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APPLICATION EXAMPLE

Setup and Configuration of Redundancy Using PRP and HSR

SCALANCE XC300, XR300, XC400, XR500, CP 443-1 RNA, SOFTNET-IE RNA

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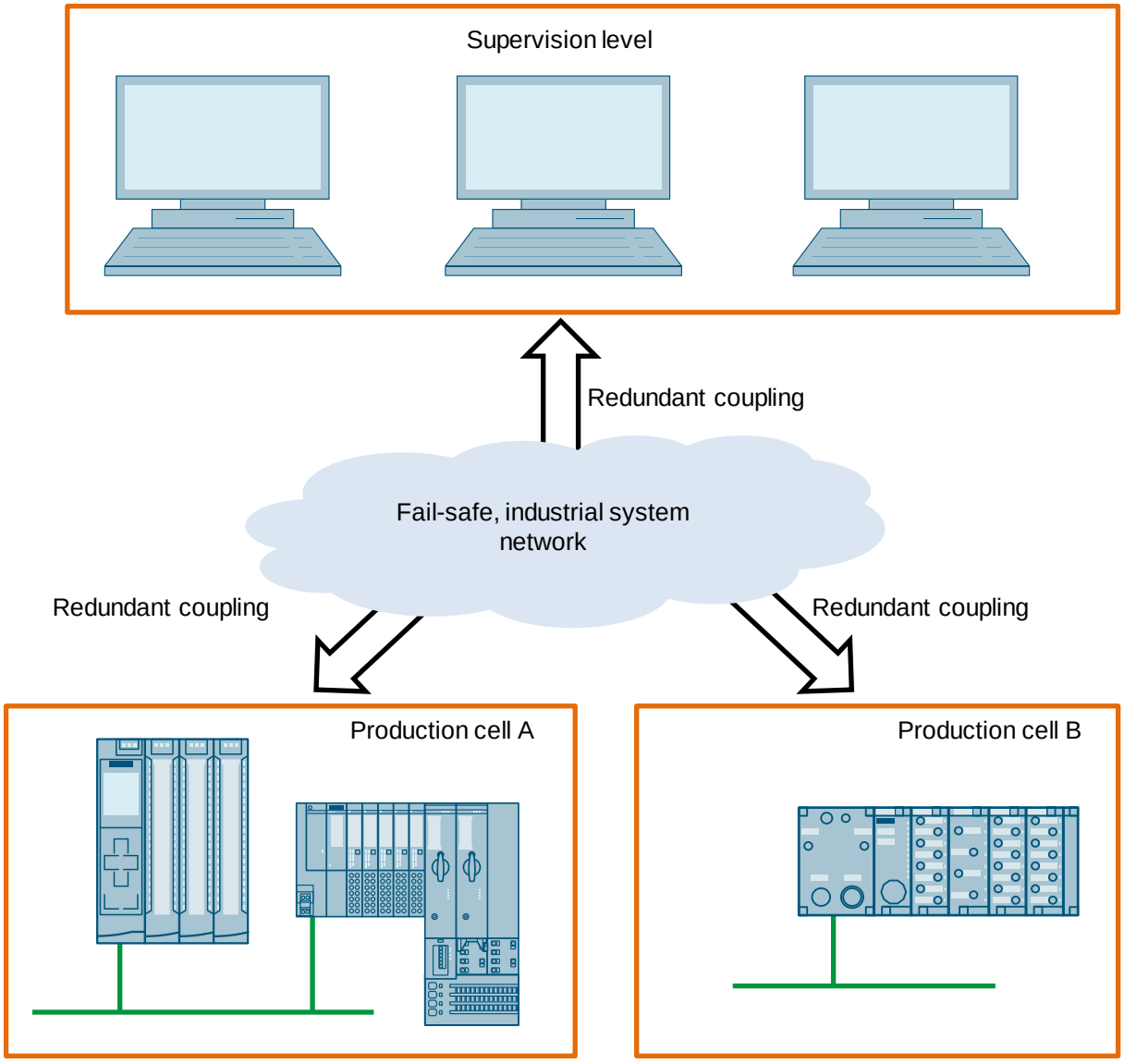
1. Introduction

1.1. Overview

The rising level of automation of industrial plants, with the focus set on enhancing productivity and quality, also increases dependence on the availability of automation systems. The failure of an automation system (e. g., due to the failure of a CPU) or the network connection (e. g., due to cable breakage) can result in high costs due to downtime and the loss of production.

To counteract this, it is very important to implement a redundancy procedure that guarantees system availability even in the event of an error. There are a variety of redundancy options with different solution and implementation approaches. The application essentially determine which mechanism is used is.

If Ethernet is used in automation, special protocols and associated hardware must ensure availability. Time- and safety-critical applications in systems (e. g., in power distribution, power plant and ship automation, tunnel construction) do not tolerate downtime. In these cases, implementation of seamless redundancy without switchover times is the highest priority.



To ensure full network functionality despite component or link failure, an automation system is equipped and configured with a redundancy procedure. The redundancy procedure prevents a single error from bringing the system to a standstill and ensures that communication is still guaranteed.

In all redundantly designed systems, monitoring is extremely important. A failure means a loss of redundancy which must be detected, located, and repaired before a second failure happens. For this reason, various diagnostic options must be implemented in the automation system.

In this application example, we describe how to set up a system network redundantly to enable seamless redundancy and meet the following requirements:

- In the event of a component or network connection failure, data transmission continues without interruption.
- In the event of a fault, the application continues to operate unaffected.
- The network is not hindered or overloaded by duplicate frames or looping.
- Transparency, compatibility, and investment security are guaranteed by utilizing standardized protocols.
- In the event of a fault, the cause of the error can be quickly detected and localized.

In the application example, we show possible reactions from the redundancy devices to the detection of a network fault.

- Error indication via LEDs for hardware components
- Statistics display in the Web Based Management (WBM) of the components
- Visualization through redundancy status display for software components
- Network information via the Simple Network Management Protocol (SNMP)

1.2. Components Used

This application example was created with the following hardware and software components:

Components	Quantity	Article number	Note
PRP und HSR			
PS 407 4A	1	6ES7407-0DA02-0AA	
CPU 416-3 DP	1	6ES7416-3XR05-0AB0	S7-400 CPU as of firmware V5.3.2
CP 443-1 RNA	1	6GK7443-1RX00-0XE0	• Firmware V1.4.1 • As of SIMATIC STEP7 V5.5 SP3, the module is integrated in STEP7. The module cannot be configured in the TIA Portal.
CPU 1513-1 PN	1	6ES7513-1AL01-0AB0	Firmware V2.8
STEP 7 V5.6 SP2	1	6ES7810-4C.11-..	
TIA Portal V19	1	• DVD: 6ES7822-1AA23-0YA5 • Download: 6ES7822-1AE23-0YA5 • Upgrade: 6ES7822-1AA23-0YE5	
PRP			
SCALANCE XC332	2	6GK5332-0GA00-2AC2	Firmware V1.2.2 Alternatively, switches from the SCALANCE XC300, XR300, XC400 and XR500 model series can also be used.
SCALANCE XB208	2	6GK5208-0BA00-2AB2	Firmware V4.2
SOFTNET IE-RNA V19 DL	1	6GK1711-1EW23-0AK0	Gigabit Ethernet network adapters can be used to connect PCs to a PRP network. It is necessary that the Gigabit Ethernet network adapters support long Ethernet frames (jumbo frames).
HSR			
SCALANCE XC332	4	6GK5332-0GA00-2AC2	Firmware V1.2.2 Alternatively, switches from the SCALANCE XC300, XR300, XC400 and XR500 model series can also be used.

The listed components can be purchased (e. g., via the Siemens Industry Mall).

1.3. RNA (Redundant Network Access)

The RNA concept is used to implement the requirements.

At Siemens Industry, RNA stands for the implementation of redundancy solutions in hardware and software. RNA includes the following redundancy procedures, which are standardized in IEC 62439-3:

- PRP: Parallel Redundancy Protocol
- HSR: High-availability Seamless Redundancy Protocol

The PRP and HSR redundancy procedures are protocols for compensating for line and module failures in the network.

The great advantage of PRP and HSR is the uninterrupted switching, which avoids any switching time in the event of an error and thereby offers the highest possible availability.

The basis for this is the double transmission of the frames in two directions.

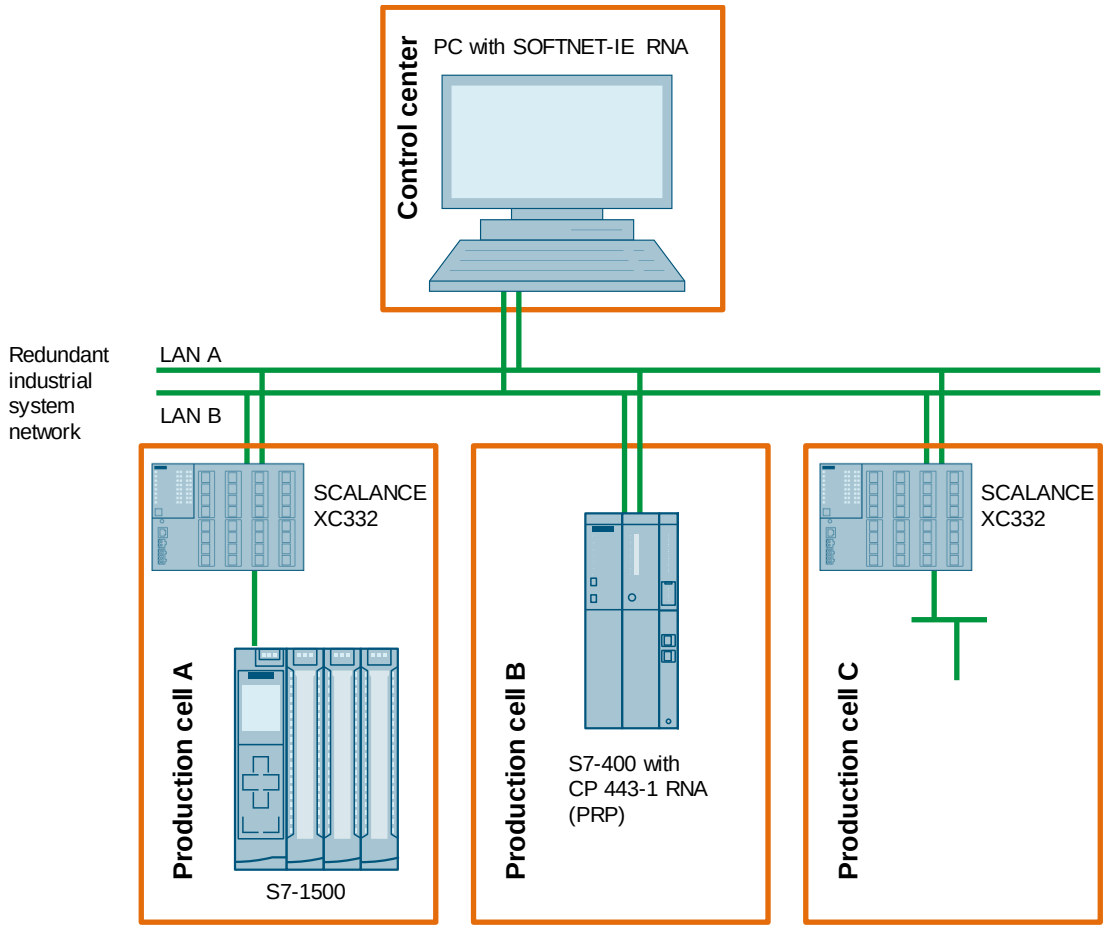
The receiver, therefore, receives two identical frames in error-free operation. The redundancy protocol ensures that it only uses the first frame and discards the second.

If only one frame is received, the receiver knows that a failure has occurred on the other connection and reacts accordingly.

Detailed information on PRP and HSR can be found in Section 5.1.

2. Installation Options

2.1. RNA with PRP



In the PRP redundancy procedure, a redundant network (RNA) consisting of two separate network topologies is set up.

In this application example, the following devices, which have two RNA interfaces, are connected to two independent networks (LAN A and LAN B):

- SIMATIC NET SOFTNET-IE RNA
- CP 443-1 RNA
- SCALANCE XC332

It is possible to connect end devices or production cells that do not support the redundancy procedure (e. g., S7 CPUs) to a SCALANCE XC332.

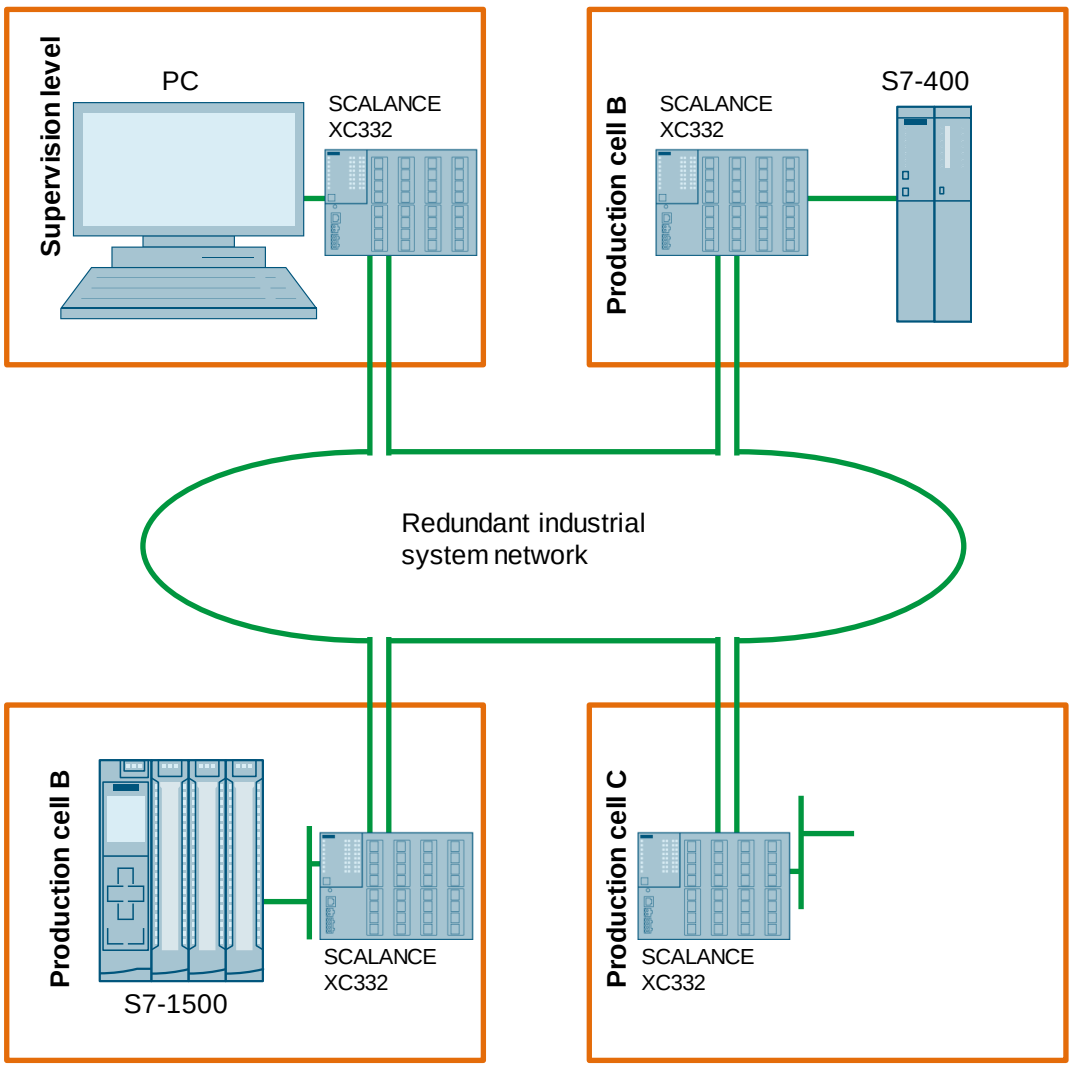
The redundant, parallel network structure is based on the PRP mechanism standardized in IEC 62439-3.

Detailed information about PRP can be found in the Section 5.1.1.

Advantages and customer benefits

- Very high system availability due to parallel data transmission via separate network structures
- Can also be used in time-critical applications due to seamless switching
- High flexibility in network construction, as the network topology can be structured as line, tree, star, or ring
- Integration into network management systems possible
- Fast commissioning without mandatory configuration

2.2. RNA with HSR



In the HSR redundancy procedure, a redundant communication structure is set up in the form of a ring topology.

In this application example, the following components are redundancy devices and have two RNA interfaces to connect network segments to the ring structure:

- SCALANCE XC332

The redundant ring structure is based on the HSR mechanism standardized in IEC 62439-3.

Detailed information about HSR can be found in Section 5.1.2.

Advantages and customer benefits

- Very high system availability thanks to parallel data transmission in a ring topology
- Can also be used in time-critical applications due to seamless switching
- Integration into network management systems possible
- Fast commissioning without mandatory configuration

2.3. Configuration modes

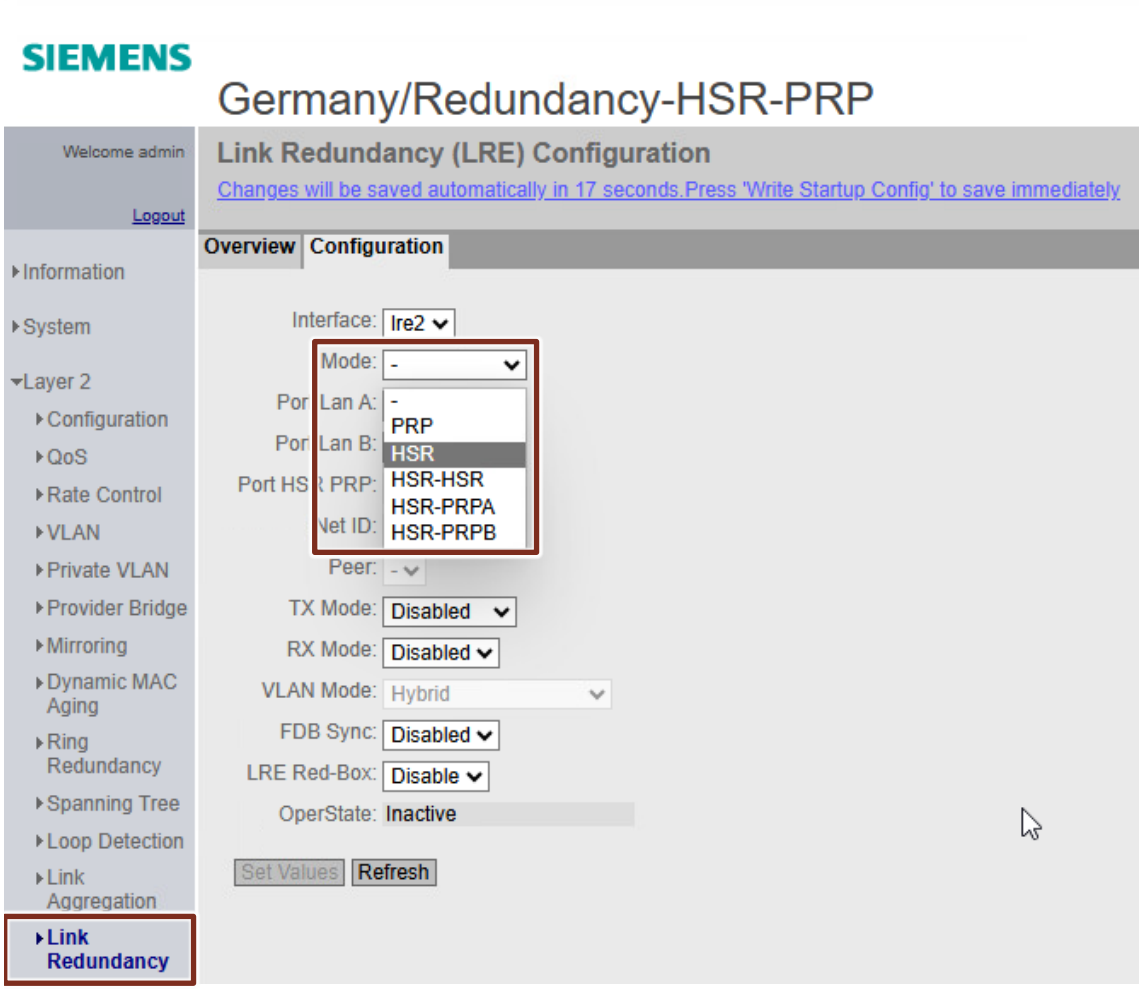
The SCALANCE models with PRP or HSR functionality are used to connect end devices or network segments without PRP or HSR capability to a PRR network setup or HSR ring.

It is also possible to use the corresponding SCALANCE switches of the XC300, XR300, XC400 and XR500 series in an HSR ring as a coupling link between a PRP network and the HSR ring.

The different modes are set in the WBM of the SCALANCE XC332. You can reach the WBM via https://{IP address}.

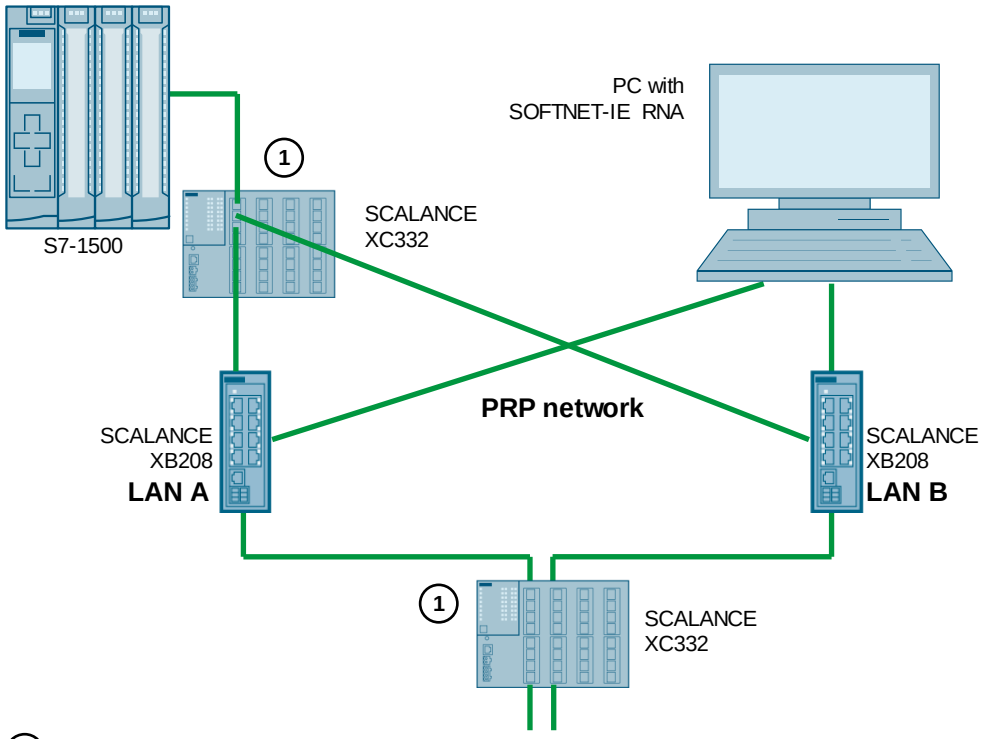
The following modes can be set:

- PRP mode
- HSR mode
- HSR-HSR mode
- Redundant HSR PRP coupling, LAN A
- Redundant HSR PRP coupling, LAN B



PRP

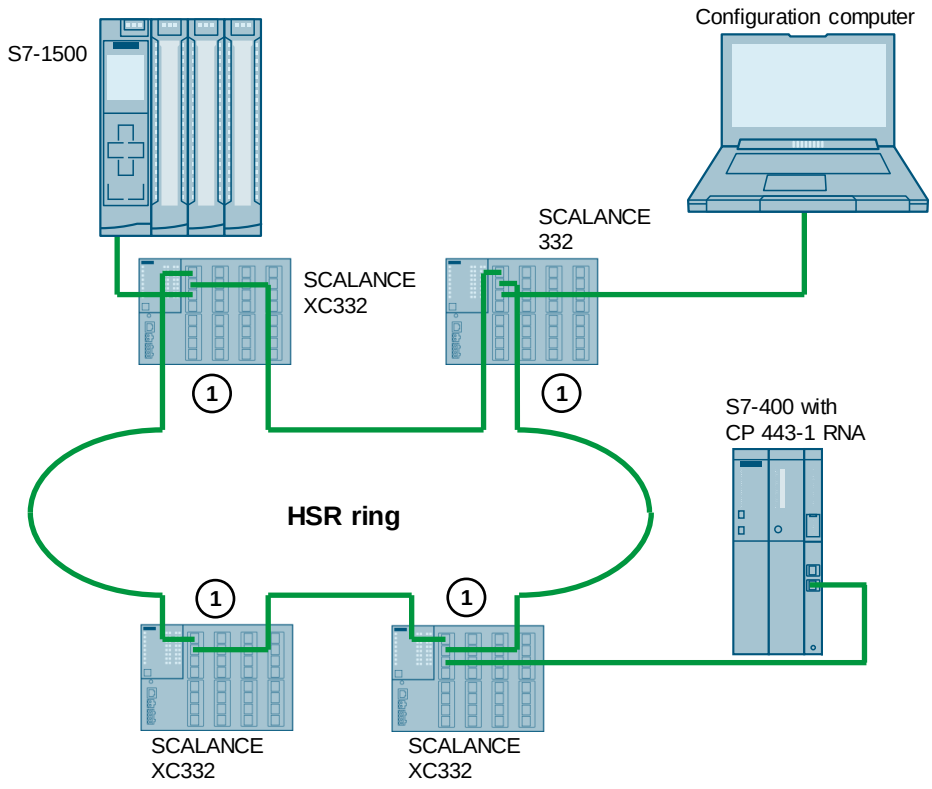
In the PRP redundancy method, a redundant network (RNA) consisting of two separate network topologies of the PRP redundancy network is connected to end devices or network segments that are not PRP-capable.



1 PRP mode

HSR

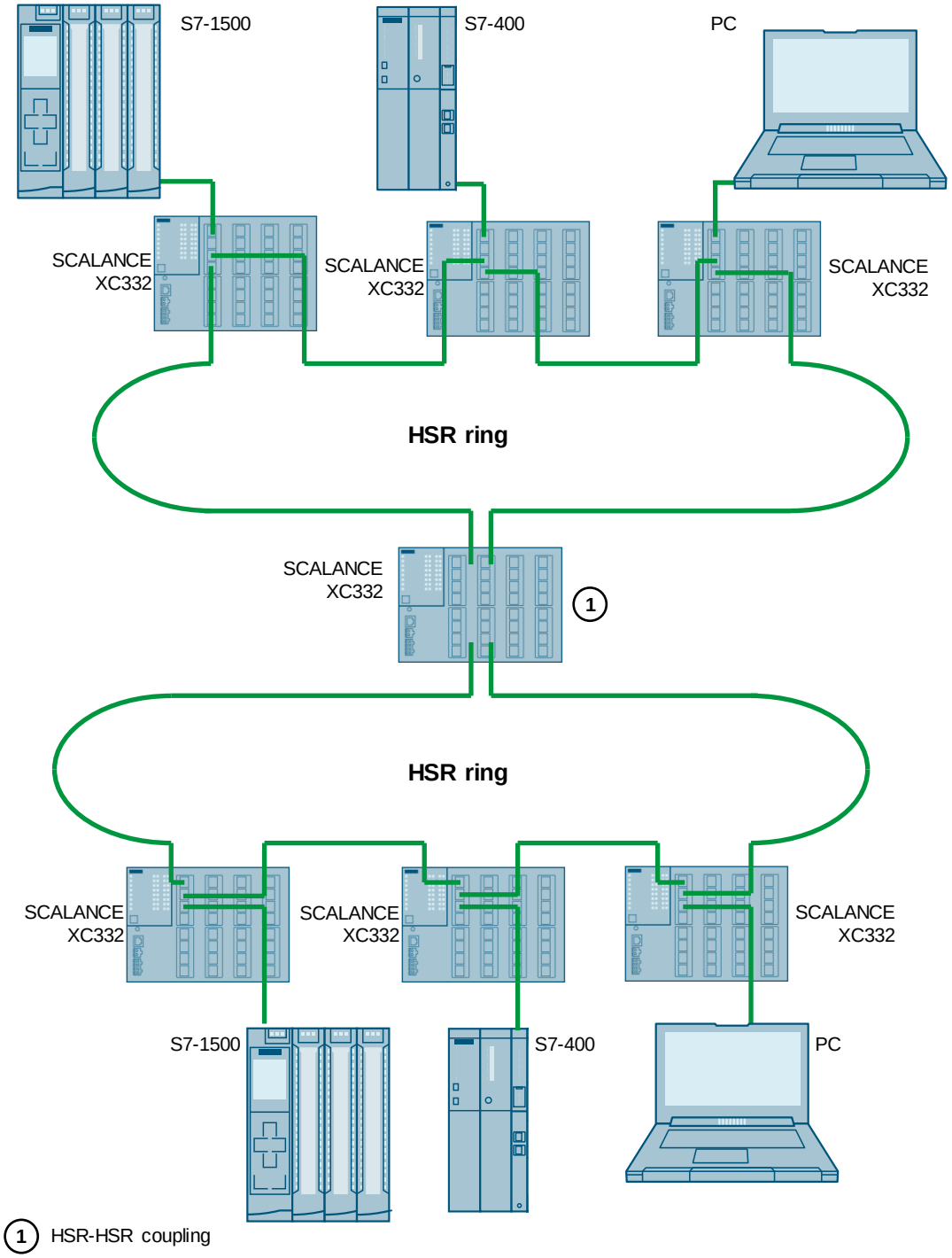
The HSR ring is connected to end devices or network segments that are not HSR-capable.



1 HSR mode

HSR-HSR coupling

The SCALANCE XC332 switch offers the possibility to have two HSR rings communicate with each other.

