MITSUBISHI

Mitsubishi Safety Programmable Controller

MELSEC QS series

QSCPU

Programming Manual (Safety FB)

SAFETY PRECAUTIONS

(Always read these instructions before using this equipment.)

Before using this product, please read this manual and the relevant manuals introduced in this manual carefully and pay full attention to safety to handle the product correctly.
The instructions given in this manual are concerned with this product. For the safety instructions of the programmable controller system, please read the CPU module user's manual.
In this manual, the safety instructions are ranked as:"⚠WARNING" and "⚠CAUTION".

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

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

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

[Design Instructions]

⚠ WARNING

- When data/program change, or status control is performed from a programmable controller to a running safety programmable controller, create an interlock circuit outside the sequence program and safety programmable controller to ensure that the whole system always operates safely.
  For the operations to a safety programmable controller, pay full attention to safety by reading the relevant manuals carefully, and establishing the operating procedure.
  Furthermore, for the online operations performed from a programmable controller to a safety CPU module, the corrective actions of the whole system should be predetermined in case that a communication error occurs due to a cable connection fault, etc.

- When a safety remote I/O module has detected a CC-Link Safety error, it turns off all the outputs.
  Note that the outputs in a ladder program are not automatically turned off.
  If a CC-Link Safety or CC-Link IE Field Network error has been detected, create a ladder program that turns off the outputs in the program.
  If the CC-Link Safety or CC-Link IE Field Network is restored with the outputs on, it may suddenly operate and result in an accident.

- To inhibit restart without manual operation after safety function was performed and outputs were turned OFF, create an interlock program which uses a reset button for restart. (See Section 2.5 General Functions (2) Reset selection.)

- In order to make a safety program, you shall do a risk assessment of your machines and systems, and shall design them according to your risk assessment. The wiring, the program and how to use safety FB are depending on required safety level.
  Safety programmable controller and Safety Function Blocks are certified confirming to IEC 61508 SIL3 and EN954-1/ISO13849-1 Category 4.

⚠ WARNING

- Please note that you are responsible for implementing all additional requirements resulting from applicable directives and legislation in order to meet the above safety integrity requirements. (See “Applicable Safety Standards” of each FB in Chap.4.)
  With regard to the use of the safety programmable controller, the manufacturers and operators of machines and systems are responsible for adhering to all applicable directives and legislation.

- In defining the safety integrity level or category for the overall safety function, you must take into consideration all components involved in the execution of this safety function (sensors, actuators, wiring, etc.).
  You must always validate the overall safety function that is the all of path input to output at completion of your design.

[Startup/Maintenance Instructions]

⚠CAUTION

- The online operations performed from a programmable controller to a running safety programmable controller (Program change when a safety CPU is RUN, device test, and operating status change between RUN and STOP) have to be executed after the manual has been carefully read and the safety has been ensured.
  Following the operating procedure predetermined at designing, the operation has to be performed by an instructed person.
  When changing a program while a safety CPU is RUN (Write during RUN), it may cause a program breakdown in some operating conditions.
  Fully understand the precautions described in the GX Developer's manual before use.

REVISIONS

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

Print Date	*Manual Number	Revision
Oct., 2007	SH(NA)-080744ENG-A	First edition
Jan., 2008	SH(NA)-080744ENG-B	Addition Section 4.9, 4.10, 4.11, 4.12 Change Section 4.9 → 4.13 Section 4.10 → 4.14 Partial correction Section 2.1, 3.1
Apr., 2009	SH(NA)-080744ENG-C	Revised overall for the safety FB version, Version 2
May, 2011	SH(NA)-080744ENG-D	Partial correction SAFETY PRECAUTIONS, MANUALS, HOW TO SEE THE MANUALG, GENERIC TERMS AND ABBREVIATIONS IN THIS MANUAL, Section 2.4, 2.5, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.10, 4.11, 4.12, 4.13, 4.14, 4.15, 4.16, APPENDIX 2

Japanese Manual Version SH-080743-D

INTRODUCTION

Thank you for choosing the Mitsubishi MELSEC-QS Series of Safety Programmable Controllers.
Before using the equipment, please read this manual carefully to develop full familiarity with the functions and performance of the QS series programmable controller you have purchased, so as to ensure correct use.
A copy of this manual should be forwarded to the end User.

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MANUALS

Introductory Manual

Read the following manual before designing and constructing a safety system.

Manual Name	Manual No. (Model Code)
Safety Application Guide Explains the overview and construction method of the safety system, laying and wiring examples, application programs and others. (Sold separately)	SH-080613ENG (13JR90)

Related Manuals

The manuals related to this product are listed below.
Please place an order as needed.

Manual Name	Manual No. (Model Code)
GX Developer Version 8 Operating Manual Explains the online functions of GX Developer, such as the programming, printout, monitoring, and debugging methods. (Sold separately)	SH-080373E (13JU41)
GX Developer Version 8 Operating Manual (Startup) Explains the system configuration, installation, and starting methods of GX Developer. (Sold separately)	SH-080372E (13JU40)
QSCPU User's Manual (Function Explanation, Program Fundamentals) Explains the functions, programming methods, devices and others that are necessary to create programs with the QSCPU. (Sold separately)	SH-080627ENG (13JR93)
QSCPU Programming Manual (Common Instructions) Explains how to use the sequence instructions, basic instructions, and QSCPU dedicated instructions. (Sold separately)	SH-080628ENG (13JW01)
CC-Link Safety System Master Module User's Manual Explains the specifications, procedures and settings before operation, parameter settings, and troubleshooting of the QS0J61BT12-type CC-Link Safety system master module. (Sold separately)	SH-080600ENG (13JR88)
CC-Link Safety System Remote I/O Module User's Manual Explains the specifications, procedures and settings before operation, parameter settings, and troubleshooting of the CC-Link Safety system remote I/O modules. (Sold separately)	SH-080612ENG (13JR89)
MELSEC-QS CC-Link IE Field Network Master/Local Module User's Manual Explains the specifications, procedures and settings before operation, parameter settings, and troubleshooting of the CC-Link IE Field Network master/local module (with safety functions). (Sold separately)	SH-080969ENG (13JZ53)

REMARK

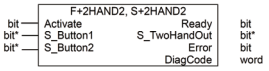
Printed materials are separately available for single item purchase.
Order the manual by quoting the manual number on the table above (Model Code).

HOW TO SEE THE MANUALG

The following shows the description pages for a safety FB in Chap.4.

4. SAFETY FB SPECIFICATIONS

4.1 F+2HAND2, S+2HAND2



OVERVIEW

This function block provides the two-hand control functionality (see EN 574, Section 4 Type II).

INPUT/OUTPUT

I/O	Name	Data Type	Initial Value	Description, Parameter Values
IN	Activate	bit	OFF	Activation of the safety FB. For details, see Section 2.5.
	S_Button1	bit*	OFF	Input of button1 (for category 3 or 4 antivalent contacts) OFF : Button1 released. ON : Button1 actuated.
	S_Button2	bit*	OFF	Input of button2 (for category 3 or 4 antivalent contacts) OFF: Button2 released. ON : Button2 actuated.
OUT	Ready	bit	OFF	Status of whether the safety FB is activated or not. For details, see Section 2.5.
	S_TwoHandOut	bit*	OFF	Safety FB output signal. OFF : No correct two hand operation. ON : S_Button1 and S_Button2 inputs are ON and no error occurred. Correct two hand operation.
	Error	bit	OFF	Error flag. For details, see Section 2.5.
	DiagCode	word	0	Diagnostic code. For details, see Section 2.5.

[DANGER]
Use safety data (See Appendix 2.) for connecting the variable whose data type is "bit*" to input and output circuits.
Wire the safety input and output devices and set parameters correctly, referring to the Safety Application Guide.

FUNCTION DESCRIPTION

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

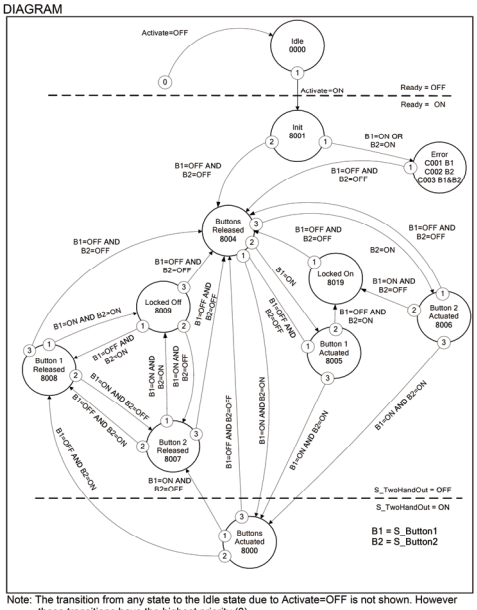
This block is the overview of safety FB.
In this document, the bit type data which is as safety data is called "bit*". You must connect bit* data to safety data in/out the safety CPU.

OVERVIEW
This table describes each input/output parameter. Each table shows FB specific variables. See "2.4 Common Specifications" about the description of common variables of safety FBs.

WARNING
It is the important topic to use the safety FB.

FUNCTION DESCRIPTION
How to use the FB and its functions are described.

STATE DIAGRAM



Note: The transition from any state to the Idle state due to Activate=OFF is not shown. However these transitions have the highest priority (0).

Figure 4.1 State Diagram for F+2HAND2, S+2HAND2

STATE DIAGRAM

The safety FB changes its state according to the combination of input variables. See “2.6 Generic State Diagram” for how to see the state diagram.

TYPICAL TIMING DIAGRAM

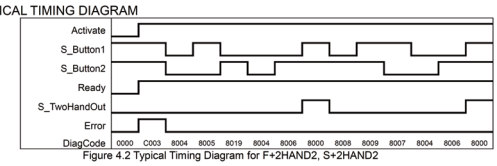


Figure 4.2 Typical Timing Diagram for F+2HAND2, S+2HAND2

ERROR BEHAVIOR

In the event of an error, the output signals behave as listed below.
For the corrective actions, see the ERROR CODES.

Output Signal	Status
Ready	ON
S_TwoHandOut	OFF
Error	ON

ERROR CODES

DiagCode (hexadecimal)	State Name	Description, Output Setting	Actions
C001	Error B1	S_Button1 was ON on FB activation.	Release S_Button1 and S_Button2.
C002	Error B2	S_Button2 was ON on FB activation.	
C003	Error B1&B2	The signals at S_Button1 and S_Button2 were ON on FB activation.	

STATE CODE (no error)

DiagCode (hexadecimal)	State Name	Description, Output Setting	Actions
0000	Idle	The function block is not active (initial state). Output Signal / Status Ready: OFF S_TwoHandOut: OFF Error: OFF	Initialize the safety FB by setting Activate to ON.
8000	Buttons Actuated	Both buttons actuated correctly. The safety FB output is enabled. Output Signal / Status Ready: ON S_TwoHandOut: ON Error: OFF	None.
8001	Init	Function block is active, but in the Init state. Output Signal / Status Ready: ON S_TwoHandOut: OFF Error: OFF	Actuate S_Button1 or S_Button2.
8004	Buttons Released	No button is actuated. Output Signal / Status Ready: ON S_TwoHandOut: OFF Error: OFF	None. Or, actuate S_Button1 and S_Button2.

TYPICAL TIMING DIAGRAM

This shows typical timing diagram of this FB. This diagram is only a sample case, it doesn’t show all of the combination of signals.

ERROR BEHAVIOR

Actions of outputs at an error, and how to reset the error are described.

ERROR CODES/ STATE CODE

When an error has occurred, DiagCode shows the error code, and when there is no error, it shows the status code of the inside.
See each state diagram for more detail.

APPLICATION EXAMPLE

For applications, see the Safety Application Guide.

APPLICABLE SAFETY STANDARDS

Standards	Requirements
EN 574: 1996	Clause 4, Table 1, Type II. 5.1 Use of both hands / simultaneous actuation. 5.2 Relationship between output signal and input signals. 5.3 Completion of the output signal. 5.6 Reinitiation of the output signal. 6.3 Use of DIN EN 954-1 category 3 (Can only be realized by NO and NC switches together with antivalent processing)
ISO 12100-2:2003	4.11.4: Restart following power failure/spontaneous restart

APPLICATION EXAMPLE

It shows the easy example which uses Safety FB, and explains connection with the data of the variable of FB.

APPLICABLE SAFETY STANDARDS

It shows the major standards related to this FB. User application must be adapted to these standards.

GENERIC TERMS AND ABBREVIATIONS IN THIS MANUAL

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

Generic term/abbreviation	Description
GX Developer	Generic product name for models SWnD5C-GPPW, SWnD5C-GPPW-A, SWnD5C-GPPW-V, and SWnD5C-GPPW-VA.
Safety remote I/O station	Remote station which handles only the information in bit units. Compatible with the safety-related system.
Safety master module	Other name for the QS0J61BT12 type CC-link Safety system master module.
Safety remote I/O module	Other name for the QS0J65BTB2-12DT type CC-Link Safety system remote I/O module.
Safety CPU module	Abbreviation for the QS001CPU type safety CPU module.
Safety Programmable Controller	Generic term for safety CPU module, safety power supply module, safety main base unit, CC-Link safety master module, CC-Link safety remote I/O module, and CC-Link IE Field Network master/local module (with safety functions).
Standard Programmable Controller	General name of each module for MELSEC-Q series, MELSEC-L series, MELSEC-QnA series, MELSEC-A series and MELSEC-FX series. (Used for distinction from safety programmable controller.)
Safety input	Generic term for the signals that are input to the safety programmable controller for realizing the safety functions.
Safety output	Generic term for the signals that are output from the safety programmable controller for realizing the safety functions.
Safety application	Generic term for the applications that are operated using the safety programmable controller for realizing the safety functions.

TERMS IN THIS MANUAL

Terminology	Description
Safety component	Equipment such as the safety compatible sensor and actuator.
Safety related system	System executing a safety functions to be required.
Safety functions	Functions to be realized for protecting a human from machinery hazards.
Safety measure	Measure for reducing the risk.
Safe category	Safety level standardized in EN954-1. The safety level is classified into 5 levels of B and 1 to 4.
SIL	Safety level which is standardized in IEC 61508. The safety level is classified into 4 levels of SIL1 to SIL4.
Risk	Degree of hazards, which is the combination of the occurrence probability and degree of an injury and a health problem.
Risk assessment	To clarify hazards in machinery and assess the degree of the hazards.
Link ID	Unique network identifier which is given to each network of the CC-Link Safety system.
Target failure measure	Target value of reliability for each SIL level standardized in IEC 61508. There are PFD and PFH depending on the operation frequency of the safety functions.
NC	Abbreviation for normal close contact which is normally closed, but opened when a switch or other function is operated.
NO	Abbreviation for normal open contact which is normally opened, but closed when a switch or other function is operated.
Close contact	Same as NC.
Open contact	Same as NO.
Safety project	A project for Safety CPU module built by GX Developer.

1 OVERVIEW

1.1 Features

Safety FB (function block) is the maker (Mitsubishi) offer FB that acquired the certification of EN954-1/ISO13849-1 Category 4 and IEC 61508 SIL3.
The feature of Safety FB is shown below.

(1) Improving the productivity and the maintenance ability of a safety program
The major functions used in programming safety applications are provided as the safety FB. Safety program is able to become simple by using the safety FB, and the productivity and maintenance ability of the safety program can improved. Moreover, the debug and the verification of the safety program are able to be more efficient.

(2) The high safe level application using the safety certified FB
Since the safety FB received the safety certification; a user can build a safety application which is compliance to EN954-1/ISO13849-1 Category 4 and IEC 61508 SIL3. User can develop an advanced safety application using the safety FB. And it becomes easy to get the safety certification of user's safety application from an inspector.

(3) Reliability of the safety program
Since a user cannot read the inside logic of the safety FB, a user cannot customize or modify the safety FB. Since there is no variation of the safety FB by any intentional or mistaken operation, the reliability of a safety feature can improve.
And a user cannot set or change the name of safety FB, a user can know that the FB is certified safety FB by only its name.

(4) Enough functions to support FB errors
When the safety FB detects an internal error (out of range of parameters, invalid static Reset, etc.), it outputs Error. Simultaneously, the FB notifies the error code. When there is no error, the FB notifies its status value. It is useful to debug and understand its behavior.

(5) Combination with a ladder
A user can make a program with the safety FB in a ladder. By the combination of a popular ladder and the certified safety functions, a user can make a safe and flexible application program.

1.2 Feature of Version 2

The safety FB has two types, namely Version 2 (F+○○) and Version 1 (S+○○).
Version 2 has been easier to use by improving functions such as speeding up the processing time and increasing the maximum number of safety FBs.
For the safety FB version compatible with the GX Developer version used and the comparison between F+○○ and S+○○ specifications, see Section 2.2 and Appendix 3, respectively.

2. GENERAL SPECIFICATION

2.1. List of Safety FB

The following is the list provides safety function blocks.

Table 2.1 List of Safety FB

FB Name	Function	Descriptions	Section
F+2HAND2 S+2HAND2	Two hand switch Type II	This FB provides the two-hand control functionality (see EN 574, Section 4 Type II).	4.1
F+2HAND3 S+2HAND3	Two hand switch Type III	This FB provides the two-hand control functionality (see EN 574, Section 4 Type III. Fixed specified time difference is 500 ms).	4.2
F+EDM S+EDM	External device monitor	External device monitoring - The FB controls a safety output and monitors controlled actuators, e.g. subsequent contactors	4.3
F+ENBLSW S+ENBLSW	Enable switch	This FB evaluates the signals of an enable switch with three positions.	4.4
F+ESPE S+ESPE	Light Curtain (ESPE)	This FB is a safety-related FB for monitoring electro-sensitive protective equipment (ESPE).	4.5
F+ESTOP S+ESTOP	Emergency Stop	This FB is a safety-related FB for monitoring an emergency stop button. This FB can be used for emergency switch off functionality (stop category 0).	4.6
F+GLOCK S+GLOCK	Guard Lock and Interlocking	This FB controls an entrance to a hazardous area via an interlocking guard with guard locking (“four state interlocking”)	4.7
F+GMON S+GMON	Guard Monitoring	This FB 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.	4.8
F+MODSEL S+MODSEL	Mode Selector	This FB selects the system operation mode, such as manual, automatic, semi-automatic, etc.	4.9
F+MUTE2 S+MUTE2	Muting with 2 sensors	Muting is the intended suppression of the safety function. (e.g., light barriers) In this FB, parallel muting with two muting sensors is specified.	4.10
F+MUTEP S+MUTEP	Parallel muting	In this FB, parallel muting with four muting sensors is specified.	4.11
F+MUTES S+MUTES	Sequential muting	In this FB, sequential muting with four muting sensors is specified.	4.12
F+OUTC S+OUTC	Output Control	Control of a safety output with a signal from the functional application and a safety signal with optional startup inhibits.	4.13
F+TSSEN S+TSSEN	Testable safety sensor	This FB 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	4.14

(To the next page)

Table 2.1 List of Safety FB (continued)

FB Name	Function	Descriptions	Section
F+EQUI	Dual input (NC+NC or NO+NO)	This FB converts two equivalent bit inputs (both NO or NC) to one bit with discrepancy time monitoring. This FB output shows the result of the evaluation of both channels.	4.15
F+ANTI	Dual input (NO+NC)	This FB converts two antivalent bit inputs (NO/NC pair) to one bit output with discrepancy time monitoring. This FB output shows the result of the evaluation of both channels.	4.16

2.2 Function Specifications

(1) Software
A safety FB library is included in GX Developer.
The software and its version required for the programming with the safety FB library are listed below.

Table 2.2 Software Required for Safety FB Program

Product Name	Compatible Version
GX Developer	Version 8.58L or later

(2) Safety FB version
A safety FB has 30 types, 16 types of the safety FBs start with F+ and 14 types of those that start with S+, respectively.
The safety FBs included in GX Developer vary as listed below depending on GX Developer versions.

Table 2.3 Safety FB Versions and its Compatible GX Developer Versions

No.	Safety FB		GX Developer
	Name	Version	
1	F+2HAND2	Version 2	Version 8.82L or later
2	F+2HAND3		
3	F+EDM		
4	F+ENBLSW		
5	F+ESPE		
6	F+ESTOP		
7	F+GLOCK		
8	F+GMON		
9	F+MODSEL		
10	F+MUTE2		
11	F+MUTEP		
12	F+MUTES		
13	F+OUTC		
14	F+TSSEN		
15	F+EQUI		
16	F+ANTI		
17	S+2HAND2	Version 1	Version 8.58L or later
18	S+2HAND3		
19	S+EDM		
20	S+ENBLSW		
21	S+ESPE		
22	S+ESTOP		
23	S+GLOCK		
24	S+GMON		
25	S+MODSEL		Version 8.62Q or later
26	S+MUTE2		
27	S+MUTEP		
28	S+MUTES		
29	S+OUTC		Version 8.58L or later
30	S+TSSEN		

POINT

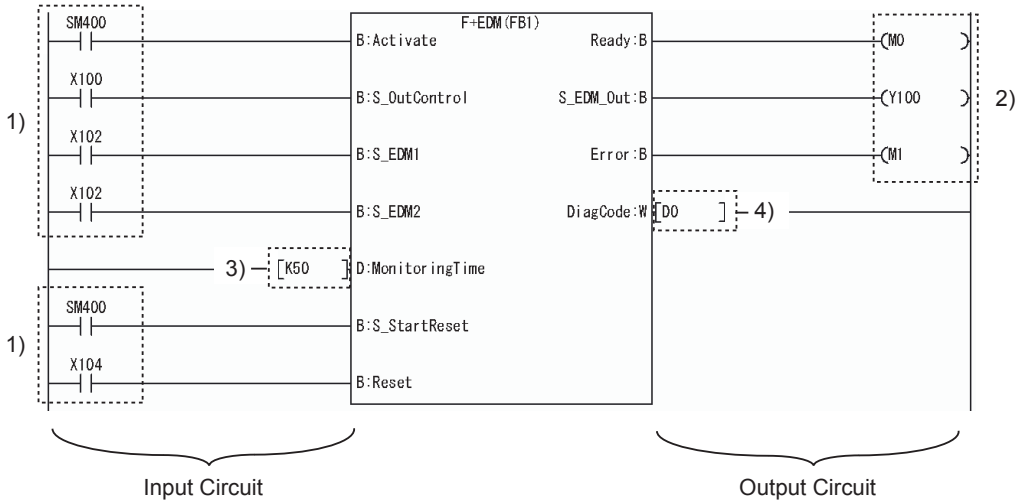
The safety FBs to be used in GX Developer required to be copied from a safety FB library into a project.
For the operating procedure of the copy, see GX Developer Version8 Operating Manual (Safety Programmable Controller) SW8D5C-GPPW-E.

(3) Number of safety FB (F+○○) steps and available safety FBs
The number of compiled safety FB steps and maximum number of safety FBs are listed below.

Table 2.4 Number of Safety FB (F+○○) Steps and Maximum Number of Safety FBs*3

No.	FB Name	Number of Compiled Steps*1	Maximum Number of Safety FBs*2	No.	FB Name	Number of Compiled Steps*1	Maximum Number of Safety FBs*2
1	F+2HAND2	35	392	9	F+MODSEL	79	124
2	F+2HAND3	35	392	10	F+MUTE2	60	193
3	F+EDM	51	260	11	F+MUTEP	76	160
4	F+ENBLSW	43	297	12	F+MUTES	68	190
5	F+ESPE	40	325	13	F+OUTC	46	275
6	F+ESTOP	40	325	14	F+TSSEN	58	201
7	F+GLOCK	50	238	15	F+EQUI	38	332
8	F+GMON	46	260	16	F+ANTI	38	332

*1:The number of steps is the number of compiled safety FB and input-output circuit steps in connecting the safety FB input-output variables with the input-output circuits.
In addition, the number of safety FB steps listed in Table 2.4 is different from those in the case of connecting more than one contact or coil with the input-output variable, no input-output circuits.



1) Connecting one contact with the bit device input variables
2) Connecting one coil with the bit device output variables
3) Connecting a constant with the word device input variable
4) Connecting one word with the word device output variable

Figure 2.1 Example of F+EDM Circuit (51 steps in the above circuit)

*2:The maximum number of safety FBs is the number that only same safety FBs can be used and up to 14K steps of the safety FB can be used. (The reserved area for online change is 500.)
*3:For the safety FB (S+○○), see Appendix 1.

2.3 Performance Specifications

The processing time of the safety FB (F+○○) is listed below.
Table 2.5 shows the processing time of the safety FB (F+○○) whose status code is 8000[*1].

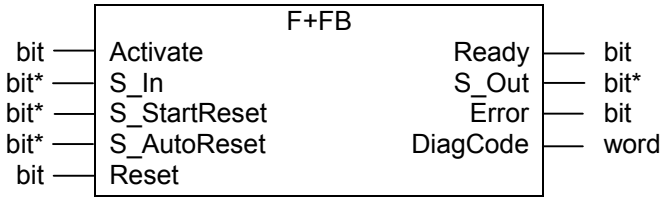
Table 2.5 Safety FB (F+○○) Processing Time[*2]

No.	FB Name	Processing Time (μs)	No.	FB Name	Processing Time (μs)
1	F+2HAND2	15	9	F+MODSEL	32
2	F+2HAND3	16	10	F+MUTE2	24
3	F+EDM	28	11	F+MUTEP	27
4	F+ENBLSW	17	12	F+MUTES	27
5	F+ESPE	16	13	F+OUTC	17
6	F+ESTOP	16	14	F+TSSEN	20
7	F+GLOCK	18	15	F+EQUI	16
8	F+GMON	17	16	F+ANTI	16

*1:The status code is the code that indicates the current status of safety FBs, and the 8000 indicates the status that the safety output is set to ON.
For the details of the safety FB status code, see each safety FB in Chapter 4.
*2:For the safety FB (S+○○), see Appendix 1.

2.4 Common Specifications

The common specifications of the safety FBs are described in this section.
The input-output specification of a general safety FB is shown in the figure below.
Variables other than S_In and S_Out are all used under same names, data types, initial values, specifications, and functions for the safety FB use.
For details of each safety FB name, data type, initial value, specification, and function of the safety input-output variables other than those described in the figure below, see Chapter 4.



[WARNING]
Use safety data(See Appendix2) for connecting the variable whose data type is “bit*” to input-output circuits.
Wire the safety input-output devices and set parameters correctly, referring to the Safety Application Guide.

INPUT/OUTPUT

I/O	Name	Data Type	Initial Value	Descriptions and values
IN	Activate	bit	OFF	Activation of the FB. Initial value is OFF. OFF : All output variables are set to the initial values. ON : The safety FB is active. For details, see Section 2.5 (1).
	S_In	bit*	OFF	Safety input signals to this FB. For details of each safety FB name, data type, initial value, specification, and function, see Chapter 4.
	S_StartReset	bit*	OFF	Selection of a reset method for the activated (first time) safety FB. OFF (= initial value): Manual reset when the safety FB is activated. ON : Automatic reset when the safety FB is activated. For details of the function, see Section 2.5 (2).
	S_AutoReset	bit*	OFF	Selection of a reset method for the input signal (S_In) reset to ON. OFF (= initial value): Manual reset when emergency stop button is released. ON : Automatic reset when emergency stop button is released. For details of the function, see Section 2.5 (2).
	Reset	bit	OFF	Reset input. This function is only active on a signal change from OFF to ON. This input can be used for different purposes: (1) Reset of the error occurred in the safety FB. (2) Manual reset in setting S_StartReset and S_AutoReset to OFF. (3) Additional FB-specific reset functions. (For details of each safety FB, see Chapter 4.) For details of the function, see Section 2.5 (3).

(To the next page)

I/O	Name	Data Type	Initial Value	Descriptions and values
OUT	Ready	bit	OFF	Status of whether the safety FB is activated or not. OFF : The safety FB is activated. ON : The safety FB is not activated. For details of the function, see Section 2.5 (1).
	S_Out	-	-	Safety output signals from the safety FB. For details of each safety FB name, data type, initial value, specification, and function, see Chapter 4.
	Error	bit	OFF	Error flag. OFF : Indicates that an error has not occurred and the safety FB is in another state. ON : Indicates that an error has occurred, and the safety FB is in an error state. The relevant error state is mirrored at the DiagCode output. For details of the function, see Section 2.5 (4).
	DiagCode	word	0	Diagnostic code. FB has a status inside, and it changes its status by inputs. DiagCode shows the status value. When there is no error, it shows the FB specific status code, and when an error is occurred DiagCode shows its error code. See DiagCode of each description of FB. In this manual, this value shows by hex (16bits=0000). For details of the function, see Section 2.5 (4).

2.5 General Functions

(1) Whether safety FBs are active or not

The Activate input signal sets whether to activate a safety FB or not.
In addition, whether the safety FB is active or not can be checked with the output signal Ready.
If the signal Activate is OFF, all values of the output signals are set to the initial values.
Inputting the signal of the safety refresh communication status for CC-Link Safety inactivates the safety FB when an error occurs in the safety station and then prevents unnecessary signals from outputting.
For details of the program example, see the Safety Application Guide.

(2) Reset selection

A reset of safety FBs can be selected from S_StartReset (after safety FBs are activated) and S_AutoReset (after safety inputs are restored).

- Manual reset

This reset disables that safety FB output signals are set to ON immediately after safety FB input signals are set correctly. If S_StartReset is set to ON, the safety output will be set to ON.

- Automatic reset

The safety FB output signal is set to ON if safety FB input signals are set correctly.

[WARNING]
Automatic reset can only be activated if it is ensured that no hazard can occur when a safety FB is activated (with S_StartReset input) or a safety FB input is set (with S_AutoReset input). (Also, the manual reset switched from the automatic reset or the automatic reset switched from the manual reset can be activated.)
Therefore, the use of automatic reset requires implementation of other system or application measures to ensure that unexpected (or unintended) startup does not occur.

(3) Securing of input signal Reset

To prevent a machine startup in the event of switch failures (contact welding, damaged springs), the safety FB can only be activated when Reset input signal is set to ON.
If Reset remains ON without detecting that it is set to ON, the safety FB detects an error. (For details of each safety FB error, see Chapter 4.)

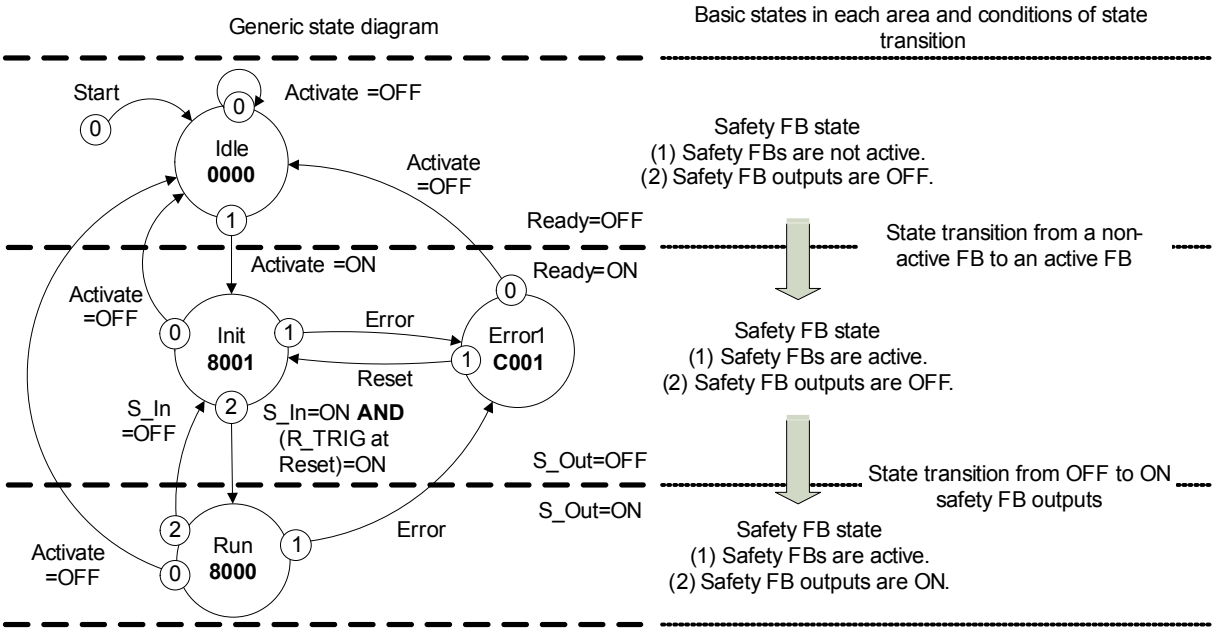
(4) Safety FB status check

The current status of safety FBs can be checked with the DiagCode (hexadecimal number) output signal.
If an error occurs in the safety FB, the Error output signal is set to ON and the error code is output to the DiagCode.
If more than one error occurs, only the error code corresponding to the error detected at first is output.
If an error does not occur in the safety FB, the Error output signal is OFF and the status code is output to the DiagCode.
(For details of each safety FB error code and status code, see Chapter 4.)

[WARNING]
Take action against error messages and perform reset operations properly.

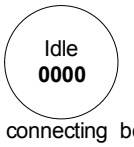
2.6 Generic State Diagram

The safety FB state transition is shown in each state diagram in Chapter 4. However, a sequence program operation is cancelled when a CPU module stops running. Consequently, the state transition is not made.
The following figure shows how to read the state transition in the state diagram.



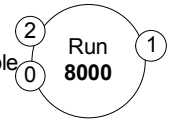
How to read the state transition

(1) The state name and diagnosis code are indicated in the circle.

Example 

The state name is Idle, and the diagnosis code is 0000h.

The arrows connecting between two circles indicate the direction of the state transition. Also, the conditions of the transitions are described by the arrows.
In the states of more than one transition, the circled numbers indicate the priority transition when more than one condition is satisfied simultaneously . (0 is the highest priority.)

Example 

The transition from the Run state to three states is shown.
The priority of the transition between the Run state and three states is from 8000 to 0000, from 8000 to C001, and from 8000 to 8001.

(3) If the Activate input signal is set to OFF , transition from any states to the Idle state is shown.

(4) Meaning of transition state symbols
AND, OR, XOR, and NOT: Logical operators
R_TRIG at signal: The signal is changed from OFF to ON.
F_TRIG at signal: The signal is changed from ON to OFF.

Figure 2.2 How to Read Generic State Diagram

2.7 Import Safety FB to your Project

See “GX Developer Version 8 Operating manual (Safety Programmable Controller)”, about how to import (copy) the safety FB to your project.

MEMO

3. RESTRICTIONS AND CAUTIONS

3.1 Restrictions

(1) Available safety FBs

The following table shows that available safety FBs vary depending on the QS001CPU version.

Table 3.1 Available Safety FBs

No.	Safety FB		Compatible QS001CPU
	Name	Version	
1	F+2HAND2	Version 2	The serial number (first five digits) is 11042 or later.
2	F+2HAND3		
3	F+EDM		
4	F+ENBLSW		
5	F+ESPE		
6	F+ESTOP		
7	F+GLOCK		
8	F+GMON		
9	F+MODSEL		
10	F+MUTE2		
11	F+MUTEP		
12	F+MUTES		
13	F+OUTC		
14	F+TSSEN		
15	F+EQUI		
16	F+ANTI		

No.	Safety FB		Compatible QS001CPU
	Name	Version	
17	S+2HAND2	Version 1	No restriction
18	S+2HAND3		
19	S+EDM		
20	S+ENBLSW		
21	S+ESPE		
22	S+ESTOP		
23	S+GLOCK		
24	S+GMON		
25	S+MODSEL		
26	S+MUTE2		
27	S+MUTEP		
28	S+MUTES		
29	S+OUTC		
30	S+TSSEN		

3.2 Precautions for System Design

(1) Correct connection with the safety devices

The variable name which is began “S_” must be connected with the safety information related with safety data from the safety remote I/O station. Don’t connect them to non-safety information; an input from/output to the standard I/O or standard CPU. See Appendix.2 for the safety data.

(2) Validation for all of the system

Please note that you must carry out a validation every time you make a safety-related modification to your overall system. Check following;

- The safe devices are connected to the correct safe sensors and actuators in your safety application.
- The safe input and output devices have been parameterized correctly.
- The variables have been linked to the safe sensors and actuators correctly (single channel or dual-channel).
- Line control (short-circuit and cable break monitoring) is implemented in your application if it is required in your application.
- Variables of the safety FB are connected to proper data.

(3) Error and DiagCode

The safety FB has an internal state, and it change to other state according to inputs. This internal state is output to DiagCode. When an error is detected in the FB, Error=ON, and DiagCode shows its error code. Use these values, if your application needs error information of the FB.

3.3 Precautions for Management

(1) Precautions for project data management

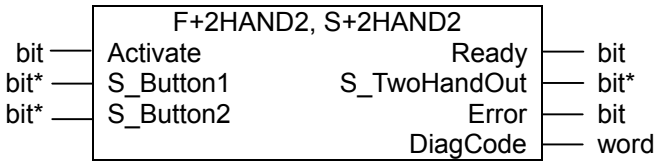
Be sure to read the Safety Application Guide for correct management/operation of project data.

A system manager has to back up the project and save the backup data so that the data restoration is always possible.

MEMO

4. SAFETY FB SPECIFICATIONS

4.1 F+2HAND2, S+2HAND2



OVERVIEW

This function block provides the two-hand control functionality (see EN 574, Section 4 Type II).

INPUT/OUTPUT

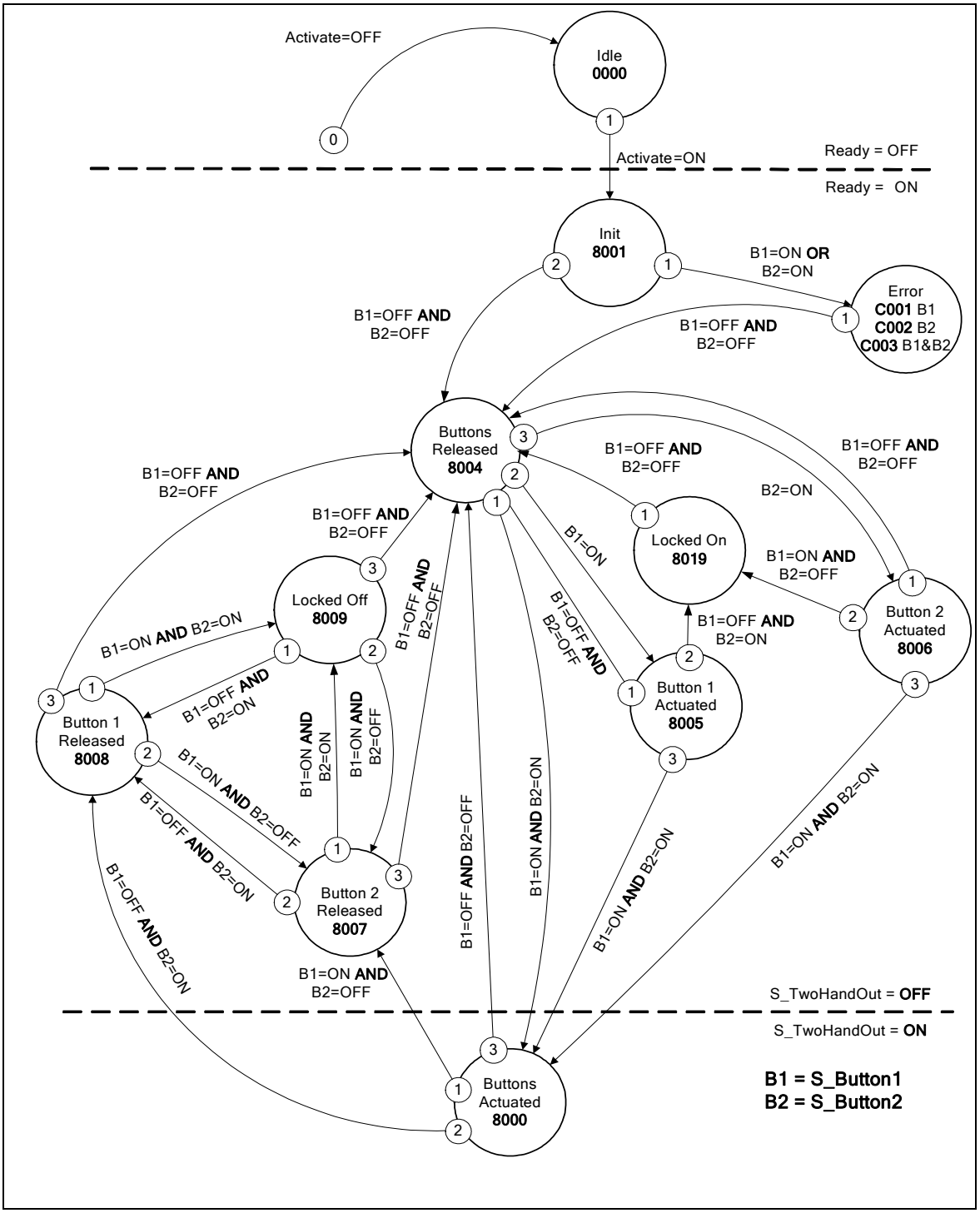
I/O	Name	Data Type	Initial Value	Description, Parameter Values
IN	Activate	bit	OFF	Activation of the safety FB. For details, see Section 2.5.
	S_Button1	bit*	OFF	Input of button1 (for category 3 or 4: NC/NO antivalent contacts) OFF : Button1 released. ON : Button1 actuated.
	S_Button2	bit*	OFF	Input of button2 (for category 3 or 4 antivalent contacts) OFF : Button2 released. ON : Button2 actuated.
OUT	Ready	bit	OFF	Status of whether the safety FB is activated or not. For details, see Section 2.5.
	S_TwoHandOut	bit*	OFF	Safety FB output signal. OFF : No correct two hand operation. ON : S_Button1 and S_Button2 inputs are ON and no error occurred. Correct two hand operation.
	Error	bit	OFF	Error flag. For details, see Section 2.5.
	DiagCode	word	0	Diagnostic code. For details, see Section 2.5.

[WARNING]
Use safety data (See Appendix 2.) for connecting the variable whose data type is “bit*” to input - output circuits.
Wire the safety input - output devices and set parameters correctly, referring to the Safety Application Guide.

FUNCTION DESCRIPTION

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

STATE DIAGRAM



Note: The transition from any state to the Idle state due to Activate=OFF is not shown. However these transitions have the highest priority (0).

