OPERATING INSTRUCTIONS

sBot Stop

Safety system

SICK
Sensor Intelligence.

Described product

sBot Stop

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:

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

1.2 Scope

These operating instructions contain information regarding the sBot Stop safety system.

NOTICE
The operating instructions of the components also apply.
The relevant information must be made available to the employees for all work performed on the safety system.

The following documents contain additional information regarding the sBot Stop safety system:

Table 1: Available documents

Document type	Title	Part number
Operating instructions	microScan3 Core I/O	8016344
Operating instructions	S300 Mini Standard	8014166
Operating instructions	deTec4 Core	8014251
Operating instructions	deTem4 Core	8020445
Operating instructions	S3000 Standard	8009791
Operating instructions	Flexi Classic Modular safety controller	8011562

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

8023419

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 Further information

www.sick.com

The following information is available via the Internet:

- This document in other languages
- Operating instructions and mounting instructions of SICK components suitable for the safety system
- Prepared subsystems for SISTEMA for this safety system
- Circuit diagram for the safety system (ePLAN)
- Guide for Safe Machinery (“Six steps to a safe machine”)

2 Safety information

2.1 General safety note

The information and tools will not fulfill the safety requirements for your application without further adjustments being made. The project planning provided by way of example is intended to serve as the basis to allow you to perform your own project planning and configuration 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 configuration, you will need to rely on qualified staff given that it is your responsibility to ensure that the following requirements are complied with at the very least:

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

2.2 Intended use

The sBot Stop safety system provides protection against mechanical hazards caused by movement of the robot arm by means of access and presence monitoring.

The safety system can be used subject to the following prerequisites:

- Robots and humans perform their work in the same workspace, but at different times (cooperation).
- The robot works at a fixed position.
- The danger results from the movement of the robot arm (mechanical hazard).
- The only access to the robot is protected by the primary protective device (e.g. safety light curtain).
- The protective field of the safety laser scanner must be able to cover the entire hazardous area (secondary protective device).
- It is ensured that it is not possible to bypass the protective field of the primary protective device and the safety laser scanner (e.g. by reaching around, stepping over, climbing over or reaching through or standing behind). This is guaranteed, for example, by fixed protective devices (e.g. fencing).

Complementary information

Table 2: Types of human-robot interaction

Human-robot interaction	Different time	Same time
Shared workspace	**Cooperation**	Collaboration
Different workspace	No interaction	Coexistence

This safety system was developed for cooperative workspaces with robots.

Certain tasks that are performed by the robot may interact with the actions of humans. Cooperative interaction between robots and humans is characterized by the fact that tasks are performed in the same workspace at different times. If a cooperative interaction is monitored reliably, the robot arm can also work at high speeds.

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 and the primary protective device function as indirect protective measures and cannot provide protection from pieces thrown out, emitted radiation, electric voltage or similar. Transparent objects are not detected.

- ▶ Take additional measures if necessary to provide protection against hazards that do not result from movement of the robot arm.

In addition to the intended use, the manufacturer of the machine must also take hazards into account in the risk assessment that can occur due to reasonably foreseeable misuse.

Foreseeable misuse by users

- Users take chairs, ladders or similar into the protective field of the safety laser scanner
- Users take transparent objects into the hazardous area
- Users jump over the scan plane of the safety laser scanner

WARNING
There is an increased residual risk in the event of misuse. If the protective field of the primary protective device and the protective field of the safety laser scanner are clear, the robot can move. In this case, the movement of the robot is not prevented by this safety system.

The manufacturer and operator must be aware of this residual risk and bear the responsibility for it.

2.4 Identifying hazards

This safety system is intended to reduce mechanical hazards in accordance with ISO 10218-1 while the robot is performing its task. This document considers the following risks:

Mechanical hazards
- Crushing
- Cutting
- Impact

Dangers posed generally by the robot's task, the robot arm or the end effector of the robot must also be considered by the manufacturer. If necessary, further measures must be taken to minimize the resulting risks.

NOTE
Risks must be reduced or eliminated by design measures or replacement, and then by protection and other additional technical measures. Residual risks must be retroactively reduced by other means such as warning signs, training, processes, etc.

Other residual risks, e.g., due to small parts being propelled, are not considered and must be considered in detail in the risk assessment, see "Manufacturer of the machine", page 24.

2.5 Requirements for the qualification of personnel

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

Project planning

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

Mechanical mounting

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 safe output signal switching devices are in the OFF status. The robot is switched off or in safe zero speed monitoring condition.

The safe state is initiated in the following cases:

- Protective field interrupted
- Emergency stop pushbutton actuated
- Connection between the safety laser scanner and safety controller interrupted
- Connection between the primary protective device and safety controller interrupted
- Voltage supply of the safety laser scanner, primary protective device or the safety controller interrupted
- Internal fault on the safety laser scanner detected
- Internal fault on the primary protective device detected
- Internal fault detected at the safety controller or one of its components

NOTE

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

3 Product description

3.1 Product identification

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

Further topics

- "Ordering information", page 52

3.2 Design of the safety system

The safety system from SICK comprises the following components:

- 1 × S300 Mini Standard, microScan3 Core I/O or S3000 Standard safety laser scanner
- 1 x deTec4 Core or deTem4 Core primary protective device
- 1 x FlexFix bracket for sender and receiver of the primary protective device
- 1 × Flexi Classic safety controller:
  - 1 × Flexi Classic main module UE410-MU4T0
    or
  - 1 × Flexi Classic main module UE410-MU4T0 and input expansion module 8DI
- Macro for ePlan
- Operating instructions for download www.sick.com
- SISTEMA file

3.3 Limits of the safety system

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

For detailed information about the interfaces see "Electrical installation", page 38.

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

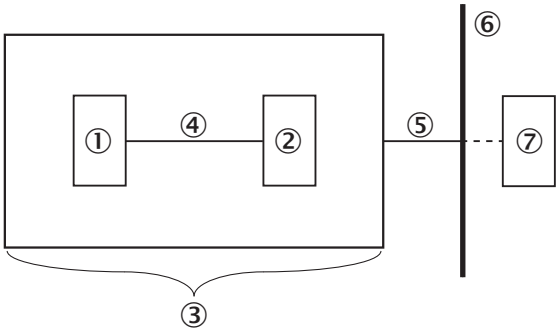


Figure 1: Limits of the safety system

① Sensors
② Logic (safety controller)
③ Sub-safety function
④ Wiring between sensors and logic
⑤ Wiring between safety system components and components outside the safety system
⑥ Limit of the safety system
⑦ Components outside the safety system, e.g., actuators, robot controller, or higher-level controller

3.4 Functionality

Scope

The sBot Stop safety system is used in cooperative work environments with industrial robot systems in order to reduce the risk of injuries caused by the movement of the robot.

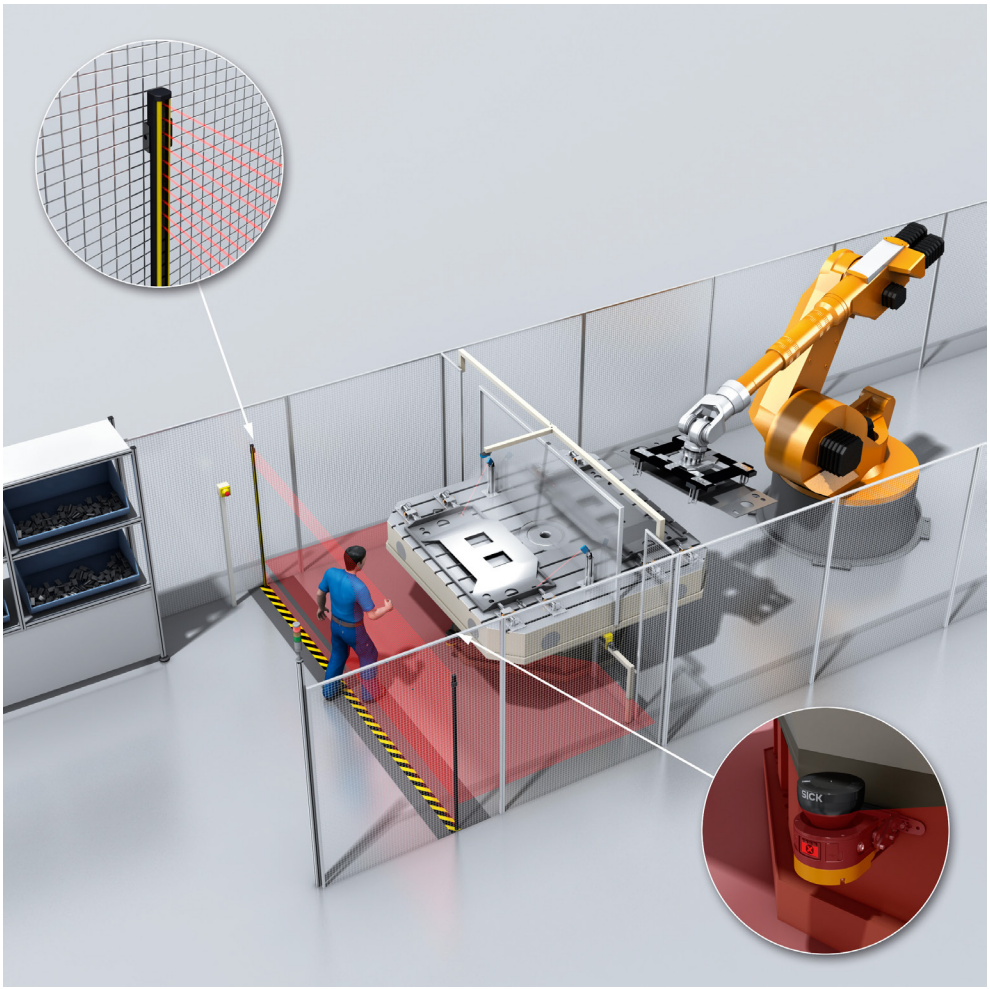


Figure 2: Example application with rotating table

Figure 3: Example application with workstation

The industrial robot system consists of the following components:

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

The primary protective device is a safety light curtain or a multiple light beam safety device. The secondary protective device is a safety laser scanner.

If a person interrupts the protective field of the primary protective device when approaching the robot, the robot performs a protective stop. The person then enters the protective field of the safety laser scanner, which monitors the hazardous area of the robot and prevents a restart.

If an automated system restart is permitted (based on the risk assessment in accordance with ISO 12100), the robot will restart automatically as soon as a person leaves the protective field of the safety laser scanner and the protective field of the primary protective device is clear.

