ConneXium Ethernet Cabling System

TCSESM, TCSESM-E Managed Switch
Redundancy Configuration User Manual

31007126.03

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Content

Safety information

Important Information

Notice: Read these instructions carefully, and look at the equipment to become familiar with the device before trying to install, operate, or maintain it. The following special messages may appear throughout this documentation or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.

The addition of this symbol to a Danger or Warning safety label indicates that an electrical hazard exists, which will result in personal injury if the instructions are not followed.

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

⚠ DANGER

DANGER indicates an imminently hazardous situation which, if not avoided, **will result in** death or serious injury.

⚠ WARNING

WARNING indicates a potentially hazardous situation which, if not avoided, **can result in** death or serious injury.

⚠ CAUTION

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Related Documents

Title of Documentation	Reference-Number
ConneXium Ethernet Cabling System Managed Switch User Manual Redundancy Configuration	31007126.03
ConneXium Ethernet Cabling System Managed Switch User Manual Basic Configuration	31007122.04
ConneXium Ethernet Cabling System Managed Switch Reference Manual Command Line Interface	31007130.03
ConneXium Ethernet Cabling System Managed Switch Reference Manual Web-based Interface	EIO0000000482.01
ConneXium Ethernet Cabling System Managed Switch Installation Manual TCSESM	31007118.05
ConneXium Ethernet Cabling System Managed Switch Installation Manual TCSESM-E	EIO0000000529.01

Note: The Glossary you will find in the Reference Manual Command Line Interface.

The “Redundancy Configuration” user manual contains the information you need to select a suitable redundancy procedure and configure it.

The “Basic Configuration” user manual contains the information you need to start operating the device. It takes you step by step from the first startup operation through to the basic settings for operation in your environment.

The “Installation” user manual contains a device description, safety instructions, a description of the display, and the other information that you need to install the device before you begin with the configuration of the device.

The "Web-based Interface" reference manual contains detailed information on using the Web interface to operate the individual functions of the device.

The "Command Line Interface" reference manual contains detailed information on using the Command Line Interface to operate the individual functions of the device.

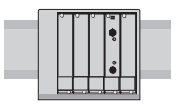
Key

The designations used in this manual have the following meanings:

▶	List
☐	Work step
■	Subheading
Link	Indicates a cross-reference with a stored link
Note:	A note emphasizes an important fact or draws your attention to a dependency.
`Courier`	ASCII representation in user interface
	Execution in the Web-based Interface user interface
	Execution in the Command Line Interface user interface

Symbols used:

	Router with firewall
	Switch with firewall
	Router
	Switch
	Bridge

	Hub
	A random computer
	Configuration Computer
	Server
	PLC - Programmable logic controller
	I/O - Robot

1 Introduction

The device contains a range of redundancy functions:

- HIPER-Ring
- MRP-Ring
- Fast HIPER-Ring (TCSESM-E)
- Ring/Network Coupling
- Rapid Spanning Tree Algorithm (RSTP)

1.1 Overview of Redundancy Topologies

To introduce redundancy onto layer 2 of a network, first clarify which network topology you require. Depending on the network topology selected, you then choose from the redundancy protocols that can be used with this network topology.

The following topologies are possible:

Network topology	Possible redundancy procedures	Comments
Tree structure without loops (cycle-free)	Only possible in combination with physical loop creation	-
Topology with 1 loop	RSTP, Ring Redundancy	Ring Redundancy procedures (HIPER-Ring, Fast HIPER-Ring or MRP) provide shorter switching times than RSTP
Topology with 2 loops	RSTP, Ring Redundancy, Sub-Ring	Ring Redundancy: one rimary ring with a Sub-Ring or an MRP-Ring with an RSTP-Ring.
Topology with 3 non-nested loops	RSTP, Ring Redundancy, Sub-Ring, Ring coupling	The ring coupling provides particular support when redundantly coupling a redundant ring to another redundant ring, or to any structure that only works with Schneider Electric devices
Topology with nested loops	RSTP, Sub-Ring, Ring coupling	Ring coupling only couples non-nested rings, though these can couple local Sub-Rings

Table 1: Overview of Redundancy Topologies

The Ring Redundancy Protocol MRP has particular properties to offer:

- It can nest MRP-Rings. A coupled ring is known as a Sub-Ring (see on page 38 “Sub-Ring“).
- You can couple to MRP-Rings to other structures that work with RSTP, including RSTP rings (see on page 101 “Combining RSTP and MRP“).

1.2 Overview of Redundancy Protocols

Redundancy procedure	Network topology	Switching time
RSTP	Random structure	typically < 1 s (STP < 30 s), up to < 30 s - depends heavily on the number of devices
	Note: Up to 79 devices possible, depending on topology and configuration. If the default values (factory settings) are used, up to 39 devices are possible, depending on the topology (see page 75).	
HIPER-Ring	Ring	typically 80 ms, up to < 500 ms or < 300 ms (selectable) - the number of switches has a minimal effect on the switch-over time
MRP-Ring	Ring	typically 80 ms, up to < 500 ms or < 200 ms (selectable) - the number of switches has a minimal effect on the switch over time
	Note: In combination with RSTP in MRP compatibility mode, up to 39 devices are possible, depending on the configuration. If the default values (factory settings) for RSTP are used, up to 19 devices are possible (see page 75).	
Fast HIPER-Ring (TCSESM-E)	Ring	< 25 ms with 50 devices in ring.
Redundant coupling	Coupling of network segment/rings via a main line and a redundant line	typically 150 ms, up to < 500 ms

Table 2: Comparison of the redundancy procedures

2 Ring Redundancy

The concept of ring redundancy allows the construction of high-availability, ring-shaped network structures.
With the help of the RM (**R**ing **M**anager) function, the two ends of a backbone in a line structure can be closed to a redundant ring. The ring manager keeps the redundant line open as long as the line structure is intact. If a segment becomes inoperable, the ring manager immediately closes the redundant line, and line structure is intact again.

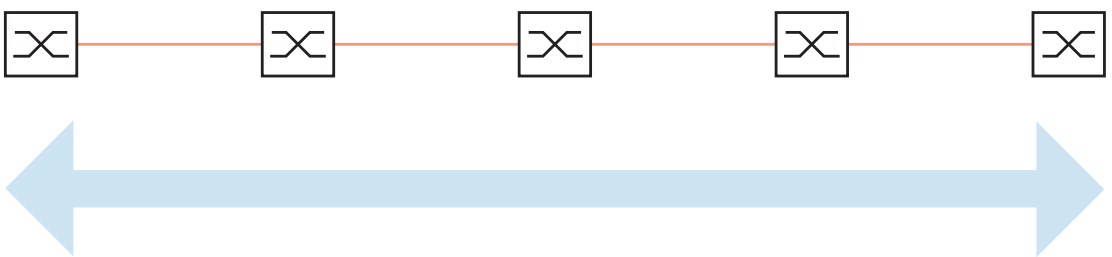


Figure 1: Line structure

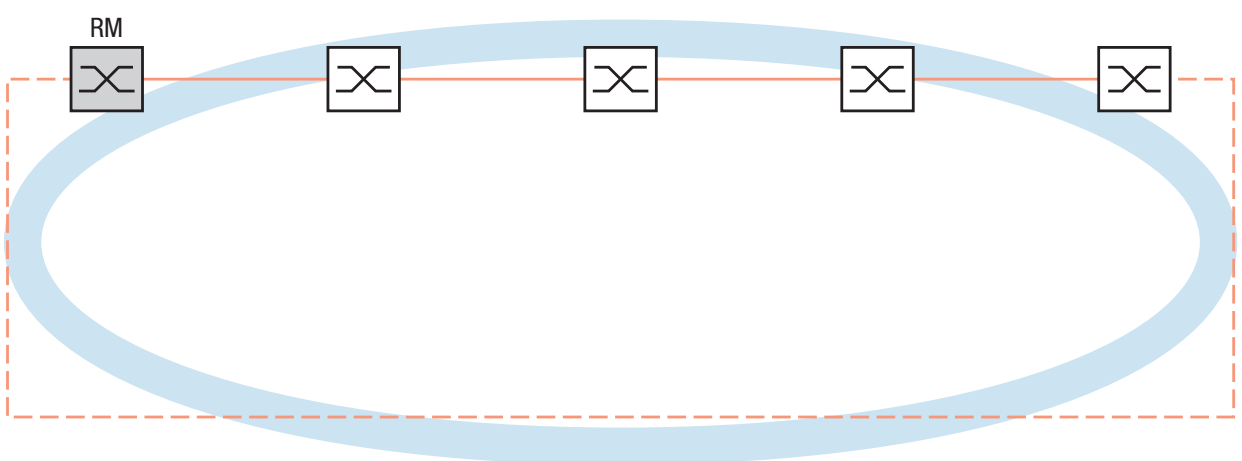


Figure 2: Redundant ring structure
RM = Ring Manager
—— main line
- - - redundant line

If a section is down, the ring structure of a

- HIPER-(**HI**GH **PE**RFORMANCE **R**EDUNDANCY) Ring with up to 50 devices typically transforms back to a line structure within 80 ms (possible settings: standard/accelerated).
- MRP (**M**edia **R**edundancy **P**rotocol) Ring (IEC 62439) of up to 50 devices typically transforms back to a line structure within 80 ms (adjustable to max. 200 ms/500 ms).
- Fast HIPER-Ring of up to 5 devices typically transforms back to a line structure within 5 ms (maximum 10 ms). With a larger number of devices, the reconfiguration time increases.

Devices with HIPER-Ring function capability:

- Within a HIPER-Ring, you can use any combination of the following devices:
  - TCSESM
  - TCSESM-E
- Within an MRP-Ring, you can use devices that support the MRP protocol based on IEC62439.
- Within a Fast HIPER-Ring, you can use the following device:
  - TCSESM-E

Note: Enabled Ring Redundancy methods on a device are mutually exclusive at any one time. When changing to another Ring Redundancy method, deactivate the function for the time being.

Note: The following usage of the term “ring manager” instead of “redundancy manager” makes the function easier to understand.

2.1 Example of a HIPER-Ring

A network contains a backbone in a line structure with 3 devices. To increase the redundancy reliability of the backbone, you have decided to convert the line structure to a HIPER-Ring. You use ports 1.1 and 1.2 of the devices to connect the lines.

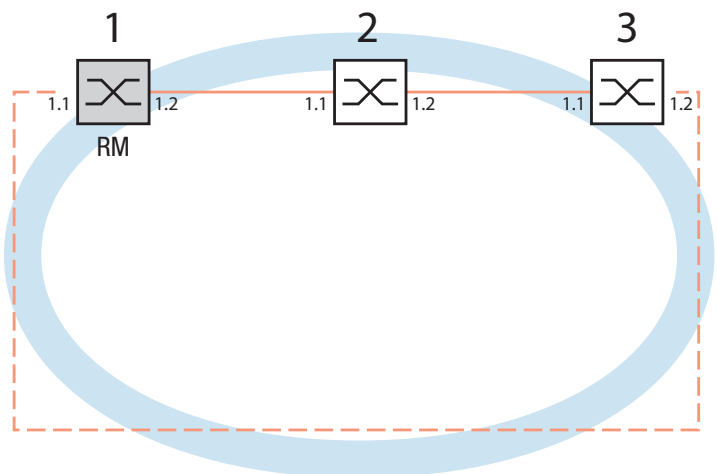


Figure 3: Example of HIPER-Ring
RM = Ring Manager
—— main line
- - - redundant line

The following example configuration describes the configuration of the ring manager device (1). The two other devices (2 to 3) are configured in the same way, but without activating the ring manager function. Select the “Standard” value for the ring recovery, or leave the field empty.

Note: As an alternative to using software to configure the HIPER-Ring, with device TCSESM you can also use a DIP switch to enter a number of settings. You can also use a DIP switch to enter a setting for whether the configuration via DIP switch or the configuration via software has priority. The state on delivery is “Software Configuration”. You can find details on the DIP switches in the User Manual Installation.

⚠ Warning

RING LOOP HAZARD

Configure all the devices of the Ring individually. Before you connect the redundant line, you must complete the configuration of all the devices of the Ring.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

2.1.1 Setting up and configuring the HIPER-Ring

☐ Set up the network to meet your demands.
☐ You configure all 6 ports so that the transmission speed and the duplex settings of the lines correspond to the following table:

Bit rate	100 Mbit/s	1000 Mbit/s
Autonegotiation (automatic configuration)	off	on
Port	on	on
Duplex	Full	–

Table 3: Port settings for ring ports

Note: When you use the DIP switch to activate the HIPER-Ring, the device makes the appropriate settings for the pre-defined ring ports in the configuration table (transmission rate and duplex mode). When the HIPER-Ring function is disabled, the ports revert from ring ports to normal ports but will keep the ring port settings. Independently of the DIP switch setting, you can still change the port settings via software.

☐ Select the `Redundancy:Ring Redundancy` dialog.
☐ Under “Version”, select `HIPER-Ring`.
☐ Define the desired ring ports 1 and 2 by making the corresponding entries in the module and port fields. If it is not possible to enter a module, then there is only one module in the device that is taken over as a default.

Display in “Operation” field:
– `active`: This port is switched on and has a link.
– `inactive`: This port is switched off or it has no link.

Figure 4: Ring Redundancy Dialog TCSESM

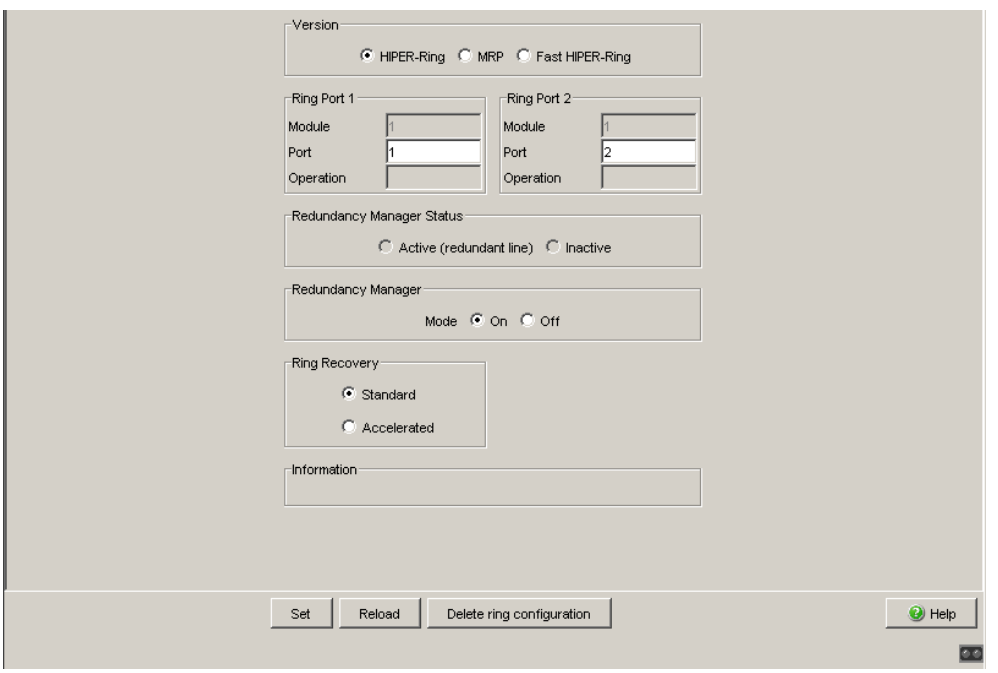


Figure 5: Ring Redundancy dialog (TCSESM-E)

☐ Activate the ring manager for this device. Do not activate the ring manager for any other device in the HIPER-Ring.

☐ In the “Ring Recovery” frame, select the value “Standard” (default).

Note: Settings in the “Ring Recovery” frame only take effect for devices configured as ring managers.

☐ Click “Set” to temporarily save the entry in the configuration.

```
enable                                  Switch to the Privileged EXEC mode.
configure                               Switch to the Configuration mode.
hiper-ring mode ring-manager            Select the HIPER-Ring ring redundancy and de-
                                        fine the device as ring manager.
Switch's HIPER Ring mode set to ring-manager
hiper-ring port primary 1/1             Define port 1 in module 1 as ring port 1.
HIPER Ring primary port set to 1/1
hiper-ring port secondary 1/2           Define port 2 in module 1 as ring port 2.
HIPER Ring secondary port set to 1/2
exit                                    Switch to the privileged EXEC mode.
show hiper-ring                         Display the HIPER-Ring parameters.
HIPER Ring Mode of the Switch.................. ring-manager
  configuration determined by.................. management
HIPER Ring Primary Port of the Switch.......... 1/1, state active
HIPER Ring Secondary Port of the Switch........ 1/2, state active
HIPER Ring Redundancy Manager State............ active
HIPER Ring Redundancy State (red. guaranteed).. no (rm is active)
HIPER Ring Setup Info (Config. failure)........ no error
HIPER Ring Recovery Delay...................... 500ms
```

☐ Now proceed in the same way for the other two devices.

Note: If you have configured VLANs, note the VLAN configuration of the ring ports.
In the configuration of the HIPER-Ring, you select for the ring ports
– VLAN ID 1 and
– VLAN membership Untagged in the static VLAN table

Note: Deactivate the Spanning Tree protocol on the ports connected to the HIPER-Ring because Spanning Tree and Ring Redundancy affect each other. If you enable the HIPER-Ring function by means of the DIP switch, RSTP will be disabled automatically.

☐ Now you connect the line to the ring. To do this, you connect the 2 devices to the ends of the line using their ring ports.

The displays in the “Redundancy Manger Status” frame mean:
– “Active (redundant line)”: The ring is open, which means that a data line or a network component within the ring is down.
– “Inactive”: The ring is closed, which means that the data lines and network components are working.

The displays in the “Information” frame mean
– “Redundancy existing”: One of the lines affected by the function may be interrupted, with the redundant line then taking over the function of the interrupted line.
– "Configuration failure”: The function is incorrectly configured or the cable connections at the ring ports are improperly configured (e.g., not plugged into the ring ports).

2.2 Example of an MRP-Ring

A network contains a backbone in a line structure with 3 devices. To increase the availability of the backbone, you decide to convert the line structure to a redundant ring. In contrast to the previous example, devices from different manufacturers are used which do not all support the HIPER-Ring protocol. However, all devices support MRP as the ring redundancy protocol, so you decide to deploy MRP. You use ports 1.1 and 2.2 of the devices to connect the lines.

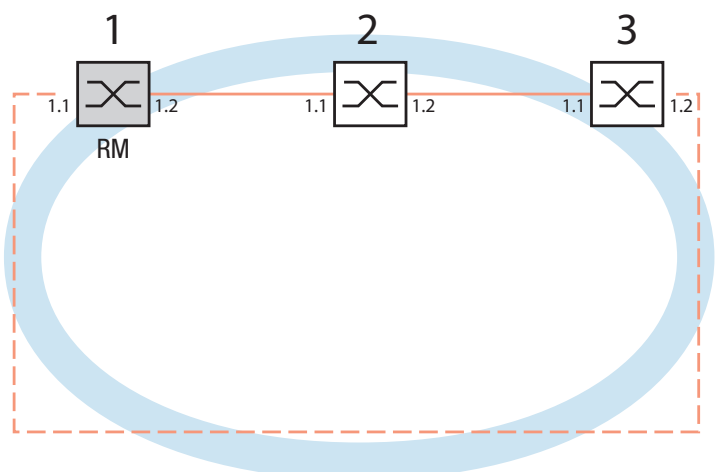


Figure 6: Example of MRP-Ring
RM = Ring Manager
—— main line
- - - redundant line

The following example configuration describes the configuration of the ring manager device (1). You configure the 2 other devices (2 to 3) in the same way, but without activating the ring manager function. This example does not use a VLAN. You have entered 200 ms as the ring recovery time, and all the devices support the advanced mode of the ring manager.

Note: For devices with DIP switches, put all DIP switches to “On”. The effect of this is that you can use the software configuration to configure the redundancy function without any restrictions. You thus avoid the possibility of the software configuration being hindered by the DIP switches.

⚠ Warning

RING LOOP HAZARD

Configure all the devices of the Ring individually. Before you connect the redundant line, you must complete the configuration of all the devices of the Ring.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

☐ Set up the network to meet your demands.
☐ You configure all 6 ports so that the transmission speed and the duplex settings of the lines correspond to the following table:

Bit rate	100 Mbit/s	1000 Mbit/s
Autonegotiation (automatic configuration)	off	on
Port	on	on
Duplex	Full	–

Table 4: Port settings for ring ports

☐ Select the `Redundancy:Ring Redundancy` dialog.
☐ Under “Version”, select `MRP`.
☐ Define the desired ring ports 1 and 2 by making the corresponding entries in the module and port fields. If it is not possible to enter a module, then there is only one module in the device that is taken over as a default.