Figure 4.1 State Diagram for F+2HAND2, S+2HAND2

TYPICAL TIMING DIAGRAM

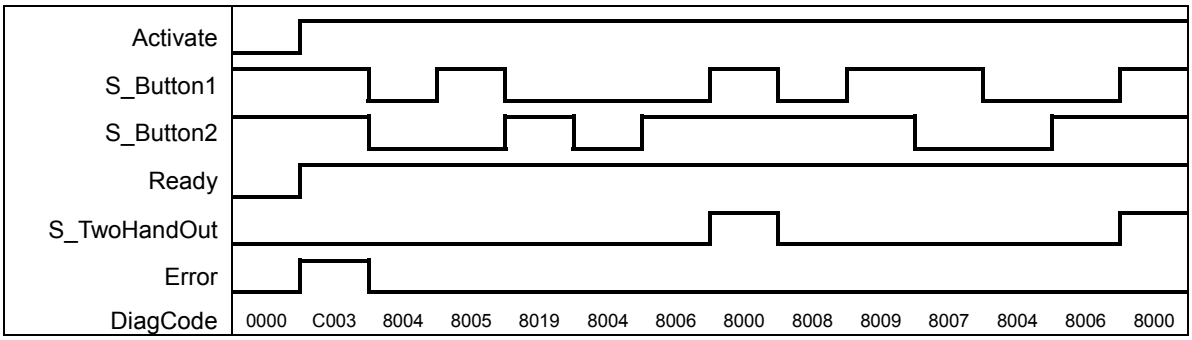


Figure 4.2 Typical Timing Diagram for F+2HAND2, S+2HAND2

ERROR BEHAVIOR

In the event of an error, the output signals behave as listed below.
For the corrective actions, see the ERROR CODES.

Output Signal	Status
Ready	ON
S_TwoHandOut	OFF
Error	ON

ERROR CODES

DiagCode (hexadecimal)	State Name	Description, Output Setting	Actions
C001	Error B1	S_Button1 was ON on FB activation.	Release S_Button1 and S_Button2.
C002	Error B2	S_Button2 was ON on FB activation.	
C003	Error B1&B2	The signals at S_Button1 and S_Button2 were ON on FB activation.	

STATE CODE (no error)

DiagCode (hexadecimal)	State Name	Description, Output Setting	Actions
0000	Idle	The function block is not active (initial state). Output Signal / Status Ready: OFF S_TwoHandOut: OFF Error: OFF	Initialize the safety FB by setting Activate to ON.
8000	Buttons Actuated	Both buttons actuated correctly. The safety FB output is enabled. Output Signal / Status Ready: ON S_TwoHandOut: ON Error: OFF	None.
8001	Init	Function block is active, but in the Init state. Output Signal / Status Ready: ON S_TwoHandOut: OFF Error: OFF	Actuate S_Button1 or S_Button2.
8004	Buttons Released	No button is actuated. Output Signal / Status Ready: ON S_TwoHandOut: OFF Error: OFF	None. Or, actuate S_Button1 and S_Button2.

(To the next page)

<table>
<tr><th>DiagCode (hexadecimal)</th><th>State Name</th><th>Description, Output Setting</th><th>Actions</th></tr>
<tr><td>8005</td><td>Button1 Actuated</td><td>Only Button1 is actuated.
<table><tr><th>Output Signal</th><th>Status</th></tr><tr><td>Ready</td><td>ON</td></tr><tr><td>S_TwoHandOut</td><td>OFF</td></tr><tr><td>Error</td><td>OFF</td></tr></table></td><td>Release S_Button1, or actuate S_Button2.</td></tr>
<tr><td>8006</td><td>Button2 Actuated</td><td>Only Button2 is actuated.
<table><tr><th>Output Signal</th><th>Status</th></tr><tr><td>Ready</td><td>ON</td></tr><tr><td>S_TwoHandOut</td><td>OFF</td></tr><tr><td>Error</td><td>OFF</td></tr></table></td><td>Release S_Button2, or actuate S_Button1.</td></tr>
<tr><td>8007</td><td>Button2 Released</td><td>The safety FB output was enabled and is disabled again.
In this state, S_Button1 is ON and S_Button2 is OFF after disabling the safety FB output.
<table><tr><th>Output Signal</th><th>Status</th></tr><tr><td>Ready</td><td>ON</td></tr><tr><td>S_TwoHandOut</td><td>OFF</td></tr><tr><td>Error</td><td>OFF</td></tr></table></td><td>Release S_Button1.</td></tr>
<tr><td>8008</td><td>Button1 Released</td><td>The safety FB output was enabled and is disabled again.
In this state, S_Button1 is OFF and S_Button2 is ON after disabling the safety FB output.
<table><tr><th>Output Signal</th><th>Status</th></tr><tr><td>Ready</td><td>ON</td></tr><tr><td>S_TwoHandOut</td><td>OFF</td></tr><tr><td>Error</td><td>OFF</td></tr></table></td><td>Release S_Button2.</td></tr>
<tr><td>8009</td><td>Locked Off</td><td>The safety FB output was enabled and is disabled again.
In this state, S_Button1 is ON and S_Button2 is ON after disabling the safety FB output.
<table><tr><th>Output Signal</th><th>Status</th></tr><tr><td>Ready</td><td>ON</td></tr><tr><td>S_TwoHandOut</td><td>OFF</td></tr><tr><td>Error</td><td>OFF</td></tr></table></td><td rowspan="2">Release S_Button1 and S_Button2.</td></tr>
<tr><td>8019</td><td>Locked On</td><td>Incorrect actuation of the buttons.
Waiting for release of both buttons.
<table><tr><th>Output Signal</th><th>Status</th></tr><tr><td>Ready</td><td>ON</td></tr><tr><td>S_TwoHandOut</td><td>OFF</td></tr><tr><td>Error</td><td>OFF</td></tr></table></td></tr>
</table>

[WARNING]
Please do the above actions when the FB detects error or is an unexpected state. However, when still the situation is not corrected, please check following.
- A failure in safe devices and emergency stop devices
- Wiring and status of a safety remote I/O stations and a safety Programmable Controller
- Programming logics, the memory allocation of safety devices and the connections of FB variables
- Setting of S_StartReset and S_AutoReset

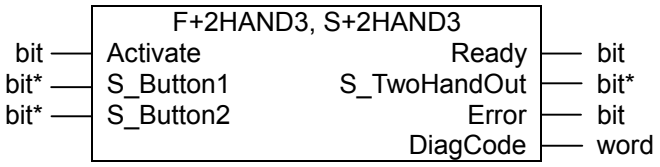
APPLICATION EXAMPLE

For applications, see the Safety Application Guide.

APPLICABLE SAFETY STANDARDS

Standards	Requirements
EN 574: 1996	Clause 4, Table 1, Type II. 5.1 Use of both hands / simultaneous actuation. 5.2 Relationship between output signal and input signals. 5.3 Completion of the output signal. 5.6 Reinitiation of the output signal. 6.3 Use of DIN EN 954-1 category 3 (Can only be realized by NO and NC switches together with antivalent processing)
ISO 12100-2:2003	4.11.4: Restart following power failure/spontaneous restart

4.2 F+2HAND3, S+2HAND3



OVERVIEW

This function block provides the two-hand control functionality (see EN 574, Section 4 Type III. Fixed specified time difference is 500ms).

INPUT/OUTPUT

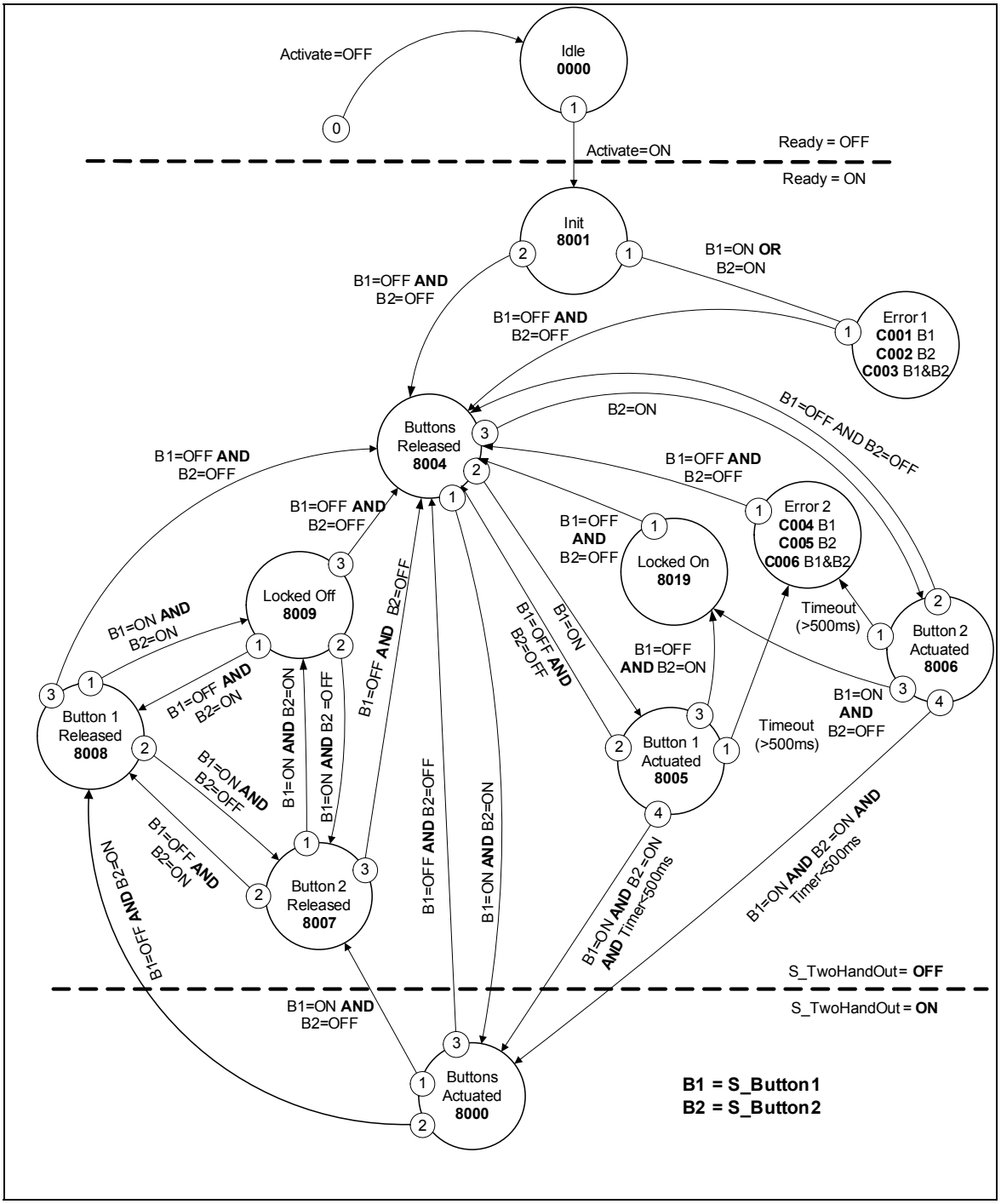
I/O	Name	Data Type	Initial Value	Description, Parameter Values
IN	Activate	bit	OFF	Activation of the safety FB. For details, see Section 2.5.
	S_Button1	bit*	OFF	Input of button1 (for category 3 or 4: NC/NO antivalent contacts) OFF : Button1 released. ON : Button1 actuated.
	S_Button2	bit*	OFF	Input of button2 (for category 3 or 4: NC/NO antivalent contacts) OFF : Button2 released. ON : Button2 actuated.
OUT	Ready	bit	OFF	Status of whether the safety FB is activated or not. For details, see Section 2.5.
	S_TwoHandOut	bit*	OFF	Safety FB output signal. OFF : No correct two hand operation. ON : S_Button1 and S_Button2 inputs changed from OFF to ON within 500ms and no error occurred. The two hand operation has been performed correctly.
	Error	bit	OFF	Error flag. For details, see Section 2.5.
	DiagCode	word	0	DiagnosticCode. For details, see Section 2.5.

[WARNING]
Use safety data (See Appendix 2.) for connecting the variable whose data type is “bit*” to input - output circuits.
Wire the safety input - output devices and set parameters correctly, referring to the Safety Application Guide.

FUNCTION DESCRIPTION

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

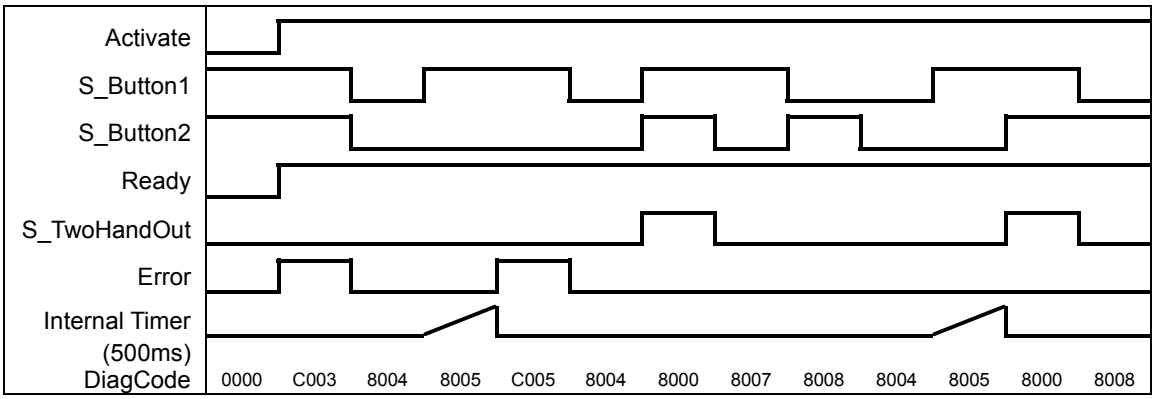
STATE DIAGRAM



Note: The transition from any state to the Idle state due to Activate=OFF is not shown. However these transitions have the highest priority (0).

Figure 4.3 State Diagram for F+2HAND3, S+2HAND3

TYPICAL TIMING DIAGRAM



*: The measurement of the InternalTimer elapsed time stops due to the stop of sequence program operations when the operating status of CPU modules is changed to STOP.

Figure 4.4 Typical Timing Diagram for F+2HAND3, S+2HAND3

ERROR BEHAVIOR

In the event of an error, the output signals behave as listed below.
For the corrective actions, see the ERROR CODES.

Output Signal	Status
Ready	ON
S_TwoHandOut	OFF
Error	ON

ERROR CODES

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
C001	Error B1	S_Button1 was ON on FB activation.	Release S_Button1 and S_Button2.
C002	Error B2	S_Button2 was ON on FB activation.	
C003	Error B1&B2	The signals at S_Button1 and S_Button2 were ON on FB activation.	
C004	Error2 B1	S_Button1 was OFF and S_Button2 was ON after 500ms in state 8005.	
C005	Error2 B2	S_Button1 was ON and S_Button2 was OFF after 500ms in state 8005.	
C006	Error2 B1&B2	S_Button1 was ON and S_Button2 was ON after 500ms 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 ON) simultaneously when the timer elapses (500ms) at the same cycle.	

STATUS CODES (no error)

<table>
<tr><th>Diag Code (Hexadecimal)</th><th>State Name</th><th>Description, Output Setting</th><th>Actions</th></tr>
<tr><td>0000</td><td>Idle</td><td>The function block is not active (initial state).
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>OFF</td></tr>
<tr><td>S_TwoHandOut</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Initialize the safety FB by setting Activate to ON.</td></tr>
<tr><td>8000</td><td>Buttons Actuated</td><td>Both buttons actuated correctly. The safety FB output is enabled.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_TwoHandOut</td><td>ON</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>None.</td></tr>
<tr><td>8001</td><td>Init</td><td>Function block is active, but in the Init state.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_TwoHandOut</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Actuate S_Button1 or S_Button2.</td></tr>
<tr><td>8004</td><td>Buttons Released</td><td>No Button is actuated.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_TwoHandOut</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>None.
Or, actuate S_Button1 or S_Button2.</td></tr>
<tr><td>8005</td><td>Button1 Actuated</td><td>Only Button1 is actuated. Start monitoring timer.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_TwoHandOut</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Release S_Button1, or actuate S_Button2.</td></tr>
<tr><td>8006</td><td>Button2 Actuated</td><td>Only Button2 is actuated. Start monitoring timer.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_TwoHandOut</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Release S_Button2, or actuate S_Button1.</td></tr>
<tr><td>8007</td><td>Button2 Released</td><td>The safety FB output was enabled and is disabled again.
In this state, S_Button1 is ON and S_Button2 is OFF after disabling the safety FB output.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_TwoHandOut</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Release S_Button1.</td></tr>
<tr><td>8008</td><td>Button1 Released</td><td>The safety FB output was enabled and is disabled again.
In this state, S_Button1 is OFF and S_Button2 is ON after disabling the safety FB output.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_TwoHandOut</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Release S_Button2.</td></tr>
<tr><td>8009</td><td>Locked Off</td><td>The safety FB output was enabled and is disabled again.
In this state, S_Button1 is ON and S_Button2 is ON after disabling the safety FB output.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_TwoHandOut</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td rowspan="2">Release S_Button1 and S_Button2.</td></tr>
<tr><td>8019</td><td>Locked On</td><td>Incorrect actuation of the buttons. Waiting for release of both buttons.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_TwoHandOut</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td></tr>
</table>

[WARNING]
Please do the above actions when the FB detects error or is an unexpected state.
However, when still the situation is not corrected, please check following.
- A failure in safe devices and emergency stop devices
- Wiring and status of a safety remote I/O stations and a safety Programmable Controller
- Programming logics, the memory allocation of safety devices and the connections of FB variables
- Setting of S_StartReset and S_AutoReset

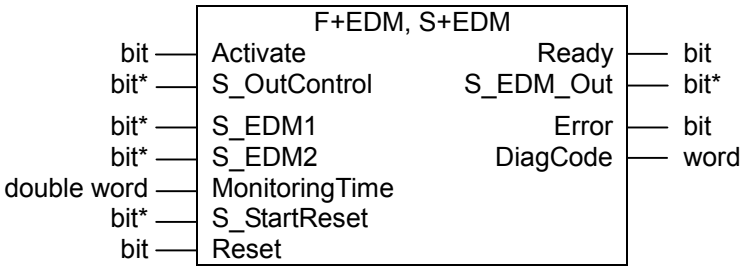
APPLICATION EXAMPLE

For applications, see the Safety Application Guide.

APPLICABLE SAFETY STANDARDS

Standards	Requirements
EN 574: 1996	Clause 4, Table 1, Type III A; B; C. 5.1 Use of both hands / simultaneous actuation. 5.2 Relationship between output signal and input signals. 5.3 Completion of the output signal. 5.6 Reinitiation of the output signal. 5.7 Synchronous actuation. 6.2 Use of DIN EN 954-1 category 1. 6.3 Use of DIN EN 954-1 category 3. (Can only be realized by NO and NC switches together with antivalent processing) 6.4 Use of DIN EN 954-1 category 4. (Can only be realized by NO and NC switches together with antivalent processing)
ISO 12100-2: 2003	4.11.4: Restart following power failure/spontaneous restart

4.3 F+EDM, S+EDM



OVERVIEW

This FB monitors connected actuators such as safety contactors and safety relays (contactors and relays with force-guided contacts) and controls outputs.

INPUT/OUTPUT

I/O	Name	Data Type	Initial Value	Description, Parameter Values
IN	Activate	bit	OFF	Activation of the safety FB. For details, see Section 2.5.
	S_OutControl	bit*	OFF	Control signal of the preceeding safety FB's. Typical function block signals from the library (e.g., F+OUTC, S+OUTC, F+2HAND2, S+2HAND2, and/or others). OFF : Disable safety output (S_EDM_Out). ON : Enable safety output (S_EDM_Out).
	S_EDM1	bit*	OFF	Feedback signal of the first connected actuator. (NC contact) OFF : Feedback signals are set to OFF. ON : Feedback signals are set to ON.
	S_EDM2	bit*	OFF	Feedback signal of the second connected actuator. (NC contact) OFF : Feedback signals are set to OFF. ON : Feedback signals are set to ON.
	MonitoringTime	double word	0	Maximum permissible time from the status of whether S_EDM_Out is ON or OFF until when S_EDM1 and S_EDM2 are set to ON or OFF correctly. (Increments of 10ms) Range: Fixed values from 0 to 60000 (0 to 600000ms=10min)
	S_StartReset	bit*	OFF	Selection of a reset method for the activated (first time) safety FB. For details, see Section 2.5.
	Reset	bit	OFF	Reset input. For details, see Section 2.5.
OUT	Ready	bit	OFF	Status of whether the safety FB is activated or not. For details, see Section 2.5.
	S_EDM_Out	bit*	OFF	Controls the actuator. The result is monitored by the feedback signal S_EDMx. OFF : Disable connected actuators. ON : Enable connected actuators.
	Error	bit	OFF	Error flag. For details, see Section 2.5.
	DiagCode	word	0	Diagnostic code. For details, see Section 2.5.

[WARNING]
Use safety data (See Appendix 2.) for connecting the variable whose data type is "bit*" to input - output circuits.
Wire the safety input - output devices and set parameters correctly, referring to the Safety Application Guide.

FUNCTION DESCRIPTION

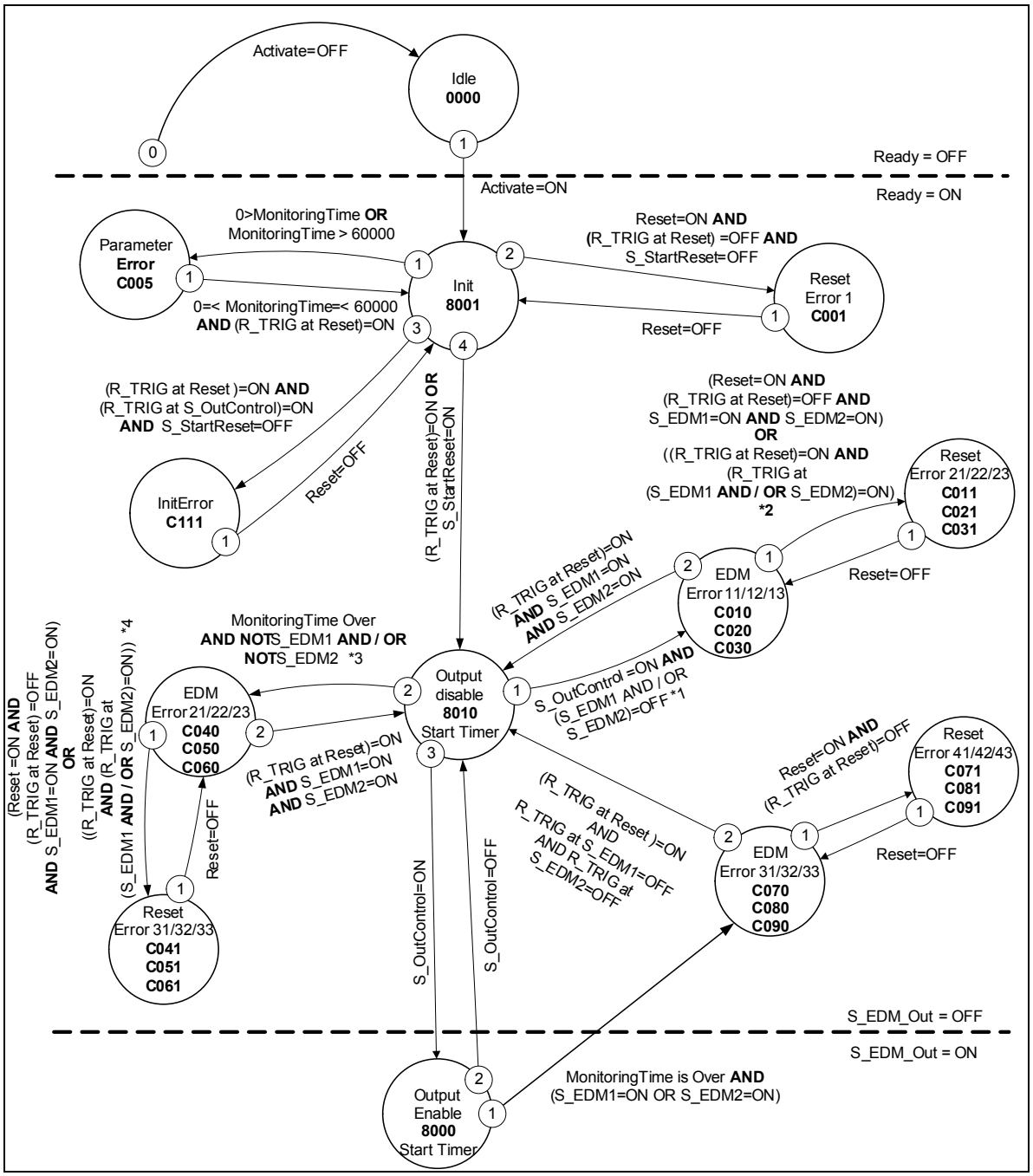
This FB controls a safety output and monitors controlled actuators.
This FB monitors the initial state of the actuators via the feedback signals (S_EDM1 and S_EDM2) before the actuators are enabled by the FB.
The function block monitors the switching state of the actuators. When both switches don't switch after MonitoringTime, the actuators are disabled by this 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 there is only one pair input from the actuators, the user must connect them to dual inputs terminals of the safety remote I/O station. And the safe input must be connected to S_EDM1 and S_EDM2.
Whether the S_EDM1, S_EDM2 and S_EDM_Out are set to ON or OFF properly depends on the following conditions in the table below.

Name	Initial state or connected actuators are not activated.	Connected actuators are activated.
S_EDM1, S_EDM2	ON	OFF
S_EDM_Out	OFF	ON

Set the S_EDM1 and S_EDM2 to ON in the initial state. The connected actuator will be activated (S_EDM_Out=ON) if S_EDM1 and S_EDM2 are set to ON when S_OutControl is set to ON. (The connected actuator is changed to error status if S_EDM1 or S_EDM2 are set to OFF.)
After the connected actuator is activated (S_EDM_Out=ON), MonitoringTime monitors that S_EDM1 and S_EDM2 are set to OFF. If S_EDM1 and S_EDM2 are not set to OFF after the MonitoringTime period, the connected actuator will not be activated (S_EDM_Out=OFF), and be changed to error status.
After the connected actuator is not activated (S_EDM_Out=OFF), MonitoringTime monitors that S_EDM1 and S_EDM2 are set to ON. If S_EDM1 and S_EDM2 are not set to ON after the MonitoringTime period, the connected actuator will be changed to error status.

⚠ [WARNING]
- The switching devices used in the safety function should be selected from the category specified in the risk analysis (EN 954-1).
- MonitoringTime shall be selected proper value and verified by the user.

STATE DIAGRAM



Note1: The transition from any state to the Idle state due to Activate=OFF is not shown. However these transitions have the highest priority (0).

Note2: The F+EDM state transition from C005 to 8001 is only due to the online change performed when the safety CPU operating mode is set to the test mode.

Figure 4.5 State Diagram for F+EDM, S+EDM

*1: The conditions of the transition from 8010 to C010, C020, or C030 are listed below.

State Transition	Condition of Transition
8010 to C010	S_OutControl=ON AND S_EDM1=OFF
8010 to C020	S_OutControl=ON AND S_EDM2=OFF
8010 to C030	S_OutControl=ON AND S_EDM2=OFF AND S_EDM1=OFF

*2: The condition of the transition from C010, C020, or C030 to C011, C021, or C031 are listed below.

State Transition	Condition of Transition
C010 to C011	R_TRIG at Reset=ON AND R_TRIG at S_EDM1=ON (after OR)
C020 to C021	R_TRIG at Reset=ON AND R_TRIG at S_EDM2=ON (after OR)
C030 to C031	R_TRIG at Reset=ON AND R_TRIG at S_EDM1=ON AND R_TRIG at S_EDM2=ON (after OR)

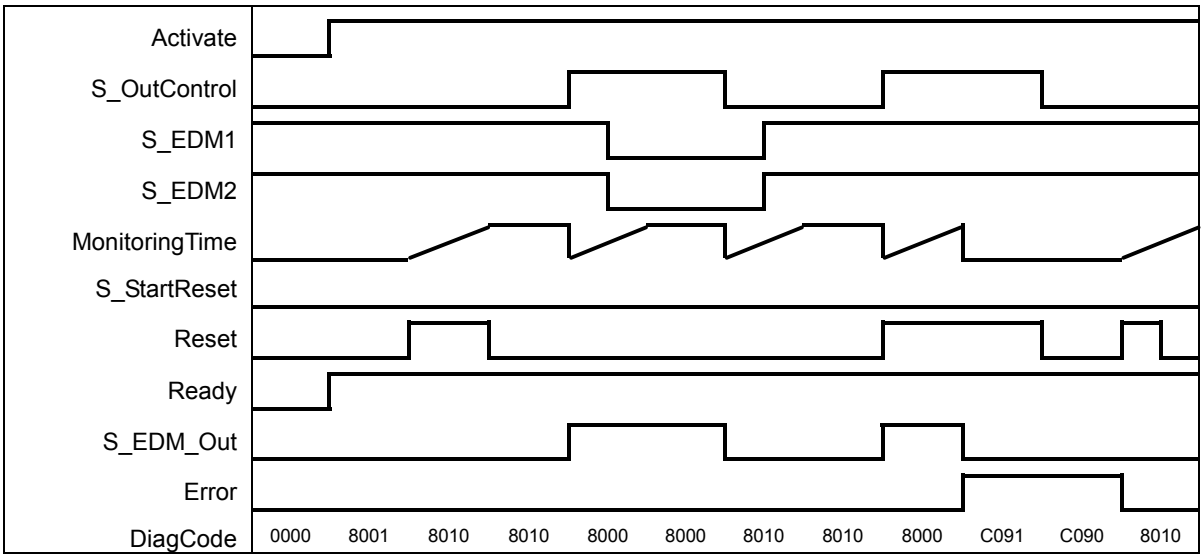
*3: The condition details of the transition from 8010 to C040, C050, or C060 are listed below.

State Transition	Condition of Transition
8010 to C040	Monitoring Time Over AND S_EDM1=OFF
8010 to C050	Monitoring Time Over AND S_EDM2=OFF
8010 to C060	Monitoring Time Over AND S_EDM2=OFF AND S_EDM1=OFF

*4: The condition details of the transition from C040, C050, or C060 to C041, C051, or C061 are listed below.

State Transition	Condition of Transition
C040 to C041	R_TRIG at Reset=ON AND R_TRIG at S_EDM1=ON (after OR)
C050 to C051	R_TRIG at Reset=ON AND R_TRIG at S_EDM2=ON (after OR)
C060 to C061	R_TRIG at Reset=ON AND R_TRIG at S_EDM1=ON AND R_TRIG at S_EDM2=ON (after OR)

TYPICAL TIMING DIAGRAM



*: The measurement of the MonitoringTime elapsed time stops due to the stop of sequence program operations when the operating status of CPU modules is changed to STOP.
The measurement of the MonitoringTimer elapsed time continues until the time configured in the safety FB input signal “MonitoringTime”, after S_EDM1 and S_EDM2 are set to ON or OFF properly according to the status of whether S_EDM_Out is ON or OFF.

Figure 4.6 Typical Timing Diagram for F+EDM, S+EDM (S_StartReset=OFF)

ERROR BEHAVIOR

In the event of an error, the output signals behave as listed below.
For the corrective actions, see the ERROR CODES.

Output Signal	Status
Ready	ON
S_EDM_Out	OFF
Error	ON

ERROR CODES

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
C001	Reset Error1	Static Reset signal in state 8001.	Set Reset to OFF.
C005	Parameter Error	The value of MonitoringTime is out of range.	Set MonitoringTime to the proper value.
C011 C021 C031	Reset Error 21/22/23	Static Reset signal or rising trigger at Reset and S_EDMx at the same time in state C010/C020/C030.	Set Reset to OFF. Check the connection and wiring of Reset and S_EDM.
C041 C051 C061	Reset Error 31/32/33	Static Reset signal or rising trigger at Reset and S_EDMx at the same time in state C040/C050/C060.	
C071 C081 C091	Reset Error 41/42/43	Static Reset signal in state C070/C080/C090.	Set Reset to OFF.
C010	EDM Error11	The signal at S_EDM1 is not valid in the initial actuator state. In state 8010 the S_EDM1 signal is OFF when enabling S_OutControl.	Set S_EDM to ON (initial value), and reset the safety FB.
C020	EDM Error12	The signal at S_EDM2 is not valid in the initial actuator state. In state 8010 the S_EDM2 signal is OFF when enabling S_OutControl.	
C030	EDM Error13	The signals at S_EDM1 and S_EDM2 are not valid in the initial actuator states. In state 8010 the S_EDM1 and S_EDM2 signals are OFF when enabling S_OutControl.	
C040	EDM Error21	The signal at S_EDM1 is not valid in the initial actuator state. In state 8010 the S_EDM1 signal is OFF and the monitoring time has elapsed.	
C050	EDM Error22	The signal at S_EDM2 is not valid in the initial actuator state. In state 8010 the S_EDM2 signal is OFF and the monitoring time has elapsed.	
C060	EDM Error23	The signals at S_EDM1 and S_EDM2 are not valid in the initial actuator states. In state 8010 the S_EDM1 and S_EDM2 signals are OFF and the monitoring time has elapsed.	
C070	EDM Error31	The signal at S_EDM1 is not valid in the actuator switching state. In state 8000 the S_EDM1 signal is ON and the monitoring time has elapsed.	Check a failure and the behavior of the actuator, the wiring and the status of the safety remote I/O station. After the check, reset the safety FB.
C080	EDM Error32	The signal at S_EDM2 is not valid in the actuator switching state. In state 8000 the S_EDM2 signal is ON and the monitoring time has elapsed.	
C090	EDM Error33	The signals at S_EDM1 and S_EDM2 are not valid in the actuator switching state. In state 8000 the S_EDM1 and S_EDM2 signals are ON and the monitoring time has elapsed.	
C111	Init Error	Similar signals at S_OutControl and Reset (R_TRIG at same cycle) detected (maybe a programming error).	Check the wiring and the connection of variables in the program. After the check, reset the safety FB.

STATUS CODES (no error)

<table>
<tr><th>Diag Code (Hexadecimal)</th><th>State Name</th><th>Description, Output Setting</th><th>Actions</th></tr>
<tr><td>0000</td><td>Idle</td><td>The function block is not active.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>OFF</td></tr>
<tr><td>S_EDM_Out</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Initialize the safety FB by setting Activate to ON.</td></tr>
<tr><td>8001</td><td>Init</td><td>Block activation startup inhibit is active.
(S_StartResetOFF)
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_EDM_Out</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Reset the safety FB.</td></tr>
<tr><td>8010</td><td>Output Disable</td><td>EDM control is not active. Timer starts when state is entered
(S_EDM_Out=OFF)
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_EDM_Out</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Set S_OutControl to ON.</td></tr>
<tr><td>8000</td><td>Output Enable</td><td>EDM control is active. Timer starts when state is entered.
(S_EDM_Out=ON)
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_EDM_Out</td><td>ON</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>None.</td></tr>
</table>

⚠ [WARNING]
Please do the above actions when the FB detects error or is an unexpected state.
However, when still the situation is not corrected, please check following.
- A failure in safe devices and emergency stop devices
- Wiring and status of a safety remote I/O stations and a safety Programmable Controller
- Programming logics, the memory allocation of safety devices and the connections of FB variables
- Setting of S_StartReset and S_AutoReset

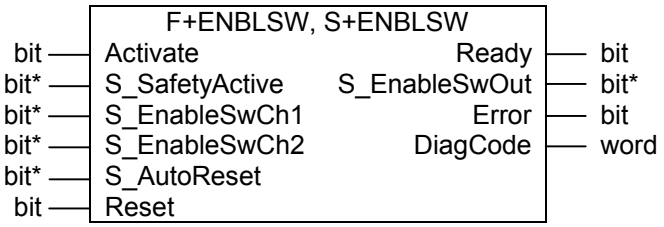
APPLICATION EXAMPLE

For applications, see the Safety Application Guide.

APPLICABLE SAFETY STANDARDS

Standards	Requirements
IEC 60204-1, Ed.5.0: 2003	Section 9.2.2: Stop function categories; Category 0
EN 954-1: 1996	5.2: Stop function; stop initiated by protective devices shall put the machine in a safe state 6.2: Specification of categories: Fault detection (of the actuator, e.g. open circuits)
ISO 12100-2:2003	4.11.4: Restart following power failure/spontaneous restart
EN 954-1: 1996	5.4 Manual reset

4.4 F+ENBLSW, S+ENBLSW



OVERVIEW

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

INPUT/OUTPUT

I/O	Name	Data Type	Initial Value	Description, Parameter Values
IN	Activate	bit	OFF	Activation of the safety FB. For details, see Section 2.5.
	S_SafetyActive	bit*	OFF	Confirmation of the safe mode (limitation of the speed or the power of motion, limitation of the range of motion). OFF : Safe mode is not active. ON : Safe mode is active.
	S_EnableSwCh1	bit*	OFF	Signal of contacts E1 and E2 of the connected enable switch. (See “Function Description”) OFF : Contacts E1 and E2 signals are set to OFF. ON : Contacts E1 and E2 signals are set to ON.
	S_EnableSwCh2	bit*	OFF	Signal of contacts E3 and E4 of the connected enable switch. (See “Function Description”) OFF : Contacts E3 and E4 signals are set to OFF. ON : Contacts E3 and E4 signals are set to ON.
	S_AutoReset	bit*	OFF	Selection of a reset method for the input signal reset to ON. For details, see Section 2.5.
	Reset	bit	OFF	Reset input. For details, see Section 2.5.
OUT	Ready	bit	OFF	Status of whether the safety FB is activated or not. For details, see Section 2.5.
	S_EnableSwOut	bit*	OFF	Safety output OFF : Disables manual operation using enable switches. ON : Enables manual operation using enable switches.
	Error	bit	OFF	Error flag. For details, see Section 2.5.
	DiagCode	word	0	Diagnostic code. For details, see Section 2.5.

[WARNING]
Use safety data (See Appendix 2.) for connecting the variable whose data type is “bit*” to input - output circuits.
Wire the safety input - output devices and set parameters correctly, referring to the Safety Application Guide.

FUNCTION DESCRIPTION

This safety FB supports the function enables manual operations by using enable switches with three positions, selecting the operating mode (S_SafetyActive is set to ON.).
The operating mode must be selected outside this safety FB.
The status of enable switch contacts (The signal E1+E2 must be connected to S_EnableSwCh1. The signal E3+E4 must be connected to S_EnableSwCh2.) is monitored and the current position of enable switches is detected.
The manual operation can be enabled by this FB whose S_EnableSwOut is set to ON, after a move from position 1 to position 2.
Other switching directions or positions may not be used to enable the manual operation when S_EnableSwOut is OFF.

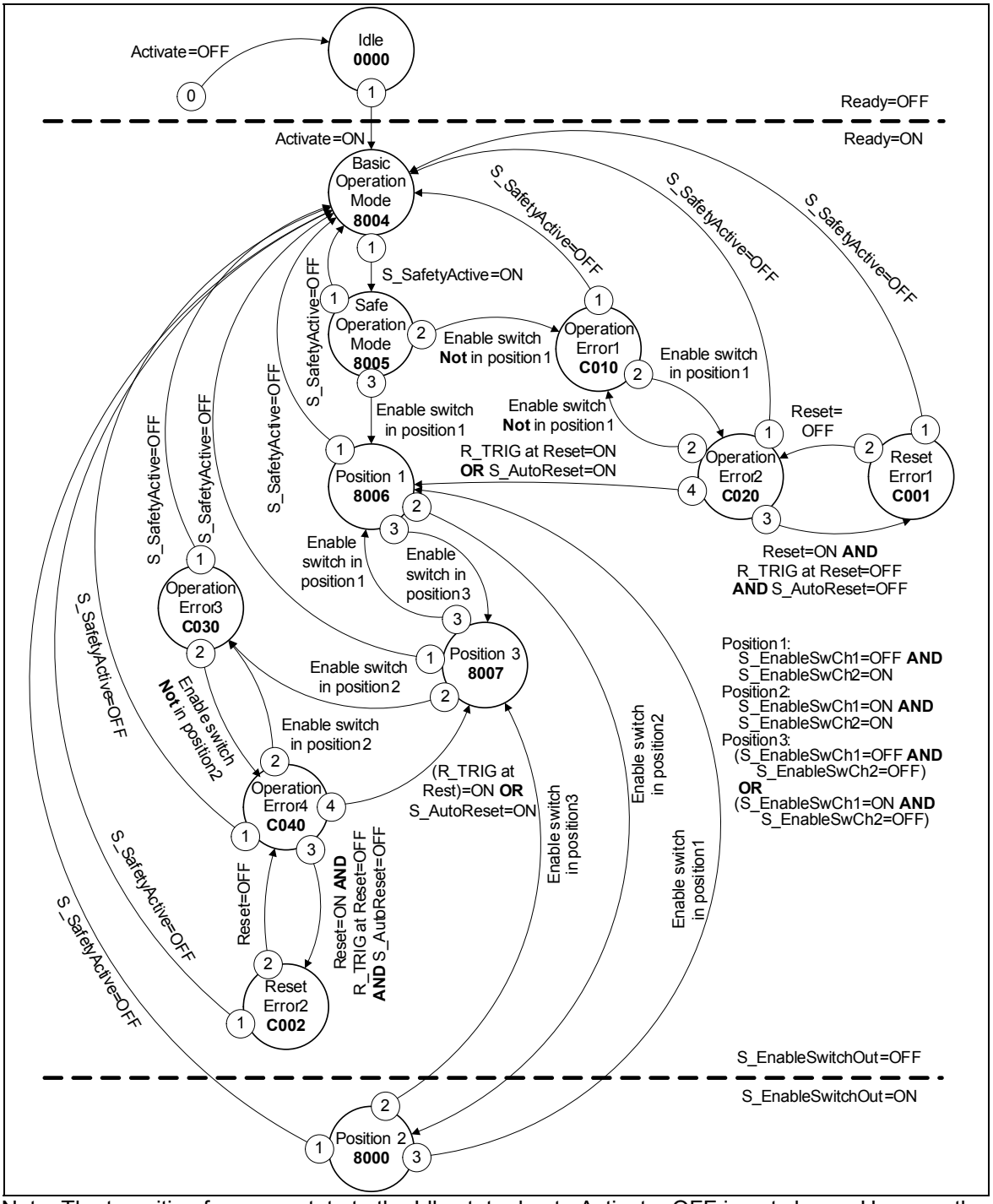
Table 4.1 Enable Switch Contacts Status and Position

	Position 1 (Not pressed)	Position 2 (Mid position)	Position 3 (Past mid position)
Contacts E1+E2 status	OFF	ON	OFF
Contacts E3+E4 status	ON	ON	OFF

When returning from position 3 to position 2, the enabling function is not activated.
The status of the contacts E1+E2 set to ON and contacts E3+E4 set to OFF does not exist as a contact status for the enable switch with three positions. If the status is detected, the status refers to position 3.

