



HIRSCHMANN

A **BELDEN** BRAND

User Manual

Redundancy Configuration

Industrial ETHERNET (Gigabit) Switch

**RS20/RS30/RS40, MS20/MS30, OCTOPUS, Power MICE,
RSR20/RSR30, MACH 100, MACH 1000, MACH 4000**

The naming of copyrighted trademarks in this manual, even when not specially indicated, should not be taken to mean that these names may be considered as free in the sense of the trademark and tradename protection law and hence that they may be freely used by anyone.

© 2009 Hirschmann Automation and Control GmbH

Manuals and software are protected by copyright. All rights reserved. The copying, reproduction, translation, conversion into any electronic medium or machine scannable form is not permitted, either in whole or in part. An exception is the preparation of a backup copy of the software for your own use. For devices with embedded software, the end-user license agreement on the enclosed CD applies.

The performance features described here are binding only if they have been expressly guaranteed in the contract. This publication has been created by Hirschmann Automation and Control GmbH according to the best of our knowledge. Hirschmann reserves the right to change the contents of this manual without prior notice. Hirschmann can give no guarantee in respect of the correctness or accuracy of the details in this publication.

Hirschmann can accept no responsibility for damages, resulting from the use of the network components or the associated operating software. In addition, we refer to the conditions of use specified in the license contract.

Printed in Germany
Hirschmann Automation and Control GmbH
Stuttgarter Str. 45-51
72654 Neckartenzlingen
Germany
Tel.: +49 1805 141538

Content

Content	3
About this Manual	5
Key	6
1 Introduction	9
1.1 Overview of Redundancy Procedure	10
2 Link Aggregation	11
2.1 Example of link aggregation	12
2.1.1 Creating and configuring the link aggregation	13
2.2 HIPER-Ring and link aggregation	18
3 Ring Redundancy	21
3.1 Example of HIPER-Ring	24
3.1.1 Setting up and configuring the HIPER-Ring	26
3.2 Example of MRP-Ring	30
3.3 Example of Fast HIPER-Ring	35
4 Sub-Ring (RSR20, RSR30, MACH1000)	41
4.1 Example configuration	45
4.1.1 Example description	45
4.1.2 Sub-Ring configuration	48
5 Ring/Network coupling	53
5.1 Variants of the ring/network coupling	54
5.2 Preparing a Ring/Network coupling	56
5.2.1 STAND-BY switch	56
5.2.2 One-Switch coupling	59
5.2.3 Two-Switch coupling	65
5.2.4 Two-Switch coupling with control line	73

6	Rapid Spanning Tree	81
6.1	The Spanning Tree Protocol	83
6.1.1	The tasks of the STP	83
6.1.2	Bridge parameters	84
6.1.3	Bridge Identifier	84
6.1.4	Root Path Costs	85
6.1.5	Port Identifier	86
6.2	Rules for creating the tree structure	88
6.2.1	Bridge information	88
6.2.2	Setting up the tree structure	88
6.3	Example of specifying the root paths	90
6.4	Example of manipulating the root paths	92
6.5	Example of manipulating the tree structure	94
6.6	The Rapid Spanning Tree Protocol	95
6.6.1	Port roles	95
6.6.2	Port states	97
6.6.3	Spanning Tree Priority Vector	97
6.6.4	Fast reconfiguration	98
6.6.5	Configuring the Rapid Spanning Tree	99
6.7	Combination of RSTP and MRP	107
6.7.1	Application example for the combination of RSTP and MRP	108
A	Readers' comments	111
B	Index	113
C	Further support	115

About this Manual

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

The “Basic Configuration” user manual contains all 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 all the other information that you need to install the device before you begin with the configuration of the device.

The “Industry Protocols” user manual describes how the device is connected by means of a communication protocol commonly used in the industry, such as EtherNet/IP and PROFINET.

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.

The Network Management Software HiVision/Industrial HiVision provides you with additional options for smooth configuration and monitoring:

- ▶ Configuration of multiple devices simultaneously.
- ▶ Graphical interface with network layouts.
- ▶ Auto-topology discovery.
- ▶ Event log.
- ▶ Event handling.
- ▶ Client / Server structure.
- ▶ Browser interface
- ▶ ActiveX control for SCADA integration
- ▶ SNMP/OPC gateway

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.
<code>Courier</code>	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

Key



A random computer



Configuration Computer



Server



PLC -
Programmable logic
controller



I/O -
Robot

1 Introduction

The device contains a range of redundancy functions:

- ▶ Link Aggregation
- ▶ HIPER-Ring
- ▶ MRP-Ring
- ▶ Fast HIPER-Ring (RSR20, RSR30 and MACH 1000)
- ▶ Sub-Ring (RSR20, RSR30 and MACH 1000)
- ▶ Ring/Network Coupling
- ▶ Rapid Spanning Tree Algorithm (RSTP)

1.1 Overview of Redundancy Procedure

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 are being used, up to 39 devices are possible, depending on the topology (see page 81).
HIPER-Ring	Ring	typically 80 ms, up to < 500 ms - practically independently of the number of devices
MRP-Ring	Ring	typically 80 ms, up to < 500 ms - practically independently of the number of devices Note: In combination with RSTP in MRP compatibility mode, up to 39 devices are possible, depending on the configuration. If the default values for RSTP are being used, up to 19 devices are possible (see page 81).
Fast HIPER-Ring (RSR20, RSR30 and MACH 1000)	Ring	< 10 ms with 5 devices in ring. With more than 5 devices, the switching time increases.
Sub-Ring (RSR20, RSR30 and MACH 1000)	Ring segment coupled to basis ring	typically 80 ms, up to < 500 ms - practically independently of the number of devices
Redundant coupling	Coupling of network segment/rings via a main line and a redundant line	typically 150 ms, up to < 500ms
Link Aggregation	Coupling of network segments via parallel active lines with dynamic load distribution and line redundancy	

Table 1: Comparison of the redundancy procedures

Note: Informations concerning the switching time you can find on the Hirschmann internet site (www.hirschmann-ac.com) at the end of the product site.

2 Link Aggregation

There is link aggregation when there are at least two parallel redundant connection lines (known as a trunk) between two devices, and these lines are combined into one logical connection. You can use link aggregation to combine up to 8 (optimally up to 4) connection lines between devices into a trunk. The LACP (Link Aggregation Control Protocol based on IEEE 802.3ad) is a network protocol for dynamically bundling physical network connections. The complete bandwidth of all connection lines is available for data transmission. In the case of a connection breaking down, the remaining connections take over the entire data transmission (redundancy). The load distribution between the connection lines is effected dynamically.

Any combination of twisted pair and F/O cables can be used as the connection lines of a trunk. You configure all the connections so that the transmission speed and the duplex settings of the related ports are matching.

The maximum that can exit a device are

- 2 trunks for rail devices with 4 ports,
- 4 trunks for rail and MICE devices with 8-10 ports,
- 7 trunks for all other devices.

2.1 Example of link aggregation

In a network consisting of seven devices in a line topology, there are two segments with a particularly large amount of data traffic. You therefore decide to set up link aggregations in these segments. As well as dividing the load between a number of lines, you also get increased redundancy reliability in these segments through the redundant lines.

The link aggregation LATP (Link Aggregation Twisted Pair) consists of 3 twisted pair lines, and the link aggregation LAFO (Link Aggregation Fiber Optic) consists of 2 glass fiber lines.

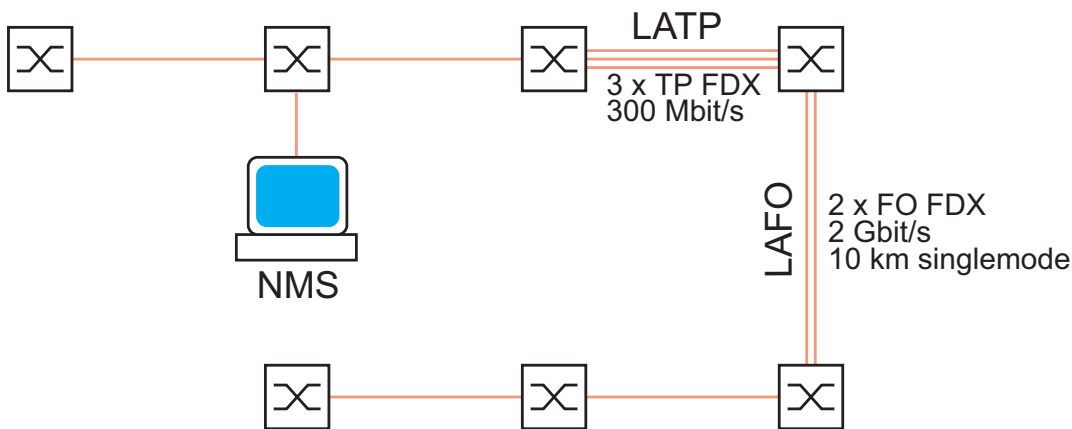


Figure 1: Example of link aggregation
NMS = Network Management Station
LATP = Link Aggregation Twisted Pair
LAFO = Link Aggregation Fiber Optic

The following example describes the configuration of the LATP link aggregation. For this link aggregation, you provide three free twisted pair ports at each of the two participating devices. (Connection: Module1 Port1 to Port3).

2.1.1 Creating and configuring the link aggregation

Note: A link aggregation always has exactly two devices.

You configure the link aggregation on each of the two devices involved. During the configuration phase, you connect a maximum of one connection line between the devices. This is to avoid loops.

- ☐ Under `Basic Settings:Port Configuration`, you configure all three connections so that the transmission speed and the duplex settings of the participating ports on both devices are matching.
- ☐ Among the devices involved in a link aggregation, you define that device that has the most devices between itself and the device to which the configuration PC/(NMS network management station) is connected. You begin the configuration at this device, otherwise the Link Aggregation Control Protocol (LACP) can block ports and disconnect devices from the network, so that they cannot be configured any more.
- ☐ In the example below (see fig. 2), you configure the link aggregation first on device 3, then on device 2. If you accidentally disconnect device 3 from the network, you can access it again by selecting “Allow static link aggregation” in the `Redundancy: Link Aggregation` dialog, or by activating this option via the CLI.

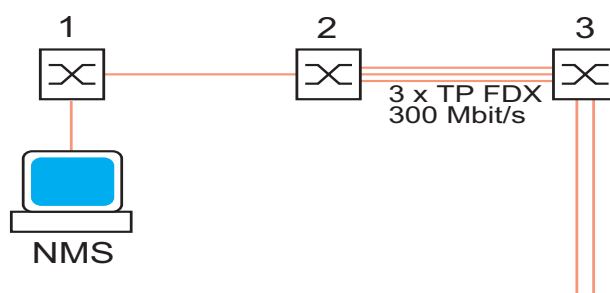


Figure 2: Example: “Defining the first device”
NMS = Network Management Station

- Proceed as follows to configure a link aggregation from 3 twisted pair lines on device 3:

- Select the Redundanz:Link Aggregation (see fig. 3) dialog.

Figure 3: Creating the link aggregation

- Select Allow static link aggregation if the partner device does not support the Link Aggregation Control Protocol (LACP) (e.g. MACH 3000).
- Click “Create entry” to create a new link aggregation.
- The Index column shows you the ID under which the device uses a link aggregation (a trunk) as a virtual port. The device creates the port in module 8, which does not physically exist, and the first link aggregation then has the ID 8.1.
- The Name column allows you to give this connection any name you want. In this example, you give the new link aggregation the name “LAPT”.
- The Enabled column allows you to enable/disable a link aggregation that has been set up. Leave the checkmark in the “Enabled” column while you are using the link aggregation.
- Leave the checkmark in the Link Trap column if you want the device to generate an alarm if all the connections of the link aggregation are interrupted.

- In the “STP Mode” column, you select `on` if the link aggregation connection is connected to a Spanning Tree, `off` if no Spanning Tree is active, or if the link aggregation is a segment of a HIPER-Ring.
 - “Type” shows whether you created this link aggregation manually (`Allow static link aggregation is selected`), or whether it was created dynamically using LACP (`Allow static link aggregation is not selected`).
- Note:** If there are multiple connections between devices that support LACP, and if `Allow static link aggregation` is nevertheless selected, `dynamic` is still displayed, because in this case the devices automatically switch to dynamic.

☐ allow static link Aggregation

Index	Name	Enabled	Link Trap	STP Mode	Type
8.1	LATP	☒	☒	on	dynamic

1.1

1.2

1.3

1.4

2.1

2.2

2.3

2.4

3.1

3.2

3.3

3.4

4.1

4.2

4.3

4.4

5.1

5.2

5.3

5.4

6.1

6.2

6.3

6.4

Figure 4: Link aggregation created and named.

- Now assign to the ports participating in the link aggregation (ports 1.1, 1.2 and 1.3) the index of the link aggregation connection LATP (8.1). (see fig. 5).

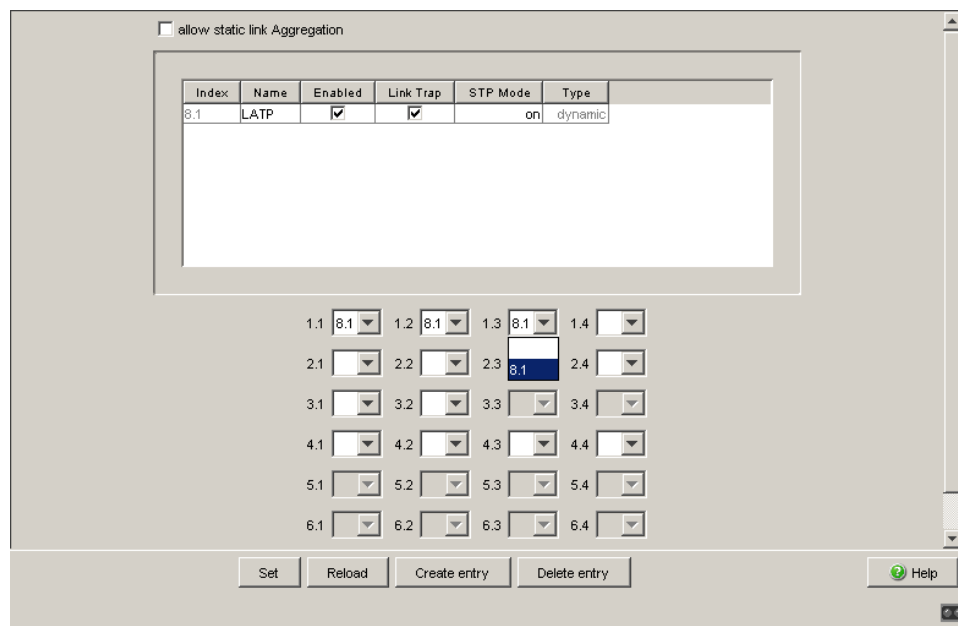


Figure 5: Assigning ports to link aggregation

```
enable
configure
link-aggregation LATP
```

New link aggregation created. Slot/port is 8.1.

```
Interface 1/1
addport 8/1
Interface 1/2
addport 8/1
Interface 1/3
addport 8/1
exit
show link-aggregation brief
```

```
Max. num. of LAGs: 7
Slot no. for LAGs: 8
Static Capability: Disabled
```

```
Logical Link-Aggr.
```

Interface	Name	Link State	Mbr Ports	Active Ports
8/1	LATP	Down	1/1,1/2,	1/3

Switch to the Privileged EXEC mode.

Switch to the Configuration mode.

Create a new link aggregation with the name LATP.

Configuration for port 1.1

Assign port 1.1 to link aggregation 8.1.

Configuration for port 1.2

Assign port 1.2 to link aggregation 8.1.

Configuration for port 1.3

Assign port 1.3 to link aggregation 8.1.

Switch to the privileged EXEC mode.

Show the parameters of all the link aggregations created on the device.

- ☐ Now you configure the partner device (device 2) in the same way.
- ☐ After the configuration, you connect the other connection line(s) between the devices.

Note: Exclude the combination of a link aggregation with the following redundancy procedures:

- ▶ Network/Ring coupling
- ▶ MRP-Ring
- ▶ Fast HIPER-Ring
- ▶ Sub-Ring

2.2 HIPER-Ring and link aggregation

For Power MICE and MACH 4000:

To increase the security on particularly critical connections, you can combine the HIPER-Ring ([see on page 21 „Ring Redundancy“](#)) and link aggregation redundancy functions.

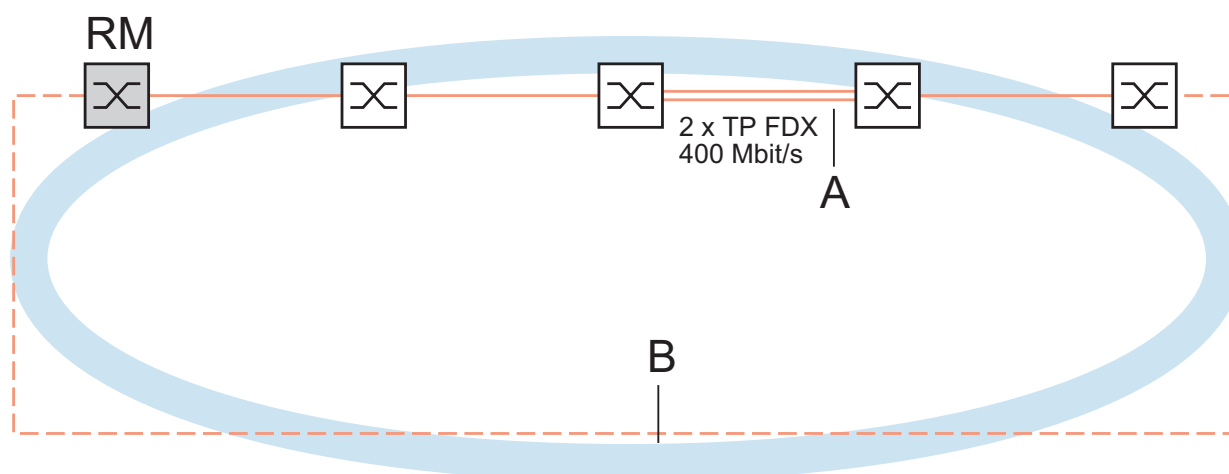


Figure 6: Example of a HIPER-Ring / link aggregation combination
RM = Ring Manager
A = link aggregation
B = HIPER-Ring

The above example shows a HIPER-Ring. One link aggregation forms a segment of the ring. When all the connection lines of the link aggregation are interrupted, the HIPER-Ring function activates the redundant line of the ring.

