User Manual

Redundancy Configuration
Industrial ETHERNET Switch
RS20, RSB20
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About this Manual

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

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

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

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:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>▶</td>
<td>List</td>
</tr>
<tr>
<td>□</td>
<td>Work step</td>
</tr>
<tr>
<td>■</td>
<td>Subheading</td>
</tr>
<tr>
<td>Link</td>
<td>Indicates a cross-reference with a stored link</td>
</tr>
<tr>
<td>Note:</td>
<td>A note emphasizes an important fact or draws your attention to a dependency.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Courier</th>
<th>ASCII representation in user interface</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Execution in the Web-based Interface user interface</td>
</tr>
<tr>
<td></td>
<td>Execution in the Command Line Interface user interface</td>
</tr>
</tbody>
</table>

### Symbols used:

- WLAN access point
- Router with firewall
- Switch with firewall
- Router
- Switch
1 Introduction

The device contains a range of redundancy functions:
- HIPER-Ring
- MRP-Ring
1.1 Overview of Redundancy Topologies

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

The following topologies are possible:

<table>
<thead>
<tr>
<th>Network topology</th>
<th>Possible redundancy procedures</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree structure without loops</td>
<td>Only possible in combination with physical loop creation</td>
<td>-</td>
</tr>
<tr>
<td>(cycle-free)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Topology with 1 loop</td>
<td>Ring Redundancy</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 1: Overview of Redundancy Topologies
1.2 Overview of Redundancy Protocols

### Redundancy procedure | Network topology | Switch-over time
--- | --- | ---
RSTP | Random structure | typically < 1 s (STP < 30 s), up to < 30 s - depends heavily on the number of devices

**Note**: Up to 79 devices possible, depending on topology and configuration. If the default values (factory settings) are used, up to 39 devices are possible, depending on the topology (see page 39).

HIPER-Ring | Ring | typically 80 ms, up to < 500 ms or < 300 ms (selectable) - the number of switches has a minimal effect on the switch-over time

MRP-Ring | ring | typically 80 ms, up to < 500 ms or < 200 ms (selectable) - the number of switches has a minimal effect on the switch over time

**Note**: In combination with RSTP in MRP compatibility mode, up to 39 devices are possible, depending on the configuration. If the default values (factory settings) for RSTP are used, up to 19 devices are possible (see page 39).

*Table 2: Comparison of the redundancy procedures*

**Note**: When you are using a redundancy function, you deactivate the flow control on the participating ports. Default setting: flow control deactivated globally and activated on all ports. If the flow control and the redundancy function are active at the same time, there is a risk of the redundancy failing.
2 Ring Redundancy

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

Figure 1: Line structure

Figure 2: Redundant ring structure

RM = Ring Manager
main line
redundant line
If a section is down, the ring structure of a
- HIPER-(HIGH PERFORMANCE REDUNDANCY) Ring with up to 50 devices typically transforms back to a line structure within 80 ms (possible settings: 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).

Devices with HIPER-Ring function capability:
- 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
  - PowerMICE
  - MACH 100
  - MACH 1000
  - MACH 1040
  - MACH 3000
  - MACH 4000
- Within an MRP-Ring, you can use devices that support the MRP protocol based on IEC62439.

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

**Note:** The following usage of the term “ring manager” instead of “redundancy manager” makes the function easier to understand.
2.1 Example of a HIPER-Ring

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

![Diagram of a HIPER-Ring]

**Figure 3:** Example of HIPER-Ring

*RM = Ring Manager*

--- main line

- - - redundant line

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

1. On modular devices the 1st number of the port designation specifies the module. The 2nd number specifies the port on the module. The specification pattern 1.x is also used on non-modular devices to ensure consistent operation for modular and non-modular devices.
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.
2.1.1 Setting up and configuring the HIPER-Ring

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

<table>
<thead>
<tr>
<th>Bit rate</th>
<th>100 Mbit/s</th>
<th>1000 Mbit/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autonegotiation (automatic configuration)</td>
<td>off</td>
<td>on</td>
</tr>
<tr>
<td>Port</td>
<td>on</td>
<td>on</td>
</tr>
<tr>
<td>Duplex</td>
<td>Full</td>
<td>–</td>
</tr>
</tbody>
</table>

*Table 3: Port settings for ring ports*

**Note:** When activating the HIPER-Ring function, the device sets the corresponding settings for the pre-defined ring ports in the configuration table (transmission rate and mode). If the HIPER-Ring function is switched off, the ports, which are changed back into normal ports, keep the ring port settings. Independently of the DIP switch setting, you can still change the port settings via the software.

- Select the Redundancy:Ring Redundancy dialog.
- 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.

