

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 "DANGER" and "CAUTION".

 **DANGER**

Indicates that incorrect handling may cause hazardous conditions, resulting in death or severe injury.

 **CAUTION**

Indicates that incorrect handling may cause hazardous conditions, resulting in medium or slight personal injury or physical damage.

Note that the  CAUTION level may lead to a serious consequence according to the circumstances.

Always follow the instructions of both levels because they are important to personal safety.

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

[Design Instructions]

 **DANGER**

- 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 error has been detected, create a ladder program that turns off the outputs in the program.

If the CC-Link Safety is restored with the outputs on, it may suddenly operate and result in an accident.

- To inhibit restart without manual operation after safety function was performed and outputs were turned OFF, create an interlock program which uses a reset button for restart.

- 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.

 **DANGER**

- 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.

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Japanese Manual Version SH-080743-B

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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

Make sure to read the following manual before configuring/designing 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 following lists the manuals for this software package.

Refer to the following table when ordering manuals.

Manual Name	Manual No. (Model Code)
GX Developer Version 8 Operating Manual Explains the online functions of the GX Developer, such as the programming, printout, monitoring, and debugging methods. (Sold separately.)	SH-080373E (13JU41)
GX Developer Version 8 Operating Manual (Startup) Explains the system configuration, installation and starting methods of the 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 QS0J61BT12 Explains the specifications, procedures and settings up to operation, parameter settings and trouble shootings of the QS0J61BT12-type CC-Link Safety system master module. (Sold separately.)	SH-080600ENG (13JR88)
CC-Link Safety System Remote I/O Module User's Manual QS0J65BTB2-12DT Explains the specifications, procedures and settings up to operation, parameter settings and trouble shootings of the CC-Link Safety Remote I/O Module. (Sold separately.)	SH-080612ENG (13JR89)

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 MANUAL

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

4. Safety FB Specifications MELSEC-QS

4. SAFETY FB SPECIFICATIONS

4.1 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 FB. See Chapter 2.2 General Specification.
	S_Button1	bit*	OFF	Input of button 1 (for category 3 or 4 contacts) OFF: Button 1 released. ON: Button 1 actuated.
IN	S_Button2	bit*	OFF	Input of button 2 (for category 3 or 4 contacts) OFF: Button 2 released. ON: Button 2 actuated.
	Ready	bit	OFF	Activate status of this FB. See Chapter 2.2 General Specification.
OUT	S_TwoHandOut	bit*	OFF	Safety related 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. See Chapter 2.2 General Specification.
OUT	DiagCode	int	0	Diagnostic register. See Chapter 2.2 General Specification.

[DANGER]

- A variable which of its data type is "bit*" must be input/output to safe data (see Appendix 1).
- When a safe data is not connected to a safety device with the correct path, a safe data is not safe. Please check a path of a safe data.

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.

4 - 1

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.

INPUT/OUTPUT

This table describes each input/output parameter. Each table shows FB specific variables. See "2.2 Generic Specification" about the description of generic variables of FB.

Note/Caution

It is the important topic to use the safety FB.

FUNCTION DESCRIPTION

How to use the FB and its functions are described.

4. Safety FB Specifications MELSEC-QS

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 S+2HAND2

4 - 2

STATE DIAGRAM

The safety FB changes its state according to the combination of input variables. See "2.4 State Diagram" for how to see the state diagram.

4. Safety FB Specifications

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TYPICAL TIMING DIAGRAM

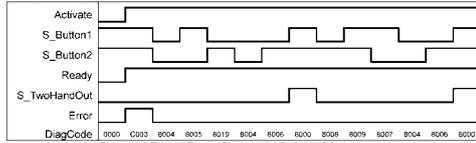


Figure 4.2 Typical Timing Diagram for S+2HAND2

ERROR DETECTION

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

ERROR BEHAVIOR

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

ERROR CODES

Diag Code	State Name	Description, Setting Output	Actions
C001	Error B	S_Button1 was ON on FB activation.	Release S_Button1 and S_Button2.
C002	Error B2	S_Button2 was ON on FB activation.	Same above.
C003	Error B1&B2	The signals at S_Button1 and S_Button2 were ON on FB activation.	Same above.

STATE CODE (no error)

Diag Code	State Name	Description, Setting Output	Actions
0000	Idle	The function block is not active (initial state). Ready = OFF	User can initialize by Activate=ON.
8000	Buttons Actuated	Both buttons actuated correctly. The safety related output is enabled. Ready = ON. Error = OFF. S_TwoHandOut = ON	None.
8001	Init	Function block is active, but in the Init state. Ready = ON.	Actuate S_Button1 or S_Button2.
8004	Buttons Released	No button is actuated.	None. Or, actuate S_Button1 and S_Button2.
8005	Button 1 Actuated	Only Button 1 is actuated.	Release S_Button1, or actuate S_Button2.
8006	Button 2 Actuated	Only Button 2 is actuated.	Release S_Button2, or actuate S_Button1.
8007	Button 2 Released	The safety related output was enabled and is disabled again. In this state, S_Button1 is ON and S_Button2 is OFF after disabling the safety related output.	Release S_Button1.
8008	Button 1 Released	The safety related output was enabled and is disabled again. In this state, S_Button1 is OFF and S_Button2 is ON after disabling the safety related output.	Release 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 DETECTION

All of FB specific errors are described.

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.

4. Safety FB Specifications

MELSEC-QS

8009	Locked Off	The safety related output was enabled and is disabled again. In this state, S_Button1 is ON and S_Button2 is ON after disabling the safety related output.	Release S_Button1 and S_Button2.
8019	Locked On	The statuses of both buttons (ON and OFF) are swapped. Waiting for release of both buttons.	Same above.



[DANGER]
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

SAMPLE APPLICATION

The example of emergency stop application of the machine by a two-hands switch is shown in the following figure.



Figure 4.3 Sample Application for S+2HAND2

- SM400: Constant (always ON)
- X100: Button 1 of a two-hands switch (safe input)
- X102: Button 2 of a two-hands switch (safe input)
- Y100: Safety contactor (safe output)
- Y200: Error indicator
- D0: An internal record for DiagCode

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 564-1 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

SAMPLE APPLICATION

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 and CC-Link safety remote I/O module.
Standard Programmable Controller	General name of each module for MELSEC-Q 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.

2. GENERAL SPECIFICATION

2.1. List of Safety FB

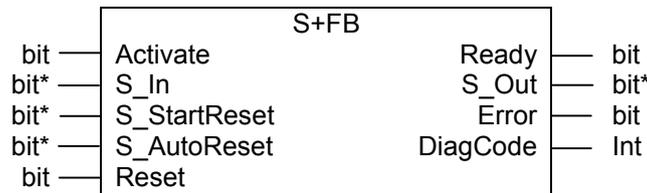
Following is the list of provides safety function blocks.

Table 2.1 List of Safety FB

FB Name	Function	Descriptions	Section
S+2HAND2	Two hand switch Type II	This FB provides the two-hand control functionality (see EN 574, Section 4 Type II).	4.1
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
S+EDM	External device monitor	External device monitoring - The FB controls a safety output and monitors controlled actuators, e.g. subsequent contactors	4.3
S+ENBLSW	Enable switch	This FB evaluates the signals of an enable switch with three positions.	4.4
S+ESPE	Light Curtain (ESPE)	This FB is a safety-related FB for monitoring electro-sensitive protective equipment (ESPE).	4.5
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
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
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
S+MODSEL	Mode Selector	This FB selects the system operation mode, such as manual, automatic, semi-automatic, etc.	4.9
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
S+MUTEP	Parallel muting	In this FB, parallel muting with four muting sensors is specified.	4.11
S+MUTES	Sequential muting	In this FB, sequential muting with four muting sensors is specified.	4.12
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
S+TSSSEN	Safety testable 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

2.2. Generic Specifications

The generic specifications of the safety FB are described in this section. S+FB function block is not the specific FB, it is an virtual FB for explanations. S_In and S_out are the safety input and output of S+FB, and these names and meanings are different in each specific FB. Other variables in this list (Activate etc.) are common variables in all of FB, and they have following meanings. Additionally, each FB has the individual variables. See “Chap.4 Safety FB Specifications” for more detail.



[DANGER]
 - A variable which of its data type is "bit*" must be input/output to safe data (see Appendix.1).
 - When a safe data is not connected to a safety device with the correct path, a safe data is not safe. Please check a path of a safe data.

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: FB is active.
	S_In	bit*	OFF	Safety input signals to this FB.
	S_StartReset	bit*	OFF	Restart inhibit option. This function can set the auto or manual restart in order to turn on S_Out=ON after the FB activation. OFF (= initial value): Manual reset when FB is activated. ON: Automatic reset when FB is activated.
	S_AutoReset	bit*	OFF	Automatic restart option. This function can be set an auto or manual reset in order to turn on S_Out=ON when S_In turn/return to ON. OFF (= initial value): Manual reset when emergency stop button is released. ON: Automatic reset when emergency stop button is released.
	Reset	bit	OFF	Reset input. At the rising trigger of the Reset signal, this input can be used for different reset behaviors; - Reset of the state machine, and coupled error and status messages as indicated via DiagCode, when the error cause has been removed. This reset behavior is as same as an error reset. - Reset at the restart inhibit. (See section 2.3(2)) - Manual reset of a “restart interlock” by the operator (see EN 954-1). This reset behavior is as same as a functional reset. - Additional FB-specific reset functions.

OUT	Ready	bit	OFF	<p>Activate status of this FB.</p> <p>Useful in debug mode or to activate/deactivate additional FB, as well as for further processing in the functional program.</p> <p>ON: Indicates that the FB is activated and the output results are valid.</p> <p>OFF: The FB is not activated.</p>
	S_Out	bit*	OFF	<p>Safety output signals from this FB.</p> <p>Every safety output variable name begins S_.</p>
	Error	bit	OFF	<p>Error flag.</p> <p>ON: Indicates that an error has occurred, and the FB is in an error state. The relevant error state is mirrored at the DiagCode output.</p> <p>OFF: There is no error.</p>
	DiagCode	int	0	<p>Diagnostic register.</p> <p>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.</p> <p>Only one consistent code is represented at the same time. In the event of multiple errors, the output indicates the first detected error until recovering from error. See DiagCode of each description of FB. In this manual, this value shows by hex (16bits=0000).</p>

2.3 General Functions

(1) Initialization

FB is not active if Activate=OFF, all binary output parameters are set to OFF, and the DiagCode diagnostic parameter is set to 0. FB is active if Activate=ON, and Ready output is set to ON.

In order to initialize the FB again after a failure of the safety remote I/O module that connects the safety device related with a safety input of the FB, you can input the special device that indicate the status of the module to Activate variable. See "Safety Application Guide, Section 4.2".

It is no problem that Activate is set to always ON, when you have no need to control the FB activation.

(2) Startup inhibit (Manual reset)

This function disables that the safe output is turn to ON immediately at the event of a valid combination of inputs. A manual reset is needed to the safe output = OFF.

Usually, startup inhibit is active at initial of FB (Activate=ON), and safe output is OFF till a manual reset. When S_StartReset is set to ON, the safe output automatically set to ON in the event of a valid combination of input signals.



[DANGER]

- Startup inhibits may only be deactivated when it is ensured that:

A hazardous situation cannot occur during machines/system startup

Or

Startup inhibits are implemented elsewhere or by other means

- The startup behavior for the specified value of S_StartReset must be validated.

When controlling the value of S_StartReset dynamically, the startup behavior must be validated for the state indicated by each value.

- Please note that an undesired ON signal results in unexpected startup. S_StartReset and S_AutoReset must therefore only be assigned the value ON when it is ensured that a dangerous situation cannot occur during safe controller startup or startup is prevented by other measures.

This function disables that the safe output is turn to ON immediately at the event of a valid combination of inputs after the safe stop. The safe output is kept OFF till the manual reset. Startup inhibit can be canceled by S_AutoRestart=ON, the safe output is automatically ON at the event of a valid combination of inputs.

(3) Diagnostics of Reset signal

FB monitors a rising trigger at Reset signal, and resets the status or the error. Some applications detect a static Reset signal as an error. This means that Reset has been ON before the event of a valid combination of input signals. The cause may be a failure of wiring or a failure of a device related to the Reset signal.

See each description of the safety FB, for more detail of errors that are able to detect in each FB.

(4) Error behaviors

When FB detects error, Error=ON and all of safety output (E_Out) turn to OFF. Error code is shown in DiagCode. If no error is present, the internal status of the function block is indicated.



[DANGER]

- It is your responsibility to ensure that no hazards occur in the event of an error message of following a reset.
- Set Reset to OFF to exit the error state of the static ON without a rising trigger at Reset signal. In other error states, set Reset from OFF to ON.

2.4 Generic State Diagram

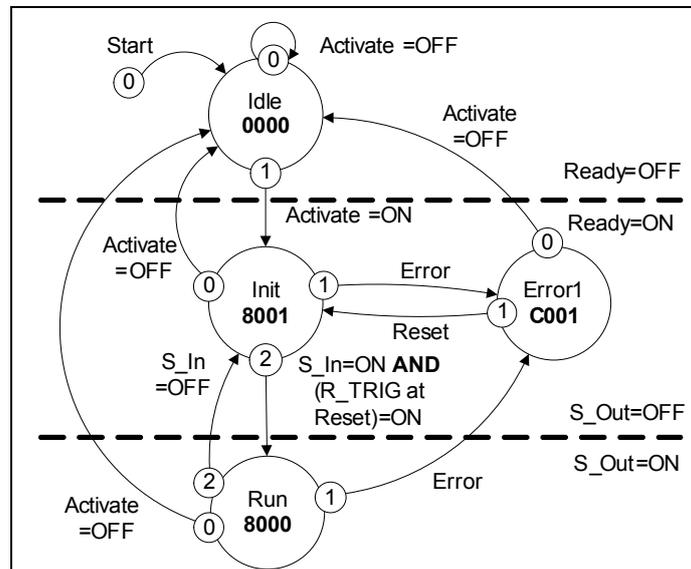


Figure.2.1 General State Diagram for FB

Each safety FB has FB specific state transitions driven by its input combination such as Figure 2.1.

- The above diagram shows a general overview of the states and transitions. A state shown a circle and a transition shown an arrow in the figure has the FB-specified meanings, and are described with the relevant FBs.
- The diagram shows three areas: At the top the FB is not active and in the Safe state (safe outputs are OFF), in the middle the FB is active and in the Safe state (safe outputs are OFF), and at the bottom the FB is in the normal state, i.e., the safe outputs are ON.
- The first horizontal line in the state diagram shows the transition from a non-active FB to an active FB.
- The second horizontal line shows the transition from a non-safe state to a safe state of the FB.
- The priorities of possible parallel transitions are indicated by numbers (0 = highest priority).
- State bubbles contain the state name and hexadecimal DiagCode.
- Conditions "OR, AND " are used as logical operators.
- Within the FB description, the starting state is Idle, with the transitions to operational states via the Init state.
- The transition from any state due to Activate = OFF, changes to Idle state (0 = highest priority reserved for Activate = OFF) - for greater clarity, these transitions are not shown in each FB-related state diagram.
- In transition condition, R_TRIG is the rising trigger at the signal, and F_TRIG is the falling trigger at the signal.

2.5 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.

3. RESTRICTIONS AND CAUTIONS

3.1 Restrictions

(1) Maximum number of usable safety FB in QSCPU

For use of the safety BF in QSCPU, below values are the maximum numbers to use in QSCPU. The value in the users' program is depend on the contents of user's program or use of multi FB type.

Table 3.1 Number of Steps and the Max. Number of Safety FB

FB Name	Step in FB	Max. number of safety FB for QSCPU
S+2HAND2	215	67
S+2HAND3	302	47
S+EDM	421	33
S+ENBLSW	218	65
S+ESPE	141	100
S+ESTOP	141	100
S+GLOCK	205	69
S+GMON	260	54
S+MODSEL	320	44
S+MUTE2	472	30
S+MUTEP	889	15
S+MUTES	553	25
S+OUTC	162	85
S+TSSEN	394	35

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.1 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

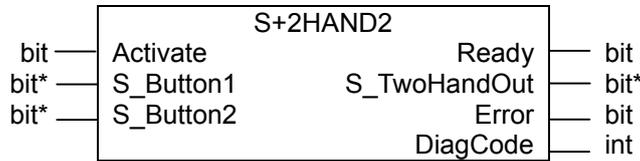
(1) Precautions for project data management

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.

4. SAFETY FB SPECIFICATIONS

4.1 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 FB. See Chapter 2.2 General Specification.
	S_Button1	bit*	OFF	Input of button 1 (for category 3 or 4 contacts) OFF: Button 1 released. ON: Button 1 actuated.
	S_Button2	bit*	OFF	Input of button 2 (for category 3 or 4 contacts) OFF: Button 2 released. ON: Button 2 actuated.
OUT	Ready	bit	OFF	Activate status of this FB. See Chapter 2.2 General Specification.
	S_TwoHandOut	bit*	OFF	Safety related 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. See Chapter 2.2 General Specification.
	DiagCode	int	0	Diagnostic register. See Chapter 2.2 General Specification.



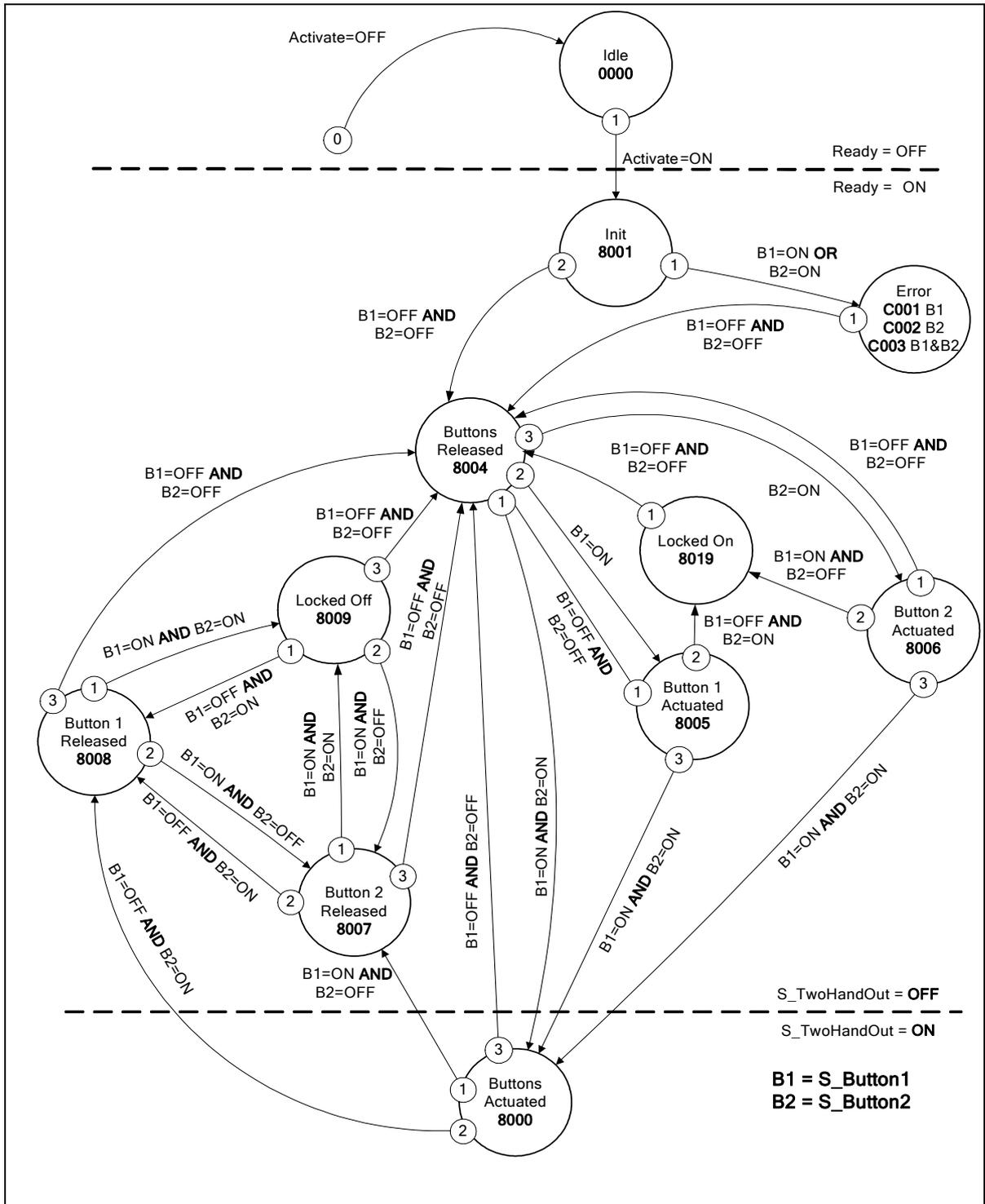
[DANGER]

- A variable which of its data type is "bit*" must be input/output to safe data (see Appendix.1).
- When a safe data is not connected to a safety device with the correct path, a safe data is not safe. Please check a path of a safe data.

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 S+2HAND2

TYPICAL TIMING DIAGRAM

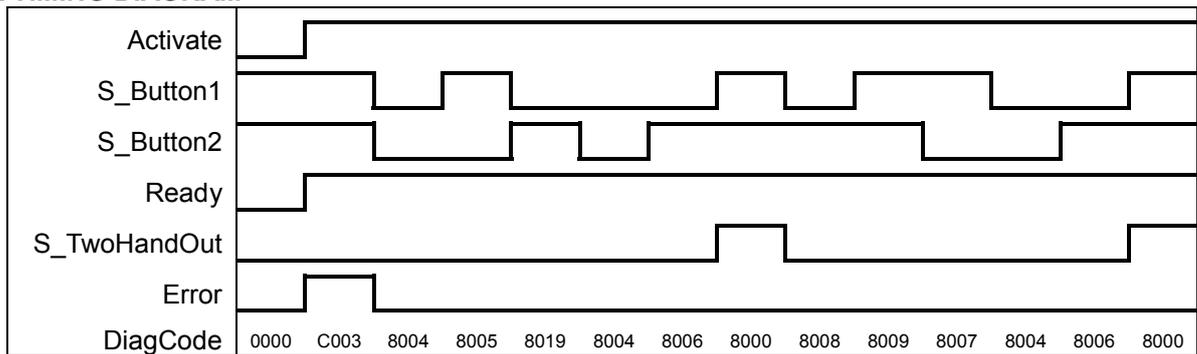


Figure 4.2 Typical Timing Diagram for S+2HAND2

ERROR DETECTION

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

ERROR BEHAVIOR

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

ERROR CODES

Diag Code	State Name	Description, Setting Output	Actions
C001	Error B	S_Button1 was ON on FB activation.	Release S_Button1 and S_Button2.
C002	Error B2	S_Button2 was ON on FB activation.	Same above.
C003	Error B1&B2	The signals at S_Button1 and S_Button2 were ON on FB activation.	Same above.

STATE CODE (no error)

Diag Code	State Name	Description, Setting Output	Actions
0000	Idle	The function block is not active (initial state). Ready = OFF	User can initialize by Activate=ON.
8000	Buttons Actuated	Both buttons actuated correctly. The safety related output is enabled. Ready = ON Error = OFF S_TwoHandOut = ON	None.
8001	Init	Function block is active, but in the Init state. Ready = ON	Actuate S_Button1 or S_Button2.
8004	Buttons Released	No button is actuated.	None. Or, actuate S_Button1 and S_Button2.
8005	Button 1 Actuated	Only Button 1 is actuated.	Release S_Button1, or actuate S_Button2.
8006	Button 2 Actuated	Only Button 2 is actuated.	Release S_Button2, or actuate S_Button1.
8007	Button 2 Released	The safety related output was enabled and is disabled again. In this state, S_Button1 is ON and S_Button2 is OFF after disabling the safety related output.	Release S_Button1.
8008	Button 1 Released	The safety related output was enabled and is disabled again. In this state, S_Button1 is OFF and S_Button2 is ON after disabling the safety related output.	Release S_Button2.

8009	Locked Off	The safety related output was enabled and is disabled again. In this state, S_Button1 is ON and S_Button2 is ON after disabling the safety related output.	Release S_Button1 and S_Button2.
8019	Locked On	The statuses of both buttons (ON and OFF) are swaped. Waiting for release of both buttons.	Same above.



[DANGER]
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

SAMPLE APPLICATION

The example of emergency stop application of the machine by a two-hands switch is shown in the following figure.

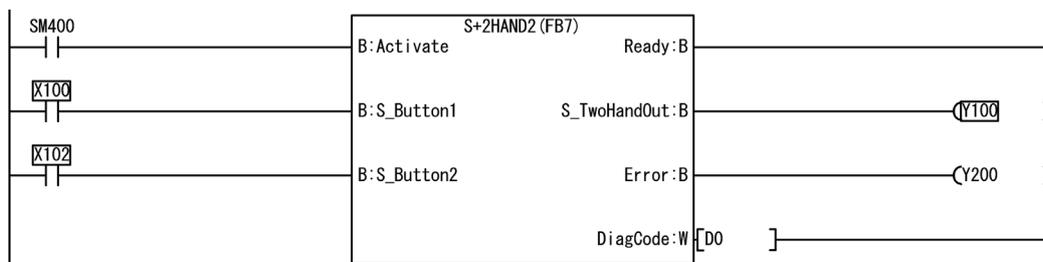


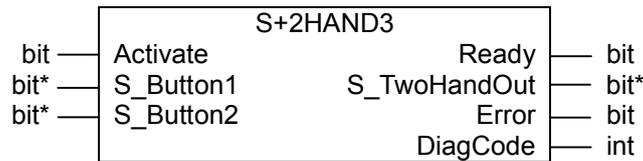
Figure 4.3 Sample Application for S+2HAND2

- SM400: Constant (always ON)
- X100: Button 1 of a two-hands switch (safe input)
- X102: Button 2 of a two-hands switch (safe input)
- Y100: Safety contactor (safe output)
- Y200: Error indicator
- D0: An internal record for DiagCode

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 S+2HAND3



OVERVIEW

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

INPUT/OUTPUT

I/O	Name	Data Type	Initial Value	Description, Parameter Values
IN	Activate	bit	OFF	Activation of the FB. See Chapter 2.2 General Specification.
	S_Button1	bit*	OFF	Input of button 1 (for category 3 or 4: NC/NO contacts) OFF: Button 1 released. ON: Button 1 actuated.
	S_Button2	bit*	OFF	Input of button 2 (for category 3 or 4: NC/NO contacts) OFF: Button 2 released. ON: Button 2 actuated.
OUT	Ready	bit	OFF	Activate status of this FB. See Chapter 2.2 General Specification.
	S_TwoHandOut	bit*	OFF	Safety related output signal. OFF: No correct two hand operation. ON: S_Button1 and S_Button2 inputs changed from OFF to ON within 500 ms and no error occurred. The two hand operation has been performed correctly.
	Error	bit	OFF	Error flag. See Chapter 2.2 General Specification.
	DiagCode	int	0	Diagnostic register. See Chapter 2.2 General Specification.

