Bumpless Media Redundancy with PROFINET IRT (MRPD)

SIMOTION & SINAMICS

Application description · July 2012

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SIMOTION & SINAMICS MRPD

Application description

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Configuration 4

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Operating the application 6

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1 Problem

1.1 Overview

Introduction

To prevent failures (cable or device defect) in an automation system, the **MRPD** (**M**edia **R**edundancy for **P**lanned **D**uplication) functionality is available as of SIMOTION V4.3.

MRPD is a procedure for the bumpless media redundancy with PROFINET IRT. This functionality assumes that the part of the system to be protected against failures should be arranged in a ring topology.

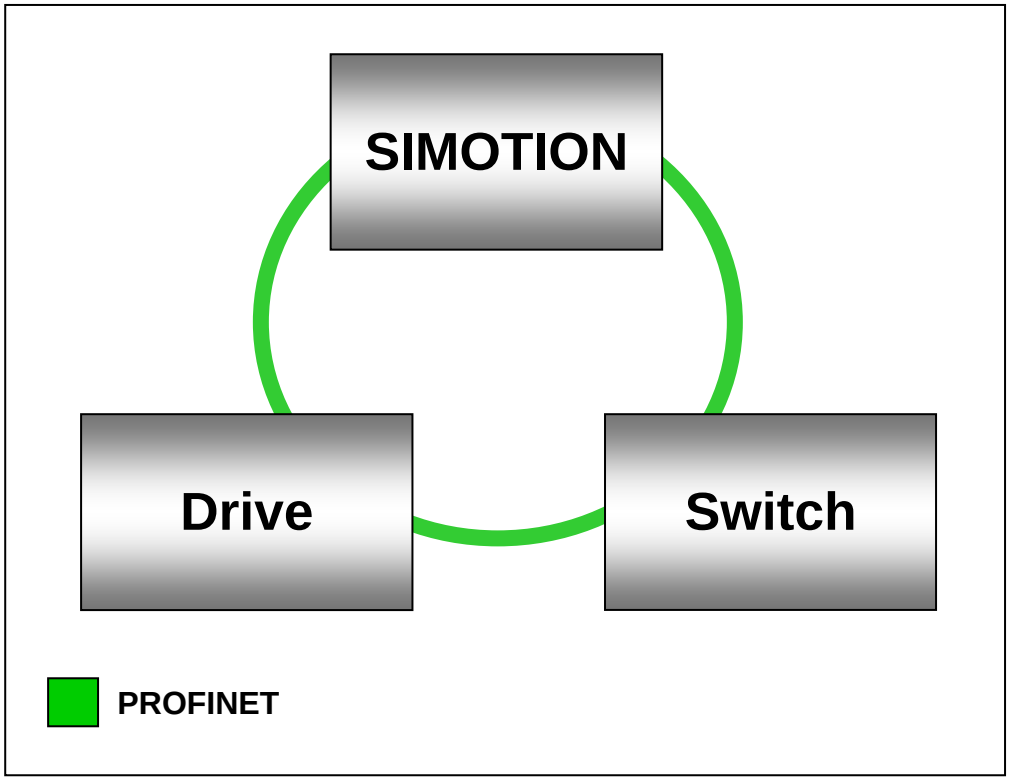
The bumplessness is ensured by the provider (IO controller) sending the cyclic data in both directions in the ring with the consumers (IO devices) then receiving the data twice. The first received message frame is evaluated by the consumer; the second message frame is discarded.

If the ring is now interrupted at one location (e.g. through the failure of a ring node), the receiving of the cyclic data via the uninterrupted side of the ring is still guaranteed.

Overview of the automation task

The following figure provides an overview of the automation task.

Fig. 1-1



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Description of the automation task

A plant is automated with a SIMOTION controller, a drive and a switch via PROFINET IRT.

The SIMOTION controller specifies the setpoint speed for the drive.

The drive, controller and switch are connected with each other using a ring topology. The SIMOTION controller continually sends the cyclical data over both directions of the ring to the drive.

If a connection to the drive is now interrupted (e.g. because of a cable defect), it can still be reached via the second connection.

The plant can so further produce bumplessly provided the node required for the production does not fail itself (controller or drive).

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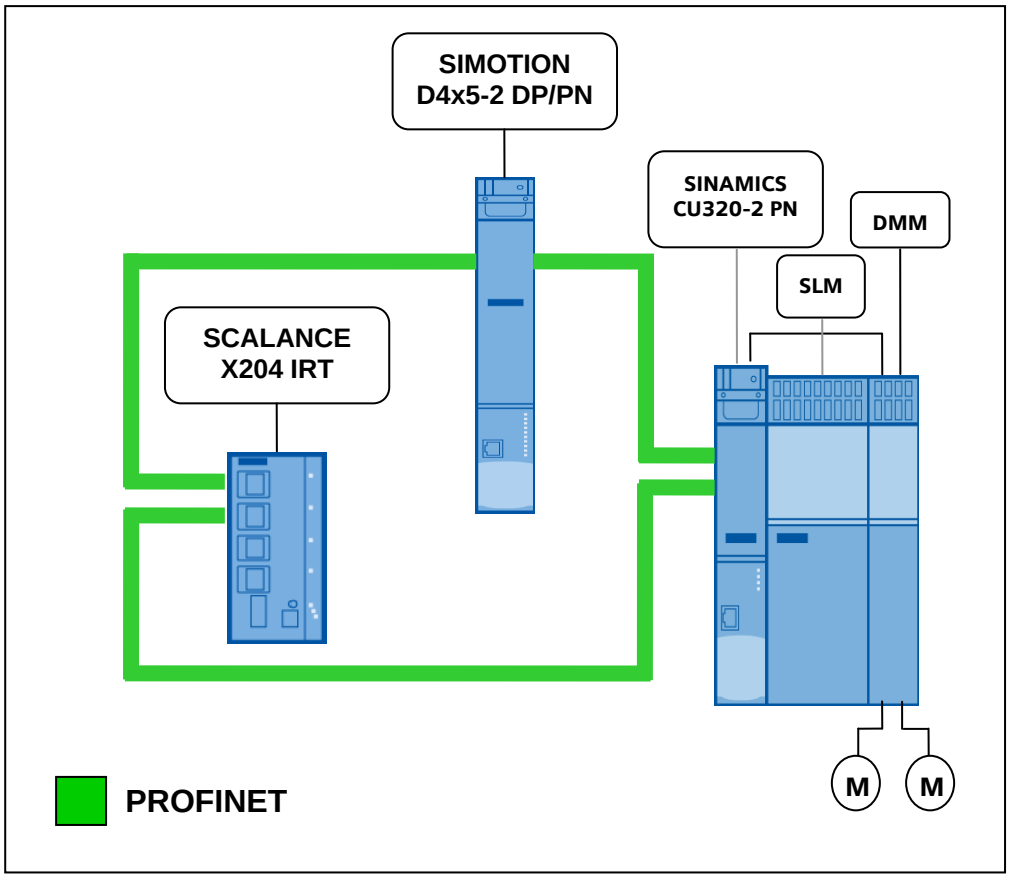
2 Solution

2.1 Overview of the overall solution

Schematic diagram

The following schematic figure shows the most important components of the solution:



In this application example, the MRPD (Media Redundancy for Planned Duplication) functionality is displayed via PROFINET IRT.

The SIMOTION controller, the SCALANCE switch and the SINAMICS drive are arranged in a ring and connected with each other.
The SCALANCE switch acts as redundancy manager; the SIMOTION controller and the SINAMICS drive act as redundancy clients.

The SIMOTION controller sends its cyclical data (at setpoint speed) over both directions of the ring to the SINAMICS drive. It evaluates the first received message frame; the second received message frame is discarded.

If the ring is now interrupted somewhere, the drive continues to receive at the setpoint speed of the SIMOTION controller over the second connection that is still intact. If the connection is restored, message frames are sent again to the drive over both directions of the ring.

This mechanism ensures a bumpless media redundancy, i.e. no reconfiguration time is required after opening or closing the ring.

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Differentiation

This application does not contain a description of:

- The general drive functions of the SINAMICS S120
- The SIMOTION controller

It is assumed that readers have basic knowledge of these topics.

Required knowledge

It is assumed that readers have basic knowledge of SIMOTION controllers and SINAMICS drives with SIMOTION SCOUT.

Boundary conditions

1. **Safety and MRPD**

   By default, safety data is transferred via PROFINET RT. MRPD, however, does not offer any bumpless redundancy for RT data, but only for IRT data.

   In order to guarantee bumpless media redundancy with Safety, the safety data within the MRPD ring must be transferred as IRT data. The SIMOTION **I-Device-F-Proxy** functionality can be used for this purpose. When the F-Proxy is used, the safety data of the F-CPU is copied from the SIMOTION controller to the IRT data of the MRPD ring and is also sent redundantly.

   The F-CPU can be connected either to a free port of the PROFINET interface of the SIMOTION configured as I-Device-F-Proxy and is also a node of the ring, or the second PROFINET interface is used as F-Proxy.

Note

The following link shows how you can configure the **I-Device-F-Proxy** functionality on a SIMOTION:

http://support.automation.siemens.com/WW/view/en/50207350

2. **MRPD and redundant sync master**

   There can be a maximum of two Ethernet nodes between one sync master and one redundant sync master in a MRPD ring.

   If the redundant sync master is used, we recommend that it is connected directly with the sync master.

   In case of an interruption in the route between the sync master and the redundant sync master, the plant initially continues to run smoothly, however faults may occur when you switch off and then restart the plant if the devices between the sync master and the redundant sync master differ too much in the ramp-up time.

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3. **MRPD: Devices operated on a branch**

   Devices that should be operated on a branch in the MRPD ring must also support the MRPD functionality.

   If this functionality is not supported, the affected devices, such as those on the second PROFINET interface of the SIMOTION controller, must be operated.

Note

The following devices support the MRPD functionality:

- SIMOTION: D4x5-2 DP/PN (+ CBE30-2), D410-2 DP/PN, C240 PN, P320-3, **not P350-3 with MCI-PN!**
- SINAMICS: CU310-2 PN, CU320-2 DP + CBE20, CU320-2 PN (+CBE20)
- SCALANCE: only X200 IRT

SIMATIC S7-300 and S7-400 CPUs, ET200 stations as well as TMC modules do not support any MRPD!

4. **Bumplessness of MRPD**

   Delayed or incomplete switchovers of MRPD caused, for example, by a network load that is too high or faults coming/going too rapidly, under unfavorable conditions, can lead to the PROFINET connection failing even with activated media redundancy.

   For example, with two consecutive faults at different locations in the ring, smooth operation is ensured only when approx. **three seconds** lie in between the two faults.

5. **Configuration with a GSD file**

   Ensure that GSD version **V2.3** is used for the configuration of the SINAMICS drive with GSD file.

   This version also supports the media redundancy procedure (MRPD) in addition to PROFIsafe and shared device.

   The GSD file can be installed as of **STEP7 V5.5 SP2** and is contained on the CF card for the associated CU variant.

Note

Further information as well as the appropriate PROFINET GSD files can be obtained at the following link:

http://support.automation.siemens.com/WW/view/en/49217480

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2.2 Hardware and software components used

The application has been created with the following components:

Hardware components

Tabelle 2-1

Component	Qty.	MLFB / order number	Note
SIMOTION D455-2 DP/PN	1	6AU1455-2AD00-0AA0	V4.3.1
SINAMICS S120 CU320-2 PN	1	6SL3040-1MA01-0AA0	V4.5.0.1
SCALANCE X204 IRT	1	6GK5204-0BA00-2BA3	V5.0
SIMOTION training case	1	6ZB2470-0AE00	

Standard software components

Tabelle 2-2

Component	Qty.	MLFB / order number	Note
STEP 7	1	6ES7810-4CC10-0YA5	V5.5 + SP2 + HF1
SIMOTION SCOUT	1	6AU1810-1BA42-1XE0	V4.3.1.1

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Sample files and projects

The list below contains all the files and projects used in this example.

Tabelle 2-3

Component	Note
60441190_PROFINET_IRT_MRPD_V1_0.zip	Sample project + sources
60441190_PROFINET_IRT_MRPD_V1_0_en.pdf	This document

Supplementary conditions

To configure MRPD, the following software and hardware versions are required.

Table 2-4

Component	Version
Windows	XP or 7 Enterprise Professional (32-bit and 64-bit)
STEP 7	V5.5 + SP2
SIMOTION SCOUT	V4.3.1
STARTER	V4.3.1 (alternative)
S7 F ConfigurationPack	V5.5 + SP8 (for Safety)
S7 Distributed Safety Programming	V5.4 + SP4 (for Safety)
Firmware for SIMOTION	V4.3
Firmware for SINAMICS	V4.5
Firmware for SCALANCE	V5.0

3 Basics

3.1 PROFINET communication

Not only the MAC address but also the device name is used to identify the devices for PROFINET. This device name must be unique across the PROFINET network.

During the commissioning phase, the HW Config or the Primary Setup Tool (PST) is used to make an initial online assignment of a device name for each PROFINET device (a so-called node initiation). This online-assigned device name is stored retentively in the PROFINET device and must match the device name in the project.

If a device is replaced, e.g. because of a defect, the new device has a different MAC address. If it is initiated with the same device name as the replaced device (e.g. by reconnecting a CF card / MMC that stores the device name retentively), it can assume the function of the replaced device without any changes in the configuration (spare-part situation).

Rules for assigning names

A device name must be stored retentively on a PROFINET device. This name must match the device name in the project. The following rules apply in this case:

- The device name stored retentively in the device must only contain lowercase letters.

Note

The device name in the project can also contain uppercase letters.
During the initiation, the engineering system replaces the uppercase letters with lowercase letters.

- Letters a-z and digits 0-9 may be used.
- Special characters are not permitted: ! " § $ % & / ( ) = ? * ' _ : ; > < , # + | ~ \ }] [{
- Blanks are also not permitted.
- The total maximum length of a name is 240 characters.
- Reserved names that cannot be used:
  "port-xyz" or "port-xyz-abcde" (a, b, c, d, e, x, y, z = 0...9)
- The minus character must not be used for a SIMOTION controller.

