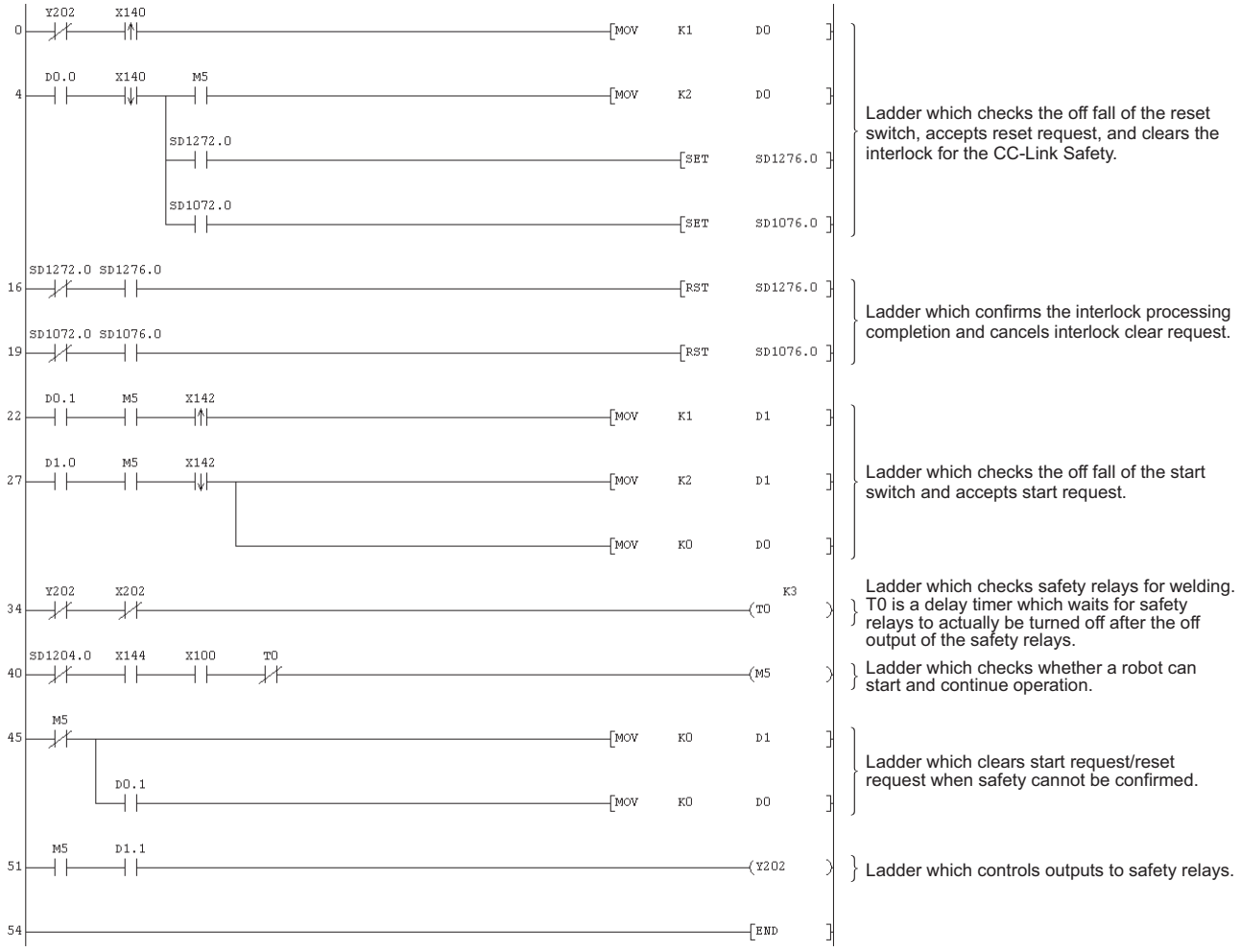


Figure 5.18 Sequence program

The following shows the constant and internal devices used in the program.

(a) Way of using the constant

K☐ indicates decimal number.

Example) K1 = 1 of decimal number

(b) Way of using the internal devices

Table 5.14 Way of using the internal devices

Internal device	Description
T0	Timer device Times out after a lapse of the time specified at K☐.
D0	Word device Used as restart status in this program. (1) D0 = 0: Initial status or start processing completed (2) D0 = 1 (D0.0: on): Reset switch activated (3) D0 = 2 (D0.1: on): Restart processing completed (Reset switch released after activated in (2))
D1	Word device Used as start status in this program. (1) D1 = 0: Initial status or safety not confirmed (2) D1 = 1 (D1.0: on): Start switch activated (3) D1 = 2 (D1.1: on): Start processing completed (Start switch released after activated in (2))

(c) Way of using word device bit specification

D☐☐.⬚ indicates the ⬚th bit data of word device D☐☐.

Example) D0.0 = 0 bits in D0

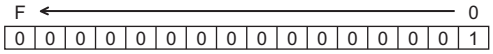


Figure 5.19 Word device bit specification

(6) Timing chart

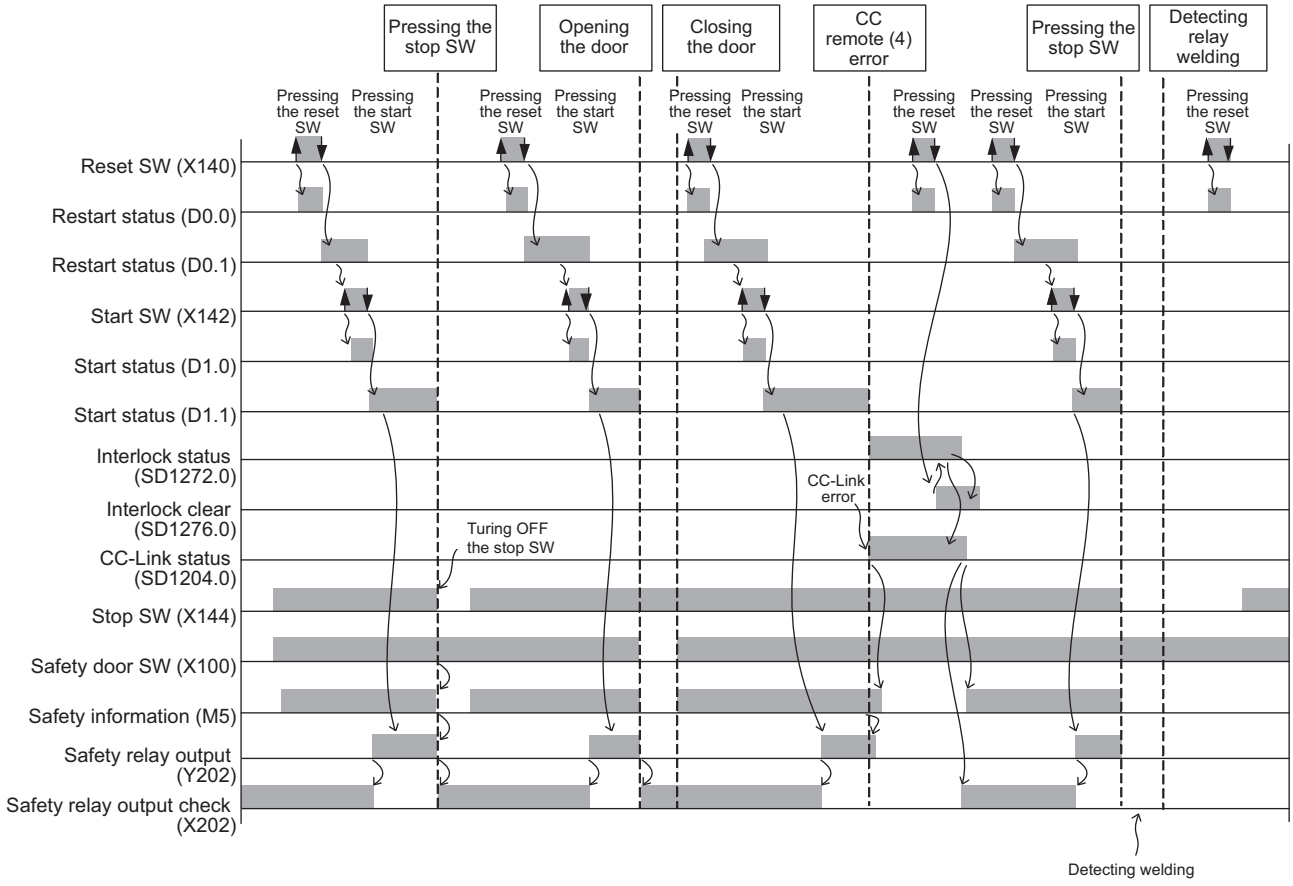


Figure 5.20 Timing chart

(7) Program using safety FB

Table 5.15 Safety FBs to be used

FB name	Function	Description
F+EDM	External device monitor	This FB monitors safety equipment such as an actuator and a contactor and controls a safety output.
F+GMON	Guard monitoring	This FB monitors a safety guard using two safety switches and dual switch discrepancy time (Monitoring Time) when the guard is closed.

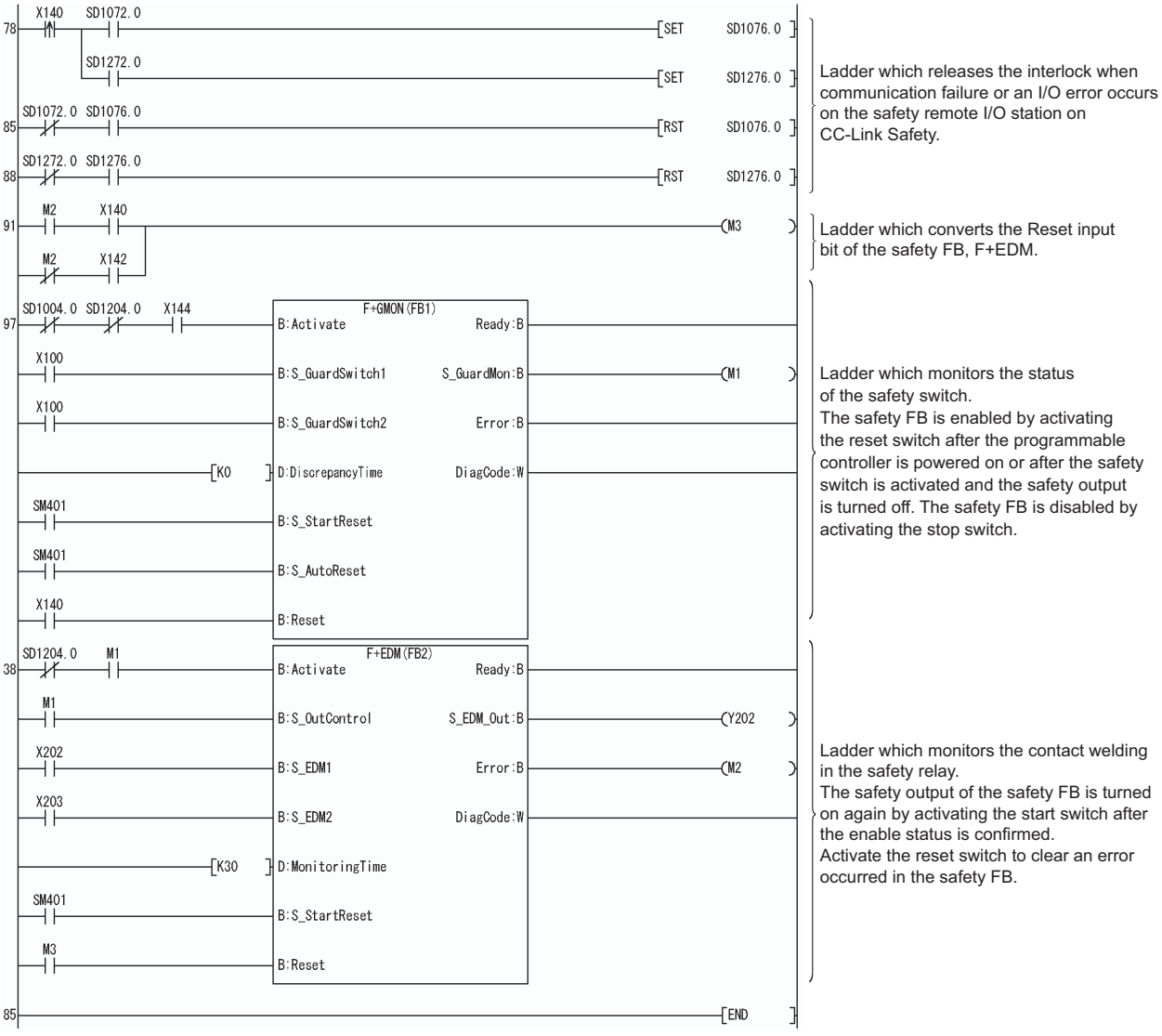


Figure 5.21 Program using safety FB

For details on the safety FBs, F+GMON, and F+EDM, refer to the following.
☞ QSCPU Programming Manual (Safety FB)

In this example, the guard status (open or close) is monitored using one safety switch. The input signals of the F+GMON (S_GuradSwitch1 and S_GuradSwitch2) are connected to the same signal of the safety switch (X100 or X101).
In addition, the value for the input signal (Discrepancy Time) of the F+GMON is set to 0 so that an error occurs immediately after the doubling input discrepancy is detected between S_GuradSwitch1 and S_GuradSwitch2.
(Since S_GuradSwitch1 and S_GuradSwitch2 are connected to the same signal, the doubling input discrepancy actually does not occur.)
If two safety switches are used to monitor the guard status, connect the input signals (S_GuradSwitch1 and S_GuradSwitch2) to two different signals of the two safety switches. Set the desired allowable discrepancy time between S_GuradSwitch1 and S_GuradSwitch2 to Discrepancy Time of the F+GMON using a constant (in increments of 10ms).
(Example: To set five seconds, connect the constant, K500.)

(8) Timing chart

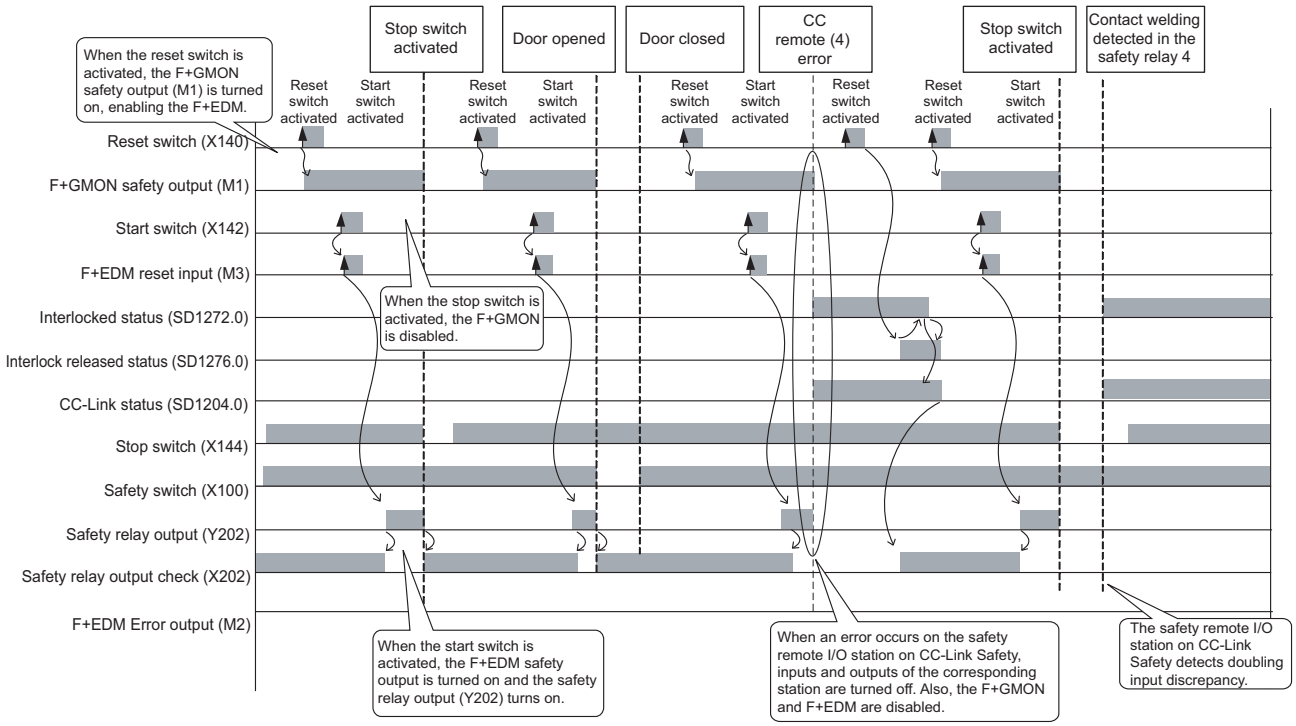


Figure 5.22 Timing Chart

5.6.3 Entering detection and existence detection circuit 1

(1) Application overview

The entering detection and existence detection circuit is the safety application that detects the entrance and existence of a human in a hazardous area and turns off the power source of a robot.
The entrance of human to the hazardous area is detected with a light shielding of the light curtain.The existence of human in the hazardous area is detected with a laser scanner. When the entrance or existence of human has been detected, a robot is stopped.
The robot cannot be started until the human leaves the hazardous area.

Connect the light curtain, laser scanner, and contactors to a safety programmable controller.
The safety programmable controller turns on/off the main contacts of the contactors with sequence program.

When the safety programmable controller detects an error by self-diagnostics, outputs to the contactors turn off independent of the sequence program.
In this case, the outputs remain off until the safety CPU module or CC-Link Safety remote I/O module is reset independent of the sequence program.

Configure the sequence program so that the following functions can be achieved.

1) After ensuring safety (The light curtain and laser scanner signals are both on.), activating the reset switch and then the start switch turns on the contactors.
2) When the main contacts of the contactors are welded, do not start the robot. Input the auxiliary contacts (normally closed contacts) to the safety programmable controller to check for welding.
3) The reset switch and start switch become valid only when turned off to avoid operation at contact welding or short-circuit.
4) The contactor outputs are turned off when the light curtain signal or laser scanner signal is turned off or an error is detected in the safety remote I/O station on CC-Link Safety after the operation is started.

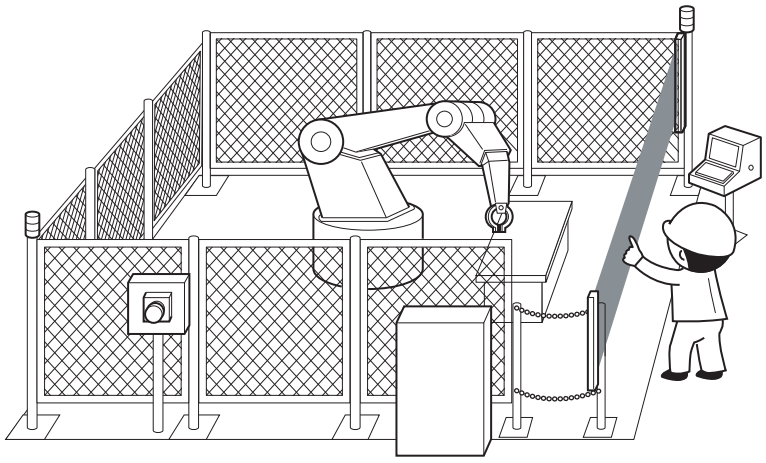


Figure 5.23 Entering detection and existence detection circuit
(Partially quoted from "Safety Guide Book - the safety measures of machinery in the workplace"
: Nippon Electric Control Equipment Industries Association.)

(2) Connection of safety devices

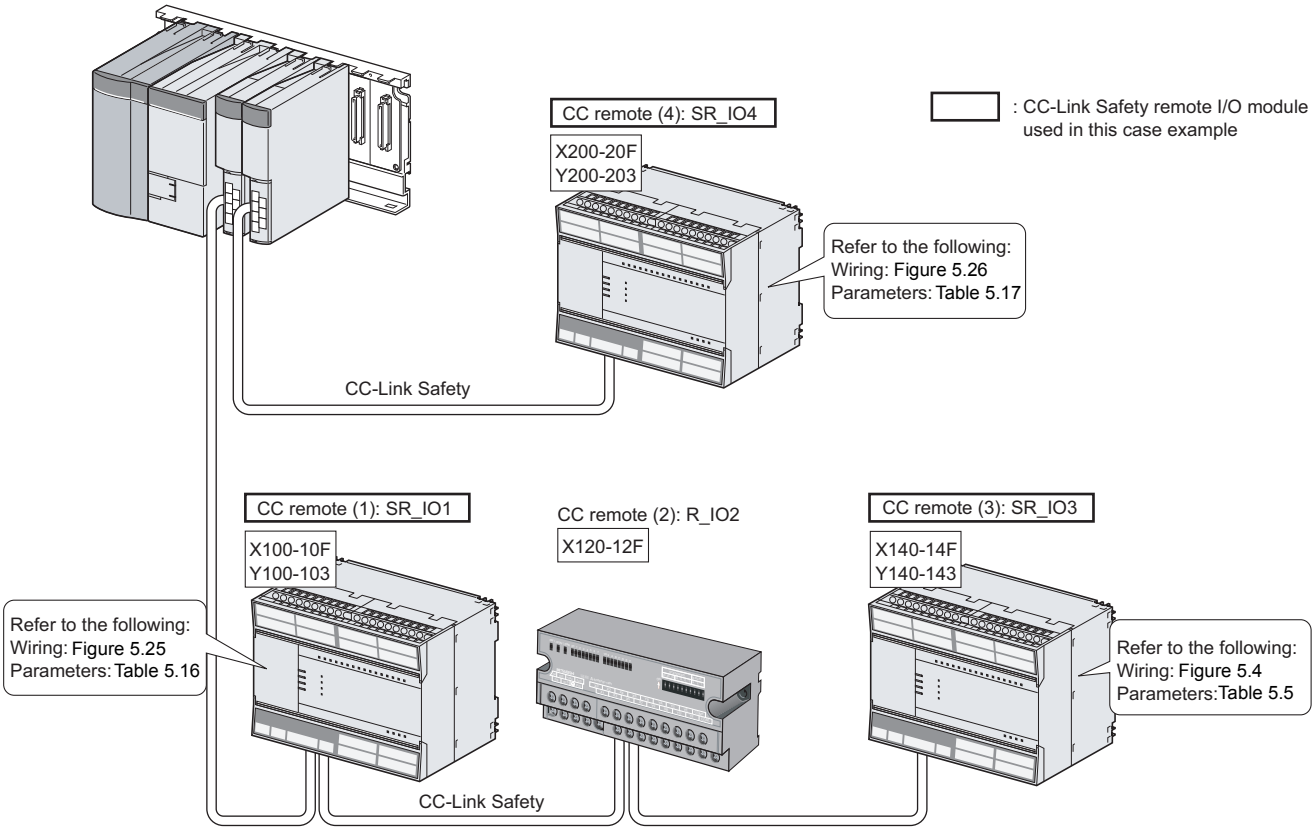


Figure 5.24 Safety device connection diagram

(3) Wiring diagram and parameter settings

Wire the light curtain and the laser scanner to the CC-Link Safety remote I/O module as follows.

(a) CC remote (1): SR_IO1

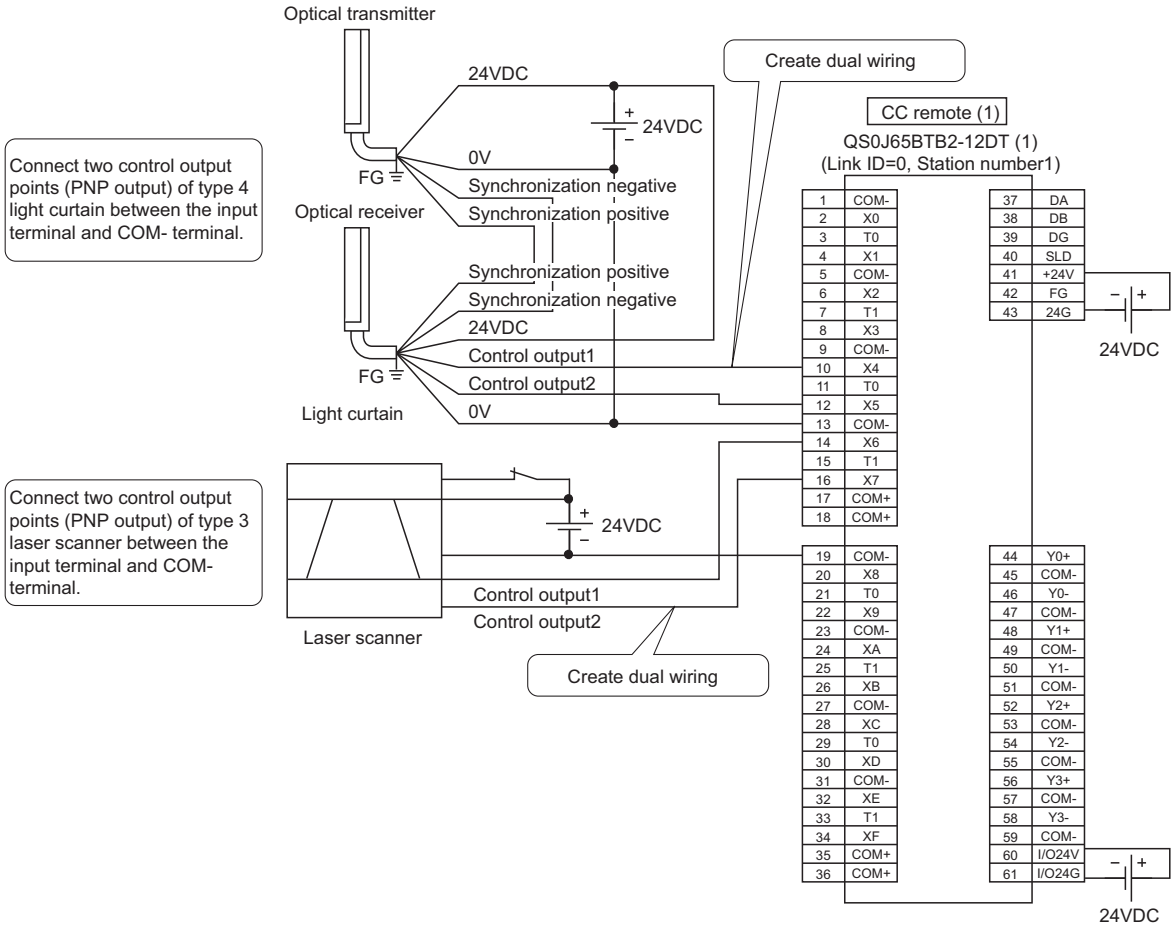


Figure 5.25 CC remote (1) SR_IO1 wiring

For the light curtain and the laser scanner, set the parameters as follows.μ

Table 5.16 CC remote (1) SR_IO1 parameter settings

Item	Setting*4*5
3. Time of noise removal filter X4, 5*1	"1ms"
4. Time of noise removal filter X6, 7*1	"1ms"
11. Doubling input discrepancy detection time X4, 5*2	"20ms"
12. Doubling input discrepancy detection time X6, 7*2	"20ms"
19. Input dark test selection X4, 5	"Not execute"
20. Input dark test selection X6, 7	"Not execute"
25. Input dark test pulse OFF time*1	"400μs"
40. Doubling/single input selection X4, 5*3	"Doubling input"
41. Doubling/single input selection X6, 7*3	"Doubling input"
46. Auto RTN Func to detect doubling input mismatch*3	"Invalid"

*1: Adjust the values of Time of noise removal filter and Input dark test pulse OFF time according to the installation environment and wiring length.

*2: Set Doubling input discrepancy detection time to 100ms for the mechanical switch and 20ms for the sensor input as a standard.

*3: The parameter is added to the QS0J65BTB2-12DT of technical version D.
When a module of technical version C or earlier is used, the parameter is not available.

*4: For setting range, refer to the following.
☞ CC-Link Safety System Remote I/O Module User's Manual

*5: Always set the enclosed option for this case example.

(b) CC remote (4): SR_IO4

Wire the contactors to the CC-Link Safety remote I/O module as follows.

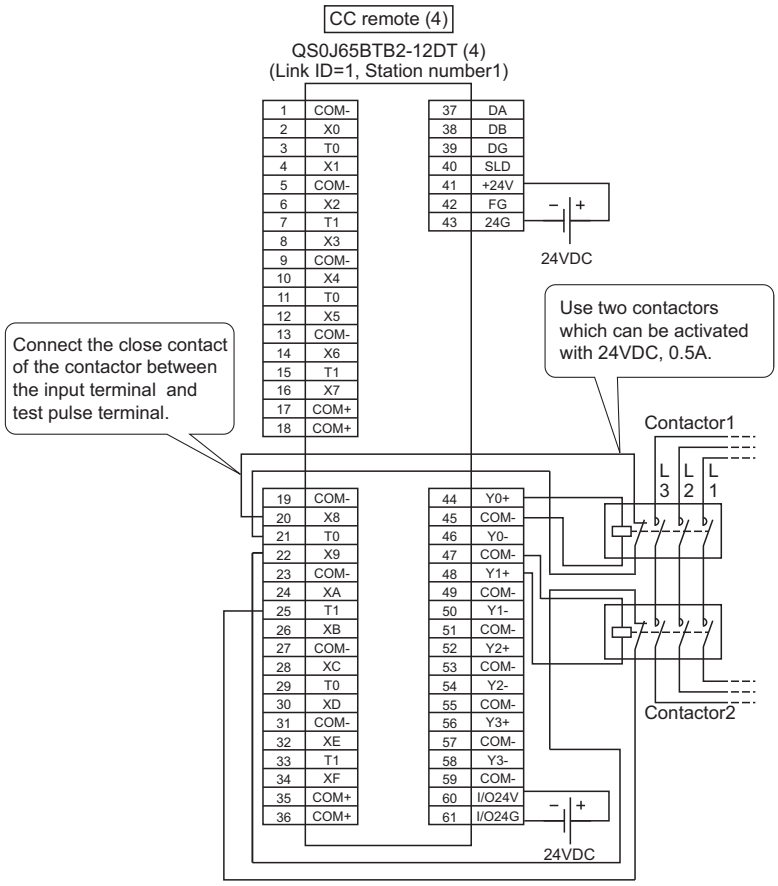


Figure 5.26 CC remote (4) SR_IO4 wiring

For the contactors, set the parameters as follows.

Table 5.17 CC remote (4) SR_IO4 parameter settings

Item	Setting*4*5
5. Time of noise removal filter X8, 9*1	"1ms"
13. Doubling input discrepancy detection time X8, 9*2	"100ms"
21. Input dark test selection X8, 9	"Execute"
25. Input dark test pulse OFF time*1	"400μs"
26. Method of wiring of output Y0	"Doubling wiring (Source+Source)"
27. Method of wiring of output Y1	"Doubling wiring (Source+Source)"
30. Output dark test selection Y0	"Execute"
31. Output dark test selection Y1	"Execute"
34. Output dark test pulse OFF time Y0*1	"1ms"
35. Output dark test pulse OFF time Y1*1	"1ms"
42. Doubling/single input selection X8, 9*3	"Doubling input"
46. Auto RTN Func to detect doubling input mismatch*3	"invalid"

*1: Adjust the values of Time of noise removal filter, Input dark test pulse OFF time, and Output dark test pulse OFF time according to the installation environment and wiring length.

*2: Set Doubling input discrepancy detection time to 100ms for the mechanical switch and 20ms for the sensor input as a standard.

*3: The parameter is added to the QS0J65BTB2-12DT of technical version D.
When a module of technical version C or earlier is used, the parameter is not available.

*4: For setting range, refer to the following.

☞ CC-Link Safety System Remote I/O Module User's Manual

*5: Always set the enclosed option for this case example.

(4) Device numbers to be used

The following device numbers are used in the sequence program.

Table 5.18 Device numbers to be used

Safety/standard	External device	Device number
Safety	Light curtain	X104 or X105
Safety	Laser scanner	X106 or X107
Safety	Contactor	Y200 and Y201
Safety	Contactor (check for welding)	X208 or X209
Standard	Reset switch	X140
Standard	Start switch	X142

(5) Sequence program

The sequence program performs the following processing.

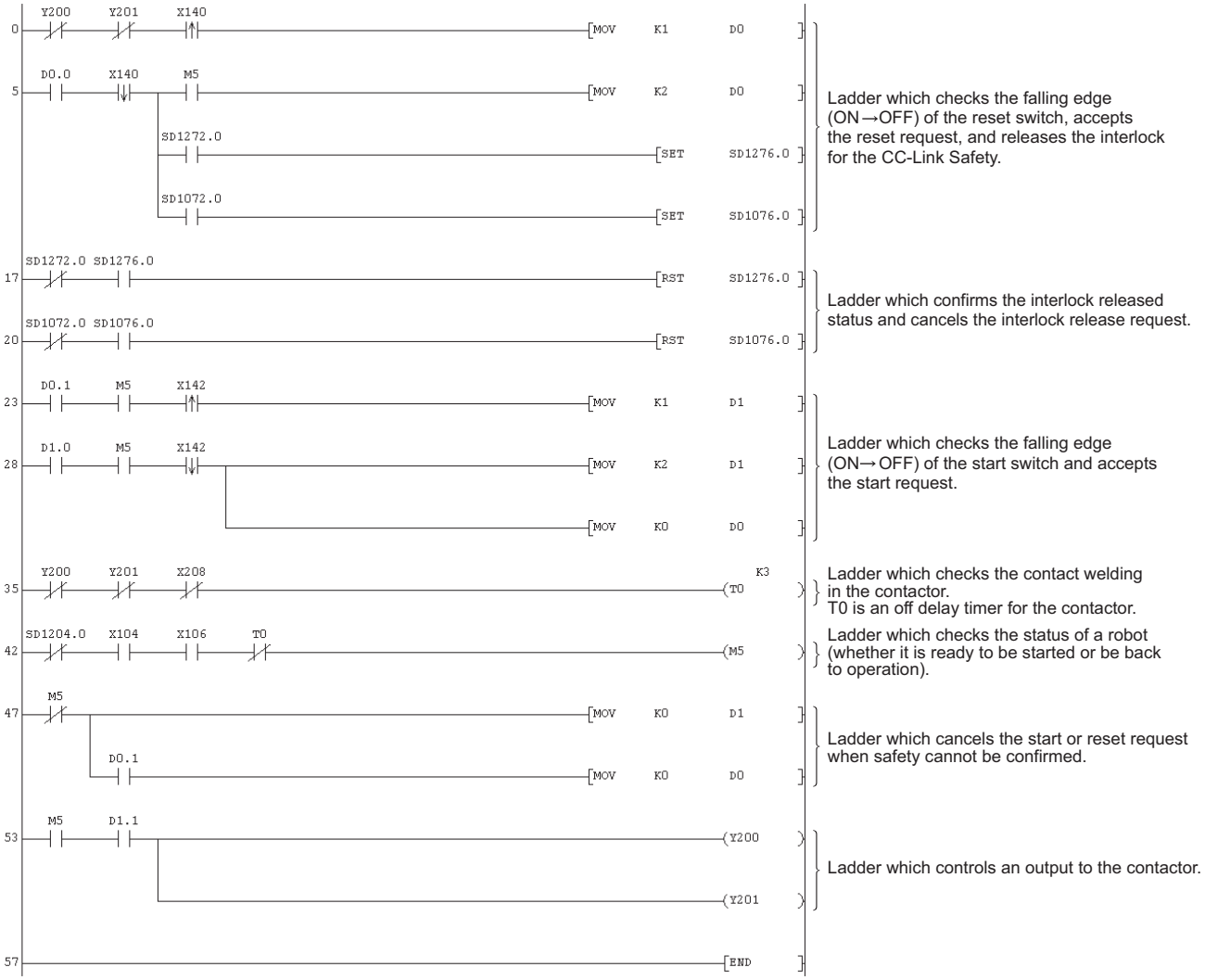


Figure 5.27 Sequence program

The following shows the constant and internal devices used in the program.