Note: If you want to use a link aggregation in a HIPER-Ring, you first configure the link aggregation, then the HIPER-Ring. In the HIPER-Ring dialog, you enter the index of the desired link aggregation as the value for the module and the port. Make sure that the respective Ring port belongs to the selected link aggregation.

Note: Deactivate RSTP when link aggregations are segments of a HIPER-Ring.

3 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 fails, the ring manager immediately closes the redundant line, and line structure is intact again.

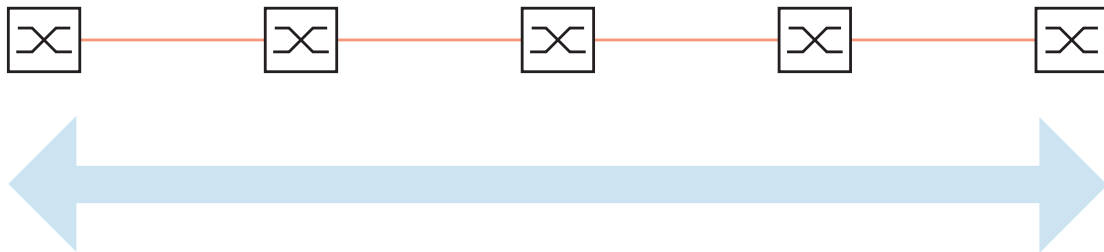


Figure 7: Line structure

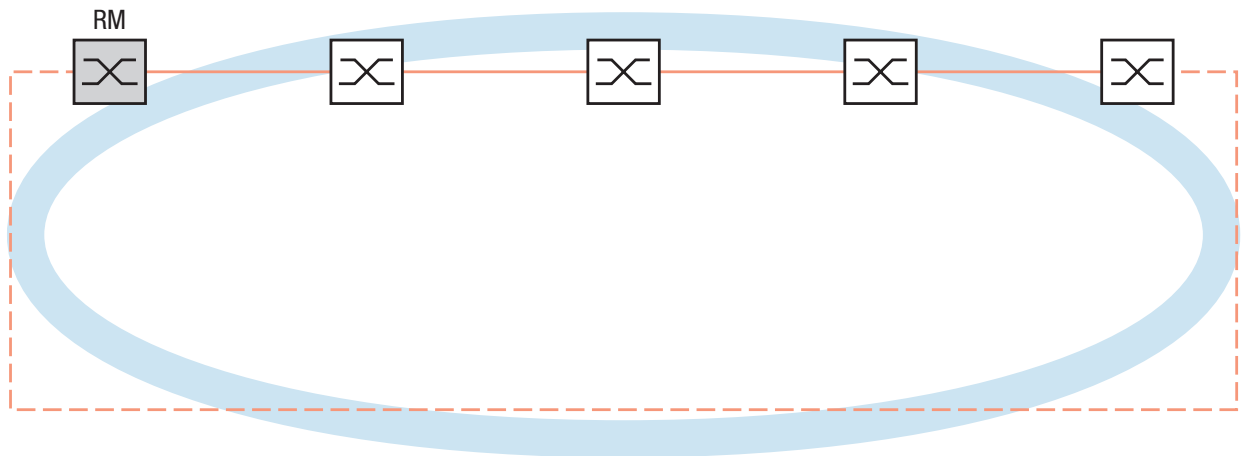


Figure 8: Redundant ring structure
RM = Ring Manager
— main line
- - - redundant line

If a section is down, the ring structure of a

- ▶ **HIPER-(HIGH PERFORMANCE REDUNDANCY)** Ring with up to 50 devices typically transforms back to a line structure within 80 ms (setting: standard/accelerated).
- ▶ **MRP (Media Redundancy Protocol)** 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). If a larger number of devices is being used, the reconfiguration time increases.

Device requirements for using the HIPER-Ring function:

- ▶ Within a HIPER-Ring, you can use any combination of the following devices:
 - RS1
 - RS2-./.
 - RS2-16M
 - RS2-4R
 - RS20, RS30, RS40
 - RSR20, RSR30
 - OCTOPUS
 - MICE
 - MS20, MS30
 - Power MICE
 - MACH 100
 - MACH 1000
 - MACH 3000
 - MACH 4000
- ▶ Within an MRP-Ring, you can use devices that support the MRP protocol based on IEC62439.
- ▶ Within a Fast HIPER-Ring, you can use any combination of the following devices:
 - RSR20, RSR30
 - MACH 1000

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.

3.1 Example of 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 and 2 in module 1 of the devices to connect the lines.

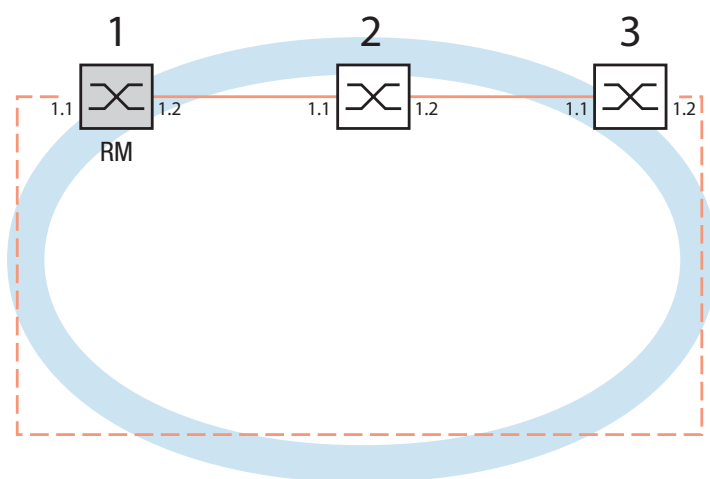


Figure 9: Example of HIPER-Ring
 RM = Ring Manager
 — main line
 - - - redundant line

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 the RS20/30/40, MS20/30 and PowerMICE Switches, 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”.

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.

3.1.1 Setting up and configuring the HIPER-Ring

- ☐ Set up the network to meet your requirements.
- ☐ 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 2: Port settings for ring ports

- ☐ 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.

Version

☒ HIPER-Ring ☐ MRP ☐ Fast HIPER-Ring

Ring Port 1

Module

Port

Operation

Ring Port 2

Module

Port

Operation

Redundancy Manager Status

☒ Active (redundant line) ☐ Inactive

Redundancy Manager

Mode ☒ On ☐ Off

Ring Recovery

☒ Standard ☐ Accelerated

Information

Figure 10: Ring Redundancy dialog (RSR20, RSR30, MACH 1000)

- ☐ 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 are only effective for devices that you have configured as ring managers.
- ☐ Click on “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 two devices to the ends of the line using their ring ports.

The displays in the “Redundancy Manager 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 can fail, whereby the redundant line will then take over the function of the failed line.
- “Configuration failure”: The function is incorrectly configured or there is an error in the ring port connection.

Note: When you use the DIP switch to switch from a normal port to a ring port, the device makes the required settings for the pre-defined ring ports in the configuration table. The port which has been switched back from a ring port to a normal port keeps the ring port settings (transmission speed and mode). Independently of the DIP switch setting, you can still change all the ports via the software.

Note: If you want to use link aggregation connections in the HIPER-Ring (PowerMICE and MACH 4000), you enter the index of the desired link aggregation entry for the module and the port.

3.2 Example of MRP-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 ring redundancy. In contrast to the previous example, devices from different manufacturers are being used which do not all support the HIPER-Ring protocol. All the devices have MRP as the ring redundancy protocol, so you decide to use MRP. You use ports 1 and 2 in module 1 of the devices to connect the lines.

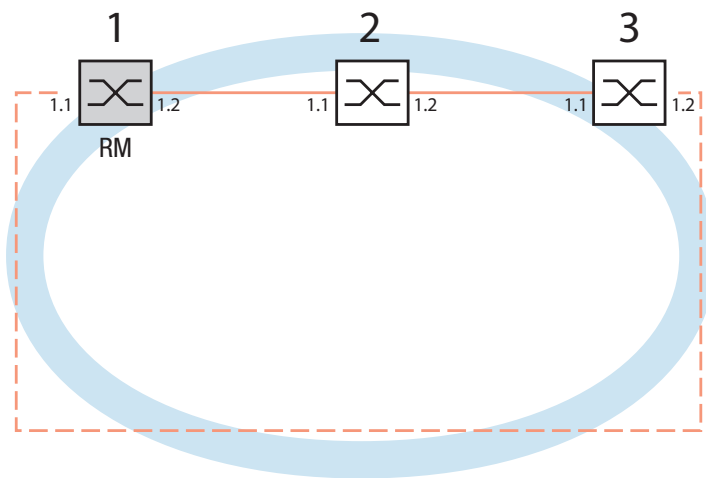


Figure 11: Example of MRP-Ring
RM = Ring Manager
—— main line
- - - redundant line

The following example configuration describes the configuration of the ring manager device (1). You configure the two 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: Configure all the devices of the MRP-Ring individually. Before you connect the redundant line, you must complete the configuration of all the devices of the MRP-Ring. You thus avoid loops during the configuration phase.

- ☐ Set up the network to meet your requirements.
- ☐ 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

- ☐ 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 switched off

not connected: this port has no link.

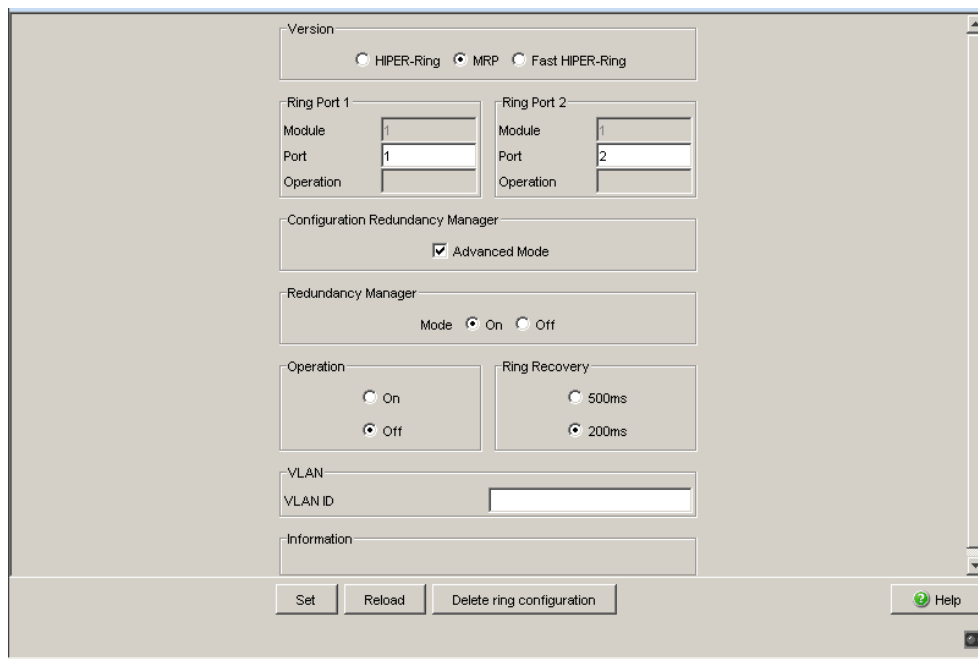


Figure 12: Ring Redundancy dialog (RSR20, RSR30, MACH 1000)

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

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

Note: Settings in the “Ring Recovery” frame are only effective for devices that you have 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 on “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 can fail, whereby the redundant line will then take over the function of the failed line.
- “Configuration failure”: The function is incorrectly configured or there is an error in the ring port connection.

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.
Note the VLAN configuration of the ring ports. Select VLAN ID 1 and VLAN membership 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.
Enter this VLAN ID in the MRP-Ring configuration for all devices in this MRP-Ring.
Note the VLAN configuration of the ring ports. For all ring ports in this MRP-Ring, select this VLAN ID and the VLAN membership Tagged in the static VLAN table.

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 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
```

