OPERATING INSTRUCTIONS

sBot Speed – UR

Safety System

SICK
Sensor Intelligence.

Described product

sBot Speed – UR

Manufacturer

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Legal information

Original document

This document is an original document of SICK AG.

Contents

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:

- Proper use of the safety system
- Improper use of the safety system
- The safeBot Speed UR safety system
- Safety function description
- Wiring diagram
- Guidelines for component mounting
- Software configuration for the complete safety system including the necessary settings for the UR robot
- Calculating the safe minimum distances
- Safety quantification with SISTEMA
- Checklist for validation
- Inspections
- Material list

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 – UR

Document identification

Document part number:

- This document: 8023056
- Available language versions of this document: 8023054

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	S300 Mini Remote	8014166
Operating instructions	Flexi Soft modular safety controller hardware	8012999
Operating instructions	Flexi Soft in the Flexi Soft Designer software	8012998

Table 2: Additional important documents

Document type	Title	Link
User manual	Universal Robots CB series UR3	https://www.universal-robots.com/download/?option=42012
User manual	Universal Robots CB series UR5	
User manual	Universal Robots CB series UR10	

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, integrators), installers, electricians, safety experts (such as CE authorized representatives, compliance officers, people who test and approve the application), operators, and maintenance personnel.

These operating instructions are organized by the life phases of the device: project planning, mounting, electrical installation, commissioning, operation and maintenance.

This safety system can be integrated as presented or together with other components.

Integrators must have technical knowledge and skills in the area of industrial safety and must be trained to use machines to ensure that the technical measures and safety functions can be assessed and implemented correctly.

1.4 Symbols and document conventions

The following symbols and conventions are used in this document:

Safety notes and other notes

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

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

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

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

NOTE
Indicates useful tips and recommendations.

Instructions to action

- ▶ The arrow denotes instructions to action.

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

✓ The check mark denotes the result of an instruction.

1.5 Terminology used

The terminology used in these operating instructions partially differs from the terminology used by Universal Robots.

Table 3: Varying terminology with the same meaning in these operating instructions and for Universal Robots

Operating instructions available from SICK	Universal Robots
Emergency stop	Emergency switch-off
Protective stop	Safety stop
Three-position enabling device	Three-position safety device
Safety-rated monitored speed	Reduced mode
Safety-rated monitored speed active	Non-reduced mode
Pushbutton	Freedrive pushbutton
Operating mode selector switch	Operating mode

For more information regarding terminology used this these operating instructions, see "Glossary", page 79.

1.6 Further information

www.sick.com

The following information is available via the Internet:

- Flexi Soft Designer configuration software
- 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

The sBot Speed – UR safety system uses presence monitoring to protect against mechanical hazards that arise due to the robot arm movement.

The safety system is suitable for all applications that meet the following prerequisites:

- The robot is of type UR3, UR5 or UR10 and manufactured by Universal Robots.
- Human and robot work in the same working area but at different times (cooperation, see "Human-robot interaction", page 19).
- The robot works in a stationary position.
- The hazard arises due to the movement of the robot arm (mechanical danger).
- Stepping into the scan field of the safety laser scanner must be the only way to enter or reach into the hazardous area.
- The protective field of the safety laser scanner must be able to cover the entire hazardous area.
- Bypassing the protective field (e.g. by reaching around or stepping over it) is not possible and this is ensured by additional measures as necessary.
- The application is located in the inner area.
- The area being monitored is free from stirred up particles or process residues in the operating status.

2.3 Improper use

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 safety laser scanner works as an indirect protective measure and cannot provide protection from pieces thrown, escaped radiation, electric voltage or similar. Transparent objects are not detected.

- If necessary, take additional measures to secure dangers that do not arise due to the robot arm movement.

This safety system is not suitable for certain robot system tasks. This also includes risks arising after the robot arm has reached a standstill. In these cases, additional technical measures must be taken to reduce risks not covered by this safety system.

For the following hazard types, the safety system alone is not enough to mitigate the risk:

- Electric hazards (risks such as electric shock, burn, fire)
- Thermal hazards (risks such as burning, drying up, scalding)
- Acoustic hazards (risks such as discomfort, permanent hearing loss)
- Vibration-related hazards (risks such as osteoarthritis, vascular disorder)
- Radiation-related hazards (risks such as damage to eyes and skin, burning)
- Material-related hazards (risks such as difficulty breathing, suffocation, explosion, poisoning)
- A combination of the hazards mentioned and other hazards

2.4 Identifying hazards

The purpose of this safety system is to mitigate mechanical hazards in accordance with ISO 10218-2 while the robot carries out its tasks. This document considers the following risks:

Mechanical hazards

- Crushing
- Cutting
- Impact

Hazards generally resulting from the task of the robot, the robot arm or the end effector of the robot must also be taken into account by the manufacturer or integrator. If necessary, further measures must be taken to minimize the resulting risks.

NOTE

Risks must be reduced or eliminated by the design and communication and then through protection and other supplementary technical measures. Remaining risks must be reduced by other means such as warning signs, training sessions, procedures etc.

Other remaining 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 26.

2.5 Requirements for the qualification of personnel

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

Project planning

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

Mechanical mounting

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

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

2.6 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.

The safe state is initiated in the following cases:

- Protective field infringed
- Emergency stop pushbutton actuated
- 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
- When changing the operating mode

3 Product description

3.1 Product identification

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

Further topics

- "Ordering information", page 70

3.2 Structure of the safety system

The safety system of SICK consists of the following components:

- 1 × S300 Mini Remote safety laser scanner
- 1 × Flexi Soft safety controller consisting of:
  - 1 × FX3-CPU1 or FX3-CPU3 Flexi Soft main module
  - 1 × Flexi Soft system plug
  - 3 × Flexi Soft expansion module FX3-XTIO
- Flexi Soft configuration file (example)
- Wiring plan
- SISTEMA project file
- Operating instructions for download www.sick.com

3.3 Structure of the overall system

The overall system consists of a total of three components:

- SICK safety devices (components of the SICK safety system)
- UR robot control system
- Safety command devices

1. SICK safety devices

The safety controller sends safety signals to the robot control system and receives safety signals from the safety laser scanner. The laser scanner monitors the hazardous area of the human-robot interaction. Safety command devices deliver input signals to the safety controller for secure robot handling.

The logic of the safety functions is implemented in the safety controller.

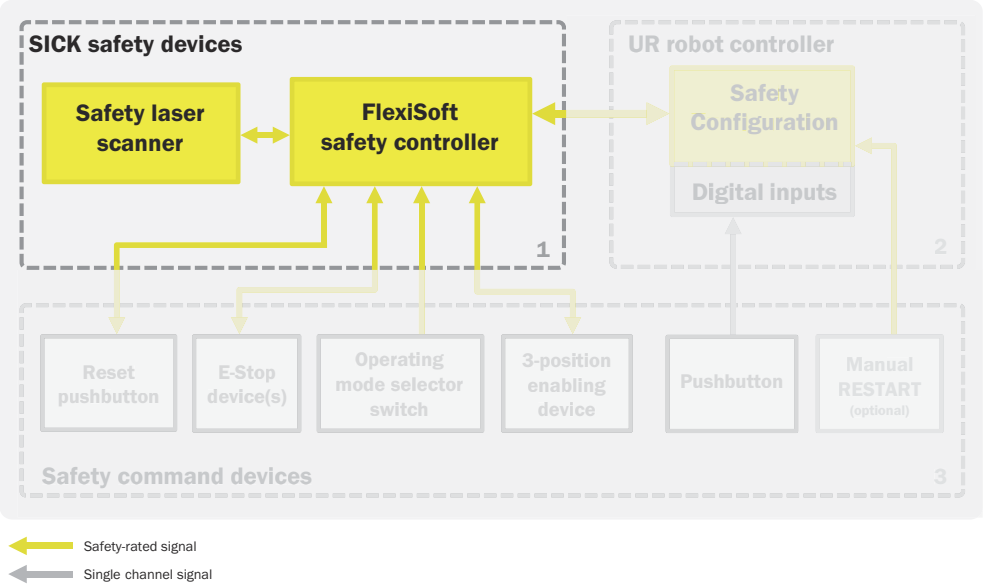


Figure 1: Location of the safety system within the overall system

2. UR robot control system

The safety controller sends safety signals to the UR robot control system. The UR robot control system responds to these signals and returns its status to the safety controller, which can then trigger the safety functions.

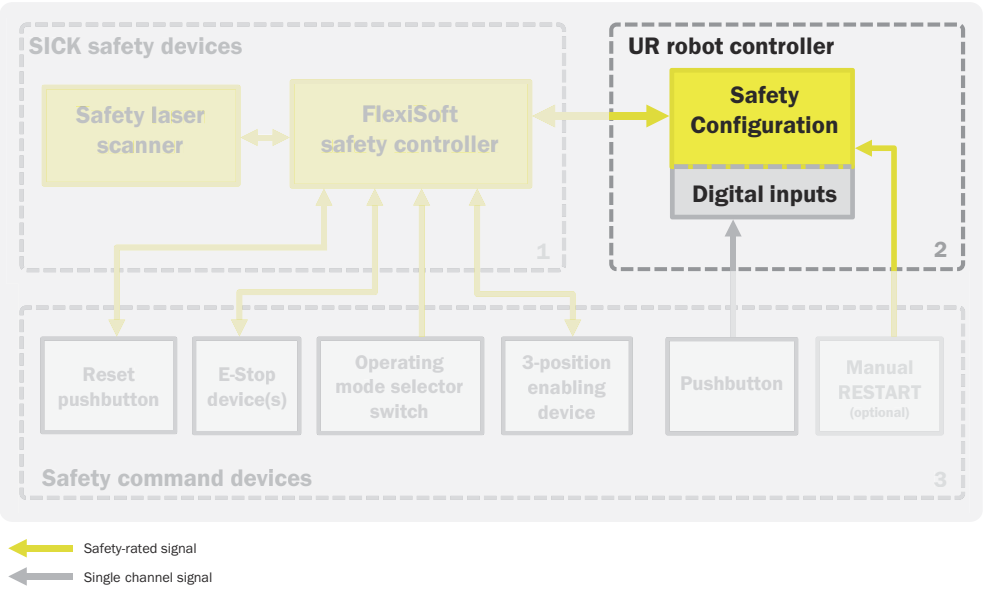


Figure 2: Location of the UR robot control system within the overall system

3. Safety command devices

Safety command devices send input signals to the safety controller so that it can trigger safety functions.

The safety controller monitors the signals of the following control switches:

- Reset pushbutton
- Emergency stop pushbutton (2 pushbuttons necessary)
- Operating mode selector switch
- Three-position enabling device

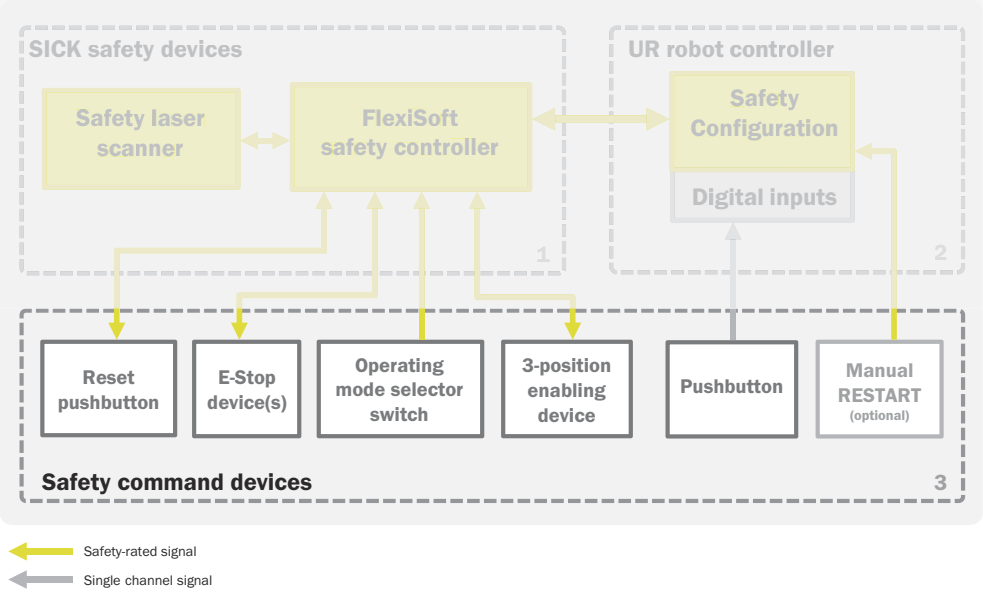


Figure 3: Location of the safety command devices within the safety system

Overall system interaction

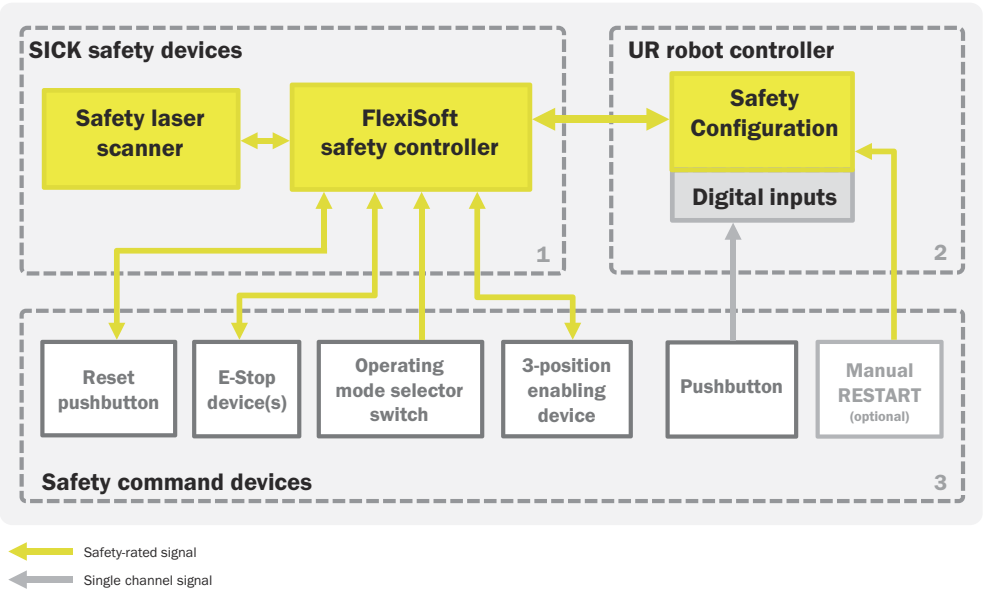


Figure 4: Overview of the overall system

3.4 Operating principle

Scope

The sBot Speed – UR safety system is used in cooperative working environments (see "Human-robot interaction", page 19) with certain robot types manufactured by Universal Robots to mitigate the risk of injuries caused by the robot's movement.

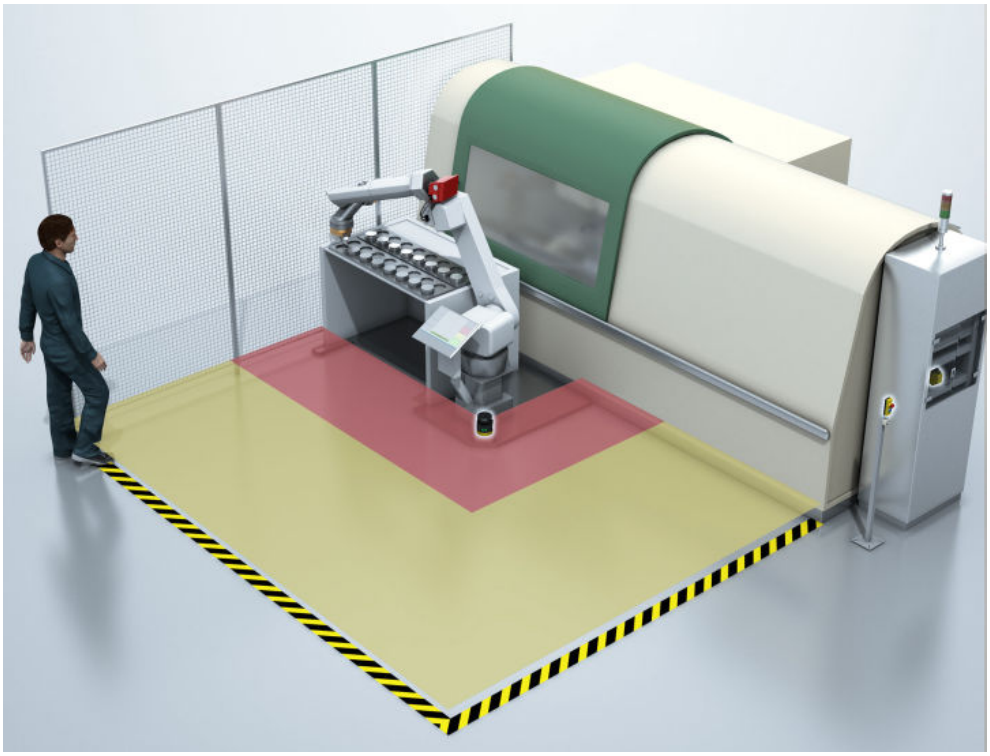


Figure 5: Example application

The industrial robot system consists of the following components:

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

The most important safety functions:

- Emergency stop function on the robot. This supplementary protective measure is active in the following cases:
  - Emergency stop is triggered by the control switch
  - The person does not comply with the intended sequence of field interruption when moving away from the hazardous area
- 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 then 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 sequence for leaving the hazardous area has been carried out correctly.

