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]

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>● 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.</td>
</tr>
<tr>
<td>● 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.</td>
</tr>
</tbody>
</table>

### [Installation Precautions]

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>● 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.</td>
</tr>
<tr>
<td>● 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.</td>
</tr>
<tr>
<td>● 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.</td>
</tr>
<tr>
<td>● 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.</td>
</tr>
<tr>
<td>● Do not directly touch the module's conductive parts or electronic components. Doing so may cause malfunctions or a failure.</td>
</tr>
</tbody>
</table>
[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. If the module mounting screw is too loose, it may cause a drop due to the damage 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]

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 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.</td>
</tr>
<tr>
<td>• 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.</td>
</tr>
<tr>
<td>• 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.</td>
</tr>
<tr>
<td>• 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).</td>
</tr>
</tbody>
</table>
[Startup and Maintenance precautions]

⚠️ **DANGER**

- Do not touch the terminals while power is on.
  Doing so 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.
### [Startup and Maintenance precautions]

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
</table>
| • 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]

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>• When disposing of this product, treat it as industrial waste.</td>
</tr>
</tbody>
</table>

### [Transportation Precautions]

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
</table>
| • 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).) |
The manual number is given on the bottom left of the back cover.

<table>
<thead>
<tr>
<th>Print date</th>
<th>Manual number</th>
<th>Revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep., 2006</td>
<td>SH(NA)-080613ENG-A</td>
<td>First edition</td>
</tr>
<tr>
<td>Mar., 2007</td>
<td>SH(NA)-080613ENG-B</td>
<td>Correction CHAPTER1, Section 4.2, 5.5, 5.6.3, 5.6.4</td>
</tr>
</tbody>
</table>

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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
SAFETY PRECAUTIONS ........................................................................................................................................ A - 1
REVISIONS .......................................................................................................................................................... A - 8
INTRODUCTION .................................................................................................................................................. A - 9
CONTENTS ......................................................................................................................................................... A - 9
ABOUT MANUALS .............................................................................................................................................. A - 11
HOW THIS MANUAL IS ORGANIZED ........................................................................................................... A - 13
HOW TO USE THIS MANUAL ....................................................................................................................... A - 14
GENERIC TERMS AND ABBREVIATIONS .................................................................................................... A - 15
TERMINOLOGY ............................................................................................................................................... A - 16

Chapter1 OVERVIEW 1 - 1 to 1 - 2

Chapter2 APPLICATION EXAMPLE 2 - 1 to 2 - 2

Chapter3 RISK ASSESSMENT AND SAFETY LEVEL 3 - 1 to 3 - 5
  3.1 Risk Assessment .................................................................................................................................... 3 - 1
  3.1.1 Risk reduction .................................................................................................................................. 3 - 2
  3.2 Safety Category ................................................................................................................................... 3 - 3
  3.3 SIL ....................................................................................................................................................... 3 - 5

Chapter4 PRECAUTIONS FOR USE OF SAFETY PLC 4 - 1 to 4 - 11
  4.1 Precautions for Designing Safety Application ................................................................................... 4 - 1
  4.2 Precautions for Programming ........................................................................................................... 4 - 5
  4.3 Precautions for Startup ....................................................................................................................... 4 - 10
  4.4 Precautions for Safety Functions Maintenance ................................................................................. 4 - 10

Chapter5 SAFETY APPLICATION CONFIGURATION EXAMPLE 5 - 1 to 5 - 35
  5.1 System Configuration .......................................................................................................................... 5 - 1
  5.2 Network-Related Switch Settings of Module .................................................................................... 5 - 2
    5.2.1 Safety Power supply module ........................................................................................................ 5 - 2
    5.2.2 Safety CPU module ..................................................................................................................... 5 - 2
    5.2.3 Safety master module ............................................................................................................... 5 - 2
    5.2.4 Safety remote I/O module ......................................................................................................... 5 - 3
  5.3 CC-Link Parameter Settings ............................................................................................................... 5 - 4
    5.3.1 CC-Link station information settings ...................................................................................... 5 - 4
5.3.2 Safety remote station parameter settings ................................................................. 5 - 5
5.4 Relationship between the Safety CPU Module Devices and Remote I/O.......................... 5 - 6
5.5 Wiring Diagram and Parameter Setting of Standard Input ............................................. 5 - 7
5.6 Case Examples .................................................................................................................. 5 - 8
  5.6.1 Emergency stop circuit ............................................................................................... 5 - 8
  5.6.2 Door lock circuit ......................................................................................................... 5 - 14
  5.6.3 Entering detection and existence detection circuit 1 .................................................. 5 - 20
  5.6.4 Entering detection and existence detection circuit 2 .................................................. 5 - 28

APPENDIX  Appendix - 1 to Appendix - 7

  Appendix.1 Calculation Method of Safety Response Time ............................................... Appendix - 1
  Appendix.2 Checklist ......................................................................................................... Appendix - 7

INDEX  INDEX - 1 to INDEX - 2
### ABOUT MANUALS

The following manuals are related to this product.

If necessary, order them by quoting the details in the tables below.

<table>
<thead>
<tr>
<th>Manual name</th>
<th>Manual number (Model code)</th>
</tr>
</thead>
</table>
| **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) |
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 configuration, 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.
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.

<table>
<thead>
<tr>
<th>Generic term/abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLC</td>
<td>Abbreviation for Programmable Controller.</td>
</tr>
<tr>
<td>GX Developer</td>
<td>Generic product name for models SWnD5C-GPPW, SWnD5C-GPPW-A, SWnD5C-GPPW-V, and SWnD5C-GPPW-VA.</td>
</tr>
<tr>
<td>RWr</td>
<td>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.)</td>
</tr>
<tr>
<td>RWw</td>
<td>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.)</td>
</tr>
<tr>
<td>RX</td>
<td>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.)</td>
</tr>
<tr>
<td>RY</td>
<td>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.)</td>
</tr>
<tr>
<td>SB</td>
<td>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.)</td>
</tr>
<tr>
<td>SW</td>
<td>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.)</td>
</tr>
<tr>
<td>Safety remote I/O station</td>
<td>Remote station which handles only the information in bit units. Compatible with the safety-related system.</td>
</tr>
<tr>
<td>Standard remote I/O station</td>
<td>Remote station which handles only the information in bit units. Not compatible with the safety-related system.</td>
</tr>
<tr>
<td>Remote I/O station</td>
<td>Generic term for safety remote I/O station and standard remote I/O station</td>
</tr>
<tr>
<td>Remote device station</td>
<td>Remote station which handles information in both bit and word units. Not compatible with the safety-related system.</td>
</tr>
<tr>
<td>Safety master module</td>
<td>Other name for the QS0J61BT12 type CC-link Safety system master module.</td>
</tr>
<tr>
<td>Safety remote I/O module</td>
<td>Other name for the QS0J65BTB2-12DT type CC-Link Safety system remote I/O module.</td>
</tr>
<tr>
<td>Safety main base unit</td>
<td>Abbreviation for the QS034B(-E) type safety main base unit.</td>
</tr>
<tr>
<td>Safety CPU module</td>
<td>Abbreviation for the QS001CPU type safety CPU module.</td>
</tr>
<tr>
<td>Safety power supply module</td>
<td>Abbreviation for the QS061P-A1 and QS061P-A2 type safety power supply modules.</td>
</tr>
<tr>
<td>Safety PLC</td>
<td>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.</td>
</tr>
<tr>
<td>Standard PLC</td>
<td>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.)</td>
</tr>
<tr>
<td>Safety input</td>
<td>Generic term for the signals that are input to the safety PLC for realizing the safety functions.</td>
</tr>
<tr>
<td>Safety output</td>
<td>Generic term for the signals that are output from the safety PLC for realizing the safety functions.</td>
</tr>
<tr>
<td>Safety application</td>
<td>Generic term for the applications that are operated using the safety PLC for realizing the safety functions.</td>
</tr>
</tbody>
</table>
## TERMINOLOGY