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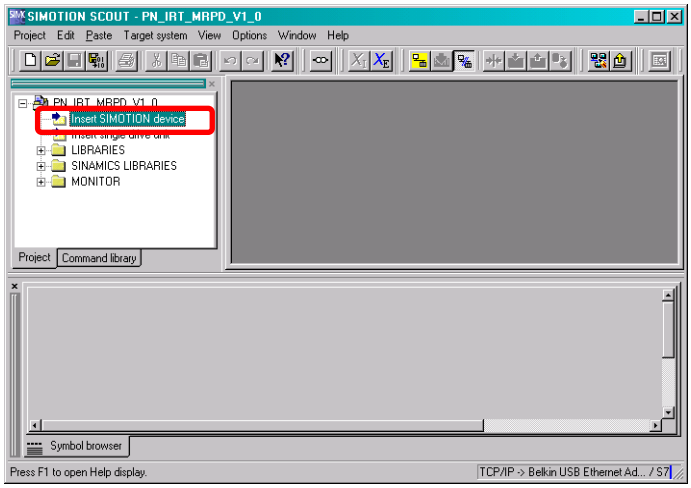
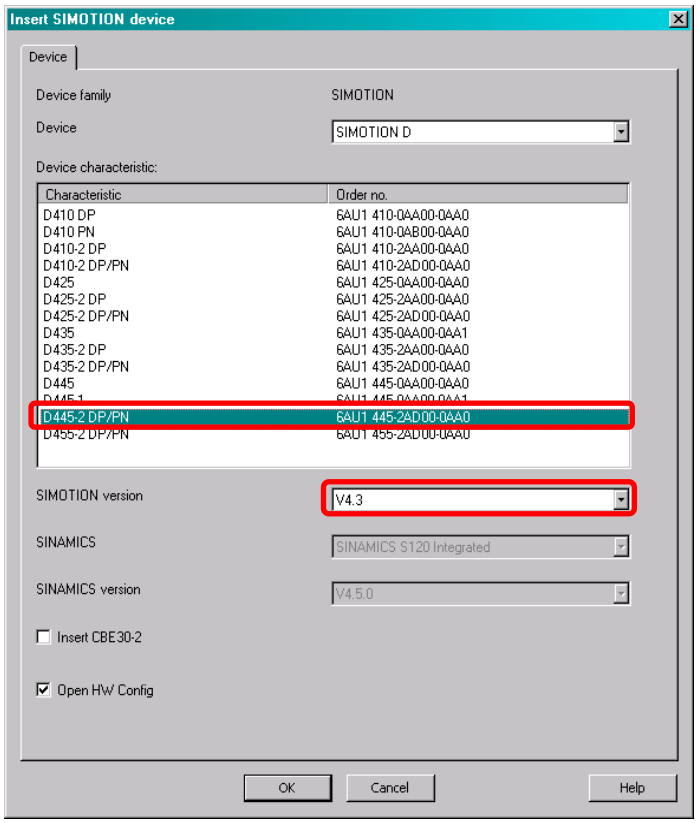
4 Configuration

4.1 HW Config of the SIMOTION controller

In the application example, a SIMOTION D455-2 DP/PN with the following configuration is deployed.

Table 4-1

No.	Action
1.	To create a new project, open the SIMOTION SCOUT engineering system. Insert a new SIMOTION device. 
2.	Select the appropriate SIMOTION hardware platform and version. 

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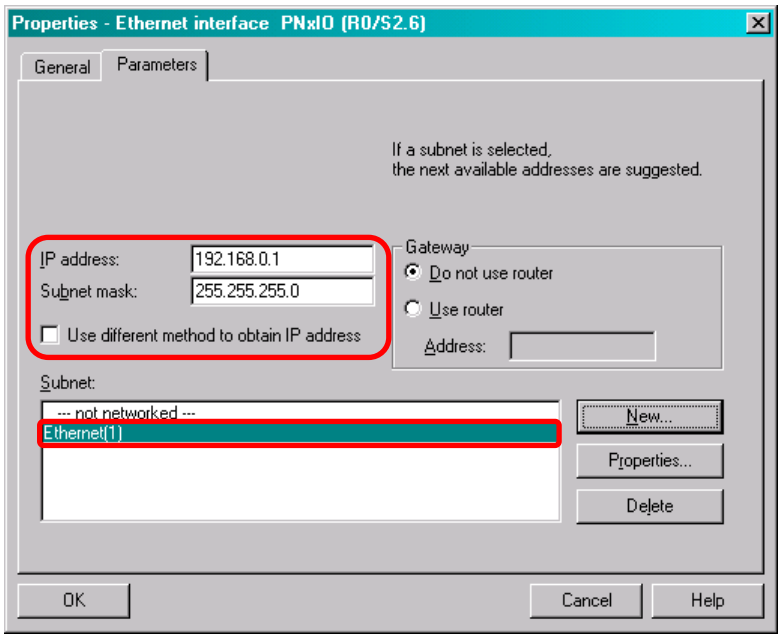
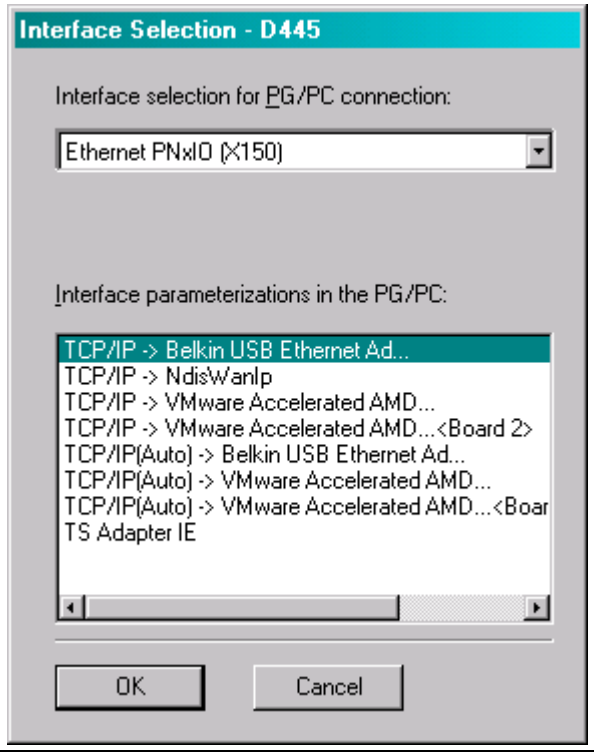
No.	Action
3.	Create a new Ethernet subnet and assign an IP address. 
4.	Configure the connection between the SIMOTION controller and the engineering system. 

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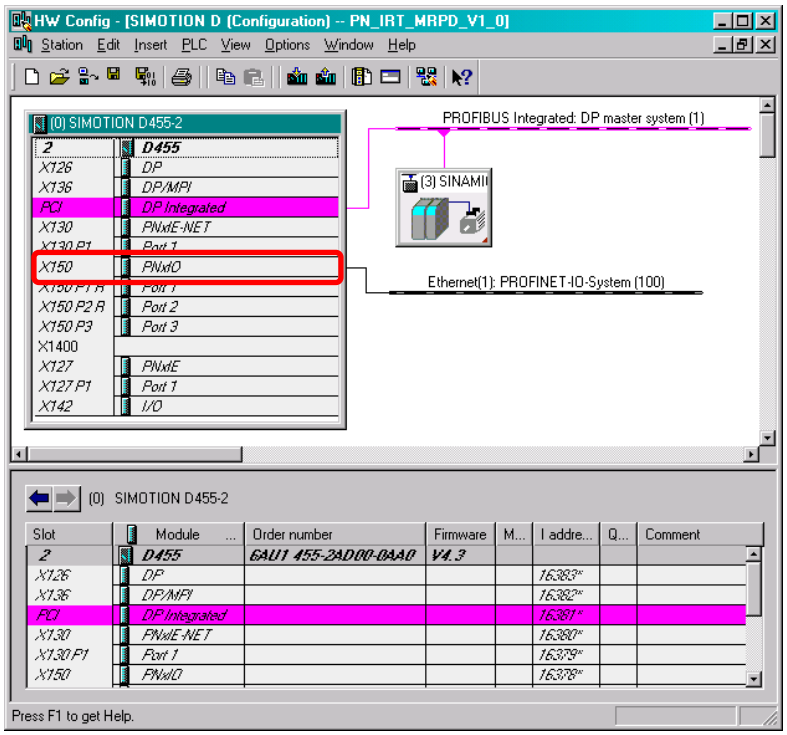
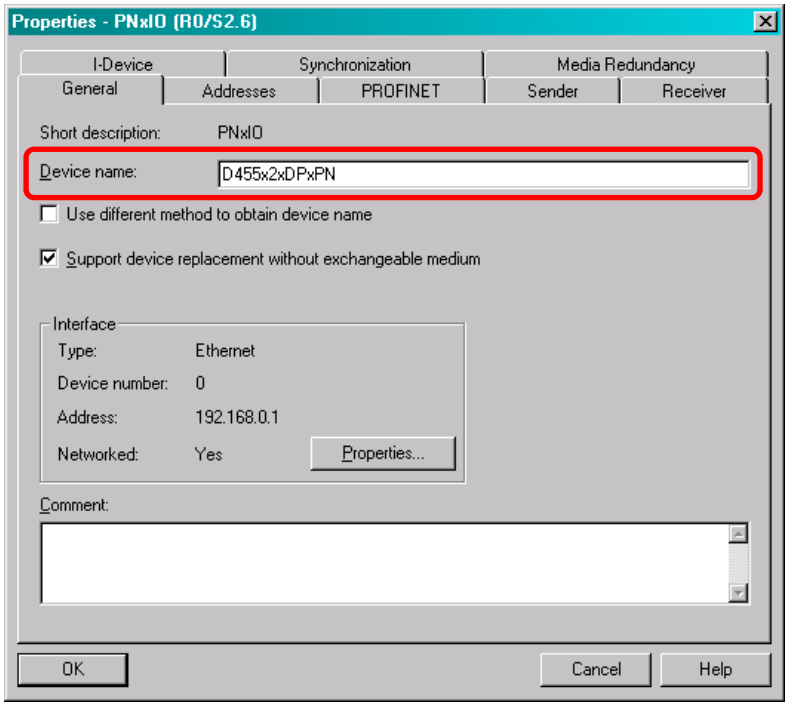
No.	Action
5.	The device name can be adapted by double-clicking the PROFINET interface (X150).  Pressing the F4 key automatically arranges the available modules in HW Config.
6.	The device name of the PROFINET interface (PNxIO) is “D455x2xDPxPN”. 

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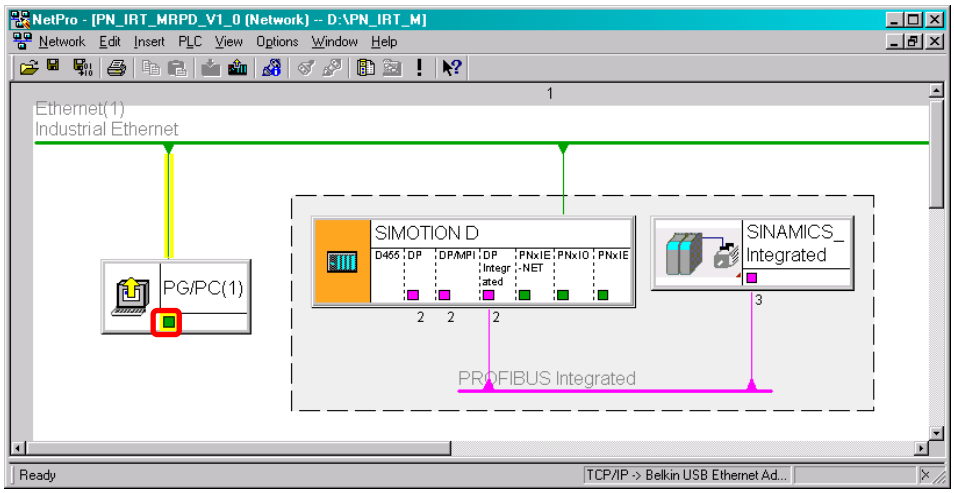
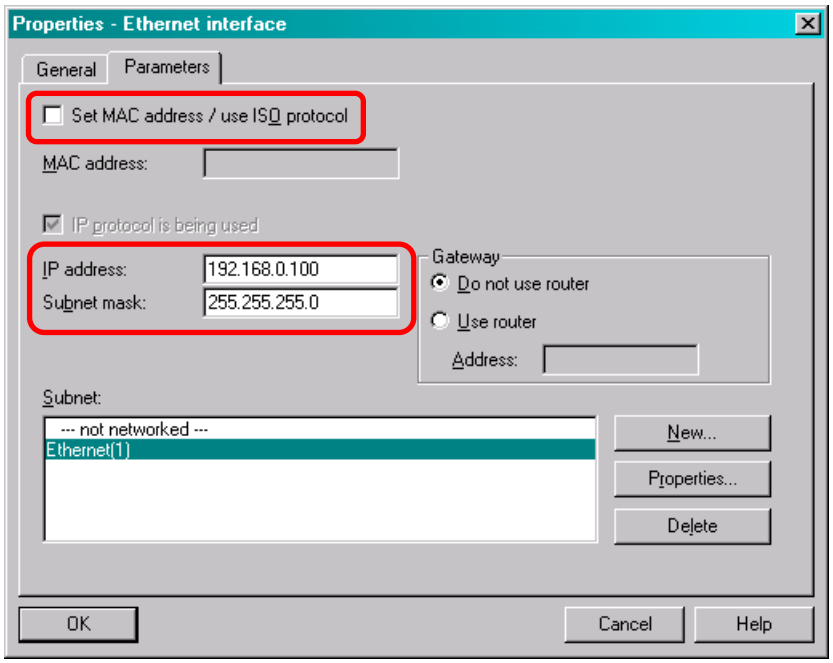
No.	Action
7.	Open NetPro in order to set the interface of the engineering system. The yellow connection at the PG/PC station indicates that the engineering system can access SINAMICS Integrated via S7 routing. Routing tables are automatically generated when saving and compiling; these must then be saved in the device with a HW Config download.  Double-click the PG/PC interface to open its properties.
8.	Deactivate the “Set MAC address / use ISO protocol” checkbox because the SIMOTION controller does not support any ISO protocol.  Assign a free IP address for the engineering system, e.g.: IP address: 192.168. 0 . 100 Subnet mask: 255.255.255. 0
9.	Save and compile the HW Config.