3.5 Design of the overall system

The overall system comprises a total of three components:

- 1. SICK safety system
- 2. Robot controller
- 3. Safety command devices

1. SICK safety system

The safety system provides output signals for the robot controller and receives input signals from the primary protective device and the safety laser scanner. In addition, the safety controller receives input signals from safety command devices for safe handling of the robot in different situations. The safety logic in the Flexi Classic safety controller allows triggering of the robot's safety functions.

2. Robot controller

The robot controller requires the emergency stop and protective stop safety functions. These safety functions are triggered by the safety controller.

3. Safety command devices

Safety command devices provide the necessary conditions to perform the actions defined by the safety functions.

Safety system types

The safety system offers two options for performing a reset after a protective stop.

- sBot Stop with manual reset
- sBot Stop with automated reset

NOTE
Implementation with automated reset is not suitable for every application. Possible use must be checked by means of the risk assessment.

NOTE
Restart implementation is the responsibility of the manufacturer.

sBot Stop with manual reset

Manual reset: the reset pushbutton is connected to the safety controller and its signal is analyzed there. The reset signal is effective for the protective stop. Reset after an emergency stop and the emergency stop itself must be implemented by the manufacturer (e.g. in the robot controller).

A manual reset and a manual restart are necessary after an emergency stop. Depending on the robot controller and the stop category used, several steps may be necessary for the protective stop. These may include error acknowledgment, switching on the drive and starting the program.

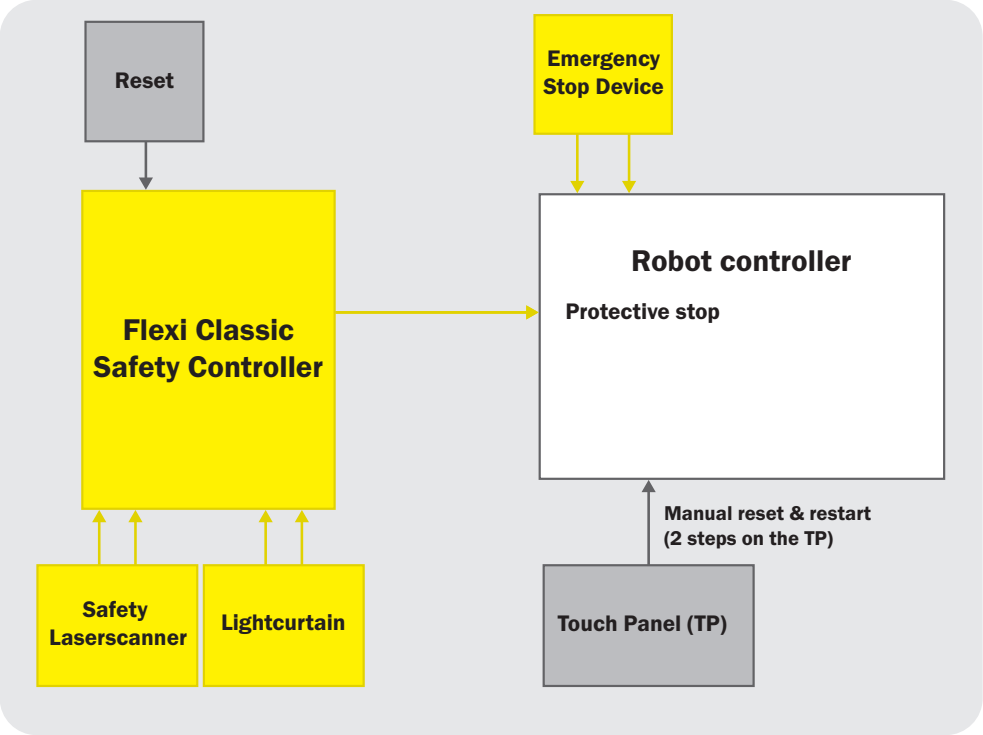


Figure 4: Schematic component network for manual reset

sBot Stop with automated reset

Automated reset: the protective stop is reset automatically. The reset pushbutton interacts with the emergency stop signal to prevent a robot start after a system start and after an emergency stop. The reset pushbutton is connected to the safety controller and its signal is analyzed there.

Depending on the robot controller and the stop category used, several steps may be necessary for the protective stop. These may include error acknowledgment, switching on the drive and starting the program. Programming can be implemented both in the robot controller and in a higher-level control. The manufacturer is responsible for restart implementation.

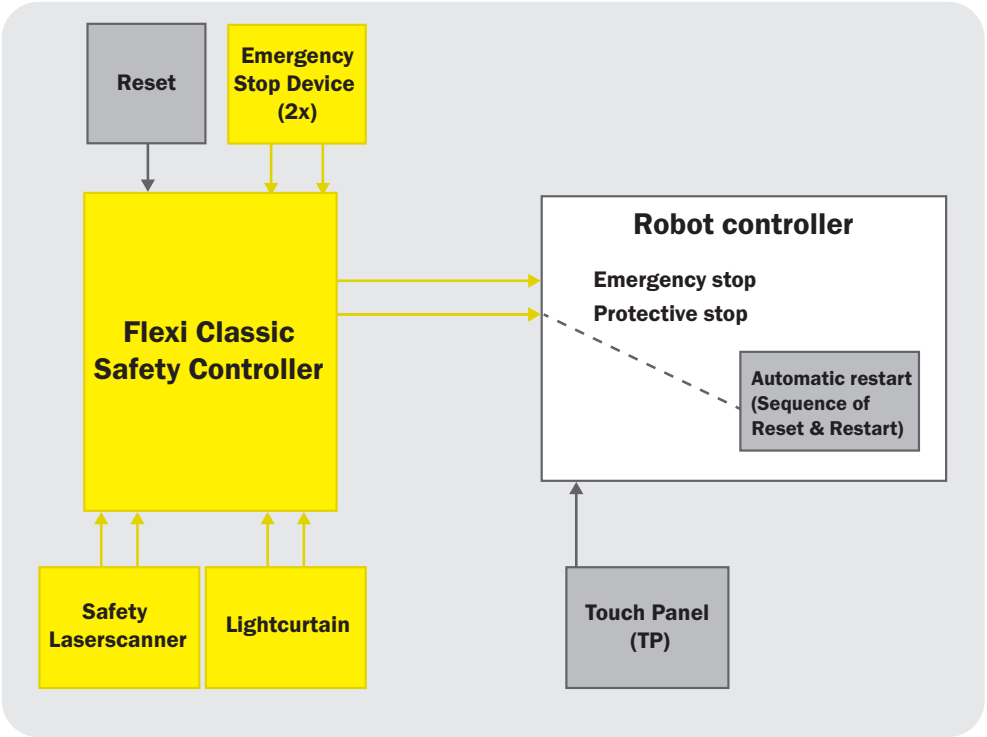


Figure 5: Schematic component network for automated reset, option 1

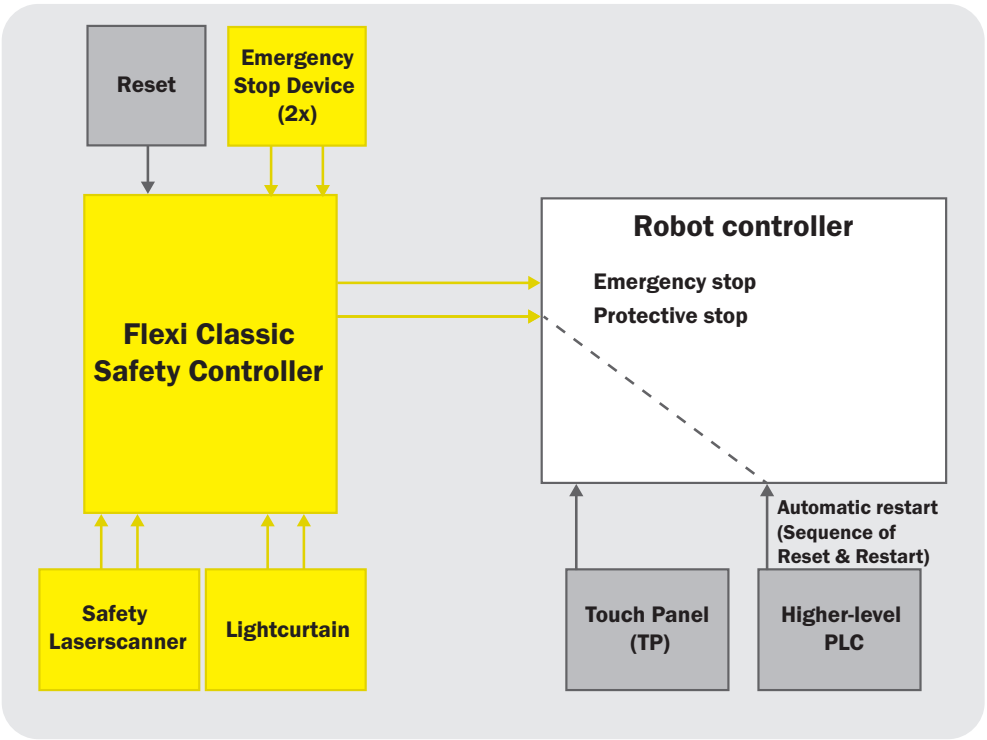


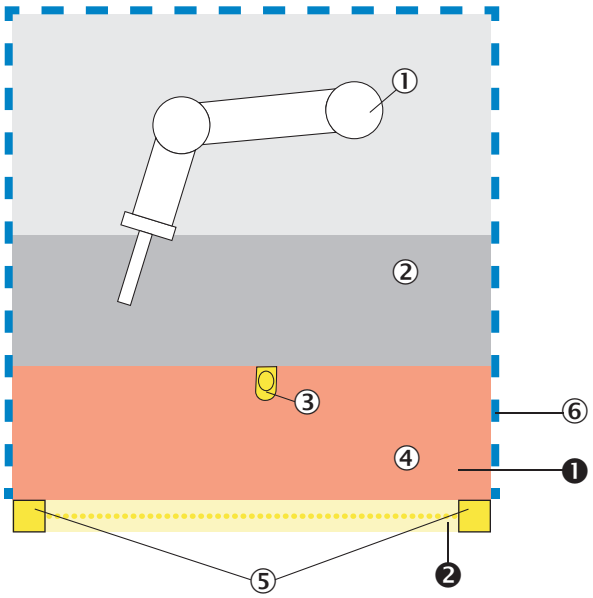
Figure 6: Schematic component network for automated reset, option 2

3.6 Product characteristics

3.6.1 Protective field types

This safety system operates with two different protective fields:

- Vertical protective field of the primary protective device (e.g. safety light curtain)
- Horizontal protective field of the secondary protective device (safety laser scanner)



① Robot arm
② Human and robot interaction area
③ Safety laser scanner
④ Safe monitored area
⑤ Primary protective device (e.g. safety light curtain)
⑥ Fixed protective devices (e.g. fencing)
❶ Secondary protective device
❷ Primary protective device

Vertical protective field

The primary protective device uses vertical light beams to continuously check whether persons enter the hazardous area.