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety component</td>
<td>Equipment such as the safety compatible sensor and actuator.</td>
</tr>
<tr>
<td>Safety-related system</td>
<td>System executing a safety functions to be required.</td>
</tr>
<tr>
<td>Safety functions</td>
<td>Functions to be realized for protecting a human from machinery hazards.</td>
</tr>
<tr>
<td>Safety measure</td>
<td>Measure for reducing the risk.</td>
</tr>
<tr>
<td>Category</td>
<td>Safety level standardized in EN954-1. The safety level is classified into 5 levels of B and 1 to 4.</td>
</tr>
<tr>
<td>SIL</td>
<td>Safety level which is standardized in IEC61508. The safety level is classified into 4 levels of SIL1 to SIL4.</td>
</tr>
<tr>
<td>Risk</td>
<td>Degree of hazards, which is the combination of the occurrence probability and degree of an injury and a health problem.</td>
</tr>
<tr>
<td>Risk assessment</td>
<td>To clarify hazards in machinery and assess the degree of the hazards.</td>
</tr>
<tr>
<td>Link ID</td>
<td>Unique network identifier which is given to each network of the CC-Link Safety system.</td>
</tr>
<tr>
<td>Target failure measure</td>
<td>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.</td>
</tr>
<tr>
<td>NC</td>
<td>Abbreviation for normal close contact which is normally closed, but opened when a switch or other function is operated.</td>
</tr>
<tr>
<td>NO</td>
<td>Abbreviation for normal open contact which is normally opened, but closed when a switch or other function is operated.</td>
</tr>
<tr>
<td>Close contact</td>
<td>Same as NC.</td>
</tr>
<tr>
<td>Open contact</td>
<td>Same as NO.</td>
</tr>
<tr>
<td>Dark test</td>
<td>Outputs a pulse to turn OFF the input/output when it is ON, and performs the failure diagnostics to contacts including external equipment.</td>
</tr>
</tbody>
</table>
CHAPTER 1  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 Figure 1.1.

- 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.

![System configuration of safety PLC](image-url)
CHAPTER 2 APPLICATION EXAMPLE

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

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.

Figure 2.1 Application image for car welding line
Memo
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 Figure 3.1. This procedure is standardized in ISO12100 and 14121.

Figure 3.1 Risk assessment procedure
(Referred to ISO12100.)
3.1.1 Risk reduction

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

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

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

Definition of symbols:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>●</td>
<td>Safety category which is desirable as a reference point</td>
</tr>
<tr>
<td>○</td>
<td>Safety category which may be over-specification</td>
</tr>
<tr>
<td>—</td>
<td>Insufficient safety category</td>
</tr>
</tbody>
</table>

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

(Referred to EN954-1.)
The requirements of standards for the safety category are shown in Table 3.1.

### Table 3.1 Summary of safety category requirements

<table>
<thead>
<tr>
<th>Category</th>
<th>Summary of requirements</th>
<th>System behaviour</th>
<th>Principles to achieve safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>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.</td>
<td>The occurrence of a fault can lead to loss of the safety function.</td>
<td>Mainly characterized by selection of components</td>
</tr>
<tr>
<td>1</td>
<td>Requirements of B shall apply.</td>
<td>The occurrence of a fault can lead to loss of the safety function, but the probability of occurrence is lower than for category B.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Requirements of B and the use of well-tried safety principles shall apply.</td>
<td>-- 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.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Requirements of B and the use of well-tried safety principles shall apply.</td>
<td>-- 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.</td>
<td>Mainly characterized by structure</td>
</tr>
<tr>
<td>4</td>
<td>Requirements of B and the use of well-tried safety principles shall apply.</td>
<td>-- When the faults occur the safety function is always performed. -- The faults will be detected in time to prevent loss of the safety function.</td>
<td></td>
</tr>
</tbody>
</table>

*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 EN 954-1.)
3.3 SIL

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

![SIL risk graph](image)

**Definition of symbols:**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>-a</td>
<td>No safety requirements.</td>
</tr>
<tr>
<td>b</td>
<td>Not sufficient with a single safety-related system.</td>
</tr>
<tr>
<td>1,2,3,4</td>
<td>Safety integrity level Stands for SIL1, SIL2, SIL3 and SIL4 respectively.</td>
</tr>
</tbody>
</table>

*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)**

<table>
<thead>
<tr>
<th>SIL</th>
<th>Low demand mode of operation*1</th>
<th>High demand mode of operation*1</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>$10^{-5} \leq \text{PFD} &lt; 10^{-4}$</td>
<td>$10^{-9} \leq \text{PFH} &lt; 10^{-8}$</td>
</tr>
<tr>
<td>3</td>
<td>$10^{-4} \leq \text{PFD} &lt; 10^{-3}$</td>
<td>$10^{-8} \leq \text{PFH} &lt; 10^{-7}$</td>
</tr>
<tr>
<td>2</td>
<td>$10^{-3} \leq \text{PFD} &lt; 10^{-2}$</td>
<td>$10^{-7} \leq \text{PFH} &lt; 10^{-6}$</td>
</tr>
<tr>
<td>1</td>
<td>$10^{-2} \leq \text{PFD} &lt; 10^{-1}$</td>
<td>$10^{-8} \leq \text{PFH} &lt; 10^{-5}$</td>
</tr>
</tbody>
</table>

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

\[
PFD/PFH = A + B \times n + C + D \ldots \quad \text{Calculation formula of PFD/PFH}
\]

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>PFD/PFH of safety CPU module, safety power supply module, safety main base unit, and CC-Link Safety master module</td>
</tr>
<tr>
<td>B</td>
<td>PFD/PFH of safety remote I/O module</td>
</tr>
<tr>
<td>n</td>
<td>Number of safety remote I/O modules to be used</td>
</tr>
<tr>
<td>C</td>
<td>PFD/PFH of safety input equipment</td>
</tr>
<tr>
<td>D</td>
<td>PFD/PFH of safety output equipment</td>
</tr>
</tbody>
</table>

\*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

<table>
<thead>
<tr>
<th>Module/unit</th>
<th>PFD</th>
<th>PFH (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFD/PFH of safety CPU module, safety power supply module, safety main base unit, and CC-Link Safety master module</td>
<td>$1.39 \times 10^{-4}$</td>
<td>$4.95 \times 10^{-9}$</td>
</tr>
<tr>
<td>PFD/PFH of safety remote I/O module</td>
<td>$2.57 \times 10^{-6}$</td>
<td>$1.15 \times 10^{-9}$</td>
</tr>
</tbody>
</table>