![Ring Redundancy dialog](image)

**Figure 4: Ring Redundancy dialog**

- Activate the ring manager for this device. Do not activate the ring manager for any other device in the HIPER-Ring.
- In the “Ring Recovery” frame, select the value “Standard” (default).
  **Note**: Settings in the “Ring Recovery” frame only take effect for devices configured as ring managers.
- Click “Set” to temporarily save the entry in the configuration.
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 for the ports connected to the HIPER-Ring, because Spanning Tree and Ring Redundancy affect each other.

If you used the DIP switch to activate the function of HIPER-Ring, RSTP is automatically switched off.

Now you connect the line to the ring. To do this, you connect the 2 devices to the ends of the line using their ring ports.
The displays in the “Information” frame mean
- “Redundancy existing”: One of the lines affected by the function may be interrupted, with the redundant line then taking over the function of the interrupted line.
- "Configuration failure": The function is incorrectly configured or the cable connections at the ring ports are improperly configured (e.g., not plugged into the ring ports).

**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.
2.2 Example of an MRP-Ring

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

Figure 5: Example of MRP-Ring

RM = Ring Manager
— main line
- - - redundant line

The following example configuration describes the configuration of the ring manager device (1). You configure the 2 other devices (2 to 3) in the same way, but without activating the ring manager function. This example does not use a VLAN. You have entered 200 ms as the ring recovery time, and all the devices support the advanced mode of the ring manager.
Note: For devices with DIP switches, put all DIP switches to “On”. The effect of this is that you can use the software configuration to configure the redundancy function without any restrictions. You thus avoid the possibility of the software configuration being hindered by the DIP switches.

Note: Configure all the devices of the MRP-Ring individually. Before you connect the redundant line, you must have completed 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 demands.
☐ You configure all 6 ports so that the transmission speed and the duplex settings of the lines correspond to the following table:

<table>
<thead>
<tr>
<th>Bit rate</th>
<th>100 Mbit/s</th>
<th>1000 Mbit/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autonegotiation (automatic configuration)</td>
<td>off</td>
<td>on</td>
</tr>
<tr>
<td>Port</td>
<td>on</td>
<td>on</td>
</tr>
<tr>
<td>Duplex</td>
<td>Full</td>
<td>–</td>
</tr>
</tbody>
</table>

*Table 4: Port settings for ring ports*

☐ Select the **Redundancy:Ring Redundancy** dialog.
☐ Under “Version”, select **MRP**.
☐ Define the desired ring ports 1 and 2 by making the corresponding entries in the module and port fields. If it is not possible to enter a module, then there is only one module in the device that is taken over as a default.
Display in “Operation” field:
- **forwarding**: this port is switched on and has a link.
- **blocked**: this port is blocked and has a link
- **disabled**: this port is disabled
- **not-connected**: this port has no link

**Figure 6: Ring Redundancy dialog**

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

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

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

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

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

- Switch the operation of the MRP-Ring on.

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

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

```
enable
configure
mrp new-domain
default-domain

MRP domain created:
Domain ID:
255.255.255.255.255.255.255.255.255.255.255.255.255.255.255.255
(Defualt MRP domain)

mrp current-domain
port primary 1/1

Switch to the Privileged EXEC mode.
Switch to the Configuration mode.
Create a new MRP-Ring with the default domain ID.
Define port 1 in module 1 as ring port 1 (primary).
```
Now you connect the line to the ring. To do this, you connect the 2 devices to the ends of the line using their ring ports.
3 Multiple Rings

The device allows you to set up multiple rings with different redundancy protocols:

- You have the option of nesting MRP-Rings. A coupled ring is known as a Sub-Ring (see on page 28 “Sub-Ring”).
- You have the option of coupling to MRP-Rings other ring structures that work with RSTP (see on page 68 “Combining RSTP and MRP”).


3.1 Sub-Ring

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

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

The SRM-capable devices support up to 4 SRM instances and can thus be the Sub-Ring manager for up to 4 Sub-Rings at the same time.

In a Sub-Ring, you can integrate as participants the devices that support MRP - the Sub-Ring Manager function is not required.

Figure 7: Beispiel für Sub-Ring-Struktur
1 blauer Ring = Basis-Ring
2 orangefarbener Ring = Sub-Ring
SRM = Sub-Ring-Manager
RM = Ring-Manager
Jeder Sub-Ring kann aus bis zu 200 Teilnehmern bestehen, dabei zählen die beiden SRM und die zwischen den SRMs liegenden Switches im Hautring nicht mit.

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 8: Example of an overlapping Sub-Ring structure*
Figure 9: Special case: a Sub-Ring Manager manages 2 Sub-Rings (2 instances). Depending on the device type, you can configure additional instances.

Figure 10: Special case: a Sub-Ring Manager manages both ends of a Sub-Ring at different ports (Single Sub-Ring Manager).