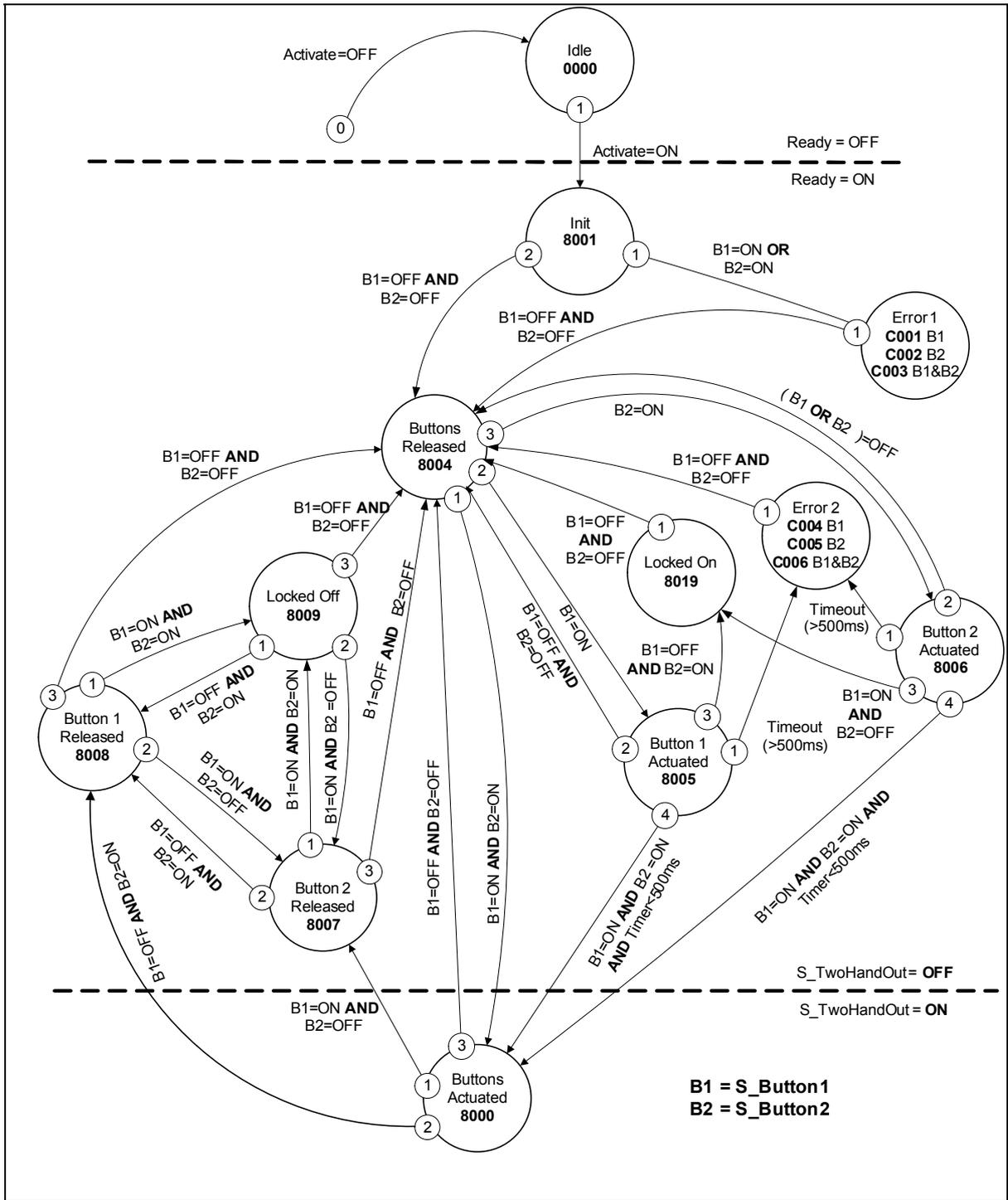


[DANGER]
 - A variable which of its data type is "bit*" must be input/output to safe data (see Appendix.1).
 - When a safe data is not connected to a safety device with the correct path, a safe data is not safe. Please check a path of a safe data.

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 4.4 State Diagram for S+2HAND3

TYPICAL TIMING DIAGRAM

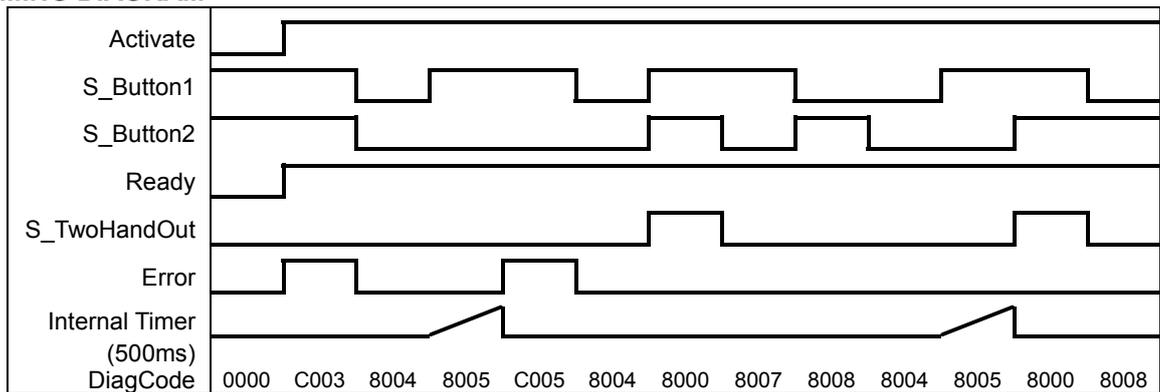


Figure 4.5 Typical Timing Diagram for S+2HAND3

ERROR DETECTION

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

The FB detects when the divergence of the input signals exceeds 500 ms.

ERROR BEHAVIOR

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

The Error state is exited when both buttons are released (set to OFF).

ERROR CODES

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

STATUS CODES (no error)

Diag Code	State Name	Description, Setting Output	Actions
0000	Idle	The function block is not active (initial state). Ready = OFF	User can initialize by Activate=ON.
8000	Buttons Actuated	Both buttons actuated correctly. The safety related output is enabled. S_TwoHandOut = ON	None.
8001	Init	Function block is active, but in the Init state. Ready= ON	Actuate S_Button1 or S_Button2.
8004	Buttons Released	No Button is actuated.	None. Or, actuate S_Button1 or S_Button2.

8005	Button 1 Actuated	Only Button 1 is actuated. Start monitoring timer.	Release S_Button1, or actuate S_Button2.
8006	Button 2 Actuated	Only Button 2 is actuated. Start monitoring timer.	Release S_Button2, or actuate S_Button1.
8007	Button 2 Released	The safety related output was enabled and is disabled again. In this state, S_Button1 is ON and S_Button2 is OFF after disabling the safety related output.	Release S_Button1.
8008	Button 1 Released	The safety related output was enabled and is disabled again. In this state, S_Button1 is OFF and S_Button2 is ON after disabling the safety related output.	Release S_Button2.
8009	Locked Off	The safety related output was enabled and is disabled again. In this state, S_Button1 is ON and S_Button2 is ON after disabling the safety related output.	Release S_Button1 and S_Button2.
8019	Locked On	The statuses of both buttons (ON and OFF) are swaped. Waiting for release of both buttons.	Same above.



[DANGER]
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

SAMPLE APPLICATION

The example of emergency stop application of the machine by a two-hands switch is shown in the following figure.

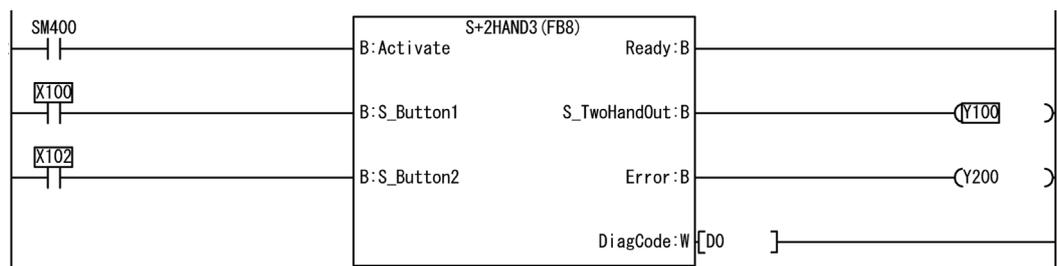


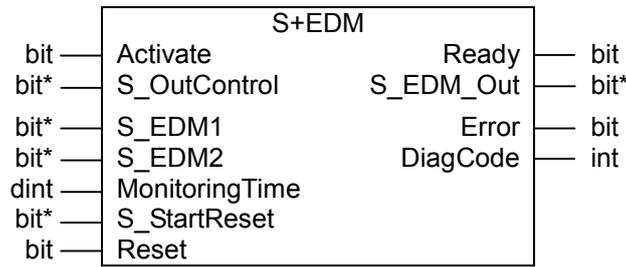
Figure 4.6 Sample Application for S+2HAND3

- SM400: Constant (always ON)
- X100: Button 1 of a two-hands switch (safe input)
- X102: Button 2 of a two-hands switch (safe input)
- Y100: Safety contactor (safe output)
- Y200: Error indicator
- D0: An internal record for DiagCode

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 S+EDM



OVERVIEW

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

INPUT/OUTPUT

I/O	Name	Data Type	Initial Value	Description, Parameter Values
IN	Activate	bit	OFF	Activation of the FB. See Chapter 2.2 General Specification.
	S_OutControl	bit*	OFF	Control signal of the preceding safety FB's. Typical function block signals from the library (e.g., SF_OutControl, SF_TwoHandControlTypell, 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. OFF: Switching state of the first connected actuator. ON: Initial state of the first connected actuator.
	S_EDM2	bit*	OFF	Feedback signal of the second connected actuator.
	MonitoringTime	dint	0	Max. response time of the connected and monitored actuators (10ms unit). You must set constant value. Range: 0 - 60000 (0 -600,000ms=10min)
	S_StartReset	bit*	OFF	Restart inhibit option. See Chapter 2.2 General Specification.
	Reset	bit	OFF	Reset input. See Chapter 2.2 General Specification.
OUT	Ready	bit	OFF	Activate status of this FB. See Chapter 2.2 General Specification.
	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. See Chapter 2.2 General Specification.
	DiagCode	int	0	Diagnostic register. See Chapter 2.2 General Specification.



[DANGER]
 - A variable which of its data type is "bit*" must be input/output to safe data (see Appendix.1).
 - When a safe data is not connected to a safety device with the correct path, a safe data is not safe. Please check a path of a safe data.

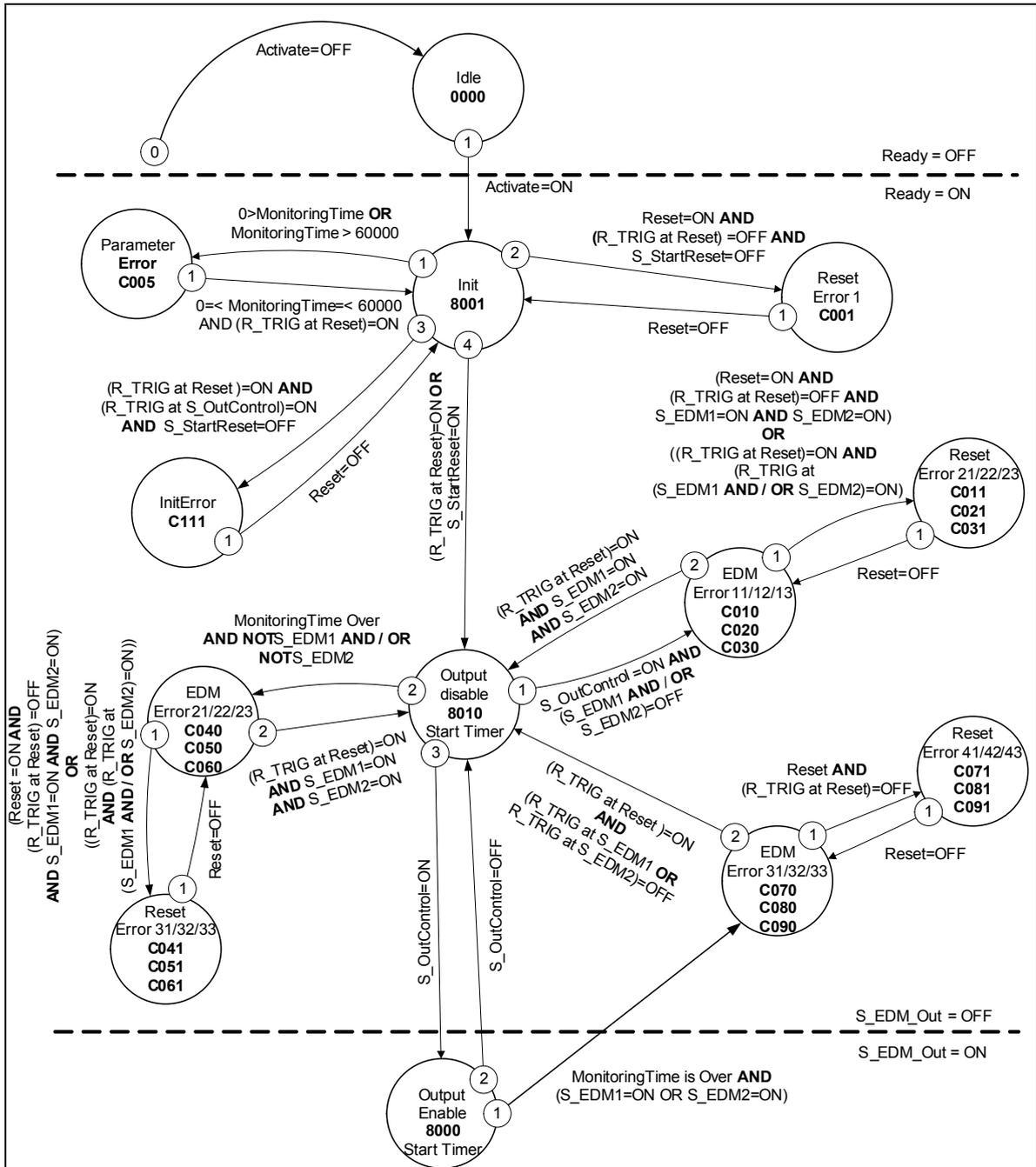
FUNCTION DESCRIPTION

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.

[DANGER]

- 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



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 S+EDM

TYPICAL TIMING DIAGRAM

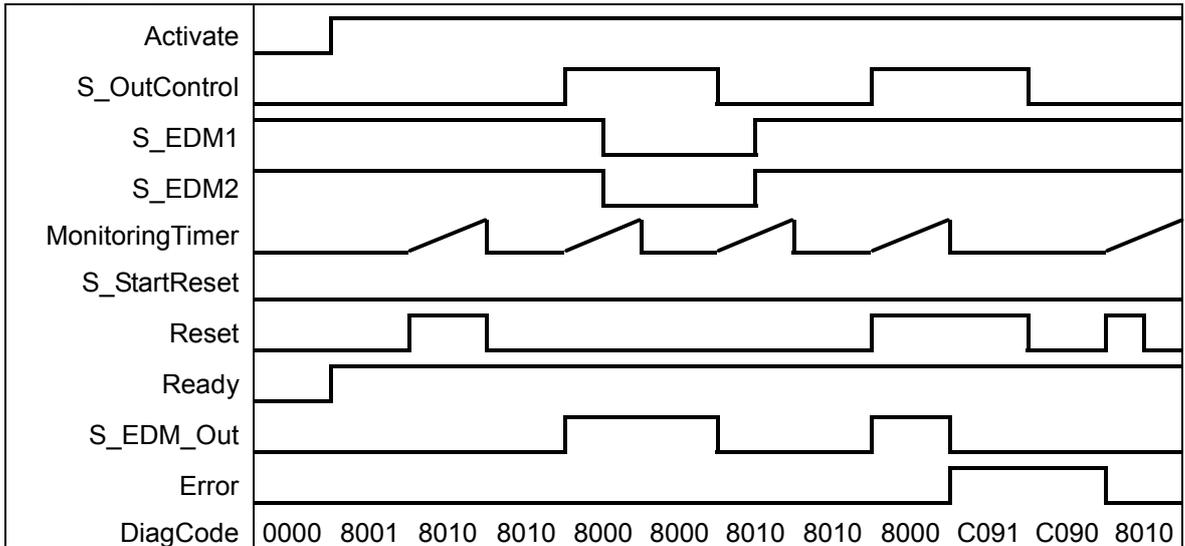


Figure 4.8 Typical Timing Diagram for S+EDM
S_StartReset=OFF

ERROR DETECTION

- The following conditions force a transition to the Error state:
- Invalid static Reset signal in the process.
 - Invalid EDM signal in the process. (After MonitoringTime)
 - Simultaneously rising trigger (R_TRIG) at S_EDMx and Reset. (Incorrectly interconnected)

ERROR BEHAVIOR

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

ERROR CODES

Diag Code	State Name	Description, Setting Output	Actions
C001	Reset Error 1	Static Reset signal in state 8001.	Reset=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.	Reset=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.	Same above.
C071 C081 C091	Reset Error 41/42/43	Static Reset signal in state C070/C080/C090.	Reset=OFF.
C010	EDM Error 11	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=ON (initial value), and reset the FB.
C020	EDM Error 12	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.	Same above.

C030	EDM Error 13	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.	Same above.
C040	EDM Error 21	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.	Same above.
C050	EDM Error 22	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.	Same above.
C060	EDM Error 23	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.	Same above.
C070	EDM Error 31	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 FB.
C080	EDM Error 32	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.	Same above.
C090	EDM Error 33	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.	Same above.
C111	Init Error	Similar signals at S_OutControl and Reset (R_TRIG at same cycle) detected.	Check the wiring and the connection of variables in the program. After the check, reset the FB.

STATUS CODES (no error)

Diag Code	State Name	Description, Setting Output	Actions
0000	Idle	The function block is not active. Ready = OFF	User can initialize by Activate=ON.
8001	Init	Block activation startup inhibit is active. (S_StartReset=OFF) Ready = ON	Reset the FB.
8010	Output Disable	EDM control is not active. Timer starts when state is entered S_EDM_Out = OFF	Wait until S_EDM changes to OFF, or set S_OutControl=ON.
8000	Output Enable	EDM control is active. Timer starts when state is entered. S_EDM_Out = ON	None.



[DANGER]
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

SAMPLE APLICATION

The example of feedback monitoring application for two external contactors is shown in the following figure.

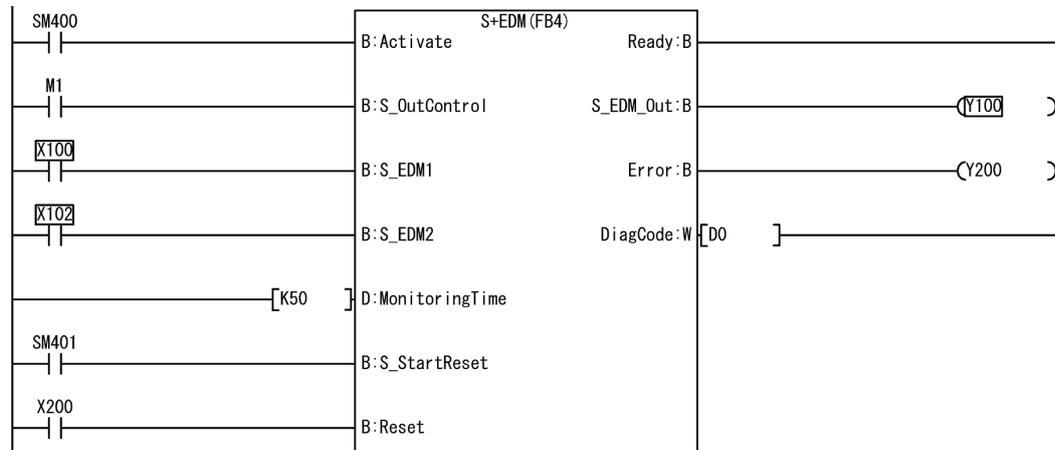


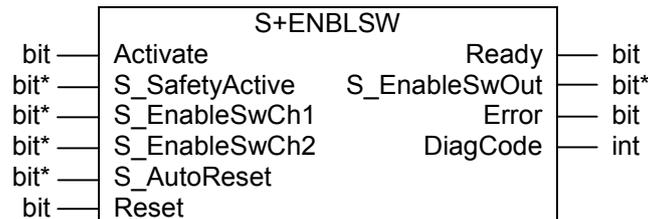
Figure 4.9 Sample Application of S+EDM

- SM400: Constant (always ON)
 - SM401: Constant (always OFF)
 - M1: Safe output from preceedings Safety FB (safe input to S+EDM)
 - X100,X102: Feedback signals from Contactor1 and Contactor2 (safe input)
 - X200: Reset switch
 - Y100: Control signal to the contactors (safe putput)
 - Y200: Error indicator
 - D0: An internal record for DiagCode
 - K50: Constant (Max. response time for contactor=500ms)
- * S_StartReset is always OFF.

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 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 FB. See Chapter 2.2 General Specification.
	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_EnableSwCh 1	bit*	OFF	Signal of contacts E1 and E2 of the connected enable switch. (See "Function Description") OFF: Connected switches are open. ON: Connected switches are closed.
	S_EnableSwCh 2	bit*	OFF	Signal of contacts E3 and E4 of the connected enable switch. (See "Function Description") OFF: Connected switches are open. ON: Connected switches are closed.
	S_AutoReset	bit*	OFF	Automatic restart option. See Chapter 2.2 General Specification.
	Reset	bit	OFF	Reset input. See Chapter 2.2 General Specification.
OUT	Ready	bit	OFF	Activate status of this FB. See Chapter 2.2 General Specification.
	S_EnableSwOut	bit*	OFF	Safety related output: Indicates suspension of guard. OFF: Disable suspension of safeguarding. (Execute the safeguarding, or stop the machine) ON: Enable suspension of safeguarding. (Permit its maintenance or arrangement)
	Error	bit	OFF	Error flag. See Chapter 2.2 General Specification.
	DiagCode	int	0	Diagnostic register. See Chapter 2.2 General Specification.



[DANGER]

- A variable which of its data type is "bit*" must be input/output to safe data (see Appendix.1).
- When a safe data is not connected to a safety device with the correct path, a safe data is not safe. Please check a path of a safe data.

FUNCTION DESCRIPTION

The S+ENBLSW FB supports the suspension of safeguarding (IEC 60204 Section 9.2.4) using enable switches (IEC 60204 Section 9.2.5.8), if the relevant operating mode is selected and active. When suspend the safeguarding for maintenance and arrangement, user must select safe operating mode (limitation of the speed or the power of motion, limitation of the range of motion) and use the enable switch to emergency stop the machine. The relevant operating mode must be selected outside of S+ENBLSW FB.

This FB evaluates the signals of an enable switch with three positions (IEC 60204 Section 9.2.5.8). The enable switch has three positions, and contacts E1 - E4 have following status at each position.

Table 4.1 Status of Contactors for Each Positions of Enable Switch

	Positions of Enable Switch		
	1	2	3
Contactor E1+E2	open	close	open
Contactor E3+E4	close	close	open

Note: When the position changes to P1 from P3, it doesn't stay on P2.

The signal from E1+E2 must be connected to the S_EnableSwitchCh1 parameter. The signal from E3+E4 must be connected to the S_EnableSwitchCh2 parameter. The position and the switching direction of the enable switch can be detected in the FB using this signal sequence.

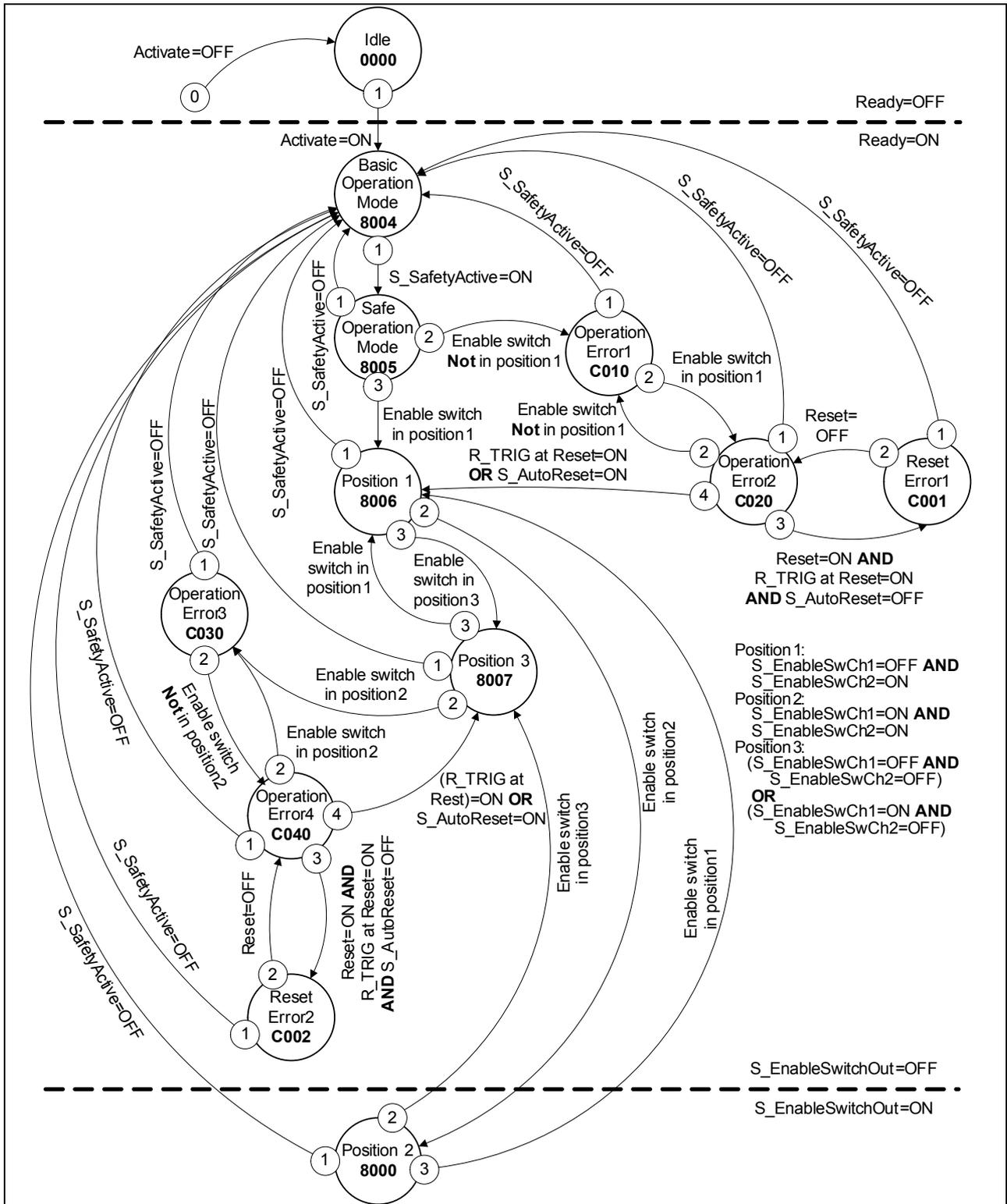


[DANGER]

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).

The S+ENBLSW processes the confirmation of the "safe mode" state via the "S_SafetyActive" parameter.