[WARNING]
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 (DIN EN 60204 Section 9.2.3) is selected in the application (automatic operation must be disabled in this operating mode using appropriate measures).

STATE DIAGRAM



Note: The transition from any state to the Idle state due to Activate=OFF is not shown. However these transitions have the highest priority (0).

Figure 4.7 State Diagram for F+ENBLSW, S+ENBLSW

TYPICAL TIMING DIAGRAM

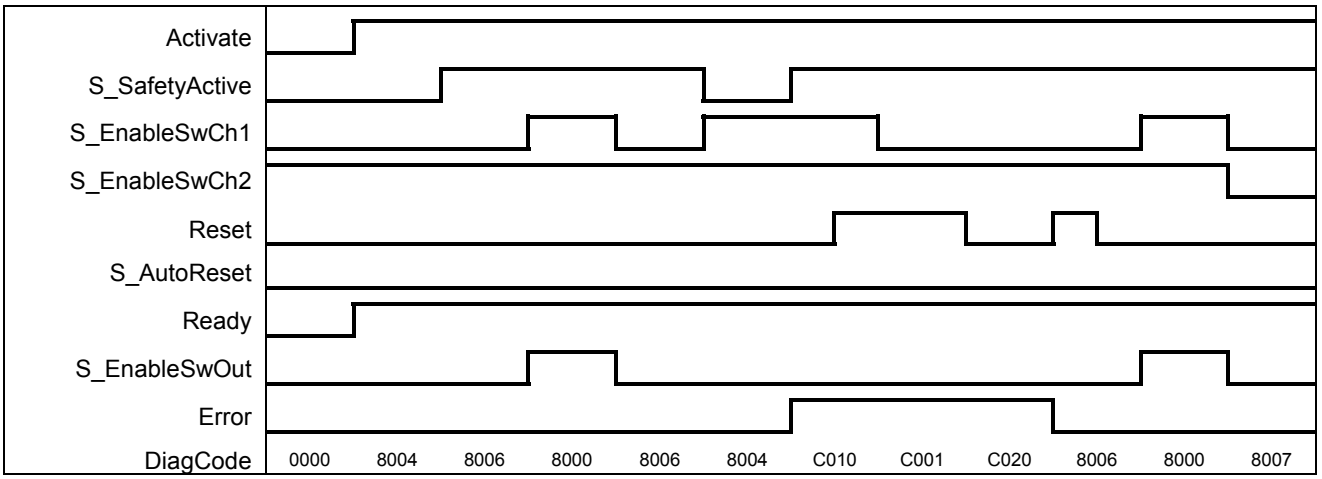


Figure 4.8 Typical Timing Diagram for F+ENBLSW, S+ENBLSW (S_AutoReset=OFF)

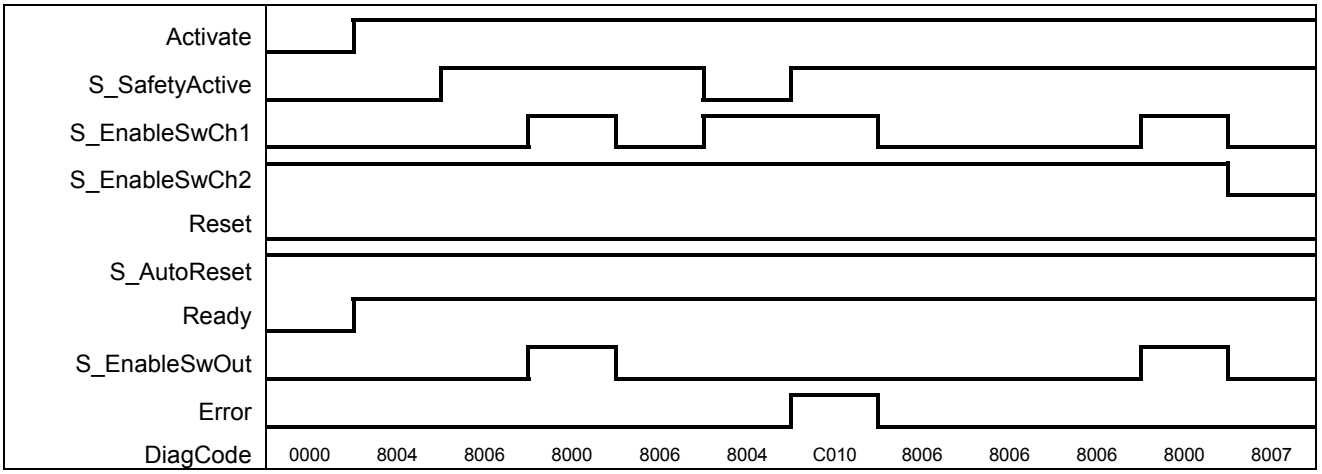


Figure 4.9 Typical Timing Diagram for F+ENBLSW, S+ENBLSW (S_AutoReset=ON)

ERROR BEHAVIOR

In the event of an error, the output signals behave as listed below.
For the corrective actions, see the ERROR CODES.

Output Signal	Status
Ready	ON
S_EnableSwOut	OFF
Error	ON

ERROR CODES

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
C001	Reset Error1	Static Reset signal detected in state C020.	Set Reset to OFF. Check the wiring and devices related to Reset signal. Set S_SafetyActiv to OFF.
C002	Reset Error2	Static Reset signal detected in state C040.	
C010	Operation Error1	Enable switch not in position1 during activation of S_SafetyActive.	Set the switch to position1, and S_SafetyActive to OFF.
C020	Operation Error2	Enable switch in position1 after C010.	Set the switch to position1, and set S_SafetyActive to OFF. Or, reset the safety FB.
C030	Operation Error3	Enable switch in position2 after position3.	
C040	Operation Error4	Enable switch not in position2 after C030.	

STATUS CODES (no error)

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
0000	Idle	The function block is not active (initial state). Output Signal / Status Ready: OFF S_EnableSwOut: OFF Error: OFF	Initialize the safety FB by setting Activate to ON.
8004	Basic Operation Mode	Safe operation mode is not active. Output Signal / Status Ready: ON S_EnableSwOut: OFF Error: OFF	Activate the safe operation mode by setting S_SafetyActive to ON.
8005	Safe Operation Mode	Safe operation mode is active. Output Signal / Status Ready: ON S_EnableSwOut: OFF Error: OFF	Set the switch to postion1. Check a failure, wiring and state of the safety remote I/O station.
8006	Position1	Safe operation mode is active and the enable switch is in position1. Output Signal / Status Ready: ON S_EnableSwOut: OFF Error: OFF	Set the switch to postion2.
8007	Position3	Safe operation mode is active and the enable switch is in position3. Output Signal / Status Ready: ON S_EnableSwOut: OFF Error: OFF	Set the switch to position1, or S_SafetyActive to OFF.
8000	Position2	Safe operation mode is active and the enable switch is in position2. Output Signal / Status Ready: ON S_EnableSwOut: ON Error: OFF	None.

[WARNING]
Please do the above actions when the FB detects error or is an unexpected state.
However, when still the situation is not corrected, please check following.
- A failure in safe devices and emergency stop devices
- Wiring and status of a safety remote I/O stations and a safety Programmable Controller
- Programming logics, the memory allocation of safety devices and the connections of FB variables
- Setting of S_StartReset and S_AutoReset

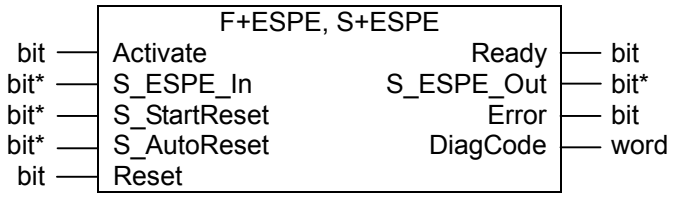
APPLICATION EXAMPLE

For applications, see the Safety Application Guide.

APPLICABLE SAFETY STANDARDS

Standards	Requirements
IEC 60204-1, Ed. 5.0: 2003	9.2.6.3: Enabling control (see also 10.9) is a manually activated control function interlock that: a) when activated allows a machine operation to be initiated by a separate start control, and b) when de-activated - initiates a stop function, and - prevents initiation of machine operation. Enabling control shall be so arranged as to minimize the possibility of defeating, for example by requiring the de-activation of the enabling control device before machine operation may be reinitiated. It should not be possible to defeat the enabling function by simple means. 10.9: When an enabling control device is provided as a part of a system, it shall signal the enabling control to allow operation when actuated in one position only. In any other position, operation shall be stopped or prevented. Enabling control devices shall be selected that have the following features: … -- for a three-position type: - position 1: off-function of the switch (actuator is not operated); - position 2: enabling function (actuator is operated in its mid position); - position 3: off-function (actuator is operated past its mid position); - when returning from position 3 to position 2, the enabling function is not activated.
EN 954-1: 1996	5.4 Manual reset
ISO 12100-2:2003	4.11.4: Restart following power failure/spontaneous restart

4.5 F+ESPE, S+ESPE



OVERVIEW

This function block is a safety-related function block for monitoring electro-sensitive protective equipment (ESPE).
This FB can be used for emergency switch off functionality (stop category 0).

INPUT/OUTPUT

I/O	Name	Data Type	Initial Value	Description, Parameter Values
IN	Activate	bit	OFF	Activation of the safety FB. For details, see Section 2.5.
	S_ESPE_In	bit*	OFF	Input signal from ESPE. OFF : Input signal from ESPE is set to OFF. (Example: Light shielding of light curtain) ON : Input signal from ESPE is set to ON. (Example : Light passing through light curtain)
	S_StartReset	bit*	OFF	Selection of a reset method for the activated (first time) safety FB. For details, see Section 2.5.
	S_AutoReset	bit*	OFF	Selection of a reset method for the input signal (S_In) reset to ON. For details, see Section 2.5.
	Reset	bit	OFF	Reset input. For details, see Section 2.5.
OUT	Ready	bit	OFF	Status of whether the safety FB is activated or not. For details, see Section 2.5.
	S_ ESPE_Out	bit*	OFF	Safety output OFF : Safety output disabled. ON : Safety output enabled.
	Error	bit	OFF	Error flag. For details, see Section 2.5.
	DiagCode	word	0	Diagnostic code. For details, see Section 2.5.

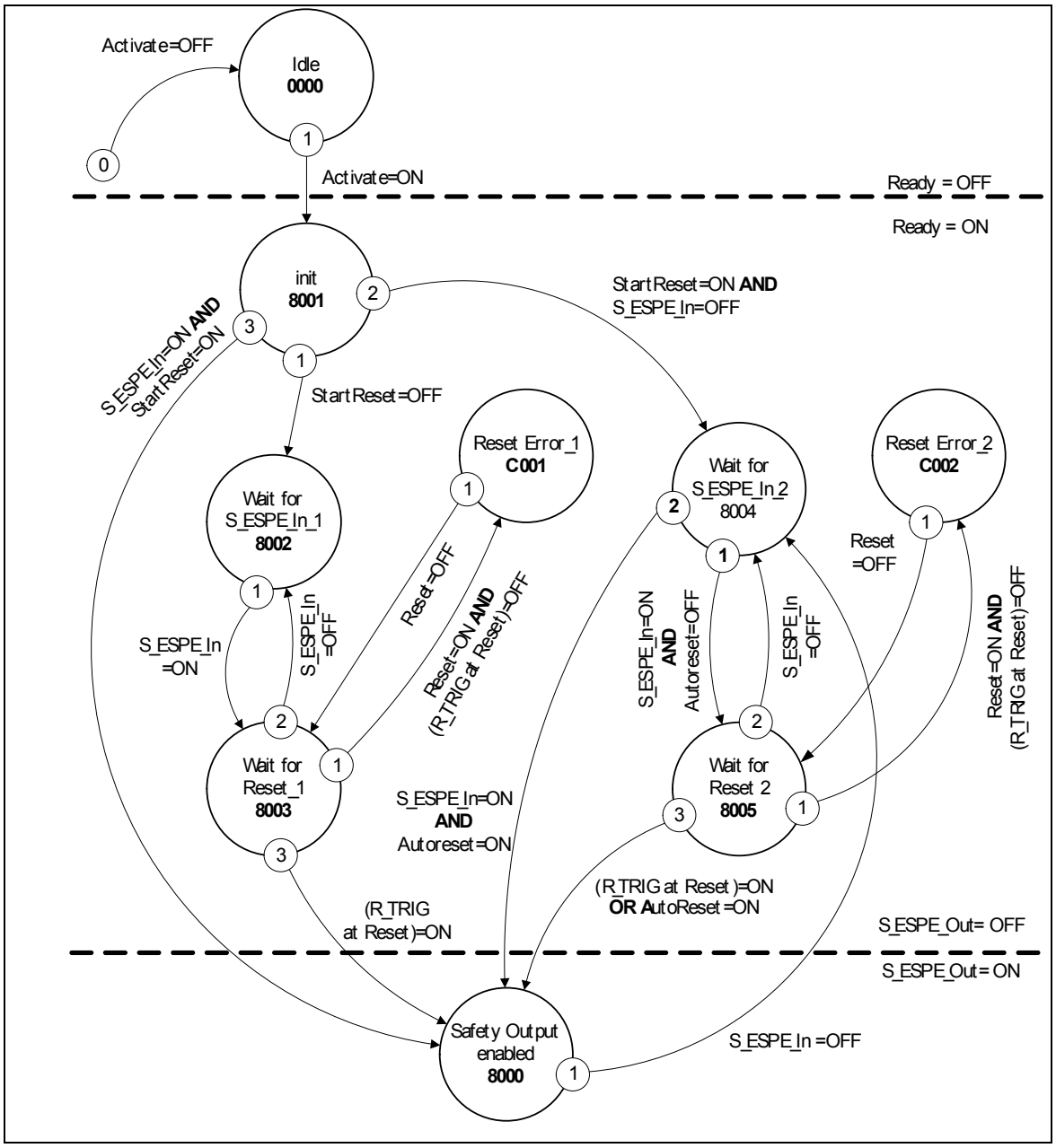
[WARNING]
Use safety data (See Appendix 2.) for connecting the variable whose data type is “bit*” to input - output circuits.
Wire the safety input - output devices and set parameters correctly, referring to the Safety Application Guide.

FUNCTION DESCRIPTION

This function block is a safety-related function block for monitoring ESPE. The function is identical to S+ESTOP. The S_ESPE_Out output signal is set to OFF as soon as the S_ESPE_In input is set to OFF. The S_ESPE_Out output signal is set to ON only if the S_ESPE_In input is set to ON and a reset occurs.

[WARNING]
- The enable signal (S_ESPE_Out) may only control the process directly if this does not adversely affect the safety function. In this regard, validate the entire path of the safety function, including the startup behavior of the process to be controlled.
- The ESPE must be selected in respect of the product standards IEC 61496-1, -2 and -3 and the required categories according EN 954-1.

STATE DIAGRAM



Note: The transition from any state to the Idle state due to Activate=OFF is not shown. However these transitions have the highest priority (0).

Figure 4.10 State Diagram for F+ESPE, S+ESPE

TYPICAL TIMING DIAGRAM

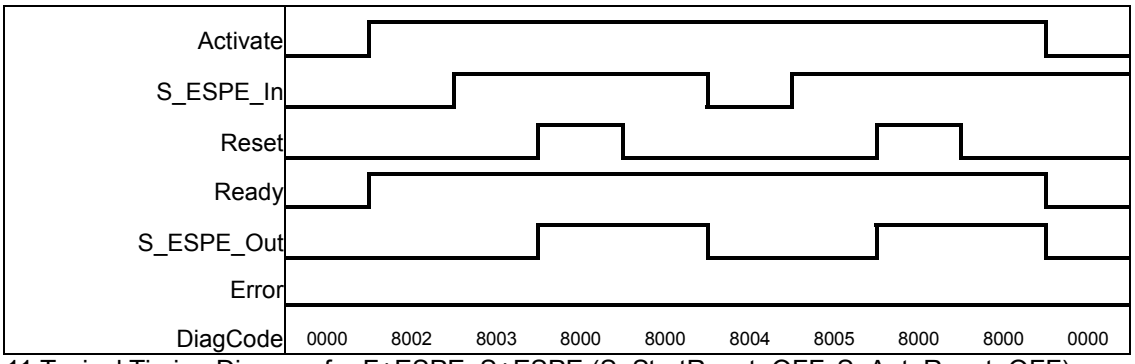


Figure 4.11 Typical Timing Diagram for F+ESPE, S+ESPE (S_StartReset=OFF, S_AutoReset=OFF)
(start, reset, normal operation, safety demand, restart)

ERROR BEHAVIOR

In the event of an error, the output signals behave as listed below.
For the corrective actions, see the ERROR CODES.

Output Signal	Status
Ready	ON
S_ESPE_Out	OFF
Error	ON

ERROR CODES

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
C001	Reset Error1	Reset is ON while waiting for S_ESPE_In=ON.	Set Reset to OFF. Check the devices and wiring related to Reset.
C002	Reset Error2	Reset is ON while waiting for S_ESPE_In=ON.	

STATUS CODES (no error)

<table>
<tr><th>DiagCode (Hexadecimal)</th><th>State Name</th><th>Description, Output Setting</th><th>Actions</th></tr>
<tr><td>0000</td><td>Idle</td><td>The function block is not active (initial state).
All safety FB outputs are OFF.
Set DiagCode to 0.
<table><tr><th>Output Signal</th><th>Status</th></tr><tr><td>Ready</td><td>OFF</td></tr><tr><td>S_ESPE_Out</td><td>OFF</td></tr><tr><td>Error</td><td>OFF</td></tr></table></td><td>Initialize the safety FB by setting Activate to ON.</td></tr>
<tr><td>8001</td><td>Init</td><td>Activation is ON. The function block was enabled.
<table><tr><th>Output Signal</th><th>Status</th></tr><tr><td>Ready</td><td>ON</td></tr><tr><td>S_ESPE_Out</td><td>OFF</td></tr><tr><td>Error</td><td>OFF</td></tr></table></td><td rowspan="2">Wait for S_ESPE_In=ON.</td></tr>
<tr><td>8002</td><td>Wait for S_ESPE_In1</td><td>Activation is ON.
(S_StartReset=OFF)
<table><tr><th>Output Signal</th><th>Status</th></tr><tr><td>Ready</td><td>ON</td></tr><tr><td>S_ESPE_Out</td><td>OFF</td></tr><tr><td>Error</td><td>OFF</td></tr></table></td></tr>
<tr><td>8003</td><td>Wait for Reset1</td><td>Activation is ON. S_ESPE_In=ON.
(S_StartReset=OFF)
<table><tr><th>Output Signal</th><th>Status</th></tr><tr><td>Ready</td><td>ON</td></tr><tr><td>S_ESPE_Out</td><td>OFF</td></tr><tr><td>Error</td><td>OFF</td></tr></table></td><td>Wait for a rising trigger of Reset.</td></tr>
<tr><td>8004</td><td>Wait for S_ESPE_In2</td><td>Safety demand detected.
(S_StartReset=ON)
<table><tr><th>Output Signal</th><th>Status</th></tr><tr><td>Ready</td><td>ON</td></tr><tr><td>S_ESPE_Out</td><td>OFF</td></tr><tr><td>Error</td><td>OFF</td></tr></table></td><td>Wait for S_ESPE_In=ON.</td></tr>
<tr><td>8005</td><td>Wait for Reset2</td><td>Activation is ON. S_ESPE_In=ON.
<table><tr><th>Output Signal</th><th>Status</th></tr><tr><td>Ready</td><td>ON</td></tr><tr><td>S_ESPE_Out</td><td>OFF</td></tr><tr><td>Error</td><td>OFF</td></tr></table></td><td>Wait for rising trigger of Reset.</td></tr>
<tr><td>8000</td><td>Safety Output Enabled</td><td>Safety demand is not detected.
<table><tr><th>Output Signal</th><th>Status</th></tr><tr><td>Ready</td><td>ON</td></tr><tr><td>S_ESPE_Out</td><td>ON</td></tr><tr><td>Error</td><td>OFF</td></tr></table></td><td>None.</td></tr>
</table>

[WARNING]
Please do the above actions when the FB detects error or is an unexpected state.
However, when still the situation is not corrected, please check following.
- A failure in safe devices and emergency stop devices
- Wiring and status of a safety remote I/O stations and a safety Programmable Controller
- Programming logics, the memory allocation of safety devices and the connections of FB variables
- Setting of S_StartReset and S_AutoReset

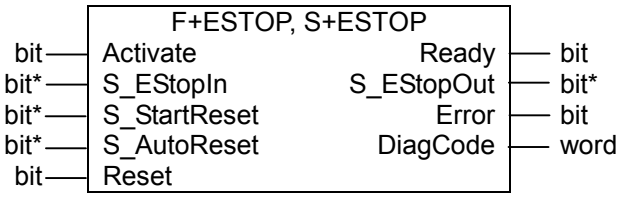
APPLICATION EXAMPLE

For applications, see the Safety Application Guide.

APPLICABLE SAFETY STANDARDS

Standards	Requirements
EN IEC 61496-1: 2004	A.5.1 Start Interlock: The start interlock shall prevent the OSSD(s) going to the ON-state when the electrical supply is switched on, or is interrupted and restored. A.5.2: A failure of the start interlock which causes it to go to, or remain in a permanent Onstate shall cause the ESPE to go to, or to remain in the lock-out condition. A.6.1 Restart interlock: … The interlock condition shall continue until the restart interlock is manually reset. However, it shall not be possible to reset the restart interlock whilst the sensing device is actuated.
EN 954-1: 1996	5.4 Manual reset
ISO 12100-2:2003	4.11.4: Restart following power failure/spontaneous restart

4.6 F+ESTOP, S+ESTOP



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).

INPUT/OUTPUT

I/O	Name	Data Type	Initial Value	Description, Parameter Values
IN	Activate	bit	OFF	Activation of the safety FB. For details, see Section 2.5.
	S_EStopIn	bit*	OFF	Input signal from an emergency stop button. OFF : Input signal from an emergency stop button is set to OFF. (An emergency stop button is engaged.) ON : Input signal from an emergency stop button is set to ON. (An emergency stop button is not engaged.)
	S_StartReset	bit*	OFF	Selection of a reset method for the activated (first time) safety FB. For details, see Section 2.5.
	S_AutoReset	bit*	OFF	Selection of a reset method for the input signal (S_EStopIn) reset to ON. For details, see Section 2.5.
	Reset	bit	OFF	Reset input. For details, see Section 2.5.
OUT	Ready	bit	OFF	Status of whether the safety FB is activated or not. For details, see Section 2.5.
	S_EStopOut	bit*	OFF	Safety ouput OFF : Safety output disabled. ON : Safety output enabled.
	Error	bit	OFF	Error flag. For details, see Section 2.5.
	DiagCode	word	0	Diagnostic code. For details, see Section 2.5.

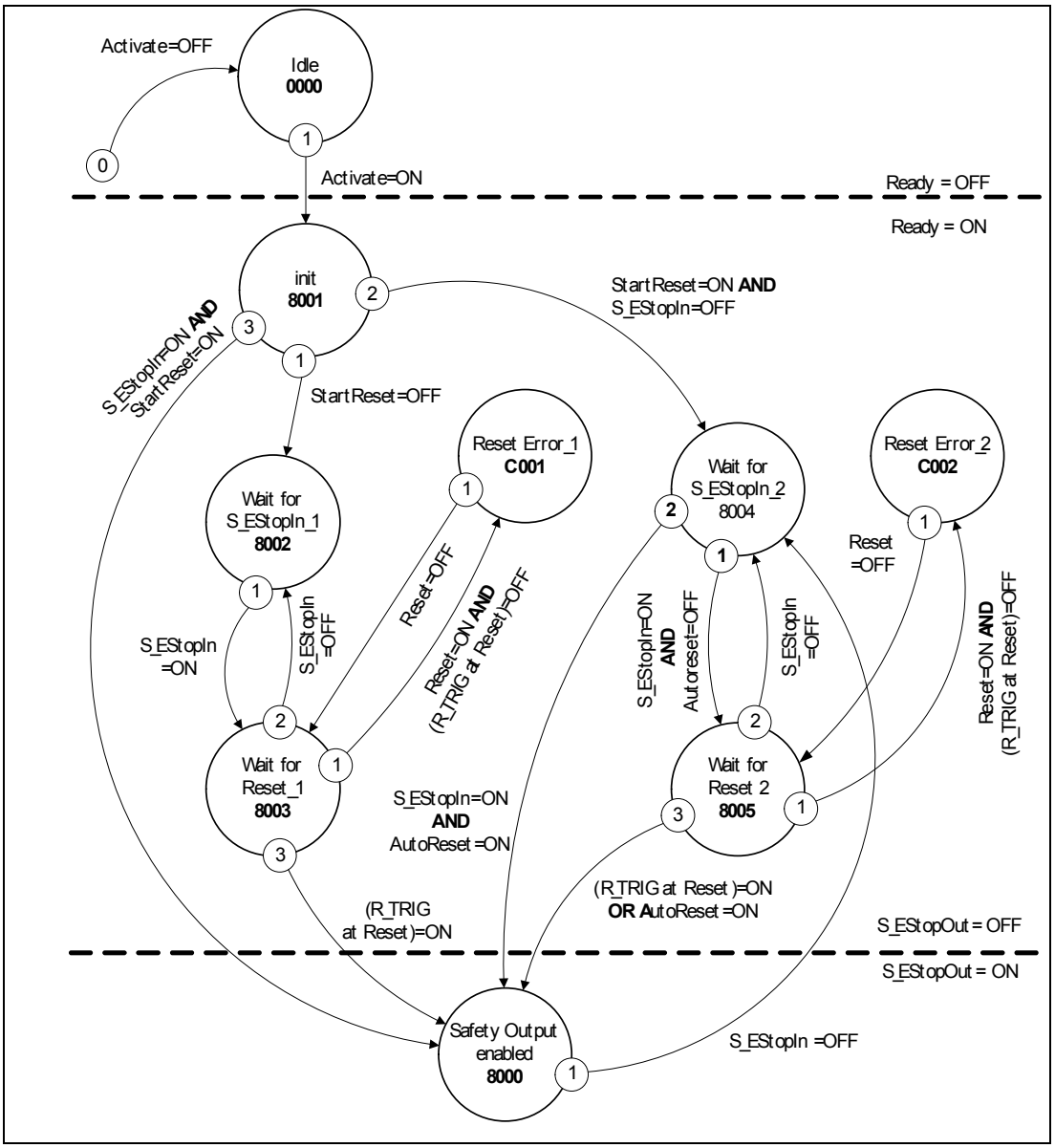
[WARNING]
Use safety data (See Appendix 2.) for connecting the variable whose data type is “bit*” to input - output circuits.
Wire the safety input - output devices and set parameters correctly, referring to the Safety Application Guide.

FUNCTION DESCRIPTION

The S_EStopOut output signal is reset to OFF as soon as the S_EStopIn input is set to OFF.
The S_EStopOut output signal is reset to ON only if the S_EStopIn input is set to ON and a reset occurs.
If the automatic reset is selected for S_StartReset and S_AutoReset, reset is not required.

[WARNING]
The signal (S_EstopOut) may only control the process directly if this does not adversely affect the safety function. In this regard, validate the entire path of the safety function, including the startup behavior of the process to be controlled.

STATE DIAGRAM



Note: The transition from any state to the Idle state due to Activate=OFF is not shown. However these transitions have the highest priority (0).

Figure 4.12 State Diagram for F+ESTOP, S+ESTOP

TYPICAL TIMING DIAGRAM

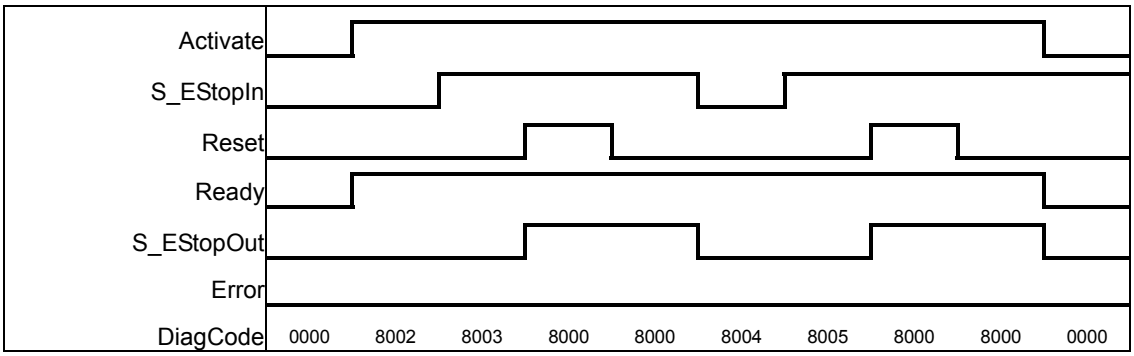


Figure 4.13 Typical Timing Diagram for F+ESTOP, S+ESTOP (S_StartReset=OFF, S_AutoReset=OFF)

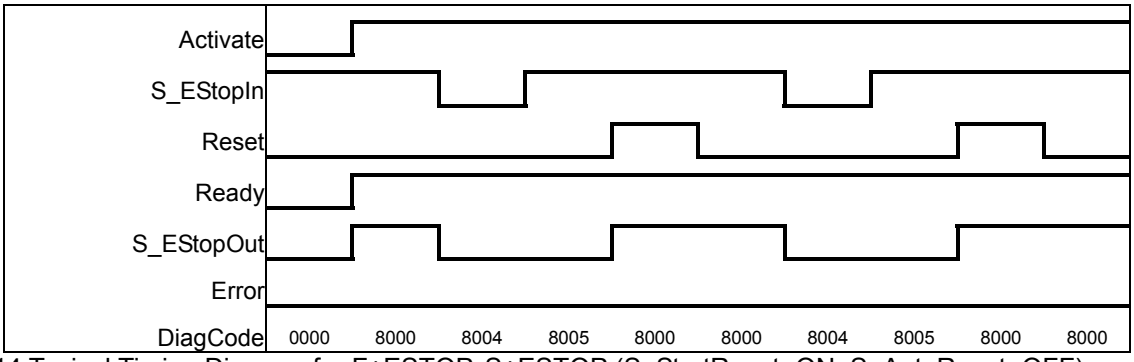


Figure 4.14 Typical Timing Diagram for F+ESTOP, S+ESTOP (S_StartReset=ON, S_AutoReset=OFF)

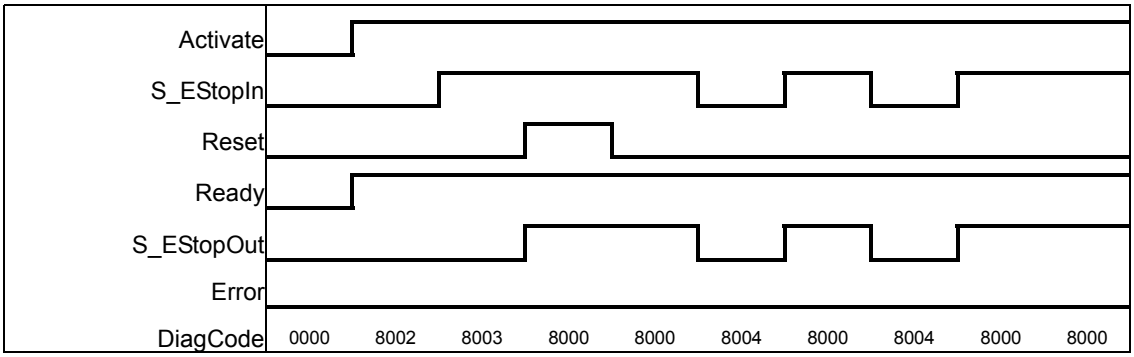


Figure 4.15 Typical Timing Diagram for F+ESTOP, S+ESTOP (S_StartReset=OFF, S_AutoReset=ON)

ERROR BEHAVIOR

In the event of an error, the output signals behave as listed below.
For the corrective actions, see the ERROR CODES.

Output Signal	Status
Ready	ON
S_EStopOut	OFF
Error	ON

ERROR CODES

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
C001	Reset Error1	Reset is ON while waiting for S_ESPE_In=ON.	Set Reset to OFF. Check the devices and wiring related to Reset.
C002	Reset Error2	Reset is ON while waiting for S_EstopIn=ON.	

STATUS CODES (no error)

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
0000	Idle	The function block is not active (initial state). All safety FB outputs are OFF. Set DiagCode to 0. Output Signal / Status Ready: OFF S_EStopOut: OFF Error: OFF	Initialize the safety FB by setting Activate to ON.
8001	Init	Activation is ON. The function block was enabled. Output Signal / Status Ready: ON S_EStopOut: OFF Error: OFF	Wait for S_EstopIn=ON.
8002	Wait for S_EstopIn1	Activation is ON. (S_StartReset=OFF) Output Signal / Status Ready: ON S_EStopOut: OFF Error: OFF	
8003	Wait for Reset1	Activation is ON. S_EstopIn=ON. (S_StartReset=OFF) Output Signal / Status Ready: ON S_EStopOut: OFF Error: OFF	Wait for a rising trigger of Reset.
8004	Wait for S_EstopIn2	Safety demand detected. (S_StartReset=ON) Output Signal / Status Ready: ON S_EStopOut: OFF Error: OFF	Wait for S_EstopIn=ON.
8005	Wait for Reset2	Activation is ON. Output Signal / Status Ready: ON S_EStopOut: OFF Error: OFF	Wait for rising trigger of Reset.
8000	Safety Output Enabled	Safety demand is not detected. Output Signal / Status Ready: ON S_EStopOut: ON Error: OFF	None.

[WARNING]
Please do the above actions when the FB detects error or is an unexpected state.
However, when still the situation is not corrected, please check following.
- A failure in safe devices and emergency stop devices
- Wiring and status of a safety remote I/O stations and a safety Programmable Controller
- Programming logics, the memory allocation of safety devices and the connections of FB variables
- Setting of S_StartReset and S_AutoReset

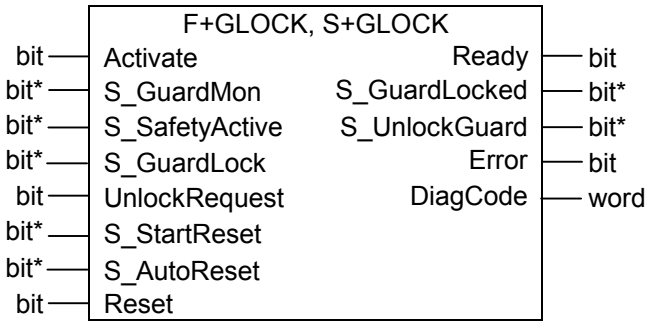
APPLICATION EXAMPLE

For applications, see the Safety Applicaion Guide.

APPLICABLE SAFETY STANDARDS

Standards	Requirements
EN 418: 1992	Definitions 4.1.12 ... Resetting the control device shall not by itself cause a restart command. **Notes**: The following requirements as defined in EN 418: 1992 have to be fulfilled by the user: Ch. 4.1.4 After activation of the actuator, the emergency stop equipment shall operate in such a way that the hazard is averted or reduced automatically in the best possible manner. 4.1.7 The emergency stop command shall override all other commands. 4.1.12 Resetting the control device shall only be possible as the result of a manual action on the control device itself.... It shall not be possible to restart the machine until all control devices which have been actuated are reset manually, individually and intentionally.
EN 954-1: 1996	5.4 Manual reset
ISO 12100-2:2003	4.11.4: Restart following power failure/spontaneous restart
EN 16204-1, 1997	9.2.2. Stop Functions

4.7 F+GLOCK, S+GLOCK



OVERVIEW

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

INPUT/OUTPUT

I/O	Name	Data Type	Initial Value	Description, Parameter Values
IN	Activate	bit	OFF	Activation of the safety FB. For details, see Section 2.5.
	S_GuardMon	bit*	OFF	Monitors the guard interlocking. OFF : Guard open. ON : Guard closed.
	S_SafetyActive	bit*	OFF	Status of the hazardous area, e.g., based on speed monitoring or safe time off delay. OFF : Machine in "non-safe" state. ON : Machine in safe state.
	S_GuardLock	bit*	OFF	Status of the mechanical guard locking. OFF : Guard is not locked. ON : Guard is locked.
	UnlockRequest	bit	OFF	Operator intervention - request to unlock the guard. OFF : No request. ON : Request made.
	S_StartReset	bit*	OFF	Selection of a reset method for the activated (first time) safety FB. For details, see Section 2.5.
	S_AutoReset	bit*	OFF	Selection of a reset method for the input signal reset to ON. For details, see Section 2.5.
	Reset	bit	OFF	Reset input. For details, see Section 2.5. Also used to request the guard to be locked again. The quality of the signal must conform to a manual reset device (EN954-1 Ch. 5.4)
OUT	Ready	bit	OFF	Status of whether the safety FB is activated or not. For details, see Section 2.5.
	S_GuardLocked	bit*	OFF	Interface to hazardous area which must be stopped. OFF : No safe state. ON : Safe state. (The guard is closed and locked, so that the machine can be operated.)
	S_UnlockGuard	bit*	OFF	Signal to unlock the guard. OFF : Close guard. ON : Unlock guard.
	Error	bit	OFF	Error flag. For details, see Section 2.5.
	DiagCode	word	0	Diagnostic code. For details, see Section 2.5.

⚠ [WARNING]
Use safety data (See Appendix 2.) for connecting the variable whose data type is “bit*” to input - output circuits.
Wire the safety input - output devices and set parameters correctly, referring to the Safety Application Guide.

FUNCTION DESCRIPTION

This FB 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.

Table.4.2 Operation Sequence for Guardlock

No.	I/O	Operation
1.	-	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	Output the signal unlocking the guard to the switch (by setting the S_UnlockGuard output to ON)
5.	In	The signal that enables the guard to be unlocked is input from the switch (by setting the S_GuardLock input to OFF), which enables the guard to be opened (S_GuardLocked is set to OFF)
	-	Operator opens the guard
6.	In	Check if the guard is closed again (by setting S_GuardMon to ON)
7.	In	Feedback from operator to restart the hazardous area (Reset)
8.	Out	Lock guard (S_UnlockGuard)
9.	In	Check if guard is locked (S_GuardLock)
10.	Out	Hazardous area can operate again (S_GuardLocked=ON) (If S_AutoReset is OFF, reset is required with the Reset input.)
11.	-	Restart the operation in the hazardous area

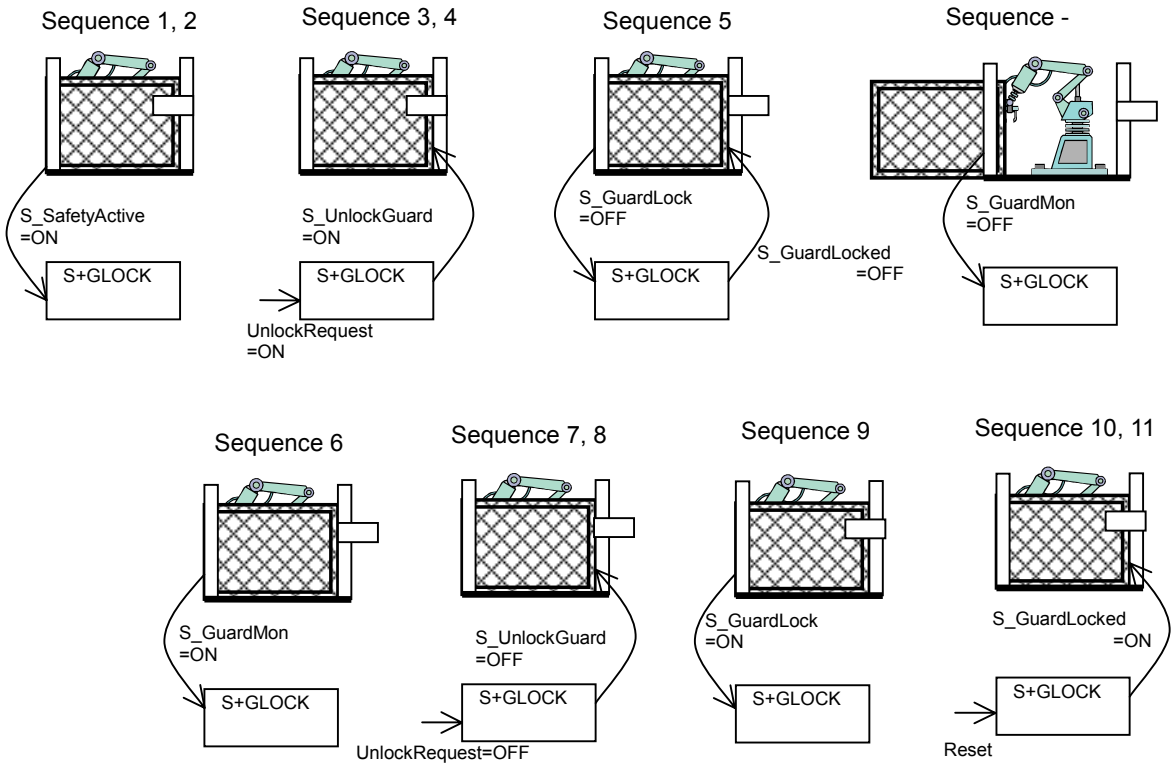
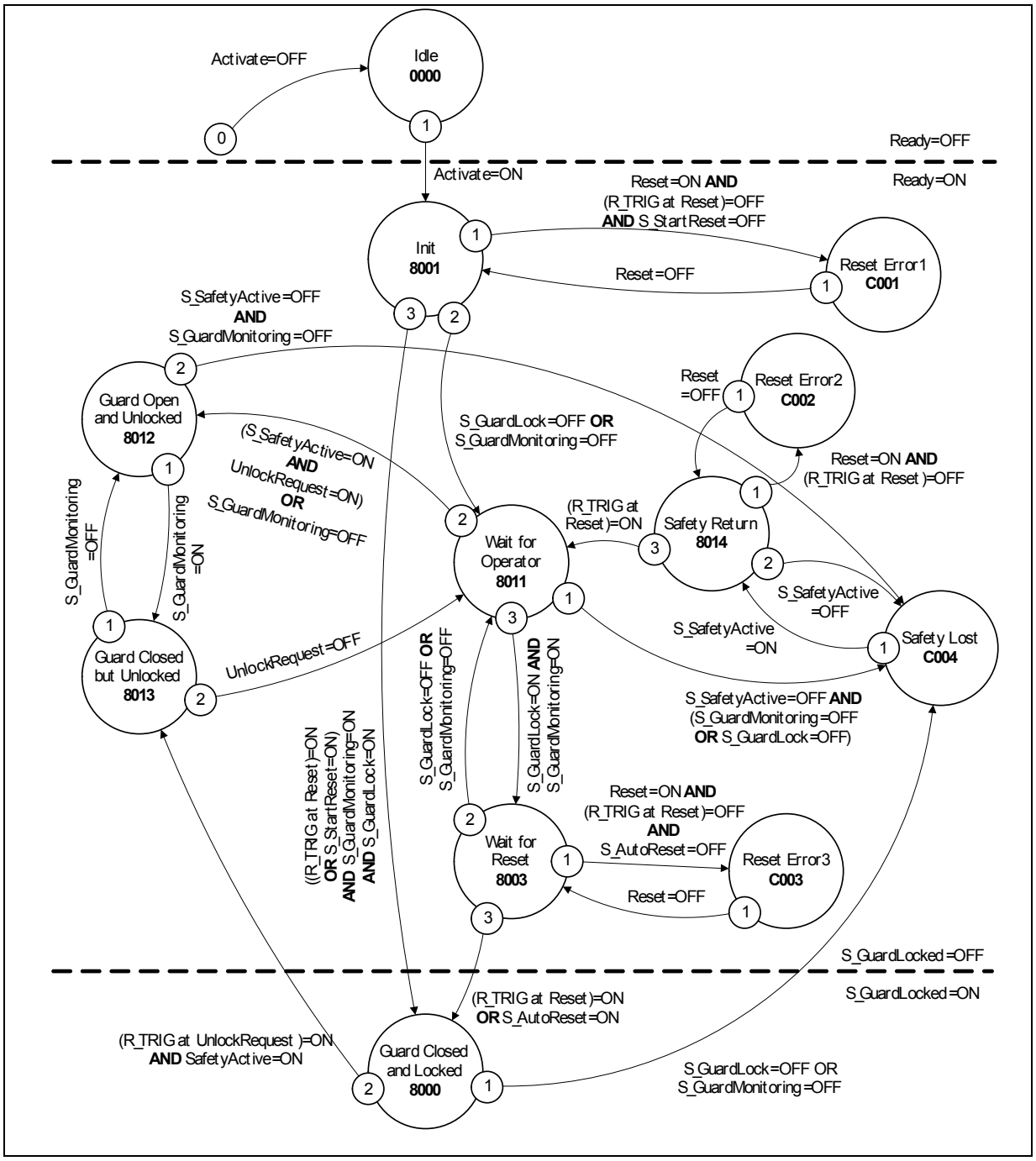


Figure 4.16 Operation Sequence for Guardlock

STATE DIAGRAM



Note: The transition from any state to the Idle state due to Activate=OFF is not shown. However these transitions have the highest priority (0).