Display in “Operation” field:

- `forwarding`: this port is switched on and has a link.
- `blocked`: this port is blocked and has a link
- `disabled`: this port is disabled
- `not-connected`: this port has no link

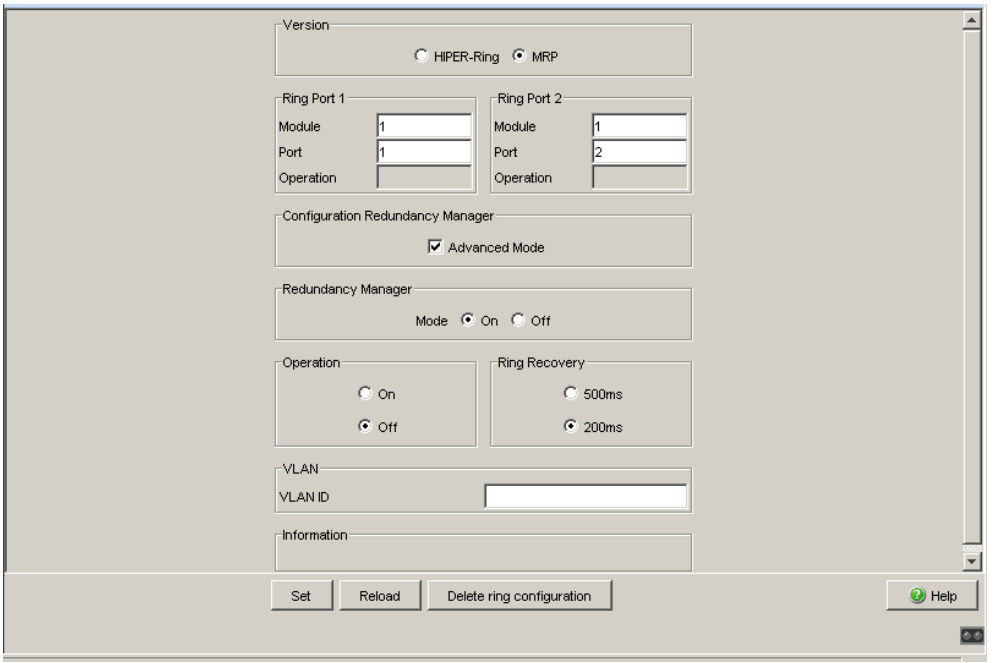


Figure 7: Ring Redundancy Dialog TCSEM

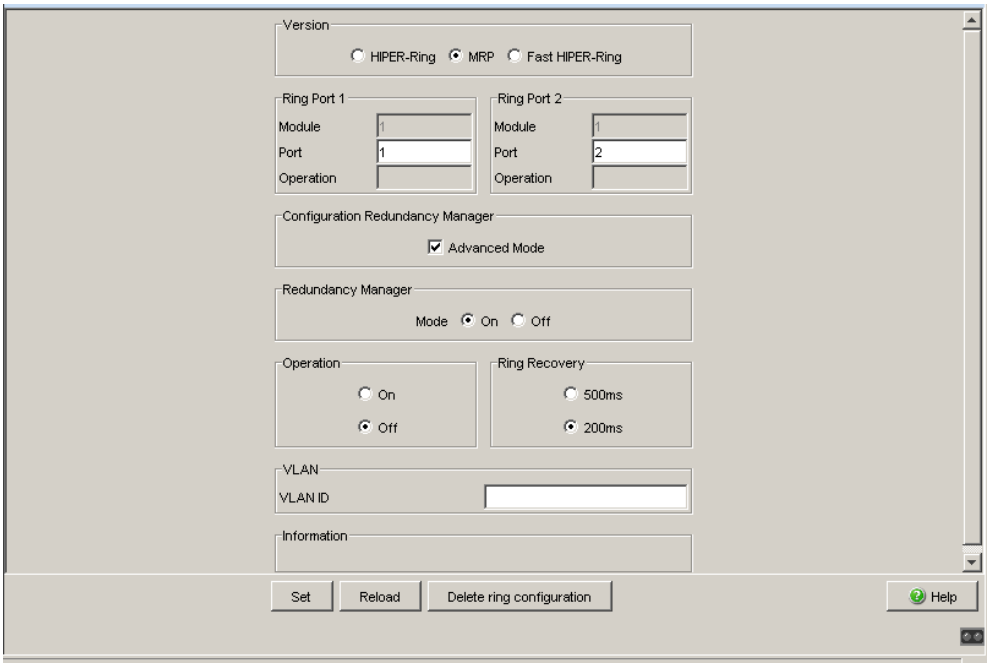


Figure 8: Ring Redundancy dialog (TCSESM-E)

☐ In the “Ring Recovery” frame, select 200 ms.

Note: If selecting 200 ms for the ring recovery does not provide the ring stability necessary to meet the requirements of your network, you select 500 ms.

Note: Settings in the “Ring Recovery” frame only take effect for devices configured as ring managers.

☐ Under “Configuration Redundancy Manager”, activate the advanced mode.

☐ Activate the ring manager for this device. Do not activate the ring manager for any other device in the MRP-Ring.

☐ Leave the VLAN ID as 0 in the VLAN field.

☐ Switch the operation of the MRP-Ring on.

☐ Click “Set” to temporarily save the entry in the configuration.

The displays in the “Information” frame mean

– “Redundancy existing”: One of the lines affected by the function may be interrupted, with the redundant line then taking over the function of the interrupted line.
– "Configuration failure”: The function is incorrectly configured or the cable connections at the ring ports are improperly configured (e.g., not plugged into the ring ports).

The “VLAN” frame enables you to assign the MRP-Ring to a VLAN:

☐ If VLANs are configured, you make the following selections in the "VLAN" frame:
  – VLAN ID 0, if the MRP-Ring configuration is not to be assigned to a VLAN, as in this example.
    Select VLAN ID 1 and VLAN membership `U` (Untagged) in the static VLAN table for the ring ports.
  – A VLAN ID > 0, if the MRP-Ring configuration is to be assigned to this VLAN.
    For all devices in this MRP-Ring, enter this VLAN ID in the MRP-Ring configuration, and then choose this VLAN ID and the VLAN membership Tagged (`T`) in the static VLAN table for all ring ports in this MRP-Ring.

Note: For all devices in an MRP-Ring, activate the MRP compatibility in the `Rapid Spanning Tree:Global` dialog if you want to use RSTP in the MRP-Ring. If this is not possible, perhaps because individual devices do not support the MRP compatibility, you deactivate the Spanning Tree protocol at the ports connected to the MRP-Ring. Spanning Tree and Ring Redundancy affect each other.

Note: If you want to configure an MRP-Ring using the Command Line Interface, you must define an additional parameter. When configured using CLI, an MRP-Ring is addressed via its MRP domain ID. The MRP domain ID is a sequence of 16 number blocks (8-bit values). Use the default domain of 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 for the MRP domain ID.
This default domain is also used internally for a configuration via the Web-based interface.
Configure all the devices within an MRP-Ring with the same MRP domain ID.

`enable`	Switch to the Privileged EXEC mode.
`configure`	Switch to the Configuration mode.
`mrp new-domain default domain`	Create a new MRP-Ring with the default domain ID 255.255.255.255.255.255.255.255.255.255.255.255.255.255.255.255

`MRP domain created:`
`Domain ID:`
`255.255.255.255.255.255.255.255.255.255.255.255.255.255.255.255`
`(Default MRP domain)`	

`mrp current-domain port primary 1/1`	Define port 1 of module 1 as ring port 1 (primary).
`Primary Port set to 1/1`	
`mrp current-domain port secondary 1/2`	Define port 2 of module 1 as ring port 2 (secondary).
`Secondary Port set to 1/2`	

`mrp current-domain mode manager`	Define this device as the ring manager.
`Mode of Switch set to Manager`	
`mrp current-domain recovery-delay 200 ms`	Define 200 ms as the value for the “Ring Recovery”.
`Recovery delay set to 200 ms`	
`mrp current-domain advanced-mode enable`	Activate the “MRP Advanced Mode”.
`Advanced Mode (react on link change) set to Enabled`	
mrp current-domain operation enable	Activate the MRP-Ring.
`Operation set to Enabled`	
exit	Go back one level.
show mrp	Show the current parameters of the MRP-Ring (abbreviated display).

```
Domain ID:
255.255.255.255.255.255.255.255.255.255.255.255.255.255.255.255
           (Default MRP domain)

Configuration Settings:
Advanced Mode (react on link change).... Enabled
Manager Priority....................... 32768
Mode of Switch (administrative setting). Manager
Mode of Switch (real operating state)... Manager
Domain Name............................ <empty>
Recovery delay......................... 200 ms
Port Number, Primary................... 1/1,  State: Not Connected
Port Number, Secondary................. 1/2,  State: Not Connected
VLAN ID................................ 0 (No VLAN)
Operation.............................. Enabled
```

☐ Now you connect the line to the ring. To do this, you connect the 2 devices to the ends of the line using their ring ports.

2.3 Example of a Fast HIPER-Ring

This example can be set up with the device type TCSESM-E.
A network contains a backbone in a line structure with 3 devices. To increase the redundancy reliability of the backbone, you have decided to convert the line structure to a ring redundancy. In contrast to the previous example, you need a very short switch-over time in a redundancy case (about 10 ms). Only TCSESM-E devices are being used, so you decide on the Fast HIPER-Ring as the ring redundancy protocol. You use ports 1.1 and 1.2 of the devices to connect the lines.

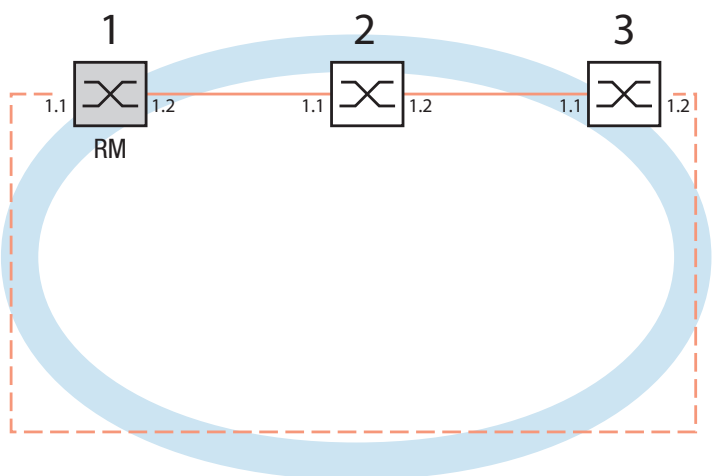


Figure 9: Example of Fast HIPER-Ring
RM = Ring Manager
—— main line
- - - redundant line

The following example configuration describes the configuration of the ring manager device (1). The 2 other devices (2 to 3) are configured in the same way, but without activating the ring manager function. No VLAN used in this example.

⚠ Warning

RING LOOP HAZARD

Configure all the devices of the Ring individually. Before you connect the redundant line, you must complete the configuration of all the devices of the Ring.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

☐ Set up the network to meet your demands.
☐ You configure all 6 ports so that the transmission speed and the duplex settings of the lines correspond to the following table:

Bit rate	100 Mbit/s	1000 Mbit/s
Autonegotiation (automatic configuration)	off	on
Port	on	on
Duplex	Full	–

Table 5: Port settings for ring ports

☐ Select the `Redundancy:Ring Redundancy` dialog.
☐ Under “Version”, select `Fast HIPER-Ring`.
☐ Define the desired ring ports 1 and 2 by making the corresponding entries in the module and port fields. If it is not possible to enter a module, then there is only one module in the device that is taken over as a default.

Display in “Operation” field:

- `forwarding`: this port is switched on and has a link.
- `blocked`: this port is blocked and has a link
- `disabled`: this port is disabled
- `not-connected`: this port has no link

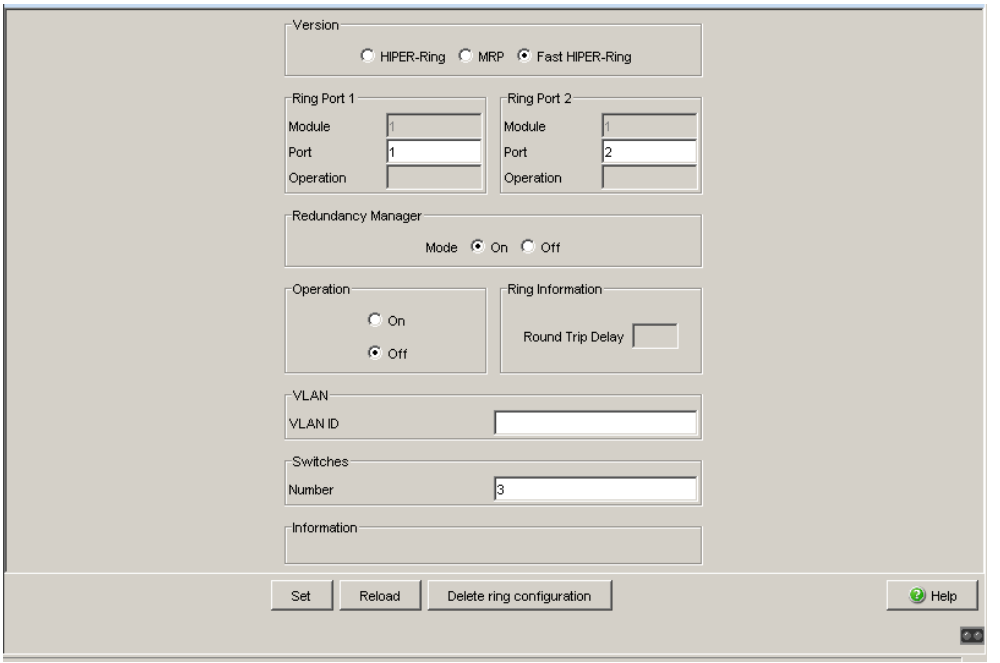


Figure 10: Ring Redundancy dialog (TCSESM-E)

- ☐ Activate the ring manager for this device. Do not activate the ring manager for any other device in the Fast HIPER-Ring.
- ☐ Activate the function in the “Operation” frame.
- ☐ Leave the VLAN ID as 0 in the VLAN field.
- ☐ In the “Switches” frame, enter the number of Switches in the ring in “Number”. This entry is used to optimize the reconfiguration time and the stability of the ring.
- ☐ Click “Set” to temporarily save the entry in the configuration.

The display in the “Ring Information” frame means:

– Round Trip Delay: round-trip delay in µs for test packets, measured by the ring manager.
  Display begins with 100 µs, in steps of 100 µs. Values of 1000 µs and greater indicate that the ring may become unstable. In this case, check that the entry for the number of Switches in the “Switches” frame is correct.

The displays in the “Information” frame mean

– “Redundancy existing”: One of the lines affected by the function may be interrupted, with the redundant line then taking over the function of the interrupted line.
– "Configuration failure”: The function is incorrectly configured or the cable connections at the ring ports are improperly configured (e.g., not plugged into the ring ports).

The “VLAN” frame enables you to assign the Fast HIPER-Ring to a VLAN:

☐ If VLANs are configured, you make the following selections in the "VLAN" frame:
  – VLAN ID 0, if the Fast HIPER-Ring configuration is not to be assigned to a VLAN, as in this example.
    Select VLAN ID 1 and VLAN membership `U` (Untagged) in the static VLAN table for the ring ports.
  – A VLAN ID > 0, if the Fast HIPER-Ring configuration is to be assigned to this VLAN.
    For all devices in this Fast HIPER-Ring, enter this VLAN ID in the Fast HIPER-Ring configuration, and then choose this VLAN ID and the VLAN membership `T` (Tagged) in the static VLAN table for all ring ports in this Fast HIPER-Ring.

Note: If you want to configure a Fast HIPER-Ring using the **C**ommand **L**ine **I**nterface (CLI), you must define an additional parameter. When configured using CLI, a Fast HIPER-Ring is addressed via its Fast HIPER-Ring ID. This ID is a number in the value range 1 to 2,147,480,647 (2^{31} - 1)). The default setting is 1. The device also uses this value internally for a configuration via the Web-based interface.
Configure all the devices within a Fast HIPER-Ring with the same Fast HIPER-Ring ID.

`enable`	Switch to the Privileged EXEC mode.
`configure`	Switch to the Configuration mode.
`fast-hiper-ring new-id default-id`	Create a new Fast HIPER-Ring with the default ID (1). Ports 1/1 and 1/2 are defined as ring ports here. You keep these default values.

```
Fast HIPER-Ring ID created:ID: 1 (Default Fast HIPER-Ring ID)
```

`fast-hiper-ring current-id mode ring-manager`	Define this device as the ring manager.

```
Mode of Switch set to Ring Manager
```

`fast-hiper-ring current-id nodes 3`	Define the number of devices in the Fast HIPER-Ring as 3.

```
Number of nodes set to 3
```

`fast-hiper-ring current-id operation enable`	Activate the Fast HIPER-Ring.

```
Operation set to Enabled
```

`exit`	Switch to the Configuration mode.
`show fast-hiper-ring`	Show the current parameters of the Fast HIPER-Ring.

```
Ring ID: 1
           (Default Fast HIPER-Ring ID)
Mode of Switch (administrative setting). Ring Manager
Mode of Switch (real operating state)... Ring Manager
Ring Name.................................<empty>
Number of nodes in the ring.............. 3
Port Number, Primary..................... 1/1,  State: Not Connected
Port Number, Secondary................... 1/2,  State: Not Connected
VLAN ID.................................. 0 (No VLAN)
Operation................................ Enabled

General Operating States:
FHR Setup Info (Config. Failure)........ Ring Port Link Error

Manager-related Operating States:
Ring State............................... Open
Redundancy Guaranteed.................... No
Round Trip Delay......................... 0
```

Note: Deactivate the Spanning Tree protocol for the ports connected to the redundant ring, because Spanning Tree and Ring Redundancy work with different reaction times (`Redundancy:Rapid Spanning Tree:Port`).

☐ Now you connect the line to the ring. To do this, you connect the 2 devices to the ends of the line using their ring ports.

2.4 Example for HIPER-Ring with Straight Cables

You can implement this example with the model TCSESM or TCSESM-E.

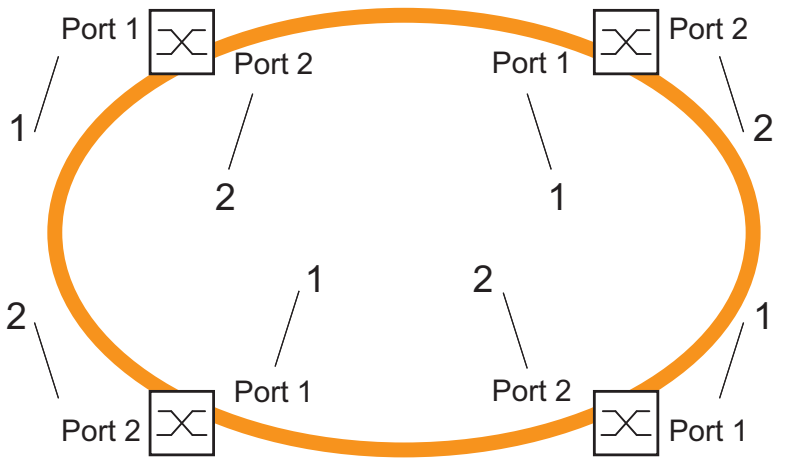


Figure 11: Example for a HIPER-Ring with straight cables
1 = Manual Cable Crossing disabled
2 = Manual Cable Crossing enabled

The following example configuration describes the configuration of a HIPER-Ring where straight cables are used between the switches, in contrast to the normal case, where crossed cables are used between switches.
The choice which switch is assigned the ring manager function as well as which line is assigned the redundant line in the normal mode of operation, is independent from that and is therefore not given in the example.

⚠ Warning

RING LOOP HAZARD

Configure all the devices of the Ring individually. Before you connect the redundant line, you must complete the configuration of all the devices of the Ring.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

Note: Configure all the devices of the HIPER-Ring individually. Before you connect the redundant line, you must complete the configuration of all the devices of the HIPER-Ring. You thus avoid loops during the configuration phase.

☐ Set up the network to meet your demands.
☐ Configure the transmission rate, the duplex mode and the manual cable crossing for the ring ports as given in the following table:

Port	1.1	1.2
Port on	yes (checked)	yes (checked)
Autonegotiation (Automatic Configuration)	no (not checked)	no (not checked)
Manual Configuration	100 Mbit/s FDX	100 Mbit/s FDX
Manual Cable Crossing	disable	enable

Table 6: Port settings for ring ports when using straight cables

Note: You can also use the ring redundancy protocol MRP instead of HIPER-Ring; when employing TCSESM-E switches, you can also use Fast HIPER-Ring.

3 Multiple Rings

You can set up multiple rings with multiple redundancy protocols:

- It can nest MRP-Rings. A coupled ring is known as a Sub-Ring (see on page 38 “Sub-Ring“).
- You can couple to MRP-Rings to other structures that work with RSTP, including RSTP rings (see on page 101 “Combining RSTP and MRP“).

3.1 Sub-Ring

For the device TCSESM-E.
The Sub-Ring concept enables you to easily couple new network segments to suitable devices in existing redundancy rings (primary rings). The devices of the primary ring to which the new Sub-Ring is being coupled are referred to as Sub-Ring Managers (SRMs).

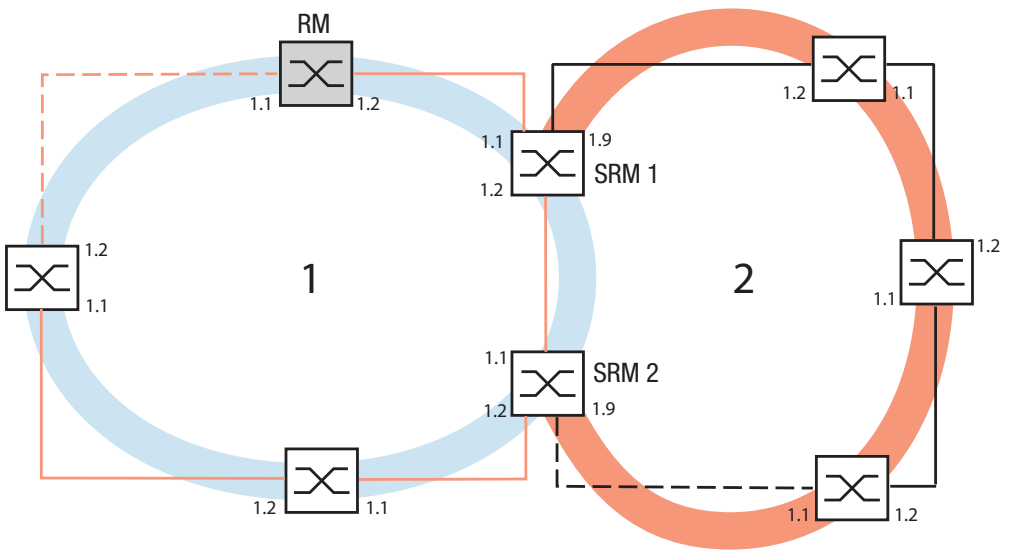


Figure 12: Example of a Sub-Ring structure
1 Blue ring = primary ring
2 Orange ring = Sub-Ring
SRM = Sub-Ring Manager
RM = Ring Manager

Note: The following devices support the Sub-Ring Manager function:
– TCSESM-E
In a Sub-Ring, you can integrate all devices that support MRP, the Sub-Ring Manager function is not neccessary.