Note: Connect Sub-Rings only to existing primary rings. Do not cascade Sub-Rings (i.e., a new Sub-Ring must not be connected to an existing Sub-Ring).
**Note:** Sub-Rings use MRP. You can couple Sub-Rings to existing primary rings with the HIPER-Ring protocol, the Fast HIPER-Ring protocol and MRP. If you couple a Sub-Ring to a primary ring under MRP, configure both rings in different VLANs. You configure

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

### 3.1.1 Example configuration

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

**Example description**

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

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

Configure these devices as Sub-Ring Managers.
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 the transmission rate and the duplex mode for all the ring ports in accordance with the following table:

<table>
<thead>
<tr>
<th>Port Type</th>
<th>Bit Rate</th>
<th>Autonegotiation</th>
<th>Port Setting</th>
<th>Duplex Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical</td>
<td>all</td>
<td>off</td>
<td>on</td>
<td>full</td>
</tr>
<tr>
<td>TX</td>
<td>100 Mbit/s</td>
<td>off</td>
<td>on</td>
<td>full</td>
</tr>
<tr>
<td>TX</td>
<td>1000 Mbit/s</td>
<td>on</td>
<td>on</td>
<td>-</td>
</tr>
</tbody>
</table>

*Table 5: Port Settings for Ring Ports*

- Other settings:
  - Define different VLAN membership for the primary ring and the Sub-Ring even if the primary ring uses the MRP protocol; e.g., VLAN ID 1 for the primary ring and VLAN ID 2 for the Sub-Ring.
  - For all ring ports in the Sub-Ring, select this VLAN ID and the VLAN membership Tagged (T) in the static VLAN table.
  - Switch the MRP-Ring function on for all devices.
– In the Ring Redundancy dialog, under MRP-Ring, configure for all devices the two ring ports used in the Sub-Ring.
– Switch the Ring Manager function off for all devices.
– Do not configure link aggregation.
– Switch RSTP off for the MRP-Ring ports used in the Sub-Ring.


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

```bash
enable
configure
mrp delete-domain current-domain
MRP current domain deleted:
Domain ID: 255.255.255.255.255.255.255.255.255.255.255.255.255.255.255.255
mrp new-domain 0.0.1.1.2.3.4.5.111.222.123.0.0.66.99
MRP domain created:
Domain ID: 0.0.1.1.2.3.4.5.111.222.123.0.0.66.99
```

#### Sub-Ring configuration
Proceed as follows to configure the 2 Sub-Ring Managers in the example:
Select the Redundancy:Sub-Ring dialog.

Click the button "New".

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

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

You have the option of entering a name for the Sub-Ring (in the example, “Test”).
Select the Sub-Ring Manager mode (SRM mode). You thus specify which connection between the primary ring and the Sub-Ring becomes the redundant line.

The options for the connection are:

- Both Sub-Ring Managers have the same setting (default manager): - the device with the higher MAC address manages the redundant line.
- In the SRM Mode field, a device is selected to be the redundant manager: - this device manages the redundancy line as long as you have configured the other Sub-Ring Manager as a manager, otherwise the higher MAC address applies.

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

Leave the fields VLAN ID (default 0) and MRP Domain (default 255.255.255.255.255.255.255.255.255.255.255.255.255.255.255.255) as they are. The example configuration does not require any change here.

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

Click “Back” to return to the Sub-Ring dialog.

```
enable
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 "Test"
sub-ring 1 mode manager
Mode of Switch set to manager
```

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

Figure 13: Completely configured Sub-Ring Manager

Configure the 2nd Sub-Ring Manager in the same way. If you have explicitly assigned SRM 1 the SRM mode manager, you configure SRM 2 as redundant manager. Otherwise, the assignment is performed automatically via the higher MAC address (see above).

Switch the two Sub-Ring Managers on under “Function on/off” in the overview of the Sub-Ring dialog.

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

Select the dialog Basic Settings: Load/Save.

In the “Save” frame, select “To Device” for the location and click “Save” to permanently save the configuration in the active configuration.
When you have configured both SRMs and, if applicable, the devices included in the Sub-Ring, close the Sub-Ring's redundant line.
4 Spanning Tree

**Note:** The Spanning Tree Protocol is a protocol for MAC bridges. For this reason, the following description employs the term bridge for Switch.

Local networks are getting bigger and bigger. This applies to both the geographical expansion and the number of network participants. Therefore, it is advantageous 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. In order to avoid this, you can use Spanning Tree. Spanning Tree enables loop-free switching through the systematic deactivation of redundant connections. Redundancy ensures the systematic reactivation of individual connections as needed.

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 required a maximum of 30 seconds to reconfigure. This is no longer acceptable in time-sensitive applications. RSTP achieves average reconfiguration times of less than a second. When you use RSTP in a ring topology with 10 to 20 devices, you can even achieve reconfiguration times in the order of milliseconds.

