OPERATING INSTRUCTIONS

Safe AGV Forklift

Functional safety system

SICK
Sensor Intelligence.

Described product

Safe AGV Forklift

Manufacturer

SICK AG
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Germany

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 functional safety system. This document describes:

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

1.2 Scope

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

NOTICE

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

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

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

Table 1: Documents available for Safe AGV Forklift

Document type	Title	Part number
Operating instructions	S3000 Remote	8009791
Operating instructions	S300 Mini Remote	8014166
Operating instructions	IN3000 Direct	8014173
Operating instructions	Flexi Soft modular safety controller hardware	8012999
Operating instructions	Flexi Soft in the Flexi Soft Designer software	8012998
Operating instructions	DFS60S Pro	8016866

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

8021208

1.3 Target groups and structure of these operating instructions

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

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

1.4 Symbols and document conventions

The following symbols and conventions are used in this document:

Safety notes and other notes

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

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

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

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

NOTE
Indicates useful tips and recommendations.

Instructions to action

▶ The arrow denotes instructions to action.

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

✓ The check mark denotes the result of an instruction.

1.5 Further information

www.sick.com

The following information is available via the Internet:

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

2 Safety information

2.1 Intended use

The Safe AGV Forklift functional safety system is used on automated guided vehicles (AGVs) to which the all following features apply:

- AGVs with 3 wheels
- AGVs with a control system in which the steering angle affects the driven wheel
- AGVs that function as a manned forklift truck
- AGVs whose lifting fork is at the rear
- AGVs that do not transport people

Safe AGV Forklift is used to protect people.

2.2 Improper use

- AGVs in cases where the areas to the left and right of the vehicle need to be monitored.
- AGVs in cases where the process of loading the lifting fork needs to be monitored. Safe AGV Forklift only monitors the position of the lifting fork.

2.3 Requirements for the qualification of personnel

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

Project planning

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

Mechanical mounting, electrical installation, and commissioning

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

Operation and maintenance

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

2.4 Safe state

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

- Protective field interrupted
- AGV speed above maximum permitted speed
- Emergency stop pushbutton has been activated
- Connection between at least one sensor and the safety controller has been interrupted
- Voltage supply of at least one sensor or the SICK safety controller has been interrupted

- Internal error diagnosed on at least one sensor
- Internal error diagnosed on the safety controller or on one of its components

3 Product description

3.1 Product identification

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

3.2 Application description

The functional safety system is used on automated guided vehicles (AGVs) with lifting forks to reduce the risk of a collision between a vehicle and people.

The functional safety system is used to monitor the area in the AGV's direction of travel and, if necessary, brake the AGV or bring it to a complete stop in the event that a person or an object enters its path.

3.3 Components of the functional safety system

Safe AGV Forklift components

- DFS60S Pro safety encoder in different variants (see "Safe AGV Forklift ordering information", page 37)
- S300 Mini Remote safety laser scanner
- S3000 Remote safety laser scanner
- Flexi Soft safety controller, main module
- Flexi Soft safety controller, extension module – I/O module (8 inputs, 4 outputs)
- Flexi Soft safety controller, extension module – I/O module (8 inputs)
- Flexi Soft safety controller, extension module – motion control module (Flexi Soft Drive Monitor)
- Flexi Soft safety controller, system plug
- 3 × IN3000 Direct safety switches

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

3.4 The limits of the functional safety system

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

For further information about the interfaces, see "Electrical installation", page 23.

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

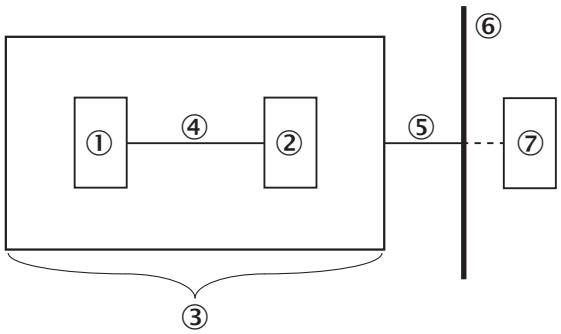


Figure 1: The limits of the functional safety system

① Sensors

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

3.5 Additional components required

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

- Drive contactor
- Brake contactor
- Emergency stop pushbutton
- Reset pushbutton
- Restart button

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

3.5.1 Emergency stop pushbutton

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

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

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

- ISO 13850
- IEC 60204

3.5.2 Reset pushbutton

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

- EN 60204

3.5.3 Restart button

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

- EN 60204

3.5.4 Contactor

The contactors must have positively guided contacts for external device monitoring (EDM).

3.6 Structure and function

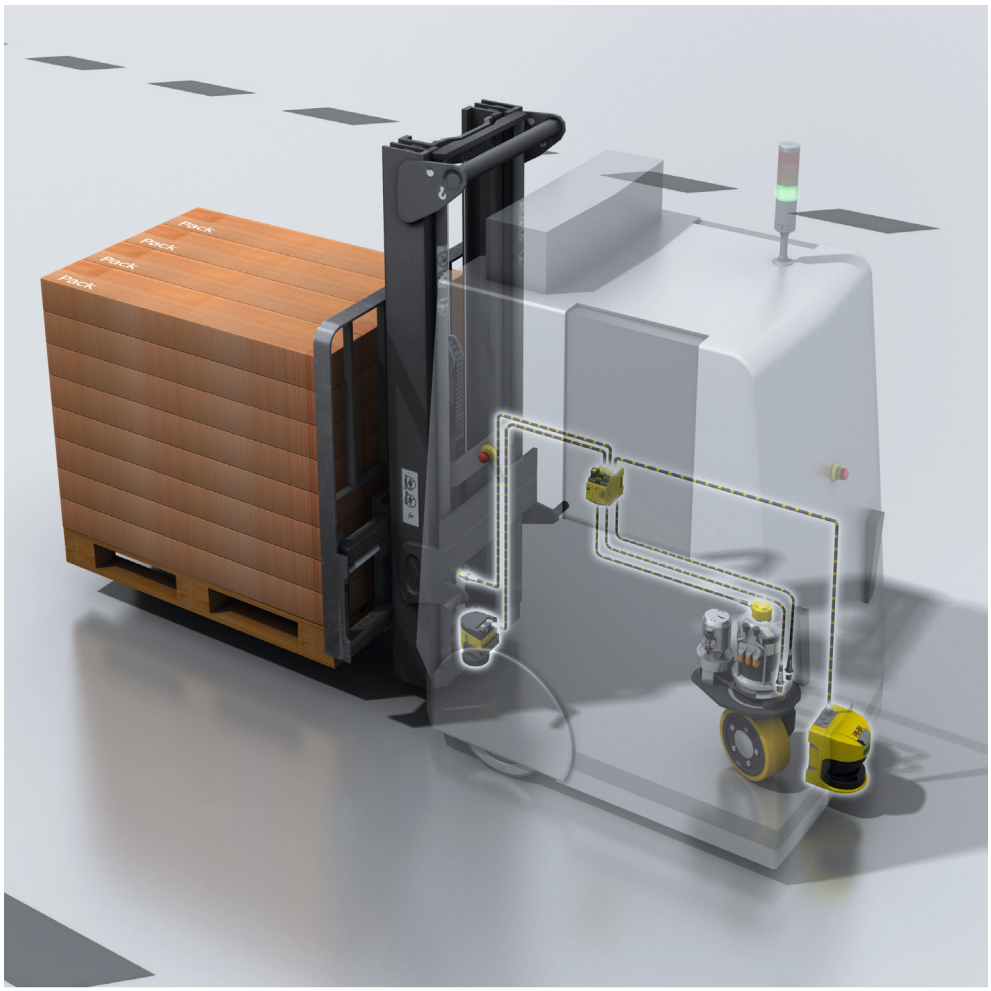
The safety laser scanners detect the area in front of and behind the AGV. The safety encoder detects the direction of travel and the speed of the AGV. 2 safety switches detect the steering angle of the AGV. Another safety switch detects the position of the lifting fork.

