The right choice for the ultimate yield!

LS ELECTRIC strives to maximize your profits in gratitude for choosing us as your partner.

Safety Controller

XGS Safety Controller

XGT Series

User Manual

XGS-CPU01A
XGS-DI08A
XGS-DIO84A

Safety Instructions

- Read this manual carefully before installing, wiring, operating, servicing or inspecting this equipment.
- Keep this manual within easy reach for quick reference.

LS ELECTRIC

Before using the product …

For your safety and effective operation, please read the safety instructions thoroughly before using the product.

- Safety Instructions should always be observed in order to prevent accident or risk with the safe and proper use the product.

- Instructions are separated into “Warning” and “Caution”, and the meaning of the terms is as follows;

⚠ **Warning**	This symbol indicates the possibility of serious injury or death if some applicable instruction is violated
⚠ **Caution**	This symbol indicates the possibility of slight injury or damage to products if some applicable instruction is violated

- The marks displayed on the product and in the user’s manual have the following meanings.

  ⚠ Be careful! Danger may be expected.

  ⚠ Be careful! Electric shock may occur.

- The user’s manual even after read shall be kept available and accessible to any user of the product.

Safety Instructions when designing

⚠Warning

- **Please, install protection circuit on the exterior of PLC to protect the whole control system from any error in external power or PLC module.** Any abnormal output or operation may cause serious problem in safety of the whole system.
  - Install applicable protection unit on the exterior of PLC to protect the system from physical damage such as emergent stop switch, protection circuit, the upper/lowest limit switch, forward/reverse operation interlock circuit, etc.
  - If any system error (watch-dog timer error, module installation error, etc.) is detected during CPU operation in PLC, the whole output is designed to be turned off and stopped for system safety. However, in case CPU error if caused on output device itself such as relay or TR can not be detected, the output may be kept on, which may cause serious problems. Thus, you are recommended to install an addition circuit to monitor the output status.

- **Never connect the overload than rated to the output module nor allow the output circuit to have a short circuit**, which may cause a fire.

- **Never let the external power of the output circuit be designed to be On earlier than PLC power**, which may cause abnormal output or operation.

- **In case of data exchange between computer or other external equipment and PLC through communication or any operation of PLC (e.g. operation mode change), please install interlock in the sequence program to protect the system from any error**. If not, it may cause abnormal output or operation.

Safety Instructions when designing

⚠ Caution

- **I/O signal or communication line shall be wired at least 100mm away from a high-voltage cable or power line.** If not, it may cause abnormal output or operation.

Safety Instructions when designing

⚠ Caution

- **Use PLC only in the environment specified in PLC manual or general standard of data sheet.** If not, electric shock, fire, abnormal operation of the product or flames may be caused.
- **Before installing the module, be sure PLC power is off.** If not, electric shock or damage on the product may be caused.
- **Be sure that each module of PLC is correctly secured.** If the product is installed loosely or incorrectly, abnormal operation, error or dropping may be caused.
- **Be sure that I/O or extension connecter is correctly secured.** If not, electric shock, fire or abnormal operation may be caused.
- **If lots of vibration is expected in the installation environment, don't let PLC directly vibrated.** Electric shock, fire or abnormal operation may be caused.
- **Don't let any metallic foreign materials inside the product**, which may cause electric shock, fire or abnormal operation.

Safety Instructions when wiring

⚠ Warning

- **Prior to wiring, be sure that power of PLC and external power is turned off.** If not, electric shock or damage on the product may be caused.

- **Before PLC system is powered on, be sure that all the covers of the terminal are securely closed.** If not, electric shock may be caused

⚠ Caution

- **Let the wiring installed correctly after checking the voltage rated of each product and the arrangement of terminals.** If not, fire, electric shock or abnormal operation may be caused.

- **Secure the screws of terminals tightly with specified torque when wiring.** If the screws of terminals get loose, short circuit, fire or abnormal operation may be caused.

- **Surely use the ground wire of Class 3 for FG terminals, which is exclusively used for PLC**. If the terminals not grounded correctly, abnormal operation may be caused.

- **Don't let any foreign materials such as wiring waste inside the module while wiring,** which may cause fire, damage on the product or abnormal operation.

Safety Instructions for test-operation or repair

⚠ Warning

- **Don't touch the terminal when powered**. Electric shock or abnormal operation may occur.
- **Prior to cleaning or tightening the terminal screws, let all the external power off including PLC power.** If not, electric shock or abnormal operation may occur.
- **Don't let the battery recharged, disassembled, heated, short or soldered**. Heat, explosion or ignition may cause injuries or fire.

⚠ Caution

- **Don't remove PCB from the module case nor remodel the module.** Fire, electric shock or abnormal operation may occur.
- **Prior to installing or disassembling the module, let all the external power off including PLC power.** If not, electric shock or abnormal operation may occur.
- **Keep any wireless installations or cell phone at least 30cm away from PLC**. If not, abnormal operation may be caused.

Safety Instructions for waste disposal

⚠ Caution

- **Product or battery waste shall be processed as industrial waste.** The waste may discharge toxic materials or explode itself.

Revision History

Version	Date	Remark	Chapter
V1.0	’15.10	First Edition	-
V1.0	’20.5	LSIS to change its corporate name to LS ELECTRIC	Entire

Thank you for purchasing PLC of LS ELECTRIC Co., Ltd.
Before use, make sure to carefully read and understand the User's Manual about the functions, performances, installation and programming of the product you purchased in order for correct use and importantly, let the end user and maintenance administrator to be provided with the User's Manual.

The User's Manual describes the product. If necessary, you may refer to the following description and order accordingly. In addition, you may connect our website (http://www.lselectric.co.kr/) and download the information as a PDF file.

Relevant User's Manuals

Title	Description
XG5000 User's Manual (for XGI, XGR)	XG5000 software user manual describing online function such as programming, print, monitoring, debugging by using XGI, XGR CPU.

Current user manual is written based on the following version.

Related OS version list

Product name	OS version
XGS-CPU01A	V1.10
XGS-DI08A	V1.10
XGS-DIO84A	V1.10

◎ TABLE OF CONTENTS ◎

Chapter 1 Introduction

1.1 How to Use this Users' Manual

This users' manual provides the information on the specifications, performance, functions and operation required for using the XGS Series safety controller.

Constitution of the user's manual is as follows;

Chapter	Subject	Description
Chapter 1	Introduction	Describes the constitution of the manual, and characteristics and terms used in relation with the product.
Chapter 2	System Constitution	Describes the product types available for the XGS Series and system configuration.
Chapter 3	General Specification	Describes basic specifications of the modules of the XGS Series.
Chapter 4	CPU Module Specification	Describes function, specification and operation of XGS CPU Module.
Chapter 5	Program Structure and Operation	
Chapter 6	Functions of CPU Module	
Chapter 7	Input/Output Module	Describes specification and operation of I/O module.
Chapter 8	Functions of I/O Module	
Chapter 9	Installation and Wiring	Describes installation and wiring of the system to ensure high reliability.
Chapter 10	Maintenance	Describes manual procedures of the system maintenance to ensure normal operation.
Chapter 11	EMC Compatibility	Describes system configuration to meet EMC requirements.
Chapter 12	Troubleshooting	Describes the errors which may occur during operation and measures to reset errors.
Chapter 13	Safety Function Block	Describes the method of using the safety function block.
Appendix 1.	Flag List	Provides the list and description of flags.
Appendix 2.	PFD/PFH Calculations	Provides information on PFD/PFH Calculations
Appendix 3.	Dimensions	Provides information on the outer dimensions of the CPU and I/O module.

1.2 Features

The XGS Safety Controller has following features.

1) Compatible to international safety standards

A safety control system can be built to satisfy international safety standards.

- SIL3 (IEC61508)
- SILCL3 (IEC62061)
- Category 4 (ISO 13849-1)

2) Compact size

Innovative compact size compared to the performance – saving expensive space.

3) System configuration

A number of user convenience functions are provided to meet user requirements.

- Input module filter value adjustment
- Enhanced self diagnosis function to save installation, commissioning and maintenance costs

4) Communication system

Network functionality is provided to achieve user convenience, compatibility and performance.

- Networking without ladder programming
- Dedicated network providing user convenience and optimized performance.

5) Enhanced programming and online functions

Simplified programming reduces programming time and enhanced online function enables completion of control systems without stopping the objective system.

6) User convenience

Use convenience further enhanced with various additional functions.

- Self-diagnosis function
- Various operation histories provided.

1.3 Terminology

For the purpose of this document, the following terms shall have the following definitions:

Term	Definition	Remark
Module	A standardized unit having a specific function, for constituting the entire system, e.g., I/O board.	E.g.) CPU module, Input/Output module
PLC System	A system comprising PLC and peripheral devices configured to be able to be controlled by user programs.	-
XG5000	A programming tool having the functions of creating, editing and debugging programs.	-
I/O image domain	Internal memory domain of CPU module provided to maintain input/output status.	-
Safety Controller	High reliability controller for safety control.	-
Mismatch time	Time elapsed from a change in one of two inputs to the corresponding change in the other input.	-
PFD (Probability of Failure on Demand)	Indicated mean failure rate of a system of device. Used to calculate SIL (Safety Integrity Level) of a safety system.	-
PFH (Probability of Failure per Hour)	Indicates per hour failure rate of a system or device. Used to calculate SIL (Safety Integrity Level) of a safety system.	-
Function	An operation unit which outputs result of operation right out, not saving the result in the command, for example, the four arithmetical operations, comparison operation.	-
Function block	An operation unit which makes use of operation results memorized across a plurality of scans, such as a timer and counter which memorizes operation result in the command.	-
Direct variables	The variables used without declaring name and type, for example, I, Q, and M domains.	E.g.)•%IX0.0.2 •%QW1.2.1 •%MD1234, etc.

Term	Definition	Remark
Symbolic variables	The variables used after declaration of name and type by the user. For example, declaring: 'INPUT_0' =%IX0.0.2, 'RESULT'=%MD1234, the programming can be created by the names of 'INPUT_0' and 'RESULT' instead of %IX0.0.2 and %MD1234.	-

Chapter 2 System Configuration

This chapter describes the method for constitution and characteristics of the system.
XGS Series safety controller has acquired the safety certification of PLe (ISO13849-1) and SIL3 (IEC61508). It can be used to build a safety system of SIL3 of IEC61508, PLe (category 4) of ISO13849-1.

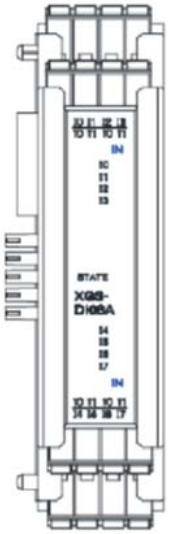
2.1 XGS Series Safety Controller System Configuration

The constitution of the XGS Series Safety Controller system is as shown in the figure below.
The XGS Series Safety Controller comprises two type of modules: safety CPU module and digital I/O module.

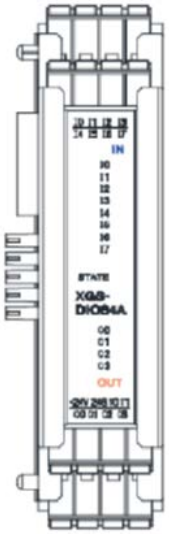
Programing Tool
XG5000

USB Cable
Ethernet Cable

Safety CPU Module
XGS-CPU01A



Safety Input
Module
XGS-DI08A



Safety In/Output
Module
XGS-DIO84A

2.2 Product Components

The constitution of the XGS Series Safety Controller product is as shown in the table below.

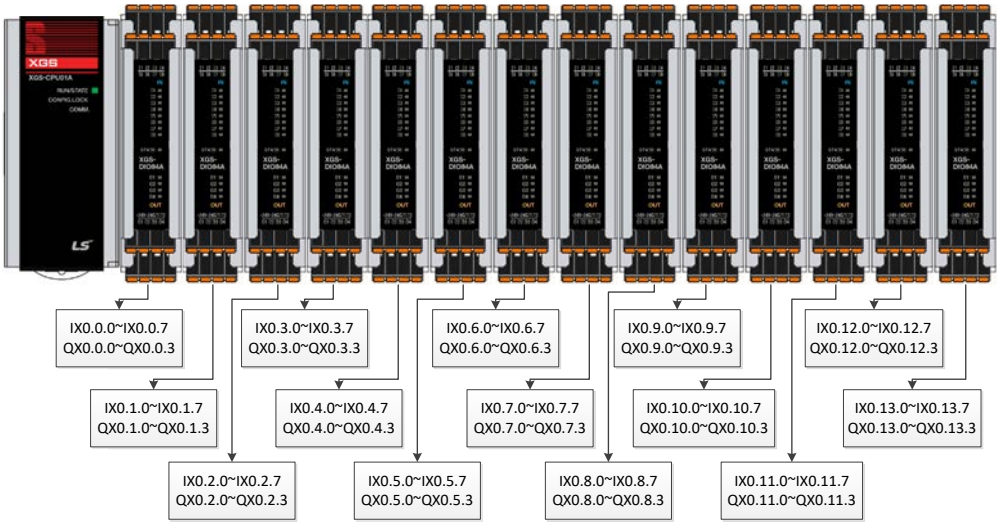
Product Name	Model	Description
Safety CPU Module,	XGS-CPU01A	• Safety CPU module (Executable program size: 256KB, upload program size: 512KB)
Safety Digital Input Module	XGS-DI08A	• DC 24V safety input: 8 inputs • Test pulse output: 2 outputs
Safety Digital Input/Output Module	XGS-DIO84A	• DC 24V safety input: 8 inputs • Test pulse output: 2 outputs • DC 24V safety output: 4 outputs

2.3 Basic System

2.3.1 Configuration of the basic system

A configuration of the system comprising safety CPU module and safety digital input module or safety digital input/output module is as follows:

Classification	XGS-CPU01A
Max. additional modules	14 modules
Max. No. of I/O points	• Max. inputs: (8 points) x (14 modules) = 112 points • Max. outputs: (4 points) x (14 modules) = 56 points • Max. No. of I/O points: 168
I/O domain allocation	• I/O numbers are allocated by 64 points per slot. • Each slot is allocated with 64 points regardless of module installation. • Below is an example of I/O number allocation to 14 slot.



NOTE

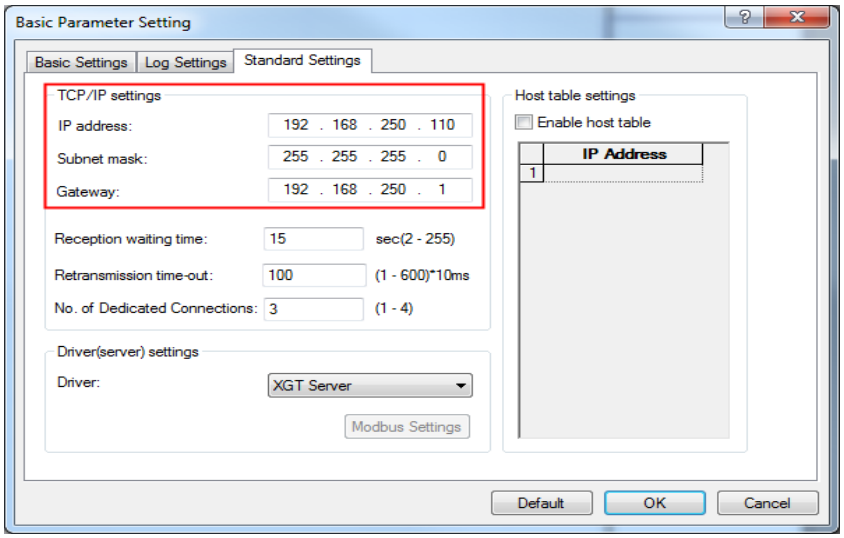
1) System can start operation only when the types of the modules set up with I/O parameters agree with the actual module types.
2) Module or system change is not allowed during system operation. For the change, system power supply must be cut off.
3) During system configuration, you must configure the safety system and the general system separately.
4) All sensors, field control devices and the wiring / equipment connected to the system are recommended to install security features that required in accordance with the IEC62061, EN ISO13849-1.

2.4 Network System

The XGS Safety Controller provides built-in Ethernet communication by the safety CPU module for monitoring with common PLC and HMI.

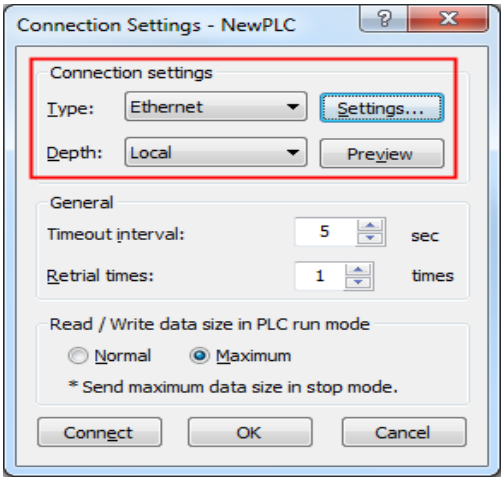
2.4.1 Ethernet setting-up

To use the built-in Ethernet in the safety CPU module, Ethernet parameters have to be set up using XG5000. In the [Basic Parameter] – [FEnet Basic Setting] window, set up IP address, subnet mask, and gateway, and write the setting in the PLC. As soon as the parameters are written while the connection to CPU module is made via USB, the parameters are applied. If they are written via Ethernet, new parameters will be applicable after system reset.

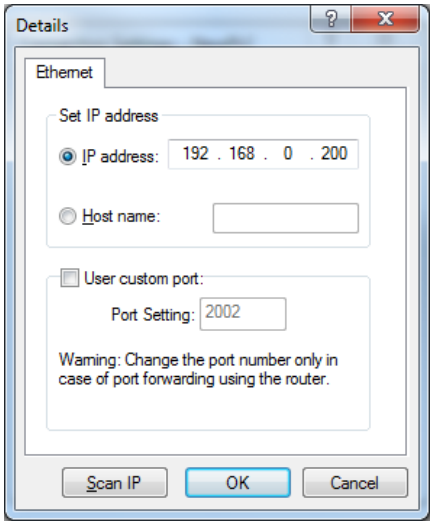


2.4.2 XG5000 Connection

Safety CPU module can be accesses via Ethernet connection.
Select: [Online]-[Set-up Access], in the access setting dialog, select Ethernet.



Select [Setting (S)…], and in the dialog, input the IP address set up at the Safety Controller and press [Confirm] button.



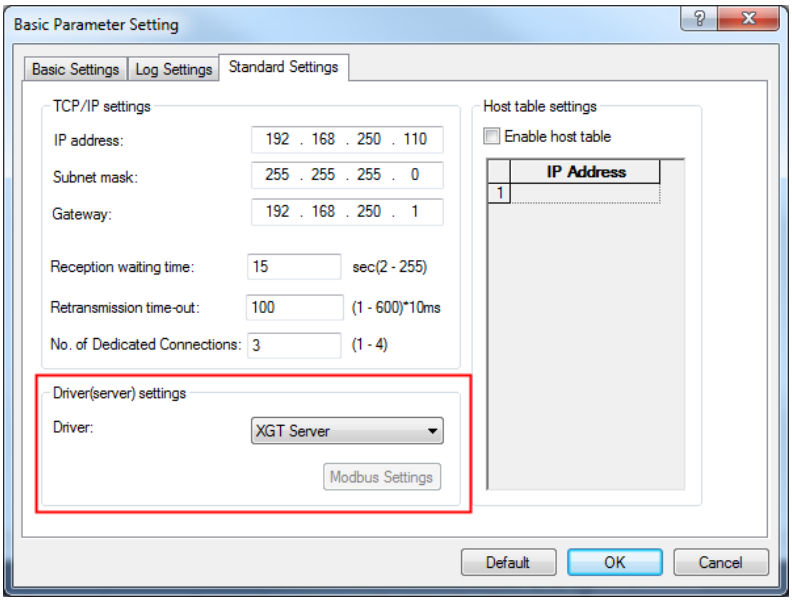
In the access setting dialog, press [Access] button to access via Ethernet.
Note that the access is allowable after Ethernet setting has been written in the safety CPU module via the first USB connection.

2.4.3 Setting up communication service

The safety CPU module provides dedicated communication server (XGT server) function and Modbus server function.

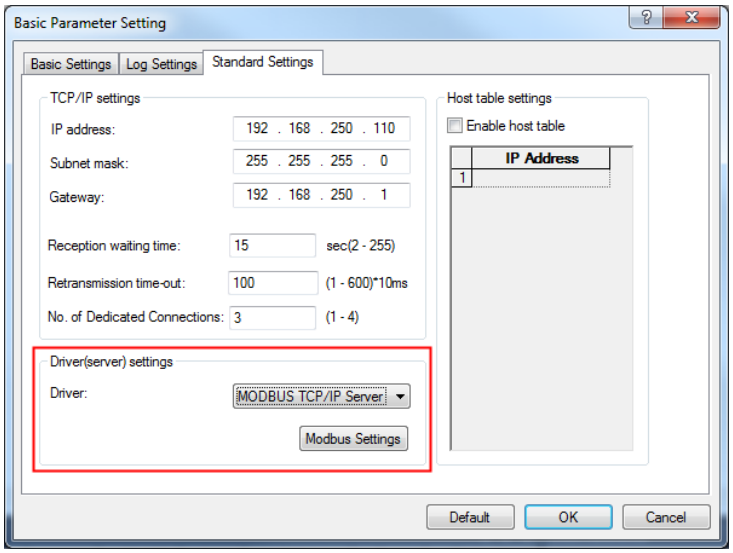
2.4.3.1 Dedicated communication server

In the [Basic Parameter] – [FEnet Basic Setting] dialog, select XGT server from the drivers, and conduct writing in PLC to provide dedicated communication server function.

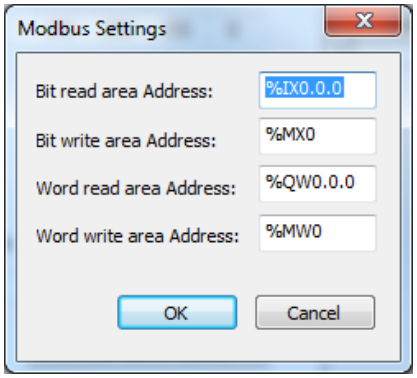


2.4.3.2 Modbus TCP/IP server

From the driver of [Basic Parameter] – [Ethernet Setting] dialog, select Modbus TCP/IP server.



Pressing the Modbus setting button will show the setting dialog shown below. Input the starting addresses in the bit read domain, bit write domain, word read domain and word write domain, and write in the PLC to execute Modbus TCP/IP server function.



NOTE

1) Ethernet communication is connected via a switching hub.
2) Up to 4 exclusive access points are supported.
3) The client can read I, Q, IS, QS, TS, and M domains of the Safety Controller.
   Write command is applicable in the M domain only.
4) For reading IS, QS, and TS domains, set up by referring to the table below:

Safety CPU module domain	When designated by client
ISB0 ~ ISB511	WB0 ~ WB511
QSB0 ~ QSB511	WB512 ~ WB1023
TSB0 ~ TSB511	WB1024 ~ WB1535

Chapter 3 General Specifications

3.1 General Specifications

The general specifications of the XGS series are as follows.

<table>
<tr><th>No.</th><th>Items</th><th colspan="6">Specifications</th><th>Related standards</th></tr>
<tr><td>1</td><td>Ambient temperature</td><td colspan="6">0 ~ 55 °C</td><td></td></tr>
<tr><td>2</td><td>Storage temperature</td><td colspan="6">–25 ~ +70 °C</td><td></td></tr>
<tr><td>3</td><td>Ambient humidity</td><td colspan="6">5 ~ 95%RH (Non-condensing)</td><td></td></tr>
<tr><td>4</td><td>Storage humidity</td><td colspan="6">5 ~ 95%RH (Non-condensing)</td><td></td></tr>
<tr><td rowspan="9">5</td><td rowspan="9">Vibration resistance</td><td colspan="5">Occasional vibration</td><td>-</td><td></td></tr>
<tr><td>Frequency</td><td colspan="2">Acceleration</td><td>Amplitude</td><td>times</td><td rowspan="9">IEC61131-2</td></tr>
<tr><td>5 ≤ f < 8.4Hz</td><td colspan="2">–</td><td>3.5mm</td><td rowspan="6">10 times each directions (X, Y and Z)</td></tr>
<tr><td>8.4 ≤ f ≤ 150Hz</td><td colspan="2">9.8m/s^2(1G)</td><td>–</td></tr>
<tr><td colspan="5">Continuous vibration</td></tr>
<tr><td>Frequency</td><td colspan="2">Acceleration</td><td>Amplitude</td></tr>
<tr><td>5 ≤ f < 8.4Hz</td><td colspan="2">–</td><td>1.75mm</td></tr>
<tr><td>8.4 ≤ f ≤ 150Hz</td><td colspan="2">4.9m/s^2(0.5G)</td><td>–</td></tr>
<tr><td>6</td><td>Shock resistance</td><td colspan="6">• Peak acceleration: 147 m/s^2(15G)
• Duration: 11ms
• Half-sine, 3 times each direction per each axis</td><td>IEC61131-2</td></tr>
<tr><td rowspan="5">7</td><td rowspan="5">Noise resistance</td><td>Square wave Impulse noise</td><td colspan="5">DC : ± 900V</td><td>LS ELECTRIC standard</td></tr>
<tr><td>Electrostatic discharge</td><td colspan="5">Voltage: 4kV (Contact discharge)</td><td>IEC61131-2
IEC61000-1-2</td></tr>
<tr><td>Radiated electromagnetic field noise</td><td colspan="5">80 ~ 500 MHz, 10V/m</td><td>IEC61131-2,
IEC61000-4-3</td></tr>
<tr><td rowspan="2">Fast transient/bust noise</td><td>Segment</td><td>Power supply module</td><td colspan="3">Digital/analog input/output communication interface</td><td rowspan="2">IEC61131-2
IEC61000-1-4</td></tr>
<tr><td>Voltage</td><td>2kV</td><td colspan="3">1kV</td></tr>
<tr><td>8</td><td>Environment</td><td colspan="6">Free from corrosive gasses and excessive dust</td><td></td></tr>
<tr><td>9</td><td>Altitude</td><td colspan="6">Up to 2,000 ms</td><td></td></tr>
<tr><td>10</td><td>Pollution degree</td><td colspan="6">2 or less</td><td></td></tr>
<tr><td>11</td><td>Cooling</td><td colspan="6">Air-cooling</td><td></td></tr>
</table>

Note

1) IEC (International Electrotechnical Commission):
An international nongovernmental organization which promotes internationally cooperated standardization in electric/electronic field, publishes international standards and manages applicable estimation system related with.

2) Pollution degree:
An index indicating pollution degree of the operating environment which decides insulation performance of the devices. For instance, Pollution degree 2 indicates the state generally that only non-conductive pollution occurs. However, this state contains temporary conduction due to dew produced.

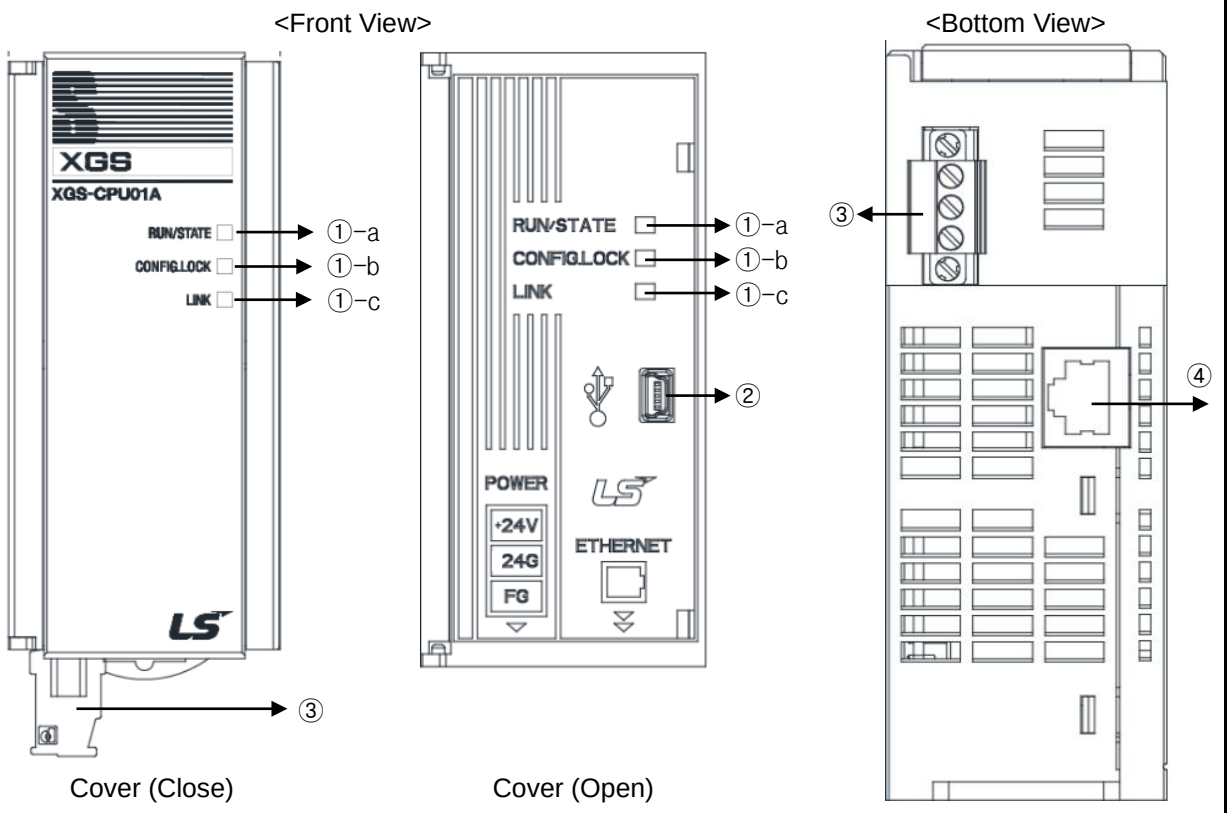
Chapter 4 Safety CPU Module

4.1 Performance Specifications

The performance specification of the safety CPU module (XGX-CPU01A) is presented in the table below.

Item		Description	Remark
Operation mode		Cyclic operation	-
I/O control mode		Scan synchronization batch processing (refresh mode)	-
Program language		Ladder diagram	-
No. of instructions	Basic function	6	-
	Basic function block	11	-
	Safety function block	17	-
Program memory size		256KB	Upload program size (512KB)
No. of I/O modules		Max 14 modules	-
I/O points (supported)		168 points (input 112, output 56)	-
Data memory	Auto variables scope (A)	10KB	Symbolic variables scope
	Input variables (I)	512B	Safety input image domain
	Input status (I)	512B	Safety input diagnosis image domain
	Output variables (Q)	512B	Safety output image domain
	Output status (QS)	512B	Safety output diagnosis image domain
	Test pulse status (TS)	512B	Test pulse diagnosis image domain
	Direct variables (M)	256B	Direct variables domain
	Flag variables (F)	1KB	System flag
Diagnosis function		Power failure, internal memory failure, I/O failure, program failure, operational device failure, module interface failure	-
Operation mode		RUN/STOP, safety lock/lock release, normal/safety mode	-
Applicable specification		SIL 3 (IEC 61508 : 2009) SILCL 3 (IEC 62061 : 2005) PLe, Category 4 (EN ISO 13849-1 : 2008)	-
Power supply		DC +24V (DC +19.2 ~ 28.8V) Extra-Low Voltages with Safe Separation power supply (SELV, PELV)	Safety Extra Low Voltage (SELV) Protective Extra Low Voltage (PELV)
PFH		3.43014×10^{-09}	-
PFD		2.478×10^{-05}	-
SFF		98.1694 %	-
H/W Fault Tolerance		1	-
Internal consumption current		130 mA	-
Weight		260g	-

4.2 Part Names and Functions



No.	Name	Description
①-a	RUN/STATE LED	Indicates operating status of the safety CPU module. • Green lamp On: operating in RUN mode • Red lamp On: operating in STOP mode • Red flashing: the system is in safety mode due to a system error
①-b	Config. Lock LED	Indicates Configuration Lock status. • Yellow lamp On: operating in Configuration Lock status • Yellow lamp flashing: operating in Configuration Unlock status
①-c	LINK LED	Indicates Ethernet Link status. • Green lamp On: Ethernet cable is connected, indicating ‘Ethernet Link’ status • Red lamp Off: Ethernet cable is disconnected, indicating 'Ethernet Unlink' status It indicates physical connection only, not actual communication.
②	USB connector	USB connector for accessing XG5000
③	Power connector	DC 24V power supply terminal block for the Safety Controller system (+24V, 24G, FG)
④	Ethernet connector	Ethernet communication connector (accessible to XG5000)

Chapter 5 Program Structure and Operation

5.1 Program Basics

5.1.1 Program execution method

1) Cyclic operation mode (Scan)

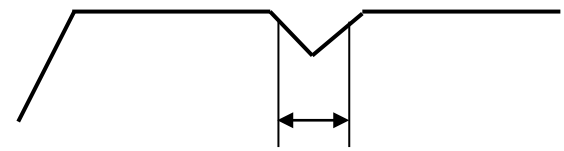
This is the typical program execution mode of PLC. Operation is carried out from the first to the last step of a program and this process is called program scan. A series of process conducted as described above is called loop operation mode The process is described in detail below by being classified into steps.

Step	Description of the Process
START	—
Initialization	• The step for starting scanning, executed once at system power on or reset to perform following functions. ▸ Reset I/O module ▸ Run self-diagnosis ▸ Clear data ▸ Allocate address and register type of I/O modules
Refresh input image domain	• Before starting program operation, read the status of the input module and save it in the input image domain.
Program Operation Start program ⋮ End program	• Perform operation from the beginning to the end of the program sequentially.
Refresh output image domain	• At the end of program operation, the content saved in the output image domain is outputted to the output module
END	• For the CPU module to return to the first step after finishing a scan process, following actions are performed: ▸ Refresh present user timer value ▸ Perform self diagnosis ▸ Perform communication service (Dedicated communication server, Modbus TCP/IP server, XG5000 service) ▸ Process mode change request

5.1.2 Operation in instantaneous power failure

In the event that the voltage input to the safety CPU module is lower than the specification, following actions are carried out: Normal function is continued for a power failure shorter than 10ms.
If the power fails for longer than 10ms, operation is stopped and output is turned off. Operation is resumed automatically at power recovery.

(1) Instantaneous power failure less than 10ms

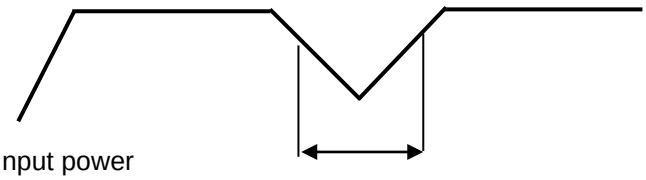


Input power

Power failure 10ms or less

• CPU continues operation.

(2) Instantaneous power failure longer than 10 ㎳



Input power

Power failure 10ms or longer

• System restarts at power return.

NOTE

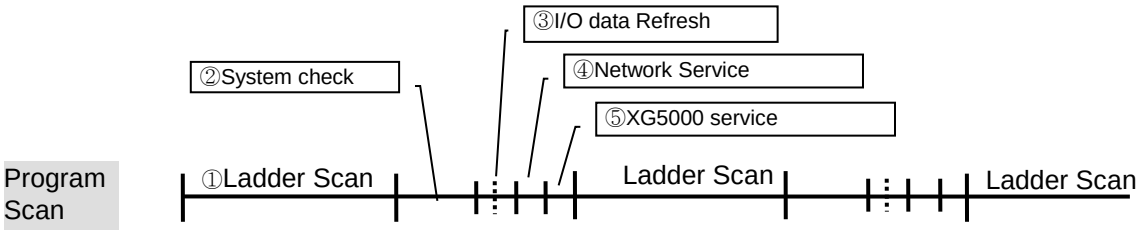
1) What is instantaneous power failure?
The system input voltage is lower than the allowable limit specified for the PLC for a very short time (several ms ~ tens of ms).

5.1.3 Scan Time

Scan time is the time elapsed from 0 step of program to the next 0 step, that is the time elapsed for completing one control operation.

1) Operation mode and performance of XGS Series Safety Controller System
Major elements affecting the scan time includes program processing time, self diagnosis time, I/O data processing time, and communication service time.

2) Calculating scan time
The safety CPU module carries out control function in the sequence shown below. The user can estimate control performance of the system that the user is planning using the calculation method below.
The minimum scan time is 4 ms.



(1) Scan time = ① Processing scan program + ② System check + ③ I/O data Refresh + ④ Network Service + ⑤ XG5000 Service

① Processing scan program = the time expected to elapse for program inspection by XG5000
② System check = Time for self diagnosis + Time for MUC synchronization
[May increase according to the use of automatic allocation variables.]
= 900 μs + 800 μs
③ I/O data refresh = 400 μs per safety I/O module
④ Network Service (built-in Ethernet communication)
⑤ XG5000 Service processing time = 500 μs for max. data monitoring

(2) Example

The scan time for [Estimated time for ladder program running (5.16 ms) + System comprising 2 I/O modules] is as follows:

Scan time (μs) = Time for executing ladder + System processing time + I/O module processing time + Communication processing time + XG5000 Service processing time
= (5,160) + (1,700) + (400 X 2) + (0) + (500)
= 8.16 ms

3) Monitoring scan time

(1) Scan time is saved in the following flag (F) areas:
_SCAN_MAX : max. scan time (0.1 ms unit)
_SCAN_MIN : min. scan time (0.1 ms unit)
_SCAN_CUR : current value of scan time (0.1 ms unit)

(3) Scan time can be monitored by; [Online] – [Diagnosis] – [PLC Information] of XG5000.

5.1.4 Safety Response Time

When it detects a failure by the diagnosis of the safety controller, the system will switch to safe mode. The system will block all output. The time it takes to detect the failure and to shut off its output is called safe response time.

1) Failure diagnostics will be handled as follows

(1) CPU module fault diagnostics
- Every scan cycle fault diagnosis function operates.

(2) I/O module fault diagnostics
- 2 scan cycle fault diagnosis function operates.

2) Maximum safe response time
Safety response time will occur depending on the failure of the CPU module and I/O module.
The diagnosis cycle of the IO module is twice the scan time. Maximum safety response times will be calculated
by the IO modules.

(1) Maximum safe response time = (2 X ①Scan time) + ②Diagnosis Processing Time
①Scan time: See Chapter 5.1.3
②Diagnosis Processing Time: fault diagnosis processing time of I/O module (0.1ms)

(2) Example
Maximum safety response time of 8ms scan time is shown below.
Maximum safe response time = (2 X ①Scan time) + ②Diagnosis Processing Time
= (2 X 8ms) + (0.1ms)
= 16.1ms

NOTE

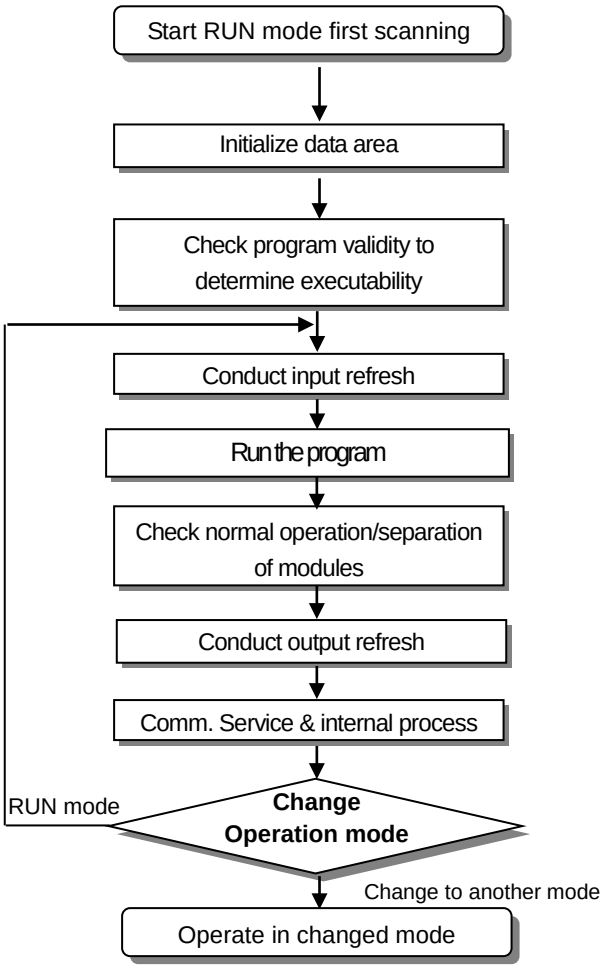
In order to calculate the response time until the output block of the actual response time of the system, response time of Input(sensor / switch) and Output(actuator) connected to the safety controller must be combined with a separate calculation.

5.2 Operation Mode

The operation modes of safety CPU module includes RUN/STOP mode, Configuration Lock/Unlock mode, and Normal/Safe. These modes are described in detail below.

5.2.1 RUN mode

In this mode, program operation is conducted normally.



1) Process at mode change
   Data area is initialized at the beginning, and the program validity is examined to determine executability.

2) Description of operation
   Conducts I/O refresh and program operation.
   (1) Conducts I/O refresh.
   (2) Conducts program operation.
   (3) Check normal operation, separation of the installed modules.
   (4) Conducts communication service and other internal processes.

5.2.2 STOP mode

The program has stopped operation.

1) Process at mode change
Delete output image domain and conducts output refresh. As a result, all output data are switched to OFF status.

2) Description of operation

(1) Conducts I/O refresh.
(2) Check normal operation, separation of the installed modules.
(3) Conducts communication service and other internal processes.

5.2.3 Configuration Lock/Unlock mode

This mode locks the configuration finished with safety sign to prevent change. In the safety lock mode, program cannot be written in the safety CPU module.

1) Process at mode change
Configuration Lock/Unlock mode does not affect operation of the XGS Series Safety Controller.

NOTE

1) What is Configuration?
Configuration is the set of all the data related to XGS Safety Controller, including basic parameters, I/O parameters, and scan program.

2) What is safety sign?
The controller of safety system signs to confirm that all the matters related with Safety Controller, including basic parameters, I/O parameters, I/OO wiring and external device installation, have been verified.
Maintenance engineers are not allowed to write the configuration without safety sign in safety CPU module.

5.2.4 Normal/Safe mode

When a problem inside or outside of the system is detected during normal operation (normal mode), the XGS Series Safety Controller switches to safe mode automatically. After entering safety mode, the error and countermeasures can be viewed by selecting the error history tap in the [Online] – [PLC History] window of the XG5000.

1) Process at safety mode change
All the output image domain is deleted to turn off all the output contact points of the safety output module.

NOTE

The XGS Series Safety Controller defines safe status as the status where all outputs have been cut off. As such, safety system shall be so designed as to enter safe condition when outputs are cut off.

5.2.5 Changing operation mode

1) How to change operation modes

Change the modes by connecting the programming tool (XG5000) to the communication port of the safety CPU module.

2) Setting up operation mode

The user can set up following operation modes:

Operation Mode	Setting Method	**Remark**
RUN	[Online]-[Mode Change]-[Run]	The projects of the XG5000 and XGS series must be the same.
STOP	[Online]-[Mode Change]-[Stop]	-
Safety Sign	[Online]-[Safety Sign]	Only authorized administrator can sign.
Safety Lock	[Online]-[Safety Lock]	Safety sign must have been downloaded.
Safety Unlock	[Online]-[Safety Unlock]	-

3) Functions according to operation modes are as follows:

Operation Mode		**Safety Lock**	**Function**
Normal mode	RUN	Lock	Program write disabled, Green LED On, Yellow LED On, No. 1 output of No. 0 molecular On Communication service operation
		Unlock	Change to Stop and write enabled Green LED On, Yellow LED flashes, No. 1 output of No. 0 molecular On Communication service operation
	STOP	Lock	Program write disabled, Red LED On, Yellow LED On, All outputs Off Communication service operation
		Unlock	Program write enabled, Red LED On, Yellow LED flashes, All outputs Off Communication service operation
Safe Mode	Safe status	N/A	Program write disabled, Red LED flashes All outputs Off Communication service operation

Chapter 6 Functions of Safety CPU Module

6.1 Self-diagnosis Function

(1) Safety CPU module can diagnosis itself for any abnormality with this function.
(2) Any abnormality at system power ON or during operation is detected to conduct preventive measures against system malfunction and preventive maintenance.

6.1.1 CPU molecular self diagnosis function

Safety CPU module performs following self-diagnosis functions to detect problem of the safety CPU module itself.

1) CPU Core self-test
2) CPU Peripheral self-test
3) CPU CCM (Core Compare module) self-test
4) Internal memory ECC (Error Correction Code) self-test
5) Firmware CRC test
6) Backup memory CRC test

If any abnormality is detected in the self testing, the Run/State LED flashes on the front of the safety CPU module and the module enters safety mode.
After switching to safety mode, the system cuts off all the outputs.

6.1.2 I/O molecular self diagnosis function

Safety CPU module performs following self-diagnosis functions to detect problem of the I/O module.

1) CPU Core self-test
2) CPU Peripheral self-test
3) CPU CCM (Core Compare module) self-test
4) Internal memory ECC (Error Correction Code) self-test
5) Firmware CRC test
6) I/O separation

If any abnormality is detected in the self testing, the Run/State LED flashes on the front of the safety CPU module and the module enters safety mode.
After switching to safety mode, the system cuts off all the outputs.

6.1.3 Synchronization between processor in module

The safety CPU module and safety I/O module have two processor inside. The two processor perform operation independently and compare the results. If the results mismatch, the system switches to safe mode. After switching to safety mode, the system cuts off all the outputs.

6.1.4 Error history saving function

The safety CPU module records error history to support easy inspection and correction of the causes.
(See 12.5 Error Code List)

NOTE

1) All the results of self test are recorded in the flag area.
2) For further information on the self testing and error correction, see 12.5 Error Code List, Chapter 12, Troubleshooting.

6.1.5 Troubleshooting

1) Classification of failures

Failures may occur in the PLC, inappropriate configuration of the system, incorrect operation result, etc. Failures are classified into Heavy failures to which the system operation must be terminated for safety, and Light failures to which the operator is notified of the failure and the system continues operation.

Major caused of PLC system failures are as follows:

- PLC hardware failure
- Erroneous system configuration
- Excessive mismatch time between dual channel inputs.
- Error detected by external device failure, open or short circuit.

2) Operation mode under failure

In the event of a failure, the PLC system records the failure description in flag and shuts down the system or continues operation according to the severity of the failure.

(1) PLC hardware failure

If the failure is severe that the PLC cannot continue normal operation, the system enters safe mode and cuts off all outputs.

(2) Erroneous system configuration

This type of failure occurs by mismatch between the PLC hardware configuration and the configuration set up at the XG5000 and downloaded to the PLC. The system shuts down.

(3) Excessive mismatch time between dual channel inputs.

Mismatch time can be set up for dual input channel configuration. Mismatch error is triggered if a mismatch time exceeds the preset allowable mismatch time. At a mismatch error, the input is recognized as OFF status and the corresponding input state domain (IS domain) turns OFF. The system operates normally except the input.

(4) Error detected by external device failure, open or short circuit.

The XGS Series Safety Controller can detect failure, open circuit and short circuit of external devices using test pulse outputs. If an error is detected, the input is recognized as OFF status and the corresponding input state domain (IS domain) turns OFF. The system operates normally except the input.

6.2 User Control

The XGS Series Safety Controller controls the users by classifying user levels as follows.

- Administrator
- Maintenance engineer

6.2.1 User authority

Users are authorized with following functions.

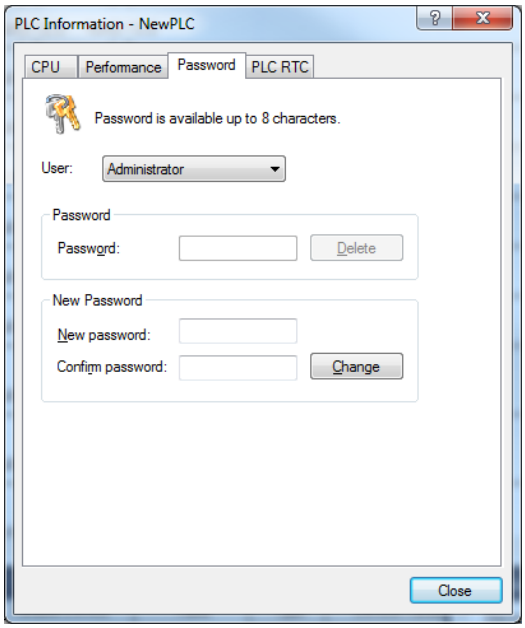
No.	Item	Administrator	Maintenance Engineer	Remark
1	Access PLC	○	○	-
2	Write PLC	○	△	Maintenance engineers are only allowed to write configurations with safety signs.
3	Read PLC	○	○	-
4	Forced I/O	○	○	-
5	Read memory	○	○	-
6	View Log	○	○	-
7	Change/delete password	○	△	A maintenance engineer can change or delete his/her own password only.
9	Safety signing	○	X	-

6.2.2 Password

Each user can access the system with a unique password.
The factory default password is **LSIS** for both administrator and maintenance engineer. When the PLC is initialized by 'PLC Delete All' function of XG5000, the current password is deleted and reset to the default password: **LSIS**.

6.2.2.1 Changing password

In the [Online] – [PLC Information] window, select Password tap and select the user whose password is to be changed. Enter the current password followed by a new password, and repeat the new password for confirm. Click change (C) button to change password.



6.2.2.2 Deleting password

In the [Online] – [PLC Information] window, select Password tap and select the user whose password is to be deleted. Enter the password and click Delete button to delete the password of the pertinent user.

6.3 Clock Function

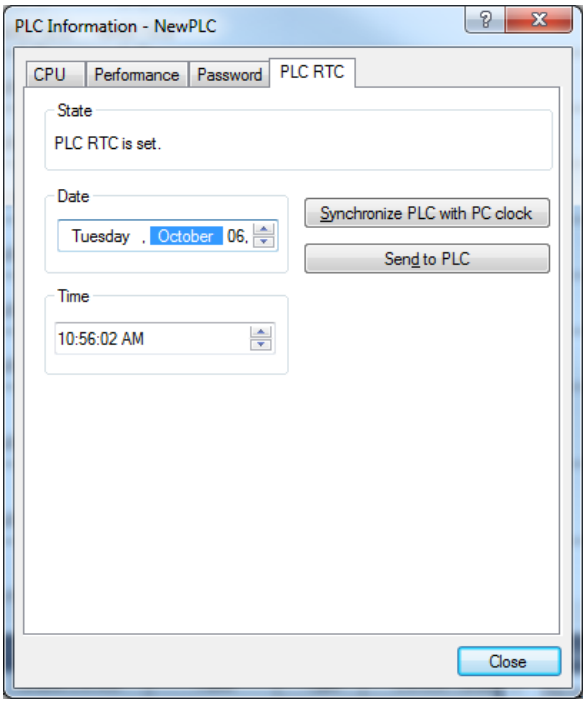
The safety CPU module is has a clock function to provide reference time to system operation history, failure history, and other temporal control.
Present time is continuously scanned and updated in the clock related F domain.

NOTE

1) The clock function operates only while the PLC is supplied with power. At power off, the clock stops and holds the point of time at power off.
As such, the clock must be reset to present time at power recovery.
2) Factory setting is 2000 (YYYY) 1 (MM) 1 (DD) 0 (HH) 0 (MM) 0 (SS) UTC and 2000 (YYYY) 1 (MM) 1 (DD) 9 (HH) 0 (MM) 0 (SS) in Korean time.

1) Reading and setting up XG5000

Click 'PLC Clock' in the [Online]-[PLC Information] window of XG5000.



Date and time of the PLC will display. To correct time display of the PLC, correct time can be transmitted to the PLC, or using 'Synchronization with PLC clock (S)' tap which transmits time from a PC connected to the PLC for synchronization.

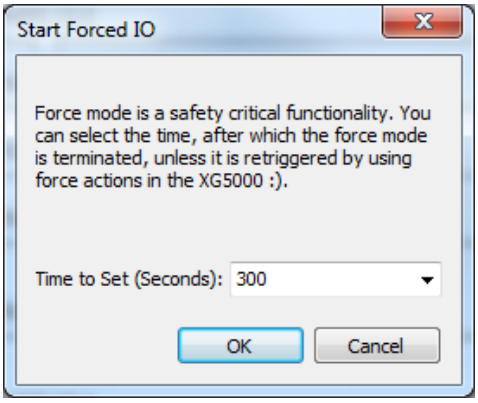
When the PLC clock is set, the dialog displays 'PLC clock is set up' as shown in the picture. If the PLC time is not valid due to power OFF/ON, or being not set up, the dialog displays 'PLC clock is not set up or incorrect' as shown in the picture to the right.

