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Safety Information

Important Information

NOTICE

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

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

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

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

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

CAUTION indicates a potentially hazardous situation, which, if not avoided, can result in injury or equipment damage.

PLEASE NOTE

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

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About the Book

At a Glance

Document Scope
The Schneider Electric ConneXium Industrial Ethernet offer is comprised of a complete family of products and tools required to build the infrastructure of an industrial Ethernet network.

The offer includes:
- switches, hubs, and transceivers
- gateways
- cables, connectors, and accessories

This manual contains a device description, safety instructions, technical data, and all the other information you need to install the ConneXium ESM Ethernet switches before you start configuring them. This manual contains all the information you need to choose and configure the appropriate redundancy procedures for a ConneXium ESM Ethernet switch.

Validity Note
The data and illustrations found in this book are not binding. We reserve the right to modify our products in line with our policy of continuous product development. The information in this document is subject to change without notice and should not be construed as a commitment by Schneider Electric.

Related Documents

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<td>ConneXium Ethernet Cabling System TCSESM Managed Switch Configuration Manual</td>
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<td>ConneXium Ethernet Cabling System TCSESM Managed Switch Installation Manual</td>
<td>31007118</td>
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About the Book

**Product Related Information**

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Failure to observe this product related warning can result in injury or equipment damage.

**User Comments**

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Introduction

Redundancy Functions and Tools

Redundancy Functions

The switch features the following redundancy functions:

- HIPER-Ring Version 1
- HIPER-Ring Version 2 (MRP Draft)
- redundant coupling of HIPER-Rings and network segments
- rapid spanning tree

Comparing the Redundancy Functions

The following table shows a comparison of the features for each of the redundancy functions that can be used with the switch.

<table>
<thead>
<tr>
<th>Redundancy Function</th>
<th>Feature</th>
<th>Network Topology</th>
</tr>
</thead>
</table>
| Rapid Spanning Tree Protocol | < 1 s  
 Spanning Tree Protocol < 30 s, typically 50 s max.  
 Depending on the number of switches used, switch-over time can vary considerably. | Any structure                           |
| HIPER-Ring V2 (MRP Draft) | adjustable to max. 200 ms/500 ms  
 typically 150 ms with fast Ethernet  
 The number of switches hardly affects switch-over time. | Ring                                     |
| HIPER-Ring V1            | adjustable to max. 300 ms/500 ms  
 typically 150 ms with fast Ethernet  
 The number of switches hardly affects switch-over time. | Ring                                     |
| Redundant Ring Coupling   | typically 0.15 s max.                                                   | The network segments are coupled via a primary and a secondary line. |

Note: Switch-over time should be tested and confirmed for every application.
There are two tools available for operating the switch with the redundancy functions:

- Web-based management
  This tool allows you to easily configure the agent. It is provided together with the switch.
- Command Line Interface (CLI)
  This tool serves to set up basic functions.

The settings of the two-pin DIP switch, located on the front of the TCSESM switch, determines which of the following modes the switch is in:

- HIPER-Ring Redundancy Mode
- HIPER-Ring Redundancy Manager Mode
- Standby Mode
- Software Mode

The DIP switch setting combinations are described below.

The figure shows the DIP switch with both switches in the ON position.

<table>
<thead>
<tr>
<th>DIP Switches</th>
<th>ESM Operation Mode</th>
<th>Default ESM Firmware Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM Stand by</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OFF OFF</td>
<td>HIPER-Ring V1 Redundancy Mode</td>
<td>ON OFF 1 &amp; 2 ON 4</td>
</tr>
<tr>
<td>ON OFF</td>
<td>HIPER-Ring Vi Redundancy Manager Mode</td>
<td>ON ON 1 &amp; 2 ON 4</td>
</tr>
<tr>
<td>OFF ON</td>
<td>Standby Mode HIPER- Ring V2 (HIPER-Ring Coupling, or Network Coupling)</td>
<td>ON ON 1 &amp; 2 ON 4</td>
</tr>
<tr>
<td>ON ON</td>
<td>Software Mode-Use Web or CLI to configure HIPER-Ring V2 or RSTP Software Mode-Use Web or CLI to configure HIPER-Ring V2 Coupling or Network coupling</td>
<td>OFF OFF</td>
</tr>
</tbody>
</table>
Redundant Ring Structure: HIPER-Ring

The HIPER-Ring

Description of the HIPER-Ring

The concept of the HIPER-Ring allows you to build ring-shaped high availability network structures.

The Redundancy Manager (RM) function of the switch allows you to close both ends of a backbone in a line-type configuration to create a redundant ring—the HIPER-Ring (see the following figure).

You can only use Schneider-Electric Connexium switches in a HIPER-Ring.

If a line segment becomes inoperative, the ring structure of up to 50 switches is changed into a line-type configuration—typically within 150 ms. The figure shows an example of a redundant line ring.

You can only use Schneider-Electric Connexium switches in a HIPER-Ring. If a line segment becomes inoperative, the ring structure of up to 50 switches is changed into a line-type configuration—typically within 150 ms. The figure shows an example of a redundant line ring.
Configuring HIPER-Ring Version 1

Configure HIPER-Ring version 1 as follows:

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Set up the network according to your requirements. To avoid loops during the configuration, do not connect the redundant path until you have concluded the HIPER-Ring configuration.</td>
</tr>
<tr>
<td>2</td>
<td>Check that the RM and Stand by DIP switches are in the off (left) position.</td>
</tr>
<tr>
<td>3</td>
<td>Connect the switches to Ethernet cables.</td>
</tr>
<tr>
<td>4</td>
<td>Connect to a switch and open the Web-based interface.</td>
</tr>
<tr>
<td>5</td>
<td>At the menu tree, go to Redundancy → HIPER-Ring to display the HIPER-Ring dialog box.</td>
</tr>
</tbody>
</table>
### Redundant Ring Structure: HIPER-Ring

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Select Version 1 in the Version box.</td>
</tr>
<tr>
<td>7</td>
<td>Enter the Port numbers for Ring Port 1 and Ring Port 2.</td>
</tr>
</tbody>
</table>
| 8    | The Operation fields in the Ring Port 1 and Ring Port 2 group boxes allow you to view the statuses of these ports:  
  - active: This means that the port is switched on and has a link.  
  - inactive: This means that the port is switched off and has no link. |
| 9    | At the menu tree go to Basics → Port Configuration. |
| 10   | Select the following settings for each ring port:  
  - Port on selected  
  - Automatic Configuration deselected  
  - Manual Configuration: 100 Mbit/s FDX  
  - Manual Cable Crossing: disable  
  **Note:** When you use 100 Mbit/s and full-duplex with twisted pair cables, with the Automatic Configuration deselected and Manual Cable Crossing set to enable, you must use a crossover cable. |
| 11   | Repeat steps 3 to 9 for all switches in the ring. |
| 12   | On one switch at either end of the line, enable the Redundancy Manager by setting the RM DIP switch on the front panel of the switch to ON. |
| 13   | Select the desired value (Standard (500 ms)) or (Accelerated (300 ms)) in the Ring Recovery group box for the switch for which you have activated the redundancy manager.  
  **Note:** Settings in the Ring Recovery group box are ineffective for switches that are not the redundancy manager. Also, if selecting the Accelerated value does not provide the ring stability required for your network, change to the Standard setting. |
| 14   | The Redundancy Manager Status group box allows you to view the switch redundancy status:  
  - Active (redundant line): the ring is open, i.e. a data line or a network node within the ring has become inoperative.  
  - Inactive: the ring is closed, i.e. the data lines and network nodes are working. |
| 15   | The Information group box allows you to view information status:  
  - Redundancy guaranteed: If a path used for the function becomes inoperative, the redundant path will take over the function of the non-working path.  
  - Configuration failure: The function is incomplete or has been incorrectly configured. |
| 16   | If there are VLANs configured, reconsider the VLAN configuration of the ring ports. |
| 17   | If a VLAN configuration is involved, go to Switching → VLAN → Static in the menu tree, and select VLAN ID 1 and VLAN membership U. |
| 18   | Disable the Spanning Tree protocol on the ports connected to the redundant ring, since Spanning Tree and ring redundancy operate at different reaction speeds:  
  At the menu tree, go to Redundancy → Rapid Spanning Tree → Port to disable Spanning Tree for the ports. |
| 19   | Close the line leading to the ring by connecting the two switches at the ends of the line via their ring ports. |
Configuring the HIPER-Ring Version 2 (MRP Draft)