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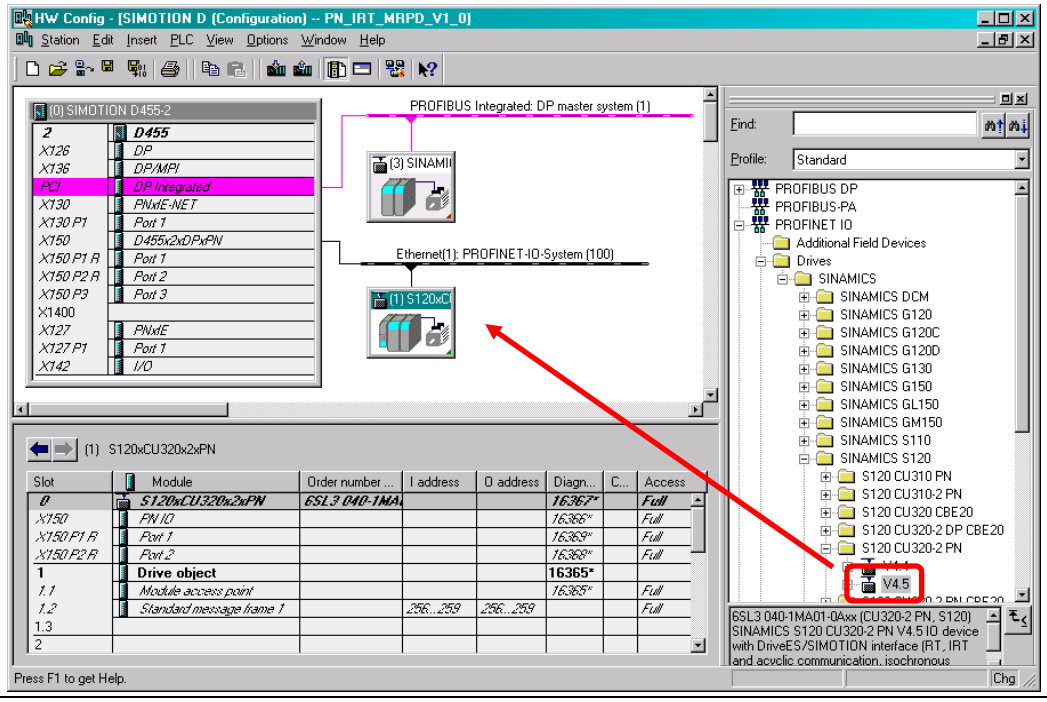
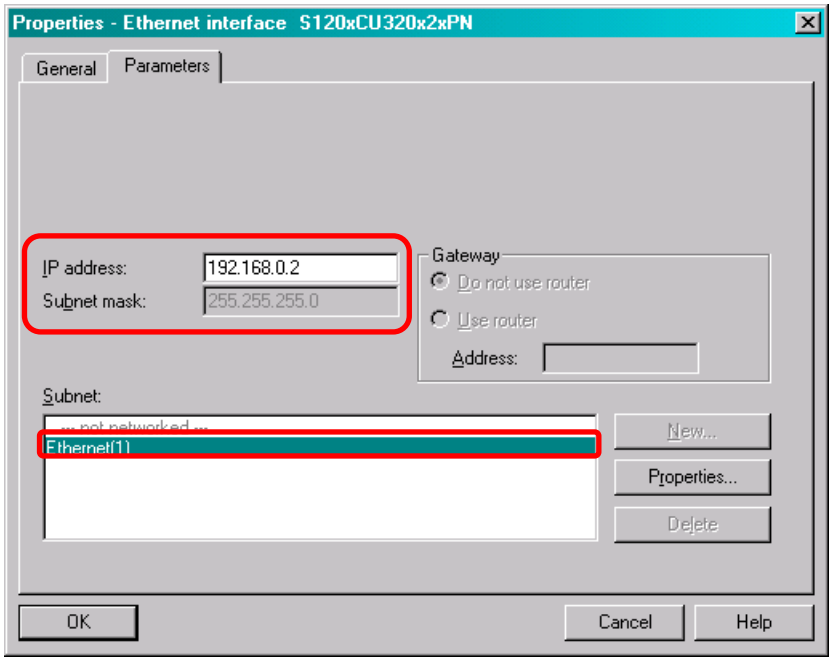
4.2 HW Config of the distributed SINAMICS drive

The SIMOTION controller communicates with a SINAMICS drive CU320-2 PN configured as follows.

Table 4-2

No.	Action
1.	Drag the SINAMICS CU320-2 PN V4.5 drive to the **PROFINET IO system (100)**. 
2.	Assign an IP address and select the existing Ethernet subnet. 

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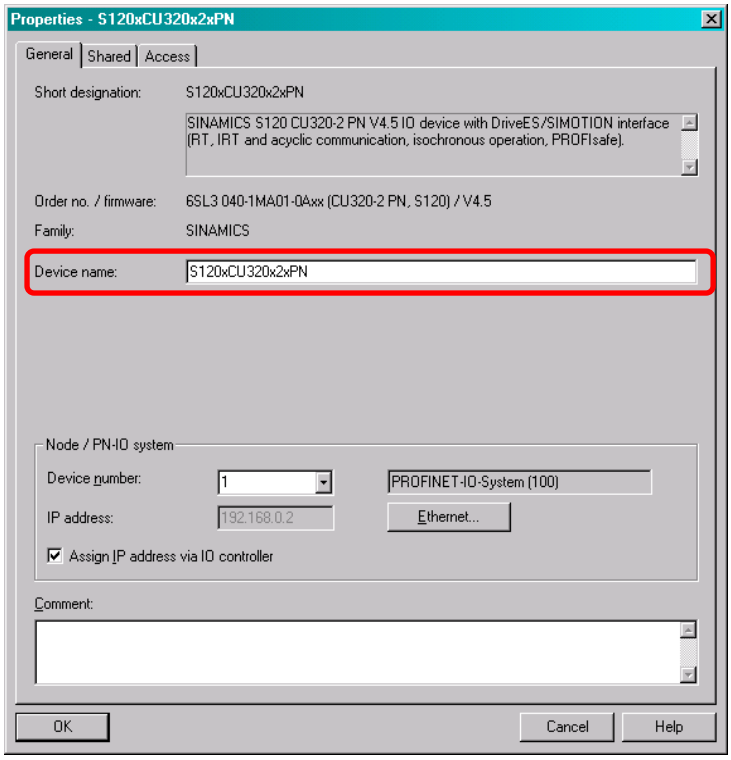
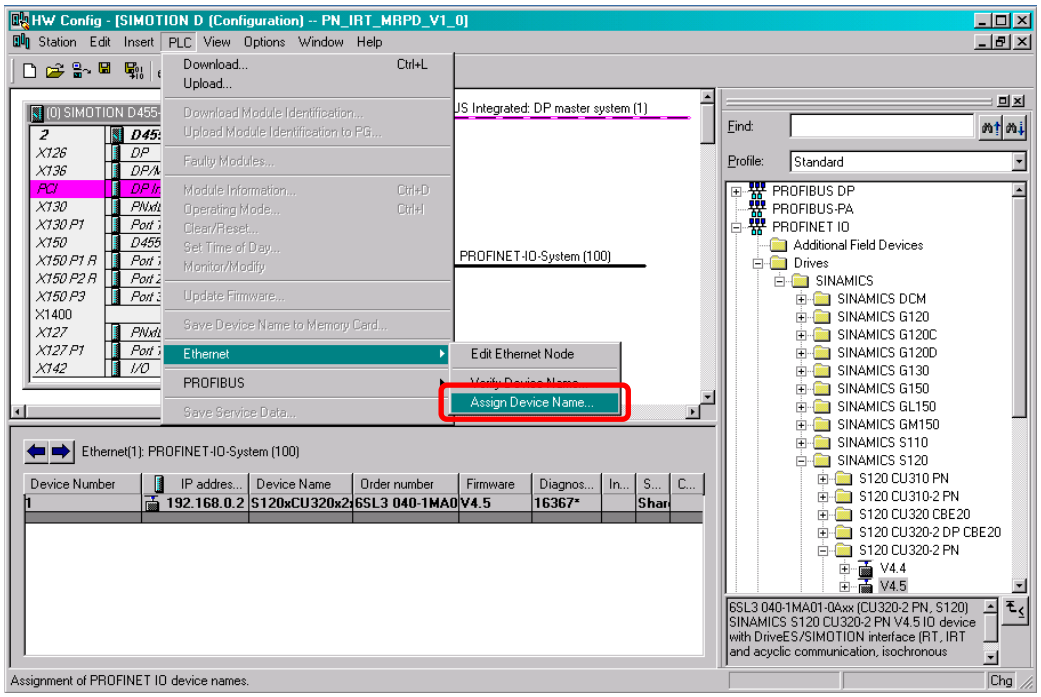
No.	Action
3.	Double-click the added SINAMICS drive to adapt its device name. The device name of the SINAMICS drive is “S120xCU320x2xPN”. 
4.	The device name must then be assigned to the SINAMICS drive. To do this, select the corresponding PROFINET IO system (100). Open the window for the name assignment via “PLC > Ethernet > Assign Device Name”. 

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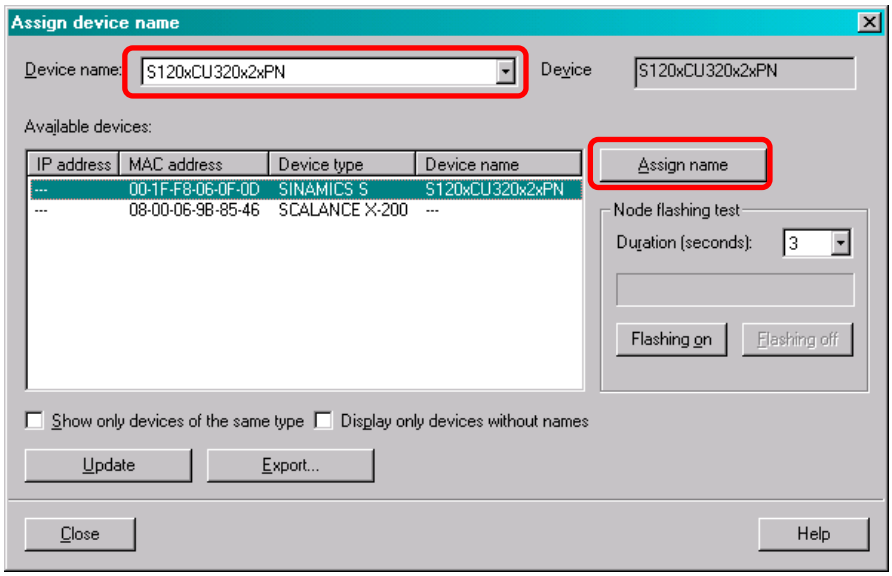
No.	Action
5.	Select the SINAMICS drive and click the “Assign name” button to assign the name configured in the HW Config. 
6.	Save and compile the HW Config.

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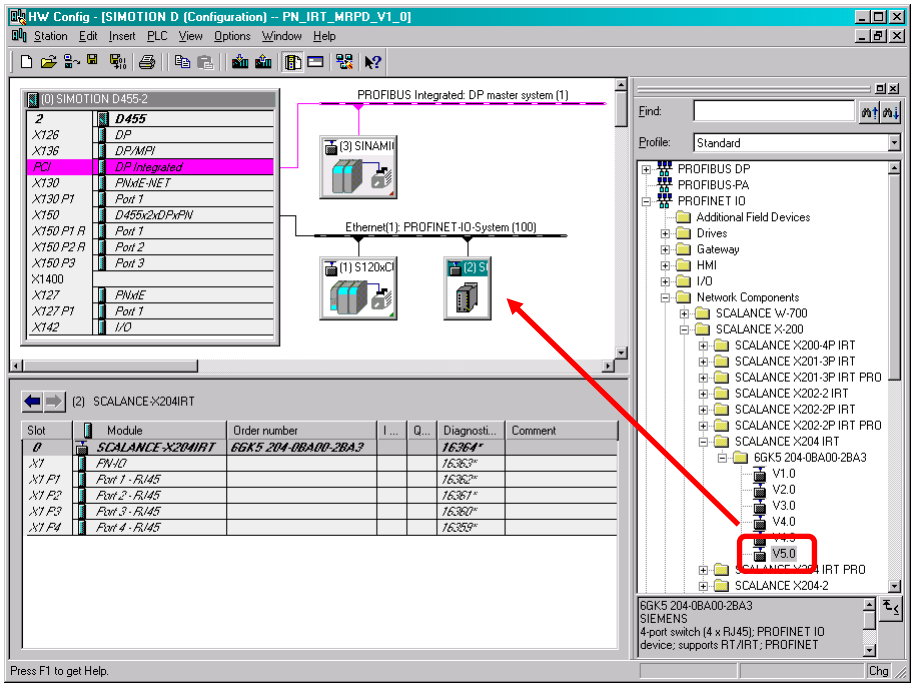
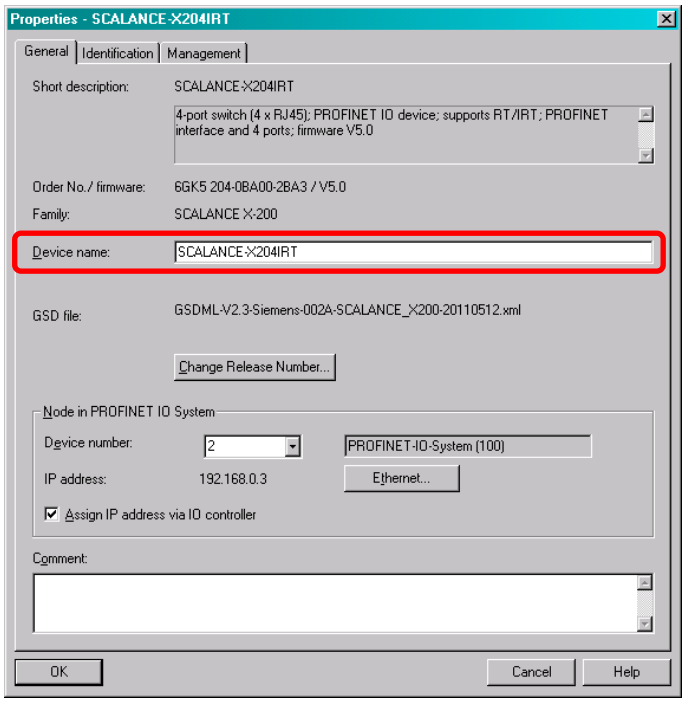
4.3 HW Config of the distributed SCALANCE switch

A SCALANCE X204IRT switch configured as follows is deployed as redundancy manager.

Table 4-3

No.	Action
1.	Drag the SCALANCE X204IRT V5.0 switch to the **PROFINET IO system (100)**. 
2.	Double-click the added SCALANCE switch to adapt its device name. The device name of the SCALANCE switch is “SCALANCE-X204IRT”. 