Setting up Sub-Rings has the following advantages:

- Through the coupling process, you include the new network segment in the redundancy concept.
- You can easily integrate new company areas into existing networks.
- You easily map the organizational structure of a company in the network topology.
- As an MRP-Ring, the switching times of the Sub-Ring in redundancy cases are typically < 100 ms.

The following graphics show examples of possible Sub-Ring topologies:

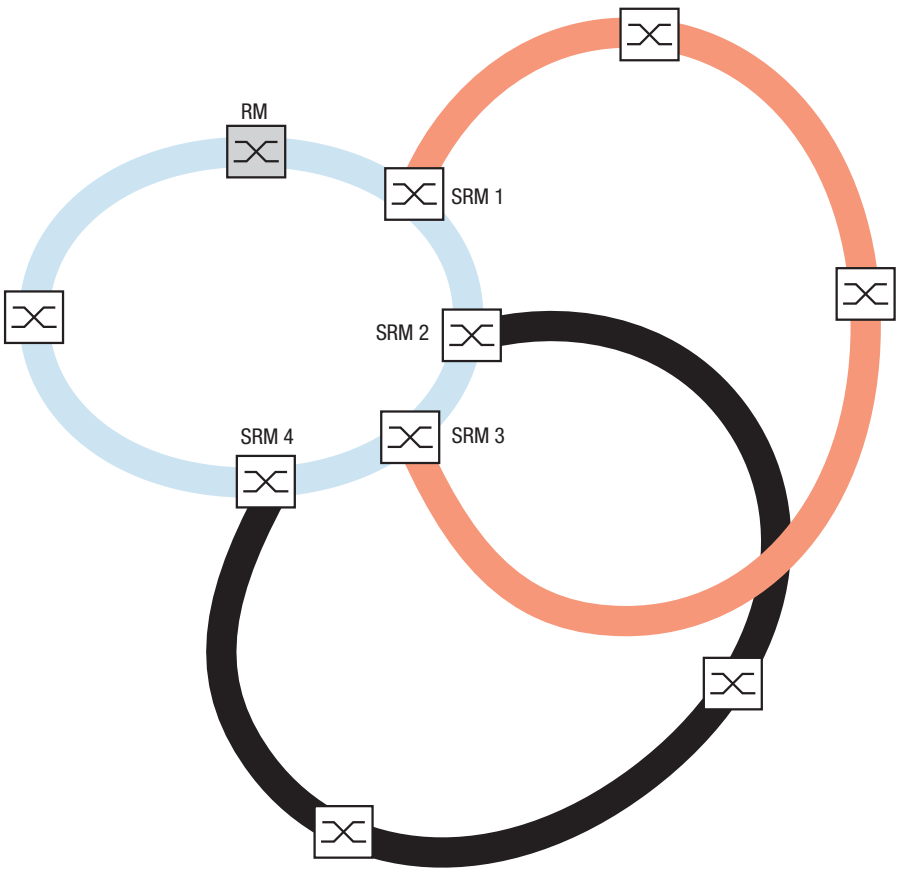


Figure 13: Example of an overlapping Sub-Ring structure

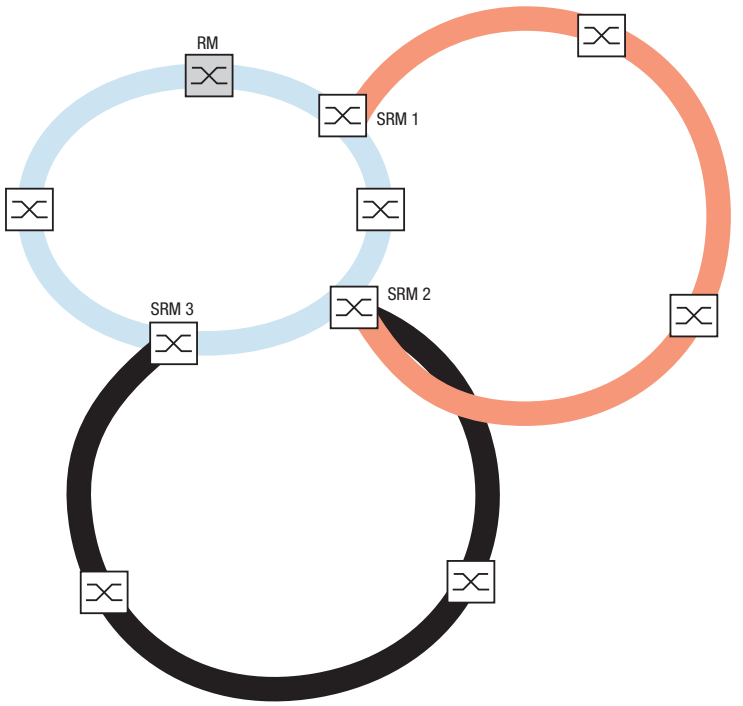


Figure 14: Special case: a Sub-Ring Manager manages 2 Sub-Rings (2 instances). Depending on the device type, you can configure additional instances.

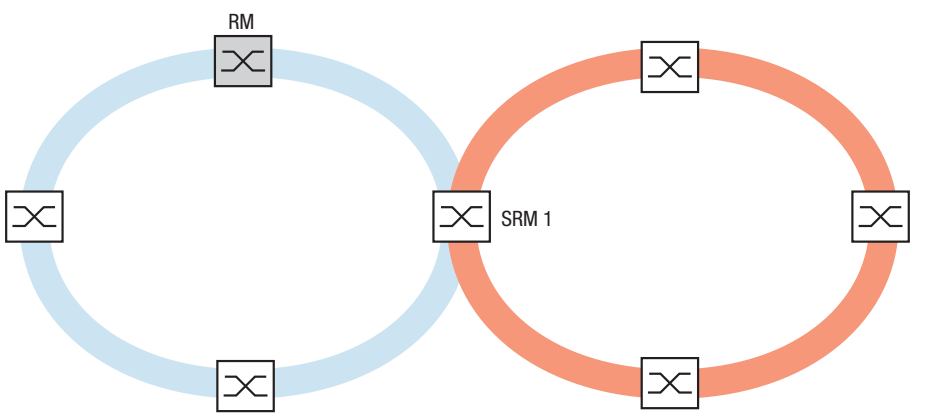


Figure 15: Special case: a Sub-Ring Manager manages both ends of a Sub-Ring at different ports (Single Sub-Ring Manger).

Note: Connect Sub-Rings only to existing primary rings. Do not cascade Sub-Rings (i.e., a new Sub-Ring must not be connected to an existing Sub-Ring).

Note: Sub-Rings use MRP. You can couple Sub-Rings to existing primary rings with the HIPER-Ring protocol, the Fast HIPER-Ring protocol and MRP. If you couple a Sub-Ring to a primary ring under MRP, configure both rings in different VLANs. You configure

- either the Sub-Ring Managers' Sub-Ring ports and the devices of the Sub-Ring in a separate VLAN. Here multiple Sub-Rings can use the same VLAN.
- or the devices of the primary ring including the Sub-Ring Managers' primary ring ports in a separate VLAN. This reduces the configuration effort when coupling multiple Sub-Rings to a primary ring.

3.1.1 Example configuration

The following section shows in detail the configuration of a simple Sub-Ring example.

Example description

You want to couple a new network segment with 3 devices to an existing redundant ring with the HIPER-Ring protocol. If you couple the network at both ends instead of only one end, this provides increased availability with the corresponding configuration.

The new network segment will be coupled as a Sub-Ring. The coupling to the primary ring is performed by existing devices of the type

– TCSESM-E

Configure these devices as Sub-Ring Managers.

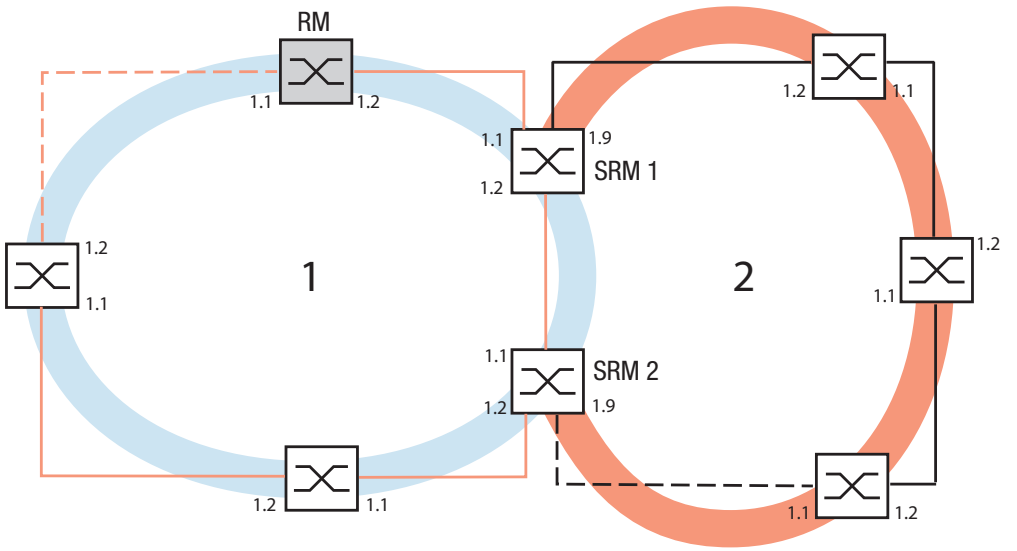


Figure 16: Example of a Sub-Ring structure
1 Blue ring = primary ring
2 Orange ring = Sub-Ring
SRM = Sub-Ring Manager
RM = Ring Manager

Proceed as follows to configure a Sub-Ring:

☐ Configure the three devices of the new network segment as participants in an MRP-Ring. This means:
– Configure all the ring ports in accordance with the port settings table (see table 7):

Bit rate	100 Mbit/s	1000 Mbit/s
Autonegotiation (automatic configuration)	Off	On
Port	On	On
Duplex	Full	–

Table 7: Port settings for ring ports

– Define different VLAN membership for the primary ring and the Sub-Ring even if the primary ring uses the MRP protocol; e.g., VLAN ID 1 for the primary ring and VLAN ID 2 for the Sub-Ring.
– For all ring ports in the Sub-Ring, select this VLAN ID and the VLAN membership Tagged (T) in the static VLAN table.
– Switch the MRP-Ring function on for all devices.
– In the Ring Redundancy dialog, under MRP-Ring, configure for all devices the two ring ports used in the Sub-Ring.

– Switch the Ring Manager function off for all devices.
– Switch RSTP off for the MRP-Ring ports used in the Sub-Ring.
– Assign the same MRP domain ID to all devices.

Note: The MRP domain ID is a sequence of 16 number blocks (value range 0 to 255). The default domain („default-domain“) is the MRP domain ID 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255. An MRP domain ID consisting only of “0” blocks is invalid.

If you need to adjust the MRP domain ID, open the Command Line Interface (CLI) and proceed as follows:

`enable`	Switch to the Privileged EXEC mode.
`configure`	Switch to the Configuration mode.
`mrp delete-domain current-domain`	Deletes the current MRP domain. If no MRP domain exists, an error message appears.

```
MRP current domain deleted:
Domain ID:
  255.255.255.255.255.255.255.255.255.255.255.255.255.255.255.255
  (Default MRP domain)
```

`mrp new-domain 0.0.1.1.2.2.3.4.4.111.222.123.0.0.66.99`	Creates a new MRP domain with the specified MRP domain ID. You can subsequently access this domain with “current-domain”.

```
MRP domain created:
Domain ID: 0.0.1.1.2.2.3.4.5.111.222.123.0.0.66.99
```

Sub-Ring configuration

⚠ Warning

SUB-RING LOOP HAZARD

Configure all the devices of the Sub-Ring individually. Before you connect the redundant line (close the Sub-Ring), you must complete the configuration of all the devices of the Sub- Ring.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

Proceed as follows to configure the 2 Sub-Ring Managers in the example:

☐ Select the `Redundancy:Sub-Ring` dialog.
☐ Click the button "New“.

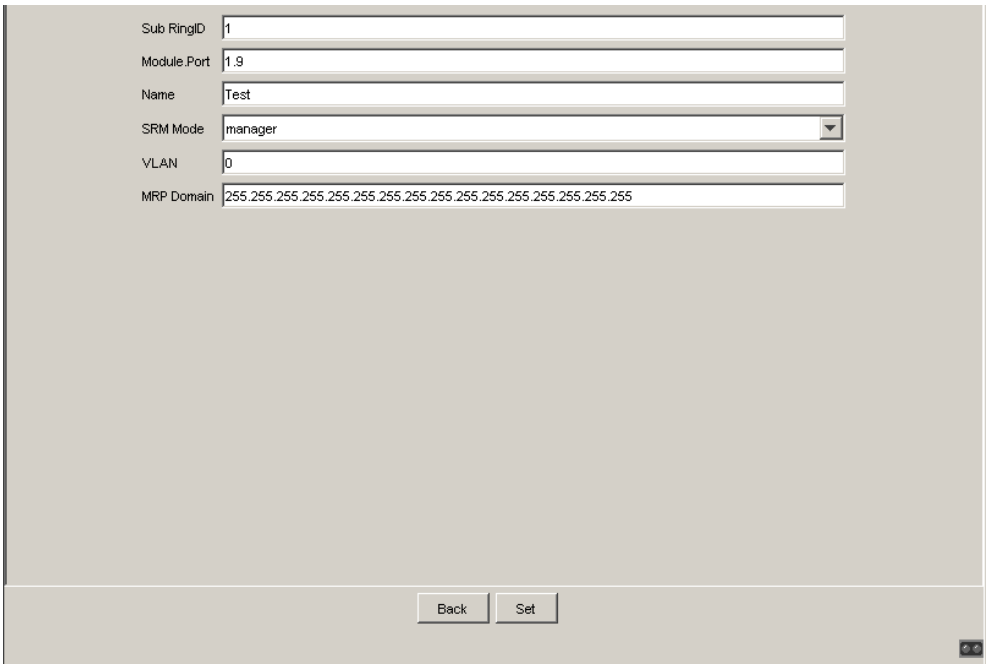


Figure 17: Sub-Ring - New Entry dialog

☐ Enter the value “1” as the ring ID of this Sub-Ring.

☐ In the Module.Port field, enter the ID of the port (in the form X.X) that connects the device to the Sub-Ring (in the example, 1.9). For the connection port, you can use all the available ports that you have not already configured as ring ports of the primary ring.

☐ You have the option of entering a name for the Sub-Ring (in the example, “Test”).

☐ Select the Sub-Ring Manager mode (SRM mode). You thus specify which connection between the primary ring and the Sub-Ring becomes the redundant line.
The options for the connection are:
- Both Sub-Ring Managers have the same setting (default `manager`): - the device with the higher MAC address manages the redundant line.
- In the SRM Mode field, a device is selected to be the `redundant manager`: - this device manages the redundancy line as long as you have configured the other Sub-Ring Manager as a `manager`, otherwise the higher MAC address applies.

Configure Sub-Ring Manager 1 as the “manager” and Sub-Ring Manager 2 as the manager of the redundant line with “redundant manager”, in accordance with the overview drawing for this example.

- ☐ Leave the fields VLAN ID (default 0) and MRP Domain (default 255.255.255.255.255.255.255.255.255.255.255.255.255.255.255.255) as they are. The example configuration does not require any change here.
- ☐ Click “Set” to temporarily save the entry in the configuration.
- ☐ Click “Back” to return to the Sub-Ring dialog.

`enable`	Switch to the Privileged EXEC mode.
`configure`	Switch to the Configuration mode.
`sub-ring new-ring 1`	Creates a new Sub-Ring with the Sub-Ring ID 1.
`Sub-Ring ID created:ID: 1`	
`sub-ring 1 port 1/9`	Defines port 9 in module 1 as the Sub-Ring port.
`Port set to 1/9`	
`sub-ring 1 ring-name Test`	Assigns the name “Test” to Sub-Ring 1
`Sub-Ring Ring name set to "Test"`	
`sub-ring 1 mode manager`	Configures the mode of this Sub-Ring Manager as “manager”.
`Mode of Switch set to manager`	

- ☐ Click “Reload” to update the Sub-Ring overview and check all the entries.

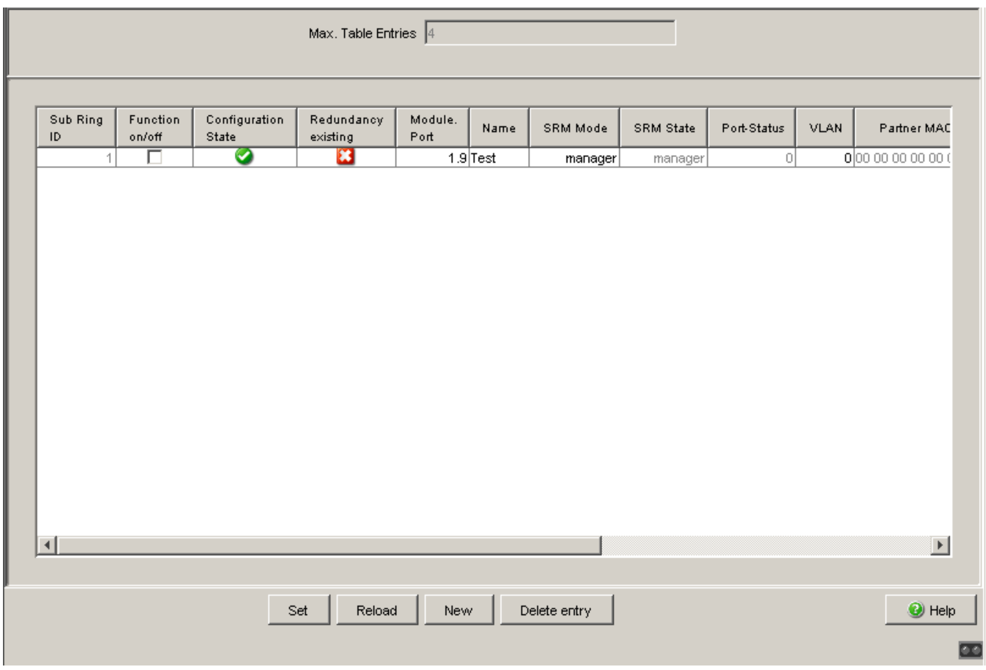


Figure 18: Completely configured Sub-Ring Manager

- ☐ Configure the 2nd Sub-Ring Manager in the same way. If you have explicitly assigned SRM 1 the SRM mode `manager`, you configure SRM 2 as `redundant manager`. Otherwise, the assignment is performed automatically via the higher MAC address (see above)
- ☐ Switch the two Sub-Ring Managers on under “Function on/off” in the overview of the Sub-Ring dialog.
- ☐ Click “Set” to temporarily save the entry in the configuration.
- ☐ Select the dialog `Basic Settings:Load/Save`.
- ☐ In the “Save” frame, select “To Device” for the location and click “Save” to permanently save the configuration in the active configuration.

`enable`	Switch to the Privileged EXEC mode.
`configure`	Switch to the Configuration mode.
`sub-ring 1 operation enable`	Switches on the Sub-Ring with the Sub-Ring ID 1.
`Operation set to Enabled`	
`exit`	Switch to the privileged EXEC mode.
`show sub-ring`	Displays the state for all Sub-Rings on this device.

```
Ring ID: 1
Mode of Switch (administrative setting)... manager
Mode of Switch (real operating state)..... manager
Port Number............................... 1/9,  State: Forwarding
Protocol.................................Standard MRP
MRP Domain ID.................................
255.255.255.255.255.255.255.255.255.255.255.255.255.255.255.255Ri
ng Name..................................... Test
Partner MAC................................... 02:E3:00:1B:00:09
VLAN ID....................................... 0 (No VLAN)
Operation..................................... Enabled

General Operating States:
SRM Setup Info (Config. Failure)............... No Error

Manager-related Operating States:
Ring State.................................... Open
Redundancy Guaranteed......................... No
```

`copy system:running-config nvram:startup-config`	Save the current configuration to the non-volatile memory.

- ☐ When you have configured both SRMs and, if applicable, the devices included in the Sub-Ring, close theSub-Ring’s redundant line.

4 Ring/Network Coupling

Ring/Network Coupling allows the redundant coupling of redundant rings and network segments. 2 rings/network segments are connected via 2 separate paths.

The ring/network coupling supports the coupling of a ring (HIPER-Ring, Fast HIPER-Ring or MRP) to a second ring (also HIPER-Ring, Fast HIPER-Ring or MRP) or to a network segment of any structure, when all the devices in the coupled network are Schneider Electric devices.
The ring/network coupling supports the following devices:

- TCSESM
- TCSESM-E

4.1 Variants of the ring/network coupling

In the **one-Switch coupling** configuration, the redundant coupling is performed by 2 ports **of one** device in the first ring/network coupled to 1 port each of 2 neighboring devices in a second ring/network segment (see fig. 20). One of the lines, the redundant line, is blocked for normal traffic during normal operation.
When the main line becomes inoperable, the device immediately opens the redundant line. When the main line becomes functional again later, the redundant line is again blocked for normal traffic and the main line is used again.
An error is detected and handled within 500 ms (typically 150 ms).