(a) Way of using the constant

K☐ indicates decimal number.

Example) K1 = 1 of decimal number

(b) Way of using the internal devices

Table 5.19 Way of using the internal devices

Internal device	Description
T0	Timer device Times out after a lapse of the time specified at K☐.
D0	Word device Used as restart status in this program. (1) D0 = 0: Initial status or start processing completed (2) D0 = 1 (D0.0: on): Reset switch activated (3) D0 = 2 (D0.1: on): Restart processing completed (Reset switch released after activated in (2))
D1	Word device Used as start status in this program. (1) D1 = 0: Initial status or safety not confirmed (2) D1 = 1 (D1.0: on): Start switch activated (3) D1 = 2 (D1.1: on): Start processing completed (Start switch released after activated in (2))

(c) Way of using word device bit specification

D☐☐.⬚ indicates the ⬚th bit data of word device D☐☐.

Example) D0.0 = 0 bits in D0

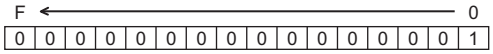


Figure 5.28 Word device bit specification

(6) Timing chart

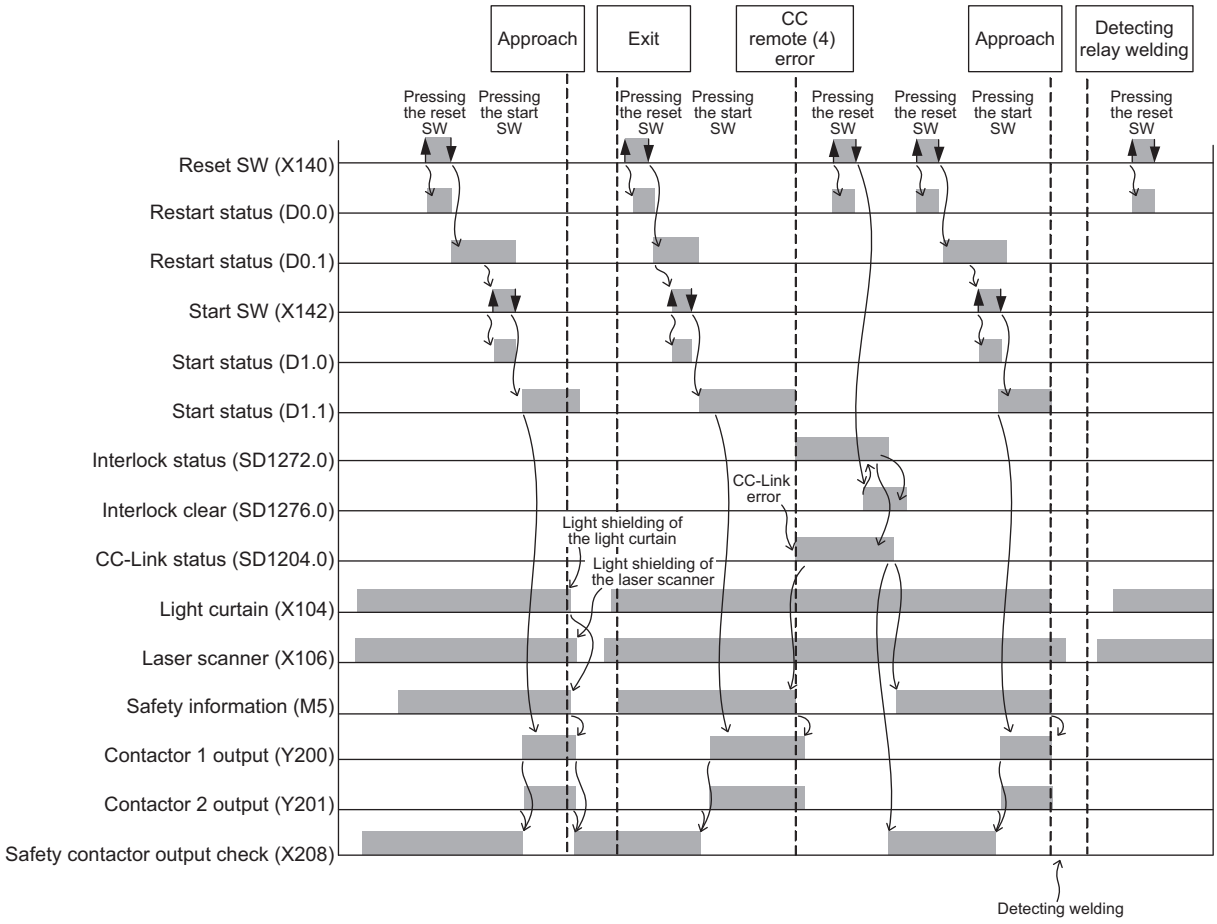


Figure 5.29 Timing chart

(7) Program using safety FB

Table 5.20 Safety FBs to be used

FB name	Function	Description
F+EDM	External device monitor	This FB monitors safety equipment such as an actuator and a contactor and controls a safety output.
F+ESPE	Light curtain (ESPE)	This FB is used for emergency stop of Stop Category 0 using a light curtain.

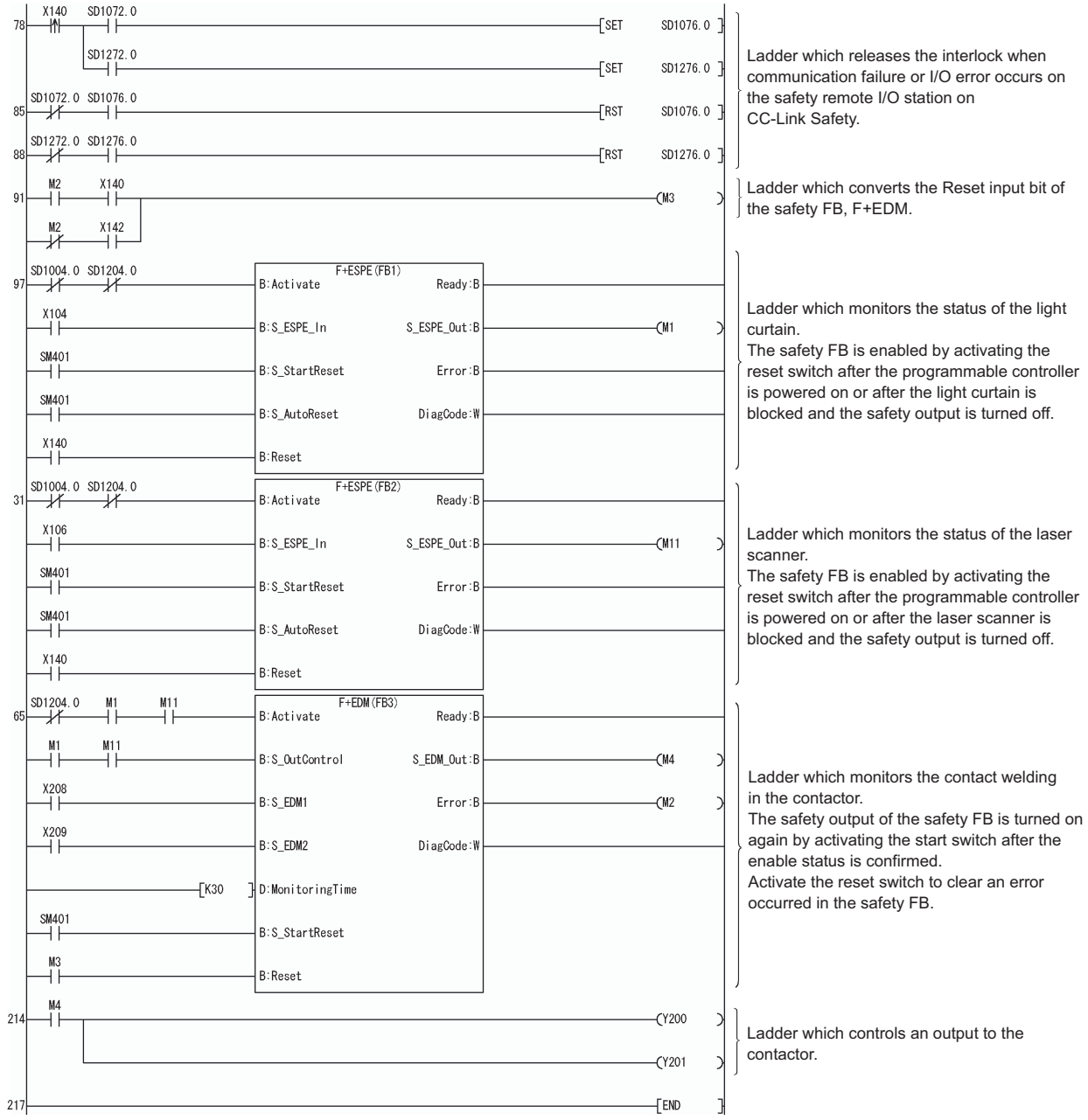


Figure 5.30 Program using safety FB

For details on the safety FBs, F+ESPE, and F+EDM, refer to the following.
☞ QSCPU Programming Manual (Safety FB)

(8) Timing chart

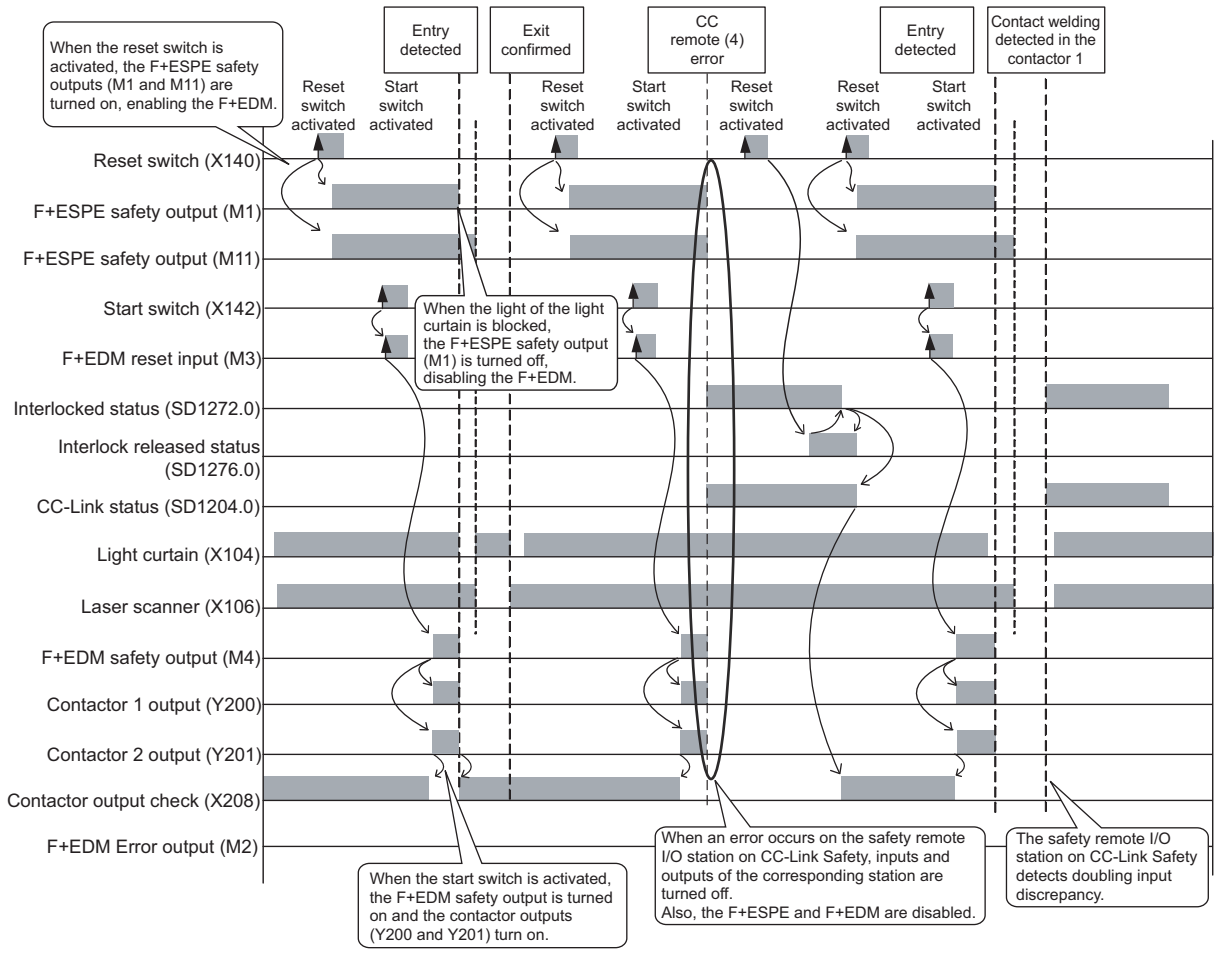


Figure 5.31 Timing chart

5.6.4 Entering detection and existence detection circuit 2

(1) Application overview

The entering detection and existence detection circuit is the safety application that detects the entrance and existence of a human in a hazardous area and turns off the power source of a robot.
The entrance of human to the hazardous area is detected with a light shielding of the light curtain. The existence of human in the hazardous area is detected with mat switch. When the entrance or existence of human has been detected, a robot is stopped.
The robot cannot be started until the human leaves the hazardous area.

Start and stop of the robot is controlled with contactors that close and open the power supply.
The safety programmable controller turns on/off the main contacts of the contactors with sequence program.

Connect the light curtain and contactors to a safety programmable controller.
The relay is connected between the mat switch and safety programmable controller.
The safety programmable controller turns on/off the main contacts of the contactors with sequence program.
When the safety programmable controller detects an error by self-diagnostics, outputs to the contactors turn off independent of the sequence program.
In this case, the outputs remain off until the safety CPU module or CC-Link Safety remote I/O module is reset independent of the sequence program.

Configure the sequence program so that the following functions can be achieved.

1) After ensuring safety (The light curtain and mat switch signals are both on.), activating the reset switch and then the start switch turns on the contactors.
2) When the main contacts of the contactors are welded, do not start the robot. Input the auxiliary contacts (normally closed contacts) to the safety programmable controller to check for welding.
3) The reset switch and start switch become valid only when turned off to avoid operation at contact welding or short-circuit.
4) The contactor output is turned off when the light curtain signal or the relay input of mat switch is turned off or an error is detected in the safety remote I/O station on CC-Link Safety after the start.

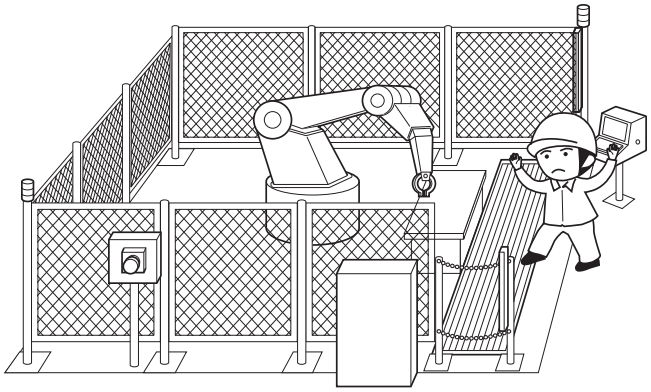


Figure 5.32 Entering detection and existence detection

(Partially quoted from "Safety Guide Book - the safety measures of machinery in the workplace" : Nippon Electric Control Equipment Industries Association.)

(2) Connection of safety devices

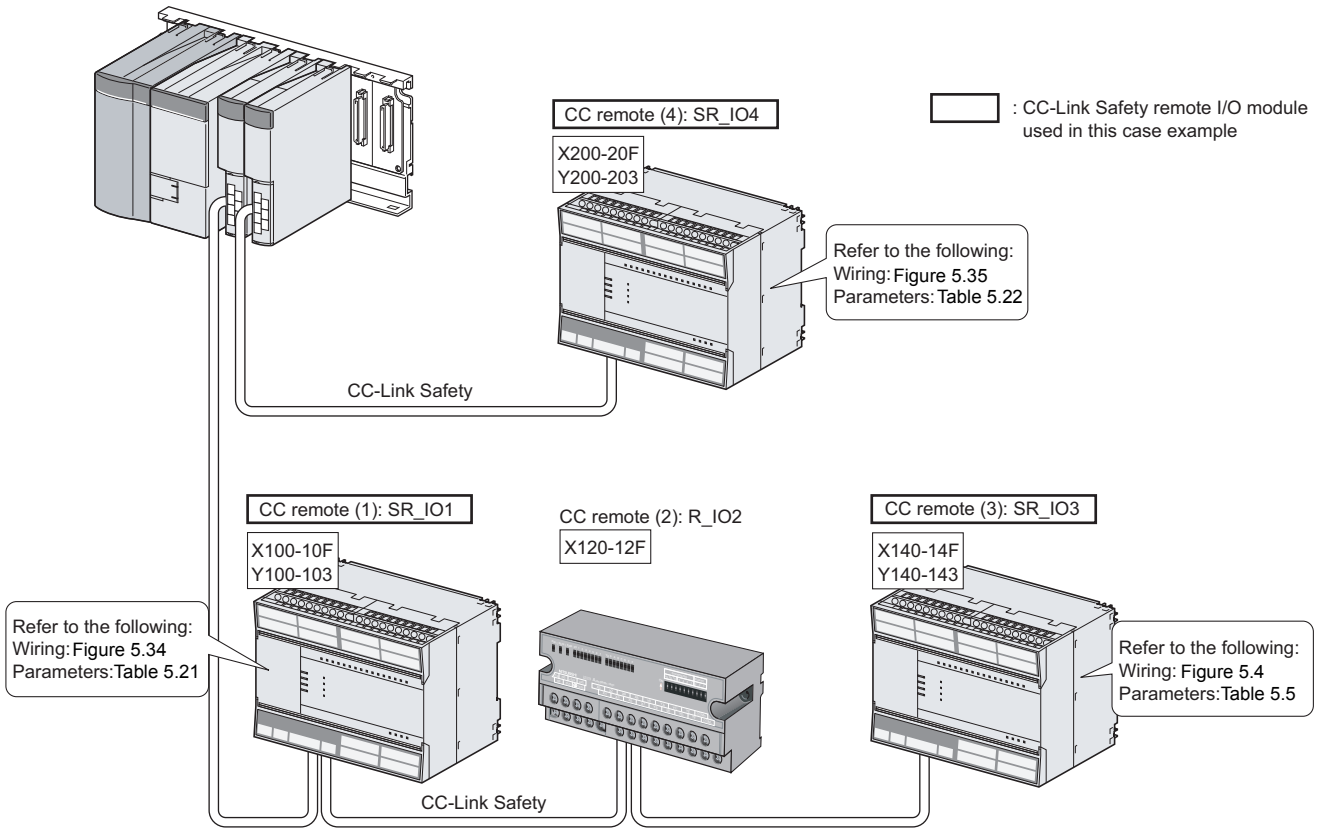
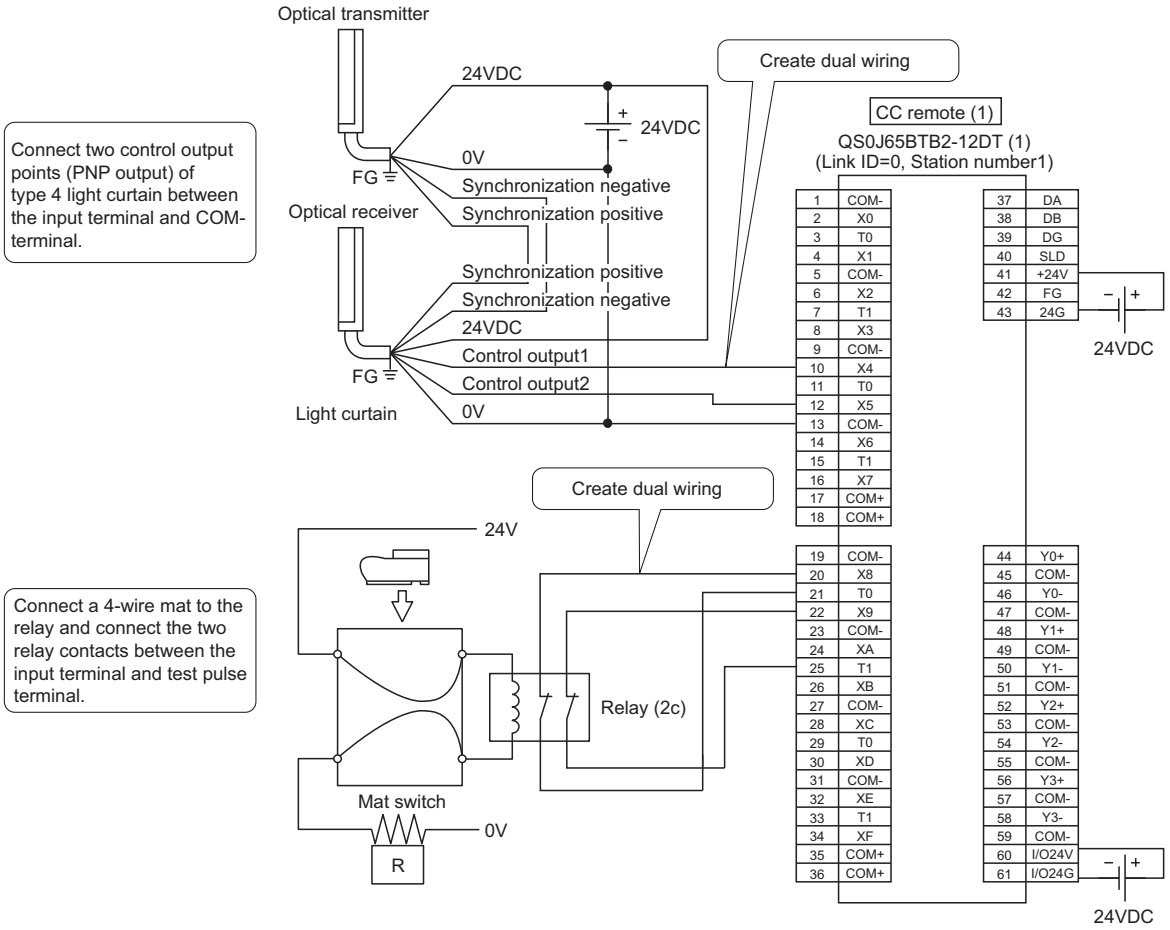


Figure 5.33 Safety device connection diagram

(3) Wiring diagram and parameter settings

(a) CC remote (1): SR_IO1

Wire the light curtain and the mat switch to the CC-Link Safety remote I/O module as follows.



1	COM-		37	DA	
2	X0		38	DB	
3	T0		39	DG	
4	X1		40	SLD	
5	COM-		41	+24V	
6	X2		42	FG	
7	T1		43	24G	
8	X3				
9	COM-				
10	X4				
11	T0				
12	X5				
13	COM-				
14	X6				
15	T1				
16	X7				
17	COM+				
18	COM+				
19	COM-		44	Y0+	
20	X8		45	COM-	
21	T0		46	Y0-	
22	X9		47	COM-	
23	COM-		48	Y1+	
24	XA		49	COM-	
25	T1		50	Y1-	
26	XB		51	COM-	
27	COM-		52	Y2+	
28	XC		53	COM-	
29	T0		54	Y2-	
30	XD		55	COM-	
31	COM-		56	Y3+	
32	XE		57	COM-	
33	T1		58	Y3-	
34	XF		59	COM-	
35	COM+		60	I/O24V	
36	COM+		61	I/O24G	

Figure 5.34 CC remote (1) SR_IO1 wiring

For the light curtain and the mat switch, set the parameters as follows.

Table 5.21 CC remote (1) SR_IO1 parameter settings

Item	Setting*4*5
3. Time of noise removal filter X4, 5*1	"1ms"
5. Time of noise removal filter X8, 9*1	"1ms"
11. Doubling input discrepancy detection time X4, 5*2	"20ms"
13. Doubling input discrepancy detection time X8, 9*2	"20ms"
19. Input dark test selection X4, 5	"Not execute"
21. Input dark test selection X8, 9	"Execute"
25. Input dark test pulse OFF time*1	"400μs"
40. Doubling/single input selection X4, 5*3	"Doubling input"
42. Doubling/single input selection X8, 9*3	"Doubling input"
46. Auto RTN Func to detect doubling input mismatch*3	"Invalid"

*1: Adjust the values of Time of noise removal filter and Input dark test pulse OFF time according to the installation environment and wiring length.

*2: Set Doubling input discrepancy detection time to 100ms for the mechanical switch and 20ms for the sensor input as a standard.

*3: The parameter is added to the QS0J65BTB2-12DT of technical version D.
When a module of technical version C or earlier is used, the parameter is not available.

*4: For setting range, refer to the following.
☞ CC-Link Safety System Remote I/O Module User's Manual

*5: Always set the enclosed option for this case example.

(b) CC remote (4): SR_IO4

Wire the contactors to the CC-Link Safety remote I/O module as follows.

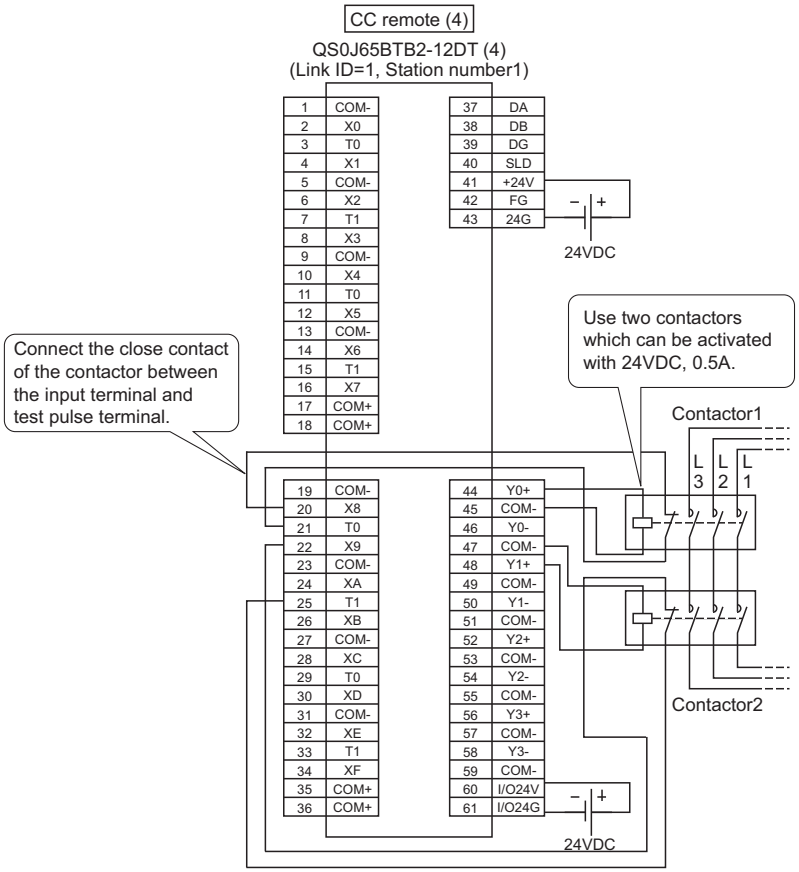


Figure 5.35 CC remote (4) SR_IO4 wiring

For the contactors, set the parameters as follows.

Table 5.22 CC remote (4) SR_IO4 parameter settings

Item	Setting[*4*5]
5. Time of noise removal filter X8, 9[*1]	"1ms"
13. Doubling input discrepancy detection time X8, 9[*2]	"100ms"
21. Input dark test selection X8, 9	"Execute"
25. Input dark test pulse OFF time[*1]	"400μs"
26. Method of wiring of output Y0	"Doubling wiring (Source+Source)"
27. Method of wiring of output Y1	"Doubling wiring (Source+Source)"
30. Output dark test selection Y0	"Execute"
31. Output dark test selection Y1	"Execute"
34. Output dark test pulse OFF time Y0[*1]	"1ms"
35. Output dark test pulse OFF time Y1[*1]	"1ms"
42. Doubling/single input selection X8, 9[*3]	"Doubling input"
46. Auto RTN Func to detect doubling input mismatch[*3]	"Invalid"

*1: Adjust the values of Time of noise removal filter, Input dark test pulse OFF time, and Output dark test pulse OFF time according to the installation environment and wiring length.

*2: Set Doubling input discrepancy detection time to 100ms for the mechanical switch and 20ms for the sensor input as a standard.

*3: The parameter is added to the QS0J65BTB2-12DT of technical version D.
When a module of technical version C or earlier is used, the parameter is not available.

*4: For setting range, refer to the following.
☞ CC-Link Safety System Remote I/O Module User's Manual

*5: Always set the enclosed option for this case example.

(4) Device numbers to be used

The following device numbers are used in the sequence program.

Table 5.23 Device numbers to be used

Safety/standard	External device	Device number
Safety	Light curtain	X104 or X105
Safety	Mat switch	X108 or X109
Safety	Contactors 1 and 2	Y200 and Y201
Safety	Contactor (check for welding)	X208 or X209
Standard	Reset switch	X140
Standard	Start switch	X142

(5) Sequence program

The sequence program performs the following processing.

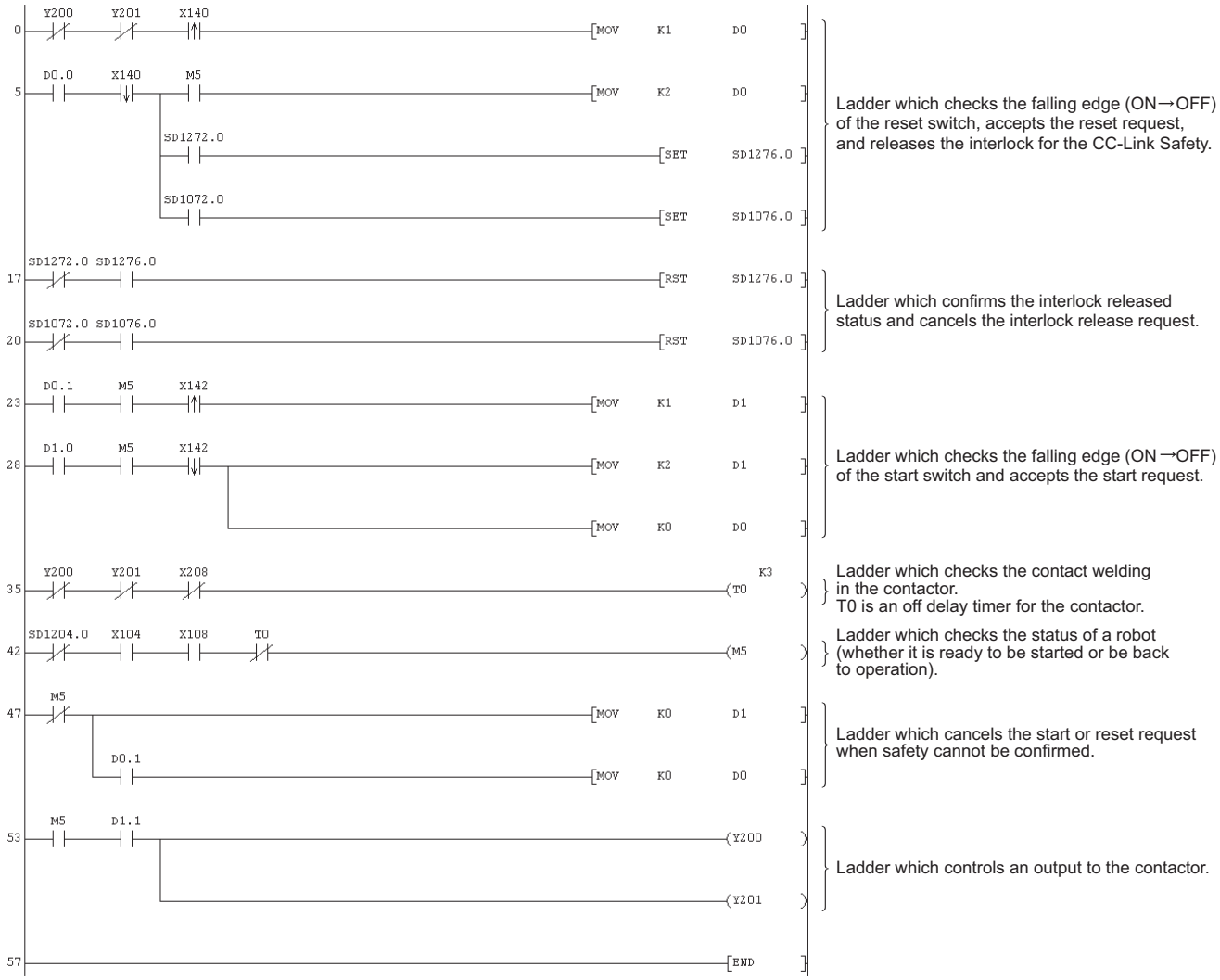


Figure 5.36 Sequence program

The following shows the constant and internal devices used in the program.

(a) Way of using the constant

K☐ indicates decimal number.

Example) K1 = 1 of decimal number

(b) Way of using the internal devices

Table 5.24 Way of using the internal devices

Internal device	Description
T0	Timer device Times out after a lapse of the time specified at K☐.
D0	Word device Used as restart status in this program. (1) D0 = 0: Initial status or start processing completed (2) D0 = 1 (D0.0: on): Reset switch activated (3) D0 = 2 (D0.1: on): Restart processing completed (Reset switch released after activated in (2))
D1	Word device Used as start status in this program. (1) D1 = 0: Initial status or safety not confirmed (2) D1 = 1 (D1.0: on): Start switch activated (3) D1 = 2 (D1.1: on): Start processing completed (Start switch released after activated in (2))

(c) Way of using word device bit specification

D☐☐.⬚ indicates the ⬚th bit data of word device D☐☐.