A range of different safety laser scanner field sets are monitored on the basis of the direction of travel, the speed, and the steering angle. Each field set consists of a warning field and a protective field. If a warning field is interrupted, the AGV reduces its speed. If a protective field is interrupted, the brake is triggered and the drive is isolated from the voltage supply (safe torque off (STO)).

Once the protective field is no longer being interrupted, the AGV waits for 2 seconds and then automatically continues traveling.

When the AGV is traveling backward (in the direction of the lifting fork), the rear-facing safety laser scanner can only monitor the direction of travel while the lifting fork is raised. It is not able to monitor this reliably while the lifting fork is lowered. For this reason, a safety switch is used to monitor the position of the lifting fork. When the lifting fork is lowered, the AGV's speed is limited to 0.3 m/s.

The system prevents the machine from restarting when it is switched off. It is only possible to put the AGV back into operation once it has been reset and the restart has been performed. An automated restart is only possible when a protective field is interrupted.



NOTE

The risk assessment may indicate that it is not necessary to take the steering angle into consideration. This may be the case if, for example, it is possible to select a protective field width that completely covers the hazardous area, even when the vehicle is taking curves. Situations such as this do not require safety switches to detect the steering angle.

If there is no need for safety switches to detect the steering angle, the logic in the safety controller must be modified to reflect this (see "Removing the curve signal", page 29). Otherwise, this document assumes that all safety switches are required.

3.7 Product characteristics

3.7.1 Variants

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

- Safety encoders in a range of variants for shafts with different mechanical designs (see "Safe AGV Forklift ordering information", page 37)

3.7.2 Field types

During operation, the safety laser scanner uses its laser beams continuously to check whether people or objects are present in one or more areas. The areas to be checked are called fields. A distinction is made between the following field types:

- Protective field
- Warning field

Protective field

The protective field protects the hazardous area of the AGV. If the protective field is interrupted, the contactors for the drive and brake are triggered.

Warning field

The warning field monitors larger areas than the protective field. If the warning field is interrupted, a signal is sent to the higher-level control system. This signal can then be used to reduce the speed of the AGV.

The warning field must not be used for safety-related tasks.

3.7.3 Field set

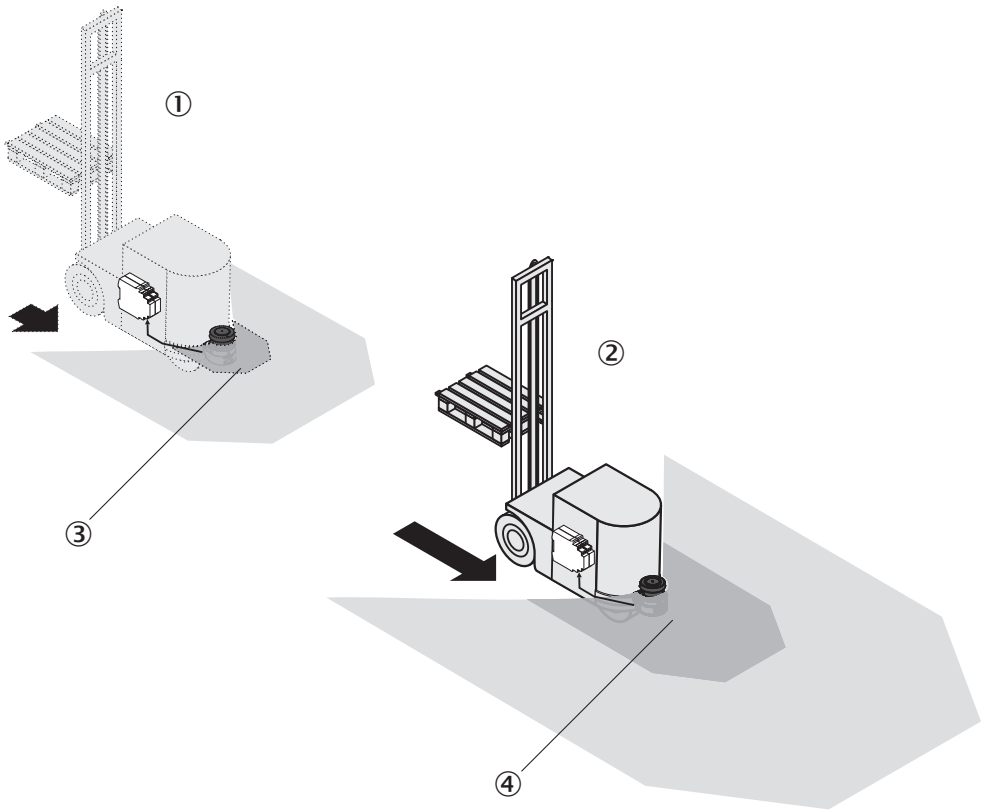
A field set consists of 2 fields. The fields in a field set are monitored simultaneously.

A field set consists of a protective field and a warning field.

3.7.4 Monitoring cases

There are a total of 9 monitoring cases; these are based on evaluations of the speed and steering angle. For each monitoring case, appropriate field sets are assigned to the safety laser scanners.

At a high speed, a field set with a large warning field and a large protective field is active. At a low speed, a field set with a small warning field and a small protective field is active.



① Monitoring case for low speeds
② Monitoring case for high speeds
③ Field set 1 with smaller protective and warning fields
④ Field set 2 with larger protective and warning fields

Table 2: Monitoring cases and field sets based on direction of travel and speed

Direction of travel	Speed	Monitoring case	Evaluated field sets
Forward, straight	Standstill or very slow	Standstill	Forward 1 Backward 1
	Slow	Forward Slow	Forward 2
	Medium	Forward Medium	Forward 3
	Fast	Forward Fast	Forward 4
Forward, right	Slow	Curve Right Slow	Curve right 1
	Fast	Curve Right Fast	Curve right 2
Forward, left	Slow	Curve Left Slow	Curve left 1
	Fast	Curve Left Fast	Curve left 2
Backward	Standstill or very slow	Standstill	Forward 1 Backward 1
	Fast	Backward	Backward 2

4 Project planning

4.1 Manufacturer of the machine

DANGER
Hazard due to lack of effectiveness of the protective device

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

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

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

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

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

The manufacturer has the following duties:

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

4.1.1 Calculation of the performance level

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

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

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

4.2 Operating entity of the machine

DANGER
Hazard due to lack of effectiveness of the protective device

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

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

4.3 Safety Functions

4.3.1 Preventing unexpected start-up

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

This safety function consists of the following sub-functions:

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

Table 3: Preventing unexpected start-up

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

Table 4: Expected frequency of safety function request

370 times per year	Valid reset sequence
Total	
370 times per year	Safety function request

4.3.2 Initiating a stop

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

This safety function consists of the following sub-functions:

- The dangerous state is monitored
- The devices connected via external device monitoring (EDM) are monitored

Initiating a stop during travel forward

Table 5: Initiating a stop

Trigger	Protective field interrupted by persons or objects
Condition	AGV travels forward, at least 1 curve signal is HIGH
Reaction	STO function is triggered. Brake is triggered.
Safe state	Standstill

Table 6: Expected frequency of safety function request during travel forward

15 times per day	Protective field interrupted by persons or objects
Total	
15 times per day	Safety function request

Initiating a stop during travel backward

Table 7: Initiating a stop

Trigger	Protective field interrupted by persons or objects
Condition	AGV is traveling backward, lifting fork is not lowered
Reaction	STO function is triggered. Brake is triggered.
Safe state	Standstill

Table 8: Expected frequency of safety function request during travel backward

5 times per day	Protective field interrupted by persons or objects
Total	
5 times per day	Safety function request

4.3.3 Monitoring machine parameters

In some operational statuses, it is necessary to monitor individual machine parameters for safety-related limits. If a limit is exceeded, suitable measures are initiated (e.g., stop).