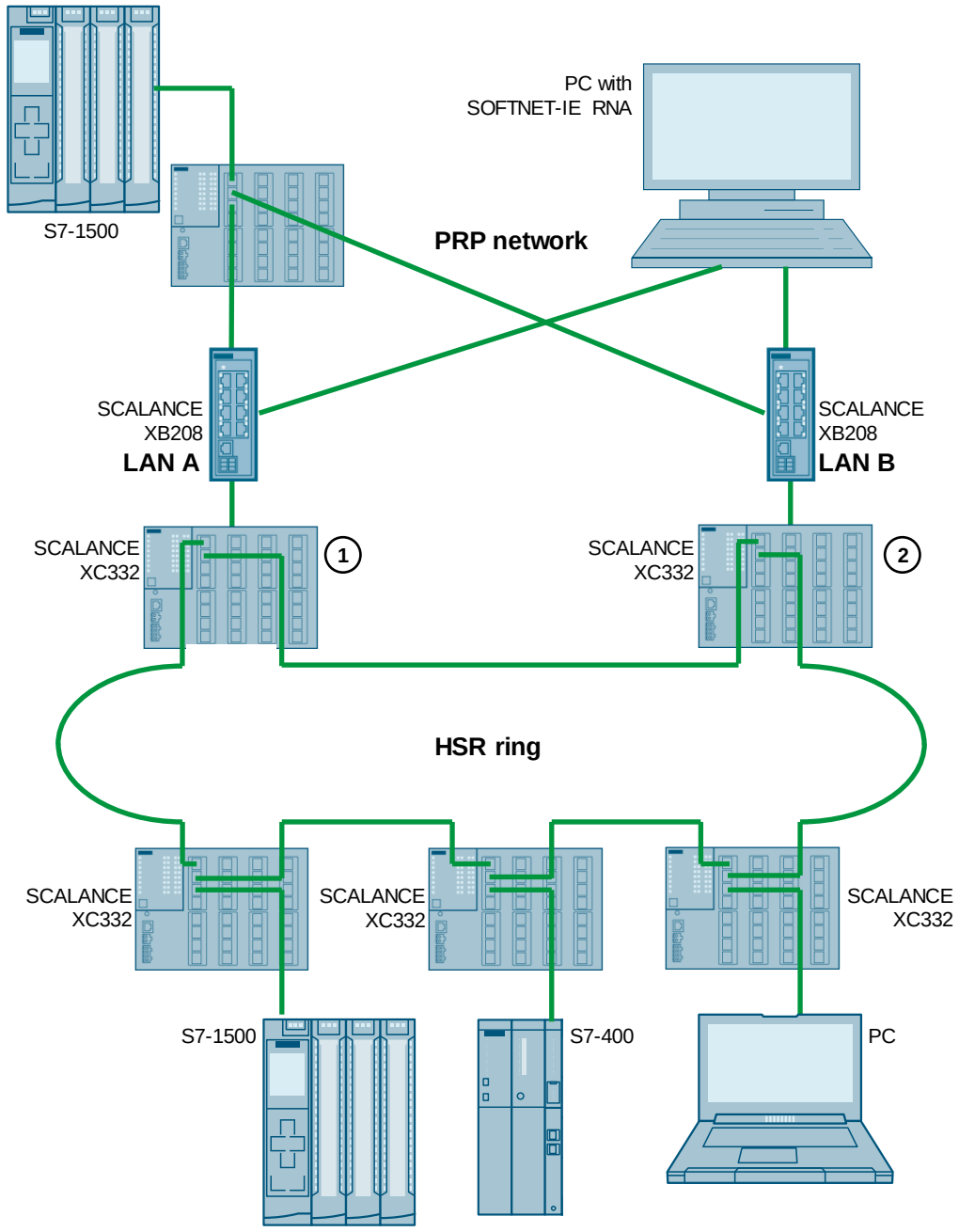


Redundant HSR PRP coupling, LAN A

Use this mode for redundant coupling of the HSR ring and PRP mesh. HSR-PRPA is connected to LAN A of a PRP network. HSR-PRPB is open and may not be used.

Redundant HSR PRP coupling, LAN B

Use this mode for redundant coupling of the HSR ring and PRP mesh. HSR-PRPB is connected to LAN B of a PRP network. HSR-PRPA is open and may not be used.



1 Redundant HSR PRP coupling, LAN A

2 Redundant HSR PRP coupling, LAN B

Detailed information about HSR-PRP coupling can be found in Section 5.1.3 and in the device manual for SCALANCE XC332 (see Section 6.2).

2.4. SIMATIC NET Product Portfolio for RNA

Overview

SIMATIC NET offers the following components in its product portfolio, which are ideally suited for use in time- and safety-critical applications due to their support of the PRP and HSR protocols:

- SCALANCE XC300, XR300, XC400 and XR500 series
- CP 443-1 RNA
- PC station with SOFTNET-IE RNA
- RUGGEDCOM RSG907R
- RUGGEDCOM RSG909R
- RUGGEDCOM RST2228
- PRP-capable protection devices SIPROTEC (EN100 module with LC connections and application status as of V4.1x)
  Detailed information can be found via the following link: http://www.siprotec.com

NOTE Detailed information on the modules can be found in the corresponding device manuals (see Section 6.2).

SCALANCE XC300 Serie

The SCALANCE XC300 series (here the SCALANCE XC332 switch) has several ports that are available for PRP or HSR functionality. Up to two different redundancy networks can be created, which can be used in a different mode (see chapter 2.3) can be used in parallel.

Two free ports are required for configuration per PRP or HSR redundancy network.

CP 443-1 RNA

The CP 443-1 RNA has the following interfaces:

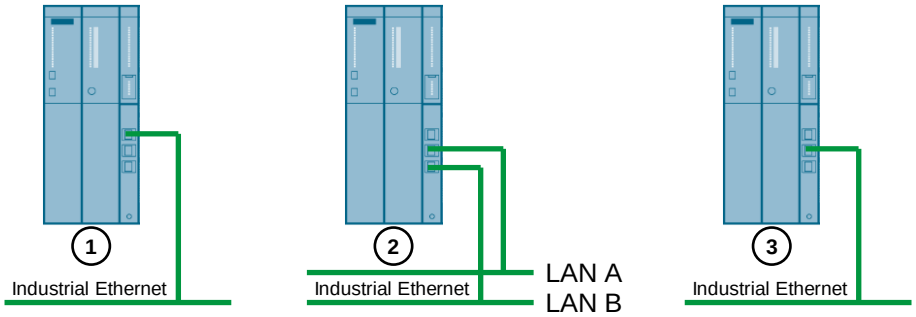
- Ethernet interface:
  A standard Ethernet port as an alternative to the PRP ports (e.g., for connecting a PG, a PC, or a superordinate company network)
- RNA interface:
  Two independent PRP ports for connection to LAN A and LAN B, operable as follows:
  - PRP operation with both ports as redundancy solution
  - Port 1 as the only used port of the RNA interface (port 2 is disabled)

NOTE

The Ethernet interface or the RNA interface can only be activated alternatively. Parallel use of both interfaces is not possible.

The setting of the active interface happens in the properties of the CP (see Section 3.2.3).

The following figure shows the connection variants of the CP 443-1 RNA:



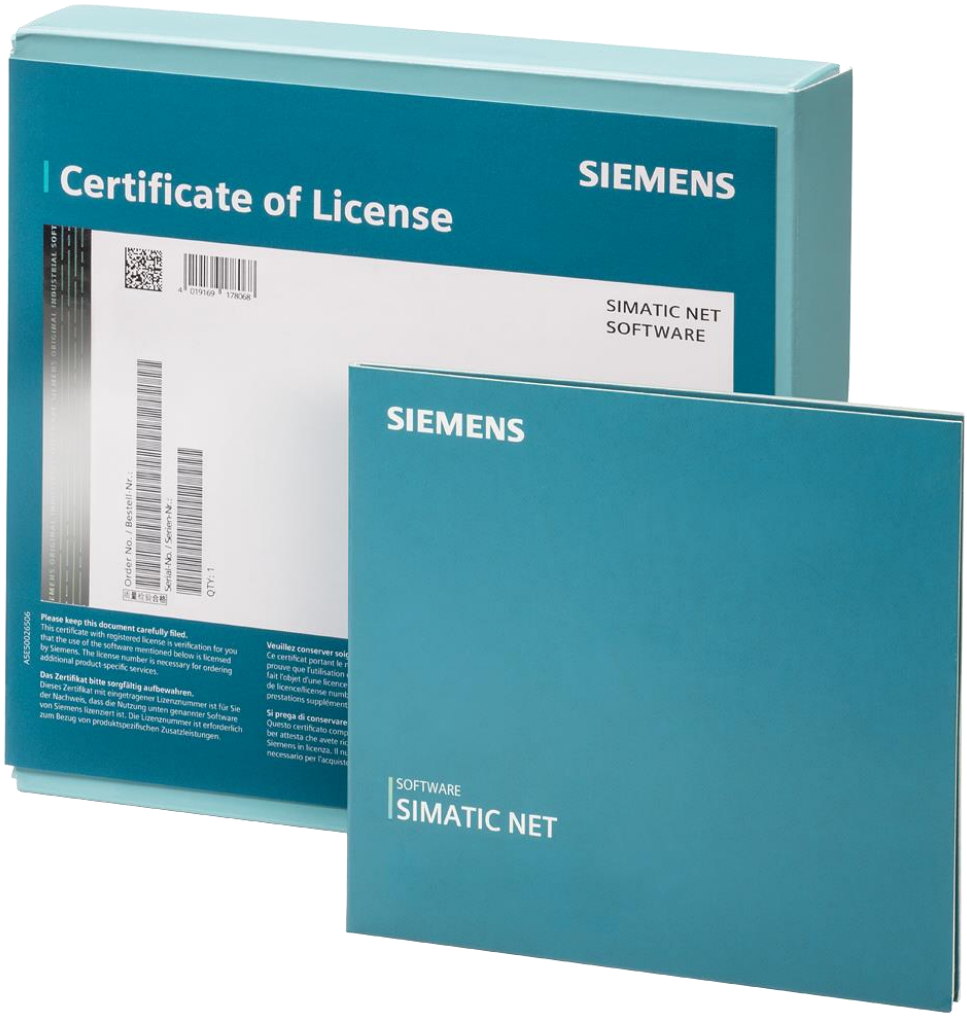
No.	Description
1	Connection to port X1P1 of the Ethernet interface (ISO transport)
2	Connection of the RNA interface to a PRP network
3	Connection to port X2P1 of the RNA interface (ISO transport/ISO-on-TCP/TCP)

The CP 443-1 RNA enables the data request at the RNA interface via SNMP in version V1. It provides the contents of certain MIB objects according to Standard MIB-II (RFC 1213), PRP MIB IEC62439 (IEC-62439-3-MIB), and Automation MIB.

If SNMP is needed (e. g., for diagnostic purposes), it is necessary to activate this in the properties of the CP (see Section 3.2.3).

In order to use the CP443-1 RNA as a terminal device with PRP function, which has one connection to each of the two independent networks (LAN A or LAN B), it is necessary to enable the PRP function in the properties of the RNA interface (see Section 3.2.3).

SOFTNET-IE RNA



Using the software "SOFTNET-IE RNA", two real Ethernet network adapters of the PC can be configured into one virtual RNA adapter. If an application uses a virtual RNA adapter, then the Ethernet communication takes place simultaneously via these two real Ethernet network adapters. Ethernet communication takes place based on PRP mechanisms.

The "SOFTNET-IE RNA" software requires the following points for operation in PRP networks:

- Two Gigabit Ethernet network adapters in the PC
- Administrator rights for the installation
- Exactly one software license per PC and product

RUGGEDCOM RSG907R

The RUGGEDCOM RSG907R is a fully managed Ethernet switch with integrated HSR/PRP RedBox.

The RUGGEDCOM RSG907R has the following interfaces:

Port	Type	Description
A and B	SFP transceiver	These ports allow the device to be connected to a PRP network or to an HSR ring.
1 to 4	Ethernet ports in fiber-optic technology	These ports allow access to the local area network (LAN).
5	SFP transceiver	The coupler port is used for the following purposes: • Connect a RUGGEDCOM RSG909R or RUGGEDCOM RSG907R to connect two HSR rings • Connecting regular Ethernet end devices to HSR or PRP networks • Connecting an HSR ring to a PRP network and vice versa • Connect the HSR ring to a Rapid Spanning Tree Protocol (RSTP) network

RUGGEDCOM RSG909R

The RUGGEDCOM RSG909R is a fully managed Ethernet switch with integrated HSR/PRP RedBox.

The RUGGEDCOM RSG909R has the following interfaces:

Port	Type	Description
A and B	SFP transceiver	These ports allow the device to be connected to a PRP network or to an HSR ring.
1 to 6	Ethernet ports in copper technology	These ports allow access to the local area network (LAN).
7	SFP transceiver	The coupler port is used for the following purposes: • Connect a RUGGEDCOM RSG909R or RUGGEDCOM RSG907R to connect two HSR rings • Connecting regular Ethernet end devices to HSR or PRP networks • Connecting an HSR ring to a PRP network and vice versa • Connect the HSR ring to a Rapid Spanning Tree Protocol (RSTP) network

RUGGEDCOM RST2228

The RUGGEDCOM RST2228 is a compact Fully Managed Ethernet Switch. The highly modular RUGGEDCOM RST2228 switch supports up to 28 interfaces.

The RUGGEDCOM RST2228 has the following interfaces:

Port	Type	Description
0	SFP/SFP+ transceiver	Port 0 has four sockets for smaller pluggable transceivers (SFP)
1 to 6	Field replaceable modules	There are numerous modules available, each equipped with ports of a specific type: • Ethernet in copper technology • Ethernet in fiber-optics and SFP The RUGGEDCOM RMM2972-2RNA module is used to connect the device to a PRP network or to an HSR ring. It is equipped with 2 SFP sockets.

2.5. Diagnostics Options

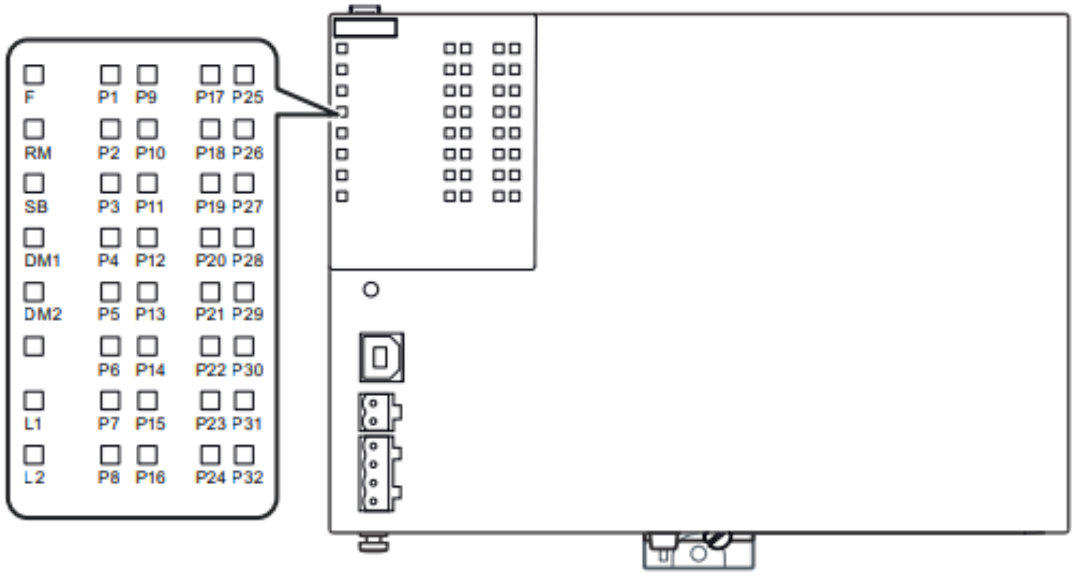
To receive indications of errors in the redundancy network, the SIMATIC NET components offer different possibilities.

2.5.1. Overview

SCALANCE XC332

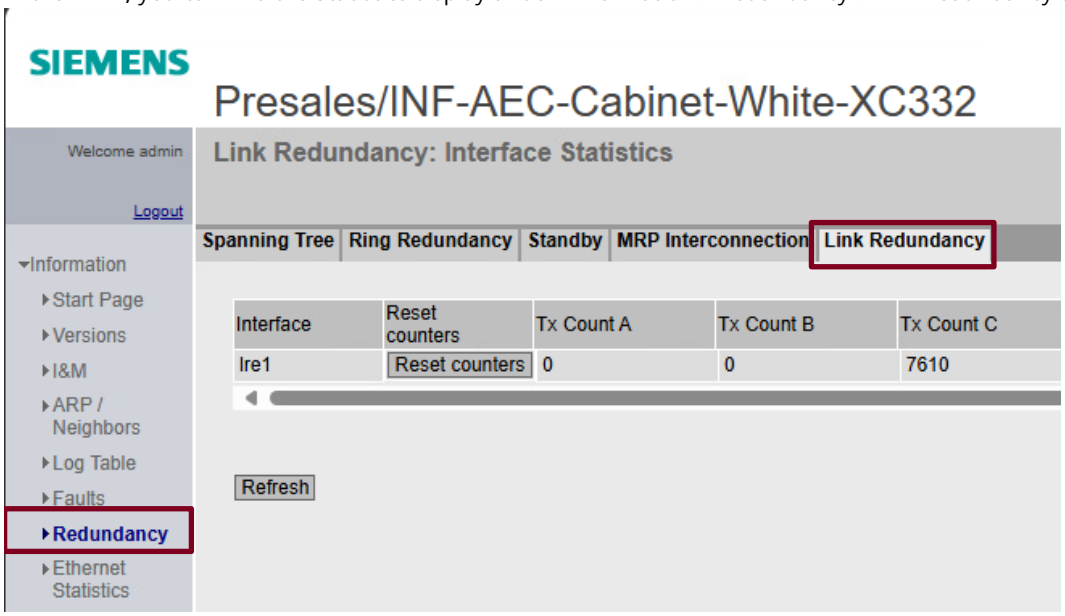
The SCALANCE XC332 offers the following diagnostic options:

- LED displays
  Detailed information on the LED indicators can be found in the device manual (see Section 6.2).



- Statistics display

  In the WBM, you can find the Statistics display under "Information > Redundancy > Link Redundancy".



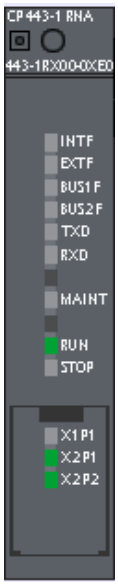
  Detailed information on the Statistics display can be found in Section 2.5.2 and in the device manual (see Section 6.2).
- Troubleshooting via the WBM

- Notification when an error occurs:
  - Email (SMTP)
  - SNMP-Traps
  - Syslog
- SNMP V1, V2, V3 (including PRP-MIB IEC62439 (IEC-62439-3-MIB))

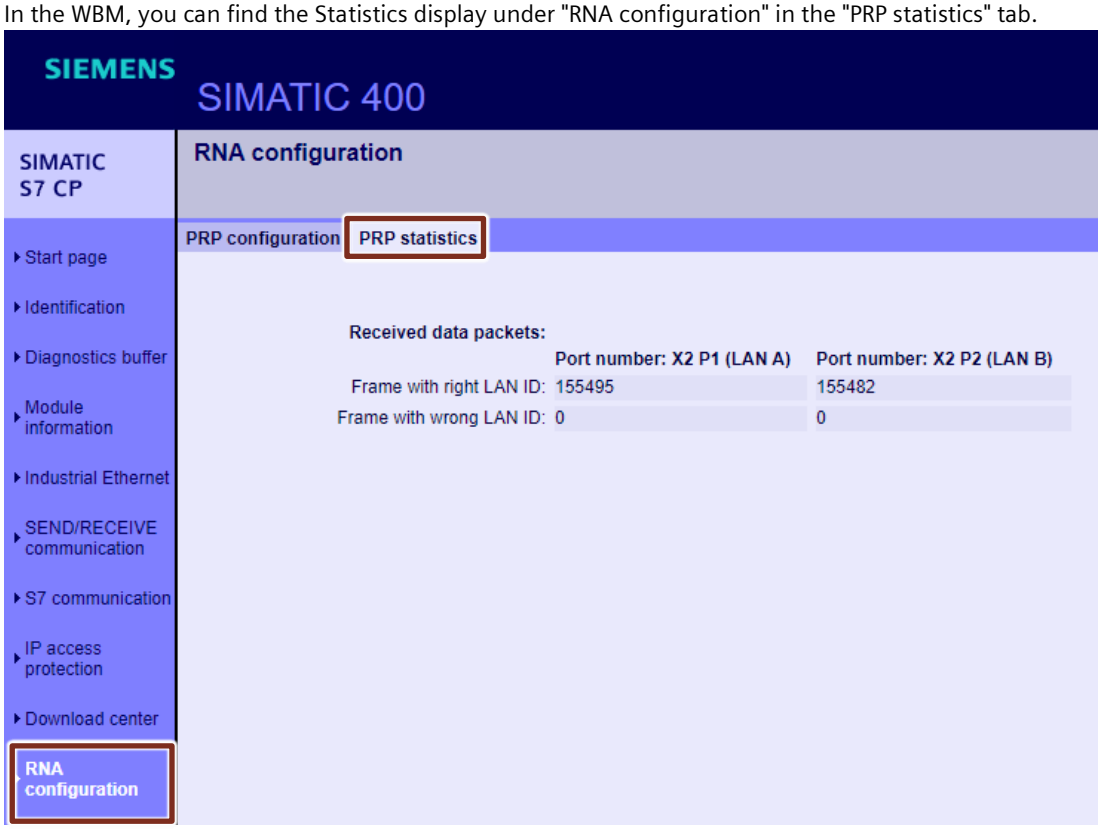
CP 443-1 RNA

The CP 443-1 RNA offers the following diagnostic options:

- LED displays
  Detailed information on the LED indicators can be found in the device manual (see Section 6.2).



- Statistics display
  In the WBM, you can find the Statistics display under "RNA configuration" in the "PRP statistics" tab.

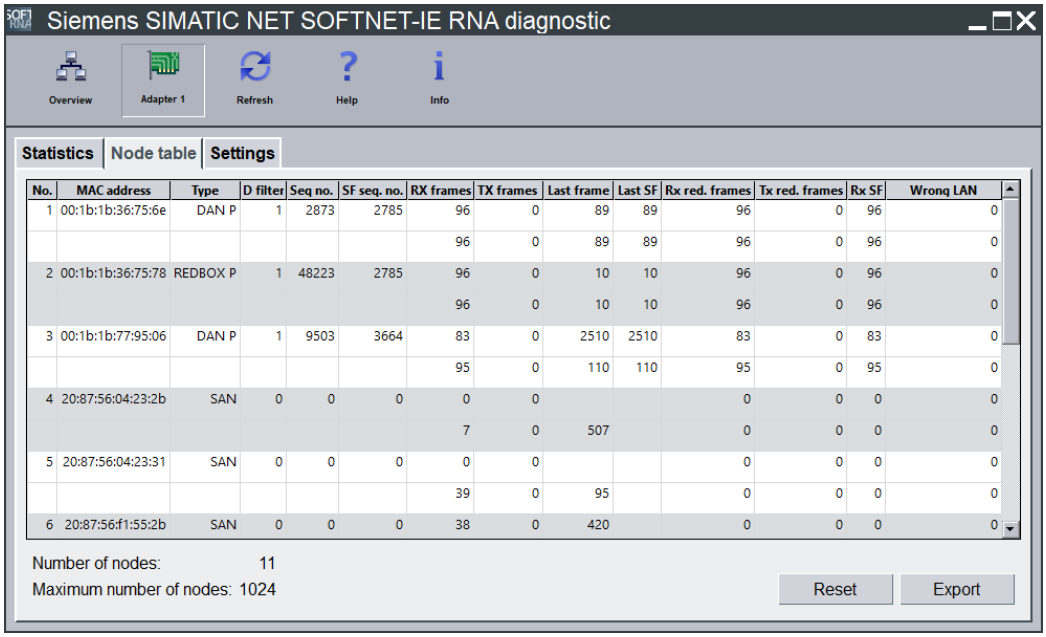


- Detailed information on the Statistics display can be found in Section 2.5.2 and in the device manual (see Section 6.2).
- Diagnostics with STEP 7
- Diagnosis of the communication with the NCM S7 diagnostics
- Diagnosis via WBM
- SNMP (including PRP-MIB IEC62439 (IEC-62439-3-MIB))
- IP double address detection

SOFTNET-IE RNA

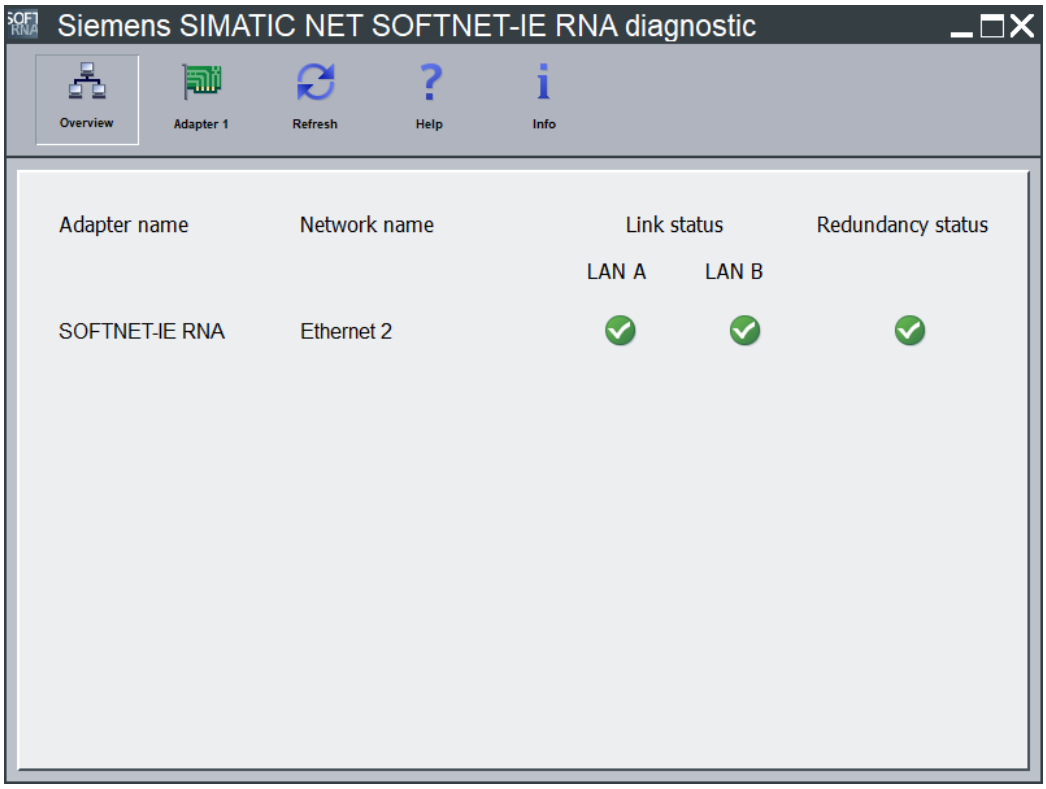
The SOFTNET-IE RNA software offers the following diagnostic options:

- SNMP (including PRP-MIB IEC62439 (IEC-62439-3-MIB))
- "SOFTNET-IE RNA diagnostic" is used for the following tasks:
  - System setup
  - Monitoring system for indications of errors in the redundant network
    In the Node table of the "SOFTNET-IE RNA diagnostic", it is possible to monitor the PRP communication of all devices in the PRP network.

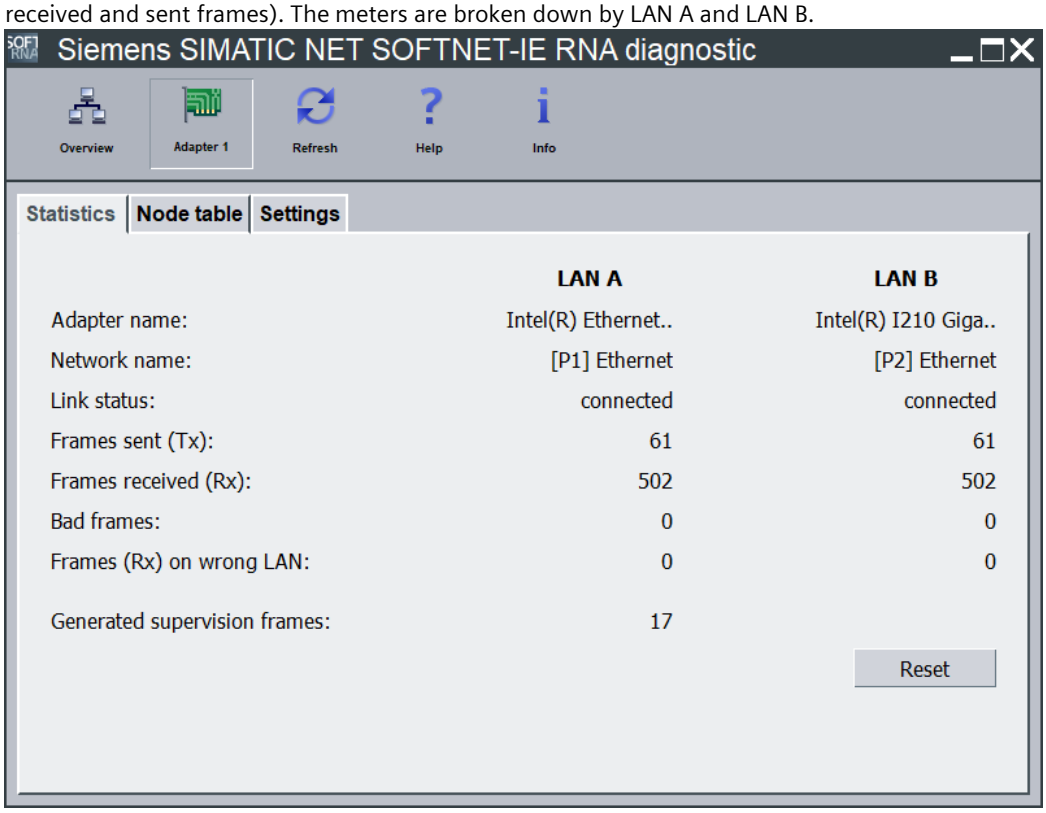


No.	MAC address	Type	D filter	Seq no.	SF seq. no.	RX frames	TX frames	Last frame	Last SF	Rx red. frames	Tx red. frames	Rx SF	Wrong LAN
1	00:1b:1b:36:75:6e	DAN P	1	2873	2785	96	0	89	89	96	0	96	0
						96	0	89	89	96	0	96	0
2	00:1b:1b:36:75:78	REDBOX P	1	48223	2785	96	0	10	10	96	0	96	0
						96	0	10	10	96	0	96	0
3	00:1b:1b:77:95:06	DAN P	1	9503	3664	83	0	2510	2510	83	0	83	0
						95	0	110	110	95	0	95	0
4	20:87:56:04:23:2b	SAN	0	0	0	0	0			0	0	0	0
						7	0	507		0	0	0	0
5	20:87:56:04:23:31	SAN	0	0	0	0	0			0	0	0	0
						39	0	95		0	0	0	0
6	20:87:56:f1:55:2b	SAN	0	0	0	38	0	420		0	0	0	0

  - Check redundant communication and network connections
    The link and redundancy status are displayed in the "SOFTNET-IE RNA diagnostic" overview. With the help of the link and redundancy status, you can detect a redundancy or connection error.



- Evaluate the Statistics display
  Important diagnostics are displayed in the statistics tab in the SOFTNET-IE RNA diagnostics (e. g., number of received and sent frames). The meters are broken down by LAN A and LAN B.



- Detailed information about the Statistics display can be found in Section 2.5.2.

NOTE Detailed information on "SOFTNET-IE RNA diagnostic" can be found in the manual (see Section 6.2).

RUGGEDCOM

RUGGEDCOM RSG907R, RSG909R, and RST2228 offer the following diagnostic options:

- LED display
- Troubleshooting via RUGGEDCOM ROS

NOTE Detailed information on the diagnostic options for the RUGGEDCOM RSG907R, RSG909R, and RST2228 can be found in the FAQ 109780236 and in the device manuals (see Section 6.2).

2.5.2. Statistics display

The Statistics display in RNA-capable devices provide information about the number of frames in the PRP network or HSR ring.

Devices with PRP Function

The SCALANCE switches of the XC300, XR300, XC400 and XR500 series perform the following measurements, among others (detailed information can be found in the manual for the WBM \8\):

- Number of frames sent from port A/B/C
- Number of frames received from port A/B/C that were destined for another port
- Number of frames received from port A/B/C
- Number of bad frames per port
- Number of received frames per port generated by the device itself (HSR mode only)

NOTE Port C includes all ports to which end devices are connected. The Port C information listed in the table is the total statistics collected across all interlink ports.

NOTE If all ports are networked correctly, the measurements that indicate an error will return the value zero "0" in the statistics display.