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 S+ENBSW

TYPICAL TIMING DIAGRAM

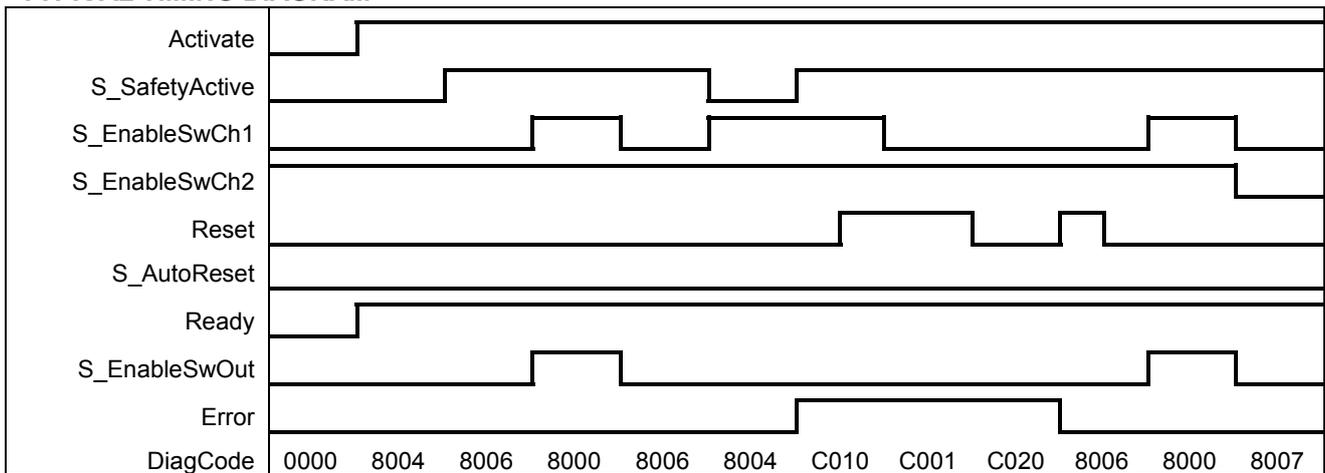


Figure 4.11 Typical Timing Diagram for S+ENBLSW
S_AutoReset=OFF

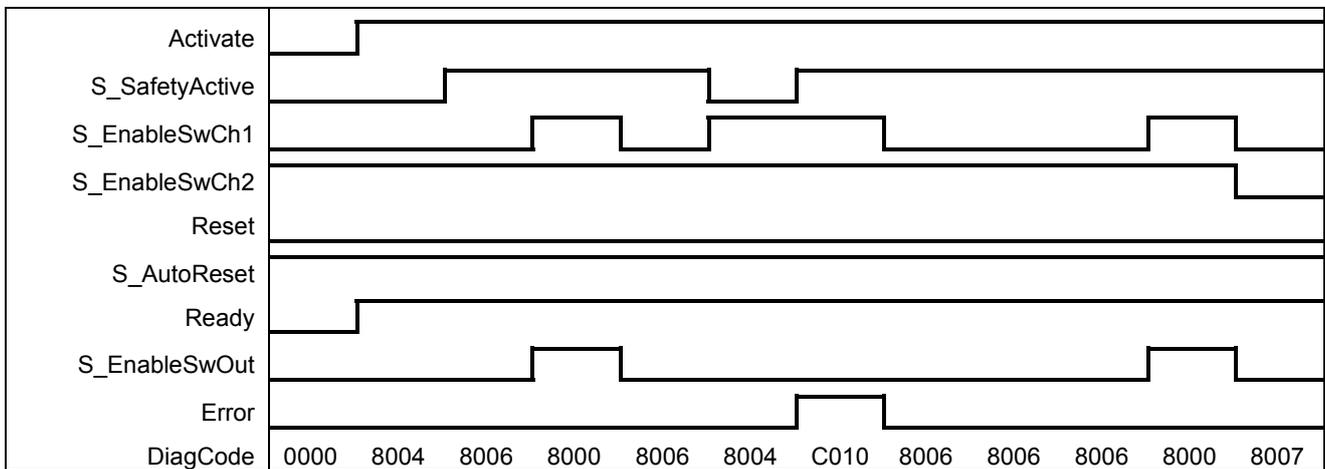


Figure 4.12 Typical Timing Diagram for S+ENBLSW
S_AutoReset=ON

ERROR DETECTION

The following conditions force a transition to the Error state:

- Invalid static Reset signal in the process.
- Invalid switch positions. (See Error Codes)

ERROR BEHAVIOR

In the event of an error, the S_EnableSwiOut safe output is set to OFF and remains in this Safe state.

Different from other FBs, a Reset Error state can be left by the condition Reset = OFF or, additionally, when the signal S_SafetyActive is OFF.

Once the error has been removed, the enable switch must be in the initial position specified in the process before the S_EnableSwOut output can be set to ON using the enable switch. If S_AutoReset = OFF, a rising trigger is required at Reset.

ERROR CODES

Diag Code	State Name	Description, Setting Output	Actions
C001	Reset Error 1	Static Reset signal detected in state C020. Ready = ON S_EnableSwOut = OFF Error = ON	Reset=OFF. Check the wiring and devices related to Reset signal.
C002	Reset Error 2	Static Reset signal detected in state C040.	Same above.
C010	Operation Error 1	Enable switch not in position 1 during activation of S_SafetyActive.	Set the switch to position 1, and S_SafetyActive=OFF.
C020	Operation Error 2	Enable switch in position 1 after C010.	Reset the FB.
C030	Operation Error 3	Enable switch in position 2 after position 3.	Set the switch to position 1, and reset the FB.
C040	Operation Error 4	Enable switch not in position 2 after C030.	Reset the FB.

STATUS CODES (no error)

Diag Code	State Name	Description, Setting Output	Actions
0000	Idle	The function block is not active (initial state). Ready = OFF	User can initialize by Activate=ON.
8004	Basic Operation Mode	Safe operation mode is not active.	Activate the safe operation mode by S_SafetyActive=ON.
8005	Safe Operation Mode	Safe operation mode is active.	Set the switch to position 1. Check a failure, wiring and state of the safety remote I/O station.
8006	Position 1	Safe operation mode is active and the enable switch is in position 1.	Set the switch to position 2.
8007	Position 3	Safe operation mode is active and the enable switch is in position 3.	Set the switch to position 1, or S_SafetyActive=OFF.
8000	Position 2	Safe operation mode is active and the enable switch is in position 2. S_EnableSwOut = ON	None.

**[DANGER]**

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

SAMPLE APLICATION

The example of emergency stop application for a machine with 3 position enable switch is shown in the following figure.

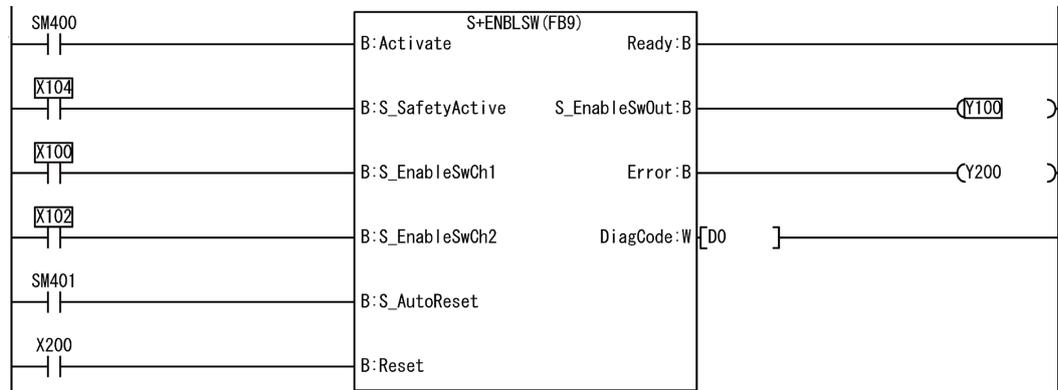


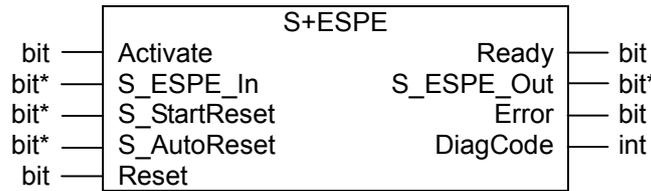
Figure 4.13 Sample Application of S+ENBLSW

- SM400: Constant (always ON) ...Activate is always ON
- SM401: Constant (always OFF) ...S_AutoReset is alwaysOFF
- X100, X102: Enable switch 1,2(safe input)
- X104: Safe operating mode for the target machine (safe input)
- X200: Reset switch
- Y100: The signal for the suspension of safeguarding (safe output)
- Y200: Error indicator
- D0: Internal record for DiagCode

APPLICABLE SAFETY STANDARDS

Standards	Requirements
IEC 60204-1, Ed. 5.0: 2003	<p>9.2.6.3: Enabling control (see also 10.9) is a manually activated control function interlock that:</p> <ul style="list-style-type: none"> 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. <p>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.</p> <p>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.</p> <p>Enabling control devices shall be selected that have the following features: ...</p> <ul style="list-style-type: none"> -- for a three-position type: <ul style="list-style-type: none"> - 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 S+ESPE



OVERVIEW

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

INPUT/OUTPUT

I/O	Name	Data Type	Initial Value	Description, Parameter Values
IN	Activate	bit	OFF	Activation of the FB. See Chapter 2.2 General Specification.
	S_ESPE_In	bit*	OFF	Safety demand input. OFF: ESPE actuated, demand for safety-related response. ON: ESPE not actuated, no demand for safety-related response.
	S_StartReset	bit*	OFF	Restart inhibit option. See Chapter 2.2 General Specification.
	S_AutoReset	bit*	OFF	Automatic restart option. See Chapter 2.2 General Specification.
	Reset	bit	OFF	Reset input. See Chapter 2.2 General Specification.
OUT	Ready	bit	OFF	Activate status of this FB. See Chapter 2.2 General Specification.
	S_ESPE_Out	bit*	OFF	Output for the safety-related response. OFF: Safety output disabled. Demand for safety-related response (e.g., reset required or internal errors active). ON: Safety output enabled. No demand for safety-related response.
	Error	bit	OFF	Error flag. See Chapter 2.2 General Specification.
	DiagCode	int	0	Diagnostic register. See Chapter 2.2 General Specification.

[DANGER]

- A variable which of its data type is "bit*" must be input/output to safe data (see Appendix.1).
- When a safe data is not connected to a safety device with the correct path, a safe data is not safe. Please check a path of a safe data.

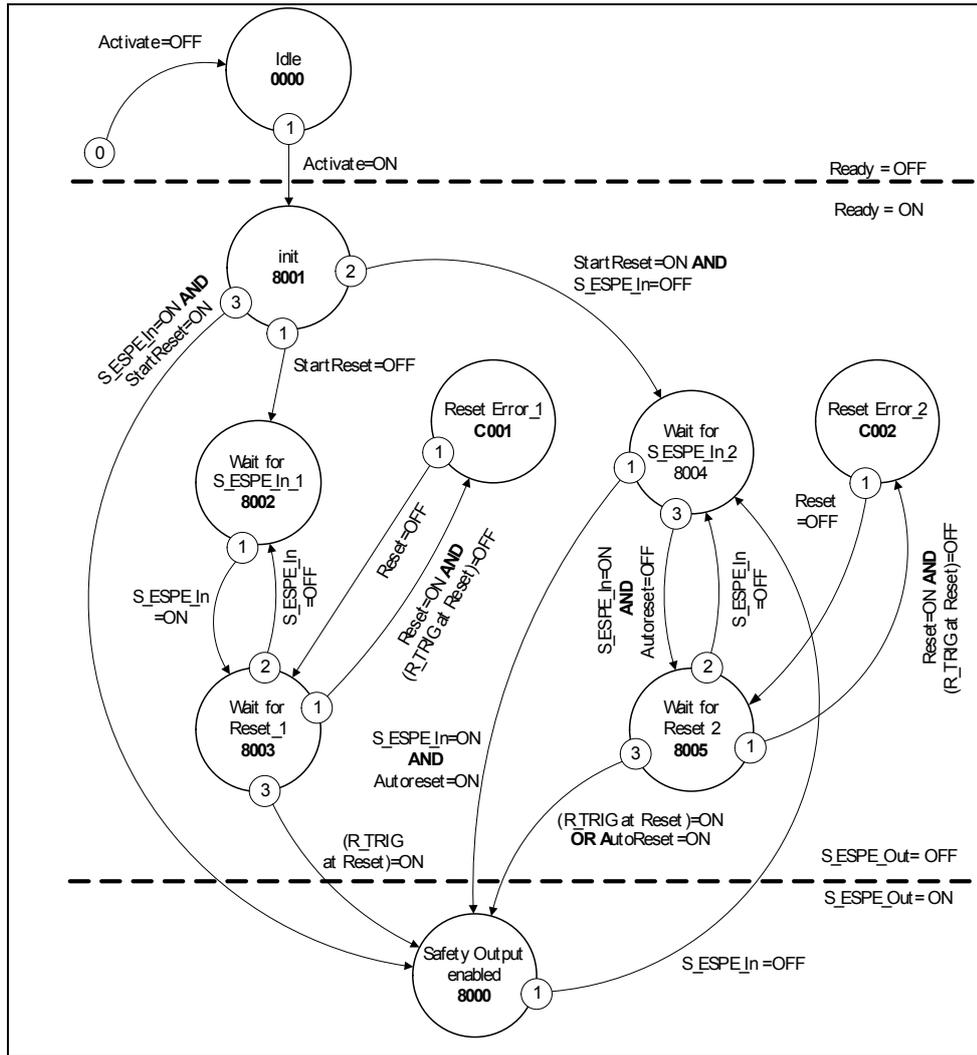
FUNCTION DESCRIPTION

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. The enable reset depends on the defined S_StartReset, S_AutoReset, and Reset inputs.

[DANGER]

- 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 4.14 State Diagram for S+ESPE

TYPICAL TIMING DIAGRAM

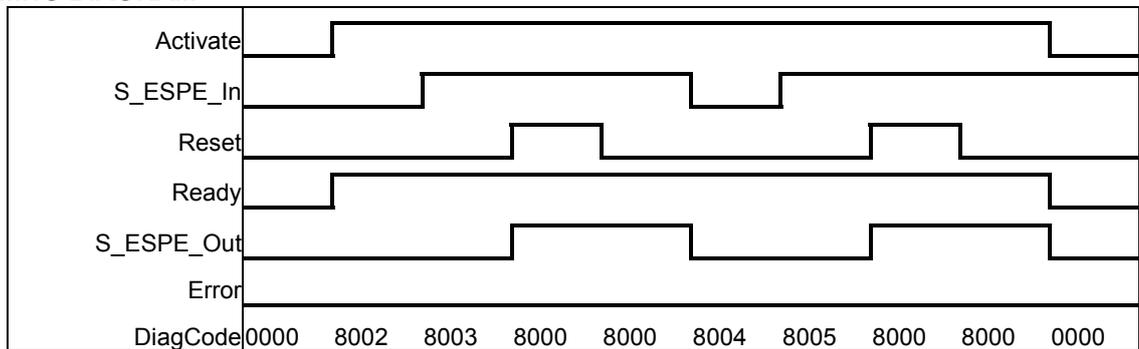


Figure 4.15 Typical Timing Diagram for S+ESPE

S_StartReset=OFF, S_AutoReset= OFF
(start, reset, normal operation, safety demand, restart)

ERROR DETECTION

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

ERROR BEHAVIOR

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

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

ERROR CODES

Diag Code	State Name	Description, Setting Output	Actions
C001	Reset Error 1	Reset is ON while waiting for S_ESPE_In = ON. Ready = ON S_ESPE_Out = OFF Error = ON	Reset=OFF. Check the devices and wiring related to Reset.
C002	Reset Error 2	Reset is ON while waiting for S_ESPE_In = ON. (S_StartReset = ON)	Same avobe.

STATUS CODES (no error)

Diag Code	State Name	Description, Setting Output	Actions
0000	Idle	The function block is not active (initial state). All of safe output=OFF, DiagCode=0 Ready = OFF	User can initialize by Activate=ON.
8001	Init	Activation is ON. The function block was enabled. Ready = ON	Wait for S_ESPE_In=ON.
8002	Wait for S_ESPE_In 1	Activation is ON. (S_StartReset = OFF)	Wait for S_ESPE_In=ON.
8003	Wait for Reset 1	Activation is ON. S_ESPE_In = ON. (S_StartReset = OFF)	Wait for a rising trigger of Reset.
8004	Wait for S_ESPE_In 2	Safety demand detected. (S_StartReset = ON)	Wait for S_ESPE_In=ON.
8005	Wait for Reset 2	Activation is ON. S_ESPE_In = ON. (S_StartReset = ON)	Wait for rising trigger of Reset.
8000	Safety Output Enabled	Safety demand is not detected. S_ESPE_In = ON. S_ESPE_Out = ON.	None.

**[DANGER]**

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

SAMPLE APLLICATION

The example of emergency stop application for a machine with 3 position enable switch is shown in the following figure.

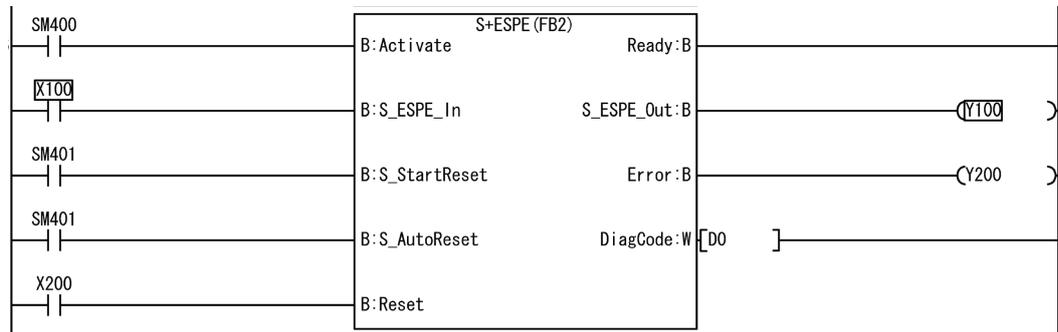


Figure 4.16 Sample Application of S+ESPE

- SM400: Constant (always ON) ...Activate is always ON
- SM401: Constant (always OFF) ...S_StartReset, S_AutoReset is always OFF
- X100: Light curtain: OSSD (safe input)
- X200: Reset switch
- Y100: Safety contactor (safe output)
- Y200: Error indicator
- D0: An internal record for DiagCode

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 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 FB. See Chapter 2.2 General Specification.
	S_EstopIn	bit*	OFF	Safety demand input. OFF: Demand for safety-related response (e.g., emergency stop button is engaged). ON: No demand for safety-related response (e.g., emergency stop button not engaged).
	S_StartReset	bit*	OFF	Restart inhibit option. See Chapter 2.2 General Specification.
	S_AutoReset	bit*	OFF	Automatic restart option. See Chapter 2.2 General Specification.
	Reset	bit	OFF	Reset input. See Chapter 2.2 General Specification.
OUT	Ready	bit	OFF	Activate status of this FB. See Chapter 2.2 General Specification.
	S_EstopOut	bit*	OFF	Output for the safety-related response. OFF: Safety output disabled. Demand for safety-related response (e.g., emergency stop button engaged, reset required or internal errors active) ON: Safety output enabled. No demand for safety-related response (e.g., emergency stop button not engaged, no internal errors active).
	Error	bit	OFF	Error flag. See Chapter 2.2 General Specification.
	DiagCode	int	0	Diagnostic register. See Chapter 2.2 General Specification.



[DANGER]
 - A variable which of its data type is "bit*" must be input/output to safe data (see Appendix.1).
 - When a safe data is not connected to a safety device with the correct path, a safe data is not safe. Please check a path of a safe data.

FUNCTION DESCRIPTION

The S_EstopOut enable signal is reset to OFF as soon as the S_EstopIn input is set to OFF. The S_EstopOut enable signal is reset to ON only if the S_EstopIn input is set to ON and a reset occurs. That is, the safe output changes to ON by resetting the FB, when the safe input is ON. The enable reset depends on the defined S_StartReset, S_AutoReset, and Reset inputs. (See 2.3. General Specifications)



[DANGER]
 - The enable 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.

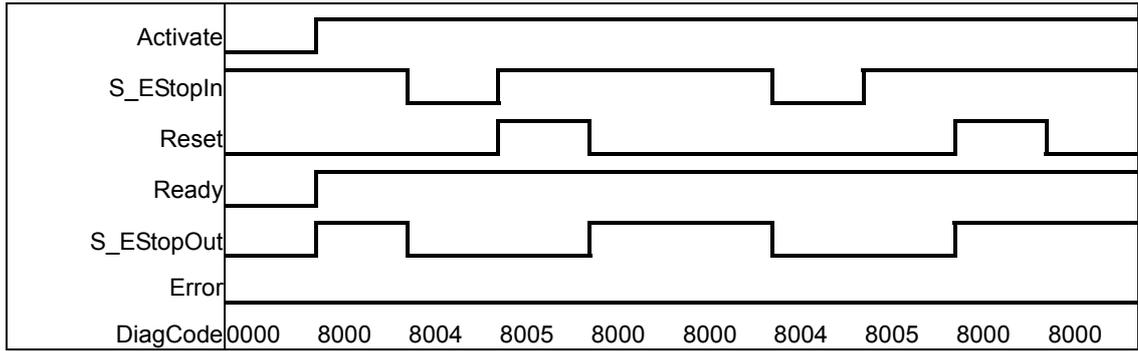


Figure 4.19 Typical Timing Diagram for S+ESTOP
 S_StartReset=ON, S_AutoReset= OFF
 (start, normal operation, safety demand, restart)

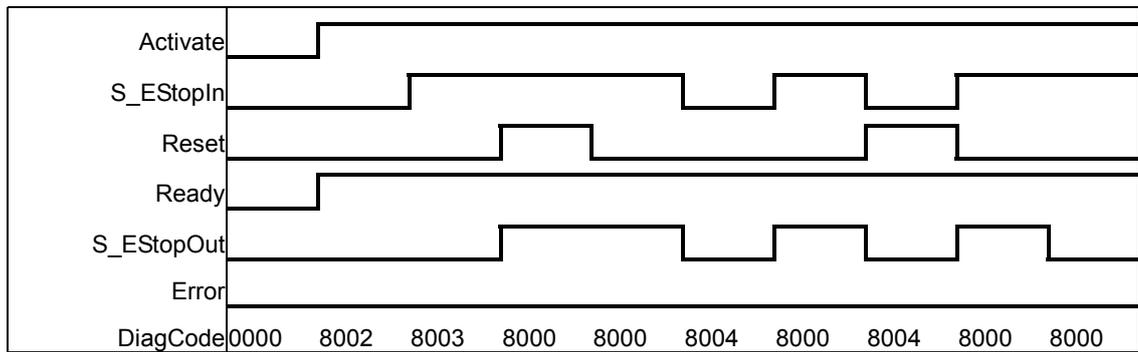


Figure 4.20 Typical Timing Diagram for S+ESTOP
 S_StartReset= OFF, S_AutoReset= ON
 (start, normal operation, safety demand, restart)

ERROR DETECTION

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

ERROR BEHAVIOR

S_EstopOut is set to OFF. In case of a static ON signal at the Reset input, the DiagCode output indicates the relevant error code and the Error output is set to ON.

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

ERROR CODES

Diag Code	State Name	Description, Setting Output	Actions
C001	Reset Error 1	Reset is ON while waiting for S_ESPE_In = ON. Ready = ON S_EstopOut = OFF Error = ON	Reset=OFF. Check the devices and wiring related to Reset.
C002	Reset Error 2	Reset is ON while waiting for S_EstopIn = ON. (S_StartReset=ON)	Same above.

STATUS CODES (no error)

Diag Code	State Name	Description, Setting Output	Actions
0000	Idle	The function block is not active (initial state). All of safe output=OFF, DiagCode=0 Ready = OFF	User can initialize by Activate=ON.
8001	Init	Activation is ON. The function block was enabled. Ready= ON	Wait for S_EstopIn=ON.

8002	Wait for S_EstopIn 1	Activation is ON. (S_StartReset=OFF)	Wait for S_EstopIn=ON.
8003	Wait for Reset 1	Activation is ON. S_EstopIn = ON. (S_StartReset=OFF)	Wait for a rising trigger of Reset.
8004	Wait for S_EstopIn 2	Safety demand detected. (S_StartReset=ON)	Wait for S_EstopIn=ON.
8005	Wait for Reset 2	Activation is ON. S_EstopIn = ON. (S_StartReset=ON)	Wait for rising trigger of Reset.
8000	Safety Output Enabled	Safety demand is not detected. S_EstopIn = ON. S_EstopOut = ON.	None.



[DANGER]
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

SAMPLE APPLICATION

The example of emergency stop application for a machine with the emergency stop switch is shown in the following figure.

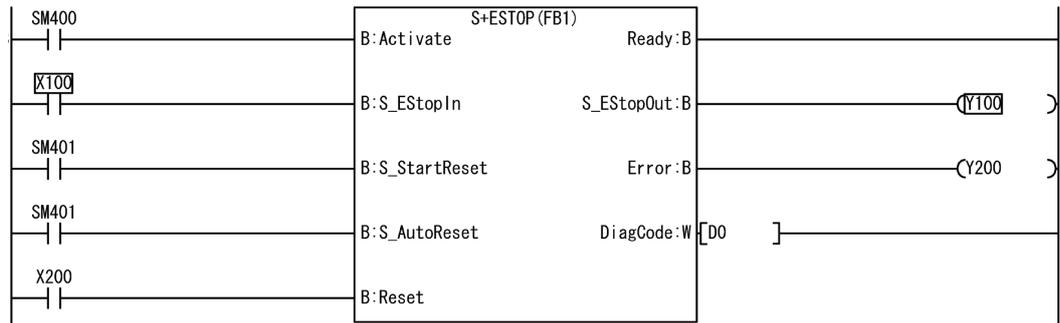


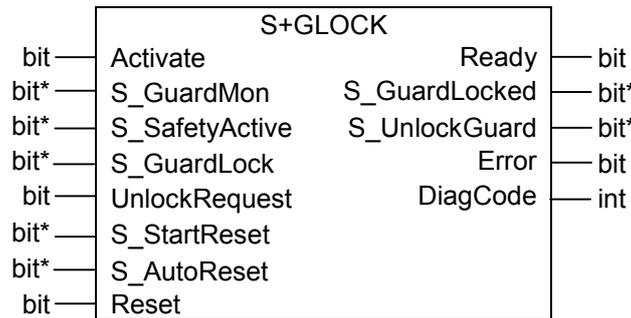
Figure 4.21 Sample Application of S+ESTOP

- SM400: Constant (always ON) ...Activate is always ON
- SM401: Constant (always OFF) ...S_StartReset, S_AutoReset is always OFF
- X100: Emergency stop switch (safe input)
- X200: Reset switch
- Y100: Safety contactor (safe output)
- Y200: Error indicator
- D0: An internal record for DiagCode

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 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 FB. See Chapter 2.2 General Specification.
	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	Restart inhibit option. See Chapter 2.2 General Specification.
	S_AutoReset	bit*	OFF	Automatic restart option. See Chapter 2.2 General Specification.
	Reset	bit	OFF	Reset input. See Chapter 2.2 General Specification. 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	Activate status of this FB. See Chapter 2.2 General Specification.
	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, the machine is enable to operate.)
	S_UnlockGuard	bit*	OFF	Signal to unlock the guard. OFF: Close guard. ON: Unlock guard.
	Error	bit	OFF	Error flag. See Chapter 2.2 General Specification.
	DiagCode	int	0	Diagnostic register. See Chapter 2.2 General Specification.

[DANGER]

- A variable which of its data type is "bit*" must be input/output to safe data (see Appendix.1).
- When a safe data is not connected to a safety device with the correct path, a safe data is not safe. Please check a path of a safe data.