This safety function consists of the following sub-functions:

- The dangerous state is monitored
- The devices connected via external device monitoring (EDM) are monitored

Table 9: Monitoring machine parameters

Trigger	Permitted speed limit exceeded
Condition	AGV is traveling backward and lifting fork is lowered
Reaction	STO function is triggered. Brake is triggered.
Safe state	Standstill

Table 10: Expected frequency of safety function request

4 times per year	Permitted speed limit exceeded
Total	
Reaction	Safety function request

4.3.4 Emergency stop

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

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

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

Table 11: Emergency stop

Trigger	Emergency stop pushbutton is actuated
Condition	At any time
Reaction	STO function is triggered. Brake is triggered.
Safe state	Standstill

Table 12: Expected frequency of safety function request during travel forward

1 time per year	Emergency stop pushbutton is actuated
Total	
1 time per year	Safety function request

4.4 Design

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

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

4.4.1 Safety switches

Safety switches for steering angle

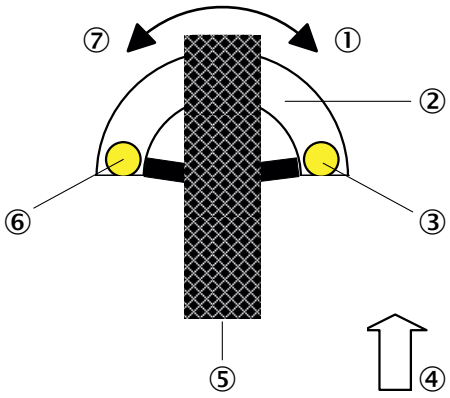


Figure 2: Detection of steering angle with 2 safety switches

① Right curve
② Actuating plate
③ Safety switch for steering angle to the left
④ Forward direction of travel
⑤ Steered wheel
⑥ Safety switch for steering angle to the right
⑦ Left curve

2 safety switches monitor the steering angle of the AGV. The safety switches are mounted in a fixed position on the AGV. An actuating plate that rotates about the steering axis together with the wheel being steered is mounted on the steering unit. When the actuating plate is in the enable zone of a safety switch, the safety switch is actuated. The design must ensure that actuation takes place as specified in the table below:

Table 13: Actuation of safety switches for steering angle

AGV steering angle	Safety switch for left curve actuated?	Safety switch for right curve actuated?
Left curve	No	Yes
Right curve	Yes	No
Straight	Yes	Yes
Rotated 180°	No	No

Safety switch for the lift height of the lifting fork

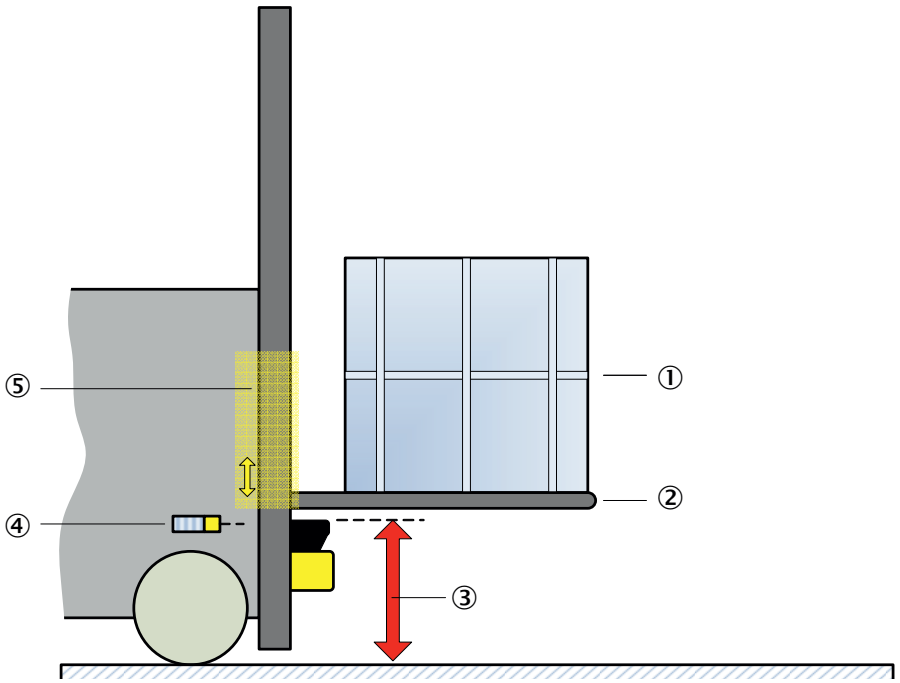


Figure 3: Detection of the lifting fork position with 1 safety switch

① Load
② Lifting fork
③ When the lifting fork is in this area, the safety switch must switch to the ON state.
④ Safety switch
⑤ Actuator, mechanically connected to fork

1 safety switch monitors the lift height of the AGV lifting fork. The safety switch is mounted in a fixed position on the AGV. An actuating plate that moves up and down together with the lifting fork is mounted on the lifting device. When the actuating plate is in the enable zone of the safety switch, the safety switch is actuated. The design must ensure that the safety switch is actuated as soon as the lifting fork is at the height of the safety laser scanner scan plane or lower.

All safety switches

- Safety switches must be connected with positive locking and friction fitting.
- The mechanics involved in this must be 1.5 times oversized.

4.4.2 Safety encoder

The safety encoder must be mounted on the driven axle of the AGV. If it is not possible to mount the safety encoder directly on the driven axle, mount it on a shaft that turns at a fixed transmission ratio in relation to the driven axle.

4.4.3 Emergency stop pushbutton

- An emergency stop pushbutton must be provided on every AGV. The emergency stop pushbutton must be positioned on the front of the AGV, in a place that is clearly visible and easy to reach.
- Multiple emergency stop pushbuttons may be required, depending on the size and type of the AGV. It must be possible to reach an emergency stop pushbutton from every direction.

4.5 Integrating the equipment into the electrical control

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

4.5.1 Circuit diagram

A detailed circuit diagram for Safe AGV Forklift is available online:

www.sick.com/Safe_AGV_Forklift

The Safe AGV Forklift components are connected to one another as shown in the diagram below:

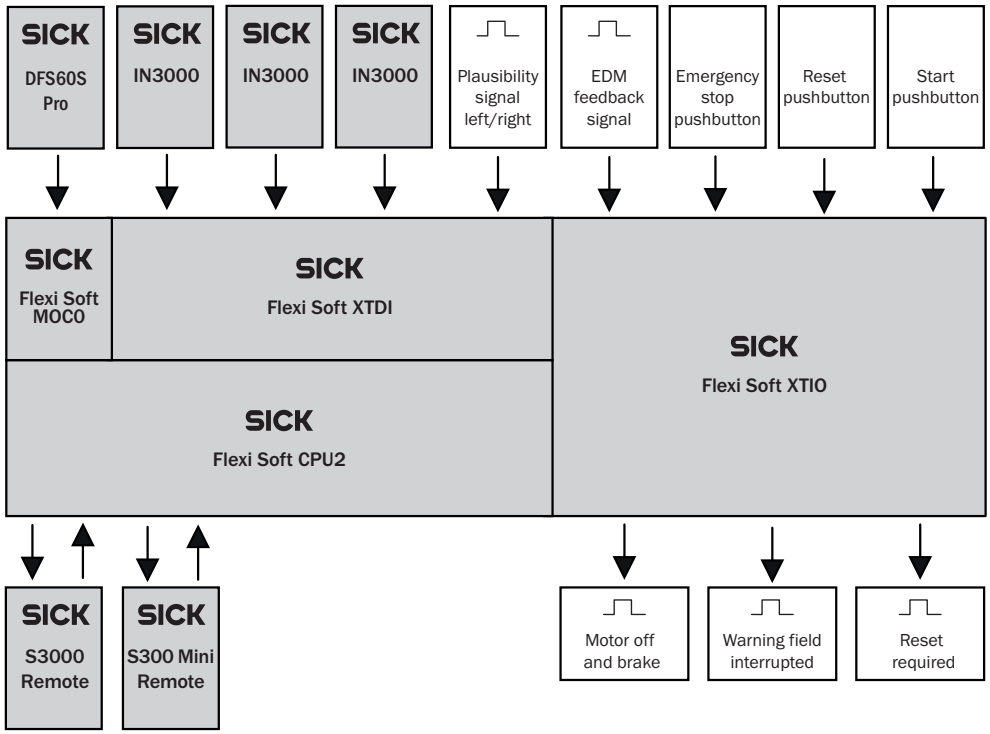


Figure 4: Safe AGV Forklift block diagram

Plausibility signal left/right	This signal determines the steering angle of the AGV
EDM Feedback	This signal determines whether the contactors have entered their safe state
Emergency stop pushbutton	The emergency stop pushbutton can be used to reset the machine to a safe state at any time
Reset pushbutton	The reset pushbutton resets the safety-related components
Start pushbutton	The restart button is used to restart the machine after a reset
Motor off and brake	This signal controls the drive in the ON state and triggers the brake in the OFF state
Warning field interrupted	Signals to the higher-level control system that the speed of the AGV needs to be reduced. The signal – for example, an acoustic signal – can also be used to indicate that a warning field is being interrupted.
Reset required	This signal – for example, an illuminated reset pushbutton – can be used to indicate that a reset is required
Items supplied with Safe AGV Forklift	The components with a gray background are included in the Safe AGV Forklift scope of delivery

For the detailed pin assignment of the safety controller, see "Safety controller pin assignment", page 23.

