Compact Manual

SAFE COUPLING
SAFE LINK
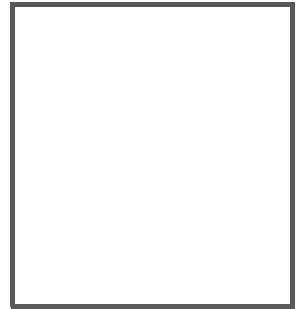
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SENSING YOUR NEEDS

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Safe Coupling Safe Link

13.04.2016

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1. Introduction

Congratulations

You have chosen a device manufactured by Pepperl+Fuchs. Pepperl+Fuchs develops, produces and distributes electronic sensors and interface modules for the market of automation technology on a worldwide scale.

Before installing this equipment and put into operation, read this manual carefully. This manual containes instructions and notes to help you through the installation and commissioning step by step. This makes sure bring such a trouble-free use of this product. This is for your benefit, since this:

- ensures the safe operation of the device
- helps you to exploit the full functionality of the device
- avoids errors and related malfunctions
- avoids costs by disruptions and any repairs
- increases the effectiveness and efficiency of your plant

Keep this manual at hand for subsequent operations on the device.

After opening the packaging please check the integrity of the device and the number of pieces of supplied.

Symbols used

The following symbols are used in this manual:

Information!

This symbol indicates important information.

Attention!

This symbol warns of a potential failure. Non-compliance may lead to interruptions of the device, the connected peripheral systems, or plant, potentially leading to total malfunctioning.

Warning!

This symbol warns of an imminent danger. Non-compliance may lead to personal injuries that could be fatal or result in material damages and destruction.

Contact

If you have any questions about the device, its functions, or accessories, please contact us at:

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2. Declaration of conformity

2.1 Declaration of conformity

This product was developed and manufactured under observance of the applicable European standards and guidelines.

Information!

A Declaration of Conformity can be requested from the manufacturer.

The product manufacturer, Pepperl+Fuchs GmbH, D-68307 Mannheim, has a certified quality assurance system that conforms to ISO 9001.

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3. Safety

3.1 Symbols relevant to safety

Information!
This symbol indicates important information.

Attention!
This symbol warns of a potential failure. Non-compliance may lead to interruptions of the device, the connected peripheral systems, or plant, potentially leading to total malfunctioning.

Warning!
This symbol warns of an imminent danger. Non-compliance may lead to personal injuries that could be fatal or result in material damages and destruction.

3.2 General notes on safety

Only instructed specialist staff may operate the device in accordance with the operating manual.

User modification and or repair are dangerous and will void the warranty and exclude the manufacturer from any liability. If serious faults occur, stop using the device. Secure the device against inadvertent operation. In the event of repairs, return the device to your local Pepperl+Fuchs representative or sales office.

The connection of the device and maintenance work when live may only be carried out by a qualified electrical specialist.

The operating company bears responsibility for observing locally applicable safety regulations.

Store the not used device in the original packaging. This offers the device optimal protection against impact and moisture.

Ensure that the ambient conditions comply with regulations.

3.3 Disposal

Information!
Electronic waste is hazardous waste. Please comply with all local ordinances when disposing this product!
The device does not contain batteries that need to be removed before disposing it.

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4. Safe Coupling via Ethernet

4.1 General introduction

Both factory and process automation are showing a trend towards ever more complex, branched applications. The most efficient possible coupling of safe networks now becomes one of the special challenges in the area of safety.

A simple and cost-effective solution

There is a simple and cost-effective solution: Safe Link, i.e. safe coupling via the Ethernet interface of the AS-i gateways with integrated safety monitor. In the maximum configuration this means up to 1922 safety two-channel input signals can be collected while controlling safety outputs either centrally or locally.

Couple up to 31 gateways

This approach enables up to 31 Safety Basis Monitors or gateways with integrated safety monitor to be coupled to each other – without losing performance at any point and without the use of additional hardware.

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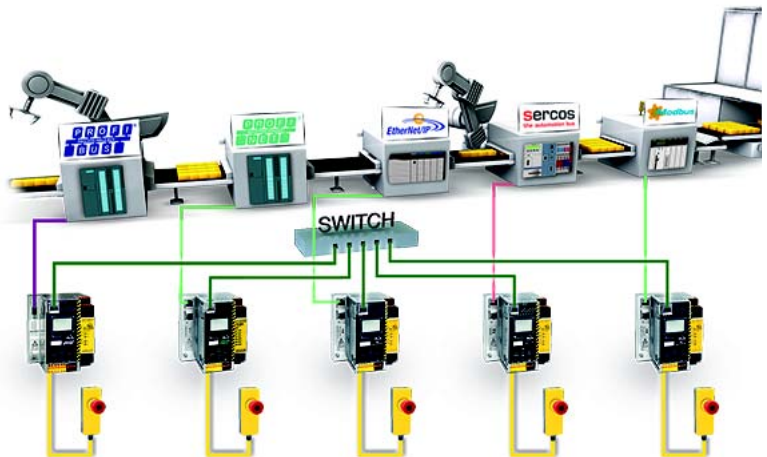
Why safe coupling?

☐ Many safe signals

• Up to 62 safe signals per safety monitor without coupling

• For more safe signals additional safety monitors are used
  • with safety monitors coupled to each other.

☐ Safely couple multiple machines

• Central E-Stop works on multiple machines

• E-Stop on one machine works for the neighboring machine.

☐ Widely distributed systems

• Encapsulating of system parts
  • segmenting Individual parts are coupled to each other

• Modular system construction
  • individual modules are coupled to each other.

4.2	Interface for the safe coupling Safe Link

For **Safe Link** the Gateways are connected via the Ethernet diagnostics interface and a switch. In the case of PROFINET and EtherNET/IP+Modbus TCP, instead the fieldbus interface[1] can be used for Safe Link.