Operating modes

There are 2 operating modes:

- **Running mode:** All safety functions are continuously active.
- **Programming mode:** Several safety functions such as the safety stop and the safety-rated monitored speed are temporarily deactivated.

Several safety functions such as the emergency stop are active in every operating mode.

The operating mode is selected using the operating mode selector switch (see "Changing the user mode", page 22)

Function in running mode

During running mode of the robot, the safety laser scanner monitors two field sets. They each consist of one warning field and one protective field (see "Field types", page 17). The protective field is designed so that people are detected within a minimum distance from the hazardous area.

If a person approaches the robot, the person first interrupts the warning field. The safety system sends a safety signal to the robot to make the robot reduce its speed.

The robot control system continuously checks whether the robot is maintaining the reduced speed and uses a safety signal to report this back to the safety controller. Because slow movement causes the minimum distance from the hazardous area to get smaller, the safety controller uses this signal to switch the field set of the safety laser scanner. This way, the person can continue approaching the robot without triggering a stop.

If the person comes closer to the hazardous area, the protective field is interrupted. The robot movement is stopped.

Once the person leaves the protective field, the robot restarts automatically. The speed of the robot initially remains reduced until the person has exited the warning field. Only at that point will the robot continue its activity at a normal speed.

If a person has interrupted the protective field and the exit sequence was not followed (the person did not exit in the expected way), then the safety system prevents restart (see "Automated restart", page 19). Regardless of how the automated restart is implemented, the following applies: After the protective field is evacuated, a reset pushbutton must be pushed in this case.

Function in programming mode

In programming mode, it is possible to move the robot by hand and teach positions. It is also possible to program the robot. If the robot requires a power supply, it is possible to actuate the enabling device. The robot can be moved by hand if the button for Freedrive is being pressed. In programming mode, the protective field and warning field of the laser scanner are not active.

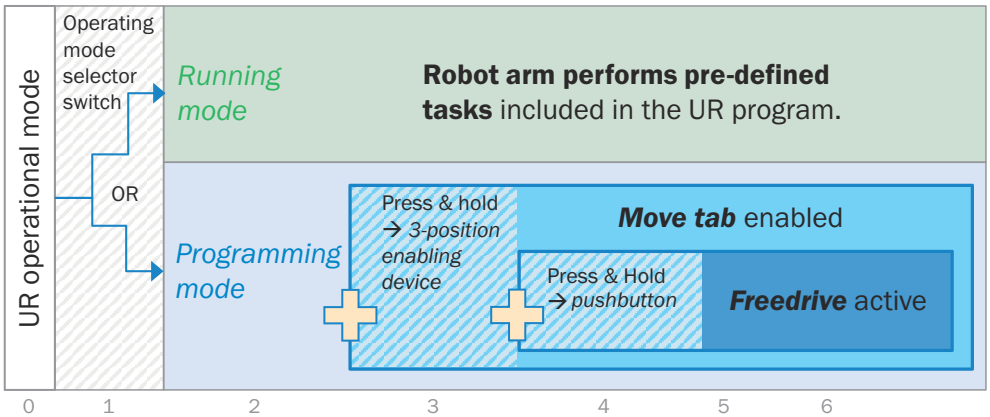


Figure 6: Interaction of the control switches in the respective operating mode

	Description
1	Programming mode is selected using the operating mode selector switch.

	Description
2	Programming mode is activated.
3	Three-position enabling device is held in the center position.
4	The robot arm can be moved using the arrow keys in the UR Teach Pendant.
5	Press and hold the Freedrive button.
6	Freedrive is activated. The robot arm can be moved by hand.

Further topics

- "Safety Functions", page 19

3.5 Safety system statuses

Safety system statuses in running mode

The robot carries out tasks based on its programming. All safety functions are active.

- Normal mode
  The robot carries out its defined activity. The speed of the robot matches the configured speed in the robot control system in the **Normal Mode** column of the **Safety configuration** (see "Robot controller configuration", page 62). Field set 1 is active.
- Reduced mode
  The robot carries out its defined activity at a reduced speed. Field set 2 (with smaller protective field) is active.
- Protective stop
  The robot stops when the protective field is interrupted. A restart is prevented as long as a person is within the protective field.
- Emergency stop
  The robot stops after an emergency stop pushbutton is pressed. Following an emergency stop, the safety system must be reset manually.

Safety system statuses in programming mode

The robot can be moved and taught as long as the three-position enabling device is kept in the center position.

- Normal mode
  The three-position enabling device is kept in the center position. The robot can be moved and taught manually. The speed is initially reduced and can be increased incrementally.
- Protective stop
  If the three-position enabling device is released or pushed in all the way, the robot stops. This function is triggered by the robot controller.
- Emergency stop
  The robot stops after an emergency stop pushbutton is pressed.

Further topics

- "Overview of software structure", page 43
- "Interfaces and signals", page 34

3.6 Product characteristics

3.6.1 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.

When the speed has been safely reduced, the field set is switched, see "Switching field sets", page 20.

Protective field

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

3.6.2 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)

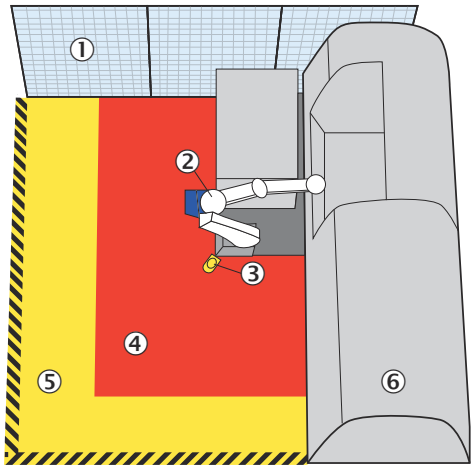


Figure 7: Field set 1

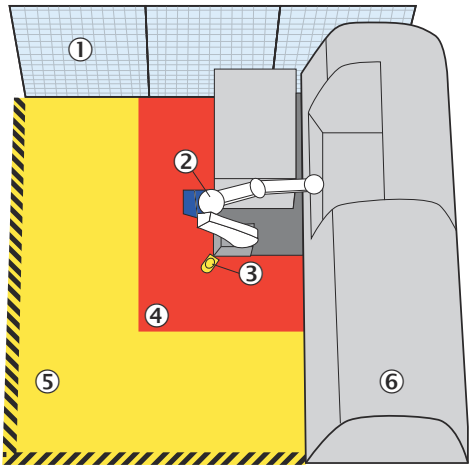


Figure 8: Field set 2

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.

3.6.3 Human-robot interaction

This safety system is suitable for cooperative human-robot interaction.

Table 4: Types of human-robot interaction

	Application with sequential processing	**Application with simultaneous processing**
Shared workspace	**Cooperation**	Collaboration
Different workspace	(Not interactive)	Coexistence

Cooperative human-robot interaction is characterized by the fact that tasks are being carried out in the same working area at different times.

3.6.4 Safety Functions

3.6.4.1 Automated restart

Overview

If a person exits the protective field from field set 2 and enters the warning field, the robot can restart at a reduced speed. During the exit sequence, a check is run to see whether the warning field is interrupted for at least 500 ms once the protective field from field set 2 is no longer being interrupted.

If this interruption of the warning field does not occur, there is no guarantee that the person has left the hazardous area. In this case, an emergency stop is carried out.

Important information

NOTE

The automated restart is a combined function made up of 2 partial functions:

- Automated reset (logic within the Flexi Soft safety controller)
- Automated restart (logic within the robot controller)

Prerequisites

- The robot is in running mode.
- The robot has been stopped by a protective stop.
- The emergency stop pushbutton was not pressed.

Sequence

Automated reset takes place if the prerequisites have been met and a person follows the intended sequence of field interruptions when leaving the hazardous area.

Automated restart must be configured in the robot controller. None of the inputs for the robot controller may have the value **Safeguard Reset** assigned to it.

As soon as the automated restart is triggered, the robot continues operating at a reduced speed. The limits of the reduced speed are defined in the robot controller in the **Safety Configuration** area.

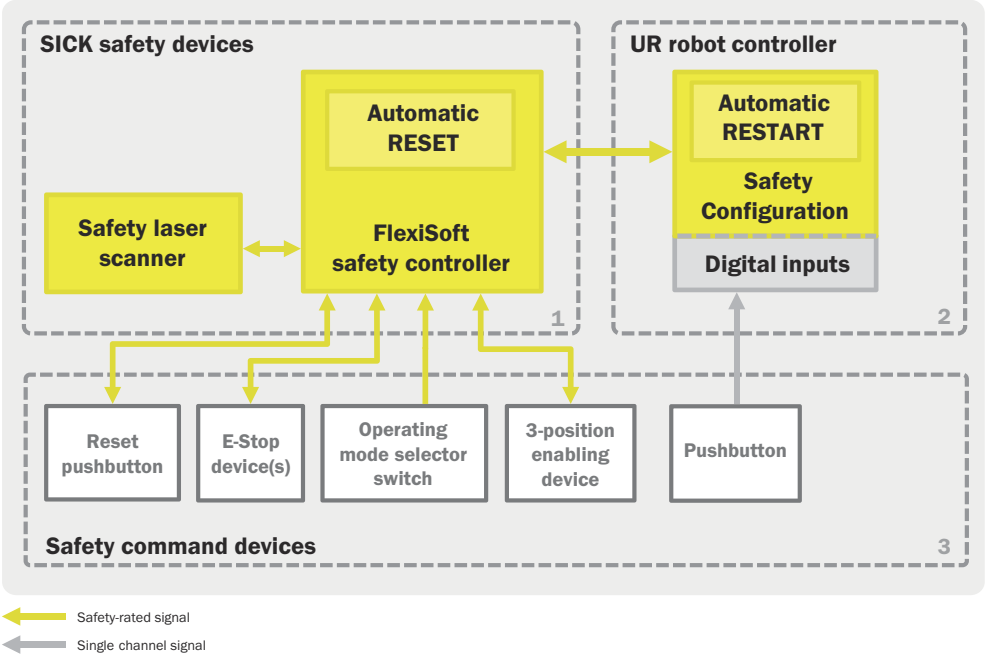


Table 5: Automated restart

Subsystem	[ESPE + Logic + Robot]
Trigger	Protective field is clear
Condition	Whenever the sequence check is valid (exception: after emergency stop)
Response	Automated reset of the safety function and automated restart of the robot
Safe state	Protective field is clear

Complementary information

If automated restart is not possible (e.g. as the result of the risk assessment), the overall system can be adapted in such a way that the restart of the robot can be triggered manually.

Further topics

- see "Robot controller configuration", page 62
- see "Automated restart not possible", page 27

3.6.4.2 Manual reset

In the following cases, the safety system must be manually reset with the reset push-button.

- After switching on the safety system
- Emergency stop is triggered by the control switch.
- The person does not comply with the intended sequence of field interruption when moving away from the hazardous area.

3.6.4.3 Switching field sets

The switching of the field set depends on the **Non-reduced mode** output of the robot. If **Reduced mode** is active, it is possible to switch to field set 2 and the smaller protective field 2 is relevant. In **Normal mode**, field set 1 is selected and therefore the larger protective field 1 is relevant.

Since the robot features the safety-rated monitored speed with PL d function, the robot controller must stop the robot independently and indicate an error.

If this safety function is activated by the Flexi Soft safety controller, then the robot is either running below the configured speed limit or is in a safe state (standstill).

The field set is selected using a dual-channel complementary EFI signal.

Table 6: Switching field sets

Subsystem	[ESPE + Logic + Robot]
Trigger	Output for non-reduced mode switches the reduced mode to active
Condition	Running mode is active: Safety-rated monitored speed is active and the warning field remains interrupted (+ delay of 500 ms)
Response	Field set for the safety laser scanner changes from protective field 1 to protective field 2
Safe state	Speed of the robot is reduced and protective field 2 is clear

3.6.4.4 Triggering 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.

Stop triggering: Activating the stop category 2 in the UR robot using the assigned protective stop input in the robot controller.

Table 7: Stop when the protective field is triggered

Subsystem	[ESPE + Robot + Logic + Robot]
Trigger	Protective field is interrupted
Condition	Running mode is active
Response	The robot carries out a protective stop (stop category 2)
Safe state	Standstill

3.6.4.5 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:

Table 8: Emergency stop

Subsystem	[E-stop + Logic + Robot]
Trigger	Emergency stop pushbutton is pressed
Condition	Always
Response	Robot carries out an emergency stop (stop category 1)
Safe state	Standstill

Table 9: Expected frequency for requests of the safety function

1 time per day	Emergency stop pushbutton is pressed
365 times per year	
52 times per year	The emergency stop pushbutton is pressed once per week for maintenance purposes or due to machine malfunctions

Total	
417 times per year	Requirement for the safety function

3.6.4.6 Preventing an unexpected start-up following an emergency stop

The emergency stop function of the robot controller is only re-established following a valid reset of the emergency stop function and actuating a manual reset. In running mode, the restart is only possible if the protective field and warning field are clear.

This safety function is active after switching on, emergency stop and changing the operating mode.

Table 10: Preventing an unexpected start-up

Subsystem	[RESET/START + Logic + Robot]
Trigger	Valid restart sequence
Condition	All affected safety devices are active The protective field and warning field must be clear
Response	Enabling the control system to receive a separate start command
Safe state	Standstill

3.6.4.7 Changing the user mode

Table 11: Changing the user mode

Subsystem	[Operating mode selector switch + Logic + Robot]
Trigger	Actuating the operating mode selector switch
Condition	-
Response	Robot switches the user mode
Safe state	Standstill

The operating mode selector switch has two statuses: Running mode and programming mode. The operating modes are controlled by Flexi Soft in accordance with the following table.

Table 12: Selecting the operating mode based on the input signals I1 and I2

	I1 (XTIO module 2)	**I2 (XTIO module 2)**
Running mode	HIGH	LOW
Programming mode	LOW	HIGH

NOTICE

It must be clearly visible as to which operating mode is currently active on the robot, e.g. using icons on the control panel and lights on the switch for switching the mode.

Table 13: Expected frequency for requests of the safety function

365 times per year	The operating mode selector switch is actuated
3 times per day	The operating mode selector switch is actuated once per shift
Total	
1095	Changing the user mode

3.6.4.8 Actuating the enabling device

Table 14: Actuating the enabling device

Subsystem	[Enabling device + Logic + Robot]
Trigger	Actuating the enabling device and holding it in the center position

Condition	Operating for the programming mode is active
Response	The robot is given a power supply and can be taught
Safe state	Standstill The robot is given a power supply and the enabling device is held in the center position

If the enabling device is pressed and held in the center position, the robot can be moved and positions can be taught. To ensure that the robot can be moved by hand, the Freedrive pushbutton must also be pressed.

Table 15: The expected frequency of actuating the enabling device

365 times per year	The enabling device is actuated
3 times per day	The enabling device is actuated once per shift
Total	
1095	Actuating the enabling device

3.7 Additional components required

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

- Emergency stop pushbutton
- Reset pushbutton
- Indicator lamp
- Robot of type UR3, UR5 or UR10 and manufactured by Universal Robots
- Additional physical guards or non-separating guards (e.g. Fence,)
- Operating mode selector switch
- Three-position enabling device, optional with additional pushbutton for Freedrive

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 70.

3.7.1 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

3.7.2 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.

An option also exists to integrate an indicator light into the reset pushbutton for the reset requirement.

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

3.7.3 Indicator light requirements

Supply voltage: 24 V DC

Current consumption: max. 500 mA

3.7.4 Robot requirements

The robot must meet the following requirements:

- Robot of type UR3, UR5 or UR10 and manufactured by Universal Robots
- Robot controller of type CB3.0 or CB3.1
- The robot controller has the firmware version 3.5.1

3.7.5 Operating mode selector switch requirements

Each switch position must be lockable (e.g. using a keyswitch). It must be possible to read the switch position on the operating mode selector switch directly.

The operating mode selector switch must be implemented as a dual-channel complementary N/O / N/C contact.

The operating mode selector switch must be positioned and designed in accordance with the following standards:

- EN ISO 10218-1
- EN ISO 10218-2

3.7.6 Three-position enabling device requirements

The three-position enabling device must be positioned and designed in accordance with the following standard:

- EN ISO 10218-1

Continuously holding the three-position enabling device in the center position allows the robot to be moved.

The enabling device must have two equivalent N/O contacts.

An option also exists to integrate an additional pushbutton for the Freedrive function (teaching in the robot through manual positioning) into the three-position enabling device.

3.7.7 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 38.

4.4 Adapting the safety system

This chapter contains several approaches for adapting the safety system as needed. With the exception of the following subchapters, this document does not consider adjustments to the safety system any further.

4.4.1 Automated restart not possible

Important information

DANGER
Failure to observe manufacturer obligations

The adaptation described in this chapter is not tested, not validated and not verified. It is **not** a part of this safety system!

The implementation of the adaptation described in this chapter makes you the manufacturer of a safety system.

- The adaptation of the safety system described here shall be carried out within the user's independent responsibility and liability only!
- Fulfill all manufacturer responsibilities for developing and implementing a safety system.

Manual restart

If the robot cannot be restarted automatically, then a manual restart can be set up. In this case, it may be necessary to carry out a manual reset of the safety logic.