```
configure
```

```
mrp new-domain default domain
```

Switch to the Privileged EXEC mode.

Switch to the Configuration mode.

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
(Default MRP domain)

mrp current-domain          Define port 1 in module 1 as ring port 1 (primary).
port primary 1/1

Primary Port set to 1/1

mrp current-domain          Define port 2 in module 1 as ring port 2 (second-
port secondary 1/2          ary).

Secondary Port set to 1/2

mrp current-domain mode     Define this device as the ring manager.
manager

Mode of Switch set to Manager

mrp current-domain recovery- Define 200ms as the value for the "Ring Recov-
delay 200ms                 ery".

Recovery delay set to 200ms

mrp current-domain advanced- Activate the "MRP Advanced Mode".
mode enable

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
(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..... 200ms
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 two devices to the ends of the line using their ring ports.

3.3 Example of Fast HIPER-Ring

This example can be set up with models RSR20, RSR30 and MACH 1000. 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 require a very short switching time in a redundancy case (about 10 ms). Only RSR20/RSR30 and MACH 1000 devices are being used, so you decide on the Fast HIPER-Ring as the ring redundancy protocol. You use ports 1 and 2 in module 1 of the devices to connect the lines.

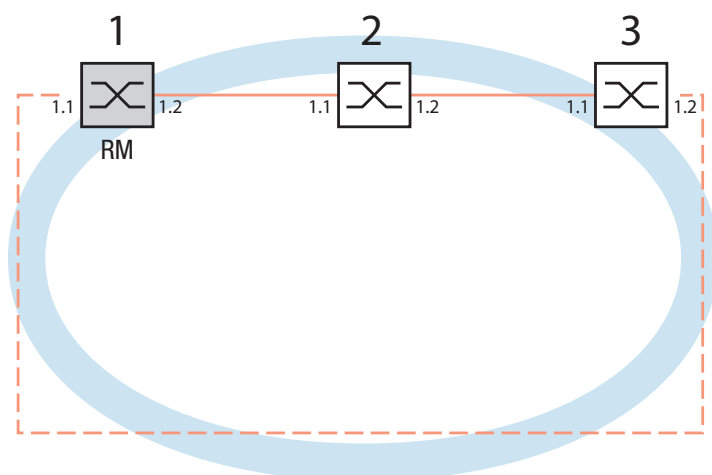


Figure 13: Example of Fast HIPER-Ring

RM = Ring Manager

— main line

- - - redundant line

The following example configuration describes the configuration of the ring manager device (1). The two other devices (2 to 3) are configured in the same way, but without activating the ring manager function. A VLAN is not used for this example.

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

- ☐ Set up the network to meet your requirements.
- ☐ 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 `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 switched off

not connected: this port has no link.

Figure 14: Ring Redundancy dialog (RSR20, RSR30, MACH 1000)

- ☐ 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 on “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 ring manager.

Display begins with 100 μs , in steps of 100 μs . Values of 1000 μs and greater indicate that the stability of the ring is in danger. 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 can fail, whereby the redundant line will then take over the function of the failed line.
- “Configuration failure”: The function is incorrectly configured or there is an error in the ring port connection.

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).
Note the VLAN configuration of the ring ports. Select VLAN ID 1 and VLAN membership 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.
Select this VLAN ID in the Fast HIPER-Ring configuration for all devices in this Fast HIPER-Ring.
Note the VLAN configuration of the ring ports. For all ring ports in this Fast HIPER-Ring, select this VLAN ID and the VLAN membership Tagged in the static VLAN table.

Note: If you want to configure a Fast HIPER-Ring using the **Command Line Interface (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 1-2147483647 ($2^{31} - 1$). 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	Create a new Fast HIPER-Ring with the default
default-id	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      Define this device as the ring manager.
mode ring-manager
Mode of Switch set to Ring Manager
fast-hiper-ring current-id      Define the number of devices in the Fast HIPER-
nodes 3                         Ring as 3.
Number of nodes set to 3
fast-hiper-ring current-id      Activate the Fast HIPER-Ring.
operation enable
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 the Spanning Tree and the 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 two devices to the ends of the line using their ring ports.

4 Sub-Ring (RSR20, RSR30, MACH1000)

The Sub-Ring concept enables you to easily couple new network segments to suitable devices in existing redundancy rings (basis ring). The devices of the basis ring to which the new Sub-Ring is being coupled are known as Sub-Ring Managers (SRM).

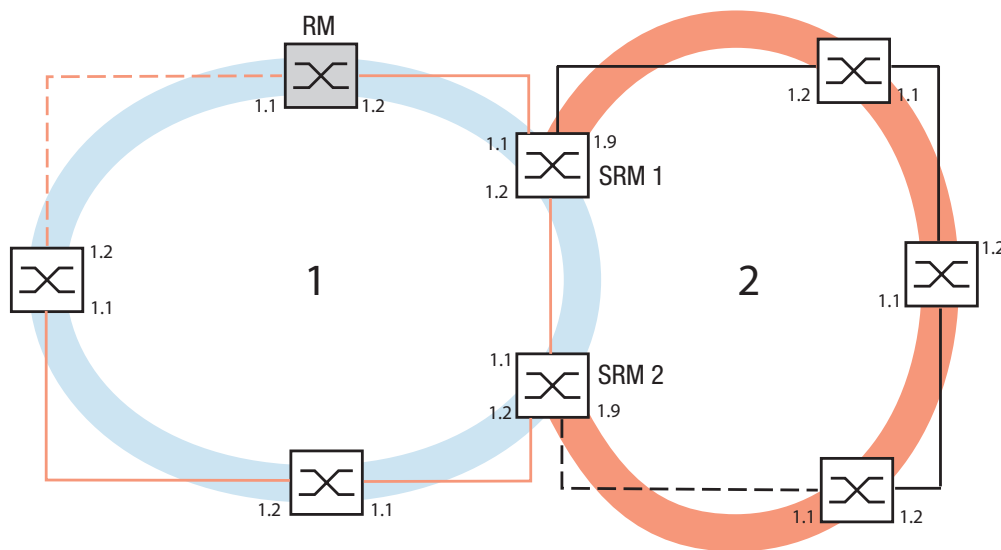


Figure 15: Example of a Sub-Ring structure

1 Blue ring = basis ring

2 Orange ring = Sub-Ring

SRM = Sub-Ring Manager

RM = Ring Manager

Note: The following devices support the Sub-Ring Manager function:

- RSR20/RSR30
- MACH 1000

In a Sub-Ring, you can integrate all devices that support MRP.

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:

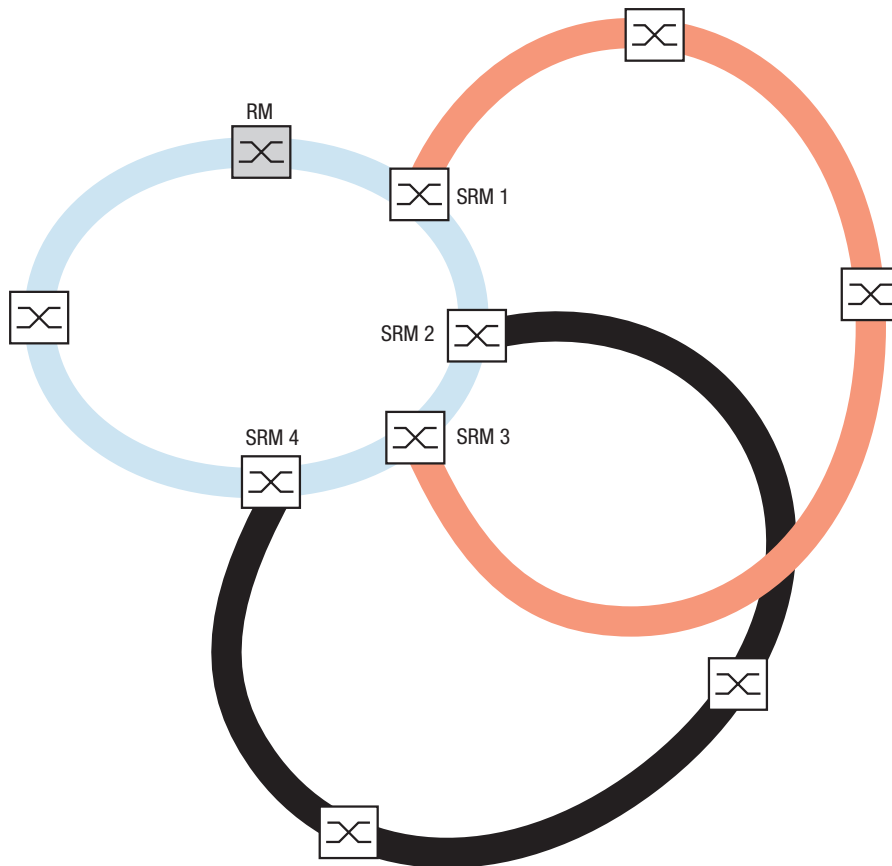


Figure 16: Example of an overlapping Sub-Ring structure

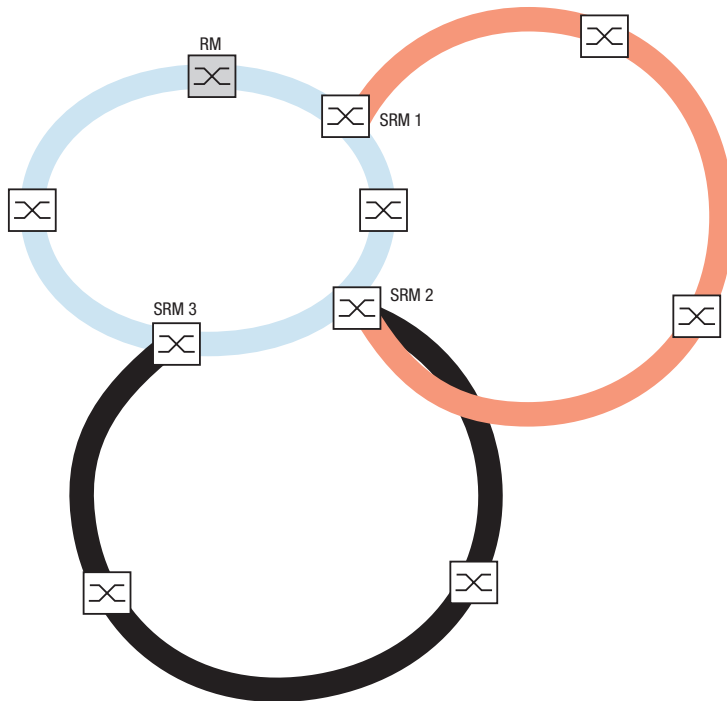


Figure 17: Special case: a Sub-Ring Manager is managing 2 Sub-Rings (2 instances). Depending on the device type, you can configure additional instances.

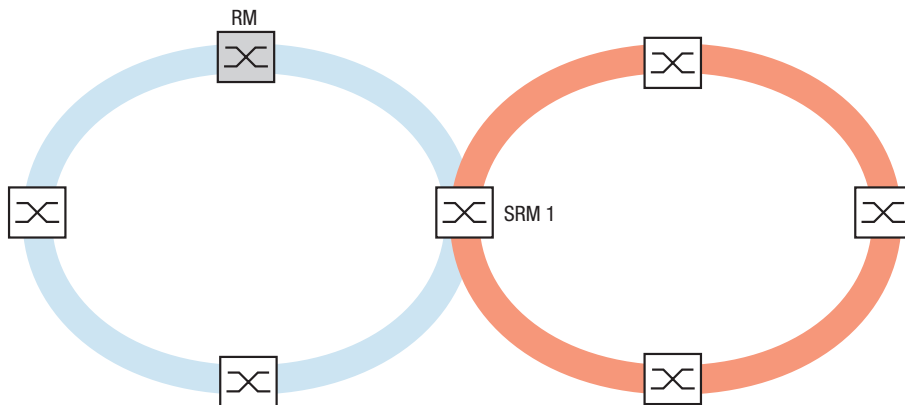


Figure 18: Special case: a Sub-Ring Manager is managing the start and the end of a Sub-Rings at different ports (Single Sub-Ring Manger).

Note: Only connect Sub-Rings to existing basis rings. Do not cascade Sub-Rings.

Note: Sub-Rings use MRP. You can couple Sub-Rings to existing basis rings with the HIPER-Ring protocol, the Fast HIPER-Ring protocol and MRP.

When you couple a Sub-Ring to a basis ring under MRP, you configure both rings in different VLANs. You configure

- ▶ either the Sub-Ring ports of the Sub-Ring Manager 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 basis ring, including the basis ring ports of the Sub-Ring Manager, in a separate VLAN. This reduces the configuration work when you are coupling multiple Sub-Rings to a basis ring.

4.1 Example configuration

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

4.1.1 Example description

You want to couple a new network segment with 3 devices to an existing redundant ring with the HIPER-Ring protocol. Do not couple the network segment to just one end, but rather to both ends, thus providing increased redundancy reliability with the corresponding configuration.

The new segment thus becomes a Sub-Ring. It is coupled to existing devices of the basis ring of the type RSR20, RSR30 or MACH 1000. You also configure these devices as Sub-Ring Managers in accordance with the new task.

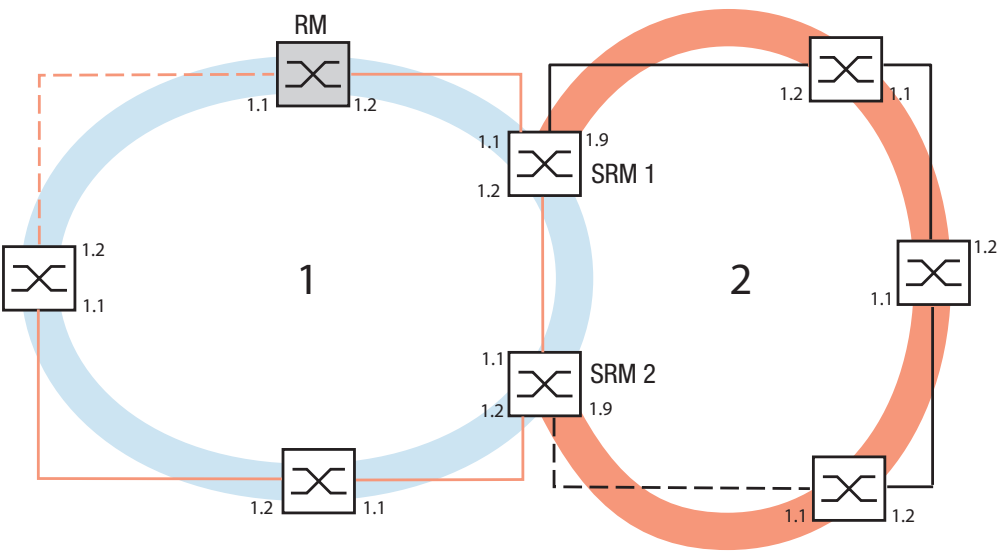


Figure 19: Example of a Sub-Ring structure
1 Blue ring = basis ring
2 Orange ring = Sub-Ring
SRM = Sub-Ring Manager
RM = Ring Manager

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 5):

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

- You define different VLAN membership for the basis ring and the Sub-Ring even if the basis ring is using the MRP protocol.
- 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.
- Do not configure link aggregation.
- Switch RSTP off for the MRP-Ring ports used in the Sub-Ring.
- Assign the same MRP domain ID to all devices. If only Hirschmann Automation and Control GmbH devices are being used, the default value for the MRP domain ID can be used.

Note: The MRP domain ID is a sequence of 16 number blocks (value range 0 to 255). The default domain is an MRP domain ID of 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 it is necessary to adjust the MRP domain ID, you open the Command Line Interface (CLI) and proceed as follows:

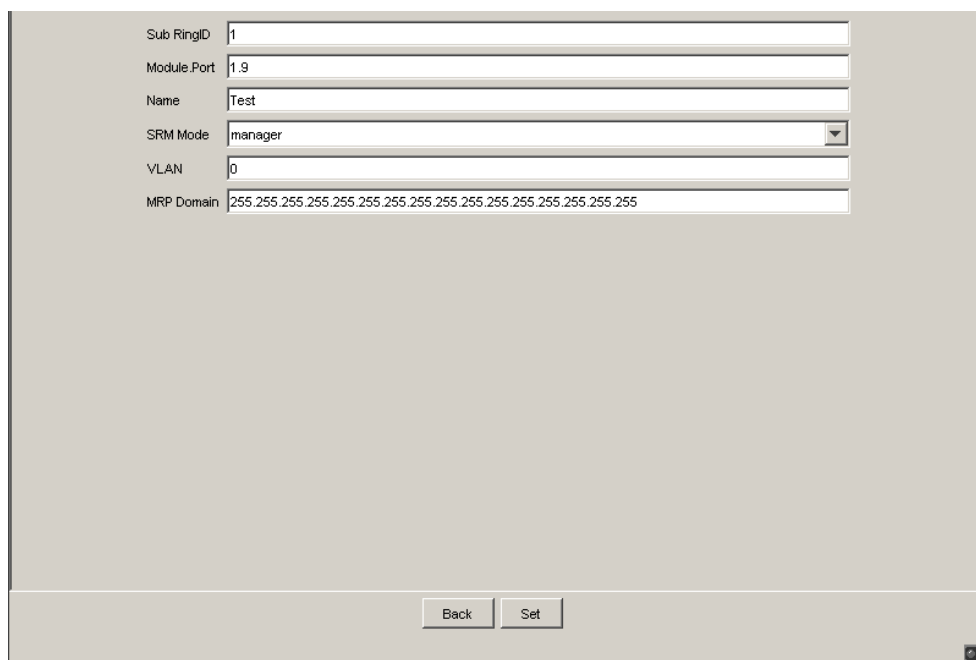
<code>enable</code>	Switch to the Privileged EXEC mode.
<code>configure</code>	Switch to the Configuration mode.
<code>mrp delete domain current domain</code>	Deletes the current MRP domain. If no MRP domain exists, an error message appears.
MRP current domain deleted:Domain ID: 255.255.255.255.255.255.255.255.255.255.255.255.255.255.255.255 (Default MRP domain)	
<code>mrp new domain</code> <code>0.0.1.1.2.2.3.4.4.111.222.123.0.0.66.99</code>	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	

4.1.2 Sub-Ring configuration

Note: Avoid loops during the configuration phase. 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.

Proceed as follows to configure the two Sub-Ring Managers of the example constellation:

- ☐ Select the Redundancy: Sub-Ring dialog.
- ☐ Click on “Create”.



The screenshot shows a 'Sub-Ring - New Entry' dialog box. It has the following fields and values:

Field	Value
Sub RingID	1
Module.Port	1.9
Name	Test
SRM Mode	manager
VLAN	0
MRP Domain	255.255.255.255.255.255.255.255.255.255.255.255.255.255.255

At the bottom of the dialog are two buttons: 'Back' and 'Set'.

Figure 20: 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 basis 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 basis 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) as they are. The example configuration does not require any change here.
- ☐ Click on “Set” to temporarily save the entry in the configuration.
- ☐ Click on “Back” to return to the Sub-Ring dialog.

```
enable
configure
sub-ring new-ring 1
Sub-Ring ID created:ID: 1
sub-ring 1 port 1/9
Port set to 1/9
sub-ring 1 ring-name Test
Sub-Ring Ring name set to
sub-ring 1 mode manager

Mode of Switch set to man
```

Switch to the Privileged EXEC mode.

Switch to the Configuration mode.

Creates a new Sub-Ring with the Sub-Ring ID 1.

Defines port 9 in module 1 as the Sub-Ring port.

Assigns the name "Test" to Sub-Ring 1

Configures the mode of this Sub-Ring Manager as “manager”.

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

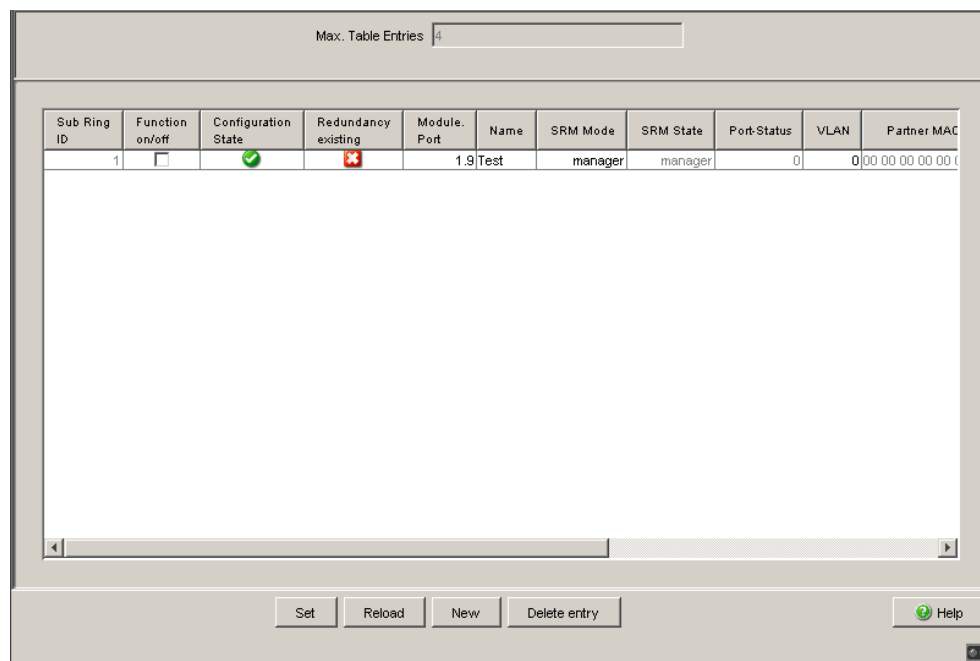


Figure 21: Completely configured Sub-Ring Manager

- ☐ 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 “Operation on/off” in the overview of the Sub-Ring dialog.
- ☐ Click on “Set” to temporarily save the entry in the configuration.
- ☐ Select the dialog
Basic Settings:Load/Save.
- ☐ In the “Save” frame, select “On device” for the location and click on “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.....
255.255.255.255.255.255.255.255.255.255.255.255.255.255Ri
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        Save the current configuration to the non-volatile
nvram:start-up-config              memory.
```

- ☐ When you have configured both Sub-Ring Managers and, if applicable, the devices included in the Sub-Ring, you close the redundant line of the Sub-Ring.

5 Ring/Network coupling

This device allows the redundant coupling of redundant rings and network segments. Two rings/network segments are connected via two separate paths.

The ring/network coupling supports the following devices:

- ▶ RS2-./.
- ▶ RS2-16M
- ▶ RS20, RS30, RS40
- ▶ OCTOPUS
- ▶ MICE (from rel. 3.0)
- ▶ Power MICE
- ▶ MS20, MS30
- ▶ RSR20, RSR30
- ▶ MACH 100
- ▶ MACH 1000
- ▶ MACH 3000 (from rel. 3.3),
- ▶ MACH 4000

5.1 Variants of the ring/network coupling

The redundant coupling is effected by the **one-Switch coupling** of two ports **of one** device in the first ring/network to one port each of two devices in a second ring/network segment ([see fig. 23](#)).

Immediately after the main line fails, the device opens the redundant line. When the main line is OK again, the main line is opened again and the redundant line is blocked again.

An error is detected and eliminated within 500 ms (typically 150 ms).

The redundant coupling is effected by the **two-Switch coupling** of one port each on **two** devices in the first ring/network to one port each of two devices in the second ring/network segment ([see fig. 29](#)).

The device in the redundant line and the device in the main line use control packets to inform each other about their operating states, via the Ethernet or the control line.

Immediately after the main line fails, the redundant device opens the redundant line. As soon as the main line is OK again, the device in the main line informs the redundant device. The main line is opened again, and the redundant line is blocked again.

An error is detected and eliminated within 500 ms (typically 150 ms).

The type of coupling primarily depends on the topological conditions and the desired level of safety ([see table 6](#)).

	One-Switch coupling	Two-Switch coupling	Two-Switch coupling with control line
Application	The two devices are in impractical topological positions. Therefore, putting a line between them would involve a lot of work for two-Switch coupling.	The two devices are in practical topological positions. Putting down a control line would involve a lot of work.	The two devices are in practical topological positions. Putting down a control line would not involve much work.
Disadvantage	If the Switch configured for the redundant coupling fails, no connection remains between the networks.	Much work involved in connecting the two devices to the network (compared with one-Switch coupling).	Much work involved in connecting the two devices to the network (compared with one-Switch and two-Switch coupling).
Advantage	Less work involved in connecting the two devices to the network (compared with two-Switch coupling).	If one of the devices configured for the redundant coupling fails, there is still a connection between the networks.	If one of the devices configured for the redundant coupling fails, there is still a connection between the networks.

