SIEMENS

Reyrolle 7SR5
Communication Protocol 7SR5

V2.40

Manual

Preface

Table of Contents

1 Communication Interfaces

2 IEC 61850

3 DNP3 TCP

4 DNP3

5 Modbus TCP

6 Modbus RTU

7 IEC 60870-5-103

8 Additional Features

9 Commissioning and Diagnostics

10 Troubleshooting

C53000-L7040-C013-1

NOTE

For your own safety, observe the warnings and safety instructions contained in this document, if available.

Document version: C53000-L7040-C013-1.01

Edition: 04.2023

Version of the product described: V2.40

Preface

Purpose of the Manual

This manual contains information about:

- Communication within the Reyrolle 7SR5 device family and to higher-level control centers
- Setting parameters in Reydisp Manager 2
- Information on commissioning

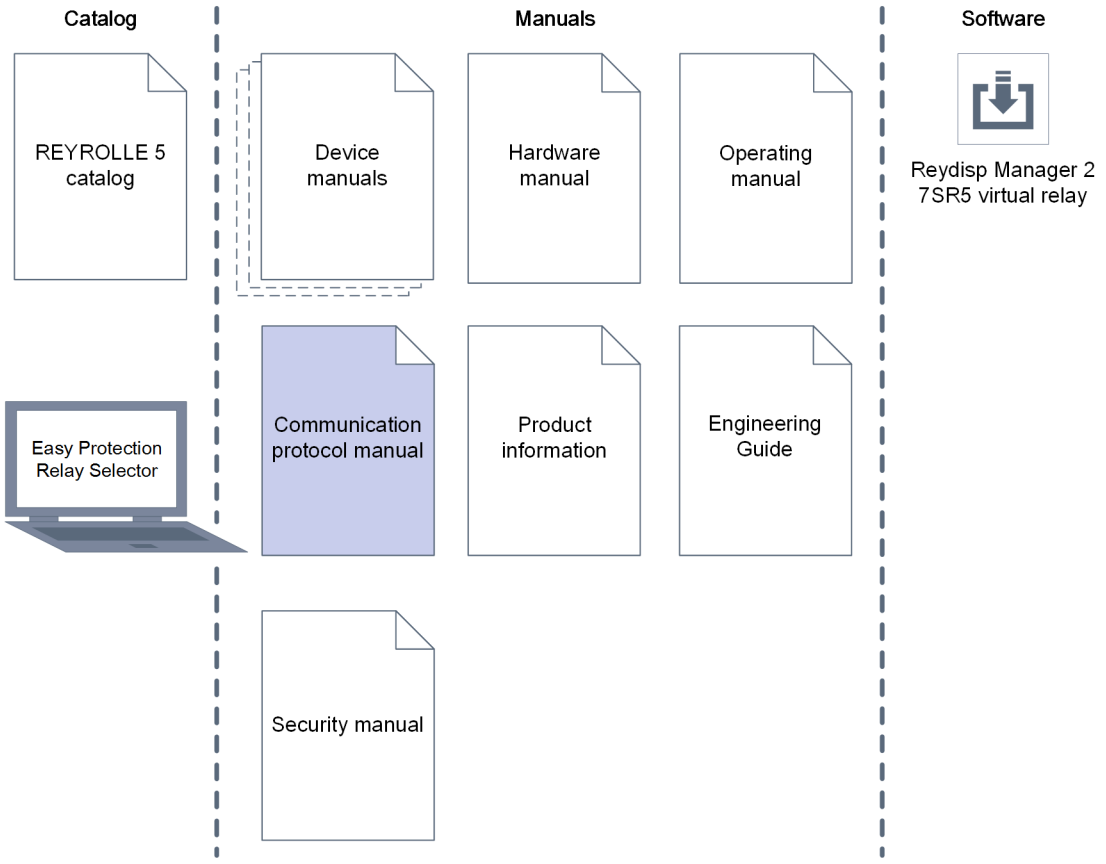
Target Audience

This manual is mainly intended for protection system engineers, commissioning engineers, persons entrusted with the setting, testing and maintenance of automation, selective protection and control equipment, and operational crew in electrical installations and power plants.

Scope

This manual applies to the Reyrolle 7SR5 device family.

Further Documentation



- Device manuals
  Each device manual describes the functions and applications of a specific Reyrolle 7SR5 device. The printed manual for the device has the same informational structure.
- Hardware manual
  The hardware manual describes the hardware building blocks and device combinations of the Reyrolle 7SR5 device family.
- Operating manual
  The operating manual describes the basic principles and procedures for operating and installing the devices of the Reyrolle 7SR5 device family.
- Communication protocol manual
  The communication protocol manual contains a description of the protocols for communication within the Reyrolle 7SR5 device family and to higher-level network control centers.
- Security manual
  The security manual describes the security features of the Reyrolle 7SR5 devices and Reydisp Manager 2.
- Product information
  The product information includes general information about device installation, technical data, limiting values for input and output modules, and conditions when preparing for operation. This document is provided with each Reyrolle 7SR5 device.
- Engineering Guide
  The engineering guide describes the essential steps when engineering with Reydisp Manager 2. In addition, the engineering guide shows you how to load a planned configuration to a Reyrolle 7SR5 device and update the functionality of the Reyrolle 7SR5 device.

- Virtual Relay
  The virtual relay allows a user to view, control and manipulate a virtual Reyrolle 7SR5 device. The virtual relay is a tool that can facilitate training and understanding of the controls and functions on a Reyrolle 7SR5 device.
- Reyrolle 7SR5 catalog
  The Reyrolle 7SR5 catalog describes the Reyrolle 7SR5 Reyrolle devices and the system features.
- Easy Protection Relay Selector for Reyrolle and SIPROTEC
  This tool gives a quick guidance to find a protection relay of SIPROTEC 5, SIPROTEC 4, SIPROTEC Compact, Reyrolle which would fit your needs.

Additional Support

For questions about the system, contact your Siemens sales partner.

Customer Support Center

Our Customer Support Center provides a 24-hour service.

Siemens AG
Smart Infrastructure – Protection Automation
Customer Support Center

Tel.: +49 911 2155 4466
E-Mail: *energy.automation@siemens.com*

Training Courses

Inquiries regarding individual training courses should be addressed to our Training Center:

Siemens AG
Siemens Power Academy TD
Humboldtstraße 59
90459 Nuremberg
Germany

Phone: +49 911 9582 7100
E-mail: *poweracademy@siemens.com*
Internet: *www.siemens.com/poweracademy*

Notes on Safety

This document is not a complete index of all safety measures required for operation of the equipment (module or device). However, it comprises important information that must be followed for personal safety, as well as to avoid material damage. Information is highlighted and illustrated as follows according to the degree of danger:

DANGER

DANGER means that death or severe injury **will** result if the measures specified are not taken.

✧ Comply with all instructions, in order to avoid death or severe injuries.

WARNING

WARNING means that death or severe injury **may** result if the measures specified are not taken.

✧ Comply with all instructions, in order to avoid death or severe injuries.

CAUTION

CAUTION means that medium-severe or slight injuries **can** occur if the specified measures are not taken.

✧ Comply with all instructions, in order to avoid moderate or minor injuries.

NOTICE

NOTICE means that property damage **can** result if the measures specified are not taken.

✧ Comply with all instructions, in order to avoid property damage.

NOTE

Important information about the product, product handling or a certain section of the documentation which must be given attention.

OpenSSL

This product includes software developed by the OpenSSL Project for use in OpenSSL Toolkit (*http://www.openssl.org/*).

This product includes software written by Tim Hudson (*tjh@cryptsoft.com*).

This product includes cryptographic software written by Eric Young (*eay@cryptsoft.com*).

Table of Contents

Preface **3**

1 Communication Interfaces **11**

1.1 Overview 12
1.2 USB Communication Interface 14
1.3 RS485 Connection (Com1) 15
1.4 Ethernet 18

2 IEC 61850 ..... **27**

2.1 Introduction 28
2.1.1 Use in 7SR5 Devices 28
2.2 Protocol Characteristics in Reydisp Manager 2 29
2.2.1 Selecting the IEC 61850 Edition 29
2.3 IEC 61850 Structure 32
2.3.1 Overview of the IEC 61850 Structure 32
2.4 Exporting 33
2.4.1 Export Formats in Reydisp Manager 2 33
2.4.2 Exporting IEC 61850 Description Files 33
2.5 IEC 61850 System Configurator 35
2.5.1 Integration with the Siemens IEC 61850 System Configurator 35
2.5.2 Network Settings 36
2.5.3 IEC 61850 System Configurator 37
2.5.4 Importing an SCD into Reydisp Manager 2 Project Device 37
2.5.5 Importing an SCD into a Station in System Configurator 37
2.6 Protocol Properties and Implementation 38
2.6.1 IEC 61850 Structure of a 7SR5 Device 38
2.6.2 IEC 61850 Services 39
2.6.3 Reporting 40
2.6.3.1 What is a Report? 40
2.6.3.2 Datasets 41
2.6.3.3 Static Reporting 42
2.6.3.4 Testing Protection Indications 44
2.6.4 File Transfer 45
2.6.5 Control via IEC 61850 46
2.6.6 Measured Values and Measured-Value Description 48
2.6.7 Device Time 50
2.6.7.1 Description 50
2.6.7.2 Determining the ClockNotSynchronized Value 52
2.6.7.3 Determining the ClockFailure Value 53
2.6.8 Asset Management 53

3 DNP3 TCP 55

3.1 Protocol Characteristics 56
3.1.1 Protocol Structure 56
3.1.2 Transfer through Ethernet 61
3.1.3 Functional Scope 62
3.1.4 Fault Record Transfer 67
3.1.5 Buffered Events 68
3.1.6 Amount of Mappable Information 68
3.1.7 Additional Information 68
3.2 Settings and Properties 71
3.2.1 Settings for Communication through Ethernet 71

4 DNP3 79

4.1 Protocol Characteristics 80
4.1.1 Functional Scope 80
4.1.2 Miscellaneous 101
4.2 Settings and Properties 102
4.2.1 Setting for the Serial connection 102
4.2.2 Device Mapping and configuration 103

5 Modbus TCP 125

5.1 Protocol Characteristics 126
5.1.1 Modbus TCP use in 7SR5 Devices 126
5.1.2 Protocol Structure 126
5.1.3 Exception Response of Modbus Slave 126
5.1.4 Supported Modbus Addresses 126
5.1.5 Supported Modbus Functions 127
5.1.6 Data Type Definition 127
5.1.7 Multi-Connection to Master via Modbus 130
5.1.8 Operating Modes 130
5.1.9 Parallel Running with IEC 61850 130
5.2 Settings and Properties 132
5.2.1 Device Mapping and Configuration 134

6 Modbus RTU 137

6.1 Protocol Characteristics 138
6.1.1 Device Mapping and configuration 147
6.2 Settings and Properties 152

7 IEC 60870-5-103 155

7.1 Protocol Characteristics 156
7.2 Settings and Properties 163

8 Additional Features 169

8.1 Activation of Services 170
8.2 List of Required Open Ports 171
8.3 Reydisp Manager 2 Protocol 172
8.4 Ethernet Time Zone 173
8.5 SNTP 174

8.6 IEEE 1588 ... 177
8.7 RSTP ... 179
8.8 PRP ... 183
8.9 HSR ... 184
8.10 SNMP ... 185
8.11 EN100 Homepage ... 195
8.12 Secure MMS ... 206
8.13 Syslog ... 207
8.14 Modbus Client ... 208

9 Commissioning and Diagnostics ... 211
9.1 Prerequisite ... 212
9.2 Settings of the Internal Switches ... 214
9.3 Diagnostic Information for DNP3 or Modbus ... 215
9.4 Diagnostic Information for Time Synchronization ... 220
9.5 Further Checks ... 221

10 Troubleshooting ... 223
10.1 RS485 Serial Communication ... 224
10.2 7SR5 to Reydisp Manager 2 from USB port ... 225
10.3 Ethernet Communication ... 226

1 Communication Interfaces

1.1	Overview	12
1.2	USB Communication Interface	14
1.3	RS485 Connection (Com1)	15
1.4	Ethernet	18

1.1 Overview

The relay data communication facility is compatible with control and automation systems and PCs running Reydisp Manager 2 suite of software. The relay can provide the following:

- Operational information
- Post-fault analysis
- Parameter interrogation
- Device configuration

This section describes how to use the communication interface with a control system or interrogating a computer. An appropriate software application within the control system or on the interrogating computer is required to access the interface.

The device data communication facility incorporates the protocols selected by you and provides compatibility with control and automation systems.

This section specifies connection details and configuration capabilities for the device over serial and Ethernet connections using the IEC 60870-5-103, DNP3 serial, DNP3 TCP, Modbus RTU, Modbus TCP protocols and IEC 61850.

You can download the configuration software from *www.siemens.com/reyrolle*.

This section specifies connection details and lists the information available through the individual protocols.

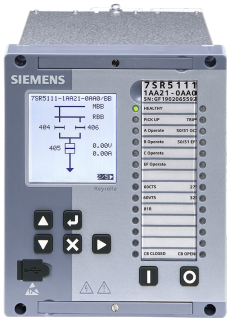


Figure 1-1 7SR5 Size 6 Device (Front)

Figure 1-2 7SR5 Size 12 Device (Front)

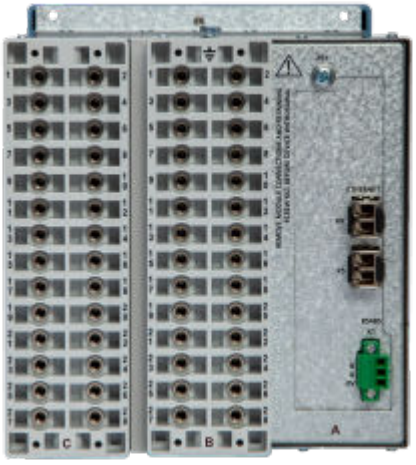


Figure 1-3 7SR5 Size 6 Device (Rear)

Figure 1-4 7SR5 Size 12 Device (Rear)

The device provides 1 front USB communication interface on the fascia and 1 RS485 (Com1) on the rear along with 2 Ethernet ports on the rear. The Ethernet ports can be ordered for connection with Electrical RJ45 or Optical LC access. The access to the communication settings for the USB port is available from the front menu structure via the keypad setting menu **`Communications`** or through the parameter configuration PC software.

Communication interface

- USB

  The Com2-USB port is used for configuring the device with Reydisp Manager 2 software and allows the updating of firmware and downloading of device data files.

  For security reasons the USB port can be configured to be switched **`Off`**.

- Com1-RS485

  The Com1-RS485 port can be used for DNP3 Serial, IEC 60870-5-103 or Modbus RTU communications to a substation SCADA, integrated control system, or engineer remote access.

  The port can be independently mapped to the **DNP3 Serial**, **IEC 60870-5-103**, **Modbus Client**, or **Modbus RTU** protocol or switched **off** in the device configuration.

- • Comx-Ethernet

  The Ethernet ports can be used for IEC 61850, Modbus TCP, and DNP3 TCP communications to a substation SCADA, integrated control system, or engineer remote access using Reydisp Manager 2 configuration software.

  For security reasons the Ethernet ports are configured by defualt to have IP address 0.0.0.0, and are therefore not operational.

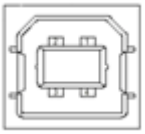
NOTE

Not all device models support Modbus Client. The protocol selection option is only visible when **`49TS Temperature Sensor Supervision`** inputs are included in the device configuration and internal sensors are not available in the hardware.

1.2 USB Communication Interface

The USB communication port is connected to the relay using a standard USB connector type B and to the PC using a standard USB connector type A.

A USB connection type B is provided for local connection to a PC on the device front fascia. A cover provides protection for the connector against pollution and humidity.

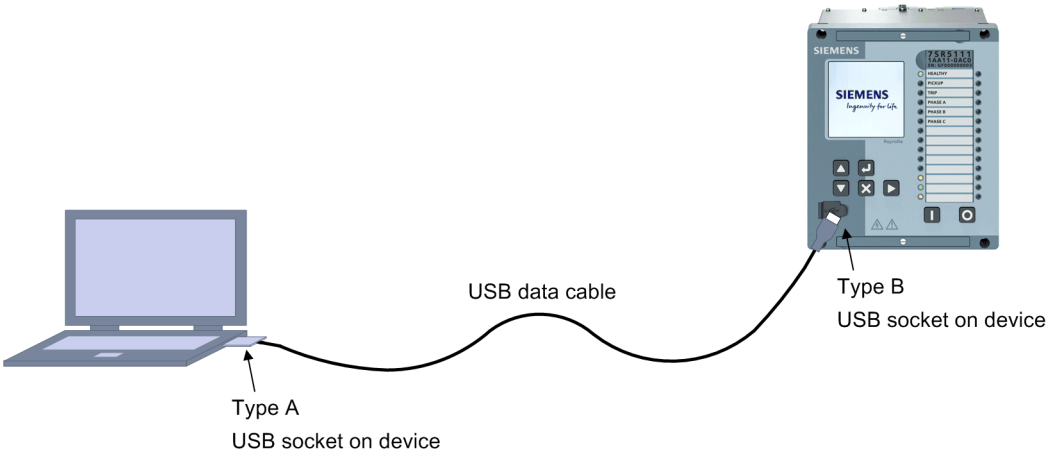
USB	User interface
Connection	USB type B 
Insulation class	PELV (Protective Extra Low Voltage) (According to IEC 60255-27)

When Reydisp Manager 2 software is installed, a suitable USB driver is installed in the PC automatically, by default the IP address of the USB port is 192.168.2.1.

The USB communication interface on the relay and its associated settings are located in the **`Configuration/Communications`** menu. When connecting to Reydisp using this connection, the default settings can be used without changing any settings.

Table 1-1 USB Interface (Com2)

Setting Name	Range/Options	Default	Setting	Notes
USB Mode	Local Remote Local or Remote	Local	–	See Device Operation mode for further information.



[dw_7SR5_communication_to_front_USB_port, 1, en_US]

Figure 1-5 Communication to Front USB Port

1.3 RS485 Connection (Com1)

The 2 wire RS485 communication port is located on the rear of the device and can be connected using a suitable RS485 120 Ω shielded twisted pair cable.

Table 1-2 RS485 Data Communication Interface

Physical layer		Electrical
Connection (RS485)		
Recommended cable		120 Ω screened twisted pair (STP) cable
Recommended external terminating resistor	RTU	120 Ω, 0.5 W
	Last relay	120 Ω, 0.5 W
Connectors		Pin crimp

The RS485 electrical connection to the SCADA can be used in a single or multi-drop configuration.

When the bus is constantly driven by the master or a long line is used (>50 m) then termination may be required – a 120 Ω 1/2 W resistor at each end of the bus connected between the A and B terminals.

When the bus is driven with an ADE converter, the terminating resistor will not normally be required.

NOTE

If any comms errors are encountered in either situation, then apply or remove termination as appropriate.

The polarity of the signal terminals is marked as A and B which is in line with the RS485 standard. When the bus is in the idle state and no communication is taking place, the polarity of terminal B is more positive that of terminal A. These terminals can be used to identify the polarity of any equipment to be connected, typically measured at each terminal in turn to ground. *Figure 1-8* shows the connection of the device to a termination network at the end of the bus and suits the idle state.

The polarity marking is often found to be reversed or marked as ± on other equipment so care is required. If the devices are connected in reverse, then communication to all devices is disturbed without any damage. If problems are experienced during commissioning, perform the connections in reverse.

The maximum number of relays that can be connected to the bus is 64.

When using the RS485 interface, you must configure the following settings in the following settings on the **`Communications`** menu:

Table 1-3 RS485 Interface (Com1)

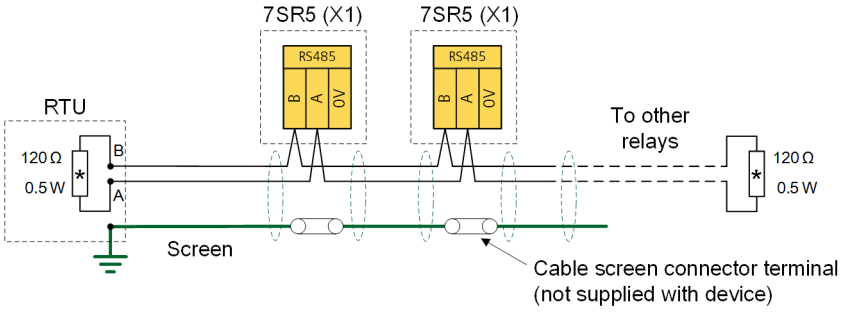
Setting Name	Range/Options	Default	Setting	Notes
COM1-RS485 Protocol	OFF DNP3 Modbus RTU IEC 60870-5-103 Modbus Client	OFF	–	The protocol is used to communicate on the standard RS485 connection. Modbus Client is not available in all device models.
COM1-RS485 Station address	0 to 254 for IEC 60870-5-103 1 to 247 for Modbus RTU 0 to 65534 for DNP3	1	–	To identify the relay, provide an address within the range of the relevant protocol. Each relay in a network must have a unique address.

Setting Name	Range/Options	Default	Setting	Notes
COM1-RS485 Baud rate	75 110 150 300 600 1200 2400 4800 9600 19200 38400 57600 115200 230400	19200	–	The baud rate set on all the relays connected to the control system must be the same as the one set in accordance with the master device.
COM1-RS485 Parity	NONE ODD EVEN	NONE	–	The parity set on all the relays connected to the control system must be the same as the one set in accordance with the master device.
COM1-RS485 Mode	Local Local or Remote Remote	Local or Remote	–	–

NOTE

When setting dependencies are enabled, some parameters may not be visable from the device fascia.

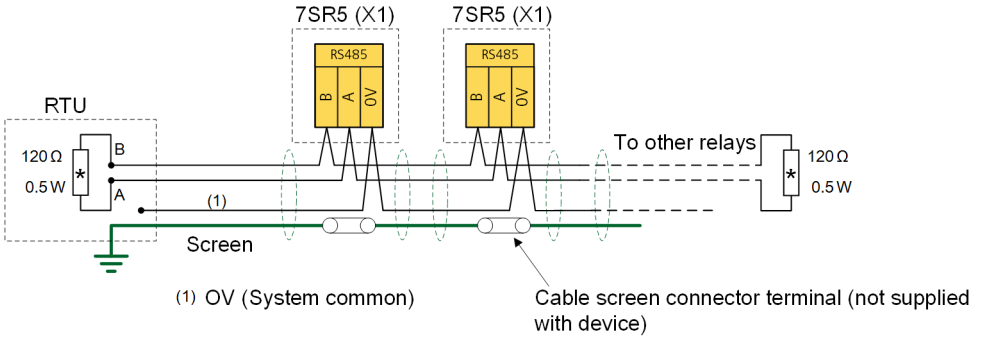
Connection – 2 Wire



[dw_connection2wire, 1, en_US]

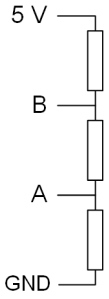
Figure 1-6 Communication to Multiple Devices using RS485 1 pair screened connection

Connection – 1.5 Pair Wire



[dw_connection_1.5wire, 2, en_US]

Figure 1-7 Communication to Multiple Devices using RS485 1.5 pair screened connection



[dw_7SR5_RS485PortComm, 1, en_US]

Figure 1-8 RS485 Biasing Connection Polarity

Display of RS485 Information on the Device

The information about the RS485 connection is displayed on the device HMI in the **`Instruments/Communication Meters`**.

The display shows:

- Com1-RS485
- Tx1 – Transmitted Data
- Rx1 – Received Data
- Rx1 Errors

1.4 Ethernet

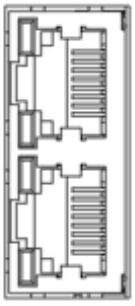
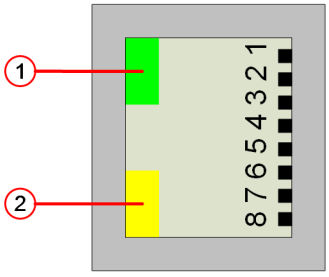
Ethernet Interface

Integrated Ethernet Interface

The device is supplied with 2 integrated Ethernet ports. Ordering options allow the user to select between Electrical RJ45 or Optical LC interfaces.

This terminal is used to load the device with Reydisp Manager 2 device configuration using Ethernet. This terminal also enables IEC 61850, Modbus TCP, and DNP3 TCP Ethernet communication.

Electrical Ethernet Interface (RJ45)

Interface	Integrated ethernet interface
Connection	  (1) LED 1: Green (2) LED 2: Yellow
Connector type	2 x RJ45
Baud rate	100 Mbit/s
Maximum line length	20 m with ethernet patch cable CAT 5/CAT 6
Insulation class	SELV (IEC 60255-27)
Connector interface design	Corresponds to IEEE 802.3, 100Base-TX
Recommended cable	Minimum: Category 5 S/FTP (shielded/screened twisted pair)
Test voltage (with regard to socket)	AC 500 V 50 Hz
Indication	Yellow Continuously lit: 100 Mbit Not lit: 10 Mbit Green Flashing: Telegram reception Continuously lit: No communication

Pin	Signal	Signal Description
1	ETH_TX_P	Transmit data +
2	ETH_TX_N	Transmit data -
3	ETH_RX_P	Receive data +
4	–	–

Pin	Signal	Signal Description
5	–	–
6	ETH_RX_N	Receive Data -
7	–	–
8	–	–
	Screen	Shield potential

Optical Ethernet Interface (LC)

Physical layer	Fibre optic		
Connectors			
Recommended fibre	62.5 µm/125 µm glass fibre with duplex-LC connector		
Transmission speed	100 MBit/s		
Optical wavelength	1300 nm		
Max. line length	2 km for 62.5 µm/125 µm and 50 µm/125 µm optical fibres		
Transmit Power	**Minimum**	**Typical**	**Maximum**
50 µm/125 µm, NA[1] = 0.2	-24 dBm	-21 dBm	-17 dBm
62.5 µm/125 µm, NA[1] = 0.275	-20 dBm	-17 dBm	-14 dBm
Reciever sensitivity	Maximum -12 dBm Minimum -31 dBm		
Optical budget	Minimum 7 dB for 50 µm/125 µm, NA[1] = 0.2 Minimum 11 dB for 62.5 µm/125 µm, NA[1] = 0.275		
Interface design	Corresponds to IEEE 802.3, 100Base-FX		
Laser class 1 as per EN 60825-1/-2	With the use of 62.5 µm/125 µm and 50 µm/125 µm optical fibres		

Device Parameters

When using the Ethernet interface, you must configure the following settings in the following settings on the **`Communications`** menu:

Table 1-4 Ethernet Protocol (Ch1/Ch2)

Setting Name	Range/Options	Default	Setting	Notes
Ethernet Mode	Local Remote Local or Remote	Remote	–	See Device Operation mode for further information.

1 Numerical aperture (NA = sin θ (launch angle))

Network Parameters

When using the Ethernet interface, you must configure the following network settings in the following settings on the **`Configure Interface`** menu:

This can only be done from the PC software tool.

[sc_7SR5_ReydispManager2IPAddressTab, 2, --_--]

Figure 1-9 Configure Interface Menu

MAC Address

The MAC address is a transparent address that is permanently stored in the module. It is a worldwide unique identifier for the module. That means the devices can be integrated into any network. The user can only read the MAC address but not change it. The MAC address can be viewed on the device fascia in the **Instruments > Communications** meter.

IP Address

The IP address is also a unique identifier for a TCP/IP link. It is a 32-bit-wide number.

The IP address is assigned during configuration of a network in a station. It can be set during device parameterization for a stand alone device and can also be set in the IEC 61850 **`System Configurator`** when the device is associated with a station.

Subnet Mask

This mask must be set according to the addressing scheme of the network.

Gateway Address

This is the IP address of the gateway. It is required whenever an address outside the LAN of the station is to be accessed. It can be set during device parameterization for a stand alone device and can also be set in the IEC 61850 **`System Configurator`** when the device is associated with a station.

NOTE

The IP address 192.168.2.1 of the front port is reserved and should never be used in the network.

SNTP Address

This address is also a TCP/IP address with which the 2 time servers, settings for the IP address, subnet mask, and gateway can be accessed in the network to ensure precise time synchronization of all devices.

PTP

IEEE 1588 network clock support can be enabled and the clock type and profile selected. Ordinary Clock Slave only, profile IEC 61850-9-3:2016 and Domain 0 are the only supported options and no change is possible.

Syslog Server

The IP address and associated port for up to 2 Syslog servers can be enabled and configured. The syslog server provides a security audit trail which chronologically acquires and categorizes security-relevant events according to the origin and severity. The 7SR5 devices automatically send the security-relevant events to an external syslog-server.

SNMP

This protocol has been implemented in order to have access to information in a network in which other units, such as external switches, are administered as well. On the basis of this protocol, the accessible information can be invoked with any MIB browser. The MIB descriptions required for this are available on the internet at *www.siemens.com/reyrolle*. In particular, the statuses of the 2 lines are readable via SNMP using a MIB browser. This protocol is implemented in all modules.

Display of the Network Parameters on the Device

The parameters of the interfaces can be viewed on the device display. This is done by entering the operating menu from the initial display via the menu key.

There, displays are accessible via the **`Instruments/Communication Meters`**.

The display includes:

- Mac address
- IP address
- Subnet mask
- Gateway
- NTP sync
- Link type

This shows the settings with which the device is working and that constitute part of the parameter set. The settings can only be changed via the Reydisp Manager 2 parameterization system.

Operation of Ethernet Interface

The Ethernet interface can be operated optionally with or without integrated switch function. This applies for the electrical as well as the optical interface. This function can be selected via the parameterization. The Ethernet modules are compatible with the EN100 modules of the Reyrolle 7SR1/2 series devices and SIPROTEC 4 and 5 series. If the RSTP protocol or the HSR protocol is active, the modules of the 7SR1/2, SIPROTEC 4 series and the SIPROTEC 5 series can be operated in a ring.

When using 7SR1/2 or SIPROTEC 4 devices with module firmware ≤ V4.05 and SIPROTEC 5 devices, the maximum allowable number of participants is 30 devices. When using 7SR1/2, devices, or SIPROTEC 4 devices with module firmware ≥ V4.07 and SIPROTEC 5 devices, the maximum allowable number of participants is 40 devices. When using 7SR5 devices, the maximum allowable number of participants is 40 devices.

Figure 1-14 shows operation of the Ethernet modules with integrated switch function. All devices of a station are shown which are connected to one another by means of optical fibers. The devices form optical rings. In addition, 2 switches are used on the substation controller for the SICAM PAS. The 2 switches take the requirements for the redundancy into account.

Network Structures

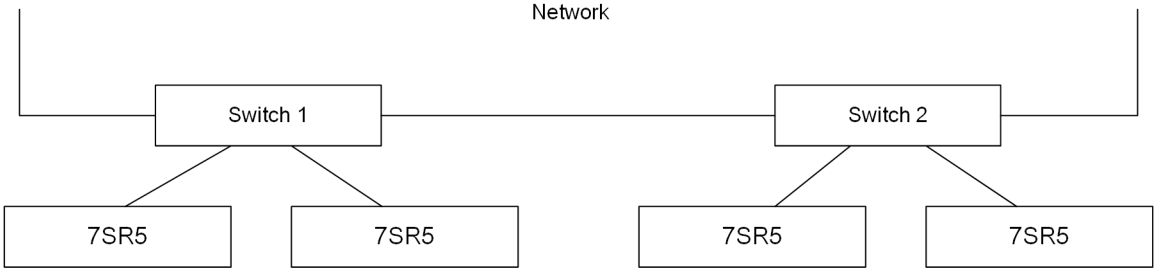
The Ethernet communication interface is available in both electrical and optical versions. Both types are provided with an integrated switch functionality. This makes it possible to integrate the devices into almost all network structures together with third-party components.

The network structures are independent of the serial communication protocol (IEC 60870-5-103, DNP3 and Modbus).

The interfaces on the devices can be used in different operating modes. A distinction is drawn between the operating modes **`Line`** and **`Switch`**.

Simple Structure

Such a structure always requires so-called switches. A switch is a device to which devices are connected via 2 or more connections. It forms the hub at the center of a star topology. Switches can be interconnected to produce networks of different sizes.



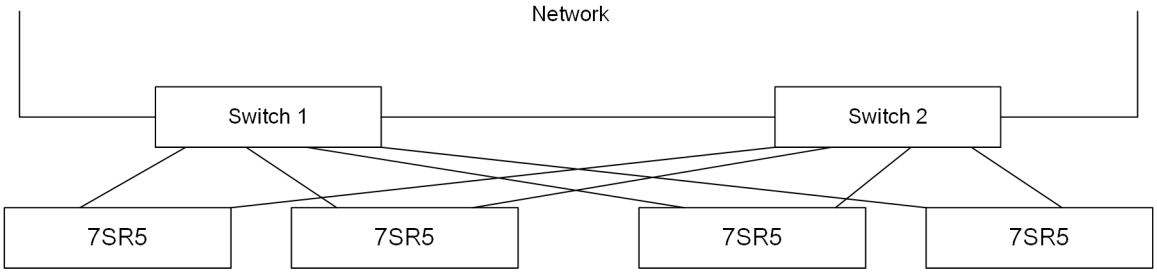
[dw_7SR5_DeviceConnected1Link, 1, en_US]

Figure 1-10 7SR5 Devices Connected Via 1 Link

As is shown in *Figure 1-10*, one device is connected to each port of a switch. The link shown is an Ethernet link. The modules have 2 connectors of which only one is active at any one time. The connector selection is detected automatically by the module. This type of structure can be realized with all module types. The redundancy type has to be set to 'Line' mode.

Line Mode

Ethernet modules have generally 2 interfaces which are designed for either electrical or optical interfacing. This means that they can communicate via 2 Ethernet cables, but not simultaneously. The second channel is a standby. This results in the network structures shown in *Figure 1-11* illustrating connection of 2 links to different switch ports. The redundancy type has to be set to Line mode.



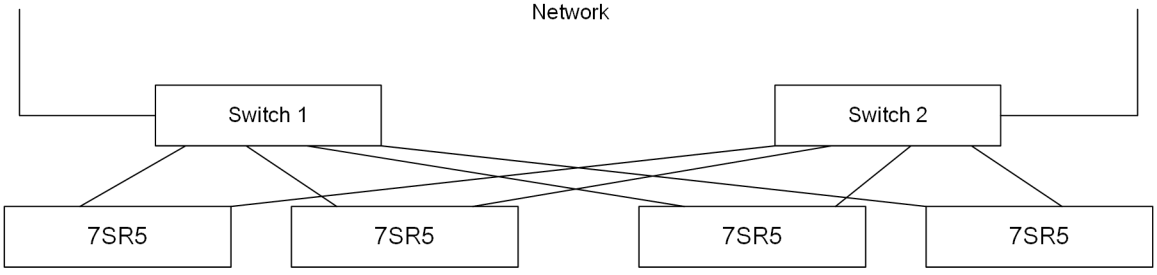
[dw_7SR5_DeviceConnected2Link, 1, en_US]

Figure 1-11 7SR5 Devices Connected Via 2 Links

The 2 physical links are monitored for their connection. This enables generation and output of a message if a link is broken. This message is to be found in the message buffer and can be routed to contacts, LED, or in the logic editor (CFC).

PRP-Structure

The PRP structure (Parallel Redundancy Protocol according to IEC 62439-3:2012) provides communication over 2 independent networks (LAN A and LAN B) simultaneously. As shown in the following figure both networks may under no circumstances be connected to one another. Siemens recommends building both networks identically. Connect LAN A with channel 1 and LAN B with channel 2.



[dw_7SR5_DeviceConnected2Networks, 1, en_US]

Figure 1-12 7SR5 Devices Connected Via 2 Independent Networks (LAN A and LAN B)

In case of an interrupted network communication the device switches seamlessly.

Channel Switchover in "Line" Mode

If the active link, i.e. the link transmitting data between the device and the external switch, is broken, the interruption is detected and signaled by the link mentioned above. When an interruption is detected, switch to the second channel is performed immediately so that data exchange can continue almost without interruption. The interruption signal is then transmitted via the standby channel.

Failure of the external switch

If both links are connected to ports in different switches, failure of one external switch does not interrupt the connection with the master. All devices with an active link via the failed switch switchover to their second link that is connected to another switch, and operation can continue. The external switches are normally connected via a ring structure, so that they realize their own redundancy between themselves.

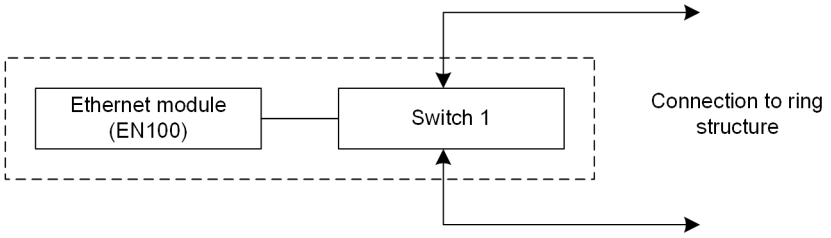
Ring Structure

Ring structures mean that all devices are connected in a ring, as shown in *Figure 1-14*. However, this operating mode requires 2 ports which actively transmit data. This includes an appropriate network control system. The prerequisite for such a structure is the integrated switch functionality.

Switch Function (Internal Switch)

The switch function provides the connection with the device, as well as a connection with the 2 other ports which then implement a ring structure. This 3-port switch is controlled so that only those telegrams which are

intended for the device are actually routed to it. Telegrams transmitted by the device are fed into the data stream on the ring. The basic structure of such an integrated switch is shown in *Figure 1-13*.

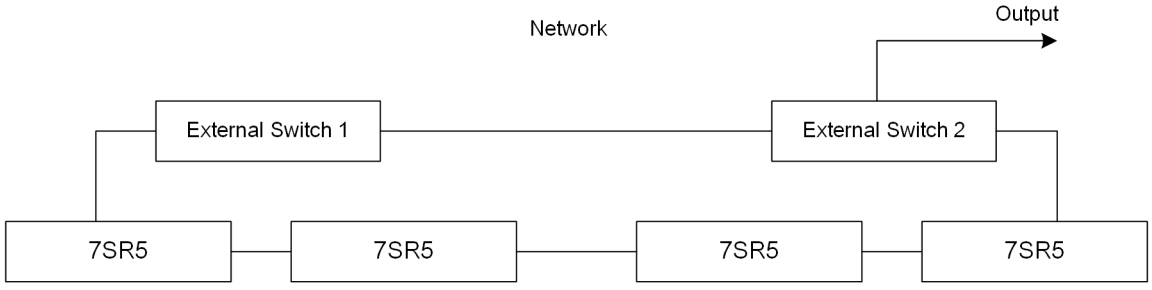


[dw_7SR5_PrincipleOfIntegralSwitch, 1, en_US]

Figure 1-13 Principle of Integral Switch

Operating Mode RSTP

This operating mode allows the kind of structure shown in *Figure 1-14*. Its characteristic feature is that all devices are arranged in a ring; one or more external switches must be integrated into this ring for the output of data, e.g. for display or for transmission into a different network.



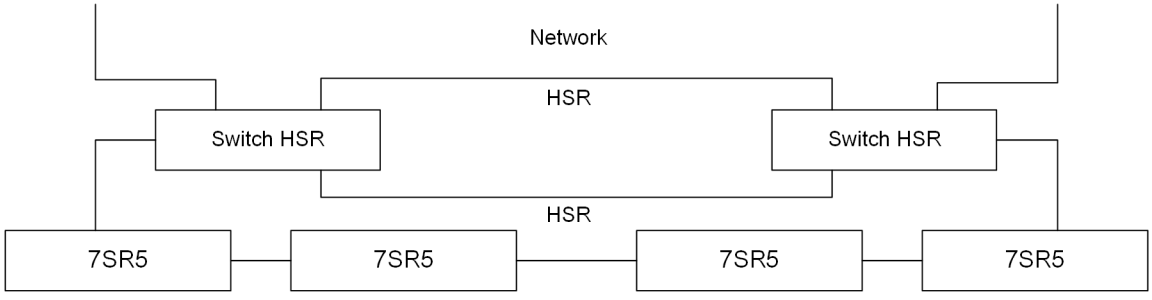
[dw_7SR5_DevicesWithIntegratedSwitch, 1, en_US]

Figure 1-14 7SR5 Devices with Integrated Switch

If the ring which includes the devices and the switch is broken, the ring becomes a line, and the functionality is maintained almost without interruption. If the ring is broken in a second place, the structure cannot handle the resulting double error any more, and one part of the line will be disconnected. This means that only single errors resulting from a broken ring can be handled.

HSR Structure

The devices are arranged in rings in the HSR structure (High-availability Seamless Redundancy according to IEC 62439-3:2012) shown in the following figure. The procedure does not have parameters of its own.



[dw_7SR5_DevicesConnectedInRings, 1, en_US]

Figure 1-15 7SR5 Devices Connected in Rings

A seamless switchover will take place if an interruption in communication occurs in a network. All components in HSR rings must support HSR. If you do not want to connect HSR-enabled devices, use special switches that support HSR.

Updating the Device Configuration via Rear Ethernet Port Communication Modules in the PRP Structure

If the device is updated using Reydisp Manager 2 over the Ethernet port, the device will revert to **`Line Mode`** and not be available for IEC 61850, Modbus TCP, and DNP3 TCP communication. If the Reydisp Manager 2 PC is inserted to the PRP network via a RedBox (Redundancy Box), the communication to the terminal device continues to function in the PRP structure with the **`Line Mode`** network redundancy protocol.

NOTE

Communication problems can occur if you insert a PC as SAN (Single Attached Node) into a PRP structure, for example, by loading the configuration when using IEC 61850. Therefore, Siemens recommends using a PC in a PRP network with a RedBox (Redundancy Box).

2 IEC 61850

2.1	Introduction	28
2.2	Protocol Characteristics in Reydisp Manager 2	29
2.3	IEC 61850 Structure	32
2.4	Exporting	33
2.5	IEC 61850 System Configurator	35
2.6	Protocol Properties and Implementation	38

2.1 Introduction

2.1.1 Use in 7SR5 Devices

The IEC 61850 protocol is implemented on an Ethernet interface. This permits communication between the client and the server for substation automation via the IEC 61850 MMS protocol (MMS – Manufacturing Message Specification) and GOOSE messages (GOOSE – Generic Object-Oriented Substation Event). The Ethernet interface comes with 2 RJ45 connectors or with 2 duplex-LC interfaces for a 1300-nm fiber-optic connection. The physical interface is always duplicated to permit redundant networks. The Ethernet module has 1 IP address.

You can use Reydisp Manager 2 to set the IEC 61850 protocol for the Ethernet module. It is also used to make all necessary network settings. Various editors are available for the different protocol services listed in the IEC 61850 Standard. The IEC 61850 object image of a device can be configured flexibly to meet your requirements. 7SR5 devices support the Editions 1 and 2 of IEC 61850. To provide complete compatibility with existing Edition 1 devices, you can use Reydisp Manager 2 to switch the IEC 61850 server of the device to the Edition 1 mode. The IEC 61850 server then operates together with Edition 1 clients and exchanges GOOSE messages with Edition 1 devices.

The IEC 61850 modules must be provided with special information for parameterization.

Storage of the Parameter Set

During device start-up, the parameter set of the device is first activated for the Ethernet module and then the module is started.

Information in the Parameter Set

The parameter set contains extensive information, such as the individual objects for the devices to which the objects of the IEC 61850 must be mapped. The user has no part in this mapping. The user may view it but not change it. However, devices with different function scope and type have different mappings.

Network Parameterization

This block of parameters describes settings that concern the entire IEC 61850 network within a substation.

These settings are especially relevant for parameterization of peer-to-peer data traffic using GOOSE. The parameters themselves are unavailable to the user. The parameterization of the network is performed with the IEC 61850 System Configurator whose online help can be used to obtain detailed information.

IEC Object Description via ICD File

The IEC 61850 protocol represents the necessary objects of the devices externally. These objects are contained in an ICD file in compliance with the standard. This file is contained in the parameterization system and is essential for integrating devices into a network. The same goes for devices of other manufacturers.

For these, too, a description must exist in an ICD file if they are to be integrated into a network. ICD files can be imported and exported by Reydisp Manager 2, which is necessary for integration of devices from other manufacturers and of 7SR5 devices in Non-Reyrolle networks.

Station Description via SCD File

A complete station is formed by several devices. These components have various communication connections between them that must be parameterized. The description of all devices,and their settings and interrelations are grouped together in the station description file. The file itself is created and processed using the IEC 61850 System Configurator. The IEC 61850 System Configurator is started from the station in Reydisp Manager 2. SCD files can also be imported and exported there.

2.2 Protocol Characteristics in Reydisp Manager 2

2.2.1 Selecting the IEC 61850 Edition

To begin the engineering of 7SR5 systems with IEC 61850, create a project and specify the IEC 61850 edition individually for each device.

NOTE

Edition 1 is the default setting.

You can set the edition for each device individually.

If you have selected Edition 1, you can upgrade to Edition 2. Switching from Edition 2 to Edition 1 is not possible however, because functionality would be lost.

If you export project or device configuration data, they are exported in the established edition.

When adding a new 7SR5 device to the Reydisp Manager 2 project the user is required to enter the IEC 61850 IED name and selection between Edition 1 and Edition 2 of the standard. For IEC 61850, you can make the following setting changes after the initial adding of the device for IEC 61850 in Reydisp Manager 2 under **`Device > Properties`**:

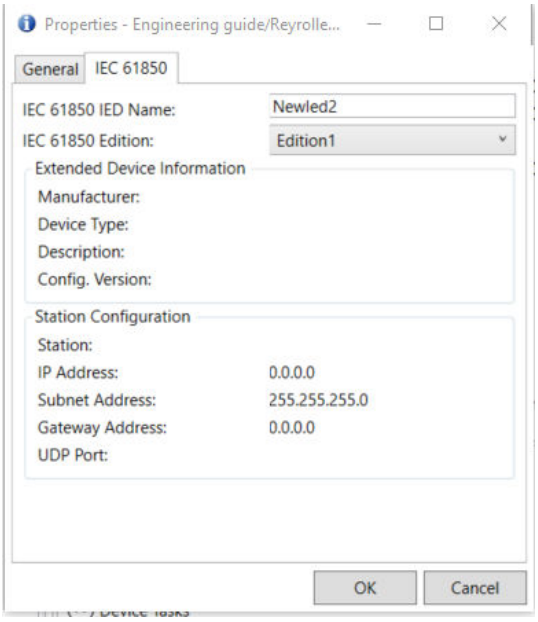


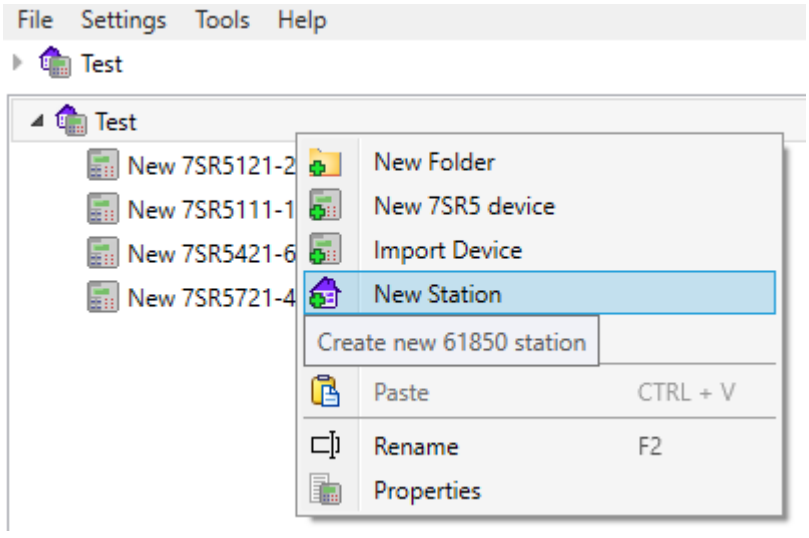
Figure 2-1 Device Settings for IEC 61850

Parameters	Meaning
IEC 61850 Edition	Selection between Edition 1 or Edition 2 of the protocol.
IEC IED Name	Each device must be given a unique IED name which must start with a letter and must not contain spaces. Only alpha numeric characters are accepted and no special characters. Maximum length is 13 characters.

Adding an IEC Station

- ✧ Open the project tree.
- ✧ Right-click on the folder in the project tree.

The element **`New Station`** is displayed.

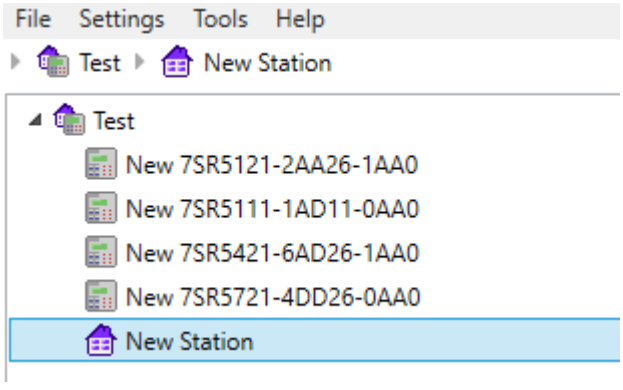


[sc_7SR5_ReydispManager2NewStation, 2, --_--]

Figure 2-2 New Station Option

✧ Click **`New Station`**.

The new station is created.



[sc_7SR5_ReydispManager2NewStationProjectTree, 2, --_--]

Figure 2-3 New Station Created

NOTE

You cannot cut, copy, or paste IEC stations.

Assigning a Device to an IEC Station

In the **`Station Configuration Editor`**, the list of devices that can be assigned to an IEC station is displayed with the device name, IEC 61850 IED name, and location information columns under the **Unassigned devices** group.

NOTE

The following devices can be displayed in the **Available devices** group:

- Devices with activated IEC capability.
- Devices that do not yet belong to the IEC station.

✧ Select one or more of the devices displayed under **Unassigned devices**.

✧ With the **Add** button, you can assign the device or devices to an **`IEC station`**.

- or -

✧ Close the **`Station Configuration`** window.

Upgrade of the IEC 61850 Edition within the IEC Station

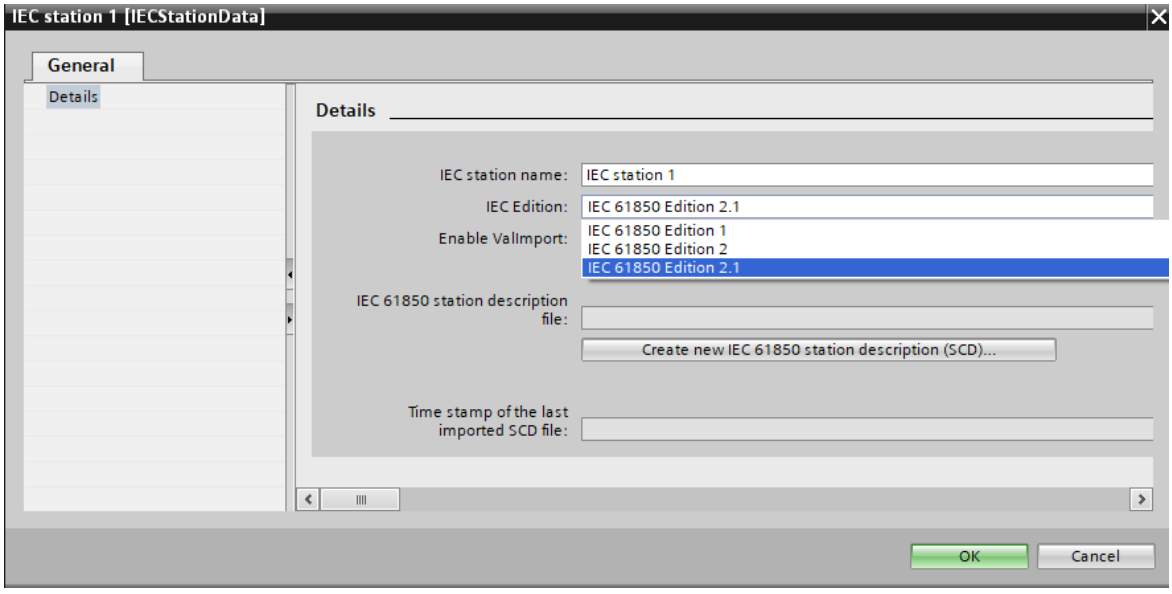
You can upgrade the IEC 61850 Edition of the devices within the IEC station from Edition 1 to Edition 2. When the station is opened in the system configurator tool the IEC station will be automatically given the edition of the highest edition of any of the assigned devices.

NOTE

In devices that are not yet assigned to the IEC station, the Edition of the devices remains set as in the devices. In this case, only devices that have the same Edition as the IEC station can later be assigned to this IEC station.

✧ In the **IEC 61850 stations** section, click the desired IEC station and select the context menu **Properties**.

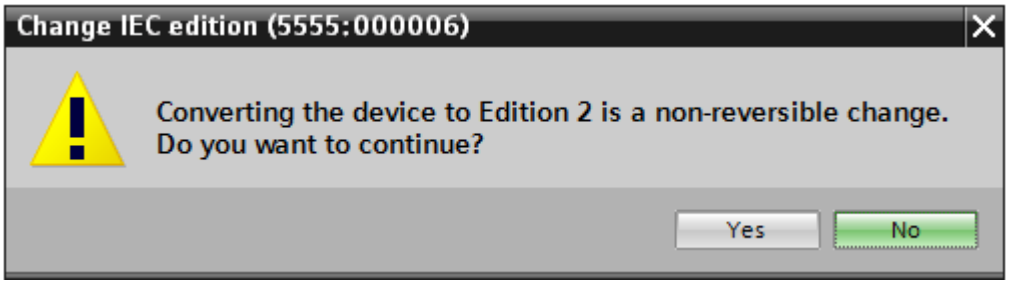
✧ In the dialog, under **IEC Edition**, select **IEC 61850 Edition 2** and click **OK**.



[sc_update_IEC_edition_station, 4, en_US]

Figure 2-4 Change of the IEC 61850 Edition in the IEC Station

A warning indication appears.



[sc_update_IEC_edition_station_warning, 3, en_US]

Figure 2-5 Warning in Case of a Change of the IEC 61850 Edition in the IEC Station

✧ Click **Yes**. If you click **No** your change is discarded.