In the **two-Switch coupling** configuration, the redundant coupling is performeded by 1 port each on **two** devices in the first ring/network to 1 port each of 2 neighboring devices in the second ring/network segment (see fig. 26).
The device for the redundant line and the device for the main line use control packets to inform each other about their operating states, via the Ethernet or the control line.
When the main line becomes inoperable, the redundant device (called the slave) opens the redundant line. When the main line becomes functional again later, the device for the main line informs the redundant device. The redundant line is again blocked for normal traffic and the main line is used again.
An error is detected and handled within 500 ms (typically 150 ms).

The type of coupling configuration is primarily determined by the topological conditions and the desired level of availability (see table 8).

	One-Switch coupling	Two-Switch coupling	Two-Switch coupling with control line
Application	The 2 devices are in impractical topological positions. Therefore, putting a line between them would involve a lot of effort for two-Switch coupling.	The 2 devices are in practical topological positions. Installing a control line would involve a lot of effort.	The 2 devices are in practical topological positions. Installing a control line would not involve much effort.
Disadvantage	If the Switch configured for the redundant coupling becomes inoperable, no connection remains between the networks.	More effort for connecting the 2 devices to the network (compared with one-Switch coupling).	More effort for connecting the two devices to the network (compared with one-Switch and two-Switch coupling).
Advantage	Less effort involved in connecting the 2 devices to the network (compared with two-Switch coupling).	If one of the devices configured for the redundant coupling becomes inoperable, the coupled networks are still connected.	If one of the devices configured for the redundant coupling becomes inoperable, the coupled networks are still connected.

Table 8: Selection criteria for the configuration types for redundant coupling

Note: Choose a configuration based on topological conditions and the level of availability you require (see table 8).

4.2 Preparing a Ring/Network coupling

4.2.1 STAND-BY switch

All devices have a STAND-BY switch, with which you can define the role of the device within a Ring/Network coupling.
Depending on the device type, this switch is either a DIP switch or a software-only setting (`Redundancy:Ring/Network Coupling` dialog). By setting this switch, you define whether the device performs the main coupling or the redundant coupling role within a Ring/Network coupling. You can find details on the DIP switches in the User Manual Installation.

Device type	STAND-BY switch type
TCSESM	Selectable: DIP switch and software setting
TCSESM-E	Software switch

Table 9: Overview of the STAND-BY switch types

Depending on the device and model, set the STAND-BY switch in accordance with the following table (see table 10):

Note: In the following screenshots and diagrams, the following conventions are used:
- Blue color denotes devices or lines in the current scope,
- black color denotes devices or lines adjacent to the current scope,
- thick lines denote lines in the current scope,
- thin lines denote lines adjacent to the current scope,
- the dashed line denotes the redundant link,

▶ the dotted line denotes the control line.

Device with	Choice of main coupling or redundant coupling
DIP switch	On “STAND-BY” DIP switch
DIP switch/software switch option	According to the option selected - on “STAND-BY” DIP switch or in the - `Redundancy:Ring/Network Coupling` dialog, by making selection in “Select configuration”. **Note:** These devices have a DIP switch, with which you can choose between the software configuration and the DIP switch configuration. You can find details on the DIP switches in the User Manual Installation.
Software switch	In the `Redundancy:Ring/Network Coupling` dialog

Table 10: Setting the STAND-BY switch

☐ Select the `Redundancy:Ring/Network Coupling` dialog.
☐ You first select the configuration you want: One-Switch coupling (“1”), two-Switch coupling (“2”) or two-Switch coupling with control line (“3”), (see fig. 19).

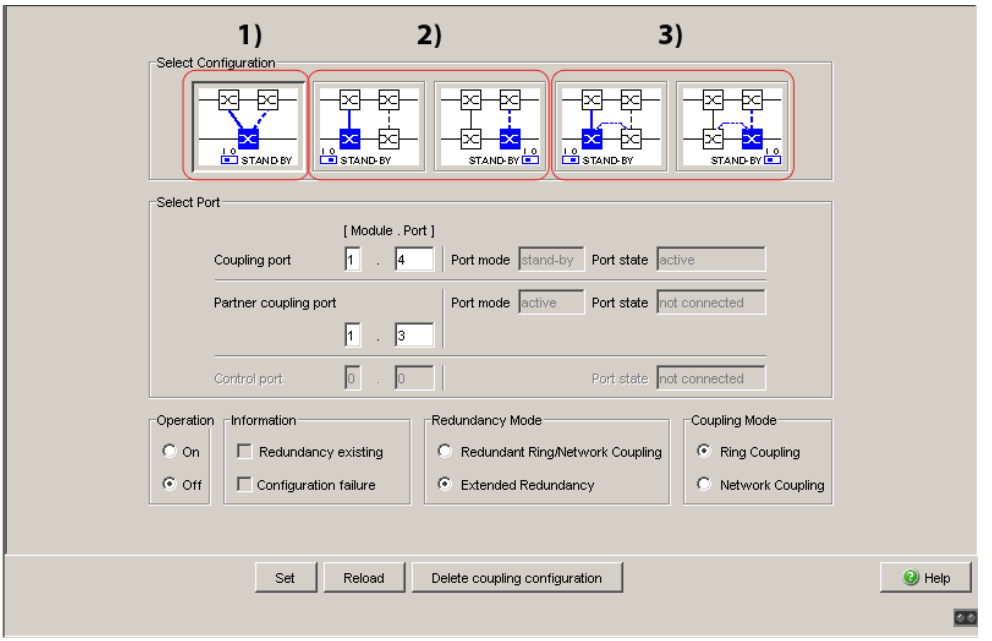


Figure 19: Choosing the ring coupling configuration (when the DIP switch is off, or for devices without a DIP switch)

For devices without DIP switches, the software settings are not restricted. For devices with DIP switches, depending on the DIP switch position, the dialog displays the possible configurations in color, while those configurations that are not possible appear in gray.
The possible configurations are:

- DIP switch RM: ON or OFF, STAND-BY: OFF:
  Two-Switch coupling as master (with or without control line)
- DIP switch RM: OFF, STAND-BY: ON:
  One-Switch coupling and two-Switch coupling as slave (with or without control line)
- DIP switch RM: ON, STAND-BY: ON:
  DIP switches are deactivated, and the software settings are not restricted

If you want to select one of the configurations that are not possible (grayed-out), you put the DIP switches on the device into another position and reload the dialog.

Note: For reasons of redundancy reliability, do not use Rapid Spanning Tree and Ring/Network Coupling in combination.

4.2.2 One-Switch coupling

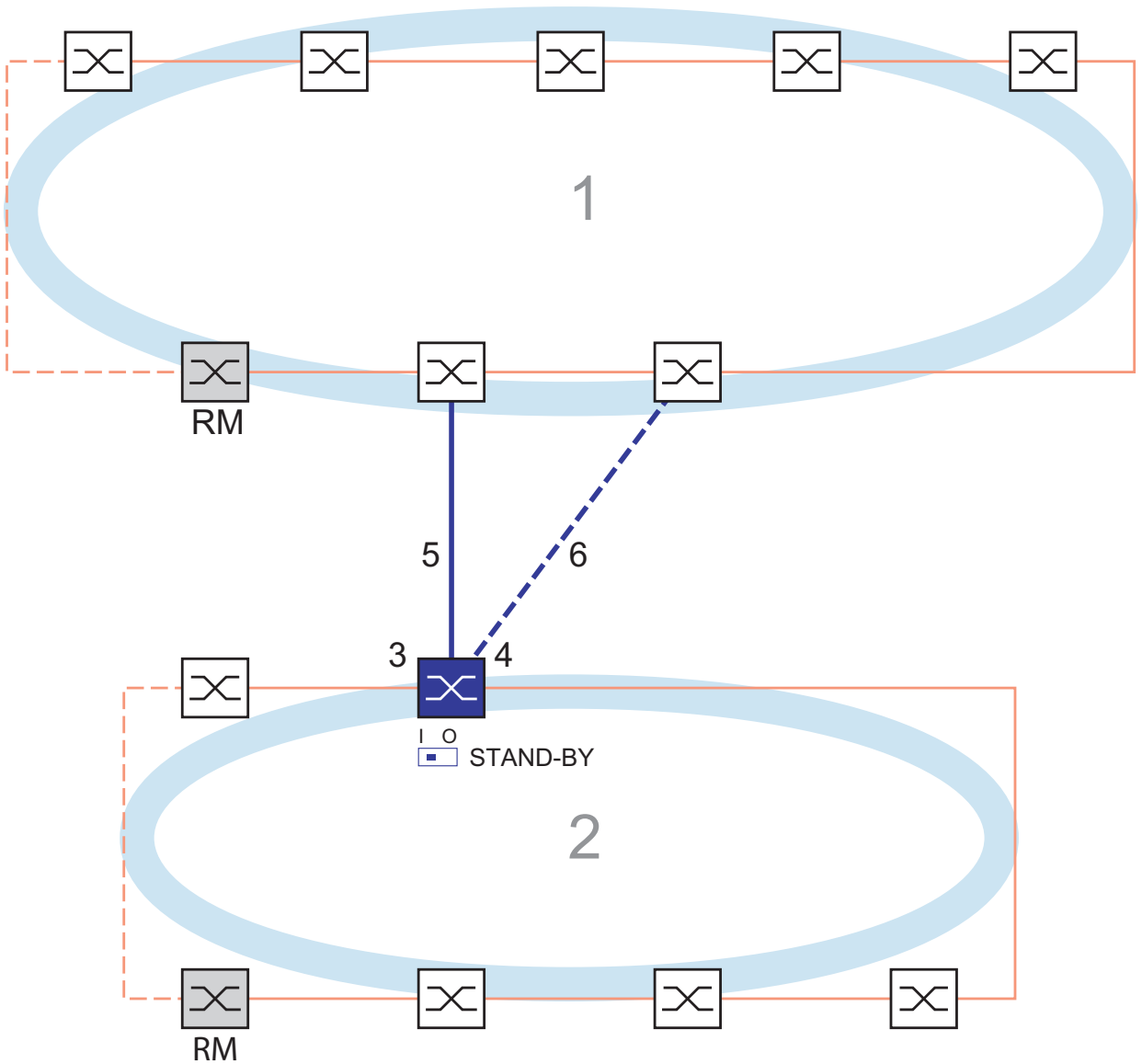


Figure 20: Example of one-Switch coupling

1: Backbone
2: Ring
3: Partner coupling port
4: Coupling port
5: Main Line
6: Redundant Line

⚠ Warning

RING-/NETWORK COUPLING LOOP HAZARD

Configure all the devices that participate actively in the Ring-/Network Coupling individually. Before you connect the redundant line, you must complete the configuration of all the devices that participate actively in the Ring-/Network Coupling.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

The coupling between two networks is performed by the main line (solid blue line) in the normal mode of operation, which is connected to the partner coupling port. If the main line becomes inoperable, the redundant line (dashed blue line), which is connected to the coupling port, takes over the ring/network coupling. The coupling switch-over is performed by **one** Switch.

☐ Select the `Redundancy:Ring/Network Coupling` dialog.
☐ Select "One-Switch coupling" by means of the dialog button with the same graphic as below (see fig. 21).

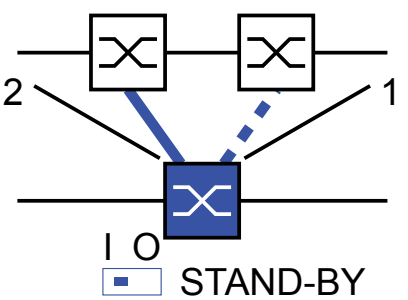


Figure 21: One-Switch-coupling
1: Coupling port
2: Partner coupling port

The following settings apply to the Switch displayed in blue in the selected graphic.

☐ Select the partner coupling port (see fig. 22), (see table 11).
With “Partner coupling port” you specify at which port you are connecting the main line.

The following tables show the selection options and default settings for the ports used in the Ring/Network coupling.

Device	Partner coupling port	Coupling port
TCSESM	All ports (default setting: port 1.3)	All ports (default setting: port 1.4)
TCSESM-E	All ports (default setting: port 1.3)	All ports (default setting: port 1.4)

Table 11: Port assignment for one-Switch coupling

Note: Configure the partner coupling port and the ring redundancy ports on different ports.

☐ Select the coupling port (see fig. 28), (see table 11).
With “Coupling port” you specify to which port you connect the remote network segment.

Note: Configure the coupling port and the redundancy ring ports on different ports.

☐ Activate the function in the “Operation” frame (see fig. 28).

☐ Now connect the redundant line.

The displays in the “Select port” frame mean (see fig. 22):

– “Port mode”: The port is either active or in stand-by mode.
– “Port state”: The port is either connected or not connected.

The displays in the “Information” frame mean (see fig. 22):

– “Redundancy existing”: If the main line becomes inoperable, the redundant line will then take over the function of the main line.
– “Configuration failure”: The function is incomplete or incorrectly configured.

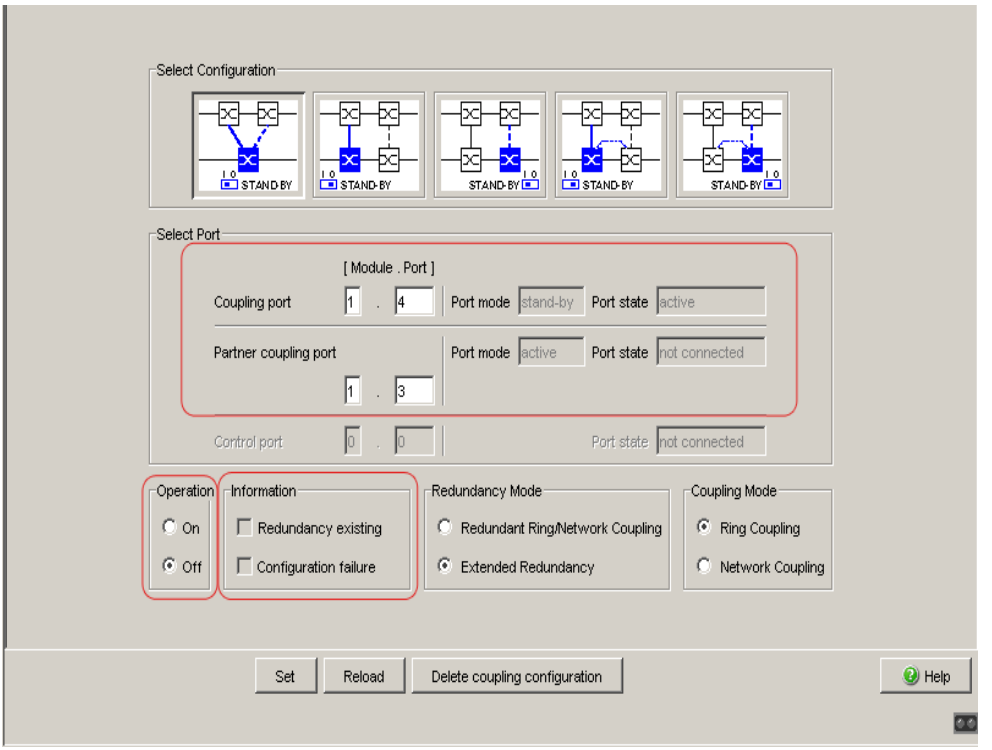


Figure 22: Selecting the port and enabling/disabling operation

Note: The following settings are required for the coupling ports (you select the `Basic Settings:Port Configuration` dialog):

– Port: on
– Automatic configuration (autonegotiation):
  on for twisted-pair connections
– Manual configuration: 100 Mbit/s FDX, 1 Gbit/s FDX, or 10 Gbit/s FDX, according to the port's capabilities
  for glass fiber connections

Note: If VLANs are configured, set the coupling and partner coupling ports' VLAN configuration as follows:

– in the dialog `Switching:VLAN:Port` Port VLAN ID 1 and „Ingress Filtering" deactivated
– in the dialog `Switching:VLAN:Static` VLAN-Membership `U` (Untagged)

Redundancy mode

☐ In the "Redundancy Mode" frame, select (see fig. 23)
– "Redundant Ring/Network Coupling" or
– "Extended Redundancy".

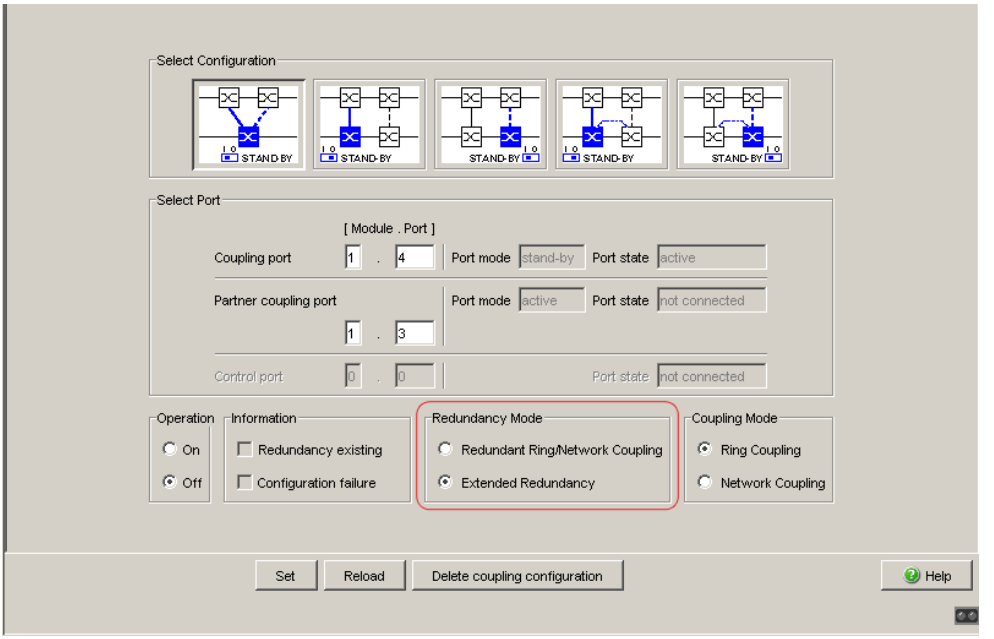


Figure 23: Selecting the redundancy mode

With the "`Redundant Ring/Network Coupling`" setting, either the main line or the redundant line is active. The lines are never both active at the same time.

With the "`Extended Redundancy`" setting, the main line and the redundant line are simultaneously active if the connection line between the devices in the connected (i.e., remote) network becomes inoperable (see fig. 24). During the reconfiguration period, packet duplications may occur. Therefore, select this setting only if your application detects package duplications.

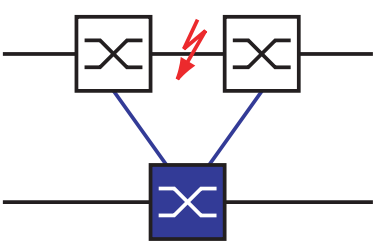


Figure 24: Extended redundancy

Coupling mode

The coupling mode indicates the type of the connected network.

☐ In the "Coupling Mode" frame, select (see fig. 25)

– "Ring Coupling" or

– "Network Coupling"

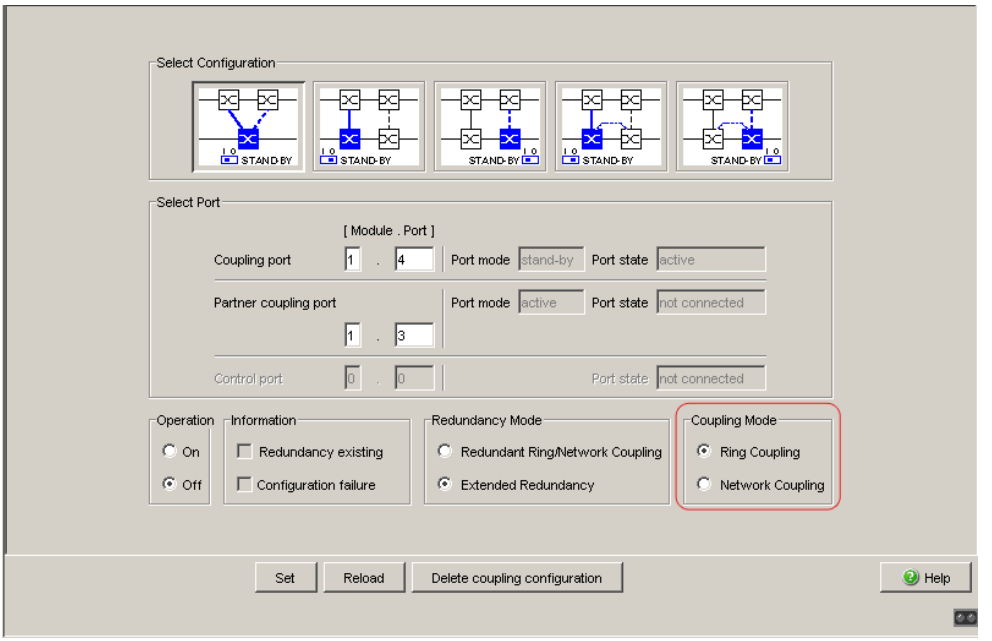


Figure 25: Selecting the coupling mode

☐ Select **"Ring coupling"** if you are connecting to a redundancy ring.
☐ Select **"Network Coupling"** if you are connecting to a line or tree structure.

Delete coupling configuration
☐ The “Delete coupling configuration” button in the dialog allows you to reset all the coupling settings of the device to the state on delivery.

