Functional Example CD-FE-I-031-V30-EN

ASIsafe
SIRIUS Safety Integrated

Emergency-Stop and Protective Door Monitoring
with monitored Start
up to SIL 3 acc. to IEC 62061 and
PL e acc. to ISO 13849-1

safety INTEGRATED

SIEMENS

Comments

"Safety Integrated" Functional Examples are functional, tested automation configurations based on A&D standard products intended for simple, quick and economic implementation of automation tasks involving safety technology. Each of these Functional Examples covers a frequently occurring subtask of a typical customer problem within safety technology.

In addition to containing a list of all of the necessary software and hardware components, and a description of their interwiring, the Functional Examples also contain tested and commented code. This enables the functions described here to be duplicated and, thus, used as a basis for individual expansions.

Important information

Safety Functional Examples are non-binding and do not claim to be complete with regard to configuration, equipment or any contingency. The Safety Functional Examples are not customer-specific solutions. They are merely intended to assist in dealing with typical problems. You are solely responsible for correct operation of the described products.

These Safety Functional Examples do not relieve you of your responsibility for safe usage, installation, operation and maintenance. By using these Safety Functional Examples you accept that Siemens is not liable for any damage beyond the liability described above. We reserve the right to make changes to these Safety Functional Examples at any time, without prior notice. If the suggestions in these Safety Functional Examples deviate from other Siemens publications (e.g. catalogs), the contents of the other document have priority.

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1. Guarantee, Liability and Support

We are not liable for any of the information contained in this document.

We are not liable for any damage caused by the use of the examples, information, programs, configuration and performance data, etc. described in this Safety Functional Example, independent of the legal ground this is based upon, unless we are imperatively liable according to the product liability law due to, e.g., cases of premeditation, an act of gross negligence, injury to life, body or health, or unless the quality of a product has been guaranteed, or due to fraudulent concealment of a defect or serious breach of contract. Damages due to serious breach of contract are, however, restricted to prevalent and predictive contractual damages, in as much as premeditation or gross negligence are not existent or there is no imperative liability due to injury to life, body or health. This does not constitute a change in the burden of proof to your disadvantage.

2. Automation Function

2.1 Scope of Validity of this Functional Example

Persons near machines (e.g. in production engineering) must be suitably protected by technical equipment. The EMERGENCY-STOP control unit and protective door monitoring are widely used components for protecting persons, machines and the environment against danger.

A standard AS-i network consists of control/master, power supply unit, a yellow AS-i cable and various slaves. Only two further components are necessary for safe usage: A safety monitor and safe slaves.

Each safe slave is programmed with a factory-default code table that clearly identifies each slave for the safety monitor.

At each master prompt, correlation is checked between the code value expected by the comparator (safety monitor) and the code value actually sent by the slave. In the case of deviations or time-outs, disconnection via 2-channel OSSDs occurs on the safety monitor.

2.1 Functionality of the Functional Example

Problem

Implementation of EMERGENCY-STOP disconnection and protective door monitoring with monitored start via ASIsafe.

Solution

In this Safety Functional Example, the EMERGENCY-STOP control unit and a protective door are monitored via two channels by a K45F ASIsafe module. When the EMERGENCY-STOP is activated or the protective door is opened, the K45F ASIsafe module sends a signal to the safety monitor. The safety monitor then switches the downstream contactor with positively-driven contacts via the safe relay output according to Stop category 0 of EN 60204-1. A drive is shut down in this example. Before renewed switching-on via the start button, a check is carried out to monitor whether the contacts of the EMERGENCY-STOP control unit and the protective door are closed and whether the contactors have switched off.

2.3 Advantages / Customer Benefits

- Secure and non-secure data on one bus
- Simple assembly thanks to standardized AS-i technology
- Existing system can be quickly and easily expanded
- Integration of safety signals in the system diagnosis
- Failsafe PLC or special master not required
- Space-saving design thanks to compact safety combination

3. Required Components

This chapter contains an overview of the hardware and software components required for the Functional Example.

Hardware components

Table 3-1

Component	Type	Order No. / Order Information	Quantity	Manufacturer
Power supply	PS307 5A	6ES73071EA00-0AA0	1	SIEMENS
AS-i power supply unit	3A power supply unit	3RX9501-0BA00	1	
DP/AS-i LINK Advanced	IP20 degree of protection, router from Profibus DP to AS-Interface	6GK1415-2BA10	1	
EMERGENCY-STOP	40-mm mushroom pushbutton with 1NC and yellow top	3SB3 801-0DG3	1	
	1NC contact block	3SB3 420-0C	1	
SIRIUS position switch	Position switch with separate actuator	3SE5 232-0RV40	2	
Actuator for position switch	Radius actuator	3SE5 000-0AV05	2	
Safety monitor	V3 safety monitor	3RK1105-1BE04-2CA0	1	
ASi Safe module K45F	Compact module with two safe inputs	3RK1205-0BQ00-0AA3	2	
	Mounting plate (for standard mounting rail)	3RK1901-2DA00	2	
	Optional: Mounting plate (for wall mounting)	3RK1901-2EA00	2	
Start button	Empty enclosure for one command point	3SB3 801-0AA3	1	
	1NO contact block for base mounting	3SB3 420-OB	1	
	Black pushbutton with flat button, 22-mm nominal diameter	3SB3 000-0AA11	1	
	Optional: "Start" designation plate	3SB3 906-1EL	1	
Q1 / Q2 contactor	Contactor, AC-3, 3 KW/400 V, 1NC, DC 24 V, 3-pole, size S00, screw terminal	3RT1015-1BB42	2	
Cable loom	PC configuration cable Transfer cable	3RK1901-5AA00	1	
AS-i shaped cable	Yellow rubberized cable	3RX9010-0AA00	1	

Note Functionality was tested with the hardware components listed above. Similar products not found in this list may also be used. If this is the case, please note that it may be necessary to change the example code (e.g. change the settings of other addresses).