Figure 4.17 State Diagram for F+GLOCK, S+GLOCK

TYPICAL TIMING DIAGRAM

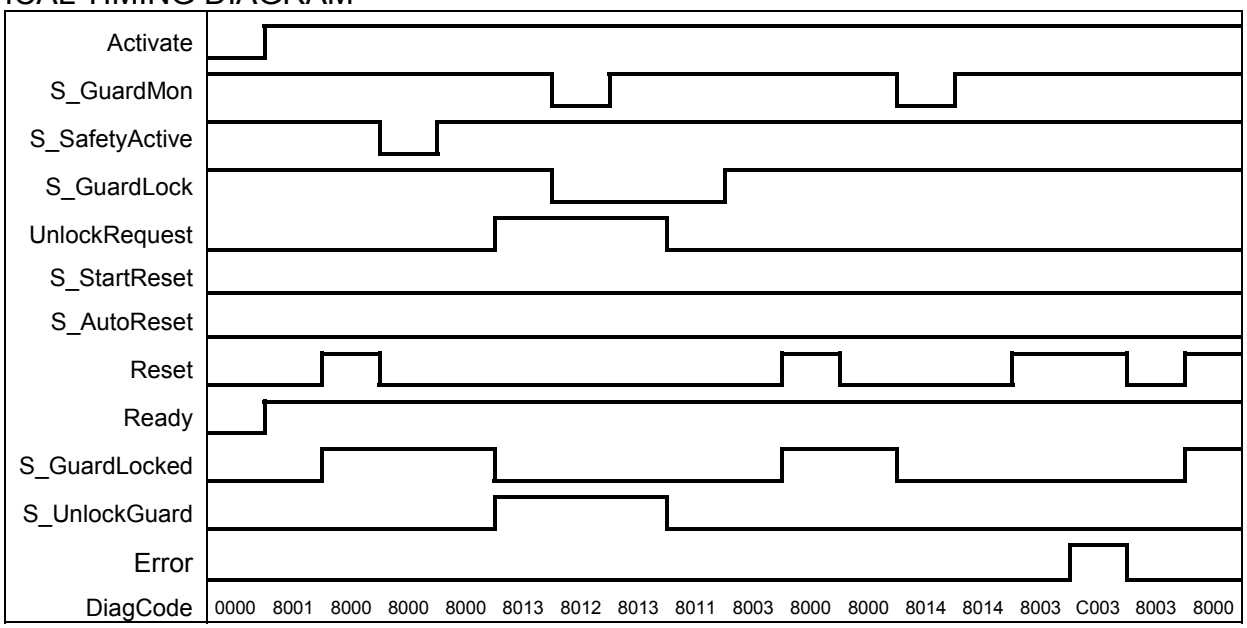


Figure 4.18 Typical Timing Diagram for F+GLOCK, S+GLOCK

ERROR BEHAVIOR

In the event of an error, the output signals behave as listed below.
For the corrective actions, see the ERROR CODES.

Output Signal	Status
Ready	ON
S_GuardLocked	OFF
S_UnlockGuard	OFF
Error	ON

ERROR CODES

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
C001	Reset Error1	Static Reset detected in state 8001. (S_StartReset=OFF)	Set Reset to OFF. Check the devices and wiring of Reset.
C002	Reset Error2	Static Reset detected in state 8014.	
C003	Reset Error3	Static Reset detected in state 8003.	
C004	Safety Lost	Safety lost, guard opened or guard unlocked.	Set S_SafetyActive to ON, and reset the FB. Check the hazardous area is safe.

STATUS CODES (no error)

<table>
<tr><th>Diag Code (Hexadecimal)</th><th>State Name</th><th>Description, Output Setting</th><th>Actions</th></tr>
<tr><td>0000</td><td>Idle</td><td>The function block is not active (initial state).
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>OFF</td></tr>
<tr><td>S_GuardLocked</td><td>OFF</td></tr>
<tr><td>S_UnlockGuard</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Initialize the safety FB by setting Activate to ON.</td></tr>
<tr><td>8000</td><td>Guard Closed and Locked</td><td>Guard is locked. The safety function is not requested for the machine in a safe area. The machine can be operated normally in the safe area.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_GuardLocked</td><td>ON</td></tr>
<tr><td>S_UnlockGuard</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>None.</td></tr>
<tr><td>8001</td><td>Init</td><td>Function block was activated and initiated.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_GuardLocked</td><td>OFF</td></tr>
<tr><td>S_UnlockGuard</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Close and lock the guard, and reset the safety FB.</td></tr>
<tr><td>8003</td><td>Wait for Reset</td><td>Door is closed and locked, now waiting for operator reset.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_GuardLocked</td><td>OFF</td></tr>
<tr><td>S_UnlockGuard</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Reset the safety FB.</td></tr>
<tr><td>8011</td><td>Wait for Operator</td><td>Waiting for operator to either unlock request or reset.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_GuardLocked</td><td>OFF</td></tr>
<tr><td>S_UnlockGuard</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Close and lock the guard, and reset the safety FB. Or, release the lock.</td></tr>
<tr><td>8012</td><td>Guard Open and Unlocked</td><td>Lock is released and guard is open.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_GuardLocked</td><td>OFF</td></tr>
<tr><td>S_UnlockGuard</td><td>ON</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Close the guard.</td></tr>
<tr><td>8013</td><td>Guard Closed but Unlocked</td><td>Lock is released but guard is closed.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_GuardLocked</td><td>OFF</td></tr>
<tr><td>S_UnlockGuard</td><td>ON</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Lock the guard.</td></tr>
<tr><td>8014</td><td>Safety Return</td><td>Return of S_SafetyActive signal, now waiting for operator acknowledge.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_GuardLocked</td><td>OFF</td></tr>
<tr><td>S_UnlockGuard</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Reset the safety FB.</td></tr>
</table>

[WARNING]
Please do the above actions when the FB detects error or is an unexpected state. However, when still the situation is not corrected, please check following.
- A failure in safe devices and emergency stop devices
- Wiring and status of a safety remote I/O stations and a safety Programmable Controller
- Programming logics, the memory allocation of safety devices and the connections of FB variables
- Setting of S_StartReset and S_AutoReset

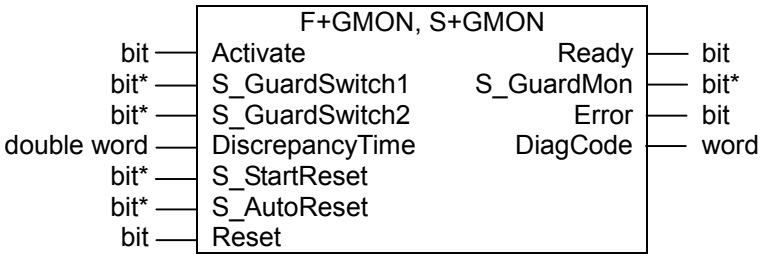
APPLICATION EXAMPLE

For applications, see the Safety Applicaion Guide.

APPLICABLE SAFETY STANDARDS

Standards	Requirements
EN 953: 1997	3.3.3 Control Guard – The hazardous machine functions "covered" by the guard cannot operate until the guard is closed; – Closing the guard initiates operation of the hazardous machine function(s).
EN 1088: 1995	3.3 Definition: Interlocking Guard With Guard Locking – The hazardous machine functions "covered" by the guard cannot operate until the guard is closed and locked; – The guard remains closed and locked until the risk of injury from the hazardous machine functions has passed; – When the guard is closed and locked, the hazardous machine functions "covered" by the guard can operate, but the closure and locking of the guard do not by themselves initiate their operation. 4.2.2 – Interlocking Device With Guard Locking Conditional unlocking ("four-state interlocking"), see Fig. 3 b2)
EN 954-1: 1996	5.4 Manual reset
ISO 12100-2:2003	4.11.4: Restart following power failure/spontaneous restart

4.8 F+GMON, S+GMON



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.

INPUT/OUTPUT

I/O	Name	Data Type	Initial Value	Description, Parameter Values
IN	Activate	bit	OFF	Activation of the safety FB. For details, see Section 2.5.
	S_GuardSwitch1	bit*	OFF	Guard switch1 input. OFF : Guard is open. ON : Guard is closed.
	S_GuardSwitch2	bit*	OFF	Guard switch2 input. OFF : Guard is open. ON : Guard is closed.
	DiscrepancyTime	double word	0	Configures the monitored discrepancy time between S_GuardSwitch1 and S_GuardSwitch2 (in increments of 10ms) for closing the guard. Range: Fixed values from 0 to 60000 (0 to 600000ms=10min)
	S_StartReset	bit*	OFF	Selection of a reset method for the activated (first time) safety FB. For details, see Section 2.5.
	S_AutoReset	bit*	OFF	Selection of a reset method for the input signal reset to ON. For details, see Section 2.5.
	Reset	bit	OFF	Reset input. For details, see Section 2.5.
OUT	Ready	bit	OFF	Status of whether the safety FB is activated or not. For details, see Section 2.5.
	S_GuardMon	bit*	OFF	Output indicating the status of the guard. OFF : Guard is not active. ON : Both S_GuardSwitches are ON, no error and acknowledgment. Guard is active.
	Error	bit	OFF	Error flag. For details, see Section 2.5.
	DiagCode	word	0	Diagnostic code. For details, see Section 2.5.

[WARNING]
Use safety data (See Appendix 2.) for connecting the variable whose data type is “bit*” to input - output circuits.
Wire the safety input - output devices and set parameters correctly, referring to the Safety Application Guide.

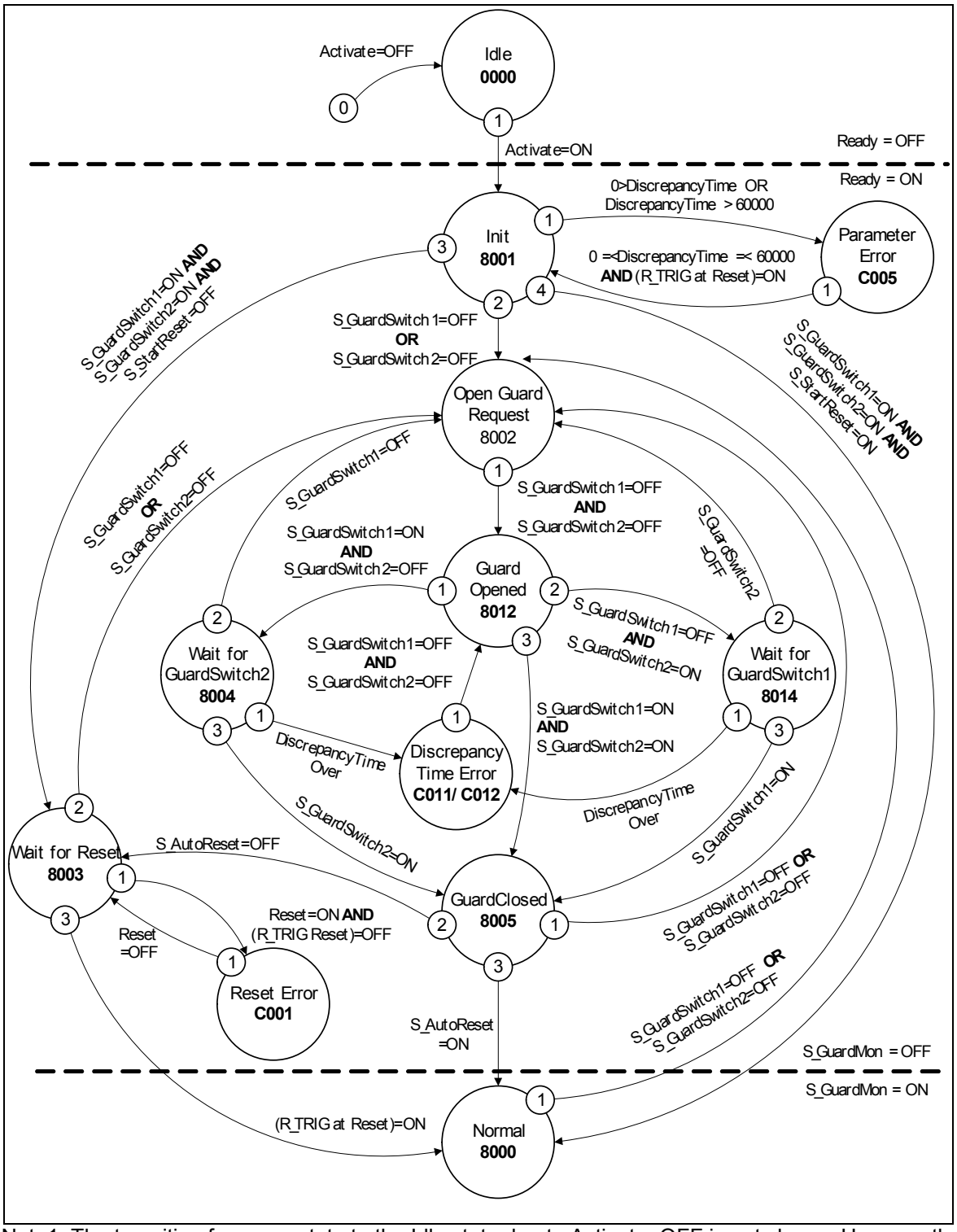
FUNCTION DESCRIPTION

The FB requires two inputs indicating the guard position for safety guards with two switches (according to EN 1088), a DiscrepancyTime input and Reset input. If the safety guard only has one switch, the S_GuardSwitch1 and S_GuardSwitch2 inputs can be same signal. The monitoring time (DiscrepancyTime) is the maximum time required for both switches to respond when closing the safety guard.
When opening the safety guard, both S_GuardSwitch1 and S_GuardSwitch2 inputs should switch to OFF. The S_GuardMon output switches to OFF as soon as one of the switches is set to OFF. When closing the safety guard, both S_GuardSwitch1 and S_GuardSwitch2 inputs should switch to ON.
This FB monitors the symmetry of the switching behavior of both switches. The S_GuardMon output remains OFF if only one of the contacts has completed an open/close process.
The behavior of the S_GuardMon 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_GuardMon output remains OFF. If the second corresponding S_GuardSwitch1/S_GuardSwitch2 input switches to ON within the value specified for the DiscrepancyTime input, the S_GuardMon output is set to ON following acknowledgment.

The S_StartReset and S_AutoReset inputs shall only be activated if it is ensured that no hazardous situation can occur when a safety programmable controller is started.

⚠ [WARNING]
- Connect the two signals/switches of a safeguard to S_GuardSwitch1 and S_GuardSwitch2 independently in your application. If you have a single signal/switch, connect same signal to both FB variables.
- The time value for the DiscrepancyTime parameter should be determined and validated according to your application and your risk analysis. This variable should be connected to the 0ms constant if both signal inputs (S_GuardSwitch1 and S_GuardSwitch2) are connected to the same signal in your application.

STATE DIAGRAM

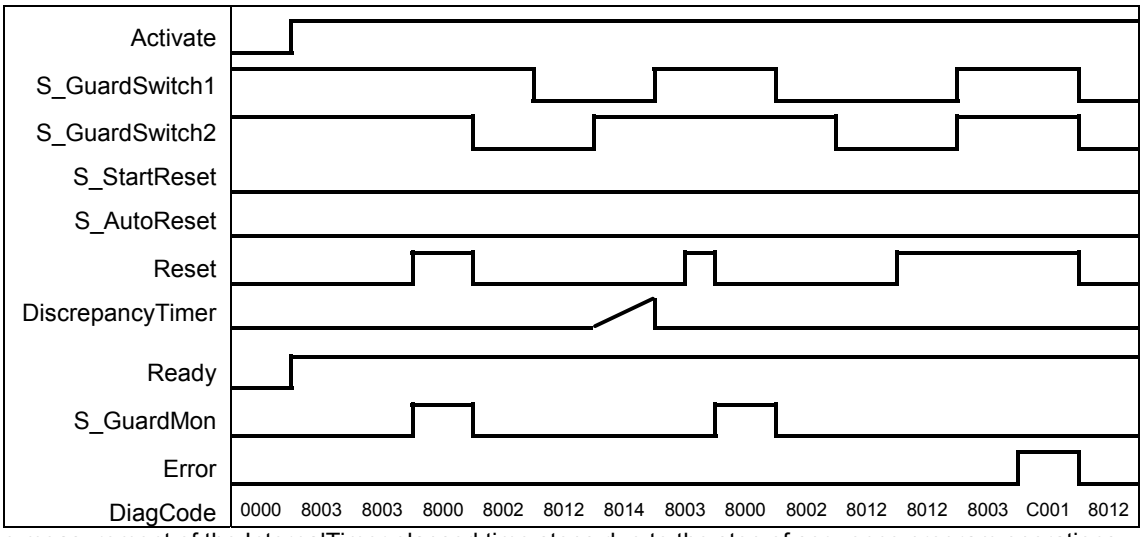


Note1: The transition from any state to the Idle state due to Activate=OFF is not shown. However these transitions have the highest priority (0).

Note2: The F+GMON state transition from C005 to 8001 is only due to the online change performed when the safety CPU operating mode is set to the test mode.

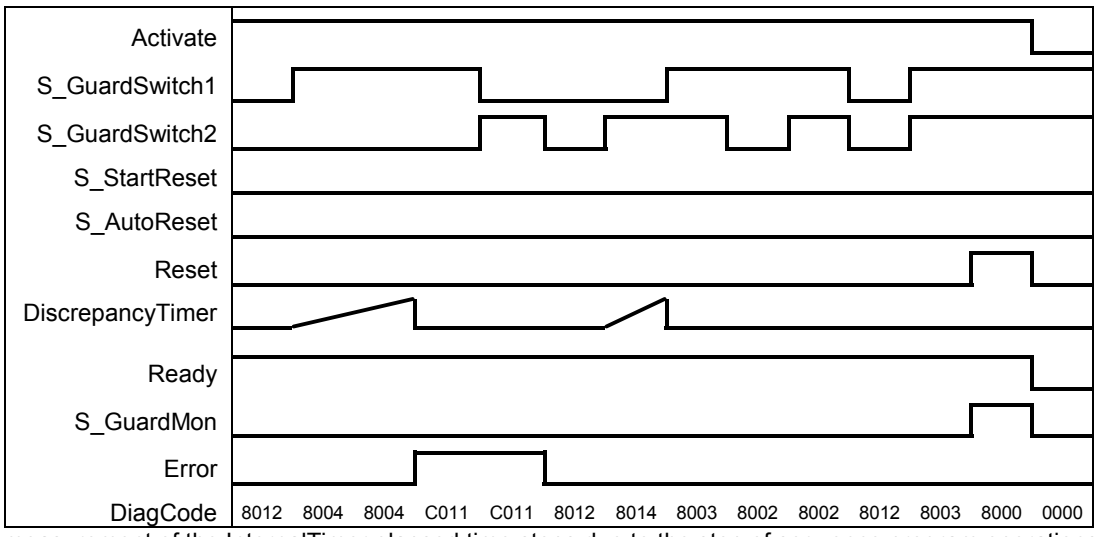
Figure 4.19 State Diagram for F+GMON, S+GMON

TYPICAL TIMING DIAGRAM



*: The measurement of the InternalTimer elapsed time stops due to the stop of sequence program operations when the operating status of CPU modules is changed to STOP.

Figure 4.20 Typical Timing Diagram for F+GMON, S+GMON



*: The measurement of the InternalTimer elapsed time stops due to the stop of sequence program operations when the operating status of CPU modules is changed to STOP.

Figure 4.21 Typical Timing Diagram for F+GMON, S+GMON

ERROR BEHAVIOR

In the event of an error, the output signals behave as listed below.
For the corrective actions, see the ERROR CODES.

Output Signal	Status
Ready	ON
S_GuardMon	OFF
Error	ON

ERROR CODES

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
C001	Reset Error	Static reset detected in state 8003.	Set Reset to OFF. Check the devices and wirng of Reset.
C005	Parameter Error	DiscrepancyTime is out of range.	Set DiscrepancyTime to proper value.
C011	Discrepancytime Error1	DiscrepancyTime elapsed in state 8004. (Switch1=ON, Switch2=OFF)	Set S_GuardSwitch1 and S_GuardSwitch2 to OFF. • Check a failure of the switches of the guard. • When the guard is closed with no failure, check the state, parameter and wiring of the safety remote I/O station. • Check the DiscrepancyTime.
C012	Discrepancytime Error2	DiscrepancyTime elapsed in state 8014. (Switch1=OFF, Switch2=ON)	

STATUS CODES (no error)

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
0000	Idle	The function block is not active (initial state). All output signals are set to OFF. Output Signal / Status Ready: OFF S_GuardMon: OFF Error: OFF	Initialize the safety FB by setting Activate to ON.
8000	Normal	Safety guard closed and Safe state acknowledged. Output Signal / Status Ready: ON S_GuardMon: ON Error: OFF	None.
8001	Init	Function block has been activated. Output Signal / Status Ready: ON S_GuardMon: OFF Error: OFF	Close the guard.
8002	Open Guard Request	Complete switching sequence required. At least one switch was OFF. Output Signal / Status Ready: ON S_GuardMon: OFF Error: OFF	Open the guard completely. When the guard is open completely, check the switch, wiring and the safety remote I/O station.
8003	Wait for Reset	Waiting for rising trigger at Reset. Output Signal / Status Ready: ON S_GuardMon: OFF Error: OFF	Reset the safety FB.
8012	Guard Opened	Guard completely opened. Output Signal / Status Ready: ON S_GuardMon: OFF Error: OFF	Close the guard.
8004	Wait for GuardSwitch2	S_GuardSwitch1 has been switched to ON - waiting for S_GuardSwitch2; discrepancy timer started. Output Signal / Status Ready: ON S_GuardMon: OFF Error: OFF	Close the guard completely.

(To the next page)

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
8014	Wait for GuardSwitch1	S_GuardSwitch2 has been switched to ON - waiting for S_GuardSwitch1; discrepancy timer started. Output Signal / Status Ready: ON S_GuardMon: OFF Error: OFF	Close the guard completely.
8005	Guard Closed	Guard closed. Waiting for Reset, if S_AutoReset=OFF. Output Signal / Status Ready: ON S_GuardMon: OFF Error: OFF	Reset the safety FB.

[WARNING]
Please do the above actions when the FB detects error or is an unexpected state. However, when still the situation is not corrected, please check following.
- A failure in safe devices and emergency stop devices
- Wiring and status of a safety remote I/O stations and a safety Programmable Controller
- Programming logics, the memory allocation of safety devices and the connections of FB variables
- Setting of S_StartReset and S_AutoReset

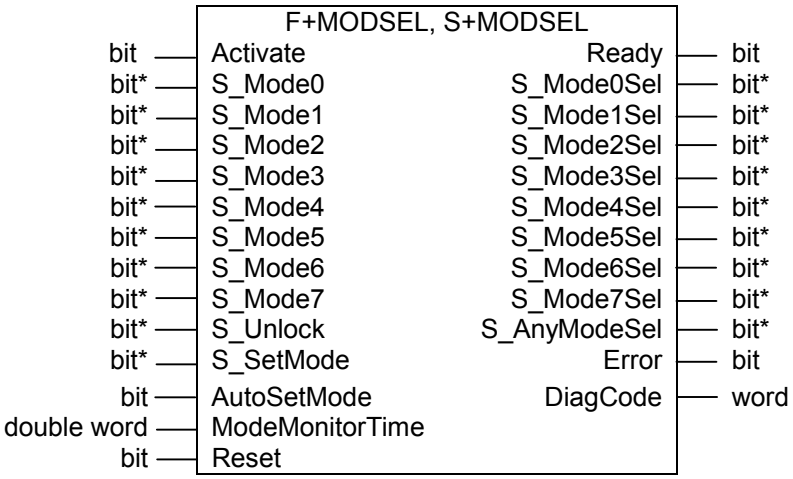
APPLICATION EXAMPLE

For applications, see the Safety Applicaion Guide.

APPLICABLE SAFETY STANDARDS

Standards	Requirements
EN 953: 1997	3.3.3 Control Guard – The hazardous machine functions "covered" by the guard cannot operate until the guard is closed; – Closing the guard initiates operation of the hazardous machine function(s).
EN 1088: 1995	3.2 Interlocking Guard – The hazardous machine functions "covered" by the guard cannot operate until the guard is closed; – If the guard is opened while the hazardous machine functions are operating, a stop instruction is given; – When the guard is closed, the hazardous machine functions "covered" by the guard can operate, but the closure of the guard does not by itself initiate their operation.
EN 954-1: 1996	5.4 Manual reset
ISO 12100-2:2003	4.11.4 Restart following power failure/spontaneous restart.

4.9 F+MODSEL, S+MODSEL



OVERVIEW

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

INPUT/OUTPUT

I/O	Name	Data Type	Initial Value	Description, Parameter Values
IN	Activate	bit	OFF	Activation of the safety FB. For details, see Section 2.5.
	S_Mode0	bit*	OFF	Input 0 from mode selector switch OFF : Mode 0 is not requested by operator. ON : Mode 0 is requested by operator.
	S_Mode1	bit*	OFF	Input 1 from mode selector switch
	S_Mode2	bit*	OFF	Input 2 from mode selector switch
	S_Mode3	bit*	OFF	Input 3 from mode selector switch
	S_Mode4	bit*	OFF	Input 4 from mode selector switch
	S_Mode5	bit*	OFF	Input 5 from mode selector switch
	S_Mode6	bit*	OFF	Input 6 from mode selector switch
	S_Mode7	bit*	OFF	Input 7 from mode selector switch
	S_Unlock	bit*	OFF	Locks the selected mode OFF : The actual S_ModeXSel output is locked. (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 S_SetMode.) ON : The selected S_ModeXSel is not locked. (A mode selection change is possible.)
	S_SetMode	bit*	OFF	Sets the selected mode. AutoSetMode=OFF OFF : Any change to new S_ModeX=ON is not confirmed. ON (Activated only when S_SetMode is set to ON) : A change to new S_ModeX is confirmed. AutoSetMode=ON Constant OFF (S_SetMode is not required.)
	AutoSetMode	bit	OFF	Parameterizes the acknowledgement mode OFF : A change in mode must be acknowledged by the operator via SetMode. ON : A valid change of the S_ModeX input to another S_ModeX automatically leads to a change in S_ModeXSel without operator acknowledgment via S_SetMode (as long as this is not locked by S_Unlock).
	ModeMonitorTime	double word	0	Maximum permissible time for changing the selection input. Increments of 10ms . Range: Fixed values from 0 to 60000 (0 to 600000ms=10min) .
	Reset	bit	OFF	Reset input. For details, see Section 2.5.

(To the next page)

I/O	Name	Data Type	Initial Value	Description, Parameter Values
OUT	Ready	bit	OFF	Status of whether the safety FB is activated or not. For details, see Section 2.5.
	S_Mode0Sel	bit*	OFF	Indicates that mode 0 is selected and acknowledged. OFF : Button1 released. ON : Mode 0 is selected and active.
	S_Mode1Sel	bit*	OFF	Indicates that mode 1 is selected and acknowledged.
	S_Mode2Sel	bit*	OFF	Indicates that mode 2 is selected and acknowledged.
	S_Mode3Sel	bit*	OFF	Indicates that mode 3 is selected and acknowledged.
	S_Mode4Sel	bit*	OFF	Indicates that mode 4 is selected and acknowledged.
	S_Mode5Sel	bit*	OFF	Indicates that mode 5 is selected and acknowledged.
	S_Mode6Sel	bit*	OFF	Indicates that mode 6 is selected and acknowledged.
	S_Mode7Sel	bit*	OFF	Indicates that mode 7 is selected and acknowledged.
	S_AnyModeSel	bit*	OFF	Indicates that any of the 8 modes is selected and acknowledged. OFF : No S_ModeX is selected. ON : One of the 8 S_ModeX is selected and active.
	Error	bit	OFF	Error flag. For details, see Section 2.5.
	DiagCode	word	0	Diagnostic code. For details, see Section 2.5.

⚠ [WARNING]
Use safety data (See Appendix 2.) for connecting the variable whose data type is “bit*” to input - output circuits.
Wire the safety input - output devices and set parameters correctly, referring to the Safety Application Guide.

FUNCTION DESCRIPTION

This function block selects the system operation mode, such as manual, automatic, semi-automatic, etc.
The default state is changed to the ModeChanged state (8005), where all S_ModeXSel and S_AnyModeSel are OFF, after the activation of the FB.
For the transition from the ModeChanged to ModeSelected state, the following conditions are required.

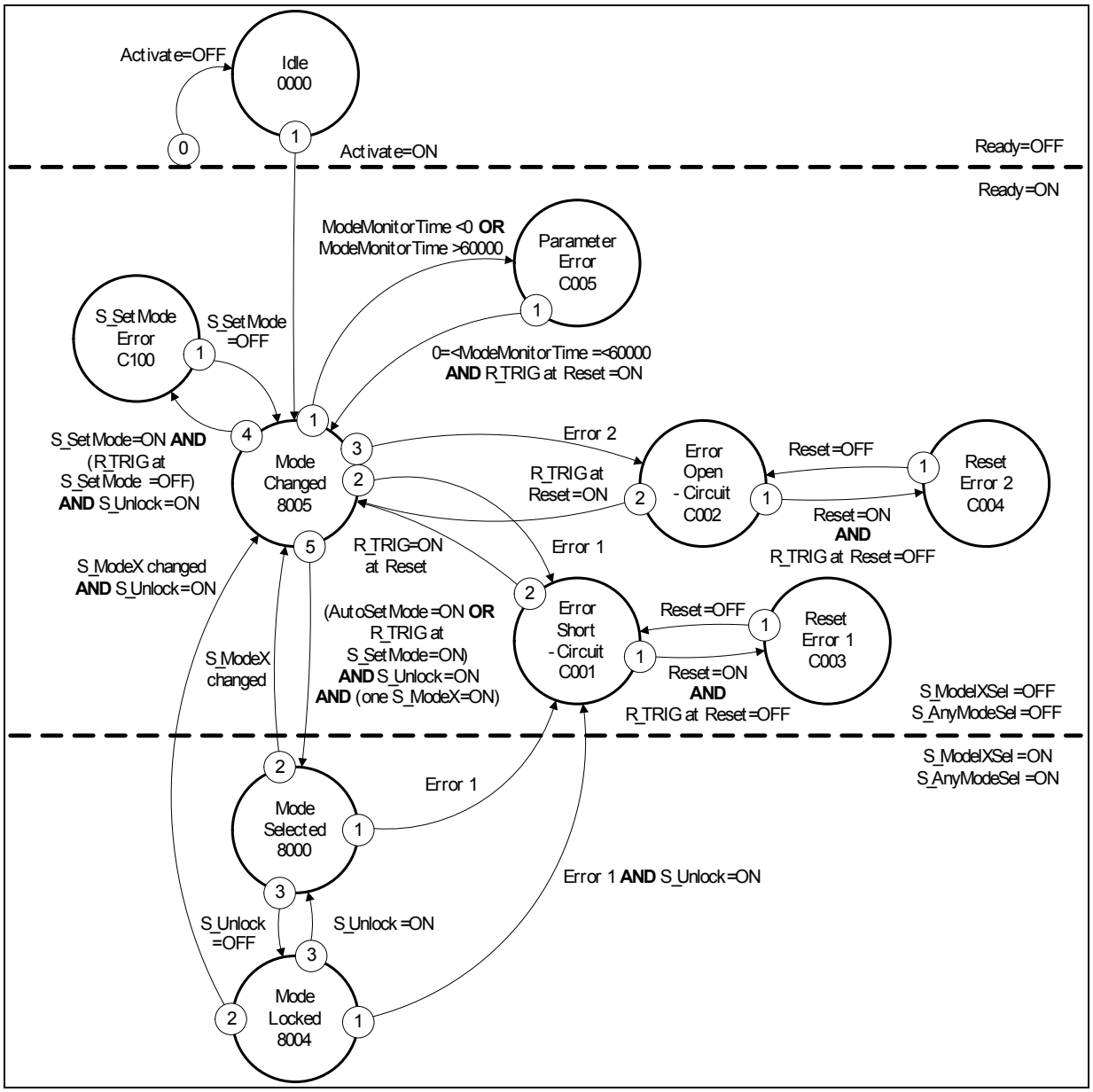
(1) AutoSetMode=OFF
When S_SetMode is set to ON, the new S_ModeX input leads to a S_ModeXSel output.
(2) AutoSetMode=ON
The new S_ModeX input automatically leads to a new S_ModeXSel output.

The transition from the ModeChanged to ModeSelected state is only valid, if one S_ModeX is ON.
In addition, the transition from one S_ModeX input (only one S_ModeX from S_Mode0 to S_Mode7 is ON) to ModeSelected state (8000) is not monitored by a timer.

If the FB is in the ModeSelected state, the simultaneously occurrence of a new S_ModeX input (higher priority) and the OFF 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 OFF to simplify program verification.
The AutoSetMode input shall only be activated if it is ensured that no hazardous situation can occur when the safety programmable controller is started.

STATE DIAGRAM



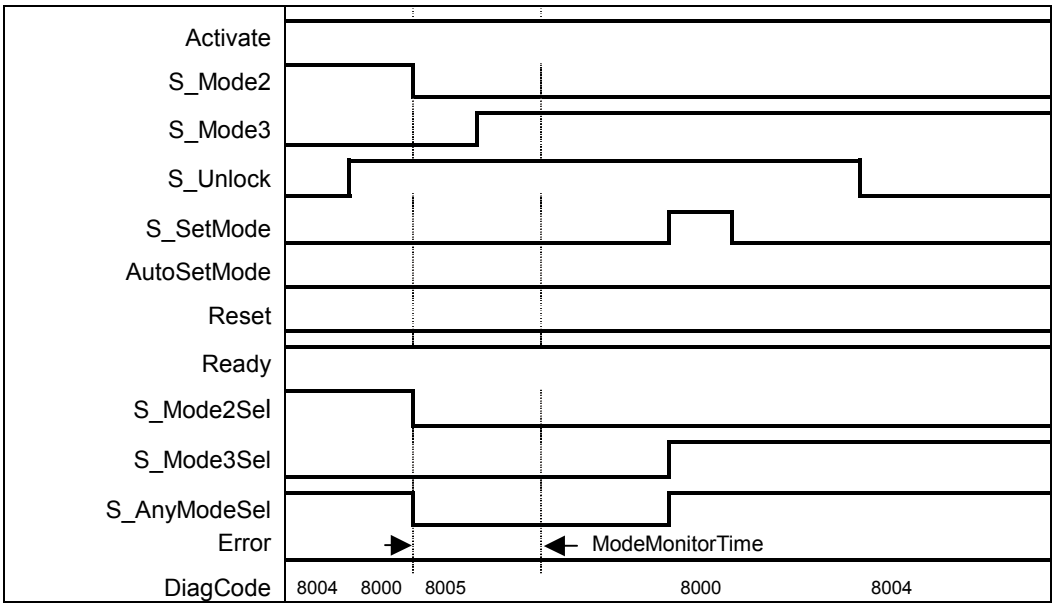
Note 1: Error1: More than one S_ModeX=ON is selected at the same time.
Error2: The S_ModeX=OFF state remains for longer than ModeMonitorTime.

Note 2: The transition from any state to the Idle state due to Activate=OFF is not shown. However these transitions have the highest priority (0).

Note 3: The F+MODSEL state transition from C005 to 8005 is only due to the online change performed when the safety CPU operating mode is set to the test mode.

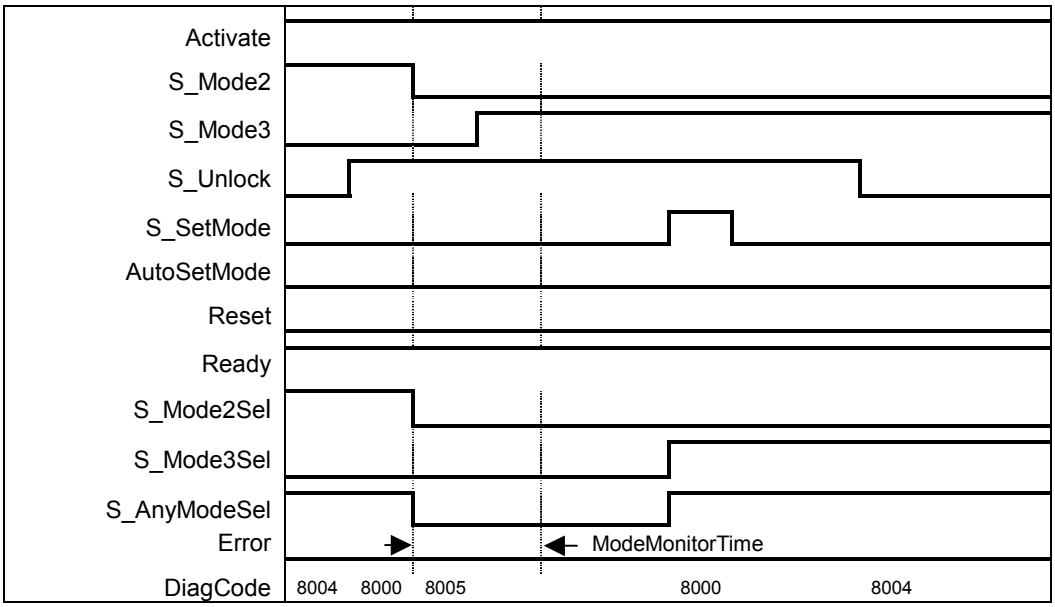
Figure 4.22 State Diagram for F+MODSEL, S+MODSEL

TYPICAL TIMING DIAGRAM



*: The measurement of the ModeMonitorTime elapsed time stops due to the stop of sequence program operations when the operating status of CPU modules is changed to STOP.

Figure 4.23 Typical Timing Diagram for F+MODSEL, S+MODSEL (S_AutoSetMode=OFF)
Valid change in Mode input with acknowledgment



*: The measurement of the ModeMonitorTime elapsed time stops due to the stop of sequence program operations when the operating status of CPU modules is changed to STOP.

Figure 4.24 Typical Timing Diagram for F+MODSEL, S+MODSEL (S_AutoSetMode=OFF)
Error condition 2 at Mode inputs (All S_ModeX=OFF after ModeMonitorTime)

ERROR BEHAVIOR

In the event of an error, the output signals behave as listed below.
For the corrective actions, see the ERROR CODES.