Configure HIPER-Ring version 2 (MRP draft) as follows:

**Step** | **Action**
--- | ---
1 | Set up the network according to your requirements. To avoid loops during the configuration, do not connect the redundant path until you have concluded the MRP-Ring configuration.
2 | Check that the RM and Stand by DIP switches are in the ON (right) position.
3 | Connect the switches to Ethernet cables.
4 | Connect a PC to a switch and open the Web-based interface.
5 | At the menu tree, go to Redundancy → HIPER-Ring to display the HIPER-Ring dialog box.
6 | Select Version 2 (MRP Draft) in the Version box.
<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>In the HIPER-Ring dialog box, designate the port numbers for Ring Port 1 and Ring Port 2.</td>
</tr>
</tbody>
</table>
| 8    | The Operation fields in the Ring Port 1 and Ring Port 2 group boxes allow you to view the status of these ports:  
     forwarding: This means that the port is switched on and has a link.  
     inactive: This means that the port is blocked and has a link.  
     disabled: This means that the port is switched off.  
     not-connected: This means that the port does not have a link. |
| 9    | At the menu tree go to Basics → Port Configuration. |
| 10   | Select the following settings for each ring port:  
     - Port on: selected  
     - Automatic Configuration: deselected  
     - Manual Configuration: 100 Mbit/s FDX  
     - Manual Cable Crossing: disable  
     **Note:** When you use 100 Mbit/s and full-duplex with twisted pair cables, with the Automatic Configuration deselected and Manual Cable Crossing set to enable, you must use a crossover cable. |
| 11   | Click On in the Operation frame. |
| 12   | Repeat steps 3 to 9 for all switches in the ring. |
| 13   | On one switch at either end of the line, enable the Redundancy Manager by setting the Redundancy Manager Mode to ON. |
| 14   | If a switch in the ring does not support the advanced mode for fast switching times, deactivate the advanced mode in the RM by unchecking the Advanced Mode check box in the Configuration Redundancy Manager group box. |
| 15   | Select the desired value (Standard (500 ms)) or (Accelerated (200 ms)) in the Ring Recovery group box for the switch for which you have activated the redundancy manager.  
     **Note:** Settings in the Ring Recovery group box are ineffective for switches that are not the redundancy manager. Also, if selecting the Accelerated value does not provide the ring stability required for your network, change to the Standard setting. |
| 16   | The Information group box allows you to view information status:  
     - Redundancy guaranteed: If a path used for the function becomes inoperative, the redundant path will take over the function of the non-working path.  
     - Configuration failure: The function is incomplete or has been incorrectly configured. |
| 17   | If the MRP ring configuration is not to be assigned to a VLAN, enter 0 in the VLAN ID field. |
| 18   | The VLAN group box allows you to assign a MRP-ring to a VLAN. If the MRP-ring is not to be assigned to a VLAN, enter 0 for the VLAN ID. If the MRP-ring is to be assigned to a VLAN, then enter the VLAN ID configured for the ring ports as the VLAN ID.  
     **Note:** All ring ports must have the same VLAN ID and membership set to U in the static VLAN table. |
| 19   | Disable the Spanning Tree protocol on the ports connected to the redundant ring, since Spanning Tree and ring redundancy operate at different reaction speeds:  
     At the menu tree, go to Redundancy → Rapid Spanning Tree → Port to disable Spanning Tree for the ports. |
| 20   | Close the line leading to the ring by connecting the two switches at the ends of the line via their ring ports. |
Redundant Ring Structure: HIPER-Ring
**Redundant Coupling**

The control intelligence built into the switch allows the redundant coupling of HIPER rings and network segments.

Two rings/network segments are connected via a separate path using the ESM switch.

In the case of a one-switch coupling, the redundant coupling line runs from ports of one switch in the first ring/network segment to ports of two different switches in the second ring/network segment.

Immediately after the main line has become inoperative, the switch releases the redundant line. After the main line has been fixed, it is released again, and the redundant line is reblocked. An error is detected and eliminated within 500 ms (typically 150 ms).

In the case of a two-switch coupling, the redundant coupling lines run from ports on two different switches in the first ring/network segment to ports on two different switches in the second ring/network segment. The switch connected to the redundant line and the switch connected to the main line exchange information about their operating states by sending control frames via Ethernet or the control line.

Immediately after the main line has failed, the redundant switch switches to the redundant line. As soon as the main line has been restored to normal operation, the switch in the main line notifies the redundant switch. The main line is released again, and the redundant line is reblocked. An error is detected and eliminated within 500 ms (typically 150 ms).
### Criteria for Choosing between the Redundant Coupling Options

This table explains the advantages and disadvantages of the different coupling options.

<table>
<thead>
<tr>
<th>Considerations</th>
<th>One-Switch Coupling</th>
<th>Two-Switch Coupling</th>
<th>Two-Switch Coupling Using a Control Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>In terms of topology, the switches involved are not favorably distributed. Thus, arranging the lines to set up a two-switch coupling would be labor intensive.</td>
<td>In terms of topology, the switches involved are favorably distributed. Installing a control line is labor intensive.</td>
<td>In terms of topology, the switches involved are favorably distributed. Installing a control line is not labor intensive.</td>
</tr>
<tr>
<td>Disadvantage</td>
<td>If the switch configured for redundant coupling becomes inoperative, the connection between the networks will be cut off.</td>
<td>Networking the switches for two-switch coupling is more labor intensive than for one-switch coupling.</td>
<td>Networking the switches for two-switch coupling with a control line is more labor intensive than for one-switch or two-switch coupling.</td>
</tr>
<tr>
<td>Advantage</td>
<td>Networking the switches for one-switch coupling is less labor intensive than for two-switch coupling.</td>
<td>If a switch configured for redundant coupling fails, the networks will still be connected.</td>
<td>If one of the switches configured for redundant coupling becomes inoperative, the networks will still be connected.</td>
</tr>
</tbody>
</table>

**Note:** Base your decision for choosing a coupling option on topological conditions and the degree of security you wish to have.
Configuring One-Switch Coupling

The figure shows an application example of one-switch coupling.

The coupling between the two networks is effected via the main line (continuous line), which is connected to the partner coupling port. If the main line becomes inoperative, the redundant line (dashed line), which is connected to the coupling port, takes over the coupling of the two networks. One switch effects the coupling.