Table 6: Selection criteria for the variants of the redundant coupling

Note: The choice of configuration primarily depends on the topological conditions and the desired level of security ([see table 6](#)).

5.2 Preparing a Ring/Network coupling

5.2.1 STAND-BY switch

The 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, this switch is a DIP switch or a software switch (Redundanz:Ring/Network Coupling dialog). By setting this switch, you define whether the device has the main coupling or the redundant coupling within a Ring/Network coupling.

Device type	STAND-BY switch type
RS2-./.	DIP switch
RS2-16M	DIP switch
RS20/RS30/RS40	Can be switched between DIP switch and software switch
MICE/Power MICE	Can be switched between DIP switch and software switch
MS20/MS30	Can be switched between DIP switch and software switch
OCTOPUS	Software switch
RSR20/RSR30	Software switch
MACH 100	Software switch
MACH 1000	Software switch
MACH 3000/MACH 4000	Software switch

Table 7: 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 8](#)):

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. If you have set the software configuration, changing the other DIP switches has no effect.
Software switch	In the Redundancy:Ring/Network Coupling dialog

Table 8: 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. 22).

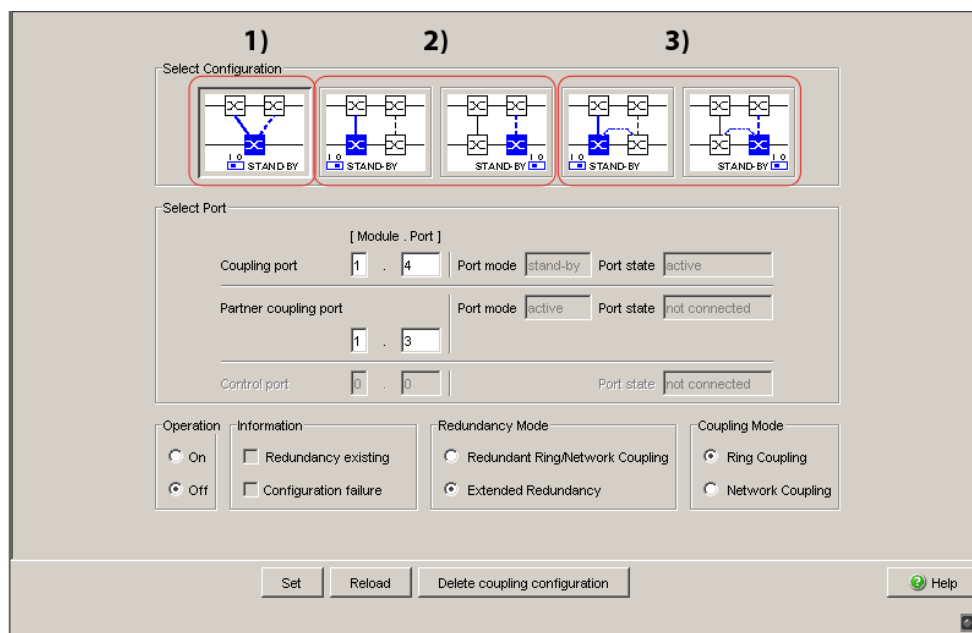


Figure 22: Selecting the configuration

Depending on the STAND-BY DIP switch position, the dialog displays those configurations that are not possible in gray. If you want to select one of these grayed-out configurations, you put the STAND-BY DIP switch on the Switch into the other position.

One-Switch coupling

Assign the device the DIP switch setting “STAND-BY”, or use the software configuration to assign the redundancy function to it.

Two-Switch coupling

Assign the device in the redundant line the DIP switch setting “STAND-BY”, or use the software configuration to assign the redundancy function to it.

Note: For redundancy security reasons, the combination of Rapid Spanning Tree and Ring/Network Coupling is not possible.

5.2.2 One-Switch coupling

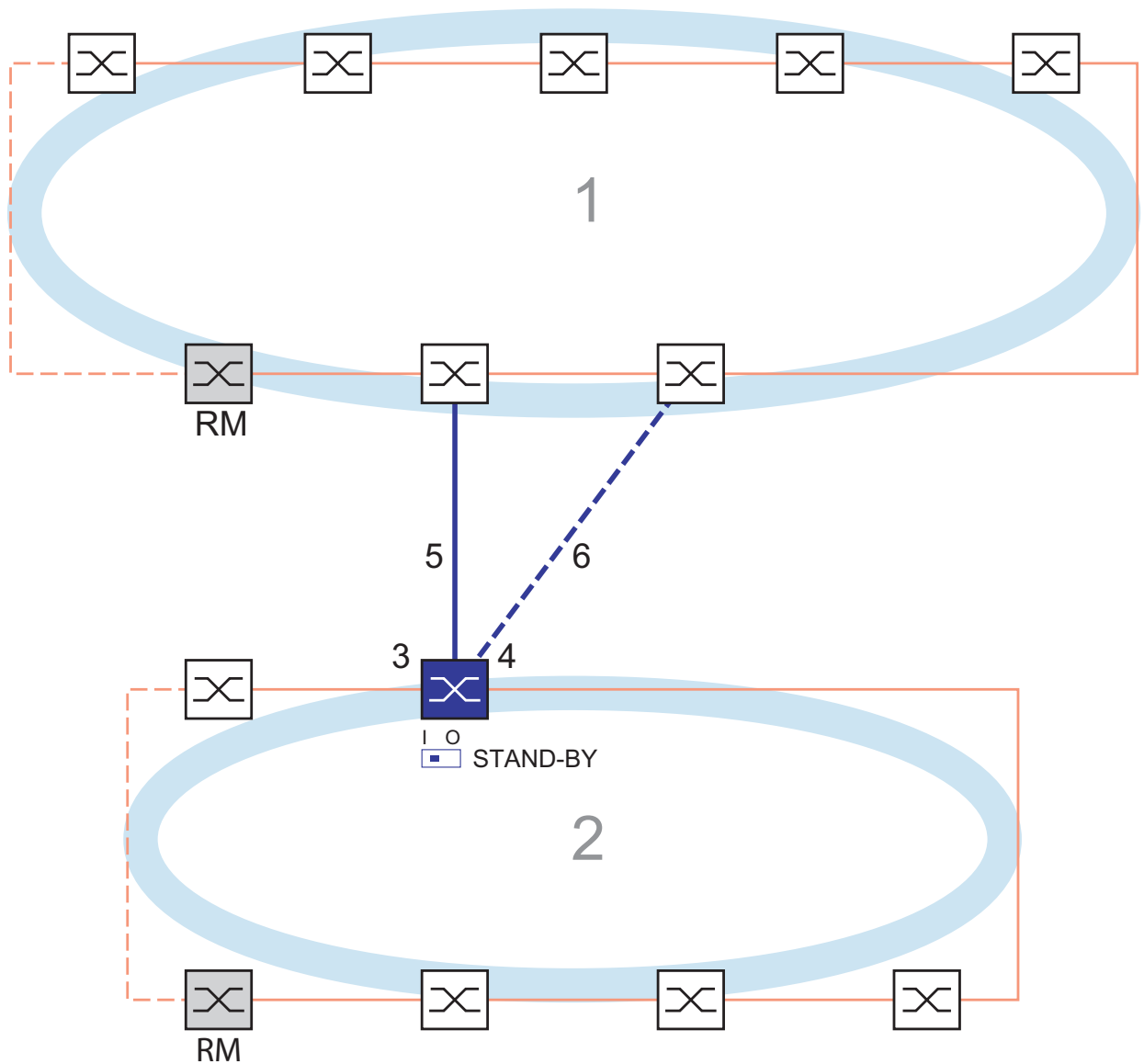


Figure 23: Example of one-Switch coupling

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

The coupling between two networks is effected by the main line (thick blue line), which is connected to the partner coupling port. If the main line fails, the redundant line (thick blue dotted line), which is connected to the coupling port, takes over coupling the two networks. The coupling is effected by **one** Switch.

- ☐ Select the Redundancy:Ring/Network Coupling dialog.
- ☐ Select one-Switch coupling (see fig. 24).

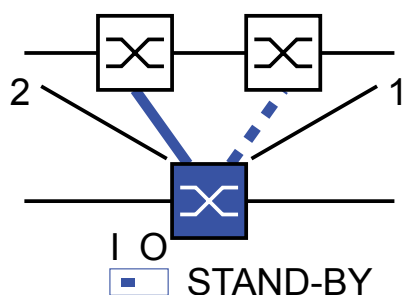


Figure 24: One-Switch-coupling
 1: Coupling port
 2: Partner coupling port

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

- ☐ Select the partner coupling port (see fig. 25), (see table 9).
 With "Partner coupling port" you specify at which port you are connecting the control 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
RS2-./.	Not possible	Not possible
RS2-16M	All ports (default setting: port 2)	All ports (default setting: port 1)
RS20, RS30, RS40	All ports (default setting: port 1.3)	All ports (default setting: port 1.4)
OCTOPUS	All ports (default setting: port 1.3)	All ports (default setting: port 1.4)
MICE	All ports (default setting: port 1.3)	All ports (default setting: port 1.4)
Power MICE	All ports (default setting: port 1.3)	All ports (default setting: port 1.4)
MS20	All ports (default setting: port 1.3)	All ports (default setting: port 1.4)
MS30	All ports (default setting: port 2.3)	All ports (default setting: port 2.4)
RSR20/30	All ports (default setting: port 1.3)	All ports (default setting: port 1.4)
MACH 100	All ports (default setting: port 2.3)	All ports (default setting: port 2.4)
MACH 1000	All ports (default setting: port 1.3)	All ports (default setting: port 1.4)
MACH 3000	All ports	All ports
MACH 4000	All ports (default setting: port 1.3)	All ports (default setting: port 1.4)

Table 9: Port assignment for one-Switch coupling

Note: Configure the partner coupling port and the HIPER-Ring ports on different ports.

- ☐ Select the coupling port (see fig. 25), (see table 9).
With “Coupling port” you specify at which port you are connecting the redundant line.

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

- ☐ Activate the function in the “Operation” frame (see fig. 31).
- ☐ You now connect the redundant line.

The displays in the “Select port” frame mean (see fig. 25):

- “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. 25):

- “Redundancy existing”: One of the lines affected can fail, as a redundant line will then take over the function of the failed line.
- “Configuration failure”: The function is incomplete or incorrectly configured.

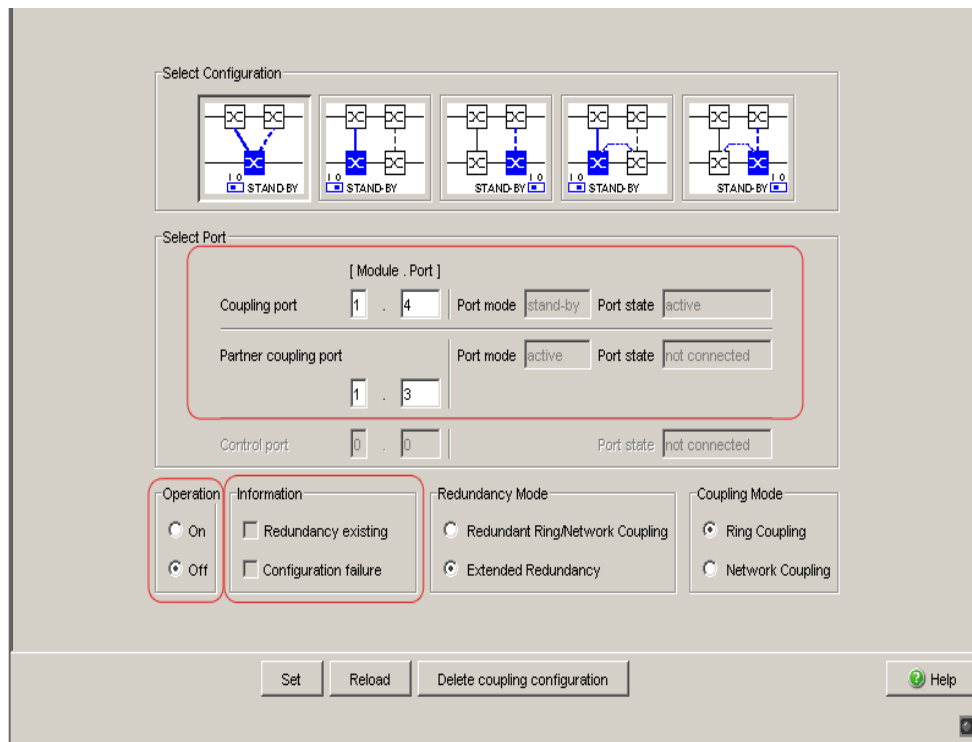


Figure 25: Selecting the port and enabling/disabling operation

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
for glass fiber connections

Note: If VLANs are configured, note the VLAN configuration of the coupling and partner coupling ports.

In the Network/Ring Coupling configuration, select for the coupling and partner coupling ports

- VLAN ID 1 and “Ingress Filtering” disabled in the port table and
- VLAN membership $\cup$ in the static VLAN table.

Redundancy mode

- ☐ In the “Redundancy Mode” frame, select (see fig. 26)
 - “Redundant Ring/Network Coupling” or
 - “Extended Redundancy”.

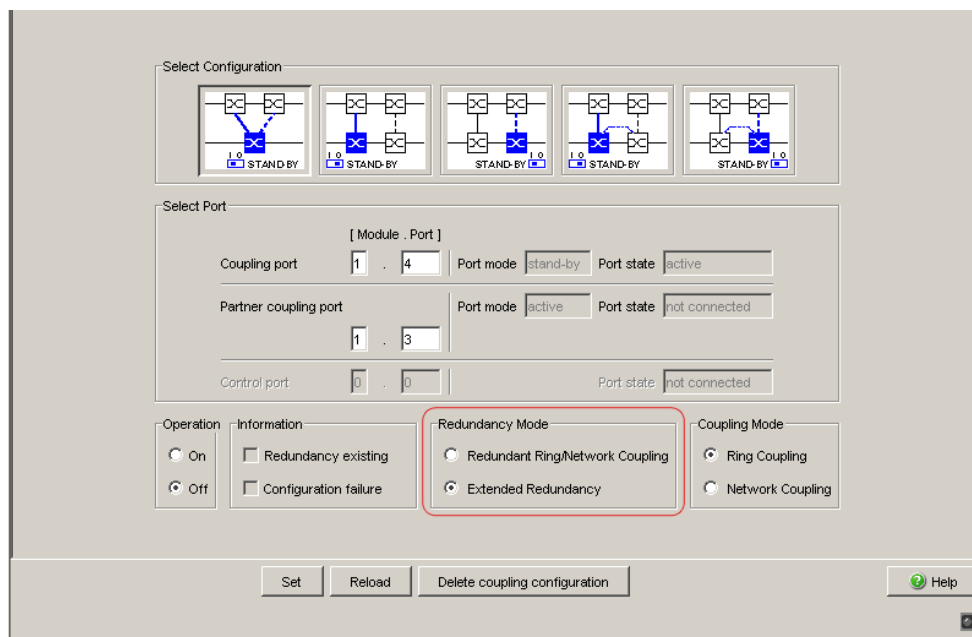


Figure 26: Selecting the redundancy mode

With the “Redundant Ring/Network Coupling” setting, either the main line or the redundant line is active. Both lines are never active simultaneously.

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 network fails (see fig. 27).

During the reconfiguration period, there may be package duplications. Therefore, only select this setting if your application detects package duplications.

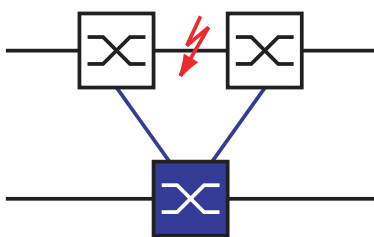


Figure 27: Extended redundancy

Coupling mode

The coupling mode indicates the type of the connected network.

□ In the “Coupling Mode” frame, select (see fig. 28)

- “Ring Coupling” or
- “Network Coupling”

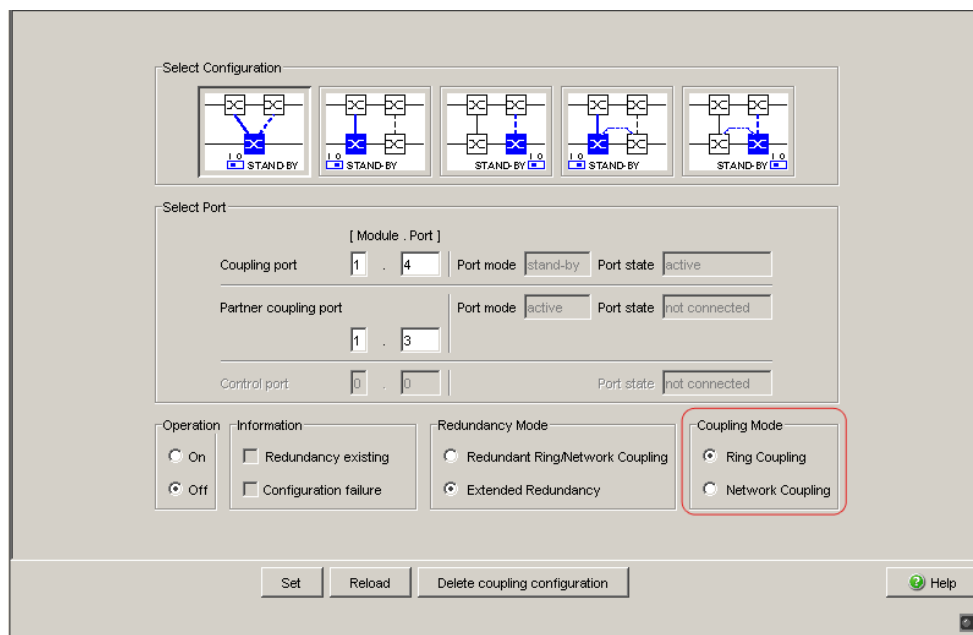


Figure 28: Selecting the coupling mode

- ☐ Select **“Ring coupling”** if you are connecting a redundancy ring.
- ☐ Select **“Network Coupling”** if you are connecting a line 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.