4.2.3 Two-Switch coupling

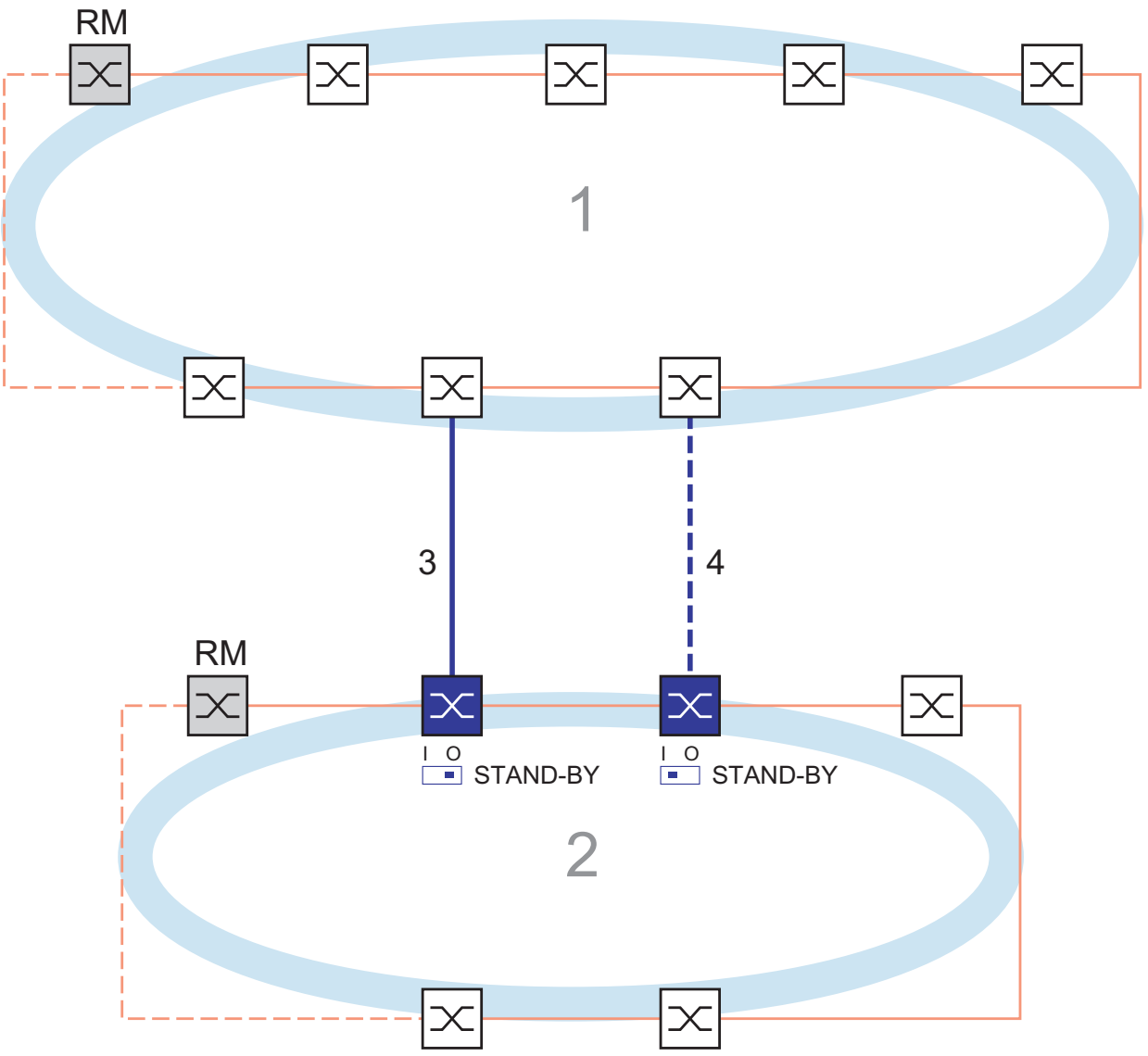


Figure 26: Example of two-Switch coupling
1: Backbone
2: Ring
3: Main line
4: Redundant line

⚠ Warning

RING-/NETWORK COUPLING LOOP HAZARD

Configure all the devices that participate actively in the Ring-/Network Coupling individually. Before you connect the redundant line, you must complete the configuration of all the devices that participate actively in the Ring-/Network Coupling.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

The coupling between 2 networks is performed by the main line (solid blue line). If the main line or one of the adjacent Switches becomes inoperable, the redundant line (dashed black line) takes over coupling the 2 networks. The coupling is performed by two Switches.
The switches send their control packages over the Ethernet.
The Switch connected to the main line, and the Switch connected to the redundant line are partners with regard to the coupling.

☐ Connect the two partners via their ring ports.

☐ Select the `Redundancy:Ring/Network Coupling` dialog.
☐ Select "Two-Switch coupling“ by means of the dialog button with the same graphic as below (see fig. 27).

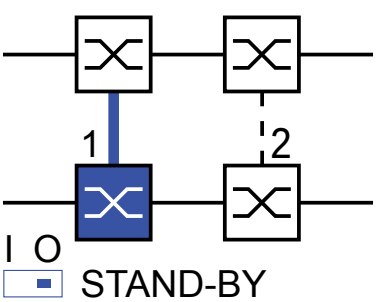


Figure 27: Two-Switch coupling
1: Coupling port
2: Partner coupling port

The following settings apply to the Switch displayed in blue in the selected graphic.

☐ Select the coupling port (see fig. 28), (see table 12).
With “Coupling port” you specify to which port you connect the remote network segment.
☐ For a device with DIP switches, you switch the STAND-BY switch to OFF or deactivate the DIP switches. Connect the main line to the coupling port.

Device	Coupling port
TCSESM	Adjustable for all ports (default setting: port 1.4)
TCSESM-E	Adjustable for all ports (default setting: port 1.4)

Table 12: Port assignment for the redundant coupling (two-Switch coupling)

Note: Configure the coupling port and the redundancy ring ports on different ports.

☐ Activate the function in the “Operation” frame (see fig. 28).
☐ Now connect the redundant line.
The displays in the “Select port” frame mean (see fig. 28):
– “Port mode”: The port is either active or in stand-by mode.
– “Port state”: The port is either connected or not connected.
– “IP Address”: The IP address of the partner, if the partner is already operating in the network.
The displays in the “Information” frame mean (see fig. 28):
– “Redundancy existing”: If the main line becomes inoperable, the redundant line will then take over the function of the main line.
– “Configuration failure”: The function is incomplete or incorrectly configured.

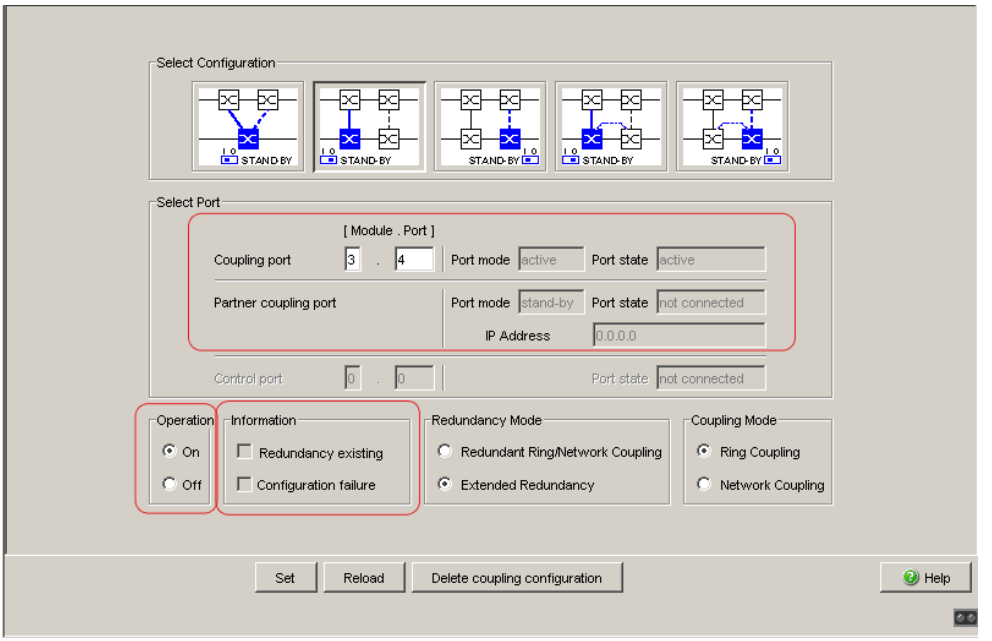


Figure 28: Selecting the port and enabling/disabling operation

To avoid continuous loops, the Switch sets the port state of the coupling port to “off” if you:

– switch off the operation setting or
– change the configuration

while the connections are in operation at these ports.

Note: The following settings are required for the coupling ports (you select the `Basic Settings:Port Configuration` dialog):

– Port: on
– Automatic configuration (autonegotiation):
  on for twisted-pair connections
– Manual configuration: 100 Mbit/s FDX, 1 Gbit/s FDX, or 10 Gbit/s FDX, according to the port’s capabilities
  for glass fiber connections

Note: If VLANs are configured, set the coupling and partner coupling ports’ VLAN configuration as follows:

– in the dialog `Switching:VLAN:Port` Port VLAN ID 1 and „Ingress Filtering“ deactivated
– in the dialog `Switching:VLAN:Static` VLAN-Membership `U` (Untagged)

Note: If you are operating the Ring Manager and two-Switch coupling functions at the same time, there is the possibility of creating a loop.

☐ Select "Two-Switch coupling“ by means of the dialog button with the same graphic as below (see fig. 27).

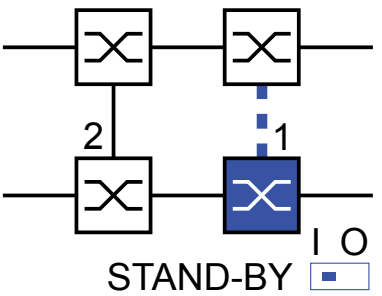


Figure 29: Two-Switch coupling
1: Coupling port
2: Partner coupling port

The following settings apply to the Switch displayed in blue in the selected graphic.

☐ Select the coupling port (see fig. 28), (see table 12).
With “Coupling port” you specify to which port you connect the remote network segment.

☐ For a device with DIP switches, you switch the STAND-BY switch to ON or deactivate the DIP switches. You connect the redundant line to the coupling port.

Note: Configure the coupling port and the redundancy ring ports on different ports.

☐ Activate the function in the “Operation” frame (see fig. 28).

The displays in the “Select port” frame mean (see fig. 28):

– “Port mode”: The port is either active or in stand-by mode.
– “Port state”: The port is either connected or not connected.
– “IP Address”: The IP address of the partner, if the partner is already operating in the network.

The displays in the “Information” frame mean (see fig. 28):

– “Redundancy existing”: If the main line becomes inoperable, the redundant line will then take over the function of the main line.
– “Configuration failure”: The function is incomplete or incorrectly configured.

To avoid continuous loops, the Switch sets the port state of the coupling port to "off” if you::

– switch off operation or
– change the configuration

while the connections are in operation at these ports.

Note: The following settings are required for the coupling ports (you select the `Basic Settings:Port Configuration` dialog):

– Port: on
– Automatic configuration (autonegotiation):
on for twisted-pair connections
– Manual configuration: 100 Mbit/s FDX, 1 Gbit/s FDX, or 10 Gbit/s FDX, according to the port’s capabilities
for glass fiber connections

Note: If VLANs are configured, set the coupling and partner coupling ports’ VLAN configuration as follows:

– in the dialog `Switching:VLAN:Port` Port VLAN ID 1 and „Ingress Filtering“ deactivated
– in the dialog `Switching:VLAN:Static` VLAN-Membership `U` (Untagged)

Note: If you are operating the Ring Manager and two-Switch coupling functions at the same time, there is the possibility of creating a loop.

Redundancy mode

☐ In the “Redundancy Mode” frame, select (see fig. 30)

– “Redundant Ring/Network Coupling” or

– “Extended Redundancy”.

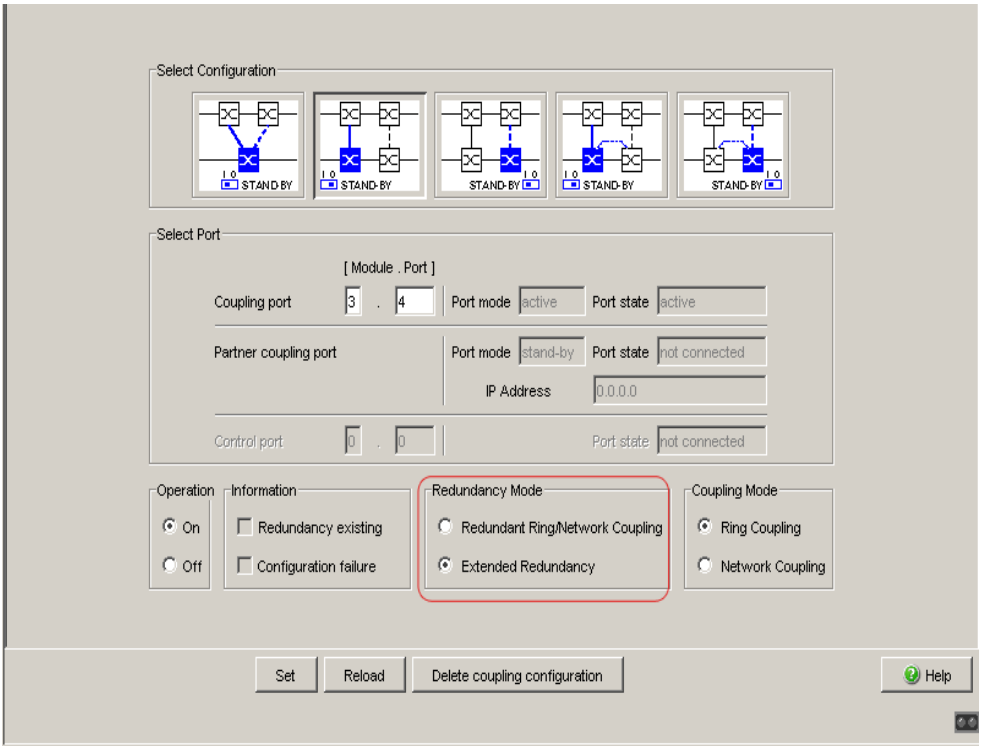


Figure 30: Selecting the redundancy mode

With the “`Redundant Ring/Network Coupling`” setting, either the main line or the redundant line is active. The lines are never both active at the same time.

With the “`Extended Redundancy`” setting, the main line and the redundant line are simultaneously active if the connection line between the devices in the connected (i.e., remote) network becomes inoperable (see fig. 31). During the reconfiguration period, packet duplications may occur. Therefore, select this setting only if your application detects package duplications.

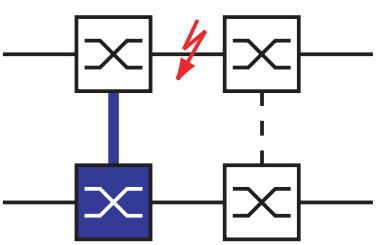


Figure 31: Extended redundancy

Coupling mode

The coupling mode indicates the type of the connected network.

☐ In the “Coupling Mode” frame, select (see fig. 32)

– “Ring Coupling” or

– “Network Coupling”

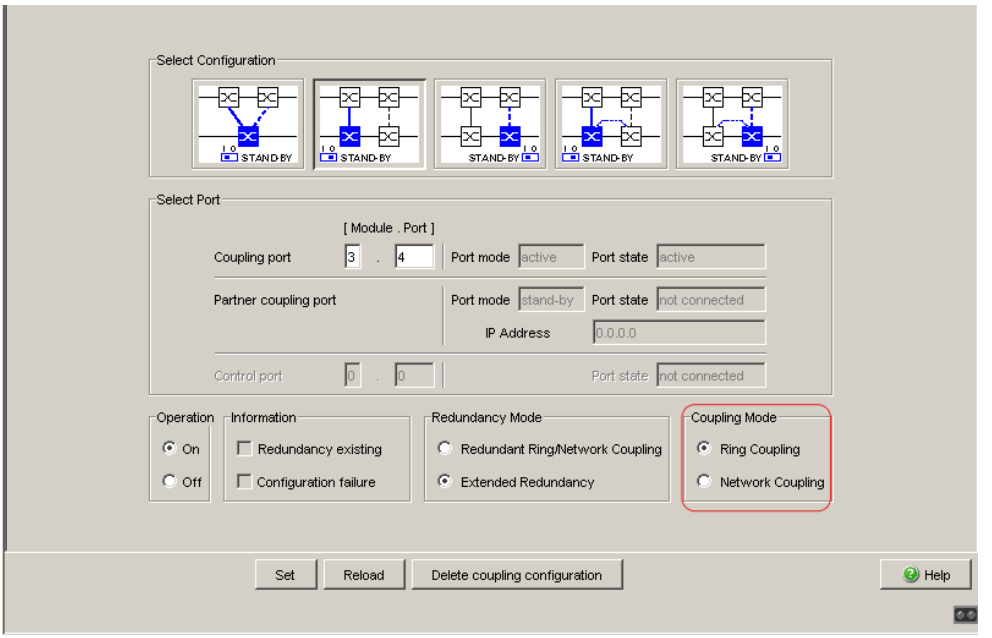


Figure 32: Selecting the coupling mode

☐ Select **"Ring coupling"** if you are connecting to a redundancy ring.

☐ Select **"Network Coupling"** if you are connecting to a line or tree structure.

Delete coupling configuration

☐ The “Delete coupling configuration” button in the dialog allows you to reset all the coupling settings of the device to the state on delivery.

4.2.4 Two-Switch Coupling with Control Line

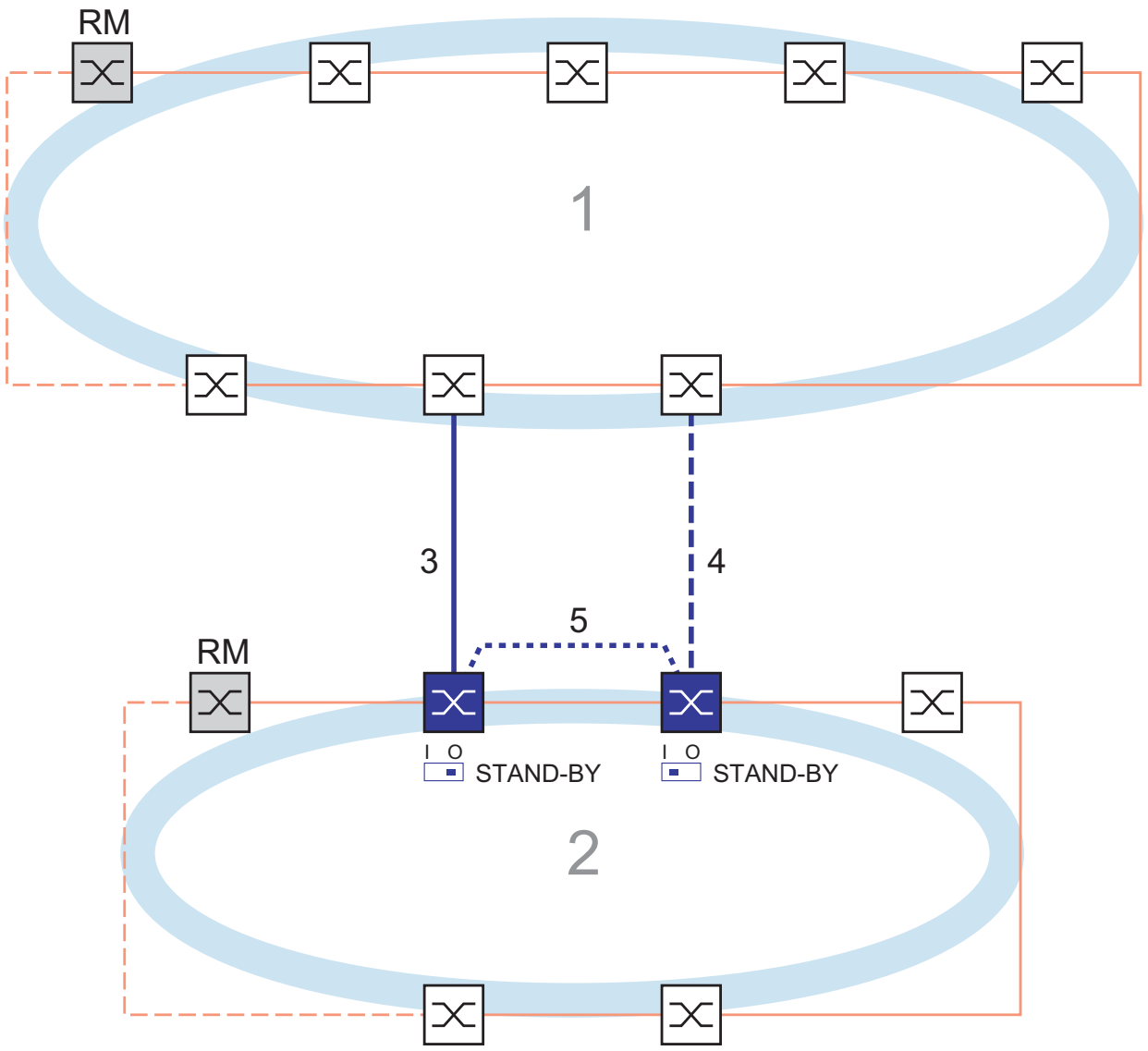


Figure 33: Example of Two-Switch coupling with control line

1: Backbone
2: Ring
3: Main line
4: Redundant line
5: Control line

⚠ Warning

RING-/NETWORK COUPLING LOOP HAZARD

Configure all the devices that participate actively in the Ring-/Network Coupling individually. Before you connect the redundant line, you must complete the configuration of all the devices that participate actively in the Ring-/Network Coupling.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

The coupling between 2 networks is performed by the main line (solid blue line). If the main line or one of the adjacent Switches becomes inoperable, the redundant line (dashed black line) takes over coupling the 2 networks. The coupling is performed by two Switches.
The Switches send their control packets over a control line (dotted line).
The Switch connected to the main line, and the Switch connected to the redundant line are partners with regard to the coupling.