**Note:** For redundancy security reasons, you cannot combine Rapid Spanning Tree and ring/network coupling.
**Configuration**

Configure one-switch coupling as follows:

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Select the appropriate switch in your network to be used as the coupling switch.</td>
</tr>
<tr>
<td>2</td>
<td>If the switch is configured for HIPER-Ring Version 1, put the RM DIP switch to off and the Stand by switch to the ON position and skip to step 4.</td>
</tr>
<tr>
<td>3</td>
<td>If the switch is configured for HIPER-Ring Version 2, put the RM and Stand by DIP switches to the ON position.</td>
</tr>
<tr>
<td>4</td>
<td>Connect to the switch.</td>
</tr>
<tr>
<td>5</td>
<td>Open the Web-based interface.</td>
</tr>
<tr>
<td>6</td>
<td>Go to Redundancy → Ring/Network Coupling.</td>
</tr>
<tr>
<td>7</td>
<td>Select one-switch main coupling (icon 1). The following settings apply to the switch displayed in blue. The figure shows the Ring/Network Coupling dialog box.</td>
</tr>
<tr>
<td>8</td>
<td>Select the Partner coupling port to specify at which port you wish to connect the main line.</td>
</tr>
<tr>
<td>9</td>
<td>Select the Coupling port to specify at which port you wish to connect the redundant line.</td>
</tr>
<tr>
<td>10</td>
<td>If the switch is configured for HIPER-Ring version 2, (RM and Stand by DIP switches ON), then select On in the Operation group box.</td>
</tr>
<tr>
<td>11</td>
<td>Connect the main and the redundant lines.</td>
</tr>
</tbody>
</table>
You can view the Ports’ mode and status state in the Select Port group box:
- Port mode: The port is either active or in stand-by mode.
- Port state: The port is either connected or not connected.

You can view the redundancy and configuration states in the Information group box:
- Redundancy guaranteed: If one of the lines concerned becomes inoperative, a redundant line will take over the function of the non-working line.
- Configuration failure: The function is incomplete or has not been configured correctly.

Go to Basic Settings → Port Configuration to configure the coupling ports.

Check Port on and Auto-negotiation.
If VLANs have been configured, consider performing a VLAN configuration of the coupling and partner coupling ports.

If you have decided to perform a VLAN configuration, proceed as follows:
1. Go to VLAN → Port, and select for the coupling and partner coupling ports Port VLAN ID 1 and disable Ingress Filtering.
2. Go to VLAN → Static, and choose U as VLAN affiliation.
3. Go to Redundancy → Ring/Network Coupling.

In the Redundancy Mode group box, select one of the following options:
- Redundant Ring/Network Coupling: If you choose this setting either the main line or the redundant line will be active. Both lines are never active simultaneously.
- Extended Redundancy: If you choose this setting, the main line and the redundancy line will be active simultaneously if the connection line between the switches in the connected network becomes inoperative. During reconfiguration, there may be packet duplications. Thus, you should only select this setting if your application detects frame duplications.

In the Coupling Mode group box, chose one of the following options to select the type of the coupled network:
- Ring Coupling: Choose this setting if you wish to couple a HIPER-Ring.
- Network Coupling: Choose this setting if you wish to couple a line-type configuration.
Configuring Two-Switch Coupling

The figure shows an application example of two-switch coupling.

The coupling between the two networks is effected via the main line (continuous line). If the main line becomes inoperative, the redundant line (dashed line) takes over coupling of the networks. The coupling is effected by two switches which send their control packets using Ethernet.

The switch to which you connect the main line and the switch to which you connect the redundant line are coupling partners.

**Note:** For redundancy security reasons, you cannot combine Rapid Spanning Tree and ring/network coupling.
**Main Line Configuration**

Choose the suitable main line coupling option as follows:

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Select the appropriate switch in your network to be used as the coupling switch for the main line.</td>
</tr>
<tr>
<td>2</td>
<td>If the switch is configured for HIPER-Ring Version 1, (RM and Stand by DIP switches Off), proceed to the next step. If the switch is configured for HIPER-Ring Version 2, (RM and Stand by DIP switches ON), then proceed to the next step.</td>
</tr>
<tr>
<td>3</td>
<td>Connect to the switch.</td>
</tr>
<tr>
<td>4</td>
<td>Open the Web-based interface.</td>
</tr>
<tr>
<td>5</td>
<td>Go to Redundancy → Ring/Network Coupling.</td>
</tr>
<tr>
<td>6</td>
<td>Select two-switch main coupling (icon 2). The following settings apply to the switch displayed in blue. The figure shows the Ring/Network Coupling dialog box.</td>
</tr>
<tr>
<td>7</td>
<td>Select Coupling port to specify at which port you wish to connect the main line.</td>
</tr>
<tr>
<td>8</td>
<td>If the switch is configured for HIPER-Ring Version 2 (RM and Stand by DIP switches ON), then in the Operation group box select On.</td>
</tr>
<tr>
<td>9</td>
<td>Connect the main line.</td>
</tr>
</tbody>
</table>
### Rendundant Coupling

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
</table>
| 10   | You can view the ports mode and status state in the Select Port group box:  
* 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 is displayed in this field, provided that it is already operating in the network. |
| 11   | You can view redundancy and configuration state in the Information group box:  
* Redundancy guaranteed: If one of the lines concerned becomes inoperative, a redundant line will take over the function of the non-working line.  
* Configuration failure: The function is incomplete or has not been configured correctly.  
To avoid continuous loops, the switch switches off the port status of the coupling port if you:  
* switch off the function or  
* changed the configuration while the connections at these ports are operating. |
| 12   | Go to Basic Settings → Port Configuration to configure the coupling ports. |
| 13   | Select Port and Auto-negotiation.  
If VLANs have been configured, consider performing a VLAN configuration of the coupling and partner coupling ports. |
| 14   | If you have decided to perform a VLAN configuration, proceed as follows:  
1. Go to VLAN → Port, and select for the coupling and partner coupling ports Port VLAN ID 1 and disable Ingress Filtering. |
| 15   | 2. Go to VLAN → Static, and choose U as VLAN affiliation.  
Bear in mind that if you use the Redundancy Manager and two-switch main coupling functions at the same time, a loop may occur. |
| 16   | In the Redundancy Mode group box, select one of the following options:  
* Redundant Ring/Network Coupling: If you choose this setting, either the main line or the redundant line will be active. Both lines are never active simultaneously.  
* Extended Redundancy: If you choose this setting, the main line and the redundancy line will be active simultaneously if the connection line between the switches in the connected network becomes inoperative. During reconfiguration, there may be packet duplications. Thus you should only select this setting if your application detects frame duplications. |
| 17   | In the Coupling Mode group box:, choose one of the following options to select the type of the coupled network:  
* Ring Coupling: Choose this setting if you wish to couple a HIPER-Ring.  
* Network Coupling: Choose this setting if you wish to couple a line-type configuration. |
Redundant Line Configuration

Choose the suitable redundant line coupling option as follows:

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Select the appropriate switch in your network to be used as the coupling switch for the redundant line.</td>
</tr>
<tr>
<td>2</td>
<td>If the switch is configured for HIPER-Ring Version 1, (RM and Stand by DIP switches Off), then put the Stand by switch to ON and proceed to the next step. If the switch is configured for HIPER-Ring Version 2 (RM and Stand by DIP switches ON), then proceed to the next step.</td>
</tr>
<tr>
<td>3</td>
<td>Connect to the switch.</td>
</tr>
<tr>
<td>4</td>
<td>Open the Web-based interface.</td>
</tr>
<tr>
<td>5</td>
<td>Go to Redundancy → Ring/Network Coupling.</td>
</tr>
<tr>
<td>6</td>
<td>Select two-switch redundant coupling icon (icon 3). The following settings apply to the switch displayed in blue. The figure shows the Ring/Network Coupling dialog box.</td>
</tr>
<tr>
<td>7</td>
<td>Select the Coupling port to specify at which port you wish to connect the redundant line.</td>
</tr>
<tr>
<td>8</td>
<td>If the switch is configured for HIPER-Ring Version 2 (RM and Stand by DIP switches ON), then in the Operation group box select On.</td>
</tr>
<tr>
<td>9</td>
<td>Connect the redundant line.</td>
</tr>
</tbody>
</table>
### Rendundant Coupling

**Step** | **Action**
--- | ---
10 | You can view the ports mode and status state in the Select Port group box:
  - 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 is displayed in this field, provided that it is already operating in the network.