Example) D0.0 = 0 bits in D0

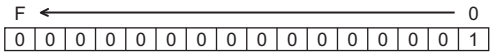


Figure 5.37 Word device bit specification

(6) Timing chart

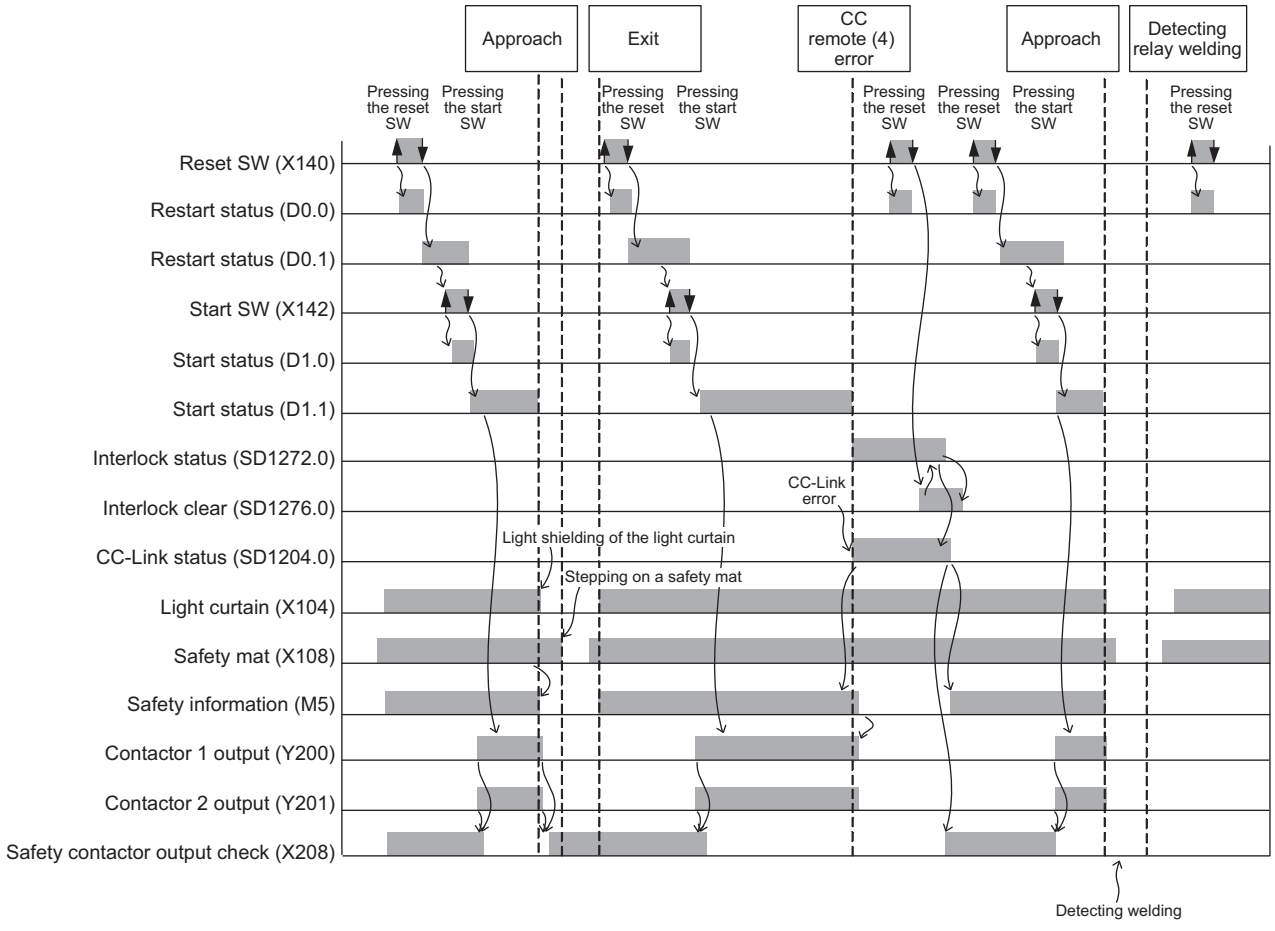


Figure 5.38 Timing chart

5.6.5 Door lock circuit

(1) Application overview

This application prevents the door from being opened until a robot is de-energized with the safety switch on the door of a safety barrier.
The safety switch is usually interlocked with spring. By applying a voltage to a solenoid, the interlock is released and the door can be opened.
The robot cannot be started while the interlock is released or the door is open.
This section shows an example where the interlock of the safety switch is released by activating the stop switch and the safety switch is re-interlocked by activating the reset switch.

Start and stop of the robot is controlled with contactors that close and open the power supply.

Connect the safety switch and contactors to a safety programmable controller.
The safety programmable controller turns on/off the main contacts of the contactors with sequence program.
When the safety programmable controller detects an error by self-diagnostics, outputs to the contactors turn off independent of the sequence program.
In this case, the outputs remain off until the safety CPU module or CC-Link Safety remote I/O module is reset independent of the sequence program.

Configure the sequence program so that the following functions can be achieved.

1) After ensuring safety (The safety switch is on.), activating the reset switch and then the start switch turns on the contactors.
2) When the main contacts of the contactors are welded, do not start the robot. Input the auxiliary contacts (normally closed contacts) to the safety programmable controller to check for welding.
3) The reset switch and start switch become valid only when turned off to avoid operation at contact welding or short-circuit.
4) Activating the stop switch turns off outputs to the contactors.
   After that, release the interlock to the safety switch (The safety barrier door can be opened).
5) Activating the reset switch re-interlocks the safety switch.
6) When an error is detected in the safety remote I/O station on CC-Link Safety after operation, outputs to the contactors turn off.

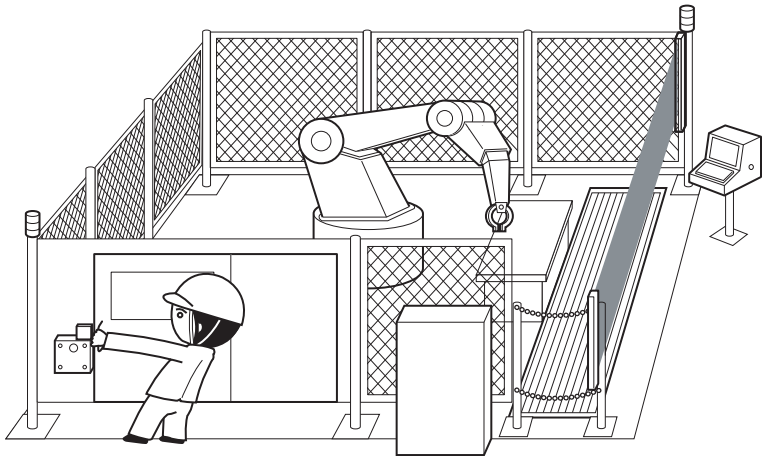


Figure 5.39 Isolation of hazardous area by door interlock

(Partially quoted from "Safety Guide Book - the safety measures of machinery in the workplace"
: Nippon Electric Control Equipment Industries Association.)

(2) Connection of safety devices

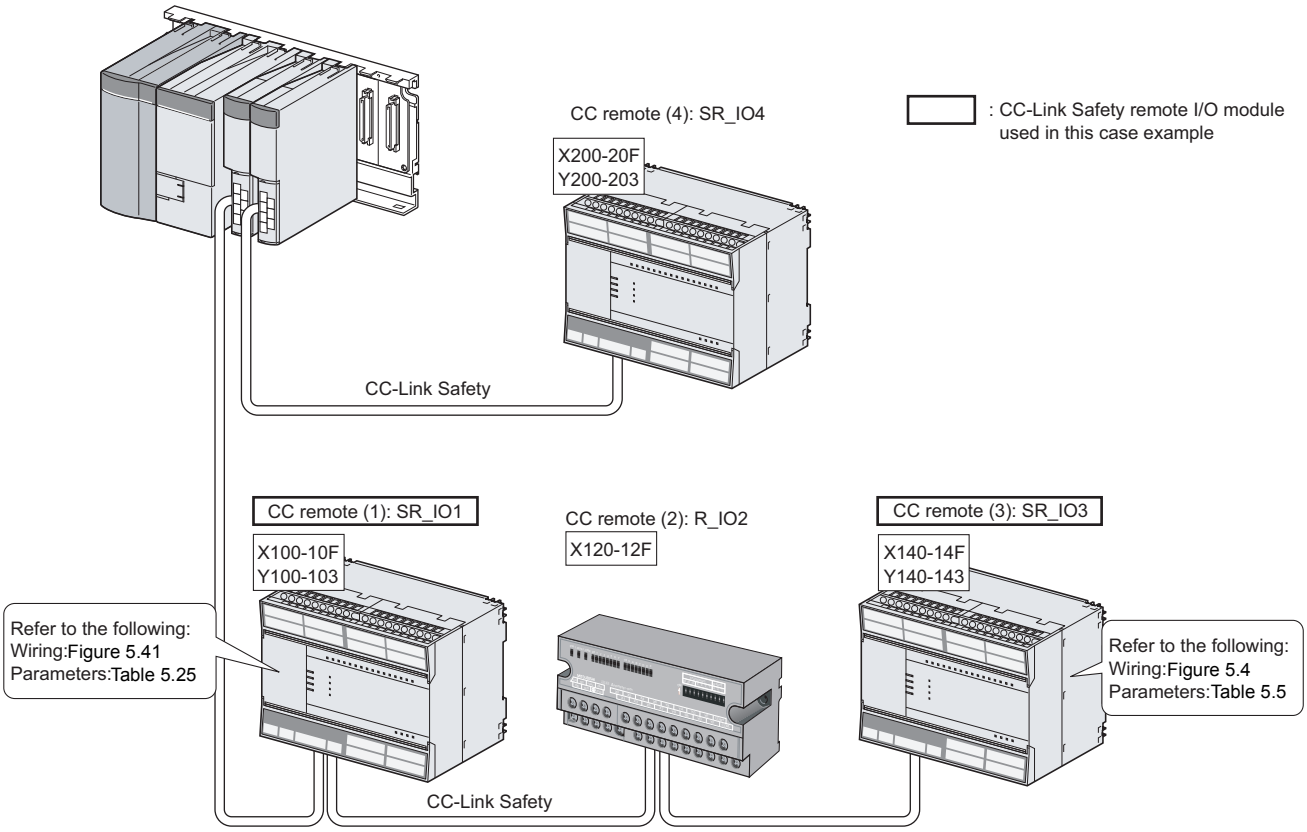


Figure 5.40 Safety device connection diagram

(3) Wiring diagram and parameter settings

(a) CC remote (1): SR_IO1

Wire the safety switch and contactors to the CC-Link Safety remote I/O module as follows.

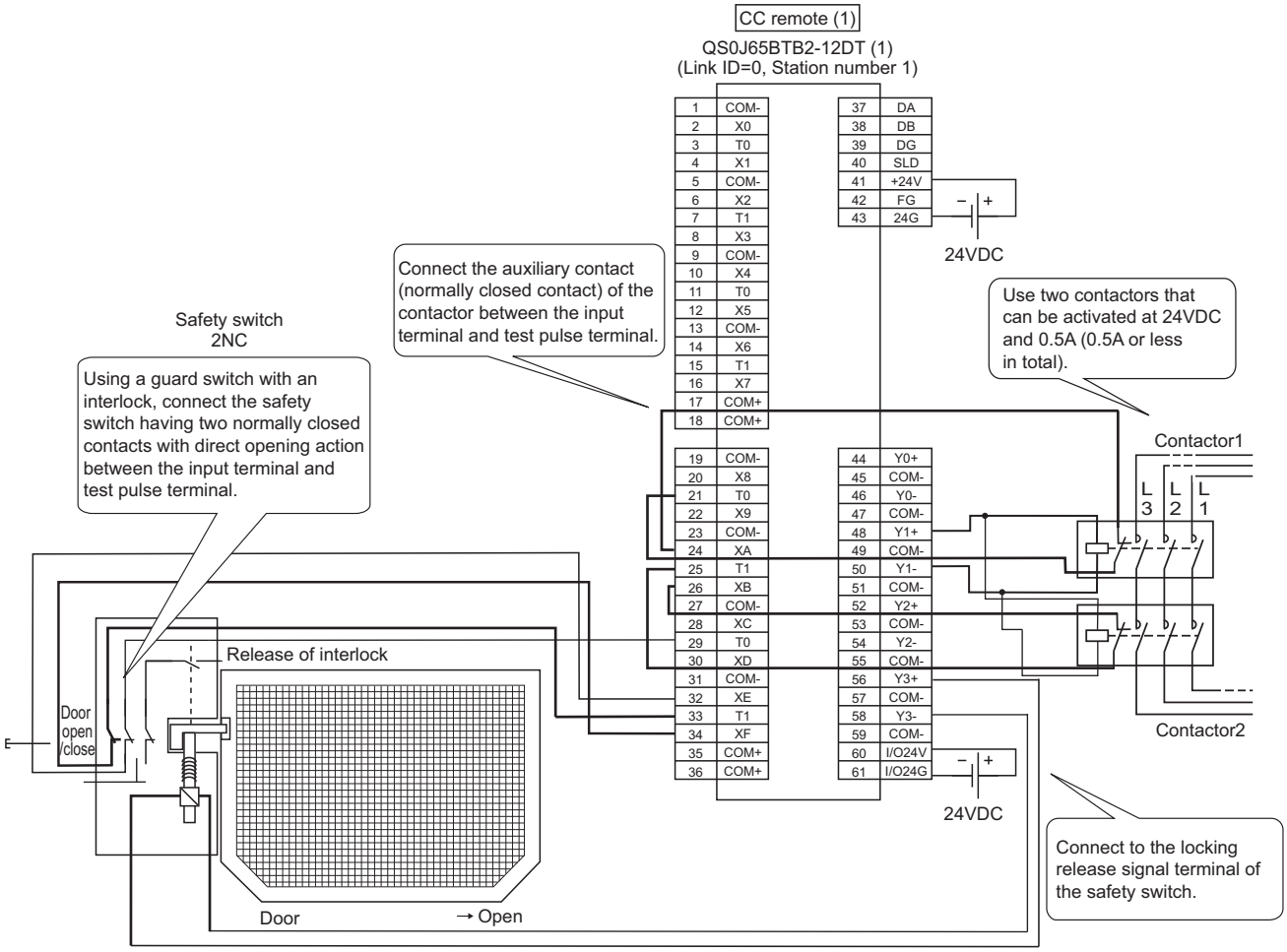


Figure 5.41 CC remote (1) SR_IO1 wiring

This example shows when the door open/close signal of the safety switch is input. When using a safety switch whose locking status can be monitored, input the locking status signal to the CC-Link Safety remote I/O module as well.

For the safety switch and contactors, set the parameters as follows.

Table 5.25 CC remote (1) SR_IO1 parameter settings

Item	Setting*4*5
6. Time of noise removal filter XA, B*1	"1ms"
8. Time of noise removal filter XE, F*1	"1ms"
14. Doubling input discrepancy detection time XA, B*2	"100ms"
16. Doubling input discrepancy detection time XE, F*2	"500ms"
22. Input dark test selection XA, B	"Execute"
24. Input dark test selection XE, F	"Execute"
25. Input dark test pulse OFF time*1	"400 μs"
27. Method of wiring of output Y1	"Doubling wiring (Source+Sink)"
29. Method of wiring of output Y3	"Doubling wiring (Source+Sink)"
31. Output dark test selection Y1	"Execute"
33. Output dark test selection Y3	"Execute"
35. Output dark test pulse OFF time Y1*1	"1ms"
37. Output dark test pulse OFF time Y3*1	"1ms"
43. Doubling/single input selection XA, B*3	"Doubling input"
45. Doubling/single input selection XE, F*3	"Doubling input"
46. Auto RTN Func to detect doubling input mismatch*3	"invalid"

*1: Adjust the values of Time of noise removal filter, Input dark test pulse OFF time, and Output dark test pulse OFF time according to the installation environment and wiring length.

*2: Set Doubling input discrepancy detection time to 100ms for the mechanical switch and 20ms for the sensor input as a standard.

*3: The parameter is added to the QS0J65BTB2-12DT of technical version D.
When a module of technical version C or earlier is used, the parameter is not available.

*4: For setting range, refer to the following.
☞ CC-Link Safety System Remote I/O Module User's Manual

*5: Always set the enclosed option for this case example.

(4) Device numbers to be used

The following device numbers are used in the sequence program.

Table 5.26 Device numbers to be used

Safety/standard	External device	Device number
Safety	Safety switch	X10E or X10F
Safety	Release of interlock to safety switch	Y103
Safety	Contactor	Y101
Safety	Contactor (check for welding)	X10A or X10B
Standard	Reset switch	X140
Standard	Start switch	X142
Standard	Stop switch	X144

(5) Sequence program

The sequence program performs the following processing.

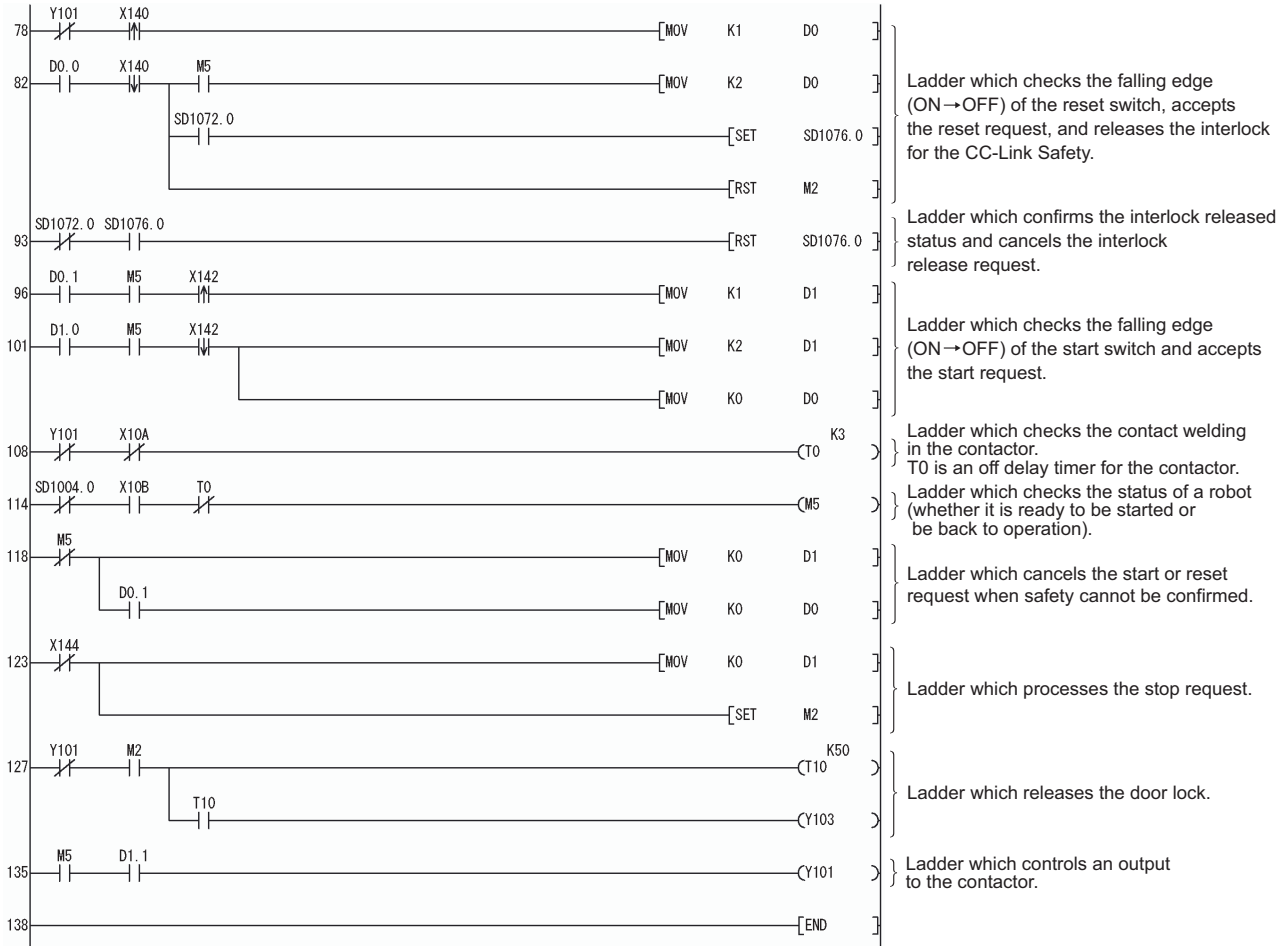


Figure 5.42 Sequence program

The following shows the constant and internal devices used in the program.

(a) Way of using the constant

K☐ indicates decimal number.

Example) K1 = 1 of decimal number

(b) Way of using the internal devices

Table 5.27 Way of using the internal devices

Internal device	Description
T0	Timer device Times out after a lapse of the time specified at K☐.
D0	Word device Used as restart status in this program. (1) D0 = 0: Initial status or start processing completed (2) D0 = 1 (D0.0: on): Reset switch activated (3) D0 = 2 (D0.1: on): Restart processing completed (Reset switch released after activated in (2))
D1	Word device Used as start status in this program. (1) D1 = 0: Initial status or safety not confirmed (2) D1 = 1 (D1.0: on): Start switch activated (3) D1 = 2 (D1.1: on): Start processing completed (Start switch released after activated in (2))

(c) Way of using word device bit specification

D☐☐.⬚ indicates the ⬚th bit data of word device D☐☐.

Example) D0.0 = 0 bits in D0

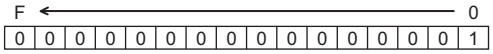


Figure 5.43 Word device bit specification

(6) Timing chart

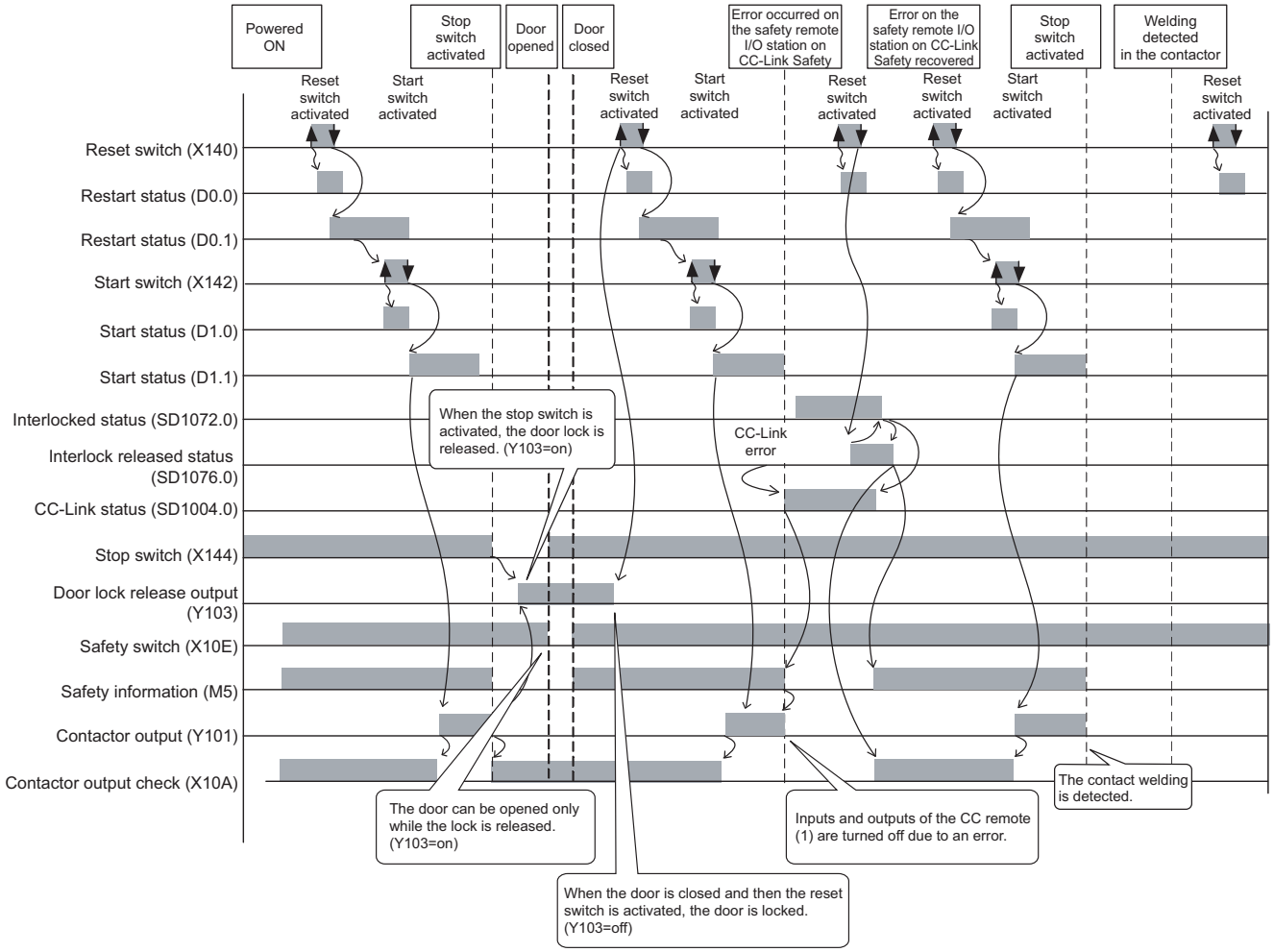


Figure 5.44 Timing chart

(7) Program using safety FB

Table 5.28 Safety FBs to be used

FB name	Function	Description
F+EDM	External device monitor	This FB monitors safety equipment such as an actuator and a contactor and controls a safety output.
F+GLOCK	Guard lock and interlocking	This FB controls an entrance to a hazardous area via an interlocking guard with guard locking ("four state interlocking").

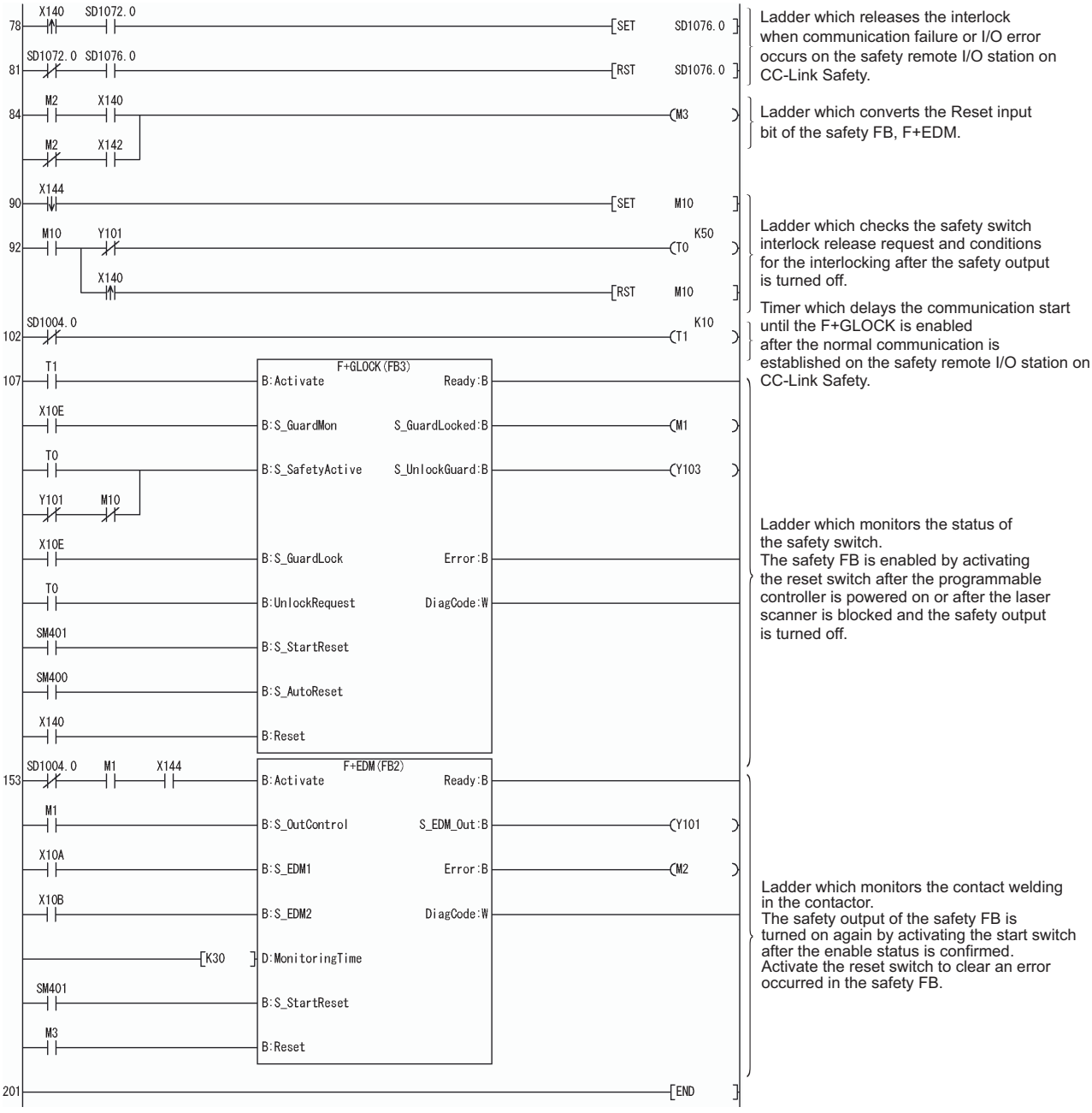


Figure 5.45 Program using safety FB

For details on the safety FBs, F+GLOCK, and F+EDM, refer to the following.
☞ QSCPU Programming Manual (Safety FB)

In this example, the door open/close signal of the safety switch is used as an input signal. Therefore, this signal (X10E) is connected to the input signal, S_GuardLock (safety guard locking status), of the F+GLOCK as well.
When using a safety switch whose locking status can be monitored, connect the locking status signal to S_GuardLock.
If a safety switch that cannot monitor the door open/close signal is used, connect the locking status signal to the two input signals, S_GuardMon (safety guard interlock status monitoring) and S_GuardLock, of the G+GLOCK.
In this case, the timer, T1 (timer for waiting the F+GLOCK to be enabled) in the program above, must be programmed.

(8) Timing chart

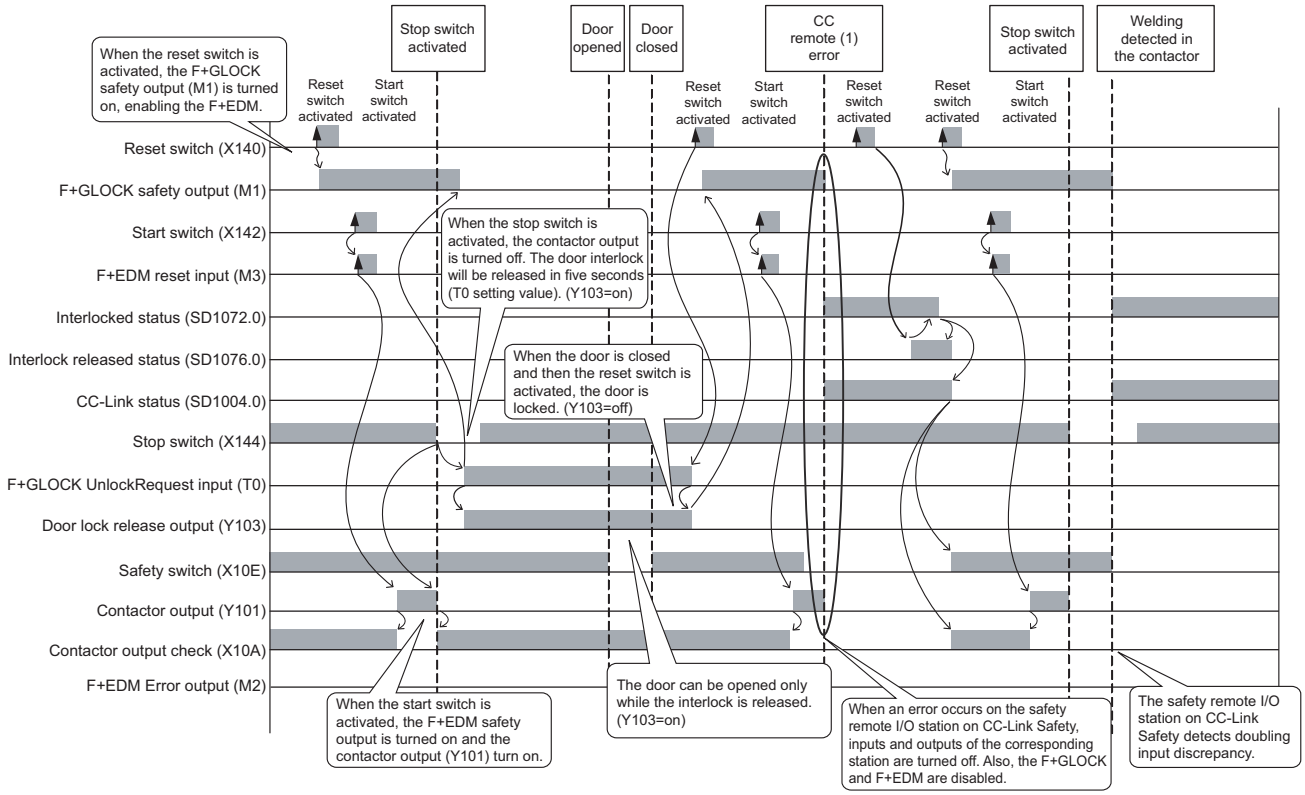


Figure 5.46 Timing chart

5.6.6 3-position enable switch

(1) Application overview

This application controls energization of a robot with 3-position enable switch while a worker teaches or maintenances the robot in a safety barrier with the safety barrier door open.

For interlocking the door and releasing the interlock during automatic operation, refer to Section 5.6.5.

Start and stop of the robot is controlled with contactors that close and open the power supply.

Connect the enable switch, safety switch, and contactors to a safety programmable controller.

The safety programmable controller turns on/off the main contacts of the contactors with sequence program.

When the safety programmable controller detects an error by self-diagnostics, outputs to the contactors turn off independent of the sequence program.

In this case, the outputs remain off until the safety CPU module or CC-Link Safety remote I/O module is reset independent of the sequence program.

Configure the sequence program so that the following functions can be achieved.

1) Switch the operation mode to manual so that automatic operation may not be allowed. In the manual mode, take measures for safety such as limitation of operation speed of the robot.
2) In the manual mode, operation using except the enable switch is inhibited.
3) When the enable switch is held down in the middle position, the robot is energized. In this case, the robot operation is independent of status of the safety barrier door (Even when the door is open, operation at limited speed is possible).
4) When the main contacts of the contactors are welded, do not start the robot. Input the auxiliary contacts (normally closed contacts) to the safety programmable controller to check for welding.
5) When an error is detected in the safety remote I/O station on CC-Link Safety after operation, outputs to the contactors turn off.

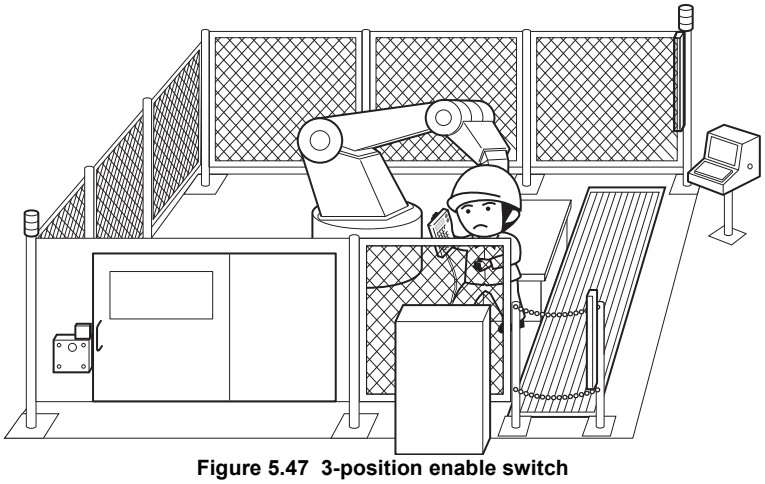


Figure 5.47 3-position enable switch

(Partially quoted from "Safety Guide Book - the safety measures of machinery in the workplace" : Nippon Electric Control Equipment Industries Association.)

