

MiCOM P40 Agile

Px4x

Technical Manual
Redundant Ethernet Boards

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CHAPTER 1

INTRODUCTION

1 CHAPTER OVERVIEW

This chapter provides some general information about the technical manual and an introduction to the device(s) described in this technical manual.

This chapter contains the following sections:

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Features and Functions	6
Compliance	8

2 FOREWORD

This technical manual provides a functional and technical description of GE's Px4x variants of Redundant Ethernet Boards, as well as a comprehensive set of instructions for using the device. The level at which this manual is written assumes that you are already familiar with protection engineering and have experience in this discipline. The description of principles and theory is limited to that which is necessary to understand the product. For further details on general protection engineering theory, we refer you to GE's publication NPAG, which is available online or from our contact centre.

We have attempted to make this manual as accurate, comprehensive and user-friendly as possible. However we cannot guarantee that it is free from errors. Nor can we state that it cannot be improved. We would therefore be very pleased to hear from you if you discover any errors, or have any suggestions for improvement. Our policy is to provide the information necessary to help you safely specify, engineer, install, commission, maintain, and eventually dispose of this product. We consider that this manual provides the necessary information, but if you consider that more details are needed, please contact us.

All feedback should be sent to our contact centre via:

contact.centre@ge.com

2.1 TARGET AUDIENCE

This manual is aimed towards all professionals charged with installing, commissioning, maintaining, troubleshooting, or operating any of the products within the specified product range. This includes installation and commissioning personnel as well as engineers who will be responsible for operating the product.

The level at which this manual is written assumes that installation and commissioning engineers have knowledge of handling electronic equipment. Also, system and protection engineers have a thorough knowledge of protection systems and associated equipment.

2.2 TYPOGRAPHICAL CONVENTIONS

The following typographical conventions are used throughout this manual.

- The names for special keys appear in capital letters.
For example: ENTER
- When describing software applications, menu items, buttons, labels etc as they appear on the screen are written in bold type.
For example: Select **Save** from the file menu.
- Filenames and paths use the courier font
For example: `Example\File.txt`
- Special terminology is written with leading capitals
For example: Sensitive Earth Fault
- If reference is made to the IED's internal settings and signals database, the menu group heading (column) text is written in upper case italics
For example: The *SYSTEM DATA* column
- If reference is made to the IED's internal settings and signals database, the setting cells and DDB signals are written in bold italics
For example: The ***Language*** cell in the *SYSTEM DATA* column
- If reference is made to the IED's internal settings and signals database, the value of a cell's content is written in the Courier font
For example: The ***Language*** cell in the *SYSTEM DATA* column contains the value `English`

2.3 NOMENCLATURE

Due to the technical nature of this manual, many special terms, abbreviations and acronyms are used throughout the manual. Some of these terms are well-known industry-specific terms while others may be special product-specific terms used by GE. The first instance of any acronym or term used in a particular chapter is explained. In addition, a separate glossary is available on the GE website, or from the GE contact centre.

We would like to highlight the following changes of nomenclature however:

- The word 'relay' is no longer used to describe the device itself. Instead, the device is referred to as the 'IED' (Intelligent Electronic Device), the 'device', or the 'product'. The word 'relay' is used purely to describe the electromechanical components within the device, i.e. the output relays.
- British English is used throughout this manual.
- The British term 'Earth' is used in favour of the American term 'Ground'.

2.4 PRODUCT SCOPE

Redundancy is required where a single point of failure cannot be tolerated. Redundancy is therefore applied to critical applications such as substation automation. Redundancy acts as an insurance policy, providing an alternative route if one route fails.

The Redundant Ethernet Board (REB) assures "bumpless" redundancy at the IED level. "Bumpless" in this context means the transfer from one communication path to another without noticeable consequences.

GE provides a range of REBs for its IED products. A REB is usually fitted as an option before the IED is shipped, but can be ordered retrospectively if required.

3 FEATURES AND FUNCTIONS

Different variants of Redundant Ethernet Boards, providing one or more of the following redundancy protocols, are available. The variant must be selected at the time of ordering

HSR (High-availability Seamless Redundancy Protocol)

- For ring topology networks in substations
- According to IEC 62439-3 Standard
- Fully software configurable
- Provides bumpless redundancy for real-time systems
- Implements the redundancy functions in the end nodes rather than in network elements.
- Stays available ensuring no data loss

PRP (Parallel Redundancy Protocol)

- For double Star-topology networks in substations
- According to IEC 62439-3 Standard
- Fully software configurable
- Provides bumpless redundancy for real-time systems
- Uses two independent networks in parallel
- Implements the redundancy functions in the end nodes rather than in network elements.
- Stays available ensuring no data loss

RSTP (Rapid Spanning Tree Protocol)

- Used on both ring and star topologies
- Quickly reconnects a network fault by finding an alternative path.
- Fault recovery time depends on the number of devices and the topology.
- Based on open standards so is compatible with other Manufacturers' IEDs that use the RSTP protocol.

SHP (Self-Healing Protocol)

- Used on double-ring network topologies
- GE proprietary standard
- Responds to the constraints of critical time applications
- When a fibre is broken, both end stations detect and repair the break.
- Repair is closed in less than 1 ms
- Provides bumpless redundancy
- Can be used to extend the network or number of devices without having to disable the network.

DHP (Dual Homing Protocol)

- Used on double-star network topologies
- GE proprietary standard
- Uses two independent networks, both active at the same time.
- Provides 0 ms failover time

Failover

- Simple form of redundancy
- Can be used on any underlying topology
- One port is active at a time. The inactive port is functionally down.
- Slow switch over time. Can be up to a few seconds and depends on how long the backup port takes to become active.

4 COMPLIANCE

The device has undergone a range of extensive testing and certification processes to ensure and prove compatibility with all target markets. A detailed description of these criteria can be found in the Technical Specifications chapter.

CHAPTER 2

SAFETY INFORMATION

1 CHAPTER OVERVIEW

This chapter provides information about the safe handling of the equipment. The equipment must be properly installed and handled in order to maintain it in a safe condition and to keep personnel safe at all times. You must be familiar with information contained in this chapter before unpacking, installing, commissioning, or servicing the equipment.

This chapter contains the following sections:

Chapter Overview	11
Health and Safety	12
Symbols	13
Installation, Commissioning and Servicing	14
Decommissioning and Disposal	20
Regulatory Compliance	21

2 HEALTH AND SAFETY

Personnel associated with the equipment must be familiar with the contents of this Safety Information.

When electrical equipment is in operation, dangerous voltages are present in certain parts of the equipment. Improper use of the equipment and failure to observe warning notices will endanger personnel.

Only qualified personnel may work on or operate the equipment. Qualified personnel are individuals who are:

- familiar with the installation, commissioning, and operation of the equipment and the system to which it is being connected.
- familiar with accepted safety engineering practises and are authorised to energise and de-energise equipment in the correct manner.
- trained in the care and use of safety apparatus in accordance with safety engineering practises
- trained in emergency procedures (first aid).

The documentation provides instructions for installing, commissioning and operating the equipment. It cannot, however cover all conceivable circumstances. In the event of questions or problems, do not take any action without proper authorisation. Please contact your local sales office and request the necessary information.

3 SYMBOLS

Throughout this manual you will come across the following symbols. You will also see these symbols on parts of the equipment.



Caution:
Refer to equipment documentation. Failure to do so could result in damage to the equipment



Warning:
Risk of electric shock



Warning:
Risk of damage to eyesight



Earth terminal. *Note: This symbol may also be used for a protective conductor (earth) terminal if that terminal is part of a terminal block or sub-assembly.*



Protective conductor (earth) terminal



Instructions on disposal requirements

Note:

The term 'Earth' used in this manual is the direct equivalent of the North American term 'Ground'.

4 INSTALLATION, COMMISSIONING AND SERVICING

4.1 LIFTING HAZARDS

Many injuries are caused by:

- Lifting heavy objects
- Lifting things incorrectly
- Pushing or pulling heavy objects
- Using the same muscles repetitively

Plan carefully, identify any possible hazards and determine how best to move the product. Look at other ways of moving the load to avoid manual handling. Use the correct lifting techniques and Personal Protective Equipment (PPE) to reduce the risk of injury.

4.2 ELECTRICAL HAZARDS



Caution:
All personnel involved in installing, commissioning, or servicing this equipment must be familiar with the correct working procedures.



Caution:
Consult the equipment documentation before installing, commissioning, or servicing the equipment.



Caution:
Always use the equipment as specified. Failure to do so will jeopardise the protection provided by the equipment.



Warning:
Removal of equipment panels or covers may expose hazardous live parts. Do not touch until the electrical power is removed. Take care when there is unlocked access to the rear of the equipment.



Warning:
Isolate the equipment before working on the terminal strips.



Warning:
Use a suitable protective barrier for areas with restricted space, where there is a risk of electric shock due to exposed terminals.



Caution:
Disconnect power before disassembling. Disassembly of the equipment may expose sensitive electronic circuitry. Take suitable precautions against electrostatic voltage discharge (ESD) to avoid damage to the equipment.



Warning:
NEVER look into optical fibres or optical output connections. Always use optical power meters to determine operation or signal level.



Warning:
Testing may leave capacitors charged to dangerous voltage levels. Discharge capacitors by reducing test voltages to zero before disconnecting test leads.



Caution:
Operate the equipment within the specified electrical and environmental limits.



Caution:
Before cleaning the equipment, ensure that no connections are energised. Use a lint free cloth dampened with clean water.

Note:
Contact fingers of test plugs are normally protected by petroleum jelly, which should not be removed.

4.3 UL/CSA/CUL REQUIREMENTS

The information in this section is applicable only to equipment carrying UL/CSA/CUL markings.



Caution:
Equipment intended for rack or panel mounting is for use on a flat surface of a Type 1 enclosure, as defined by Underwriters Laboratories (UL).



Caution:
To maintain compliance with UL and CSA/CUL, install the equipment using UL/CSA-recognised parts for: cables, protective fuses, fuse holders and circuit breakers, insulation crimp terminals, and replacement internal batteries.

4.4 FUSING REQUIREMENTS



Caution:
Where UL/CSA listing of the equipment is required for external fuse protection, a UL or CSA Listed fuse must be used for the auxiliary supply. The listed protective fuse type is: Class J time delay fuse, with a maximum current rating of 15 A and a minimum DC rating of 250 V dc (for example type AJT15).



Caution:
Where UL/CSA listing of the equipment is not required, a high rupture capacity (HRC) fuse type with a maximum current rating of 16 Amps and a minimum dc rating of 250 V dc may be used for the auxiliary supply (for example Red Spot type NIT or TIA).
For P50 models, use a 1A maximum T-type fuse.
For P60 models, use a 4A maximum T-type fuse.



Caution:
Digital input circuits should be protected by a high rupture capacity NIT or TIA fuse with maximum rating of 16 A. for safety reasons, current transformer circuits must never be fused. Other circuits should be appropriately fused to protect the wire used.



Caution:
CTs must NOT be fused since open circuiting them may produce lethal hazardous voltages

4.5 EQUIPMENT CONNECTIONS



Warning:
Terminals exposed during installation, commissioning and maintenance may present a hazardous voltage unless the equipment is electrically isolated.



Caution:
Tighten M4 clamping screws of heavy duty terminal block connectors to a nominal torque of 1.3 Nm.
Tighten captive screws of terminal blocks to 0.5 Nm minimum and 0.6 Nm maximum.



Caution:
Always use insulated crimp terminations for voltage and current connections.



Caution:
Always use the correct crimp terminal and tool according to the wire size.



Caution:
Watchdog (self-monitoring) contacts are provided to indicate the health of the device on some products. We strongly recommend that you hard wire these contacts into the substation's automation system, for alarm purposes.

4.6 PROTECTION CLASS 1 EQUIPMENT REQUIREMENTS



Caution:
Earth the equipment with the supplied PCT (Protective Conductor Terminal).



Caution:
Do not remove the PCT.



Caution:
The PCT is sometimes used to terminate cable screens. Always check the PCT's integrity after adding or removing such earth connections.



Caution:
Use a locknut or similar mechanism to ensure the integrity of stud-connected PCTs.



Caution:
The recommended minimum PCT wire size is 2.5 mm² for countries whose mains supply is 230 V (e.g. Europe) and 3.3 mm² for countries whose mains supply is 110 V (e.g. North America). This may be superseded by local or country wiring regulations. For P60 products, the recommended minimum PCT wire size is 6 mm². See product documentation for details.



Caution:
The PCT connection must have low-inductance and be as short as possible.



Caution:
All connections to the equipment must have a defined potential. Connections that are pre-wired, but not used, should be earthed, or connected to a common grouped potential.

4.7 PRE-ENERGISATION CHECKLIST



Caution:
Check voltage rating/polarity (rating label/equipment documentation).



Caution:
Check CT circuit rating (rating label) and integrity of connections.



Caution:
Check protective fuse or miniature circuit breaker (MCB) rating.



Caution:
Check integrity of the PCT connection.



Caution:
Check voltage and current rating of external wiring, ensuring it is appropriate for the application.

4.8 PERIPHERAL CIRCUITRY



Warning:
Do not open the secondary circuit of a live CT since the high voltage produced may be lethal to personnel and could damage insulation. Short the secondary of the line CT before opening any connections to it.

Note:

For most GE equipment with ring-terminal connections, the threaded terminal block for current transformer termination is automatically shorted if the module is removed. Therefore external shorting of the CTs may not be required. Check the equipment documentation and wiring diagrams first to see if this applies.



Caution:
Where external components such as resistors or voltage dependent resistors (VDRs) are used, these may present a risk of electric shock or burns if touched.



Warning:
Take extreme care when using external test blocks and test plugs such as the MMLG, MMLB and P990, as hazardous voltages may be exposed. Ensure that CT shorting links are in place before removing test plugs, to avoid potentially lethal voltages.



Warning:
Data communication cables with accessible screens and/or screen conductors, (including optical fibre cables with metallic elements), may create an electric shock hazard in a sub-station environment if both ends of the cable screen are not connected to the same equipotential bonded earthing system.

To reduce the risk of electric shock due to transferred potential hazards:

- i. The installation shall include all necessary protection measures to ensure that no fault currents can flow in the connected cable screen conductor.
- ii. The connected cable shall have its screen conductor connected to the protective conductor terminal (PCT) of the connected equipment at both ends. This connection may be inherent in the connectors provided on the equipment but, if there is any doubt, this must be confirmed by a continuity test.
- iii. The protective conductor terminal (PCT) of each piece of connected equipment shall be connected directly to the same equipotential bonded earthing system.
- iv. If, for any reason, both ends of the cable screen are not connected to the same equipotential bonded earth system, precautions must be taken to ensure that such screen connections are made safe before work is done to, or in proximity to, any such cables.
- v. No equipment shall be connected to any download or maintenance circuits or connectors of this product except temporarily and for maintenance purposes only.
- vi. Equipment temporarily connected to this product for maintenance purposes shall be protectively earthed (if the temporary equipment is required to be protectively earthed), directly to the same equipotential bonded earthing system as the product.



Warning:
Small Form-factor Pluggable (SFP) modules which provide copper Ethernet connections typically do not provide any additional safety isolation. Copper Ethernet SFP modules must only be used in connector positions intended for this type of connection.

4.9 UPGRADING/SERVICING

**Warning:**

Do not insert or withdraw modules, PCBs or expansion boards from the equipment while energised, as this may result in damage to the equipment. Hazardous live voltages would also be exposed, endangering personnel.

**Caution:**

Internal modules and assemblies can be heavy and may have sharp edges. Take care when inserting or removing modules into or out of the IED.

5 DECOMMISSIONING AND DISPOSAL



Caution:

Before decommissioning, completely isolate the equipment power supplies (both poles of any dc supply). The auxiliary supply input may have capacitors in parallel, which may still be charged. To avoid electric shock, discharge the capacitors using the external terminals before decommissioning.



Caution:

Avoid incineration or disposal to water courses. Dispose of the equipment in a safe, responsible and environmentally friendly manner, and if applicable, in accordance with country-specific regulations.

6 REGULATORY COMPLIANCE

Compliance with the European Commission Directive on EMC and LVD is demonstrated using a technical file.



6.1 EMC COMPLIANCE: 2014/30/EU

The product specific Declaration of Conformity (DoC) lists the relevant harmonised standard(s) or conformity assessment used to demonstrate compliance with the EMC directive.

6.2 LVD COMPLIANCE: 2014/35/EU

The product specific Declaration of Conformity (DoC) lists the relevant harmonized standard(s) or conformity assessment used to demonstrate compliance with the LVD directive.

Safety related information, such as the installation I overvoltage category, pollution degree and operating temperature ranges are specified in the Technical Data section of the relevant product documentation and/or on the product labelling.

Unless otherwise stated in the Technical Data section of the relevant product documentation, the equipment is intended for indoor use only. Where the equipment is required for use in an outdoor location, it must be mounted in a specific cabinet or housing to provide the equipment with the appropriate level of protection from the expected outdoor environment.

6.3 R&TTE COMPLIANCE: 2014/53/EU

Radio and Telecommunications Terminal Equipment (R&TTE) directive 2014/53/EU.

Conformity is demonstrated by compliance to both the EMC directive and the Low Voltage directive, to zero volts.

6.4 UL/CUL COMPLIANCE

If marked with this logo, the product is compliant with the requirements of the Canadian and USA Underwriters Laboratories.

The relevant UL file number and ID is shown on the equipment.



CHAPTER 3

HARDWARE DESIGN

1 CHAPTER OVERVIEW

This chapter provides information about the product's hardware design.

This chapter contains the following sections:

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Board Connections	27

2 BOARD VERSIONS

Each board combines Ethernet communications, with IRIG-B timing functionality. There is a choice of embedded protocols for the Ethernet communications, and two types of IRIG-B.

Board variants

Board	Part No.	Compatible With
Redundant Ethernet SHP, 2 multi-mode fibre ports + modulated IRIG-B	ZN0071 001	Proprietary Self-Healing Protocol C264-SWR212 and MiCOM H35x multi-mode switches
Redundant Ethernet SHP, 2 multi-mode fibre ports + demodulated IRIG-B	ZN0071 002	Proprietary Self-Healing Protocol C264-SWR212 and MiCOM H35x multi-mode switches
Redundant Ethernet RSTP, 2 multi-mode fibre ports + modulated IRIG-B	ZN0071 005	Any RSTP device
Redundant Ethernet RSTP, 2 multi-mode fibre ports + demodulated IRIG-B	ZN0071 006	Any RSTP device
Redundant Ethernet DHP, 2 multi-mode fibre ports + modulated IRIG-B	ZN0071 007	Proprietary Dual-Homing Protocol C264-SWD212 and MiCOM H36x multi-mode switches
Redundant Ethernet DHP, 2 multi-mode fibre ports + demodulated IRIG-B	ZN0071 008	Proprietary Dual-Homing Protocol C264-SWD212 and MiCOM H36x multi-mode switches
Redundant Ethernet PRP, 2 multi-mode fibre ports + modulated IRIG-B	ZN0071 009	Any PRP device
Redundant Ethernet PRP, 2 multi-mode fibre ports + demodulated IRIG-B	ZN0071 010	Any PRP device
Redundant Ethernet PRP/HSR, 2 multi-mode fibre ports + modulated IRIG-B	ZN0071 109	Any PRP or HSR device
Redundant Ethernet PRP/HSR, 2 multi-mode fibre ports + demodulated IRIG-B	ZN0071 110	Any PRP or HSR device
Redundant Ethernet PRP/HSR/RSTP/Failover, 2 multi-mode fibre ports + Modulated/Un-Modulated IRIG-B	ZN0087 001	Any PRP, HSR, RSTP or standard Ethernet network.
Redundant Ethernet PRP/HSR/RSTP/Failover, 2 copper ports RJ45 + Modulated/Un-Modulated IRIG-B	ZN0087 002	Any PRP, HSR, RSTP or standard Ethernet network.
Redundant Ethernet PRP/HSR/RSTP/Failover, 1 copper port RJ45 + 1 multi-mode fibre port + Modulated/Un-Modulated IRIG-B	ZN0087 003	Any PRP, HSR, RSTP or standard Ethernet network.

When using any of the redundant Ethernet boards on an IED the final product will have two MAC addresses and will require two IP addresses, one for the managed embedded switch that handles the redundancy and one for the IED that handles the communications at protocol level (IEC 61850 or DNP3.0 over Ethernet) and to S1 Agile. The MAC address of the embedded switch is printed on the board. The MAC address of the IED is printed on the rear panel of the IED. The redundant Ethernet board is fitted into Slot A of the IED, which is the optional communications slot.

All Ethernet connections are made with 1300 nm multi mode 100BaseFx fiber optic Ethernet ports (ST® connector). The boards can support both IEC 61850 and DNP3.0 over Ethernet.

Note:

SHP and DHP are proprietary protocols providing extremely fast recovery time. These boards offer compatibility with C264-SWR212/SWD212 and MiCOM H35x/H36x multi-mode switches.