The area covered by the light beams is referred to as the protective field of the primary protective device.

Horizontal protective field

During operation, the safety laser scanner uses its horizontal laser beams to continuously check whether people are present in a hazardous area.

The protective field of the safety laser scanner must be designed so that the entire hazardous area is reliably monitored. In conjunction with this safety system, the safety laser scanner is referred to as a secondary protective device.

3.6.2 Safety Functions

3.6.2.1 Overview of safety functions

- Initiate stop (protective stop)
- Automatic restart
- Prevent unexpected startup
- Emergency stop

3.6.2.2 Initiating stop (SF10)

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 of the primary protective device is interrupted, a protective stop is carried out. As long as the protective fields of the primary protective device and safety laser scanner are not both clear, unintentional startup of the robot is prevented.

Table 3: Initiating stop when the protective field of the primary protective device is interrupted

Trigger	Protective field of the primary protective device is interrupted by persons
Condition	Possible at any time
Reaction	Robot executes a protective stop
Safe state	Standstill

This safety function is independent of the robot operating modes (e.g. Automated or Manual). If this safety function is triggered, it initiates a protective stop via the corresponding safe inputs of the robot controller.

If no protective stop should be performed in an operating mode (e.g. manual), this must be configured correspondingly in the robot controller.

NOTE
The robot controller of some robots may implement the protective stop signal differently in different operating modes. For example, initiation of a protective stop could be ignored in a manual operating mode.

In this case, the risks must be reduced in another way, e.g. by the safety-rated monitored speed function in manual robot operation. The manufacturer must take this into account in the risk assessment.

NOTE
Expected frequency for requests of this safety function: 1 / hour and thus 8,760 / year.

3.6.2.3 Preventing unexpected startup following a protective stop with manual reset (SF01.1)

The manufacturer must decide whether a manual or automated reset is necessary after a protective stop (depending on risk assessment).

Table 4: Allowing restart after protective stop

Trigger	Valid reset sequence
Condition	Protective fields of primary protective device and safety laser scanner are clear
Reaction	Allows the control to accept a single start command
Safe state	Standstill

A valid reset sequence takes place as follows: the change LOW-HIGH-LOW is evaluated in the safety controller, whereby the HIGH pulse must be present for a duration between 50 ms and 5 s.

This safety function is mandatory if a manual reset is necessary after a protective stop.

This safety function is not needed if an automated reset is possible after a protective stop because unexpected startup is prevented by the safety function SF01.2.

NOTE
Expected frequency for requests of this safety function: 1 / hour and thus 8,760 / year.

3.6.2.4 Preventing unexpected startup following a protective stop with automated reset (SF01.2)

Table 5: Preventing an unexpected start-up

Trigger	Protective field of the safety laser scanner interrupted
Reaction	Robot protective stop
Safe state	Hazardous movement of the robot is stopped

This safety function is mandatory if an automated reset is possible after a protective stop. The safety laser scanner prevents deactivation (HIGH status) of the protective stop signal and thus robot startup as long as the protective field of the safety laser scanner is interrupted.

NOTE
Expected frequency for requests of this safety function: 1 / hour and thus 8,760 / year.

3.6.2.5 Emergency stop (SF99)

This safety function is relevant only for the automated restart function order to ensure manual operation of the reset pushbutton. The emergency stop signal must be processed in the safety controller and must not be processed in the robot controller.

- When the emergency stop function is triggered, the dangerous movements and states of the robot are ended depending on the application.
- Aside from triggering the emergency stop function, no other action is needed from a person to create a safe state
- No additional dangers are created when ending the dangerous movement and statuses

Table 6: Emergency stop

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

If an emergency stop pushbutton is pressed, the safety system triggers an emergency stop via the corresponding safe inputs on the robot controller. The robot executes an emergency stop.

NOTE
Expected frequency for requests of the safety function:
365 / year +52 / year = 417 requests in total per year.

3.6.2.6 Preventing unexpected startup following an emergency stop (SF01.3)

A manual reset is necessary after an emergency stop.

Table 7: Preventing unexpected startup following an emergency stop

Trigger	Valid reset sequence
Condition	Emergency stop control switch reset
Reaction	Allows the control to accept a single start command
Safe state	Standstill

A valid reset sequence takes place as follows: the change LOW-HIGH-LOW is evaluated in the safety controller, whereby the HIGH pulse must be present for a duration between 50 ms and 5 s.

The reset is evaluated in the safety system.

This safety function is relevant for the automated reset.

NOTE

Expected frequency for requests of the safety function:

365 / year +52 / year = 417 requests in total per year.

3.7 Additional components required

The following additional components are essential for use of safety system in an application:

- Emergency stop pushbutton
- Reset pushbutton
- Robot controller
- Additional physical guard (e.g. fencing)

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 "Scope of delivery", page 52.

3.7.1 Emergency stop pushbutton requirements

At least one device for stopping in an emergency must be installed, e.g. emergency stop pushbutton.

At least two devices for stopping in an emergency (e.g. emergency stop pushbuttons) must be installed as follows if the automated restart is used:

- Inside the monitored area - as close as possible to the robot so that the operator can easily reach the emergency stop pushbutton when in the monitored area close to the robot
- Outside the monitored area

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

Each emergency stop pushbutton must have two N/C contacts which are both opened e.g. by pressing the button.

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.

The pushbutton must be designed according to the following standard:

- EN 60204

The reset signal must be triggered only if the reset pushbutton has be released from its activated position again (in accordance with ISO 13849-1).

For this reason, the signal processing function must detect the falling edge of the signal from the reset pushbutton. A reset is permitted only if all safety functions and protective devices are functional.

3.7.3 Robot controller requirements

Safety functions

The robot must have the following safety functions and safety inputs suitable for these in accordance with category 3 (ISO 10218-1, 5.4.2) with Performance Level d or SIL 2 (IEC 62061):

- Emergency stop (ISO 10218-1, 5.5.2)
- Protective stop (ISO 10218-1, 5.5.3)

Robot controller functions

Table 8: Robot controller functions

	Emergency stop	Protective stop
Required	Yes	Yes
Reset, restart	Manual	Automated/manual
Stop category	Stop category 0 or stop category 1	Stop category 1 or stop category 2 [1)]
Secure signal from safety system to safety controller	Yes	Yes

1) SS1 (corresponding stop category 1) or SS2 (corresponding stop category 2) can be used. When SS1 is used, the signal for restart must come from a superior control.

Reset and restart requirements

After emergency stop or switching on:

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

After protective stop (with manual reset):

- Depending on the robot type and the requirements of the application, a manual restart may be necessary after performing the risk assessment. In this case, a manual reset must be implemented on the safety controller. Resetting the robot is only possible if the user has executed a restart. Implementation is the responsibility of the manufacturer.

After protective stop (with automated reset):

- An automated restart may be implemented if this is permitted by the risk assessment of the robot application. The safety system performs an automated reset if the protective fields of the primary protective device and the safety laser scanner are clear. This switches the protective stop output to the ON state (HIGH) so that the robot can be started.
- The automated restart can be implemented in the robot controller or in a higher-level control. Implementing automatic restart is the responsibility of the manufacturer.

3.7.4 Physical guard

On the basis of the manufacturer's risk assessment, it may be necessary to install fixed guards such as fencing to avoid and restrict access to the hazardous area of the robot.

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

The dangerous state of the machine may not be stopped or not be stopped in a timely manner in the event of non-compliance with the following instructions.

- 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 laser scanner.

The manufacturer must check whether the individual components of the safety system are suitable for the respective application depending on the risk assessment and ambient conditions. Among other things, it is necessary to take into account the size of the protective fields and the requirements for the machine design.

The manufacturer has the following duties:

- Carrying out 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.

4.1.1 Notes on automated restart

The automated restart function may only be used if a comprehensive and detailed manufacturer's risk assessment has been performed and all requirements for use of this safety system are fulfilled.

There is no necessary requirement for a general restart interlock in ISO 10218-2. Chapter 5.10.3.3 of ISO 10218-2 makes explicit reference to a presence sensing function in order to prevent a restart. This conforms with the basic safety and health requirements and standards of the Machinery Directive.

If the operator is reliably detected in the monitored area and there is no possibility of entering the hazardous area undetected, the automated restart complies with the requirements of the standard.

4.1.2 Reference standards

The following standards must be taken into account when preparing and using the safety system:

- ISO 10218 – Robots and robotic devices – Safety requirements for industrial robots – Part 1: Robots
- ISO 13849-1 Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design
- ISO 13849-2 Safety of machinery - Safety-related parts of control systems - Part 2: Validation
- ISO 13857 Safety of machinery - Safety distances to prevent hazard zones being reached by upper and lower limbs
- ISO 13855 Safety of machinery - Positioning of protective devices with respect to the approach speeds of parts of the human body

4.1.3 Quantification of components

For quantification of the safety functions, the manufacturer's safety-relevant data of the components used was taken into account. Where this data was not available, the typical component values in accordance with ISO 13849-1 were used.

The values for the normal operating cycle must be adapted by the machine manufacturer.

In safety function SF01.1 - Preventing an unintentional restart (manual reset), the normal operating cycle is estimated with a value of 8,760 cycles/year and the B10d value is a typical component value of 100,000 cycles.

If this is not adapted to the values of the components used, the pushbuttons must be replaced after 11 years.

Corresponding changes must be made for this safety system for the emergency stop pushbutton, the reset pushbutton and the relay.

4.2 Operating entity of the machine

DANGER
Hazard due to lack of effectiveness of the protective device

The dangerous state of the machine may not be stopped or not be stopped in a timely manner in the event of non-compliance with the following instructions.

- ▶ 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. The file is available on the Internet for this safety system. 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 project file for each user-defined sub-system. In addition, the correct values for the value must be chosen for the components that are not part of the scope of delivery, see "General requirements", page 38.

4.4 Design

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

- Overall height of the protective field of the primary protective device
- Height of the lower edge of the protective field of the primary protective device
- Height of the scan plane of the safety laser scanner
- Protective field length
- Protective field width
- Robot stopping/run-down time

4.4.1 Safety laser scanner

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

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

NOTE

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

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

Depending on the application and the risk assessment, the manufacturer must decide which safety laser scanner must be used.