Software Components

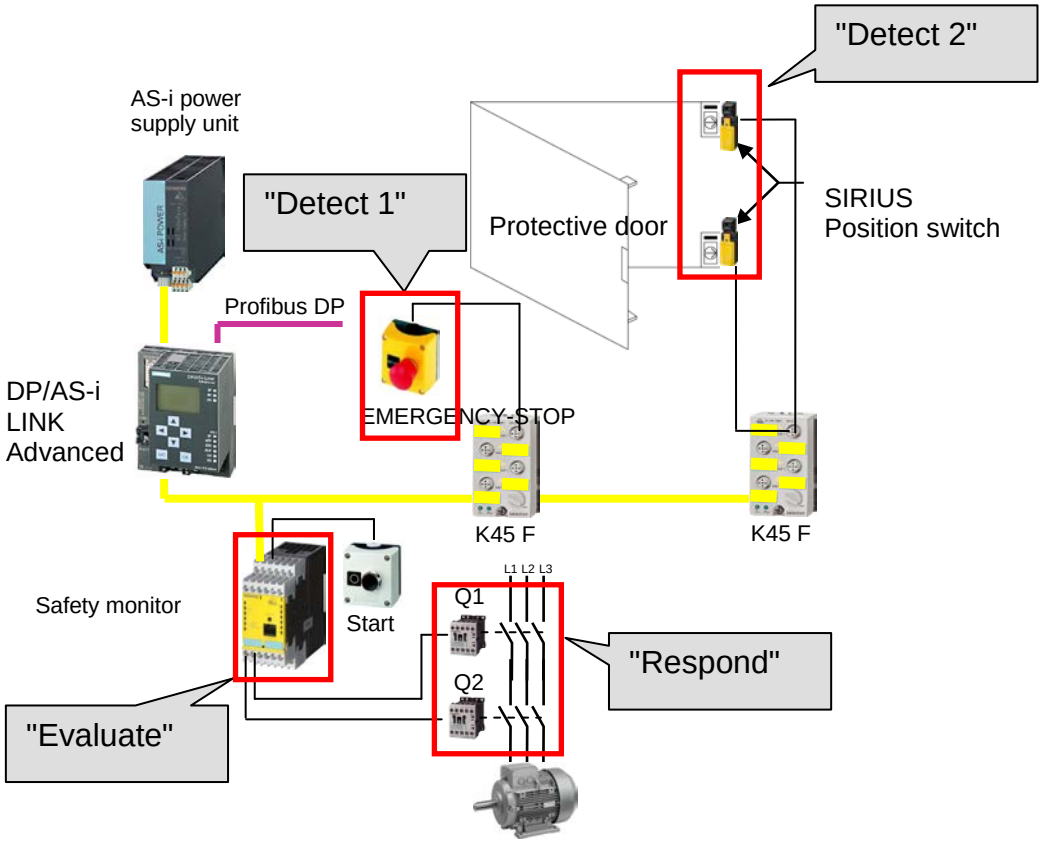
Table 3-2

Component	Type	Order No. / Order Information	Quantity	Manufacturer
asimon V3	Safety monitor configuration	3RK1802-2FB06-0GA1	1	SIEMENS