6.4 Forced On/Off of Input/Output

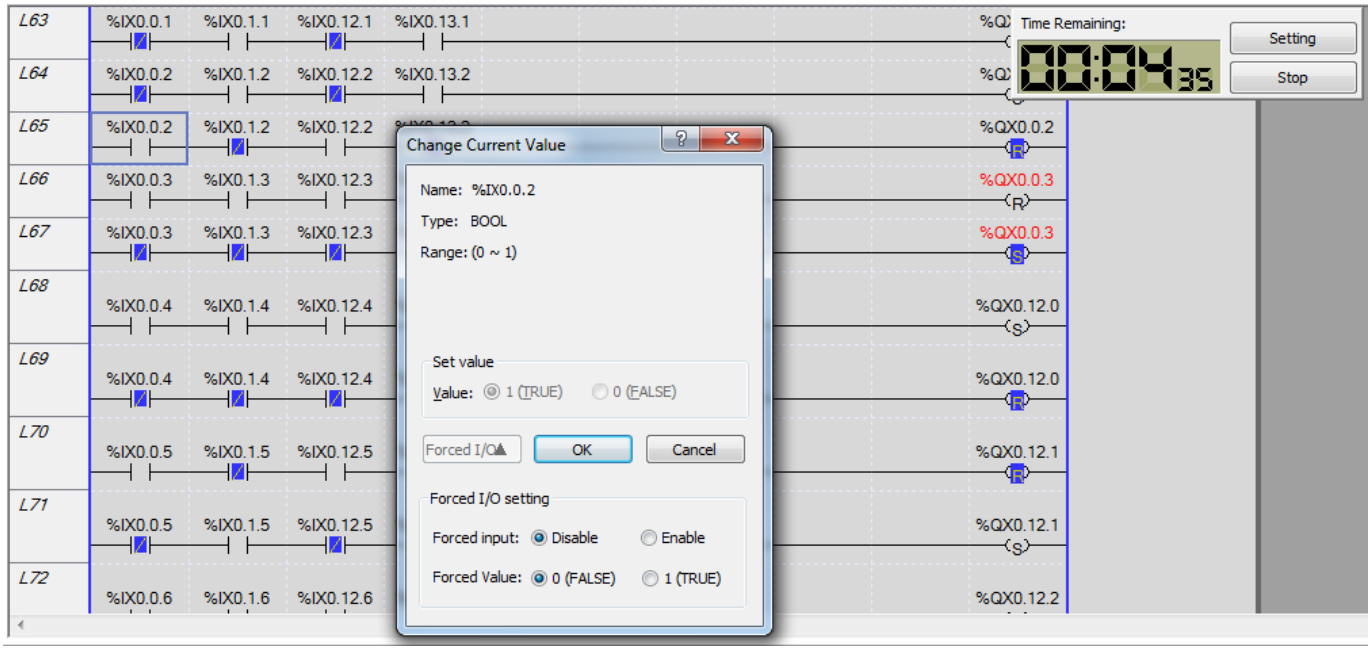
The forced input/output function turns I/O area On/Off regardless of the function of the program. This function is for design and testing of the safety system, and does not function in safety lock condition.

6.4.1 Forced I/O Setting

Specify the time for setting in [Online] – [Forced I/O Setting] window. At the set up time, the PLC will reset I/O and enter stop mode.



Click [Monitor] – [Start Monitor] and double click the contact point to which forced I/O is to be set up. A window appears in which present value can be changed.
Click [Forced I/O ▼] to enter forced I/O setting window. Select: Allow Forced Input (Output) and Forced Value taps, and click Confirm to effect forced I/O function



NOTE

1) All forced I/O settings are initialized at PLC power off.

6.4.2 Point of time and method for forced On / Off action

(1) Forced input

This function updates input image area, the data read from the input module at the time point of input refresh, is substituted for the data of the point set up by forced ON/OFF. As a result, the user program operates using actually input data and the forced set-up data.

(2) Forced output

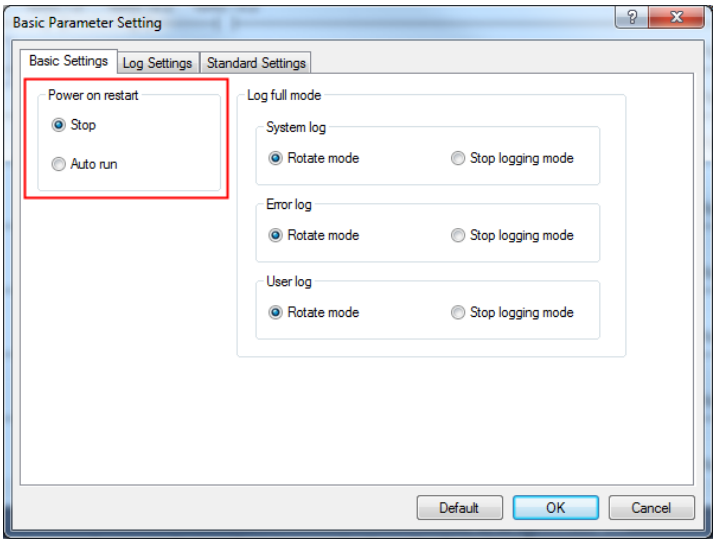
This function updates the data of the point set up by forced ON/OFF, of the data in the output image area containing results of operation, by substituting the data at the time point of output refresh after completion of a user program operation, with the forced set-up data.

6.5 Auto Run Function

Auto run function switches to Run mode after system power on, in Run mode status.

6.5.1 Setting up Auto Run function

Select Basic Operation setting tap in the [Parameter] – [Basic Parameter] window. From the Auto Run at Start-up menu, select Auto Run and then Write to finish the setting.



6.5.2 Operation of Auto Run function

The table below presents the operation mode at power Off and On, according to the operation mode and Auto Run function setting at the time of power Off.

Operation mode at Off / Auto Run Setting	STOP Mode	RUN Mode	Safety Mode
Stop	STOP mode	STOP mode	STOP mode when normal
Auto Run	STOP mode	RUN mode	RUN mode when normal

6.6 Log Save Function

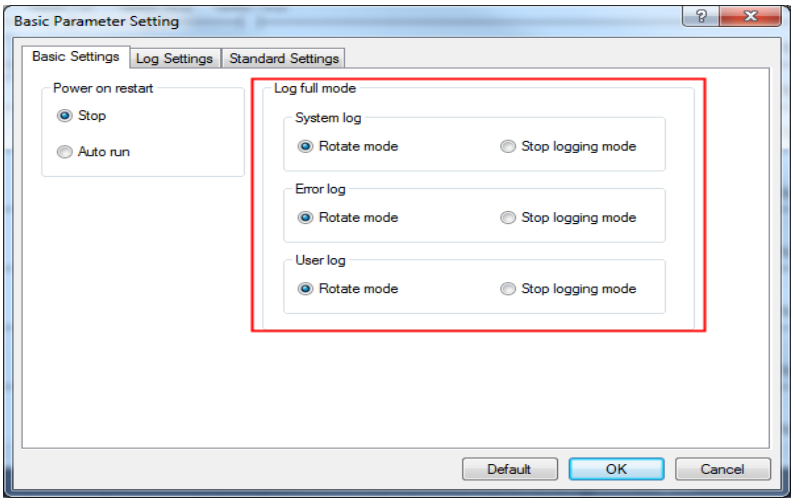
The PLC history (log) of the safety CPU module can be classified into 3 types: system log, error log, and user log.
The point of time, , etc. are saved in the memory for convenient monitoring at the XG5000.

6.6.1 Setting up max. log mode

Log save method can be changed if the maximum number of logs (3,000) is exceeded.

- Loop mode: the number of log is reset to and restarts from zero.
- Stop mode: the number of log is no more recorded.

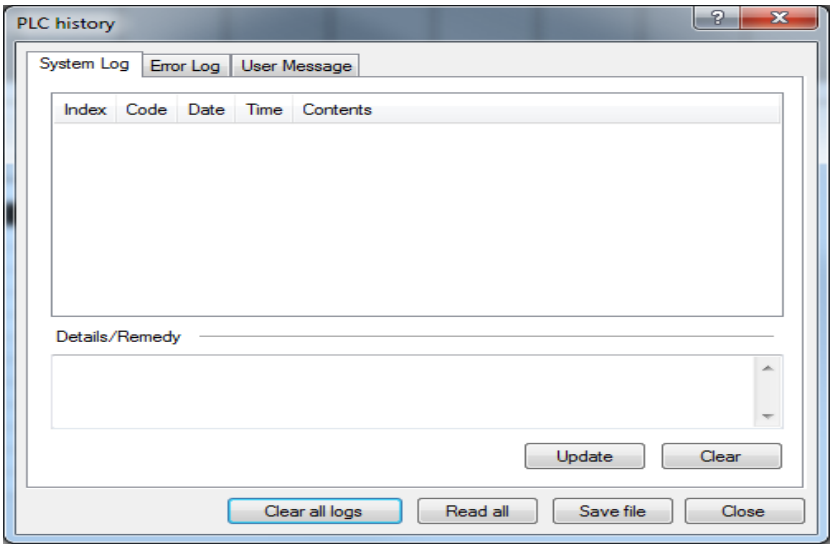
Select [Basic Operation Setting] tap in the [Parameter] – [Basic Parameter] window. Max. log mode can be set up to system log, error log and user log, respectively.



6.6.2 System log

Saves the history of the system operation occurred during operation.

- Save history code, date and time
- Up to 3,000 logs are saved



6.6.3 Error log

Saves the content and time of system error occurred during operation.

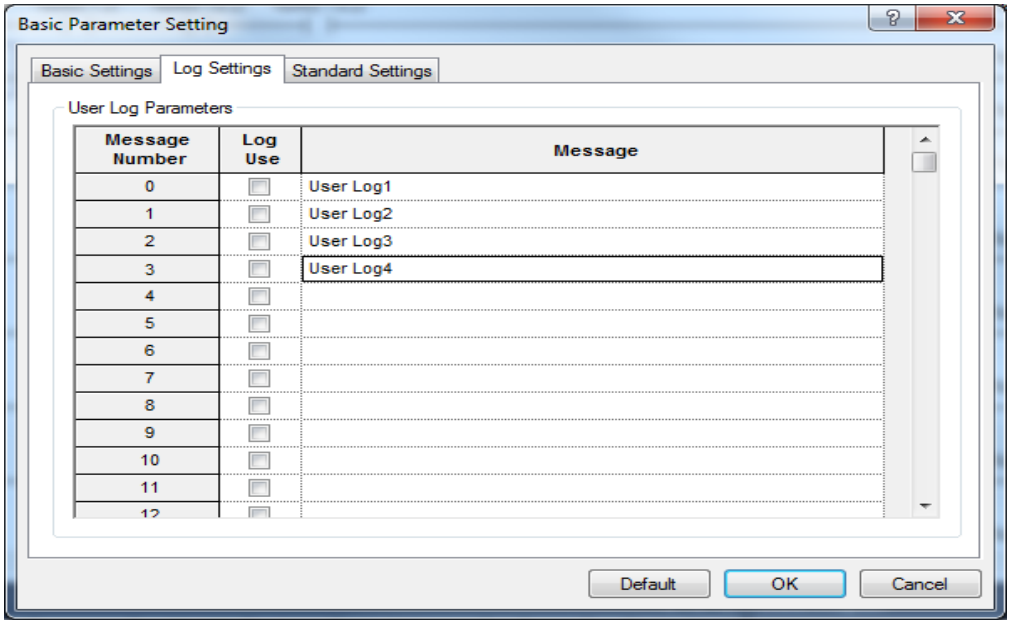
- Save date, time and error code
- Up to 3,000 logs are saved

6.6.4 User log

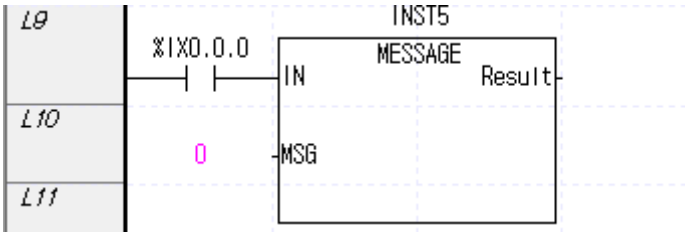
Use log can be recorded using MESSAGE or MESSAGE_S function block.

- Up to 3,000 logs are saved

Select [Log Setting] tap in the [Parameter] – [Basic Parameter] window. Check the Use check box and input the message to be recorded at an event.



At an IN input rise event, the message corresponding to the message No. of MSG input value is recorded in the user log.
Refer to the command manual for further details of the MESSAGE or MESSAGE_S function block.



NOTE

1) Saved information is maintained until deleted with pertinent menu of the XG5000.
2) If the history count exceeds 100, only a portion of the histories are displayed. To read all the histories, conduct View All.

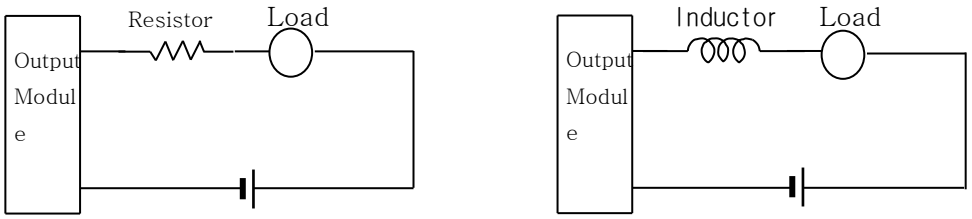
Chapter 7 Safety I/O Module

7.1 Cautions for Using I/O Safety Module

This is to provide information on the cautions for using the safety input/output module of the XGS Series Safety Controller.

1) For driving an inductive (L) load at the output point, set up the maximum opening and closing frequencies at ON for 1 s and OFF for 1 s.

2) If the output point is set up with average current, inrush current at output point ON or during operation may cause troubles. In order to protect the system from inrush current, install resistance or inductor in series to the load or select the load taking margin for maximum allowable current into consideration.



3) The size of the wire connected to the terminal block shall be stranded 0.3~0.75 ㎟ or a single line 2.8 ㎜ or less thickness. Check the allowable current of the wire which may differ by insulation thickness, etc.

4) Power supply to the output contact must be isolated from the power supply to the safety CPU module.

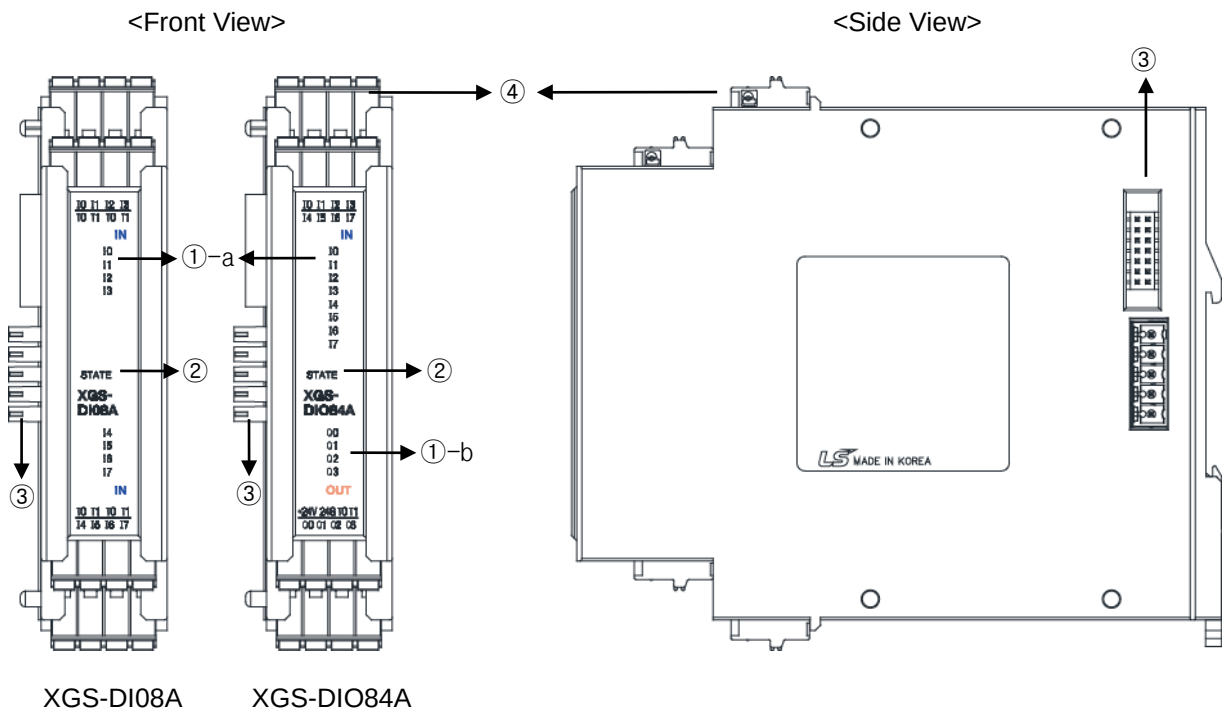
7.2 Specification of Safety Input Module

Item			Specification	Remark
			XGS-DI08A	
Safety Digital Input	Input points		8	-
	Input Mode	Single channel input mode	8 input points used individually (I0 ~ I7)	-
		Dual channel input mode	4 input points used by dual (I0/I1, I2/I3, I4/I5, I6/I7)	-
	Rated input		DC +24V, 4.0mA	-
	On assured voltage/ On current		DC +11V or more, 12mA or more	-
	Off assured voltage / Off current		DC +5V or less, 0.8mA or less	-
	Off → On input filter		0 ms ~ 200 ms	Set up by 1 ms unit
	On → Off input filter		0 ms ~ 200 ms	
	Dual input mode	Mismatch time	0 ms ~ 65535 ms	-
		Error latch time	0 ms ~ 65535 ms	
		Input mode	Equivalent, Complementary	
Test Pulse Output	Test pulse output contact		2	Use or No can be set up
	Test pulse output mode		PNP output	-
	Test pulse output voltage		DC +24V (+19.2V ~ +28.8V)	-
	Test pulse output current		Max. 120 mA/contact	-
	Test pulse cycle		40ms ~ 1000ms	Set up by 4 ms unit
	Test pulse width		1ms ~ 100ms	Set up by 1 ms unit
Applicable specification			SIL 3 (IEC 61508 : 2009) SILCL 3 (IEC 62061 : 2005) PLe, Category 4 (EN ISO 13849-1 : 2008)	-
Power supply			Via extension connect to CPU module	-
PFH			3.28678×10^{-09}	-
PFD			2.091×10^{-05}	-
SFF			99.1174 %	-
H/W Fault Tolerance			1	
Internal consumption current			0.36A	
Weight			210g	

7.3 Specification of Safety Input/Output Module

Item			Specification	Remark
			XGS-DIO84A	
Safety Digital Input	Input points		8	-
	Input mode	Single channel input mode	8 input points used individually (I0 ~ I7)	-
		Dual channel input mode	4 input points used by dual (I0/I1, I2/I3, I4/I5, I6/I7)	-
	Rated input		DC +24V, 4.0mA	-
	On assured voltage /On current		DC +11V or more, 12mA or more	-
	Off assured voltage /Off current		DC +5V or less, 0.8mA or less	-
	Off → On input filter		0 ms ~ 200 ms	Set up by 1 ms unit
	On → Off input filter		0 ms ~ 200 ms	
	Dual input mode	Mismatch time	0 ms ~ 65535 ms	-
		Error latch time	0 ms ~ 65535 ms	
		Input mode	Equivalent, Complementary	
Test Pulse Output	Test pulse output contact		2	Use or No can be set up
	Test pulse output mode		PNP output	-
	Test pulse output voltage		DC +24V (+19.2V ~ +28.8V)	-
	Test pulse output current		Max. 120 mA/contact	-
	Test pulse cycle		40ms ~ 1000ms	Set up by 4 ms unit
	Test pulse width		1ms ~ 100ms	Set up by 1 ms unit
Safety Digital Output	Output points		4	-
	Output mode		PNP output	-
	Output mode	Single channel output mode	4 input points used individually (Q0 ~ Q1)	-
		Dual channel output mode	2 output points used by dual (Q0/Q1, Q2/Q3)	-
	Output voltage		DC +24V (+19.2V ~ +28.8V)	-
	Output current		Max. 0.5 A/contact	-
	Error latch time		0 ~ 65535 ms	-
	Power supply for output		DC +24V (+19.2V ~ +28.8V) extra-low voltages with safe separation Power supply (SELV, PELV)	Via external connector
Applicable specification			SIL 3 (IEC 61508 : 2009) SILCL 3 (IEC 62061 : 2005) PLe, Category 4 (EN ISO 13849-1 : 2008)	-
Power supply			Via extension connect to CPU module	-
PFH			6.67541×10^{-09}	-
PFD			3.623×10^{-05}	-
SFF			99.1174 %	-
H/W Fault Tolerance			1	
Internal consumption current			0.51A	-
Weight			220g	-

7.4 Part Names and Functions



XGS-DI08A XGS-DIO84A

No.	Name	Application
①-a	IN LED	Indicates input contact status. • Green On: input contact On • Green Off: input contact Off • Red On: input contact error – Dual channel inputs mismatch error. – Test pulse abnormal input
①-b	OUT LED	Indicates output contact status. • Green On: output contact On • Green Off: output contact Off • Red On: output contact error – Output contact On while output power supply is abnormal (over voltage, low voltage) – Dual channel outputs mismatch error.
②	STATE LED	Indicates operation status of module. • Green On: normal operation / RUN mode • Green On: normal operation / STOP mode • Red flashing: I/O module error / safety mode
③	Extension connectors	Safety CPU or additional safety input / I/O module connector
④	Contact connector	Connectors for I/O contacts, test pulse, output contact power supply

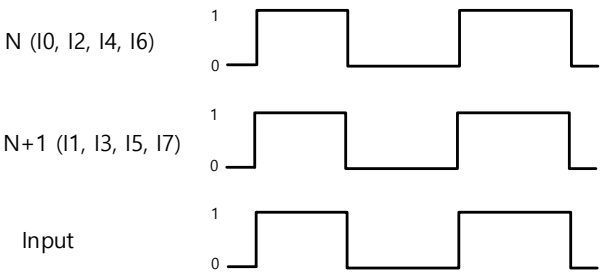
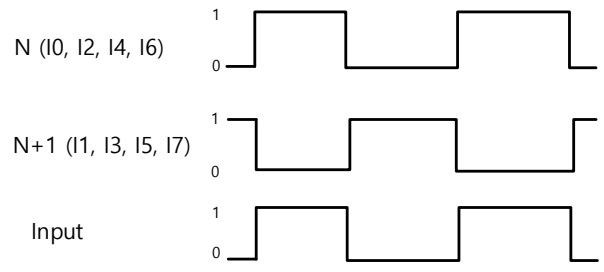
Chapter 8 Functions of Safety I/O Module

8.1 Setting-up and Operation of Input Mode

The safety I/O module of the XGS Series provides following input modes.

Input Mode		Description	Default Setting
Single channel input mode		Processed individually	Single channel input mode
Dual channel input mode	Equivalent	2 contact points are processed as a pair (N / N+1 contacts, N is an even number) - I0 / I1 - I2 / I3 - I4 / I5 - I6 / I7	
	Complementary		

Operation under dual channel input setting is as follows.

Input Mode	Description	Default Setting
Equivalent mode	 When two input signals turn On or Off simultaneously, input is changed	Equivalent mode
Complementary mode	 When two input signals are different simultaneously, input is changed ; if N is high then input is high and if N is low then input is low	

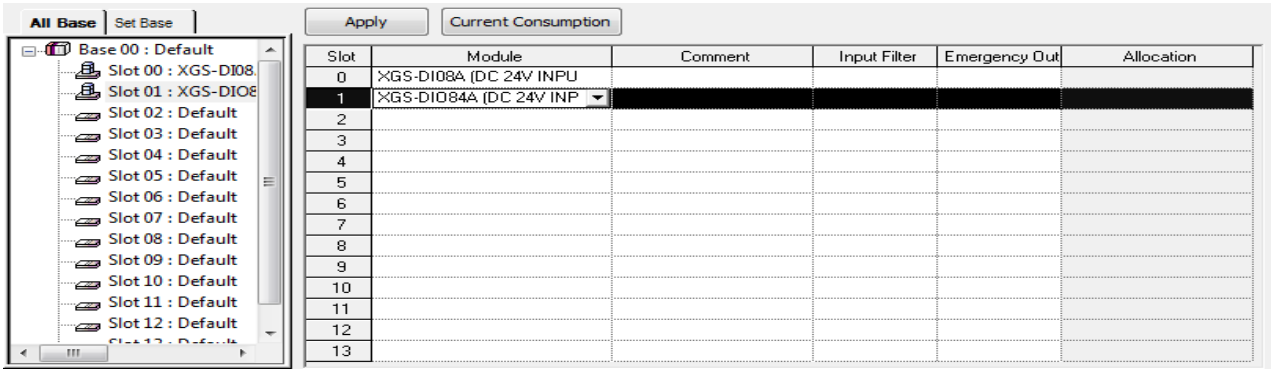
In Dual Channel input mode, input image area (Area I), input diagnosis device (Area IS), and safety I/O module contact LED functions according to the status of input contact, as follows.

Dual Channel Input Mode	Actual Input		Safety Input Image Area (Input variable Area I)		Safety Input Diagnosis Image Area (Input status Area IS)		LED Status		Input Matching
	Input N	Input N+1	%IX0.y.N	%IX0.y.N+1	%ISX0.y.N	%ISX0.y.N+1	Input N	Input N+1	
Equivalent Mode	Low	Low	0	0	1	1	Off	Off	Normal
	Low	High	0	0	0	0	Red	Red	Input mismatch
	High	Low	0	0	0	0	Red	Red	Input mismatch
	High	High	1	1	1	1	Green	Green	Normal
Complementary Mode	Low	Low	0	0	0	0	Red	Red	Input mismatch
	Low	High	0	0	1	1	Off	Green	Normal
	High	Low	1	1	1	1	Green	Off	Normal
	High	High	0	0	0	0	Red	Red	Input mismatch

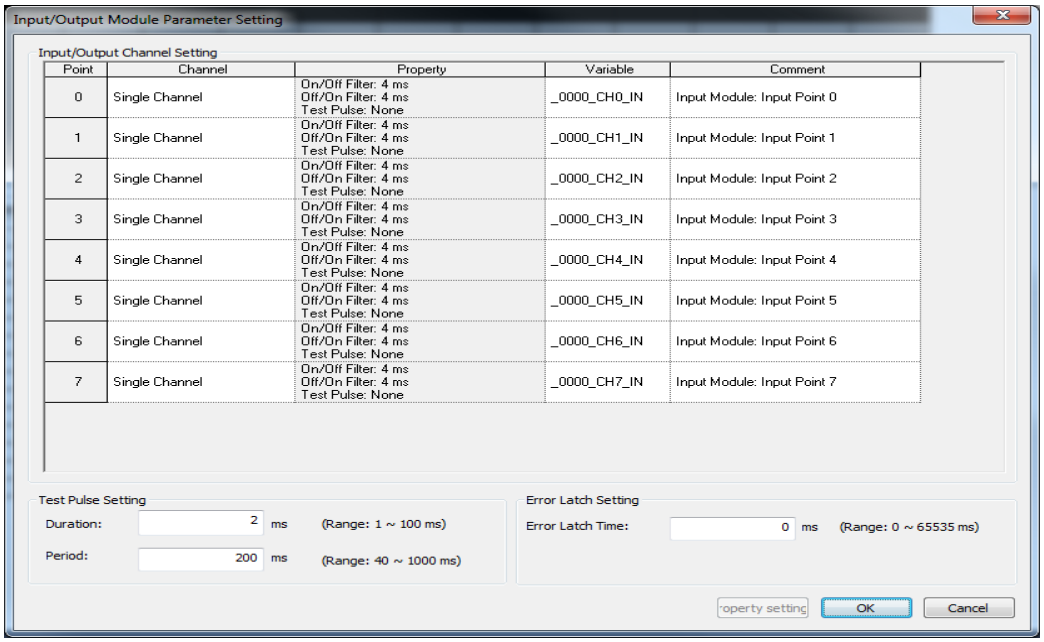
N represents even number input contact, y represents No. of slot where the module is installed.
IS image areas display “1” at normal and “0” at abnormal.

8.2 Input On/Off Filter and Off/On Filter

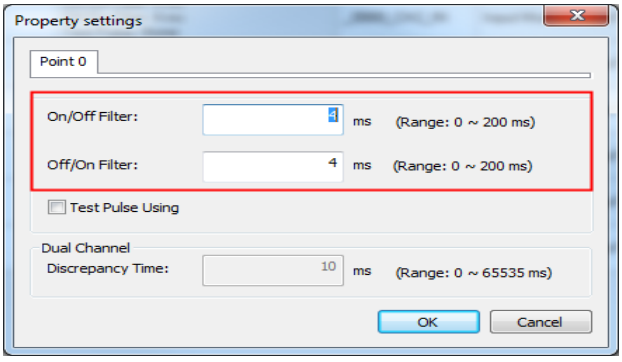
Input filters can be set up by input channel.
In the [Parameter] – [I/O Parameter] window, select the module installed in the slot to be set up. Click [Detail] button or double-click the module to set up I/O parameters.



Click [Set-up Properties] button to set up I/O channel parameters.

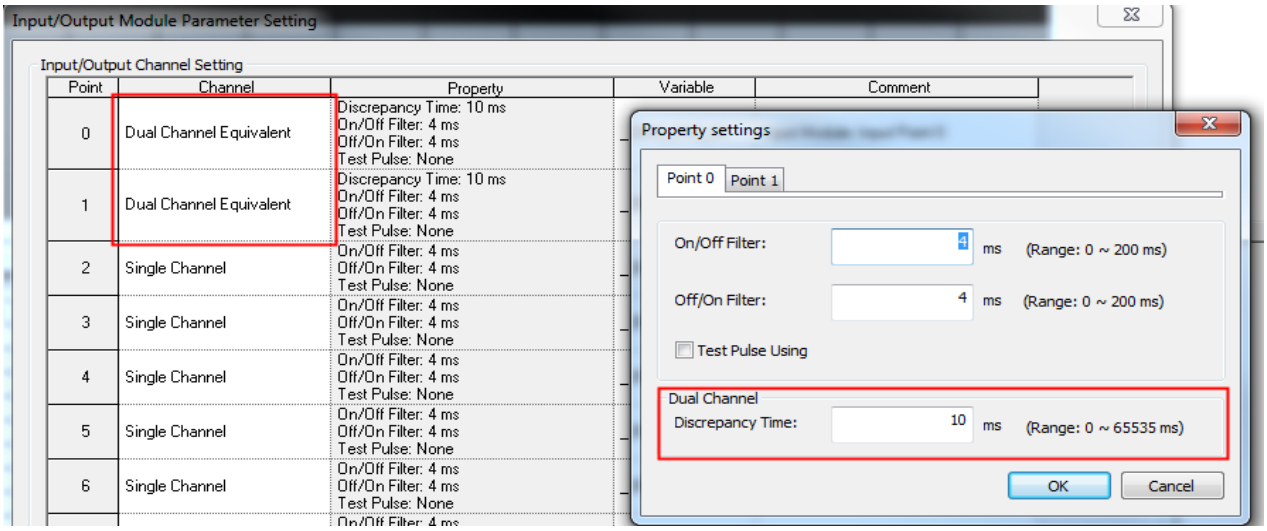


Set up On/Off filter time and Off/On filter time. Setting can be made within 0 ~ 200 ms range by 1 ms unit. The initial (default) setting is 4 ms.



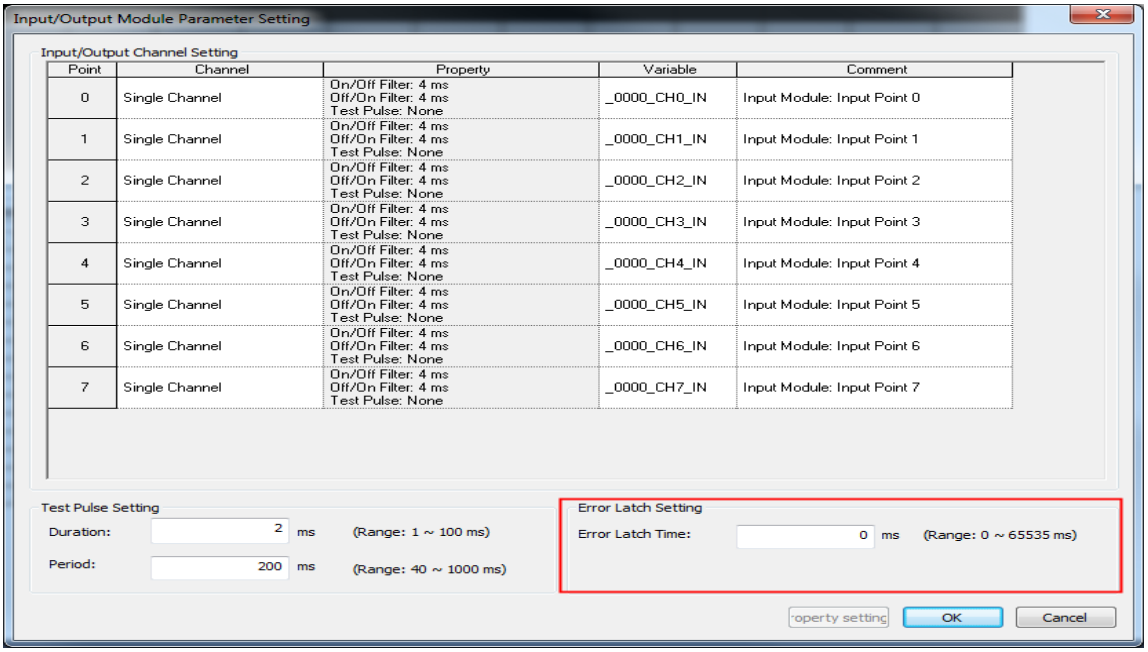
8.3 Mismatch Error (Input)

The input contacts set up by dual channel can be set up with mismatch time between the contact points.
When the time of mismatch between two inputs set up in Equivalent or Complementary mode exceeds setting time, the inputs trigger mismatch error. At a mismatch error, the relevant IS area turns Off and the system functions normally.
The mismatch time setting can be made within 0 ~ 65535 ms range by 1 ms unit. The initial (default) setting is 10 ms.

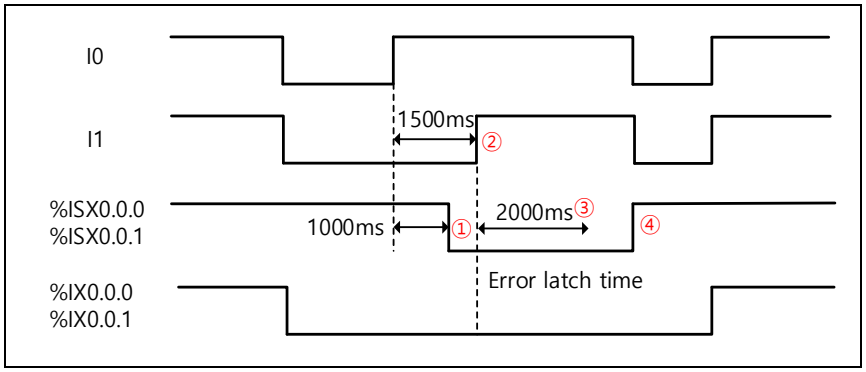


8.4 Error Latch Time (Input)

After a mismatch error of dual inputs, when the inputs recover normal function, the error latch time resumes normal operation after maintaining mismatch status for a preset error latch time. Setting can be made within 0 ~ 65535 ms range by 1 ms unit. The initial (default) setting is 0ms. The setting applies to dual input and output contacts. In Equivalent mode, both inputs have to become Low to reset the error, and in Complementary mode, N and N+1 inputs must become Low and High to reset the error.



The picture below illustrates an exemplary case wherein input 0 and input 1 contacts of the input module installed at No. 0 slot are set up as dual equivalent input mode, on condition that mismatch time in Equivalent mode operation 1,000ms and latch time 2,000ms.



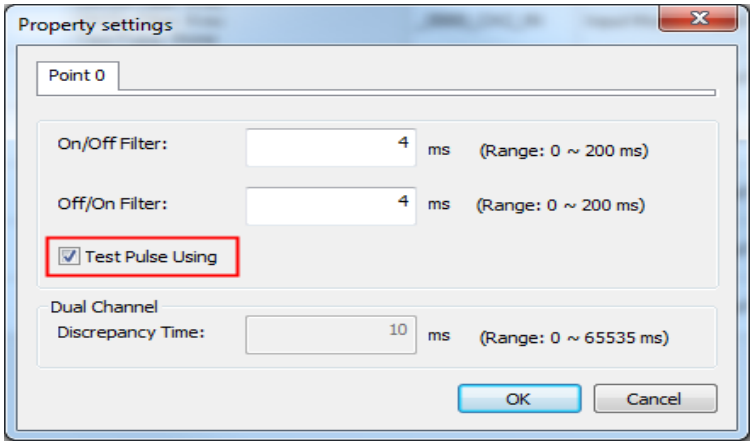
1) When the I0 and I1 contacts maintain mismatched status for 1,000 ms, a mismatch error is triggered and the corresponding IS area turns Off.
2) Both I0 and I1 contacts becomes normal high status, the mismatch error is maintained for the error latch time.
3) Although 2,000 ms has elapsed in normal condition, the error persists because both inputs are high. In Equivalent mode, both inputs must become Low to reset error.
4) Both inputs became Low and the time of normal condition has exceeded the error latch time 2,000 ms, thus, the error is reset and the system functions normally.

8.5 Test Pulse Setting (Input)

Test pulse output is used to detect failure of safety input devices (sensors, switches, light curtain, etc.) and wiring error at input terminals. The I/O module of the XGS Series provides 2 (T1, T2) test pulse outputs.

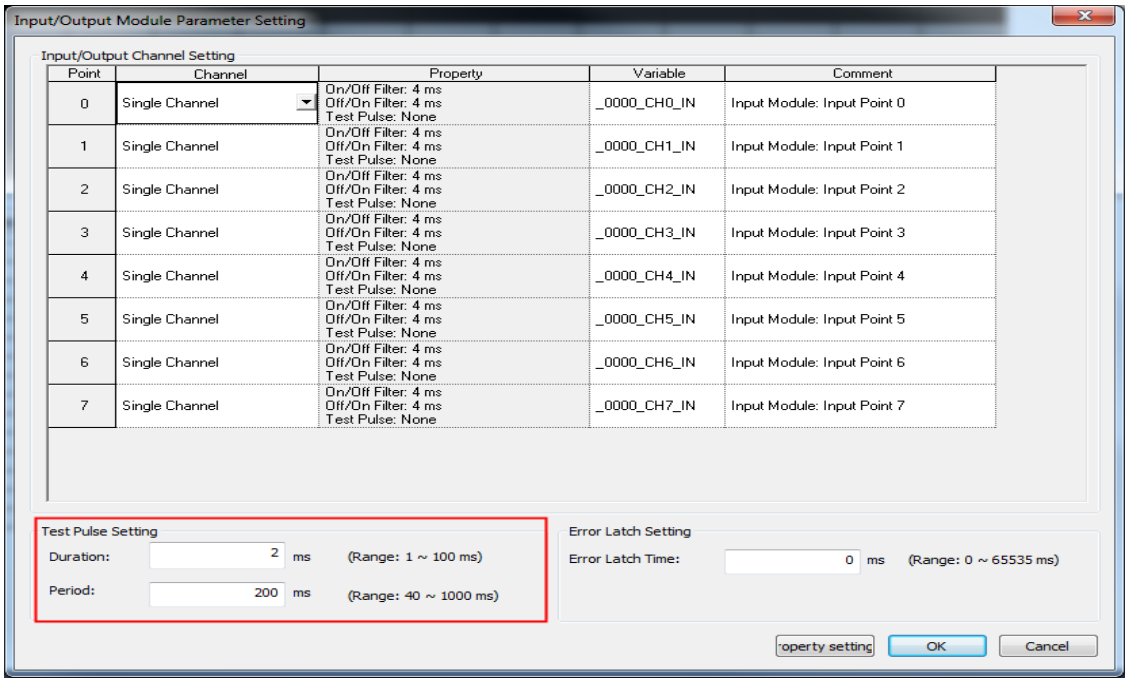
Each input contacts must use designated test pulse outputs as presented in the table below.

Test pulse output	Input contacts	Remark
T1	I0, I2, I4, I6	Use-or-not of test pulse for each input can be set up with the parameters
T2	I1, I3, I5, I7	

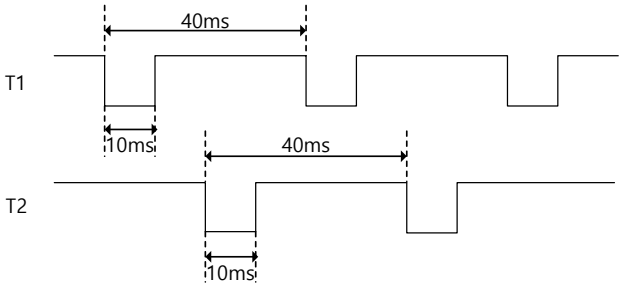


The cycle and width of test pulse can be set up per I/O module; cycle within 40 ~ 1000 ms by 4 ms steps, and pulse width within 1~100 ms by 1 ms steps.

Item	Setting Value	Default	Remark
Test pulse duration	1ms ~ 100ms	2ms	Set up by 1 ms unit
Test pulse cycle	40ms ~ 1000ms	200ms	Set up by 4 ms unit

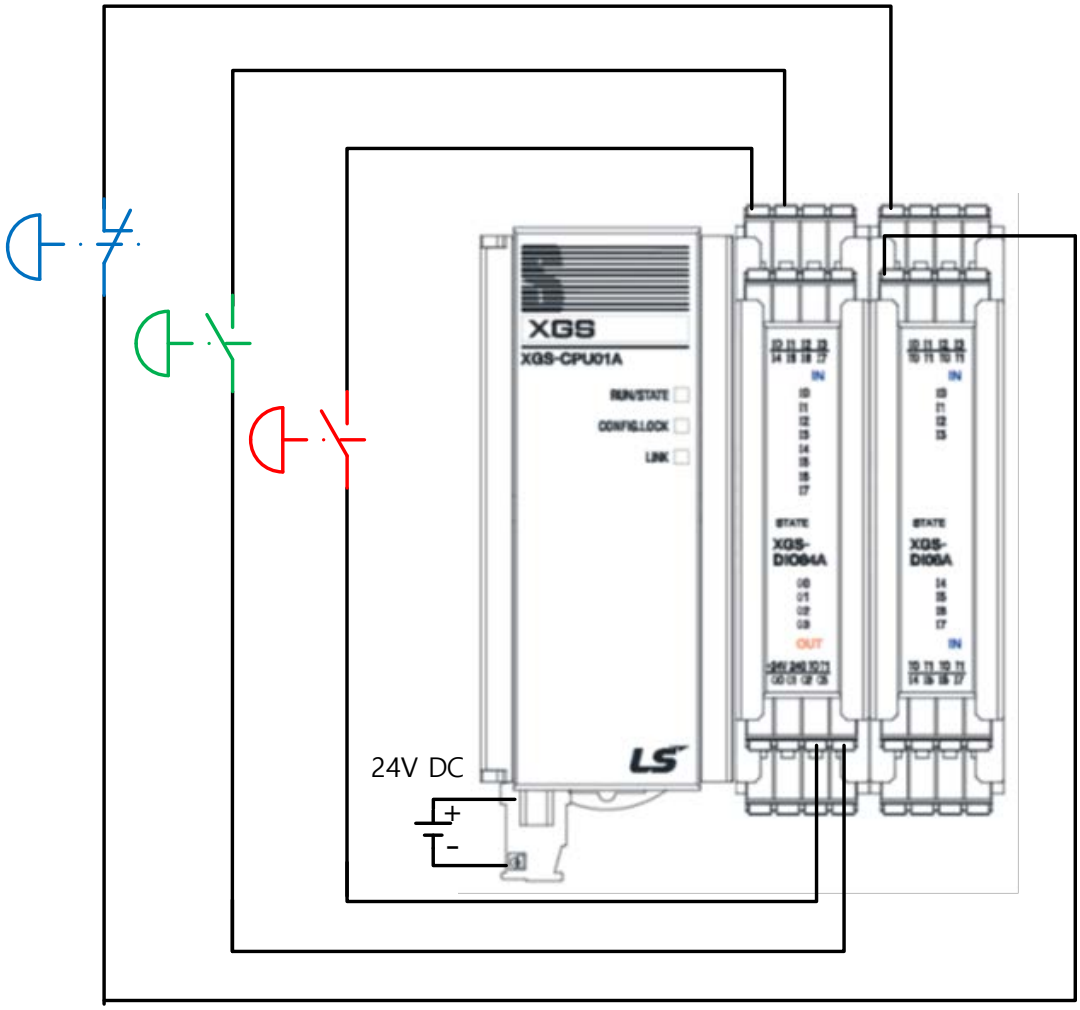


Width of the test pulse must be set up less than 1/2 of the test pulse cycle.
The picture below illustrates an exemplary case pf test pulse output under the setting of 40 ms cycle and 10 ms width.

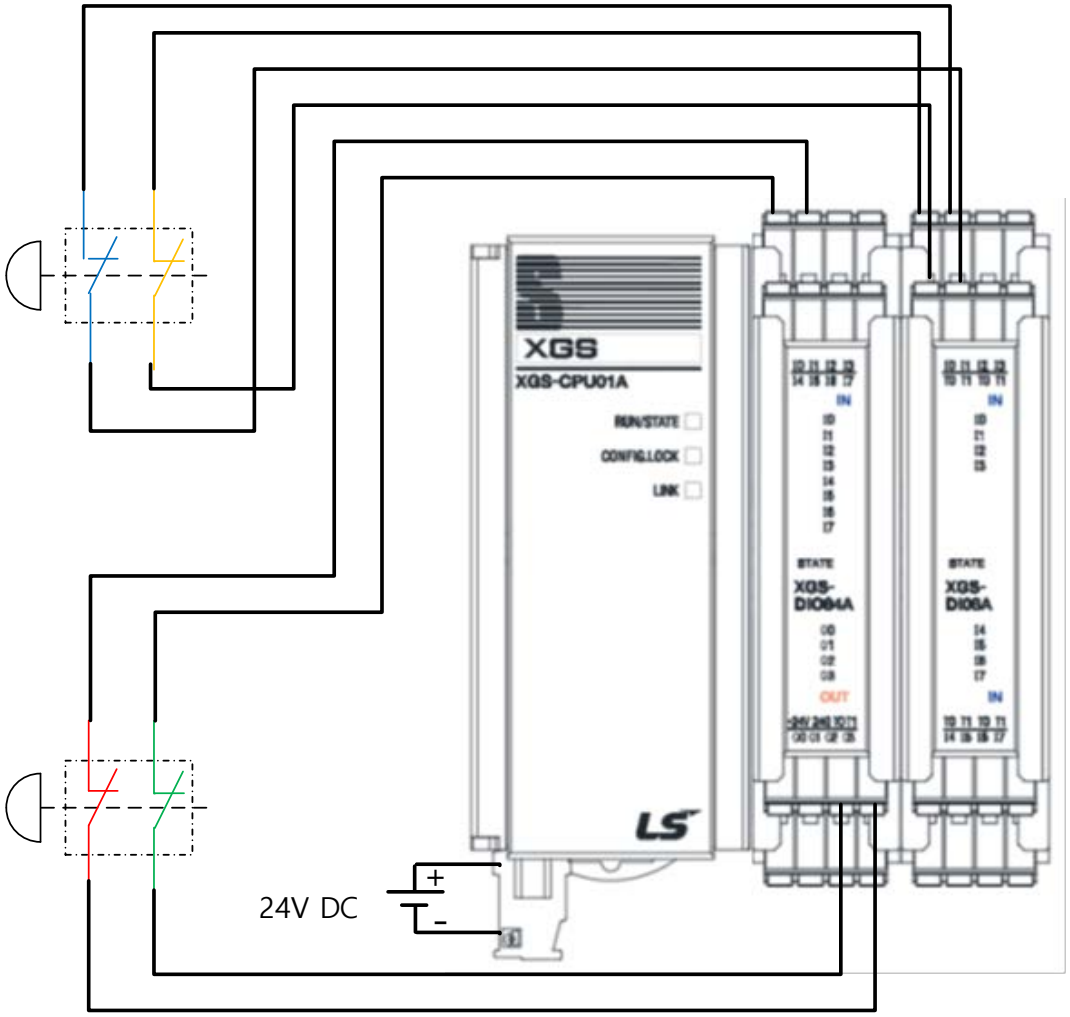


8.6 Input Wiring

The picture below illustrates an exemplary case of wiring wherein test pulse output is used in single channel mode.



The picture below illustrates an exemplary case of wiring wherein test pulse output is used in dual channel input, Equivalent mode.


XGS
XGS-CPU01A
RUN/STATE
CONFIG.LOCK
LINK
XGS-DIO64A
XGS-DI06A
24V DC
+
-

8.7 Setting-up and Operation of Output Mode

The safety I/O module of the XGS Series provides following output modes.

Output Mode	Description	Default Setting
Single channel output mode	Processed individually	Single channel output mode
Dual channel output mode	2 contact points are processed as a pair (N / N+1 contacts, N is an even number) - Q0 / Q1 - Q2 /QI3	

In Dual Channel output mode, according to the output image area (Q area), the input diagnosis device (Area QS) and actual output and safety I/O module contact LED functions as follows.

Mode	Safety Output Image Area (Output variable Area Q)		Safety Output Diagnosis Image Area (Output status Area QS)		LED Status		Actual Output		Output matching
	%QX0.y.N	%QX0.y.N+1	%QSX0.y.N	%QSX0.y.N+1	Input N	Input N+1	Output N	Output N+1	
Dual output mode	0	0	1	1	Off	Off	Off	Off	Normal
	1	0	0	0	Red	Red	Off	Off	Output mismatch
	0	1	0	0	Red	Red	Off	Off	Output mismatch
	1	1	1	1	Green	Green	On	On	Normal

N represents even number output contact, y represents No. of slot where the module is installed.

NOTE

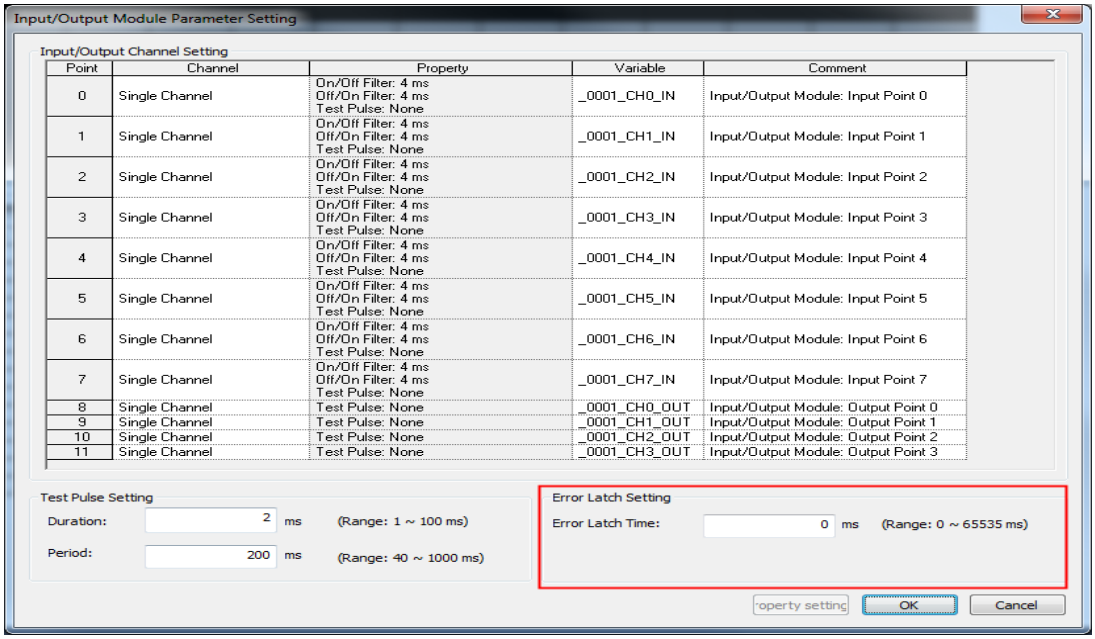
If the output contact is turned ON while the output power supply for the XGS-DIO84A (DC24V) is not applied, same as the output mismatch condition, the safety output diagnosis area turns off and the corresponding output contact LED lights up in red.