\*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 \((n=1)\)

\[
PFD = (PFD \text{ of } A) + (PFD \text{ of } B) \times n + (PFD \text{ of } C) + (PFD \text{ of } D) \\
= (1.39 \times 10^{-4}) + (2.57 \times 10^{-5}) \times 1 + (PFD \text{ of } C) + (PFD \text{ of } D) \\
= 1.65 \times 10^{-4} + (PFD \text{ of } C) + (PFD \text{ of } D)
\]

\[
PFH = (PFH \text{ of } A) + (PFH \text{ of } B) \times n + (PFH \text{ of } C) + (PFH \text{ of } D) \\
= (4.95 \times 10^{-9}) + (1.15 \times 10^{-9}) \times 1 + (PFH \text{ of } C) + (PFH \text{ of } D) \\
= 6.10 \times 10^{-9} + (PFH \text{ of } C) + (PFH \text{ of } D)
\]
(b) For two remote I/O modules \( (n = 2) \)

\[
PFD = (PFD \text{ of } A) + (PFD \text{ of } B) \times n + (PFD \text{ of } C) + (PFD \text{ of } D)
\]
\[
= (1.39 \times 10^{-4}) + ((2.57 \times 10^{-5}) \times 2) + (PFD \text{ of } C) + (PFD \text{ of } D)
\]
\[
= 1.90 \times 10^{-4} + (PFD \text{ of } C) + (PFD \text{ of } D)
\]

\[
PFH = (PFH \text{ of } A) + (PFH \text{ of } B) \times n + (PFH \text{ of } C) + (PFH \text{ of } D)
\]
\[
= (4.95 \times 10^{-9}) + ((1.15 \times 10^{-9}) \times 2) + (PFH \text{ of } C) + (PFH \text{ of } D)
\]
\[
= 7.25 \times 10^{-9} + (PFH \text{ of } C) + (PFH \text{ of } D)
\]

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 Figure 4.3.

![Figure 4.3 Wiring of safety components](image)

**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.


(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.

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.

(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 Table 4.3. 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 Table 4.3.

Table 4.3 Register names and compatible numbers

<table>
<thead>
<tr>
<th>Name</th>
<th>No.</th>
<th>Definition for bits of special register (safety station refresh communication status)</th>
</tr>
</thead>
</table>
| Safety station refresh communication status (1st safety master module) | SD1004 to SD1007        | b15 b14 – b1 b0 
|                                                 |                         | SD1004  16 15 to 2 1 
|                                                 |                         | SD1005  32 31 to 18 17 
|                                                 |                         | SD1006  48 47 to 34 33 
|                                                 |                         | SD1007  64 63 to 50 49 
| Safety station refresh communication status (2nd safety master module) | SD1204 to SD1207        | b15 b14 – b1 b0 
|                                                 |                         | SD1204  16 15 to 2 1 
|                                                 |                         | SD1205  32 31 to 18 17 
|                                                 |                         | SD1206  48 47 to 34 33 
|                                                 |                         | SD1207  64 63 to 50 49 

1 to 64 in the table indicate the station numbers.

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 Figure 4.6. Figure 4.6 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.

Figure 4.6 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 Table 4.4 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.

<table>
<thead>
<tr>
<th>Table 4.4 Register names and compatible numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name</strong></td>
</tr>
<tr>
<td>-----------------------------------------</td>
</tr>
<tr>
<td>Safety station interlock status</td>
</tr>
<tr>
<td>(1st safety master module)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Safety station interlock clear request</td>
</tr>
<tr>
<td>(1st safety master module)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Safety station interlock status</td>
</tr>
<tr>
<td>(2nd safety master module)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Safety station interlock clear request</td>
</tr>
<tr>
<td>(2nd safety master module)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

For details, refer to the following manual.
QSCPU User's Manual (Function Explanation, Program Fundamentals)
4.2 Precautions for Programming

(a) Program example

Figure 4.7 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.

![Diagram showing a program example](image)

Figure 4.7 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.

![Version management screenshot](image)

Figure 4.8 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.

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.

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 Table 4.5.

<table>
<thead>
<tr>
<th>Module/unit</th>
<th>Module/unit replacement cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety power supply module</td>
<td>5 years</td>
</tr>
<tr>
<td>Safety CPU module</td>
<td>10 years</td>
</tr>
<tr>
<td>Safety master module</td>
<td>10 years</td>
</tr>
<tr>
<td>Safety remote I/O module</td>
<td>5 years</td>
</tr>
<tr>
<td>Safety main base unit</td>
<td>10 years</td>
</tr>
</tbody>
</table>
(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.
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.

![Figure 5.1 System configuration](image)

**Figure 5.1 System configuration**

- Master (1): Safety master station (Link ID: 0, Station number: 0)
- Master (2): Safety master station (Link ID: 1, Station number: 0)
- Remote (1): Code name SR_IO1
- Safety remote I/O station (Link ID: 0, Station number: 1)
- Remote (2): Code name SR_IO2
- Safety remote I/O station (Link ID: 0, Station number: 2)
- Remote (3): Code name SR_IO3
- Safety remote I/O station (Link ID: 0, Station number: 3)
- Remote (4): Code name SR_IO4
- Safety remote I/O station (Link ID: 1, Station number: 1)

- GX Developer
- CC-Link Safety
- Safety input: Safety switch, Light curtain, Laser scanner, Mat switch
- Safety output: Emergency stop switch
- Safety relay
- MC

Parameters:
- Programs:
  - Remote (4) Code name SR_IO4
  - Safety remote I/O station (Link ID: 1, Station number: 1)
  - Master (1): Safety master station (Link ID: 0, Station number: 0)
  - Master (2): Safety master station (Link ID: 1, Station number: 0)
  - Remote (1): Code name SR_IO1
  - Safety remote I/O station (Link ID: 0, Station number: 1)
  - Remote (2): Code name SR_IO2
  - Safety remote I/O station (Link ID: 0, Station number: 2)
  - Remote (3): Code name SR_IO3
  - Safety remote I/O station (Link ID: 0, Station number: 3)

Standard input:
- Reset switch
- Start switch
- Stop switch
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.

