OPERATING INSTRUCTIONS

Safe Interlocking

Functional safety system

SICK
Sensor Intelligence.

Described product

Safe Interlocking

Manufacturer

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Legal information

Original document

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Contents

1 About this document 5
1.1 Purpose of this document 5
1.2 Scope 5
1.3 Target groups and structure of these operating instructions 5
1.4 Symbols and document conventions 6
1.5 Further information 6

2 Safety information 7
2.1 General safety note 7
2.2 Intended use 7
2.3 Requirements for the qualification of personnel 7
2.4 Safe state 8

3 Product description 9
3.1 Product identification 9
3.2 Application description 9
3.3 Components 10
3.4 Components 10
3.5 Structure and function 11
3.6 Product characteristics 12
3.7 The limits of the functional safety system 12

4 Project planning 13
4.1 Manufacturer of the machine 13
4.2 Operating entity of the machine 14
4.3 Safety Functions 14
4.4 Design 16
4.5 Integrating into the electrical control 16
4.6 Testing plan 18

5 Mounting 19

6 Electrical installation 20

7 Configuration 21
7.1 Requirements on software and firmware 21
7.2 Pre-configured project files 21
7.3 Opening project file 21
7.4 Configuring motion control module element settings 22
7.5 Configuring logics for Flexi Soft CPU 22
7.6 Configuring logics for motion control module 23
7.7 Transfer configuration 24

8 Commissioning 25
8.1 Safety 25

8.2 Thorough check 25

9 Maintenance 26

10 Troubleshooting 27

11 Operation 28

12 Technical data 29
12.1 Data sheet 29
12.2 Response times 29

13 Ordering information 30
13.1 Scope of delivery 30
13.2 Safe Interlocking ordering information 30

14 Spare parts 32
14.1 Safety encoder 32
14.2 Additional spare parts 32

15 Accessories 33
15.1 Connectivity 33
15.2 Actuator 33
15.3 Mounting bracket 33

16 Annex 34
16.1 Checklist for initial commissioning and commissioning 34

1 About this document

1.1 Purpose of this document

These operating instructions contain the information required during the life cycle of the functional safety system. This document describes:

- The individual components
- The project planning
- The mounting and electrical installation, provided these are necessary for the functional safety system
- The configuration
- The necessary thorough checks
- The commissioning
- The maintenance
- The troubleshooting

1.2 Scope

These operating instructions contain information regarding the Safe Interlocking functional safety system.

NOTICE

The operating instructions of the components also apply. In the event of contradictions between the operating instructions, the information specified in the operating instructions for the functional safety system apply.

The relevant information must be made available to the employees for all work performed on the functional safety system.

The following documents contain information regarding the Safe Interlocking functional safety system:

Table 1: Documents available for Safe Interlocking

Document type	Title	Part number
Operating instructions	RE1, RE2	8015580
Operating instructions	TR10 Lock	8019930
Operating instructions	Flexi Soft Modular Safety Controller Hardware	8012999
Operating instructions	Flexi Soft in the Flexi Soft Designer software	8012998
Operating instructions	DFS60S Pro	8016866

This document is included with the following SICK part numbers (this document in all available language versions):

8020817

1.3 Target groups and structure of these operating instructions

These operating instructions are intended for the following target groups: project developers (planners, developers, designers), installers, electricians, operators, and maintenance personnel.

The structure of these operating instructions is based on the life cycle phases of the functional safety system: project planning, mounting, electrical installation, commissioning, operation and maintenance.

1.4 Symbols and document conventions

The following symbols and conventions are used in this document:

Safety notes and other notes

DANGER
Indicates a situation presenting imminent danger, which will lead to death or serious injuries if not prevented.

WARNING
Indicates a situation presenting possible danger, which may lead to death or serious injuries if not prevented.

CAUTION
Indicates a situation presenting possible danger, which may lead to moderate or minor injuries if not prevented.

NOTICE
Indicates a situation presenting possible danger, which may lead to property damage if not prevented.

NOTE
Indicates useful tips and recommendations.

Instructions to action

▶ The arrow denotes instructions to action.

1. The sequence of instructions for action is numbered.
2. Follow the order in which the numbered instructions are given.

✓ The check mark denotes the result of an instruction.

1.5 Further information

www.sick.com

The following information is available via the Internet:

- This document in other languages
- Operating instructions and installation instructions of suitable SICK components for the functional safety system
- The Flexi Soft Designer configuration software
- Pre-configured project file for Flexi Soft Designer for this functional safety system
- Pre-configured project file for SISTEMA for this functional safety system
- Circuit diagram for the functional safety system (ePLAN)
- Guide for Safe Machinery (“Six steps to a safe machine”)

2 Safety information

2.1 General safety note

The information and tools will not fulfill the safety requirements for your application without further adjustments being made. The project planning provided by way of example is intended to serve as the basis to allow you to perform your own project planning and programming in line with your specific requirements. What this means is that the information and tools merely provide an example to demonstrate how a safety function can be taken care of.

When it comes to your own project planning and programming, you will need to rely on qualified staff given that it is your responsibility to ensure that the following requirements are complied with at the very least:

- Carrying out a risk assessment
- Taking into account applicable standards
- Verifying and validating the safety function

2.2 Intended use

The Safe Interlocking functional safety system is used in machines for which all the following features apply:

- The dangerous state is caused by a rotational movement
- The separation of man and machine by a physical guard (e.g. a fence) is the primary safety concept
- Access to dangerous areas is only possible through a movable physical guard (e.g. door)

NOTE
The components in the scope of delivery of all Safe Interlocking variants make it possible to protect a movable physical guard. If access to the hazardous area is no longer possible due to more than one movable physical guard, additional components and measures are needed. This case will not be considered further in this document.

Safe Interlocking is used to protect persons.

2.3 Requirements for the qualification of personnel

The protective device must be configured, installed, connected, commissioned, and serviced by qualified safety personnel only.