11 | You can view redundancy and configuration state in the Information group box:
  - Redundancy guaranteed: If one of the lines concerned becomes inoperative, a redundant line will take over the function of the non-working line.
  - Configuration failure: The function is incomplete or has not been configured correctly.
  To avoid continuous loops, the switch switches off the port status of the coupling port if you:
  - switch off the function or
  - changed the configuration while the connections at these ports are operating.

12 | Go to Basic Settings → Port Configuration to configure the coupling ports.

13 | Check Port on and Auto-negotiation.
If VLANs have been configured, consider performing a VLAN configuration of the coupling and partner coupling ports.

14 | If you have decided to perform a VLAN configuration, proceed as follows:
1. Go to VLAN → Port, and select for the coupling and partner coupling ports Port VLAN ID 1 and disable Ingress Filtering.

15 | 2. Go to VLAN → Static, and choose U as VLAN affiliation.
Bear in mind that if you use the Redundancy Manager and two-switch main coupling functions at the same time, a loop may occur.

16 | In the Redundancy Mode group box, select one of the following options:
  - Redundant Ring/Network Coupling: If you choose this setting, either the main line or the redundant line will be active. Both lines are never active simultaneously.
  - Extended Redundancy: If you choose this setting, the main line and the redundancy line will be active simultaneously if the connection line between the switches in the connected network fails During reconfiguration, there may be packet duplications. Thus you should only select this setting if your application detects frame duplications.

17 | In the Coupling Mode group box, choose one of the following options to select the type of the coupled network:
  - Ring Coupling: Choose this setting if you wish to couple a HIPER-Ring.
  - Network Coupling: Choose this setting if you wish to couple a line-type configuration.
Configuring Two-Switch Coupling Using a Control Line

The figure shows an application example of two-switch coupling using a control line.

The coupling between the two networks is effected via the main line (continuous line). If the main line becomes inoperative, the redundant line (dashed line) takes over coupling of the networks. The coupling is effected by two switches which send their control packets using the control line.

The switch to which you connect the main line and the switch to which you connect the redundant line are coupling partners.

**Note:** For redundancy security reasons, you cannot combine Rapid Spanning Tree and ring/network coupling.
# Rendundant Coupling

## Main Line Configuration

Configure the main line as follows:

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Select the appropriate switch in your network to be used as the coupling switch for the main line.</td>
</tr>
<tr>
<td>2</td>
<td>If the switch is configured for HIPER-Ring Version 1, RM and Stand by DIP switches Off), proceed to the next step. If the switch is configured for HIPER-Ring Version 2 RM and Stand by DIP switches ON), then proceed to the next step.</td>
</tr>
<tr>
<td>3</td>
<td>Connect the two coupling partners via their ring ports.</td>
</tr>
<tr>
<td>4</td>
<td>Connect to the switch.</td>
</tr>
<tr>
<td>5</td>
<td>Open the Web-based interface.</td>
</tr>
<tr>
<td>6</td>
<td>Go to Redundancy → Ring/Network Coupling.</td>
</tr>
<tr>
<td>7</td>
<td>Select two-switch main coupling with a control line (icon 4). The following settings apply to the switch displayed in blue. The figure shows the Ring/Network Coupling dialog box.</td>
</tr>
<tr>
<td>8</td>
<td>Select Coupling port to specify at which port you wish to connect the main line.</td>
</tr>
<tr>
<td>9</td>
<td>Select Control port to specify at which port you wish to connect the control line.</td>
</tr>
<tr>
<td>10</td>
<td>If the switch is configured for HIPER-Ring Version 2 RM and Stand by DIP switches ON, then in the Operation group box select On.</td>
</tr>
<tr>
<td>11</td>
<td>Connect the main line and the control line.</td>
</tr>
</tbody>
</table>
### Rendundant Coupling

**Step** | **Action**
--- | ---
12 | You can view the Ports mode and status state in the Select Port group box:
- 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 is displayed in this field, provided that it is already operating in the network.

13 | You can view redundancy and configuration state in the Information group box:
- Redundancy guaranteed: If one of the lines concerned becomes inoperative, a redundant line will take over the function of the non-working line.
- Configuration failure: The function is incomplete or has not been configured correctly.
  To avoid continuous loops, the switch switches off the port status of the coupling port if you:
  - switch off the function or
  - changed the configuration while the connections at the ports are operating.

14 | Go to Basics → Port Configuration to configure the coupling ports.

15 | Check Port on and Auto-negotiation.
If VLANs have been configured, consider performing a VLAN configuration of the coupling and partner coupling ports.

16 | If you have decided to perform a VLAN configuration, proceed as follows:
1. Go to VLAN → Port, and select for the coupling and partner coupling ports Port VLAN ID 1 and disable Ingress Filtering.

17 | 2. Go to VLAN → Static, and choose U as VLAN affiliation.
Bear in mind that if you use the redundancy manager and two-switch main coupling functions at the same time, a loop may occur.

18 | In the Redundant Mode group box, select one of the following options:
- Redundant Ring/Network Coupling: If you choose this setting, either the main line or the redundant line will be active. Both lines are never active simultaneously.
- Extended Redundancy: If you choose this setting, the main line and the redundancy line will be active simultaneously if the connection line between the switches in the connected network becomes inoperative. During reconfiguration, there may be packet duplications. You should select this setting only if your application detects frame duplications.

