OPERATING INSTRUCTIONS

sBot Speed – YA

Safety System

SICK
Sensor Intelligence.

Described product

sBot Speed – YA

Manufacturer

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Legal information

Original document

This document is an original document of SICK AG.

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1 About this document

1.1 Purpose of this document

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

- The individual components
- The project planning
- The mounting and electrical installation, insofar as special measures are necessary for the safety system
- The configuration
- The necessary thorough checks
- The commissioning
- The maintenance
- The troubleshooting

1.2 Scope

Important information

NOTE

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 safety system applies.

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

Product

This document applies to the following products: sBot Speed – YA

Document identification

Document part number:

- This document: 8024620
- Available language versions of this document: 8024617

You can find the current version of all documents at www.sick.com.

Other documents relevant for the product

Table 1: Documents available from SICK

Document type	Title	Part number
Operating instructions	microScan3 Core I/O	8016344
Operating instructions	nanoScan3 I/O	8024594
Operating instructions	Flexi Soft modular safety controller hardware	8012999
Operating instructions	Flexi Soft in the Flexi Soft Designer software	8012998

Table 2: Robot controller documents

Document type	Title	Link
Operating instructions	YRC1000 instructions for functional safety functions	https://www.motoman.com/en-us/service-training/product-documentation
Operating instructions	YRC1000micro	
Operating instructions	DX200 instructions for functional safety functions	

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.

These operating instructions are organized by the life phases of the 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:

Warnings 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
Highlights useful tips and recommendations as well as information for efficient and trouble-free operation.

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 mounting instructions for suitable for the safety system
- Prepared subsystems for SISTEMA for this safety system
- Circuit diagram for the 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 functions.

2.2 Intended use

This safety system was developed for cooperative work environments with robots (cooperative = humans and robots working in the same space at different times).

This safety system protects these cooperative work environments by monitoring access to hazardous areas using safety laser scanners and, if necessary, slowing or stopping the robots.

Prerequisites

In order to use this safety system, the following requirements must be met:

- The supplied Flexi Soft file and the SISTEMA file must be adjusted to the individual application in accordance with the manufacturer's requirements.
- Additional protective devices must be provided by the manufacturer to protect against hazards that arise independently of the robot movement.

2.3 Improper use

The safety system is **not** suitable for applications to which at least one of the following features applies:

- The robot can be accessed from all sides.
- It is possible for parts to be propelled in the robot workspace.
- It is possible for radiation to escape in the robot workspace.
- Hazards remain even when the robot is stopped, due to causes such as radiation, heat or electricity.
- The protective field and warning field of the safety laser scanner cannot completely cover all open access points to the robot (see "Field set", page 15).
- Field sets are not configured correctly, e.g. the protective field is too small.
- It is possible to enter the hazardous area by climbing over it, standing behind it or reaching through it.
- Chairs, ladders or similar objects are used in the safety laser scanner field.
- Transparent objects are used in the safety laser scanner field.

Limitations

This safety system is only suitable for protecting against mechanical hazards caused by the movement of the robot.

Hazards caused by the ejection of solid or liquid materials, emissions, radiation and electricity cannot be reduced by this safety system.

NOTICE
In order to determine whether Sbot Speed can be used for the particular application (with or without automatic restart), a risk assessment is required in accordance with EN ISO 12100.

2.4 Identifying hazards

This document considers the following risks according to ISO 10218-1:

Mechanical hazards

- Crushing
- Cutting
- Impacts

Dangers posed at the end effector of the robot must also be considered by the manufacturer. If necessary, further measures must be taken to minimize the resulting risks.

Other residual risks, e.g., due to small parts being propelled, are not considered and must be considered in detail in the risk assessment, see "Manufacturer of the machine", page 22.

2.5 Requirements for the qualification of personnel

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

Project planning

You need safety expertise to implement safety functions and select suitable products for that purpose. You need expert knowledge of the applicable standards and regulations.

Mechanical mounting

For mechanical mounting, 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 that he/she can assess its operational safety status.

Electrical installation

For electrical installation, 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 that he/she can assess its operational safety status.

Commissioning

For commissioning, 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 that he/she can assess its operational safety status.

Operation and maintenance

You need suitable expertise and experience. You must be instructed in machine operation by the machine operator. For maintenance, you must be able to assess if the machine is operating safely.

2.6 Safe state

In the safe state, the accordingly configured safe output signal switching devices are in the OFF state. The robot is and remains switched off.

If the output for the safety-rated monitored speed is set to LOW, the robot controller must safely monitor the speed of movement.

The safe state is initiated in the following cases:

- Protective field infringed
- Emergency stop pushbutton actuated
- Fields are not infringed in an expected sequence (sequence error, no safety function)
- Connection between the safety laser scanner and safety controller interrupted
- Voltage supply of the safety laser scanner or the safety controller interrupted
- Internal error on the safety laser scanner detected
- Internal fault detected at the safety controller or one of its components

NOTE

When the safety system initiates the safe state, the machine manufacturer and user must ensure that the safe switching outputs are evaluated appropriately and that the hazardous state is rectified.

3 Product description

3.1 Product identification

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

Further topics

- "Ordering information", page 65

3.2 Structure of the overall system

The safety system is used in cooperative work environments with industrial robot systems in order to reduce the risk of injuries caused by the movement of the robot, while also increasing productivity.

Figure 1: Example application

The industrial robot system consists of the following components:

- Industrial robots
- End effector(s)
- Machines, devices, equipment, external auxiliary axes or sensors which support the robots in doing its task

The safety system is suitable for work environments such as those in which the hazardous area surrounding the robot must be entered for repeated operations, e.g. for loading or product inspection. In such cases, fixed physical guards are often obstacles.

The safety system ensures that the speed of the robot is reduced and that the robot reliably monitors the reduced speed when a person approaches. The minimum distance is reduced due to the reduced speed. As soon as the minimum distance to the hazardous area is exceeded, the robot safety system stops.

As long as the person remains in the hazardous area, the safety system prevents a restart.

If automated restart is permitted, its implementation is dependent on the robot controller used and the configuration of the robot.

As soon as a person leaves the hazardous area, the robot restarts automatically. The speed of the robot remains reduced until the person has exited the warning field (for more details on protective and warning fields see "Field types", page 15). Only at that point will the robot continue its activity at a normal speed.

If automated restart is not to be used, manual restart can be implemented instead.

If a person does not leave the hazardous area in the intended manner, the safety system prevents a restart. Regardless of how the automatic restart is implemented, a reset pushbutton must be pushed in this case after the hazardous area is evacuated. In addition, the robot controller must be reset.

Interaction between the safety system and the robot controller

The safety system consists of a safety laser scanner and a programmable Flexi Soft safety controller. A simple logic program for Flexi Soft, which serves as an example, is available for downloading. The example program activates safety functions of the robot controller and uses a reset signal.

The safety functions must also be configured in the robot controller.

The used devices and the logics program of the safety controller are designed for hazardous area protection. The machine manufacturer can expand the safety system as needed.

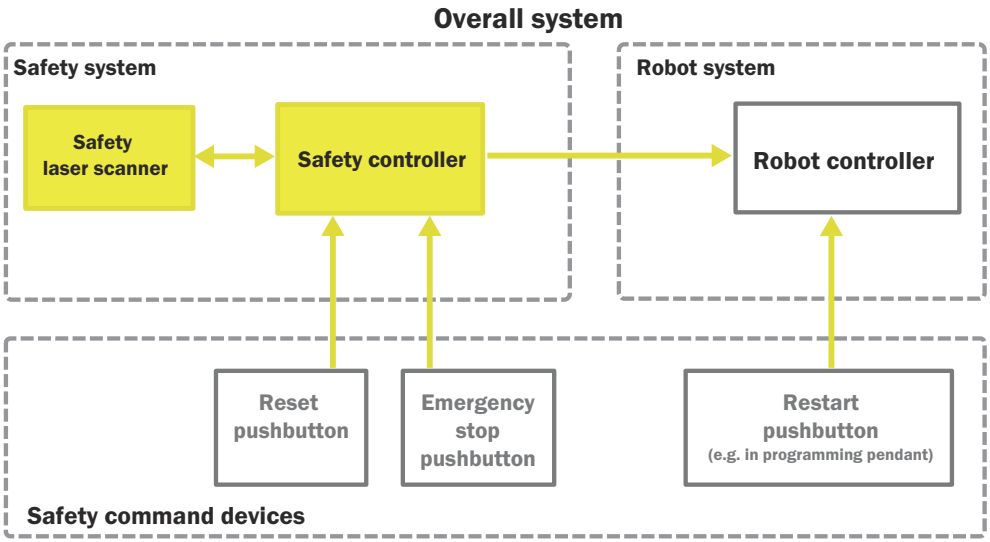


Figure 2: Overall system overview

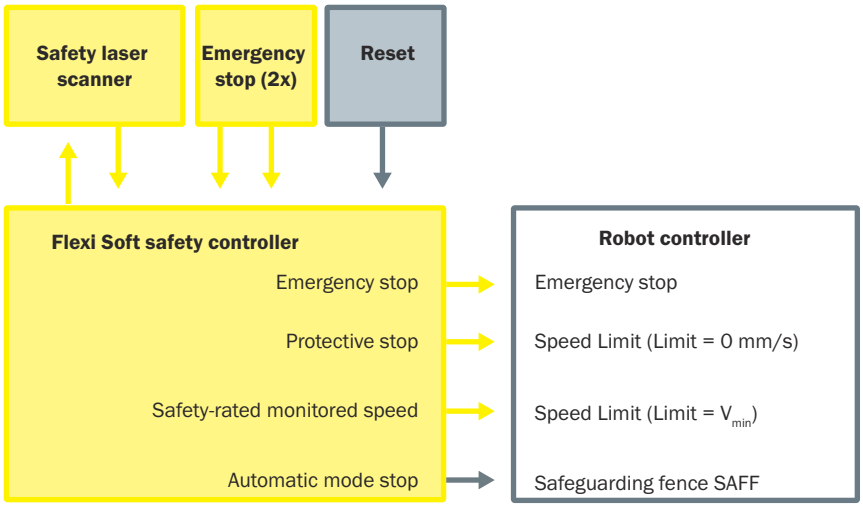


Figure 3: Block diagram

The most important safety functions

- Emergency stop function on the robot.
- Combination: initiate stop and prevent start. If the protective field is interrupted, dangerous movements are stopped. The robot remains stopped as long as the interruption lasts (standstill monitoring).
- Activation of safety-rated monitored speed. A safe, dual-channel output of the Flexi Soft sends a signal to the robot controller to activate the safety-rated monitored speed. The robot reduces the speed and checks whether the reduced speed can be safely upheld.
- Automated restart: this function may only be implemented if permitted by the risk assessment for the specific application in the robot system. If the function has been implemented, automated restart occurs once the entire hazardous area of the safety laser scanner is monitored and the sequence for leaving the hazardous area has been carried out correctly.

Additional functions

- Automatic mode stop: Initiates stop and prevents start (only in Automatic operating mode). Automatic mode stop is not a safety function. If a person does not follow the intended sequence of field infringement when leaving the hazardous area, the robot will trigger the SAFF safeguarding fence function.

3.3 Safety system function

The safety laser scanner monitors a defined area around the robot.

DANGER
Risk of death

The safety laser scanner only monitors a limited area around the robot.

► Prevent access to the areas not being monitored (e.g., by providing fencing).

During normal robot operation, the safety laser scanner monitors two field sets. They each consist of one warning field and one protective field.

If the warning field is interrupted, the robot reduces its speed. If a protective field is interrupted, movement of the robot is stopped.

Once the protective field is no longer infringed, the robot automatically continues its movement at a slow speed. When the warning field is no longer infringed, the robot moves again at normal speed.

3.4 Product characteristics

3.4.1 Field types

During operation, the safety laser scanner uses its laser beams to continuously check whether people are present in an area. The areas to be checked are called “fields”. The following field types are differentiated:

- Warning field
- Protective field

Warning field

The warning field monitors a larger area than the protective field. If the warning field is interrupted, a safety function is triggered which reduces the robot speed.

Protective field

The protective field protects the hazardous area immediately surrounding the robot. If the protective field is interrupted, the robot is stopped.

3.4.2 Field set

The safety system provides two field sets.

Each field set consists of 2 fields: a warning field and a protective field. The fields in a field set are monitored simultaneously. The size of the two protective fields must be adapted to the minimum distances. The warning field is identical in both field sets.

- Field set 1 = warning field 1 + protective field 1 (large)
- Field set 2 = warning field 2 + protective field 2 (small)

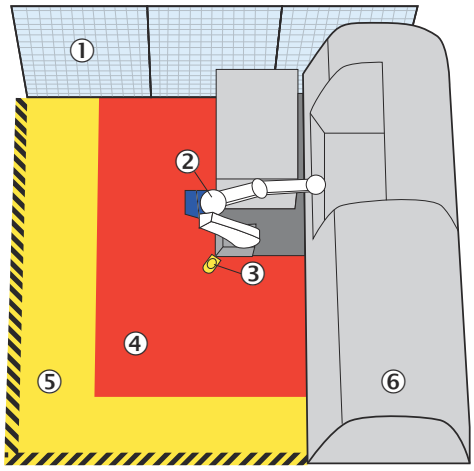


Figure 4: Field set 1

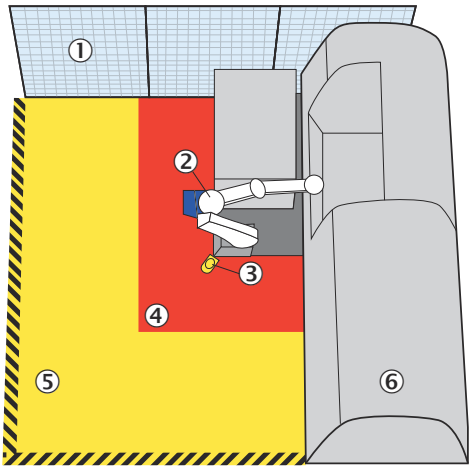


Figure 5: Field set 2

① Physical guard
② Robot
③ Safety laser scanner
④ Protective field
⑤ Warning field
⑥ Machine

Field set 1 is active by default. If the warning field is interrupted, the robot reduces its speed. When the reduced speed is safely reached, a smaller protective field is required than is necessary when operating at full speed. The safety system switches to field set 2.

As long as the warning field is interrupted, the reduced speed level remains activated. The robot stops when the protective field from field set 2 is interrupted. The robot will only become active again at a reduced speed when the interruption in the protective field has ended.

When first the protective field and then the warning field are again clear, field set 2 will be switched back to field set 1. The robot will resume work at maximum speed only once the warning field and the protective field are clear.

3.4.3 Safety Functions

3.4.3.1 Switch field sets

Two field sets must be configured for the safety laser scanner, each containing a warning and a protective field, (see "Field types", page 15):

- Field set 1 = warning field 1 + protective field 1 (large)
- Field set 2 = warning field 2 + protective field 2 (small)

3.4.3.1.1 Approaching the hazardous area

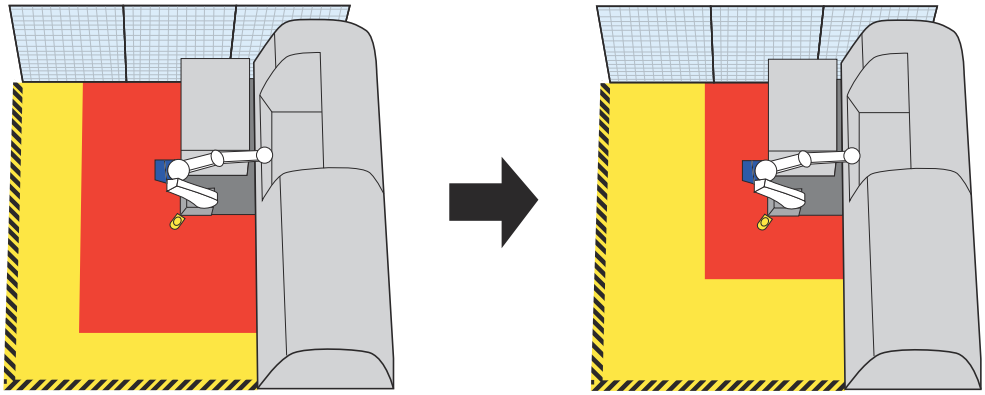


Figure 6: Switch field sets

If the warning field is infringed, the safety controller sends the request for safety-rated monitored speed. The robot will then reduces its speed and reliably monitors it. After a defined delay time, there is a switch from field set 1 to field set 2.

This delay time must be adjusted for each application accordingly. The delay time is configured in the safety controller and in the robot controller. This delay time is safety-relevant.