Output Signal	Status
Ready	ON
S_Mode0Sel to S_Mode7Sel	OFF
S_AnyModeSel	OFF
Error	ON

ERROR CODES

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
C001	Error Short-circuit	The FB detected that two or more S_ModeX=ON	Set only one S_ModeX to ON and reset the safety FB. Check the connection and wiring related to Reset.
C002	Error Open-circuit	The FB detected that all S_ModeX=OFF: The period following a falling S_ModeX trigger exceeds ModeMonitorTime.	Set only one S_ModeX to ON and reset the safety FB. Check the connection and wiring related to Reset. Check the value of ModeMonitorTime.
C003	Reset Error1	Static Reset signal detected in state C001.	Set Reset to OFF. Check the devices and wiring related to Reset.
C004	Reset Error2	Static Reset signal detected in state C002.	
C005	Parameter Error	The value of ModeMonitorTime is out of range (0 to 60000).	Set proper value to ModeMonitorTime, and Reset.
C100	S_SetMode Error	Static S_SetMode signal detected with S_Unlock=ON in state 8005.	Reset the safety FB. Set S_SetMode to OFF. Check the devices and wiring related to Reset.

STATUS CODES (no error)

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
0000	Idle	The function block is not active. Output Signal / Status Ready: OFF S_Mode0Sel to S_Mode7Sel: OFF S_AnyModeSel: OFF Error: OFF	Initialize the safety FB by setting Activate to ON.
8005	ModeChanged	State after activation or when S_ModeX has changed (unless locked) or after Reset of an error state. Output Signal / Status Ready: ON S_Mode0Sel to S_Mode7Sel: OFF S_AnyModeSel: OFF Error: OFF	Select a mode after setting S_Unlock to ON, and set S_SetMode to ON.
8000	ModeSelected	Valid mode selection, but not yet locked. Output Signal / Status Ready: ON S_Mode0Sel to S_Mode7Sel: *1 S_AnyModeSel: ON Error: OFF *1: Only one signal is ON.	Lock the selected mode by setting S_Unlock to OFF.

(To the next page)

<table>
<tr><th>Diag Code (Hexadecimal)</th><th>State Name</th><th>Description, Output Setting</th><th>Actions</th></tr>
<tr><td>8004</td><td>ModeLocked</td><td>Valid mode selection is locked.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_Mode0Sel to S_Mode7Sel</td><td>*1</td></tr>
<tr><td>S_AnyModeSel</td><td>ON</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table>
*1: Only one signal is ON.</td><td>To change the mode, set S_Unlock to ON.</td></tr>
</table>

[WARNING]
Please do the above actions when the FB detects error or is an unexpected state. However, when still the situation is not corrected, please check following.
- A failure in safe devices and emergency stop devices
- Wiring and status of a safety remote I/O stations and a safety Programmable Controller
- Programming logics, the memory allocation of safety devices and the connections of FB variables
- Setting of AutoSetMode.

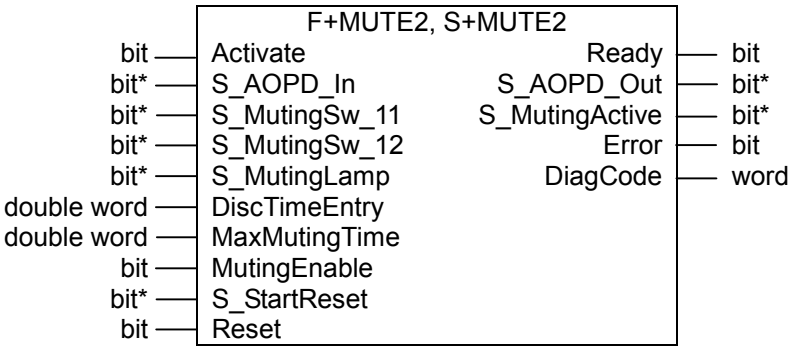
APPLICATION EXAMPLE

For applications, see the Safety Application Guide.

APPLICABLE SAFETY STANDARDS

Standards	Requirements
MRL 98/37/EC, Annex 1	1.2.3. Starting ... It must be possible to start machinery only by voluntary actuation of a control provided for the purpose.... The same requirement applies: ... - when effecting a significant change in the operating conditions.... 1.2.5 ... mode selector which can be locked in each position. Each position of the selector must correspond to a single operating or control mode....
EN ISO 12100-2: 2003	4.11.10 Selection of Control and Operating Modes … shall be fitted with a mode selector which can be locked in each position. Each position of the selector shall be clearly identifiable and shall exclusively enable one control or operating mode to be selected…
IEC 60204-1, Ed. 5.0: 2003	9.2.3 Operating Modes ...When a hazardous condition can result from a mode selection, unauthorized and/or inadvertent selection shall be prevented by suitable means (e.g. key operated switch, access code). Mode selection by itself shall not initiate machine operation. A separate action by the operator shall be required. ...Indication of the selected operating mode shall be provided...
EN 954-1: 1996	5.4 Manual reset

4.10 F+MUTE2, S+MUTE2



OVERVIEW

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

INPUT/OUTPUT

I/O	Name	Data Type	Initial Value	Description, Parameter Values
IN	Activate	bit	OFF	Activation of the safety FB. For details, see Section 2.5.
	S_AOPD_In	bit*	OFF	OSSD (safety output) signal from AOPD (Active opto-electronic protective devices). OFF : Protection field interrupted. ON : Protection field not interrupted.
	S_MutingSw_11	bit*	OFF	Status of Muting sensor 11. OFF : Muting sensor 11 not actuated. ON : Workpiece actuates muting sensor 11.
	S_MutingSw_12	bit*	OFF	Status of Muting sensor 12.
	S_MutingLamp	bit*	OFF	Indicates operation of the muting lamp. OFF : Muting lamp failure. ON : Muting lamp no failure.
	DiscTimeEntry	double word	0	Max. discrepancy time for S_MutingSw_11 and S_MutingSw_12 entering muting gate. Increments of 10ms. Range: Fixed values from 0 to 400 (0 to 4000ms=4sec)
	MaxMutingTime	double word	0	Maximum time for complete muting sequence, timer started when first muting sensor is actuated. Increments of 10ms. The timer is started at the trigger of switching first muting sensor. Range: Fixed values from 0 to 60000 (0 to 600000ms=10min)
	MutingEnable	bit	OFF	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. OFF : Muting not enabled ON : Start of Muting function enabled
	S_StartReset	bit*	OFF	Selection of a reset method for the activated (first time) safety FB. For details, see Section 2.5.
	Reset	bit	OFF	Reset input. For details, see Section 2.5.
OUT	Ready	bit	OFF	Status of whether the safety FB is activated or not. For details, see Section 2.5.
	S_AOPD_Out	bit*	OFF	Safety FB output, indicates status of the muted guard. OFF : AOPD protection field interrupted and muting not active. ON : AOPD protection field not interrupted or muting active.
	S_MutingActive	bit*	OFF	Indicates status of Muting process. OFF : Muting not active. ON : Muting active.
	Error	bit	OFF	Error flag. For details, see Section 2.5.
	DiagCode	word	0	Diagnostic Code. For details, see Section 2.5.

[WARNING]
Use safety data (See Appendix 2.) for connecting the variable whose data type is “bit*” to input - output circuits.
Wire the safety input - output devices and set parameters correctly, referring to the Safety Application Guide.

FUNCTION 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 in Figure 4.34. 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 when there is no manipulation in the danger zone.

The FB input parameters include the signals of the two muting sensors (S_MutingSw_11 and S_MutingSw_12), the OSSD signal from the "active opto-electronic protective device", S_AOPD_In, as well as two parameterizable times (Disc-TimeEntry and MaxMutingTime).

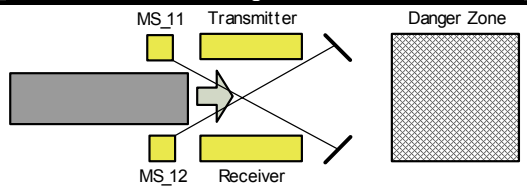
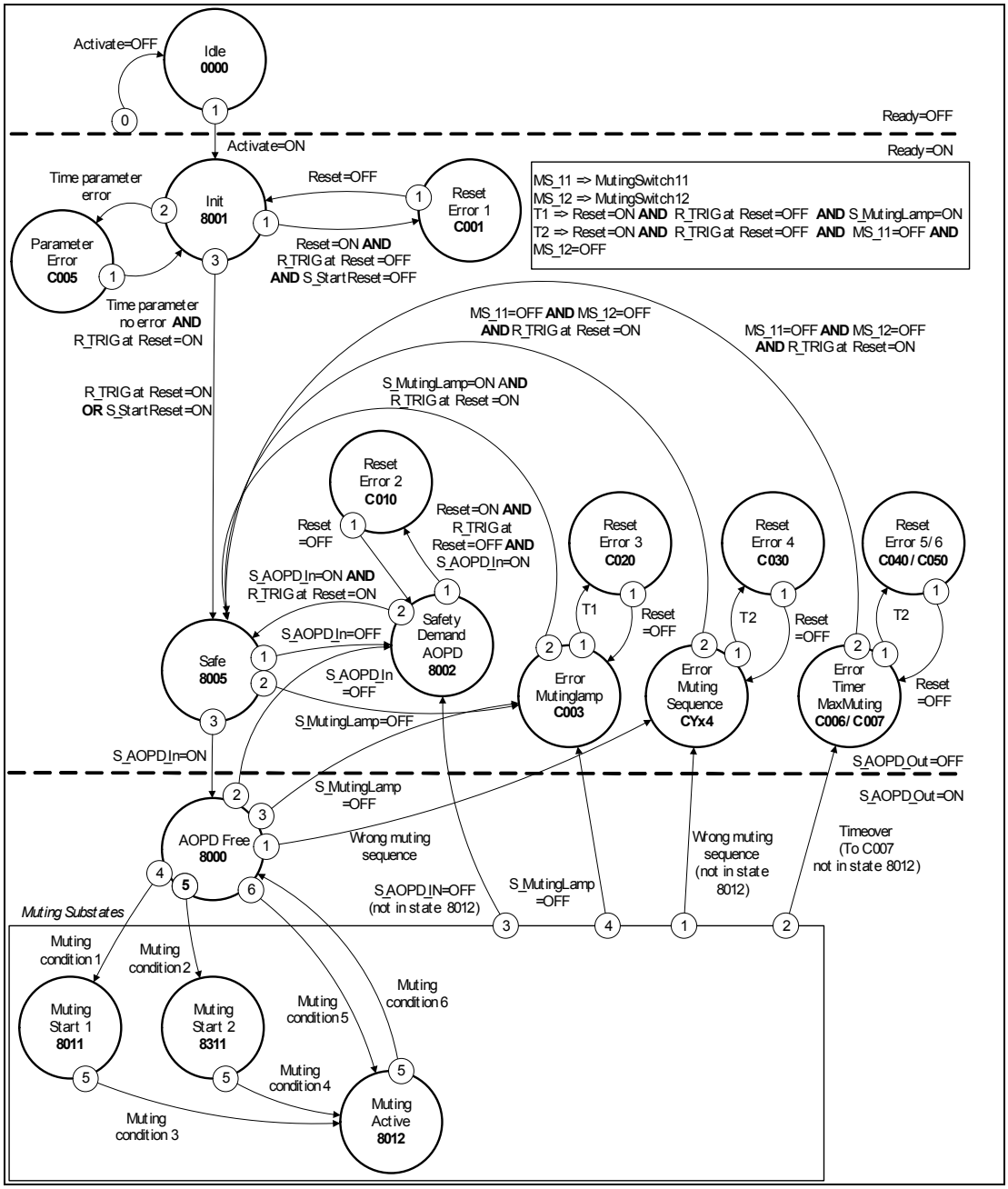
No.	Figure	Explanation
1		If reflection light barriers are used as muting sensors, they are generally arranged diagonally. In general, this arrangement of reflection light barriers as muting sensors requires only two light barriers, and only S_MutingSw_11 (MS_11) and S_MutingSw_12 (MS_12) are allocated.

Figure 4.25 Example for F+MUTE2, S+MUTE2 with two reflecting light barriers

STATE DIAGRAM



Note1: The transition from any state to the Idle state due to Activate=OFF is not shown. However these transitions have the highest priority (0).

Note2: Within muting substates, transitions due to Error Muting sequence (priority 1), Error Timer (priority 2), Safety demand AOPD (priority 3) or Error Muting lamp (priority 4) have higher priority than transitions to Muting substates (priority 5).
If the safety FB is in the timing error state, the simultaneously occurrence of C006 and C007 leads to C006 state.

Note3: Muting condition 1-6 and Wrong muting sequences are shown in next page.

Note4: Time parameter error (condition of transition from 8001 to C005) is detected in either one of the following two cases.

1) DiscTimeEntry has been set to a value less than 0ms or greater than 400ms.
(0 > DiscTimeEntry OR DiscTimeEntry > 400)

2) MaxMutingTime has been set to a value less than 0ms or greater than 10min.
(0 > MaxMutingTime OR MaxMutingTime > 60000)

Note5: The F+MUTE2 state transition from C005 to 8001 is only due to the online change performed when the safety CPU operating mode is set to the test mode.

Figure 4.26 State Diagram for F+MUTE2, S+MUTE2

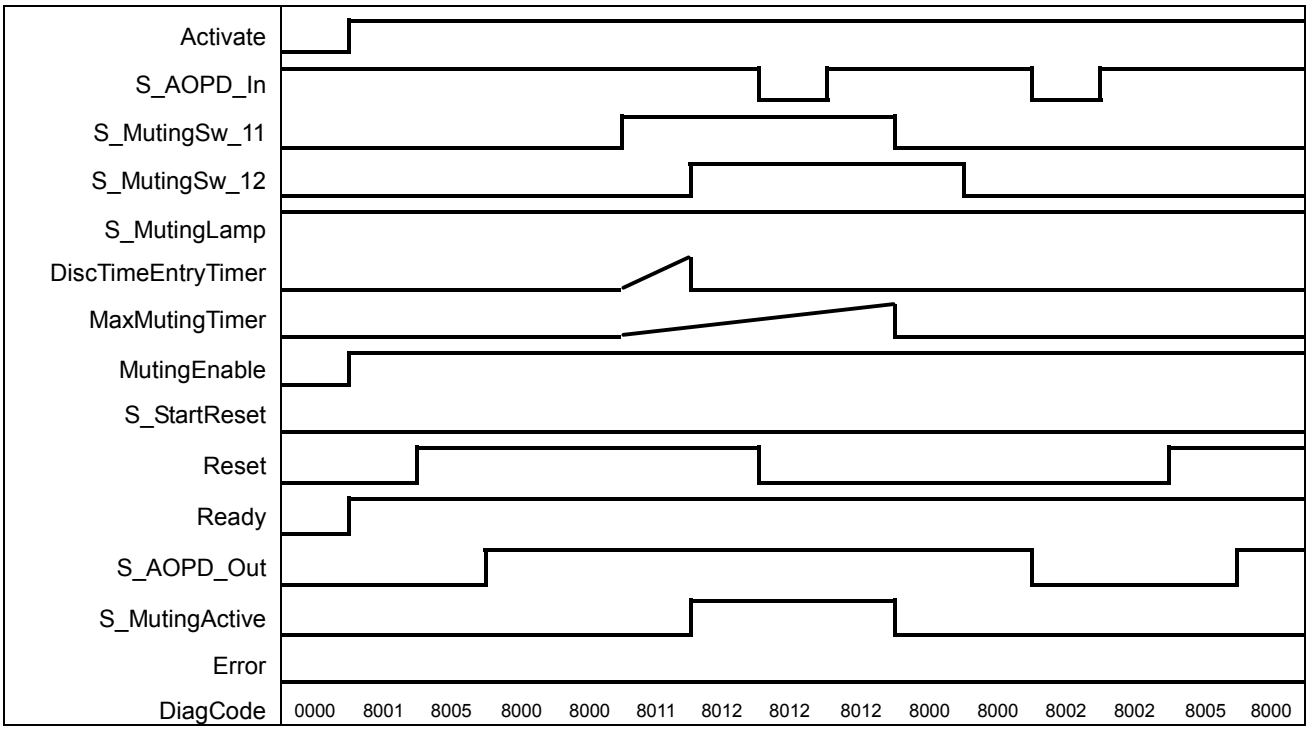
Muting Conditions

No.	State Transision	Condition/Action
1	8000→8011	MS_11 is the first entry switch actuated: Start timer DiscTimeEntry and MaxMutingTime. MutingEnable=ON AND MS_11=OFF→ON AND MS_12=OFF
2	8000→8311	MS_12 is the first entry switch actuated: Start timer DiscTimeEntry and MaxMutingTime. MutingEnable=ON AND MS_11=OFF AND MS_12=OFF→ON
3	8011→8012	MS_12 is the second entry switch actuated: Stop timer DiscTimeEntry. MutingEnable=ON AND MS_11=ON AND MS_12=OFF→ON
4	8311→8012	MS_11 is the second entry switch actuated: Stop timer DiscTimeEntry. MutingEnable=ON AND MS_11=OFF→ON AND MS_12=ON
5	8000→8012	Both switches actuated in same cycle: Start Timer MaxMutingTime. MutingEnable=ON AND MS_11=OFF→ON AND MS_12=OFF→ON
6	8012→8000	Both switches released in same cycle or MS_11 and MS_12 released consecutively: Stop timer MaxMutingTime. MS_11=OFF OR MS_12=OFF

Wrong Muting Sequences

Status	Wrong muting sequences
8000	MS_11=OFF→ON AND MS_12=ON AND MS_12=OFF→ON not yet
	MS_12=OFF→ON AND MS_11=ON AND MS_11=OFF→ON not yet
	(MS_11=ON AND MS_11=OFF→ON not yet) AND (MS_12=ON AND MS_12=OFF→ON not yet)
	MutingEnable=OFF AND MS_11=OFF→ON
	MutingEnable=OFF AND MS_12=OFF→ON
8011	MutingEnable=OFF OR MS_11=OFF
8311	MutingEnable=OFF OR MS_12=OFF
8012	None

TYPICAL TIMING DIAGRAM



*: The measurement of the DiscTimeEntryTimer and MaxMutingTimer elapsed time stops due to the stop of sequence program operations when the operating status of CPU modules is changed to STOP.

Figure 4.27 Typical Timing Diagram for F+MUTE2, S+MUTE2 (S_StartReset=OFF)

ERROR BEHAVIOR

In the event of an error, the output signals behave as listed below.
For the corrective actions, see the ERROR CODES.

Output Signal	Status
Ready	ON
S_AOPD_Out	OFF
S_MutingActive	OFF
Error	ON

ERROR CODES

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
C001	Reset Error1	Static Reset condition detected after FB activation in state 8001.	Set Reset to OFF. Check the devices and wiring related to Reset.
C003	Error Muting Lamp	Error detected in muting lamp.	Reset the safety FB. Check the devices and wiring related to Reset.
CYx4 C004 to CF34	Error Muting Sequence	Error detected in muting sequence state 8000, 8011, 8311. (See page 4-54) Y=Status in the sequence C0x4=Error occurred in state 8000 C1x4=Error occurred in state 8011 C2x4=Error occurred in state 8311 CFx4=MutingEnable=OFF. The states of wrong muting sequences (See Page 4-54) including MutingEnable=OFF are changed to this Error Muting Sequence whose DiagCode is always CFx4 when MutingEnable is set to OFF. (Never changed to other states) x=Status of the sensors when error occurred CY04: both SW=OFF CY14: S_MutingSw_11=ON CY24: S_MutingSw_12=ON CY34: both SW=ON	Set both Muting Switches to OFF and Reset the safety FB. Check the devices and wiring related to Reset.
C005	Parameter Error	DiscTimeEntry or MaxMutingTime value out of range.	Set a proper value to the parameter, and reset the safety FB.
C006	Error Timer MaxMuting	Timing error. Active muting time exceeds MaxMutingTime.	Set both Muting Switches to OFF and reset the FB. Check the actual muting status.
C007	Error Timer MS11_12	Timing error: Discrepancy time for switching S_MutingSw11→and S_MutingSw12 > DiscTimeEntry.	
C010	Reset Error2	Static Reset condition detected in state 8002.	Set Reset to OFF. Check the devices and wiring related to Reset.
C020	Reset Error3	Static Reset condition detected in state C003.	
C030	Reset Error4	Static Reset condition detected in state CYx4.	
C040	Reset Error5	Static Reset condition detected in state C006	
C050	Reset Error6	Static Reset condition detected in state C007.	

STATUS CODES (no error)

<table>
<tr><th>Diag Code (Hexadecimal)</th><th>State Name</th><th>Description, Output Setting</th><th>Actions</th></tr>
<tr><td>0000</td><td>Idle</td><td>The function block is not active (initial state).
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>OFF</td></tr>
<tr><td>S_AOPD_Out</td><td>OFF</td></tr>
<tr><td>S_MutingActive</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Initialize the safety FB by setting Activate to ON.</td></tr>
<tr><td>8000</td><td>AOPD Free</td><td>Muting not active and no safety demand from AOPD. If timers from subsequent muting are still running, they are stopped.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>ON</td></tr>
<tr><td>S_MutingActive</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>None.
Starting muting is possible.</td></tr>
<tr><td>8001</td><td>Init</td><td>Function block was activated.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>OFF</td></tr>
<tr><td>S_MutingActive</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Reset the safety FB.</td></tr>
<tr><td>8002</td><td>Safety Demand AOPD</td><td>Safety demand detected by AOPD, muting not active.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>OFF</td></tr>
<tr><td>S_MutingActive</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Reset the safety FB after the completion of safety demand.</td></tr>
<tr><td>8005</td><td>Safe</td><td>Safety function activated.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>OFF</td></tr>
<tr><td>S_MutingActive</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Wait the completion of safety demand.</td></tr>
<tr><td>8011</td><td>Muting Start1</td><td>Muting sequence is in starting phase after rising trigger of S_MutingSw_11. Monitoring of DiscTimeEntry is activated.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>ON</td></tr>
<tr><td>S_MutingActive</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td rowspan="2">Both muting switches are ON within DiscTimeEntry.</td></tr>
<tr><td>8311</td><td>Muting Start2</td><td>Muting sequence is in starting phase after rising trigger of S_MutingSw_12. Monitoring of DiscTimeEntry is activated.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>ON</td></tr>
<tr><td>S_MutingActive</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td></tr>
<tr><td>8012</td><td>Muting Active</td><td>Muting sequence is active either:
• When both S_MutingSw_11/12 have been actuated in serial.
• When both S_MutingSw_11/12 have been actuated in the same cycle.
Monitoring of DiscTimeEntry is stopped.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>ON</td></tr>
<tr><td>S_MutingActive</td><td>ON</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Complete muting within MaxMutingTime.</td></tr>
</table>

[WARNING]
Please do the above actions when the FB detects error or is an unexpected state.
However, when still the situation is not corrected, please check following.
- A failure in safe devices and emergency stop devices
- Wiring and status of a safety remote I/O stations and a safety Programmable Controller
- Programming logics, the memory allocation of safety devices and the connections of FB variables
- Setting of S_StartReset.

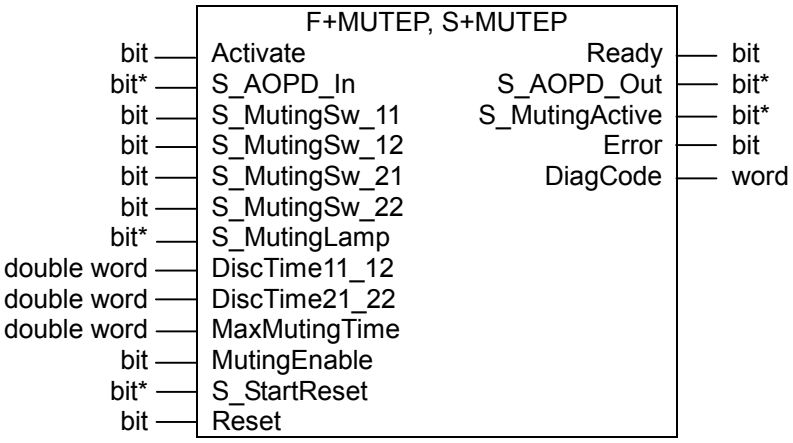
APPLICATION EXAMPLE

For applications, see the Safety Application Guide.

APPLICABLE SAFETY STANDARDS

Standards	Requirements
IEC 61496-1: 2004	A.7 Muting, A.7.1.2 There shall be at least two independent hard-wired muting signal sources to initiate the function. It shall not be possible to initiate muting when the OSSDs are already in the OFFstate. A.7.1.3 The mute function shall only be inititated by the correct sequence and/or timing of the mute signals. Should conflicting muting signals occur, the ESPE shall not allow a muted condition to occur. A.7.1.4 There shall be at least two independent hard-wired muting signal sources to stop the function. The muting function shall stop when the first of these muting signals changes state. The deactivation of the muting function shall not rely only on the clearance of the ESPE. A.7.1.5 The muting signals should be continuously present during muting. When the signals are not continuously present, an incorrect sequence and/or the expiration of a pre-set time limit shall cause either a lock-out condition or a restart interlock. A.7.4 Indication: A mute status signal or indicator shall be provided (in some applications, an indication signal of muting is necessary.
CD IEC 62046/Ed.1: 2005	5.5.1: .. an indicator to show when the muting function is active can be necessary. The muting function shall be initiated and terminated automatically….Incorrect signals, sequence, or timing of the muting sensors or signals shall not allow a mute condition. It shall not be possible to initiate the muting function when: – the protective equipment OSSDs are in the OFF-state; – the protective equipment is in the lock-out condition. - initiation of the muting function by two or more independent muting sensors such that a single fault cannot cause a muted condition; - termination of the muting function by two or more independent muting sensors such that deactivation of one sensor will terminate the muting function; - use of timing and sequence control of the muting sensors to ensure correct muting operation; 5.5.3: The following measures shall be considered: … - limiting muting to a fixed time that is only sufficient for the material to pass through the detection zone. When this time is exceeded, the muting function should be cancelled and all hazardous movements stopped; Annex F.7 Two sensors – Crossed beams (see also Fig. F.7.2 and F.7.3) The muting function should only be initiated when the two beams are activated within a time limit of 4 sec. The muting function should be terminated as soon as one of the two beams of the muting sensors is no longer activated. A monitored timer that limits the muting function to the minimum time practicable is required. Annex F.5: Methods to avoid manipulation of the muting function: … use a muting enable command generated by the control system of the machine that will only enable the muting function when needed by the machine cycle.
EN 954-1: 1996	5.4 Manual reset
ISO 12100-2: 2003	4.11.4: Restart following power failure/spontaneous restart

4.11 F+MUTEP, S+MUTEP



OVERVIEW

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

INPUT/OUTPUT

I/O	Name	Data Type	Initial Value	Description, Parameter Values
IN	Activate	bit	OFF	Activation of the safety FB. For details, see Section 2.5.
	S_AOPD_In	bit*	OFF	OSSD (safety output) signal from AOPD (Active opto-electronic protective devices). OFF : Protection field interrupted. ON : Protection field not interrupted.
	S_MutingSw_11	bit	OFF	Status of Muting sensor 11. OFF : Muting sensor 11 not actuated. ON : Workpiece actuates muting sensor 11.
	S_MutingSw_12	bit	OFF	Status of Muting sensor 12. OFF : Muting sensor 12 not actuated. ON : Workpiece actuates muting sensor 12.
	S_MutingSw_21	bit	OFF	Status of Muting sensor 21. OFF : Muting sensor 21 not actuated. ON : Workpiece actuates muting sensor 21.
	S_MutingSw_22	bit	OFF	Status of Muting sensor 22. OFF : Muting sensor 22 not actuated. ON : Workpiece actuates muting sensor 22.
	S_MutingLamp	bit*	OFF	Indicates operation of the muting lamp. OFF : Muting lamp failure. ON : Muting lamp no failure.
	DiscTime11_12	double word	0	Max. discrepancy time for S_MutingSw_11 and S_MutingSw_12. Increments of 10ms. Range: Fixed values from 0 to 400 (0 to 4000ms=4sec)
	DiscTime21_22	double word	0	Max. discrepancy time for S_MutingSw_21 and S_MutingSw_22. Increments of 10ms. Range: Fixed values from 0 to 400 (0 to 4000ms=4sec)
	MaxMutingTime	double word	0	Maximum time for complete muting sequence, timer started when first muting sensor is actuated. Increments of 10ms. The timer is started at the trigger of switching first muting sensor. Range: Fixed values from 0 to 60000 (0 to 600000ms=10min)
	MutingEnable	bit	OFF	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. OFF : Muting not enabled ON : Start of Muting function enabled
	S_StartReset	bit*	OFF	Selection of a reset method for the activated (first time) safety FB. For details, see Section 2.5.
	Reset	bit	OFF	Reset input. For details, see Section 2.5.

(To the next page)

I/O	Name	Data Type	Initial Value	Description, Parameter Values
OUT	Ready	bit	OFF	Status of whether the safety FB is activated or not. For details, see Section 2.5.
	S_AOPD_Out	bit*	OFF	Safety FB output, indicates status of the muted guard. OFF : AOPD protection field interrupted and muting not active. ON : AOPD protection field not interrupted or muting active.
	S_MutingActive	bit*	OFF	Indicates status of Muting process. OFF : Muting not active. ON : Muting active.
	Error	bit	OFF	Error flag. For details, see Section 2.5.
	DiagCode	word	0	Diagnostic Code. For details, see Section 2.5.

[WARNING]
- Use safety data (See Appendix 2.) for connecting the variable whose data type is “bit*” to input - output circuits.
  Wire the safety input - output devices and set parameters correctly, referring to the Safety Application Guide.
- Safe input must be connected to S_MutingSW_11/12/21/22 depending on the safety requirements.
- A short circuit in the muting sensor signals, or a functional application error to supply these signals, are not detected by this FB but interpreted as incorrect muting sequence. However, this condition should not lead to unwanted muting. The user should take care to include this in his risk analysis.

FUNCTION 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 in Figure 4.38. The FB can be used in both directions, forward and backward. The muting should be enabled with the MutingEnable signal by the process control when there is no manipulation in the danger zone.

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).
For forward direction, while both S_MutingSw_11/12 turn ON to S_MutingSW_21 or 22 turns OFF after both turn ON, muting is active and S_AOPD_Out=ON however S_AOPD_In=OFF. For backward direction, while both S_MutingSw_21/22 turn ON to S_MutingSw_11 or 12 turns OFF after both turn ON, muting is active.

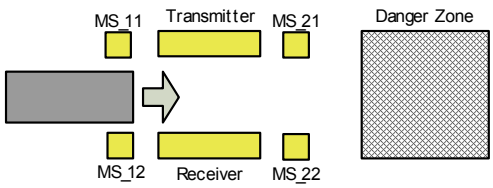
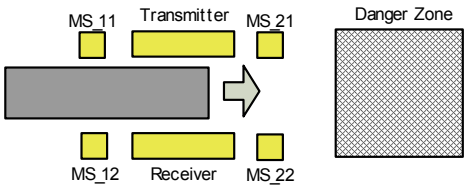
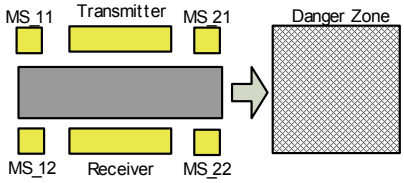
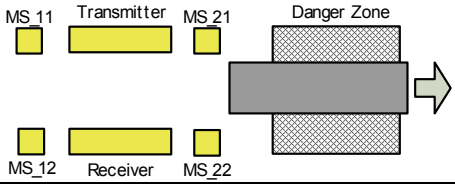
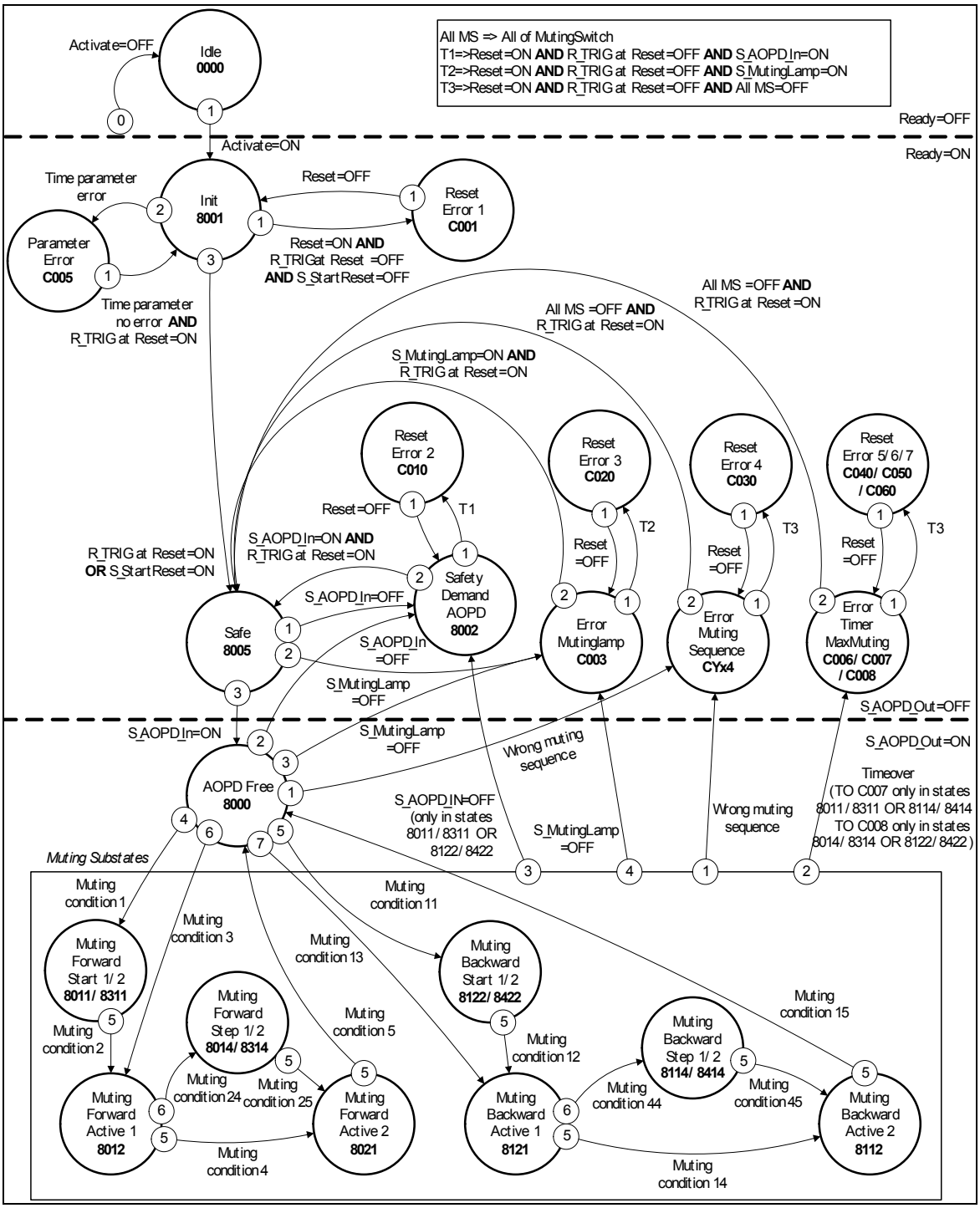
No.	Figure	Explanation
1		If the muting sensors S_MutingSw_11 (MS_11) and S_MutingSw_12 (MS_12) are activated by the product within the time DiscTime11_12, muting mode is activated (S_MutingActive=ON).
2		Muting mode remains active as long as MS_11 and MS_12 are activated by the product. The product may pass through the light curtain without causing a machine stop.
3		Before muting sensors MS_11 and MS_12 are disabled, muting sensors S_MutingSw_21 (MS_21) and S_MutingSw_22 (MS_22) must be activated. This ensures that muting mode remains active. The time discrepancy between switching of MS_21 and MS_22 is monitored by the time DiscTime21_22.
4		Muting mode is terminated if either muting sensor MS_21 or MS_22 is disabled by the product. The maximum time for muting mode to be active is the MaxMutingTime.

Figure 4.28 Example for F+MUTEP, S+MUTEP in forward direction with 4 sensors

STATE DIAGRAM



Note1: The transition from any state to the Idle state due to Activate=OFF is not shown. However these transitions have the highest priority (0).

Note2: Within muting substates, transitions due to Error Muting sequence (priority 1), Error Timer (priority 2), Safety demand AOPD (priority 3) or Error Muting lamp (priority 4) have higher priority than transitions to Muting substates (priority 5 or 6).
If the safety FB is in the timing error state, the simultaneously occurrence of C006 and C007 or C006 and C008 leads to C006 state.

Note3: Muting condition 1-6 and Wrong muting sequences are shown in next page.

Note4: Time parameter error (condition of transition from 8001 to C005) is detected in either one of the following two cases.

1) DiscTime11_12 has been set to a value less than 0ms or greater than 400ms.
(0 > DiscTime11_12 OR DiscTime11_12 > 400)
2) DiscTime21_22 has been set to a value less than 0ms or greater than 400ms.
(0 > DiscTime21_22 OR DiscTime21_22 > 400)
3) MaxMutingTime has been set to a value less than 0ms or greater than 10min.
(0 > MaxMutingTime OR MaxMutingTime > 60000)

Note5: The F+MUTEP state transition from C005 to 8001 is only due to the online change performed when the safety CPU operating mode is set to the test mode.

Figure 4.29 State Ddiagram for F+MUTEP, S+MUTEP

Muting Conditions (forward direction)

No.	State Transistion	Condition/Actions
1	8000→8011	MS_11 is the first entry switch actuated: Start timers MaxMutingTime and DiscTime11_12. MutingEnable=ON AND MS_11=OFF→ON AND MS_12=OFF AND MS_21=OFF AND MS_22=OFF
	8000→8311	MS_12 is the first entry switch actuated: Start timers MaxMutingTime and DiscTime11_12. MutingEnable=ON AND MS_11=OFF AND MS_12=OFF→ON AND MS_21=OFF AND MS_22=OFF
2	8011→8012	MS_12 is the second entry switch actuated: Stop timer DiscTime11_12. MutingEnable=ON AND MS_11=ON AND MS_12=OFF→ON AND MS_21=OFF AND MS_22=OFF
	8311→8012	MS_11 is the second entry switch actuated: Stop timer DiscTime11_12. MutingEnable=ON AND MS_11=OFF→ON AND MS_12=ON AND MS_21=OFF AND MS_22=OFF
3	8000→8012	Both entry switches actuated in same cycle: Start timer MaxMutingTime. MutingEnable=ON AND MS_11=OFF→ON AND MS_12=OFF→ON AND MS_21=OFF AND MS_22=OFF
4	8012→8021	All switches actuated: MS_11=ON AND MS_12=ON AND MS_21=ON AND MS_22=ON
24	8012→8014	MS_21 is the first exit switch actuated: Start timer DiscTime21_22. MS_11=ON AND MS_12=ON AND MS_21=OFF→ON AND MS_22=OFF
	8012→8314	MS_22 is the first exit switch actuated: Start timer DiscTime21_22. MS_11=ON AND MS_12=ON AND MS_21=OFF AND MS_22=OFF→ON
25	8014→8021	MS_22 is the second exit switch actuated: Stop timer DiscTime21_22. MS_11=ON AND MS_12=ON AND MS_21=ON AND MS_22=OFF→ON
	8314→8021	MS_21 is the second exit switch actuated: Stop timer DiscTime21_22. MS_11=ON AND MS_12=ON AND MS_21=OFF→ON AND MS_22=ON
5	8021→8000	One of the exit switches released: Stop timer MaxMutingTime. MS_11=OFF AND MS_12=OFF AND (MS_21=ON→OFF OR MS_22=ON→OFF)

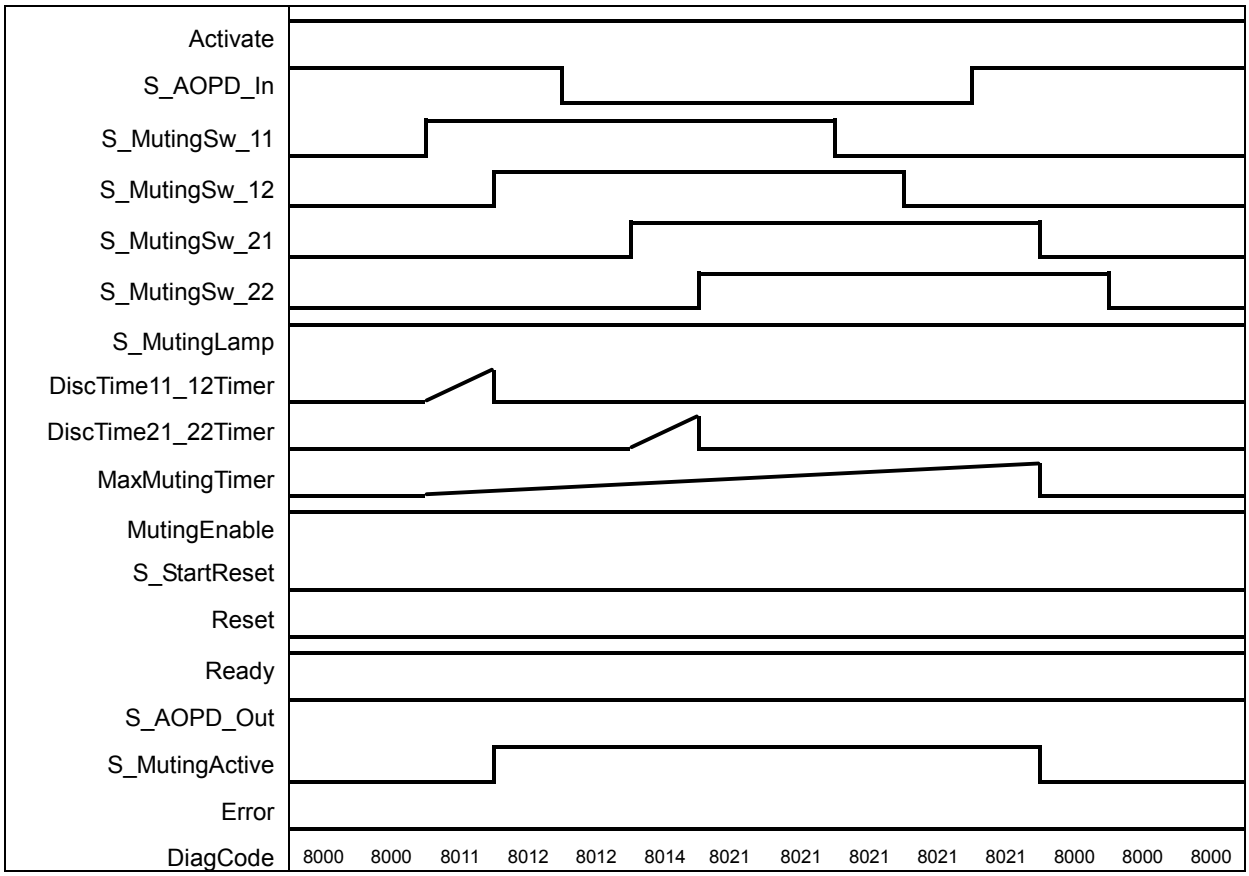
Muting Condition (backward condition)

No.	State Transistion	Condition/Action
11	8000→8122	MS_21 is the first entry switch actuated: Start timers MaxMutingTime and DiscTime21_22. MutingEnable=ON AND MS_21=OFF→ON AND MS_22=OFF AND MS_11=OFF AND MS_12=OFF
	8000→8422	MS_22 is the first entry switch actuated: Start timers MaxMutingTime and DiscTime21_22. MutingEnable=ON AND MS_21=OFF AND MS_22=OFF→ON AND MS_11=OFF AND MS_12=OFF
12	8122→8121	MS_22 is the second entry switch actuated: Stop timer DiscTime21_22. MutingEnable=ON AND MS_21=ON AND MS_22=OFF→ON AND MS_11=OFF AND MS_12=OFF
	8422→8121	MS_21 is the second entry switch actuated: Stop timer DiscTime21_22. MutingEnable=ON AND MS_21=OFF→ON AND MS_22=ON AND MS_11=OFF AND MS_12=OFF
13	8000→8121	Both entry switches actuated in same cycle: Start timer MaxMutingTime. MutingEnable=ON AND MS_21=OFF→ON AND MS_22=OFF→ON AND MS_11=OFF AND MS_12=OFF
14	8121→8112	All switches actuated: MS_21=ON AND MS_22=ON AND MS_11=ON AND MS_12=ON
44	8121→8114	MS_11 is the first exit switch actuated: Start timer DiscTime11_12. MS_21=ON AND MS_22=ON AND MS_11=OFF→ON AND MS_12=OFF
	8121→8414	MS_12 is the first exit switch actuated: Start timer DiscTime11_12. MS_21=ON AND MS_22=ON AND MS_11=OFF AND MS_12=OFF→ON
45	8114→8112	MS_12 is the second exit switch actuated: Stop timer DiscTime11_12. MS_21=ON AND MS_22=ON AND MS_11=ON AND MS_12=OFF→ON
	8414→8112	MS_11 is the second exit switch actuated: Stop timer DiscTime11_12 MS_21=ON AND MS_22=ON AND MS_11=OFF→ON AND MS_12=ON
15	8112→8000	One of the exit switches released: Stop timer MaxMutingTime. MS_21=OFF AND MS_22=OFF AND (MS_11=ON→OFF OR MS_12=ON→OFF)

Wrong Muting Sequences

Status	Wrong muting sequences
8000	When muting sequence starts, MutingEnable=OFF
	(MS_11=ON OR MS_12=ON) AND (MS_21=ON OR MS_22=ON)
	MS_11=OFF→ON AND MS_12=ON AND undetected MS_12=OFF→ON
	MS_12=OFF→ON AND MS_11=ON AND undetected MS_11=OFF→ON
	MS_21=OFF→ON AND MS_22=ON AND undetected MS_22=OFF→ON
	MS_22=OFF→ON AND MS_21=ON AND undetected MS_21=OFF→ON
	(MS_11=ON AND undetected MS_11=OFF→ON) AND (MS_12=ON AND undetected MS_12=OFF→ON)
	(MS_21=ON AND undetected MS_21=OFF→ON) AND (MS_22=ON AND undetected MS_22=OFF→ON)
8011	MutingEnable=OFF OR MS_11=OFF OR MS_21=ON OR MS_22=ON
8311	MutingEnable=OFF OR MS_12=OFF OR MS_21=ON OR MS_22=ON
8012	MS_11=OFF OR MS_12=OFF
8021	MS_11=OFF→ON OR MS_12=OFF→ON
	(MS_11=ON OR MS_12=ON) AND (MS_21=ON→OFF OR MS_22=ON→OFF)
	(MS_11=ON→OFF OR MS_12=ON→OFF) AND (MS_21=ON→OFF OR MS_22=ON→OFF)
8014	MS_11=OFF OR MS_12=OFF OR MS_21=OFF
8314	MS_11=OFF OR MS_12=OFF OR MS_22=OFF
8122	MutingEnable=OFF OR MS_11=ON OR MS_12=ON OR MS_21=OFF
8422	MutingEnable=OFF OR MS_11=ON OR MS_12=ON OR MS_22=OFF
8121	MS_21=OFF OR MS_22=OFF
8112	MS_21=OFF→ON OR MS_22=OFF→ON
	(MS_21=ON OR MS_22=ON) AND (MS_11=ON→OFF OR MS_12=ON→OFF)
	(MS_11=ON→OFF OR MS_12=ON→OFF) AND (MS_21=ON→OFF OR MS_22=ON→OFF)
8114	MS_21=OFF OR MS_22=OFF OR MS_11=OFF
8414	MS_21=OFF OR MS_22=OFF OR MS_12=OFF

TYPICAL TIMING DIAGRAM



*: The measurement of the DiscTime11_12Timer, DiscTim21_22Timer, and MaxMutingTimer elapsed time stops due to the stop of sequence program operations when the operating status of CPU modules is changed to STOP.