Project planning

For project planning, a person is considered competent when he/she has expertise and experience in the selection and use of protective devices on machines and is familiar with the relevant technical rules and national work safety regulations.

Mechanical mounting, electrical installation, and commissioning

For the task, a person is considered qualified when he/she has the expertise and experience in the relevant field and is sufficiently familiar with the application of the protective device on the machine to be able to assess whether it is in an operationally safe state.

Operation and maintenance

For operation and maintenance, a person is considered competent when he/she has the expertise and experience in the relevant field and is sufficiently familiar with the application of the protective device on the machine and has been instructed by the machine operator in its operation.

2.4 Safe state

In the safe state, the accordingly configured safe switching outputs are in the off state. The machine is and remains switched off. The safe state is initiated in the following cases:

- Door open
- Emergency stop pushbutton has been activated
- Connection between at least one sensor and the safety controller has been interrupted
- Voltage supply of at least one sensor or the SICK safety controller has been interrupted
- Internal error diagnosed on at least one sensor
- Internal error diagnosed on the safety controller or on one of its components

3 Product description

3.1 Product identification

The part number of the functional safety system is located on the packaging.

3.2 Application description

The Safe Interlocking functional safety system is used on stationary machines to reduce the risk that a machine movement could injure someone.

The functional safety system is used to safely enter the closed-off hazardous area around the machine. It ensures that the machine stops before access to the closed-off hazardous area becomes possible. Alternatively, access to the hazardous area can also become possible if the machine is put into a defined safe state (e.g. maintenance mode with limited speed).

If the machine stops, unexpected restart is prevented. Not until access to the hazardous area is closed and locked and the machine has been reset can the machine be restarted. An emergency switching off function is also integrated.

Figure 1: Overview of Safe Interlocking

3.3 Components

Components of Safe Interlocking

- DFS60S Pro safety encoder in different variants (see "Safe Interlocking ordering information", page 30)
- Flexi Soft safety controller main module
- Flexi Soft safety controller expansion module - I/O module (8 inputs, 4 outputs)
- Flexi Soft safety controller expansion module - I/O module (8 inputs)
- Flexi Soft safety controller expansion module - motion control module (Flexi Soft Drive Monitor)
- Flexi Soft safety controller system plug
- RE2 safety switch
- TR10 Lock safety locking device

Implementing all the safety functions for the application requires a complete system consisting of sensors, a controller, actuators, and control switches. This functional safety system comprises sensors and a controller only and is therefore only a subsystem. The user is responsible for the safe design of the complete system and all safety functions.

3.4 Components

The following components are also absolutely mandatory for using the Safe Interlocking functional safety system in an application:

- Drive with electronic STO function (integrated or via external relay)
- Safety relay (only for drives in which the integrated electronic STO function is **not** triggered by a decrease in the 24 V signal)
- Emergency stop pushbutton
- Reset pushbutton
- Physical guard (e.g. fence) with movable physical guard (e.g. door)

The following components are only needed if the respective signals cannot or should not be provided by the superordinate control.

- Restart button for starting the machine
- Pushbutton for unlocking the movable physical guard

NOTE

All necessary components influence the parameters of the entire application that relate to safety technology. The components must therefore have an $MTTF_d$ value suitable for the entire application and satisfy the necessary performance level. The necessary performance level results from the risk assessment. The SISTEMA project file available in the Internet can be used to calculate the performance level.

3.4.1 Drive

The drive must feature an integrated STO function. Ideally, the STO function of the drive is triggered via a 24 V signal.

The drive parameters regarding safety technology influence the performance level of the safety functions. The drive must be selected so that the calculation of the performance level of the safety functions results in performance level PL d.

3.4.2 Safety relay

A safety relay is only necessary if the STO function of the monitored drive is **not** triggered via a single-channel 24 V signal.

If necessary, select the safety relay so that a single-channel 24 V signal triggers a respective signal for the STO function of the drive. Suitable safety relays are available from SICK.

3.4.3 Emergency stop pushbutton

An emergency stop pushbutton with 2 positive opening normally closed contacts are necessary.

The functional safety system tests the connected emergency stop pushbutton for cross- and short-circuits, and also for discrepancy and sequence errors.

The emergency stop pushbutton must be designed in accordance with the following standards:

- ISO 13850
- IEC 60204

3.4.4 Reset pushbutton

The reset pushbutton must be designed in accordance with the following standard:

- EN 60204

3.4.5 Restart button

The restart button must be designed in accordance with the following standard:

- EN 60204

The signal for the restart can optionally come from a superordinate machine controller.

3.4.6 Physical guard

The requirements on the physical guard and the movable physical guard are not part of the functional safety system. They must be defined by the manufacturer during risk assessment.

In addition to the C standards applicable for the application, the following standards contain information on designing physical guards:

- EN ISO 14120
- EN ISO 13857

3.5 Structure and function

The safety encoder detects the movement status of the machine. If the machine is moving, the movable physical guard of the safety locking device is locked. If the machine is not moving, the safety locking device unlocks on request and access to the hazardous area becomes possible.

If the movable physical guard is opened, the machine is permanently switched off by the safety switch signal and cannot restart on its own.

As soon as all work in the hazardous area is complete and the movable physical guard is closed, the machine can be restarted using the reset pushbutton and the restart button.

A stop command can be triggered manually in every operational status.

3.6 Product characteristics

3.6.1 Variants

The functional safety system is delivered in different variants. You will find an overview of important distinguishing features of the variants in the following.

- Safety encoder in various variants for shafts with different mechanical designs (see "Safe Interlocking ordering information", page 30)

3.7 The limits of the functional safety system

The functional safety system ends at all inputs and outputs that are not used to wire the components of the functional safety system.