**Note:** RSTP reduces a layer 2 network topology with redundant paths into a tree structure (Spanning Tree) that does not contain any more redundant paths. One of the Switches takes over the role of the root bridge here. The maximum number of devices permitted in a branch (from the root bridge to the tip of the branch) is specified by the variable Max Age for the current root bridge. The preset value for Max Age is 20, which can be increased up to 40. If the device working as the root fails and another device takes over its function, the Max Age setting of the new root bridge determines the maximum number of devices allowed in a branch.
**Note:** The RSTP standard dictates that all the devices within a network work with the (Rapid) Spanning Tree Algorithm. If STP and RSTP are used at the same time, the advantages of faster reconfiguration with RSTP are lost. A device that only supports RSTP works together with MSTP devices by not assigning an MST region to itself, but rather the CST (Common Spanning Tree).

**Note:** By changing the IEEE 802.1D-2004 standard for RSTP, the Standards Commission reduced the maximum value for the “Hello Time” from 10 s to 2 s. When you update the Switch software from a release before 5.0 to release 5.0 or higher, the new software release automatically reduces the locally entered “Hello Time” values that are greater than 2 s to 2 s. If the device is not the RSTP root, “Hello Time” values greater than 2 s can remain valid, depending on the software release of the root device.
4.1 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.

4.1.1 The tasks of the STP

The Spanning Tree Algorithm reduces network topologies built with bridges and containing ring structures due to redundant links to a tree structure. In doing so, STP opens ring structures according to preset rules by deactivating redundant paths. If a path is interrupted due to a failure, STP reactivates the previously deactivated path again. This allows redundant links to increase the availability of communication.

STP determines a so-called root bridge when building the tree structure. It will become the STP tree structure’s base.

Features of the STP algorithm:

- automatic reconfiguration of the tree structure in the case of a bridge becoming inoperable or the interruption of a data path
- the tree structure is stabilized up to the maximum network size (up to 39 hops, depending on the setting for Max Age, (see table 8)
- stabilization is achieved within a short time period
- topology can be specified and reproduced by the administrator
- transparency for the terminal devices
- low network load relative to the available transmission capacity due to the tree structure created
4.1.2 Bridge parameters

Each bridge is uniquely described by the parameters:

- Bridge Identifier
- Root Path Cost for the bridge ports,
- Port Identifier

4.1.3 Bridge Identifier

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

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

Figure 14: Bridge Identifier, Example (values in hexadecimal notation)
4.1.4 Root Path Cost

Each path that connects 2 bridges is assigned a cost for the transmission (path cost). The Switch determines this value based on the transmission speed (see table 6). It assigns a higher path cost to paths with lower transmission speeds.

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

The root path cost is the sum of all individual costs of those paths that a data packet has to traverse from a connected bridge’s port and the root bridge.

Figure 15: Path costs
### 4.1 The Spanning Tree Protocol

#### Data rate

<table>
<thead>
<tr>
<th>Data rate</th>
<th>Recommended value</th>
<th>Recommended range</th>
<th>Possible range</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=100 kBit/s</td>
<td>200,000,000&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20,000,000-200,000,000</td>
<td>1-200,000,000</td>
</tr>
<tr>
<td>1 MBit/s</td>
<td>20,000,000&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2,000,000-200,000,000</td>
<td>1-200,000,000</td>
</tr>
<tr>
<td>10 MBit/s</td>
<td>2,000,000&lt;sup&gt;a&lt;/sup&gt;</td>
<td>200,000-20,000,000</td>
<td>1-200,000,000</td>
</tr>
<tr>
<td>100 MBit/s</td>
<td>200,000&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20,000-2,000,000</td>
<td>1-200,000,000</td>
</tr>
<tr>
<td>1 GBit/s</td>
<td>20,000</td>
<td>2,000-200,000</td>
<td>1-200,000,000</td>
</tr>
<tr>
<td>10 GBit/s</td>
<td>2,000</td>
<td>200-20,000</td>
<td>1-200,000,000</td>
</tr>
<tr>
<td>100 GBit/s</td>
<td>200</td>
<td>20-2,000</td>
<td>1-200,000,000</td>
</tr>
<tr>
<td>1 TBit/s</td>
<td>20</td>
<td>2-200</td>
<td>1-200,000,000</td>
</tr>
<tr>
<td>10 TBit/s</td>
<td>2</td>
<td>1-20</td>
<td>1-200,000,000</td>
</tr>
</tbody>
</table>

*Table 6: Recommended path costs for RSTP based on the data rate.*

---

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

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

![Port Identifier Diagram]

*Figure 16: Port Identifier*
4.2 Rules for Creating the Tree Structure

4.2.1 Bridge information

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

The contents of a BPDU include

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

(see IEEE 802.1D).