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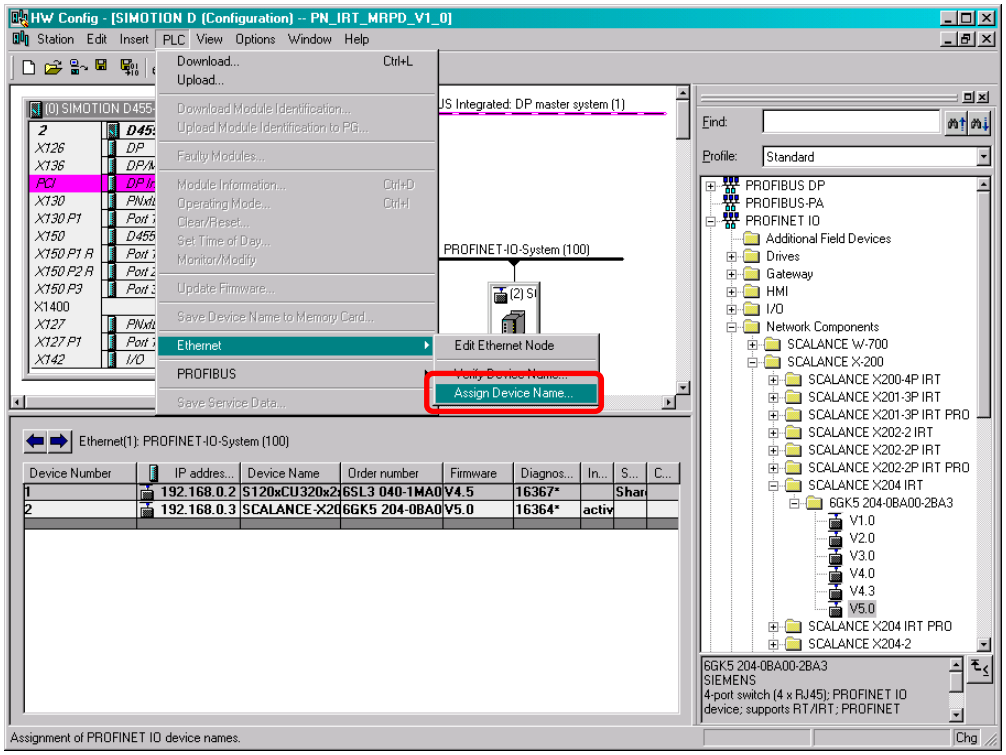
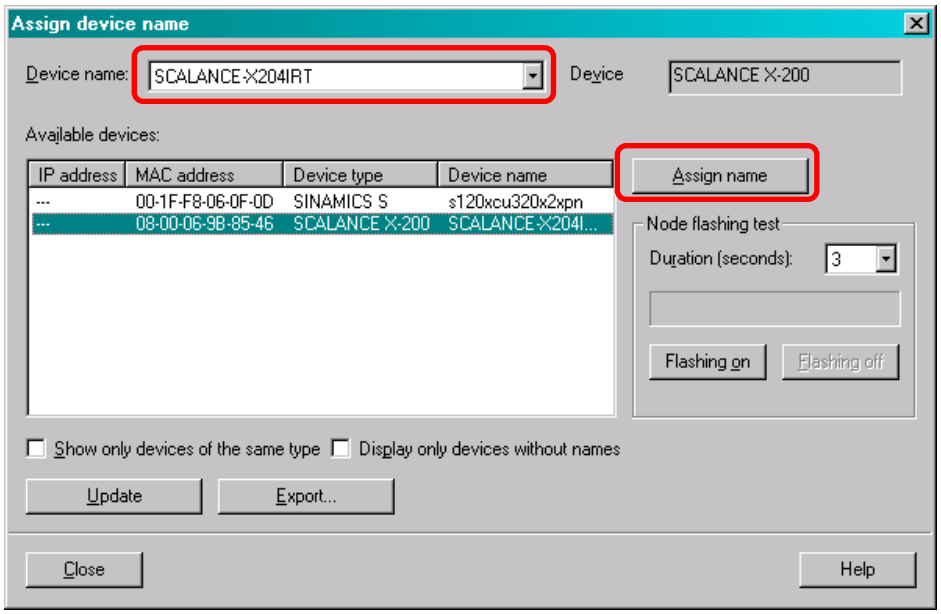
No.	Action
3.	The device name must then be assigned to the SCALANCE switch. To do this, select the corresponding PROFINET IO system (100). Open the window for the name assignment via “PLC > Ethernet > Assign Device Name”. 
4.	Select the SCALANCE switch and click the “Assign name” button to assign the name configured in the HW Config. 
5.	Save and compile the HW Config.

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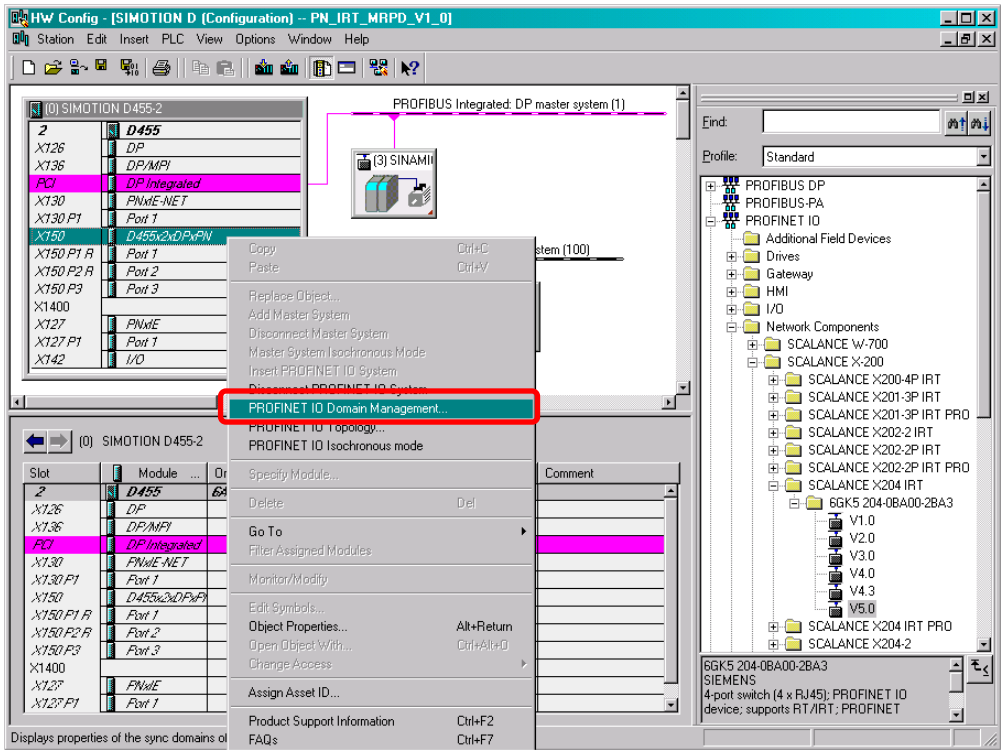
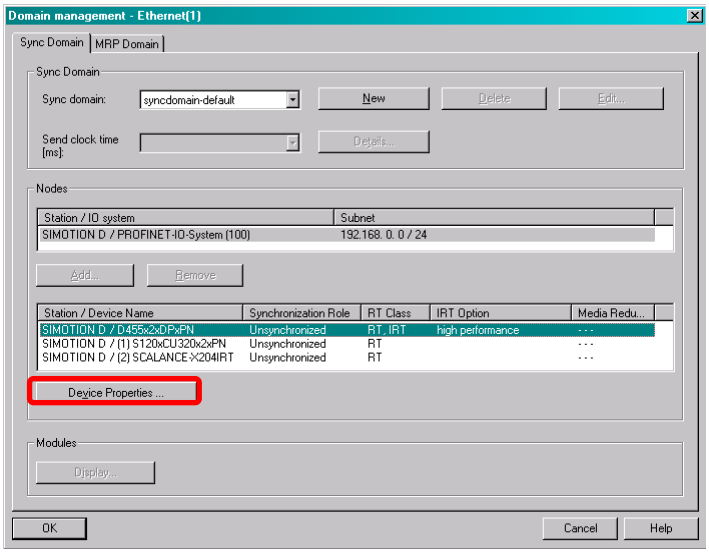
4.4 Configuring the PROFINET IRT

PROFINET IRT must be activated for MRPD. To do this, the PN interfaces must be synchronized and the PROFINET topology configured. MRPD can then be configured.

Table 4-4

No.	Action
1.	Open the “PROFINET IO Domain Management” in the context menu of the PROFINET interface (X150) of the SIMOTION controller. 
2.	Select the SIMOTION controller, respectively the SINAMICS drive and the SCALANCE switch and open their properties. 

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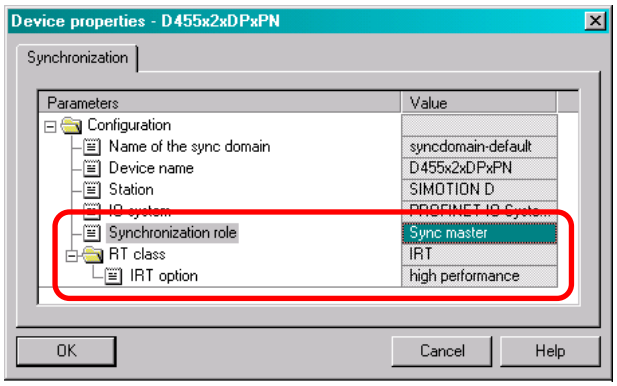
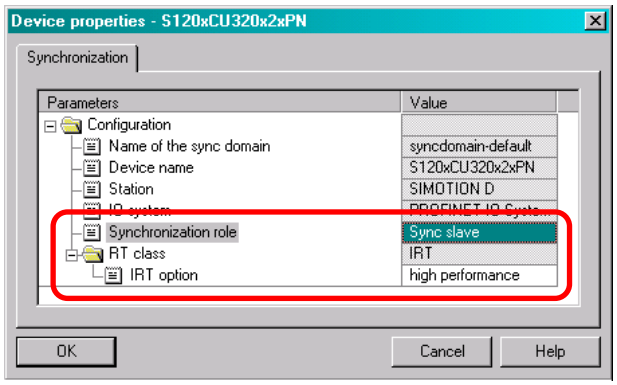
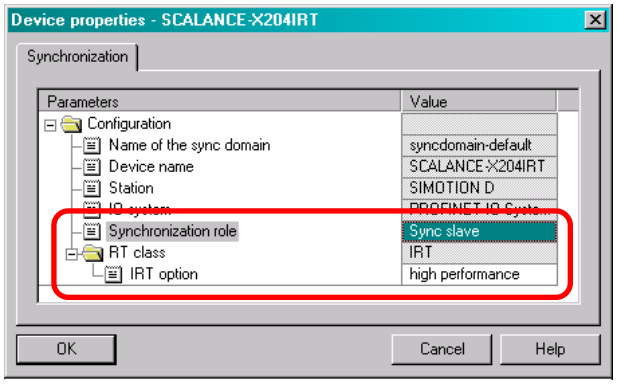
No.	Action
3.	Set the “Sync master” option as synchronization role for the SIMOTION controller. Only one sync master is permitted in each PROFINET network. 
4.	The SINAMICS drive is parameterized as “Sync slave”. A sync slave synchronizes itself to the associated sync master in the PROFINET network. Ensure that “high performance” is selected for the IRT options! 
5.	The SCALANCE switch is also parameterized as “Sync slave”. Also ensure here that “high performance” is selected for the IRT options! 

Note

IRT "high flexibility" cannot be used for isochronous applications.
Further information can be found at the following link:

RT classes for PROFINET IO

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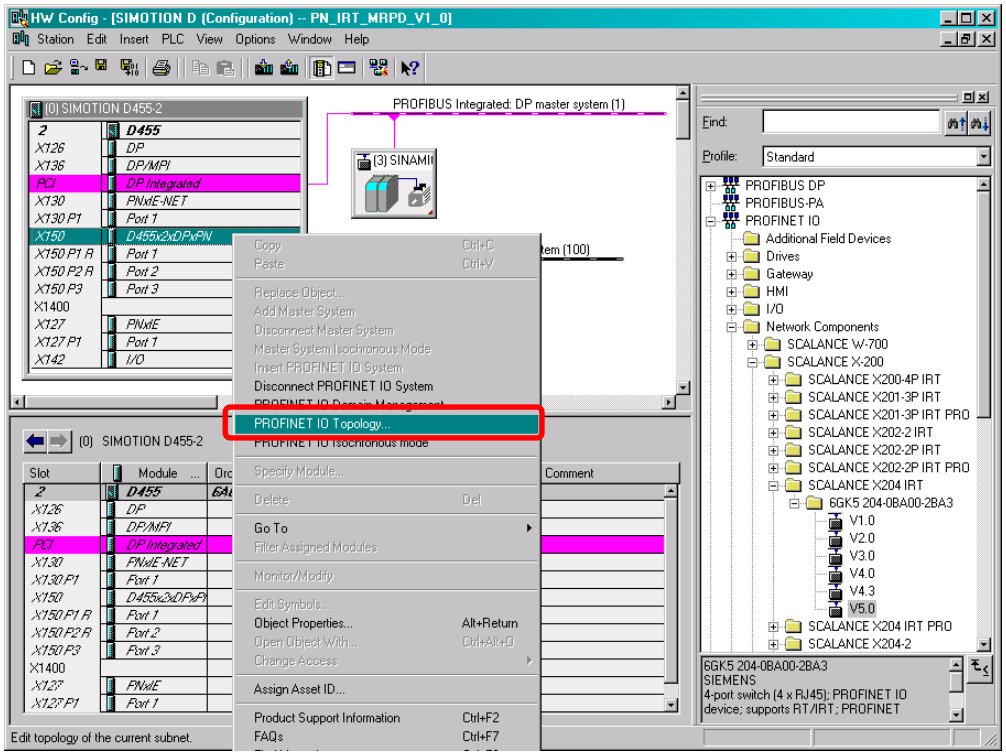
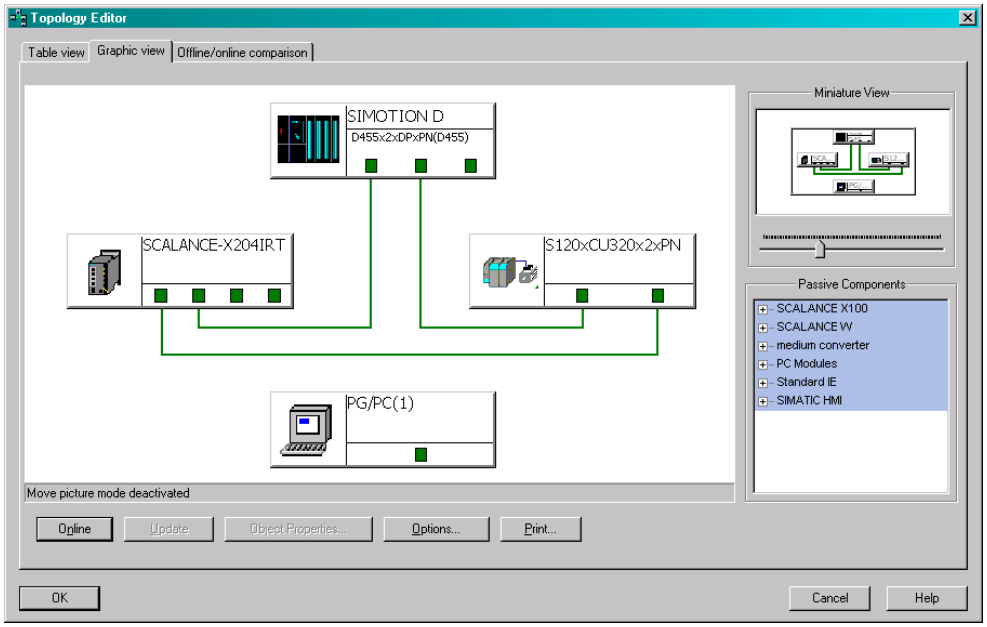
No.	Action
6.	The topology must be configured for PROFINET IRT. Open the “PROFINET IO Topology” in the context menu of the PROFINET interface of the SIMOTION controller. 
7.	For example, the following ports of the devices are connected with each other in order to receive a ring topology: • SIMOTION port 1 ←→ SCALANCE port 2 • SIMOTION port 2 ←→ SINAMICS port 1 • SCALANCE port 1 ←→ SINAMICS port 2 Create the connections in the “Graphic view” of the Topology Editor. 