4. Assembly and Wiring

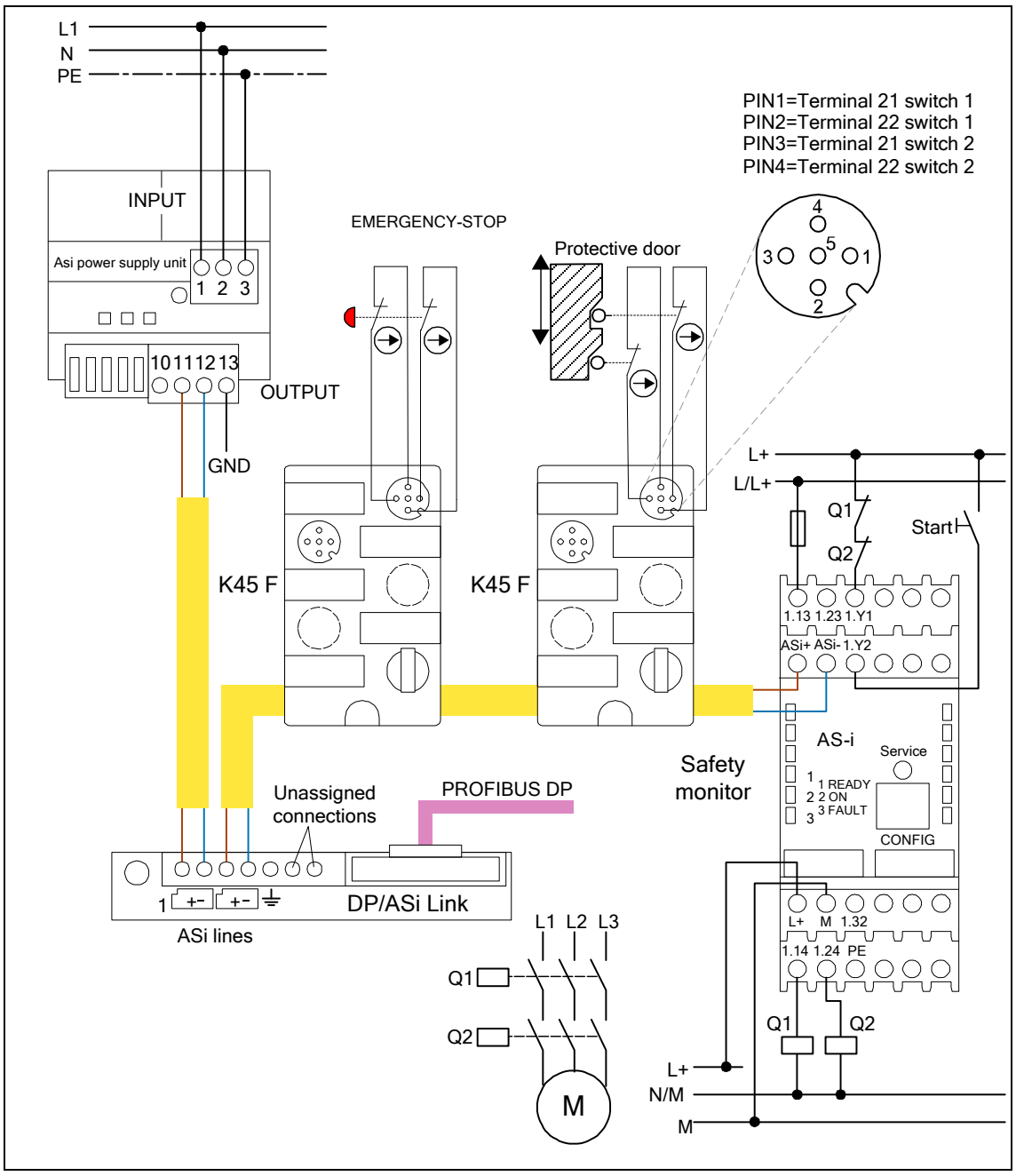
This chapter describes the hardware assembly and wiring of the Functional Example.

4.1 Overview of Hardware Setup



Note The actuators of the SIRIUS position switches must be protected against external impacts.

4.2 Hardware Component Wiring



4.3 Important Hardware Component Settings

DP/AS-i LINK Advanced

Prerequisites

- The DP/AS-INTERFACE LINK Advanced is mounted and connected to the AS-i line.
- The AS-i power supply unit is connected to the AS-i line.
- The AS-i slaves are not yet connected.
- The slaves that are to be connected have default address "0" (delivery status).

Procedure

Working on the DP/AS-INTERFACE LINK Advanced

1. Switch on the AS-i power supply unit so that the DP/AS-INTERFACE LINK Advanced is in operation
2. Connect each AS-i slave to the AS-i line and allocate each the desired slave address.
   (K45F module, address 1 or 2).

SYSTEM  ASI line 1  Lifelist  Change address 

Change slave address

3. Adopt the actual configuration of the slave as the defined configuration in the DP/AS-INTERFACE LINK Advanced

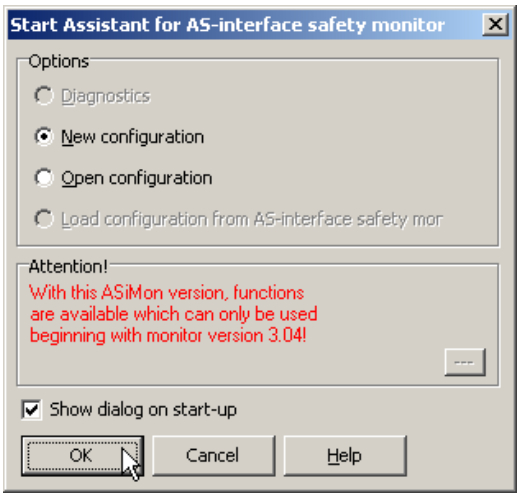
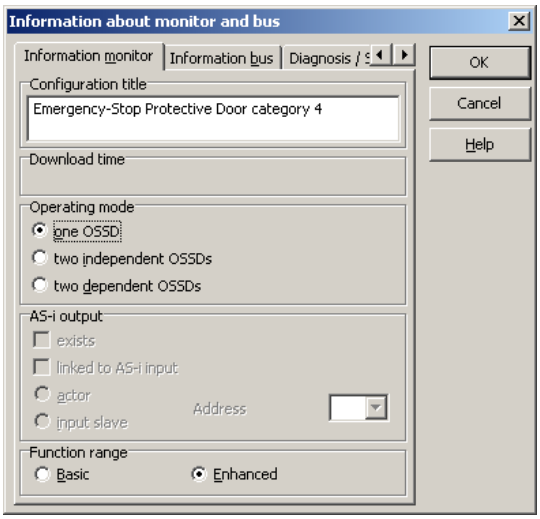
SYSTEM  AS-i line 1  Lifelist  Actual -> Defined 
Actual -> Adopt defined