The manufacturer must check after the risk assessment whether use of the respective safety laser scanner and this safety system is suitable for the application in question. The requirements for use of an automated optical protective device must be met and the size of the protective field as well as the requirements for the machine design must be taken into account.

4.4.2 Primary protective device

The protective field of the primary protective device must be oriented vertically and observe a minimum distance to the hazardous area in accordance with ISO 13588.

The lowest beam of the primary protective device should be ≤ 300 mm above the ground.

If the safety system is not used in an industrial environment, the lowest beam of the primary protective device should be ≤ 200 mm above the ground (in accordance with ISO 16855).

It must not be possible to reach over or reach under the device.

A minimum distance to reflective surfaces must be maintained. The operating instructions of the primary protective device must be observed in all cases.

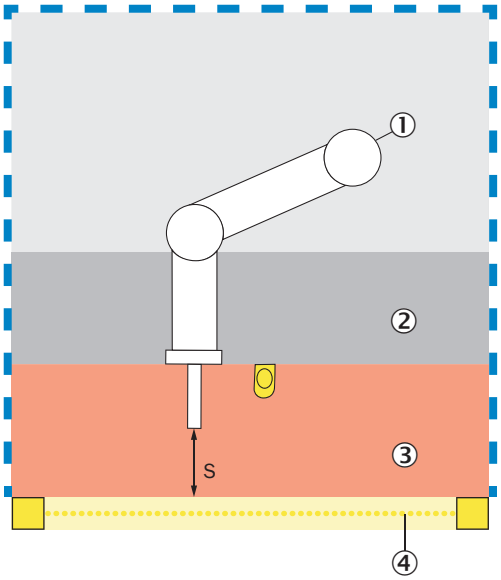
4.4.3 Calculating minimum distance

The minimum distance of the primary protective device to the hazardous area must be calculated in accordance with ISO 13855. 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 ($t_{SafetySystem}$)
  - Robot stopping time (t_{Robot})
- Supplements to protective field
  - Supplement to prevent reaching over (C_{RO}) or reaching through (C_{RT})

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



① Robot arm
② Human and robot interaction area
③ Protective field of secondary protective device (safety laser scanner)
④ Protective field of primary protective device (e.g. safety light curtain)

The safe minimum distance S is determined using the following formula:

$S = (K \times T) + C$

Table 9: Variables in the calculation

Formula symbols	Meaning
S	Minimum distance to hazardous area
K	Approach speed of the body or parts of the body (2,000 mm/s according to ISO 13855)
T	Stopping time of the entire machine in seconds
$t_{SafetySystem}$	Response time of safety system
t_{Robot}	Robot stopping time
C	Entry distance, C is the larger value of C_{RO} (reaching over) and C_{RT} (reaching through)
$t_{SafetyController}$	Safety controller response time
t_{Relay}	Response time of the interface or the relay

NOTE
It is also possible to use other primary protective devices than the stated deTec4 Core and deTem4 Core devices. Calculation on the minimum distance must take place in accordance with ISO 13855 and the risk assessment. The documentation (SISTEMA, block diagrams, etc) must be adapted accordingly by the manufacturer.

Response time

The response time of the safety system ($t_{SafetySystem}$) comprises the following times:

- Response time of the primary protective device ($t_{PrimaryProtDev}$)
- Response time of the safety controller ($t_{SafetyController}$)
- Response time of the interface or relays (t_{Relay})

$t_{SafetySystem} = t_{PrimaryProtDev} + t_{SafetyController} + t_{Relay}$

The robot stopping time (t_{Robot}) comprises the following times:

- Robot controller response time
- Stopping/run-down time of robot arm including tool and work piece

Further topics

- "Minimum distance with deTec4 Core", page 28
- "Minimum distance with deTem4 Core", page 29
- "Response time", page 51

4.4.3.1 Minimum distance with deTec4 Core

If the primary protective device deTec4 Core is used in the safety system, the minimum distance is calculated in accordance with the following formula:

$S = K \times T + C$

$S = K \times (t_{SafetySystem} + t_{Robot}) + C$

$S = K \times (t_{PrimaryProtDev} + t_{SafetyController} + t_{Relay} + t_{Robot}) + C$

Formula symbols	Meaning
S	Minimum distance to hazardous area
K	Approach speed of the body or parts of the body (2,000 mm/s according to ISO 13855)
T	Stopping time of the entire machine in seconds $T = t_{SafetySystem} + t_{Robot}$
C	Entry distance, C is the larger value of C_{RO} (reaching over) and C_{RT} (reaching through)
$t_{SafetySystem}$	Response time of safety system
t_{Robot}	Robot stopping time
$t_{PrimaryProtDev}$	Response time of the primary protective device
$t_{SafetyController}$	Safety controller response time
t_{Relay}	Response time of the interface or the relay

NOTE

If the value for S exceeds 500 mm, K = 1,600 mm/s can be used (see ISO 13855). In this case, the value of S must be at least 500 mm.

NOTE

The stopping time of the robot depends on the inputs used on the robot controller and corresponding stop category (stop category 0, 1 or 2).

C is the larger value of C_{RT} (reaching through) or C_{RO} (reaching over).

$C_{RT} = 8 \times (d - 14) \rightarrow$ but not less than 0

For the primary protective device deTec4 Core with a resolution d of 30 mm, C_{RT} is calculated as follows:

C_{RT} = 8 × (d - 14)
= 8 × (30 mm - 14)
= 128 mm

C_{RO} depends on the height of the protective field of the primary protective device and on the height of the hazardous area. The values must be determined by means of ISO 13855, Chapter 6.5.1, Table 1.

NOTE
The primary protective device deTec4 Core is available in two variants with protective field heights of 1,500 mm and 1,200 mm. The different values must be taken into account in the calculation of the supplement for reaching over and reaching under.

The height of the protective field of the primary protective device deTec4 Core is 1,200 mm or 1,500 mm, depending on variant. The upper edge of the protective field therefore depends on the mounting height of the primary protective device.

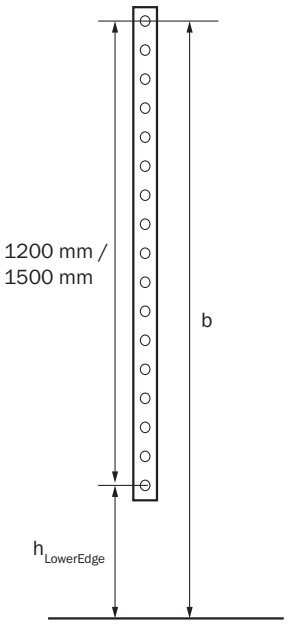


Figure 7: Protective field of primary protective device

Calculation for protective field height 1,200 mm	Calculation for protective field height 1,500 mm
b = 1,200 mm + $h_{LowerEdge}$	b = 1,500 mm + $h_{LowerEdge}$

Formula symbols	Meaning
b	Height of the upper edge of the protective field
$h_{LowerEdge}$	Height of the lower edge of the protective field

4.4.3.2 Minimum distance with deTem4 Core

If the primary protective device deTem4 Core is used in the safety system, the minimum distance is calculated in accordance with the following formula:

S = K × T + C

S = K × ($t_{SafetySystem}$ + t_{Robot}) + C

$S = K \times (t_{PrimaryProtDev} + t_{SafetyController} + t_{Relay} + t_{Robot}) + C$

Formula symbols	Meaning
S	Minimum distance to hazardous area
K	Approach speed of the body or parts of the body (2,000 mm/s according to ISO 13855)
T	Stopping time of the entire machine
C	Entry distance, C is the larger value of C_{RO} (reaching over) and C_{RT} (reaching through)
$t_{SafetySystem}$	Response time of safety system
t_{Robot}	Robot stopping time
$t_{PrimaryProtDev}$	Response time of the primary protective device
$t_{SafetyController}$	Safety controller response time
t_{Relay}	Response time of the interface or the relay

NOTE

The stopping time of the robot depends on the inputs used on the robot controller and corresponding stop category (stop category 0, 1 or 2).

C is the larger value of C_{RT} (reaching through) or C_{RO} (reaching over).

For the primary protective device deTem4 Core with a resolution d of 300 mm, the standard sensing range of an arm is assumed for C_{RT}:

C_{RT} = 850 mm

C_{RO} depends on the height of the protective field of the primary protective device and on the height of the hazardous area. The values must be determined by means of ISO 13855, Chapter 6.5.1, Table 1.

The height of the protective field of the primary protective device deTem4 Core is 900 mm. The upper edge of the protective field therefore depends on the mounting height of the primary protective device.

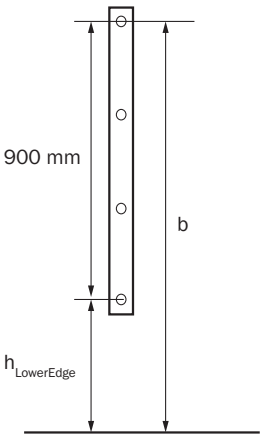


Figure 8: Protective field of primary protective device

$b = 900\ mm + h_{LowerEdge}$

Formula symbols	Meaning
b	Height of the upper edge of the protective field
$h_{LowerEdge}$	Height of the lower edge of the protective field

4.4.4 Emergency stop pushbutton

At least one emergency stop pushbutton must be installed outside the monitored area.

If the automated restart is used, a further emergency stop pushbutton must be installed close to the robot.

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

For additional information, see see "Emergency stop pushbutton requirements", page 21.

4.4.5 Reset pushbutton

The reset pushbutton must be located outside the hazardous area and outside the protective fields of the primary protective device of the safety laser scanner.

For additional information, see see "Reset pushbutton requirements", page 22.

4.5 Electrical layout

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.

The safety system can be connected to the most common industrial robots with two normally open contacts in the safety relay.

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

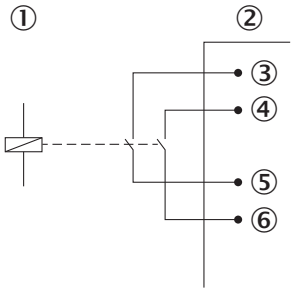


Figure 9: Circuitry with test pulse outputs

① Safety relay
② Robot controller
③ Test pulse output A
④ Test pulse output B
⑤ Safe input A
⑥ Safe input B

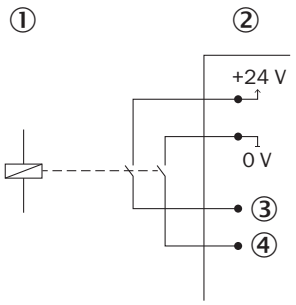


Figure 10: Circuitry with complementary safety capable inputs

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

NOTE
For the voltage supply (especially with separate power supply units), observe the notes in the Flexi Classic operating instructions.