☐ Connect the two partners via their ring ports.

☐ Select the `Redundancy:Ring/Network Coupling` dialog.
☐ Select „Two-Switch coupling with control line“ by means of the dialog button with the same graphic as below (see fig. 34).

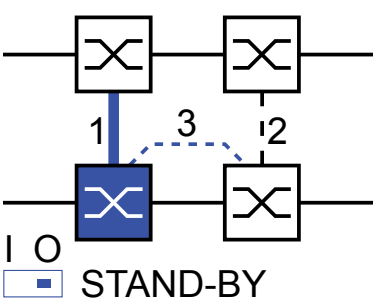


Figure 34: Two-Switch coupling with control line
1: Coupling port
2: Partner coupling port
3: Control line

The following settings apply to the Switch displayed in blue in the selected graphic.

☐ Select the coupling port (see fig. 35), (see table 13).
With “Coupling port” you specify to which port you connect the remote network segment.
☐ For a device with DIP switches, you switch the STAND-BY switch to OFF or deactivate the DIP switches. Connect the main line to the coupling port.
☐ Select the control port (see fig. 35), (see table 13).
With “Control port” you specify to which port you connect the control line.

Device	Coupling port	Control port
TCSESM	Adjustable for all ports (default setting: port 1.4)	Adjustable for all ports (default setting: port 1.3)
TCSESM-E	Adjustable for all ports (default setting: port 1.4)	Adjustable for all ports (default setting: port 1.3)

Table 13: Port assignment for the redundant coupling (two-Switch coupling with control line)

Note: Configure the coupling port and the redundancy ring ports on different ports.

☐ Activate the function in the “Operation” frame (see fig. 28).
☐ Now connect the redundant line and the control line.
The displays in the “Select port” frame mean (see fig. 35):
– “Port mode”: The port is either active or in stand-by mode.
– “Port state”: The port is either connected or not connected.
– “IP Address”: The IP address of the partner, if the partner is already operating in the network.
The displays in the “Information” frame mean (see fig. 22):
– “Redundancy existing”: If the main line becomes inoperable, the redundant line will then take over the function of the main line.
– “Configuration failure”: The function is incomplete or incorrectly configured.

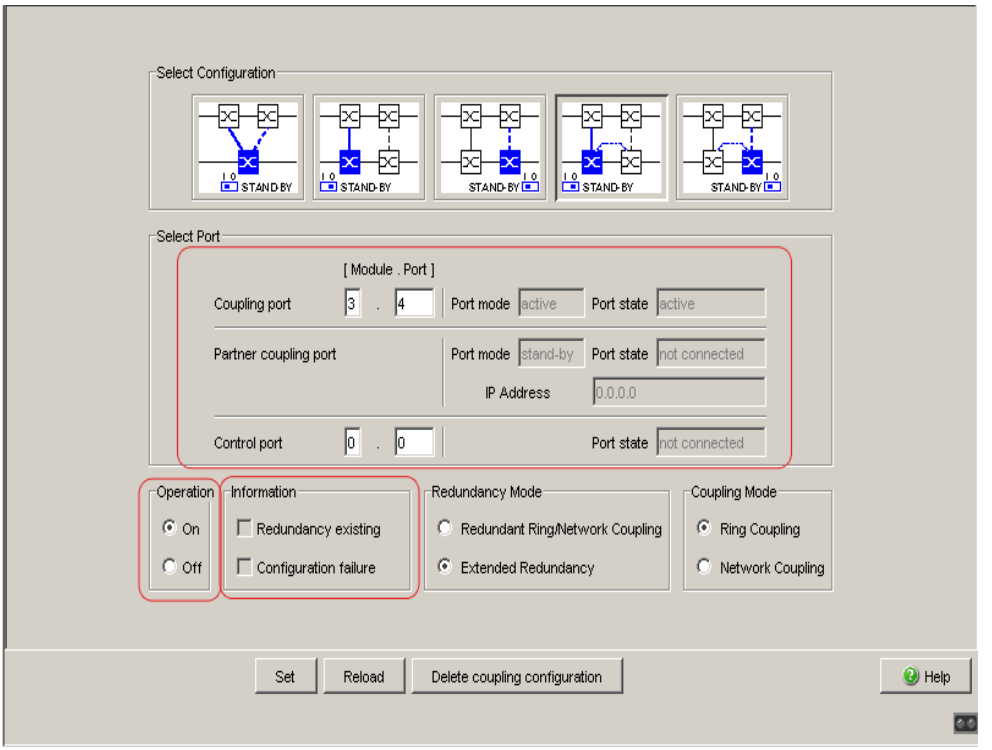


Figure 35: Selecting the port and enabling/disabling operation

To avoid continuous loops, the Switch sets the port state of the coupling port to “off” if you:

– switch off the operation setting or
– change the configuration

while the connections are in operation at these ports.

Note: The following settings are required for the coupling ports (you select the `Basic Settings:Port Configuration` dialog):

– Port: on
– Automatic configuration (autonegotiation):
  on for twisted-pair connections
– Manual configuration: 100 Mbit/s FDX, 1 Gbit/s FDX, or 10 Gbit/s FDX, according to the port’s capabilities
  for glass fiber connections

Note: If VLANs are configured, set the coupling and partner coupling ports’ VLAN configuration as follows:

– in the dialog `Switching:VLAN:Port` Port VLAN ID 1 and „Ingress Filtering“ deactivated
– in the dialog `Switching:VLAN:Static` VLAN-Membership `U` (Untagged)

☐ Select "Two-Switch coupling with control line“ by means of the dialog button with the same graphic as below (see fig. 36).

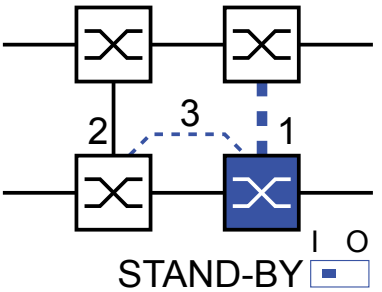


Figure 36: Two-Switch coupling with control line
1: Coupling port
2: Partner coupling port
3: Control line

The following settings apply to the Switch displayed in blue in the selected graphic.

☐ Select the coupling port (see fig. 35), (see table 13).
With “Coupling port” you specify to which port you connect the remote network segment.

☐ For a device with DIP switches, you switch the STAND-BY switch to ON or deactivate the DIP switches. You connect the redundant line to the coupling port.

☐ Select the control port (see fig. 35), (see table 13).
With “Control port” you specify to which port you connect the control line.

Note: Configure the coupling port and the redundancy ring ports on different ports.

☐ Activate the function in the “Operation” frame (see fig. 28).

☐ Now connect the redundant line and the control line.

The displays in the “Select port” frame mean (see fig. 35):

– “Port mode”: The port is either active or in stand-by mode.
– “Port state”: The port is either connected or not connected.
– “IP Address”: The IP address of the partner, if the partner is already operating in the network.

The displays in the “Information” frame mean (see fig. 22):
– “Redundancy existing”: If the main line becomes inoperable, the redundant line will then take over the function of the main line.
– “Configuration failure”: The function is incomplete or incorrectly configured.

To avoid continuous loops, the Switch sets the port state of the coupling port to “off” if you:
– switch off the operation setting or
– change the configuration

while the connections are in operation at these ports.

Note: The following settings are required for the coupling ports (you select the `Basic Settings:Port Configuration` dialog):
– Port: on
– Automatic configuration (autonegotiation):
on for twisted-pair connections
– Manual configuration: 100 Mbit/s FDX, 1 Gbit/s FDX, or 10 Gbit/s FDX, according to the port’s capabilities
for glass fiber connections

Note: If VLANs are configured, set the coupling and partner coupling ports’ VLAN configuration as follows:
– in the dialog `Switching:VLAN:Port` Port VLAN ID 1 and „Ingress Filtering“ deactivated
– in the dialog `Switching:VLAN:Static` VLAN-Membership `U` (Untagged)

Redundancy mode

☐ In the “Redundancy Mode” frame, select (see fig. 37)
– “Redundant Ring/Network Coupling” or
– “Extended Redundancy”.

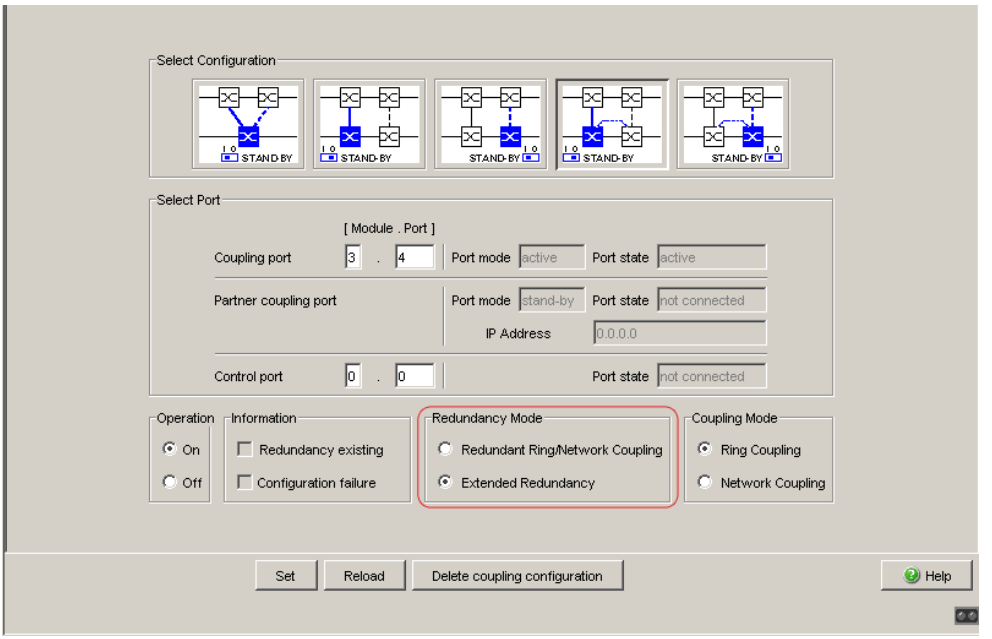


Figure 37: Selecting the redundancy mode

With the "`Redundant Ring/Network Coupling`" setting, either the main line or the redundant line is active. The lines are never both active at the same time.

With the "`Extended Redundancy`" setting, the main line and the redundant line are simultaneously active if the connection line between the devices in the connected (i.e., remote) network becomes inoperable (see fig. 38). During the reconfiguration period, packet duplications may occur. Therefore, select this setting only if your application detects package duplications.

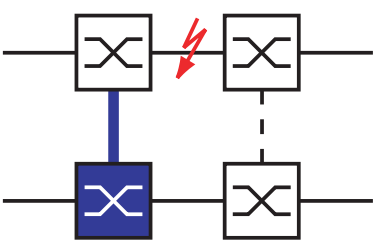


Figure 38: Extended redundancy

Coupling mode

The coupling mode indicates the type of the connected network.

☐ In the "Coupling Mode" frame, select (see fig. 39)

– "Ring Coupling" or

– "Network Coupling"

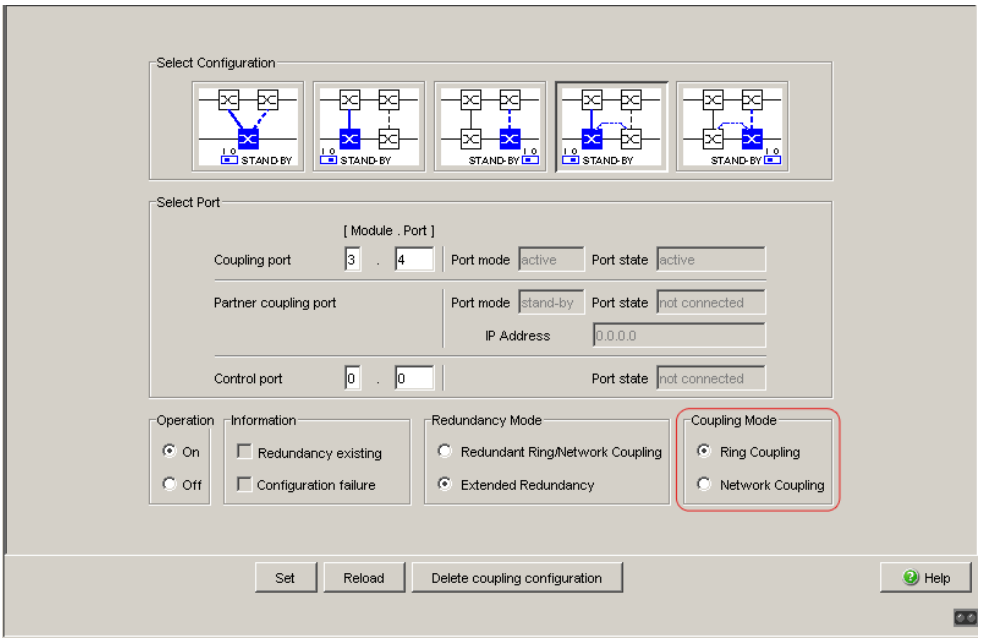


Figure 39: Selecting the coupling mode

☐ Select **"Ring coupling"** if you are connecting to a redundancy ring.
☐ Select **"Network Coupling"** if you are connecting to a line or tree structure.

Delete coupling configuration

☐ The “Delete coupling configuration” button in the dialog allows you to reset all the coupling settings of the device to the state on delivery.

5 Rapid Spanning Tree

Note: The Spanning Tree and Rapid Spanning Tree protocols based on IEEE 802.1D-2004 and IEEE 802.1w respectively are protocols for MAC bridges. For this reason, the following description of these protocols usually employs the term bridge instead of switch.

Local networks are getting bigger and bigger. This applies to both the geographical expansion and the number of network participants. Therefore, it usually makes sense to use multiple bridges, for example:

- to reduce the network load in sub-areas,
- to set up redundant connections and
- to overcome distance limitations.

However, using multiple bridges with multiple redundant connections between the subnetworks can lead to loops that can stop communications on the network. The Rapid Spanning Tree Protocol (RSTP) enables redundancy by interrupting these loops.

RSTP is a further development of the Spanning Tree Protocol (STP) and is compatible with it. If communication is unable to pass through a connection or a bridge, the STP takes up to 30 seconds to reconfigure. This was no longer acceptable in time-sensitive applications. The STP was therefore developed to the RSTP, leading to average reconfiguration times of less than a second. If you use RSTP in a ring topology with 10 to 20 devices, you can achieve reconfiguration times in the range of milliseconds.

Note: RSTP resolves a given topology to a tree structure (Spanning Tree). The number of devices in a branch (from the root to the branch tip) is limited by the parameter `Max Age`. The default value for `Max Age` is 20, it can be increased to 40.
If the root device becomes inoperable and another device takes over the root function, the maximum possible number of devices in a branch will be limited by the new root's `Max Age` setting.

Note: The RSTP Standard dictates that all the devices within a network work with the (Rapid) Spanning Tree Algorithm. However, if STP and RSTP are used at the same time, the advantages of faster reconfiguration with RSTP are lost.

Note: Due to a change in the IEEE 802.1D-2004 standard on which RSTP is based, the Standards Commission has reduced the maximum value for the “Hello Time” from 10 to 2. When firmware versions prior to 5.x are upgraded to version 5.x or higher, the firmware automatically changes a locally entered “Hello Time” value > 2 to 2.
If the device is not the RSTP root, “Hello Time” values greater than 2 can remain valid, depending on the firmware version of the root device.

5.1 The Spanning Tree Protocol

Because RSTP is a further development of the STP, all the following descriptions of the STP also apply to the RSTP.

5.1.1 The tasks of the STP

The Spanning Tree algorithm reduces network topologies that are set up using bridges, and that have ring structures with redundant connections, to a tree structure. In doing this, STP divides up the ring structures on the basis of specified rules by deactivating redundant paths. If a path is interrupted by mistake, the STP reactivates the path just deactivated. This enables redundant connections for increased communication availability.
In forming the tree structure, the STP determines what is known as a root bridge. This forms the basis of the STP tree structure.

Features of the STP algorithm:

- automatic reconfiguration of the tree structure in the case of a bridge becoming inoperable or the interruption of a data path
- the tree structure is stabilized up to the maximum network size (up to 39 hops, depending on the setting for `Max Age`, (see table 16)
- stabilization is achieved within a short time period
- topology can be specified and reproduced by the administrator
- transparency for the terminal devices
- low network load relative to the available transmission capacity due to the tree structure created

5.1.2 Bridge parameters

Each bridge is uniquely described by the parameters:

- Bridge Identifier
- Root Path Costs for the bridge ports
- Port Identifier

5.1.3 Bridge Identifier

The Bridge Identifier consists of 8 bytes. The 2 highest-value bytes are the priority. The default setting for the priority number is 32,768, but the Management Administrator can change this when configuring the network. The 6 lowest-value bytes of the bridge identifier are the bridge's MAC address. The MAC address allows each bridge to have unique bridge identifiers.
The bridge with the smallest number for the bridge identifier has the highest priority.

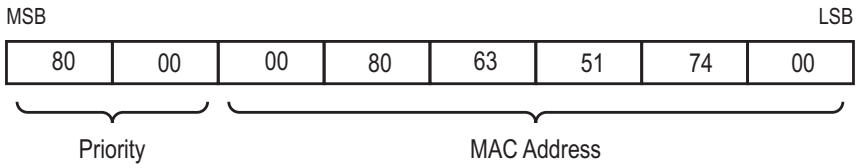


Figure 40: Bridge Identifier, Example (values in hexadecimal notation)

5.1.4 Root Path Costs

Each path that connects 2 bridges is assigned a cost for the transmission (path cost). The Switch determines this value based on the transmission speed (see table 14). It assigns a higher path cost to paths with lower transmission speeds.

Alternatively, the Administrator can set the path cost. Like the Switch, the Administrator assigns a higher path cost to paths with lower transmission speeds. However, since the Administrator can choose this value freely, he has a tool with which he can give a certain path an advantage among redundant paths.

The root path cost is the sum of all the individual path costs for all paths a data packet travels between the connected port of a bridge and the root bridge.

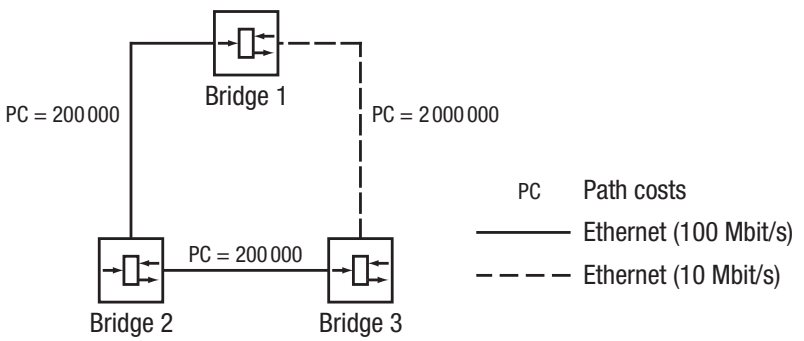


Figure 41: Path costs

Data rate	Recommended value	Recommended range	Possible range
<=100 kBit/s	200,000,000[a]	20,000,000-200,000,000	1-200,000,000
1 MBit/s	20,000,000[a]	2,000,000-200,000,000	1-200,000,000
10 MBit/s	2,000,000[a]	200,000-20,000,000	1-200,000,000
100 MBit/s	200,000[a]	20,000-2,000,000	1-200,000,000
1 GBit/s	20,000	2,000-200,000	1-200,000,000
10 GBit/s	2,000	200-20,000	1-200,000,000
100 GBit/s	200	20-2,000	1-200,000,000
1 TBit/s	20	2-200	1-200,000,000
10 TBit/s	2	1-20	1-200,000,000

Table 14: Recommended path costs for RSTP based on the data rate.

a. Bridges conforming to IEEE 802.1D-1998 that only support 16-bit values for path costs should use the value 65,535 for path costs when they are used in conjunction with bridges that support 32-bit values for the path costs.

5.1.5 Port Identifier

The Port Identifier consists of 2 bytes. One part, the least-significant byte, contains the physical port number. This provides a unique identifier for each port of the bridge. The second part is the port priority, which can be set by the Administrator (default value: 128). It also applies here that the port with the smallest number for the port identifier has the highest priority.

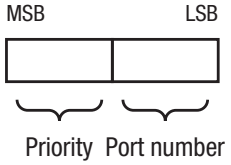


Figure 42: Port Identifier

5.2 Rules for Creating the Tree Structure

5.2.1 Bridge information

To determine the tree structure, the bridges need more detailed information about the other bridges located in the network.
To obtain this information, each bridge sends a BPDU (Bridge Protocol Data Unit) to the other bridges.

The contents of a BPDU include

- bridge identifier,
- root path costs and
- port identifier

(see IEEE 802.1D).

5.2.2 Setting up the tree structure

- The bridge with the smallest number for the bridge identifier is called the root bridge. It is (or will become) the root of the tree structure.
- The structure of the tree depends on the root path costs. STP selects the structure so that the path costs between each individual bridge and the root bridge become as small as possible.
- If more than 1 path exists with the same root path costs, the priority of the bridge identifier for the bridge connected to one of these paths decides which bridge should block.

- Of more than 1 path with the same root path costs originate from a bridge, the port identifier is used as the last criterion (see fig. 42). This decides which port is selected.

