MITSUBISHI

Mitsubishi Safety Programmable Controller

MELSEC QS series

Safety Application Guide

● SAFETY PRECAUTIONS ●

(Always read these instructions before using this equipment.)

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

In this manual, the safety instructions are ranked as "DANGER" and "CAUTION".

DANGER	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 medium or slight personal injury or physical damage.

Note that the CAUTION level may lead to a serious consequence according to the circumstances. Always follow the instructions of both levels because they are important to personal safety.

Please save this manual to make it accessible when required and always forward it to the end user.

[Design Precautions]

DANGER

- When a safety PLC detects an error in an external power supply or a failure in PLC 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 PLC.

- 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 PLC, create an interlock circuit outside the sequence program and safety PLC to ensure that the whole system always operates safely.
  For the operations to a safety PLC, 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 system master module 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 PLC system may cause malfunctions and safety operation cannot be guaranteed.

- When a 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 error has been detected, create a sequence program that turns off the outputs in the program.
  If the CC-Link Safety 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 100 mm (3.94 inch) 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 PLC in the environment that meets the general specifications described in the QSCPU User's Manual (Hardware Design, Maintenance and Inspection).
Using this PLC 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.
Over tightening 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 mounting 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.
Over tightening 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]

⚠DANGER

- 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.

⚠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 mounting 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 mounting screw is too loose, it may cause a drop of the screw or module.
  Over tightening 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 system, use the ones specified by the manufacturer. Otherwise, the performance of the CC-Link Safety system 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.

● Install our PLC 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).

[Stratup and Maintenance precautions]

⚠ DANGER

● Do not touch the terminals while power is on.
Doing so could could result in electric shock.

● Correctly connect the battery.
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 mounting screws.
Not doing so could result in electric shock.
Tighten a terminal block mounting screw, terminal screw, and module mounting 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 mounting screw is too loose, it may cause a drop of the screw or module.
Over tightening the screw may cause a drop due to the damage of the screw or module.

⚠ CAUTION

● The online operations performed from a PC to a running safety PLC (Program change when a safety CPU 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 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 (9.85 inch) away in all directions of safety PLC.
Not doing so can cause malfunctions.

[Stratup 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 (IEC61131-2-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.

- Completely turn off the external supply power used in the system before mounting or removing the module to/from the 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.

[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).

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	Correction CHAPTER1, Section 4.2, 5.5, 5.6.3, 5.6.4

Japanese Manual Version SH-080611-B

INTRODUCTION

Thank you for purchasing the Mitsubishi 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 PLC you have purchased, so as to ensure correct use.

CONTENTS

ABOUT MANUALS

The following manuals are related to this product.
If necessary, order them by quoting the details in the tables below.

Related manuals

Manual name	Manual number (Model code)
QSCPU User's Manual (Hardware) Explains the specifications of the QSCPU, safety power supply module and safety base unit, etc. (Supplied with the product)	IB-0800340ENG (13JR91)
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)
CC-Link Safety System Master Module User's Manual (Hardware) QS0J61BT12 Explains the specifications of the QS0J61BT12 type CC-Link Safety system master module. (Supplied with the product)	IB-0800344ENG (13JP95)
CC-Link Safety System Master Module User's Manual QS0J61BT12 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 (Hardware) QS0J65BTB2-12DT Explains the specifications of the QS0J65BTB2-12DT type CC-Link Safety system remote I/O module. (Supplied with the product)	IB-0800345ENG (13JP96)
CC-Link Safety System Remote I/O Module User's Manual QS0J65BTB2-12DT Explains the specifications, procedures and settings up to operation, parameter settings and trouble shootings of the QS0J65BTB2-12DT type CC-Link Safety system remote I/O module. (Sold separately)	SH-080612ENG (13JR89)
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-080026ENG (13JD04)
GX Developer Version 8 Operating Manual (Startup) Explains the system configration, installation and starting methods of GX Developer. (Sold separately)	SH-080372ENG (13JU40)
GX Developer Version 8 Operating Manual Explains the online functions of the GX Developer, such as the programming, printout, monitoring, and debugging methods. (Sold separately)	SH-080373ENG (13JU41)
GX Developer Version 8 Operating Manual (Safety PLC) Explains the functions of GX Developer that are added or changed to support the safety PLC. (Sold separately)	SH-080576ENG (13JU53)

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

In this manual,

(☞Section 3.5) A reference destination is indicated as (☞Section 3.5).

In addition, this manual provides the following explanations.

☒POINT Explains the matters to be especially noted, the functions and others related to the description on that page.

Remark Provides the reference destination related to the description on that page and the useful information.

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 PLC.
Although the safety application configuration example is shown in CHAPTER 5 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 PLC.
Chapter 2 Describes the safety application that is configured using the safety PLC.
Chapter 3 Describes the risk assessment, Category, and SIL.
Chapter 4 Describes the cautions for use of the safety PLC.
Chapter 5 Describes the safety application examples.

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
PLC	Abbreviation for Programmable Controller.
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 system) Information entered in 16-bit units from the remote device station to the master station. (Expressed as RWr for convenience.)
RWw	Remote register (Write area for CC-Link Safety system) Information output in 16-bit units from the master station to the remote device station. (Expressed as RWw for convenience.)
RX	Remote input (for CC-Link Safety system) Information entered in bit units from the remote station to the master station. (Expressed as RX for convenience.)
RY	Remote output (for CC-Link Safety system) Information output in bit units from the master station to the remote station. (Expressed as RY for convenience.)
SB	Link special relay (for CC-Link Safety system) Bit information that indicates the module operating status and data link status of the master station. (Expressed as SB for convenience.)
SW	Link special register (for CC-Link Safety system) 16-bit information that indicates the module operating status and data link status of the master station. (Expressed as SW for convenience.)
Safety remote I/O station	Remote station which handles only the informaion in bit units. Compatible with the safety-related system.
Standard remote I/O station	Remote station which handles only the information in bit units. Not compatible with the safety-related system.
Remote I/O station	Generic term for safety remote I/O station and standard remote I/O station
Remote device station	Remote station which handles information in both bit and word units. Not compatible with the safety-related system.
Safety master module	Other name for the QS0J61BT12 type CC-link Safety system master module.
Safety remote I/O module	Other name for the QS0J65BTB2-12DT type CC-Link Safety system remote I/O module.
Safety main base unit	Abbreviation for the QS034B(-E) type safety main base unit.
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 PLC	Generic term for safety CPU module, safety power supply module, safety main base unit, CC-Link safety master module and CC-Link safety remote I/O module.
Standard PLC	General name of each module for MELSEC-Q series, MELSEC-QnA series, MELSEC-A series and MELSEC-FX series. (Used for distinction from safety PLC.)
Safety input	Generic term for the signals that are input to the safety PLC for realizing the safety functions.
Safety output	Generic term for the signals that are output from the safety PLC for realizing the safety functions.
Safety application	Generic term for the applications that are operated using the safety PLC 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.
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 system.
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.

CHAPTER1 OVERVIEW

This chapter describes the overview of the safety PLC.
The safety PLC is a PLC that acquired the safety approval of EN954-1/ISO13849-1 Category 4 and IEC61508 SIL3.
The safety PLC can be used in safety-related system configuration up to Category 4 of EN954-1 and SIL3 of IEC61508.
The system configuration diagram of the safety PLC is shown in Figure1.1.

- Install the safety power supply module, safety CPU module, and safety master module to the safety main base unit.
- Connect the safety master module and the safety remote I/O module to a network.
- Connect a personal computer with GX Developer installed to the safety CPU module via USB when setting programs and parameters.

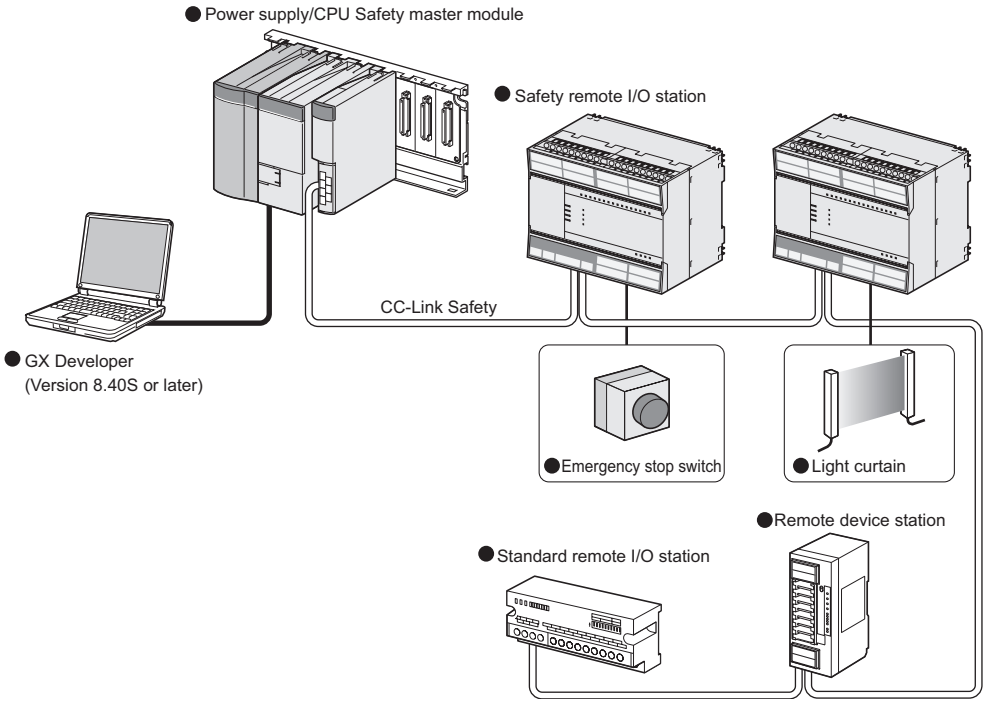


Figure1.1 System configuration of safety PLC

Memo

CHAPTER2 APPLICATION EXAMPLE

The application image for the car welding line is shown as an application example of the safety PLC in Figure2.1.

The safety application operated by the safety PLC is configured for the following purposes.
When the safe state signal can be confirmed, supply the power to a robot.
When the safe state signal cannot be confirmed, turn off the power to a robot .
Confirm the safe state signal using an emergency stop switch or a light curtain.

The safety PLC is operated as follows.
The safe state signal is connected to a safety remote I/O module.
The safe state signal is sent from the safety remote I/O module to the safety CPU module.
The safety CPU module processes the received safe state signal with the sequence program and sends the safety output to the safety remote I/O module.
The safety output stops the power of a robot.

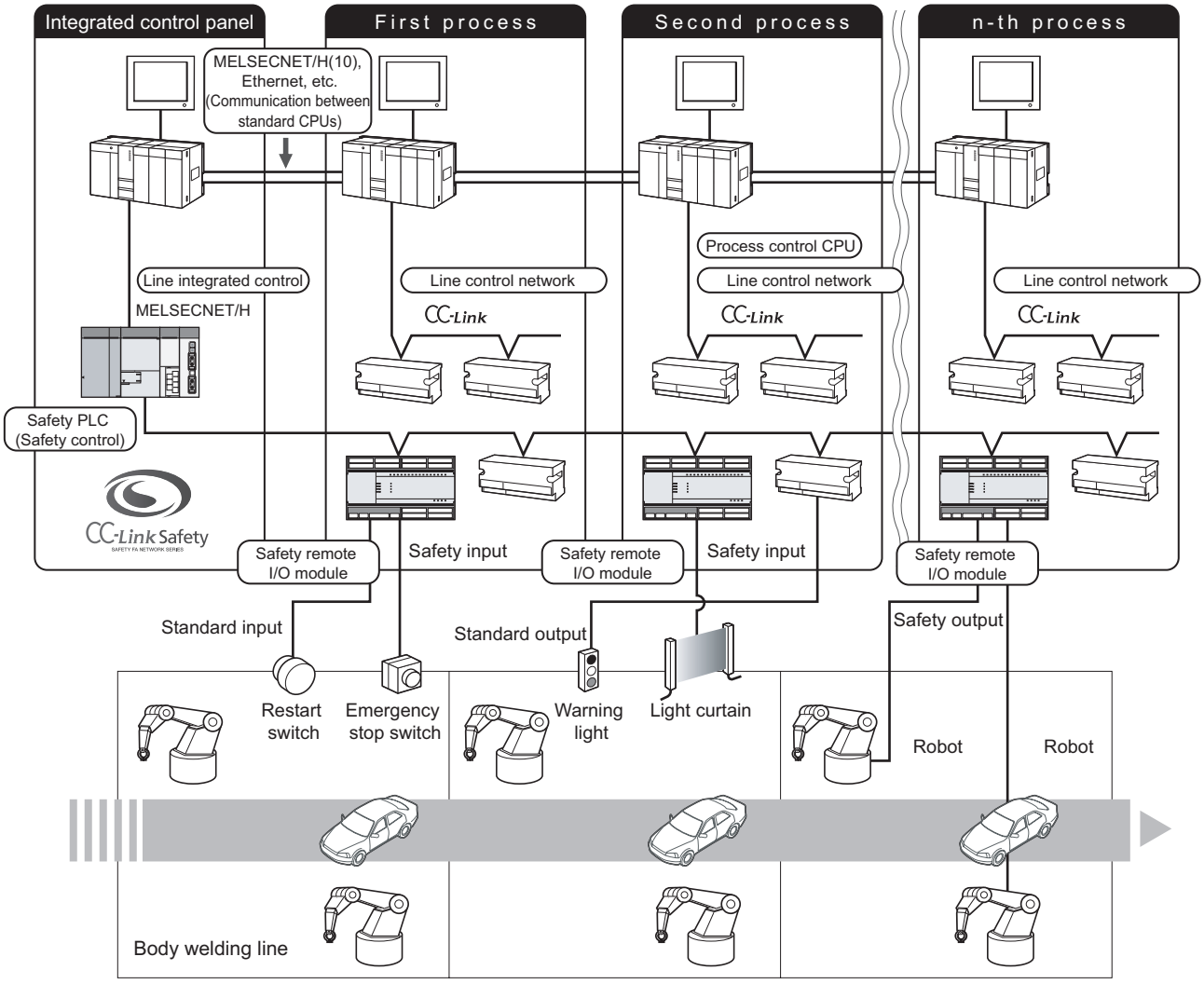


Figure2.1 Application image for car welding line

Memo

CHAPTER3 RISK ASSESSMENT AND SAFTY LEVEL

Conforming to EN954-1 and IEC61508, select the risk assessment, safety category, and SIL to reduce the risk.
This chapter briefly describes the risk assessment, risk reduction and safety category, 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 Figure3.1. This procedure is standardized in ISO12100 and 14121.

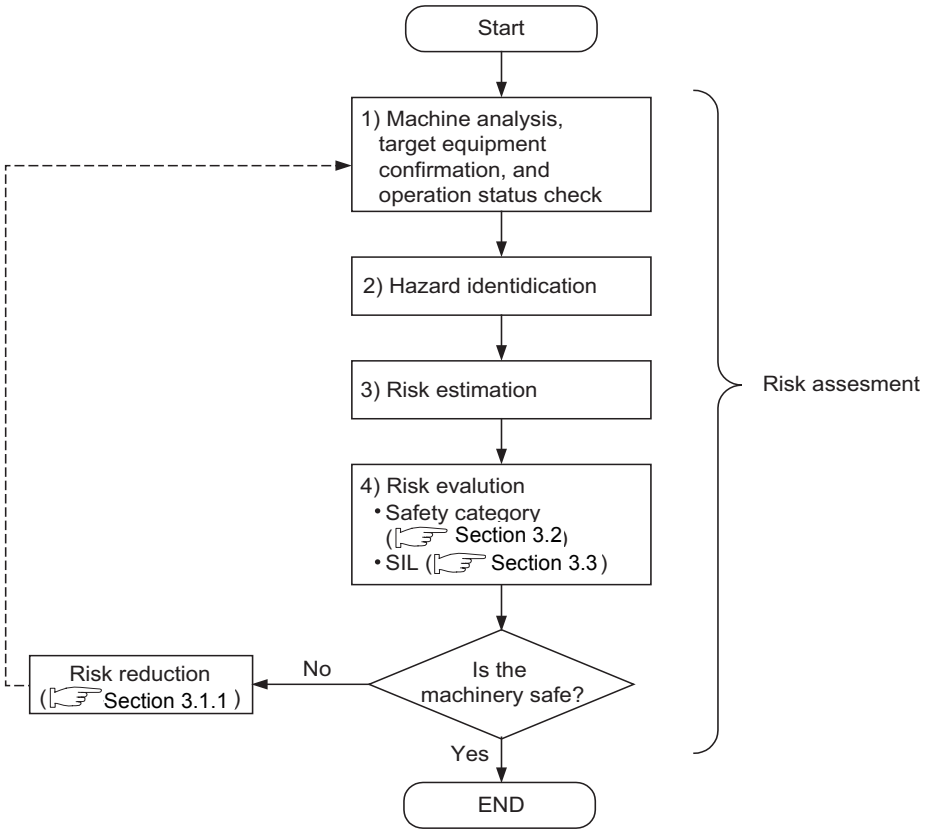


Figure3.1 Risk assessment procedure

(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 Figure3.2.

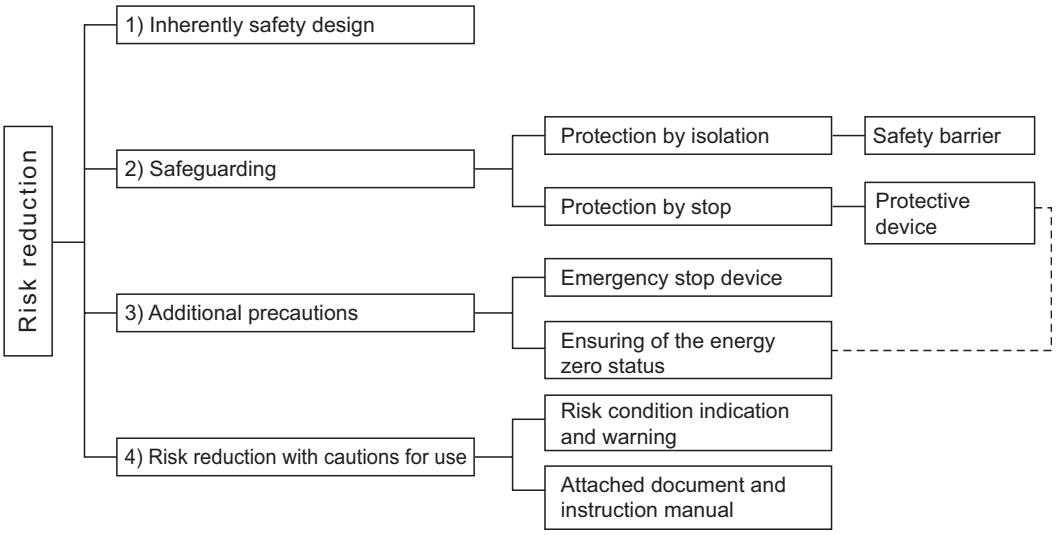


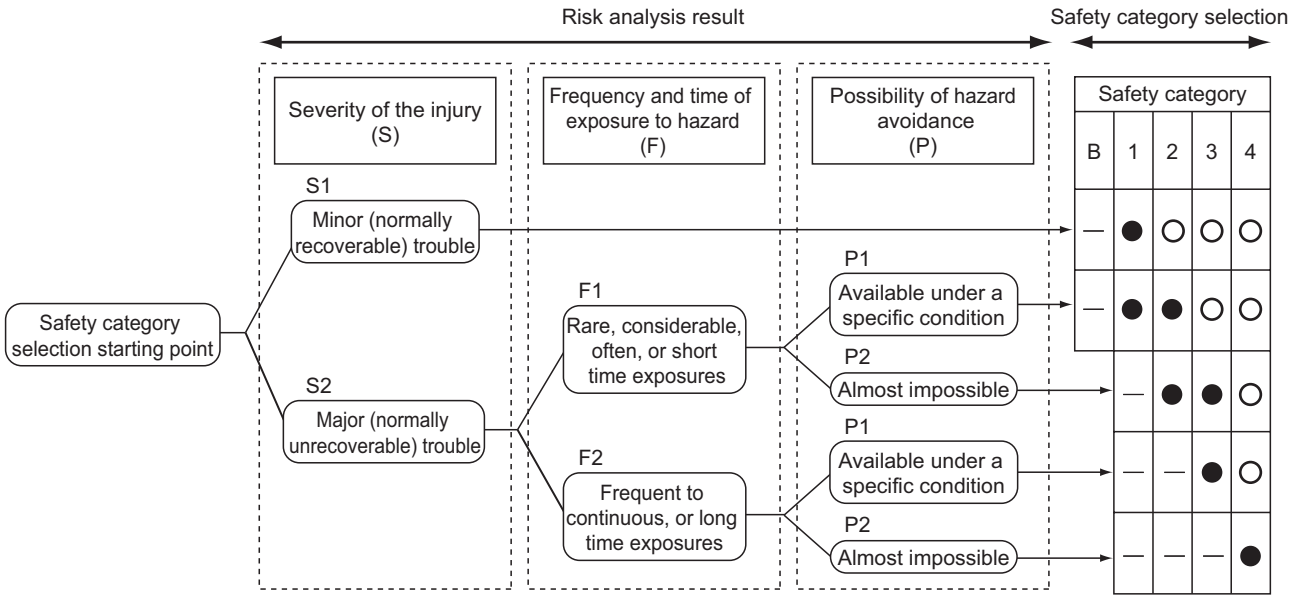
Figure3.2 Risk reduction

(Referred to ISO12100 and 14121.)