3 BOARD CONNECTIONS

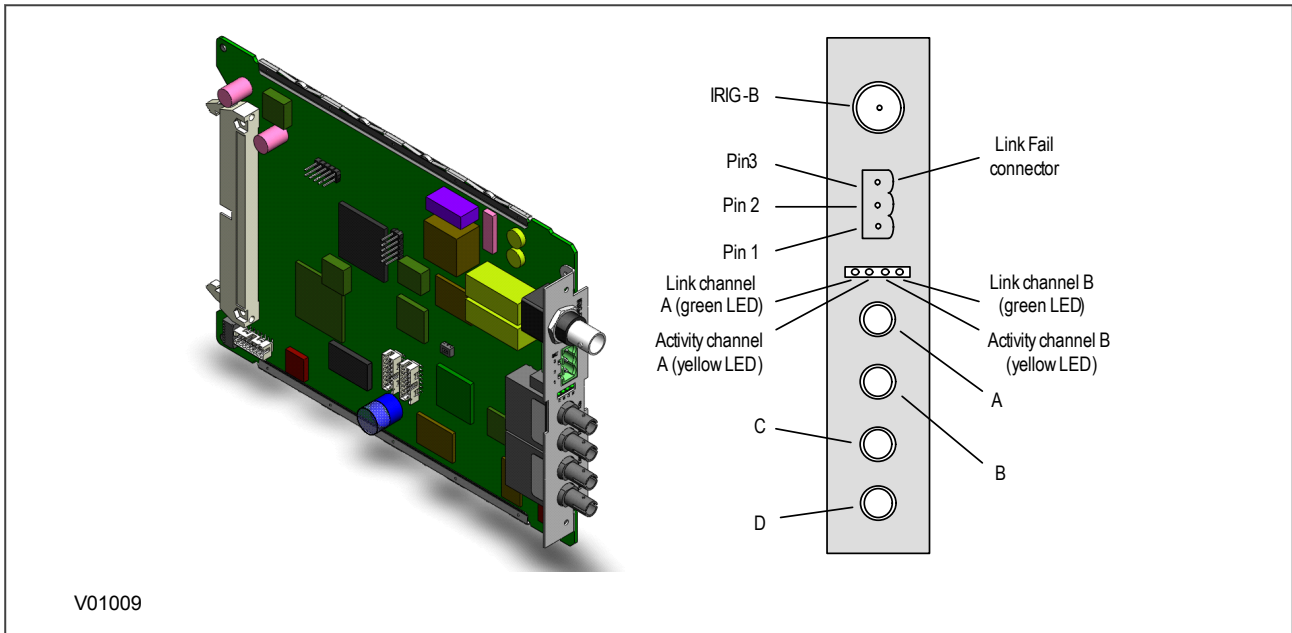


Figure 1: Board connectors

IRIG-B Connector

Available as a modulated or demodulated input. Centre connection, signal. Outer connection, Earth.

Link Fail Connector (Watchdog Relay)

Pin	Closed	Open
1-2	Link fail Channel 1 (A)	Link ok Channel 1 (A)
2-3	Link fail Channel 2 (B)	Link ok Channel 2 (B)

LEDs

LED	Function	On	Off	Flashing
Green	Link	Link ok	Link broken	
Yellow	Activity	SHP running		PRP, RSTP, HSR or DHP traffic

Optical Fibre Connectors

Uses 1300 nm multi mode 100BaseFx and ST connectors.

Connector	DHP	RSTP	SHP	PRP	HSR
A	RXA	RX1	RS	RXA	RXA
B	TXA	TX1	ES	TXA	TXA
C	RXB	RX2	RP	RXB	RXB
D	TXB	TX2	EP	TXB	TXB

CHAPTER 4

CONFIGURATION

1 CHAPTER OVERVIEW

Each product has different configuration parameters according to the functions it has been designed to perform. There is, however, a common methodology used across the entire product series to set these parameters.

Some of the communications setup can only be carried out using the HMI, and cannot be carried out using settings applications software. This chapter includes concise instructions of how to configure the device, particularly with respect to the communications setup, as well as a description of the common methodology used to configure the device in general.

This chapter contains the following sections:

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Redundant Ethernet Configurator	37
PRP/HSR Configurator	43
RSTP Configurator	46
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2 CONFIGURING IP ADDRESSES

An IP address is a logical address assigned to devices in a computer network that uses the Internet Protocol (IP) for communication between nodes. IP addresses are stored as binary numbers but they are represented using Decimal Dot Notation, where four sets of decimal numbers are separated by dots as follows:

XXX.XXX.XXX.XXX

For example:

10.86.254.85

An IP address in a network is usually associated with a subnet mask. The subnet mask defines which network the device belongs to. A subnet mask has the same form as an IP address.

For example:

255.255.255.0

Both the IED and the REB each have their own IP address. The following diagram shows the IED as IP1 and the REB as IP2.

Note:

IP1 and IP2 are different but use the same subnet mask.

The REB IP address (IP2) must be configured through the Ethernet network.

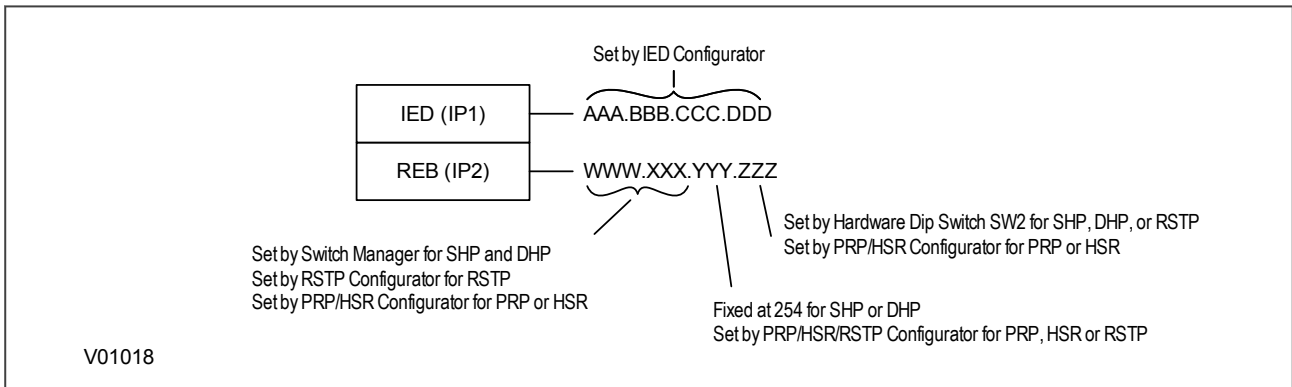


Figure 2: IED and REB IP address configuration

2.1 CONFIGURING THE IED IP ADDRESS

If you are using IEC 61850, set the IED IP1 address using the IEC 61850 Configurator software. In the IEC 61850 Configurator, set **Media** to **Single Copper or Redundant Fibre** for all Redundant Ethernet Board variants.

If you are using DNP3 over Ethernet, set the IED IP1 address by editing the DNP3 file, using the DNP3 Configurator software. In the DNP3 Configurator, set **Ethernet Media** to **Copper**, even though the redundant Ethernet network uses fibre optic cables.

2.2 CONFIGURING THE REB IP ADDRESS

The board IP address must be configured before connecting the IED to the network to avoid an IP address conflict. The way you configure the IP address depends on the redundancy protocol you have chosen.

PRP/HSR/RSTP/Failover

From S1 Agile 2.0.1. onwards cards that support the PRP/HSR/RSTP/Failover protocols in any of the combinations are configured using the Redundant Ethernet Configurator software tool. If you are using a ZN008700X card only this tool supports it. If using S1 Agile 1.4.2 or older you will need to use the PRP/HSR Configurator for PRP and/or HSR, and the RSTP Configurator for RSTP cards.

SHP or DHP

If using SHP or DHP the first two octets are set by the Switch Manager software or an SNMP MIB browser. The third octet is fixed at 254 (FE hex, 11111110 binary), and the fourth octet is set by the on-board dip switch.

Note:

An H35 (SHP) or H36 (DHP) network device is needed in the network to configure the REB IP address if you are using SNMP.

Board	Part No.	Compatible With
Redundant Ethernet SHP, 2 multi-mode fibre ports + modulated IRIG-B	ZN0071 001	Switch Manager
Redundant Ethernet SHP, 2 multi-mode fibre ports + demodulated IRIG-B	ZN0071 002	Switch Manager
Redundant Ethernet RSTP, 2 multi-mode fibre ports + modulated IRIG-B	ZN0071 005	Redundant Ethernet Configurator (S1 Agile 2.0.1 onwards) / RSTP Configurator (S1 Agile 1.4.2 or older)
Redundant Ethernet RSTP, 2 multi-mode fibre ports + demodulated IRIG-B	ZN0071 006	Redundant Ethernet Configurator (S1 Agile 2.0.1 onwards) / RSTP Configurator (S1 Agile 1.4.2 or older)
Redundant Ethernet DHP, 2 multi-mode fibre ports + modulated IRIG-B	ZN0071 007	Switch Manager
Redundant Ethernet DHP, 2 multi-mode fibre ports + demodulated IRIG-B	ZN0071 008	Switch Manager
Redundant Ethernet PRP, 2 multi-mode fibre ports + modulated IRIG-B	ZN0071 009	Redundant Ethernet Configurator (S1 Agile 2.0.1 onwards) / PRP/HSR Configurator (S1 Agile 1.4.2 or older)
Redundant Ethernet PRP, 2 multi-mode fibre ports + demodulated IRIG-B	ZN0071 010	Redundant Ethernet Configurator (S1 Agile 2.0.1 onwards) / PRP/HSR Configurator (S1 Agile 1.4.2 or older)
Redundant Ethernet PRP/HSR, 2 multi-mode fibre ports + modulated IRIG-B	ZN0071 109	Redundant Ethernet Configurator (S1 Agile 2.0.1 onwards) / PRP/HSR Configurator (S1 Agile 1.4.2 or older)
Redundant Ethernet PRP/HSR, 2 multi-mode fibre ports + demodulated IRIG-B	ZN0071 110	Redundant Ethernet Configurator (S1 Agile 2.0.1 onwards) / PRP/HSR Configurator (S1 Agile 1.4.2 or older)
Redundant Ethernet PRP/HSR/RSTP/Failover, 2 multi-mode fibre ports + Modulated/Un-Modulated IRIG-B	ZN0087 001	Redundant Ethernet Configurator (S1 Agile 2.0.1 onwards)

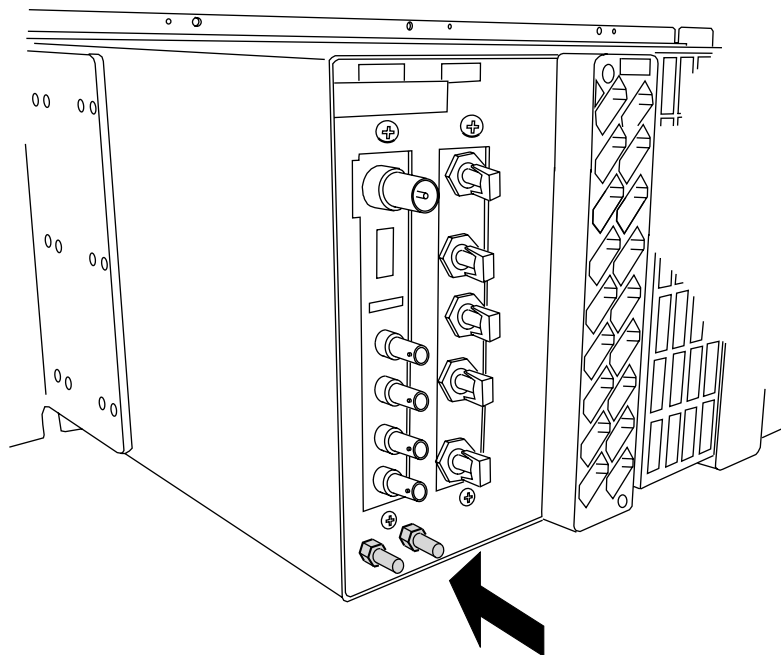
Board	Part No.	Compatible With
Redundant Ethernet PRP/HSR/RSTP/Failover, 2 copper ports RJ45 + Modulated/Un-Modulated IRIG-B	ZN0087 002	Redundant Ethernet Configurator (S1 Agile 2.0.1 onwards)
Redundant Ethernet PRP/HSR/RSTP/Failover, 1 copper port RJ45 + 1 multi-mode fibre port + Modulated/Un-Modulated IRIG-B	ZN0087 003	Redundant Ethernet Configurator (S1 Agile 2.0.1 onwards)

2.2.1 CONFIGURING THE LAST OCTET (SHP, DHP, RSTP)

If using SHP or DHP, the last octet is configured using board address switch SW2 on the board. Remove the IED front cover to gain access to the board address switch.

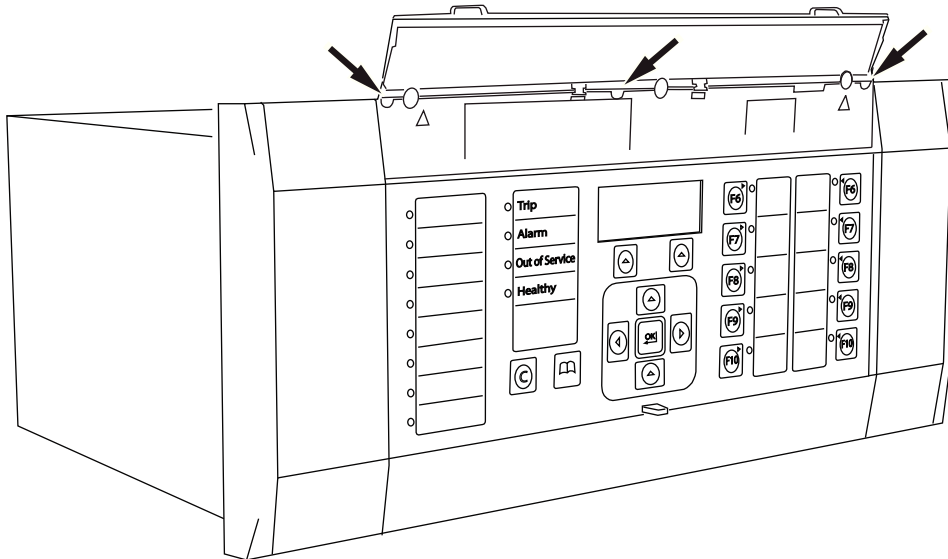
Warning:
Configure the hardware settings before the device is installed.

1. Refer to the safety section of the IED.
2. Switch off the IED. Disconnect the power and all connections.
3. Before removing the front cover, take precautions to prevent electrostatic discharge damage according to the ANSI/ESD-20.20 -2007 standard.
4. Wear a 1 M Ω earth strap and connect it to the earth (ground) point on the back of the IED.



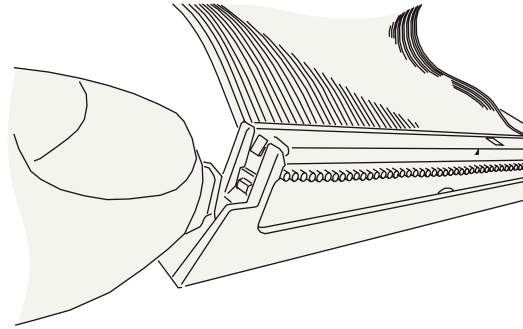
E01019

5. Lift the upper and lower flaps. Remove the six screws securing the front panel and pull the front panel outwards.



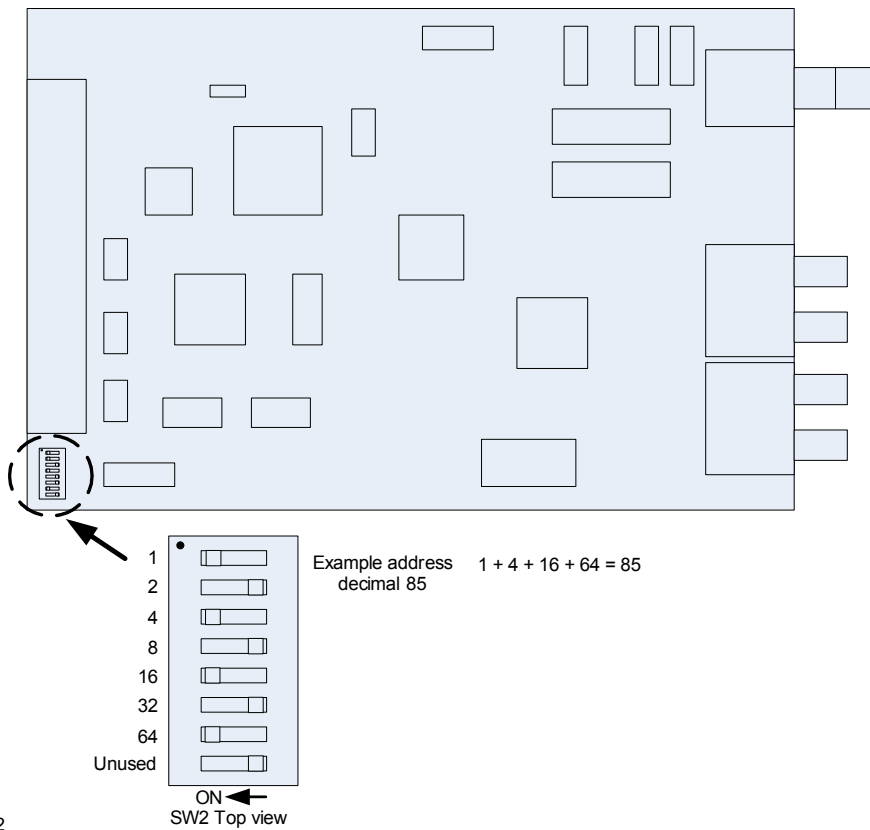
E01020

- Press the levers either side of the connector to disconnect the ribbon cable from the front panel.



E01021

- Remove the redundant Ethernet board. Set the last octet of IP address using the DIP switches. The available range is 1 to 127.



V01022

- Once you have set the IP address, reassemble the IED, following these instructions in the reverse order.

Warning:

Take care not to damage the pins of the ribbon cable connector on the front panel when reinserting the ribbon cable.

3 REDUNDANT ETHERNET CONFIGURATOR

The Redundant Ethernet Configurator tool is intended for MiCOM Px4x IEDs with redundant Ethernet using PRP (Parallel Redundancy Protocol), HSR (High-availability Seamless Redundancy), RSTP (Rapid Spanning Tree Protocol) or Failover. This tool is used to identify IEDs, switch between PRP, HSR, RSTP and Failover, configure their parameters, configure the redundancy IP address, or configure the SNTP IP address.

3.1 CONNECTING THE IED TO A PC

Connect the IED to the PC on which the Configurator tool is used. This connection is done through an Ethernet switch or through a media converter.

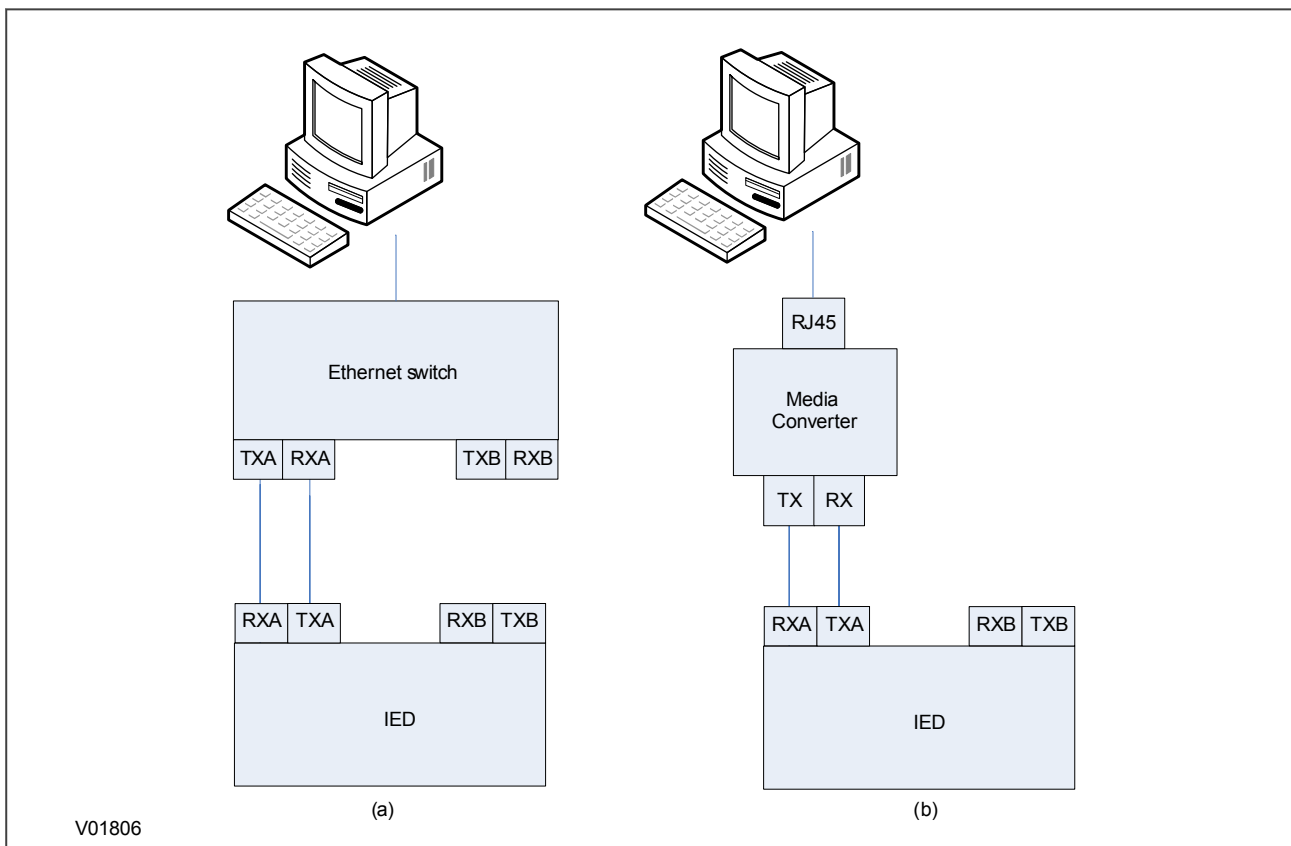


Figure 3: Connection using (a) an Ethernet switch and (b) a media converter

3.2 INSTALLING THE CONFIGURATOR

The Redundant Ethernet Configurator is installed as part of S1 Agile 2.0.1 onwards.