4.2.2 Setting up the tree structure

- The bridge with the smallest number for the bridge identifier is called the root bridge. It is (or will become) the root of the tree structure.
- The structure of the tree depends on the root path costs. STP selects the structure so that the path costs between each individual bridge and the root bridge become as small as possible.
- If more than 1 path exists with the same root path costs, the priority of the bridge identifier for the bridge connected to one of these paths decides which bridge should block.
Of more than 1 path with the same root path costs originates from a bridge, the port identifier is used as the last criterion (see fig. 16). This decides which port is selected.

Figure 17: Flow diagram for specifying the root path
4.3 Example of Root Path Determination

The network plan (see fig. 18) can be used to create the flow diagram (see fig. 17) for defining the root path. The Administrator has defined a different priority for each bridge’s bridge identifier. The bridge with the smallest number for the bridge identifier will become the root bridge, in this case bridge 1. In the example, all the sub-paths have the same path costs. The path between bridge 2 and bridge 3 is blocked, because a connection from bridge 3 to the root bridge via bridge 2 has a higher path cost.

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

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

Figure 18: Example of root path determination

![Diagram showing root path determination with bridges and ports labeled with P-BIDs: Bridge 1: P-BID = 16384, Bridge 2: P-BID = 20480, Bridge 3: P-BID = 24576, Bridge 4: P-BID = 28672, Bridge 5: P-BID = 32768, Bridge 6: P-BID = 36864, Bridge 7: P-BID = 40960. The figure includes root path and interrupted path markings.]
4.4 Example of Root Path Manipulation

The network plan (see fig. 18) can be used to create the flow diagram (see fig. 17) for defining the root path. The Administrator – left the default value of 32,768 for each bridge except for bridge 1,– bridge 1 value was set to 16,384, thus making it the root bridge. In the example, all the sub-paths have the same path costs. The path between bridge 2 and bridge 3 is blocked by the protocol because a connection from bridge 3 to the root bridge via bridge 2 has a higher path cost.

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

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

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

Figure 19: Example of root path manipulation
4.5 Example of Tree Structure Manipulation

The Management Administrator soon discovers that this configuration with bridge 1 as the root bridge (see on page 10 “Example of Root Path Determination”) is unfavorable. On the paths from bridge 1 to bridge 2 and bridge 1 to bridge 3, the control packets which the root bridge sends to all other bridges are adding up. If the Management Administrator makes bridge 2 the root bridge, the burden of the control packets on the subnetworks is distributed much more evenly. The result is the configuration shown here (see fig. 20). The distances between the individual bridges and the root bridge are now shorter.

Figure 20: Example of tree structure manipulation
4.6 The Rapid Spanning Tree Protocol

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

The ports play a significant role in this context.

4.6.1 Port roles

RSTP assigns each bridge port one of the following roles (see fig. 21):

- **Root port**
  This is the port on which a bridge receives data packets with the lowest path costs from the root bridge.
  If there is more than 1 port with the same low path costs, the bridge identifier determines which port is the root port.
  If there is more than 1 port with the same low path costs connected to the same bridge, the port identifier determines which port is the root port (see fig. 17).
  The root bridge itself does not have a root port.

- **Designated port**
  The bridge in a network segment that has the lowest root path costs is the designated bridge. If more than 1 bridge has the same root path costs, the bridge with the smallest value bridge identifier becomes the designated bridge. The port on this bridge that connects it to a network segment leading to the root bridge, is the designated port.
► **Edge port**  
Every network segment with no additional RSTP bridges is connected with exactly one designated port. In this case, this designated port is also an edge port. The distinction of an edge port is the fact that it does not receive any RST BPDUs (Rapid Spanning Tree Bridge Protocol Data Units).

► **Alternate port**  
This is a blocked port that takes over the task of the bridge port if the connection to the root bridge is lost. The alternate port provides a backup connection to the root bridge.

► **Backup port**  
This is a blocked port that serves as a backup in case the connection to the designated port of this network segment (without any RSTP bridges) is lost.

► **Disabled port**  
This is the port that does not participate in the Spanning Tree Operation, i.e., is switched off or does not have any connection.
4.6.2 Port states

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

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

### 4.6.3 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 BPDU and contains the following information:

- Bridge identifier of the root bridge
- Root path costs for the sending bridge
- Bridge identifier for the sending bridge
- Port identifiers of the port through which the message was sent
- Port identifiers of the port that has received the message
Based on this information, the bridges participating in RSTP are able to determine port roles autonomously and define their local ports’ states.

### 4.6.4 Fast reconfiguration

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

- **Introduction of edge ports:**
  During a reconfiguration, RSTP sets an edge port to the transmission mode after 3 seconds and then waits for the “Hello Time” (see table 8) to elapse, to ascertain that no BPDU-sending bridge is connected. When the user ascertains that a terminal device is connected at this port and will remain connected, he can switch off RSTP at this port. Thus no waiting times occur at this port in the case of a reconfiguration.