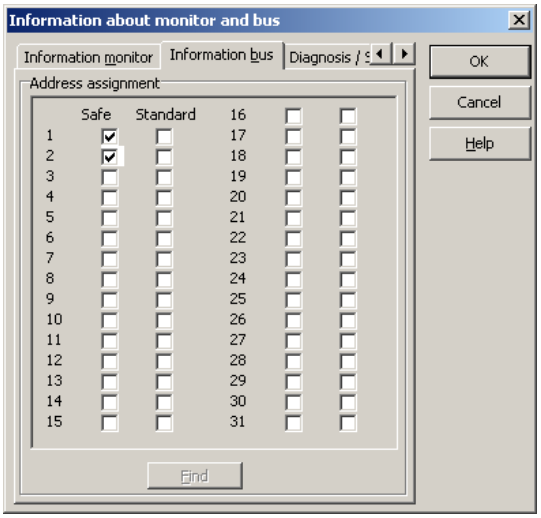
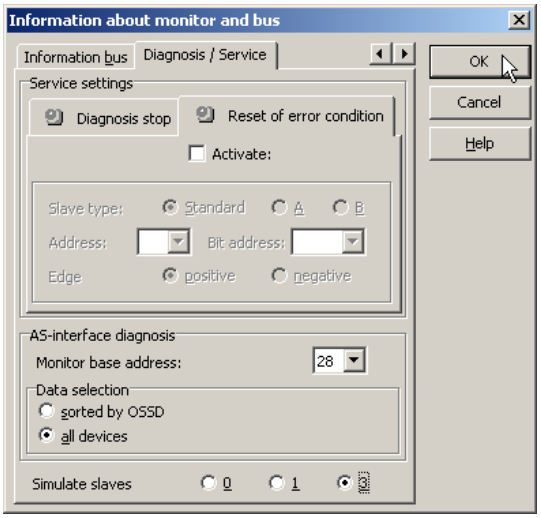
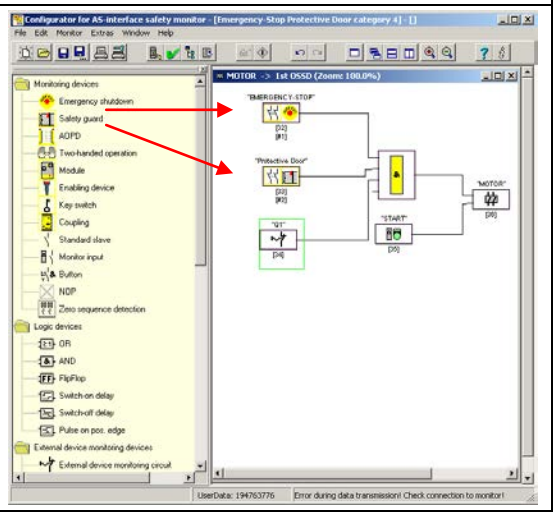
Result: All displays for the AS-i line on the DP/AS-INTERFACE LINK Advanced are off or green, i.e. all slaves have been successfully integrated.

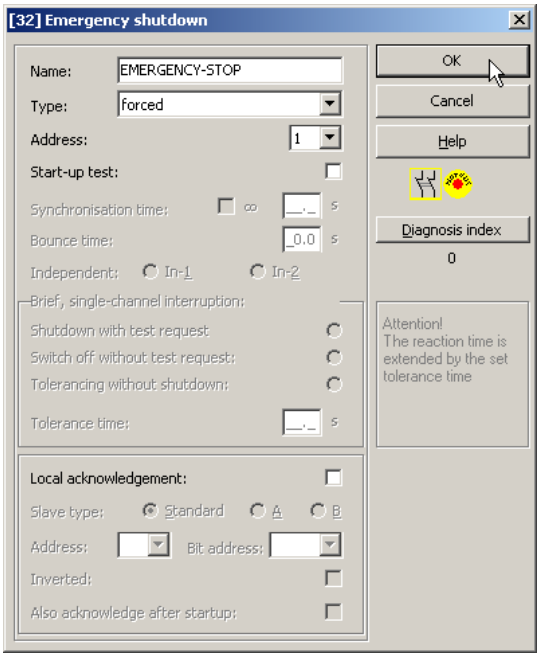
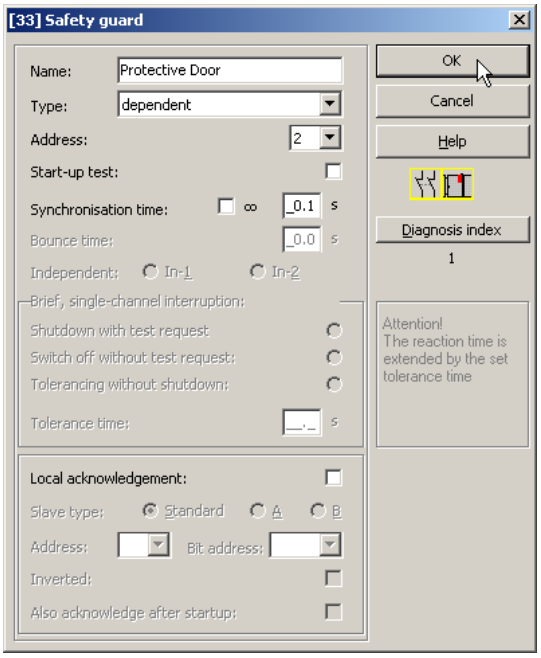
5. Example Code

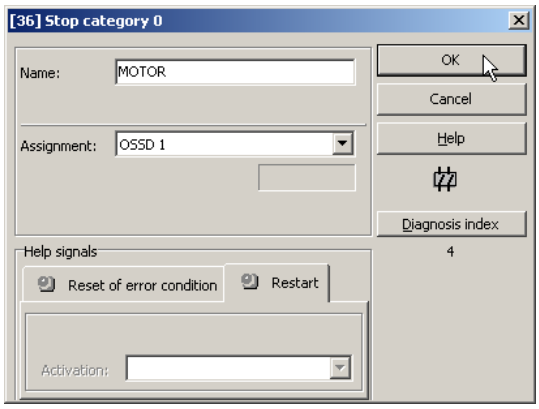
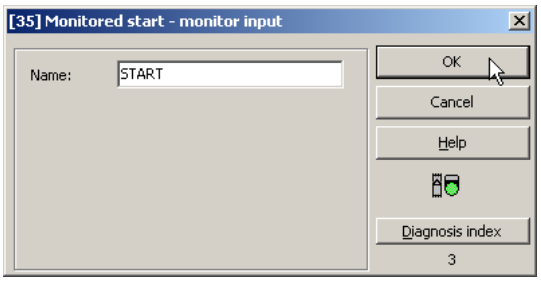
This chapter describes which functions are implemented and how the asimon program is structured.