2.3 IEC 61850 Structure

2.3.1 Overview of the IEC 61850 Structure

The IEC 61850 structure indicates the hierarchical arrangement of the IEC 61850 elements in an application.

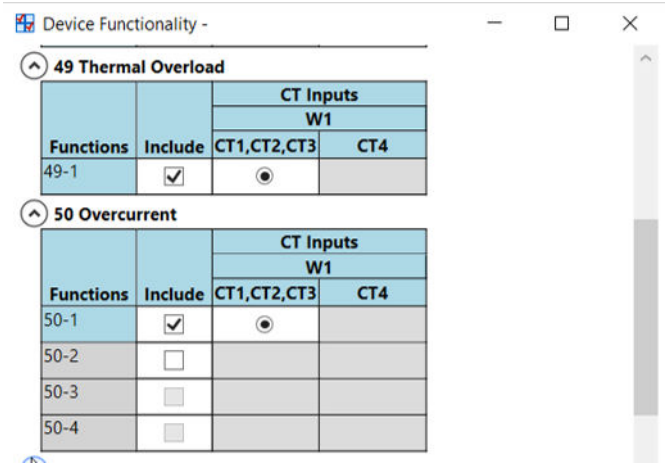
Application Structure and IEC 61850 Structure

The following table illustrates the assignment between the application structure and the IEC 61850 structure:

Application Structure	IEC 61850 Structure
Function FN	Logical device(s) (LD)
Function block FB	Logical node(s) LN
Data object DO	Data object DO

An application in 7SR5 devices is organized into functions. Functions can consist of one or more function blocks.
The IEC 61850 structure is created when the device functions are added or removed in Reydisp Manager 2 Function configuration:

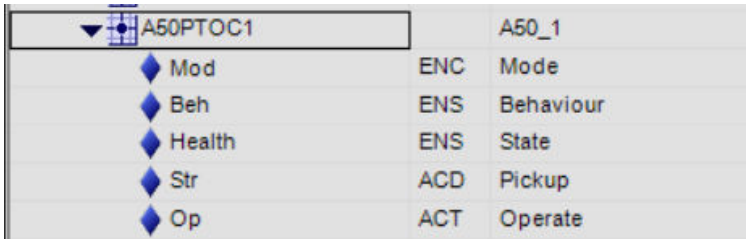
- The function can be added or removed from the configuration tool, this will add or remove the logical node from the device. From function 50 Overcurrent with the function 50-1 included in the device configuration the logical node becomes A50PTOC1 in the IEC 61850 structure. The prefix and suffix of a logical node are predefined.



[sc_7SR5_Function50DeviceConfiguration, 1, --_--]

Figure 2-6 Function 50 Device Configuration

This IEC 61850 structure view is arranged in the 7SR5 devices with the logical devices **PROT**, **CTRL**, **MEAS**, and **DR** predefined as fixed values. In the logical devices the function blocks are logical nodes. Logical nodes and the superordinate controlling nodes are displayed in the sequence (Logical device, Logical node, Data object and Data attributes).



[sc_7SR5_Function50LogicalNode, 1, --_--]

Figure 2-7 Logical Node A50PTOC1

2.4 Exporting

2.4.1 Export Formats in Reydisp Manager 2

Export files permit interoperable data exchange of IEC 61850 data between the configuration tools of various manufacturers. They can be used for documentation purposes or in other IEC 61850 configurators.
The following export formats are available at the device level to export device-specific IEC 61850 data:

Data Format	Meaning	Export Source		Import Target	
ICD	IED Capability Description	Device	—	Device	—
SCD	Substation Configuration Description	—	IEC Station	—	IEC Station
MICS RTF/HTML	Model Implementation Conformance Statement	Device	—	—	—
HTML	Protocol settings from IEC 60870-5-103, Modbus & DNP3 Serial	Device	—	—	—
Zip	Export project for archive	—	Project	—	Project

MICS

This file is the XML description of the device data model in a rich text or HTML format for documentation and information purposes.

2.4.2 Exporting IEC 61850 Description Files

IEC 61850 description files include, for example, ICD. They include descriptions of the performance properties of an IED.

✧ In order to export IEC 61850 description files, highlight the device in the project tree.

✧ Select the **Export ICD** function from the **Tasks** window.

The export dialog appears. You can select a location to save the ICD file and name the file.

[sc_7SR5_ExportICD, 1, --_--]

Figure 2-8 Export ICD

Exporting MICS

✧ In order to export the MICS file, highlight the device in the project tree.
The MICS file is an XML file. 2 other files are exported. These files enable formatting the MICS XML file for visualization and for printing with a browser or for using an XML editor. Siemens recommends exporting these files into a separate directory, for example, c:/Temp/MICS.

✧ Select the **`Export IEC61850 MICS`** function from the **`Tasks`** window.

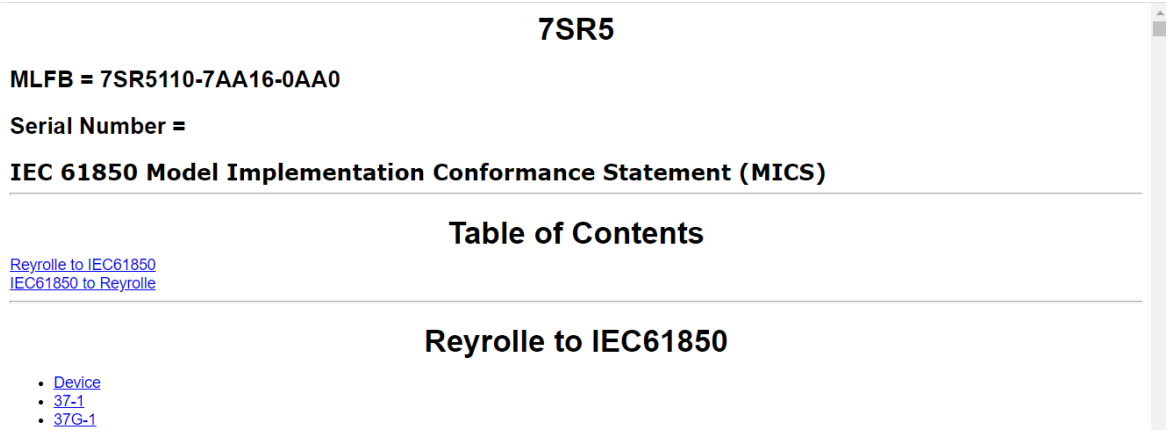
The export dialog appears. You can select a location to save the ICD file and name the file .

[sc_7SR5_ReydispManager2ExportIEC61850MICS, 1, --_--]

Figure 2-9 Export IEC 61850 MICS

The homepage of the MICS file is displayed in the browser when saved as a HTML file and opened.

The subsequent pages show all IEC 61850 logical devices and logical nodes of the device. From there, you can navigate via hyperlinks to the further details. You can navigate through the entire IEC 61850 data structure of the device and find all the definitions of data objects in the chapters of the data types. You can also save as an **.rtf** file but the browser view is more comfortable.



7SR5

MLFB = 7SR5110-7AA16-0AA0

Serial Number =

IEC 61850 Model Implementation Conformance Statement (MICS)

Table of Contents

Reyrolle to IEC61850
IEC61850 to Reyrolle

Reyrolle to IEC61850

- Device
- 37-1
- 37G-1

[sc_7SR5_MICSFileHomepage, 1, --_--]

Figure 2-10 Homepage of the MICS File

2.5 IEC 61850 System Configurator

2.5.1 Integration with the Siemens IEC 61850 System Configurator

System Parameterization

System parameterization is only performed after parameterization of the device. The Digsi IEC 61850 System Configurator is used to do this. Alternatively a 3rd party tool can be used.

As part of system parameterization, the ICD files of each device are imported and the complete station is assembled using the information they contain. Distribution of the IP and multicast addresses as well as subnet masks is performed in the IEC 61850 System Configurator. It is also used to produce and parameterize the inter-device communication, i.e. the link from objects of one device to those of other devices. This defines and routes direct flows of information between devices.

Only after completion of system parameterization is the parameter sets generated for the individual devices.

These now contain the links with other devices in the network and only then is the complete station fully functional. The station-wide parameterization information can be exported in an SCD file.

✧ Create a new IEC 61850 station by clicking **Add New Station** under **IEC 61850 Stations** in the **Project tree**.

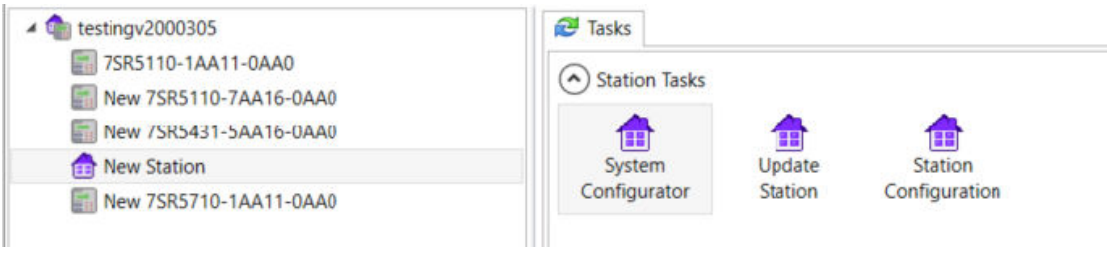
A new IEC 61850 station **IEC station 1** is created.

✧ Select the IEC 61850 station and assign the devices as described in *2.2 Protocol Characteristics in Reydisp Manager 2*

NOTE

You can only assign a device to one station.

✧ Open the IEC 61850 System Configurator if installed.



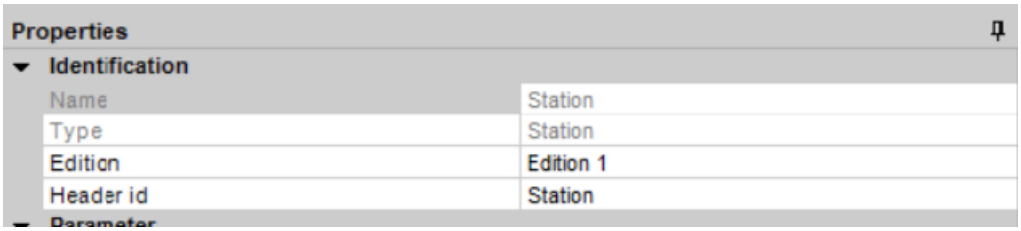
[sc_7SR5_SysConfig, 1, --_--]

Figure 2-11 System Configurator

NOTE

The Digsi system configurator can be purchased as a standalone IEC 61850 System Configuration tool and is not installed with Reydisp Manager 2. If Digsi is already installed on the PC with a licensed system configurator, Reydisp Manager 2 will automatically detect and use it.

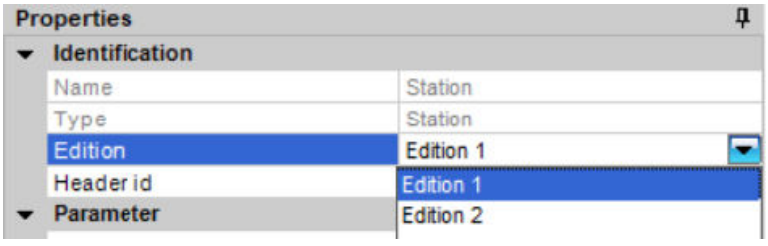
✧ Check the Edition number of the Station in the **Devices > Station > Properties**.



[sc_7SR5_SysConfigEditionNumberCheck, 1, --_--]

Figure 2-12 Edition Number Check

✧ Change the Edition number of the Station in the **Devices > Station > Properties** if required.



[sc_7SR5_SysConfigEditionNumberChange, 1, --_--]

Figure 2-13 Edition Number Change

2.5.2 Network Settings

The network is shown as a tree. The root of the tree is the station to which subnets are assigned that then contain devices.

The station, devices, and subnets can be assigned a comment or description text.

Subnets

The start address, subnet mask, and standard gateway can be set for subnets. The baud rate of the network and type of network are also displayed. It is not necessary to change them.

The start address is only important for automatic assignment of the network addresses of the devices. In this case, addresses are assigned to the devices starting at this address.

Devices Settings

The devices can be selected and set like subnets. The setting dialog that opens initially shows the device properties.

In addition to the freely assignable name, the device type, device version, and manufacturer of the device are also visible. Moreover, the ability for peer-to-peer communication, for routing, and for providing a time signal are displayed. The only settable value is the IP address.

Setting of Routing

The setting for routing is an essential feature of the IEC 61850 System Configurator. Only then is it possible for the devices to intercommunicate directly. Routing has its own setting dialog that lists all the devices it contains.

Routing itself is performed by defining an application, selection of devices, and their objects that intercommunicate.

Memory Management

The storage used for “Buffered Reports” of the communication module is physically restricted. The same amount of storage capacity is provided to every report control block for the buffering of the reports per default . The user has, however, the ability to assign individual amounts of the storage capacity dialog controlled using the IEC 61850 System Configurator.

2.5.3 IEC 61850 System Configurator

You can find more information on the following topics in the *IEC 61850-System Configurator* manual:

- GOOSE applications:
  - GOOSE communication
  - Creating a GOOSE application
- Report applications:
  - Creating a report application
  - Configuring the dataset
  - Report control blocks
- Export of SCD/SED files
- Export of IID/CID files

2.5.4 Importing an SCD into Reydisp Manager 2 Project Device

✧ Select the device to import the station to.

✧ Click the icon 

.

- or -

✧ Select the file from the correct location and press open.

2.5.5 Importing an SCD into a Station in System Configurator

✧ Select the IEC 61850 station.

✧ Open the Station System Configurator.

✧ Select **Station > Import > IEC61850 station**.

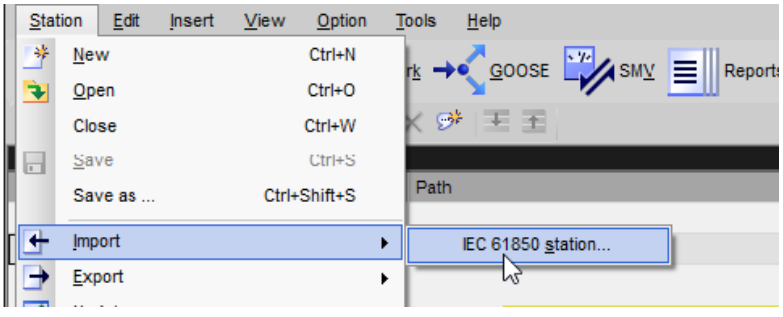


Figure 2-14 Import From the IEC 61850 Station

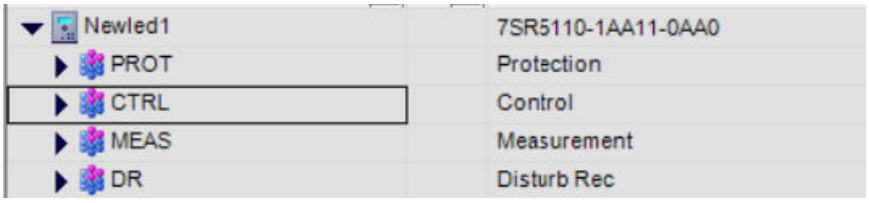
✧ Locate the file to be imported and close the system configurator.

2.6 Protocol Properties and Implementation

2.6.1 IEC 61850 Structure of a 7SR5 Device

The logical devices are given with the following designations:

- PROT
- CTRL
- MEAS
- DR

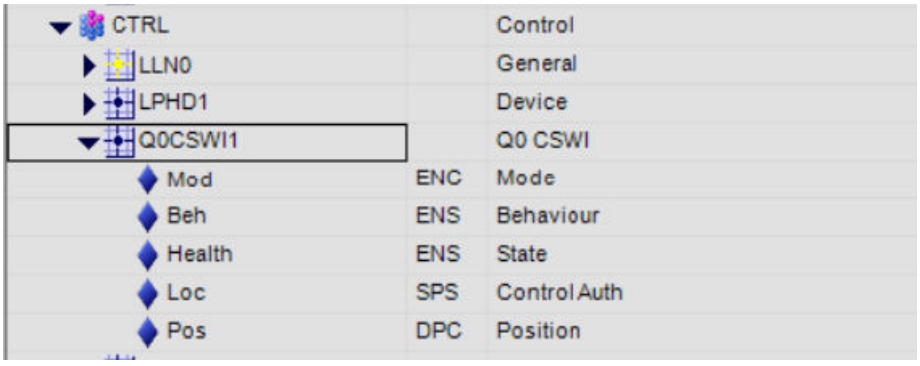


[sc_7SR5_DeviceDesignations, 1, --_--]

Figure 2-15 Logical Device Designations

The logical devices contain the tripping stages, for example, protection function stages, and the superordinate stages that control them as logical nodes.

In the logical devices the function blocks are logical nodes. Logical nodes and the superordinate controlling nodes are displayed in the sequence (Logical device, Logical node, Data object and Data attributes).

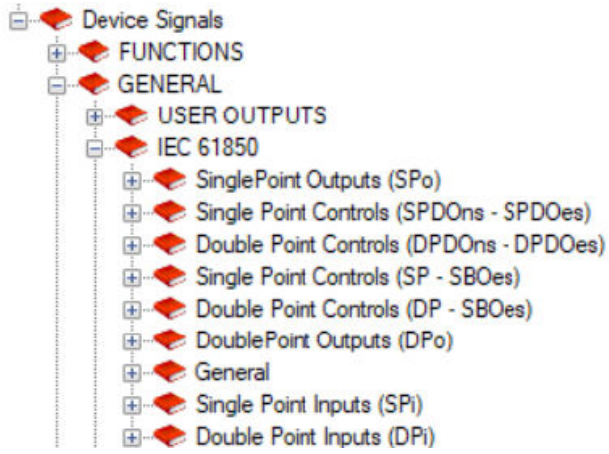


[sc_7SR5_LogicalDeviceFunctionBlock, 1, --_--]

Figure 2-16 Logical Device Function Block

The 7SR5 device has a fixed number of Generic I/O logical nodes, GGIO class. The GGIO's can be configured to interface with the 7SR5 device signals through the Reylogic editor in Reydisp Manager 2. A combination of single point and double point inputs and outputs are available, with and without quality bits.

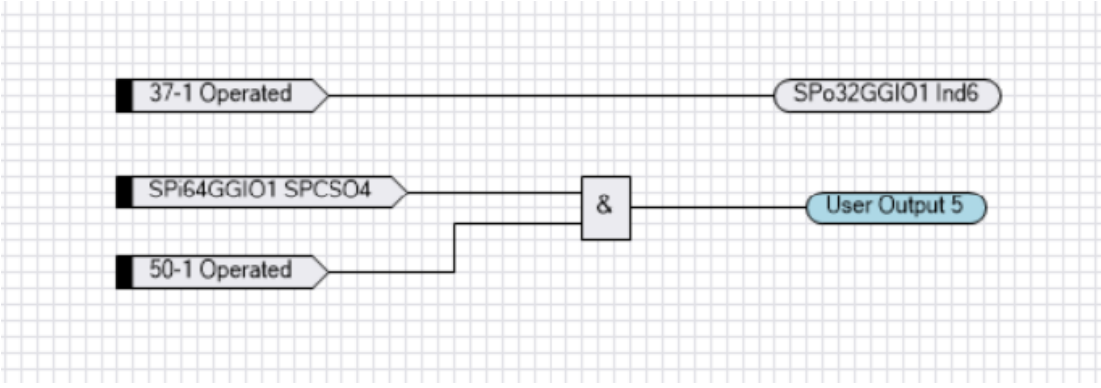
The 7SR5 device also has a fixed number of single point and double point controls with Normal or Enhanced security and also for direct operate and select before operate options.



[sc_7SR5_SingleDoublePoints, 1, --_--]

Figure 2-17 Single and Double Points

The signals are connected within the device by dragging onto the diagram and connecting to another signal. The signals can be used in combination with user logic diagrams or connected directly.



[sc_7SR5_UserLogicDiagram, 1, --_--]

Figure 2-18 User Logic Diagram

2.6.2 IEC 61850 Services

You can find details in PICS (Protocol Implementation Conformance Statement) which is included in the 7SR5 PIXIT document (C53000-T5040-C031-1) available to download from the website.

7SR5 devices support the following IEC 61850 services:

GOOSE Messages

Datasets are created in the device by GOOSE applications. This takes place in the logical node **LLN0** of a logical device. You can specify where these datasets are created.

The first object configured in a GOOSE message from a logical device creates a dataset for a GOOSE message in LLN0. Further objects are configured in this dataset and added to this dataset, even if they originated in other LDs. Alternatively, if you wish to send objects in different datasets, you can also create a new GOOSE application and thus a new dataset.

NOTE

Sending objects in different datasets generates unnecessary data traffic, since each dataset created is transmitted via its own GOOSE message.

The dataset is sent as a GOOSE message and distributed to all network participants in the form of multicast telegrams. If participants wish to receive specific objects in a GOOSE message, the user can select these objects via the system configuration and receive them later online.

GOOSE messages are transmitted with high priority and repeated at an interval of a few milliseconds in the event of a spontaneous change of the data object. You set the repetition time in the IEC 61850 System Configurator.

You can find more information on GOOSE parameterization and on creating a GOOSE application in the *System Configurator* manual.

Control Commands

You can control an object in a device with control commands. By using the control model **Select Before Operate**, you can actuate a circuit breaker reliably, for instance. Commands without feedback can be executed in the device as well, for example, resetting the LEDs (LED Reset) by the client.

You can find more information on the configuration and control of switching objects in chapter *2.6.5 Control via IEC 61850*.

2.6.3 Reporting

2.6.3.1 What is a Report?

When using IEC 61850 in switchgear as well, you must test communication between protection devices and the substation automation technology just as you do with the other protocols. This requires, among other things, the knowledge of the power system protection technician who selects and generates the signals sent to the substation control system. Testing these connections is a basic part of commissioning.

The IEC 61850 Standard defines various types of communication.

For **classic** communication, for example, between the substation control system and a bay unit, the Standard describes various services based on the data model:

- **Control** for controlling
- **Report** for transmission of indications and measured values

There are static and dynamic reports. You can find more detailed information on this in chapter *2.6.3.3 Static Reporting*.

The following sections describe reports involving data exchange between a protection or bay unit (server) and the substation automation technology (client) and its tests. Reports are transmitted over Ethernet connections via TCP/IP (Transmission Control Protocol/Internet Protocol).

Data objects (indications) of a device are summarized as a list in a report. For instance, indication changes, caused for example, by a raising and cleared protection tripping event, are transmitted spontaneously from server to client. Therefore, the client does not have to query the server cyclically, as is the case with serial protocols, but automatically receives a notification of the event, for example, an indication change or a change of the measured value.

If the server permits, it is also possible to have cyclic transmission of data and general interrogation. The event control of data transmission is a property that is contained in the attributes of each report. You can affect these properties by using the IEC 61850 System Configurator.

Buffered and Unbuffered Reports

The Standard distinguishes between **Buffered Reports** and **Unbuffered Reports**. The **Buffered Report** is used most frequently today.

- **Buffered Report**
  In the case of a Buffered Report Control Block (BRCB), internal events trigger immediate transmission of reports. If the connection between the server and client is interrupted, indication changes in the protection device are stored. As soon as the connection has been reestablished, these indications are transmitted to the substation control system with a time stamp and the attribute **Historic**. To enable saving to a practicable limit – as recommended in the standard – the server must have adequate storage capacity. If an uninterrupted connection exists between the client and server, for example, in the case of controlled operation in a switchgear, then the behavior of both procedures appear identical from the user view of the substation control system.
- **Unbuffered report**
  In the case of an **Unbuffered Report Control Block** (URCB), internal events trigger immediate transmission of reports. If there is no connection or if the transport data flow is not fast enough, events can be lost.

Datasets are needed for reports.

Client LNs can be set. ICD files from the client are imported. Here, you will find the IP address. With this, you can assign the report to the client. This ensures that only this client will receive the report. You can do these settings in the System Configurator.

You can find information on subscribing to reports in the IEC 61850 Browser.

2.6.3.2 Datasets

Static and Dynamic Datasets

Every IEC 61850 service relies on data from the data model. This requires **Datasets** that reference actual values in the model.

There are report datasets with data for this report, for example, indication of the positions of the disconnector switch and circuit breaker in the feeder. These datasets can be created statically or dynamically.

Static Datasets

In the case of a static dataset, the number of indications and measured values is specified in the Report Editor. Once these configuration data are loaded into the server, the client can no longer change the contents of the configuration data. A fixed report that the client can retrieve is stored in the server. Changing the number/scope of the indications requires new parameterization followed by loading to the server.

The benefit is that the data provided by a server are stored in an SCD configuration file (Station Configuration Description). The drawback is that the settings in the server must be changed if the number/scope of indications is changed for the substation automation technology. The 7SR5 device has 2 configurable RCB in each logical node and 100 in each of the 4 logical devices.

Dynamic Datasets

In the case of dynamic datasets, the settings in the server do not need to be changed when the number/scope of indications changes. The client has 2 opportunities to read all data points that the server can potentially make available:

- Offline with a configuration file (ICD or SCD file), for example, in a SICAM substation automation technology.
- Online by connection establishment to the server, for example, in the IEC Browser Test tool.

The client specifies the information that a report from a device should contain. Thus, the content of a report is not fixed, but rather can be changed while the system is operating. The parameters set in the server do not have to be changed.

In this way, the client can be set to watch for special indications or measured values, for instance, for only a specific period. It can then create a report in the server, retrieve this report in order to obtain the information and then delete the report. No classic protocol offers this flexibility.

NOTE

Siemens supports the concept of dynamic datasets.

You can find additional information on the creation of datasets in the *System configurator manual*.

You can find information on creating and checking datasets in the Siemens IEC 61850 Browser PC application tool which is distributed with DIGSI.

2.6.3.3 Static Reporting

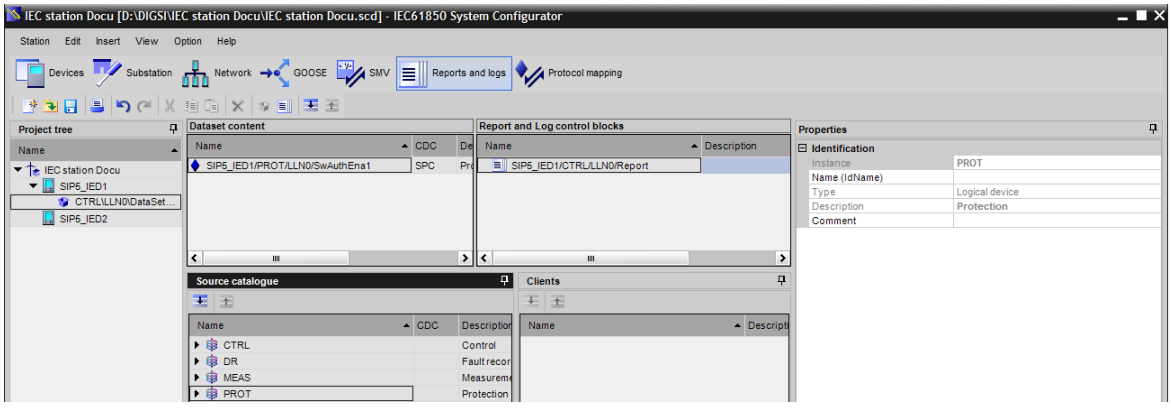
What Is a Static Report?

In a static report, the datasets are generated by the configuration in the IEC 61850 System Configurator. Such a dataset contains the data objects that are to be transmitted to an IEC 61850 client. This dataset is associated with a report. There are numerous possible configurations for a report.

IEC 61850 View in the System Configurator

The devices provide a system configurator with all of the information that can be transmitted to a client (substation control system) or between servers in the form of an ICD or IID file. In the case of protection functions, the manufacturer specifies the number/scope of the indications. For control functions, you establish the number/scope of indications with the configuration tool of the server. The IEC 61850 Standard defines how this information is displayed in a separate XML scheme called SCL (Substation Configuration Language).

The system configurator displays the indication texts (**Description** column) together with the IEC 61850 texts (**Name** column).



[sc_syscon_reports_structure, 2, en_US]

Figure 2-19 Structure in the System Configurator

Only names (designations) from the data model (**IEC texts**) are transmitted between client and server. In this way, only the IEC texts can be seen in the case of eavesdropping of the Ethernet by a network sniffer.

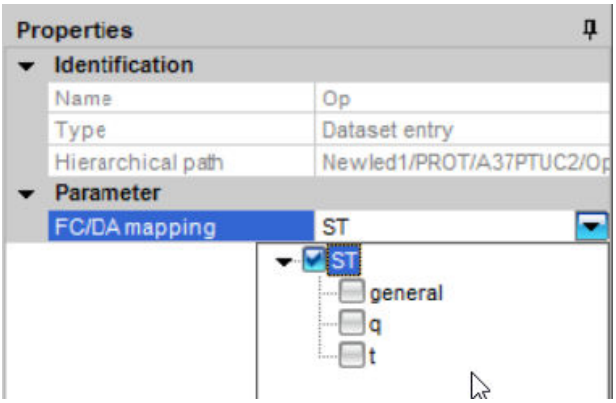
Indications and measured values from the server of an IEC 61850 station are configured in a static report. For this purpose, the devices are displayed as information sources in terms of their IEC 61850 structure.

Configuration of a Static Report in the System Configurator

Device View

Select only information from the Device view that you wish to configure in the report. For this, create datasets. Describe the datasets using the properties dialog in the IEC 61850 System Configurator. The functional

constraint data attribute (FC/DA) mapping can be changed as required to include or exclude information by checking/unchecking the selection box for that attribute from the drop down list.

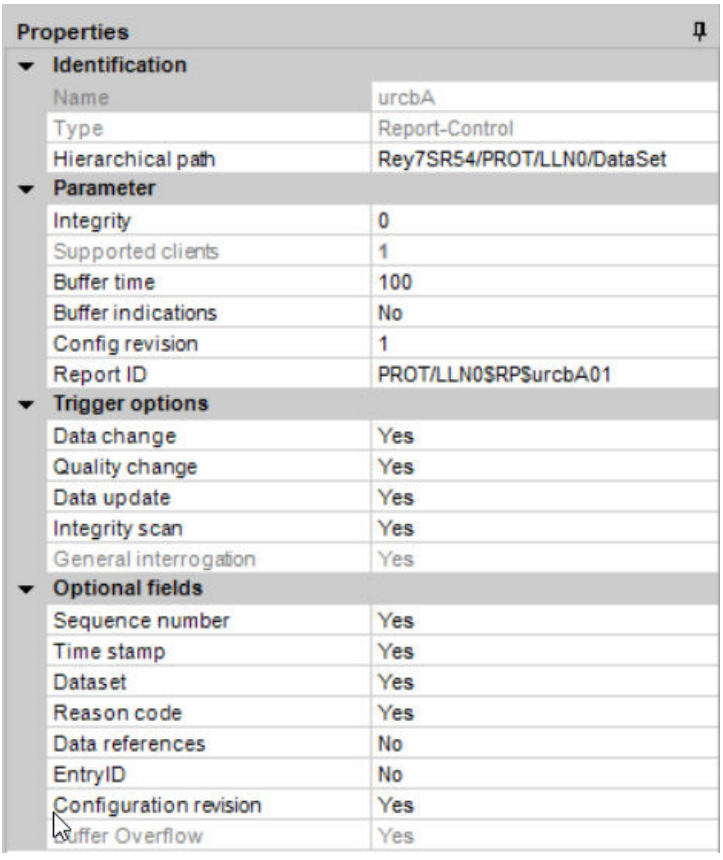


[sc_7SR5_DatasetProperties, 1, --_--]

Figure 2-20 Properties of the Dataset

Drag elements from the **Source catalog** into the dataset.

Right-click the dataset and select **Insert report** to add a ReportControlBlock (in this case: Protection) to this dataset. You also select between a **Buffered report** and an **Unbuffered report**.



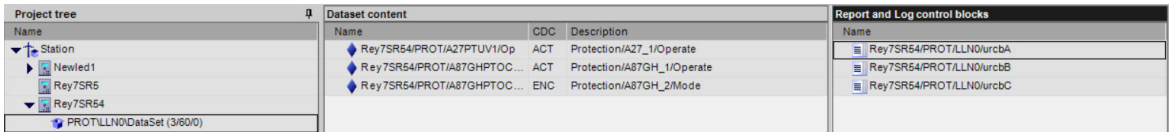
[sc_7SR5_StaticReport, 1, --_--]

Figure 2-21 Properties of a Static Report

You can find more detailed information on the **Optional fields** and the **Trigger options** in the chapter on Report Control Blocks in the ***System Configurator*** manual.

The server specifies these properties for the report and they cannot be changed. Under **Report number**, you can see the report ID (rptID). You can find the dataset under this ID to review.

All protection indications that are to be transmitted to the client are added to the dataset with the name **Protection**.



[sc_7SR5_StaticReportIndications, 1, --_--]

Figure 2-22 Static Report with Protection Device Indications from the Overcurrent Protection

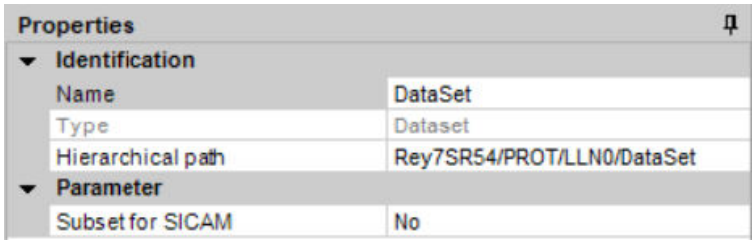
Server

The buffers in which the indications are located in the device are specified in the server on a manufacturer-specific basis.

The properties of the report (dataset, trigger conditions...) are saved in so-called **Report Control Blocks (RCB)**.

You can also change the dataset names that the system suggests (dataset) in the properties dialog of the dataset.

To make it easier to find the data during the subsequent review, Siemens recommends that you change the dataset name. In the example, the name of the dataset is changed to **Protection**.



[sc_7SR5_PropertiesDialog, 1, --_--]

Figure 2-23 Properties Dialog for a Dataset with Protection Device Indications

Test Mode

All data objects can be identified with a test flag. If the function block to which the data object belongs is in **Test** mode, then the test flag for a date object has been set. However, not all objects that are received via communication are identified with the test flag by the test mode of the function block. Input proxy objects, for example, contain the test flag that was received via communication.

The **Test** mode of a function block can be simulated by the following actions:

- The function block has been placed in test mode by the parameter **Mode** or by the controllable **Mod**.
- The entire device has been placed in the application test mode (HMI: Device functions/Operating modes/test).

If the reports have been configured, the data are written to an SCD file (Substation Configuration Description File) after the export. This file is important for loading the data in the device that is simultaneously the IEC 61850 server. To import indication lists into the client, use the SCD file. In this way, the client knows the scope of the reports and the datasets that contain the information. This standardized data exchange is a great benefit compared to previous substation control protocols in which manufacturer-specific indication lists are exchanged in proprietary file formats or manually. The SCD file can be exported from the IEC 61850 System Configurator and is available as an input to the test program.

2.6.3.4 Testing Protection Indications

Using Reports to Test Protection Indications

✧ Create a report for the protection indication and connect the dynamic dataset with the control block.

✧ Operate the protection element by secondary inject

- or -

✧ Use binary inputs that trigger the protection application in order to pick up the protection indication.

Protection Indication on the IEC Browser

✧ Select the **Reporting** field.

- or -

✧ Click the **Auto Refresh** button in the IEC client.

✧ Pick up the protection indication.

This will enable you to detect changes on the device via the client.

2.6.4 File Transfer

File transfer is used to transmit fault records from a server to a client. The fault records, such as defined in the COMTRADE standard, are stored in the server as a configuration file (.cfg) and a binary data file (.dat). The analysis program reads both files and can then display the fault record with analog and binary traces. This requires special analysis programs, for example, SIGRA or Reydisp Evolution 32.

The configuration file contains, among other information:

- All analog and binary traces contained in the fault record
- Names of the traces
- Sampling rate

The raw data for these traces are contained in the data file, which is stored as a binary COMTRADE file in the device.

An IEC 61850 client can retrieve a directory of the fault record from the device. It can later transmit the records from the device with MMS file transfer. You can find more information in the *PIXIT, PICS, TICS IEC 61850 Manual*.

NOTE

Fault records can also be read from the device by Reydisp Manager 2 and viewed in Reydisp Evolution 32. Transmission to Reydisp Manager 2 does not use the IEC 61850 protocol, but instead uses a compressed and encrypted protocol.

The IEC 61850 Standard defines a **SETTING-GROUP-CONTROL-BLOCK** model (SGCB). This model allows an item to have several values that can be used individually. It provides mechanisms for switching between several values of one or more data objects. Related values form the settings group.

The device supports up to 4 different settings groups that can be configured with Reydisp Manager 2. The SGCB of a 7SR5 device is found in the logical node LLN0 of the logical device (LD) **PROT**.

The following structure is defined for the SGCB model:

SGCB Class			
Attribute Name	**Attribute Type**	**Read and Write Access (Read (r)/Write (w))**	**Description**
NumOfSG	INT8U	r	The attribute **NumOfSG** identifies the total number of available settings groups. n = NumOfSG
ActSG	INT8U	w	The attribute **ActSG** identifies the values of the settings group that are in the active buffer. Admissible range: 1 to n

SGCB Class			
Attribute Name	**Attribute Type**	**Read and Write Access (Read (r)/Write (w))**	**Description**
EditSG	INT8U	w	7SR5 does not support setting edit in a specific settings group, only active group change via **ActSG**. Admissible range: 0
CnfEdit	BOOLEAN	w	Not supported as EditSG, Setting change not supported.
LactTm	TimeStamp	r	The attribute **LActTm** designates the time at which the **SelectActiveSG** service was edited.
Services SelectActiveSG GetSGCBValue			

2.6.5 Control via IEC 61850

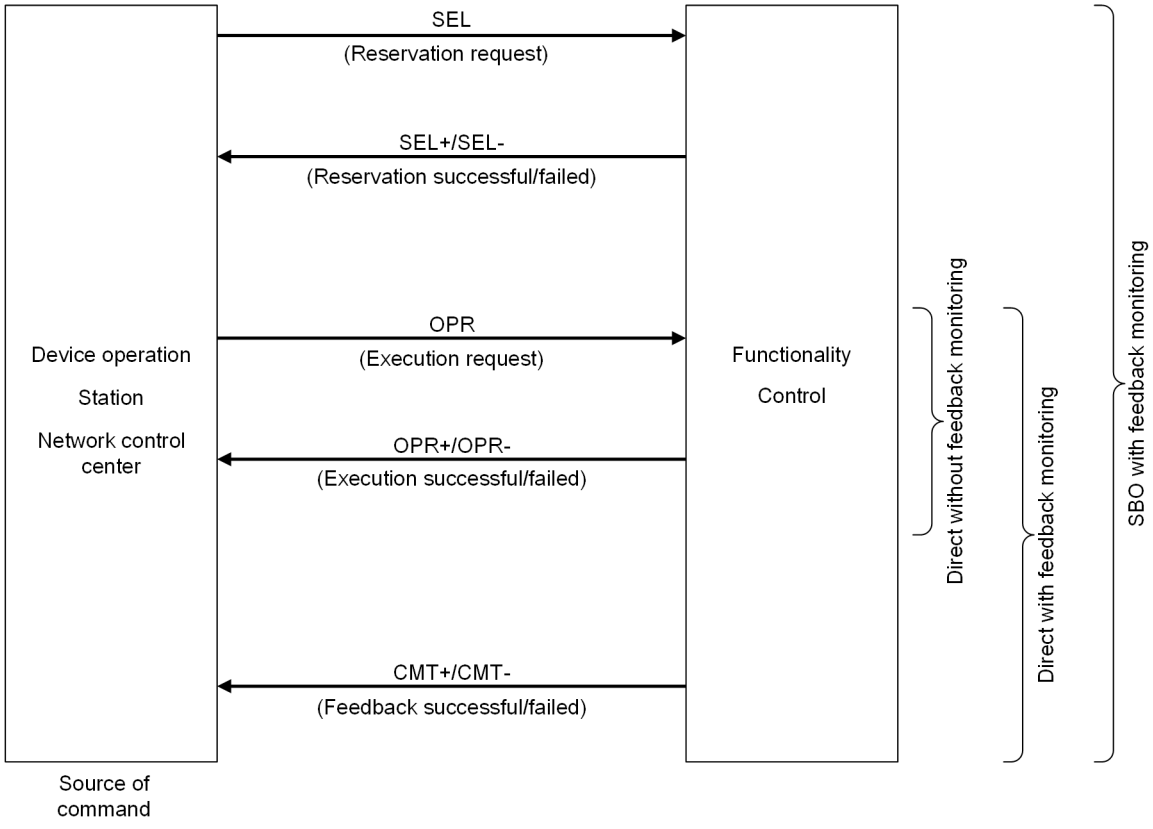
7SR5 devices support 3 control models defined in the standard:

- Direct without feedback monitoring
- Direct with feedback monitoring
- SBO (Select Before Operate) with feedback monitoring

NOTE

When using IEC 61850 over the front USB port, control functions will only be enabled when the device is in **Remote** mode, as IEC 61850 control is designated as a Remote SCADA protocol for control functions.

The next figure shows the command sources, command types, and control models.

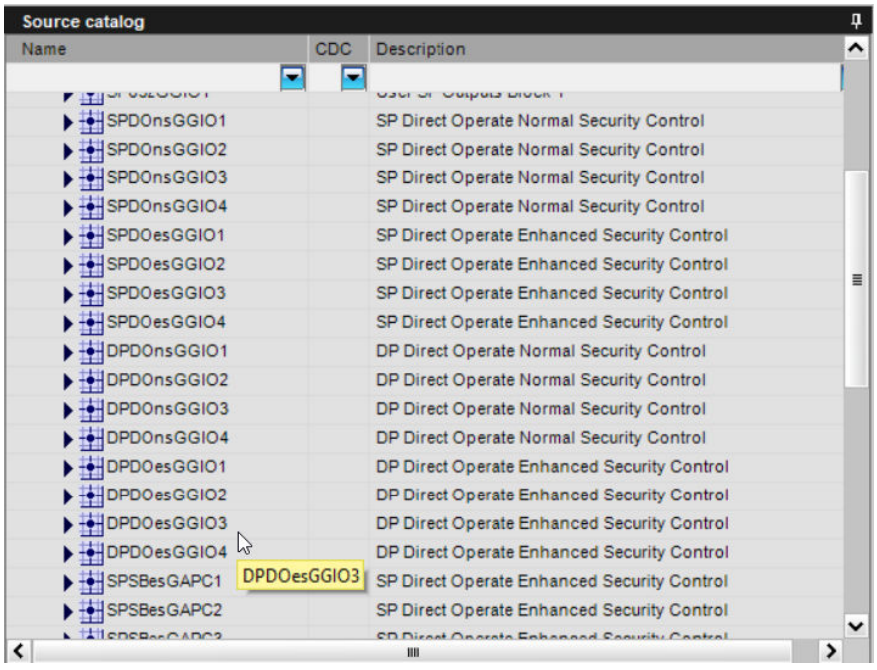


[dw_7SR5_ControlViaIEC61850.vsd, 1, en_US]

Figure 2-24 Command Sources, Command Types and Control Models

SBO control models support the **operate-once** variant. The command may only be interrupted if it conforms with the standard.

A control model is preset for all objects.



[sc_7SR5_ControlModel, 1, --, --]

Figure 2-25 Control Model Selectable Nodes

For controllable objects that are coupled to the process, Siemens and the standard recommend always selecting the control models **with enhanced security** (feedback monitoring).

According to the standard, commands with test state indicator are supported. This implies that a test command can be only implemented if the object **Beh** of the associated LNs has the value **test**.

The IEC 61850 protocol permits testing the switching commands for their operability prior to implementation. Test bits allow the interlocking devices to be switched on and off. The interlocking check bit affects which command checks are to be performed.

7SR5 devices have an **`IEC 61850 Check Bits`** parameter in the Device setting file which is set to **`Disabled`** by default. This means the test attribute is disregarded and the interlocking check is always performed for the synchrocheck and interlocking, where applicable.

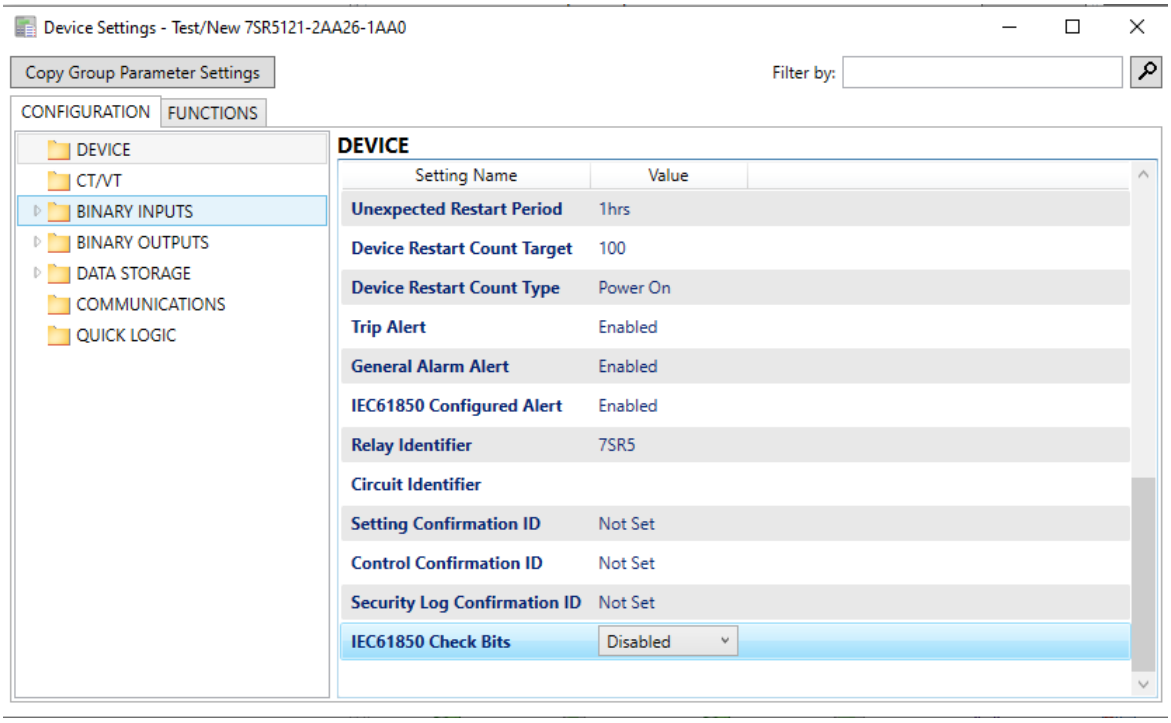


Figure 2-26 IEC 61850 Check Bits

- If the Device parameter **`IEC 61850 Check Bits`** is set to **`enabled`** the test bit will be checked.
- If the test bit is set, it will be treated like the **`Interlocking`** and synchrocheck conditions will be tested and the switching command will be executed only if all other command checks prove to be successful.
- If the synchrocheck is not switched on for a circuit breaker and a switching command with the respective test bit is transmitted via IEC 61850 to the device, this switching command will be rejected with a negative acknowledgment **OPR-**. If the synchronization function is not a part of the **Circuit-breaker** function group, the test bit will be ignored and the switching command will be executed if all other command checks prove to be successful.
- If the test bit is not set, it will be treated like the **non-interlocked** switching mode. If the **Interlocking** function block is not available in the **Circuit-breaker** function group, the interlocking conditions will not be tested and the switching command will be executed if all other command checks prove to be successful.

2.6.6 Measured Values and Measured-Value Description

In order to detect the measured values in the buffer or transmission via reports, the application of the deadband is important.

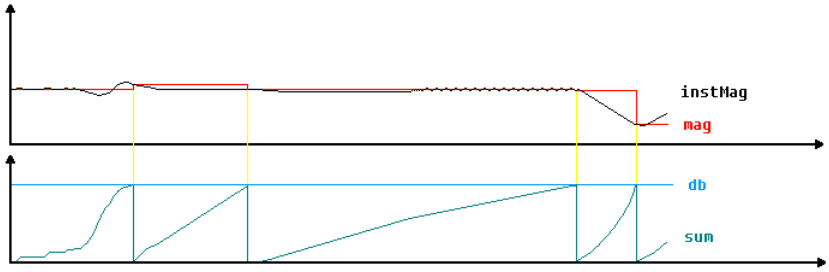
Measured values **instMag** are only forwarded with the deadband mechanism if they change outside of an adjustable window. The window is defined as an upper and lower limit, a percentage of the actual measured value.

NOTE

The summation takes place every 1 s.

If the measured value **instMag** deviates from the deadband value **mag**, then the amount of the difference of these 2 values will be added. If over time the accumulated sum exceeds the upper limit **db** (deadband value), the deadband value **mag** will be set to the current value of **instMag**, and the sum will be reset to 0.

By using the trigger option **TrgOp=dchg**, the deadband value **mag** can be saved in the buffer or can be reported. After setting the trigger option **TrgOp=dchg**, the device may wait several milliseconds before the report is sent.



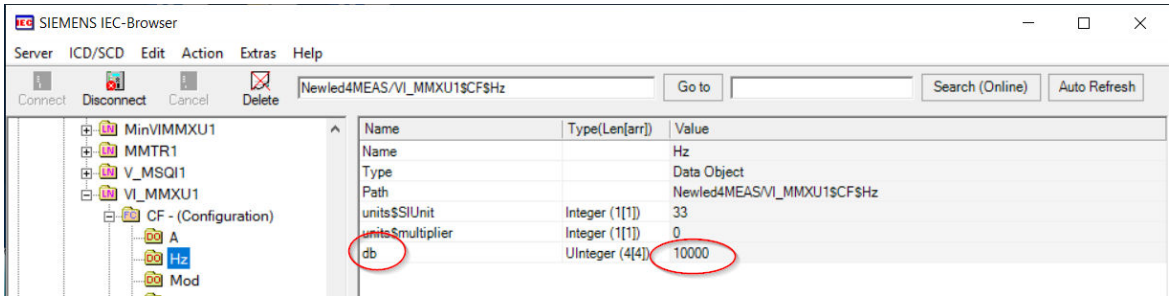
[sc_dia_iec, 1, --_--]

Figure 2-27 Diagram on the Behavior of Values

The diagram illustrates the relationship between the following values:

- Measured value **instMag** (instCVal.mag)
- Deadband value **mag** (CVal.mag)
- Upper limit **db** (deadband value)
  The upper limit **db** is used as a unit of 0.001 % and refers as a percentage to the currently measured value.
- Accumulated sum, referred to simply as **sum**

The deadband value **mag** changes significantly slower than the measured value **instMag**.



[sc_7SR5_DBValue, 1, --_--]

Figure 2-28 Example of db Value

The figure shows the **db** value in the Siemens IEC Browser PC application tool which is distributed with DIGSI.

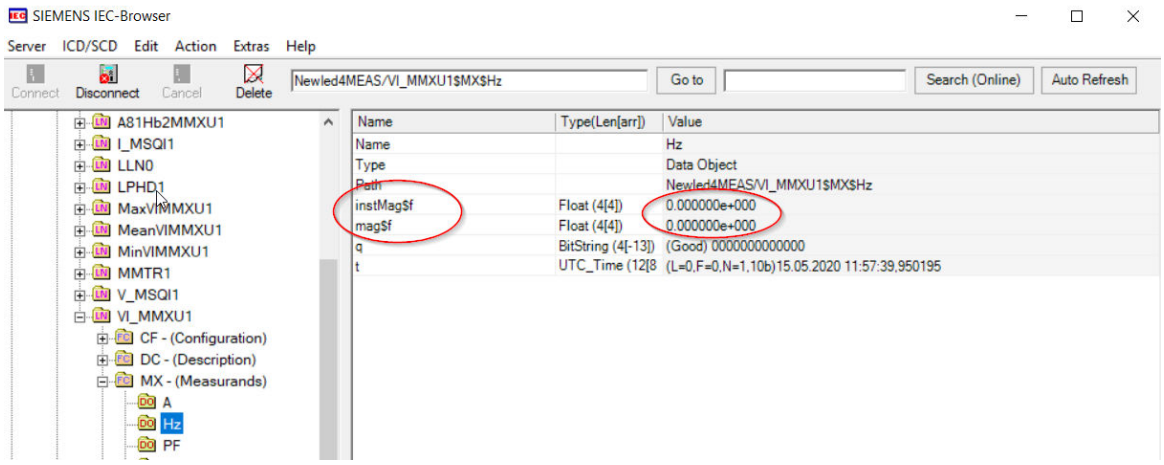


Figure 2-29 instMag and mag Values

Large differences between **instMag** and **mag** lead to the repeated updating of **mag**.
Small differences between **instMag**and **mag** lead to an infrequent change of **mag**.

NOTE

Since **db** is a percentage of the measured value, very small measured values and increased noise may cause a flood of **mag** indications. An additional threshold in the device prevents a flood of indications.

If spontaneous changes do not need to be sent quickly, reports with measured values can also be transmitted cyclically.

2.6.7 Device Time

2.6.7.1 Description

The SNTP protocol can be used for time synchronization via Ethernet networks.

If Ethernet is selected in the device parameters as either the Master or Back up time source the time synchronization would be performed via the Ethernet network; this option is available both for electrical and optical interfaces.

In addition to this synchronization protocol, other options are available for the 7SR5 devices. Selection is performed in Reydisp Manager 2 device parameterization. If such a method has been activated, time synchronization via the Ethernet network is not performed and each device must be set for the selected time synchronization method.