Table 3: Switching field sets when the warning field is infringed

Trigger	Expiration of time delay after request for safety-rated monitored speed
Condition	Safety-rated monitored speed is active
Reaction	Safety laser scanner switches from field set 1 to field set 2
Safe state	Speed of the robot is reduced and the protective field is clear

Further topics

- "Response times", page 63
- "SafetyRatedMonitoredSpeed page", page 42

3.4.3.1.2 Exiting the hazardous area

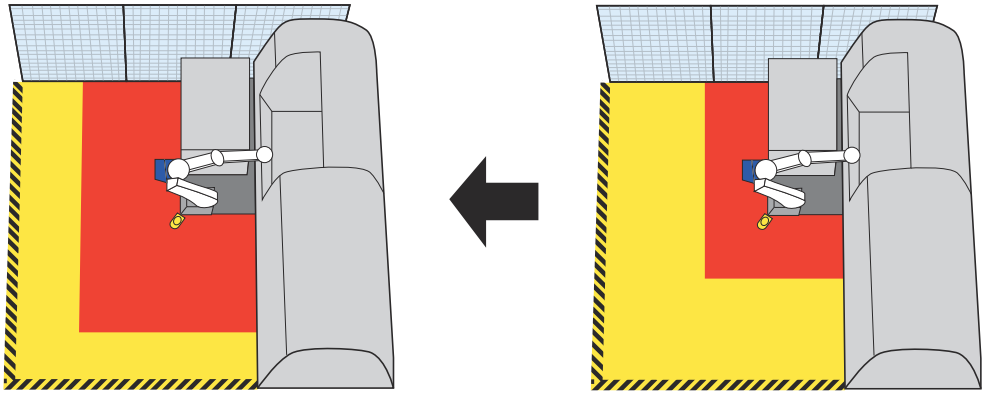


Figure 7: Exiting the hazardous area

When exiting the hazardous area, the protective field from field set 2 is clear and the warning field remains infringed. After fulfillment of this sequence, the protective stop becomes deactivated again and the robot can automatically start at a reduced speed.

When the warning field is clear, the system switches to field set 1. Once the protective field and the warning field are clear, the robot may resume work at maximum speed.

Table 4: Sequence monitoring and field set switching when exiting

Trigger: Following sequence	
1.	Protective field from field set 2 is clear
2.	Warning field remains infringed for at least 500 ms
3.	Warning field is clear
Condition: safety-rated monitored speed is active after fulfillment of steps 1 and 2 of the sequence	
Reaction:	
1.	The protective stop is deactivated and the safety-rated monitored speed remains active
2.	The robot can restart at a reduced speed
3.	The safety laser scanner switches to field set 1 when the warning field is clear
4.	Once protective field 1 and the warning field are clear, the robot may resume work at maximum speed
Safe distance: protective field from field set 1 and the warning field are clear when the robot resumes work at maximum speed	

3.4.3.2 Automatic restart

If a person exits the protective field from field set 2 and enters the warning field, the robot can restart at a reduced speed. After the infringement of the protective field from field set 2 has ended, the warning field must be infringed for at least 500 ms. The continuous monitoring of field infringement is called sequence monitoring.

If this infringement does not occur, there is no guarantee that the person has left the hazardous area. In this case, the robot triggers the SAFF safeguarding fence safety function (stop category 1).

Sequence monitoring is an additional measure for automatic restart. Sequence monitoring is not a safety function. The automatic restart safety function only depends on the protective field.

For more information see "Project file logic", page 36.

WARNING

If the protective field is clear but the warning field is not subsequently infringed, the automatic restart must be prevented.

This scenario may occur if a person leaves the protective field without entering the warning field.

Table 5: Sequence monitoring and field set switch when exiting

Trigger: Following sequence	
1.	Protective field from field set 2 is clear
2.	Warning field remains infringed for at least 500 ms
Condition: safety-rated monitored speed is active after fulfillment of the sequence	
Reaction:	
1.	The protective stop is deactivated and the safety-rated monitored speed remains active
2.	The robot can restart at a reduced speed
Safe distance: protective field from field set 2 is clear and the robot resumes work at safety-rated monitored speed	

NOTE

The automatic restart function may only be used if permitted by the manufacturer's risk assessment and all requirements for the use of this safety system are fulfilled.

The risk assessment must determine if:

- People in the hazardous area are detected by the safety laser scanner at all times.
- The restart remains locked until the person has completely and safely exited the hazardous area while maintaining the minimum distance.

If these requirements are fulfilled, an automatic restart can be executed after a protective stop.

The manual reset after startup or after an emergency stop remains unaffected and is compliant with ISO 10218-2.

3.4.3.3 Initiating a stop

A safety-related stop function places the robot in a safe state on demand (e.g., infringement of a protective field).

If the protective field is infringed, a protective stop is carried out. As long as the protective field remains infringed, an unintentional start-up of the robot is prevented.

Table 6: Stop when the protective field is triggered

Trigger	Protective field infringed by persons
Condition	Possible at any time
Reaction	Robot executes a protective stop
Safe state	Standstill

Table 7: Expected frequency for requests of this safety function

24 times per day	Protective field infringed by persons
Total	
24 times per day	Request for the safety function
8760 times per year	

3.4.3.4 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 robot 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 state
- No additional dangers are created when ending the dangerous movement and statuses

Table 8: Emergency stop

Trigger	Emergency stop pushbutton is actuated
Condition	At any time
Reaction	Robot executes an emergency stop
Safe state	Standstill

Table 9: Expected frequency for requests of the safety function

500 times per year [1)]	Emergency stop pushbutton is actuated
Total	
500 times per year	Request for the safety function

1) Value corresponds to the requirements in the robot controller.

3.4.3.5 Preventing an unexpected start-up following an emergency stop

If an emergency stop has been triggered, the stop state is to 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.
- Resetting after an emergency stop or faulty sequence is only possible if the protective field and warning field are clear.
- The reset device must be actuated after switching on the machine. The protective field and warning field must be clear.

Table 10: Preventing an unexpected start-up

Trigger	Valid reset sequence after emergency stop
Condition	All affected safety devices are active
Reaction	Safety controller accepts restart
Safe state	Standstill

3.5 Additional components required

The following additional components are essential for using the safety system in an application:

- Emergency stop pushbutton
- Reset pushbutton
- Robot controller of type YRC1000, YRC1000micro or DX200 from manufacturer Yaskawa, with functional safety I/O logic PCB (functional safety kits, kit FSU)
- Additional physical guards or non-separating guards (e.g. Fence,)

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. For evaluating the performance level achieved, subsystems for SISTEMA are available under:

www.sick.com

For the components included with delivery see "Ordering information and scope of delivery", page 65.

3.5.1 Emergency stop pushbutton requirements

At least two devices for bringing to a standstill in an emergency must be installed, e.g. emergency stop pushbutton:

- Inside the hazardous area - as close as possible to the robot
- Outside the hazardous area - as an added safety function

Depending on the manufacturer's risk assessment, it may be necessary to install additional emergency stop pushbuttons.

Each emergency stop pushbutton must feature two N/C contacts that can both be opened by pressing (for example).

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

- ISO 13850
- IEC 60204

3.5.2 Reset pushbutton requirements

The reset pushbutton must be installed outside of the hazardous area. From the position of the pushbutton, there must be a complete view of the hazardous area.

The reset pushbutton must be implemented as a single-channel N/O contact.

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

- EN 60204

3.5.3 Indicator light requirements

Supply voltage: 24 V DC

Current consumption: max. 500 mA

3.5.4 Robot controller requirements

Type of robot controller

The robot controller must be one of the following types from manufacturer YASKAWA:

Table 11: Supported robot controllers

Robot controller	Functional safety PCB	Component number
YRC1000	Kit FSU	348799101
YRC1000micro	Kit FSU 2M	351033102
	Kit FSU 5M	351033105
DX200 [1)]	Kit FSU	348799200

1) The robot controller must have at least firmware version DN1.83.00A(–)-00.

Robot controller functions

Table 12: Robot controller functions

	Emergency stop	Protective stop[1)]	Safety-rated monitored speed [2)]
Required	Yes	Yes	Yes
Reset, restart	Manual	Automatic	Not applicable
Stop category	Stop category 0 or stop category 1	Stop category 2	Not applicable
Secure signal from safety system to safety controller	Yes	Yes	Yes

1) The protective stop is implemented in the robot controller with the **speed limiting** safety function and the **speed limit** = 0 mm/s value.
2) The safety-rated monitored speed is implemented in the robot controller in the **speed limiting** safety function.

Reset and restart requirements

After emergency stop or switching on:

- Manual reset is monitored by the safety system. If resetting is possible and the reset button is pushed, the emergency stop output switches to the ON state (high) so that the robot can be started.
- Resetting the robot is only possible if the user has executed a restart. The restart is a manual restart. Implementing manual restart is the responsibility of the manufacturer.
- The robot controller must prevent restart after a change in the operating mode (e.g. from automated teach-in mode). A restart is only possible after a valid reset.

After protective stop:

- The safety system automatically resets and switches the safety stop output to the ON state (high) so that the robot can be started.
- Automated restart must be implemented in the robot controller. Implementing automated restart is the responsibility of the manufacturer.
- Depending on the robot type and the requirements of the application, the manufacturer can implement manual restart. In this case, manual reset of the robot controller is necessary. Implementation is the responsibility of the manufacturer.

3.5.5 Physical guard

Pursuant to the manufacturer's risk assessment, it may be necessary to install fixed physical guards such as fencing around the robot's hazardous area.

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

- EN ISO 14120
- EN ISO 13857

NOTICE

The possibility of entering the hazardous area by climbing over it, standing behind it or reaching through it must be prevented.

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

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

If the thorough check shows that the safety system is not suitable for the specific application case, the 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 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.
- Compliance with the applicable laws, regulations and standards is required.

4.2 Operating entity of the overall system

Changes to the electrical integration of the safety system in the machine control and changes to the mechanical mounting of the safety system necessitate a new risk assessment. The results of this risk assessment may require the entity operating the machine to meet the obligations of a manufacturer.

Changes to the safety system's configuration may impair the protective function. The effectiveness of the 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 safety system.

4.3 Performance level

The calculation of the performance level can be carried out using the SISTEMA file. SICK provides you with a ZIP archive. The manufacturer of the machine must decide which measures should be taken against failures with the same cause.

These measures must be selected in the SISTEMA file for each user-defined sub-system. In addition, the correct values must be selected for those components that are not part of the scope of delivery, see "General requirements", page 31.

4.4 Design

This chapter contains information about implementing the design of the functional safety system. Any design-related contents of the relevant operating instructions also apply. The following information is provided in the operating instructions for safety laser scanners in particular:

- Height of the scan plane
- Protective field length
- Protective field width
- Stopping distance
- Monitoring case switching time

4.4.1 Safety laser scanner

It is recommended to mount the safety laser scanner horizontally so that the scan plane is 300 mm above the ground. This means a resolution of 70 mm can be used.

If the mounting height is less than 300 mm above the ground, the resolution must be adjusted to 50 mm and the protective field must be enlarged.

NOTE

At a resolution of 50 mm, the maximum size of the protective field is reduced. The manufacturer must ensure that there is no possibility of avoiding the protective field.

If the height of the scan plane is greater than 300 mm, additional measures must be taken to prevent crawling beneath.

4.4.2 Robot operating modes

Implementation of operating modes and the operating modes considered

Selecting between the robot operating modes is not a part of this safety system. You must select the operating mode using the robot controller (e.g. with the operating mode selector switch in the robot operating panel).

This safety system takes the following operating modes into account:

- Automatic
- Manual operating mode with reduced speed

Table 13: Functional scope depending on the selected operating mode

Function	Automatic operating mode	Manual operating mode with reduced speed
Emergency stop	Active	Active
Safety-rated monitored speed	Active	Not active
Initiate a protective stop	Active	Not active
Automatic mode stop (SAFF safeguarding fence)	Active	Not active

Complementary information

- You must configure the robot controller for the manual operating mode so that signals for a protective stop and safety-rated monitored speed can be bridged.
- Each time the user mode is changed, the safety system must be manually reset.
- The different operating modes of a robot are standardized in ISO 10218-2. Some manufacturers use names deviating from the standard.

Operating mode name according to ISO 10218-2	Operating mode name in the robot controller from Yaskawa
Automatic	Play mode

Operating mode name according to ISO 10218-2	Operating mode name in the robot controller from Yaskawa
Manual operating mode with reduced speed	Teach mode

Further topics

- see "Configuration of the robot controller", page 54

4.4.3 Calculating minimum distance

The minimum distance to the hazardous area must be calculated according to ISO 13855 (protective field parallel to direction of approach). The manufacturer of the machine must calculate the minimum distance for the entire machine.

The minimum distance to the hazardous area (S_{total}) depends on the following factors:

- Approach speed of the body or parts of the body (K)
- Stopping time of the entire machine (T)
  - Response time of the safety system (t_R)
  - Robot stopping time (t_{Robot})
- Supplements
  - Supplement to prevent reaching over (C_{RO})
  - Supplement for the maximum sensing range of the robot arm (C_{Robot})
  - Supplement for the distance between the mounting plate of the robot and the end point of the end effector (tool) including the work piece (C_{Tool})

The response time of the safety system (t_R) is composed of the following times:

- Response time of the safety laser scanner (t_S)
- Response time of the safety controller ($t_{FlexiSoft}$)
- Response time of the interface or the relay (t_{Relays})

The robot stopping down time (t_{Robot}) is composed of the following times:

- Response time of the robot controller including the switch-on delay time (detection delay time) and stopping time in the event of an error
- Stopping/run-down time of robot arm including tool and work piece

The actual stopping/run-down time of the robot must be checked with a measurement.

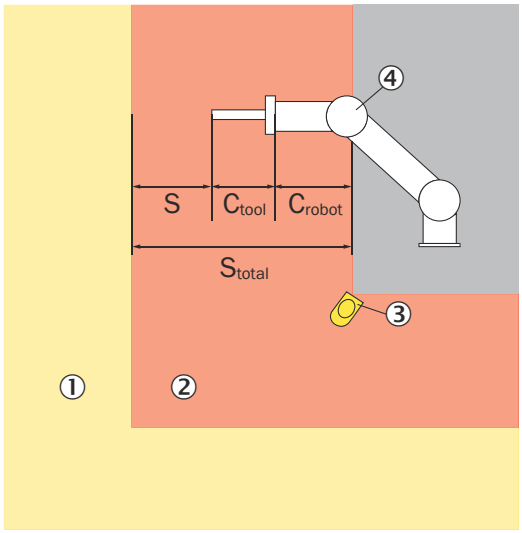


Figure 8: Calculating minimum distance

① Warning field
② Protective field
③ Safety laser scanner
④ Robot

The safe minimum distance is determined using the following formula:

$S_{total} = K \times T + C_{RO} + C_{Robot} + C_{Tool} + C_{TZ}$

$S_{total} = K \times (t_R + t_{Robot}) + C_{RO} + C_{Robot} + C_{Tool} + C_{TZ}$

$S_{total} = K \times (t_S + t_{FlexiSoft} + t_{Relays} + t_{Robot}) + C_{RO} + C_{Robot} + C_{Tool} + C_{TZ}$

Table 14: Variables in the calculation

Formula symbols	Relevance
S_{total}	Minimum distance to hazardous area
K	Approach speed of the body or parts of the body (1,600 mm/s according to ISO 13855)
T	Stopping time of the entire machine
t_R	Response time of safety system
t_{Robot}	Robot stopping/run-down time
C_{RO}	Supplement to prevent reaching over (1,200 mm – (0.4 × H))
C_{Robot}	Maximum sensing range of the robot
C_{Tool}	Distance between the mounting plate of the robot and the end point of the end effector (tool) including the work piece
C_{TZ}	Tolerance zone of the safety laser scanner microScan3 Core I/O (variants with a max. protective field range of 5.5 m): 65 mm nanoScan3 Core I/O: 65 mm
t_S	Response time of the safety laser scanner
$t_{FlexiSoft}$	Safety controller response time
t_{Relays}	Response time of the interface or the relay
H	Height of the scan field of the safety laser scanner

NOTE
If the robot's range of motion is safely restricted, the minimum distances may decrease (e.g. if the robot is equipped with a safety function that safely limits the robot movement).

Further topics

- "Response times", page 63

4.4.4 Emergency stop pushbutton

At least two emergency stop pushbuttons must be installed.

One emergency stop pushbutton must be installed inside the protective field near the robot, and the second outside the hazardous area. Depending on the manufacturer's risk assessment, it may be necessary to install additional emergency stop pushbuttons.