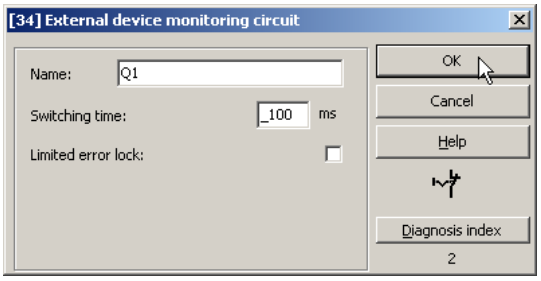
5.1 Description of the asimon Program

After the asimon software has been started, the start assistant is used to create a new safety monitor configuration.	
Enter a name for the configuration in the "Information monitor" tab, select the operating mode and the function range of the AS Interface safety monitor ("Basic" or "Enhanced").	

In the "Information bus" tab, you must enter the AS-Interface bus addresses of the standard slaves used and the safety-oriented AS-Interface slaves in this network.	
In the "Diagnosis / Service" tab you can adjust the settings for "Diagnosis stop" and "Reset of error condition" as well as configure the AS-Interface bus diagnosis. **Simulating slaves** If less than 4 safe or standard AS-Interface slaves are connected to the AS-Interface bus, you must activate the control box "Simulate slaves". At least 4 slave addresses must be activated to ensure that the AS-Interface safety monitor functions correctly.	
Configuration of an AS-Interface safety monitor with asimon software is graphic interactive, i.e. you can select and collectively configure the safe AS-Interface slaves that are to be monitored and further function devices from a symbol library that is classified according to devices (left window).	

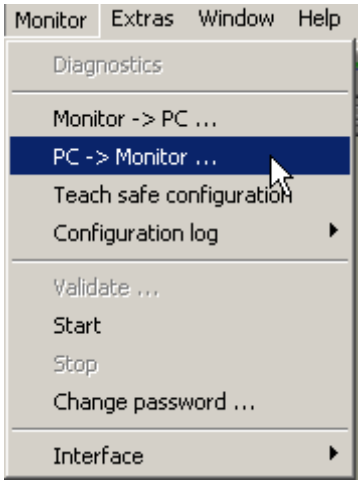
For the **forced** EMERGENCY-OFF monitoring device, the switching signal of the corresponding safe AS-Interface slave affects all 4 bits of the transfer sequence. As an option, a start-up test and/or a local acknowledgement can be carried out. When the control box "Always" is activated, a local acknowledgement must also always be carried out whenever the AS-Interface safety monitor is switched on or a communication error (warm restart of the AS-Interface safety monitor) occurs.	
For the **dependent** protective door monitoring device, each of the two switching signals of the corresponding save AS-Interface slave affects 2 bits of the transfer sequence. Both switching signals must be received within the synchronization time defined by the user. If only one contact opens, the second contact must also open before both contacts can be once again closed. As an option, a start-up test and/or a local acknowledgement can be carried out. When the control box "Always" is activated, a local acknowledgement must also always be carried out whenever the AS-Interface safety monitor is switched on or a communication error (warm restart of the AS-Interface safety monitor) occurs.	

When the circuit is enabled (ON), the signal output and the output circuit are simultaneously activated by the **Stop category 0** output device. When the circuit is switched off (OFF), the signal output and the output circuit are immediately switched off without a delay.	
The **Monitored start – monitor input** device requires activation of the start input of the corresponding OSSD as an additional start requirement. If the AND link of all the monitoring, linking and external device monitoring circuit devices of an OSSD delivers an ON result, and if the start requirements have been fulfilled, the "monitored start - monitor input" start device relays the enabling request to the output device.	

The contactor control input of the AS-Interface safety monitor must be active = ON as long as the safety outputs are switched off. After the safety outputs are switched on (enabled), the contactor control input is no longer relevant for the set switching time. Thereafter, the input must be inactive = OFF. The **external device monitoring circuit** device is active = ON (switched on). After the safety outputs have been switched off, the **external device monitoring circuit** device becomes inactive = OFF (switched off) and the contactor control input is no longer queried for the duration of the set switching time. Thereafter, the contactor control input is active = ON again. When the **external device monitoring circuit** is inactive = OFF, the safety outputs cannot be switched on again until the downstream contactor has reached its resting position. After switching on the AS-Interface safety monitor, the contactor control input must be active = ON.	

5.2 Commissioning the AS Interface Safety Monitor

Transferring a configuration to the AS Interface safety monitor



To transfer the current asimon configuration to the connected AS-Interface safety monitor, select the **Monitor** menu and then the **PC -> Monitor** command.

The configuration is then transferred to the AS-Interface safety monitor. Transfer takes several seconds.

After successful completion of the data transfer to the AS-Interface safety monitor, the configuration is saved in the AS-Interface safety monitor.