(2) Connection of safety devices

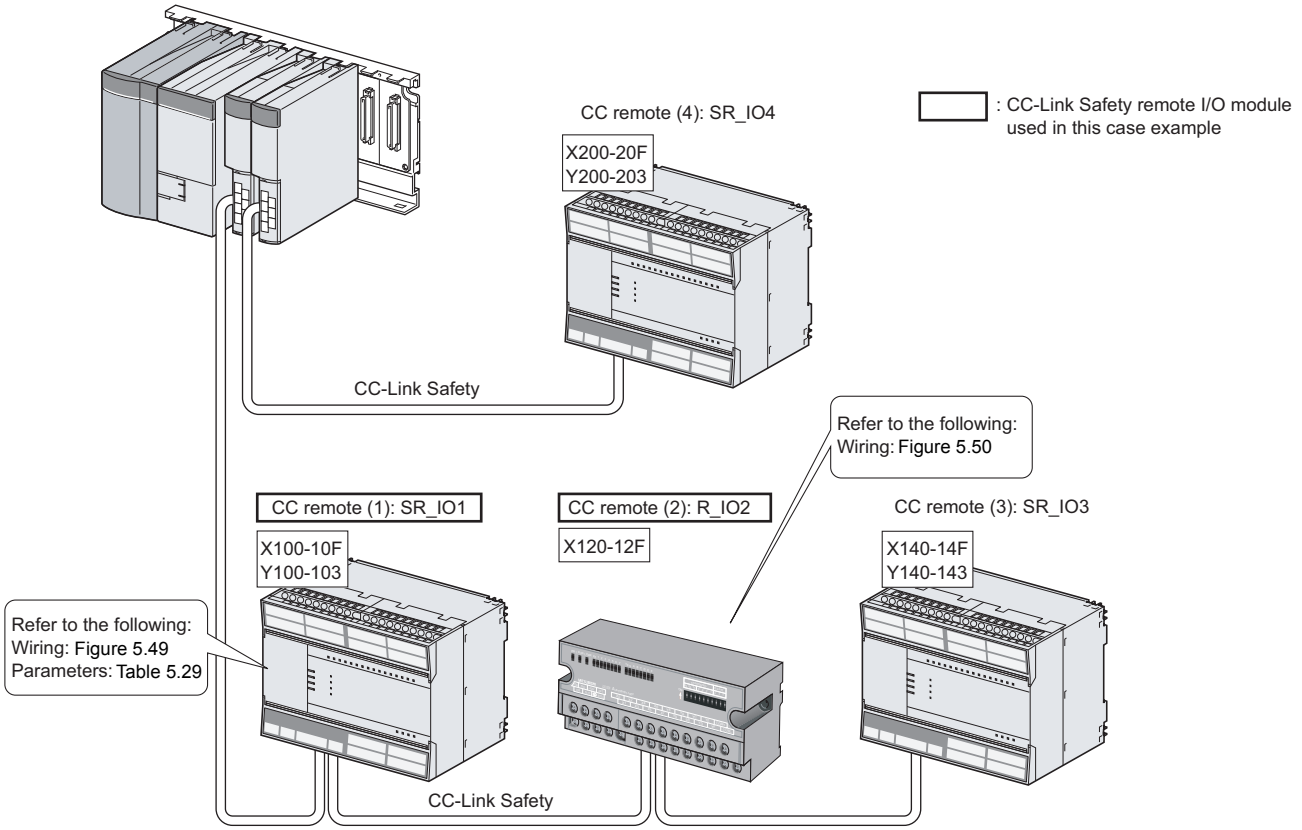


Figure 5.48 Safety device connection diagram

(3) Wiring diagram and parameter settings

(a) CC remote (1): SR_IO1

Wire the enable switch, safety switch, and contactors to the CC-Link Safety remote I/O module as follows.

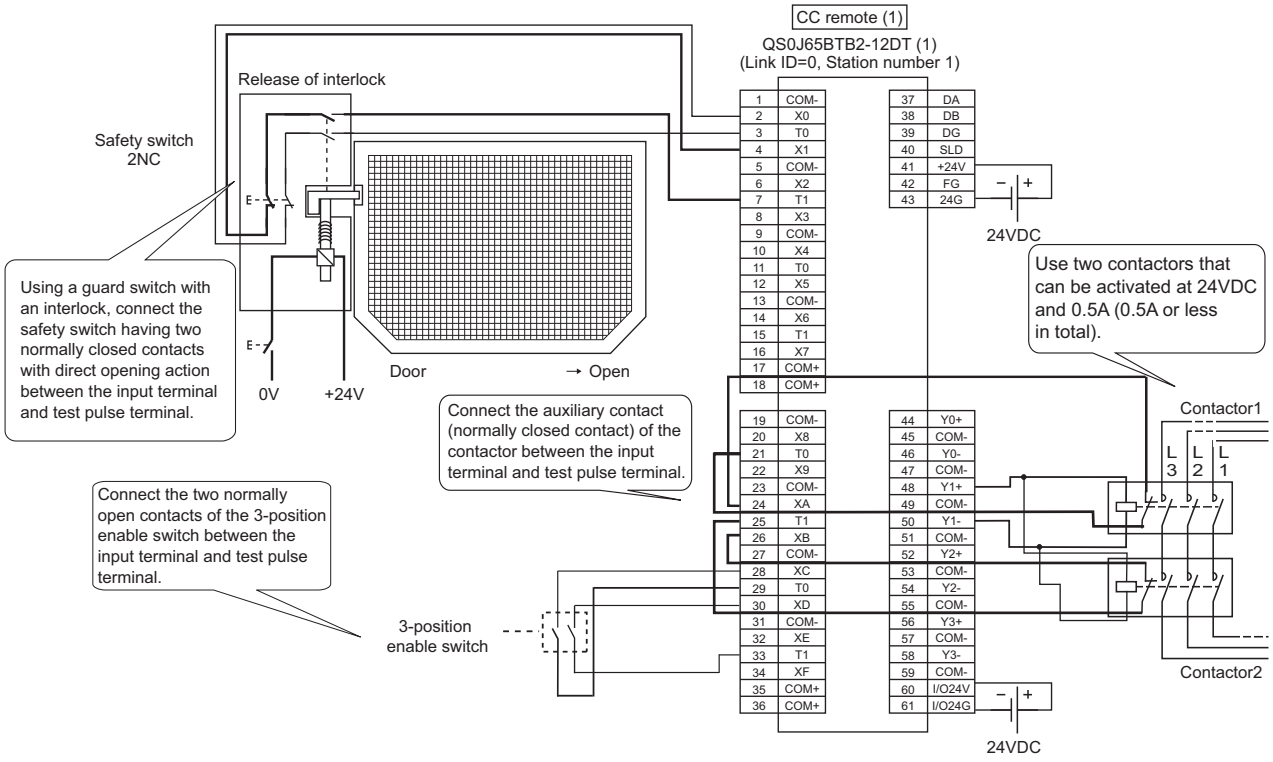


Figure 5.49 CC remote (1) SR_IO1 wiring

For the enable switch, safety switch, and contactors, set the parameters as follows.

Table 5.29 CC remote (1) SR_IO1 parameter settings

Item	Setting*4*5
1. Time of noise removal filter X0, 1*1	"1ms"
6. Time of noise removal filter XA, B*1	"1ms"
7. Time of noise removal filter XC, D*1	"1ms"
9. Doubling input discrepancy detection time X0, 1*2	"500ms"
14. Doubling input discrepancy detection time XA, B*2	"100ms"
15. Doubling input discrepancy detection time XC, D*2	"100ms"
17. Input dark test selection X0, 1	"Execute"
22. Input dark test selection XA, B	"Execute"
23. Input dark test selection XC, D	"Execute"
25. Input dark test pulse OFF time*1	"400 μs"
27. Method of wiring of output Y1	"Doubling wiring (Source+Sink)"
31. Output dark test selection Y1	"Execute"
35. Output dark test pulse OFF time Y1*1	"1ms"
38. Doubling/single input selection X0, 1*3	"Doubling input"
43. Doubling/single input selection XA, B*3	"Doubling input"
44. Doubling/single input selection XC, D*3	"Doubling input"
46. Auto RTN Func to detect doubling input mismatch*3	"invalid"

*1: Adjust the values of Time of noise removal filter, Input dark test pulse OFF time, and Output dark test pulse OFF time according to the installation environment and wiring length.

*2: Set Doubling input discrepancy detection time to 100ms for the mechanical switch and 20ms for the sensor input as a standard.

*3: The parameter is added to the QS0J65BTB2-12DT of technical version D.
When a module of technical version C or earlier is used, the parameter is not available.

*4: For setting range, refer to the following.
☞ CC-Link Safety System Remote I/O Module User's Manual

*5: Always set the enclosed option for this case example.

(b) CC remote (2): R_IO2

Wire the reset switch, start switch, and mode selection (manual, automatic) switch to the standard remote I/O module as follows.

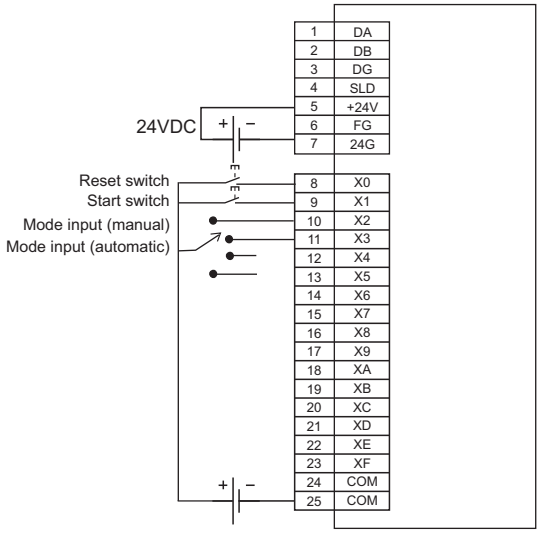


Figure 5.50 CC remote (2) R_IO2 wiring

(4) Device numbers to be used

The following device numbers are used in the sequence program.

Table 5.30 Device numbers to be used

Safety/standard	External device	Device number
Safety	Safety switch	X100 or X101
Safety	Enable switch	X10C or X10D
Safety	Contactor	Y101
Safety	Contactor (check for welding)	X10A or X10B
Standard	Reset switch	X120
Standard	Start switch	X121
Standard	Manual mode	X122
Standard	Automatic mode	X123

(5) Sequence program

The sequence program performed the following processing.

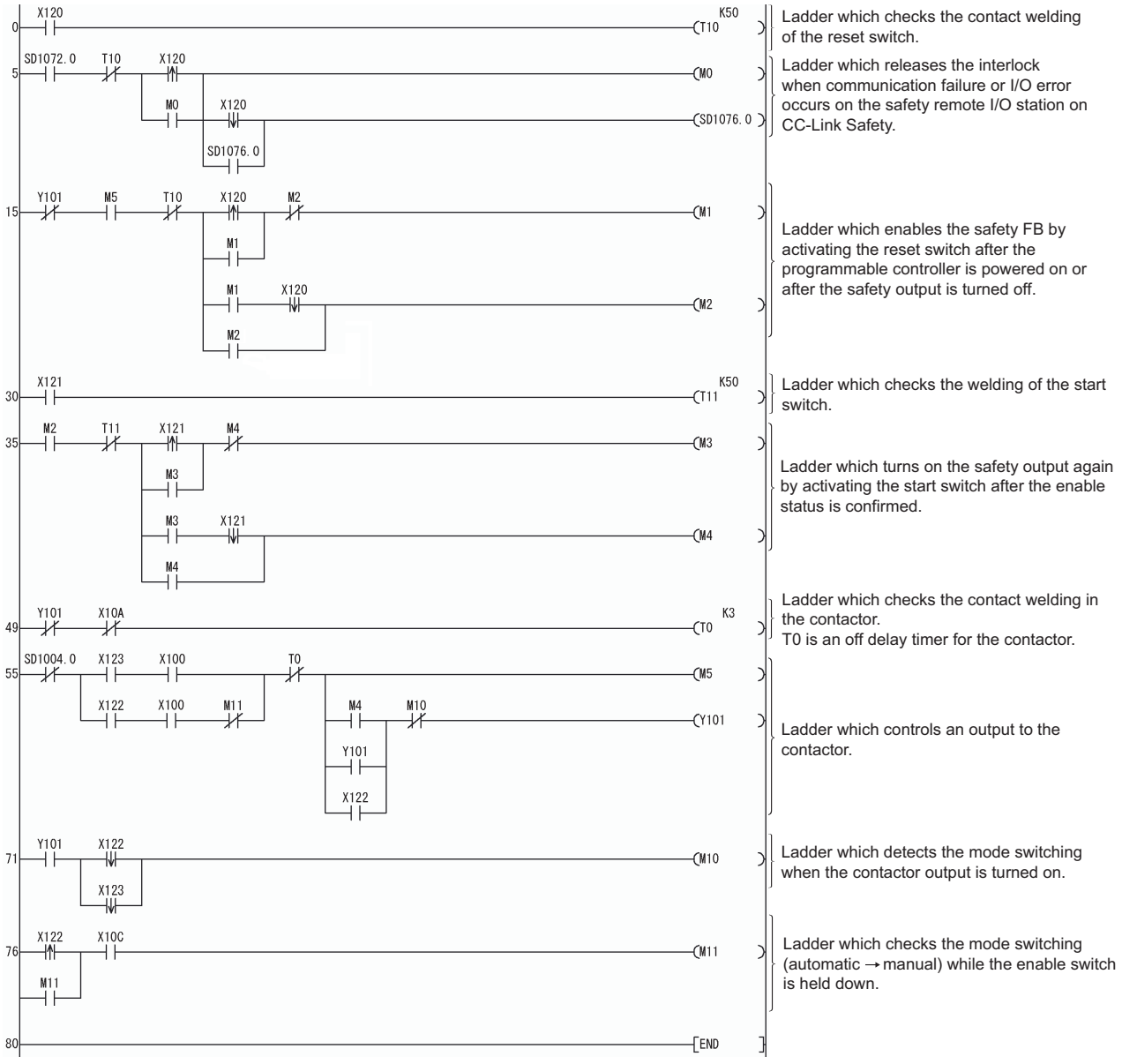


Figure 5.51 Sequence program

The following shows the constant and internal devices used in the program.

(a) Way of using the constant

K☐ indicates decimal number.

Example) K1 = 1 of decimal number

(b) Way of using the internal devices

Table 5.31 Way of using the internal devices

Internal device	Description
T0	Timer device Times out after a lapse of the time specified at K☐.

(c) Way of using word device bit specification

D☐☐.⬚ indicates the ⬚th bit data of word device D☐☐.

Example) D0.0 = 0 bits in D0

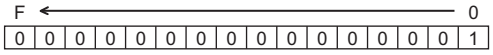


Figure 5.52 Word device bit specification

(6) Timing chart

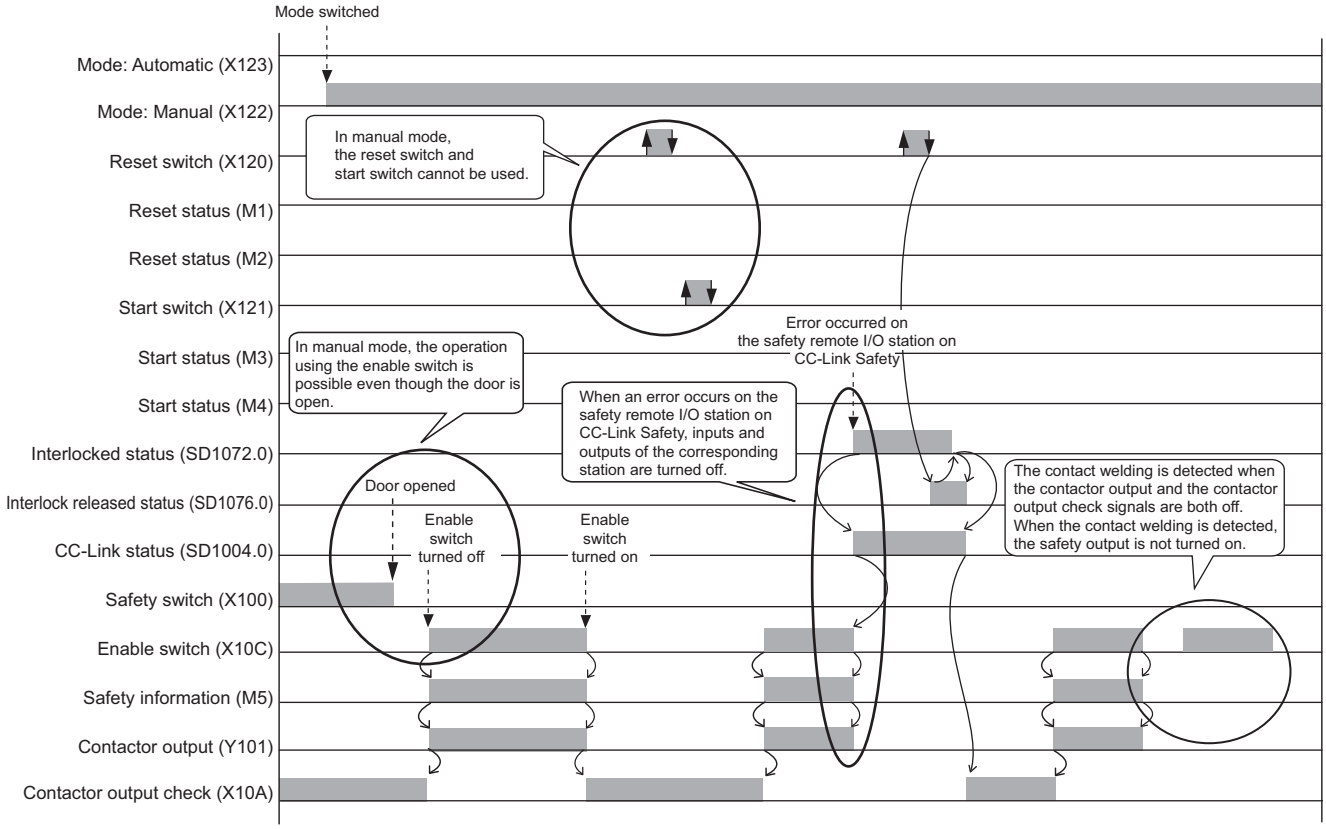
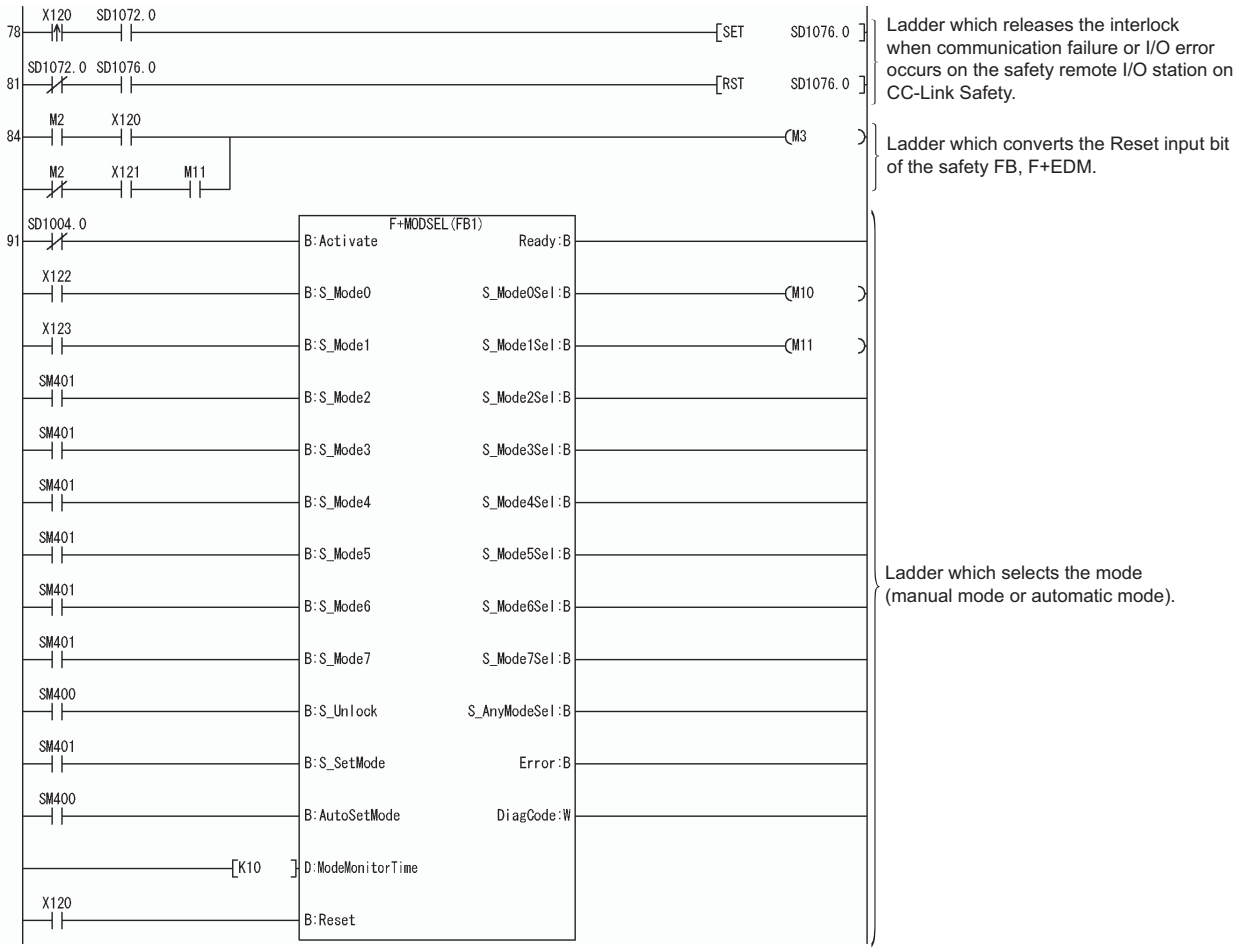


Figure 5.53 Timing chart

(7) Program using safety FB

Table 5.32 Safety FBs to be used

FB name	Function	Description
F+EDM	External device monitor	This FB monitors safety equipment such as an actuator and a contactor and controls a safety output.
F+ENBLSW	Enable switch	This FB monitors the 3-position enable switch signal.
F+GMON	Guard monitoring	This FB monitors a safety guard using two safety switches and dual switch discrepancy time (Monitoring Time) when the guard is closed.
F+MODSEL	Mode selector	This FB is used for selecting an operation mode such as manual and semi-automatic.



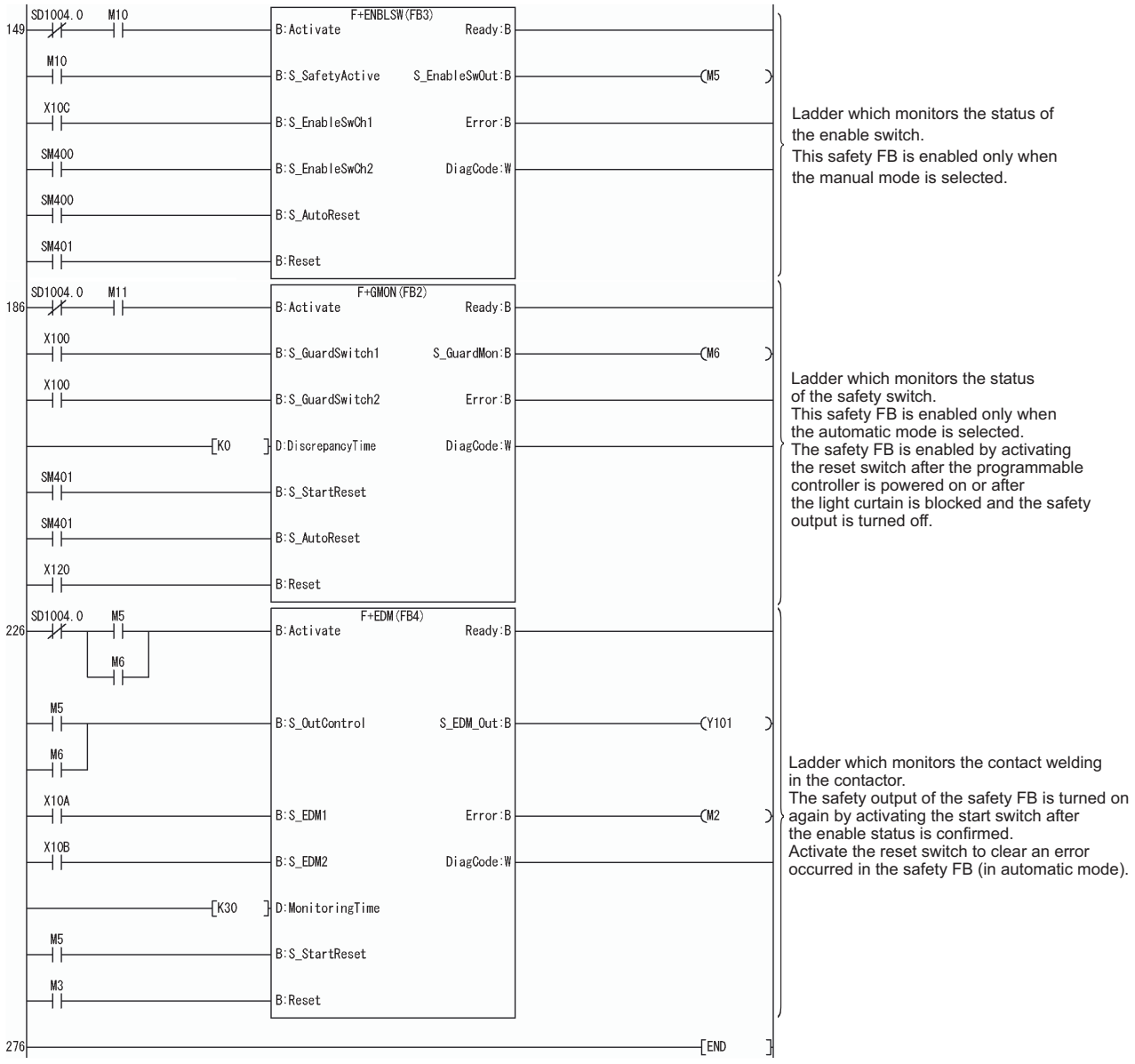


Figure 5.54 Program using safety FB

For details on the safety FBs, F+MODSEL, F+GMON, F+ENBLSW, and F+EDM, refer to the following.

☞ QSCPU Programming Manual (Safety FB)

In this example, an enable switch with no monitor signal for position 3 is used. Therefore, SM400 (always ON) is connected to the input signal, S_EnableSwCh2, of the F+ENBLSW. (S_EnableSwCh2 is a signal for the contacts E3 and E4 of the connected enable switch.)
When an enable switch with monitor signal for position 3 is used, connect the corresponding signal to the input signal, S_EnableSwCh2, to monitor the status of position 3.

(8) Timing chart

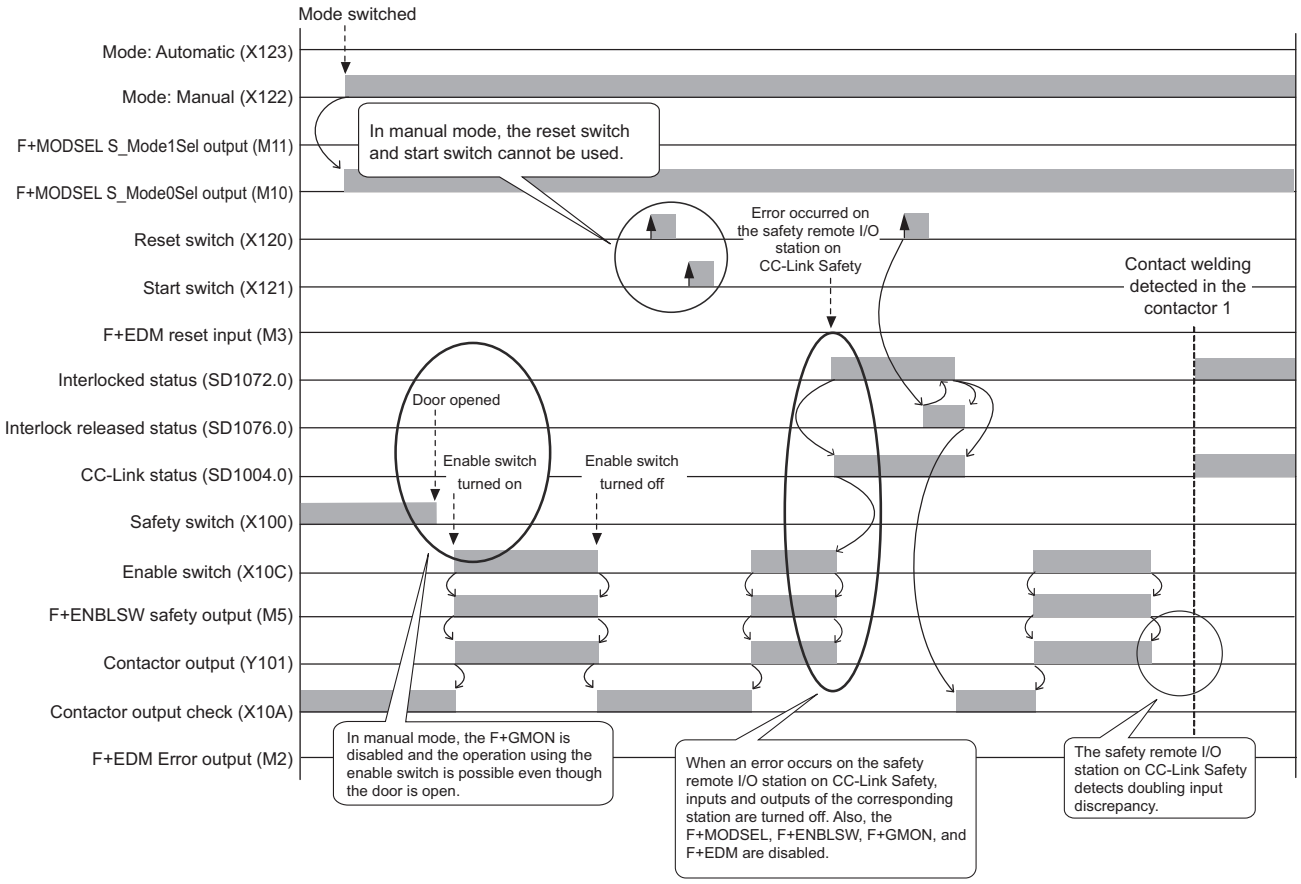


Figure 5.55 Timing chart

5.6.7 Sequential muting

(1) Application overview

This function temporarily invalidates a shading detection signal such as a light curtain. This function allows carrying members into a hazardous area without de-energizing a robot.

The muting is controlled with a muting sensor.
This section explains a sequential muting with four muting sensors.
Start and stop of the robot is controlled with contactors that close and open the power supply.
Connect the light curtain and contactors to a safety programmable controller.
The safety programmable controller turns on/off the main contacts of the contactors with sequence program.
When the safety programmable controller detects an error by self-diagnostics, outputs to the contactors turn off independent of the sequence program.
In this case, the outputs remain off until the safety CPU module or CC-Link Safety remote I/O module is reset independent of the sequence program.

Configure the sequence program so that the following functions can be achieved.

1) After completing the previous process, allow the muting and then start carrying members in the hazardous area.
   This section shows an example when a start of carry is detected with sensors.
2) The muting is enabled when the four muting sensors detected works in correct timing and order while the muting is set to be allowed.
   The robot is de-energized when detected timing or order is incorrect.
   For the correct timing and order, and conditions to start and end the muting, refer to the QSCPU Programming Manual (Safety FB).
   Once muting has been started, the second muting operation will be disabled.
3) Set valid period of muting.
   If the muting does not end within the set period, it is forcibly terminated and the robot is de-energized.
4) A muting lamp is on during the muting so that muting status can be easily recognized.
   If an error such as disconnection occurs due to faulty wiring to a muting lamp during muting, the muting is suspended.
5) When the main contacts of the contactors are welded, do not start the robot. Input the auxiliary contacts (normally closed contacts) to the safety programmable controller to check for welding.
6) When an error is detected in the safety remote I/O station on CC-Link Safety after operation, outputs to the contactors turn off.

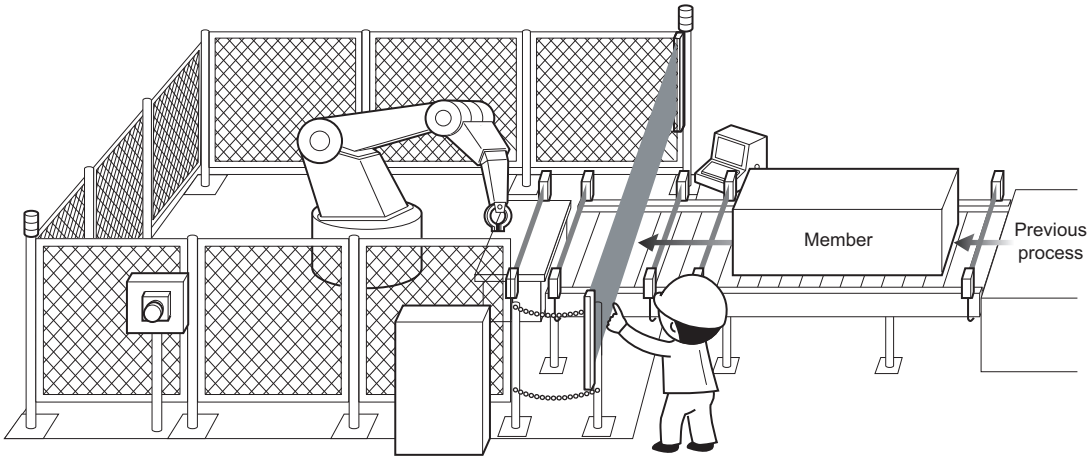


Figure 5.56 Sequential muting

(Partially quoted from "Safety Guide Book - the safety measures of machinery in the workplace" : Nippon Electric Control Equipment Industries Association.)

(2) Connection of safety devices

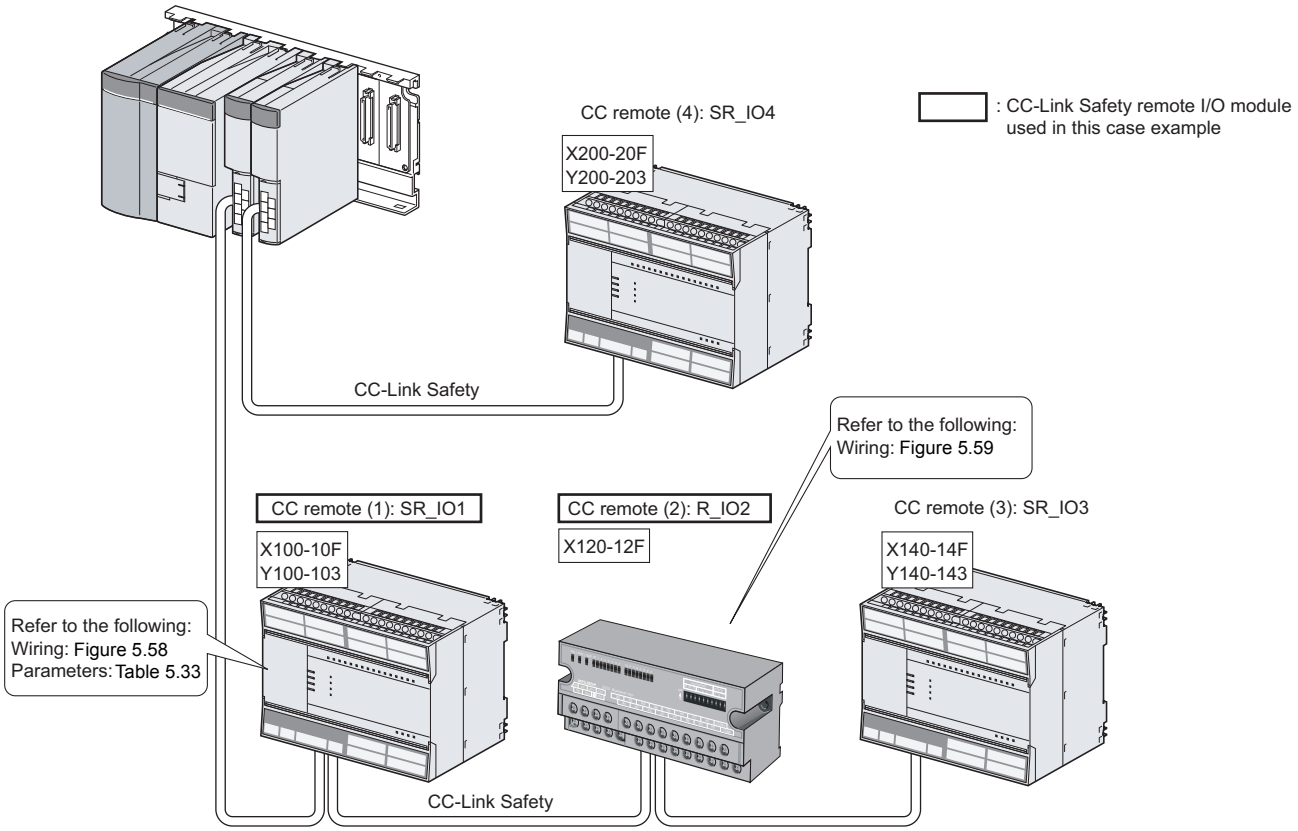


Figure 5.57 Safety device connection diagram

(3) Wiring diagram and parameter settings

(a) CC remote (1): SR_IO1

Wire the light curtain and contactors to the CC-Link Safety remote I/O module as follows.