19 | In the Coupling Mode group box, choose one of the following options to select the type of the coupled network:
- Ring Coupling: Choose this setting if you wish to couple a HIPER-Ring.
- Network Coupling: Choose this setting if you wish to couple a line-type configuration.
**Redundant Line Configuration**

Configure the redundant line as follows:

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Select the appropriate switch in your network to be used as the coupling switch for the redundancy line.</td>
</tr>
<tr>
<td>2</td>
<td>If the switch is configured for HIPER-Ring Version 1, RM and Stand by DIP switches Off, then put the Standby switch to ON and proceed to the next step. If the switch is configured for HIPER Version 2, RM and Stand by DIP switches ON, then proceed to the next step.</td>
</tr>
<tr>
<td>3</td>
<td>Connect the two coupling partners via their ring ports.</td>
</tr>
<tr>
<td>4</td>
<td>Connect to the switch.</td>
</tr>
<tr>
<td>5</td>
<td>Open the Web-based interface.</td>
</tr>
<tr>
<td>6</td>
<td>Go to Redundancy → Ring/Network Coupling.</td>
</tr>
<tr>
<td>7</td>
<td>Select two-switch redundant coupling with a control line (icon 5). The following settings apply to the switch displayed in blue. The figure shows the Ring/Network Coupling dialog box.</td>
</tr>
<tr>
<td>8</td>
<td>Select Coupling port to specify at which port you wish to connect the redundant line.</td>
</tr>
<tr>
<td>9</td>
<td>Select Control port to specify at which port you wish to connect the coupling line.</td>
</tr>
<tr>
<td>10</td>
<td>If the switch is configured for HIPER-Ring Version 2 (RM and Stand by DIP switches ON), then in the Operation group box select On.</td>
</tr>
<tr>
<td>11</td>
<td>Connect the redundant line and the control line.</td>
</tr>
</tbody>
</table>
### Rendundant Coupling

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
</table>
| 12   | You can view the Ports mode and status state in the Select port group box:  
  - 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 is displayed in this field, provided that it is already operating in the network. |
| 13   | You can view redundancy and configuration state in the Information group box:  
  - Redundancy guaranteed: If one of the lines concerned becomes inoperative, a redundant line will take over the function of the non-working line.  
  - Configuration failure: The function is incomplete or has not been configured correctly.  
  To avoid continuous loops, the switch switches off the port status of the coupling port if you:  
  - switch off the function or  
  - changed the configuration  
  while the connections at the ports are operating. |
| 14   | Go to Basic Settings → Port Configuration to configure the coupling ports. |
| 15   | Check Port On and Auto-negotiation.  
If VLANs have been configured, consider performing a VLAN configuration of the coupling and partner coupling ports. |
| 16   | If you have decided to perform a VLAN configuration, proceed as follows:  
1. Go to VLAN → Port, and select for the coupling and partner coupling ports Port VLAN ID 1 and disable Ingress Filtering. |
| 17   | 2. Go to VLAN → Static, and choose U as VLAN affiliation.  
Bear in mind that if you use the redundancy manager and two-switch main coupling functions at the same time, a loop may occur. |
| 18   | In the Redundant Mode group box, select one of the following options:  
  - Redundant Ring/Network Coupling: If you choose this setting either the main line or the redundant line will be active. Both lines are never active simultaneously.  
  - Extended Redundancy: If you choose this setting, the main line and the redundant line will be active simultaneously if the connection line between the switches in the connected network becomes inoperative. During reconfiguration there may be packet duplications. Thus, you should only select this setting if your application detects frame duplications. |
| 19   | In the Coupling Mode group box, choose one of the following options to select the type of the coupled network:  
  - Ring Coupling: Choose this setting if you wish to couple a HIPER-Ring.  
  - Network Coupling: Choose this setting if you wish to couple a line-type configuration. |
Rendundant Coupling
Rapid Spanning Tree

Introducing the Spanning Tree and the Rapid Spanning Tree Protocols

General Information Concerning (Rapid) Spanning Tree

The Spanning Tree protocol (STP) and the Rapid Spanning protocol (RSTP) are used for MAC bridges and are described in the standards IEEE 802.1D-2004 and IEEE 802.1w respectively. Since they are MAC bridge protocols, the term bridge is used instead of switch in the following description of these protocols.

The sizes of LANs are continuously increasing both in terms of geographic dispersion and in terms of the number of stations used. Hence, several bridges should be used at the same time to

- reduce the network load in some subnetworks,
- to set up redundant connections, and
- to overcome distance-related limits.

Advantage of RSTP over STP

Using multiple bridges with multiple, redundant connections between stations can, however, give rise to loops and thus cause the network to become completely inoperative. To prevent such a scenario, the (Rapid) Spanning Tree protocol (RSTP) was designed. RSTP allows redundancy by interrupting loops.

It is an enhanced version of STP to which it is compatible. STP needs 30 s for reconfiguration in case of a connection or bridge that becomes inoperative. This was not always acceptable in time-critical applications. Hence, RSTP was designed to enhance STP, allowing reconfiguration times of less than one second.

Note: The above mentioned standards stipulate that all bridges in a network work with the (Rapid) Spanning Tree protocol. However, if you use STP and RSTP at the same time, the faster RSTP reconfiguration function will not work.
The Spanning Tree Protocol

STP Tasks

Note: As the RSTP is an enhanced version of the STP, the following descriptions of the STP also apply to the RSTP.

The Spanning Tree algorithm reduces network topologies which are set up using bridges and which possess ring structures owing to redundant connections to tree structures. In so doing, STP unravels the ring structures according to given rules by deactivating redundant paths. If, in case of an error, a path is interrupted, STP reactivates the path it had deactivated before. Thus, it enables redundant connections to enhance data security.

When building a tree structure, STP selects a root bridge.

The STP algorithm has the following features:

- automatic reconfiguration of the tree structure in case of bridge errors or interruptions of data paths
- stabilization of the tree structure until the maximum network size (up to 39 hops, depending on the Max Age setting) has been reached
- stabilization at short notice
- reproducible topology that can be predefined by the management
- transparency for terminal equipment
- low network load relative to the transmission capacity available due to the setting up of a tree structure

Bridge Parameters

Each bridge is described by the following unique parameters:

- bridge identification
- root path costs of the bridge ports
- port identification

Bridge Identification

The bridge identification is eight bytes long, with the two highest bytes being the priority figure. The default setting for the priority figure is 32768. However, the management administrator can change this figure when configuring the network. The six low-byte values of the bridge identification form the MAC address of the bridge. The MAC address guarantees that each bridge possesses an unique identifier.

The bridge with the lowest numerical identification value has the highest priority.

The 8-byte bridge identification tab is shown below:
**Root Path Costs**

Each path connecting two bridges has transmission costs (path costs) assigned to it. The switch sets this value according to the transmission rate. In so doing, it assigns higher path costs to a path with a lower transmission rate.

Alternatively, the management administrator can also set the path costs. In so doing, he assigns - like the switch - higher path costs to a path with a lower transmission rate. Since he can freely choose this value, he has a tool at his disposal which allows him to give a certain redundant path priority over all the other redundant paths. The root path costs equals the sum of the costs of the individual paths which a data packet passes between the connected port of a bridge and the root.

Path costs are shown below:

![Diagram of bridge connections with path costs]

The recommended path costs according to the data rate are shown in the following table:

<table>
<thead>
<tr>
<th>Link Speed</th>
<th>Recommended Value</th>
<th>Recommended Range</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=100 KBit/s</td>
<td>200 000 000   (*see note)</td>
<td>20 000 000-200 000 000</td>
<td>1-200 000 000</td>
</tr>
<tr>
<td>1 Mb/s</td>
<td>20 000 000   (*see note)</td>
<td>2 000 000-200 000 000</td>
<td>1-200 000 000</td>
</tr>
<tr>
<td>10 Mb/s</td>
<td>2 000 000   (*see note)</td>
<td>200 000-20 000 000</td>
<td>1-200 000 000</td>
</tr>
<tr>
<td>100 Mb/s</td>
<td>200 000   (*see note)</td>
<td>20 000-2 000 000</td>
<td>1-200 000 000</td>
</tr>
<tr>
<td>1 Gb/s</td>
<td>20 000</td>
<td>2 000-200 000</td>
<td>1-200 000 000</td>
</tr>
<tr>
<td>10 Gb/s</td>
<td>2 000</td>
<td>200-20 000</td>
<td>1-200 000 000</td>
</tr>
<tr>
<td>100 Gb/s</td>
<td>200</td>
<td>20-2 000</td>
<td>1-200 000 000</td>
</tr>
<tr>
<td>1 Tb/s</td>
<td>20</td>
<td>2-200</td>
<td>1-200 000 000</td>
</tr>
<tr>
<td>10 Tb/s</td>
<td>2</td>
<td>1-20</td>
<td>1-200 000 000</td>
</tr>
</tbody>
</table>
Port Identification

The port identification consists of two bytes. One part, the low-value byte, reflects a fixed relationship to the physical port number. This part ensures that no port in a bridge receives the same designation as another port in the same bridge. The second part contains the priority number which is set by the management administrator (default: 128). The port with the lowest numerical identification value has also in this case the highest priority.