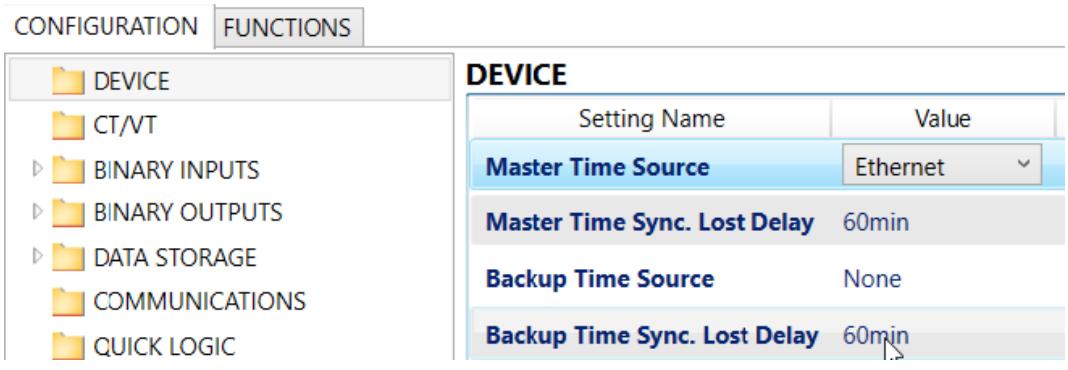
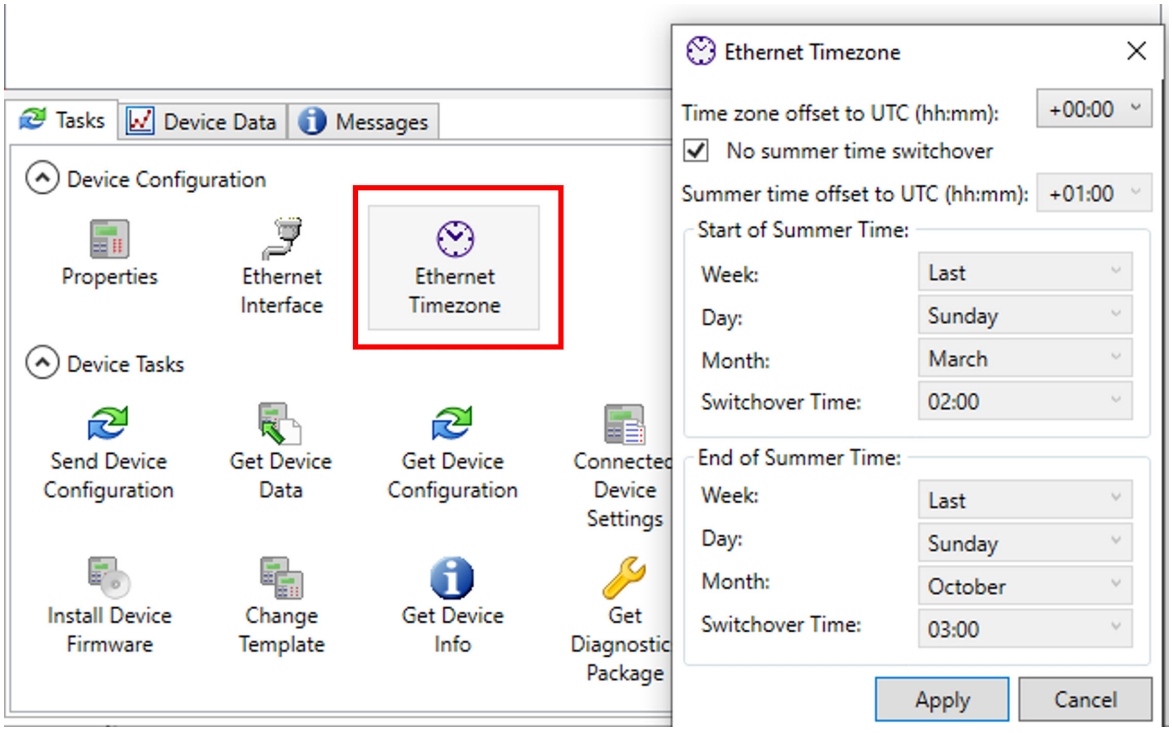


Figure 2-30 Device Parameter Time Source Setting

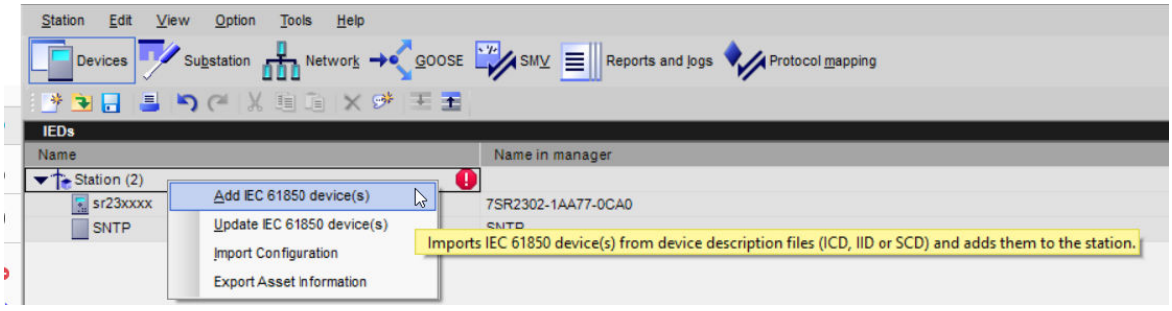
The Ethernet time zone must also be configured as the Ethernet will use UTC which may differ from the device local time.



[sc_7SR5_EthernetTimezone, 2, --_--]

Figure 2-31 Device-Time Messages – Example LN/LTIM

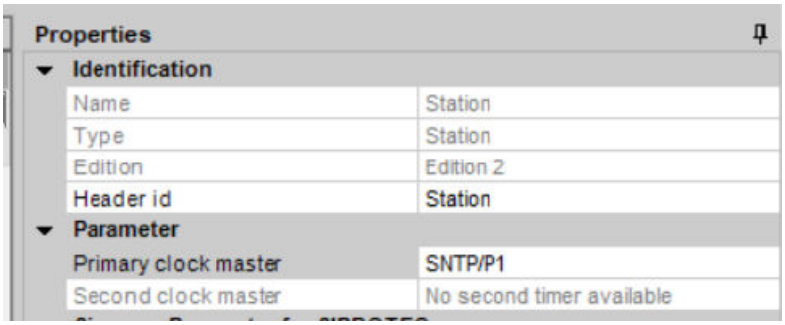
The SNTP ICD file(s) must be added as a device to the Station in the IEC 61850 configurator.



[sc_7SR5_AddIECDevice, 1, --_--]

Figure 2-32 Add IEC 61850 Device

The SNTP devices are shown in the station properties and must be configured as the Primary and Secondary clock source from the drop down list. Each SNTP must have a unique IP address.
An SNTP file is supplied with RDM2. See *8.5 SNTP*.



[sc_7SR5_StationProperties, 1, --_--]

Figure 2-33 Station Properties for IEC 61850 Clock

7SR5 devices support both Edition 1 and Edition 2 according to IEC 61850-7-2. In Edition 2, the logical attributes **LeapSecondsKnown**, **ClockFailure**, **ClockNotSynchronized**, and the value **TimeAccuracy** are maintained in each time stamp. In Edition1, these signals contain default values. Thus, the interoperability for substation automation technologies is ensured for both editions.

Status and Accuracy

The internal clock of the 7SR5 device reaches the steady state of ±1 ms after a maximum of 15 minutes of a healthy synchronization. This internal accuracy cannot be measured here because a precise trigger option is not available. For checking purpose, a binary input is often triggered (configured: without a software filter, with recalculation of the hardware filtering time). Such measurement, however, including jitter in binary input processing, has deviations of approx. ±3 ms.

Time Fault Indication

A time fault indication is output when the clock server does not respond to inquiries of the device (after the configured Sync Lost delay monitoring time has expired. From now on, the status of type time fault is set in the time stamp of all indications. The bit clock failure in the IEC 61850-8-1 will be set accordingly in the time stamp of the Data Object.

The time fault indication does not appear when the SNTP server itself has no connection to the time source (e.g. no antenna signal, ...) and sends clock signals to all devices according to its internal accuracy. However, at start-up, as long as no connection has been established with the SNTP server or the time synchronization message indicates a stratum greater than 3, the bit **`ClockNotSynchronized`** will be set in the time stamp of the Data Object, to indicate that the clock has not yet been synchronized.

With a synchronized device, the following values are set:

- TimeAccuracy = 10
- ClockNotSynchronized = false
- ClockFailure = false

With an unsynchronized device, the following values are displayed for all indications:

- TimeAccuracy = 10
- ClockNotSynchronized = true

These sources are considered as perfect – apart from a measured offset to device time.

2.6.7.2 Determining the ClockNotSynchronized Value

After device startup, this value is first set to **true**. Through a 1st synchronization using one of the set sources, it changes to **false**.

However, if no more synchronization telegrams are received for the set time **Fault indication after** (default: 600 s), then the value is set to **ClockNotSynchronized** = **true**.

If the value **ClockFailure** is set, then also **ClockNotSynchronized** is always set.

The status of **ClockNotSynchronized** corresponds to the state of the message **Time sync. error** right up to startup. However, the message status at startup is **off**. If no synchronization takes place, for parameterized sources, this status changes to **on** after **Fault indication after**.

2.6.7.3 Determining the ClockFailure Value

If hardware errors occur on the time components, the logical value **ClockFailure** is set to **true**.

This value is set at startup until a valid time can be read from the clock module buffered with the button cell or until the time can be set manually (HMI, Reydisp Manager 2) or by a parameterized synchronization source.

If **ClockFailure** is set, **ClockNotSynchronized** = **true**.

The status of the message **Clock fail** corresponds to the status of the value.

2.6.8 Asset Management

You can monitor firmware and configuration statuses across the entire plant. Attributes of the devices are used for this purpose.

The following versions and information are made available for asset management via the IEC 61850 interface.

Asset	IEC 61850 Name	Note
Device Firmware Version	Every LPHD.DCPhyNam.swRev	Version V02.20 is displayed as **02.20.xx**
Communication Module Firmware Version	Every LLNO.DCNamPlt.swRev	Version V01.20 is displayed as **01.20.xx**
User Configuration	Every LLNO.DCNamPlt.configRev	Displayed as date and time of sent file.
Vendor	LPHD.PhyName.vendor	
Serial Number	LPHD.PhyName.serNum	
Product Code HW Version	LPHD.PhyName.hwRev	
Device Type MLFB	LPHD.PhyNam.model	

3 DNP3 TCP

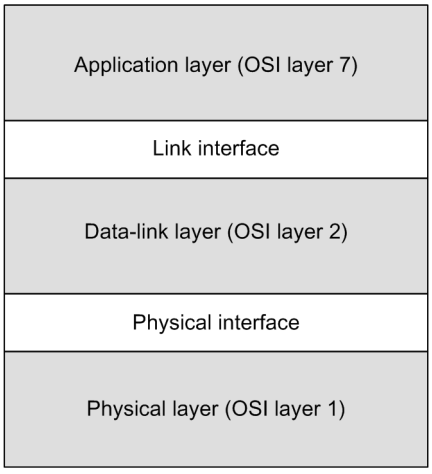
3.1	Protocol Characteristics	56
3.2	Settings and Properties	71

3.1 Protocol Characteristics

3.1.1 Protocol Structure

Description

DNP3 has a graded architecture. Instead of the OSI model, however, a simplified 3-layer model suggested by the IEC is used. This model was named **Enhanced Performance Architecture** (EPA) by the IEC. However, DNP3 adds a 4th layer, a pseudo transport layer, with which messages can be segmented. The graphics were taken from the DNP3-Spec-V1-Introduction-20071215.pdf standard.



[dw_epadia, 1, en_US]

Figure 3-1 EPA Diagram

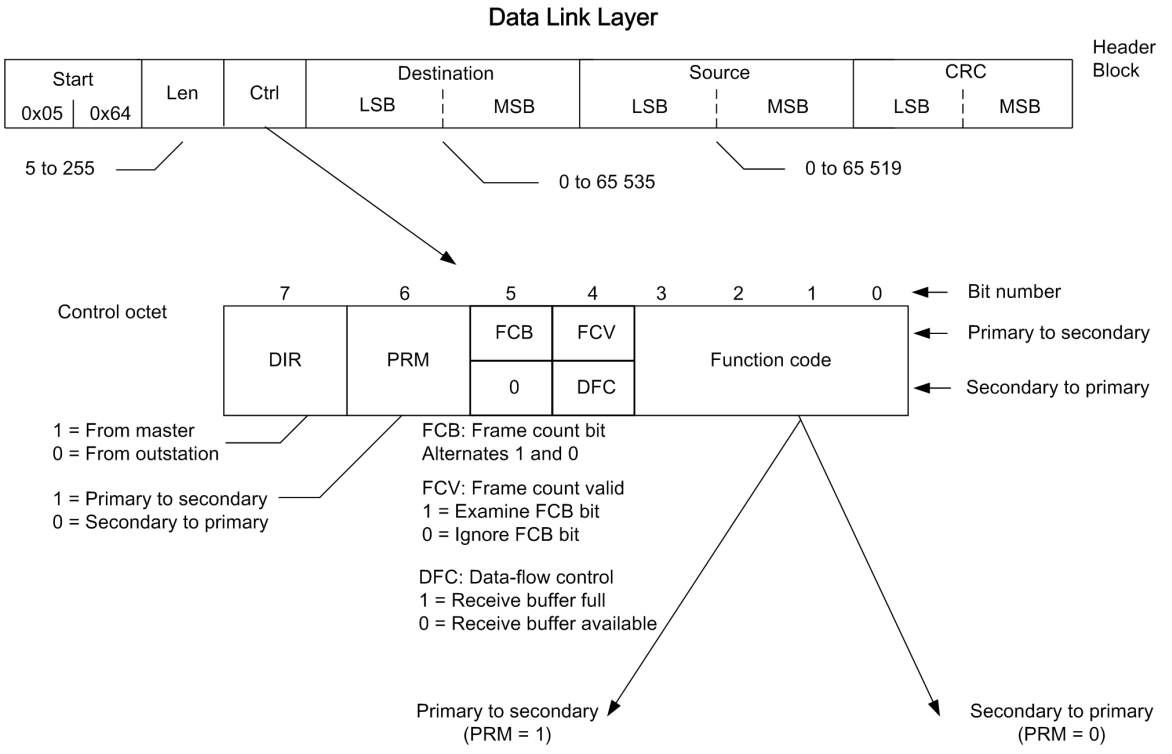
The 7SR5 device supports the DNP3, level 2 version.

You can find additional information in the standard IEEE 1815 at *http://standards.ieee.org/*.

Physical Layer

The physical layer mainly deals with the physical media through which the protocol is transferred. The physical layer deals with, for example, the condition of the media (free or occupied) and the synchronization through the media (start and stop).

DNP3 most frequently uses a simple, asynchronous serial transmission like RS232 or RS485 with physical media like pilot wires and optical fiber. Moreover, the transmission can take place through Ethernet.



Primary function code	Function-code name	FCV bit
0	RESET_LINK_STATES	0
1	-	-
2	TEST_LINK_STATES	1
3	CONFIRMED_USER_DATA	1
4	UNCONFIRMED_USER_DATA	0
5	-	-
6	-	-
7	-	-
8	-	-
9	REQUEST_LINK_STATUS	0
A	-	-
B	-	-
C	-	-
D	-	-
E	-	-
F	-	-

Secondary function code	Function-code name
0	ACK
1	NACK
2	-
3	-
4	-
5	-
6	-
7	-
8	-
9	-
A	-
B	LINK_STATUS
C	-
D	-
E	-
F	NOT_SUPPORTED

[dw_dalila, 1, --_--]

Figure 3-2 Physical Layer

Data-Link Layer

The data link layer manages the logical connection between the transmitter and the receiver of the information and improves the fault tolerance of the physical line. This is achieved with DNP3 by starting every data transmission package with a data head, and a 16 bit CRC (cyclic redundancy check) is executed for every 16 bytes of the package.

A package is a part of the complete message transferred through the physical layer. The maximum size of a data package is 256 bytes. Each package has a 16-bit source address and a 16-bit target address, which can also be a general address (0xFFFF).

The 10-byte data link layer head contains:

- Address information
- 16-bit start code

- Frame length
- Data link control byte

The data link control byte displays the cause of the data transmission and the status of the logical connection. The data link control byte can have the following values:

- ACK (data link confirmation)
- NACK (negative confirmation)
- Connection needs to be reset
- Connection is reset
- Data link confirmation from the package required

If a data link confirmation is needed, the receiver must respond with an ACK data package if the package was received and the CRC checks were successful. If no data link confirmation is requested, no response is required.

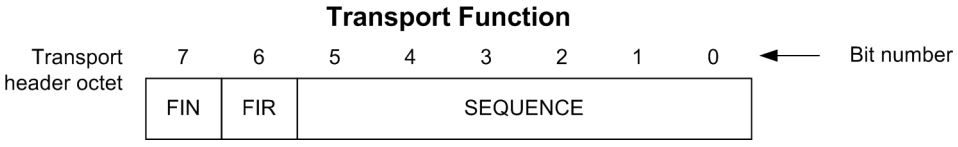
Pseudo Transport Layer

The pseudo transport layer segments application messages in multiple data transmission packages.

The pseudo transport layer implements an individual byte function code for every package. The byte function code displays what the data transmission package is:

- The 1st package of a message
- The last package of a message
- Both (for individual message packages)

The function code delivers a running package number. This subsequent package number is increased with each package and allows the receiver's transport layer to analyze the package.



{dw_trfnct, 1, _...}

Figure 3-3 Pseudo Transport Layer

Application Layer

The application layer responds to received messages and creates messages based on the necessity and availability of the user data. As soon as messages are available, they are sent to the pseudo transport layer. The messages are segmented here, sent to the data link layer and transferred through the physical layer.

If the data that is to be sent is too large for an individual application message, a number of application messages can be created and sent in a sequential manner. Each message is an independent application message. Their only connection with each other is the label in all messages that says that more messages will follow. Only the last message does not contain this label. Each application message refers to a fragment due to the fact that the user data may be fragmented. A message can thus be a single fragment message or a multi-fragment message.

Application packages from DNP3 slaves are normally responses to queries. A DNP3 slave can also send a message without a request, thus, an unsolicited response.

As in the data link layer, application fragments can be sent with a confirmation request. An application confirmation indicates that a message was not only received, but rather it was also syntactically analyzed without any errors. A data transmission confirmation or an ACK indicate only that the transmission package was received and that the CRC checks were error-free.

Each application package begins with an application layer header, followed by one or more object heads/ object data. The application layer header contains an application control code and an application function code.

If one of the following conditions is fulfilled, then the application control code contains labels:

- The package is a multi-package message.
- An application layer acknowledgment is requested for the package.
- The package is not requested.

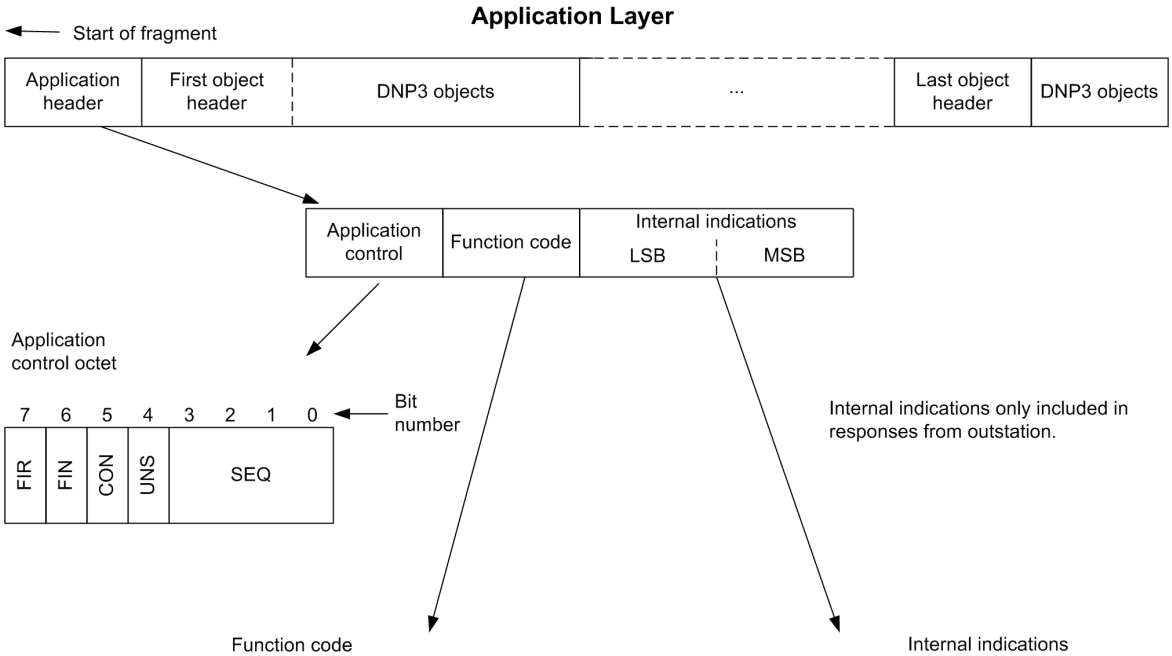
The application control code contains a continual application layer number. With this application layer number, the receiving application layer can recognize alien packages or lost packages.

The application function code in the header of the application layer indicates the cause or the requested function in the message. While DNP3 allows a number of data types in a single message, it also allows only an individual query for a data type within the message.

Examples for application function codes include:

- Acknowledgments for confirmation on the application layer
- Read and write
- Select and execute (SBO (select before operate), controls)
- Direct control (for switching objects without SBO)
- Save and delete (for counters)
- Restart
- Enable and disable non-requested messages
- Selection of the classes

The application function code in the header of the application layer applies for all object headers. Thus, the application function code applies for all data within the message package.



Function code

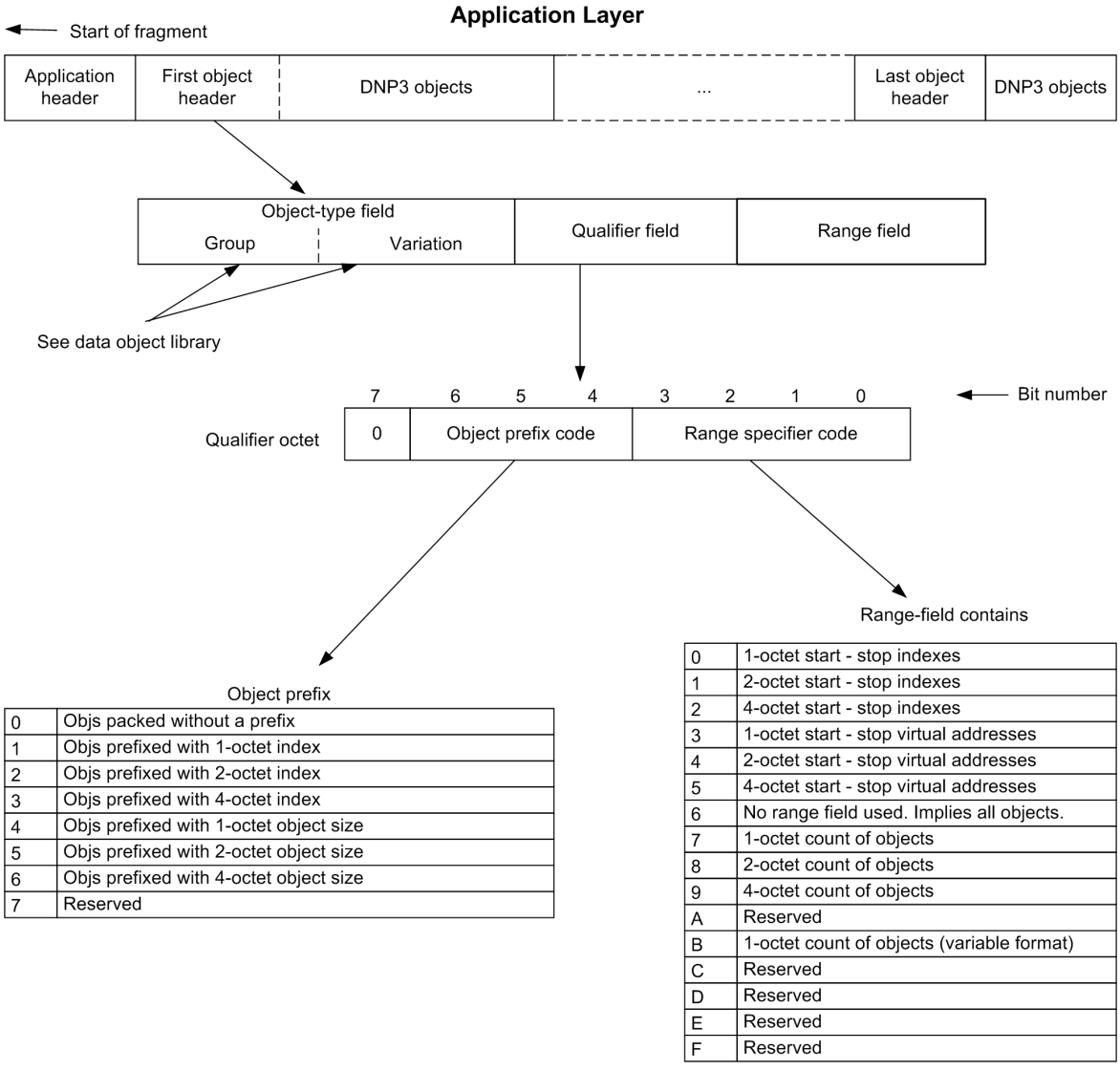
Requests (Hex)			
0	Confirm	10	Initialize application
1	Read	11	Start application
2	Write	12	Stop application
3	Select	14	Enable unsolicited
4	Operate	15	Disable unsolicited
5	Dir operate	16	Assign class
6	Dir operate - No resp	19	Open file
		1A	Close file
		1C	Get file information
D	Cold restart	1D	Authenticate file
E	Warm restart	1E	Cancel file
F	Initialize data		
Responses (Hex)			
81	Response		
82	Unsolicited response		

Internal indications

LSB	
IIN1.0	All stations
IIN1.1	Class 1 events
IIN1.2	Class 2 events
IIN1.3	Class 3 events
IIN1.4	Need time
IIN1.5	Local control
IIN1.6	Device trouble
IIN1.7	Device restart
MSB	
IIN2.0	Function code not supported
IIN2.1	Object unknown
IIN2.2	Parameter error
IIN2.3	Event buffer overflow
IIN2.4	Already executing
IIN2.5	Configuration corrupt
IIN2.6	Reserved 1
IIN2.7	Reserved 2

[dw_aplay_1, 1, --_--]

Figure 3-4 Application Layer – Part 1



[dw_aplay_2, 1, --_--]

Figure 3-5 Application Layer – Part 2

3.1.2 Transfer through Ethernet

Requirements for the Physical, Transport, and Application Layers

The transmission through Ethernet takes place according to the same specifications as transmission through serial connections. Only the method for the time synchronization through the network must be changed. All requirements in the other protocol layers can be applied. Connection packages are transported in an unchanged manner through the Ethernet protocol suite under the control of the data link layer.

Acknowledgements

If the 7SR5 devices communicate through Ethernet, they must not work with confirmations from the physical layer (CONFIRMED_USER_DATE). If necessary, the confirmations must be used by the application layer. For confirmations of the application layer, there is no difference between IP networks (IP = Internet protocol) and serial channels.

Message Transmission

As soon as the data-link layer has established a TCP connection (TCP = Transmission Control Protocol), the physical layer of DNP3 can transmit packages as needed. The type of query (requested or not requested) does not depend on the type of connection.

The 7SR5 devices support dual DNP3 Ethernet masters on the same Ethernet module.

A typical case for each DNP3 master is as follows:

- TCP connection is established with a device
- Class 1, 2, 3, 0 request is executed once
  The data integrity is checked.
- Non-requested transmission is made possible
- Work is continued in this mode.

3.1.3 Functional Scope

The following table identifies which object variations, function codes and qualifiers the DNP3 IP implementation of the Multi-Functional Protective Relay will support in both request messages and in response messages.

For static (non-change-event) objects, requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01.

Requests sent with qualifiers 17 or 28 will be responded with qualifiers 17 or 28.

For change-event objects, qualifiers 17 or 28 are always responded.

Table 3-1 Triangle MicroWorks, Inc. DNP 3.0 Slave Source Code Library

Objects			Request		Response	
Object No.	Variation No.	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
1	0	Binary Input – Any Variations	1 (read)	00, 01 (start-stop) 06 (no range) 07, 08 (limited qfy) 17, 28 (index)		
1	1	Binary Input with Status	1 (read)	00, 01 (start-stop) 06 (no range) 07, 08 (limited qfy) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
2	0	Binary Input Change – Any Variations	1 (read)	06 (no range, or all) 07, 08 (limited qfy)		
2	2	Binary Input Change with Time	1 (read)	06 (no range, all) 07, 08 (limited qfy)	129 (response) 130 (unsol. resp)	17, 28 (index)

Objects			Request		Response	
Object No.	Variation No.	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
10	0	Binary Output – Any Variations	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qfy) 17, 28 (index)		
10	2	Binary Output with Status	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qfy) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
12	1	Control Relay Output Block	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, noack)	17, 28 (index)	129 (response)	echo of response
20	0	Binary Counter – Any Variations	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qfy) 17, 28 (index)		
20	1	32-bit Binary Counter (with Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qfy) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
22	0	Counter Change Event – Any Variations	1 (read)	06 (no range, or all) 07, 08 (limited qfy)		
22	1	32-bit Counter Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited qfy)	129 (response) 130 (unsol. resp)	17, 28 (index)
30	0	Analog Input – Any Variations (default variation = 2)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qfy) 17, 28 (index)		

Objects			Request		Response	
Object No.	Variation No.	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
30	2	16-bit Analog Input (used for measured values)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qfy) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index)
32	0	Analog Change Event – Any Variations (default = 2)	1 (read)	06 (no range, or all) 07, 08 (limited qfy)		
32	2	16-bit Analog Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited qfy)	129 (response) 130 (unsol. resp)	17, 28 (index)
50	1	Time and Date	1 (read)	07 (limited qfy = 1)	129 (response)	07 (limited qfy = 1)
			2(write)	07 (limited qfy = 1)		
60	1	Class 0 Data	1 (read)	06 (no range, or all)		
60	2	Class 1 Data	1 (read)	06 (no range, or all) 07, 08 (limited qfy)		
60	3	Class 2 Data	1 (read)	06 (no range, or all) 07, 08 (limited qfy)		
60	4	Class 3 Data	1 (read)	06 (no range, or all) 07, 08 (limited qfy)		
70	3	File Command	25 (open)	5b (free format)		
70	4	File Command Status	26 (close) 30 (abort)	5b (free format)	129 (response) 130 (unsol. resp)	5B (free format)
70	5	File Transfer	1 (read)	5b (free format)	129 (response) 130 (unsol. resp)	5B (free format)
70	6	File Transfer Status			129 (response) 130 (unsol. resp)	5B (free format)
70	7	File Descriptor	28 (get file info)	5b (free format)	129 (response) 130 (unsol. resp)	5B (free format)
80	1	Internal Indications	2 (write)	00, 01 (start-stop) (Index must = 4 or 7)		

Table 3-2 DNP3 IP Device Profile Documents

<table>
<tr><td colspan="2">DNP3 IP
DEVICE PROFILE DOCUMENT</td></tr>
<tr><td colspan="2">Vendor Name: Siemens AG</td></tr>
<tr><td colspan="2">Device Name: 7SR5</td></tr>
<tr><td>Highest DNP Level Supported:
For Requests: Level 2
For Responses: Level 2</td><td>Device Function:
☐ Master
☒ Slave</td></tr>
<tr><td colspan="2">Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table):
For static (non-change-event) object requests, request qualifier codes 07 and 08 (limited quantity), and 17 and 28 (index) are supported. Static object requests sent with qualifiers 07, or 08, will be responded with qualifiers 00 or 01.
16-bit and 32-bit Analog Change Events without Time may be requested.
Sequential file transfer, Object 70, variations 3 through 7, are supported.</td></tr>
<tr><td>Maximum Data Link Frame Size (octets):
Transmitted: 292
Received: 292</td><td>Maximum Application Fragment Size (octets):
Transmitted: 2048
Received: 2048</td></tr>
<tr><td>Maximum Data Link Re-tries:
☒None
☐Fixed
☐Configurable from 0 to 65535</td><td>Maximum Application Layer Re-tries:
☒None
☐Configurable from 0 to 65535</td></tr>
</table>

Requires Data Link Layer Confirmation: ☒Never ☐Always ☐Sometimes ☐Configurable
Requires Application Layer Confirmation: ☐Never ☐Always ☒When reporting Event Data (Slave devices only) ☒When sending multi-fragment responses (Slave devices only) ☐Sometimes ☐Configurable
Timeouts while waiting for: Data Link Confirm: ☒None ☐Fixed at ____☐Variable ☐Configurable Complete Appl. Fragment: ☒None ☐Fixed at ____ ☐Variable ☐Configurable Application Confirm: ☐None ☐Fixed at ____ ☐Variable ☒Configurable Complete Appl. Response: ☒None☐ Fixed at ____ ☐Variable ☐Configurable Others: Transmission Delay: no intentional delay Select/Operate Timeout: configurable (default 5 s) Need Time Interval: fixed to 60 s Unsolicited Notification Delay: configuarble (default 5 s) Unsolicited Response Retry Delay: configurable (default 5 s)
Sends/Executes Control Operations: WRITE Binary Outputs ☒Never ☐Always ☐Sometimes ☐Configurable SELECT/OPERATE ☐Never ☒Always ☐Sometimes ☐Configurable DIRECT OPERATE ☐Never ☒Always ☐Sometimes ☐Configurable DIRECT OPERATE – NO ACK ☐Never ☒Always ☐Sometimes ☐Configurable Count > 1 ☒Never ☐Always ☐Sometimes ☐Configurable Pulse On ☐Never ☒Always ☐Sometimes ☐Configurable Pulse Off ☒Never ☐Always ☐Sometimes ☐Configurable Latch On ☐Never ☒Always ☐Sometimes ☐Configurable Latch Off ☐Never ☒Always ☐Sometimes ☐Configurable Queue ☒Never ☐Always ☐Sometimes ☐Configurable Clear Queue ☒Never ☐Always ☐Sometimes ☐Configurable
Note: CONTROL RELAY OUTPUT BLOCK parameters (count, on-time, off-time) are ignored.

Reports Binary Input Change Events when no specific variation requested: ☐Never ☒Only time-tagged ☐Only non-time-tagged ☐Configurable to send one or the other	Reports time-tagged Binary Input Change Events when no specific variation requested: ☐Never ☒Binary Input Change With Time ☐Binary Input Change With Relative Time ☐Configurable

Sends Unsolicited Responses: ☐Never ☒Configurable ☐Only certain objects ☐Sometimes (attach explanation) ☒ENABLE/DISABLE UNSOLICITED Function codes supported	Sends Static Data in Unsolicited Responses: ☒Never ☐When Device Restarts ☐When Status Flags Change No other options are permitted.
Default Counter Object/Variation: ☐No Counters Reported ☐Configurable ☒Default Object 20 and Default Variation 01 Default Variation: ☐Point-by-point list attached	Counters Roll Over at: ☐No Counters Reported ☐Configurable (attach explanation) ☐16 Bits ☒**32 Bits** ☐Other Value: _____ ☐Point-by-point list attached
Sends Multi-Fragment Responses: ☒Yes ☐No ☐Configurable	
Sequential File Transfer Support: Append File Mode ☐Yes ☒No Custom Status Code Strings ☐Yes☒No Permissions Field ☒Yes ☐No File Events Assigned to Class ☐Yes ☒No File Events Send Immediately ☐Yes ☒No Multiple Blocks in a Fragment ☐Yes ☒No Max Number of Files 1	

3.1.4 Fault Record Transfer

The file transfer can be used to transfer a fault record (Object 70). The **Rcd Made** message can be used to query the availability of the fault record. When the message is mapped and there is a new fault in the device the message is transferred. Cyclical reading of the directory is also possible. If there are files in the directory then there are also fault records. Specifically, the transfer takes place as follows:

The following steps are required to read the directory:

- Reading of the directory with File Transport Object (obj 70 var 7)
- Waiting for the response
- If the read operation was successful, the master station increases the block number and reads the next block.
- If the status indicator **Last** is set in the response, the master station closes the file with **File Operation Status Object** (obj 70 var 4).

Every fault record is identified by an existing file. The following information is transferred for this:

- File Name Offset
- File Name Size
- File Type
- File Size
- Time Of Creation
- Permissions

- Request ID
- File Name

The master station can now select the required fault. The transfer takes place in the same manner as with reading the directory.

3.1.5 Buffered Events

Table 3-3 Maximum Number of Buffered Events

Event	Numbers	Note
Binary input change: DNP3 IP Object 2	100 as sequence of events	All changes will be entered in the event list, also multiple events from the same data object. In case of overflow, the internal indication IIN2.3 bit EVENT_BUFFER_OVER-FLOW is set and the oldest event is lost. This internal indication remains set and is reported to the DNP3 IP master until there is again storage in the event buffer for at least one event.
Counter change: DNP3 IP Object 22	10 most recent events	If a data object changes multiple times without the previous event being sent, then a new event will overwrite the value already stored in the event list.
Analog input change: DNP3 IP Object 32	50 most recent events	

3.1.6 Amount of Mappable Information

The following information can be mapped:

Information	Maximum Mappable Amount
Indications + Controllables at Tx	5000
Controllables at Rx	5000
Settings at Tx	Not supported
Measurements at Tx	5000
Counters at Tx	5000

NOTE

All addresses must use values of 5000 or less.

3.1.7 Additional Information

The mapping of the commands occurs like the mapping of messages. Here, object group 12 is preset.

Scaling Measured Values

The measured values between the 7SR5 device and the DNP3 master are transferred as integer values in 16-bit format. 16 bits correspond with a range from -32768 to 32767.

Converting Measured Values

Before the transfer of a measured value through DNP3, the measured values must be converted in the 7SR5 device. The measured values are scaled.

The scaling of a measured value determines the form of transmission. These forms of transmission are:

- Value type
- Scaling factor as configured in the CT/VT configuration

Changing the Setting Group

Switching on a setting group simultaneously switches off the currently active setting group. Transmission of the off value is insignificant for the switching of the setting group and is rejected by the 7SR5 device.

Control Mode Remote

Control mode from DNP3 is only allowed when the device Ethernet port is set to **`Remote`** mode or **`Local or Remote`** mode.

Scaling Factor

The measured value is multiplied in the 7SR5 device by the scaling factor.

The internal values are scaled as defined in the scaling values parameterized in Reydisp Manager 2, to 16 bit integers for sending in DNP3.

Percent Values

For percent values, Siemens recommends a scaling factor of 100. This results in an interpretation of the integer measured value (measured $value_{Integer}$) through DNP3 with a measured value from ± 32 767. This corresponds with a percentage value of ± 327.67%.

Primary Values

The position of the decimal point and the respective unit are determined for primary values based on the parameterized rated variables configured in the CT/VT ratio menu of the device configuration.

Multiplier

In addition for analogue inputs the communications editor allows a multiplier factor to be specified for each point, the value is multiplied by this factor before transmission. The multiplier could be used to scale values to fit in specific data variants, for example, if you have a value of 5.678 and need to send it back as a 16 bit 2, set the multiplier to 1000 and it will be send as 5678 keeping the precision.

Dead Band

For analogue inputs the communications editor allows a dead band factor to be specified for each point. This ± dead band specifies the window outside of which an event is generated.

Mapping on the Object Status

The following table shows mapping on the object status.

Table 3-4 Mapping on the Object Status

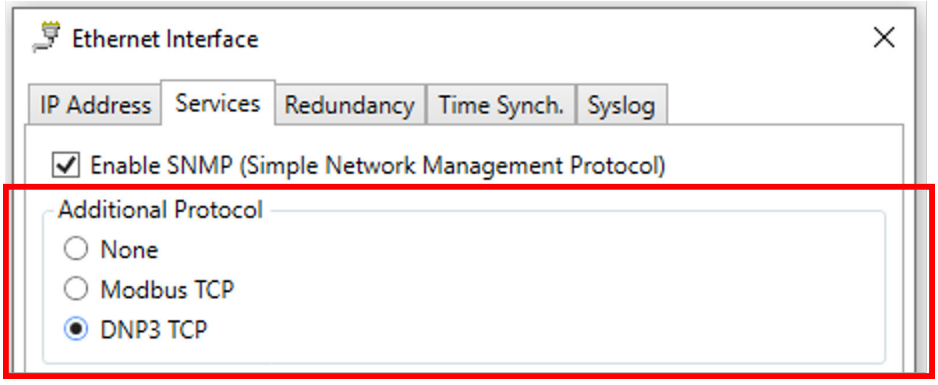
IEC 61850 Implementation			Preferred DNP3 Implementation		
Attribute Name	**Attribute Type**	**Value/Value Range**	**Point Type**	**Point Count or Note**	**Comment**
	PACKED LIST	–	–	–	–
validity	CODED ENUM	Good	–	ONLINE set if **good**	–
		Questionable	–	COMM_LOST	–

IEC 61850 Implementation				Preferred DNP3 Implementation		
Attribute Name		Attribute Type	Value/Value Range	Point Type	Point Count or Note	Comment
detailQual		PACKED LIST	–	–	–	–
	overflow	BOOLEAN	DEFAULT FALSE	–	ROLLOVER	–
	outOfRange	BOOLEAN	DEFAULT FALSE	–	OVER_RANGE	–
	badReference	BOOLEAN	DEFAULT FALSE	–	REFERENCE_ERR	–
	oscillatory	BOOLEAN	DEFAULT FALSE	–	CHATTER_FILTER	–
	failure	BOOLEAN	DEFAULT FALSE	–	OFFLINE	–
	oldData	BOOLEAN	DEFAULT FALSE	–	COMM_LOST	–
	inconsistent	BOOLEAN	DEFAULT FALSE	–	DISCONTINUITY	–
	inaccurate	BOOLEAN	DEFAULT FALSE	–	–	–
source		CODED ENUM	Process	–	–	–
			Substituted	–	LOCAL_FORCED	–
test		BOOLEAN	DEFAULT FALSE	–	LOCAL_FORCED	–
operatorBlocked		BOOLEAN	DEFAULT FALSE	–	LOCAL_FORCED	–

3.2 Settings and Properties

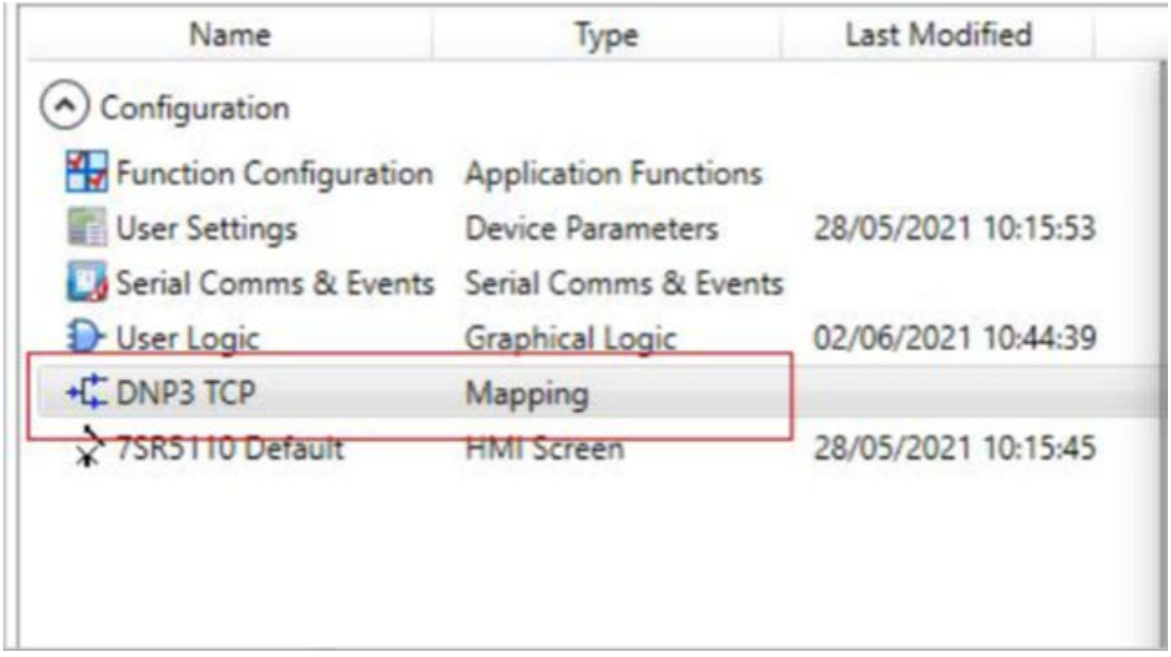
3.2.1 Settings for Communication through Ethernet

During parameterization, make the following settings for the communication on the Ethernet module between systems control and the device via DNP3:



[sc_7SR5_EnableDNP3TCP, 2, --_--]

Figure 3-6 Enable DNP3 TCP – Services in Ethernet Interface



[sc_7SR5_SettingsforDNP3, 1, --_--]

Figure 3-7 Settings for DNP3 – Device Configuration

Device Mapping and Configuration

Each specific device model will have a unique configuration file.

The supported information available for each device can be viewed using the Reydisp Manager 2 PC software tool in the mapping file.

This protocol can be used on the USB port for testing purposes but primarily it should be used on the rear ethernet ports.

The configuration allows the enabling/disabling of points, editing addresses, class, scaling, multiplier, and deadband where applicable in the associated tab.

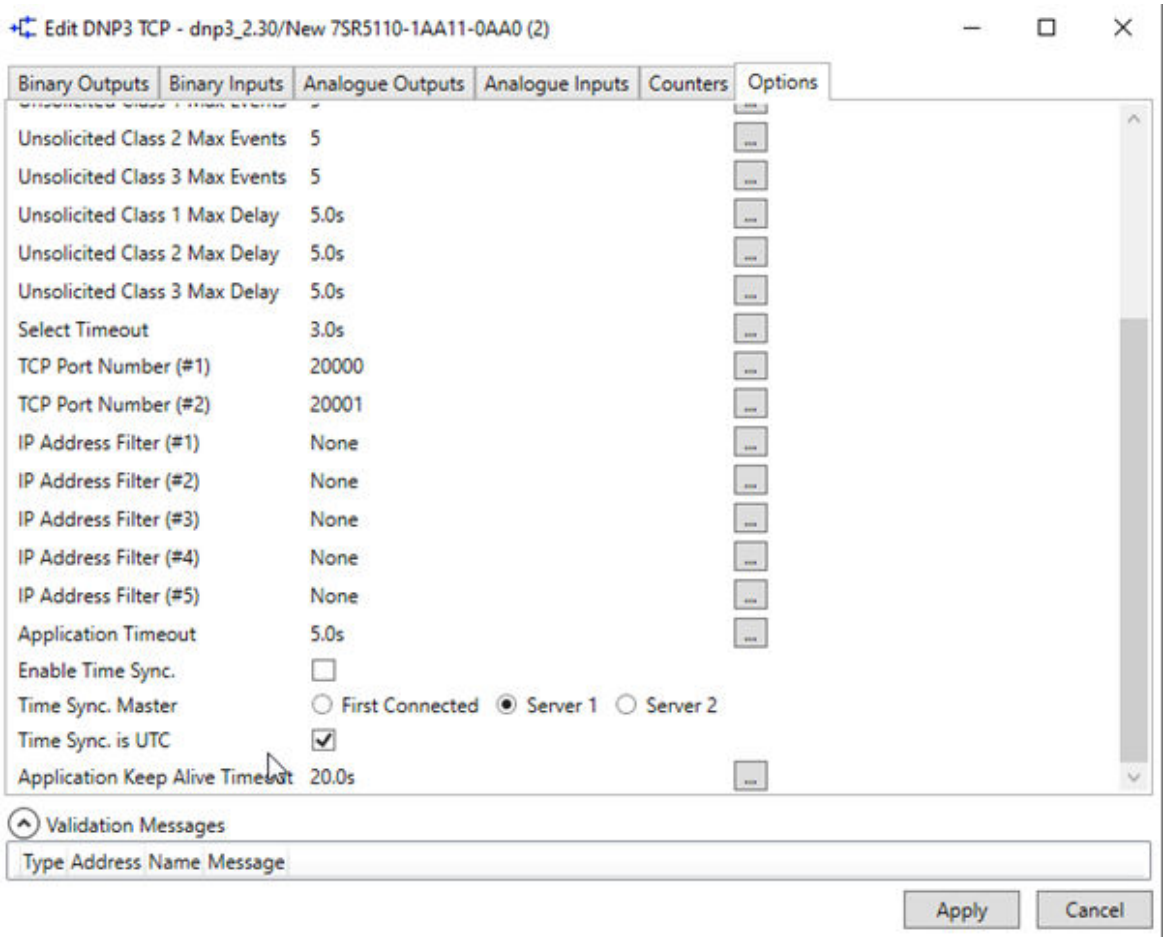
Table 3-5 The information types in the configuration tool have the following fixed format:

Binary Output Status Points
Object Number: 10
Request Function Codes supported: 1 (Read)
Default Variation reported when variation 0 requested: 2 (Binary Output Status)
Control Relay Output Blocks/Binary Output Status Object
Number: 12
Request Function Codes supported: 3 (select), 4 (operate), 5 (direct operate), 6 (direct operate, no ack)

Binary Input Points
Static (Steady-State) Object Number: 1 Change
Event Object Number: 2
Request Function Codes supported: 1 (read)
Static Variation reported when variation 0 requested: 1 (Binary Input with Status)
Change Event Variation reported when variation 0 requested: 2 (Binary Input Change with Time)

Counters
Static (Steady-State) Object Number: 20 Change
Event Object Number: 22
Request Function Codes supported: 1 (read)
Static Variation reported when variation 0 requested: 1 (32-bit Counter with Flag)
Change Event Variation reported when variation 0 requested: 1 (32-bit Counter without Time)

Analog Inputs
Static (Steady-State) Object Number: 30 Change
Event Object Number: 32
Request Function Codes supported: 1 (read)
Static Variation reported when variation 0 requested: 02 (16-bit Analog Input)
Change Event Variation reported when variation 0 requested: 02 (Analog Change Event without Time)



[sc_7SR5_DNP3TCPOptions, 1, --_--]

Figure 3-8 DNP3 TCP Configuration

The **Options** tab provides the general and unsolicited DNP3 TCP parameters.
On completing any parameter and configuration changes select the **Apply** option.

Time Synchronization with DNP3 TCP

DNP3 TCP offers an own time synchronization from the DNP3 TCP outstations using object number 50 var 1.
During configuration of the 7SR5 device in Reydisp Manager 2, set the time synchronization parameters for time synchronization via DNP3 TCP in the same manner as for SNTP:

- In device parameter settings: Source of time synchronization
- Master/Back up time source: Ethernet
- Ethernet Interface SNTP: Enable the Primary Timer Server and Enter the IP Address, subnet mask and Standard Gateway information

The following DNP3 TCP-specific parameters are relevant for time synchronization via DNP3 TCP:

Parameter	Description
Enable time sync.	Determines whether the device (DNP3 TCP outstation) expects and evaluates time synchronization from DNP3 TCP master.
Time sync. master: First connected/ Server 1/Server 2	Determines in case of 2 connected DNP3 TCP clients which one acts as time master for the time synchronization via DNP3 TCP. If only 1 client is connected, this one is also the time master.
Time sync. is UTC	Acc. to "Time Synchronization" in DNP3 IP Spec. Vol. 5, the time for DNP3 TCP time synchronization shall (since Jan. 1st, 2008) correspond to Universal Time Coordinated, UTC. This setting is used to support DNP3 TCP clients which send time synchronization in local time but should normally remain unchanged to default value.

NOTE

For time synchronization with NTP or DNP3 TCP, at least one NTP server must be configured in the IEC 61850 System Configurator.

If DNP3 TCP time synchronization is enabled, the DNP3 TCP master shall perform time synchronization to the outstation periodically every 55 s to 61 s, because the time control algorithm in the 7SR5 devices is based on a cyclical synchronization within this time period.

The accuracy of the time synchronization via DNP3 TCP protocol is 5 ms when time telegrams are being recieved continuously in the interval stated previously.

Additionaly, the internal indication **`IIN1.4 bit NEED_TIME`** is set in a telegram to the DNP3 TCP master if the device needs time synchronization (Is set all 60 s if no time synchronization message is recieved).

If 2 DNP3 TCP clients are connected to the device, the parameter **`Time sync. master`** determines which client acts as time master. Time syncronization messages from the client which is not the time master are rejected. The **`IIN1.4 bit NEED_TIME`** is only set in telegrams to the DNP3 TCP client which is the time master.

Table 3-6 The DNP3 TCP-specific parameter **`Enable time sync.`** determines whether SNTP or DNP3 TCP is used for time synchronization:

Source Time Synchronization Selection in Reydisp Manager 2	SNTP Server is Configured in Station Configurator	Setting EnableDNPTimeSynch	Result
Ethernet	Yes	= 0: SNTP is used	Device is synchronized from SNTP (no time requests with IIN1.4 to a DNP3 TCP master and time telegrams from DNP3 TCP master are rejected)
		= 1: DNP3 TCP is used	Device is synchronized from DNP3 TCP

Source Time Synchronization Selection in Reydisp Manager 2	SNTP Server is Configured in Station Configurator	Setting EnableDNPTimeSynch	Result
Ethernet	No	Not relevant	No time synchronization (no time requests with IIN1.4 to a DNP master and time telegrams from DNP3 TCP master are rejected)
Other than Ethernet (e.g. serial, binary input)	Not relevant		Device is synchronized from the selected source (no time requests with IIN1.4 to a DNP3 TCP master and time telegrams from DNP3 TCP master are rejected)

DNP3 TCP time objects contain the number of milliseconds from the DNP3 TCP time epoch, which is defined as 1970-01-01 00:00:00.000 UTC. Before transmitting internally from the virtual EN100 to the 7SR5 device, the local time correction factor that is configured for SNTP time synchronization (and which contains the time zone and daylight saving time factors is added; only if **`Time sync. is UTC`** parameter is set to 1 (default).