3.3 STARTING THE CONFIGURATOR

To start the configurator:

1. Go to S1 Agile and select the **Ethernet Configuration** tile, then select the **Redundant Ethernet Configurator** tile.
2. The Login screen appears. For user mode login, enter the **Login name** as **User** and click **OK** with no password. This level allows for IP address changes only. For Admin mode login, enter the **Login name** as **Admin** and password **Admin** and click **OK**. This level allows for network protocol configurations.
3. If the login screen does not appear, check all network connections.
4. From the **Network Board** drop-down list select the Network Board, IP Address and MAC Address of the PC in which the Configurator is running.

3.4 DEVICE IDENTIFICATION

To configure the redundant Ethernet board, go to the main window and click the **Identify Device** button. A list of devices are shown with the following details:

- Device address
- MAC address
- Version number of the firmware
- SNTP IP address
- Date & time of the real-time clock, from the board.

Select the device you wish to configure. The MAC address of the selected device is highlighted.

3.5 SELECTING THE DEVICE MODE

You must now select the device mode that you wish to use. This will be either PRP, HSR, RSTP or Failover. To do this, select the appropriate radio button then click the **Update** button. You will be asked to confirm a device reboot. Click **OK** to confirm.

3.6 FILTER BY BOARD TYPE

Once the list has been populated you can use the filter option to show only Process Bus cards or Station Bus cards by selecting the appropriate checkbox.

3.7 PASSWORD CONFIGURATION

To assign a password the current password needs to be input first, then a new password can be given. The default password is AAAA.

If the password does not follow NERC rules a message will be shown. Click on the **NERC Rules** button to review the rules.

If the password is not known then the password can be recovered by using the **Recover Password** button and following the instructions.

3.8 IP ADDRESS CONFIGURATION

To change the network address component of the IP address:

1. From the main window click the **IP Config** button. The **Device setup** screen appears.
2. Enter the required board IP address and click **OK**. This is the network address for the redundancy card, not the IED IP address, which is set in the IED Configurator or DNP3.0 over Ethernet section.
3. The board network address is updated and displayed in the main window.

3.9 SNTP IP ADDRESS CONFIGURATION

If using SNMP to poll information from the REB an SNTP server can be used to synchronise the time of the reported messages. To configure the SNTP server IP address:

1. From the main window click the **SNTP Config** button. The **Device setup** screen appears.
2. Enter the required **MAC SNTP address** and server **IP SNTP Address**. Click **OK**.
3. The updated MAC and IP SNTP addresses appear in the main screen.

3.10 CHECK MAC TABLE FOR CONNECTED EQUIPMENT

To check what devices are connected to the device being monitored:

1. From the main window, select the device.
2. Click the **MAC Table** button.
3. At the bottom of the main window, a box shows the ports where devices are connected and their MAC addresses.

3.11 PRP CONFIGURATION

To view or configure the PRP Parameters:

1. Ensure that you have set the device mode to **PRP**.
2. Click the **PRP/HSR Configuration** button. The **PRP Configuration Parameters** screen appears.
3. To view the available parameters, click the **Get PRP Parameters** button.
4. To change the parameters, click the **Set Parameters** button and modify their values.

If you need to restore the default values of the parameters, click the **Restore Defaults** button.

The configurable parameters are as follows:

- **Multicast Address:** Use this field to configure the multicast destination address. All DANPs in the network must be configured to operate with the same multicast address for the purpose of network supervision.
- **Node Forget Time:** This is the time after which a node entry is cleared in the nodes table.
- **Life Check Interval:** This defines how often a node sends a PRP_Supervision frame. All DANPs shall be configured with the same Life Check Interval.

3.12 HSR CONFIGURATION

To view or configure the HSR Parameters:

1. Click the **PRP/HSR Configuration** button. The **HSR Configuration Parameters** screen appears.
2. To view the available parameters in the board that is connected, click the **Get HSR Parameters** button.
3. To change the parameters, click the **Set HSR Parameters** button and modify their values.

If you need to restore the default values of the parameters, click the **Restore Defaults** button.

The configurable parameters are as follows:

- **Multicast Address:** Use this field to configure the multicast destination address. All DANPs in the network must be configured to operate with the same multicast address for the purpose of network supervision.
- **Node Forget Time:** This is the time after which a node entry is cleared in the nodes table.
- **Life Check Interval:** This defines how often a node sends a PRP Supervision frame. All DANPs must be configured with the same Life Check Interval.
- **Proxy Node Table Forget Time:** This is the time after which a node entry is cleared in the ProxyTable

- **Proxy Node Table Max Entries:** This is the maximum number of entries in the ProxyTable
- **Entry Forget Time:** This is the time after which an entry is removed from the duplicates
- **Node Reboot Interval:** This is the minimum time during which a node that reboots remains silent

3.13 RSTP CONFIGURATION

1. To view or configure the RSTP Bridge Parameters, from the main window, click the device address to select the device. The selected device MAC address appears highlighted.
2. Click the **RSTP Configuration** button. The **RSTP Configuration** screen appears.
3. To view the available parameters in the board that is connected, click the **Get RSTP Parameters** button.
4. To set the configurable parameters such as Bridge Max Age, Bridge Hello Time, Bridge Forward Delay, and Bridge Priority, modify the parameter values according to the following table and click **Set RSTP Parameters**.

S.No	Parameter	Default value (second)	Minimum value (second)	Maximum value (second)
1	Bridge Max Age	20	6	40
2	Bridge Hello Time	2	1	10
3	Bridge Forward Delay	15	4	30
4	Bridge Priority	32768	0	61440

3.14 BRIDGE PARAMETERS

To read the RSTP bridge parameters from the board,

1. From the main window click the device address to select the device. The **RSTP Configuration** window appears and the default tab is **Bridge Parameters**.
2. Click the **Get RSTP Parameters** button. This displays all the RSTP bridge parameters from the Ethernet board.
3. To modify the RSTP parameters, enter the values and click **Set RSTP Parameters**.
4. To restore the default values, click **Restore Default** and click **Set RSTP Parameters**.

The grayed parameters are read-only and cannot be modified.

Note:

When assigning the bridge priority, make sure the root of the network is the Ethernet switch, not the IEDs. This reduces the number of hops to reach all devices in the network. Also make sure the priority values for all IEDs are higher than that of the switch.

3.15 PORT PARAMETERS

This function is useful if you need to view the parameters of each port.

1. From the main window, click the device address to select the device. The **RSTP Configuration** window appears.
2. Select the **Port Parameters** tab, then click **Get Parameters** to read the port parameters. Alternatively, select the port numbers to read the parameters.

3.16 PORT STATES

This is used to see which ports of the board are enabled or disabled.

1. From the main window, click the device address to select the device. The **RSTP Configuration** window appears.
2. Select the **Port States** tab then click the **Get Port States** button. This lists the ports of the Ethernet board. A tick shows they are enabled.

3.17 FAILOVER CONFIGURATION

To view or configure the Failover Parameters:

Click the **Failover Configuration** button. The **Failover Configuration** screen appears.

1. To view the available parameters in the board that is connected, click the **Get Failover Parameters** button.
2. To change the parameters, click the **Set Failover Parameters** button and modify their values.

If you need to restore the default values of the parameters, click the **Restore Defaults** button. The configurable parameters are as follows:

- Port A and Port B select your main port for the Failover (Port A is the port at the top of your REB).
- The Failover time defines how long it takes for the redundancy switch over to trigger. The minimum value is 2s.

3.18 FILTERING DATABASE

The Filtering Database is used to determine how frames are forwarded or filtered across the on-board Ethernet switch. Filtering information specifies the set of ports to which frames received from a specific port are forwarded. The Ethernet switch examines each received frame to see if the frame's destination address matches a source address listed in the Filtering Database. If there is a match, the device uses the filtering/forwarding information for that source address to determine how to forward or filter the frame. Otherwise the frame is forwarded to all the ports in the Ethernet switch (broadcast).

General tab

The Filtering Database contains two types of entry; static and dynamic. The Static Entries are the source addresses entered by an administrator. The Dynamic Entries are the source addresses learnt by the switch process. The Dynamic Entries are removed from the Filtering Database after the Ageing Time. The Database holds a maximum of 1024 entries.

1. To access the forwarding database functions, if required, click the Filtering Database button in the main window.
2. To view the Forwarding Database Size, Number of Static Entries and Number of Dynamic Entries, click **Read Database Info**.
3. To set the Ageing Time, enter the number of seconds in the text box and click the **Set** button.

Filtering Entries tab

The Filtering Database configuration pages are used to view, add or delete entries from the Filtering Database. This feature is available only for the administrator. This Filtering Database is mainly used during the testing to verify the PRP/HSR functionality. To add an entry in the forwarding database, click the **Filtering Entries** tab. Configure as follows:

1. Select the Port Number and MAC Address
2. Set the Entry type (Dynamic or Static)
3. Set the cast type (Unicast or Multicast)
4. Set theMGMT and Rate Limit
5. Click the **Create** button. The new entry appears in the forwarding database.

To delete an entry from the forwarding database, select the entry and click the **Delete Entry** button.

Goose Filtering tab

This page configures the source MACs from which GOOSE messages will be allowed or blocked. The filtering can be configured by either the MAC address range boxes or by selecting or unselecting the individual MAC addresses in the MAC table. After you have defined the addresses to be allowed or blocked you need to update the table and apply the filter:

- **Update Table:** This updates the MAC table according to the filtering range entered in the MAC address range boxes.
- **Apply Filter:** This applies the filtering configuration in the MAC table to the HSR/PRP board.

3.19 END OF SESSION

To finish the session:

1. In the main window, click the **Quit** button, a new screen appears.
2. If a database backup is required, click **Yes**, a new screen appears.
3. Click the ... button to browse the path. Enter the name in the text box.

4 PRP/HSR CONFIGURATOR

The PRP/HSR Configurator tool is intended for MiCOM Px4x IEDs with redundant Ethernet using PRP (Parallel Redundancy Protocol), or HSR (High-availability Seamless Redundancy). This tool is used to identify IEDs, switch between PRP and HSR or configure their parameters, configure the redundancy IP address, or configure the SNMP IP address.

4.1 CONNECTING THE IED TO A PC

Connect the IED to the PC on which the Configurator tool is used. This connection is done through an Ethernet switch or through a media converter.

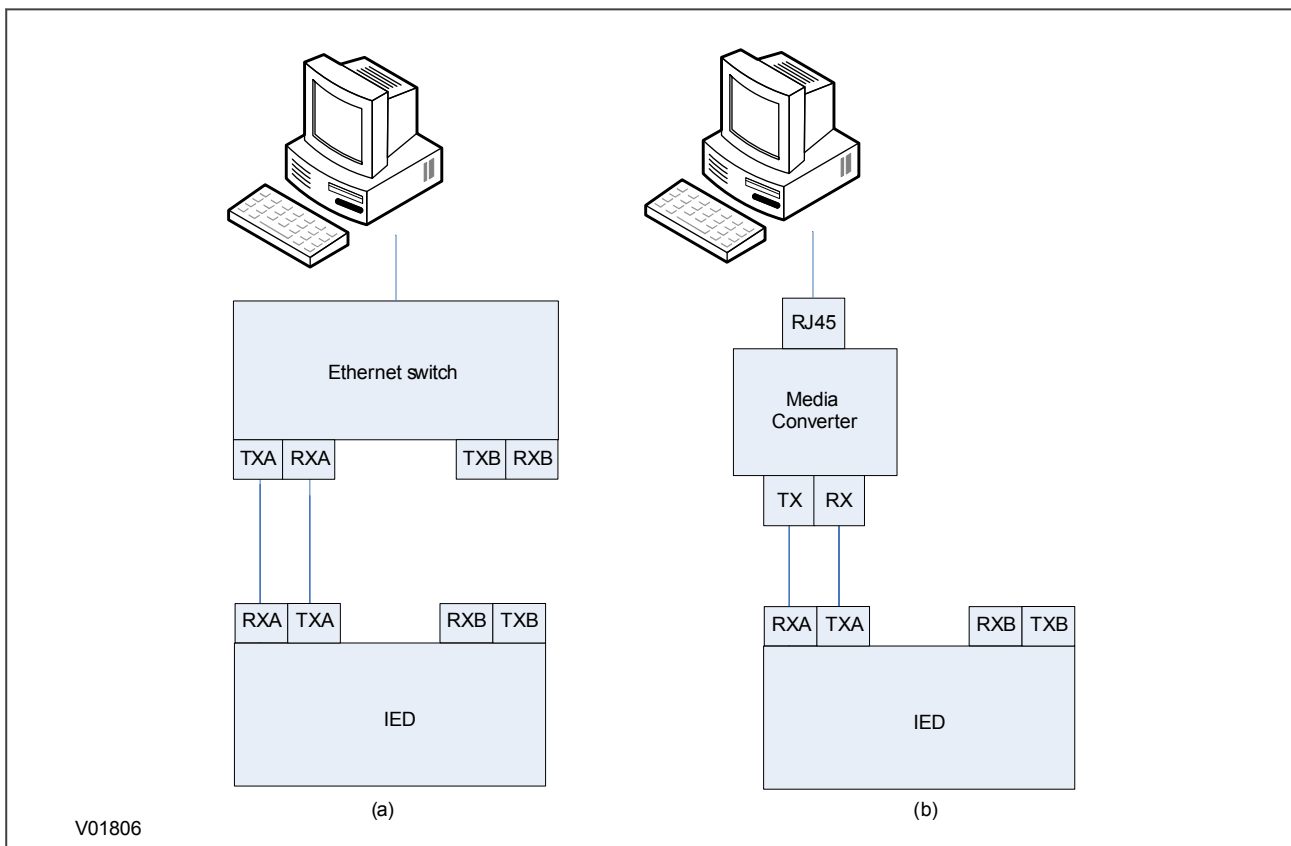


Figure 4: Connection using (a) an Ethernet switch and (b) a media converter

4.2 INSTALLING THE CONFIGURATOR

To install the configurator:

1. Double click the Configurator installer.
2. Click Next and follow the on-screen instructions.

4.3 STARTING THE CONFIGURATOR

To start the configurator:

1. Select the Configurator from the Windows **Programs** menu.
2. The Login screen appears. For user mode login, enter the **Login name** as **User** and click **OK** with no password.

3. If the login screen does not appear, check all network connections.
4. The main window appears. In the bottom right-hand corner of the main window, click the **Language** button to select the language.
5. The **Network Board** drop-down list shows the Network Board, IP Address and MAC Address of the PC in which the Configurator is running

4.4 PRP/HSR DEVICE IDENTIFICATION

To configure the redundant Ethernet board, go to the main window and click the **Identify Device** button. A list of devices are shown with the following details:

- Device address
- MAC address
- Version number of the firmware
- SNTP IP address
- Date & time of the real-time clock, from the board.

Select the device you wish to configure. The MAC address of the selected device is highlighted.

4.5 SELECTING THE DEVICE MODE

You must now select the device mode that you wish to use. This will be either PRP or HSR. To do this, select the appropriate radio button then click the Update button. You will be asked to confirm a device reboot. Click OK to confirm

4.6 PRP/HSR IP ADDRESS CONFIGURATION

To change the network address component of the IP address:

1. From the main window click the **IP Config** button. The **Device setup** screen appears.
2. Enter the required board IP address and click **OK**. This is the redundancy network address, not the IEC 61850 IP address.
3. The board network address is updated and displayed in the main window.

4.7 SNTP IP ADDRESS CONFIGURATION

To configure the SNTP server IP address:

1. From the main window click the **SNTP Config** button. The **Device setup** screen appears.
2. Enter the required **MAC SNTP address** and server **IP SNTP Address**. Click **OK**.
3. The updated MAC and IP SNTP addresses appear in the main screen.

4.8 CHECK FOR CONNECTED EQUIPMENT

To check what devices are connected to the device being monitored:

1. From the main window, select the device.
2. Click the **Equipment** button.
3. At the bottom of the main window, a box shows the ports where devices are connected and their MAC addresses.

4.9 PRP CONFIGURATION

To view or configure the PRP Parameters:

1. Ensure that you have set the device mode to **PRP**.
2. Click the **PRP/HSR Configuration** button. The **PRP Configuration Parameters** screen appears.
3. To view the available parameters, click the **Get PRP Parameters** button.
4. To change the parameters, click the **Set Parameters** button and modify their values.

If you need to restore the default values of the parameters, click the **Restore Defaults** button.

The configurable parameters are as follows:

- **Multicast Address:** Use this field to configure the multicast destination address. All DANPs in the network must be configured to operate with the same multicast address for the purpose of network supervision.
- **Node Forget Time:** This is the time after which a node entry is cleared in the nodes table.
- **Life Check Interval:** This defines how often a node sends a PRP_Supervision frame. All DANPs shall be configured with the same Life Check Interval.

4.10 HSR CONFIGURATION

To view or configure the HSR Parameters:

1. Click the **PRP/HSR Configuration** button. The **HSR Configuration Parameters** screen appears.
2. To view the available parameters in the board that is connected, click the **Get HSR Parameters** button.
3. To change the parameters, click the **Set HSR Parameters** button and modify their values.

If you need to restore the default values of the parameters, click the **Restore Defaults** button.

The configurable parameters are as follows:

- **Multicast Address:** Use this field to configure the multicast destination address. All DANPs in the network must be configured to operate with the same multicast address for the purpose of network supervision.
- **Node Forget Time:** This is the time after which a node entry is cleared in the nodes table.
- **Life Check Interval:** This defines how often a node sends a PRP Supervision frame. All DANPs must be configured with the same Life Check Interval.
- **Proxy Node Table Forget Time:** This is the time after which a node entry is cleared in the ProxyTable
- **Proxy Node Table Max Entries:** This is the maximum number of entries in the ProxyTable
- **Entry Forget Time:** This is the time after which an entry is removed from the duplicates
- **Node Reboot Interval:** This is the minimum time during which a node that reboots remains silent

4.11 END OF SESSION

To finish the session:

1. In the main window, click the **Quit** button, a new screen appears.
2. If a database backup is required, click **Yes**, a new screen appears.
3. Click the ... button to browse the path. Enter the name in the text box.

5 RSTP CONFIGURATOR

The RSTP Configurator tool is intended for MiCOM Px4x IEDs with redundant Ethernet using RSTP (Rapid Spanning Tree Protocol). This tool is used to identify IEDs, configure the redundancy IP address, configure the SNTP IP address and configure the RSTP parameters.

5.1 CONNECTING THE IED TO A PC

Connect the IED to the PC on which the Configurator tool is used. This connection is done through an Ethernet switch or through a media converter.