According to the procedure of Figure3.1, 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 Figure3.3.



Definition of symbols:

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

Figure3.3 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 Table3.1.

Table3.1 Summary of safety category requirements

Category*1	Summary of requirements	System behaviour*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 te faults occur the safety function is always performed. -- The faults will be detected in time to prevent loss of the safety function.	

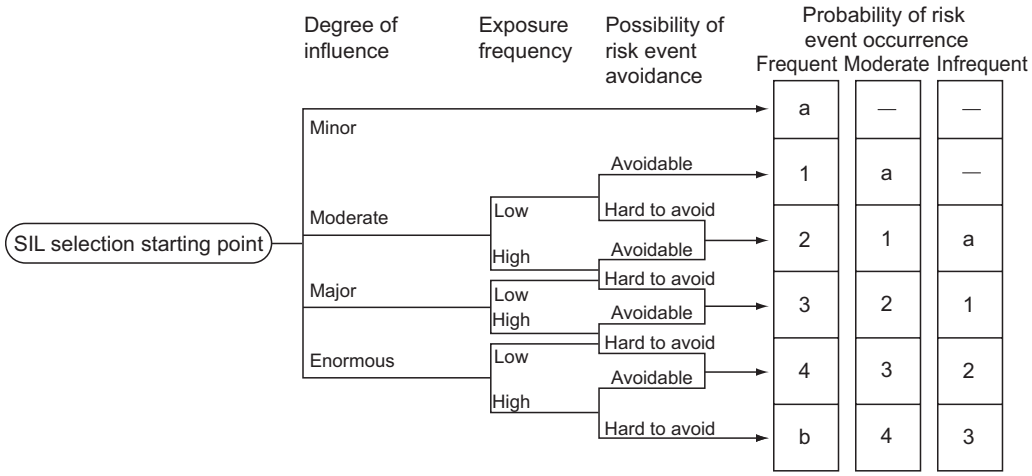
*1:The categories are not intended to be used in any given order or in any given hierarchy in respect of safety requirements.

*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 SIL

SIL is standardized in IEC61508.
The risk graph to be used for the SIL selection is shown in Figure3.4.



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.

Figure3.4 SIL risk graph

(Referred to IEC61508-5.)

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

Table3.5 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.)

CHAPTER4 PRECAUTIONS FOR USE OF SAFETY PLC

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. 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 PLC.

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 PLC.
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.

POINT

For the safety PLC, 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 3.3)
Calculate the target failure measure (PFD/PFH) with the following formula for each safety function.

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

Table4.1 Definition of each variable

Variable	Definition
A	PFD/PFH of safety CPU module, safety power supply module, safety main base unit, and CC-Link Safety master module
B	PFD/PFH of safety remote I/O module
n	Number of safety remote I/O modules to be used
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 PLC is listed in Table4.2.

Table4.2 PFD/PFH of safety PLC

Module/unit	PFD	PFH (/h)
PFD/PFH of safety CPU module, safety power supply module, safety main base unit, and CC-Link Safety master module*2	1.39×10^{-4}	4.95×10^{-9}
PFD/PFH of safety remote I/O module	2.57×10^{-5}	1.15×10^{-9}

*2: The number of the safety master modules is not relevant to the values of PFD or PFH.

(a) For one remote I/O module (n=1)

PFD = (PFD of A) + {(PFD of B) × n} + (PFD of C) + (PFD of D)

$=(1.39\times 10^{-4}) + ((2.57 \times 10^{-5}) \times 1)$ + (PFD of C) + (PFD of D)

$= 1.65 \times 10^{-4}$ + (PFD of C) + (PFD of D)

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

$=(4.95 \times 10^{-9}) + ((1.15 \times 10^{-9}) \times 1)$ + (PFH of C) + (PFH of D)

$= 6.10\times 10^{-9}$ + (PFH of C) + (PFH of D)

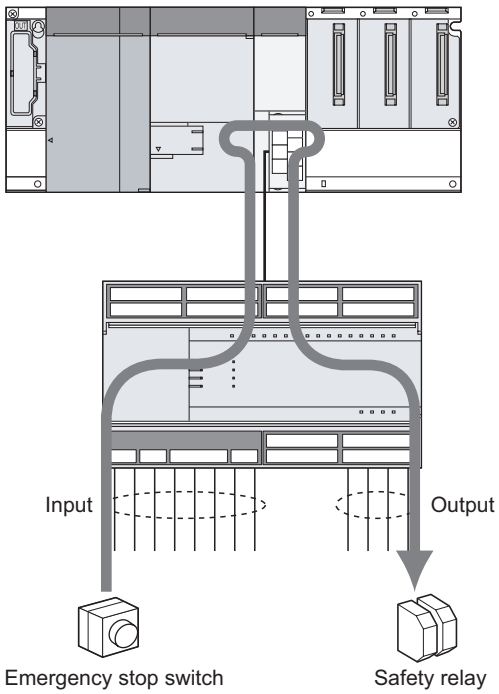


Figure4.1 Example when using one safety remote I/O module

(b) For two remote I/O modules (n = 2)

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

$=(1.39 \times 10^{-4}) + ((2.57 \times 10^{-5}) \times 2)$ + (PFD of C) + (PFD of D)

$= 1.90 \times 10^{-4}$ + (PFD of C) + (PFD of D)

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

$=(4.95 \times 10^{-9}) + ((1.15 \times 10^{-9}) \times 2)$ + (PFH of C) + (PFH of D)

$= 7.25 \times 10^{-9}$ + (PFH of C) + (PFH of D)

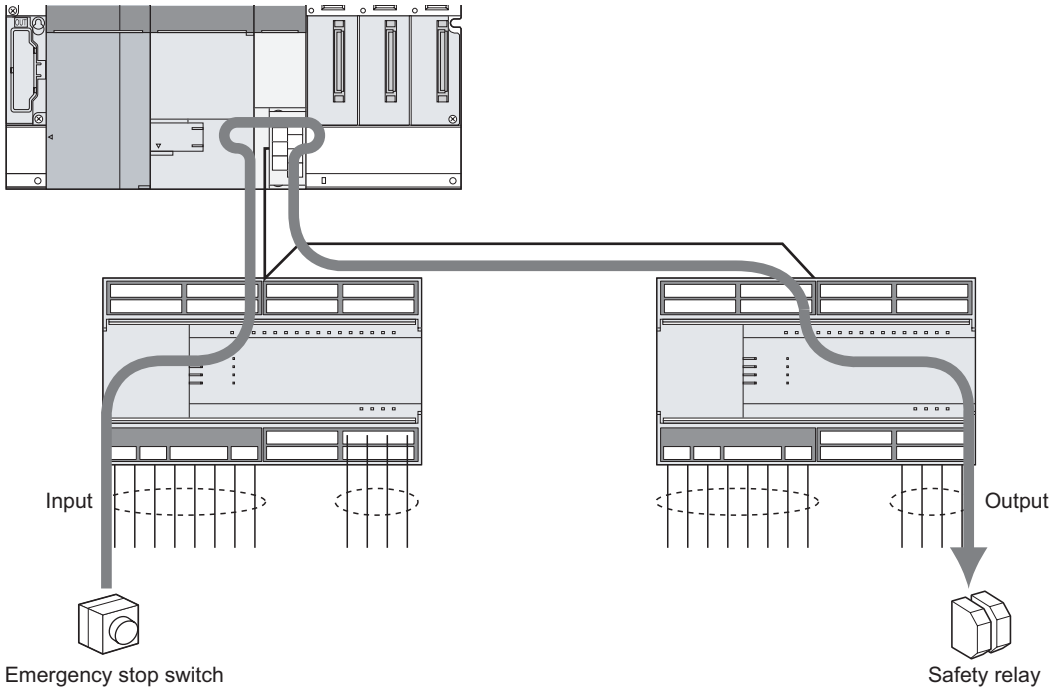


Figure4.2 Example when using two safety remote I/O modules

(3) Connecting safety components

Make a doubling wiring for safety components as shown in Figure4.3.

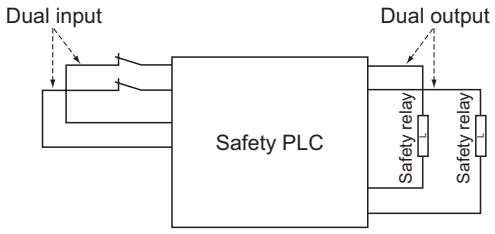


Figure4.3 Wiring of safety components

POINT

Use the doubling input signal to the 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 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

For wiring and setting methods, refer to Chapter 5.
For details of doubling wiring and Input dark test function, refer to the following manual.

☞ 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.

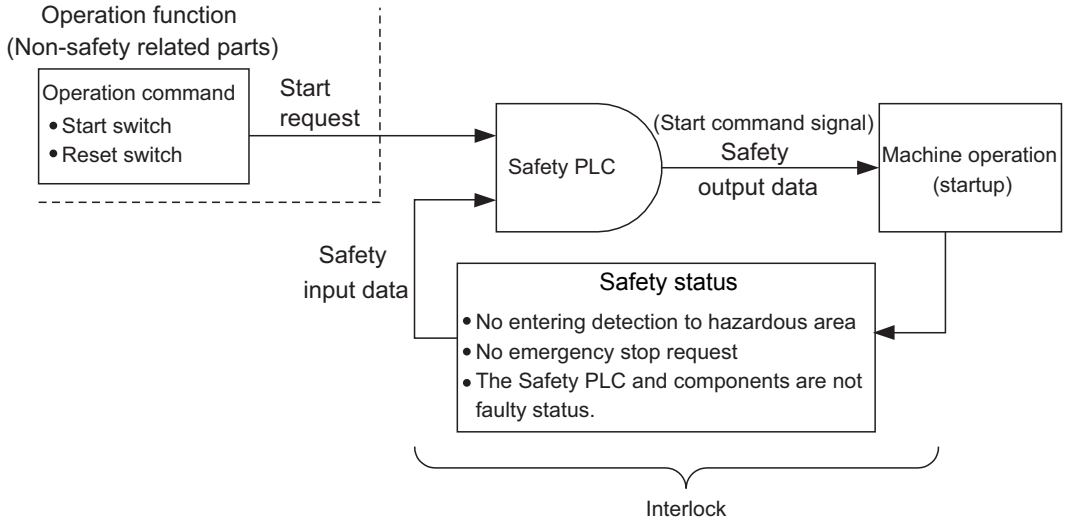


Figure4.4 Configuration example of safety-related system

For the program example, refer to Chapter 5.

(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

The data of internal device refreshed by communicating to the safety remote I/O station is the safety I/O data.

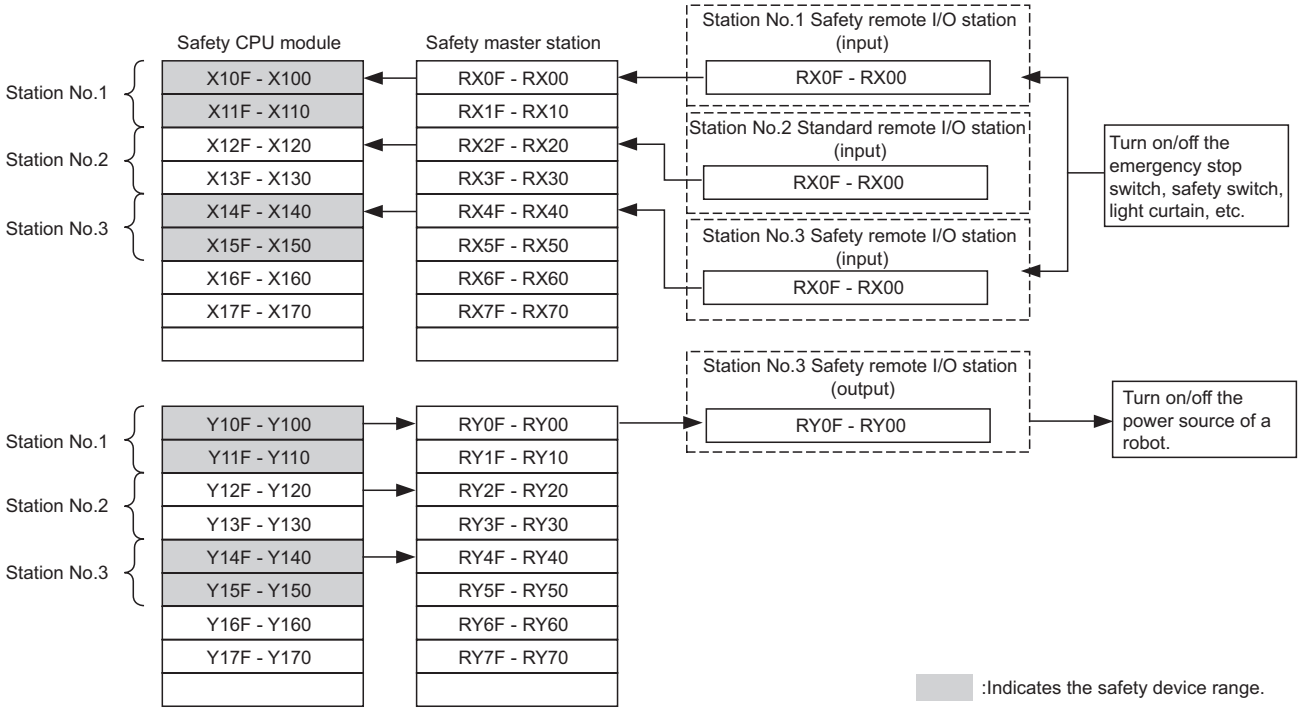


Figure4.5 I/O data of safety remote station[*1]

*1: Figure4.5 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 station are included.
Station No. 1: X110 to X11F, Y110 to Y11F, Station No. 3: X150 to X15F, Y150 to Y15F

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

Only SM1000 to SM1299 and SD1000 to SD1299, which are CC-Link Safety-related devices, can be used in a program for realizing the safety functions.

(3) Error detection of CC-Link Safety

Errors concerning CC-Link Safety can be detected by safety station refresh communication status which is described in Table4.3.
Create a proper sequence program using the information for error detection (SD) which turns safety outputs OFF.

(a) Safety station refresh communication status

Names and numbers of the special registers for confirming the safety station refresh communication status are shown in Table4.3.

Table4.3 Register names and compatible numbers

<table>
<tr><th rowspan="2">Name</th><th rowspan="2">No.</th><th>Definition for bits of special register (safety station refresh communication status)</th></tr>
<tr><th>Definition of each bit indicated as station No. in the table
0: Normal, reserved station select, not connected, or standard remote station
1: Safety station communication error</th></tr>
<tr><td>Safety station refresh communication status (1st safety master module)</td><td>SD1004 to SD1007</td><td>
<table>
<tr><th></th><th>b15</th><th>b14</th><th>–</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 station refresh communication status (2nd safety master module)</td><td>SD1204 to SD1207</td><td>
<table>
<tr><th></th><th>b15</th><th>b14</th><th>–</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 manual.
☞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 Figure4.6.
Figure4.6 shows the program used when outputting from the safety remote I/O station of station No.1 connected to the first module of the safety master module using SD1004.0.

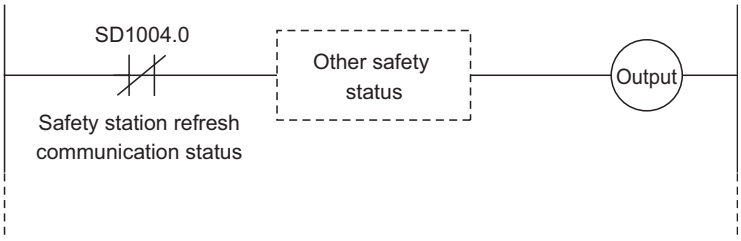


Figure4.6 Program for handling error detection of CC-Link Safety

(4) Reset of CC-Link Safety error

When an CC-Link Safety error is detected, the safety station interlock status shown in Table4.4 turns on.

To resume communications of the CC-Link Safety, turn on the safety station interlock clear request.

Create the program which requests the safety station interlock clear by manual operation using a reset button.

Table4.4 Register names and compatible 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
(1st safety master module)</td><td>SD1072 to
SD1075</td><td>0: Does not interlocked.
1: During interlock (head station number only)
<table><tr><td></td><td>b15</td><td>b14</td><td>–</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 clear request
(1st safety master module)</td><td>SD1076 to
SD1079</td><td>0: Does not clear I/O interlock in safety station.
1: Clears I/O interlock in safety station.
(head station number only)
<table><tr><td></td><td>b15</td><td>b14</td><td>–</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
(2nd safety master module)</td><td>SD1272 to
SD1275</td><td>0: Does not interlocked.
1: During interlock (head station number only)
<table><tr><td></td><td>b15</td><td>b14</td><td>–</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 clear request
(2nd safety master module)</td><td>SD1276 to
SD1279</td><td>0: Does not clear I/O interlock in safety station.
1: Clears I/O interlock in safety station.
(head station number only)
<table><tr><td></td><td>b15</td><td>b14</td><td>–</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 manual.

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

(a) Program example

Figure4.7 shows the program when the interlock for the safety remote I/O station of station 1, connected to the first safety master module is cleared.

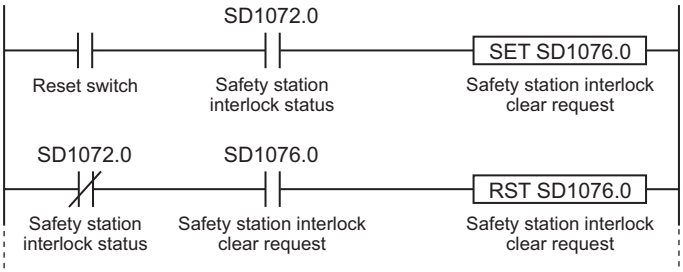


Figure4.7 Program example when interlock for the CC-Link Safety is cleared

(5) 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 the program will be modified, fill in the modified date, modified person, and modified description at the modified place using the statement function of GX Developer for change history management.