5.2.3 Two-Switch coupling

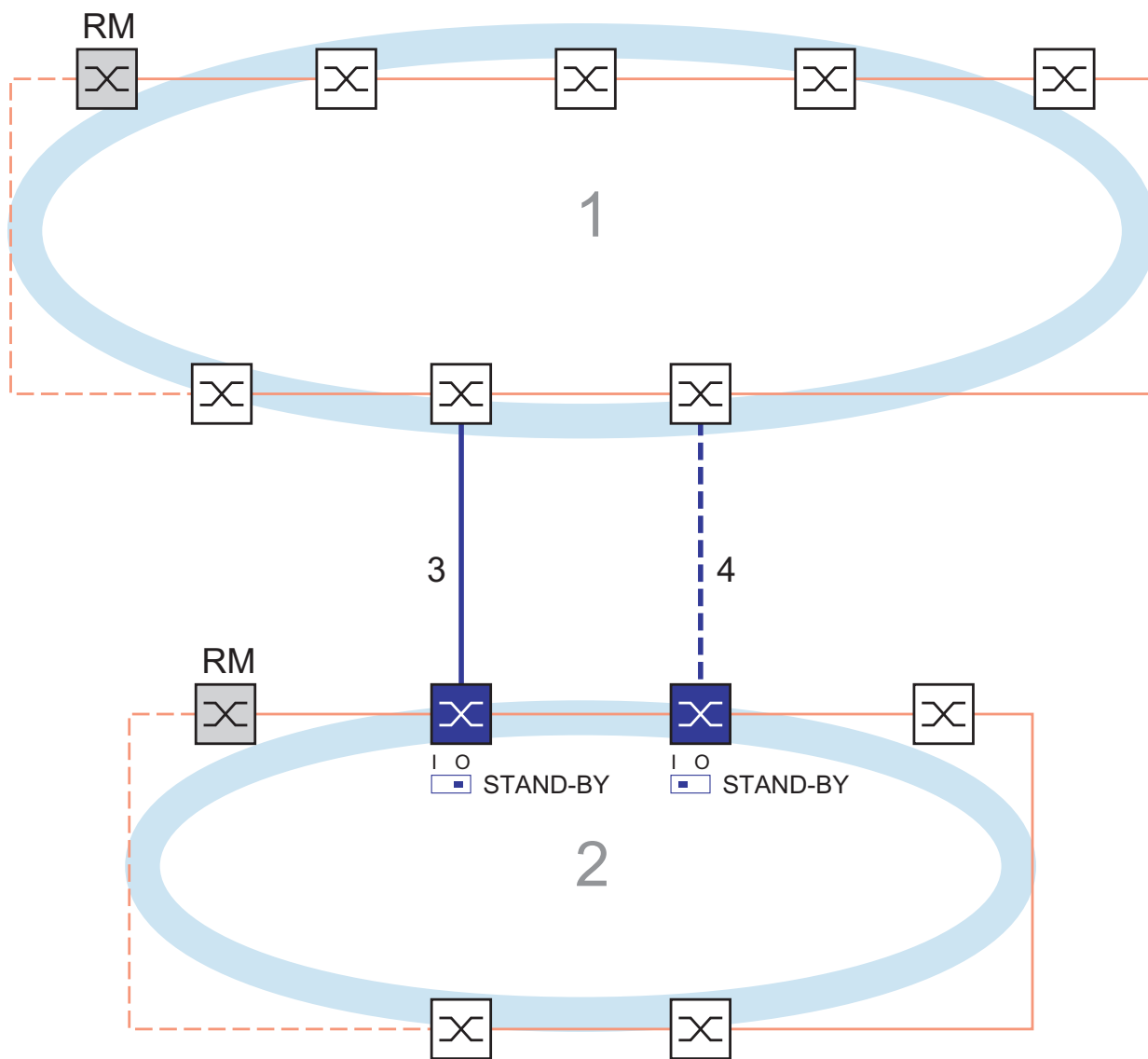


Figure 29: Example of two-Switch coupling

1: Backbone

2: Ring

3: Main line

4: Redundant line

The coupling between two networks is effected by the main line (thick blue line). If the main line fails, the redundant line (thick blue dotted line) takes over coupling the two networks.

The coupling is effected by two Switches.

The switches send their control packages via the Ethernet.

The Switch to which you connect the main line, and the Switch to which you connect the redundant line, are partners as regards the coupling.

☐ Connect the two partners via their ring ports.

☐ Select the Redundancy:Ring/Network Coupling dialog.

☐ Select two-Switch main coupling (see fig. 30).

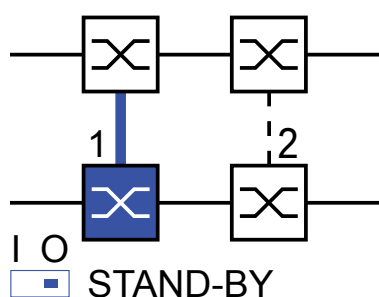


Figure 30: Two-Switch coupling

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. 25), (see table 9).

With “Coupling port” you specify at which port you are connecting the redundant line.

☐ If the STANDBY DIP switch is OFF, connect the main line to the coupling port.

Device	Coupling port
RS2-./.	Not possible
RS2-16M	Adjustable for all ports (default setting: port 1)
RS20, RS30, RS40	Adjustable for all ports (default setting: port 1.4)
OCTOPUS	Adjustable for all ports (default setting: port 1.4)
MICE	Adjustable for all ports (default setting: port 1.4)
Power MICE	Adjustable for all ports (default setting: port 1.4)
MS20	Adjustable for all ports (default setting: port 1.4)
MS30	Adjustable for all ports (default setting: port 2.4)
RSR20/30	Adjustable for all ports (default setting: port 1.4)
MACH 100	Adjustable for all ports (default setting: port 2.4)
MACH 1000	Adjustable for all ports (default setting: port 1.4)
MACH 3000	Adjustable for all ports
MACH 4000	Adjustable for all ports (default setting: port 1.4)

Table 10: 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. 31).
- ☐ You now connect the redundant line.

The displays in the “Select port” frame mean (see fig. 31):

- “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. 38):

- “Redundancy existing”: One of the lines affected can fail, as a redundant line will then take over the function of the failed line.
- “Configuration failure”: The function is incomplete or incorrectly configured.

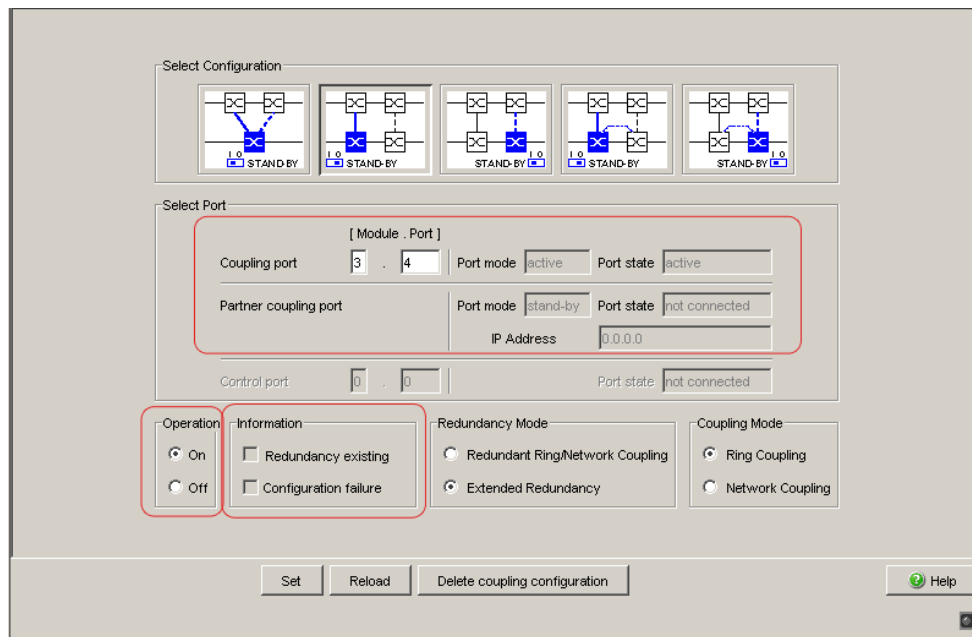


Figure 31: Selecting the port and enabling/disabling operation

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

- switch off 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
for glass fiber connections

Note: If VLANs are configured, note the VLAN configuration of the coupling and partner coupling ports.

In the Network/Ring Coupling configuration, select for the coupling and partner coupling ports

- VLAN ID 1 and “Ingress Filtering” disabled in the port table and
- VLAN membership U in the static VLAN table.

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

- ☐ Select two-Switch redundant coupling (see fig. 33).

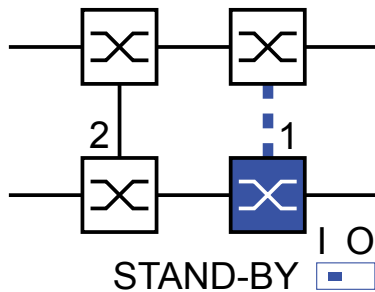


Figure 32: Two-Switch coupling

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. 31), (see table 9).
With “Coupling port” you specify at which port you are connecting the network segments.
- ☐ If the STANDBY DIP switch is ON, connect the main 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. 31).

The displays in the “Select port” frame mean (see fig. 31):

- “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. 31):

- “Redundancy existing”: One of the lines affected can fail, as a redundant line will then take over the function of the failed 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
for glass fiber connections

Note: If VLANs are configured, note the VLAN configuration of the coupling and partner coupling ports.

In the Network/Ring Coupling configuration, select for the coupling and partner coupling ports

- VLAN ID 1 and “Ingress Filtering” disabled in the port table and
- VLAN membership $\cup$ in the static VLAN table.

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

Redundancy mode

- ☐ In the “Redundancy Mode” frame, select [\(see fig. 33\)](#)
- “Redundant Ring/Network Coupling” or
- “Extended Redundancy”.

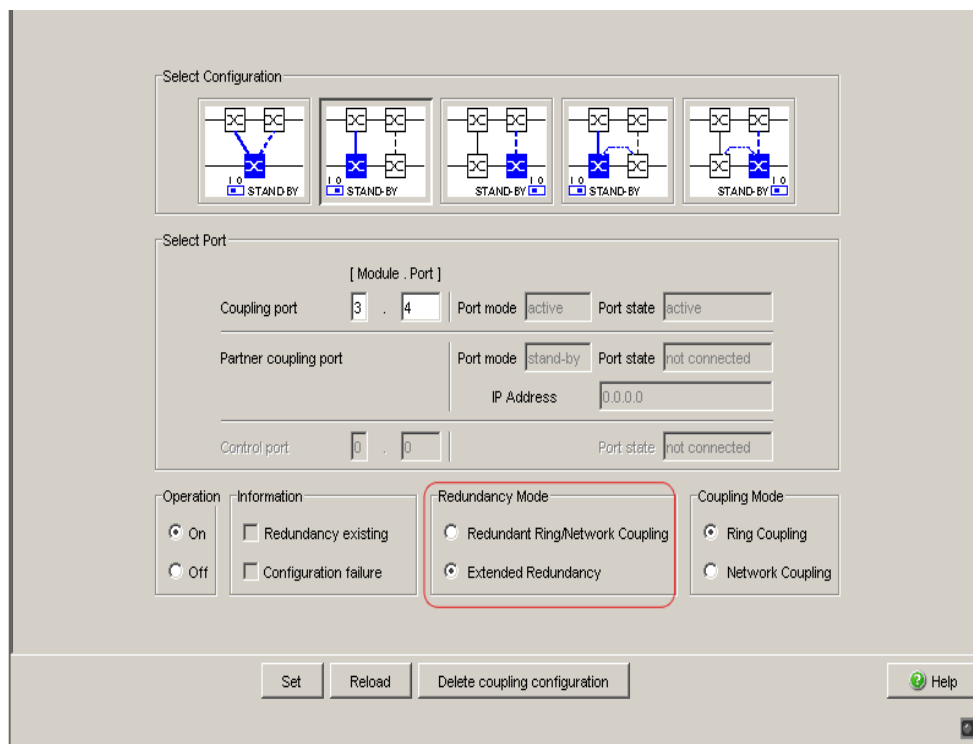


Figure 33: Selecting the redundancy mode

With the “Redundant Ring/Network Coupling” setting, either the main line or the redundant line is active. Both lines are never active simultaneously.

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 network fails (see fig. 27).

During the reconfiguration period, there may be package duplications. Therefore, only select this setting if your application detects package duplications.

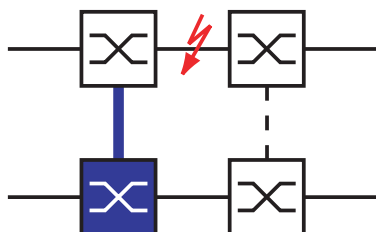


Figure 34: Extended redundancy

Coupling mode

The coupling mode indicates the type of the connected network.

- ☐ In the “Coupling Mode” frame, select (see fig. 35)
 - “Ring Coupling” or
 - “Network Coupling”

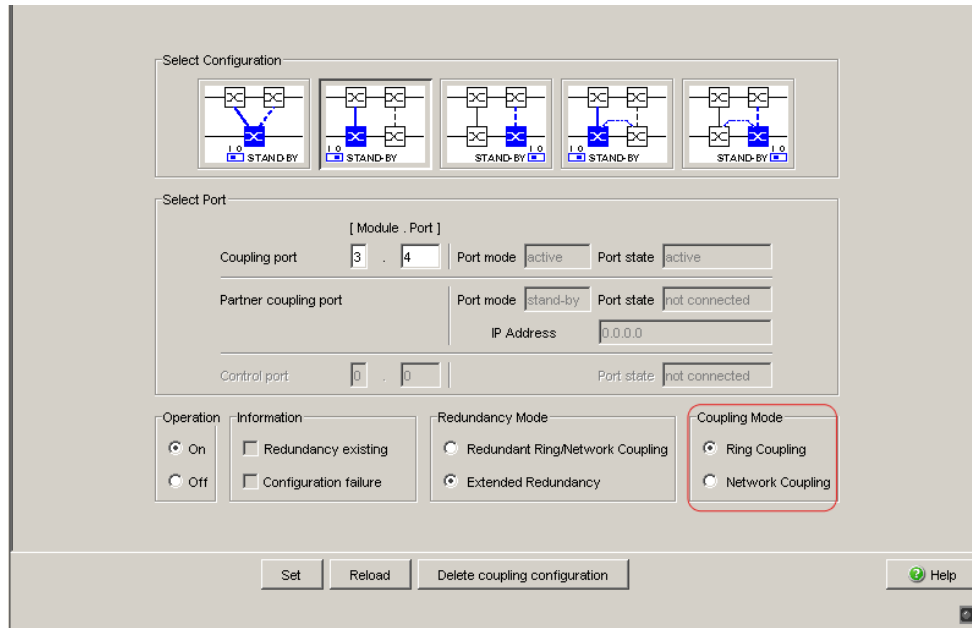


Figure 35: Selecting the coupling mode

- ☐ Select “**Ring coupling**” if you are connecting a redundancy ring.
- ☐ Select “**Network Coupling**” if you are connecting a line 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.

5.2.4 Two-Switch coupling with control line

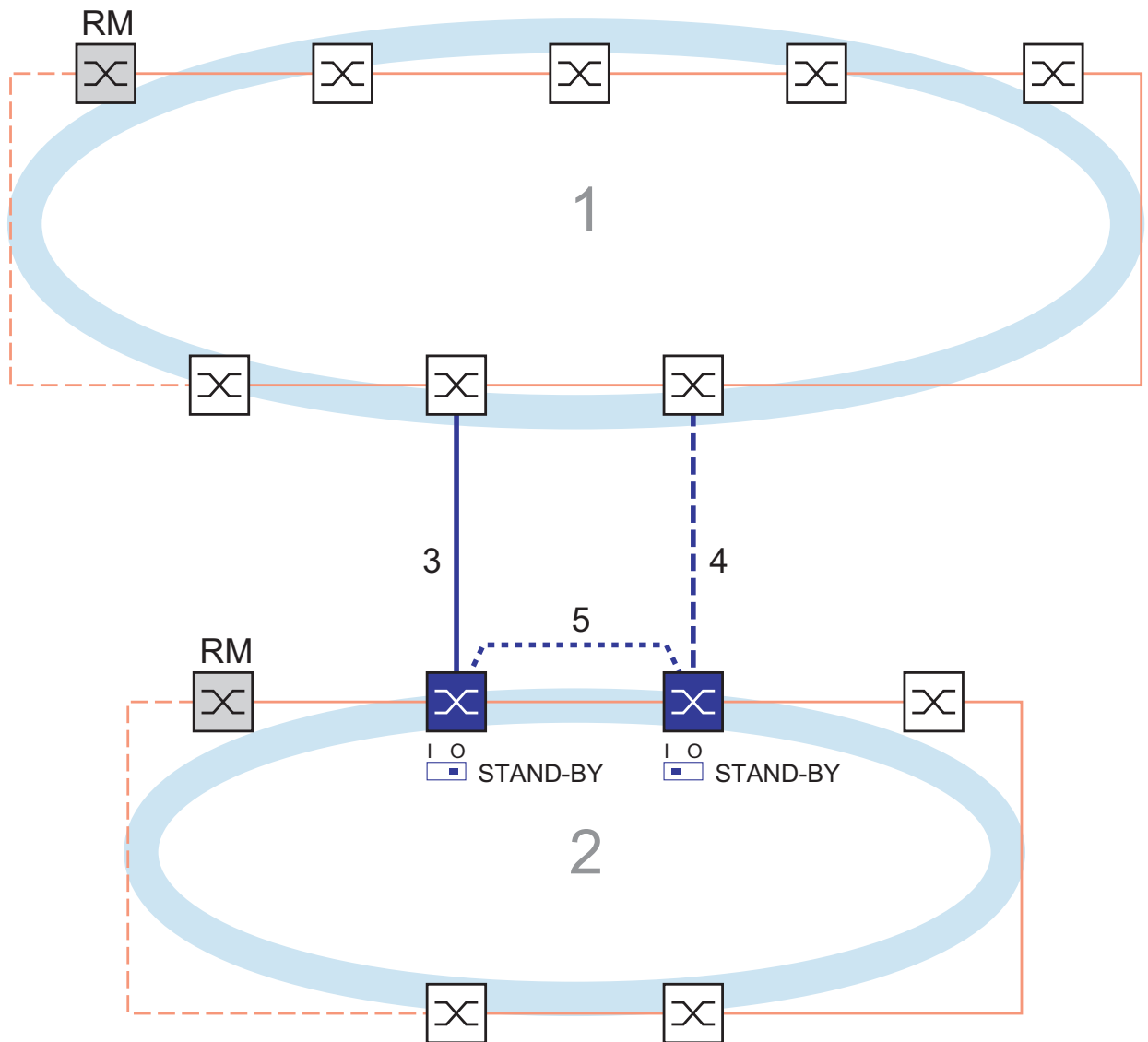


Figure 36: Example of Two-Switch coupling with control line

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

The coupling between two networks is effected by the main line (thick blue line). If the main line fails, the redundant line (thick blue dotted line) takes over coupling the two networks.