- **Introduction of alternate ports:**
  As the port roles are already determined in normal operation, a bridge can immediately switch from the root port to the alternate port after the connection to the root bridge is lost.

- **Communication with neighboring bridges (point-to-point connections):**
  The decentralized, direct communication between neighboring bridges enables immediate reaction to status changes in the spanning tree architecture.

- **Address table:**
  With STP, the age of the entries in the address table determines the updating of the communication. RSTP immediately deletes the entries for those ports affected by a reconfiguration.

- **Reaction to events:**
  Without having to adhere to any time specifications, RSTP immediately reacts to events such as connection interruptions, connection reinstatements, and the like.
4.6 The Rapid Spanning Tree Protocol

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

4.6.5 Configuring the Rapid Spanning Tree

☐ Set up the network to meet your demands.

Note: Before you connect the redundant lines, you must complete the configuration of the RSTP. You thus avoid loops during the configuration phase.

☐ For devices with DIP switches, you switch these to “deactivated” (both to ON), so that the software configuration is not restricted.

☐ Select the Redundancy: Rapid Spanning Tree: Global dialog.
Switch on RSTP on each device

Figure 22: Operation on/off
Define the desired Switch as the root bridge by assigning it the lowest priority in the bridge information among all the bridges in the network, in the “Protocol Configuration/Information” frame. Note that only multiples of 4,096 can be entered for this value (see table 8). In the “Root Information” frame, the dialog shows this device as the root.

A root switch has no root port and a root cost of 0.

If necessary, change the default priority value of 32,768 in other bridges in the network in the same way to the value you want (multiples of 4,096).

For each of these bridges, check the display in the “Root Information” frame:
- Root-ID: Displays the root bridge's bridge identifier
- Root Port: Displays the port leading to the root bridge
- Root Cost: Displays the root cost to the root bridge

in the “Protocol Configuration/Information” frame:
- Priority: Displays the priority in the bridge identifier for this bridge
- MAC Address: Displays the MAC address of this Switch
- Topology Changes: Displays the number of changes since the start of RSTP
- Time since last change: Displays the time that has elapsed since the last network reconfiguration

If necessary, change the values for “Hello Time”, “Forward Delay” and “Max. Age” on the rootbridge. The root bridge then transfers this data to the other bridges. The dialog displays the data received from the root bridge in the left column. In the right column you enter the values which shall apply when this bridge becomes the root bridge. For the configuration, take note of table 8.
Figure 23: Assigning Hello Time, Forward Delay and Max. Age

The times entered in the RSTP dialog are in units of 1 s

Example: a Hello Time of 2 corresponds to 2 seconds.

Now connect the redundant lines.
### 4.6 The Rapid Spanning Tree Protocol

#### Table 8: Global RSTP settings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Meaning</th>
<th>Possible Values</th>
<th>Default Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priority</td>
<td>The priority and the MAC address go together to make up the bridge identification.</td>
<td>0 &lt; (n \times 4,096 &lt; 61,440)</td>
<td>32,768</td>
</tr>
<tr>
<td>Hello Time</td>
<td>Sets the Hello Time. The local Hello Time is the time in seconds between the sending of two configuration messages (Hello packets). If the local device is the root, the other devices in the entire network take over this value. Otherwise the local device uses the value of the root bridge in the “Root” column on the right.</td>
<td>1 - 2</td>
<td>2</td>
</tr>
<tr>
<td>Forward Delay</td>
<td>Sets the Forward Delay parameter. In the previous STP protocol, the Forward Delay parameter was used to delay the status change between the statuses disabled, discarding, learning, forwarding. Since the introduction of RSTP, this parameter only has a subordinate role, because the RSTP bridges negotiate the status change without any specified delay. If the local device is the root, the other devices in the entire network take over this value. Otherwise the local device uses the value of the root bridge in the “Root” column on the right.</td>
<td>4 - 30 s</td>
<td>15 s</td>
</tr>
<tr>
<td>Max Age</td>
<td>Sets the Max Age parameter. In the previous STP protocol, the Max Age parameter was used to specify the validity of STP BPDUs in seconds. For RSTP, Max Age signifies the maximum permissible branch length (number of devices to the root bridge). If the local device is the root, the other devices in the entire network take over this value. Otherwise the local device uses the value of the root bridge in the “Root” column on the right.</td>
<td>6 - 40 s</td>
<td>20 s</td>
</tr>
</tbody>
</table>
4.6 The Rapid Spanning Tree Protocol

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

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

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

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

When necessary, change and verify the settings and displays that relate to each individual port (dialog: **Rapid Spanning Tree:Port**).
**Figure 25: Configuring RSTP per port**