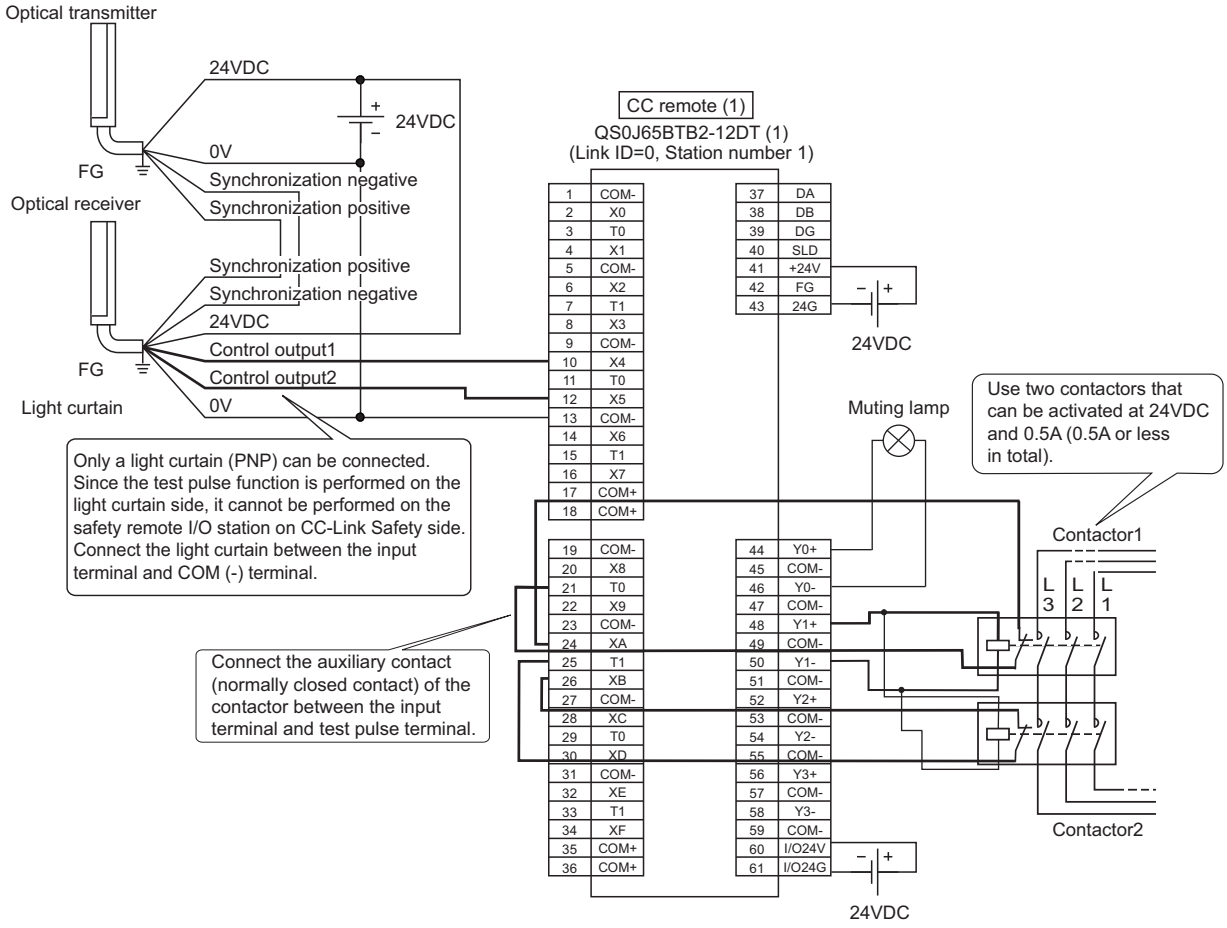


Figure 5.58 CC remote (1) SR_IO1 wiring

One muting lamp is connected in this example.
When two muting lamps are connected between Y0+ and Y0- (same wiring with the contactors 1 and 2 in the figure above), the muting is not suspended even if disconnection occurs to wiring of either of the muting lamp (suspended if disconnection occurs to wiring of both of the muting lamps).

For the light curtain and contactors, set the parameters as follows.

Table 5.33 CC remote (1) SR_IO1 parameter setting

Item	Setting*4*5
3. Time of noise removal filter X4, 5*1	"1ms"
6. Time of noise removal filter XA, B*1	"1ms"
11. Doubling input discrepancy detection time X4, 5*2	"100ms"
14. Doubling input discrepancy detection time XA, B*2	"100ms"
19. Input dark test selection X4, 5	"Not execute"
22. Input dark test selection XA, B	"Execute"
25. Input dark test pulse OFF time*1	"400μs"
26. Method of wiring of output Y0	"Doubling wiring (Source+Sink)"
27. Method of wiring of output Y1	"Doubling wiring (Source+Sink)"
30. Output dark test selection Y0	"Execute"
31. Output dark test selection Y1	"Execute"
34. Output dark test pulse OFF time Y0*1	"1ms"
35. Output dark test pulse OFF time Y1*1	"1ms"
40. Doubling/single input selection X4, 5*3	"Doubling input"
43. Doubling/single input selection XA, B*3	"Doubling input"
46. Auto RTN Func to detect doubling input mismatch*3	"Invalid"

*1: Adjust the values of Time of noise removal filter, Input dark test pulse OFF time, and Output dark test pulse OFF time according to the installation environment and wiring length.

*2: Set Doubling input discrepancy detection time to 100ms for the mechanical switch and 20ms for the sensor input as a standard.

*3: The parameter is added to the QS0J65BTB2-12DT of technical version D.
When a module of technical version C or earlier is used, the parameter is not available.

*4: For setting range, refer to the following.
☞ CC-Link Safety System Remote I/O Module User's Manual

*5: Always set the enclosed option for this case example.

(b) CC remote (2): R_IO2

Wire the reset switch, start switch, and muting sensors to the standard remote I/O module as follows.

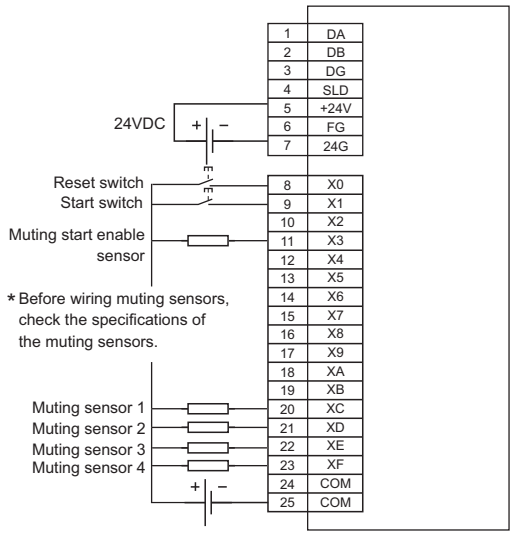


Figure 5.59 CC remote (2) R IO2 wiring

(4) Device numbers to be used

The following device numbers are used in the sequence program.

Table 5.34 Device numbers to be used

Safety/standard	External device	Device number
Safety	Light curtain	X104 or X105
Safety	Contactor	Y101
Safety	Contactor (check for welding)	X10A or X10B
Safety	Muting clamp	Y100
Standard	Reset switch	X120
Standard	Start switch	X121
Standard	Muting start enable sensor	X123
Standard	Muting sensor 1	X12C
Standard	Muting sensor 2	X12D
Standard	Muting sensor 3	X12E
Standard	Muting sensor 4	X12F

(5) Program using safety FB

Table 5.35 Safety FBs to be used

FB name	Function	Description
F+EDM	External device monitor	This FB monitors safety equipment such as an actuator and a contactor and controls a safety output.
F+MUTES	Sequential muting	In this FB, sequential muting with four muting sensors is specified.

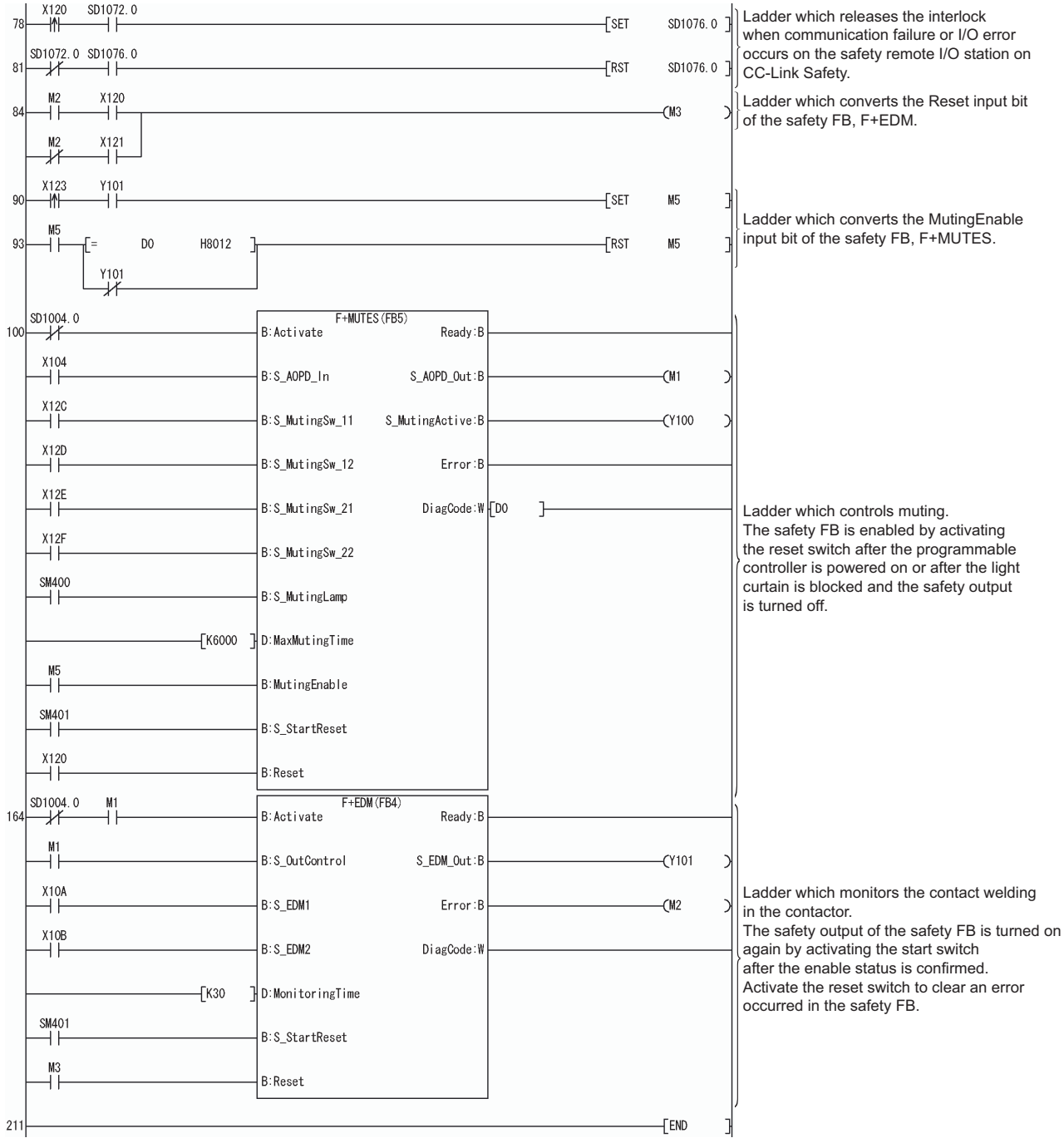


Figure 5.60 Program using safety FB

For details on the safety FBs, F+MUTES, and F+EDM, refer to the following.

☞ QSCPU Programming Manual (Safety FB)

In this example, an error occurs on the safety remote I/O station on CC-Link Safety when a disconnection occurs in the muting lamp wiring.
To avoid an error in the safety remote I/O station on CC-Link Safety due to this kind of error, perform the following:

- Set "1: Not execute" for "Output dark test selection" for the output where the muting clamp is connected.
- Use a muting lamp that can output its status (turns on at normal and turns off if an error occurs).
- Connect a state output signal to the input of the safety FB, S_MutingLamp.

This is an example for performing sequential muting with four muting sensors. To perform parallel muting, use F+MUTE2 or F+MUTEP instead of F+MUTES.

(6) Timing chart

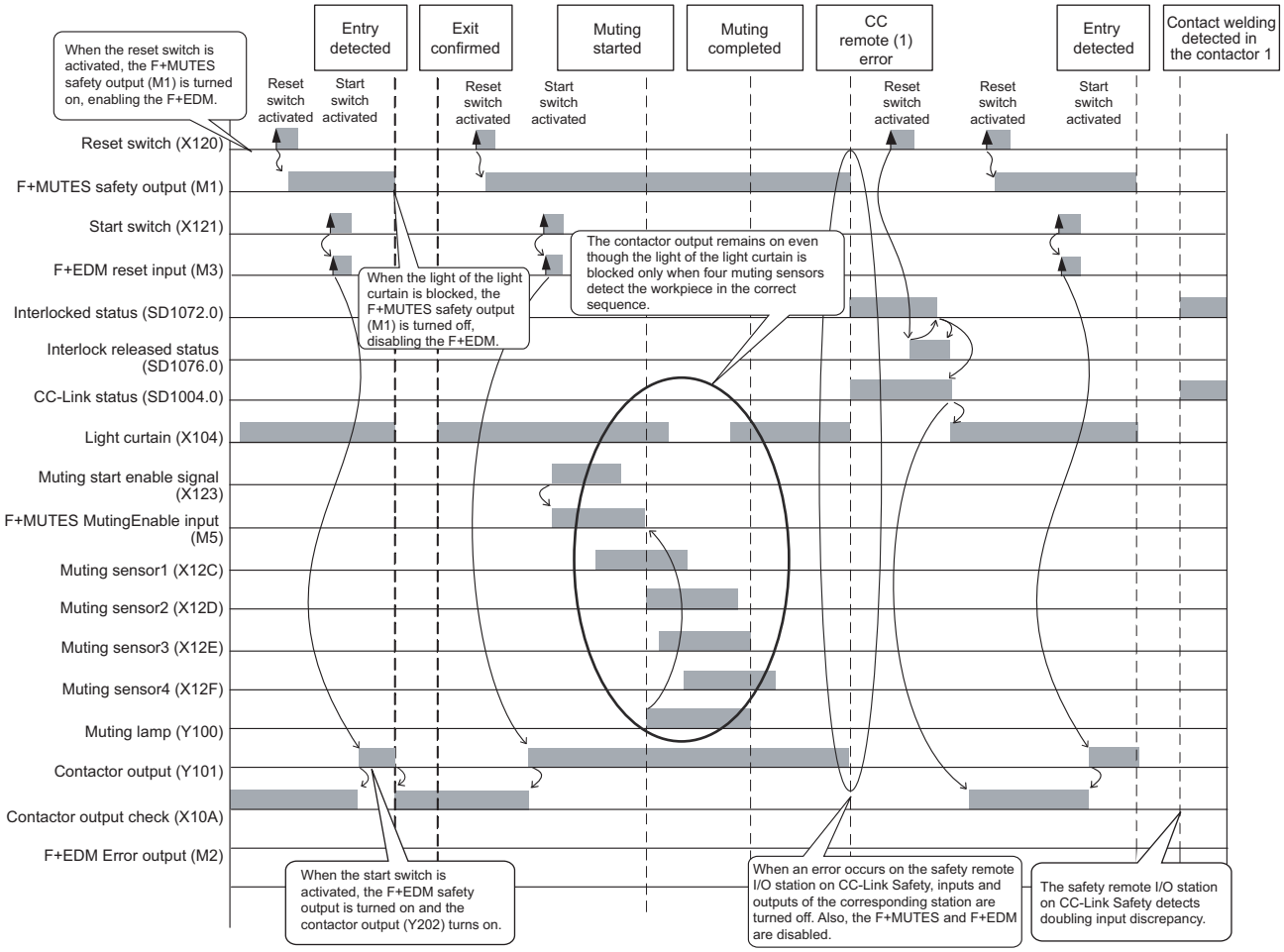


Figure 5.61 Timing chart

5.6.8 Two-hand operation switch

(1) Application overview

This application prevents a worker from approaching to hazardous area by energizing a robot only when two buttons are simultaneously activated with both hands.
A press machine that starts sliding by activating two buttons is the typical application example.
Start and stop of the robot is controlled with contactors that close and open the power supply.

Connect the two-hand operation switch and contactors to a safety programmable controller.
The safety programmable controller turns on/off the main contacts of the contactors with a sequence program.
When the safety programmable controller detects an error by self-diagnostics, outputs to the contactors turn off independent of the sequence program.
In this case, the outputs remain off until the safety CPU module or CC-Link Safety remote I/O module is reset independent of the sequence program.

Configure the sequence program so that the following functions can be achieved.

1) After ensuring safety, activate the two buttons on the two-hand operation switch. The contactors turn on only when timing when the buttons are activated is within 500ms difference.
2) When the main contacts of the contactors are welded, do not start the robot. Input the auxiliary contacts (normally closed contacts) to the safety programmable controller to check for welding.
3) When one or both of the hands are released from the buttons or an error is detected in the safety remote I/O station on CC-Link Safety after operation, outputs to the contactors turn off.

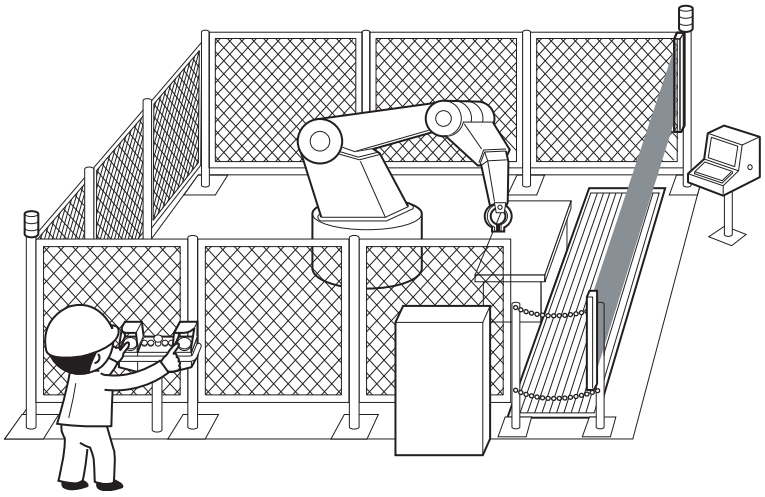


Figure 5.62 Two-hand operation switch

(Partially quoted from "Safety Guide Book - the safety measures of machinery in the workplace" : Nippon Electric Control Equipment Industries Association.)

(2) Connection of safety devices

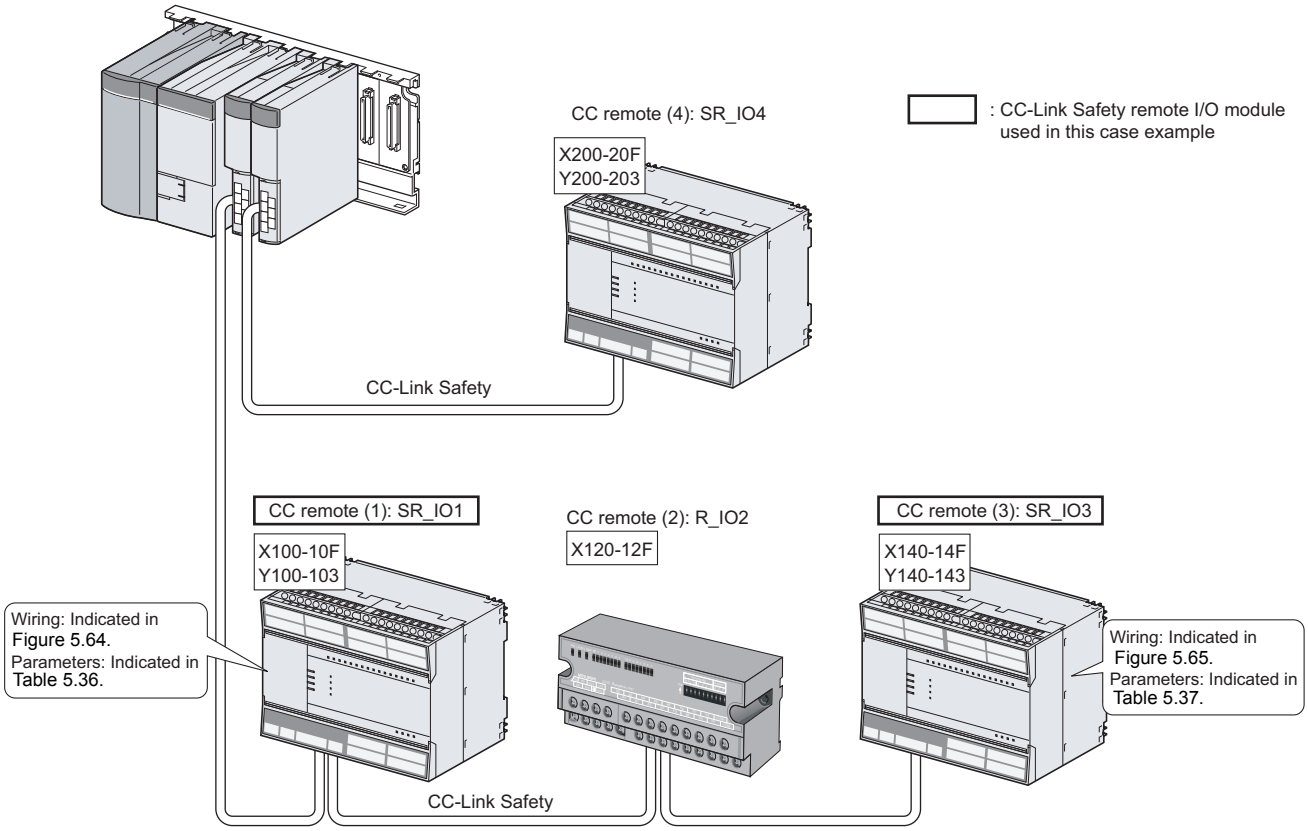


Figure 5.63 Safety device connection diagram

(3) Wiring diagram and parameter settings

(a) CC remote (1): SR_IO1

Wire the contactors to the CC-Link Safety remote I/O module as follows.

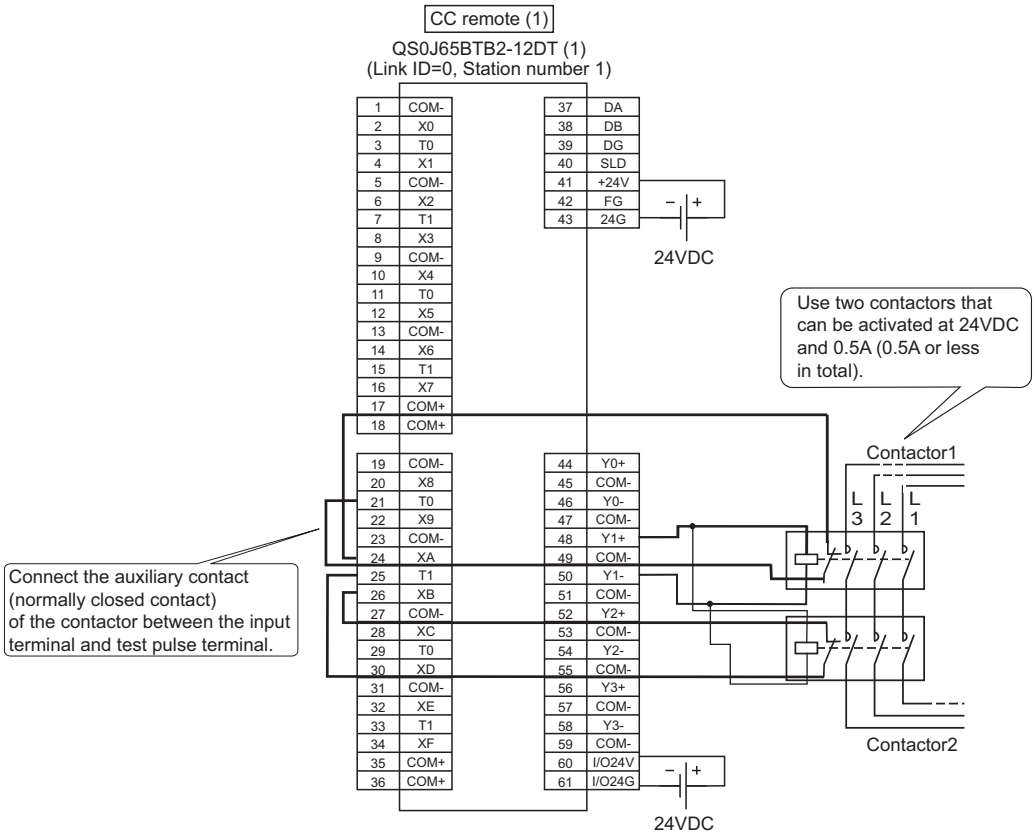


Figure 5.64 CC remote (1) SR IO1 wiring

For the contactors, set the parameters as follows.

Table 5.36 CC remote (1) SR_IO1 parameter settings

Item	Setting*4*5
6. Time of noise removal filter XA, B*1	"1ms"
14. Doubling input discrepancy detection time XA, B*2	"100ms"
22. Input dark test selection XA, B	"Execute"
25. Input dark test pulse OFF time*1	"400μs"
27. Method of wiring of output Y1	"Doubling wiring (Source+Sink)"
31. Output dark test selection Y1	"Execute"
35. Output dark test pulse OFF time Y1*1	"1ms"
43. Doubling/single input selection XA, B*3	"Doubling input"
46. Auto RTN Func to detect doubling input mismatch*3	"Invalid"

*1: Adjust the values of Time of noise removal filter, Input dark test pulse OFF time, and Output dark test pulse OFF time according to the installation environment and wiring length.

*2: Set Doubling input discrepancy detection time to 100ms for the mechanical switch and 20ms for the sensor input as a standard.

*3: The parameter is added to the QS0J65BTB2-12DT of technical version D.
When a module of technical version C or earlier is used, the parameter is not available.

*4: For setting range, refer to the following.
☞ CC-Link Safety System Remote I/O Module User's Manual

*5: Always set the enclosed option for this case example.

(b) CC remote (3): R_IO3

1) Using the QS0J65BTB2-12DT of module technical version D or later

• Wiring example of a two-hand operation switch*1

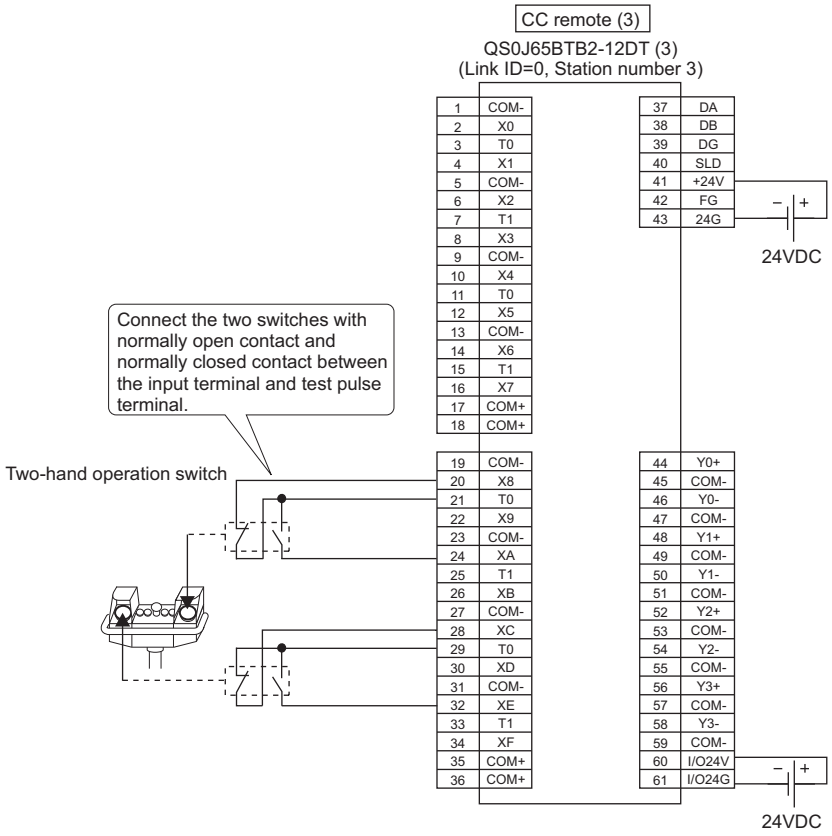


Figure 5.65 CC remote (3) R_IO3 wiring

*1: The switches can be wired to X8, X9, XA, and XB terminals.

• Parameter setting example

Table 5.37 CC remote (3) SR_IO3 parameter settings

Item	Setting *3*4
5. Time of noise removal filter X8, 9*1	"1ms"
6. Time of noise removal filter XA, B*1	"1ms"
7. Time of noise removal filter XC, D*1	"1ms"
8. Time of noise removal filter XE, F*1	"1ms"
13. Doubling input discrepancy detection time X8, 9*2	"Do not detect"
14. Doubling input discrepancy detection time XA, B*2	"Do not detect"
15. Doubling input discrepancy detection time XC, D*2	"Do not detect"
16. Doubling input discrepancy detection time XE, F*2	"Do not detect"
21. Input dark test selection X8, 9	"Execute"
22. Input dark test selection XA, B	"Execute"
23. Input dark test selection XC, D	"Execute"
24. Input dark test selection XE, F	"Execute"
25. Input dark test pulse OFF time*1	"400μs"
42. Doubling/single input selection X8, 9	"X8: Single input, X9: No Use"
43. Doubling/single input selection XA, B	"XA: Single input, XB: No Use"
44. Doubling/single input selection XC, D	"XC: Single input, XD: No Use"
45. Doubling/single input selection XE, F	"XE: Single input, XF: No Use"
46. Auto RTN Func to detect doubling input mismatch	"Invalid"

*1: Adjust the values of Time of noise removal filter and Input dark test pulse OFF time according to the installation environment and wiring length.

*2: Set Doubling input discrepancy detection time to 100ms for the mechanical switch and 20ms for the sensor input as a standard.

*3: For setting range, refer to the following.

☞ CC-Link Safety System Remote I/O Module User's Manual

*4: Always set the enclosed option for this case example.

2) Using the QS0J65BTB2-12DT of module technical version C or earlier

• Wiring example of a two-hand operation switch

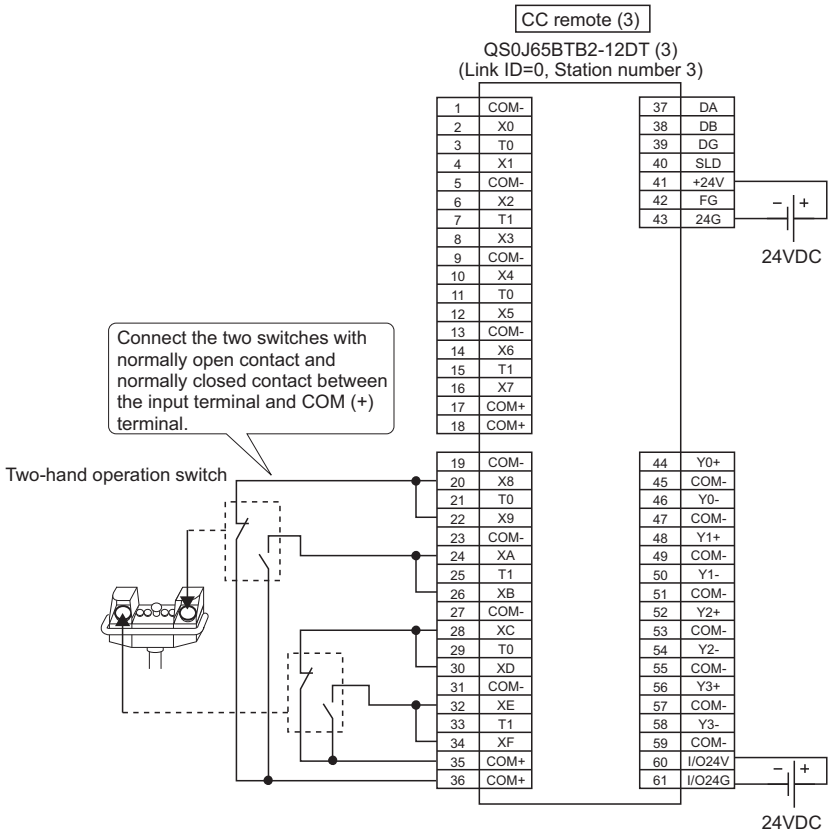


Figure 5.66 CC remote (3) R_IO3 wiring

• Parameter setting example

Table 5.38 CC remote (3) SR_IO3 parameter settings

Item	Setting *3*4
5. Time of noise removal filter X8, 9*1	"1ms"
6. Time of noise removal filter XA, B*1	"1ms"
7. Time of noise removal filter XC, D*1	"1ms"
8. Time of noise removal filter XE, F*1	"1ms"
13. Doubling input discrepancy detection time X8, 9*2	"100ms"
14. Doubling input discrepancy detection time XA, B*2	"100ms"
15. Doubling input discrepancy detection time XC, D*2	"100ms"
16. Doubling input discrepancy detection time XE, F*2	"100ms"
21. Input dark test selection X8, 9	"Not execute"
22. Input dark test selection XA, B	"Not execute"
23. Input dark test selection XC, D	"Not execute"
24. Input dark test selection XE, F	"Not execute"
25. Input dark test pulse OFF time*1	"400μs"

*1: Adjust the values of Time of noise removal filter and Input dark test pulse OFF time according to the installation environment and wiring length.

*2: Set Doubling input discrepancy detection time to 100ms for the mechanical switch and 20ms for the sensor input as a standard.

*3: For setting range, refer to the following.