For more information see "Emergency stop pushbutton requirements", page 20.

4.4.5 Reset pushbutton

The reset pushbutton must be located outside the hazardous area and outside the warning field of the safety laser scanner.

For more information see "Reset pushbutton requirements", page 20.

4.5 Integrating the equipment 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 safety system, such as switches, fuses, and contactors. The circuit diagrams contain information on wiring the safety system with additional components within an application.

4.5.1 Circuit diagram

Important information

NOTE
For the voltage supply (especially with separate voltage supply units), observe the notes in the operating instructions for the Flexi Soft safety controller.

Circuit diagram

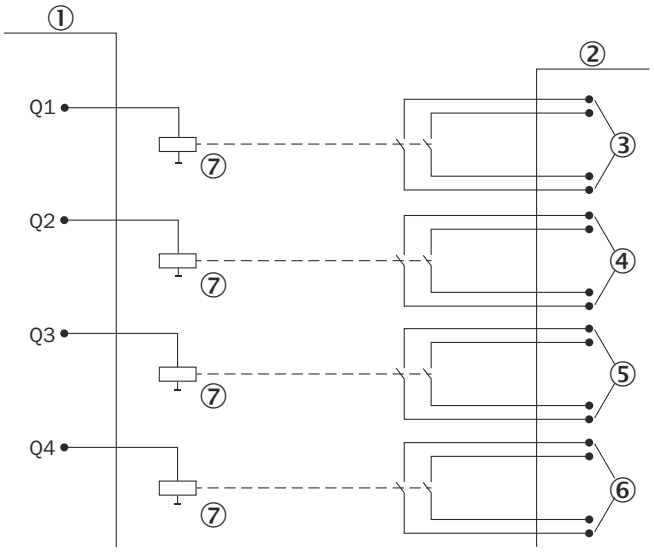


Figure 9: Safe Robotics Area Protection switching point

① Safety controller
② Robot controller
③ Emergency stop
④ Protective stop
⑤ Safety-rated monitored speed
⑥ Automatic mode stop (SAFF safeguarding fence)
⑦ Safety relay

Outputs Q1, Q2, Q3 and Q4 activate the safe inputs of the robot controller via the safety relay. The safety system can therefore be used on a robot controller with test pulse output or with complementary/equivalent inputs.

Examples

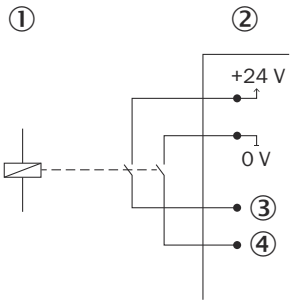


Figure 10: Circuit with complementary safety capable inputs

① Safety relay
② Robot controller
③ Safe input 11
④ Safe input 21

SICK provides you with a detailed circuit diagram for the safety system as an EPLAN macro.

4.5.2 Interfaces and signals

Description

The enabling current path of the relay modules create the interface to the robot controller.

Table 15: Signals for robot controller

Safety system signal designation	Safety controller connection	Yaskawa signal designation	Description
Emergency stop	Module 4 • 13/14 • 23/24 The enabling current paths are switched by safety output Q1, module 2.	EXESP	The LOW signal state initiates the safety function.
Protective stop	Module 4 • 33/34 • 43/44 The enabling current paths are switched by safety output Q2, module 2.	XIN1	The LOW signal state initiates the safety function. Must be configured in robot controller (SPEED LIMIT).
Safety-rated monitored speed	Module 5 • 13/14 • 23/24 The enabling current paths are switched by safety output Q3, module 2.	XIN2	The LOW signal state initiates the safety function. Must be configured in robot controller (SPEED LIMIT).
Automatic mode stop (SAFF safeguarding fence)	Module 5 • 33/34 • 43/44 The enabling current paths are switched by safety output Q4, module 2.	SAFF	The LOW signal state initiates the function.

Further topics

- "Safety controller pin assignment", page 31

4.6 Testing plan

The safety system must be thoroughly checked by appropriately qualified safety personnel during commissioning, after changes at regular intervals.

The regular thorough checks serve to ensure the effectiveness of the safety system and to identify defects as a result of changes or other influences (e.g., 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 safety system must fulfill certain minimum requirements. The minimum requirements for the thorough check of the safety system comply at least with the sum of the minimum requirements for the thorough check of the components of the 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 58
- Checklist for initial commissioning and commissioning, see "Annex", page 69
- Regular thorough check, see "Maintenance of the components", page 60

5 For mounting the components

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

5.1 Mounting the safety laser scanner

Prerequisites

The protective field of the safety laser scanner must be aligned horizontally and able to cover the entire hazardous area.

Recommended values for mounting the safety laser scanner

Table 16: Recommended values for mounting the safety laser scanner

Height of scan plane	Configured resolution	Additional measures for protection against crawling beneath required?
< 300 mm	50 mm	No
300 mm	70 mm	No
> 300 mm	70 mm	Yes

6 Electrical installation of the components

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

6.1 General requirements

The manufacturer must take measures against failures resulting from the same cause. These are to be documented in SISTEMA accordingly. During the electrical installation, the following, for example, must be taken into consideration:

- Separation of the signal pathways for the safety system signals, e.g., by separated cable laying
- Protection against overvoltage, overcurrent, etc. per the manufacturer instructions for the individual components
- Mechanical fastening of the wiring of the pushbutton for the hold to run device, e.g., with cable ties
- Measures for controlling the consequences of voltage failure, voltage fluctuations, overcurrent and undercurrent in the voltage supply of the robot controller

6.2 Safety controller pin assignment

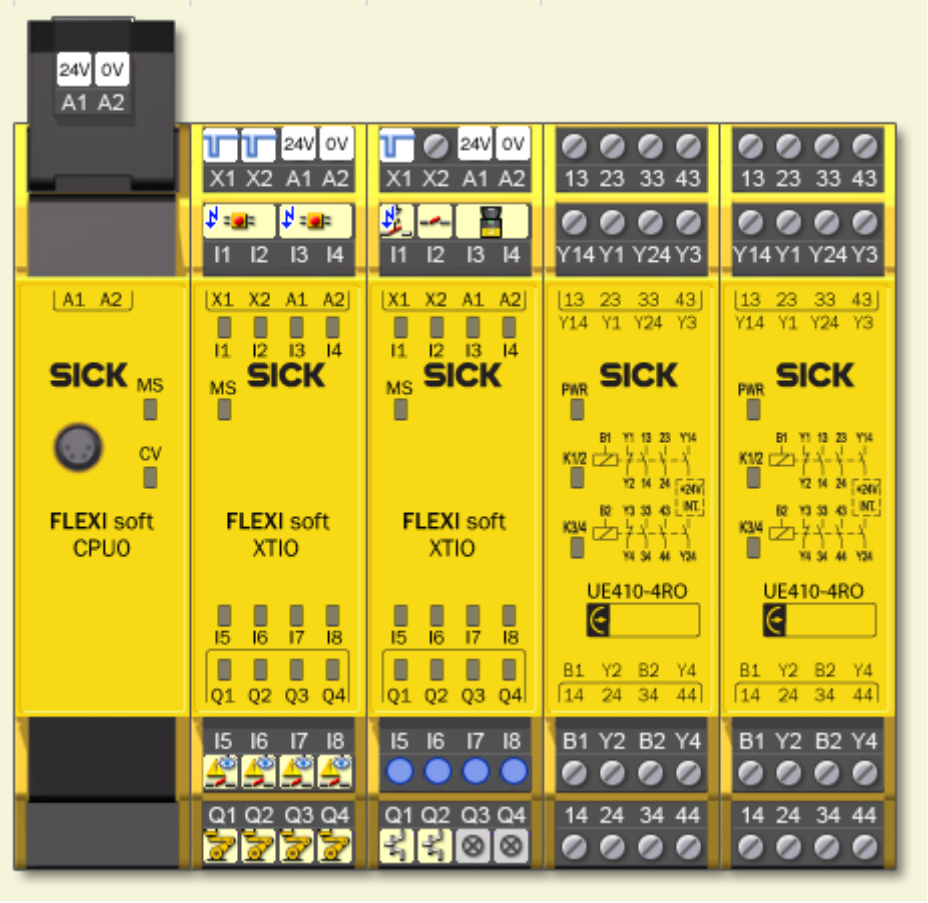


Figure 11: Flexi Soft pin assignment

Table 17: Modules of the safety controller

Module 1	FX3-CPU0 main module

Module 2	I/O module FX3-XTIO
Module 3	I/O module FX3-XTIO
Module 4	Relay module UE410
Module 5	Relay module UE410

Module 2 connections

Table 18: Module 2 inputs

Terminal	Connect to	Function
A1	Voltage supply 24 V DC	Voltage supply
A2	Voltage supply 0 V DC	Voltage supply
I1	Emergency stop push-button in the hazard-ous area	Emergency stop (within the hazardous area)
I2	Emergency stop push-button in the hazard-ous area	Emergency stop (within the hazardous area)
I3	Emergency stop push-button outside the hazardous area	Emergency stop (outside the hazardous area)
I4	Emergency stop push-button outside the hazardous area	Emergency stop (outside the hazardous area)
I5	Module 4, Y2	EDM emergency stop
I6	Module 4, Y4	EDM protective stop
I7	Module 5, Y2	Safety-rated monitored speed EDM
I8	Module 5, Y4	EDM automatic mode stop (SAFF safeguarding fence)

Table 19: Module 2 outputs

Terminal	Connect to	Function
Q1	Module 4, B1	Emergency stop
Q2	Module 4, B2	Protective stop
Q3	Module 5, B1	Safety-rated monitored speed
Q4	Module 5, B2	Automatic mode stop (SAFF safeguarding fence)
X1	Emergency stop push-button	Emergency stop test pulses
X2	Emergency stop push-button	Emergency stop test pulses

Module 3 connections

Table 20: Module 3 inputs

Terminal	Connect to	Function
I1	Reset pushbutton, pushbutton	Reset
I2	Safety laser scanner, pin 5	Warning field
I3	Safety laser scanner, pin 2	OSSD 1
I4	Safety laser scanner, pin 4	OSSD 2

Module 4 connections

Table 21: Module 4

Terminal	Connection to robot controller type YRC1000 or DX200 [1]	Connection to robot controller type YRC1000 micro [1]	Function
13/14	Terminal strip X18: 5/6	XD1: 4/14	Emergency stop
23/24	Terminal strip X18: 7/8	XD1: 5/15	Emergency stop
33/34	Terminal strip X181: 1/2	XD2: 2/12	Protective stop
43/44	Terminal strip X181: 3/4	XD2: 3/13	Protective stop

1) The designation of the terminal strips can deviate outside of EU countries. If designations deviate, you can identify the terminal strip using the connected PCB (see table 23).

Module 5 connections

Table 22: Module 5

Terminal	Connection to robot controller type YRC1000 or DX200 [1]	Connection to robot controller type YRC1000 micro [1]	Function
13/14	Terminal strip X181: 5/6	XD2: 25/23	Safety-rated monitored speed
23/24	Terminal strip X181: 7/8	XD2: 21/19	Safety-rated monitored speed
33/34	Terminal strip X18: 1/2	XD1: 33/31	Automatic mode stop (SAFF safeguarding fence)
43/44	Terminal strip X18: 3/4	XD1: 29/27	Automatic mode stop (SAFF safeguarding fence)

1) The designation of the terminal strips can deviate outside of EU countries. If designations deviate, you can identify the terminal strip using the connected PCB (see table 23).

Complementary information

Table 23: Assignment of terminal strip and connected robot controller PCB

Robot controller	Terminal strip	Connected PCBs
DX200	X18	YSF22
	X181	YSF24
YRC1000	X18	ASF01
	X181	ASF02
YRC1000micro	XD1	ASF30
	XD2	ASF32

6.3 Further connections of the individual components

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

7 Configuration

7.1 Overview of configuration

Overview

The safety system is added to a project in Flexi Soft Designer. Most of the configuration is already implemented in the project. You have to complete, verify and validate the configuration in accordance with the requirements of your application.

Table 24: Required configuration software

Component	Configuration software
Flexi Soft safety controller	Flexi Soft Designer
microScan3 Core I/O safety laser scanner	Safety Designer
nanoScan3 Core I/O safety laser scanner	Safety Designer

Important information

NOTE
This document only contains information for configuring the safety system. You will find detailed information for use of the configuration software in the associated operating instructions.

- “Flexi Soft in the Flexi Soft Designer” (8012998)
- “Safety Designer” (8018178)

Procedure

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

Further topics

- "Main module configuration", page 37
- "Configuring safety laser scanner", page 45

7.2 Requirements on software and firmware

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

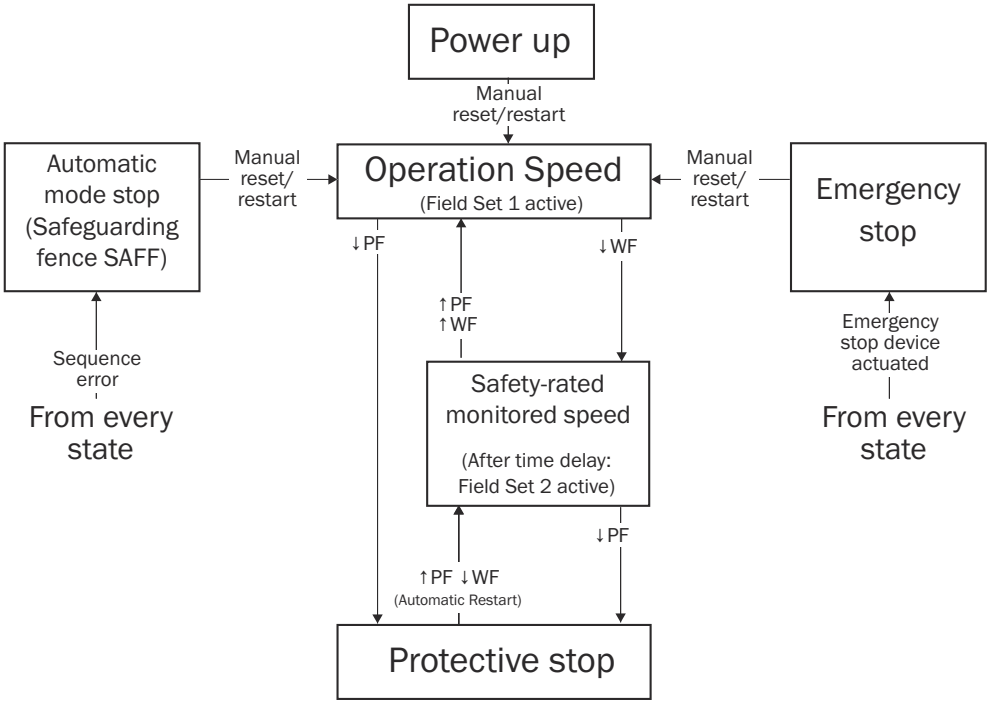
Table 25: SICK component versions

Software/Firmware	Tested version
Flexi Soft Designer	1.9.4
Safety Designer	2023.01
Firmware FX3-CPUx	4.0
Firmware FX3-XTIO	3.0

Table 26: Robot controller versions

Software/Firmware	Tested version
YRC1000	YAS2.94.00A(JP/EN)-00
YRC1000micro	YBS2.22.00A(EN/DE)-00
DX200	DN2.80.00A(US/DE)-00

7.3 Overview of software structure



↑	Field becomes free.
↓	Field is infringed.
PF	Protective field
WF	Warning field
Operation speed	Robot executes tasks at normal speed.
Monitored speed	Robot executes tasks at safety-rated monitored speed.
Emergency Stop	If the emergency stop pushbutton has been actuated, the robot executes a protective stop.
Automatic mode stop (SAFF safeguarding fence)	If the fields have been infringed in an invalid sequence, the robot executes a protective stop.

7.3.1 Project file logic

Process when a person is directly next to the robot.