Figure4.30 Typical Timing Diagram for F+MUTEP, S+MUTEP (S_StartReset=OFF, forward direction)

ERROR BEHAVIOR

In the event of an error, the output signals behave as listed below.
For the corrective actions, see the ERROR CODES.

Output Signal	Status
Ready	ON
S_AOPD_Out	OFF
S_MutingActive	OFF
Error	ON

ERROR CODES

Diag Code (Hexadecimal)	State Name	State Description and Output Setting	Actions
C001	Reset Error1	Static Reset condition detected after FB activation in state 8001.	Set Reset to OFF. Check the devices and wiring related to Reset.
C003	Error Muting Lamp	Error detected in muting lamp.	Reset the safety FB. Check the devices and wiring related to Reset.
CYx4 C004 to CFF4	Error Muting Sequence	Error detected in muting sequence state 8000, 8011, 8311, 8012, 8021, 8014, 8314, 8122, 8422, 8121, 8112, 8114 or 8414. Y=Status in the sequence (6 states for forward and 6 states for backward direction). C0x4=Error occurred in state 8000 C1x4=in state Forward 8011 C2x4=in state Forward 8311 C3x4=in state Forward 8012 C4x4=in state Forward 8014 C5x4=in state Forward 8314 C6x4=in state Forward 8021 C7x4=in state Backward 8122 C8x4=in state Backward 8422 C9x4=in state Backward 8121 CAx4=in state Backward 8114 CBx4=in state Backward 8414 CCx4=in state Backward 8112 CFx4=Muting Enable missing MutingEnable is OFF. The states of wrong muting sequences (See Page 4-65) including MutingEnable=OFF are changed to this Error Muting Sequence whose DiagCode is always CFx4 when MutingEnable is set to OFF. (Never changed to other states) x=Status of the sensors when error occurred (MS_11, MS_12, MS_21, MS_22 in order) CY04=OFF, OFF, OFF, OFF CY14=ON, OFF, OFF, OFF CY24=OFF, ON, OFF, OFF CY34=ON, ON, OFF, OFF CY44=OFF, OFF, ON, OFF CY54=ON, OFF, ON, OFF CY64=OFF, ON, ON, OFF CY74=ON, ON, ON, OFF CY84=OFF, OFF, OFF, ON CY94=ON, OFF, OFF, ON CYA4=OFF, ON, OFF, ON CYB4=ON, ON, OFF, ON CYC4=OFF, OFF, ON, ON CYD4=ON, OFF, ON, ON CYE4=OFF, ON, ON, ON CYF4=ON, ON, ON, ON	Set all Muting Switches to OFF and Reset the safety FB. Check the devices and wiring related to Reset.
C005	Parameter Error	DiscTime11_12, DiscTime21_22 or MaxMutingTime value out of range.	Set all values of DiscTime11_12, DiscTime21_22, and MaxMutingTime within the setting range, and reset the safety FB.

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Diag Code (Hexadecimal)	State Name	State Description and Output Setting	Actions
C006	Error Timer MaxMuting	Timing error: Active muting time exceeds MaxMutingTime.	Set all Muting Switches to OFF and Reset the safety FB. Check the muting situation in the process.
C007	Error Timer MS11_12	Timing error: Discrepancy time for switching S_MutingSW_11 and 12 > DiscTime11_12.	
C008	Error Timer MS21_22	Timing error: Discrepancy time for switching MutingSwitch21 and MutingSwitch22 > DiscTime21_22.	
C010	Reset Error2	Static Reset condition detected after FB activation in state 8002.	Set Reset to OFF. Check the devices and wiring related to Reset.
C020	Reset Error3	Static Reset condition detected after FB activation in state C003.	
C030	Reset Error4	Static Reset condition detected after FB activation in state CYx4.	
C040	Reset Error5	Static Reset condition detected after FB activation in state C006.	
C050	Reset Error6	Static Reset condition detected after FB activation in state C007.	
C060	Reset Error7	Static Reset condition detected after FB activation in state C008.	

STATUS CODES (no error)

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
0000	Idle	The function block is not active (initial state). Output Signal / Status Ready: OFF S_AOPD_Out: OFF S_MutingActive: OFF Error: OFF	Initialize the safety FB by setting Activate to ON.
8000	AOPD Free	Muting not active and no safety demand from AOPD. If timers from subsequent muting are still running, they are stopped. Output Signal / Status Ready: ON S_AOPD_Out: ON S_MutingActive: OFF Error: OFF	None. Starting muting is possible.
8001	Init	Function block was activated. Output Signal / Status Ready: ON S_AOPD_Out: OFF S_MutingActive: OFF Error: OFF	Reset the safety FB.
8002	Safety Demand AOPD	Safety demand detected by AOPD, muting not active. Output Signal / Status Ready: ON S_AOPD_Out: OFF S_MutingActive: OFF Error: OFF	Reset the safety FB after the completion of safety demand.
8005	Safe	Safety function activated. Output Signal / Status Ready: ON S_AOPD_Out: OFF S_MutingActive: OFF Error: OFF	Wait the completion of safety demand.

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<table>
<tr><th>Diag Code (Hexadecimal)</th><th>State Name</th><th>Description, Output Setting</th><th>Actions</th></tr>
<tr><td>8011</td><td>Muting Forward Start1</td><td>Muting forward sequence is in starting phase after rising trigger of S_MutingSw_11. Monitoring of DiscTime11_12 is activated. Monitoring of MaxMutingTime is activated.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>ON</td></tr>
<tr><td>S_MutingActive</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td rowspan="2">Both S_MutingSw_11 and S_MutingSw_12 are ON within DiscTime11_12.</td></tr>
<tr><td>8311</td><td>Muting Forward Start2</td><td>Muting forward sequence is in starting phase after rising trigger of S_MutingSw_12. Monitoring of DiscTime11_12 is activated. Monitoring of MaxMutingTime is activated.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>ON</td></tr>
<tr><td>S_MutingActive</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td></tr>
<tr><td>8012</td><td>Muting Forward Active1</td><td>Muting forward sequence is active when both S_MutingSwi_11 and 12 have been actuated in the same cycle or in serial. Monitoring of DiscTime11_12 is stopped. Monitoring of MaxMutingTime is activated, when transition came directly from state 8000.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>ON</td></tr>
<tr><td>S_MutingActive</td><td>ON</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Complete muting within MaxMutingTime.</td></tr>
<tr><td>8014</td><td>Muting Forward Step1</td><td>Muting forward sequence is active. S_MutingSw_21 is the first exit switch actuated. Monitoring of DiscTime21_22 is started.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>ON</td></tr>
<tr><td>S_MutingActive</td><td>ON</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td rowspan="2">Both S_MutingSw_21/22 are ON.
Complete muting within MaxMutingTime.</td></tr>
<tr><td>8314</td><td>Muting Forward Step2</td><td>Muting forward sequence is active. S_MutingSw_22 is the first exit switch actuated. Monitoring of DiscTime21_22 is started.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>ON</td></tr>
<tr><td>S_MutingActive</td><td>ON</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td></tr>
<tr><td>8021</td><td>Muting Forward Active2</td><td>Muting forward sequence is still active. Both S_MutingSwitch21 and 22 are actuated, the monitoring of DiscTime21_22 is stopped.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>ON</td></tr>
<tr><td>S_MutingActive</td><td>ON</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Complete muting within MaxMutingTime.</td></tr>
</table>

(To the next page)

<table>
<tr><th>Diag Code (Hexadecimal)</th><th>State Name</th><th>Description, Output Setting</th><th>Actions</th></tr>
<tr><td>8122</td><td>Muting Backward Start1</td><td>Muting backward sequence is in starting phase after rising trigger of S_MutingSw_21. Monitoring of DiscTime21_22 is activated. Monitoring of MaxMutingTime is activated.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>ON</td></tr>
<tr><td>S_MutingActive</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Both S_MutingSw_21 and 22 are ON.
Complete muting within MaxMutingTime.</td></tr>
<tr><td>8422</td><td>Muting Backward Start2</td><td>Muting backward sequence is in starting phase after rising trigger of S_MutingSw_22. Monitoring of DiscTime21_22 is activated. Monitoring of MaxMutingTime is activated.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>ON</td></tr>
<tr><td>S_MutingActive</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Both S_MutingSw_21 and 22 are ON.
Complete muting within MaxMutingTime.</td></tr>
<tr><td>8121</td><td>Muting Backward Active1</td><td>Muting backward sequence is active when both S_MutingSw21 and 22 have been actuated in the same cycle or in serial. Monitoring of DiscTime21_22 is stopped. Monitoring of MaxMutingTime is activated, when transition came directly from state 8000.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>ON</td></tr>
<tr><td>S_MutingActive</td><td>ON</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Complete muting within MaxMutingTime.</td></tr>
<tr><td>8114</td><td>Muting Backward Step1</td><td>Muting backward sequence is active. S_MutingSw_11 is the first exit switch actuated. Monitoring of DiscTime11_12 is started.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>ON</td></tr>
<tr><td>S_MutingActive</td><td>ON</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td rowspan="2">Both S_MutingSw_11 12 are ON.
Complete muting within MaxMutingTime.</td></tr>
<tr><td>8414</td><td>Muting Backward Step2</td><td>Muting backward sequence is active. S_MutingSw_12 is the first exit switch actuated. Monitoring of DiscTime11_12 is started.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>ON</td></tr>
<tr><td>S_MutingActive</td><td>ON</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td></tr>
<tr><td>8112</td><td>Muting Backward Active2</td><td>Muting backward sequence is still active. Both exit switches S_MutingSw_11 and 12 are actuated, the monitoring of DiscTime11_12 is stopped.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>ON</td></tr>
<tr><td>S_MutingActive</td><td>ON</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Complete muting within MaxMutingTime.</td></tr>
</table>

[WARNING]
Please do the above actions when the FB detects error or is an unexpected state.
However, when still the situation is not corrected, please check following.
- A failure in safe devices and emergency stop devices
- Wiring and status of a safety remote I/O stations and a safety Programmable Controller
- Programming logics, the memory allocation of safety devices and the connections of FB variables
- Setting of S_StartReset.

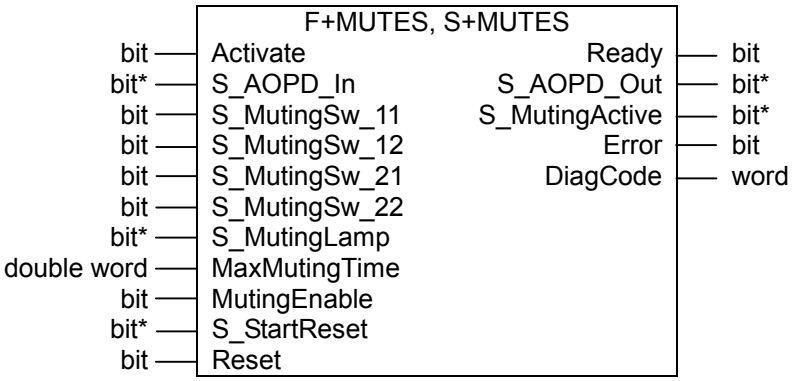
APPLICATION SAMPLE

For applications, see the Safety Application Guide.

APPLICABLE SAFETY STANDARDS

Standards	Requirements
IEC 61496-1: 2004	A.7 Muting, A.7.1.2 There shall be at least two independent hard-wired muting signal sources to initiate the function. It shall not be possible to initiate muting when the OSSDs are already in the OFF-state. A.7.1.3 The mute function shall only be inititated by the correct sequence and/or timing of the mute signals. Should conflicting muting signals occur, the ESPE shall not allow a muted condition to occur. A.7.1.4 There shall be at least two independent hard-wired muting signal sources to stop the function. The muting function shall stop when the first of these muting signals changes state. The deactivation of the muting function shall not rely only on the clearance of the ESPE. A.7.1.5 The muting signals should be continuously present during muting. When the signals are not continuously present, an incorrect sequence and/or the expiration of a pre-set time limit shall cause either a lock-out condition or a restart interlock. A.7.4 Indication: A mute status signal or indicator shall be provided (in some applications, an indication signalof muting is necessary
CD IEC 62046/Ed.1: 2005	5.5.1: .. an indicator to show when the muting function is active can be necessary. The muting function shall be initiated and terminated automatically….Incorrect signals, sequence, or timing of the muting sensors or signals shall not allow a mute condition. It shall not be possible to initiate the muting function when: – the protective equipment OSSDs are in the OFF-state; – the protective equipment is in the lock-out condition. - initiation of the muting function by two or more independent muting sensors such that a single fault cannot cause a muted condition; - termination of the muting function by two or more independent muting sensors such that deactivation of one sensor will terminate the muting function; - use of timing and sequence control of the muting sensors to ensure correct muting operation; 5.5.3: The following measures shall be considered: … - limiting muting to a fixed time that is only sufficient for the material to pass through the detection zone. When this time is exceeded, the muting function should be cancelled and all hazardous movements stopped; Annex F.2 Four beams – timing control: (see also Fig. F.2.4): The monitoring of the muting function is based on time limitation between the actuation of the sensors S1 [in this document MS_11] and S2 [in this document MS_12] and between the actuation of sensors S3 [in this document MS_21] and S4 [in this document MS_22]. A maximum time limit of 4 sec. is recommended. The muting function is initiated by the two sensors S1, S2 and maintained by the two sensors S3, S4; this means that for a certain time all the four sensors are activated. The muting function is terminated when S3 or S4 is deactivated. Annex F.5: Methods to avoid manipulation of the muting function: … use a muting enable command generated by the control system of the machine that will only enable the muting function when needed by the machine cycle.
EN 954-1: 1996	5.4 Manual reset
ISO 12100-2: 2003	4.11.4: Restart following power failure/spontaneous restart

4.12 F+MUTES, S+MUTES



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.

INPUT/OUTPUT

I/O	Name	Data Type	Initial Value	Description, Parameter Values
IN	Activate	bit	OFF	Activation of the safety FB. For details, see Section 2.5.
	S_AOPD_In	bit*	OFF	OSSD (safety output) signal from AOPD (Active opto-electronic protective devices). OFF : Protection field interrupted. ON : Protection field not interrupted.
	S_MutingSw_11	bit	OFF	Status of Muting sensor 11. OFF : Muting sensor 11 not actuated. ON : Workpiece actuates muting sensor 11.
	S_MutingSw_12	bit	OFF	Status of Muting sensor 12. OFF : Muting sensor 12 not actuated. ON : Workpiece actuates muting sensor 12.
	S_MutingSw_21	bit	OFF	Status of Muting sensor 21. OFF : Muting sensor 21 not actuated. ON : Workpiece actuates muting sensor 21.
	S_MutingSw_22	bit	OFF	Status of Muting sensor 22. OFF : Muting sensor 22 not actuated. ON : Workpiece actuates muting sensor 22.
	S_MutingLamp	bit*	OFF	Indicates operation of the muting lamp. OFF : Muting lamp failure. ON : Muting lamp no failure
	MaxMutingTime	double word	0	Maximum time for complete muting sequence, timer started when first muting sensor is actuated. Increments of 10ms. The timer is started at the trigger of switching first muting sensor. Range: Fixed values from 0 to 60000 (0 to 600000ms=10min)
	MutingEnable	bit	OFF	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. OFF : Muting not enabled ON : Start of Muting function enabled
	S_StartReset	bit*	OFF	Selection of a reset method for the activated (first time) safety FB. For details, see Section 2.5.
	Reset	bit	OFF	Reset input. For details, see Section 2.5.

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I/O	Name	Data Type	Initial Value	Description, Parameter Values
OUT	Ready	bit	OFF	Status of whether the safety FB is activated or not. For details, see Section 2.5.
	S_AOPD_Out	bit*	OFF	Safety FB output, indicates status of the muted guard. OFF : Protection field interrupted and muting not active. ON : Protection field not interrupted or muting active.
	S_MutingActive	bit*	OFF	Indicates status of Muting process. OFF : Muting not active. ON : Muting active.
	Error	bit	OFF	Error flag. For details, see Section 2.5.
	DiagCode	word	0	Diagnostic Code. For details, see Section 2.5.

[WARNING]
- Use safety data (See Appendix 2.) for connecting the variable whose data type is "bit*" to input - output circuits.
  Wire the safety input - output devices and set parameters correctly, referring to the Safety Application Guide.
- Safe input must be connected to S_MutingSW_11/12/21/22 depending on the safety requirements.
- A short circuit in the muting sensor signals, or a functional application error to supply these signals, are not detected by this FB but interpreted as incorrect muting sequence. However, this condition should not lead to unwanted muting. The user should take care to include this in his risk analysis.

FUNCTION 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 four muting sensors was used; an explanation is provided in Figure 4.42. The FB can be used in both directions, forward and backward. The muting should be enabled with the MutingEnable signal by the process control when there is no manipulation in the danger zone. When the MutingEnable signal is not available, this input must be set to ON.

The FB input parameters include the signals of the four muting sensors (S_MutingSwitch11… S_MutingSwitch22) as well as the OSSD signal from the "active opto-electronic protective device", S_AOPD_In.
For forward direction, while both S_MutingSw_11/12 turn ON to only S_MutingSW_22 turns ON after Muting_Sw_21/22 turn ON, muting is active and S_AOPD_Out turns ON however S_AOPD_In turns OFF. For backward direction, while both S_MutingSw_21/22 turn ON to only S_MutingSw_11 turns ON after Muting_Sw_11/12 turn ON, muting is active.

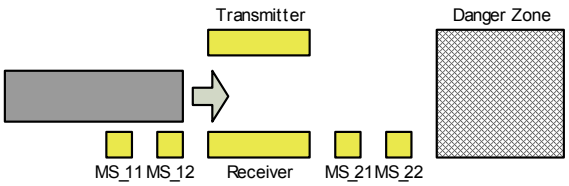
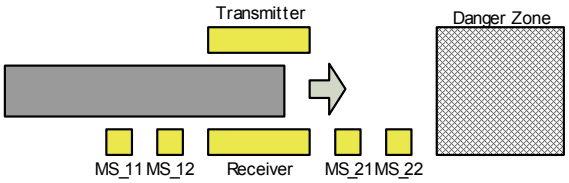
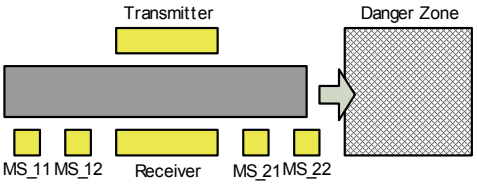
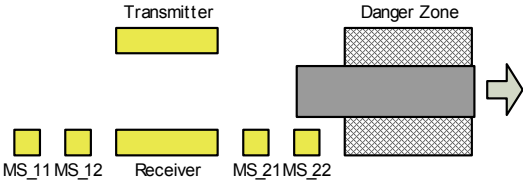
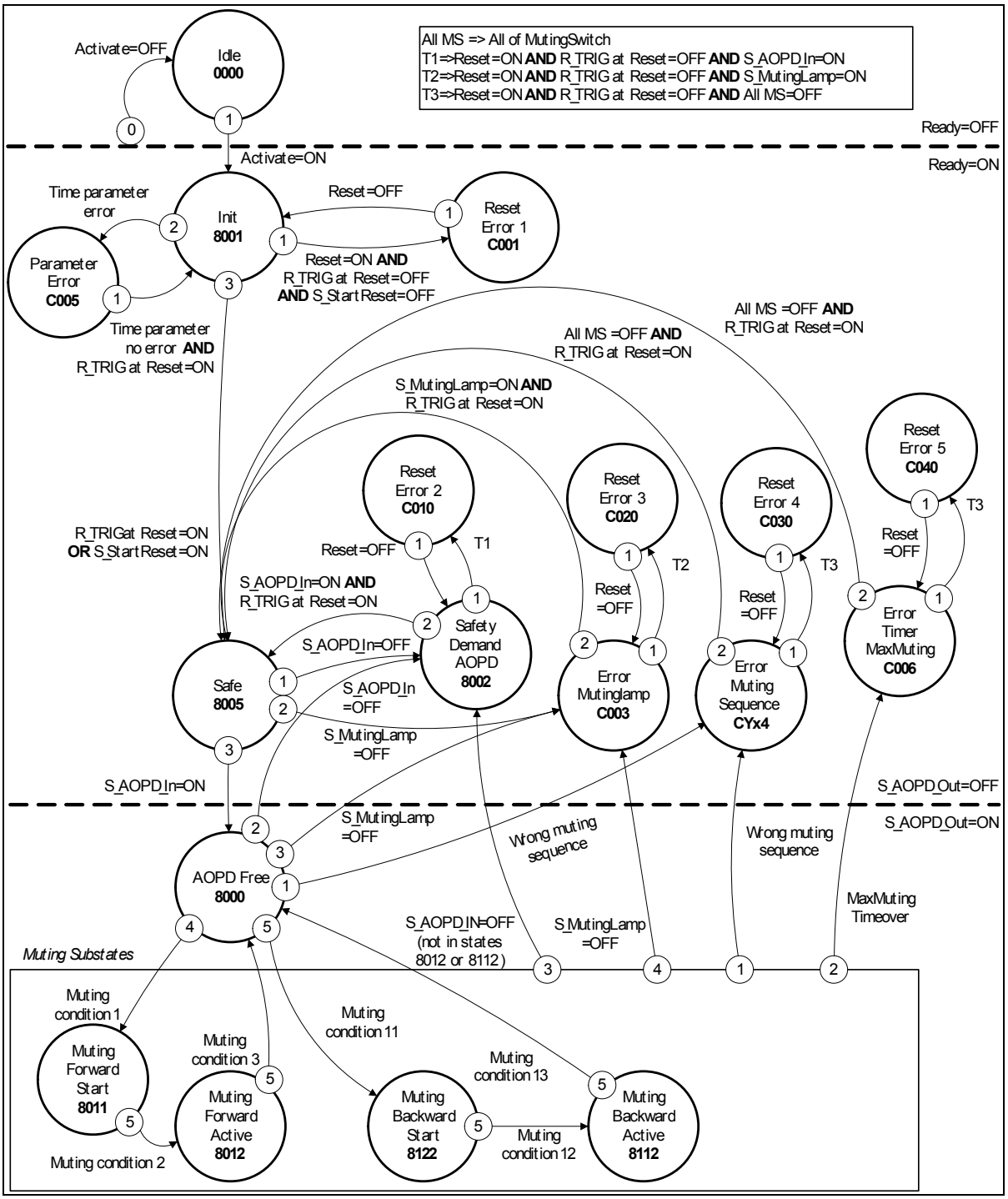
No.	Figure	Explanation
1		If muting sensor S_MutingSw_12 (MS_12) is activated by the product after S_MutingSw_11 (MS_11), the muting mode is activated.
2		Muting mode remains active as long as MS_11 and MS_12 are activated by the product. The product may pass through the light curtain without causing a machine stop.
3		Before muting sensors MS_11 and MS_12 are disabled, muting sensors S_MutingSw_21 (MS_21) and S_MutingSw_22 (MS_22) must be activated. This ensures that muting mode remains active.
4		Muting mode is terminated if only muting sensor MS_22 is activated by the product.

Figure 4.31 Example for F+MUTES, S+MUTES in forward direction with four sensors

STATE DIAGRAM



Note1: The transition from any state to the Idle state due to Activate=OFF is not shown. However these transitions have the highest priority (0).

Note2: Within muting substates, transitions due to Error Muting sequence (priority 1), Error Timer (priority 2), Safety demand AOPD (priority 3) or Error Muting lamp (priority 4) have higher priority than transitions to Muting substates (priority 5).

Note3: Muting condition 1-3/11-13 and Wrong muting sequences are shown in next page.

Note4: Time parameter error (condition of transition from 8001 to C005) is detected in either one of the following two cases.

1) MaxMutingTime has been set to a value less than 0ms or greater than 10min.
(0 > MaxMutingTime OR MaxMutingTime > 60000)

Note5: The F+MUTES state transition from C005 to 8001 is only due to the online change performed when the safety CPU operating mode is set to the test mode.

Figure 4.32 State Diagram for F+MUTES, S+MUTES

Muting Conditions (Forward Direction)

No.	State Transision	Condition/Action
1	8000→8011	MS_11 is the first entry switch actuated: Start timer MaxMutingTime. MutingEnable=ON AND MS_11=OFF→ON AND MS_12=OFF AND MS_21=OFF AND MS_22=OFF
2	8011→8012	MS_12 is the second entry switch actuated: MutingEnable=ON AND MS_11=ON AND MS_12=OFF→ON AND MS_21=OFF AND MS_22=OFF
3	8012→8000	MS_21 is the first exit switch released: Stop timer MaxMutingTime. MS_11=OFF AND MS_12=OFF AND MS_21=ON→OFF AND MS_22=ON

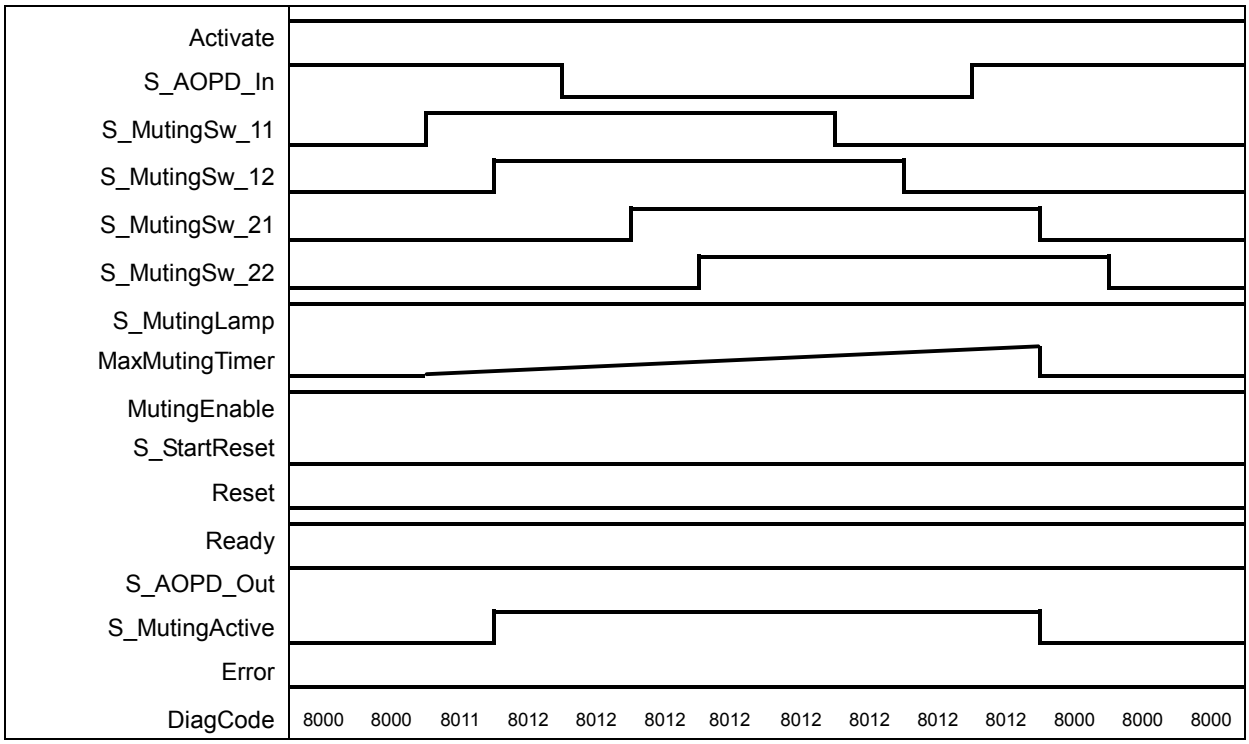
Muting Conditions (Backward Direction)

No.	State Transision	Condition/Action
11	8000→8122	MS_22 is the first entry switch actuated: Start timer MaxMutingTime. MutingEnable=ON AND MS_11=OFF AND MS_12=OFF AND MS_21=OFF AND MS_22=OFF→ON
12	8122→8112	MS_21 is the second entry switch actuated: MutingEnable=ON AND MS_11=OFF AND MS_12=OFF AND MS_21=OFF→ON AND MS_22=ON
13	8112→8000	MS_12 is the first exit switch released: Stop timer MaxMutingTime. MS_11=ON AND MS_12=ON→OFF AND MS_21=OFF AND MS_22=OFF

Wrong Muting Sequences

Status	Wrong muting Sequences
8000	MutingEnable=OFF AND MS_11=OFF→ON
	MutingEnable=OFF AND MS_22=OFF→ON
	MS_12=ON OR MS_21=ON
	MS_11=ON AND MS_22=ON
8011	MutingEnable=OFF OR MS_11=OFF OR MS_21=ON OR MS_22=ON
8012	MS_11=OFF→ON OR MS_12=OFF→ON OR MS_22=ON→OFF
	MS_11=ON AND MS_12=ON→OFF
	(MS_11=ON OR MS_12=ON) AND MS_21=ON→OFF
	(MS_11=OFF OR MS_12=OFF) AND MS_21=ON AND MS_22=OFF
	(MS_11=OFF OR MS_12=OFF OR MS_21=OFF) AND MS_22=OFF→ON
	MS_11=OFF AND MS_12=OFF AND MS_21=OFF AND MS_22=OFF
	MS_11=ON AND (MS_12=OFF OR MS_21=OFF) AND MS_22=ON
	MS_11=OFF AND MS_12=ON AND MS_21=OFF AND MS_22=ON
	MS_21=OFF→ON AND MS_22=OFF→ON
	MS_11=ON→OFF AND MS_12=ON→OFF
	MS_12=ON→OFF AND MS_21=ON→OFF
	MS_11=OFF AND MS_12=ON AND MS_21=OFF
8112	MS_11=ON→OFF OR MS_21=OFF→ON OR MS_22=OFF→ON
	MS_21=ON→OFF AND MS_22=ON
	MS_12=ON→OFF AND (MS_21=ON OR MS_22=ON)
	MS_11=OFF AND MS_12=ON AND (MS_21=OFF OR MS_22=OFF)
	MS_11=OFF→ON AND (MS_12=OFF OR MS_21=OFF OR MS_22=OFF)
	MS_11=OFF AND MS_12=OFF AND MS_21=OFF AND MS_22=OFF
	MS_11=ON AND (MS_12=OFF OR MS_21=OFF) AND MS_22=ON
	MS_11=ON AND MS_12=OFF AND MS_21=ON AND MS_22=OFF
	MS_11=OFF→ON AND MS_12=OFF→ON
	MS_21=ON→OFF AND MS_22=ON→OFF
	MS_12=ON→OFF AND MS_21=ON→OFF
	MS_12=OFF AND MS_21=ON AND MS_22=OFF
8122	MutingEnable=OFF OR MS_11=ON OR MS_12=ON OR MS_22=OFF

TYPICAL TIMING DIAGRAM



*: The measurement of the MaxMutingTimer elapsed time stops due to the stop of sequence program operations when the operating status of CPU modules is changed to STOP.

Figure4.33 Typical Timing Diagram for F+MUTES, S+MUTES (forward direction)

ERROR BEHAVIOR

In the event of an error, the output signals behave as listed below.
For the corrective actions, see the ERROR CODES.

Output Signal	Status
Ready	ON
S_AOPD_Out	OFF
S_MutingActive	OFF
Error	ON

ERROR CODES

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
C001	Reset Error1	Static Reset condition detected after FB activation.	Set Reset to OFF. Check the devices and wiring related to Reset.
C003	Error Muting Lamp	Error detected in muting lamp.	Reset the safety FB. Check the devices and wiring related to Reset.
C005	Parameter Error	MaxMutingTime value out of range.	Set a proper value to the parameter and reset the safety FB.
C006	Error Timer MaxMuting	Timing error: Active muting time exceeds MaxMutingTime.	Set all Muting Switch to OFF and reset the safety FB. Check the muting situation in the process.
C010	Reset Error2	Static Reset condition detected at 8002.	Set Reset to OFF. Check the devices and wiring related to Reset.
C020	Reset Error3	Static Reset condition detected at C003.	
C030	Reset Error4	Static Reset condition detected at CYx4.	
C040	Reset Error5	Static Reset condition detected at C006.	
CYx4 C004 to CFF4	Error Muting Sequence	Error detected in muting sequence in states 8000, 8011, 8012, 8112 or 8122. Y=Status in the sequence (2 states for forward and 2 states for backward direction). C0x4=Error occurred in 8000 C1x4=Error occurred in Forward 8011 C2x4=Error occurred in Forward 8012 C3x4=Error occurred in Backward 8122 C4x4=Error occurred in Backward 8112 CFx4=Muting Enable missing The states of wrong muting sequences (See Page 4-77) including MutingEnable=OFF are changed to this Error Muting Sequence whose DiagCode is always CFx4 when MutingEnable is set to OFF. (Never changed to other states) x=Status of the sensors when error occurred (MS_11, MS_12, MS_21, MS_22) CY04=OFF, OFF, OFF, OFF CY14=ON, OFF, OFF, OFF CY24=OFF, ON, OFF, OFF CY34=ON, ON, OFF, OFF CY44=OFF, OFF, ON, OFF CY54=ON, OFF, ON, OFF CY64=OFF, ON, ON, OFF CY74=ON, ON, ON, OFF CY84=OFF, OFF, OFF, ON CY94=ON, OFF, OFF, ON CYA4=OFF, ON, OFF, ON CYB4=ON, ON, OFF, ON CYC4=OFF, OFF, ON, ON CYD4=ON, OFF, ON, ON CYE4=OFF, ON, ON, ON CYF4=ON, ON, ON, ON	Set all Muting Switches to OFF and reset the safety FB. Check the devices and wiring related to Reset.

STATUS CODES (no error)

<table>
<tr><th>Diag Code (Hexadecimal)</th><th>State Name</th><th>Description, Output Setting</th><th>Actions</th></tr>
<tr><td>0000</td><td>Idle</td><td>The function block is not active (initial state).
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>OFF</td></tr>
<tr><td>S_AOPD_Out</td><td>OFF</td></tr>
<tr><td>S_MutingActive</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Initialize the safety FB by setting Activate to ON.</td></tr>
<tr><td>8000</td><td>AOPD Free</td><td>Muting not active and no safety demand from AOPD.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>ON</td></tr>
<tr><td>S_MutingActive</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>None.
Starting muting is possible.</td></tr>
<tr><td>8001</td><td>Init</td><td>Function block has been activated.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>OFF</td></tr>
<tr><td>S_MutingActive</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Reset the safety FB.</td></tr>
<tr><td>8002</td><td>Safety Demand AOPD</td><td>Safety demand detected by AOPD, muting not active.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>OFF</td></tr>
<tr><td>S_MutingActive</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Reset the safety FB after the completion of safety demand.</td></tr>
<tr><td>8005</td><td>Safe</td><td>Safety function activated.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>OFF</td></tr>
<tr><td>S_MutingActive</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Wait the completion of safety demand.</td></tr>
<tr><td>8011</td><td>Muting Forward Start</td><td>Muting forward, sequence is in starting phase and no safety demand.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>ON</td></tr>
<tr><td>S_MutingActive</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Both S_MutingSw_11 and S_MutingSw_12 are ON.
Complete muting within MaxMutingTime.</td></tr>
<tr><td>8012</td><td>Muting Forward Active</td><td>Muting forward, sequence is active.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>ON</td></tr>
<tr><td>S_MutingActive</td><td>ON</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td rowspan="2">Complete muting within MaxMutingTime.</td></tr>
<tr><td>8112</td><td>Muting Backward Active</td><td>Muting backward, sequence is active.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>ON</td></tr>
<tr><td>S_MutingActive</td><td>ON</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td></tr>
<tr><td>8122</td><td>Muting Backward Start</td><td>Muting backward, sequence is in starting phase and no safety demand.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_AOPD_Out</td><td>ON</td></tr>
<tr><td>S_MutingActive</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Both S_MutingSw_21 and S_MutingSw_22 are ON.
Complete muting within MaxMutingTime.Complete muting within MaxMutingTime.</td></tr>
</table>

[WARNING]
Please do the above actions when the FB detects error or is an unexpected state.
However, when still the situation is not corrected, please check following.
- A failure in safe devices and emergency stop devices
- Wiring and status of a safety remote I/O stations and a safety Programmable Controller
- Programming logics, the memory allocation of safety devices and the connections of FB variables
- Setting of S_StartReset.

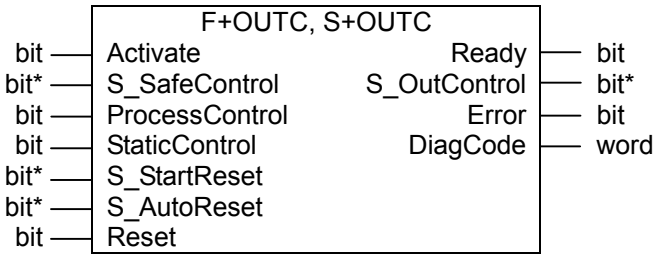
APPLICATION SAMPLE

For applications, see the Safety Applicaion Guide.