☞ CC-Link Safety System Remote I/O Module User's Manual

*4: Always set the enclosed option for this case example.

(4) Device numbers to be used

The following device numbers are used in the sequence program.

Table 5.39 Device numbers to be used

Safety/standard	External device	Device number
Safety	Two-hand operation switch 1 (NC)	X148
Safety	Two-hand operation switch 1 (NO)	X14A
Safety	Two-hand operation switch 2 (NC)	X14C
Safety	Two-hand operation switch 2 (NO)	X14E
Safety	Contactor	Y101
Safety	Contactor (check for welding)	X10A or X10B
Standard	Reset switch	X140

(5) Program using safety FB

Table 5.40 Safety FBs to be used

FB name	Function	Description
F+2HAND3	Two hand switch Type III	This FB provides the two-hand control functionality (Fixed specified time difference is 500 ms).
F+ANTI	Dual input (NO+NC)	This FB converts two bit inputs (NO/NC pair) to one bit output with discrepancy time monitoring.
F+EDM	External device monitor	This FB monitors safety equipment such as an actuator and a contactor and controls a safety output.

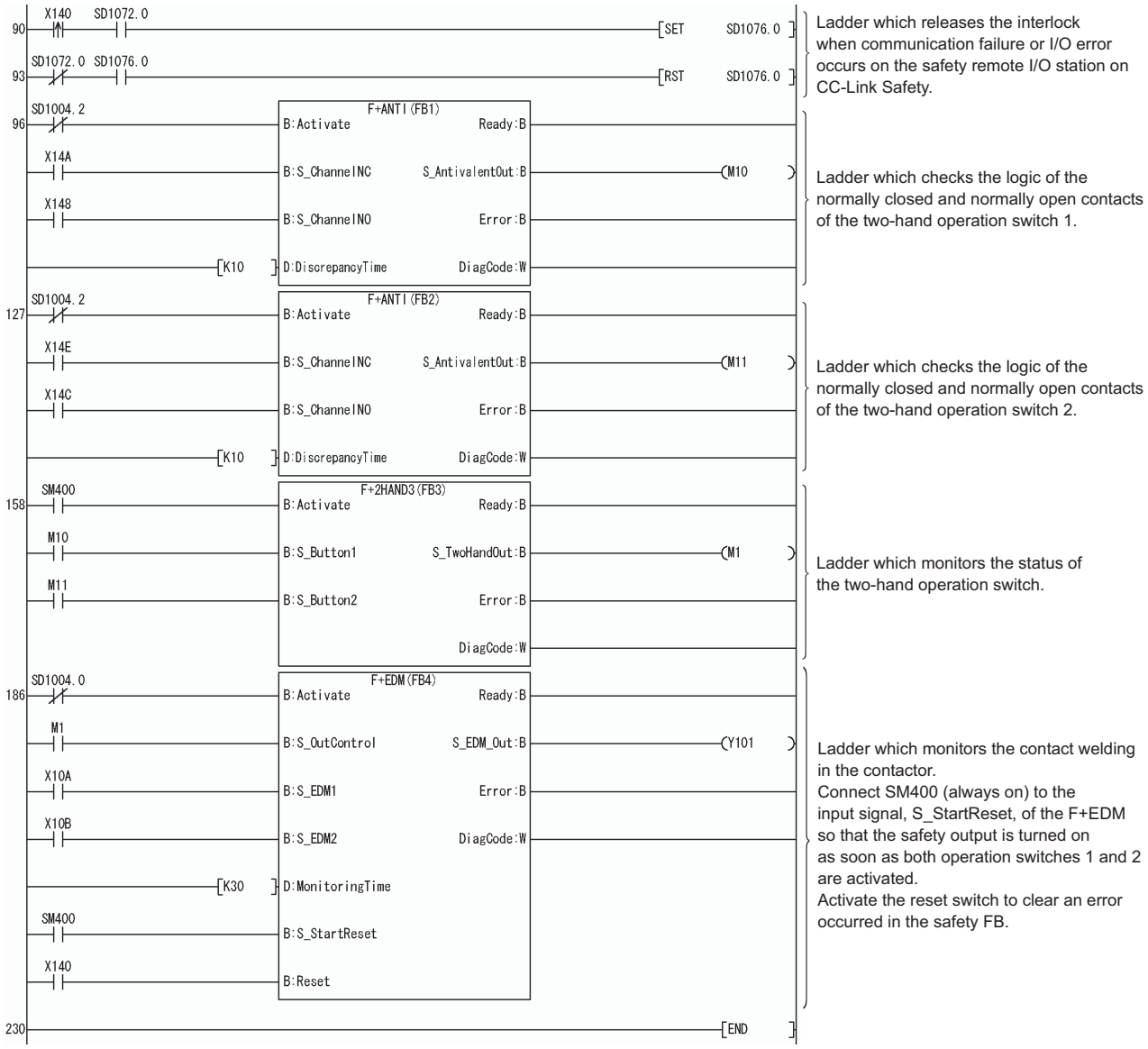


Figure 5.67 Program using safety FB

For details on the safety FBs, F+ANTI, F+2HAND3, and F+EDM, refer to the following.

☞ QSCPU Programming Manual (Safety FB)

In this example, the time difference (within 500ms) for two buttons to be turned on is checked. If the time difference does not need to be checked, use the F+2HAND2, instead of the F+2HAND3.

(6) Timing chart

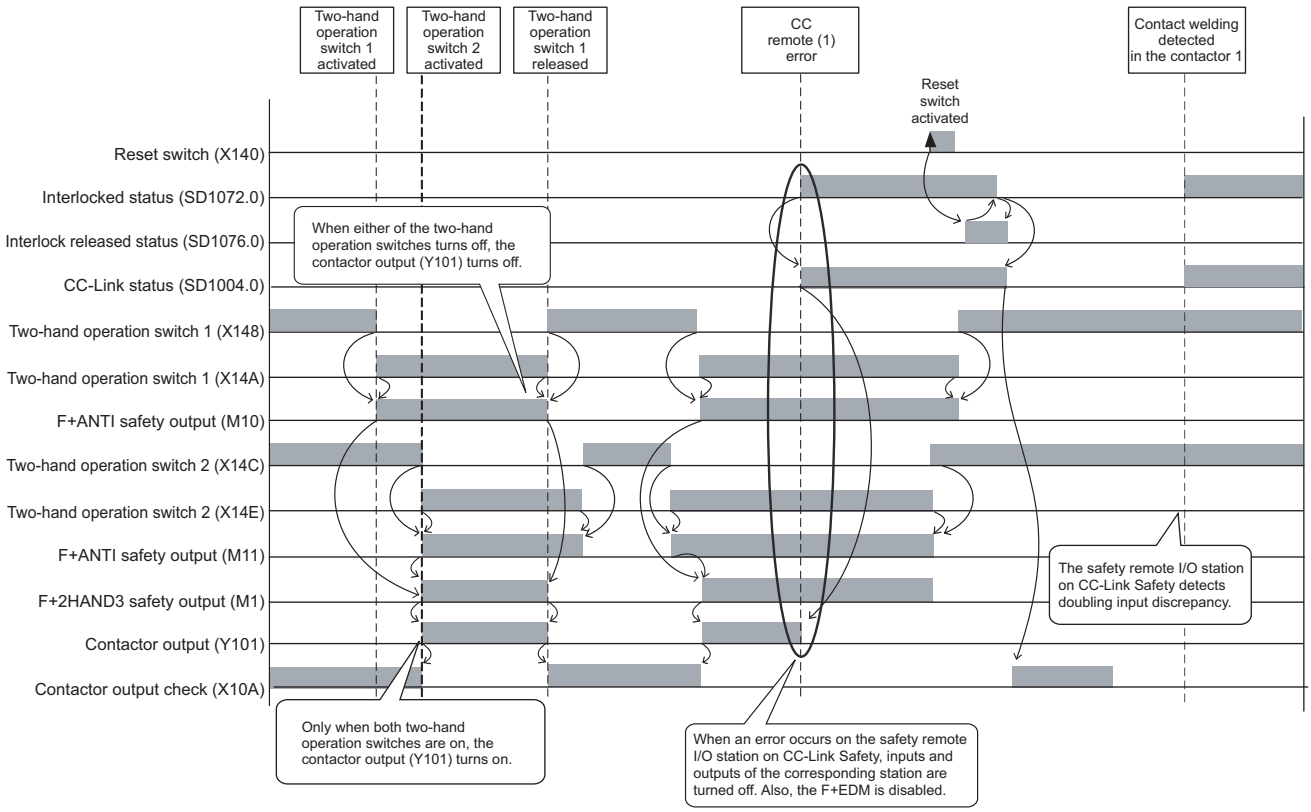


Figure 5.68 Timing chart

CHAPTER 6 SAFETY APPLICATION CONFIGURATION EXAMPLE (USING SEVERAL SAFETY PROGRAMMABLE CONTROLLERS)

This chapter describes a configuration example of a safety application using three safety programmable controllers that perform safety communication.

6.1 System Configuration

This chapter describes a safety application using the system configuration shown in Figure 6.1.

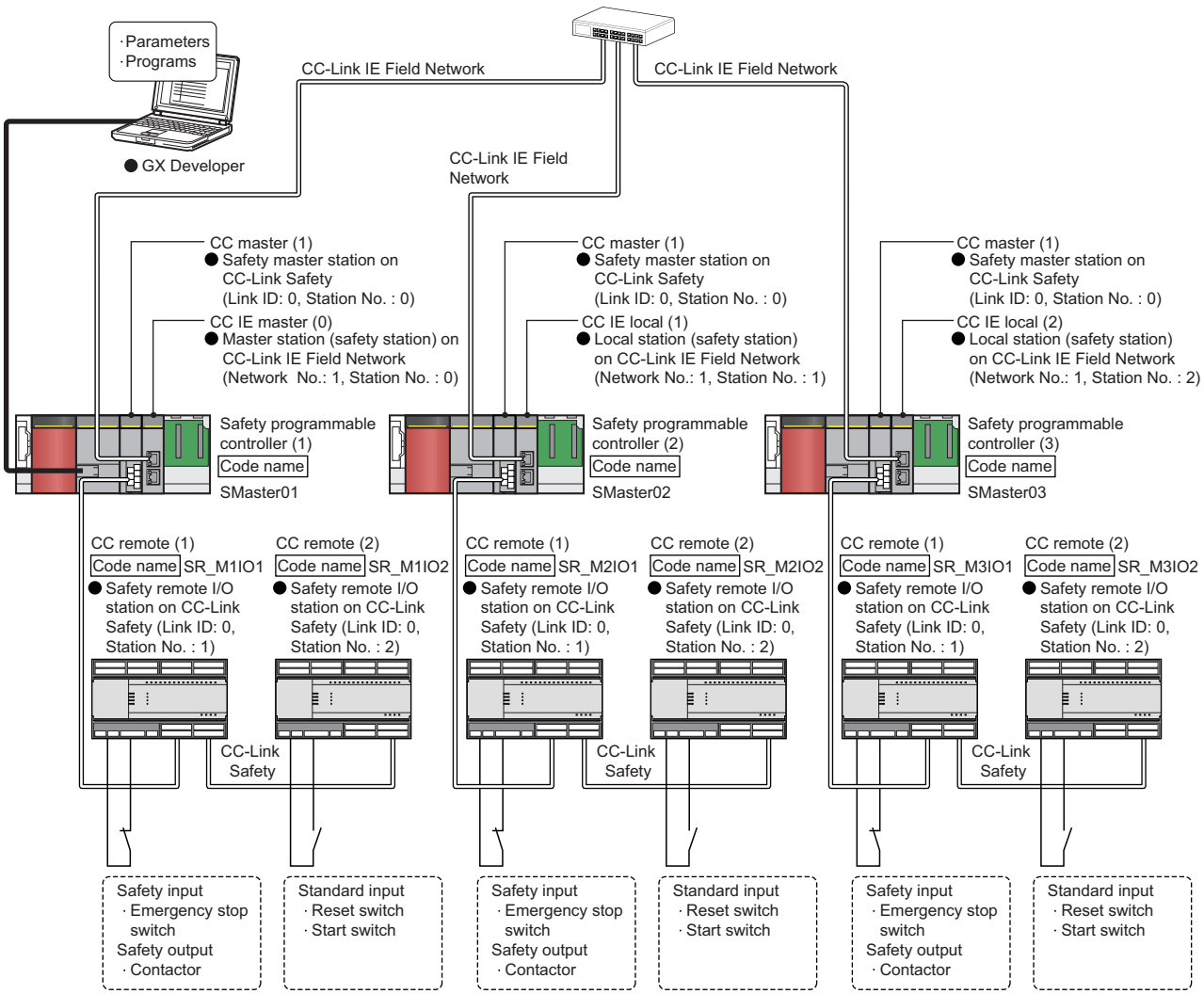


Figure 6.1 System configuration

Remark

In this chapter, the following abbreviations are used for each module.

Network	Abbreviation	Module name
CC-Link Safety	CC master (1)	CC-Link Safety master module (station No. 0)
	CC remote (1)	CC-Link Safety remote I/O module (station No. 1)
	CC remote (2)	CC-Link Safety remote I/O module (station No. 2)
CC-Link IE Field Network	CCIE master (0)	CC-Link IE Field Network master/local module (with safety functions) (station No. 0)
	CCIE local (1)	CC-Link IE Field Network master/local module (with safety functions) (station No. 1)
	CCIE local (2)	CC-Link IE Field Network master/local module (with safety functions) (station No. 2)

6.2 Network-Related Switch Settings of Module

Set module switches as described below.

6.2.1 Safety power supply module

The safety power supply module does not have switches.

6.2.2 Safety CPU module

The safety CPU module does not have network-related switches.

6.2.3 CC-Link Safety master module

The CC-Link Safety master module does not have switches.

6.2.4 CC-Link Safety remote I/O module

Set the link ID setting switch, station number setting switch, and transmission speed setting switch.

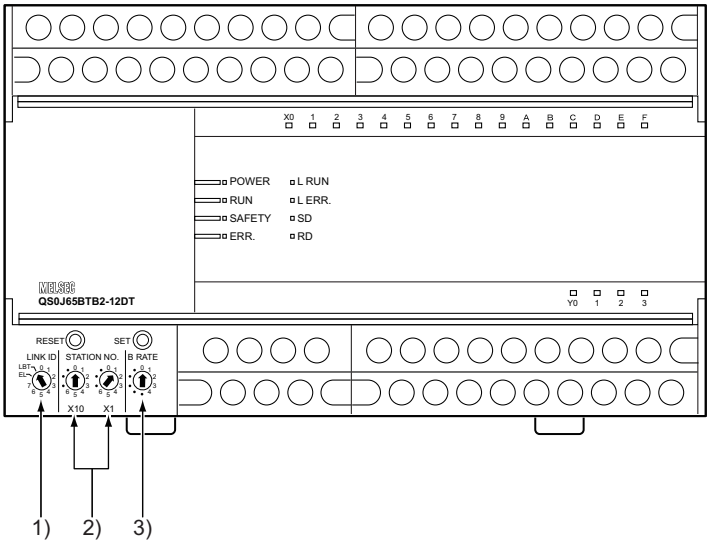


Figure 6.2 Positions of CC-Link Safety remote I/O module's switches

Table 6.1 Settings of CC-Link Safety remote I/O module's switches

Switch number	Remote I/O module number	Safety programmable controller (1)		Safety programmable controller (2)		Safety programmable controller (3)	
		CC remote (1) SR_M1IO1	CC remote (2) SR_M1IO2	CC remote (1) SR_M2IO1	CC remote (2) SR_M2IO2	CC remote (1) SR_M3IO1	CC remote (2) SR_M3IO2
1)	Link ID setting switch	0	0	0	0	0	0
2)	Station number setting switch	1	2	1	2	1	2
3)	Transmission speed setting switch	2 (2.5Mbps)	2 (2.5Mbps)	2 (2.5Mbps)	2 (2.5Mbps)	2 (2.5Mbps)	2 (2.5Mbps)

POINT

For the procedure to validate the switch settings of the CC-Link Safety remote I/O module, refer to the following.

CC-Link Safety System Remote I/O Module User's Manual

6.2.5 CC-Link IE Field Network master/local module (with safety functions)

The CC-Link IE Field Network master/local module (with safety functions) does not have switches.

6.3 Parameter Settings

This section describes parameter setting examples.
For descriptions and setting ranges of the parameters, refer to the following.

☞ CC-Link Safety System Master Module User's Manual

☞ MELSEC-QS CC-Link IE Field Network Master/Local Module User's Manual

6.3.1 Parameter settings of CC-Link Safety

(1) Network parameter settings

Set the following values to the network parameters for safety master stations of safety programmable controllers (1) to (3) on CC-Link Safety.

Table 6.2 Setting example of network parameters

Module		Safety programmable controllers (1) to (3)
		CC master (1)
Start I/O No.		0000H
Operational settings	Case of CPU STOP setting*1	Clears compulsorily
Mode		Safety remote net (Ver. 1 mode)
Transmission speed		2.5Mbps
Safety refresh monitoring time		50ms
Safety data monitoring time		80ms
Link ID		0
All connect count		2
Remote input (RX)		X100
Remote output (RY)		Y100
Remote register (RWr)		–
Remote register (RWw)		–
Special relay (SB)		SB0
Special register (SW)		SW0
Retry count		3
Automatic reconnection station count		1
Scan mode setting		Synchronous
Station information setting	Station information	☞ Section 6.3.1 (2)
	Safety remote station settings	☞ Section 6.4.1 (4)
Remote device station initial setting		None

* 1: Fixed at "Clears compulsorily" when the safety CPU operation mode is set to SAFETY MODE.

POINT

Set the link ID and transmission speed values of the network parameter and those of the switches of the connected CC-Link Safety remote I/O module so that they may be the same.

(2) Station information setting

Set station information of safety master stations on CC-Link Safety as follows.

Table 6.3 Example of station information setting

Module		Station No.	Station type	Exclusive station count	Reserve station count
Safety programmable controllers (1) to (3)	CC master (1)	1/1	Safety remote I/O station	Exclusive station 1	No setting
		2/2	Safety remote I/O station	Exclusive station 1	No setting

(3) Safety remote station settings

For safety remote station settings of safety master stations on CC-Link Safety, refer to Section 6.4.1 (4).

6.3.2 Parameter settings of CC-Link IE Field Network

(1) Network parameter settings

Set the following values to the network parameters for the master station (safety station) and local stations (safety stations) on CC-Link IE Field Network.

Table 6.4 Setting example of network parameters

Module			Safety programmable controller (1)		Safety programmable controller (2)	Safety programmable controller (3)
			CCIE master (0)		CCIE local (1)	CCIE local (2)
Ethernet/CC IE/ MELSECNET	Network type		CC IE Field (Master station [Safety])		CC IE Field (Local station [Safety])	
	Starting I/O No.		0020H		0020H	0020H
	Network No.		1		1	1
	Total stations		2		(Cannot be set)	(Cannot be set)
	Station No.		0		1	2
	Mode		Online (Normal Mode)		Online	Online
Network Configuration Setting	Station No.		1	2	(Cannot be set)	(Cannot be set)
	Station Type		Local Station			
	RX/RY Setting	Points	(Blank)	(Blank)		
		Start	(Blank)	(Blank)		
		End	(Blank)	(Blank)		
	RWw/RWr Setting	Points	(Blank)	(Blank)		
		Start	(Blank)	(Blank)		
		End	(Blank)	(Blank)		
	Reserved/Error Invalid Station		No Setting	No Setting		
	Alias		(Blank)	(Blank)		
	Comment		(Blank)	(Blank)		
	Supplementary Setting	Link Scan Mode Setting	Select "Asynchronous", and do not set "Constant Scan".			
		Loopback Function Setting	Clear the "Use" checkbox.			
		Block Data Assurance per Station	Assure Block Data			
Network Operation Setting	Parameter Name		(Blank)		(Blank)	(Blank)
	Data Link Faulty Station Setting		Turn OFF or 0 Clear Input Data (RX/RY)			
	Output Setting During CPU STOP*1		Clear (ALL OFF)			
Refresh parameters	Link side ⇔ PLC side		(Blank)		(Blank)	(Blank)
Interlink transmission parameters			(Cannot be set)		(Cannot be set)	(Cannot be set)
Routing parameters			(Blank)		(Blank)	(Blank)

* 1: Fixed at "Clear (ALL OFF)" when the safety CPU operation mode is set to SAFETY MODE.

(2) Safety communication setting

Configure the following values to the safety communication setting for the master station (safety station) and local stations (safety stations) on CC-Link IE Field Network.

Table 6.5 Example of safety communication setting

Module			Safety programmable controller (1)		Safety programmable controller (2)	Safety programmable controller (3)
			CCIE master (0)		CCIE local (1)	CCIE local (2)
Communication Target Station No.			1	2	0	0
Open Method			Active	Active	Passive	Passive
Transmission Interval Monitoring Time (ms)			50		50	50
Safety Refresh Monitoring Time (ms)			120	120	(Blank)	(Blank)
Safety Data Transfer Device Setting	Receive Data Storage Device	Device Name	X	X	X	X
		Points	128	128	128	128
		Start	1000	1080	1000	1080
		End	107F	10FF	107F	10FF
	Send Data Storage Device	Device Name	Y	Y	Y	Y
		Points	128	128	128	128
		Start	1000	1080	1000	1080
		End	107F	10FF	107F	10FF

6.4 Case Example

6.4.1 Emergency stop circuit (stop of all equipment)

(1) Application overview

This application uses a safety programmable controller in each process and cuts off a power to robots in all processes using an emergency stop switch in any process. The application controls the start and stop of a robot by turning on or off the main contact of the contactor which opens and closes the power source of a robot at the safety relay contact.

Connect emergency stop switches and safety relays to safety programmable controllers.
Connect safety programmable controllers in all processes through CC-Link IE Field Network.
The safety programmable controller turns on/off the contacts of the safety relays with sequence program.
When the safety programmable controller detects an error by self-diagnostics, outputs to the safety relays turn off independent of the sequence program.
In this case, the outputs remain off until the safety CPU module or CC-Link Safety remote I/O module is reset independent of the sequence program.

Configure the sequence program so that the following functions can be achieved.

1) Check that safety is ensured (The emergency stop signal is on.) and that an emergency stop request is not received from another safety programmable controllers on CC-Link IE Field Network. Press the reset switch and the start switch. The safety relay will turn on.
2) When a safety relay connected to any safety programmable controller is welded, input the auxiliary relays (normally closed contacts) to the safety programmable controller to prevent start of the robots, and check for welding.
3) The reset switch and start switch become valid only when turned off to avoid operation at contact welding or short-circuit.
4) Outputs of the safety relays turn off when input of the emergency stop switch turns off, an emergency stop request is received from another safety programmable controller on CC-Link IE Field Network, or an error is detected in a safety remote I/O station on CC-Link Safety after the operation is started.
5) To stop the entire system, transfer the emergency stop request to other safety programmable controllers.

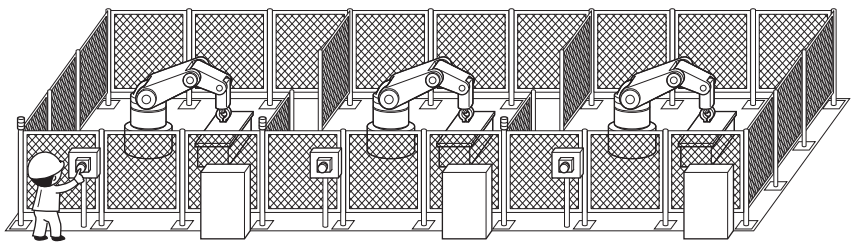


Figure 6.3 Emergency stop circuit (stop of all equipment)

(Partially quoted from "Safety Guide Book - the safety measures of machinery in the workplace" : Nippon Electric Control Equipment Industries Association.)

(2) Connection of safety devices

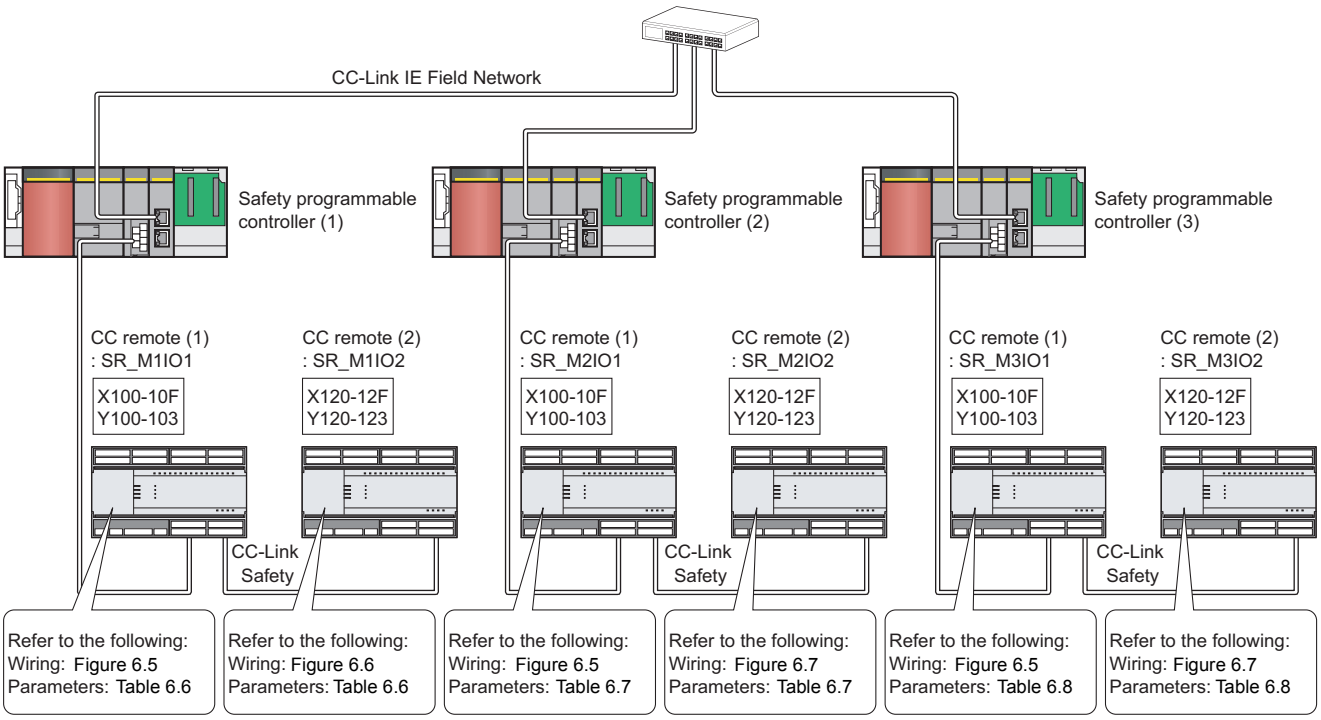


Figure 6.4 Safety device connection diagram

(3) Wiring diagram

(a) CC remote (1): SR_M1IO1, SR_M2IO1, SR_M3IO1

Wire the emergency stop switches and safety relays to CC-Link Safety remote I/O modules of safety programmable controllers (1) to (3) as follows.

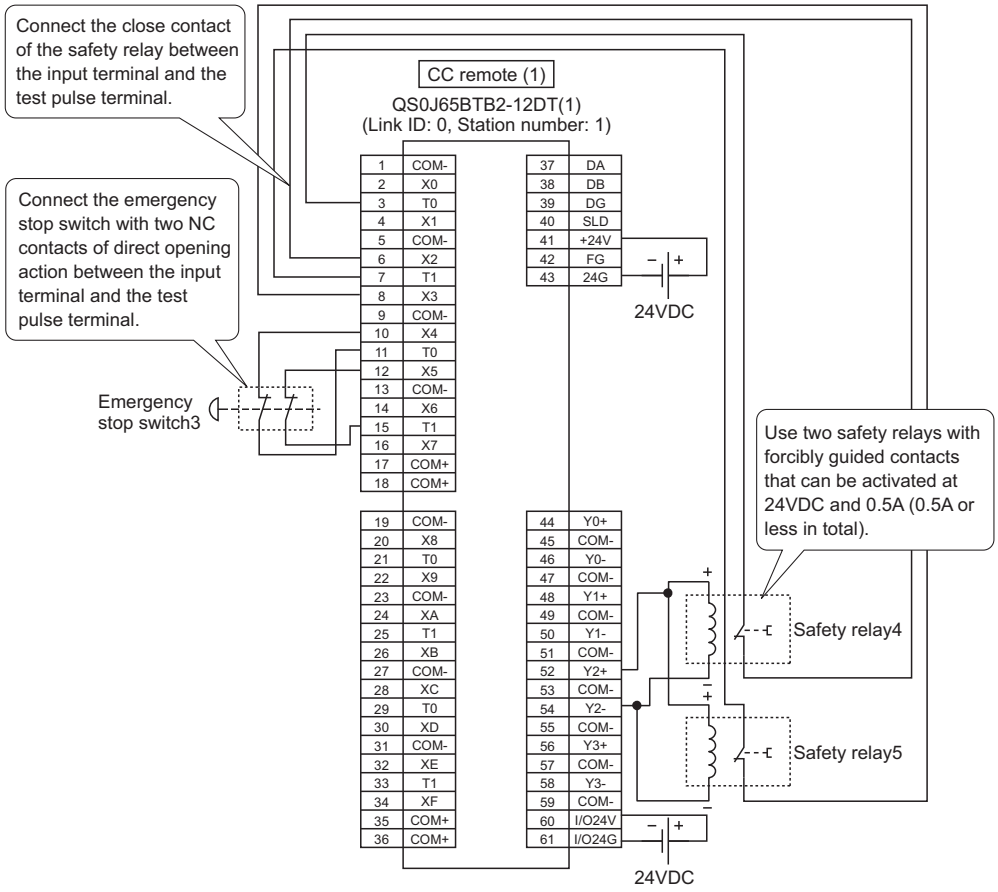


Figure 6.5 CC remote (1) SR_M1IO1, SR_M2IO1, SR_M3IO1 wiring (using a module of module technical version D or later)

(b) CC remote (2): SR_M1IO2

Wire the reset switch and start switch to the CC-Link Safety remote I/O module of the safety programmable controller (1) as follows.

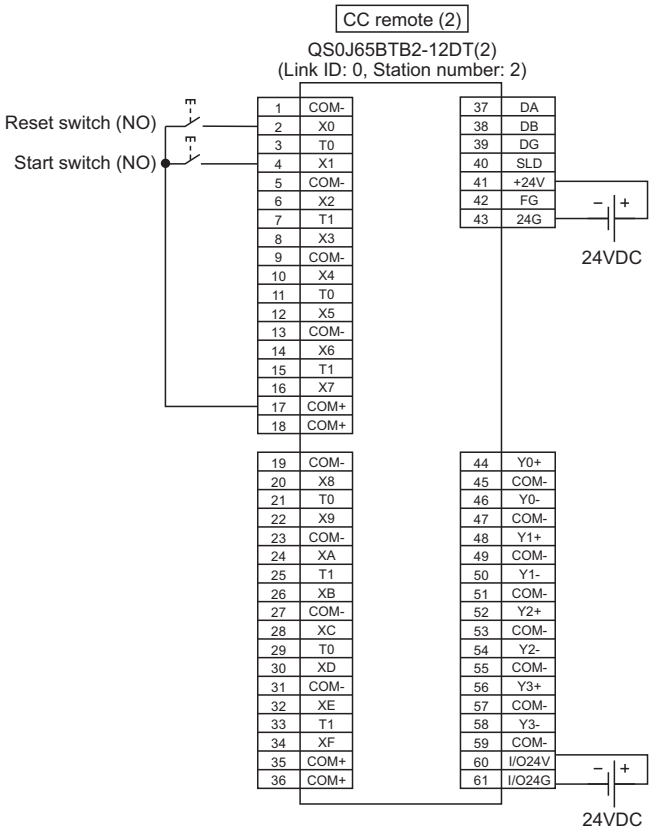


Figure 6.6 Remote (2) SR_M1IO2 wiring (using a module of module technical version D or later)

(c) CC remote (2): SR_M2IO2, SR_M3IO2

Wire the reset switches and start switches to CC-Link Safety remote I/O modules of safety programmable controllers (2) and (3) as follows.

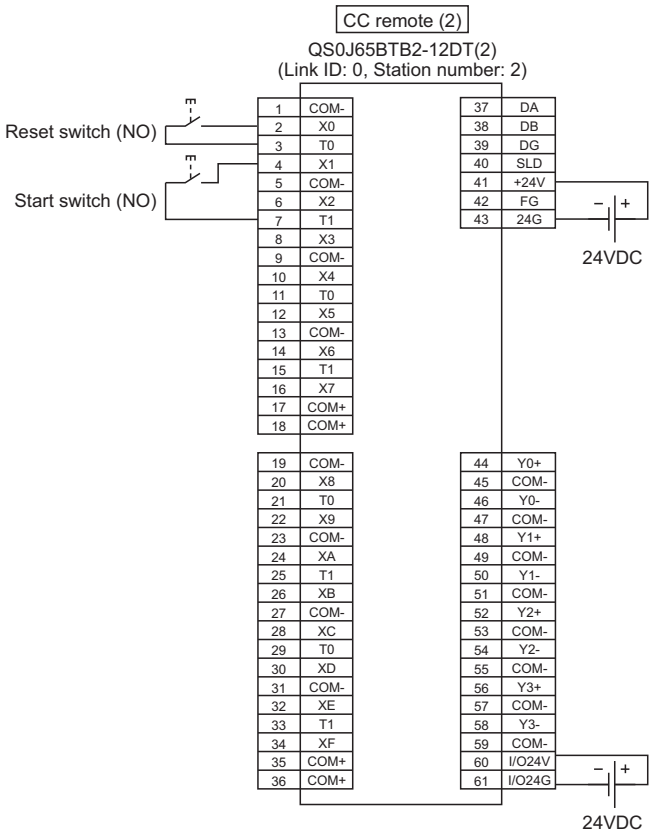


Figure 6.7 CC remote (2) SR_M2IO2, SR_M3IO2 wiring (using a module of module technical version D or later)

(4) Parameter settings

Configure safety remote station settings of the safety programmable controllers (1) to (3) as shown in Table 6.6 to Table 6.8.

Table 6.6 Safety remote station settings of the safety programmable controller (1)

(using a module of module technical version D or later)

– : Default (unused)

Module	Safety programmable controller (1)*6 *7	
	SR_M1IO1	SR_M1IO2
Model name	QS0J65BTB2-12DT	QS0J65BTB2-12DT
Module technical version*1	D	D
Specify production information to find module	Specified (selected)	Specified (selected)
Production information*2	100411110960100	100411110960150
1. Time of noise removal filter X0, X1*3	–	"1ms"
2. Time of noise removal filter X2, 3*3	"1ms"	–
3. Time of noise removal filter X4, 5*3	"1ms"	–
9. Doubling input discrepancy detection time X0, 1*4	–	"Do not detect"
10. Doubling input discrepancy detection time X2, 3*4	"100ms"	–
11. Doubling input discrepancy detection time X4, 5*4	"100ms"	–
17. Input dark test selection X0, 1	–	"Not execute"
18. Input dark test selection X2, 3	"Execute"	–
19. Input dark test selection X4, 5	"Execute"	–
25. Input dark test pulse OFF time*3	"400 μs"	"400 μs"
28. Method of wiring of output Y2	"Doubling wiring (Source+Sink)"	–
32. Output dark test selection Y2	"Execute"	–
36. Output dark test pulse OFF time Y2*3	"1ms"	–
38. Doubling/single input selection X0, 1*5	–	"X0, X1: Single input"
39. Doubling/single input selection X2, 3*5	"Doubling input"	–
40. Doubling/single input selection X4, 5*5	"Doubling input"	–
46. Auto RTN Func to detect doubling input mismatch*5	"invalid"	"invalid"

* 1: Check the module technical version on the rating plate located on the side of the module that is mounted on the corresponding safety remote I/O station on CC-Link Safety.
Depending on module combination, the station cannot be connected. For details, refer to the following.