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

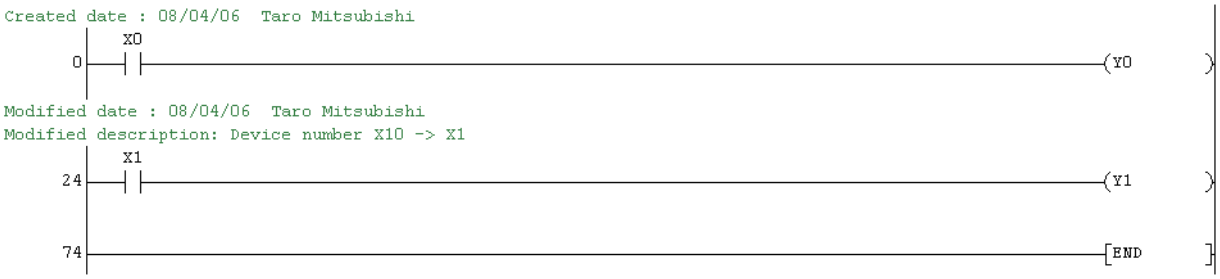


Figure4.8 Version management of GX Developer project file

(6) 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 manual.

☞GX Developer Version 8 Operating Manual (Safety PLC)

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 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 station, refer to the following manual.
☞ 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 PLC.
For the parameter settings by using GX Developer, refer to the following manual.
☞ GX Developer Version 8 Operating Manual (Safety PLC)
For parameter definition and setting range for parameter settings of GX Developer, refer to the following manual.
☞ CC-Link Safety System Master 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.2.

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 month for meeting Category 4.
As well as diagnostics of the safety PLC, perform a test from the emergency stop request to machine stop as safety functions.

(2) Module/unit replacement

For the safety PLC, execute the module/unit replacement according to the replacement cycle in Table4.5.

Table4.5 Module/unit replacement period

Module/unit	Module/unit replacement cycle
Safety power supply module	5 years
Safety CPU module	10 years
Safety master module	10 years
Safety remote I/O module	5 years
Safety main base unit	10 years

(3) Operation mode while a safety PLC is in operation

Set the operation mode of the safety PLC to SAFETY MODE when the PLC is in operation.

(4) ROM information management of a safety CPU

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 confirming the ROM information, refer to the following manual.

☞ GX Developer Version 8 Operating Manual (Safety PLC)

(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.

CHAPTER5 SAFETY APPLICATION CONFIGURATION EXAMPLE

This chapter describes the configuration example of the safety application using the safety PLC.

5.1 System Configuration

This section describes the safety application using the system configuration of Figure5.1 as an example.

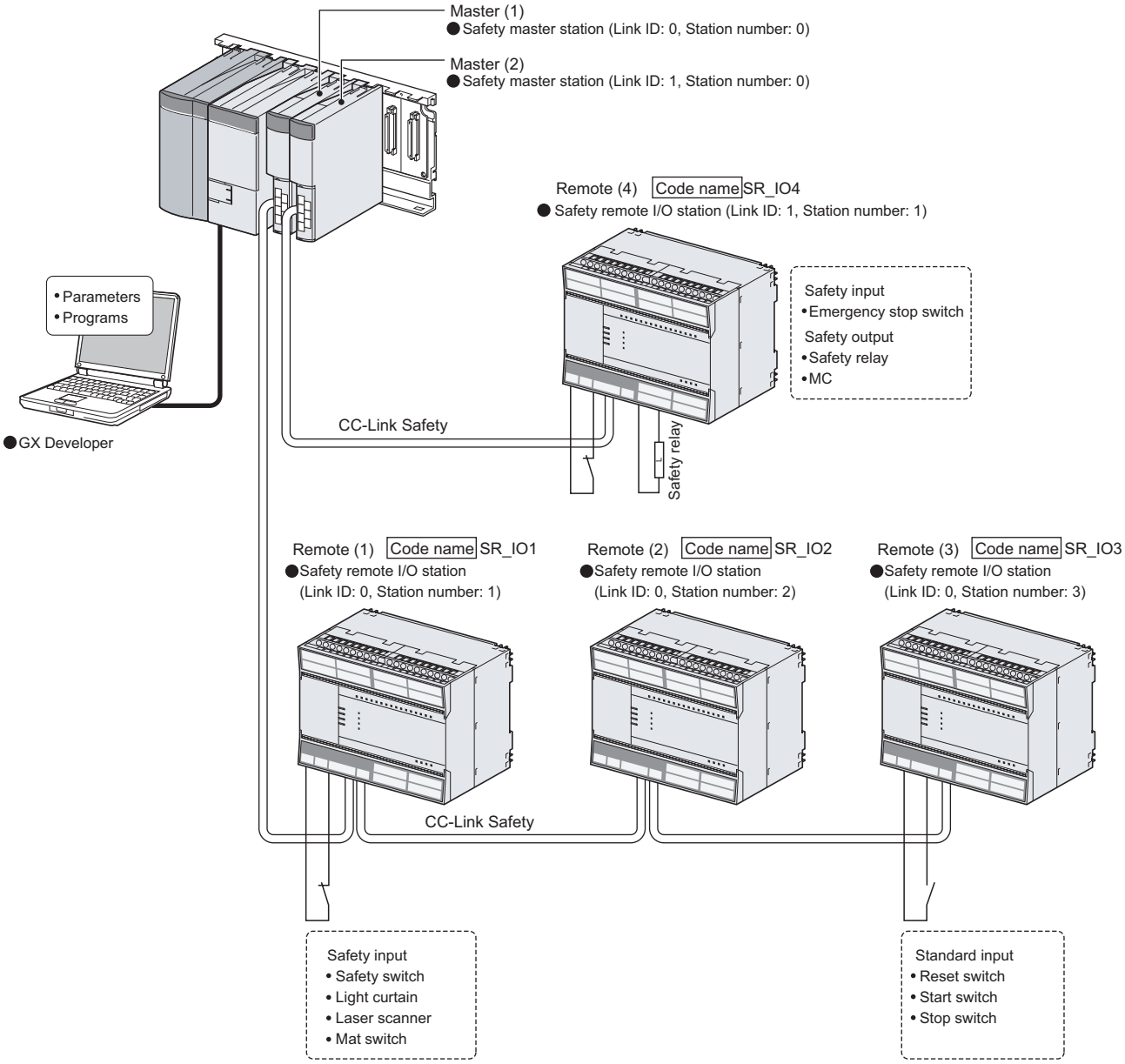


Figure5.1 System configuration

5.2 Network-Related Switch Settings of Module

Set the switch settings of each main module as follows

5.2.1 Safety Power supply module

No switch on the safety power supply module

5.2.2 Safety CPU module

No network-related switch on the safety CPU module

5.2.3 Safety master module

No switch on the safety master module

5.2.4 Safety remote I/O module

Set the link ID, station No. setting switch, and transmission speed setting switch.

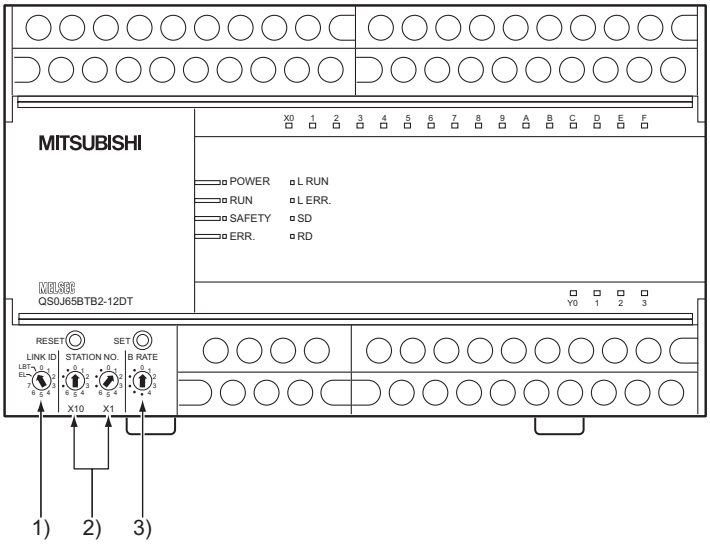


Figure5.2 Switch position of safety remote I/O module

Table5.1 Switch settings of safety remote I/O module

Switch numbers in the Figure	Remote I/O module number	Remote (1) SR_I01	Remote (2) SR_I02	Remote (3) SR_I03	Remote (4) SR_I02
1)	Link ID	0	0	0	1
2)	Station number setting switch	1	2	3	1
3)	Transmission speed setting switch	2 (2.5Mbps)	2 (2.5Mbps)	2 (2.5Mbps)	2 (2.5Mbps)

POINT

For the procedure to enable the switch settings of the safety remote I/O module, refer to the following manual.

☞ CC-Link Safety System Remote I/O Module User's Manual QS0J65BT2-12DT

5.3 CC-Link Parameter Settings

Set the CC-Link parameters as follows.
For the definition or setting range of each parameter, refer to the following manual.

☞ CC-Link Safety System Master Module User's Manual QS0J61BT12

Table5.2 CC-Link parameter setting example

Module		Master (1)	Master (2)
Start I/O No.		00H	20H
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		300ms	300ms
Link ID		0	1
All connect count		3	1
Remote input (RX)		X100	X200
Remote input (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
Station information setting	Station information setting	☞ Section 5.3.1	
	Safety remote station settings	☞ Section 5.3.2	
Remote device station initial setting		None	None

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

POINT

Make the same settings between the link ID and transmission speed in the CC-Link parameter of GX Developer and those of the switches on remote I/O main module to be connected.

5.3.1 CC-Link station information settings

Set the CC-Link station information settings as follows.

Table5.3 Setting example of master (1) station information /

Module	Station No.	Station type	Exclusive station count	Reserve station count
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
	3/3	Safety remote I/O station	Exclusive station 1	No setting

Table5.4 Setting example of master (2) station information

Module	Station No.	Station type	Exclusive station count	Reserve station count
Master (2)	1/1	Safety remote I/O station	Exclusive station 1	No setting

5.3.2 Safety remote station parameter settings

Set the safety remote station parameter settings as follows.

Table5.5 Safety remote station parameter settings

Module	(1)	(2)	(3)	(4)
	SR_IO1	SR_IO2	SR_IO3	SR_IO4
Model name	QS0J65BTB2-12DT	QS0J65BTB2-12DT	QS0J65BTB2-12DT	QS0J65BTB2-12DT
Module technical version*1	A	A	A	A
Specify production information to find module	Yes (check)	No (no check)	No (no check)	Yes (check)
Production information*2	1100000000000010	–	–	1100000000000020
Parameter	Indicated in each case example of Section 5.6 or later.			

*1: For Module technical version, check the rated plate on the module side in the corresponding safety remote station.

☞ CC-Link Safety System Remote I/O Module User's Manual QS0J65BTB2-12DT

*2: Enter Production information field referring to the rated plate on the module side in the corresponding safety remote station.

☞ CC-Link Safety System Remote I/O Module User's Manual QS0J65BTB2-12DT

The use of production information is needed to maintain a proper function after module exchange or to detect any incorrect station number settings such as station number duplication. Use the production information to use safety PLC properly and safely.

5.4 Relationship between the Safety CPU Module Devices and Remote I/O

The following shows the relationship between the safety CPU module devices and the remote I/O stations in the settings of Table5.2.
The shaded device numbers are used to create sequence programs.

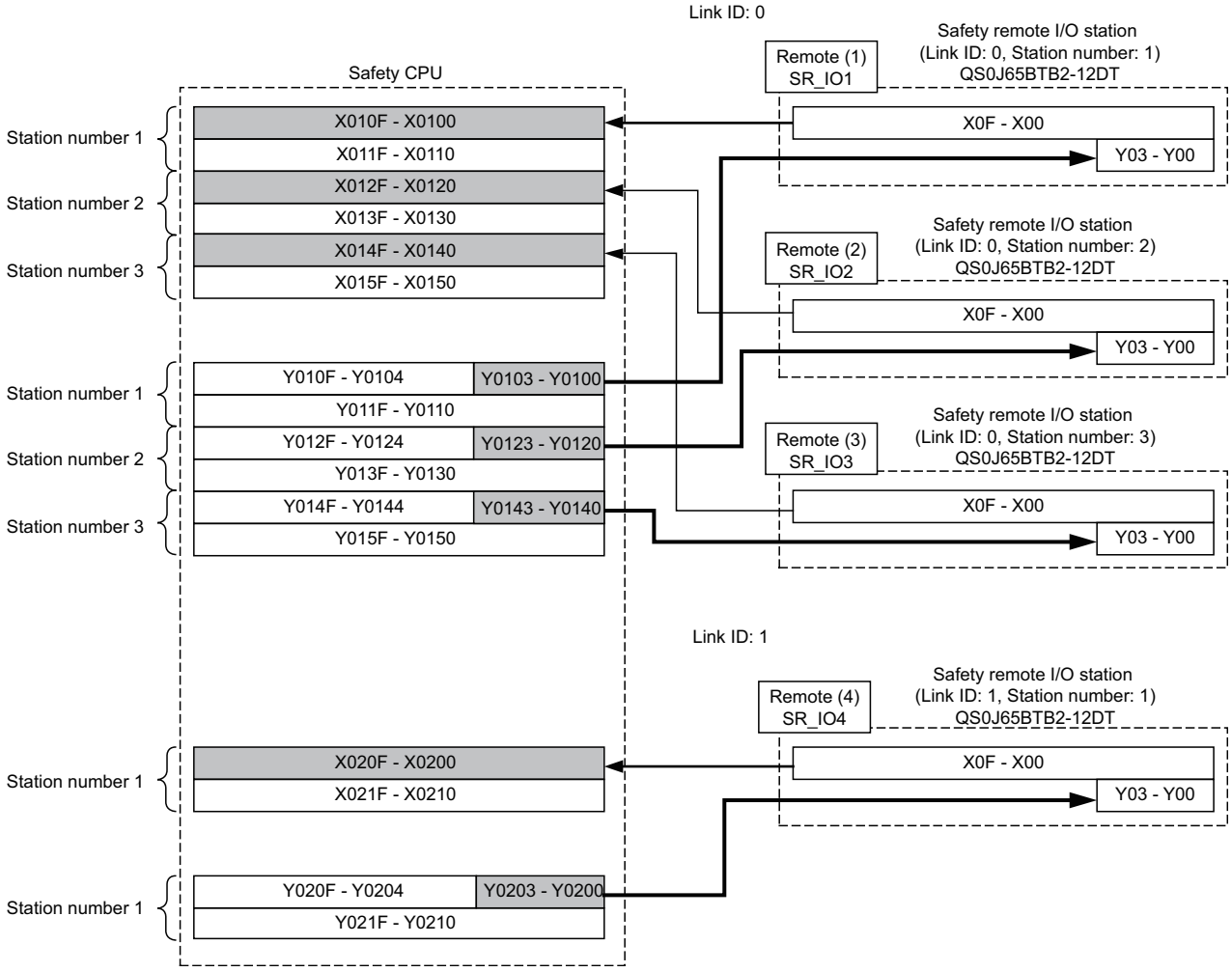


Figure5.3 Relationship between safety CPU devices and remote I/O

5.5 Wiring Diagram and Parameter Setting of Standard Input

Wire the reset switch, start switch, and stop switch as follows.

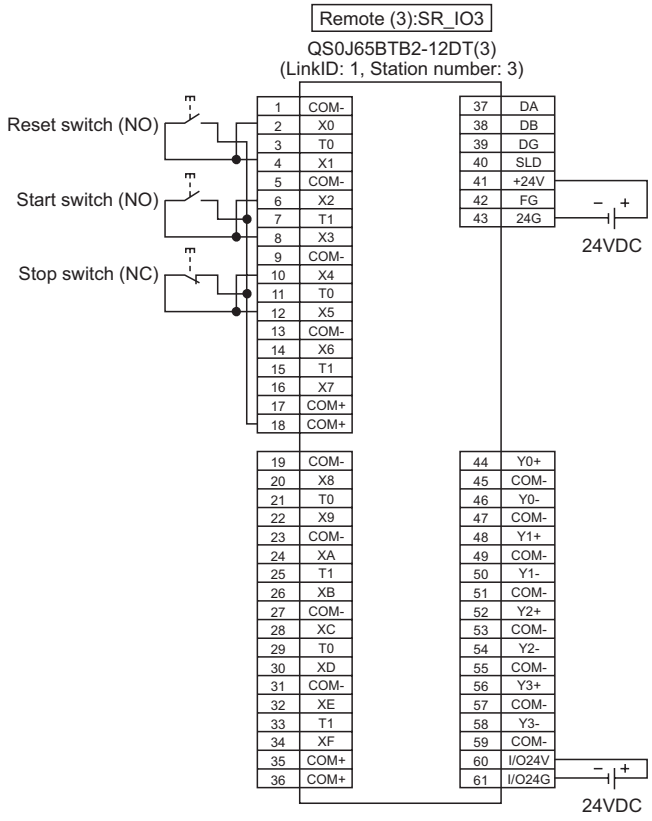


Figure5.4 Remote (3) SR_IO3 standard input wiring

For the reset switch, start switch, and stop switch, set the parameters as follows.

Table5.6 Remote (3) SR_IO3 parameter settings

Item	Setting
Time of noise removal filter X0, 1*1	[0: 1ms], 1: 5ms, 2: 10ms, 3: 20ms, 4: 50ms
Time of noise removal filter X2, 3*1	[0: 1ms], 1: 5ms, 2: 10ms, 3: 20ms, 4: 50ms
Time of noise removal filter X4, 5*1	[0: 1ms], 1: 5ms, 2: 10ms, 3: 20ms, 4: 50ms
Doubling input discrepancy detection time X0, 1*1	100ms (setting range: 20 to 500ms)
Doubling input discrepancy detection time X2, 3*1	100ms (setting range: 20 to 500ms)
Doubling input discrepancy detection time X4, 5*1	100ms (setting range: 20 to 500ms)
Input dark test selection X0, 1	0: Execute, [1: Not execute]
Input dark test selection X2, 3	0: Execute, [1: Not execute]
Input dark test selection X4, 5	0: Execute, [1: Not execute]
Input dark test pulse OFF time	[0: 400μs], 1: 1ms, 2: 2ms

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

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.

The emergency stop switch and safety relays are connected to the safety PLC.
The safety PLC controls the ON/OFF status of the safety relays with a sequence program.
When the safety PLC detects an error using the self-diagnostics, the outputs to the safety relays are turned off independent of the sequence program.
When the outputs are turned off with the self-diagnostics, the OFF status is maintained regardless of the sequence program until the safety CPU module or safety remote I/O module is reset.

The following functions are realized with the sequence program.

1) After safety is ensured (Emergency stop signal is on), pushing the reset switch, then the start switch turning the safety relays on.
2) When the safety relays are welding, input the close contacts of the safety relays to the safety PLC for avoiding the start, and check for welding.
3) The reset switch and start switch are set to start only when changed from ON to OFF for avoiding an accidental start of the switches at 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 after the operation is started.