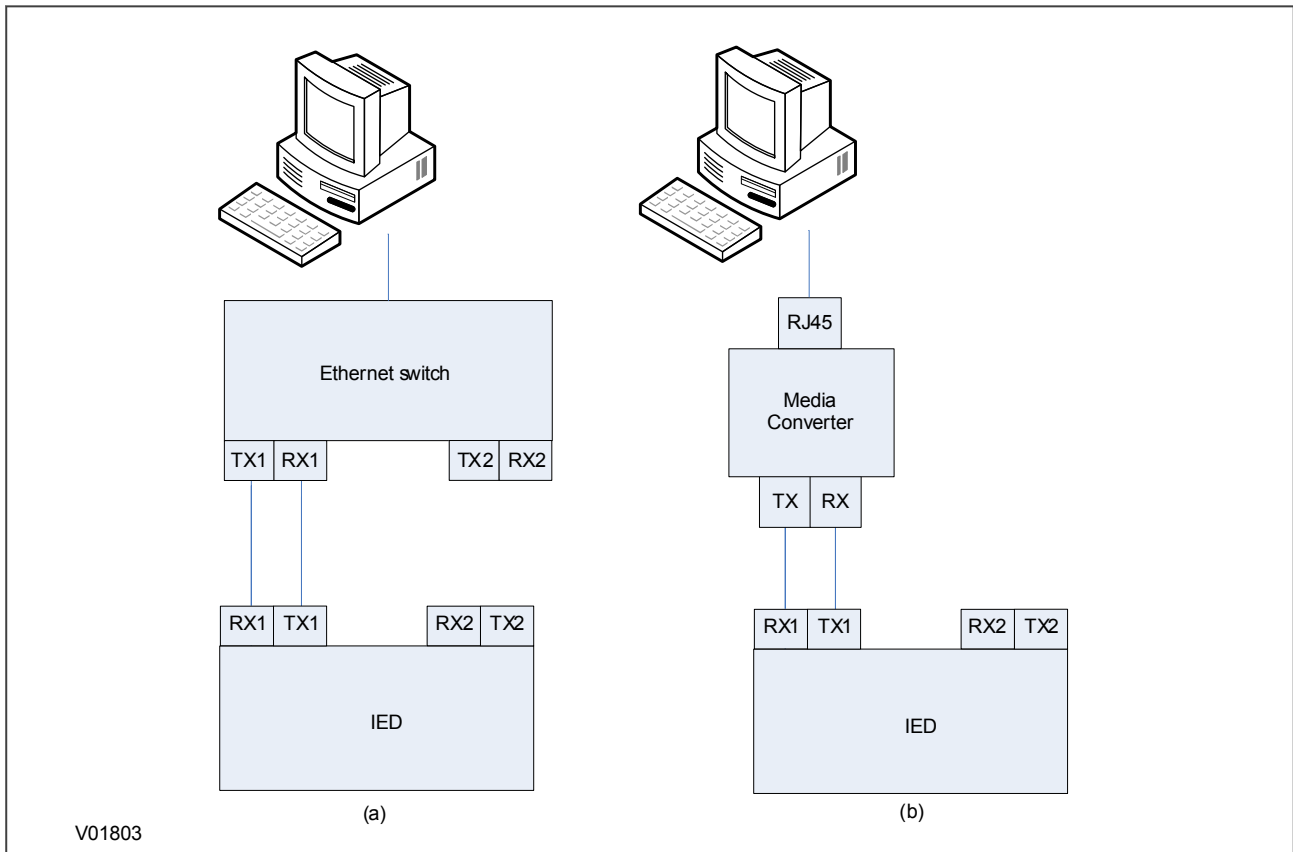


Figure 5: Connection using (a) an Ethernet switch and (b) a media converter

5.2 INSTALLING THE CONFIGURATOR

To install the configurator:

1. Double click the Configurator installer.
2. Click Next and follow the on-screen instructions.

5.3 STARTING THE CONFIGURATOR

To start the configurator:

1. Select the Configurator from the Windows **Programs** menu.
2. The Login screen appears. For user mode login, enter the **Login name** as **User** and click **OK** with no password.

3. If the login screen does not appear, check all network connections.
4. The main window appears. In the bottom right-hand corner of the main window, click the **Language** button to select the language.
5. The **Network Board** drop-down list shows the Network Board, IP Address and MAC Address of the PC in which the Configurator is running

5.4 RSTP DEVICE IDENTIFICATION

To configure the redundant Ethernet board, go to the main window and click **Identify Device**.

Note:

Due to the time needed to establish the RSTP protocol, wait 25 seconds between connecting the PC to the IED and clicking the Identify Device button.

The redundant Ethernet board connected to the PC is identified and its details are listed.

- Device address
- MAC address
- Version number of the firmware
- SNTP IP address
- Date & time of the real-time clock, from the board.

5.5 RSTP IP ADDRESS CONFIGURATION

To change the network address component of the IP address,

1. From the main window click the **IP Config** button.
2. The **Device Setup** screen appears showing the **IP Base Address**. This is the board redundancy network address, not the IEC 61850 IP address.
3. Enter the required board IP address.
4. Click **OK**. The board network address is updated and displayed in the main window.

5.6 SNTP IP ADDRESS CONFIGURATION

To configure the SNTP server IP address:

1. From the main window click the **SNTP Config** button. The **Device setup** screen appears.
2. Enter the required **MAC SNTP address** and server **IP SNTP Address**. Click **OK**.
3. The updated MAC and IP SNTP addresses appear in the main screen.

5.7 CHECK FOR CONNECTED EQUIPMENT

To check what devices are connected to the device being monitored:

1. From the main window, select the device.
2. Click the **Equipment** button.
3. At the bottom of the main window, a box shows the ports where devices are connected and their MAC addresses.

5.8 RSTP CONFIGURATION

1. To view or configure the RSTP Bridge Parameters, from the main window, click the device address to select the device. The selected device MAC address appears highlighted.
2. Click the **RSTP Configuration** button. The **RSTP Configuration** screen appears.
3. To view the available parameters in the board that is connected, click the **Get RSTP Parameters** button.
4. To set the configurable parameters such as Bridge Max Age, Bridge Hello Time, Bridge Forward Delay, and Bridge Priority, modify the parameter values according to the following table and click **Set RSTP Parameters**.

S.No	Parameter	Default value (second)	Minimum value (second)	Maximum value (second)
1	Bridge Max Age	20	6	40
2	Bridge Hello Time	2	1	10
3	Bridge Forward Delay	15	4	30
4	Bridge Priority	32768	0	61440

5.8.1 BRIDGE PARAMETERS

To read the RSTP bridge parameters from the board,

1. From the main window click the device address to select the device. The **RSTP Configuration** window appears and the default tab is **Bridge Parameters**.
2. Click the **Get RSTP Parameters** button. This displays all the RSTP bridge parameters from the Ethernet board.
3. To modify the RSTP parameters, enter the values and click **Set RSTP Parameters**.
4. To restore the default values, click **Restore Default** and click **Set RSTP Parameters**.

The grayed parameters are read-only and cannot be modified.

Note:

When assigning the bridge priority, make sure the root of the network is the Ethernet switch, not the IEDs. This reduces the number of hops to reach all devices in the network. Also make sure the priority values for all IEDs are higher than that of the switch.

5.8.2 PORT PARAMETERS

This function is useful if you need to view the parameters of each port.

1. From the main window, click the device address to select the device. The **RSTP Configuration** window appears.
2. Select the **Port Parameters** tab, then click **Get Parameters** to read the port parameters. Alternatively, select the port numbers to read the parameters.

5.8.3 PORT STATES

This is used to see which ports of the board are enabled or disabled.

1. From the main window, click the device address to select the device. The **RSTP Configuration** window appears.
2. Select the **Port States** tab then click the **Get Port States** button. This lists the ports of the Ethernet board. A tick shows they are enabled.

5.9 END OF SESSION

To finish the session:

1. In the main window, click the **Quit** button, a new screen appears.
2. If a database backup is required, click **Yes**, a new screen appears.
3. Click the ... button to browse the path. Enter the name in the text box.

6 SWITCH MANAGER

Switch Manager is used to manage Ethernet ring networks and MiCOM H35x-V2 and H36x-V2 SNMP facilities. It is a set of tools used to manage, optimize, diagnose and supervise your network. It also handles the version software of the switch.

The Switch Manager tool is also intended for MiCOM Px4x IEDs with redundant Ethernet using Self Healing Protocol (SHP) and Dual Homing Protocol (DHP). This tool is used to identify IEDs and GE Switches, and to configure the redundancy IP address for the GE proprietary Self Healing Protocol and Dual Homing Protocol.

Switch hardware

GE switches are stand-alone devices (H3xx, H6x families) or embedded in a computer device rack, for example MiCOM C264 (SWDxxx, SWRxxx, SWUxxx Ethernet boards) or PC board (MiCOM H14x, MiCOM H15x, MiCOM H16x).

Switch range

There are 3 types of GE switches:

- Standard switches: SWU (in C264), H14x (PCI), H34x, H6x
- Redundant Ring switches: SWR (in C264), H15x (PCI), H35x,
- Redundant Dual Homing switches: SWD (in C264), H16x (PCI), H36x

Switch Manager allows you to allocate an IP addresses for GE switches. Switches can then be synchronized using the Simple Network Time Protocol (SNTP) or they can be administrated using the Simple Network Management Protocol (SNMP).

All switches have a single 6-byte MAC address.

Redundancy Management

Standard Ethernet does not support a loop at the OSI link layer (layer 2 of the 7 layer model). A mesh topology cannot be created using a standard Hub and switch. Redundancy needs separate networks using hardware in routers or software in dedicated switches using STP (Spanning Tree Protocol). However, this redundancy mechanism is too slow for one link failure in electrical automation networks.

GE has developed its own Redundancy ring and star mechanisms using two specific Ethernet ports of the redundant switches. This redundancy works between GE switches of the same type. The two redundant Ethernet connections between GE switches create one private redundant Ethernet LAN.

The Ethernet ports dedicated to the redundancy are optical Ethernet ports. The GE redundancy mechanism uses a single specific address for each Ethernet switch of the private LAN. This address is set using DIP switches or jumpers.

Switch Manager monitors the redundant address of the switches and the link topology between switches.

6.1 INSTALLATION

Switch Manager requirements

- PC with Windows XP or later
- Ethernet port
- 200 MB hard disk space
- PC IP address configured in Windows in same IP range as switch

Network IP address

IP addressing is needed for time synchronization of GE switches and for SNMP management.

Switch Manager is used to define IP addresses of GE switches. These addresses must be in the range of the system IP, depending on the IP mask of the engineering PC for substation maintenance.

GE switches have a default multicast so the 3rd word of the IP address is always 254.

Installation procedure

Run **Setup.exe** and follow the on-screen instructions.

6.2 SETUP

1. Make sure the PC has one Ethernet port connected to the GE switch.
2. Configure the PC's Ethernet port on the same subnet as the GE switch.
3. Select **User** or **Admin** mode. In User mode enter the user name as **User**, leave the password blank and click **OK**. In Admin mode you can not upload the firmware on the Ethernet repeaters.
4. In Admin mode enter the user name as **Admin**, enter the password and click **OK**. All functions are available including Expert Maintenance facilities.
5. Click the **Language** button in the bottom right of the screen and select your language.
6. If several Ethernet interfaces are used, in the **Network** board drop-down box, select the PC Network board connected to the GE switch. The IP and MAC addresses are displayed below the drop-down box.
7. Periodically click the **Ring Topology** button (top left) to display or refresh the list of GE switches that are connected.

6.3 NETWORK SETUP

To configure the network options:

1. From the main window click the **Settings** button. The Network Setup screen appears.
2. Enter the required board IP address. The first two octets can be configured. The third octet is always 254. The last octet is set using the DIP switches (SW2) on the redundant Ethernet board, next to the ribbon connector.
3. Click **OK**. The board network address is updated and displayed in the main window.
4. From the main window click the **SNTP Config** button. The Device setup screen appears.
5. Enter the required **MAC SNTP Address** and server **IP SNTP Address**. Click **OK**.
6. The updated MAC and IP SNTP addresses appear in the main screen.
7. Click the **Saturation** button. A new screen appears.
8. Set the saturation level and click **OK**. The default value is 300.

6.4 BANDWIDTH USED

To show how much bandwidth is used in the ring,

Click the **Ring%** button, at the bottom of the main window. The percentage of bandwidth used in the ring is displayed.

6.5 RESET COUNTERS

To reset the switch counters,

1. Click **Switch Counter Reset**.
2. Click **OK**.

6.6 CHECK FOR CONNECTED EQUIPMENT

To check what devices are connected to the device being monitored:

1. From the main window, select the device.
2. Click the **Equipment** button.
3. At the bottom of the main window, a box shows the ports where devices are connected and their MAC addresses.

6.7 MIRRORING FUNCTION

Port mirroring is a method of monitoring network traffic that forwards a copy of each incoming and outgoing packet from one port of the repeater to another port where the data can be studied. Port mirroring is managed locally and a network administrator uses it as a diagnostic tool.

To set up port mirroring:

1. Select the address of the device in the main window.
2. Click the Mirroring button, a new screen appears.
3. Click the checkbox to assign a mirror port. A mirror port copies the incoming and outgoing traffic of the port.

6.8 PORTS ON/OFF

To enable or disable ports:

1. Select the address of the device in the main window.
2. Click **Ports On/Off**, a new screen appears.
3. Click the checkbox to enable or disable a port. A disabled port has an empty checkbox.

6.9 VLAN

The Virtual Local Area Network (VLAN) is a technique used to split an interconnected physical network into several networks. This technique can be used at all ISO/OSI levels. The VLAN switch is mainly at OSI level 1 (physical VLAN) which allows communication only between some Ethernet physical ports.

Ports on the switch can be grouped into Physical VLANs to limit traffic flooding. This is because it is limited to ports belonging to that VLAN and not to other ports.

Port-based VLANs are VLANs where the packet forwarding decision is based on the destination MAC address and its associated port. You must define outgoing ports allowed for each port when using port-based VLANs. The VLAN only governs the outgoing traffic so is unidirectional. Therefore, if you wish to allow two subscriber ports to talk to each other, you must define the egress port for both ports. An egress port is an outgoing port, through which a data packet leaves.

To assign a physical VLAN to a set of ports:

1. Select the address of the device in the main window.
2. Click the **VLAN** button, a new screen appears.
3. Use the checkboxes to select which ports will be in the same VLAN. By default all the ports share the same VLAN.

6.10 END OF SESSION

To finish the session:

1. In the main window, click the **Quit** button, a new screen appears.
2. If a database backup is required, click **Yes**, a new screen appears.
3. Click the ... button to browse the path. Enter the name in the text box.

CHAPTER 5

OPERATION

1 CHAPTER OVERVIEW

This chapter provides details of how the product functions.

This chapter contains the following sections:

Chapter Overview	57
Redundant Ethernet Communication	58
Redundancy Protocols	59
General Functions for Redundant Ethernet Boards	69

2 REDUNDANT ETHERNET COMMUNICATION

Redundancy is transparent backup. It is required where a single point of failure cannot be tolerated, and required in critical applications such as substation automation. Redundancy acts as an insurance policy, providing an alternative route if one route fails.

The Redundant Ethernet Board (REB) designed for the Px40 series assures "bumpless" redundancy at the intelligent electronic device (IED) level. "Bumpless" in this context is a term used to describe the transferring from one communication path to another without noticeable consequences.

3 REDUNDANCY PROTOCOLS

REB variants for each of the following protocols are available:

- PRP (Parallel Redundancy Protocol)
- HSR (High-availability Seamless Redundancy)
- RSTP (Rapid Spanning Tree Protocol)
- SHP (Self-Healing Protocol)
- DHP (Dual Homing Protocol)
- Failover

PRP and HSR are open standards, so their implementation is compatible with any standard PRP or HSR device respectively. PRP provides "bumpless" redundancy. RSTP is also an open standard, so its implementation is compatible with any standard RSTP devices. RSTP provides redundancy, however, it is not "bumpless".

SHP and DHP are proprietary protocols intended for use with specific GE products:

- SHP is compatible with the C264-SWR212 as well as H35x multimode switches.
- DHP is compatible with the C264-SWD212 as well as H36x multimode switches.

Both SHP and DHP provide "bumpless" redundancy.

Note:
The protocol you require must be selected at the time of ordering.

3.1 PARALLEL REDUNDANCY PROTOCOL (PRP)

Power system companies have traditionally used proprietary protocols for redundant communications. This is because standardized protocols could not meet the requirements for real-time systems. Even a short loss of connectivity may result in loss of functionality.

However, Parallel Redundancy Protocol (PRP) uses the IEC 62439 standard in Dual Homing Star Topology networks, designed for IEDs from different manufacturers to operate with each other in a substation redundant-Ethernet network. PRP provides bumpless redundancy for real-time systems and is the standard for double Star-topology networks in substations.

3.1.1 PRP NETWORKS

Redundant networks usually rely on the network's ability to reconfigure if there is a failure. However, PRP uses two independent networks in parallel.

PRP implements the redundancy functions in the end nodes rather than in network elements. This is one major difference to RSTP. An end node is attached to two similar LANs of any topology which operate in parallel.

The sending node replicates each frame and transmits them over both networks. The receiving node processes the frame that arrives first and discards the duplicate. Therefore there is no distinction between the working and backup path. The receiving node checks that all frames arrive in sequence and that frames are correctly received on both ports.

The PRP layer manages this replicate and discard function, and hides the two networks from the upper layers. This scheme works without reconfiguration and switchover, so it stays available ensuring no data loss.

There should be no common point of failure between the two LANs. Therefore they are not powered by the same source and cannot be connected directly together. They are identical in protocol at the MAC level but may differ in performance and topology. Both LANs must be on the same subnet so all IP addresses must be unique.

3.1.2 NETWORK ELEMENTS

A PRP compatible device has two ports that operate in parallel. Each port is connected to a separate LAN. In the IEC 62439 standard, these devices are called DANP (Doubly Attached Node running PRP). A DAN has two ports, one MAC address and one IP address.

A Single Attached Node (SAN) is a non-critical node attached to only one LAN. SANs that need to communicate with each other must be on the same LAN.

The following diagram shows an example of a PRP network. The Doubly Attached Nodes DANP 1 and DANP 2 have full node redundancy. The Singly Attached Nodes SAN 1 and SAN 4 do not have any redundancy. Singly attached nodes can be connected to both LANs using a Redundancy Box (RedBox). The RedBox converts a singly attached node into a doubly attached node. Devices such as PCs with one network card, printers, and IEDs with one network card are singly attached nodes. A SAN behind a RedBox appears like a DAN so is called a Virtual DAN (VDAN).

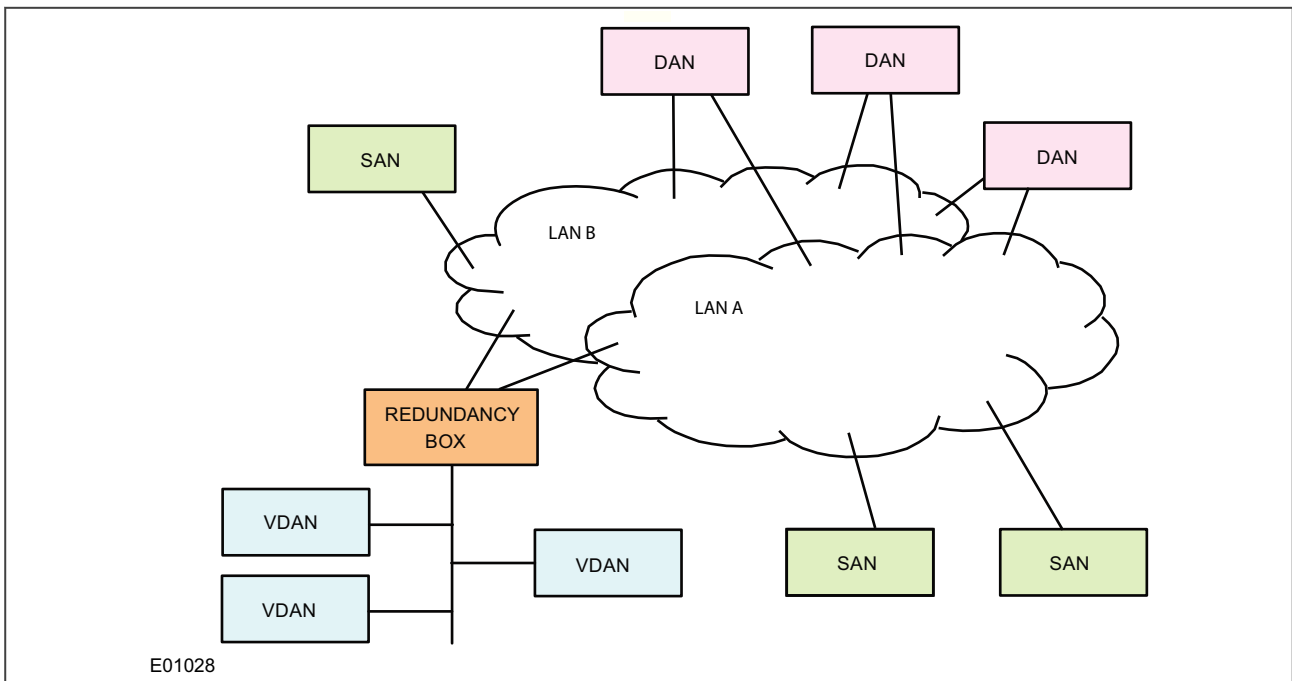


Figure 6: Example PRP redundant network

In a DAN, both ports share the same MAC address so it does not affect the way devices talk to each other in an Ethernet network (Address Resolution Protocol at layer 2). Every data frame is seen by both ports.

When a DAN sends a frame of data, the frame is duplicated on both ports and therefore on both LAN segments. This provides a redundant path for the data frame if one of the segments fails. Under normal conditions, both LAN segments are working and each port receives identical frames. There are two ways of handling this: Duplicate Accept and Duplicate Discard.

The GE RedBox is the H382 switch. This is compatible with any other vendor's PRP device.