The coupling is effected by two Switches.

The Switches send their control packets via a control line.

The device to which you connect the main line, and the device to which you connect the redundant line, are partners as regards the coupling.

☐ Connect the two partners via their ring ports.

☐ Select the Redundancy:Ring/Network Coupling dialog.

☐ Select two-Switch main coupling with control line (see fig. 37).

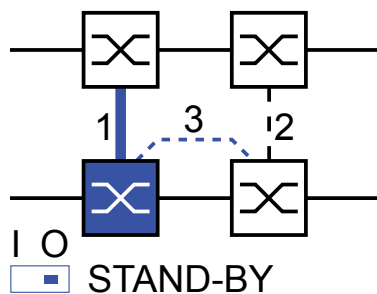


Figure 37: Two-Switch coupling with control line

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. 38), (see table 11).

With “Coupling port” you specify at which port you are connecting the redundant line.

☐ If the STANDBY DIP switch is OFF, connect the main line to the coupling port.

☐ Select the control port (see fig. 38), (see table 11).

With “Control port” you specify at which port you are connecting the control line.

Device	Coupling port	Control port
RS2-./.	Port 1	Stand-by port (can only be combined with RS2-../..)
RS2-16M	Adjustable for all ports (default setting: port 1)	Adjustable for all ports (default setting: port 2)
RS20, RS30, RS40	Adjustable for all ports (default setting: port 1.4)	Adjustable for all ports (default setting: port 1.3)
OCTOPUS	Adjustable for all ports (default setting: port 1.4)	Adjustable for all ports (default setting: port 1.3)
MICE	Adjustable for all ports (default setting: port 1.4)	Adjustable for all ports (default setting: port 1.3)
Power MICE	Adjustable for all ports (default setting: port 1.4)	Adjustable for all ports (default setting: port 1.3)
MS20	Adjustable for all ports (default setting: port 1.4)	Adjustable for all ports (default setting: port 1.3)
MS30	Adjustable for all ports (default setting: port 2.4)	Adjustable for all ports (default setting: port 2.3)
RSR20/RSR30	Adjustable for all ports (default setting: port 1.4)	Adjustable for all ports (default setting: port 1.3)
MACH 100	Adjustable for all ports (default setting: port 2.4)	Adjustable for all ports (default setting: port 2.3)
MACH 1000	Adjustable for all ports (default setting: port 1.4)	Adjustable for all ports (default setting: port 1.3)
MACH 3000	Adjustable for all ports	Adjustable for all ports
MACH 4000	Adjustable for all ports (default setting: port 1.4)	Adjustable for all ports (default setting: port 1.3)

Table 11: 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. 31).
 - ☐ You now connect the redundant line and the control line.
- The displays in the “Select port” frame mean (see fig. 38):
- “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. 38):

- “Redundancy existing”: One of the lines affected can fail, as a redundant line will then take over the function of the failed line.
- “Configuration failure”: The function is incomplete or incorrectly configured.

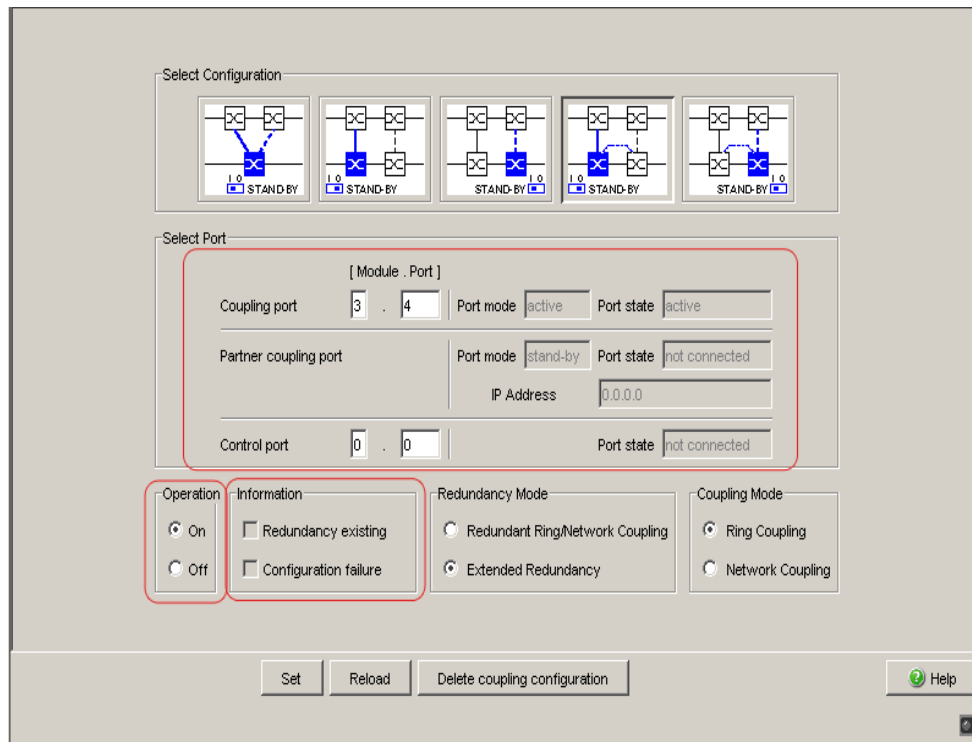


Figure 38: Selecting the port and enabling/disabling operation

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

- switch off 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
for glass fiber connections

Note: If VLANs are configured, note the VLAN configuration of the coupling and partner coupling ports.

In the Network/Ring Coupling configuration, select for the coupling and partner coupling ports

- VLAN ID 1 and “Ingress Filtering” disabled in the port table and
- VLAN membership $\cup$ in the static VLAN table.

- ☐ Select two-Switch redundant coupling with control line (see fig. 39).

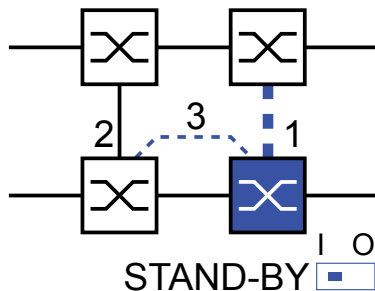


Figure 39: Two-Switch coupling with control line

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. 38), (see table 11).
With “Coupling port” you specify at which port you are connecting the network segments.
- ☐ If the STANDBY DIP switch is ON, connect the main line to the coupling port.
- ☐ Select the control port (see fig. 38), (see table 11).
With “Control port” you specify at which port you are connecting 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. 31).
- ☐ You now connect the redundant line and the control line.

The displays in the “Select port” frame mean (see fig. 38):

- “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. 38):

- “Redundancy existing”: One of the lines affected can fail, as a redundant line will then take over the function of the failed 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
for glass fiber connections

Note: If VLANs are configured, note the VLAN configuration of the coupling and partner coupling ports.

In the Network/Ring Coupling configuration, select for the coupling and partner coupling ports

- VLAN ID 1 and “Ingress Filtering” disabled in the port table and
- VLAN membership $\cup$ in the static VLAN table.

Redundancy mode

- ☐ In the “Redundancy Mode” frame, select (see fig. 40)
 - “Redundant Ring/Network Coupling” or
 - “Extended Redundancy”.

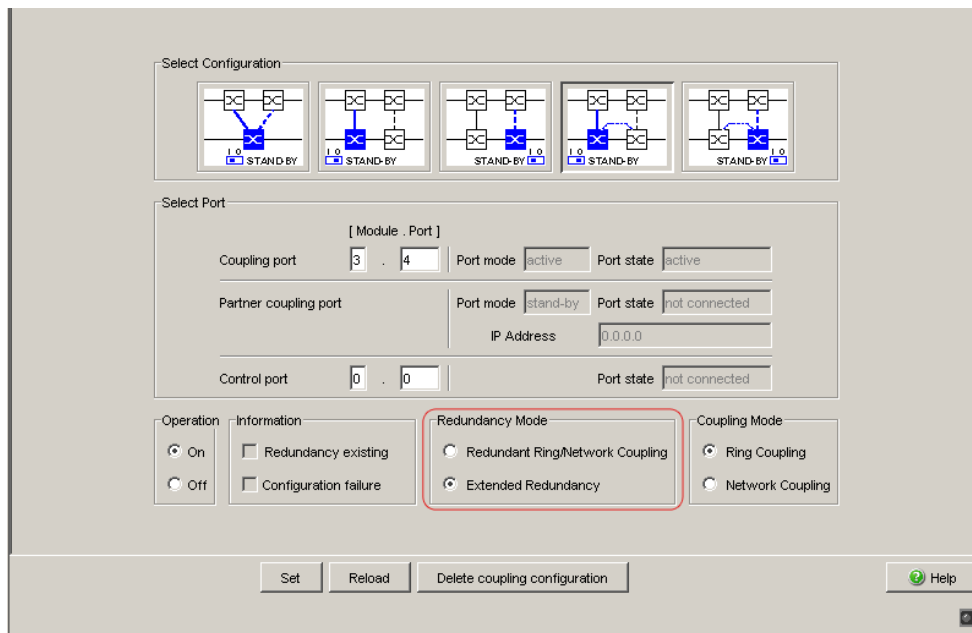


Figure 40: Selecting the redundancy mode

With the “Redundant Ring/Network Coupling” setting, either the main line or the redundant line is active. Both lines are never active simultaneously.

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 network fails (see fig. 27).

During the reconfiguration period, there may be package duplications. Therefore, only select this setting if your application detects package duplications.

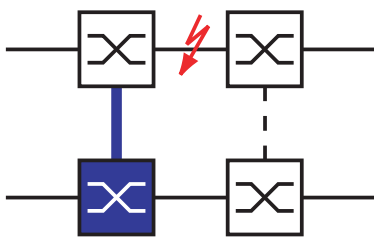


Figure 41: Extended redundancy

Coupling mode

The coupling mode indicates the type of the connected network.

- ☐ In the “Coupling Mode” frame, select (see fig. 42)
 - “Ring Coupling” or
 - “Network Coupling”

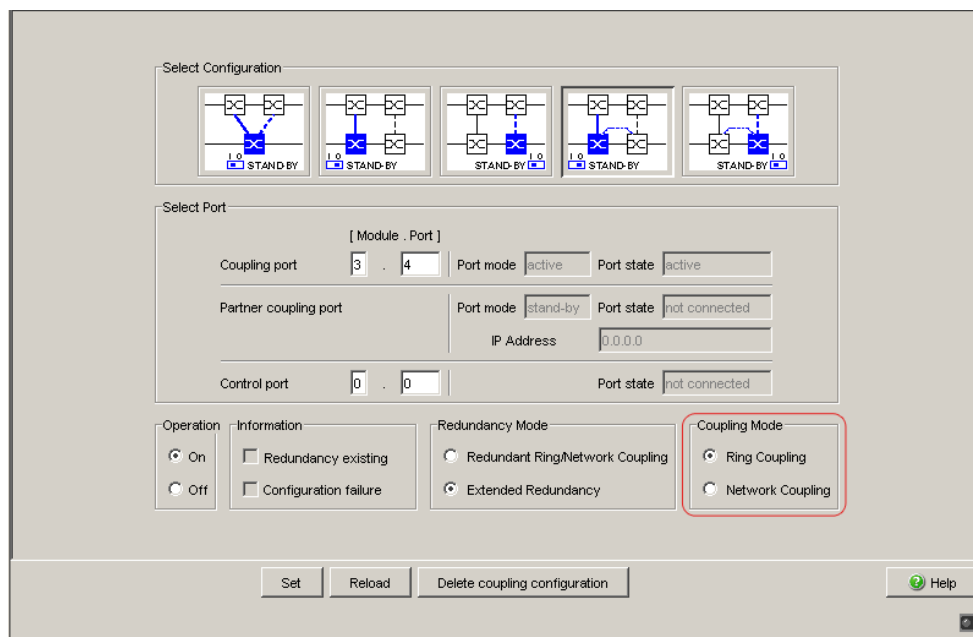


Figure 42: Selecting the coupling mode

- ☐ Select **“Ring coupling”** if you are connecting a redundancy ring.
- ☐ Select **“Network Coupling”** if you are connecting a line 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.

6 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 and thus the total failure of the network. To prevent this, the (Rapid) Spanning Tree Algorithm was developed. The Rapid Spanning Tree Protocol (RSTP) enables redundancy by interrupting loops.

RSTP is a further development of the Spanning Tree Protocol (STP) and is compatible with it. If a connection or a bridge fails, the STP requires a maximum of 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 - 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.

You should note the following here: If the root device fails and another device takes over the root function, the largest possible number of devices decreases accordingly.

When network segments are connected to a MRP ring and you enable MRP compatibility, a peculiarity results. If the root bridge is located inside the MRP ring, the devices inside the MRP ring are combined into one virtual device for the purpose of calculating the branch length.

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. RSTP devices also work in a limited MSTP environment within the scope of their functionality.

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 earlier firmware versions are upgraded to version 5.x or higher, the firmware automatically changes a locally entered “Hello Time” value greater than 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.

6.1 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.

6.1.1 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 data safety.

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 error 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”)
- ▶ stabilization is effected within a brief, specified 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

6.1.2 Bridge parameters

Each bridge is uniquely described using parameters:

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

6.1.3 Bridge Identifier

The Bridge Identifier consists of 8 bytes. The two 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 six lowest-value bytes of the bridge identifier are the MAC address of the bridge. The MAC address guarantees that every bridge has a different bridge identifier.

The bridge with the smallest number for the bridge identifier has the highest priority.

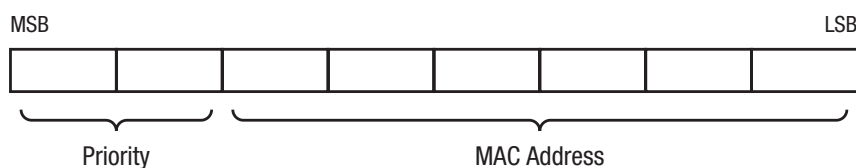


Figure 43: Bridge Identifier

6.1.4 Root Path Costs

Every path that connects two bridges is assigned costs for the transmission (path costs). The Switch specifies this value based on the transmission speed ([see table 12](#)). It assigns the higher path costs to paths with lower transmission speeds.

Alternatively, the Administrator can specify the path costs. Like the Switch, the Administrator assigns the higher path costs 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 costs are the sum of all the individual path costs for all paths along which a data packet travels between the connected port of a bridge and the root bridge.

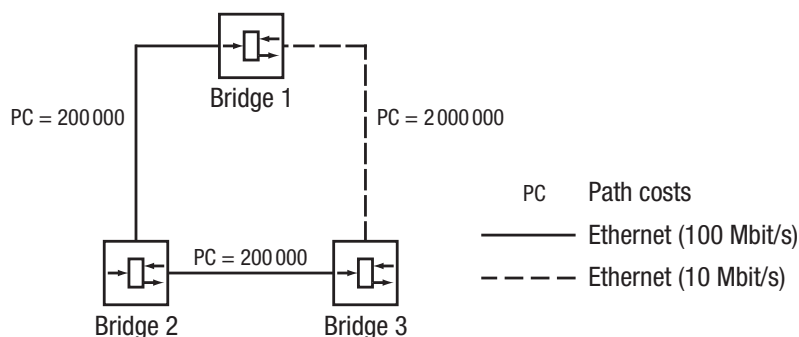


Figure 44: Path costs

Data rate	Recommended value	Recommended range	Possible range
<=100 KBit/s	200.000.000*	20.000.000-200.000.000	1-200.000.000
1 MBit/s	20.000.000*	2.000.000-200.000.000	1-200.000.000
10 MBit/s	2.000.000*	200.000-20.000.000	1-200.000.000
100 MBit/s	200.000*	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 12: Recommended path costs for RSTP based on the data rate

** Bridges that conform with IEEE 802.1D, 1998 edition, and only support 16-bit values for the 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.*

Note: If link aggregation ([see on page 11 „Link Aggregation“](#)) is used to combine the connection lines between devices into a trunk, then the automatically specified path costs are reduced by half.

6.1.5 Port Identifier

The Port Identifier consists of 2 bytes. One part, the lowest-value byte, signifies the fixed relationship with the physical port number. This part ensures that no port of a bridge has the same identifier as another port of this bridge. The second part is the port priority, which is specified 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.

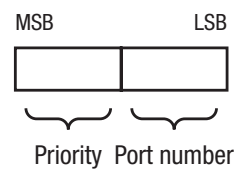


Figure 45: Port Identifier

6.2 Rules for creating the tree structure

6.2.1 Bridge information

To calculate the tree structure, the bridges require 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).

6.2.2 Setting up the tree structure

- ▶ The bridge with the smallest number for the bridge identifier is the root bridge. It is 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 are kept to a minimum.
- ▶ In the case of a number of paths 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.

- If two paths with the same root path costs lead out from a bridge, the port identifier is used as the last criterion (see fig. 45). This decides which port is selected.