If the Ethernet diagnostics interface is used for coupling, devices having different controller systems (such as PROFIBUS, PROFINET, EtherNet/IP, Modbus, Sercos, etc.) can exchange signals with each other without any additional effort using the switch.

Since data transmission is based on the sending of multicasts, it must be ensured that the switch used can process and pass along the corresponding broadcasts.
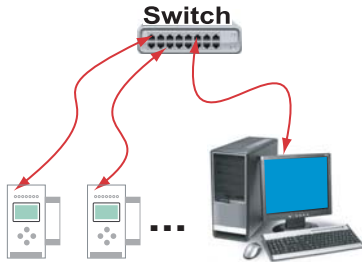
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1.   If there is no DHCP server available for the EtherNet/IP devices, then a fixed IP address for the fieldbus interface should be set.

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5. Starting up Safe Link
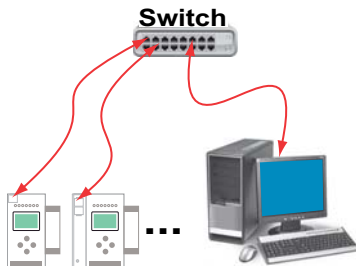
5.1 Installation

Connection through an external switch is required:

☐ If the Ethernet diagnostics port is used for **Safe Link**, the nodes must be connected through an external switch!

Documentation "ASIMON"

☐ An Ethernet diagnostics port may only be connected to an Ethernet fieldbus port through an external switch!

☐ A direct connection (without a switch) is not permitted!

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Safe Link	
Fieldbus interface	100 MBit, full duplex
Ethernet diagnostics interface	10 MBit, half duplex or 100 MBit, full duplex[1]
Ports	depends on the multicast group port 1024 to 1038
Protocol	UDP
Data packets	71 bytes per packet average 33 packets per second and node[2]
Group organisation	
Number	max. 15 groups (group addresses 1 to 15)
No. of devices	max. 31 devices per group
System size	
max. system size	31 gateways x 62 safe input slaves = 1922 safe inputs in full configuration
Coupling	
max. no. of coupled signals	31 gateways x 31 signal bits = 961 safe coupled signals in full configuration
Switch / network	
Requirements	supports cyclical multicasts and broadcasts

1. See data sheet for details.
2. The exact time interval in which a node generates a telegram depends on the number of nodes and can be taken from the configuration protocol as 'Update Time':

```
0131 ****************************************************** 1
0132 Safe Cross Communication                             2
0133 ****************************************************** 3
0134 Station Addr.: 1, group manager                      4
0135 Group:        4                                      5
0136 Communication:UDP 239.192.1.3:1027 on diagnosis interface 6
0137 Update Time:   30ms                                  7
0138 ****************************************************** 8
```

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Other requirements for the switch/network:

☐ Limiting of telegram runtimes.

A stable connection over the **Safe Link** network requires that you ensure the telegrams never require more than 55 ms (for max. 10 nodes), 70 ms (for max. 20 nodes), 85 ms (for a fully populated group) to be sent over the network. Telegrams with too long a runtime are rejected even if correctly sent! The average transmission time should be maximum approx. 15 … 20 ms below this limit.

☐ Switch with a mirror port.

To enable more exact analysis in case of an error, it is helpful if the switch has a mirror port.

5.2 Configuration using ASIMON

Warning!
*Two **Safe Link** groups which are already in operation and have the same group number must never be switched to the same multicast group during operation! Two groups with the same group number are not permitted!*

Complete configuration of **Safe Link** is done using the ASIMON software, in the *Monitor/Bus information* section **[1]** on the *Safe Link* tab **[2]**.
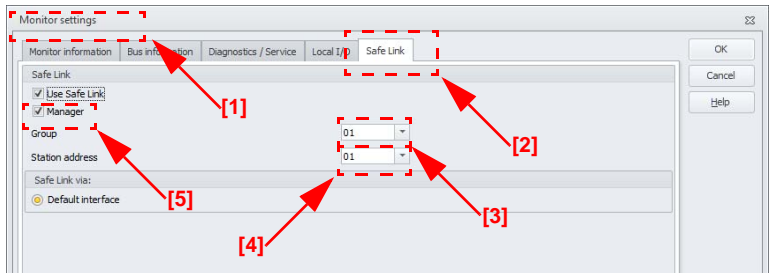
Here the group and device addresses are assigned and the safe programs for the individual Gateways managed. Information about the IP addresses of the participating devices are also stored in the project structure.

In organizational terms all Gateways that need to communicate with each other are combined in one group (Group addresses 1 to 15) **[3]**.

Each device in a group is given a unique device address (Device addresses 1 to 31) **[4]**.
One of the devices is assigned as the manager of the group **[5]**, which means it monitors whether all the participating devices are present in the network.

31 bits are available in each Gateway which can be used by the other nodes as safe signals. In a full configuration with 31 Gateways this means a total of 961 safe coupled signals are available.

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Settings for the **Safe Link** of multiple safety monitors can be configured on this tab. With safe coupling, it is possible to exchange safe data between safety monitors independent of AS-i.

The data to be sent are created in the **Output Assignment**[1]. The received data can be received with the **Safe Link** input device[1].

To use safe coupling, the configurations of all participating devices must be saved in the **Configuration Manager** (workspace).

If the configuration has not yet been loaded to a monitor, "Automatic selection" is displayed under **Current Interface**. In this case, during the download the interface is either set to the only available interface or it must be selected manually. If the configuration has already been loaded to a monitor, this interface is displayed under **Current Interface**. During the download, this interface is given preference if possible. The interface can be set back to "Automatic selection" using the **Reset** button.

Information!

*If **Safe Link** is used, all configurations of the participating monitors must be saved in the same workspace! While downloading the configurations, ASIMON then enters the missing communication parameters in the configurations.*

Information!