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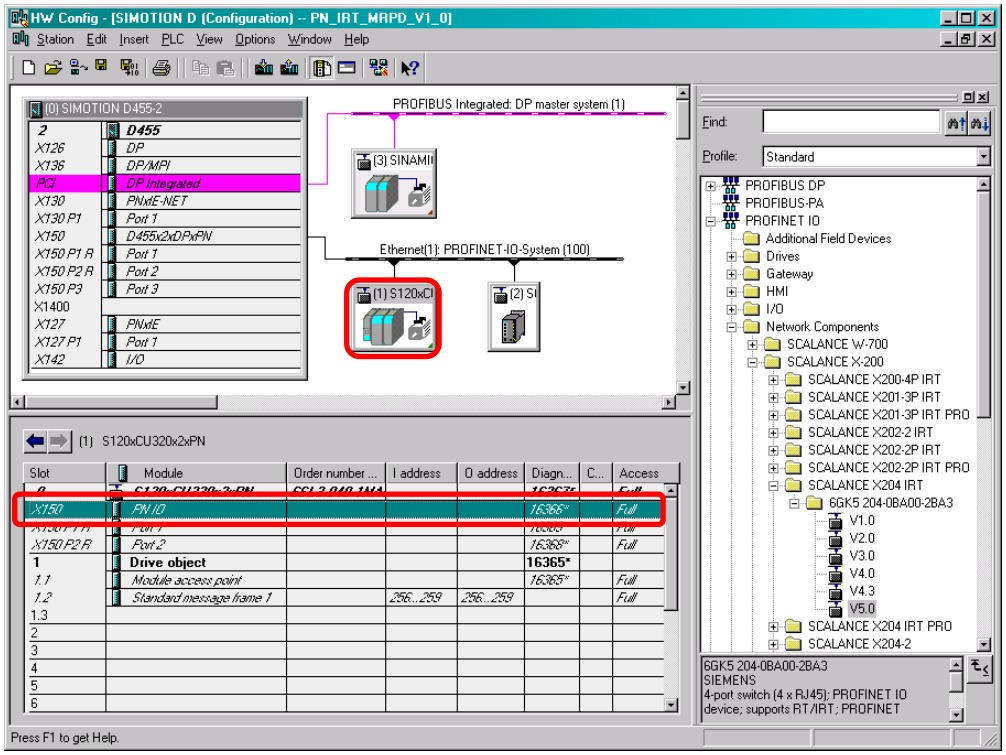
Note

A SIMOTION controller or SINAMICS drive may only be inserted in an MRPD ring as a node with MRPD-capable ports.

For SIMOTION D (drive-based), the first two ports of the PROFINET interface are marked as ring ports.
For SINAMICS S120 drives, these are ports P1 and P2.
For SCALANCE X200 IRT switches, all ports can be configured as ring ports.

The MRPD-capable ports for SIMOTION controllers and SINAMICS drives are identified with an **"R"** in the HW Config.

No.	Action
8.	To operate the SINAMICS drive isochronously, mark it and open the properties of the PROFINET interface (PN IO). 

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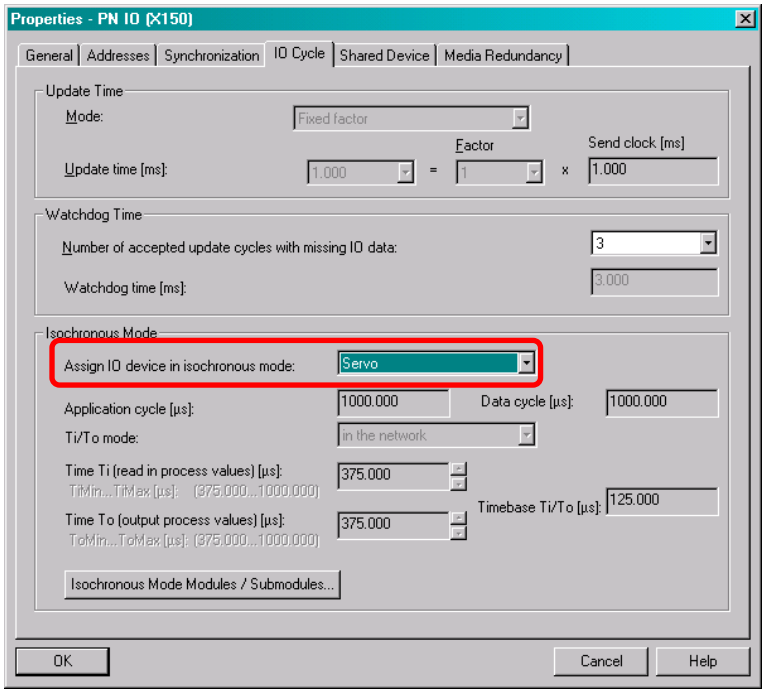
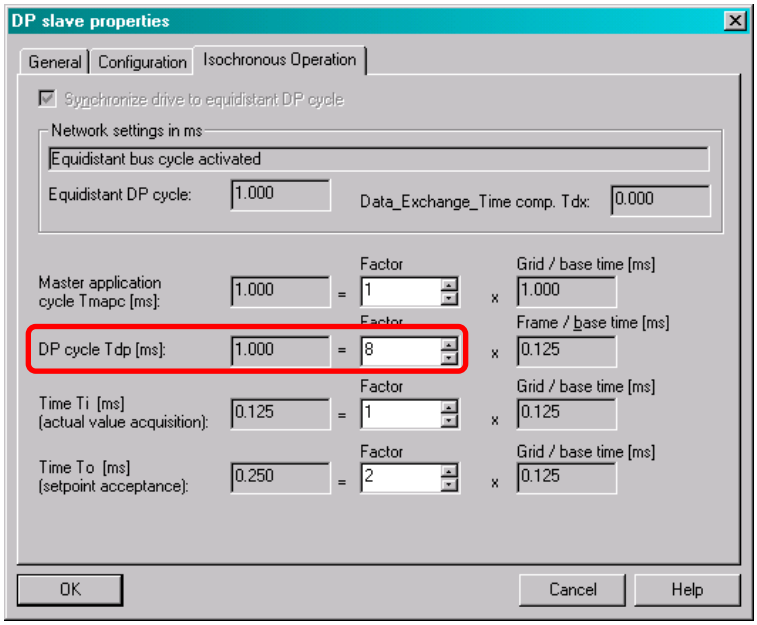
No.	Action
9.	Switch to the “IO Cycle” tab and select “Servo” as isochronous execution level for the SINAMICS drive. 
10.	When using PROFINET IRT, the PROFIBUS send cycle clock of the SINAMICS_Integrated of the SIMOTION controller must be the same as the servo send cycle clock. Double-click the SINAMICS_Integrated to open its properties and switch to the “Isochronous Operation” tab. The servo send cycle clock is, for example, 1,000 ms. Adjust the PROFIBUS send cycle clock accordingly. 

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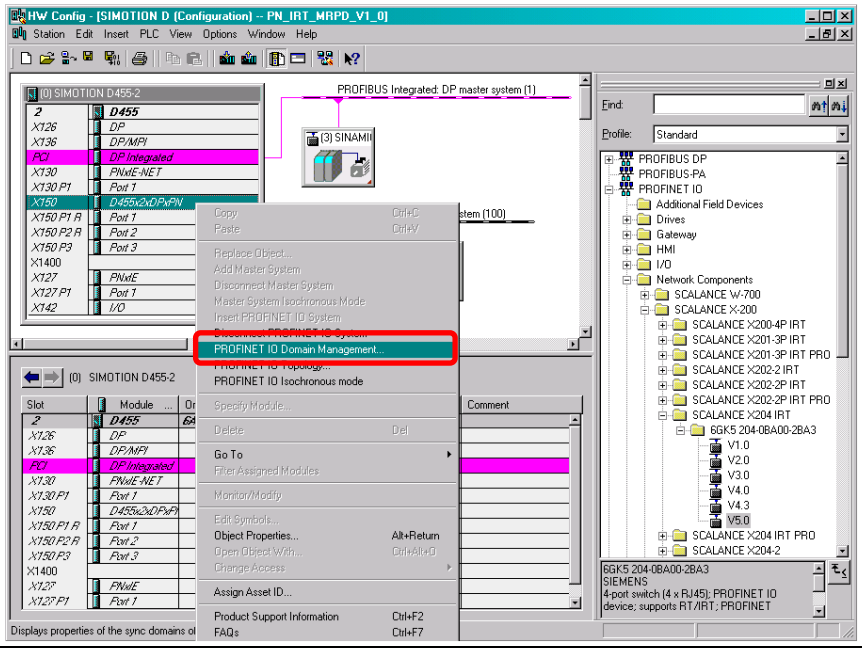
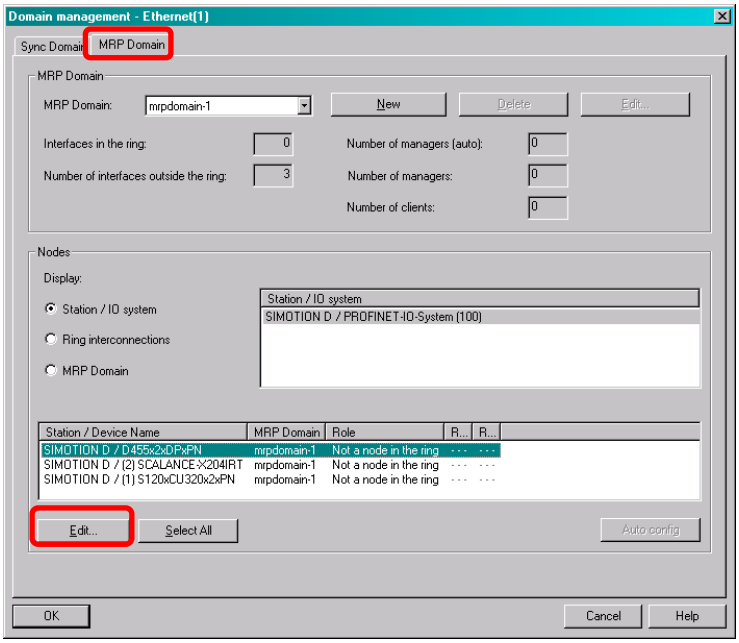
4.5 Configuring the media redundancy (MRPD)

After activation of PROFINET IRT and the configuration of the PROFINET ring topology, MRPD can now be configured.

Table 4-5

No.	Action
1.	Open the “PROFINET IO Domain Management” in the context menu of the PROFINET interface (X150) of the SIMOTION controller. 
2.	Change to the “MRP Domain” tab and mark the SIMOTION controller, respectively the SCALANCE switch and the SINAMICS drive. Click the “Edit” button to specify the associated functions of the nodes in the MRPD ring. 

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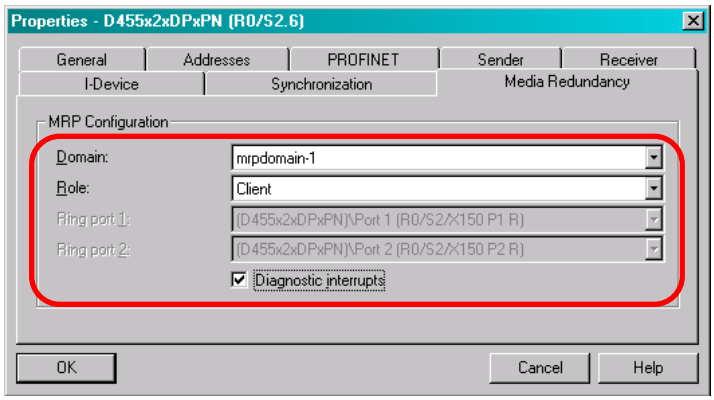
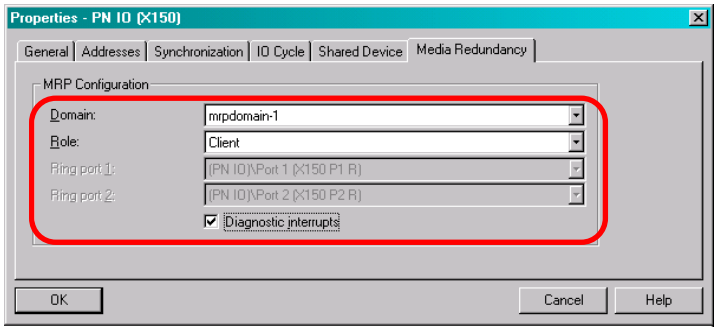
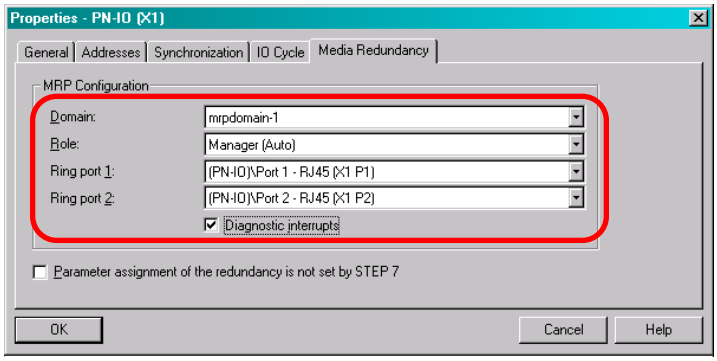
No.	Action
3.	Select the “Client” function for the SIMOTION controller. The ring ports are preassigned and cannot be changed subsequently. The “Diagnostic interrupts” checkbox can be used to activate specific MRPD diagnostic messages. 
4.	The “Client” function is also selected for the SINAMICS drive. The ring ports are also predefined here. 
5.	The SCALANCE switch can be configured both as redundancy manager and as client of the MRPD ring. The ring ports can be freely selected from the four available ports. Select the “Manager (Auto)“ function. 

Note

SIMOTION controllers and SINAMICS drives support only the “Client” function.

The redundancy-manager function required for an MRPD ring can only accept SCALANCE X200IRT switches.

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No.	Action
6.	Save and compile the HW Config.
7.	Download the SIMOTION controller configuration to the respective device.

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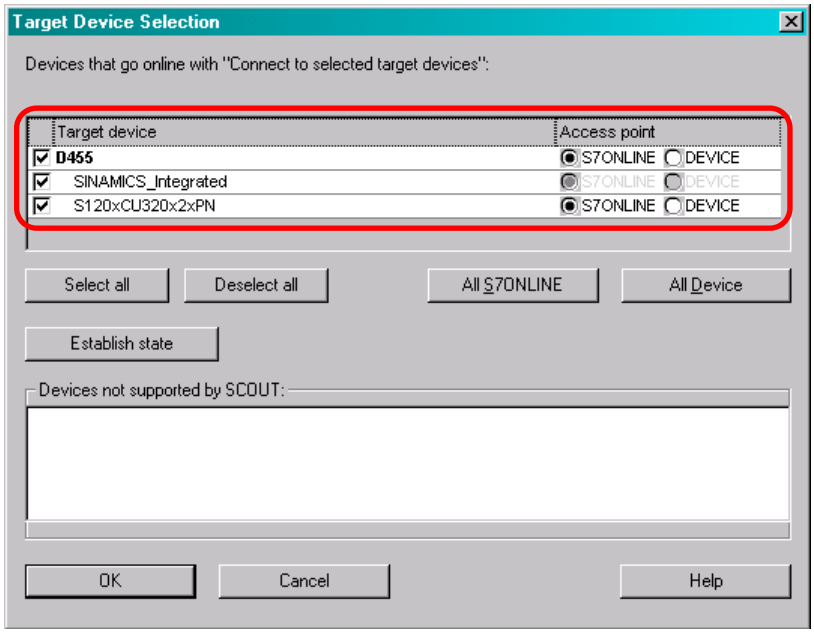
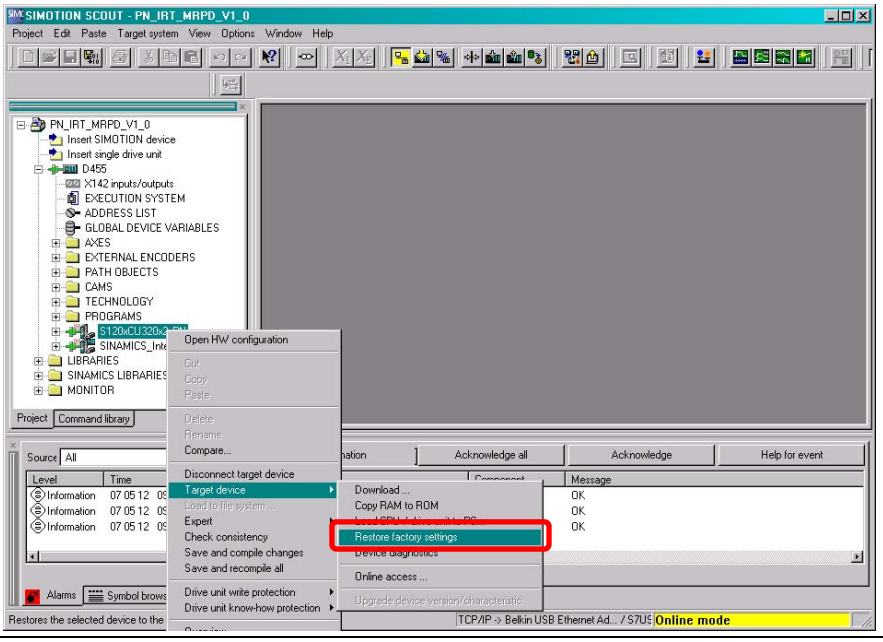
4.6 Configuring the distributed SINAMICS drive

The standard configuration of the distributed SINAMICS drive with the SIMOTION SCOUT engineering system is shown below.