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	Enable guard to be opened (via S_UnlockGuard)
5.	In	Guard unlocked (via S_GuardLock). Guard can be opened now. (S_GuardLocked = OFF)
	-	Operator opens the guard
6.	In	Monitoring of status guard via S_GuardMon - signals when guard is closed again
7.	In	Feedback from operator to restart the hazardous area (UnlockRequest = OFF)
8.	Out	Lock guard guard (S_UnlockGuard)
9.	In	Check if guard is locked (S_GuardLock), reset (Reset)
10.	Out	Hazardous area can operate again (S_GuardLocked = ON)
11.	-	Restart the operation in the hazardous area

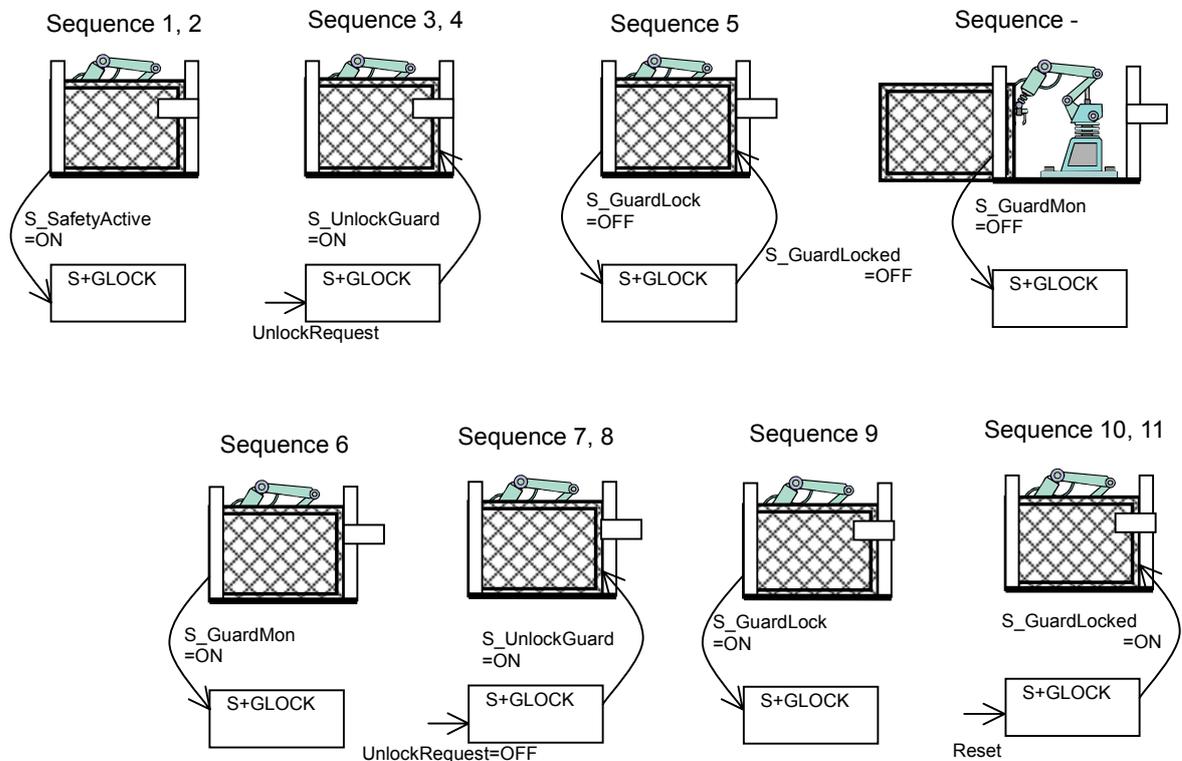
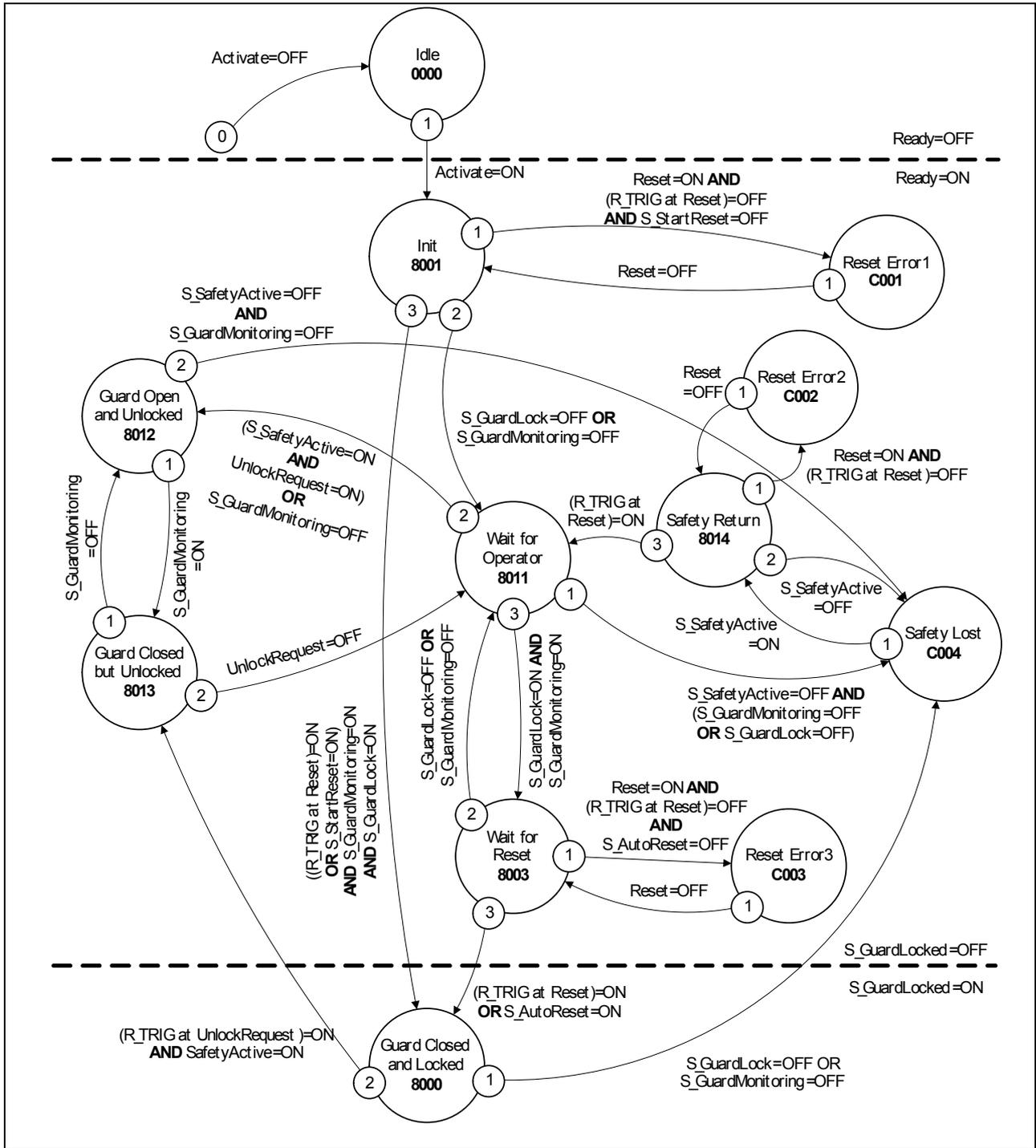


Figure 4.22 Operation Sequence for Guardlock

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 4.23 State Diagram for S+GLOCK

TYPICAL TIMING DIAGRAM

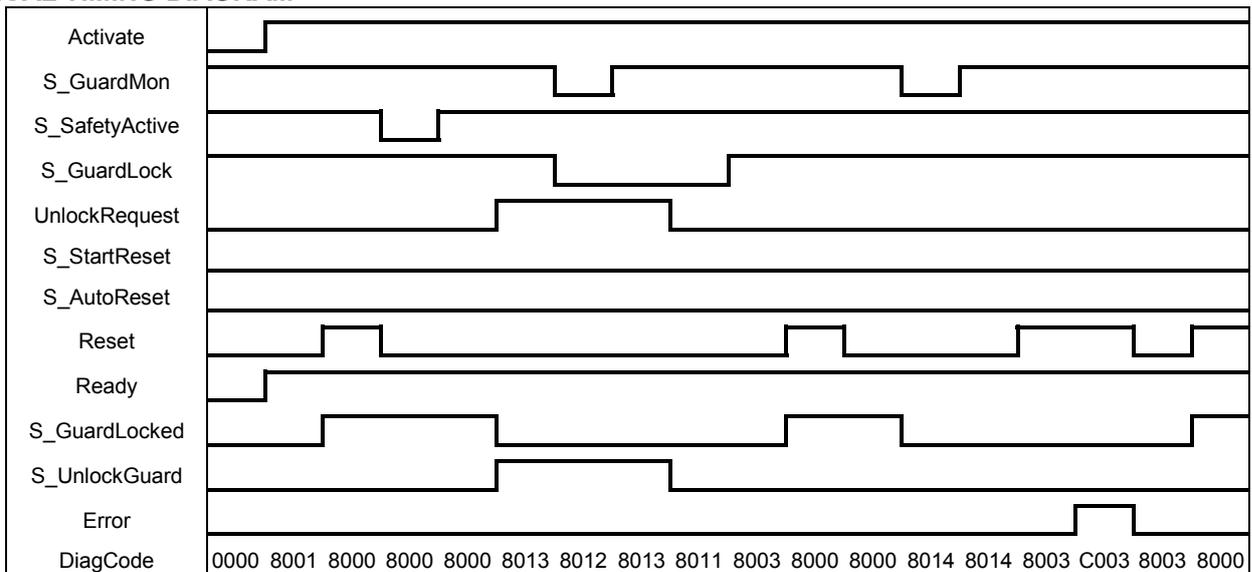


Figure 4.24 Typical Timing Diagram for S+GLOCK

ERROR DETECTION

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

ERROR BEHAVIOR

In the event of an error the S_GuardLocked and S_UnlockGuard outputs are set to OFF, the DiagCode output indicates the relevant error code, and the Error output is set to ON. An error must be acknowledged by a rising trigger at the Reset input

ERROR CODES

Diag Code	State Name	Description, Setting Output	Actions
C001	Reset Error1	Static Reset detected in state 8001. (S_StartReset=OFF) Ready = ON S_GuardLocked = OFF S_UnlockGuard = OFF Error = ON	Reset=OFF. Check the devices and wiring of Reset.
C002	Reset Error 2	Static Reset detected in state 8014.	Same above.
C003	Reset Error 3	Static Reset detected in state 8003.	Same above.
C004	Safety Lost	Safety lost, guard opened or guard unlocked.	Set S_SafetyActive=ON, and reset the FB. Check the hazardous area is safe.

STATUS CODES (no error)

Diag Code	State Name	Description, Setting Output	Actions
0000	Idle	The function block is not active (initial state). Ready = OFF	User can initialize by Activate=ON.
8000	Guard Closed and Locked	Guard is locked. There is no request for the safety functions in this hazardous area, and it is enable to normal operation. S_GuardLocked = ON	None.
8001	Init	Function block was activated and initiated. Ready = ON	Close and lock the guard, and reset the FB.
8003	Wait for Reset	Door is closed and locked, now waiting for operator reset.	Reset the FB.

8011	Wait for Operator	Waiting for operator to either unlock request or reset.	Close and lock the guard, and reset the FB. Or, release the lock.
8012	Guard Open and Unlocked	Lock is released and guard is open.	Close the guard.
8013	Guard Closed but Unlocked	Lock is released but guard is closed.	Lock the guard.
8014	Safety Return	Return of S_SafetyActive signal, now waiting for operator acknowledge.	Reset the FB.



[DANGER]
 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

SAMPLE APPLICATION

The example of the machine control application with the guard is shown in the following figure.

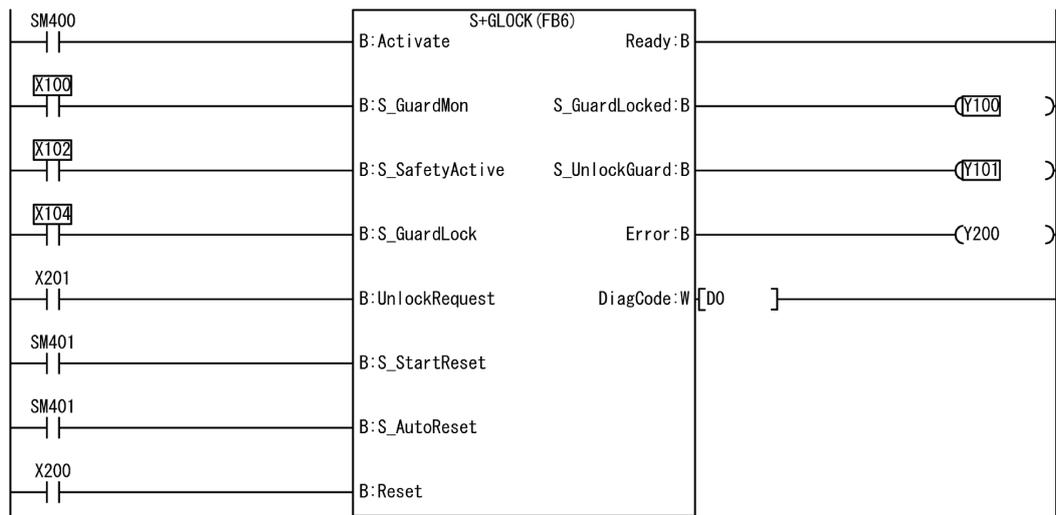


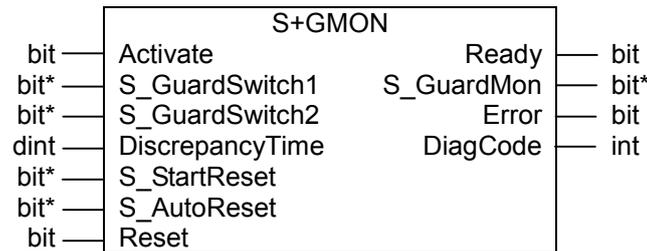
Figure 4.25 Sample Application of S+GLOCK

- SM400: Constant (always ON) ... Activate is always ON.
- SM401: Constant (always OFF) ... S_StartReset, S_AutoReset are always OFF.
- X100: Status of the guard (safe input)
- X102: Safe status in hazardous area (safe input)
- X104: Status of guard locking (safe input)
- X200: Reset switch
- X201: Unlock request
- Y100: Enable signal to the machine in the hazardous area (safe output)
- Y102: Unlock guard request (safe output)
- Y200: Error indicator
- D0: An internal record area for DiagCode

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 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 FB. See Chapter 2.2 General Specification.
	S_GuardSwitch1	bit*	OFF	Guard switch 1 input. OFF: Guard is open. ON: Guard is closed.
	S_GuardSwitch2	bit*	OFF	Guard switch 2 input. OFF: Guard is open. ON: Guard is closed.
	DiscrepancyTime	dint	0	Configures the monitored synchronous time between S_GuardSwitch1 and S_GuardSwitch2 (10ms unit). You must set constant value. Range: 0-60000 (0 to 600,000ms=10min)
	S_StartReset	bit*	OFF	Restart inhibit option. See Chapter 2.2 General Specification.
	S_AutoReset	bit*	OFF	Automatic restart option. See Chapter 2.2 General Specification.
	Reset	bit	OFF	Reset input. See Chapter 2.2 General Specification.
OUT	Ready	bit	OFF	Activate status of this FB. See Chapter 2.2 General Specification.
	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. See Chapter 2.2 General Specification.
	DiagCode	int	0	Diagnostic register. See Chapter 2.2 General Specification.



[DANGER]

- A variable which of its data type is "bit*" must be input/output to safe data (see Appendix.1).
- When a safe data is not connected to a safety device with the correct path, a safe data is not safe. Please check a path of a safe data.

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.

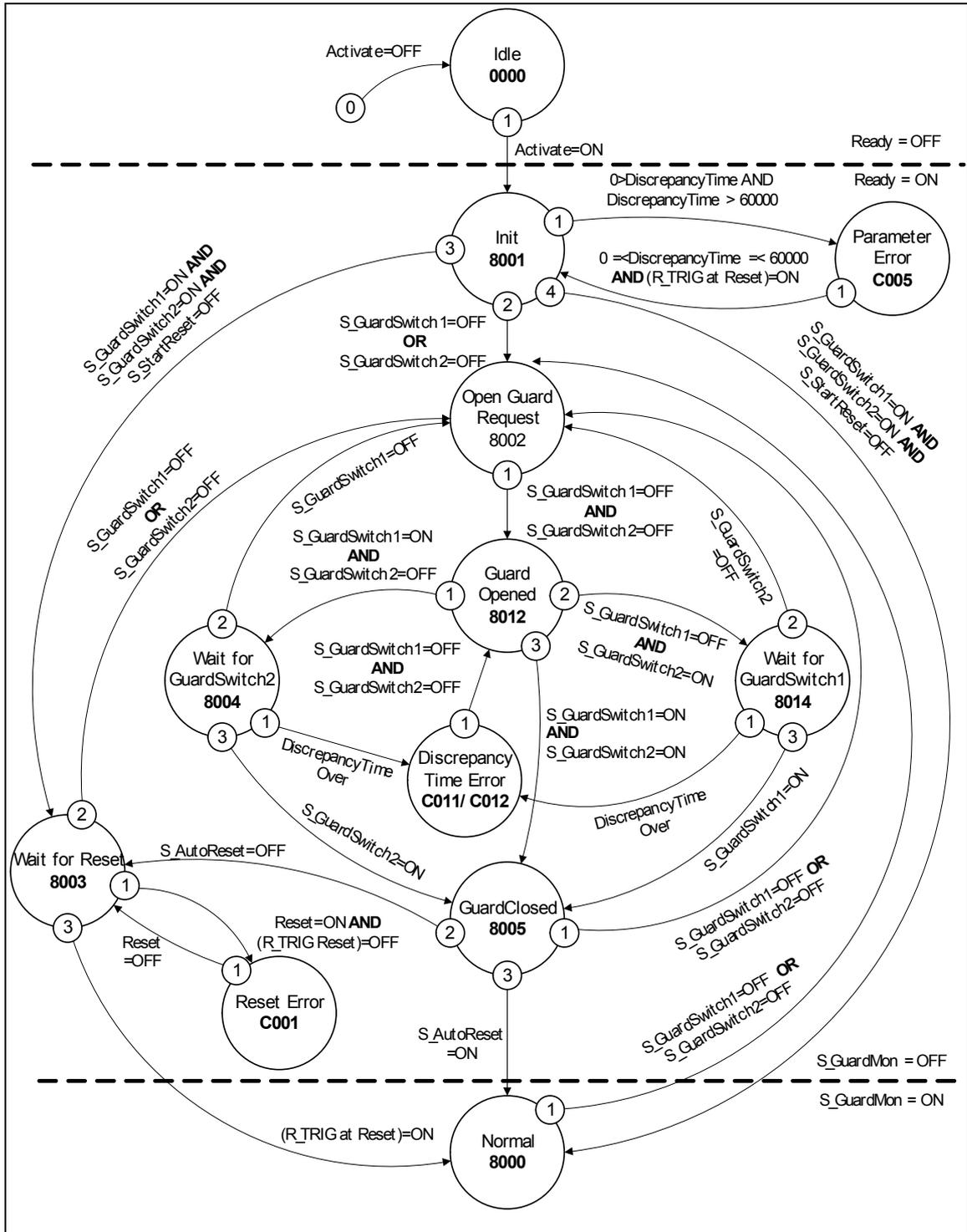
The behavior of the S_GuardMon output depends on the time difference between the switching inputs. The discrepancy time is monitored as soon as the value of both S_GuardSwitch1/S_GuardSwitch2 inputs differs. If the DiscrepancyTime has elapsed, but the inputs still differ, the S_GuardMon output remains 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.

S_StartReset and S_AutoReset must only be assigned the value ON when it is ensured that a dangerous situation cannot occur once the safety function is no longer requested (S_GuardSwitch1 and S_GuardSwitch2: OFF to ON) or startup is prevented by other measures.

**[DANGER]**

- 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



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 4.26 State Diagram for S+GMON

TYPICAL TIMING DIAGRAM

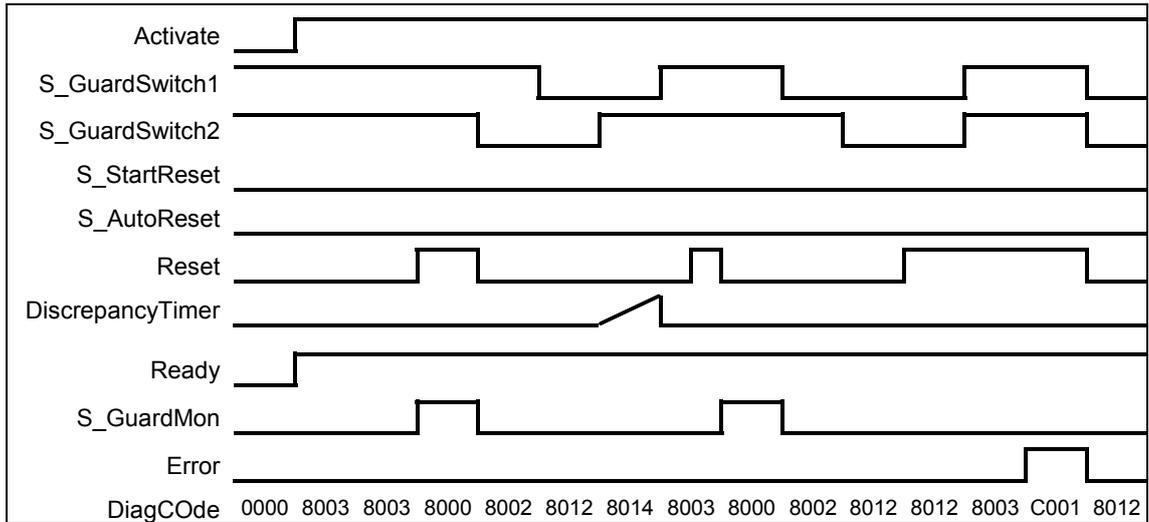


Figure 4.27 Typical Timing Diagram for S+GMON

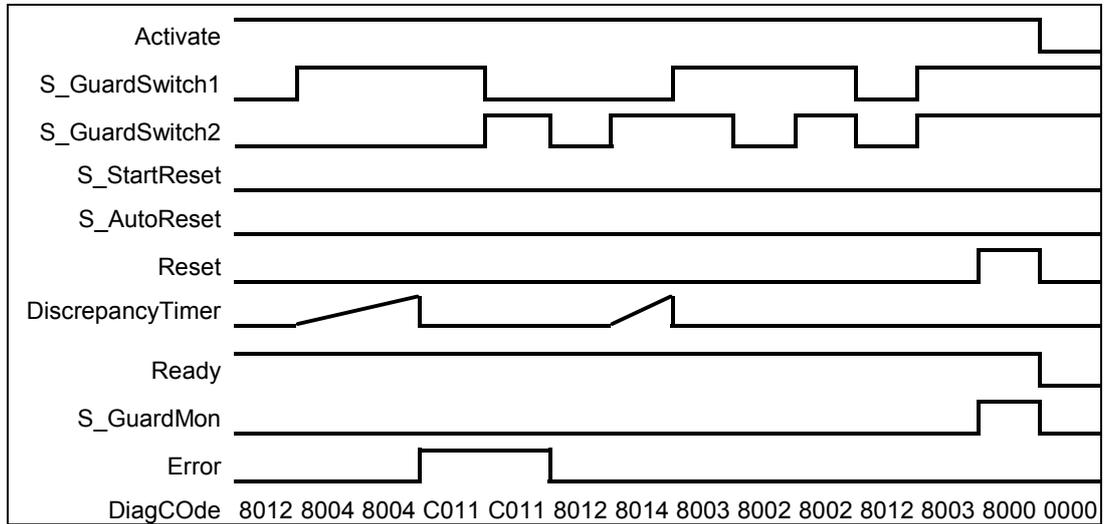


Figure 4.28 Typical Timing Diagram for S+GMON

ERROR DETECTION

- The FB detects following errors, and Error output is changed to ON.
- The function block monitors the discrepancy time between S_GuardSwitch1 and S_GuardSwitch2, when switching to ON and also when switching to OFF.
- A static ON signal at Reset input.
- Out of range of DiscrepancyTime.

ERROR BEHAVIOR

- The S_GuardMon output is set to OFF.
- To leave the Reset error state, the Reset input must be set to OFF.
- To leave the discrepancy time errors, the inputs S_GuardSwitch1 and 2 must both be set to OFF.

ERROR CODES

Diag Code	State Name	Description, Setting Output	Actions
C001	Reset Error	Static reset detected in state 8003. Ready = ON S_GuardMon = OFF Error = ON	Reset=OFF. Check the devices and wiring of Reset.
C005	Parameter Error	DiscrepancyTime is out of range.	Set DiscrepancyTime to proper value.
C011	Discrepancytime Error 1	DiscrepancyTime elapsed in state 8004. (Switch1=ON, Switch2=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 Error 2	DiscrepancyTime elapsed in state 8014. (Switch1=OFF, Switch2=ON)	Same above.

STATUS CODES (no error)

Diag Code	State Name	Description, Setting Output	Actions
0000	Idle	The function block is not active (initial state). All output = OFF, DiagCode=0 Ready = OFF	User can initialize by Activate=ON.
8000	Normal	Safety guard closed and Safe state acknowledged. S_GuardMon = ON	None.
8001	Init	Function block has been activated. Ready= ON	Close the guard.
8002	Open Guard Request	Complete switching sequence required. At least one switch was 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.	Reset the FB.
8012	Guard Opened	Guard completely opened.	Close the guard.
8004	Wait for GuardSwitch2	S_GuardSwitch1 has been switched to ON - waiting for S_GuardSwitch2; discrepancy timer started.	Close the guard completely.
8014	Wait for GuardSwitch1	S_GuardSwitch2 has been switched to ON - waiting for S_GuardSwitch1; discrepancy timer started.	Close the guard completely.
8005	Guard Closed	Guard closed. Waiting for Reset, if S_AutoReset = OFF.	Reset the FB.

**[DANGER]**

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

SAMPLE APLLICATION

The example of the machine control application with monitoring the safeguard is shown in the following figure.

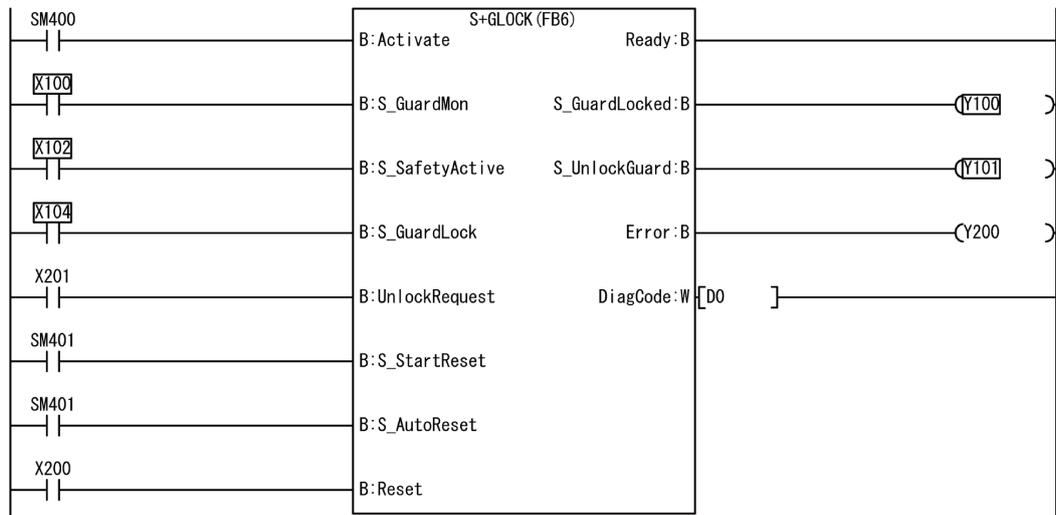


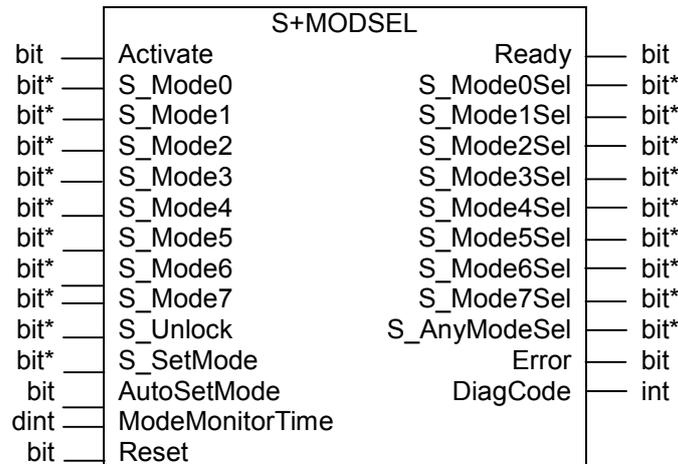
Figure 4.29 Sample Application of S+GMON

- SM400: Constant (always ON) ... Active is always ON
- SM401: Constant (always OFF) ... S_StartReset, S_AutoReset are always OFF
- X100, X102: Guard switch 1,2 (safe input)
- X200: Reset switch
- Y100: Output enable signal (safe output)
- Y200: Error indicator
- D0: An internal record for DiagCode

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 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 FB. See Chapter 2.2 General Specification.
	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 therefore a change of any S_ModeX input does not lead to a change in the S_ModeXSel output even in the event of a rising edge of S_SetMode. ON: The selected S_ModeXSel is not locked; a mode selection change is possible.
	S_SetMode	bit*	OFF	Sets the selected mode Operator acknowledges the setting of a mode. Any change to new S_ModeX = ON leads to S_AnyModeSel/S_ModeXSel = OFF, only a rising SetMode trigger then leads to new S_ModeXSel = ON. (constant OFF, if AutoSetMode = ON)
	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	dint	0	Maximum permissible time for changing the selection input. 10ms unit. Range: 0 – 60000(10min).	
Reset	bit	OFF	Reset input. See Chapter 2.2 General Specification.	