Devices with PRP Function

The CP 443-1 RNA and SOFTNET-IE RNA perform the following measurements:

- Number of telegrams received (identifier "LAN A") at PRP port A (LAN A)
- Number of telegrams received (identifier "LAN B") at PRP port B (LAN B)
- Number of telegrams received (identifier "LAN A") at PRP port B (LAN B) (error)
- Number of telegrams received (identifier "LAN B") at PRP port A (LAN A) (error)

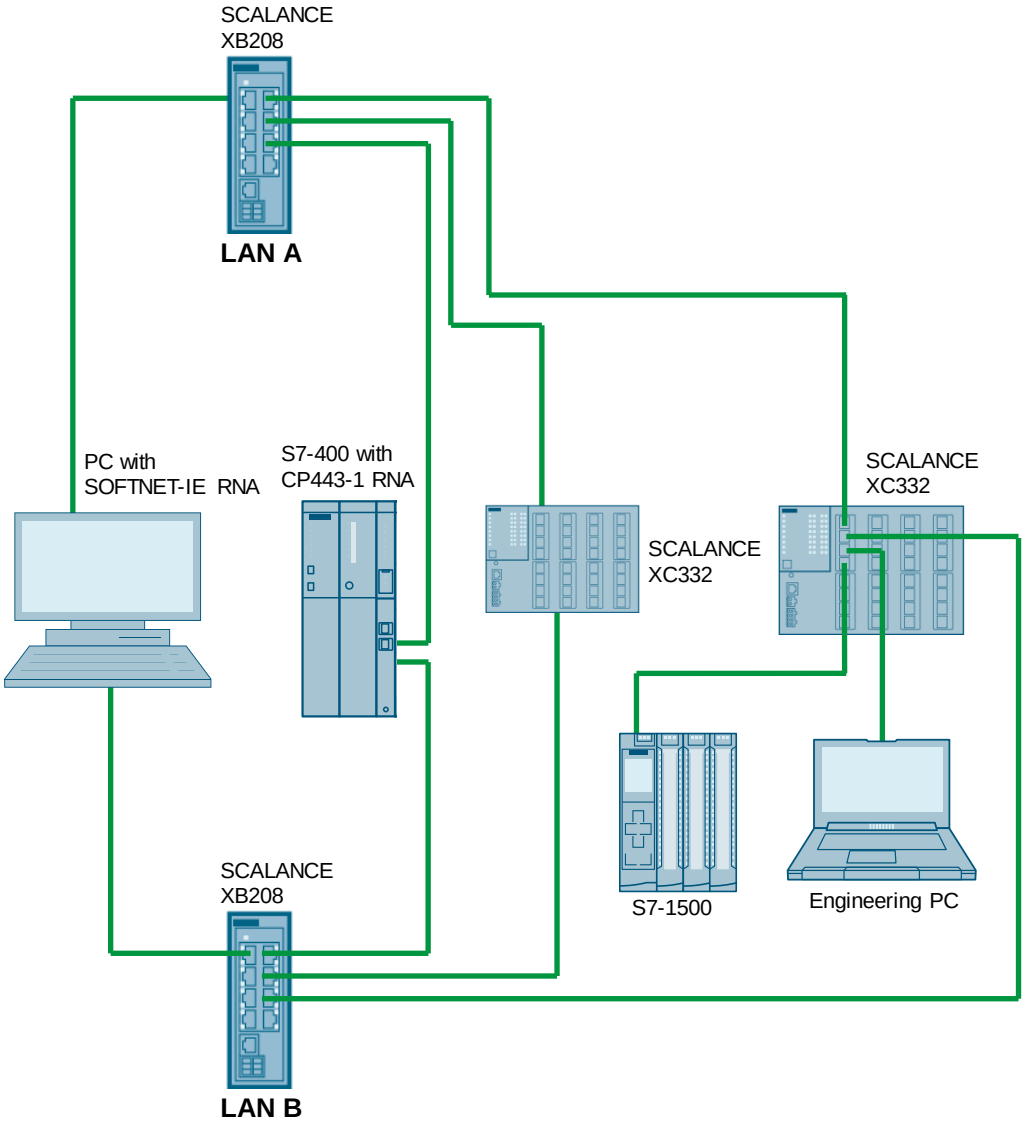
NOTE If all ports are networked correctly, the measurements that indicate an error will return the value zero "0" in the statistics display.

3. Engineering

3.1. Hardware Setup

RNA with PRP

The following figure shows the hardware setup of the application for RNA with PRP.



Connect all SIMATIC components each to a 24V power supply.

Connect the defined PRP nodes (in this application example, these are ports P0.7 and P0.8) to the first SCALANCE XB208 via their LAN A port and to the second SCALANCE XB208 via their LAN B port.

Connect the S7-1500 to port P4 of the SCALANCE XC332 via the integrated CPU interface.

Connect the Engineering PC to port P3 of the SCALANCE XC332 via the Ethernet network adapter

Use Industrial Ethernet cables.

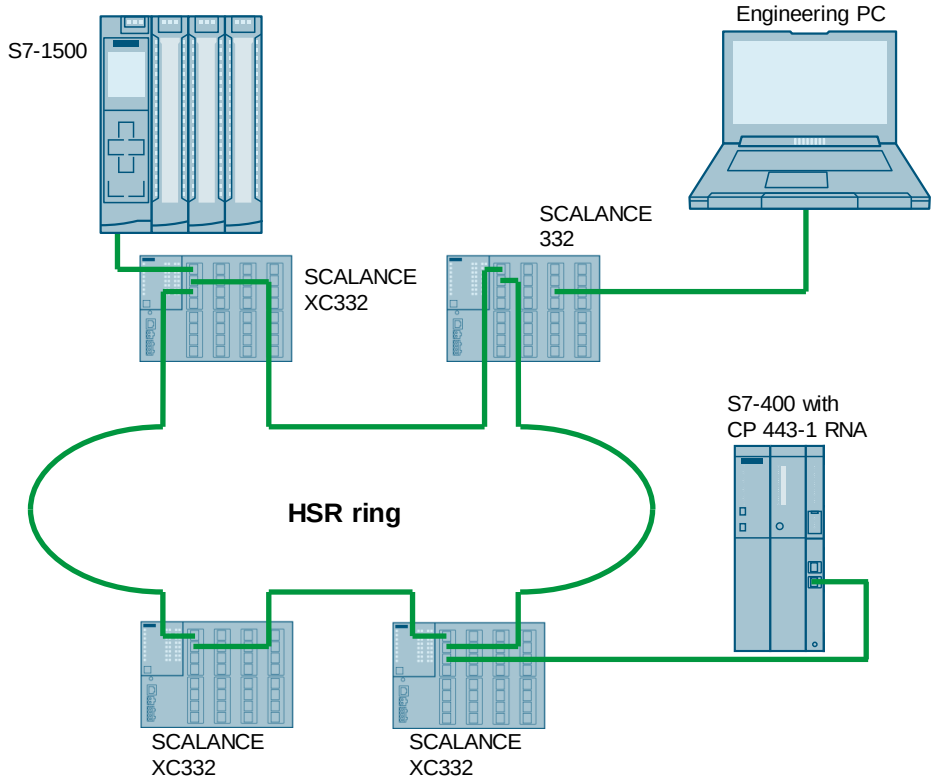
NOTE

Ensure that the PRP ports of the devices are correctly connected to LAN A or LAN B. A frame with the identifier "LAN A" must also be received by the receiver at the "LAN A" port. A frame with identifier "LAN B" must be received by the receiver at the "LAN B" port.

Set up the networks as symmetrically as possible. Differences in the number of frames received on the LANs (see Statistics display of the XC332 and SOFTNET-IE RNA) make it easier to identify redundancy errors in the network.

RNA with HSR

The following figure shows the hardware setup of the use for RNA with HSR.



Connect all SIMATIC components to a 24V power supply.

Connect all HSR nodes via their HSR ports (in this application example, these are ports P0.7 and P0.8) to form a ring topology.

Connect the S7-1500 to port P1 of the SCALANCE XC332 via the integrated CPU interface.

Connect the CP 443-1 RNA via port X2P1 of the RNA interface to port 3 of the SCALANCE XC332.

Connect the Engineering PC to a free port of the SCALANCE XC332.

Use Industrial Ethernet cables.

3.2. Configuration

The application example provides a user program for the S7-400 CPU and the S7-1500 CPU for data exchange between the controllers via an S7 connection. The S7-1500 transmits its time every 5 s to the S7-400 CPU. For the S7-1500 CPU, there is a Watch table in the STEP 7 project where the data exchange can be observed. For the S7-400 CPU, there is a Variable table in the STEP 7 project where the data exchange can be observed.

With this data exchange, it is possible to demonstrate the redundancy (see Section 4.1.2 and Section 4.2.2).

3.2.1. Requirements

- The SIMATIC components are reset to their factory settings.
- The following software components are installed on the Engineering PC:
  - STEP 7 V5.6 SP2 or higher
  - TIA Portal V19 or higher
- The following software component is installed on the PC:
  - SOFTNET-IE RNA V19 or higher

NOTE Instructions for resetting to factory settings can be found in the device manuals of the SIMATIC components (see Section 6.2).

3.2.2. Assigning IP Addresses

Overview for RNA with PRP

In this application example, the following IP addresses are assigned to the hardware components:

Hardware Component	IP address	Subnet mask
CPU 1513-1 PN	172.16.43.35	255.255.0.0
CP 443-1 RNA	172.16.43.55	255.255.0.0
SCALANCE XC332	172.16.43.21	255.255.0.0
SCALANCE XC332	172.16.43.22	255.255.0.0
SCALANCE XB208 (LAN A)	172.16.43.30	255.255.0.0
SCALANCE XB208 (LAN B)	172.16.43.31	255.255.0.0
PC with SOFTNET-IE RNA	172.16.43.40	255.255.0.0
Engineering PC	172.16.43.199	255.255.0.0

Overview for RNA with HSR

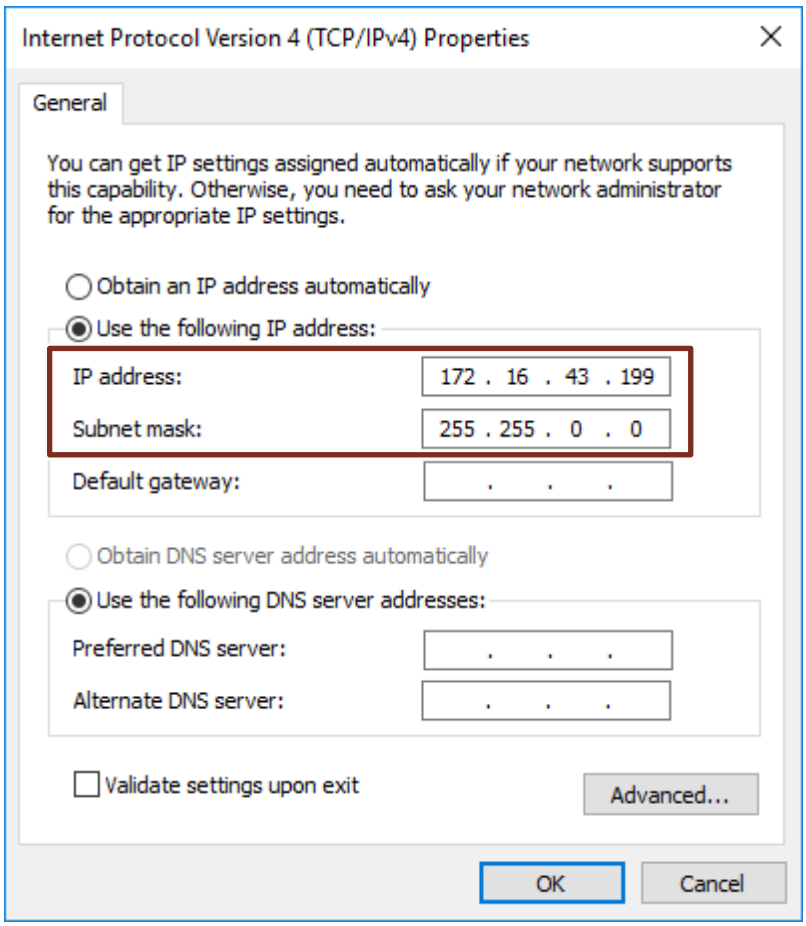
In this application example, the following IP addresses are assigned to the hardware components:

Hardware Component	IP address	Subnet mask
CPU 1513-1 PN	172.16.43.35	255.255.0.0
CP 443-1 RNA	172.16.43.55	255.255.0.0
SCALANCE XC332	172.16.43.21	255.255.0.0
SCALANCE XC332	172.16.43.22	255.255.0.0
SCALANCE XC332	172.16.43.23	255.255.0.0
SCALANCE XC332	172.16.43.24	255.255.0.0
Engineering PC	172.16.43.199	255.255.0.0

NOTE All hardware components are in the same subnet.

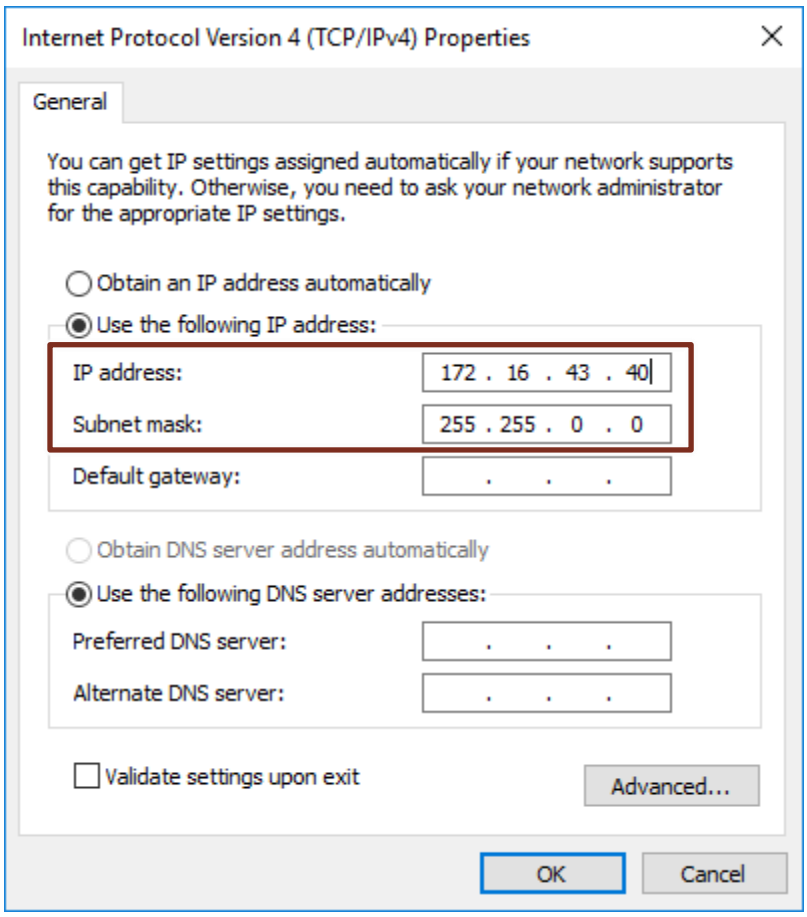
Engineering PC

Set the IP address and subnet mask of the Engineering PC in the properties of the network adapter in Windows.



SOFTNET IE-RNA

Set the IP address and subnet mask in the properties of the virtual SOFTNET-IE RNA interface in Windows.

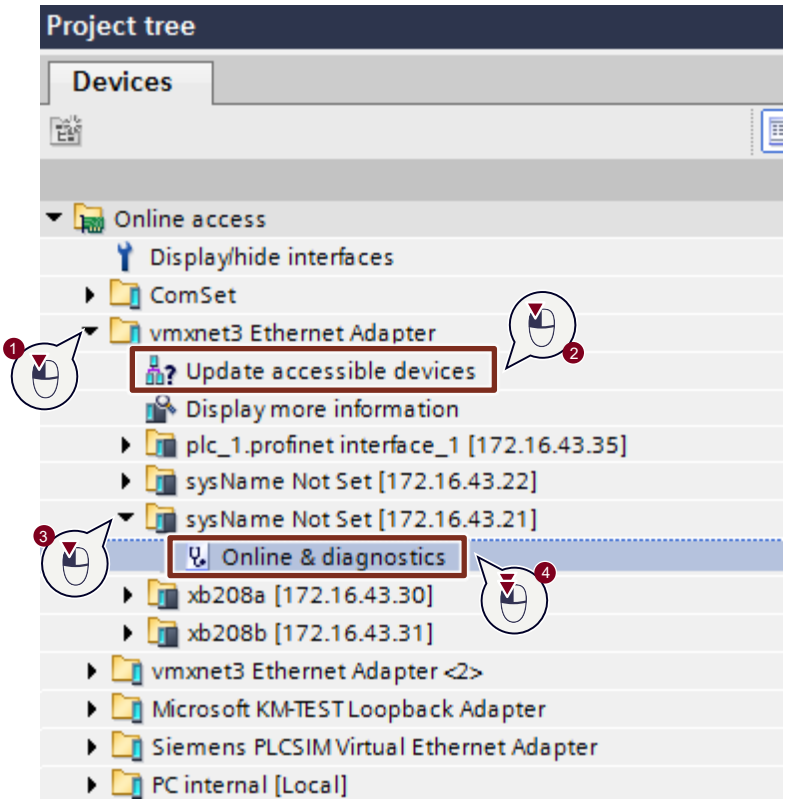


SIMATIC components

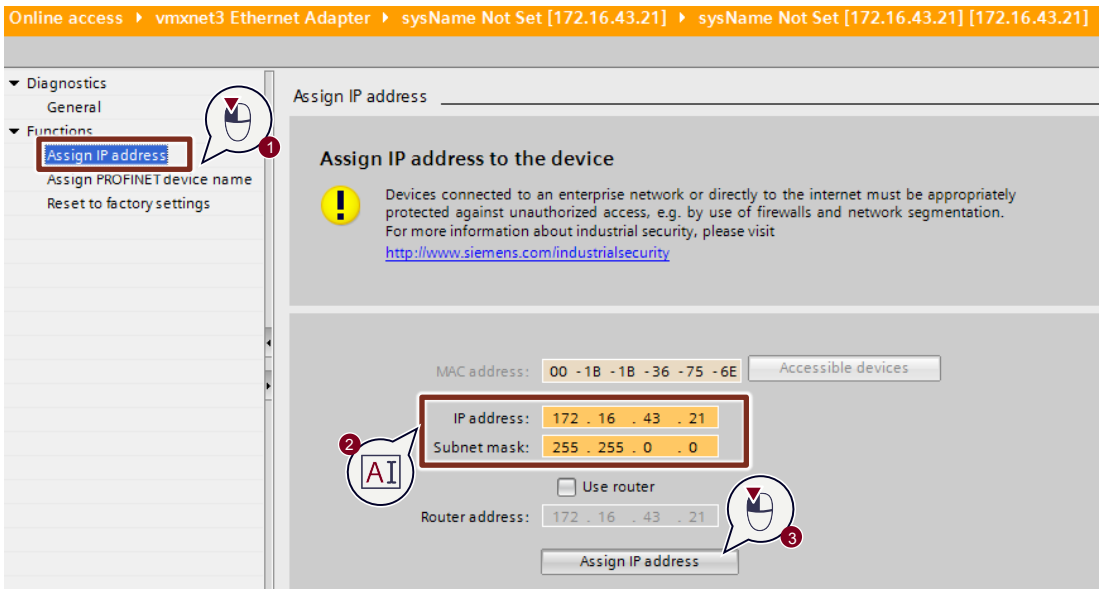
To assign an IP address to the SIMATIC components, connect the Engineering PC to the respective module via an Industrial Ethernet cable.

The example of the SCALANCE XC332 shows how to assign an IP address to a module in TIA Portal. Proceed according to these instructions when addressing the other modules.

1. Open TIA Portal.
2. In the project navigation under "Online access", click the arrow to the left of the network adapter to which the SCALANCE XC332 is connected.
3. Double-click the "Update accessible devices" command.
   All devices available on the network adapter are displayed with IP address or MAC address.
4. Click the arrow to the left of the SCALANCE XC332 to which you want to assign an IP address and subnet mask.
5. Double-click the command "Online & diagnostics".The "Online & diagnostics" dialog will open.



6. Under "Functions", click "Assign IP addresses".
7. Enter the desired IP address and subnet mask.
8. Click the "Assign IP address" button to set the parameters.



NOTE

If you have an S7-1500 CPU, you can also set the IP address and subnet mask on the display.

You may only assign an IP address to the CP443-1 RNA (PRP) in the factory settings state.

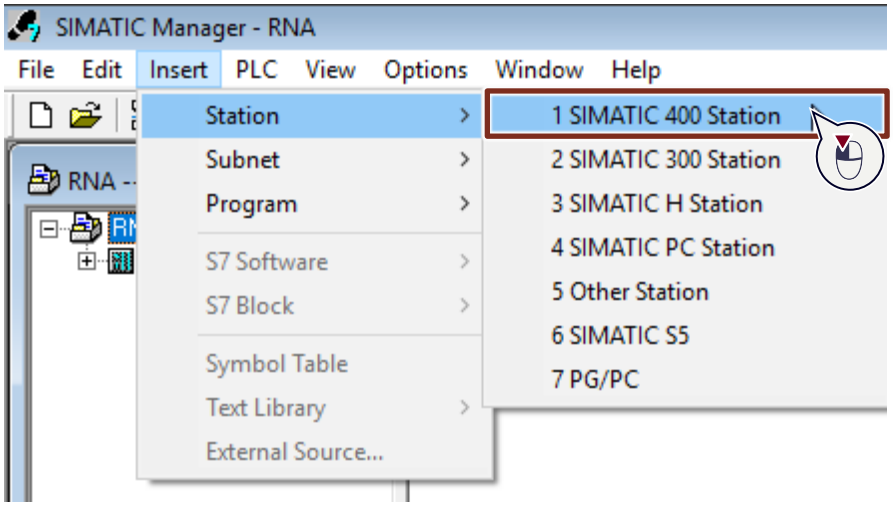
3.2.3. Configuring an S7-400

Requirements

- STEP 7 V5.6 is open.
- A new project is created, or an existing project is opened.

Inserting an S7-400 station

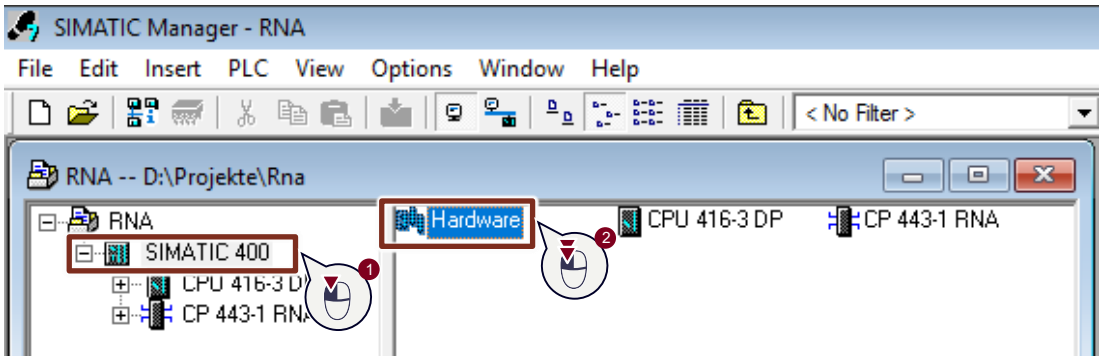
1. Select the menu "Insert > Station > SIMATIC 400 Station".



A SIMATIC 400 station is created in the STEP 7 project.

Configuring the SIMATIC 400 station

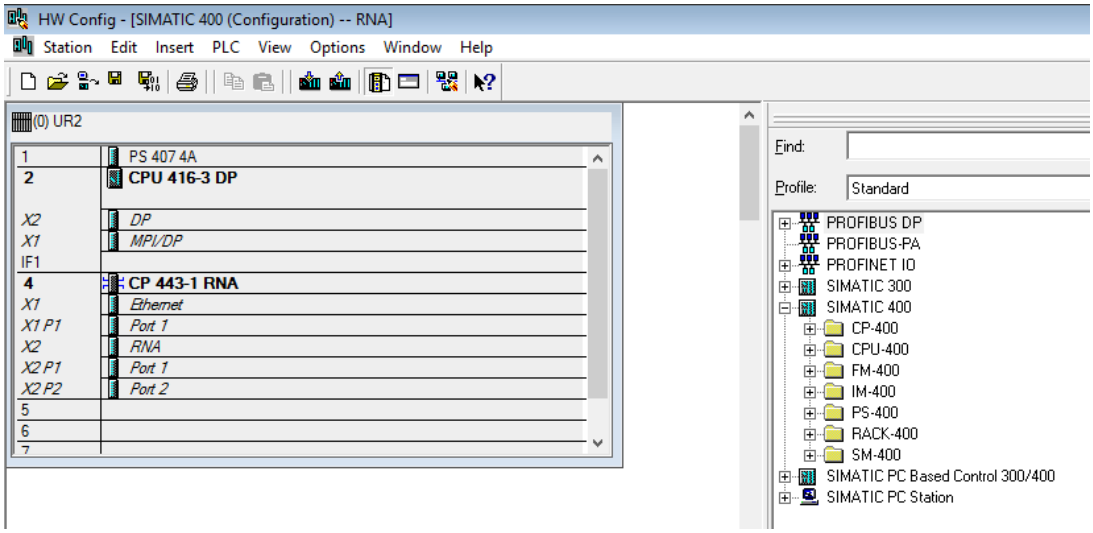
1. Select the SIMATIC 400 station in the STEP 7 project.
2. Double-click the entry "Hardware".



The hardware configuration opens

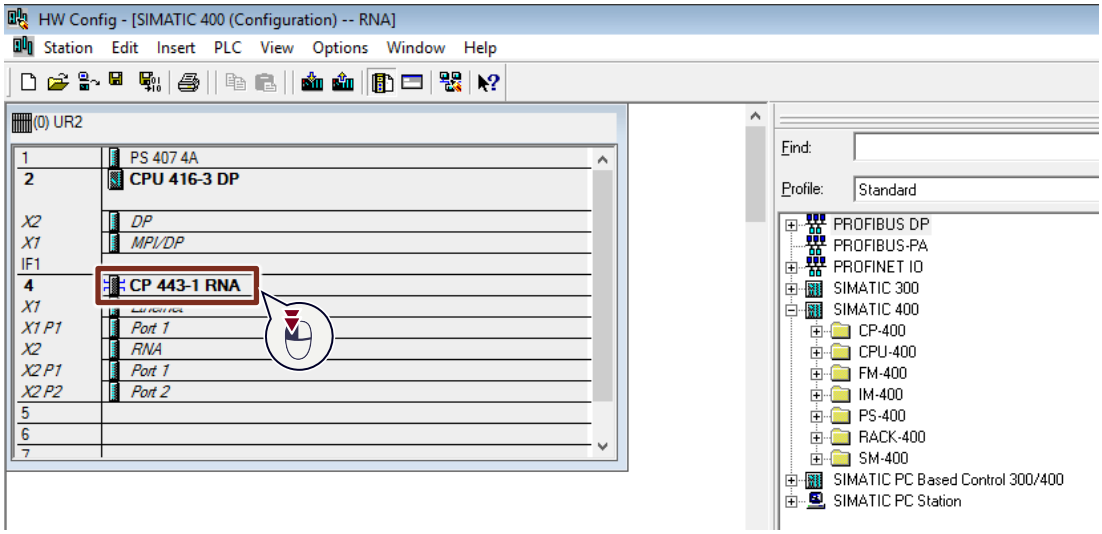
3. Insert all modules that you use in your hardware setup of the SIMATIC 400 station via drag & drop from the hardware catalog into the hardware configuration.
   The following modules are used in this example:

   - Rack: UR2
   - Power supply: PS407 4A
   - CPU: CPU 416-3 DP
   - CP: CP443-1 RNA



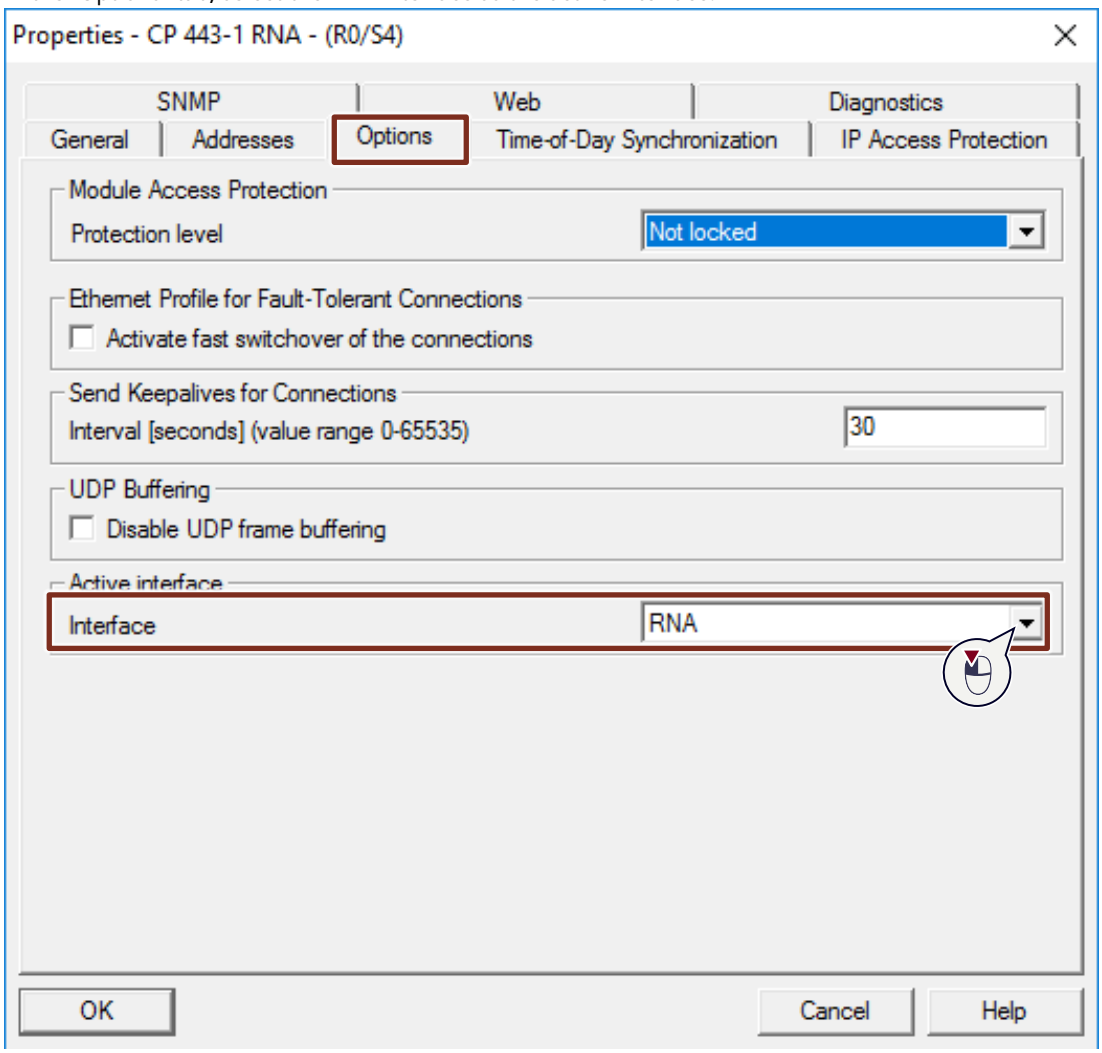
Configuring a CP443-1 RNA

1. Double-click the CP 443-1 RNA.

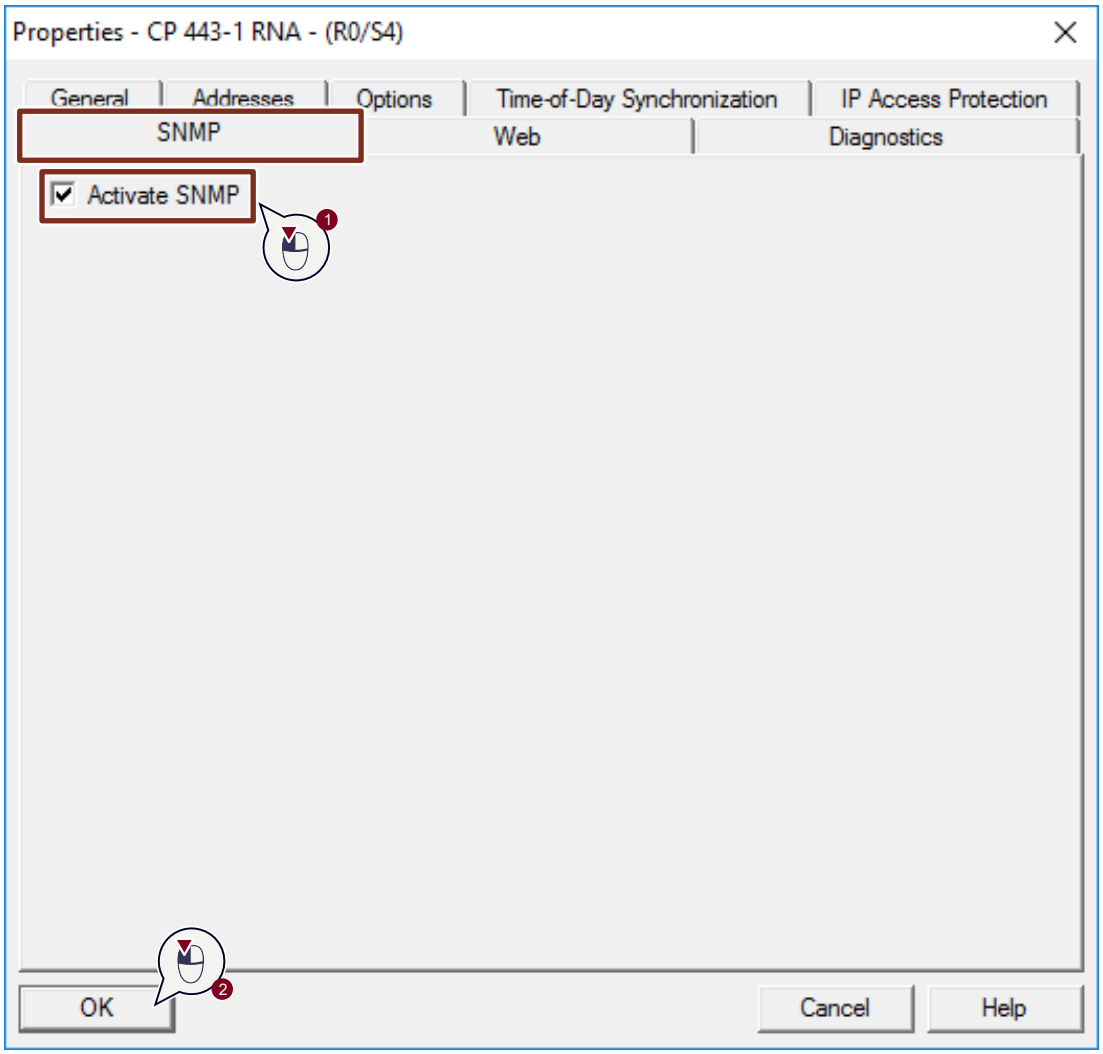


The properties dialog of the CP opens.