More information can be found in the operating instructions for the UR robot.

4.4.2 Safety laser scanner does not cover the required area

Important information

DANGER
Failure to observe manufacturer obligations

The adaptation described in this chapter is not tested, not validated and not verified. It is **not** a part of this safety system!

The implementation of the adaptation described in this chapter makes you the manufacturer of a safety system.

- The adaptation of the safety system described here shall be carried out within the user's independent responsibility and liability only!
- Fulfill all manufacturer responsibilities for developing and implementing a safety system.

Additional safety laser scanners

In many application cases, the area being safeguarded cannot be safeguarded with a single safety laser scanner. In this case, the safety system can be expanded by adding up to 3 safety laser scanners to achieve an appropriate risk reduction.

4.4.3 The robot is on a moving platform

Important information

DANGER
Failure to observe manufacturer obligations

The adaptation described in this chapter is not tested, not validated and not verified. It is **not** a part of this safety system!

The implementation of the adaptation described in this chapter makes you the manufacturer of a safety system.

- ▶ The adaptation of the safety system described here shall be carried out within the user's independent responsibility and liability only!
- ▶ Fulfill all manufacturer responsibilities for developing and implementing a safety system.

Safe position detection

The safety system has been developed for applications with stationary robot systems. If a robot is located on a moving platform (e.g. in order to move the robot to different work stations), then an additional device must be added to the safety system for secure position detection.

4.5 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

4.5.1 Safety laser scanner

Planning the safety laser scanner

The safety laser scanner must be planned so that the following requirement is met:

- Scan plane parallel to the floor (horizontal alignment).

Recommendation: Height of the scan plane

The height of the scan plane should be 300 mm. Deviations lead to the following limitations:

- Scan plane > 300 mm: Additional measures must be taken to prevent anyone from crawling beneath it.
- Scan plane < 300 mm: An increased resolution must be used. This reduces the maximum field radius. In addition, the minimum distance must be increased, since persons may move further into the area before they interrupt the protective field.

Further topics

- "Configuring the S300 Mini Remote", page 58
- see "Protective field", page 29
- see "Calculating minimum distance", page 29

4.5.1.1 Protective field

Protective field size

The protective field must be designed so that it detects a person at a minimum distance from the hazardous area. This distance is required to prevent a person or part of their body from reaching the hazardous area before the end of the robot's hazardous movement.

The minimum distance from the hazardous area determines the required protective field size. In addition, the protective field must also cover the entire hazardous area in which a person may be present.

Each field set must have its own protective field that is calculated and configured.

Further topics

- "Safety laser scanner", page 28
- "Calculating minimum distance", page 29
- "Configuring the S300 Mini Remote", page 58
- "Field set", page 18

4.5.2 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 ($t_{FlexiSoft}$)

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

- Robot controller response time
- 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.

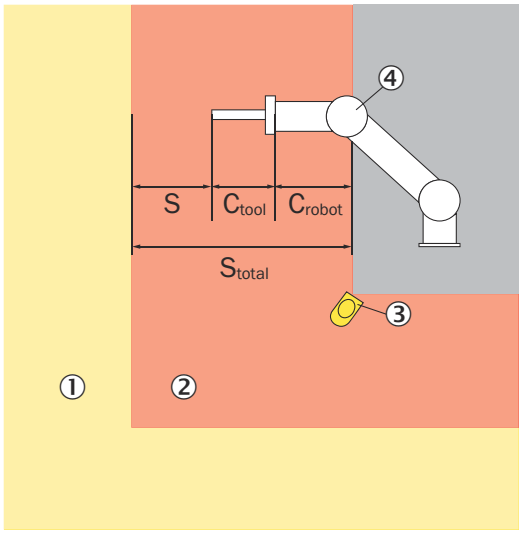


Figure 9: Calculating minimum distance

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

The safe minimum distance is determined using the following formula:

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

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

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

Table 16: 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 s300 Mini Remote: 100 mm
t_S	Response time of the safety laser scanner
$t_{FlexiSoft}$	Safety controller response time
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 69

4.5.3 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 23.

4.5.4 Reset pushbutton

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

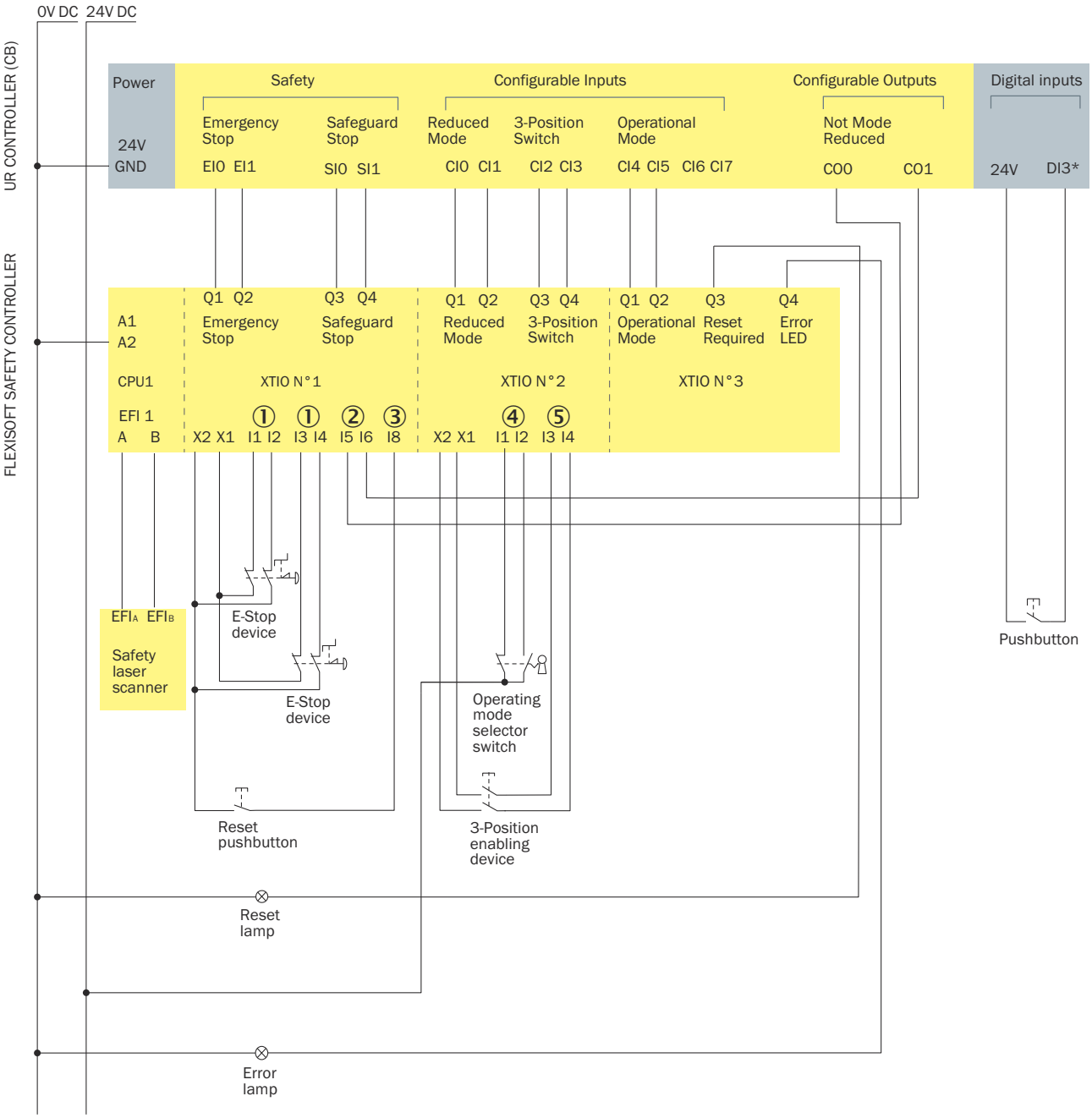
For more information see "Reset pushbutton requirements", page 24.

4.6 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.

4.6.1 Circuit diagram



① Emergency stop (emergency switch-off)
② Non-reduced mode
③ Reset
④ Operating mode selector switch
⑤ Three-position enabling device

For a better overview, the connections for the power supply of the safety laser scanner and Flexi Soft modules are not displayed. A detailed overview can be found in the ePLAN PDF. Only the GND connection is shown in order to represent the fact that the reference potential of both systems must be combined. DI3* is a digital standard input configured as a Freedrive button.

This input is required depending on the implementation of the enabling switch in order to enable simultaneous actuation of the enabling switch and the Freedrive button.

4.6.2 Connection of safety controller and robot controller

Important information

DANGER
Cross-circuit at the interface between the safety controller and the robot controller
The safety system no longer meets the specified safety-related parameters.

- ▶ Follow the instructions in this chapter.

Approach

The safety capable inputs for the robot controller are dual-channel equivalent inputs without a test pulse. Thus, a cross-circuit cannot be detected between the 2 channels.

- ▶ Separate the safety signal channels into 2 different cables so that the 2 channels of one signal are not running through one cable.
  Example:
  - Cable W1: All connections for the safety controller with an **odd** number
  - Cable W2: All connections for the safety controller with an **even** number

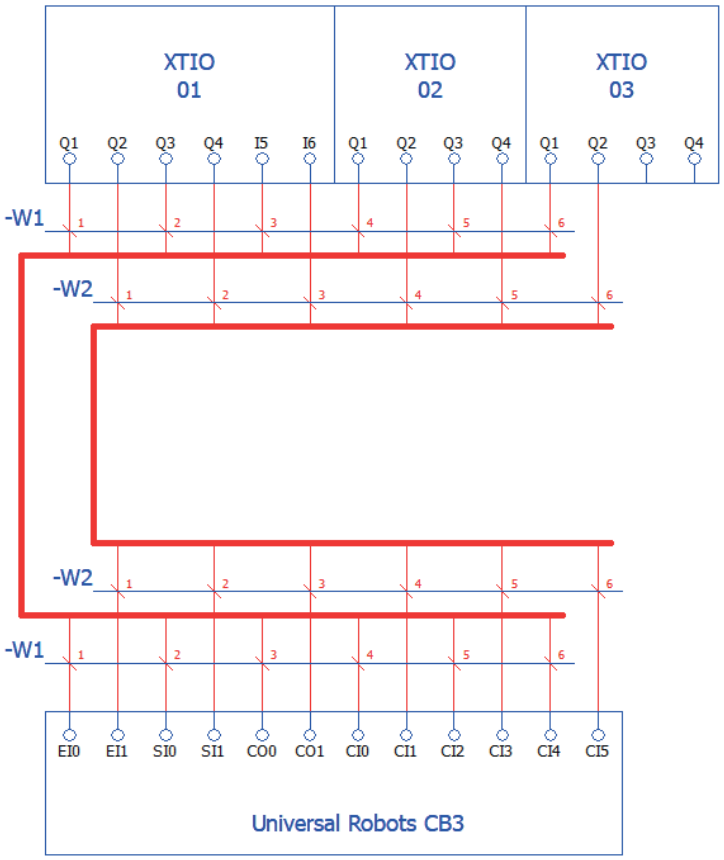


Figure 10: Connection of safety controller and robot controller

- ✓ Fault exclusion in acc. with ISO 13849-2 is possible.

4.6.3 Interfaces and signals

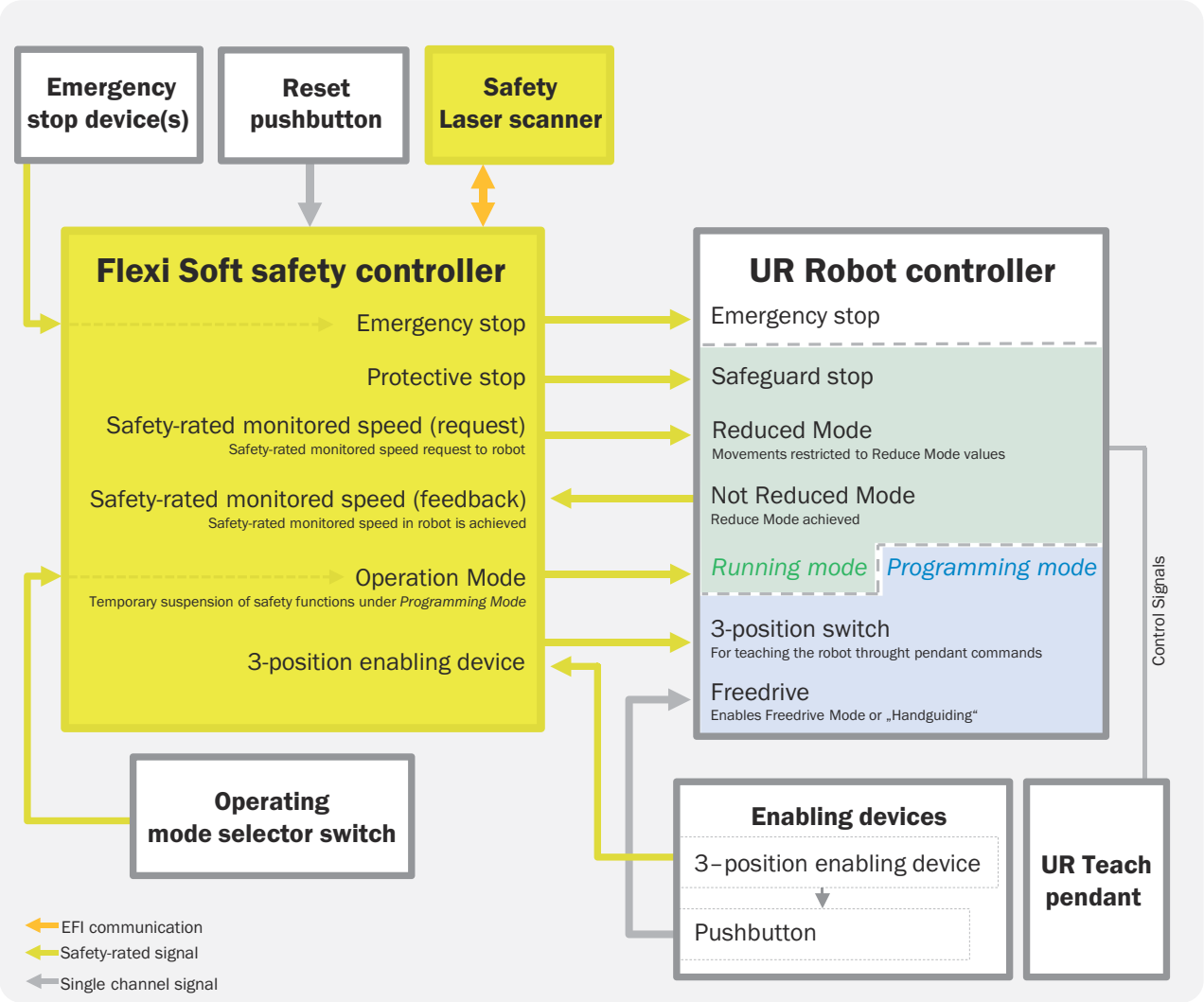


Figure 11: Signals in the overall system

Detailed information on signals between the safety controller and robot controller

Table 17: Signals between the safety controller and robot controller

Flexi Soft	Name	Correspondence for Universal Robot	Description
Output	Emergency stop	Emergency switch-off	Activates the emergency stop function and triggers the robot arm stop. To ensure that the movement can be continued, a manual reset must be carried out. Corresponds to stop category 1 Requires manual a reset afterward.
Output	Protective stop	Safety stop	Triggers the robot arm stop and provides the option for an automated restart. Corresponds to stop category 2
Output	Safety-rated monitored speed active (request)	Reduced mode	Activates limit stops for the robot such as the reduced speed of the robot arm (safety-rated monitored speed).

Flexi Soft	Name	Correspondence for Universal Robot	Description
Output	Operating mode	Operating mode	Used for selecting one of the two possible operating modes of the UR robot. HIGH signal level: Programming mode LOW signal level: Running mode
Output	Three-position enabling device	Three-position safety device	Enables robot teaching in programming mode.
Input	Safety-rated monitored speed active (response)	No reduced mode	Reports whether the robot is operating within the movement limitations.

Signal states for the outputs of the safety system depending on the status

Table 18: Signals depending on the status

Status of the safety system		Signal state for the outputs of the safety system				
		Emergency stop 1) 2)	Protective stop 1) 3)	Safety-rated monitored speed active (request) 1) 4)	Operating mode	Three-position enabling device
Operating mode: Running mode	**Normal mode**	HIGH	HIGH	HIGH	LOW	–
	Reduced mode	HIGH	HIGH	LOW	LOW	–
	Protective stop	HIGH	LOW	LOW	LOW	–
	Emergency stop	LOW	–	–	–	–
Operating mode: Programming mode	**Normal mode**	HIGH	HIGH	HIGH	HIGH	HIGH
	Protective stop	HIGH	HIGH	HIGH	HIGH	LOW
	Emergency stop	LOW	–	–	–	–

1) The outputs for emergency stop, safety-rated monitored speed and protective stop are in negative logic.
2) If the emergency stop output is LOW, the robot stops.
3) If the protective stop output is LOW, the robot stops.
4) When the safety-rated monitored speed output is LOW, the robot checks to see if the reduced speed (reduced mode) has been safely reached. When the reduced mode is active, the robot controller confirms this with a change of the "Non-reduced mode" signal from LOW to HIGH. (see figure 12, page 35.