If there are configurations which are not located in the workspace that were already downloaded once, these can be written to the monitor without changing the safe communication parameters.

The following options are available:

- **Use Safe Link**: This option is used to activate **Safe Link** in the monitor.
- **Manager**: A participant in a communication group (same group number) of the safe coupling must be a manager. After downloading and starting the configurations of all group participants, the manager must then still be taught.
- **Group**: Only participants with the same group number can communicate with one another.
- **Station address**: Each device in a group must have a unique device number.
- **Safe Link via**: The interface for **Safe Link** can be selected here.

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1. For further information please view the documentation of the ASIMON-Software.

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5.2.1 Teaching the nodes in a communication group

Before **Safe Link** can be started up, the manager must be taught the group Ids. For this the manager must be able to access all nodes over the network via multicast. ASIMON is used for teaching:
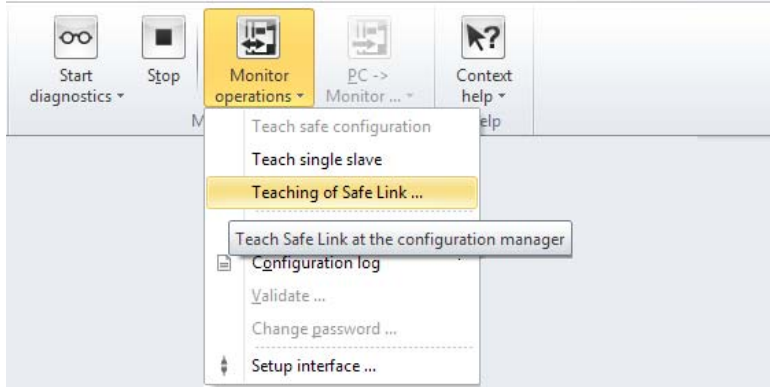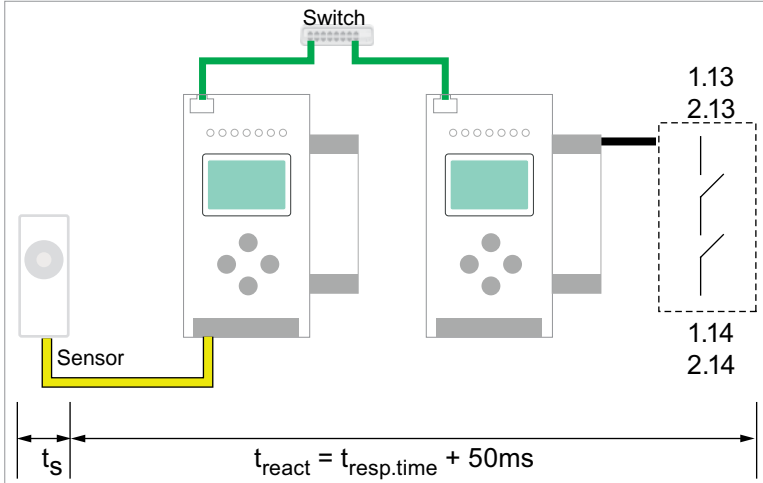

Information!

*Please refer also to the Quick Start Guide for **Safe Link**!*

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5.3 Reaction times

5.3.1 Safe Link via ethernet -> local relay output

$t_{max} = t_s + t_{react}$

t_{max} = total reaction time
t_s = maximal reaction time of the sensor (see data sheet)
t_{react} = maximal reaction time of the system
$t_{resp.time}$ = reaction time from configuration log

Information!

The "$t_{resp.time}$" value should always be taken from the ASIMON configuration log!

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5.3.1.1 Example of reaction time "$t_{resp.time}$" from the configuration log

The typical values "tresp.time":
- 2 nodes: 184 ms
- 31 nodes: 576 ms

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5.3.2 Safe Link via ethernet -> local electronic output
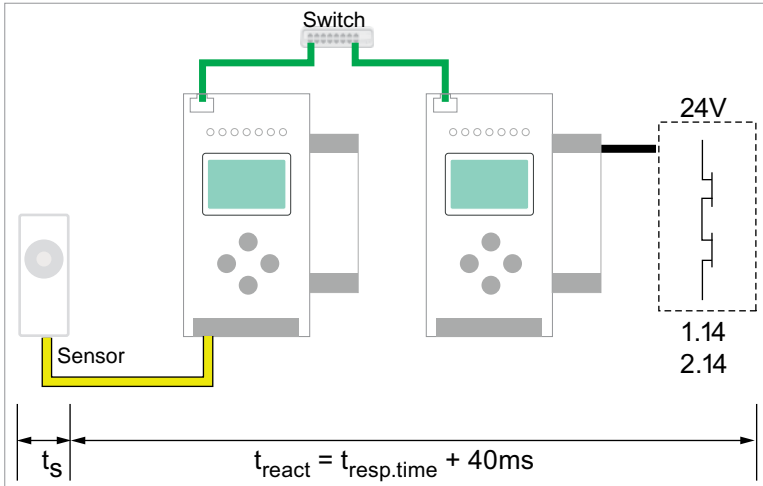
$t_{max} = t_s + t_{react}$

t_{max} = total reaction time
t_s = maximal reaction time of the sensor (see data sheet)
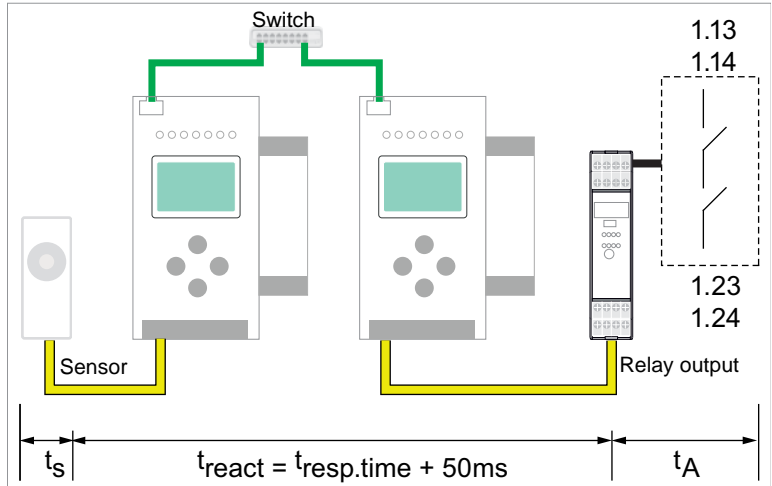t_{react} = maximal reaction time of the system
$t_{resp.time}$ = reaction time acc. to the configuration log

Information!