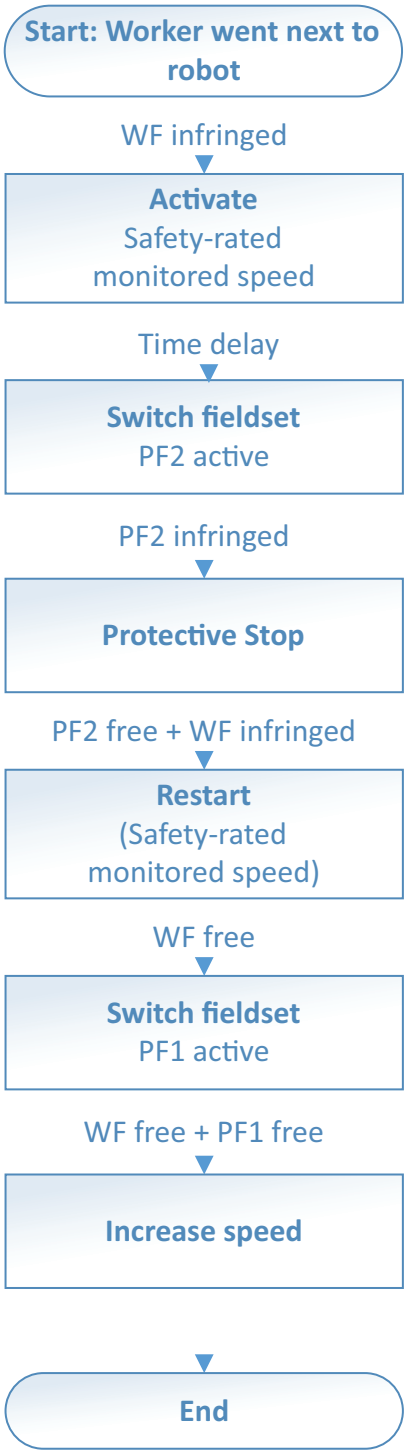


Figure 12: Logic of the project file - person stands next to robot

Process when a person passes by the robot.

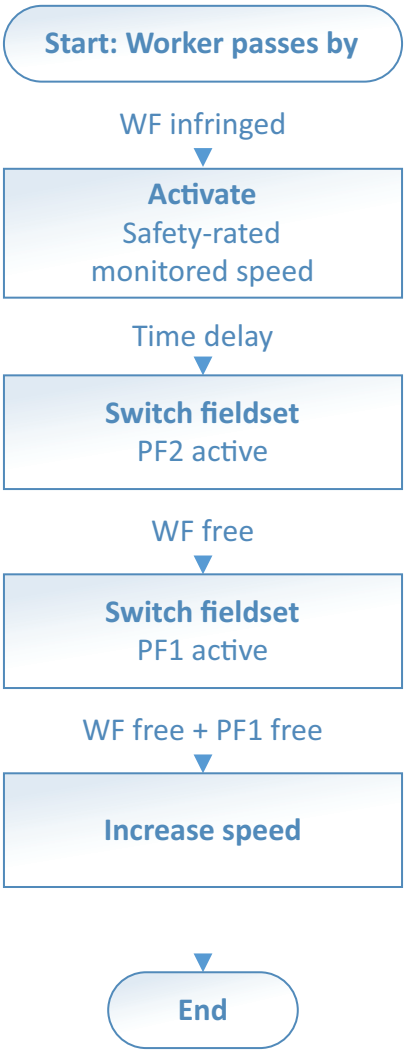


Figure 13: Logic of the project file - person passes robot

7.4 Main module configuration

7.4.1 Adding a safety system in Flexi Soft Designer

Overview

When adding a safety system, the hardware configuration and logic configuration for the current project are imported into Flexi Soft Designer.

Procedure

Selecting the safety system

1. Open Flexi Soft Designer.
2. **Project** > **New** > **Standalone station project**
3. Dependant on the safety system, drag a suitable main module out of the **Modules** window into the **Configuration area**.
4. Click on the **Safety Systems** selection window in the bottom left.
5. In the **Available Safety System** list, select the desired safety system.

✓ A description of the selected safety system is displayed.

Checking the version of the safety system

ⓘ **NOTE** | The license applies only to the current version of the safety system. If you do not use the current version of the safety system, verification problems may arise. If Flexi Soft Designer hasn't been updated recently, a manual check of the version of the safety system is required.

6. If the version has been confirmed as current: Continue at step 15..
   To check, whether the version of the safety system is the current version: Continue at step 7..
7. Click on the **Description** tab and check the version number of the safety system in the **Version** field.
8. Click on **Find the latest safety systems**.

✓ The SICK website is opened.

9. On the **Downloads** > **Software** tab, search for the desired safety system and check the version of the safety system available online.
10. If the version in the configuration matches the version on the website, continue at step 15..

Importing the current version from the website

11. On the SICK website, click on **Download** for the desired safety system and save the SSA file locally.

✓ The SSA file of the safety system is downloaded.

12. In Flexi Soft Designer, click on the **Import Safety System and add to list** button.

13. Select the downloaded SSA file and click **OK** to confirm.
14. In the **Available Safety System** list, select the new version of the safety system.

Adding the safety system

15. Click on **Add Safety System** in the bottom left.

✓ The safety system is added to the project.

Further topics

- "Activating the license for the safety system", page 44

7.4.1.1 Checking the checksums of the safety system

Procedure

1. Click on **Hardware configuration**.
2. In the **Info** selection window, click on **info**.
3. Make sure that the checksum that is displayed corresponds to one of the following checksums:

Table 27: Checksums

Description	Checksum
CPU0	0x8440502
CPU1	0x075FE341
CPU2	0x075FE341
CPU3	0xE66AF8C1

Complementary information

Changing the configuration logic or the hardware configuration changes the checksum.

7.4.2 Opening the logic editor

Procedure

► Click on **Logic editor**.
✓ The logic editor opens.

7.4.3 Creating or deleting links

Overview

The logics in the configuration software mainly consist of the following elements:

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

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.

✓ The link is deleted.

7.4.4 Jump addresses

Jump addresses consist of a source jump address and a destination jump address. The destination jump address assumes the same value (HIGH or LOW) as the associated source jump address without a delay.

Among other things, jump addresses are used to connect the various pages of logic with each other.

7.4.4.1 Finding source and destination jump addresses that belong together

Procedure

1. Right-click on the source or destination jump address.
2. Click **Used on page**.
✓ A list of all pages containing elements of the jump address is displayed.
3. Click on the desired page.
✓ The desired page is displayed. All elements of the jump address are highlighted in color.

7.4.4.2 Adding a new source jump address

1. Drag the **Add source jump address** symbol from the toolbar on the left of the logic creation page into the working range.
2. Enter a unique name in the **Create jump mark** dialog box.
3. Click on **OK**.

7.4.4.3 Adding a new destination jump address

1. Drag the **Add destination jump address** symbol from the toolbar on the left of the logic creation page into the working range.
2. Select the desired jump mark in the **Select jump mark** dialog box.
3. Click on **OK**.

7.4.5 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.

► 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.

The manufacturer of the machine must verify the logic and link the input signals of the safety laser scanner before the logic is transferred to the Flexi Soft.

The manufacturer of the machine is responsible for the output connections and for the logic verification. The logic can only be verified with a valid license.

7.4.6 Linking outputs and logic

Important information

NOTE
Some output elements have not yet been connected with the logic on some pages. You must first check whether the logic of the safety system is sufficient for the requirements of your application. Only then can you connect the output elements with the logic.

7.4.7 Content of the logic editor

The logic editor contains the following pages:

Table 28: Logic editor overview

Page name	Contents
Description	Disclaimer and safety notes

Page name	Contents
Laser scanner	Signals to and from safety laser scanner
EmergencyStop	Emergency stop with manual reset
ProtectiveStop	Protective stop with automatic restart
SafetyRatedMonitoredSpeed	Reduction of speed and monitoring of safe speed
SequenceCheck	Automatic restart if a person has exited the hazardous area on the intended path
ExternalSAFF	Optional: An additional external signal can be integrated on this page. This signal is used as an additional trigger condition for the SAFF safeguarding fence function.
ErrorHandling	setting a signal if the sequence is invalid

7.4.7.1 Laser scanner page

This page contains the links to the safety laser scanner signals.

The logic for switching field set depends on the signal **MonitoredSpeedActive**. The field set of the safety laser scanner is switched after the safety-rated monitored speed has been activated.

7.4.7.2 EmergencyStop page

This page is used to configure the logic for the emergency stop.

The emergency stop is triggered by actuating the emergency stop pushbutton or by a short-circuit in the cabling between the safety controller and the safety laser scanner.

The emergency stop must be manually reset from a position outside of the warning and protective fields. This action must also always be performed after starting up the machine.

Once a reset is possible, the **EMG_RESET** output flashes. If an EDM error occurs on any of the three relevant relays, the robot performs an emergency stop and a reset is not possible (see "ErrorHandling page", page 44).

The safety relay is monitored by the predefined EDM function block.

The emergency stop pushbutton is monitored using test pulses and the discrepancy time (maximum 1 s) is checked.

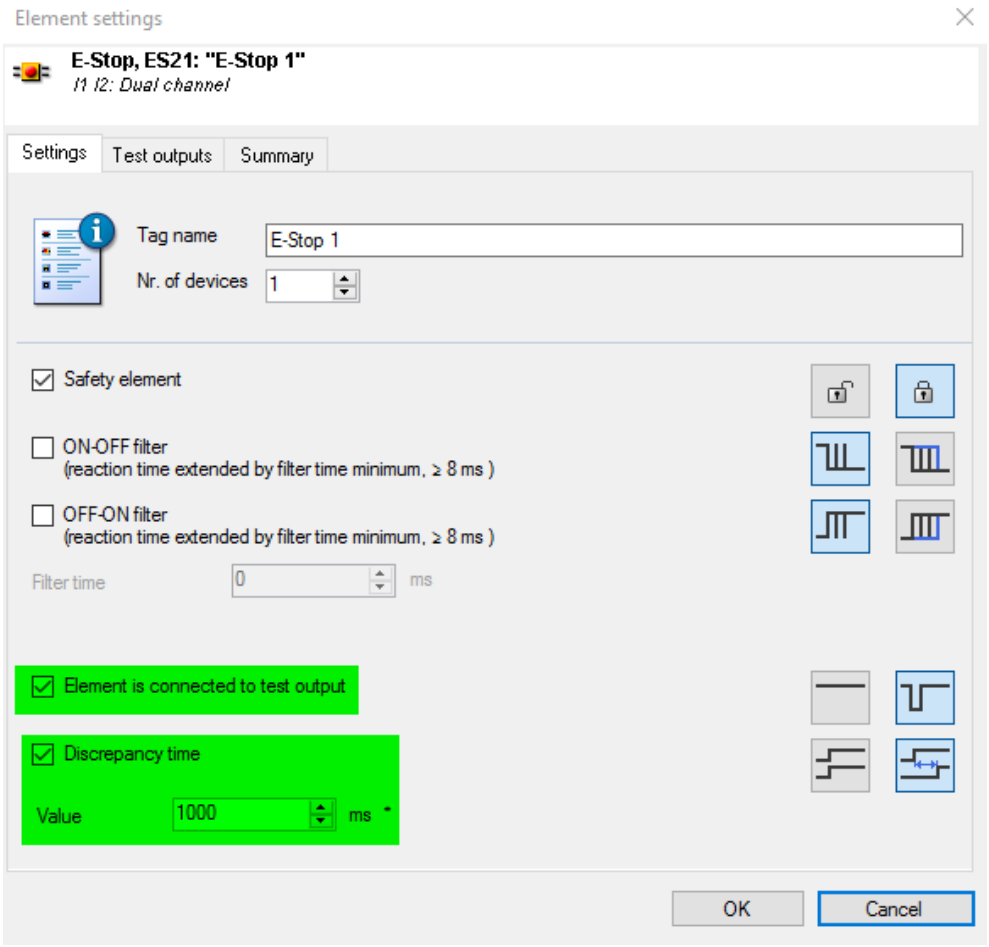


Figure 14: EmergencyStop page view

The time sequence for the reset pushbutton is checked within the predefined **RESET** function block. In this function block, the **Min. reset pulse time** parameter must configured within the following limits:

100 ms ... 30 s

A reset is only possible if the warning field and protective field are clear.

7.4.7.3 ProtectiveStop page

This page is used to configure the logic for the protective stop.

The **ProtectiveStop** output is High if the protective field is free and the emergency stop is not triggered.

In order to avoid a continuous switching of the output, a delay time of 300 ms is executed if a person is located at the exact edge of the protective field.

The safety relay is monitored by the predefined EDM function block.

7.4.7.4 SafetyRatedMonitoredSpeed page

Important information

DANGER
Premature switchover to the smaller field set

The robot might not stop on time.

► Select the delay time so that it is the same or longer than the switch-on delay time of the robot (DETECTION DELAY TIME).

Overview

This page is used to configure the logic for the safety-rated monitored speed.

If the warning field is infringed, the **MonitoredSpeed_KF301** output is set to Low and the robot slows down.

After a delay time in which the robot reaches the reduced speed and this is then monitored and evaluated for safety, the **MonitoredSpeedActive** marker is set to High. This is used to switch to the smaller field set of the safety laser scanner.

The duration of the delay time is safety-relevant and must be defined by the manufacturer (see "Approaching the hazardous area", page 16).

If the warning field clears (rising signal edge), then the **MonitoredSpeedActive** signal is immediately set to Low, allowing a switch to the field set with the larger protective field. After a delay time of 100 ms, the safety-rated monitored speed is deactivated on the robot (High at **MonitoredSpeed_KF301** output) and the robot speed is increased again.

The safety relay is monitored by the predefined EDM function block.

Configuration of delay time

The delay time of the safety system must be selected depending on the application and must be the same length or longer than the switch-on delay time of the robot (DETECTION DELAY TIME).

You can configure the delay time in the **Off-delay timer 0** function block with the **Delay time** parameter.

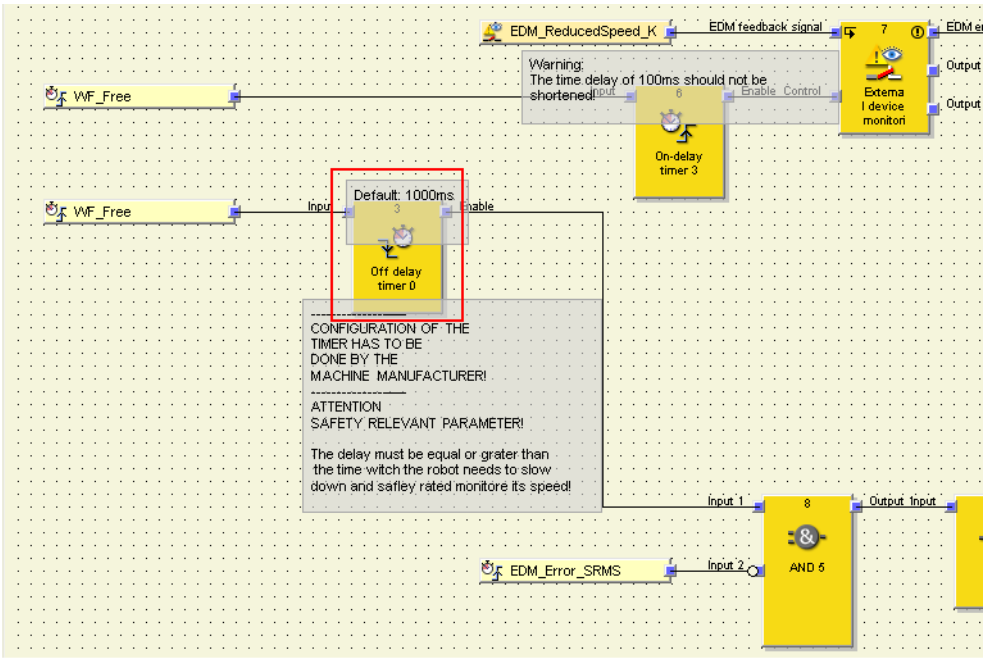
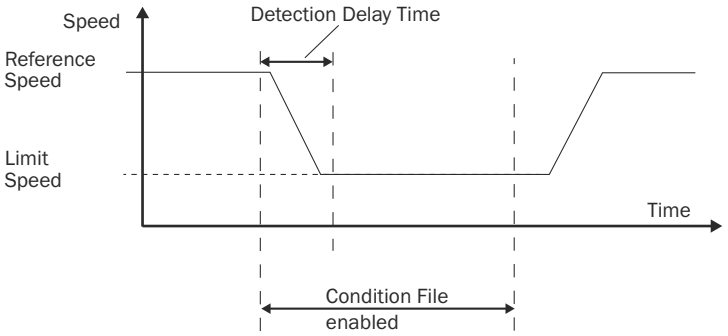


Figure 15: Function block for configuration of the delay time



Complementary information

If the delay time of the safety system is much longer than the switch-on delay time of the robot, the larger protective field is still active even though the robot is already moving at a safe reduced speed. This is not safety-relevant, but limits availability.

Further topics

- "Configuring the condition file for safety-rated monitored speed", page 56

7.4.7.5 SequenceCheck page

This page is used to configure the logic for sequence monitoring.