4.6 Testing plan

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

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

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

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

Further chapters

- Thorough check see "Commissioning", page 32
- Checklist for initial commissioning and commissioning see "Annex", page 41

5 Mounting

NOTE
All information is included in the operating instructions for the components.

6 Electrical installation

6.1 Safety controller pin assignment

Figure 5: Safety controller setup

Module 1	Main module FX3-CPU2
Module 2	Motion control module FX3-MOC0
Module 3	I/O module FX3-XTIO
Module 4	I/O module FX3-XTDI

Table 14: Interfaces on the limit of the functional safety system

Module and connection	Meaning	Function
Module 3, X1	Test output	Contact for connecting the external device monitoring (EDM input)
Module 3, X1 + X2	Test outputs	Contacts for connecting a dual-channel emergency stop pushbutton (emergency stop pushbutton inputs)
Module 3, I1 + I2	Emergency stop	Contacts for connecting a dual-channel emergency stop pushbutton (emergency stop pushbutton outputs)
Module 3, I3	Reset	Contact for connecting a reset pushbutton
Module 3, I4	Restart	Contact for connecting a restart button
Module 3, I5	External device monitoring (EDM)	Contact for connecting the external device monitoring (EDM output)
Module 3, Q1 + Q2	Drive and brake contactors	LOW signal level opens the drive and brake contactors. (STO and SBC)
Module 3, Q3	Warning field interrupted	LOW signal level when warning field is interrupted. The higher-level control system uses the signal to reduce the speed of the AGV.
Module 3, Q4	Reset required	A pulsating signal level (1 Hz) signals that a reset is required.

Module and connection	Meaning	Function
Module 4, I5	Right curve plausibility signal	The higher-level control system uses the LOW signal level to signal a right curve to the safety controller. With the signals of the safety switches also involved, the steering angle is detected in a range of ways.
Module 4, I6	Left curve plausibility signal	The higher-level control system uses the LOW signal level to signal a left curve to the safety controller. With the signals of the safety switches also involved, the steering angle is detected in a range of ways.

Table 15: Interfaces within the functional safety system

Module and connection	Meaning	Function
Module 1, A1	Voltage supply, 24 V	Contact for the voltage supply of the safety controller
Module 1, A2	Voltage supply, 0 V	Contact for the voltage supply of the safety controller
Module 1, EFI1 A + B	Safety laser scanner	Contacts for connecting the EFI system of the S3000 Remote and S300 Mini Remote safety laser scanners
Module 2, E1	Safety encoder	Plug connector for connecting the safety encoder
Module 3, A1	Voltage supply, 24 V	Contact for the voltage supply of the safety controller
Module 3, A2	Voltage supply, 0 V	Contact for the voltage supply of the safety controller
Module 4, I1 + I2	Right curve sensor	Contacts for connecting a dual-channel safety switch for detecting a steering angle to the right
Module 4, I3 + I4	Left curve sensor	Contacts for connecting a dual-channel safety switch for detecting a steering angle to the left
Module 4, I7 + I8	Lifting fork sensor	Contacts for connecting a dual-channel safety switch for detecting the position of the lifting fork

6.2 Further connections of the individual components

NOTE
All information is included in the operating instructions for the components.

7 Configuration

Overview of configuration

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

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

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

NOTE

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

7.1 Requirements on software and firmware

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

Table 16: Minimum versions

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

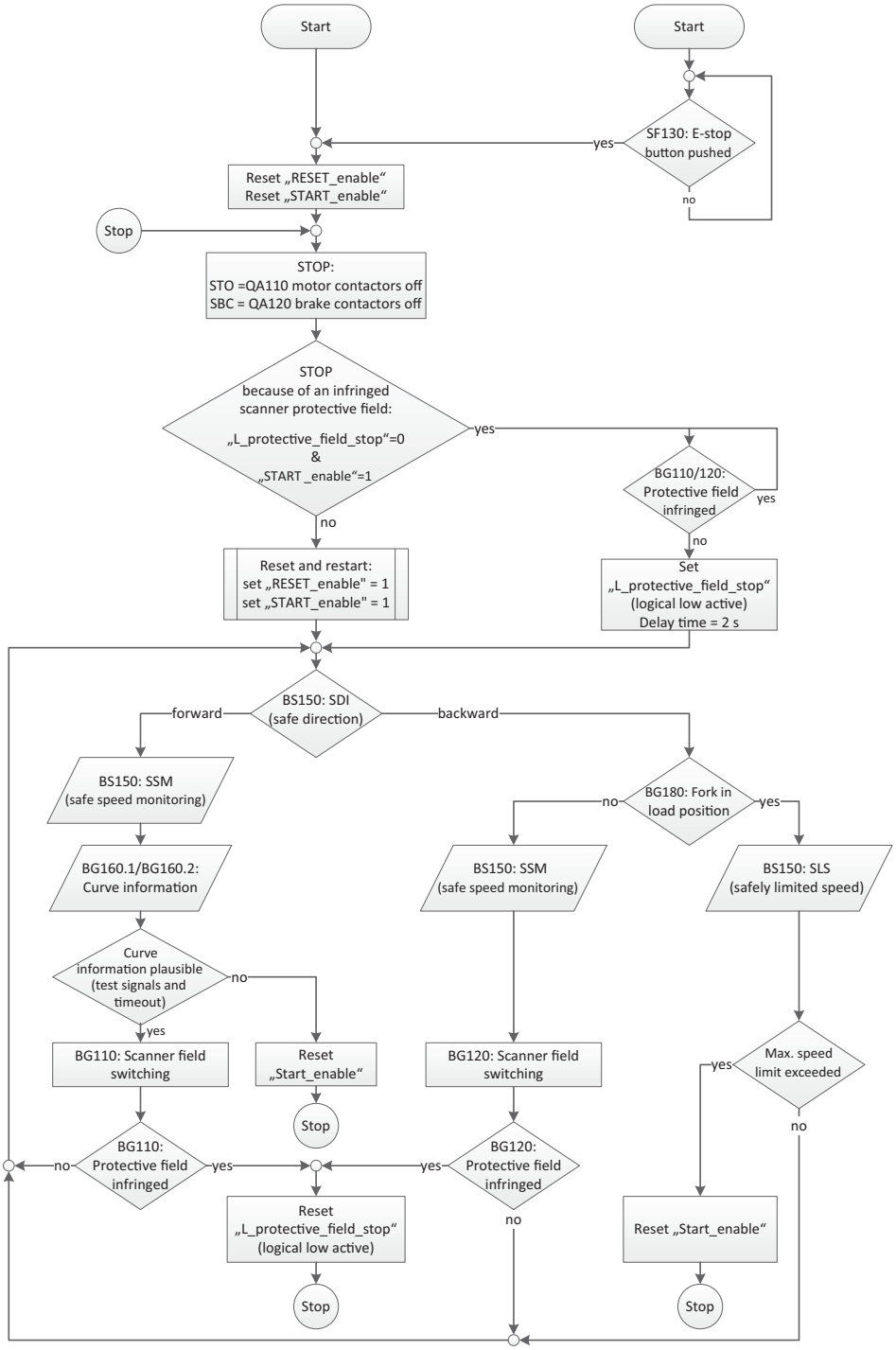
7.2 Pre-configured project files

Pre-configured project files

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

www.sick.com/Safe_AGV_Forklift

7.2.1 Project file logic



7.2.2 Opening project file

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

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

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

7.3 Additional configuration required

7.3.1 Configuring the motion control module element settings

Opening element settings

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

Configuring the measurement system scaling

1. Click on the **Measurement system scaling** tab.
2. Click on the **Wizard** button.
3. Only if a set without an encoder has been selected: In **Encoder resolution**, check the periods per revolution of the encoder and correct if necessary. The default value is 1024.
4. In **Gearbox factor**, set the ratio between the drive axis and the encoder axis.
5. Set the circumference of the monitored drive wheel under “Mechanics factor”.