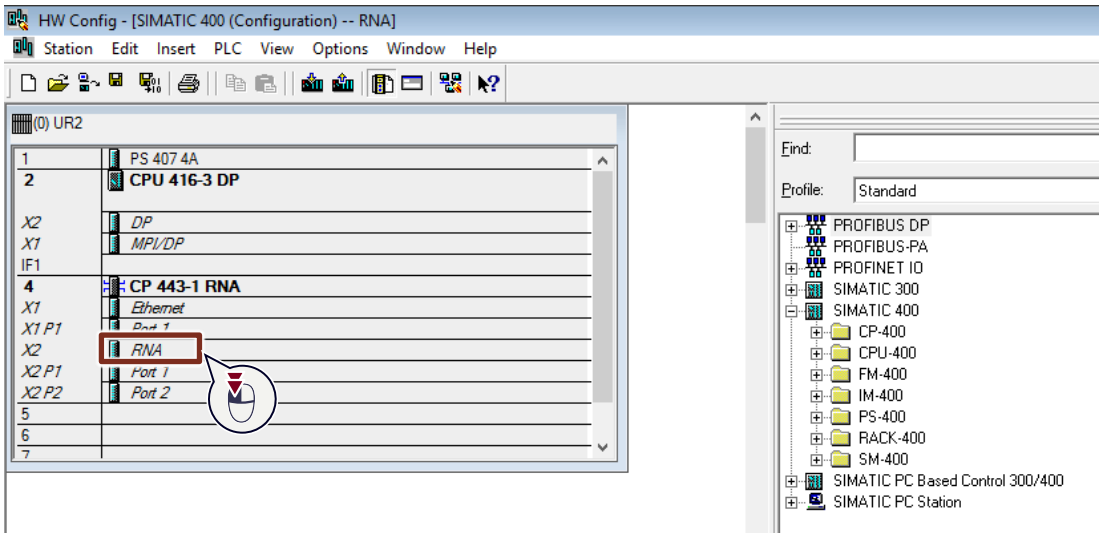
2. In the "Options" tab, select the RNA interface as the active interface.



3. In the "SNMP" tab, enable the "Activate SNMP" function.
4. Click "OK" to apply the settings.

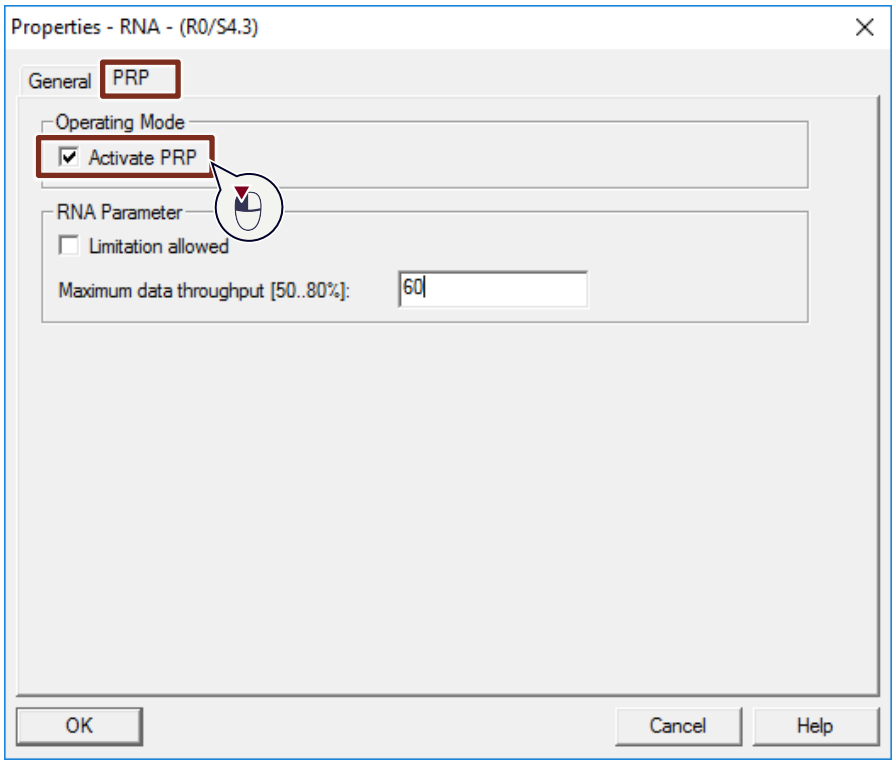


5. Double-click the RNA interface of the CP.

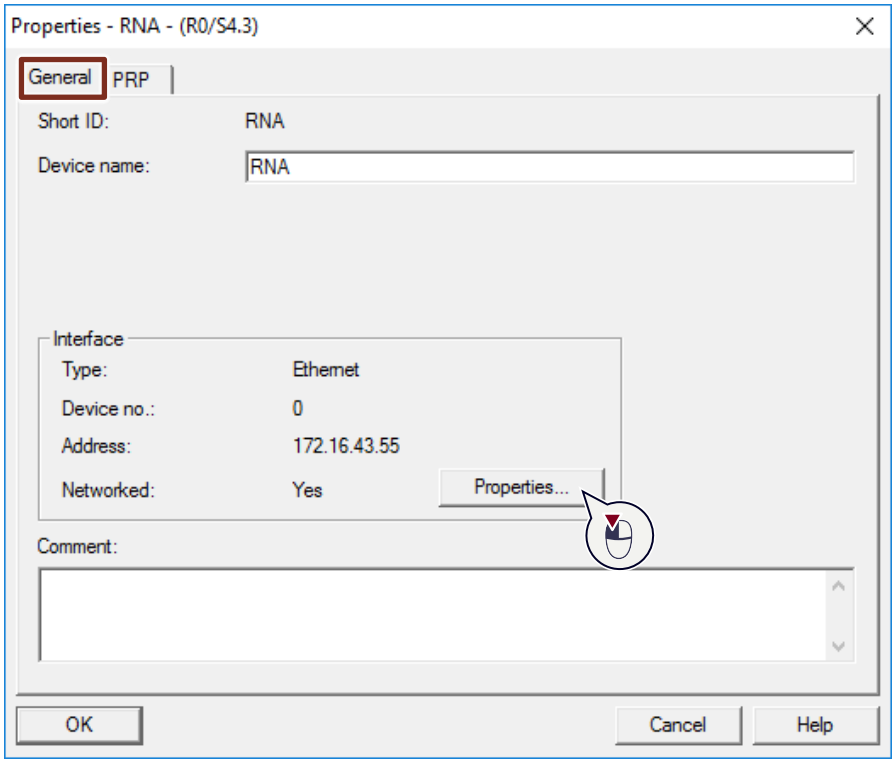


The properties dialog of the RNA interface opens.

6. Deactivate the "PRP" operating mode in the "PRP" tab if you use the CP 443-1 RNA as the standard component (SAN), (e. g., with an HSR ring).

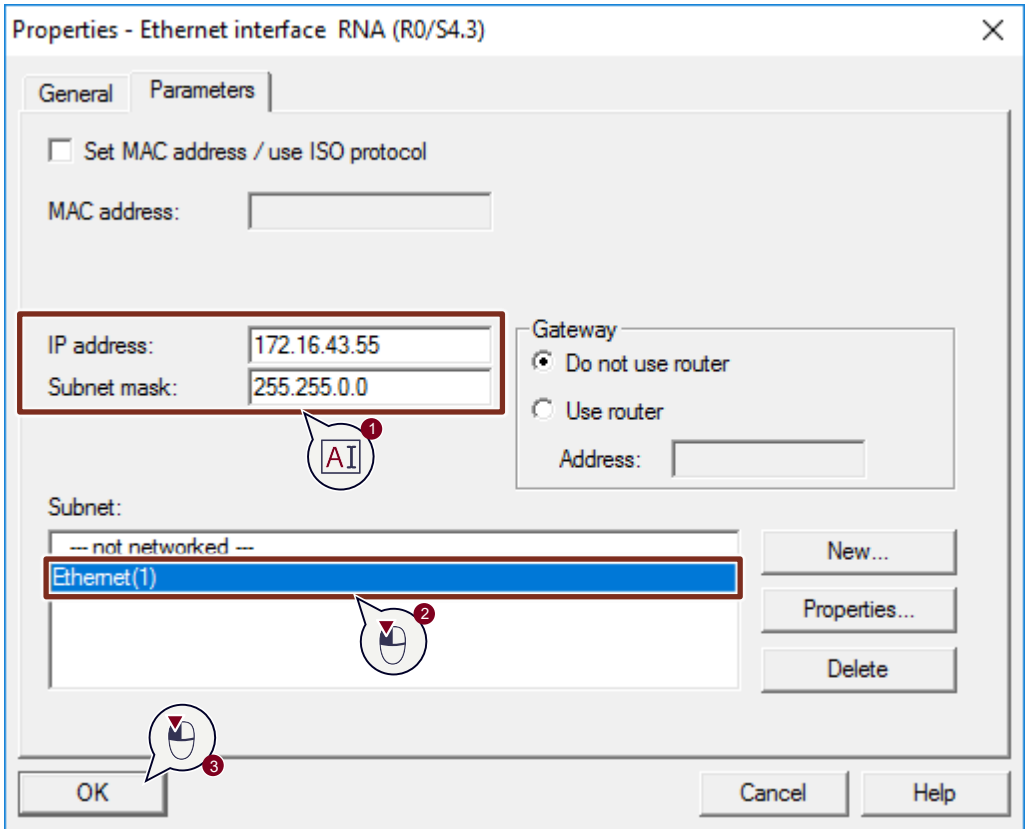


7. On the "General" tab, click the "Properties" button.

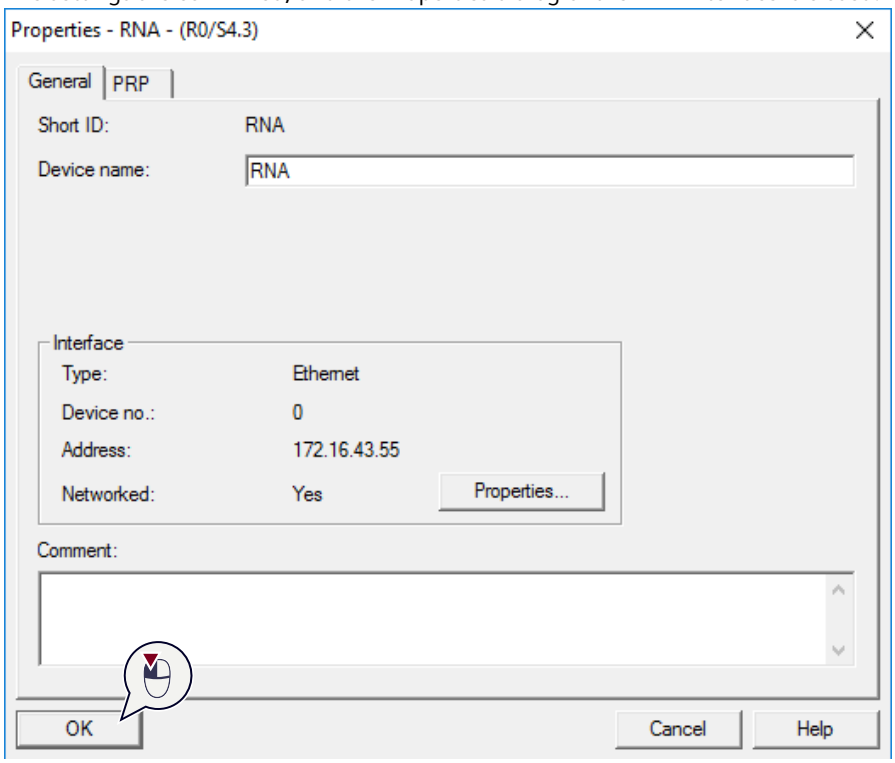


The properties dialog for networking the RNA interface opens.

8. In the "Parameters" tab, enter the IP address and subnet mask that you have assigned to the CP 443-1 RNA.
9. Assign an existing subnet to the RNA interface or click the "New" button to create a new subnet.
10. Click the "OK" button.
    The settings are confirmed and the Properties dialog for networking the RNA interface is closed.



11. Click the "OK" button in the properties dialog of the RNA interface.
    The settings are confirmed, and the Properties dialog of the RNA interface is closed.



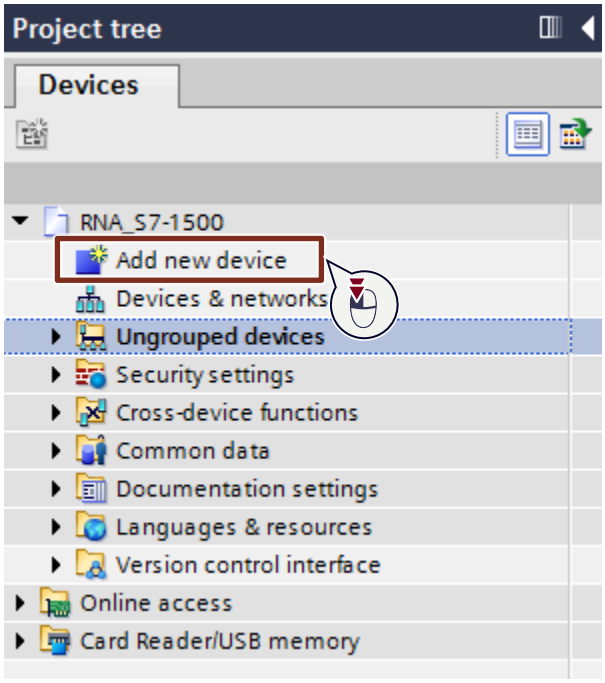
3.2.4. Configuring an S7-1500

Requirements

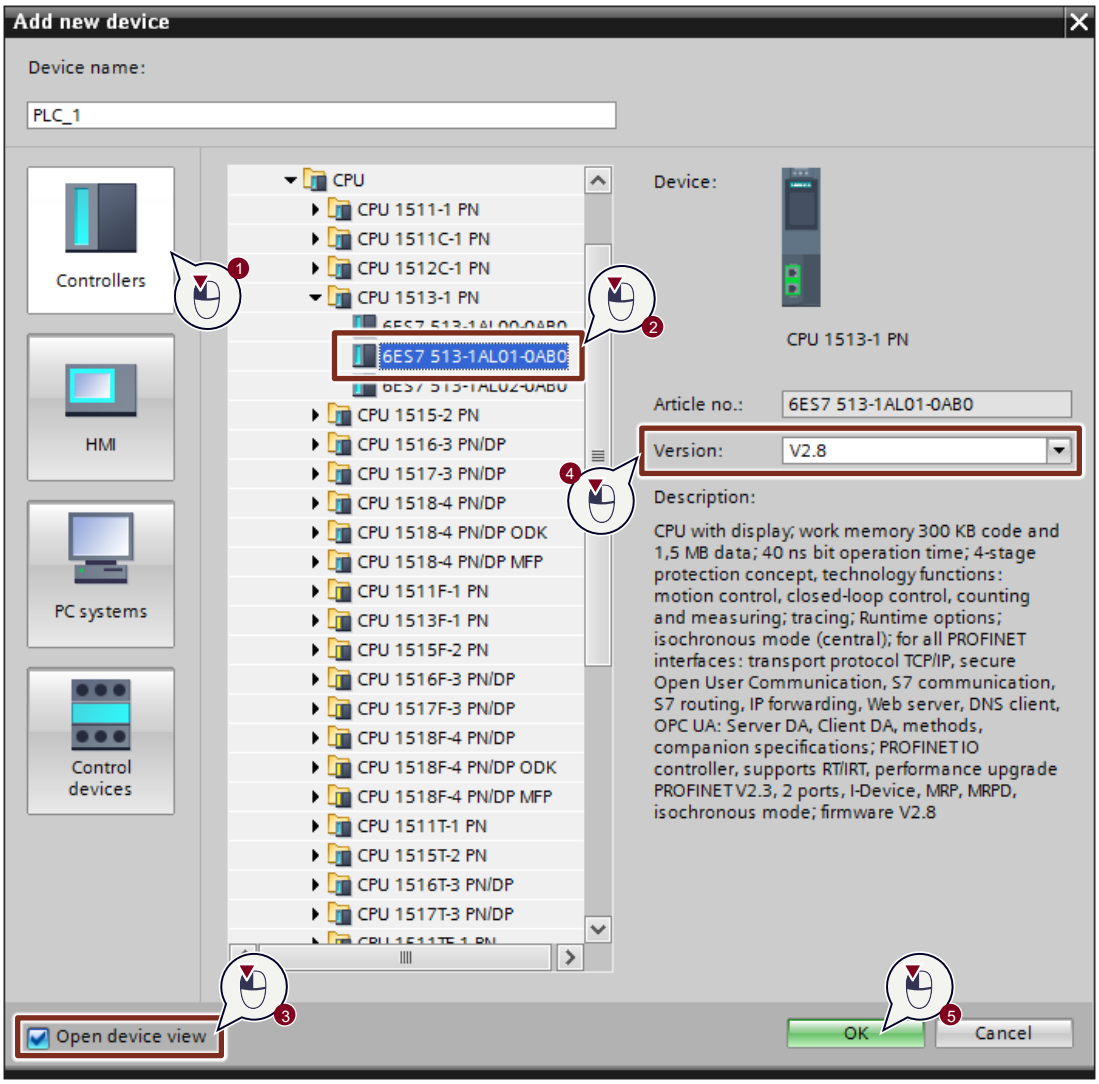
- TIA Portal is open.
- A new project is created, or an existing project is opened.

Insert device

1. Double-click the command "Add new device" in the project tree.
   The dialog box "Add new device" opens.



2. Click the "Controllers" button.
3. Select the S7 CPU according to your hardware setup, e. g. CPU 1513-1 PN.
4. Enable the option "Open Device view".
5. Under "Version:", select the firmware version of the S7 CPU.
6. Click the "OK" button.

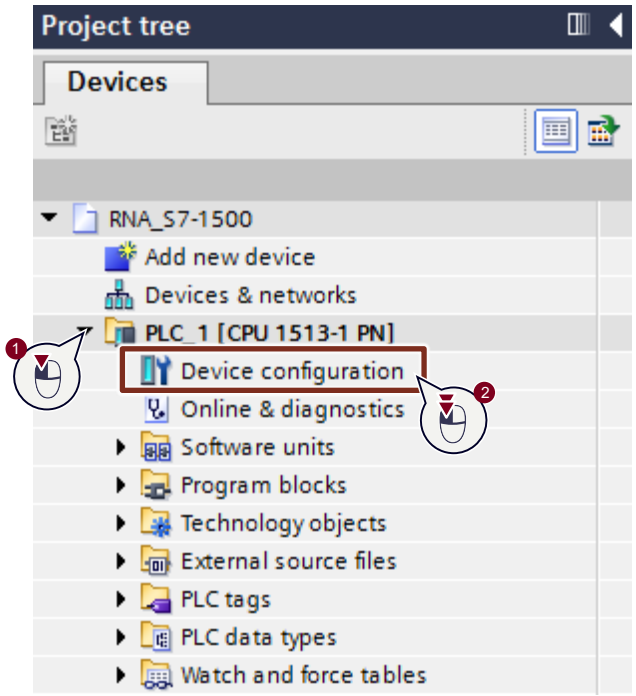


The selected S7 CPU is inserted into the STEP 7 project.

NOTE If you enabled the option "Open device view", the "Device view" for the S7 CPU will open automatically in the hardware and network editor.

Open the Device view

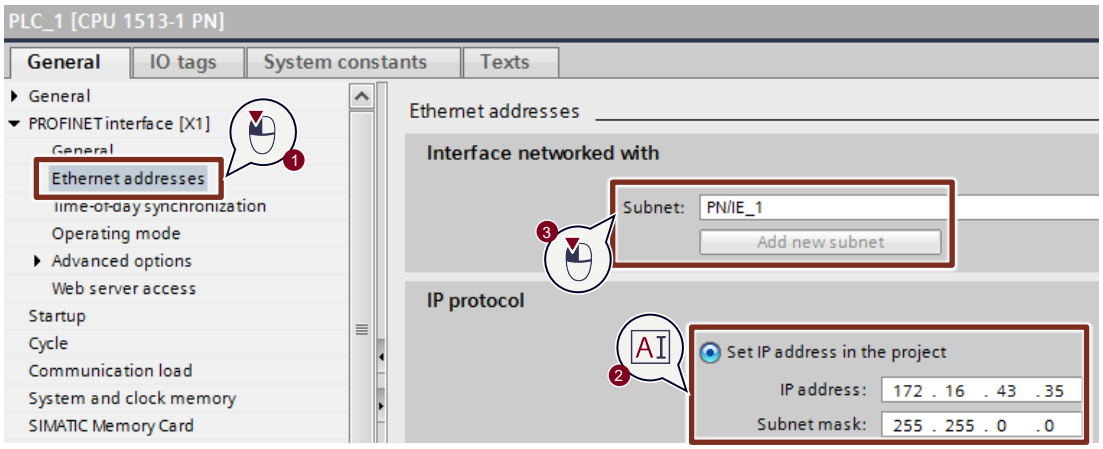
1. In the project tree, open the device folder of the S7 CPU.
2. Double-click the "Device configuration" command.



The "Device view" of the S7 CPU opens in the hardware and network editor.

Set address parameters

1. Select the S7 CPU in the Device view.
   The properties of the S7 CPU are displayed in the Inspector window.
2. In the "General" tab, navigate to "PROFINET interface [X1] > Ethernet addresses".
3. Enter the IP address and subnet mask that you have assigned to the S7-1500 CPU.
4. Click on the "Add new subnet" button to create a new subnet or select an existing subnet.

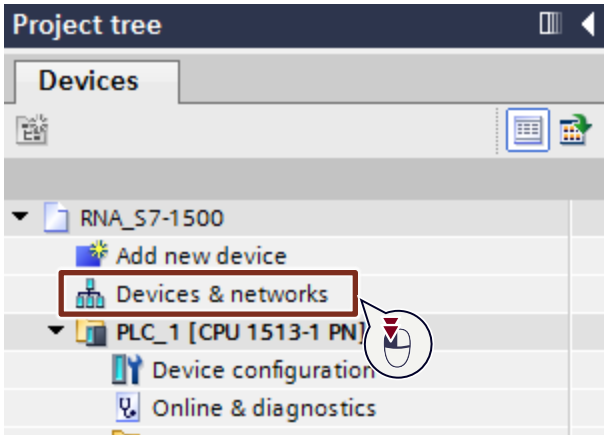


3.2.5. Configuring a Connection

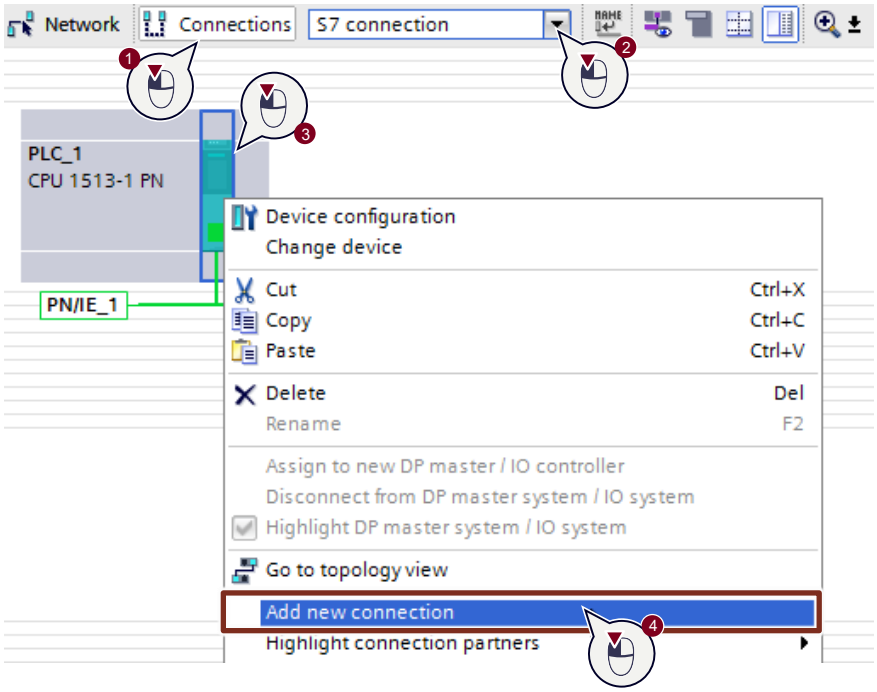
To be able to exchange data between S7-1500 CPU and S7-400 CPU, it is necessary to configure a communication link. In this application example, an S7 connection is configured.

Creating a connection

1. Double-click "Devices & Networks" in the project tree.
   The graphical area of the "Network view" opens in the hardware and network editor.

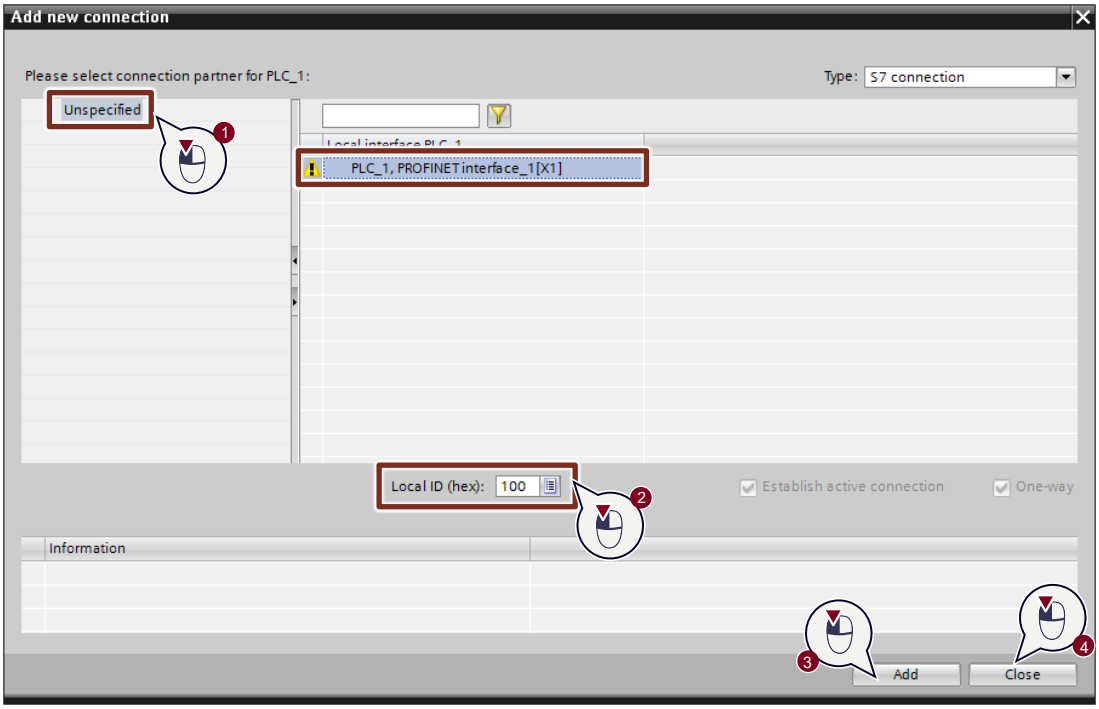


2. In the function bar, click the "Connections" button to enable the connection mode.
3. Select the connection type "S7 connection" in the nearby dropdown menu.
   In the "Network view", the S7-1500 CPU that is available for an S7 connection is marked in color.
4. Right-click the S7-1500 CPU.
   The context menu opens.
5. Select "Add new connection".
   The "Add new connection" dialog will open.



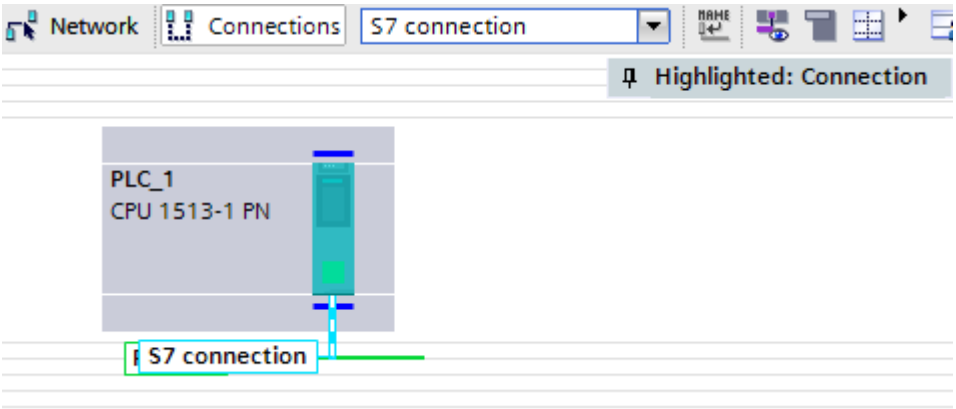
6. Specify the following connection parameters: "Unspecified".
7. Set the local ID of the connection (e. g., 100 (hex)).
8. Select the local interface in your station via which the S7 connection is established (e. g., the integrated PROFINET interface of the S7-1500 CPU).
9. Click the "Add" button.
   An unspecified S7 connection is added.