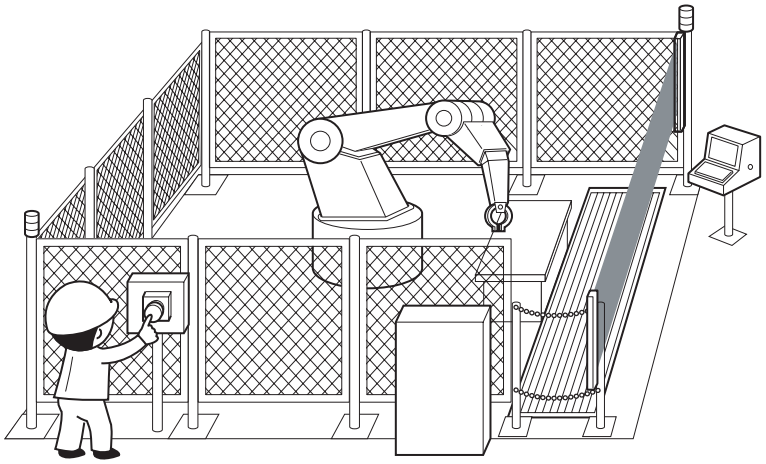


Figure5.5 Emergency stop switch

(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

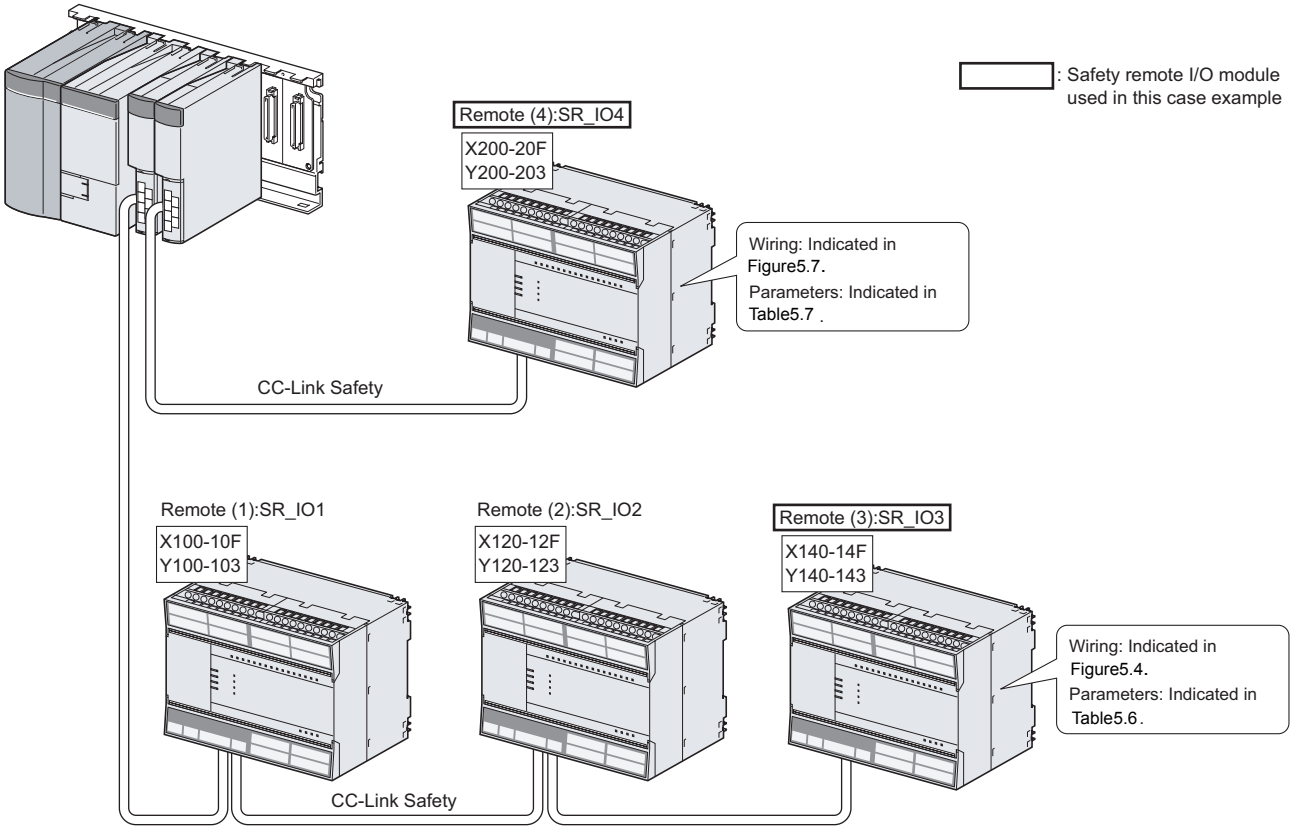


Figure5.6 Safety device connection diagram

(3) Wiring diagram and parameter settings

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

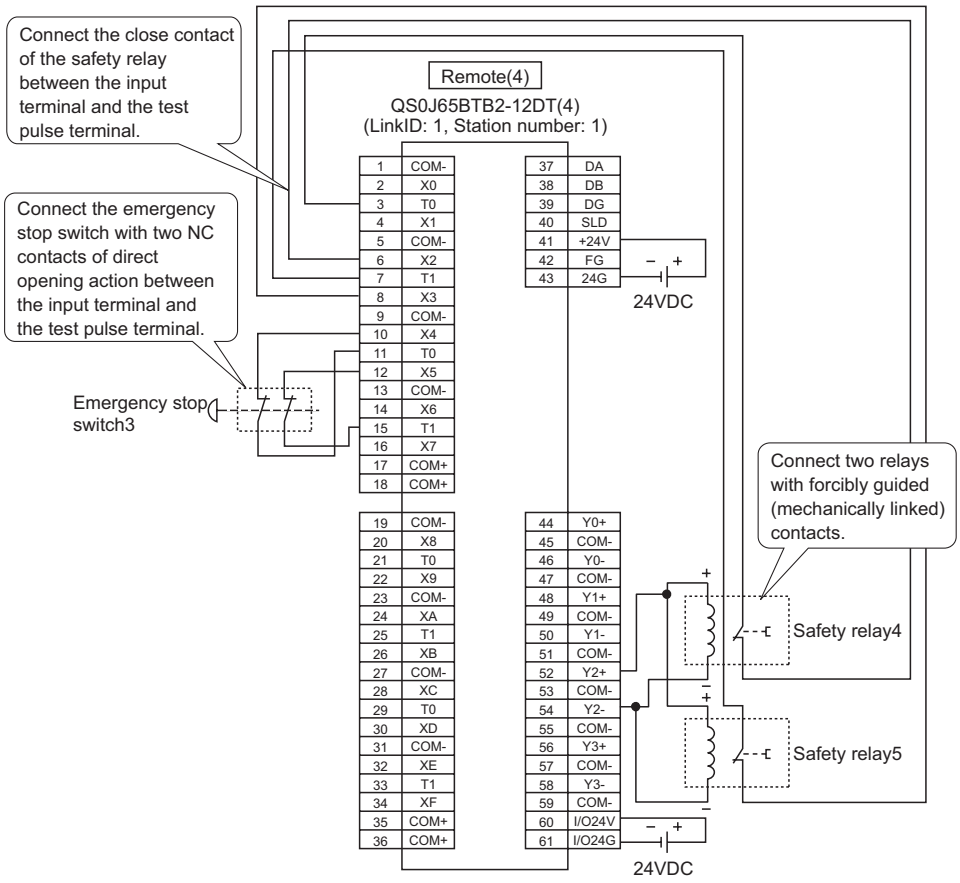


Figure5.7 Remote (4) SR_IO4 wiring

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

Table5.7 Remote (4) SR_IO4 parameter settings

Item	Setting
Time of noise removal filter X2, 3*1	[0: 1ms], 1: 5ms, 2: 10ms, 3: 20ms, 4: 50ms
Time of noise removal filter X4, 5*1	[0: 1ms], 1: 5ms, 2: 10ms, 3: 20ms, 4: 50ms
Doubling input discrepancy detection time X2, 3*1	100ms (setting range: 20 to 500ms)
Doubling input discrepancy detection time X4, 5*1	100ms (setting range: 20 to 500ms)
Input dark test selection X2, 3	[0: Execute], 1: Not execute
Input dark test selection X4, 5	[0: Execute], 1: Not execute
Input dark test pulse OFF time	[0: 400μs], 1: 1ms, 2: 2ms
Method of wiring of output Y2	0: No Use, [1: Doubling wiring (Source + Sink)], 2: Doubling wiring (Source+Source)
Output dark test selection Y2	[0: Execute], 1: Not execute
Output dark test pulse OFF time Y2*1	0: 400μs, [1: 1ms], 2: 2ms

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

(4) Device numbers to be used

Use the following device numbers for creating sequence programs.

Table5.8 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

Make the following processing on sequence programs.

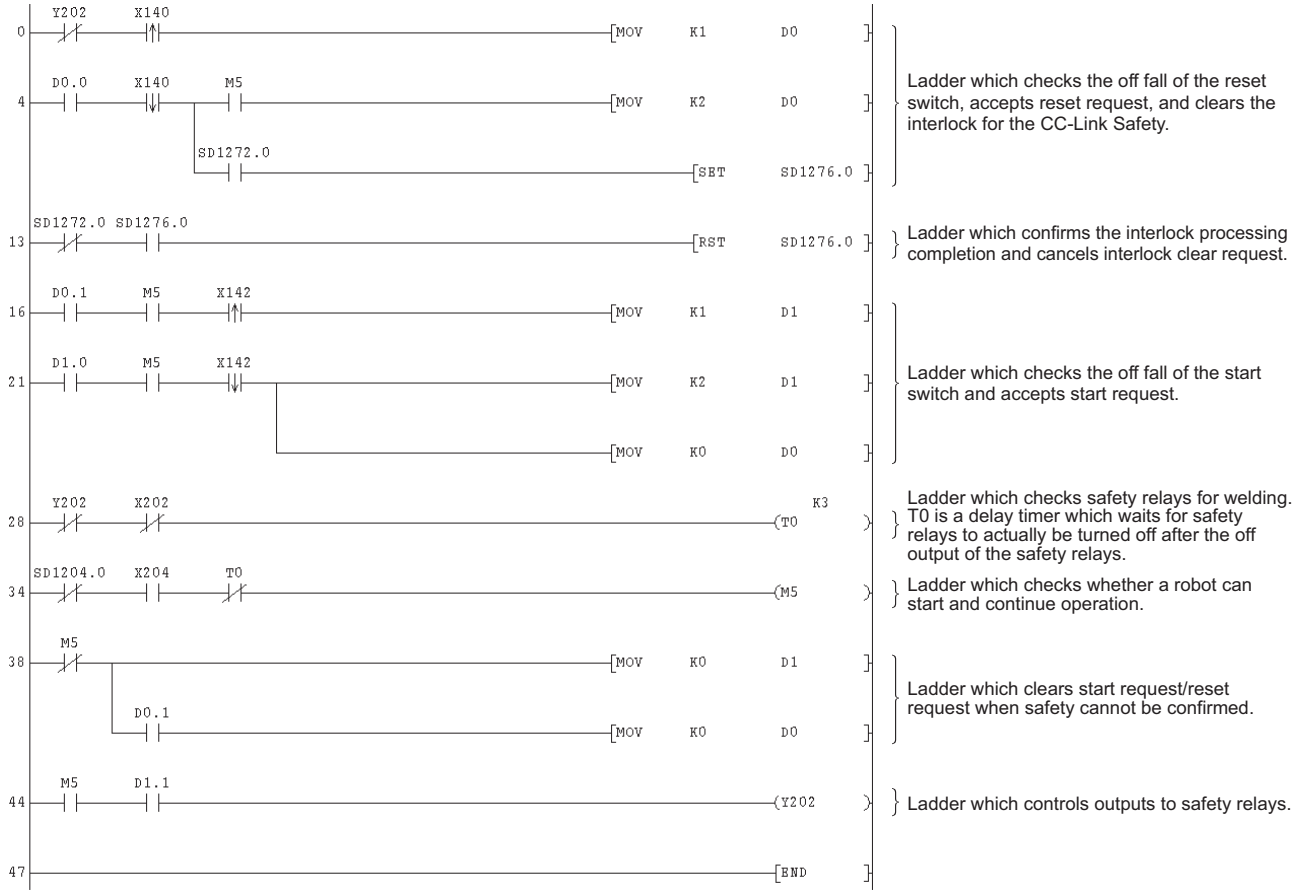


Figure5.8 Sequence program

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

(a) Way of using the constant

K□: indicates decimal number.

Example) K1→ indicates 1 of decimal number.

(b) Way of using the internal devices

Table5.9 Way of using the internal devices

Internal	Details
T0	Designates a timer device. Times out after a lapse of the time specified at K □.
D0	Designates a word device. In the program, this is used as restart status. (1) D0 = 0 designates that the system is in initial status or start processing is completed. (2) D0 = 1 (D0.0: ON) designates that the reset switch is pressed. (3) D0 = 2 (D0.1: ON) designates that the reset switch is released in (2) status and restart processing is completed.
D1	Designates a word device. In the program, this is used as start status. (1) D1 = 0 designates that the system is in initial status or safety is not confirmed. (2) D1 = 1 (D1.0: ON) designates that the start switch is pressed. (3) D1= 2 (D1.1: ON) designates that the start switch is released in (2) status and start processing is completed.

(c) Way of using word device bit specification

D□□.□ : designates the □ th bit data of word device D □□.

Example) D0.0 → indicates 0 bits in D0.

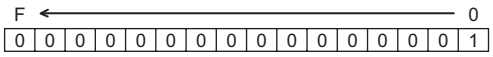


Figure5.9 Word device bit specification

(6) Timing chart

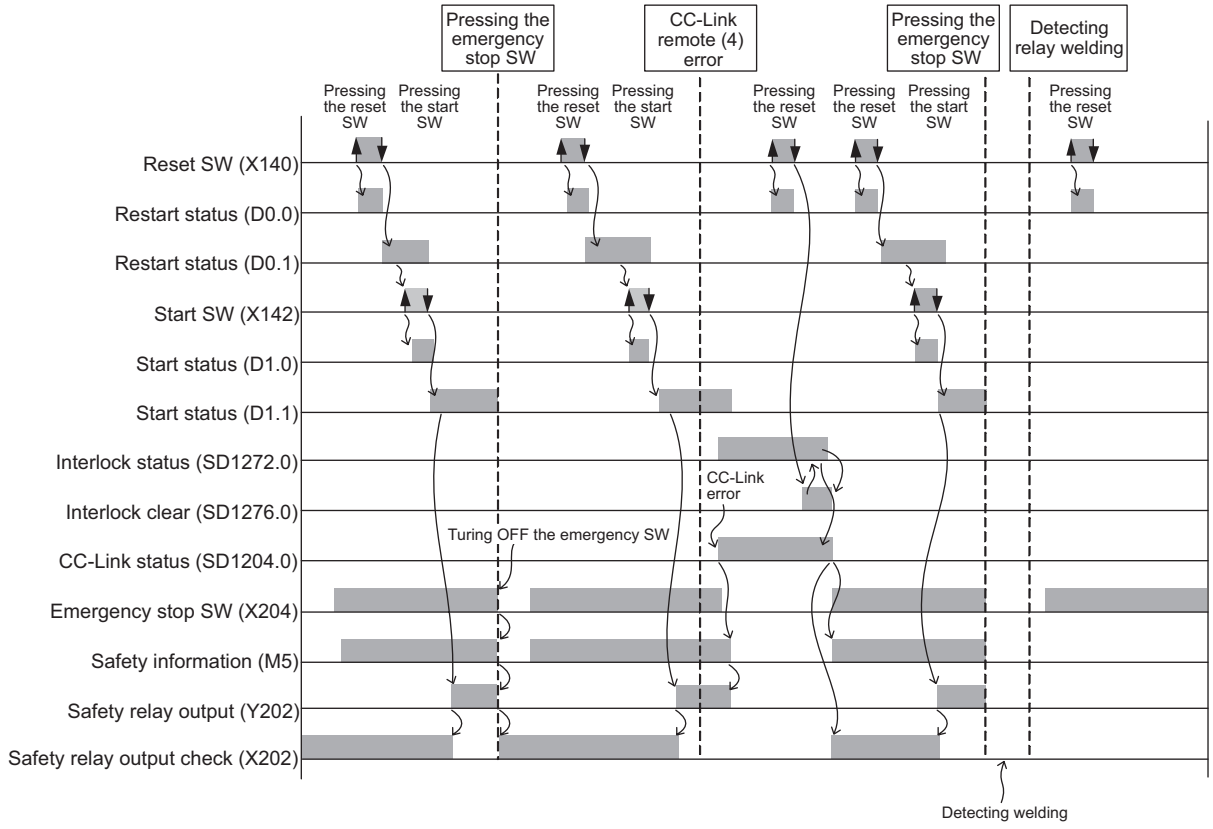


Figure5.10 Timing chart

5.6.2 Door lock circuit

(1) Application overview

The door lock circuit is the application that keeps the door closed until the power source of a robot stops with the spring lock type safety switch attached to the door of the safety barrier.
The safety switch is normally locked by spring power. When voltage is applied to the solenoid, the lock is released and the door can be opened. Specifically, the lock is released with the status signal, indicating such as the stop status of a robot.
The robot cannot be started during unlocking or opening the door.

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.

The safety switches and the safety relays are connected to the safety PLC.
The safety PLC controls the ON/OFF status of the safety relays with a sequence program.
When the safety PLC detects an error using the self-diagnostics, the outputs to the safety relays are turned off independent of the sequence program.
When the outputs are turned off with the self-diagnostics, the OFF status is maintained regardless of the sequence program until the safety CPU module or safety remote I/O module is reset.

The following functions are realized with the sequence program.

1) When the safety switch is on, pushing the reset switch, then the start switch turning the safety relays on.
2) When the safety relays are welding, input the close contacts of the safety relays to the safety PLC for avoiding the start, and check for welding.
3) The reset switch and start switch are set to start only when changed from ON to OFF for avoiding an accidental start of the switches at welding or short-circuit.
4) The safety relay outputs are turned off when the stop switch is pressed.
5) The safety relay outputs are turned off when an error is detected in the safety remote I/O station after the operation is started.

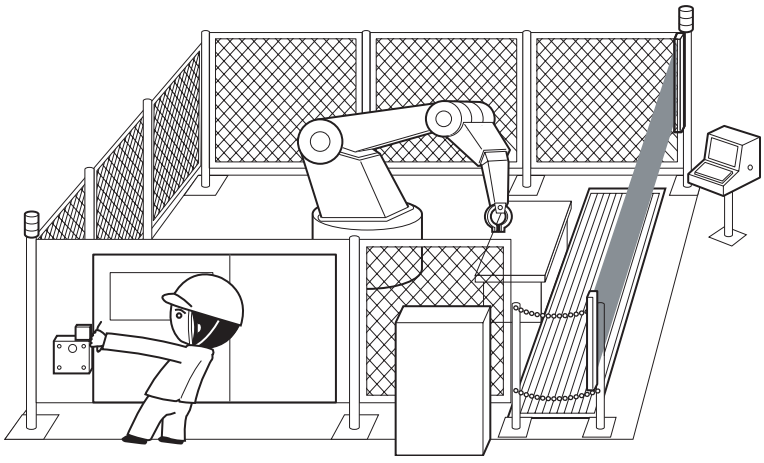


Figure5.11 Door lock circuit

(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

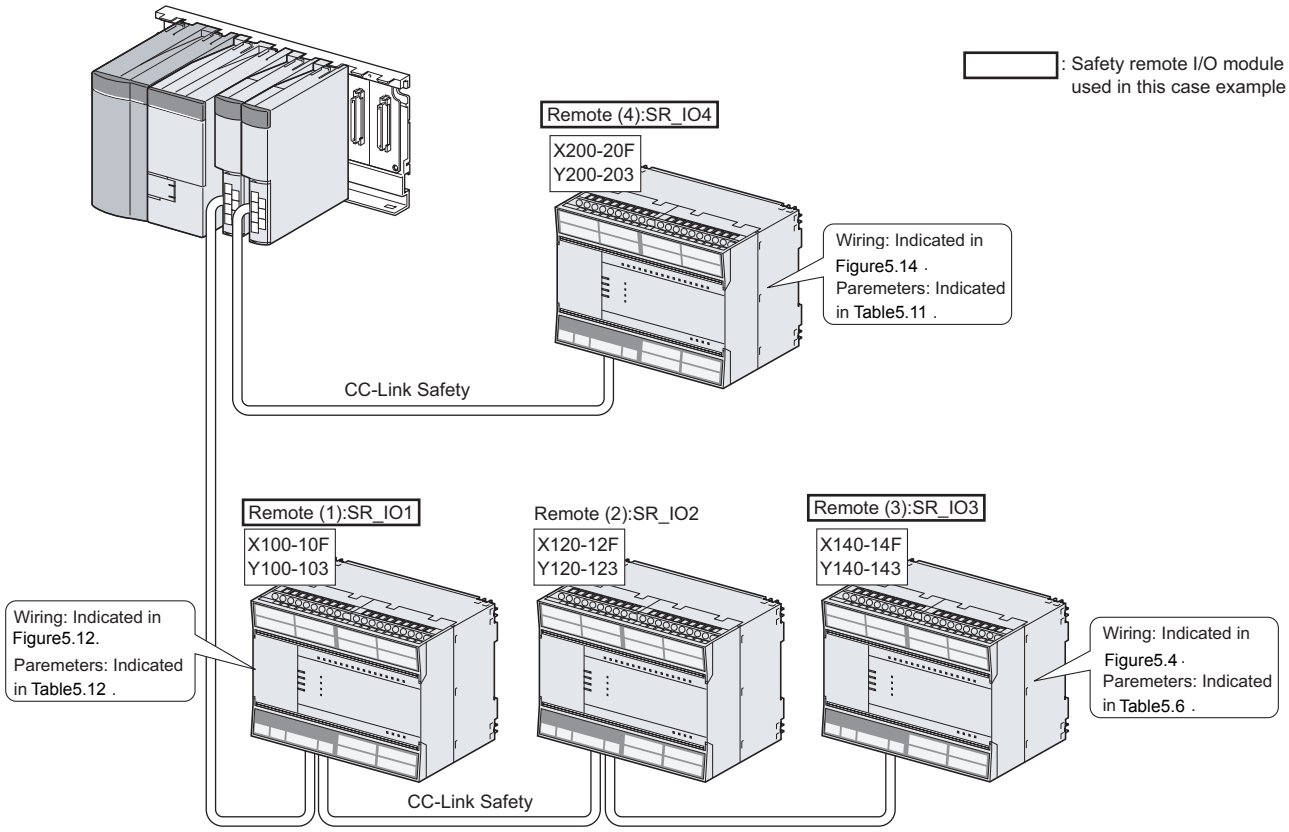


Figure5.12 Safety device connection diagram

(3) Wiring diagram and parameter settings

(a) Remote (1): SR_IO1

Wire the spring lock type safety switch to the safety remote I/O module as follows.