The limits of the functional safety system are presented in abstract and general terms in the figure below:

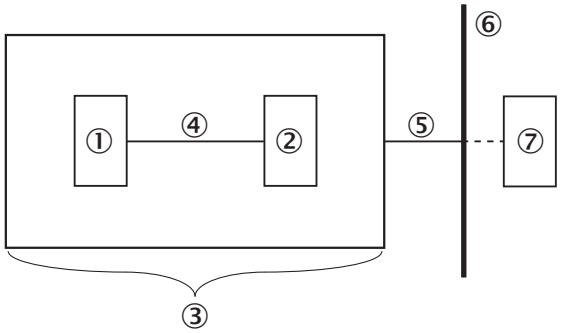

Figure 2: The limits of the functional safety system

① Sensors
② Logic (safety relay or safety controller)
③ Functional safety system
④ Wiring between sensors and logic
⑤ Wiring between functional safety system components and components outside the functional safety system
⑥ Limit of the functional safety system
⑦ Components outside the functional safety system, e.g., actuators, safety capable input devices, or higher-level controller

4 Project planning

4.1 Manufacturer of the machine

DANGER
Hazard due to lack of effectiveness of the protective device

In the case of non-compliance, it is possible that the dangerous state of the machine may not be stopped or not stopped in a timely manner.

- Use of the functional safety system requires a risk assessment. Check whether additional protective measures are required.
- Comply with the applicable national regulations derived from the application (e.g., work safety regulations, safety rules, or other relevant safety guidelines).

The functional safety system was developed under consideration of typical application cases. A partial safety function can be implemented with the functional safety system in these application cases. The manufacturer must check whether the functional safety system is suitable for its specific application case (risk assessment).

If the thorough check shows that the functional safety system is not suitable for the specific application case, the functional safety system can be used as a basis for an individualized development suitable for the specific application case. This case will not be considered further in this document.

In any event, additional work is necessary for the functional safety system to be used, e.g. subsequent configuration of the safety controller.

The manufacturer has the following duties:

- Executing a risk assessment.
- Verifying and validating the safety functions.
- Integrating the individual components in accordance with the appropriate standards.
- Considering that C standards have priority compared to statements about this functional safety system.

4.1.1 Calculation of the performance level

The performance level can be calculated with the SISTEMA file which is available in the Internet for this functional safety system.

The manufacturer of the machine must decide which measures must be taken against failures with the same cause. These measures must be selected in the SIMSTEMA file for each user-defined sub-system.

In addition, the correct values for the value must be filled out for the components which are not part of the scope of delivery.

4.2 Operating entity of the machine

DANGER
Hazard due to lack of effectiveness of the protective device

In the case of non-compliance, it is possible that the dangerous state of the machine may not be stopped or not stopped in a timely manner.

- Changes to the electrical integration of the functional safety system in the machine control and changes to the mechanical mounting of the functional safety system necessitate a new risk assessment. The results of this risk assessment may require the operating entity of the machine to meet a manufacturer's obligations.
- Changes to the functional safety system's configuration may impair the protective function. The effectiveness of the functional safety system must be checked after any change to the configuration. The person carrying out the change is also responsible for maintaining the protective function of the functional safety system.

4.3 Safety Functions

4.3.1 Avoiding unexpected start-up

If a protective device has issued a stop command, the stop state shall be maintained until a manual reset device is activated and the machine can subsequently be restarted.

This safety function consists of the following sub-functions:

- Start-up due to an internal error of the safety controller is prevented
- Start-up due to an external influence on the safety controller is prevented
- Start-up due to a respective signal at an incorrect time is prevented
- Start-up due to internal or external influences on parts of the machine is prevented

Table 2: Avoiding unexpected start-up

Trigger	Valid reset sequence
Condition	All affected safety devices are active
Reaction	Safe operating stop (SOS) until a valid reset sequence is performed
Safe state	No dangerous movement

Table 3: Expected frequency of requesting the safety function

520 times per year	Triggering a stop by opening the movable physical guard (10 times per week, e.g. for maintenance work)
260 times per year	Switching off the machine (e.g. at night)
52 times per year	Triggering a stop by unlocking the safety locking device without then opening the door
1 time per year	Switching off the machine due to an emergency
Total	
833 times per year	Requesting the safety function

4.3.2 Initiating a stop

A safety-related stop function places the machine in a safe state on demand (e.g., opening of the movable physical guard).

This safety function consists of the following sub-functions:

- The dangerous movement is monitored
- The state of the movable physical guard is monitored
- The state of the external devices connected per external device monitoring (EDM) is monitored

Table 4: Initiating a stop

Trigger	Opening or unlocking the movable physical guard
Condition	No stop
Reaction	If the machine stops, a safe operating stop (SOS) is triggered. If the machine does not stop or the drive is moving, the STO function of the drive is triggered.
Safe state	No dangerous movement

Table 5: Expected frequency of requesting the safety function

260 times per year	Switching off the machine (e.g. at night)
1 time per year	Machine moves although the movable physical guard is open.
1 time per year	Switching off the machine due to an emergency
Total	
262 times per year	Requesting the safety function

4.3.3 Temporarily preventing access

Access to a hazardous point is prevented until the machine is in a safe state.

This safety function consists of the following sub-functions:

- The dangerous movement of the machine cannot occur until the movable physical guard is closed and locked
- The movable physical guard remains closed and locked until the dangerous movement comes to a stop
- If the movable physical guard is closed and locked, this does not automatically lead to the machine starting

Table 6: Temporarily preventing access

Trigger	–
Condition	Idle
Reaction	The movable physical guard is locked before a dangerous movement occurs. The movable physical guard remains locked as long as the dangerous movement has not stopped.
Safe state	No dangerous movement

4.3.4 Emergency stop

Emergency stop is a complementary protective measure; it is not a primary means of reducing risk.