Configuring counting direction

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

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

Saving the configuration

▶ Click on the **OK** button.

7.3.2 Configuring logics for Flexi Soft CPU

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

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

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

▶ Read and observe the information on manufacturer duties.

7.3.2.1 Creating or deleting links

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

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

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

Creating link

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

✓ A link is created between 2 elements.

Deleting link

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

✓ The link is deleted.

7.3.2.2 Jump addresses

A jump address consists of a source jump address and a destination jump address. The destination jump address takes on the same value (high or low) as the corresponding source jump address without delay – provided it is not a loopback. Information on loopbacks can be found in the “Flexi Soft in the Flexi Soft Designer” (8012998) operating instructions.

Jump addresses are an elegant way of implementing complex logic relationships. Among other things, jump addresses are used to connect the various pages of logic with each other.

7.3.2.2.1 Finding source and destination jump addresses that belong together

To find the corresponding destination jump address for a source jump address (or vice versa), proceed as follows:

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.

7.3.2.2.2 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 area.
2. Enter a unique name in the **Create jump mark** dialog box.
3. Click on **OK**.

7.3.2.2.3 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 area.
2. Select the desired jump mark in the **Select jump mark** dialog box.
3. Click on **OK**.

7.3.2.3 Verification of the logics

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

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

7.3.2.4 Removing the curve signal

If the risk assessment shows that is it not necessary to evaluate the curve signals, the logic must be changed.

1. Change to the **Curve signal** page.
2. Delete the link between **BG160.1 - CURVE.RIGHT.K110.3 - XTDI[3].I1I2** and **input 1** of function block **Routing N:N 4**.
3. Delete the link between **BG160.2 - CURVE.LEFT.K110.3 - XTDI[3].I3I4** and **input 1** of function block **Routing N:N 4**.
4. Delete the link between **KF161 - Plausibility RIGHT.K110.3 - XTDI[3].I5** and **input 1** of function block **Routing N:N 4**.
5. Delete the link between **KF171 - Plausibility LEFT.K110.3 - XTDI[3].I6** and **input 1** of function block **Routing N:N 4**.
6. Create a link between **Logic 1** and all inputs of function block **Routing N:N 4**.
7. Click on **Hardware configuration**.
8. Delete the following elements from the configuration:
   - **CURVE RIGHT** (module 4, I1 + I2)
   - **CURVE LEFT** (module 4, I3 + I4)
   - **Plausibility RIGHT** (module 4, I5)
   - **Plausibility LEFT** (module 4, I6)

✓ The logic will now work without safety switches for detecting the steering angle.

7.3.2.5 Configuring the time limit for the curve signal

In its factory settings, the functional safety system is configured in such a way that it switches to the error state as soon as a safety switch or a plausibility signal displays a steering angle for more than 120 s. If the risk assessment requires a different time limit, configure this as follows:

1. Change to the **Curve signal** page.
2. Double-click on function block **Switch-off delay 1**.
3. Enter the required value in the **Delay time** field.
4. Click on **OK**.
5. Repeat steps 2 to 4 for function blocks **Switch-off delay 2**, **Switch-off delay 3**, and **Switch-off delay 4**.

✓ The required value applies to the time limit of the curve signal.

7.3.2.6 Linking the logic and outputs

Once the logic has been verified, it is possible to link it to the relevant safety controller outputs.

1. Change to the **Stop/Reset/Restart** page.
2. Create a link between **Output 1** of function block **External device monitoring 0** and **QA110/120 - Motor+Brake Contactors.K110.2 - XTIO[2].Q1Q2**.

7.3.3 Configuring the motion control module logic

1. Move the cursor over the **Logic editor** button.
2. Click on **K110.1 - MOC0[1] - Logic editor**.

✓ The **K110.1 - MOC0[1] - Logic editor** view opens. The **Motion Control** page appears.

7.3.3.1 Configuring the **Speed Monitor** function block

1. Click on the **Speed Monitor** function block.
2. Click on the **Units** tab.
3. Under **Speeds:** select the desired unit for determining the encoder speed (see "Configuring the motion control module element settings", page 27).
4. Click on the **Max. speed** tab.
5. Under **Max. speed**, enter the permitted maximum speed of the AGV.

NOTE
The value must be higher than the speed values of the safety laser scanner monitoring cases.

6. Click on the **OK** button.

7.3.4 Configuring the safety laser scanner

- ▶ In the **Configuration area** within the **Hardware configuration** view, double-click on a safety laser scanner icon at input EFI1 of the main module for the safety controller.
- ✓ The **S3000** configuration window opens.

7.3.4.1 Configuring monitoring cases

There are a total of 9 monitoring cases in the configuration. For each monitoring case, field sets are pre-assigned to the two safety laser scanners. Each monitoring case applies to a particular speed window of the AGV.

DANGER
Failure to comply with manufacturer's obligations

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

In the factory settings, the configuration only contains examples of speed values. These speed values must be adjusted.

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

1. Click on **Cases**.
2. Click on the **Backward** monitoring case.
3. In the **Activation/Field set assignment** area, set the required limit values of the speed window for this monitoring case in the **from** and **to** fields.
4. Repeat steps 2 and 3 for the remaining 8 monitoring cases.

7.3.4.2 Configuring field sets

There are a total of 10 field sets in the configuration. 8 of them apply to the S3000 Remote safety laser scanner (host, forward direction of travel). 2 of them apply to the S300 Mini Remote safety laser scanner (guest, backward direction of travel).

DANGER

Failure to comply with manufacturer's obligations

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

The field sets have been created, but have not been definitively configured. In the factory settings, the protective fields are therefore set to the maximum size in all the field sets.

- Define suitable sizes for the protective and warning fields. These are determined on the basis of the risk assessment and the properties of the AGV.

1. Click on **Field sets (host)**.
2. Click on the **Forward 1** field set.
3. Define the protective field (red) and the warning field (yellow) as required using the drawing tools.
4. Repeat steps 2 and 3 for the remaining 7 field sets of the S3000 Remote safety laser scanner (host, forward direction of travel).
5. Click on **Field sets (guest)**.
6. Click on the **Backward 1** field set.
7. Define the protective field (red) and the warning field (yellow) as required using the drawing tools.
8. Repeat steps 6 and 7 for the **Backward 2** field set.

7.4 Fixed configuration

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.

- The following settings must remain unchanged in every application.

7.4.1 Sin/Cos analog voltage check

In the motion control module element settings, the **Sin/Cos analog voltage check** check box must always remain activated under the Sin/Cos analog voltage check tab.

7.5 Transfer configuration

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

8 Commissioning

8.1 Safety

DANGER
Hazard due to lack of effectiveness of the protective device

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

DANGER
Dangerous state of the machine

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

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

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

8.2 Thorough check

Requirements for the thorough check during commissioning and in certain situations

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

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

The thorough check ensures the following:

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

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

1. Check the effectiveness of the protective device for all operating modes selectable on the machine in accordance with the checklist for initial commissioning and commissioning (see "Annex", page 41).
2. Make sure that the operating personnel has been instructed in the function of the protective device before starting work on the machine. The instruction is the responsibility of the machine operator and must be carried out by qualified personnel.

9 Maintenance

NOTE
All information is included in the operating instructions for the components.

10 Troubleshooting

NOTE
All information is included in the operating instructions for the components.