3.2 HIGH-AVAILABILITY SEAMLESS REDUNDANCY (HSR)

HSR is standardized in IEC 62439-3 (clause 5) for use in ring topology networks. Similar to PRP, HSR provides bumpless redundancy and meets the most demanding needs of substation automation. HSR has become the reference standard for ring-topology networks in the substation environment. The HSR implementation of the redundancy Ethernet board (REB) is compatible with any standard HSR device.

HSR works on the premise that each device connected in the ring is a doubly attached node running HSR (referred to as DANH). Similar to PRP, singly attached nodes such as printers are connected via Ethernet Redundancy Boxes (RedBox).

3.2.1 HSR MULTICAST TOPOLOGY

When a DANH is sending a multicast frame, the frame (C frame) is duplicated (A frame and B frame), and each duplicate frame A/B is tagged with the destination MAC address and the sequence number. The frames A and B differ only in their sequence number, which is used to identify one frame from the other. Each frame is sent to the network via a separate port. The destination DANH receives two identical frames, removes the HSR tag of the first frame received and passes this (frame D) on for processing. The other duplicate frame is discarded. The nodes forward frames from one port to the other unless it was the node that injected it into the ring.

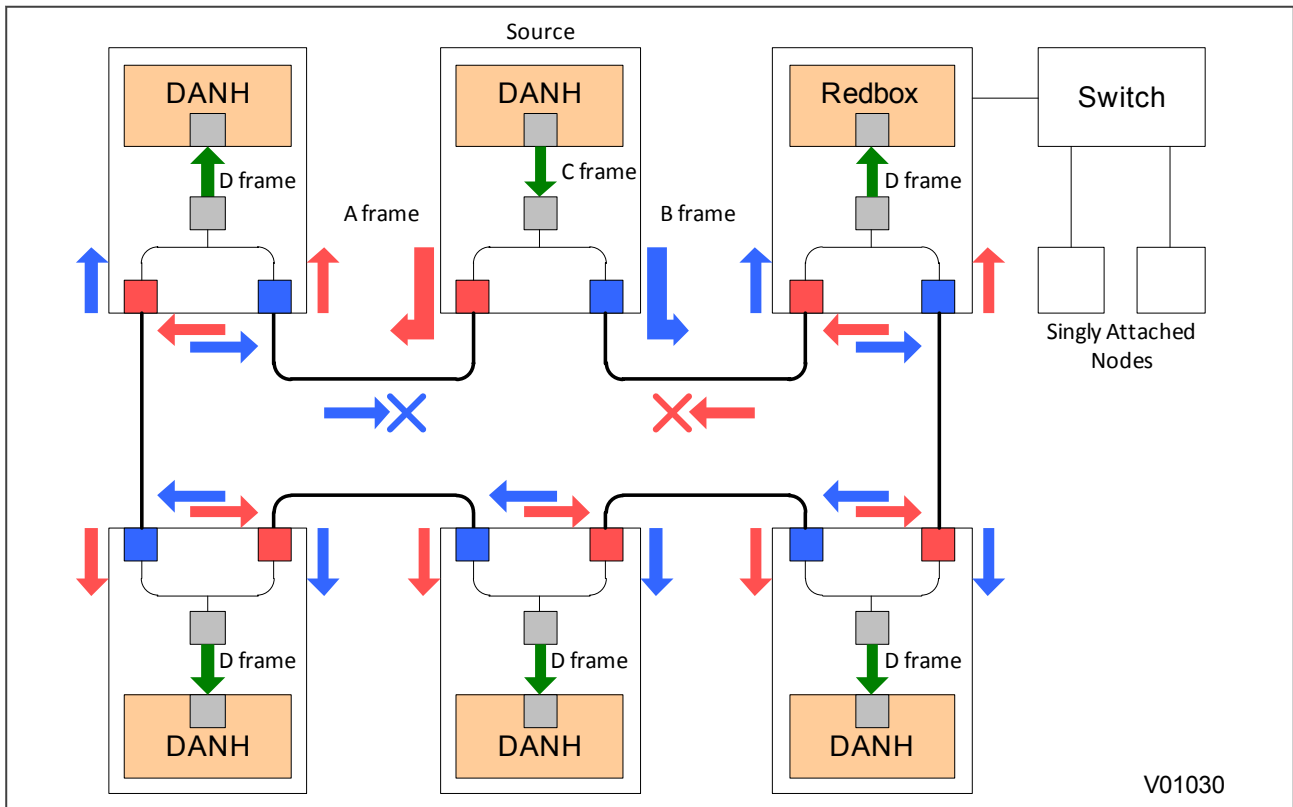


Figure 7: HSR multicast topology

Only about half of the network bandwidth is available in HSR for multicast or broadcast frames because both duplicate frames A & B circulate the full ring.

3.2.2 HSR UNICAST TOPOLOGY

With unicast frames, there is just one destination and the frames are sent to that destination alone. All non-recipient devices simply pass the frames on. They do not process them in any way. In other words, D frames are produced only for the receiving DANH. This is illustrated below.

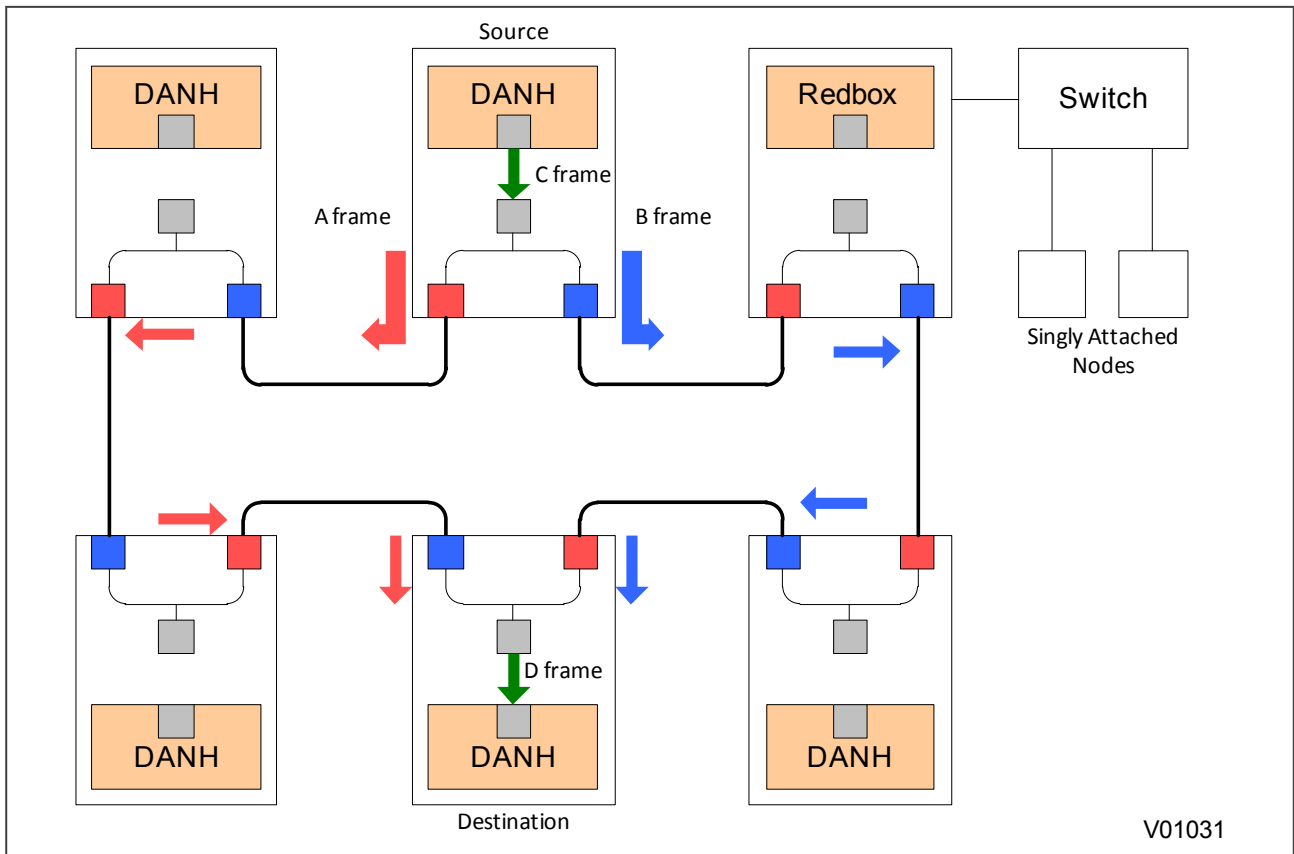


Figure 8: HSR unicast topology

For unicast frames, the whole bandwidth is available as both frames A & B stop at the destination node.

3.2.3 HSR APPLICATION IN THE SUBSTATION

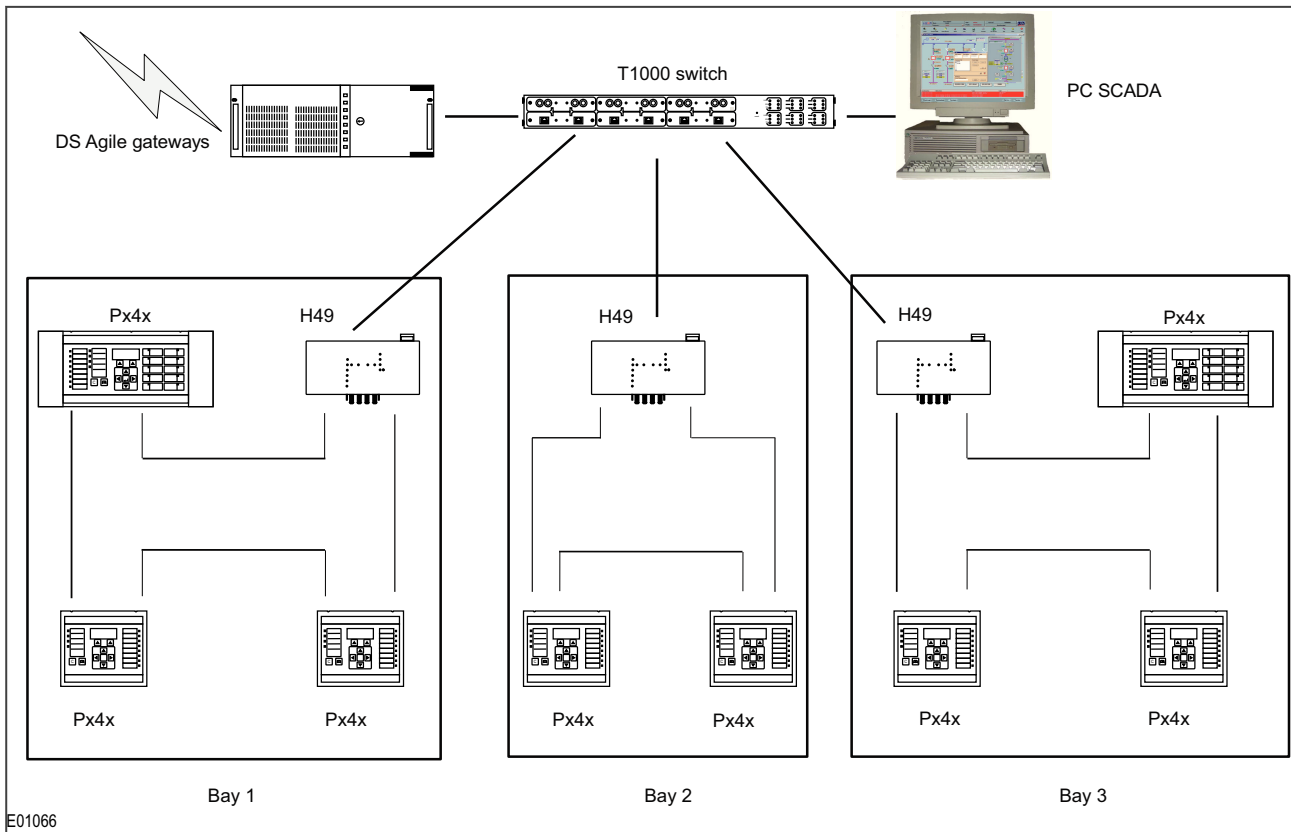


Figure 9: HSR application in the substation

3.3 RAPID SPANNING TREE PROTOCOL (RSTP)

RSTP is a standard used to quickly reconnect a network fault by finding an alternative path, allowing loop-free network topology. Although RSTP can recover network faults quickly, the fault recovery time depends on the number of devices and the topology. The recovery time also depends on the time taken by the devices to determine the root bridge and compute the port roles (discarding, learning, forwarding). The devices do this by exchanging Bridge Protocol Data Units (BPDUs) containing information about bridge IDs and root path costs. See the IEEE 802.1D 2004 standard for further information.

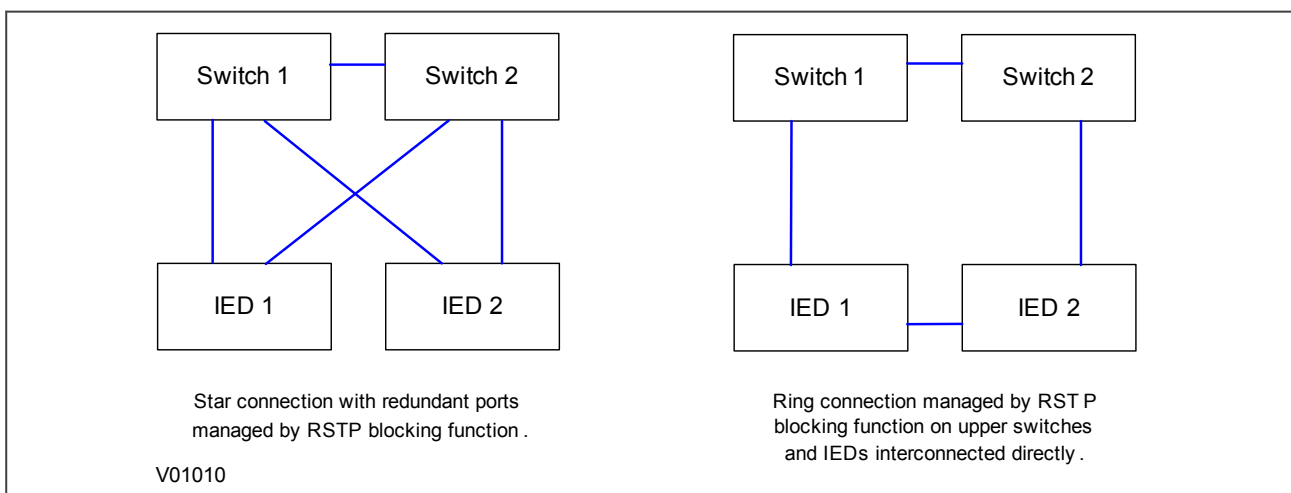


Figure 10: IED attached to redundant Ethernet star or ring circuit

The RSTP solution is based on open standards. It is therefore compatible with other Manufacturers' IEDs that use the RSTP protocol. The RSTP recovery time is typically 300 ms but it increases with network size, therefore cannot achieve the desired bumpless redundancy.

To ensure optimal performance of the protocol, make sure that one of the Ethernet switches is always the root of the RSTP topology.

3.4 SELF-HEALING PROTOCOL (SHP)

Unlike RSTP, the GE SHP solution responds to the constraints of critical time applications such as the GOOSE messaging of IEC 61850. SHP in MiCOM Px4x is fully compatible with SHP used in the MiCOM C264 and MiCOM H series of switches that are components of the PACiS Substation Automation System.

SHP is applied to double-ring network topologies. When a fibre is broken, both end stations detect the break. Using both the primary and redundant networks the ring is automatically reclosed.

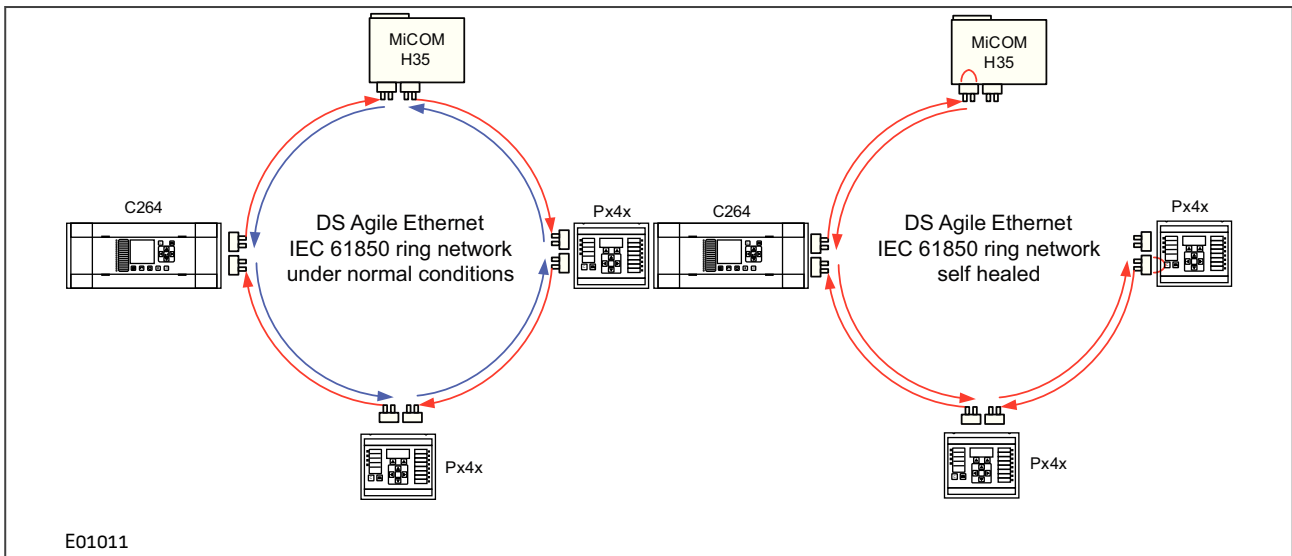


Figure 11: IED, bay computer and Ethernet switch with self healing ring facilities

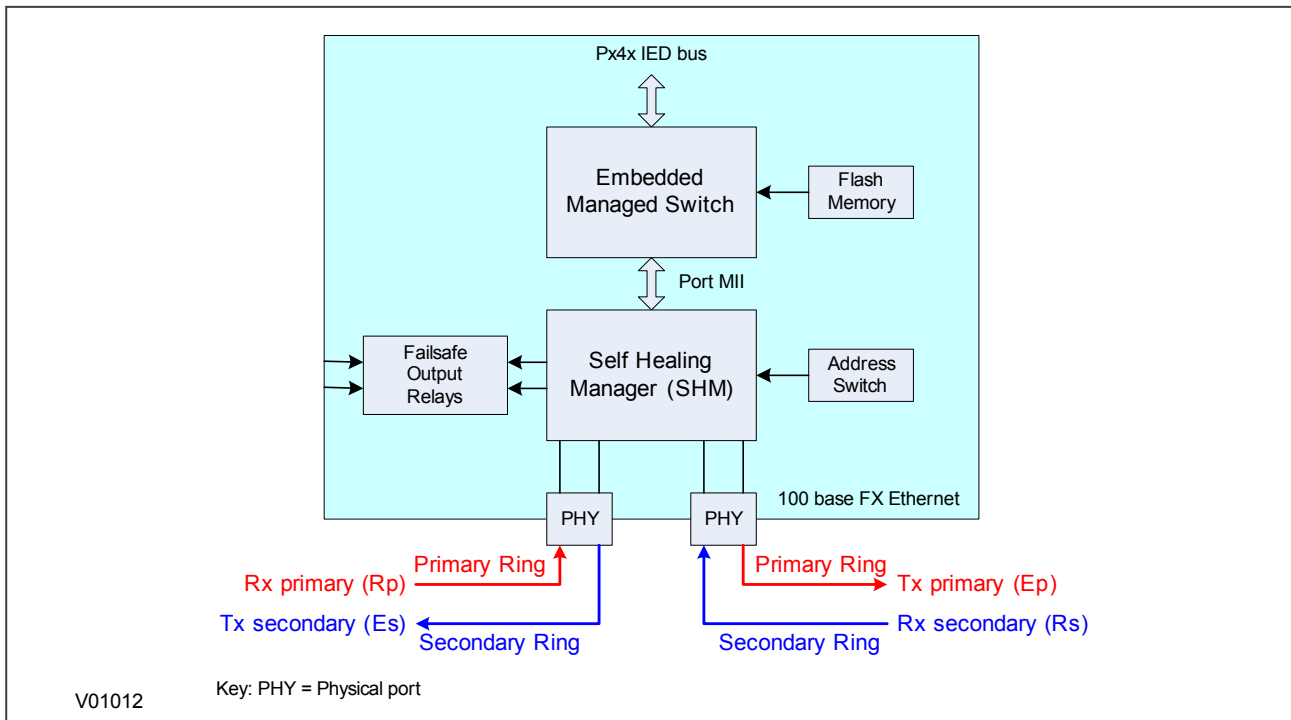


Figure 12: Internal architecture of IED, C264 bay computer and H36x Ethernet switch

The SHM functions manage the ring. If the fibre optic connection between two devices is broken, the network continues to run correctly.