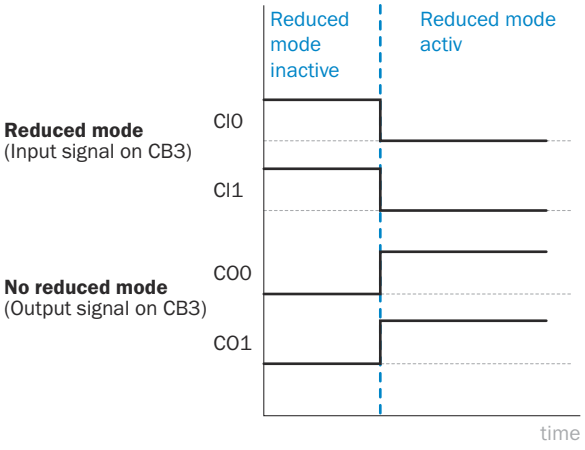


Figure 12: The signal states change when switching to reduced mode.

Complementary information

All safety functions triggered by the signals satisfy the criteria of Performance Level d (EN ISO 13849-1).

Further topics

- see "Circuit diagram", page 32

4.7 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 64
- Checklist for initial commissioning and commissioning, see "Annex", page 73
- Regular thorough check, see "Maintenance of the components", page 66

5 For mounting the components

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

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

Table 19: Modules of the safety controller

Module 1	Main module FX3-CPUx
Module 2	I/O module FX3-XTIO
Module 3	I/O module FX3-XTIO
Module 4	I/O module FX3-XTIO

Module 1 connections

Table 20: Module 1 connections

Connection	Function
EFI 1 (A)	S300 Mini Remote
EFI 1 (B)	S300 Mini Remote
EFI 2 (A)	Clear
EFI 2 (B)	Clear

Module 2 connections

Table 21: Module 2 inputs

Connection	Function
I1	Emergency stop (within the hazardous area)
I2	Emergency stop (within the hazardous area)
I3	Emergency stop (outside the hazardous area)
I4	Emergency stop (outside the hazardous area)
I5	Robot controller (CO0): Non-reduced mode
I6	Robot controller (CO1): Non-reduced mode
I8	Reset pushbutton

Table 22: Module 2 outputs

Connection	Function
Q1	Robot controller (EI0): Emergency stop
Q2	Robot controller (EI1): Emergency stop
Q3	Robot controller (SI0): Protective stop
Q4	Robot controller (SI1): Protective stop
X1	Emergency stop test pulses
X2	Test pulses for emergency stop and reset pushbutton

Module 3 connections

Table 23: Module 3 inputs

Connection	Function
I1	Operating mode selector switch
I2	Operating mode selector switch
I3	Three-position enabling device
I4	Three-position enabling device

Table 24: Module 3 outputs

Connection	Function
Q1	Robot controller (CI0): Reduced mode
Q2	Robot controller (CI1): Reduced mode
Q3	Robot controller (CI2): Three-position safety device
Q4	Robot controller (CI3): Three-position safety device
X1	Three-position enabling device test pulses
X2	Three-position enabling device test pulses

Module 4 connections

Table 25: Module 4 outputs

Connection	Function
Q1	Robot controller (CI4): Operating mode
Q2	Robot controller (CI5): Operating mode
Q3	Lamp for reset
Q4	Lamp for sequence error
X1	Clear
X2	Clear

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 26: Required configuration software

Component	Configuration software
Flexi Soft safety controller	Flexi Soft Designer
S300 Mini Remote safety laser scanner	Flexi Soft 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)

Approach

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 45
- "Configuring the safety laser scanner", page 58

7.2 Requirements on software and firmware

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

Table 27: SICK component versions

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

7.3 Overview of software structure

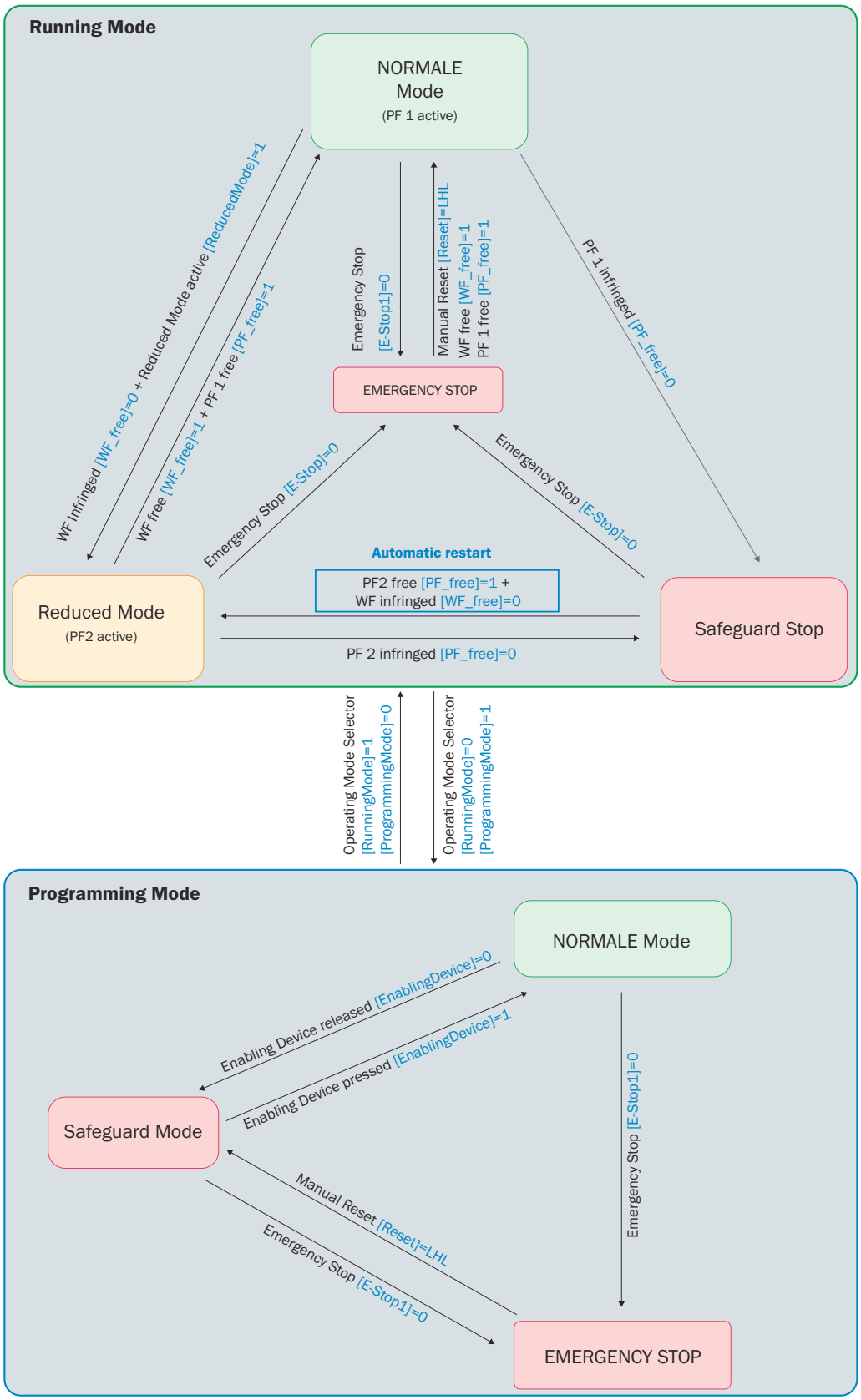


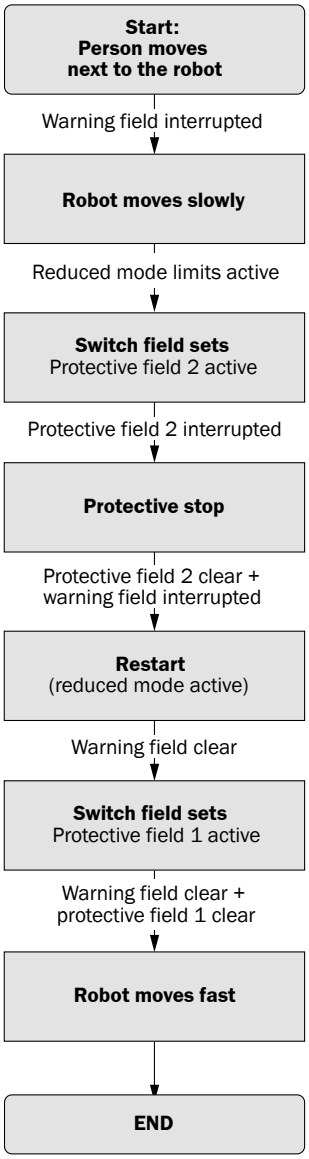
Figure 13: Overview of software structure

The blue-colored commands in the overview of the software structure represent the names of the operators in the Flexi Soft program that affect the transition of the statuses. The status of the operators is displayed as follows:

- 1 = Status is HIGH
- 0 = Status is LOW

7.3.1 Sequences

Sequence, when a person is directly next to the robot



Sequence, when a person passes by the robot

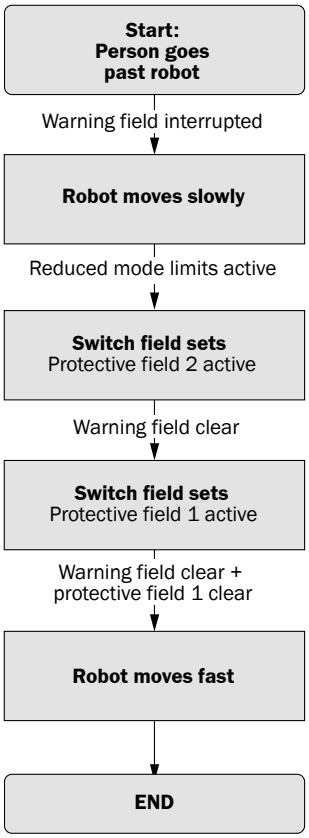


Figure 14: Sequence, when a person passes by the robot

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.

Approach

Selecting the safety system

1. Open Flexi Soft Designer.
2. **Project** > **New** > **Standalone station project**
3. Drag the desired 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** | Which versions of the safety system are pre-installed depends on the version of the configuration software. Because the license applies only to the current version of the safety system, verification problems may arise if you do not use the current version of the safety system.

6. To check the safety system version: Continue at step 7..
   If the version has been confirmed as current: Continue at step 15..
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** > **Other downloads** tab, search for the desired safety system and check the version of the safety system available on-line.
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 the configuration software, 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.

Further topics

- "Activating the license for the safety system", page 57

7.4.1.1 Adding the safety laser scanner to the hardware configuration

Approach

1. Open the **Elements** selection window.
2. Under **EFI elements**, expand the **Electro-sensitive protective device** area.
3. Using drag and drop, drag the S300 Mini safety laser scanner to the **EFI 1** connections of the main module.

7.4.1.2 Checksums

Prerequisites

- The safety laser scanner has been added to the hardware configuration of the safety controller.

Important information

NOTE

The specified checksums apply only to the delivery state after adding the safety laser scanner. Any customization of the logic configuration, e.g., external signals for the safety functions, will result in a change in the checksum.

Checksums for Flexi Soft

Checksums

- CPU1 main module, 0x610CD769
- CPU2 main module, 0x610CD769
- CPU3 main module, 0x8039CCE9

Checksums for s300 Mini Remote

Checksums

- s300 Mini Remote safety laser scanner: 0x4CBE

7.4.1.3 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.

7.4.1.4 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.

7.4.1.4.1 Finding source and destination jump addresses that belong together

Approach

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.

7.4.1.4.2 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**.

7.4.1.4.3 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**.

7.4.2 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 logic in the safety requirements of the application is sufficient before outputs of the function blocks are linked to outputs of the safety controller.

The manufacturer of the machine is responsible for the output connections and for the logic verification.

7.4.3 Linking outputs and logic

When the logic has been verified, then this logic can be linked with the respective outputs of the safety controller.