11 Operation

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

12 Technical data

12.1 Data sheet

Table 17: Safe AGV Forklift data sheet

	Safe AGV Forklift
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 altitude	≤ 2,000 m
Safe state	The safety-related semiconductor outputs are in the OFF state.

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 times for the “Initiating a stop” and “Monitoring machine parameters” safety functions are calculated using the formulas below:

- Initiating a stop during travel forward
  268 ms + $T_{Cont.}$ + T_{Brake} + T_{Logic}
- Initiating a stop during travel backward
  188 ms + $T_{Cont.}$ + T_{Brake} + T_{Logic}
- Monitoring the machine parameter reverse speed when lifting a load (lifting fork lowered)
  12.5 ms + $T_{Cont.}$ + T_{Brake} + T_{Logic}

Formula symbols	Meaning
$T_{Cont.}$	Contactor response time
T_{Brake}	Braking time Dependent on factors including the following: • Speed of the AGV • Total mass of the AGV (including load) • Properties of the AGV wheels • Properties of the surface • Brake response time • Braking power
T_{Logic}	Logic execution time * 2 The logic execution time in the configuration file provided is 4 ms, so T_{Logic}= 8 ms. If the configuration file is modified for an individual development, the logic execution time may change. The logic execution time can be determined in the logic editor via the **FB info** index card.

13 Ordering information

13.1 Scope of delivery

Safe AGV Forklift scope of delivery

- DFS60S Pro safety encoder (part number dependent on selected Safe AGV Forklift variant)
- S300 Mini Remote safety laser scanner (part number 1056431)
- S3000 Remote safety laser scanner (part number 1023548)
- Flexi Soft safety controller, main module (part number 1058999)
- Flexi Soft safety controller, extension module – I/O module (8 inputs, 4 outputs) (part number 1044125)
- Flexi Soft safety controller, extension module – I/O module (8 inputs) (part number 1044124)
- Flexi Soft safety controller, extension module – motion control module (Flexi Soft Drive Monitor) (part number 1062344)
- Flexi Soft safety controller, system plug (part number 1047162)
- 3 × IN3000 Direct safety switches (part number 6034582)

13.2 Safe AGV Forklift ordering information

The only difference between the Safe AGV Forklift variants is the variant of the DFS60S Pro safety encoder they contain. The selection criteria relate to the properties of the DFS60S Pro safety encoder.

Table 18: Safe AGV Forklift ordering information

Mechanical shaft version	Shaft diameter	Length of the shaft	Type code	Part number
Solid shaft with face, servo flange, M4 thread	6 mm	10 mm	SAPPB0D-14A0021	1087180
Solid shaft with feather key, servo flange, M4 thread	6 mm	10 mm	SAPPB0D-14A0023	1087182
Solid shaft with face, face mount flange, M4 thread	10 mm	19 mm	SAPPB0D-14A0022	1087181
Solid shaft with feather key, face mount flange, M4 thread	10 mm	19 mm	SAPPB0D-14A0019	1087178
Blind hollow shaft with feather key groove	10 mm	–	SAPPB0D-14A0020	1087179
Blind hollow shaft with feather key groove	12 mm	–	SAPPB0D-14A0027	1087186
Blind hollow shaft with feather key groove	14 mm	–	SAPPB0D-14A0028	1087187
Through hollow shaft with feather key groove	10 mm	–	SAPPB0D-14A0024	1087183
Through hollow shaft with feather key groove	12 mm	–	SAPPB0D-14A0025	1087184
Through hollow shaft with feather key groove	14 mm	–	SAPPB0D-14A0026	1087185
Through hollow shaft with feather key groove	5/8”	–	SAPPB0D-14A0029	1087188
Other shaft			see table 19, page 38	

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

NOTE

The variants of the Safe AGV Forklift functional safety system contain recommended variants of the DFS60S Pro safety encoder. If none of the Safe AGV Forklift variants contain a DFS60S Pro safety encoder that is suitable for the application, please order the set from the table below without a safety encoder and then select a compatible DFS60S Pro safety encoder separately.

Table 19: Set without safety encoder

Description	Type code	Part number
Set consisting of all Safe AGV Forklift components with the exception of the DFS60S Pro safety encoder	SAPPB0D-14A0030	1087492

14 Spare parts

14.1 Safety encoder

Table 20: Safety encoder ordering information for Safe AGV Forklift

Spare part for		Spare part	Type code	Part number
Functional safety system	**Part number**			
Safe AGV Forklift	1087178	DFS60S safety encoder	DFS60S-SE0C01024	1067912
	1087179		DFS60S-BD0C01024	1067915
	1087180		DFS60S-S10C01024	1069517
	1087181		DFS60S-S40C01024	1069519
	1087182		DFS60S-SD0C01024	1069524
	1087183		DFS60S-TD0C01024	1069527
	1087184		DFS60S-TE0C01024	1069529
	1087185		DFS60S-TG0C01024	1069532
	1087186		DFS60S-BE0C01024	1069538
	1087187		DFS60S-BG0C01024	1069541
	1087188		DFS60S-TJ0C01024	1079319

14.2 Additional spare parts

Table 21: Ordering information for additional Safe AGV Forklift spare parts

Product	Type code	Part number
IN3000 Direct safety switch	IN30-E0407K	6034582
S3000 Remote safety laser scanner	S30A-6011EA	1023548
S300 Mini Remote safety laser scanner	S32B-3011EA	1056431
Flexi Soft safety controller, main module	FX3-CPU230002	1058999
Flexi Soft safety controller, extension module – I/O module (8 inputs, 4 outputs)	FX3-XTIO84002	1044125
Flexi Soft safety controller, extension module – I/O module (8 inputs)	FX3-XTDI80002	1044124
Flexi Soft safety controller, extension module – motion control module (Flexi Soft Drive Monitor)	FX3-MOC000000	1062344
Flexi Soft safety controller, system plug	FX3-MPL100001	1047162

15 Accessories

15.1 Connectivity

Table 22: Ordering information for connecting cables

Quantity	Part	Type code	Part number
1	System plug, 5 m cable, open end For connecting S3000 Remote safety laser scanner	SX0A-B0905B	2027170
3	Straight female connector, M12, 4-pin, 15 m cable, open end For connecting IN3000 Direct safety switch	DOL-1204-G15M	6010753
1	Straight female connector, M12, 7-pin, 5 m cable, open end Extension cable for connecting S300 Mini Remote safety laser scanner	DOL-1SS2G5M0E15KM3	6042338
1	Straight male connector, M8, 4-pin, 10 m cable, male connector, USB-A straight For configuring the Flexi Soft safety controller as well as S3000 Remote and S300 Mini Remote safety laser scanners	DSL-8U04G10M025KM1	6034575
1	Y cable, D-Sub, 15-pin, 2 × M12, 8-pin For connecting DFS60S Pro safety encoder	FX3-MOC encoder	2071072

15.2 Mounting bracket

Table 23: Ordering information for mounting bracket

Part	Type code	Part number
Mounting bracket for S300 Mini Remote	Mounting kit 1a	2034324
Mounting bracket for S3000 Remote	Mounting kit 1	2015623

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.

Tests of the “Emergency stop” safety function

Table 24: Tests of the “Emergency stop” safety function

Test sequence	Expected result	Result OK?
1. Have the AGV travel at a low speed (≤ 0.3 mm/s) 2. Press the emergency stop pushbutton. 3. Wait until the machine has come to a standstill. 4. Reset the emergency stop pushbutton. Perform the test sequence for each individual emergency stop pushbutton.	Stop is initiated (STO and SBC). If a brake is connected, it is triggered. The voltage supply for the drive is switched off. Resetting the emergency stop pushbutton does not trigger a restart.	Yes ☐ No ☐
Here, note down the designations of the emergency stop pushbuttons you have tested.		

Tests of the “Preventing unexpected start-up” safety function

Table 25: Tests of the “Preventing unexpected start-up” safety function

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

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

Tests of the “Initiating a stop” safety function

NOTE

For subsequent tests, the AGV must be raised using a lifting device. The drive wheel must not come into contact with the ground.