Table 4-6

No.	Action
1.	Go online in the SCOUT project.
2.	Select the following target systems with which an online connection is to be established. 
3.	Restore the factory settings on the distributed SINAMICS drive. 

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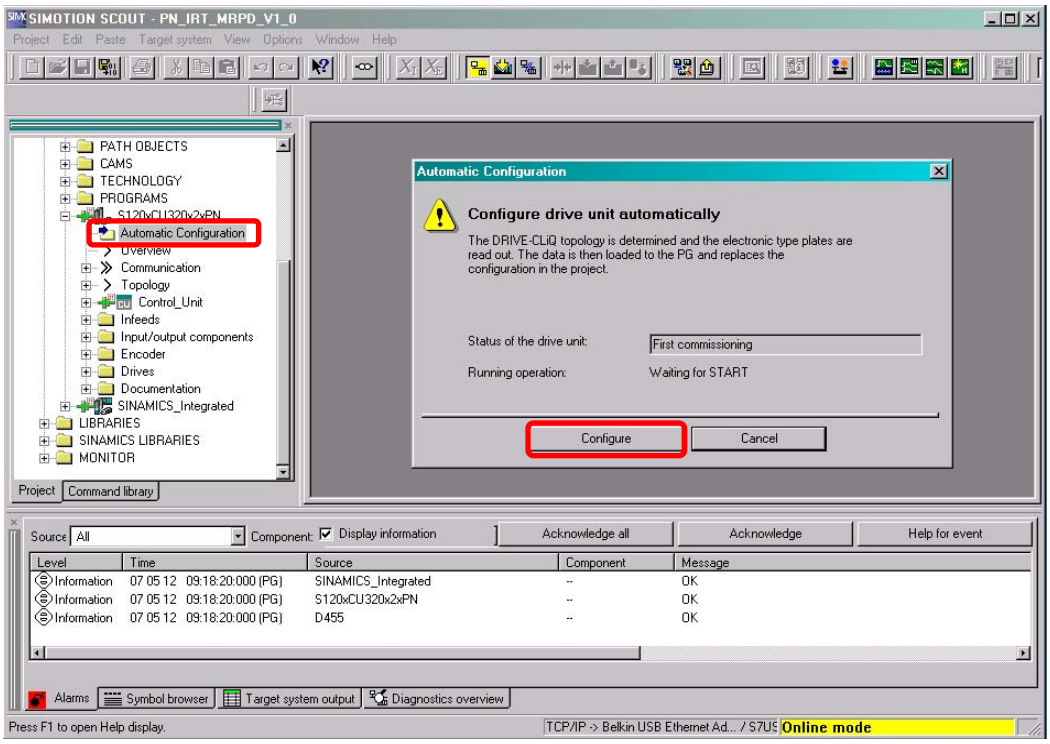
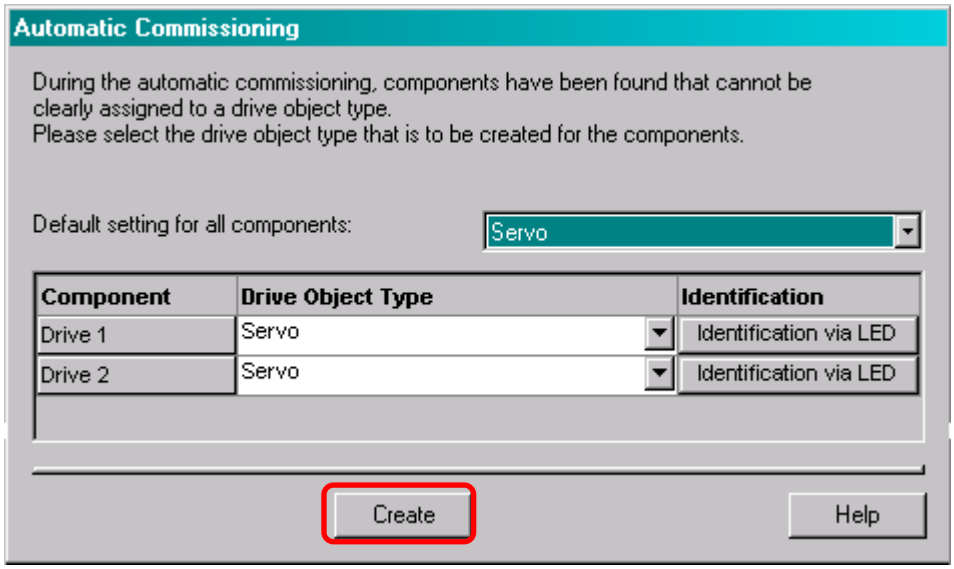
No.	Action
4.	Perform the automatic configuration of the drive. 
5.	The two motors of the SIMOTION training case are created as servo motors. 

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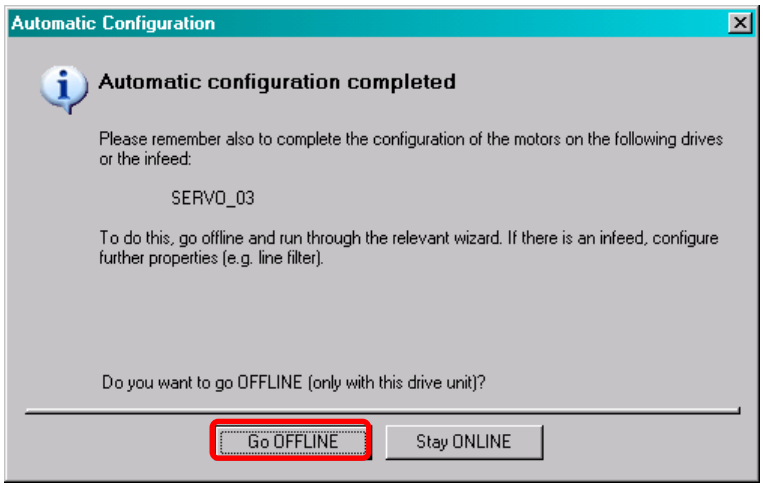
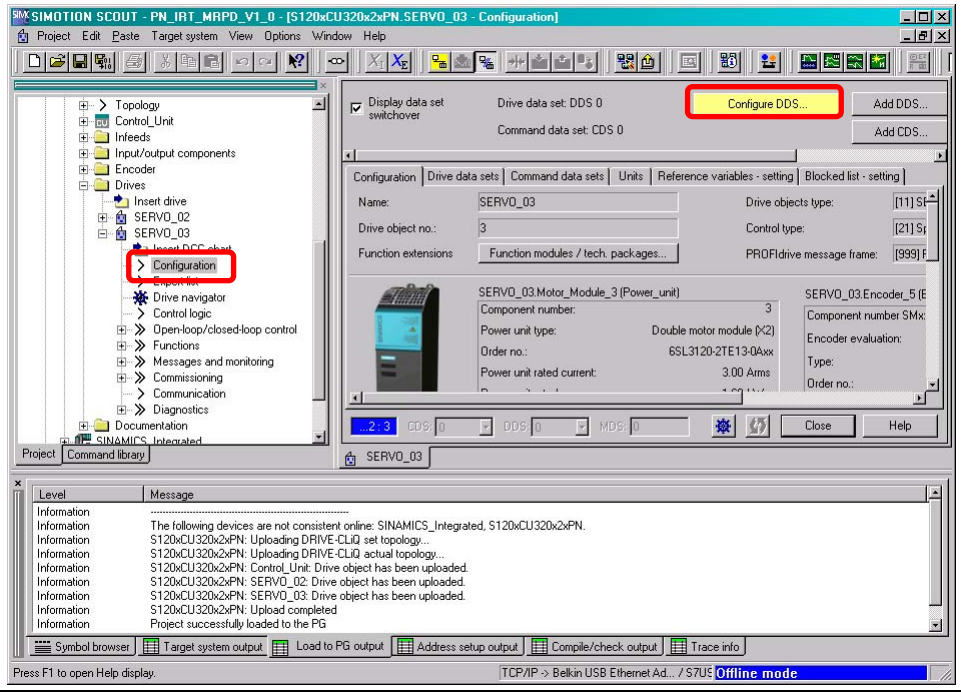
No.	Action
6.	Because the blue drive (SERVO_03) does not have any DRIVE-CLiQ interface, after the automatic configuration, the blue drive must be reconfigured at the SIMOTION training case. a) Go offline  b) Open the configuration of the SERVO_03 drive. For the configuration of the SIMOTION training case, all windows not shown can be bypassed. 

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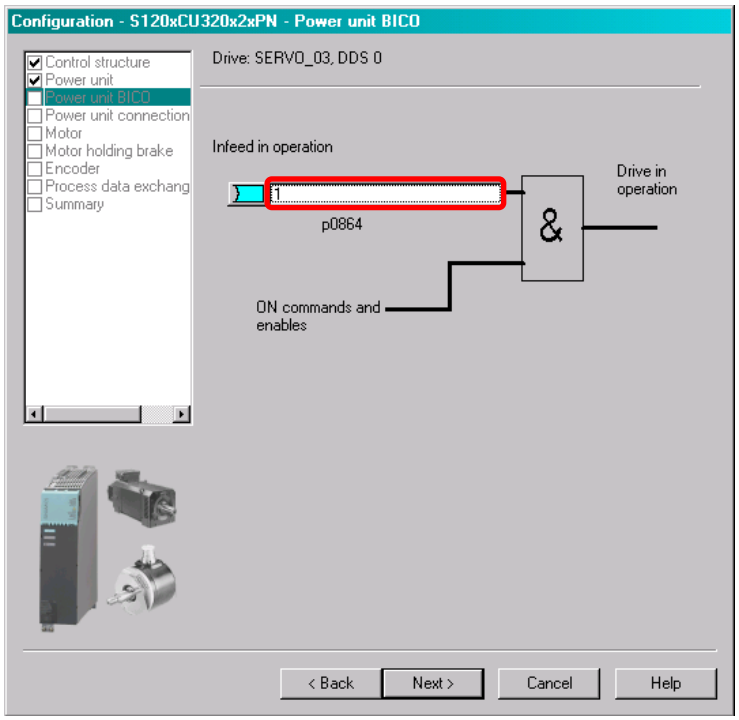
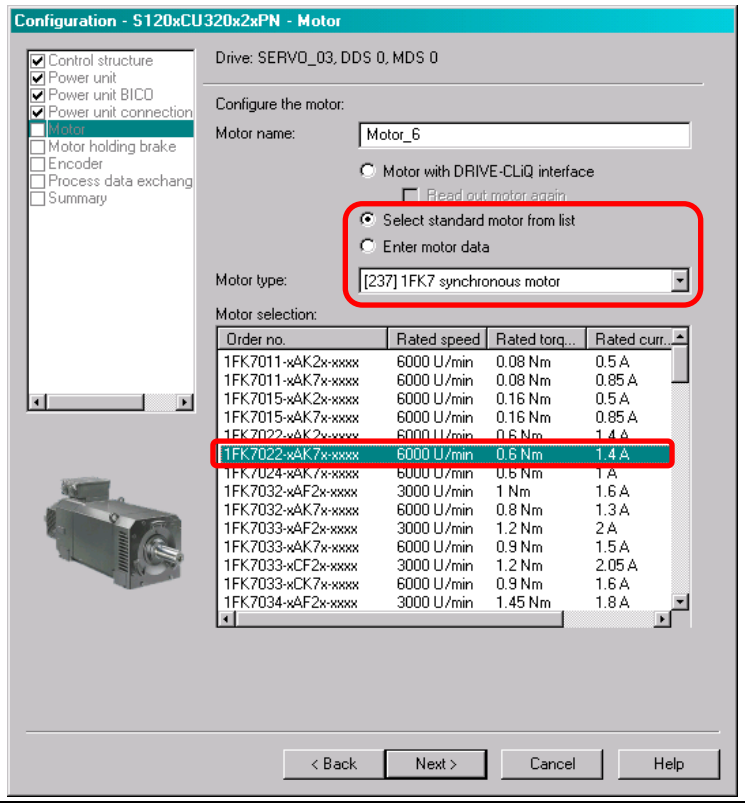
No.	Action
7.	c) Wire the release for the infeed (p0864) with the permanent binector 1.



d) Select the correct motor type.



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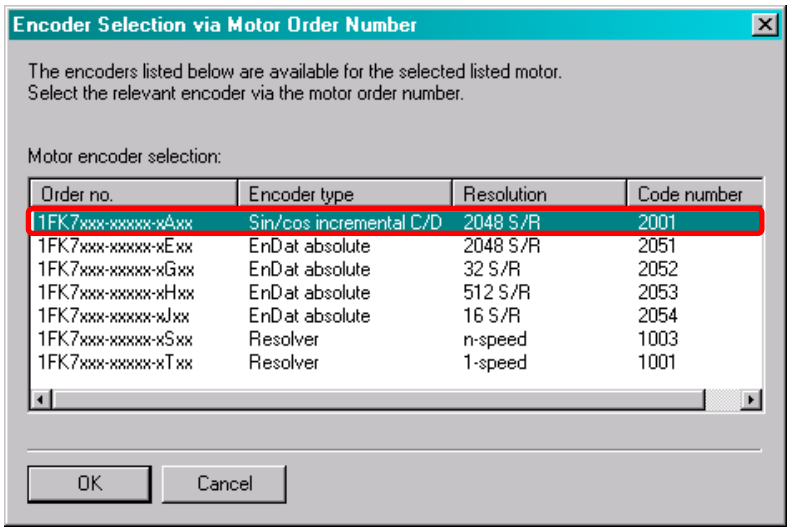
<table>
<tr><th>No.</th><th>Action</th></tr>
<tr><td>8.</td><td>
e) The correct encoder type must also be selected.


f) Close the configuration and save the settings.

g) Go online.

h) Download to the SINAMICS drive.

i) Copy RAM to ROM.

j) Go offline to make the following settings.