☞ CC-Link Safety System Remote I/O Module User's Manual

* 2: Enter the production information referring to the serial number printed on the rating plate located on the side of the module that is mounted on the corresponding safety remote I/O station on CC-Link Safety. For details, refer to the following.

☞ CC-Link Safety System Remote I/O Module User's Manual

The production information is useful to maintain functions after the module is changed and to detect a setting error such as station number duplication of safety remote I/O stations on CC-Link Safety. Check the production information to use the safety programmable controllers properly and safely.

* 3: Adjust the values of Time of noise removal filter, Input dark test pulse OFF time, and Output dark test pulse OFF time according to the installation environment and wiring length.
* 4: Set Doubling input discrepancy detection time to 100ms for the mechanical switch and 20ms for the sensor input as a standard.

* 5: The parameters are added to the QS0J65BTB2-12DT of technical version D or later, and is not available for modules of technical version C or earlier.
* 6: For setting range, refer to the following.

  ☞ CC-Link Safety System Remote I/O Module User's Manual
* 7: Always set the enclosed option for this case example.

Table 6.7 Safety remote station settings of the safety programmable controller (2)

(using a module of module technical version D or later)

– : Default (unused)

Module	Safety programmable controller (2)*6 *7	
	SR_M2IO1	SR_M2IO2
Model name	QS0J65BTB2-12DT	QS0J65BTB2-12DT
Module technical version*1	D	D
Specify production information to find module	Specified (selected)	Specified (selected)
Production information*2	100411110960200	100411110960250
1. Time of noise removal filter X0, 1*3	–	"1ms"
2. Time of noise removal filter X2, 3*3	"1ms"	–
3. Time of noise removal filter X4, 5*3	"1ms"	–
9. Doubling input discrepancy detection time X0, 1*4	–	"Do not detect"
10. Doubling input discrepancy detection time X2, 3*4	"100ms"	–
11. Doubling input discrepancy detection time X4, 5*4	"100ms"	–
17. Input dark test selection X0, 1	–	"Execute"
18. Input dark test selection X2, 3	"Execute"	–
19. Input dark test selection X4, 5	"Execute"	–
25. Input dark test pulse OFF time*3	"400 μ s"	"400 μ s"
28. Method of wiring of output Y2	"Doubling wiring (Source+Sink)"	–
32. Output dark test selection Y2	"Execute"	–
36. Output dark test pulse OFF time Y2*3	"1ms"	–
38. Doubling/single input selection X0, 1*5	–	"X0, X1: Single input"
39. Doubling/single input selection X2, 3*5	"Doubling input"	–
40. Doubling/single input selection X4, 5*5	"Doubling input"	–
46. Auto RTN Func to detect doubling input mismatch*5	"invalid"	"invalid"

* 1: Check the module technical version on the rating plate located on the side of the module that is mounted on the corresponding safety remote I/O station on CC-Link Safety.
Depending on module combination, the station cannot be connected. For details, refer to the following.
☞ CC-Link Safety System Remote I/O Module User's Manual
* 2: Enter the production information referring to the serial number printed on the rating plate located on the side of the module that is mounted on the corresponding safety remote I/O station on CC-Link Safety. For details, refer to the following.
☞ CC-Link Safety System Remote I/O Module User's Manual
The production information is useful to maintain functions after the module is changed and to detect a setting error such as station number duplication of safety remote I/O stations on CC-Link Safety. Check the production information to use the safety programmable controllers properly and safely.
* 3: Adjust the values of Time of noise removal filter, Input dark test pulse OFF time, and Output dark test pulse OFF time according to the installation environment and wiring length.
* 4: Set Doubling input discrepancy detection time to 100ms for the mechanical switch and 20ms for the sensor input as a standard.
* 5: The parameter is added to the QS0J65BTB2-12DT of technical version D.
When a module of technical version C or earlier is used, the parameter is not available.
* 6: For setting range, refer to the following.
☞ CC-Link Safety System Remote I/O Module User's Manual
* 7: Always set the enclosed option for this case example.

Table 6.8 Safety remote station settings of the safety programmable controller (3)

(using a module of module technical version D or later)

– : Default (unused)

Module	Safety programmable controller (3)*6 *7	
	SR_M3IO1	SR_M3IO2
Model name	QS0J65BTB2-12DT	QS0J65BTB2-12DT
Module technical version*1	D	D
Specify production information to find module	Specified (selected)	Specified (selected)
Production information*2	100411110960300	100411110960350
1. Time of noise removal filter X0, 1*3	–	"1ms"
2. Time of noise removal filter X2, 3*3	"1ms"	–
3. Time of noise removal filter X4, 5*3	"1ms"	–
9. Doubling input discrepancy detection time X0, 1*4	–	"Do not detect"
10. Doubling input discrepancy detection time X2, 3*4	"100ms"	–
11. Doubling input discrepancy detection time X4, 5*4	"100ms"	–
17. Input dark test selection X0, 1	–	"Execute"
18. Input dark test selection X2, 3	"Execute"	–
19. Input dark test selection X4, 5	"Execute"	–
25. Input dark test pulse OFF time*3	"400 μ s"	"400 μ s"
28. Method of wiring of output Y2	"Doubling wiring (Source+Sink)"	–
32. Output dark test selection Y2	"Execute"	–
36. Output dark test pulse OFF time Y2*3	"1ms"	–
38. Doubling/single input selection X0, 1*5	–	"X0, X1: Single input"
39. Doubling/single input selection X2, 3*5	"Doubling input"	–
40. Doubling/single input selection X4, 5*5	"Doubling input"	–
46. Auto RTN Func to detect doubling input mismatch*5	"invalid"	"invalid"

* 1: Check the module technical version on the rating plate located on the side of the module that is mounted on the corresponding safety remote I/O station on CC-Link Safety.
Depending on module combination, the station cannot be connected. For details, refer to the following.

☞ CC-Link Safety System Remote I/O Module User's Manual

* 2: Enter the production information referring to the serial number printed on the rating plate located on the side of the module that is mounted on the corresponding safety remote I/O station on CC-Link Safety. For details, refer to the following.

☞ CC-Link Safety System Remote I/O Module User's Manual

The production information is useful to maintain functions after the module is changed and to detect a setting error such as station number duplication of safety remote I/O stations on CC-Link Safety. Check the production information to use the safety programmable controllers properly and safely.

* 3: Adjust the values of Time of noise removal filter, Input dark test pulse OFF time, and Output dark test pulse OFF time according to the installation environment and wiring length.
* 4: Set Doubling input discrepancy detection time to 100ms for the mechanical switch and 20ms for the sensor input as a standard.
* 5: The parameter is added to the QS0J65BTB2-12DT of technical version D.
When a module of technical version C or earlier is used, the parameter is not available.
* 6: For setting range, refer to the following.

☞ CC-Link Safety System Remote I/O Module User's Manual

* 7: Always set the enclosed option for this case example.

(5) Devices used

(a) Relationship between safety CPU module devices and remote inputs/outputs in CC-Link Safety

The following shows the relationship between safety CPU module devices and inputs/outputs of safety remote I/O stations on CC-Link Safety with the settings described in Section 6.3.1.

Use devices in shaded areas in the sequence program.

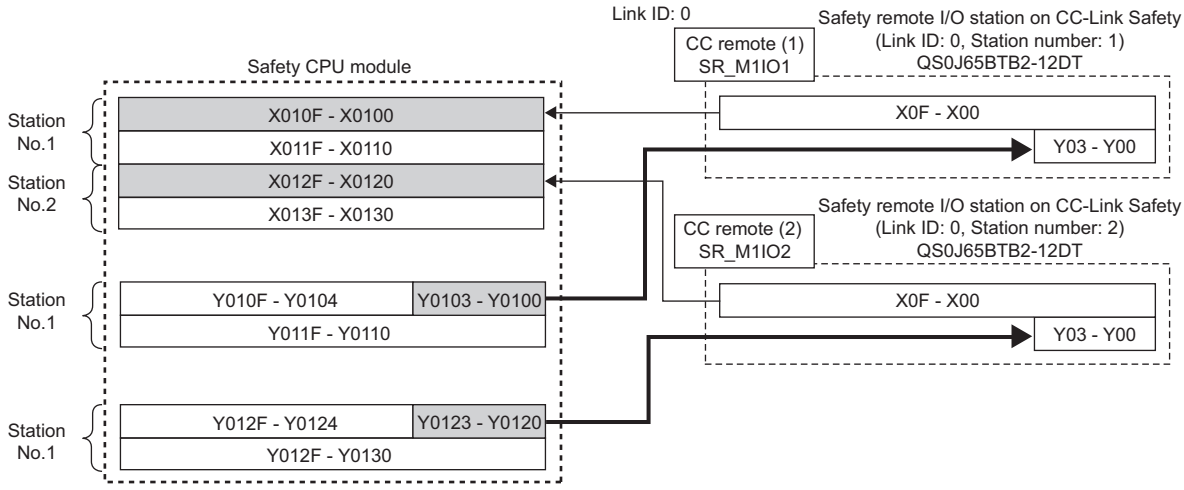


Figure 6.8 Relationship between safety CPU module devices and remote inputs/outputs in CC-Link Safety

(b) Relationship among safety CPU module devices in CC-Link IE Field Network

The following shows the relationship among safety CPU module devices with the settings described in Section 6.3.2.

Use devices in shaded areas in the sequence program.

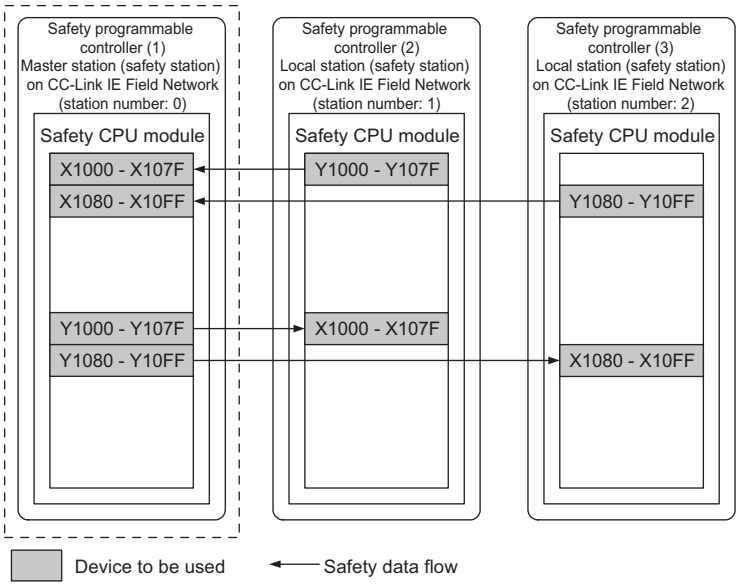


Figure 6.9 Relationship among safety CPU module devices in CC-Link IE Field Network

(c) Device numbers to be used

The following device numbers are used in the sequence program.

Table 6.9 Device numbers to be used

Safety programmable controller	Safety/standard	External device	Device number
Safety programmable controller (1)	Safety	Emergency stop switch	X104 or X105
	Safety	Safety relay	Y102
	Safety	Safety relay (check for welding)	X102 or X103
	Safety	Emergency stop request from safety programmable controller (2)	X1000
	Safety	Emergency stop request from safety programmable controller (3)	X1080
	Safety	Emergency stop request to safety programmable controller (2)	Y1000
	Safety	Emergency stop request to safety programmable controller (3)	Y1080
	Standard	Start switch	X121
	Standard	Reset switch	X120
Safety programmable controller (2)	Safety	Emergency stop switch	X104 or X105
	Safety	Safety relay	Y102
	Safety	Safety relay (check for welding)	X102 or X103
	Safety	Emergency stop request from safety programmable controller (1)	X1000
	Safety	Emergency stop request to safety programmable controller (1)	Y1000
	Standard	Start switch	X121
	Standard	Reset switch	X120
Safety programmable controller (3)	Safety	Emergency stop switch	X104 or X105
	Safety	Safety relay	Y102
	Safety	Safety relay (check for welding)	X102 or X103
	Safety	Emergency stop request from safety programmable controller (1)	X1080
	Safety	Emergency stop request to safety programmable controller (1)	Y1080
	Standard	Start switch	X121
	Standard	Reset switch	X120

(6) Sequence program using safety FB

Figure 6.10 to Figure 6.12 show sequence programs used in safety programmable controllers (1) to (3).

Table 6.10 Safety FBs used

FB name	Function name	Description
F+EDM	External device monitor	This FB monitors safety equipment such as an actuator and a contactor and controls a safety output.
F+ESTOP	Emergency stop	This FB is a safety-related FB for monitoring an emergency stop button. This FB can be used for emergency switch off functionality (stop category 0).

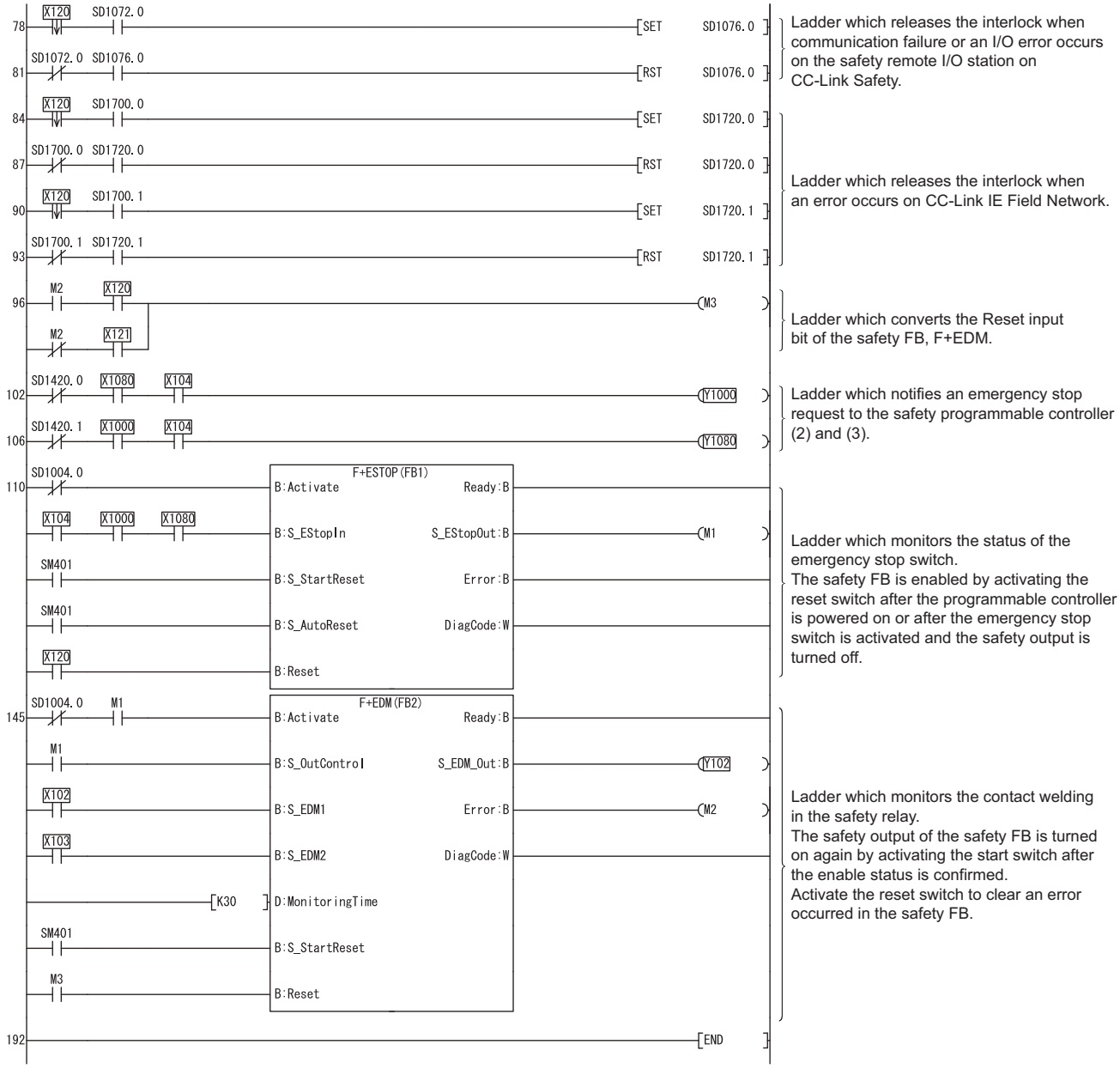


Figure 6.10 Safety FB program for safety programmable controller (1)

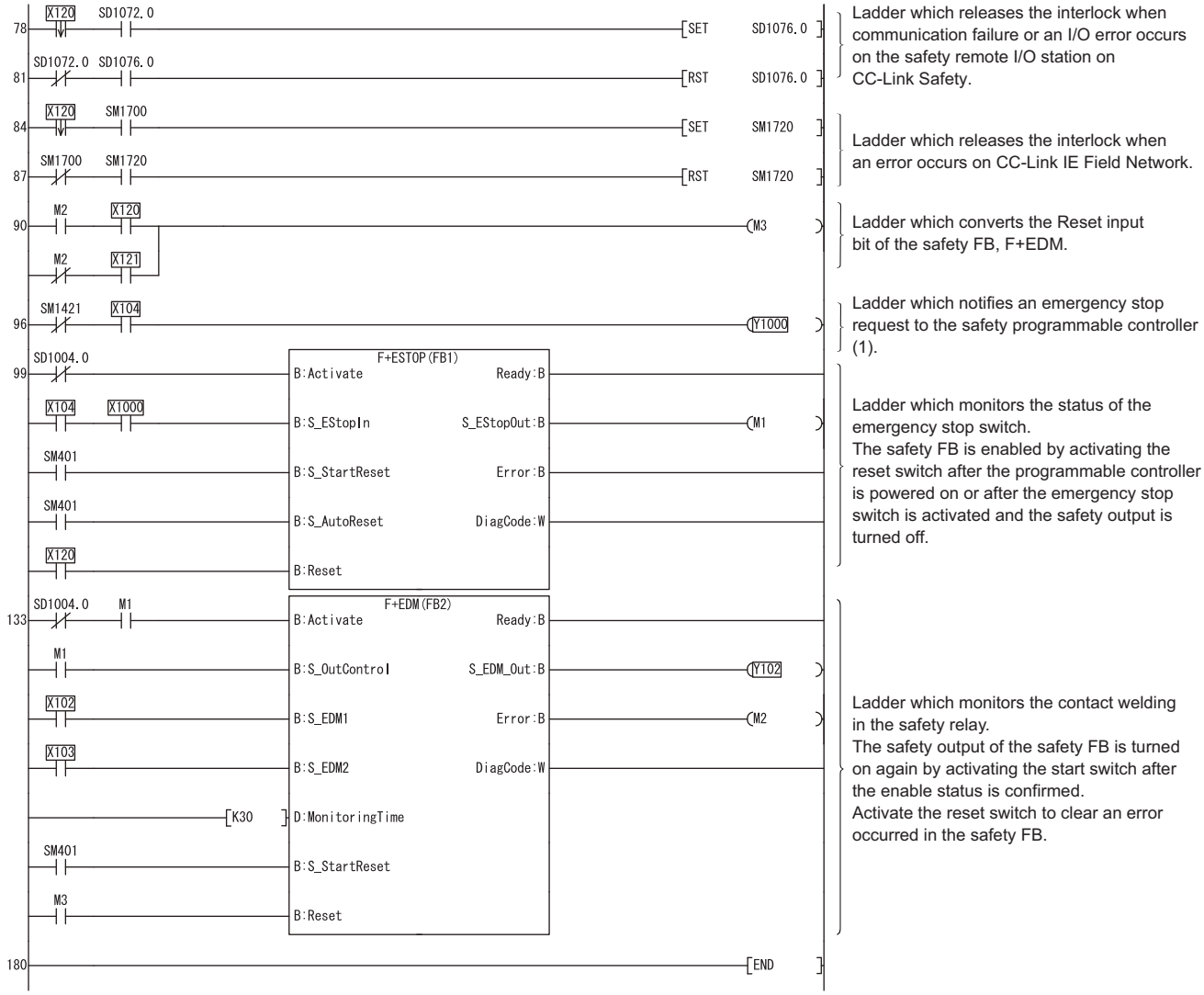
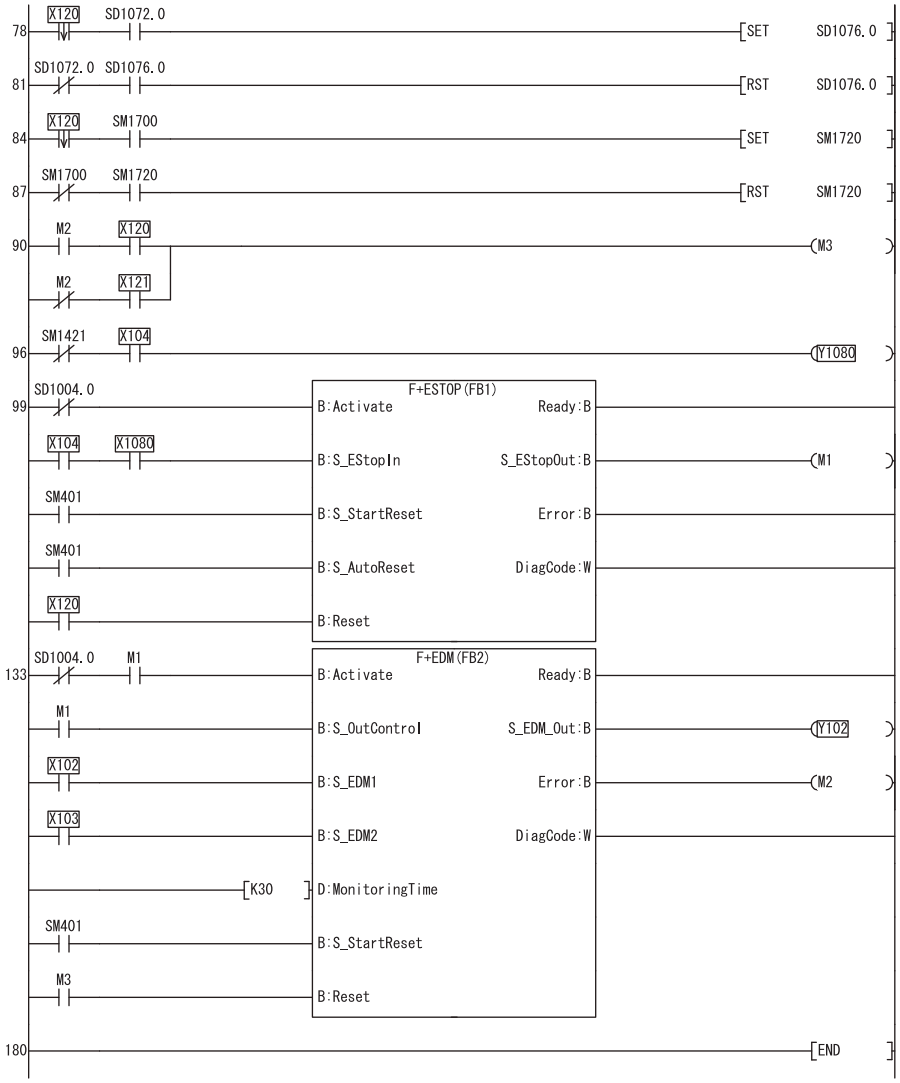


Figure 6.11 Safety FB program for safety programmable controller (2)



Ladder which releases the interlock when communication failure or an I/O error occurs on the safety remote I/O station on CC-Link Safety.

Ladder which releases the interlock when an error occurs on CC-Link IE Field Network.

Ladder which converts the Reset input bit of the safety FB, F+EDM.

Ladder which notifies an emergency stop request to the safety programmable controller (1).

Ladder which monitors the status of the emergency stop switch.
The safety FB is enabled by activating the reset switch after the programmable controller is powered on or after the emergency stop switch is activated and the safety output is turned off.

Ladder which monitors the contact welding in the safety relay.
The safety output of the safety FB is turned on again by activating the start switch after the enable status is confirmed.
Activate the reset switch to clear an error occurred in the safety FB.

Figure 6.12 Safety FB program for safety programmable controller (3)

For details on the safety FBs, F+ESTOP, and F+EDM, refer to the following.

☞QSCPU Programming Manual (Safety FB)

(7) Timing chart

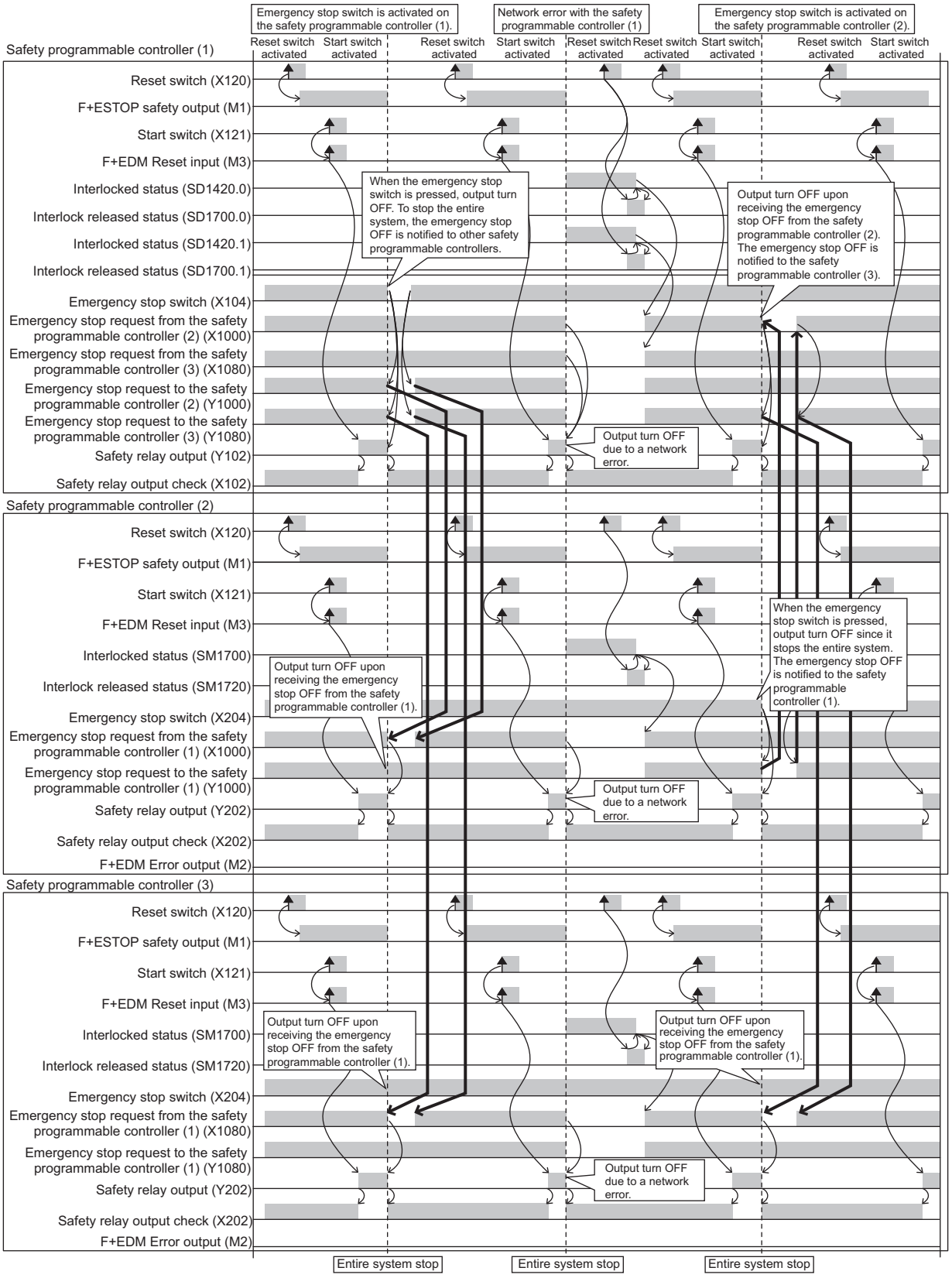


Figure 6.13 Timing chart

APPENDICES

Appendix 1 Calculating Safety Response Time of CC-Link Safety

This manual explains the maximum value of safety response time. For normal values, refer to the following.

☞CC-Link Safety System Master Module User's Manual

To employ calculation formulas described in this section, use GX Developer and modules with the following versions.

For calculation formulas when GX Developer or any module with the version other than below is used, refer to the above manual.

GX Developer version	Serial number (first five digits)			
	Safety CPU module	CC-Link Safety master module	Safety remote I/O station on CC-Link Safety	
			QS0J65BTS2-8D, QS0J65BTS2-4T	QS0J65BTB2-12DT
Ver. 8.65T or later	10032 or later	10032 or later	10031 or later	10032 or later

(1) Calculation method

The maximum value of safety response time will be the sum of (a) to (e) in Table APPX.1.

For timing when the safety response time will be the maximum value, refer to Figure APPX.1.

Table APPX.1 Calculation of safety response time (maximum value)

Item	Maximum value
(a) Input device response time	DT1
(b) Safety remote station input response time	Refer to the user's manual for the safety remote I/O station used on CC-Link Safety.
(c) Monitoring time from safety input to safety output	Safety data monitoring time
(d) Safety remote station output response time	Refer to the user's manual for the safety remote I/O station used on CC-Link Safety.
(e) Output device response time	DT2
Total	DT1 + DT2 + Safety remote station input response time + Safety data monitoring time + Safety remote station output response time

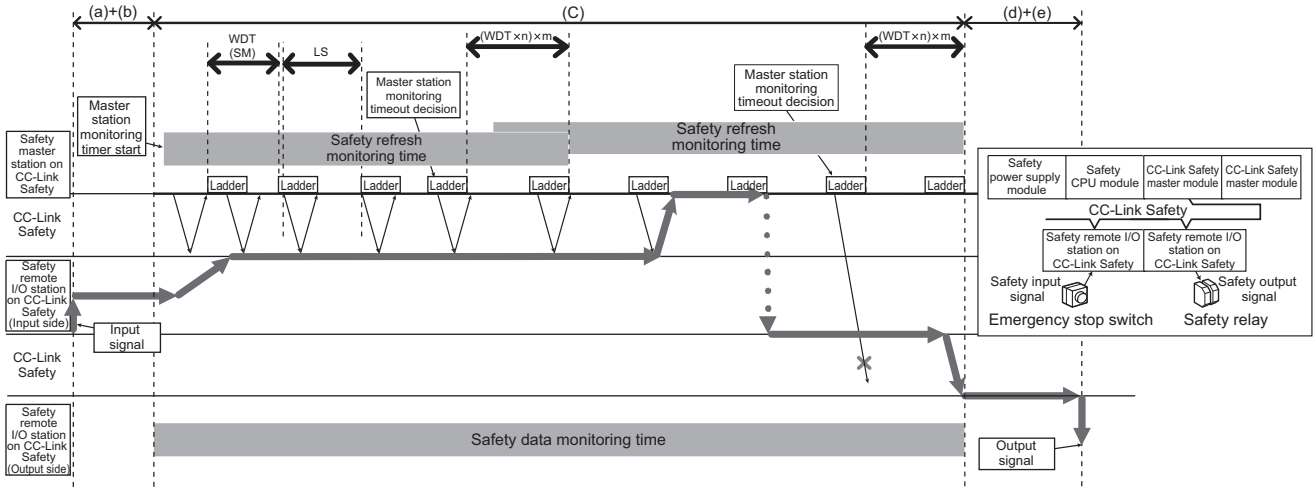
LS:	Link Scan Time of CC-Link Safety
n:	LS/WDT (Round up the calculated value to the nearest integer.)
m:	Safety refresh response processing time/(WDT × n) (Round up the calculated value to the nearest integer.)
	Safety refresh response processing time
	☞ User's manual for the safety remote I/O station used on CC-Link Safety
DT1, DT2:	Response time of a sensor or output-target device. Check and add the response time of the device used.
Safety refresh monitoring time:	Time set in network parameter.
	Use the value gained by the following calculation formula as measure.
	In synchronous mode
	(WDT × n) × 3 + ((WDT × n) × m) × 2 + (WDT × α) [ms]
	α: 0 when LS $\leqq$ 1.5ms, 1 when LS $>$ 1.5ms
	In asynchronous mode
	(WDT × n) × 3 + LS + ((WDT × n) × m) × 2 + (WDT× α) [ms]
	α: 0 when LS $\leqq$ 1.5ms, 1 when LS $>$ 1.5ms
Safety data monitoring time:	Time set in network parameter for CC-Link Safety
	Use the value gained by the following calculation formula as measure.
	Safety refresh monitoring time × 2 - ((WDT × n) × m) - 10 [ms]
WDT (Watchdog timer):	Time set in programmable controller parameter.
	Calculate the SM (scan time) value referring to the following manual and set this timer value equal to or more than the calculated value.
	☞ QSCPU User's Manual (Function Explanation, Program Fundamentals)
Synchronous mode:	Mode which performs data link when sequence scan is synchronized with link scan.
	In synchronous mode, sequence scan and link scan start simultaneously.
	☞ CC-Link Safety System Master Module User's Manual
Asynchronous mode:	Mode which performs data link without synchronizing sequence program
	☞ CC-Link Safety System Master Module User's Manual

POINT

(1) If setting value of the safety data monitoring time is equal to or less than the value gained by the calculation formula above, an error may occur even in normal communication status.
If setting value of the safety data monitoring time is needlessly long, the time taken for (c) in Table APPX.1 may lengthen in the case of a safety programmable controller error, resulting in excessive delay of safety response performance.

(2) The maximum value of safety response time is explained in this manual. For this reason, WDT, the maximum value of SM (scan time), is used in calculation formulas, instead of SM.
Use SM when calculating a normal value.

(3) When the safety CPU module detects CC-LINK DATA RECEPTION TIMEOUT (error code: 8320 to 8322), increase the safety refresh monitoring time and safety data monitoring time as needed.



(a) to (e) in the figure corresponds to (a) to (e) in Table APPX.1.

Figure APPX.1 Timing chart

(a) Link scan time of CC-Link Safety (LS)

The following is the formula to calculate link scan time (LS) [μs] of CC-Link Safety.

LS = BT × (27 + (NI × 4.8) + (NW × 9.6) + (N × 30) + (ni × 4.8) + (nw × 9.6) + TR) + ST + RT+ F [μs] ⋯ LS calculation formula

BT: Constant

Transmission speed	156kbps	625kbps	2.5Mbps	5Mbps	10Mbps
BT	51.2	12.8	3.2	1.6	0.8

NI : Final station No. in A and B (Higher value between A and B)
(including the station number of occupied station and excluding that of reserved station, in multiples of 8.)

NW : Final station No. in B
(including the station number of occupied station and excluding that of reserved station, in multiples of 8.)

A : Final station No. of standard remote I/O stations on CC-Link Safety
(including the station number of occupied station and excluding that of reserved station)
(When not connecting standard remote station on CC-Link Safety, put 0 to A.)