![Switch position of safety remote I/O module](image)

**Table 5.1 Switch settings of safety remote I/O module**

<table>
<thead>
<tr>
<th>Switch numbers in the Figure</th>
<th>Remote I/O module number</th>
<th>Remote (1)</th>
<th>Remote (2)</th>
<th>Remote (3)</th>
<th>Remote (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Link ID</td>
<td>Link ID</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2) Station number setting switch</td>
<td>Station number setting switch</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>3) Transmission speed setting switch</td>
<td>Transmission speed setting switch</td>
<td>2 (2.5Mbps)</td>
<td>2 (2.5Mbps)</td>
<td>2 (2.5Mbps)</td>
<td>2 (2.5Mbps)</td>
</tr>
</tbody>
</table>

**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.

Table 5.2 CC-Link parameter setting example

<table>
<thead>
<tr>
<th>Module</th>
<th>Master (1)</th>
<th>Master (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start I/O No.</td>
<td>00H</td>
<td>20H</td>
</tr>
<tr>
<td>Operational setting</td>
<td>Case of CPU STOP setting*1</td>
<td>Clears compulsorily</td>
</tr>
<tr>
<td>Mode</td>
<td>Safety remote net(Ver. 1 mode)</td>
<td>Safety remote net(Ver. 1 mode)</td>
</tr>
<tr>
<td>Transmission speed</td>
<td>2.5Mbps</td>
<td>2.5Mbps</td>
</tr>
<tr>
<td>Safety refresh monitoring time</td>
<td>300ms</td>
<td>300ms</td>
</tr>
<tr>
<td>Link ID</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>All connect count</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Remote input (RX)</td>
<td>X100</td>
<td>X200</td>
</tr>
<tr>
<td>Remote input (RY)</td>
<td>Y100</td>
<td>Y200</td>
</tr>
<tr>
<td>Remote register (RWr)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Remote register (RWw)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Special relay (SB)</td>
<td>SB0</td>
<td>SB200</td>
</tr>
<tr>
<td>Special relay (SW)</td>
<td>SW0</td>
<td>SW200</td>
</tr>
<tr>
<td>Retry count</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Automatic reconnection station count</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

*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.

Table 5.3 Setting example of master (1) station information /

<table>
<thead>
<tr>
<th>Module</th>
<th>Station No.</th>
<th>Station type</th>
<th>Exclusive station count</th>
<th>Reserve station count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master (1)</td>
<td>1/1</td>
<td>Safety remote I/O station</td>
<td>Exclusive station 1</td>
<td>No setting</td>
</tr>
<tr>
<td></td>
<td>2/2</td>
<td>Safety remote I/O station</td>
<td>Exclusive station 1</td>
<td>No setting</td>
</tr>
<tr>
<td></td>
<td>3/3</td>
<td>Safety remote I/O station</td>
<td>Exclusive station 1</td>
<td>No setting</td>
</tr>
</tbody>
</table>

Table 5.4 Setting example of master (2) station information

<table>
<thead>
<tr>
<th>Module</th>
<th>Station No.</th>
<th>Station type</th>
<th>Exclusive station count</th>
<th>Reserve station count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master (2)</td>
<td>1/1</td>
<td>Safety remote I/O station</td>
<td>Exclusive station 1</td>
<td>No setting</td>
</tr>
</tbody>
</table>
5.3.2 Safety remote station parameter settings

Set the safety remote station parameter settings as follows.

Table 5.5 Safety remote station parameter settings

<table>
<thead>
<tr>
<th>Module</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR_IO1</td>
<td>Model name</td>
<td>QS0J65BTB2-12DT</td>
<td>QS0J65BTB2-12DT</td>
<td>QS0J65BTB2-12DT</td>
</tr>
<tr>
<td></td>
<td>Module technical version*1</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Specify production information to find module</td>
<td>Yes (check)</td>
<td>No (no check)</td>
<td>No (no check)</td>
</tr>
<tr>
<td></td>
<td>Production information*2</td>
<td>1100000000000010</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

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.

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

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 Table 5.2. The shaded device numbers are used to create sequence programs.
Wire the reset switch, start switch, and stop switch as follows.

![Remote (3) SR_IO3 Wiring Diagram](image)

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

**Table 5.6 Remote (3) SR_IO3 Parameter settings**

<table>
<thead>
<tr>
<th>Item</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of noise removal filter X0, 1°</td>
<td>0: 1ms, 1: 5ms, 2: 10ms, 3: 20ms, 4: 50ms</td>
</tr>
<tr>
<td>Time of noise removal filter X2, 3°</td>
<td>0: 1ms, 1: 5ms, 2: 10ms, 3: 20ms, 4: 50ms</td>
</tr>
<tr>
<td>Time of noise removal filter X4, 5°</td>
<td>0: 1ms, 1: 5ms, 2: 10ms, 3: 20ms, 4: 50ms</td>
</tr>
<tr>
<td>Doubling input discrepancy detection time X0, 1°</td>
<td>100ms (setting range: 20 to 500ms)</td>
</tr>
<tr>
<td>Doubling input discrepancy detection time X2, 3°</td>
<td>100ms (setting range: 20 to 500ms)</td>
</tr>
<tr>
<td>Doubling input discrepancy detection time X4, 5°</td>
<td>100ms (setting range: 20 to 500ms)</td>
</tr>
<tr>
<td>Input dark test selection X0, 1</td>
<td>0: Execute, 1: Not execute</td>
</tr>
<tr>
<td>Input dark test selection X2, 3</td>
<td>0: Execute, 1: Not execute</td>
</tr>
<tr>
<td>Input dark test selection X4, 5</td>
<td>0: Execute, 1: Not execute</td>
</tr>
<tr>
<td>Input dark test pulse OFF time</td>
<td>0: 400 μs, 1: 1ms, 2: 2ms</td>
</tr>
</tbody>
</table>

*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.

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

5.6.1 Emergency stop circuit

(2) Connection of safety devices

Figure 5.6 Safety device connection diagram

- Remote (1): SR_IO1
  - X100-10F
  - Y100-103

- Remote (2): SR_IO2
  - X120-12F
  - Y120-123

- Remote (3): SR_IO3
  - X140-14F
  - Y140-143

- Remote (4): SR_IO4
  - X200-20F
  - Y200-203

Wiring: Indicated in Figure 5.7.
Parameters: Indicated in Table 5.7.

: Safety remote I/O module used in this case example

CC-Link Safety

Table 5.7: Indicating parameters used in this case example.
(3) Wiring diagram and parameter settings

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

Connect the close contact of the safety relay between the input terminal and the test pulse terminal.

Connect the emergency stop switch with two NC contacts of direct opening action between the input terminal and the test pulse terminal.

Connect two relays with forcibly guided (mechanically linked) contacts.

Figure 5.7 Remote (4) SR_IO4 wiring
For the emergency stop switch and the safety relay, set the parameters as follows.

**Table 5.7 Remote (4) SR_IO4 parameter settings**

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

\(^1\): 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.

**Table 5.8 Device numbers to be used**

<table>
<thead>
<tr>
<th>Safety/Standard</th>
<th>External device</th>
<th>Device number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Emergency stop switch</td>
<td>X204 or X205</td>
</tr>
<tr>
<td>Safety</td>
<td>Safety relay</td>
<td>Y202</td>
</tr>
<tr>
<td>Safety</td>
<td>Safety relay (check for welding)</td>
<td>X202 or X203</td>
</tr>
<tr>
<td>Standard</td>
<td>Start switch</td>
<td>X142</td>
</tr>
<tr>
<td>Standard</td>
<td>Reset switch</td>
<td>X140</td>
</tr>
</tbody>
</table>

\((4)\) Device numbers to be used

Use the following device numbers for creating sequence programs.
(5) Sequence program

Make the following processing on sequence programs.

![Sequence program diagram]

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.
5 SAFETY APPLICATION CONFIGURATION EXAMPLE

5.6 Case Examples

5.6.1 Emergency stop circuit

(b) Way of using the internal devices

Table 5.9 Way of using the internal devices

<table>
<thead>
<tr>
<th>Internal</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>Designates a timer device. Times out after a lapse of the time specified at K.</td>
</tr>
<tr>
<td>D0</td>
<td>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.</td>
</tr>
<tr>
<td>D1</td>
<td>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.</td>
</tr>
</tbody>
</table>

(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.