After transferring a configuration to a connected AS-Interface safety monitor, the safe configuration has to be "learned". To this end, the code tables of the safe AS-Interface slaves that are to be monitored are read in via the AS-Interface. The code table of each safe AS-Interface slave that is to be monitored is stored in the configuration log.

Learning the safe configuration

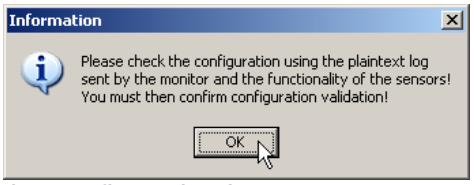
Before the safe configuration can be learned, the-AS Interface bus including all safe AS-Interface slaves that are to be monitored must be commissioned, and all safe AS-Interface slaves that are to be monitored must be switched ON. Only then can the AS-Interface safety monitor learn the code tables of all the relevant safe AS-Interface slaves.

To learn the code tables, select the "**Teach safe configuration**" in the Monitor menu and confirm the question "**Do you want to learn the code sequence?**" with **Yes**.

The code tables are then learned by the AS-Interface safety monitor. Learning takes several seconds. Progress is displayed in a window.

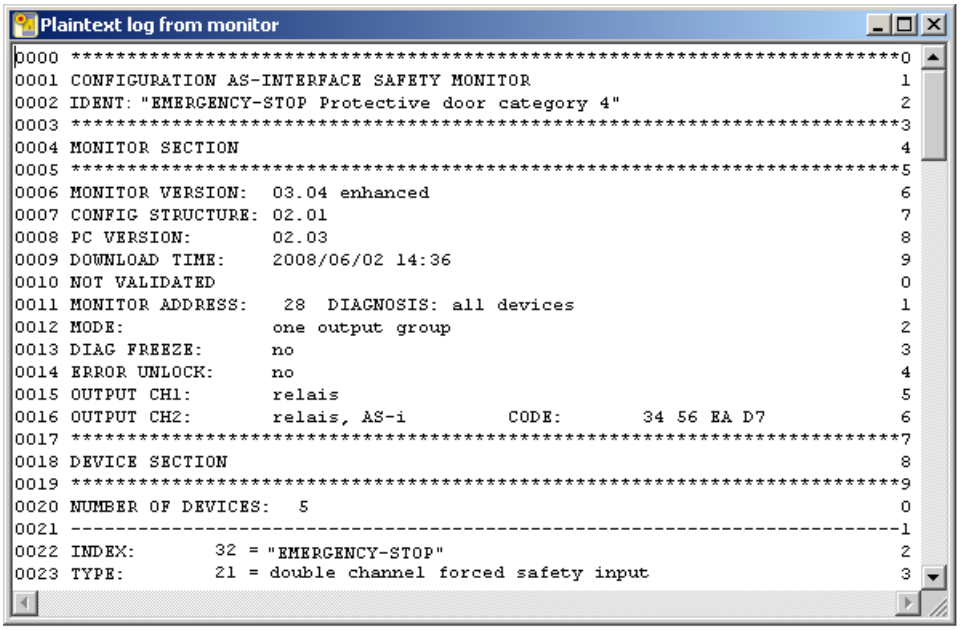
Once the code tables of all the safe AS-Interface slaves that are to be monitored have been successfully learned, a provisional configuration log will be immediately transferred to **asimon**.

The progress of the transfer of the provisional configuration log is displayed in a window.

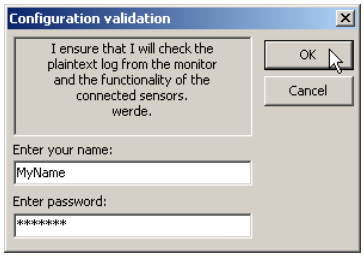


An information window will then prompt you to have the configuration checked by the safety appointee responsible for the application using the configuration log.

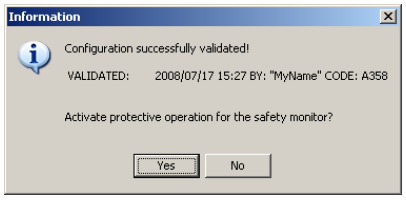
The provisional configuration log is displayed in **asimon** in its own window.



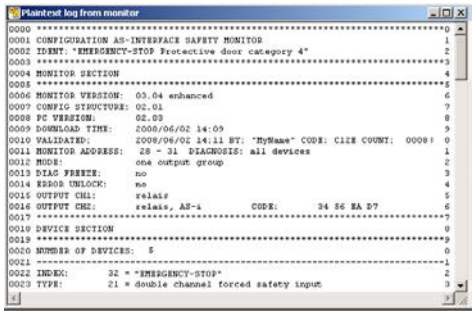
Configuration validation



To validate a configuration, select the **Validate** command in the **Monitor** menu. A window will appear in which you can validate a configuration by entering your name and password.



Confirm your entry with the "Yes" button. An information window will then confirm that the configuration has been successfully validated.



The configuration log will then be immediately transferred. Progress of the transfer of the final configuration log is displayed in a window.

The final configuration log is displayed in asimon in its own window. To illustrate that the configuration has been validated and to differentiate between a validated and a provisional configuration log, the validation information will be displayed in Line 10.

Starting the AS-Interface safety monitor

If a valid, validated configuration is available on the AS-Interface safety monitor, you can switch the AS-Interface safety monitor from configuration mode to protection mode via the **Start** command in the **Monitor** menu. After the protection mode has been started, the status line will indicate the change to the new operating mode.