The "$t_{resp.time}$" value should always be taken from the ASIMON configuration log!

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5.3.3 Safe Link via ethernet -> AS-i relay output

$t_{max} = t_S + t_{react} + t_A$

t_{max} = total reaction time
t_S = maximal reaction time of the sensor (see data sheet)
t_{react} = maximal reaction time of the system
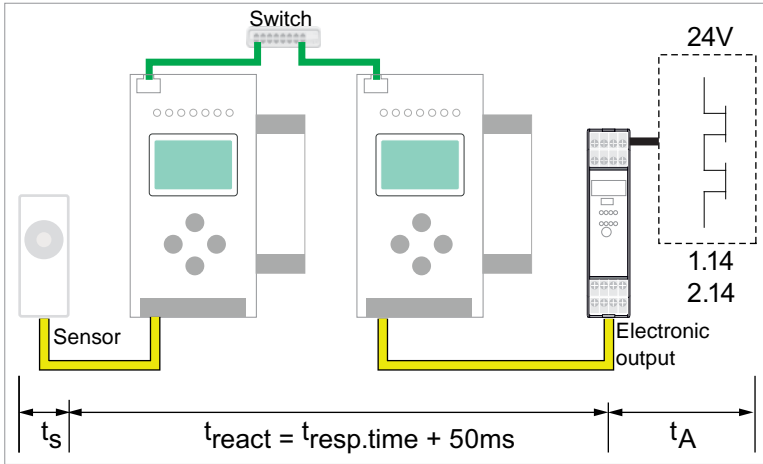$t_{resp.time}$ = reaction time acc. to the configuration log
t_A = maximum reaction time of the actuator (see operating manual)

Information!

The "$t_{resp.time}$" value should always be taken from the ASIMON configuration log!

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5.3.4   Safe Link via ethernet -> electronic output

$$t_{max} = t_S + t_{react} + t_A$$

t_{max} = total reaction time

t_S = maximal reaction time of the sensor (see data sheet)

t_{react} = maximal reaction time of the system

$t_{resp.time}$ = typ.value at 5 gateways 199 ms; typ.value at 32 gateways 432 ms

t_A = maximum reaction time of the actuator (see operating manual)

Attention!

The value "$t_{resp.time}$" should always be taken from the ASIMON configuration log!
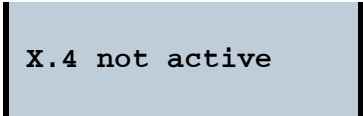
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6. Diagnostics

Information!

*Using the **Safe Link**, it is necessary to use the software ASIMON, including subordinate programs (AS-i Control Tools), for the diagnostics instead of the built-in Web server.*

Directly on the device

If a group member does not receive the expected messages from another member, it displays the device address of the missing Gateway together with the message "not active".

e.g. missing data telegrams from Device 4:

X.4 not active

About ASIMON

The ASIMON software can be used at any time to perform diagnostics for the **Safe Link** by invoking **Safe Link** diagnostics from the **Start diagnostics** menu in the **Applications** section. This opens a window with a graphical detailed view of the state of communication for all group members.

If an error occurs in **Safe Link**, the corresponding signals are shown in gray in the ASIMON configuration, and at the same time a popup window opens automatically with a reference to missing devices.
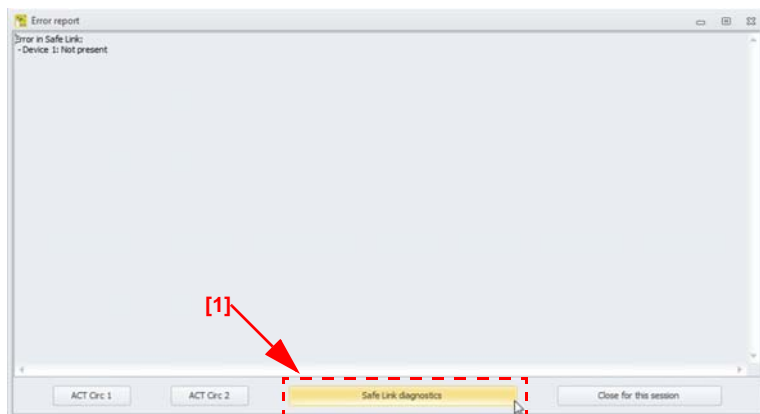
Clicking on the **Safe Link diagnostics** button **[1]** on the bottom edge of the popup window also opens the diagnostics window for **Safe Link**.

6.1   Example of a Safe Link diagnostics

- With **Safe Link**, it is possible to exchange signals across many devices (nodes) via complex network structures. So that **Safe Link** works efficiently, certain basic conditions are necessary:

- The nodes that exchange signals must be able to reach each other on the network level in the multicast group.

- The node which is the manager of the **Safe Link** must be able to reach all devices involved in the multicast group.