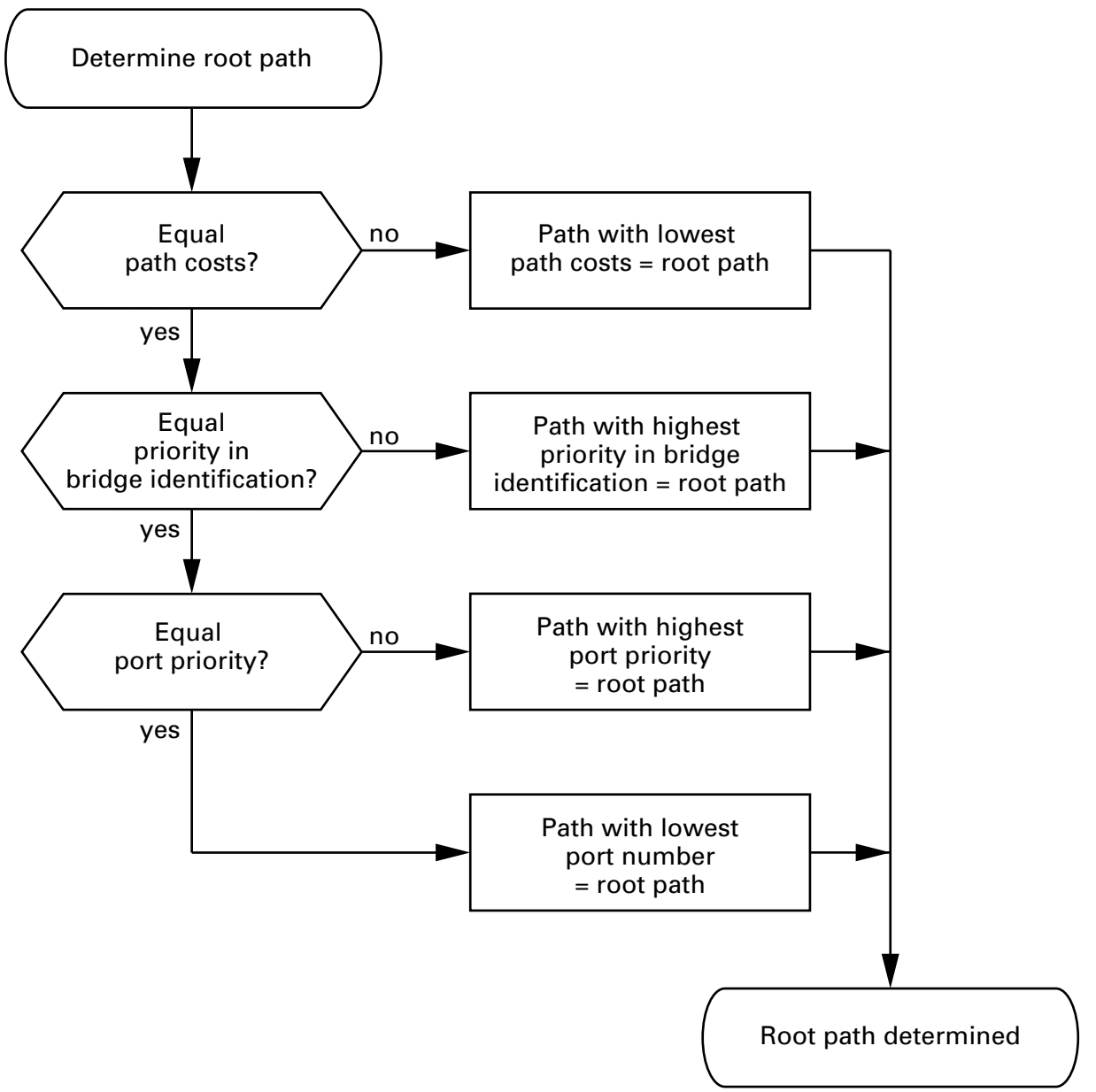


Figure 43: Flow diagram for specifying the root path

5.3 Example of Root Path Determination

The network plan (see fig. 44) can be used to create the flow diagram (see fig. 43) for defining the root path. The Administrator has defined a different priority for for each bridge's bridge identifier. The bridge with the smallest number for the bridge identifier will become the root bridge, in this case bridge 1. In the example, all the sub-paths have the same path costs. The path between bridge 2 and bridge 3 isblocked, because a connection from bridge 3 to the root bridge via bridge 2 has a higher path cost.

The path from bridge 6 to the root bridge is interesting:

- The path via bridge 5 and bridge 3 create the same root path costs as the path via bridge 4 and bridge 2.
- The path via bridge 4 is selected because the value 28,672 for its priority in the bridge identifier is smaller than value 32,768.
- However, there are also 2 paths between bridge 6 and bridge 4. The port identifier is decisive here.

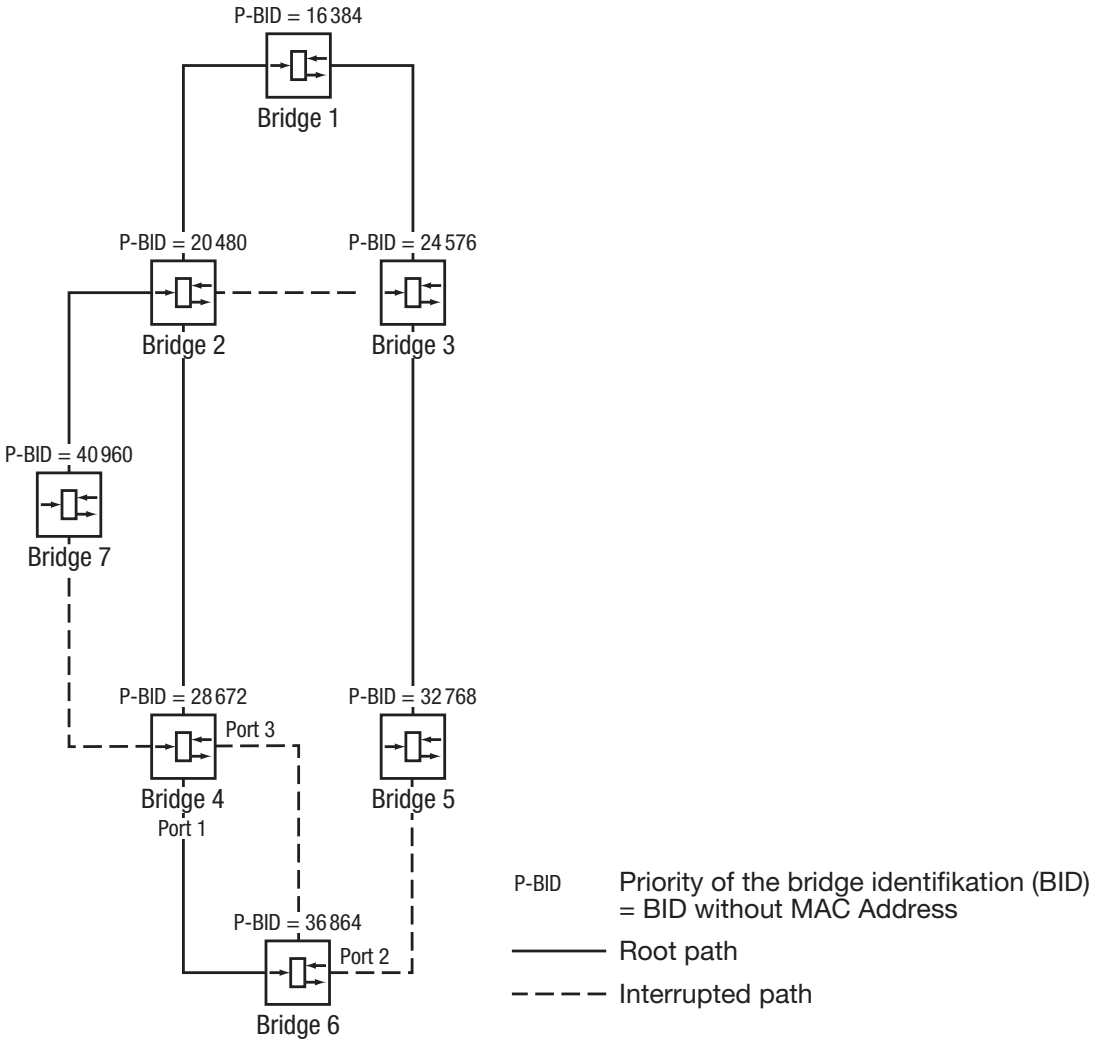


Figure 44: Example of root path determination

5.4 Example of Root Path Manipulation

The network plan (see fig. 44) can be used to create the flow diagram (see fig. 43) for defining the root path. The Administrator
– left the default value of 32,768 for each bridge except for bridge 1,
– bridge 1 value was set to 16,384, thus making it the root bridge.
In the example, all the sub-paths have the same path costs. The path between bridge 2 and bridge 3 is blocked by the protocol because a connection from bridge 3 to the root bridge via bridge 2 has a higher path cost.

The path from bridge 6 to the root bridge is interesting:

- The path via bridge 5 and bridge 3 creates the same root path costs as the path via bridge 4 and bridge 2.
- STP selects the path using the bridge that has the lowest MAC address in the bridge identification (bridge 4 in the illustration).
- However, there arealso 2 paths between bridge 6 and bridge 4. The port identifier is decisive here.

Note: Because the Administrator does not change the default values for the priorities of the bridges in the bridge identifier, apart from the value for the root bridge, the MAC address in the bridge identifier alone determines which bridge becomes the new root bridge if the root bridge becomes inoperable.

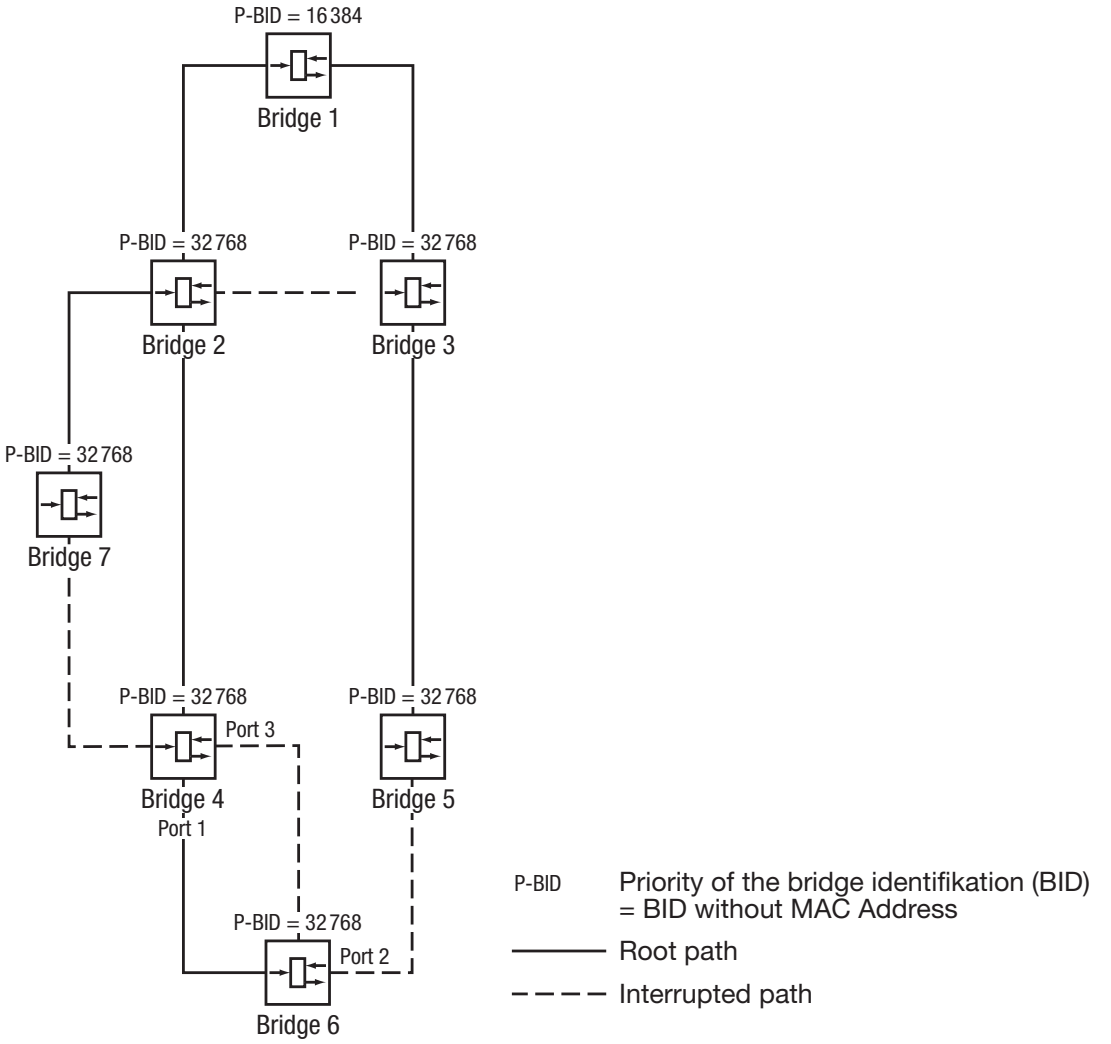


Figure 45: Example of root path manipulation

5.5 Example of Tree Structure Manipulation

The Management Administrator soon discovers that this configuration with bridge 1 as the root bridge (see on page 83 “Example of Root Path Determination“) is unfavorable. On the paths from bridge 1 to bridge 2 and bridge 1 to bridge 3, the control packets which the root bridge sends to all other bridges are adding up.
If the Management Administrator makes bridge 2 the root bridge, the burden of the control packets on the subnetworks is distributed much more evenly. The result is the configuration shown here (see fig. 46). The distances between the individual bridges and the root bridge are now shorter.

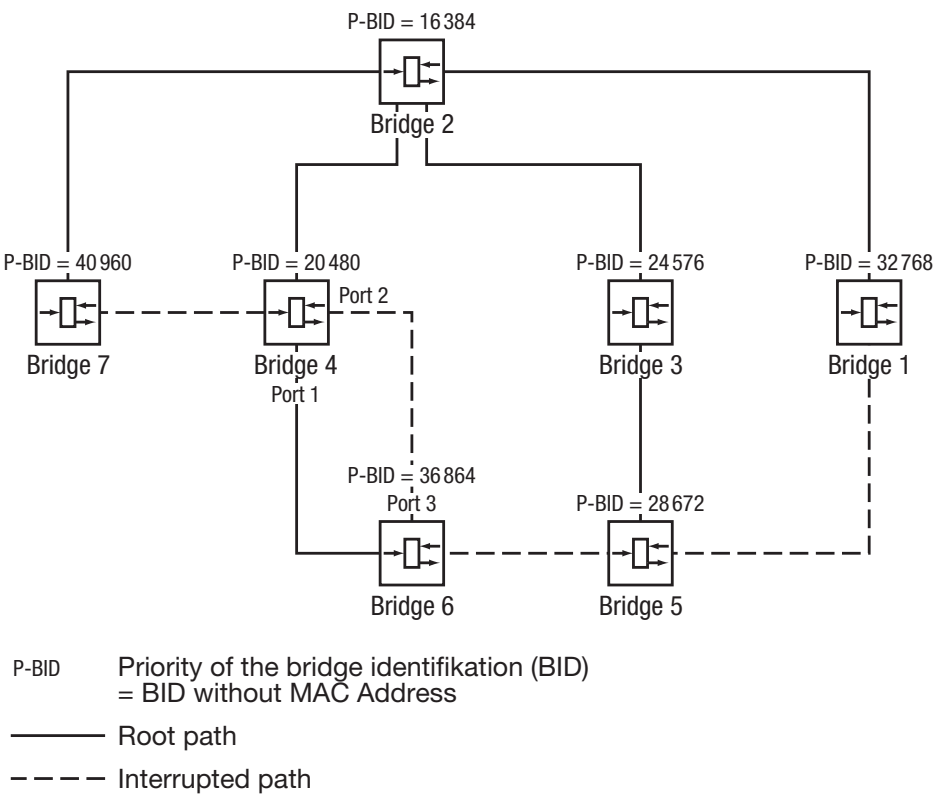


Figure 46: Example of tree structure manipulation

5.6 The Rapid Spanning Tree Protocol

The RSTP uses the same algorithm for determining the tree structure as STP. RSTP merely changes parameters, and adds new parameters and mechanism that speed up the reconfiguration if a link or bridge becomes inoperable.
The ports play a significant role in this context.

5.6.1 Port roles

RSTP assigns each bridge port one of the following roles (see fig. 47):

- Root port
  This is the port on which a bridge receives data packets with the lowest path costs from the root bridge.
  If there is more than 1 port with the same low path costs, the bridge identifier determines which port is the root port.
  If there is more than 1 port with the same low path costs connected to the same bridge, the port identifier determines which port is the root port (see fig. 43).
  The root bridge itself does not have a root port.
- Designated port
  The bridge in a network segment that has the lowest root path costs is the designated bridge. If more than 1 bridge has the same root path costs, the bridge with the smallest value bridge identifier becomes the designated bridge. The port on this bridge that connects it to a network segment leading to the root bridge, is the designated port.

- Edge port
  Every network segment with no additional RSTP bridges is connected with exactly one designated port. In this case, this designated port is also an edge port. The distinction of an edge port is the fact that it does not receive any RST BPDUs (Rapid Spanning Tree Bridge Protocol Data Units).
- Alternate port
  This is a blocked port that takes over the task of the bridge port if the connection to the root bridge is lost. The alternate port provides a backup connection to the root bridge.
- Backup port
  This is a blocked port that serves as a backup in case the connection to the designated port of this network segment (without any RSTP bridges) is lost
- Disabled port
  This is the port that does not participate in the Spanning Tree Operation, i.e., is switched off or does not have any connection.

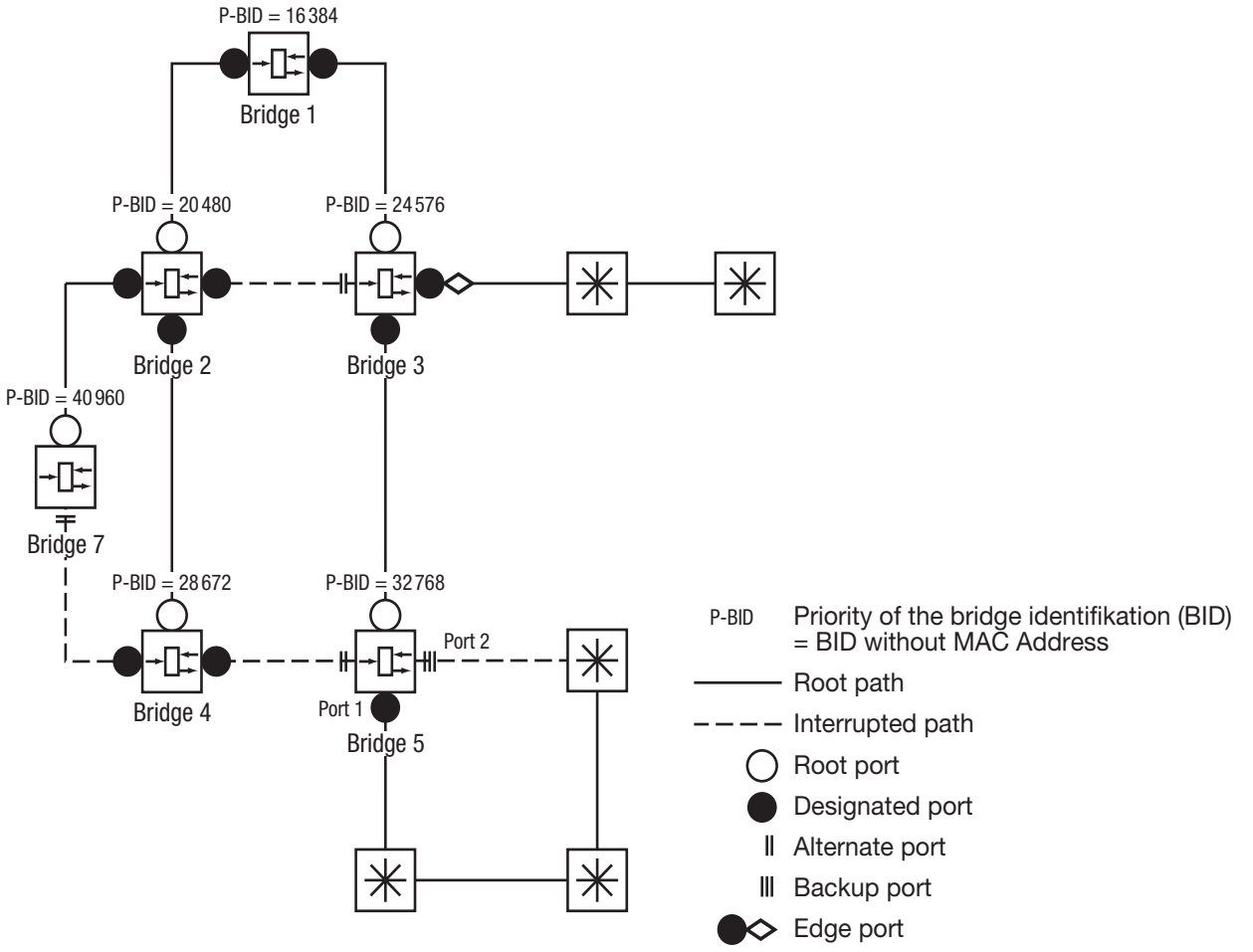


Figure 47: Port role assignment

5.6.2 Port states

Depending on the tree structure and the state of the selected connection paths, the RSTP assigns the ports their states.