8.8 Mismatch Error (Output)

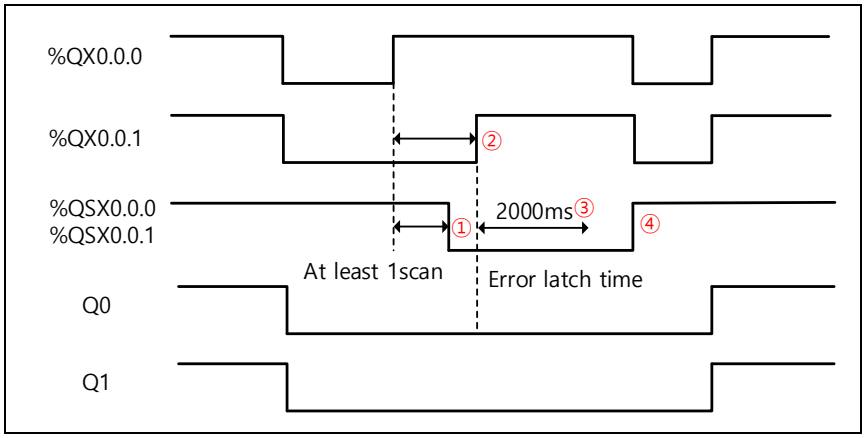
When the output contacts are set up in Dual Channel mode, a mismatch error is triggered if two safety output image values within one scan of the program do not match. At a mismatch error, the relevant output contact point only is indicated as error (relevant QS area Off) and the system operates normally.

8.9 Error Latch Time (Output)

After a mismatch error outputs, outputs keep error for the error latch time. Setting can be made within 0 ~ 65535 ms range by 1 ms unit. The initial (default) setting is 0 ms.
The setting applies to dual input and output contacts.



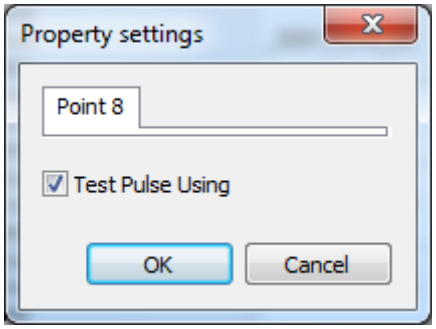
The picture below illustrates an exemplary case wherein Q0 and Q1 contacts of the input module installed at No. 0 slot are set up as dual equivalent input mode, on condition that error latch time is set by 2,000ms.



1) If the Area QX i.e. %QX0.0.0 and %QX0.0.1 set up in dual output mismatch in one scan program, mismatch error is triggered and the corresponding QS area turns Off.
2) QX areas resumed normal high status, the mismatch error is maintained for the error latch time.
3) Although 2,000 ms has elapsed in normal condition, the two Q areas must become low to reset the error.
4) Both two QX areas became Low and the time of normal condition has exceeded the error latch time 2,000 ms, thus, the error is reset and the system functions normally.

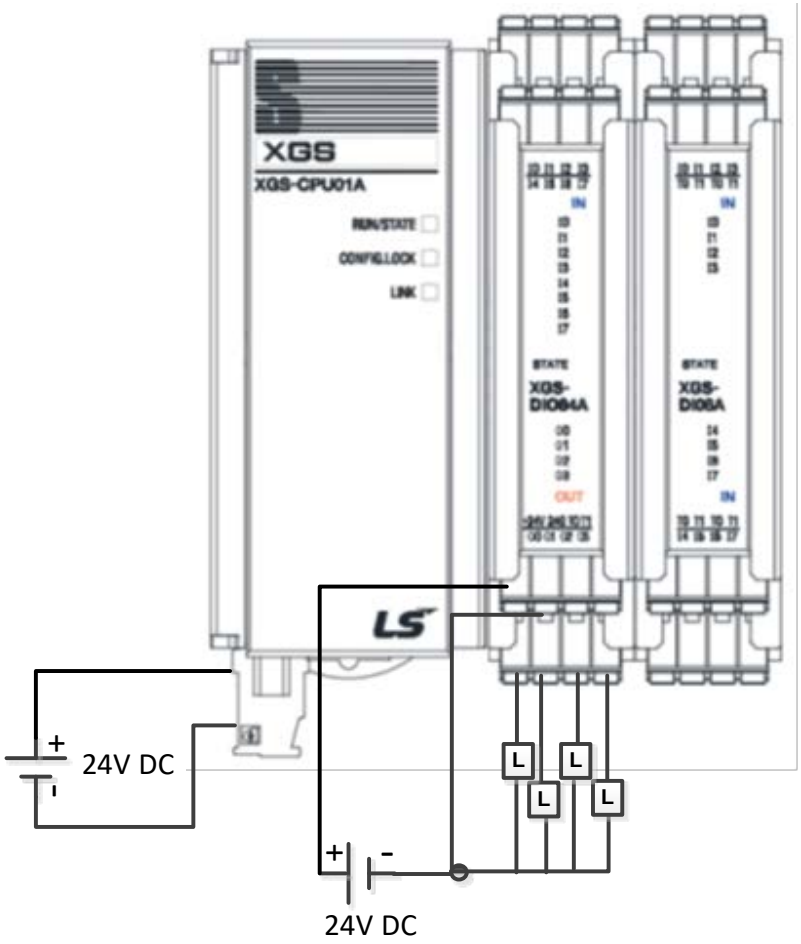
8.10 Test Pulse Setting (Output)

Test pulse outputs are used to detect internal output failure. Test pulses(500us) are generated inside of the output contact. Use-or-not of the pulse can be set up. Check the influence of the test pulse on the output load before application of this function.



8.11 Output Wiring

The picture below shows an exemplary output wiring. For details of power supply wiring, refer to users' manual 'Chapter 9 Installation and Wiring.'



Chapter 9 Installation and Wiring

9.1 Installation

9.1.1 Environment

The product is highly reliability regardless of the environmental conditions. However, to maintain reliability and stability, please take care of the conditions described in this chapter.

1) Environmental conditions
   (1) Install in a waterproof and dust-proof cabinet.
   (2) Avoid continuous impact or vibration.
   (3) Avoid direct sunlight
   (4) Avoid rapid temperature change which may form dew drops
   (5) Ambient temperature shall be within 0 ~ 60 °C
   (6) Relative humidity shall be within 5 ~ 95 %
   (7) Avoid corrosive or flammable gases.

2) Installation Work
   (1) Protect the PLC from foreign materials during installation and wiring work.
   (2) Select a position suitable for operation.
   (3) Do not install in the same panel with a high voltage device.
   (4) Keep at least 50 mm of space between the wire duct and adjacent modules.
   (5) Ground the PLC to a point where noise environment is favorable.

9.1.2 Cautions for handling

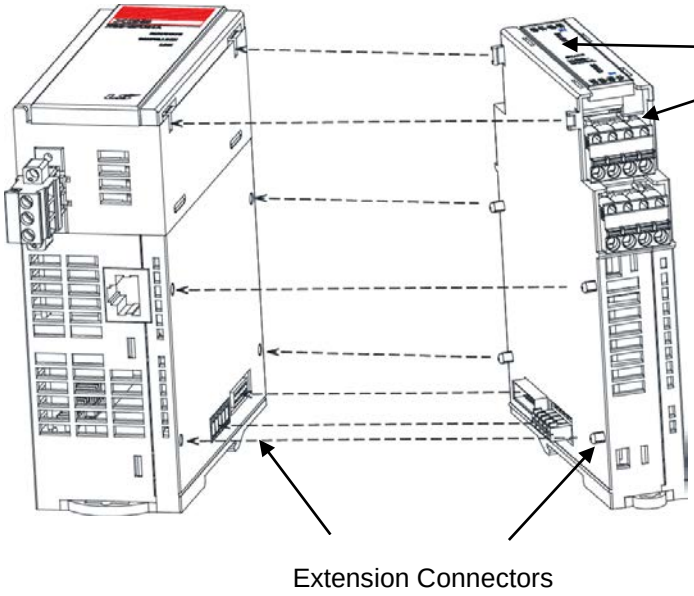
1) Do not fall on the ground. Avoid shock.
2) Do not separate PCB from the case. Otherwise, failure may be caused.
3) Protect the module from debris generated from wiring work. Remove any foreign material entered in the module.
4) Do not connect or disconnect the module while power is on.
5) Use standard cables whose lengths do not exceed the maximum allowable length.
6) Keep the communication lines away from the surge and induction noise generated in the AC lines.
7) If the cables are laid in cable conduits, ground the conduits.

9.1.3 Cautions for wiring

1) Do not lay AC power line and external signal lines of the module close together. Provide at least 100 mm distance, or lay the lines in conduits. Sufficient space must be provided to avoid interference from the surge or induction noise from the AC lines.
2) The wires shall be selected taking the ambient temperature and allowable current into consideration, with a minimum size of AWG22 (0.3 ㎟).
3) For power source monitoring, the wires should be twisted as densely as possible and arranged in the shortest path. (Max. wiring distance 15 m or less)
4) Keep the wires away from heat source and oil or other harmful materials. Otherwise, shot-circuit may occur leading to damage or malfunction of the system.
5) Keep the wires away from high voltage and power lines to avoid induction interference which can cause malfunction or failure.

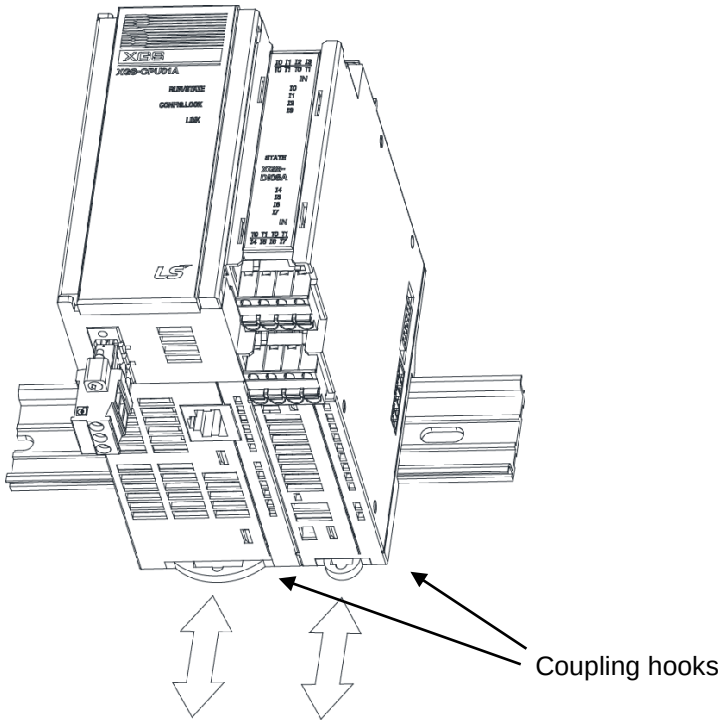
9.1.4 Installation and removal of module

1) Module installation
Position the module so that the extension connector on the lateral side and projections at the corners come correct positions.
Check that the coupling hooks are properly joined.



2) Module detachment
Hold and remove the module by both hands. (Do not apply excessive force.)

3) Module installation
The product is designed to be installed on DIN rails (width 35 mm). Install the module on DIN rails and push the coupling hooks to fix the module.



9.1.5 Cautions for installation

(1) General precaution

1) The XGS Series Safety Controller turns output off when any problem in the external power source or product itself is detected. The external circuit shall be so configured as to cut off the power supply to the load so that connected device(s) is shut down, when the output is turned off. Otherwise, the entire line may result in a severe problem or accident.

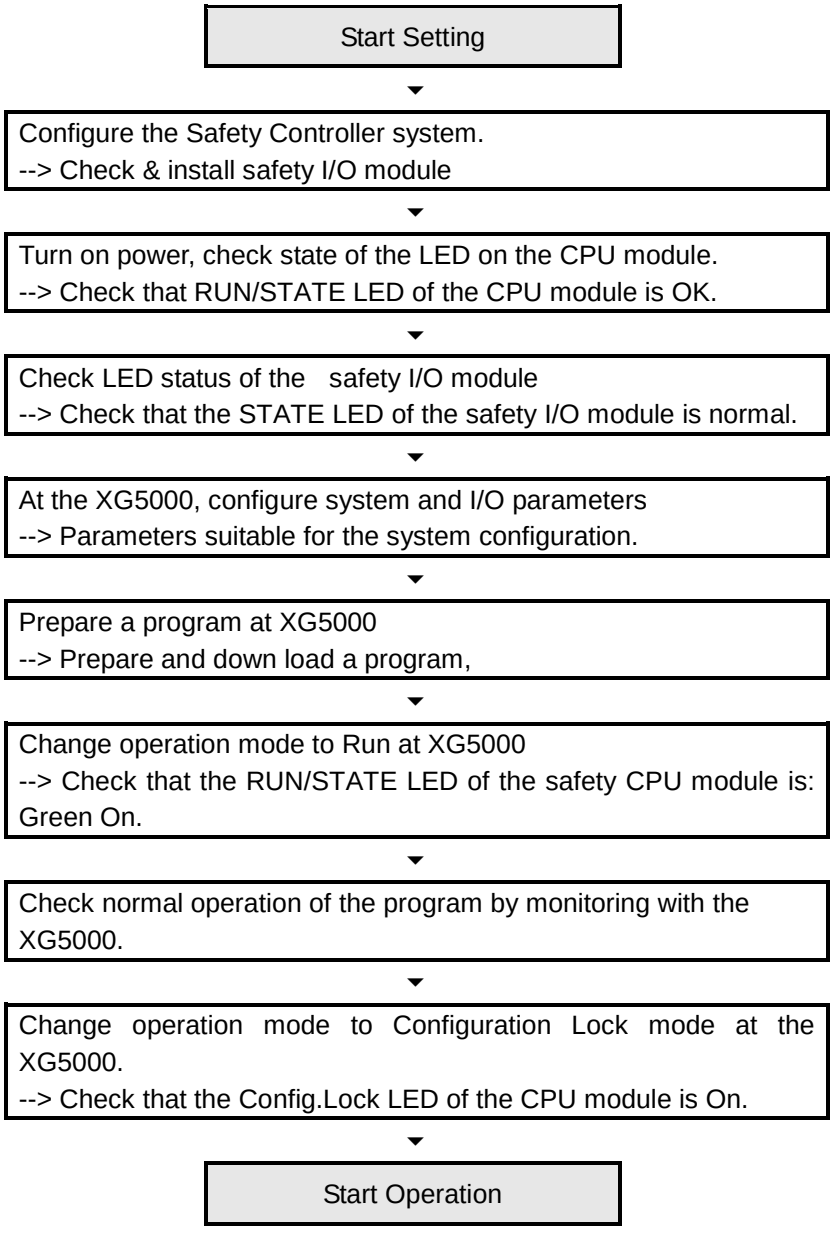
2) When changing data, program, or status of an operating safety controller, provide an interlock circuit with the sequence program and system outside to secure safe operation of the system. Read the manual carefully and determine operating sequence before operating the Safety Controller for safety. In addition, for online control of the Safety Controller at a PC, prepare countermeasures against communication error, may be due to cable connection failure, for the system.

3) When a safety function is activated and the output has been cut off, prepare an interlock program using reset button, etc., to prevent unauthorized manual restarting.

4) In case that the temperature inside of the operation panel where the Safety Controller is installed may exceed the allowable temperature range, it is highly recommended to install a heat exchanger in the operation panel to control the temperature. Using an ordinary ventilation fan may introduce dust from outside, affecting the function of the Safety Controller.

9.1.6 Product setting procedure up to commissioning

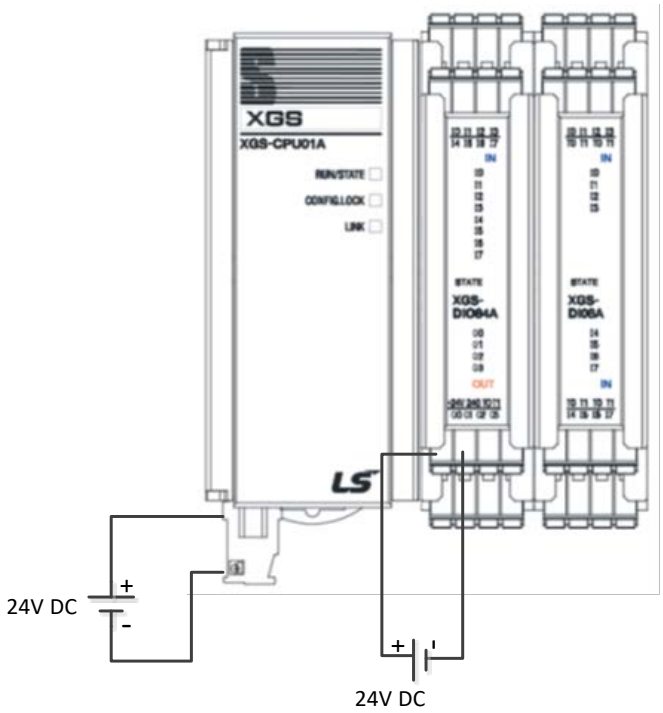
The procedures from installation to commissioning are described below. After installation, perform following procedures:



9.2 Wiring

This section provides information on the system wiring.

9.2.1 Power supply



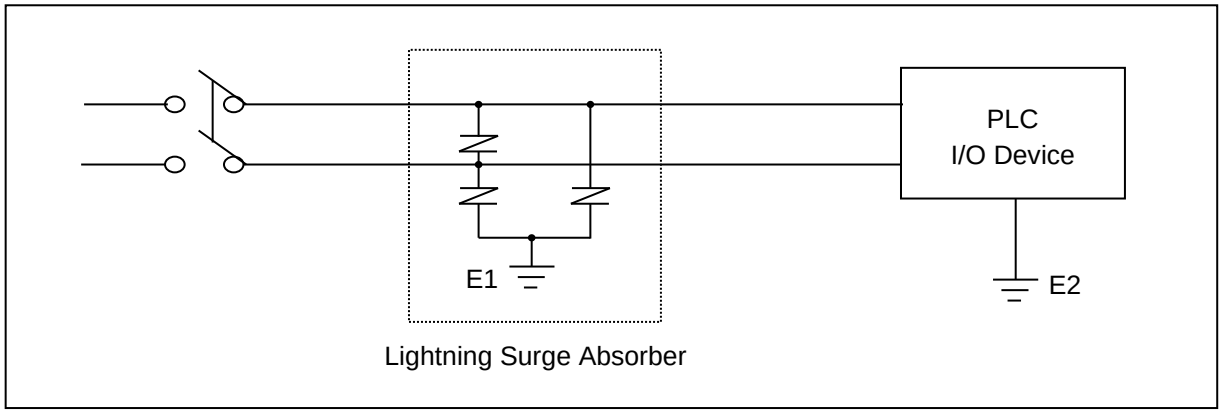
1) Use a power source having low line-to-line, line-to-ground noise.
(If noise is high, connect an insulation transformer.)

2) Isolate the systems of PLC power source, I/O devices and drive devices, as shown below.

3) It is recommended to twist the power wires densely and make the total length as short as possible.

4) Keep the DC 24V line away from the main circuit (high voltage, large current) lines and I/O signal lines. Provide at least 100 mm or more of space.

5) Install a lightning surge absorber to protect the system from lightning surge.



NOTE

1) The ground connection (E1) of the surge absorber and the ground connection (E2) of the PLC must be isolated.
2) the surge absorber must be able to absorb surge within the maximum allowable voltage at the maximum voltage peak of the power supply.

6) If noise may permeate, install an insulation transformer or noise filter.

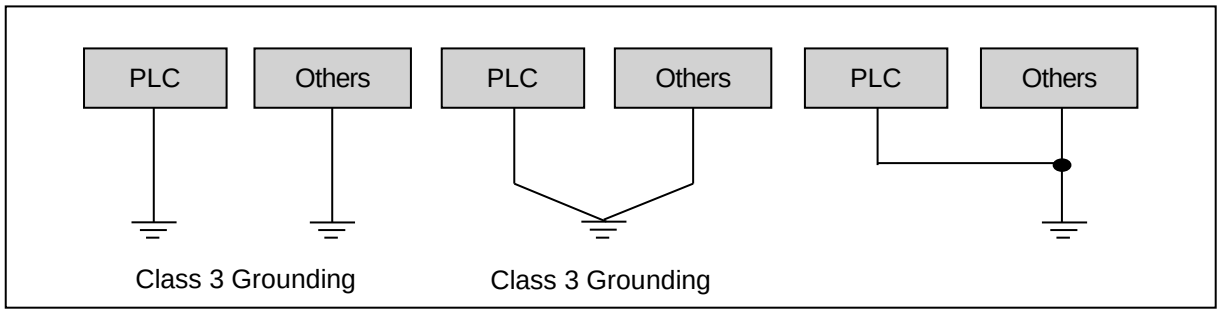
7) Use shortest, twisted wires for I/O power supplies. Do not lay the wires of the insulation transformer or noise filter in a conduit.

9.2.2 Grounding circuit

1) The PLC is implemented with sufficient anti-noise measures, thus, ground is not necessary unless the system is subject to very high noise level. If grounding is necessary, take following information into consideration.

2) The ground circuit should be exclusive as possible.
The grounding work shall be Class 3 (Ground resistance 100 Ω or less).

3) If exclusive grounding is unavailable, install common grounding circuit as illustrated in figure b) below.



a) Exclusive grounding: recommended
b) Common grounding: acceptable
c) Common grounding: unacceptable

4) Ground wire shall be at least 2 mm^2. Grounding point shall be as close to the PLC as possible to reduce the wire length.

9.2.3 wire specification

The table below presents specifications for the wires.

External Connection	Wire Size (mm^2)	
	Low Limit	Upper Limit
Digital Input	0.18 (AWG24)	1.5 (AWG16)
Digital Output	0.18 (AWG24)	2.0 (AWG14)
Main Power Supply	1.5 (AWG16)	2.5 (AWG12)
Protective Grounding	1.5 (AWG16)	2.5 (AWG12)

Chapter 10 Maintenance

Daily and regular maintenance must be performed to maintain the PLC always at the best condition.
The lifetime of the controllers is about 20 years. However, the impact on the environment can cause damage to the devices.
Results for all of the checks and administrative actions must be recorded. Please record information about the serial number of the product.

10.1 Inspection and Maintenance

The table below presents the items which should be inspected by 1~2 times per half year.

Items for Inspection		Decision Criteria	Corrective Action
Power supply		Within allowable range (Within –15% / +10%)	Adjust the power supply to meet the allowable voltage range.
Power supply for input/ output		Input/ output specification of each module	Adjust the power supply to meet the allowable voltage range of each module.
Environment	Temperature	0 ~ 55 ℃	Control the operation temperature and humidity to meet the specification.
	Humidity	5 ~ 95% RH	
	Vibration	No vibration	Apply anti-vibration rubber pads or other means to prevent vibration.
Shaking of module		No free movement is acceptable	No module must show looseness.
Loose terminating screws		No loose screw	Tighten loose bolts and nuts.
Spare parts		Check inventory and storage condition	Replenish with shortage, keep in good condition.

10.2 Daily Inspection

Daily inspection shall be performed for the items listed below.

Items for Inspection		Actions	Decision Criteria	Corrective Action
Mounting of I/O module		Check mounting of I/O module	Shall be firmly mounted	-
Connection at terminal block and extension cables		Close crimpled terminals	Shall have appropriate spacing	correction
Indicator LED	RUN/STATE LED	Check red lighting at Run status	Light up (abnormal if out)	See Chap.12
	CONFIG. LOCK LED	Check yellow lamp in safety lock mode Check yellow lamp flash in safety unlock	ON or flash	See Chap.12
	COMM LED	Red when connected to Ethernet cable	Abnormal if flashes	See Chap.12
	Input LED	Check ON/Off	Light ON at input On, Out at input Off	See Chap.12
	Output LED	Check ON/Off	Light ON at output On, Out at output Off	See Chap.12

10. 3 Regular Inspection

Check following items biannually and take corrective actions as necessary.

Items for Inspection		Inspection Method	Decision Criteria	Corrective Action
Environment	Ambient Temperature	Measure with thermometer/ hygrometer Measure corrosive gases	0 ~ 55 °C	Control within general specification. (Standard environment in the panel)
	Ambient humidity		5 ~ 95%RH	
	Ambient contamination		No corrosive gas allowed	
PLC	Looseness	Shake the modules.	Shall be firmly mounted	Tighten the screws
	dust, foreign matter	Visual inspection	No contaminant	-
Connection	Loose screws	Tighten with screw driver	No loose screw	Tighten
	Close crimpled terminals	Visual inspection	Shall have appropriate spacing	Correction
	Loose connection	Visual inspection	No loose screw	Correct the connector
Check supply voltage		Test the supply voltage with a tester	DC24V:DC19.2 ~ 28.8V	Adjust supply voltage
Fuses		Visual inspection	Shall be not blown	

NOTE

For all devices that are configured for safety applications, please follow the instructions for daily and regular inspections described in the manual for each device.

Chapter 11 EMC Compliance

11.1 Requirements Complying with EMC Specifications

EMC Directions describe “Do not emit strong electromagnetic wave to the outside: Emission” and “Do not have an influence of electromagnetic wave from the outside: Immunity”, and the applicable products are requested to meet the directions. The chapter summarizes how to structure a system using XGT PLC to comply with the EMC directions. The description is the data summarized for the requirements and specifications of EMC regulation acquired by the company but it does not mean that every system manufactured according to the description meets the following specifications. The method and determination to comply with the EMC directions should be finally determined by the system manufacturer self.

11.1.1 EMC specifications

The EMC specifications affecting the PLC are as follows.

Specification	Test items	Test details	Standard value
EN50081-2	EN55011 Radiated noise * 2	Measure the wave emitted from a product.	30~230 MHz QP : 50 dBμV/m * 1 230~1000 MHz QP : 57 dBμV/m
	EN55011 conducted noise	Measure the noise that a product emits to the power line.	150~500 kHz QP : 79 dB Mean : 66 dB 500~230 MHz QP : 73 dB Mean : 60 dB
EN61131-2	EN61000-4- Electrostatic immunity	Immunity test allowing static electricity to the case of a device.	8 kV Air discharge 6 kV Contact discharge
	EN61000-4-4 Fast transient burst noise	Immunity test allowing a fast noise to power cable and signal cable.	Power line : 2 kV Digital I/O : 1 kV Analogue I/O, signal lines : 1 kV
	EN61000-4-3 Radiated field AM modulation	Immunity test injecting electric field to a product.	10Vm, 26~1000 MHz 80% AM modulation@ 1 kHz
	EN61000-4-12 Damped oscillatory wave immunity	Immunity test allowing attenuation vibration wave to power cable.	Power line : 1 kV Digital I/O(24V and higher) : 1 kV

* 1 : QP: Quasi Peak, Mean : average value

* 2 : PLC is a type of open device(installed on another device) and to be installed in a panel.
For any applicable tests, the system is tested with the system installed in a panel.

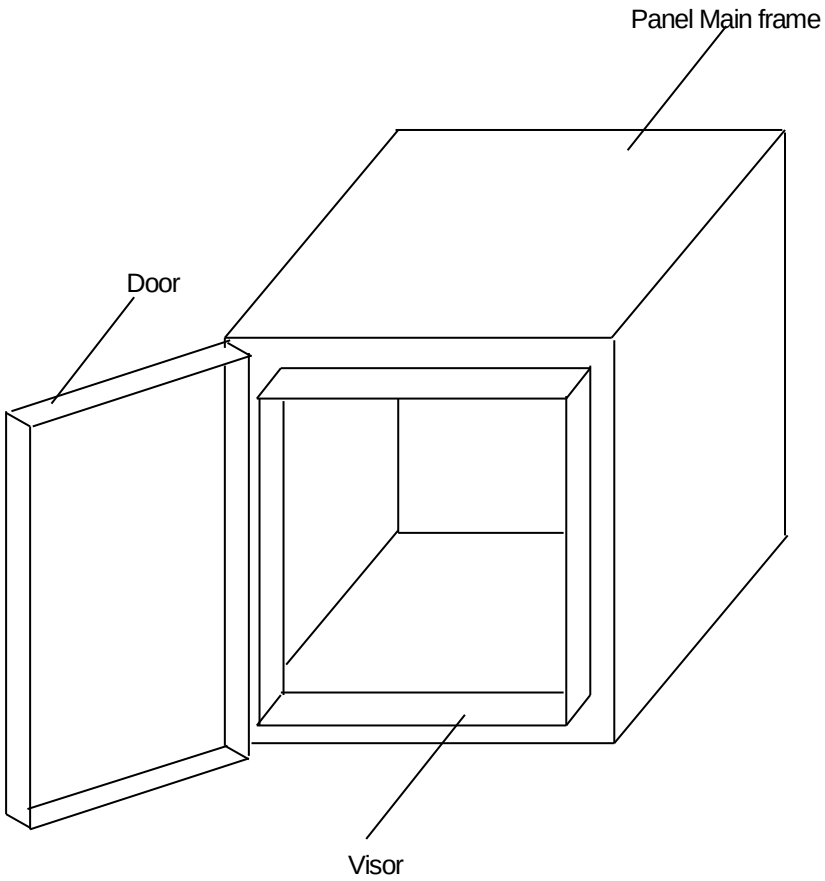
11.1.2 Panel

The PLC is a kind of open device(installed on another device) and it should be installed in a panel. It is because the installation may prevent a person from suffering from an accident due to electric shock as the person contacts with the product(XGT PLC) and the panel can attenuates the noise generating from the PLC.
In case of XGT PLC, to restrict EMI emitted from a product, it should be installed in a metallic panel. The specifications of the metallic panel are as follows.

1) Panel

The panel for PLC should be installed and manufactured as follows.

(1) The panel should be made of SPCC(Cold Rolled Mild Steel)
(2) The plate should be 1.6mm and thicker
(3) The power supplied to the panel should be protected against surge by using insulated transformer.
(4) The panel should be structured so that electric wave is not leaked outside. For instance, make the door as a box as presented below. The main frame should be also designed to be covered the door in order to restrict any radiating noise generated from the PLC.



(5) The inside plate of panel should have proper conductivity with a wide surface as possible by eliminating the plating of the bolt used to be mounted on the main frame in order to secure the electric contact with the frame.

2) Power cable and grounding cable

The grounding/power cable of PLC should be treated as follows.

(1) The panel should be grounded with a thick wire() to secure a lower impedance even in high frequency.
(2) LG(Line Ground) terminal and FG(Frame Ground) terminal functionally let the noise inside the PLC flow into the ground, so a wire of which impedance is low should be used.
(3) Since the grounding cable itself may generate noise, thick and short wiring may prevent it serving as an antenna.

11.1.3 Cable

1) Fixing a cable in the panel

If the extension cable of XGS series is to be installed on the metallic panel, the cable should be 1cm and more away from the panel, preventing the direct contact.
The metallic plate of panel may shield noise from electromagnetic wave while it a cable as a noise source is close to the place, it can serve as an antenna. Every fast signal cable as well as the extension cable needs proper spacing from the panel.

Chapter 12 Troubleshooting

This chapter describes the errors which may occur during operation and the causes, measures to detect and correct the errors

12.1 Basic Procedures for Troubleshooting

While it is important to employ reliable devices to improve system reliability, prompt response and taking corrective actions are also as much important.

In order to recover a troubled system, it is very important to identify and correct the cause of the problem, taking the following points into consideration.

1) Visual inspection

Check following points by visual inspection:

- Machine status (shut down, operating)
- Power supply
- I/O devices
- Wiring (I/O cables, extension and communication tables)
- Check the statuses of the indicators (RUN/STATE LED, CONFIG.LOCK LED, C LED, etc.), connect peripheral devices to test the operation of the PLC and program.

2) Check abnormality

Conduct following operation and check the change of the problem.

- Turn power supply Off and On.

3) Identify the source of problem

Investigate the cause of problem with the following procedures:

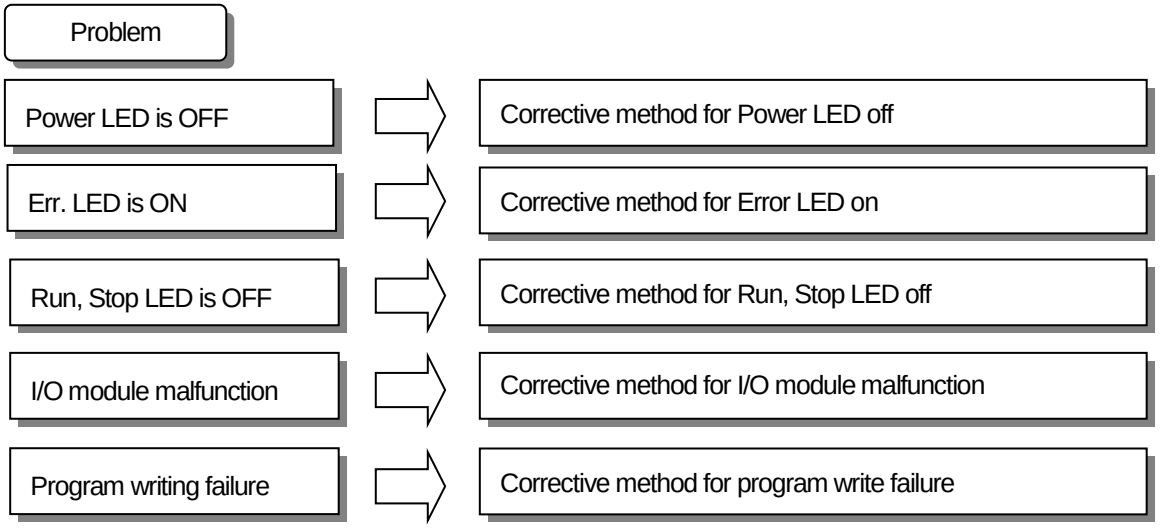
- PLC itself? Or external cause?
- Input/Output module? Or else?
- PLC program?

NOTE

When replacing the products, try operation after resetting all the information necessary for the operation resumed and checking safety functions.

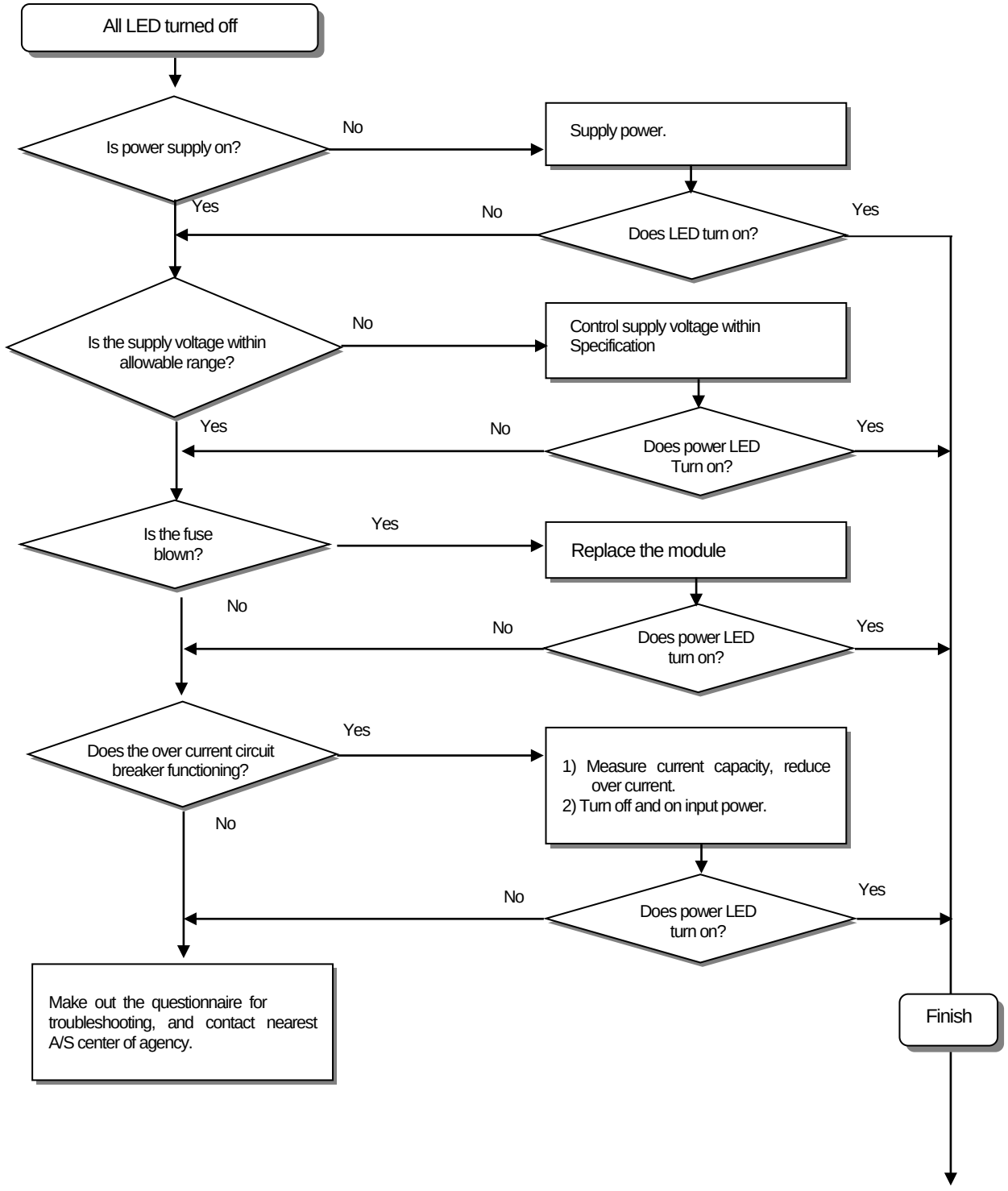
12.2 Troubleshooting

Methods for identifying problems, description of errors and error codes are provided below by symptoms.



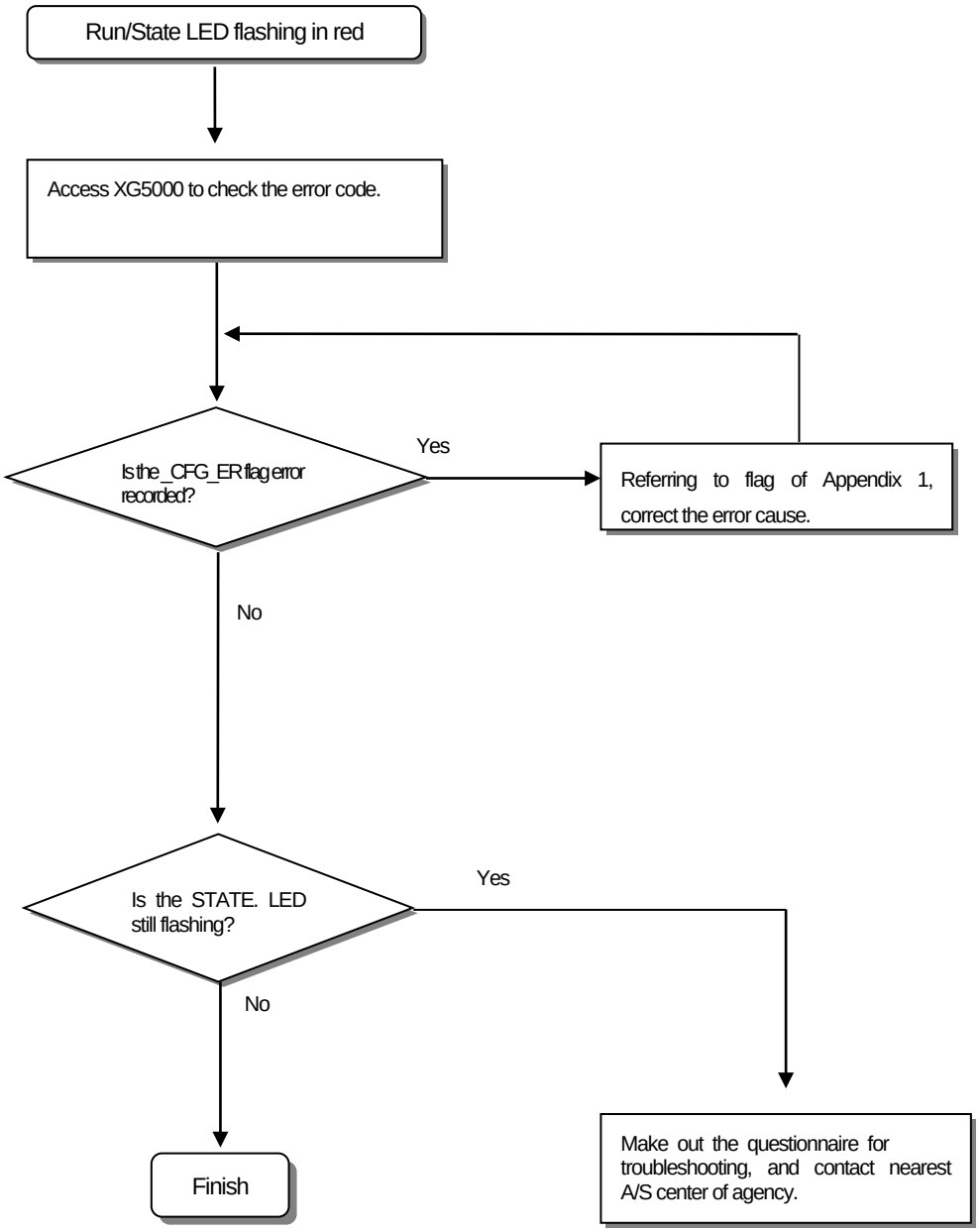
12.2.1 Corrective method for all LED OFF

If all LED turns off at power on or during operation, take following actions in said sequence.



12.2.2 Corrective method for Run/State LED flashing in red

If the Run/State LED blinks in red at power on or at starting or during operation, take following actions in said sequence.

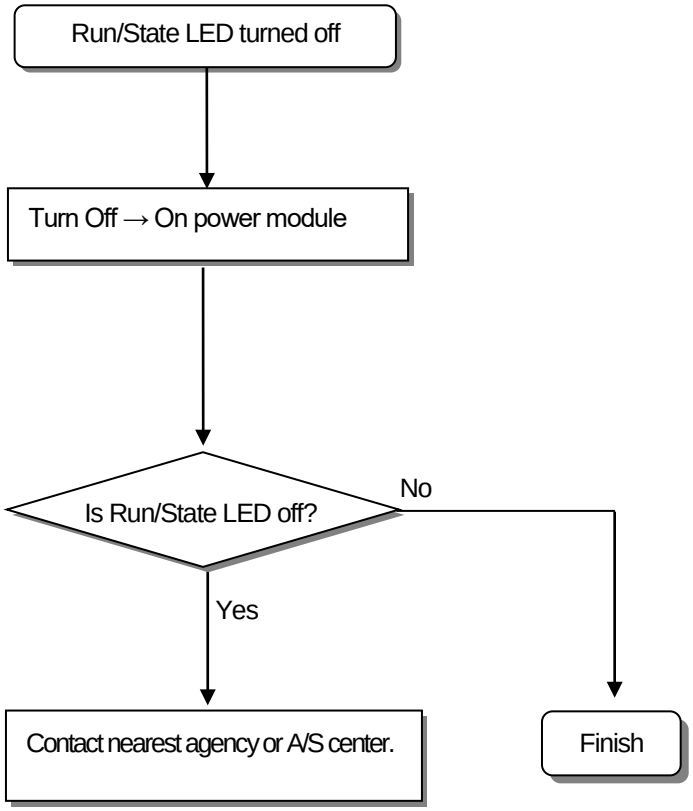


NOTE

The PLC will continue operation at a light error, however, check and correct the error cause as soon as possible. Otherwise, a light problem may become a heavy problem.

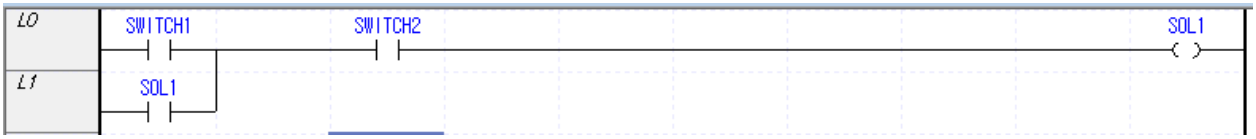
12.2.3 Corrective method for Run/State LED OFF

If the Run or Stop LED turns off at power on or during operation, take following actions in said sequence.



12.2.4 Corrective method for I/O module malfunctioning

This is to provide information on the corrective method for I/O module malfunctioning during operation.



I/I module malfunctioning

Is the output LED of SOL1 on?

No

Yes

Measure terminal voltage of SOL1 with a multitester

Check correct wiring

Replace terminal block connector

Monitor SOL1 with XG5000

Is the measurement value normal?

No

Is output wiring correct?

No

Are the terminal block connectors OK?

Yes

Normal?

No

Yes

Cont

Yes

Yes

Disconnect external wiring and test continuity of module output part.

Yes

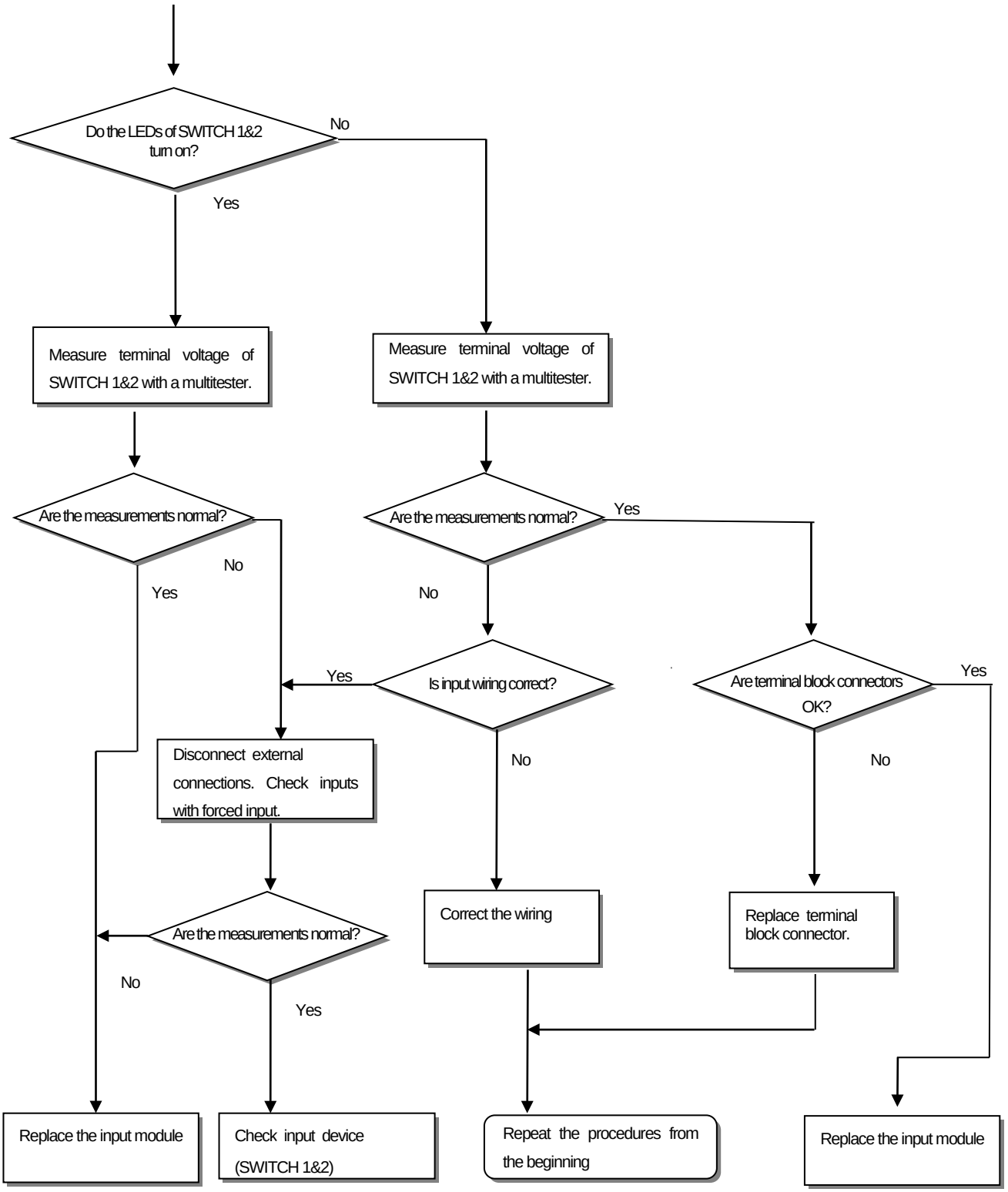
Normal?

No

Inspect output device (SOL1)

Replace the output module.

Cont


Do the LEDs of SWITCH 1&2 turn on?
No
Yes
Measure terminal voltage of SWITCH 1&2 with a multitester.
Measure terminal voltage of SWITCH 1&2 with a multitester.
Are the measurements normal?
No
Yes
Are the measurements normal?
Yes
No
Yes
Is input wiring correct?
Are terminal block connectors OK?
Yes
No
No
Disconnect external connections. Check inputs with forced input.
Are the measurements normal?
No
Yes
Correct the wiring
Replace terminal block connector.
Replace the input module
Check input device (SWITCH 1&2)
Repeat the procedures from the beginning
Replace the input module

12.3 Questionnaire for Troubleshooting

In case of a problem in operating the XGI series, please fill up this questionnaire and contact nearest A/S center via telephone of FAX.

• For an error related to special or communication module, use the questionnaire form attached to the users' ml of the product.

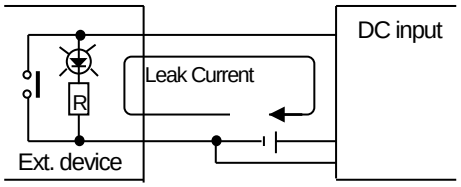
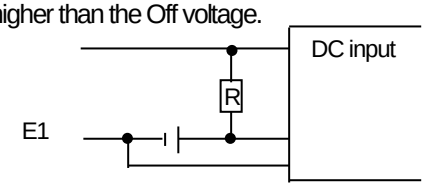
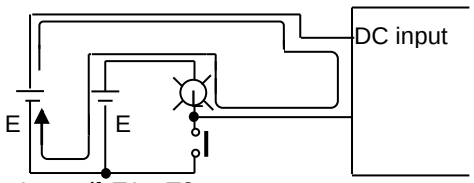
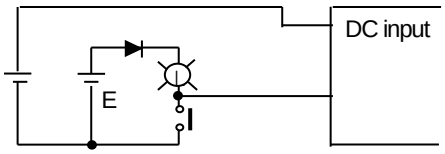
1. User contact: TEL) _____
   FAX) _____
2. Model: ( )
3. Information on the device
   – CPU module: – OS version ( ), – Product serial No. ( )
   – Version of XG5000 used for program compiling: ( )
4. Brief description on the controlled device/system:
5. Operation of the CPU module:
   – Operation by key switch ( ), – Operation by XG5000 or communication ( )
   – Operation by memory module ( )
6. Does the Stop LED of CPU module turn on? Yes ( ), No ( )
7. Error message of the XG5000:
8. Actions made in response to the error code of above 7:
9. Other troubleshooting methods taken to remove the error:
10. Characteristics of the error
    • Repetitive ( ): Cyclic ( ), Related to specific sequence ( )
      Environment-based error ( )
    • Intermittent ( ): average error intervals
11. Description of the error symptom
12. Structural diagram of the application system:

12.4 Case Study

This section describes the types of troubles in various circuits and the corrective actions.

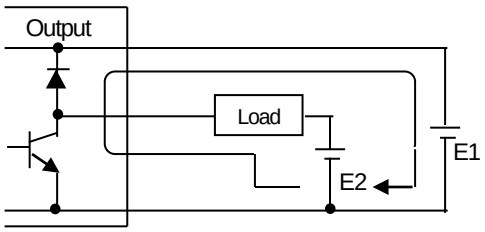
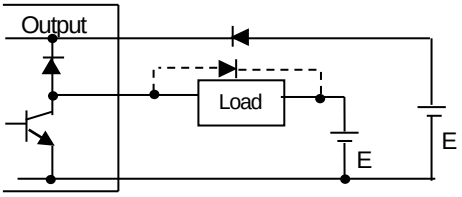
12.4.1 Types of troubles in input circuit and corrective actions

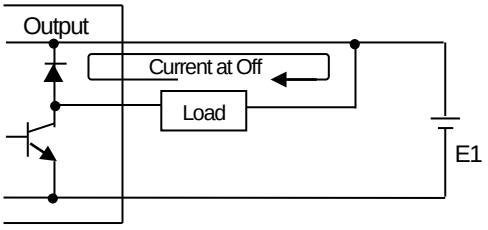
This section describes the cases of troubles in the input circuits and the corrective actions.