Normally the Ethernet packets travel on the primary fibre in the same direction, and only a checking frame (4 octets) is sent every 5 μ s on the secondary fibre in the opposite direction.

If the link goes down, both SHMs immediately start the network self-healing. At one side of the break, received messages are no longer sent to the primary fibre but are sent to the secondary fibre. On the other side of the break, messages received on the secondary fibre are sent to the primary fibre and the new topological loop is closed in less than 1 ms.

As well as providing bumpless redundancy for unintentional network failure, this system can also be used to extend the number of devices, or the size of a sub-station network, without having to disable the network.

First, the loop is opened intentionally and it immediately self heals. Then the new equipment is connected and it immediately self heals again, closing the loop.

To increase the reliability some additional mechanisms are used:

- The quality of transmission is monitored. Each frame (Ethernet packet or checking frame) is controlled by the SHM. Even if the link is not broken, but a larger than normal error rate is detected, the redundancy mechanism is initiated.
- Even if there is no traffic in the primary link, the secondary link is still supervised by sending out checking frames every 5 μ s.

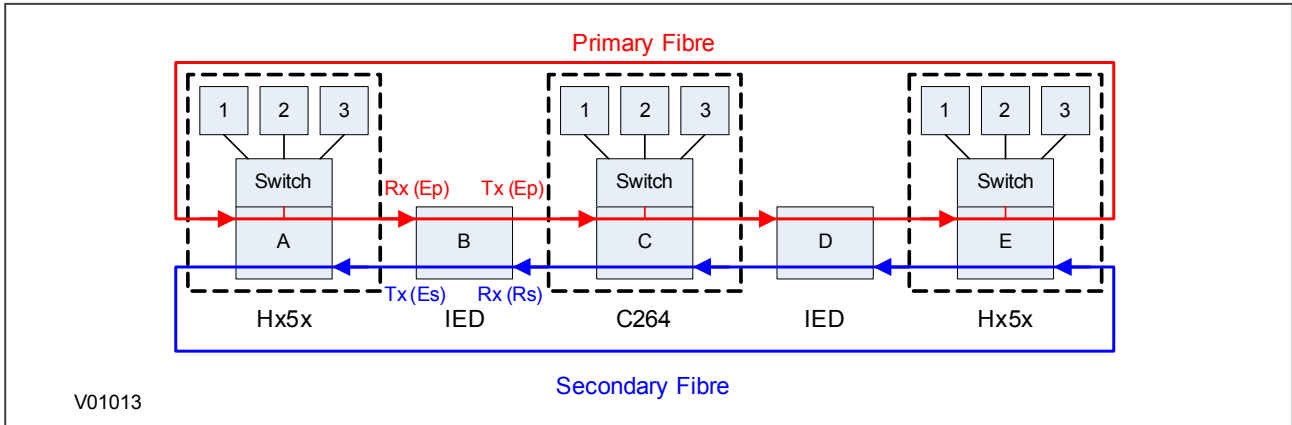


Figure 13: Redundant Ethernet ring architecture with IED, bay computer and Ethernet switches

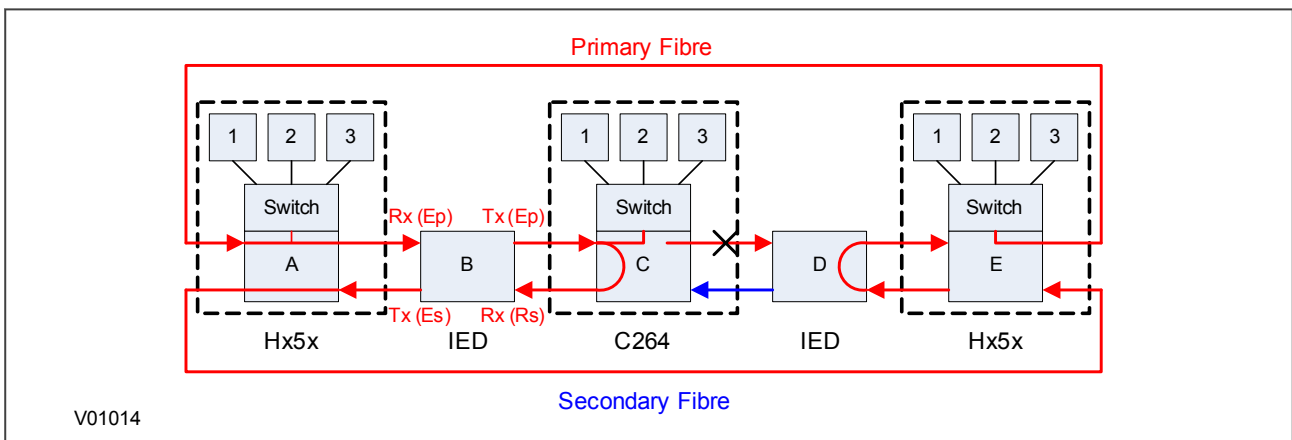


Figure 14: Redundant Ethernet ring architecture with IED, bay computer and Ethernet switches after failure

3.5 DUAL-HOMING PROTOCOL (DHP)

Unlike RSTP, the GE DHP solution responds to the constraints of critical time applications such as the GOOSE messaging of IEC 61850.

DHP is applied to double-star network topologies. If the optical fibre connection between two devices is broken, the network continues to operate correctly.

The Dual Homing Manager (DHM) handles topologies where a device is connected to two independent networks, one being the "main" path, the other being the "backup" path. Both are active at the same time.

In sending mode, packets from the device are sent by the DHM to the two networks. In receive mode, the duplicate discard principle is used. This means that when both links are up, the MiCOM Alstom H16x switch receives the same Ethernet frame twice. The DHM transmits the first frame received to upper layers for processing, and the second frame is discarded. If one link is down, the frame is sent through the link, received by the device, and passed to upper layers for processing.

GE's DHM fulfils automation requirements by delivering a very fast recovery time for the entire network (less than 1 ms).

To increase reliability some specific mechanisms are used:

- Each frame carries a sequence number which is incremented and inserted into both frames.
- Specific frames are used to synchronize the discard mechanism.

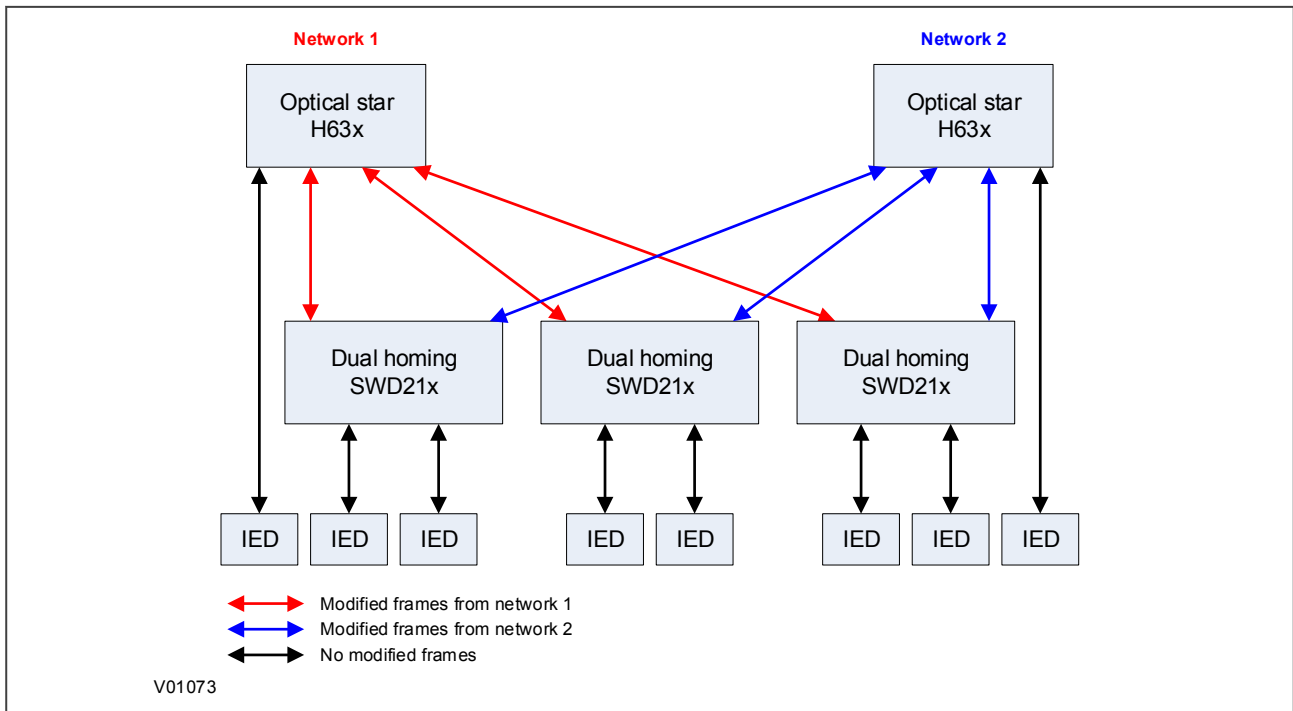


Figure 15: Dual homing mechanism

The H36x is a repeater with a standard 802.3 Ethernet switch, plus the DHM.

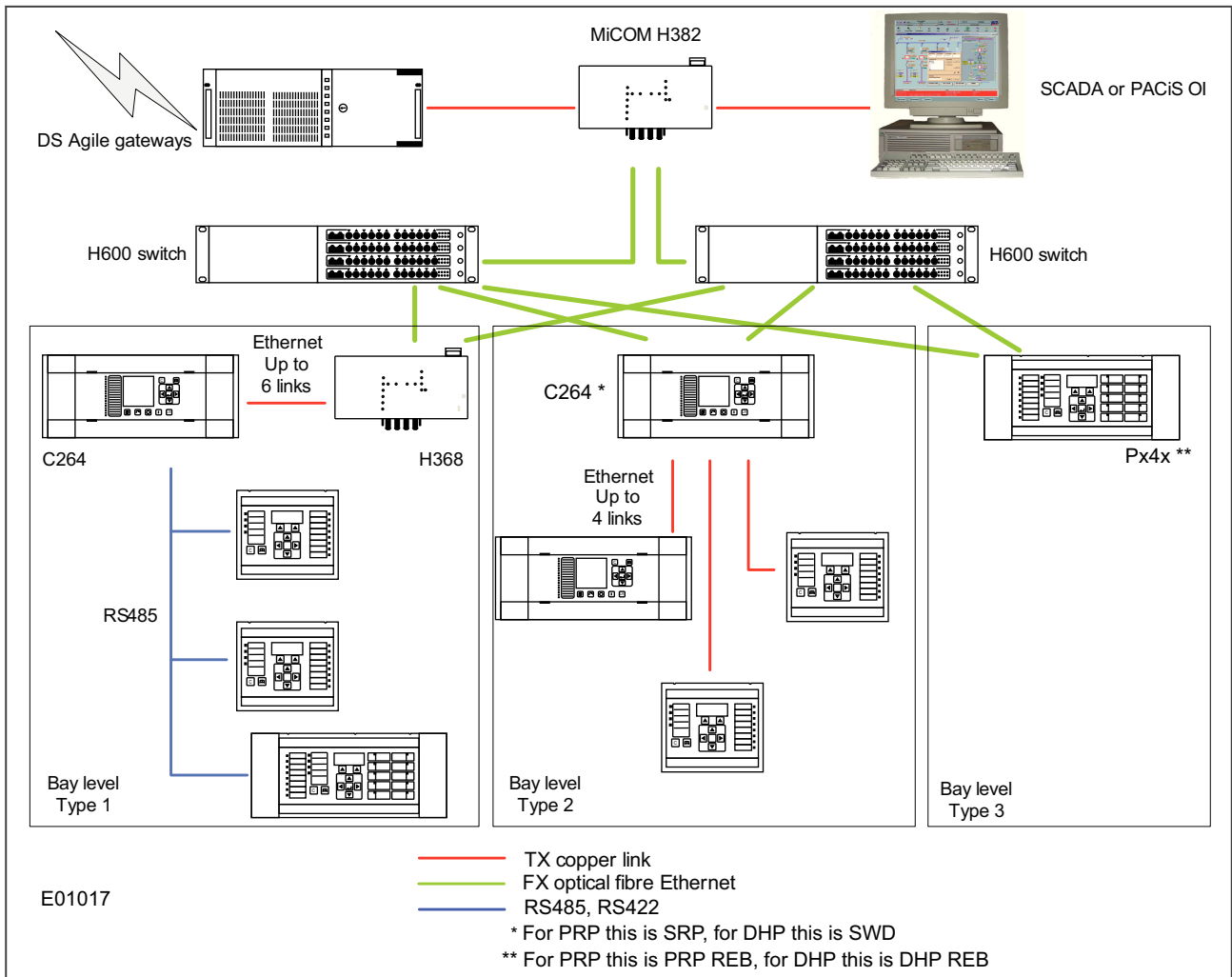


Figure 16: Application of Dual Homing Star at substation level

3.6 FAILOVER

Failover is a simple redundancy mechanism that is not tied to any protocol. It works by selecting a main port and a switching time that can be as low as 2 seconds. When the main port link fails, the redundant port becomes physically active. At no point are both ports physically active, which means it can be used on any redundant or non-redundant network.

4 GENERAL FUNCTIONS FOR REDUNDANT ETHERNET BOARDS

The following functions apply to all redundant Ethernet protocols.

4.1 FORWARDING

The MiCOM Ethernet switch products support store and forward mode. The switch forwards messages with known addresses to the appropriate port. The messages with unknown addresses, the broadcast messages and the multicast messages are forwarded out to all ports except the source port. MiCOM switches do not forward error packets, 802.3x pause frames, or local packets. 802.1p priority tagging is enabled on all ports.

4.2 SIMPLE NETWORK MANAGEMENT PROTOCOL (SNMP)

Simple Network Management Protocol (SNMP) is a network protocol designed to manage devices in an IP network. SNMP uses a Management Information Base (MIB) that contains information about parameters to supervise. The MIB format is a tree structure, with each node in the tree identified by a numerical Object Identifier (OID). Each OID identifies a variable that can be read or set using SNMP with the appropriate software. The information in the MIB is standardized.

Each system in a network (workstation, server, router, bridge, etc.) maintains a MIB that reflects the status of the managed resources on that system, such as the version of the software running on the device, the IP address assigned to a port or interface, the amount of free hard drive space, or the number of open files. The MIB does not contain static data, but is instead an object-oriented, dynamic database that provides a logical collection of managed object definitions. The MIB defines the data type of each managed object and describes the object.

The SNMP-related branches of the MIB tree are located in the internet branch, which contains two main types of branches:

- Public branches (mgmt=2), which are defined by the Internet Engineering Task Force (IETF).
- Private branches (private=4), which are assigned by the Internet Assigned Numbers Authority (IANA). These are defined by the companies and organizations to which these branches are assigned.

The following figure shows the structure of the SNMP MIB tree. There are no limits on the width and depth of the MIB tree.

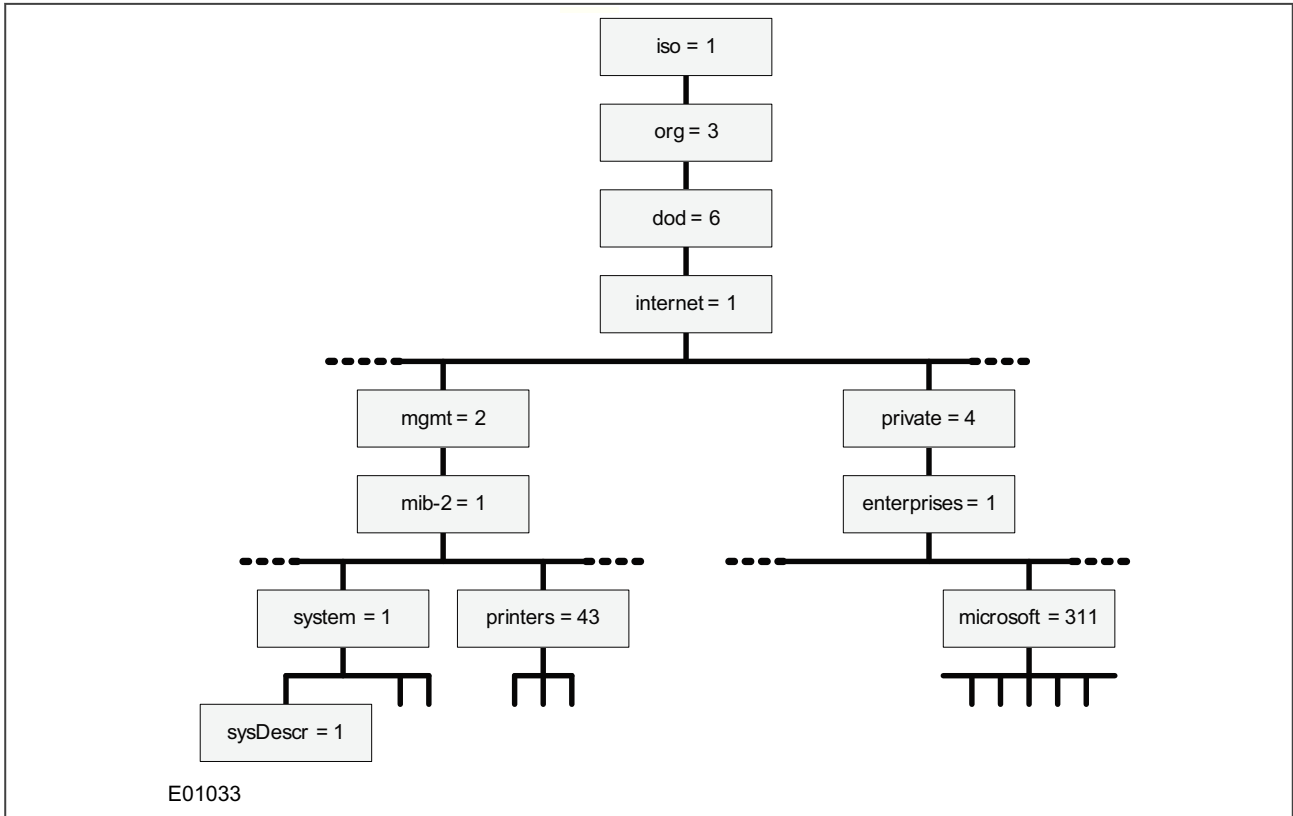


Figure 17: SNMP MIB tree

The top four levels of the hierarchy are fixed. These are:

- International Standards Organization (iso)
- Organization (org)
- Department of Defence (dod)
- Internet

Management (mgmt) is the main public branch. It defines network management parameters common to devices from all vendors. Underneath the Management branch is MIB-II (mib-2), and beneath this are branches for common management functions such as system management, printers, host resources, and interfaces.

The private branch of the MIB tree contains branches for large organizations, organized under the enterprises branch. This is not applicable to GE.

4.3 SNMP MIB STRUCTURE FOR RSTP, DHP AND SHP

Our MIB uses three types of OID:

- sysDescr
- sysUpTime
- sysName

Address										Name
0										CCITT
	1									ISO
		3								Org
			6							DOD

Address										Name
				1						Internet
					2					mgmt
						1				Mib-2
							1			sys
								1		sysDescr
								3		sysUpTime
								4		sysName
Remote Monitoring										
							16			RMON
								1		statistics
									1	etherstat
										etherStatsEntry
									9	etherStatsUndersizePkts
									10	etherStatsOversizePkts
									12	etherStatsJabbers
									13	etherStatsCollisions
									14	etherStatsPkts64Octets
									15	etherStatsPkts65to127Octets
									16	etherStatsPkts128to255Octets
									17	etherStatsPkts256to511Octets
									18	etherStatsPkts512to1023Octets

Various SNMP client software tools can be used. We recommend using an SNMP MIB browser, which can perform the basic SNMP operations such as GET, GETNEXT and RESPONSE.

Note:

When communicating with the Redundant Ethernet Card, there are two IP addresses visible: one for the IED and one for the Ethernet switch on the redundant Ethernet board. To access the network using SNMP, use the IP address of the redundant Ethernet board switch and not that of the IED. See the Configuration chapter for further information.