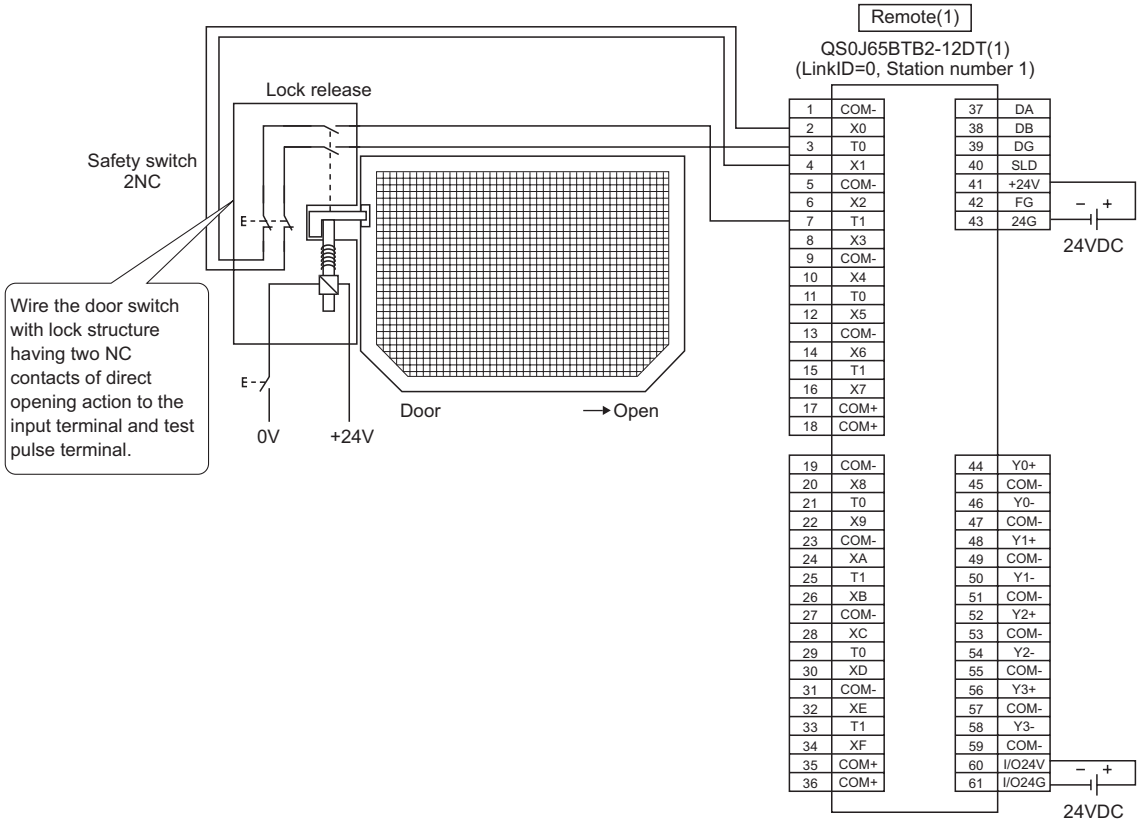


Figure5.13 Remote (1) SR_IO1 wiring

For the spring lock type safety switch, set the parameters as follows.

Table5.10 Remote (1) SR_IO1 parameter settings

Item	Setting range
Time of noise removal filter X0, 1*1	0: 1ms, 1: 5ms, 2: 10ms, 3: 20ms, 4: 50ms
Doubling input discrepancy detection time X0, 1*1	100ms (setting range: 20 to 500ms)
Input dark test selection X0, 1	0: Execute, 1: Not execute
Input dark test pulse OFF time*1	0: 400μs, 1: 1ms, 2: 2ms

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

(b) Remote (4): SR_IO4

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

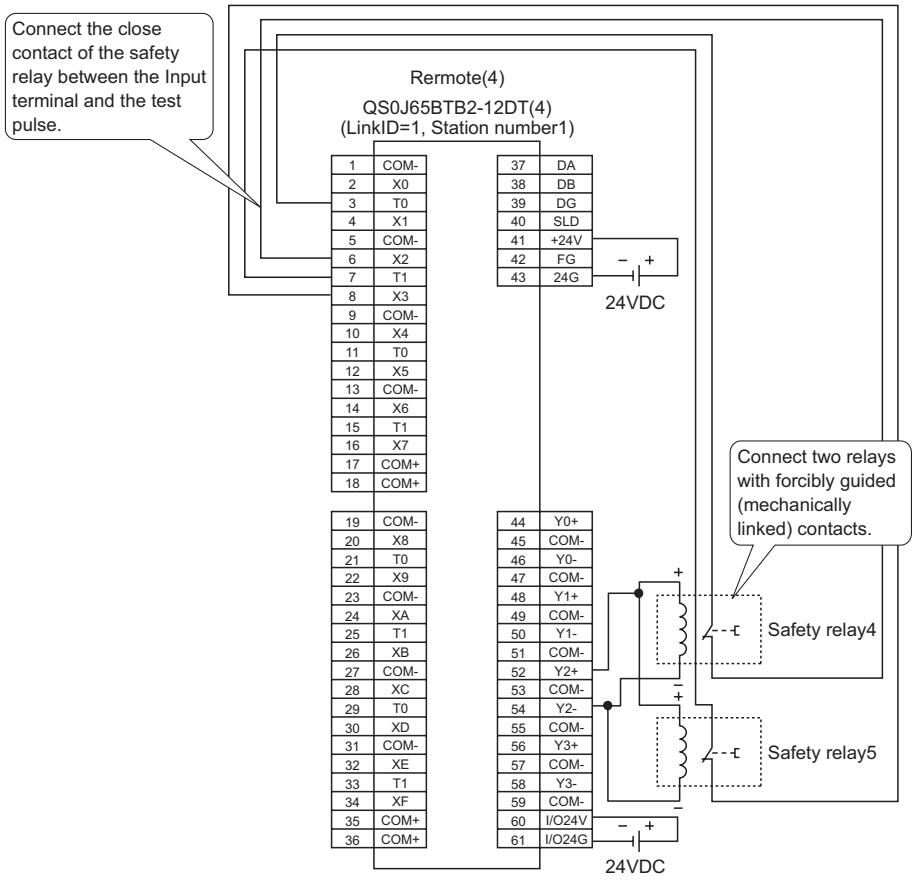


Figure5.14 Remote (4) SR_IO4 wiring

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

Table5.11 Remote (4) SR_IO4 parameter settings

Item	Setting range
Time of noise removal filter X2, 3*1	[0: 1ms], 1: 5ms, 2: 10ms, 3: 20ms, 4: 50ms
Doubling input discrepancy detection time X2, 3*1	100ms (setting range: 20 to 500ms)
Input dark test selection X2, 3	[0: Execute], 1: Not execute
Input dark test pulse OFF time*1	[0: 400μs], 1: 1ms, 2: 2ms
Method of wiring of output Y2	0: No Use, [1: Doubling wiring (Source + Sink)], 2: Doubling wiring (Source+Source)
Output dark test selection Y2	[0: Execute], 1: Not execute
Output dark test pulse OFF time Y2*1	0: 400μs, [1: 1ms], 2: 2ms

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

(4) Device numbers to be used

Use the following device numbers for creating sequence programs.

Table5.12 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

Make the following processing on sequence programs.

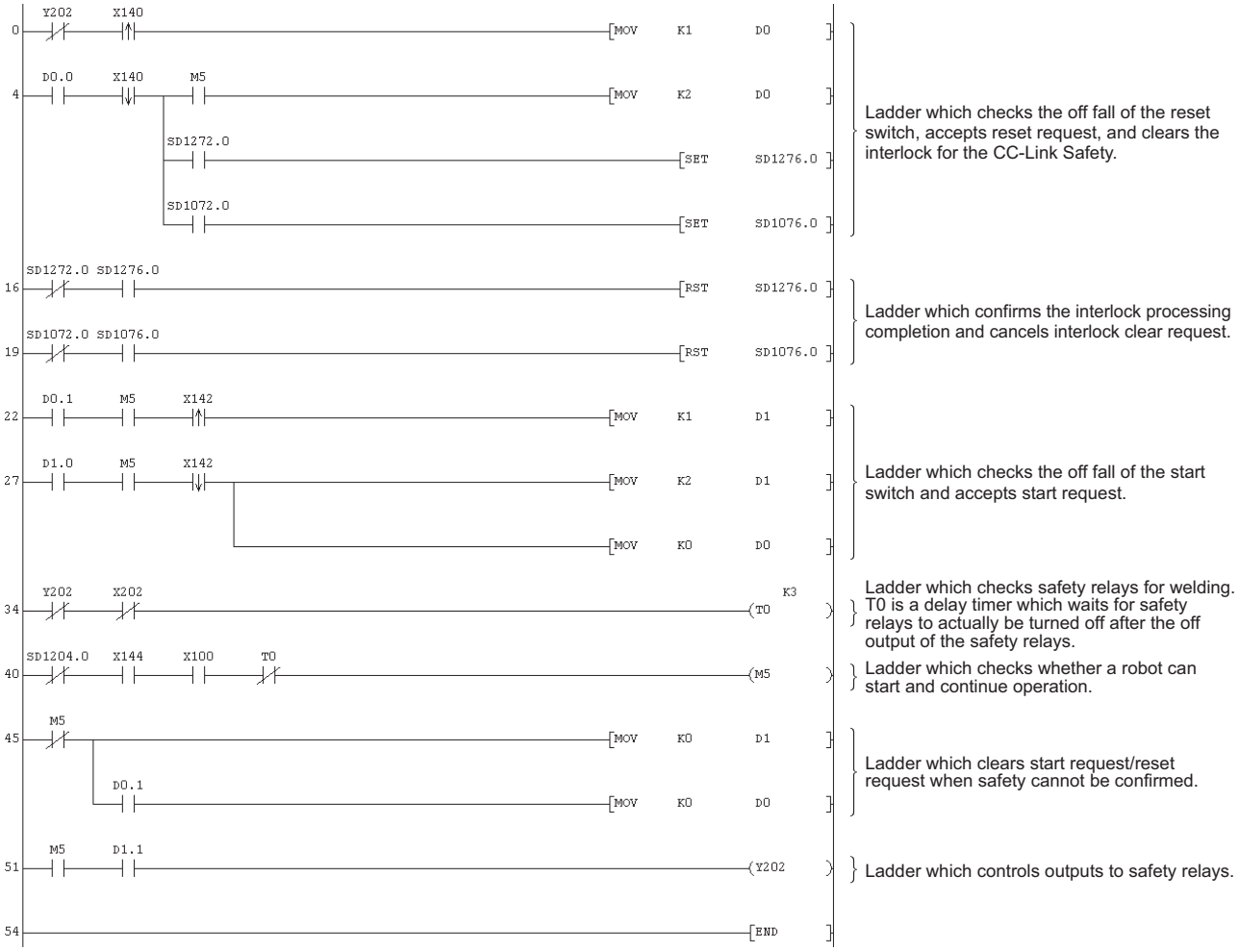


Figure5.15 Sequence program

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

(a) Way of using the constant

K□: indicates decimal number.

Example) K1→ indicates 1 of decimal number.

(b) Way of using the internal devices

Table5.13 Way of using the internal devices

Internal	Details
T0	Designates a timer device. Times out after a lapse of the time specified at K☐.
D0	Designates a word device. In the program, this is used as restart status. (1) D0 = 0 designates that the system is in initial status or start processing is completed. (2) D0 = 1 (D0.0: ON) designates that the reset switch is pressed. (3) D0 = 2 (D0.1: ON) designates that the reset switch is released in (2) status and restart processing is completed.
D1	Designates a word device. In the program, this is used as start status. (1) D1 = 0 designates that the system is in initial status or safety is not confirmed. (2) D1 = 1 (D1.0: ON) designates that the start switch is pressed. (3) D1 = 2 (D1.1: ON) designates that the start switch is released in (2) status and start processing is completed.

(c) Way of using word device bit specification

D☐☐.⬚: designates the ⬚ th bit data of word device D☐☐.

Example) D0.0 →indicates 0 bits in D0.

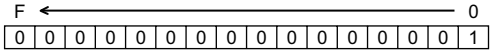


Figure5.16 Word device bit specification

(6) Timing chart

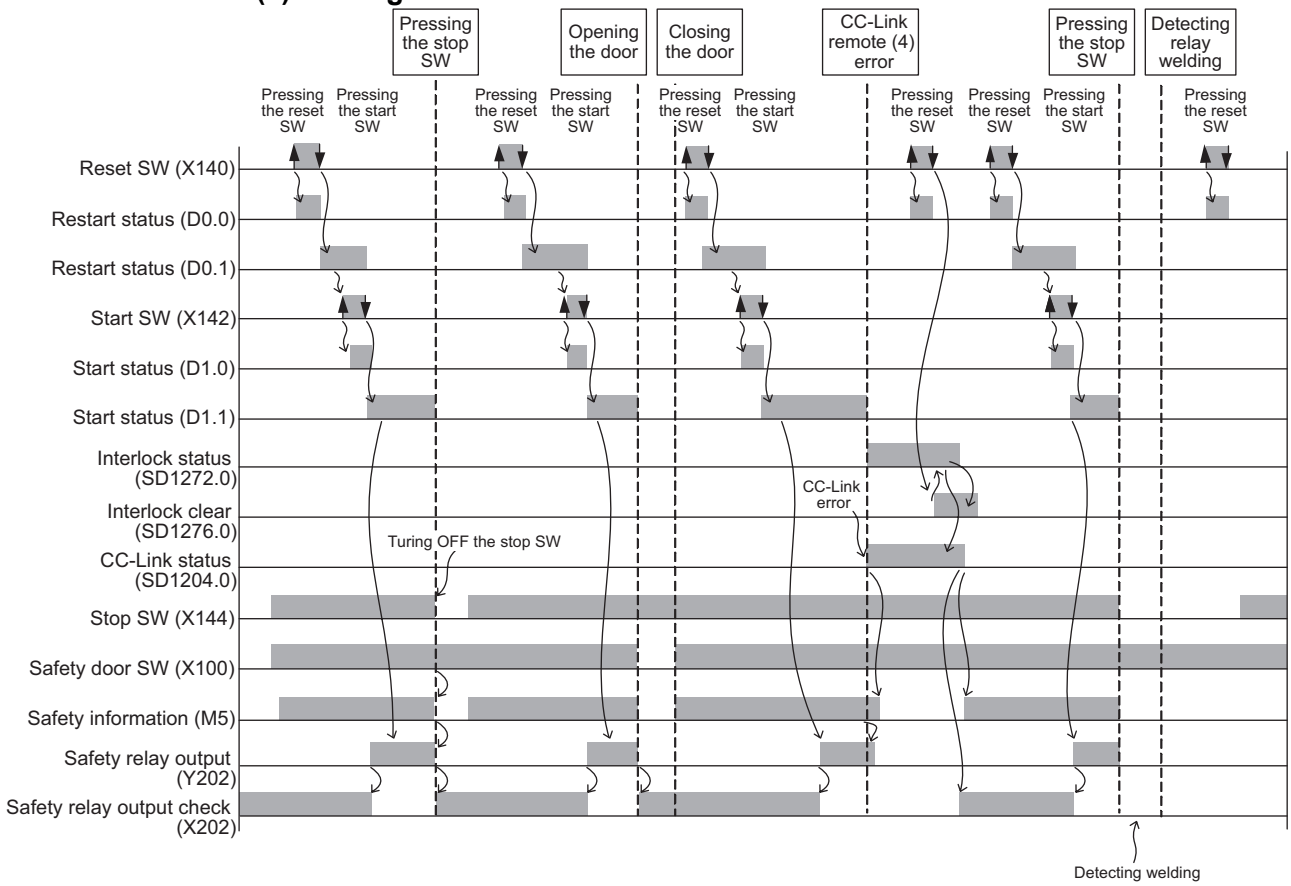


Figure5.17 Timing chart

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.

The light curtain, laser scanner, and contactors are connected to the safety PLC.
The safety PLC controls ON/OFF status of the contactors with a sequence program.
When the safety PLC detects an error using the self-diagnostics, the outputs to the contactors are turned off independent of the sequence program.
When the outputs are turned off with the self-diagnostics, the OFF status is maintained regardless of the sequence program until the safety CPU module or safety remote I/O module is reset.

The following functions are realized with the sequence program.

1) After safety is ensured (The light curtain and laser scanner signals are both on), pushing the reset button, then the start button turning the contactor on.
2) When the contactors are welding, input the close contacts of the safety relays to the safety PLC for avoiding the start, and check for welding.
3) The reset switch and start switch are set to start only when changed from ON to OFF for avoiding an accidental start of the switches at 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 after the operation is started.

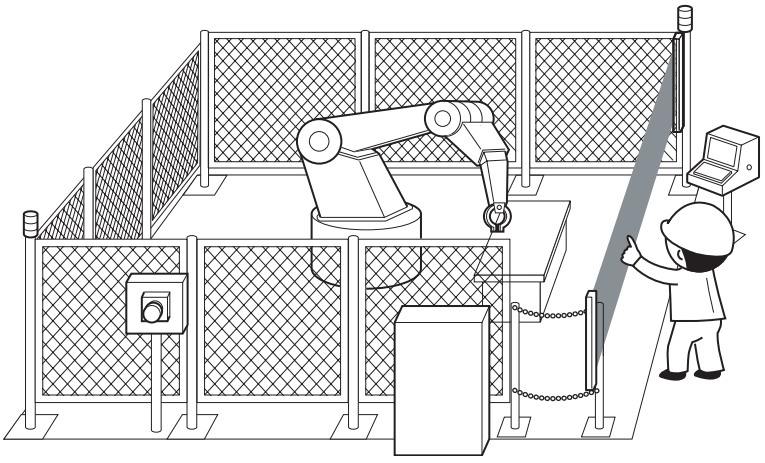


Figure5.18 Entering detection and existence detection circuit
(Partially quoted from "Safety Guide Book - the safety measures of machinery in the workplace"
: Nippon Electric Control Equipment Industries Association.)