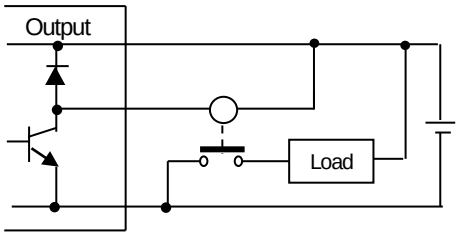
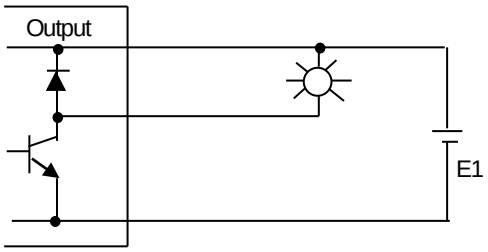
Problem	Possible Cause	Corrective Action
Input signal cannot be turned off	Leakage current of external device (driven by switch attached with LED mark) 	• Insert an appropriate resistor as shown in the diagram below so that the voltage between the input module terminal and common terminal is higher than the Off voltage. 
Input signal cannot be turned off	• Loop current by multiple power sources  • Loops if: E1 > E2	• Unify the power sources. • Install loop current cut off diode (Fig. below) 

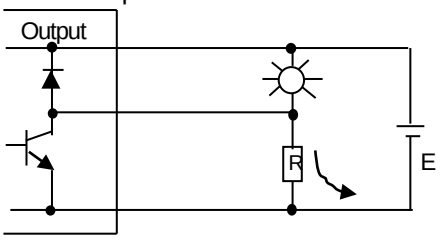
12.4.2 Types of troubles in output circuit and corrective actions

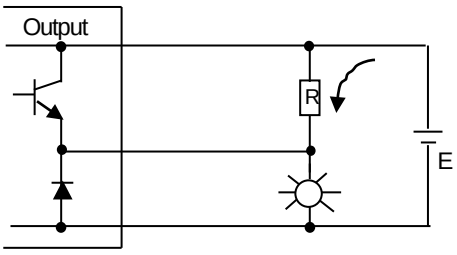
This section describes the cases of troubles in the output circuits and the corrective actions.

Problem	Possible Cause	Corrective Action
Load cannot be turned off (DC)	• Loop current by 2 power sources  • Loops if: E1< E2 • Also loops if E1 is Off (E2 is On)	• Unify power sources. • Install loop current cut off diode (Fig. below)  Note) If the load is a relay or similar device, a back EMF voltage absorbing diode is necessary as shown in the diagram by dot line.

<table>
<tr>
<td>Off response of load is too late.</td>
<td>• over current at Off
A dynamic load (large tome constant L/R) drawing large current (solenoid, etc.) is driven directly with transistor output
 

• Due to the current through the diode at transistor output off, the delay may 1 s or more.</td>
<td>• As shown in the diagram below, install a magnetic connector or a similar device having a small time constant to drive the load with the contact.
 
</td>
</tr>
<tr>
<td>Output transistor destroyed</td>
<td>Inrush current of incandescent lamp
 

Inrush current of 10 times or more may be induced at ON.</td>
<td>• To suppress inrush current, apply a leakage (background) current about 1/3 ~ 1/5 of the rated current of the lamp.
 

Sink type transistor output
 

Source type transistor output</td>
</tr>
</table>

12.5 Error Code List

12.5.1 CPU module error code

Code	Cause of Error	Corrective Action (Restart mode after correction)	Operating Condition	LED Status	When
128	System power supply error	Check the supply voltage	Safe	State LED flash	Regularly
144	CPU module self-test abnormal error	If problem persists when power reinput , ask A/S	Safe	State LED flash	Regularly
145	CPU module hardware abnormal error	If problem persists when power reinput , ask A/S	Safe	State LED flash	Regularly
146	CPU module CCM (Core Compare Module) error	If problem persists when power reinput , ask A/S	Safe	State LED flash	Regularly
147	CPU module internal memory data altered error	If problem persists when power reinput , ask A/S	Safe	State LED flash	Regularly
148	CPU module firmware altered error	If problem persists when power reinput , ask A/S	Safe	State LED flash	Regularly
149	Synchronization between module cores error	If problem persists when power reinput , ask A/S	Safe	State LED flash	Regularly
150	CPU module backup memory data altered error	If problem persists when power reinput , ask A/S	Safe	State LED flash	Regularly
151	Parameter error	If problem persists when power reinput , ask A/S	Safe	State LED flash	Regularly
152	Program watchdog error	If problem persists when power reinput , ask A/S	Safe	State LED flash	Regularly

12.5.2 I/O contact point error code

Code	Cause of Error	Corrective Action (Restart mode after correction)	Operating Condition	LED Status	When
1	Input circuit error	Check input circuit and wiring	Normal	Corresponding input LED flash	End of scan
2	Output circuit error	Check output circuit and wiring	Normal	Corresponding output LED flash	End of scan
3	Input circuit internal failure	If problem persists when power reinput , ask A/S	Safe	State LED flash	End of scan
4	Output circuit internal failure	If problem persists when power reinput , ask A/S	Safe	State LED flash	End of scan
5	Dual channel input mismatch error	Check input circuit and wiring	Normal	Corresponding input LED flash	End of scan
6	External test signal failure	Check input circuit and wiring	Normal	Corresponding input LED flash	End of scan

Code	Cause of Error	Corrective Action (Restart mode after correction)	Operating Condition	LED Status	When
8	I/O module separated	Check firm installation of I/O module	Safe	State LED flash	End of scan
9	I/O module type mismatch error	At the XG5000, compare I/O modules setting and actual module	Safe	State LED flash	End of scan
10	I/O module interface error	If problem persists when power reinput , ask A/S	Safe	State LED flash	End of scan
11	I/O data error	If problem persists when power reinput , ask A/S	Safe	State LED flash	End of scan
32	I/O module self-test abnormal error	If problem persists when power reinput , ask A/S	Safe	State LED flash	End of scan
33	I/O module hardware error	If problem persists when power reinput , ask A/S	Safe	State LED flash	End of scan
34	I/O module CCM (Core Compare Module) error	If problem persists when power reinput , ask A/S	Safe	State LED flash	End of scan
35	I/O module internal memory data altered error	If problem persists when power reinput , ask A/S	Safe	State LED flash	End of scan
36	I/O module firmware altered error	If problem persists when power reinput , ask A/S	Safe	State LED flash	End of scan
37	Synchronization between I/O module cores error	If problem persists when power reinput , ask A/S	Safe	State LED flash	End of scan
38	I/O module test pulse output 0 circuit error	If problem persists when power reinput , ask A/S	Safe	State LED flash	End of scan
39	I/O module test pulse output 1 circuit error	If problem persists when power reinput , ask A/S	Safe	State LED flash	End of scan
40	I/O module output power error	Check output voltage whether voltage level is normal range.	Safe	State LED flash	End of scan

Chapter 13 Safety Function Blocks

13.1 Safety Function Blocks List

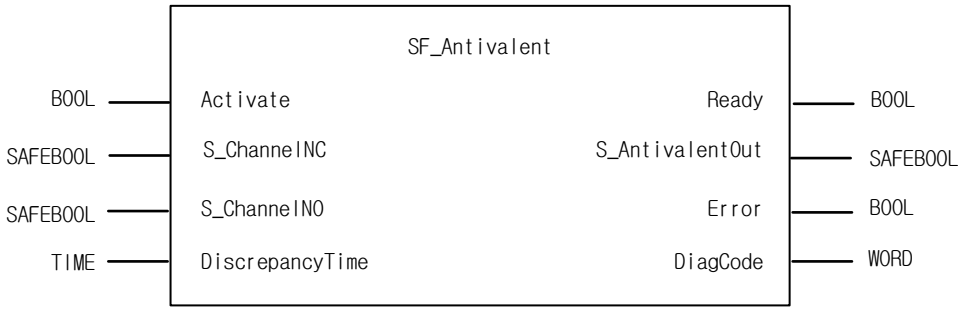
No	Function Block
1	SF_ANTIVALENT
2	SF_EDM
3	SF_ENABLESWITCH
4	SF_EQUIVALENT
5	SF_ESPE
6	SF_ESTOP
7	SF_GUARDLOCKING
8	SF_MODESEL
9	SF_MUTINGPAR
10	SF_MUTINGPAR_2SENSOR
11	SF_MUTINGSEQ
12	SF_OUTCONTROL
13	SF_SAFEGUARD
14	SF_SAFETYREQUEST
15	SF_TESTABLESAFETYSENSOR
16	SF_TWOHANDCTRLII
17	SF_TWOHANDCTRLIII

13.2 Safety Function Blocks

13.2.1 SF_ANTIVALENT

1) Overview

This function block converts two antivalent SAFEBOOL inputs (NO/NC pair) to one SAFEBOOL output with discrepancy time monitoring. This FB should not be used stand-alone since it has no restart interlock. It is required to connect the output to other safety related functionalities.



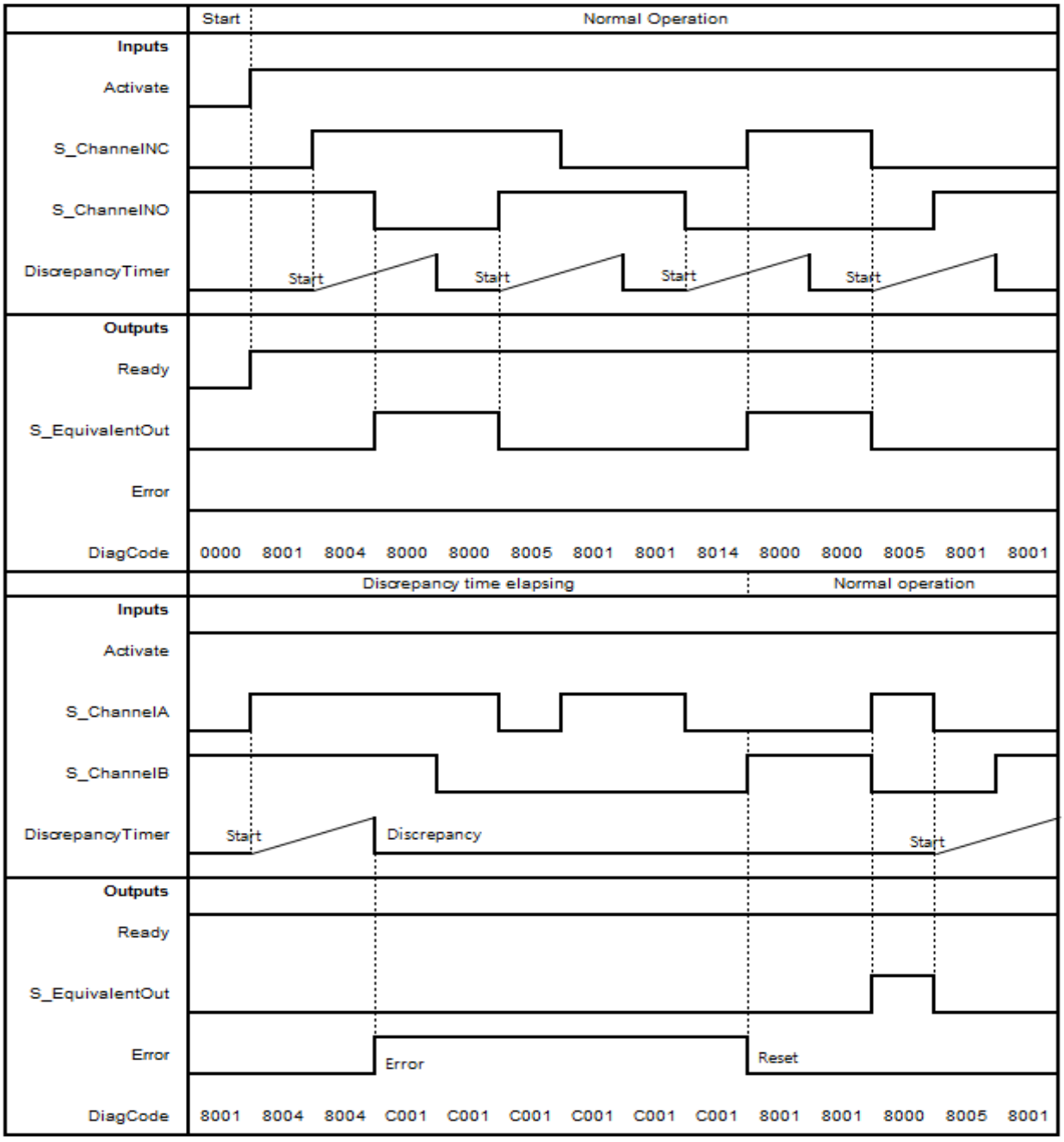
2) Input / Output Variables

Type	Name	Data Type	Initial Value	Description
Input	Activate	BOOL	0	Activation of the FB
	S_ChannelNC	SAFEBOOL	0	Variable. NC stands for Normally Closed. Input for NC connection. FALSE: NC contact open. TRUE: NC contact closed.
	S_ChannelNO	SAFEBOOL	1	Variable. NO stands for Normally Open. Input for NO connection. FALSE: NO contact open TRUE: NO contact closed
	DiscrepancyTime	TIME	T#0ms	Constant. Maximum monitoring time for discrepancy status of both inputs.
Output	Ready	BOOL	0	If TRUE, indicates that the FB is activated and the output results are valid.
	S_AntivalentOut	SAFEBOOL	0	Safety related output FALSE: Minimum of one input signal "not active" or status change outside of monitoring time. TRUE: Both inputs signals "active" and status change within monitoring time.
	Error	BOOL	0	Error flag
	DiagCode	WORD	16#0000	Diagnostic register. All states of the FB are represented by this register. This information is encoded in hexadecimal format in order to represent more then 16 codes.

3) Functional Description

This function block converts two equivalent SAFEBOOL inputs to one SAFEBOOL output with discrepancy time monitoring. Both input Channels A and B are interdependent. The function block output shows the result of the evaluation of both channels. If one channel signal changes from TRUE to FALSE the output immediately switches off (FALSE) for safety reasons.
Discrepancy time monitoring: The discrepancy time is the maximum period during which both inputs may have different states without the function block detecting an error. Discrepancy time monitoring starts when the status of an input changes. The function block detects an error when both inputs do not have the same status once the discrepancy time has elapsed.
The inputs must be switched symmetrically. This means that monitoring is performed for both the switching on process as well as the switching off process.

4) Typical Timing Diagrams



5) Error Detection

The function block monitors the discrepancy time between Channel NO and Channel NC.

6) Error Behavior

The output SF_AntivalentOut is set to FALSE. Error is set to TRUE. DiagCode indicates the Error states.
There is no Reset defined as an input coupled with the reset of an error. If an error occurs in the inputs, one new set of inputs with the correct value must be able to reset the error flag. (Example: if a switch is faulty and replaced, using the switch again results in a correct output)

7) Error Codes

DiagCode	State Name	State Description and Output Setting
C001	Error 1	Discrepancy time elapsed in state 8004. Ready = TRUE S_AntivalentOut = FALSE Error = TRUE
C002	Error 2	Discrepancy time elapsed in state 8014. Ready = TRUE S_AntivalentOut = FALSE Error = TRUE
C003	Error 3	Discrepancy time elapsed in state 8005. Ready = TRUE S_AntivalentOut = FALSE Error = TRUE

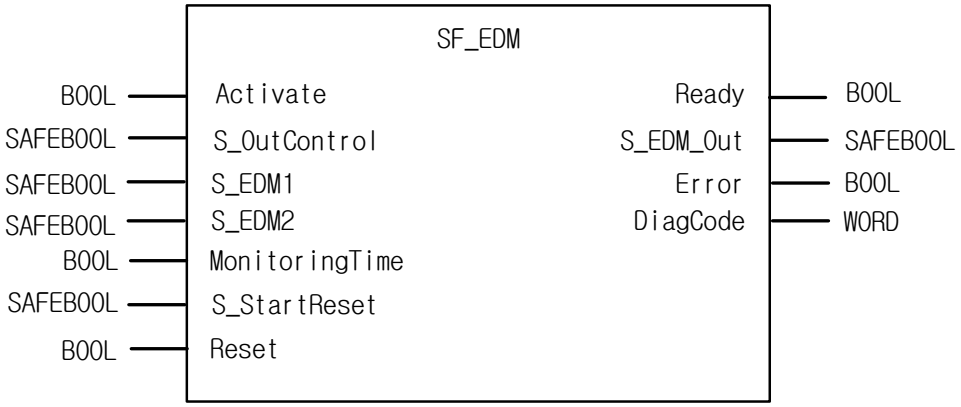
8) Status codes

DiagCode	State Name	State Description and Output Setting
0000	Idle	The function block is not active (initial state). Ready = FALSE S_AntivalentOut = FALSE Error = FALSE
8001	Init	An activation has been detected by the FB and the FB is now activated. Ready = TRUE S_AntivalentOut = FALSE Error = FALSE
8000	Safety Output Enabled	The inputs switched to the Active state in antivalent mode. Ready = TRUE S_AntivalentOut = TRUE Error = FALSE
8004	Wait for NO	ChannelNC has been switched to TRUE - waiting for ChannelNO to be switched to FALSE; discrepancy timer started. Ready = TRUE S_AntivalentOut = FALSE Error = FALSE
8014	Wait for NC	ChannelNO has been switched to FALSE - waiting for ChannelNC to be switched to TRUE; discrepancy timer started. Ready = TRUE S_AntivalentOut = FALSE Error = FALSE
8005	From Active Wait	One channel has been switched to inactive; waiting for the second channel to be switched to inactive too. Ready = TRUE S_AntivalentOut = FALSE Error = FALSE

13.2.2 SF_EDM

1) Overview

External device monitoring – The FB controls a safety output and monitors controlled actuators, e.g. subsequent contactors



2) Input / Output Variables

Type	Name	Data Type	Initial Value	Description
Input	Activate	BOOL	0	Activation of the FB
	S_OutControl	SAFEBOOL	0	Control signal of the preceeding safety FB's. Typical function block signals from the library (e.g.,SF_OutControl, SF_TwoHandControlTypeII, and/or others). FALSE: Disable safety output (S_EDM_Out). TRUE: Enable safety output (S_EDM_Out).
	S_EDM1	SAFEBOOL	0	Feedback signal of the first connected actuator. FALSE: Switching state of the first connected actuator. TRUE: Initial state of the first connected actuator.
	S_EDM2	SAFEBOOL	0	Feedback signal of the second connected actuator. If using only one signal in the application, the user must use a graphic connection to jumper the S_EDM1 and S_EDM2 parameters. S_EDM1 and S_EDM2 are then controlled by the same signal. FALSE: Switching state of the second connected actuator. TRUE: Initial state of the second connected actuator.
	MonitoringTime	TIME	#0ms	Max. response time of the connected and monitored actuators.
	S_StartReset			FALSE (= initial value): Manual reset when PES is started (warm or cold). TRUE: Automatic reset when PES is started (warm or cold).
	Reset	BOOL	0	Reset

Type	Name	Data Type	Initial Value	Description
Output	Ready	BOOL	0	If TRUE, indicates that the FB is activated and the output results are valid.
	S_EDM_Out	SAFEBOOL	0	Controls the actuator. The result is monitored by the feedback signal S_EDMx. FALSE: Disable connected actuators. TRUE: Enable connected actuators.
	Error	BOOL	0	Error flag
	DiagCode	WORD	16#0000	Diagnostic register. All states of the FB are represented by this register. This information is encoded in hexadecimal format in order to represent more then 16 codes.

3) Functional Description

General:

The SF_EDM FB controls a safety output and monitors controlled actuators.

This function block monitors the initial state of the actuators via the feedback signals (S_EDM1 and S_EDM2) before the actuators are enabled by the FB.

The function block monitors the switching state of the actuators (MonitoringTime) after the actuators have been enabled by the FB.

Two single feedback signals must be used for an exact diagnosis of the connected actuators. A common feedback signal from the two connected actuators must be used for a restricted yet simple diagnostic function of the connected actuators. When doing so, the user must connect this common signal to both parameter S_EDM1 and parameter S_EDM2. S_EDM1 and S_EDM2 are then controlled by the same signal.

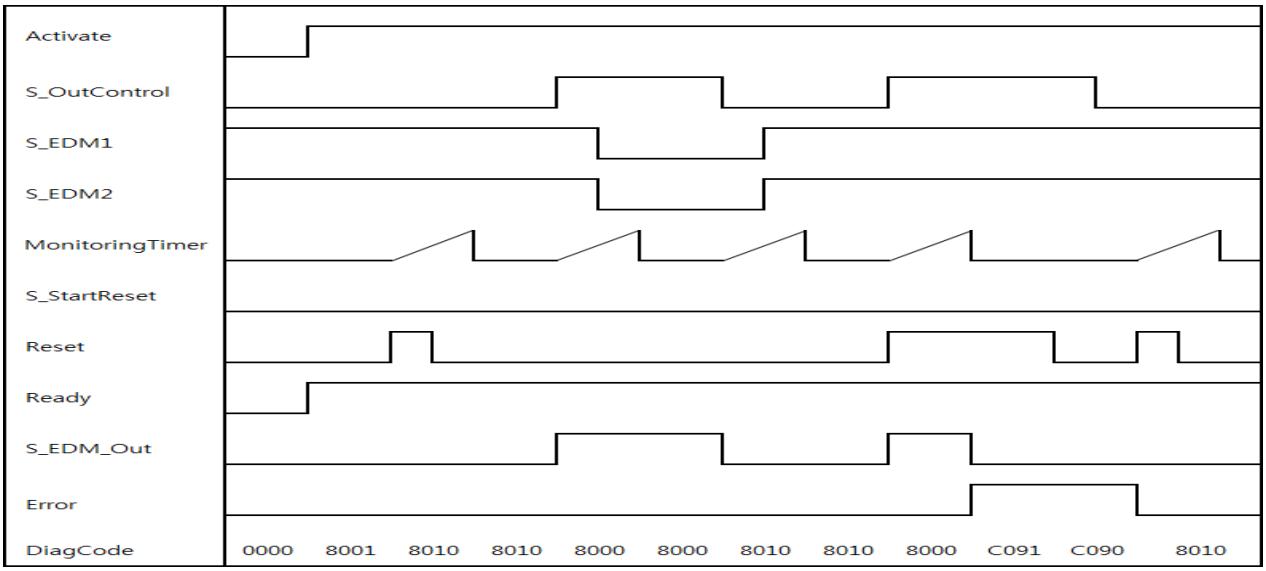
The switching devices used in the safety function should be selected from the category specified in the risk analysis (EN 954-1).

Optional startup inhibits:

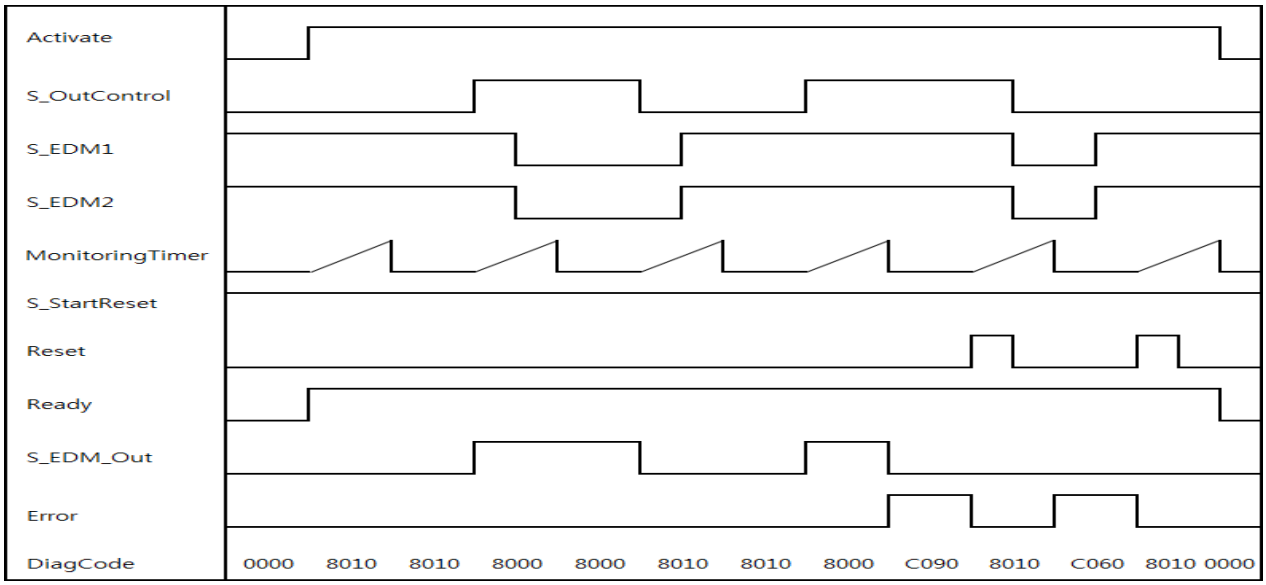
• Startup inhibit in the event of block activation.

The S_StartReset input shall only be activated if it is ensured that no hazardous situation can occur when the PES is started.

4) Typical Timing Diagrams



< S_StartReset=Off >



< S_StartReset=On >

5) Error Detection

The following conditions force a transition to the Error state:

- Invalid static Reset signal in the process.
- Invalid EDM signal in the process.
- S_OutControl and Reset are incorrectly interconnected due to programming error.

6) Error Behavior

In error states, the outputs are as follows:

- In the event of an error, the S_EDM_Out is set to FALSE and remains in this safe state.
- An EDM error message must always be reset by a rising trigger at Reset.
- A Reset error message can be reset by setting Reset to FALSE.

After block activation, the optional startup inhibit can be reset by a rising edge at the Reset input.

7) Error Codes

DiagCode	State Name	State Description and Output Setting
C001	Reset Error 1	Static Reset signal in state 8001. Ready = TRUE S_EDM_Out = FALSE Error = TRUE
C011	Reset Error 21	Static Reset signal or same signals at EDM1 and Reset (rising trigger at Reset and EDM1 at the same time) in state C010. Ready = TRUE S_EDM_Out = FALSE Error = TRUE
C021	Reset Error 22	Static Reset signal or same signals at EDM2 and Reset (rising trigger at Reset and EDM2 at the same time) in state C020. Ready = TRUE S_EDM_Out = FALSE Error = TRUE
C031	Reset Error 23	Static Reset signal or same signals at EDM1, EDM2, and Reset (rising trigger at Reset, EDM1, and EDM2 at the same time) in state C030. Ready = TRUE S_EDM_Out = FALSE Error = TRUE
C041	Reset Error 31	Static Reset signal or same signals at EDM1 and Reset (rising trigger at Reset and EDM1 at the same time) in state C040. Ready = TRUE S_EDM_Out = FALSE Error = TRUE
C051	Reset Error 32	Static Reset signal or same signals at EDM2 and Reset (rising trigger at Reset and EDM2 at the same time) in state C050. Ready = TRUE S_EDM_Out = FALSE Error = TRUE
C061	Reset Error 33	Static Reset signal or same signals at EDM1, EDM2, and Reset (rising trigger at Reset, EDM1, and EDM2 at the same time) in state C060. Ready = TRUE S_EDM_Out = FALSE Error = TRUE
C071	Reset Error 41	Static Reset signal in state C070. Ready = TRUE S_EDM_Out = FALSE Error = TRUE
C081	Reset Error 42	Static Reset signal in state C080. Ready = TRUE S_EDM_Out = FALSE Error = TRUE

DiagCode	State Name	State Description and Output Setting
C091	Reset Error 43	Static Reset signal in state C090. Ready = TRUE S_EDM_Out = FALSE Error = TRUE
C010	EDM Error 11	The signal at EDM1 is not valid in the initial actuator state. In state 8010 the EDM1 signal is FALSE when enabling O_OutControl. Ready = TRUE S_EDM_Out = FALSE Error = TRUE
C020	EDM Error 12	The signal at EDM2 is not valid in the initial actuator state. In state 8010 the EDM2 signal is FALSE when enabling O_OutControl. Ready = TRUE S_EDM_Out = FALSE Error = TRUE
C030	EDM Error 13	The signals at EDM1 and EDM2 are not valid in the initial actuator states. In state 8010 the EDM1 and EDM2 signals are FALSE when enabling O_OutControl. Ready = TRUE S_EDM_Out = FALSE Error = TRUE
C040	EDM Error 21	The signal at EDM1 is not valid in the initial actuator state. In state 8010 the EDM1 signal is FALSE and the monitoring time has elapsed. Ready = TRUE S_EDM_Out = FALSE Error = TRUE
C050	EDM Error 22	The signal at EDM2 is not valid in the initial actuator state. In state 8010 the EDM2 signal is FALSE and the monitoring time has elapsed. Ready = TRUE S_EDM_Out = FALSE Error = TRUE
C060	EDM Error 23	The signals at EDM1 and EDM2 are not valid in the initial actuator states. In state 8010 the EDM1 and EDM2 signals are FALSE and the monitoring time has elapsed. Ready = TRUE S_EDM_Out = FALSE Error = TRUE
C070	EDM Error 31	The signal at EDM1 is not valid in the actuator switching state. In state 8000 the EDM1 signal is TRUE and the monitoring time has elapsed. Ready = TRUE S_EDM_Out = FALSE Error = TRUE

DiagCode	State Name	State Description and Output Setting
C080	EDM Error 32	The signal at EDM2 is not valid in the actuator switching state. In state 8000 the EDM2 signal is TRUE and the monitoring time has elapsed. Ready = TRUE S_EDM_Out = FALSE Error = TRUE
C090	EDM Error 33	The signals at EDM1 and EDM2 are not valid in the actuator switching state. In state 8000 the EDM1 and EDM2 signals are TRUE and the monitoring time has elapsed. Ready = TRUE S_EDM_Out = FALSE Error = TRUE
C111	Init Error	S Similar signals at S_OutControl and Reset (R_TRIG at same cycle) detected (may be a programming error) Ready = TRUE S_EDM_Out = FALSE Error = TRUE

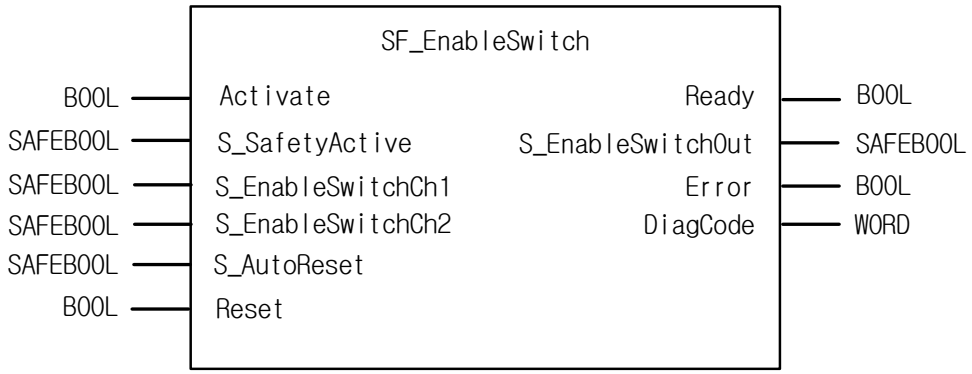
8) Status codes

DiagCode	State Name	State Description and Output Setting
0000	Idle	The function block is not active (initial state). Ready = FALSE S_EDM_Out = FALSE Error = FALSE
8001	Init	Block activation startup inhibit is active. Reset required. Ready = TRUE S_EDM_Out = FALSE Error = FALSE
8010	Output Disable	EDM control is not active. Timer starts when state is entered Ready = TRUE S_EDM_Out = FALSE Error = FALSE
8000	Output Enable	EDM control is active. Timer starts when state is entered Ready = TRUE S_EDM_Out = TRUE Error = FALSE

13.2.3 SF_ENABLESWITCH

1) Overview

The SF_EnableSwitch FB evaluates the signals of an enable switch with three positions.



2) Input / Output Variables

Type	Name	Data Type	Initial Value	Description
Input	Activate	BOOL	0	Activation of the FB
	S_SafetyActive	SAFEBOOL	0	Confirmation of the safe mode (limitation of the speed or the power of motion, limitation of the range of motion). FALSE: Safe mode is not active. TRUE: Safe mode is active.
	S_EnableSwitchCh1	SAFEBOOL	0	Signal of contacts E1 and E2 of the connected enable switch. FALSE: Connected switches are open. TRUE: Connected switches are closed.
	S_EnableSwitchCh2	SAFEBOOL	0	Signal of contacts E3 and E4 of the connected enable switch. FALSE: Connected switches are open. TRUE: Connected switches are closed.
	S_AutoReset	SAFEBOOL	0	FALSE (= initial value): Manual reset when emergency stop button is released. TRUE: Automatic reset when emergency stop button is released. This function shall only be activated if it is ensured that no hazard can occur at the start of the PES. Therefore the use of the Automatic Circuit Reset feature of the function blocks requires implementation of other system or application measures to ensure that unexpected (or unintended) startup does not occur.
	Reset	BOOL	0	Reset

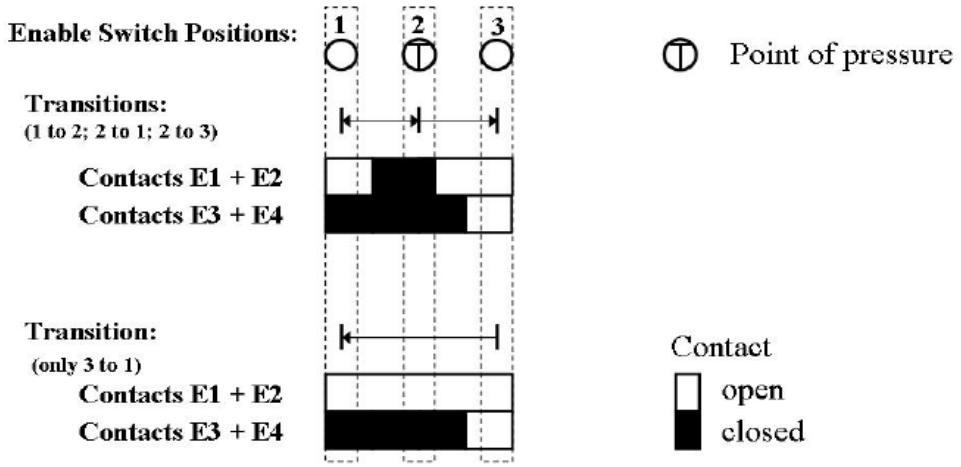
Type	Name	Data Type	Initial Value	Description
Output	Ready	BOOL	0	If TRUE, indicates that the FB is activated and the output results are valid.
	S_EnableSwitchOut	SAFEBOOL	0	Safety related output: Indicates suspension of guard. FALSE: Disable suspension of safeguarding. TRUE: Enable suspension of safeguarding.
	Error	BOOL	0	Error flag
	DiagCode	WORD	16#0000	Diagnostic register. All states of the FB are represented by this register. This information is encoded in hexadecimal format in order to represent more then 16 codes.

3) Functional Description

The SF_EnableSwitch FB supports the suspension of safeguarding using enable switches, if the relevant operating mode is selected and active. The relevant operating mode (limitation of the speed or the power of motion, limitation of the range of motion) must be selected outside the SF_EnableSwitch FB.

The SF_EnableSwitch FB evaluates the signals of an enable switch with three positions

The S_EnableSwitchCh1 and S_EnableSwitchCh2 input parameters process the following signal levels of contacts E1 to E4:



The signal from E1+E2 must be connected to the S_EnableSwitchCh1 parameter. The signal from E3+E4 must be connected to the S_EnableSwitchCh2 parameter. The position of the enable switch is detected in the FB using this signal sequence. The transition from position 2 to 3 can be different from shown here.

The switching direction (position 1 => position 2/position 3 => position 2) can be detected in the FB using the defined signal sequence of the enable switch contacts. The suspension of safeguarding can only be enabled by the FB after a move from position 1 to position 2. Other switching directions or positions may not be used to enable the suspension of safeguarding.

In order to meet the requirements of DIN EN 60204 Section 9.2.4, the user shall use a suitable switching device. In addition, the user must ensure that the relevant operating mode is selected in the application (automatic operation must be disabled in this operating mode using appropriate measures).

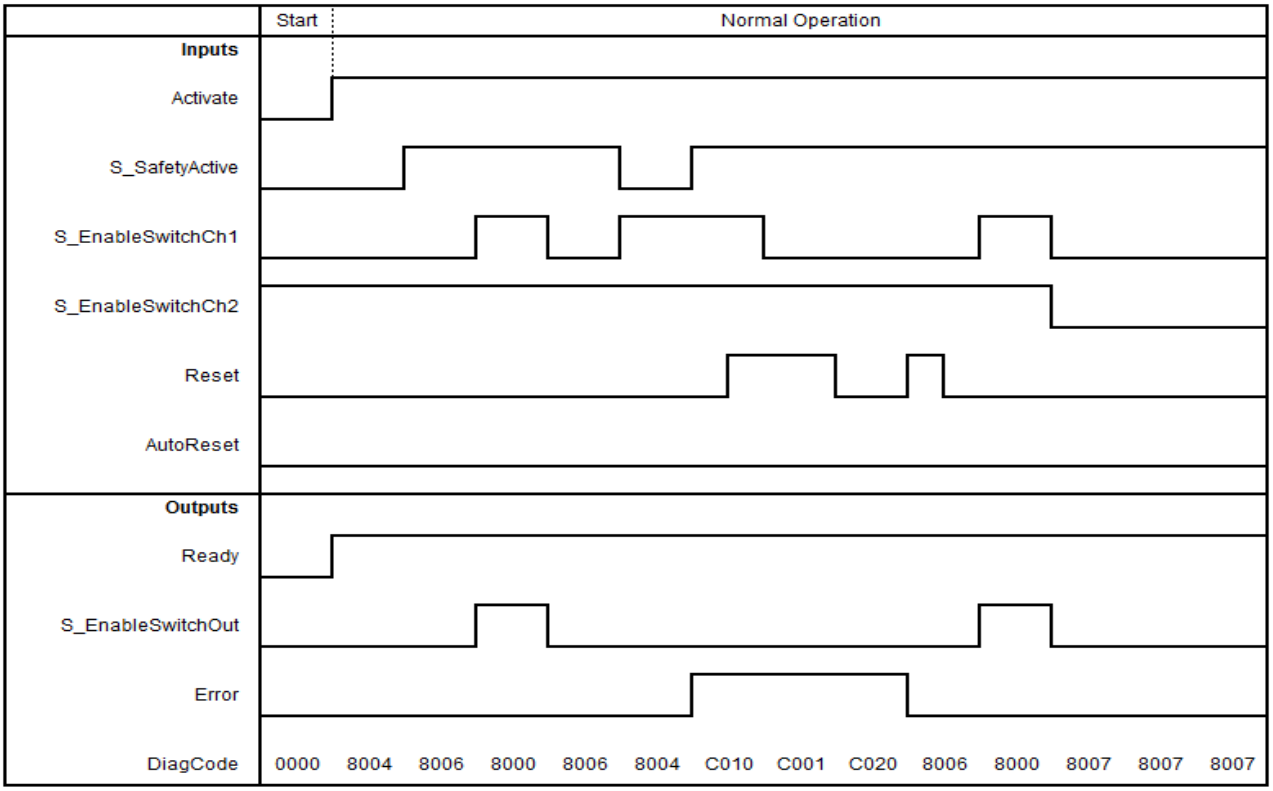
The operating mode is usually specified using an operating mode selection switch in conjunction with the SF_ModeSelector FB and the SF_SafeRequest or SF_SafelyLimitedSpeed FB.

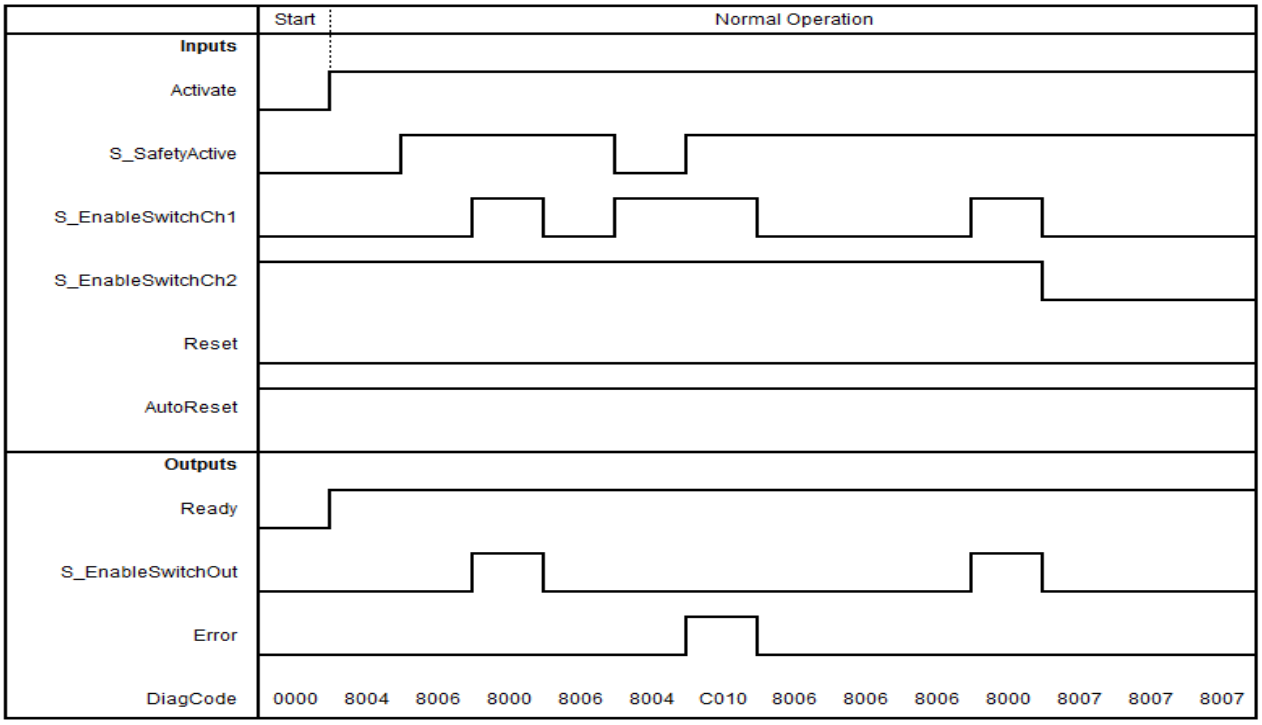
The SF_EnableSwitch FB processes the confirmation of the "safe mode" state via the "S_SafetyActive" parameter. On implementation

in an application of the safe mode without confirmation, a static TRUE signal is connected to the "S_SafetyActive" parameter.

The S_AutoReset input shall only be activated if it is ensured that no hazardous situation can occur when the PES is started.

4) Typical Timing Diagrams





5) Error Detection

The following conditions force a transition to the Error state:

- Invalid static Reset signal in the process.
- Invalid switch positions.

6) Error Behavior

In the event of an error, the S_EnableSwitchOut safe output is set to FALSE and remains in this Safe state. Different from other FBs, a Reset Error state can be left by the condition Reset = FALSE or, additionally, when the signal S_SafetyActive is FALSE. Once the error has been removed, the enable switch must be in the initial position specified in the process before the S_EnableSwitchOut output can be set to TRUE using the enable switch. If S_AutoReset = FALSE, a rising trigger is required at Reset.

7) Error Codes

DiagCode	State Name	State Description and Output Setting
C001	Reset Error 1	Static Reset signal detected in state C020. Ready = TRUE S_EnableSwitchOut = FALSE Error = TRUE
C002	Reset Error 2	Static Reset signal detected in state C040. Ready = TRUE S_EnableSwitchOut = FALSE Error = TRUE
C010	Operation Error 1	Enable switch not in position 1 during activation of S_SafetyActive. Ready = TRUE S_EnableSwitchOut = FALSE Error = TRUE
C020	Operation Error 2	Enable switch in position 1 after C010. Ready = TRUE S_EnableSwitchOut = FALSE Error = TRUE
C030	Operation Error 3	Enable switch in position 2 after position 3. Ready = TRUE S_EnableSwitchOut = FALSE Error = TRUE
C040	Operation Error 4	Enable switch not in position 2 after C030. Ready = TRUE S_EnableSwitchOut = FALSE Error = TRUE

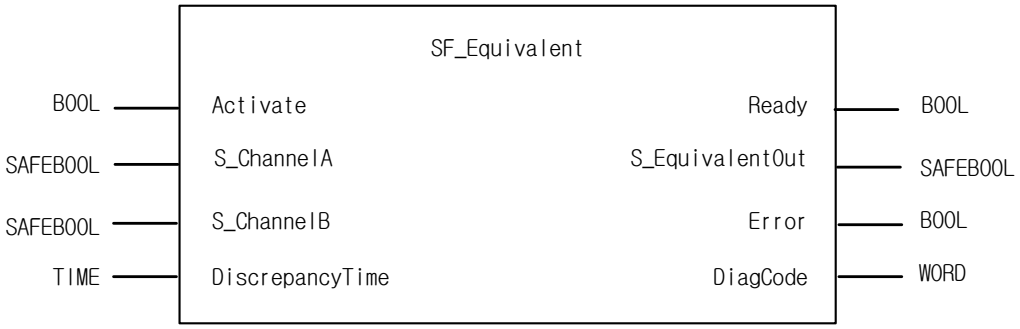
8) Status codes

DiagCode	State Name	State Description and Output Setting
0000	Idle	The function block is not active (initial state). Ready = FALSE S_EnableSwitchOut = FALSE Error = FALSE
8004	Basic Operation Mode	Safe operation mode is not active. Ready = TRUE S_EnableSwitchOut = FALSE Error = FALSE
8005	Safe Operation Mode	Safe operation mode is active. Ready = TRUE S_EnableSwitchOut = FALSE Error = FALSE
8006	Position 1	Safe operation mode is active and the enable switch is in position 1. Ready = TRUE S_EnableSwitchOut = FALSE Error = FALSE
8007	Position 3	Safe operation mode is active and the enable switch is in position 3. Ready = TRUE S_EnableSwitchOut = FALSE Error = FALSE
8000	Position 2	Safe operation mode is active and the enable switch is in position 2. Ready = TRUE S_EnableSwitchOut = TRUE Error = FALSE

13.2.4 SF_EQUIVALENT

1) Overview

This function block converts two equivalent SAFEBOOL inputs (both NO or NC) to one SAFEBOOL output, including discrepancy time monitoring. This FB should not be used stand-alone since it has no restart interlock. It is required to connect the output to other safety related functionalities.



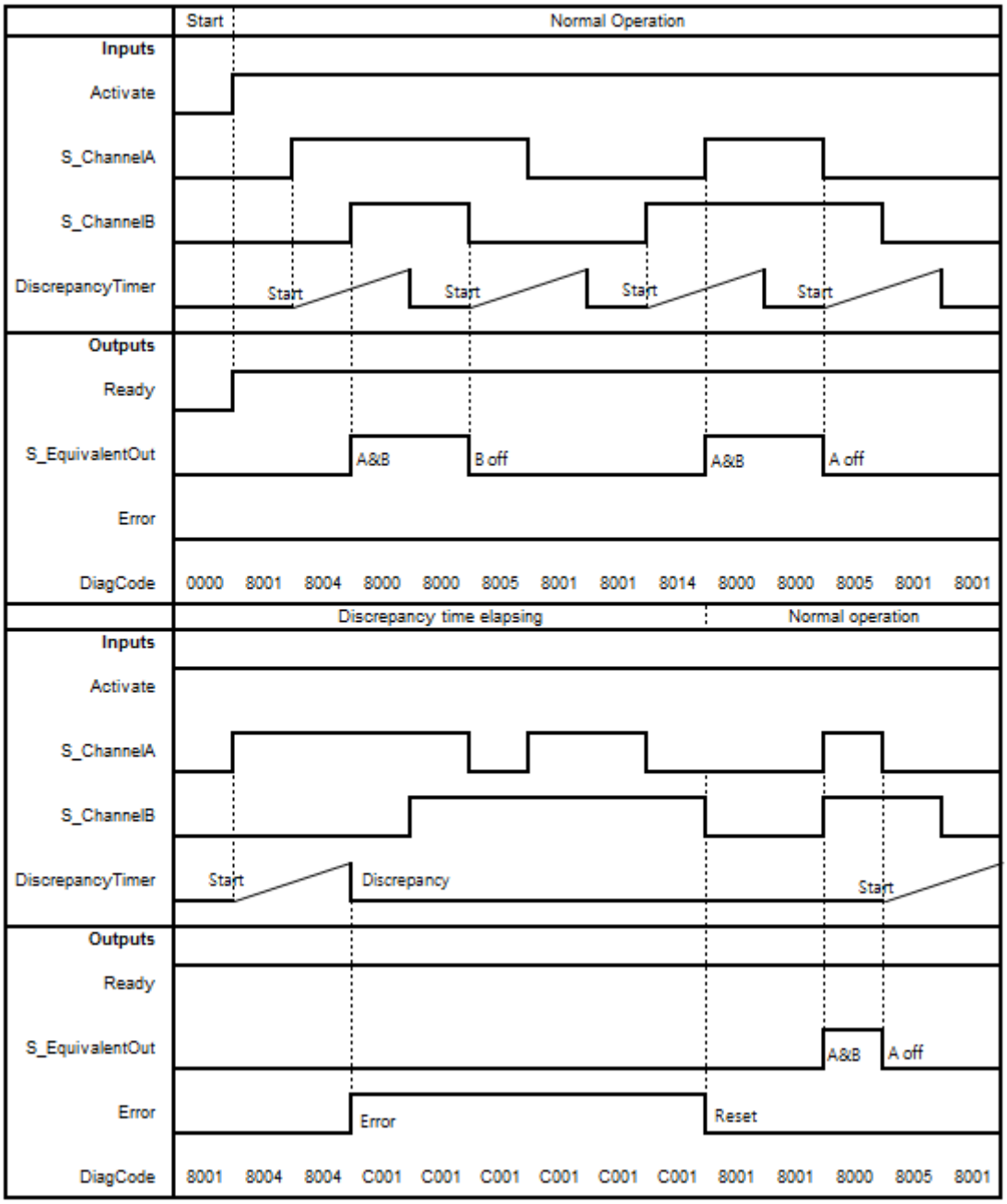
2) Input / Output Variables

Type	Name	Data Type	Initial Value	Description
Input	Activate	BOOL	0	Activation of the FB
	S_ChannelA	SAFEBOOL	0	Input A for logical connection. FALSE: Contact A open TRUE: Contact A closed.
	S_ChannelB	SAFEBOOL	0	Input B for logical connection. FALSE: Contact B open TRUE: Contact B closed.
	DiscrepancyTime	TIME	T#0ms	2 개 Input 의 Discrepancy time 설정 0 ~ 65535ms
Output	Ready	BOOL	0	Maximum monitoring time for discrepancy status of both inputs.
	S_EquivalentOut	SAFEBOOL	0	Safety related output FALSE: Minimum of one input signal = "FALSE" or status change outside of monitoring time. TRUE: Both input signals "active" and status change within monitoring time
	Error	BOOL	0	Error flag
	DiagCode	WORD	16#0000	Diagnostic register. All states of the FB are represented by this register. This information is encoded in hexadecimal format in order to represent more then 16 codes.

3) Functional Description

This function block converts two equivalent SAFEBOOL inputs to one SAFEBOOL output with discrepancy time monitoring. Both input Channels A and B are interdependent. The function block output shows the result of the evaluation of both channels. If one channel signal changes from TRUE to FALSE the output immediately switches off for safety reasons. Discrepancy time monitoring: The discrepancy time is the maximum period during which both inputs may have different states without the function block detecting an error. Discrepancy time monitoring starts when the status of an input changes. The function block detects an error when both inputs do not have the same status once the discrepancy time has elapsed.
The inputs must be switched symmetrically. This means that monitoring is performed for both the switching on process as well as the switching off process.

4) Typical Timing Diagrams



5) Error Detection

The function block monitors the discrepancy time between Channel A and B, when switching to TRUE and also when switching to FALSE.

6) Error Behavior

S_EquivalentOut is set to FALSE. Error is set to TRUE. DiagCode indicates the Error states. There is no Reset defined as an input coupled with the reset of an error. If an error occurs in the inputs, a new set of inputs with correct S_EquivalentOut must be able to reset the error flag. (Example: if a switch is faulty and replaced, using the switch again results in a correct output)

7) Error Codes

DiagCode	State Name	State Description and Output Setting
C001	Error 1	Discrepancy time elapsed in state 8004. Ready = TRUE S_EquivalentOut = FALSE Error = TRUE
C002	Error 2	Discrepancy time elapsed in state 8014. Ready = TRUE S_EquivalentOut = FALSE Error = TRUE
C003	Error 3	Discrepancy time elapsed in state 8005. Ready = TRUE S_EquivalentOut = FALSE Error = TRUE

8) Status codes

DiagCode	State Name	State Description and Output Setting
0000	Idle	The function block is not active (initial state). Ready = FALSE S_EquivalentOut = FALSE Error = FALSE
8001	Init	An activation has been detected by the FB and the FB is now activated. Ready = TRUE S_EquivalentOut = FALSE Error = FALSE
8000	Safety Output Enabled	The inputs switched to TRUE in equivalent mode. Ready = TRUE S_EquivalentOut = TRUE Error = FALSE
8004	Wait for Channel B	Channel A has been switched to TRUE - waiting for Channel B; discrepancy timer started. Ready = TRUE S_EquivalentOut = FALSE Error = FALSE
8014	Wait for Channel A	Channel B has been switched to TRUE - waiting for Channel A; discrepancy timer started. Ready = TRUE S_EquivalentOut = FALSE Error = FALSE
8005	From Active Wait	One channel has been switched to FALSE; waiting for the second channel to be switched to FALSE, discrepancy timer started. Ready = TRUE S_EquivalentOut = FALSE Error = FALSE

13.2.5 SF_ESPE

1) Overview

This function block is a safety-related function block for monitoring electro-sensitive protective equipment (ESPE).