Emergency stop

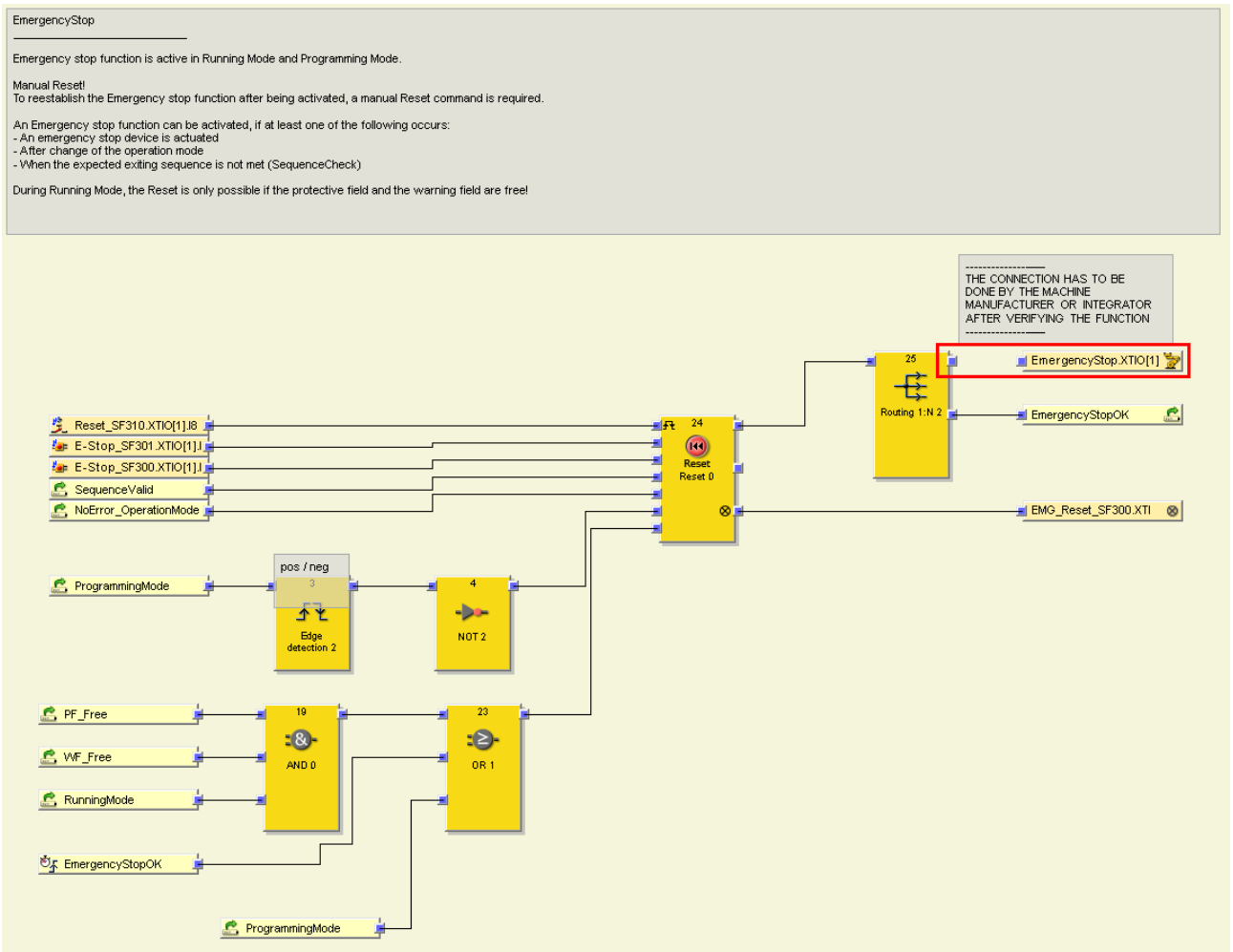


Figure 15: Linking emergency stop

Protective stop

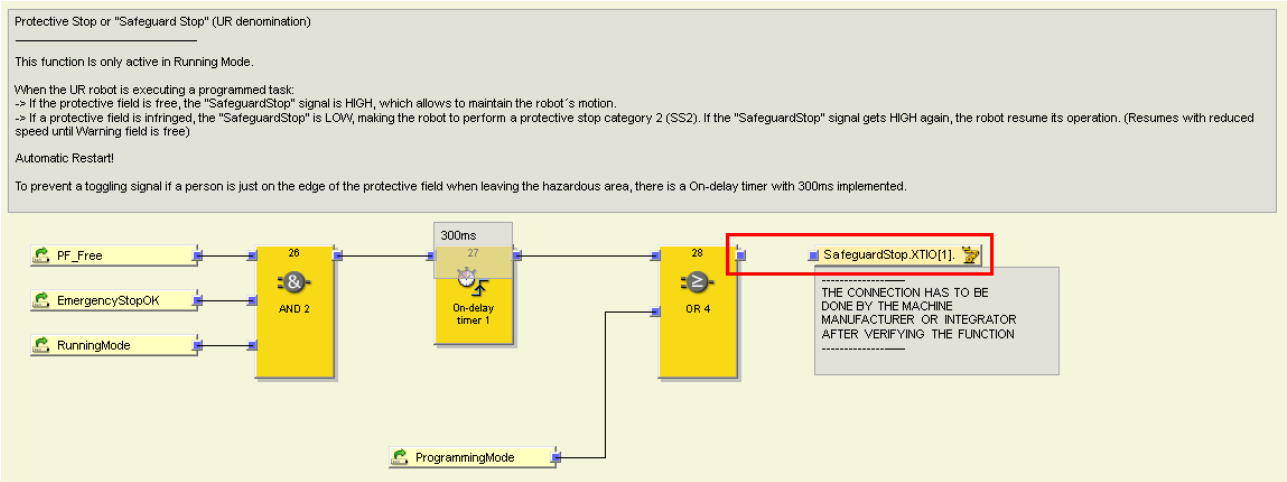


Figure 16: Linking protective stop

Safety-rated monitored speed

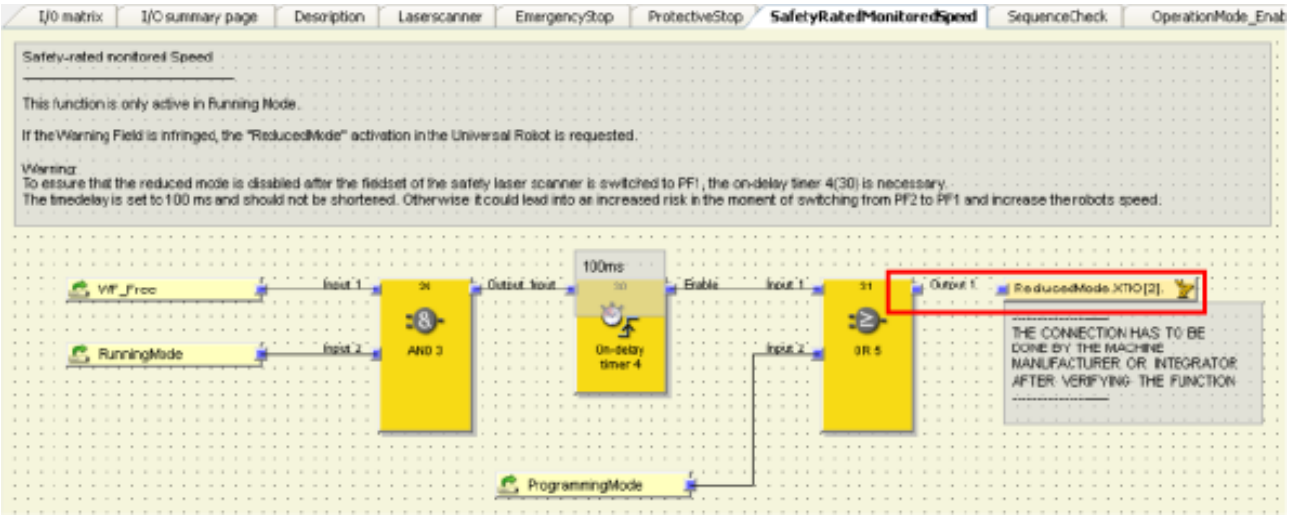


Figure 17: Linking safety-rated monitored speed

Operating mode selector switch

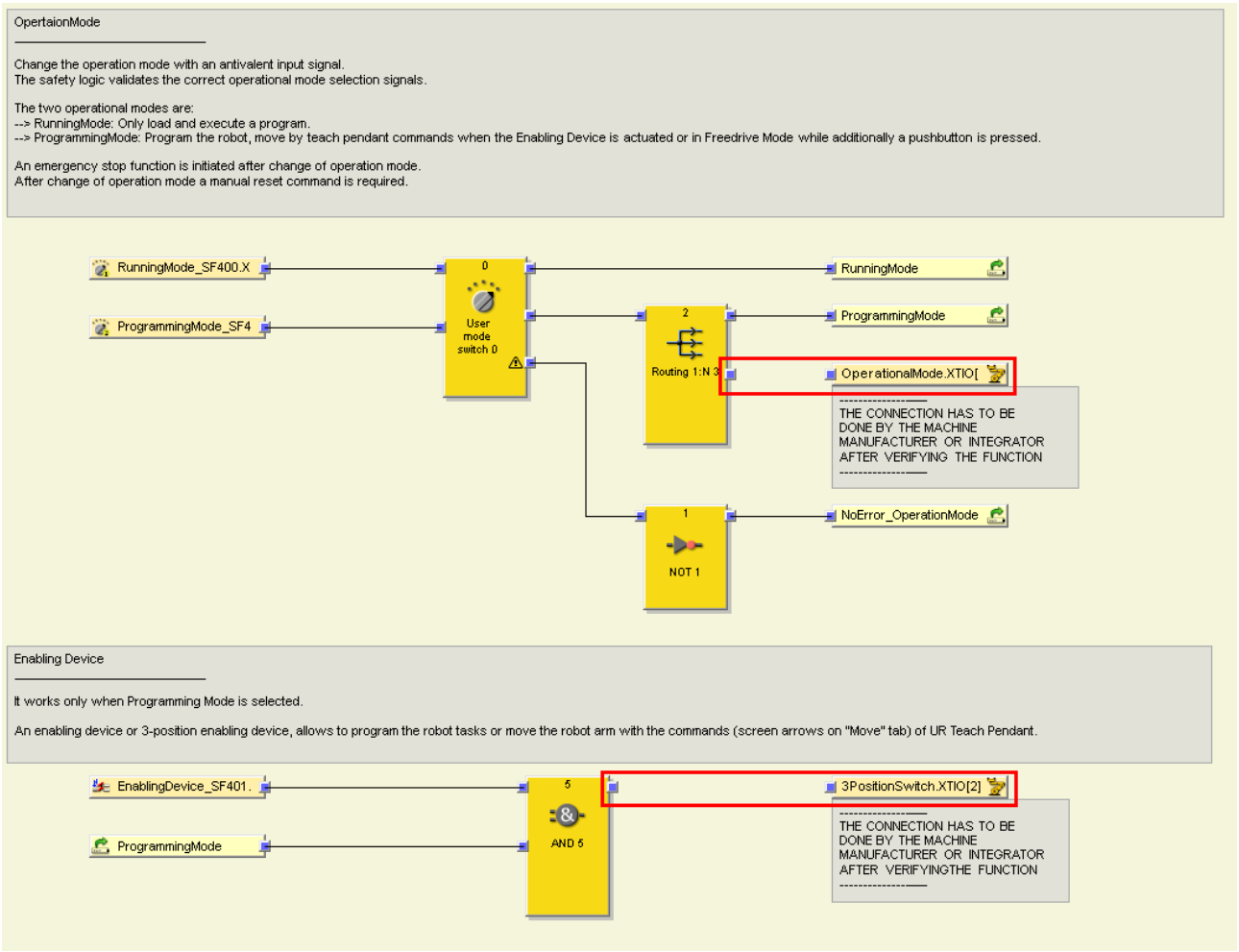


Figure 18: Linking operating mode selector switch

7.4.4 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
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
OperationMode_EnablingDevice	Switches between running mode and programming mode
ErrorHandling	setting a signal if the sequence is invalid

7.4.4.1 Page Description

This page contains the disclaimer and a short description of the application.

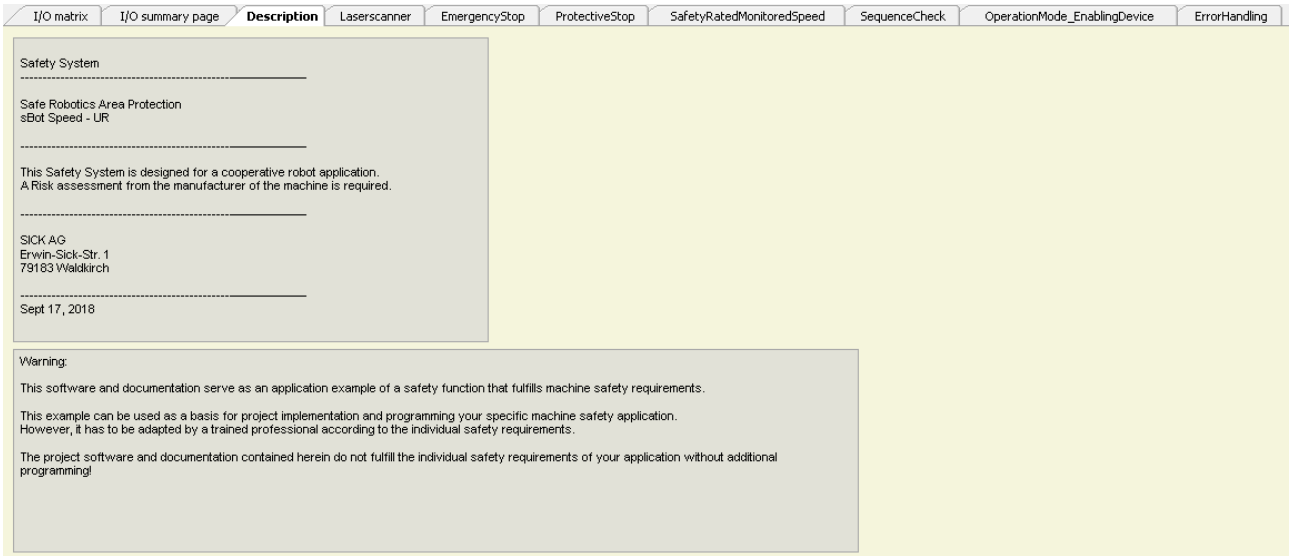


Figure 19: Page view description

7.4.4.2 Laser scanner page

This page contains the links to the safety laser scanner signals. These include the signals of the protective field, the warning field and the inputs for changing the field sets.

The signals for the protective field and the warning field have to be linked using a link address. The inputs and outputs are implemented via EFI.

Figure 20: Side view of laser scanner

The distance between the protective field and warning field must be defined relative to the movement speed of a person. The fields are changed after the warning field has been interrupted for at least 500 ms.

If the person moves too quickly, they interrupt the protective field before the smaller protective field of field set 2 could be activated.

When leaving the protective field, the warning field must remain interrupted for at least 500 ms (see "SequenceCheck page", page 55), otherwise, an emergency stop is triggered.

Therefore, the distance between the protective field and warning field must be large enough to prevent a sequence error as a result of a person's excessive movement speed. The following formula is suitable for the calculation:

Distance = Movement speed × 0.5 s

Example: For a movement speed of 1,000 mm/s, the distance between the protective field and the warning field should be at least 500 mm.

The logic for switching the field sets depends on the signal **NotReducedMode**. The field set of the laser scanner changes 500 ms after the **NotReducedMode** signal has been set to HIGH. This time delay is described in the operating instructions for the UR robot.

Table 29: Changing field sets for signal change

ReducedMode	NotReducedMode	Active field set
Inactive	LOW	1
Active	HIGH	2

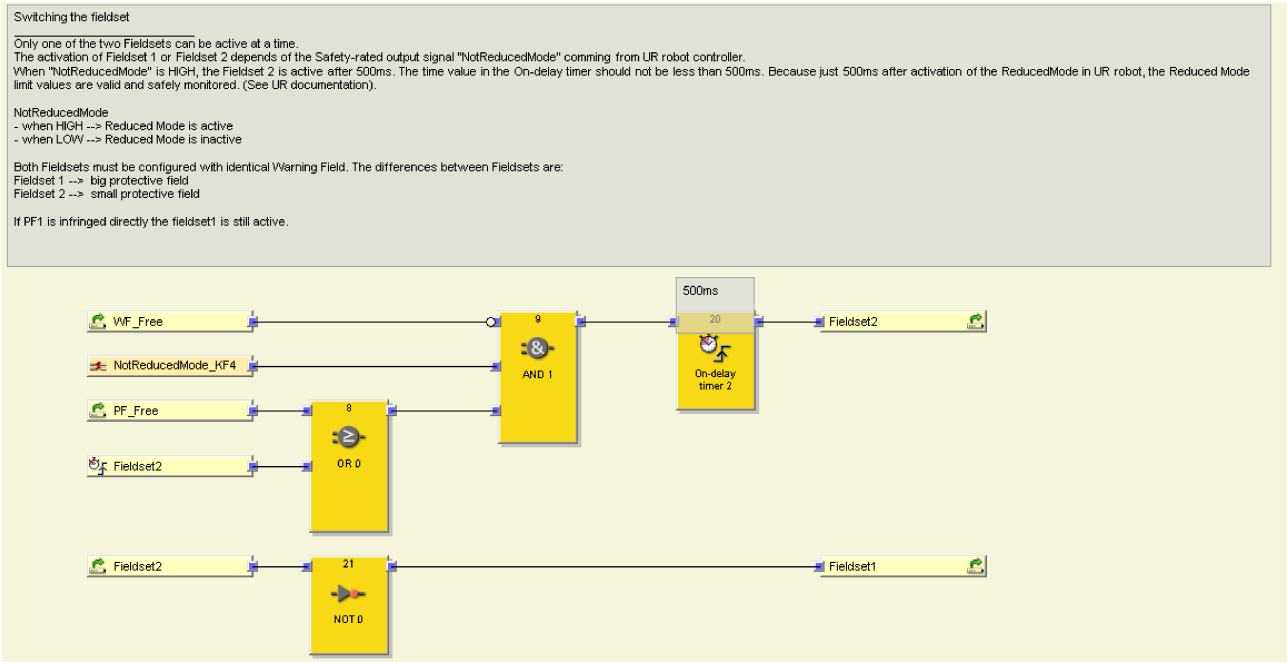


Figure 21: Side view of laser scanner

The inputs of the laser scanner for switching the field sets are dual-channel complementary signals **A1** and **A2** via EFI.

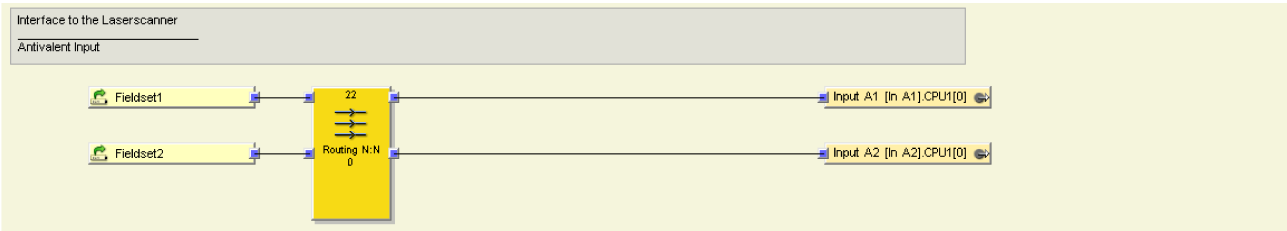


Figure 22: Side view of laser scanner

If programming mode is active, the laser scanner is in standby. The display shows the corresponding symbol: ⍝

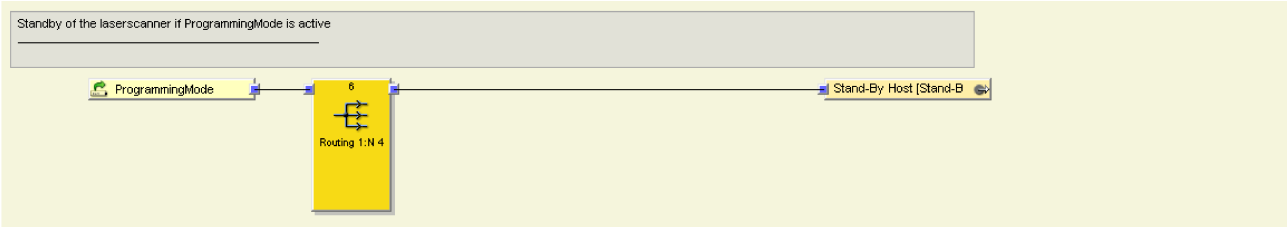


Figure 23: Side view of laser scanner

The manufacturer of the machine must verify the logic before the logic is transferred to the Flexi Soft.

7.4.4.3 EmergencyStop page

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

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 switching on the robot.