The safety function is available at all times and has priority before other functions. Stopping in the event of an emergency must be designed as follows:

- At the time of triggering, the dangerous movements and states of the machine are ended in an appropriate manner
- Aside from triggering the emergency stop function, no other action is needed from a person to create a safe status
- No additional dangers are created when ending the dangerous movement and statuses

Table 7: Emergency stop

Trigger	Emergency stop pushbutton is activated.
Condition	At any time
Reaction	Stopping in the event of an emergency after a safe stop 1 (SS1) begins and monitors the slowing down of the drive within set limits in order to stop the drive. If the speed falls below a defined limit, the STO function of the drive is triggered. Additionally, the optional output for a safety brake is switched off.
Safe state	No dangerous movement

4.4 Design

The constructional integration of the individual components is done in accordance with the respective operating instructions. Also be aware of the following:

- Mount the RE2 safety switch on the movable physical guard so that the actuator is only detected when the movable physical guard is closed
- Mount the TR10 Lock safety locking device on the movable physical guard so that the movable physical guard can be locked in the closed state
- Mount the DFS60S Pro safety encoder on the drive shaft of the machine to be protected
  If mounting directly on the drive shaft is not possible, then mount the safety encoder on a shaft which rotates in a fixed transmission ratio to the drive shaft. If the drive does not rotate but instead moves in a linear manner, then mount the safety encoder on a shaft whose rotation is in a fixed relation to the linear movement of the drive.
- The reset pushbutton must be attached outside of the hazardous area. The entire hazardous area must be highly visible for all operators from the reset pushbutton. If the hazardous area is not completely visible, then a special reset procedure is necessary. This special reset procedure must ensure that no person or body parts are situated inside the hazardous area before the machine is reset.
- An emergency stop pushbutton must be available at every operating station. In addition, an emergency stop pushbutton must be available anywhere it could foreseeably be necessary to trigger an emergency stop.

NOTE
Up to 2 additional emergency stop pushbuttons can be connected to the Flexi Soft safety controller. If 4 or more emergency stop pushbuttons are to be connected, the Flexi Soft safety controller must be expanded with additional I/O modules.

4.5 Integrating into the electrical control

NOTE
Several safety functions are generally necessary in order to ensure a safe design for the entire application. This requires additional components that are not part of the functional safety system, such as switches, fuses, and contactors. The circuit diagrams contain information on wiring the functional safety system with additional components within an application.

NOTE
The components in the scope of delivery of all Safe Interlocking variants make it possible to protect a movable physical guard. If access to the hazardous area is no longer possible due to more than one movable physical guard, additional components and measures are needed. This case will not be considered further in this document.

4.5.1 Inputs and outputs of the safety controller

Table 8: Inputs and outputs of the safety controller

Designation	Meaning	Function
Q1	Initiating a stop	The LOW signal level requests that the superordinate control stop the machine.
Q2	STO	Signal level LOW interrupts the voltage supply of the drive.
Q3	Brake	Signal level LOW triggers the brake function. The use of a brake is optional.
I5	Unlocking protective device	Signal level HIGH requests the movable physical guard be opened. The signal can be generated from a pushbutton or a superordinate control. This signal does not generate a machine stop. If the machine is in a safe state, then the safety locking device unlocks. In all other cases, the signal does not have an effect.

4.5.2 Circuit diagram

A detailed circuit diagram for Safe Interlocking is available online:

www.sick.com/Safe_Interlocking

The Safe Interlocking components are connected according to the following diagram:

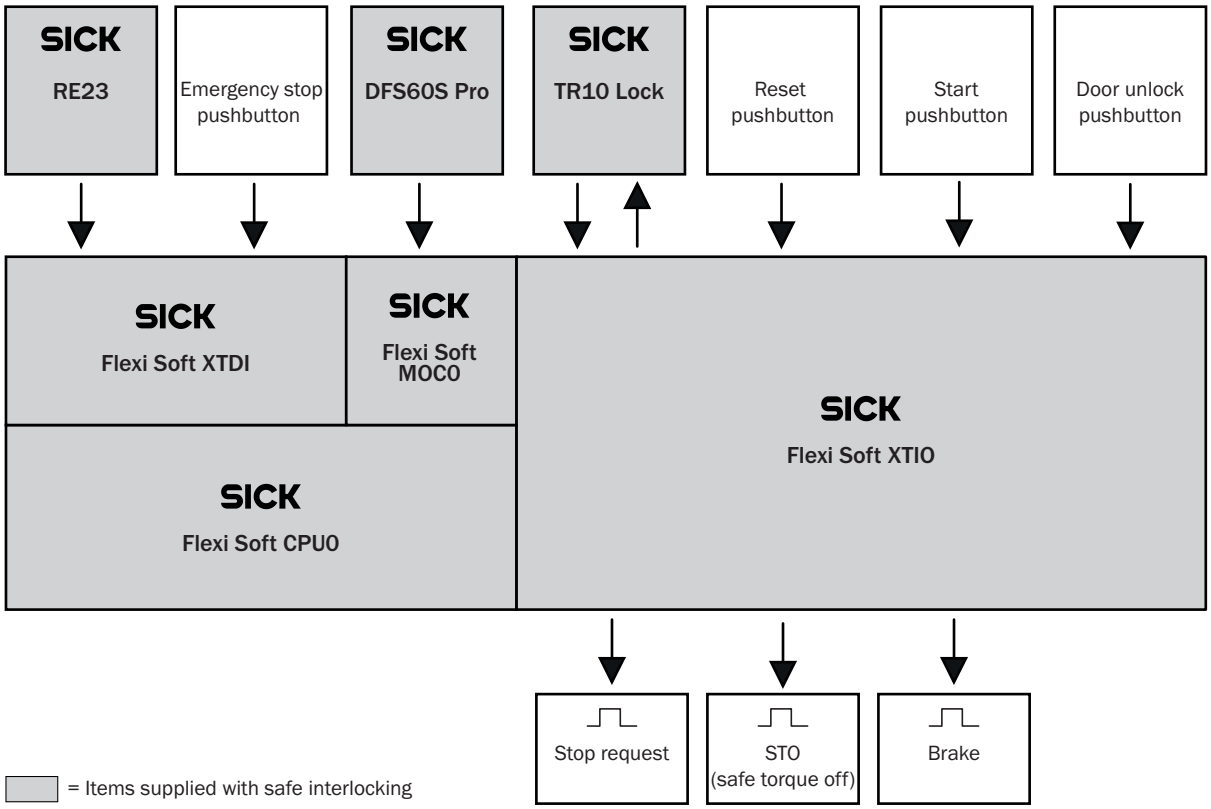

Figure 3: Safe Interlocking block diagram

Emergency stop pushbutton	The machine can be put into a safe state at any time with the emergency stop pushbutton
Reset pushbutton	The safety-relevant components are reset with the reset pushbutton