6. Evaluation according to IEC 62061 and ISO 13849-1:2006

6.1 Safety Function

Comments

- Emergency-stop is not a means of risk mitigation.
- Emergency-stop is not a "safety function"
- Emergency-stop is a "supplementary safety function"

Further considerations are based on the following safety functions:

Supplementary safety function	
SF 1	The motor must be switched off when "Emergency-stop" is actuated.

Safety function	
SF 2	The motor must be switched off when the "Protective door" is opened.

The safety functions listed above are evaluated below according to the two standards IEC 62061 and ISO 13849-1:2006.

6.2 Evaluation of Safety Function 1

6.2.1 Evaluation according to IEC 62061

Parameters for the calculation of PFH_D for "Detection1" (Emergency-stop) and "Responding" (Contactor)

Parameter	Value	Reason	Definition
B10 Emergency-stop Contactor	$1 * 10^5$ $1 * 10^6$	Manufacturer specifications	Siemens
Proportion of hazardous failures Emergency-stop Contactor	0.2 0.73	Manufacturer specifications (20%) (73%)	
T1 Service life	175,200 hrs (20 years)	Manufacturer specifications	
C Number of emergency-stop operations Number of operations of contactors	$6 * 10^{-3}$ /hr 0.125/hrs	Assumptions: Actuated once per week (7 * 24 hours) (Test Emergency Stop). Actuated once per shift, i.e. every 8 hours. Actuation takes place every day of the year (365 days)	User
T2 Diagnostics test interval Emergency-stop Diagnostics test interval contactor	168hrs 8hrs	When the emergency stop is actuated, a defective contact is detected in the safety monitor. An actuation takes place every week (7 * 24 hours) (see "**C**"). When actuated, a defective contactor is detected in the safety monitor. An actuation takes place once per shift, i.e. every 8 hours (see "**C**").	
β (CCF Factor) Prone to failures due to common cause	0.1	If installed according to IEC 62061, a CCF factor of 0.1 (10%) can be assumed. With this value the user errs on the side of safety ("conservative value").	
DC Degree of diagnostic coverage	0.99 (99%)	Discrepancy evaluation at emergency stop; Evaluation of read-back signals (positively driven contacts) of both contactors	

Evaluation parameter

Parameter	Component	Value	Definition
PFH_D	Safety monitor	$9.60 * 10^{-09}$	Siemens

Results

	IEC 62061			
	SILCL		PFH_D	
Detect	3	Hardware error tolerance: HFT = 1 Proportion of safe failures: SFF ≥ 0.99 (99%)	$1{,}19 * 10^{-10}$	Architecture: Basic sub-system architecture D
Evaluate	3	Manufacturer specifications	$9.60 * 10^{-09}$	Manufacturer specifications
Respond	3	Hardware error tolerance: HFT = 1 Proportion of safe failures: SFF ≥ 0.99 (99%)	$9.12 * 10^{-10}$	Architecture: Basic sub-system architecture D
Results	3	SILCL of all tasks of the supplementary safety function is at least 3. PFH_D (= $1.06* 10^{-08}$) of the entire supplementary safety function fulfilled SIL 3.		

6.2.2 Evaluation according to ISO 13849-1:2006

Parameters for the calculation of $MTTF_d$ for "Detection 1" (Emergency stop) and "Responding" (Contactor)

Parameter	Value	Reason	Definition
B10 Emergency-stop Contactor	 $1 * 10^5$ $1 * 10^6$	Manufacturer specifications	Siemens
Proportion of hazardous failures Emergency-stop Contactor	 0.2 0.73	Manufacturer specifications (20%) (73%)	
d_{op} Mean operating time in days per year	365 days per year	Assumption: Actuation takes place every day of the year	User
h_{op} Mean operating time in hours per day	24 hours per day		
t_{Cycle} Mean time between the start of two consecutive cycles of the component Emergency-stop Contactor	 168 hrs/cycle 8 hrs/cycle	Assumption: There is an interval of one week between actuations of the Emergency Stop (Emergency Stop test) (7 * 24 hours) There is an interval of 8 hours between actuations of the contactors (one shift)	

Interim results (are identical in this example for emergency stop and contactor):

Interim results		Reason
$MTTF_d$	High	$MTTF_d$ ≥30 years
DC	High	DC=99% Discrepancy evaluation for emergency stop; evaluation of read-back signals (positively driven contacts) of both contactors
Measures against CCF	Fulfilled	It is assumed that the necessary measures are taken by the user.
Category	4	System behavior: A single fault does not cause the loss of the safety function. The single fault is detected. $MTTF_d$: High, DC: High, measures against CCF: Fulfilled

Evaluation parameter

Parameter	Component	Value	Definition
PFH_D	Safety monitor	$9.60 * 10^{-09}$	Siemens

Results

	ISO 13849-1:2006	
	PL	**PFH_D**
Detect	e	$2.47 * 10^{-08}$ (from Annex K; see note)
Evaluate	e	$9.60 * 10^{-09}$
Respond	e	$2.47 * 10^{-08}$ (from Annex K; see note)
Results	e	PL of all tasks of the supplementary safety function is at least e. Number of tasks is less than or equal to 3.

Note: The $MTTF_d$ for each channel is limited to max. 100 years!