APPLICABLE SAFETY STANDARD

Standards	Requirements
IEC 61496-1: 2004	A.7 Muting, A.7.1.2 There shall be at least two independent hard-wired muting signal sources to initiate the function. It shall not be possible to initiate muting when the OSSDs are already in the OFF-state. A.7.1.3 The mute function shall only be inititated by the correct sequence and/or timing of the mute signals. Should conflicting muting signals occur, the ESPE shall not allow a muted condition to occur. A.7.1.4 There shall be at least two independent hard-wired muting signal sources to stop the function. The muting function shall stop when the first of these muting signals changes state. The deactivation of the muting function shall not rely only on the clearance of the ESPE. A.7.1.5 The muting signals should be continuously present during muting. When the signals are not continuously present, an incorrect sequence and/or the expiration of a pre-set time limit shall cause either a lock-out condition or a restart interlock. A.7.4 Indication: A mute status signal or indicator shall be provided (in some applications, an indication signal of muting is necessary)
CD IEC 62046/Ed.1: 2005	5.5.1: .. an indicator to show when the muting function is active can be necessary. The muting function shall be initiated and terminated automatically….Incorrect signals, sequence, or timing of the muting sensors or signals shall not allow a mute condition. It shall not be possible to initiate the muting function when: – the protective equipment OSSDs are in the OFF-state; – the protective equipment is in the lock-out condition. - initiation of the muting function by two or more independent muting sensors such that a single fault cannot cause a muted condition; - termination of the muting function by two or more independent muting sensors such that deactivation of one sensor will terminate the muting function; - use of timing and sequence control of the muting sensors to ensure correct muting operation; 5.5.3: The following measures shall be considered: … - limiting muting to a fixed time that is only sufficient for the material to pass through the detection zone. When this time is exceeded, the muting function should be cancelled and all hazardous movements stopped; Annex F.3 Four beams - sequence control: (see also Fig. F.3.1 and table F.1) The initiation of the muting function depends on monitoring the correct sequence of activation of the muting sensors. For example, in the muted condition, if S2 [in this document MS_12] is deactivated before S3 [in this document MS_21] is activated, muting is terminated. Annex F.5: Methods to avoid manipulation of the muting function: … use a muting enable command generated by the control system of the machine that will only enable the muting function when needed by the machine cycle.
EN 954-1: 1996	5.4 Manual reset
ISO 12100-2: 2003	4.11.4: Restart following power failure/spontaneous restart

4.13 F+OUTC, S+OUTC



OVERVIEW

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

INPUT/OUTPUT

I/O	Name	Data Type	Initial Value	Description, Parameter Values
IN	Activate	bit	OFF	Activation of the safety FB. For details, see Section 2.5.
	S_SafeControl	bit*	OFF	Safety output signals from other FB libraries. OFF : Safety output signals from other FB libraries are OFF. ON : Safety output signals from other FB libraries are ON.
	ProcessControl	bit	OFF	Control signal from the functional application. OFF : Request to set S_OutControl to OFF. ON : Request to set S_OutControl to ON.
	StaticControl	bit	OFF	Optional conditions for process control. (Constant) OFF : Dynamic change at ProcessControl (OFF to ON) required after block activation or triggered safety function. ON : No dynamic change at ProcessControl (OFF to ON) required after block activation or triggered safety function.
	S_StartReset	bit*	OFF	Selection of a reset method for the activated (first time) safety FB. For details, see Section 2.5.
	S_AutoReset	bit*	OFF	Selection of a reset method for the input signal reset to ON. For details, see Section 2.5.
	Reset	bit	OFF	Reset input. For details, see Section 2.5.
OUT	Ready	bit	OFF	Status of whether the safety FB is activated or not. For details, see Section 2.5.
	S_OutControl	bit*	OFF	Controls connected actuators. OFF : Disable connected actuators. ON : Enable connected actuators.
	Error	bit	OFF	Error flag. For details, see Section 2.5.
	DiagCode	word	0	Diagnostic Code. For details, see Section 2.5.

[WARNING]
Use safety data (See Appendix 2.) for connecting the variable whose data type is “bit*” to input - output circuits.
Wire the safety input - output devices and set parameters correctly, referring to the Safety Application Guide.

FUNCTION DESCRIPTION

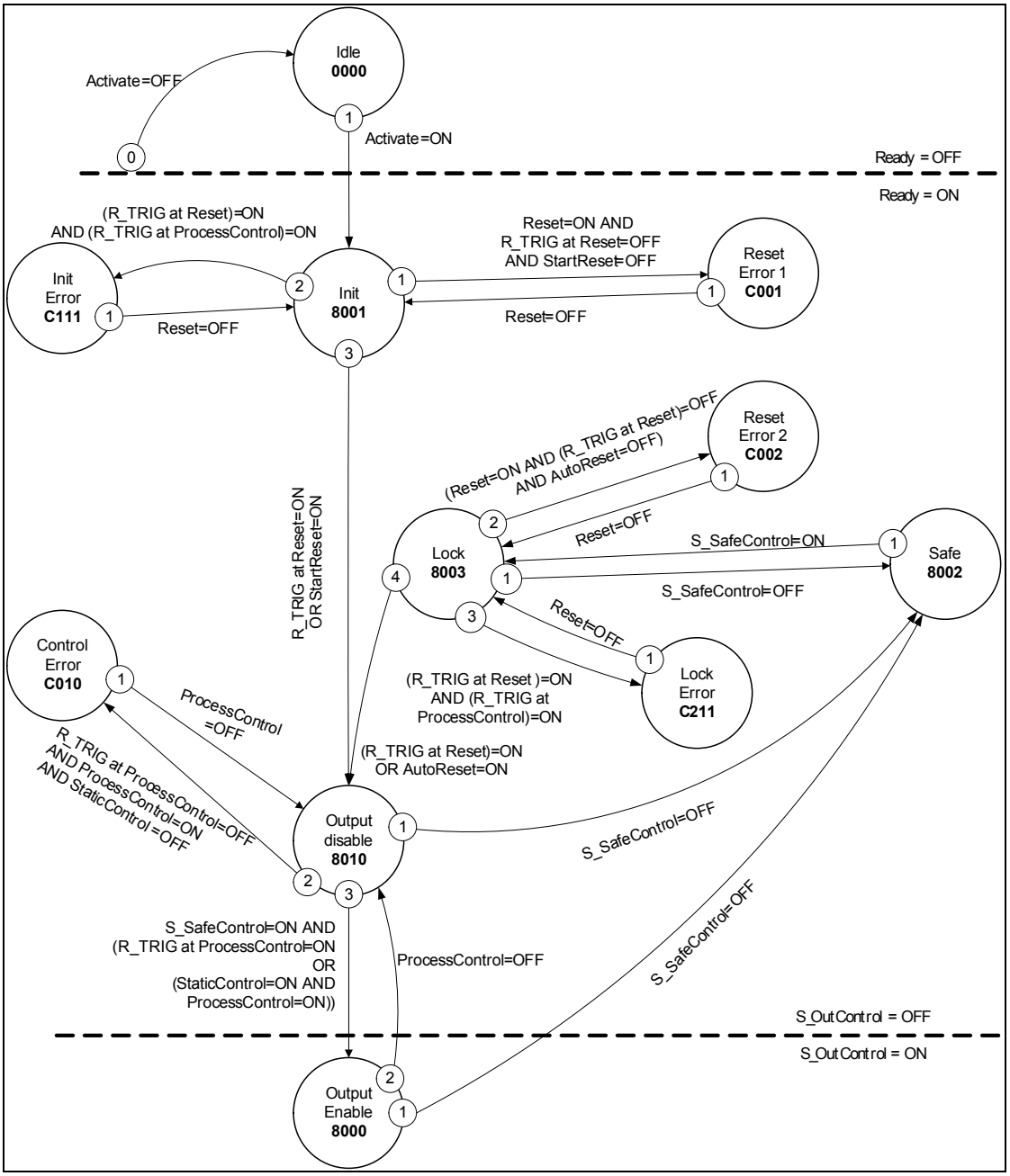
This FB is an output driver for a safety output. The safety output is controlled via S_OutControl using a signal from the standard application (ProcessControl) and a signal from the safety application (S_SafeControl).

Optional conditions for process control (ProcessControl)
SatticControl is able to set the option of an additional function start (ProcessControl OFF to ON) following the FB activation or feedback of the safe signal.

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

[WARNING]
Safe data (e.g. emergency stop demand) must not connect to ProcessControl.
You are responsible for planning the behavior of the stop functions according to the result of your risk analysis for the safety function.

STATE DIAGRAM



Note: The transition from any state to the Idle state due to Activate=OFF is not shown. However these transitions have the highest priority (0).

Figure 4.34 State Diagram for F+OUTC, S+OUTC

TYPICAL TIMING DIAGRAM

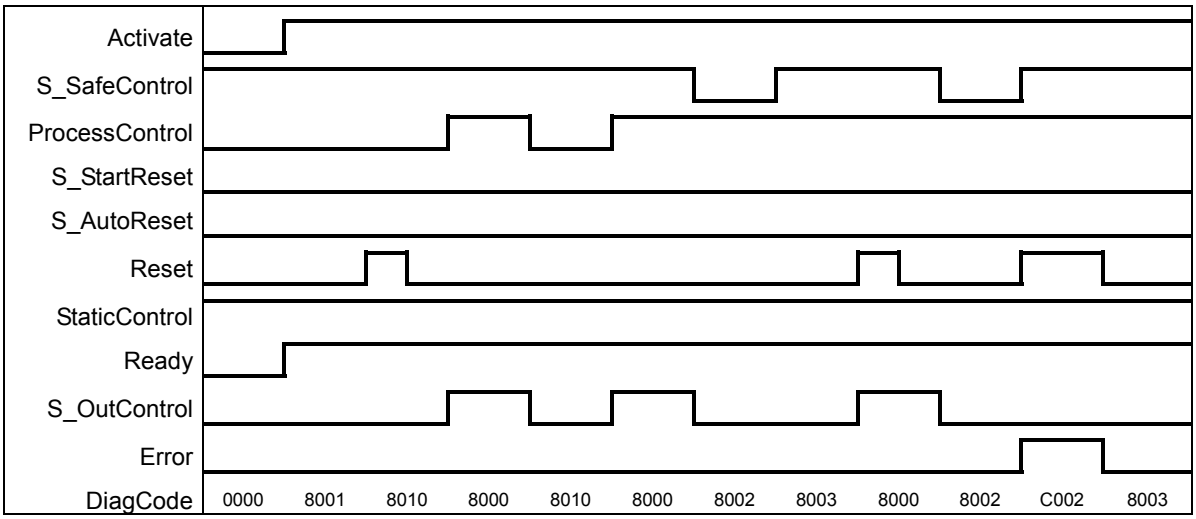


Figure 4.35 Typical Timing Diagram for F+OUTC, S+OUTC (S_StartReset=OFF, S_AutoReset=OFF)

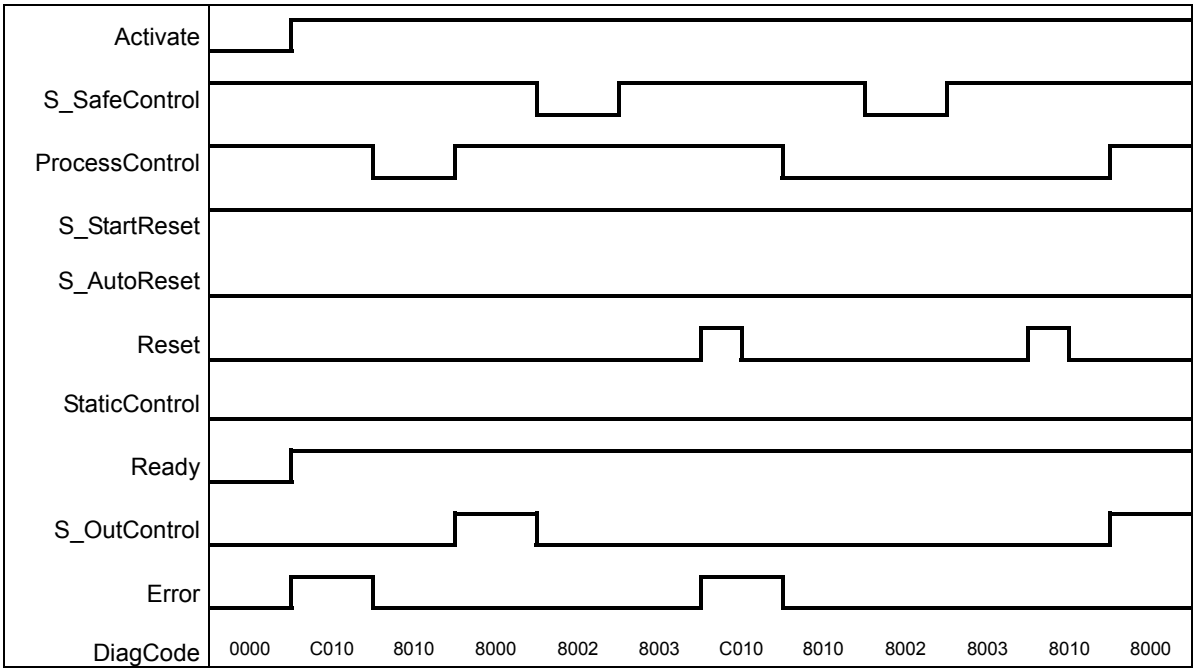


Figure 4.36 Typical Timing Diagram for F+OUTC, S+OUTC (S_StartReset=ON, S_AutoReset=OFF)

ERROR BEHAVIOR

In the event of an error, the output signals behave as listed below.
For the corrective actions, see the ERROR CODES.

Output Signal	Status
Ready	ON
S_OutControl	OFF
Error	ON

ERROR CODES

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
C001	Reset Error1	Static Reset signal in state 8001.	Set Reset to OFF. Check the devices and wiring of Reset.
C002	Reset Error2	Static Reset signal in state 8003.	
C010	Control Error	Static signal at ProcessControl in state 8010.	Set ProcessControl to OFF. Check the seting of StaticControl.
C111	Init Error	Simultaneous rising trigger at Reset and ProcessControl in state 8001.	Set Reset to OFF. Check the independece between ProcessControl and Reset.
C211	Lock Error	Simultaneous rising trigger at Reset and ProcessControl in state 8003.	

STATUS CODES (no error)

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
0000	Idle	The function block is not ac tive (initial state). All outputs are set to OFF. Output Signal / Status Ready: OFF S_OutControl: OFF Error: OFF	Initialize the safety FB by setting Activate to ON.
8001	Init	Block activation startup inhibit is active. Output Signal / Status Ready: ON S_OutControl: OFF Error: OFF	Reset required.
8002	Safe	Triggered safety function. Safety outputs are disabled. S_SafeControl=OFF Output Signal / Status Ready: ON S_OutControl: OFF Error: OFF	S_SafeControl required.
8003	Lock	Safety function startup inhibit is active. Output Signal / Status Ready: ON S_OutControl: OFF Error: OFF	Reset required.
8010	Output Disable	Process control is not active and safety is disabled. Output Signal / Status Ready: ON S_OutControl: OFF Error: OFF	ProcessControl required.
8000	Output Enable	Process control is active and safety is enabled. Output Signal / Status Ready: ON S_OutControl: ON Error: OFF	None.

[WARNING]
Please do the above actions when the FB detects error or is an unexpected state.
However, when still the situation is not corrected, please check following.
- A failure in safe devices and emergency stop devices
- Wiring and status of a safety remote I/O stations and a safety Programmable Controller
- Programming logics, the memory allocation of safety devices and the connections of FB variables
- Setting of S_StartReset and S_AutoReset.

APPLICATION EXAMPLE

The application example of S+OUTC is shown below.

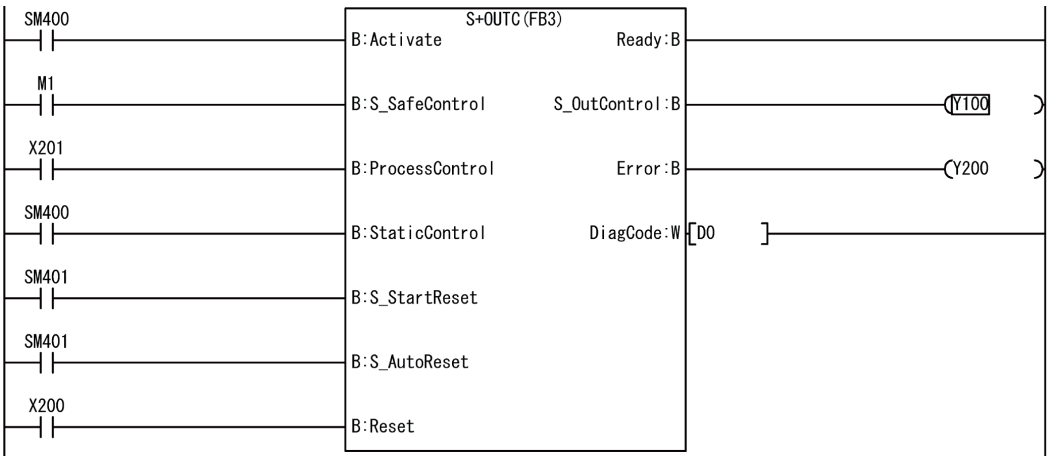


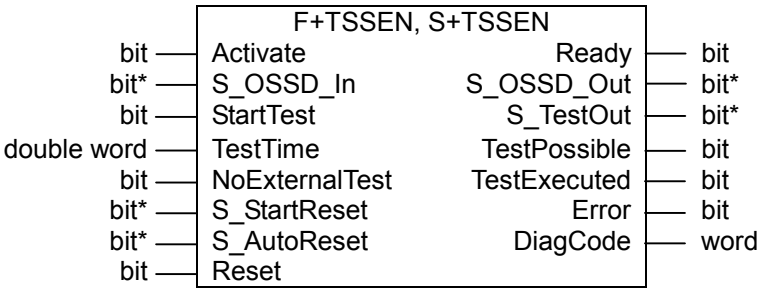
Figure 4.37 Sample Application of S+OUTC

SM400 : Constant (always ON)
SM401 : Constant (always OFF)
M1 : Safety status from preceeding FBs (e.g.output from S+Estop or S+ESPE)
X201 : Functional restart input from standard Programmable Controller (via an standard input)
X200 : Reset switch
Y100 : Safety contactor (safe output)
Y200 : Error indicator
D0 : Range for storing DiagCode
S_StartReset, S_AutoReset are always OFF.

APPLICABLE SAFETY STANDARDS

Standrds	Requirements
IEC 60204-1, Ed.5.0: 2003	9.2.2: Stop functions: Stop function categories; Category 0 - stopping by immediate removal of power to the machine actuators (i.e. an uncontrolled stop …) 9.2.5.2: Start: The start of an operation shall be possible only when all of the relevant safety functions and/or protective measures are in place and are operational except for conditions as described in 9.2.4. Suitable interlocks shall be provided to secure correct sequential starting.
EN 954-1: 1996	5.2: Stop function; stop initiated by protective devices shall put the machine in a safe state … and shall have priority over a stop for operational reasons 5.5: Start and restart; automatic restart only if a hazardous situation cannot exist. 5.11: Fluctuations in energy levels; in case of loss of energy supply, provide or initiate outputs to maintain a safe state.
ISO 12100-2:2003	4.11.4: Restart following power failure/spontaneous restart
EN 954-1: 1996	5.4 Manual reset

4.14 F+TSSEN, S+TSSEN



OVERVIEW

This FB can be used for external testable safety sensors (ESPE: Electro-sensitive protective equipment, such as a light beam).

INPUT/OUTPUT

I/O	Name	Data Type	Initial Value	Description, Parameter Values
IN	Activate	bit	OFF	Activation of the safety FB. For details, see Section 2.5.
	S_OSSD_In	bit*	OFF	Status of sensor output, e.g., light curtain. OFF : Safety sensor in test state or demand for safety-related response. ON : Sensor in the state for normal operating conditions.
	StartTest	bit	OFF	Input to start sensor test. Sets "S_TestOut" and starts the internal time monitoring function in the FB. OFF : No test requested. ON : Test requested.
	TestTime	double word	0	Test time of safety sensor. (Increments of 10ms) Range: Fixed values from 0 to 15 (0 to 150ms)
	NoExternalTest	bit	OFF	Indicates if external manual sensor test is supported. OFF : 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. ON : The external manual sensor test is not supported. An automatic test is possible again without a manual sensor switchingsequence after faulty automatic sensor test.
	S_StartReset	bit*	OFF	Selection of a reset method for the activated (first time) safety FB. For details, see Section 2.5.
	S_AutoReset	bit*	OFF	Selection of a reset method for the input signal (S_In) reset to ON. For details, see Section 2.5.
	Reset	bit	OFF	Reset input. For details, see Section 2.5.
OUT	Ready	bit	OFF	Status of whether the safety FB is activated or not. For details, see Section 2.5.
	S_OSSD_Out	bit*	OFF	Safety FB output indicating the status of the ESPE. OFF : The sensor has a safety-related action request or test error. ON : The sensor has no safety-related action request AND no test error.
	S_TestOut	bit*	ON	Coupled with the test input of the sensor. OFF : Test request issued. ON : No test request.
	TestPossible	bit	OFF	Feedback signal to the process. OFF : An automatic sensor test is not possible. ON : An automatic sensor test is possible.
	TestExecuted	bit	OFF	A positive signal edge indicates the successful execution of the automatic sensor test. OFF : An automatic sensor test was not executed yet, an automatic sensor test is active and an automatic sensor test was faulty. ON : A sensor test was executed successfully.
	Error	bit	OFF	Error flag. For details, see Section 2.5.
	DiagCode	word	0	Diagnostic Code. For details, see Section 2.5.

[WARNING]
Use safety data (See Appendix 2.) for connecting the variable whose data type is “bit*” to input - output circuits.
Wire the safety input - output devices and set parameters correctly, referring to the Safety Application Guide.

FUNCTION DESCRIPTION

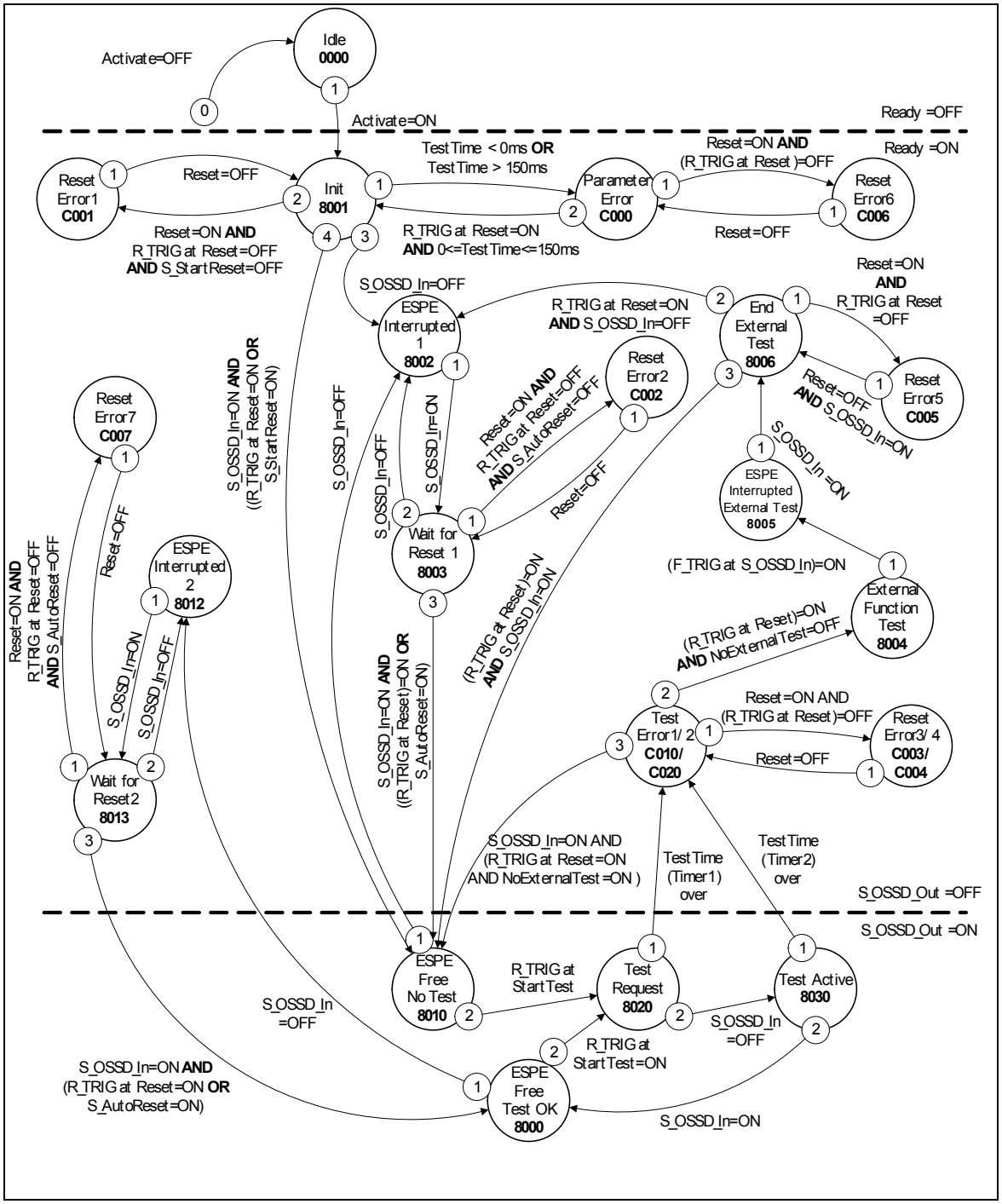
Type 2 ESPE shall have a means of periodic testing to detect a hazardous fault (e.g., loss of sensing unit detection capability, response time exceeding that specified).
The test shall verify that each light beam operates in the manner specified by the supplier.
The test signal shall simulate the actuation of the sensing device and the duration of the periodic test shall not exceed 150 ms. The upper limit of test time is set by TestTime parameter, and the FB monitors the test time and detects an error.

[WARNING]
- 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.
- In order to use this FB, the ESPE shall be provided with suitable input facilities (e.g., terminals) and the test functions.
- It must be monitored by separate functionality, that the test is initiated within appropriate intervals.

Automatic Test Sequence

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

STATE DIAGRAM

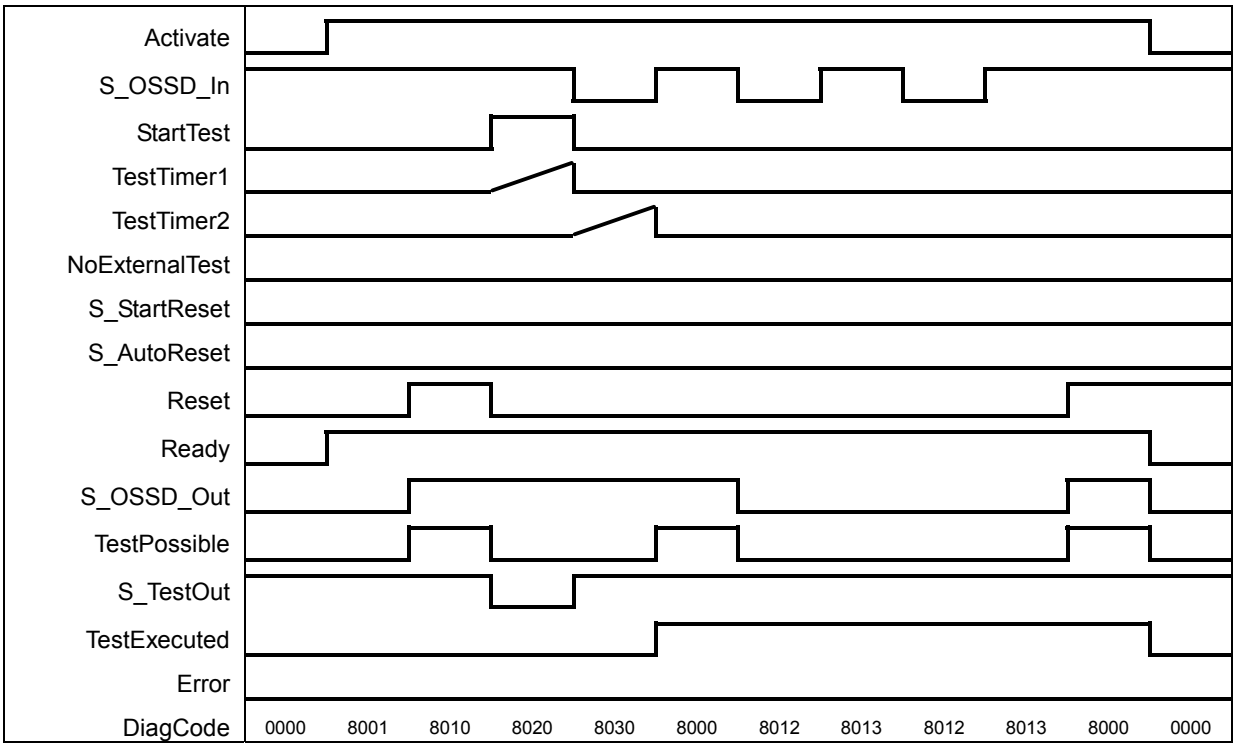


Note1: The transition from any state to the Idle state due to Activate=OFF is not shown. However these transitions have the highest priority (0).

Note2: The F+TSSEN state transition from C000 to 8001 is only due to the online change performed when the safety CPU operating mode is set to the test mode.

Figure 4.38 State Diagram for F+TSSEN, S+TSSEN

TYPICAL TIMING DIAGRAM



*: The measurement of the TestTimer1 and TestTimer2 elapsed time stops due to the stop of sequence program operations when the operating status of CPU modules is changed to STOP.

Figure 4.39 Typical Timing Diagram for F+TSSEN, S+TSSEN

ERROR BEHAVIOR

In the event of an error, the output signals behave as listed below.
The C007 output signal is excepted from the signals in the list. (For the C007output signal, see the ERROR CODES.)
For the corrective actions, see the ERROR CODES.

Output Signal	Status
Ready	ON
S_OSSD_Out	OFF
S_TestOut	ON
TestPossible	OFF
TestExecuted	OFF
Error	ON

ERROR CODES

<table>
<tr><th>Diag Code (Hexadecimal)</th><th>State Name</th><th>Description, Output Setting</th><th>Actions</th></tr>
<tr><td>C000</td><td>Parameter Error</td><td>Invalid value at the TestTime parameter.
Values between: 0ms to 150ms are possible.</td><td>Set TestTime to proper value.</td></tr>
<tr><td>C001</td><td>Reset Error1</td><td>Static Reset condition detected after FB activation.</td><td rowspan="7">Set Reset to OFF.
Check the devices and wiring of Reset.</td></tr>
<tr><td>C002</td><td>Reset Error2</td><td>Static Reset condition detected in state 8003.</td></tr>
<tr><td>C003</td><td>Reset Error3</td><td>Static Reset condition detected in state C010.</td></tr>
<tr><td>C004</td><td>Reset Error4</td><td>Static Reset condition detected in state C020.</td></tr>
<tr><td>C005</td><td>Reset Error5</td><td>Static Reset condition detected in state 8006.</td></tr>
<tr><td>C006</td><td>Reset Error6</td><td>Static Reset condition detected in state C000.</td></tr>
<tr><td>C007</td><td>Reset Error7</td><td>Static Reset condition detected in state 8013.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_OSSD_Out</td><td>OFF</td></tr>
<tr><td>S_TestOut</td><td>ON</td></tr>
<tr><td>TestPossible</td><td>OFF</td></tr>
<tr><td>TestExecuted</td><td>ON</td></tr>
<tr><td>Error</td><td>ON</td></tr>
</table></td></tr>
<tr><td>C010</td><td>Test Error1</td><td>S_OSSD_In is not set to OFF during the testing time. (State 8020)</td><td rowspan="2">Check the connected sensors. Remove any errors, and reset the FB.
ATTENTION:
Repeat the automatic test of the safeguard and re-evaluate the result of this repeat test.</td></tr>
<tr><td>C020</td><td>Test Error2</td><td>S_OSSD_In is not set to ON during the testing time. (State 8030)</td></tr>
</table>

STATUS CODES (no error)

<table>
<tr><th>Diag Code (Hexadecimal)</th><th>State Name</th><th>Description, Output Setting</th><th>Actions</th></tr>
<tr><td>0000</td><td>Idle</td><td>The function block is not active (initial state).
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>OFF</td></tr>
<tr><td>S_OSSD_Out</td><td>OFF</td></tr>
<tr><td>S_TestOut</td><td>ON</td></tr>
<tr><td>TestPossible</td><td>OFF</td></tr>
<tr><td>TestExecuted</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Initialize the safety FB by setting Activate to ON.</td></tr>
<tr><td>8001</td><td>Init</td><td>Activation has been detected by the FB.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_OSSD_Out</td><td>OFF</td></tr>
<tr><td>S_TestOut</td><td>ON</td></tr>
<tr><td>TestPossible</td><td>OFF</td></tr>
<tr><td>TestExecuted</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Reset the FB at S_OSSD_In =ON.</td></tr>
<tr><td>8002</td><td>ESPE Interrupted1</td><td>The FB has detected a safety demand. The switch has not been automatically tested yet.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_OSSD_Out</td><td>OFF</td></tr>
<tr><td>S_TestOut</td><td>ON</td></tr>
<tr><td>TestPossible</td><td>OFF</td></tr>
<tr><td>TestExecuted</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Reset the safety demand for the connected safeguard by resetting the interruption of the sensors.
Check a failure or an error of the sensor.</td></tr>
<tr><td>8003</td><td>Wait for Reset1</td><td>Wait for rising trigger of Reset after state 8002.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_OSSD_Out</td><td>OFF</td></tr>
<tr><td>S_TestOut</td><td>ON</td></tr>
<tr><td>TestPossible</td><td>OFF</td></tr>
<tr><td>TestExecuted</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Reset the safety FB.</td></tr>
</table>

(To the next page)

<table>
<tr><th>Diag Code (Hexadecimal)</th><th>State Name</th><th>Description, Output Setting</th><th>Actions</th></tr>
<tr><td>8004</td><td>External Function Test</td><td>The automatic sensor test was faulty.
An external manual sensor test is necessary.
A negative signal (S_OSSD_In) edge at the sensor is required.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_OSSD_Out</td><td>OFF</td></tr>
<tr><td>S_TestOut</td><td>ON</td></tr>
<tr><td>TestPossible</td><td>OFF</td></tr>
<tr><td>TestExecuted</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Occur a safety demand (e.g. across the beam of the sensor).</td></tr>
<tr><td>8005</td><td>ESPE Interrupted External Test</td><td>The automatic sensor test was faulty.
An external manual sensor test is necessary. (NoExternalTest is OFF.)
An ON feedback signal (S_OSSD_In) from the sensor is required.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_OSSD_Out</td><td>OFF</td></tr>
<tr><td>S_TestOut</td><td>ON</td></tr>
<tr><td>TestPossible</td><td>OFF</td></tr>
<tr><td>TestExecuted</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Remove the safety demand from the sensor.</td></tr>
<tr><td>8006</td><td>End External Test</td><td>The automatic sensor test was faulty.
The external manual test is complete.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_OSSD_Out</td><td>OFF</td></tr>
<tr><td>S_TestOut</td><td>ON</td></tr>
<tr><td>TestPossible</td><td>OFF</td></tr>
<tr><td>TestExecuted</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Reset the safety FB.</td></tr>
<tr><td>8010</td><td>ESPE Free No Test</td><td>The FB has not detected a safety demand. (The sensor has not been tested automatically.)
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_OSSD_Out</td><td>ON</td></tr>
<tr><td>S_TestOut</td><td>ON</td></tr>
<tr><td>TestPossible</td><td>ON</td></tr>
<tr><td>TestExecuted</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Execute the automatic test by setting S_StartReset to ON.
None.</td></tr>
<tr><td>8020</td><td>Test Request</td><td>The light of sensors is stopped (S_TestOut is set to OFF.), and the testing time waiting for the OFF OSSD signal of sensors (S_OSSD_In is set to OFF.) is monitored (first time).
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_OSSD_Out</td><td>ON</td></tr>
<tr><td>S_TestOut</td><td>OFF</td></tr>
<tr><td>TestPossible</td><td>OFF</td></tr>
<tr><td>TestExecuted</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td rowspan="2">None</td></tr>
<tr><td>8030</td><td>Test Active</td><td>The automatic sensor test is active.
The light of sensors is restarted (S_TestOut is set to ON.), and the testing time waiting for the ON OSSD signal of sensors (S_OSSD_In is set to ON.) is monitored (second time).
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_OSSD_Out</td><td>ON</td></tr>
<tr><td>S_TestOut</td><td>ON</td></tr>
<tr><td>TestPossible</td><td>OFF</td></tr>
<tr><td>TestExecuted</td><td>OFF</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td></tr>
</table>

(To the next page)

<table>
<tr><th>Diag Code (Hexadecimal)</th><th>State Name</th><th>Description, Output Setting</th><th>Actions</th></tr>
<tr><td>8000</td><td>ESPE Free Test ok</td><td>The FB has not detected a safety demand.
The sensor was automatically tested.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_OSSD_Out</td><td>ON</td></tr>
<tr><td>S_TestOut</td><td>ON</td></tr>
<tr><td>TestPossible</td><td>ON</td></tr>
<tr><td>TestExecuted</td><td>ON</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>None.
In order to carry out the safeguard test again, a signal changes from OFF to ON be required at StartTest.</td></tr>
<tr><td>8012</td><td>ESPE Interrupted2</td><td>The FB has detected a safety demand from the sensor at the status 8000 or 8013.
The switch was automatically tested.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_OSSD_Out</td><td>OFF</td></tr>
<tr><td>S_TestOut</td><td>ON</td></tr>
<tr><td>TestPossible</td><td>OFF</td></tr>
<tr><td>TestExecuted</td><td>ON</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Reset the safety demand for the connected safeguard by resetting the interruption of the sensors.
Check a failure or an error of the sensor.</td></tr>
<tr><td>8013</td><td>Wait for Reset2</td><td>Wait for rising trigger of Reset after state 8012.
<table>
<tr><th>Output Signal</th><th>Status</th></tr>
<tr><td>Ready</td><td>ON</td></tr>
<tr><td>S_OSSD_Out</td><td>OFF</td></tr>
<tr><td>S_TestOut</td><td>ON</td></tr>
<tr><td>TestPossible</td><td>OFF</td></tr>
<tr><td>TestExecuted</td><td>ON</td></tr>
<tr><td>Error</td><td>OFF</td></tr>
</table></td><td>Reset the safety FB.</td></tr>
</table>

[WARNING]
Please do the above actions when the FB detects error or is an unexpected state.
However, when still the situation is not corrected, please check following.
- A failure in safe devices and emergency stop devices
- Wiring and status of a safety remote I/O stations and a safety Programmable Controller
- Programming logics, the memory allocation of safety devices and the connections of FB variables
- Setting of S_StartReset and S_AutoReset.

APPLICATION EXAMPLE

The application example of S+TSSEN is shown below.

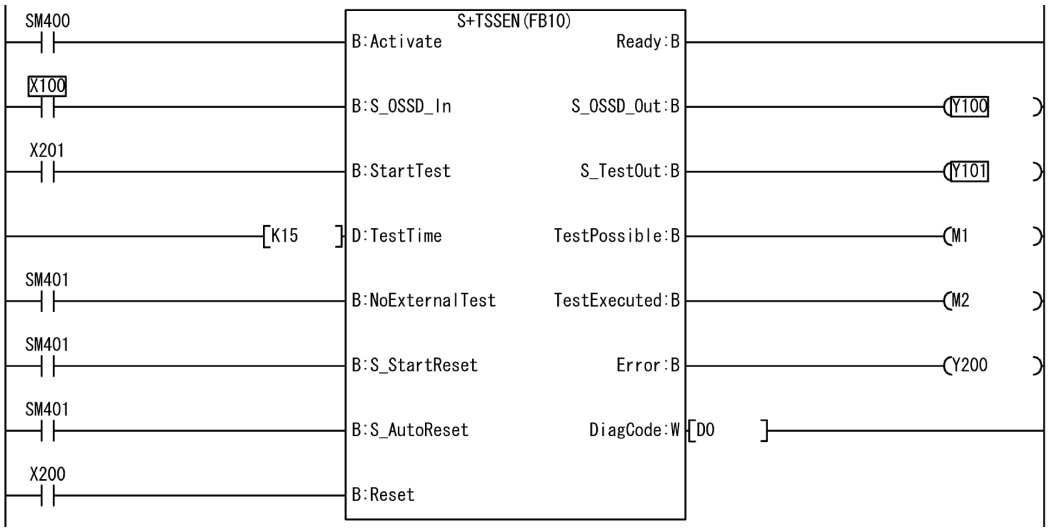


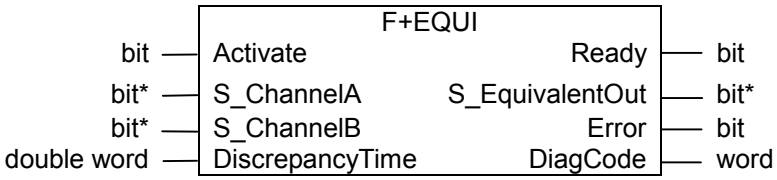
Figure 4.40 Sample Appliation for S+TSSEN

SM400 : Constant (always ON)
SM401 : Constant (always OFF)
X100 : Safety output from the light curtain; OSSD (safe input)
X201 : Start test switch (standard input)
X200 : Reset switch
Y100 : Safety demand considering with the test (safe output)
Y101 : Request for the automatic sensor test (safe output)
M1 : Possibility of an automatic test
M2 : The result of an automatic tes.
Y200 : Error indicator
D0 : Range for storing DiagCode

APPLICABLE SAFETY STANDARDS

Standards	Requirements
IEC 6196-1: 2004	4.2.2.3 Particular requirements for a type 2 ESPE A type 2 ESPE shall have an means of periodic test to reveal a failure to danger (for example loss of detection capability, response time exceeding that specified). A single fault resulting in the loss of detection capability or the increase in response time beyond the specified time or preventing one or more of the OSSDs going to the OFF-state, shall result in a lock-out condition as a result of the next periodic test. Where the periodic test is intended to be initiated by an external (for example machine) safetyrelated control system, the ESPE shall be provided with suitable input facilities (for example terminals). The duration of the periodic test shall be such that the intended safety function is not impaired. NOTE If the type 2 ESPE is intended for use as a trip device (for example when used as a perimeter guard), and the duration of the periodic test is greater than 150 ms, it is possible for a person to pass through the detection zone without being detected. In this case a restart interlock should be included. If the periodic test is automatically initiated, the correct functioning of the periodic test shall be monitored and a single fault in the parts implementing the monitoring function shall be detected. In the event of a fault, the OSSD(s) shall be signalled to go to the OFF-state. If one or more OSSDs don't go to the OFF-state, a lock-out condition shall be initiated.
EN 954-1: 1996	5.4 Manual reset
ISO 12100-2:2003	4.11.4: Restart following power failure/spontaneous restart

4.15 F+EQUI



OVERVIEW

This FB converts two equivalent bit inputs (both NO or NC) to one bit with discrepancy time monitoring. This FB output shows the result of the evaluation of both channels.