Table 3-7 IP Settings in the Module Setting

Parameter Name	Description	Settings
Outstation address	Link address of the 7SR5 device	Permitted range = 1 to 61439 Default setting = 1
Master address (#1)	Address of the DNP3 master	Permitted range = 1 to 61439 Default setting = 100
Master address (#2)	Address of the DNP3 master	Permitted range = 1 to 61439 Default setting = 101
Validate DNP addresses	Specifies if the stack should validate the source address in the receive frames. Note: DNP3 frames contain both a source and destination address.	Off = (default setting) On =
Enable unsolicited reponses	You specify whether unsolicited responses are configured with this parameter.	Off = The unsolicited responses is not configured and can never be switched on from a connected master (default setting). On = The unsolicited responses is configured and must be made possible after the 1st unsolicited response from the master.
Unsolicited retry delay	If no unsolicited response was sent within the **`Unsolicited class max delay`** parameter, then this parameter regulates how often a different unsolicited response should be sent.	Default setting = 5 s
Unsolicited max retries	This parameter regulates the maximum number of unsolicited retries.	Default setting = 3

Parameter Name	Description	Settings
Unsolicited class n max events	This parameter regulates a condition of the nonrequested transmission for every class of changed events (class 1, class 2, and class 3). If the number of events per class corresponds to this value or exceeds this value, then an unsolicited response will be sent.	Default setting = 5 s
Unsolicited class n max delay	This parameter regulates a condition of the nonrequested transmission for every class of changed events (class 1, class 2, and class 3). If the time after an event corresponds to this value or exceeds this value, an unsolicited response will be transmitted. Also sent if only 1 event occurred.	Default setting = 5 s
Unsolic. confirm. time-out	Time until the receiver confirmed the non-requested response. If an inquiry is received to read, then the read query will first be answered. The unsolicited response is then not transmitted.	Default setting = 3 s
TCP port number (#1)	Port number in the range of 1 to 61439	Default setting = 20000
TCP port number (#2)	Port number in the range of 1 to 61439	Default setting = 20001
IP address filter (#n)	Enables or disables filtering of Master IP addresses.	Default setting = None
Application timeout	The receiver waits a desired amount of time until the previous response is confirmed. If the confirmation of the application layer is used together with the link confirmation, then make sure that the time-out of the application layer (ApplTimeout) is long enough in order to end all transmissions. The following formula describes this requirement: AppConTime-out > LinkConTime-out * (Link retries + 1)	Default setting = 5 s

Parameter Name	Description	Settings
Enable time sync.	The receiver waits a desired amount of time until the previous response is confirmed. If the confirmation of the application layer is used together with the link confirmation, then make sure that the time-out of the application layer (ApplTimeout) is long enough in order to end all transmissions. The following formula describes this requirement: AppConTime-out > LinkConTime-out * (Link retries + 1)	Off = (default setting) On =
Time sync. master	The receiver waits a desired amount of time until the previous response is confirmed. If the confirmation of the application layer is used together with the link confirmation, then make sure that the time-out of the application layer (ApplTimeout) is long enough in order to end all transmissions. The following formula describes this requirement: AppConTime-out > LinkConTime-out * (Link retries + 1)	First connected Server 1 (default setting) Server 2
Time sync. is UTC	The receiver waits a desired amount of time until the previous response is confirmed. If the confirmation of the application layer is used together with the link confirmation, then make sure that the time-out of the application layer (ApplTimeout) is long enough in order to end all transmissions. The following formula describes this requirement: AppConTime-out > LinkConTime-out * (Link retries + 1)	Off = On = (default setting)
Application keep alive timeout	The receiver waits a desired amount of time until the previous response is confirmed. If the confirmation of the application layer is used together with the link confirmation, then make sure that the time-out of the application layer (ApplTimeout) is long enough in order to end all transmissions. The following formula describes this requirement: AppConTime-out > LinkConTime-out * (Link retries + 1)	Default setting = 20 s

The other required IP settings are taken from the module setting.

4 DNP3

4.1	Protocol Characteristics	80
4.2	Settings and Properties	102

4.1 Protocol Characteristics

Description

This document gives a general description of the DNP3 (Distributed Network Protocol v3) protocol and its implementation on the Reyrolle relay platform. It is not a description of the functionality of each specific relay, you must still refer to the documentation of a device for detailed information.

This protocol can be set to use the RS485 port.

4.1.1 Functional Scope

The following table provides a "Device Profile Document" in the standard format defined in the DNP3 Subset Definitions Document. While it is referred to in the DNP3 Subset Definitions as a "Document," it is in fact a table, and only a component of a total interoperability guide. The table, in combination with the Implementation Table provided and the Point List Tables provided should provide a complete configuration/interoperability guide for communicating with a device implementing the Triangle MicroWorks, Inc. DNP3 Slave Source Code Library.

<table>
<tr><td colspan="2">DNP V3.0
DEVICE PROFILE DOCUMENT</td></tr>
<tr><td colspan="2">Vendor Name: Siemens Protection Devices</td></tr>
<tr><td colspan="2">Device Name: 7SR5 using the Triangle MicroWorks, Inc. DNP3 Slave Source Code Library, Version 3.</td></tr>
<tr><td>Highest DNP Level Supported:
For Requests: Level 3
For Responses: Level 3</td><td>Device Function:
☐ Master
☒ Slave</td></tr>
<tr><td colspan="2">Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table):
For static (non-change-event) object requests, request qualifier codes 07 and 08 (limited quantity), and 17 and 28 (index) are supported. Static object requests sent with qualifiers 07, or 08, will be responded with qualifiers 00 or 01.
Output Event Object 11 is supported.</td></tr>
<tr><td>Maximum Data Link Frame Size (octets):
Transmitted: 256
Received: 256</td><td>Maximum Application Fragment Size (octets):
Transmitted: 2048
Received: 2048</td></tr>
<tr><td>Maximum Data Link Re-tries:
☐None
☐Fixed
☒Configurable from 0 to 65535 (Default 3)</td><td>Maximum Application Layer Re-tries:
☒None
☐Configurable</td></tr>
</table>

Requires Data Link Layer Confirmation: ☐Never ☐Always ☐Sometimes **☒Configurable as: Never, Only for multi-frame messages, or Always**
Requires Application Layer Confirmation: ☐Never ☐Always **☒When reporting Event Data (Slave devices only)** **☒When sending multi-fragment responses (Slave devices only)** ☐Sometimes ☐Configurable as: “Only when reporting event data”, or “When reporting event data or multi-fragment messages.”
Timeouts while waiting for: Data Link Confirm: ☐None ☐Fixed at ____☐Variable **☒Configurable (2 sec)** Complete Appl. Fragment: **☒None** ☐Fixed at ____ ☐Variable ☐Configurable Application Confirm: ☐None ☐Fixed at ____ ☐Variable **☒Configurable (10 sec)** Complete Appl. Response: **☒None**☐ Fixed at ____ ☐Variable ☐Configurable Others: **Transmission Delay, (Configurable, default 0 sec)** **Select/Operate Arm Timeout, (Configurable, default 5 sec)** **Need Time Interval, (Configurable, default 30 minutes)** **Unsolicited Notification Delay, (Configurable, default 5 seconds)** **Unsolicited Response Retry Delay, (Configurable (between 3 - 9), default 5 seconds)** **Unsolicited Offline Interval, (Configurable, default 30 seconds)** **Binary Change Event Scan Period, (Polled; Not Applicable)** **Double Bit Change Event Scan Period, (Unsupported; Not Applicable)** **Analog Change Event Scan Period, (Unsupported; Not Applicable)** **Counter Change Event Scan Period, (Unsupported; Not Applicable)** **Frozen Counter Change Event Scan Period, (Unsupported; Not Applicable)** **String Change Event Scan Period, (Unsupported; Not Applicable)** **Virtual Terminal Event Scan Period, (Unsupported; Not Applicable)**
Sends/Executes Control Operations: WRITE Binary Outputs **☒Never** ☐Always ☐Sometimes ☐Configurable SELECT/OPERATE ☐Never **☒Always** ☐Sometimes ☐Configurable DIRECT OPERATE ☐Never **☒Always** ☐Sometimes ☐Configurable DIRECT OPERATE – NO ACK ☐Never **☒Always** ☐Sometimes ☐Configurable Count > 1 **☒Never** ☐Always ☐Sometimes ☐Configurable Pulse On ☐Never ☐Always **☒Sometimes** ☐Configurable

Pulse Off ☐Never ☐Always ☒**Sometimes** ☐Configurable Latch On ☐Never ☐Always ☒**Sometimes** ☐Configurable Latch Off ☐Never ☐Always ☒**Sometimes** ☐Configurable Queue ☒**Never** ☐Always ☐Sometimes ☐Configurable Clear Queue ☒**Never** ☐Always ☐Sometimes ☐Configurable Attach explanation if 'Sometimes' or 'Configurable' was checked for any operation.	
Reports Binary Input Change Events when no specific variation requested: ☐Never ☐Only time-tagged ☐Only non-time-tagged ☒**Configurable to send one or the other**	Reports time-tagged Binary Input Change Events when no specific variation requested: ☐Never ☐Binary Input Change With Time ☐Binary Input Change With Relative Time ☒**Configurable**
Sends Unsolicited Responses: ☐Never ☒**Configurable** ☐Only certain objects ☐Sometimes (attach explanation) ☒**ENABLE/DISABLE UNSOLICITED Function codes supported**	Sends Static Data in Unsolicited Responses: ☒**Never** ☐When Device Restarts ☐When Status Flags Change No other options are permitted.
Default Counter Object/Variation: ☐No Counters Reported ☒**Configurable** ☐Default Object Default Variation: ☒**Point-by-point list attached**	Counters Roll Over at: ☐No Counters Reported ☐Configurable (attach explanation) ☐16 Bits ☒**32 Bits** ☐Other Value: _____ ☒**Point-by-point list attached**
Sends Multi-Fragment Responses: ☒**Yes** ☐No ☐Configurable	
Sequential File Transfer Support: File Transfer Support ☐Yes ☒**No** Append File Mode ☐Yes ☒**No** Custom Status Code Strings ☐Yes☒**No** Permissions Field ☐Yes ☒**No** File Events Assigned to Class ☐Yes ☒**No** File Events Send Immediately ☐Yes ☒**No** Multiple Blocks in a Fragment ☐Yes ☒**No** Max Number of Files Open **0**	

DNP3 Serial consists of a set of functions and a library of data types, called Groups (or sometimes Objects), upon which they may be performed. The functions include commands such as Read, Write, Select and Operate. Not all the functions and data groups need be implemented, although the devices must respond correctly, for example, by returning object unknown, to an unimplemented command or group.

A full list of the DNP3 Serial data groups is given in Table below. At present we specifically support groups associated with Analogue Inputs, Binary Inputs and Binary Outputs as well as standard groups e.g. Time and Date etc.

For simplicity, for now, Analogue Inputs can be thought of as read only meters, Binary Inputs as read only Booleans (True or False) and Binary Outputs as read / write Booleans.

Table 4-1 Functional Implementation Table

EVENT FORMAT		
Static Object Number	**Description**	**Supported**
0	Device Attributes	✗
1	Binary Input	✓
2	Binary Input Event	✓
3	Double Bit Binary Input	✓
4	Double Bit Binary Input Event	✓
10	Binary Output	✓
11	Binary Output Event	✓
12	Binary Command	✓
13	Binary Output Command Event	✓
20	Counter	✓
21	Frozen Counter	✓
22	Counter Event	✓
23	Frozen Counter Event	✓
30	Analogue Input	✓
31	Frozen Analogue Input	✗
32	Analogue Input Event	✓
33	Frozen Analogue Input Event	✗
34	Analogue Input Dead Band	✓
40	Analogue Output Status	✗
41	Analogue Output	✗
42	Analogue Output Event	✗
43	Analogue Output Command Event	✗
50	Time and Date	✓
51	Time and Date CTO	✓
52	Time Delay	✓
60	Class Objects	✓
70	File Control	✗
80	Internal Indications	✓
81	Device Storage	✗
82	Device Profile	✗
83	Data Set	✗
85	Data Set Prototype	✗
86	Data Set Descriptor	✗
87	Data Set	✗
88	Data Set	✗

EVENT FORMAT		
Static Object Number	**Description**	**Supported**
90	Application Identifier	✗
91	Status of Requested Operation	✗
100	Floating Point	✗
101	Binary Coded Decimal (BCD)	✗
102	Unsigned Integer	✗
110	Octet String	✗
111	Octet String Event	✗
112	Virtual Terminal Output Block	✗
113	Virtual Terminal Event Data	✗
120	Authentication	✗

The following table identifies which object variations, function codes, and qualifiers the Triangle MicroWorks, Inc. DNP 3.0 Slave Source Code Library supports in both request messages and in response messages. For static (non-change-event) objects, requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01. Requests sent with qualifiers 17 or 28 will be responded with qualifiers 17 or 28. For change-event objects, qualifiers 17 or 28 are always responded.

In the table below, underlined text as 00, 01 (start stop) indicates Subset Level 3 functionality (beyond Subset Level 2).

In the table below, italic text as *07, 08 (limited qty)* indicates functionality beyond Subset Level 3.

Table 4-2 Triangle MicroWorks, Inc. DNP 3.0 Slave Source Code Library

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	**Variation Number**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
1	0	Binary Input – Any Variation	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) *07, 08 (limited qty)* *17, 27, 28 (index)*		
1	1	Binary Input	1 (read)	00, 01 (start-stop) 06 (no range, or all) *07, 08 (limited qty)* *17, 27, 28 (index)*	129 (response)	00, 01 (start-stop) *17, 28* [2]

2 For static (non-change-event) objects, qualifiers 17 or 28 are only responded when a request is sent with qualifiers 17 or 28, respectively. Otherwise, static object requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01. (For change-event objects, qualifiers 17 or 28 are always responded.)

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
1	2 [3]	Binary Input with Status	1 (read)	00, 01 (start-stop) 06 (no range, or all) *07, 08 (limited qty)* *17, 27, 28 (index)*	129 (response)	00, 01 (start-stop) *17, 28* [2]
2	0	Binary Input Change – Any Variation	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
2	1	Binary Input Change without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
2	2 [3]	Binary Input Change with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
2	3	Binary Input Change with Relative Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
3	0	Double Bit Input – Any Variation	*1 (read)* *22 (assign class)*	*00, 01 (start-stop)* *06 (no range, or all)* *07, 08 (limited qty)* *17, 27, 28 (index)*		

3 A Default variation refers to the variation responded when variation 0 is requested and/or in class 0, 1, 2, or 3 scans. Default variations are configurable; however, default settings for the configuration parameters are indicated in the table above.

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
3	1 [3]	Double Bit Input	*1 (read)*	*00, 01 (start-stop)* *06 (no range, or all)* *07, 08 (limited qty)* *17, 27, 28 (index)*	*129 (response)*	*00, 01 (start-stop)* *17, 28* [3]
3	2	Double Bit Input with Status	*1 (read)*	*00, 01 (start-stop)* *06 (no range, or all)* *07, 08 (limited qty)* *17, 27, 28 (index)*	*129 (response)*	*00, 01 (start-stop)* *17, 28* [3]
4	0	Double Bit Input Change – Any Variation	*1 (read)*	*06 (no range, or all)* *07, 08 (limited qty)*		
4	1	Double Bit Input Change without Time	*1 (read)*	*06 (no range, or all)* *07, 08 (limited qty)*	*129 (response)* *130 (unsol. resp)*	*17, 28 (index)*
4	2	Double Bit Input Change with Time	*1 (read)*	*06 (no range, or all)* *07, 08 (limited qty)*	*129 (response)* *130 (unsol. resp)*	*17, 28 (index)*
4	3 [3]	Double Bit Input Change with Relative Time	*1 (read)*	*06 (no range, or all)* *07, 08 (limited qty)*	*129 (response)* *130 (unsol. resp)*	*17, 28 (index)*

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
10	0	Binary Output – Any Variation	1 (read) *22 (assign class)*	00, 01 (start-stop) 06 (no range, or all) *07, 08 (limited qty)* *17, 27, 28 (index)*		
10	1	Binary Output	*1 (read)*	*00, 01 (start-stop)* *06 (no range, or all)* *07, 08 (limited qty)* *17, 27, 28 (index)*	*129 (response)*	*00, 01 (start-stop)* *17, 28* [2]
			1 (write)	*00, 01 (start-stop)*		
10	2 [3]	Binary Output Status	1(read)	00, 01 (start-stop) 06 (no range, or all) *07, 08 (limited qty)* *17, 27, 28 (index)*	129 (response)	00, 01 (start-stop) *17, 28* [2]
11	0	Binary Output Change – Any Variation	*1 (read)*	*06 (no range, or all)* *07, 08 (limited qty)*		
11	1	Binary Output Change without Time	*1 (read)*	*06 (no range, or all)* *07, 08 (limited qty)*	*129 (response)* *130 (unsol. resp)*	*17, 28 (index)*

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
11	2 [3]	Binary Output Change with Time	*1 (read)*	*06 (no range, or all)* *07, 08 (limited qty)*	*129 (response)* *130 (unsol. resp)*	*17, 28 (index)*
12	0	Control Relay Output Block	*22 (assign class)*	*00, 01 (start-stop)* *06 (no range, or all)* *07, 08 (limited qty)* *17, 27, 28 (index)*		
12	1	Control Relay Output Block	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, noack)	17, 28 (index)	129 (response)	echo of request
12	2	Pattern Control Block	*3 (select)* *4 (operate)* 5 (direct op) 6 (dir. op, noack)	7 (limited quantity)	129 (response)	echo of request
12	3	Pattern Mask	*3 (select)* *4 (operate)* 5 (direct op) 6 (dir. op, noack)	00, 01 (start-stop)	129 (response)	echo of request
13	0	Binary Output Command Event – Any Variation	*1 (read)*	*06 (no range, or all)* *07, 08 (limited qty)*		
13	1 [3]	Binary Output Command Event without Time	*1 (read)*	*06 (no range, or all)* *07, 08 (limited qty)*	*129 (response)* *130 (unsol. resp)*	*17, 28 (index)*

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
13	2	Binary Output Command Event with Time	*1 (read)*	*06 (no range, or all)* *07, 08 (limited qty)*	*129 (response)* *130 (unsol. resp)*	*17, 28 (index)*
20	0	Binary Counter – Any Variation	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) *07, 08 (limited qty)* *17, 27, 28 (index)*		
			7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack)	00, 01 (start-stop) 06 (no range, or all) *07, 08 (limited qty)*		
20	1	32-Bit Binary Counter (with Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) *07, 08 (limited qty)* *17, 27, 28 (index)*	129 (response)	00, 01 (start-stop) *17, 28* [2]
20	2	16-Bit Binary Counter (with Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) *07, 08 (limited qty)* *17, 27, 28 (index)*	129 (response)	00, 01 (start-stop) *17, 28* [2]
20	3	32-Bit Delta Counter (with Flag)				
20	4	16-Bit Delta Counter (with Flag)				

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
20	5 [3]	32-Bit Binary Counter (without Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) *07, 08 (limited qty)* *17, 27, 28 (index)*	129 (response)	00, 01 (start-stop) *17, 28* [2]
20	6	16-Bit Binary Counter (without Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) *07, 08 (limited qty)* *17, 27, 28 (index)*	129 (response)	00, 01 (start-stop) *17, 28* [2]
20	7	32-Bit Delta Counter (without Flag)				
20	8	16-Bit Delta Counter (without Flag)				
21	0	Frozen Counter – Any Variation	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) *07, 08 (limited qty)* *17, 27, 28 (index)*		
21	1	32-Bit Frozen Counter (with Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) *07, 08 (limited qty)* *17, 27, 28 (index)*	129 (response)	00, 01 (start-stop) *17, 28* [2]

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
21	2	16-Bit Frozen Counter (with Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) *07, 08 (limited qty)* *17, 27, 28 (index)*	129 (response)	00, 01 (start-stop) *17, 28* [2]
21	3	32-Bit Frozen Delta Counter (with Flag)				
21	4	16-Bit Frozen Delta Counter (with Flag)				
21	5	32-Bit Frozen Counter (without Time Of Freeze)	*1 (read)*	*00, 01 (start-stop)* *06 (no range, or all)* *07, 08 (limited qty)* *17, 27, 28 (index)*	*129 (response)*	*00, 01 (start-stop)* *17, 28* [2]
21	6	16-Bit Frozen Counter (without Time Of Freeze)	*1 (read)*	*00, 01 (start-stop)* *06 (no range, or all)* *07, 08 (limited qty)* *17, 27, 28 (index)*	*129 (response)*	*00, 01 (start-stop)* *17, 28* [2]
21	7	32-Bit Frozen Delta Counter (with Time Of Freeze)				
21	8	16-Bit Frozen Delta Counter (with Time Of Freeze)				

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
21	9 [3]	32-Bit Frozen Counter (without Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) *07, 08 (limited qty)* *17, 27, 28 (index)*	129 (response)	00, 01 (start-stop) *17, 28* [2]
21	10	16-Bit Frozen Counter (without Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) *07, 08 (limited qty)* *17, 27, 28 (index)*	129 (response)	00, 01 (start-stop) *17, 28* [2]
21	11	32-Bit Frozen Delta Counter (without Flag)				
21	12	16-Bit Frozen Delta Counter (without Flag)				
22	0	Counter Change Event – Any Variation	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
22	1 [3]	32-Bit Counter Change Event (without Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
22	2	16-Bit Counter Change Event (without Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
22	3	32-Bit Delta Counter Change Event (without Time)				
22	4	16-Bit Delta Counter Change Event (without Time)				

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
22	5	32-Bit Counter Change Event (with Time)	*1 (read)*	*06 (no range, or all)* *07, 08 (limited qty)*	*129 (response)* *130 (unsol. resp)*	*17, 28 (index)*
22	6	16-Bit Counter Change Event (with Time)	*1 (read)*	*06 (no range, or all)* *07, 08 (limited qty)*	*129 (response)* *130 (unsol. resp)*	*17, 28 (index)*
22	7	32-Bit Delta Counter Change Event (with Time)				
22	8	16-Bit Delta Counter Change Event (with Time)				
23	0	Frozen Counter Event (Variation 0 is used to request default variation)	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
23	1 [3]	32-Bit Frozen Counter Event	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response)	17, 28 (index)
23	2	16-Bit Frozen Counter Event	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response)	17, 28 (index)
23	3	32-Bit Frozen Delta Counter Event				
23	4	16-Bit Frozen Delta Counter Event				
23	5	32-Bit Frozen Counter Event (with Time)	*1 (read)*	*06 (no range, or all)* *07, 08 (limited qty)*	*129 (response)* *130 (unsol. resp)*	*17, 28 (index)*

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
23	6	32-Bit Frozen Counter Event (with Time)	*1 (read)*	*06 (no range, or all)* *07, 08 (limited qty)*	*129 (response)* *130 (unsol. resp)*	*17, 28 (index)*
23	7	32-Bit Frozen Delta Counter Event (with Time)				
23	8	16-Bit Frozen Delta Counter Event (with Time)				
30	0	Analog Input - Any Variation	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) *07, 08 (limited qty)* *17, 27, 28 (index)*		
30	1	32-Bit Analog Input	1(read)	00, 01 (start-stop) 06 (no range, or all) *07, 08 (limited qty)* *17, 27, 28 (index)*	129 (response)	00, 01 (start-stop) *17, 28* [2]
30	2 [3]	16-Bit Analog Input	1(read)	00, 01 (start-stop) 06 (no range, or all) *07, 08 (limited qty)* *17, 27, 28 (index)*	129 (response)	00, 01 (start-stop) *17, 28* [2]

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
30	3	32-Bit Analog Input without Flag	1(read)	00, 01 (start-stop) 06 (no range, or all) *07, 08 (limited qty)* *17, 27, 28 (index)*	129 (response)	00, 01 (start-stop) *17, 28* [2]
30	4	16-Bit Analog Input without Flag	1(read)	00, 01 (start-stop) 06 (no range, or all) *07, 08 (limited qty)* *17, 27, 28 (index)*	129 (response)	00, 01 (start-stop) *17, 28* [2]
30	5	short floating point	*1(read)*	*00, 01 (start-stop)* *06 (no range, or all)* *07, 08 (limited qty)* *17, 27, 28 (index)*	*129 (response)*	*00, 01 (start-stop)* *17, 28* [2]
30	6	long floating point	*1 (read)*	*00, 01 (start-stop)* *06 (no range, or all)* *07, 08 (limited qty)* *17, 27, 28 (index)*	*129 (response)*	*00, 01 (start-stop)* *17, 28* [2]
31	0	Frozen Analog Input – Any Variation				
31	1	32-Bit Frozen Analog Input				
31	2	16-Bit Frozen Analog Input				

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
31	3	32-Bit Frozen Analog Input (with Time of freeze)				
31	4	16-Bit Frozen Analog Input (with Time of freeze)				
31	5	32-Bit Frozen Analog Input (without Flag)				
31	6	16-Bit Frozen Analog Input (without Flag)				
32	0	Analog Change Event – Any Varia-tion	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
32	1	32-Bit Analog Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	2	16-Bit Analog Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	3	32-Bit Analog Change Event with Time	*1 (read)*	*06 (no range, or all)* *07, 08 (limited qty)*	*129 (response)* *130 (unsol. resp)*	*17, 28 (index)*
32	4 [3]	16-Bit Analog Change Event with Time	*1 (read)*	*06 (no range, or all)* *07, 08 (limited qty)*	*129 (response)* *130 (unsol. resp)*	*17, 28 (index)*
32	5	short floating point Analog Change Event without Time	*1 (read)*	*06 (no range, or all)* *07, 08 (limited qty)*	*129 (response)* *130 (unsol. resp)*	*17, 28 (index)*

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
32	6	long floating point Analog Change Event without Time	*1 (read)*	*06 (no range, or all)* *07, 08 (limited qty)*	*129 (response)* *130 (unsol. resp)*	*17, 28 (index)*
32	7	short floating point Analog Change Event with Time	*1 (read)*	*06 (no range, or all)* *07, 08 (limited qty)*	*129 (response)* *130 (unsol. resp)*	*17, 28 (index)*
32	8	long floating point Analog Change Event with Time	*1 (read)*	*06 (no range, or all)* *07, 08 (limited qty)*	*129 (response)* *130 (unsol. resp)*	*17, 28 (index)*
33	0	Frozen Analog Event – Any Variation				
33	1	32-Bit Frozen Analog Event (without Time)				
33	2	16-Bit Frozen Analog Event (without Time)				
33	3	32-Bit Frozen Analog Event (with Time)				
33	4	16-Bit Frozen Analog Event (with Time)				
33	5	Short Floating Point Frozen Analog Event				
33	6	Long Floating Point Frozen Analog Event				
33	7	Extended Floating Point Frozen Analog Event				

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
34	0	Analog Input Deadband (Variation 0 is used to request default variation)	*1 (read)*	*00, 01 (start-stop)* *06 (no range, or all)* *07, 08 (limited qty)* *17, 27, 28 (index)*		
34	1	16 bit Analog Input Deadband	*1 (read)*	*00, 01 (start-stop)* *06 (no range, or all)* *07, 08 (limited qty)* *17, 27, 28 (index)*	*129 (response)*	*00, 01 (start-stop)* *17, 28* [2]
			2 (write)	*00, 01 (start-stop)* *07, 08 (limited qty)* *17, 27, 28 (index)*		
34	2 [3]	32 bit Analog Input Deadband	*1 (read)*	*00, 01 (start-stop)* *06 (no range, or all)* *07, 08 (limited qty)* *17, 27, 28 (index)*	*129 (response)*	*00, 01 (start-stop)* *17, 28* [2]
			2 (write)	*00, 01 (start-stop)* *07, 08 (limited qty)* *17, 27, 28 (index)*		

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
34	3	Short Floating Point Analog Input Dead-band	*1 (read)*	*00, 01 (start-stop)* *06 (no range, or all)* *07, 08 (limited qty)* *17, 27, 28 (index)*	*129 (response)*	*00, 01 (start-stop)* *17, 28* [2]
			2 (write)	*00, 01 (start-stop)* *07, 08 (limited qty)* *17, 27, 28 (index)*		
50	0	Time and Date				
50	1 [3]	Time and Date	1(read)	07, 08 (limited qty)	129 (response)	07 (limited qty = 1)
			2(write)	*00, 01 (start-stop)* *07, 08 (limited qty)* *17, 27, 28 (index)*		
50	3	Time and Date Last Recorded Time	*2(write)*	07 (limited qty)		
51	1	Time and Date CTO			129 (response) 130 (unsol. resp)	(limited qty = 1)
51	2	Unsynchron-ized Time and Date CTO			129 (response) 130 (unsol. resp)	(limited qty = 1)
52	1	Time Delay Coarse			129 (response)	(limited qty = 1)
52	2	Time Delay Fine			129 (response)	(limited qty = 1)
60	0	Not Defined				
60	1	Class 0 Data	1 (read)	06 (no range, or all)		

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
60	2	Class 1 Data	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
			20 (enbl. unsol.) 21 (dab. unsol.) 22 (assign class)	06 (no range, or all)		
60	3	Class 2 Data	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
			20 (enbl. unsol.) 21 (dab. unsol.) 22 (assign class)	06 (no range, or all)		
60	4	Class 3 Data	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
			20 (enbl. unsol.) 21 (dab. unsol.) 22 (assign class)	06 (no range, or all)		
80	1	Internal Indications	1 (read)	00, 01 (start-stop)	129 (response)	00, 01 (start-stop)
			2 (write) [4]	00 (start-stop) index=7		
	No Object (function code only)		13 (cold restart)			
	No Object (function code only)		*14 (warm restart)*			
	No Object (function code only)		23 (delay meas.)			
	No Object (function code only)		24 (record current time)			

4 Writes of Internal Indications are only supported for index 7 (Restart IIN1-7)

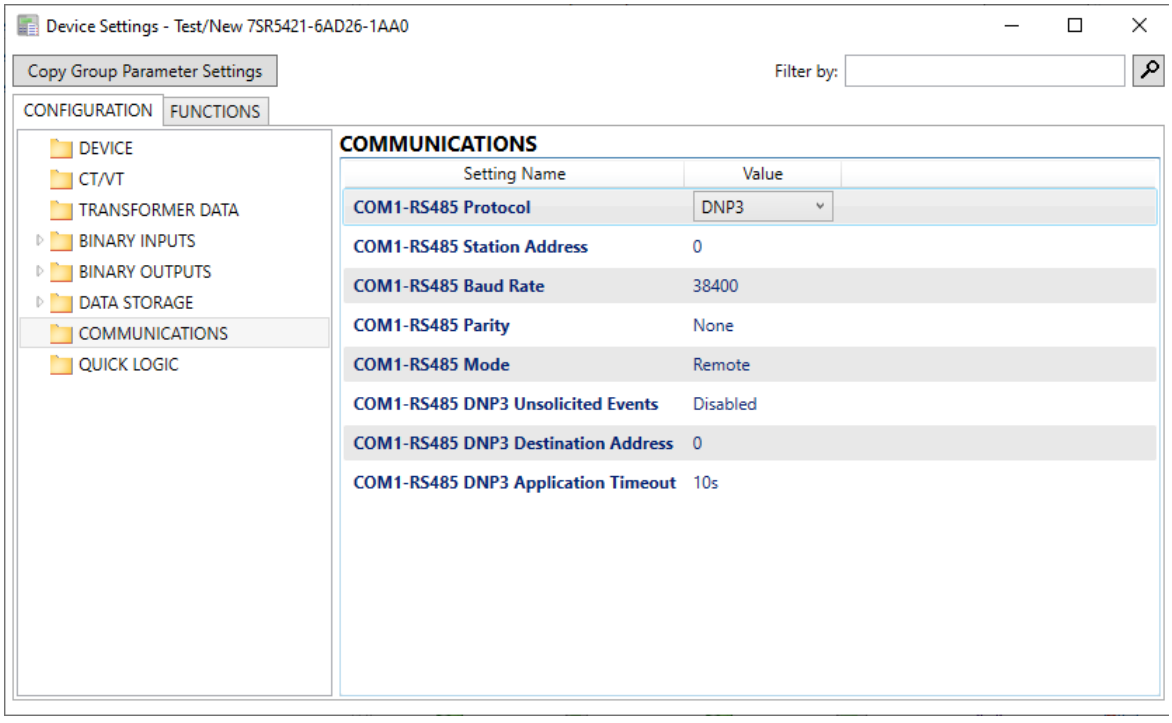
4.1.2 Miscellaneous

DNP3 Serial also provides functionality for time synchronizing, writing control commands etc. For details about these aspects refer to *Table 4-2*.

4.2 Settings and Properties

4.2.1 Setting for the Serial connection

The settings for the rear serial communications are located in the Communications menu of the setting tree. DNP3 Serial as implemented is a classic master and slave arrangement, with 1 master and numerous slaves in a system. Each device, including the master, is assigned a unique address in the range 0 – 65520. Other addresses are reserved for specific purposes, for example, 65535 is for broadcast commands.



[sc_7SR5_CommunicationsMenu, 2, --_--]

Figure 4-1 Communications Menu in the Settings Tree

Setting name	Range	Default	Setting	Notes
Station Address	0 to 254 (IEC 60870-5-103) 0 to 247 (Modbus-RTU) 0 to 65534 (DNP3)	0	1 to As required	An address must be given to identify the relay. Each relay must have a unique address.
COM1-RS485 Protocol	OFF, IEC 60870-5-103, Modbus-RTU, DNP3	IEC 60870-5-103	DNP3	Sets the protocol used to communicate on the RS485 connection.
COM1-RS485 Baud Rate	75 110 150 300 600 1200 2400 4800 9600 19200 38400 57600 115200 230400	19200	As Required	The baud rate set on all of the relays connected to the same RS485 bus must be the same as the one set on the master device.

Setting name	Range	Default	Setting	Notes
COM1-RS485 Parity	NONE, ODD, EVEN	NONE	As Required	The parity set on all of the relays connected to the same RS485 bus must be the same and in accordance with the master device.
COM1-RS485 Mode	Local, Remote, Local Or Remote	Remote	Remote	Selects whether the port is Local or Remote.
DNP3 Unsolicited Mode	DISABLED ENABLED	DISABLED	As Required	When Enabled unsolicited event transmission can be controlled by the Master. When Disabled the Master requests are ignored.
DNP3 Destination Address	0 to 65534	0	As Required	Setting is only visible when COM1 Protocol is set to DNP3. The address of the Master to which unsolicited events will be sent.
DNP3 Application Timeout	5 ..to 300 s	10 s	As Required	Specifies the response timeout for the Application layer confirmation

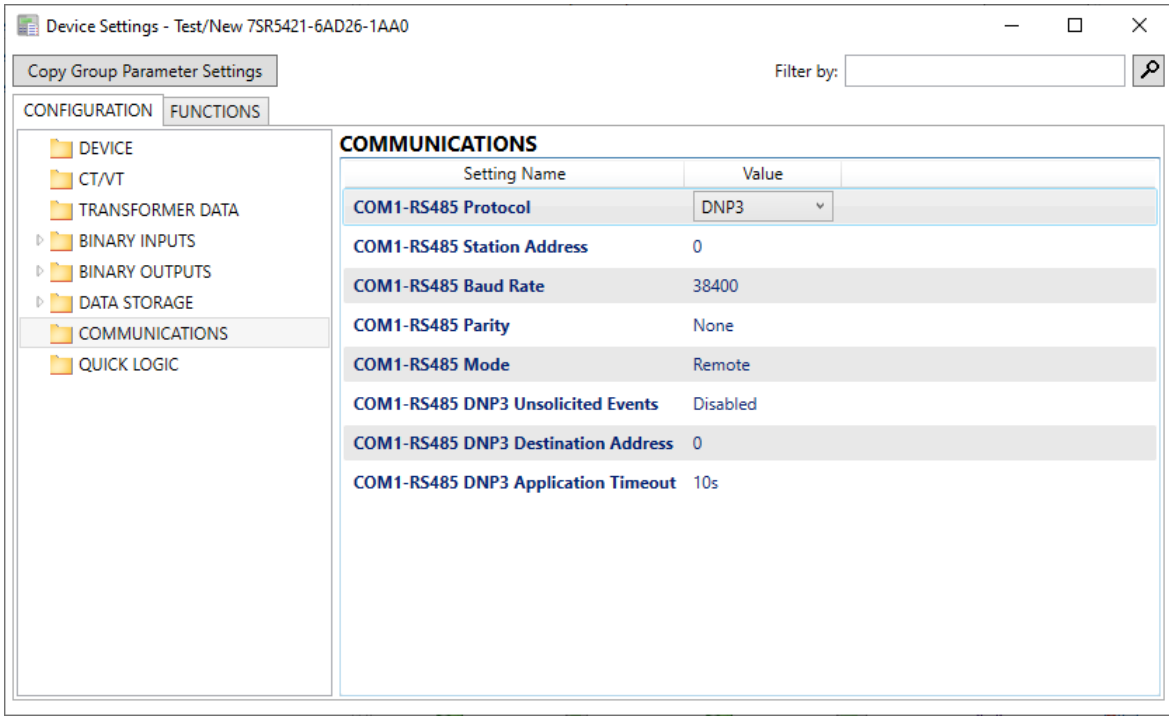
4.2.2 Device Mapping and configuration

Each specific device model will have a unique configuration file.

The supported information available for each device can be viewed using the Reydisp Manager 2 PC Software Commincation Editor tool. The device template must be installed and selected.

Unsolicited Events

DNP3 Serial offers a mode, unsolicited events, where slave devices may send events without being polled by the master. To do this the slave must be set to allow unsolicited events, and must have a destination address for the master to which they are sent. These features are enabled and available via two settings on the communications menu. When the slave allows unsolicited events the master can enable and disable this feature at will. When the slave device starts it is by default disabled, therefore to use it one of the first things the master must do is set it to enabled.



[sc_7SR5_CommunicationsMenu, 2, --_--]

Figure 4-2 Basic Setting Parameters

In addition further configuration is available via the Advanced Configuration within the Communications Editor configuration file in Reydisp Manager 2 when the DNP3 Serial tab is selected, see *Figure 4-4*.

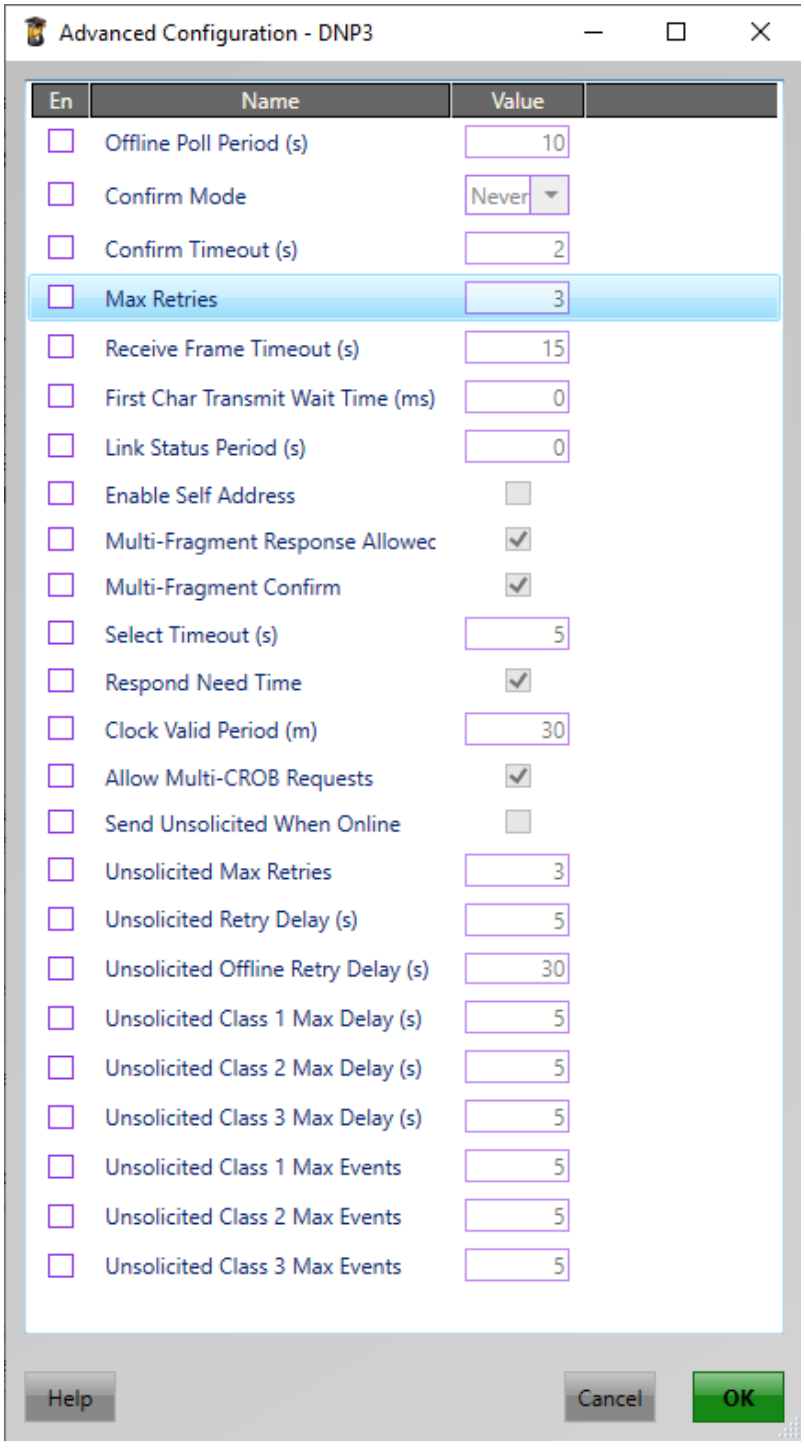
Unsolicited mode is enabled / disabled on a per class basis. Any combination of the three event classes can be enabled for unsolicited mode. Therefore, for example, you may put events into class 1 that you want sent as unsolicited, while classes 2 and 3 are polled.

You can create a table with entries as shown in *Figure 4-4*.

To access the Advanced Configuration window the user must click on the following icon.

[sc_7SR5_DNP3AdvancedConfig, 1, --_--]

Figure 4-3 Icon for Advanced Configuration Window



[Platform Communications Protocol Manual Unsolicited Events2, 2, —_—]

Figure 4-4 Advanced Configuration

Parameter: **`DNP3 > Advanced Settings > Offline Poll Period (s)`**

- Default: **`Disabled`**
  Default setting: **`10 s`**
  This setting selects the period to re-establish communication for an offline poll.

Parameter: **DNP3 > Advanced Settings > Confirm Mode**

- Default: **Disabled**
  Default setting: **Never**
  This setting is to set a link layer confirmation, if required. Setting options are **Never**, **Sometimes**, and **Always**.

Parameter: **DNP3 > Advanced Settings > Confirm Timeout (s)**

- Default: **Disabled**
  Default setting: **2 s**
  This setting is the maximum time to wait for a link layer confirmation.

Parameter: **DNP3 > Advanced Settings > Max Retries**

- Default: **Disabled**
  Default setting: **3**
  This setting sets the maximum number of link layer retries if link layer confirms timeout.

Parameter: **DNP3 > Advanced Settings > Receive Frame Timeout (s)**

- Default: **Disabled**
  Default setting: **15 s**
  This setting selects the maximum time to wait for a complete frame after a valid sync frame character is received.

Parameter: **DNP3 > Advanced Settings > First Char Transmit Wait Time (ms)**

- Default: **Disabled**
  Default setting: **0 ms**
  This setting is the minimum wait time after a character is received before the device will transmit a character.

Parameter: **DNP3 > Advanced Settings > Link Status Period (s)**

- Default: **Disabled**
  Default setting: **0 s**
  This setting configures the keep alive period to send link requests if no frames have been received.

Parameter: **DNP3 > Advanced Settings > Enable Self Address**

- Default: **Disabled**
  Default setting: **Disabled**
  This setting selects if the self address functionality is enabled on this slave device.

Parameter: **DNP3 > Advanced Settings > Multi-Fragment Response Allowed**

- Default: **Disabled**
  Default setting: **Enabled**
  This setting allows the use of multi fragment message responses.

Parameter: **DNP3 > Advanced Settings > Multi-Fragment Confirm**

- Default: **Disabled**
  Default setting: **Enabled**
  This setting is enabled if confirmations are requested for frames within a multi fragment response.

Parameter: **DNP3 > Advanced Settings > Select Timeout (s)**

- Default: **Disabled**
  Default setting: **5 s**
  This setting is the maximum amount of time that a select will remain valid before the corresponding operate is received.

Parameter: **DNP3 > Advanced Settings > Respond Need Time**

- Default: **Disabled**
  Default setting: **Enabled**
  This setting selects if after start up the device will set the Need time INN bit.

Parameter: **DNP3 > Advanced Settings > Clock Valid Period (m)**

- Default: **Disabled**
  Default setting: **30 m**
  This setting selects the duration the device clock will remain valid after receiving a DNP3 Serial time synchronization.

Parameter: **DNP3 > Advanced Settings > Allow Multi-CROB Requests**

- Default: **Disabled**
  Default setting: **Enabled**
  This setting is to allow the use of multiple Control Relay Output Block (CROB) requests.

Parameter: **DNP3 > Advanced Settings > Send Unsolicited when online**

- Default: **Disabled**
  Default setting: **Disabled**
  This setting selects if unsolicited responses will be sent when the session comes online.

Parameter: **DNP3 > Advanced Settings > Max Retries**

- Default: **Disabled**
  Default setting: **3**
  This setting selects the maximum number of unsolicited retries allowed. After this is exceeded the offline retries timeout is applied.

Parameter: **DNP3 > Advanced Settings > Unsolicited Retry Delay (s)**

- Default: **Disabled**
  Default setting: **5 s**
  This setting is to select the delay period after an unsolicited confirm timeout before retrying the response.

Parameter: **DNP3 > Advanced Settings > Unsolicited Offline Retry Delay (s)**

- Default: **Disabled**
  Default setting: **30 s**
  This setting selects the time after the **Max retries** to wait before retrying the unsolicited response after an unsolicited timeout.

Parameter: **DNP3 > Advanced Settings > Unsolicited Class 1 Max Delay (s)**

- Default: **Disabled**
  Default setting: **5 s**
  This setting selects the maximum amount of time after an event before an unsolicited class 1 response is generated when unsolicited events are enabled.

Parameter: **DNP3 > Advanced Settings > Unsolicited Class 2 Max Delay (s)**

- Default: **Disabled**
  Default setting: **5 s**
  This setting selects the maximum amount of time after an event before an unsolicited class 2 response is generated when unsolicited events are enabled.

Parameter: **DNP3 > Advanced Settings > Unsolicited Class 3 Max Delay (s)**

- Default: **Disabled**
  Default setting: **5 s**
  This setting selects the maximum amount of time after an event before an unsolicited class 3 response is generated when unsolicited events are enabled.

Parameter: **DNP3 > Advanced Settings > Unsolicited Class 1 Max Events**

- Default: **Disabled**
  Default setting: **5**
  This setting selects the maximum number of events that are stored before an unsolicited class 1 response is generated when unsolicited events are enabled.

Parameter: **DNP3 > Advanced Settings > Unsolicited Class 2 Max Events**

- Default: **Disabled**
  Default setting: **5**
  This setting selects the maximum number of events that are stored before an unsolicited class 2 response is generated when unsolicited events are enabled.

Parameter: **DNP3 > Advanced Settings > Unsolicited Class 3 Max Events**

- Default: **Disabled**
  Default setting: **5**
  This setting selects the maximum number of events that are stored before an unsolicited class 3 response is generated when unsolicited events are enabled.

Point Indexes

Each Group will have one or more data points associated with it. DNP3 does not define the content of a data point, this is entirely down to the implementer or end user. The data points are usually numbered from 0. As

an example, a simple device may have 3 Analogue Inputs (0-2), 5 Binary Inputs (0-4) and 2 Binary Outputs (0-1). Note, that that same index can be used for different Groups, illustrated in *Table 4-3*.

Table 4-3 Example Point Map 1

Analogue Input	Binary Input	Binary Output
0	0	0
1	1	1
2	2	–
–	3	–
–	4	–

The point indexes need not be continuous, although for efficiency it is not recommended that large gaps are left in the sequence. For example, the 3 Analogue Inputs may be points 0-1 and 4. This is useful if some models of a device omit certain features and you wish to keep the bulk of the documentation the same, illustrated in *Table 4-4*.

Table 4-4 Example Point Map 2

Analogue Input	Binary Input	Binary Output
0	0	0
1	1	1
	2	
	3	
4	4	

The communications editor allows changing of the point index for a particular point, and setting whether that point is enabled in the device, as illustrated in *Figure 4-5*.

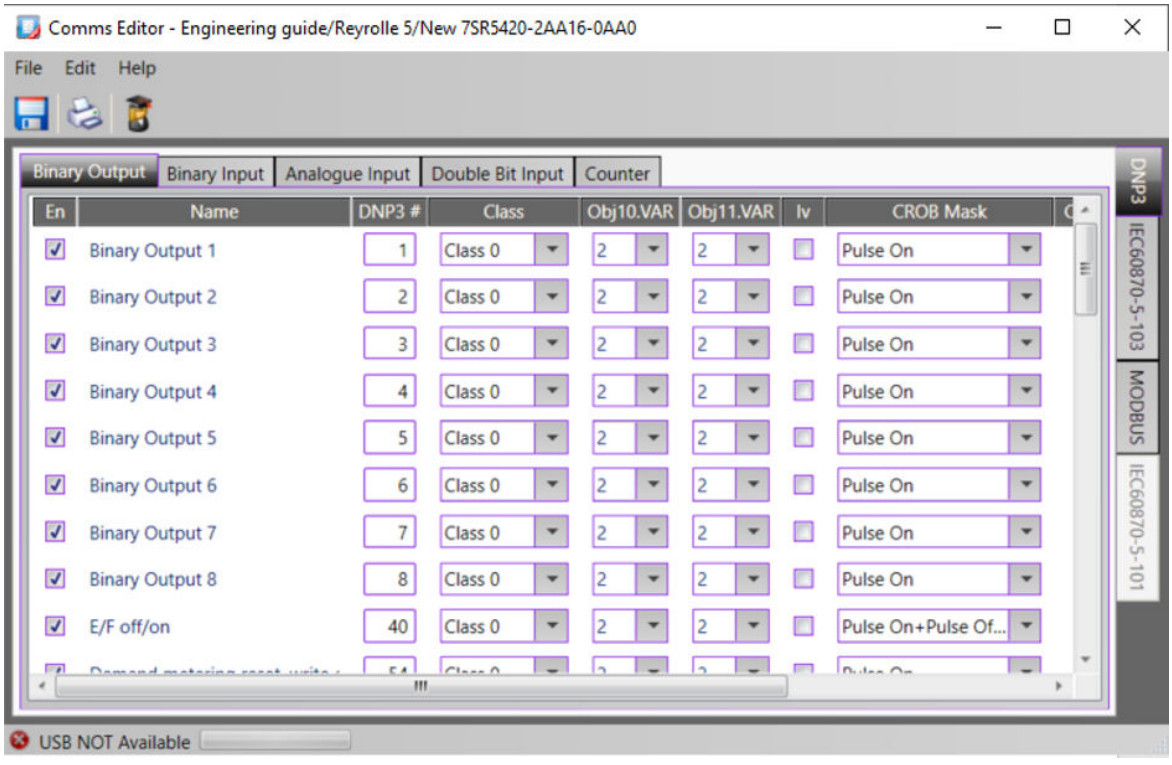


Figure 4-5 Setting the Point Index and Enabled Fields (Binary Inputs)

Reading Specific Data

In addition to reading all data or polling for events, the master can read a specific point or range of points from a Group as it requires. For example, if it only wants to read Binary Inputs 2 and 3 it can do so. This is the efficient way to read the present value of a point which is not in an event class without doing a full class 0 poll.

The range must be continuous with no unallocated points. Point mapping should be configured as a continuous range to efficiently use this method.

Classes

DNP3 data points are arranged into four classes 0, 1, 2 and 3.

Class 0 (or static data) contains all the active points in the device. The master station will periodically perform a poll of class 0, which is similar to IEC 870-5-103 General Interrogation, to populate its database with the present values from a device. It cannot be changed at run time, the only way to remove a point from Class 0 is to disable it or disable the function using the communications editor.

Classes 1, 2 and 3 (or event data) contain a sub set of the points within Class 0 and are used to report event data. Unlike static data event data is usually time-stamped when something happens. The time stamp and format variation can be configured in the Communications editor. Originally it was assumed that the three classes would represent some sort of priority of data, e.g. high, medium and low, however this is not defined by the standard and it is left up to the user to define the meaning, if any, of each class. The master can assign and remove points from classes 1, 2 and 3 at run time. A class can contain a mixture of points from different data Groups. For the purpose of reporting events a point can be assigned to any combination of classes 1, 2 or 3 or none, as illustrated in *Table 4-5*.

Table 4-5 Example Class Map

	Class 1	Class 2	Class 3
Analogue Input 0	–	–	–
Analogue Input 1	–	–	✓
Analogue Input 2	–	✓	–
Binary Input 0	–	✓	✓
Binary Input 1	✓	–	–
Binary Input 2	✓	–	✓
Binary Input 3	–	–	–
Binary Input 4	–	–	–
Binary Output 0	✓	✓	–
Binary Output 1	✓	✓	✓

Default classes for points can be assigned by the Communications Editor, as illustrated in *Figure 4-6*, these classes can then be reassigned by the master at run time.