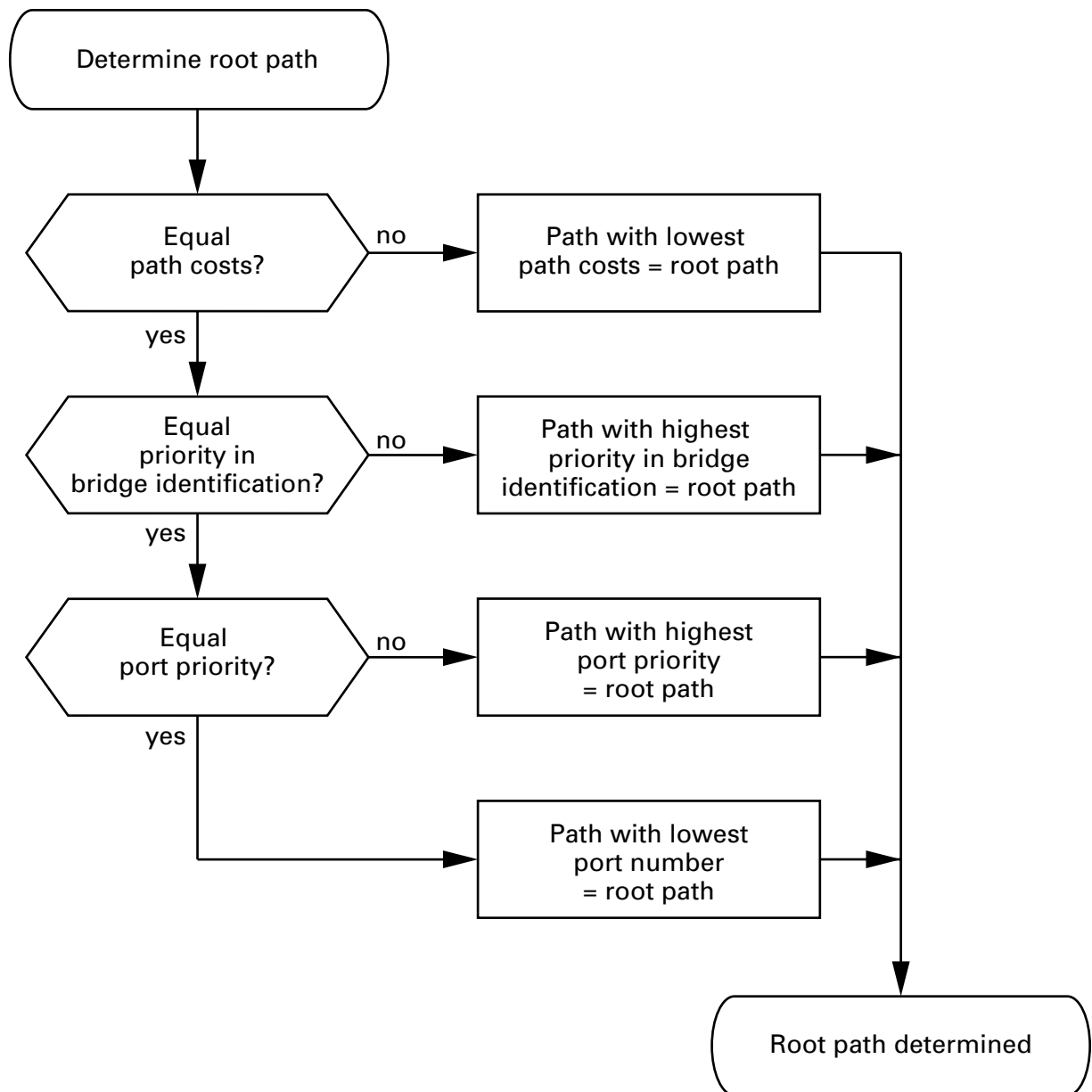


Figure 46: Flow diagram for specifying the root path

6.3 Example of specifying the root paths

The network plan (see fig. 47) can be used to create the flow diagram (see fig. 46) for defining the root path. The Administrator defined a different priority in the bridge identifier for each bridge. The bridge with the smallest number for the bridge identifier is 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 is interrupted, because a connection from bridge 3 to the root bridge via bridge 2 would double the path costs.

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.
- ▶ The path via bridge 4 is selected because value 28 672 for the priority in the bridge identifier is smaller than value 32 768.
- ▶ However, there are two paths between bridge 6 and bridge 4. The port identifier is decisive here.

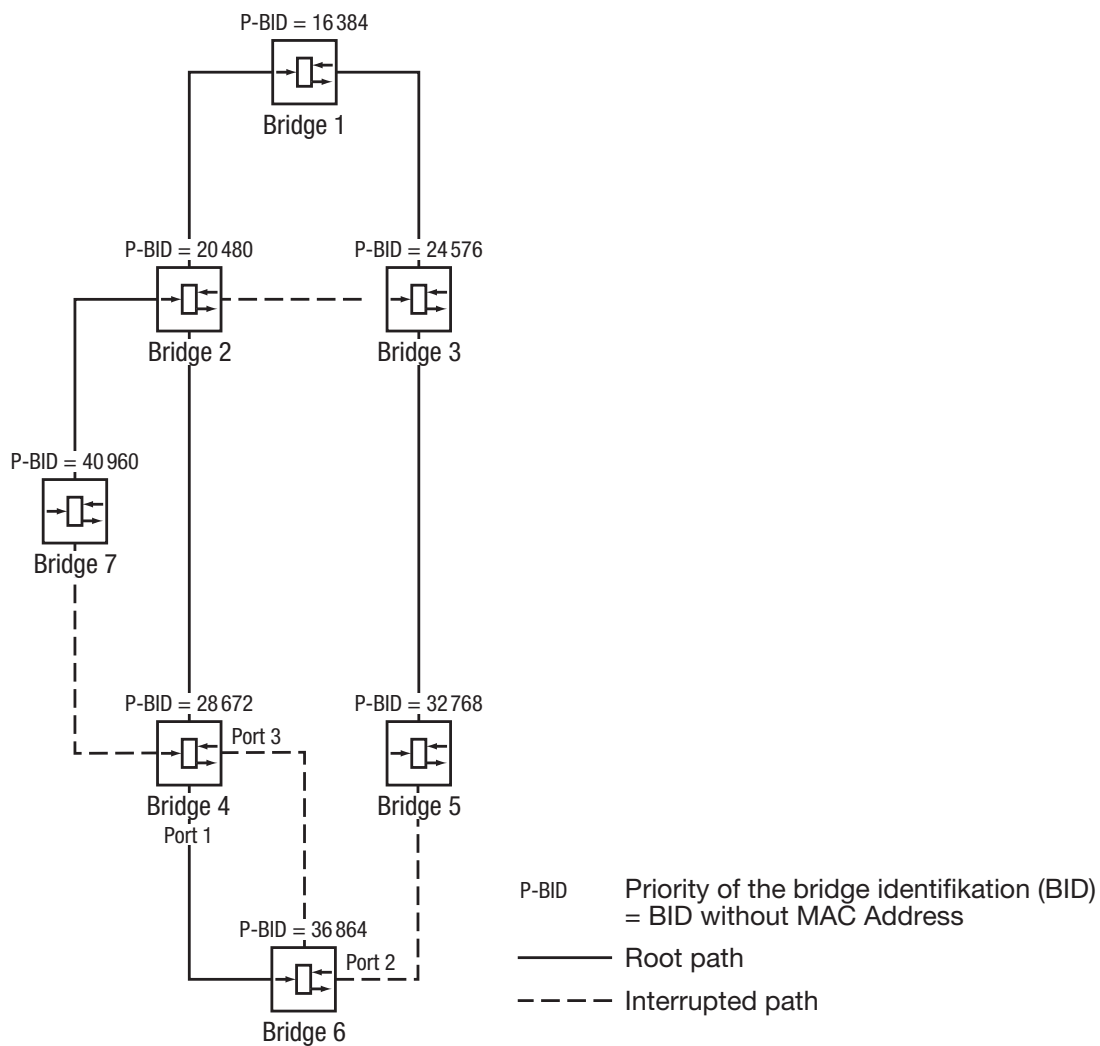


Figure 47: Example of specifying the root path

6.4 Example of manipulating the root paths

The network plan (see fig. 47) can be used to create the flow diagram (see fig. 46) for defining the root path. The Administrator

- left the default value of 32 768 for each bridge apart from bridge 1, and
- gave bridge 1 the value 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 interrupted, because a connection from bridge 3 to the root bridge via bridge 2 would double the path costs.

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 are two 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 goes down.

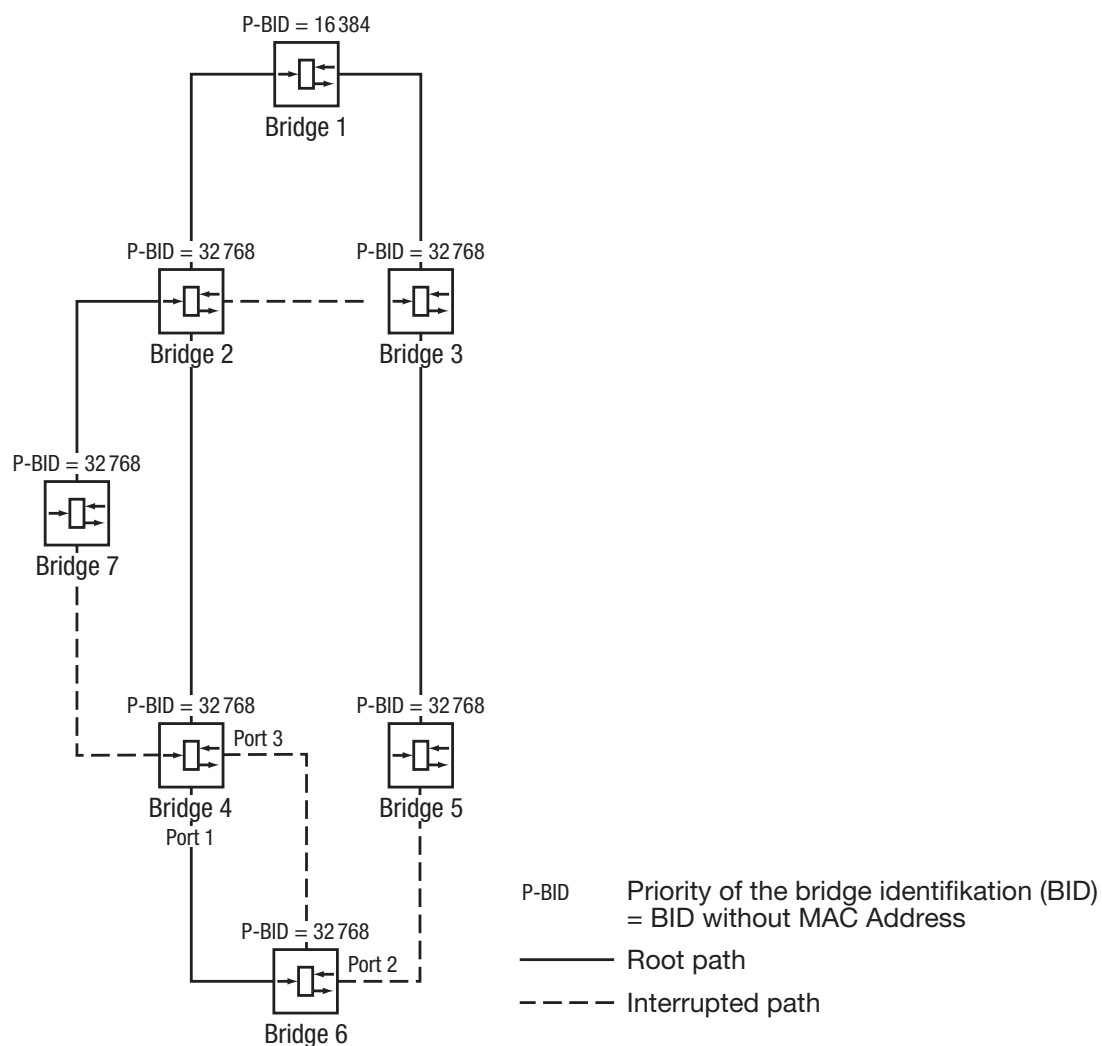
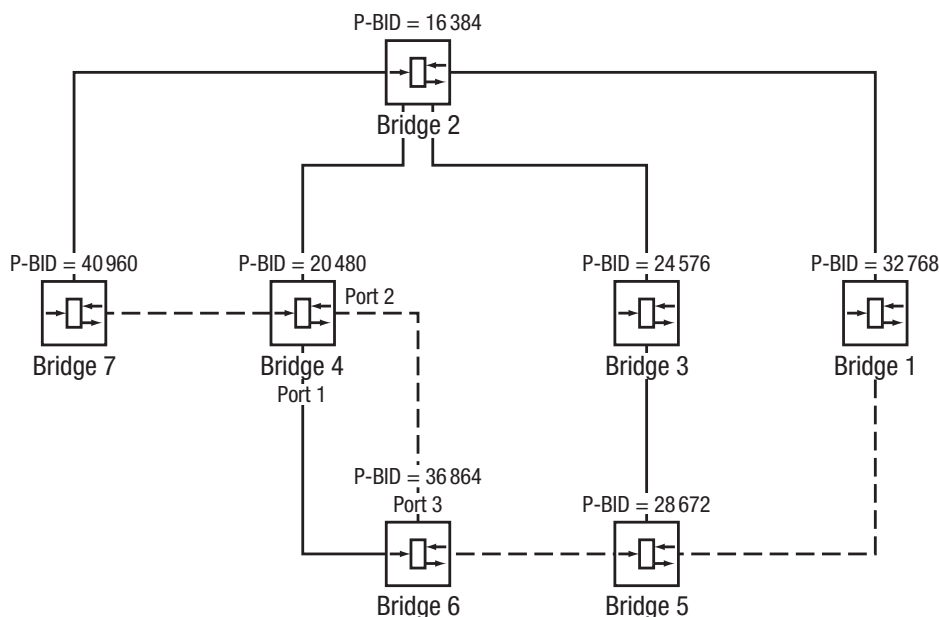


Figure 48: Example of manipulating the root path

6.5 Example of manipulating the tree structure

The Management Administrator soon discovers that this configuration with bridge 1 as the root bridge (see on page 90 „Example of specifying the root paths“) 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. 49). The distances between the individual bridges and the root bridge are now shorter.



P-BID Priority of the bridge identification (BID)
 = BID without MAC Address

———— Root path

----- Interrupted path

Figure 49: Example of manipulating the tree structure

6.6 The Rapid Spanning Tree Protocol

The RSTP takes over the calculation of the tree structure by the STP unchanged. RSTP merely changes parameters, and adds new parameters and mechanism that speed up the reconfiguration in the case of a failure. The ports play a significant role in this context.

6.6.1 Port roles

RSTP assigns each bridge port one of the following roles ([see fig. 50](#)):

- ▶ **Root port**
This is the port at which a bridge receives data packets with the lowest path costs from the root bridge.
If there are multiple ports with the same low path costs, the bridge identifier determines which port is the root port.
If there are multiple ports with the same low path costs and the same bridge identifier, the port identifier determines which port is the root port ([see fig. 46](#)).
The root bridge 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 multiple bridges have the same root path costs, then the bridge with the smallest value for the bridge identifier becomes the designated bridge. The port on this bridge that connects it to a network segment that leads from the root bridge, is the designated port.
- ▶ **Edge port**
Every network segment in which there are no additional RSTP bridges is connected with exactly one designated port. This designated port is then 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 Unit).

- **Alternate port**
This is a blocked port that takes over the task of the bridge port if the connection to the root bridge fails. The alternate port guarantees the connection of the bridge 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 RSTP bridge) fails.
- **Disabled port**
This is the port that does not play any role with the Spanning Tree Operation, and is therefore switched off or does not have any connection.

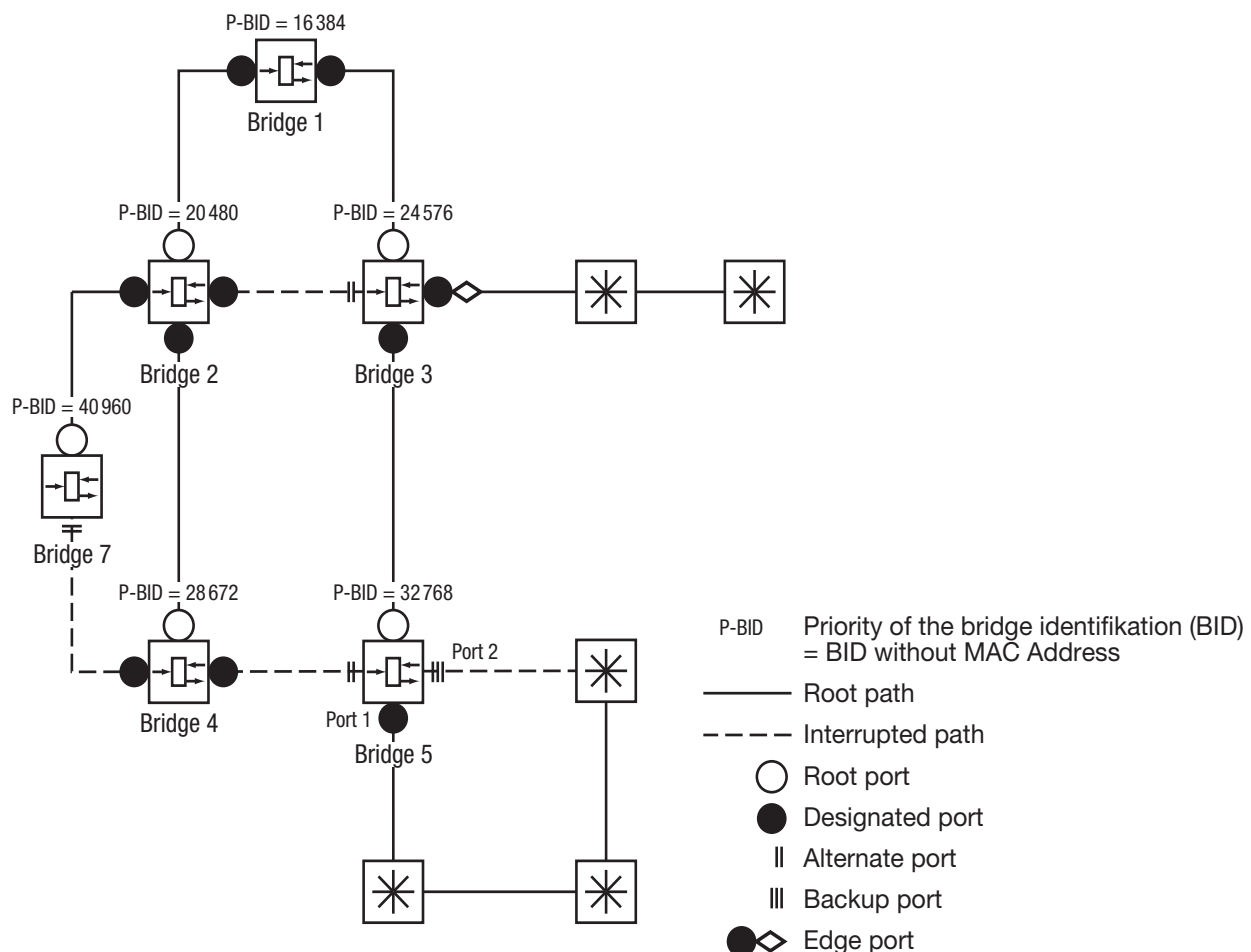


Figure 50: Port role assignment

6.6.2 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*	Excluded (disabled)
DISABLED	Enabled	FALSE	Discarding*	Excluded (disabled)
BLOCKING	Enabled	TRUE	Discarding**	Excluded (alternate, backup)
LISTENING	Enabled	TRUE	Discarding**	Included (root, designated)
LEARNING	Enabled	TRUE	Learning	Included (root, designated)
FORWARDING	Enabled	TRUE	Forwarding	Included (root, designated)

Table 13: Relationship between port state values in STP and RSTP.