Figure 5.9 Word device bit specification

(6) Timing chart

Figure 5.10 Timing chart

Pressing the reset SW | Pressing the start SW | Pressing the emergency stop SW | Pressing the emergency stop SW | Pressing the reset SW | Pressing the start SW | Detecting relay welding |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Reset SW (X140)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restart status (D0.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restart status (D0.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start SW (X142)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start status (D1.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start status (D1.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interlock status (SD1272.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interlock clear (SD1276.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC-Link status (SD1204.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency stop SW (X204)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety information (M5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety relay output (Y202)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety relay output check (X202)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detecting welding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pressing the emergency stop SW | Pressing the emergency stop SW | Pressing the emergency stop SW | Pressing the emergency stop SW | Pressing the emergency stop SW | Pressing the emergency stop SW | Pressing the emergency stop SW |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Turing OFF the emergency SW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC-Link error</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.6 Case Examples

5.6.1 Emergency stop circuit
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.

Figure 5.11 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

Remote (1): SR_IO1
X100-10F
Y100-103
Wiring: Indicated in Figure 5.12. Parameters: Indicated in Table 5.12.

Remote (2): SR_IO2
X120-12F
Y120-123

Remote (3): SR_IO3
X140-14F
Y140-143
Wiring: Indicated in Figure 5.14. Parameters: Indicated in Table 5.11.

Remote (4): SR_IO4
X200-20F
Y200-203

Wiring: Indicated in Figure 5.14. Parameters: Indicated in Table 5.11.

Figure 5.12 Safety device connection diagram

Wiring: Indicated in Figure 5.14. Parameters: Indicated in Table 5.6.

Parameter: Indicated in Table 5.6.

Parameter: Indicated in Table 5.10.
(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.

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

Table 5.10 Remote (1) SR_IO1 parameter settings

<table>
<thead>
<tr>
<th>Item</th>
<th>Setting range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of noise removal filter X0, 1&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0: 1ms, 1: 5ms, 2: 10ms, 3: 20ms, 4: 50ms</td>
</tr>
<tr>
<td>Doubling input discrepancy detection time X0, 1&lt;sup&gt;1&lt;/sup&gt;</td>
<td>100ms (setting range: 20 to 500ms)</td>
</tr>
<tr>
<td>Input dark test selection X0, 1</td>
<td>0: Execute, 1: Not execute</td>
</tr>
<tr>
<td>Input dark test pulse OFF time&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0: 400 μs, 1: 1ms, 2: 2ms</td>
</tr>
</tbody>
</table>

*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.

**Figure 5.14 Remote (4) SR_IO4 wiring**

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

**Table 5.11 Remote (4) SR_IO4 parameter settings**

<table>
<thead>
<tr>
<th>Item</th>
<th>Setting range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of noise removal filter X2, 3&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0: 1ms, 1: 5ms, 2: 10ms, 3: 20ms, 4: 50ms</td>
</tr>
<tr>
<td>Doubling input discrepancy detection time X2, 3&lt;sup&gt;1&lt;/sup&gt;</td>
<td>100ms (setting range: 20 to 500ms)</td>
</tr>
<tr>
<td>Input dark test selection X2, 3</td>
<td>0: Execute, 1: Not execute</td>
</tr>
<tr>
<td>Input dark test pulse OFF time&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0: 400 µs, 1: 1ms, 2: 2ms</td>
</tr>
<tr>
<td>Method of wiring of output Y2</td>
<td>0: No Use, 1: Doubling wiring (Source + Sink), 2: Doubling wiring (Source+Source)</td>
</tr>
<tr>
<td>Output dark test selection Y2</td>
<td>0: Execute, 1: Not execute</td>
</tr>
<tr>
<td>Output dark test pulse OFF time Y2&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0: 400 µs, 1: 1ms, 2: 2ms</td>
</tr>
</tbody>
</table>

*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.

<table>
<thead>
<tr>
<th>Safety/Standard</th>
<th>External device</th>
<th>Device number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Safety switch</td>
<td>X100 or X101</td>
</tr>
<tr>
<td>Safety</td>
<td>Safety relay</td>
<td>Y202</td>
</tr>
<tr>
<td>Safety</td>
<td>Safety relay (check for welding)</td>
<td>X202 or X203</td>
</tr>
<tr>
<td>Standard</td>
<td>Reset switch</td>
<td>X140</td>
</tr>
<tr>
<td>Standard</td>
<td>Start switch</td>
<td>X142</td>
</tr>
<tr>
<td>Standard</td>
<td>Stop switch</td>
<td>X144</td>
</tr>
</tbody>
</table>

(5) Sequence program

Make the following processing on sequence programs.

![Sequence program diagram](image)

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

Table 5.13 Way of using the internal devices

<table>
<thead>
<tr>
<th>Internal</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>Designates a timer device. Times out after a lapse of the time specified at K□.</td>
</tr>
<tr>
<td>D0</td>
<td>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.</td>
</tr>
<tr>
<td>D1</td>
<td>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.</td>
</tr>
</tbody>
</table>

(c) Way of using word device bit specification

\[ D\□\□.\□ \rightarrow \text{designates the } \□ \text{ th bit data of word device } D\□\□. \]

Example) D0.0 \rightarrow \text{indicates 0 bits in D0.}

\[
\begin{array}{cccccccccccc}
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\
\end{array}
\]

Figure 5.16 Word device bit specification

(6) Timing chart

Figure 5.17 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.
(2) Connection of safety devices

Figure 5.19 Safety device connection diagram

- Remote(1): SR_IO1
  - X100-10F
  - Y100-103
  - Wiring: Indicated in Figure 5.20
  - Parameters: Indicated in Table 5.14

- Remote(2): SR_IO2
  - X120-12F
  - Y120-123
  - Wiring: Indicated in Figure 5.4
  - Parameters: Indicated in Table 5.6

- Remote(3): SR_IO3
  - X140-14F
  - Y140-143
  - Wiring: Indicated in Figure 5.4
  - Parameters: Indicated in Table 5.6

- Remote(4): SR_IO4
  - X200-20F
  - Y200-203

CC-Link Safety

: Safety remote I/O module used in this case example

Wiring: Indicated in Figure 5.21
Parameters: Indicated in Table 5.15

Wiring: Indicated in Figure 5.21
Parameters: Indicated in Table 5.15
(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

Connect two control output points (PNP output) of type 4 light curtain between the input terminal and COM- terminal.

Connect two control output points (PNP output) of type 3 laser scanner between the input terminal and COM- terminal.

Figure 5.20 Remote (1) SR_IO1 wiring
For the light curtain and the laser scanner, set the parameters as follows.

<table>
<thead>
<tr>
<th>Table 5.14 Remote (1) SR_IO1 parameter settings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Item</strong></td>
</tr>
<tr>
<td>Time of noise removal filter X4, 5&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>Time of noise removal filter X6, 7&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>Doubling input discrepancy detection time X4, 5&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>Doubling input discrepancy detection time X6, 7&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>Input dark test selection X4, 5</td>
</tr>
<tr>
<td>Input dark test selection X6, 7</td>
</tr>
<tr>
<td>Input dark test OFF time&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

*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.