INPUT/OUTPUT

I/O	Name	Data Type	Initial Value	Description, Parameter Values
IN	Activate	bit	OFF	Activation of the safety FB. For details, see Section 2.5.
	S_ChannelA	bit*	OFF	Safety input signal A OFF : Contact A OFF ON : Contact A ON
	S_ChannelB	bit*	OFF	Safety input signal B OFF : Contact B OFF ON : Contact S ON
	DiscrepancyTime	double word	0	Configures the monitoring time for discrepancy status of S_ChannelA and S_ChannelB (in increments of 10ms). Range: Fixed values from 0 to 60000 (0 to 600000ms=10min)
OUT	Ready	bit	OFF	Status of whether the safety FB is activated or not. For details, see Section 2.5.
	S_EquivalentOut	bit *	OFF	Safety output signal OFF : Either S_ChannelA or S_ChannelB, or both S_ChannelA and S_ChannelB are set to OFF. Or, both S_ChannelA and S_ChannelB are set to ON. The time is out of the monitoring time of DiscrepancyTime. ON : Both S_ChannelA and S_ChannelB are set to ON within the monitoring time of DiscrepancyTime.
	Error	bit	OFF	Error flag. For details, see Section 2.5.
	DiagCode	word	0	Diagnostic code. For details, see Section 2.5.

[WARNING]
Use safety data (See Appendix 2.) for connecting the variable whose data type is “bit*” to input - output circuits.
Wire the safety input - output devices and set parameters correctly, referring to the Safety Application Guide.

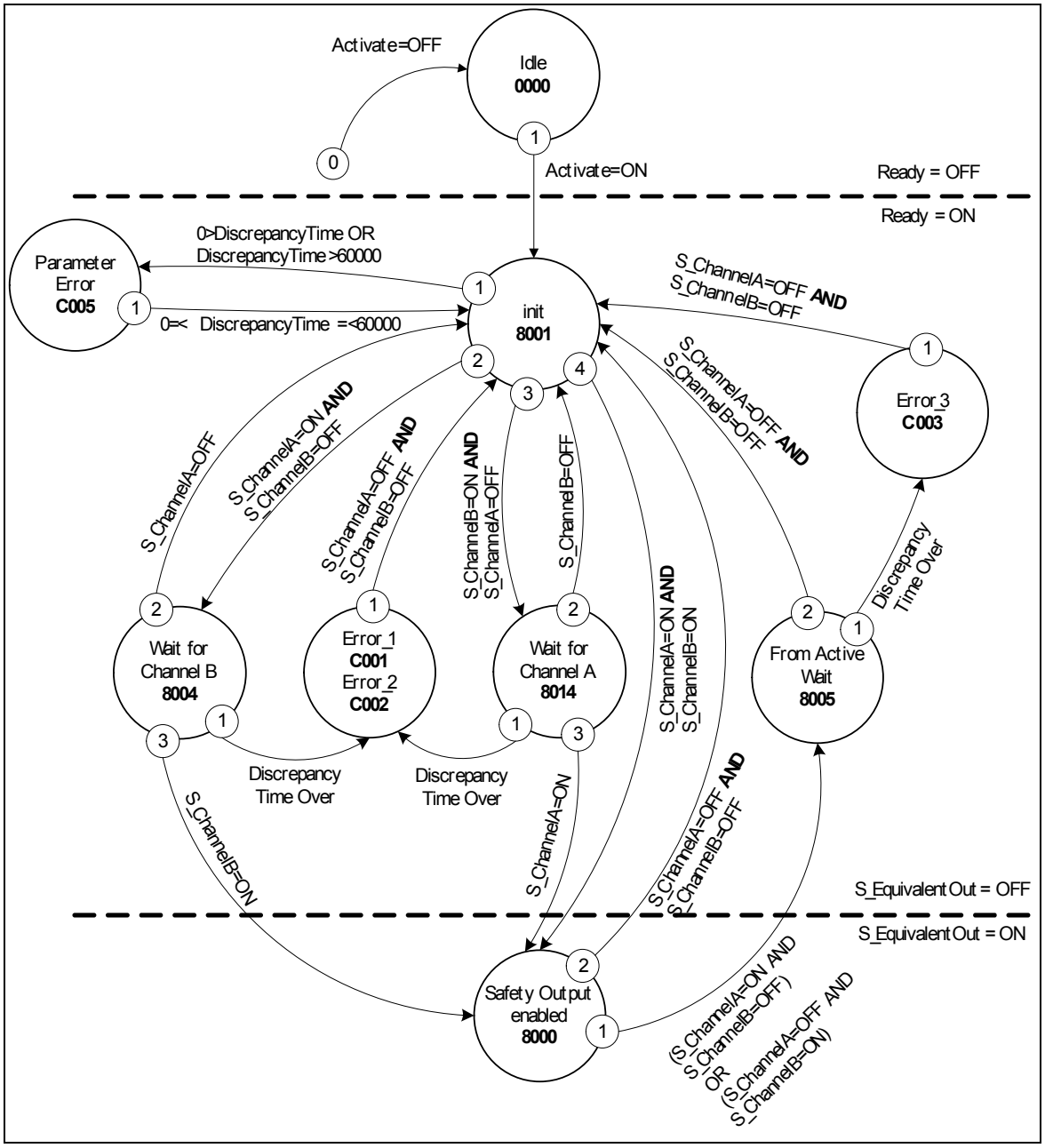
FUNCTION DESCRIPTION

S_EquivalentOut is set to ON or OFF depending on the S_ChannelA and S_ChannelB statuses.

No.	S_ChannelA Status	S_ChannelB Status	S_EquivalentOut Output Value
1	0	0	0
2	0	1	0
3	1	0	0
4	1	1	1

If the status of the number 2 and 3 listed in the table above stays after the discrepancy time, the safety FB detects an error, changing to error status.

STATE DIAGRAM

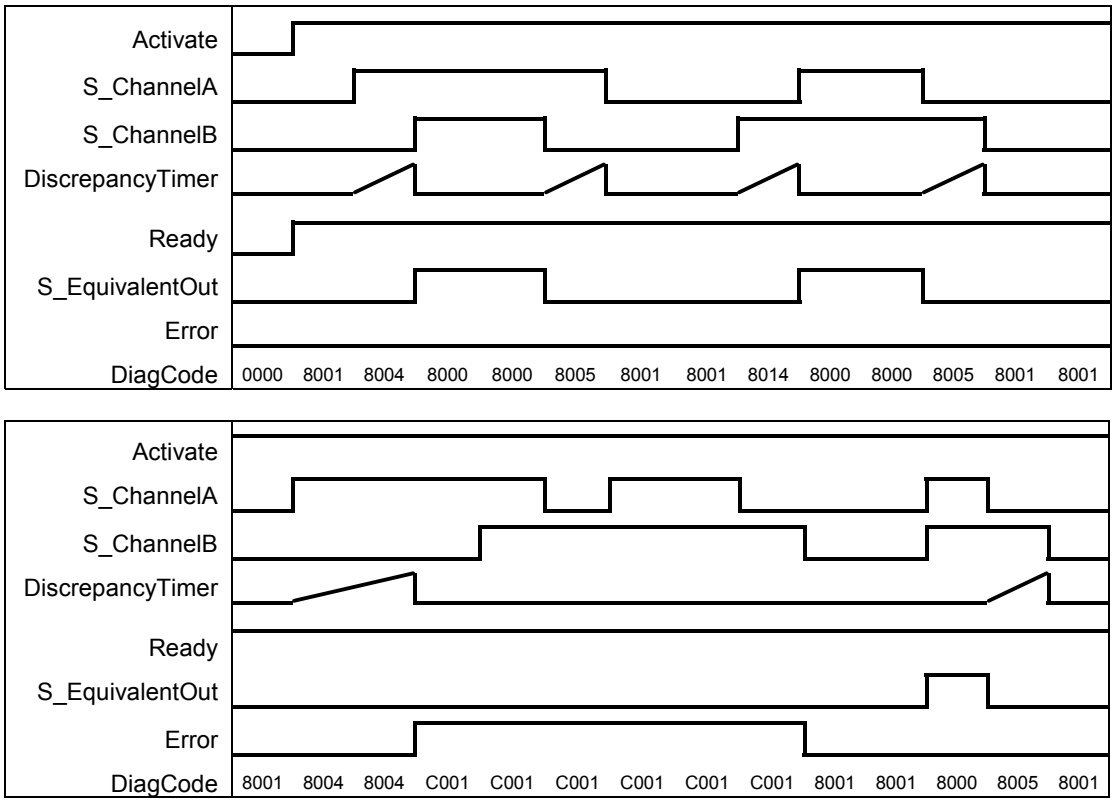


Note1: The transition from any state to the Idle state due to Activate=OFF is not shown. However these transitions have the highest priority (0).

Note2: The F+EQUI state transition from C005 to 8001 is only due to the online change performed when the safety CPU operating mode is set to the test mode.

Figure 4.41 State Diagram for F+EQUI

TYPICAL TIMING DIAGRAM



*: The measurement of the DiscrepancyTimer elapsed time stops due to the stop of sequence program operations when the operating status of CPU modules is changed to STOP.

Figure 4.42 Typical Timing Diagram for F+EQUI

ERROR BEHAVIOR

In the event of an error, the output signals behave as listed below.
For the corrective actions, see the ERROR CODES.

Output Signal	Status
Ready	ON
S_EquivalentOut	OFF
S_TestOut	ON

ERROR CODES

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
C001	Error1	ChannelA has been switched to ON, waiting for ChannelB, but ChannelB has not been set to ON during the setting value of DiscrepancyTime.	Review the DiscrepancyTime setting value. Set both ChannelA and ChannelB to OFF.
C002	Error2	ChannelB has been switched to ON, waiting for ChannelA, but ChannelA has not been set to ON during the setting value of DiscrepancyTime.	
C003	Error3	Either ChannelA or ChannelB, set to ON both, has been switched to OFF. One channel, waiting for the second channel to be switched to OFF, has not been switched to OFF during the setting value of DiscrepancyTime.	
C005	Parameter Error	The DiscrepancyTime value is out of the setting range.	Configure the DiscrepancyTime value in the setting range.

STATUS CODES (no error)

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
0000	Idle	The safety FB is not active. (Initial state) Output Signal / Status Ready: OFF S_EquivalentOut: OFF Error: OFF	Initialize the safety FB by setting Activate to ON.
8001	Init	The safety FB is active. Activate is ON. Output Signal / Status Ready: ON S_EquivalentOut: OFF Error: OFF	Wait for S_ChannelA and S_ChannelB to be set to ON.
8000	Safety Output Enabled	The safety output is ON. Output Signal / Status Ready: ON S_EquivalentOut: ON Error: OFF	None.
8004	Wait for ChannelB	ChannelB is OFF. ChannelA has been switched to ON and waiting for ChannelB to be set to ON. Output Signal / Status Ready: ON S_EquivalentOut: OFF Error: OFF	Set ChannelB to ON.
8014	Wait for ChannelA	ChannelA is OFF. ChannelB has been switched to ON and waiting for ChannelA to be set to ON. Output Signal / Status Ready: ON S_EquivalentOut: OFF Error: OFF	Set ChannelA to ON.
8005	From Active Wait	Either ChannelA or ChannelB, set to ON both, has been switched to OFF. Output Signal / Status Ready: ON S_EquivalentOut: OFF Error: OFF	Set both ChannelA and ChannelB to OFF.

[WARNING]
Please do the above actions when the FB detects error or is an unexpected state.
However, when still the situation is not corrected, please check following.
- A failure in safe devices and emergency stop devices
- Wiring and status of a safety remote I/O stations and a safety programmable controller
- Programming logics, the memory allocation of safety devices and the connections of FB variables
- Setting of S_StartReset and S_AutoReset

APPLICATION EXAMPLE

The application example of F+EQUI is shown below.

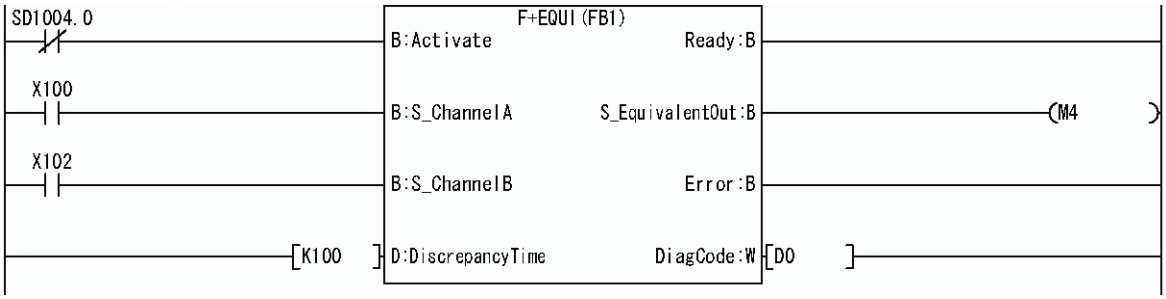
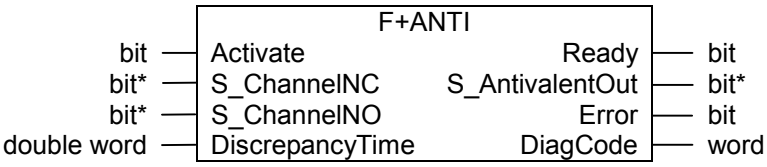


Figure 4.43 Sample Application of F+EQUI

SD1004.0 : Status refreshed by communicating to the safety remote I/O station (Station 1)
X100 : Safety input signal A
X102 : Safety input signal B
K100 : One second
M4 : Safety output signal
D0 : Range for storing DiagCode

4.16 F+ANTI



OVERVIEW

This FB converts two antivalent bit inputs (NO/NC pair) to one bit output with discrepancy time monitoring. The FB output shows the result of the evaluation of both channels.

INPUT/OUTPUT

I/O	Name	Data Type	Initial Value	Description, Parameter Values
IN	Activate	bit	OFF	Activation of the safety FB. For details, see Section 2.5.
	S_ChannelNC	bit *	OFF	Safety input signal (NC contact) OFF : NC contact open. ON : NC contact closed.
	S_ChannelNO	bit *	OFF	Safety input signal (NO contact) OFF : NO contact open. ON : NO contact closed.
	DiscrepancyTime	double word	0	Configures the monitoring time for consistent status of S_ChannelINC and S_ChannelINO (increments of 10ms). Range: Fixed value from 0 to 60000 (0 to 600000ms=10min)
OUT	Ready	bit	OFF	Status of whether the safety FB is activated or not. For details, see Section 2.5.
	S_AntivalentOut	bit*	OFF	Safety output signal OFF : Statuses other than the status of S_ChannelNC set to ON and S_ChannelNO set to OFF. Or, S_ChannelNC is set to ON and S_ChannelNO is set to OFF, however, the time is out of the monitoring time of DiscrepancyTime. ON : S_ChannelNC is set to ON and S_ChannelNO is set to OFF within the range of the monitoring time of DiscrepancyTime.
	Error	bit	OFF	Error flag. For details, see Section 2.5.
	DiagCode	word	0	Diagnostic code. For details, see Section 2.5.

⚠ [WARNING]
Use safety data (See Appendix 2.) for connecting the variable whose data type is “bit*” to input - output circuits.
Wire the safety input - output devices and set parameters correctly, referring to the Safety Application Guide.

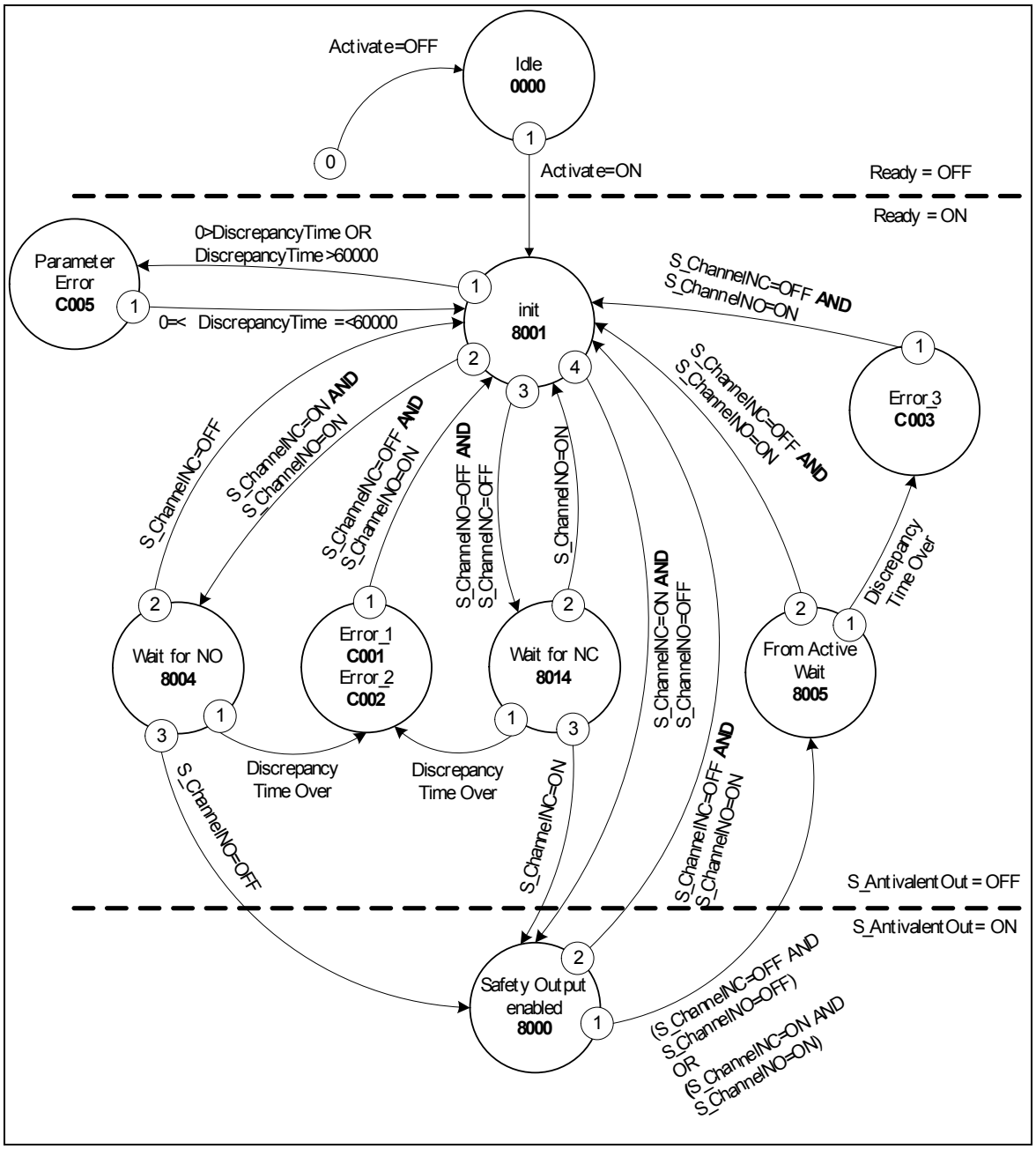
FUNCTION DESCRIPTION

S_AntivalentOut is set to ON or OFF depending on the S_ChannelNC and S_ChannelNO statuses.

No.	S_ChannelNC Status	S_ChannelNO Status	S_AntivalentOut Output Value
1	0	0	0
2	0	1	0
3	1	0	1
4	1	1	0

If the status of the number 1 and 4 listed in the table above stays after the discrepancy time, the safety FB detects an error, changing to error status.

STATE DIAGRAM

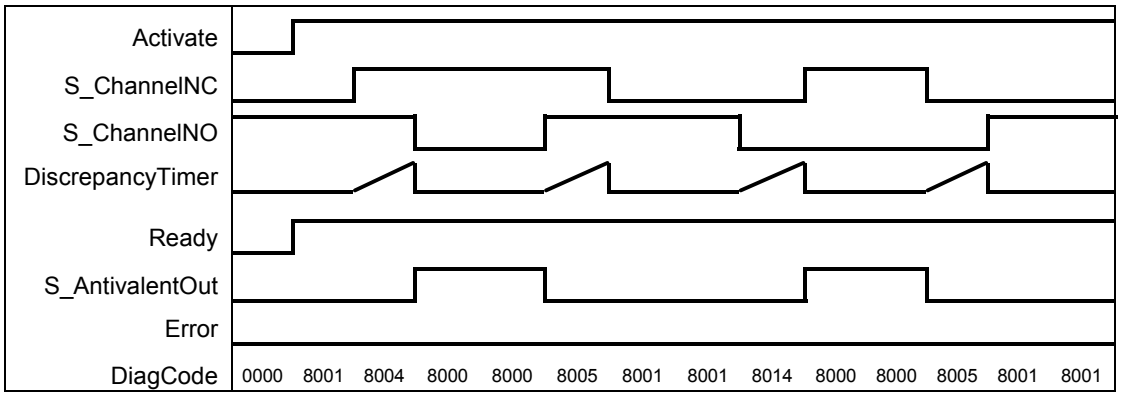


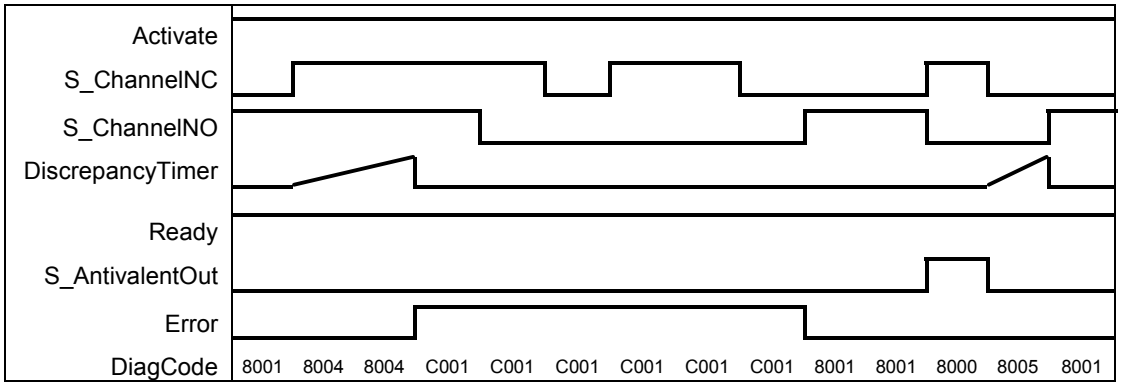
Note1: The transition from any state to the Idle state due to Activate=OFF is not shown. However these transitions have the highest priority (0).

Note2: The F+ANTI state transition from C005 to 8001 is only due to the online change performed when the safety CPU operating mode is set to the test mode.

Figure 4.44 State Diagram for F+ANTI

TYPICAL TIMING DIAGRAM





*: The measurement of the DiscrepancyTimer elapsed time stops due to the stop of sequence program operations when the operating status of CPU modules is changed to STOP.

Figure 4.45 Typical Timing Diagram for F+ANTI

ERROR BEHAVIOR

In the event of an error, the output signals behave as listed below.
For the corrective actions, see the ERROR CODES.

Output Signal	Status
Ready	ON
S_AntivalentOut	OFF
Error	ON

ERROR CODES

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
C001	Error1	ChannelNC has been switched to ON, waiting for ChannelNO, but ChannelNO has not been set to OFF during the setting value of DiscrepancyTime.	Review the DiscrepancyTime setting value. Set both ChannelNC and ChannelNO to OFF.
C002	Error2	ChannelNO has been switched to OFF, waiting for ChannelNO, but ChannelNO has not been set to ON during the setting value of DiscrepancyTime.	
C003	Error3	Both ChannelNC set to ON and ChannelNO set to OFF has been switched to ON or OFF. One channel, waiting for the second channel to be switched to OFF, has not been switched to OFF during the setting value of DiscrepancyTime.	
C005	Parameter Error	The DiscrepancyTime value is out of the setting range.	Configure the DiscrepancyTime value in the setting range.

STATUS CODES (no error)

Diag Code (Hexadecimal)	State Name	Description, Output Setting	Actions
0000	Idle	The safety FB is not active. (Initial state) Output Signal / Status Ready: OFF S_AntivalentOut: OFF Error: OFF	Initialize the safety FB by setting Activate to ON.
8001	Init	The safety FB is active. Activate is ON. Output Signal / Status Ready: ON S_AntivalentOut: OFF Error: OFF	Wait for ChannelNC to be set to ON and ChannelNO to be set to OFF.
8000	Safety Output Enabled	The safety output is ON. Output Signal / Status Ready: ON S_AntivalentOut: ON Error: OFF	None.
8004	Wait for NO	ChannelNO is ON. ChannelNC has been switched to ON and waiting for ChannelNO to be set to OFF. Output Signal / Status Ready: ON S_AntivalentOut: OFF Error: OFF	Set ChannelNO to OFF.
8014	Wait for NC	ChannelNC is OFF. ChannelNO has been switched to OFF and waiting for ChannelNC to be set to ON. Output Signal / Status Ready: ON S_AntivalentOut: OFF Error: OFF	Set ChannelNC to ON.
8005	From Active Wait	Both ChannelNC set to ON and ChannelNO set to OFF has been switched to ON or OFF. Output Signal / Status Ready: ON S_AntivalentOut: OFF Error: OFF	Set ChannelNC to OFF and ChannelNO ON.

[WARNING]
Please do the above actions when the FB detects error or is an unexpected state.
However, when still the situation is not corrected, please check following.
- A failure in safe devices and emergency stop devices
- Wiring and status of a safety remote I/O stations and a safety programmable controller
- Programming logics, the memory allocation of safety devices and the connections of FB variables

SAMPLE APLLICATION

The application example of F+ANTI is shown below.

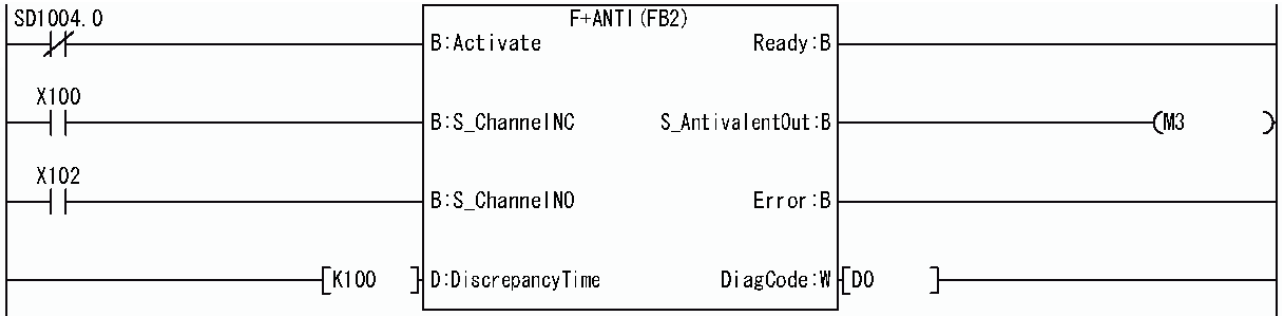


Figure 4.46 Sample Application of F+ANTI

SD1004.0 : Status refreshed by communicating to the safety remote I/O station (Station 1)
X100 : Safety input signal (NC contact)
X102 : Safety input signal (NO contact)
K100 : One second
M3 : Safety output signal
D0 : Range for storing DiagCode

APPENDIX

Appendix 1 Safety FB (S+○○) Specifications

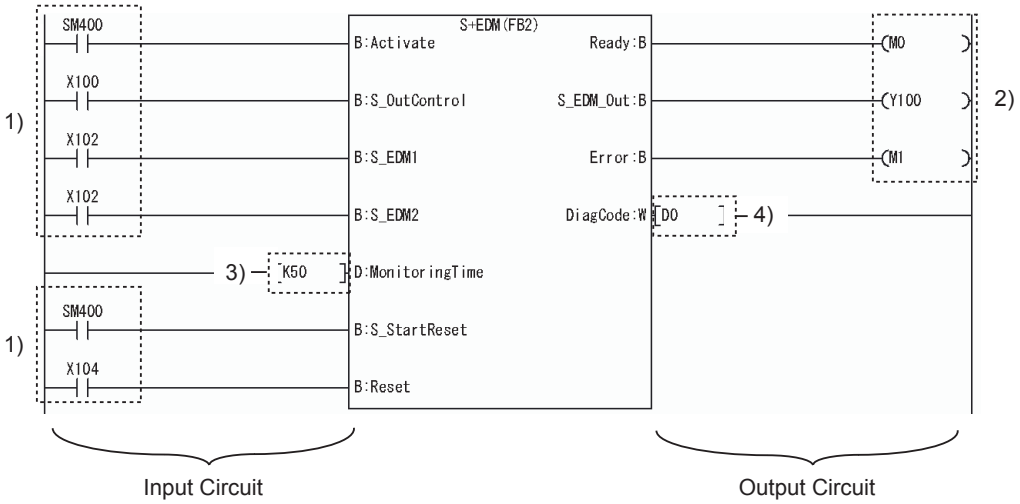
The specifications of the safety FB (S+○○) are different from those of the safety FB (F+○○).
For the specifications of the safety FB (F+○○), see Chapter 2 and Chapter 3.

(1) Number of safety FB (F+○○) steps and available safety FBs
The number of compiled safety FB steps and maximum number of safety FBs are listed below.

Table APP.1 Number of Safety FB (F+○○) Steps and Maximum Number of Safety FBs

No.	FB Name	Number of Compiled Steps*1	Maximum Number of Safety FB*2
1	S+2HAND2	230	59
2	S+2HAND3	317	43
3	S+EDM	450	30
4	S+ENBLSW	239	57
5	S+ESPE	160	85
6	S+ESTOP	160	85
7	S+GLOCK	232	59
8	S+GMON	285	48
9	S+MODSEL	383	35
10	S+MUTE2	507	27
11	S+MUTEP	937	14
12	S+MUTES	588	23
13	S+OUTC	185	74
14	S+TSSEN	427	32

*1: The number of steps is the number of compiled safety FB and input-output circuit steps in connecting the safety FB input-output variables with the input-output circuits.
In addition, the number of safety FB steps listed in Table APP.1 is different from those in the case of connecting more than one contact or coil with the input-output variable, no input-output circuits.



1) Connecting one contact with the bit device input variables
2) Connecting one coil with the bit device output variables
3) Connecting a constant with the word device input variable
4) Connecting one word with the word device output variable

Figure App.1 Example of S+EDM Circuit

*2: The maximum number of safety FBs is the number that only same safety FBs can be used and up to 14K steps of the safety FB can be used. (The reserved area for online change is 500.)

(2) Performance specifications of safety FB (S+○○)

The processing time of the safety FB (S+○○) is listed below.

Table Appendix.2 shows the processing time of the safety FB (S+○○) for the status code 8000*1.

Table App.2 Safety FB (F+○○) Processing Time*1

No.	FB Name	Processing Time (μs)	No.	FB Name	Processing Time (μs)
1	S+2HAND2	25	8	S+GMON	32
2	S+2HAND3	35	9	S+MODSEL	43
3	S+EDM	106	10	S+MUTE2	56
4	S+ENBLSW	26	11	S+MUTEP	102
5	S+ESPE	18	12	S+MUTES	64
6	S+ESTOP	18	13	S+OUTC	20
7	S+GLOCK	25	14	S+TSSEN	47

*1: The status code is the code that indicates the current status of safety FBs, and the 8000 indicates the status that the safety output is set to ON. For details of the safety FB (S+○○), see Section 2.5 (4).

Appendix 2 Safety Data

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

(1) Safety refresh device

(a) Internal devices refreshed by communication with the safety remoter I/O station

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

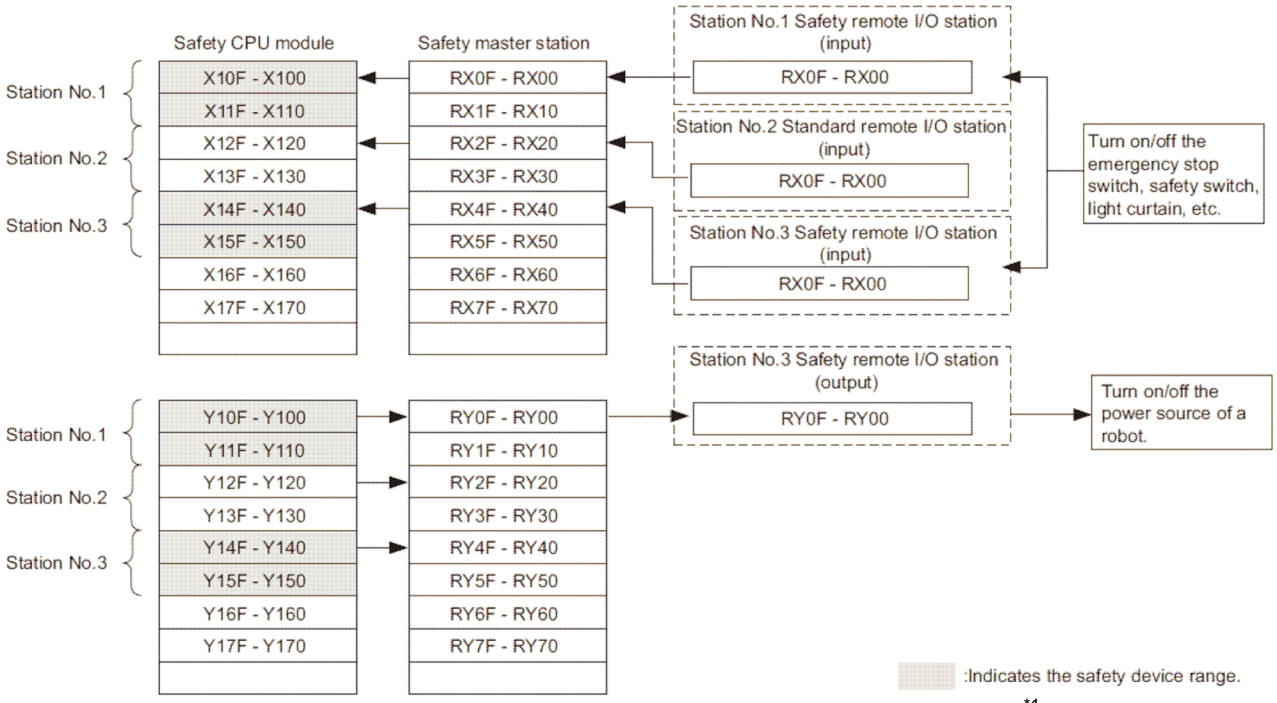


Figure APP.2 I/O data of safety remote station*1

*1: Figure APP.2 shows a case where X100 and Y100 are set with the auto refresh parameter.
The following device ranges actually not input/output to the safety remote I/O station are included.
Station No. 1: X110 to X11F, Y110 to Y11F, Station No. 3: X150 to X15F, Y150 to Y15F

(b) Safety data transfer device by communication between safety stations on CC-Link IE Field Network

The device data transferred by communication between safety stations on CC-Link IE Field Network is safety data.
For details, refer to the MELSEC-QS CC-Link IE Field Network Master/local Module User's Manual.

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

Only the following devices can be used in a program that supports safety functions:

- Devices related to CC-Link Safety: SM1000 to SM1299 and SD1000 to SD1299.
- Devices related to CC-Link IE Field Network: SM1400 to SM1799 and SD1400 to SD1799.

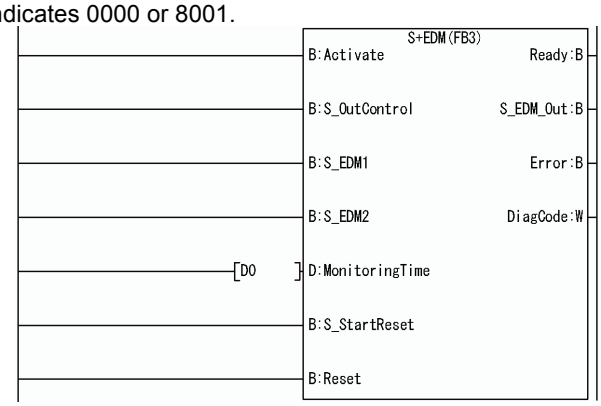
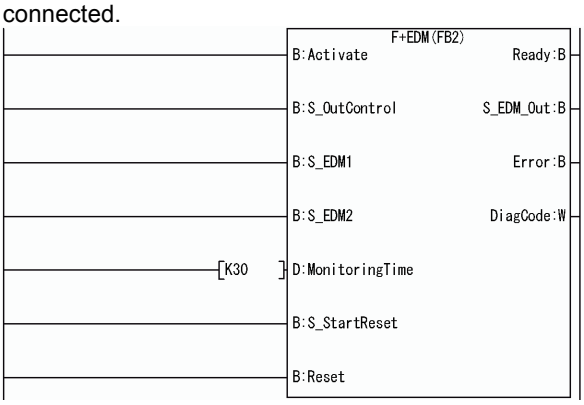
Appendix 3 Comparison between Safety FB Specifications

The difference between safety FB (F+○○) and safety FB (S+○○) specifications is shown in the table below.
The target input signals are listed in Table App. 3 below. In addition, the comparison between the safety FB (F+○○) and safety FB (S+○○) input specifications is shown in Table App.4 below.

Table App.3 List of Input Signals whose Specifications are Different between the Safety FB (F+○○) and Safety FB (S+○○)

FB Name	Input Signal Name	Data Type
F+EDM	MonitoringTime	double word
F+GMON	DiscrepancyTime	
F+MODSEL	ModeMonitorTime	
F+MUTE2	DiscTimeEntry	
	MaxMutingTime	
F+MUTEP	DiscTime11_12	
	DiscTime21_22	
	MaxMutingTime	
F+MUTES	MaxMutingTime	
F+TSSEN	TestTime	
F+EQUI	DiscrepancyTime	
F+ANTI	DiscrepancyTime	

Table App.4 Comparison between the Safety FB (S+○○) and Safety FB (F+○○) Specifications of Fixed Value Inputs*1

Specifications of Safety FB (S+○○)	Specifications of Safety FB (F+○○)
The input variables listed in Table App.4 can be connected to variables (word device) or constants (K○○ or H○○). Change device data on programming when DiagCode indicates 0000 or 8001. 	The input variables listed in Table App.4 can only be connected to constants (K○○ or H○○). An error occurs for changing device data, if a word device is connected. 

*1: When changing the input values for the signals listed in Table App.4, that is, changing the device data in an input circuit connected to the safety FB in the safety CPU operating mode set to the test mode, change the status code (DiagCode) of the safety FB to 0000 or 8001 once after the online change is completed.

Appendix 4 Operation Using Combination

The operations using the combination of a safety FB library, safety CPU module, and GX Developer are listed in Table App.5 below.

Table App.5 Operations for Safety CPUs

Project File	GX Developer	Safety CPU	Operation	
			PC Read	PC Write
Safety FB (S+○○) only	Version 8.58L to 8.81K	Serial number (first five digits) is 11041 or earlier	Normal operation	Normal operation
		Serial number (first five digits) is 11042 or later		
	Version 8.82L or later	Serial number (first five digits) is 11041 or earlier		
		Serial number (first five digits) is 11042 or later		
Safety FB (S+○○) and Safety FB (F+○○) integrated	Version 8.58L to 8.81K	Serial number (first five digits) is 11041 or earlier	Normal operation (Not compiled)	Not available for write
		Serial number (first five digits) is 11042 or later		
	Version 8.82L or later	Serial number (first five digits) is 11041 or earlier	Normal operation	Normal operation for write INSTRUCTION CODE ERROR occurs when a CPU module is reset or powered on.
		Serial number (first five digits) is 11042 or later		Normal operation
Safety FB (F+○○) only	Version 8.58L to 8.81K	Serial number (first five digits) is 11041 or earlier	Normal operation (Not compiled)	Not available for write
		Serial number (first five digits) is 11042 or later		
	Version 8.82L or later	Serial number (first five digits) is 11041 or earlier	Normal operation	Normal operation for write INSTRUCTION CODE ERROR occurs when a CPU module is reset or powered on.
		Serial number (first five digits) is 11042 or later		Normal operation

POINT

If the project file including safety FBs (F+○○) compiled by using old GX Developer (Version 8.58L to 8.81K) is opened with new GX Developer Version8.82L or later, the project file will not have been compiled.

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

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c. For this warranty to apply:
   (1) Customer shall give MELCO (i) notice of a warranty claim to MELCO and the authorized dealer or distributor from whom the Products were purchased, (ii) the notice shall describe in reasonable details the warranty problem, (iii) the notice shall be provided promptly and in no event later than thirty (30) days after the Customer knows or has reason to believe that Products are not as warranted, and (iv) in any event, the notice must given within the warranty period;
   (2) Customer shall cooperate with MELCO and MELCO's representatives in MELCO's investigation of the warranty claim, including preserving evidence of the claim and its causes, meaningfully responding to MELCO's questions and investigation of the problem, grant MELCO access to witnesses, personnel, documents, physical evidence and records concerning the warranty problem, and allow MELCO to examine and test the Products in question offsite or at the premises where they are installed or used; and
   (3) If MELCO requests, Customer shall remove Products it claims are defective and ship them to MELCO or MELCO's authorized representative for examination and, if found defective, for repair or replacement. The costs of removal, shipment to and from MELCO's designated examination point, and reinstallation of repaired or replaced Products shall be at Customer's expense.
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SH(NA)-080744ENG-D

Mitsubishi Safety
Programmable Controller MELSEC QS series

QSCPU
Programming Manual
(Safety FB)

MODEL	QSCPU-P-SAFETYFB-E
MODEL CODE	13JW05
SH(NA)-080744ENG-D(1105)MEE	

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