OUT	Ready	bit	OFF	Activate status of this FB. See Chapter 2.2 General Specification.
	S_Mode0Sel	bit*	OFF	Indicates that mode 0 is selected and acknowledged. OFF: Mode 0 is not selected or not active. 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. See Chapter 2.2 General Specification.
DiagCode	int	0	Diagnostic register. See Chapter 2.2 General Specification.	



[DANGER]

- A variable which of its data type is "bit*" must be input/output to safe data (see Appendix.1).
- When a safe data is not connected to a safety device with the correct path, a safe data is not safe. Please check a path of a safe data.

FUNCTION DESCRIPTION

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

The default state following activation of the FB is the state where all S_ModeXSel and S_AnyModeSel are OFF (DiagCode 8005: ModeChanged state).

If the FB is in the ModeChanged state:

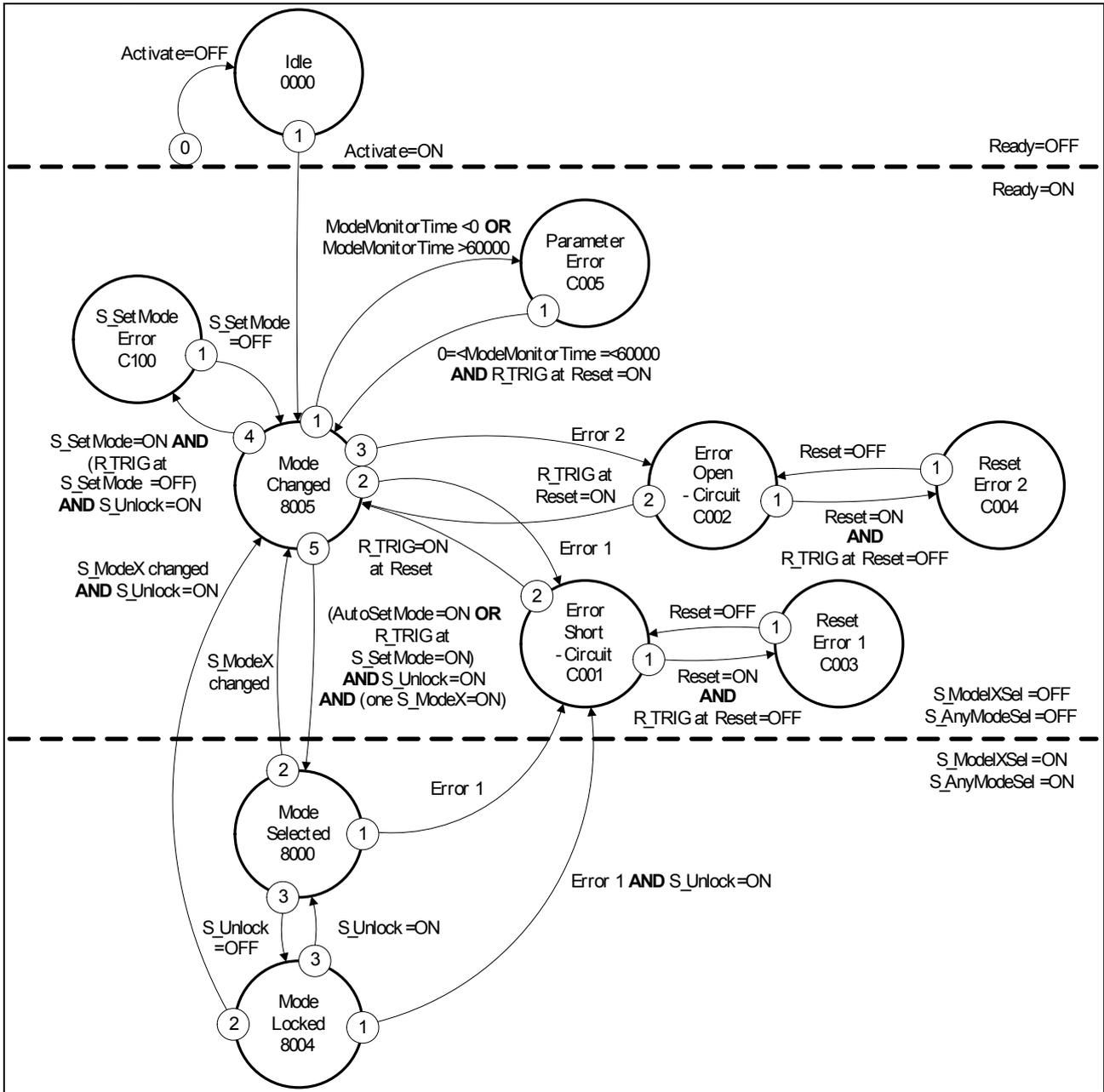
- The new S_ModeX input must be acknowledged by a rising S_SetMode trigger (if AutoSetMode = OFF), which leads to a new S_ModeXSel output.
- The new S_ModeX input automatically leads to a new S_ModeXSel output (if AutoSetMode = ON).
- Such a transition from state ModeChanged to ModeSelected is only valid,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

The transition from the ModeChanged to ModeSelected state, i.e., S_SetMode set by the operator, is not monitored by a timer. If the FB is in the ModeSelected state, the simultaneous occurrence of a new S_ModeX input (higher priority) and the NOT S_Unlock signal (lower priority) leads to the ModeChanged state.

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

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

STATE DIAGRAM



Note 1: Error1= More than one S_ModeX=ON at the same time.
 Error2= All S_ModeX=OFF 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).

Figure 4.30 State Diagram for S+MODSEL

TYPICAL TIMING DIAGRAM

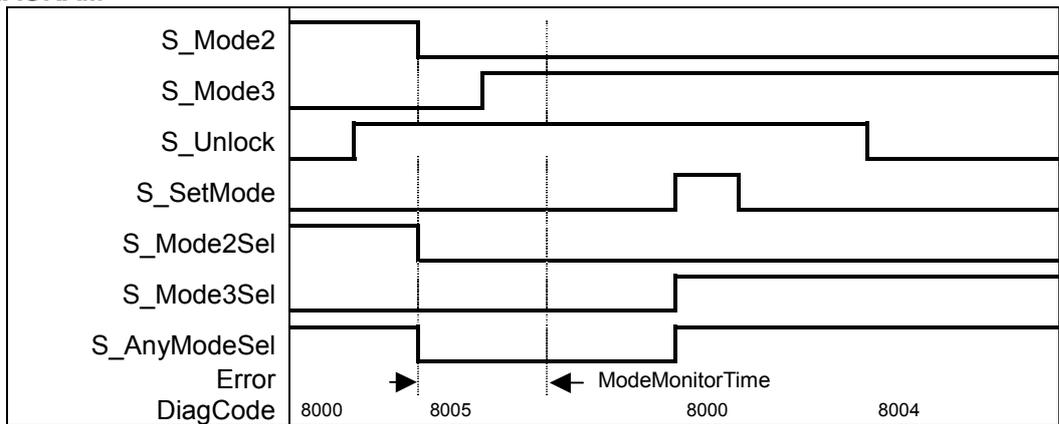


Figure 4.31 Typical Timing Diagram for S+MODSEL (S_AutoSetMode=OFF)
Valid change in Mode input with acknowledgment

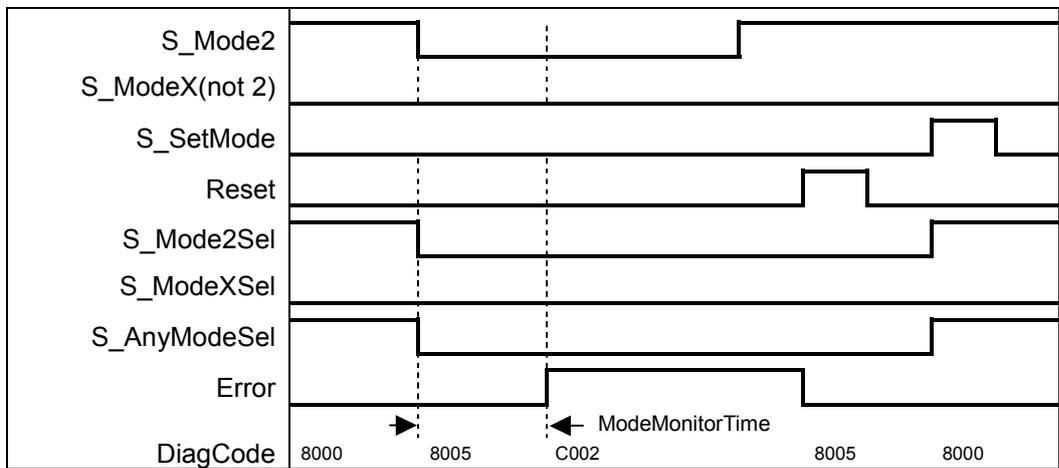


Figure 4.32 Typical Timing Diagram for S+MODSEL (S_AutoSetMode=OFF)
Error condition 2 at Mode inputs (All S_ModeX=OFF after ModeMonitorTime)

ERROR DETECTION

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

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

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

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

ERROR BEHAVIOR

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

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

ERROR CODES

Diag Code	State Name	Description, Setting Output	Actions
C001	Error Short-circuit	The FB detected that two or more S_ModeX = ON Error = ON S_AnyModeSel = OFF All S_ModeXSel = OFF	Select only one S_ModeX = ON, and reset. 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.	Select only one S_ModeX = ON, and reset. Check the connection and wiring related to Reset. Check the value of ModeMonitorTime.
C003	Reset Error 1	Static Reset signal detected in state C001.	Reset = OFF. Check the devices and wiring related to Reset.
C004	Reset Error 2	Static Reset signal detected in state C002.	Reset = OFF. Check the devices and wiring related to Reset.
C005	Parameter Error	The value of ModeMonitorTime is out of range (0-60000).	Set proper value to ModeMonitorTime, and Reset.
C100	S_SetMode Error	Static S_SetMode signal detected with S_Unlock = ON in state 8005.	Reset. Check the devices and wiring related to Reset.

STATUS CODES (no error)

Diag Code	State Name	Description, Setting Output	Actions
0000	Idle	The function block is not active. All of safe output = OFF, DiagCode = 0 Ready = OFF	User can initialize by Activate = ON.
8005	ModeChanged	State after activation or when S_ModeX has changed (unless locked) or after Reset of an error state. S_AnyModeSel = OFF All S_ModeXSel = OFF	Select a mode after S_Unlock = ON, and S_SetMode = ON.
8000	ModeSelected	Valid mode selection, but not yet locked. S_AnyModeSel = ON S_ModeXSel = Selected X is ON, others are OFF.	Lock the selected mode by S_Unlock = OFF.
8004	ModeLocked	Valid mode selection is locked. S_AnyModeSel = ON S_ModeXSel = Selected X is ON, others are OFF.	Atchanging a mode, select the proper mode after S_Unlock = ON.

**[DANGER]**

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.

SAMPLE APPLICATION

The example of 2 mode selector is shown in the following figure.

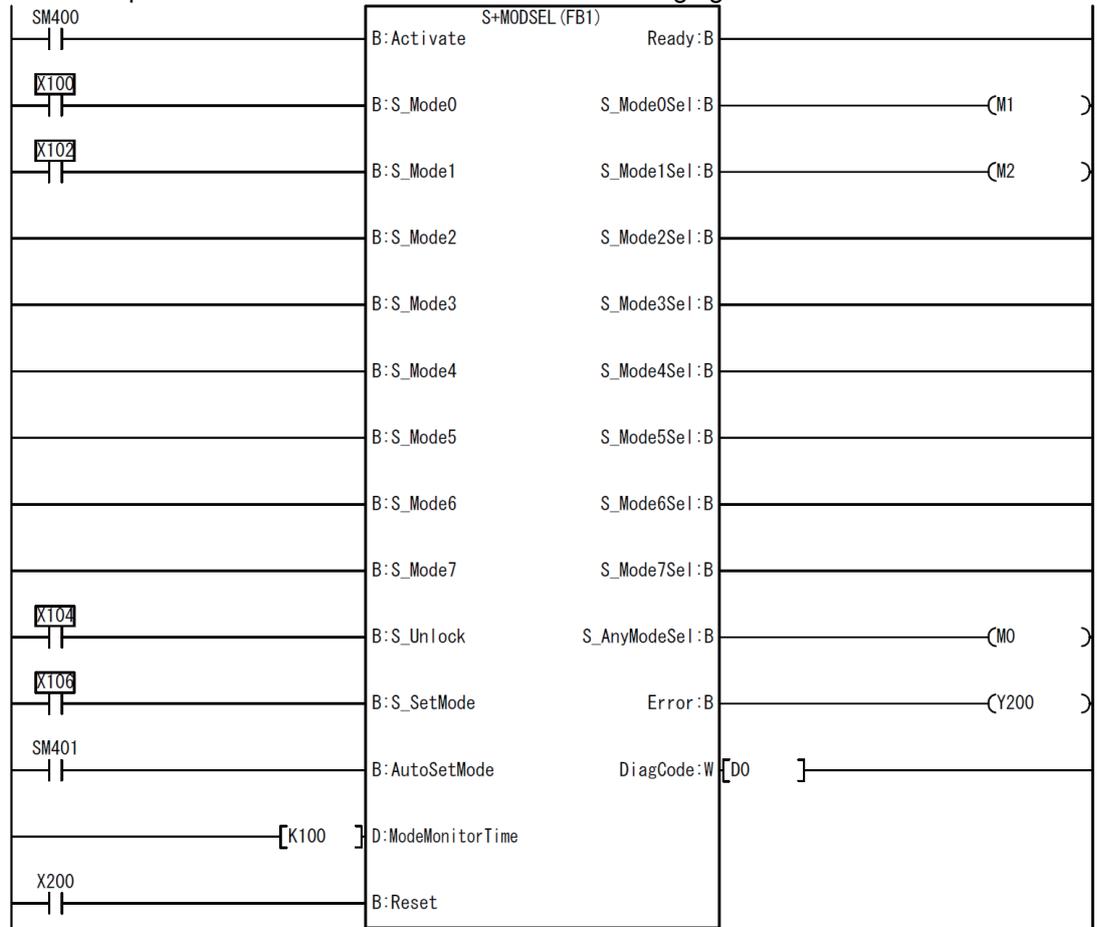


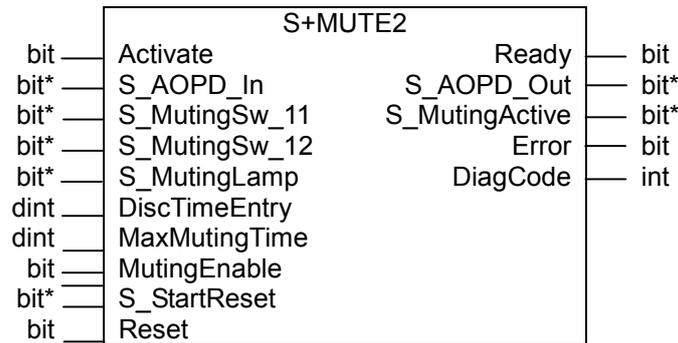
Figure 4.33 Sample Application of S+MODSEL

- SM400: Constant (always ON)
- SM401: Constant (always OFF)
- X100: Mode selector switch = Mode 0 (safe input)
- X102: Mode selector switch = Mode 1 (safe input)
- X104: Mode lock switch (safe input) ... locked at OFF
- X106: Mode set switch (safe input) ... operator acknowledges the selected mode
- X200: Reset switch
- K100: ModeMonitoringTime = 1sec (100×10ms)
- M0, M1: Selected status of Mode0 and 1
- Y200: Error indicator
- D0: An internal record for DiagCode

APPLICABLE SAFETY STANDARDS

Standards	Requirements
MRL 98/37/EC, Annex 1	<p>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....</p> <p>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....</p>
EN ISO 12100-2: 2003	<p>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...</p>
IEC 60204-1, Ed. 5.0: 2003	<p>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...</p>
EN 954-1: 1996	5.4 Manual reset

4.10 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 FB. See Chapter 2.2 General Specification.
	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	dint	0s	Max. discrepancy time for S_MutingSw_11 and S_MutingSw_12 entering muting gate. 10ms unit. Range: 0-400 (0-4sec)
	MaxMutingTime	dint	0s	Maximum time for complete muting sequence, timer started when first muting sensor is actuated. 10ms unit. Range: 0-60000 (0-10min) The timer is started at the trigger of switching first muting sensor.
	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	Restart inhibit option. See Chapter 2.2 General Specification.
	Reset	bit	OFF	Reset input. See Chapter 2.2 General Specification.
OUT	Ready	bit	OFF	Activate status of this FB. See Chapter 2.2 General Specification.
	S_AOPD_Out	bit*	OFF	Safety related 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. See Chapter 2.2 General Specification.
	DiagCode	int	0	Diagnostic register. See Chapter 2.2 General Specification.



[DANGER]

- A variable which of its data type is "bit*" must be input/output to safe data (see Appendix.1).
- When a safe data is not connected to a safety device with the correct path, a safe data is not safe. Please check a path of a safe data.

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.

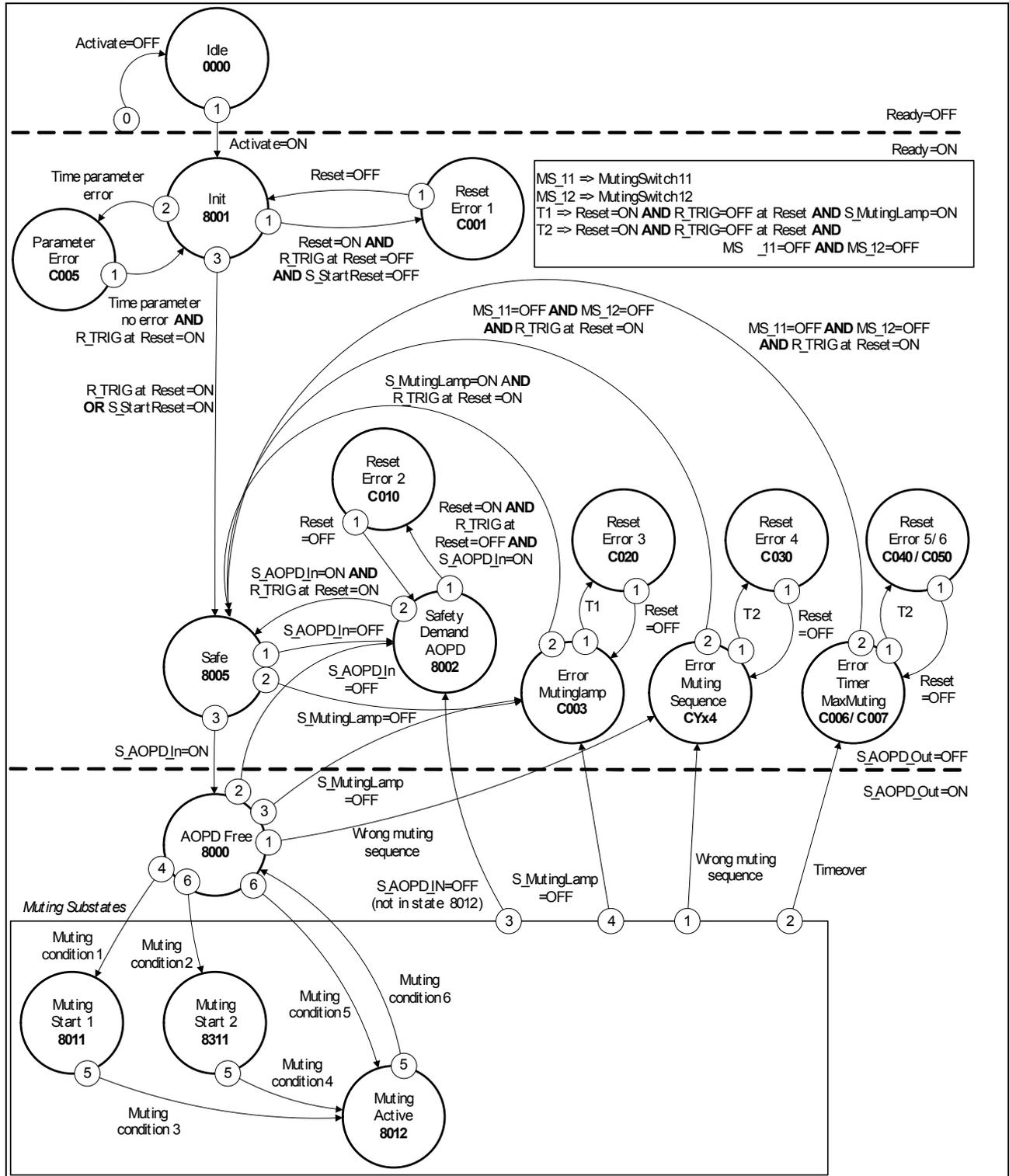
There are sequential and parallel muting procedures. In this FB, parallel muting with two muting sensors was used; an explanation is provided in Figure 4.34. The positioning of the sensors should be as described in Annex F.7 of IEC 62046, CD 2005, as shown in Figure 48. The FB can be used in both directions, 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 4.34 Example for 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).

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

Figure 4.35 State Diagram for S+MUTE2

Muting Conditions

No.	State Transition	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, 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, MS_12 = OFF→ON
3	8011→8012	MS_12 is the second entry switch actuated: Stop timer DiscTimeEntry. MutingEnable = ON AND MS_11 = ON, 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, MS_12 = ON
5	8000→8012	both switches actuated in same cycle: Start Timer MaxMutingTime. MutingEnable = ON AND MS_11 = OFF→ON, 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

State	Wrong muting sequences
8000	MS_11 = OFF→ON, MS_12 = ON, MS_12 = OFF→ON not yet
	MS_12 = OFF→ON, MS_11 = ON, MS_11 = OFF→ON not yet
	MS_11 = ON, MS_11 = OFF→ON not yet, MS_12 = ON, MS_12 = OFF→ON not yet
	MutingEnable = OFF, MS_11 = OFF→ON
	MutingEnable = OFF, MS_12 = OFF→ON
8011	MutingEnable = OFF OR MS_11 = OFF
8311	MutingEnable = OFF OR MS_12 = OFF

TYPICAL TIMING DIAGRAM

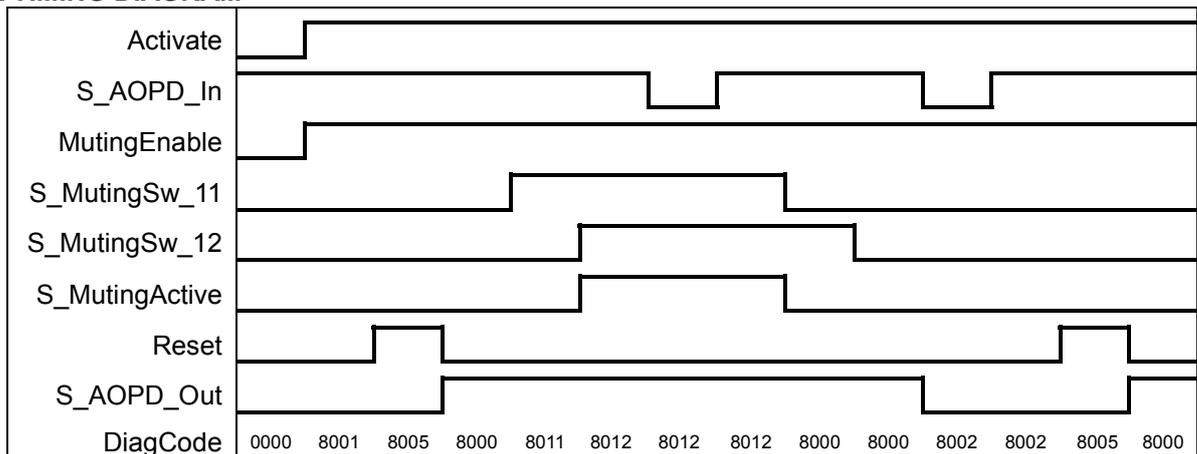


Figure 4.36 Typical Timeng Diagram for S+MUTE2 (S_StartReset=OFF)

ERROR DETECTION

The FB detects the following error conditions:

- DiscTimeEntry has been set to value less than 0sec or greater than 4sec.
- MaxMutingTime has been set to a value less than 0sec or greater than 10min.
- The discrepancy time for the S_MutingSw_11/ 12 sensor pair has been exceeded.
- The muting function (S_MutingActive = ON) exceeds the maximum muting time MaxMutingTime.
- Muting sensors S_MutingSw_1/12 are activated in the wrong order.
- Muting sequence starts without being enabled by MutingEnable
- Static muting sensor signals.
- A faulty muting lamp is indicated by S_MutingLamp = OFF.
- A static Reset condition is detected in state 8001.

ERROR BEHAVIOR

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

ERROR CODES

Diag Code	State Name	Description, Setting Output	Actions
C001	Reset Error 1	Static Reset condition detected after FB activation in state 8001.	Reset = OFF. Check the devices and wiring related to Reset.
C003	Error Muting Lamp	Error detected in muting lamp.	Reset. 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 the last page) S_AOPD_Out = OFF S_MutingActive = OFF 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. x = Status of the sensors when error occurred CY04: both SW = OFF CY14: S_MutingSw_11 = ON CY24: S_MutingSw_12 = ON CF34: both SW = ON	Set both Muting Switches = OFF and Reset. 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.
C006	Error Timer MaxMuting	Timing error: Active muting time (when S_MutingActive = ON) exceeds MaxMutingTime.	Set both Muting Switches = OFF and Reset. Check the muting situation in the process.
C007	Error Timer MS11_12	Timing error: Discrepancy time for switching S_MutingSw11/12 from (OFF→ON) > DiscTimeEntry.	Reset. Check the devices and wiring related to Reset.

C010	Reset Error 2	Static Reset condition detected in state 8002.	Reset = OFF. Check the devices and wiring related to Reset.
C020	Reset Error 3	Static Reset condition detected in state C003.	Same above.
C030	Reset Error 4	Static Reset condition detected in state CYx4.	Same above.
C040	Reset Error 5	Static Reset condition detected in state C006	Same above.
C050	Reset Error 6	Static Reset condition detected in state C007.	Same above.

STATUS CODES (no error)

Diag Code	State Name	Description, Setting Output	Actions
0000	Idle	The function block is not active (initial state). Ready = OFF	User can initialize by Activate = ON.
8000	AOPD Free	Muting not active and no safety demand from AOPD. If timers from subsequent muting are still running, they are stopped. Ready = ON S_AOPD_Out = ON	None. Starting muting is possible.
8001	Init	Function block was activated. Ready = ON	Reset
8002	Safety Demand AOPD	Safety demand detected by AOPD, muting not active. S_AOPD_Out = OFF	Reset after the completion of safety demand.
8005	Safe	Safety function activated. S_AOPD_Out = OFF	Wait the completion of safety demand.
8011	Muting Start 1	Muting sequence is in starting phase after rising trigger of S_MutingSw_11. Monitoring of DiscTimeEntry is activated. S_AOPD_Out = ON	Both muting switches are ON within DiscTimeEntry.
8311	Muting Start 2	Muting sequence is in starting phase after rising trigger of S_MutingSw_12. Monitoring of DiscTimeEntry is activated.	Same above.
8012	Muting Active	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. Monitoring of MaxMutingTime is activated. S_AOPD_Out = ON S_MutingActive = ON	Complete muting within MaxMutingTime.