10. Click the "Close" button.
    The "Add new connection" dialog is closed.

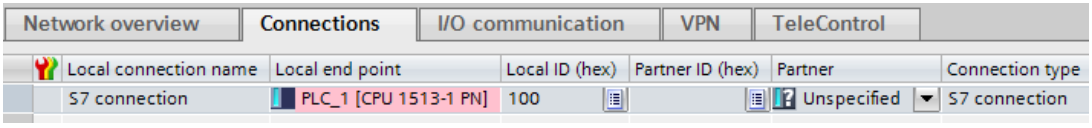


An unspecified S7 connection is created.

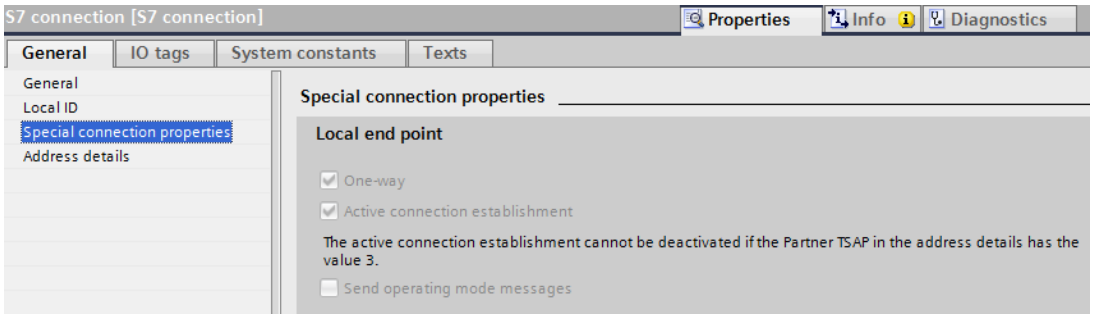
- The connection path is highlighted.



- The S7 connection is entered in the connection table.



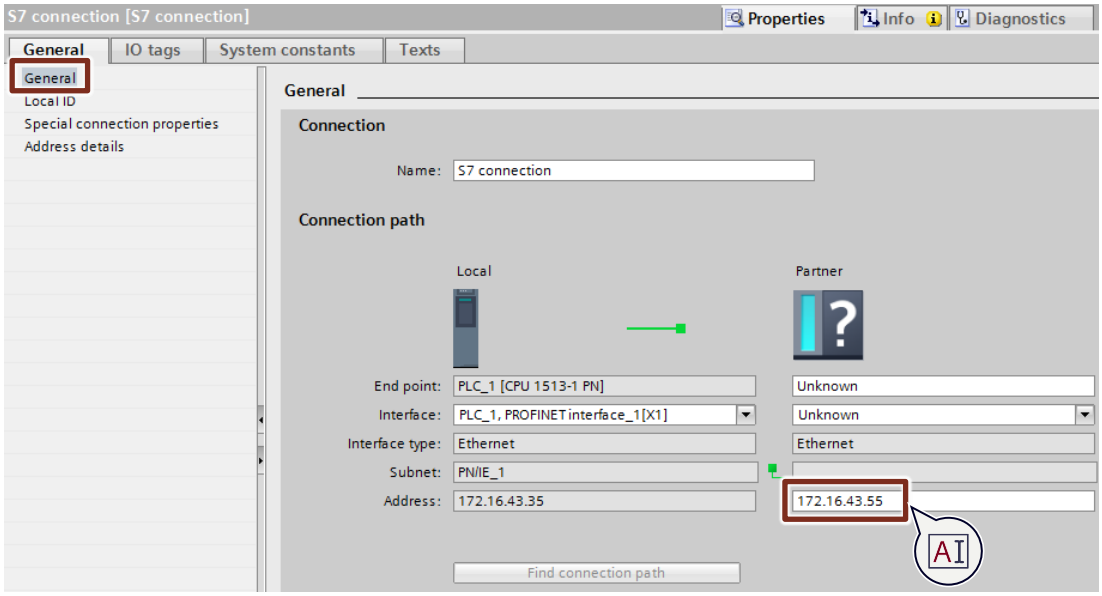
- The S7-1500 CPU actively establishes the S7 connection.



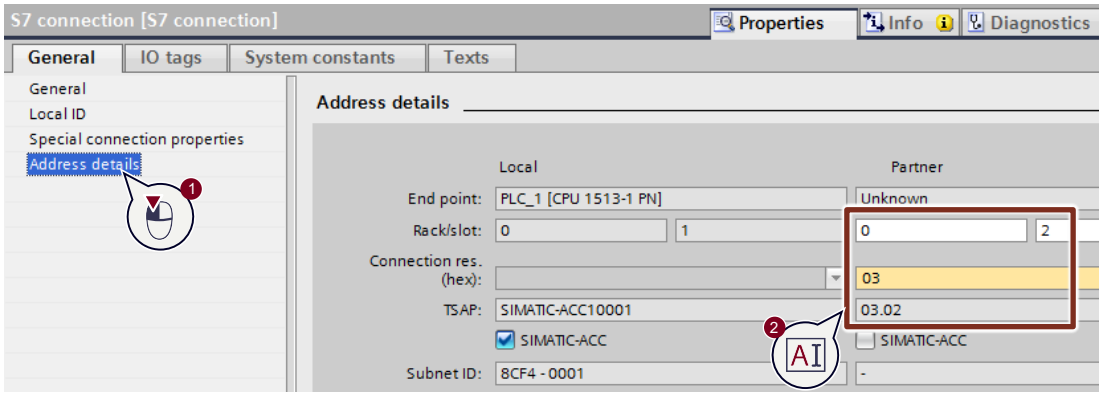
NOTE If the connection parameters are not yet fully set up, the S7 connection will be shown with errors in the connection table.

Set connection parameters

1. Select the S7 connection in the connection table.
   The properties of the S7 connection are displayed in the Inspector window.
2. Enter the IP address of the communication partner in the "General" tab under "General". In this application example, the CP 443-1 RNA is the communication partner.



3. In the "General" tab under "Address details", enter the partner TSAP. The partner TSAP is composed as follows: 03.<CPU slot> (e. g., S7-400 CPU on slot 2): 03.02



3.2.6. User Program of the S7-1500 CPU

"SendData" data block

The "SendData" data block stores the send data (e. g., the time of the S7-1500 CPU).

SendData

	Name	Data type	Start value	Monitor value
1	Static			
2	data	Array[0..7] of Byte		
3	data[0]	Byte	16#0	16#21
4	data[1]	Byte	16#0	16#05
5	data[2]	Byte	16#0	16#27
6	data[3]	Byte	16#0	16#14
7	data[4]	Byte	16#0	16#28
8	data[5]	Byte	16#0	16#22
9	data[6]	Byte	16#0	16#00
10	data[7]	Byte	16#0	16#55

"InOutData" data block

Variables are created in the "InOutData" data block to assign the inputs and outputs of the "PUT" and "RD_SYS_T" instructions.

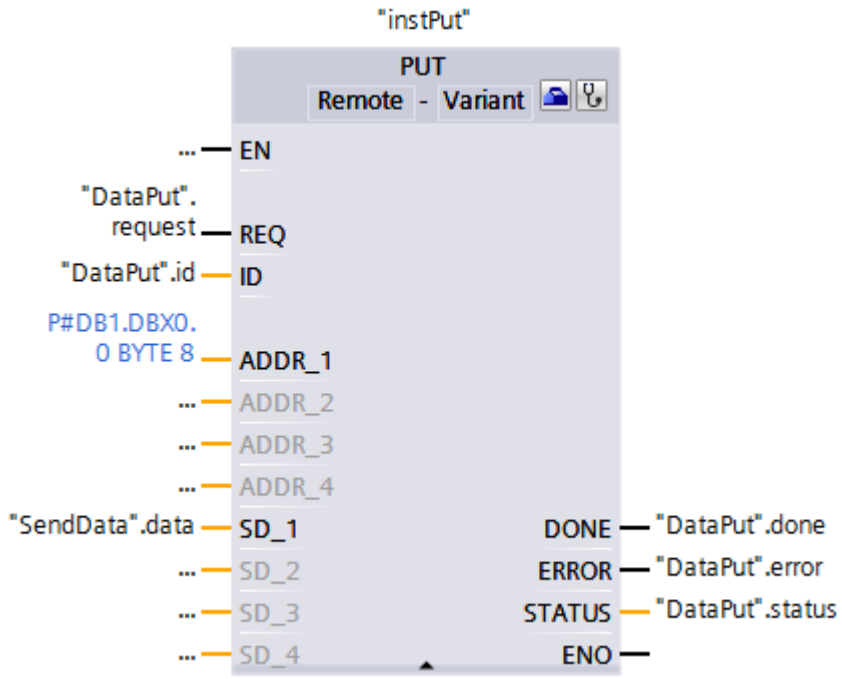
InOutData

	Name	Data type	Start value	Monitor value
1	Static			
2	request	Bool	false	FALSE
3	id	CONN_OUC	16#100	16#0100
4	done	Bool	false	FALSE
5	error	Bool	false	FALSE
6	status	Word	16#0	16#0000
7	statusSave	Word	16#0	16#0000
8	moduleTime	Date_And_Time	DT#1990-01-01-00:00:00	DT#2021-05-27-14:27:32.005
9	retval	Int	0	0

OB1 "Main"

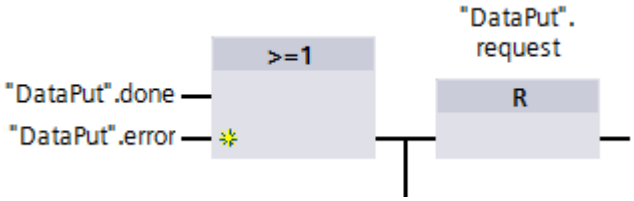
To send data from the S7-1500 CPU to the S7-400 CPU, it is necessary to call the "PUT" instruction in the user program of the S7-1500 CPU.

The following figure shows the call of the "PUT" instruction in OB1.



The send job is activated by a positive edge at the input "REQ". The activation of the send job is done in the cyclic interrupt OB "OB30".

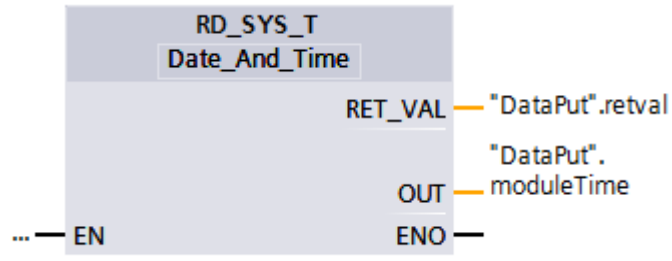
When a send job is completed with "DONE"=1 or "ERROR"=1, the "REQ" input is reset.



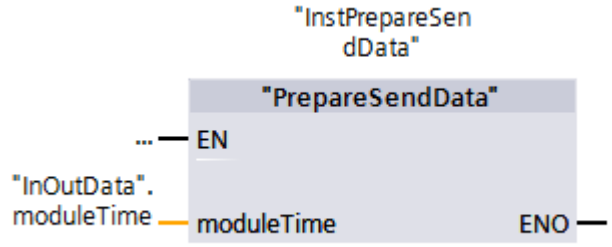
"Cyclic interrupt" OB30

To read the time of the module, it is necessary to call the "RD_SYS_T" instruction in the user program of the S7-1500 CPU.

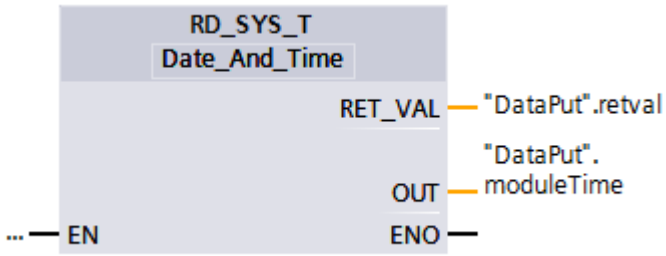
The following figure shows the call of the "RD_SYS_T" instruction in the cyclic interrupt OB "OB30".



The FB "PrepareSendData" is called in the cyclic interrupt OB "OB30" to prepare the read-out time so that it can be transferred to the S7-400 CPU with the "PUT" instruction.



In the cyclic interrupt OB "OB30", the send job is activated.



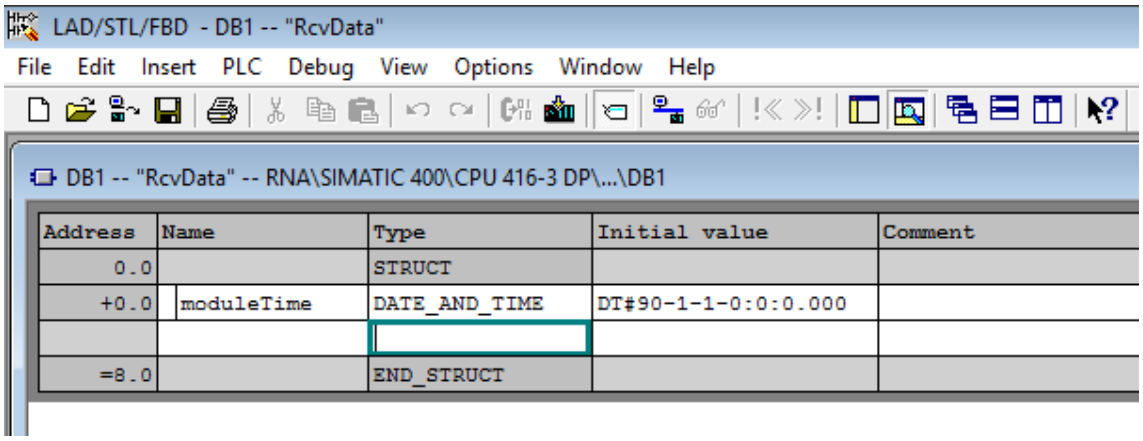
The time interval of the cyclic interrupt OB "OB30" is set to 5 s.
Therefore, the following actions are performed within a time interval of 5 s:

- Read S7-1500 CPU time
- Prepare time as send data
- Activate send job

3.2.7. User Program of the S7-400 CPU

In the user program of the S7-400, a data block is required in which the received data is stored.

In this application example, the received time is stored in DB1.



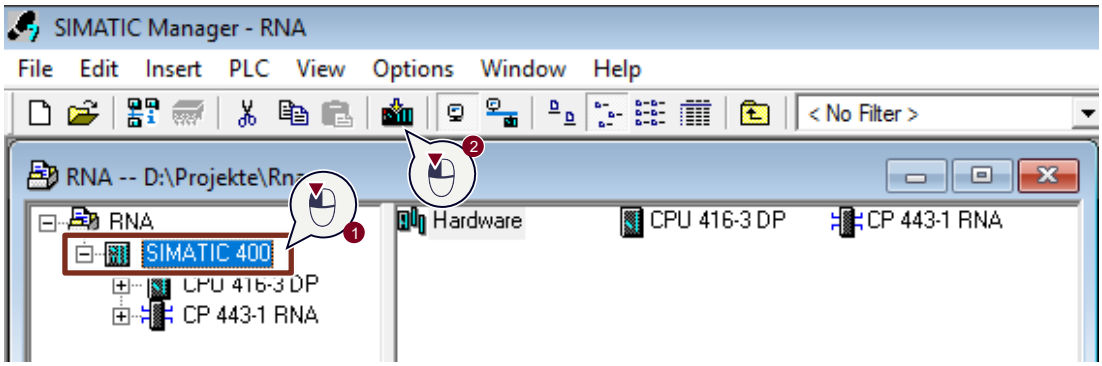
3.2.8. Loading the Configuration

Requirements

- Engineering PC and S7 CPU are in the same subnet
- You have set the IP address and subnet mask for the S7 CPU that you entered in the hardware configuration (see Section 3.2.2)

Load Project Configuration into the S7-400 CPU

1. Select the S7-400 station in the STEP 7 project.
2. Click the "Download" button.

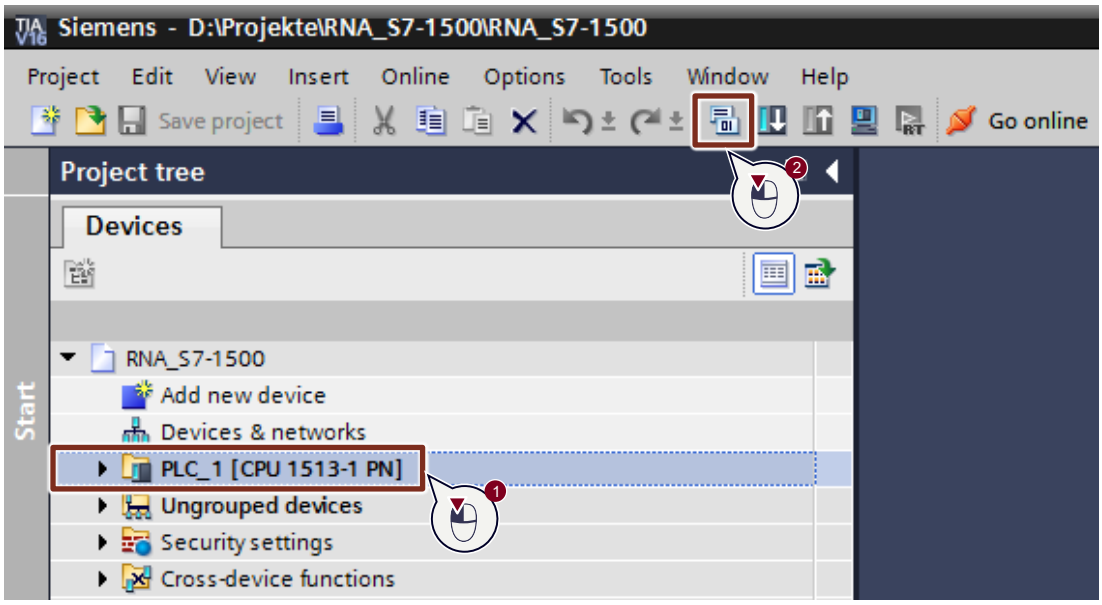


The configuration is loaded into the S7-400 CPU.

Load configuration into the S7-1500 CPU

Compiling:

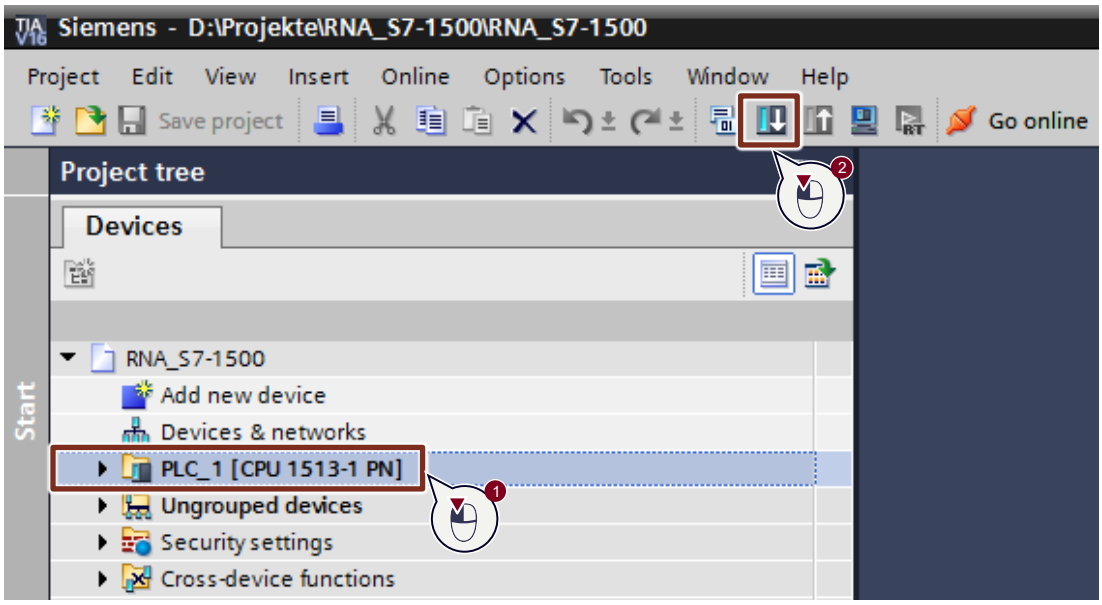
1. Select the S7-1500 CPU in the project navigation.
2. Click on the "Compile" button in the function bar.



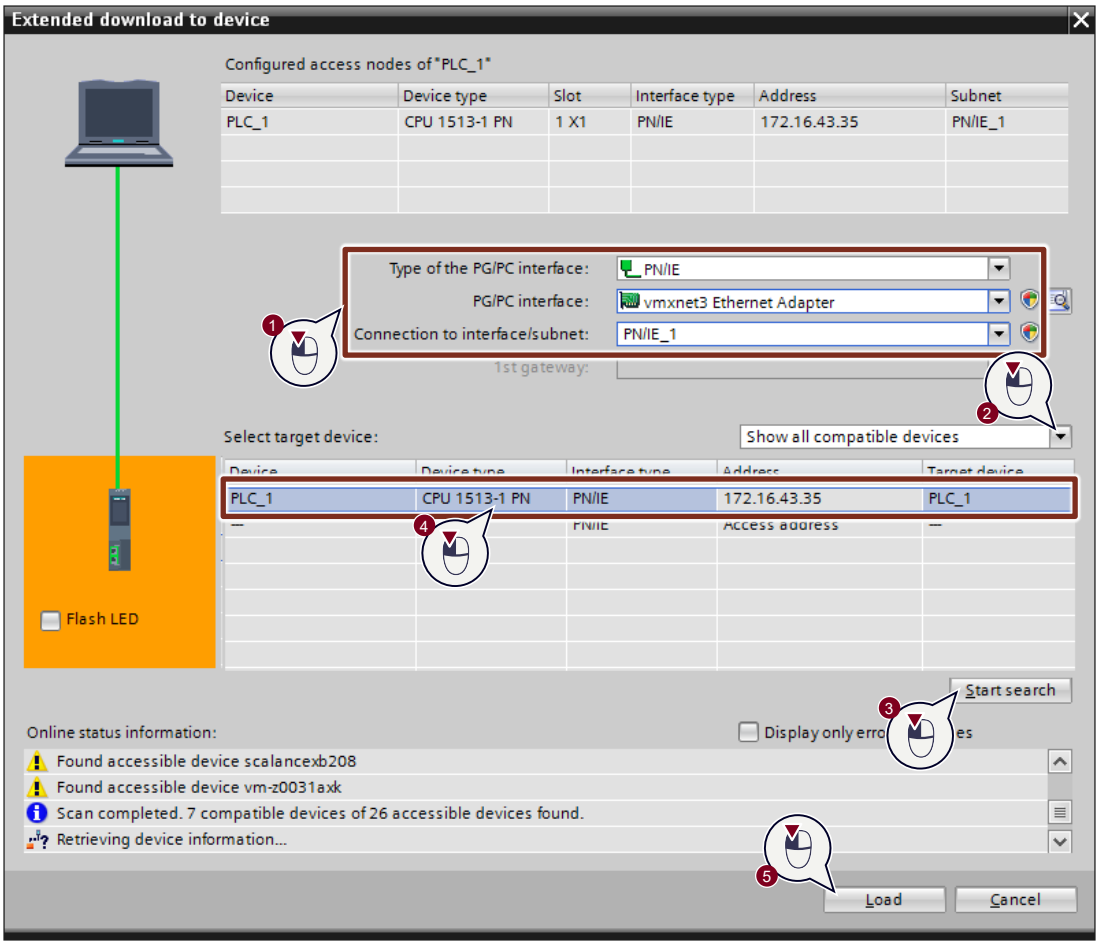
The Inspector window displays the result of the compiling process.
When the compiling process has been completed without errors, the configuration may be loaded into the S7-1500 CPU as follows.

Download:

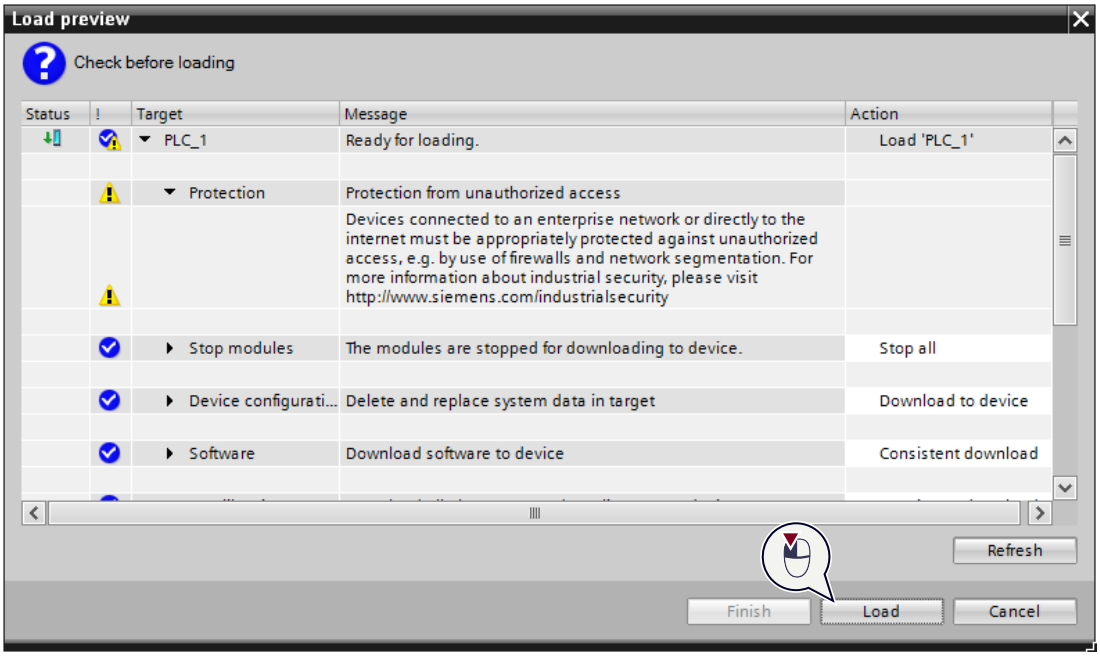
1. Select the S7-1500 CPU in the project navigation.
2. Click on the "Download to device" button in the function bar.
   The "Extended download to device" or "Load preview" dialog will open.



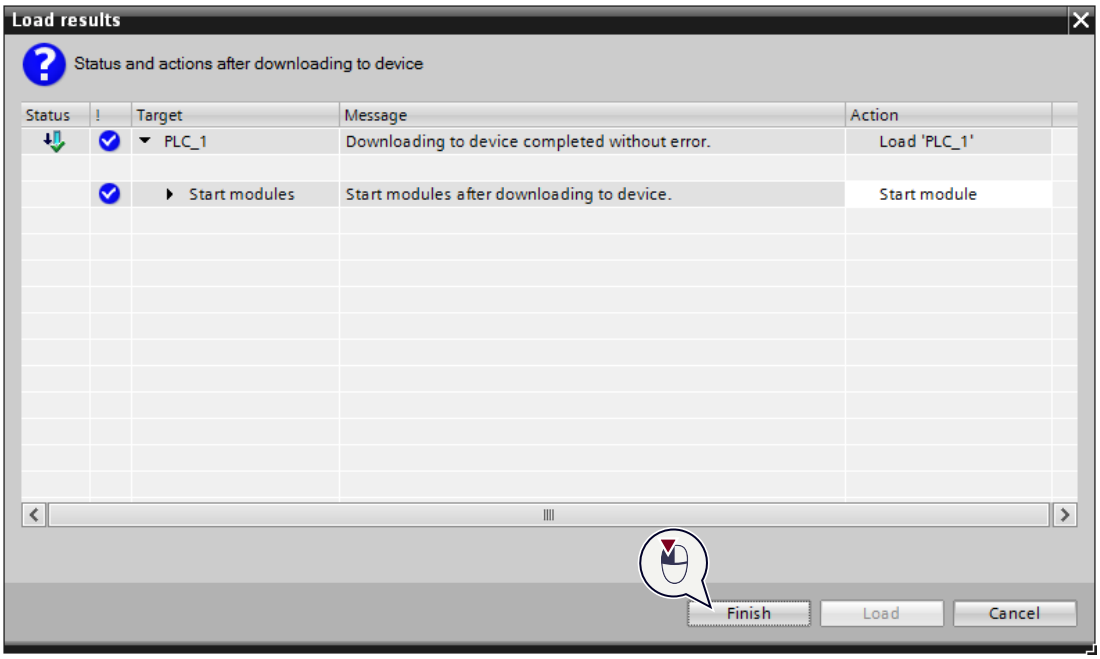
3. Configure the following settings in the "Extended download to device" dialog to access the S7-1500 CPU via TCP/IP:
   - Type of PG/PC interface: PN/IE
   - PG/PC interface: PG/PC network adapter
   - Connection to interface/subnet: Subnet of the S7 CPU, e. g. PN/IE_1
4. Select the "Show all compatible devices" option.
5. Click the "Start search" button.
6. Select the S7-1500 CPU as the target device.
7. Click "Load".
   The "Load preview" dialog window opens.



8. Click the "Load" button to start the load process.
   The "Load results" dialog opens.



9. Click the "Finish" button to finish downloading.



The configuration is loaded into the S7-1500 CPU.

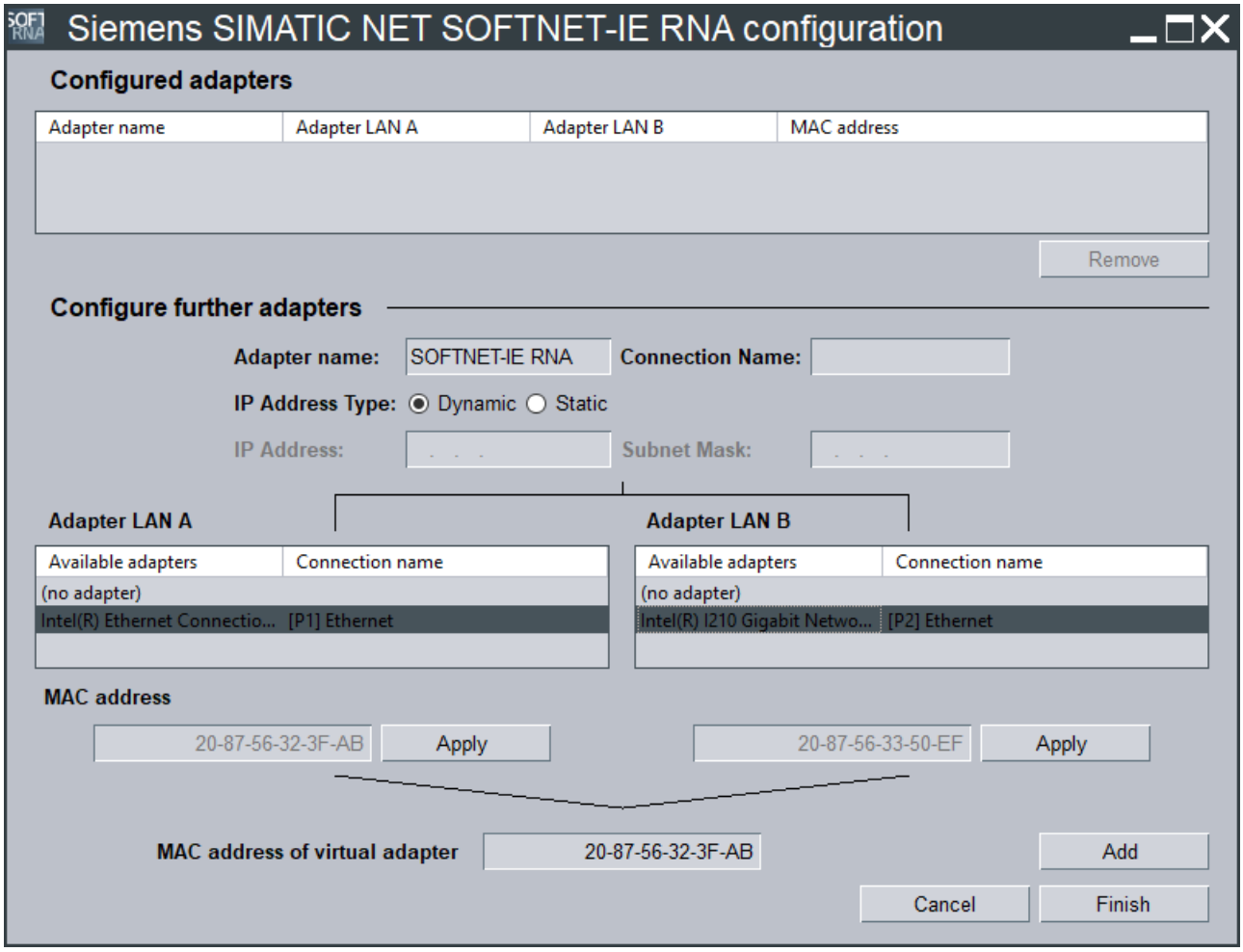
3.2.9. Configuration of the SOFTNET-IE RNA

Requirements

- For the operation of the SOFTNET-IE RNA on the PC: at least two free Ethernet network adapters for connection to LAN A and LAN B of the PRP network
- Administrator permissions

Configuration

The assignment of the network adapters to the SOFTNET-IE RNA protocol is done in the SOFTNET-IE RNA configuration.