2) Input / Output Variables

Type	Name	Data Type	Initial Value	Description
Input	Activate	BOOL	0	Activation of the FB
	S_ESPE_In	SAFEBOOL	0	Safety demand input. FALSE: ESPE actuated, demand for safety-related response. TRUE: ESPE not actuated, no demand for safety-related response. Safety control system must be able to detect a very short interruption of the sensor (which is specified in 61496-1: minimum 80 ms), when the ESPE is used in applications as a trip device
	S_StartReset	SAFEBOOL	0	FALSE (= initial value): Manual reset when PES is started (warm or cold). TRUE: Automatic reset when PES is started (warm or cold). This function shall only be activated if it is ensured that no hazard can occur at the start of the PES. Therefore the use of the Automatic Circuit Reset feature of the function blocks requires implementation of other system or application measures to ensure that unexpected (or unintended) startup does not occur.

Type	Name	Data Type	Initial Value	Description
Input	S_AutoReset	SAFEBOOL	0	FALSE (= initial value): Manual reset when emergency stop button is released. TRUE: Automatic reset when emergency stop button is released. This function shall only be activated if it is ensured that no hazard can occur at the start of the PES. Therefore the use of the Automatic Circuit Reset feature of the function blocks requires implementation of other system or application measures to ensure that unexpected (or unintended) startup does not occur.
	Reset	BOOL	0	Reset
Output	Ready	BOOL	0	If TRUE, indicates that the FB is activated and the output results are valid.
	S_ESPE_OUT	SAFEBOOL	0	Output for the safety-related response. FALSE: Safety output disabled. Demand for safety-related response (e.g., reset required or internal errors active). TRUE: Safety output enabled. No demand for safety-related response.
	Error	BOOL	0	Error flag
	DiagCode	WORD	16#0000	Diagnostic register. All states of the FB are represented by this register. This information is encoded in hexadecimal format in order to represent more then 16 codes.

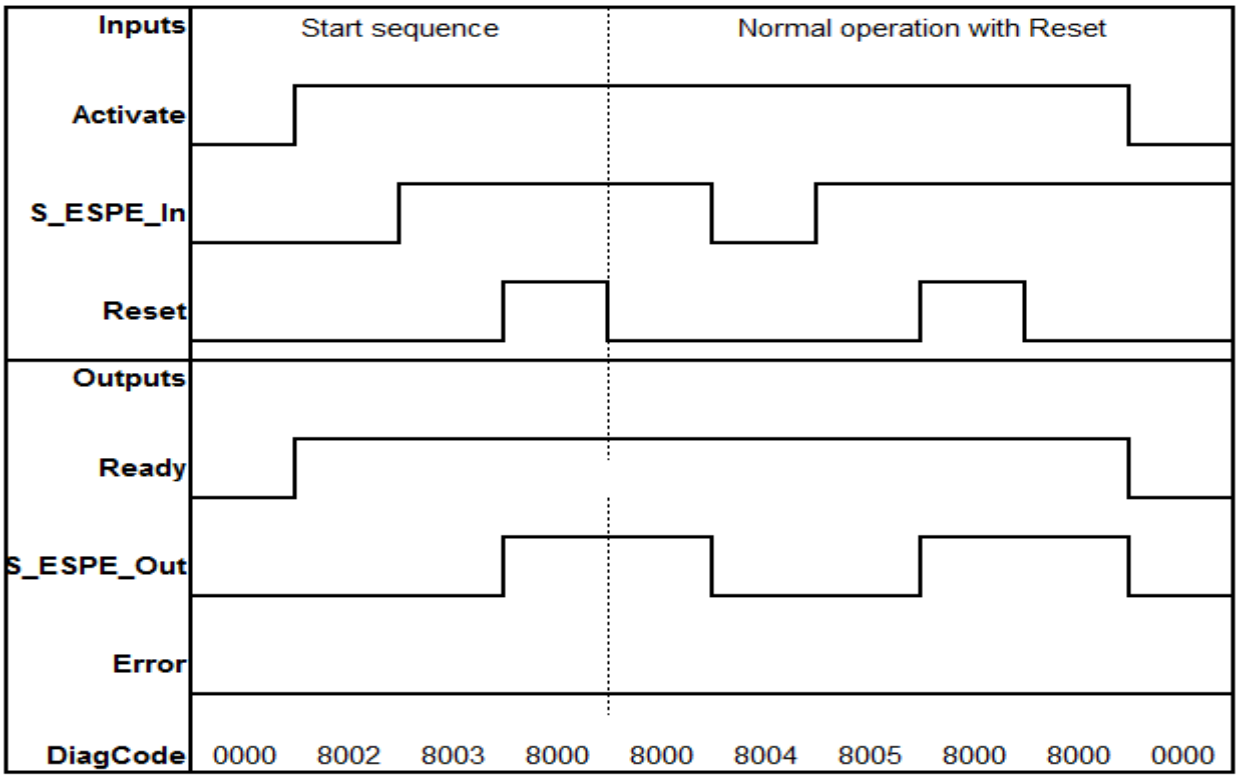
3) Functional Description

This function block is a safety-related function block for monitoring electro-sensitive protective equipment (ESPE). The function is identical to SF_EmergencyStop. The S_ESPE_Out output signal is set to FALSE as soon as the S_ESPE_In input is set to FALSE. The S_ESPE_Out output signal is set to TRUE only if the S_ESPE_In input is set to TRUE and a reset occurs. The enable reset depends on the defined S_StartReset, S_AutoReset, and Reset inputs.

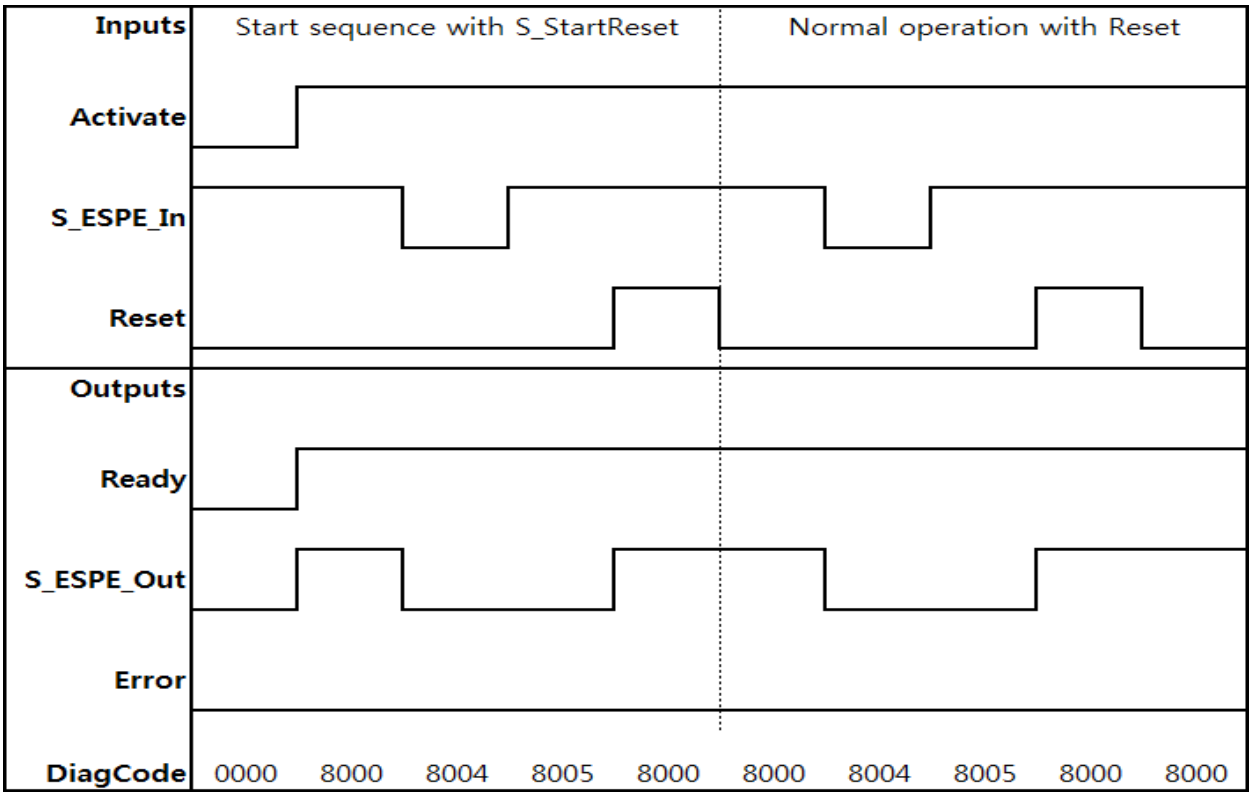
If S_AutoReset = TRUE, acknowledgment is automatic.
If S_AutoReset = FALSE, a rising trigger at the Reset input must be used to acknowledge the enable.
If S_StartReset = TRUE, acknowledgment is automatic the PES is started the first time.
If S_StartReset = FALSE, a rising trigger at the Reset input must be used to acknowledge the enable.

The S_StartReset and S_AutoReset inputs shall only be activated if it is ensured, that no hazardous situation can occur when the PES is started.

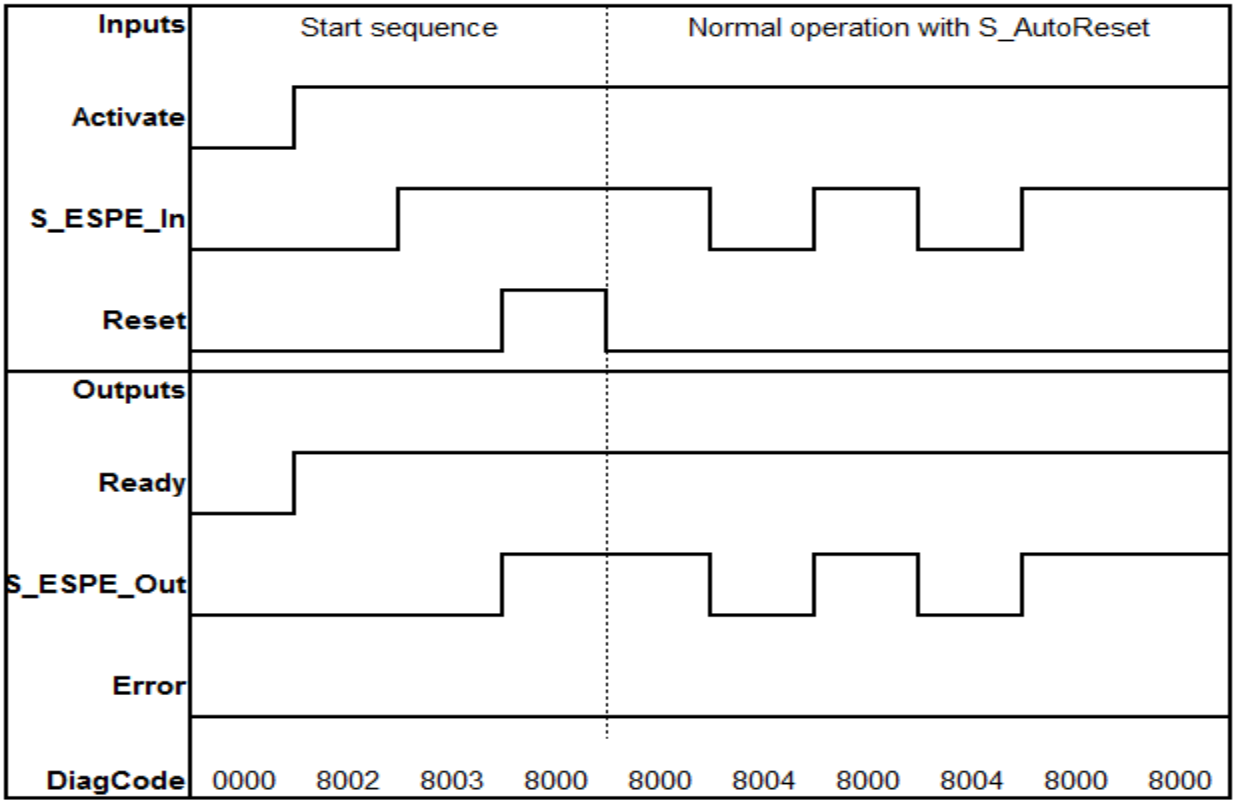
4) Typical Timing Diagrams



< S_StartReset=Off, S_AutoReset=Off >



< S_StartReset=On, S_AutoReset=Off >



< S_StartReset=Off, S_AutoReset=On >

5) Error Detection

The function block detects a static TRUE signal at Reset input.

6) Error Behavior

S_ESPE_Out is set to FALSE. In case of a static TRUE signal at the Reset input, the DiagCode output indicates the relevant error code and the Error output is set to TRUE.

To leave the error states, the the Reset must be set to FALSE.

7) Error Codes

DiagCode	State Name	State Description and Output Setting
C001	Reset Error 1	Reset is TRUE while waiting for S_ESPE_In = TRUE. Ready = TRUE S_ESPE_Out = FALSE Error = TRUE
C002	Reset Error 2	Reset is TRUE while waiting for S_ESPE_In = TRUE. Ready = TRUE S_ESPE_Out = FALSE Error = TRUE

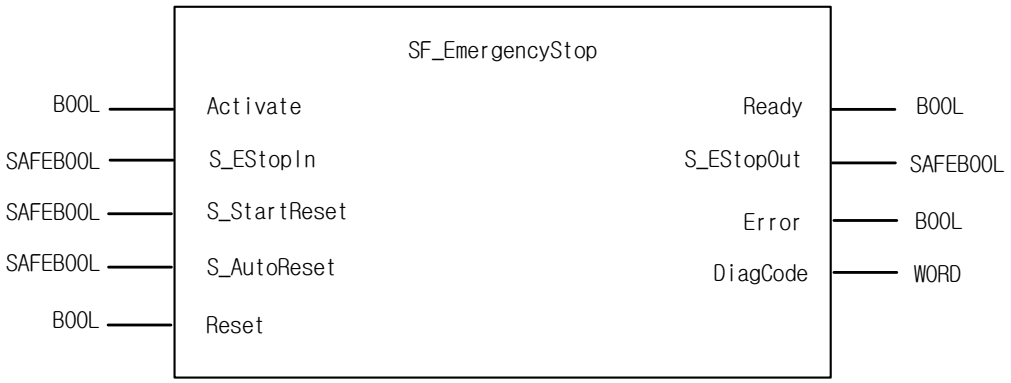
8) Status codes

DiagCode	State Name	State Description and Output Setting
0000	Idle	The function block is not active (initial state). Ready = FALSE S_ESPE_Out = FALSE Error = FALSE
8001	Init	Activation is TRUE. The function block was enabled. Check if S_StartReset is required. Ready = TRUE S_ESPE_Out = FALSE Error = FALSE
8002	Wait for S_ESPE_In 1	Activation is TRUE. Check if Reset is FALSE and wait for S_ESPE_In = TRUE. Ready = TRUE S_ESPE_Out = FALSE Error = FALSE
8003	Wait for Reset 1	Activation is TRUE. S_ESPE_In = TRUE. Wait for rising trigger of Reset. Ready = TRUE S_ESPE_Out = FALSE Error = FALSE
8004	Wait for S_ESPE_In 2	Activation is TRUE. Safety demand detected. Check if Reset is FALSE and wait for S_ESPE_In = TRUE. Ready = TRUE S_ESPE_Out = FALSE Error = FALSE
8005	Wait for Reset 2	Activation is TRUE. S_ESPE_In = TRUE. Check for S_AutoReset or wait for rising trigger of Reset. Ready = TRUE S_ESPE_Out = FALSE Error = FALSE
8000	Safety Output Enabled	Activation is TRUE. S_ESPE_In = TRUE. Functional mode with S_ESPE_Out = TRUE. Ready = TRUE S_ESPE_Out = TRUE Error = FALSE

13.2.6 SF_ESTOP

1) Overview

This function block is a safety-related function block for monitoring an emergency stop button. This FB can be used for emergency switch off functionality (stop category 0), or - with additional peripheral support - as emergency stop.



2) Input / Output Variables

Type	Name	Data Type	Initial Value	Description
Input	Activate	BOOL	0	Activation of the FB
	S_EStopIn	SAFEBOOL	0	Safety demand input. FALSE: Demand for safety-related response (e.g., emergency stop button is engaged). TRUE: No demand for safety-related response (e.g., emergency stop button not engaged).
	S_StartReset	SAFEBOOL	0	FALSE (= initial value): Manual reset when PES is started (warm or cold). TRUE: Automatic reset when PES is started (warm or cold). This function shall only be activated if it is ensured that no hazard can occur at the start of the PES. Therefore the use of the Automatic Circuit Reset feature of the function blocks requires implementation of other system or application measures to ensure that unexpected (or unintended) startup does not occur.

Type	Name	Data Type	Initial Value	Description
Input	S_AutoReset	SAFEBOOL	0	FALSE (= initial value): Manual reset when emergency stop button is released. TRUE: Automatic reset when emergency stop button is released. This function shall only be activated if it is ensured that no hazard can occur at the start of the PES. Therefore the use of the Automatic Circuit Reset feature of the function blocks requires implementation of other system or application measures to ensure that unexpected (or unintended) startup does not occur.
	Reset	BOOL	0	Reset
Output	Ready	BOOL	0	If TRUE, indicates that the FB is activated and the output results are valid.
	S_EStopOut	SAFEBOOL	0	Output for the safety-related response. FALSE: Safety output disabled. Demand for safety-related response (e.g., emergency stop button engaged, reset required or internal errors active) TRUE: Safety output enabled. No demand for safety-related response (e.g., emergency stop button not engaged, no internal errors active).
	Error	BOOL	0	Error flag
	DiagCode	WORD	16#0000	Diagnostic register. All states of the FB are represented by this register. This information is encoded in hexadecimal format in order to represent more then 16 codes.

3) Functional Description

The S_EStopOut enable signal is reset to FALSE as soon as the S_EStopIn input is set to FALSE. The S_EStopOut enable signal is reset to TRUE only if the S_EStopIn input is set to TRUE and a reset occurs. The enable reset depends on the defined S_StartReset, S_AutoReset, and Reset inputs.

If S_AutoReset = TRUE, acknowledgment is automatic.

If S_AutoReset = FALSE, a rising trigger at the Reset input must be used to acknowledge the enable.

If S_StartReset = TRUE, acknowledgment is automatic the fist time the PES is started.

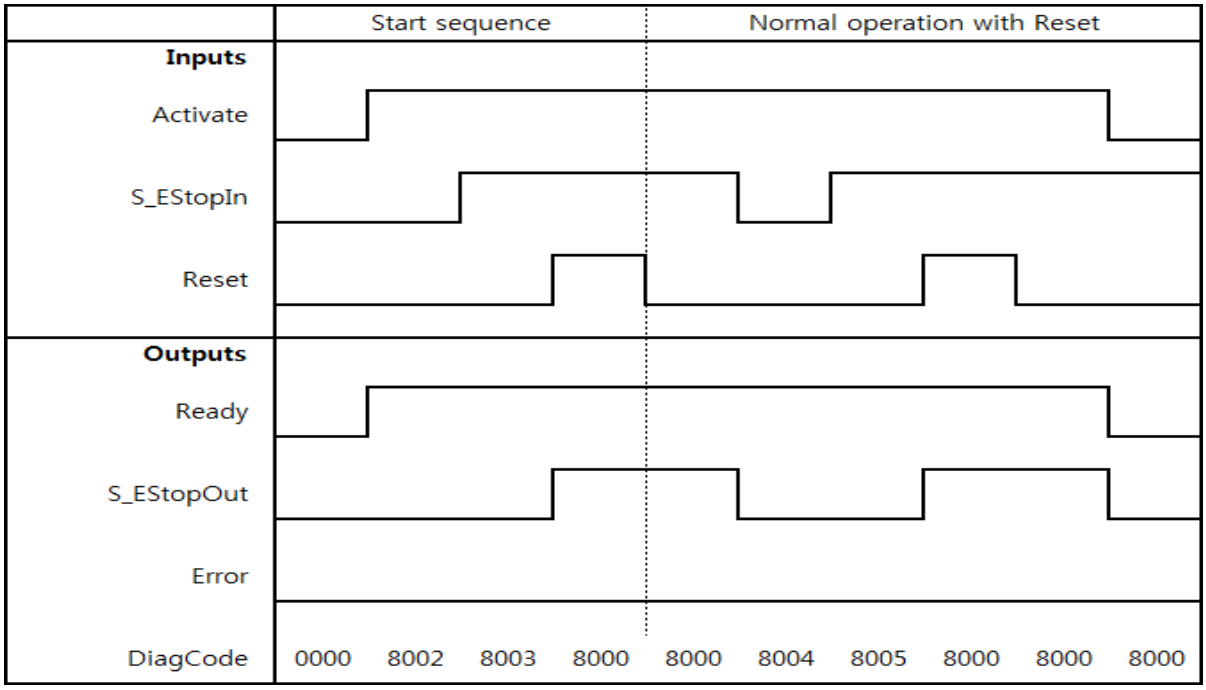
If S_StartReset = FALSE, a rising trigger at the Reset input must be used to acknowledge the enable.

The S_StartReset and S_AutoReset inputs shall only be activated if it is ensured that no hazardous situation can occur when the PES is started.

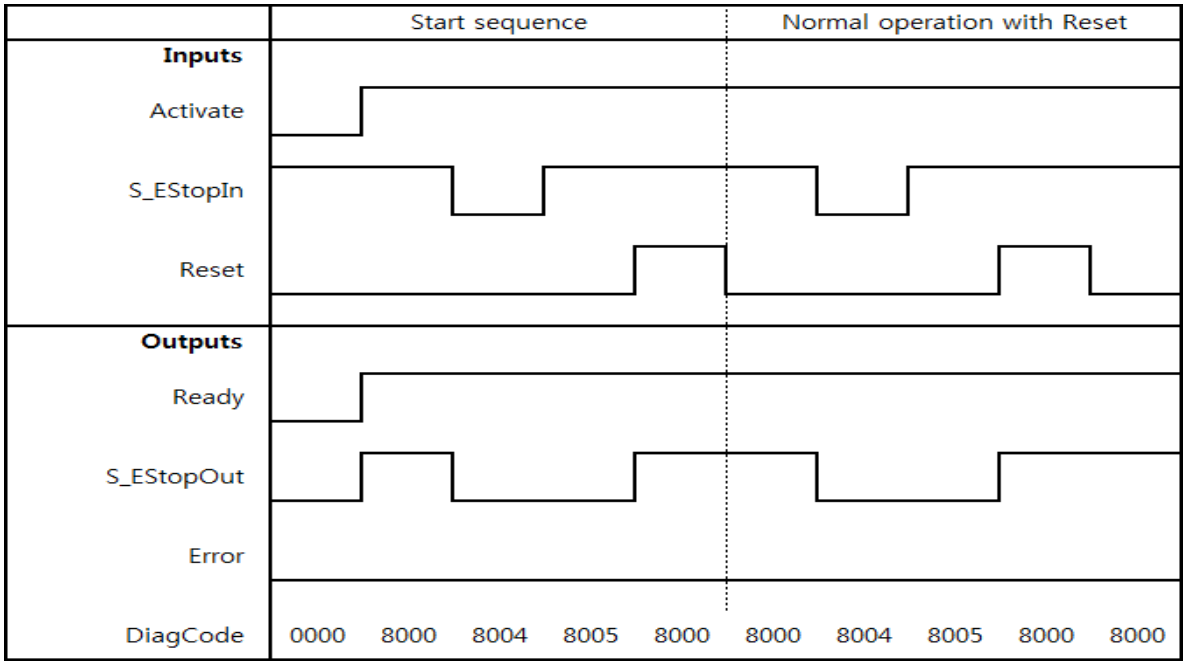
SF_EmergencyStop can be used to monitor both single and two-channel emergency stop buttons. For example, for twochannel applications, the additional function blocks SF_Equivalent can be used to detect whether the contact synchronization has been exceeded. The category classification in accordance with EN 954-1 will depend on the final elements that are used.

The SF_EmergencyStop automatically detects a static TRUE on Reset. Further error detection, e.g., wire break, short circuit depends on the dedicated hardware that is used.

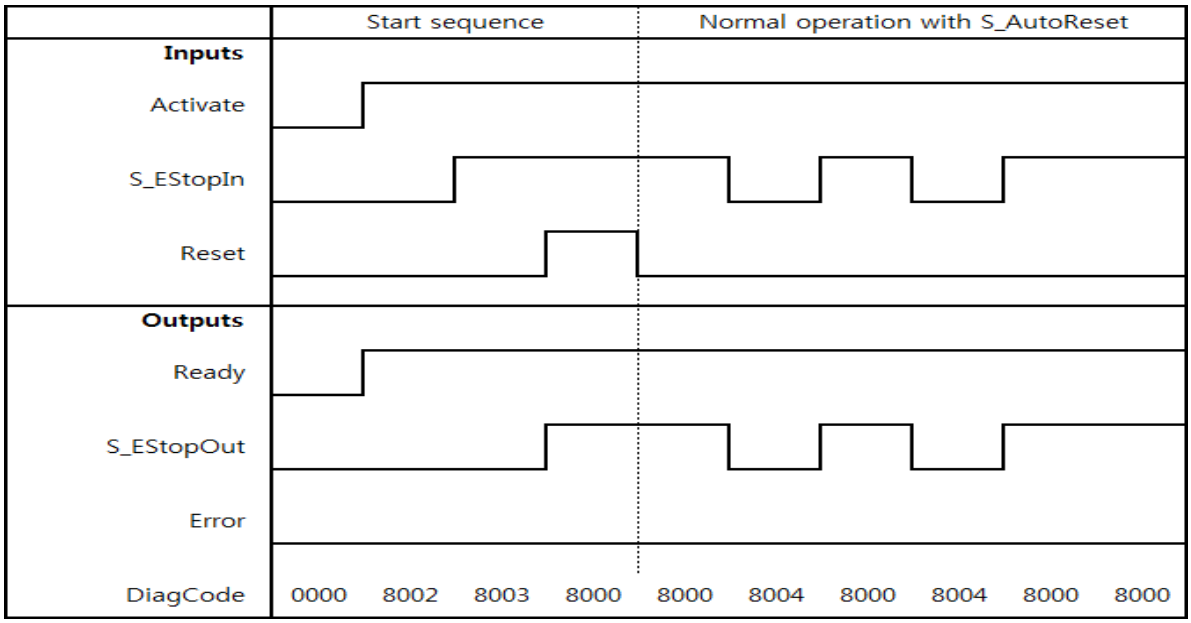
4) Typical Timing Diagrams



< S_StartReset=Off, S_AutoReset=Off >



< S_StartReset=On, S_AutoReset=Off >



< S_StartReset=Off, S_AutoReset=On >

5) Error Detection

The function block detects a static TRUE signal at Reset input.

6) Error Behavior

S_EStopOut is set to FALSE. In case of a static TRUE signal at the Reset input, the DiagCode output indicates the relevant error code and the Error output is set to TRUE.

To leave the error states, the Reset must be set to FALSE.

7) Error Codes

DiagCode	State Name	State Description and Output Setting
C001	Reset Error 1	Reset is TRUE while waiting for S_EStopIn = TRUE. Ready = TRUE S_EStopOut = FALSE Error = TRUE
C002	Reset Error 2	Reset is TRUE while waiting for S_EStopIn = TRUE. Ready = TRUE S_EStopOut = FALSE Error = TRUE

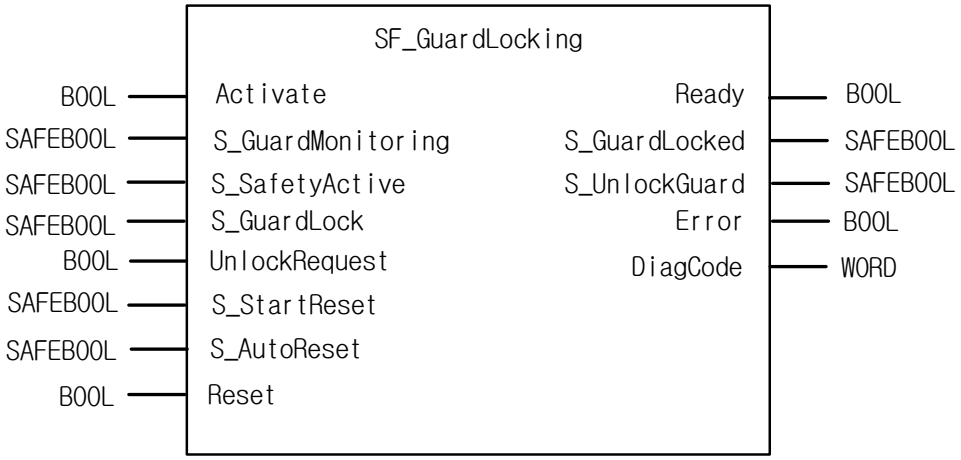
8) Status codes

DiagCode	State Name	State Description and Output Setting
0000	Idle	The function block is not active (initial state). Ready = FALSE S_EStopOut = FALSE Error = FALSE
8001	Init	Activation is TRUE. The function block was enabled. Check if S_StartReset is required. Ready = TRUE S_EStopOut = FALSE Error = FALSE
8002	Wait for S_EstopIn 1	Activation is TRUE. Check if Reset is FALSE and wait for S_EStopIn = TRUE. Ready = TRUE S_EStopOut = FALSE Error = FALSE
8003	Wait for Reset 1	Activation is TRUE. S_EStopIn = TRUE. Wait for rising trigger of Reset. Ready = TRUE S_EStopOut = FALSE Error = FALSE
8004	Wait for S_EstopIn 2	Activation is TRUE. Safety demand detected. Check if Reset is FALSE and wait for S_EStopIn = TRUE. Ready = TRUE S_EStopOut = FALSE Error = FALSE
8005	Wait for Reset 2	Activation is TRUE. S_EStopIn = TRUE. Check for S_AutoReset or wait for rising trigger of Reset. Ready = TRUE S_EStopOut = FALSE Error = FALSE
8000	Safety Output Enabled	Activation is TRUE. S_EStopIn = TRUE. Functional mode with S_EStopOut = TRUE. Ready = TRUE S_EStopOut = TRUE Error = FALSE

13.2.7 SF_GUARDLOCKING

1) Overview

This FB controls an entrance to a hazardous area via an interlocking guard with guard locking (“four state interlocking”)



2) Input / Output Variables

Type	Name	Data Type	Initial Value	Description
Input	Activate	BOOL	0	Activation of the FB
	S_GuardMonitoring	SAFEBOOL	0	Variable. Monitors the guard interlocking. FALSE: Guard open. TRUE: Guard closed.
	S_SafetyActive	SAFEBOOL	0	Status of the hazardous area (EDM), e.g., based on speed monitoring or safe time off delay. FALSE: Machine in "non-safe" state. TRUE: Machine in safe state.
	S_GuardLock	SAFEBOOL	0	Status of the mechanical guard locking. FALSE: Guard is not locked. TRUE: Guard is locked.
	UnlockRequest	BOOL	0	Operator intervention – request to unlock the guard. FALSE: No request. TRUE: Request made.

Type	Name	Data Type	Initial Value	Description
Input	S_StartReset	SAFEBOOL	0	FALSE (= initial value): Manual reset when PES is started (warm or cold). TRUE: Automatic reset when PES is started (warm or cold). This function shall only be activated if it is ensured that no hazard can occur at the start of the PES. Therefore the use of the Automatic Circuit Reset feature of the function blocks requires implementation of other system or application measures to ensure that unexpected (or unintended) startup does not occur.
	S_AutoReset	SAFEBOOL	0	FALSE (= initial value): Manual reset when emergency stop button is released. TRUE: Automatic reset when emergency stop button is released. This function shall only be activated if it is ensured that no hazard can occur at the start of the PES. Therefore the use of the Automatic Circuit Reset feature of the function blocks requires implementation of other system or application measures to ensure that unexpected (or unintended) startup does not occur.
	Reset	BOOL	0	Reset
Output	Ready	BOOL	0	If TRUE, indicates that the FB is activated and the output results are valid.
	S_GuardLocked	SAFEBOOL	0	Interface to hazardous area which must be stopped. FALSE: No safe state. TRUE: Safe state.
	S_UnlockGuard	SAFEBOOL	0	Signal to unlock the guard. FALSE: Close guard. TRUE: Unlock guard.
	Error	BOOL	0	Error flag
	DiagCode	WORD	16#0000	Diagnostic register. All states of the FB are represented by this register. This information is encoded in hexadecimal format in order to represent more then 16 codes.

3) Functional Description

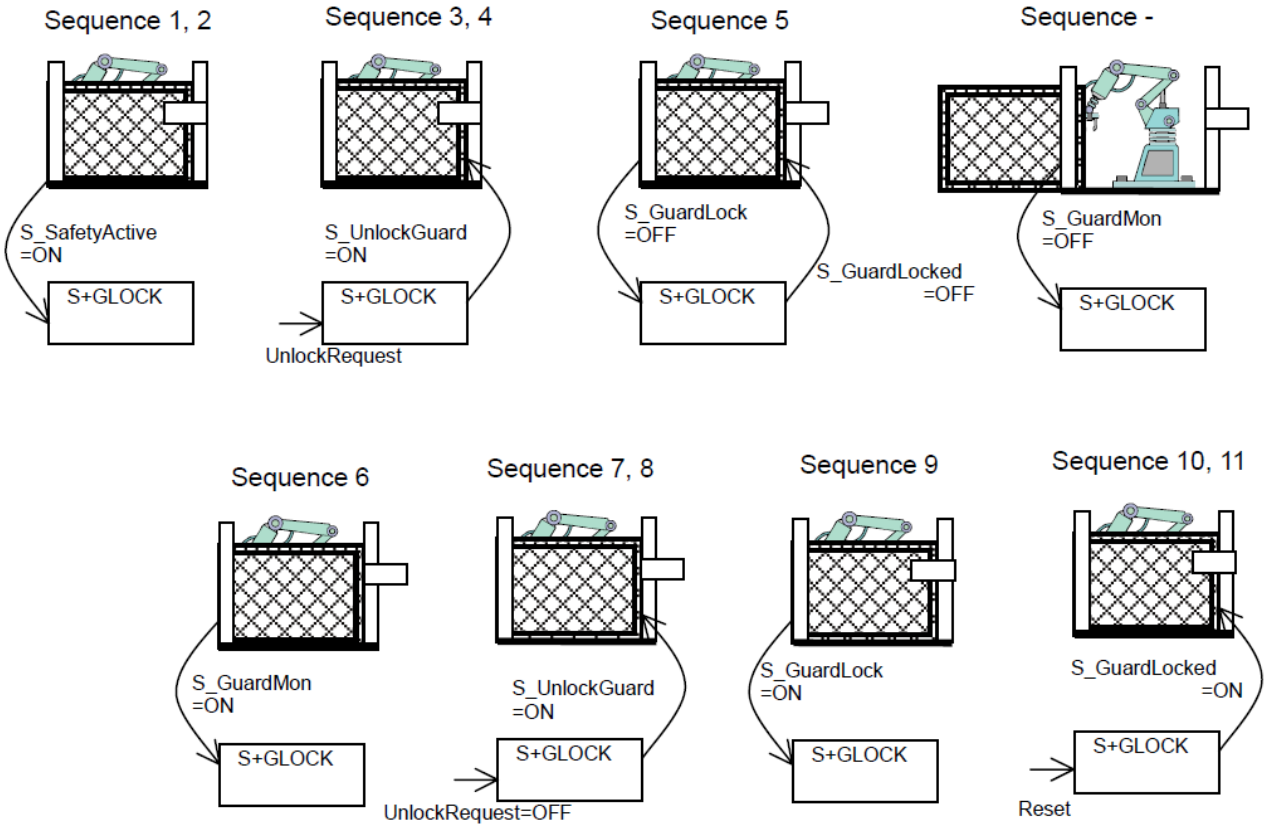
The function controls the guard lock and monitors the position of the guard and the lock. This function block can be used with a mechanical locked switch.

The operator requests to get access to the hazardous area. The guard can only be unlocked when the hazardous area is in a safe state.The guard can be locked if the guard is closed. The machine can be started when the guard is closed and the guard is locked. An open guard or unlocked guard will be detected in the event of a safety-critical situation.

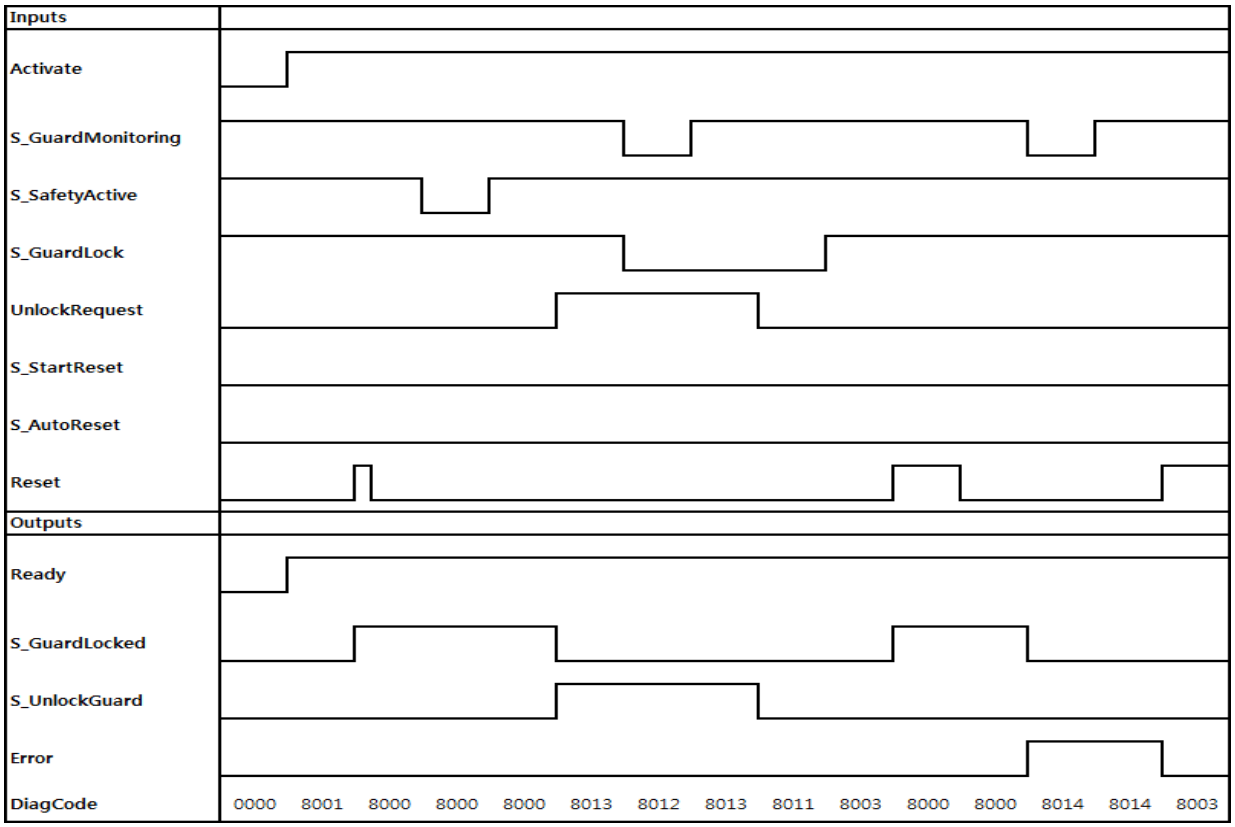
The S_StartReset and S_AutoReset inputs shall only be activated if it is ensured that no hazardous situation can occur when the PES is started.

Operation Sequence

NO	Position	Operation
1	External	Request to get the hazardous area to a safe state - not part of this FB
2	In	Feedback from applicable hazardous area that it is in a safe state (via S_SafetyActive)
3	In	Operator request to unlock the guard (via UnlockRequest)
4	Out	Enable guard to be opened (via S_UnlockGuard)
5	In	Guard unlocked (via S_GuardLock). Guard can be opened now. (S_GuardLocked = FALSE)
-	-	Operator opens the guard
6	In	Monitoring of status guard via S_GuardMonitoring – signals when guard is closed again
7	In	Feedback from operator to restart the hazardous area (Reset)
8	Out	Lock guard guard (S_UnlockGuard)
9	In	Check if guard is locked (S_GuardLock)
10	Out	Hazardous area can operate again (S_GuardLocked = TRUE)
11	Extern	Restart the operation in the hazardous area



4) Typical Timing Diagrams



5) Error Detection

Static signals are detected at Reset. Errors are detected at the Guard switches.

6) Error Behavior

In the event of an error the S_GuardLocked and S_UnlockGuard outputs are set to FALSE, the DiagCode output indicates the relevant error code, and the Error output is set to TRUE.

An error must be acknowledged by a rising trigger at the Reset input.

7) Error Codes

DiagCode	State Name	State Description and Output Setting
C001	Reset Error1	Static Reset detected in state 8001. Ready = TRUE S_GuardLocked = FALSE S_UnlockGuard = FALSE Error = TRUE
C002	Reset Error2	Static Reset detected in state C004. Ready = TRUE S_GuardLocked = FALSE S_UnlockGuard = FALSE Error = TRUE
C003	Reset Error3	Static Reset detected in state 8011. Ready = TRUE S_GuardLocked = FALSE S_UnlockGuard = FALSE Error = TRUE
C004	Safety Lost	Safety lost, guard opened or guard unlocked. Ready = TRUE S_GuardLocked = FALSE S_UnlockGuard = FALSE Error = TRUE

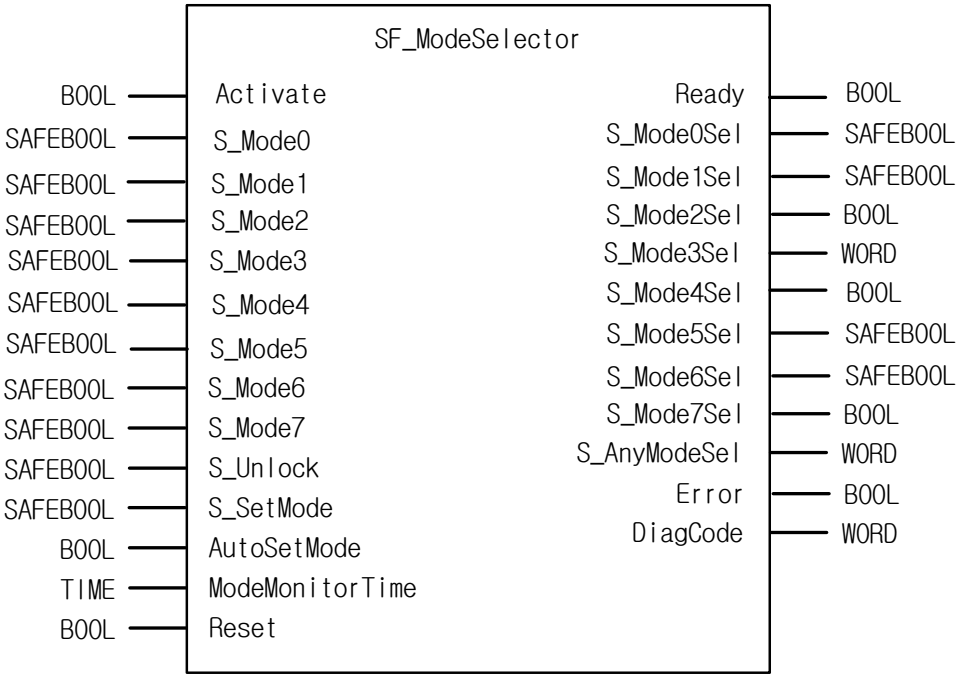
8) Status codes

DiagCode	State Name	State Description and Output Setting
0000	Idle	The function block is not active (initial state). Ready = FALSE S_GuardLocked = FALSE S_UnlockGuard = FALSE Error = FALSE
8000	Guard Closed and Locked	Guard is locked. Ready = TRUE S_GuardLocked = TRUE S_UnlockGuard = FALSE Error = FALSE
8001	Init	Function block was activated and initiated. Ready = TRUE S_GuardLocked = FALSE S_UnlockGuard = FALSE Error = FALSE
8003	Wait for Reset	Door is closed and locked, now waiting for operator reset Ready = TRUE S_GuardLocked = FALSE S_UnlockGuard = FALSE Error = FALSE
8011	Wait for Operator	Waiting for operator to either unlock request or reset. Ready = TRUE S_GuardLocked = FALSE S_UnlockGuard = FALSE Error = FALSE
8012	Guard Open and Unlocked	Lock is released and guard is open. Ready = TRUE S_GuardLocked = FALSE S_UnlockGuard = TRUE Error = FALSE
8013	Guard Closed but Unlocked	Lock is released but guard is closed. Ready = TRUE S_GuardLocked = FALSE S_UnlockGuard = TRUE Error = FALSE
8014	Safety Return	Return of S_SafetyActive signal, now waiting for operator acknowledge. Ready = TRUE S_GuardLocked = FALSE S_UnlockGuard = FALSE Error = FALSE

13.2.8 SF_MODESEL

1) Overview

This function block selects the system operation mode, such as manual, automatic, semi-automatic, etc.



2) Input / Output Variables

Type	Name	Data Type	Initial Value	Description
Input	Activate	BOOL	0	Activation of the FB
	S_ModeX (X = 0~7)	SAFEBOOL	0	Input X from mode selector switch FALSE: Mode X is not requested by operator. TRUE: Mode X is requested by operator.
	S_Unlock	SAFEBOOL	0	Locks the selected mode FALSE: The actual S_ModeXSel output is locked therefore a change of any S_ModeX input does not lead to a change in the S_ModeXSel output even in the event of a rising edge of Set-Mode. TRUE: The selected S_ModeXSel is not locked; a mode selection change is possible.
	S_SetMode	SAFEBOOL	0	Sets the selected mode Operator acknowledges the setting of a mode. Any change to new S_ModeX = TRUE leads to S_AnyModeSel/S_ModeXSel = FALSE, only a rising SetMode trigger then leads to new S_ModeXSel = TRUE.

Type	Name	Data Type	Initial Value	Description
Input	AutoSetMode	BOOL	0	Parameterizes the acknowledgement modeFALSE: A change in mode must be acknowledged by the operator via SetMode. TRUE: A valid change of the S_ModeX input to another S_ModeX automatically leads to a change in S_ModeXSel without operator acknowledgment via SetMode (as long as this is not locked by S_Unlock).
	ModeMonitorTime	TIME	T#0	Maximum permissible time for changing the selection input.
	Reset	BOOL	0	Reset
Output	Ready	BOOL	0	If TRUE, indicates that the FB is activated and the output results are valid.
	S_ModeXSel (X = 0~7)	SAFEBOOL	0	Indicates that mode X is selected and acknowledged. FALSE: Mode X is not selected or not active. TRUE: Mode X is selected and active.
	S_AnyModeSel	SAFEBOOL	0	Indicates that any of the 8 modes is selected and acknowledged. FALSE: No S_ModeX is selected. TRUE: One of the 8 S_ModeX is selected and active
	Error	BOOL	0	Error flag
	DiagCode	WORD	16#0000	Diagnostic register. All states of the FB are represented by this register. This information is encoded in hexadecimal format in order to represent more then 16 codes.

3) Functional Description

This function block selects the system operation mode, such as manual, automatic, semi-automatic, etc. On controller startup, it should be assumed that the machine is in safe mode. On machine startup, the transition to the mode set by the mode selector switch must be initiated by a function block input (e.g., machine START button).

The default state following activation of the FB is the ModeChanged state. This is also the safe state of the FB, where all S_ModeXSel and S_AnyModeSel are FALSE.

If the FB is in the ModeChanged state:

- The new S_ModeX input must be acknowledged by a rising S_SetMode trigger (if AutoSetMode = FALSE), which leads to a new S_ModeXSel output.
- The new S_ModeX input automatically leads to a new S_ModeXSel output (if AutoSetMode = TRUE).
- Such a transition from state 8005 to 8000 is only valid, if one S_ModeX input is TRUE. As long as all S_ModeX are FALSE, the FB remains in state 8005, even if the S_SetMode triggers.

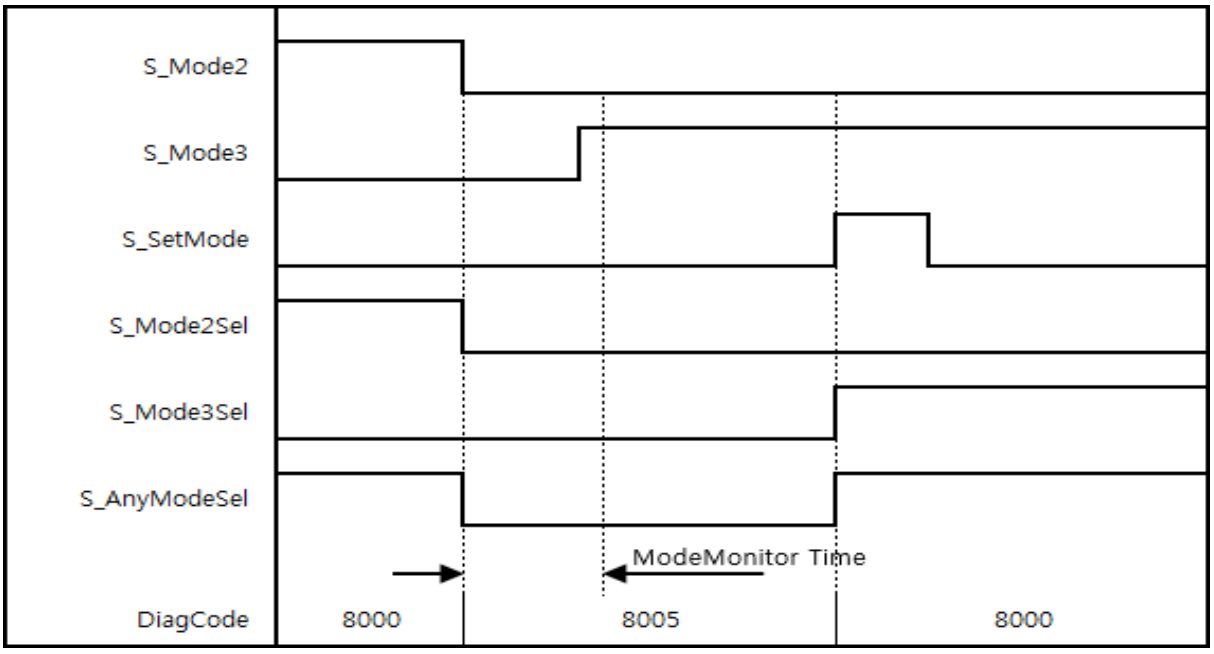
The transition from the ModeChanged to ModeSelected state, i.e., S_SetMode set by the operator, is not monitored by a timer.

If the FB is in the ModeSelected state, the simultaneous occurrence of a new S_ModeX input (higher priority) and the NOT S_Unlock signal (lower priority) leads to the ModeChanged state.

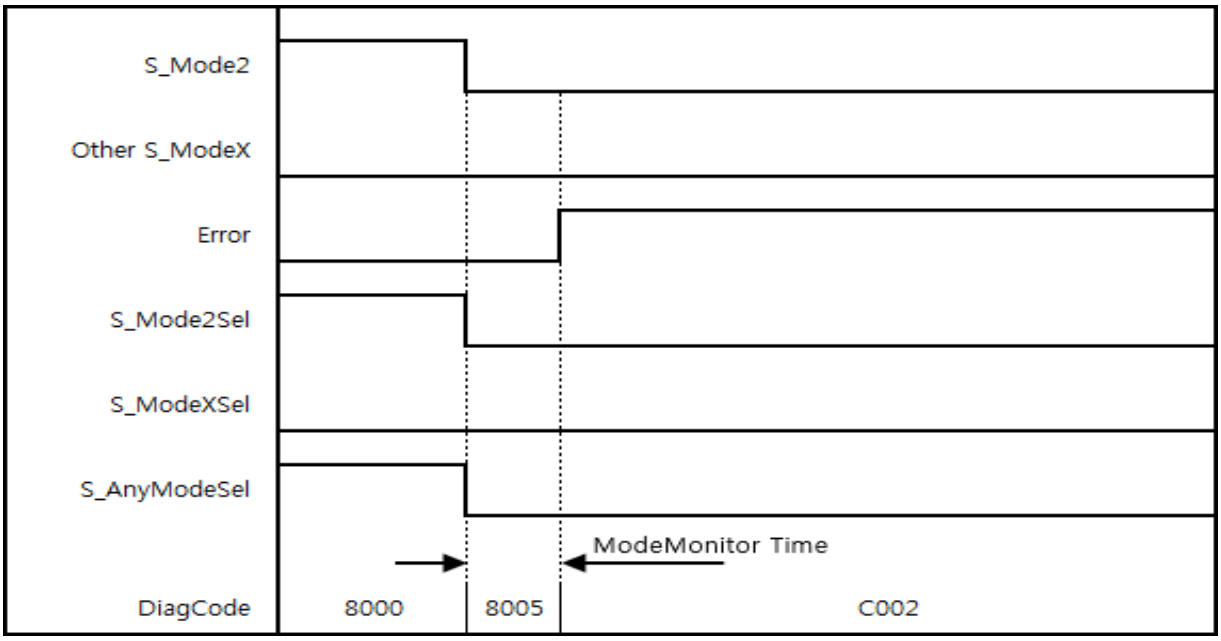
The S_ModeX input parameters, which are not used for mode selection, should be called with the default value FALSE to simplify program verification.