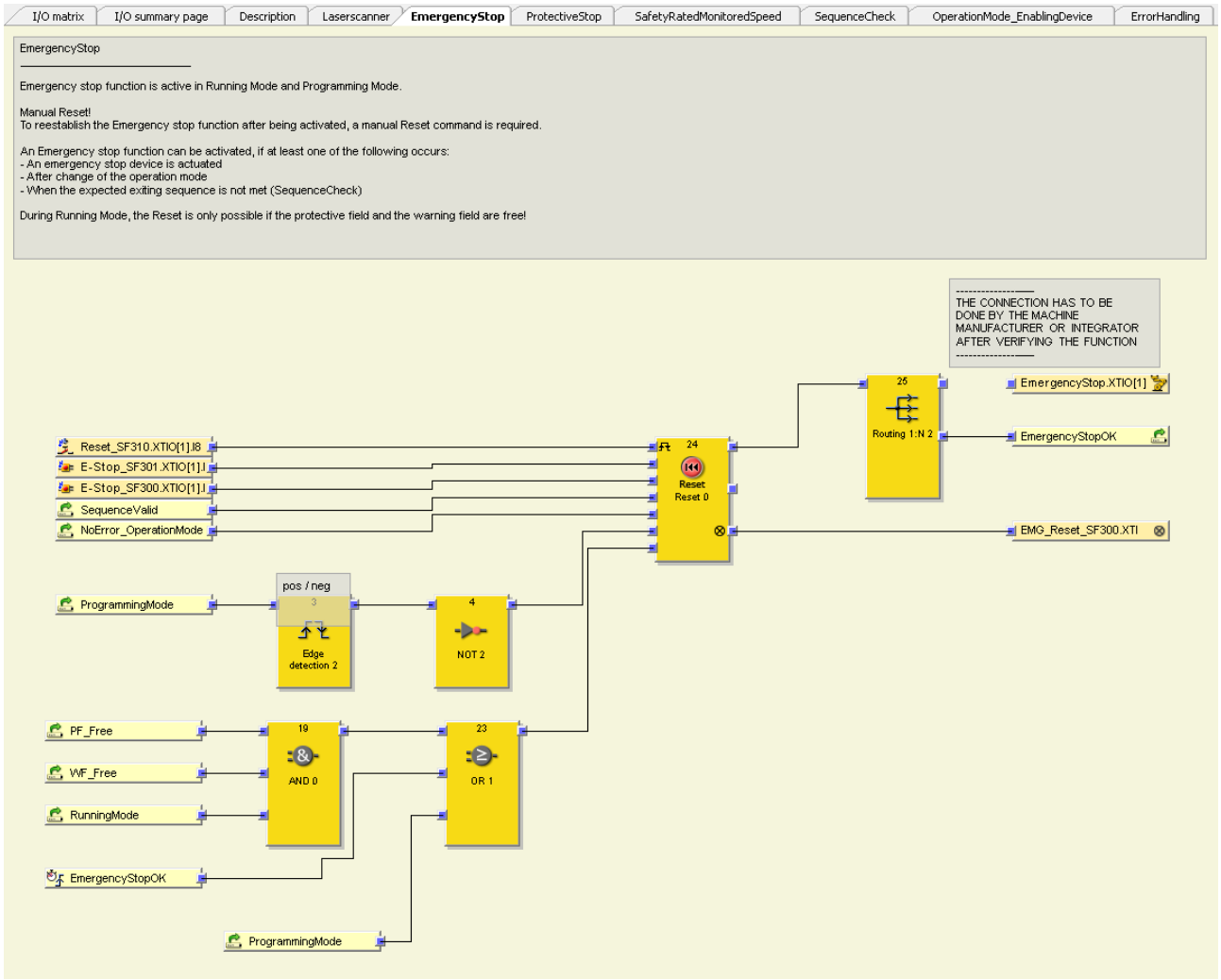


Figure 24: EmergencyStop page view

Once a reset is possible, the **EMG_RESET** output flashes.

An emergency stop is then carried out if a sequence is invalid or the operating mode has been changed (see "SequenceCheck page", page 55).

A reset can be carried out if programming mode is active, even if the scan fields are interrupted (safety laser scanner is in standby).

If running mode is selected, the protective and warning field must be clear before reset.

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

The time sequence for the reset pushbutton is checked within the predefined **RESET** function block (24). There must be a HIGH pulse that lasts at least 100 ms and a maximum of 30 s.

7.4.4.4 ProtectiveStop page

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

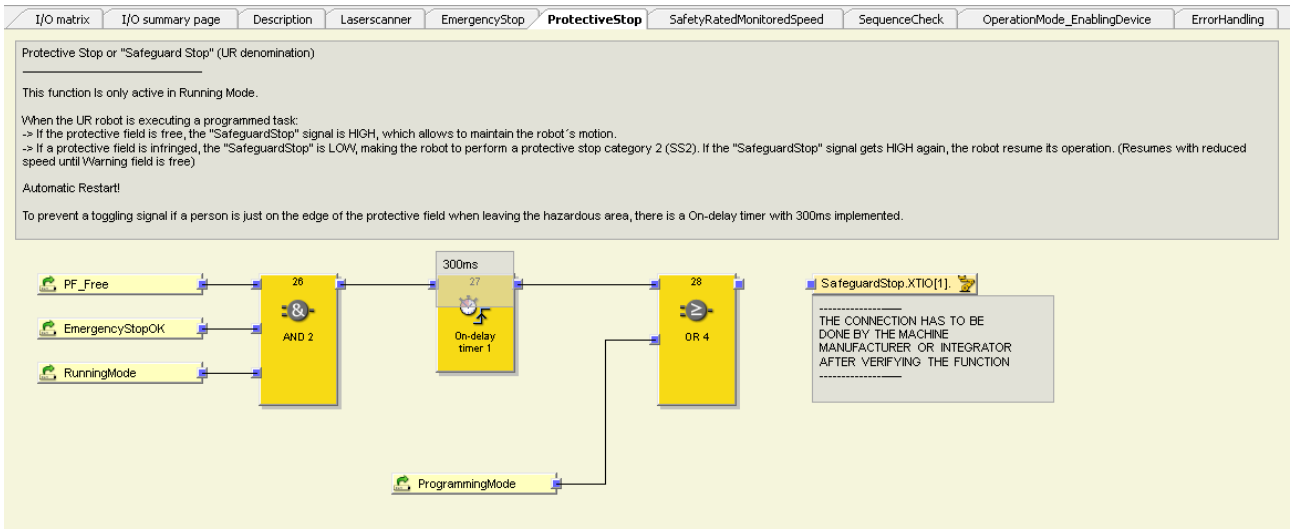


Figure 25: ProtectiveStop page view

The ProtectiveStop output is HIGH if the protective field is clear, the sequence is valid and the conditions for **EmergencyStopOK** are valid (see "SequenceCheck page", page 55 and see "EmergencyStop page", page 53).

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 manufacturer of the machine or the integrator must verify the logic and link the output signals before the logic is transferred to the Flexi Soft.

7.4.4.5 SafetyRatedMonitoredSpeed page

Overview

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

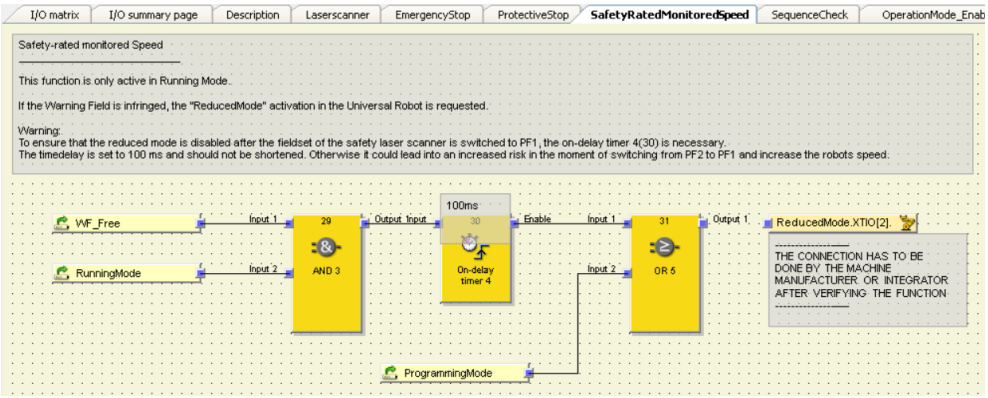


Figure 26: SafetyRatedMonitoredSpeed page view

Important information

CAUTION

Increased risk if on-delay timer 4 is reduced

The reduced mode may not be activated, or not activated in time.

- Do not reduce the configured delay of 100 ms.

Description

If running mode is selected and the warning field is interrupted, the safety-rated monitored speed is activated. The limits of the safety-rated monitored speed have to be defined in the robot controller in accordance with the manufacturer's risk analysis.

When programming mode is active, the warning field of the safety laser scanner has no effect and the safety-rated monitored speed is deactivated. In programming mode, the speed of the robot is reduced to 250 mm/s and can be increased incrementally, during which the three-position enabling device is kept in the center position.

The manufacturer of the machine or the integrator must verify the logic and link the output signals before the logic is transferred to the Flexi Soft.

Delay time

When switching from the smaller to the larger protective field, it is important that the protective field be switched first and then the safety-rated monitored speed deactivated. To ensure the robot does not accelerate even in the event of a fault, it is necessary for the output to have a time delay of 100 ms in case a person is present in the protective field during field set switching. This must not be reduced. If you set a higher multiple sampling in the safety laser scanner, it is not necessary to increase the delay time because the safety laser scanner performs an evaluation directly after the field set switching.

7.4.4.6 SequenceCheck page

This page is used to configure the logic for sequence monitoring. This includes the sequence a person has to fulfill when they exit the hazardous area.

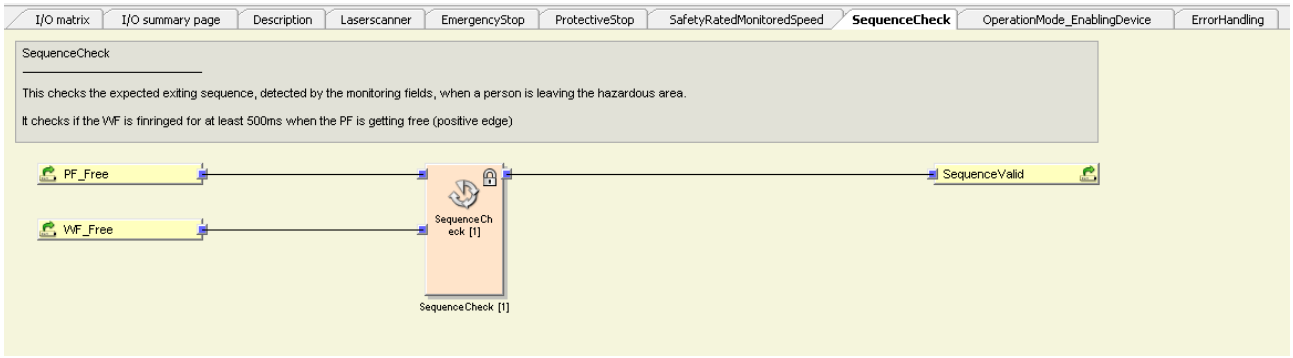


Figure 27: SequenceCheck page view

To prevent an automated restart if misuse takes place or a person does not remove themselves from the hazardous area in the intended manner, the **SequenceCheck** function is always active in running mode.

For a valid sequence, the warning field must be interrupted 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 (for more information, see see "ErrorHandling page", page 56).

Accordingly, the SequenceValid must be connected to the trigger of a reset function block (see "EmergencyStop page", page 53).

7.4.4.7 OperationMode_EnablingDevice page

This page is used to configure the operating mode.

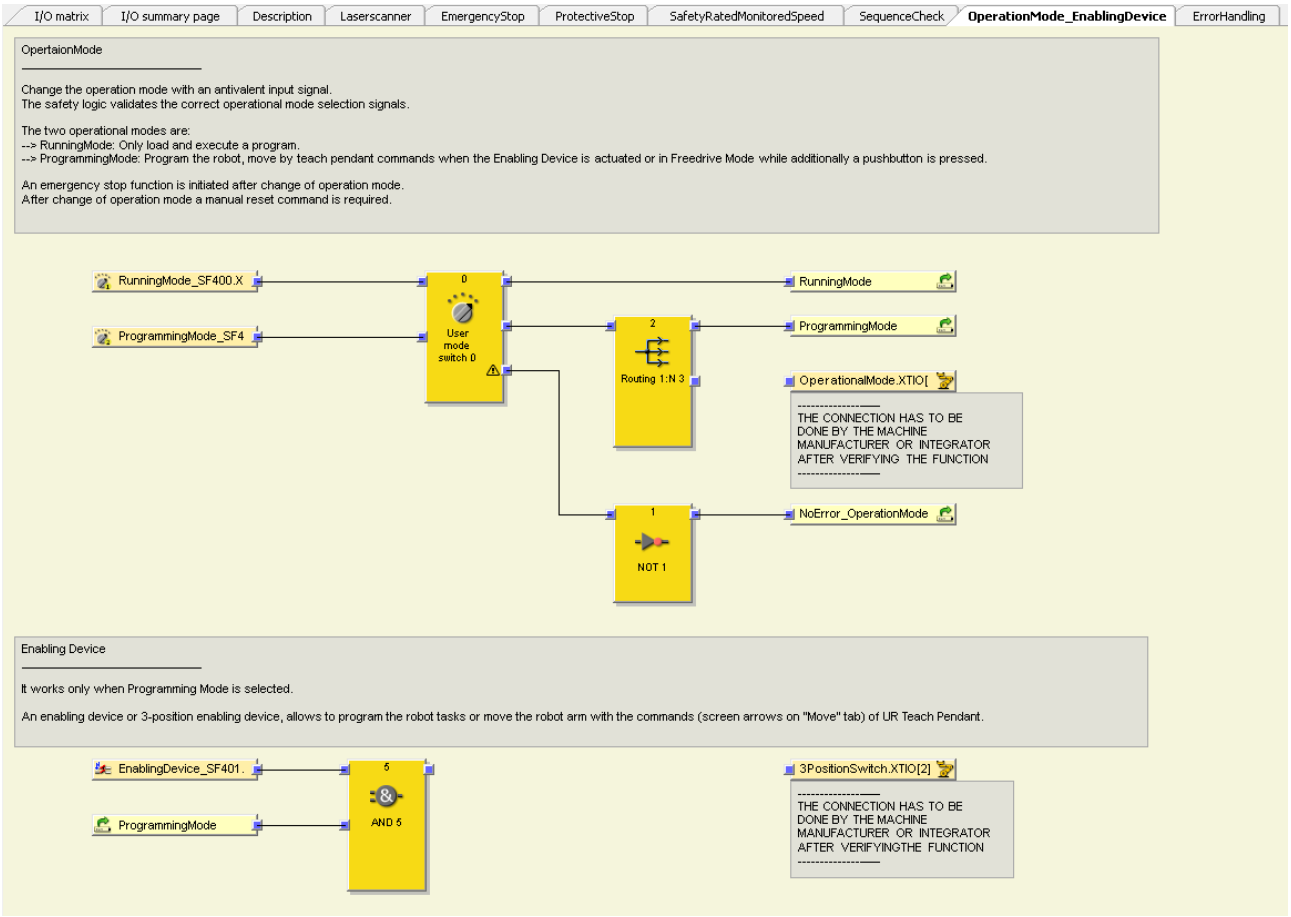


Figure 28: OperationMode_EnablingDevice page view

The operating mode is selected using a complementary input signal of an operating mode selector switch. A maximum discrepancy time of 1,000 ms is permitted and only one signal can be at HIGH. Thus, only running mode or programming mode can be active.

If no operating mode is selected, an error occurs and a emergency stop is triggered.

The three-position enabling device is linked to the test pulse output in order to detect cross-circuits and short-circuits. A maximum discrepancy time of 300 ms is allowed. When programming mode is active, the signals from the three-position enabling device are fed directly to the robot controller input.

7.4.4.8 ErrorHandling page

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

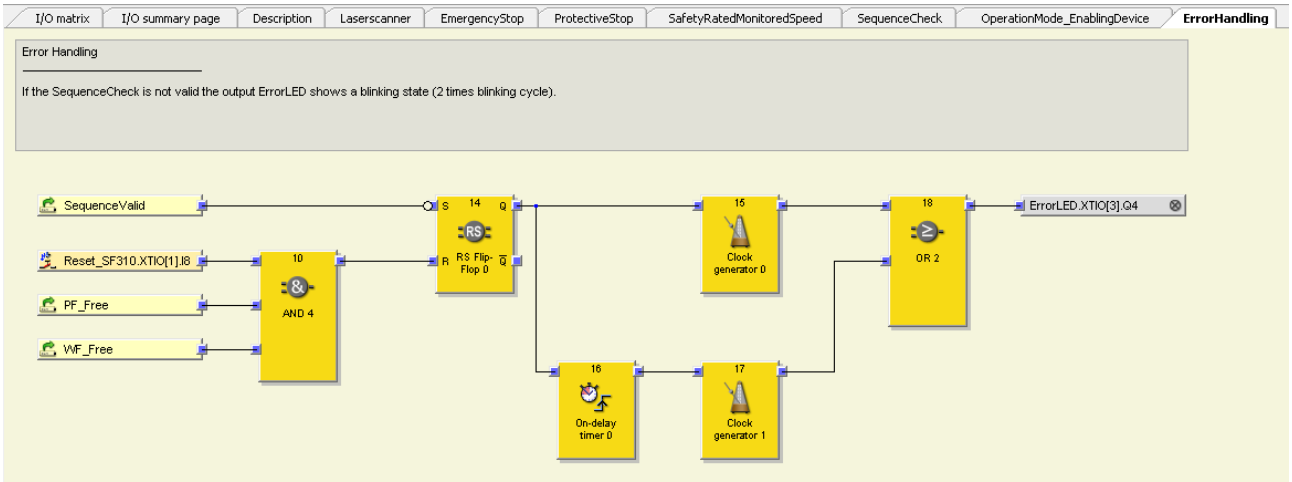


Figure 29: ErrorHandling page view

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. For additional information, see see "SequenceCheck page", page 55.

7.4.5 Activating the license for the safety system

Overview

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

Approach

1. In the **Extras** menu, select the **Software licenses** command.
2. In the **Software licenses** dialog box, select the relevant feature and 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 the safety laser scanner

7.5.1 Configuring the S300 Mini Remote

The files associated with the safety system can be seen on the **Files** tab of the **Safety Systems** selection window. These include a configuration file for the safety laser scanner in which most of the configuration is already implemented. You have to complete, verify and validate the configuration in accordance with the requirements of your application.

1. Right-click the configuration file and select copy file to save the file locally.
2. Select the desired save location and click **Save** to confirm.
3. In the **Configuration area** view: Right-click the safety laser scanner (EFI 1 – A and B) > **Configurations draft** > **Import**
4. Select the locally saved configuration file and confirm.
5. In the **Configuration area** view, double-click a safety laser scanner icon at input EFI 1 of the main module for the safety controller.