Port identification is shown below:

![MSB LSB priority port number]

Rules for Building the Spanning Tree Structure

In order to compute their tree structures, the bridges need information about other bridges that are present in the network. Each bridge obtains this information by sending a BPDU (bridge protocol data unit) to all other bridges.

The BPDU includes the following information:

- bridge identification
- root path costs
- port identification

(see IEEE 802.1D)
Building the Tree Structure

Bear the following in mind when building the tree structure:

- The bridge with the numerically lowest bridge identification is made the root bridge. It forms the root of the tree structure.
- The structure of the tree depends upon the root path costs. The structure that is chosen is the one that provides the lowest path costs between each individual bridge and the root bridge.
- If there are multiple paths with the same root path costs, the priorities of the identifications of the bridges connected to this path determine which bridge is blocked.
- If there are two paths leading away from a single bridge with the same root path costs, the port identification is used as the last criterion for determining which path is used and which port is selected.

The flow chart for determining the root path is shown below:
Application Example of Root Path Determination

Viewing the network diagram (below), you can follow the logic in the flow chart for determining the root path. Concerning the bridge identification, the administrator has set a unique priority for each bridge. The bridge with the numerically lowest identification (in this case, bridge 1) is selected as the root bridge. In this example, the partial paths all have the same path costs. The path between bridge 2 and bridge 3 is removed because a connection from bridge 3 via bridge 2 to the root bridge would double the path costs.

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

- The path via the bridges 5 and 3 generates the same root path costs as the path via the bridges 4 and 2.
- The path via bridge 4 is selected because the numerical value 28 672 for the priority in the bridge identification is lower than the numerical value 32 768.
- However, there are two paths between bridge 6 and bridge 4. In this case, the larger port priority is crucial.
A network diagram that exemplifies root path determination is shown below:

- e.g. 16384 = bridge ID
- root path
- --- redundant path
Application Example: Root Path Manipulation

Using the network diagram (see illustration below), you can follow the logic in the flow chart (see flow chart) for determining the root path.

The administrator has

- with the exception of bridge 1 - not changed the value 32768, which was preset for the bridges to default. (As a result, only the MAC address in the bridge identification determines which bridge becomes the new root bridge if the old one stops working.)
- made bridge 1 the root bridge by assigning the value 16384 to it.

In this example, the partial paths all have the same path costs. The path between bridge 2 and bridge 3 is removed because a connection from bridge 3 to the root bridge via bridge 2 would result in double the path costs.

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

- The path via the bridges 5 and 3 generates the same root path costs as the path via the bridges 4 and 2.
- STP chooses the path via the bridge which has the lowest MAC address in the bridge identification (bridge 4 in the illustration).
- There are, however, two paths between bridge 6 and bridge 4. In this case, the larger port priority is crucial.
A network diagram that exemplifies root path determination is shown below:

- e.g. 16384 = bridge ID
- root path
- redundant path
The management administrator of the network soon discovers that this configuration, which uses bridge 1 as root bridge, is unfavorable. The control packets that bridge 1 sends to the other bridges are concentrated on the paths between bridge 1 and bridge 2 and between bridge 1 and bridge 3.

If the management administrator selects bridge 2 as the root bridge, control packet load balancing among the subnetworks will be enhanced. This would result in the configuration shown in the illustration below. The paths between the individual bridges and the root bridge have become shorter.

An example of root path manipulation is shown below:

![Diagram of network topology showing root path manipulation]
The Rapid Spanning Tree Protocol

Introduction
RSTP does not change the tree structure calculation as opposed to STP. It only alters parameters and adds new parameters and mechanisms that accelerate the reconfiguration in the event of an error. For this purpose, the ports play a major role.

Port Roles
RSTP assigns one of the following roles to each bridge port (discussed individually below):
- root port
- designated port
- alternate port
- backup port
- disabled port

Root Port
This is a port at which a bridge receives data packets with the lowest path costs from the root bridge. If there are several such ports, the bridge identification determines which port is the root port. If there is also more than one of these ports, the port identification determines which port is the root port. The root bridge does not have a root port itself.

Designated Port
The bridge in a network segment that has the lowest root path costs is the designated bridge. If some bridges have the same root path costs, the bridge with the lowest numerical identification value becomes the designated bridge. The port at this bridge which connects it to a network segment that leads away from the root bridge is the designated port.

Edge Port
Each network segment in which there is no further RSTP bridge is connected to exactly one designated port. This designated port operates as an edge port at the same time. Characteristic of an edge port is the fact that it does not receive any RST BPDU's (Rapid Spanning Tree Bridge Protocol Data Units).

Alternate Port
This is a port that takes over the function of the root port if the connection to the root bridge becomes inoperative. The alternate port re-establishes a reliable connection from the bridge to the root bridge.

Backup Port
A port that can be used as a replacement in case the connection to the designated port of this network segment (without RSTP bridge) becomes inoperative. The replacement port leads to the branches of the Spanning Tree.
**Disabled Port**

This is a port that is not important for the Spanning Tree operation, so it is disabled or has no link.

The port role assignment is shown in the following table:

<table>
<thead>
<tr>
<th>Value</th>
<th>Bridge 1</th>
<th>Bridge 2</th>
<th>Bridge 3</th>
<th>Bridge 4</th>
<th>Bridge 5</th>
<th>Port 1</th>
<th>Port 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>16384</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20480</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24576</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28672</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32768</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40960</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Example: 16384 = port ID, root path, interrupted path, root port, designated port, alternate port, backup port, edge port*
Rapid Spanning Tree

Port Statuses

According to the tree structure and the status of the selected connection paths, RSTP assigns their statuses to the ports.