The AutoSetMode input shall only be activated if it is ensured that no hazardous situation can occur when the PES is started.

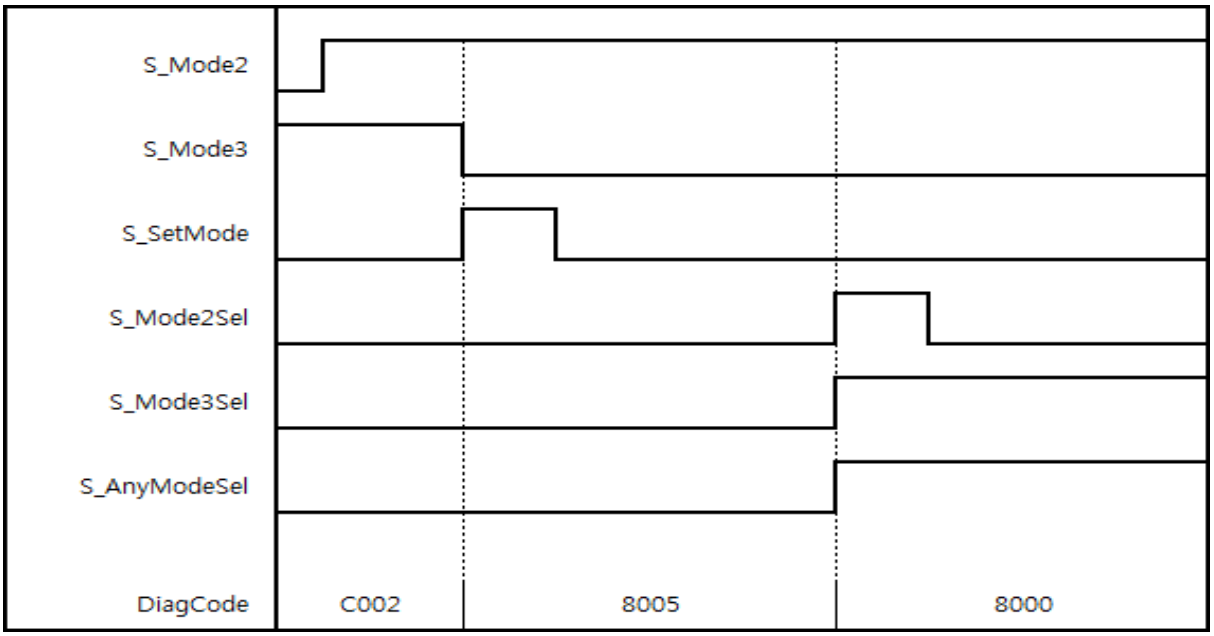
4) Typical Timing Diagrams



< Timing diagram for SF_ModeSelector, valid change in Mode input with acknowledgment>



< Timing diagram for SF_ModeSelector, error condition 2 at Mode inputs >



< Timing diagram for SF_ModeSelector, reset of error condition >

5) Error Detection

The FB detects whether none of the mode inputs is selected. This invalid condition is detected after ModeMonitorTime has elapsed:

- Which restarts with each falling trigger of an S_ModeX switched mode input
- Which is then in the ModeChanged state following activation of the FB

In contrast, the FB directly detects whether more than one S_ModeX mode input is selected at the same time.

A static reset condition is detected when the FB is either in Error state C001 or C002.

6) Error Behavior

In the event of an error, the S_ModeXSel and S_AnyModeSel outputs are set to safe state = FALSE. The DiagCode output indicates the relevant error code and the Error output is set to TRUE.

An error must be acknowledged with the rising trigger of the Reset BOOL input. The FB changes from an error state to the ModeChanged state.

7) Error Codes

DiagCode	State Name	State Description and Output Setting
C001	Error Short-circuit	The FB detected that two or more S_ModeX are TRUE, e.g., short-circuit of cables. Ready = TRUE Error = TRUE S_AnyModeSel = FALSE All S_ModeXSel = FALSE
C002	Error Open-circuit	The FB detected that all S_ModeX are FALSE: The period following a falling S_ModeX trigger exceeds ModeMonitorTime, e.g., open-circuit of cables. Ready = TRUE Error = TRUE S_AnyModeSel = FALSE All S_ModeXSel = FALSE
C003	Reset Error 1	Static Reset signal detected in state C001. Ready = TRUE Error = TRUE S_AnyModeSel = FALSE All S_ModeXSel = FALSE
C004	Reset Error 2	Static Reset signal detected in state C002. Ready = TRUE Error = TRUE S_AnyModeSel = FALSE All S_ModeXSel = FALSE

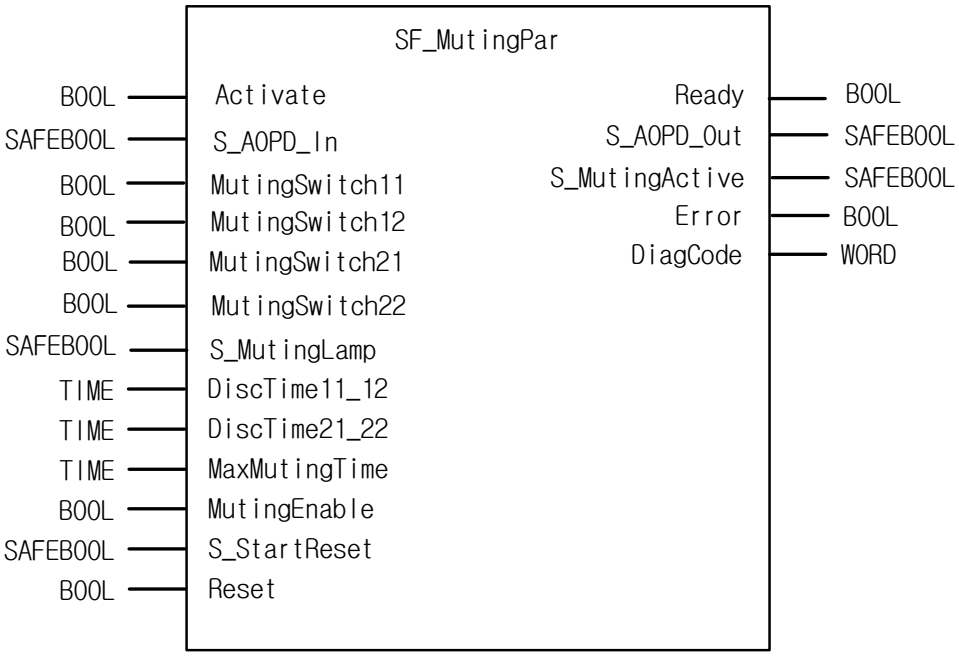
8) Status codes

DiagCode	State Name	State Description and Output Setting
0000	Idle	The function block is not active (initial state). Ready = FALSE Error = FALSE S_AnyModeSel = FALSE All S_ModeXSel = FALSE
8005	ModeChanged	State after activation or when S_ModeX has changed (unless locked) or after Reset of an error state. Ready = TRUE Error = FALSE S_AnyModeSel = FALSE All S_ModeXSel = FALSE
8000	ModeSelected	Valid mode selection, but not yet locked. Ready = TRUE Error = FALSE S_AnyModeSel = TRUE S_ModeXSel = Selected X is TRUE, others are FALSE.
8004	ModeLocked	Valid mode selection is locked. Ready = TRUE Error = FALSE S_AnyModeSel = TRUE S_ModeXSel = Selected X is TRUE, others are FALSE

13.2.9 SF_MUTINGPAR

1) Overview

Muting is the intended suppression of the safety function. In this FB, parallel muting with four muting sensors is specified.



2) Input / Output Variables

Type	Name	Data Type	Initial Value	Description
Input	Activate	BOOL	0	Activation of the FB
	S_AOPD_In	SAFEBOOL	0	OSSD signal from AOPD. FALSE: Protection field interrupted. TRUE: Protection field not interrupted.
	MutingSwitch11	BOOL	0	Status of Muting sensor 11. FALSE: Muting sensor 11 not actuated. TRUE: Workpiece actuates muting sensor 11. It shall be noted in the FB manual that a SAFEBOOL must be connected instead of a BOOL depending on the safety requirements.
	MutingSwitch12	BOOL	0	Status of Muting sensor 12. FALSE: Muting sensor 12 not actuated. TRUE: Workpiece actuates muting sensor 12. It shall be noted in the FB manual that a SAFEBOOL must be connected instead of a BOOL depending on the safety requirements.

Type	Name	Data Type	Initial Value	Description
Input	MutingSwitch21	BOOL	0	Status of Muting sensor 21. FALSE: Muting sensor 21 not actuated. TRUE: Workpiece actuates muting sensor 21. It shall be noted in the FB manual that a SAFEBOOL must be connected instead of a BOOL depending on the safety requirements.
	MutingSwitch22	BOOL	0	Status of Muting sensor 22. FALSE: Muting sensor 22 not actuated. TRUE: Workpiece actuates muting sensor 22. It shall be noted in the FB manual that a SAFEBOOL must be connected instead of a BOOL depending on the safety requirements.
	S_MutingLamp	SAFEBOOL	0	Indicates operation of the muting lamp. FALSE: Muting lamp failure. TRUE: Muting lamp no failure.
	DiscTime11_12	TIME	T#0s	Constant 0..4 s; Maximum discrepancy time for MutingSwitch11 and MutingSwitch12.
	DiscTime21_22	TIME	T#0s	Constant 0..4 s; Maximum discrepancy time for MutingSwitch21 and MutingSwitch22
	MaxMutingTime	TIME	T#0s	Constant 0..10 min; Maximum time for complete muting sequence, timer started when first muting sensor is actuated.
	MutingEnable	BOOL	0	Command by the control system that enables the start of the muting function when needed by the machine cycle. After the start of the muting function, this signal can be switched off. FALSE: Muting not enabled TRUE: Start of Muting function enabled
	S_StartReset	SAFEBOOL	0	FALSE (= initial value): Manual reset when PES is started (warm or cold). TRUE: Automatic reset when PES is started (warm or cold). This function shall only be activated if it is ensured that no hazard can occur at the start of the PES. Therefore the use of the Automatic Circuit Reset feature of the function blocks requires implementation of other system or application measures to ensure that unexpected (or unintended) startup does not occur.
	Reset	BOOL	0	Reset

Type	Name	Data Type	Initial Value	Description
Output	Ready	BOOL	0	If TRUE, indicates that the FB is activated and the output results are valid.
	S_AOPD_Out	SAFEBOOL	0	Safety related output, indicates status of the muted guard. FALSE: AOPD protection field interrupted and muting not active. TRUE: AOPD protection field not interrupted or muting active.
	S_MutingActive	SAFEBOOL	0	Indicates status of Muting process. FALSE: Muting not active. TRUE: Muting active.
	Error	BOOL	0	Error flag
	DiagCode	WORD	16#0000	Diagnostic register. All states of the FB are represented by this register. This information is encoded in hexadecimal format in order to represent more then 16 codes.

3) Functional Description

Muting is the intended suppression of the safety function. This is required, e.g., when transporting the material into the danger zone without causing the machine to stop. Muting is triggered by muting sensors. The use of two or four muting sensors and correct integration into the production sequence must ensure that no persons enter the danger zone while the light curtain is muted. Muting sensors can be proximity switches, photoelectric barriers, limit switches, etc. which do not have to be failsafe. Active muting mode must be indicated by indicator lights.

There are sequential and parallel muting procedures. In this FB, parallel muting with four muting sensors was used; an explanation is provided below. The FB can be used in both directions, forward and backward. The muting should be enabled with the MutingEnable signal by the process control to avoid manipulation.

The FB input parameters include the signals of the four muting sensors (MutingSwitch11 ... MutingSwitch22), the OSSD signal from the "active opto-electronic protective device", S_AOPD_In, as well as three parameterizable times (DiscTime11_12, DiscTime21_22, and MaxMutingTime).

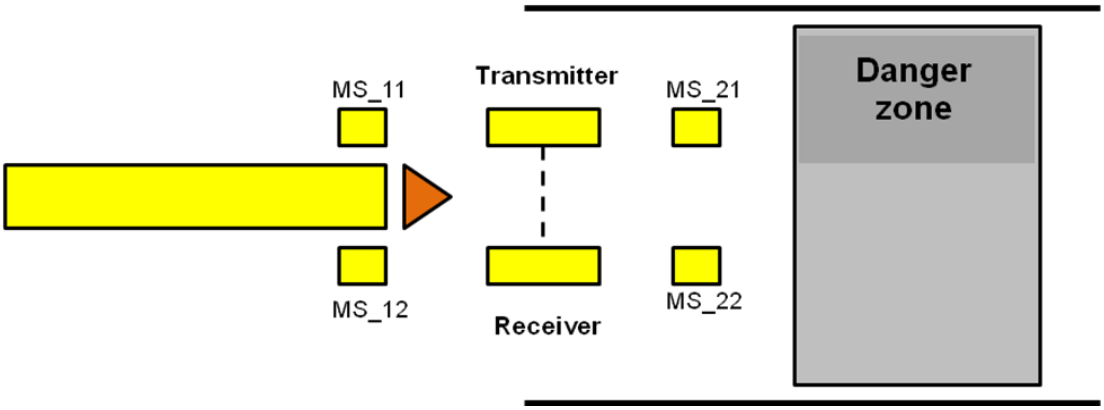
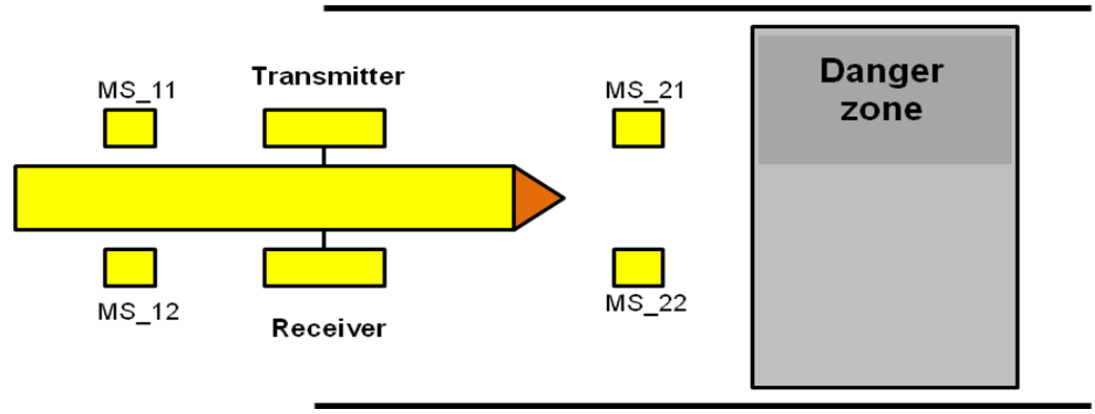
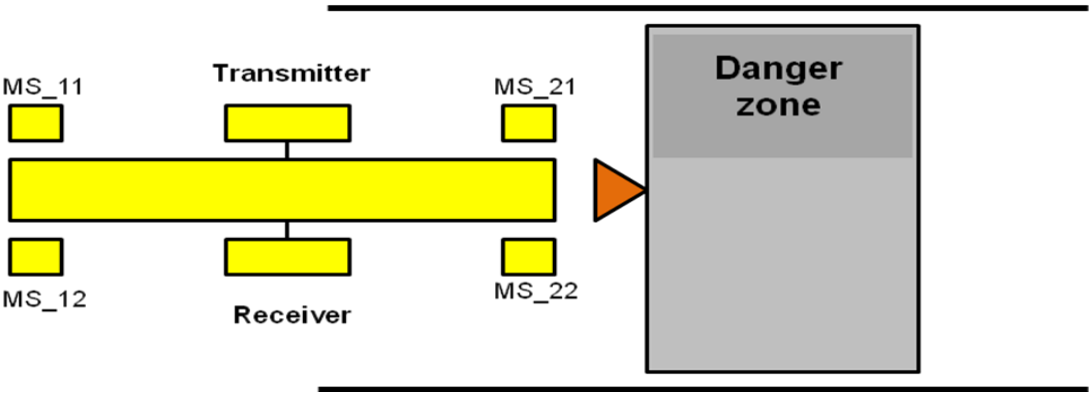
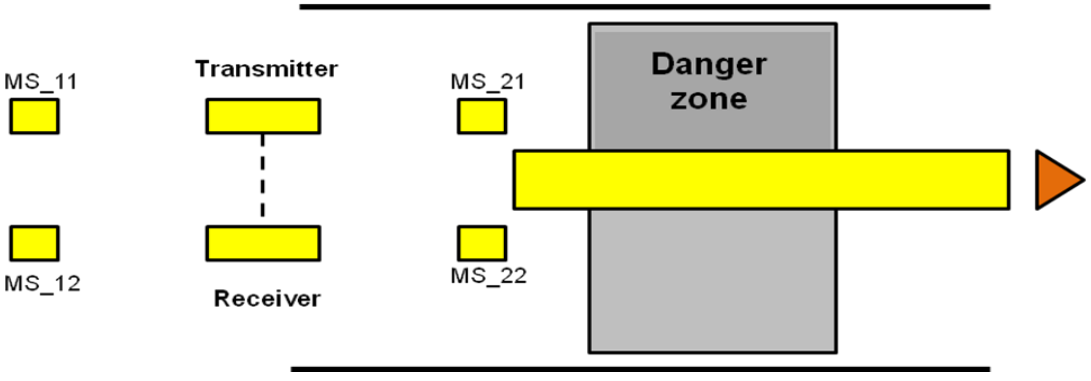
The S_StartReset input shall only be activated if it is ensured that no hazardous situation can occur when the PES is started.

Step 1: If the muting sensors MutingSwitch11 (MS_11) and MutingSwitch12 (MS_12) are activated by the product within the time DiscTime11_12, muting mode is activated (S_MutingActive = TRUE).

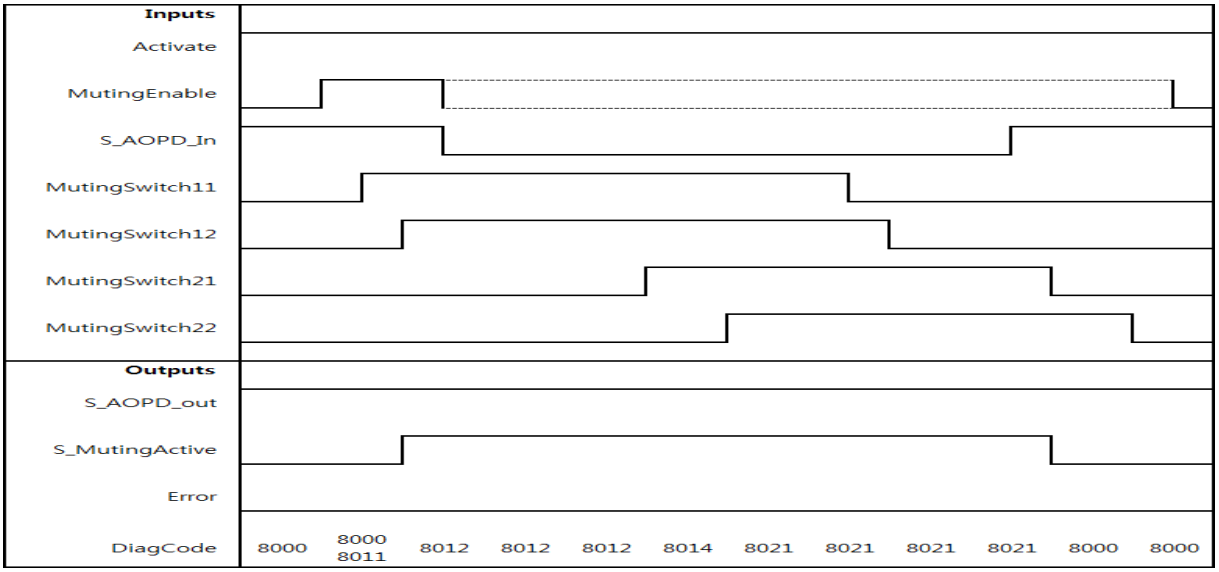
Step 2: Muting mode remains active as long as MutingSwitch11 (MS_11) and MutingSwitch12 (MS_12) are activated by the product. The product may pass through the light curtain without causing a machine stop.

Step 3: Before muting sensors MutingSwitch11 (MS_11) and MutingSwitch12 (MS_12) are disabled, muting sensors MutingSwitch21 (MS_21) and MutingSwitch22 (MS_22) must be activated. This ensures that muting mode remains active. The time discrepancy between switching of MutingSwitch21 and MutingSwitch22 is monitored by the time DiscTime21_22.

Step 4: Muting mode is terminated if either muting sensor MutingSwitch21 (MS_21) or MutingSwitch22 (MS_22) is disabled by the product. The maximum time for muting mode to be active is the Max-MutingTime.

No.	Figure
1	
2	
3	
4	

4) Typical Timing Diagrams



5) Error Detection

The FB detects the following error conditions:

- DiscTime11_12 and DiscTime21_22 have been set to values less than T#0s or greater than T#4s.
- MaxMutingTime has been set to a value less than T#0s or greater than T#10min.
- The discrepancy time for the MutingSwitch11/MutingSwitch12 or MutingSwitch21/MutingSwitch22 sensor pairs has been exceeded.
- The muting function (S_MutingActive = TRUE) exceeds the maximum muting time MaxMutingTime.
- Muting sensors MutingSwitch11, MutingSwitch12, MutingSwitch21, and MutingSwitch22 are activated in the wrong order.
- Muting sequence starts without being enabled by MutingEnable
- A faulty muting lamp is indicated by S_MutingLamp = FALSE.
- A static Reset condition is detected in state 8001 and 8003.

6) Error Behavior

In the event of an error, the S_AOPD_Out and S_MutingActive outputs are set to FALSE. The DiagCode output indicates the relevant error code and the Error output is set to TRUE.
A restart is inhibited until the error conditions are cleared and the Safe state is acknowledged with Reset by the operator.

7) Error Codes

DiagCode	State Name	State Description and Output Setting
C001	Reset Error 1	Static Reset condition detected after FB activation in state 8001. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = TRUE
C002	Reset Error 2	Static Reset condition detected in state 8003. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = TRUE

DiagCode	State Name	State Description and Output Setting
C003	Error Muting Lamp	Error detected in muting lamp. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = TRUE
CYx4	Error Muting sequence	Error detected in muting sequence state 8000, 8011, 8311, 8012, 8021, 8014, 8314, 8122, 8422, 8121, 8112, 8114 or 8414. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = TRUE Y = Status in the sequence (6 states for forward and 6 states for backward direction). C0x4 = Error occurred in state 8000 C1x4 = Error occurred in state Forward 8011 C2x4 = Error occurred in state Forward 8311 C3x4 = Error occurred in state Forward 8012 C4x4 = Error occurred in state Forward 8014 C5x4 = Error occurred in state Forward 8314 C6x4 = Error occurred in state Forward 8021 C7x4 = Error occurred in state Backward 8122 C8x4 = Error occurred in state Backward 8422 C9x4 = Error occurred in state Backward 8121 CAx4 = Error occurred in state Backward 8114 CBx4 = Error occurred in state Backward 8414 CCx4 = Error occurred in state Backward 8112 CFx4 = Muting Enable missing x = Status of the sensors when error occurred (4 bits: LSB = MS_11; MS_12; MS_21; MSB = MS_22)
C005	Parameter Error	DiscTime11_12, DiscTime21_22 or MaxMutingTime value out of range. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = TRUE
C006	Error Timer MaxMuting	Timing error: Active muting time (when S_MutingActive = TRUE) exceeds MaxMutingTime. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = TRUE
C007	Error Timer MS11_12	Timing error: Discrepancy time for switching MutingSwitch11 and MutingSwitch12 > DiscTime11_12. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = TRUE

DiagCode	State Name	State Description and Output Setting
C008	Error Timer MS21_22	Timing error: Discrepancy time for switching MutingSwitch21 and MutingSwitch22 > DiscTime21_22. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = TRUE

8) Status codes

DiagCode	State Name	State Description and Output Setting
0000	Idle	The function block is not active (initial state). Ready = FALSE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = FALSE
8000	AOPD Free	Muting not active and no safety demand from AOPD. If timers from subsequent muting are still running, they are stopped. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = FALSE Error = FALSE
8001	Init	Function block has been activated. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = FALSE
8002	Safety Demand AOPD	Safety demand detected by AOPD, muting not active. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = FALSE
8003	Wait for Reset	Safety demand or errors have been detected and are now cleared. Operator acknowledgment by Reset required. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = FALSE
8005	Safe	Safety function activated. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = FALSE
8011	Muting Forward Start 1	Muting forward sequence is in starting phase after rising trigger of MutingSwitch 11. Monitoring of DiscTime11_12 is activated. Monitoring of MaxMutingTime is activated. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = FALSE Error = FALSE
8311	Muting Forward Start 2	Muting forward sequence is in starting phase after rising trigger of MutingSwitch 12. Monitoring of DiscTime11_12 is activated. Monitoring of MaxMutingTime is activated. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = FALSE Error = FALSE

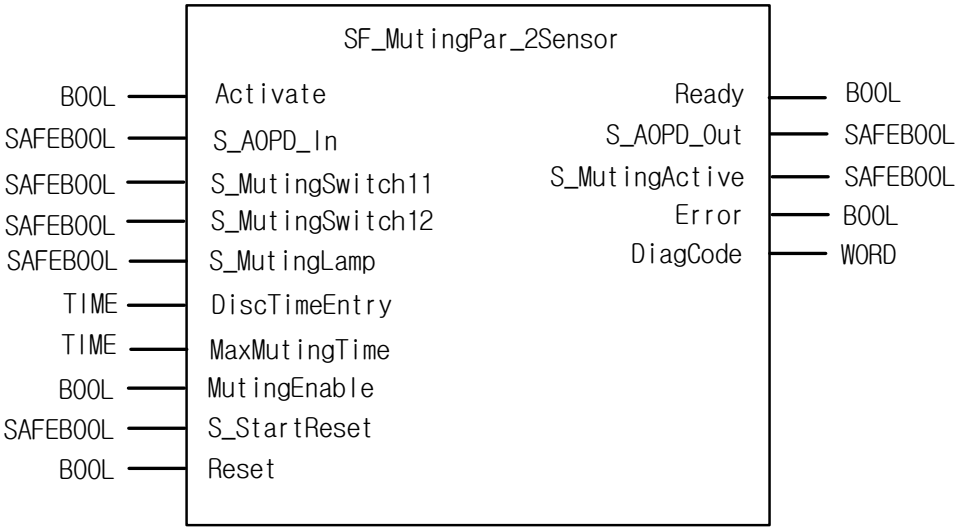
DiagCode	State Name	State Description and Output Setting
8012	Muting Forward Active 1	Muting forward sequence is active either: - After rising trigger of the second entry MutingSwitch 12 or 11 has been detected. - When both MutingSwitch 11 and 12 have been actuated in the same cycle. Monitoring of DiscTime11_12 is stopped. Monitoring of MaxMuting-Time is activated, when transition came directly from state 8000. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = TRUE Error = FALSE
8014	Muting Forward Step 1	Muting forward sequence is active. MutingSwitch21 is the first exit switch actuated. Monitoring of DiscTime21_22 is started. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = TRUE Error = FALSE
8314	Muting Forward Step 2	Muting forward sequence is active. MutingSwitch22 is the first exit switch actuated. Monitoring of DiscTime21_22 is started. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = TRUE Error = FALSE
8021	Muting Forward Active 2	Muting forward sequence is still active. Both MutingSwitch21 and 22 are actuated, the monitoring of DiscTime21_22 is stopped. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = TRUE Error = FALSE
8122	Muting Backward Start 1	Muting backward sequence is in starting phase after rising trigger of MutingSwitch21. Monitoring of DiscTime21_22 is activated. Monitoring of MaxMutingTime is activated. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = FALSE Error = FALSE
8422	Muting Backward Start 2	Muting backward sequence is in starting phase after rising trigger of MutingSwitch22. Monitoring of DiscTime21_22 is activated. Monitoring of MaxMutingTime is activated. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = FALSE Error = FALSE

DiagCode	State Name	State Description and Output Setting
8121	Muting Backward Active 1	Muting backward sequence is active either: - After rising trigger of the second MutingSwitch 21 or 22 has been detected. - When both MutingSwitch 21 and 22 have been actuated in the same cycle. Monitoring of DiscTime21_22 is stopped. Monitoring of MaxMuting-Time is activated, when transition came directly from state 8000. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = TRUE Error = FALSE
8114	Muting Backward Step 1	Muting backward sequence is active. MutingSwitch11 is the first exit switch actuated. Monitoring of DiscTime11_12 is started. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = TRUE Error = FALSE
8414	Muting Backward Step 2	Muting backward sequence is active. MutingSwitch12 is the first exit switch actuated. Monitoring of DiscTime11_12 is started. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = TRUE Error = FALSE
8112	Muting Backward Active 2	Muting backward sequence is still active. Both exit switches MutingSwitch11 and 12 are actuated, the monitoring of DiscTime11_12 is stopped. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = TRUE Error = FALSE

13.2.10 SF_MUTINGPAR_2SENSOR

1) Overview

Muting is the intended suppression of the safety function. In this FB, parallel muting with two muting sensors is specified..



2) Input / Output Variables

Type	Name	Data Type	Initial Value	Description
Input	Activate	BOOL	0	Activation of the FB
	S_AOPD_In	SAFEBOOL	0	OSSD signal from AOPD. FALSE: Protection field interrupted. TRUE: Protection field not interrupted.
	MutingSwitch11	BOOL	0	Status of Muting sensor 11. FALSE: Muting sensor 11 not actuated. TRUE: Workpiece actuates muting sensor 11.
	MutingSwitch12	BOOL	0	Status of Muting sensor 12. FALSE: Muting sensor 12 not actuated. TRUE: Workpiece actuates muting sensor 12
	S_MutingLamp	SAFEBOOL	0	Indicates operation of the muting lamp. FALSE: Muting lamp failure. TRUE: Muting lamp no failure.
	DiscTimeEntry	TIME	T#0s	Constant 0..4 s; Max. discrepancy time for S_MutingSwitch11 and S_MutingSwitch12 entering muting gate
	MaxMutingTime	TIME	T#0s	Constant 0..10 min; Maximum time for complete muting sequence, timer started when first muting sensor is actuated.

Type	Name	Data Type	Initial Value	Description
Input	MutingEnable	BOOL	0	Command by the control system that enables the start of the muting function when needed by the machine cycle. After the start of the muting function, this signal can be switched off. FALSE: Muting not enabled TRUE: Start of Muting function enabled
	S_StartReset	SAFEBOOL	0	FALSE (= initial value): Manual reset when PES is started (warm or cold). TRUE: Automatic reset when PES is started (warm or cold). This function shall only be activated if it is ensured that no hazard can occur at the start of the PES. Therefore the use of the Automatic Circuit Reset feature of the function blocks requires implementation of other system or application measures to ensure that unexpected (or unintended) startup does not occur.
	Reset	BOOL	0	Reset
Output	Ready	BOOL	0	If TRUE, indicates that the FB is activated and the output results are valid.
	S_AOPD_Out	SAFEBOOL	0	Safety related output, indicates status of the muted guard. FALSE: AOPD protection field interrupted and muting not active. TRUE: AOPD protection field not interrupted or muting active.
	S_MutingActive	SAFEBOOL	0	Indicates status of Muting process. FALSE: Muting not active. TRUE: Muting active.
	Error	BOOL	0	Error flag
	DiagCode	WORD	16#0000	Diagnostic register. All states of the FB are represented by this register. This information is encoded in hexadecimal format in order to represent more than 16 codes.

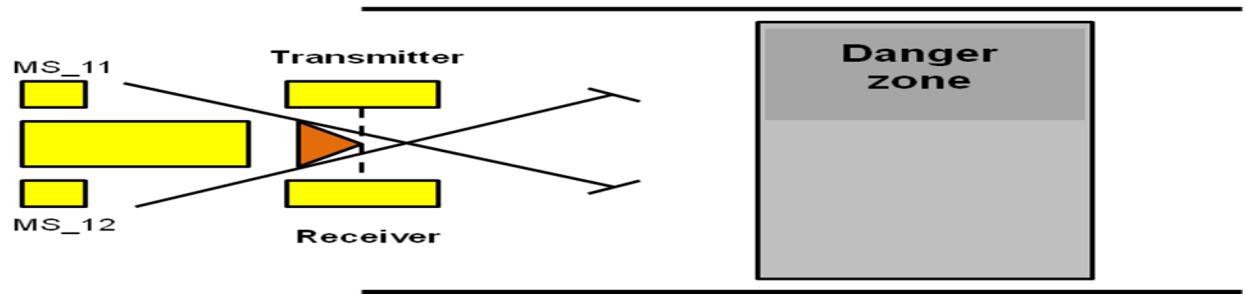
3) Functional Description

Muting is the intended suppression of the safety function. This is required, e.g., when transporting the material into the danger zone without causing the machine to stop. Muting is triggered by muting sensors. The use of two muting sensors and correct integration into the production sequence must ensure that no persons enter the danger zone while the light curtain is muted.
Muting sensors can be push buttons, proximity switches, photoelectric barriers, limit switches, etc. which do not have to be failsafe. Active muting mode must be indicated by indicator lights.

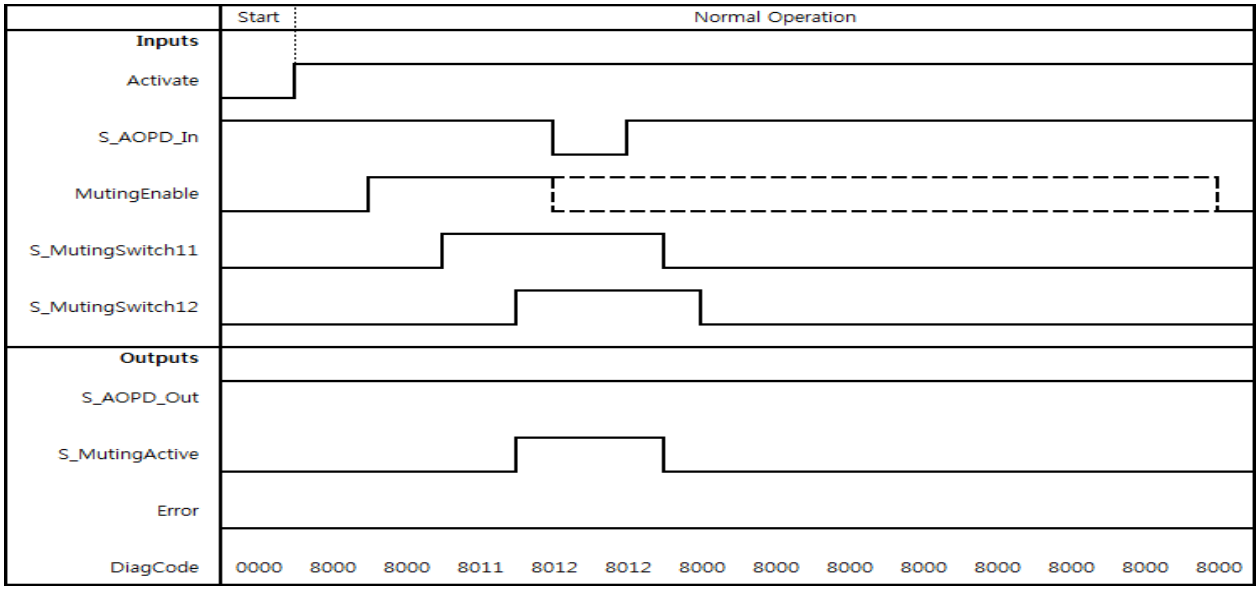
There are sequential and parallel muting procedures. In this FB, parallel muting with two muting sensors was used; an explanation is provided below. The positioning of the sensors should be as described in Annex F.7 of IEC 62046, CD 2005, as shown in Figure 48. The FB can be used in both directions, forward and backward. However, the actual direction cannot be identified. The muting should be enabled with the MutingEnable signal by the process control to avoid manipulation.

The FB input parameters include the signals of the two muting sensors (S_MutingSwitch11 and S_MutingSwitch12), the OSSD signal from the "active opto-electronic protective device", S_AOPD_In, as well as two parameterizable times (Disc-TimeEntry and MaxMutingTime).

The S_StartReset input shall only be activated if it is ensured that no hazardous situation can occur when the PES is started
Step 1: If reflection light barriers are used as muting sensors, they are generally arranged diagonally. In general, this arrangement of reflection light barriers as muting sensors requires only two light barriers, and only S_MutingSwitch11 (MS_11) and S_MutingSwitch12 (MS_12) are allocated.

NO.	Figure
1	

4) Typical Timing Diagrams



5) Error Detection

The FB detects the following error conditions:

- DiscTimeEntry has been set to value less than T#0s or greater than T#4s.
- MaxMutingTime has been set to a value less than T#0s or greater than T#10min.
- The discrepancy time for the S_MutingSwitch11/S_MutingSwitch12 sensor pair has been exceeded.
- The muting function (S_MutingActive = TRUE) exceeds the maximum muting time MaxMutingTime.
- Muting sensors S_MutingSwitch11,S_MutingSwitch12 are activated in the wrong order.
- Muting sequence starts without being enabled by MutingEnable
- Static muting sensor signals.
- A faulty muting lamp is indicated by S_MutingLamp = FALSE.
- A static Reset condition is detected in state 8001 and 8003.

6) Error Behavior

In the event of an error, the S_AOPD_Out and S_MutingActive outputs are set to FALSE. The DiagCode output indicates the relevant error code and the Error output is set to TRUE.

A restart is inhibited until the error conditions are cleared and the Safe state is acknowledged with Reset by the operator.

7) Error Codes

DiagCode	State Name	State Description and Output Setting
C001	Reset Error 1	Static Reset condition detected after FB activation in state 8001. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = TRUE
C002	Reset Error 2	Static Reset condition detected in state 8003. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = TRUE
C003	Error Muting Lamp	Error detected in muting lamp. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = TRUE
CYx4	Error Muting sequence	Error detected in muting sequence state 8000, 8011, 8311. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = TRUE Y = Status in the sequence C0x4 = Error occurred in state 8000 C1x4 = Error occurred in state 8011 C2x4 = Error occurred in state 8311 CFx4 = Muting Enable missing x = Status of the sensors when error occurred (4 bits: LSB = MS_11; next to LSB = MS_12).
C005	Parameter Error	DiscTimeEntry or MaxMutingTime value out of range. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = TRUE
C006	Error timer MaxMuting	Timing error: Active muting time (when S_MutingActive = TRUE) exceeds MaxMutingTime. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = TRUE
C007	Error timer Entry	Timing error: Discrepancy time for switching S_MutingSwitch11 and S_MutingSwitch12 from FALSE to TRUE > DiscTimeEntry. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = TRUE

8) Status codes

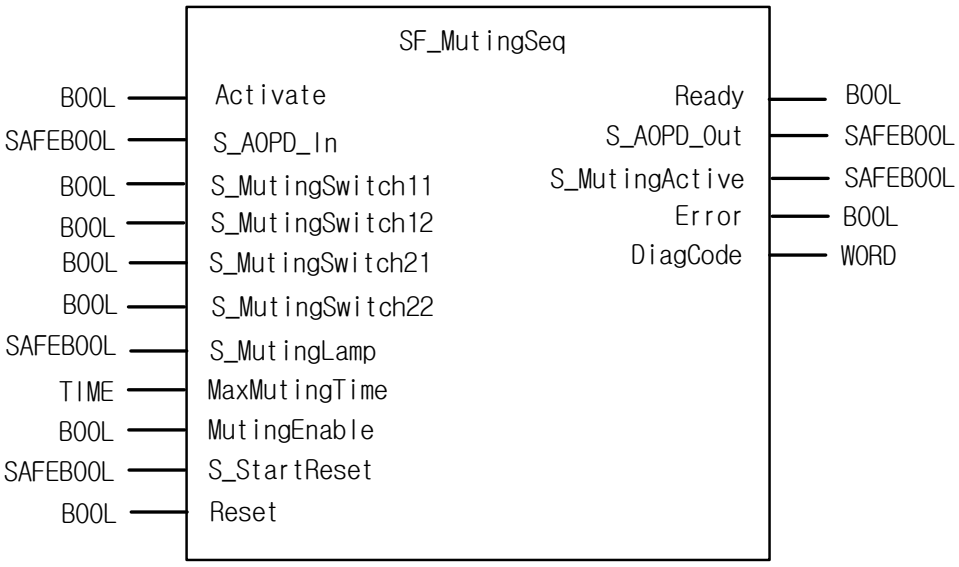
DiagCode	State Name	State Description and Output Setting
0000	Idle	The function block is not active (initial state). Ready = FALSE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = FALSE
8000	AOPD Free	Muting not active and no safety demand from AOPD. If timers from subsequent muting are still running, they are stopped. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = FALSE Error = FALSE
8001	Init	Function block was activated. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = FALSE
8002	Safety Demand AOPD	Safety demand detected by AOPD, muting not active. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = FALSE
8003	Wait for Reset	Safety demand or errors have been detected and are now cleared. Operator acknowledgment by Reset required. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = FALSE
8005	Safe	Safety function activated. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = FALSE
8011	Muting Start 1	Muting sequence is in starting phase after rising trigger of S_MutingSwitch11. Monitoring of DiscTimeEntry is activated. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = FALSE Error = FALSE
8311	Muting Start 2	Muting sequence is in starting phase after rising trigger of S_MutingSwitch12. Monitoring of DiscTimeEntry is activated. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = FALSE Error = FALSE

DiagCode	State Name	State Description and Output Setting
8012	Muting Active	Muting sequence is active either: - After rising trigger of the second S_MutingSwitch 12 or 11 has been detected. - When both S_MutingSwitch 11 and 12 have been actuated in the same cycle. Monitoring of DiscTimeEntry is stopped. Monitoring of MaxMutingTime is activated. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = TRUE Error = FALSE

13.2.11 SF_MUTINGSEQ

1) Overview

Muting is the intended suppression of the safety function (e.g., light barriers). In this FB, sequential muting with four muting sensors is specified.



2) Input / Output Variables

Type	Name	Data Type	Initial Value	Description
Input	Activate	BOOL	0	Activation of the FB
	S_AOPD_In	SAFEBOOL	0	OSSD signal from AOPD. FALSE: Protection field interrupted. TRUE: Protection field not interrupted.
	MutingSwitch11	BOOL	0	Status of Muting sensor 11. FALSE: Muting sensor 11 not actuated. TRUE: Workpiece actuates muting sensor 11. It shall be noted in the FB manual that a SAFEBOOL must be connected instead of a BOOL depending on the safety requirements.
	MutingSwitch12	BOOL	0	Status of Muting sensor 12. FALSE: Muting sensor 12 not actuated. TRUE: Workpiece actuates muting sensor 12. It shall be noted in the FB manual that a SAFEBOOL must be connected instead of a BOOL depending on the safety requirements.

Type	Name	Data Type	Initial Value	Description
Input	MutingSwitch21	BOOL	0	Status of Muting sensor 21. FALSE: Muting sensor 21 not actuated. TRUE: Workpiece actuates muting sensor 21. It shall be noted in the FB manual that a SAFEBOOL must be connected instead of a BOOL depending on the safety requirements.
	MutingSwitch22	BOOL	0	Status of Muting sensor 22. FALSE: Muting sensor 22 not actuated. TRUE: Workpiece actuates muting sensor 22. It shall be noted in the FB manual that a SAFEBOOL must be connected instead of a BOOL depending on the safety requirements.
	S_MutingLamp	SAFEBOOL	0	Indicates operation of the muting lamp. FALSE: Muting lamp failure. TRUE: Muting lamp no failure
	MaxMutingTime	TIME	T#0s	Constant 0 .. 10 min; Maximum time for complete muting sequence, timer started when first muting sensor is actuated.
	MutingEnable	BOOL	0	Command by the control system that enables the start of the muting function when needed by the machine cycle. After the start of the muting function, this signal can be switched off. FALSE: Muting not enabled TRUE: Start of Muting function enabled
	S_StartReset	SAFEBOOL	0	FALSE (= initial value): Manual reset when PES is started (warm or cold). TRUE: Automatic reset when PES is started (warm or cold). This function shall only be activated if it is ensured that no hazard can occur at the start of the PES. Therefore the use of the Automatic Circuit Reset feature of the function blocks requires implementation of other system or application measures to ensure that unexpected (or unintended) startup does not occur.
	Reset	BOOL	0	Reset

Type	Name	Data Type	Initial Value	Description
Output	Ready	BOOL	0	If TRUE, indicates that the FB is activated and the output results are valid.
	S_AOPD_Out	SAFEBOOL	0	Safety related output, indicates status of the muted guard. FALSE: AOPD protection field interrupted and muting not active. TRUE: AOPD protection field not interrupted or muting active.
	S_MutingActive	SAFEBOOL	0	Indicates status of Muting process. FALSE: Muting not active. TRUE: Muting active.
	Error	BOOL	0	Error flag
	DiagCode	WORD	16#0000	Diagnostic register. All states of the FB are represented by this register. This information is encoded in hexadecimal format in order to represent more than 16 codes.

3) Functional Description

Muting is the intended suppression of the safety function. This is required, e.g., when transporting the material into the danger zone without causing the machine to stop. Muting is triggered by muting sensors. The use of two or four muting sensors and correct integration into the production sequence must ensure that no persons enter the danger zone while the light curtain is muted. Muting sensors can be proximity switches, photoelectric barriers, limit switches, etc. which do not have to be failsafe. Active muting mode must be indicated by indicator lights.

There are sequential and parallel muting procedures. In this FB, sequential muting with four muting sensors was used; an explanation for the forward direction of transportation is provided below. The FB can be used in both directions, forward and backward. The muting should be enabled with the MutingEnable signal by the process control to avoid manipulation. When the MutingEnable signal is not available, this input must be set to TRUE.

The FB input parameters include the signals of the four muting sensors (MutingSwitch11 ... MutingSwitch22) as well as the OSSD signal from the "active opto-electronic protective device", S_AOPD_In.

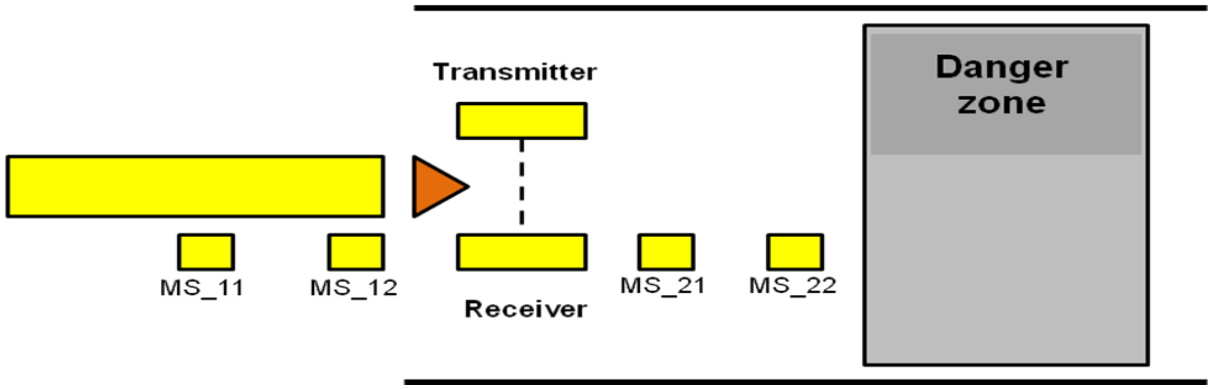
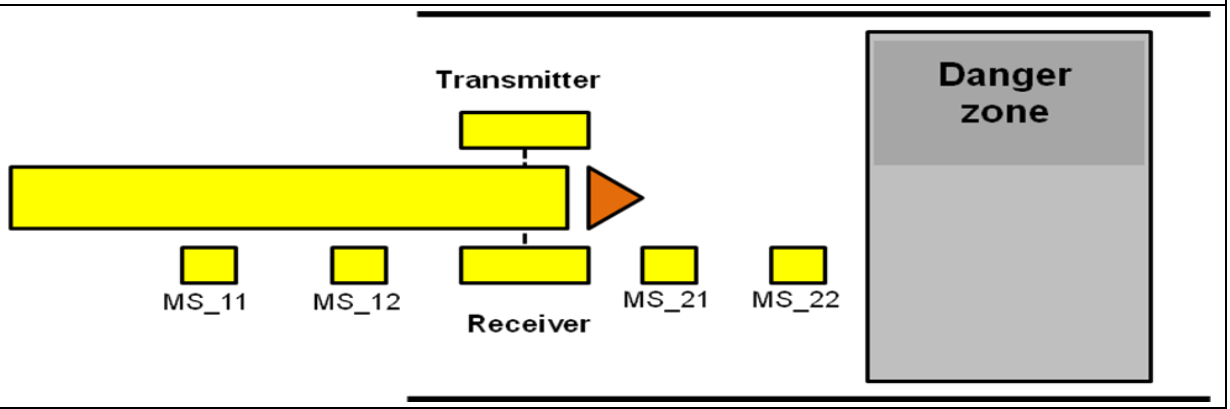
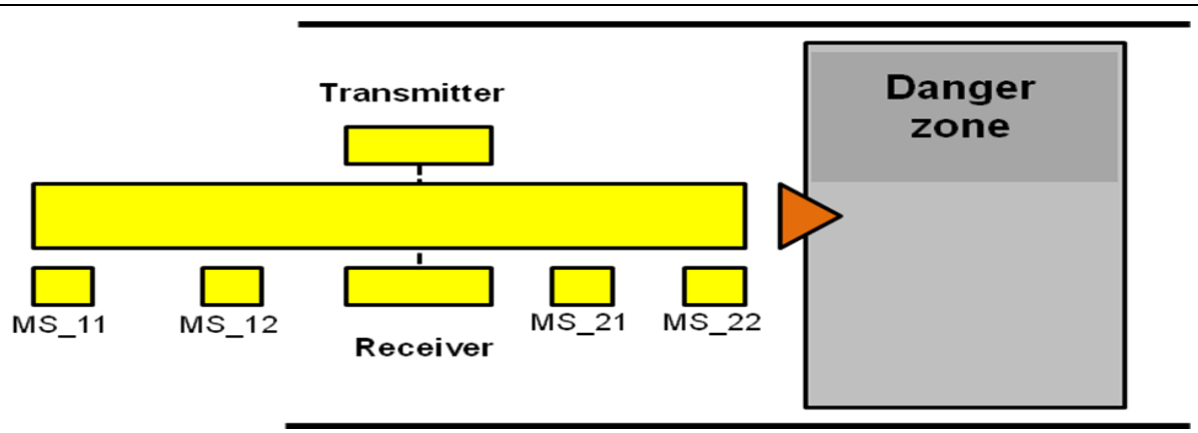
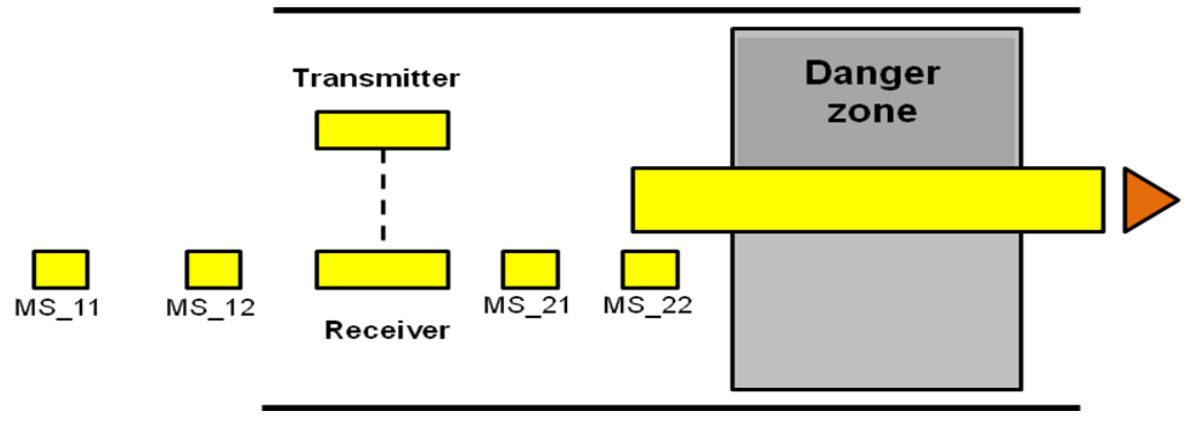
The S_StartReset input shall only be activated if it is ensured that no hazardous situation can occur when the PES is started.