Start pushbutton	The machine can be restarted after the reset with the restart button
Door unlock pushbutton	Unlocking the movable physical guard can be requested with this pushbutton
Stop request	A machine stop is requested with this signal
STO (Safe torque off)	The “safe torque off (STO)” function is triggered with this signal
Brake	The brake is triggered with this signal
Items supplied with safe interlocking	The components highlighted in gray are included in the Safe Interlocking scope of delivery

4.5.3 Design of the emergency stop function

The emergency stop function must be available and effective in every operational status of the machine. It must not impair any equipment or functions used to free trapped persons. If the emergency stop function has been triggered, no start command (intentional, unintentional or unexpected) may lead to a machine start until the emergency stop function has been manually reset.

The emergency stop function must be designed so that the dangerous state of the machine is ended in an appropriate manner without creating additional dangers and without requiring interruption from a person.

4.5.4 Locking device and restart

If the opening of a movable physical guard triggers a stop command, the machine must not restart until the reset pushbutton has been actuated. Closing and locking the movable physical guard must not trigger a dangerous state.

4.6 Testing plan

The functional safety system must be tested by appropriately qualified safety personnel when commissioning, after modifications, and at regular intervals.

The regular thorough checks serve to investigate the effectiveness of the functional safety system and discover defects caused by modifications or external influences (such as damage or manipulation).

The manufacturer and user must define the type and frequency of the thorough checks on the basis of the application conditions and the risk assessment. Determination of the thorough checks must be documented in a traceable manner.

- A thorough check must be carried out during commissioning and following modifications.
- The regular thorough checks of the functional safety system must fulfill certain minimum requirements. The minimum requirements on the thorough check of the functional safety system comply at least with the sum of the minimum requirements on the thorough check of the components of the functional safety system (see operating instructions of the components).
- In many cases, depending on the application conditions, the risk assessment can determine that further thorough checks are required.

Further chapters

- Thorough check see "Commissioning", page 25
- Checklist for initial commissioning and commissioning see "Annex", page 34

5 Mounting

NOTE
Information is included in the operating instructions for the components.

6 Electrical installation

NOTE
Information is included in the operating instructions for the components.

7 Configuration

Overview of configuration

The entire functional safety system is configured using the Flexi Soft Designer software.

A project file is part of the functional safety system; the majority of the configuration is done with this file. The following steps are required to complete configuration:

1. Download and open configuration file.
2. Set application-specific parameters.
3. Complete configuration.
4. Transmit configuration to the safety controller.
5. Verify and validate the configuration.

NOTE

This chapter only contains information for implementing the configuration for the functional safety system. Detailed information on using the Flexi Soft Designer software can be found in the “Flexi Soft in Flexi Soft Designer” document (8012998).

7.1 Requirements on software and firmware

Configuration of the functional safety system requires at least the following versions of the software or firmware:

Table 9: Minimum versions

	Minimum version
Flexi Soft Designer	1.7.1
Firmware FX3-CPUx	4.0
Firmware FX3-XTIO	3.0
Firmware FX3-XTDI	3.0
Firmware FX3-MOC0	1.0

7.2 Pre-configured project files

Pre-configured project files

Pre-configured project files are available for the functional safety system under the following link:

www.sick.com/Safe_Interlocking

7.3 Opening project file

1. Start Flexi Soft Designer.
2. Click on **Project**.
3. Click on **Open**.
4. Select the project file.
5. Click on **Open**.

✓ The project file opens. The **Hardware configuration** view appears.

In the **Configuration area**, the entire hardware configuration of the Flexi Soft safety controller and the connected devices is displayed graphically.

7.4 Configuring motion control module element settings

Opening element settings

▶ Double-click on the sine-cosine symbol in the **Hardware configuration** view in the **Configuration area** at Input E1 of the motion control module.
✓ The **Element settings** dialog box opens. The **Movement type (rotational movement, linear movement) and type of measurement system** appear.

Configuring movement type

▶ Select movement type which applies for the application:
- **Rotational movement**
  or
- **Linear movement with conversion and encoder**

Configuring scaling of the measurement system

1. Click on the **Scaling the measurement system** index card.
2. Click on the **Assistant** button.
3. Only if a set without encoder has been selected: Under **Encoder resolution**, check the period per revolution of the encoder and correct if necessary. Value 1024 is set as a default.
4. Under **Gear factor**, set the ratio between drive axis and encoder axis.
5. When the machine drive makes a linear movement, then set the ratio between the linear movement and revolutions on the encoder axis under **Mechanics factor**.

Configuring counting direction

Normal is set by default. If the encoder counts in the opposite direction based on the mounting position, this parameter must be adjusted as follows.

1. Click on the **Counting direction** index card.
2. Select **Inverted**.

Saving the configuration

▶ Click on the **OK** button.

7.5 Configuring logics for Flexi Soft CPU

1. Move the mouse cursor to the **Logic editor** button.
2. Click on **Logic editor**.
✓ The Logic editor view opens. The **Information** page appears.

The Information page contains information on manufacturer duties when handling the provided project file.

DANGER
Failure to comply with manufacturer's obligations
Death or severe injury

▶ Read and observe the information on manufacturer duties.