4.4 SNMP MIB STRUCTURE FOR PRP AND HSR

Address										Name
0										ITU
	1									ISO
		0								Standard
			62439							IECHighavailability
				3						PRP
					1					linkRedundancyEntityObjects
						0				lreConfiguration
							0			lreConfigurationGeneralGroup
								1		lreManufacturerName
									2	lreInterfaceCount
									1	lreConfigurationInterfaceGroup

Address										Name
						0				lreConfigurationInterfaces
							1			lreInterfaceConfigTable
								1		lreInterfaceConfigEntry
									1	lreInterfaceConfigIndex
									2	lreRowStatus
									3	lreNodeType
									4	lreNodeName
									5	lreVersionName
									6	lreMacAddressA
									7	lreMacAddressB
									8	lreAdapterAdminStateA
									9	lreAdapterAdminStateB
									10	lreLinkStatusA
									11	lreLinkStatusB
									12	lreDuplicateDiscard
									13	lreTransparentReception
									14	lreHsrLREMode
									15	lreSwitchingEndNode
									16	lreRedBoxIdentity
									17	lreSanA
									18	lreSanB
									19	lreEvaluateSupervision
									20	lreNodesTableClear
									21	lreProxyNodeTableClear
				1						lreStatistics
					1					lreStatisticsInterfaceGroup
						0				lreStatisticsInterfaces
							1			lreInterfaceStatsTable
									1	lreInterfaceStatsIndex
									2	lreCntTotalSentA
									3	lreCntTotalSentB
									4	lreCntErrWrongLANA
									5	lreCntErrWrongLANB
									6	lreCntReceivedA
									7	lreCntReceivedB
									8	lreCntErrorsA
									9	lreCntErrorsB
									10	lreCntNodes
									11	lreOwnRxCntA
									12	lreOwnRxCntB
							3			lreProxyNodeTable
								1		lreProxyNodeEntry
									1	reProxyNodeIndex

Address										Name
									2	reProxyNodeMacAddress
	3									Org
		6								Dod
			1							Internet
				2						mgmt
					1					mib-2
						1				System
							1			sysDescr
								3		sysUpTime
									5	sysName
									7	sysServices
						2				interfaces
							2			ifTable
								1		ifEntry
									1	ifIndex
									2	ifDescr
									3	ifType
									4	ifMtu
									5	ifSpeed
									6	ifPhysAddress
									7	ifAdminStatus
									8	ifOpenStatus
									9	ifLastChange
									10	ifInOctets
									11	ifInUcastPkts
									12	ifInNUcastPkts
									13	ifInDiscards
									14	ifInErrors
									15	ifInUnknownProtos
									16	ifOutOctets
									17	ifOutUcastPkts
									18	ifOutNUcastPkts
									19	ifOutDiscards
									20	ifOutErrors
									21	ifOutQLen
									22	ifSpecific
					16					rmon
							1			statistics
								1		etherStatsTable
									1	etherStatsEntry
									1	etherStatsIndex
									2	etherStatsDataSource
									3	etherStatsDropEvents

Address										Name	
										4	etherStatsOctets
										5	etherStatsPkts
										6	etherStatsBroadcastPkts
										7	etherStatsMulticastPkts
										8	etherStatsCRCAlignErrors
										9	etherStatsUndersizePkts
										10	etherStatsOversizePkts
										11	etherStatsFragments
										12	etherStatsJabbers
										13	etherStatsCollisions
										14	etherStatsPkts64Octets
										15	etherStatsPkts65to127Octets
										16	etherStatsPkts128to255Octets
										17	etherStatsPkts256to511Octets
										18	etherStatsPkts512to1023Octets
										19	etherStatsPkts1024to1518Octets
										20	etherStatsOwner
										21	etherStatsStatus

Various SNMP client software tools can be used. GE recommends using an SNMP MIB browser, which can perform the basic SNMP operations such as GET, GETNEXT and RESPONSE.

Note:

When communicating with the Redundant Ethernet Card, there are two IP addresses visible: one for the IED and one for the Ethernet switch on the redundant Ethernet board. To access the network using SNMP, use the IP address of the redundant Ethernet board switch and not that of the IED. See the Configuration chapter for further information.

4.5 SIMPLE NETWORK TIME PROTOCOL (SNTP)

Simple Network Time Protocol (SNTP) is used to synchronize the clocks of computer systems over packet-switched, variable-latency data networks, such as IP. A jitter buffer is used to reduce the effects of variable latency introduced by queuing, ensuring a continuous data stream over the network.

SNTP is supported by both the IED and the switch in the redundant Ethernet board. Both the IED and the redundant Ethernet board have their own IP address. Using the IP address of each device it can be synchronised to the SNTP server.

For the IED this is done by entering the IP address of the SNTP server into the IED using the IEC 61850 Configurator software.

For the redundant Ethernet board, this is done depending on the redundant Ethernet protocol being used. For PRP or HSR, use the PRP/HSR Configurator. For RSTP use the RSTP Configurator. For SHP and DHP use Switch Manager.

CHAPTER 6

COMMISSIONING INSTRUCTIONS

1 CHAPTER OVERVIEW

This chapter contains the following sections:

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Visual Inspection	78
Test Ethernet Communication	79
SHP Ring Connection	80
PRP Star Connection	81
PRP Star Connection	82
DHP Star Connection	83
RSTP Ring Connection	84
RSTP Star Connection	85
Large RSTP Networks Combining Star and Ring	86

2 VISUAL INSPECTION



Warning:
Check the rating information under the top access cover on the front of the IED.

Warning:
Check that the IED being tested is correct for the line or circuit.

Warning:
Record the circuit reference and system details.

Warning:
Check the CT secondary current rating and record the CT tap which is in use.

Carefully examine the IED to see that no physical damage has occurred since installation.

Ensure that the case earthing connections (bottom left-hand corner at the rear of the IED case) are used to connect the IED to a local earth bar using an adequate conductor.

3 TEST ETHERNET COMMUNICATION

For products that employ Ethernet communications, we recommend that testing be limited to a visual check that the correct ports are fitted and that there is no sign of physical damage.

If there is no board fitted or the board is faulty, a NIC link alarm will be raised (providing this option has been set in the **NIC Link Report** cell in the *COMMUNICATIONS* column).

4 SHP RING CONNECTION

Connect Es to Rs and Ep to Rp on each device until it makes a ring.

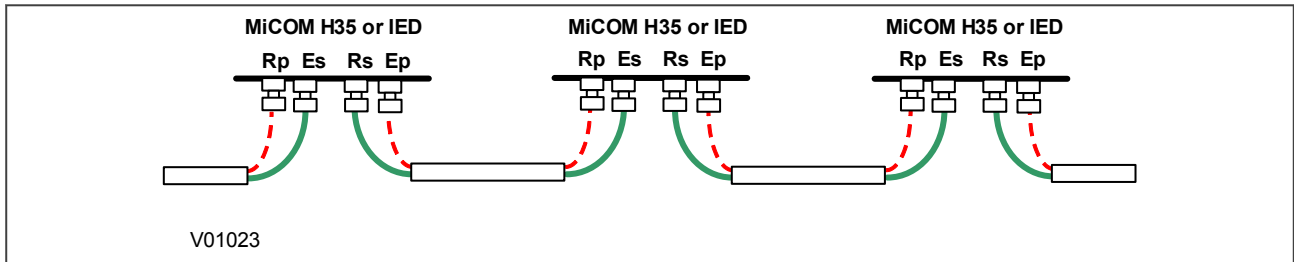


Figure 18: SHP ring connections

5 PRP STAR CONNECTION

Connect TX to RX and RX to TX on each device. When connecting to a C264-SRP20X PRP card or an H368 RedBox, an LC Fibre connector patch filter is needed.

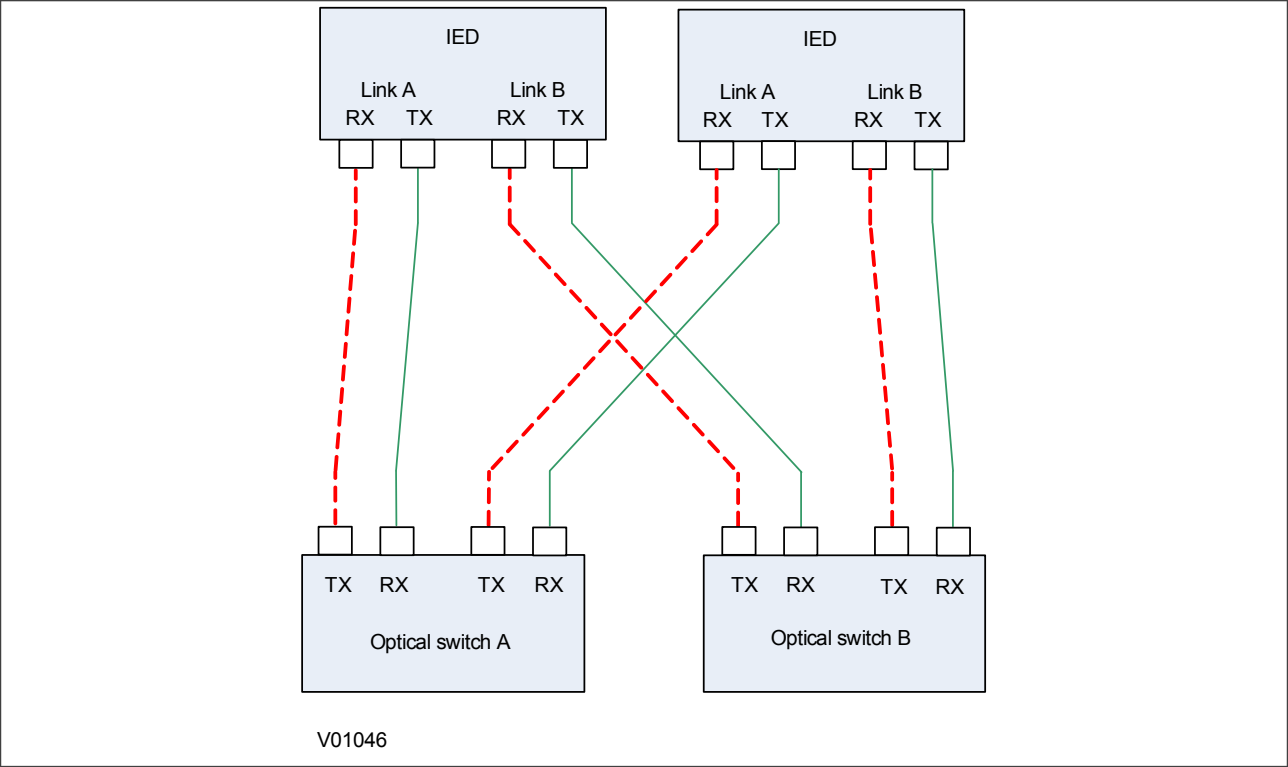


Figure 19: PRP star connections

6 PRP STAR CONNECTION

Connect TX to RX and RX to TX on each device. When connecting to other devices such as a RedBox, LC Fibre connector patch filters may be needed.

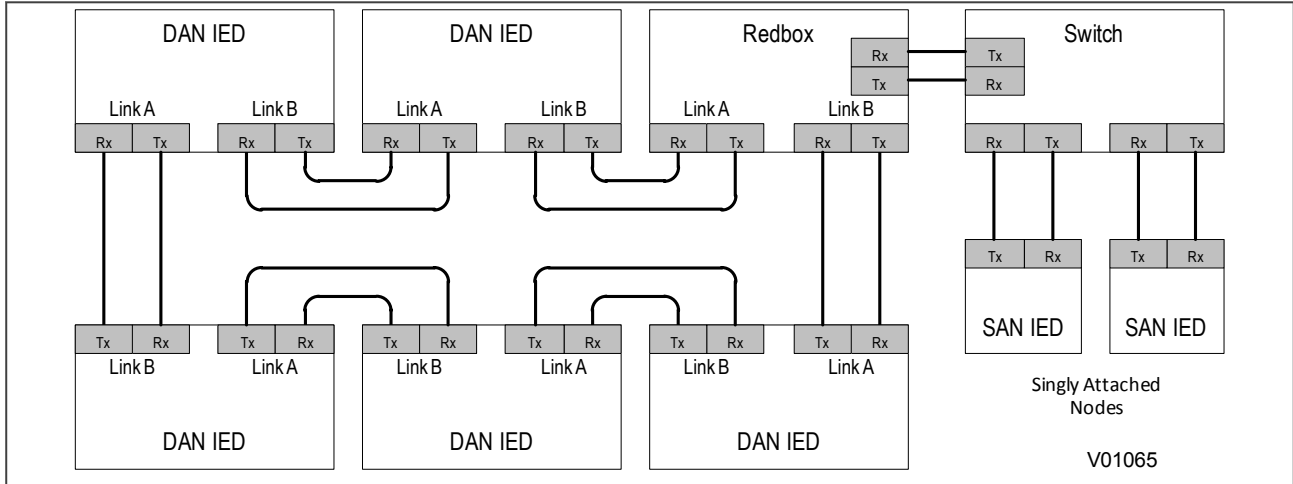


Figure 20: HSR ring connections

7 DHP STAR CONNECTION

Connect TX to RX and RX to TX on each device.

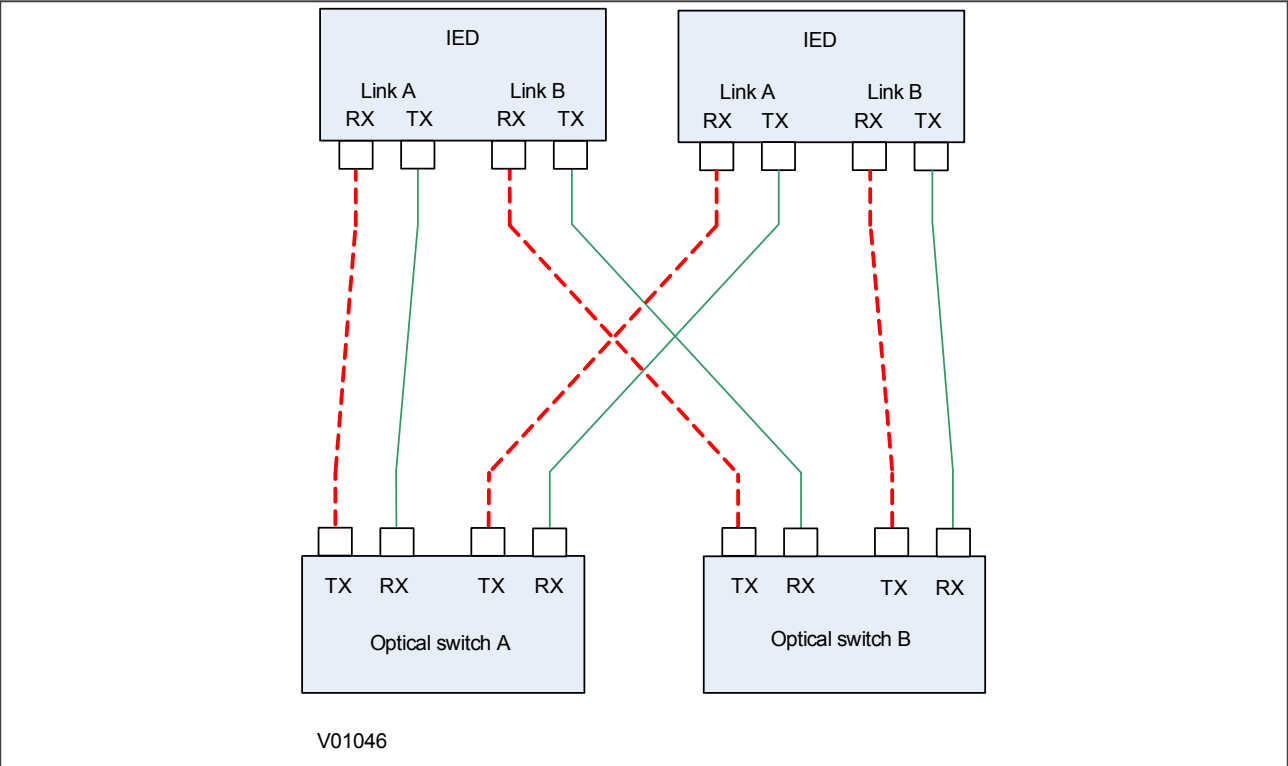


Figure 21: DHP star connections

8 RSTP RING CONNECTION

The following diagram shows the Px4x IEDs (Px4x – IED 1 to IED N) using RSTP redundant Ethernet boards connected in a ring topology.

This topology can have one or more RSTP-enabled Ethernet switches to interface with another network or control centre. The Ethernet switch is an RSTP-enabled switch with a higher number of ports.

The Ethernet switch, which is connected to the controlling PC, should be configured as the root bridge. The bridge priority of the Ethernet switch should be configured to the minimum value in the network.

The maximum number of IEDs that can be connected in the ring network depends on the Max Age parameter configured in the root bridge.

The Max Age parameter can be varied from 6 to 40 seconds.

If Max Age = 6 seconds, the minimum number of IEDs in the ring is $6 - 1 = 5$.

If Max Age = 40 seconds, the maximum number of IEDs in the ring is $40 - 1 = 39$.

Therefore the number of IEDs that can be connected in the ring can vary from 5 to 39.

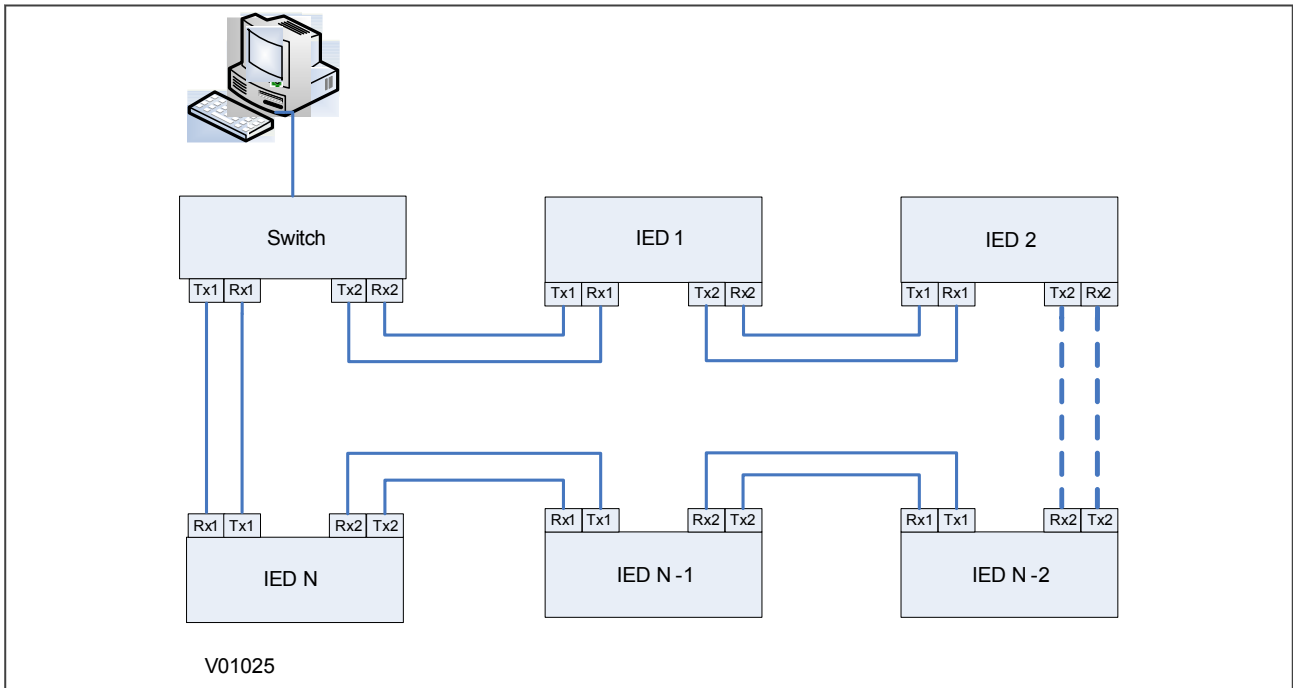


Figure 22: RSTP ring connections

9 RSTP STAR CONNECTION

The following diagram shows the Px4x IEDs (Px4x – IED 1 to IED N) using RSTP redundant Ethernet boards connected in a star topology.

This topology can have one or more RSTP-enabled Ethernet switches to interface with other networks, control centers, or Px4x IEDs. The Ethernet switch is an RSTP-enabled switch with a greater number of ports.

The Ethernet switch, which is connected to the controlling PC, should be configured as the root bridge. The bridge priority of the Ethernet switch should be configured to the minimum value in the network.

The Px4x IEDs are placed at two hop distance from the root bridge, therefore the Max Age parameter has no impact on star topology.

The maximum number of IEDs that can be connected in the star network depends on the number of ports available in the Ethernet switch, provided that the hop count from the root bridge is less than the Max Age parameter.

Therefore the number of IEDs that can be connected in the ring can vary from 5 to 39.