**[DANGER]**

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.

SAMPLE APPLICATION

The example of parallel muting function with 2 sensors is shown in the following figure.

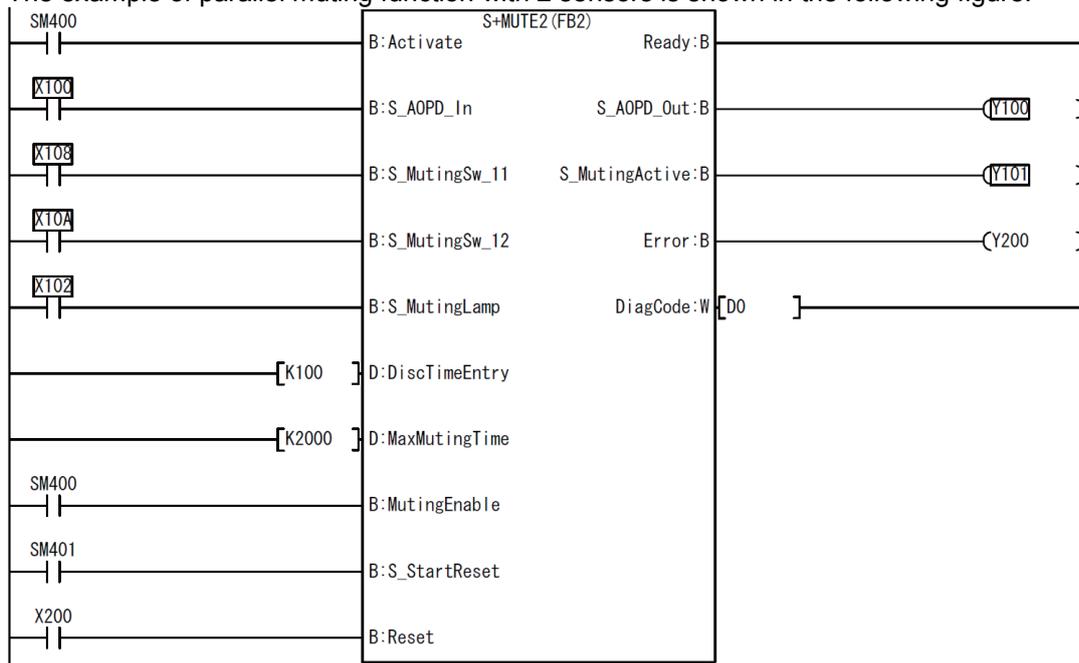


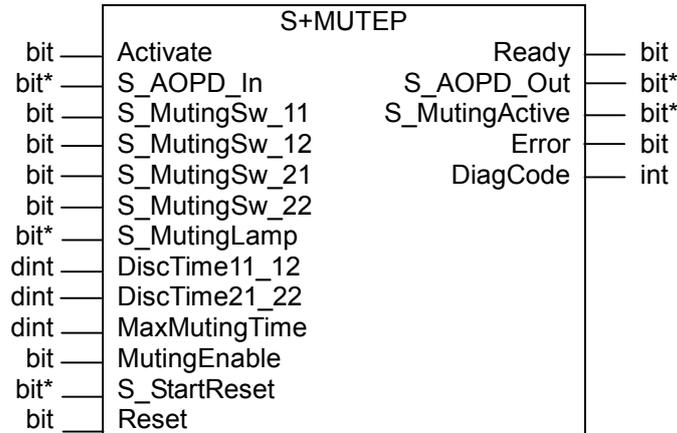
Figure 4.37 Sample Application of S+MUTE2

- SM400: Constant (always ON)
- SM401: Constant (always OFF)
- X100: OSSD (safe input)
- X102: Normal condition of a muting lamp (safe input)
- X108, X10A: Muting sensor11, 12
- X200: Reset switch
- Y100: Contactor (safe output)
- Y101: Muting lamp (safe output)
- Y200: Error indicator
- D0: An internal record for DiagCode

APPLICABLE SAFETY STANDARDS

Standards	Requirements
IEC 61496-1: 2004	<p>A.7 Muting,</p> <p>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.</p> <p>A.7.1.3 The mute function shall only be initiated 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.</p> <p>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.</p> <p>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.</p> <p>A.7.4 Indication: A mute status signal or indicator shall be provided (in some applications, an indication signal of muting is necessary).</p>
CD IEC 62046/Ed.1: 2005	<p>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:</p> <ul style="list-style-type: none"> - 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; <p>5.5.3: The following measures shall be considered: ...</p> <ul style="list-style-type: none"> - 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; <p>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.</p> <p>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.</p>
EN 954-1: 1996	5.4 Manual reset
ISO 12100-2: 2003	4.11.4: Restart following power failure/spontaneous restart

4.11 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 FB. See Chapter 2.2 General Specification.
	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_MutingSw_21	bit	OFF	Status of Muting sensor 21.
	S_MutingSw_22	bit	OFF	Status of Muting sensor 22.
	S_MutingLamp	bit*	OFF	Indicates operation of the muting lamp. OFF: Muting lamp failure. ON: Muting lamp no failure.
	DiscTime11_12	dint	0s	Max. discrepancy time for S_MutingSw_11 and S_MutingSw_12 entering muting gate. 10ms unit. Range: 0-400 (0-4sec)
	DiscTime21_22	dint	0s	Max. discrepancy time for S_MutingSw_21 and S_MutingSw_22 entering muting gate. 10ms unit. Range: 0-400 (0-4sec)
	MaxMutingTime	dint	0s	Maximum time for complete muting sequence, timer started when first muting sensor is actuated. Range: 0-60000 (0-10min) The timer is started at the trigger of switching first muting sensor.
	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	Restart inhibit option. See Chapter 2.2 General Specification.
	Reset	bit	OFF	Reset input. See Chapter 2.2 General Specification.

OUT	Ready	bit	OFF	Activate status of this FB. See Chapter 2.2 General Specification.
	S_AOPD_Out	bit*	OFF	Safety related 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. See Chapter 2.2 General Specification.
	DiagCode	int	0	Diagnostic register. See Chapter 2.2 General Specification.



[DANGER]

- A variable which of its data type is "bit*" must be input/output to safe data (see Appendix.1).
- When a safe data is not connected to a safety device with the correct path, a safe data is not safe. Please check a path of a safe data.
- Safe input must be connected to S_MutingSW_11/12/21/22 depending on the safety requirements.



[DANGER]

- 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.

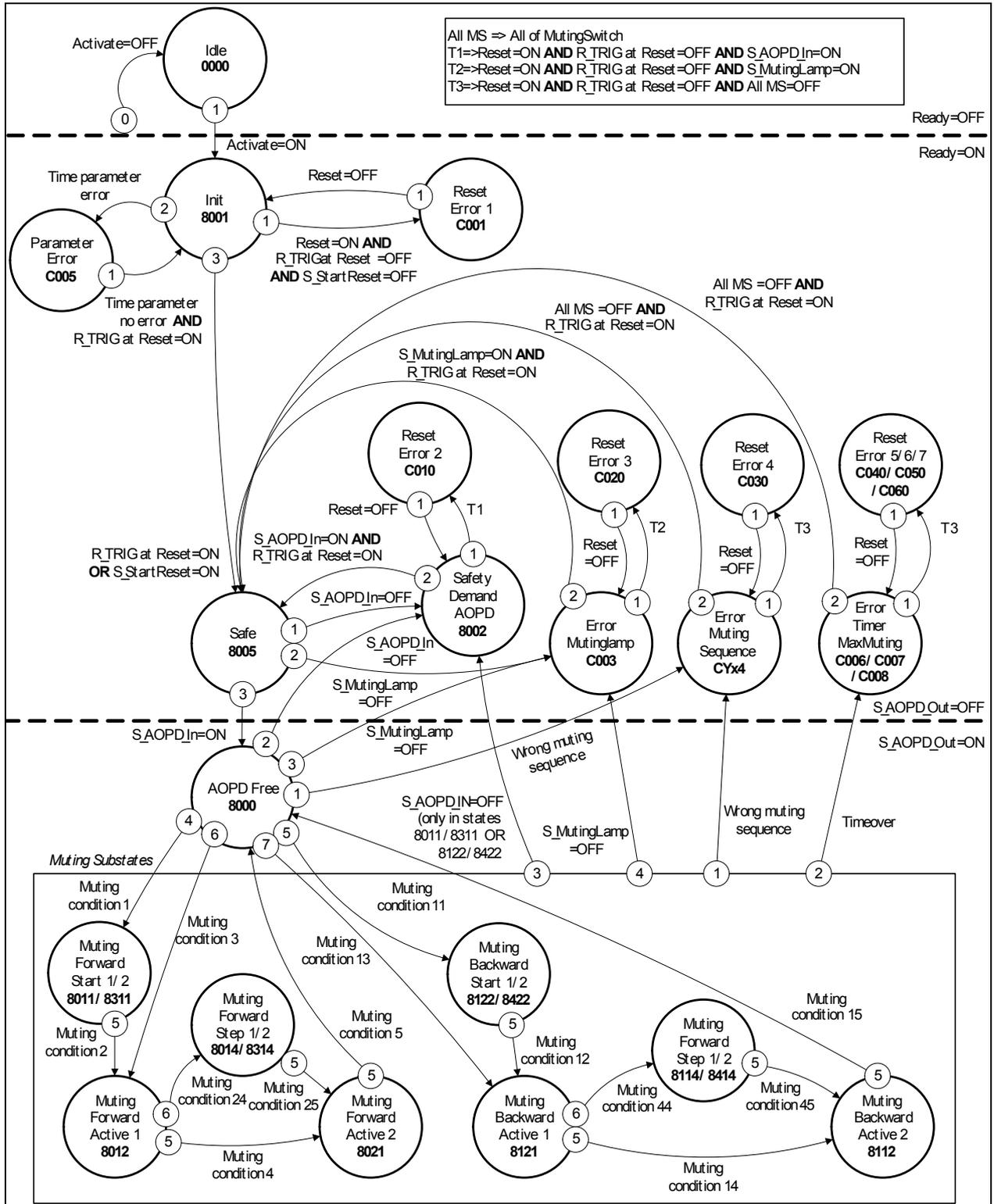
The FB input parameters include the signals of the four muting sensors (MutingSwitch11 ... MutingSwitch22), the OSSD signal from the "active opto-electronic protective device", S_AOPD_In, as well as three parameterizable times (DiscTime11_12, DiscTime21_22, and MaxMutingTime).

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 4.38 Example for 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).

Note 2: 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).

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

Figure 4.39 State Ddiagram for S+MUTEP

Muting Conditions (forward direction)

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

Muting Condition (backward condition)

No.	State Transition	Condition/Action
11	8000→8122	MS_21 is the first entry switch actuated: Start timers MaxMutingTime and DiscTime21_22. MutingEnable=ON, MS_21=OFF→ON, MS_22=OFF, MS_11=OFF, MS_12=OFF
	8000→8422	MS_22 is the first entry switch actuated: Start timers MaxMutingTime and DiscTime21_22. MutingEnable=ON, MS_21=OFF, MS_22=OFF→ON, MS_11=OFF, MS_12=OFF
12	8122→8121	MS_22 is the second entry switch actuated: Stop timer DiscTime21_22. MutingEnable=ON, MS_21=ON, MS_22=OFF→ON, MS_11=OFF, MS_12=OFF
	8422→8121	MS_21 is the second entry switch actuated: Stop timer DiscTime21_22. MutingEnable=ON, MS_21=OFF→ON, MS_22=ON, MS_11=OFF, MS_12=OFF
13	8000→8121	both entry switches actuated in same cycle: Start timer MaxMutingTime. MutingEnable=ON, MS_21=OFF→ON, MS_22=OFF→ON, MS_11=OFF, MS_12=OFF

14	8121→8112	all switches actuated: MS_21=ON, MS_22=ON, MS_11=ON, MS_12=ON
44	8121→8144	MS_11 is the first exit switch actuated: Start timer DiscTime11_12. MS_21=ON, MS_22=ON, MS_11=OFF→ON, MS_12=OFF
	8121→8144	MS_12 is the first exit switch actuated: Start timer DiscTime11_12. MS_21=ON, MS_22=ON, MS_11=OFF, MS_12=OFF→ON
45	8144→8112	MS_12 is the second exit switch actuated: Stop timer DiscTime11_12. MS_21=ON, MS_22=ON, MS_11=ON, MS_12=OFF→ON
	8414→8112	MS_11 is the second exit switch actuated: Stop timer DiscTime11_12 MS_21=ON, MS_22=ON, MS_11=OFF→ON, MS_12=ON
15	8112→8000	one of the exit switches released: Stop timer MaxMutingTime. MS_21=OFF, MS_22=OFF, (MS_11=ON→OFF OR MS_12=ON→OFF)

Wrong Muting Sequences:

State	Wrong muting sequences
8000	when muting sequence starts, MutingEnable=OFF
	(MS_11=ON OR MS_12=ON) AND (MS_21=ON OR MS_21=ON)
	MS_11=OFF→ON, MS_12=ON, NOT MS_12=OFF→ON
	MS_12=OFF→ON, MS_11=ON, NOT MS_11=OFF→ON
	MS_21=OFF→ON, MS_22=ON, NOT MS_22=OFF→ON
	MS_22=OFF→ON, MS_21=ON, NOT MS_21=OFF→ON
	(MS_11=ON, NOT MS_11=OFF→ON) AND (MS_12=ON, NOT MS_12=OFF→ON) (MS_21=ON, NOT MS_21=OFF→ON) AND (MS_22=ON, NOT MS_22=OFF→ON)
8011	MutingEnable=OFF, MS_11=OFF, (MS_21=ON OR MS_22=ON)
8311	MutingEnable=OFF, MS_12=OFF, (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 OR MS_21=OFF→ON OR MS_22=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_11=OFF→ON OR MS_12=OFF→ON OR 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, (MS_22=OFF OR MS_11=OFF)
8414	MS_21=OFF, (MS_22=OFF OR MS_12=OFF)

TYPICAL TIMING DIAGRAM

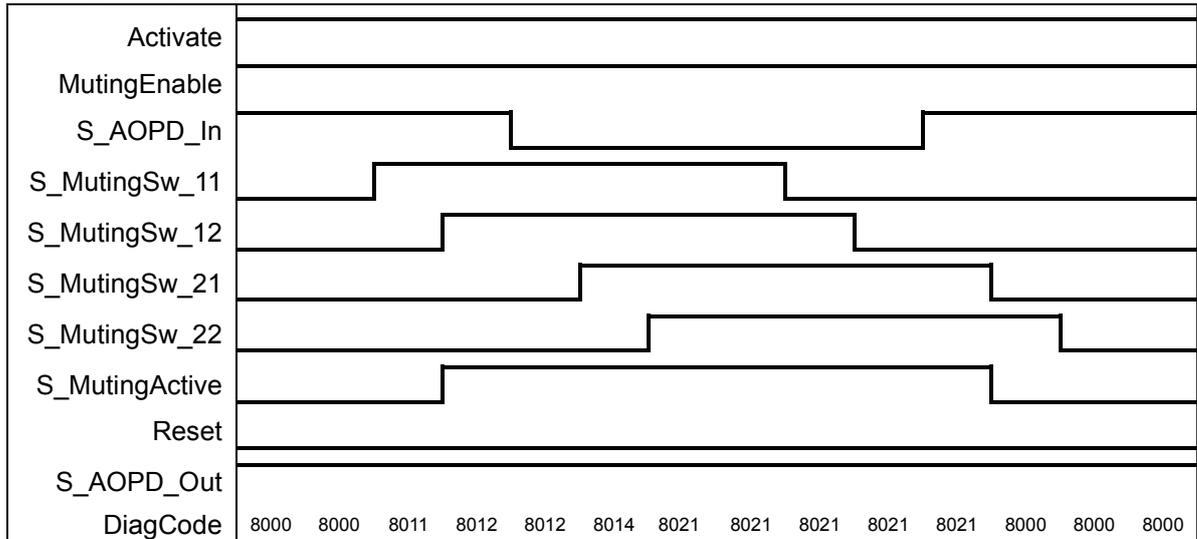


Figure4.40 Typical Timing Diagram for S+MUTEP (S_StartReset = OFF, forward direction)

ERROR DETECTION

The FB detects the following error conditions:

- DiscTime11_12 and DiscTime21_22 have been set to values less than 0ms or greater than 4s.
- MaxMutingTime has been set to a value less than 0s or greater than 10min.
- The discrepancy time for the S_MutingSW_11/12 or S_MutingSW_21/22 sensor pairs has been exceeded.
- The muting function (S_MutingActive = ON) exceeds the maximum muting time MaxMutingTime.
- Muting sensors S_MutingSW_11/12/21/22 are activated in the wrong order.
- Muting sequence starts without being enabled by MutingEnable
- A faulty muting lamp is indicated by S_MutingLamp = OFF.
- A static Reset condition is detected in state 8001.

ERROR BEHAVIOR

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

ERROR CODES

Diag Code	State Name	State Description and Output Setting	Actions
C001	Reset Error 1	Static Reset condition detected after FB activation in state 8001.	Reset = OFF. Check the devices and wiring related to Reset.
C003	Error Muting Lamp	Error detected in muting lamp.	Reset. Check the devices and wiring related to Reset.
CYx4 C004 to CCF4	Error Muting Sequence	<p>Error detected in muting sequence state 8000, 8011, 8311, 8012, 8021, 8014, 8314, 8122, 8422, 8121, 8112, 8114 or 8414.</p> <p>Y = Status in the sequence (6 states for forward and 6 states for backward direction).</p> <p>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</p> <p>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</p>	Set all Muting Switches = OFF and Reset. Check the devices and wiring related to Reset.
C005	Parameter Error	DiscTime11_12, DiscTime21_22 or MaxMutingTime value out of range.	Set a proper value to the parameter, and Reset.
C006	Error Timer MaxMuting	Timing error: Active muting time (when S_MutingActive = ON) exceeds MaxMutingTime.	Set all Muting Switches = OFF and Reset. 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.	Reset. Check the devices and wiring related to Reset.

C008	Error Timer MS21_22	Timing error: Discrepancy time for switching MutingSwitch21 and MutingSwitch22 > DiscTime21_22.	Reset. Check the devices and wiring related to Reset.
C010	Reset Error 2	Static Reset condition detected after FB activation in state 8002.	Reset = OFF. Check the devices and wiring related to Reset.
C020	Reset Error 3	Static Reset condition detected after FB activation in state C003.	Same above.
C030	Reset Error 4	Static Reset condition detected after FB activation in state CYx4.	Same above.
C040	Reset Error 5	Static Reset condition detected after FB activation in state C006.	Same above.
C050	Reset Error 6	Static Reset condition detected after FB activation in state C007.	Same above.
C060	Reset Error 7	Static Reset condition detected after FB activation in state C008.	Same above.

STATUS CODES (no error)

Diag Code	State Name	Description, Setting Output	Actions
0000	Idle	The function block is not active (initial state). Ready = OFF	User can initialize by Activate = ON.
8000	AOPD Free	Muting not active and no safety demand from AOPD. If timers from subsequent muting are still running, they are stopped. Ready = ON S_AOPD_Out = ON	None. Starting muting is possible.
8001	Init	Function block was activated. Ready = ON	Reset.
8002	Safety Demand AOPD	Safety demand detected by AOPD, muting not active. S_AOPD_Out = OFF	Reset after the completion of safety demand.
8005	Safe	Safety function activated. S_AOPD_Out = OFF	Wait the completion of safety demand.
8011	Muting Forward Start 1	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. S_AOPD_Out = ON S_MutingActive = OFF	Both S_MutingSw_11 and S_MutingSw_12 are ON within DiscTime11_12.
8311	Muting Forward Start 2	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.	Same above.
8012	Muting Forward Active 1	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. S_AOPD_Out = ON S_MutingActive = ON	Complete muting within MaxMutingTime.

8014	Muting Forward Step 1	Muting forward sequence is active. S_MutingSw_21 is the first exit switch actuated. Monitoring of DiscTime21_22 is started. S_AOPD_Out = ON S_MutingActive = ON	Both S_MutingSw_21/22 are ON. Complete muting within MaxMutingTime.
8314	Muting Forward Step 2	Muting forward sequence is active. S_MutingSw_22 is the first exit switch actuated. Monitoring of DiscTime21_22 is started.	Same above.
8021	Muting Forward Active 2	Muting forward sequence is still active. Both S_MutingSwitch21 and 22 are actuated, the monitoring of DiscTime21_22 is stopped. S_AOPD_Out = ON S_MutingActive = ON	Complete muting within MaxMutingTime.
8122	Muting Backward Start 1	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. S_AOPD_Out = ON S_MutingActive = OFF	Both S_MutingSw_21 and 22 are ON. Complete muting within MaxMutingTime.
8422	Muting Backward Start 2	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.	Same above.
8121	Muting Backward Active 1	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. S_AOPD_Out = ON S_MutingActive = ON	Complete muting within MaxMutingTime.
8114	Muting Backward Step 1	Muting backward sequence is active. S_MutingSw_11 is the first exit switch actuated. Monitoring of DiscTime11_12 is started.	Both S_MutingSw_11 12 are ON. Complete muting within MaxMutingTime.
8414	Muting Backward Step 2	Muting backward sequence is active. S_MutingSw_12 is the first exit switch actuated. Monitoring of DiscTime11_12 is started.	Same above.
8112	Muting Backward Active 2	Muting backward sequence is still active. Both exit switches S_MutingSw_11 and 12 are actuated, the monitoring of DiscTime11_12 is stopped.	Complete muting within MaxMutingTime.



[DANGER]

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

The example of a parallel muting using four muting sensors is shown in the following figure. In this case, safety devices are used for muting sensors.

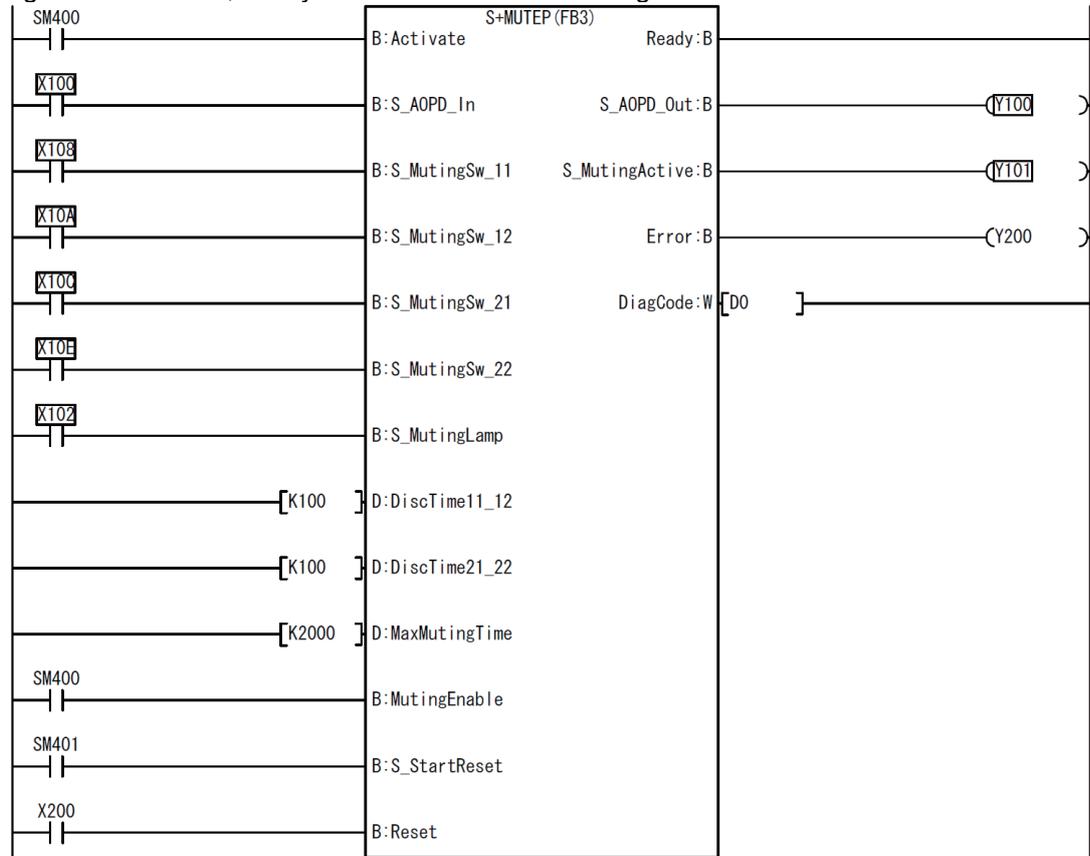


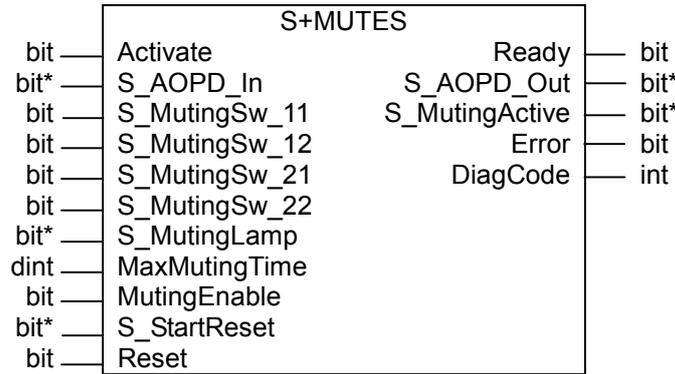
Figure.4.41 Sample Application of S+MUTEP

- SM400: Constant (always ON)
- SM401: Constant (always OFF)
- X100: OSSD (safe input)
- X102: Normal condition of a muting lamp (safe input)
- X108, X10A, X10C, X10E: Muting sensor 11/12/21/22
- X200: Reset switch
- Y100: Contactor (safe output)
- Y101: Muting lamp (safe output)
- Y200: Error indicator
- D0: An internal record for DiagCode

APPLICABLE SAFETY STANDARDS

Standards	Requirements
IEC 61496-1: 2004	<p>A.7 Muting,</p> <p>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.</p> <p>A.7.1.3 The mute function shall only be initiated 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.</p> <p>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.</p> <p>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.</p> <p>A.7.4 Indication: A mute status signal or indicator shall be provided (in some applications, an indication signal of muting is necessary)</p>
CD IEC 62046/Ed.1: 2005	<p>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:</p> <ul style="list-style-type: none"> - the protective equipment OSSDs are in the OFF-state; - the protective equipment is in the lock-out condition. <p>- initiation of the muting function by two or more independent muting sensors such that a single fault cannot cause a muted condition;</p> <p>- termination of the muting function by two or more independent muting sensors such that deactivation of one sensor will terminate the muting function;</p> <p>- use of timing and sequence control of the muting sensors to ensure correct muting operation;</p> <p>5.5.3: The following measures shall be considered: ...</p> <ul style="list-style-type: none"> - 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; <p>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.</p> <p>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.</p>
EN 954-1: 1996	5.4 Manual reset
ISO 12100-2: 2003	4.11.4: Restart following power failure/spontaneous restart

4.12 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 FB. See Chapter 2.2 General Specification.
	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_MutingSw_21	bit	OFF	Status of Muting sensor 21.
	S_MutingSw_22	bit	OFF	Status of Muting sensor 22.
	S_MutingLamp	bit*	OFF	Indicates operation of the muting lamp. OFF: Muting lamp failure. ON: Muting lamp no failure
	MaxMutingTime	dint	0s	Maximum time for complete muting sequence, timer started when first muting sensor is actuated. 10ms unit. Range: 0-60000 (0-10min) The timer is started at the trigger of switching first muting sensor.
	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	Restart inhibit option. See Chapter 2.2 General Specification.
Reset	bit	OFF	Reset input. See Chapter 2.2 General Specification.	
OUT	Ready	bit	OFF	Activate status of this FB. See Chapter 2.2 General Specification.
	S_AOPD_Out	bit*	OFF	Safety related 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. See Chapter 2.2 General Specification.
	DiagCode	int	0	Diagnostic register. See Chapter 2.2 General Specification.