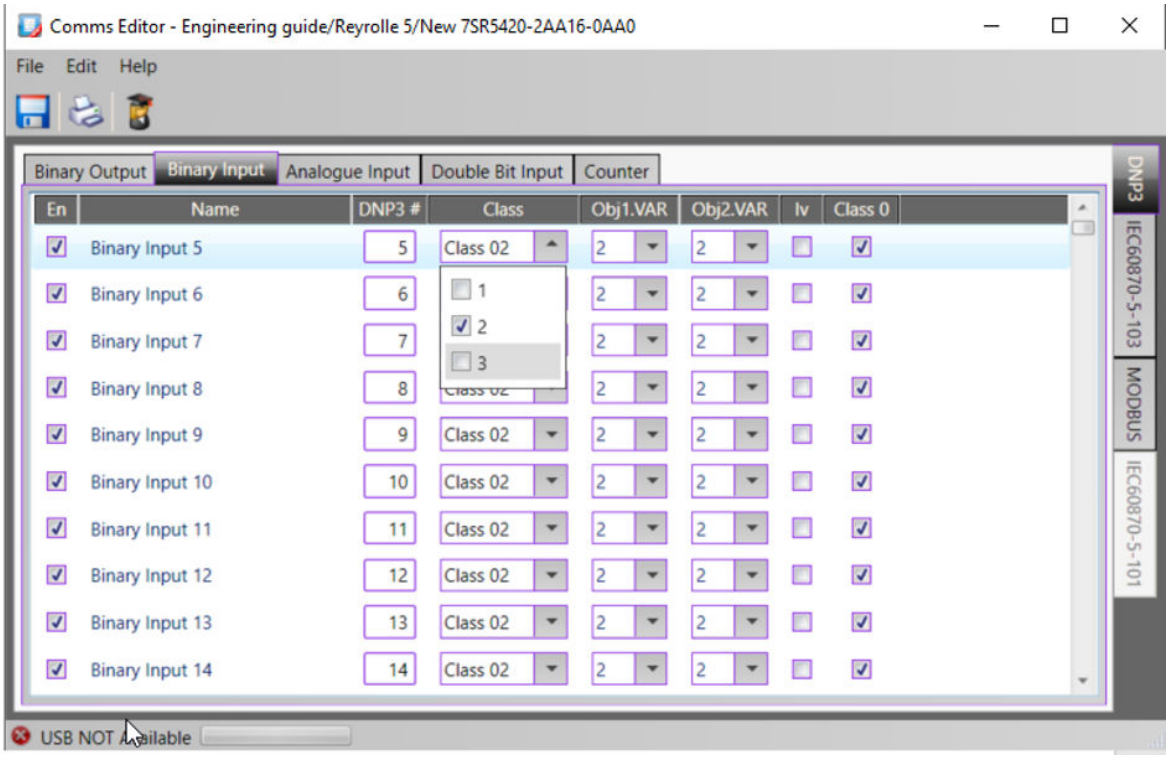


Figure 4-6 Setting the Default Class (Binary Inputs)

The master can poll for event data for any combination of classes 1, 2 and 3. An event will only be reported if the point is assigned to a class polled by the master. If a point is not assigned to class 1, 2 or 3 it will not be reported as an event.

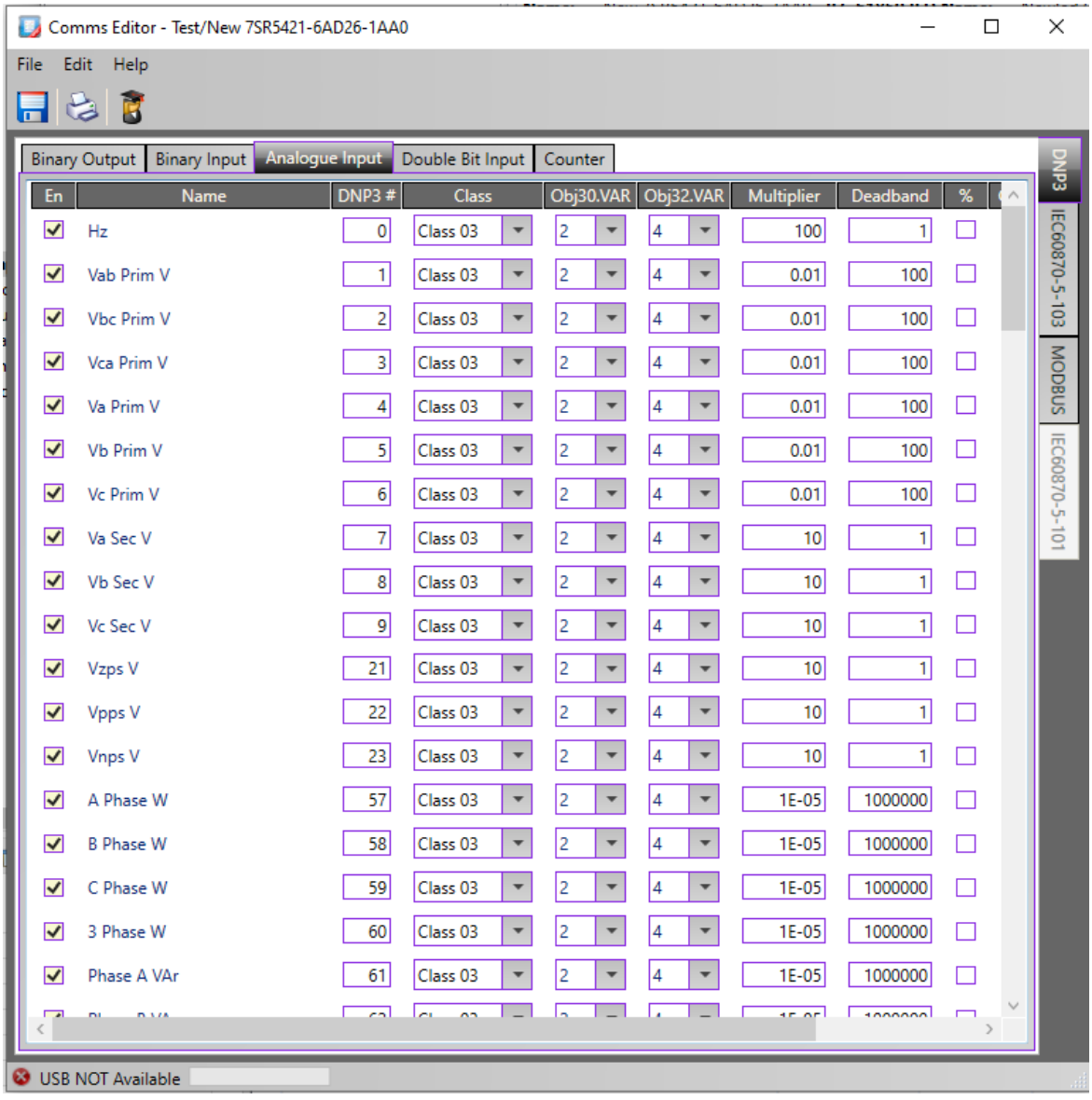
The reported status of **`Binary Inputs`** can be inverted by selecting the **`Iv`** field in the Communications editor.

Analogue Inputs

Table 4-6 lists Analog Inputs (Object 30). It is important to note that 16-bit and 32-bit variations of Analog Inputs, Analog Output Control Blocks, and Analog Output Statuses are transmitted through DNP as signed numbers.

The “Default Deadband,” and the “Default Change Event Assigned Class” columns are used to represent the absolute amount by which the point must change before an analog change event will be generated, and once generated in which class poll (1, 2, 3, or none) will the change event be reported.

The default analog input event buffer size is set to 30.



En	Name	DNP3 #	Class	Obj30.VAR	Obj32.VAR	Multiplier	Deadband	%
☑	Hz	0	Class 03	2	4	100	1	☐
☑	Vab Prim V	1	Class 03	2	4	0.01	100	☐
☑	Vbc Prim V	2	Class 03	2	4	0.01	100	☐
☑	Vca Prim V	3	Class 03	2	4	0.01	100	☐
☑	Va Prim V	4	Class 03	2	4	0.01	100	☐
☑	Vb Prim V	5	Class 03	2	4	0.01	100	☐
☑	Vc Prim V	6	Class 03	2	4	0.01	100	☐
☑	Va Sec V	7	Class 03	2	4	10	1	☐
☑	Vb Sec V	8	Class 03	2	4	10	1	☐
☑	Vc Sec V	9	Class 03	2	4	10	1	☐
☑	Vzps V	21	Class 03	2	4	10	1	☐
☑	Vpps V	22	Class 03	2	4	10	1	☐
☑	Vnps V	23	Class 03	2	4	10	1	☐
☑	A Phase W	57	Class 03	2	4	1E-05	1000000	☐
☑	B Phase W	58	Class 03	2	4	1E-05	1000000	☐
☑	C Phase W	59	Class 03	2	4	1E-05	1000000	☐
☑	3 Phase W	60	Class 03	2	4	1E-05	1000000	☐
☑	Phase A VAr	61	Class 03	2	4	1E-05	1000000	☐

[Platform Communications Protocol Manual Analogue Inputs1, 2, –_–]

The implementations of DNP3 support Analogue Inputs via Data Groups 30 (static) and 32 (events). Each of these groups divides into the variants listed below, followed by an example of how they are set in the communications editor.

Table 4-6 Data Group 30 Variants

Group 30	Variant	Name	Description
	1	Analogue Input – 32 bit with flag	The inputs are sent as a 32 bit integer with an 8 bit quality flag.
	2	Analogue Input – 16 bit with flag	The inputs are sent as a 16 bit integer with an 8 bit quality flag.
	3	Analogue Input – 32 bit without flag	The inputs are sent as a 32 bit integer.

Group 30	Variant	Name	Description
	4	Analogue Input – 16 bit without flag	The inputs are sent as a 16 bit integer.
	5	Analogue Input – single precision, floating point with flag	The inputs are sent as a 32 bit float, conforming to IEEE-754 standard, with an 8 bit quality flag.

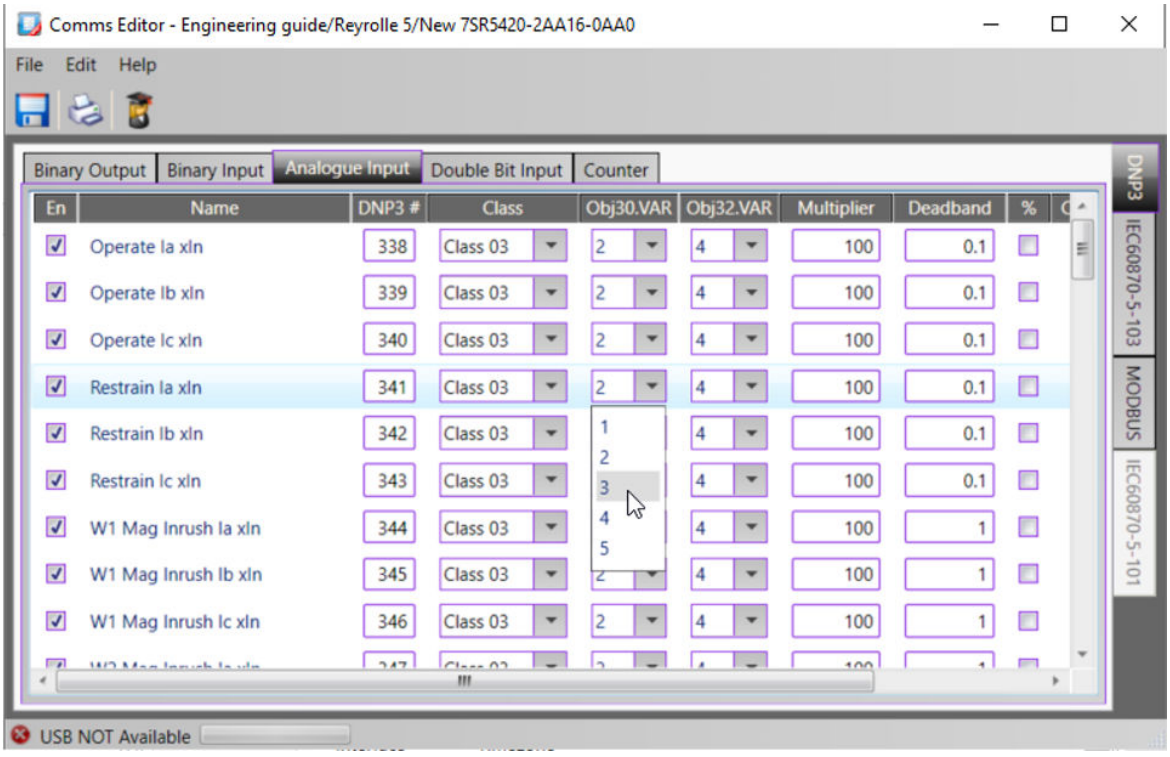


Figure 4-7 Setting the Analogue Input Group 30 Variant

Table 4-7 Data Group 32 Variants

Group 32	Variant	Name	Description
	1	Analogue Input Event – 32 bit without time	The inputs are sent as a 32 bit integer without a time.
	2	Analogue Input – 16 bit without time	The inputs are sent as a 16 bit integer without an absolute time.
	3	Analogue Input – 32 bit with time	The inputs are sent as a 32 bit integer with an absolute time.
	4	Analogue Input – 16 bit with time	The inputs are sent as a 16 bit integer with a time.

Group 32	Variant	Name	Description
	5	Analogue Input – single precision, floating point without time	The inputs are sent as a 32 bit float, conforming to IEEE-754 standard, without a time.
	7	Analogue Input – single precision, floating point with time	The inputs are sent as a 32 bit float, conforming to IEEE-754 standard, with an absolute time.

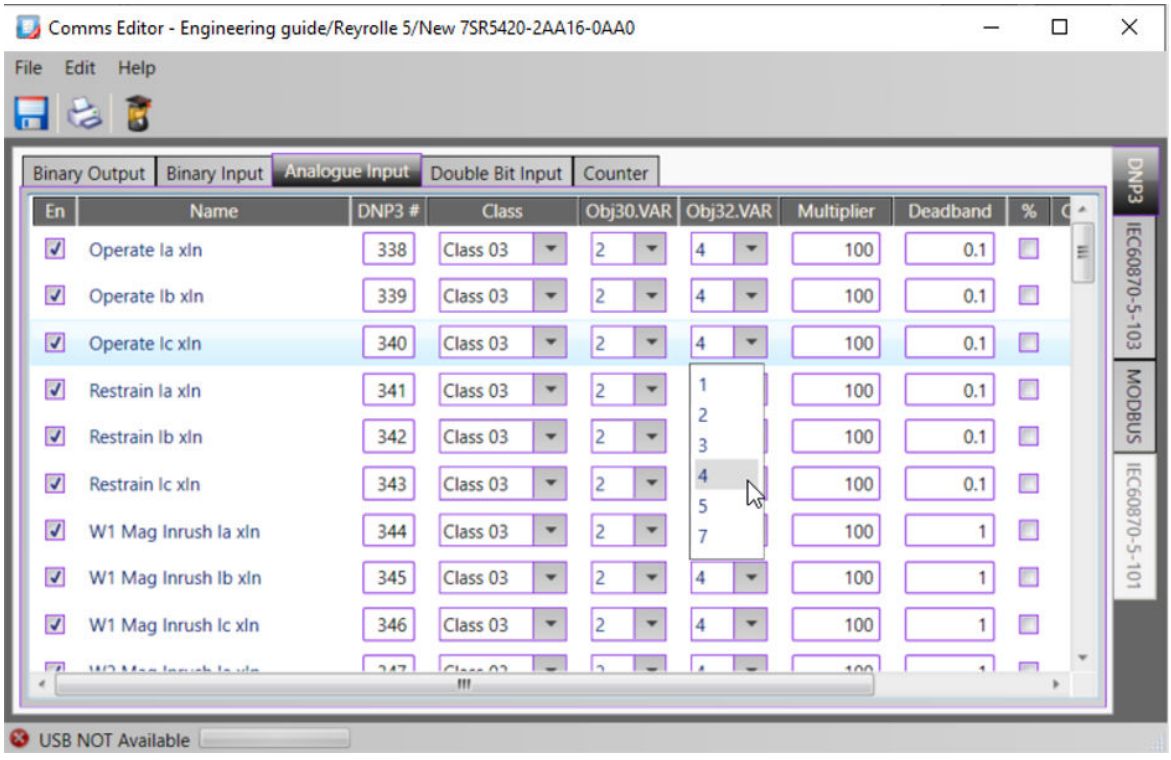
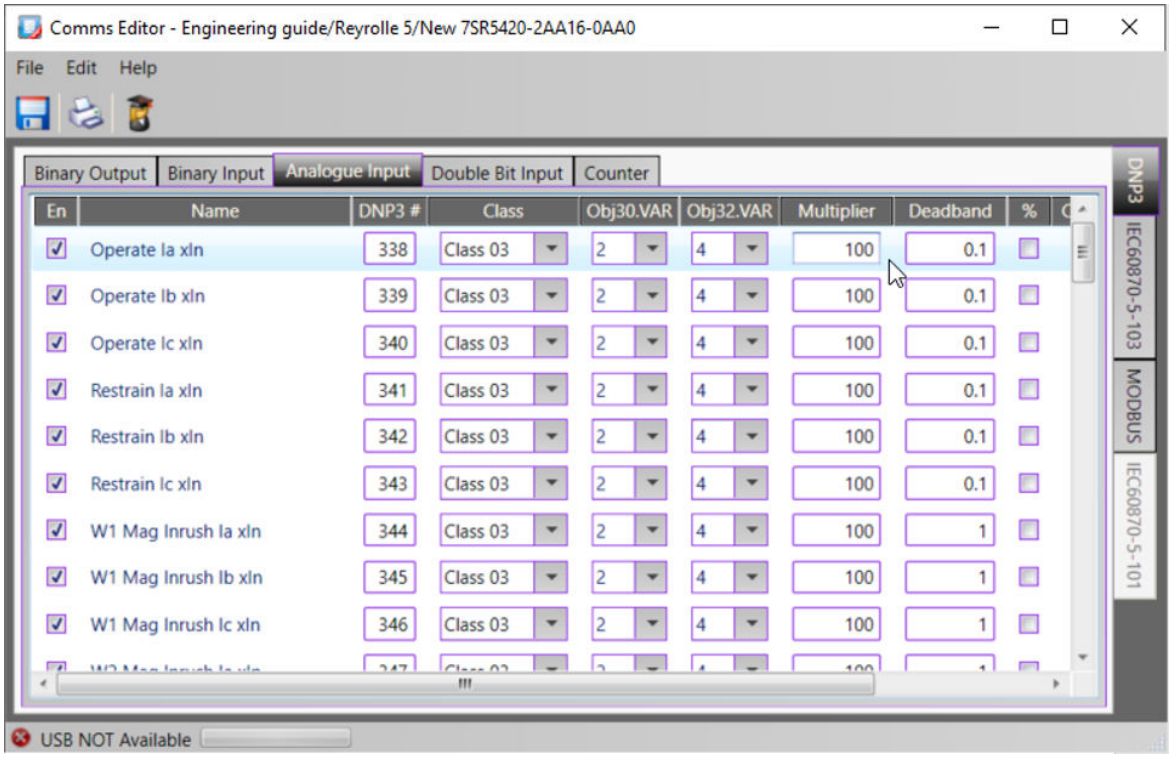


Figure 4-8 Setting the Analogue Input Group 32 Variant

In addition for Analogue Inputs the communications editor allows a multiplier factor to be specified for each point, the value is multiplied by this factor before transmission. The multiplier could be used to scale values to fit in specific data variants, for example, if you have a value of 5.678 and need to send it back as a 16 bit integer, e.g. g30v2, set the multiplier to 1000 and it will be send as 5678 keeping the precision. Setting the multiplier is illustrated below.



[sc_7SR5_AnalogueInputsInpMult, 1, --_--]

Figure 4-9 Setting the Analogue Input Multiplier

Also for Analogue Inputs the communications editor allows a dead band factor to be specified for each point. This ± dead band specifies the window outside of which an event is generated. The % flag specifies that the dead band value should be treated as a percentage. Setting both parameters is illustrated below.

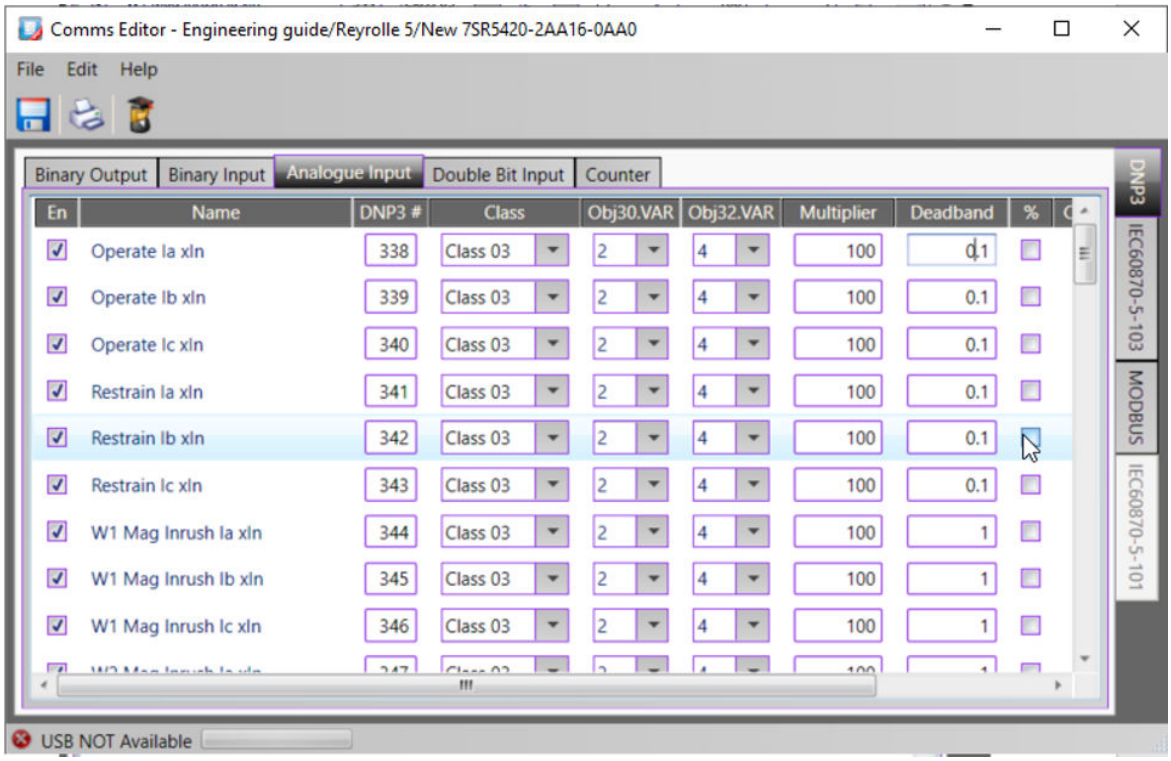


Figure 4-10 Setting the Analogue Input Dead Band and Percentage Flag

Binary Inputs

Binary Input Points

The default binary input event buffer size is set to allow 100 events.

DNP3 support Binary Inputs via Data Groups 1 (static) and 2 (events). Each of these groups divides into the variants listed in *Table 4-8*, followed by an example of how they are set in the communications editor.

Table 4-8 Data Group 1 Variants

Group 1	Variant	Name	Description
	1	Binary Input – Packed Format	The inputs are sent in a packed format with 1 bit per input.
	2	Binary Input – With Flags	The inputs are sent individually 1 byte per input with additional quality bits.

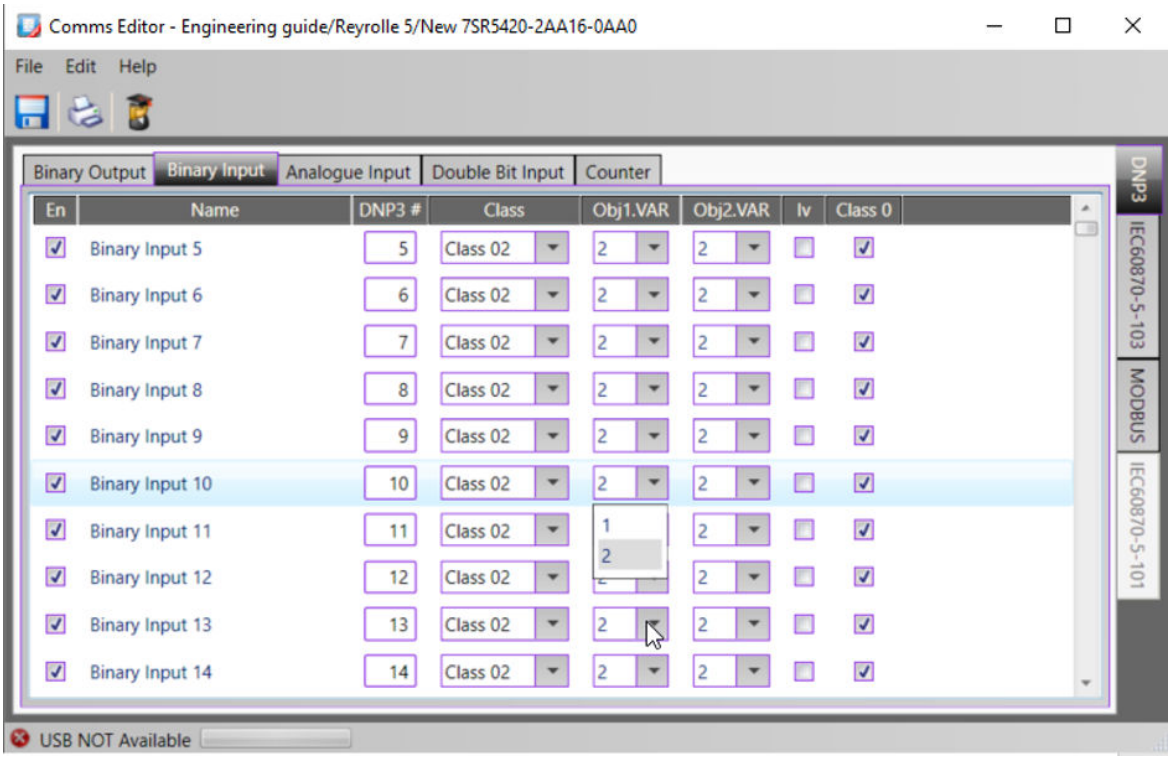


Figure 4-11 Setting the Binary Input Group 1 Variant

Table 4-9 Data Group 2 Variants

Group 2	Variant	Name	Description
	1	Binary Input Event – Without Time	The inputs are sent individually 1 byte per input with additional quality bits.
	2	Binary Input Event – With Absolute Time	As above + 48 bit absolute time
	3	Binary Input Event – With Relative Time	As 1 + 16 bit relative time

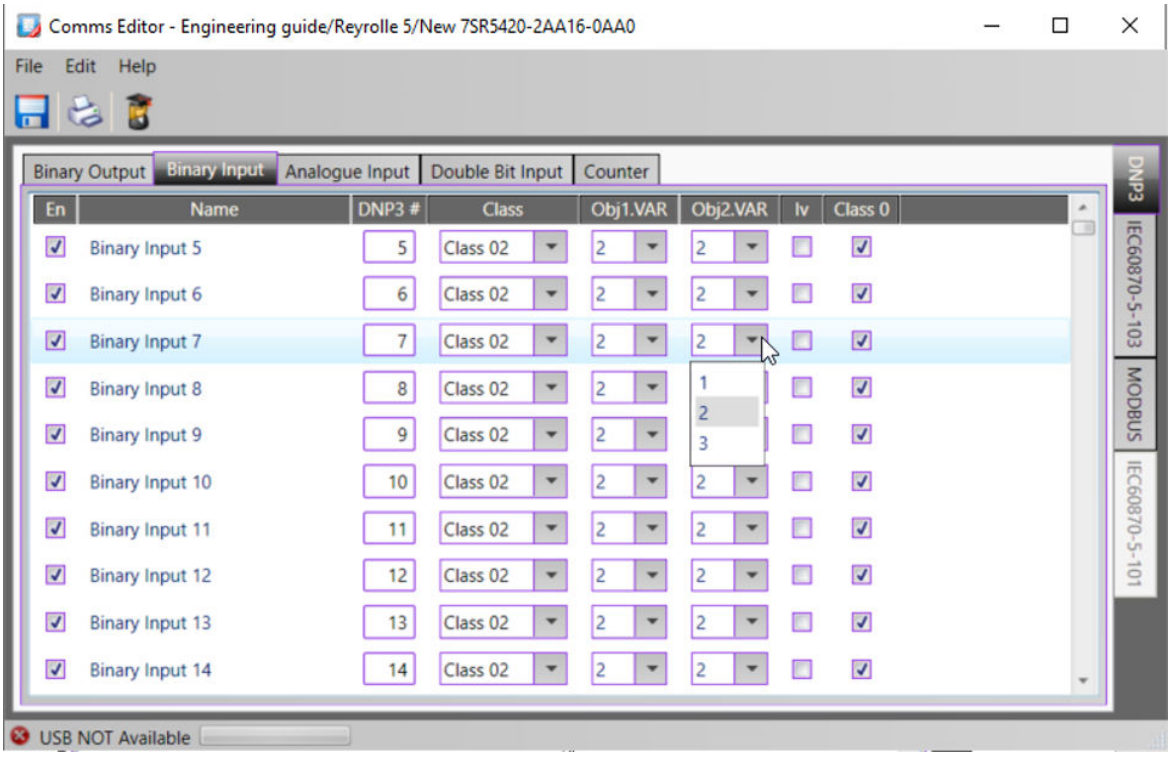


Figure 4-12 Setting the Binary Input Group 2 Variant

In addition for Binary Inputs the communications editor allows an inversion flag to be set, to invert the values before transmission, as illustrated in *Figure 4-13*.

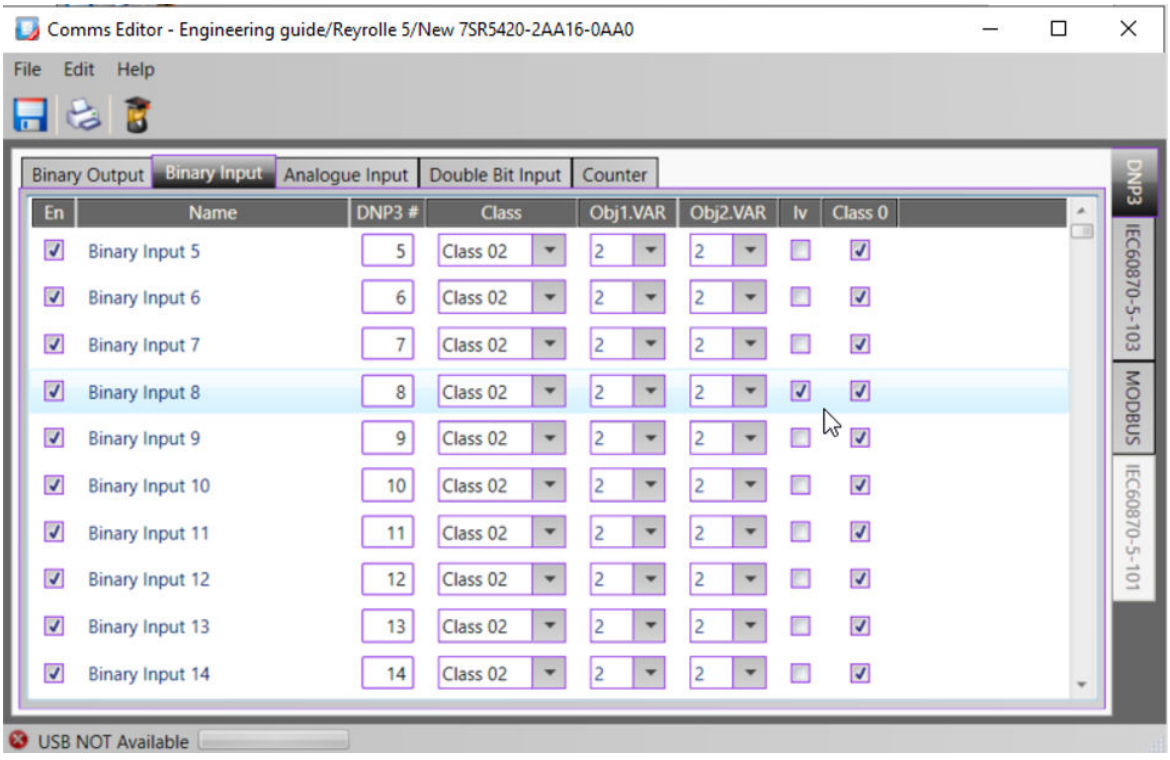


Figure 4-13 Setting the Binary Input Invert Flag

Binary Output Status Points and Control Relay Output Blocks

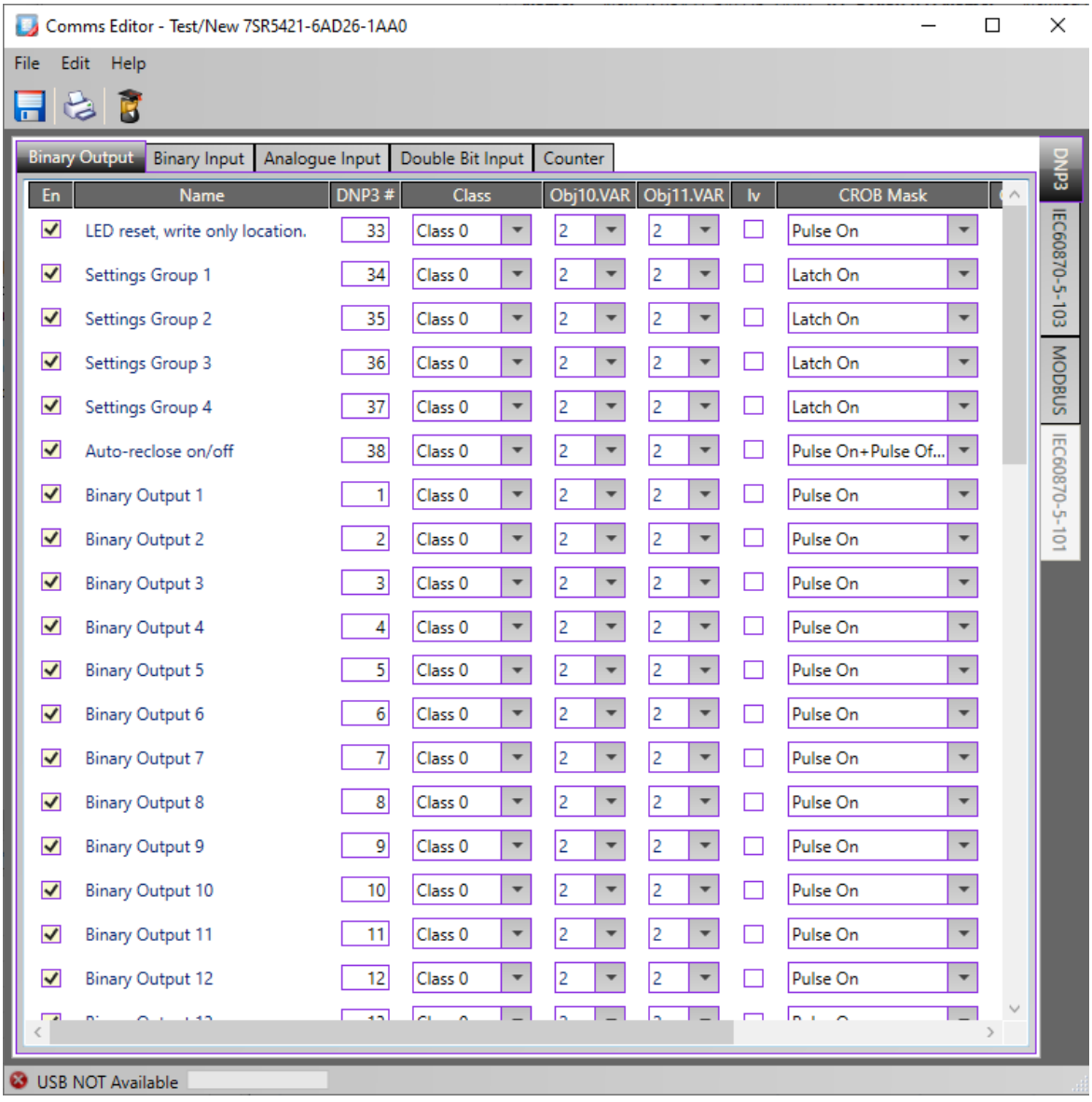
Figure 4-14 shows both the Binary Output Status Points (Object 10), Events (Object 11) and the Control Relay Output Blocks (Object 12).

While Binary Output Status Points are included here for completeness, they are not often polled by DNP3 Masters. It is recommended that Binary Output Status points represent the most recent DNP "commanded" value for the corresponding Control Relay Output Block point. Because many, if not most, Control Relay Output Block points are controlled through pulse mechanisms, the value of the output status may in fact be meaningless. Binary Output Status points are not recommended to be included in class 0 polls.

As an alternative, it is recommended that "actual" status values of Control Relay Output Block points be looped around and mapped as Binary Inputs. (The "actual" status value, as opposed to the "commanded" status value, is the value of the actuated control. For example, a DNP control command may be blocked through hardware or software mechanisms; in this case, the actual status value would indicate the control failed because of the blocking. Looping Control Relay Output Block actual status values as Binary Inputs has several advantages:

- It allows actual statuses to be included in class 0 polls,
- It allows change event reporting of the actual statuses, which is a more efficient and time-accurate method of communicating control values, and it allows reporting of time-based information associated with controls, including any delays before controls are actuated, and any durations if the controls are pulsed.

The default select/control buffer size is large enough to hold 10 of the largest select requests possible.



En	Name	DNP3 #	Class	Obj10.VAR	Obj11.VAR	Iv	CROB Mask
☑	LED reset, write only location.	33	Class 0	2	2	☐	Pulse On
☑	Settings Group 1	34	Class 0	2	2	☐	Latch On
☑	Settings Group 2	35	Class 0	2	2	☐	Latch On
☑	Settings Group 3	36	Class 0	2	2	☐	Latch On
☑	Settings Group 4	37	Class 0	2	2	☐	Latch On
☑	Auto-reclose on/off	38	Class 0	2	2	☐	Pulse On+Pulse Of...
☑	Binary Output 1	1	Class 0	2	2	☐	Pulse On
☑	Binary Output 2	2	Class 0	2	2	☐	Pulse On
☑	Binary Output 3	3	Class 0	2	2	☐	Pulse On
☑	Binary Output 4	4	Class 0	2	2	☐	Pulse On
☑	Binary Output 5	5	Class 0	2	2	☐	Pulse On
☑	Binary Output 6	6	Class 0	2	2	☐	Pulse On
☑	Binary Output 7	7	Class 0	2	2	☐	Pulse On
☑	Binary Output 8	8	Class 0	2	2	☐	Pulse On
☑	Binary Output 9	9	Class 0	2	2	☐	Pulse On
☑	Binary Output 10	10	Class 0	2	2	☐	Pulse On
☑	Binary Output 11	11	Class 0	2	2	☐	Pulse On
☑	Binary Output 12	12	Class 0	2	2	☐	Pulse On

[Platform Communications Protocol Manual Binary Inputs4, 2, --_--]

Figure 4-14 Binary Outputs

Communication editor PC software can be used to enable/ disable each information, specify the point number, Class, Object Variables, CROB mask and invert the point information, as illustrated below.

Binary Outputs via Data Groups 10 (static) and 11 (events) are supported. Each of these groups divides into the variants listed in *Table 4-10*, followed by an example of how they are set in the communications editor.

Table 4-10 Data Group 10 Variants

Group 10	Variant	Name	Description
	1	Binary Output – Packed Format	The outputs are sent in a packed format with 1 bit per input.
	2	Binary Output – With Flags	The outputs are sent individually 1 byte per input with additional quality bits.

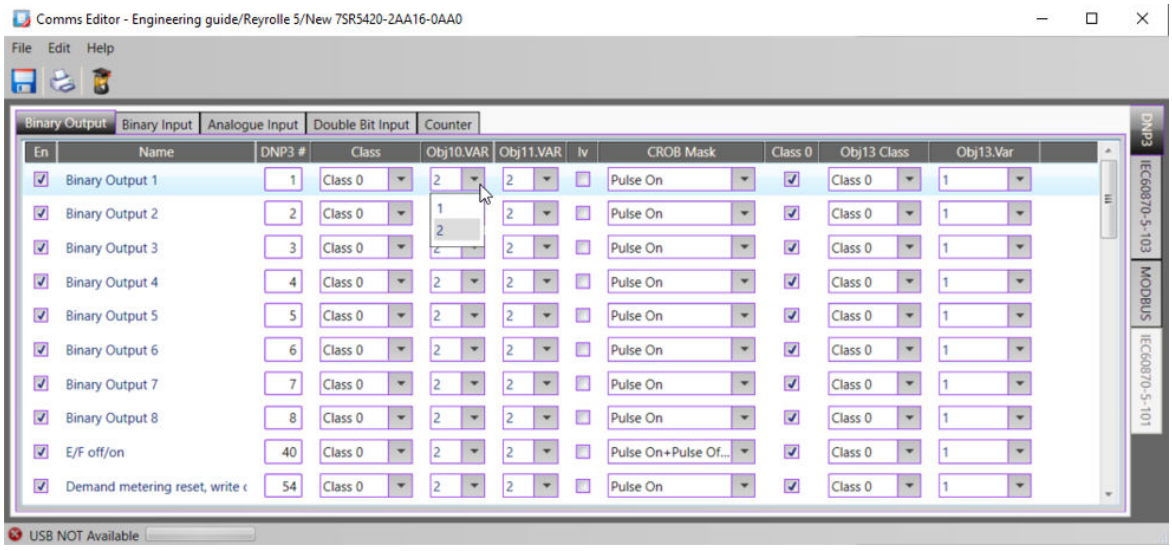


Figure 4-15 Setting the Binary Output Group 10 Variant

Table 4-11 Data Group 11 Variants

Group 11	Variant	Name	Description
	1	Binary Output Event – Without Time	The outputs are sent individually 1 byte per input with additional quality bits.
	2	Binary Output Event – With Absolute Time	As above + 48 bit absolute time

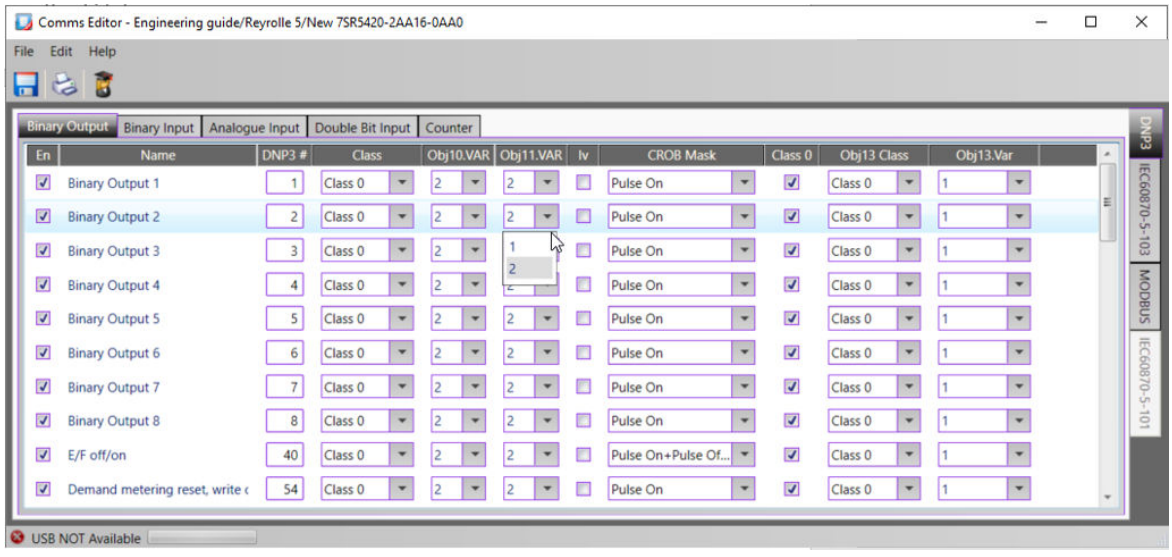


Figure 4-16 Setting the Binary Output Group 11 Variant

In addition for Binary Outputs the communications editor allows an inversion flag to be set, to invert the values before transmission, as illustrated in *Figure 4-17*.

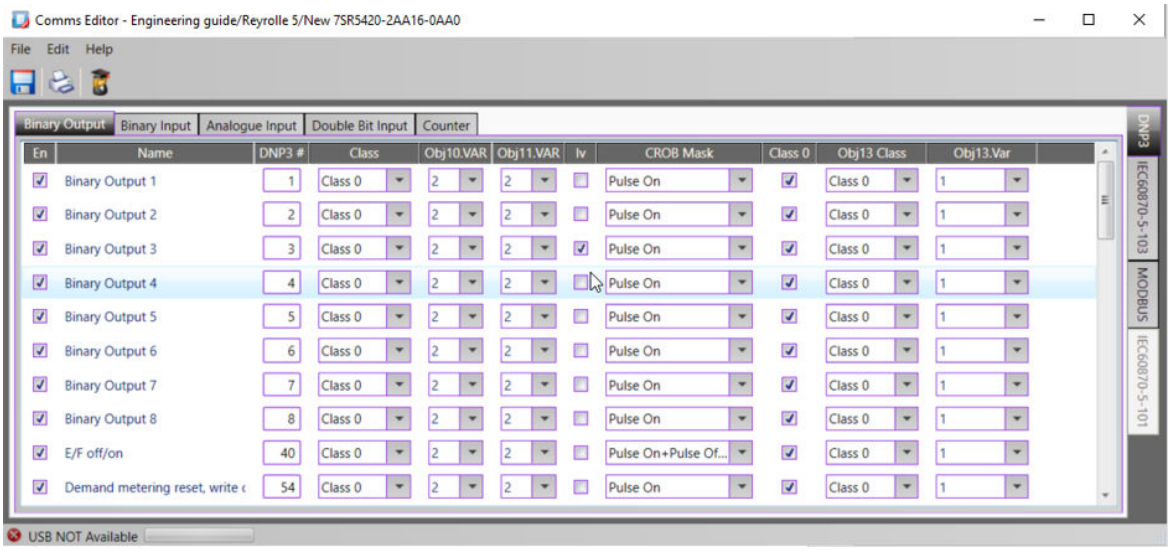


Figure 4-17 Setting the Binary Output Invert Flag

Binary Output Commands

The implementations of DNP3 Serial support Binary Output Commands via Data Group 12 - Binary Output Command. As these commands are sent by the master it is its responsibility to choose whether to use variant 1 CROB (Control Relay Output Block) or 2 PCB (Pattern Control Block).

The communications editor allows setting which CROB commands are allowed in a Binary Output Command. Depending on the command there will be a sub-set of PULSE-ON, PULSE-OFF, LATCH-ON, LATCH-OFF, Paired Trip, and Close.

NOTE

The pulse or latch functionality is defined by the function being controlled and is independent of the command format. The pulse, latch and trip and close selection is provided only to provide compatibility with the command format of different master systems.

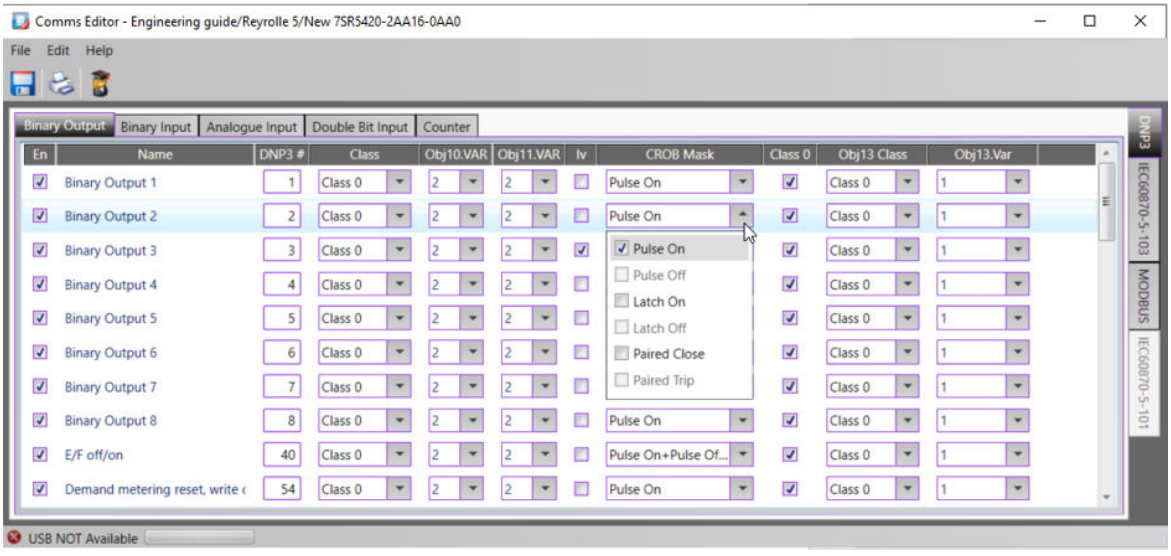


Figure 4-18 Setting the Binary Command CROB Mask

Double Bit Input

The implementations of DNP3 Serial supports the double bit input.

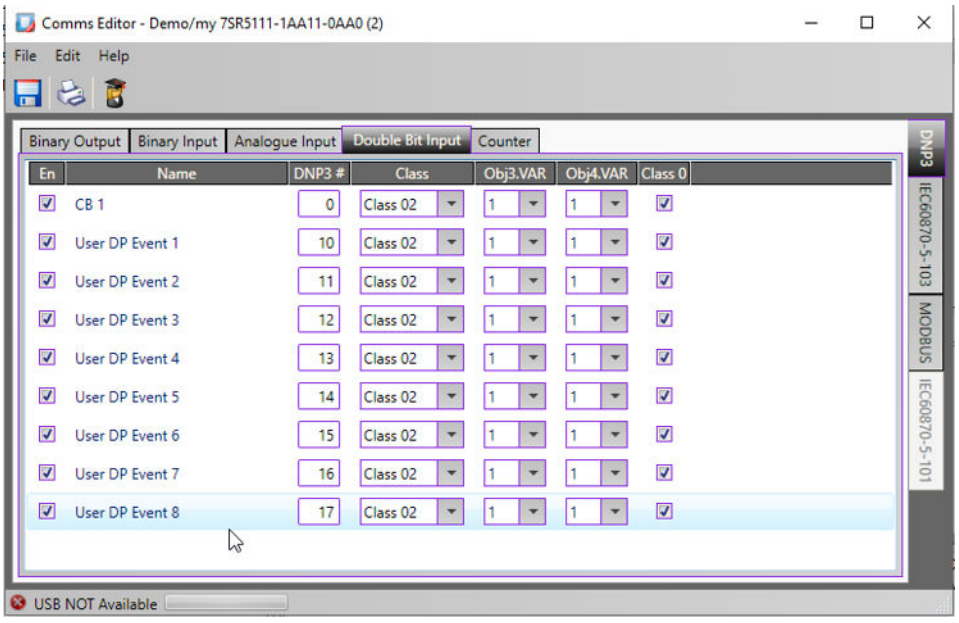


Figure 4-19 Double Bit Input Tab

Counters

The implementations of DNP3 Serial supports counters.

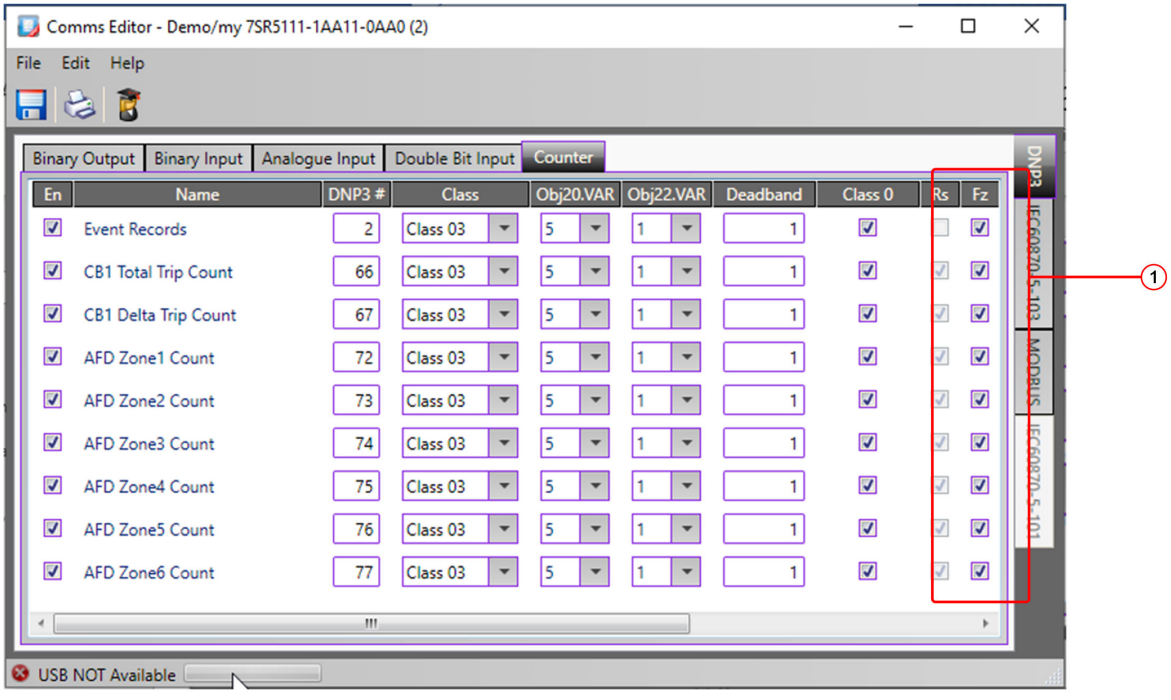


Figure 4-20 Counter Tab

(1) Frozen counters are also supported and points can be selected in the **Fz** column in the Communications editor.

5 Modbus TCP

5.1	Protocol Characteristics	126
5.2	Settings and Properties	132

5.1 Protocol Characteristics

5.1.1 Modbus TCP use in 7SR5 Devices

The Modbus TCP protocol is implemented on the Ethernet interface. This permits communication between the master and the slave for substation automation via the Modbus TCP protocol. The Ethernet interfaces come with 2 RJ45 connectors or with 2 duplex-LC interfaces for a 1300-nm fibre optic connection. The physical interface is always duplicated to permit redundant networks. The Ethernet interface has 1 IP address.

The device supports the use of IEC 61850 protocol and the Modbus TCP at the same time.

Reydisp Manager 2 is used for the configuration of the Modbus TCP protocol.

Storage of the Parameter Set

During device start-up, the parameter set of the device is first activated for the Ethernet interface and then the interface is started.

Information in the Parameter Set

The parameter set contains extensive information, such as the individual information for the devices configuration which can be mapped. This is carried out automatically by Reydisp Manager 2 during the device function configuration and the user has no part in this mapping. Devices with different function scope and type have different available information.

5.1.2 Protocol Structure

Modbus registers are 16 bit registers. There is not a standard as to how they are used; sometimes multiple registers are used to hold a data value. This section describes the Modbus data types we are using. Where a data type occupies more than one register, it is required that the number of consecutive registers are reserved. For example, if a two register data point starts at 30101, it is required that register 30102 is also reserved and so the next available register would be 30103.