STP port state	Administrative bridge port state	MAC operational	RSTP Port state	Active topology (port role)
DISABLED	Disabled	FALSE	Discarding[a]	Excluded (disabled)
DISABLED	Enabled	FALSE	Discarding[a]	Excluded (disabled)
BLOCKING	Enabled	TRUE	Discarding[b]	Excluded (alternate, backup)
LISTENING	Enabled	TRUE	Discarding[b]	Included (root, designated)
LEARNING	Enabled	TRUE	Learning	Included (root, designated)
FORWARDING	Enabled	TRUE	Forwarding	Included (root, designated)

Table 15: Relationship between port state values for STP and RSTP

a. The dot1d MIB shows “Disabled
b. The dot1d MIB shows “Blocked”

Meaning of the RSTP port states:

- Disabled: port does not belong to the active topology
- Discarding: no address learning in FDB, no data traffic except BPDUs
- Learning: address learning active (FDB), no data traffic except BPDUs
- Forwarding: address learning active (FDB), sending and receiving of all frame types (not only BPDUs)

5.6.3 Spanning Tree Priority Vector

To assign roles to the ports, the RSTP bridges exchange configuration information with each other. This information is known as the Spanning Tree Priority Vector. It is part of the RST BPDUs and contains the following information:

- Bridge identifier of the root bridge
- Root path costs for the sending bridge
- Bridge identifier for the sending bridge
- Port identifiers of the port through which the message was sent
- Port identifiers of the port that has received the message

Based on this information, the bridges participating in RSTP are able to determine port roles autonomously and define their local ports' states.

5.6.4 Fast reconfiguration

Why can RSTP react faster than STP to an interruption of the root path?

- Introduction of edge ports:
  During a reconfiguration, RSTP sets an edge port to the transmission mode after 3 seconds and then waits for the "Hello Time" (see table 16) to elapse, to ascertainthat no BPDU-sending bridge is connected.
  When the user ascertains that a terminal device is connected at this port and will remain connected, he can switch off RSTP at this port. Thus no waiting times occur at this port in the case of a reconfiguration.
- Introduction of alternate ports:
  As the port roles are already determined in normal operation, a bridge can immediately switch from the root port to the alternate port after the connection to the root bridge is lost.
- Communication with neighboring bridges (point-to-point connections):
  The decentralized, direct communication between neighboring bridges enables immediate reaction to status changes in the spanning tree architecture.
- Address table:
  With STP, the age of the entries in the address table determines the updating of the communication. RSTP immediately deletes the entries for those ports affected by a reconfiguration.
- Reaction to events:
  Without having to adhere to any time specifications, RSTP immediately reacts to events such as connection interruptions, connection reinstatements, and the like.

Note: The drawback for this fast reconfiguration is the possibility that data packets may be duplicated or their sequence be altered during the reconfiguration phase. If this is unacceptable for your application, use the slower Spanning Tree Protocol or select one of the other, faster redundancy procedures described in this manual.

5.6.5 Configuring the Rapid Spanning Tree

☐ Set up the network to meet your demands.

⚠ Warning

RSTP LOOP HAZARD

Configure all the devices of the RSTP configuration individually. Before you connect the redundant lines, you must complete the configuration of all devices in the RSTP configuration.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

☐ For devices with DIP switches, you switch these to “deactivated” (both to ON), so that the software configuration is not restricted.
☐ Select the `Redundancy:Rapid Spanning Tree:Global` dialog.

☐ Switch on RSTP on each device

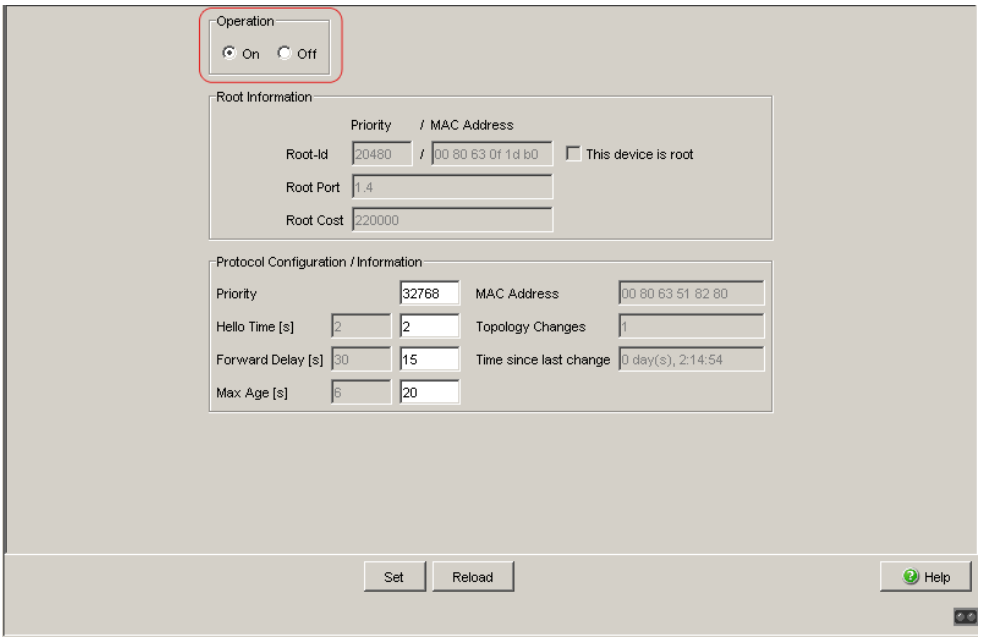


Figure 48: Operation on/off

☐ Define the desired Switch as the root bridge by assigning it the lowest priority in the bridge information among all the bridges in the network, in the “Protocol Configuration/Information” frame. Note that only multiples of 4.096 can be entered for this value (see table 16).
In the “Root Information” frame, the dialog shows this device as the root.
A root switch has no root port and a root cost of 0.

☐ If necessary, change the default priority value of 32,768 in other bridges in the network in the same way to the value you want (multiples of 4.096).
For each of these bridges, check the display
in the “Root Information” frame:
– Root-ID: Displays the root bridge’s bridge identifier
– Root Port: Displays the port leading to the root bridge
– Root Cost: Displays the root cost to the root bridge
in the “Protocol Configuration/Information” frame:
– Priority: Displays the priority in the bridge identifier for this bridge
– MAC Address: Displays the MAC address of this Switch
– Topology Changes: Displays the number of changes since the start of RSTP
– Time since last change: Displays the time that has elapsed since the last network reconfiguration

☐ If necessary, change the values for “Hello Time”, “Forward Delay” and “Max. Age” on the rootbridge. The root bridge then transfers this data to the other bridges. The dialog displays the data received from the root bridge in the left column. In the right column you enter the values which shall apply when this bridge becomes the root bridge. For the configuration, take note of table 16.

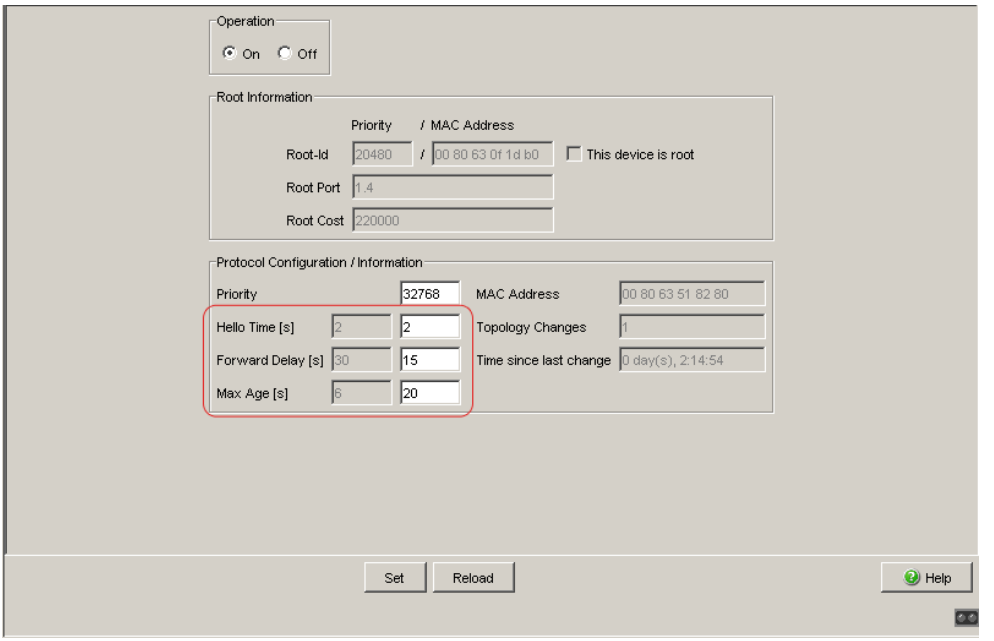


Figure 49: Assigning Hello Time, Forward Delay and Max. Age

The times entered in the RSTP dialog are in units of 1 s
Example: a Hello Time of 2 corresponds to 2 seconds.

☐ Now connect the redundant lines.

Parameter	Meaning	Value range	Default setting
Priority	The priority and the MAC address go together to make up the bridge identification.	0 < n*4,096 < 61,440	32,768
Hello Time	The left column shows the value currently being used by the root bridge. The device periodically receives configuration frames (Hello frames) from the root bridge. The Hello Time shows the time between 2 successive configuration frames sent by the root bridge. If you configure the current device as the root bridge, the other devices in the entire network will assume the value in the right column.	1 - 2 s	2 s
Forward Delay	The left column shows the value currently being used by the root bridge. The predecessor protocol STP used the parameter to control (delay) the transition time between the states "disabled“, "blocking“, "learning“, "forwarding“. Since the introduction of RSTP, this parameter has only secondary relevance because state transitions are negotiated between RSTP bridges without a given time delay. If you configure the current device as the root bridge, the other devices in the entire network will assume the value in the right column.	4 - 30 s (see a:)	30 s
Max Age	The left column shows the value currently being used by the root bridge. Contrary to the past (STP) meaning, Max Age now (for RSTP) denotes the maximum permissible branch length (number of devices to the root bridge). If you configure the current device as the root bridge, the other devices in the entire network will assume the value in the right column.	6 - 40 s (see a:)	6 s

Table 16: Global RSTP settings

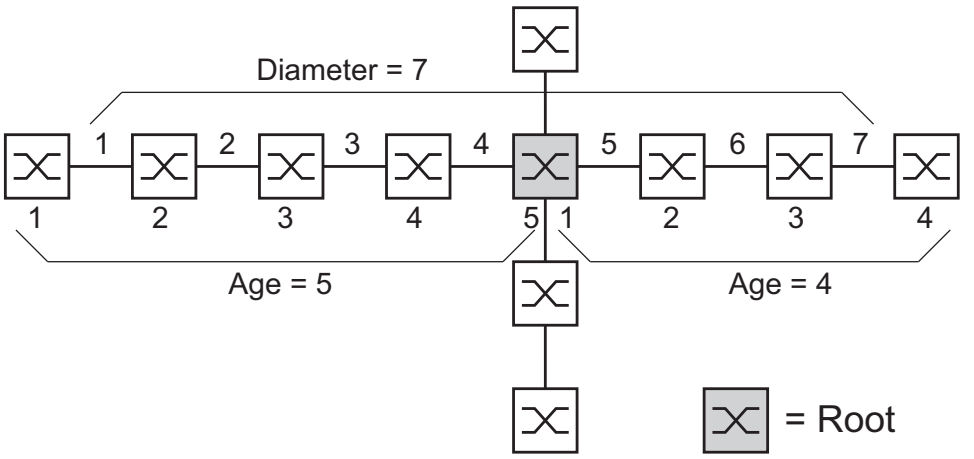


Figure 50: Definition of diameter and age

The diameter is the number of connections between the two devices furthest away from the root bridge.

The parameters
– Forward Delay and
– Max Age
have a relationship to each other:

Forward Delay >= (Max Age/2) + 1

If you enter values that contradict this relationship, the device then replaces these values with a default value or with the last valid values.

☐ When necessary, change and verify the settings and displays that relate to each individual port (dialog: `Rapid Spanning Tree:Port`).

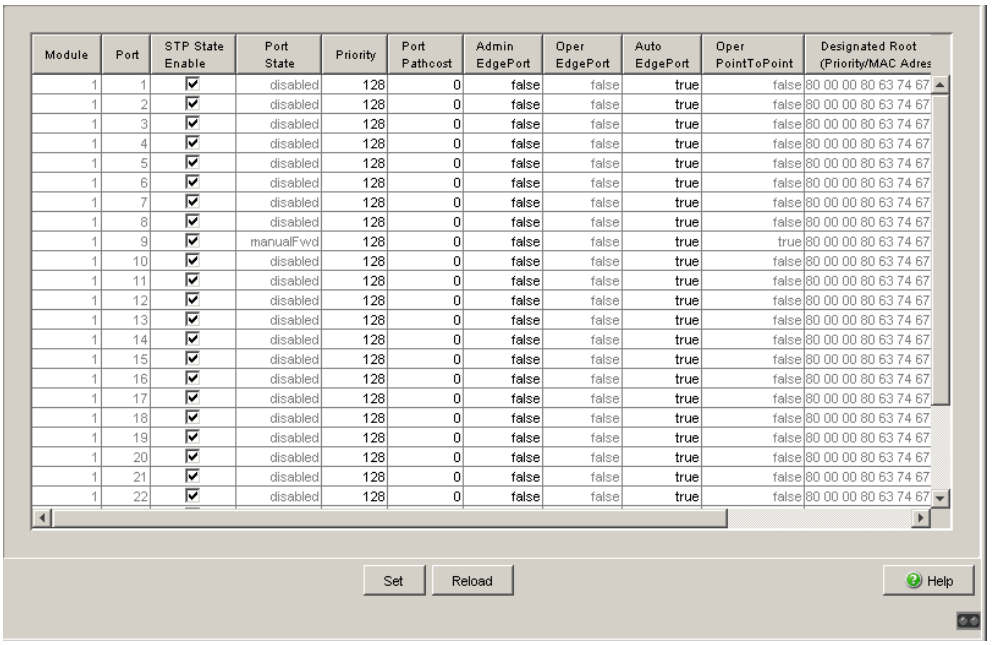


Figure 51: Configuring RSTP per port

Note: Deactivate the Spanning Tree Protocol on the ports connected to a redundant ring, because Spanning Tree and Ring Redundancy work with different reaction times.

Parameter	Meaning	Value range	Default setting
STP State Enable	Here you can turn RSTP on or off for this port. If you turn RSTP off for this port while RSTP is globally enabled for the device, the device will discard RSTP frames received on this port.	on, off	on
Port State	Displays the port state	disabled, forwarding, discarding, blocking, learning	-
Priority	Here you enter the first byte of the port identification.	16 < n*16 < 240	128
Port Path Cost	Enter the path costs to indicate preference for redundant paths. If the value is 0, the Switch automatically calculates the path costs according to the transmission rate.	0 - 200,000,000	0
Admin Edge Port	If the parameter is set to "true“, the port will transition to the forwarding state. If the port nevertheless receives an RSTP frame, it will transition to the blocking state and the bridge will then determine the new port role. .If the parameter’s value is "false“, the port remains in the blocked state until the bridge has determined the port role. Only after that will the port transition to its final state.	true, false	false
Oper Edge Port	Is "true“ if no RSTP frames have been received, i. e., a terminal device that does notsend RSTP frames is connected to this port. Is "false“ if RSTP frames have been received, i. e., no terminal device but a bridge is connected.	true, false	-
Auto Edge Port	The setting for Auto Edge Port only takes effect if the parameter "Oper Edge Port“ has been set to "false“. if "Auto Edge Port“ is set to "true“, the port will transition to the forwarding state within 1.5 * Hello Time (3 seconds). If is is set to "false“, it will take 30 seconds until the edge port forwards data frames.	true, false	false

Table 17: Port-related RSTP settings and displays

Parameter	Meaning	Value range	Default setting
Oper Point-ToPoint	If this port has a full-duplex link to another RSTP device, the value for "Oper PointToPoint“ will become "true“, else it will become "false“ (e.g., if a hub is connected). A Point-to-point connection is a direct connection between 2 RSTP devices. The direct, local communications between the 2 switches results in a short reconfiguration time.	true, false	auto (is calculated): FDX: true HDX: false
Designated Root	Displays the bridge identification of the designated root bridge for this port.	Bridge identification (hexadecimal)	-
Designated Cost	Display of the costs for the path from this port to the root Switch.	Cost	-
Designated Port	Display of the port identifier (on the designated Switch) of the port that connects to the root bridge - for the local port.	Port identification (hexadecimal) and port number	-

Table 17: Port-related RSTP settings and displays

5.7 Combining RSTP and MRP

In the MRP compatibility mode, the device allows you to combine RSTP with MRP.
With the combination of RSTP and MRP, the fast switching times of MRP are maintained.
The RSTP diameter (see fig. 50) depends on the “Max Age”. It applies to the devices outside the MRP-Ring.

Note: The combination of RSTP and MRP presumes that both the root bridge and the backup root bridge are located within the MRP-Ring.

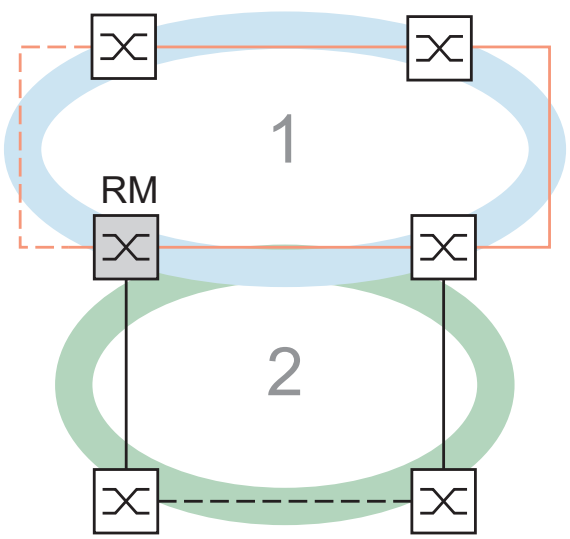


Figure 52: Combination of RSTP and MRP
1: MRP-Ring
2: RSTP-Ring
RM: Ring Manager

To combine RSTP with MRP, you perform the following steps in sequence:
- Configure MRP on each device in the MRP-Ring.
- Activate RSTP on the RSTP ports and on the MRP-Ring ports.

- Configure the RSTP root bridge and the RSTP backup root bridge in the MRP-Ring:
  - Set the priority.
  - If you exceed the RSTP diameter specified by the default value of Max Age = 20, modify “Max Age” and “Forward Delay” accordingly.
- Activate RSTP globally.
- Activate the MRP compatibility mode.
- After configuring all the participating devices, connect the redundant RSTP connection.

5.7.1 Application example for the combination of RSTP and MRP

The figure (see fig. 53) shows an example for the combination of RSTP and MRP.

Table 18: Values for the switch configuration in the MRP/RSTP example

Parameter	S1	S2	S3	S4	S5	S6
MRP settings						
Ring redundancy: MRP version	MRP	MRP			MRP	MRP
Ring port 1	1.2	1.1			1.1	1.1
Ring port 2	1.1	1.2			1.2	1.2
Port from MRP-Ring to the RSTP net	1.3	1.3	-	-	-	-
Redundancy Manager mode	On	Off	–	–	Off	Off
MRP operation	On	On	Off	Off	On	On
RSTP settings						
For each RSTP port: STP State Enable	On	On	On	On	On	On
Protocol Configuration: Priority (S2<S1<S3 and S2<S1<S4)	4,096	0	32,768	32,768	32.768	32.768
RSTP:Global: Operation	On	On	On	On	On	On
RSTP:Global: MRP compatibility	On	On	–	–	On	On

Prerequisities for further configuration:

- You have configured the MRP settings for the devices in accordance with the above table.
- The MRP-Ring's redundant line is connected.

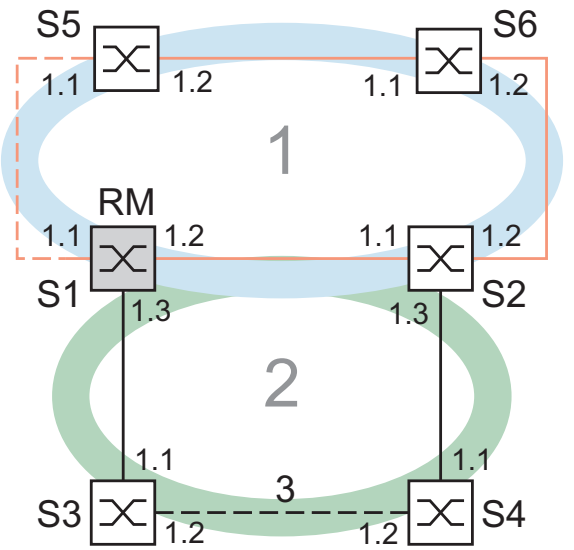


Figure 53: Application example for the combination of RSTP and MRP
1: MRP-Ring, 2: RSTP-Ring, 3: Redundant RSTP connection
RM: Ring Manager
S2 is RSTP Root Bridge
S1 is RSTP Backup Root Bridge

☐ Activate RSTP at the ports, using S1 as an example.

`enable`	Switch to the Privileged EXEC mode.
`configure`	Switch to the Configuration mode.
`interface 1/1`	Switch to the Interface Configuration mode of interface 1/1.
`spanning-tree port mode`	Activate RSTP on the port.
`exit`	Switch to the Configuration mode.
`interface 1/2`	Switch to the interface configuration mode for port 1.2.
`spanning-tree port mode`	Activate RSTP on the port.
`exit`	Switch to the Configuration mode.
`interface 1/3`	Switch to the interface configuration mode for port 1.3.
`spanning-tree port mode`	Activate RSTP on the port.
`exit`	Switch to the Configuration mode.

☐ Configure the global settings, using S1 as an example:
- the RSTP priority
- global operation
- the MRP compatibility mode

`spanning-tree mst priority 0 4096`	Set the RSTP priority to the value 4,096.
`spanning-tree`	Activate RSTP operation globally.
`spanning-tree stp-mrp-mode`	Activate MRP compatibility.

☐ Configure the other switches S2 though S6 with their respective values (see table 18).

☐ Connect the redundant RSTP connection.

A Index