7.5.1 Creating or deleting links

The logics in the Flexi Soft Designer mainly consist of the following elements:

- Safety controller inputs
- Safety controller outputs
- Function blocks with inputs and outputs

Links connect these elements. Links are represented as lines. Every element contains blue anchor points which represent the inputs and outputs of the elements. A link can only be created between the anchor point on the right side of an element and the anchor point on the left side of another element.

Creating link

1. Click and hold the blue anchor point on the right side of an element.
2. Move and release the mouse cursor on the blue anchor point on the left side of an element.

✓ A link is created between 2 elements.

Deleting link

1. Click on the link between 2 elements.
2. Press the **Del** pushbutton.
3. In the **Delete page** dialog box, click on the **Yes** button.

✓ The link is deleted.

7.5.2 Removing brake

If a risk assessment determines that no brake is needed, then the logics must be changed.

1. Change to the **Safe stop** page.
2. Delete the link between **EDM_Brake** and **Input 3** of function block **AND 6**.
3. Create a link between **Logical 0** and **Input 3** of function block **AND 6**.

✓ The logics now function without a connected brake.

7.5.3 Verification of the logics

There is no link between the logics and the outputs of the safety controller in the delivered state. That means the logics cannot yet be transmitted into the safety controller.

1. Check whether the logics in the safety requirements of the application are sufficient before outputs of the function blocks are linked to outputs of the safety controller.

7.5.4 Linking logics and outputs

When the logics have been verified, then the logics can be linked with the respective outputs of the safety controller.

1. Change to the **Safety** page.
2. Create a link between **Output Q** of function block **RS Flip-Flop 0** and **RL210 Locking.XTIO(1)**.
3. Change to the **EDM/Outputs** page.
4. Create a link between **Output 1** of function block **AND 2** and **Stop request.XTIO(1).Q1**.
5. Create a link between **Output 1** of function block **External device monitoring 1** and **QA110 STO.XTIO(1).Q2**.
6. If a brake is connected, create a link between **Output 1** of function block **External device monitoring 0** and **Brake.XTIO(1).Q3**.

7.6 Configuring logics for motion control module

1. Move the mouse cursor to the **Logic editor** button and click on **MOC0(3) - Logic editor**.

✓ The **MOC0(3) - Logic editor** view opens. The page **Seite 1** appears.

7.6.1 Configuring Speed monitor function block

1. Double-click on the **Speed monitor** function block.
2. Click on the **Units** index card.
3. Under **Speeds:** Select the desired unit for determining the encoder speed (see "Configuring motion control module element settings", page 22).
4. Click on the **Max. speed** index card.
5. Enter the highest permissible speed of the application under **Max. speed**.
6. Click on the **Stop monitoring** index card.
7. Enter the speed that is defined as a stop under **Stop speed**.
8. Under **Stop speed acceptance time**, enter the minimum time for which the **Stop speed** must be measured before a stop is to be detected.
9. Enter the value under **Stop position window**. This value defines which relative position change still counts as a stop independent of the speed.
10. Click on the **OK** button.

7.6.2 Configuring Safe stop function block

1. Double click on the **Safe stop** function block.
2. Click on the **Units** index card.
3. Under **Speeds:** Select the desired unit for determining the encoder speed (see "Configuring motion control module element settings", page 22).
4. Click on the **Stop ramp** index card.
5. Under **Delay time until ramp start**, enter the desired delay time until stop ramp monitoring begins.
   This makes it possible to set a tolerance time for drive reaction. This may be necessary for communication due to process cycles and minimum times.
6. Enter the desired deviation of the speed of the stop ramp under **Speed offset of the stop ramps**.
   This can ensure that the stop ramp is not unintentionally undercut. This can be necessary in the event of mechanical vibrations or a strong acceleration up to the time of the stop signal.
7. Define ramp. The ramp is defined by the reduction in speed in a certain time window. The preset values are only example values for the speed reduction.
8. Click on the **OK** button.

7.7 Transfer configuration

- Transmit configuration to the Flexi Soft main module (see operating instructions 8012998).

8 Commissioning

8.1 Safety

DANGER
Hazard due to lack of effectiveness of the protective device

- ▶ Before commissioning the machine, make sure that the machine is first checked and released by qualified safety personnel.
- ▶ Only operate the machine with a perfectly functioning protective device.

DANGER
Dangerous state of the machine

During commissioning, the machine or the protective device may not yet behave as you have planned.

- ▶ Make sure that there is no-one in the hazardous area during commissioning.

Before initial commissioning can be performed, project planning, mounting, electrical installation and configuration must be completed in accordance with this document.

8.2 Thorough check

Requirements for the thorough check during commissioning and in certain situations

The functional safety system and its application must be thoroughly checked in the following cases:

- Before commissioning
- After changes to the configuration or the safety function
- After changes to the mounting or the electrical connection
- After exceptional events, such as after a manipulation has been detected, after modification of the machine, or after replacing components

The thorough check ensures the following:

- All relevant regulations are complied with and the functional safety system is active for all of the machine's operating modes
- The documentation corresponds to the state of the machine, including the protective device

The thorough checks must be carried out by qualified safety personnel or specially qualified and authorized personnel and must be documented in a traceable manner.

1. Check the effectiveness of the protective device for all operating modes selectable on the machine in accordance with the checklist for initial commissioning and commissioning (see "Annex", page 34).
2. Make sure that the operating personnel has been instructed in the function of the protective device before starting work on the machine. The instruction is the responsibility of the machine operator and must be carried out by qualified personnel.

9 Maintenance

NOTE
Information is included in the operating instructions for the components.

10 Troubleshooting

NOTE
Information is included in the operating instructions for the components.

11 Operation

Operation is dependent on integration of the functional safety system into the application.