![Remote (4) SR_IO4 Wiring Diagram](image-url)

Connect the close contact of the contactor between the input terminal and test pulse terminal.

Use two contactors which can be activated with 24VDC, 0.5A.
For the contactors, set the parameters as follows.

### Table 5.15 Remote (4) SR_IO4 parameter settings

<table>
<thead>
<tr>
<th>Item</th>
<th>Setting range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of noise removal filter X8, 9&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0: 1ms, 1: 5ms, 2: 10ms, 3: 20ms, 4: 50ms</td>
</tr>
<tr>
<td>Doubling input discrepancy detection time X8, 9&lt;sup&gt;1&lt;/sup&gt;</td>
<td>100ms (setting range: 20 to 500ms)</td>
</tr>
<tr>
<td>Input dark test selection X8, 9</td>
<td>0: Execute, 1: Not execute</td>
</tr>
<tr>
<td>Input dark test pulse OFF time&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0: 400μs, 1: 1ms, 2: 2ms</td>
</tr>
<tr>
<td>Method of wiring of output Y0</td>
<td>0: No Use, 1: Doubling wiring (Source+Sink), 2: Doubling wiring (Source + Source)</td>
</tr>
<tr>
<td>Method of wiring of output Y1</td>
<td>0: No Use, 1: Doubling wiring (Source+Sink), 2: Doubling wiring (Source + Source)</td>
</tr>
<tr>
<td>Output dark test selection Y0</td>
<td>0: Execute, 1: Not execute</td>
</tr>
<tr>
<td>Output dark test selection Y1</td>
<td>0: Execute, 1: Not execute</td>
</tr>
<tr>
<td>Output dark test pulse OFF time Y0&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0: 400μs, 1: 1ms, 2: 2ms</td>
</tr>
<tr>
<td>Output dark test pulse OFF time Y1&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0: 400μs, 1: 1ms, 2: 2ms</td>
</tr>
</tbody>
</table>

<sup>1</sup>: 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.

### Table 5.16 Device numbers to be used

<table>
<thead>
<tr>
<th>Safety/Standard</th>
<th>External device</th>
<th>Device number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Light curtain</td>
<td>X104 or X105</td>
</tr>
<tr>
<td>Safety</td>
<td>Laser scanner</td>
<td>X106 or X107</td>
</tr>
<tr>
<td>Safety</td>
<td>Contactor (check for welding)</td>
<td>X208 or X209</td>
</tr>
<tr>
<td>Standard</td>
<td>Reset switch</td>
<td>X140</td>
</tr>
<tr>
<td>Standard</td>
<td>Start switch</td>
<td>X142</td>
</tr>
</tbody>
</table>
(5) Sequence program

Make the following processing on sequence programs.

Figure 5.22 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

Table 5.17 Way of using the internal devices

<table>
<thead>
<tr>
<th>Internal</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>Designates a timer device. Times out after a lapse of the time specified at K□.</td>
</tr>
<tr>
<td>D0</td>
<td>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.</td>
</tr>
<tr>
<td>D1</td>
<td>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.</td>
</tr>
</tbody>
</table>

(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.

\[
\begin{array}{cccccccccccc}
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
\end{array}
\]

Figure 5.23 Word device bit specification
5.6.3 Entering detection and existence detection circuit

Figure 5.24 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](image)

(Partially quoted from "Safety Guide Book - the safety measures of machinery in the workplace" : Nippon Electric Control Equipment Industries Association.)
5.6.4 Entering detection and existence detection circuit 2

(2) Connection of safety devices

Figure 5.26 Safety device connection diagram

Remote (4): SR_IO4
X200-20F
Y200-203

Remote (1): SR_IO1
X100-10F
Y100-103

Remote (2): SR_IO2
X120-12F
Y120-123

Remote (3): SR_IO3
X140-14F
Y140-143

Wiring: Indicated in Figure 5.28.
Parameters: Indicated in Table 5.19.

Wiring: Indicated in Figure 5.27.
Parameters: Indicated in Table 5.18.

Wiring: Indicated in Figure 5.28.
Parameters: Indicated in Table 5.19.

Wiring: Indicated in Figure 5.4.
Parameters: Indicated in Table 5.6.
(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.

Connect two control output points (PNP output) of type 4 light curtain between the input terminal and COM-terminal.

Connect a 4-wire mat to the relay and connect the two relay contacts between the input terminal and test pulse terminal.

Figure 5.27 Remote (1) SR_IO1 wiring
For the light curtain and the mat switch, set the parameters as follows.

Table 5.18 Remote (1) SR_IO1 parameter settings

<table>
<thead>
<tr>
<th>Item</th>
<th>Setting range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of noise removal filter X4, 5¹</td>
<td>0: 1ms, 1: 5ms, 2: 10ms, 3: 20ms, 4: 50ms</td>
</tr>
<tr>
<td>Time of noise removal filter X8, 9¹</td>
<td>0: 1ms, 1: 5ms, 2: 10ms, 3: 20ms, 4: 50ms</td>
</tr>
<tr>
<td>Doubling input discrepancy detection time X4, 5¹</td>
<td>20ms (setting range: 20 to 500ms)</td>
</tr>
<tr>
<td>Doubling input discrepancy detection time X8, 9¹</td>
<td>20ms (setting range: 20 to 500ms)</td>
</tr>
<tr>
<td>Input dark test selection X4, 5</td>
<td>0: Execute, 1: Not execute</td>
</tr>
<tr>
<td>Input dark test selection X8, 9</td>
<td>0: Execute, 1: Not execute</td>
</tr>
<tr>
<td>Input dark test pulse OFF time¹</td>
<td>0: 400μs, 1: 1ms, 2: 2ms</td>
</tr>
</tbody>
</table>

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.

Figure 5.28 Remote (4) SR_IO4 wiring
For the contactors, set the parameters as follows.

### Table 5.19 Remote (4) SR_IO4 parameter settings

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

\(^1\): 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.

### Table 5.20 Device numbers to be used

<table>
<thead>
<tr>
<th>Safety/Standard</th>
<th>External device</th>
<th>Device number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Light curtain</td>
<td>X104 or X105</td>
</tr>
<tr>
<td>Safety</td>
<td>Mat switch</td>
<td>X108 or X109</td>
</tr>
<tr>
<td>Safety</td>
<td>Contactor 1 and 2</td>
<td>Y200 and Y201</td>
</tr>
<tr>
<td>Safety</td>
<td>Contactor (check for welding)</td>
<td>X208 or X209</td>
</tr>
<tr>
<td>Standard</td>
<td>Reset switch</td>
<td>X140</td>
</tr>
<tr>
<td>Standard</td>
<td>Start switch</td>
<td>X142</td>
</tr>
</tbody>
</table>
(5) Sequence program

Make the following processing on sequence programs.

Ladder which checks the off fall of the reset switch, accepts reset request, and clears the interlock for the CC-Link Safety.

Ladder which confirms the interlock processing completion and cancels interlock clear request.

Ladder which checks the off fall of the start switch and accepts start request.