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Meaning</th>
<th>Possible Values</th>
<th>Default Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>STP active</td>
<td>Here you can switch Spanning Tree on or off for this port. If Spanning Tree is activated globally and switched off at one port, this port does not send STP-BPDUs and drops any STP-BPDUs received.</td>
<td>On, Off</td>
<td>On</td>
</tr>
</tbody>
</table>

**Note:** If you want to use other layer 2 redundancy protocols such as HIPER-Ring or Ring/Network coupling in parallel with Spanning Tree, make sure you switch off the ports participating in these protocols in this dialog for Spanning Tree. Otherwise the redundancy can fail or loops can result.

| Port status (read only) | Displays the STP port status with regard to the global MSTI (IST). | discarding, learning, forwarding, disabled, manualForwarding, notParticipate | -                |

| Port priority         | Here you enter the port priority (the four highest bits of the port ID) with regard to the global MSTI (IST) as a decimal number of the highest byte of the port ID. | 16 ≤ n·16 ≤ 240 | 128              |

| Port path costs       | Enter the path costs with regard to the global MSTI (IST) to indicate preference for redundant paths. If the value is 0, the Switch automatically calculates the path costs for the global MSTI (IST) depending on the transmission rate. | 0 - 200,000,000 | 0 (automatically) |

Table 9: Port-related RSTP settings and displays
### Admin Edge Port

Activate this setting when a terminal device is connected to the port. Then the port immediately has the forwarding status after a link is set up, without first going through the STP statuses. If the port still receives an STP-BPDU, the device blocks the port and clarifies its STP port role. In the process, the port can switch to a different status, e.g. forwarding, discarding, learning.

Deactivate the setting when the port is connected to a bridge. After a link is set up, the port then goes through the STP statuses first before taking on the forwarding status, if applicable.

This setting applies to all MSTIs.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Meaning</th>
<th>Possible Values</th>
<th>Default Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admin Edge Port</td>
<td>Activate this setting when a terminal device is connected to the port. Then the port immediately has the forwarding status after a link is set up, without first going through the STP statuses. If the port still receives an STP-BPDU, the device blocks the port and clarifies its STP port role. In the process, the port can switch to a different status, e.g. forwarding, discarding, learning. Deactivate the setting when the port is connected to a bridge. After a link is set up, the port then goes through the STP statuses first before taking on the forwarding status, if applicable. This setting applies to all MSTIs.</td>
<td>active (box selected), inactive (box empty)</td>
<td>inactive</td>
</tr>
</tbody>
</table>

### Oper Edge Port (read only)

The “Oper Edge Port” condition is true if no STP-BPDUs have been received, i.e. a terminal device is connected. It is false if STP-BPDUs have been received, i.e. a bridge is connected.

This condition applies to all MSTIs.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Meaning</th>
<th>Possible Values</th>
<th>Default Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oper Edge Port</td>
<td>The “Oper Edge Port” condition is true if no STP-BPDUs have been received, i.e. a terminal device is connected. It is false if STP-BPDUs have been received, i.e. a bridge is connected. This condition applies to all MSTIs.</td>
<td>true, false</td>
<td>-</td>
</tr>
</tbody>
</table>

### Auto Edge Port

The Auto Edge Port setting is only considered when the Admin Edge Port parameter is deactivated.

If Auto Edge Port is active, after a link is set up the device sets the port to the forwarding status after 1.5 · Hello Time (in the default setting 3 s).

If Auto Edge Port is deactivated, the device waits for 2 · Forward Delay instead (in the default setting 30 s).

This setting applies to all MSTIs.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Meaning</th>
<th>Possible Values</th>
<th>Default Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto Edge Port</td>
<td>The Auto Edge Port setting is only considered when the Admin Edge Port parameter is deactivated. If Auto Edge Port is active, after a link is set up the device sets the port to the forwarding status after 1.5 · Hello Time (in the default setting 3 s). If Auto Edge Port is deactivated, the device waits for 2 · Forward Delay instead (in the default setting 30 s). This setting applies to all MSTIs.</td>
<td>active (box selected), inactive (box empty)</td>
<td>active</td>
</tr>
</tbody>
</table>

Table 9: Port-related RSTP settings and displays
### 4.6 The Rapid Spanning Tree Protocol