(2) Connection of safety devices

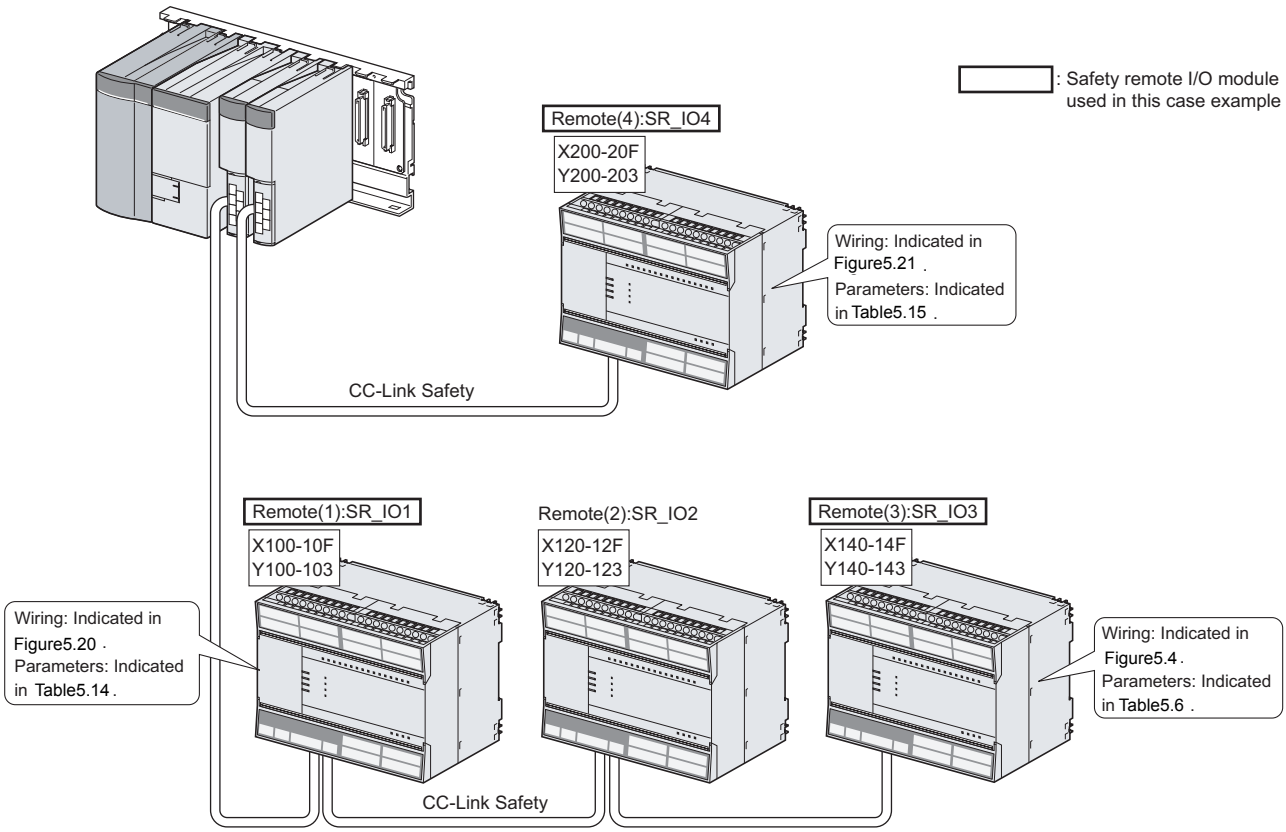


Figure5.19 Safety device connection diagram

(3) Wiring diagram and parameter settings

Wire the light curtain and the laser scanner to the safety remote I/O module as follows.

(a) Remote (1): SR_IO1

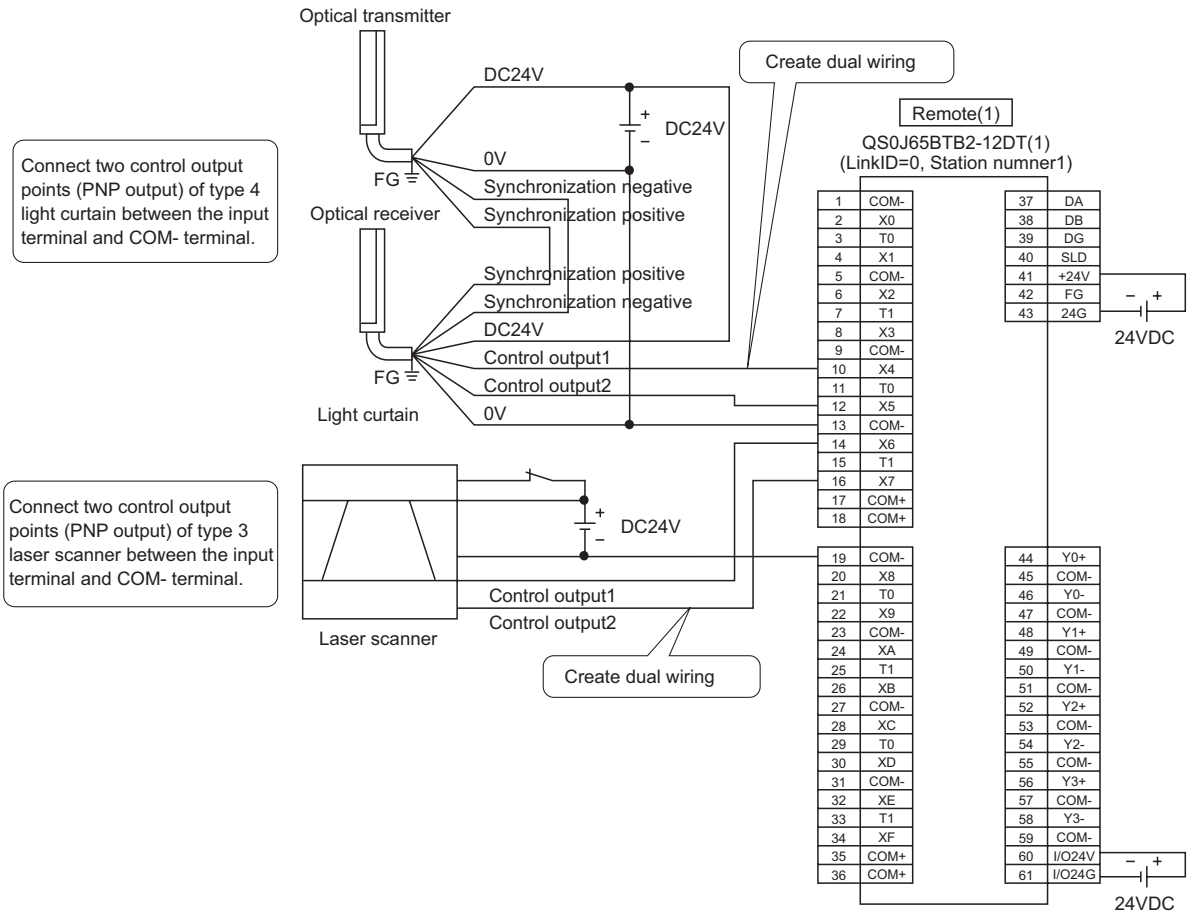


Figure5.20 Remote (1) SR_IO1 wiring

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

Table5.14 Remote (1) SR_IO1 parameter settings

Item	Setting range
Time of noise removal filter X4, 5*1	[0: 1ms], 1: 5ms, 2: 10ms, 3: 20ms, 4: 50ms
Time of noise removal filter X6, 7*1	[0: 1ms], 1: 5ms, 2: 10ms, 3: 20ms, 4: 50ms
Doubling input discrepancy detection time X4, 5*1	20ms (setting range: 20 to 500ms)
Doubling input discrepancy detection time X6, 7*1	20ms (setting range: 20 to 500ms)
Input dark test selection X4, 5	0: Execute, [1: Not execute]
Input dark test selection X6, 7	0: Execute, [1: Not execute]
Input dark test pulse OFF time*1	[0: 400μs], 1: 1ms, 2: 2ms

*1: Adjust Time of noise removal filter according to the installation environment and wiring length. Set Doubling input discrepancy detection time to 100ms for the mechanical switch and 20ms for the sensor input as a guideline.

(b) Remote (4): SR_IO4

Wire the contactors to the safety remote I/O module as follows.

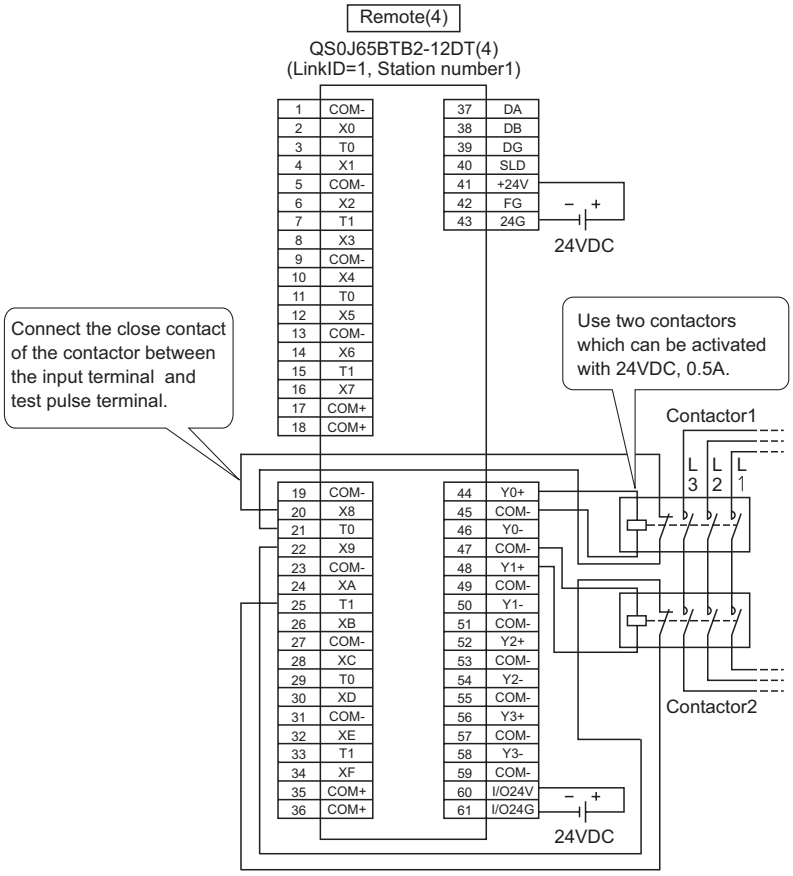


Figure5.21 Remote (4) SR_IO4 wiring

For the contactors, set the parameters as follows.

Table5.15 Remote (4) SR_IO4 parameter settings

Item	Setting range
Time of noise removal filter X8, 9*1	[0: 1ms], 1: 5ms, 2: 10ms, 3: 20ms, 4: 50ms
Doubling input discrepancy detection time X8, 9*1	100ms (setting range: 20 to 500ms)
Input dark test selection X8, 9	[0: Execute], 1: Not execute
Input dark test pulse OFF time*1	[0: 400μs], 1: 1ms, 2: 2ms
Method of wiring of output Y0	0: No Use,1: Doubling wiring (Source+Sink), [2: Doubling wiring (Source + Source)]
Method of wiring of output Y1	0: No Use,1: Doubling wiring (Source+Sink), [2: Doubling wiring (Source + Source)]
Output dark test selection Y0	[0: Execute], 1: Not execute
Output dark test selection Y1	[0: Execute], 1: Not execute
Output dark test pulse OFF time Y0*1	0: 400μs, [1: 1ms], 2: 2ms
Output dark test pulse OFF time Y1*1	0: 400μs, [1: 1ms], 2: 2ms

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

(4) Device numbers to be used

Use the following device numbers for creating sequence programs.

Table5.16 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

Make the following processing on sequence programs.

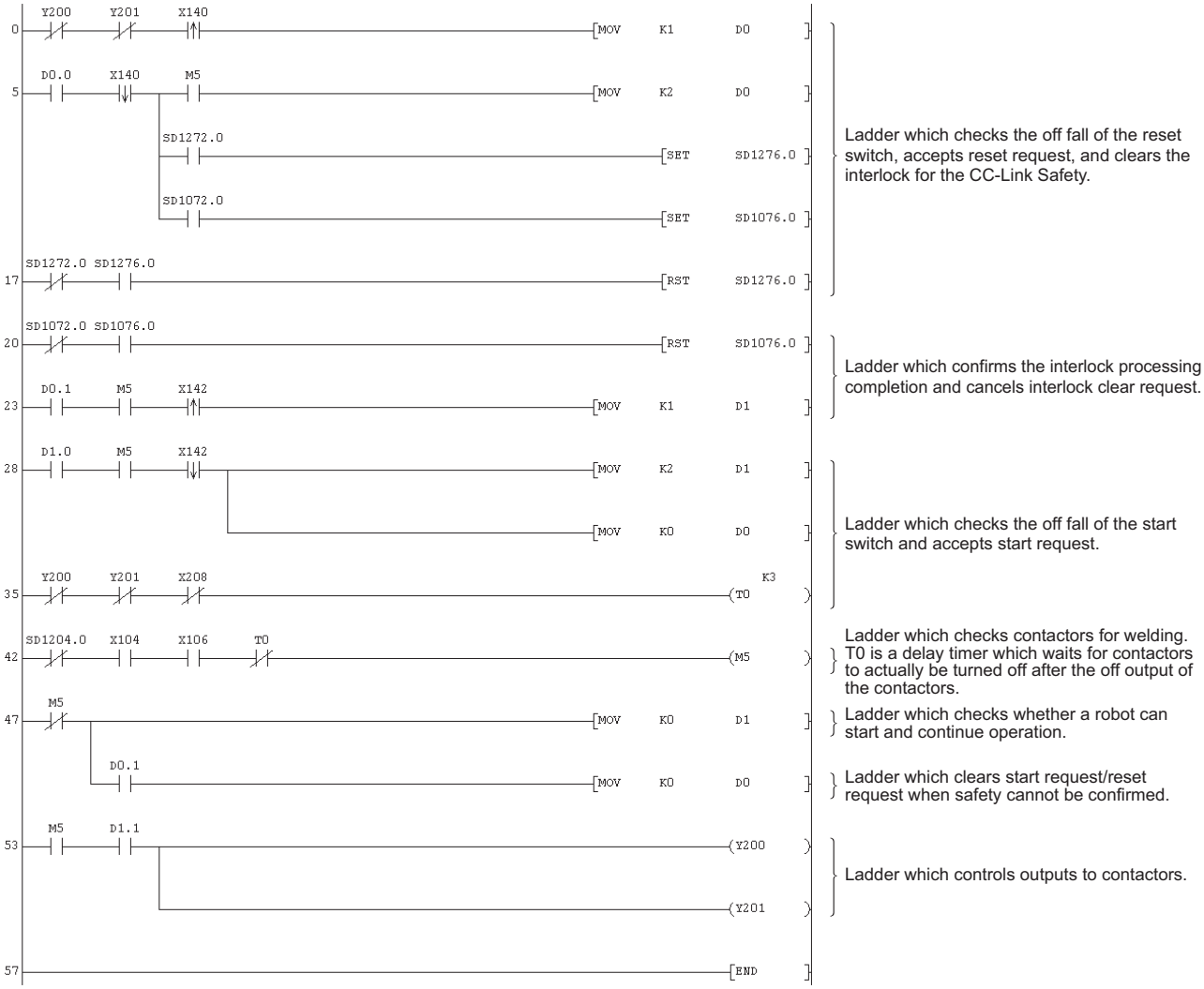


Figure5.22 Sequence program

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

(a) Way of using the constant

K☐: indicates decimal number.

Example) K1→indicates 1 of decimal number.

(b) Way of using the internal devices

Table5.17 Way of using the internal devices

Internal	Details
T0	Designates a timer device. Times out after a lapse of the time specified at K☐.
D0	Designates a word device. In the program, this is used as restart status. (1) D0 = 0 designates that the system is in initial status or start processing is completed. (2) D0 = 1 (D0.0: ON) designates that the reset switch is pressed. (3) D0 = 2 (D0.1: ON) designates that the reset switch is released in (2) status and restart processing is completed.
D1	Designates a word device. In the program, this is used as start status. (1) D1 = 0 designates that the system is in initial status or safety is not confirmed. (2) D1 = 1 (D1.0: ON) designates that the start switch is pressed. (3) D1 = 2 (D1.1: ON) designates that the start switch is released in (2) status and start processing is completed.

(c) Way of using word device bit specification

D☐☐.⬚: designates the ⬚th bit data of word device D☐☐.

Example) D0.0→indicates 0 bits in D0.

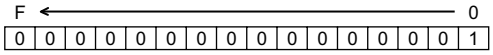


Figure5.23 Word device bit specification

(6) Timing chart

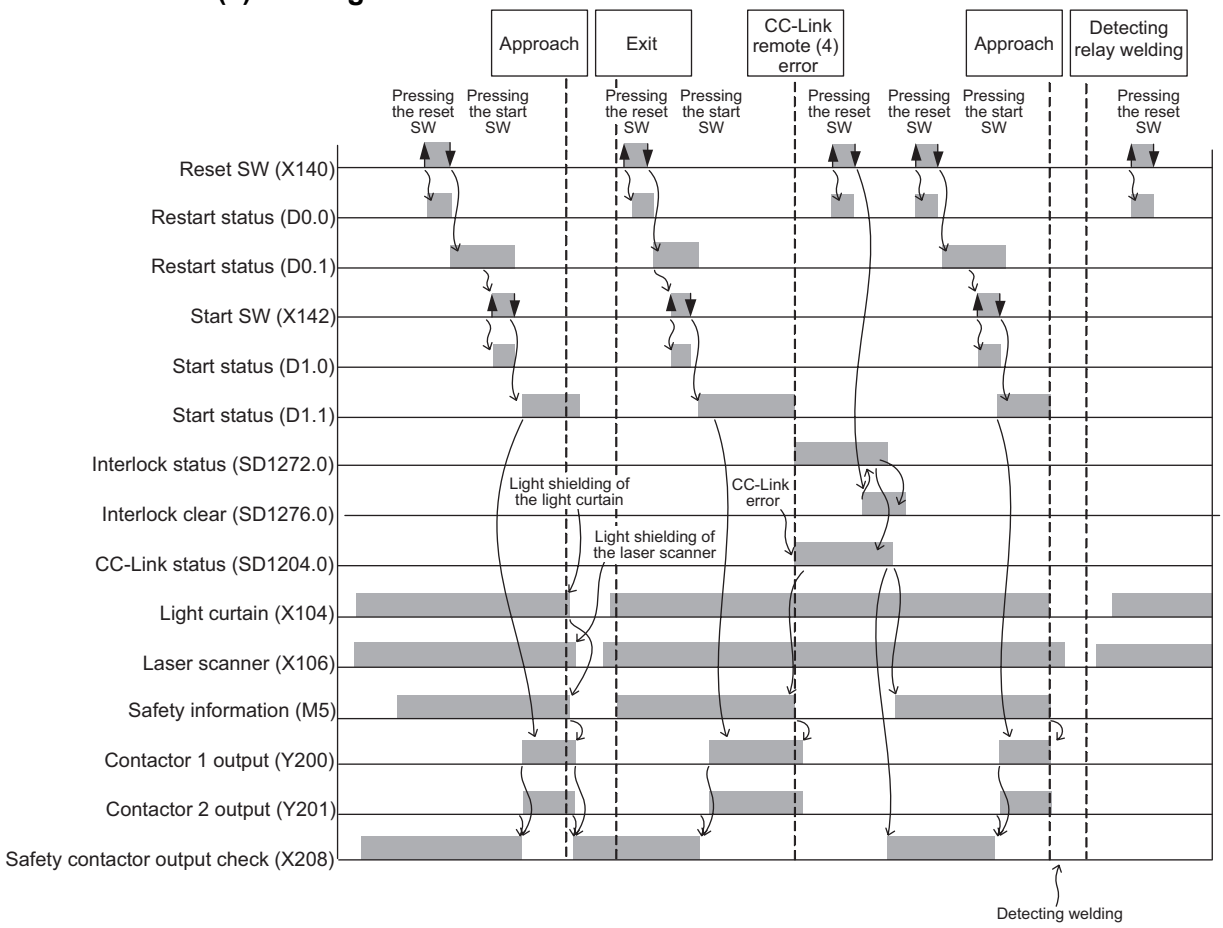


Figure5.24 Timing chart

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.