Step 1 : If muting sensor MutingSwitch12 (MS_12) is activated by the product after MutingSwitch11 (MS_11), the muting mode is activated.

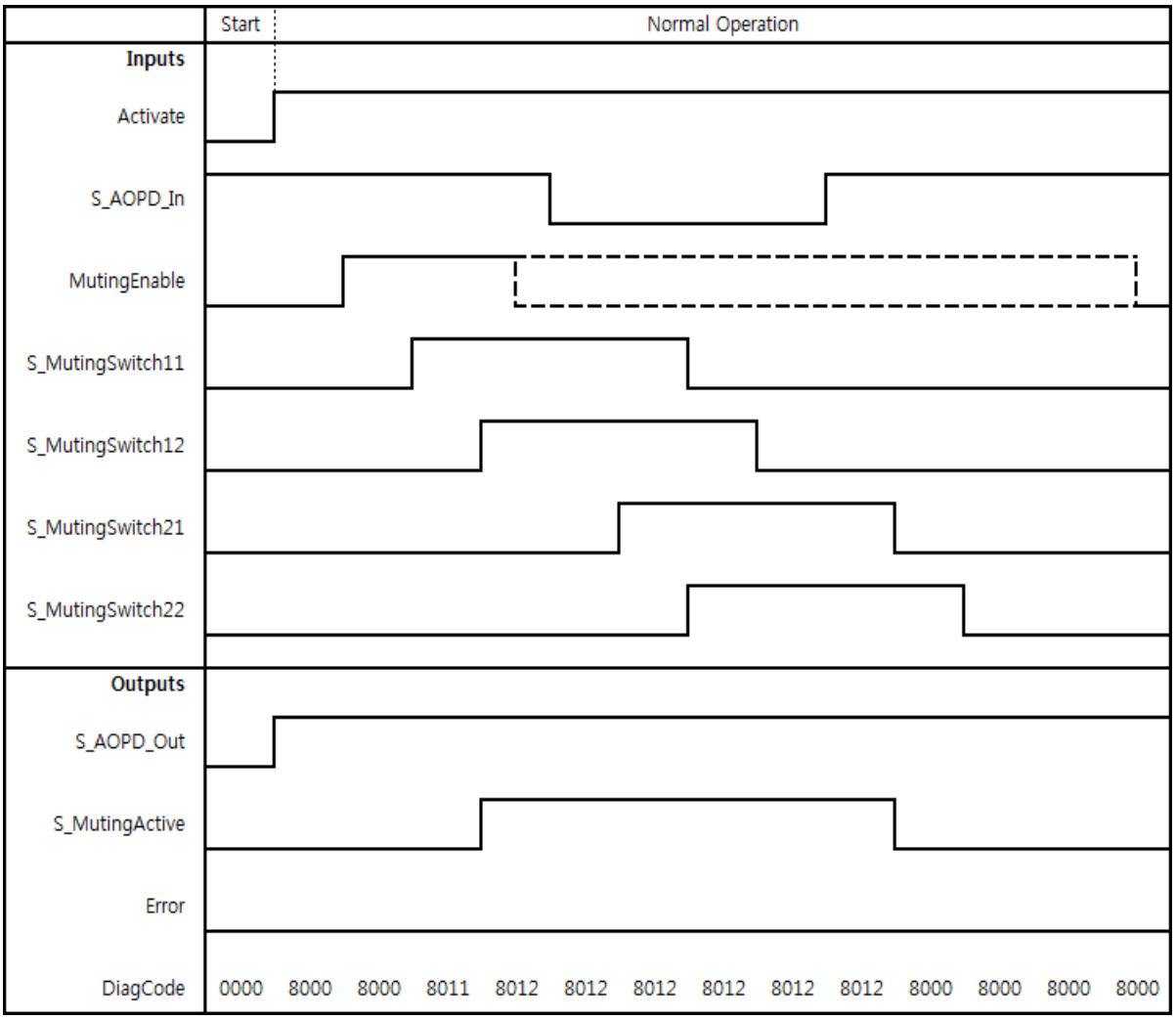
Step 2 : Muting mode remains active as long as MutingSwitch11 (MS_11) and MutingSwitch12 (MS_12) are activated by the product. The product may pass through the light curtain without causing a machine stop.

Step 3 : Before muting sensors MutingSwitch11 (MS_11) and MutingSwitch12 (MS_12) are disabled, muting sensors MutingSwitch21 (MS_21) and MutingSwitch22 (MS_22) must be activated. This ensures that muting mode remains active.

Step 4 : Muting mode is terminated if only muting sensor MutingSwitch22 (MS_22) is activated by the product.

NO.	Figure
1	
2	
3	
4	

4) Typical Timing Diagrams



5) Error Detection

The FB detects the following error conditions:

- Muting sensors MutingSwitch11, MutingSwitch12, MutingSwitch21, and MutingSwitch22 are activated in the wrong order.
- Muting sequence starts without being enabled by MutingEnable
- A faulty muting lamp is indicated by S_MutingLamp = FALSE.
- A static Reset condition.
- MaxMutingTime has been set to a value less than T#0s or greater than T#10min.
- The muting function (S_MutingActive = TRUE) exceeds the maximum muting time MaxMutingTime.

6) Error Behavior

In the event of an error, the S_AOPD_Out and S_MutingActive outputs are set to FALSE. The DiagCode output indicates the relevant error code and the Error output is set to TRUE.

A restart is inhibited until the error conditions are cleared and the Safe state is acknowledged with Reset by the operator.

7) Error Codes

DiagCode	State Name	State Description and Output Setting
C001	Reset Error 1	Static Reset condition detected after FB activation. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = TRUE
C002	Reset Error 2	Static Reset condition detected in state 8003. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = TRUE
C003	Error Muting lamp	Error detected in muting lamp. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = TRUE
CYx4	Error Muting sequence	Error detected in muting sequence in states 8000, 8011, 8012, 8112 or 8122. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = TRUE Y = Status in the sequence (2 states for forward and 2 states for backward direction). C0x4 = Error occurred in state 8000 C1x4 = Error occurred in state Forward 8011 C2x4 = Error occurred in state Forward 8012 C3x4 = Error occurred in state Backward 8122 C4x4 = Error occurred in state Backward 8112 CFx4 = Muting Enable missing x = Status of the sensors when error occurred (4 bits: LSB = MS_11; MS_12; MS_21; MSB = MS_22).
C005	Parameter Error	MaxMutingTime value out of range. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = TRUE
C006	Error Timer MaxMuting	Timing error: Active muting time (when S_MutingActive = TRUE) exceeds MaxMutingTime. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = TRUE

8) Status codes

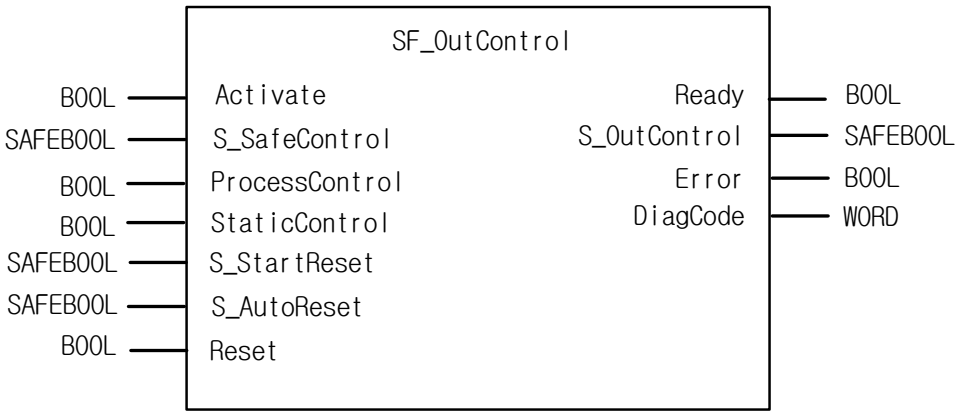
DiagCode	State Name	State Description and Output Setting
0000	Idle	The function block is not active (initial state). Ready = FALSE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = FALSE
8000	AOPD Free	Muting not active and no safety demand from AOPD. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = FALSE Error = FALSE
8001	Init	Function block has been activated. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = FALSE
8002	Safety Demand AOPD	Safety demand detected by AOPD, muting not active. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = FALSE
8003	Wait for Reset	Safety demand or errors have been detected and are now cleared. Operator acknowledgment by Reset required. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = FALSE
8005	Safe	Safety function activated. Ready = TRUE S_AOPD_Out = FALSE S_MutingActive = FALSE Error = FALSE
8011	Muting Forward Start	Muting forward, sequence is in starting phase and no safety demand. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = FALSE Error = FALSE
8012	Muting Forward Active	Muting forward, sequence is active. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = TRUE Error = FALSE
8112	Muting Backward Active	Muting backward, sequence is active. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = TRUE Error = FALSE

DiagCode	State Name	State Description and Output Setting
8122	Muting Backward Start	Muting backward, sequence is in starting phase and no safety demand. Ready = TRUE S_AOPD_Out = TRUE S_MutingActive = FALSE Error = FALSE

13.2.12 SF_OUTCONTROL

1) Overview

Control of a safety output with a signal from the functional application and a safety signal with optional startup inhibits.



2) Input / Output Variables

Type	Name	Data Type	Initial Value	Description
Input	Activate	BOOL	0	Activation of the FB
	S_SafetyControl	SAFEBOOL	0	Control signal of the preceding safety FB. Typical function block signals from the library (e.g., SF_EStop, SF_GuardMonitoring, SF_TwoHandControlTypeII, and/or others). FALSE: The preceding safety FB's are in safe state. TRUE: The preceding safety FB's enable safety control.
	ProcessControl	BOOL	0	Control signal from the functional application. FALSE: Request to set S_OutControl to FALSE. TRUE: Request to set S_OutControl to TRUE.
	StaticControl	BOOL	0	Optional conditions for process control. FALSE: Dynamic change at ProcessControl (FALSE => TRUE) required after block activation or triggered safety function. Additional function start required. TRUE: No dynamic change at ProcessControl (FALSE => TRUE) required after block activation or triggered safety function.

Type	Name	Data Type	Initial Value	Description
Input	S_StartReset	SAFEBOOL	0	FALSE (= initial value): Manual reset when PES is started (warm or cold). TRUE: Automatic reset when PES is started (warm or cold). This function shall only be activated if it is ensured that no hazard can occur at the start of the PES. Therefore the use of the Automatic Circuit Reset feature of the function blocks requires implementation of other system or application measures to ensure that unexpected (or unintended) startup does not occur.
	S_AutoReset	SAFEBOOL	0	FALSE (= initial value): Manual reset when emergency stop button is released. TRUE: Automatic reset when emergency stop button is released. This function shall only be activated if it is ensured that no hazard can occur at the start of the PES. Therefore the use of the Automatic Circuit Reset feature of the function blocks requires implementation of other system or application measures to ensure that unexpected (or unintended) startup does not occur.
	Reset	BOOL	0	Reset
Output	Ready	BOOL	0	If TRUE, indicates that the FB is activated and the output results are valid.
	S_OutControl	SAFEBOOL	0	Controls connected actuators. FALSE: Disable connected actuators. TRUE: Enable connected actuators.
	Error	BOOL	0	Error flag
	DiagCode	WORD	16#0000	Diagnostic register. All states of the FB are represented by this register. This information is encoded in hexadecimal format in order to represent more than 16 codes.

3) Functional Description

General:

The SF_OutControl FB is an output driver for a safety output.

The safety output is controlled via S_OutControl using a signal from the functional application (ProcessControl/BOOL to control the process) and a signal from the safety application (S_SafeControl/SAFEBOOL to control the safety function).

Optional conditions for process control (ProcessControl):

- An additional function start (ProcessControl FALSE => TRUE) is required following block activation or feedback of the safe signal (S_SafeControl). A static TRUE signal at ProcessControl does not set S_OutControl to TRUE.
- An additional function start (ProcessControl FALSE => TRUE) is not required following block activation or feedback of the safe signal (S_SafeControl). A static TRUE signal at ProcessControl sets S_OutControl to TRUE if the other conditions have been

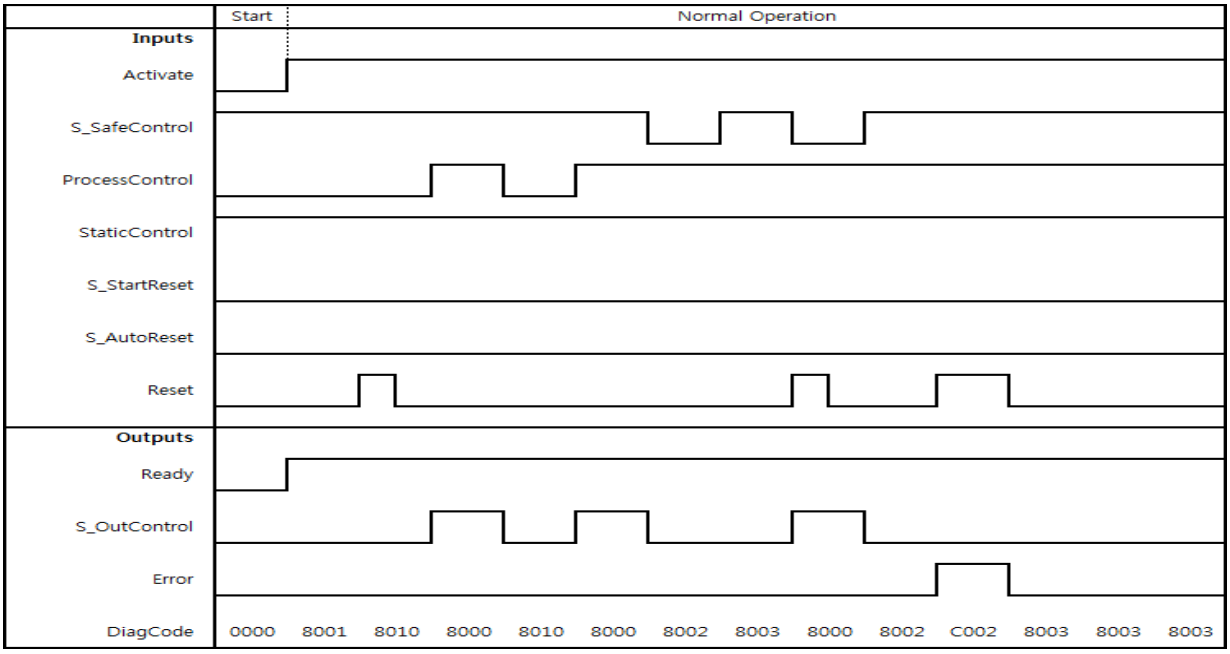
met.

Optional startup inhibits:

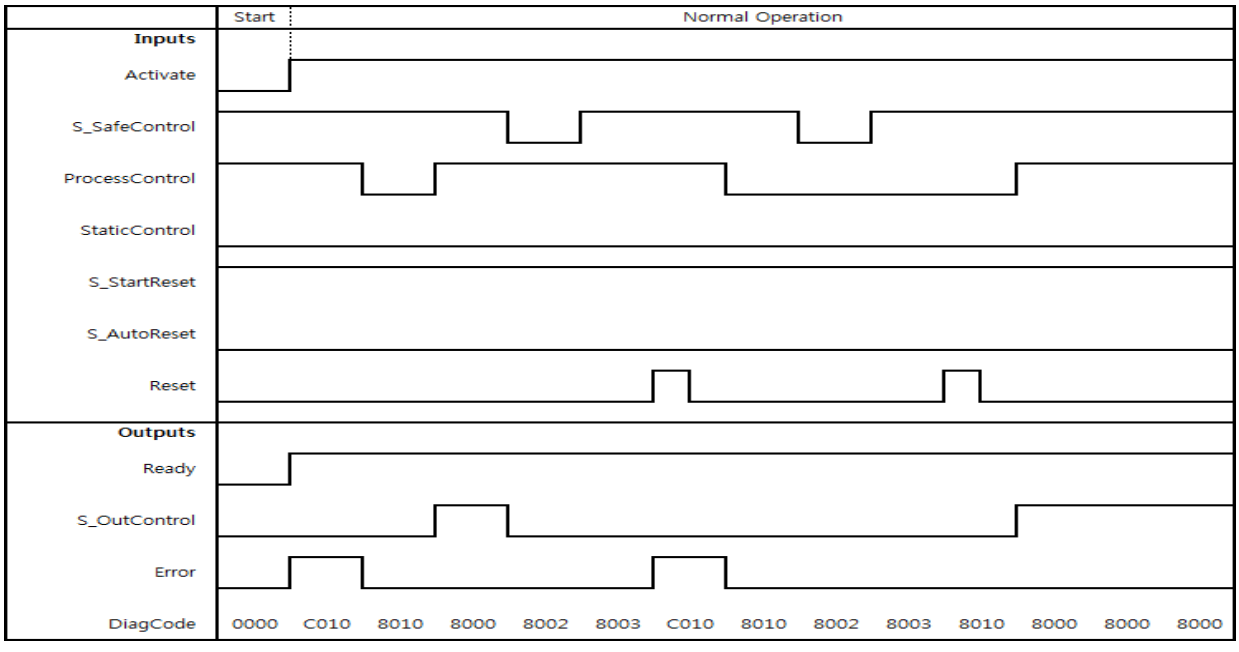
- Startup inhibit after function block activation.
- Startup inhibit after interruption of the protective device.

The StaticControl, S_StartReset and S_AutoReset inputs shall only be activated if it is ensured that no hazardous situation can occur when the PES is started.

4) Typical Timing Diagrams



< S_StartReset=Off >



< S_StartReset=On >

5) Error Detection

The following conditions force a transition to the Error state:

- Invalid static Reset signal in the process.
- Invalid static ProcessControl signal.
- ProcessControl and Reset are incorrectly interconnected due to programming error.

6) Error Behavior

In the event of an error, the S_OutControl output is set to FALSE and remains in this safe state.

To leave the Reset, Init or Lock error states, the Reset input must be set to FALSE. To leave the Control error state, the ProcessControl input must be set to FALSE.

After transition of S_SafeControl to TRUE, the optional startup inhibit can be reset by a rising edge at the Reset input.

After block activation, the optional startup inhibit can be reset by a rising edge at the Reset input.

7) Error Codes

DiagCode	State Name	State Description and Output Setting
C001	Reset Error 1	Static Reset signal in state 8001. Ready = TRUE S_OutControl = FALSE Error = TRUE
C002	Reset Error 2	Static Reset signal in state 8003. Ready = TRUE S_OutControl = FALSE Error = TRUE
C010	Control Error	Static signal at ProcessControl in state 8010. Ready = TRUE S_OutControl = FALSE Error = TRUE
C111	Init Error	Simultaneous rising trigger at Reset and ProcessControl in state 8001. Ready = TRUE S_OutControl = FALSE Error = TRUE
C211	Lock Error	Simultaneous rising trigger at Reset and ProcessControl in state 8003. Ready = TRUE S_OutControl = FALSE Error = TRUE

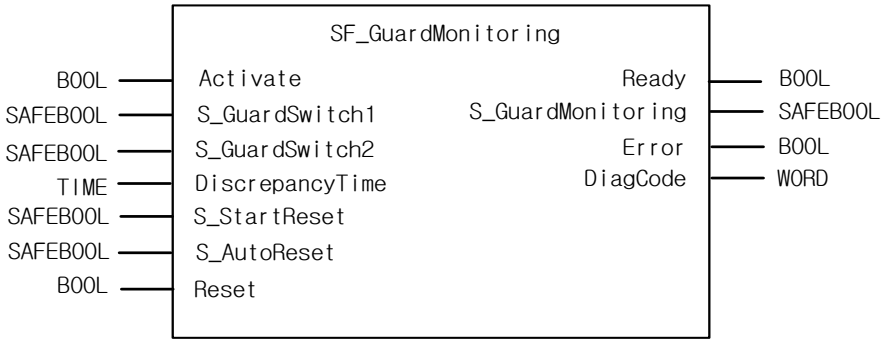
8) Status codes

DiagCode	State Name	State Description and Output Setting
0000	Idle	The function block is not active (initial state). Ready = FALSE S_OutControl = FALSE Error = FALSE
8001	Init	Block activation startup inhibit is active. Reset required. Ready = TRUE S_OutControl = FALSE Error = FALSE
8002	Safe	Triggered safety function. Ready = TRUE S_OutControl = FALSE Error = FALSE
8003	Lock	Safety function startup inhibit is active. Reset required. Ready = TRUE S_OutControl = FALSE Error = FALSE
8010	Output Disable	Process control is not active. Ready = TRUE S_OutControl = FALSE Error = FALSE
8000	Output Enable	Process control is active and safety is enabled. Ready = TRUE S_OutControl = TRUE Error = FALSE

13.2.13 SF_SAFEGUARD

1) Overview

This function block monitors the relevant safety guard. There are two independent input parameters for two switches at the safety guard coupled with a time difference (MonitoringTime) for closing the guard.



2) Input / Output Variables

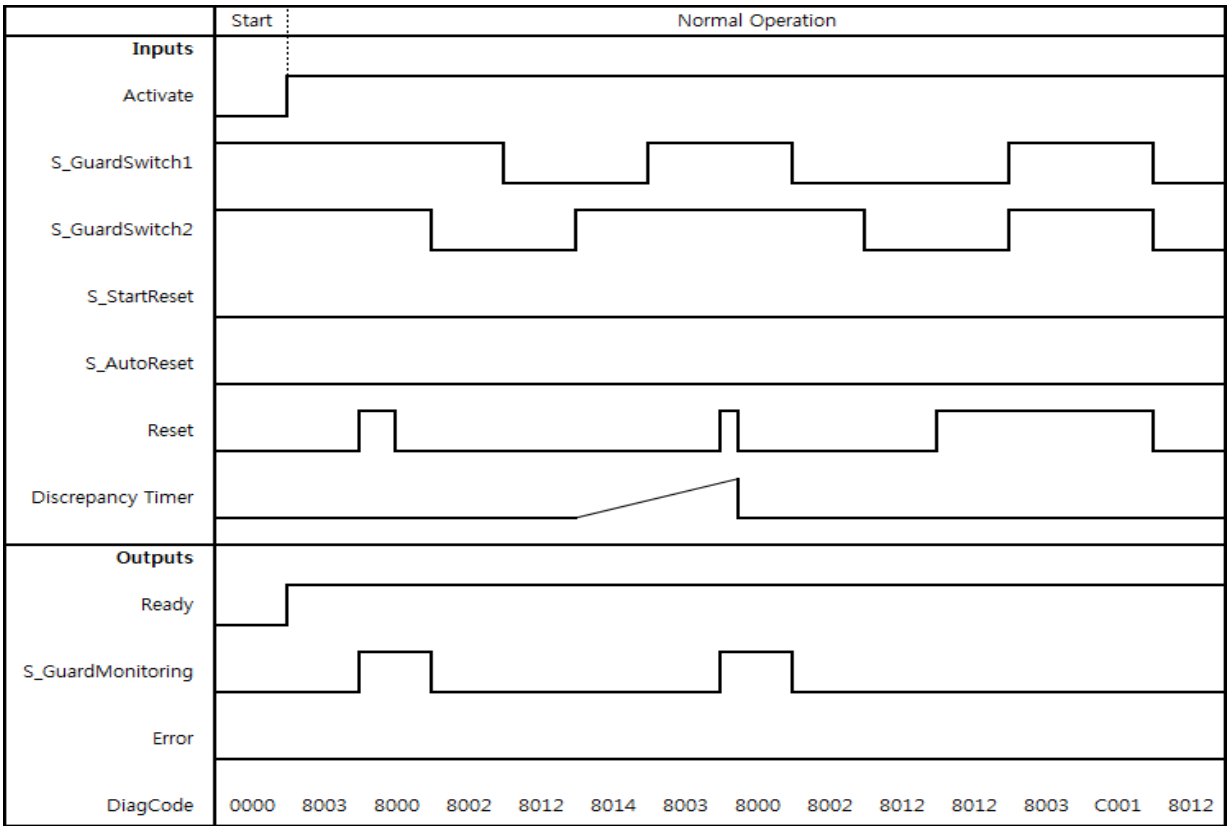
Type	Name	Data Type	Initial Value	Description
Input	Activate	BOOL	0	Activation of the FB
	S_GuardSwitch1	SAFEBOOL	0	Guard switch 1 input. FALSE: Guard is open. TRUE: Guard is closed.
	S_GuardSwitch2	SAFEBOOL	0	Guard switch 2 input. FALSE: Guard is open. TRUE: Guard is closed.
	DiscrepancyTime	Time	T#0ms	Configures the monitored synchronous time between S_GuardSwitch1 and S_GuardSwitch2.
	S_StartReset	SAFEBOOL	0	FALSE (= initial value): Manual reset when PES is started (warm or cold). TRUE: Automatic reset when PES is started (warm or cold). This function shall only be activated if it is ensured that no hazard can occur at the start of the PES. Therefore the use of the Automatic Circuit Reset feature of the function blocks requires implementation of other system or application measures to ensure that unexpected (or unintended) startup does not occur.

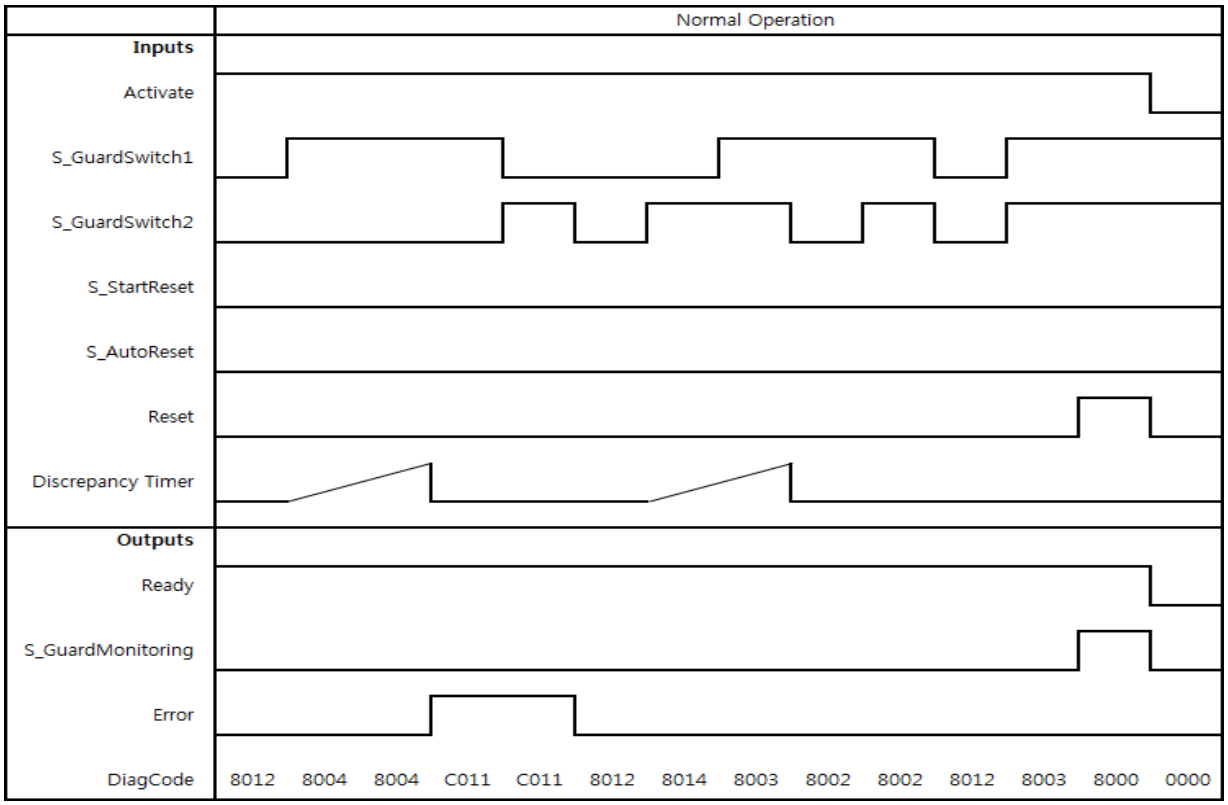
Type	Name	Data Type	Initial Value	Description
	S_AutoReset	SAFEBOOL	0	FALSE (= initial value): Manual reset when emergency stop button is released. TRUE: Automatic reset when emergency stop button is released. This function shall only be activated if it is ensured that no hazard can occur at the start of the PES. Therefore the use of the Automatic Circuit Reset feature of the function blocks requires implementation of other system or application measures to ensure that unexpected (or unintended) startup does not occur.
	Reset	BOOL	0	Reset
Output	Ready	BOOL	0	If TRUE, indicates that the FB is activated and the output results are valid.
	S_GuardMonitoring	SAFEBOOL	0	Output indicating the status of the guard. FALSE: Guard is not active. TRUE: both S_GuardSwitches are TRUE, no error and acknowledgment. Guard is active.
	Error	BOOL	0	Error flag
	DiagCode	WORD	16#0000	Diagnostic register. All states of the FB are represented by this register. This information is encoded in hexadecimal format in order to represent more than 16 codes.

3) Functional Description

The function block requires two inputs indicating the guard position for safety guards with two switches, a DiscrepancyTime input and Reset input. If the safety guard only has one switch, the S_GuardSwitch1 and S_GuardSwitch2 inputs can be bridged. The monitoring time is the maximum time required for both switches to respond when closing the safety guard. The Reset, S_StartReset, and S_AutoReset inputs determine how the function block is reset after the safety guard has been opened.
When opening the safety guard, both S_GuardSwitch1 and S_GuardSwitch2 inputs should switch to FALSE. The S_GuardMonitoring output switches to FALSE as soon as one of the switches is set to FALSE. When closing the safety guard, both S_GuardSwitch1 and S_GuardSwitch2 inputs should switch to TRUE.
This FB monitors the symmetry of the switching behavior of both switches. The S_GuardMonitoring output remains FALSE if only one of the contacts has completed an open/close process.
The behavior of the S_GuardMonitoring output depends on the time difference between the switching inputs. The discrepancy time is monitored as soon as the value of both S_GuardSwitch1/S_GuardSwitch2 inputs differs. If the DiscrepancyTime has elapsed, but the inputs still differ, the S_GuardMonitoring output remains FALSE. If the second corresponding S_GuardSwitch1/S_GuardSwitch2 input switches to TRUE within the value specified for the DiscrepancyTime input, the S_GuardMonitoring output is set to TRUE following acknowledgment.
The S_StartReset and S_AutoReset inputs shall only be activated if it is ensured that no hazardous situation can occur when the PES is started.

4) Typical Timing Diagrams





5) Error Detection

External signals: SAFEBOOL inputs provide inherent error detection. Mechanical setup combines that of an opening and closing switch according to EN 954 (safety guard with two switches). Discrepancy time monitoring for time lag between both mechanical switches reaction, according to EN 954 (to be considered as "application error" detection, i.e., generated by the application).

An error is detected if the time lag between the first S_GuardSwitch1/S_GuardSwitch2 input and the second is greater than the value for the DiscrepancyTime input. The Error output is set to TRUE.

The function block detects a static TRUE signal at the RESET input.

6) Error Behavior

The S_GuardMonitoring output is set to FALSE. If the two S_GuardSwitch1 and S_Guardswitch2 inputs are bridged, no error is detected. To leave the Reset error state, the Reset input must be set to FALSE. To leave the discrepancy time errors, the inputs S_GuardSwitch1 and 2 must both be set to FALSE.

7) Error Codes

DiagCode	State Name	State Description and Output Setting
C001	Reset Error	Static reset detected in state 8003. Ready = TRUE S_GuardMonitoring = FALSE Error = TRUE
C011	Discrepancytime Error 1	DiscrepancyTime elapsed in state 8004. Ready = TRUE S_GuardMonitoring = FALSE Error = TRUE
C012	Discrepancytime Error 2	DiscrepancyTime elapsed in state 8014. Ready = TRUE S_GuardMonitoring = FALSE Error = TRUE

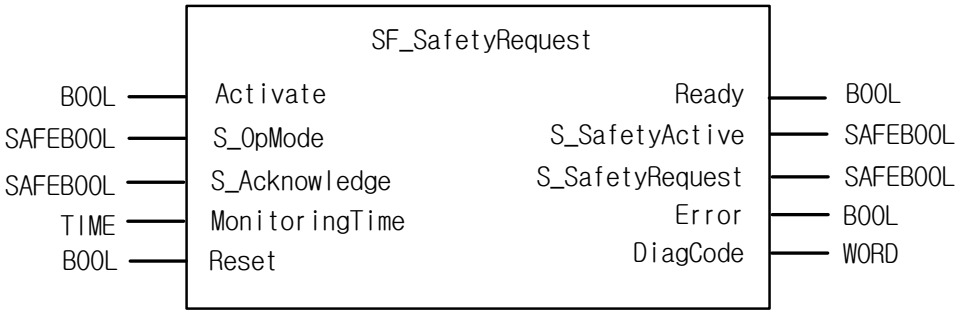
8) Status codes

DiagCode	State Name	State Description and Output Setting
0000	Idle	The function block is not active (initial state). Ready = FALSE S_GuardMonitoring = FALSE Error = FALSE
8000	Normal	Safety guard closed and Safe state acknowledged. Ready = TRUE S_GuardMonitoring = TRUE Error = FALSE
8001	Init	Function block has been activated. Ready = TRUE S_GuardMonitoring = FALSE Error = FALSE
8002	Open Guard Request	Complete switching sequence required. Ready = TRUE S_GuardMonitoring = FALSE Error = FALSE
8003	Wait for Reset	Waiting for rising trigger at Reset. Ready = TRUE S_GuardMonitoring = FALSE Error = FALSE
8012	Guard Opened	Guard completely opened. Ready = TRUE S_GuardMonitoring = FALSE Error = FALSE
8004	Wait for GuardSwitch2	S_GuardSwitch1 has been switched to TRUE - waiting for S_GuardSwitch2; discrepancy timer started. Ready = TRUE S_GuardMonitoring = FALSE Error = FALSE
8014	Wait for GuardSwitch1	S_GuardSwitch2 has been switched to TRUE - waiting for S_GuardSwitch1; discrepancy timer started. Ready = TRUE S_GuardMonitoring = FALSE Error = FALSE
8005	Guard Closed	Guard closed. Waiting for Reset, if S_AutoReset = FALSE. Ready = TRUE S_GuardMonitoring = FALSE Error = FALSE

13.2.14 SF_SAFETYREQUEST

1) Overview

This function block provides the interface to a generic actuator, e.g. a safety drive or safety valve, to place the actuator in a safe state.



2) Input / Output Variables

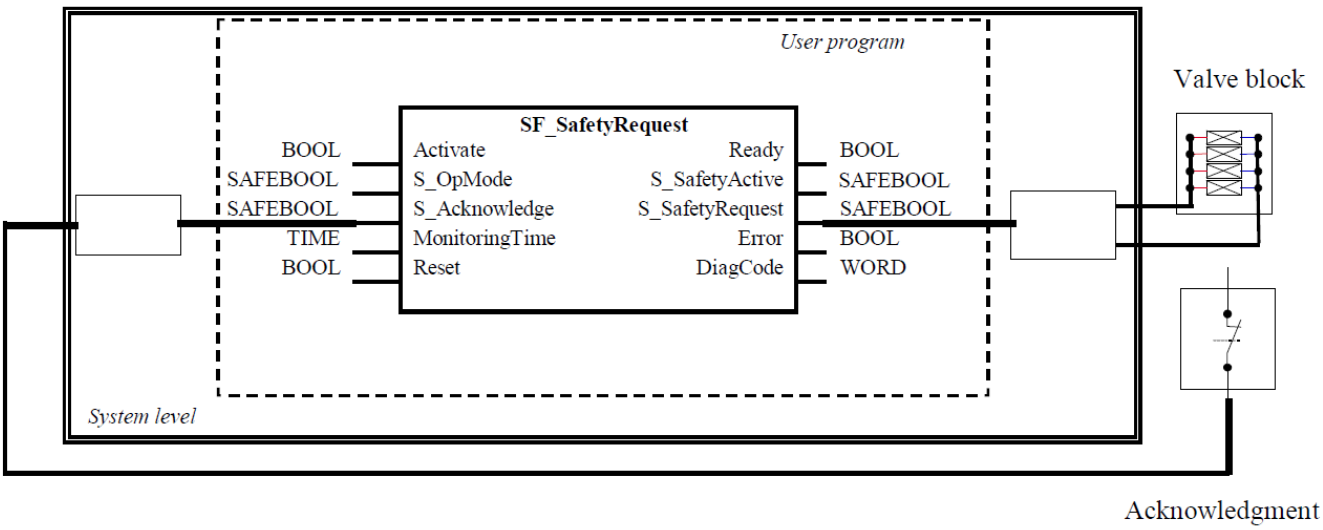
Type	Name	Data Type	Initial Value	Description
Input	Activate	BOOL	0	Activation of the FB
	S_OpMode	SAFEBOOL	0	Requested mode of a generic safe actuator. FALSE: Safe mode is requested. TRUE: Operation mode is requested.
	S_Acknowledge	SAFEBOOL	0	Confirmation of the generic actuator, if actuator is in the Safe state. FALSE: Operation mode (non-safe). TRUE: Safe mode.
	MonitoringTime	TIME	T#0s	Monitoring of the response time between the safety function request (S_OpMode set to FALSE) and the actuator acknowledgment (S_Acknowledge switches to TRUE).
	Reset	BOOL	0	Reset
Output	Ready	BOOL	0	If TRUE, indicates that the FB is activated and the output results are valid.
	S_SafetyActive	SAFEBOOL	0	Confirmation of the Safe state. FALSE: Non-safe state. TRUE: Safe state.
	S_SafetyRequest	SAFEBOOL	0	Request to place the actuator in a safe state. FALSE: Safe state is requested. TRUE: Non-safe state.
	Error	BOOL	0	Error flag
	DiagCode	WORD	16#0000	Diagnostic register. All states of the FB are represented by this register. This information is encoded in hexadecimal format in order to represent more than 16 codes.

3) Functional Description

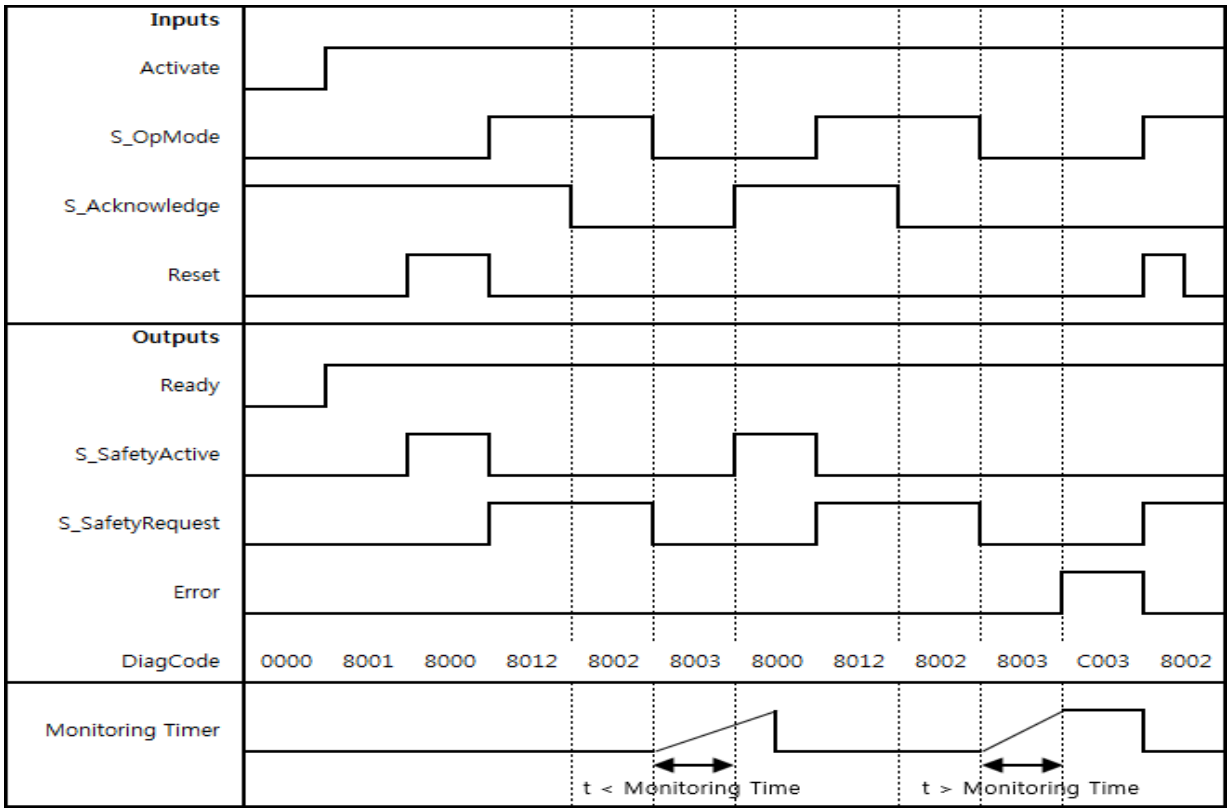
This FB provides the interface between the safety-related system and a generic actuator. This means that the safety-related functions of the actuator are available within the application program. However, there are only two binary signals to control the Safe state of the generic actuator, i.e., one for requesting and one for receiving the confirmation.

The safety function will be provided by the actuator itself. Therefore the FB only initiates the request, monitors it, and sets the output when the actuator acknowledges the Safe state. This will be indicated with the "S_SafetyActive" output.

This FB does not define any generic actuator-specific parameters. They should have been specified in the generic actuator itself. It switches the generic actuator from the operation mode to a safe state.



4) Typical Timing Diagrams



5) Error Detection

The FB detects whether the actuator does not enter the Safe state within the monitoring time.
The FB detects whether the acknowledge signal is lost while the request is still active.
The FB detects a static Reset signal.

External FB errors:
There are no external errors, since there is no error bits/information provided by the generic actuator.

6) Error Behavior

In the event of an error, the S_SafetyActive output is set to FALSE.
An error must be acknowledged by a rising trigger at the Reset input. To continue the function block after this reset, the S_OpMode request must be set to TRUE.

7) Error Codes

DiagCode	State Name	State Description and Output Setting
C002	Acknowledge Lost	Acknowledgment lost while in the Safe state. Ready = TRUE S_SafetyActive = FALSE S_SafetyRequest = FALSE Error = TRUE
C003	MonitoringTime Elapsed	S_OpMode request could not be completed within the monitoring time. Ready = TRUE S_SafetyActive = FALSE S_SafetyRequest = FALSE Error = TRUE
C004	Reset Error 2	Static Reset detected in state C002 (Acknowledge Lost). Ready = TRUE S_SafetyActive = FALSE S_SafetyRequest = FALSE Error = TRUE
C005	Reset Error 3	Static Reset detected in state C003 (MonitoringTime Elapsed). Ready = TRUE S_SafetyActive = FALSE S_SafetyRequest = FALSE Error = TRUE

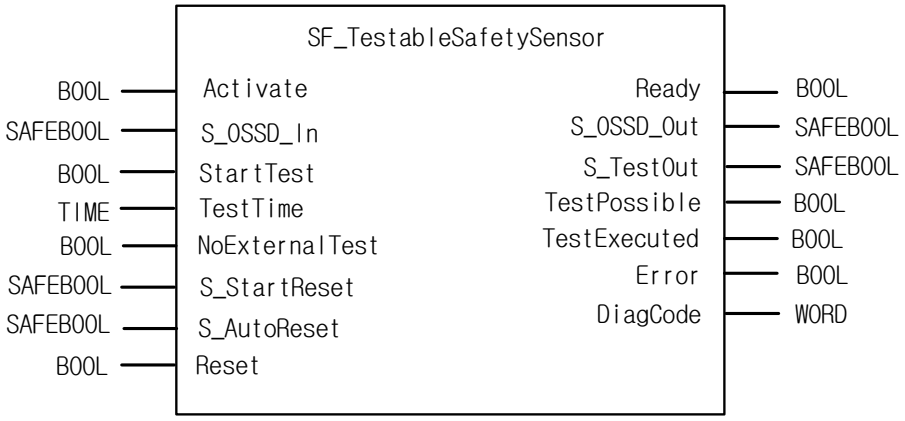
8) Status codes

DiagCode	State Name	State Description and Output Setting
0000	Idle	The function block is not active (initial state). Ready = FALSE S_SafetyActive = FALSE S_SafetyRequest = FALSE Error = FALSE
8000	Safe Mode	Actuator is in a safe mode. Ready = TRUE S_SafetyActive = TRUE S_SafetyRequest = FALSE Error = FALSE
8001	Init	State after Activate is set to TRUE or after a rising trigger at Reset. Ready = TRUE S_SafetyActive = FALSE S_SafetyRequest = FALSE Error = FALSE
8002	Operation Mode	Operation mode without Acknowledge of safe mode Ready = TRUE S_SafetyActive = FALSE S_SafetyRequest = TRUE Error = FALSE
8012	Wait for Confirmation OpMode	Operation mode with Acknowledge of safe mode Ready = TRUE S_SafetyActive = FALSE S_SafetyRequest = TRUE Error = FALSE
8003	Wait for Confirmation	Waiting for confirmation from the drive (system interface). Ready = TRUE S_SafetyActive = FALSE S_SafetyRequest = FALSE Error = FALSE
8005	Wait for OpMode	Error was cleared. However S_OpMode must be set to TRUE before the FB can be initialized. Ready = TRUE S_SafetyActive = FALSE S_SafetyRequest = FALSE Error = FALSE

13.2.15 SF_TESTABLESAFETYSENSOR

1) Overview

This function block detects, for example, the loss of the sensing unit detection capability, the response time exceeding that specified, and static ON signal in single-channel sensor systems. It can be used for external testable safety sensors (ESPE: Electro-sensitive protective equipment, such as a light beam).



2) Input / Output Variables

Type	Name	Data Type	Initial Value	Description
Input	Activate	BOOL	0	Activation of the FB
	S_OSSD_In	SAFEBOOL	0	Status of sensor output, e.g., light curtain. FALSE: Safety sensor in test state or demand for safety-related response. TRUE: Sensor in the state for normal operating conditions.
	StartTest	BOOL	0	Input to start sensor test. Sets "S_TestOut" and starts the internal time monitoring function in the FB. FALSE: No test requested. TRUE: Test requested.
	TestTime	Time	T#10ms	Constant. Range: 0 … 150ms. Test time of safety sensor.
	NoExternalTest	BOOL	0	Indicates if external manual sensor test is supported. FALSE: The external manual sensor test is supported. Only after a complete manual sensor switching sequence, a automatic test is possible again after a faulty automatic sensor test. TRUE: The external manual sensor test is not supported. An automatic test is possible again without a manual sensor switching sequence after faulty automatic sensor test.

Type	Name	Data Type	Initial Value	Description
	S_AutoReset	SAFEBOOL	0	FALSE (= initial value): Manual reset when emergency stop button is released. TRUE: Automatic reset when emergency stop button is released. This function shall only be activated if it is ensured that no hazard can occur at the start of the PES. Therefore the use of the Automatic Circuit Reset feature of the function blocks requires implementation of other system or application measures to ensure that unexpected (or unintended) startup does not occur.
	Reset	BOOL	0	Reset
Output	Ready	BOOL	0	If TRUE, indicates that the FB is activated and the output results are valid.
	S_OSSD_Out	SAFEBOOL	0	Safety related output indicating the status of the ESPE. FALSE: The sensor has a safety-related action request or test error. TRUE: The sensor has no safety-related action request AND no test error.
	S_TestOut	SAFEBOOL	1	Coupled with the test input of the sensor. Although specified as SAFEBOOL, in practice this signal will often be connected to a BOOL output. FALSE: Test request issued. TRUE: No test request.
	TestPossible	BOOL	0	Feedback signal to the process. FALSE: An automatic sensor test is not possible. TRUE: An automatic sensor test is possible.
	TestExecuted	BOOL	0	A positive signal edge indicates the successful execution of the automatic sensor test. FALSE: - An automatic sensor test was not executed yet. - An automatic sensor test is active. - An automatic sensor test was faulty. TRUE: A sensor test was executed successfully.
	Error	BOOL	0	Error flag
	DiagCode	WORD	16#0000	Diagnostic register. All states of the FB are represented by this register. This information is encoded in hexadecimal format in order to represent more than 16 codes.

3) Functional Description

Type 2 ESPE shall have a means of periodic testing to detect a hazardous fault (e.g., loss of sensing unit detection capability, response time exceeding that specified). The test signal shall simulate the actuation of the sensing device and the duration of the periodic test shall not exceed 150 ms. The test shall verify that each light beam operates in the manner specified by the supplier. If the periodic test is intended to be initiated by an external safety-related control system (e.g., a machine), the ESPE shall be provided with suitable input facilities (e.g., terminals).The ESPE must be selected in respect of the product standards EN IEC 61496-1, -2 and -3 and the required categories according EN 954-1. It must be monitored by separate functionality, that the test is initiated within appropriate intervals. The S_StartReset and S_AutoReset inputs shall only be activated if it is ensured that no hazardous situation can occur when the PES is started.

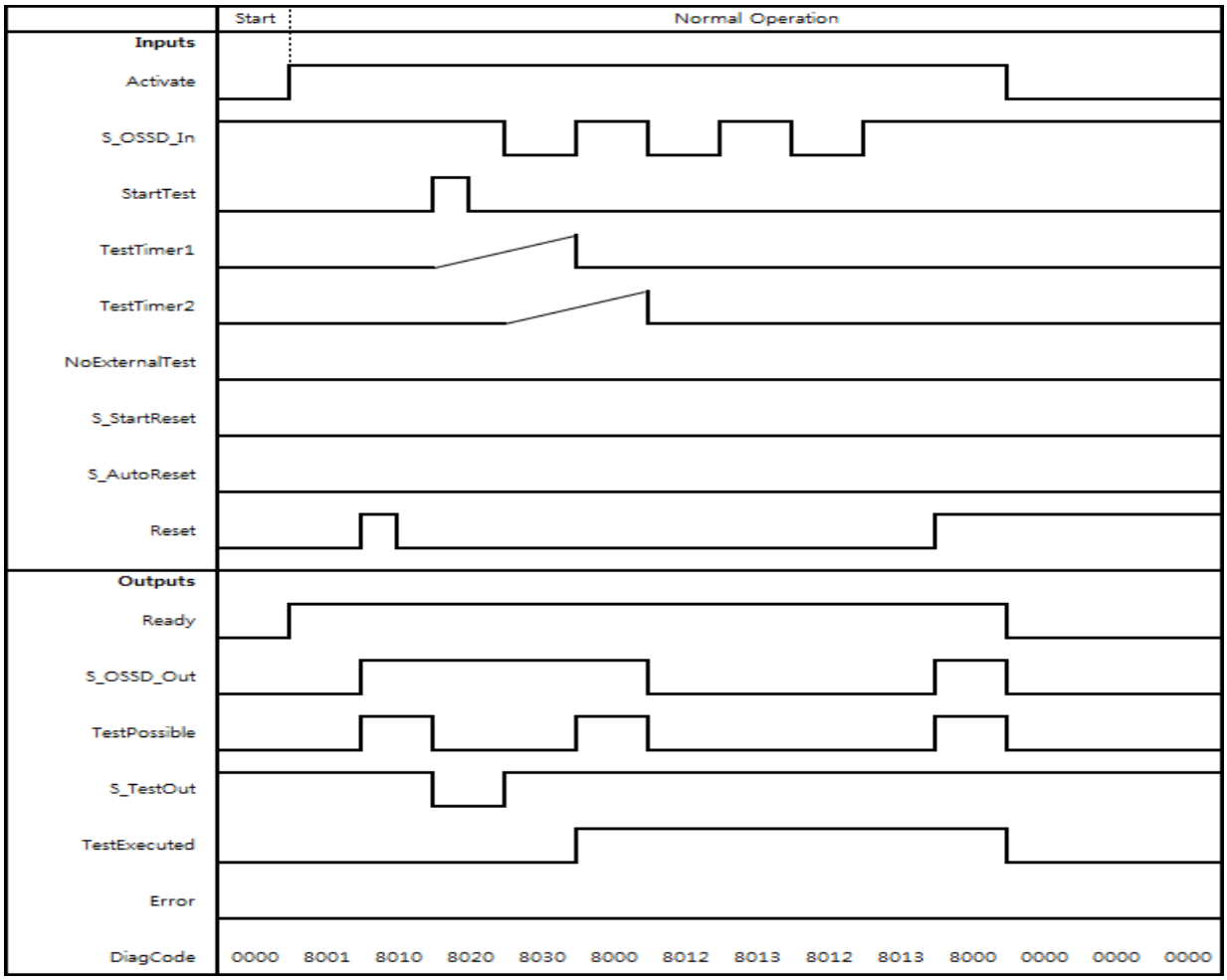
Test mode:

1. StartTest = TRUE: S_TestOut = FALSE. Start monitoring time
2. S_TestOut signal stops transmitter (Monitoring of TestTime started first time)
3. S_OSSD_In changes from TRUE to FALSE (Monitoring of TestTime started second time)
4. S_TestOut changes from FALSE to TRUE
5. Start transmitter
6. Sensor S_OSSD_In changes from FALSE to TRUE
7. Stop monitoring time
8. S_OSSD_Out is set to TRUE during testing

Optional startup inhibits:

- Startup inhibit after function block activation.
- Startup inhibit after interruption of the protective device.