6.2.3 Summary of Safety Function 1

	IEC 62061		ISO 13849-1:2006	
	SILCL	**PFH_D**	**PL**	**PFH_D**
Detect	3	$1.19 * 10^{-10}$	e	$2.47 * 10^{-08}$
Evaluate	3	$9.60 * 10^{-09}$	e	$9.60 * 10^{-09}$
Respond	3	$9.12 * 10^{-10}$	e	$2.47 * 10^{-08}$

Results	SIL 3	PL e

6.3 Evaluation of Safety Function 2

6.3.1 Evaluation according to IEC 62061

Parameters for the calculation of PFH_D for "Detection 2" (Position switch) and "Responding" Contactor)

Parameter	Value	Reason	Definition
B10 Position switches Contactor	 $1 * 10^6$ $1 * 10^6$	Manufacturer specifications	Siemens
Proportion of hazardous failures Position switches Contactor	 0.2 0.73	Manufacturer specifications (20%) (73%)	
T1 Service life	175,200 hrs (20 years)	Manufacturer specifications	
C Number of actuations of position switches Number of operations of contactors	0.125/hrs 0.125/hrs	Assumptions: Actuated once per shift, i.e. every 8 hours. Actuation takes place every day of the year (365 days)	User
T2 Diagnostics test interval position switches Diagnostics test interval contactor	8hrs 8hrs	When the protective door is opened, a defective contact is detected in the safety monitor. An actuation takes place once per shift, i.e. every 8 hours (see "**C**"). When actuated, a defective contactor is detected in the safety monitor. An actuation takes place once per shift, i.e. every 8 hours (see "**C**").	
β (CCF Factor) Prone to failures due to common cause	0.1	If installed according to IEC 62061, a CCF factor of 0.1 (10%) can be assumed. With this value the user errs on the side of safety ("conservative value").	
DC Degree of diagnostic coverage	0.99 (99%)	Discrepancy evaluation for position switches; Evaluation of read-back signals (positively driven contacts) of both contactors	

Evaluation parameter

Parameter	Component	Value	Definition
PFH_D (asimon)	Safety monitor	$9.60 * 10^{-09}$	Siemens

Results

	IEC 62061			
	SILCL		PFH_D	
Detect	3	Hardware error tolerance: HFT = 1 Proportion of safe failures: SFF ≥ 0.99 (99%)	$1.37 * 10^{-10}$	Architecture: Basic sub-system architecture D
Evaluate	3	Manufacturer specifications	$9.60 * 10^{-09}$	Manufacturer specifications
Respond	3	Hardware error tolerance: HFT = 1 Proportion of safe failures: SFF ≥ 0.99 (99%)	$9.12 * 10^{-10}$	Architecture: Basic sub-system architecture D
Results	3	SILCL of all tasks of the safety function is at least 3. PFH_D (= $1.06 * 10^{-08}$) of the entire supplementary safety function fulfilled SIL 3.		

6.3.2 Evaluation according to ISO 13849-1:2006

Parameters for the calculation of $MTTF_d$ for "Detection 2" (Position switch) and "Responding" Contactor)

Parameter	Value	Reason	Definition
B10 Position switches Contactor	 $1 * 10^6$ $1 * 10^6$	Manufacturer specifications	Siemens
Proportion of hazardous failures Position switches Contactor	 0.2 0.73	Manufacturer specifications (20%) (73%)	
d_{op} Mean operating time in days per year	365 days per year	Assumption: Actuation takes place every day of the year	User
h_{op} Mean operating time in hours per day	24 hours per day		
t_{Cycle} Mean time between the start of two consecutive cycles of the component position switches Contactor	 8 hrs/cycle 8 hrs/cycle	Assumption: There is an interval of 8 hours between each protective door opening/contactor actuation (one shift)	

Interim results (are identical in this example for the position switch and the contactor):

Interim results		Reason
$MTTF_d$	High	$MTTF_d$ ≥30 years
DC	High	DC=99% Discrepancy evaluation for position switches; evaluation of read-back signals (positively driven contacts) of both contactors
Measures against CCF	Fulfilled	It is assumed that the necessary measures are taken by the user.
Category	4	System behavior: A single fault does not cause the loss of the safety function. The single fault is detected. $MTTF_d$: High, DC: High, measures against CCF: Fulfilled

Evaluation parameter

Parameter	Component	Value	Definition
PFH_D (asimon)	Safety monitor	$9.60 * 10^{-09}$	Siemens

Results

	ISO 13849-1:2006	
	PL	**PFH_D**
Detect	e	$2.47 * 10^{-08}$ (from Annex K; see note)
Evaluate	e	$9.60 * 10^{-09}$
Respond	e	$2.47 * 10^{-08}$ (from Annex K; see note)
Results	e	PL of all tasks of the safety function is at least e. Number of tasks is less than or equal to 3.

Note: The $MTTF_d$ for each channel is limited to max. 100 years!

6.3.3 Summary of Safety Function 2

	IEC 62061		ISO 13849-1:2006	
	SILCL	**PFH_D**	**PL**	**PFH_D**
Detect	3	$1.37 * 10^{-10}$	e	$2.47 * 10^{-08}$
Evaluate	3	$9.60 * 10^{-09}$	e	$9.60 * 10^{-09}$
Respond	3	$9.12 * 10^{-10}$	e	$2.47 * 10^{-08}$

Results	SIL 3	PL e

7. Contact

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8. History

Table 0-1 History

Version	Date	Change
V1.0	09.08.2006	First issue
V2.0	23.07.2008	- Update of the order numbers of the position switches - Revision of the hardware configuration overview - New chapter: Evaluation according to IEC 62061 and ISO 13849-1 - Update of the screenshots in chapter 5
V3.0	13.09.2013	- Revision of title and description of functionality - Adjustment of Proportion of hazardous failures for contactors to 73% and resulting PFH_D values - Adjustment of PFH_D value of Safety monitor to 9.60 * 10^{-09}