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.
The safety PLC controls ON/OFF status of the contactors with a sequence program.

The light curtain and the contactors are connected to the safety PLC.
The relay is connected between the mat switch and safety PLC.
The safety PLC controls ON/OFF status of the contactors with a sequence program.
When the safety PLC detects an error using the self-diagnostics, the outputs to the contactors are turned off independent of the sequence program.
When the outputs are turned off with the self-diagnostics, the OFF status is maintained regardless of the sequence program until the safety CPU module or safety remote I/O module is reset.

The following functions are realized with the sequence program.

1) After safety is ensured (The light curtain and mat switch signals are both on), pushing the reset button, then the start button turning the contactor on.
2) When the contactors are welding, input the close contacts of the safety relays to the safety PLC for avoiding the start, and check for welding.
3) The reset switch and start switch are set to start only when changed from ON to OFF for avoiding an accidental start of the switches at 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 after the start.

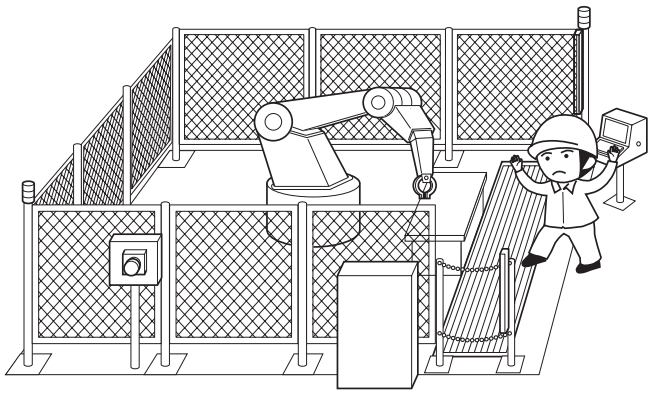


Figure5.25 Entering detection and existence detection
(Partially quoted from "Safety Guide Book - the safety measures of machinery in the workplace"
: Nippon Electric Control Equipment Industries Association.)

(2) Connection of safety devices

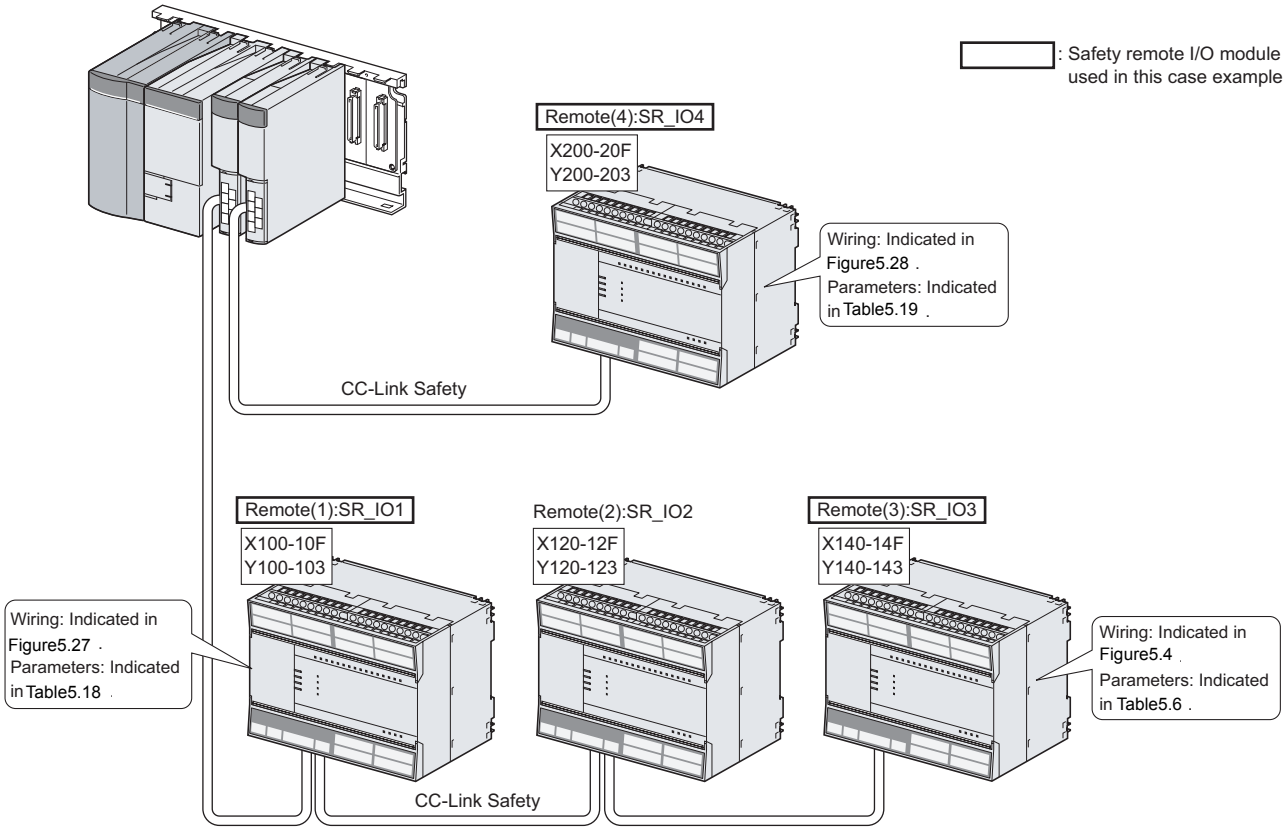
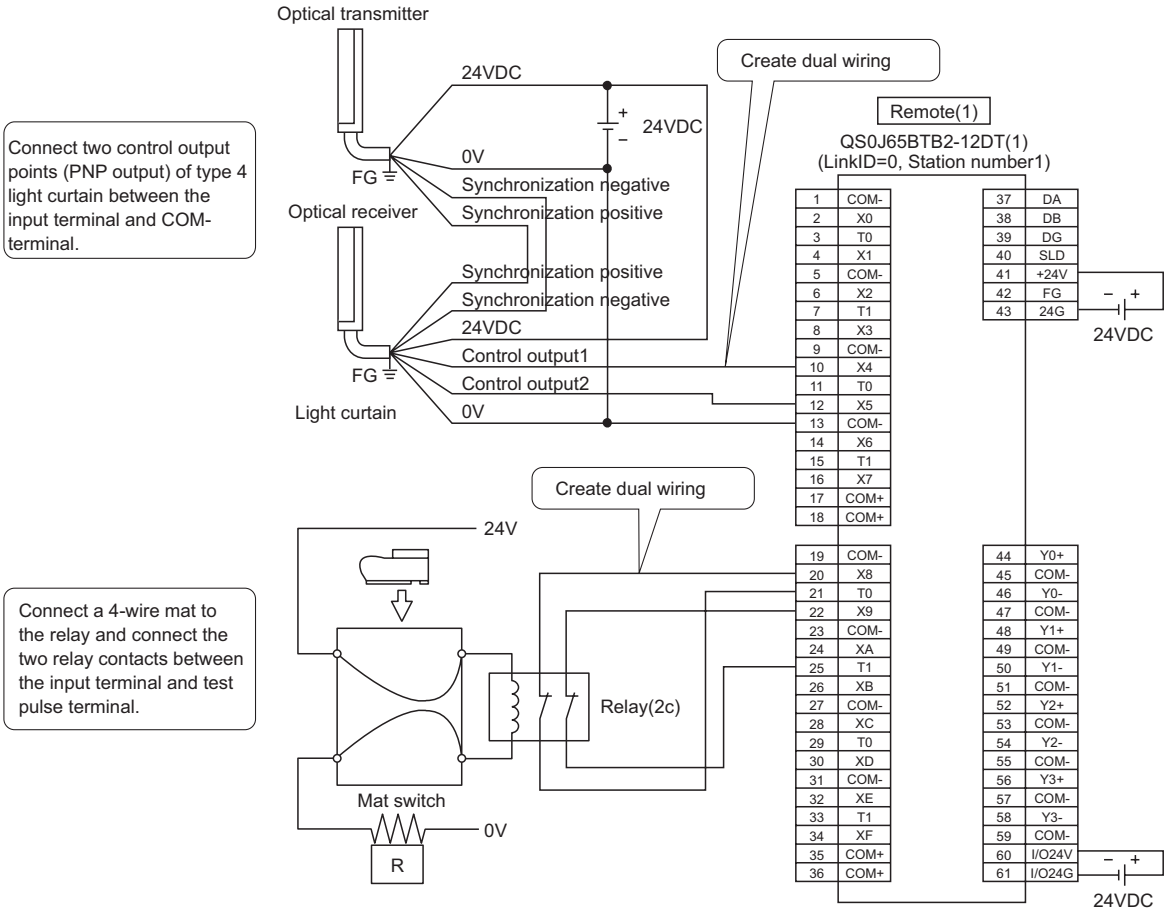


Figure5.26 Safety device connection diagram

(3) Wiring diagram and parameter settings

(a) Remote (1): SR_IO1

Wire the light curtain and the mat switch to the 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

Figure5.27 Remote (1) SR_IO1 wiring

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

Table5.18 Remote (1) SR_IO1 parameter settings

Item	Setting range
Time of noise removal filter X4, 5*1	[0: 1ms], 1: 5ms, 2: 10ms, 3: 20ms, 4: 50ms
Time of noise removal filter X8, 9*1	[0: 1ms], 1: 5ms, 2: 10ms, 3: 20ms, 4: 50ms
Doubling input discrepancy detection time X4, 5*1	20ms (setting range: 20 to 500ms)
Doubling input discrepancy detection time X8, 9*1	20ms (setting range: 20 to 500ms)
Input dark test selection X4, 5	0: Execute, [1: Not execute]
Input dark test selection X8, 9	[0: Execute], 1: Not execute
Input dark test pulse OFF time*1	[0: 400μs], 1: 1ms, 2: 2ms

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

(b) Remote (4): SR_IO4

Wire the contactors to the safety remote I/O module as follows.

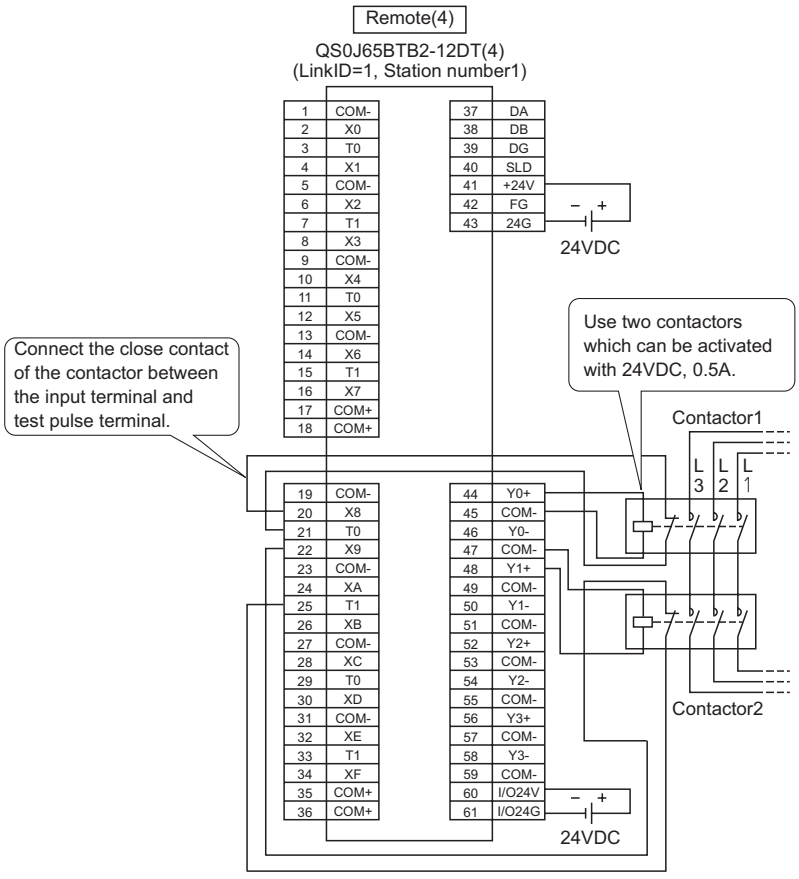


Figure5.28 Remote (4) SR_IO4 wiring

For the contactors, set the parameters as follows.

Table5.19 Remote (4) SR_IO4 parameter settings

Item	Setting range
Time of noise removal filter X8, 9*1	[0: 1ms], 1: 5ms, 2: 10ms, 3: 20ms, 4: 50ms
Doubling input discrepancy detection time X8, 9*1	100ms (setting range: 20 to 500ms)
Input dark test selection X8, 9	[0: Execute], 1: Not execute
Input dark test pulse OFF time*1	[0: 400μs], 1: 1ms, 2: 2ms
Method of wiring of output Y0	0: No Use,1: Doubling wiring (Source+Sink), [2: Doubling wiring (Source + Source)]
Method of wiring of output Y1	0: No Use,1: Doubling wiring (Source+Sink), [2: Doubling wiring (Source + Source)]
Output dark test selection Y0	[0: Execute], 1: Not execute
Output dark test selection Y1	[0: Execute], 1: Not execute
Output dark test pulse OFF time Y0*1	0: 400μs, [1: 1ms], 2:2ms
Output dark test pulse OFF time Y1*1	0: 400μs, [1: 1ms], 2: 2ms

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

(4) Device numbers to be used

Use the following device numbers for creating sequence programs.

Table5.20 Device numbers to be used

Safety/Standard	External device	Device number
Safety	Light curtain	X104 or X105
Safety	Mat switch	X108 or X109
Safety	Contactor 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

Make the following processing on sequence programs.

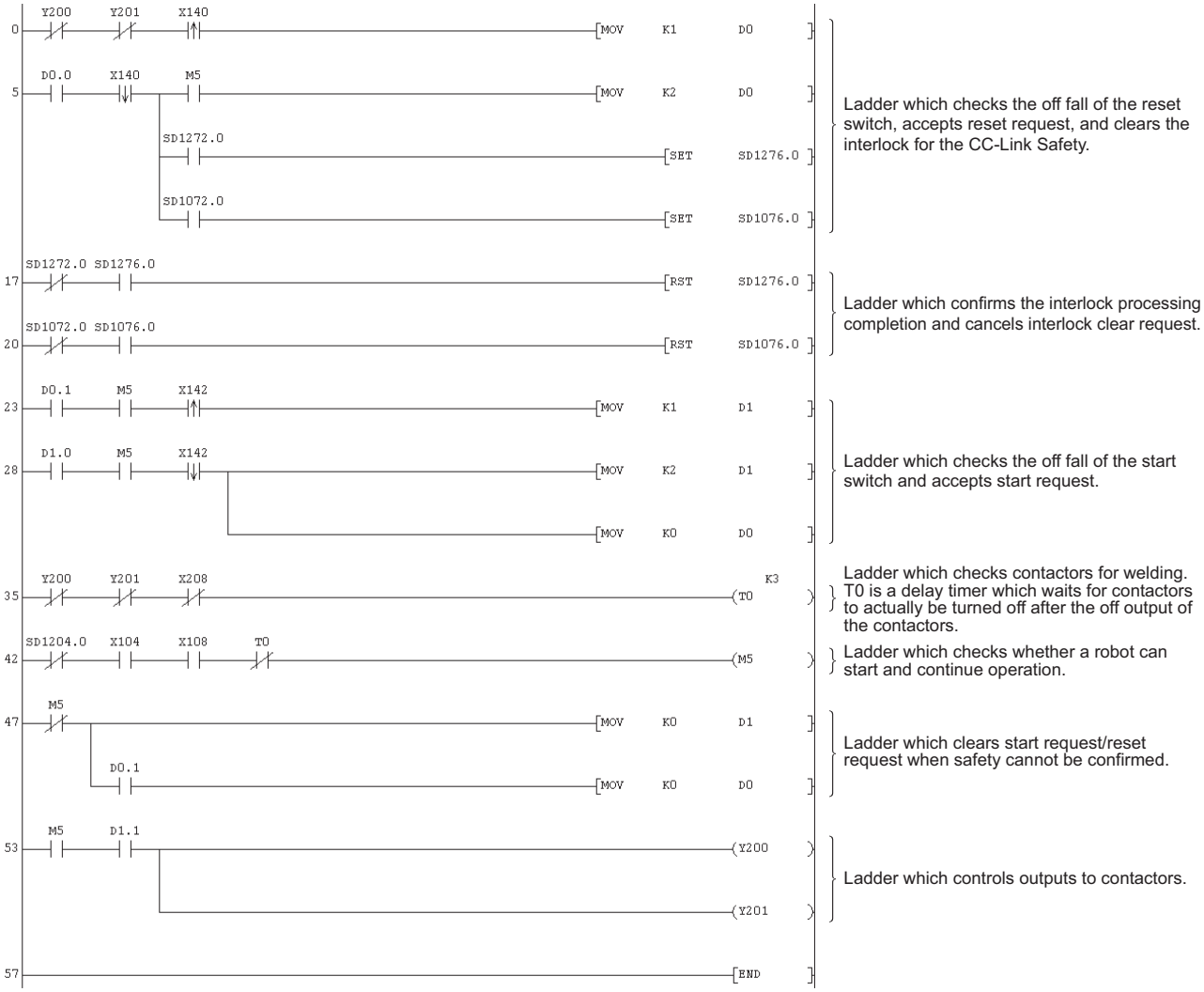


Figure5.29 Sequence program

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

(a) Way of using the constant

K☐: indicates decimal number.

Example) K1→indicates 1 of decimal number.

(b) Way of using the internal devices

Table5.21 Way of using the internal devices

Internal	Details
T0	Designates a timer device. Times out after a lapse of the time specified at K☐.
D0	Designates a word device. In the program, this is used as restart status. (1) D0 = 0 designates that the system is in initial status or start processing is completed. (2) D0 = 1 (D0.0: ON) designates that the reset switch is pressed. (3) D0 = 2 (D0.1: ON) designates that the reset switch is released in (2) status and restart processing is completed.
D1	Designates a word device. In the program, this is used as start status. (1) D1 = 0 designates that the system is in initial status or safety is not confirmed. (2) D1 = 1 (D1.0: ON) designates that the start switch is pressed. (3) D1 = 2 (D1.1: ON) designates that the start switch is released in (2) status and start processing is completed.

(c) Way of using word device bit specification

D☐☐.⬚: designates the ⬚ th bit data of word device D☐☐.

Example) D0.0 → indicates 0 bits in D0.