**[DANGER]**

- A variable which of its data type is "bit*" must be input/output to safe data (see Appendix.1).
- When a safe data is not connected to a safety device with the correct path, a safe data is not safe. Please check a path of a safe data.
- Safe input must be connected to S_MutingSW_11/12/21/22 depending on the safety requirements.

**[DANGER]**

- 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 two muting sensors was used; an explanation is provided in Figure 4.42. 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.

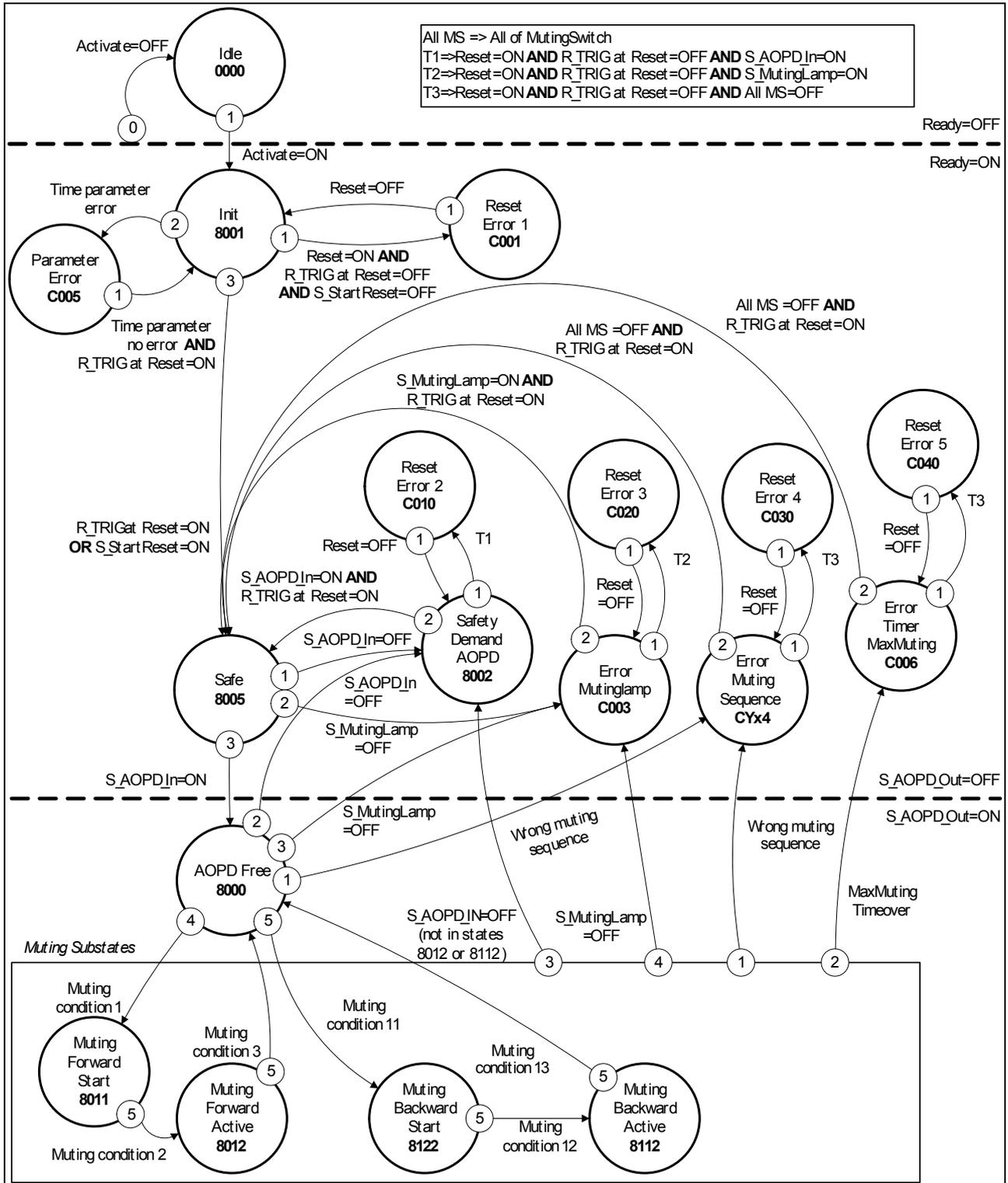
The FB input parameters include the signals of the two muting sensors (S_MutingSwitch11 and S_MutingSwitch12), the OSSD signal from the "active opto-electronic protective device", S_AOPD_In, as well as two parameterizable times (Disc-TimeEntry and MaxMutingTime).

For forward direction, while both S_MutingSw_11/12 turn ON to only S_MutingSW_22 is ON after all Muting_Sw are 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 only S_MutingSw_11 is ON after all Muting_Sw are 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 4.42 Example for S+MUTES in forward direction with four sensors

STATE DIAGRAM



Note 1: 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 2: 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.

Figure 4.43 State Diagram for S+MUTES

Muting Conditions (Forward Direction)

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

Muting Conditions (Backward Direction)

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

Wrong Muting Sequences

State	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, MS_12=ON→OFF	
	(MS_11=ON OR MS_12=ON), MS_21=ON→OFF	
	(MS_11=OFF OR MS_12=OFF), MS_21=ON, MS_22=OFF	
	(MS_11=OFF OR MS_12=OFF OR MS_21=OFF), MS_22=OFF→ON	
	MS_11=OFF, MS_12=OFF, MS_21=OFF, MS_22=OFF	
	MS_11=ON, (MS_12=OFF OR MS_21=OFF), MS_22=ON	
	MS_11=OFF, MS_12=ON, MS_21=OFF, MS_22=ON	
	MS_21=OFF→ON, MS_22=OFF→ON	
	MS_11=ON→OFF, MS_12=ON→OFF	
	MS_12=ON→OFF, MS_21=ON→OFF	
	MS_11=OFF, MS_12=ON, MS_21=OFF	
	8112	MS_11=ON→OFF OR MS_21=OFF→ON OR MS_22=OFF→ON
		MS_21=ON→OFF, MS_22=ON
MS_12=ON→OFF, (MS_21=ON OR MS_22=ON)		
MS_11=OFF, MS_12=ON, (MS_21=OFF OR MS_22=OFF)		
MS_11=OFF→ON, (MS_12=OFF OR MS_21=OFF OR MS_22=OFF)		
MS_11=OFF, MS_12=OFF, MS_21=OFF, MS_22=OFF		
MS_11=ON, (MS_12=OFF OR MS_21=OFF), MS_22=ON		
MS_11=ON, MS_12=OFF, MS_21=ON, MS_22=OFF		
MS_11=OFF→ON, MS_12=OFF→ON		
MS_21=ON→OFF, MS_22=ON→OFF		
MS_12=ON→OFF, MS_21=ON→OFF		
MS_12=OFF, MS_21=ON, MS_22=OFF		
8122	MutingEnable=OFF OR MS_11=ON OR MS_12=ON OR MS_22=OFF	

TYPICAL TIMING DIAGRAM

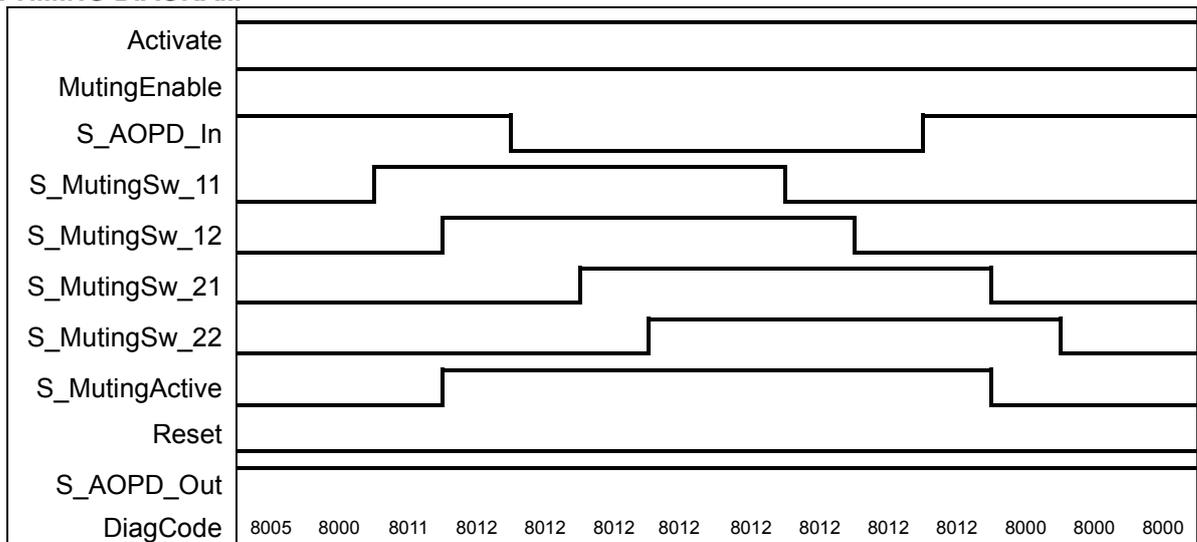


Figure4.44 Typical Timing Diagram for S+MUTES (forward direction)

ERROR DETECTION

The FB detects the following error conditions:

- Muting sensors S_MutingSw_11/12/21/22 are activated in the wrong order.
- Muting sequence starts without being enabled by MutingEnable
- A faulty muting lamp is indicated by S_MutingLamp = OFF.
- A static Reset condition.
- MaxMutingTime has been set to a value less than 0msec or greater than 10min.
- The muting function (S_MutingActive = ON) exceeds the maximum muting time MaxMutingTime.

ERROR BEHAVIOR

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

ERROR CODES

Diag Code	State Name	Description, Setting Output	Actions
C001	Reset Error 1	Static Reset condition detected after FB activation.	Reset = OFF. Check the devices and wiring related to Reset.
C003	Error Muting Lamp	Error detected in muting lamp.	Reset. 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.
C006	Error Timer MaxMuting	Timing error: Active muting time (when S_MutingActive = ON) exceeds MaxMutingTime.	Set all Muting Switch = OFF and Reset. Check the muting situation in the process.
C010	Reset Error 2	Static Reset condition detected at 8002.	Reset = OFF. Check the devices and wiring related to Reset.
C020	Reset Error 3	Static Reset condition detected at C003.	Same above.
C030	Reset Error 4	Static Reset condition detected at CYx4.	Same above.
C040	Reset Error 5	Static Reset condition detected at C006.	Same above.

CYx4	Error Muting Sequence	<p>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 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</p>	<p>Set all Muting Switches = OFF and Reset. Check the devices and wiring related to Reset.</p>
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STATUS CODES (no error)

Diag Code	State Name	Description, Setting Output	Actions
0000	Idle	The function block is not active (initial state). Ready = OFF	User can initialize by Activate = ON.
8000	AOPD Free	Muting not active and no safety demand from AOPD. S_AOPD_Out = ON S_MutingActive = OFF	None. Starting muting is possible.
8001	Init	Function block has been activated. S_AOPD_Out = OFF S_MutingActive = OFF	Reset
8002	Safety Demand AOPD	Safety demand detected by AOPD, muting not active. S_AOPD_Out = OFF S_MutingActive = OFF	Reset after the completion of safety demand.
8005	Safe	Safety function activated. S_AOPD_Out = OFF S_MutingActive = OFF	Wait the completion of safety demand.
8011	Muting Forward Start	Muting forward, sequence is in starting phase and no safety demand. S_AOPD_Out = ON S_MutingActive = OFF	Both S_MutingSw_11 and S_MutingSw_12 are ON. Complete muting within MaxMutingTime.
8012	Muting Forward Active	Muting forward, sequence is active. S_AOPD_Out = ON S_MutingActive = ON	Complete muting within MaxMutingTime.

8112	Muting Backward Active	Muting backward, sequence is active. S_AOPD_Out = ON S_MutingActive = ON	Both S_MutingSw_21 and S_MutingSw_22 are ON. Complete muting within MaxMutingTime.
8122	Muting Backward Start	Muting backward, sequence is in starting phase and no safety demand. S_AOPD_Out = ON S_MutingActive = OFF	Complete muting within MaxMutingTime.



[DANGER]
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

The example of sequential muting using 4 muting sensors is shown in the following figure. In this case, safety devices are used for muting sensors.

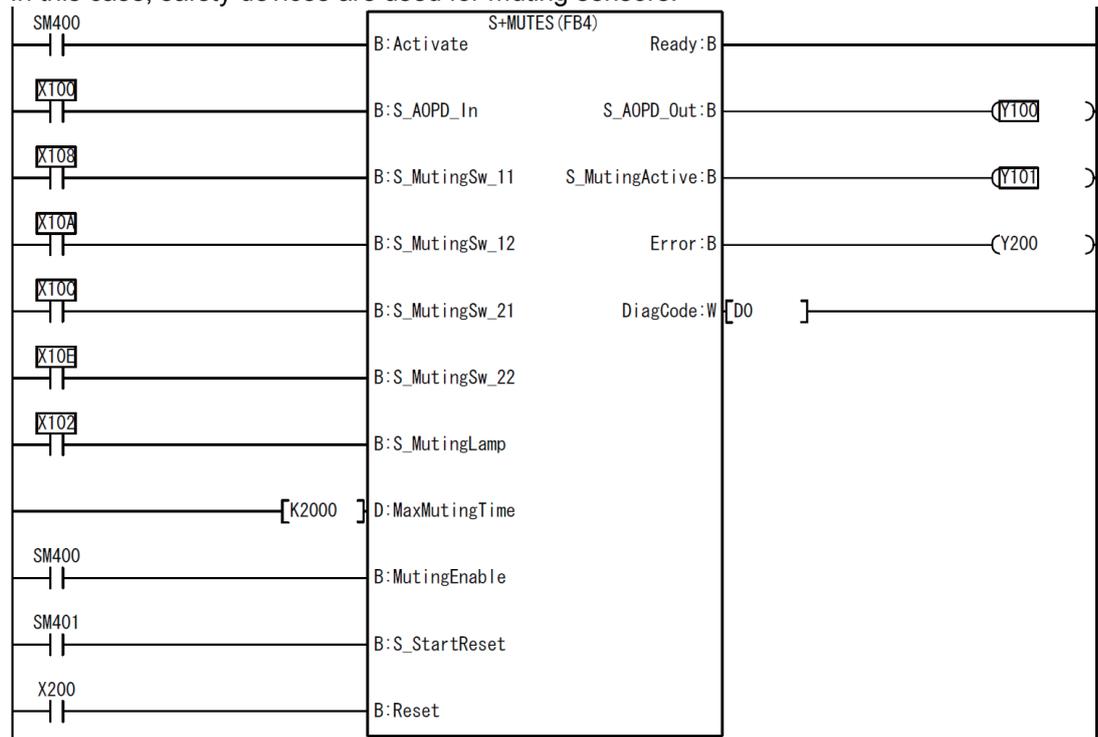


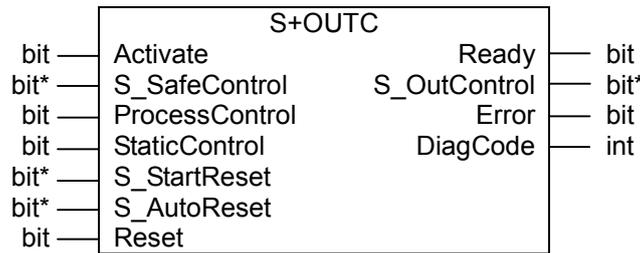
Figure.4.45 Sample Application of S+MUTES

- SM400: Constant (always ON)
- SM401: Constant (always OFF)
- X100: OSSD (safe input)
- X102: Normal condition of a muting lamp (safe input)
- X108, X10A, X10C, X10E: Muting sensor11/12/21/22
- X200: Reset switch
- Y100: Contactor (safe output)
- Y101: Muting lamp (safe output)
- Y200: Error indicator
- D0: An internal record for DiagCode

APPLICABLE SAFETY STANDARD

Standards	Requirements
IEC 61496-1: 2004	<p>A.7 Muting,</p> <p>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.</p> <p>A.7.1.3 The mute function shall only be initiated 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.</p> <p>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.</p> <p>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.</p> <p>A.7.4 Indication: A mute status signal or indicator shall be provided (in some applications, an indication signal of muting is necessary)</p>
CD IEC 62046/Ed.1: 2005	<p>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:</p> <ul style="list-style-type: none"> - the protective equipment OSSDs are in the OFF-state; - the protective equipment is in the lock-out condition. <p>- initiation of the muting function by two or more independent muting sensors such that a single fault cannot cause a muted condition;</p> <p>- termination of the muting function by two or more independent muting sensors such that deactivation of one sensor will terminate the muting function;</p> <p>- use of timing and sequence control of the muting sensors to ensure correct muting operation;</p> <p>5.5.3: The following measures shall be considered: ...</p> <ul style="list-style-type: none"> - 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; <p>Annex F.3 Four beams - sequence control: (see also Fig. F.3.1 and table F.1)</p> <p>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.</p> <p>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.</p>
EN 954-1: 1996	5.4 Manual reset
ISO 12100-2: 2003	4.11.4: Restart following power failure/spontaneous restart

4.13 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 FB. See Chapter 2.2 General Specification.
	S_SafeControl	bit*	OFF	Control signal of the preceding safety FB. Typical function block signals from the library (e.g., SF_EStop, SF_GuardMonitoring, SF_TwoHandControlTypell, and/or others). OFF: The preceding safety FB's are in safe state. ON: The preceding safety FB's enable safety control.
	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. Additional function start required. ON: No dynamic change at ProcessControl (OFF to ON) required after block activation or triggered safety function.
	S_StartReset	bit*	OFF	Restart inhibit option. See Chapter 2.2 General Specification.
	S_AutoReset	bit*	OFF	Automatic restart option. See Chapter 2.2 General Specification.
	Reset	bit	OFF	Reset input. See Chapter 2.2 General Specification.
OUT	Ready	bit	OFF	Activate status of this FB. See Chapter 2.2 General Specification.
	S_OutControl	bit*	OFF	Controls connected actuators. OFF: Disable connected actuators. ON: Enable connected actuators.
	Error	bit	OFF	Error flag. See Chapter 2.2 General Specification.
	DiagCode	int	0	Diagnostic register. See Chapter 2.2 General Specification.



[DANGER]

- A variable which of its data type is "bit*" must be input/output to safe data (see Appendix.1).
- When a safe data is not connected to a safety device with the correct path, a safe data is not safe. Please check a path of a safe data.

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)

SaticControl 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

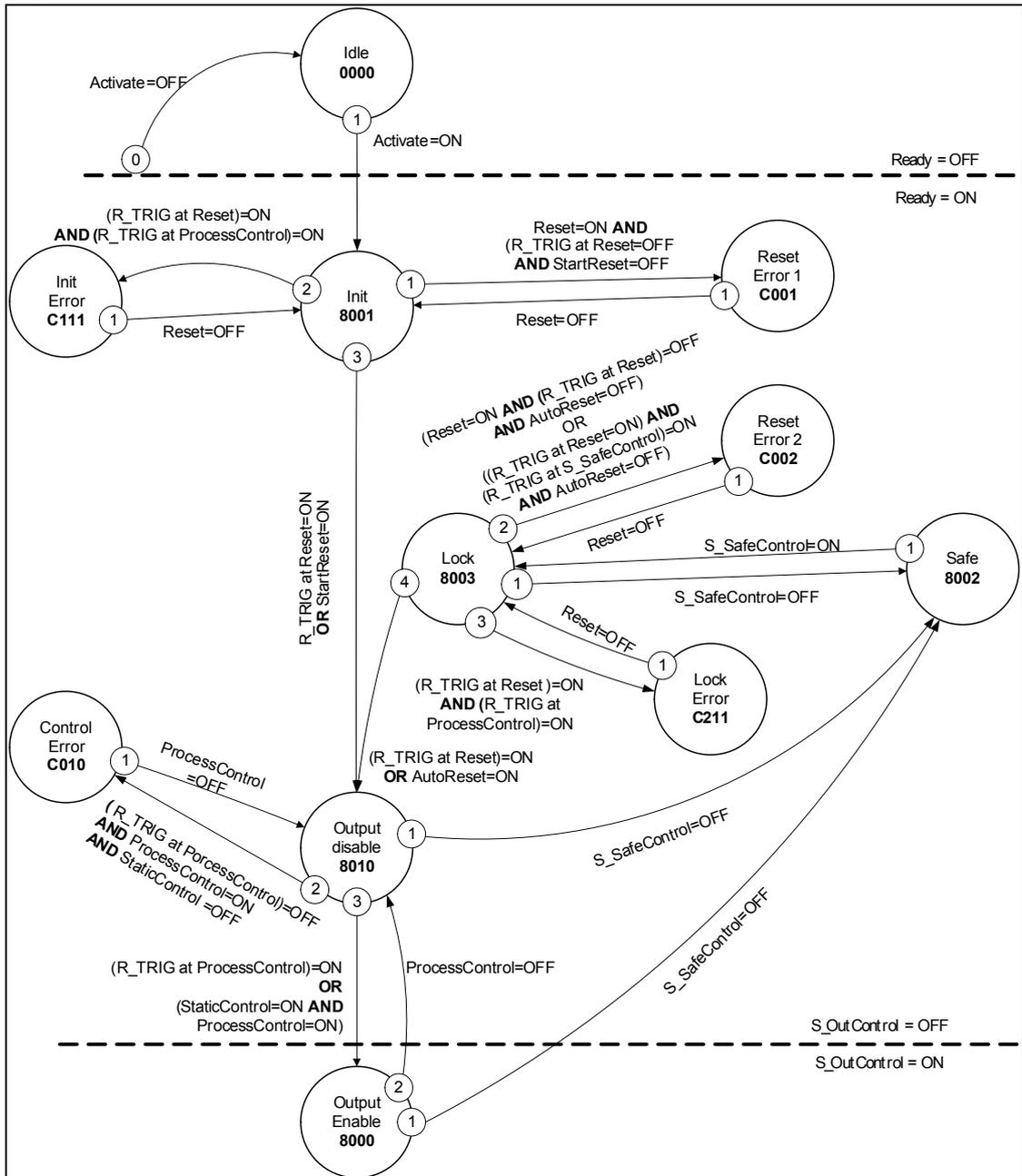
- signal at ProcessControl does not set S_OutControl to ON.
- StaticControl=OFF: An additional function start (ProcessControl OFF to ON) is not required following block activation or feedback of the safe signal (S_SafeControl). The static ON signal at ProcessControl sets S_OutControl to ON if the other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



[DANGER]

- 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 4.46 State Diagram for S+OUTC

TYPICAL TIMING DIAGRAM

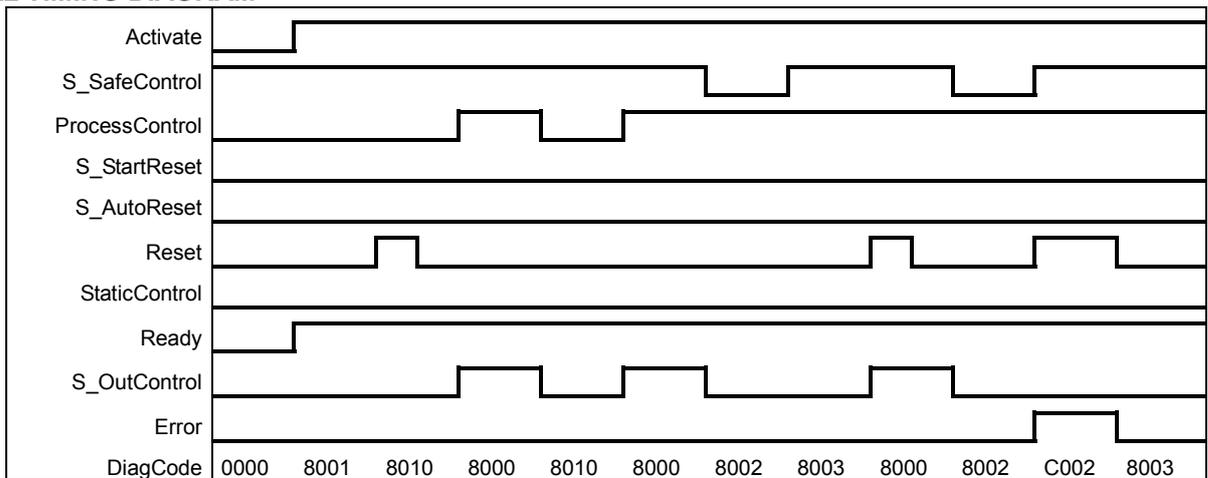


Figure 4.47 Typical Timing Diagram for S+OUTC
S_StartReset=OFF, S_AutoReset = OFF

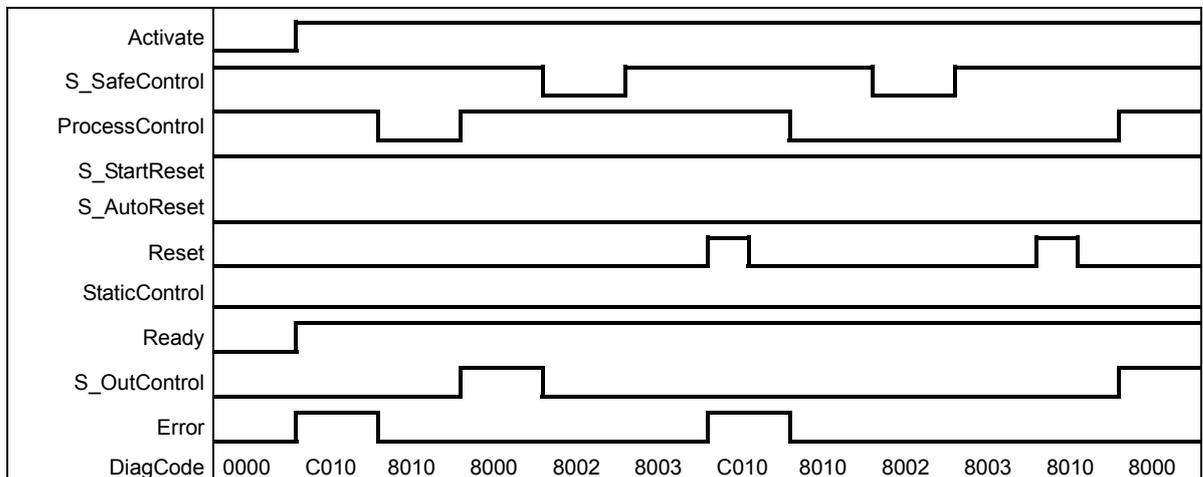


Figure 4.48 Typical Timing Diagram for S+OUTC
S_StartReset=ON, S_AutoReset = OFF

ERROR DETECTION

- The following conditions force a transition to the Error state:
- Invalid static Reset signal in the process. (Only at S_AutoRestart=OFF)
 - Invalid static ProcessControl signal. (Only at StaticControl=OFF)
 - ProcessControl and Reset are incorrectly interconnected due to programming error.

ERROR BEHAVIOR

- In the event of an error, the S_OutControl output is set to OFF and remains in this safe state.
- To leave the Reset, Init or Lock error states, the Reset input must be set to OFF. To leave the Control error state, the ProcessControl input must be set to OFF.
- After transition of S_SafeControl to ON, the optional startup inhibit can be reset by a rising edge at the Reset input.
- After FB activation, the optional startup inhibit can be reset by a rising edge at the Reset input.