</td></tr>
<tr><td>9.</td><td>
The following parameters of both drives (SERVO_02 + SERVO_03) must be checked after the automatic configuration. To do this, open the expert list.
<table>
<tr><th>Parameters</th><th>Description</th><th>Value</th></tr>
<tr><td>p0340</td><td>Automatic calculation</td><td>0</td></tr>
<tr><td>p0210</td><td>Power supply</td><td>345 V</td></tr>
<tr><td>p0864</td><td>Infeed in operation</td><td>1</td></tr>
<tr><td>p1244[0]</td><td>Upper voltage limit for the DC link</td><td>401 V</td></tr>
<tr><td>p1248[0]</td><td>Lower voltage limit for the DC link</td><td>240 V</td></tr>
<tr><td>p1460[0]</td><td>P-component for the speed controller (in the sample project)</td><td>0.01 Nms/rad</td></tr>
<tr><td>p1462[0]</td><td>Integrator time for the speed controller (in the sample project)</td><td>20 ms</td></tr>
</table>
These settings apply only when you are working with a SIMOTION training case!
</td></tr>
</table>

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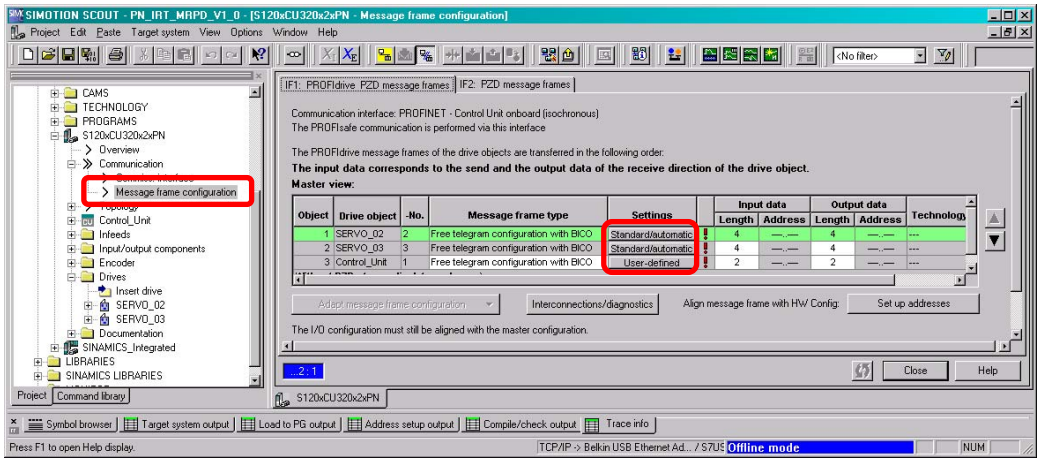
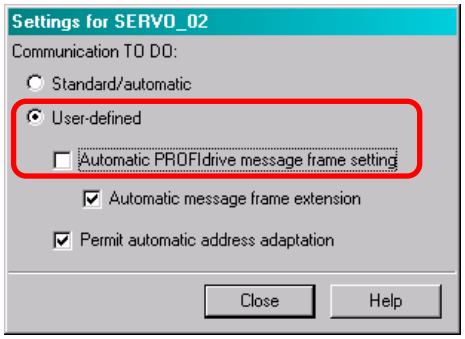
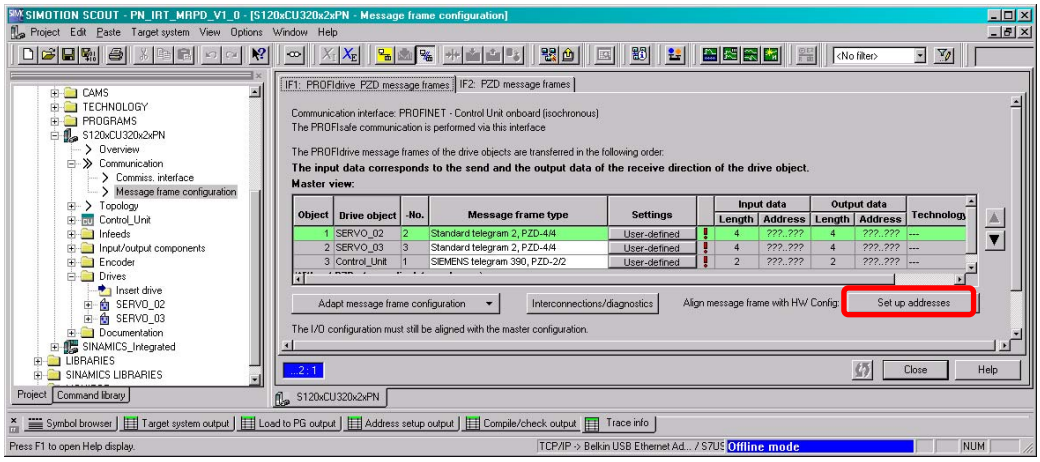
No.	Action
10.	Open the message-frame settings in the SINAMICS drive.  Change the message-frame selection for the two servos from “Standard/automatic” to “User-defined”. 
11.	The correct message frames must be selected for the cyclic communication to the CU and to the two servo motors. Because the “Standard telegram 1” does not support any IRT communication, at least “Standard telegram 2” must be selected for SERVO_02 and SERVO_03!  Then match the selection of the message frames with the hardware configuration.

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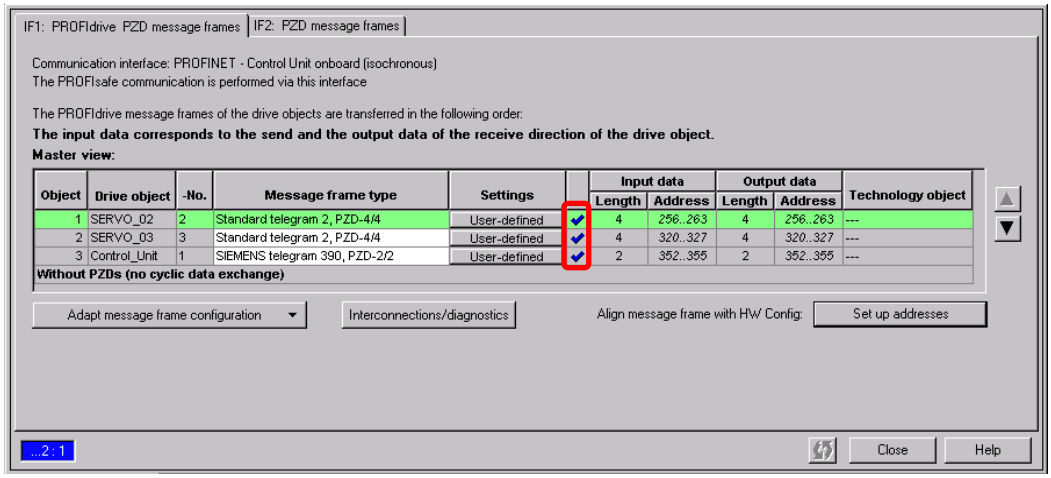
No.	Action
12.	A blue tick after the message frames indicates the correct matching with HW Config. 
13.	Save and compile the HW configuration.
14.	Go online.
15.	Download to the SINAMICS drive and the SIMOTION controller.
16.	Copy RAM to ROM.

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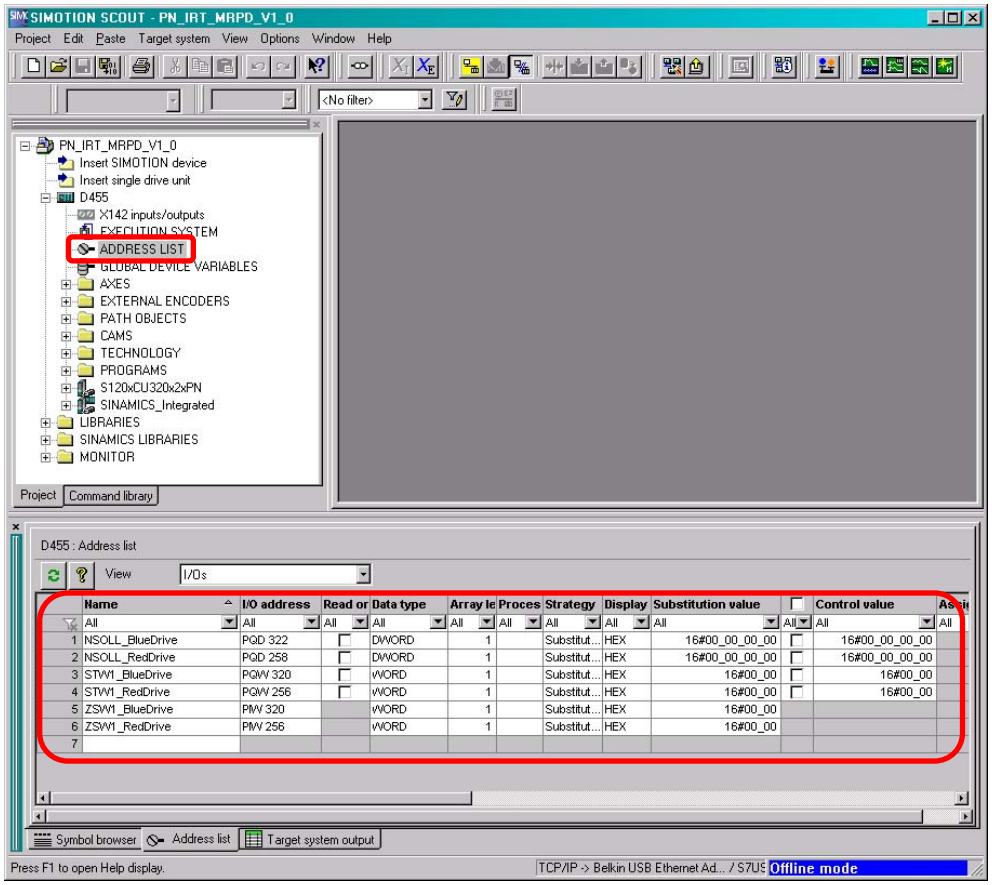
4.7 Configuring the SIMOTION controller

The standard configuring of the SIMOTION controller using the SIMOTION SCOUT engineering system is shown below.

Table 4-7

No.	Action
1.	Go offline. Create the following IO variables in order to exchange data with the SINAMICS drive. In the application example, releases in control word 1 (STW1_BlueDrive, STW1_RedDrive) as well as speed setpoints (NSOLL_BlueDrive, NSOLL_RedDrive) are sent from the SIMOTION controller to the SINAMICS drive. The current states in status word 1 (ZSW1_BlueDrive, ZSW1_RedDrive) are sent back from the SINAMICS drive to the SIMOTION controller where they are evaluated. 

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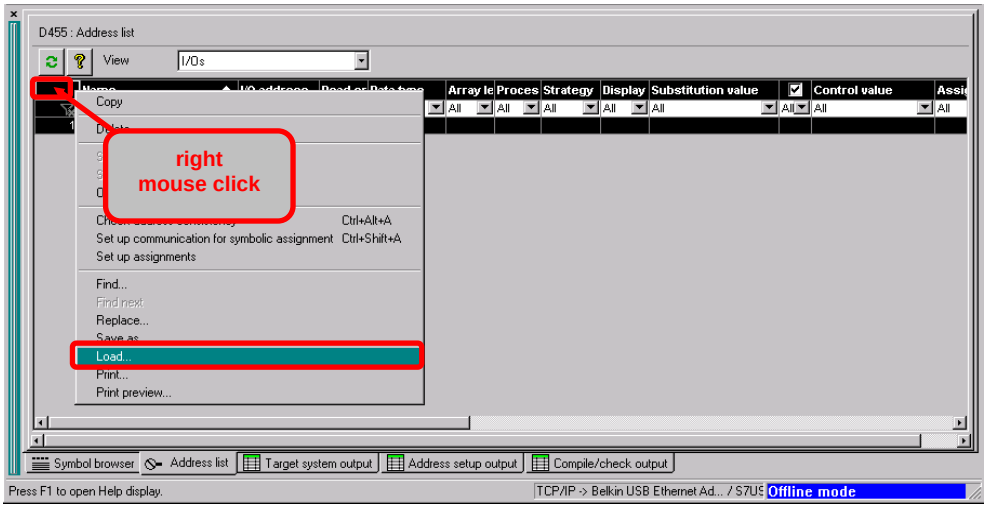
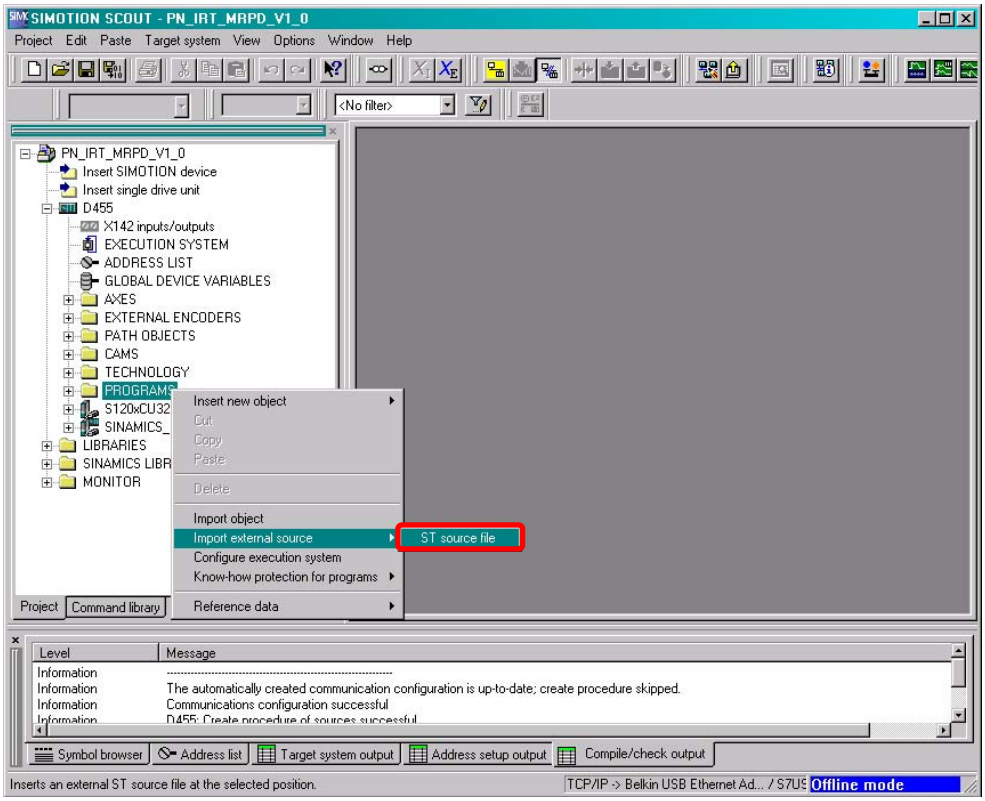
No.	Action
2.	In the sample project, the “IO_Variables.csv” file located in the folder can be imported by right-clicking > “Load”. 
3.	The "fault" source is contained in the sample project. This source contains three programs that are called in the particular FaultTask. The "motionControl" source contains the "pBackgroundTask" program used to control the servos (releases + speed specification). As the name implies, this program is called in the BackgroundTask. These sources can be imported from the "ST_Units" folder of the "60441190_PROFINET_IRT_MRPD_V1_0.zip" ZIP archive. 