✓ The configuration window for the safety laser scanner opens.

Resolution and application variant

Application variants: stationary

Resolution:

- For a scan plane ≥ 300 mm above ground: 70 mm
- For a scan plane < 300 mm above ground: 50 mm

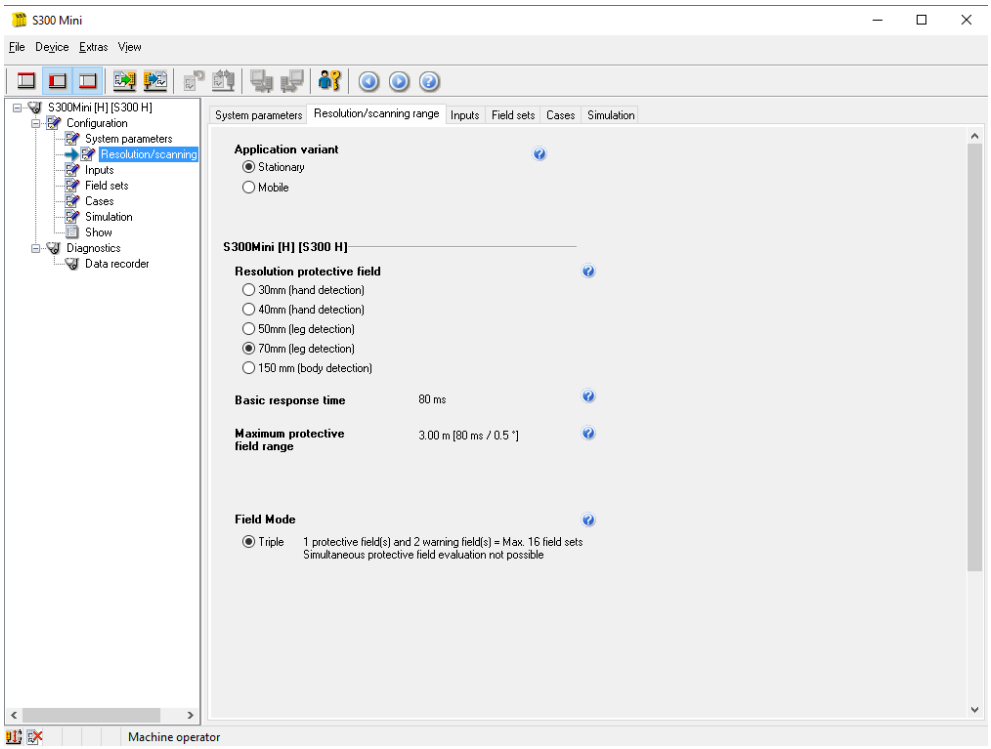


Figure 30: Configuration window of S300 Mini Remote (example)

Inputs

Input A complementary

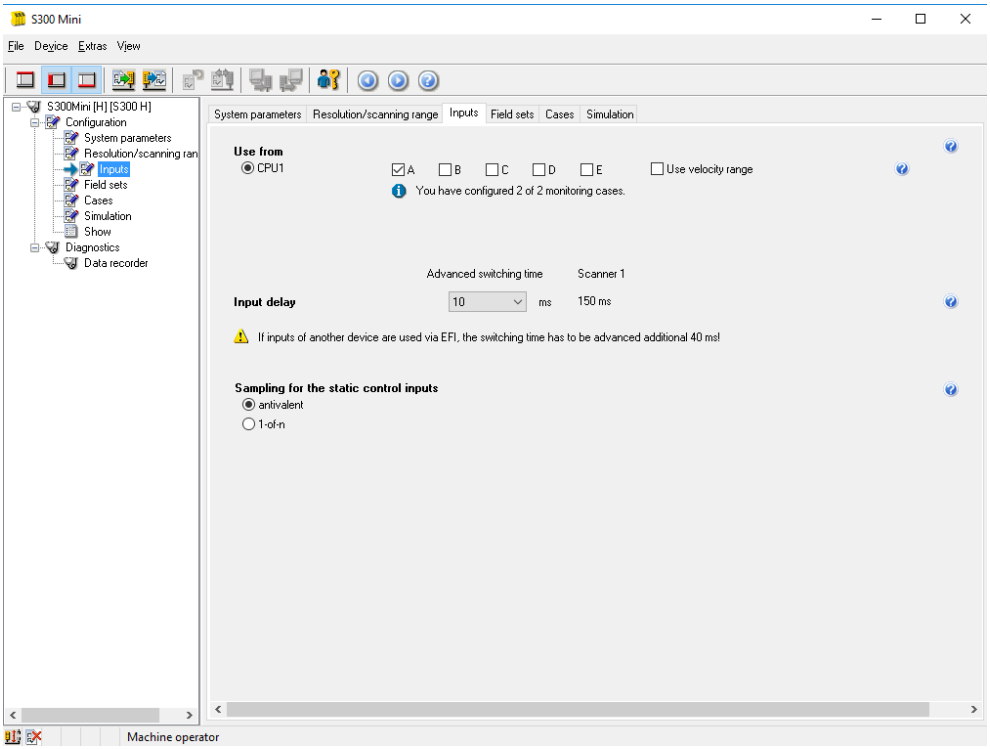


Figure 31: Configuration window of S300 Mini Remote (example)

Field Sets

Two field sets, each with one warning field and one protective field, are required. The warning field is identical for both field sets. The protective fields are of different sizes.

DANGER
The configuration shown here is for example purposes only! Warning and protective fields must be matched to the application according to the risk assessment.

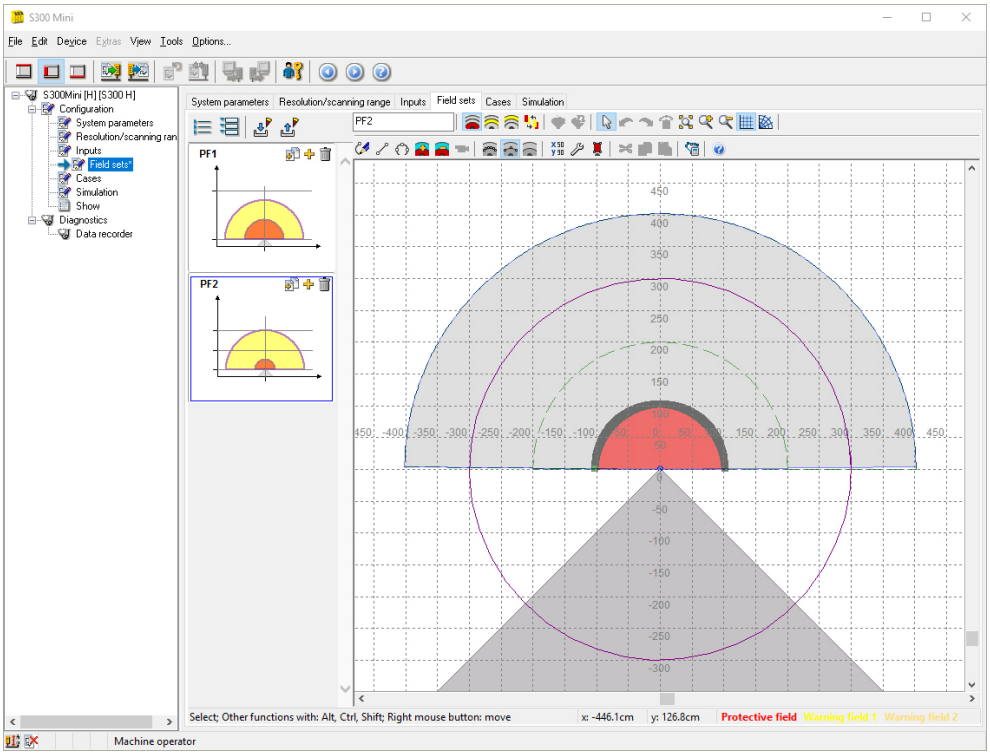


Figure 32: Configuration window of S300 Mini Remote (example)

Configuring monitoring cases

If A = 0, field set 1 with a larger protective field is active.

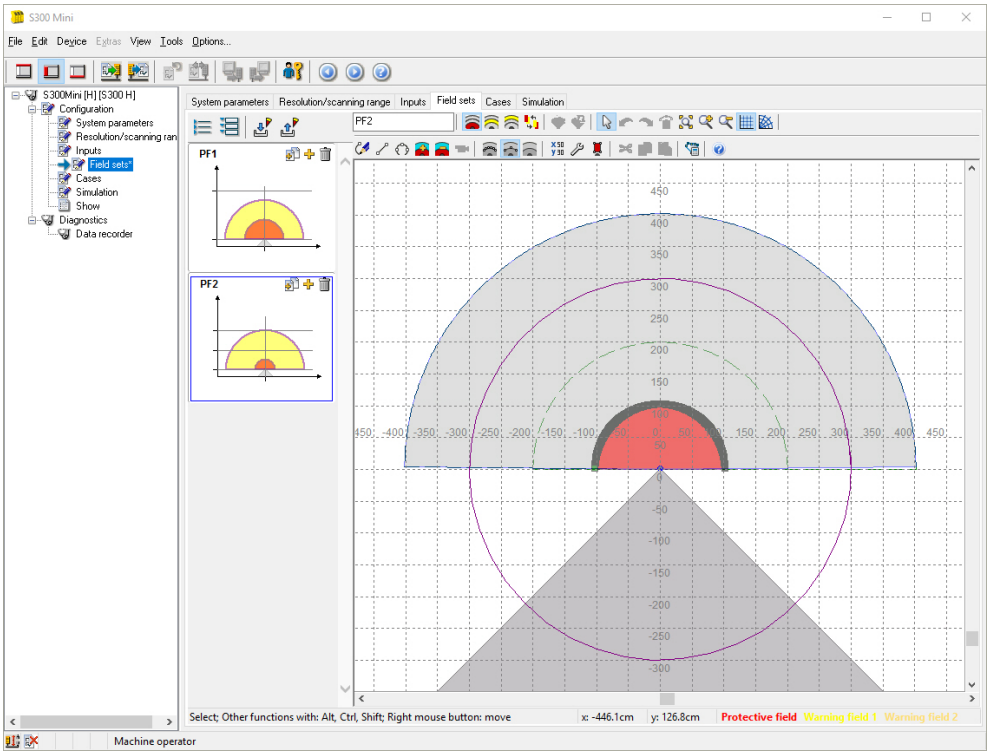


Figure 33: Configuration view of S300 Mini Remote with small protective field (example)

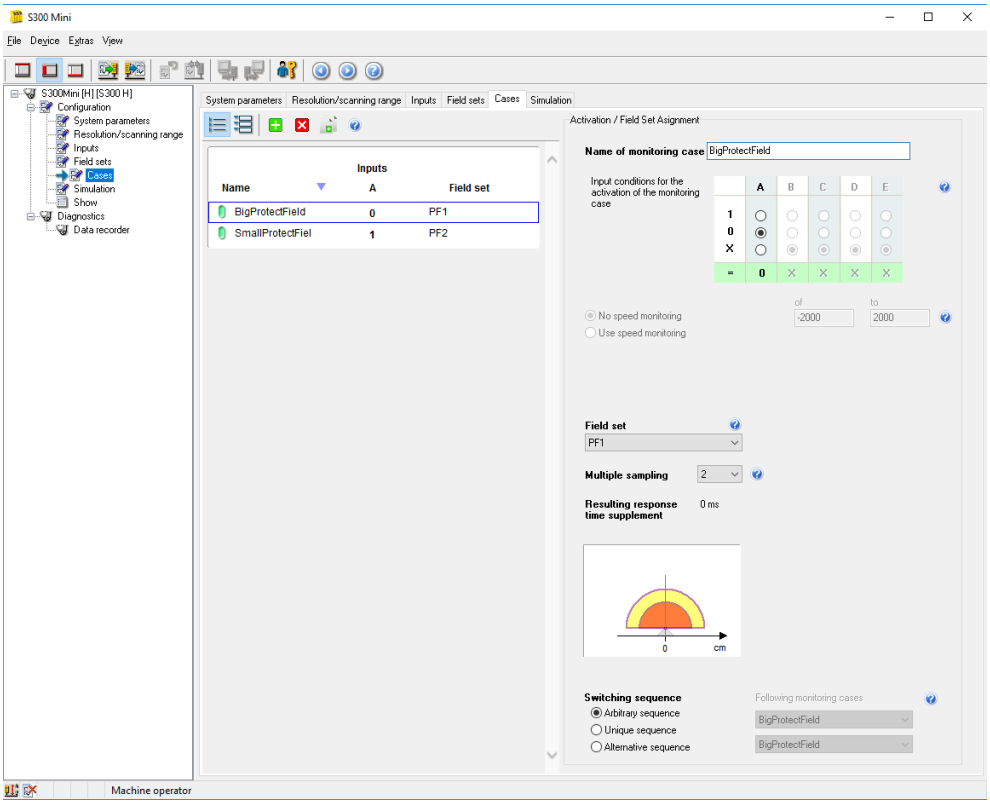


Figure 34: Configuration view of S300 Mini Remote with large protective field (example)

If A = 1, field set 2 with a smaller protective field is active.

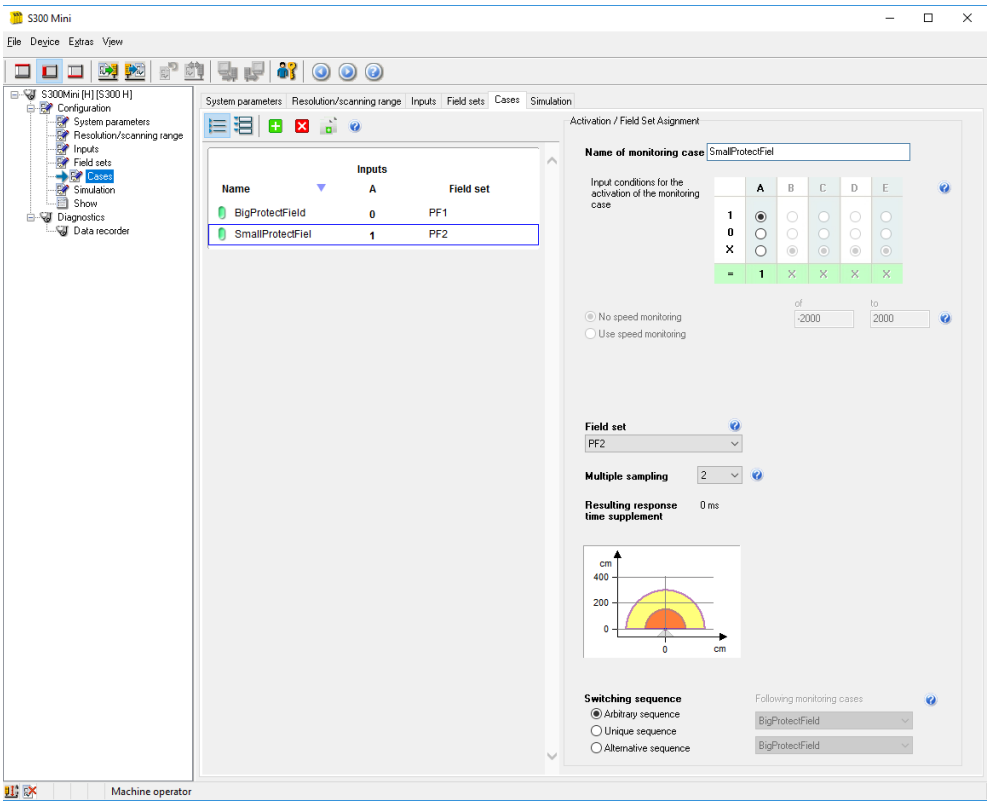


Figure 35: Configuration view of S300 Mini Remote with small protective field (example)

7.6 Robot controller configuration

On the robot controller, the following configurations must be carried out for the safe inputs and outputs.

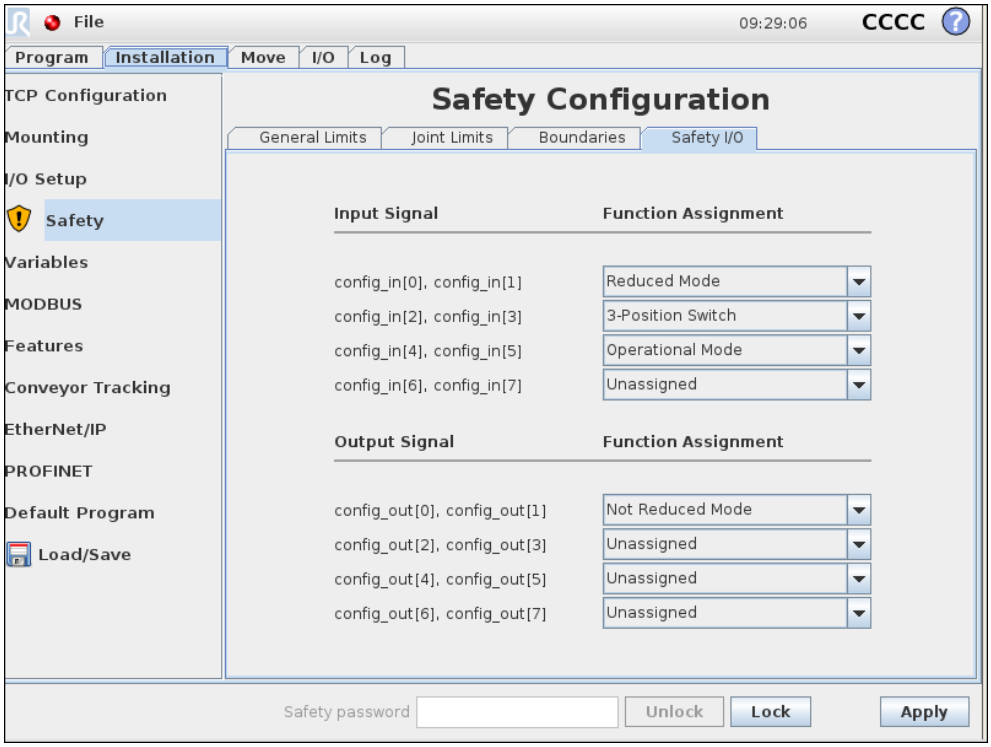


Figure 36: Configuration of inputs and outputs

Configuring safety-rated monitored speed (reduced mode)

If the safety-rated monitored speed (reduced mode) is activated by a safe input, the robot begins to reduce its speed until the values specified in the Reduced Mode column are achieved.