The relationship between the port status values in the STP and RSTP are in the following table:

<table>
<thead>
<tr>
<th>STP Port State</th>
<th>Administrative Bridge Port State</th>
<th>MAC Operational</th>
<th>RSTP Port State</th>
<th>Active Topology (Port Role)</th>
</tr>
</thead>
<tbody>
<tr>
<td>disabled</td>
<td>disabled</td>
<td>false</td>
<td>discarding (The dot1d-MIB displays Disabled.)</td>
<td>excluded (disabled)</td>
</tr>
<tr>
<td>disabled</td>
<td>enabled</td>
<td>false</td>
<td>discarding (The dot1d-MIB displays Disabled.)</td>
<td>excluded (disabled)</td>
</tr>
<tr>
<td>blocking</td>
<td>enabled</td>
<td>true</td>
<td>discarding (The dot1d-MIB displays Disabled.)</td>
<td>excluded (alternate, backup)</td>
</tr>
<tr>
<td>listening</td>
<td>enabled</td>
<td>true</td>
<td>discarding (The dot1d-MIB displays Disabled.)</td>
<td>included (root, designated)</td>
</tr>
<tr>
<td>learning</td>
<td>enabled</td>
<td>true</td>
<td>learning</td>
<td>included (root, designated)</td>
</tr>
<tr>
<td>forwarding</td>
<td>enabled</td>
<td>true</td>
<td>forwarding</td>
<td>included (root, designated)</td>
</tr>
</tbody>
</table>

The port statuses listed above have the following meanings:

- disabled = The port is not part of the active topology.
- discarding = There is no address learning in the forwarding database (FDB), and there is no traffic apart from sending and receiving.
- learning = Address learning is active in the FDB, and there is no traffic apart from BPDUs.
- forwarding = Address learning is active (FDB), and sending and receiving is possible from and to all frames (not only BPDUs = Bridged Protocol Data Units).

Spanning Tree Priority Vector

To assign roles to ports, the RSTP bridges exchange configuration information between themselves. This information is known as a Spanning Tree priority vector. It can identify

- the root bridge
- the root path costs of the transmitting bridge
- the transmitting bridge
- the port through which the message was sent
- the port through which the message was received

Based on this information, the bridges involved in the RSTP are capable of calculating the port roles by themselves and defining the status of their own ports.
For the following reasons, RSTP reacts faster to an interruption of the root path than STP:

- **Introduction of edge ports**: During reconfiguration, RSTP switches an edge port to forwarding mode after three seconds and waits for Hello Time to be sure that no BPDU sending bridge is connected. If the user is sure that terminal device is connected to this port and remains connected, he can switch off RSTP on this port. Thus, there will be no latency at this port during reconfiguration.

- **Introduction of alternate ports**: Since the port roles are already distributed in regular operation, a bridge can switch over immediately from the root port to the alternative port after having been disconnected from the root bridge.

- **Communicating with neighboring bridges**: Decentralized, direct communication between neighboring bridges permits immediate reaction to changes in the state of the Spanning Tree architecture.

- **Filter table**: When STP is used, the age of the entries in the table determines what is to be updated. RSTP specifies the ports that are affected by reconfiguration, deleting them immediately.

- **Reaction to an event**: Without having to adhere to any time specifications, RSTP reacts immediately to events such as the interruption of a connection.

**Note:** The price for this fast reconfiguration is the risk that data packets may be duplicated or misplaced during reconfiguration. If you cannot accept such a risk in your application, switch back to the slower Spanning Tree protocol or select one of the other redundancy procedures described in this manual.
Configuring Rapid Spanning Tree

Configure a RSTP network as follows:

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Connect your network devices according to your requirements. To avoid loops during the network configuration, do not connect the redundant paths until you have completed the configuration of the RSTP switches.</td>
</tr>
<tr>
<td>2</td>
<td>If you are going to designate a root switch, choose it at this time.</td>
</tr>
<tr>
<td>3</td>
<td>Configure the chosen root switch, following the steps in Configuring a RSTP Root Switch Using the Web-Based Interface, p. 48.</td>
</tr>
<tr>
<td>4</td>
<td>Configure the remaining switches for RSTP operation, following the steps in Configuring a Switch for RSTP Using the Web-Based Interface, p. 50.</td>
</tr>
<tr>
<td>5</td>
<td>Connect the redundant paths for the switches.</td>
</tr>
</tbody>
</table>
## Configuring a RSTP Root Switch Using the Web-Based Interface

Configure a RSTP network as follows:

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Connect to root switch.</td>
</tr>
</tbody>
</table>
| 2    | Open the Web-based interface.  
**Note:** All TCSESM switches in the network must have their RM and Stand by DIP switches in the ON position. |
| 3    | Go to Redundancy → Rapid Spanning Tree → Global.  
The figure shows the RSTP Global dialog box. |
| 4    | Enable RSTP by selecting On in the Operation group box. |
| 5    | In the Protocol Configuration/Information group box, assign to this switch the lowest bridge identification priority relative to all the other network switches. This switch becomes the root switch. You can use only values that are multiples of 4096.  
In the Root Information group box, this switch will subsequently be displayed as Root.  
A root switch has no root port and no root costs. |

### Root Information

<table>
<thead>
<tr>
<th>Root-ID</th>
<th>Priority</th>
<th>MAC Address</th>
<th>This device is root</th>
</tr>
</thead>
<tbody>
<tr>
<td>32768</td>
<td></td>
<td>00 80 63 2f 9f 6f</td>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Root Port</th>
<th>Root Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0</td>
</tr>
</tbody>
</table>

### Protocol Configuration / Information

<table>
<thead>
<tr>
<th>Priority</th>
<th>MAC Address</th>
<th>MAC Address</th>
<th>Hello Time [sec]</th>
<th>Topology Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>32768</td>
<td></td>
<td>00 80 63 2f 9f 6f</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Forward Delay [sec]</th>
<th>Time since last change</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>0 day(s), 1:39:01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Max Age [sec]</th>
<th>Time since last change</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0 day(s), 1:39:01</td>
</tr>
</tbody>
</table>
### Step | Action
---|---
6 | When changing a switch value, always check the following values which are displayed in the Root Information group box:
   - The Root ID field displays the bridge identification of the root switch.
   - The Root Port field displays the number of the port leading to the root switch.
   - The Root Costs field displays the root costs on the path to the root switch.

7 | When changing a switch value, check the following values which are displayed in the Protocol Configuration/Information group box:
   - The Priority field shows the priority in the bridge identification of the switch.
   - The MAC Address field displays the MAC address of the switch.
   - The Topology Changes field displays the number of changes since RSTP was started.
   - The Time since last change field displays the time passed since the last reconfiguration of the network.

8 | If necessary, change the Hello Time, Forward Delay, and Max Age values of the root switch. Subsequently, the root switch transfers this data to the other switches. In the left column, you can view the data received from the root switch. In the right column, you can enter the values applying when the switch becomes the root switch.
### Configuring a Switch for RSTP Using the Web-Based Interface

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Connect to switch.</td>
</tr>
</tbody>
</table>
| 2    | Open the Web-based interface.  
**Note:** All TCSESM switches in the network must have their RM and Stand by DIP switches in the ON position. |
| 3    | Go to Redundancy → Rapid Spanning Tree → Global.  
The figure shows the RSTP Global dialog box. |
| 4    | Enable RSTP by selecting On in the Operation group box. |
| 5    | Configure ports as needed by following *Configuring the Ports Using the Web-Based Interface, p. 51.* |

![RSTP Global dialog box](image-url)

- **Operation**
  - On
  - Off
- **Root Information**
  - **Root-Id**: 32768  
  - **Root Port**: 0.0  
  - **Root Cost**: 0
- **Protocol Configuration / Information**
  - **Priority**: 32768  
  - **MAC Address**: 00 80 63 2f 1f 6f  
  - **Hello Time [sec]**: 2  
  - **Forward Delay [sec]**: 15  
  - **Max Age [sec]**: 20  
  - **Root-Id**
  - **Priority**
  - **Hello Time [sec]**
  - **Forward Delay [sec]**
  - **Max Age [sec]**

**Protocol Configuration / Information**

- **MAC Address**: 00 80 63 2f 1f 6f
- **Topology Changes**: 0  
- **Time since last change**: 0 day(s), 1:39:01
- **Set**
- **Reload**
- **Help**
Rapid Spanning Tree