4) Typical Timing Diagrams



5) Error Detection

The following conditions force a transition to the Error state:

- Test time overrun without delayed sensor feedback.
- Test without sensor signal feedback.
- Invalid static reset signal in the process.
- Plausibility check of the monitoring time setting.

6) Error Behavior

In the event of an error, the S_OSSD_Out output is set to FALSE and remains in this safe state.
Once the error has been removed and the sensor is on (S_OSSD_In = TRUE) – a reset removes the error state and sets the S_OSSD_Out output to TRUE.
If S_AutoReset = FALSE, a rising trigger is required at Reset.
After transition of S_OSSD_In to TRUE, the optional startup inhibit can be reset by a rising edge at the Reset input.
After block activation, the optional startup inhibit can be reset by a rising edge at the Reset input.

7) Error Codes

DiagCode	State Name	State Description and Output Setting
C000	Parameter Error	Invalid value at the TestTime parameter. Values between 0 ms and 150 ms are possible. Ready = TRUE S_OSSD_Out = FALSE S_TestOut = TRUE TestPossible = FALSE TestExecuted = FALSE Error = TRUE
C001	Reset Error 1	Static Reset condition detected after FB activation. Ready = TRUE S_OSSD_Out = FALSE S_TestOut = TRUE TestPossible = FALSE TestExecuted = FALSE Error = FALSE
C002	Reset Error 2	Static Reset condition detected in state 8003. Ready = TRUE S_OSSD_Out = FALSE S_TestOut = TRUE TestPossible = FALSE TestExecuted = FALSE Error = TRUE
C003	Reset Error 3	Static Reset condition detected in state C010. Ready = TRUE S_OSSD_Out = FALSE S_TestOut = TRUE TestPossible = FALSE TestExecuted = FALSE Error = TRUE
C004	Reset Error 4	Static Reset condition detected in state C020. Ready = TRUE S_OSSD_Out = FALSE S_TestOut = TRUE TestPossible = FALSE TestExecuted = FALSE Error = TRUE
C005	Reset Error 5	Static Reset condition detected in state 8006. Ready = TRUE S_OSSD_Out = FALSE S_TestOut = TRUE TestPossible = FALSE TestExecuted = FALSE Error = TRUE

DiagCode	State Name	State Description and Output Setting
C006	Reset Error 6	Static Reset condition detected in state C000. Ready = TRUE S_OSSD_Out = FALSE S_TestOut = TRUE TestPossible = FALSE TestExecuted = FALSE Error = TRUE
C007	Reset Error 7	Static Reset condition detected in state 8013. Ready = TRUE S_OSSD_Out = FALSE S_TestOut = TRUE TestPossible = FALSE TestExecuted = TRUE Error = TRUE
C010	Test Error 1	Test time elapsed in state 8020. Ready = TRUE S_OSSD_Out = FALSE S_TestOut = TRUE TestPossible = FALSE TestExecuted = FALSE Error = TRUE
C020	Test Error 2	Test time elapsed in state 8030. Ready = TRUE S_OSSD_Out = FALSE S_TestOut = TRUE TestPossible = FALSE TestExecuted = FALSE Error = TRUE

8) Status codes

DiagCode	State Name	State Description and Output Setting
0000	Idle	The function block is not active (initial state). Ready = FALSE S_OSSD_Out = FALSE S_TestOut = TRUE TestPossible = FALSE TestExecuted = FALSE Error = FALSE
8001	Init	An activation has been detected by the FB. Ready = TRUE S_OSSD_Out = FALSE S_TestOut = TRUE TestPossible = FALSE TestExecuted = FALSE Error = FALSE
8002	ESPE Interrupted 1	The FB has detected a safety demand. The switch has not been automatically tested yet. Ready = TRUE S_OSSD_Out = FALSE S_TestOut = TRUE TestPossible = FALSE TestExecuted = FALSE Error = FALSE
8003	Wait for Reset 1	Wait for rising trigger of Reset after state 8002. Ready = TRUE S_OSSD_Out = FALSE S_TestOut = TRUE TestPossible = FALSE TestExecuted = FALSE Error = FALSE
8004	External Function Test	The automatic sensor test was faulty. An external manual sensor test is necessary. The support for the necessary external manual sensor test has been activated at the FB (NoExternalTest = FALSE). A negative signal edge at the sensor is required. Ready = TRUE S_OSSD_Out = FALSE S_TestOut = TRUE TestPossible = FALSE TestExecuted = FALSE Error = FALSE

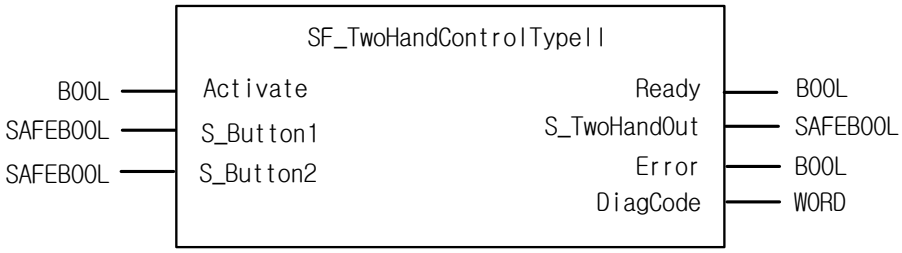
DiagCode	State Name	State Description and Output Setting
8005	ESPE Interrupted External Test	The automatic sensor test was faulty. An external manual sensor test is necessary. The support for the necessary external manual sensor test has been activated at the FB (NoExternalTest = FALSE). A TRUE signal at the sensor is required. Ready = TRUE S_OSSD_Out = FALSE S_TestOut = TRUE TestPossible = FALSE TestExecuted = FALSE Error = FALSE
8006	End External Test	The automatic sensor test was faulty. An external manual sensor test is necessary. The support for the necessary external manual sensor test has been activated at the FB (NoExternalTest = FALSE). The external manual test is complete. The FB detected a complete sensor switching cycle (external controlled). Ready = TRUE S_OSSD_Out = FALSE S_TestOut = TRUE TestPossible = FALSE TestExecuted = FALSE Error = FALSE
8010	ESPE Free No Test	The FB has not detected a safety demand. The sensor has not been tested automatically. Ready = TRUE S_OSSD_Out = TRUE S_TestOut = TRUE TestPossible = TRUE TestExecuted = FALSE Error = FALSE
8020	Test Request	The automatic sensor test is active. Test Timer is started first time. The transmitter signal of the sensor is switched off by the FB. The signal of the receiver must follow the signal of the transmitter. Ready = TRUE S_OSSD_Out = TRUE S_TestOut = FALSE TestPossible = FALSE TestExecuted = FALSE Error = FALSE

DiagCode	State Name	State Description and Output Setting
8030	Test Active	The automatic sensor test is active. Test Timer is started second time. The transmitter signal of the sensor is switched on by the FB. The signal of the receiver must follow the signal of the transmitter. Ready = TRUE S_OSSD_Out = TRUE S_TestOut = TRUE TestPossible = FALSE TestExecuted = FALSE Error = FALSE
8000	ESPE Free Test ok	The FB has not detected a safety demand. The sensor was automatically tested. Ready = TRUE S_OSSD_Out = TRUE S_TestOut = TRUE TestPossible = TRUE TestExecuted = TRUE Error = FALSE
8012	ESPE Interrupted 2	The FB has detected a safety demand. The switch was automatically tested. Ready = TRUE S_OSSD_Out = FALSE S_TestOut = TRUE TestPossible = FALSE TestExecuted = TRUE Error = FALSE
8013	Wait for Reset 2	Wait for rising trigger of Reset after state 8012. Ready = TRUE S_OSSD_Out = FALSE S_TestOut = TRUE TestPossible = FALSE TestExecuted = TRUE Error = FALSE

13.2.16 SF_TWOHANDCTRLII

1) Overview

This function block provides the two-hand control functionality.



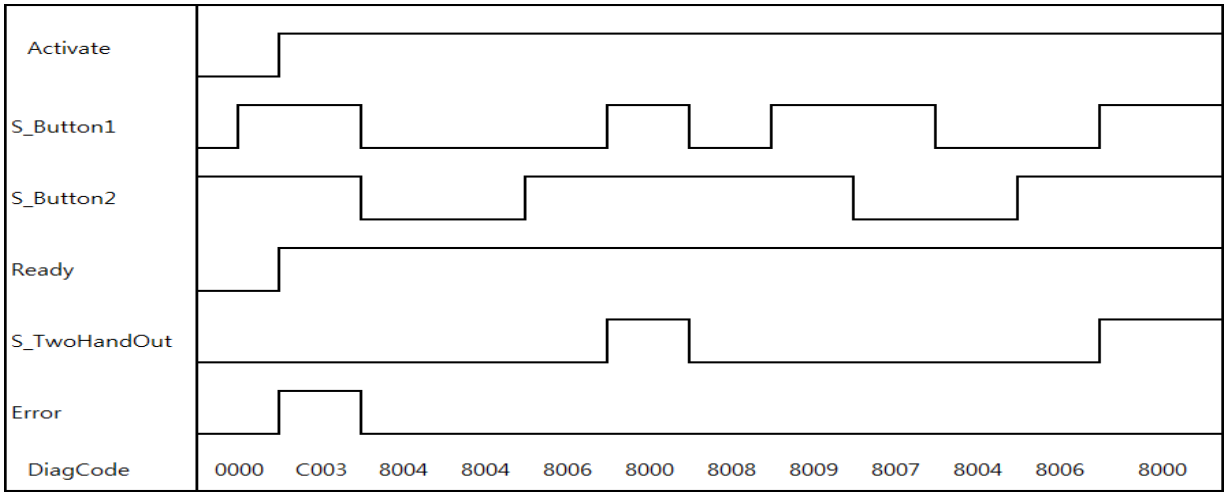
2) Input / Output Variables

Type	Name	Data Type	Initial Value	Description
Input	Activate	BOOL	0	Activation of the FB
	S_Button1	SAFEBOOL	0	FALSE: Button 1 released. TRUE: Button 1 actuated.
	S_Button2	SAFEBOOL	0	FALSE: Button 2 released. TRUE: Button 2 actuated.
Output	Ready	BOOL	0	If TRUE, indicates that the FB is activated and the output results are valid.
	S_TwoHandOut	SAFEBOOL	0	Safety related output signal. FALSE: No correct two hand operation. TRUE: S_Button1 and S_Button2 inputs are TRUE and no error occurred. Correct two hand operation.
	Error	BOOL	0	Error flag
	DiagCode	WORD	16#0000	Diagnostic register. All states of the FB are represented by this register. This information is encoded in hexadecimal format in order to represent more than 16 codes.

3) Functional Description

This function block provides the two-hand control functionality according to EN 574, Section 4 Type II. If S_Button1 and S_Button2 are set to TRUE in correct sequence, then the S_TwoHandOut output will also be set to TRUE. The FB also controls the release of both buttons before setting the output S_TwoHandOut again to TRUE.

4) Typical Timing Diagrams



5) Error Detection

After activation of the FB, any button set to TRUE is detected as an invalid input setting leading to an error.

6) Error Behavior

In the event of an error, the S_TwoHandOut output is set to FALSE and remains in this safe state.
The Error state is exited when both buttons are released (set to FALSE).

7) Error Codes

DiagCode	State Name	State Description and Output Setting
C001	Error B1	S_Button1 was TRUE on FB activation. Ready = TRUE Error = TRUE S_TwoHandOut = FALSE
C002	Error B2	S_Button2 was TRUE on FB activation. Ready = TRUE Error = TRUE S_TwoHandOut = FALSE
C003	Error B1&B2	The signals at S_Button1 and S_Button2 were TRUE on FB activation. Ready = TRUE Error = TRUE S_TwoHandOut = FALSE

8) Status codes

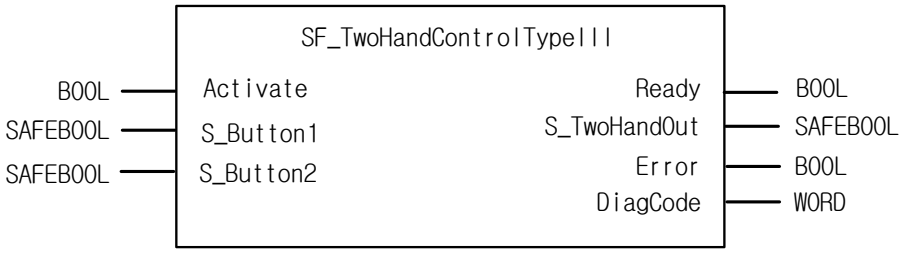
DiagCode	State Name	State Description and Output Setting
0000	Idle	The function block is not active (initial state). Ready = FALSE Error = FALSE S_TwoHandOut = FALSE
8000	Buttons Actuated	Both buttons actuated correctly. The safety related output is enabled. Ready = TRUE Error = FALSE S_TwoHandOut = TRUE
8001	Init	Function block is active, but in the Init state. Ready = TRUE Error = FALSE S_TwoHandOut = FALSE
8004	Buttons Released	No button is actuated. Ready = TRUE Error = FALSE S_TwoHandOut = FALSE
8005	Button 1 Actuated	Only Button 1 is actuated. Ready = TRUE Error = FALSE S_TwoHandOut = FALSE
8006	Button 2 Actuated	Only Button 2 is actuated. Ready = TRUE Error = FALSE S_TwoHandOut = FALSE
8007	Button 2 Released	The safety related output was enabled and is disabled again. FALSE at both S_Button1 and S_Button2 was not achieved after disabling the safety related output. In this state, S_Button1 is TRUE and S_Button2 is FALSE after disabling the safety related output. Ready = TRUE Error = FALSE S_TwoHandOut = FALSE
8008	Button 1 Released	The safety related output was enabled and is disabled again. FALSE at both S_Button1 and S_Button2 was not achieved after disabling the safety related output. In this state, S_Button1 is FALSE and S_Button2 is TRUE after disabling the safety related output. Ready = TRUE Error = FALSE S_TwoHandOut = FALSE

DiagCode	State Name	State Description and Output Setting
8009	Locked Off	The safety related output was enabled and is disabled again. FALSE at both S_Button1 and S_Button2 was not achieved after disabling the safety related output. In this state, S_Button1 is TRUE and S_Button2 is TRUE after disabling the safety related output. Ready = TRUE Error = FALSE S_TwoHandOut = FALSE
8019	Locked On	Incorrect actuation of the buttons. Waiting for release of both buttons. Ready = TRUE Error = FALSE S_TwoHandOut = FALSE

13.2.17 SF_TWOHANDCTRLIII

1) Overview

This function block provides the two-hand control functionality.



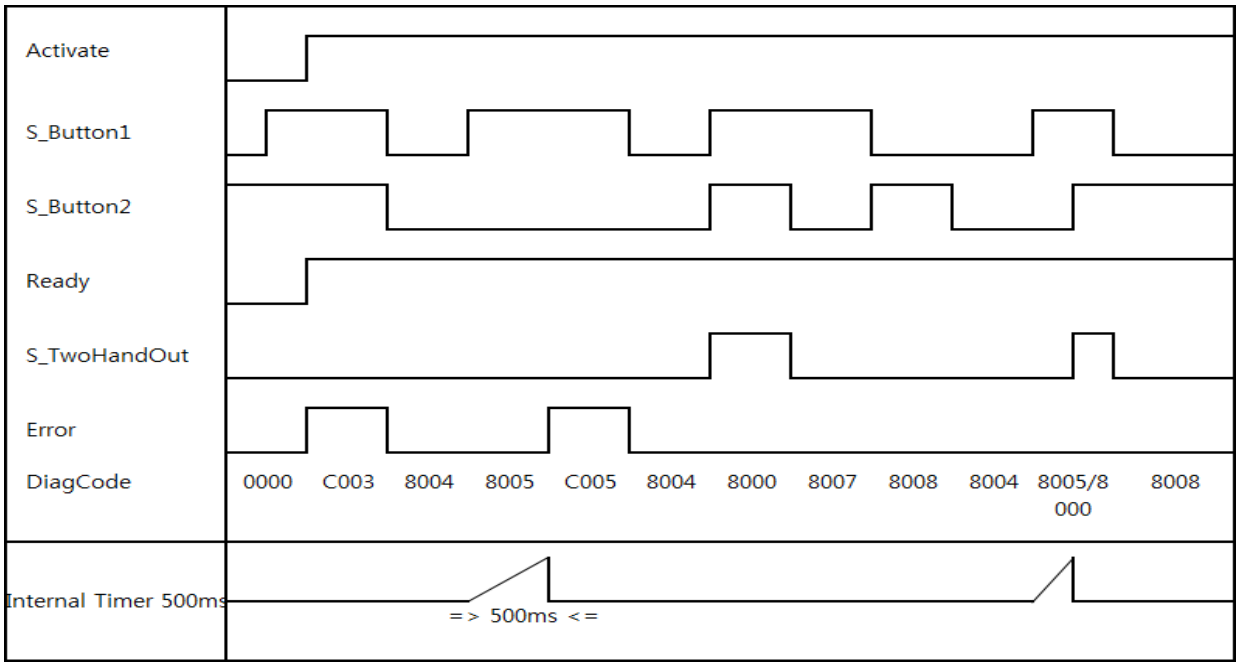
2) Input / Output Variables

Type	Name	Data Type	Initial Value	Description
Input	Activate	BOOL	0	Activation of the FB
	S_Button1	SAFEBOOL	0	Input of button 1 FALSE: Button 1 released. TRUE: Button 1 actuated.
	S_Button2	SAFEBOOL	0	Input of button 2 FALSE: Button 2 released. TRUE: Button 2 actuated.
Output	Ready	BOOL	0	If TRUE, indicates that the FB is activated and the output results are valid.
	S_TwoHandOut	SAFEBOOL	0	Safety related output signal. FALSE: No correct two hand operation. TRUE: S_Button1 and S_Button2 inputs changed from FALSE to TRUE within 500 ms and no error occurred. The two hand operation has been performed correctly.
	Error	BOOL	0	Error flag
	DiagCode	WORD	16#0000	Diagnostic register. All states of the FB are represented by this register. This information is encoded in hexadecimal format in order to represent more than 16 codes.

3) Functional Description

This function block provides the two-hand control functionality according to EN 574, Section 4 Type III. If S_Button1 and S_Button2 are set to TRUE within 500 ms and in correct sequence, then the S_TwoHandOut output is also set to TRUE. The FB also controls the release of both buttons before setting the output S_TwoHandOut again to TRUE.

4) Typical Timing Diagrams



5) Error Detection

After activation of the FB, any button set to TRUE is detected as an invalid input setting leading to an error. The FB detects when the divergence of the input signals exceeds 500 ms.

6) Error Behavior

In the event of an error, the S_TwoHandOut output is set to FALSE and remains in this safe state.
The Error state is exited when both buttons are released (set to FALSE).

7) Error Codes

DiagCode	State Name	State Description and Output Setting
C001	Error 1 B1	S_Button1 was TRUE on FB activation. Ready = TRUE Error = TRUE S_TwoHandOut = FALSE
C002	Error 1 B2	S_Button2 was TRUE on FB activation. Ready = TRUE Error = TRUE S_TwoHandOut = FALSE
C003	Error 1 B1&B2	The signals at S_Button1 and S_Button2 were TRUE on FB activation. Ready = TRUE Error = TRUE S_TwoHandOut = FALSE
C004	Error 2 B1	S_Button1 was FALSE and S_Button 2 was TRUE after 500 ms in state 8005. Ready = TRUE Error = TRUE S_TwoHandOut = FALSE
C005	Error 2 B2	S_Button1 was TRUE and S_Button 2 was FALSE after 500 ms in state 8005. Ready = TRUE Error = TRUE S_TwoHandOut = FALSE
C006	Error 2 B1&B2	S_Button1 was TRUE and S_Button 2 was TRUE after 500 ms in state 8005 or 8006. This state is only possible when the states of the inputs (S_Button1 and S_Button2) change from divergent to convergent (both TRUE) simultaneously when the timer elapses (500 ms) at the same cycle. Ready = TRUE Error = TRUE S_TwoHandOut = FALSE

8) Status codes

DiagCode	State Name	State Description and Output Setting
0000	Idle	The function block is not active (initial state). Ready = FALSE Error = FALSE S_TwoHandOut = FALSE
8000	Buttons Actuated	Both buttons actuated correctly. The safety related output is enabled. Ready = TRUE Error = FALSE S_TwoHandOut = TRUE
8001	Init	Function block is active, but in the Init state. Ready = TRUE Error = FALSE S_TwoHandOut = FALSE
8004	Buttons Released	No Button is actuated. Ready = TRUE Error = FALSE S_TwoHandOut = FALSE
8005	Button 1 Actuated	Only Button 1 is actuated. Start monitoring timer. Ready = TRUE Error = FALSE S_TwoHandOut = FALSE
8006	Button 2 Actuated	Only Button 2 is actuated. Start monitoring timer. Ready = TRUE Error = FALSE S_TwoHandOut = FALSE
8007	Button 2 Released	The safety related output was enabled and is disabled again. FALSE at both S_Button1 and S_Button2 was not achieved after disabling the safety related output. In this state, S_Button1 is TRUE and S_Button2 is FALSE after disabling the safety related output. Ready = TRUE Error = FALSE S_TwoHandOut = FALSE
8008	Button 1 Released	The safety related output was enabled and is disabled again. FALSE at both S_Button1 and S_Button2 was not achieved after disabling the safety related output. In this state, S_Button1 is FALSE and S_Button2 is TRUE after disabling the safety related output. Ready = TRUE Error = FALSE S_TwoHandOut = FALSE

DiagCode	State Name	State Description and Output Setting
8009	Locked Off	The safety related output was enabled and is disabled again. FALSE at both S_Button1 and S_Button2 was not achieved after disabling the safety related output. In this state, S_Button1 is TRUE and S_Button2 is TRUE after disabling the safety related output. Ready = TRUE Error = FALSE S_TwoHandOut = FALSE
8019	Locked On	Incorrect actuation of the buttons. Waiting for release of both buttons. Ready = TRUE Error = FALSE S_TwoHandOut = FALSE

Appendix 1 Flag List

Appendix 1.1 Flag List

1) Modes and status

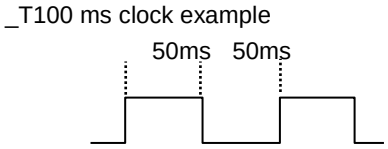
Flag Name	TYPE	Description	Remark
_RUN	BOOL	RUN mode	Show operating condition of the CPU module.
_STOP	BOOL	STOP mode	
_CNFG_UNLOCK	BOOL	Configuration Unlock	
_CNFG_LOCK	BOOL	Configuration Lock	
_NORMAL	BOOL	Normal mode	
_SAFE	BOOL	Safe mode	
_UNVERIFIED	BOOL	No safety sign	
_VERIFIED	BOOL	Safety sign finished	
_FORCE_IO_EN	BOOL	Forced I/O active	Shows that forced I/O are active
_FORCE_IO_TIME	INT	Forced I/O time	Shows remaining time of forced I/O.

2) System error

Flag Name	TYPE	Description	Remark
_SELFTEST_ERROR	BOOL	CPU module self-test abnormal error	System abnormality detected in self-test.
_PERIPHERAL_ERROR	BOOL	CPU module hardware error	Hardware error detected.
_CCM_ERROR	BOOL	CPU module CCM (Core Compare Module) error	CCM error is detected.
_MEMORY_ERROR	BOOL	CPU module internal memory data altered error	Internal memory alteration detected
_FIRMWARE_ERROR	BOOL	CPU module firmware alteration error	Firmware alteration detected.
_MCU_SYNC_ERROR	BOOL	CPU module core synchronization error	Synchronization of the cores in module failed.
_BACKUP_MEMORY_ ERROR	BOOL	CPU module backup memory data altered error	Backup memory data alteration detected
_PARAMETER_ERROR	BOOL	Parameter error	Parameter error detected.
_IO_DETACH_ERROR	BOOL	I/O module separation error	I/O module separation detected
_IO_TYPE_ERROR	BOOL	I/O module type mismatch error	I/O module type mismatch with the setting
_IO_INTERFACE_ERROR	BOOL	I/O module interface error	I/O module interface error detected
_IO_SELFTEST_ERROR	BOOL	I/O module self-test error	Error detected in I/O module self-test
_IO_PERIPHERAL_ ERROR	BOOL	I/O module hardware error	Hardware error detected.
_IO_CCM_ERROR	BOOL	I/O module CCM (Core Compare Module) error	CCM error detected.

Flag Name	TYPE	Description	Remark
_IO_MEMORY_ERROR	BOOL	I/O module internal memory data altered error	Internal memory alteration detected
_IO_FIRMWARE_ERROR	BOOL	I/O module firmware altered error	Firmware alteration detected.
_IO_MCU_SYNC_ERROR	BOOL	I/O core synchronization error	Synchronization of the cores in module failed.
_IO_TP0_ERROR	BOOL	I/O module test pulse output 0 circuit error	I/O module test pulse output 0 circuit error detected
_IO_TP1_ERROR	BOOL	I/O module test pulse output 1 circuit error	I/O module test pulse output 1 circuit error detected
_IO_POWER_ERROR	BOOL	I/O module output power supply error	Error detected in I/O module output power supply
_IO_IN_CIRCUIT_ ERROR	BOOL	I/O module input circuit error	Error detected in I/O module input circuit
_IO_OUT_CIRCUIT_ ERROR	BOOL	I/O module output circuit error	Error detected in I/O module output circuit
_MAIN_POWER_ERROR	BOOL	Power supply failure	Error detected in system power supply
_IO_TYER_L00 ~ _IO_TYER_L13	BOOL	Local 00~13 module type mismatch error	Type of local NO. xx I/O module type mismatch with the setting
_IO_DEER_L00 ~ _IO_DEER_L13	BOOL	Local 00~13 module separation error	Local No. xx I/O module separated.

3) User flag

Flag Name	Type	Description	Remark
_T20MS	BOOL	20 ms cycle clock	the clock signals available in user programs, which are switched On/Off at every half cycle. Since signals are toggled after completing scan, clock signal may be delayed or distorted according to the execution of the program. Use sufficiently long clocks. Clock signals begin from OFF status at starting of initialized program and scan program, 
_T100MS	BOOL	100 ms cycle clock	
_T200MS	BOOL	200 ms cycle clock	
_T1S	BOOL	1 s cycle clock	
_T2S	BOOL	2 s cycle clock	
_T10S	BOOL	10 s cycle clock	
_T20S	BOOL	20 s cycle clock	
_T60S	BOOL	60 s cycle clock	
_ON	BOOL	Normal ON	Normal ON flag available for user programming
_OFF	BOOL	Normal Off	Normal OFF flag available for user programming
_1ON	BOOL	First scan On	The flag turned ON only for the first scan after starting operation.
_1OFF	BOOL	First scan Off	The flag turned OFF only for the first scan after starting operation.
_STOG	BOOL	Scan toggle	The flag toggled ON/OFF at every scan in program running (ON at the first scan)

4) System operation status information

Flag Name	Type	Description	Remark
_USB_MAINTENANCE	BOOL	Access USB by authority of maintenance engineer	Being connected to a USB by authority of maintenance engineer
_USB_AUTH_CLIENT	BOOL	Access USB by authority of administrator	Being connected to a USB by authority of administrator
_ETH0_MAINTENANCE	BOOL	Access Ethernet by authority of maintenance engineer	Being connected to Ethernet by authority of maintenance engineer
_ETH0_AUTH_CLENT	BOOL	Access Ethernet by authority of administrator	Being connected to Ethernet by authority of administrator
_CPU_TYPE	DINT	Shows CPU type information	Displays system operation mode and operating status information.
_OS_VER	DINT	Shows OS version	Shows system O/S version No.
_OS_DATE	DINT	Shows OS date	Shows OS date.
_OS_VER	DINT	Shows OS version	Shows system O/S version No.
_OS_DATE	DINT	Shows OS date	Shows OS date.
_SCAN_MAX	DINT	Max. scan time	Records max. value of scan time during operation. The unit is 0.1 ms.
_SCAN_MIN	DINT	Min. scan time	Records min. value of scan time during operation. The unit is 0.1 ms.
_SCAN_CUR	DINT	Shows present scan time	Updates present value of scan time during operation. The unit is 0.1 ms.
_YEAR	INT	Clock information data (year)	Shows present time saved in the CPU module At power failure, stops at the time of failure, and the clock starts from the time point of the failure when power is recovered.
_MONTH	BYTE	Clock information data (month)	
_DATE	BYTE	Clock information data (day)	
_HOUR	BYTE	Clock information data (hour)	
_MINUTE	BYTE	Clock information data (min)	
_SEC	BYTE	Clock information data (s)	
_MSEC	INT	Clock information data (ms)	
_WDAY	BYTE	Clock information data (day of week)	
_POWERON_YEAR	INT	Power On time (year)	Shows point of time when the CPU module is powered.
_POWERON_MONTH	BYTE	Power On time (month)	
_POWERON_DATE	BYTE	Power On time (day)	
_POWERON_HOUR	BYTE	Power On time (hour)	
_POWERON_MINUTE	BYTE	Power On time (min)	
_POWERON_SEC	BYTE	Power On time (s)	
_POWERON_MSEC	INT	Power On time (ms)	
_POWERON_WDAY	BYTE	Power On time (day of week)	

Appendix 1.2 Reserved Words

The following words are reserved for exclusive use by the system. Therefore, it is not allowed to make use of these words as an identifier.

Reserved Words
ACTION ... END_ACTION
ARRAY ... OF
AT
CASE ... OF ... ELSE ... END_CASE CONFIGURATION ... END_CONFIGURATION
Data type name
DATE#, D# DATE_AND_TIME#, DT#
EXIT
FOR ... TO ... BY ... DO ... END_FOR
FUNCTION ... END_FUNCTION
FUNCTION_BLOCK ... END_FUNCTION_BLOCK
Function Block name
IF ... THEN ... ELSIF ... ELSE ... END_IF
OK
Operator (IL language) Operator (ST language)
PROGRAM
PROGRAM ... END_PROGRAM
REPEAT ... UNTIL ... END_REPEAT
RESOURCE ... END_RESOURCE
RETAIN
RETURN
STEP ... END_STEP
STRUCTURE ... END_STRUCTURE
T#
TASK ... WITH
TIME_OF_DAY#, TOD#
TRANSITION ... FROM... TO ... END_TRANSITION
TYPE ... END_TYPE
VAR ... END_VAR VAR_INPUT ... END_VAR VAR_OUTPUT ... END_VAR VAR_IN_OUT ... END_VAR VAR_EXTERNAL ... END_VAR
VAR_ACCESS ... END_VAR
VAR_GLOBAL ... END_VAR
WHILE ... DO ... END_WHILE
WITH

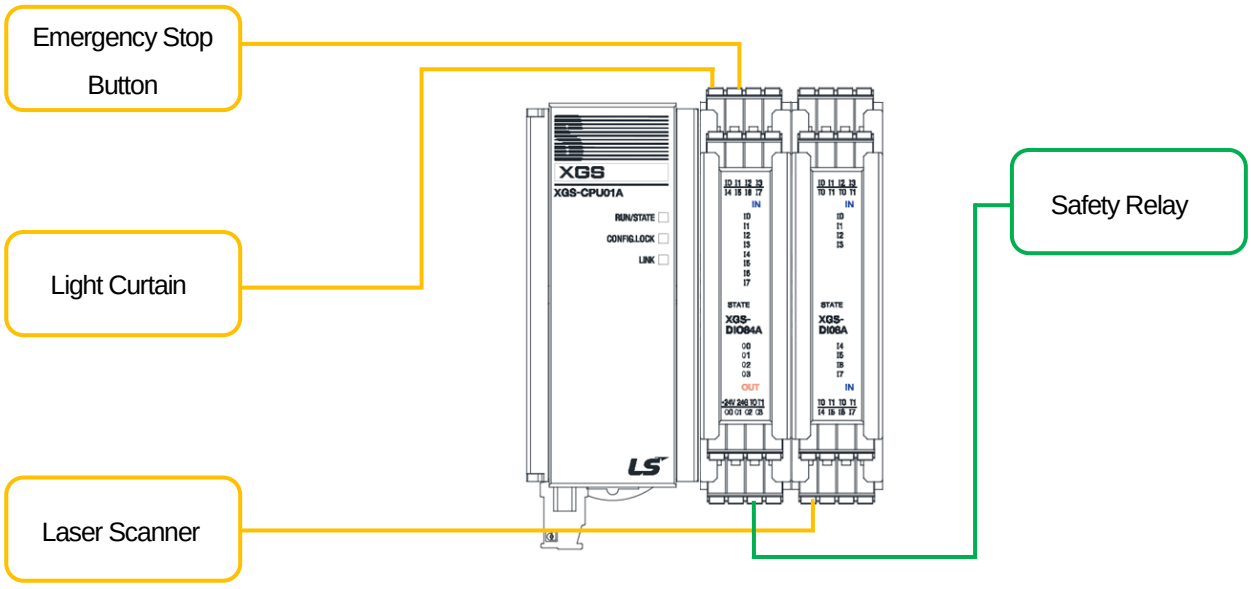
Appendix 2 PFD/PFH Value

Calculate all the PFD/PFH values of systems to achieve SIL required from application.

Module	PFD	PFH
Safety CPU Module(XGS-CPU01A)	2.478 X 10^{-05}	3.43014 x 10^{-09}
Safety Input Module (XGS-DI08A)	2.091 x 10^{-05}	3.28678 x 10^{-09}
Input of Safety Input Module (XGS-DI08A)	1.02647 x 10^{-05}	1.9816 x 10^{-09}
Common Logic of Safety Input Module (XGS-DI08A)	1.064 x 10^{-05}	1.30517 x 10^{-09}
Safety I/O Module (XGS-DIO84A)	3.623 x 10^{-05}	6.67541 x 10^{-09}
Input of Safety I/O Module (XGS-DIO84A)	1.02647 x 10^{-05}	1.9816 x 10^{-09}
Output of Safety I/O Module (XGS-DIO84A)	8.38991 x 10^{-07}	4.64482 x 10^{-09}
Common Logic of Safety I/O Module (XGS-DIO84A)	2.512 x 10^{-05}	4.89901 x 10^{-11}

Example of PFD/PFH Calculation.

Systems : XGS-CPU01A, XGS-DIO84A(Input 2 Points, Output 1Point), XGS-DI08A(Input 1 Point)



$PFD_{SYS} = PFD_{CPU01A} + PFD_{DIO84A} + PFD_{DI08A}$

$= PFD_{CPU01A} + PFD_{DIO84A}$ (Using I/O Port + Common Logic) $+ PFD_{DI08A}$ (Using Input Port + Common Logic)

$= PFD_{CPU01A} + PFD_{DIO84A}$ (Input 2 points + Output 2 points + Common Logic) $+ PFD_{DI08A}$ (Input 1point + Common Logic)

$= (2.478 \times 10^{-05}) + \{(1.02647 \times 10^{-05} / 8 * 2) + (8.38991 \times 10^{-07} / 4 * 2) + (2.512 \times 10^{-05})\}$

$+ \{(1.02647 \times 10^{-05} / 8 * 1) + (1.064 \times 10^{-05})\}$

$= 6.482 \times 10^{-05}$

$PFH_{SYS} = PFH_{CPU01A} + PFH_{DIO84A} + PFH_{DI08A}$

$= PFH_{CPU01A} + PFH_{DIO84A}$ (Using I/O Port + Common Logic) + PFH_{DI08A} (Using Input Port + Common Logic)

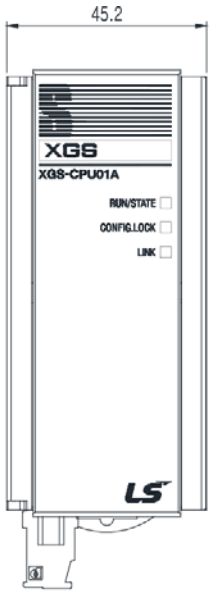
$= PFH_{CPU01A} + PFH_{DIO84A}$ (Input 2 points + Output 2 points + Common Logic) + PFH_{DI08A} (Input 1point + Common Logic)

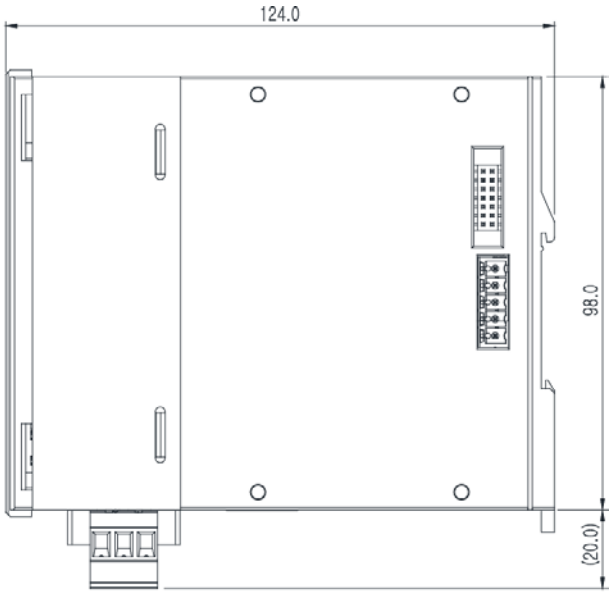
$= (3.43014 \times 10^{-09}) + \{(1.9816 \times 10^{-09} / 8 * 2) + (4.64482 \times 10^{-09} / 4 * 2) + (4.89901 \times 10^{-11})\}$

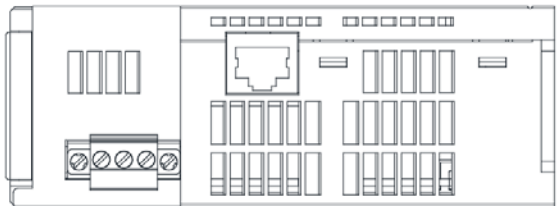
$+ \{(1.9816 \times 10^{-09} / 8 * 1) + (1.30517 \times 10^{-09})\}$

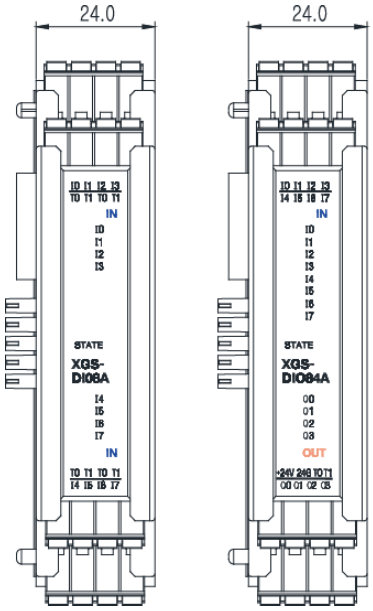
$= 7.850 \times 10^{-09}$

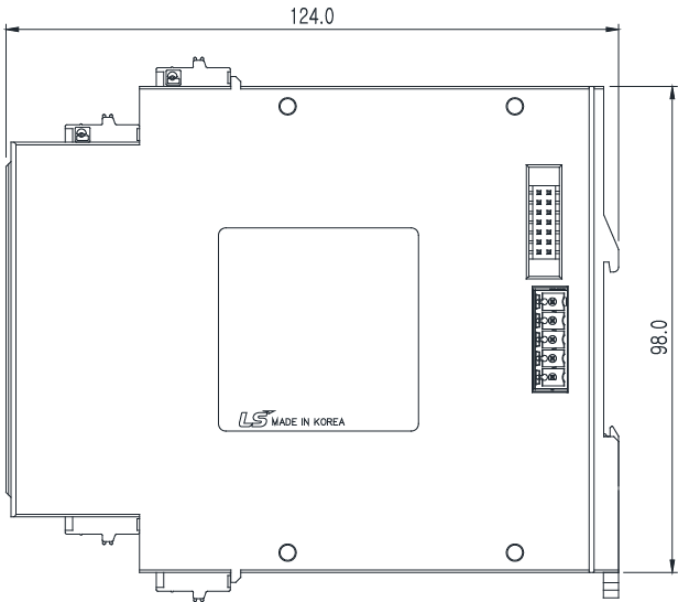
Appendix 3 Dimensions (Unit : mm)







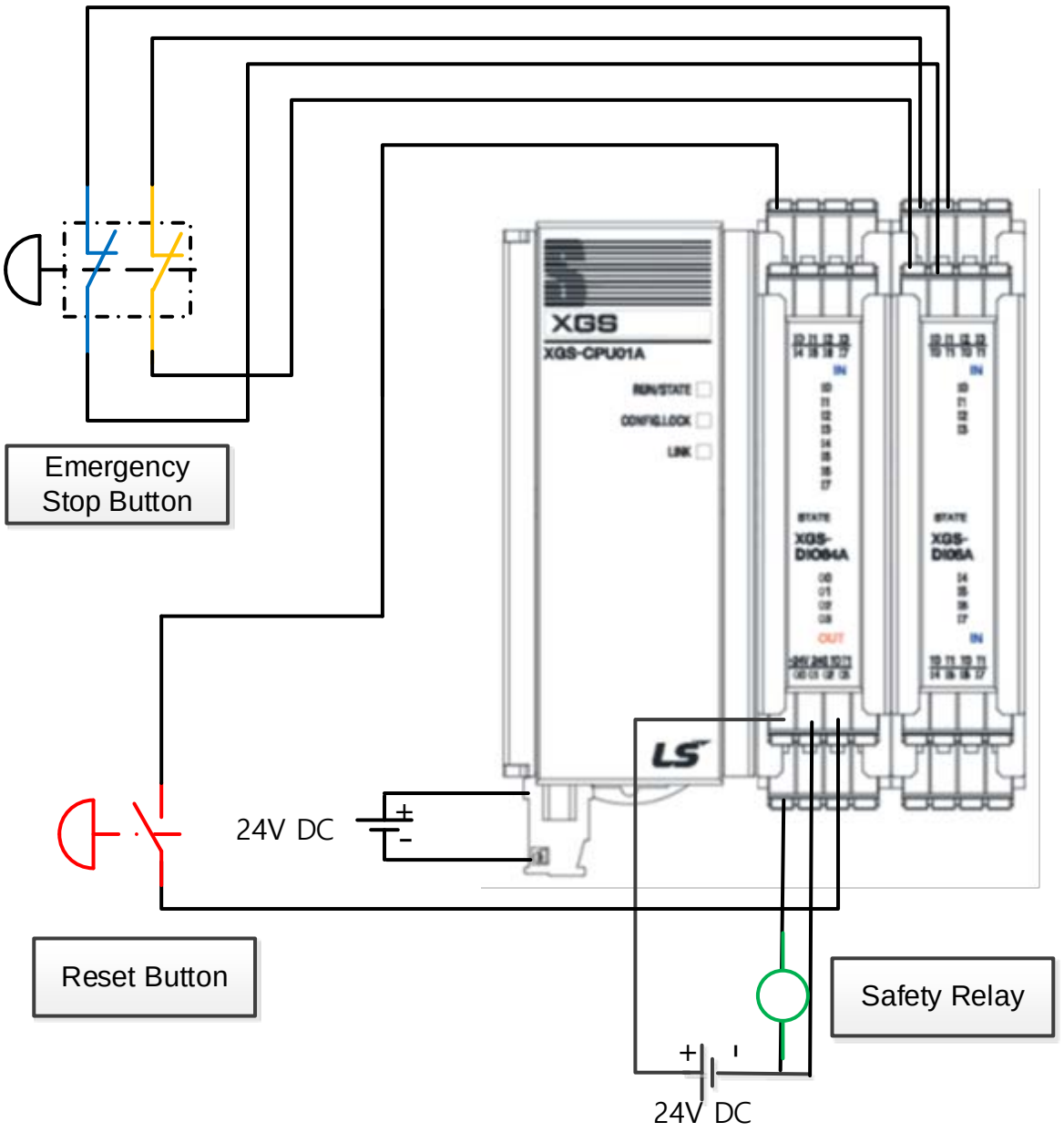




Appendix 4. Example of Safety Application

It is an example of safety application to control the safety relay by the input of the emergency stop button.

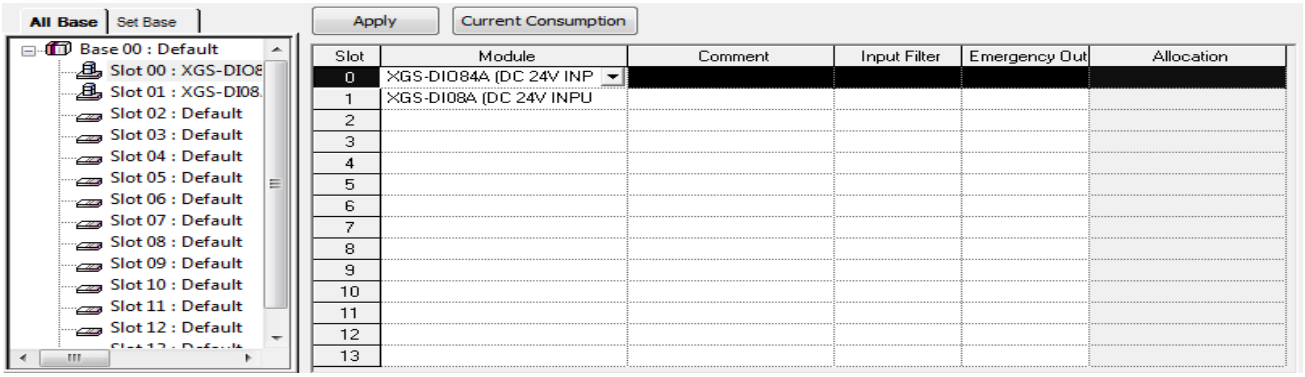
1) Wiring example



No.	Connecting devices	Program Devices
1	Emergency Stop Button	%IX1.0.0 / %IX1.0.1
2	Safety Relay	%QX0.0.0
3	Reset Switch	%IX0.0.0

2) Safety Input / Output Parameter setting example

- I/O Parameter setting



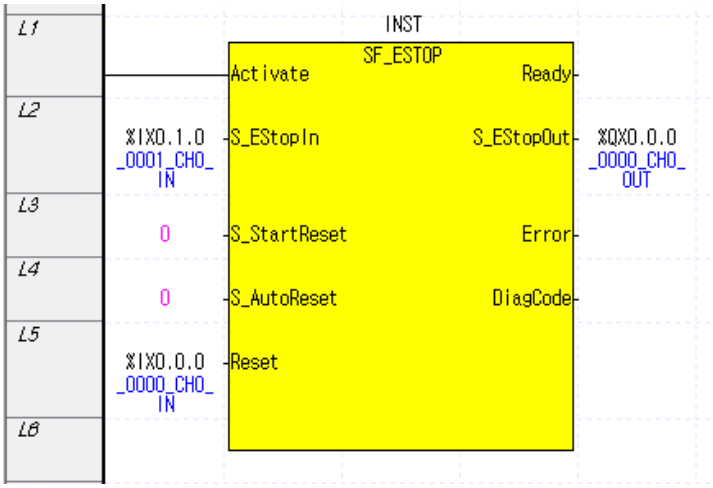
- XGS-DIO84A Parameter setting

Point	Channel	Property	Variable	Comment
0	Single Channel	On/Off Filter: 4 ms Off/On Filter: 4 ms Test Pulse: None	_0000_CH0_IN	Input/Output Module: Input Point 0
8	Single Channel	Test Pulse: None	_0000_CH0_OUT	Input/Output Module: Output Point 0

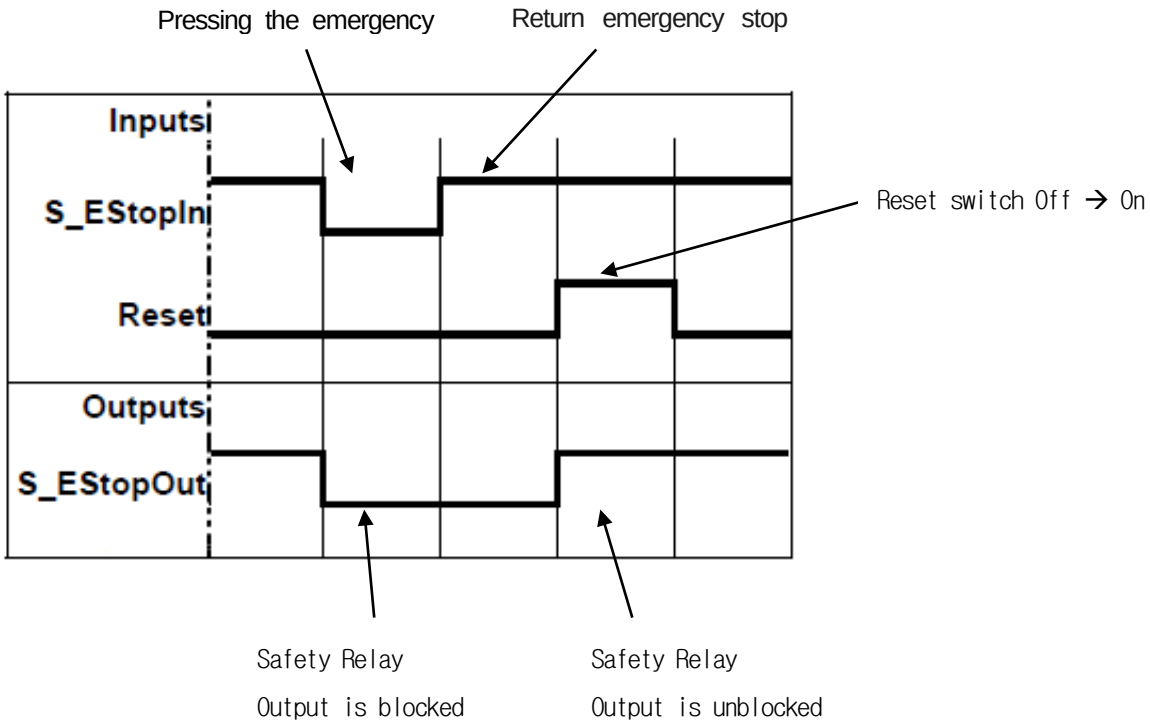
- XGS-DI08A Parameter setting

Point	Channel	Property	Variable	Comment
0	Single Channel	On/Off Filter: 4 ms Off/On Filter: 4 ms Test Pulse: None	_0001_CH0_IN	Input Module: Input Point 0
1	Single Channel	On/Off Filter: 4 ms Off/On Filter: 4 ms Test Pulse: None	_0001_CH1_IN	Input Module: Input Point 1

3) Program example



4) Timing chart



Warranty

1. Warranty Period

The product you purchased will be guaranteed for 18 months from the date of manufacturing.

2. Scope of Warranty

Any trouble or defect occurring for the above-mentioned period will be partially replaced or repaired. However, please note the following cases will be excluded from the scope of warranty.

(1) Any trouble attributable to unreasonable condition, environment or handling otherwise specified in the manual,
(2) Any trouble attributable to others' products,
(3) If the product is modified or repaired in any other place not designated by the company,
(4) Due to unintended purposes
(5) Owing to the reasons unexpected at the level of the contemporary science and technology when delivered.
(6) Not attributable to the company; for instance, natural disasters or fire

3. Since the above warranty is limited to PLC unit only, make sure to use the product considering the safety for system configuration or applications.

Environmental Policy

LS ELECTRIC Co., Ltd supports and observes the environmental policy as below.

Environmental Management

LS ELECTRIC considers the environmental preservation as the preferential management subject and every staff of LS ELECTRIC use the reasonable endeavors for the pleasurably environmental preservation of the earth.

About Disposal

LS ELECTRIC' PLC unit is designed to protect the environment. For the disposal, separate aluminum, iron and synthetic resin (cover) from the product as they are reusable.

www.lselectric.co.kr

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Specifications in this instruction manual are subject to change without notice due to continuous products development and improvement.

2020.05