4.5.1 Circuit diagrams

4.5.1.1 Circuit diagram for manual reset

In order to configure the logic for the safety system, this must be set with the rotary switch of the Flexi Classic safety controller.

Program 7 must be selected on the UE410-MU.

The outputs Q3 and Q4 switch depending on the status of the used safety laser scanner and primary protective device.

The normally open contacts of the relays at Q3 and Q4 must have a dual-channel connection to the protective stop input in the robot controller.

For EDM, the normally closed contacts must be connected in series with the reset pushbutton on S2.

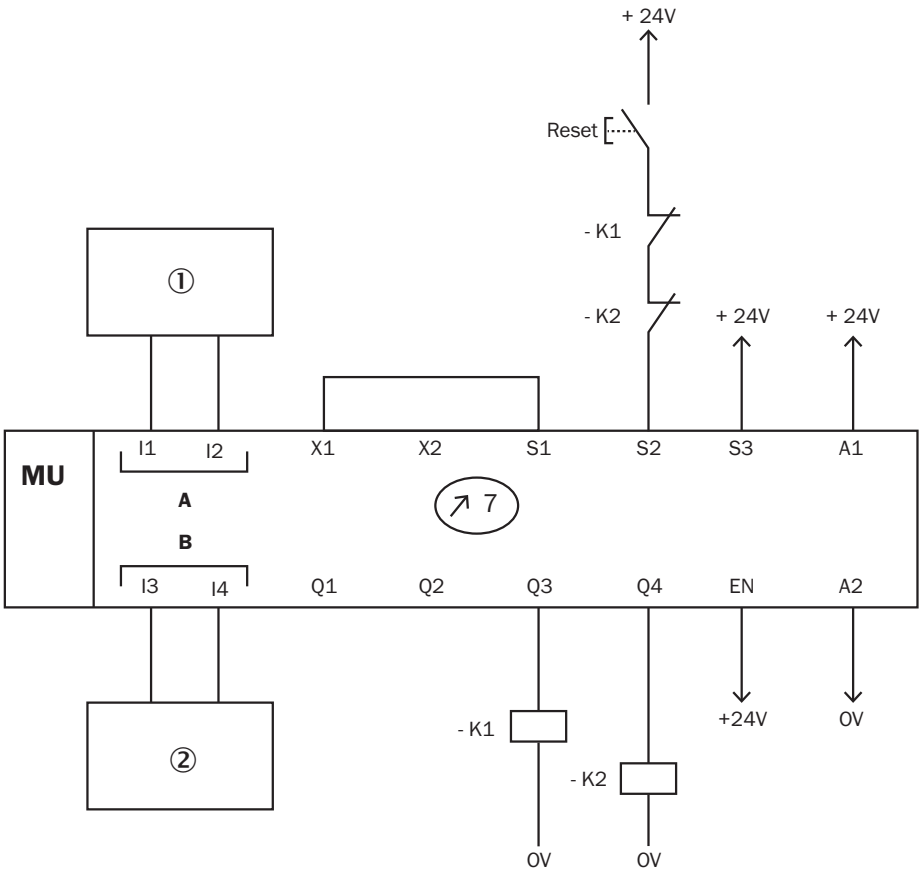


Figure 11: Circuit diagram for manual reset

① OSSDs of primary protective device (e.g. safety light curtain)

② OSSDs of safety laser scanner

If the protective field of the primary protective device or of the safety laser scanner is interrupted, Q3 and Q4 of UE410-MU are LOW. In order for a reset to take place, the protective fields of the primary protective device and safety laser scanner must be clear.

After a reset has been performed, Q3 and Q4 are in HIGH status (24 V DC).

4.5.1.2 Circuit diagram for manual reset with UE410-2RO

A more detailed description is provided by the supplied circuit diagram (PDF).

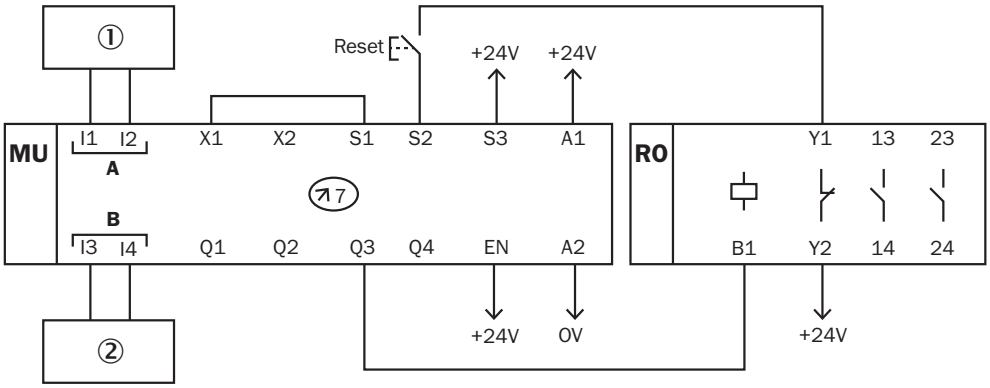


Figure 12: Circuit diagram for manual reset with UE410-2RO

① OSSDs of primary protective device (e.g. safety light curtain)

② OSSDs of safety laser scanner

4.5.1.3 Circuit diagram for automated reset

In order to configure the logic for the safety system, this must be set with the rotary switch of the Flexi Classic safety controller.

Program 8 must be selected on the UE410-MU.

Program 3 must be selected for channel A on the UE410-8DI and program 6 for channel B.

Q3 and Q4 switch depending on the status of the primary protective device and safety laser scanner used (channel B).

Q1 and Q2 switch depending on the status of the emergency stop pushbutton (channel A).

The normally open contacts of the relays at Q3 and Q4 must have a dual-channel connection to the protective stop input in the robot controller.

For automated reset and EDM, the normally closed contacts must be connected in series on S2.

The normally open contacts of the relays at Q1 and Q2 must have a dual-channel connection to the emergency stop input in the robot controller.

For manual reset and EDM, the normally closed contacts must be connected in series with the reset pushbutton on S1.

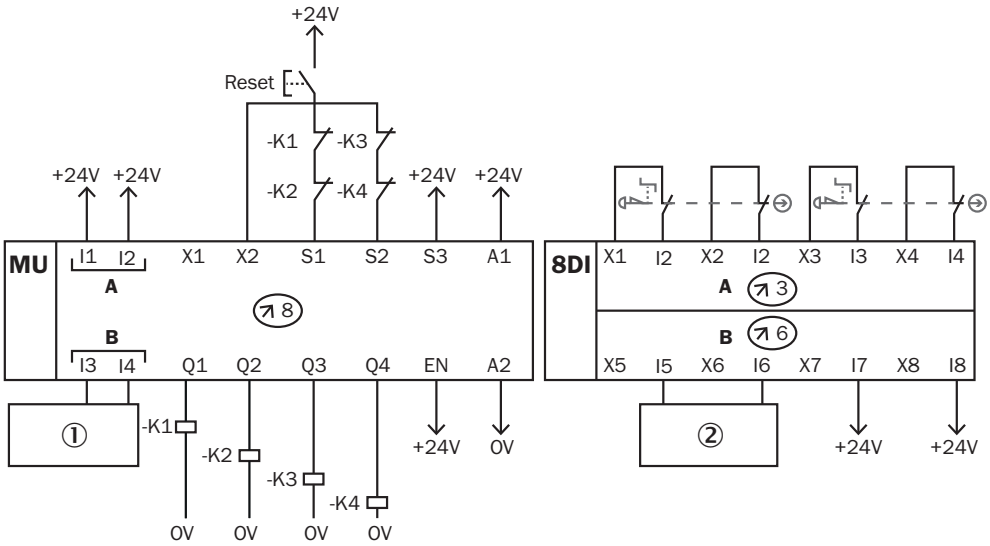


Figure 13: Circuit diagram for automated reset

① OSSDs of primary protective device (e.g. safety light curtain)

② OSSDs of safety laser scanner

4.5.1.4 Circuit diagram for automated reset with UE410-4RO

A more detailed description is provided by the supplied circuit diagram (PDF).

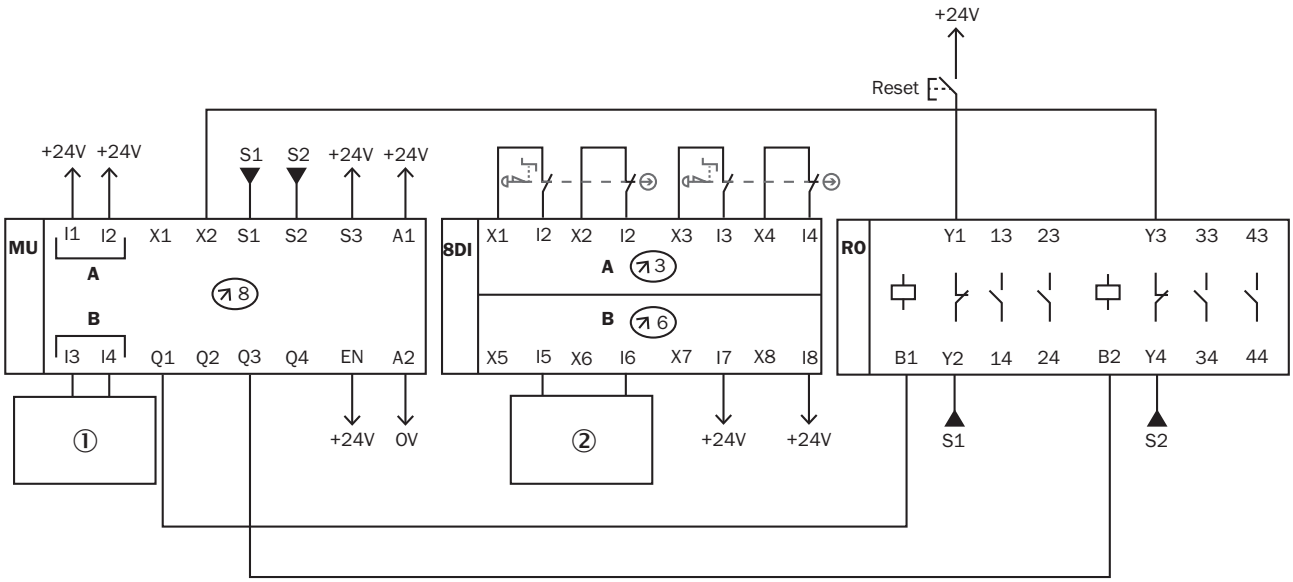


Figure 14: Circuit diagram for automated reset with UE410-4RO

① OSSDs of primary protective device (e.g. safety light curtain)

② OSSDs of safety laser scanner

4.5.1.5 Extension with second laser scanner

Only in conjunction with the variant with automated reset, the safety system can be extended by a second safety laser scanner. This may be necessary if the robot area to be monitored cannot be monitored with a single safety laser scanner.