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Meaning</th>
<th>Possible Values</th>
<th>Default Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual point-to-point (read only)</td>
<td>The “Actual point-to-point” condition is true if this port has a full duplex connection to an STP device, otherwise it is false (e.g. if a hub is connected). The point-to-point connection makes a direct connection between 2 RSTP devices. The direct, decentralized communication between the two bridges results in a short reconfiguration time. This condition applies to all MSTIs.</td>
<td>true, false is determined from duplex mode: FDX: true HDX: false</td>
<td>-</td>
</tr>
<tr>
<td>Received bridge ID (read only)</td>
<td>Displays the remote bridge ID from which this port last received an STP-BPDU. In the stable condition (no topology change), this is usually the designated bridge ID, as only its port has the role “designated” and thus sends BPDUs.</td>
<td>Bridge ID (format ppppp / mm mm mm mm mm)</td>
<td>-</td>
</tr>
<tr>
<td>Received path costs (read only)</td>
<td>Displays the path costs of the remote bridge from its root port to the CIST root bridge.</td>
<td>0-200,000,000</td>
<td>-</td>
</tr>
<tr>
<td>Received port ID (read only)</td>
<td>Displays the port ID at the remote bridge from which this port last received an STP-BPDU. In the stable condition (no topology change), this is usually the designated port of the designated bridge, as only its port sends BPDUs.</td>
<td>Port ID, format pn nn, with p: port priority / 16, nnn: port No., (both hexadecimal)</td>
<td>-</td>
</tr>
</tbody>
</table>

*Table 9: Port-related RSTP settings and displays*
4.7 Combining RSTP and MRP

In the MRP compatibility mode, the device allows you to combine RSTP with MRP. With the combination of RSTP and MRP, the fast switching times of MRP are maintained. The RSTP diameter (see fig. 24) depends on the “Max Age”. It applies to the devices outside the MRP-Ring.

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

---

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

- Configure the RSTP root bridge and the RSTP backup root bridge in the MRP-Ring:
  - Set the priority.
  - If you exceed the RSTP diameter specified by the default value of Max Age = 20, modify “Max Age” and “Forward Delay” accordingly.

- Activate RSTP globally.
- Activate the MRP compatibility mode.
- After configuring all the participating devices, connect the redundant RSTP connection.
4.7.1 Application example for the combination of RSTP and MRP

The figure (see fig. 27) shows an example for the combination of RSTP and MRP.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>S6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MRP settings</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ring redundancy: MRP version</td>
<td>MRP</td>
<td>MRP</td>
<td>MRP</td>
<td>MRP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ring port 1</td>
<td>1.2</td>
<td>1.1</td>
<td></td>
<td>1.1</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>Ring port 2</td>
<td>1.1</td>
<td>1.2</td>
<td></td>
<td>1.2</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>Port from MRP-Ring to the RSTP net</td>
<td>1.3</td>
<td>1.3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Redundancy Manager mode</td>
<td>On</td>
<td>Off</td>
<td>–</td>
<td>–</td>
<td>Off</td>
<td>Off</td>
</tr>
<tr>
<td>MRP operation</td>
<td>On</td>
<td>On</td>
<td>Off</td>
<td>Off</td>
<td>On</td>
<td>On</td>
</tr>
<tr>
<td><strong>RSTP settings</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For each RSTP port: STP State Enable</td>
<td>On</td>
<td>On</td>
<td>On</td>
<td>On</td>
<td>On</td>
<td>On</td>
</tr>
<tr>
<td>Protocol Configuration: Priority</td>
<td>4,096</td>
<td>0</td>
<td>32,768</td>
<td>32,768</td>
<td>32,768</td>
<td>32,768</td>
</tr>
<tr>
<td>RSTP:Global: Operation</td>
<td>On</td>
<td>On</td>
<td>On</td>
<td>On</td>
<td>On</td>
<td>On</td>
</tr>
<tr>
<td>RSTP:Global: MRP compatibility</td>
<td>On</td>
<td>On</td>
<td>–</td>
<td>–</td>
<td>On</td>
<td>On</td>
</tr>
</tbody>
</table>

Table 10: Values for the switch configuration in the MRP/RSTP example

Prerequisites for further configuration:
- You have configured the MRP settings for the devices in accordance with the above table.
- The MRP-Ring’s redundant line is connected.
Activate RSTP at the ports, using S1 as an example.

```plaintext
enable
configure
interface 1/1
spanning-tree port mode
exit
interface 1/2
spanning-tree port mode
exit
interface 1/3
spanning-tree port mode
exit
```

Switch to the Privileged EXEC mode.
Switch to the Configuration mode.
Switch to the Interface Configuration mode of interface 1/1.
Activate RSTP on the port.
Switch to the Configuration mode.
Switch to the interface configuration mode for port 1.2.
Activate RSTP on the port.
Switch to the Configuration mode.
Switch to the interface configuration mode for port 1.3.
Activate RSTP on the port.
Switch to the Configuration mode.
Configure the global settings, using S1 as an example:
- the RSTP priority
- global operation
- the MRP compatibility mode

```
spanning-tree mst priority 0 4096
Set the RSTP priority for the MST instance 0 to the value 4,096. the MST instance 0 is the default instance.

spanning-tree
Activate RSTP operation globally.

spanning-tree stp-mrp-mode
Activate MRP compatibility.
```

Configure the other switches S2 though S6 with their respective values (see table 10).

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.

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If so, on what page?

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