- The diagnostics of the **Safe Link** aids in the search for connection errors or problems caused when the above-mentioned points interfere with data exchange. It is used for:

- Finding bad / missing data connections between individual nodes

- Detecting of not activated / missing nodes

- Detecting of incorrectly configured nodes

After the monitor diagnostics has been started, ASIMON gathers additional information on **Safe Link** from the devices in the background. When faulty states are detected in this process, a corresponding note appears in the error report. The error report provides the Safe Link diagnostics button to start a more accurate analysis.

When the diagnostics of the **Safe Link** starts, a comprehensive overview of the devices (nodes) involved first appears. All relationships between the devices are represented by colored lines.

The meanings of the symbols and colors are explained in the following using an example of a diagnostics of three nodes.

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6.1.1 Example - three nodes

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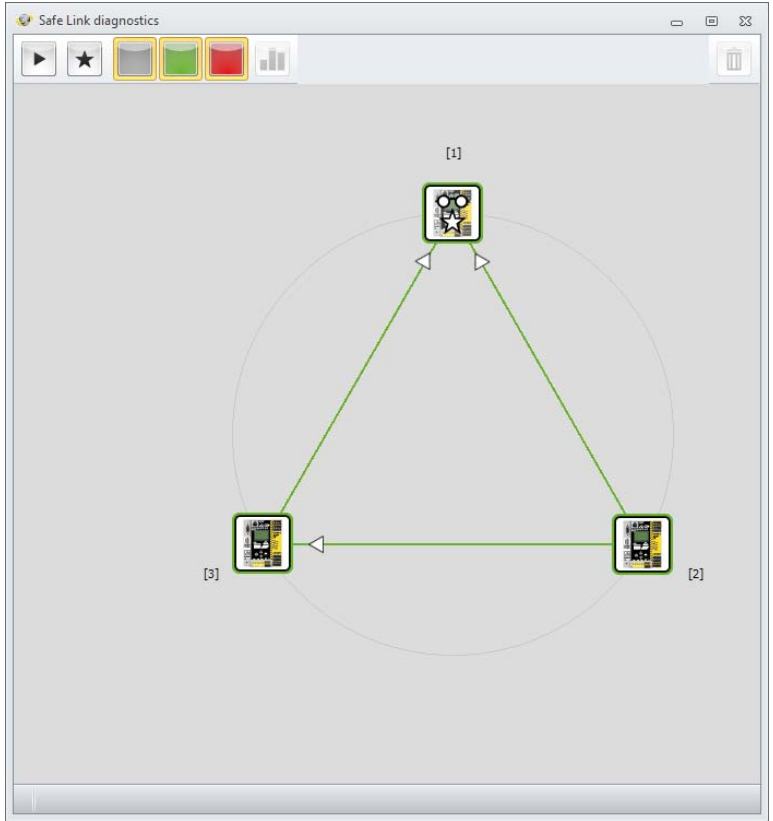
The diagnostics shows the three nodes and their connections to each other. Each node is represented with a symbol .

The symbol has a colorful border which specifies the current state of the node:

- green: the node is active
- red: the node is in 'init', 'pre-operational' state.

If the node cannot be detected directly before the diagnostics, it is shown in gray and cannot be selected in the following since no data exists.

The address of the **Safe Link** is located next to the symbol of the device. A star is added to the symbol of the manager node (node [1] here). The device which is currently being diagnosed by ASIMON has the "glasses" symbol.

The menu buttons in the upper border of the window are used to handle the rest of the diagnostics. The following functions are possible:

6.1.2 Operational controls

⏸	This switch can be used to pause the diagnostics of the Safe Link. This can cause the current overview to "freeze".
★	If the manager node has been selected, this button can be used to switch between the node view and the manager view. In the manager view, devices can be detected which have not been put into operation or are not detected by the manager. The node view is the view of the data connections - this is also the case for other devices.
▮▮▮	These buttons are used to filter relationships between nodes based on their states. The relationships of the respective color are then suppressed. In the case of larger configurations, this allows the "intact" relationships to be suppressed, for example, making it easier to identify the problematic connection. The filter function does not refer to the connection, but exclusively to its state. If, for example, the green relationships are filtered out and one of these connections becomes "faulty", then it is again represented in red or gray.
📊	This button switches between the histogram view and the connection view.
🗑	This button resets all histogram values and error counters of all involved nodes.

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A node is selected with a click of the mouse. It moves to the middle of the circle to make its relationships to other nodes easier to detect (particularly in the case of larger configurations).

Information!

*When "**Safe Link** input" is clicked on in the ASIMON monitor diagnostics, the selection changes to the corresponding node in the diagnostics of **Safe Link**.*

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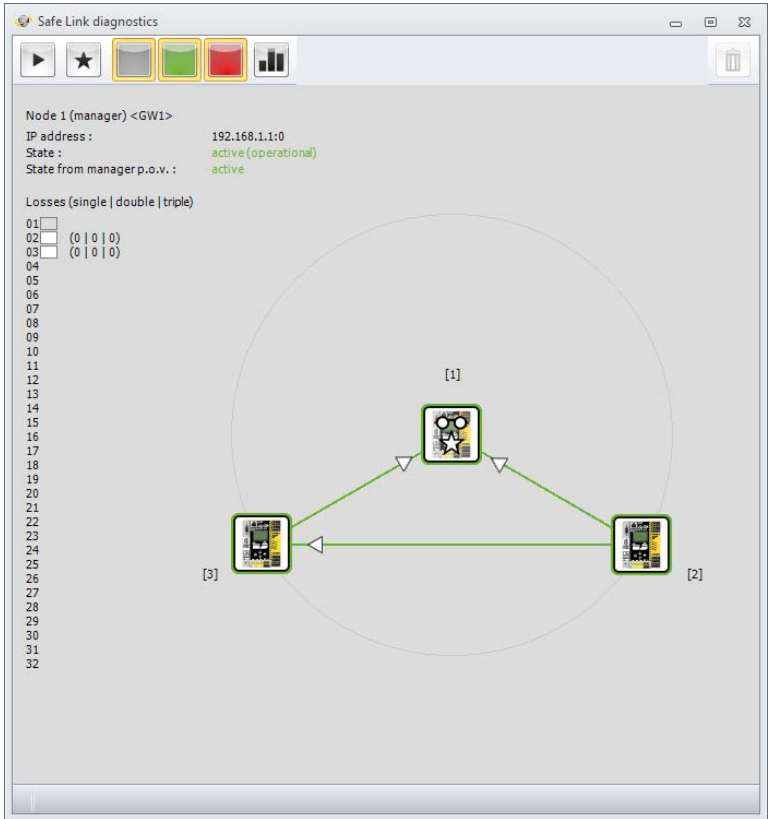
The information on this node is now displayed in the upper left area of the window:

- The address and the name of the device
- The IP address:
- The status reported by the node itself
- The status reported by the manager

Below is a listing of telegram error counters of the selected node:

Every line corresponds to the respective node address. If the node is present in the configuration of the **Safe Link**, a gray frame appears around the address. The nodes whose data is used by the selected device have a colored-in frame. The colors show the telegram error counters in traffic light form:

- white - no failure counters are accumulated
- green - single errors have occurred
- orange - double errors have occurred
- red - triple errors have occurred (switch-off).

The color of the critical event dominates the representation.

The data connections to other nodes are displayed as lines between the nodes. The direction of the data connection is indicated with an arrow on the line. In this example it can be seen that node 1 has relationships to the two other nodes. The arrows show that node 1 is the user of the data. The configuration of this device therefore has (at least one) '**Safe Link** input' device which refers to the other nodes. In other words, the node uses safe input bits from nodes 2 and 3.

Both relationships are represented in green. The input bits are correctly exchanged.

Information!

Each node can only give information about which data it is expecting and if it receives it. Data is sent connectionless via the multicast protocols. The transmitter does not receive feedback for its transmit data.

If a node has been selected, the ▮▮ button can be used to switch between the view of the connections and the histogram view.

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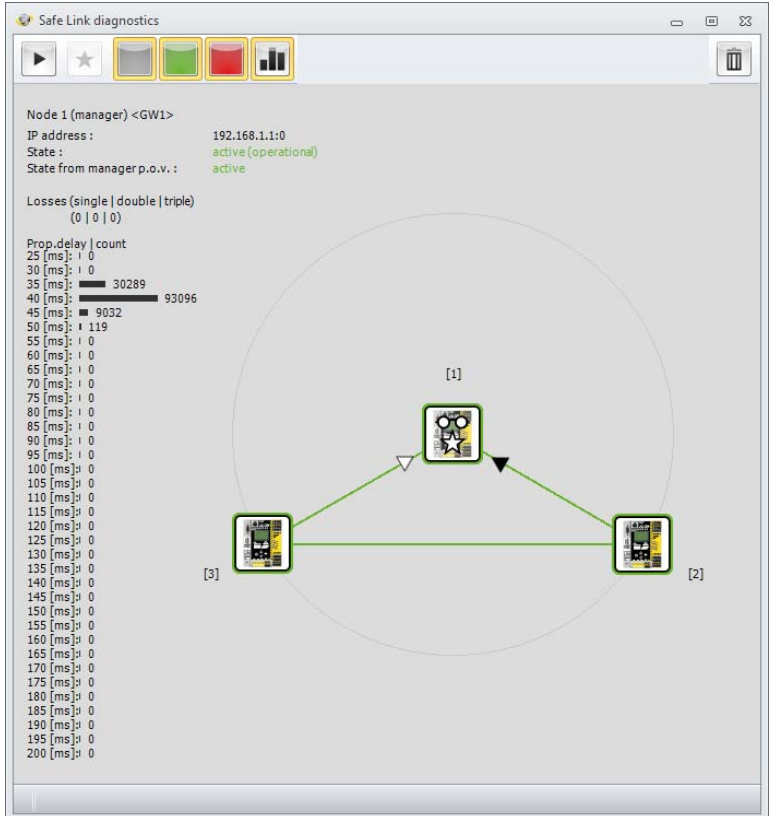
Now a connection between two nodes can be chosen in this representation by selecting the tip of the arrow of the connection. For this relationship, the estimated telegram propagation times from the perspective of the selected node now appear in the left-hand border of the image.

In addition, the telegram error counters for this one relationship are displayed above the histogram.

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The colors of the nodes and their relationships have the following meanings in the histogram view:

Color of the node:

- green: all telegram error counters '0'
- orange: single and/or double error counter
- red: triple error counter (this node had switch-offs)

Color of the lines:

- green: no error on this connection
- orange: single and/or double error on this connection
- red: triple error on this connection (switch-off due to this connection).

Information!

*In this view, only the **incoming** data connections to the selected nodes are marked with arrows, since data from the selected device can only be requested for these relationships. All other relationships are displayed with simple lines.*

The button with the trash can 🗑 resets **all** histogram values and error counters.