DANGER

Failure to observe manufacturer obligations

This adaptation is **not** part of this safety system!

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

- ▶ Carry out the adaptation of the safety system described here only subject to own responsibility.
- ▶ Comply with all manufacturer obligations for development and implementation of a safety system.

NOTE

The manufacturer must adapt the documentation (circuit diagrams, SISTEMA) correspondingly if the safety system is extended with a second laser scanner.

The OSSDs of the second laser scanner can be connected to I7 and I8 of the UE410-8DI module. No other changes to the program or wiring are necessary.

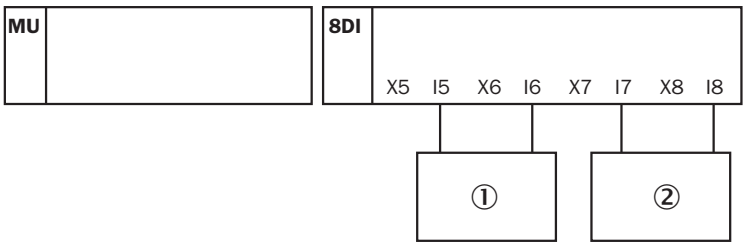


Figure 15: Circuit diagram for use of a second safety laser scanner

① OSSDs of safety laser scanner 1

② OSSDs of safety laser scanner 2

4.6 Testing plan

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

The regular thorough checks serve to ensure the effectiveness of the safety system and to identify defects as a result of changes or other influences (e.g., damage or manipulation).

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

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

Further chapters

- Thorough check, see "Commissioning", page 46
- Checklist for initial commissioning and commissioning, see "Annex", page 56
- Regular thorough check, see "Maintenance", page 48

5 Mounting

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

5.1 Mounting the safety laser scanner

The protective field of the safety laser scanner must be oriented horizontally and cover the complete area to be monitored up to the primary protective device.

There must be no gap between the protective field of the safety laser scanner and the protective field of the primary protective device.

The following safety laser scanners can be used for this safety system:

Table 10: Safety laser scanner characteristics

Safety laser scanner	Scanning range	Scanning angle
S300 Mini Standard	3 m	270°
microScan3 Core I/O	5.5 m	275°
S3000 Standard	5.5 m	190°

Safety laser scanner - recommended values

The following values apply to all three compatible safety laser scanners:

Table 11: Safety laser scanner - recommended values

Height of scan plane	300 mm
Resolution	70 mm

NOTE
If the height of the scan plane is less than 300 mm, then a resolution of 50 mm must be selected.

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

5.2 Mounting the primary protective device

The protective field of the primary protective device must be oriented vertically. There must be no gap between the protective field of the safety laser scanner and the protective field of the primary protective device.

The following primary protective devices can be used for this safety system:

Table 12: Primary protective device characteristics

Primary protective device	Resolution/beam separation	Protective field height
deTec4 Core	30 mm	1,500 mm
deTec4 Core	30 mm	1,200 mm
deTem4 Core	300 mm	900 mm

Table 13: Primary protective device - recommended value

Height of lowest light beam	300 mm

5.3 Mounting the Flexi Classic safety controller

Further mounting information can be found in the Flexi Classic operating instructions.

6 Electrical installation

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

6.1.1 Measures when using relays

External device monitoring (EDM) of the relays is necessary to achieve high diagnostic coverage. For this reason, the relays must have mechanically connected, positively guided contact elements.

This must be evaluated by the manufacturer or integrator. The number of switching cycles must also be evaluated by the manufacturer or integrator with respect to compliance with the safety requirements.

6.2 Safety controller pin assignment

Manual reset

Table 14: UE410-MU4T0 main module inputs

Connection	Function
I1	OSSDs of primary protective device (e.g. safety light curtain)
I2	OSSDs of primary protective device (e.g. safety light curtain)
I3	OSSDs of safety laser scanner
I4	OSSDs of safety laser scanner

Table 15: UE410-MU4T0 main module outputs

Connection	Function
Q1	Not used
Q2	Not used
Q3	Protective stop
Q4	Protective stop
X1	Test output, connected to S1
X2	Not used
EN	Enable, connected to +24 V DC
A1	Voltage supply +24 V DC
A2	Voltage supply 0 V DC
S1	Connected to X1

Connection	Function
S2	Manual reset and EDM
S3	Input, connected to +24 V DC

Automated reset

Table 16: UE410-MU4T0 main module inputs

Connection	Function
I1	Connected to +24 V DC
I2	Connected to +24 V DC
I3	Primary protective device (e.g. safety light curtain)
I4	Primary protective device (e.g. safety light curtain)

Table 17: UE410-MU4T0 main module outputs

Connection	Function
Q1	Emergency stop
Q2	Emergency stop
Q3	Protective stop
Q4	Protective stop
X1	Not used
X2	Test output, EDM
EN	Enable, connected to +24 V DC
A1	Voltage supply +24 V DC
A2	Voltage supply 0 V DC
S1	Reset, EDM, emergency stop
S2	Automated reset, EDM, protective stop
S3	Connected to +24 V DC

Table 18: UE410-8DI4 module inputs

Connection	Function
I1	Emergency stop 1
I2	Emergency stop 2
I3	Emergency stop 3
I4	Emergency stop 4
I5	OSSDs of safety laser scanner
I6	OSSDs of safety laser scanner
I7	Not used, connected to +24 V DC
I8	Not used, connected to +24 V DC

Table 19: UE410-8DI4 module outputs

Connection	Function
X1	Emergency stop test pulses 1
X2	Emergency stop test pulses 1
X3	Emergency stop test pulses 2
X4	Emergency stop test pulses 2
X5	Not used
X6	Not used

Connection	Function
X7	Not used
X8	Not used

6.3 Pin assignment of the individual components

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

7 Configuration

Configuration of the safety controller

The safety controller is configured by means of a rotary switch on the main module.

For further information on configuration and start sequence, see "Configuring the Flexi Classic safety controller", page 41 and see operating instructions for the Flexi Classic safety controller.

Configuring the safety laser scanners

Depending on model, the safety laser scanners are configured using the Safety Designer software or the CDS (Configuration & Diagnostic Software). For further information on configuration, see "Configuring the safety laser scanner", page 42 and see operating instructions of the respective safety laser scanner.

Safety laser scanner	Configuration software
S300 Mini Standard	CDS (Configuration & Diagnostic Software)
microScan3 Core I/O	Safety Designer
S3000 Standard	CDS (Configuration & Diagnostic Software)

7.1 Requirements for software and firmware

Configuration of the safety laser scanner in this safety system requires at least the following versions of the software or firmware:

Table 20: Minimum versions

Software and firmware	Minimum version
Safety Designer	1.2
CDS (Configuration & Diagnostic Software)	3.7.2

The software can be downloaded at www.sick.com.

7.2 Additional configuration required

7.2.1 Configuring the Flexi Classic safety controller

The Flexi Classic safety controller is configured by means of a rotary switch. A screwdriver is required for this.

CAUTION
If a change is made to the configuration, the protective device must be checked to ensure that it is effective. For this purpose, the test instructions in the operating instructions of the respective component must be observed.

1. Switch off the voltage supply at all main modules (terminals A1 and A2).
2. Using a screwdriver, set the desired switch settings (programs and functions) at the rotary switches on all modules.
3. Set the control functions through external wiring of terminals S1, S2 and S3 on all modules.
4. Switch on the voltage supply of all modules while pressing the Enter pushbutton of the main module.

NOTICE
Do not press any of the connected reset pushbuttons when doing this.

5. When the ERR display starts to flash, release the Enter pushbutton again within 3 seconds.

✓ The selected operating mode is stored as a non-volatile setting and is active.

NOTE

If the Enter pushbutton is pressed for longer than 3 seconds, the entire system will change to error status. The ERR display flashes.

All subsequent changes to the wiring at S1, S2 or S3 will lead to lock-out (ERR).

7.2.2 Configuring the safety laser scanner

NOTE

A protective field must be configured in the safety laser scanner which acts on the OSSDs connected to the Flexi Classic safety controller.

7.2.2.1 Configuring the S300 Mini Standard

The S300 Mini Standard is configured with the CDS (Configuration & Diagnostic Software).

For configuration, refer to the S300 Mini Standard operating instructions.

NOTE

The resolution must be set in accordance with the risk assessment and the height of the scan plane. For recommended values, see "Mounting the safety laser scanner", page 37.

NOTE

The height of the scan plane must be checked, see "Mounting the safety laser scanner", page 37.

Configuring the protective field

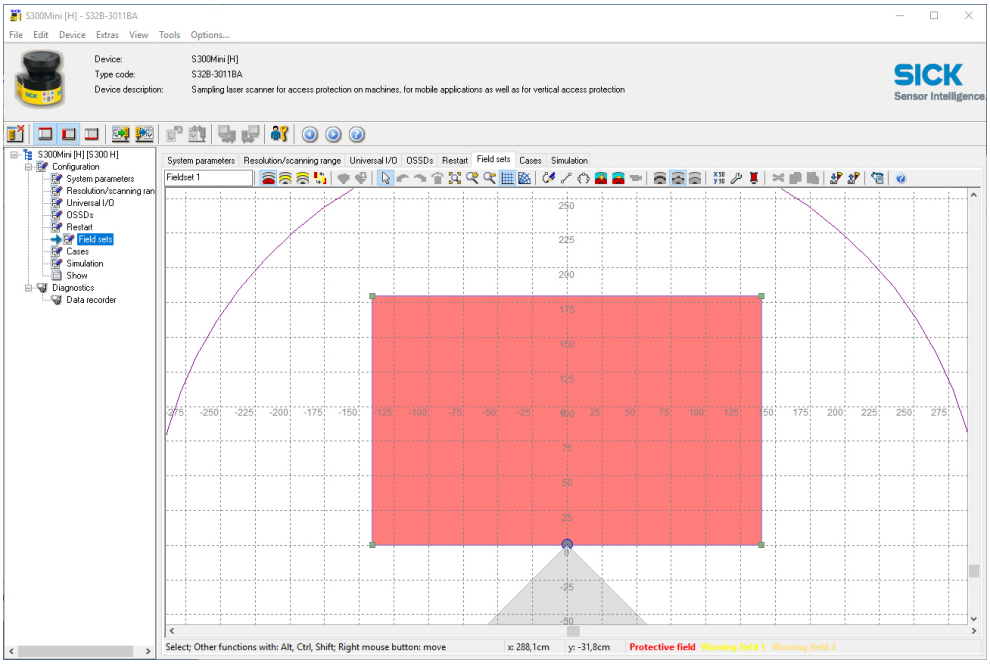


Figure 16: S300 Mini Standard configuration view (example)

CAUTION
The configuration shown here is for example purposes only! The protective field must be matched to the application according to the risk assessment.