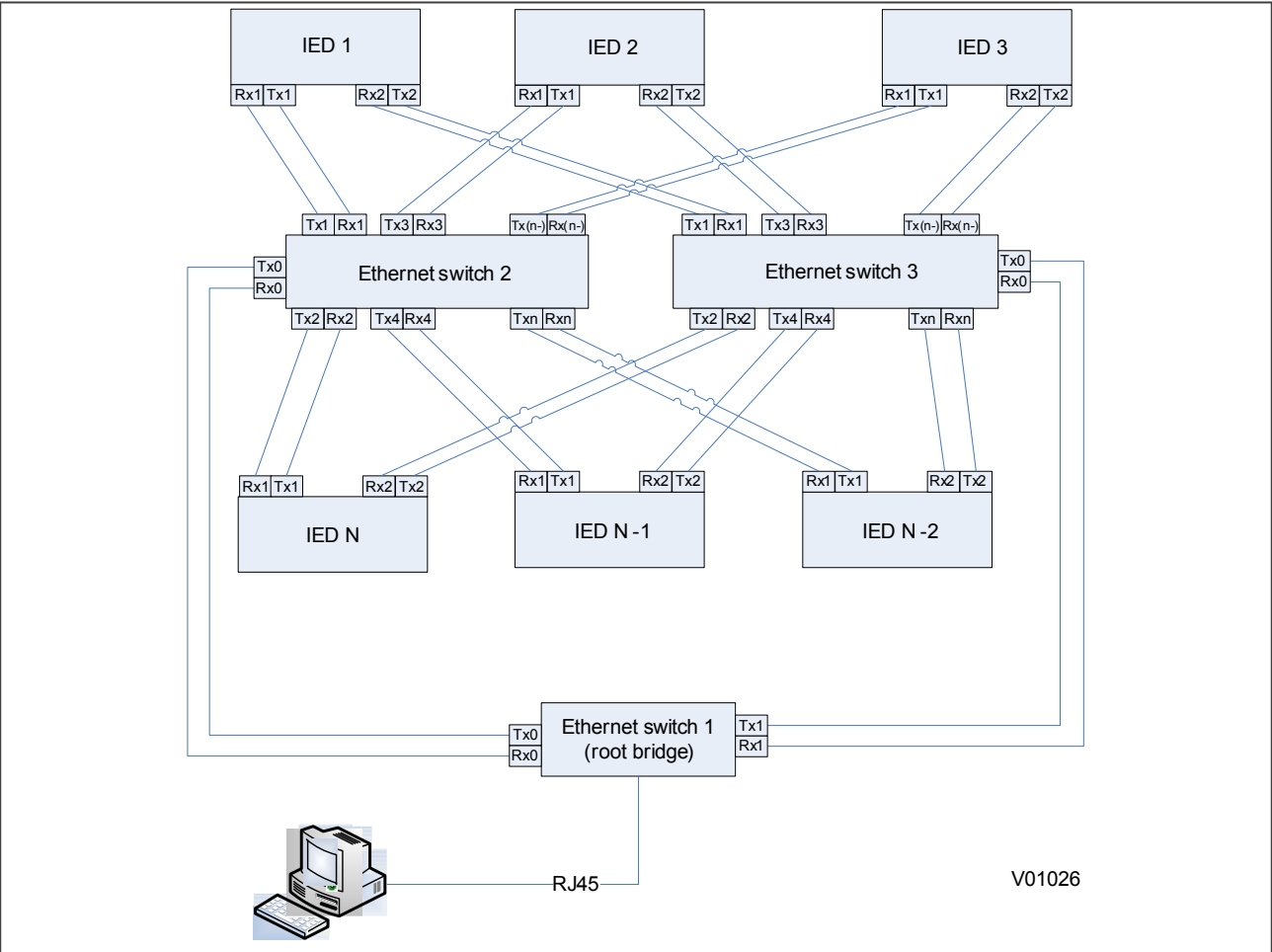


Figure 23: RSTP star connections

10 LARGE RSTP NETWORKS COMBINING STAR AND RING

The following diagram shows a star of four rings. Each ring is connected to the root bridge. The root bridge is a high-end RSTP-enabled bridge with the maximum number of ports as required. The devices A1, A2...Anmax, B1, B2...Bnmax, C1, C2...Cnmax, D1, D2...Dnmax, represent the RSTP redundant Ethernet boards.

The maximum number of boards that can be connected in single ring in an RSTP-enabled network depends on the Max Age parameter. The hop count from the root bridge can not be greater than the Max Age parameter.

The maximum number of RSTP bridges in a ring is given by

$$N_{max} = (Max\ Age - 1)$$

Where:

N_{max} = maximum number of devices in a ring

Max Age = Max Age value configured in the root bridge.

In the following diagram, if the default value of Max Age is 20 seconds, the maximum number of devices that can be connected in ring A is 19.

If Max Age is configured as 40 seconds, the maximum number of IEDs that can be connected in the network is $(40-1) = 39$. According to the IEEE 802.1D 2004 standard, the maximum value for the Max Age parameter is limited to 40. To use the maximum number of IEDs in the ring, the following configuration should be used.

Max Age = 40 seconds

Forward Delay = 30 seconds

Hello Time = 2 seconds

Bridge Priority = As required by the end user.

The IEEE 802.1D 2004 standard defines the relation between Max Age and Forward Delay as:

$$2 * (Forward\ Delay - 1.0\ seconds) \geq Max\ Age$$

To have the maximum number of nodes in the RSTP network, the number of rings can be increased, depending on the number of ports available in the root bridge.

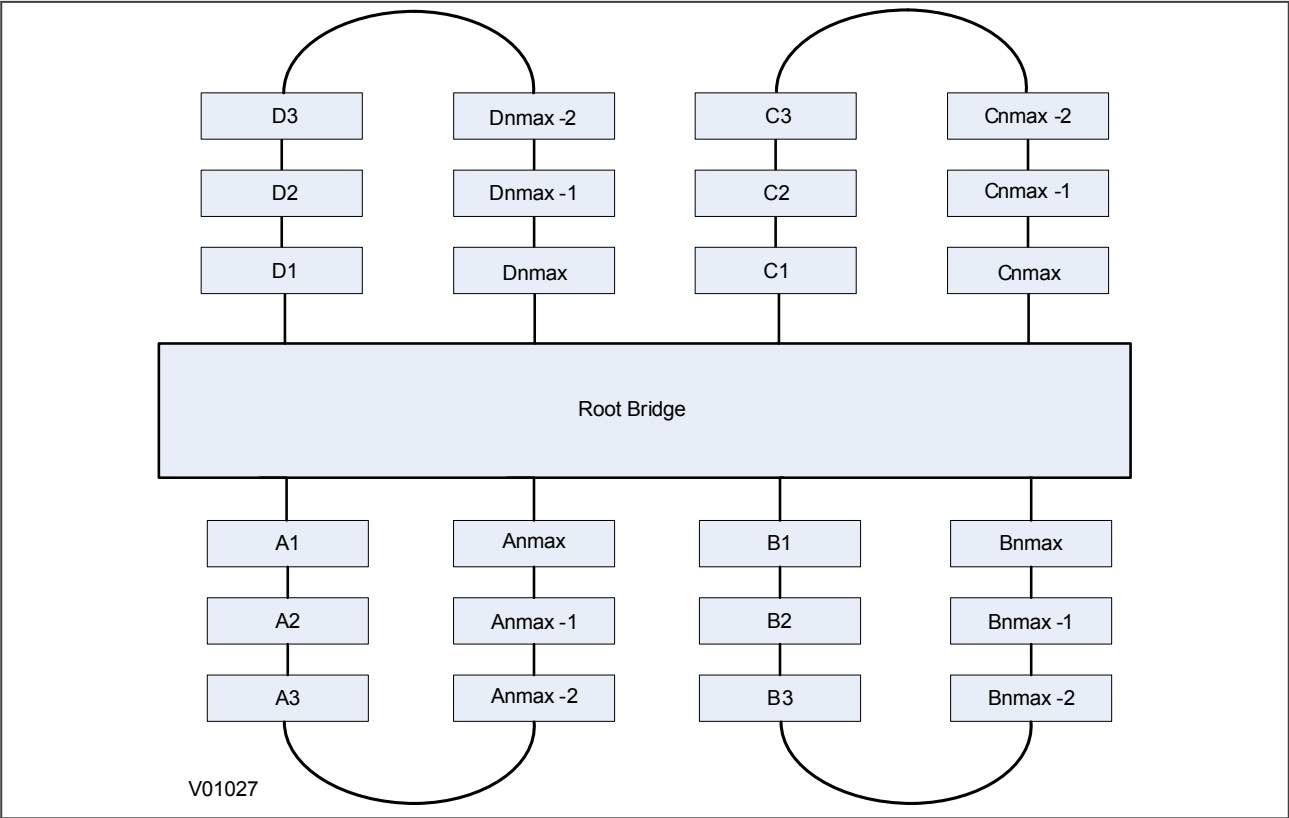


Figure 24: Combined RSTP star and ring topology

CHAPTER 7

TECHNICAL SPECIFICATIONS

1 CHAPTER OVERVIEW

This chapter describes the technical specifications of the product.

This chapter contains the following sections:

Chapter Overview	91
Interfaces	92
Mechanical Specifications	94
Standards Compliance	95
Environmental Conditions	96
Type Tests	97
Electromagnetic Compatibility	98

2 INTERFACES

2.1 IRIG-B (MODULATED)

IRIG-B Interface (Modulated)	
Use	External clock synchronisation signal
Standard	IRIG 200-98 format B12X
Connector	BNC
Cable type	50 ohm coaxial
Isolation	Isolation to SELV level
Input signal	peak to peak, 200 mV to 20 mV
Input impedance	6 k ohm at 1000 Hz
Accuracy	+/- 1 ms

2.2 IRIG-B (DEMULATED)

IRIG-B Interface (Demodulated)	
Use	External clock synchronisation signal
Standard	IRIG 200-98 format B00X
Connector	BNC
Cable type	50 ohm coaxial
Isolation	Isolation to SELV level
Input signal	TTL level
Input impedance	10 k ohm at dc
Accuracy	+/- 1 ms

2.3 100 BASE FX TRANSMITTER CHARACTERISTICS

Parameter	Sym	Min.	Typ.	Max.	Unit
Output Optical Power BOL 62.5/125 μm NA = 0.275 Fibre EOL	PO	-19 -20	-16.8	-14	dBm avg.
Output Optical Power BOL 50/125 μm NA = 0.20 Fibre EOL	PO	-22.5 -23.5	-20.3	-14	dBm avg.
Optical Extinction Ratio				10 -10	% dB
Output Optical Power at Logic "0" State	PO			-45	dBm avg.

Conditions: TA = 0°C to 70°C

2.4 100 BASE FX RECEIVER CHARACTERISTICS

Parameter	Sym	Min.	Typ.	Max.	Unit
Input Optical Power Minimum at Window Edge	PIN Min. (W)		-33.5	-31	dBm avg.
Input Optical Power Minimum at Eye Center	PIN Min. (C)		-34.5	-31.8	Bm avg.

Parameter	Sym	Min.	Typ.	Max.	Unit
Input Optical Power Maximum	PIN Max.	-14	-11.8		dBm avg.

Conditions: TA = 0°C to 70°C

2.5 FIBRE DEFECT CONNECTOR (WATCHDOG RELAY)

Connector (3 Terminals)	2 NC Contacts Potential Free
Rated voltage	250 VAC
Rated continuous current	5 A
Make current	Max. 30 A and carry for 3s
Breaking capacity AC	1500 VA resistive (cos F = unity) 1500 VA inductive (cos F = 0.5)
Breaking capacity DC	50 W, 250 VDC resistive 25 W inductive (L/R=40 ms)

3 MECHANICAL SPECIFICATIONS

3.1 MECHANICAL ROBUSTNESS

Vibration test per EN 60255-21-1:1998	Response: class 2, Endurance: class 2
Shock and bump immunity per EN 60255-21-2:1988	Shock response: class 2, Shock withstand: class 1, Bump withstand: class 1
Seismic test per EN 60255-21-3: 1993	Class 2

4 STANDARDS COMPLIANCE

Compliance with the European Commission Directive on EMC and LVD is demonstrated by self certification against international standards.



4.1 EMC COMPLIANCE: 2004/108/EC

Compliance with EN60255-26:2009 was used to establish conformity.

4.2 PRODUCT SAFETY: 2006/95/EC

Compliance with EN60255-27:2005 was used to establish conformity.

Protective Class

IEC 60255-27: 2005 Class 1 (unless otherwise specified in equipment documentation). This equipment requires a protective conductor (earth) to ensure user safety.

Installation category

IEC 60255-27: 2005 Overvoltage Category 3. Equipment in this category is qualification tested at 5kV peak, 1.2/50 μ S, 500 Ohms, 0.5 J, between all supply circuits and earth and also between independent circuits.

Environment

IEC 60255-27: 2005, IEC 60255-26:2009. The equipment is intended for indoor use only. If it is required for use in an outdoor environment, it must be mounted in a cabinet with the appropriate degree of ingress protection.

4.3 R&TTE COMPLIANCE

Radio and Telecommunications Terminal Equipment (R&TTE) directive 99/5/EC.

Conformity is demonstrated by compliance to both the EMC directive and the Low Voltage directive, to zero volts.

4.4 UL/CUL COMPLIANCE

If marked with this logo, the product is compliant with the requirements of the Canadian and USA Underwriters Laboratories.

The relevant UL file number and ID is shown on the equipment.



5 ENVIRONMENTAL CONDITIONS

5.1 AMBIENT TEMPERATURE RANGE

Compliance	IEC 60255-27: 2013
Test Method	IEC 60068-2-1:2007 and IEC 60068-2-2 2007
Operating temperature range	-25°C to +55°C (continuous)
Storage and transit temperature range	-25°C to +70°C (continuous)

5.2 AMBIENT HUMIDITY RANGE

Compliance	IEC 60068-2-78: 2013 and IEC 60068-2-30: 2005
Durability	56 days at 93% relative humidity and +40°C
Damp heat cyclic	six (12 + 12) hour cycles, 93% RH, +25 to +55°C

5.3 CORROSIVE ENVIRONMENTS

Compliance	IEC 60068-2-42: 2003, IEC 60068-2-43: 2003
Industrial corrosive environment/poor environmental control, Sulphur Dioxide	21 days exposure to elevated concentrations (25ppm) of SO ₂ at 75% relative humidity and +25°C
Industrial corrosive environment/poor environmental control, Hydrogen Sulphide	21 days exposure to elevated concentrations (10ppm) of H ₂ S at 75% relative humidity and +25°C
Salt mist	IEC 60068-2-52: 1996 KB severity 3

6 TYPE TESTS

6.1 INSULATION

Compliance	IEC 60255-27: 2013
Insulation resistance	> 100 M ohm at 500 V DC (Using only electronic/brushless insulation tester)

6.2 CREEPAGE DISTANCES AND CLEARANCES

Compliance	IEC 60255-27: 2013
Pollution degree	3
Overvoltage category	III
Impulse test voltage (not RJ45)	5 kV
Impulse test voltage (RJ45)	1 kV

6.3 HIGH VOLTAGE (DIELECTRIC) WITHSTAND

IEC Compliance	IEC 60255-27: 2013
Between all independent circuits	2 kV ac rms for 1 minute
Between independent circuits and protective earth conductor terminal	2 kV ac rms for 1 minute
Between all case terminals and the case earth	2 kV ac rms for 1 minute
Across open watchdog contacts	1 kV ac rms for 1 minute
Across open contacts of changeover output relays	1 kV ac rms for 1 minute
Between all RJ45 contacts and protective earth	1 kV ac rms for 1 minute
Between all screw-type EIA(RS)485 contacts and protective earth	1 kV ac rms for 1 minute
ANSI/IEEE Compliance	ANSI/IEEE C37.90-2005
Across open contacts of normally open output relays	1.5 kV ac rms for 1 minute
Across open contacts of normally open changeover output relays	1 kV ac rms for 1 minute
Across open watchdog contacts	1 kV ac rms for 1 minute

6.4 IMPULSE VOLTAGE WITHSTAND TEST

Compliance	IEC 60255-27: 2013
Between all independent circuits	Front time: 1.2 μ s, Time to half-value: 50 μ s, Peak value: 5 kV, 0.5 J
Between terminals of all independent circuits	Front time: 1.2 μ s, Time to half-value: 50 μ s, Peak value: 5 kV, 0.5 J
Between all independent circuits and protective earth conductor terminal	Front time: 1.2 μ s, Time to half-value: 50 μ s, Peak value: 5 kV, 0.5 J

Note:
Exceptions are communications ports and normally-open output contacts, where applicable.

7 ELECTROMAGNETIC COMPATIBILITY

7.1 1 MHZ BURST HIGH FREQUENCY DISTURBANCE TEST

Compliance	IEC 60255-22-1: 2008, Class III, IEC 60255-26:2013
Common-mode test voltage (level 3)	2.5 kV
Differential test voltage (level 3)	1.0 kV

7.2 DAMPED OSCILLATORY TEST

Compliance	EN61000-4-18: 2011: Level 3, 100 kHz and 1 MHz. Level 4: 3 MHz, 10 MHz and 30 MHz, IEC 60255-26:2013
Common-mode test voltage (level 3)	2.5 kV
Common-mode test voltage (level 4)	4.0 kV
Differential mode test voltage	1.0 kV

7.3 IMMUNITY TO ELECTROSTATIC DISCHARGE

Compliance	IEC 60255-26:2013, IEC 61000-4-2:2009
Class 4 Condition	15 kV discharge in air to user interface, display, and exposed metalwork
Class 3 Condition	8 kV discharge in air to all communication ports

7.4 ELECTRICAL FAST TRANSIENT OR BURST REQUIREMENTS

Compliance	IEC 60255-26:2013, IEC 61000-4-4:2012
Applied to communication inputs	Amplitude: 2 kV, burst frequency 5 kHz and 100 KHz (level 4)
Applied to power supply and all other inputs except for communication inputs	Amplitude: 4 kV, burst frequency 5 kHz and 100 KHz (level 4)

7.5 SURGE WITHSTAND CAPABILITY

Compliance	IEEE/ANSI C37.90.1: 2002
Condition 1	4 kV fast transient and 2.5 kV oscillatory applied common mode and differential mode to opto inputs, output relays, CTs, VTs, power supply
Condition 2	4 kV fast transient and 2.5 kV oscillatory applied common mode to communications, IRIG-B

7.6 SURGE IMMUNITY TEST

Compliance	IEC 60255-26:2013, IEC 61000-4-5:2014+AMD1:2017
Pulse duration	Time to half-value: 1.2/50 μ s
Between all groups and protective earth conductor terminal	Amplitude 4 kV
Between terminals of each group (excluding communications ports, where applicable)	Amplitude 2 kV

7.7 IMMUNITY TO RADIATED ELECTROMAGNETIC ENERGY

Compliance	IEC 60255-26:2013, IEC 61000-4-3:2006 + A2:2010
Frequency band	80 MHz to 3.0 GHz
Spot tests at	80, 160, 380, 450, 900, 1850, 2150 MHz
Test field strength	10 V/m
Test using AM	1 kHz @ 80%
Compliance	IEEE/ANSI C37.90.2: 2004
Frequency band	80 MHz to 1 GHz
Spot tests at	80, 160, 380, 450 MHz
Waveform	1 kHz @ 80% am and pulse modulated
Field strength	35 V/m

7.8 RADIATED IMMUNITY FROM DIGITAL COMMUNICATIONS

Compliance	IEC 61000-4-3:2006 + A2:2010
Frequency bands	800 to 960 MHz, 1.4 to 2.0 GHz
Test field strength	30 V/m
Test using AM	1 kHz / 80%

7.9 RADIATED IMMUNITY FROM DIGITAL RADIO TELEPHONES

Compliance	IEC 60255-26:2013, IEC 61000-4-3:2006 + A2:2010
Frequency bands	900 MHz and 1.89 GHz
Test field strength	10 V/m

7.10 IMMUNITY TO CONDUCTED DISTURBANCES INDUCED BY RADIO FREQUENCY FIELDS

Compliance	IEC 60255-26:2013, IEC 61000-4-6:2013 Level 3
Frequency bands	150 kHz to 80 MHz

Test disturbance voltage	10 V rms
Test using AM	1 kHz @ 80%
Spot tests	27 MHz and 68 MHz

7.11 MAGNETIC FIELD IMMUNITY

Compliance	IEC 61000-4-8:2009 Level 5 IEC 61000-4-9:2016 Level 5 IEC 61000-4-10:2016 Level 5
IEC 61000-4-8 test	100 A/m applied continuously, 1000 A/m applied for 3 s
IEC 61000-4-9 test	1000 A/m applied in all planes
IEC 61000-4-10 test	100 A/m applied in all planes at 100 kHz/1 MHz with a burst duration of 2 seconds

7.12 CONDUCTED EMISSIONS

Compliance	IEC 60255-26:2013, EN 55016-2-1:2014
Power supply test 1	0.15 - 0.5 MHz, 79 dB μ V (quasi peak) 66 dB μ V (average)
Power supply test 2	0.5 - 30 MHz, 73 dB μ V (quasi peak) 60 dB μ V (average)
RJ45 test 1 (where applicable)	0.15 - 0.5 MHz, 97 dB μ V (quasi peak) 84 dB μ V (average)
RJ45 test 2 (where applicable)	0.5 - 30 MHz, 87 dB μ V (quasi peak) 74 dB μ V (average)

7.13 RADIATED EMISSIONS

Compliance	IEC 60255-26:2013
Test 1	30 - 230 MHz, 40 dB μ V/m at 10 m measurement distance
Test 2	230 - 1 GHz, 47 dB μ V/m at 10 m measurement distance
Test 3	1 - 2 GHz, 76 dB μ V/m at 10 m measurement distance

7.14 POWER FREQUENCY

Compliance	IEC 60255-26:2013, IEC 61000-4-16:2015
Opto-inputs (Compliance is achieved using the opto-input filter)	300 V common-mode (Class A) 150 V differential mode (Class A)

Note:
Compliance is achieved using the opto-input filter.



Imagination at work

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