Table 26: Tests of the “Initiating a stop” safety function at a standstill, forward

Test sequence	Expected result	Result OK?
1. Make sure that the AGV is not being driven. 2. On the PC, start Flexi Soft Designer and open the project file for Safe AGV Forklift. 3. Connect the PC to the Flexi Soft main module. 4. Click on a safety scanner in the **Hardware configuration** view. ✓ CDS opens. 5. Click on the **Diagnostics** tab, then on **Data recorder**. ▶ Continue immediately with the next test.	Scanner <Host>: Monitoring case = Standstill Field set = Forward 1	Yes ☐ No ☐
1. In CDS, click on **Cases** and make a note of the following parameters in the test report: Inputs: _____ Velocity from _____ to _____ Host field set: _____ ▶ Continue immediately with the next test.		
1. Check the size of the warning field using a test rod. The following LED signals that a warning field has been interrupted:  2. Check the size of the protective field using a test rod. The following LED signals that a protective field has been interrupted: 	The sizes of the fields correspond to the calculated field sizes for this AGV at this speed. If the protective field is interrupted, a stop is initiated. If the test rod is removed from the protective field, it will take at least 2 s for a restart to occur.	Yes ☐ No ☐

Table 27: Tests of the “Initiating a stop” safety function during slow travel, forward, straight

Test sequence	Expected result	Result OK?
1. Have the AGV travel straight. The speed of the AGV must be in the range configured for the “Forward 2” field set. 2. On the PC, start Flexi Soft Designer and open the project file for Safe AGV Forklift. 3. Connect the PC to the Flexi Soft main module. 4. Click on a safety scanner in the **Hardware configuration** view. ✓ CDS opens. 5. Click on the **Diagnostics** tab, then on **Data recorder**. ▶ Continue immediately with the next test.	Scanner <Host>: Monitoring case = Forward Slow Field set = Forward 2	Yes ☐ No ☐

Test sequence	Expected result	Result OK?
1. In CDS, click on **Cases** and make a note of the following parameters in the test report: Inputs: _____ Velocity from _____ to _____ Host field set: _____ ▶ Continue immediately with the next test.		
1. Check the size of the warning field using a test rod. The following LED signals that a warning field has been interrupted:  2. Check the size of the protective field using a test rod. The following LED signals that a protective field has been interrupted: 	The sizes of the fields correspond to the calculated field sizes for this AGV at this speed. If the protective field is interrupted, a stop is initiated. If the test rod is removed from the protective field, it will take at least 2 s for a restart to occur.	Yes ☐ No ☐

Table 28: Tests of the "Initiating a stop" safety function during medium-fast travel, forward, straight

Test sequence	Expected result	Result OK?
1. Have the AGV travel straight. The speed of the AGV must be in the range configured for the "Forward 3" field set. 2. On the PC, start Flexi Soft Designer and open the project file for Safe AGV Forklift. 3. Connect the PC to the Flexi Soft main module. 4. Click on a safety scanner in the **Hardware configuration** view. ✓ CDS opens. 5. Click on the **Diagnostics** tab, then on **Data recorder**. ▶ Continue immediately with the next test.	Scanner <Host>: Monitoring case = Forward Medium Field set = Forward 3	Yes ☐ No ☐
1. In CDS, click on **Cases** and make a note of the following parameters in the test report: Inputs: _____ Velocity from _____ to _____ Host field set: _____ ▶ Continue immediately with the next test.		
1. Check the size of the warning field using a test rod. The following LED signals that a warning field has been interrupted:  2. Check the size of the protective field using a test rod. The following LED signals that a protective field has been interrupted: 	The sizes of the fields correspond to the calculated field sizes for this AGV at this speed. If the protective field is interrupted, a stop is initiated. If the test rod is removed from the protective field, it will take at least 2 s for a restart to occur.	Yes ☐ No ☐

Table 29: Tests of the “Initiating a stop” safety function during fast travel, forward, straight

Test sequence	Expected result	Result OK?
1. Have the AGV travel straight. The speed of the AGV must be in the range configured for the “Forward 3” field set. 2. On the PC, start Flexi Soft Designer and open the project file for Safe AGV Forklift. 3. Connect the PC to the Flexi Soft main module. 4. Click on a safety scanner in the **Hardware configuration** view. ✓ CDS opens. 5. Click on the **Diagnostics** tab, then on **Data recorder**. ▶ Continue immediately with the next test.	Scanner <Host>: Monitoring case = Forward Fast Field set = Forward 4	Yes ☐ No ☐
1. In CDS, click on **Cases** and make a note of the following parameters in the test report: Inputs: _____ Velocity from _____ to _____ Host field set: _____ ▶ Continue immediately with the next test.		
1. Check the size of the warning field using a test rod. The following LED signals that a warning field has been interrupted:  2. Check the size of the protective field using a test rod. The following LED signals that a protective field has been interrupted: 	The sizes of the fields correspond to the calculated field sizes for this AGV at this speed. If the protective field is interrupted, a stop is initiated. If the test rod is removed from the protective field, it will take at least 2 s for a restart to occur.	Yes ☐ No ☐

Table 30: Tests of the “Initiating a stop” safety function during slow travel, forward, right curve

Test sequence	Expected result	Result OK?
1. Have the AGV travel in a curve to the right. The speed of the AGV must be in the range configured for the “Curve Right Slow” field set. 2. On the PC, start Flexi Soft Designer and open the project file for Safe AGV Forklift. 3. Connect the PC to the Flexi Soft main module. 4. Click on a safety scanner in the **Hardware configuration** view. ✓ CDS opens. 5. Click on the **Diagnostics** tab, then on **Data recorder**. ▶ Continue immediately with the next test.	Scanner <Host>: Monitoring case = Curve Right Slow Field set = Curve right 1	Yes ☐ No ☐

Test sequence	Expected result	Result OK?
1. In CDS, click on **Cases** and make a note of the following parameters in the test report: Inputs: _____ Velocity from _____ to _____ Host field set: _____ ▶ Continue immediately with the next test.		
1. Check the size of the warning field using a test rod. The following LED signals that a warning field has been interrupted:  2. Check the size of the protective field using a test rod. The following LED signals that a protective field has been interrupted: 	The sizes of the fields correspond to the calculated field sizes for this AGV at this speed. If the protective field is interrupted, a stop is initiated. If the test rod is removed from the protective field, it will take at least 2 s for a restart to occur.	Yes ☐ No ☐

Table 31: Tests of the "Initiating a stop" safety function during fast travel, forward, right curve

Test sequence	Expected result	Result OK?
1. Have the AGV travel in a curve to the right. The speed of the AGV must be in the range configured for the "Curve Right Fast" field set. 2. On the PC, start Flexi Soft Designer and open the project file for Safe AGV Forklift. 3. Connect the PC to the Flexi Soft main module. 4. Click on a safety scanner in the **Hardware configuration** view. ✓ CDS opens. 5. Click on the **Diagnostics** tab, then on **Data recorder**. ▶ Continue immediately with the next test.	Scanner <Host>: Monitoring case = Curve Right Fast Field set = Curve right 2	Yes ☐ No ☐
1. In CDS, click on **Cases** and make a note of the following parameters in the test report: Inputs: _____ Velocity from _____ to _____ Host field set: _____ ▶ Continue immediately with the next test.		
1. Check the size of the warning field using a test rod. The following LED signals that a warning field has been interrupted:  2. Check the size of the protective field using a test rod. The following LED signals that a protective field has been interrupted: 	The sizes of the fields correspond to the calculated field sizes for this AGV at this speed. If the protective field is interrupted, a stop is initiated. If the test rod is removed from the protective field, it will take at least 2 s for a restart to occur.	Yes ☐ No ☐

Table 32: Tests of the “Initiating a stop” safety function during slow travel, forward, left curve