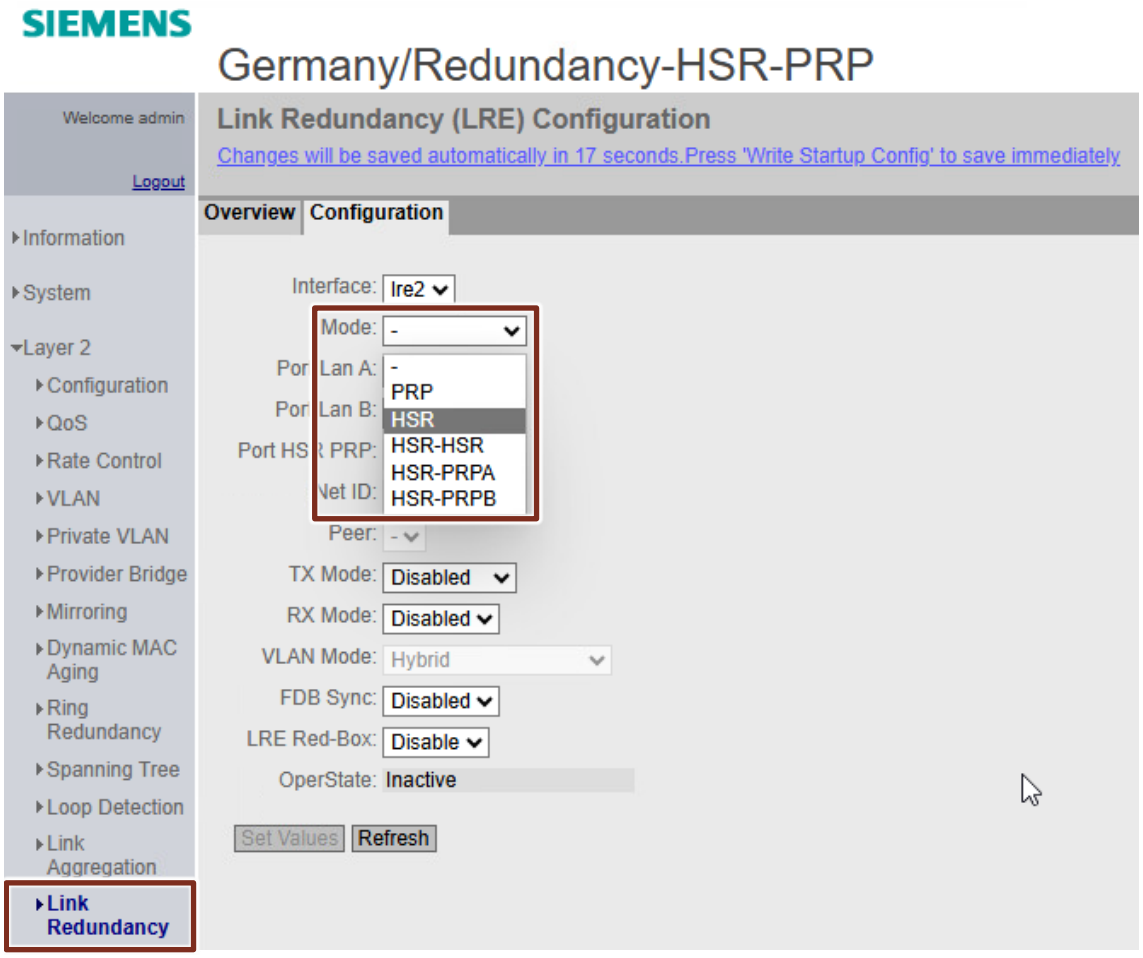


The two selected adapters are joined together by the SOFTNET-IE RNA software to form one virtual adapter. After the configuration is complete, only the virtual adapter appears in the Windows network connection overview instead of the two network adapters provided for PRP.

NOTE For detailed information on the SOFTNET-IE RNA configuration, refer to the corresponding SOFTNET-IE RNA device manual (see Section 6.2).

3.2.10. Configuring the SCALANCE XC332

In this application example, the "PRP" and "HSR" coupling modes are used.

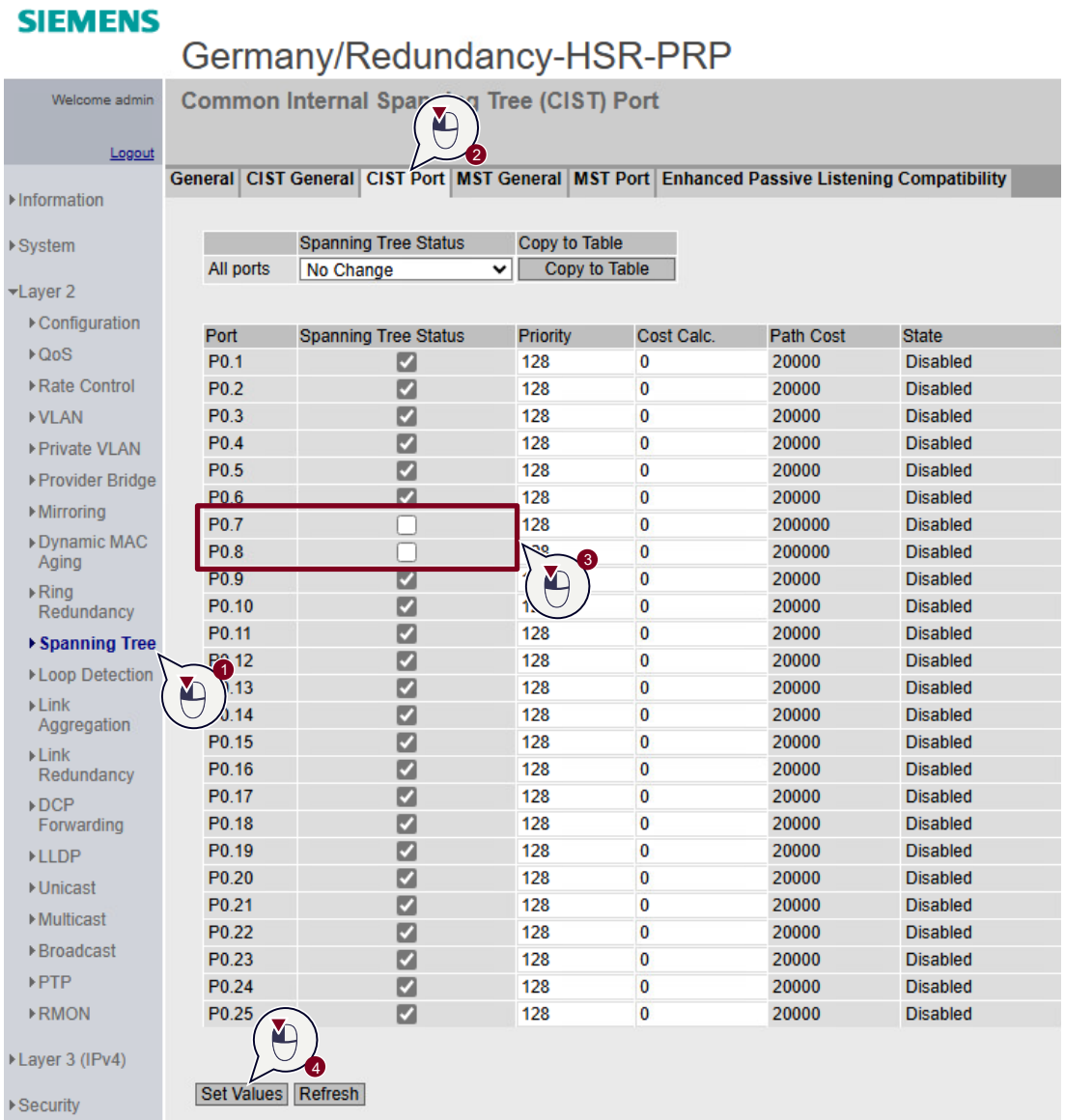


The PRP or HSR redundancy network is configured using the following steps. Carry out these steps for each switch used for redundancy.

3.2.10.1. Deactivating the spanning tree for PRP or HSR ports

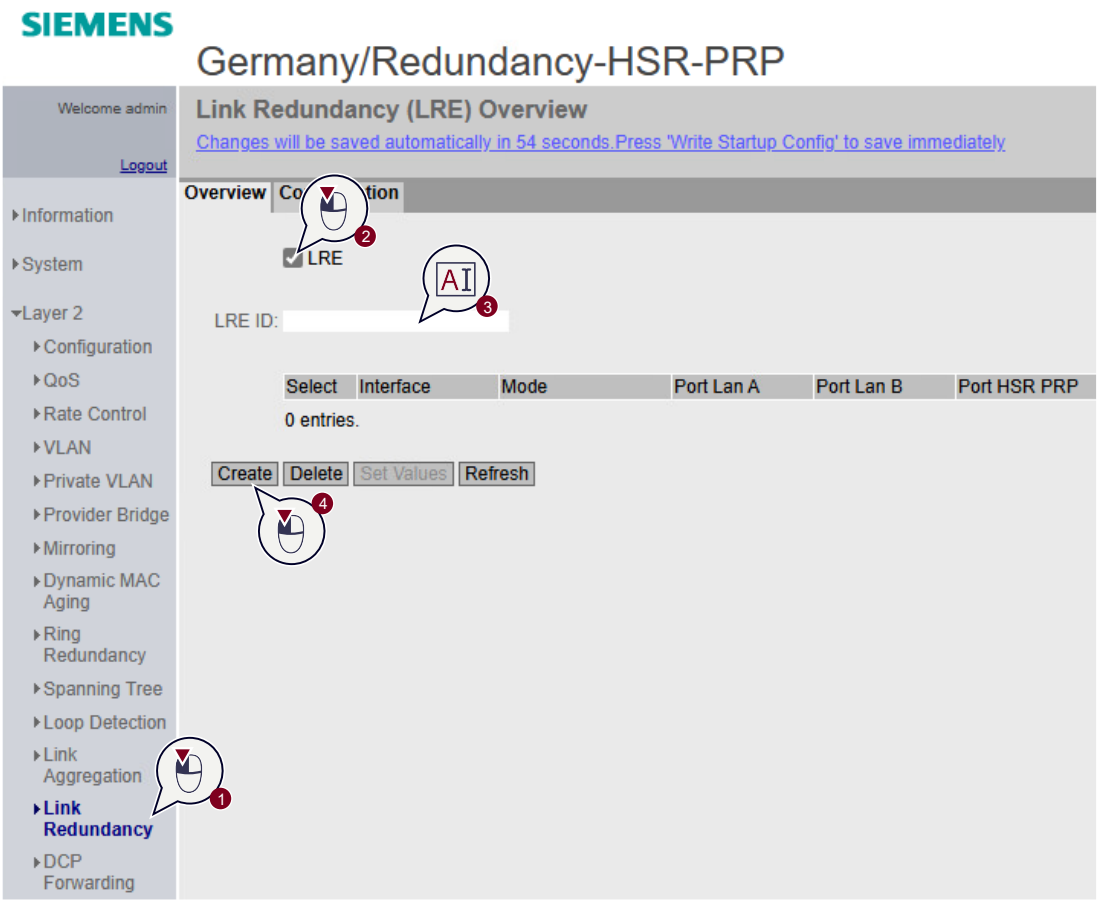
The ports used in the redundancy network must first be deactivated in the spanning tree, as double assignment is not possible. To do this, proceed as follows:

1. Open the "Spanning Tree" configuration under "Layer 2" in the WBM of the switch.
2. Switch to the "CIST Port" tab.
3. Deactivate the corresponding ports, here "P0.7" and "P0.8".
4. Click on the "Set Values" button to confirm the changes.

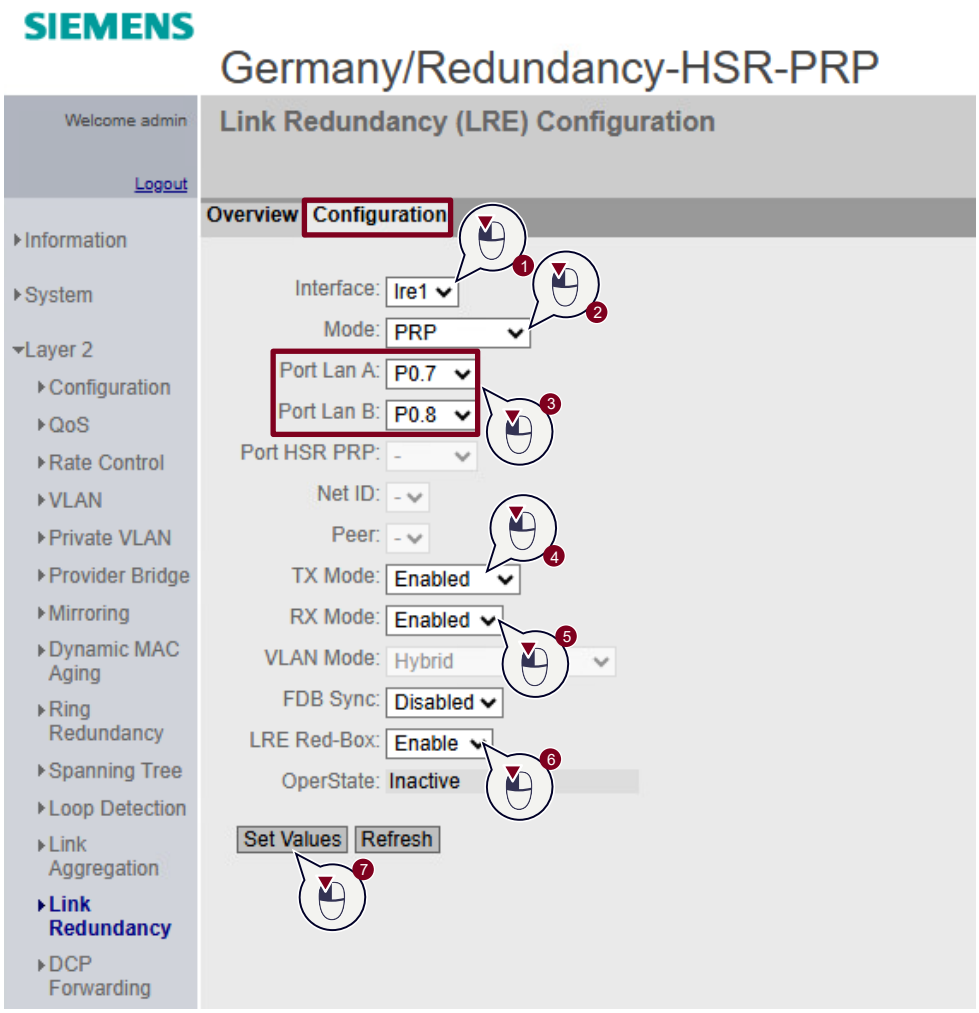


3.2.10.2. Activate PRP- or HSR redundancy

1. Open the "Link Redundancy" configuration under "Layer 2".
2. Activate the "LRE" checkbox and assign an "LRE ID".
3. Click on the "Create" button to create the network.



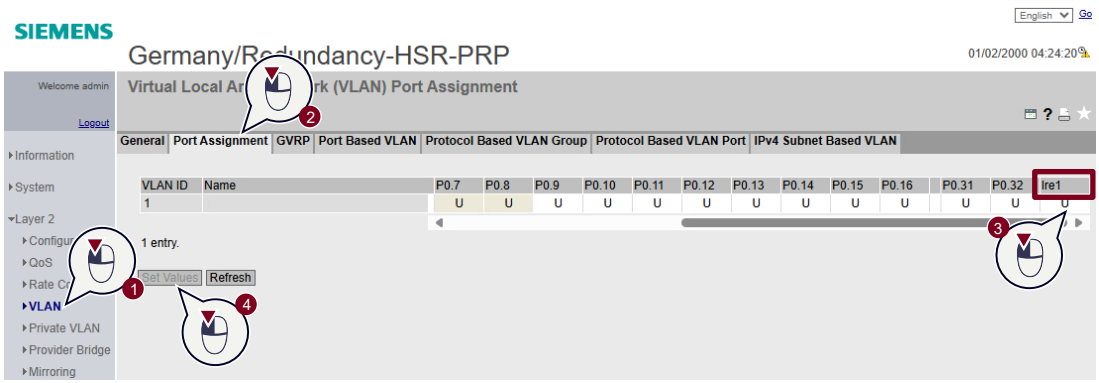
4. Switch to the "Configuration" tab and select the created network "lre1".
5. Select PRP or HSR in the "Mode" drop-down menu.
6. Assign the ports previously deactivated in the "Spanning Tree", here "P0.7" and "P0.8", to "Port Lan A" and "Port Lan B".
7. Activate the "TX Mode", the "RX Mode" and the "LRE Red-Box" option.
8. Click on the "Set Values" button. The "OperState" status display should change to "active".



3.2.10.3. VLAN configuration

Finally, you must set the generated redundancy network "lre1" to "Untagged" in the VLAN settings. To do this, proceed as follows:

1. Go to the "VLAN" settings under "Layer 2" and switch to the "Port Assignment" tab.
2. Scroll all the way to the right in the port table to the redundancy network "lre1" and select the "U" option in the drop-down menu to set the network to "Untagged".
3. Click on "Set Values" to confirm the changes.



4. Redundancy Device Reactions in the Event of Network Failures

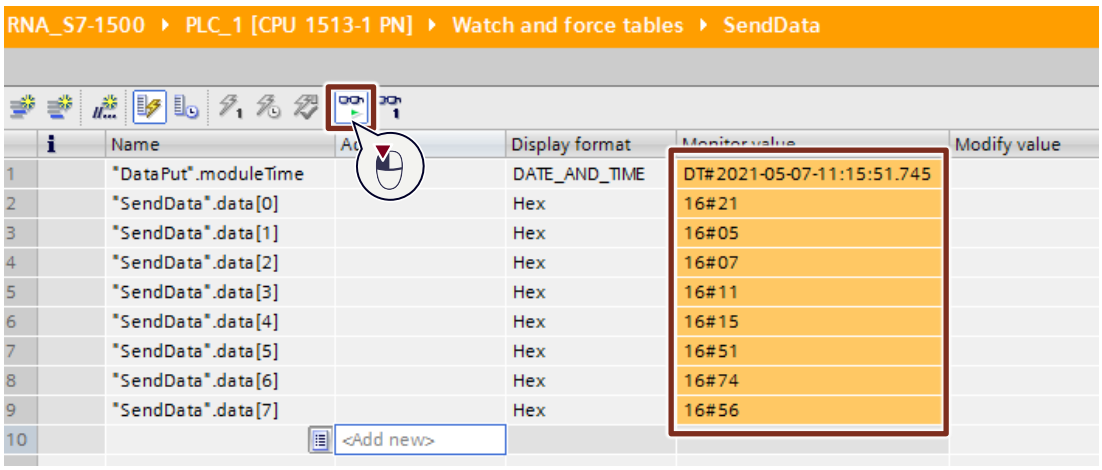
4.1. RNA with PRP

4.1.1. Requirements

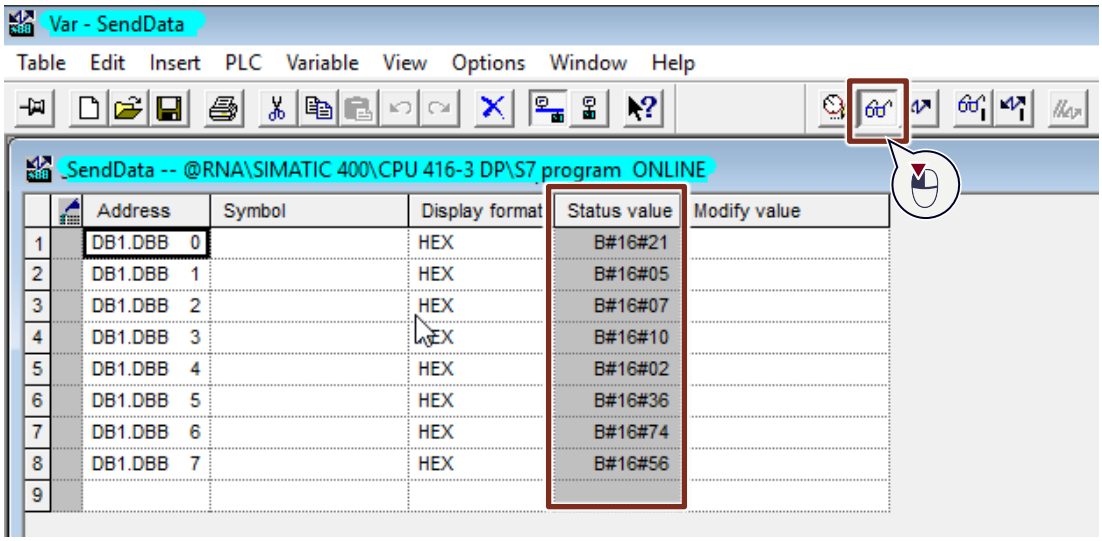
- All components are networked in accordance with chapter 3.1. Ensure that LAN A and LAN B are correctly connected to PRP ports A and B of the redundancy devices.
- The Engineering PC is connected to the still free LAN port of the SCALANCE XC332.
- The configuration was loaded into the S7-1500 CPU and S7-400 CPU.

4.1.2. Demonstration of Redundancy

1. Click the "Monitor all" button in the Watch table of the S7-1500 to monitor the send data.
   The time of the S7-1500 CPU is transmitted to the S7-400 CPU in a time interval of 5 s.



2. Click the "Monitor variable" button in the Variable table of the S7-400 CPU to monitor the received data. The S7-1500 CPU time is received in a time interval of 5 s.



3. Remove a network connection between two devices (e. g., remove the network connector from PRP port A of the CP 443-1 RNA).

Because of the double network design, the data exchange between S7-1500 CPU and S7-400 CPU continues.

4.1.3. Redundancy Device Reactions

SCALANCE XC332

A missing network connection (e. g., at PRP port A), is detected and indicated by various mechanisms.

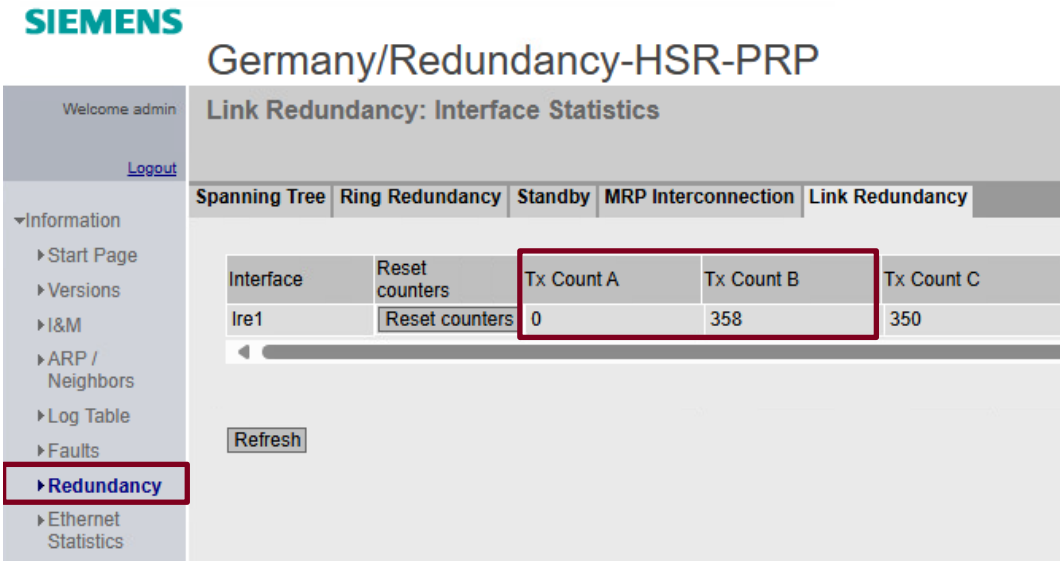
1. Error indication via LED:

   - Due to the missing network connection, PRP port A and PRP port B are receiving a different number of PRP frames. This redundancy error is indicated by the Redundancy Manager LED "RM" lighting up yellow.

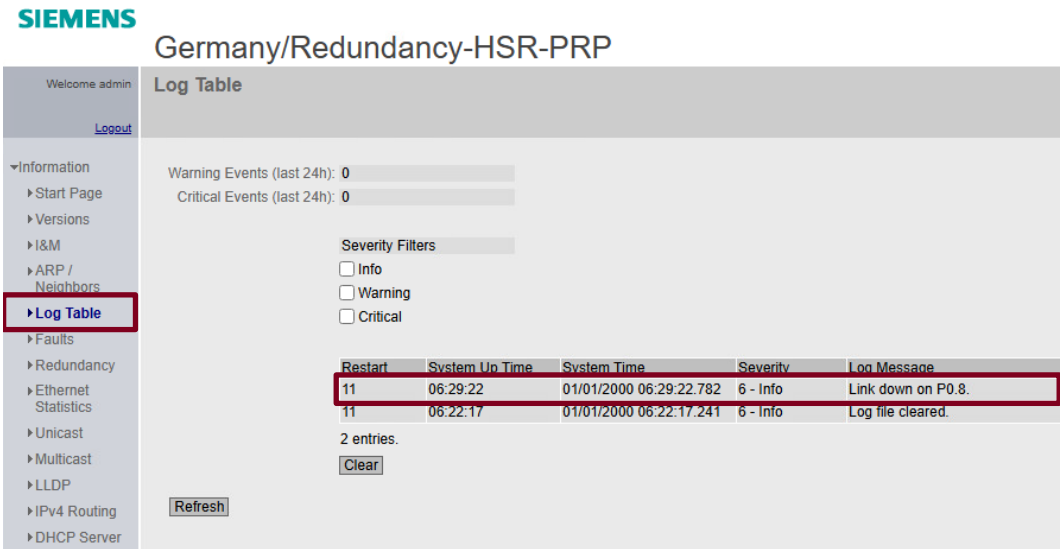
NOTE The switch must be set up as a redundancy manager so that this LED flashes in the event of a redundancy error. If this is not the case, the LED will not light up/flash even in the event of an error.

2. Troubleshooting via WBM:

   - In the Statistics display of the SCALANCE XC332 the value for the number of frames at the PRP A port (LAN A) remains static, while at the PRP B port (LAN B), the counter is increased.



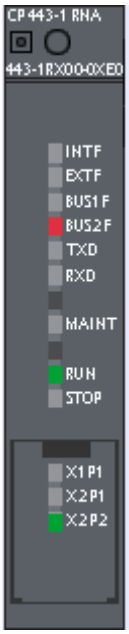
   - The XC332 switch reports in its "Log Table" that the port at "P0.8" is not available.



CP 443-1 RNA

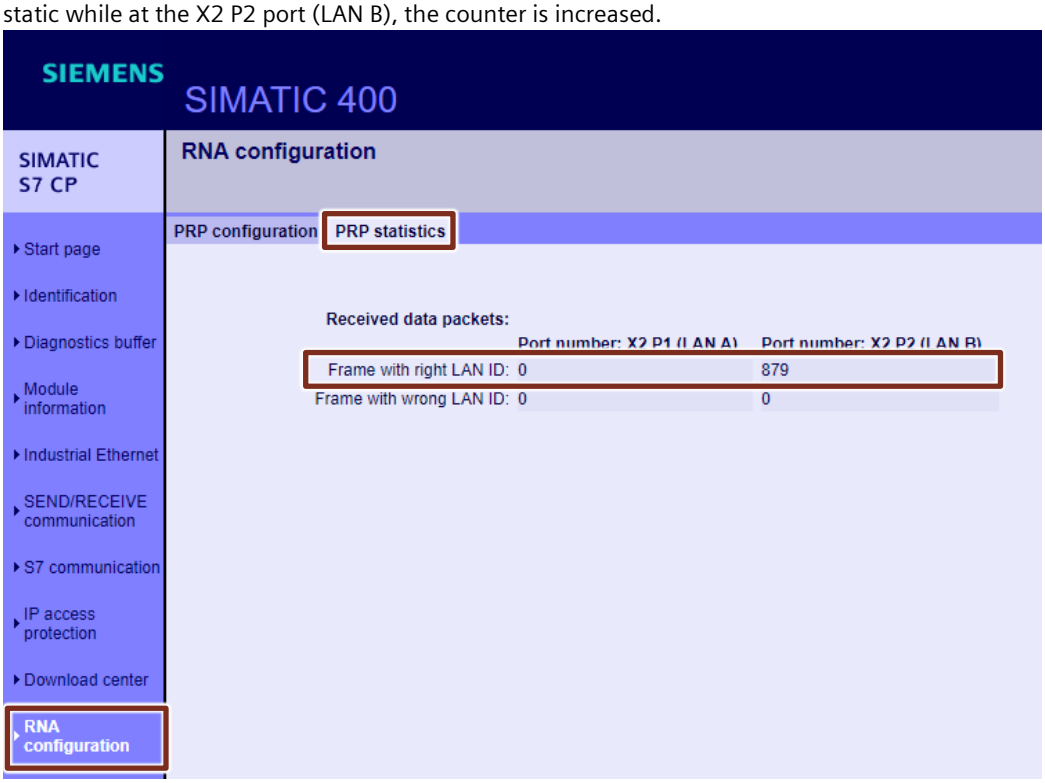
A missing network connection (e. g., at PRP port A), is detected and indicated by various mechanisms.

1. Error indication via LED
   Because of the missing network connection, an error is detected at the RNA interface. If an error is detected on the RNA interface, the BUS2F LED lights up red.