7.2.2.2 Configuring microScan3 Core I/O

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

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

The application variant must be set to stationary.

NOTE
The resolution must be set in accordance with the risk assessment and the height of the scan plane. For recommended values, see "Mounting the safety laser scanner", page 37.

NOTE
The height of the scan plane must be checked, see "Mounting the safety laser scanner", page 37.

Configuring the protective field

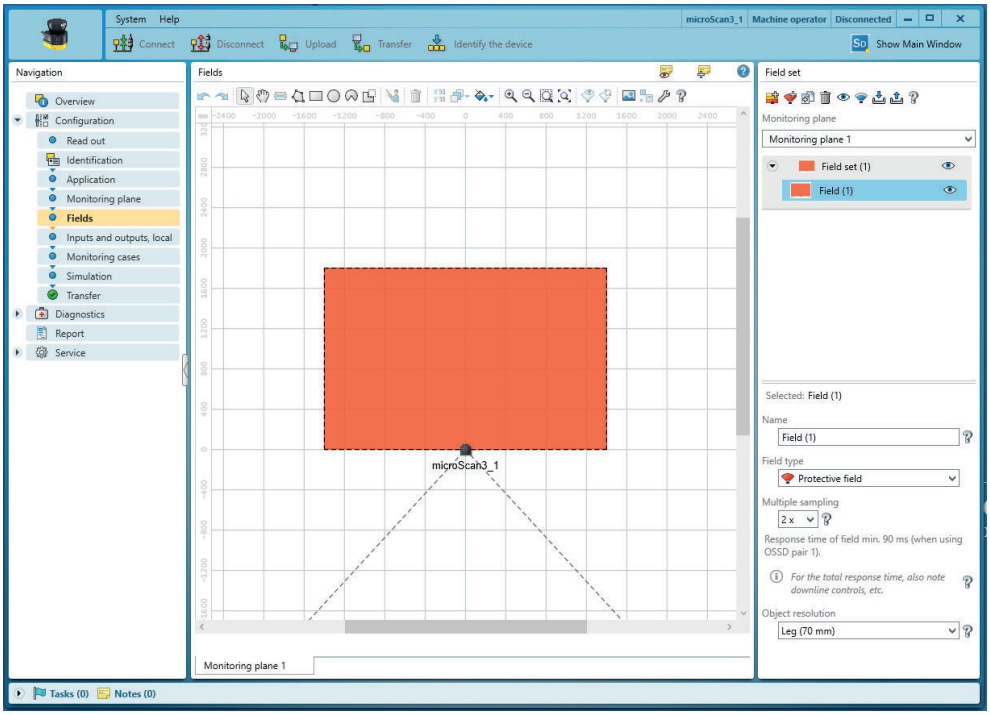


Figure 17: microScan3 Core I/O configuration view (example)

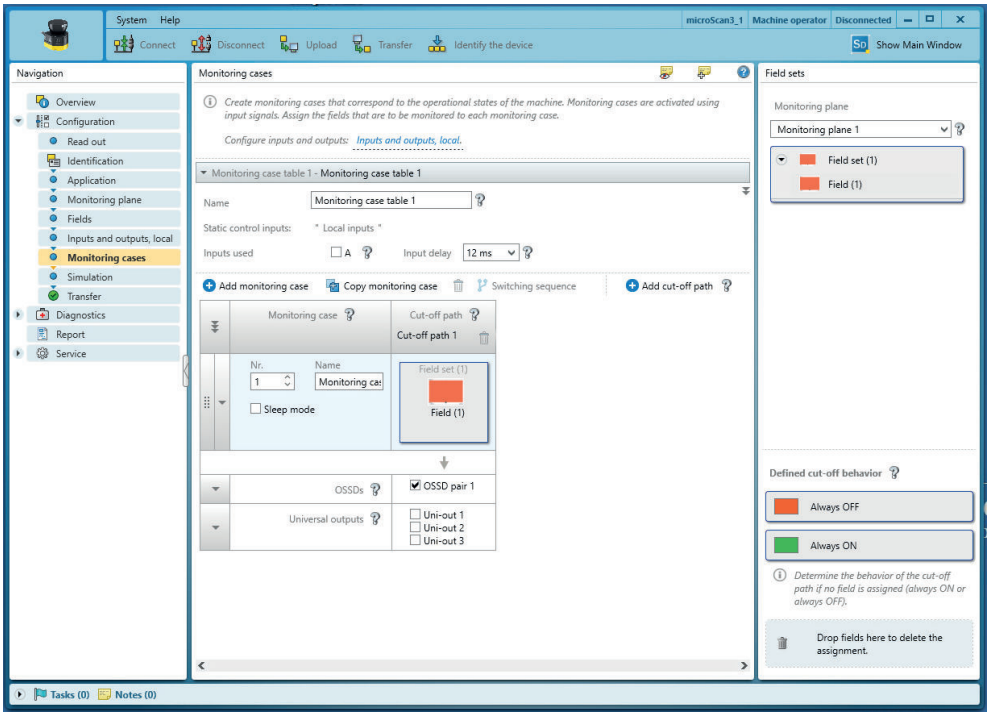


Figure 18: microScan3 Core I/O configuration view (example)

CAUTION
The configuration shown here is for example purposes only! The protective field must be matched to the application according to the risk assessment.

7.2.2.3 Configuring the S3000 Standard

The S3000 Standard is configured with the CDS (Configuration & Diagnostic Software).

For configuration, refer to the S3000 Standard operating instructions.

The application variant must be set to stationary.

NOTE
The resolution must be set in accordance with the risk assessment and the height of the scan plane. For recommended values, see "Mounting the safety laser scanner", page 37.

NOTE
The height of the scan plane must be checked, see "Mounting the safety laser scanner", page 37.

Configuring the protective field

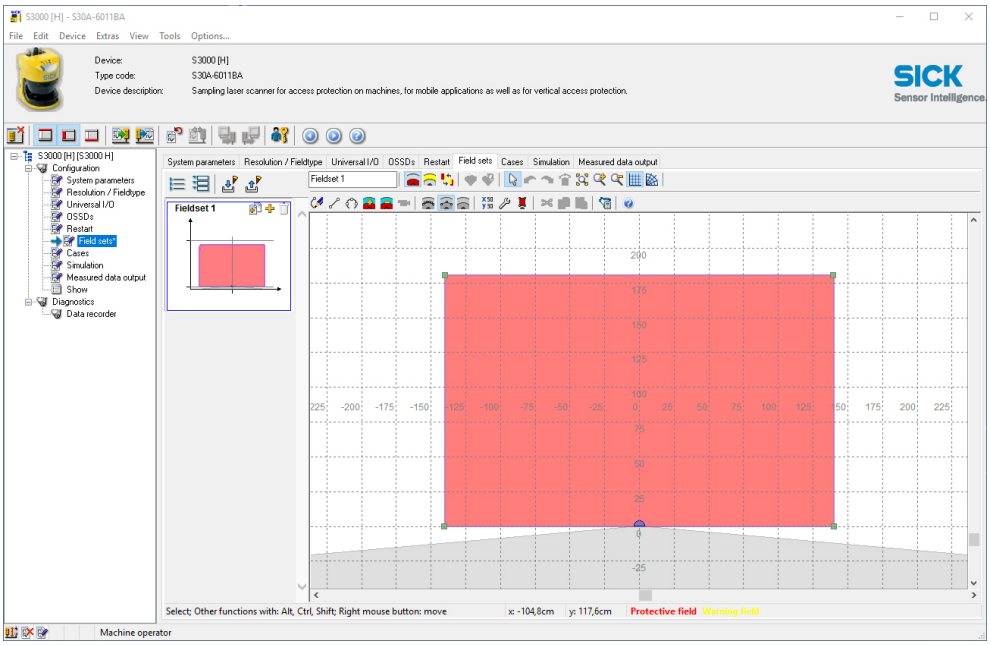


Figure 19: S3000 Standard configuration view (example)

CAUTION

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

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 56).
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 Operation

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

9.1 Start sequence after start-up

1. Make sure that the protective field of the primary protective device and the protective field of the safety laser scanner are clear.
2. Press the reset pushbutton.

✓ The robot can start.

10 Maintenance

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

Primary protective device

Information on regular thorough checks of the primary protective device can be found in the operating instructions of the primary protective device.

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.

Flexi Classic safety controller

Information on regular thorough checks of the Flexi Classic safety controller can be found in the operating instructions of the safety controller.

The safety controller must be switched off and then back on again at least once a year.

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.

12 Technical data

12.1 Data sheet

Table 21: Data sheet for the safety system

Performance level	PL d (ISO 13849-1)
Supply voltage V_S	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
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 time

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

- Response time of the primary protective device ($t_{PrimaryProtDev}$)
- Response time of the logic ($t_{SafetyController}$)
- Response time of the relay(s) (t_{Relay})

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

$t_{SafetySystem} = t_{PrimaryProtDev} + t_{SafetyController} + t_{Relay}$

Response time of components

Table 22: Overview of component response times

Components	Part number	Response time
Primary protective device		
deTec4 (resolution 30 mm, length 1,500 mm)	1211506	13 ms
deTec4 (resolution 30 mm, length 1,200 mm)	1211502	12 ms
deTem4 (4 beams, distance between beams 300 mm)	1082692	20 ms
Logic		
Flexi Classic main module UE410-MU4T0 (program 7 or 8)	6035243	13 ms
Relay		
UE410-2RO4	6032677	30 ms
UE410-4RO4	6032676	30 ms

NOTE

If relays other than those stated above are used, the response time of the relays used must be taken into account.