B : Final station No. of safety remote I/O stations on CC-Link Safety and remote device stations (including the station number of occupied station and excluding that of reserved station)

Final station No.	1 to 8	9 to 16	17 to 24	25 to 32	33 to 40	41 to 48	49 to 56	57 to 64
NI, NW	8	16	24	32	40	48	56	64

N : Number of connected modules (excluding reserved stations)

ni : a + b

a : Total number of occupied standard remote I/O stations on CC-Link Safety (excluding the station number of reserved station)

b : Total number of occupied safety remote I/O stations on CC-Link Safety and remote device stations (excluding the station number of reserved station)

nw : b

TR : Constant

Constant	Numeric value
TR	38.4

ST : Constant
(for asynchronous mode only. For synchronous mode, ST = 0.)
(1) or 2), whichever is greater. Ignore 2) when B = 0.)
1) 800 + (A × 15)
2) 900 + (B × 50)

RT : Retry processing time (only when there is a faulty station)

$\alpha + \beta \times$ (Number of detected faulty stations - 1)

α : Retry processing time for first module

BT × ((200 + R) × Set number of retries + 200)

R: 51.6 + (NI × 4.8) + (NW × 9.6)

β : Retry processing time for second or subsequent module

BT × ((200 + P) × Set number of retries + 200)

P: 10.8

F : Return to system processing time (only when a communication error station exists)

In synchronous mode:

BT × 244.4 + 213.2 × (Number of automatic return modules -1)

In asynchronous mode:

BT × 218 + 213.2 × (Number of automatic return modules -1

POINT

If connecting the remote I/O station on CC-Link Safety to the station with the reserved station setting, and then clear the setting, the values of NI, NW, N, ni, and nw in the LS calculation formula will change.
When the reserved station was changed, recalculate the LS and safety response performance.
For the reserved station function, refer to the following.
☞ CC-Link Safety System Master Module User's Manual.

(2) Calculation example

This section describes calculation examples when the following values are set:

- WDT setting value: 10ms
- Link scan time (synchronous mode): 0.3ms
- Link scan time (asynchronous mode): 1.4ms
- Safety remote station input response time: 12.2ms
- Safety remote station output response time: 10.4ms
- Safety refresh response processing time: 9.6ms

(a) Calculation example of safety refresh monitoring time

1) In synchronous mode

n : LS/WDT = 0.3/10 ⇒ 1

m : (Safety refresh response processing time/(WDT × n))

= 9.6/(10 × 1) ⇒ 1

α : LS = 0.3 ≦ 1.5 ms → 0

(WDT × n) × 3 + ((WDT × n) × m) × 2 + (WDT × α)

= (10 × 1) × 3 + ((10 × 1) × 1) × 2 + (10 × 0)

= 50 [ms]

2) In asynchronous mode

n : LS/WDT = 1.4/10 ⇒ 1

m : (Safety refresh response processing time/(WDT × n))

= 9.6/(10 × 1) ⇒ 1

α : LS = 1.4 ≦ 1.5 ms ⇒ 0

(WDT × n) × 3 + LS + ((WDT × n) × m) × 2 + (WDT × α)

= (10 × 1) × 3 + 1.4 + ((10 × 1) × 1) × 2 + (10 × 0)

= 51.4 [ms]

(b) Calculation example of safety data monitoring time

1) In synchronous mode

Safety refresh monitoring time × 2 - ((WDT × n) × m) - 10

= 50 × 2 - (10 × 1 × 1) - 10

= 80 [ms]

2) In asynchronous mode

Safety refresh monitoring time × 2 - ((WDT × n) × m) - 10

= 51.4 × 2 - (10 × 1 × 1) - 10

= 82.8 [ms]

(c) Calculation example for the maximum value of response time

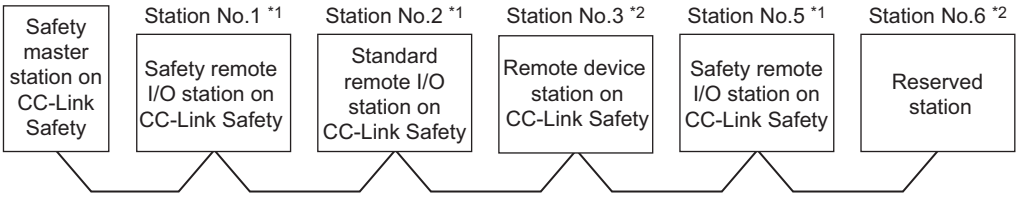
1) In synchronous mode
DT1 + DT2 + Safety remote station input response time + Safety data monitoring time + Safety remote station output response time
= DT1 + DT2 + 12.2 + 80 + 10.4
= DT1 + DT2 + 102.6 [ms]

2) In asynchronous mode
DT1 + DT2 + Safety remote station input response time + Safety data monitoring time + Safety remote station output response time
= DT1 + DT2 + 12.2 + 82.8 + 10.4
= DT1 + DT2 + 105.4 [ms]

(3) Calculation example of link scan time of CC-Link Safety

The following shows the calculation example of LS (Link scan time) used in Appendix 1 (2) Calculation example.

The following shows the calculation example when the transmission speed is 10 Mbps in the following system configuration example. (Condition: No communication error station exists.)



*1: 1 occupied station *2: 2 occupied station

- BT = 0.8
- NI = 5 ⇒ 8
- NW = 5 ⇒ 8
- N = 4
- ni = 5
- nw = 4
- A = 2, B = 5
- ST = 1150
  1) 800 + (2 × 15) = 830
  2) 900 + (5 × 50) = 1150
- TR = 38.4, RT = 0, F = 0

1) In synchronous mode

LS = BT × (27 + (NI × 4.8) + (NW × 9.6) + (N × 30) + (ni × 4.8) + (nw × 9.6) + TR) + RT + F

= 0.8 × (27 + (8 × 4.8) + (8 × 9.6) + (4 × 30) + (5× 4.8) + (4 × 9.6) + 38.4) + 0 + 0

= 290.4 [μs]

= 0.3 [ms]

2) In asynchronous mode

LS = BT × (27 + (NI × 4.8) + (NW × 9.6) + (N × 30) + (ni × 4.8) + (nw × 9.6) + TR) + ST + RT + F

= 0.8 × (27 + (8 × 4.8) + (8 × 9.6) + (4 × 30) + (5 × 4.8) + (4 × 9.6) + 38.4) + 1150 + 0 + 0

= 1440.4 [μs]

= 1.4 [ms]

Appendix 2 Calculating Safety Response Time When CC-Link Safety and CC-Link IE Field Network are Used

This section describes the maximum value of safety response time in a system where CC-Link Safety and CC-Link IE Field Network are used.

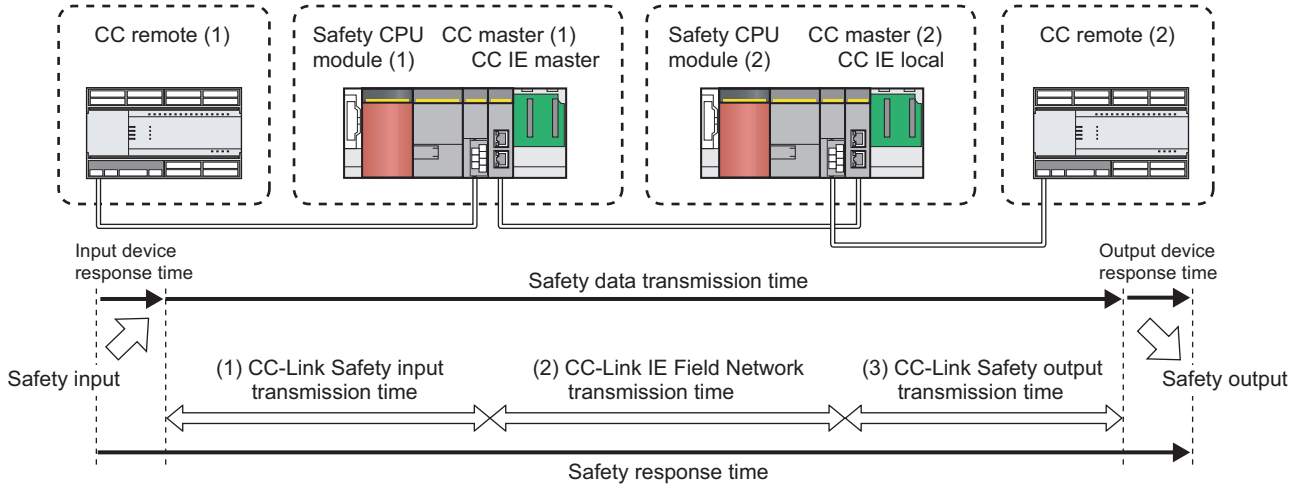


Figure APPX.2 Safety response time

Remark

In this section, the following abbreviations are used for each module.

Network	Abbreviation	Module name
CC-Link Safety	CC master (1)	CC-Link Safety master module
	CC master (2)	
	CC remote (1)	CC-Link Safety remote I/O module
	CC remote (2)	
CC-Link IE Field Network	CC IE master	CC-Link IE Field Network master/local module (with safety functions)
	CC IE local	

To employ calculation formulas described in this section, use GX Developer and modules with the following versions.

For calculation formulas when GX Developer or any module with the version other than below is used, refer to the following.

☞ CC-Link Safety System Master Module User's Manual

GX Developer version	Serial number (first five digits)			
	Safety CPU module	CC-Link Safety master module	Safety remote I/O station on CC-Link Safety	
			QS0J65BTS2-8D, QS0J65BTS2-4T	QS0J65BTB2-12DT
Ver.8.98C or later	13042 or later	10032 or later	10031 or later	10032 or later

(1) Calculation method

The maximum value of safety response time will be the sum of (a) to (c) in Table APPX.2 For normal values, refer to the following.

- Transmission time of CC-Link Safety
  ☞ CC-Link Safety System Master Module User's Manual
- Transmission time of CC-Link IE Field Network
  ☞ MELSEC-QS CC-Link IE Field Network Master/Local Module User's Manual

Table APPX.2 Calculation of safety response time (maximum value)

Item		Maximum value
(a)	Input device response time	DT1
(b)	Safety data transmission time (maximum value)	Input transmission time of CC-Link Safety + Transmission time of CC-Link IE Field Network + Output transmission time of CC-Link Safety
(c)	Output device response time	DT2
Total		DT1 + DT2 + Safety data transmission time (maximum value)

DT1, DT2 : Response time of a sensor or output-target device. Check and add the response time of the device used.
Input transmission time of CC-Link Safety : Refer to Appendix 2 (1) (a).
Transmission time of CC-Link IE Field Network : Refer to Appendix 2 (1) (c).
Output transmission time of CC-Link Safety : Refer to Appendix 2 (1) (b).

(a) Calculating input transmission time of CC-Link Safety

The following is the formula to calculate input transmission time [ms] of CC-Link Safety.

Input transmission time of CC-Link Safety = (Safety refresh monitoring time of CC master (1) × 2)
+ Input response time of CC remote (1)
- (((WDT (1) × n) × m) × 2 + (WDT (1) × n) + WDT (1)) [ms]

WDT (1) : A watchdog timer for the safety CPU module (1). A value is set in PLC parameter.
CCLS (1) : Link scan time of CC-Link Safety in the safety CPU module (1)
n : CCLS (1)/WDT (1) (Round up the calculated value to the nearest integer.)
m : Safety refresh response processing time/(WDT (1) × n) (Round up the calculated value to the nearest integer.)

1) Safety refresh monitoring time of CC-Link Safety
This time is required to calculate input transmission time of CC-Link Safety. For the calculation method, refer to Appendix 1 (1).

2) Link scan time of CC-Link Safety (CCLS (1))
This time is required to calculate input transmission time of CC-Link Safety. For the calculation method, refer to Appendix 1 (1) (a).

POINT

The maximum value of safety response time is explained in this manual. For this reason, WDT, the maximum value of SM (scan time), is used in calculation formulas, instead of SM.
Use SM when calculating a normal value.

(b) Calculating output transmission time of CC-Link Safety

The following is the formula to calculate output transmission time [ms] of CC-Link Safety.

Output transmission time of CC-Link Safety = (Safety refresh monitoring time of CC master (2) × 2)
+ Output response time of CC remote (2)
- (((WDT (2) × n) × m) × 2 + (WDT (2) × n) + WDT (2)) [ms]

WDT (2) : A watchdog timer value for the safety CPU module (2). A value is set in PLC parameter.
CCLS (2) : Link scan time of CC-Link Safety in the safety CPU module (2)
n : CCLS (2)/WDT (2) (Round up the calculated value to the nearest integer.)
m : Safety refresh response processing time/(WDT (2) × n) (Round up the calculated value to the nearest integer.)

1) Safety refresh monitoring time of CC-Link Safety
This time is required to calculate output transmission time of CC-Link Safety.
For the calculation method, refer to Appendix 1 (1).

2) Link scan time of CC-Link Safety (CCLS (2))
This time is required to calculate output transmission time of CC-Link Safety.
For the calculation method, refer to Appendix 1 (1) (a).

POINT

The maximum value of safety response time is explained in this manual. For this reason, WDT, the maximum value of SM (scan time), is used in calculation formulas, instead of SM.
Use SM when calculating a normal value.

(c) Calculating transmission time of CC-Link IE Field Network
The following is the formula to calculate transmission time [ms] of CC-Link IE Field Network.

Transmission time of CC-Link IE Field Network = (Safety refresh monitoring time of CC-Link IE Field Network × 4)
- (Transmission interval monitoring time of CC IE master × 3)
- (Transmission interval monitoring time of CC IE local × 4)
+ (WDT(2) × 3) [ms]

1) Safety refresh monitoring time of CC-Link IE Field Network
This time is required to calculate the transmission time of CC-Link IE Field Network. This is the time monitored by the receiving station for each safety connection to detect the following safety communication errors.
- Safety communication stop due to an error on the sending station
- Safety communication stop due to an error on the transmission path, such as cable disconnection or hub failure

Set the time to one of the safety stations (active side) that performs safety communication.*1 The time value must satisfy the following formula.

*1 The active side and the passive side use the same safety refresh monitoring time.

Safety refresh monitoring time ≧ Transmission interval monitoring time (active side)
+ Transmission interval monitoring time (passive side)
+ LS × (β + 1) [ms]

LS : Link scan time of CC-Link IE Field Network (Refer to Appendix 2 (1) (c) 3).)

β : • Number of safety connections on the active side ≧ Number of safety connections on the passive side:
Number of safety connections on the active side ÷ 8
(Round up the calculated value to the nearest integer.)
• Number of safety connections on the active side < Number of safety connections on the passive side:
Number of safety connections on the passive side ÷ 8
(Round up the calculated value to the nearest integer.)

If time between a safety data reception and the next safety data reception on the receiving station exceeds the safety refresh monitoring time, the receiving station detects an safety monitoring timeout error and stops safety communication. The safety data to be received from the sending station is cleared at the time.

POINT

When the safety CPU module detects a safety monitoring timeout error, check if the safety refresh monitoring time satisfies the formula above.

2) Transmission interval monitoring time of CC-Link IE Field Network
This time is required to calculate the transmission time of CC-Link IE Field Network. This is the time monitored by the receiving station for each safety connection to detect the following safety communication errors.
- Delay in transmission interval of safety data due to an error on the sending station
- Safety data loss on the transmission path due to noise

Set the time to both safety stations (active side and passive side) that perform safety communication. The time value must satisfy the following formula.

Transmission interval monitoring time (asynchronous mode)[*1] = WDT (1) of sending station + 2 [ms][*2]
or
LS × α × 2 + 2 [ms][*2]

*1 When the link scan mode of the CC-Link IE Field Network master/local module (with safety functions) is synchronous mode, refer to the following.
☞ MELSEC-QS CC-Link IE Field Network Master/Local Module User's Manual

*2 Use the larger value.

WDT (1) : A watchdog timer for the safety CPU module (1). A value is set in PLC parameter.
LS : Link scan time of CC-Link IE Field Network (Refer to Appendix 2 (1) (c) 3).)
α : Number of safety connections at the sending station ÷ 8
(Round up the calculated value to the nearest integer.)

If time between a safety data transmission and the next safety data transmission on the sending station exceeds the transmission interval monitoring time, the receiving station detects a safety monitoring timeout error and stops safety communication. The safety data to be received from the sending station is cleared at the time.

POINT

- When the safety CPU module detects a safety monitoring timeout error, check if the transmission interval monitoring time satisfies the formula above.
- If the difference between the transmission interval monitoring time of own station and that of the communication target station is four times or more, change the transmission interval monitoring time so that the difference stays less than four times.

3) Link scan time (LS) of CC-Link IE Field Network
This time is required to calculate the transmission time of CC-Link IE Field Network. The following is the calculation example.

LS = (Total points assigned for cyclic transmission × 0.08
+ (Number of connected slave stations × Ka) + Kb + Kc + Kd) ÷ 1000
+ (Number of interrupt conditions in the interrupt setting) × 0.02
+ (Total Ke values of all stations) ÷ 1000 [ms]

Total points assigned for cyclic transmission : Total number of points assigned for cyclic transmission, (RX points + RY points)/8
+ (RWr points + RWw points) × 2 [byte]

Number of connected slave stations : Number of slave stations connected in a network

The following table lists values of factors for each cyclic transmission mode.

Table APPX.3 Factors used in the formula

Item	Cyclic transmission mode	
	Normal mode	High speed mode
Ka	25.8	When "Set input data (RX/RY) to OFF or cleared to 0" is set in the Network Operation Setting: 18.5 When "Hold input data (RX/RY)" is set in the Network Operation Setting: 9.75
Kb	655	168
Kc (Maximum transient processing time)	160 +60 × Total number of slave stations set in the parameters	80
Kd (Maximum data link processing time when the station is disconnected from or returned to the network)	9000 + Total number of ports used in the switching hub × 3000	
Ke (Processing time factor of each module)	The following is the processing time factor of each module. Add values of all stations. • CC-Link IE Field Network master/local module (with safety functions) Safety station: 300 Standard station: 0 • Other than the module above: 0	

(2) Calculation example

In the system configuration of Figure APPX.2, when a signal from an emergency stop switch is input to the CC remote (1), a contactor connected to the CC remote (2) stops its output. This section describes examples for calculating safety response time for the situation above, using the following set values.

- WDT setting value for the safety CPU module (1) and (2): 10ms
- Input response time of CC remote (1): 12.2ms
- Output response time of CC remote (2): 10.4ms
- Safety refresh response processing time: 9.6ms

(a) Calculation example of input transmission time of CC-Link Safety

1) Link scan time of CC-Link Safety

This time is required to calculate input transmission time of CC-Link Safety. The following is the calculation example.

In these example, transmission speed, 10Mbps, is used. (Condition: No communication error station exists.)

- BT = 0.8
- NI = 1 → 8
- NW = 1 → 8
- N = 1
- ni = 1
- nw = 1
- A = 0, B = 1
- ST = 950

  1) 800 + (0 × 15) = 800

  2) 900 + (1 × 50) = 950
- TR = 38.4, RT = 0, F = 0

  - In synchronous mode

$$\begin{aligned} LS &= BT \times (27 + (NI \times 4.8) + (NW \times 9.6) + (N \times 30) \\ &\quad + (ni \times 4.8) + (nw \times 9.6) + TR) + RT + F \\ &= 0.8 \times (27 + (8 \times 4.8) + (8 \times 9.6) + (1 \times 30) \\ &\quad + (1 \times 4.8) + (1 \times 9.6) + 38.4) + 0 + 0 \\ &= 180\ [\mu s] \\ &= 0.2\ [ms] \end{aligned}$$

  - In asynchronous mode

$$\begin{aligned} LS &= BT \times (27 + (NI \times 4.8) + (NW \times 9.6) + (N \times 30) \\ &\quad + (ni \times 4.8) + (nw \times 9.6) + TR) + ST + RT + F \\ &= 0.8 \times (27 + (8 \times 4.8) + (8 \times 9.6) + (1 \times 30) \\ &\quad + (1 \times 4.8) + (1 \times 9.6) + 38.4) + 950 + 0 + 0 \\ &= 1130\ [\mu s] \\ &= 1.2\ [ms] \end{aligned}$$

2) Safety refresh monitoring time of CC-Link Safety
This time is required to calculate input transmission time of CC-Link Safety.
The following is the calculation example for CC master (1).

• In synchronous mode

n: CCLS (1)/WDT (1) = 0.2/10 ⇒ 1

m: (Safety refresh response processing time/(WDT (1) × n))
= 9.6/(10 × 1) ⇒ 1

α: CCLS (1) = 0.2 ≦ 1.5ms ⇒ 0

(WDT (1) × n) × 3 + ((WDT (1) × n) × m) × 2 + (WDT (1) × α)
= (10 × 1) × 3 + ((10 × 1) × 1) × 2 + (10 × 0)
= 50 [ms]

• In asynchronous mode

n: CCLS (1)/WDT (1) = 1.2/10 ⇒ 1

m: (Safety refresh response processing time/(WDT (1) × n))
= 9.6/(10 × 1) ⇒ 1

α: CCLS (1) = 1.2 ≦ 1.5ms ⇒ 0

(WDT (1) × n) × 3 + CCLS (1) + ((WDT (1) × n) × m) × 2 + (WDT (1) × α)
= (10 × 1) × 3 + 1.2 + ((10 × 1) × 1) × 2 + (10 × 0)
= 51.2 ⇒ 52 [ms]

3) Input transmission time of CC-Link Safety
The following is the calculation example of input transmission time of CC-Link Safety.

• In synchronous mode

(Safety refresh monitoring time of CC master (1) × 2)
+ Input response time of CC remote (1)
- (((WDT (1) × n) × m) × 2 + (WDT (1) × n) + WDT (1))
= (50 × 2) +12.2 - (((10 × 1) × 1) × 2 + (10 × 1) +10)
= 72.2 [ms] (Calculation result A-1)

• In asynchronous mode

(Safety refresh monitoring time of CC master (1) × 2)
+ Input response time of CC remote (1)
- (((WDT (1) × n) × m) × 2 + (WDT (1) × n) + WDT (1))
= (52 × 2) +12.2 - (((10 × 1) × 1) × 2 + (10 × 1) + 10)
= 76.2 [ms] (Calculation result A-2)

(b) Calculation example of output transmission time of CC-Link Safety

1) Link scan time of CC-Link Safety
This time is required to calculate output transmission time of CC-Link Safety.
For the calculation example, refer to Appendix 2 (1) (a).

2) Safety refresh monitoring time of CC-Link Safety
This time is required to calculate output transmission time of CC-Link Safety.
The following is the calculation example for CC master (2).

• In synchronous mode

n: CCLS (2)/WDT (2) = 0.2/10 ⇒ 1

m: (Safety refresh response processing time/(WDT (2) × n))
= 9.6/(10 × 1) ⇒ 1

α: CCLS (2) = 0.2 ≦ 1.5ms ⇒ 0

(WDT (2) × n) × 3 + ((WDT (2) × n) × m) × 2 + (WDT (2) × α)
= (10 × 1) × 3 + ((10 × 1) × 1) × 2 + (10 × 0)
= 50 [ms]

• In asynchronous mode

n: CCLS (2)/WDT (2) = 1.2/10 ⇒ 1

m: (Safety refresh response processing time/(WDT (2) × n))
= 9.6/(10 × 1) ⇒ 1

α: CCLS (2) = 1.2 ≦ 1.5ms ⇒ 0

(WDT (2) × n) × 3 + CCLS (2) + ((WDT (2) × n) × m) × 2 + (WDT (2) × α)
= (10 × 1) × 3 + 1.2 + ((10 × 1) × 1) × 2 + (10 × 0)
= 51.2 ⇒ 52 [ms]

3) Output transmission time of CC-Link Safety
The following is the calculation example of output transmission time of CC-Link Safety.

• In synchronous mode

(Safety refresh monitoring time of CC master (2) × 2)
+ Output response time of CC remote (2)
- (((WDT (2) × n) × m) × 2 + (WDT (2) × n) + WDT (2))
= (50 × 2) + 10.4 - (((10 × 1) × 1) × 2 + (10 × 1) + 10)
= 70.4 [ms] (Calculation result B-1)

• In asynchronous mode

(Safety refresh monitoring time of CC master (2) × 2)
+ Output response time of CC remote (2)
- (((WDT (2) × n) × m) × 2 + (WDT (2) × n) + WDT (2))
= (52 × 2) + 10.4 - (((10 × 1) × 1) × 2 + (10 × 1) + 10)
= 74.4 [ms] (Calculation result B-2)

(c) Calculation example of transmission time of CC-Link IE Field Network

1) Link scan time (LS) of CC-Link IE Field Network
This time is required to calculate transmission time of CC-Link IE Field Network. The following is the calculation example. (Condition: Only safety communication is performed and no communication error station exists.) For Ka to Ke, use values when the station is set to Normal mode.

LS = (((RX points + RY points)/8
+ (RWr points + RWw points) × 2) × 0.08
+ (Number of connected slave stations × Ka) + Kb + Kc + Kd) ÷ 1000
+ (Number of interrupt conditions in the interrupt setting) × 0.02
+ (Total of Ke values of each module) ÷ 1000
= (0 + (1 × 25.8) + 655 + (160 + 60 × 1) + 0) ÷ 1000 + (0 × 0.02)
+ (300 + 300) ÷ 1000
= 1.6 [ms]

2) Transmission interval monitoring time of CC-Link IE Field Network
This time is required to calculate transmission time of CC-Link IE Field Network. The following is the calculation example.

Transmission interval monitoring time = WDT (1) of sending station + 2
10 + 2 = 12 [ms]

3) Safety refresh monitoring time of CC-Link IE Field Network
This time is required to calculate transmission time of CC-Link IE Field Network. The following is the calculation example.
β: Number of safety connections/8 = 1/8 ⇒ 1

Safety refresh monitoring time ≧ Transmission interval monitoring time (active side)
+ Transmission interval monitoring time (passive side)
+ LS × (β + 1)
= 12 + 12 + 1.6 × (1 + 1)
= 27.2 ⇒ 28 [ms]

4) Transmission time of CC-Link IE Field Network
The following is the calculation example of transmission time of CC-Link IE Field Network.

Transmission time of CC-Link IE Field Network = (Safety refresh monitoring time of CC-Link IE Field Network × 4)
- (Transmission interval monitoring time of CC IE master × 3)
- (Transmission interval monitoring time of CC IE local × 4)
+ (WDT(2) × 3)
= (28 × 4) - (12 × 3) - (12 × 4) + (10 × 3)
= 58 [ms] (Calculation result C)

(d) Calculation example of safety response time (maximum value)
The following is the calculation example of safety response time (maximum value).

• In synchronous mode

Safety response time (maximum value) = DT1 + DT2 + Safety data transmission time (maximum value)
= DT1 + DT2
+ Input transmission time of CC-Link Safety
+ Transmission time of CC-Link IE Field Network
+ Output transmission time of CC-Link Safety
= DT1 + DT2
+ (Calculation result A-1) + (Calculation result C)
+ (Calculation result B-1)
= DT1 + DT2 + 72.2 + 58 + 70.4
= DT1 + DT2 + 200.6 [ms]

• In asynchronous mode

Safety response time (maximum value) = DT1 + DT2 + Safety data transmission time (maximum value)
= DT1 + DT2
+ Input transmission time of CC-Link Safety
+ Transmission time of CC-Link IE Field Network
+ Output transmission time of CC-Link Safety
= DT1 + DT2
+ (Calculation result A-2) + (Calculation result C)
+ (Calculation result B-2)
= DT1 + DT2 + 76.2 + 58 + 74.4
= DT1 + DT2 + 208.6 [ms]

Appendix 3 Checklist

Table APPX.4 Checklist

No.	Description	Reference	Check
Backup and version management of a file			
1	Were the created date and author entered at the top of the sequence program using the statement function of GX Developer?	Section 4.2(7)	☐
2	When modifying the sequence program, were the created date, author, and modified description entered at the modified place using the statement function?	Section 4.2(7)	☐
3	Were the data downloaded to the programmable controller stored into the hard disk of a personal computer or CD?	Section 4.2(7)	☐
Checking the setting			
4	Was it confirmed that the link ID, station number, and transmission speed of the CC-Link Safety remote I/O module on the site were set as designed?	Section 4.3(1)	☐
5	Are the appropriate values set to "Safety refresh monitoring time", "Safety data monitoring time", and "WDT Setting" for CC-Link Safety?	Appendix 1	☐
6	Are the appropriate values set to "Transmission Interval Monitoring Time" and "Safety Refresh Monitoring Time" in Safety communication setting for CC-Link IE Field Network?	Appendix 2	☐
7	When the safety system is shifted to the actual operation, is the safety CPU operation mode set to the SAFETY MODE?	Section 4.4(3)	☐
Operation check			
8	Were all safety application functions (e.g. emergency stop function, restart interlock) inspected?	---	☐
9	Were the response time of the safety application inspected?	---	☐
Checking write data			
10	Before writing the data to the programmable controller, was it confirmed that sequence program and parameter setting values were configured as desired?	Section 4.3(2)	☐
11	Was it confirmed that the ROM information of CPU corresponds with that of the project file with the ROM information screen of GX Developer?	Section 4.4(4)	☐
Others			
12	Was it confirmed that there are no errors with the LEDs on the module and the programmable controller diagnostics screen of GX Developer?	---	☐
13	In output signals from a safety CPU module to the CC-Link Safety master module on sequence program, was it confirmed that "prohibited to use" signal was not mistakenly turned on or off? (For "prohibited to use" signal, refer to the CC-Link Safety System Master Module User's Manual.)	---	☐
14	Are the registered passwords (Login password, CPU access password) managed properly?	Section 4.4(5)	☐

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WARRANTY

Please confirm the following product warranty details before using this product.

1. Limited Warranty and Product Support.

a. Mitsubishi Electric Company ("MELCO") warrants that for a period of eighteen (18) months after date of delivery from the point of manufacture or one year from date of Customer's purchase, whichever is less, Mitsubishi MELSEC Safety programmable logic controllers (the "Products") will be free from defects in material and workmanship.
b. At MELCO's option, for those Products MELCO determines are not as warranted, MELCO shall either repair or replace them or issue a credit or return the purchase price paid for them.
c. For this warranty to apply:
   (1) Customer shall give MELCO (i) notice of a warranty claim to MELCO and the authorized dealer or distributor from whom the Products were purchased, (ii) the notice shall describe in reasonable details the warranty problem, (iii) the notice shall be provided promptly and in no event later than thirty (30) days after the Customer knows or has reason to believe that Products are not as warranted, and (iv) in any event, the notice must given within the warranty period;
   (2) Customer shall cooperate with MELCO and MELCO's representatives in MELCO's investigation of the warranty claim, including preserving evidence of the claim and its causes, meaningfully responding to MELCO's questions and investigation of the problem, grant MELCO access to witnesses, personnel, documents, physical evidence and records concerning the warranty problem, and allow MELCO to examine and test the Products in question offsite or at the premises where they are installed or used; and
   (3) If MELCO requests, Customer shall remove Products it claims are defective and ship them to MELCO or MELCO's authorized representative for examination and, if found defective, for repair or replacement. The costs of removal, shipment to and from MELCO's designated examination point, and reinstallation of repaired or replaced Products shall be at Customer's expense.
   (4) If Customer requests and MELCO agrees to effect repairs onsite at any domestic or overseas location, the Customer will pay for the costs of sending repair personnel and shipping parts. MELCO is not responsible for any re-commissioning, maintenance, or testing on-site that involves repairs or replacing of the Products.
d. Repairs of Products located outside of Japan are accepted by MELCO's local authorized service facility centers ("FA Centers"). Terms and conditions on which each FA Center offers repair services for Products that are out of warranty or not covered by MELCO's limited warranty may vary.
e. Subject to availability of spare parts, MELCO will offer Product repair services for (7) years after each Product model or line is discontinued, at MELCO's or its FA Centers' rates and charges and standard terms in effect at the time of repair. MELCO usually produces and retains sufficient spare parts for repairs of its Products for a period of seven (7) years after production is discontinued.
f. MELCO generally announces discontinuation of Products through MELCO's Technical Bulletins. Products discontinued and repair parts for them may not be available after their production is discontinued.

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a. MELCO does not warrant or guarantee the design, specify, manufacture, construction or installation of the materials, construction criteria, functionality, use, properties or other characteristics of the equipment, systems, or production lines into which the Products may be incorporated, including any safety, fail-safe and shut down systems using the Products.
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e. MELCO does not warrant any Product:
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   (2) subjected to negligence, carelessness, accident, misuse, or damage;
   (3) improperly stored, handled, installed or maintained;
   (4) integrated or used in connection with improperly designed, incompatible or defective hardware or software;
   (5) that fails because consumable parts such as batteries, backlights, or fuses were not tested, serviced or replaced;
   (6) operated or used with equipment, production lines or systems that do not meet applicable and commensurate legal, safety and industry-accepted standards;
   (7) operated or used in abnormal applications;
   (8) installed, operated or used in contravention of instructions, precautions or warnings contained in MELCO's user, instruction and/or safety manuals, technical bulletins and guidelines for the Products;
   (9) used with obsolete technologies or technologies not fully tested and widely accepted and in use at the time of the Product's manufacture;
   (10) subjected to excessive heat or moisture, abnormal voltages, shock, excessive vibration, physical damage or other improper environment; or
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f. In no event shall any cause of action arising out of breach of warranty or otherwise concerning the Products be brought by Customer more than one year after the cause of action accrues.
g. Each of the limitations on remedies and damages set forth in these terms is separate and independently enforceable, notwithstanding the unenforceability or failure of essential purpose of any warranty, undertaking, damage limitation, other provision of these terms or other terms comprising the contract of sale between Customer and MELCO.

4. Delivery/Force Majeure.

a. Any delivery date for the Products acknowledged by MELCO is an estimated and not a promised date. MELCO will make all reasonable efforts to meet the delivery schedule set forth in Customer's order or the purchase contract but shall not be liable for failure to do so.
b. Products stored at the request of Customer or because Customer refuses or delays shipment shall be at the risk and expense of Customer.
c. MELCO shall not be liable for any damage to or loss of the Products or any delay in or failure to deliver, service, repair or replace the Products arising from shortage of raw materials, failure of suppliers to make timely delivery, labor difficulties of any kind, earthquake, fire, windstorm, flood, theft, criminal or terrorist acts, war, embargoes, governmental acts or rulings, loss or damage or delays in carriage, acts of God, vandals or any other circumstances reasonably beyond MELCO's control.

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These terms and any agreement or contract between Customer and MELCO shall be governed by the laws of the State of New York without regard to conflicts of laws. To the extent any action or dispute is not arbitrated, the parties consent to the exclusive jurisdiction and venue of the federal and state courts located in the Southern District of the State of New York. Any judgment there obtained may be enforced in any court of competent jurisdiction.

6. Arbitration.

Any controversy or claim arising out of, or relating to or in connection with the Products, their sale or use or these terms, shall be settled by arbitration conducted in accordance with the Center for Public Resources (CPR) Rules for Non-Administered Arbitration of International Disputes, by a sole arbitrator chosen from the CPR's panels of distinguished neutrals. Judgment upon the award rendered by the Arbitrator shall be final and binding and may be entered by any court having jurisdiction thereof. The place of the arbitration shall be New York City, New York. The language of the arbitration shall be English. The neutral organization designated to perform the functions specified in Rule 6 and Rules 7.7(b), 7.8 and 7.9 shall be the CPR.

SH(NA)-080613ENG-H

SH(NA)-080613ENG-H(1811)MEE
MODEL: QSCPU-APPLI-E
MODEL CODE: 13JR90

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