The sequence check should prevent an unexpected restart if there is misuse or if a person has not left the hazardous area via the intended route. For a valid sequence, the warning field must be infringed for at least 500 ms after the protective field has become clear (rising signal edge).

After the signal edge of the protective field has risen, the switch-off delay keeps the signal high for 500 ms. If the warning field remains infringed (low), then the sequence is valid. If the warning field clears within 500 ms (high), then the sequence is invalid and **SequenceValid** is on low.

SequenceValid remains Low on a logic cycle if the sequence is not met. The SAFF safeguarding fence function is initiated, which triggers a protective stop.

7.4.7.6 ExternalSAFF page

Overview

You can use external safety signals to trigger the Automatic mode stop function directly on the robot controller (SAFF safeguarding fence) (e.g. signals from additional safety switches, safety light curtain, etc.). This signal is used as an additional trigger condition for the function. The functionality of the safety system described in this document is not impeded by this. The safety functions with external safety signals are not a part of this safety system and are the responsibility of the manufacturer.

Important information

NOTE
The Automatic mode stop function is only considered in the Automatic operating mode. This applies regardless of whether the trigger is an internal or external signal.

Procedure

► Replace the **STATIC 1** signals in the **AND** function block with the safety signal.

7.4.7.7 ErrorHandling page

This page is used to configure the logic for error rectification.

If the defined sequence is not complied with, the **ErrorLED** output flashes. After a manual reset (while the warning field and protective field are clear), the flashing stops.

If there is no valid **EXT_SAFF_OK** signal, the **ErrorLED** output is set to High.

All EDM errors are collected in one signal. If there is an error on one of the three relays, then the **No_EDM_Error** signal is set to Low.

7.4.8 Activating the license for the safety system

Overview

A project can only be verified if a license is activated.

Procedure

1. In the **Extras** menu, select the **Software licenses** command.
2. In the **Software licenses** dialog box, click on the **Activate** button.
3. Enter the Ticket ID and confirm with **OK**.

✓ The CodeMeter License Central WebDepot opens in your browser.

4. Select the binding for the licenses:
   - Binding to a PC
   - Binding to a dongle
5. Select the desired licenses.

   NOTE | Note the specified number of licenses. If you have purchased a license package and only want to activate specific licenses in it, you need to first distribute the licenses.
6. Activate the licenses by clicking the **Now activate the selected licenses** button.
7. Click on **Close** to apply the changes and close the **Software licenses** window.

Complementary information

- It is also possible to activate a license offline. To do so, following the **File-based license transfer** instructions in the WebDepot.
- Licenses are only marked as used after being transfered to the controller.
- Licenses cannot be copied or transferred. It is not possible, for example, to transfer it back to the PC.
- For details on managing licenses, see the operating instructions for the configuration software: 8012998.

7.5 Configuring safety laser scanner

7.5.1 Pre-configured file

SICK provides you with files in which a majority of the configuration for the safety laser scanner is already implemented. You have to complete, verify and validate the configuration in accordance with the requirements of your application.

7.5.2 Checking the checksums of the safety laser scanner

Procedure

1. Open the configuration file for the safety laser scanner in Safety Designer.
2. Click on **Configuration**.
3. In the **Device overview** window, double-click on the desired safety laser scanner.

✓ The device window opens.

4. Make sure that the checksum that is displayed corresponds to one of the following checksums:

Table 29: Checksums

Safety laser scanner	Checksum
microScan3	0x7AC4DB38
nanoScan3	0xA3E2A8CB

Complementary information

Changing the configuration logic or the hardware configuration changes the checksum.

7.5.3 Configuring microScan3 Core I/O

The microScan3 Core I/O is configured with Safety Designer.

For configuration, refer to the microScan3 Core I/O operating instructions.

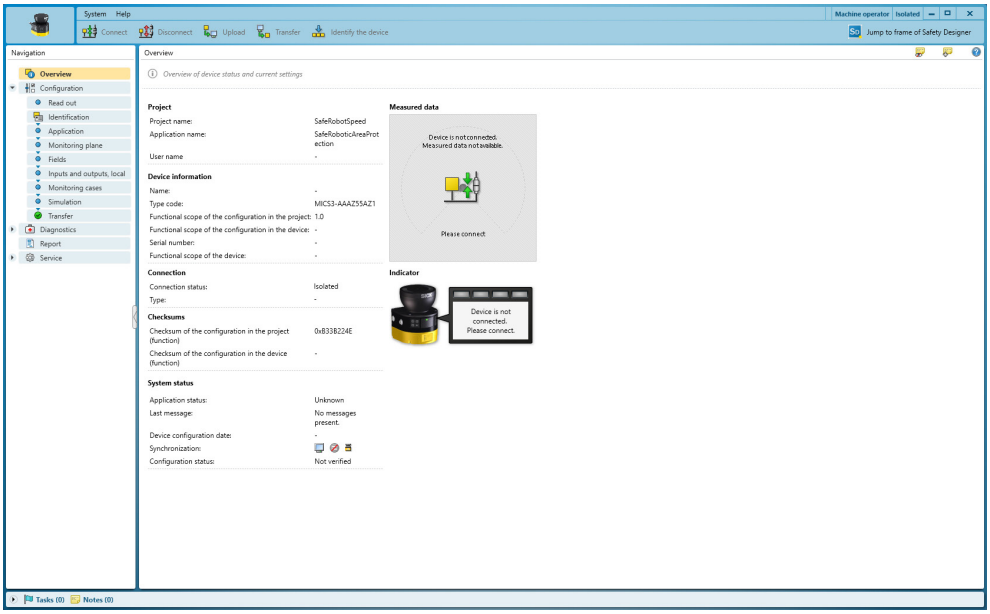


Figure 16: microScan3 Core I/O configuration overview

Application variants: stationary

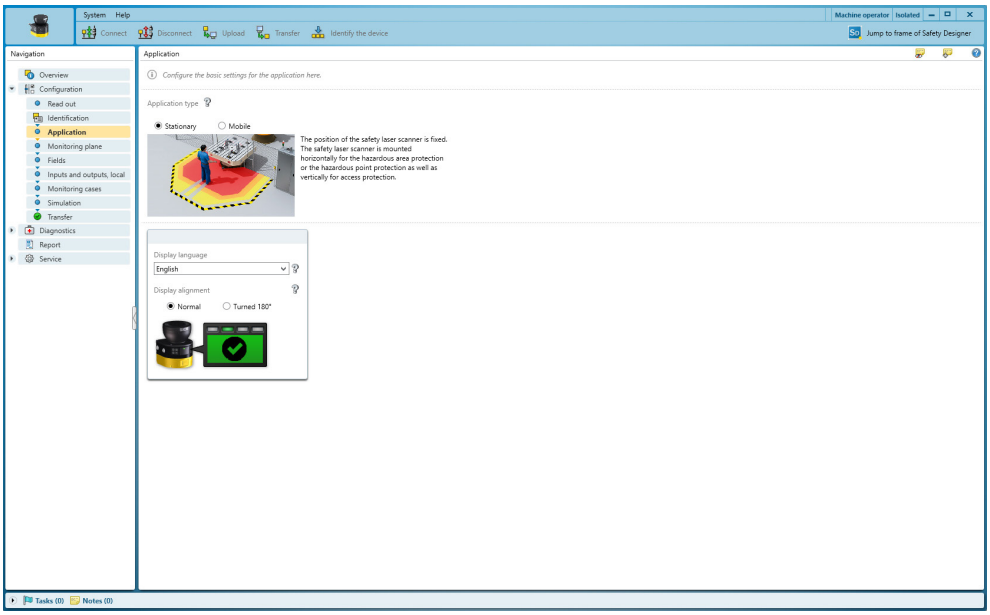


Figure 17: microScan3 Core I/O configuration overview

Resolution: 70 mm

NOTE

The height of the scan plane must be checked, see "Mounting the safety laser scanner", page 30.

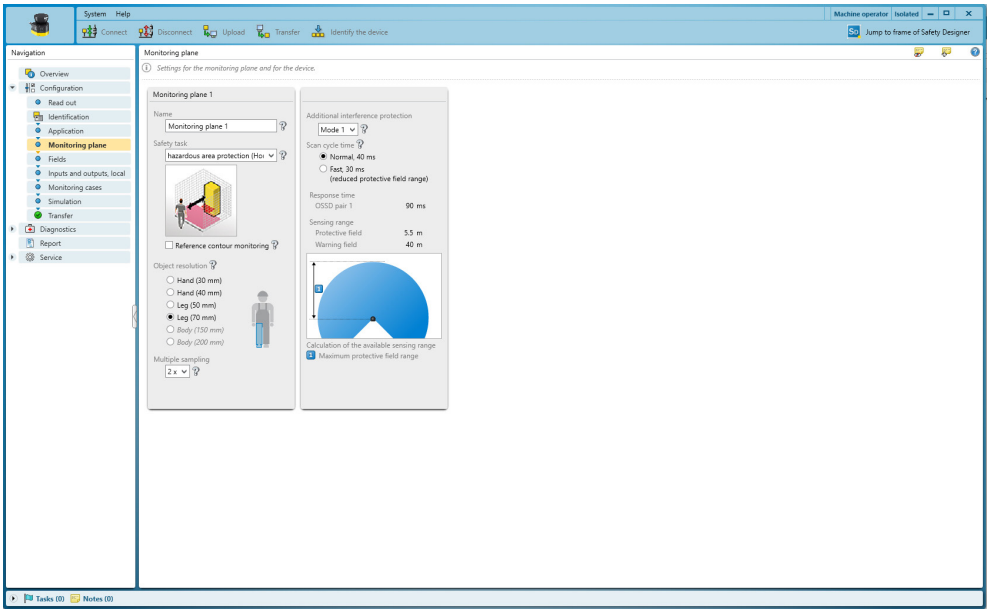


Figure 18: microScan3 Core I/O configuration overview

Configuring the large protective field

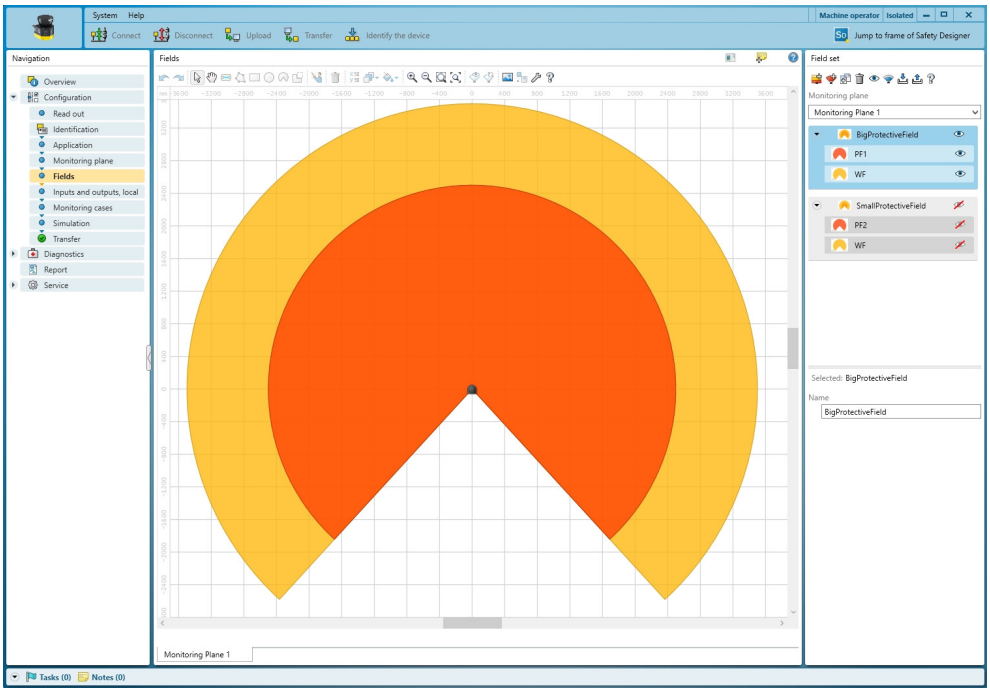


Figure 19: microScan3 Core I/O configuration overview

Configuring the small protective field

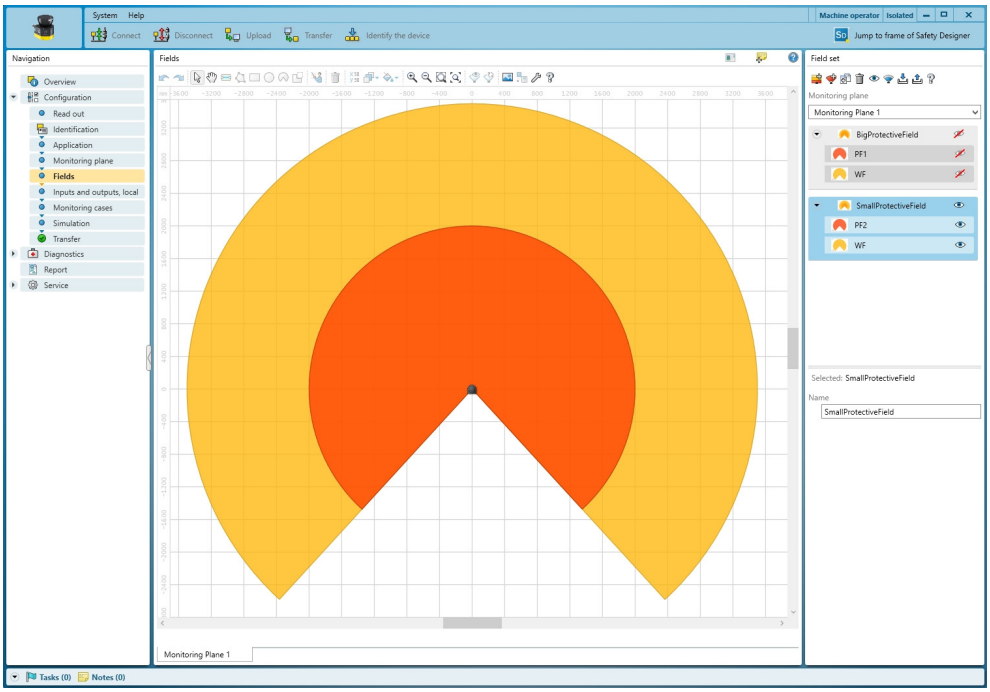


Figure 20: microScan3 Core I/O configuration overview

Configuring Uni-I/Os

The **Monitoring result** signal outputs the state of the warning field at Uni-I/O 1 (pin 5) and must be set to high by default (blue line in the square in the pin description).

The **static control input** signal is complementary input A at Uni-I/O 2 and Uni-I/O 3 for switching field sets.

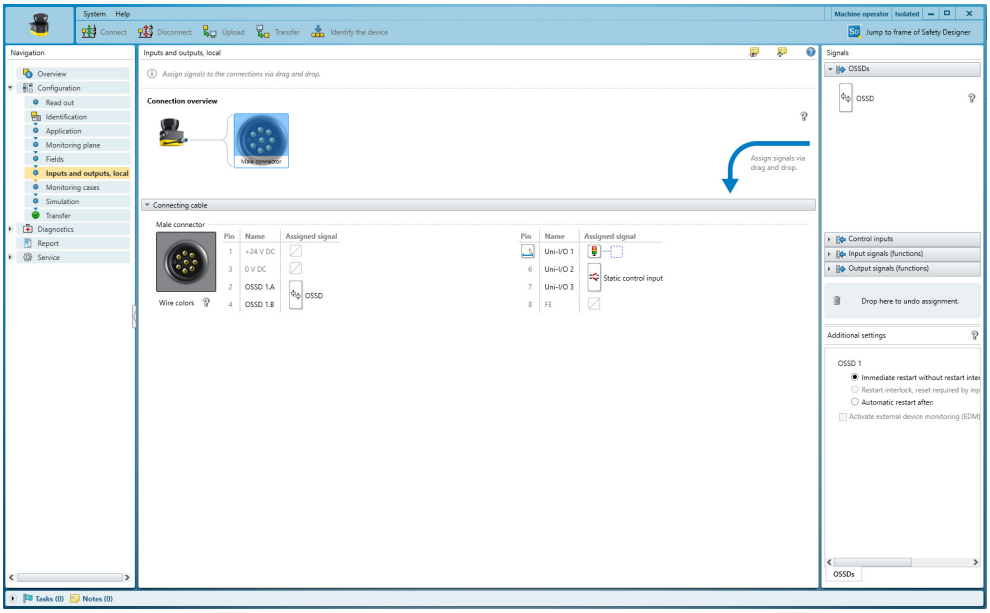


Figure 21: microScan3 Core I/O configuration overview

Configuring monitoring cases

DANGER

Failure to comply with manufacturer's obligations

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.