5.1.3 Exception Response of Modbus Slave

If the Modbus slave receives a command from the Modbus master which cannot be processed (for example, a request to read a non-existent register), then the slave answers with an exception-response message. The following table shows the exception codes that are signaled in an exception-response message to the Modbus master by the Modbus slave of the 7SR5 device.

Table 5-1 Exception Response

Exception Code	Exception Response Message	Description
01	ILLEGAL_FUNCTION	The Modbus slave of the 7SR5 device does not support the function code used in the query by the Modbus master.
02	ILLEGAL_DATA_ADDRESS	The register address is not configured in the Modbus slave.
03	ILLEGAL_DATA_VALUE	The Modbus master tries to write to a register with illegal data.

5.1.4 Supported Modbus Addresses

Each data type has a Modbus point address between 0001 and 9999, with a single digit prefix defining the data type.

- 0xxxx – Coils
- 1xxxx – Inputs (Read only)
- 3xxxx – Status Registers (Read only)
- 4xxxx – Holding Registers

The complete list of points for a specific device configuration can be viewed and edited in Reydisp Manager 2 device configuration, Modbus TCP mapping file.

5.1.5 Supported Modbus Functions

The Modbus slave of the 7SR5 device supports the following Modbus functions:

Function Code	Function Name	Description	Broadcast Supported
1	Read Coil Status	Reading one or several coil-status registers of the Modbus slave. The coil-status registers reflect the ON/OFF status of discrete outputs of the 7SR5 device.	no
2	Read Input Status	Reading one or several input-status registers of the Modbus slave. The input-status registers reflect the ON/OFF status of discrete inputs and the status of the protection function of the 7SR5 device.	no
3	Read Holding Registers	Reading one or several holding registers of the Modbus slave. The holding registers contain device-status indications, measured values, mean values and metered measurand.	no
4	Read Input Registers	Reading one or several input registers of the Modbus slave. The input registers contain recorded measured values.	no
5	Force Single Coil	Writing (force to ON or OFF) one coil-status register.	no
15	Force Multiple Coils	Writing (force to ON or OFF) multiple coil-status registers	no
16	Preset Multiple Registers	Writing holding registers for resetting counters and setting the time.	no

5.1.6 Data Type Definition

Single-Point Indications: SPS

You can read single point indications by function code 1 or 2 via Modbus TCP. All these single point indications are CDC (Common Data Class) types defined in IEC 61850-7-3.

Different data structures are used with different function codes.

For more information, refer to the following tables:

Table 5-2 Reading SPS by Read Coil Status (FC1) or Read Input Status (FC2)

Bit x
Value

Double Point Status

You can read double point indications, such as DPS (Double-point status), by function code 1 or 2 via Modbus TCP.

Different data structures are used with different function codes.

For more information, refer to the following tables:

Table 5-3 Reading DPS by Read Coil Status (FC1) or Read Input Status (FC2)

Bit x+1	Bit x
Value	

Single Point Control

You can send Single Point Control (SPC) by function code 5.

Table 5-4 Sending SPC by Force Single Coil (FC5)

Bit x
Value

Range of values: 0 = Off
1 = On

Double Point Control

You can send Double Point Control (DPC) by function code 15.

Table 5-5 Sending DPC by Force Multiple Coils (FC15)

Bit x+1	Bit x
Value	

Range of values: 0 = Not allowed
1 = Off
2 = On
3 = Not allowed

Time Set and Counter Reset

You can send the time and reset device counters by function code 16.

Table 5-6 Sending Preset Multiple Registers (FC16)

Holding Register x+1		Holding Register x	
Byte 3 (MSB:Most Significant Byte)	Byte 2	Byte 1	Byte 0 (LSB:Least Significant Byte)
Value			

Range of values (Integer 32): -2 147 483 648 to 2 147 483 647

Time Meter

The time and date are set using 4 holding registers, by default starting at 40065. The time is loaded into these registers by a Modbus client in the following format:

Holding Register x	Holding Register x+1		Holding Register x+2		Holding Register x+3	
Milliseconds	Hours	Minutes	Months	Days	Day of Week	Year – 1900

The time will be activated when written. Alternatively, the **`Use Set Time and Date Register`** can be enabled, default holding register 40069, to signal activating the loaded time. The time registers do not update and will always show the last written time.

Measurements

You can read measured values, such as MV (Measured Value), by function code 4.

The MV input register type can be selected in the Reydisp Manager 2 Modbus mapping file. The options provided are Integer 16, Integer 32 or Float 32. The multiplier can also be selected from a predefined list.

Table 5-7 Reading MV by Read Input Register (FC4)

Holding Register x		Holding Register x+1	
Byte 3 (MSB)	Byte 2	Byte 1	Byte 0 (LSB)
Value			

Table 5-8 Reading MV by Read Input Register (FC4) Integer 16

Holding Register x	
Byte 1 (MSB)	Byte 0 (LSB)
Value	

Range of values (Float 32): $-3.4 \cdot 10^{38}$ to $3.4 \cdot 10^{38}$
$0 \cdot 7F8000001$ = NaN (Not a Number)
Range of values (Integer 32): -2 147 483 648 to 2 147 483 647
Range of values (Integer 16): -32768 to 32767

Binary Counter Reading

You can read counter values, such as Binary Counter Reading (BCR), by function code 3.

The counters have a fixed type of either Integer 16 or Integer 32 as defined in the mapping file. They also have a fixed scaling and mulitplier.

Table 5-9 Reading BCR by Read Holding Register (FC3)

Holding Register x		Holding Register x+1	
Byte 3 (MSB)	Byte 2	Byte 1	Byte 0 (LSB)
Value			

Range of values (Integer 32): -2 147 483 648[5] to 2 147 483 647

Device Information

Modbus master can read the device information fixed in the 7SR5 device. Encoded as ASCII text. Registers are Read Only. Read using FC3.

Item	Register Address	Description
Communication ref	40001 to 40008	Example: 4E45h 3031h 0030h Means: EN100
Communication module firmware revision	40009 to 40010	Example: 0014h 0100h 0.1.20.0

5 The minimum value -2 147 483 648 indicates that the value is not valid.

Item	Register Address	Description
Device MLFB code	40011 to 40026	Example: 5337h 3552h 3131h 2D31h 4131h 3141h 2D31h 4130h 3041h 7SR5111-1AA11-0AA0
Date and time of mapping data generation	40027 to 40034	Example: 3430h 3930h 3032h 3031h 3330h 3231h 3030h 0030h 4th Sept. 20 10:03:12.000

NOTE

Address 40035 to 40048 are reserved for device information.

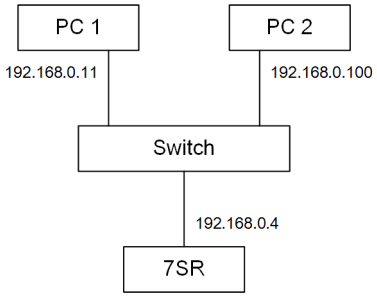
5.1.7 Multi-Connection to Master via Modbus

General

7SR5 supports multi-connection via Modbus as follows:

- Maximum 2 Modbus masters connect to the Modbus slave (7SR5 device) simultaneoulsy.

The port number for each Modbus TCP port can be configured, see *5.2.1 Device Mapping and Configuration*.



[dw_7SR5_ExampleModbusConnection, 1, en_US]

Figure 5-1 Example Connection

The device can also communicate simultaneously using Modbus TCP over the front USB and rear ethernet ports when configured using different ports.

Configuration Scenario	TCP Port Number (#1) Default: 502	TCP Port Number (#2) Default: 504	Note
1	Rear Ethernet	Rear Ethernet	Port addresses must not be the same.
2	Rear Ethernet	Front USB	
3	Front USB	Rear Ethernet	

5.1.8 Operating Modes

The behavior of the protocol does not depend on the operating mode of the device.

5.1.9 Parallel Running with IEC 61850

7SR5 device supports the Modbus TCP and IEC 61850 protocols running on the same Ethernet interface.

The following restrictions are recommended:

- IEC 61850 clients: maximum 6 IEC 61850 clients communicate with 7SR5 device at one time.
- GOOSE (Generic Object Oriented Substation Event): maximum 5 GOOSE applications/datasets per device, with 50 data objects in total. Use the standard settings of the communication profile **`PriorityLow`** in GOOSE parameters of the IEC 61850 GOOSE application.

The recommendations mentioned in the preceding paragraph are not fixed. For example, you can configure and download more GOOSE applications with more data objects as source and destination to the device. Higher GOOSE load can lead to a delayed transmission.

5.2 Settings and Properties

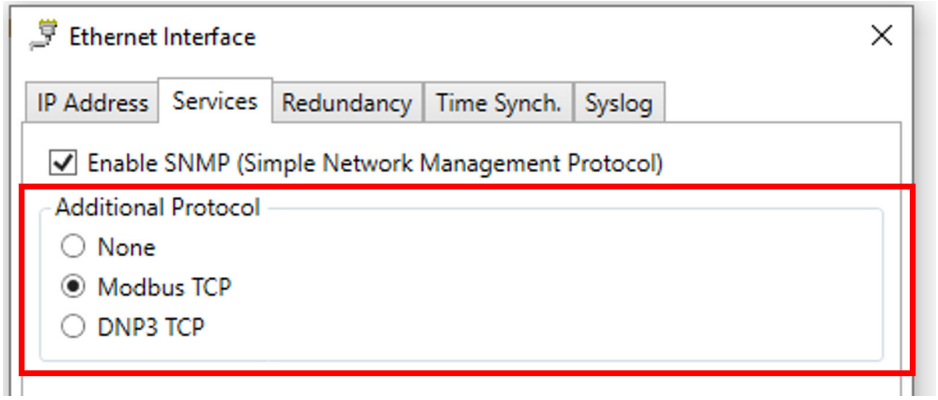
If supported by the device template, Modbus TCP can be enabled by the end user. For security reasons it is disabled by default and has no IP address configured.

Enabling Modbus TCP

Select the device in the project tree.

Open the Ethernet Interface from the task area.

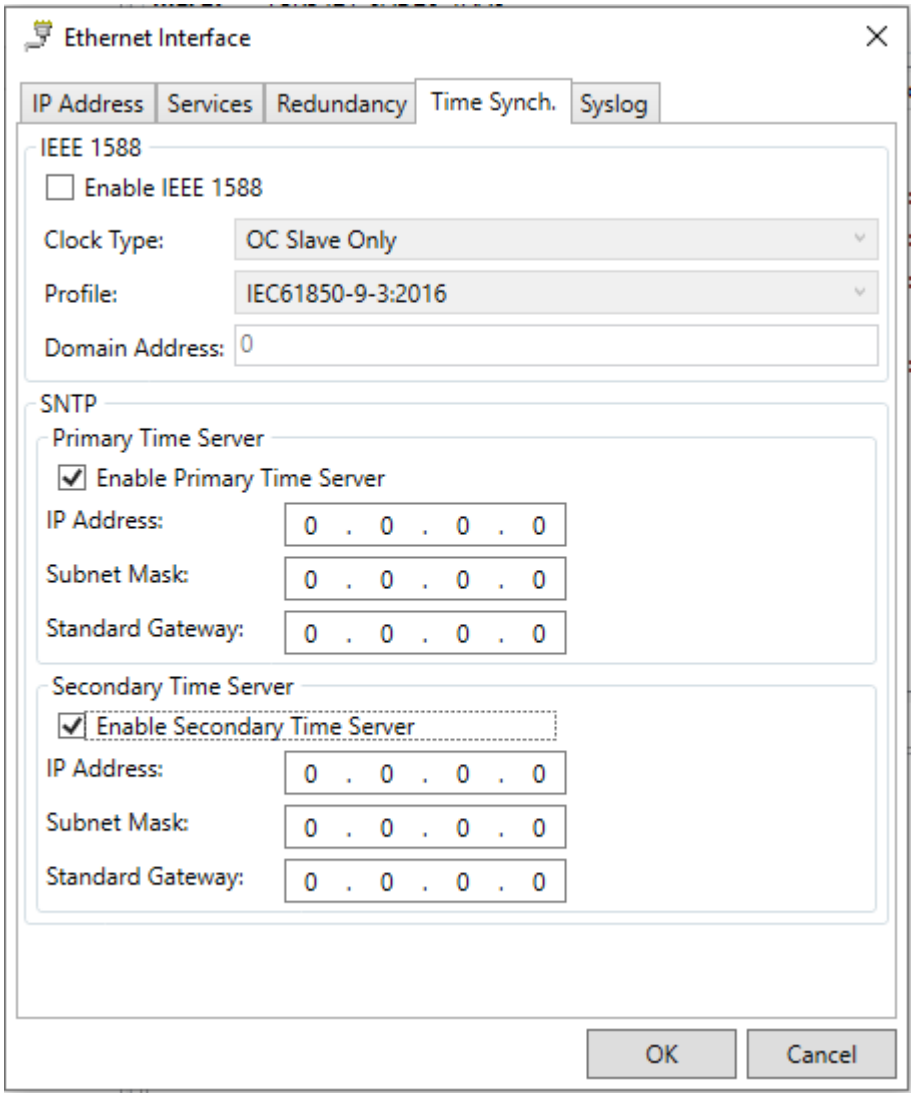
Modbus TCP is enabled using the **Services** tab of the **`Ethernet Interface`** task.



[sc_7SR5_DNP3Configuration, 2, --_--]

Figure 5-2 Enable Modbus TCP

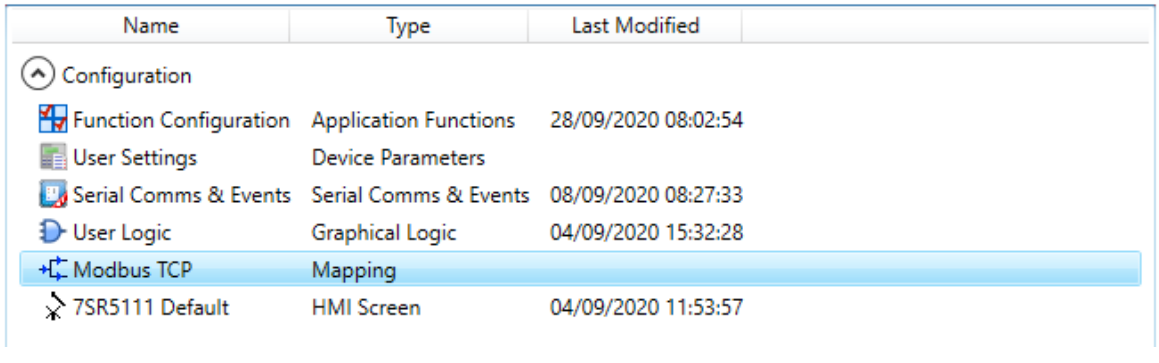
To enable the Ethernet port to use the Modbus TCP master as a time source the **Enable Primary Time Server** must be selected in the Configure Interface, Time Synch tab. The IP address, subnet mask and standard gateway should be configured in accordance with the network parameters for operation and *5.1.7 Multi-Connection to Master via Modbus*.



[sc_7SR5_ReydispManager2SNTPTab, 3, --_--]

Figure 5-3 Enable Primary Time Server

Once Modbus TCP is enabled, a resource file will be available within main device configuration view as shown in *Figure 5-4*.



[sc_7SR5_ModbusTCPResourceFile, 1, --_--]

Figure 5-4 Modbus TCP Resource File

5.2.1 Device Mapping and Configuration

Each specific device model will have a unique configuration file.

The supported information available for each device can be viewed using the Reydisp Manager 2 PC software tool in the Mapping file.

This protocol can be used on the USB port for testing purposes but primarily it should be used on the rear ethernet ports.

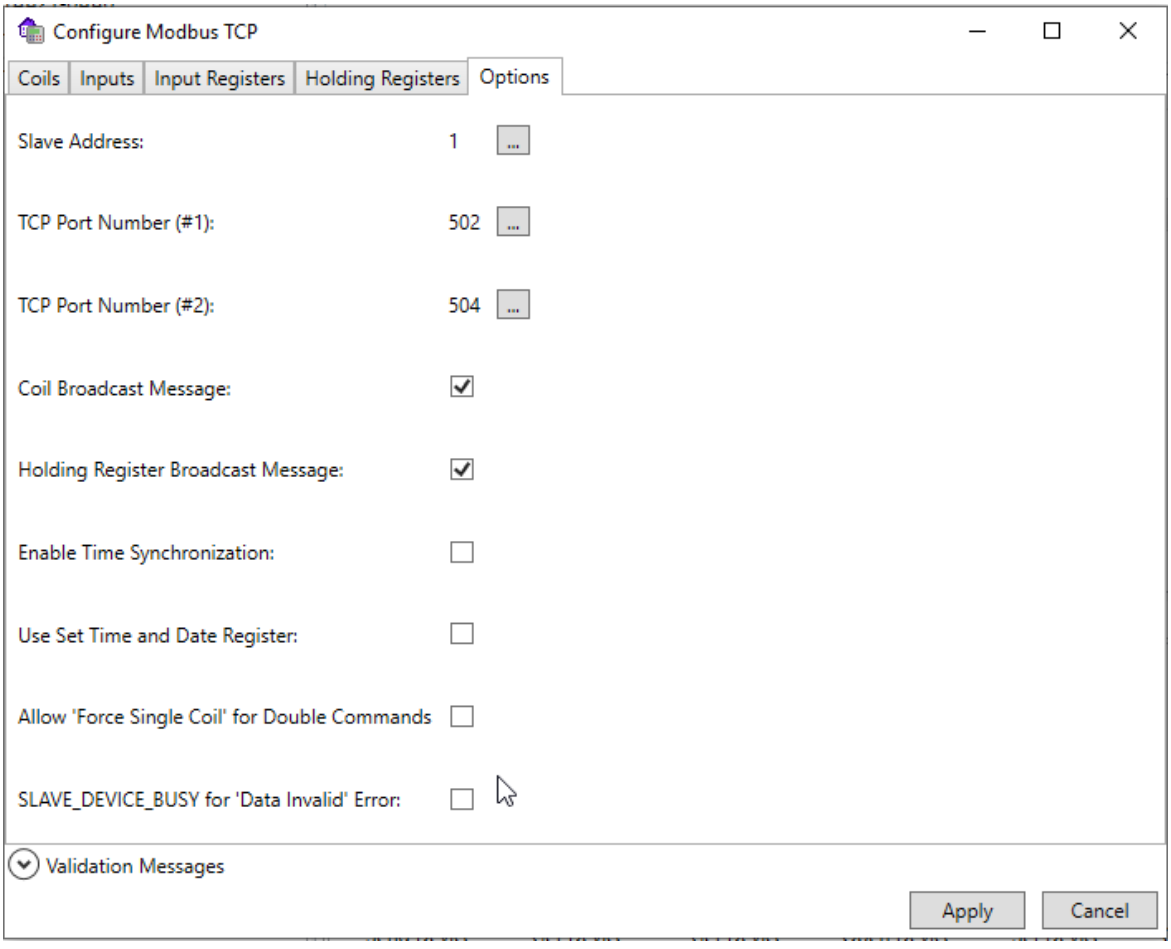


Figure 5-5 Modbus TCP Configuration

The **Options** tab provides the General Modbus TCP parameters.

On completing any parameter and configuration changes select the **`Apply`** option.

Setting Name	Range	Default	Setting	Notes
Slave Address	1 to 247	1	As required	An address must be given to identify the device. Each device must have a unique address. This needs to match the **`Unit Identifier`** field sent by the Modbus client.
TCP Port Number #1	100 to 65535	502	502 Recommended, although flexible range is provided	Selects the Transmission Control Protocol port used by the Modbus server to listen and receive data.
TCP Port Number #2	100 to 65535	504	504 Recommended, although flexible range is provided	Selects the Transmission Control Protocol port used by a second Modbus server to listen and receive data.
Coil Broadcast Message	Yes No	Yes	Yes	Selects if the device shall be allowed to broadcast coil messages.
Holding Register Broadcast Message	Yes No	Yes	Yes	Selects if the device shall be allowed to broadcast holding register messages.
Enable Time Synchronization	Disabled Enabled	Disabled	As required	Selects if time synchronization is enabled from Modbus TCP. Should not be used when SNTP is used.
Use Set Time and Date Register	Disabled Enabled	Disabled	As required	Selects if time and date register can be updated for acceptance of previous written clock synchronization data or when disabled the time data is set at the time of writing.

Setting Name	Range	Default	Setting	Notes
Allow 'Force Single Coil' for Double commands	Disabled Enabled	Disabled	As required	When enabled both single and multiple coils may be forced, when disabled only multiple coils may be forced.
SLAVE_DEVICE_BUSY for 'Data Invalid' Error	Yes No	No	As required	When selected only Read Input register and Write commands are executed. When not selected a bit in the Diagnostics Register indicates 'Data Invalid'.

NOTE

If the Modbus time synch is Enabled, the Modbus TCP master shall perform time synchronization to the slave periodically. The time source information sent from the NTP server will be rejected.

6 Modbus RTU

6.1	Protocol Characteristics	138
6.2	Settings and Properties	152

6.1 Protocol Characteristics

Description

This section describes the Modbus RTU protocol implementation in the relays. This protocol is used for the communication with a suitable control system. This section provides a general description of the Modbus RTU serial protocol and its implementation on the Reyrolle relay platform. It is not a description of the functionality of each specific relay.

This protocol can be set to use the RS485 port.

NOTE

Please note, not all data addresses will apply to all models. The exact information for a particular 7SR5 device model can be viewed in the Reydisp Manager 2 configuration using the Serial Comms & Events tool.

Protocol Structure

Modbus registers are 16 bit registers. There is not standard as to how they are used; sometimes multiple registers are used to hold a data value. This section describes the Modbus data types we are using. Where a data type occupies more than one register, it is required that the number of consecutive registers are reserved. For example, if a two register data point starts at 30101, it is required that register 30102 is also reserved and so the next available register would be 30103.

The number of registers required for each data type is shown in the table below:

Data Type	# Registers required
EVENTCOUNT	1
EVENT	8
FP_32BITS_3DP	2
UINT16	1
UINT32	2
STR32	16
STR64	32
TIMEMETER	4

Data Types

EVENTCOUNT

Single register containing the number of event records stored, refer below.

EVENT

Modbus does not define a method for extracting events; therefore a private method has been defined based on that defined by IEC 60870-5-103.

The EVENTCOUNT register contains the current number of events in the relays event buffer. The EVENT registers contains the earliest event record available. The event record is 8 registers (16 bytes) of information, whose format is described below. When this record has been read it will be replaced by the next available record. Event records must be read completely; therefore the quantity value must be set to 8 before reading.

FP_32BITS_3DP

A real value transmitted as a 32 bit integer scaled and fixed point to three decimal places, for example, 12.345 would be sent as 12345.

UINT16

A 16 bit unsigned integer.

UINT32

A 32 bit unsigned integer.

STR32
A 32 byte String.

STR64
A 64 byte String.

TIMEMETER
A 4 register (8 byte) Time Meter formatted as shown below

Byte	Key	Description
0	ms L	Milliseconds low byte
1	ms H	Milliseconds high byte
2	Mi	Minutes (MSB = invalid, time not set > 23 hours)
3	Ho	Hours (MSB - Summer time flag)
4	Da	Days
5	Mo	Months
6	Ye L	Years low byte
7	Ye H	Years high byte (If Not Used = 0)

Modbus Address

The Modbus point address.

Each data type has an address between 0001 and 9999, with a single digit prefix defining the data type.

0xxxx = Coils

1xxxx = Inputs (Read Only)

3xxxx= Status Registers (Read Only)

4xxxx= Holding Registers

Examples of requests and responses are given. If an invalid address is sent or the data is not available an exception code will be returned.

Coils (0xxxx)

The coils are read and written by functions 1 (Read Coil Status) and 5 (Write Coil Status) respectively. Writing to a coil is the mechanism we use to make Modbus perform a command, e.g. closing an output relay.

The Read Coil Status function will return an exception code 2 if any of the addresses in a range are invalid. The addresses listed with an (*) cannot be read (polled) as their value is indeterminable. They are listed as write only coils for sending commands to the device.

The Write Coil Status function will return an exception code (2) if the address is invalid, or if the command cannot be executed. Some addresses listed above are ON only commands, rather than ON/OFF, sending OFF to these addresses will also return exception code 2.

Example Reading Coils

Request the output relay coils 1 to 11. The start address is 01075, as per the Modbus standard this is sent by the master without the 0xxxx identification and has 1 subtracted from it to make it zero based indexing i.e. 1075 - 1 = 1074 (0x0432). The quantity is set to 11 bits for the 11 output relays. In this example the slave address is 1. All values are shown in hex notation. The response shows only output relay 1 is on.

Request	Example
Slave Address	0x01
Function Code	0x01
Start Address Hi	0x04
Start Address Lo	0x32
Quantity of outputs Hi	0x00
Quantity of outputs Lo	0x0b
CRC Lo	0xdd
CRC Hi	0x32

Response	Example
Slave Address	0x01
Function Code	0x01
Byte Count	0x02
Output status 1-8	0x01
Output status 9-11	0x00
CRC Lo	0xb8
CRC Hi	0x6c

Example Writing Coil

Request settings group 3 to be selected. The address is 00025, therefore sent as 25 - 1 = 24 (0x0018). The command is on = 0xFF00. The slave address is 1.

Request	Example
Slave Address	0x01
Function Code	0x05
Start Address Hi	0x00
Start Address Lo	0x18
Output Value Hi	0xff
Output Value Lo	0x00
CRC Lo	0x0c
CRC Hi	0x3d

Response	Example
Slave Address	0x01
Function Code	0x05
Start Address Hi	0x00
Start Address Lo	0x18
Output Value Hi	0xFF
Output Value Lo	0x00
CRC Lo	0x0c
CRC Hi	0x3d

Inputs (1xxxx)

The input addresses are read by function 2 (Read Input Status). The Read Input Status function will return an exception code 2 if any of the addresses in a range are invalid.

Example Reading Inputs

Request the status inputs 1 to 4. The start address is 10027, as per the Modbus standard this is sent by the master without the 1xxxx identification and has 1 subtracted from it to make it zero based indexing i.e. 27 - 1

= 26 (0x001A). The quantity is set to 4 bits for the 4 inputs. In this example the slave address is 1. All values are shown in hex notation. The response shows none of the status inputs is on.

Request	Example
Slave Address	0x01
Function Code	0x02
Start Address Hi	0x00
Start Address Lo	0x1a
Quantity of inputs Hi	0x00
Quantity of inputs Lo	0x04
CRC Lo	0x58
CRC Hi	0x0e

Response	Example
Slave Address	0x01
Function Code	0x02
Byte Count	0x01
Input status 1-4	0x00
CRC Lo	0xa1
CRC Hi	0x88

Input Registers (3xxxx)

The read input registers are returned as either a fixed point number or a string. Fixed point numbers will be either 16 bits (1 register/word) or 32 bits (2 registers/words). The value may be scaled by the value in the Scaling column of the above table, for example, a number sent as 1013 which is scaled by 1000 is equal to 1.013. The units of measure for the values are given in the Scaled Units column and refer to when any scaling has been removed.

NOTE

Only one of these measurands can be read per poll.

Event Record

Modbus does not define a method for extracting events; therefore a private method has been defined based on that defined by section 5 IEC 60870-5-103.

Register 30001 contains the current number of events in the relays event buffer. Register 30002 contains the earliest event record available. The event record is 8 registers (16 bytes) of information, whose format is described below. When this record has been read it will be replaced by the next available record. Event records must be read completely; therefore the quantity value must be set to 8 before reading. Failing to do this will result in an exception code 2. If no event record is present the exception code 2 will be returned. The event address should be polled regularly by the master for events.

Format

The format of the event record is defined by the zero byte. It signifies the type of record which is used to decode the event information. The zero byte can be one of the following.

Table 6-1 Event Types

Type	Description
1	Event
2	Event with Relative Time
4	Measurand Event with Relative Time

Table 6-2 describes the fields in the event record.

Table 6-2 Event Mnemonics

Key	Description
FUN	Function Type, as defined for IEC 870-5-103, refer to section 5.
INF	Information Number, as defined for IEC 870-5-103, refer to section 5.
DPI	Measurand Event with Relative Time, values 1 = OFF, 2 = ON.
ms L	Time Stamp Milliseconds low byte
ms H	Time Stamp Milliseconds high byte
Mi	Time Stamp Minutes (MSB = invalid, time not set > 23 hours)
Ho	Time Stamp Hours (MSB = Summer time flag)
RT L	Relative Time low byte
RT H	Relative Time high byte
F# L	Fault Number low byte
F# H	Fault Number high byte
Meas	Measurand format R32.23, sent least significant byte first

Table 6-3, *Table 6-4*, and *Table 6-5* show the fields in the different event records as they are returned.

Table 6-3 Event Type 1 Format

Byte	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Content	1	0	FUN	INF	DPI	0	0	0	0	0	0	0	ms L	ms H	Mi	Ho

Table 6-4 Event Type 2 Format

Byte	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Content	2	0	FUN	INF	DPI	RT L	RT H	F# L	F# H	0	0	0	ms L	ms H	Mi	Ho

Table 6-5 Event Type 4 Format

Byte	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Content	4	0	FUN	INF	Meas				RT L	RT H	F# L	F# H	ms L	ms H	Mi	Ho

Example

Request the event registers. The address is 30002, as per the Modbus standard this is sent by the master without the 3xxxx identification and has 1 subtracted from it to make it zero based indexing (i.e. 1 = 0x0001). The quantity is set to 8 registers. In this example the slave address is 1. All values are shown in hex notation. The response shown is a type 1 event

Request	Example
Slave Address	0x01
Function Code	0x04
Start Address Hi	0x00
Start Address Lo	0x01
Quantity of input Reg. Hi	0x00
Quantity of input Reg. Lo	0x08

Request	Example
CRC Lo	0xa0
CRC Hi	0x0c

Response (1)	Example
Slave Address	0x01
Function Code	0x04
Byte Count	0x10
Type	0x01
Reserved	0x00
FUN	0xa0
INF	0x19
DPI	0x01
Reserved	0x00
Reserved	0x00
Reserved	0x00
Reserved	0x00
Reserved	0x00
Reserved	0x00
Reserved	0x00
ms L	0x52
ms H	0x6c
Mi	0xad
Ho	0x17
CRC Lo	0x06
CRC Hi	0xbd

Table 6-6 and *Table 6-7* illustrate type 2 and 4 event records.

Table 6-6 Type 2 Event Records

Response (2)	Example
Slave Address	0x01
Function Code	0x04
Byte Count	0x10
Type	0x02
Reserved	0x00
FUN	0xa0
INF	0x54
DPI	0x02
RT L	0x00
RT H	0x00
F# L	0x41
F# H	0x30
Reserved	0x00
Reserved	0x00
Reserved	0x00
ms L	0x38
ms H	0x09
Mi	0xba

Response (2)	Example
Ho	0x17
CRC Lo	0x92
CRC Hi	0xb5

Table 6-7 Type 4 Event Records

Response (4)	Example
Slave Address	0x01
Function Code	0x04
Byte Count	0x10
Type	0x04
Reserved	0x00
FUN	0xa4
INF	0x47
Meas Lo	0x00
Meas 1	0x80
Meas 2	0x1d
Meas Hi	0x44
RT L	0x00
RT H	0x00
F# L	0x00
F# H	0x00
ms L	0xb2
ms H	0x11
Mi	0xba
Ho	0x17
CRC Lo	0x79
CRC Hi	0xb1

Table 6-8 is an example of the exception response returned when no event records are available.

Table 6-8 Example of Exception Response to Event Record Request

Request	Response
Slave Address	0x01
Function Code	0x84
Exception Code	0x02
CRC Lo	0x00
CRC Hi	0x43

Table 6-9 Holding Registers (4xxxx)

Address	Description	FORMAT	SIZE (WORDS)
40001	Set Time	Time 8	4

The holding register addresses listed in *Table 6-9* are read by function 3 (Read Holding Registers) and written by function 16 (Write Multiple Registers).

Register 40001 contains the devices time. The time must be read or written in one step; therefore the quantity should be 4 registers. Failing to do this will result in an exception code 2. The time format is 8 bytes as follows.

Table 6-10 describes the fields in the time.

Table 6-10 Time Stamp Mnemonics

Key	Description
ms L	Time Stamp Milliseconds low byte
ms H	Time Stamp Milliseconds high byte
Mi	Time Stamp Minutes (MSB = invalid, time not set > 23 hours)
Ho	Time Stamp Hours (MSB = Summer time flag)
Da	Time Stamp Days
Mo	Time Stamp Months
Ye L	Time Stamp Years low byte
Ye H	Time Stamp Years high byte (Not Used)

Table 6-11 shows the fields in the time as they are returned.

Table 6-11 Time Format

Byte	0	1	2	3	4	5	6	7
Content	ms L	ms H	Mi	Ho	Da	Mo	Ye L	Ye H

Examples

Request time registers. The address is 40001, as per the Modbus standard this is sent by the master without the 4xxxx identification and has 1 subtracted from it to make it zero based indexing. The quantity is set to 4 registers. In this example the slave address is 17. All values are shown in hex notation. The time returned is 00:08:05.340, 2/Jan/00.

Request	Example
Slave Address	0x01
Function Code	0x03
Start Address Hi	0x00
Start Address Lo	0x00
Quantity of inputs Hi	0x00
Quantity of inputs Lo	0x04
CRC Lo	0x44
CRC Hi	0x09

Response	Example
Slave Address	0x01
Function Code	0x03
Byte Count	0x08
ms L	0xdc
ms H	0x14
Mi	0x08
Ho	0x00
Da	0x02
Mo	0x01
Ye L	0x00
Ye H	0x00
CRC Lo	0x9d
CRC Hi	0xef

Set time registers. Again the address is 40001. The quantity is set to 8 registers. In this example the slave address is 17. All values are shown in hex notation. The time being set is 16 hours, 5 minutes, 30563 (0x7763) ms and the date 29 October 03.

Request	Example
Slave Address	0x01
Function Code	0x10
Start Address Hi	0x00
Start Address Lo	0x00
Quantity of inputs Hi	0x00
Quantity of inputs Lo	0x04
Byte Count	0x08
ms L	0x63
ms H	0x77
Mi	0x05
Ho	0x10
Da	0x1d
Mo	0x0a
Ye L	0x03
Ye H	0x00
CRC Lo	0x10
CRC Hi	0x48

Response	Example
Slave Address	0x01
Function Code	0x10
Start Address Hi	0x00
Start Address Lo	0x00
Quantity of inputs Hi	0x00
Quantity of inputs Lo	0x04
CRC Lo	0xc1
CRC Hi	0xca

The floating point value in a type 4 event record is defined by IEC 60870-5-103 being a Real value 32 bits wide with a 23 bit fraction, 8 bit exponent and 1 bit sign, encoded as shown in *Table 6-12*.

Table 6-12 Floating Point Value

MSB																												LSB
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
S				Exponent														Fraction													

The value is transmitted in little endian format, Least Significant Byte (LSB) first, Most Significant Byte (MSB) last.

NOTE

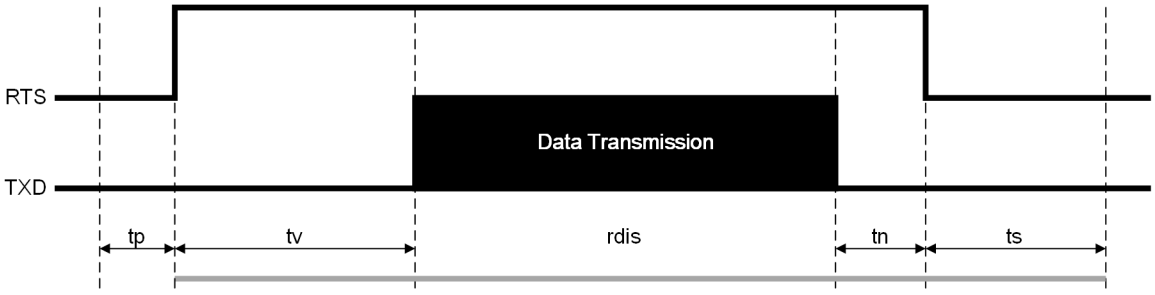
In the RTU mode, message frames are separated with a silent interval of at least 3.5 character times and the time interval is also called t3.5. The Modbus RTU master provides the t3.5 delay for responding to another query.

The following silent interval time equation is implemented in the 7SR5 Relay:

t_{delay} required = 11 bits · 3.5/b

Where, b = baud rate in bit/s

t_{delay} for 7SR5 = t_{delay} required + 10 ms tolerance



[dw_time-setting_message-frame, 1, en_US]

Figure 6-1 Time Settings for Message Frame

tp = Pause time (pause before RTS = ON)
tv = Setup time (transmission delay after RTS = ON)
tn = Hold time (pause time after sending before RTS = tOFF)
ts = Hold receiver disabled after RTS = OFF
rdis = Disable receiver when using half duplex protocol

NOTE

Only active when ts = 0

NOTE

Only tp or ts must be equal to t_{delay} for the 7SR5 Relay.

6.1.1 Device Mapping and configuration

The implementation of Modbus supports the reading and writing of coils.

The communications editor allows the following items to be configured by the user.

EN - Enable

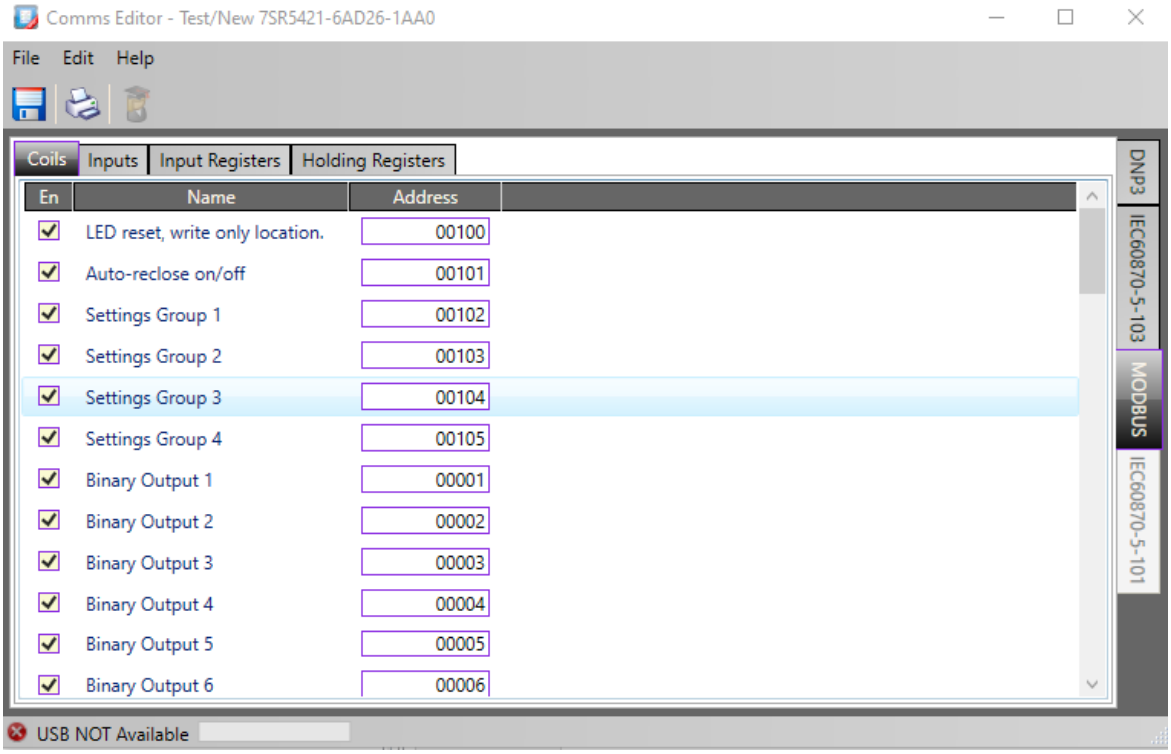
This check box enables each point in the Modbus data map. A point must be enabled to be accessed via Modbus.

Name

The internal name of the point.

Address

The address of the coil in the data map.



The implementation of Modbus supports the reading inputs.

The communications editor allows the following items to be configured by the user.

EN - Enable

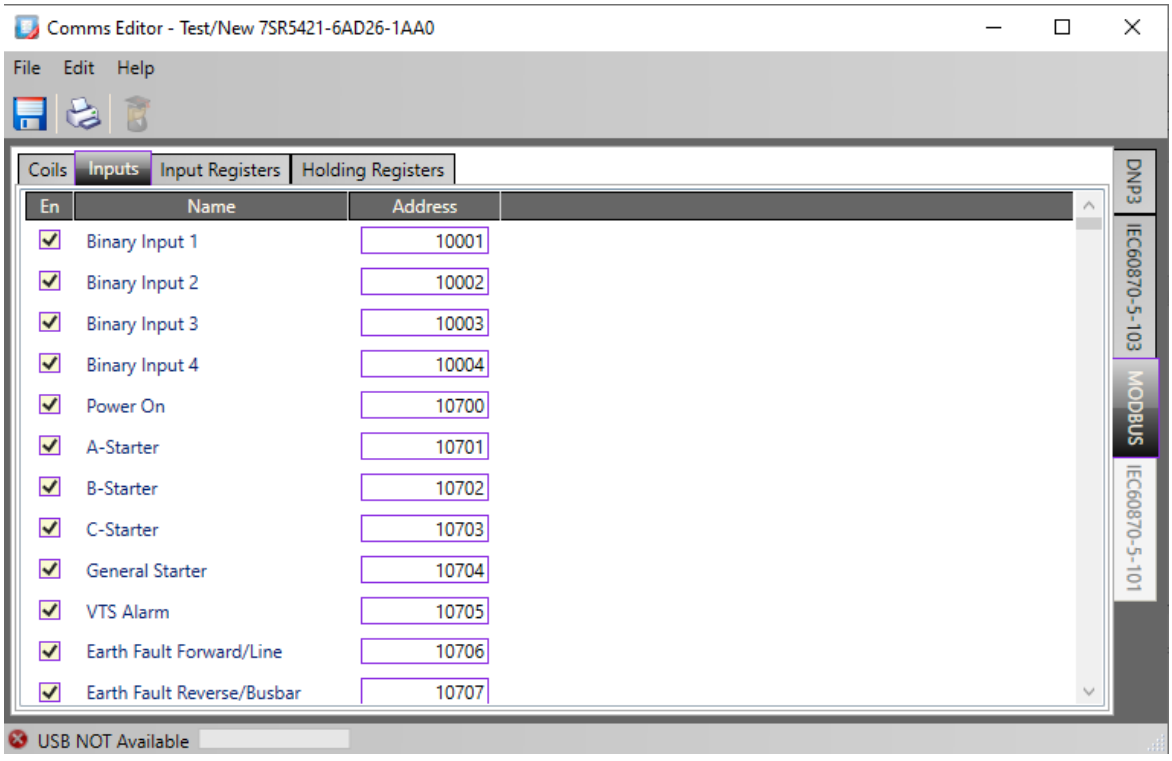
This check box enables each point in the Modbus data map. A point must be enabled to be accessed via Modbus.

Name

The internal name of the point.

Address

The address of the input in the data map.



[Platform Communications Protocol Manual Settings and Properties3, 2, --_--]

The implementation of Modbus supports the reading of input registers.

The communications editor allows the following items to be configured by the user.

EN - Enable

This check box enables each point in the Modbus data map. A point must be enabled to be accessed via Modbus.

Name

The internal name of the point.

Address

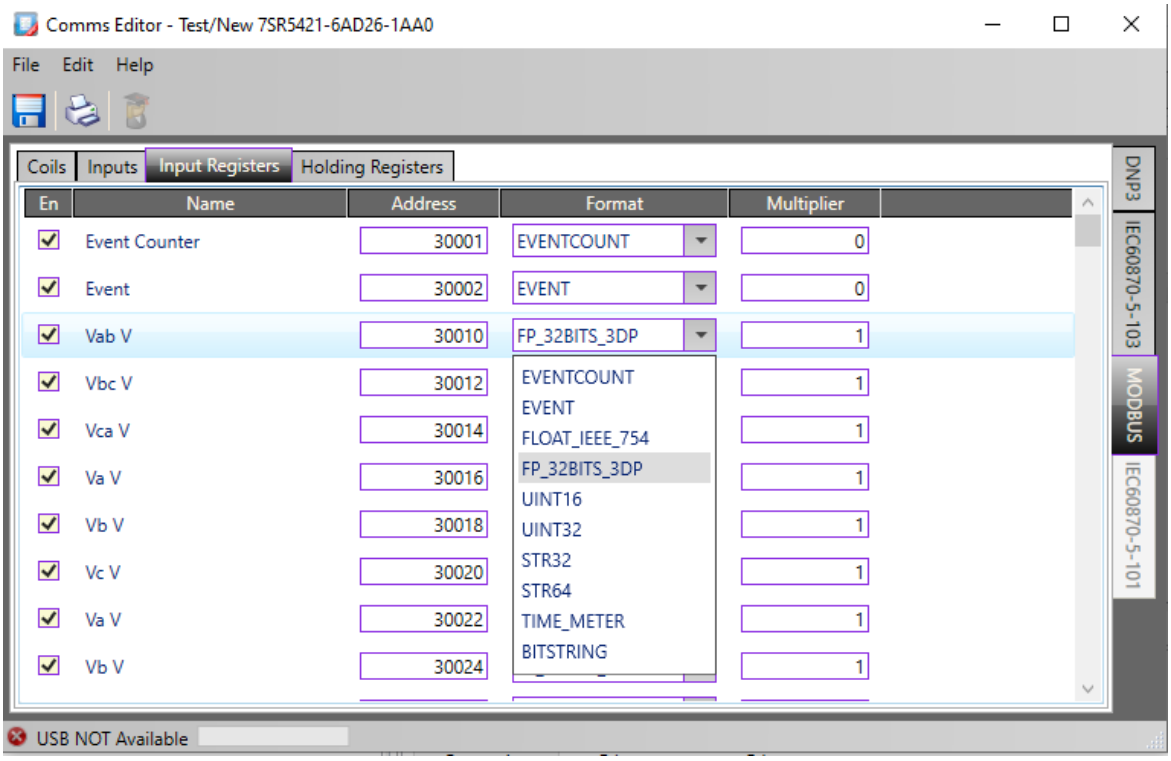
The starting address of the register in the data map.

Format

The format of the register(s) in the data map. Definitions of format are given in the above section.

Multiplier

This column specifies the value a point is multiplied by before being transmitted. For example, it can be used to scale a value to fit within the precision of a storage unit. A real value of 1.234 converted to a 16 bit integer would be 1. Therefore, it may be first multiplied by 1000 giving 1234 which would then be stored as 1234. It can be any floating point number.



NOTE

Note: The image above shows all fields which are possible to edit. For some versions of device firmware not all fields will be available for changing

The implementation of Modbus supports the reading and writing to holding registers.

The communications editor allows the following items to be configured by the user.

EN - Enable

This check box enables each point in the Modbus data map. A point must be enabled to be accessed via Modbus.

Name

The internal name of the point.

Address

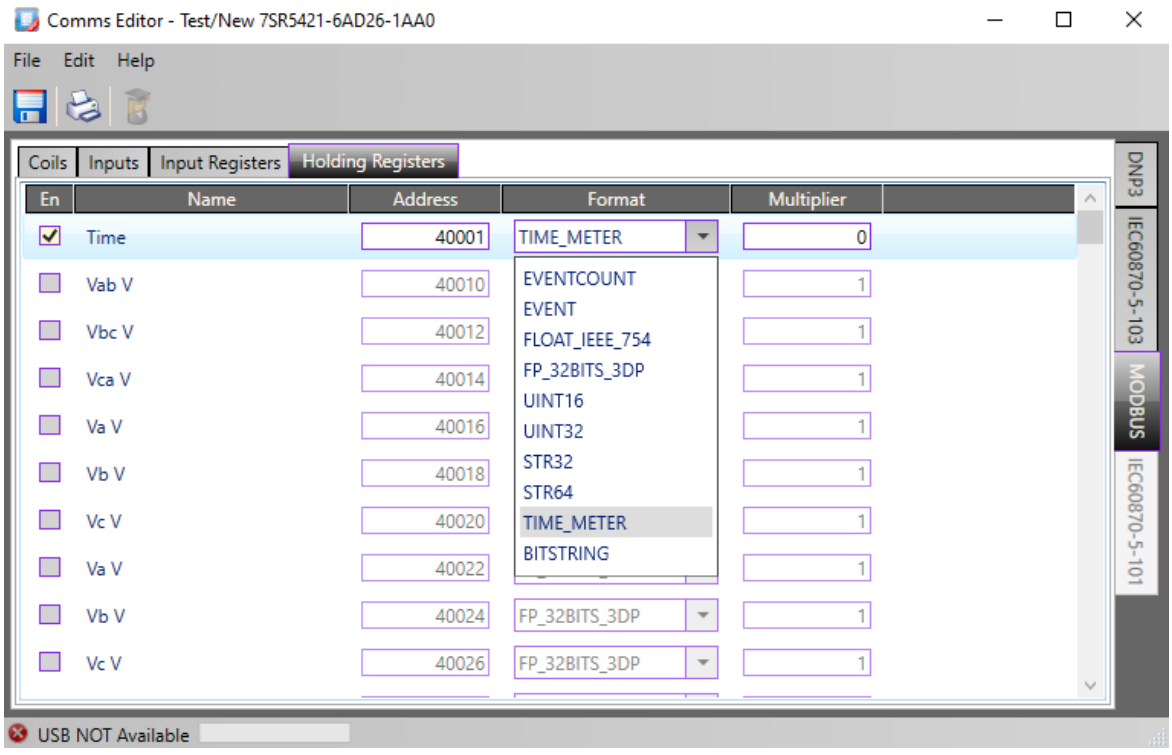
The starting address of the register in the data map.

Format

The format of the register(s) in the data map. Definitions of format are given in the above section

Multiplier

This column specifies the value a point is multiplied by before being transmitted. For example, it can be used to scale a value to fit within the precision of a storage unit. A real value of 1.234 converted to a 16 bit integer would be 1. Therefore, it may be first multiplied by 1000 giving 1234 which would then be stored as 1234. It can be any floating point number.



[Platform Communications Protocol Manual Settings and Properties5, 2, --_--]

NOTE

Note: The image above shows all fields which are possible to edit. For some versions of device firmware not all fields will be available for changing

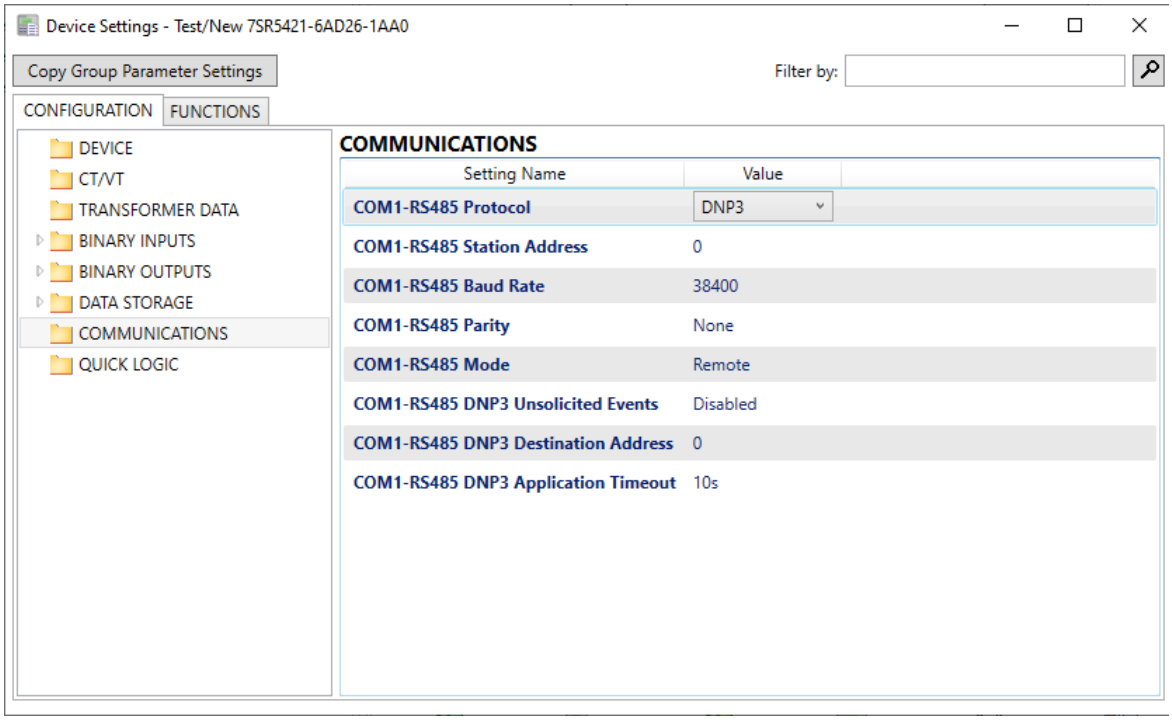
6.2 Settings and Properties

Setting for the Serial connection

The Modbus RTU protocol implementation in the relays is used for the communication with a suitable control system.

This protocol can be set to use the USB or RS485 ports. The relay can communicate simultaneously on all ports regardless of protocol used.

Each device must be given an address to enable communication and can be set by the Communication Interface:Device Address. A device with the default address of 0 will not be able to communicate.



[sc_7SR5_CommunicationsMenu, 2, --]

Setting name	Range	Default	Setting	Notes
COM1-RS485 Station Address	0 to 254 (IEC 60870-5-103) 0 to 247 (Modbus RTU) 0 to 65534 (DNP3)	0	1 to As required	An address must be given to identify the device. Each device must have a unique address.
COM1-RS485 Protocol	OFF, IEC 60870-5-103, Modbus RTU, DNP3	Off	Modbus RTU	Sets the protocol used to communicate on the RS485 connection.
COM1-RS485 Baud Rate	75 110 150 300 600 1200 2400 4800 9600 19200 38400 57600 115200 230400	38400	As Required	The baud rate set on all of the relays connected to the same RS485 bus must be the same as the one set on the master device.