Ladder which checks contactors for welding. T0 is a delay timer which waits for contactors to actually be turned off after the off output of the contactors.

Ladder which checks whether a robot can start and continue operation.

Ladder which clears start request/reset request when safety cannot be confirmed.

Ladder which controls outputs to contactors.

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

(a) Way of using the constant

$K\Box$: indicates decimal number.

Example) $K1\rightarrow$ indicates 1 of decimal number.
(b) Way of using the internal devices

Table 5.21 Way of using the internal devices

<table>
<thead>
<tr>
<th>Internal</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>Designates a timer device. Times out after a lapse of the time specified at K.</td>
</tr>
<tr>
<td>D0</td>
<td>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.</td>
</tr>
<tr>
<td>D1</td>
<td>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.</td>
</tr>
</tbody>
</table>

(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.

0000000000000001

Figure 5.30 Word device bit specification
### SAFETY APPLICATION CONFIGURATION EXAMPLE

#### 5.6 Case Examples

#### 5.6.4 Entering detection and existence detection circuit 2

**Figure 5.31 Timing chart**

<table>
<thead>
<tr>
<th></th>
<th>Approach</th>
<th>Exit</th>
<th>CC-Link remote (4) error</th>
<th>Approach</th>
<th>Detecting relay welding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reset SW (X140)</td>
<td>Pressing the reset SW</td>
<td>Pressing the start SW</td>
<td>Pressing the reset SW</td>
<td>Pressing the reset SW</td>
<td>Pressing the start SW</td>
</tr>
<tr>
<td>Restart status (D0.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restart status (D0.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start SW (X142)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start status (D1.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start status (D1.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interlock status (SD1272.0)</td>
<td></td>
<td>Light shielding of the light curtain</td>
<td>CC-Link error</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interlock clear (SD1276.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC-Link status (SD1204.0)</td>
<td></td>
<td>Stepping on a safety mat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light curtain (X104)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety mat (X108)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety information (M5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contactor 1 output (Y200)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contactor 2 output (Y201)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety contactor output check (X208)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Detecting welding

---

5.6 Case Examples

5.6.4 Entering detection and existence detection circuit 2
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.

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

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) 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
\[ WDT + (WDT \times n) \times 4 + (WDT \times n) \times m \text{ [ms]} \]
In asynchronous mode
\[ WDT + (WDT \times n) \times 4 + LS + (WDT \times n) \times m \text{ [ms]} \]
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.
Asynchronous mode: Mode which performs data link without synchronizing sequence program.

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, timeout 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 Table App. 1.

Figure App.1 Timing chart
APPENDIX

(a) Link scan time (LS)

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

\[
LS = BT \times (27 + (NI \times 4.8) + (NW \times 9.6) + (N \times 30) + (ni \times 4.8) + (nw \times 9.6) + TR) \\
+ ST + RT + F \ [\mu s] \ldots \text{LS calculation formula}
\]

<table>
<thead>
<tr>
<th>Transmission speed</th>
<th>156kbps</th>
<th>625kbps</th>
<th>2.5Mbps</th>
<th>5Mbps</th>
<th>10Mbps</th>
</tr>
</thead>
<tbody>
<tr>
<td>BT</td>
<td>51.2</td>
<td>12.8</td>
<td>3.2</td>
<td>1.6</td>
<td>0.8</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Final station No.</th>
<th>1 to 8</th>
<th>9 to 16</th>
<th>17 to 24</th>
<th>25 to 32</th>
<th>33 to 40</th>
<th>41 to 48</th>
<th>49 to 56</th>
<th>57 to 64</th>
</tr>
</thead>
<tbody>
<tr>
<td>NI,NW</td>
<td>8</td>
<td>16</td>
<td>24</td>
<td>32</td>
<td>40</td>
<td>48</td>
<td>56</td>
<td>64</td>
</tr>
</tbody>
</table>

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

- (for asynchronous mode only. For synchronous mode, ST = 0.)

- (1) or (2), whichever is greater. Ignore 2) when B = 0.)

1) 800 + (A × 15)

2) 900 + (B × 50)

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

\[ \alpha + \beta \times (\text{Number of detected faulty stations} - 1) \]

\[ \alpha : \text{Return processing time for 1}^{\text{st}} \text{module} \]

\[ BT \times ((200 + R) \times \text{Set number of retries} + 200) \]

\[ R: 51.6 + (NI \times 4.8) + (NW \times 9.6) \]

\[ \beta : \text{Return processing time for 2}^{\text{nd}} \text{or subsequent module} \]

\[ BT \times ((200 + P) \times \text{Set number of retries} + 200) \]

\[ P: 10.8 \]

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

\[ BT \times 218 \times \text{Number of automatic return modules} \]
If connecting the remote station to the station with the reserved station setting, and then clear the setting, the values of NI, NW, N, ni, and nw in the LS calculation formula will change. When the reserved station was changed, recalculate the LS and safety response performance. For the reserved station function, refer to the 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

\[
\begin{align*}
    n &= \frac{LS}{WDT} = 1.6/30 \rightarrow 1 \\
    m &= \frac{38}{(WDT \times n)} = \frac{38}{(30 \times 1)} \rightarrow 2 \\
    WDT + (WDT \times n) \times 4 + (WDT \times n) \times m \\
    &= 30 + (30 \times 1) \times 4 + (30 \times 1) \times 2 \\
    &= 210 \text{ [ms]}
\end{align*}
\]

2) In asynchronous mode

\[
\begin{align*}
    n &= \frac{LS}{WDT} = 3.0/30 \rightarrow 1 \\
    m &= \frac{38}{(WDT \times n)} = \frac{38}{(30 \times 1)} \rightarrow 2 \\
    WDT + (WDT \times n) \times 4 + LS + (WDT \times n) \times m \\
    &= 30 + (30 \times 1) \times 4 + 3 + (30 \times 1) \times 2 \\
    &= 213 \text{ [ms]}
\end{align*}
\]

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

\[
\begin{align*}
    DT1 + DT2 + 64 + \text{Time of noise removal filter} + (\text{Safety refresh monitoring time} \times 3) - ((WDT \times n) \times 6)
\end{align*}
\]

1) In synchronous mode

\[
\begin{align*}
    DT1 + DT2 + 64 + \text{Time of noise removal filter} + (\text{Safety refresh monitoring time} \times 3) - ((WDT \times n) \times 6) \\
    &= DT1 + DT2 + 64 + 1 + 210 \times 3 - ((30 \times 1) \times 6 ) \\
    &= DT1 + DT2 + 515 \text{ [ms]}
\end{align*}
\]

2) In asynchronous mode

\[
\begin{align*}
    DT1 + DT2 + 64 + \text{Time of noise removal filter} + (\text{Safety refresh monitoring time} \times 3) - ((WDT \times n) \times 6) \\
    &= DT1 + DT2 + 64 + 1 + 213 \times 3 - ((30 \times 1) \times 6 ) \\
    &= DT1 + DT2 + 524 \text{ [ms]}
\end{align*}
\]
(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).