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The following graphic shows an example of a connection with the present error counters:
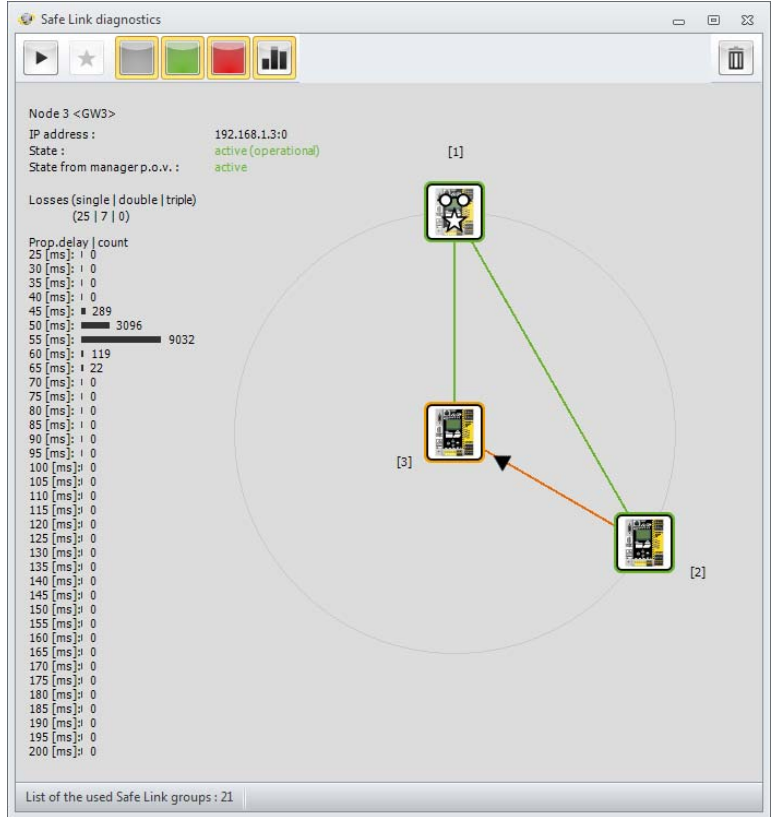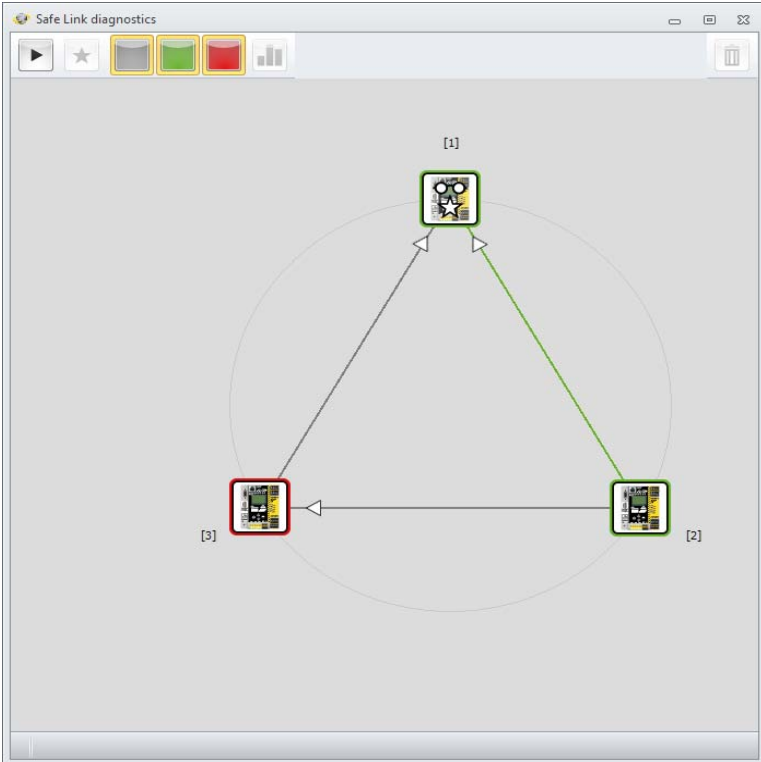

Information!

The term 'switch-off' in this chapter refers to switch-offs of the safety due to the connection quality of the **Safe Link**. *Switch-offs due to safety-oriented partici-pants are neither detected nor represented by this diagnostic form.*

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### 6.1.3   Example - 3 nodes, 1 node not taught

The following graphic shows the same setup, in which node 3 has not yet been taught / activated by the manager.

The overview shows node 3 with a red border and gray (missing) relationships.
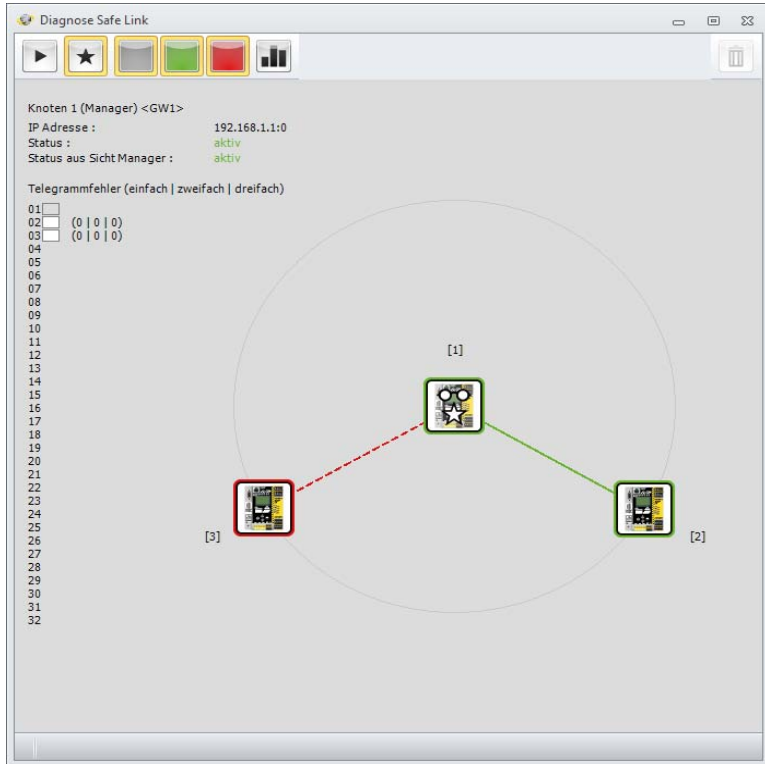

After the node has been selected, the corresponding information appears which, in this case, points directly to the problem.

The information view of the node displays that it is in the 'not taught' state.