Setting name	Range	Default	Setting	Notes
COM1-RS485 Parity	NONE, ODD, EVEN	EVEN	As Required	The parity set on all of the relays connected to the same RS485 bus must be the same and in accordance with the master device.
COM1-RS485 Mode	Local, Remote, Local Or Remote	Remote	Remote	Selects whether the port is Local or Remote.

7 IEC 60870-5-103

7.1	Protocol Characteristics	156
7.2	Settings and Properties	163

7.1 Protocol Characteristics

Description

This section provides a general description of the IEC 60870-5-103 (henceforth 103) serial protocol and its implementation on the Reyrolle relay platform. It is not a description of the functionality of each specific relay.

This protocol is used for the communication with a suitable control system. The control system or local PC acts as the master in the system with the relay operating as a slave responding to the master's commands. The implementation provides event information, time synchronizing, commands and measurands and also supports the transfer of disturbance records.

This protocol can be set to use the rear RS485 port.

NOTE

This section is also not a description of the 103 standard, although it will include a brief description of the relevant parts of the protocol as it is intended that significant knowledge of 103 is not required to use this document.

NOTE

Where necessary, comparison will be made to other protocols, DNP3 Serial and Modbus RTU. In addition where configuration is available via the **`Communications Editor`** examples will be shown.

Protocol Structure

IEC 60870 part 5 was developed by IEC Technical Committee 57 Working Group 3 as a standard for sending telecontrol messages between 2 systems. It comprises 5 documents which define the Transmission Protocols, listed in the following table.

Table 7-1 IEC 60870 Part 5 Documents

Prefix	Description
IEC 60870-5-1	Transmission frame formats
IEC 60870-5-2	Link transmission procedures
IEC 60870-5-3	General structure of application data
IEC 60870-5-4	Definition and coding of application information elements
IEC 60870-5-5	Basic application functions

The protocol IEC 60870-5-103 is structured on the 3-layer model:

- Physical layer
- Data-link layer
- Application layer

Physical Layer

The physical layer specifies the transmission medium for the protocol.

Data transmission can be implemented as follows:

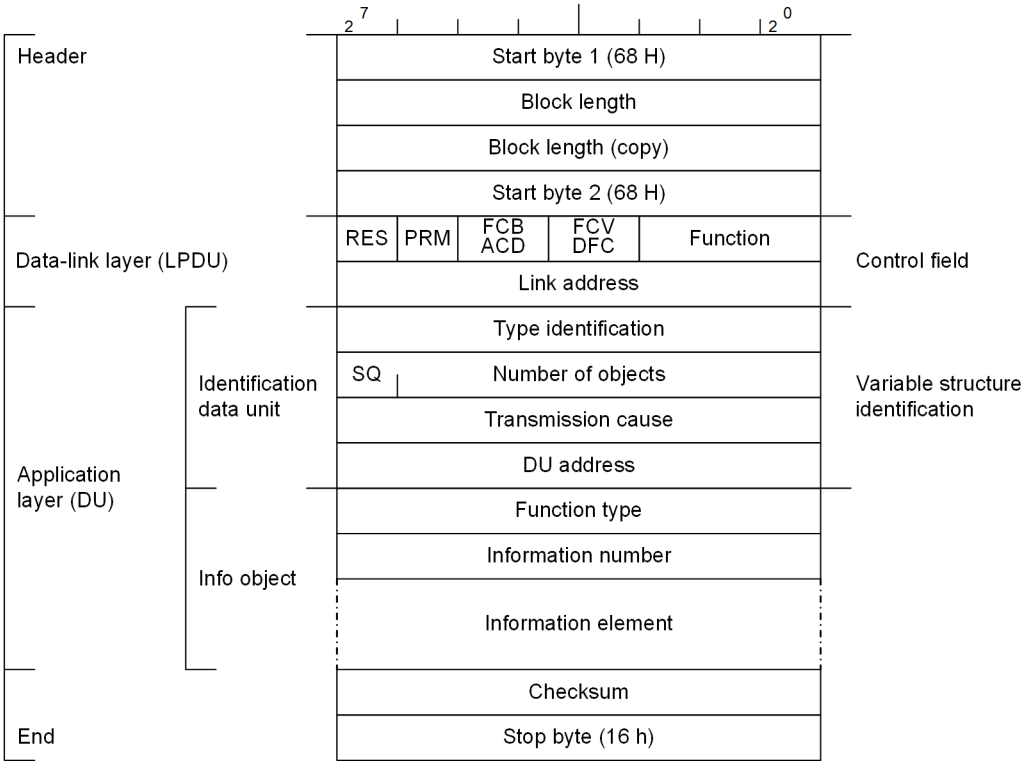
- Via optical fibers
- Via a wire-bound transmission system

The 7SR5 device supports the wire-bound transmission type and takes place via an RS485 interface.

Data-Link Layer

The connections between a substation automation and the protection device must be executed via an unbalanced link. This thereby prevents several protection devices from transmitting simultaneously. The IEC 60870-5-103 protocol uses exclusively the format class FT 1.2 defined in IEC 60870-5-1 (transmission formats). At the same time, formats with fixed and variable length as well as the single character E5H are permissible.

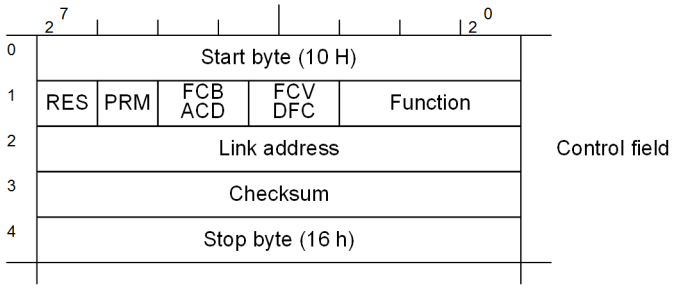
The telegram with variable length is used for transmission of the user data between the monitoring and monitored station and in the opposite direction.



[dw_tgrvlg, 3, en_US]

Figure 7-1 Telegram with Variable Length

The telegram with fixed length is intended for services of the data-link layer. In special cases, this format with fixed length is used as an acknowledgment instead of an individual character.



[dw_tgrflg, 3, en_US]

Figure 7-2 Telegram with Fixed Length

The individual character is used to acknowledge service data of the data-link layer and user data.

E5H = ACK: Positive acknowledgment

Application Layer

The application layer describes the Data Units (Data Units (DU)) for the transport telegrams. The 7SR5 platform supports the following functions:

- Standard DUs in monitoring direction
- Standard DUs in control direction

ASDU Functions

ASDU 1 – Time-tagged message (Direction – Monitor)	Message containing an event defined by FUN and INF, a double point information (DPI) state, and a short time (no date).
ASDU 2 – Time-tagged message with relative time (Monitor)	As ASDU 1 plus a relative time offset from the start of the fault in milliseconds and a fault number.
ASDU 3 – Measurands I (Monitor)	Measurand frame, defined as containing one of four measurand groups. The groups are {I}, {I,V}, {I,V,P,Q} or {IN, VN}. Alternative measurands could be sent by defining private FUN and INF values.
ASDU 4 – Time-tagged Measurands with relative time (Monitor)	Message containing an "Analogue" event. As ASDU 2 except rather than the DPI state contains an analogue value. The only value defined by 103 is "Fault Location X in ohms". Other values can be sent via this method with different FUN and INF values defined.
ASDU 5 – Identification Message (Monitor)	Message sent in response to an Initialisation (Reset) command from the master. Contains manufacturer and compatibility information.
ASDU 6 – Time Synchronization (Control & Monitor)	Message sent by the master to instigate a synchronization of the time. It contains a long time (time & date) for synchronisation. If it is sent as a non-broadcast message this ASDU will be returned by the outstation to confirm the synchronisation.
ASDU 7 – Initiation of general interrogation (Control)	Sent by the master to start a GI sequence from an outstation. The GI messages are returned after class 1 polls by the master. This message contains an identifier allowing returned messages to be synchronized to a request.
ASDU 8 – Termination of general interrogation (Monitor)	Message sent by the outstation at the end of its GI sequence to inform the master it is complete.
ASDU 9 – Measurands II (Monitor)	Measurand message very similar to ASDU 3. It is possible to truncate the fixed content by reducing the measurand count in the frame.
ASDU 10 – Generic Data (Control & Monitor)	We do not support Generic Data.
ASDU 11 – Generic Information (Monitor)	We do not support Generic Information.
ASDU 20 – General command (Control)	Message sent by the master to send a command to the outstation. The command is defined by the FUN and INF numbers. The command option is ON or OFF. This message contains an identifier allowing returned messages to be synchronized to a command.
ASDU 21 – Generic command (Control)	We do not support Generic Commands.
ASDU 23 – List of recorded disturbances (Monitor)	Message sent by the outstation to announce the availability of disturbance records to the master. Contains a listing of up to 8 records, each is identified by a fault number and a long time stamp.

ASDU 24 – Order for disturbance data transmission (Control)	Message sent by the master to request part of a disturbance record. Various commands are available, for example Request Disturbance Data, Request Channel, Request Tags, Abort Channel etc.
ASDU 25 – Acknowledgement for disturbance data transmission (Control)	Message sent by the master to acknowledge part of a disturbance record. Various acknowledgements are available.
ASDU 26 – Ready for transmission of disturbance data (Monitor)	Sent by the outstation to announce the first part of a disturbance data record is available. Contains information such as Number of Channels, Number of Elements per Channel, Interval between Elements etc.
ASDU 27 – Ready for transmission of a channel (Monitor)	Sent by the outstation to announce an analogue channel of a disturbance data record is available. Contains information about the channel such Channel Number and Scaling Factors.
ASDU 28 – Ready for transmission of tags (Monitor)	Sent by the outstation to announce the (binary) tags of a disturbance data record are available.
ASDU 29 – Transmission of tags (Monitor)	Message containing binary tags, sent by the outstation. There are a maximum of 25 tags per message, therefore it is likely there will be several of these message to send all the tags. Each tags contains FUN and INF numbers and a DPI state.
ASDU 30 – Transmission of disturbance values (Monitor)	Message containing analogue disturbance values, sent by the outstation. There are a maximum of 25 values per message, therefore it is likely there will be several of these message to send all the values. Each value is a 16 bit number.
ASDU 31 – End of transmission (Monitor)	Sent by the outstation to announce the end of part of the disturbance data transmission. Various announcements are available.
ASDU 253 – Private Data - Termination of data transfer (Monitor)	Sent by the outstation to terminate a private (Reydisp) data transfer before it is complete.
ASDU 254 – Private Data – Not last frame (Control & Monitor)	Sent by the outstation, contains a segment of data of a private (Reydisp) data transfer. Depending of the size of data transferred, a number of these segments may be required, or non is the response is small, see below.
ASDU 255 – Private Data – Last frame (Control & Monitor)	Sent by the outstation, contains the last segment of data of a private (Reydisp) data transfer. It is functionally identical to ASDU 254. There will always be one of these segments returned by the outstation, depending of the size of data transferred it may be the only segment required.

Cause of Transmission

All ASDUs sent by 103 are tagged with a cause of transmission (COT) from the table listed below.

Table 7-2 IEC60870-5-103 Cause of Transmission

Control Direction (Sent To Relay)	Function Type	Monitor Direction (Sent From Relay)
	1	Spontaneous
	2	Cyclic
	3	Reset Frame Count But (FCB)
	4	Reset Communication Unit (CU)

Control Direction (Sent To Relay)	Function Type	Monitor Direction (Sent From Relay)
	5	Start / Restart
	6	Power On
	7	Test Mode
Time Synchronization	8	Time Synchronization
Initiation of General Interrogation	9	General Interrogation
	10	Termination of General Interrogation
	11	Local Operation
	12	Remote Operation
General Command	20	Positive Acknowledgement of Command
	21	Negative Acknowledgement of Command
Transmission of Disturbance Data	31	Transmission of Disturbance Data
Generic Write Command	40	Positive Acknowledge Generic Write Command
	41	Negative Acknowledge Generic Write Command
Generic Read Command	42	Valid Data Response to Generic Read Command
	43	Invalid Data Response to Generic Read Command
	44	Generic Write Confirmation

The cause of transmission (COT) column of the 'Information Number and Function' table lists possible causes of transmission for these frames. The following abbreviations are used:

Table 7-3 IEC 60870-5-103 Cause of Transmission Abbreviations

Abbreviation	Description
SE	spontaneous event
T	test mode
GI	general interrogation
Loc	local operation
Rem	remote operation
Ack	command acknowledge
Nak	Negative command acknowledge

NOTE

Note: Events listing a GI cause of transmission can be raised and cleared; other events are raised only.

Function Type and Information Number

Data points in 103 are identified with two codes, a Function Type (FUN) and an Information Number (INF). The following table lists the standard function types that are defined. In addition private function types have been defined.

Table 7-4 IEC 60870-5-103 Function Types

FUN	Description	Mnemonic
128	Distance Protection	t(z)
160	Overcurrent Protection	I>>
176	Transformer Differential Protection	ΔI_T
192	Line Differential Protection	ΔI_L
254	Generic Function Type	GEN
255	Global Function Type	GLB

A list of information numbers corresponding to standard types is defined. In addition private INF numbers have been defined for the private INF numbers. The following table gives an extract of the list of standard INF numbers and the functions under which they are used.

Table 7-5 IEC 60870-5-103 Extract of INF Numbers

INF	Description	Function
0	Time Synchronization	GLB
48	Earth Fault L_1	t(z), I>>
64	Start / Pick-Up L_1	t(z), I>>, ΔI_L
68	General Trip	t(z), I>>, ΔI_T, ΔI_L
78	Zone 1	t(z)
86	Trip Measuring System L_1	ΔI_T
90	Trip I>	I>>
148	Measurands $I_{L1,2,3,}$ $V_{L1,2,3,}$ P, Q, f	t(z)

List of Function Codes Used in Reyrolle Devices

FUN	Description	Mnemonic
60	Reyrolle General	
61	Reyrolle General Alarm	
70	Reyrolle Status/Binary Inputs	
75	Virtual Input/Output	
80	Reyrolle Plant Controls/Binary Outputs	
85	Reyrolle GGIO	
90	Reyrolle LED	
91	Reyrolle LED Pick Up	
160	Overcurrent Protection	I>>
164	Reyrolle Overcurrent Protection	
176	Transformer Differential Protection	ΔI_T
182	Reyrolle General	
183	Reyrolle General	
185	Reyrolle General	
187	Reyrolle General	
189	Reyrolle General	
190	Reyrolle General	
200	Reyrolle Control Commands	
254	Generic Function Type	GEN
255	Global Function Type	GLB

Classes

103 divides functions into two classes, 1 and 2. Class 1 is high priority data, for example, Time Tagged Messages (Events). Class 2 is low priority, usually Measurands, sent with COT of cyclic.

The usual procedure for a master station is to poll each outstation periodically for class 2 data. If this data exists it is returned. If class 1 data exists the master is informed as part of the response and can then concentrate on polling that outstation while the class 1 data is available.

Initialisation

Before communications can take place the master sends a reset message to each outstation to synchronize the communications systems. Until the outstation receives this message it will not respond.

Time Synchronization

103 specifies a Time Synchronization procedure where the master broadcasts a message, containing the synchronize time, to all outstations.

General Interrogation

General Interrogation (GI) is the process by which the master stating polls all the (enabled) data points in a device to populate its database with the present values. Usually only bi-state points are returned during GI, points which only have one state, e.g. trips, are not returned.

Command Transmission

103 sends command to an outstation using the FUN and INF numbers with an ON or OFF command state. Note, some commands may only support the ON command, for example, switching characteristic – the new characteristic becomes active, the old one is automatically deactivated. Events will usually be sent confirming the new state of a point. They use the same FUN and INF numbers as the command.

Blocking Mode

During Blocking Mode all indication messages generated by the outstation are not transmitted. In addition functions such as General Interrogation are immediately terminated. General Commands are rejected and returned with negative acknowledgement. Time Synchronization and Initialisation functions will still operate.

Measurand Information

Information from the analogue channels of the 7SR5 device is provided in the measurand data as ASDU 9. Details of the type of information and format is provided in the device manual. The measurands are cyclic with a refresh rate of 5 seconds or a change greater than a fixed % window. The time multiplier for the values are fixed.

Disturbance Data

Disturbance Data is transmitted as ASDU 31, as a series of Tags representing binary points, which use the FUN and INF numbers, and channels of analogue data representing currents and voltages etc. Each analogue channel has scaling factors to convert from raw samples to Primary or Secondary quantities. Disturbance data is NOT transmitted as COMTRADE records. To convert to COMTRADE addition processing must be performed after the record is downloaded. 103 supports Disturbance records via ASDU 23-31. Reydisp supports waveforms that can be converted to Comtrade.

The disturbance record information provided for a particular 7SR5 device is detailed in the device manual.

Generic Services

We do not support Generic Services.

7.2 Settings and Properties

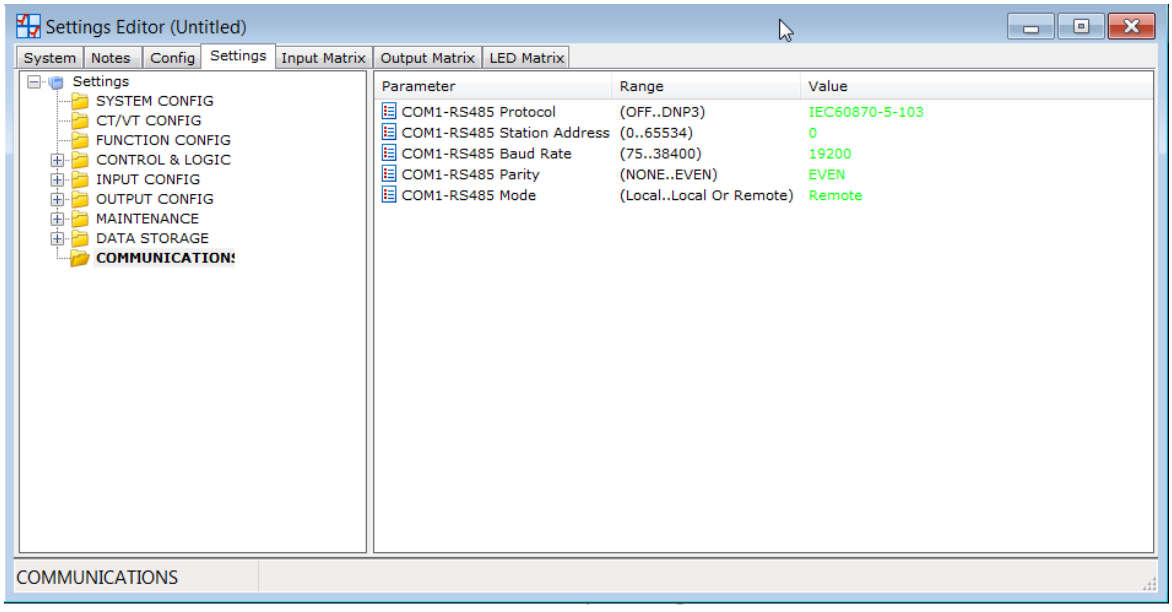
Setting for the Serial Connection

The rear communication port can be used to connect with a SCADA system using the IEC 60870-5-103 protocol.

The settings for the rear communication port are located in the Communications menu of the setting tree.

IEC 60870-5-103 as implemented is a classic master and slave arrangement, with 1 master and numerous slaves. Other addresses are reserved for specific purposes, for example, 255 is for broadcast commands.

Each relay must be given an address to enable communication and can be set by the Communication Interface:Relay Address. A relay with the default address of 0 will not be able to communicate.



[Platform Communications Protocol Manual IEC60870-5-103 Image3, 1, –_–]

Figure 7-3 Settings Editor

Setting name	Range	Default	Setting	Notes
COM1-RS485 Station Address	0 to 254 (IEC 60870-5-103) 0 to 247 (Modbus RTU) 0 to 65534 (DNP3 Serial)	0	1 to As required	An address must be given to identify the relay. Each relay must have a unique address.
COM1-RS485 Protocol	OFF, IEC 60870-5-103, Modbus RTU, DNP3 Serial	Off	IEC 60870-5-103	Sets the protocol used to communicate on the RS485 connection.
COM1-RS485 Baud Rate	75 110 150 300 600 1200 2400 4800 9600 19200 38400 57600 115200 230400	38400	As Required	The baud rate set on all of the relays connected to the same RS485 bus must be the same as the one set on the master device.

Setting name	Range	Default	Setting	Notes
COM1-RS485 Parity	NONE, ODD, EVEN	None	As Required	The parity set on all of the relays connected to the same RS485 bus must be the same and in accordance with the master device.
COM1-RS485 Mode	Local, Remote, Local Or Remote	Remote	Remote	Selects whether the port is Local or Remote.

Device mapping and configuration

Each specific relay model will have a unique configuration file.

The supported information available for each device can be viewed using the Reydisp Manager 2 PC Software Commincation Editor tool. The device template must be installed and selected.

The communications editor can be used to specify FUN and INF numbers for data points, and to enable or disable data points within the device, as illustrated below.

The display text allows the user to Edit the text displayed by 7SR5 device fascia Event log when viewing the relays Event on the LCD.

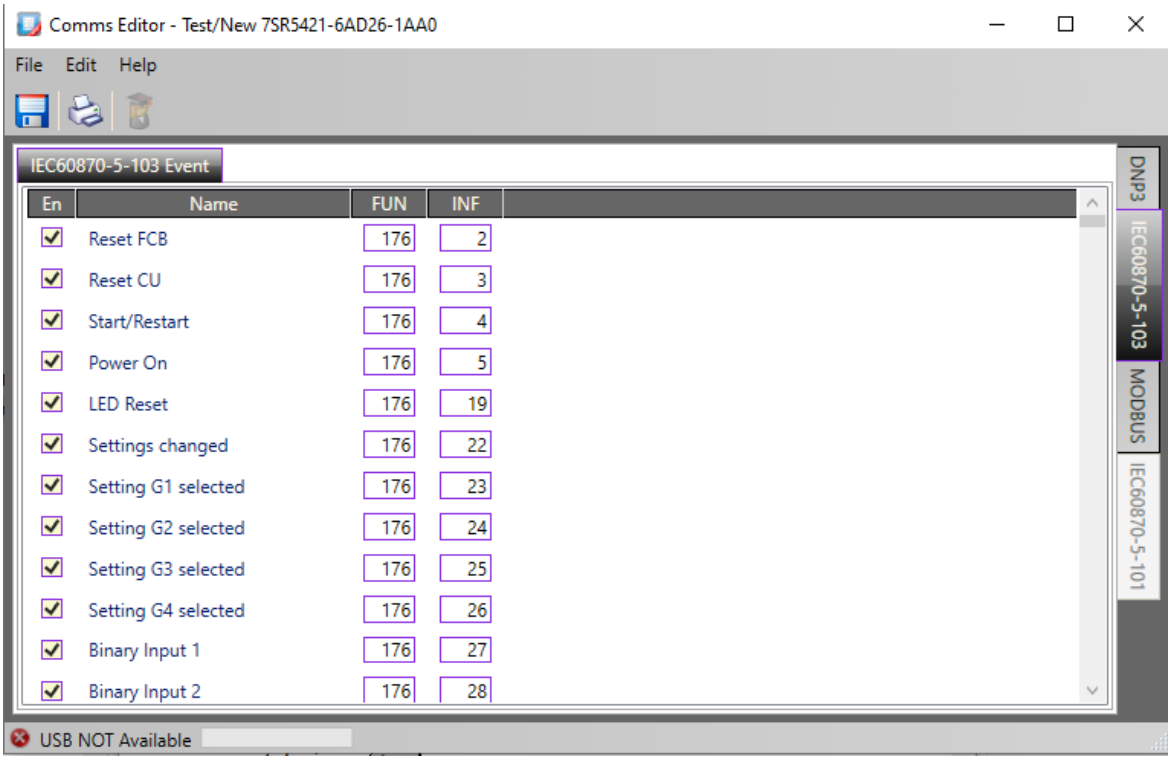


Figure 7-4 Setting the FUN and INF values

Measurands

Table 7-6 The following measurand information is applicable to the 7SR51 and 7SR57 non-directional devices.

FUN	INF	Description	ASDU	COT
190	148	Measurand $I_{L1,2,3}$ I_{L1} (2.4x) I_{L2} (2.4x) I_{L3} (2.4x)	9	Cyclic – Refresh rate 5 seconds or value change greater than Window 1 %.
190	16	Measurand Max $I_{L1,2,3}$ I_{L1} Max (2.4x) I_{L2} Max (2.4x) I_{L3} Max (2.4x)	9	Cyclic – Refresh rate 5 seconds or value change greater than Window 1 %.

Table 7-7 The following measurand information is applicable to the 7SR5 directional devices.

FUN	INF	Description	ASDU	COT
190	148	Measurand $I_{L1,2,3}$, $V_{L1,2,3}$, P, Q, F, $V_{L1-2,L2-3,L3-1}$ I_{L1} (2.4x) (Window 1%) I_{L2} (2.4x) (Window 1%) I_{L3} (2.4x) (Window 1%) V_{L1} (1.2x) (Window 1%) V_{L2} (1.2x) (Window 1%) V_{L3} (1.2x) (Window 1%) P (2.4x) (Window 1%) Q (2.4x) (Window 1%) F (1.2x) (Window 0.1%) V_{L12} (1.2x) (Window 1%) V_{L23} (1.2x) (Window 1%) V_{L31} (1.2x) (Window 1%)	9	Cyclic – Refresh rate 5 seconds or value change greater than Window x %.
190	17 (7SR51 and 7SR57) 21 (7SR54)	Measurand Max $I_{L1,2,3}$, $V_{L1,2,3}$, P, Q, $V_{L1-2,L2-3,L3-1}$ I_{L1} Max (2.4x) (Window 1%) I_{L2} Max (2.4x) (Window 1%) I_{L3} Max (2.4x) (Window 1%) V_{L1} Max (1.2x) (Window 1%) V_{L2} Max (1.2x) (Window 1%) V_{L3} Max (1.2x) (Window 1%) P Max (2.4x) (Window 1%) Q Max (2.4x) (Window 1%) V_{L12} Max (1.2x) (Window 1%) V_{L23} Max (1.2x) (Window 1%) V_{L31} Max (1.2x) (Window 1%)	9	Cyclic – Refresh rate 5 seconds or value change greater than Window x %.

Table 7-8 The following measurand information is applicable to the 7SR54 transformer devices.

FUN	INF	Description	ASDU	COT
190	10	W1 $I_{L1,2,3}$ I_{L1} (2.4 x) I_{L2} (2.4 x) I_{L3} (2.4 x)	9	Cyclic – Refresh rate 5 seconds or value change greater than 1 %.
190	12	W2 $I_{L1,2,3}$ I_{L1} (2.4 x) I_{L2} (2.4 x) I_{L3} (2.4 x)	9	Cyclic – Refresh rate 5 seconds or value change greater than 1 %.
190	14	W3 $I_{L1,2,3}$ I_{L1} (2.4 x) I_{L2} (2.4 x) I_{L3} (2.4 x)	9	Cyclic – Refresh rate 5 seconds or value change greater than 1 %.
190	16	W1 Max $I_{L1,2,3}$ I_{L1} (2.4 x) I_{L2} (2.4 x) I_{L3} (2.4 x)	9	Cyclic – Refresh rate 5 seconds or value change greater than 1 %.
190	18	W2 Max $I_{L1,2,3}$ I_{L1} (2.4 x) I_{L2} (2.4 x) I_{L3} (2.4 x)	9	Cyclic – Refresh rate 5 seconds or value change greater than 1 %.
190	20	W3 Max $I_{L1,2,3}$ I_{L1} (2.4 x) I_{L2} (2.4 x) I_{L3} (2.4 x)	9	Cyclic – Refresh rate 5 seconds or value change greater than 1 %.

Disturbance Data

The following Disturbance Recorder channel (ACC) numbers apply to the 7SR5 device.

NOTE

Not all information is available in all device models.

FUN	ACC	Description
182	1	V1
182	2	V2
182	3	V3
182	4	V4
182	5	Ia
182	6	Ib
182	7	Ic
182	8	W1 Ia
182	9	W1 Ib
182	10	W1 Ic

FUN	ACC	Description
182	11	W2 Ia
182	12	W2 Ib
182	13	W2 Ic
182	14	W3 Ia
182	15	W3 Ib
182	16	W3 Ic
182	17	Ig-1
182	18	Ig-2
182	19	Ig-3

8 Additional Features

8.1	Activation of Services	170
8.2	List of Required Open Ports	171
8.3	Reydisp Manager 2 Protocol	172
8.4	Ethernet Time Zone	173
8.5	SNTP	174
8.6	IEEE 1588	177
8.7	RSTP	179
8.8	PRP	183
8.9	HSR	184
8.10	SNMP	185
8.11	EN100 Homepage	195
8.12	Secure MMS	206
8.13	Syslog	207
8.14	Modbus Client	208

8.1 Activation of Services

The following additional Ethernet services are available for the integrated Ethernet interface of the device:

- Reydisp protocol
  For connection to the Reydisp PC configuration tool.
- SNTP Simple Network Time Protocol (SNTP) for the Ethernet module
  This protocol is supported for the time synchronization over an Ethernet network.
- IEEE 1588 Precision Time Protocol (PTP)
  This protocol is supported for the time synchronization over an Ethernet network.
- SNMP Simple Network Management Protocol (SNMP)
  Provides monitoring information about the device to the network-management system.
- Syslog Protocol
  Provides the device security log over the ethernet communication to 1 or 2 syslog servers.
- Homepage
  Homepage for the Ethernet module. Ethernet communication modules provide a diagnostic function, password setting and Communication firmware uploading. With the IP address/home, the page can be viewed with a browser.
- Line Mode
  Activates the line structure.
- Switch Mode
  Activates the switch structure.

You can select the following network redundancy protocols:

- RSTP
  Activates the Rapid Spanning Tree Protocol (RSTP) for the Ethernet module. This protocol will be needed for redundant ring structures in the Ethernet networks.
- PRP
  Activates the Parallel Redundancy Protocol (PRP) for the Ethernet module. With the PRP structure, communication takes place simultaneously over 2 independent networks.
- HSR
  Activates the High Availability Seamless Redundancy Protocol (HSR) for the Ethernet module. With the HSR structure, the devices are arranged in rings.

The parameters associated with the above features are configured in Reydisp Manager 2 device configuration Ethernet Interface.

The device can support a Modbus Client implementation for connecting an external Temperature Sensor monitoring box to the rear RS485 port in devices that do not provide built in temperature sensor hardware.

8.2 List of Required Open Ports

Table 8-1 List of Required Open Ports

Service	Layer 4 Protocol	Layer 7 Protocol	Typical Client	Client Port	Typical Server	Server Port
Reydisp Manger to 7SR5 device	TCP	HTTPS	PC: Reydisp Manager 2	>1024	7SR5	443
Reydisp Manger to 7SR5 device	UDP	DTLS	PC: Reydisp Manager 2	>1024	7SR5	50000
PC to 7SR5 device via EN100 homepage	TCP	HTTPS	PC: Web browser	>1024	7SR5	443
PC to 7SR5 device via WebUI	TCP	HTTPS	PC: Web browser	>1024	7SR5	443
IEC 61850, MMS, Reporting	TCP	IEC 61850	IEC 61850 client	>1024	7SR5	102
Time synch. SNTP	UDP	SNTP	7SR5	123	SNTP clock server	123
Time synch. PTP	PTP V2	–	7SR5	–	PTP clock server	–
Monitoring via Simple Network Management Protocol (SNMPv3)	UDP	SNMPv3	PC: SNMP client (e.g. SICAM PAS)	>1024	7SR5	161
Modbus TCP	TCP	Modbus	Substation SCADA	>1024	7SR5	502
DNP3 TCP	TCP	DNP3	Substation SCADA	>1024	7SR5	#1 20,000 #2 20,001
Syslog client	UDP	–	7SR5	–	Syslog server	514

You can find more information about supported communication protocols in the 7SR5 Communication Protocols Manual.

NOTE

The Modbus TCP also supports port 504 and can be configured in Reydisp Manager 2. The syslog port default is 514 but can be modified in Reydisp Manager 2. The DNP3 server ports can be configured in Reydisp Manager 2.

8.3 Reydisp Manager 2 Protocol

There are 2 ways to connect from Reydisp Manager 2 to a device:

- Via USB
- Via an Ethernet interface

NOTE

Only a Reyrolle device can be connected with Reydisp Manager 2 via USB.

Reydisp Manager 2 and the 7SR5 device are authenticated. The necessary certificates are contained in the device upon delivery.

8.4 Ethernet Time Zone

If the source of the time synchronism is from the device Ethernet port the device local time can be set using the **Ethernet Timezone** function. The device time is set with an offset time relative to UTC reference and can also include an automatic summertime switchover.

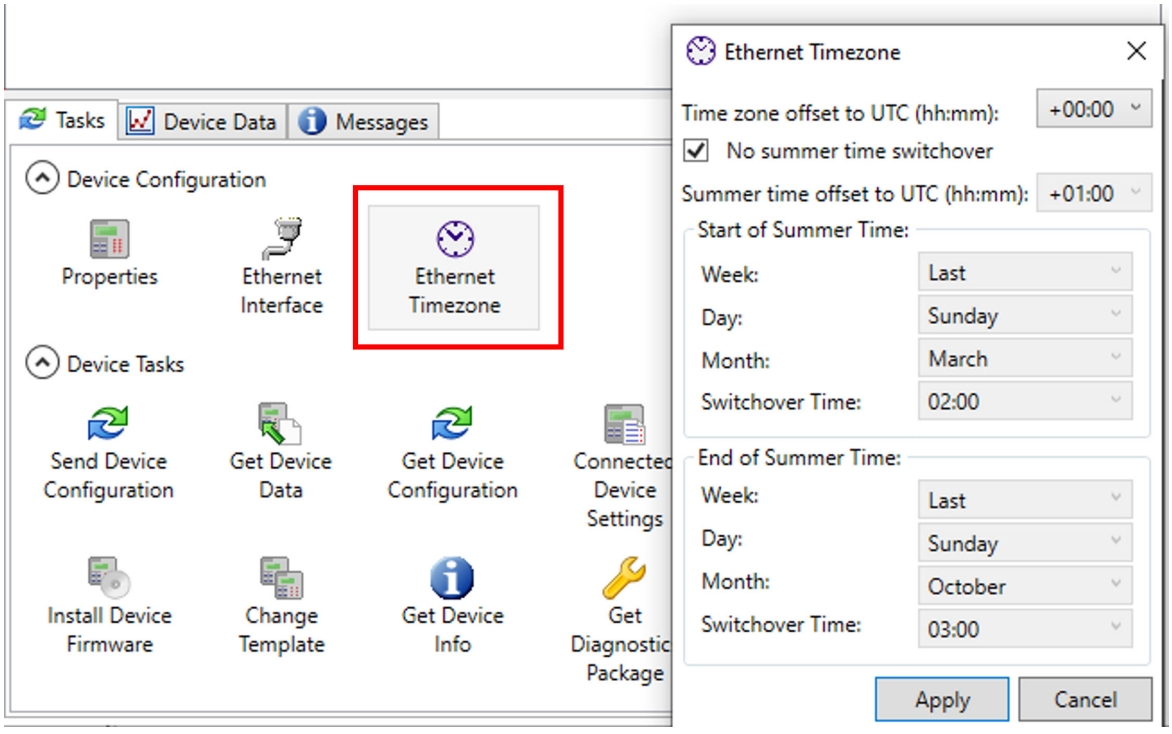


Figure 8-1 Ethernet Time Zone

Configuration

A drop down selection is provided for the Timezone offset. If a summertime switchover is required the selection should not be selected and the summertime dates and offset time selected.

NOTE

Both the time zone offset and the Summertime offset are set relative to UTC.

8.5 SNTP

Protocol Description

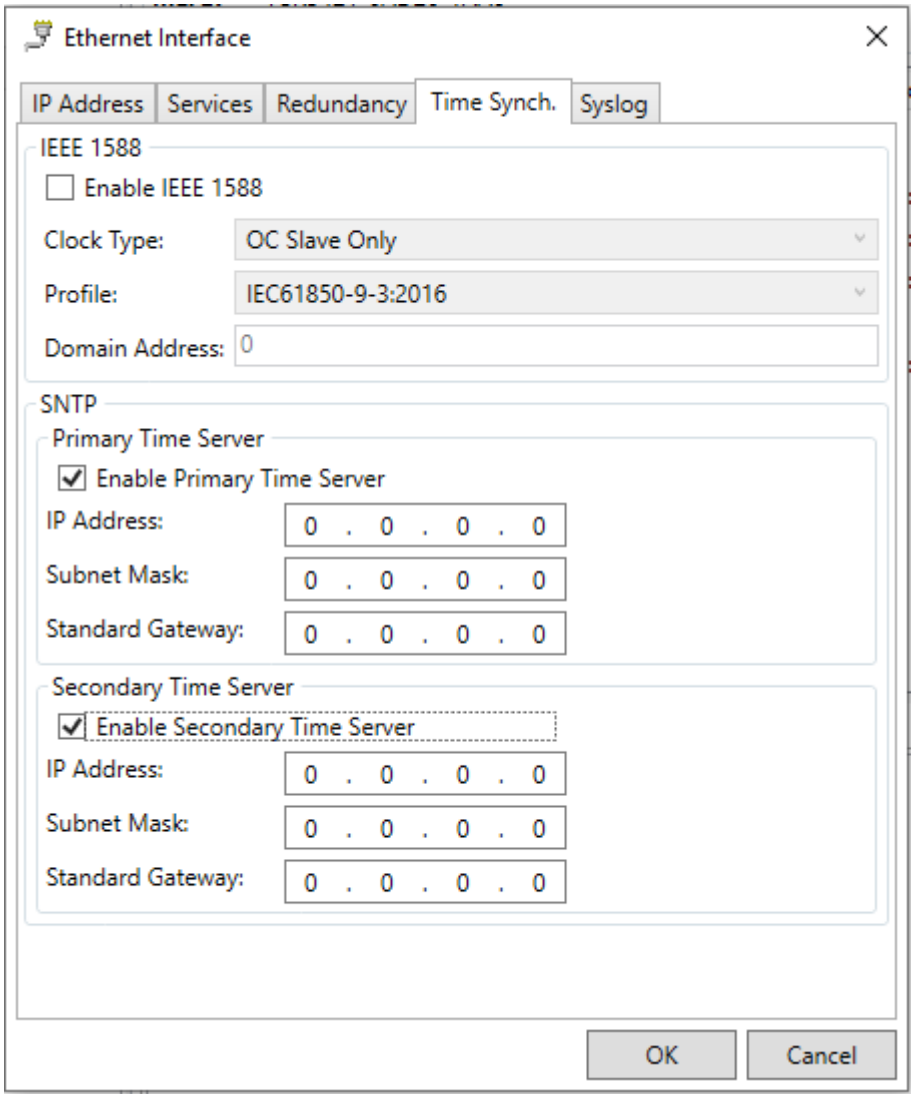
For time synchronization via Ethernet according to SNTP, a time server must be present in the network. 1 or 2 time servers are supported. This time server must also be able to address the different time requirements of the devices as defined in SNTP. Time servers can be reached through an IP address.

The Simple Network Time Protocol is used to synchronize clocks via the Internet. With SNTP, client devices can synchronize their clocks with a time server via the Internet.

SNTP enables a time resolution of 1 ms. When considering similar runtimes, SNTP can determine the average runtime of a synchronization telegram between the client and the server in the Ethernet network. This transmission time can be taken into account in the terminal device and improves synchronization of terminal devices.

The following settings can be configured in Reydisp Manager 2 device Ethernet Interface.

When the 7SR5 devices are not part of a station the SNTP can be configured in Reydisp Manager 2 using the Configure Interface tool and Time Synch tab.



[sc_7SR5_ReydispManager2SNTPTab, 3, --_--]

Figure 8-2 Time Synch Tab

The SNTP servers are configured in the IEC 61850 system configurator when the 7SR5 device are allocated to a Station and the options in Reydisp Manager 2 configuration will be greyed out and not available to configure.

The NTP servers are integrated as Other IEC 61850 communicators via an ICD File which is included in Reydisp Manager 2.

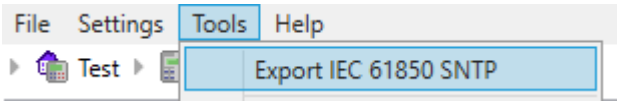


Figure 8-3 Tools Menu

The first server functions as preferred server to ensure that all equipment runs with the same master clock if possible. The second server is available as redundancy.

Status and Accuracy

The internal clock of the 7SR5 device reaches the steady state of ±1 ms after max. 15 minutes of a healthy synchronization. This internal accuracy cannot be measured here because a precise trigger option is not available. For checking purpose, a binary input is often triggered (configured: without a software filter, with recalculation of the hardware filtering time). Such measurement, however, including jitter in binary input processing, has deviations of approx. ±3 ms.

Time Fault Indication

A time fault indication is output when the clock server does not respond to inquiries of the 7SR5 device (after the configured monitoring time has expired, in this example 10 minutes). From now on, the status of type time fault is set in the time stamp of all indications. The bit clock failure in the IEC 61850-8.1 will be set accordingly in the time stamp of the Data Object.

The time fault indication does not appear when the SNTP server itself has no connection to the time source (e.g. no antenna signal, ...) and sends clock signals to all devices according to its internal accuracy. However, at start-up, as long as no connection has been established with the SNTP server or the time synchronization message indicates a stratum greater than 5, the bit ClockNotSynchronized will be set in the time stamp of the Data Object, to indicate that the clock has not yet been synchronized.

Operation of the Redundant Time Server

The first, primary server remains the preferred server so that all devices, if possible, operate with the same master clock.

The 7SR5 ethernet module interrogates both SNTP servers cyclically every minute. It normally synchronizes itself on the first parameterized primary SNTP server. If the first SNTP server doesn't respond to a query twice successively within the 1 minute polling interval, the time synchronization switchovers to the secondary, second server. Further switchover criteria are:

- The server shows alarm on the response telegram (variable leap = 3)
- The Stratum of the server is 0 (unknown) or greater than 5
- The current time is indicated with 0 (if no reception)
- The running time of the telegram in the net is greater than 5 ms

The switchover will be prevented if the second server delivers no considerably better time signal, i.e. if the server only was attainable last for less than 10 minutes, if it announces alarm or its Stratum is 0 or greater than 5, or it indicates the current time with 0 or the running time of the telegram in the net is greater than 5 ms. In all of these cases the device is then no longer synchronized. It runs with the internal ms time base and the last valid drift. After the parameterized time delay the device announces a time disturbance signal.

While the module is synchronizing on the second server, it also interrogates the first server. The switch back to the first server will only take place if it has performed an acceptable quality for 10 minutes as already mentioned. The switch back is delayed as long as all conditions are fulfilled.

At the startup of the module the first server will be interrogated, about 5 seconds later the second server, too. The time of the first server will also be taken if the Stratum is 0 or greater than 5 or the second server offers a better Stratum 5 seconds later.

The announcement of a time disturbance signal works purely from the view of the device. I.e. it will only be announced if the device is no longer synchronized from the module.

For the redundant SNTP client on the module this means that the announcement of the time disturbance signal will not be issued during a successful switchover on the second server. If the time delay of the indication is parameterized on the minimum value of 2 minutes in the device, which corresponds to a twice repeated failure, then the behavior isn't determined and the indication could possibly appear. So for a defined behavior the time delay for the time disturbance indication has to be parameterized up to at least 3 minutes. The time delay for the time disturbance indication is not available as a parameter on the module and therefore can neither be tested nor be used for an adapted switchover time (the above mentioned 10 min).

While switching back to the first SNTP server no time disturbance indication will appear because the transition takes place without loss of synchronization.

8.6 IEEE 1588

Protocol Description

The IEEE 1588 protocol is used for the synchronization of clocks via network communication.
The IEEE 1588 accuracy is 1 ms in line with other functionality of the device.

The 7SR5 uses clock type **OC Slave Only**.
OC Slave Only stands for **O**rdinary **C**lock **S**lave **O**nly. This kind of clock is used for high accuracy time synchronization. In case of OC Slave Only, the PTP (PTP Protocol) port or port pair never changes into the master state.

The 7SR5 uses clock profile **IEC 61850-9-3:2016**.

The 7SR5 uses clock domain number **0**.

Line mode and switch mode are supported.

Redundancy protocols supported are:

- HSR
- PRP
- RSTP

NOTE

The 7SR5 devices do not support PTP messages that have VLAN tags.

Configuration

The following settings can be configured in Reydisp Manager 2 device Ethernet Interface. The IEEE 1588 may be enabled or disabled from this page. The remaining parameters are fixed as described previously.

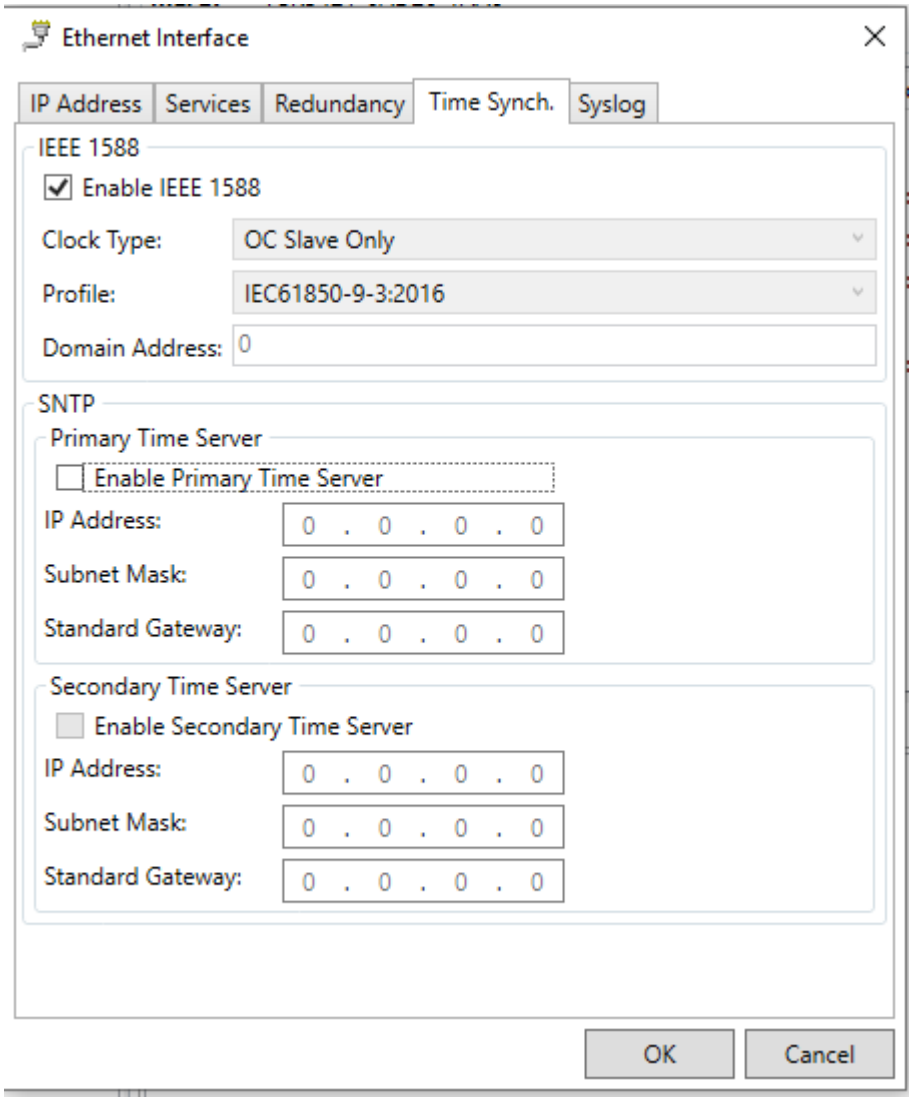


Figure 8-4 IEEE 1588 Enabled

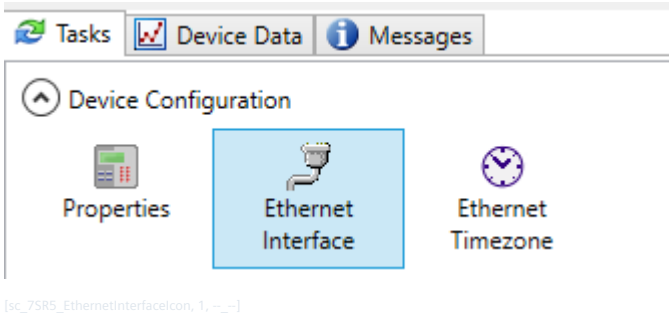
8.7 RSTP

Description

The Rapid Spanning Tree Protocol (RSTP) serves for the reorganization of the network structure in the event of an error. In other words, RSTP reroutes the data to another path after the failure of a network path.

Parameter Settings for Networks

The setting parameters for the RSTP are located in the Ethernet Interface Device configuration tasks area in Reydisp Manager 2.

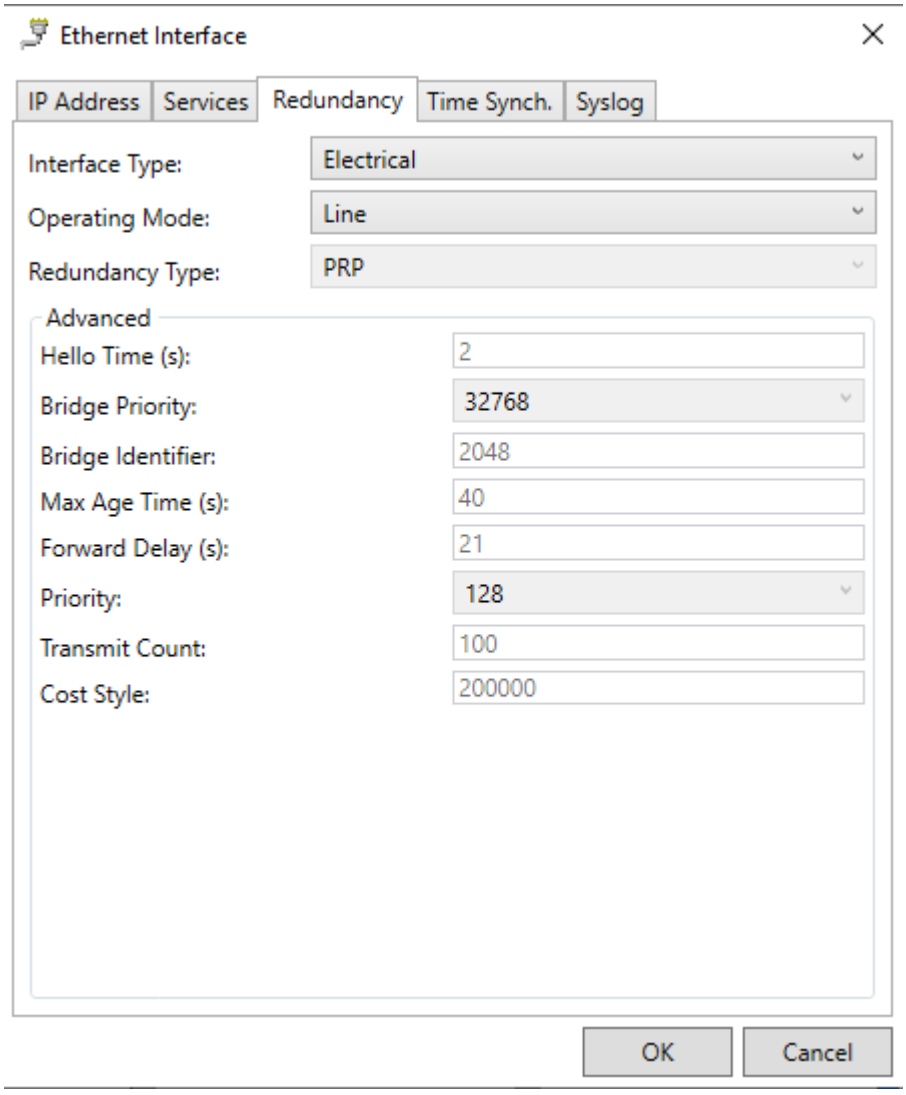


[sc_7SR5_EthernetInterfaceIcon, 1, --_--]

Figure 8-5 Ethernet Interface Icon

Double-click the Ethernet Interface and select the Redundancy tab to change the configuration.

The values are either entered directly or selected from a drop down list of available options.



[sc_7SR5_ReydispManager2RedundancyTab, 3, --_--]

Figure 8-6 Redundancy Tab

NOTE

In this document bridge and switch refer to the same thing.

On completion select OK. The chosen parameters will be sent to the device when the configuration is sent to the device. Please refer to the 7SR5 Engineering Guide for further detailed information on configuring a device.

Parameter Name	Settings
Hello Time	This time determines at what intervals the Hello Time telegrams are transmitted. 1 s or 2 s Standard setting = 2 s
Max Age Time	The extent of a network is relevant when setting the value. MaxAge is a meter that counts down with each pass through a bridge. Each switch must be able to reach the root switch. For this reason, the MaxAge has to be set such that the value on all paths to the root bridge can never be 0. If this condition is not met, then the network will break down and will not regenerate on its own. This results in constant topology changes. 6 to 40 Standard setting = 40
Forward Delay	The bridge Forward Delay Time setting is only relevant if an STP switch is active in the network. In such a case, the Forward Delay Time determines the reconfiguration time of the network after an interruption. Siemens recommends not changing the Forward Delay Time setting. 4 s to 30 s Standard setting = 21 s
Transmit Count	Transmit Hold Count is a meter that applies to all ports of the bridge. It limits the number of RSTP telegrams per port transmitted in sequence and without delay. When this telegram is transmitted, only one more telegram per second is transmitted. For a highly meshed system, a Transmit Hold Count that is set low will result in a significant slowing of the reconfiguration when the root switch fails. Siemens recommends not changing the Transmit Hold Count setting. 1 to 10 Standard setting = 10
Bridge Priority	Bridge priority establishes the position of the bridge in the network. The lower the value, the higher the priority. The bridge with the highest priority is the root bridge. Siemens recommends setting the priority of the root bridge to 0. Siemens recommends setting the priority of the replacement root bridge, which should be located right next to the root bridge, to 4096. The replacement root bridge should replace the root bridge in case of a failure. Siemens recommends setting the priority of all other devices and bridges to 32 768. 0 to 61 440, in increments of 4096 Standard setting = 32 768

Parameter Name	Settings
Bridge Identifier	The priority value of a bridge consists of the bridge priority and bridge identifier. The bridge identifier therefore provides a finer gradation of the switches. This enables you to set the location of the alternate switches in the network. Siemens recommends not changing the default setting of 2048. 0 to 4095 Standard setting = 2048
Cost Style	The costs indicate the quality of a line. The higher the value, the worse the line. In IEEE Std 802.1D™ – 2004, this value is established depending on the velocity. For example, for 100 Mbit, path costs of 200 000 are defined. The setting is included in the valence calculation of the vector. Siemens recommends not changing this setting. 0 to 200 000 000 Standard setting = 200 000

RSTP Cooperation with Siprotec 5

In the network topology where 7SR5 and EN100 based devices are connected, the parameter **`Cost Style`** must be the same value (200000 or 200001) in all devices.