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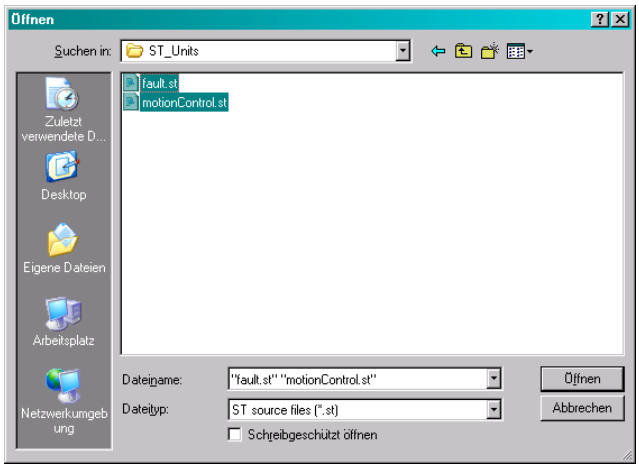
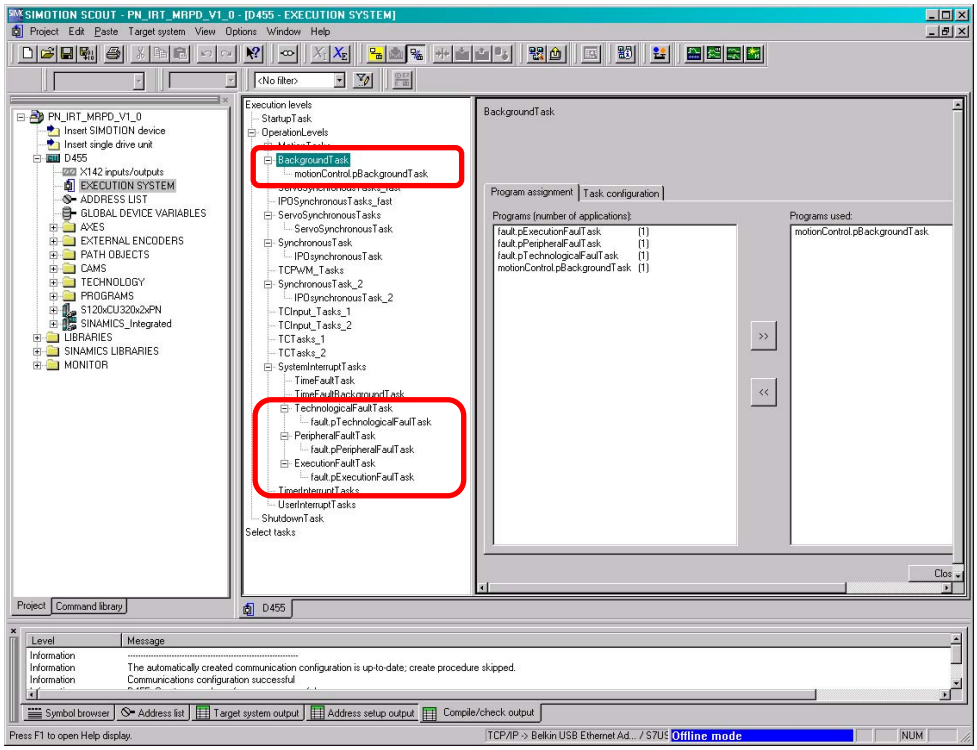
No.	Action
4.	Several ST-sources can be imported simultaneously.  After the import, the SIMOTION project must be saved and compiled so that the programs are visible in the execution system.
5.	Open the execution system and add the sample programs to the intended task. 
6.	Save and compile the SIMOTION project.
7.	Now go online and download the complete SIMOTION project to the controller.
8.	Copy RAM to ROM.

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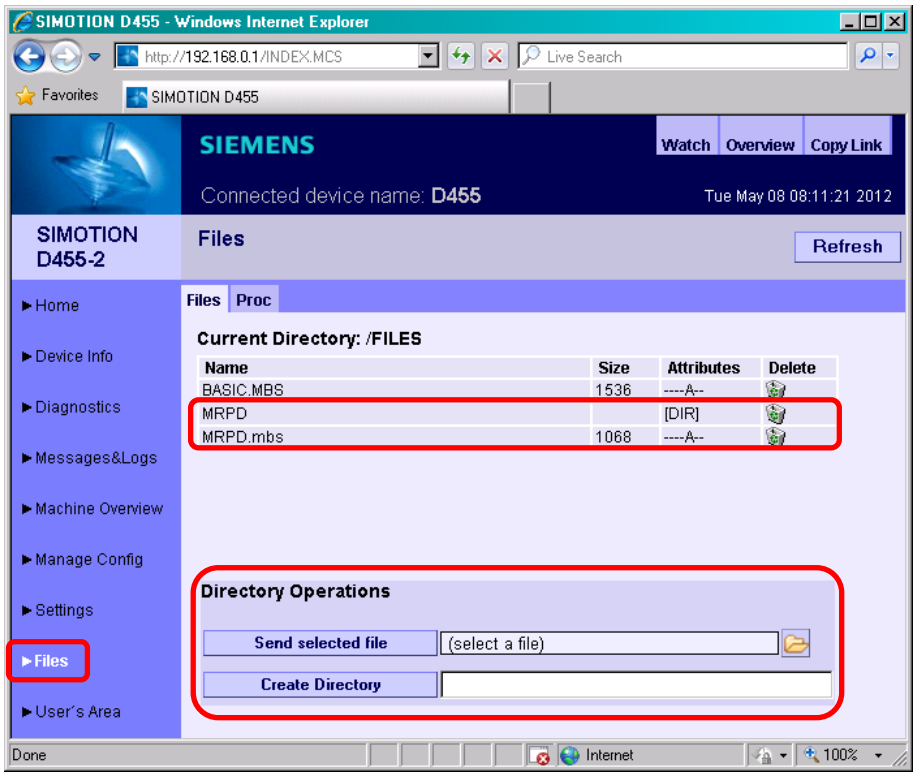
5 Commissioning the application

The following steps must be performed to commission the project example.

5.1 Startup

Table 5-1

No.	Action
1.	All hardware components specified in Table 2-1 (page 11) are present and have been upgraded to the required firmware version.
2.	If you want to operate the sample project via a Web browser, you must copy the HTML pages (*.mbs files) to the CF card. Three options are available for this: 1. "Files" website for SIMOTION IT DIAG, in which case the following folder structure must be created.  → user/simotion/hmi/files (all files of the Files website are stored in this folder) → **MRPD** as folder for… → **Subcode** as folder for the files "MRPDControl.mbs", "MRPDState.mbs" and "javascript.js" → "MRPD.mbs" 2. FTP → ftp://simotion:simotion@192.168.0.1/USER/SIMOTION/HMI/FILES/ 1. CF card reader, copy the "IDevFPro" folder and the "IDevFPro.mbs" file on the CF card to the "user\simotion\hmi\files" folder The *.mbs files are located in the ZIP archive → "HTML/MBS" folder. 3. Alternatively, you can operate the application example from the symbol browser in SIMOTION SCOUT.

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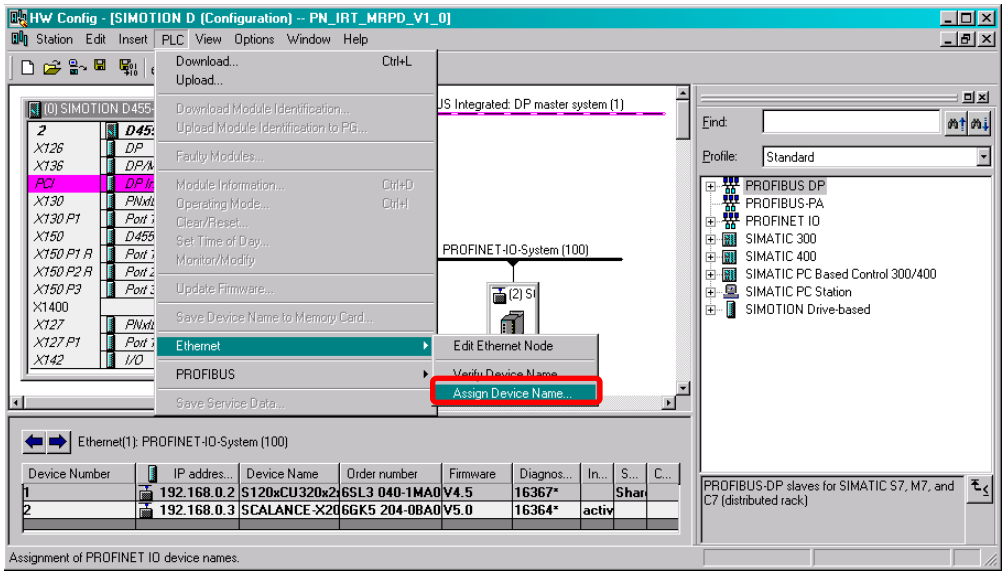
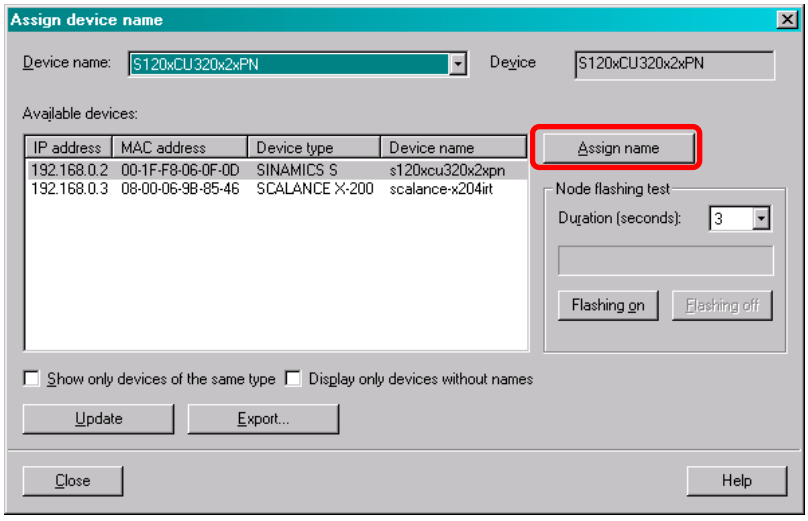
No.	Action
3.	All PROFINET components are networked and accessible from the engineering system.
4.	The Ethernet interface of the engineering system is configured correctly. IP address: `192.168. 0 .100` Subnet mask: `255.255.255. 0`
5.	Start the SIMOTION SCOUT engineering system.
6.	Unzip the "60441190_PROFINET_IRT_MRPD_V1_0.zip" sample project.
7.	Open the SCOUT project "PN_IRT_MRPD_V1_0".
8.	Open HW Config in order to perform the node initiation.  Mark the PROFINET line and open the window for the name assignment via “PLC > Ethernet > Assign Device Name”.
9.	You can select the configured device names and assign them to the associated device (IO device).  **Note** Only IO devices are listed. The IO controllers receive the device name when the HW Config is downloaded.

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No.	Action
10.	As an alternative, the Primary Setup Tool (PST) can also be used to perform the node initiation. The PST can be downloaded from the following link. http://support.automation.siemens.com/WW/view/en/19440762
11.	In the SIMOTION SCOUT, go online to the target systems.
12.	Load the SIMOTION project, including the configuration of the SINAMICS drive, into the target system. If you cannot go online with the SIMOTION controller, then first load the HW Config into the SIMOTION device so that it has the correct IP address and device name.
13.	Copy RAM to ROM.
14.	The sample project can now be operated.

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6 Operating the application

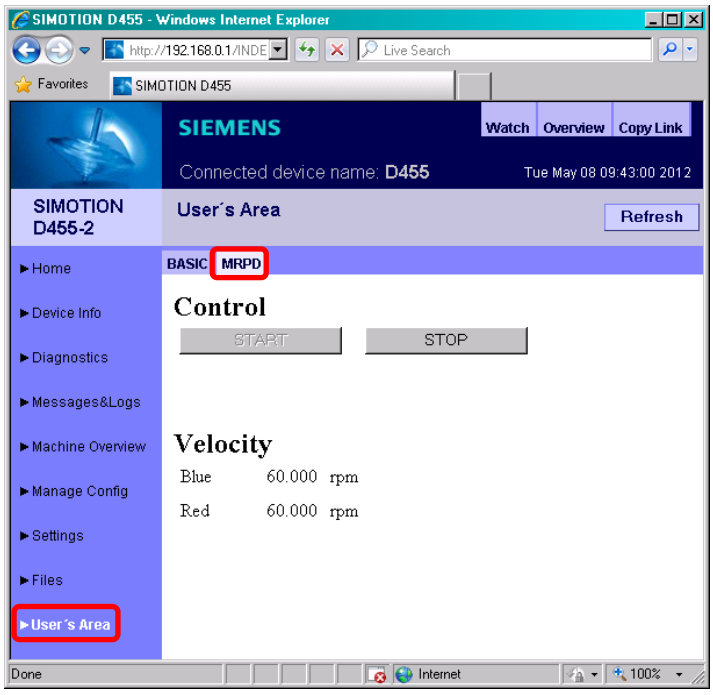
6.1 Overview

The sample project is operated either from a website or alternatively from the symbol browser in SIMOTION SCOUT.

6.2 Testing the bumpless media redundancy (MRPD)

The setpoint speed of the servo is specified by the SIMOTION controller. By dragging a PROFINET cable, e.g. between the SIMOTION controller and a SINAMICS drive, the servos do not stop but continue to turn with the specified setpoint speed. The **MRPD** functionality makes this possible.

Table 6-1

No.	Action
1.	Open any Web browser (preferably Mozilla Firefox). Alternatively, you can also operate the sample project from the SIMOTION SCOUT engineering system (mark source “motionControl” > symbol browser).
2.	Enter the IP address of the SIMOTION controller in the address line of the Web browser. The following IP address is configured in the sample project. IP address: `192.168. 0 .1` Subnet mask: `255.255.255.0` Change to the “MRPD” tab on the “User’s Area” page.  **Control** The **START/STOP** buttons are used to control the “gboMove” global variable and so start or stop the two servos. **Velocity** The setpoint speeds of the two servos are displayed here.

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No.	Action
3.	If the two servos turn with the specified setpoint speed of 60 RPM, **one** connection between the nodes of the MRPD ring can now be opened. The servos do not stop because they are now sent the setpoint speeds via the connection of the MRPD ring that is still operational.
4.	If the ring is opened at **two** locations, the two communications paths from the SIMOTION controller to the SINAMICS drive are interrupted and the servos stop. If the ring is closed again at one location, the application acknowledges the errors pending on the SINAMICS drive and the servos continue to turn with the setpoint speed.

Note

The application acknowledgement of the drive errors is permitted only in the sample project!

Also ensure that approx. **three seconds** must lie in between two successive "errors" (e.g. the ring is open → the ring will be closed→ the ring will be opened at another location) so that the two servos do not stop.

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7 Contact

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8 History

Tabelle 8-1

Version	Date	Change
V1.0	07/2012	First edition

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