500 ms after activation of the safety-rated monitored speed (reduced mode), the limits are valid and are reliably monitored by the robot controller.

DANGER
The configuration shown here is for example purposes only! The values for Normal Mode and Reduced Mode must be matched to the application according to the risk assessment.

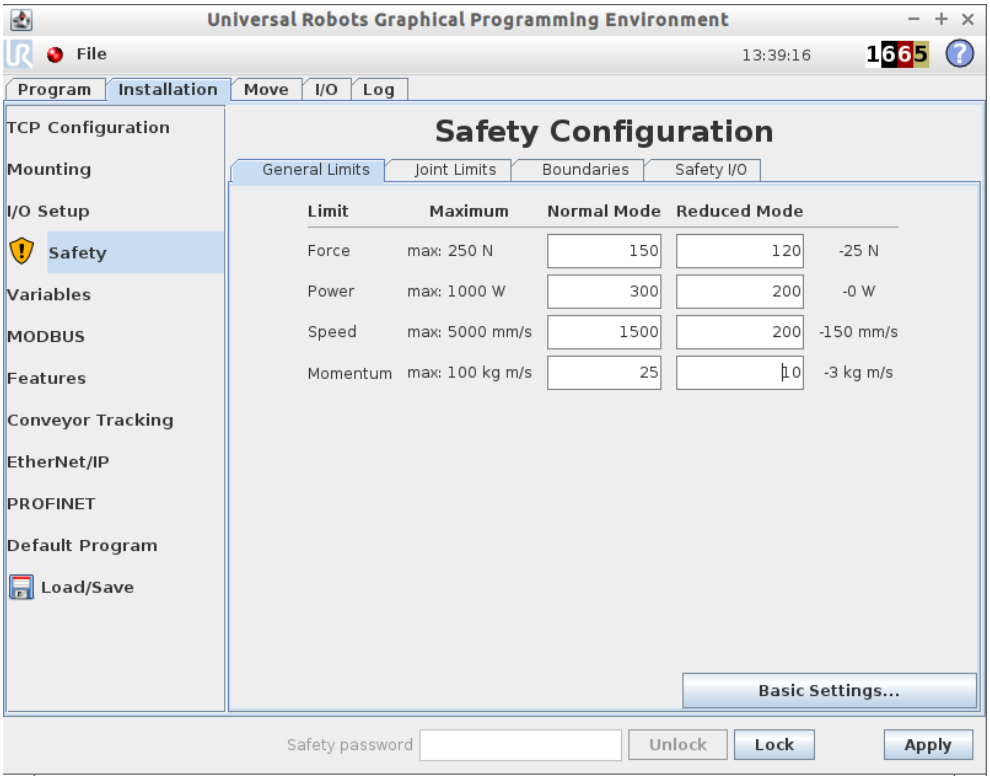


Figure 37: Configuration (example) of safety-rated monitored speed (reduced mode)

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 73).
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 36).

- 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.

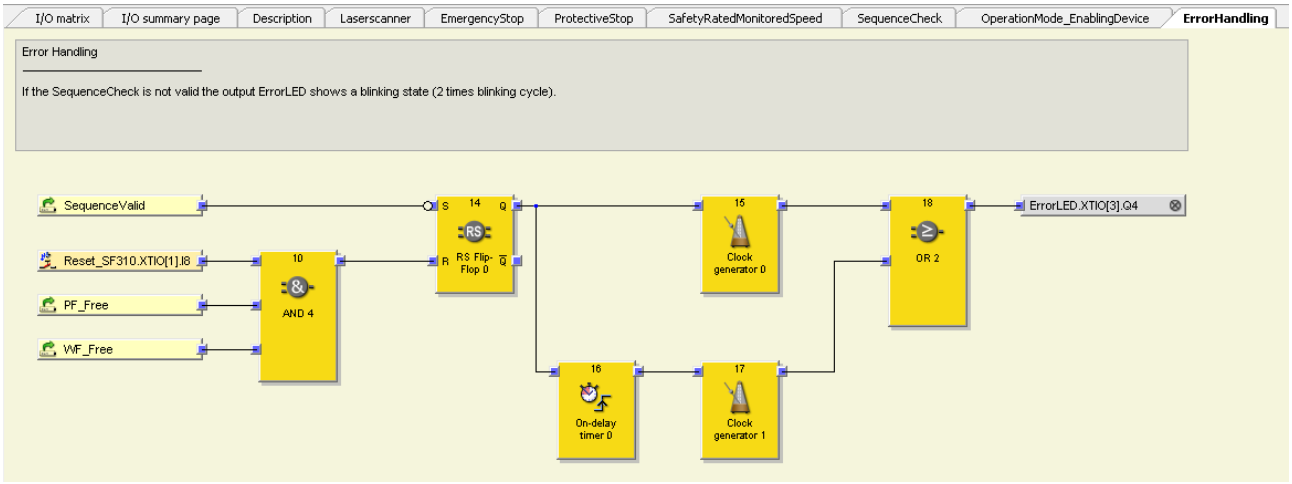


Figure 38: Troubleshooting

When leaving the protective field, the warning field must remain interrupted 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 immediately detected. An invalid sequence triggers an emergency stop in the robot and requires a manual reset.

For more information, see see "SequenceCheck page", page 55 and see "ErrorHandling page", page 56.

12 Technical data

12.1 Data sheet

Table 30: 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 ($t_{FlexiSoft}$)

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

$t_R = t_S + t_{FlexiSoft}$

Table 31: Variables in the calculation

Formula symbols	Relevance
t_R	Response time of safety system
t_S	Response time of the S300 Mini safety laser scanner
$t_{FlexiSoft}$	Response time of the safety controller ($t_{FlexiSoft} = t_{IN} + t_{CPU} + t_{OUT}$)
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 S300 Mini Remote safety laser scanner

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

$t_S = t_{basic} + t_{MS} + t_{EFI}$

Table 32: Variables in the calculation

Formula symbols	Meaning
t_S	Response time of the S300 Mini Remote safety laser scanner
t_{basic}	S300 Mini Remote basic response time (80 ms)
t_{MS}	Additional time for multiple sampling (0 ms for 2x multiple sampling)
t_{EFI}	Time for EFI communication (20 ms)

13 Ordering information

13.1 Ordering information and scope of delivery

Table 33: Ordering information sBot Speed – UR

	Hardware and software		Hardware only		Software only
Part number	1117270	1117272	1096129	1109136	1615124
Hardware					
Flexi Soft safety controller					
CPU0 main module	1 ×	–	1 ×	–	–
System plug for CPU0	1 ×	–	1 ×	–	–
CPU3 main module	–	1 ×	–	1 ×	–
System plug for CPU3	–	1 ×	–	1 ×	–
XTIO expansion module (8 inputs, 4 outputs)	3 ×	3 ×	3 ×	3 ×	–
Safety laser scanner					
S300 Mini Remote	1 ×	1 ×	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 45				

14 Spare parts

14.1 Safety laser scanner

Table 34: Safety laser scanner order data

Spare part	Type code	Part number
S300 Mini Remote safety laser scanner	S32B-3011EA	1056431

14.2 Safety controller

Table 35: Safety controller ordering information

Description	Type code	Part number
Flexi Soft main module FX3-CPU1	FX3-CPU130002	1043784
System plug for FX3-CPU1	FX3-MPL000001	1043700
Flexi Soft main module FX3-CPU3	FX3-CPU320002	1059305
System plug for FX3-CPU3	FX3-MPL100001	1047162
I/O module, 8 safe inputs, 4 safe outputs, plug-in dual-level spring terminals	FX3-XTIO84002	1044125

15 Accessories

15.1 Connectivity

S300 Mini Remote

Table 36: Connecting cable ordering information

Part	Type code	Part number
Female connector, M12, 7-pin, straight, 5 m cable, open end For connecting S300 Mini Remote safety laser scanner	DOL-1SS2G5M0E15KM3	6042338
Female connector, M12, 7-pin, straight, 10 m cable, open end S300 Mini Remote extension cable	DOL-1SS2G10ME15KM3	6042340
Female connector, M12, 7-pin, straight, 15 m cable, open end S300 Mini Remote extension cable	DOL-1SS2G15ME15KM3	6042341
Female connector, M12, 7-pin, straight, 20 m cable, open end	DOL-1SS2G20ME15KM3	6042342

Connecting cables

Table 37: Connecting cable ordering information

Part	Type code	Part number
Male connector, M8, 4-pin, USB-A, straight, 2 m cable For configuring the Flexi Soft safety controller and S300 Mini Remote safety laser scanners	DSL-8U04G02M025KM1	6034574
Male connector, M8, 4-pin, USB-A, straight, 10 m cable For configuring the Flexi Soft safety controller and S300 Mini Remote safety laser scanners	DSL-8U04G10M025KM1	6034575

15.2 Mounting bracket

S300 Mini Remote

Part	Part number
Mounting kit 1b For mounting the safety laser scanner	2034325

16 Annex

16.1 Checklist for initial commissioning and start-up

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 38: 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. Note the designations of the tested emergency stop pushbuttons here.		

Test for “Preventing unexpected start-up” safety function

Table 39: Test for “Preventing unexpected start-up” safety function

Test sequence	Expected result	Result OK?
1. Press Emergency stop pushbutton. 2. Unlock the emergency stop push-button. 3. Check whether the emergency stop pushbutton is installed outside the hazardous area and outside the warning field. 4. Press the reset pushbutton and press restart while the warning field is interrupted.	The robot does not start.	Yes ☐ No ☐
1. Press Emergency stop pushbutton. 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 and start the robot.	The robot does not start.	Yes ☐ No ☐
1. Press Emergency stop pushbutton. 2. Unlock the emergency stop push-button. 3. Ensure that the warning field and protective field are clear. 4. Hold down the restart button for at least 100 ms and for no more than 30 s.	The robot starts.	Yes ☐ No ☐

16.2 Checklist for black box test

Test for “Switching field sets” safety function

Table 40: Checking the “Switch field sets” configuration

Test sequence	Expected result	Result OK?
1. Check the configuration and logic in Flexi Soft Designer. 2. Check and document the configured times for the switch-on and switch-off delay.	**Laser scanner** page: Switch-on delay **On-delay timer 2** ≥ 500 ms. **SafetyRatedMonitoredSpeed** page: Switch-on delay **On-delay timer 2** ≥ 100 ms.	Yes ☐ No ☐

Table 41: Test for “Switching field sets” safety function

Test sequence	Expected result	Result OK?
1. Activate active mode. 2. In the Flexi Soft Designer, start the **Data recorder** function. 3. Make sure that the large protective field is active. 4. Check the actual size of the fields. 5. Start the robot at a higher speed. 6. Interrupt the warning field of the safety laser scanner. 7. Check the actual size of the fields. 8. Release the warning field.	The size of the warning and protective fields is appropriate for the calculated field size for the robot application. When approaching the hazardous area: The robot reduces its speed, switches to the reduced mode, and after a delay time (500 ms) the smaller protective field becomes active. When leaving the hazardous area: The device first switches to the larger protective field before the robot increases its speed.	Yes ☐ No ☐

Test for warning field and protective field

Table 42: Test for warning field and protective field

Test sequence	Expected result	Result OK?
1. Check the 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 safety laser scanner is configured in such as way that the protective field identifies a person at the minimum distance to the hazardous area. 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 43: 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 that the protective field identifies a person at the minimum distance to 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 automated restart

Table 44: Test for automated restart

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 a higher speed. 4. Interrupt 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. 5. Interrupt the protective field of the safety laser scanner. ✓ The robot stops. 6. Vacate the warning field and protective field at the same time. ✓ The robot remains still and a manual reset is necessary.	The robot remains still until the warning field and protective field become clear. Manual reset is necessary.	Yes ☐ No ☐
Tools may be necessary to avoid hazardous situations.		

Test for changing the operating modes

Table 45: Test for changing the operating modes

Test sequence	Expected result	Result OK?
1. Activate running mode by pressing the operating mode selector switch. 2. Make sure that the laser scanner is active. 3. Make sure that the display for the robot shows the symbol for running mode. ✓ **Program robot** button on the teach panel is not available. 4. Switch operating mode by actuating the operating mode selector switch. ✓ A manual reset is necessary. 5. Make sure that the laser scanner is not active. 6. Make sure that the display for the robot shows the symbol for programming mode. ✓ **Program robot** button on the teach panel is available. ✓ After the operating mode is changed again by pressing the operating mode selector switch, a manual reset is required.	Symbol for running mode:  Symbol for programming mode:  The robot can be programmed while programming mode is active. The robot cannot be programmed during running mode.	Yes ☐ No ☐

NOTE

The symbols for active operation and the programming mode are not visible until the operating mode selector switch has been configured in the robot safety settings.

Test of the three-position enabling device

Table 46: Test of the three-position enabling device

Test sequence	Expected result	Result OK?
1. Activate programming mode by pressing the operating mode selector switch. ✓ The robot is in protective stop (safety stop) as the three-position enabling device is no longer being pressed. 2. Press the three-position enabling device in the middle position and hold it. ✓ The robot switches to idle and can be started. ✓ The robot switches to protective stop (safety stop) as soon as the three-position enabling device is no longer being actuated.	The robot can be moved and taught as long as the three-position enabling device is kept in the center position.	Yes ☐ No ☐

16.3 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 47: 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 ☐

16.4 Overview of sensors and actuators

In the following table, the "Operating material labels" and "Flexi Soft Address" are used in the SISTEMA calculation file and circuit diagram.

Table 48: Overview of sensors and actuators

Operating material labels (BMK)	Flexi Soft address	Description
Sensors and switches		
BG210	KF110 EFI1	S300 Mini Remote
SF301	KF111 I1/I2	Emergency stop pushbutton within the hazardous area
SF300	KF111 I3/I4	Emergency stop pushbutton outside the hazardous area
KF400	KF111 I5/I6	Non-reduced mode
SF310	KF111 I8	Reset pushbutton
SF400	KF112 I1/I2	Inputs for switching operating mode
SF401	KF112 I3/I4	Three-position enabling device
Actuators		
KF400	KF111 Q1/Q2	Robot controller - Emergency stop

Operating material labels (BMK)	Flexi Soft address	Description
KF400	KF111 Q3/Q4	Robot controller - Protective stop
KF400	KF112 Q1/Q2	Robot controller - Reduced mode
KF400	KF112 Q3/Q4	Robot controller - Three-position safety device
KF400	KF113 Q1/Q2	Robot controller - Operating mode
KF400	KF113 Q3	Lamp for reset
KF400	KF113 Q4	Lamp for sequence error

17 Glossary

Enabling device	Additional manually operated device used in conjunction with a start control and which, when continuously actuated, allows a machine to function. [EN ISO 12100:2010; definition 3.28.2] [see also IEC 60204-1:2016; 9.2.3.9 ; 10.9] (further explanation in ISO 10218-1; 5.8.3 Enabling device)
Industrial robot system	System comprising: • Industrial robot; • End-effector(s); • Any machinery, equipment, devices, external auxiliary axes or sensors supporting the robot performing its tasks. [ISO 10218-1:2011, definition 3.11]
Integrator	Entity that designs, provides, manufactures or assembles robot systems or integrated manufacturing systems and is in charge of the safety strategy, including the protective measures, control interfaces and interconnections of the control system. [ISO 10218-2:2011, definition 3.7]
Protective stop	Type of interruption of operation that allows a cessation of motion for safeguarding purposes and which retains the program logic to facilitate a restart. [ISO 10218-1:2011, definition 3.17]
Safety function	Fnction of a machine whose failure can result in an immediate increase of the risk(s). [ISO 12100:2010, definition 3.30] (see also EN61508-4:2010; definition 3.5.1)
Safety-rated monitored speed	Safety-related function that causes a protective stop when either the Cartesian speed of a point relative to the robot flange (e.g. the TCP), or the speed of one or more axes exceeds a specified limit value. [ISO 10218-1:2011, definition 3.19.1] (see also 5.6.3, under Speed Control)
Stop Category 1	Robot motion is stopped with power available to the robot to achieve the stop and then removal of power when the stop is achieved. It is a controlled stop, where the robot will continue along the programmed path. Power is removed as soon as the robot stands still. For more information, see ISO 13850 or IEC 60204-1.
Stop Category 2	A controlled stop with power left available to the robot. The safety-related control system monitors that the robot stays at the stop position. For more information, see IEC 60204-1.

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