<table>
<thead>
<tr>
<th>Station No.1</th>
<th>Station No.2</th>
<th>Station No.3</th>
<th>Station No.5</th>
<th>Station No.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety master station</td>
<td>Safety remote I/O station</td>
<td>Standard remote I/O station</td>
<td>Reserved station</td>
<td>Remote device station</td>
</tr>
</tbody>
</table>

*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 × \((27 + (NI \times 4.8) + (NW \times 9.6) + (N \times 30) + (ni \times 4.8) + (nw \times 9.6) + TR) + RT + F\)

= 3.2 × \((27 + (16 \times 4.8) + (16 \times 9.6) + (4 \times 30) + (7 \times 4.8) + (6 \times 9.6) + 38.4) + 0 + 0\)

= 1622.4 [μs]  
= 1.6 [ms]

In asynchronous mode

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

= 3.2 × \((27 + (16 \times 4.8) + (16 \times 9.6) + (4 \times 30) + (7 \times 4.8) + (6 \times 9.6) + 38.4) + 1350 + 0 + 0\)

= 2972.4 [μs]  
= 3.0 [ms]
## Appendix.2 Checklist

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Reference</th>
<th>Check</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Were the created date and author entered at the top of the sequence program using the statement function of GX Developer?</td>
<td>Section 4.2(5)</td>
<td>☐</td>
</tr>
<tr>
<td>2</td>
<td>When modifying the sequence program, were the created date, author, and modified description entered at the modified place using the statement function?</td>
<td>Section 4.2(5)</td>
<td>☐</td>
</tr>
<tr>
<td>3</td>
<td>Were the data downloaded to the PLC stored into the hard disk of a personal computer or CD?</td>
<td>Section 4.2(5)</td>
<td>☐</td>
</tr>
<tr>
<td>4</td>
<td>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?</td>
<td>Section 4.3(1)</td>
<td>☐</td>
</tr>
<tr>
<td>5</td>
<td>Were the appropriate values set to Safety refresh monitoring time and WDT Setting?</td>
<td>Appendix.1</td>
<td>☐</td>
</tr>
<tr>
<td>6</td>
<td>When the safety system is shifted to the actual operation, is the operation mode set to the SAFETY MODE?</td>
<td>Section 4.4(3)</td>
<td>☐</td>
</tr>
<tr>
<td>7</td>
<td>Were all safety application functions (e.g. emergency stop function, restart interlock) inspected?</td>
<td>---</td>
<td>☐</td>
</tr>
<tr>
<td>8</td>
<td>Were the response time of the safety application inspected?</td>
<td>---</td>
<td>☐</td>
</tr>
<tr>
<td>9</td>
<td>Before writing the data to the PLC, was it confirmed that sequence program and parameter setting values were configured as desired?</td>
<td>Section 4.3(2)</td>
<td>☐</td>
</tr>
<tr>
<td>10</td>
<td>Was it confirmed that the ROM information of CPU corresponds with that of the project file with the ROM information screen of GX Developer?</td>
<td>Section 4.4(4)</td>
<td>☐</td>
</tr>
<tr>
<td>11</td>
<td>Was it confirmed that there are no errors with the LEDs on the module and the PLC diagnostics screen of GX Developer?</td>
<td>---</td>
<td>☐</td>
</tr>
<tr>
<td>12</td>
<td>In output signals from a safety CPU module to the CC-Link Safety master module on sequence program, was it confirmed that &quot;prohibited to use&quot; signal was not mistakenly turned on or off? (For &quot;prohibited to use&quot; signal, refer to the CC-Link Safety System Master Module User's Manual.)</td>
<td>---</td>
<td>☐</td>
</tr>
<tr>
<td>13</td>
<td>Are the registered passwords (Login password, CPU access password) managed properly?</td>
<td>Section 4.4(5)</td>
<td>☐</td>
</tr>
</tbody>
</table>
INDEX

[A]
Application example .............................................. 2-1

[C]
Case examples
  Door lock circuit ............................................... 5-14
  Emergency stop circuit........................................ 5-8
  Light curtain, laser scanner .................................. 5-20
  Light curtain, mat switch .................................... 5-28
Category .................................................................. A-16,3-3
CC-Link Parameter Settings ....................................... 5-4
Checklist .................................................................. 4-10,Appendix-7

[E]
  EN954-1 ................................................................ 3-3
  Error detection of CC-Link Safety .............................. 4-7

[H]
  High demand mode of operation .............................. 3-5

[I]
  IEC61508 ................................................................ 1-1,3-5
  ISO12100 ........................................................ 3-1,3-2
  ISO14121 ........................................................ 3-1,3-2

[L]
  Link scan time ................................................... Appendix-1
  Low demand mode of operation ............................. 3-5
  LS ................................................................... Appendix-1

[M]
  Module replacement ............................................. 4-10

[N]
  NI ..................................................................... Appendix-4

Symbols
  NW .................................................................... Appendix-4

[P]
  Password management ........................................ 4-11
  Periodic inspection .............................................. 4-10
  PFD .................................................................. A-16,3-5,4-1
  PFH .................................................................. A-16,3-5,4-1
  Production information .......................................... 5-5

[R]
  Related manuals ................................................ A-11
  Reset of CC-Link Safety error ................................ 4-8
  Response time .................................................... 4-11
  Risk .................................................................. A-16

Risk assessment.................................................. A-16,3-1
Risk graph........................................................... 3-3,3-5
Risk reduction .................................................... 3-2
ROM information management ......................... 4-11

[S]
  Safety component .................................................. A-16
  Safety functions .................................................. A-16
  Safety input ........................................................ A-15,4-6
  Safety output ...................................................... A-15,4-6
  Safety precautions .............................................. A-1
  Safety refresh monitoring time ................................. Appendix-1
  Safety status ....................................................... 4-5
  Safety-related system .......................................... A-16,4-5
  Scan time .......................................................... Appendix-1
  SIL .................................................................... A-16,3-5
  SM (Scan time) ................................................... Appendix-1
  Standard remote ................................................ A-15
  Switch setting ..................................................... 5-2
  System configuration .......................................... 1-1

[T]
  Target failure measure(PFD, PFH) ........ A-16,3-5,4-1

[U]
  Unit replacement .................................................. 4-10
  User registration ................................................ A-15

[W]
  Watchdog timer .................................................. Appendix-1
  WDT .............................................................. Appendix-1

Index - 1
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   (5) that fails because consumable parts such as batteries, backlights, or fuses were not tested, serviced or replaced;
   (6) operated or used with equipment, production lines or systems that do not meet applicable and commensurate legal, safety and industry-accepted standards;
   (7) operated or used in abnormal applications;
   (8) installed, operated or used in contravention of instructions, precautions or warnings contained in MELCO's user, instruction and/or safety manuals, technical bulletins and guidelines for the Products;
   (9) used with obsolete technologies or technologies not fully tested and widely accepted and in use at the time of the Product's manufacture;
   (10) subjected to excessive heat or moisture, abnormal voltages, shock, excessive vibration, physical damage or other improper environment; or
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<table>
<thead>
<tr>
<th>MODEL CODE</th>
<th>QSCPU-APPLI-E</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODEL CODE</td>
<td>13JR90</td>
</tr>
<tr>
<td>SH(NA)-080613ENG-B(0703)MEE</td>
<td></td>
</tr>
</tbody>
</table>

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