ERROR CODES

Diag Code	State Name	Description, Setting Output	Actions
C001	Reset Error 1	Static Reset signal in state 8001. Ready = ON S_OutControl = OFF Error = ON	Reset=OFF. Check the devices and wiring of Reset.
C002	Reset Error 2	Static Reset signal in state 8003.	Reset=OFF. Check the devices and wiring of Reset.
C010	Control Error	Static signal at ProcessControl in state 8010.	ProcessControl=OFF. Check the setting of StaticControl.
C111	Init Error	Simultaneous rising trigger at Reset and ProcessControl in state 8001.	Reset=OFF. Check the independence between ProcessControl and Reset.
C211	Lock Error	Simultaneous rising trigger at Reset and ProcessControl in state 8003.	Same above.

STATUS CODES (no error)

Diag Code	State Name	Description, Setting Output	Actions
0000	Idle	The function block is not active (initial state). All output=OFF, DiagCode=0 Ready = OFF	User can initialize by Activate=ON.
8001	Init	Block activation startup inhibit is active. Ready= ON	Reset required.
8002	Safe	Triggered safety function. Don't permit the enable output. S_SafeControl=OFF	S_SafeControl required.
8003	Lock	Safety function startup inhibit is active. Ready = ON S_OutControl = OFF Error = OFF	Reset required.
8010	Output Disable	Process control is not active and safety is disabled. S_OutControl = OFF	ProcessControl required.
8000	Output Enable	Process control is active and safety is enabled. S_OutControl = ON	None.

**[DANGER]**

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.

SAMPLE APLLICATION

The example of the machine restart control application with combination of safety control and functional control from the standard Programmable Controller is shown in the following figure.

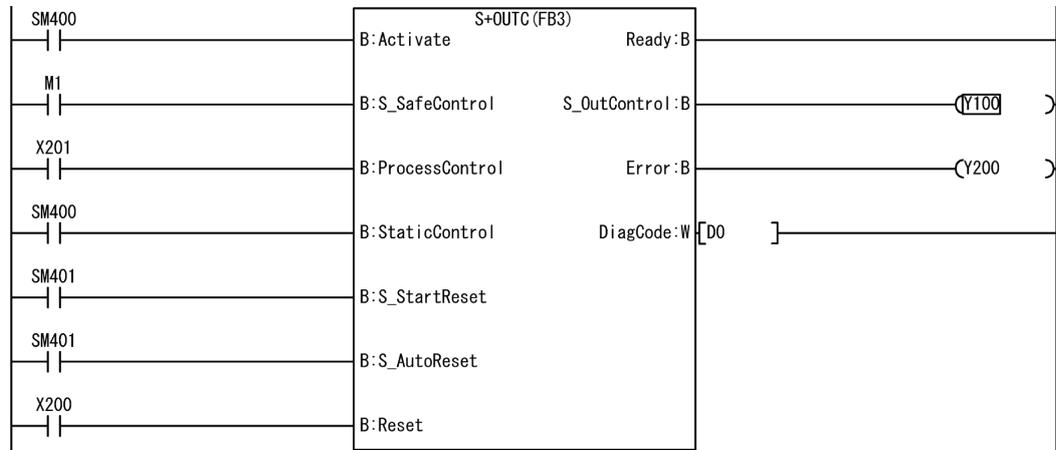


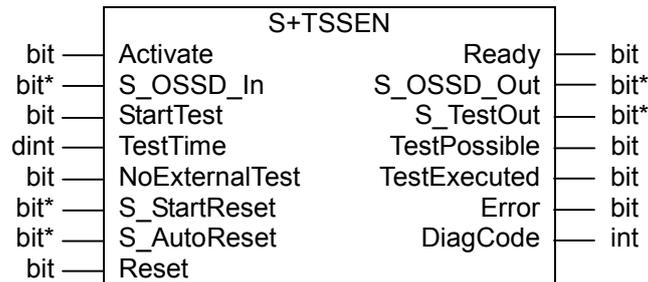
Figure 4.49 Sample Application of S+OUTC

- 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: An internal record area for 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 S+TSEN



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 FB. See Chapter 2.2 General Specification.
	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	dint	0	Test time of safety sensor (10ms unit). You must set constant value. Range: 0 - 15 (0-150ms)
	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 switching sequence after faulty automatic sensor test.
	S_StartReset	bit*	OFF	Restart inhibit option. See Chapter 2.2 General Specification.
	S_AutoReset	bit*	OFF	Automatic restart option. See Chapter 2.2 General Specification.
	Reset	bit	OFF	Reset input. See Chapter 2.2 General Specification.
OUT	Ready	bit	OFF	Activate status of this FB. See Chapter 2.2 General Specification.
	S_OSSD_Out	bit*	OFF	Safety related 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. See Chapter 2.2 General Specification.
	DiagCode	int	0	Diagnostic register. See Chapter 2.2 General Specification.

**[DANGER]**

- A variable which of its data type is "bit*" must be input/output to safe data (see Appendix.1).
- When a safe data is not connected to a safety device with the correct path, a safe data is not safe. Please check a path of a safe data.

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 testtime is set by TestTime parameter, and the FB monitors the test time and detect an error.

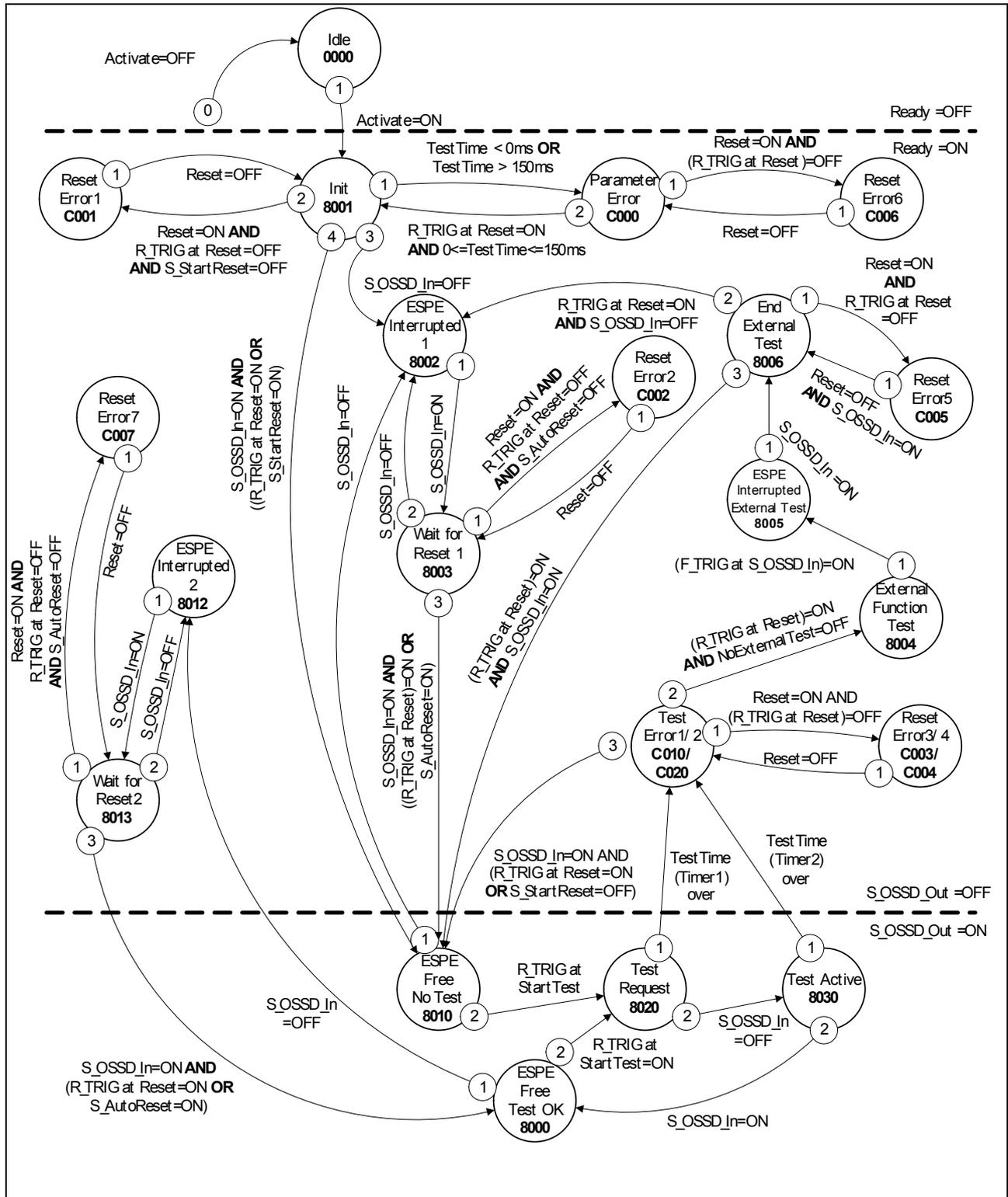
**[DANGER]**

- 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 transmitter (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. Start transmitter
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



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 4.50 State Diagram for S+TSEN

TYPICAL TIMING DIAGRAM

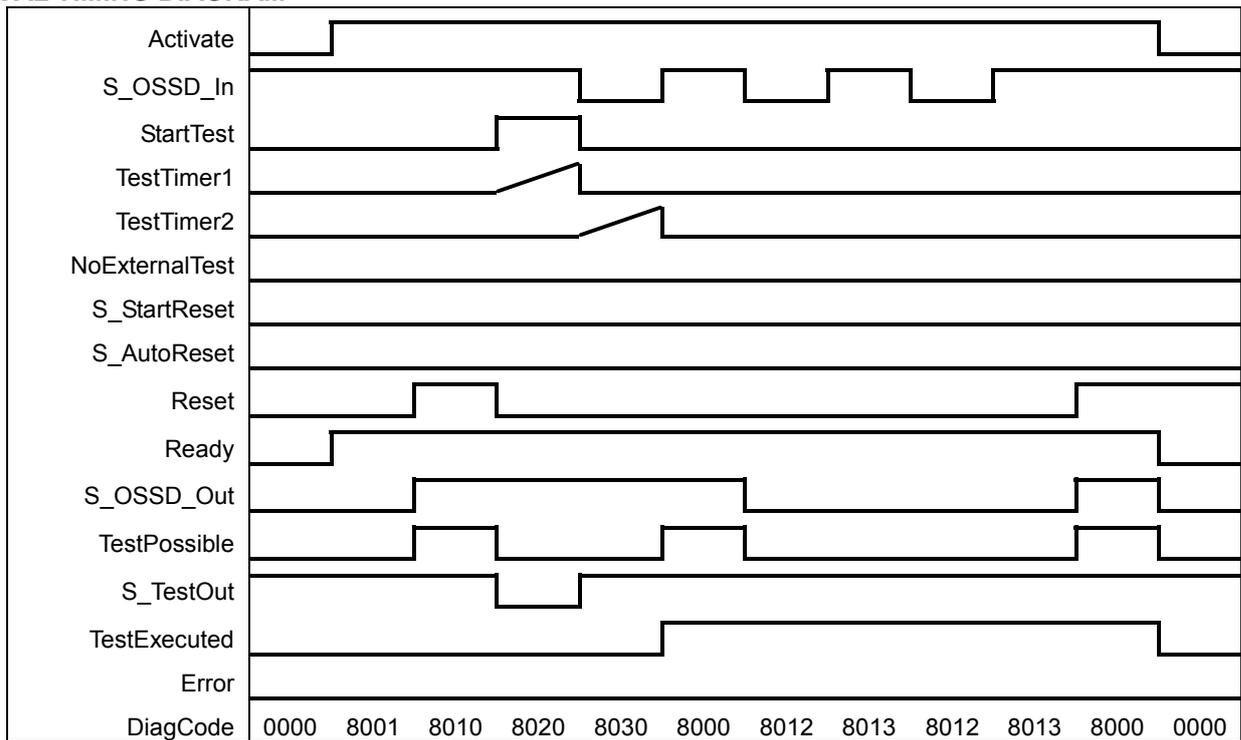


Figure 4.51 Typical Timing Diagram for S+TSEN

ERROR DETECTION

The following conditions force a transition to the Error state:

- Out of range of TestTime parameter.
- Invalid static reset signal in the process.
- Test time (TestTimer1) overrun without delayed sensor feedback (S_OSSD_In=OFF).
- Test time (TestTimer2) overrun without delayed sensor feedback (S_OSSD_In=ON).

ERROR BEHAVIOR

In the event of an error, the S_OSSD_Out output is set to OFF and remains in this safe state. Once the error has been removed and the sensor is on (S_OSSD_In = ON) - a reset removes the error state and sets the S_OSSD_Out output to ON. After transition of S_OSSD_In to ON, the optional startup inhibit can be reset by a rising edge at the Reset input.

ERROR CODES

Diag Code	State Name	Description, Setting Output	Actions
C000	Parameter Error	Invalid value at the TestTime parameter. Values between 0 ms and 150 ms are possible.	Set TestTime to proper value.
C001	Reset Error 1	Static Reset condition detected after FB activation.	Reset=OFF. Check the devices and wiring of Reset.
C002	Reset Error 2	Static Reset condition detected in state 8003.	Same above.
C003	Reset Error 3	Static Reset condition detected in state C010.	Same above.
C004	Reset Error 4	Static Reset condition detected in state C020.	Same above.
C005	Reset Error 5	Static Reset condition detected in state 8006.	Same above.
C006	Reset Error 6	Static Reset condition detected in state C000.	Same above.
C007	Reset Error 7	Static Reset condition detected in state 8013.	Same above.

C010	Test Error 1	Test time overrun without delayed sensor feedback (S_OSSD_In=OFF).	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.
C020	Test Error 2	Test time overrun without delayed sensor feedback (S_OSSD_In=ON). Test is not completed within test time.	Same above.

STATUS CODES (no error)

Diag Code	State Name	Description, Setting Output	Actions
0000	Idle	The function block is not active (initial state). Ready = OFF	User can initialize by Activate=ON.
8001	Init	Activation has been detected by the FB. Ready = ON	Reset the FB at S_OSSD_In =ON.
8002	ESPE Interrupted 1	The FB has detected a safety demand. The switch has not been automatically tested yet.	Reset the safety demand for the connected safeguard by resetting the interruption of the sensors. Check a failure or an error of the sensor.
8003	Wait for Reset1	Wait for rising trigger of Reset after state 8002.	Reset the FB.
8004	External Function Test	The support for the necessary external manual sensor test has been activated at the FB (NoExternalTest = OFF). A negative signal edge at the sensor (S_OSSD_In) is required. The automatic sensor test was faulty, and was disabled.	Occur a safety demand (e.g. across the beam of the sensor).
8005	ESPE Interrupted External Test	The support for the necessary external manual sensor test has been activated at the FB (NoExternalTest = OFF). A ON signal at the sensor (S_OSSD_In) is required. The automatic sensor test was faulty.	Remove the safety demand from the sensor.
8006	End External Test	The test routine for an external manual test of the connected safeguard has been completed successfully. Please note that it is not possible to start the test routine.	Reset the FB.
8010	ESPE Free No Test	The FB has not detected a safety demand. The sensor has not been tested automatically. S_OSSD_Out = ON S_TestOut = ON TestPossible = ON TestExecuted = OFF	Execute the automatic test by S_StartReset=ON.
8020	Test Request	The automatic sensor test is active, and the signal from the sensor (S_OSSD_In =OFF) is required. Test Timer is started first time. The transmitter signal of the sensor is switched off by the FB. The signal of the receiver must follow the signal of the transmitter. S_OSSD_Out = ON S_TestOut = OFF TestPossible = OFF TestExecuted = OFF	None.

8030	Test Active	The automatic sensor test is active, and the signal from the sensor (S_OSSD_In=ON) is required. Test Timer is started second time. The transmitter signal of the sensor is switched on by the FB. The signal of the receiver must follow the signal of the transmitter. S_OSSD_Out = ON S_TestOut = ON TestPossible = OFF TestExecuted = OFF	None.
8000	ESPE Free Test ok	The FB has not detected a safety demand. The sensor was automatically tested. S_OSSD_Out = ON S_TestOut = ON TestPossible = ON TestExecuted = ON	None. In order to carry out the safeguard test again, a signal changes from OFF to ON be required at StartTest.
8012	ESPE Interrupted 2	The FB has detected a safety demand from the sensor at the status 8000 or 8013. The switch was automatically tested. S_OSSD_Out = OFF S_TestOut = ON TestPossible = OFF TestExecuted = ON	Reset the safety demand for the connected safeguard by resetting the interruption of the sensors. Check a failure or an error of the sensor.
8013	Wait for Reset 2	Wait for rising trigger of Reset after state 8012.	Reset the FB.



[DANGER]

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.

SAMPLE APLLICATION

The example of an emergency stop application with Type2 light is shown in the following figure.

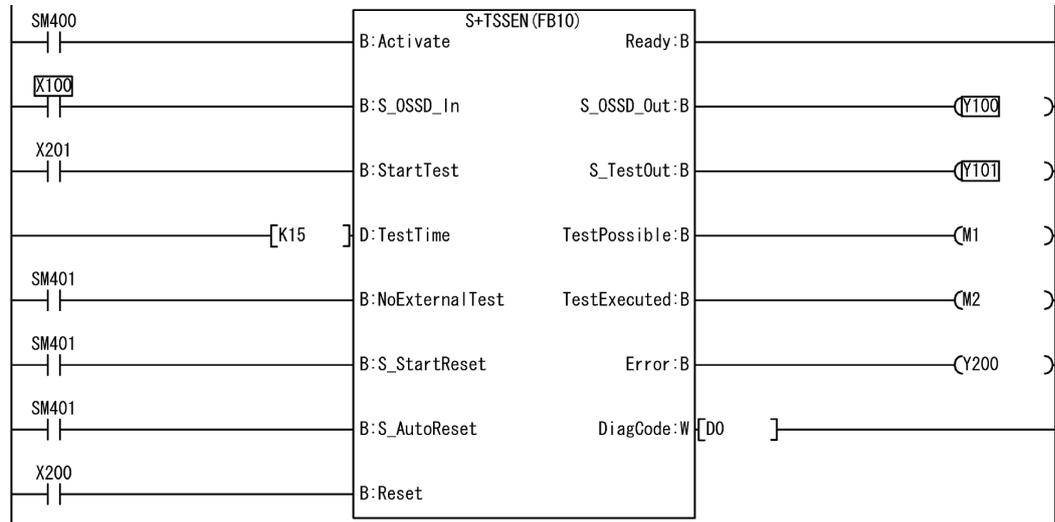


Figure 4.52 Sample Application for S+TSEN

- 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)
- M0: 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: An internal record area for DiagCode

APPLICABLE SAFETY STANDARDS

Standards	Requirements
IEC 6196-1: 2004	<p>4.2.2.3 Particular requirements for a type 2 ESPE</p> <p>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).</p> <p>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.</p> <p>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).</p> <p>The duration of the periodic test shall be such that the intended safety function is not impaired.</p> <p>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.</p> <p>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.</p> <p>In the event of a fault, the OSSD(s) shall be signalled to go to the OFF-state.</p> <p>If one or more OSSDs don't go to the OFF-state, a lock-out condition shall be initiated.</p>
EN 954-1: 1996	5.4 Manual reset
ISO 12100-2:2003	4.11.4: Restart following power failure/spontaneous restart

APPENDICES

Appendix 1 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.

(a) Safety refresh device

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

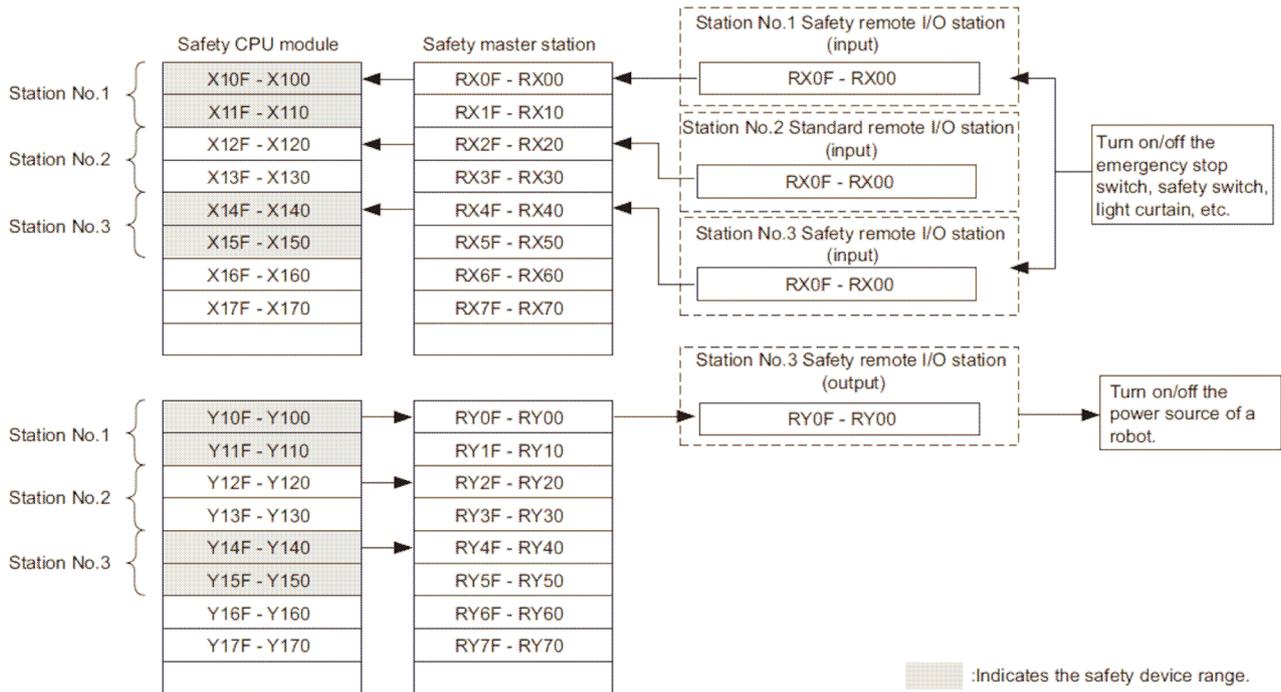


Figure APP.1 I/O data of safety remote station *1

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

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

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

WARRANTY

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

1. Limited Warranty and Product Support.

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

2. Limits of Warranties.

- a. MELCO does not warrant or guarantee the design, specify, manufacture, construction or installation of the materials, construction criteria, functionality, use, properties or other characteristics of the equipment, systems, or production lines into which the Products may be incorporated, including any safety, fail-safe and shut down systems using the Products.
- b. MELCO is not responsible for determining the suitability of the Products for their intended purpose and use, including determining if the Products provide appropriate safety margins and redundancies for the applications, equipment or systems into which they are incorporated.
- c. Customer acknowledges that qualified and experienced personnel are required to determine the suitability, application, design, construction and proper installation and integration of the Products. MELCO does not supply such personnel.
- d. MELCO is not responsible for designing and conducting tests to determine that the Product functions appropriately and meets application standards and requirements as installed or incorporated into the end-user's equipment, production lines or systems.
- e. MELCO does not warrant any Product:
 - (1) repaired or altered by persons other than MELCO or its authorized engineers or FA Centers;
 - (2) subjected to negligence, carelessness, accident, misuse, or damage;
 - (3) improperly stored, handled, installed or maintained;
 - (4) integrated or used in connection with improperly designed, incompatible or defective hardware or software;
 - (5) that fails because consumable parts such as batteries, backlights, or fuses were not tested, serviced or replaced;
 - (6) operated or used with equipment, production lines or systems that do not meet applicable and commensurate legal, safety and industry-accepted standards;
 - (7) operated or used in abnormal applications;
 - (8) installed, operated or used in contravention of instructions, precautions or warnings contained in MELCO's user, instruction and/or safety manuals, technical bulletins and guidelines for the Products;
 - (9) used with obsolete technologies or technologies not fully tested and widely accepted and in use at the time of the Product's manufacture;
 - (10) subjected to excessive heat or moisture, abnormal voltages, shock, excessive vibration, physical damage or other improper environment; or
 - (11) damaged or malfunctioning due to Acts of God, fires, acts of vandals, criminals or terrorists, communication or power failures, or any other cause or failure that results from circumstances beyond MELCO's control.
- f. All Product information and specifications contained on MELCO's website and in catalogs, manuals, or technical information materials provided by MELCO are subject to change without prior notice.

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

3. Limits on Damages.

- a. MELCO'S MAXIMUM CUMULATIVE LIABILITY BASED ON ANY CLAIMS FOR BREACH OF WARRANTY OR CONTRACT, NEGLIGENCE, STRICT TORT LIABILITY OR OTHER THEORIES OF RECOVERY REGARDING THE SALE, REPAIR, REPLACEMENT, DELIVERY, PERFORMANCE, CONDITION, SUITABILITY, COMPLIANCE, OR OTHER ASPECTS OF THE PRODUCTS OR THEIR SALE, INSTALLATION OR USE SHALL BE LIMITED TO THE PRICE PAID FOR PRODUCTS NOT AS WARRANTED.
- b. Although MELCO has obtained the certification for Product's compliance to the international safety standards IEC61508 and EN954-1/ISO13849-1 from TUV Rheinland, this fact does not guarantee that Product will be free from any malfunction or failure. The user of this Product shall comply with any and all applicable safety standard, regulation or law and take appropriate safety measures for the system in which the Product is installed or used and shall take the second or third safety measures other than the Product. MELCO is not liable for damages that could have been prevented by compliance with any applicable safety standard, regulation or law.
- c. MELCO prohibits the use of Products with or in any application involving power plants, trains, railway systems, airplanes, airline operations, other transportation systems, amusement equipments, hospitals, medical care, dialysis and life support facilities or equipment, incineration and fuel devices, handling of nuclear or hazardous materials or chemicals, mining and drilling, and other applications where the level of risk to human life, health or property are elevated.
- d. MELCO SHALL NOT BE LIABLE FOR SPECIAL, INCIDENTAL, CONSEQUENTIAL, INDIRECT OR PUNITIVE DAMAGES, FOR LOSS OF PROFITS, SALES, OR REVENUE, FOR INCREASED LABOR OR OVERHEAD COSTS, FOR DOWNTIME OR LOSS OF PRODUCTION, FOR COST OVERRUNS, OR FOR ENVIRONMENTAL OR POLLUTION DAMAGES OR CLEAN-UP COSTS, WHETHER THE LOSS IS BASED ON CLAIMS FOR BREACH OF CONTRACT OR WARRANTY, VIOLATION OF STATUTE, NEGLIGENCE OR OTHER TORT, STRICT LIABILITY OR OTHERWISE.
- e. In the event that any damages which are asserted against MELCO arising out of or relating to the Products or defects in them, consist of personal injury, wrongful death and/or physical property damages as well as damages of a pecuniary nature, the disclaimers and limitations contained in these terms shall apply to all three types of damages to the fullest extent permitted by law. If, however, the personal injury, wrongful death and/or physical property damages cannot be disclaimed or limited by law or public policy to the extent provided by these terms, then in any such event the disclaimer of and limitations on pecuniary or economic consequential and incidental damages shall nevertheless be enforceable to the fullest extent allowed by law.
- f. In no event shall any cause of action arising out of breach of warranty or otherwise concerning the Products be brought by Customer more than one year after the cause of action accrues.
- g. Each of the limitations on remedies and damages set forth in these terms is separate and independently enforceable, notwithstanding the unenforceability or failure of essential purpose of any warranty, undertaking, damage limitation, other provision of these terms or other terms comprising the contract of sale between Customer and MELCO.

4. Delivery/Force Majeure.

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

5. Choice of Law/Jurisdiction.

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

6. Arbitration.

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

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QSCPU Programming Manual (Safety FB)

MODEL	QSCPU-P-SAFETYFB-E
MODEL CODE	13JW05
SH(NA)-080744ENG-B(0801)MEE	



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