12 Technical data

12.1 Data sheet

Table 10: Safe Interlocking data sheet

	Safe Interlocking
Performance level	PL d (ISO 13849-1)
SIL claim limit	SILCL2 (EN 62061)
Supply voltage V_S	24 V DC (16,8 V DC ... 30 V DC) (PELV) [1]
Ambient operating temperature	–20 °C ... +55 °C
Storage temperature	–20 °C ... +60 °C
Air humidity	50 °C, 90% relative humidity (EN 61131-2)
Permissible operating height	≤ 2000 m
Safe state	The safety-related semiconductor outputs are in the OFF state.

1) The external supply voltage must bridge a brief power failure of 20 ms as specified in IEC 60204-1. Suitable power supply units are available as accessories from SICK.

12.2 Response times

Emergency stop

The response times for the “Stop in the event of an emergency” and “Initiating a stop” safety function are calculated using the following formulas:

- Emergency stop
  $23.5\ ms + T_{Ramp} + 4 \times T_{Logic} + T_{Cont.} + T_{STO} + T_{DEC}$
- Initiating a stop
  $12.5\ ms + T_{Window} + 2 \times T_{Logic} + T_{Cont.} + T_{STO} + T_{DEC}$

Formula symbols	Meaning
T_{Ramp}	Delay time until the start of the stop ramp The value results from the configuration of the **Safe stop** function block in Flexi Soft Designer.
T_{Window}	The value results from the configured stop window (S) and the maximum acceleration of the drive (a_{max}): $T_{Window} = (4 \times S / a_{max})^{0.5}$
T_{Logic}	Logics execution time of the Flexi Soft safety controller. The minimum logics execution time is 4 ms. The actual logics execution time depends on the complexity of the program (see operating instructions 8012478).
$T_{Cont.}$	Response time of the safety relay
T_{STO}	Response time of the STO function of the drive
T_{DEC}	Stopping/Run-down time of the drive considering the following factors: • Moved weight • Speed when triggering the safety function • Brake power (only if brake is available)

13 Ordering information

13.1 Scope of delivery

Safe Interlocking scope of delivery

- DFS60S Pro safety encoder (part number depends on the Safe Interlocking variant)
- Flexi Soft safety controller main module (part number 1043783)
- Flexi Soft safety controller expansion module - I/O module (8 inputs, 4 outputs) (part number 1044125)
- Flexi Soft safety controller expansion module - I/O module (8 inputs) (part number 1044124)
- Flexi Soft safety controller expansion module - motion control module (Flexi Soft Drive Monitor) (part number 1062344)
- Flexi Soft safety controller system plug (part number 1043700)
- RE2 safety switch (part number 1062542)
- TR10 Lock safety locking device (part number 6054764)

13.2 Safe Interlocking ordering information

The Safe Interlocking variant are differentiated only by the variant of the DFS60S Pro safety encoders they contain. The selection criteria refer to the properties of the DFS60S Pro safety encoder.

Table 11: Safe Interlocking ordering information

Mechanical shaft version	Shaft diameter	Length of the shaft	Type code	Part number
Solid shaft with surface, servo flange, M4 thread	6 mm	10 mm	SAPPB0D-07A0010	1087157
Solid shaft with feather key, servo flange, M4 thread	6 mm	10 mm	SAPPB0D-07A0012	1087159
Solid shaft with surface, clamping flange, M4 thread	10 mm	19 mm	SAPPB0D-07A0011	1087158
Solid shaft with feather key, clamping flange, M4 thread	10 mm	19 mm	SAPPB0D-07A0008	1087151
Blind hollow shaft with feather key groove	10 mm	–	SAPPB0D-07A0009	1087156
Blind hollow shaft with feather key groove	12 mm	–	SAPPB0D-07A0016	1087164
Blind hollow shaft with feather key groove	14 mm	–	SAPPB0D-07A0017	1087165
Through hollow shaft with feather key groove	10 mm	–	SAPPB0D-07A0013	1087160
Through hollow shaft with feather key groove	12 mm	–	SAPPB0D-07A0014	1087161
Through hollow shaft with feather key groove	14 mm	–	SAPPB0D-07A0015	1087162
Through hollow shaft with feather key groove	5/8"	–	SAPPB0D-07A0018	1087166
Other shaft			see table 12, page 31	

All supplied variants of the DFS60S Pro safety encoder have a plug connector (male connector, M12, 8-pin, radial).

NOTE

The variants of the Safe Interlocking functional safety system contain recommended variants of the DFS60S Pro safety encoder. If none of the Safe Interlocking variants contain the appropriate DFS60S Pro safety encoder, then order the set without safety encoder from the following table and then order an appropriate DFS60S Pro safety encoder separately.

Table 12: Set without safety encoder

Description	Type code	Part number
Set consisting of all components of Safe Interlocking with the exception of the DFS60S Pro safety encoder	SAPPB0D-07A0031	1087491

14 Spare parts

14.1 Safety encoder

Table 13: Safe Interlocking safety encoder ordering information

Spare part for		Spare part	Type code	Part number
Functional safety system	**Part number**			
Safe Interlocking	1087151	DFS60S safety encoder	DFS60S-SE0C01024	1067912
	1087156		DFS60S-BD0C01024	1067915
	1087157		DFS60S-S10C01024	1069517
	1087158		DFS60S-S40C01024	1069519
	1087159		DFS60S-SD0C01024	1069524
	1087160		DFS60S-TD0C01024	1069527
	1087161		DFS60S-TE0C01024	1069529
	1087162		DFS60S-TG0C01024	1069532
	1087164		DFS60S-BE0C01024	1069538
	1087165		DFS60S-BG0C01024	1069541
	1087166		DFS60S-TJ0C01024	1079319

14.2 Additional spare parts

Table 14: Safe Interlocking spare parts ordering information

Product	Type code	Part number
RE2 safety switch	RE23-SA64	1062542
TR10 Lock safety locking device	TR10-SRU01C	6054764
Flexi Soft safety controller main module	FX3-CPU000000	1043783
Flexi Soft safety controller expansion module - I/O module (8 inputs, 4 outputs)	FX3-XTIO84002	1044125
Flexi Soft safety controller expansion module - I/O module (8 inputs)	FX3-XTDI80002	1044124
Flexi Soft safety controller expansion module - motion control module (Flexi Soft Drive Monitor)	FX3-MOC000000	1062344
Flexi Soft safety controller system plug	FX3-MPL000001	1043700