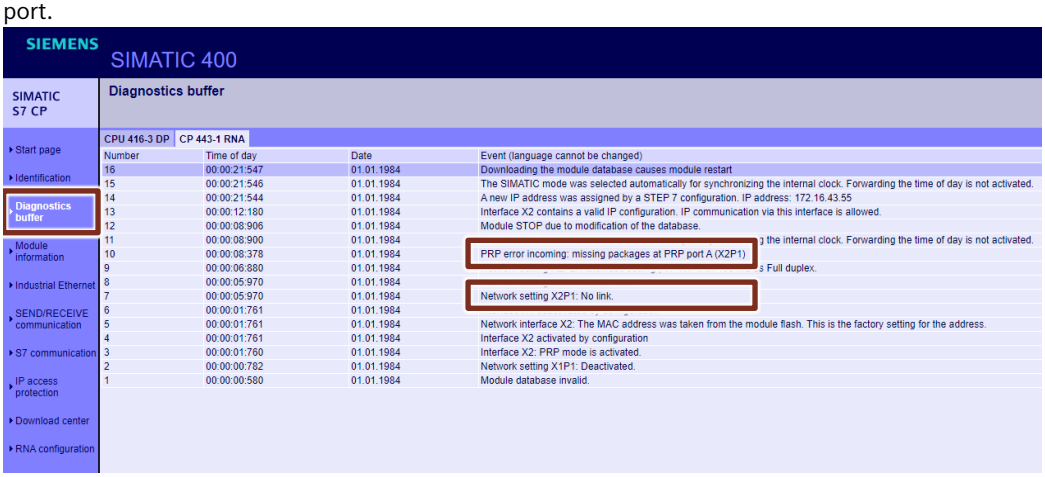


2. Troubleshooting via WBM

   - In the Statistics display of the CP 443-1 RNA, the value for the number of frames at port X2 P1 (LAN A) remains static while at the X2 P2 port (LAN B), the counter is increased.

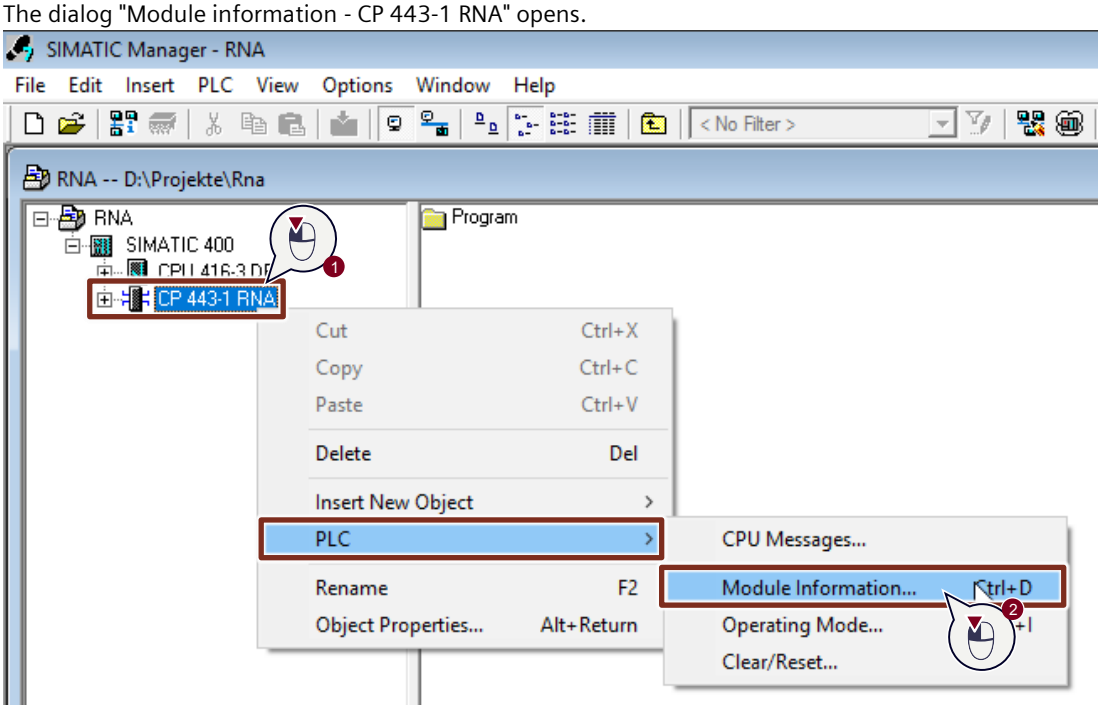


- In the diagnostic buffer, the CP443-1 RNA reports an absence of frames from LAN A and the missing link at the port.

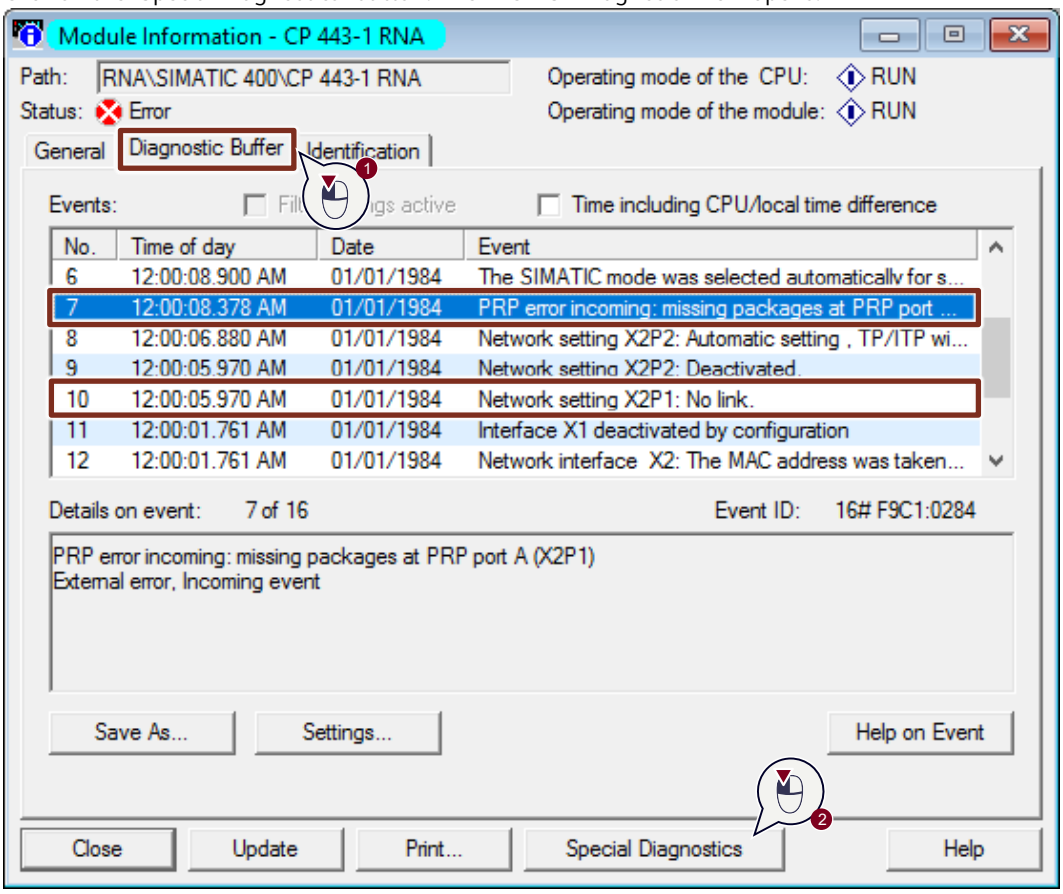


3. Diagnostics with STEP 7 and NCM S7 Diagnostics
   In STEP 7 and in the NCM S7 diagnostics, you may display the diagnostic buffer of the CP 443-1 RNA (PRP).

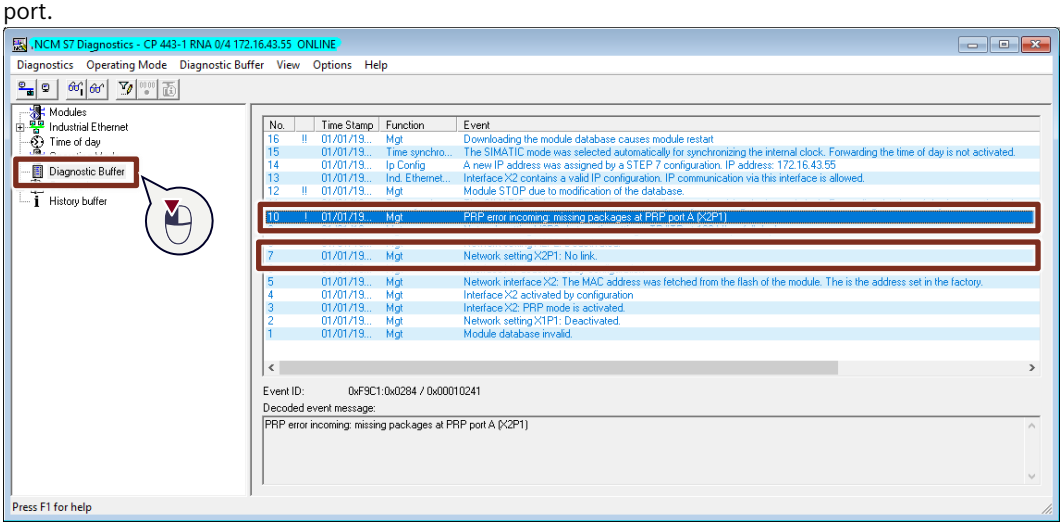
   - Click in the STEP 7 project with the right mouse button on the CP 443-1 RNA (PRP).
     The context menu opens.
   - Select the context menu "PLC > Module information".
     The dialog "Module information - CP 443-1 RNA" opens.



- Open the "Diagnostic Buffer" tab.
  In the diagnostic buffer, the CP443-1 RNA reports an absence of frames from LAN A and the missing link at the port.
- Click on the "Special Diagnostics" button. The "NCM S7 Diagnosis" view opens.



- Click the entry "Diagnostic Buffer".
  In the diagnostic buffer, the CP443-1 RNA reports an absence of frames from LAN A and the missing link at the port.

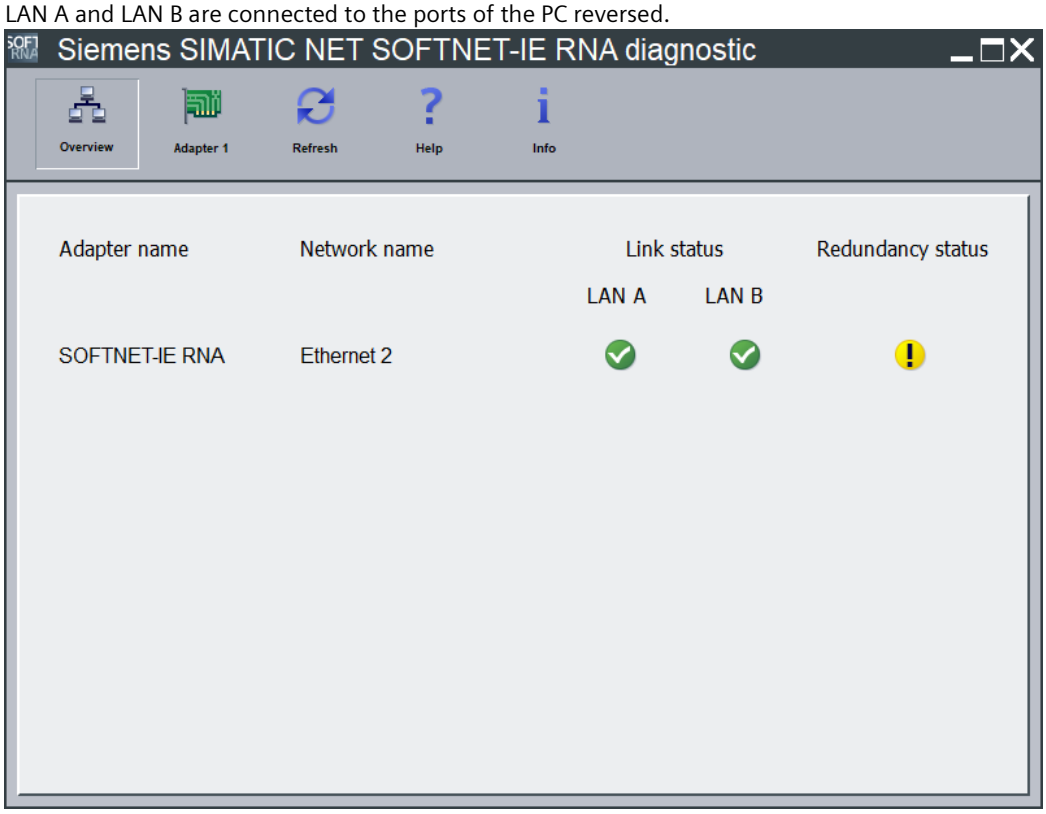


NOTE The view "NCM S7 Diagnostics" may alternatively be opened in Windows via the menu "Siemens Automation > Diagnostics".

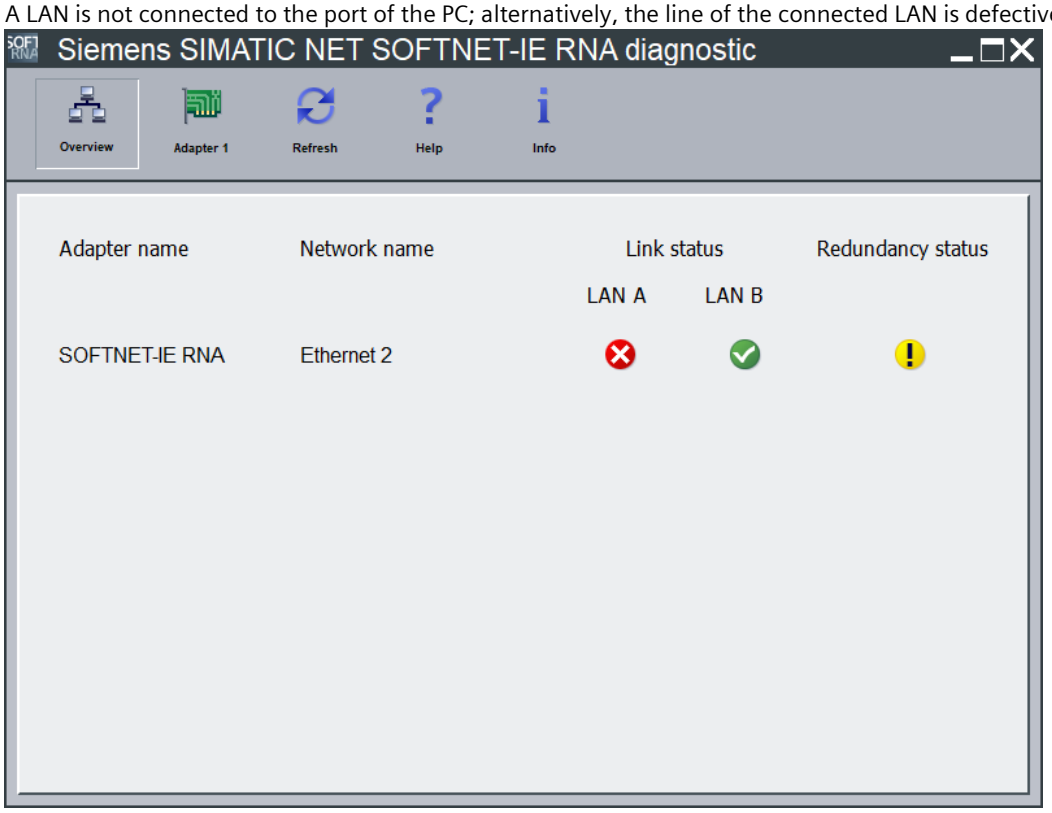
SOFTNET-IE RNA diagnostic

1. In the "SOFTNET-IE RNA diagnostic" view, a redundancy error is represented by an exclamation mark. A redundancy error occurs in the following cases, for example:

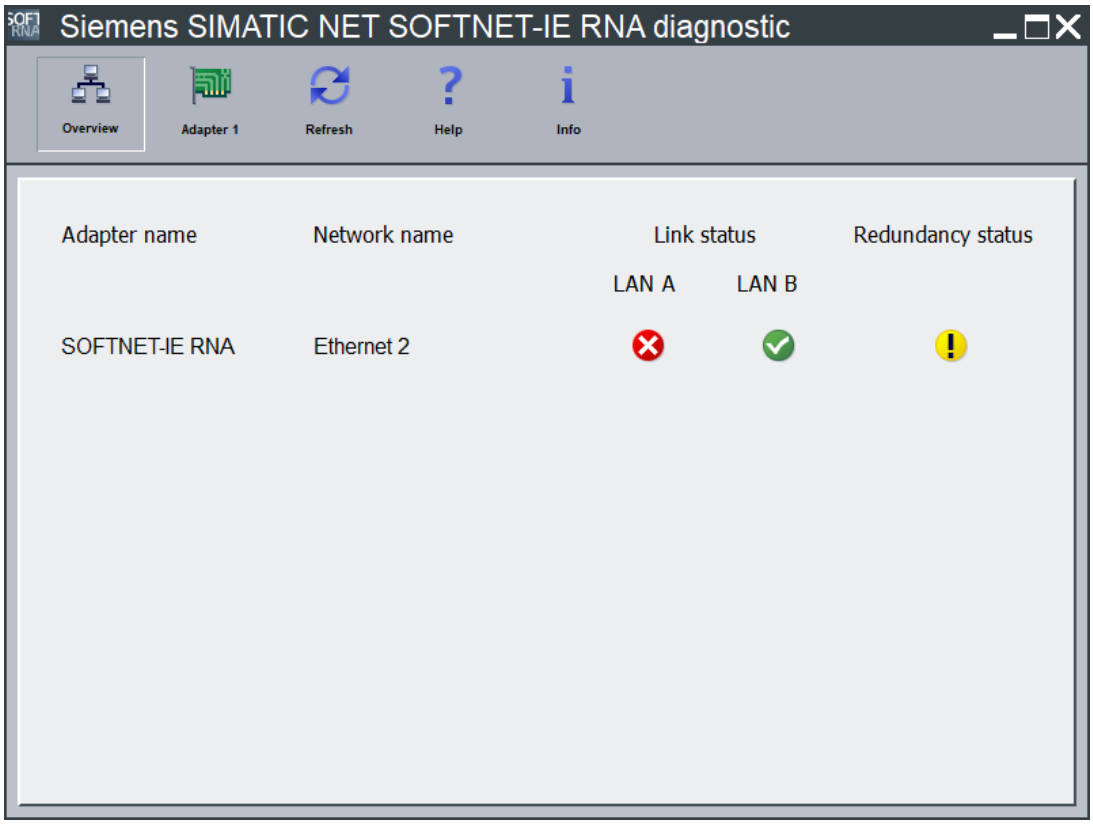
   - LAN A and LAN B are connected to the ports of the PC reversed.



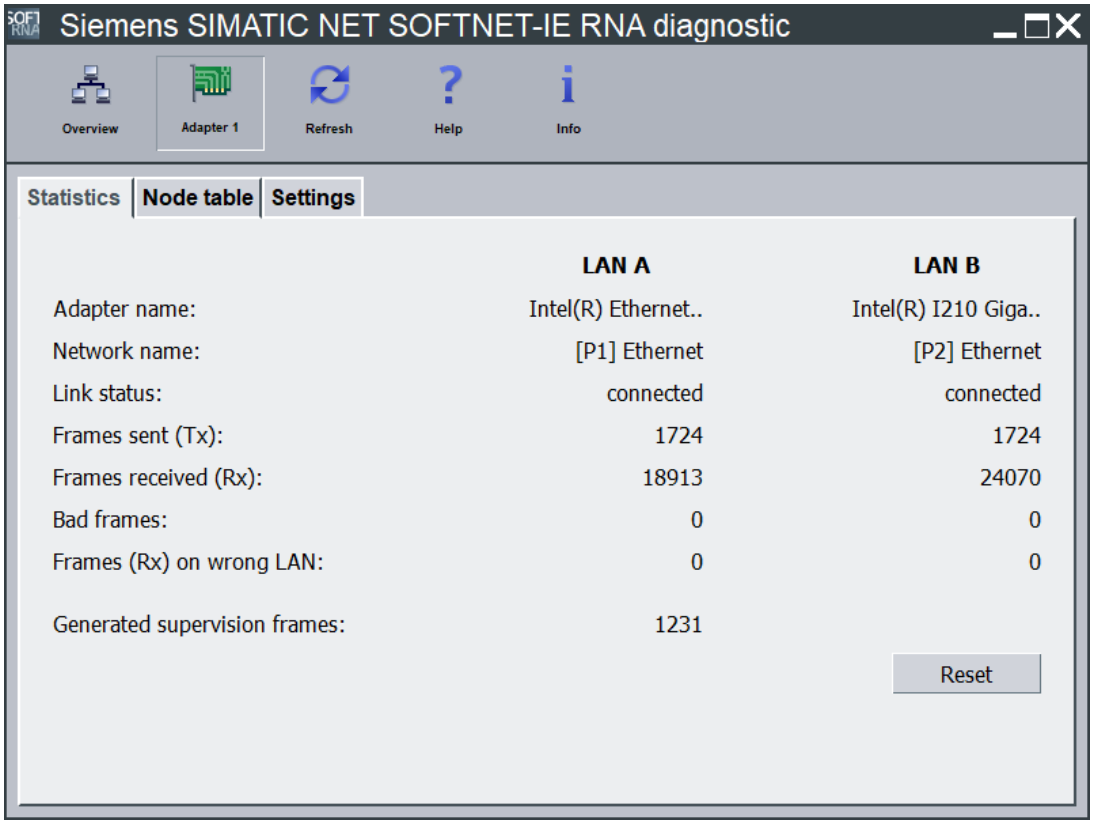
   - A LAN is not connected to the port of the PC; alternatively, the line of the connected LAN is defective.



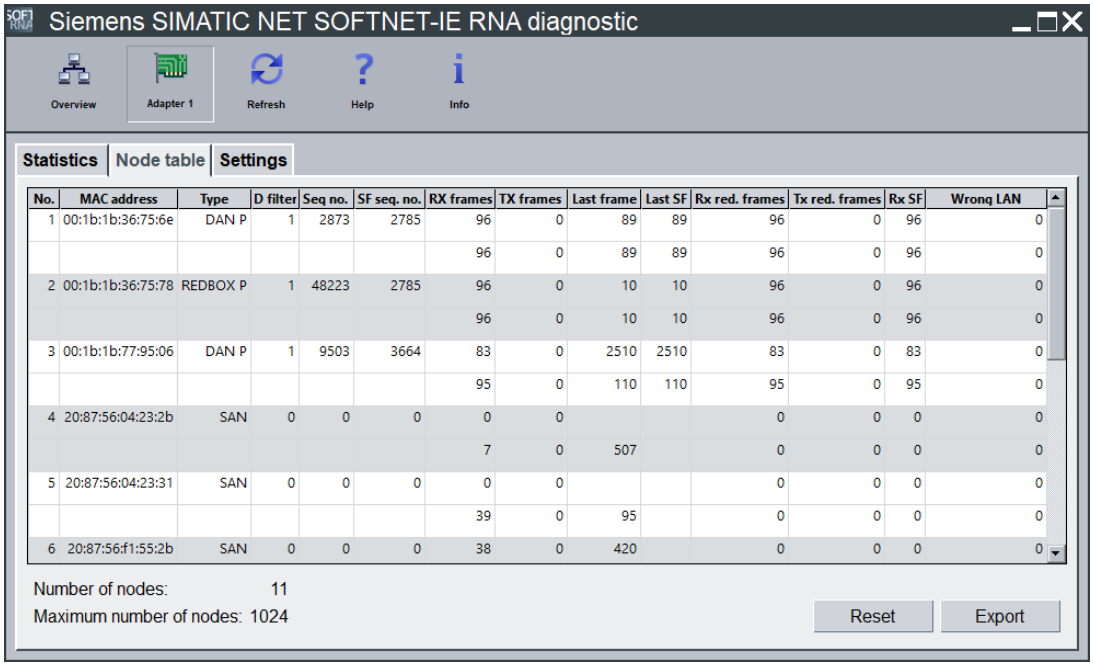
2. In the "SOFTNET-IE RNA diagnostic" view, the connection error is indicated by an "X" under the corresponding LAN (e. g., if a LAN is not connected to the port of the PC or the line of the connected LAN is defective).



3. In the "SOFTNET-IE RNA diagnostic" view, the number of frames received and sent at LAN A and LAN B is displayed in the statistics. If, for example, fewer PRP frames are received at LAN A than at LAN B, this indicates an error.



4. In the "SOFTNET-IE RNA diagnostic" view, open the Node table to monitor all devices. You can identify the device that is experiencing a malfunction when sending or receiving PRP frames.
   At the CP 443-1 RNA, the value for the received PRP frames at LAN A remains static while the counter is incremented at LAN B.



No.	MAC address	Type	D filter	Seq no.	SF seq. no.	RX frames	TX frames	Last frame	Last SF	Rx red. frames	Tx red. frames	Rx SF	Wrong LAN
1	00:1b:1b:36:75:6e	DAN P	1	2873	2785	96	0	89	89	96	0	96	0
						96	0	89	89	96	0	96	0
2	00:1b:1b:36:75:78	REDBOX P	1	48223	2785	96	0	10	10	96	0	96	0
						96	0	10	10	96	0	96	0
3	00:1b:1b:77:95:06	DAN P	1	9503	3664	83	0	2510	2510	83	0	83	0
						95	0	110	110	95	0	95	0
4	20:87:56:04:23:2b	SAN	0	0	0	0	0			0	0	0	0
						7	0	507		0	0	0	0
5	20:87:56:04:23:31	SAN	0	0	0	0	0			0	0	0	0
						39	0	95		0	0	0	0
6	20:87:56:f1:55:2b	SAN	0	0	0	38	0	420		0	0	0	0

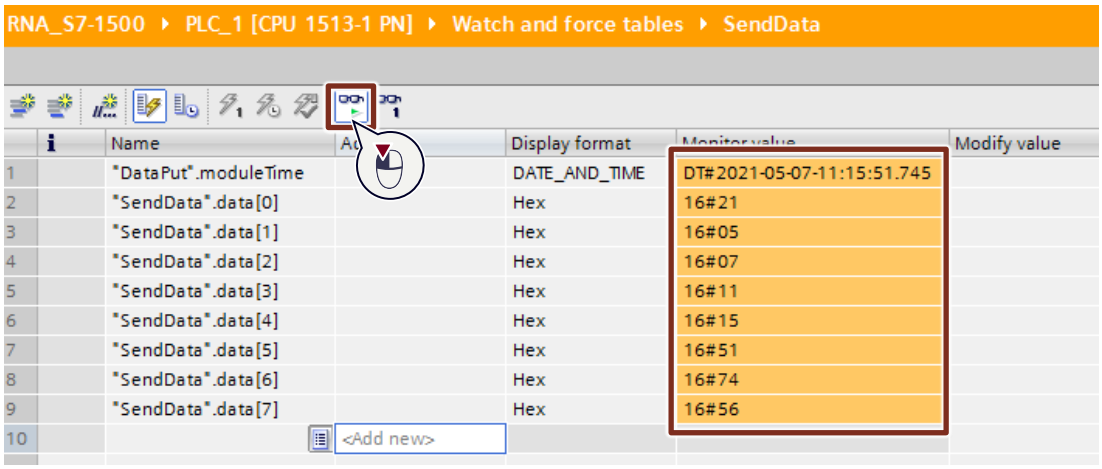
4.2. RNA with HSR

4.2.1. Requirements

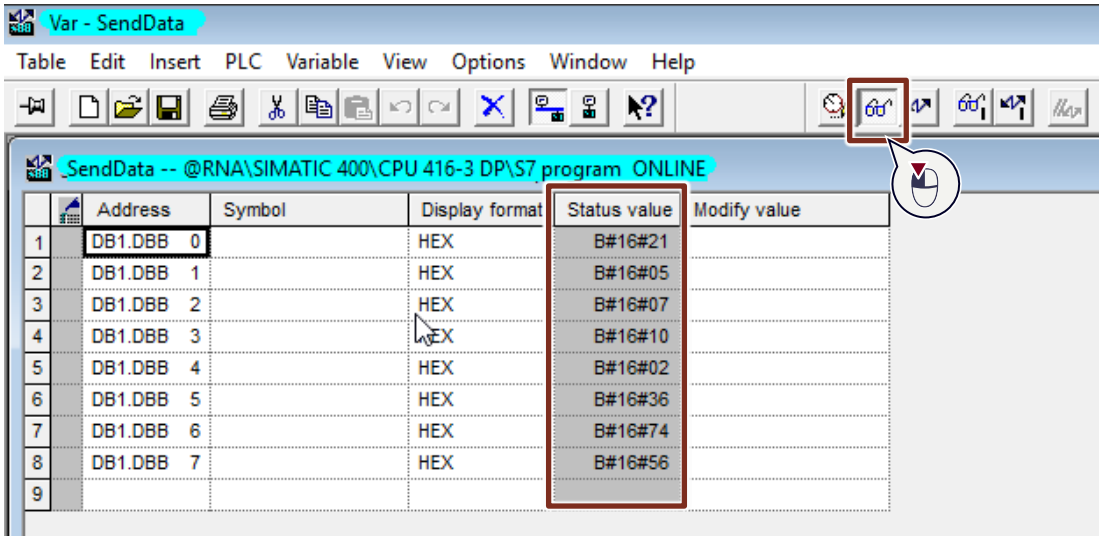
- All components are networked in accordance with chapter 3.1. Ensure that the ring ports are connected correctly.
- The Engineering PC is connected to a free LAN port on the SCALANCE XC332.
- The configuration was loaded into the S7-1500 CPU and S7-400 CPU.

4.2.2. Demonstration of Redundancy

1. Click the "Monitor all" button in the Watch table of the S7-1500 to monitor the send data.
   The time of the S7-1500 CPU is transmitted to the S7-400 CPU in a time interval of 5 s.



2. Click the "Monitor variable" button in the Variable table of the S7-400 CPU to monitor the received data.
   The S7-1500 CPU time is received in a time interval of 5 s.



3. Remove one of the network connections between two devices in the HSR ring (e. g., remove the network connector from the ring port "HSR 1" of the SCALANCE XC332 to which the S7-1500 CPU or CP443-1 RNA is connected).

Because of the double network design, the data exchange between S7-1500 CPU and S7-400 CPU continues.

4.2.3. Redundancy Device Reactions

An open ring (e. g., due to a missing network connection at the HSR ports) is detected by the SCALANCE XC332 and identified by a variety of mechanisms.

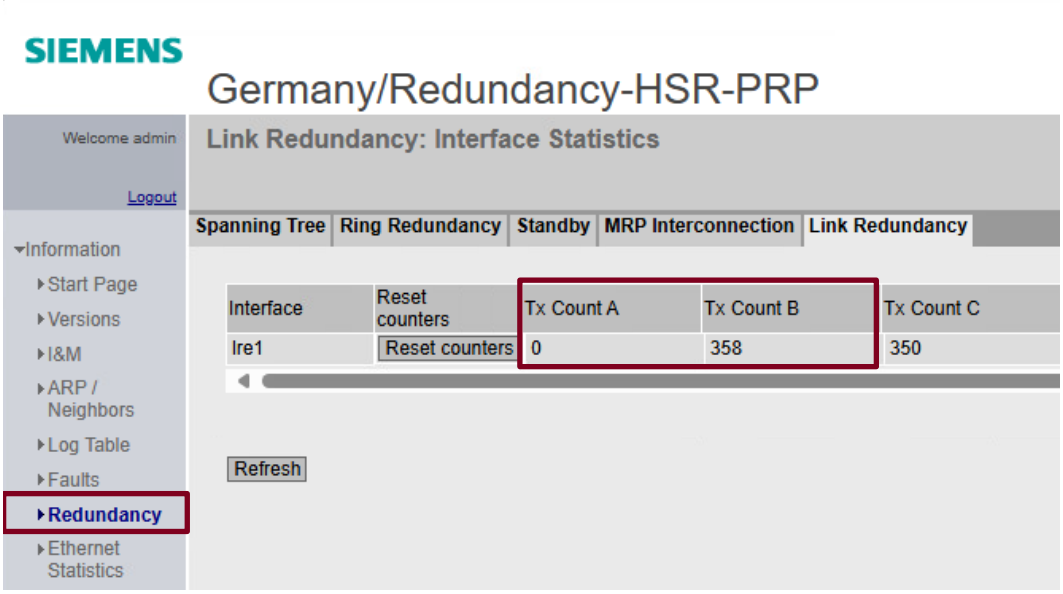
1. Error indication via LED:

   - Due to the missing network connection, PRP port A and PRP port B are receiving a different number of PRP frames. This redundancy error is indicated by the Redundancy Manager LED "RM" lighting up yellow.