* the dot1d MIB shows "Disabled"

** 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 and no data traffic apart from sending and receiving
- ▶ Learning = address learning active (FDB) and no data traffic apart from BPDUs
- ▶ Forwarding = address learning active (FDB) and sending and receiving active from all frames (not only BPDUs)

6.6.3 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 bridges
- ▶ Root path costs for the sending bridges
- ▶ Bridge identifier for the sending bridges
- ▶ Port identifiers of the ports through which the message was sent
- ▶ Port identifiers of the ports through which the message was received

Based on this information, the bridges participating in RSTP are able to calculate port roles themselves and define the port states of their own ports.

6.6.4 Fast reconfiguration

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

- ▶ Introduction of edge ports
During a reconfiguration, RSTP switches an edge port into the transmission mode after three seconds and then waits for the “Hello Time” (see [table 14](#)) to elapse, to be sure that no bridge sending BPDUs is connected.
When the user is sure 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 distributed 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)
Decentralized, direct communication between neighboring bridges enables immediate reaction to status changes in the spanning tree architecture.
- ▶ Filter table
With STP, the age of the entries in the filter table determines the updating. RSTP immediately deletes the entries in 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, etc.

Note: The price to be paid for this fast reconfiguration is the risk that data packets may be duplicated or mixed up during the reconfiguration phase. If this is unacceptable for your application, switch to the slower Spanning Tree Protocol or select one of the other, faster redundancy procedures described in this manual.

6.6.5 Configuring the Rapid Spanning Tree

- ☐ Set up the network to meet your requirements.

Note: Before you connect the redundant lines, you must complete the configuration of the RSTP.

You thus avoid loops during the configuration phase.

-  ☐ Select the `Redundancy:Rapid Spanning Tree:Global` dialog.
- ☐ Switch on RSTP on every device

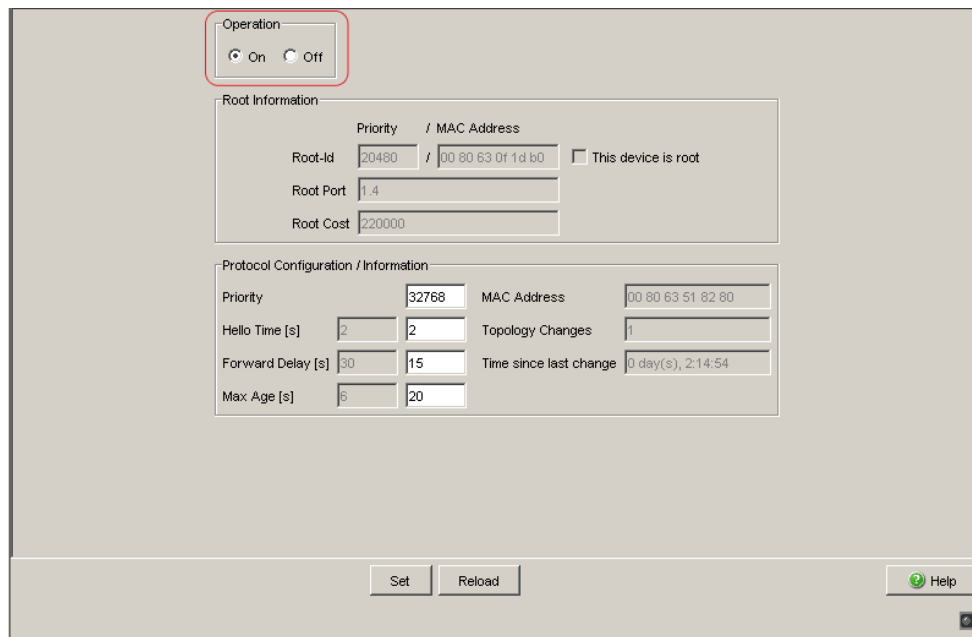


Figure 51: Operation on/off

- ☐ You now connect the redundant lines.
- ☐ Define the desired Switch as the root Switch by assigning it the lowest priority in the bridge information among all the Switches in the network, in the “Protocol Configuration/Information” frame. Note that only multiples of 4096 can be entered for this value (see table 14). In the “Root Information” frame, the dialog shows this device as the root.
A root switch has no root port and no root costs.
- ☐ As required, you change the default priority value of 32768 in other Switches in the network in the same way to the value you want (multiple of 4096).
For each of these Switches, check the display in the “Root Information” frame:
 - Root-Id: Displays the bridge identifier of the root Switch
 - Root Port: Displays the port that leads to the root Switch
 - Root Cost: Displays the root costs to the root Switch
 in the “Protocol Configuration/Information” frame:
 - Priority: Displays the priority in the bridge identifier for this Switch
 - 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 required, change the values for “Hello Time”, “Forward Delay” and “Max. Age” in the root Switch. The root Switch then transfers this data to the other Switches. The dialog displays the data received from the root Switch in the left column. In the right column you enter the values which shall apply when this Switch becomes a root Switch. For the configuration, take note of [table 14](#).

Operation
☒ On ☐ Off

Root Information

	Priority	/	MAC Address	
Root-Id	20480	/	00:80:63:0f:1d:b0	☐ This device is root
Root Port	1.4			
Root Cost	220000			

Protocol Configuration / Information

Priority	32768	MAC Address	00:80:63:51:82:80
Hello Time [s]	2	Topology Changes	1
Forward Delay [s]	30	Time since last change	0 day(s), 2:14:54
Max Age [s]	6		

Set Reload Help

Figure 52: Assigning Hello Time, Forward Delay und Max. Age

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

Parameter	Meaning	Value range	Default setting
Priority	The priority and the MAC address go together to make up the bridge identification.	$0 < n \cdot 4,096 < 61,440$	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 two 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	2
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 (see a:)	30
Max Age	The left column shows the value currently being used by the root Switch. 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 (see a:)	6

Table 14: Global RSTP settings

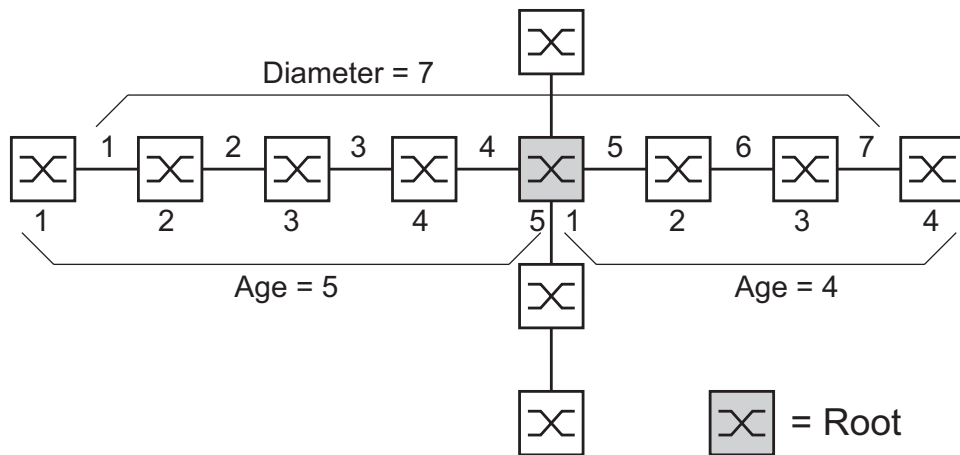


Figure 53: Definition of diameter and age

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:

$$\text{Forward Delay} \geq (\text{Max Age}/2) + 1$$

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

- ☐ As required, change and verify the settings and displays that relate to each individual port (menu bar: Rapid Spanning Tree - Port).

Module	Port	STP State Enable	Port State	Priority	Port Pathcost	Admin EdgePort	Oper EdgePort	Auto EdgePort	Oper PointToPoint	Designated Root (Priority/MAC Adres)
1	1	☒	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	2	☒	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	3	☒	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	4	☒	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	5	☒	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	6	☒	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	7	☒	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	8	☒	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	9	☒	manualFwd	128	0	false	false	true	true	80 00 00 80 63 74 67
1	10	☒	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	11	☒	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	12	☒	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	13	☒	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	14	☒	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	15	☒	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	16	☒	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	17	☒	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	18	☒	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	19	☒	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	20	☒	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	21	☒	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	22	☒	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67

Set
Reload
Help

Figure 54: Configuring the RSTP port

Note: Deactivate the Spanning Tree Protocol for the ports connected to a redundant ring, because the Spanning Tree and the 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.	$16 < n \cdot 16 < 240$	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 depending on 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 a 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 were received, i. e., a terminal device that sends no RSTP frames is connected to this port. Is „false“ if RSTP frames were 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 $1.5 \cdot \text{Hello Time}$ (3 seconds). If it is set to „false“, it will take 30 seconds until the edge port forwards data frames.	true, false	false

Table 15: 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 two RSTP devices. The direct, local communications between the two 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 Switch for this port.	Bridge identification (hexadecimal)	-
Designated Costs	Display of the costs of the path from this port to the root Switch.	Costs	-
Designated Port	Display of the port identifier of the port that creates the connection to the root Switch for this port (on the designated Switch).	Port identification (hexadecimal) and port number	-

Table 15: Port-related RSTP settings and displays

6.7 Combination of 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. 53) depends on the “Max Age”. It applies to the devices outside the MRP-Ring.

Note: The combination of RSTP and MRP requires the root bridge and the backup root bridge to be within the MRP-Ring.

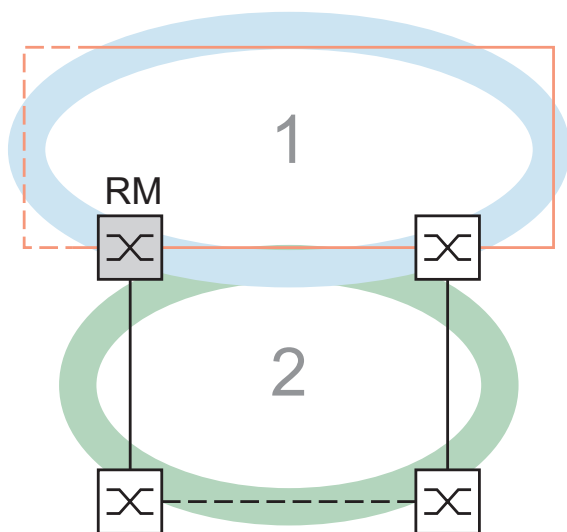


Figure 55: Combination of RSTP and MRP

1: MRP-Ring

2: RSTP-Ring

RM: Ring Manager

To combine RSTP with MRP, you perform the following steps in sequence:

- ▶ Configure MRP on all devices in the MRP-Ring.
- ▶ Activate RSTP at the RSTP ports and also at 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 preset value of Max Age = 20, you modify “Max Age” and “Forward Delay”.
- ▶ Activate RSTP globally.
- ▶ Activate the MRP compatibility mode.
- ▶ After configuring all the participating devices, connect the redundant RSTP connection.

6.7.1 Application example for the combination of RSTP and MRP

The figure (see fig. 56) shows an example for the combination of RSTP and MRP.

Parameter	S1	S2	S3	S4
MRP settings				
Ring redundancy: MRP version	MRP	MRP		
Ring port 1	1.1	1.2		
Ring port 2	1.1	1.2		
Redundancy Manager mode	On	Off	–	–
MRP operation	On	On	Off	Off
RSTP settings				
For each RSTP port: STP State Enable	On	On	On	On
Protocol Configuration: Priority (S2<S1<S3 and S2<S1<S4)	4096	0	32768	32768
RSTP:Global: Operation	On	On	On	On
RSTP:Global: MRP compatibility	On	On	–	–

Prerequisites for further configuration:

- You have configured the MRP settings for the devices in accordance with the above table.

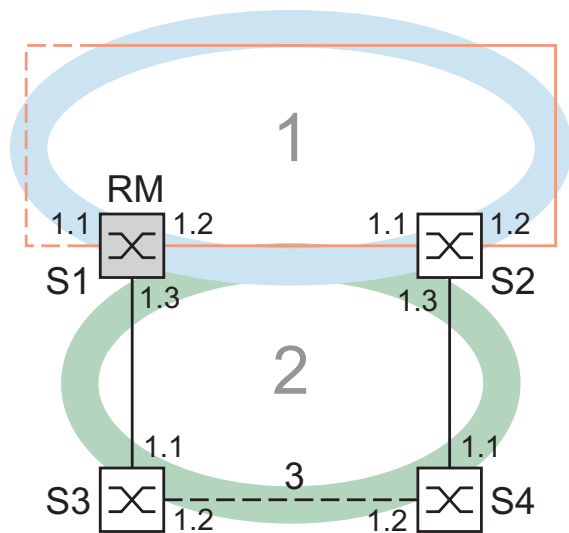


Figure 56: Application example for the combination of RSTP and MRP

1: MRP-Ring

2: RSTP-Ring

3: Redundant RSTP connection

RM: Ring Manager

- Activate RSTP at the ports here 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 at 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 at 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 at port.
exit	Switch to the Configuration mode.

- Configure globally here 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 4096.
spanning-tree	Activate RSTP operation globally.
spanning-tree stp-mrp-mode	Activate MRP compatibility.

- Configure all the participating devices in accordance with the table.
- Connect the redundant RSTP connection.

A Readers' comments

What is your opinion of this manual? We are always striving to provide as comprehensive a description of our product as possible, as well as important information that will ensure trouble-free operation. Your comments and suggestions help us to further improve the quality of our documentation.

Your assessment of this manual:

	Very good	Good	Satisfactory	Medio- cre	Poor
Precise description	☐	☐	☐	☐	☐
Readability	☐	☐	☐	☐	☐
Understandability	☐	☐	☐	☐	☐
Examples	☐	☐	☐	☐	☐
Structure	☐	☐	☐	☐	☐
Completeness	☐	☐	☐	☐	☐
Graphics	☐	☐	☐	☐	☐
Drawings	☐	☐	☐	☐	☐
Tables	☐	☐	☐	☐	☐

Did you discover any errors in this manual?
If so, on what page?

Readers' comments

Suggestions for improvement and additional information:

General comments:

Sender:

Company / Department:

Name / Telephone number:

Street:

Zip code / City:

E-mail:

Date / Signature:

Dear User,

Please fill out and return this page

- ▶ as a fax to the number +49 (0)7127/14-1600 or
- ▶ to

Hirschmann Automation and Control GmbH
Department AED
Stuttgarter Str. 45-51
72654 Neckartenzlingen

B Index

A

Advanced Mode	30
Age	103
Alternate port	96

B

Backup port	96
Bridge Identifier	84

C

Configuration error	29, 32, 37
Configuring the HIPER-Ring	25, 36

D

Designated bridge	95
Designated port	95
Diameter	103
Disabled port	96

E

Edge port	95
-----------	----

F

FAQ	115
Fast HIPER-Ring	9
Forward Delay	102

H

Hello Time	102
HIPER-Ring	9, 18
HiVision	5

I

Industry protocols	5
--------------------	---

L

LACP Link Aggregation Control Protocol	11
Link Aggregation	9, 11, 18
Loops	68, 70, 76, 78

M

Max Age	102
---------	-----

N

Network load	83
Network Management Software	5

O

One-Switch coupling	58
---------------------	----

P

Port state	97
PROFINET	5

R

Rapid Spanning Tree	9, 81
Redundancy	5
Redundancy existing	29, 32, 37
Redundancy functions	9
Redundancy Manager	23
Redundant	21
Redundant coupling	9
Ring	21
Ring Manager	23
Ring structure	22
Ring/Network Coupling	9
Root port	95
RST BPDUs	95, 97
RSTP	9

S

Sub-Ring	9
Sub-Ring configuration	48
Symbol	6

T

Technical questions	115
Training courses	115
Trunk	11
Two-Switch coupling	58
Two-Switch coupling with control line	58

V

VLAN	28
------	----

C Further support

■ **Technical questions and training courses**

In the event of technical queries, please contact your local Hirschmann distributor or Hirschmann office.

You can find the addresses of our distributors on the Internet:

www.hirschmann-ac.com.

Our support line is also at your disposal:

- ▶ Tel. +49 1805 14-1538
- ▶ Fax +49 7127 14-1551

Answers to Frequently Asked Questions can be found on the Hirschmann internet site (www.hirschmann-ac.com) at the end of the product sites in the FAQ category.

The current training courses to technology and products can be found under <http://www.hicomcenter.com>.

■ **Hirschmann Competence Center**

In the long term, excellent products alone do not guarantee a successful customer relationship. Only comprehensive service makes a difference worldwide. In the current global competition scenario, the Hirschmann Competence Center is ahead of its competitors on three counts with its complete range of innovative services:

- ▶ Consulting incorporates comprehensive technical advice, from system evaluation through network planning to project planning.
- ▶ Training offers you an introduction to the basics, product briefing and user training with certification.
- ▶ Support ranges from the first installation through the standby service to maintenance concepts.

With the Hirschmann Competence Center, you have decided against making any compromises. Our client-customized package leaves you free to choose the service components you want to use.

Internet:

<http://www.hicomcenter.com>.



HIRSCHMANN

A **BELDEN** BRAND