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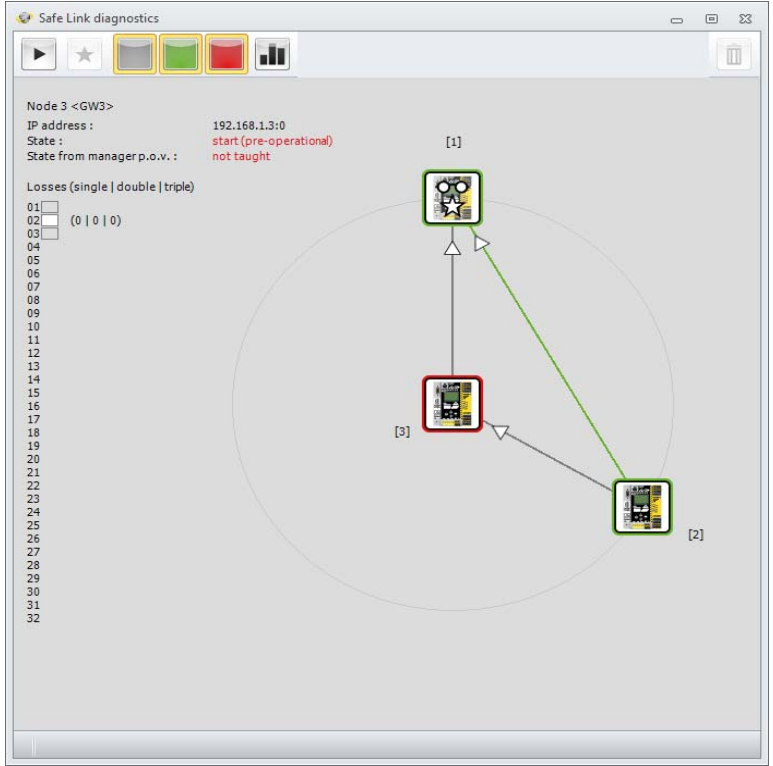
Selecting node 1 (manager) and switching to the 'Manager view' also results in the red connection to node 3 being displayed.

Information!

*The term 'Switch-off' in this section refers to safety switch-offs due to the connection quality of **Safe Link**. Switch-offs due to the safety nodes are not detected or shown by this diagnostic form.*

The colors of the manager view mean the following:

- green: 'active'
- gray: 'missing'
- red: 'present' but not activated.

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6.1.4 Diagnostic procedure

The cause of interference often lies in individual nodes or connections. In this case, it is wise to first find out in the overall view which devices or connections are not functioning correctly.

Information!

In the event that the configuration contains many nodes, it is wise to suppress the green lines with the corresponding button in the menu.

To then observe individual nodes, select the node and switch to the individual view.

Information!

It can happen that the data exchange between two nodes only works in one direction, meaning that both nodes can send data but only one node can also receive data. This then indicates the network communication is insufficient and is, for example, blocked by a switch, the multicast protocols.

During diagnostics, it is important that the **Safe Link** uses a different 'network channel' than the diagnostic tools. **Safe Link** uses the so-called multicast process in which all participants communicate via a certain target IP address and its packets from the network topology are distributed to the participants. Target-oriented protocols are used for diagnostics which are answered by the individual devices.

This makes it possible for the two types of data exchange to be handled differently by the network and for them to take different paths if necessary. Both of the following cases would be conceivable:

- Multicast protocols are partially blocked: **Safe Link** is not working or is incomplete. When the diagnostic communication is working, the participating nodes are nevertheless detected and their data is available. Some / all connections appear as faulty since the nodes could not establish **Safe Link**.

- Diagnostic protocols are blocked / do not reach all nodes. When the multicast domain is working, **Safe Link** can function, but the diagnostics fails. In this case, some nodes are displayed in gray and reported as missing.

6.1.5 Device replacement

The devices within the **Safe Link** group are identified among other things by the serial number. This means a new device must be re-taught when it replaces an existing one.

The correct procedure for replacing a device is described in the installation guide for the unit.

6.2   Problem handling/troubleshooting

If the **Safe Link** connection cannot be opened, perform the following steps:

- Are all the devices in the correct group and was the correct port for **Safe Link** set?

  This information can be accessed on the device in the menu *Safety* -> *Cross Comm.* in the sub-menus *Interface*, *Node Status*, *Manager Overview* and *Node Overview*. Alternately the **Safe Link** diagnostics can be used to check whether all devices are configured and accessible over the network. Here the diagnosis should be checked from the view of each node to ensure that every device can access all other nodes.

- Are the interface parameters (IP address, subnet mask, standard gateway and in case of a PROFINET gateway the PROFINET device name) assigned and are they correct?

- Are the IDs for all devices taught and was the teach procedure performed without error?

- If only individual nodes cannot be reached, does the error follow along when cross-replacing devices?

- In case of doubt perform a factory reset on each device, reset the interface parameters/addresses, then load the configurations back into each device and reteach **Safe Link**.

To troubleshoot sporadic errors and analyze the quality of the **Safe Link** connection, the following procedure is recommended:

- Is the **Safe Link** connection the real reason for the switch-off?

  This can be determined from the switch-off history of the monitor (**Safe Link** input bit is gray) or on the device in the menu *Safety* -> *Cross Comm.* -> *Node Overview Hist.*

- Carry out a **Safe Link** diagnostics over a longer period of time:
    - Is the estimated age of the telegrams within the expected limits (average/maximum)?
      If *no*, the throughput time over the network as well as the other network load should be checked.
    - Are there telegram errors (single/double/triple)?
      If *yes*, the cause could be EMC (telegrams are corrupted), mechanical problems with the cable (telegram loss) or a wrong switch (telegrams are rejected or delayed too long).

- In case of error, a network analyzing tool (e.g. Wireshark) can be used on the mirror port of the switch to analyze the pause times between individual telegrams.

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