Test sequence	Expected result	Result OK?
1. Have the AGV travel in a curve to the left. The speed of the AGV must be in the range configured for the “Curve Left Slow” field set. 2. On the PC, start Flexi Soft Designer and open the project file for Safe AGV Forklift. 3. Connect the PC to the Flexi Soft main module. 4. Click on a safety scanner in the **Hardware configuration** view. ✓ CDS opens. 5. Click on the **Diagnostics** tab, then on **Data recorder**. ▶ Continue immediately with the next test.	Scanner <Host>: Monitoring case = Curve Left Slow Field set = Curve left 1	Yes ☐ No ☐
1. In CDS, click on **Cases** and make a note of the following parameters in the test report: Inputs: _____ Velocity from _____ to _____ Host field set: _____ ▶ Continue immediately with the next test.		
1. Check the size of the warning field using a test rod. The following LED signals that a warning field has been interrupted:  2. Check the size of the protective field using a test rod. The following LED signals that a protective field has been interrupted: 	The sizes of the fields correspond to the calculated field sizes for this AGV at this speed. If the protective field is interrupted, a stop is initiated. If the test rod is removed from the protective field, it will take at least 2 s for a restart to occur.	Yes ☐ No ☐

Table 33: Tests of the “Initiating a stop” safety function during fast travel, forward, left curve

Test sequence	Expected result	Result OK?
1. Have the AGV travel in a curve to the left. The speed of the AGV must be in the range configured for the “Curve Left Fast” field set. 2. On the PC, start Flexi Soft Designer and open the project file for Safe AGV Forklift. 3. Connect the PC to the Flexi Soft main module. 4. Click on a safety scanner in the **Hardware configuration** view. ✓ CDS opens. 5. Click on the **Diagnostics** tab, then on **Data recorder**. ▶ Continue immediately with the next test.	Scanner <Host>: Monitoring case = Curve Left Fast Field set = Curve left 2	Yes ☐ No ☐

Test sequence	Expected result	Result OK?
1. In CDS, click on **Cases** and make a note of the following parameters in the test report: Inputs: _____ Velocity from _____ to _____ Host field set: _____ ▶ Continue immediately with the next test.		
1. Check the size of the warning field using a test rod. The following LED signals that a warning field has been interrupted:  2. Check the size of the protective field using a test rod. The following LED signals that a protective field has been interrupted: 	The sizes of the fields correspond to the calculated field sizes for this AGV at this speed. If the protective field is interrupted, a stop is initiated. If the test rod is removed from the protective field, it will take at least 2 s for a restart to occur.	Yes ☐ No ☐

Table 34: Tests of the "Initiating a stop" safety function at a standstill, backward

Test sequence	Expected result	Result OK?
1. Make sure that the AGV is not being driven. 2. Make sure that the lifting fork is in the top lifting position. 3. On the PC, start Flexi Soft Designer and open the project file for Safe AGV Forklift. 4. Connect the PC to the Flexi Soft main module. 5. Click on a safety scanner in the **Hardware configuration** view. ✓ CDS opens. 6. Click on the **Diagnostics** tab, then on **Data recorder**. ▶ Continue immediately with the next test.	Scanner <Guest>: Monitoring case = Standstill Field set = Backwards 1	Yes ☐ No ☐
1. In CDS, click on **Cases** and make a note of the following parameters in the test report: Inputs: _____ Velocity from _____ to _____ Host field set: _____ ▶ Continue immediately with the next test.		
1. Check the size of the warning field using a test rod. The following LED signals that a warning field has been interrupted:  2. Check the size of the protective field using a test rod. The following LED signals that a protective field has been interrupted: 	The sizes of the fields correspond to the calculated field sizes for this AGV at this speed. If the protective field is interrupted, a stop is initiated. If the test rod is removed from the protective field, it will take at least 2 s for a restart to occur.	Yes ☐ No ☐

Table 35: Tests of the “Initiating a stop” safety function during travel, backward

Test sequence	Expected result	Result OK?
1. Have the AGV travel backward at the minimum speed for the “Backwards” monitoring case. 2. On the PC, start Flexi Soft Designer and open the project file for Safe AGV Forklift. 3. Connect the PC to the Flexi Soft main module. 4. Click on a safety scanner in the **Hardware configuration** view. ✓ CDS opens. 5. Click on the **Diagnostics** tab, then on **Data recorder**. ▶ Continue immediately with the next test.	Scanner <Guest>: Monitoring case = Backwards Field set = Backwards 2	Yes ☐ No ☐
1. In CDS, click on **Cases** and make a note of the following parameters in the test report: Inputs: _____ Velocity from _____ to _____ Host field set: _____ ▶ Continue immediately with the next test.		
1. Check the size of the warning field using a test rod. The following LED signals that a warning field has been interrupted:  2. Check the size of the protective field using a test rod. The following LED signals that a protective field has been interrupted: 	The sizes of the fields correspond to the calculated field sizes for this AGV at this speed. If the protective field is interrupted, a stop is initiated. If the test rod is removed from the protective field, it will take at least 2 s for a restart to occur.	Yes ☐ No ☐

Table 36: Tests of the “Initiating a stop” safety function at an excessively high speed

Test sequence	Expected result	Result OK?
1. Have the AGV travel forward. 2. Have the AGV travel straight (no steering angle). 3. Increase the speed above the maximum value for the “Forward Fast” monitoring case.	Stop is initiated (STO and SBC).	Yes ☐ No ☐
1. Have the AGV travel forward. 2. Have the AGV travel in a curve to the right. 3. Increase the speed above the maximum value for the “Curve Right Fast” monitoring case.	Stop is initiated (STO and SBC).	Yes ☐ No ☐
1. Have the AGV travel forward. 2. Have the AGV travel in a curve to the left. 3. Increase the speed above the maximum value for the “Curve Left Fast” monitoring case.	Stop is initiated (STO and SBC).	Yes ☐ No ☐

Test sequence	Expected result	Result OK?
1. Have the AGV travel backward. 2. Increase the speed above the maximum value for the “Backwards” monitoring case.	Stop is initiated (STO and SBC).	Yes ☐ No ☐

NOTICE

If the AGV is traveling too fast, the Motion Control safety controller normally initiates the stop. If the maximum speed configured for the safety laser scanner is lower than the maximum speed configured for the Motion Control safety controller, then the safety laser scanner initiates the stop. At this point, the safety laser scanner switches to the error state (error “n1”).

Table 37: Tests of the “Initiating a stop” safety function using curve signals

Test sequence	Expected result	Result OK?
1. Steer the AGV to the right. 2. Maintain the steering angle for longer than indicated in the configuration (Flexi Soft Designer, **curve signal** page, **time limit** section).	Stop is initiated (STO and SBC).	Yes ☐ No ☐
1. Steer the AGV to the left. 2. Maintain the steering angle for longer than indicated in the configuration.	Stop is initiated (STO and SBC).	Yes ☐ No ☐
1. Interrupt the two plausibility signals for the steering angle.	Stop is initiated (STO and SBC).	Yes ☐ No ☐
1. Interrupt the safety switch signals for the steering angle.	Stop is initiated (STO and SBC).	Yes ☐ No ☐

Tests of the “Monitoring machine parameters” safety function

NOTE

For subsequent tests, the AGV must be raised using a lifting device. The drive wheel must not come into contact with the ground.

Table 38: Tests of the “Monitoring machine parameters” safety function

Test sequence	Expected result	Result OK?
1. Lower the lifting fork to the loading position. 2. Have the AGV travel backward. 3. Increase the speed above the limit of 0.3 m/s.	Stop is initiated (STO and SBC). If a brake is connected, it is triggered. The voltage supply for the drive is switched off.	Yes ☐ No ☐

Tests for verifying the measured speed

Table 39: Tests for verifying the measured speed

Test sequence	Expected result	Result OK?
1. Lower the AGV again and prepare it for travel. 2. On the PC, start Flexi Soft Designer and open the project file for Safe AGV Forklift. 3. Connect the PC to the Flexi Soft main module. 4. In Flexi Soft Designer, start the **Data recorder** function and configure it so that the **E1.Motion->Speed** value is recorded from the **Diagnostics** area. 5. Have the AGV travel at the specified speed. 6. Measure the speed using an independent method (such as distance/time measurement). 7. Read out the speed value of the Motion Control safety controller and compare it with the actual measured speed.	Both speed values are identical.	Yes ☐ No ☐

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