15 Accessories

15.1 Connectivity

Table 15: Connecting cable ordering information

Part	Type code	Part number
Straight female connector, M12, 8-pin, 20 m cable, open end For connecting TR10 Lock safety locking devices	YF2A18-200UA5XLEAX	2095680
Straight female connector, M12, 4-pin, 15 m cable, open end For connecting RE2 safety switches	YF2A14-150VB3XLEAX	2096237
Straight male connector, M8, 4-pin, 10 m cable, male connector, USB-A straight For configuration of Flexi Soft safety controllers	DSL-8U04G10M025KM1	6034575
Angled male connector, D-Sub, 15-pin, 5 m cable, straight female connector, M12, 8-pin For connecting DFS60S Pro safety encoders	FX3-MOC CABLE ANG. AB SINOCS 5M	2094427

15.2 Actuator

Table 16: Actuator ordering information

Description	Type code	Part number
Replacement actuator for TR10 Lock	TR10-RRU000	5329550

15.3 Mounting bracket

Table 17: Mounting bracket ordering information

Part	Type code	Part number
Mounting bracket for TR10 Lock safety locking device actuator	TR10-MA0000	5329552
Mounting bracket for TR10 Lock safety locking device safety switch	TR10-MS0000	5329553

16 Annex

16.1 Checklist for initial commissioning and commissioning

This checklist should be retained and kept with the machine documentation to serve as reference during recurring thorough checks.

This checklist is not a substitute for initial commissioning or periodic thorough checks by qualified safety personnel.

Test for “Emergency stop” safety function

Table 18: Test for “Emergency stop” safety function

Test sequence	Expected result	Result OK?
1. Let machine run at a slow speed. 2. Press Emergency stop pushbutton. 3. Wait until the machine stops. 4. Reset the emergency stop pushbutton. Run the test sequence for every emergency stop pushbutton individually.	Safe Stop 1 (SS1) is triggered. The reduction in speed is monitored. If a brake is connected, it is triggered. If the stop has been achieved, then the voltage supply of the drive is switched off. Resetting the emergency stop pushbutton does not trigger restart.	Yes ☐ No ☐
Note the designations of the tested emergency stop pushbutton here.		

Test for “Preventing unexpected start-up” safety function

Table 19: Test for “Preventing unexpected start-up” safety function

Test sequence	Expected result	Result OK?
1. Press Emergency stop pushbutton. 2. Release the emergency stop pushbutton. Then reset the emergency stop pushbutton. 3. Press the reset pushbutton and hold down for at least 30 s. 4. Press and hold the restart button for at least 100 ms and no more than 30 s.	The machine does not start.	Yes ☐ No ☐
1. Press Emergency stop pushbutton. 2. Release the emergency stop pushbutton. Then reset the emergency stop pushbutton. 3. Briefly press the reset pushbutton (≤ 100 ms). 4. Press and hold the restart button for at least 100 ms and no more than 30 s.	The machine does not start.	Yes ☐ No ☐
1. Press Emergency stop pushbutton. 2. Release the emergency stop pushbutton. Then reset the emergency stop pushbutton. 3. Press and hold the reset pushbutton for at least 100 ms and no more than 30 s. 4. Press and hold the restart button for at least 100 ms and no more than 30 s.	The machine starts.	Yes ☐ No ☐

Test sequence	Expected result	Result OK?
1. Press Emergency stop pushbutton. 2. Release the emergency stop pushbutton. Then reset the emergency stop pushbutton. 3. Press and hold the restart button for at least 100 ms and no more than 30 s.	The machine does not start.	Yes ☐ No ☐
1. Press Emergency stop pushbutton. 2. Release the emergency stop pushbutton. Then reset the emergency stop pushbutton. 3. Press and hold the reset pushbutton for at least 100 ms and no more than 30 s. 4. Press and hold the restart button for 30 s.	The machine does not start.	Yes ☐ No ☐
1. Press Emergency stop pushbutton. 2. Release the emergency stop pushbutton. Then reset the emergency stop pushbutton. 3. Press and hold the reset pushbutton for at least 100 ms and no more than 30 s. 4. Briefly press the restart button (≤ 100 ms).	The machine does not start.	Yes ☐ No ☐

Test for “Initiating a stop” safety function

Table 20: Test for “Initiating a stop” safety function

Test sequence	Expected result	Result OK?
1. Make sure that the door is unlocked and open. 2. Press and hold the reset pushbutton for at least 100 ms and no more than 30 s. 3. Press and hold the restart button for at least 100 ms and no more than 30 s.	Door is not locked. Machine start not possible.	Yes ☐ No ☐
1. Make sure that the door is unlocked and closed. 2. Press and hold the reset pushbutton for at least 100 ms and no more than 30 s.	The door is locked. The machine can be started with the restart button.	Yes ☐ No ☐
1. Make sure that the door is unlocked and closed. 2. Press and hold the restart button for at least 100 ms and no more than 30 s.	Door is not locked. Machine start not possible.	Yes ☐ No ☐

Test for “Temporarily preventing access” safety function

Table 21: Test for “Temporarily preventing access” safety function

Test sequence	Expected result	Result OK?
1. Make sure that the safety switch and the safety locking device are mounted correctly. 2. Make sure that suitable measures for manipulation protection have been taken.	The manipulation protection measures are suitable and comply with the specification in the respective operating instructions.	Yes ☐ No ☐
1. Let machine run at a slow speed. 2. Give the signal for unlocking the door.	Door remains locked. Machine continues running.	Yes ☐ No ☐
1. Make sure that the machine stops. 2. Give the signal for unlocking the door.	The door is unlocked.	Yes ☐ No ☐

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