Explanation of the Configuration Settings

**Note:** The time entries in the dialog box are units of 1 s. Example: Max Age = 20 amounts to 20 seconds.

The configuration settings are explained in the following table:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Meaning</th>
<th>Possible Values</th>
<th>Default Settings</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*4096 &lt; 61440</td>
<td>32768</td>
</tr>
<tr>
<td>Hello Time</td>
<td>The bridge sends configuration messages (Configuration Bridge Protocol Data Units, CBPDU) if it is the root bridge, or when it is attempting to become the root bridge. Hello Time is the time in seconds between the sending of two configuration messages (Configuration Bridge Protocol Data Units, CBPDU). This is the current value being used by the switch.</td>
<td>1 - 10</td>
<td>2</td>
</tr>
<tr>
<td>Forward Delay</td>
<td>The condition diagram of the Spanning Tree protocol has four possible conditions: disabled, blocking, learning, and forwarding. A certain amount of time passes when switching from one condition to another. This is the current value being used by the bridge. The condition change from normal to blocking occurs without a time lapse.</td>
<td>4 - 30</td>
<td>30</td>
</tr>
<tr>
<td>Max Age</td>
<td>After the Max Age time period has lapsed, a BDPU is invalid and discarded.</td>
<td>6 - 40</td>
<td>6</td>
</tr>
</tbody>
</table>

Configuring the Ports Using the Web-Based Interface

Configure the ports as follows:

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Connect to the switch.</td>
</tr>
<tr>
<td>2</td>
<td>Open the Web-based interface.</td>
</tr>
<tr>
<td>3</td>
<td>Go to Redundancy → Rapid Spanning Tree → Port.</td>
</tr>
<tr>
<td>4</td>
<td>Change and check the settings and displayed values for the individual ports.</td>
</tr>
<tr>
<td>5</td>
<td>Connect the redundant paths. To avoid loops and networks that stop functioning during the configuration, connect the redundant paths after configuring the switches.</td>
</tr>
</tbody>
</table>
### Explanation of the Port-Specific Settings

These settings apply to every individual port.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Meaning</th>
<th>Possible Values</th>
<th>Default Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>STP State</td>
<td>Switch (R)STP on/off at this port. Switch (R)STP off when connecting a terminal device in order to avoid unnecessary waiting periods ((p. 46)).</td>
<td>on, off</td>
<td>on</td>
</tr>
<tr>
<td>Port State</td>
<td>This field displays the port status.</td>
<td>disabled, forwarding, discarding, blocking, learning</td>
<td></td>
</tr>
<tr>
<td>Priority</td>
<td>Enter the first byte of the port identification ((p. 36)).</td>
<td>(16 &lt; n \times 16 &lt; 240)</td>
<td>128</td>
</tr>
<tr>
<td>Port Path Cost</td>
<td>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 ((p. 35)).</td>
<td>0 - 200 000 000</td>
<td>0</td>
</tr>
<tr>
<td>Admin Edge Port</td>
<td>In Admin Edge Port, you specify whether a terminal device ((= true)) or an RSTP bridge ((= false)) is to be connected to this port. During reconfiguration, the Edge Port of a terminal device can switch to forwarding within 3 seconds ((p. 43)).</td>
<td>true, false</td>
<td>false</td>
</tr>
<tr>
<td>Oper Edge Port</td>
<td>This field displays whether an RSTP switch is connected to this port. The switch will always detect a connected RSTP switch no matter which value has been set in Admin Edge Port. Subsequently, it sets Edge Port = false ((p. 43)).</td>
<td>true, false</td>
<td></td>
</tr>
<tr>
<td>Oper Point-to-Point</td>
<td>This field displays whether there is a half duplex connection at this port to connect two RSTP switches ((true = \text{half duplex connection}; \ false = \text{no half duplex connection})). This point-to-point connection is a direct connection between two RSTP switches. Fast reconfiguration is achieved using direct remote communication between the switches.</td>
<td>true, false</td>
<td>auto is computed</td>
</tr>
<tr>
<td>Designated Root Bridge (Priority/MAC-Address)</td>
<td>This field displays the bridge identification of the designated root bridge for this port.</td>
<td>bridge identification (hexadecimal)</td>
<td></td>
</tr>
<tr>
<td>Designated Costs</td>
<td>This field displays the path costs from this port to the root switch. For cost see table in Root Path Costs, (p. 35).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Designated Port</td>
<td>This field displays the identification of the port that establishes for this port (on the designated switch) the connection to the root switch.</td>
<td>port identification (hexadecimal) and port number</td>
<td></td>
</tr>
</tbody>
</table>
Glossary

DHCP  Dynamic Host Configuration Protocol. A protocol used by networked devices (clients) to obtain the parameters necessary for operation in an IP network. It reduces system administration workload, allowing devices to be added to the network with little or no manual configurations.

DSCP  DiffServ Code Point. A networking architecture that specifies a simple, scalable and coarse-grained mechanism for classifying, managing network traffic and providing Quality of Service guarantees on modern IP networks.

EAM  Memory back up adapter. A USB device which stores the configuration data of the ESM switch. If the switch becomes inoperative, the configuration data can be easily transferred to another switch.

FDB  forwarding database, which stores addresses (MAC addresses or network addresses) against the relevant forwarding data (that is, port numbers).
Glossary

G

GARP  General Attribute Registration Protocol. A standard for registering a client station into a multicast domain. GARP is an industry-standard protocol defined by IEEE 802.1P.

GMRP  GARP Multicast Registration Protocol. A General Attribute Registration Protocol application that provides a constrained multicast flooding facility. GMRP is an industry-standard protocol defined by IEEE 802.1P.

I

ICMP  Internet Control Message Protocol. TCP/IP protocol used to send status and control messages. For example, a router uses ICMP to notify the sender that its destination node is not available.

IGMP  Internet Group Management Protocol. A protocol that governs the management of multicast groups in a TCP/IP network.

L

LLDP  Link Layer Discovery Protocol. A protocol that provides a method for switches, routers and access points to advertise their identification, configuration and capabilities to neighboring devices that store the data in a MIB (management information base).

N

NTP  Network Time Protocol. Used to update the real time clock in a computer. There are numerous primary and secondary servers in the Internet that are synchronized to the international time standard Coordinated Universal Time (UTC) via radio, satellite or modem.
QoS  
*Quality of Service.* A function that identifies high-priority time-critical data traffic such as language/video or real-time data and reduces possible disruptions caused by less critical traffic during busy network periods.

RFC  
*Request For Comment.* A document that describes the specifications for a recommended technology. RFCs are used by the Internet Engineering Task Force (IETF) and other standards bodies.

RM  
*Redundancy Manager.* A switch function which allows you to close both ends of a backbone in a line-type configuration to create a redundant HIPER ring.

RSTP  
*Rapid Spanning Tree protocol.* A protocol that provides a loop free topology for any LAN (Local Area Network) or bridged network.

SFP  
*Small Form Factor Pluggable* interface. An industry standard daughter card used in networking. Its main advantage is that new speeds can be interfaced to an expensive network device by changing only the SFP card.

TFTP  
*Trivial Transfer File Protocol.* A version of the TCP/IP FTP protocol that has no directory or password capability.
VLAN  Virtual Local Area Network. A logical subgroup within a local area network that is created via software rather than manually moving cables in the wiring closet.
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