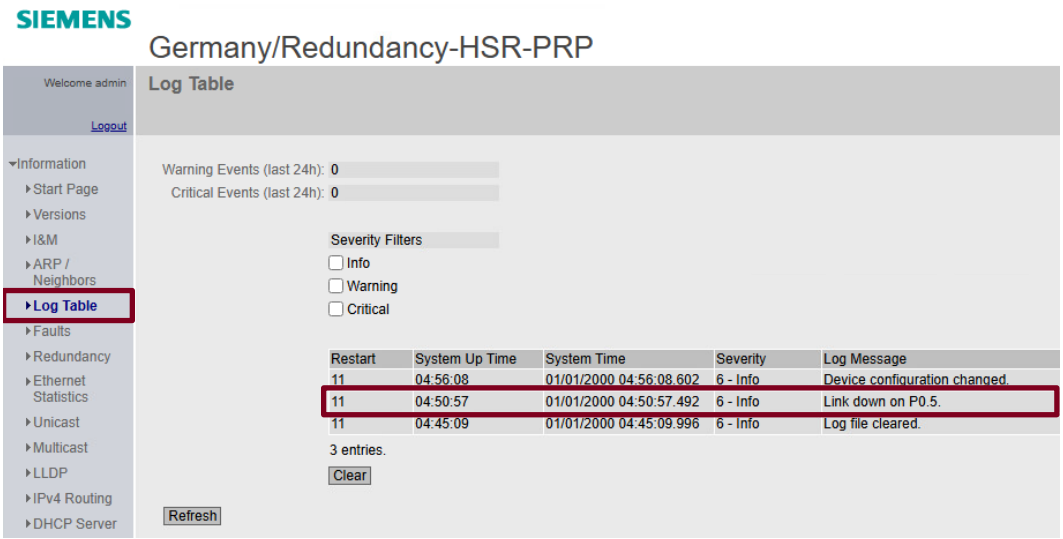
NOTE The switch must be set up as a redundancy manager so that this LED flashes in the event of a redundancy error. If this is not the case, the LED will not light up/flash even in the event of an error.

2. Troubleshooting via WBM

   - In the Statistics display of the SCALANCE XC332, the value for the number of frames at the "HSR 1" HSR port remains static, while at the "HSR 2" HSR port, the counter is incremented.



   - The XC332 RNA reports the missing link from the port in its "Event Log" table.



5. Useful Information

5.1. Fundamentals

Demanding industrial applications require seamless switching in the event of an error. One approach to implement this procedure is to transmit each frame several times on different, independent paths at the same time.

The receiver uses the first frame received and discards the duplicate that arrives later.

The IEC 62439-3 standard specifies two such protocols:

- PRP: Parallel Redundancy Protocol
- HSR: High-availability Seamless Redundancy

5.1.1. PRP (Parallel Redundancy Protocol)

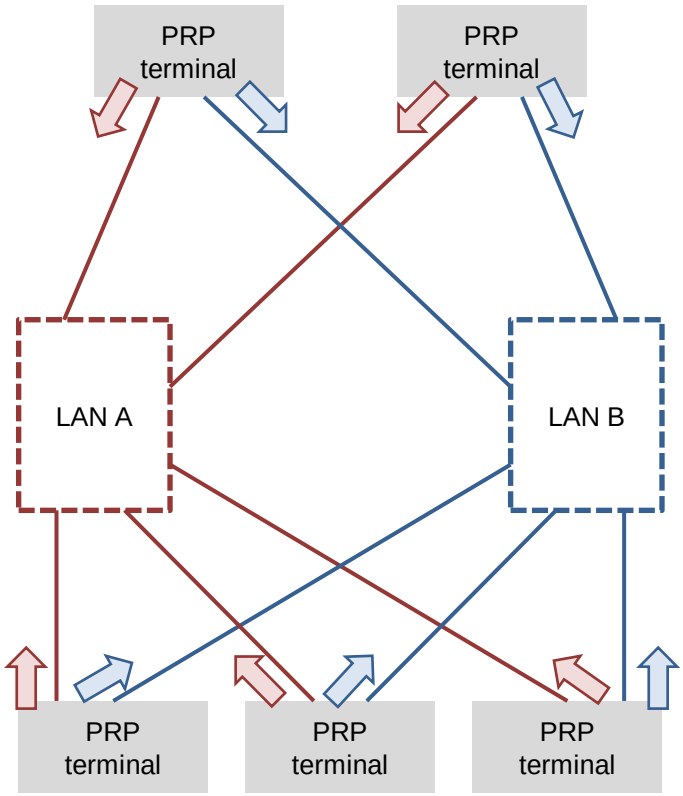
PRP belongs to the category of network redundancy and is based on two independent networks of any topology (LAN A, LAN B).

In contrast to other redundancy procedures, PRP is implemented in the end devices. The protocol is implemented in a software layer that is inserted above the link layer.

The end devices each have at least two separate network connections which are connected to independent networks.

PRP is a redundancy solution on layer 2. A component appears on both networks with the same MAC address (Media Access Control), so that all protocols for network management can be used without any changes.

The duplicate frame is detected via an additional trailer at the end of the Ethernet frame.



To ensure high availability in the event of an error, the redundancy nodes send their frames via LAN A and LAN B.

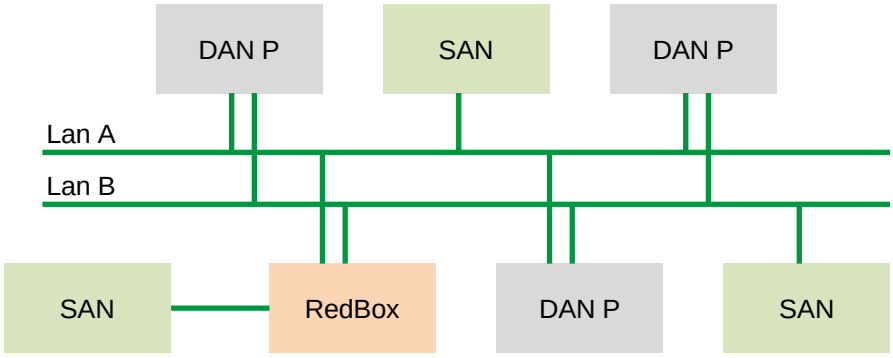
Establishment of a redundant network with PRP

The topology of a redundant network with PRP consists of two completely independent Ethernet subnets. These two networks (LAN A and LAN B, respectively) can either have identical structures or they can differ in topology or performance.

NOTE However, the structures should at least be similar, as extreme differences will cause the duplicate filter to be overridden due to excessive time difference.

You have the option of setting up the redundant network with PRP-capable end devices and with standard components.

The following figure shows the structure of a redundant network with PRP.



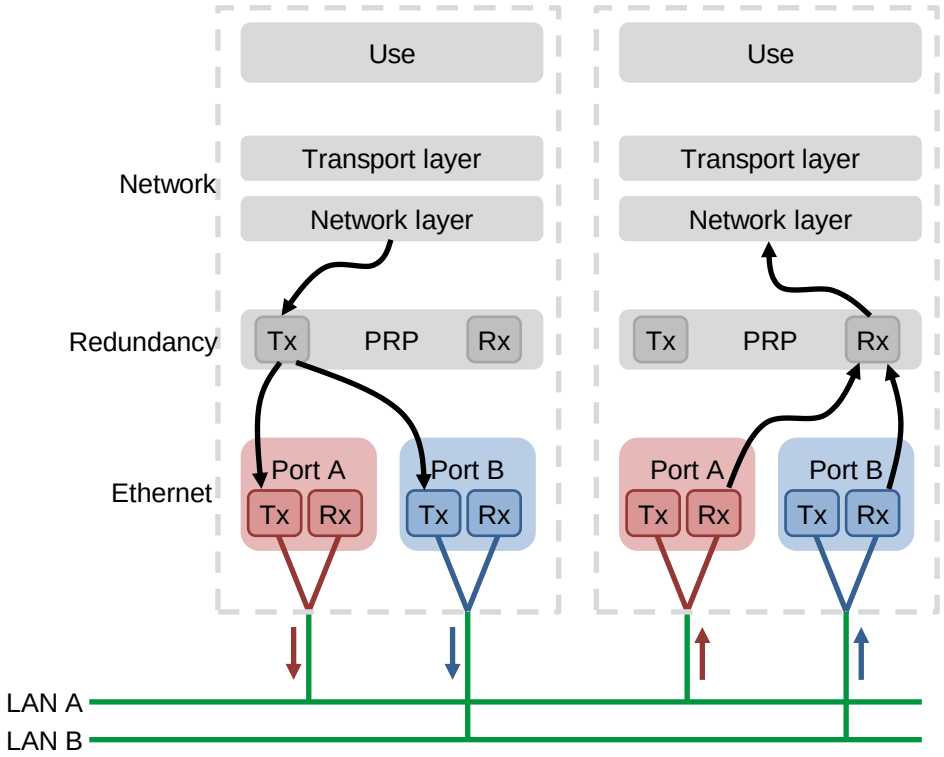
- Terminal (DAN P):
  A terminal device with PRP function is called "Double Attached Node for PRP" (DAN P) and has one connection to each of the two independent networks (LAN A and LAN B).
  In the SIMATIC NET product range, the following modules, among others, are PRP-capable:
  - CP 443-1 RNA
  - PC station with SOFTNET-IE RNA
  - PRP-capable protection devices SIPROTEC (EN100 module with LC connections and application status as of V4.1x)
  - SCALANCE model series XC300, XR300, XC400 and XR500
  - RUGGEDCOM RSG907R, RSG909R, and RST2228

NOTE Each frame that is sent via the PRP mechanisms is given an identifier that determines whether it is sent via LAN A or LAN B. The identifier is used to identify the frame.
Ensure that the PRP ports of the devices are correctly connected to LAN A or LAN B throughout.
A frame with the identifier "LAN A" must also be received by the receiver at the corresponding port.

- Standard Components (SAN):
  Standard components with a single network interface are called "Single Attached Node" (SAN) and can be connected directly to one of the two networks. In the event of a failure, the device has no redundant connection available and does not benefit from network redundancy.
- It is possible to connect a SAN as a Virtual DAN (VDAN) to a redundancy box. It is not necessary for SANs to support PRP.
- System connection (redundancy box)
  A redundancy box (RedBox) allows one or more SANs to connect to both networks and performs PRP functions on behalf of all SANs connected to it.
  The following SIMATIC NET products can be used as a RedBox:
  - SCALANCE XC332
  - RUGGEDCOM RSG907R, RSG909R, and RST2228

Communication in a redundant network with PRP

The specification of PRP requires that two end devices are connected to each other via two independent networks (LAN A and LAN B). Each end device is represented with the same MAC and IP address in both networks.



- Send:
  A PRP-enabled terminal device doubles each frame to be sent via the PRP interface.
  The two duplicates are sent to the communication partner via the two ports of the PRP interface over the two separate networks LAN A and LAN B. The duplicates are sent to the communication partner via the two ports of the PRP interface.
  If a SAN is connected to a RedBox, the RedBox performs the PRP functions on behalf of the SANs: It doubles the frame to be sent and sends it via LAN A and LAN B to the communication partner. The RedBox thus works as a kind of redundancy proxy for any kind of standard components.
- Receive:
  Accordingly, the two duplicates are received by a PRP-capable terminal via LAN A and LAN B on the two ports of the PRP interface. The PRP unit forwards the first incoming frame to the application layer and discards the second (identical) frame. The interface to the application is, therefore, identical to any other Ethernet interface.
  If the receiver is a standard component connected by a RedBox, the RedBox takes over the detection of the duplicate and forwards only the first incoming frame to the addressee. The second frame is discarded.
- Special case with SAN:
  A SAN connected without RedBox can communicate in a PRP network with all DAN Ps and with SANs of the same network (either LAN A or LAN B). A SAN has no connection to the nodes of the other network.
  If a SAN must also communicate with the nodes of the other network, a RedBox is required.

NOTE

In PRP mode, the first frame from an unknown device is discarded and remains unanswered. This behavior must be considered for services that generally do not initiate retrying frames, such as:

- Firmware loading
- Network searching
- Ping

Modification of the Ethernet frame

Duplicates are detected by means of a "Redundancy Control Trailer" (RCT) inserted into each frame by the DAN P or RedBox.

The identification field consists of the following parameters:

- Sequence number (16-bit)
- Identifier for the LAN (4-bit)
  - 0xA for LAN A
  - 0xB for LAN B
- Payload length (12-bit)

The RCT is inserted at the end of the frame. This means that all data traffic can be read without restriction even by SANs that do not support PRP. SANs interpret the trailer as meaningless "padding".

NOTICE

The additional trailer increases the size of the Ethernet frame to 1532 bytes (standard Ethernet: 1518 bytes).

Ensure that the standard components used can process frames with a larger size of up to 1532 bytes (oversize frames).

NOTE

An overview of the compatible SIMATIC NET components can be found in the manual of the SCALANCE XC332 and CP 443-1 RNA (see Section 6.2).

5.1.2. HSR (High-availability Seamless Redundancy Protocol)

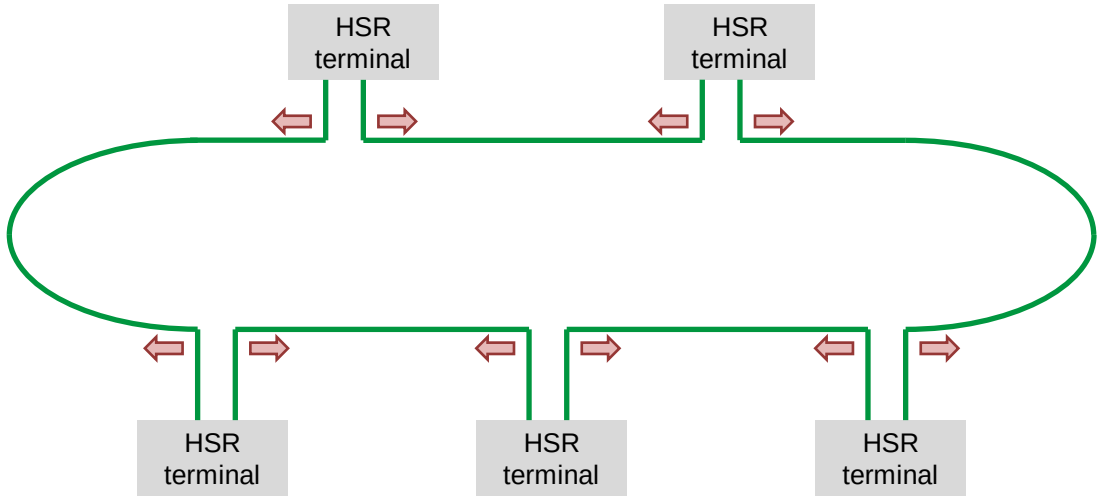
HSR is defined in the same specification as PRP. HSR belongs to the category of media redundancy and is designed for use in ring topologies.

HSR is also a redundancy protocol implemented in the end devices.

The protocol is implemented in a software layer that is integrated above the link layer.

The end devices each have at least two network connections that are interconnected to form a ring.

The frame duplicate is detected by extending the Ethernet header (HSR tag).



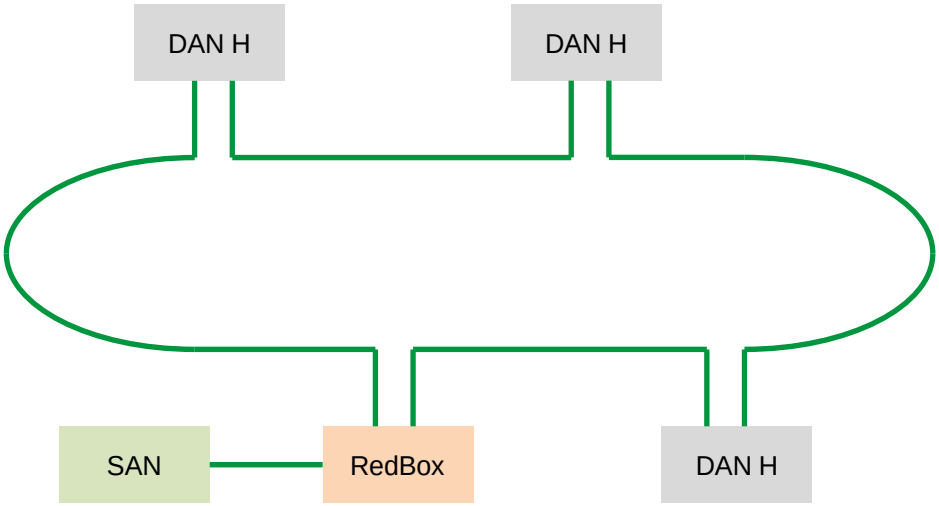
To ensure high availability in the event of an error, the redundancy devices send one frame clockwise and an identical one counterclockwise.

Establishment of a redundant network with HSR

The ring structure serves as the HSR network topology. This can be set up with HSR-capable end devices as well as with standard components via a ballast (RedBox).

HSR allows a redundant design of the ring and a coupling to a PRP network.

The following figure shows how an HSR network can be set up with the components mentioned.

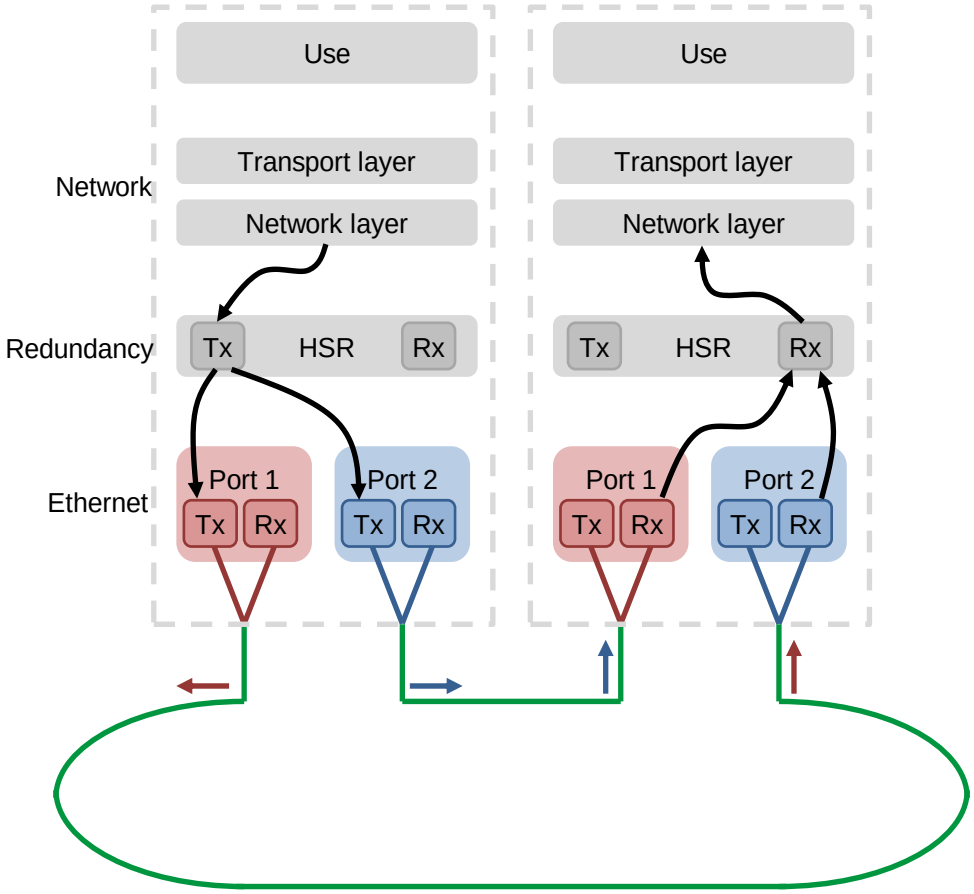


- Terminal (DAN H)
  A terminal device with HSR function is called "Double Attached Node for HSR" (DAN H) and has at least two integrated network interfaces (ring ports) for connecting to the ring. Some devices have multiple internal ports.
- Standard component (SAN)
  Standard components with a single network interface are called "Single Attached Node" (SAN) and can only be connected to the ring via a redundancy box.
  SANs do not need to support the HSR feature.
- System connection (redundancy box)
  With the help of the Redundancy Box (RedBox), one or more SANs are integrated into the HSR network. The RedBox takes over the HSR functions on behalf of all SANs connected to it.
  In addition, the RedBox enables the coupling of PRP networks and HSR ring.
  Two HSR rings are connected via two redundant paths using "quad boxes". These HSR end devices have at least four integrated ring ports.

NOTE Coupling an HSR ring to the rest of the network requires parameterization of the ports via the WBM.

Communication in a redundant network with HSR

The specification of HSR provides that all end devices are connected via a ring.



- Send:
  An HSR-capable terminal device doubles each frame that is sent at the HSR interface.
  The two duplicates are sent to the communication partner via the ring ports as follows:
  - A clockwise frame
  - A counterclockwise frame
  - If a SAN is connected to a RedBox, the RedBox performs the HSR function on behalf of the SANs: It doubles the frame to be sent and sends it accordingly via the ring to the communication partner. The RedBox thus works as a kind of redundancy proxy for any kind of standard components.
- Receive:
  The two duplicates are received by an HSR-capable terminal via the two ring ports. The HSR unit forwards the first incoming frame to the application layer and discards the second (identical) frame. The interface to the application is, therefore, identical to any other Ethernet interface.
  If the receiver is a standard component connected by a RedBox, the RedBox takes over the detection of the duplicate and forwards only the first incoming frame to the addressee. The second frame is discarded.

NOTE Due to the double transmission of the frames in both directions, only 50% of the network bandwidth is effectively available for data traffic.

- Special case with SAN
  It is not possible to integrate a SAN into an HSR network without a RedBox. A SAN lacks the second network interface to close the ring. The ring would be disconnected. In addition, the HSR header encapsulates the network traffic. In PRP, SANs can interpret the RCT as meaningless padding. This is not possible with the HSR tag. Due to its position in

the frame, the HSR tag is always interpreted by the SAN as valid layer 2 information. Therefore, a correct readout of the data payload is not possible. If a SAN is intended to connect to the network, a RedBox is required.

Modification of the Ethernet frame

To detect duplicates, the DAN H devices or RedBoxes extend the Ethernet header in the frame by an HSR tag. The identification field consists of the following parameters:

- Sequence number (16-bit)
- Identifier for the port (4-bit)
- Payload length (12-bit).

The HSR tag is positioned at the beginning of the frame. The position offers the advantage that the detection of the duplicate for each individual frame in each device takes place immediately after receiving the HSR tag. Waiting until the frame is completely received is no longer necessary.

Therefore, the HSR end devices already start forwarding the frame at the second ring port as soon as the HSR information has been completely read in and the duplicate has been detected.

Only frames addressed to itself are forwarded by the HSR terminal to the application and taken off the network.

Multicast or broadcast frames are forwarded by each node on the ring and are also forwarded to the application.

NOTE To avoid permanent circling of multicast or broadcast frames in the ring, they are taken off the network after one loop through the ring.

5.1.3. Combination of PRP and HSR

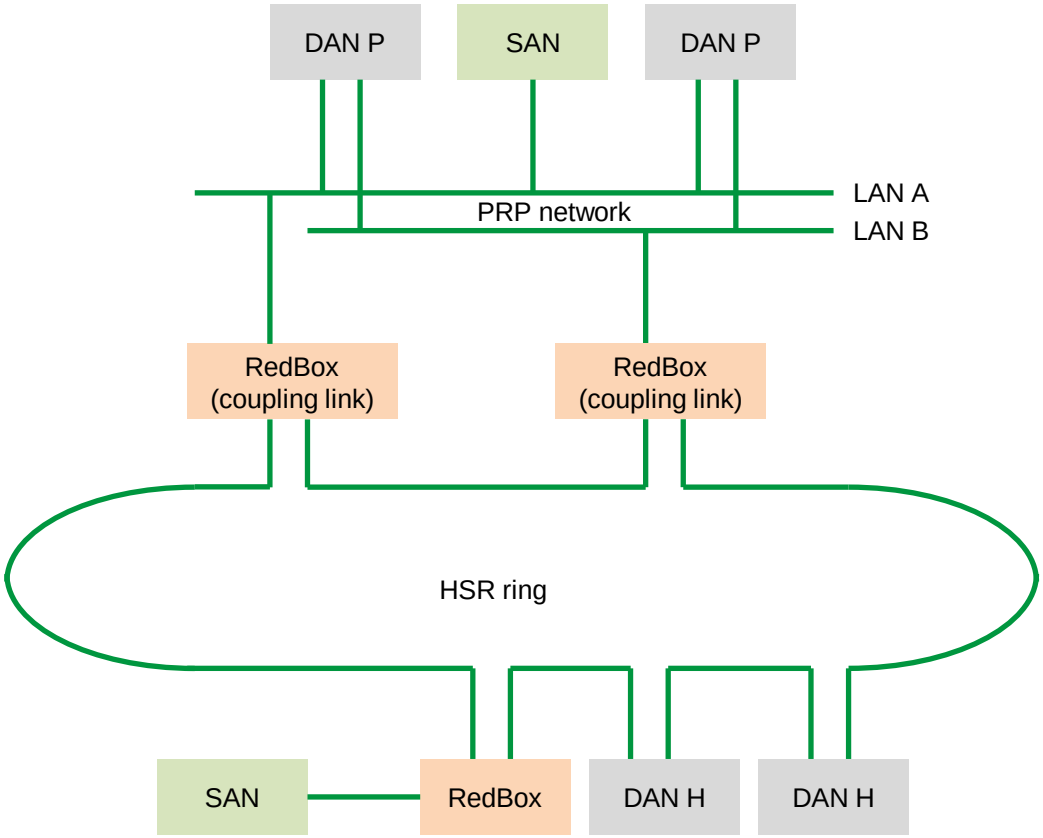
With the help of the redundancy box, it is possible to implement the coupling of a PRP network and an HSR ring.

The SCALANCE XC332 is used as a coupling link between a PRP network and HSR ring. Two Ethernet ports defined as PRP are used for the connection to the two PRP networks (LAN A and LAN B). Two other Ethernet ports defined as HSR are used to set up the HSR ring topology.

To enable this, the mode of coupling between HSR and the rest of the network must be set in the WBM of the SCALANCE XC332) (see Section 3.2.10).

Establishment of a redundant HSR-PRP coupling

The following figure shows the redundant coupling of an HSR ring with a PRP network.



This coupling is designed redundantly, as described in the IEC62439-3 standard.

Two SCALANCE XC332 switches are required for redundant coupling. The first device connects the HSR ring to the PRP network LAN A. The second device connects the HSR ring to the PRP network LAN B.

In case of failure of a transition point, complete communication is still guaranteed. The exceptions to this are SANs that are connected to the disconnected PRP network without a RedBox.

NOTE

Coupling with a PRP network can also be non-redundant. Only one SCALANCE XC332 is used. This device is connected to the PRP network LAN A and to LAN B.

This type of coupling is not recommended because, if the transition point fails, communication between HSR and PRP devices will also be interrupted.

5.2. Alternative Solutions

Several redundancy options are available to increase availability in Communication networks. Special protocols ensure a loop-free network topology and the detection of communication interruptions.

In practice, neither the perfect network topology nor the perfect media redundancy protocol exists to cover all application areas and requirements.

The following factors influence which topology and which protocol is most suitable for the automation network.

- Physical installation specifications
- Requirements of the application for the switching time
- Number of network devices
- Data transmission requirements (real-time or standard Ethernet)

The following table shows the most common protocols.

Report	Abbreviation	Reference	Category
Link aggregation	LAG	IEEE 802.1ad	Redundant paths
Spanning Tree Protocol	STP	IEEE 802.1d	
Rapid Spanning Tree Protocol	RSTP	IEEE 802.1d-2004	
Multiple Spanning Tree Protocol	MSTP	IEEE 802.1s	
High Speed Redundancy Protocol	HRP	SIEMENS proprietary	Ring topology with redundancy manager
Standby coupling	–	SIEMENS proprietary	
Media Redundancy Protocol	MRP	IEC 62439-2	
Media Redundancy for Planned Duplication	MRPD	IEC 61158	
Parallel Redundancy Protocol	PRP	IEC 62439-3	Double network design
High-availability Seamless Redundancy	HSR	IEC 62439-3	Ring topology

6. Appendix

6.1. Service and support

SiePortal

The integrated platform for product selection, purchasing and support - and connection of Industry Mall and Online support. The SiePortal home page replaces the previous home pages of the Industry Mall and the Online Support Portal (SIOS) and combines them.

- Products & Services
  In Products & Services, you can find all our offerings as previously available in Mall Catalog.
- Support
  In Support, you can find all information helpful for resolving technical issues with our products.
- mySieportal
  mySiePortal collects all your personal data and processes, from your account to current orders, service requests and more. You can only see the full range of functions here after you have logged in.

You can access SiePortal via this address: sieportal.siemens.com

Technical Support

The Technical Support of Siemens Industry provides you fast and competent support regarding all technical queries with numerous tailor-made offers – ranging from basic support to individual support contracts.
Please send queries to Technical Support via Web form: support.industry.siemens.com/cs/my/src

SITRAIN – Digital Industry Academy

We support you with our globally available training courses for industry with practical experience, innovative learning methods and a concept that's tailored to the customer's specific needs.
For more information on our offered trainings and courses, as well as their locations and dates, refer to our web page: siemens.com/sitrain

Industry Online Support app

You will receive optimum support wherever you are with the "Industry Online Support" app. The app is available for iOS and Android:

6.2. Links and literature

No.	Topic
\1\	Siemens Industry Online Support https://support.industry.siemens.com
\2\	Link to this entry page of this application example https://support.industry.siemens.com/cs/ww/en/view/78790945
\3\	SIMATIC NET: S7-400 - Industrial Ethernet CP 443-1 RNA https://support.industry.siemens.com/cs/ww/view/69265740
\4\	SIMATIC NET: Industrial Ethernet Switches SCALANCE XC300 https://support.industry.siemens.com/cs/document/109964146
\5\	SIMATIC NET: Industrial Ethernet Switches SCALANCE XR300 https://support.industry.siemens.com/cs/document/109972620
\6\	SIMATIC NET: Industrial Ethernet Switches SCALANCE XC400 https://support.industry.siemens.com/cs/document/109964151
\7\	SIMATIC NET: Industrial Ethernet Switches SCALANCE XR500 https://support.industry.siemens.com/cs/document/109823936
\8\	SIMATIC NET Industrial Ethernet Switches SCALANCE Layer 2 / Layer 3 Web Based Management (WBM) V1.2 https://support.industry.siemens.com/cs/document/109826940
\9\	SIMATIC NET: PG/PC - Industrial Ethernet SOFTNET-IE RNA https://support.industry.siemens.com/cs/ww/view/77377603
\10\	How to Configure RNA on RSG907R, RSG909R and RST2228 devices https://support.industry.siemens.com/cs/ww/view/109780236
\11\	RUGGEDCOM RSG907R Installation Manual https://support.industry.siemens.com/cs/document/109827420
\12\	RUGGEDCOM RSG909R Installation Manual https://support.industry.siemens.com/cs/document/109827421
\13\	RUGGEDCOM RST2228 Equipment Manual https://support.industry.siemens.com/cs/document/109825997

6.3. Change documentation

Version	Date	Modifications
V1.0	09/2013	First version
V2.0	08/2021	Complete revision
V3.0	08/2024	Complete revision – replacement of SCALANCE X204 (RNA)