In the factory settings, the configuration only contains example values. These values must be adjusted.

- ► Calculate the values for the monitoring cases. These are determined based on the risk assessment and the properties of the robot.
- ► Bear in mind that someone may already be in the protective field at the point when the monitoring cases switch. Only switching in time (namely before the danger arises for the person at this location) ensures protection.

If input A is set to 0, then the large protective field must be active. If input A is set to 1, then the small protective field must be active.

The protective field affects OSSD pair 1 and the warning field affects Uni-Out 1.

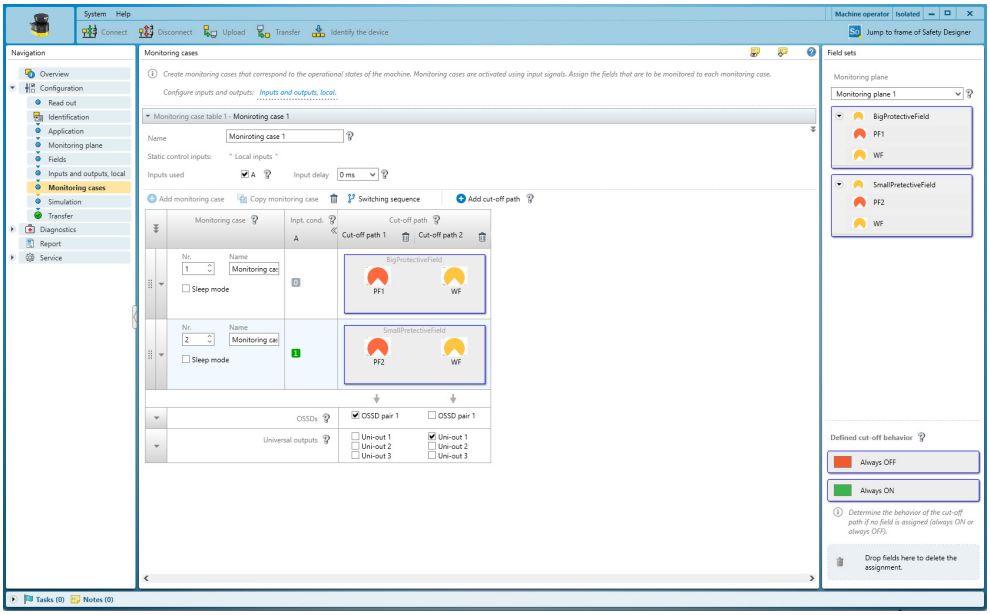


Figure 22: Configuration view monitoring cases

7.5.4 Configuring nanoScan3 Core I/O

The nanoScan3 Core I/O is configured with Safety Designer.

For configuration, refer to the nanoScan3 Core I/O operating instructions.

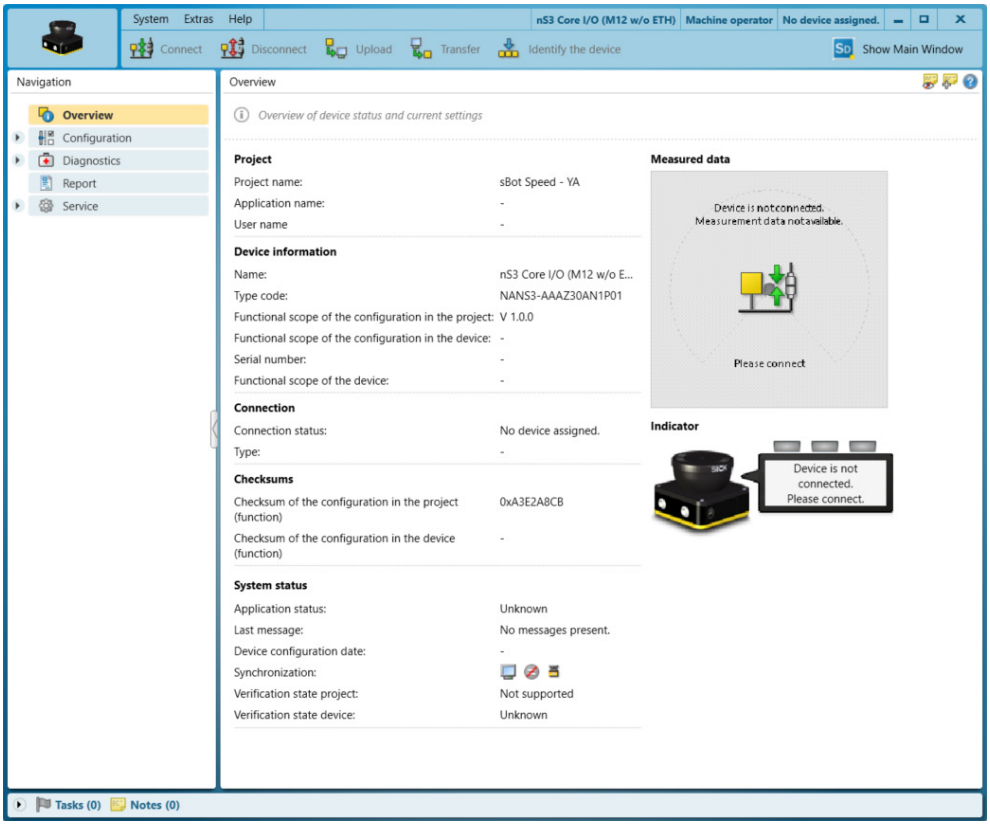


Figure 23: nanoScan3 Core I/O configuration overview

Application variants: stationary

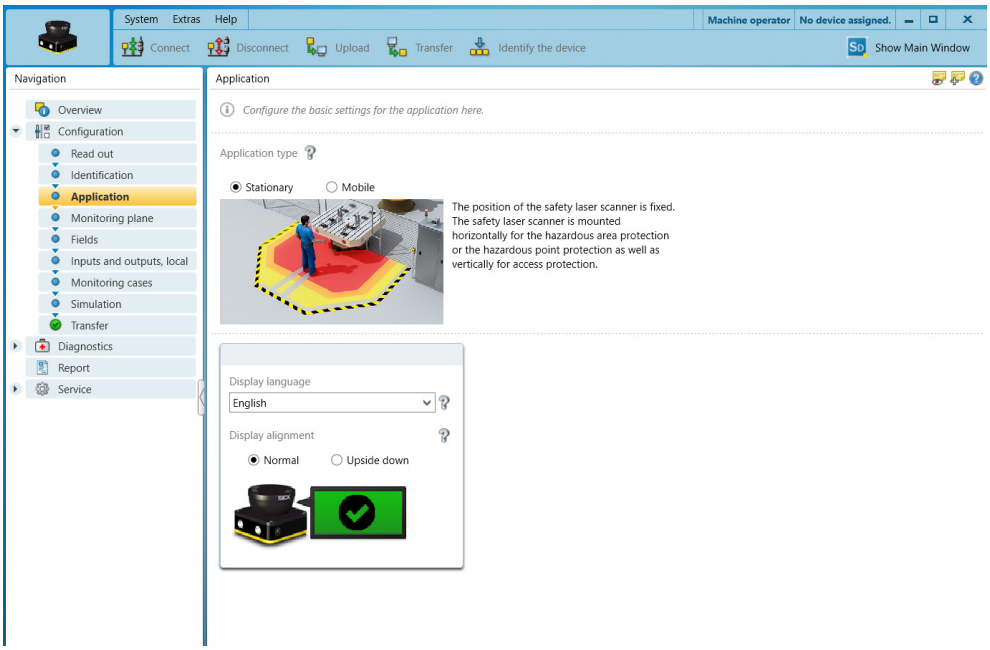


Figure 24: nanoScan3 Core I/O configuration overview

Resolution: 70 mm

NOTE

The height of the scan plane must be checked, see "Mounting the safety laser scanner", page 30.

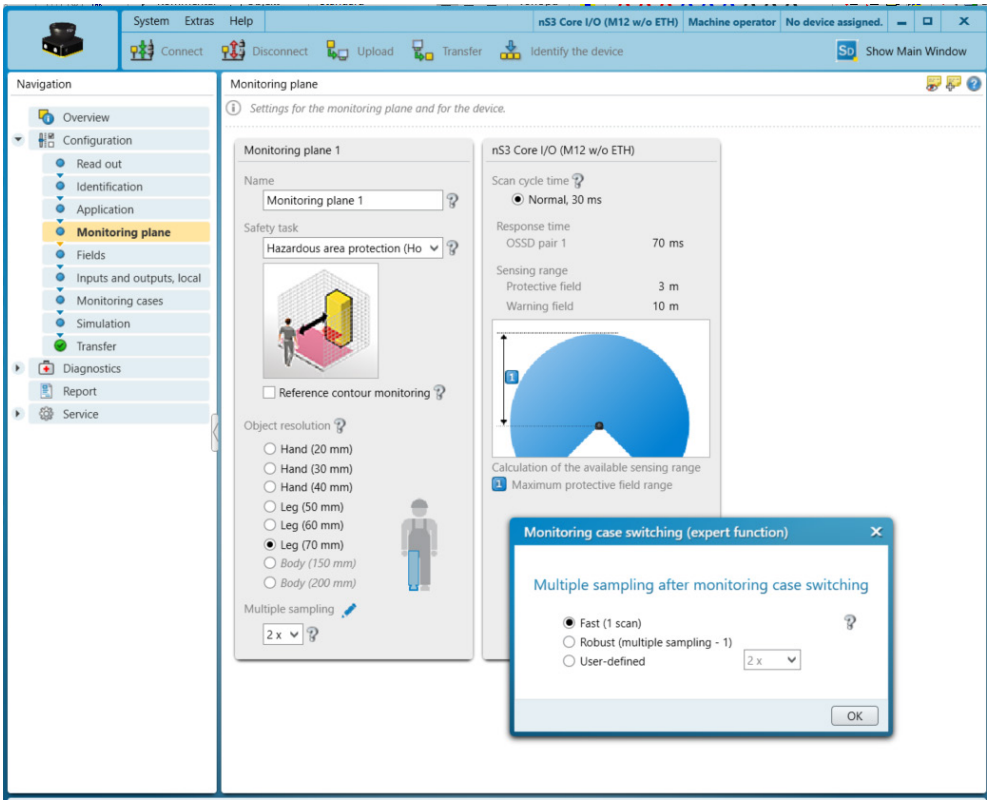


Figure 25: nanoScan3 Core I/O configuration overview

Multiple sampling after switching the monitoring case: Fast (1 scan)

Configuring the large protective field

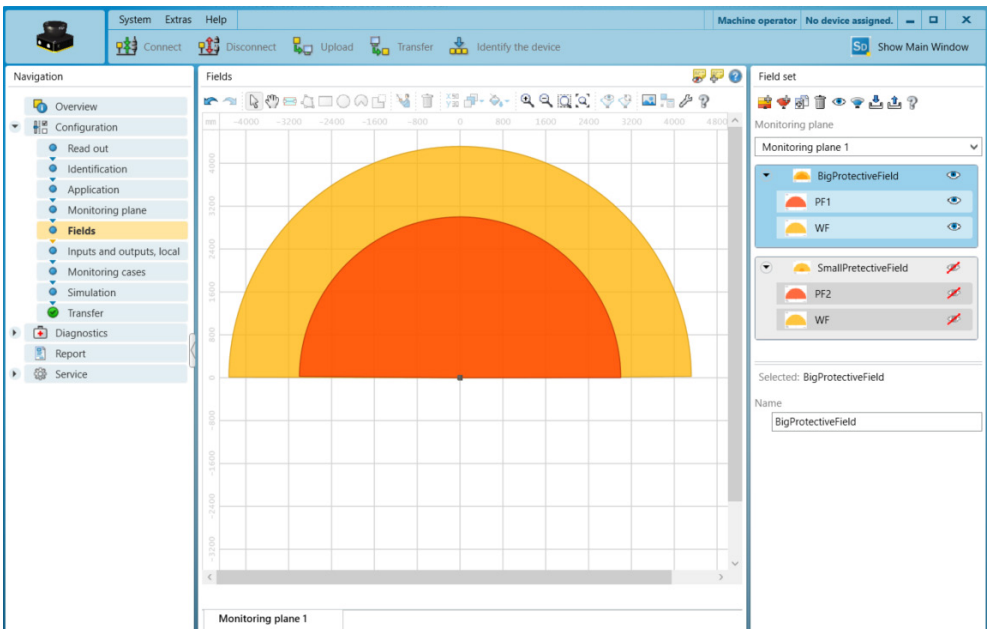


Figure 26: nanoScan3 Core I/O configuration overview

Configuring the small protective field

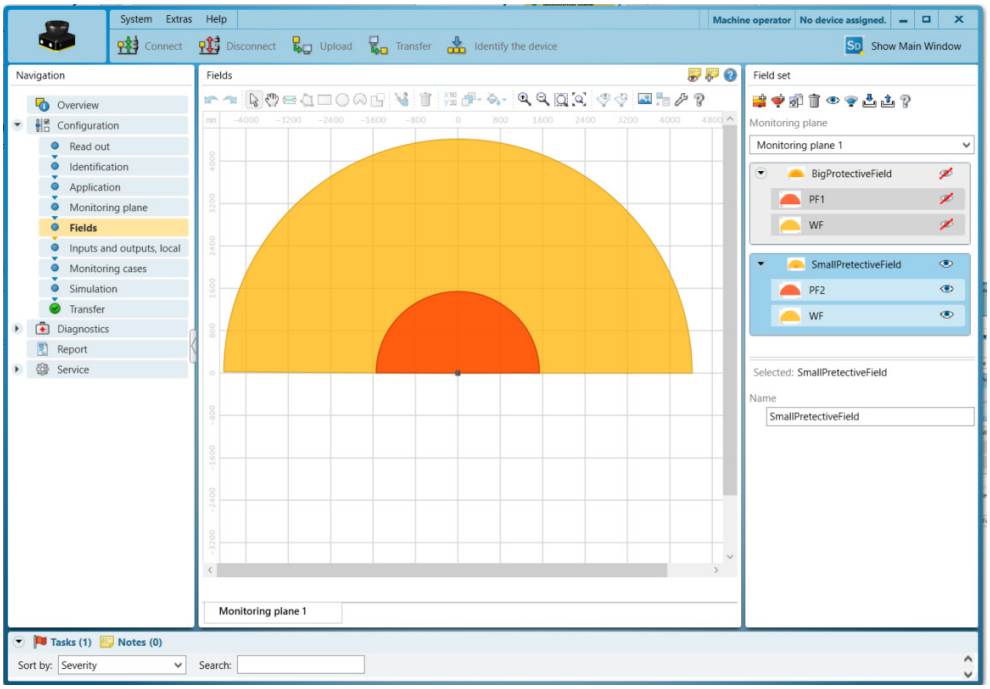


Figure 27: nanoScan3 Core I/O configuration overview

Configuring Uni-I/Os

The **Monitoring result** signal outputs the state of the warning field at Uni-I/O 1 (pin 5) and must be set to high by default (blue line in the square in the pin description).

The **Static control input** signal is complementary input A at Uni-I/O 2 and Uni-I/O 3 (pin 6 and pin 7) for switching field sets.

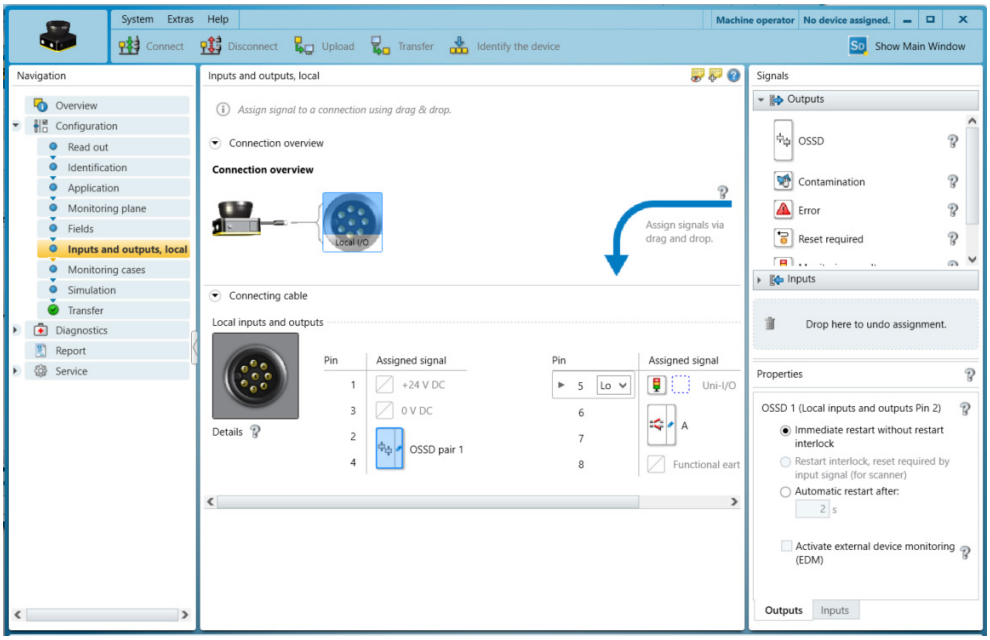


Figure 28: nanoScan3 Core I/O configuration overview

Configuring monitoring cases

DANGER

Failure to comply with manufacturer's obligations

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.