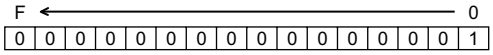


Figure5.30 Word device bit specification

(6) Timing chart

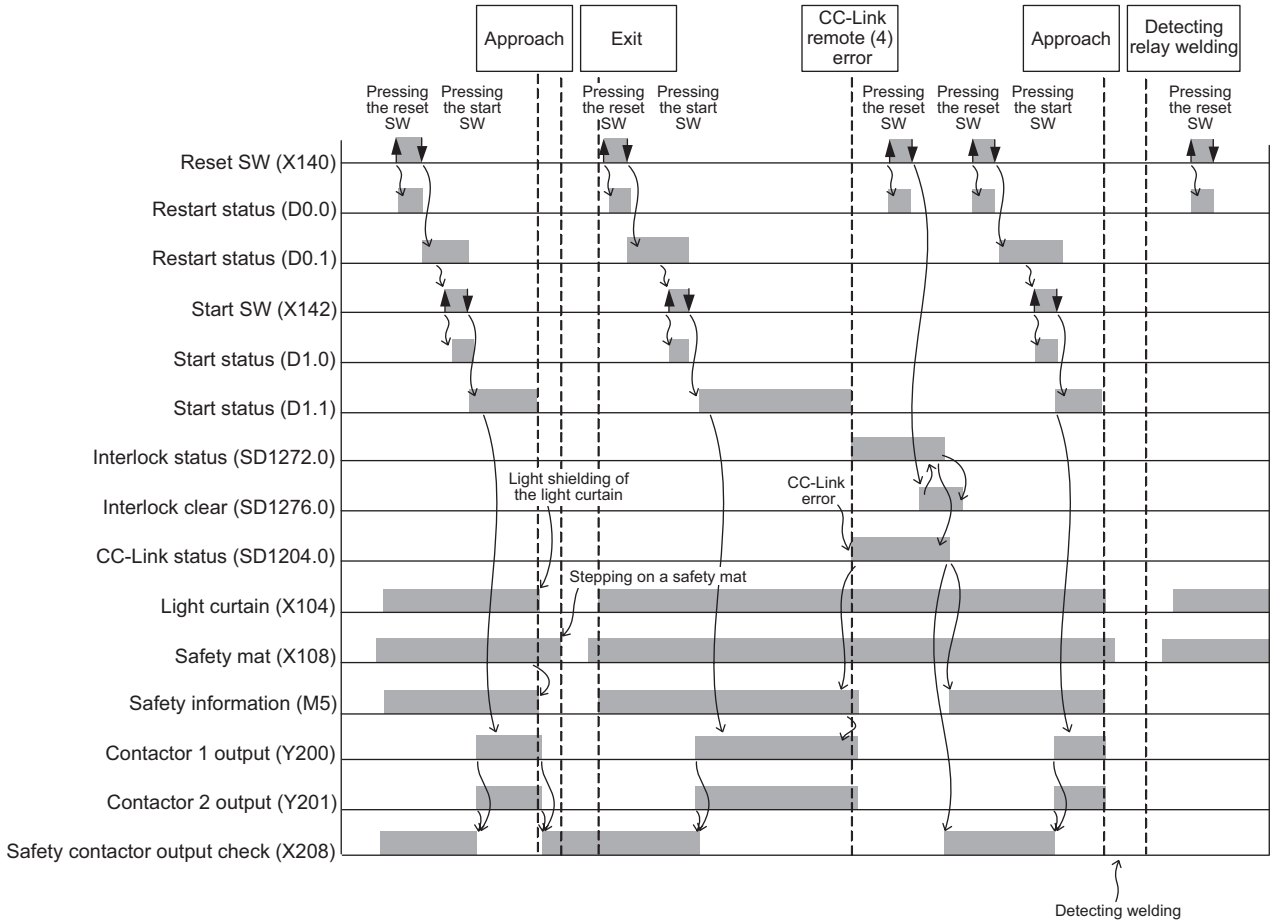


Figure5.31 Timing chart

APPENDIX

Appendix.1 Calculation Method of Safety Response Time

This manual explains about the maximum value of safety response time.

(1) Calculation method

The maximum value of the safety response time will be the sum of (a) to (f) in TableApp.1.

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

TableApp.1 Calculation method for the maximum value of safety response time

Item		Maximum
(a)	Input device response time	DT1
(b)	Safety remote I/O station input processing time	Time of noise removal filter + 32 [ms]
(c)	Time from when the safety master station receives the input data of the safety remote I/O station until send data is created in the sequence program	(Safety refresh monitoring time - ((WDT × n) × 2)) × 2 [ms]
(d)	Time from when the safety master station sends data after the execution of (c) until the safety remote station receives the data	Safety refresh monitoring time - ((WDT × n) × 2) [ms]
(e)	Safety remote I/O station output processing time	32[ms]
(f)	Output device response time	DT2
Total		DT1 + DT2 + 64 + Time of noise removal filter + (Safety refresh monitoring time × 3) - ((WDT × n) × 6)

LS: Link Scan Time (☞ This Item (1) (a))

n: Value after the decimal point of (LS/WDT) is rounded up

m: Value after the decimal point of (38 ms/(WDT × n)) is rounded up

Time of noise removal filter: Set this in parameter of Safety remote station settings (Setting value: 1 to 50 ms).

DT1, DT2: Response time of sensor or output destination controlling device. Check and add the response time of the device to be 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 + (WDT × n) × 4 + (WDT × n)× m [ms]

In asynchronous mode

WDT + (WDT × n) × 4 + LS + (WDT × n)× m [ms]

WDT (Watchdog timer): Time set in PLC parameter.

Calculate SM (Scan time) with referring to the QSCPU User's Manual (Function Explanation, Program Fundamentals), and set the watchdog timer value more equal to or more than the gained value.

Synchronous mode: Mode which performs data link when sequence scan is synchronized with link scan.

In the 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

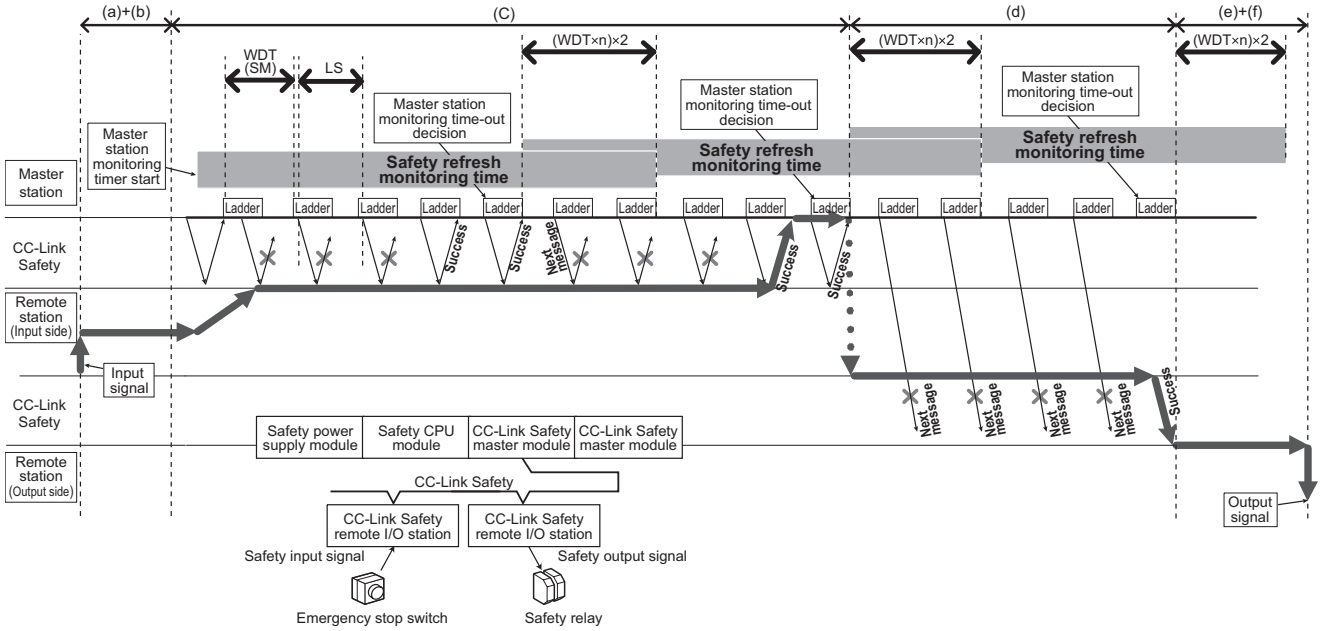
POINT

(1) If the setting value for the safety refresh monitoring time is equal to or less than the value gained by the formula on the previous page, an error may occur even in normal communication status.
If the setting value is needlessly long, the time taken for (c) and (d) in TableApp.1 may lengthen in case of a safety PLC error, resulting in excessive delay of safety response time.

(2) If the setting value for WDT is needlessly long, the safety response time may delay in case of a safety CPU module error.
When safety CPU module has a fault, SM (Scan time) will become the value set in "WDT Setting" of PLC parameter.
To show the maximum value of safety response time, this manual uses WDT, the maximum value of SM (Scan time), instead of SM to the calculating formula.
For the usual calculation, substitute for WDT, SM is used.

Remark

The safety master station simultaneously updates all send data in safety remote stations connected to the master station.
To the safety remote station from which communications are disconnected, timuout processing is performed; and to the other normal safety remote stations, communications are continued.
Therefore, the safety master station judges whether to perform timeout processing by the time calculated from "Safety refresh monitoring time - (WDT × n) × 2)".
Note that (WDT × n) × 2 is the time required for the safety master module to send communication data.
Also refer to the timing chart in FigureApp.1.



(a) to (f) in the figure corresponds to (a) to (f) in TableApp.1 .

FigureApp.1 Timing chart

(a) Link scan time (LS)

The following shows the formula for the CC-Link Safety link scan time (LS)[μs].

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 number of occupied stations and excluding reserved stations, in multiples of 8.)
NW : Final station No. in B
(Including the number of occupied stations and excluding reserved stations, in multiples of 8.)
A : Final station No. of standard remote I/O stations
(When not connecting standard remote station, put 0 to A.)
B : Final station No. of safety remote I/O stations and remote device stations

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 (excluding reserved stations)
a : Total number of occupied standard remote I/O stations
b : Total number of occupied safety remote I/O stations and remote device stations
nw : b (excluding reserved stations)
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)

α + β × (Number of detected faulty stations - 1)
α: Return processing time for 1st module
BT × ((200 + R) × Set number of retries + 200)
R: 51.6+(NI × 4.8)+(NW × 9.6)
β: Return processing time for 2nd or sebsequent module
BT × ((200 + P) × Set number of retries + 200)
P: 10.8

F : Return to system processing time (only when communication faulty station exists)
BT × 218 × Number of automatic return modules

POINT

If connecting the remote station to the station with the reserved station setting, and then clear the setting, the valus 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 CC-Link Safety System Master Module User's Manual.

(2) Calculation example of response time

The following shows the calculation example when WDT setting value: 30 ms, link scan time (Synchronous mode): 1.6 ms, link scan time (Asynchronous mode): 3.0 ms, and time of noise removal filter: 1 ms.

(a) Calculation example of safety refresh monitoring time

1) In synchronous mode

n = LS/WDT = 1.6/30 → 1
m = (38/(WDT × n)) = 38/(30 × 1) → 2

WDT + (WDT × n) × 4 + (WDT × n) m
= 30 + (30 × 1) × 4 + (30 × 1) × 2
= 210 [ms]

2) In asynchronous mode

n = LS/WDT = 3.0/30 → 1
m = (38/(WDT × n)) = 38/(30 × 1) → 2

WDT + (WDT × n) × 4 + LS + (WDT × n) × m
= 30 + (30 × 1) × 4 + 3 + (30 × 1) × 2
= 213 [ms]

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

DT1 + DT2 + 64 + Time of noise removal filter +
(Safety refresh monitoring time × 3) - ((WDT × n) × 6)

1) In synchronous mode

DT1 + DT2 + 64 + Time of noise removal filter + (Safety refresh monitoring time × 3) - ((WDT × n) × 6)
= DT1 + DT2 + 64 + 1 + 210 × 3 - ((30 × 1) × 6)
= DT1 + DT2 + 515 [ms]

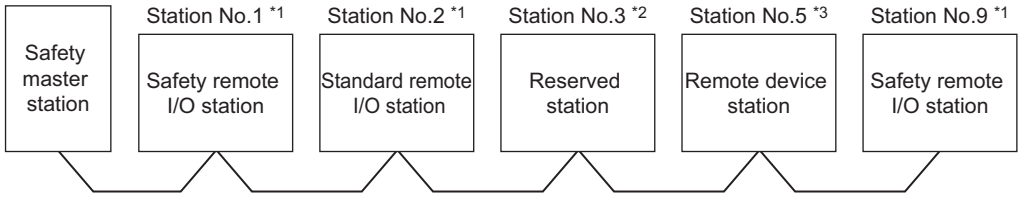
2) In asynchronous mode

DT1 + DT2 + 64 + Time of noise removal filter + (Safety refresh monitoring time × 3) - ((WDT × n) × 6)
= DT1 + DT2 + 64 + 1 + 213 × 3 - ((30 × 1) × 6)
= DT1 + DT2 + 524 [ms]

(3) Calculation example of link scan time

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

The following shows the calculation example when the transmission speed is 2.5 Mbps in the following system configuration example (It is assumed that there is no faulty stations).



*1: 1 occupied station *2: 2 occupied station *3: 4 occupied station

BT = 3.2
NI = 9 → 16
NW = 9 → 16
N = 4
ni = 7
nw = 6
A = 2, B = 9
ST = 1350
1) 800 + (2 × 15) = 830
2) 900 + (9 × 50) = 1350

In synchronous mode

$$LS = BT \times (27 + (NI \times 4.8) + (NW \times 9.6) + (N \times 30) + (ni \times 4.8) + (nw \times 9.6) + TR) + RT + F$$
$$= 3.2 \times (27 + (16 \times 4.8) + (16 \times 9.6) + (4 \times 30) + (7 \times 4.8) + (6 \times 9.6) + 38.4) + 0 + 0$$
$$= 1622.4\ [\mu s]$$
$$= 1.6\ [ms]$$

In asynchronous mode

$$LS = BT \times (27 + (NI \times 4.8) + (NW \times 9.6) + (N \times 30) + (ni \times 4.8) + (nw \times 9.6) + TR) + ST + RT + F$$
$$= 3.2 \times (27 + (16 \times 4.8) + (16 \times 9.6) + (4 \times 30) + (7 \times 4.8) + (6 \times 9.6) + 38.4) + 1350 + 0 + 0$$
$$= 2972.4\ [\mu s]$$
$$= 3.0\ [ms]$$

Appendix.2 Checklist

TableApp.2 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(5)	☐
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(5)	☐
3	Were the data downloaded to the PLC stored into the hard disk of a personal computer or CD?	Section 4.2(5)	☐
Checking the setting			
4	Was it confirmed that the link ID, station number, and transmission speed of the safety remote I/O module on the site were set as designed?	Section 4.3(1)	☐
5	Were the appropriate values set to Safety refresh monitoring time and WDT Setting?	Appendix.1	☐
6	When the safety system is shifted to the actual operation, is the operation mode set to the SAFETY MODE?	Section 4.4(3)	☐
Operation check			
7	Were all safety application functions (e.g. emergency stop function, restart interlock) inspected?	---	☐
8	Were the response time of the safety application inspected?	---	☐
Checking write data			
9	Before writing the data to the PLC, was it confirmed that sequence program and parameter setting values were configured as desired?	Section 4.3(2)	☐
10	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			
11	Was it confirmed that there are no errors with the LEDs on the module and the PLC diagnostics screen of GX Developer?	---	☐
12	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.)	---	☐
13	Are the registered passwords (Login password, CPU access password) managed properly?	Section 4.4(5)	☐

INDEX

MEMO

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 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.

2. Limits of Warranties.

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.
b. MELCO is not responsible for determining the suitability of the Products for their intended purpose and use, including determining if the Products provide appropriate safety margins and redundancies for the applications, equipment or systems into which they are incorporated.
c. Customer acknowledges that qualified and experienced personnel are required to determine the suitability, application, design, construction and proper installation and integration of the Products. MELCO does not supply such personnel.
d. MELCO is not responsible for designing and conducting tests to determine that the Product functions appropriately and meets application standards and requirements as installed or incorporated into the end-user's equipment, production lines or systems.
e. MELCO does not warrant any Product:
   (1) repaired or altered by persons other than MELCO or its authorized engineers or FA Centers;
   (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
   (11) damaged or malfunctioning due to Acts of God, fires, acts of vandals, criminals or terrorists, communication or power failures, or any other cause or failure that results from circumstances beyond MELCO's control.
f. All Product information and specifications contained on MELCO's website and in catalogs, manuals, or technical information materials provided by MELCO are subject to change without prior notice.

g. The Product information and statements contained on MELCO's website and in catalogs, manuals, technical bulletins or other materials provided by MELCO are provided as a guide for Customer's use. They do not constitute warranties and are not incorporated in the contract of sale for the Products.
h. These terms and conditions constitute the entire agreement between Customer and MELCO with respect to warranties, remedies and damages and supersede any other understandings, whether written or oral, between the parties. Customer expressly acknowledges that any representations or statements made by MELCO or others concerning the Products outside these terms are not part of the basis of the bargain between the parties and are not factored into the pricing of the Products.
i. THE WARRANTIES AND REMEDIES SET FORTH IN THESE TERMS ARE THE EXCLUSIVE AND ONLY WARRANTIES AND REMEDIES THAT APPLY TO THE PRODUCTS.
j. MELCO DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

3. Limits on Damages.

a. MELCO'S MAXIMUM CUMULATIVE LIABILITY BASED ON ANY CLAIMS FOR BREACH OF WARRANTY OR CONTRACT, NEGLIGENCE, STRICT TORT LIABILITY OR OTHER THEORIES OF RECOVERY REGARDING THE SALE, REPAIR, REPLACEMENT, DELIVERY, PERFORMANCE, CONDITION, SUITABILITY, COMPLIANCE, OR OTHER ASPECTS OF THE PRODUCTS OR THEIR SALE, INSTALLATION OR USE SHALL BE LIMITED TO THE PRICE PAID FOR PRODUCTS NOT AS WARRANTED.
b. Although MELCO has obtained the certification for Product's compliance to the international safety standards IEC61508 and EN954-1/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.
c. MELCO prohibits the use of Products with or in any application involving power plants, trains, railway systems, airplanes, airline operations, other transportation systems, amusement equipments, hospitals, medical care, dialysis and life support facilities or equipment, incineration and fuel devices, handling of nuclear or hazardous materials or chemicals, mining and drilling, and other applications where the level of risk to human life, health or property are elevated.
d. MELCO SHALL NOT BE LIABLE FOR SPECIAL, INCIDENTAL, CONSEQUENTIAL, INDIRECT OR PUNITIVE DAMAGES, FOR LOSS OF PROFITS, SALES, OR REVENUE, FOR INCREASED LABOR OR OVERHEAD COSTS, FOR DOWNTIME OR LOSS OF PRODUCTION, FOR COST OVERRUNS, OR FOR ENVIRONMENTAL OR POLLUTION DAMAGES OR CLEAN-UP COSTS, WHETHER THE LOSS IS BASED ON CLAIMS FOR BREACH OF CONTRACT OR WARRANTY, VIOLATION OF STATUTE, NEGLIGENCE OR OTHER TORT, STRICT LIABILITY OR OTHERWISE.
e. In the event that any damages which are asserted against MELCO arising out of or relating to the Products or defects in them, consist of personal injury, wrongful death and/or physical property damages as well as damages of a pecuniary nature, the disclaimers and limitations contained in these terms shall apply to all three types of damages to the fullest extent permitted by law. If, however, the personal injury, wrongful death and/or physical property damages cannot be disclaimed or limited by law or public policy to the extent provided by these terms, then in any such event the disclaimer of and limitations on pecuniary or economic consequential and incidental damages shall nevertheless be enforceable to the fullest extent allowed by law.
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.

5. Choice of Law/Jurisdiction.

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.

Mitsubishi Safety
Programmable Controller MELSEC QS series

Safety Application Guide

MODEL	QSCPU-APPLI-E
MODEL CODE	13JR90
SH(NA)-080613ENG-B(0703)MEE	

MITSUBISHI ELECTRIC CORPORATION

HEAD OFFICE : TOKYO BUILDING, 2-7-3 MARUNOUCHI, CHIYODA-KU, TOKYO 100-8310, JAPAN
NAGOYA WORKS : 1-14 , YADA-MINAMI 5-CHOME , HIGASHI-KU, NAGOYA , JAPAN