13 Ordering information

13.1 Scope of delivery

The scope of delivery of the safety system includes the following components:

- 1 x safety laser scanner in the chosen variant
- 1 x primary protective device in the chosen variant
- 1 x Flexi Classic safety controller main module
- Additionally for version with automated reset:
  1 x input expansion module 8DI
- 1 x mountings for primary protective device

13.2 Ordering information

Table 23: Orderable variants

		Primary protective device			Safety laser scanner			Flexi Classic modules	
	Part no.	**deTec4 Core 1,500 mm**	**deTec4 Core 1,200 mm**	**deTem4 Core**	**microScan3 Core I/O**	**S300 Mini Standard**	**S3000 Standard**	**UE410-MU**	**UE410-8DI**
Automated reset	1097907	x				x		x	x
	1097908			x		x		x	x
	1097909	x			x			x	x
	1097911			x	x			x	x
Manual reset	1097902	x				x		x	
	1097904			x		x		x	
	1097905	x			x			x	
	1097906			x	x			x	
	1098639		x		x			x	
	1098640	x					x	x	
	1098641		x				x	x	

14 Spare parts

Safety laser scanner

Table 24: Ordering information for safety laser scanner

Spare part	Type code	Part number
S300 Mini Standard	S32B-3011BA	1056430
microScan3 Core I/O	MICS3-AAAZ55AZ1P01	1075843
S3000 Standard	S30A-6011BA	1023546

Primary protective device

Table 25: Ordering information for primary protective device

Spare part	Type code	Part number
deTec4 Core, 1,500 mm length (sender)	C4C-SA15030A10000	1211505
deTec4 Core, 1,500 mm length (receiver)	C4C-EA15030A10000	1211506
deTec4 Core, 1,200 mm length (sender)	C4C-SA12030A10000	1211501
deTec4 Core, 1,200 mm length (receiver)	C4C-EA12030A10000	1211502
deTem4 Core (sender)	M4C-SA0430LA10	1082690
deTem4 Core (receiver)	M4C-EA04300A10	1082692

Safety controller

Table 26: Ordering information

Num-ber	Name	Description	Part number
1	UE410-MU4T0	Flexi Classic main module UE410-MU	6035243
1	UE410-8DI4	Flexi Classic I/O module UE410-8DI	6032675
Optional			
1	UE410-2RO4[1)]	Relay module	6032677
1	UE410-4RO4[1)]	Relay module	6032676

1) Relay modules are not included with delivery as standard.

15 Accessories

15.1 Connectivity

S300 Mini Standard

Table 27: Connecting cable ordering information

Part	Part number
Straight female cable connector M12, 8-pin, 5 m	2076541
Straight female cable connector M12, 8-pin, 10 m	2076543
Straight female cable connector M12, 8-pin, 15 m	2076544
Configuration cable: male connector, M8, 4-pin, USB-A, straight, 2 m cable	6034574

microScan3 Core I/O

Table 28: Connecting cable ordering information

Part	Part number
Female connector (straight), M12, 8-pin, 5 m cable, flying leads	2079315
Female connector (straight), M12, 8-pin, 10 m cable, flying leads	2079316
Configuration cable: USB mini-B male connector, 3 m cable, USB A male connector	6042517

S3000 Standard

Table 29: Connecting cable ordering information

Part	Part number
System plug: pre-assembled, 5 m cable length, 9 wires, rear cable outlet, one M20 cable gland and one M12 dummy plug	2049222
System plug: pre-assembled, 10 m cable length, 9 wires, one M20 cable gland and one M12 dummy plug	2027171
System plug: pre-assembled, 20 m cable length, 9 wires, one M20 cable gland and one M12 dummy plug	2027814
Configuration cable: male connector, M8, 4-pin, USB-A, straight, 2 m	6034574

deTec4 Core and deTem4 Core

NOTE
Two cables per pair of a primary protective device are required.

Table 30: Connecting cable ordering information

Part	Type code	Part number
Straight cable, M12, 5-pin, 10 m, flying leads	YF2A15-100UB5XLEAX	2095619
Straight cable, M12, 5-pin, 5 m, flying leads	YF2A15-050UB5XLEAX	2095618
Straight cable, M12, 5-pin, 2 m, flying leads	YF2A15-020UB5XLEAX	2095617

15.2 Mounting bracket

S300 Mini Standard

Table 31: Mounting bracket ordering information

Part	Part number
Mounting bracket for rear mounting	2034325

microScan3 Core I/O

Table 32: Mounting bracket ordering information

Part	Part number
Mounting bracket with optics cover protection	2074242

S3000 Standard

Table 33: Mounting bracket ordering information

Part	Part number
Mounting bracket for rear mounting	2015624
Mounting bracket for direct rear mounting on wall or machine. No adjustment possibility	2015623

deTec4 Core and deTem4 Core

Mounting brackets for the primary protective devices are included in the scope of delivery of the safety system.

15.3 Emergency stop and reset pushbutton

Table 34: Emergency stop and reset pushbutton

Description	Type code	Part number
Emergency stop with reset pushbutton	ES11-SC4D8	6051329
Emergency stop pushbutton	ES21-SA10E1	6036147
Emergency stop pushbutton	ES21-SB10E1	6041507
Reset pushbutton	ER12-SB3C4	6051330

16 Annex

16.1 Checklist for initial commissioning and commissioning

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

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

Test for “Emergency stop” safety function

Table 35: 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.		

Tests for safety function “Preventing unexpected startup following an emergency stop”

Table 36: Tests for safety function “Preventing unexpected startup following an emergency stop”

Test sequence	Expected result	Result OK?
1. Press Emergency stop pushbutton. 2. Unlock the emergency stop push-button. 3. Initiate restart of the robot. 4. Check whether the emergency stop pushbutton is installed outside the monitored area. 5. Press the reset pushbutton. 6. Start the robot.	The robot starts only after the reset pushbutton is pressed.	Yes ☐ No ☐

Test for “Triggering a protective stop” safety function

Table 37: Tests for “Triggering a protective stop” safety function

Test sequence	Expected result	Result OK?
1. Make sure that the protective fields of the primary protective device and safety laser scanner are clear. 2. Start the robot. 3. Interrupt the protective field of the primary protective device. 4. Initiate a restart of the robot while the protective field of the safety laser scanner is interrupted. 5. Initiate a restart of the robot while the protective field of the primary protective device is interrupted. 6. For the variant with manual reset: check whether a manual reset can be performed while the protective field of the safety laser scanner is interrupted.	The movement of the robot stops and remains stopped as long as the protective field of the primary protective device or safety laser scanner is interrupted.	Yes ☐ No ☐

Test sequence	Expected result	Result OK?
Tools may be necessary to avoid hazardous situations.		

Thorough check of the protective fields

Table 38: Thorough check of the protective fields

Test sequence	Expected result	Result OK?
1. Check minimum distance between the primary protective device and hazardous area. 2. Check configuration of the safety laser scanner.	The protective field of the primary protective device is vertical. The minimum distance is observed in accordance with ISO 13855. The protective field of the safety laser scanner covers the complete area to be monitored up to the primary protective device. There is no gap between the protective field of the safety laser scanner and the protective field of the primary protective device.	Yes ☐ No ☐
Calculated minimum distance: Measured minimum distance:		

Test for mounting the safety laser scanner

Table 39: Test for mounting the safety laser scanner

Test sequence	Expected result	Result OK?
1. Thoroughly check the mounting of the safety laser scanner.	The safety laser scanner is mounted in such as way as to cover the entire area to be monitored up to the primary protective device. The safety laser scanner is configured in such as way as to cover the entire area to be monitored up to the primary protective device. 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 ☐
Measured height of the scan plane:		

Complete approval of the application

The application must be put into operation only if the complete approval was successful. The complete approval must be performed only be correspondingly trained expert personnel.

The following activities must be performed for a complete approval:

- Check that all the safety-related parts of the installation (cables, connected sensors and actuators, configuration settings) conform to the relevant safety standards (e.g. EN ISO 13849-1 or EN 62061).
- Check the devices connected to the safety controller according to the instructions in the respective operating instructions.
- Check that all connections on the safety controller are clearly and legibly labeled.
- Check all signal paths and make sure that they have been correctly integrated into the higher-level control.
- Check the logic program of the safety controller.

- Carry out a complete check of the safety functions of each system in every operating mode. Carry out fault simulation. Monitor the response times of the application.
- Document all configurations on the system, the connected devices and the safety check.

In addition, the requirements of the thorough check before initial commissioning of the components must be met:

- deTec4 Core (8014253)
- deTem4 Core (8020453)
- microScan3 Core I/O (8016346)
- S300 Mini Standard (8014170)
- S3000 Standard (8009791)

Emergency stop pushbutton test

Mechanical operational check

- The Emergency stop pushbutton is mounted so that it cannot be twisted.
- The mounting nut tightened so that no play is possible in the longitudinal direction.

Electrical operational check

1. Start the machine.
2. Actuate the emergency stop pushbutton.
3. Carry out a thorough check of the machine stop to make sure that the machine has come to a stop due to operation of the emergency stop pushbutton.

16.2 Requirements for automated 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 40: Checklist for the manufacturer

Requirements	
It is not possible to enter the hazardous area without interrupting the protective field of the primary protective device.	Yes ☐ No ☐
It is not possible to walk behind the protective field of the safety 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 primary protective device and the safety 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 manipulation.	Yes ☐ No ☐
Protective devices are secured against manipulation.	Yes ☐ No ☐
Protective devices are installed in such a way that it is not possible to stand behind them, bypass them or crawl 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	

Requirements	
An emergency stop pushbutton is installed in the hazardous area near the robot.	Yes ☐ No ☐
For the variant with automated reset: there is a warning sign attached with the pictogram and note “Warning, automated start-up” (according to ISO 7010-W018).	Yes ☐ No ☐

NOTE
This checklist was produced for this specific application and is not claimed to be complete. Further measures may be necessary based on the manufacturer’s risk assessment.

16.3 Overview of sensors and actuators

Table 41: Control

Logic (L)	Equipment ID	Device
Configurable	KF100	Safety controller

Table 42: Sensors and switches

Trigger (T)	Equipment ID	Device
Protective field	BG100	Primary protective device
Protective field	BG110	Safety laser scanner
Emergency stop	SF200	Emergency stop pushbutton
Emergency stop	SF210	Emergency stop pushbutton
Reset	SF300	Reset pushbutton
Restart	SF310	Manual input on robot, e.g. teach pendant

Table 43: Actuators

Reaction (R)	Equipment ID	Device
Switching	KF150	Relay
Protective stop	KF160	Robot controller, protective stop input
Switching	KF200	Relay
Emergency stop	KF210	Robot controller, emergency stop input

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