In the factory settings, the configuration only contains example values. These values must be adjusted.

- ► Calculate the values for the monitoring cases. These are determined based on the risk assessment and the properties of the robot.
- ► Bear in mind that someone may already be in the protective field at the point when the monitoring cases change over. Only switching in time (namely before the danger arises for the person at this location) ensures protection.

If input A is set to 0, then the large protective field must be active. If input A is set to 1, then the small protective field must be active.

The protective field affects OSSD pair 1 and the warning field affects Uni-Out 1.

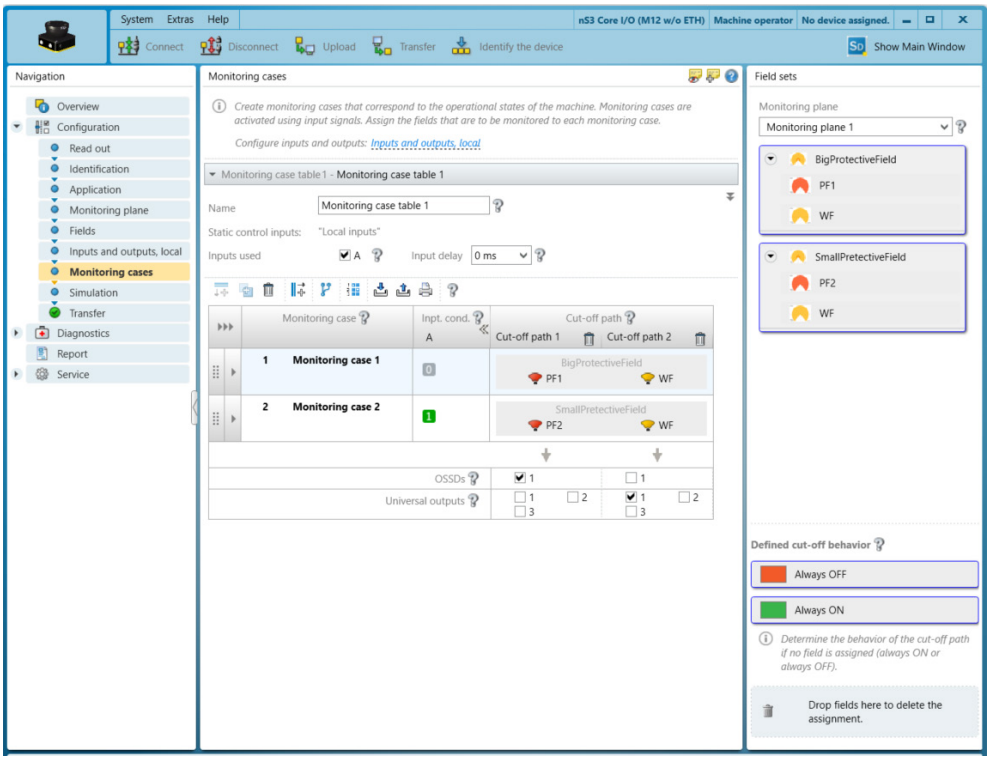
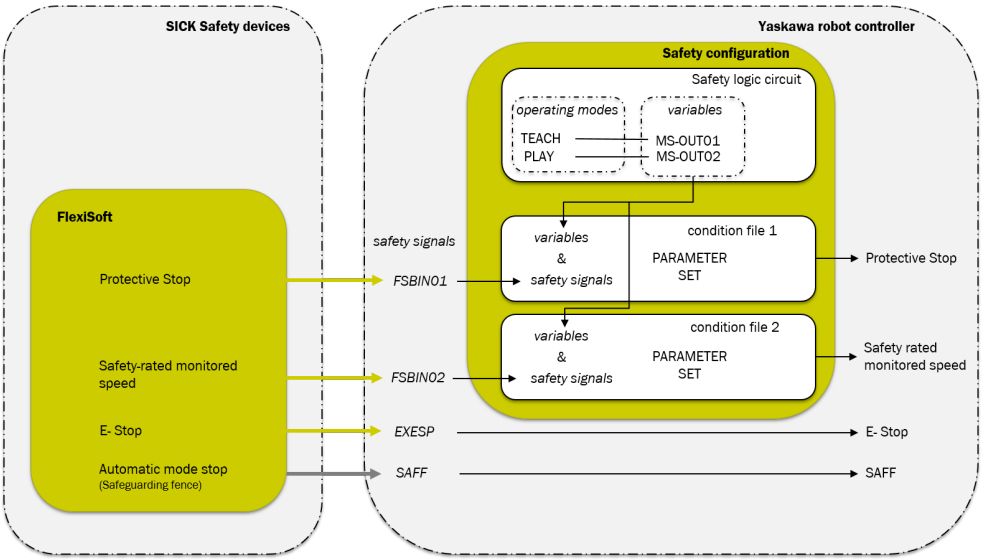


Figure 29: Configuration view monitoring cases

7.6 Configuration of the robot controller



7.6.1 Configuring safety logic

Overview

The SAFETY LOGIC CIRCUIT is a function which creates safety logic on the hand-held programming device. Working processes can be set-up in this way, e.g. stopping the robot.

Procedure

Switching to SAFETY MODE:

1. Select the **SYSTEM INFO** in the main menu.
2. Select **SECURITY**.
3. Select **SAFETY MODE**.
4. Enter the password if necessary.

Configure SAFETY LOGIC CIRCUIT.

5. Select **SAFETY FUNC.** in the main menu.
6. Select **SAFETY LOGIC CIRCUIT**.
7. Press **PAGE** on the hand-held programming device.
8. Configure the safety logic as in the following table.

Table 30: Configuration of safety logic

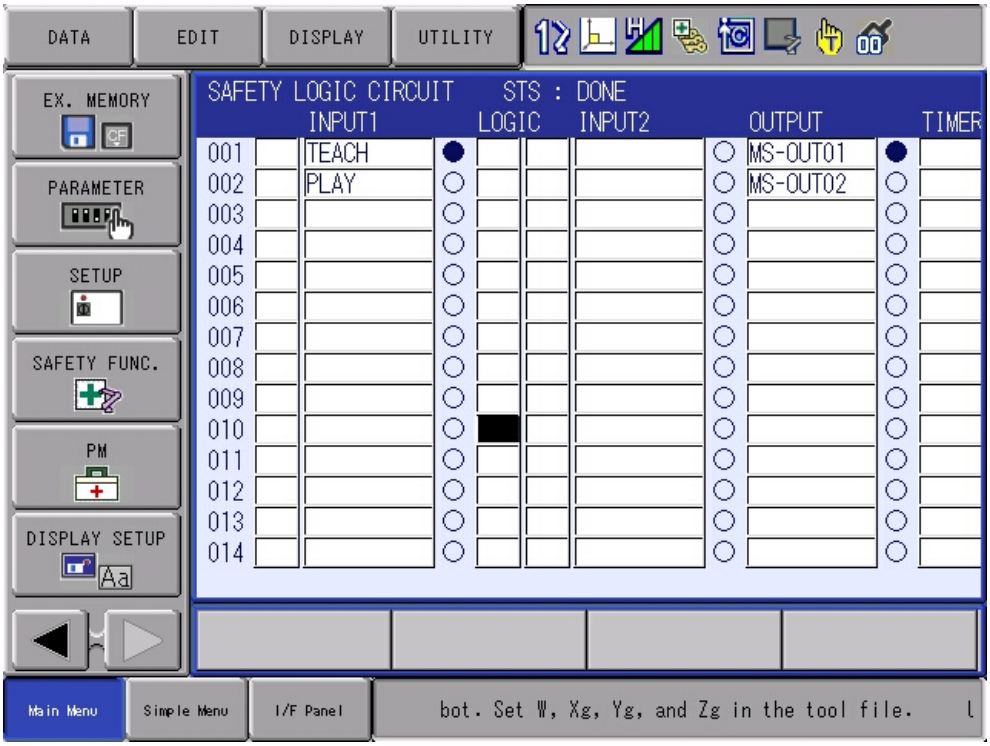
	LOGIC	INPUT1	LOGIC	INPUT2	OUTPUT	TIMER	COMM
001		TEACH			MS-OUT01		
002		PLAY			MS-OUT02		

9. Press **WRITE**.

✓ The **Update the file?** dialog box appears.

10. Press **YES**.

Example:



7.6.2 Configuring condition file for protective stop

Prerequisites

The **SAFETY MODE** is active (**SYSTEM INFO** > **SECURITY** > **SAFETY MODE**).

Procedure

Configuring condition file

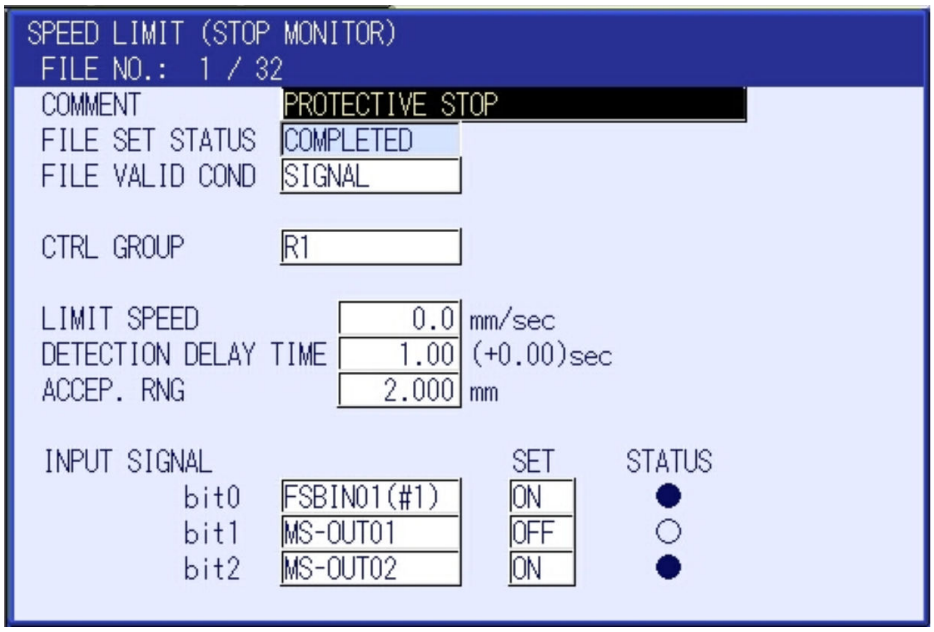
1. Select **SAFETY FUNC.** in the main menu.
2. Select **SPEED LIMIT**.
3. Select a free condition file.
4. Perform the following settings:

Table 31: SPEED LIMIT settings for protective stop

Field	Value	Set
COMMENT	PROTECTIVE STOP	
FILE VALID CON	SIGNAL	
CTRL GROUP	R1 [1]	
LIMIT SPEED	0.0 mm/sec	
DETECTION DELAY TIME	1.00 sec [1] [2]	
ACCEP. RNG	2,000 mm [1] [3]	
INPUT SIGNAL		
bit0	FSBIN01 (#1)	ON
bit1	MS-OUT01	OFF
bit2	MS-OUT02	ON

1) Example value. The value must be defined by the machine manufacturer and/or integrator.
2) The value is relevant for calculating the minimum distance of the protective field to the hazardous area.
3) The values should be as low as possible.

Example:



5. Press **WRITE**.
✓ The **Update the file?** dialog box appears.
6. Press **YES**.

Check safety logic and condition file

7. Protective field infringed.
8. Set the Automatic (PLAY) operating mode using the operating mode selector switch.
✓ Under **INPUT SIGNAL**, the **STATUS** column has the following values:

Line	Symbol
bit0	●
bit1	○
bit2	●

7.6.3 Configuring the condition file for safety-rated monitored speed

Prerequisites

The **SAFETY MODE** is active (**SYSTEM INFO** > **SECURITY** > **SAFETY MODE**).

Procedure

Configuring the condition file for safety-rated monitored speed

1. Select a free condition file.
2. Perform the following settings:

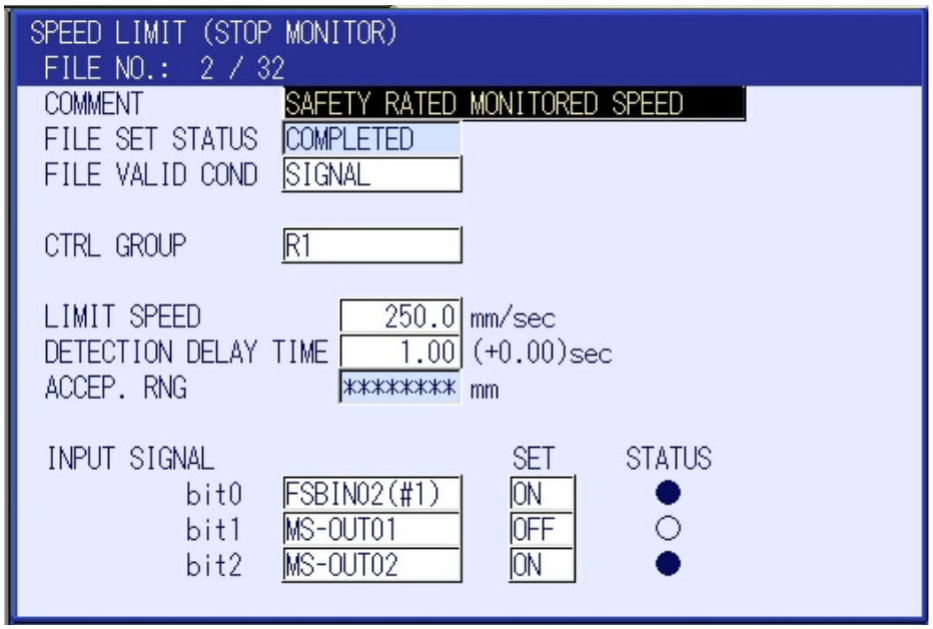
Table 32: SPEED LIMIT settings for safety-rated monitored speed

Field	Value	SET
COMMENT	SAFETY RATED MONITORED SPEED	
FILE VALID CON	SIGNAL	
CTRL GROUP	R1 [1]	
LIMIT SPEED	250.0 mm/sec [1]	
DETECTION DELAY TIME	1.00 sec [1] [2]	
INPUT SIGNAL		

Field	Value	SET
bit0	FSBIN02 (#1)	ON
bit1	MS-OUT01	OFF
bit2	MS-OUT02	On

1) Example value. The value must be defined by the machine manufacturer and/or integrator. The value must be set so that the robot reaches the reduced speed within this time.
2) You must consider the value configured here when configuring the delay time of the safety controller (see "SafetyRatedMonitoredSpeed page", page 42).

Example:



3. Press **WRITE**.
✓ The **Update the file?** dialog box appears.
4. Press **YES**.

Check safety logic and condition file

5. Warning field infringed.
6. Set the Automatic (PLAY) operating mode using the operating mode selector switch.
✓ Under **INPUT SIGNAL**, the **STATUS** column has the following values:

Line	Symbol
bit0	●
bit1	○
bit2	●

8 Commissioning

8.1 Safety

WARNING
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 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 safety system and its application must be thoroughly checked in the following situations:

- 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 safety system is effective in 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. 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 69).
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 Operating the components

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

9.1 Start sequence after start-up

1. Ensure that the protective field and warning field are clear.
2. Press the reset button.

✓ Robot can start.

10 Maintenance of the components

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

10.1 Regular thorough check

DANGER
Hazard due to lack of effectiveness of the protective device

Persons and parts of the body to be protected may not be recognized in case of non-observance.

► The checks must be carried out by qualified safety personnel or specially qualified and authorized personnel and must be recorded and documented to ensure that the tests can be reconstructed and retraced at any time.

General thorough check

Intervals for thorough checks of the individual components must be determined by the manufacturer of the machine, based on the risk assessment (see "Testing plan", page 28).

- Thorough checks must be carried out in accordance with national regulations
- After repairs or adjustments to the safety system, a thorough check must be performed
- All components must be mounted, configured and operated according to their specifications
- Safety features must be regularly checked for reliability

NOTE
Safety devices must not be disassembled, modified or repaired. Doing so could otherwise impair the security functions.

Emergency stop pushbutton

The thorough check interval must be determined by the manufacturer of the machine based on the risk assessment.

At least once a year, all emergency stop pushbuttons should be thoroughly checked for functionality.

Thorough optical check

- Mechanical and electrical function are in perfect order
- The emergency stop pushbutton is mounted correctly and firmly
- No visible damage
- Cable entry is closed tightly
- All connections are firmly attached

Thorough mechanical check

- Emergency stop pushbutton is firmly mounted and cannot be twisted
- Mounting nut is attached so that no play is possible in the longitudinal direction

Thorough electrical check

- Pressing the emergency stop pushbutton stops the robot immediately in a safe manner

Safety laser scanner

Information on regular thorough checks of the safety laser scanner can be found in the operating instructions of the safety laser scanner.

Safety signs, information labels

- ► Regularly check the information labels for the following points:
  - Presence
  - Readability
- ► Replace the information labels if missing, damaged or illegible.

11 Troubleshooting

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

Sequence error

When leaving the protective field, the warning field must remain infringed for at least 500 ms in order for a valid sequence to be detected.

If the warning field is cleared during this 500 ms, then an invalid sequence is detected immediately. An invalid sequence triggers a protective stop in the robot and requires a manual reset. The output Q4 (ErrorLED) of the XTIO module 2 can be used to diagnose the status of the sequence monitoring.

If the EXT_SAFF_OK signal is faulty, the Q4 output is continuously set to High.

In the event of a faulty sequence, the output is activated, allowing the status LED of the output to flash twice cyclically. The LED will continue to flash until a manual reset is performed when there is a clear protective field and warning field.

Unexpected emergency stop

If the safety controller diagnoses a short-circuit in the wiring to the safety laser scanner, an emergency stop is triggered. In such cases, check the wiring.

12 Technical data

12.1 Data sheet

Table 33: Data sheet for the safety system

Performance level	PL d (ISO 13849-1)
Supply voltage U_V	24 V DC (16.8 V DC ... 28.8 V DC) (SELV) [1]
Ambient operating temperature	–10 °C ... +50 °C
Storage temperature	–20 °C ... +50 °C
Air humidity	50 °C, 90% relative humidity (EN 61131-2)
Permissible operating height	≤ 2,000 m above sea level (ASL)
Safe state	The safety-related semiconductor outputs are in the OFF state (low).

1) The external supply voltage must jumper 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

The response time of the safety system is composed of the following times:

- Response time of the safety laser scanner (t_S)
- Response time of the safety controller ($t_{FlexiSoft}$)
- Response time of the interface or the relay (t_{Relays})

The response time of the safety system is determined using the following formula:

$t_R = t_S + t_{FlexiSoft} + t_{Relays}$

Table 34: Variables in the calculation

Formula symbols	Relevance
t_R	Response time of safety system
t_S	Response time of the microScan3 Core I/O or nanoScan3 Core I/O safety laser scanner
$t_{FlexiSoft}$	Response time of the safety controller ($t_{FlexiSoft} = t_{IN} + t_{CPU} + t_{OUT}$)
t_{Relays}	Response time of the interface or the relay (30 ms)
t_{IN}	Processing time of the safety controller input (6.5 ms)
t_{CPU}	Program processing time, 2 × logic cycle time of the safety controller
t_{OUT}	Processing time of the safety controller output (4.5 ms)

12.2.1 Response time of the microScan3 Core I/O safety laser scanner

The response time of the safety laser scanner is determined using the following formula:

$t_S = (t_C + t_I) \times n + t_O$

Table 35: Variables in the calculation

Formula symbols	Meaning
t_S	Response time of the microScan3 Core I/O safety laser scanner
t_C	Set scan cycle time
t_I	Time for interference protection

Formula symbols	Meaning
n	Set multiple sampling
t_O	Time for processing and output of the microScan3 Core I/O (10 ms)

12.2.2 Response time of the nanoScan3 Core I/O safety laser scanner

The response time of the safety laser scanner is determined using the following formula:

$t_S = n \times 30\ ms + 10\ ms$

Table 36: Variables in the calculation

Formula symbols	Meaning
t_S	Response time of the nanoScan3 Core I/O safety laser scanner
n	Set multiple sampling

13 Ordering information

13.1 Ordering information and scope of delivery

Table 37: Ordering information sBot Speed – YA

	Hardware and software		Hardware only		Software only
Part number	**1117273**	**1117274**	**1106014**	**1112111**	**1614202**
Hardware					
Flexi Soft safety controller					
CPU0 main module	1 ×	1 ×	1 ×	1 ×	–
System plug for CPU0	1 ×	1 ×	1 ×	1 ×	–
XTIO expansion module (8 inputs, 4 outputs)	2 ×	2 ×	2 ×	2 ×	–
Relay					
Relay module UE410	2 ×	2 ×	2 ×	2 ×	–
Safety laser scanner					
microScan3 Core I/O [1)]	1 ×	–	1 ×	–	–
nanoScan3 Core I/O	–	1 ×	–	1 ×	–
nanoScan3 Core I/O system plug	–	1 ×	–	1 ×	–
Software					
Ticket ID for software license	1 ×	1 ×	–	–	1 ×
Files	The files are available free of charge in the configuration software. see "Adding a safety system in Flexi Soft Designer", page 37				

1) The microScan3 safety laser scanner is supplied with a pre-mounted system plug.

14 Spare parts

14.1 Safety laser scanner

Table 38: Ordering information for safety laser scanner

Spare part	Type code of the safety laser scanner	Part number of the safety laser scanner
microScan3 Core I/O	MICS3-AAAZ55AZ1P01	1075843
nanoScan3 Core I/O	NANS3-AAAZ30AN1	1100333
System plug for nanoScan3 Core I/O	NANSX-AAABZZZZ1	2105106

14.2 Order Details Safety controller

Table 39: Order Details Safety controller

Number	Name	Description	Part number
1	FX3-CPU000000	Flexi Soft main module FX3-CPU0	1043783
1	FX3-MPL000001	System plug for FX3-CPU0	1043700
2	FX3-XTIO84002	I/O module, 8 safe inputs, 4 safe outputs, plug-in dual-level spring terminals	1044125
2	UE410-4RO4	Relay module	6032676

15 Accessories

15.1 Connectivity

microScan3 Core I/O

Table 40: Connecting cable ordering information

Part	Type code	Part number
Female connector, M12, 8-pin, straight, A-coded, 5 m cable, open end For drag chain operation	DOL- 1208G05MD25KM1	2079315
Female connector, M12, 8-pin, straight, A-coded, 10 m cable, open end For drag chain operation	DOL- 1208G10MD25KM1	2079316
Male connector, M8, 4-pin, USB-A, straight, 2 m cable For configuration of Flexi Soft safety controllers	DSL-8U04G02M025KM1	6034574
Male connector, USB-A, straight, mini USB, 3 m cable Configuration of the microScan3 Core I/O safety laser scanner		6042517

nanoScan3 Core I/O

Table 41: Connecting cable ordering information

Part	Type code	Part number
Female connector, M12, 8-pin, straight, A-coded, 5 m cable, open end For drag chain operation	DOL- 1208G05MD25KM1	2079315
Female connector, M12, 8-pin, straight, A-coded, 10 m cable, open end For drag chain operation	DOL- 1208G10MD25KM1	2079316
Male connector, M8, 4-pin, USB-A, straight, 2 m cable For configuration of Flexi Soft safety controllers	DSL-8U04G02M025KM1	6034574
Male connector, USB-A, straight, mini USB, 3 m cable Configuration of the nanoScan3 Core I/O safety laser scanner		6042517

15.2 Mounting bracket

microScan3 Core I/O

Part	Part number
Mounting kit 1b For mounting the safety laser scanner	2074242

nanoScan3 Core I/O

Part	Part number
Mounting kit 1b For mounting the safety laser scanner	2111768

15.3 Emergency stop and reset pushbutton

Table 42: Emergency stop and reset pushbutton

Description	Type code	Part number
Emergency stop with reset pushbutton	ES11-SC4D8	6051329

Description	Type code	Part number
Emergency stop pushbutton	ES21-SA10E1	6036147
Emergency stop pushbutton	ES21-SB10E1	6041507
Reset pushbutton	ER12-SB3C4	6051330

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 43: Test for “Emergency stop” safety function

Test sequence	Expected result	Result OK?
1. Let robot work at a slow speed. 2. Press the emergency stop push-button.	Stop is triggered. Unlocking the emergency stop push-button does not trigger restart.	Yes ☐ No ☐
Perform a test with all emergency stop pushbuttons integrated in the safety system. Run test in all operating modes. Note the designations of the tested emergency stop pushbuttons here.		

Test for “Preventing unexpected start-up” safety function

Table 44: Test for “Preventing unexpected start-up” safety function

Test sequence	Expected result	Result OK?
1. Press Emergency stop pushbut-ton. 2. Unlock the emergency stop push-button. 3. Check whether the emergency stop pushbutton is installed out-side the hazardous area and out-side the warning field. 4. Press the reset pushbutton and press restart while the warning field is infringed.	The robot does not start.	Yes ☐ No ☐
1. Press Emergency stop pushbut-ton. 2. Unlock the emergency stop push-button. 3. Ensure that the warning field and protective field are clear. 4. Press the restart button for less than 100 ms.	The robot does not start.	Yes ☐ No ☐
1. Press Emergency stop pushbut-ton. 2. Unlock the emergency stop push-button. 3. Ensure that the warning field and protective field are clear. 4. Press restart button on robot. 5. Hold down the reset pushbutton on the safety system for at least 100 ms and for no more than 30 s. 6. Press restart button on robot.	It is only possible to restart the robot after a valid reset.	Yes ☐ No ☐

Test for “Triggering a protective stop” safety function

Table 45: Tests for “Triggering a protective stop and preventing a restart” safety function

Test sequence	Expected result	Result OK?
1. Make sure that the protective field is clear. 2. Start the robot. 3. Infringe the protective field of the safety laser scanner. 4. Initiate a restart of the robot when the protective field is infringed.	The movement of the robot stops and remains stopped as long as the protective field is infringed. The FSBIN01 input signal of the condition file for the protective stop is set to High.	Yes ☐ No ☐
Tools may be necessary to avoid hazardous situations.		

Test for “Switching field sets” safety function

Table 46: Test for “Switching field sets” safety function

Test sequence	Expected result	Result OK?
1. In the Flexi Soft Designer, start the **Data recorder** function. 2. Make sure that the large protective field is active. 3. Start the robot at normal speed. 4. Infringe the warning field of the safety laser scanner. ✓ The robot reduces its speed, and after the configured delay time, the smaller protective field is active.	The robot remains still until the warning field and protective field become clear. Then the robot starts automatically.	Yes ☐ No ☐
1. In the configuration file of the safety controller, open the **SafetyRatedMonitoredSpeed** page. 2. Double click on the **On-delay timer 0** function block. 3. Note the value of the **Delay time** parameter. 4. In the robot controller, open the condition file (SPEED LIMIT) for the safety-rated speed. 5. Compare the noted value of the **Delay time** parameter with the **DETECTION DELAY TIME** value in the robot controller.	**Delay time** ≥ **DETECTION DELAY TIME**	Yes ☐ No ☐
1. In the robot controller, open the condition file (SPEED LIMIT) for the protective stop. 2. Note the value of the **DETECTION DELAY TIME** parameter.	The value of the **DETECTION DELAY TIME** parameter agrees with the calculation for the minimum distance.	Yes ☐ No ☐
Tools may be necessary to avoid hazardous situations.		

Test for warning field and protective field

Table 47: Test for warning field and protective field

Test sequence	Expected result	Result OK?
1. Check configuration of the safety laser scanner.	The warning field (WF) is the same size in field set 1 and field set 2. The protective field (PF1) in field set 1 is larger than the protective field (PF2) in field set 2, making PF2 a subfield of PF1. The minimum distance for each of the protective fields has been calculated in accordance with EN ISO 13855.	Yes ☐ No ☐

Test for mounting the safety laser scanner

Table 48: Test for mounting the safety laser scanner

Test sequence	Expected result	Result OK?
1. Thoroughly check the mounting of the safety laser scanner.	The safety laser scanner is mounted in such as way as to cover the entire scan plane of the hazardous area. The safety laser scanner is configured in such as way as to cover the entire protective field of the hazardous area. The resolution of the safety laser scanner is in correct proportion to the height of the scan plane. It is not possible to walk behind the protective field.	Yes ☐ No ☐

Test for automatic restart

Table 49: Test for automatic restart

Test sequence	Expected result	Result OK?
1. Start the Safety Designer configuration software. 2. Start the **Data recorder** function. 3. Make sure that the large protective field is active. 4. Start the robot at a higher speed. 5. Infringe the warning field of the safety laser scanner. ✓ The robot slows its speed, and after the configured delay time, the smaller protective field is active. 6. Infringe the protective field of the safety laser scanner. ✓ The robot stops. 7. Release the warning field and protective field at the same time. ✓ The robot remains at a standstill. Manual reset of the safety system and manual restart of the robot are required.	The robot remains at a standstill until all fields are free, the safety system is manually reset and a manual restart is run on the robot.	Yes ☐ No ☐
Tools may be necessary to avoid hazardous situations.		

Additional test

Table 50: Additional test

Test sequence	Expected result	Result OK?
1. Start the robot in the manual operating mode with reduced speed. 2. Switch to the Automatic operating mode.	The robot stops. The robot must be manually restarted.	Yes ☐ No ☐

16.2 Requirements for automatic restart

NOTE

The following checklist only applies to this specific safety system and no claim is made for completeness.

Pursuant to the manufacturer's risk assessment, additional requirements may be necessary.

Table 51: Checklist for the manufacturer

Requirements	
It is not possible to walk behind the protective field of the laser scanner.	Yes ☐ No ☐
It is ensured that no people are in the hazardous area during or after the reset.	Yes ☐ No ☐
The hazardous area can only be entered when passing through the protective field of the laser scanner.	Yes ☐ No ☐
Appropriate measures have been taken to protect people within the hazardous area (fence, screen, etc.) or to provide monitoring activities (protective device).	Yes ☐ No ☐
Additional protective measures (fence, screen, etc.) are installed in such a way as to prevent their removal or tampering.	Yes ☐ No ☐
Protective devices are protected against manipulation.	Yes ☐ No ☐
Protective devices are installed in such a way that it is not possible to stand behind them, bypass them or crawled beneath them.	Yes ☐ No ☐
Guards are installed to provide the required minimum distance to the nearest point in the hazardous area.	Yes ☐ No ☐
Necessary additional measures	
Automated restart is not possible if the protective field becomes clear but the warning field is not subsequently interrupted.	Yes ☐ No ☐
An emergency stop pushbutton is installed in the hazardous area near the robot.	Yes ☐ No ☐
In the hazardous area, there is a warning sign attached with the pictogram and note "Warning, automated start-up" (in accordance with ISO 7010-W018).	Yes ☐ No ☐

16.3 Overview of sensors and actuators

Reference designation	Flexi Soft address	Description
Sensors and switches		
BG210	KF112 I3/I4	microScan3 Core I/O OSSDs
BG210	KF112 I3/I4	nanoScan3 Core I/O OSSDs
BG210	KF112 I2	microScan3 Core I/O warning field

Reference designation	Flexi Soft address	Description
BG210	KF112 I2	nanoScan3 Core I/O warning field
SF300	KF111 I3/I4	Emergency stop pushbutton outside the hazardous area
SF301	KF111 I1/I2	Emergency stop pushbutton within the hazardous area
SF300	KF112 I1	Reset pushbutton
KF300	KF111 I5	EDM B1
KF300	KF111 I6	EDM B2
KF301	KF111 I7	EDM B3
KF301	KF111 I8	EDM B4
Actuators		
BG210	KF112 Q1	microScan3 Core I/O Uni-I/O 2
BG210	KF112 Q1	nanoScan3 Core I/O Uni-I/O 2
BG210	KF112 Q2	microScan3 Core I/O Uni-I/O 3
BG210	KF112 Q2	nanoScan3 Core I/O Uni-I/O 3
SF300	KF112 Q3	Reset required
KF300	KF111 Q1	B1 (E-Stop)
KF300	KF111 Q2	B2 (protective stop)
KF301	KF111 Q3	B1 (safety-rated monitored speed)
KF301	KF111 Q4	B2 (SAFF safeguarding fence)

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