In an RSTP network topology containing both 7SR5 and SIPROTEC 5 devices in the same ring, the **`Cost Style`** must be set to 200001 on all devices.

8.8 PRP

PRP (Parallel Redundancy Protocol) is a redundancy protocol for Ethernet networks. This protocol is specified in the norm IEC 62439-3. In comparison to conventional redundancy procedures, for example, RSTP (Rapid Spanning Tree Protocol, IEEE 802.1D-2004), PRP offers a switchover without interruptions. This avoids a dead time in the event of a fault, and thus the highest availability.

Previous redundancy methods are based on mechanisms where the power-system components (switches and bridges) agree with each other and find the best communication path for normal operation.

In the event of a fault, for example, in a cable, an optical fiber, or in case of a switch failure, the interruption is detected and alternative paths are found in the network and connected. No communication can take place during this switching procedure. Depending on the size and on the configuration of the Ethernet network, this state can last for 10 ms up to around 1 s. A protocol extension in the end device is not necessary in this case because the protocol is implemented in the switches.

PRP adopts a different approach.

The redundancy procedure is generated in the end device itself. The procedure is simple: The redundant end device has 2 Ethernet interfaces with the same address (DAN, Double Attached Node). Then, the same indication is sent twice, with PRP (parallel) via 2 separated networks. Both indications are unambiguously identified with a sequence number.

The receiver takes the information that arrives first, stores the ID of the information in a duplicate filter using the source address and the sequence number of the information. Thereby, the receiver recognizes the 2nd redundant information and discards it.

If the 1st indication is missing, the 2nd indication with the same information arrives via the other network. This redundancy avoids a switchover of the network and is therefore a redundancy without interruption. The end device does not forward any indication to the other network.

In addition, it is possible to use one of the 2 networks for the transmission of not redundant indications. To do so, connect a SAN (Single Attached Node) device to a network. In this way, a PRP end device can communicate with a SAN end device (in a not redundant way). If you wish to connect a SAN end device in a redundant way to a PRP system, use a REDBOX (redundancy box). This REDBOX provides PRP functionality externally as an inline device. However, the PRP procedure also presents a disadvantage: You are buying the increased redundancy function at the cost of a duplicate network (2x switches, cables).

NOTE

Both networks must not be connected as this causes Ethernet double addressing and this can result in malfunctions!

There are 2 versions of PRP: PRP-0 and the successor PRP-1. Siemens implements PRP-1.

8.9 HSR

Like PRP, HSR (High Availability Seamless Redundancy Protocol) is specified in the norm IEC 62439-3. Both protocols provide a redundancy without switchover.

The basic function can be found in the definition of PRP. With PRP, the same indication is sent via 2 separated networks. In contrast to that, with HSR, the indication is sent twice in both directions of the ring. The receiver gets the indication via 2 ways in the ring, takes the 1st indication, and discards the 2nd (see PRP). Whereas a PRP end device does not forward any indication, an HSR node has a switch function. Thus, the HSR node forwards indications in the ring that are not addressed.

In order to avoid circling indications in the ring, special measures are defined in the case of HSR. SAN (Single Attached Node) end devices can only be connected with a REDBOX in the case of HSR. PRP systems and HSR systems can be coupled in a redundant way with 2 REDBOXES.

8.10 SNMP

Description

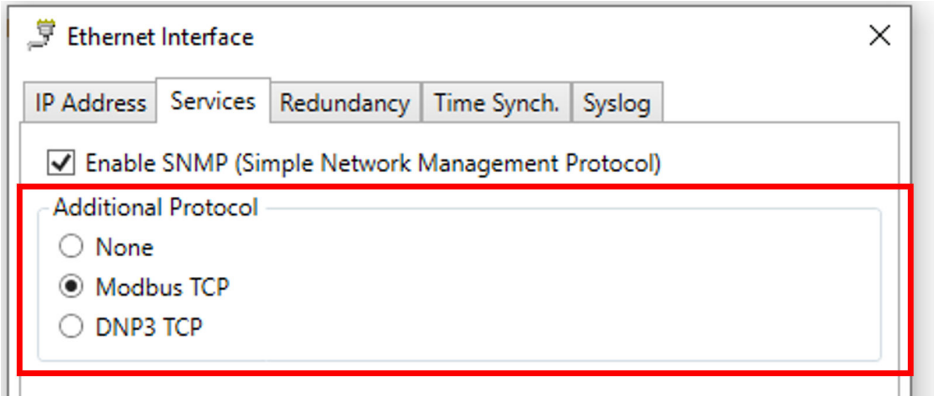
The SNMP protocol is implemented in all 7SR5 devices.

Devices with firmware earlier than V02.20, with communication firmware earlier than V01.20 SNMPv2 is supported.

Device firmware from V02.20, with communication firmware greater than V01.20, SNMPv3 with security features is supported and SNMPv2 can not be used. The security features cover both strong authentication and encryption (privacy) according to RFC 3414 and RFC 3415.

Usage of SNMPv3 is strongly recommended over earlier SNMP versions for security reasons.

The SNMP can be enabled and disabled in the Ethernet device configuration **Services** tab as shown in *Figure 8-7* or from the security page on the homepage by entering the maintenance password.



[sc_7SR5_DNP3Configuration, 2, --_--]

Figure 8-7 Enable/Disable SNMP

SNP3v3 Features

Security is a weak aspect in SNMP versions 1 through 2c. These versions of SNMP do not support logon with password and user names; instead, communities were used. The disadvantage is that every user in the network with a suitable program can read data and even change values. For additional security, in 7SR5 devices you cannot change any settings or values of the device via SNMP, except for settings affecting SNMP.

SNMPv3 Password Definitions

- USM-MIB (RFC3414, 2574)
- VACM-MIB (RFC3415, 2575)

You can find standard MIB information under *http://www.snmplink.org/OnLineMIB/Standards*.

.SNMPv3 offers improved authentication and privacy. 2 predefined user accounts exist in the device, with different access levels.

The user **usmUserTables** are managed via an MIB browser software tool. The tables and passwords can also be reset from the fascia using the Reset Passwords feature, see device manual for further information on resetting passwords.

Table 8-2 Predefined User Accounts

User Name	Authentication	Authentication Password	Encryption	Encryption Password	Access
initial	No	No	No	No	Read
templateMD5	HMAC-MD5	12345678	DES	12345678	Read, Write
templateSHA	HMAC-SHA-1	12345678	DES	12345678	Read, Write

The manner in which you create groups and users as well as change passwords depends on the SNMP manager application used.

NOTE

Connecting to the 7SR5 with SNMPv3 **noAuthNoPriv** template user 'initial', you can only read the MIBs and datagram captured by wireshark in plaintext.

NOTE

For security reasons, Siemens recommends removing these initial standard users, creating your own users, and assigning passwords. Up to 16 users are allowed to be added into USM table. The corresponding SNMP tree structures and tables for user management are readable and writable (USM-MIB). You can find more information in the RFC documentation: USM-MIB (RFC 3414, 2574) and VACM-MIB (RFC3415, 2575).

NOTE

Initial users can be restored via this webpage: https://IP-address/resetsnmpv3 and entering the Maintenance password or using the **Reset passwords** feature on the device fascia.

The user can manage and configure the access in **usmUserTable** via the MIB Browser, which includes:

- View users
  View existing SNMP users.
- Clone user
  Create a new SNMPv3 user from an existing one. The new user has the same parameters as the clone-from user. The new user has no access right to connect 7SR5 before it is binded to a group
- Delete user
  Delete the existing SNMPv3 user.
- Enable/Activate user
  Enable a disabled SNMPv3 user and change the row status from **notInService(2)** to **active(1)**.
- Disable/Deactivate user
  Disable the active SNMPv3 user and change the row status from **active(1)** to **notInService(2)**.
- Authentication Password change
  Change the authentication password to a new one.
- Privacy Password change
  Change the privacy password to a new one.

An MIB2 browser and the associated description file is required to detect the module information or module statuses using SNMP. MIB browsers allow to display SNMP information objects and their content.

In *Figure 8-8* the product of *iReasoning* has been used, but any browser with a comparable scope will be suitable.

The file SipEthernet.mib and digitalgridproductinventory.mib describes the available information objects and allows to display them. The MIB can be found in the internet under *http://www.siemens.com/Reyrolle*.

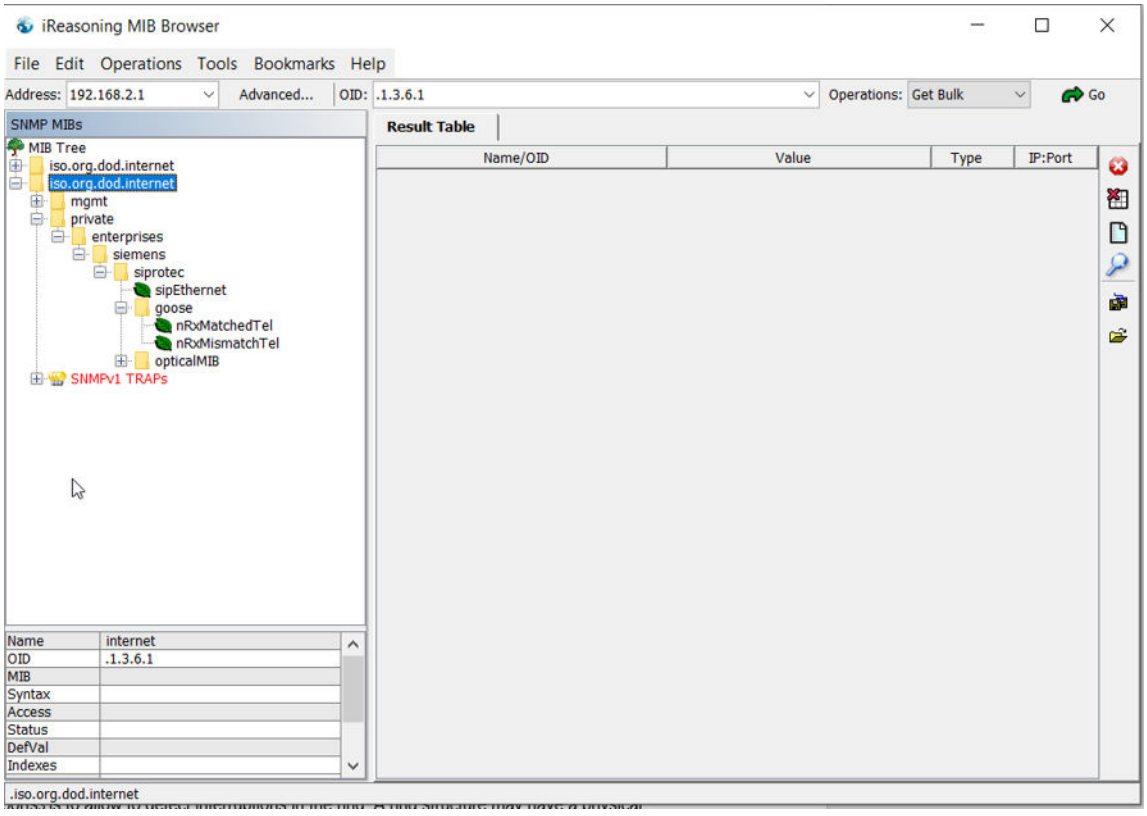


Figure 8-8 iReasoning MIB Browser

Display of Link and RSTP Information

To display the information, the MIB file must first be loaded into the browser. Next, the IP address of the desired device is set, and the information can be retrieved from the device. These settings and the operator action can vary from one browser to the next.

Essential information on link and RSTP

Figure 8-9 shows the most essential items of information. The first 2 items are the status of the 2 interfaces and the functionalities of RSTP.

If the module is operated as a switch, both channels must be active (Link Up). Data is transmitted and received on both channels.

Role of the ports

The role of the ports is to allow to detect interruptions in the ring. A ring structure may have a physical interruption. In that case the associated link is also set unavailable (LinkDown). The role of the port is then disabled.

The physical connection via this port is interrupted, which means an error.

Logic break point in the ring

In normal operation with RSTP, however, the ring is broken at one point in the network in order to prevent telegrams from circulating endlessly, which would make network operation impossible. The roles designated and root indicate that there is no logic break point at the ports, i.e. that the logic break point is not located on the connection between this port and the other device. Only one device in the ring shows the roles alternate and designated, with the logic break point being located at the alternate port.

If the ports show the combination alternate-designated or backup-designated, the logic break point is located at the port which is identified as alternate or backup. Knowing about the logic break point is useful for commissioning (see also *Figure 8-9*).

Port status

The port status only changes when the network is reconfigured due to an error. The logic break point is then closed. The corresponding ports then take on the status discarding, in which no payload data is yet transmitted; only administration information, such as changes of the role of a port, is transmitted. The status which follows, learning, is only transitory because of the fixed address setting of the internal switches; still no payload data is transmitted. The status forwarding characterizes the normal state, in which payload data telegrams are transmitted.

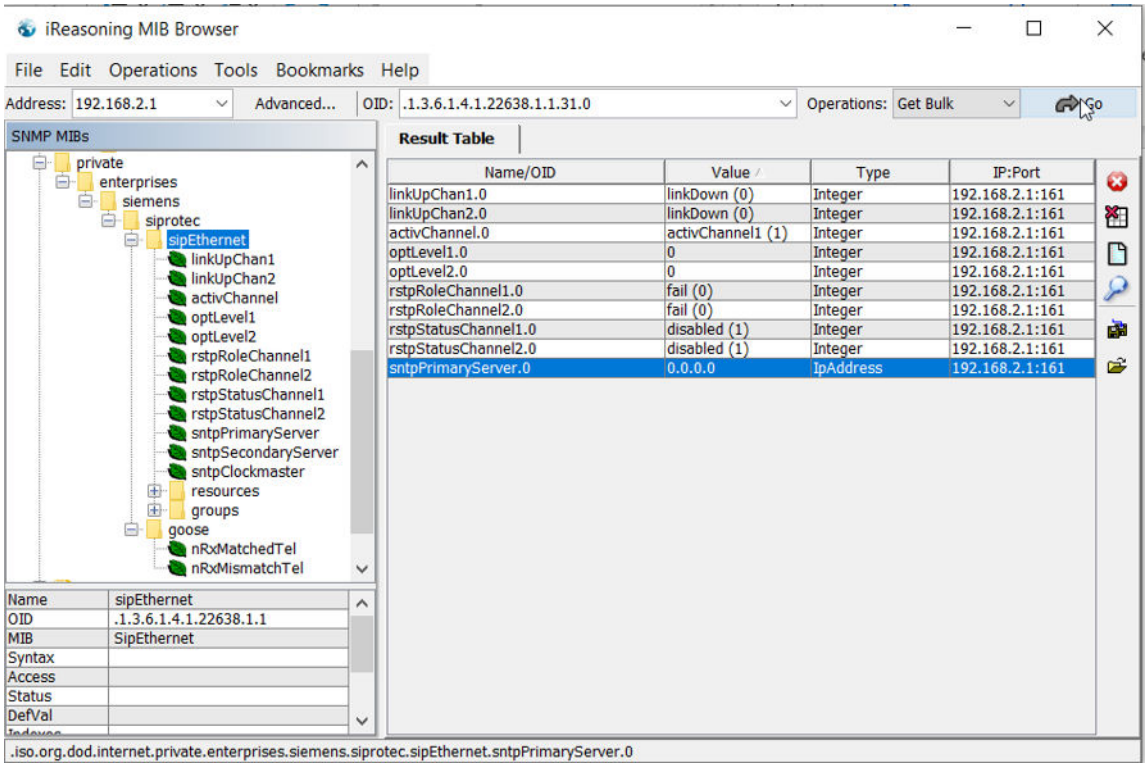


Figure 8-9 iReasoning Essential Information

Display of GOOSE Information

GOOSE information can be displayed quite easily with SNMP. Only the MIB file **`SipGoose.mib`** is necessary.

The detail view in *Figure 8-10* shows the 2 counters for the GOOSE telegrams.

The counter **`nRxMatchedTel`** shows the telegrams which have passed the multicast filter.

The counter **`nRxMismatchTel`** shows the number of telegrams revoked by the check of the further GOOSE Parameters.

Multicast filter setting

In the present case only those telegrams are received which are intended for the device. The number of blocked telegrams provides information of the network load due to other multicast telegrams. Both counters also allow the correct setting of the multicast filter, provided that the number of multicast circuits is known. Where there are several multicast circuits, some of which are not routed to the device, the counter **`nRxMismatchTel`** in this device must have a value that is not zero. If this is not the case, the filter setting is wrong, and overloads in the communication may be the consequence. This display is of particular importance for the commissioning of plants containing devices whose multicast addresses have not been routed using Reydisp Manager 2 system configurator.

This filter is automatically set in Reydisp Manager 2 system configurator during the configuration of GOOSE messages in the IEC 61850 System Configurator.

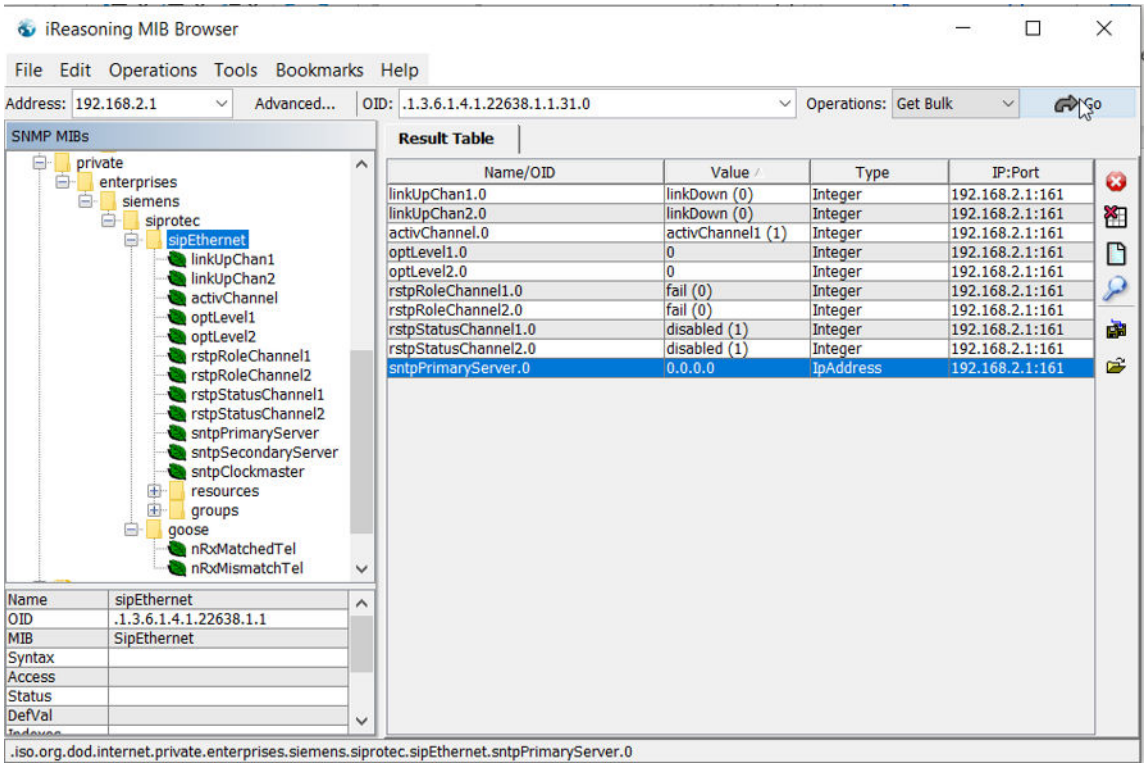


Figure 8-10 GOOSE Telegram Information

Display of RSTP Parameters

The RSTP parameters are set and changed in Reydisp Manager 2. A read access to these parameters is also possible via SNMP. Using the MIB file **`ReyOptical.mib`**, the following information is displayed.

The display shown in *Figure 8-11* visualizes the RSTP parameters set in Reydisp Manager 2. They correspond to the values shown in the display.

Figure 8-11 on the left shows that all existing MIB files can be loaded into the browser. This provides a tool that allows to monitor all 7SR5 devices throughout the network with regard to their accessible information.

The devices can thus be integrated into the customer's power system management, and can be monitored automatically.

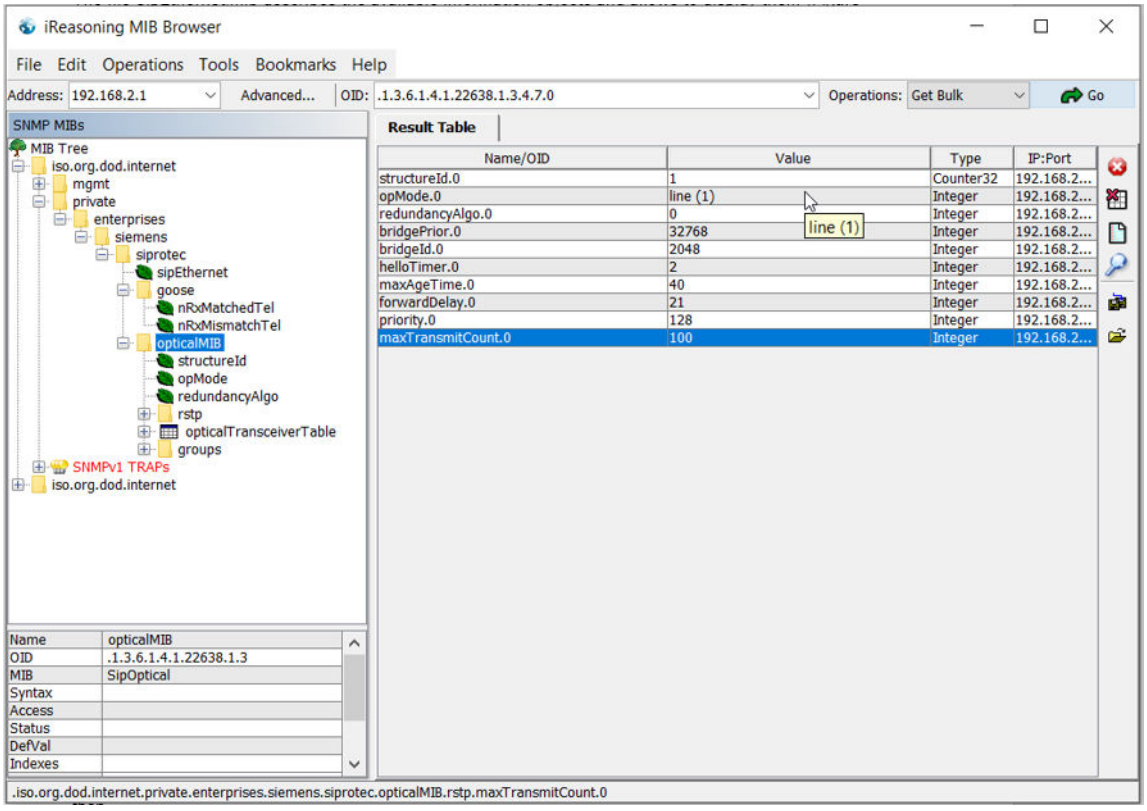


Figure 8-11 RSTP Parameter Settings

For instance, the overall information about the ring allows to monitor its physical and logic state.

Display of RSTP information using the BRIDGE-MIB

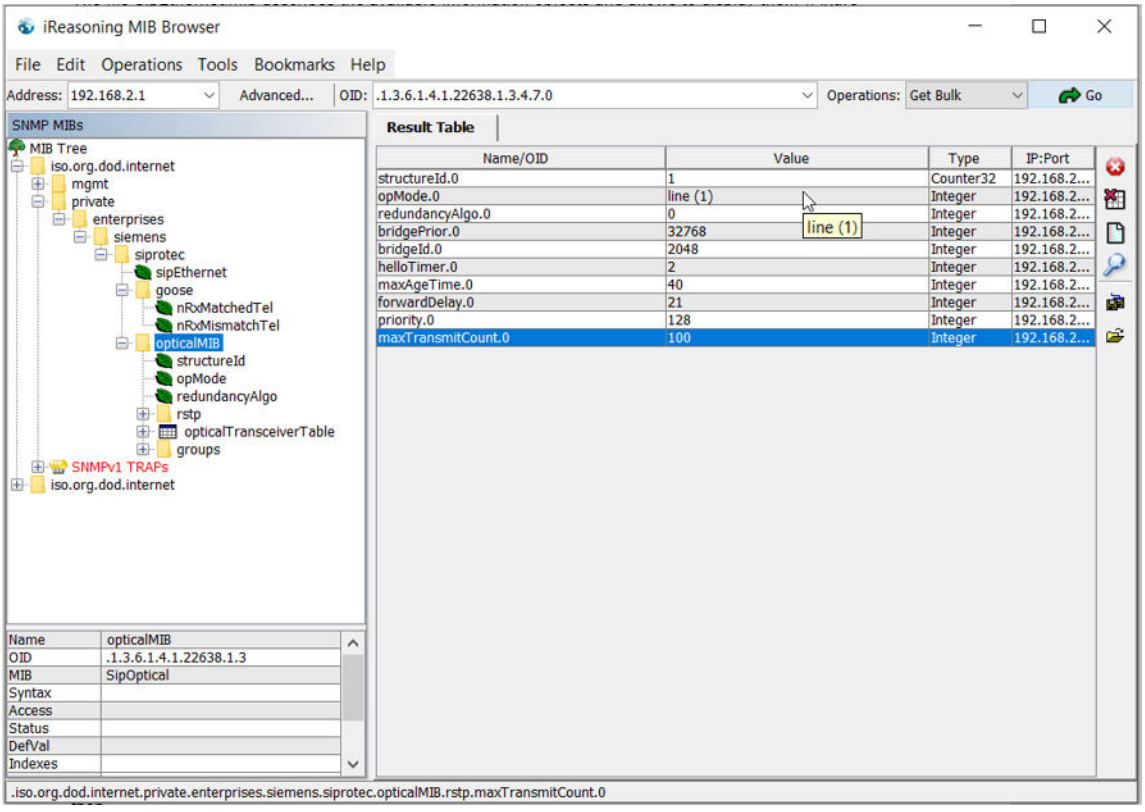


Figure 8-12 RSTP Information

Table listing

For single information there are descriptions in the **`Bridge MIB.mib`**.

Name	Value
dot1dBaseBridgeAddress.0	00-00-02-82-08-80
dot1dBaseNumPorts.0	2
dot1dBaseType.0	transparent-only
dot1dBasePort.1	1
dot1dBasePort.2	2
dot1dBasePortIfIndex.1	1
dot1dBasePortIfIndex.2	2
dot1dBasePortCircuit.1	.0.0
dot1dBasePortCircuit.2	.0.0
dot1dBasePortDelayExceededDiscards.1	0
dot1dBasePortDelayExceededDiscards.2	0
dot1dBasePortMtuExceededDiscards.1	0
dot1dBasePortMtuExceededDiscards.2	0
dot1dStpProtocolSpecification.0	ieee8021d
dot1dStpPriority.0	34951
dot1dStpTimeSinceTopologyChange.0	269
dot1dStpTopChanges.0	0
dot1dStpDesignatedRoot.0	0x10 0x00 0x00 0x0A 0xDC 0x02 0x5D 0xC0
dot1dStpRootCost.0	0

Name	Value
dot1dStpRootPort.0	2
dot1dStpMaxAge.0	40
dot1dStpHelloTime.0	2
dot1dStpHoldTime.0	100
dot1dStpForwardDelay.0	21
dot1dStpBridgeMaxAge.0	40
dot1dStpBridgeHelloTime.0	2
dot1dStpBridgeForwardDelay.0	21
dot1dStpPort.1	1
dot1dStpPort.2	2
dot1dStpPortPriority.1	128
dot1dStpPortPriority.2	128
dot1dStpPortState.1	Blocking
dot1dStpPortState.2	Forwarding
dot1dStpPortEnable.1	Enabled
dot1dStpPortEnable.2	Enabled
dot1dStpPortPathCost.1	200000
dot1dStpPortPathCost.2	200000
dot1dStpPortDesignatedRoot.1	0x10 0x00 0x00 0x0A 0xDC 0x02 0x5D 0xC0
dot1dStpPortDesignatedRoot.2	0x10 0x00 0x00 0x0A 0xDC 0x02 0x5D 0xC0
dot1dStpPortDesignatedCost.1	400000
dot1dStpPortDesignatedCost.2	400000
dot1dStpPortDesignatedBridge.1	0x80 0x34 0x08 0x00 0x06 0x86 0x58 0xB4
dot1dStpPortDesignatedBridge.2	0x80 0x34 0x08 0x00 0x06 0x86 0x58 0xA7
dot1dStpPortDesignatedPort.1	0x80 0x02
dot1dStpPortDesignatedPort.2	0x80 0x01
dot1dStpPortForwardTransitions.1	0
dot1dStpPortForwardTransitions.2	0

Setting and Properties

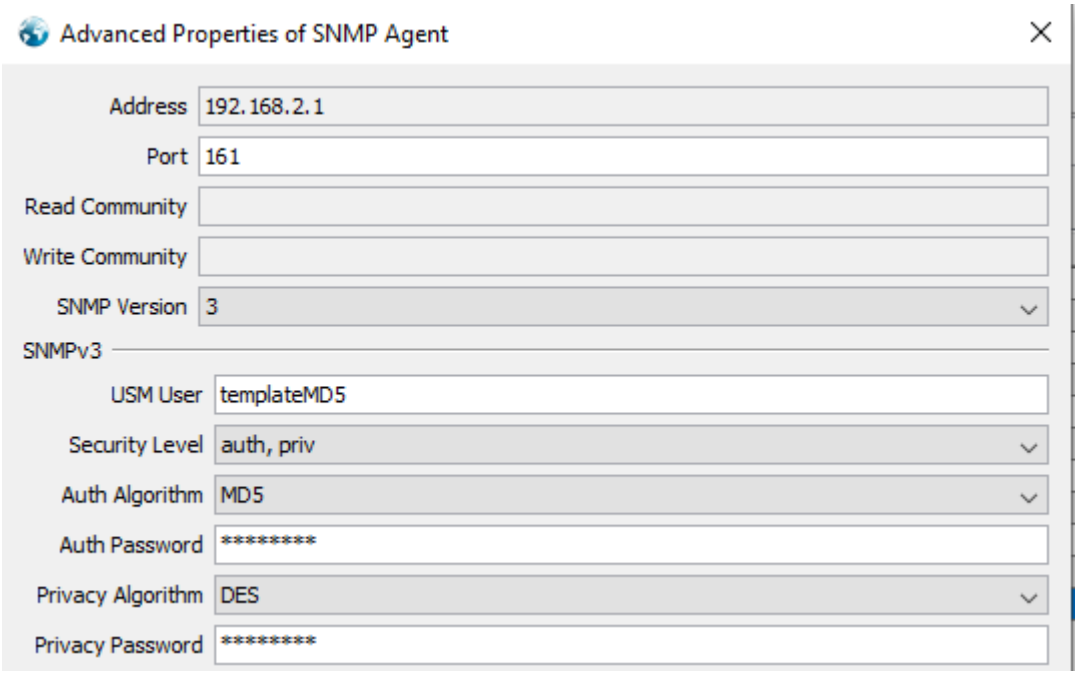
The SNMP is enabled by default in the 7SR5 device.

Setting for SNMPv3

The following example setting uses the iReasoning tool, but any browser with a comparable scope will be suitable.

The parameters of the desired user should be configured in the Advanced configuration. For this example we are using the default user templateMD5 shown in *Table 8-2*.

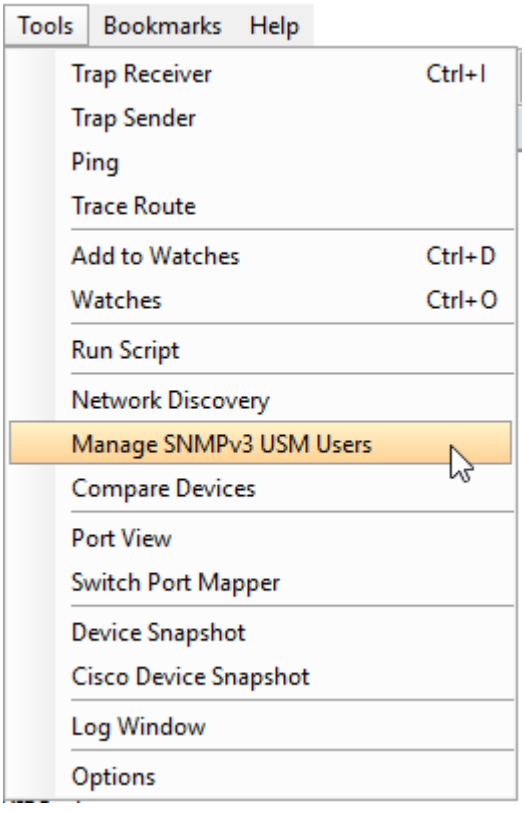
Address:	xxx.xxx.xxx.xxx
Port:	161
USM User:	templateMD5
Security Level:	auth, priv
Auth Algorithm:	MD5
Auth Password:	12345678
Privacy Algorithm:	DES
Privacy Password:	12345678



[sc_7SR5_SNMPAgentAdvancedProperties, 1, --_--]

Figure 8-13 SNMP Agent Advanced Properties

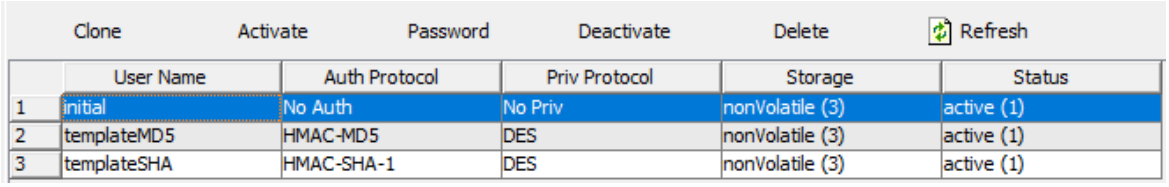
When connected the **`Manage SNMPv3 USM Users`** is used to view and configure the users.



[sc_7SR5_ManageSNMPUsers, 1, --_--]

Figure 8-14 Manage SNMPv3 USM Users

The default users are displayed and users can be modified using the **Activate**, **Deactivate** and the passwords changed using the relevant tool. In addition the users can be deleted or cloned. Using the **Clone** option new users are created from the template user (or existing created user) with the same parameters but the user has no access rights to the 7SR5.



	User Name	Auth Protocol	Priv Protocol	Storage	Status
1	initial	No Auth	No Priv	nonVolatile (3)	active (1)
2	templateMD5	HMAC-MD5	DES	nonVolatile (3)	active (1)
3	templateSHA	HMAC-SHA-1	DES	nonVolatile (3)	active (1)

[sc_7SR5_DefaultUserParameters, 1, --_--]

Figure 8-15 Default User Parameters

The passwords for the new user should now be changed.

Users should then modify the vacm security group table to bind the security of the user and create access for the group using the vacm Access Table.

8.11 EN100 Homepage

Description

The ethernet module is provided with a homepage, which can be invoked on all devices using the respective IP address. *Figure 8-16* shows an example of a homepage. The homepage is invoked by entering the IP address of the device combined with home in the address line of the browser on the PC (e.g.: https://172.16.52.53/home with IP = 172.16.52.53 set with Reydisp Manager 2). The homepage can also be entered from the device fascia USB port using the front port IP, https://192.168.2.1/home. In special cases it may be useful to read out the contents of the system log and send them to the hotline.

[sc_7SR5_EthernetEN100Homepage, 2, --_--]

Figure 8-16 Homepage of Ethernet EN100 Module

The module homepage always shows at its end the version and creation date of the software version loaded on the module.

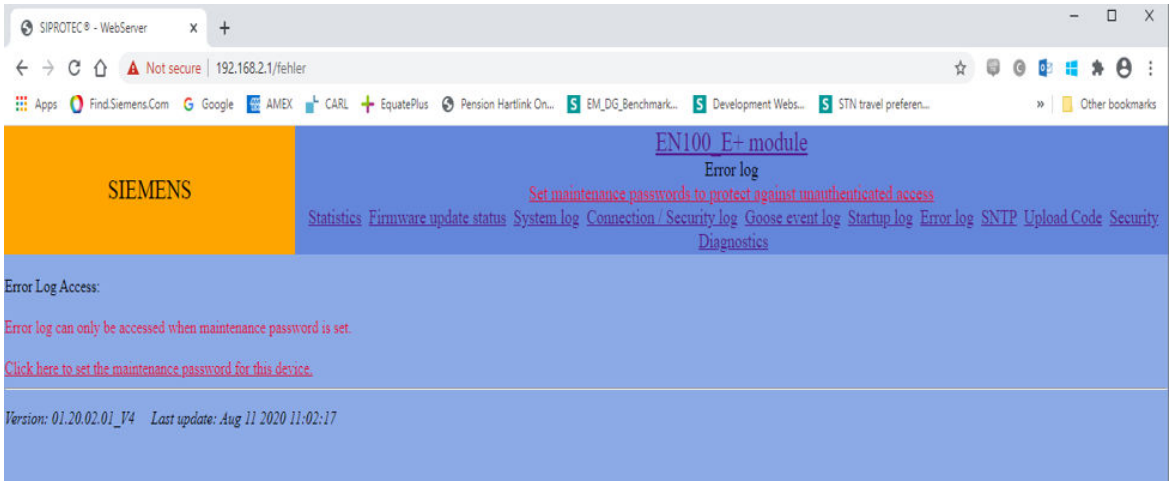
The homepage is not required in normal operation, and does not contain any relevant information for it. The following pages (*Table 8-3*) on the left area of the homepage contains information for commissioning. They contain operational information and internal error messages.

Table 8-3 Further Pages

Page	Description
Statistics	Shows relevant information of Ethernet
System Log	Shows information of system behavior, being produced from operation time
Connection Log	Contains information about Client-Server-Connection
Startup	Contains information about run-up behavior and configuration settings respecting network and GOOSE Parameters
Error Log	Contains internal error messages
SNTP	Contains information about settings and condition of time synchronization
PTP	Contains information about settings and conditions of PTP IEEE 1588 time synchronization
RSTP	Contains information about settings and condition of the network redundancy
Diagnostics	Shows specified parameter of modules, which are accessible by Siemens on demand
PRP Logs	HSR/PRP, contains information about network statistics
Upload Code	Provide the way to upload EN100 software via web
Set Passwords	Goes to the link where Reydisp Manager 2 connection password and maintenance password can be set or changed separately

Page	Description
Setup Secure Engineering Access	Enables secure maintenance connection
Setup SNMP Service	Enables SNMPv3 or SNMPv1/v2 function
Secure MMS	Not supported
Modbus TCP	Contains information about settings and condition of the network redundancy
DNP3 TCP	Contains information about settings and condition of the network redundancy
Security	Resetting of access, SNMP users, and passwords

In normal operation the error buffer display is empty, as shown in *Figure 8-17*. The maintenance password must be set to view the page.

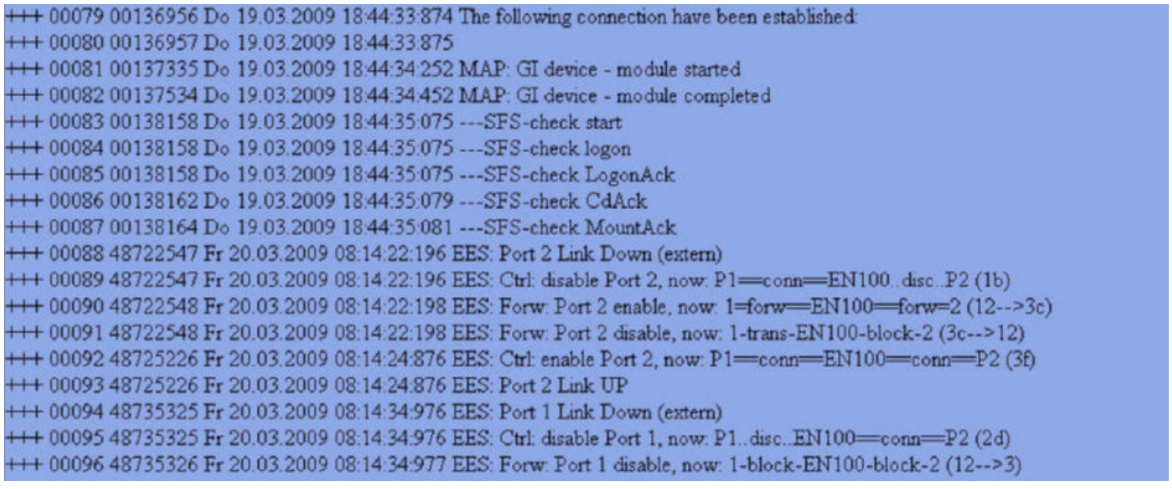


[sc_7SR5_ErrorLogBuffer, 1, --_--]

Figure 8-17 Error Log Buffer

System Log

The system log serves to display internal information. A detail of the startup procedure is shown in *Figure 8-18*. However, detailed insider knowledge is necessary to interpret the information displayed.



[sc_7SR5_SystemLog, 1, --_--]

Figure 8-18 Detail of System Log

Connection Log

The connection log shows the logs of connection details to the EN100 module.

```
+++ 00000 00167351 Fr 25.11.2016 16:39:39:762 IEC Server: New Connection with Client 192.168.  0.179 with port 60982
+++ 00001 00176445 Fr 25.11.2016 16:39:48:855 IEC Server: New Connection with Client 192.168.  0.111 with port 60570
+++ 00002 00182452 Fr 25.11.2016 16:39:54:863 IEC Server: Connection Terminated with Client 192.168.  0.179 with port 60982
+++ 00003 01521405 Fr 25.11.2016 17:02:13:834 DIGSI connected, IP = 192.168.000.179
end of log
```

[sc_7SR5_ConnectionLog, 1, --_--]

Figure 8-19 Detail of Connection Log

GOOSE Event Log

The GOOSE event log displays the GOOSE subscription as soon as changes occur (data value or quality from GOOSE Publisher or the result of an internal processing in subscriber, e.g. after a communication interruption). The GOOSE repetitions are not logged in this page. *Figure 8-20* shows the Web page of GOOSE log. *Table 8-4* shows the description of each item in GOOSE log.

[sc_7SR5_GooseLog, 1, --_--]

Figure 8-20 Detail from GOOSE Event Log

Table 8-4 Information Description on GOOSE Event Log Page

Name	Description
No.	Index of the events logged since module start
Rel. time (ms)	Number of milliseconds since module start
Date & Time	Time within the device at time of event (depends on device synchronization)
Source MAC	MAC address of the processed GOOSE publisher
Object	Contains internal error messages
Value	Internal number pointing to the element in the GOOSE dataset that has changed (the according Data Object can be read in startup log)
State	Internal value for the quality of the changed object, corresponding e.g. to valid (0)/invalid (40)
st num	Number of state change of received GOOSE message which is processed
sq num	Sequence number of received GOOSE message which is processed
Dataset	GOOSE Control Block Reference containing the changed object

Statistics

The statistics show a detail from the information which is available for special purposes and concerns data transmission, including switches. *Figure 8-21* shows a detail. The number of faulty symbols is of particular importance, because it indicates a poor link quality. This value is incremented when switching on/off, or on a break of the link. The number must not vary during operation.

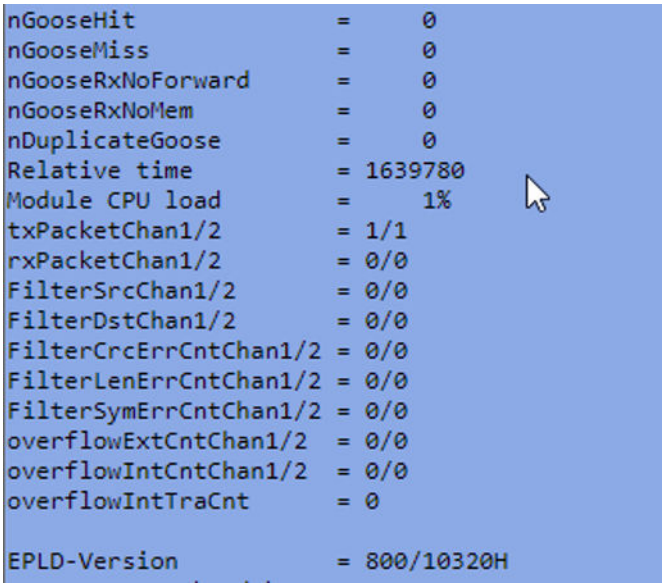


Figure 8-21 Detail from the Statistics

Important Information to be found on the Statistic Page

Table 8-5 contains the most important values to interpret the statistics. Set points are only given if they are static. If they are not, the entry remains empty.

Table 8-5 Information Values on the Statistic Page

Name	Set Point	Description
RxFrames		Counter for telegrams received which are forwarded to module applications and the TCP/IP stack.
BD out of sequence	0	Counter for receive buffer overflows in the communications processor. This value must always be zero.
Miss		Counter for telegrams received that do not match the MAC address of the device.
Broadcast		Counter for broadcast telegrams received
Multicast		Counter for multicast telegrams registered
More than 0x5f0 Bytes		Counter for telegrams (1520 bytes) that are too long. Such telegrams are discarded.
Non Octett	0	Counter for the number of bits which cannot be divided by 8. If this value is not equal to zero, there may be problems on the transmission link. This can also be the case if the link is physically broken.
CRC Error	0	Counter for telegrams received with a CRC-check error. Indicates possible problems on the transmission link.
Overrun	0	Counter for receive buffer overflow. Indicates possible performance problems of the Ethernet controller.
Truncated	0	MAC-internal counter. Counter for reduced telegrams received (> 2 kb)

Name	Set Point	Description
TxFrames	0	Counter of telegrams transmitted.
no transmit buffer	0	Incrementing can only happen if the collision or retransmission volume is very high.
FNS queue overflow	0	Counts broadcast telegrams which were not evaluated because of a processor overload. Activation usually due to circulating telegrams.
Frames Loss	0	Counts of discarded received telegrams; if more than 1000 such telegrams have arrived per second. Can only occur with circulating telegrams.
MaxRxBDs		Max. level of the receiving buffer.
RxLoopMax	0	Counter for receiving buffer overrun.
RxOverload	0	Counter for receiving overload. Receiving telegrams are lost.
TxDef	0	Counts the 'defers' when sending frames. An incrementation of the counter indicates that half duplex mode is set.
TxHB	0	Heartbeat counter
TxLC	0	Late Collision counter
TxRL	0	Counts violations of the retransmission limit
TxRC	0	Counts retransmissions. Indicates collisions
TxUN	0	Counts 'Buffer underrun'
TxCSL	0	Counts 'Carrier sense lost'
MaxTxBD		Max. level of the transmitting buffer.
nGooseHit		Counts the GOOSE telegrams received
nGooseMiss		Counts the GOOSE telegrams which passed the multicast filter, but are not addressed to the device (e.g. by incorrect GOOSE-parameterization).
Relative time		Momentary value of the relative time counter. This is a 32 bit counter which is incremented once per millisecond. Starts at 120000 (is equal to appr. 49 days, after it reboots with 0).
Module CPU load		Efficiency CPU
txPacketChan1/2		Counts of data packages, which was sent by the port.
rxPacketChan1/2		Counts of all data packages, which was received by the port.
FilterSrcChan1/2		Counter of all received data packages, which doesn't agree with all received data packages of the source address with the own address.
FilterDstChan1/2		Counter of all received data packages, which doesn't agree with all received data packages of the destination address with the own address.
FilterCRCErrCnt Chan1/2	0	Counter of data packages with CRC error

Name	Set Point	Description
FilterLenErrCnt Chan1/2	0	Counter of data packages, which are too long or too short. The acceptable length is 64 bytes to 1518 bytes.
FilterSymErrCnt Chan1/2	0	Counter of received symbol errors on the line (4b5b value is invalid). This monitoring is completed by the Phy.
overflowExtCnt Chan1/2	0	No counter for this value.
overflowIntCnt Chan1/2	0	No counter for this value.
overflowIntTraCnt	0	No counter for this value.
OptLevelChan1/2	> 2300	Level of the optical receiver in mV. Should not be less than is connected.
EPLD Version		Current EPLD version
Malloc Size		Primary storage management
Data Size, Code Size, NORMAL pool, ENTRY pool, GOOSE pool, WEAK pool		Primary storage management

The information shown in *Figure 8-22* are used for the analysis of broadcast telegram operations.

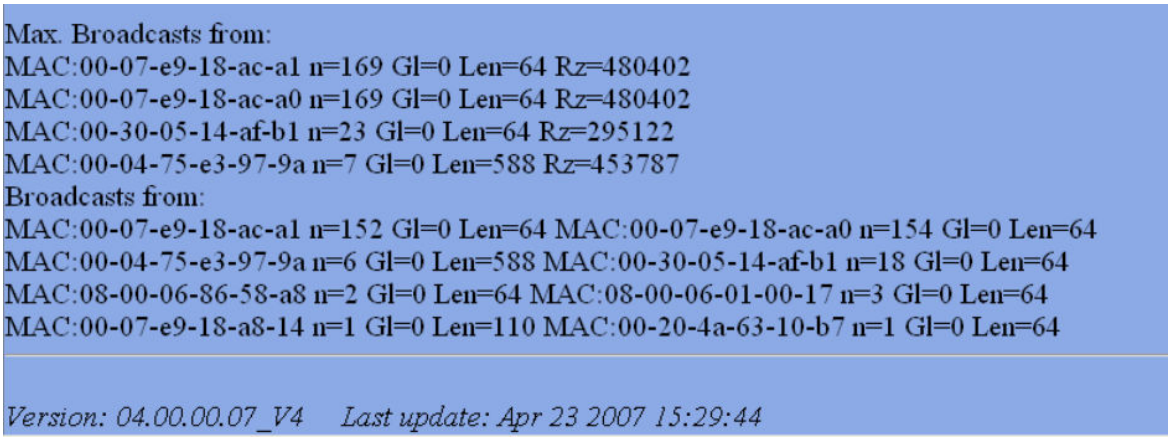
`Max Broadcasts from` lists the 4 most frequent broadcasts since the module was started. They are generated from Broadcasts from and contain the following information:

- MAC address of the broadcast transmitter (MAC)
- Quantity of this broadcast during the last 4 m (n)
- Number of successive identical telegrams (GI)
- Length of telegrams (Len)
- Relative time (Rz)

`Broadcasts from` lists the current broadcasts in the running 4-minute interval. Each line contains 2 transmitters with the following:

- MAC address of the broadcast transmitter (MAC)
- Number of broadcasts since the interval started (n)
- Number of successive identical telegrams (GI)
- Length of telegrams (Len)

The last line shows the current protocol software version and the time of generation.

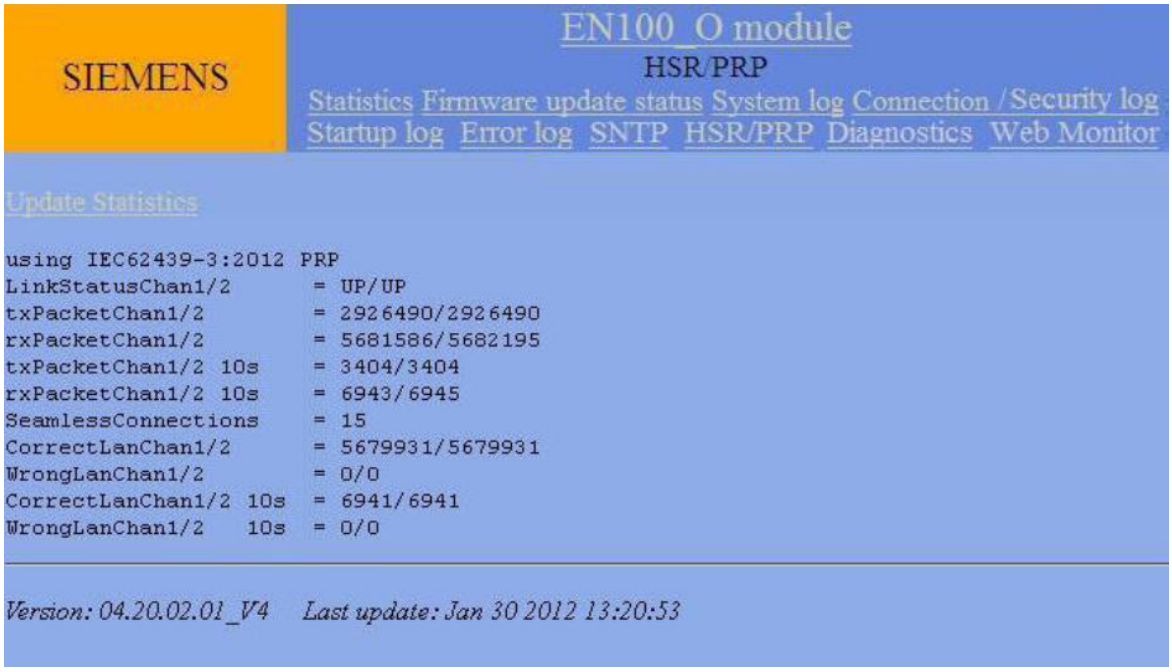


[sc_7SR5_StatisticsPt2, 1, --_--]

Figure 8-22 Statistics, Part 2

PRP

The following figure shows the PRP homepage. The main values of the PRP homepage are described in *Table 8-6*.



[sc_7SR5_PRPHomepage, 1, --_--]

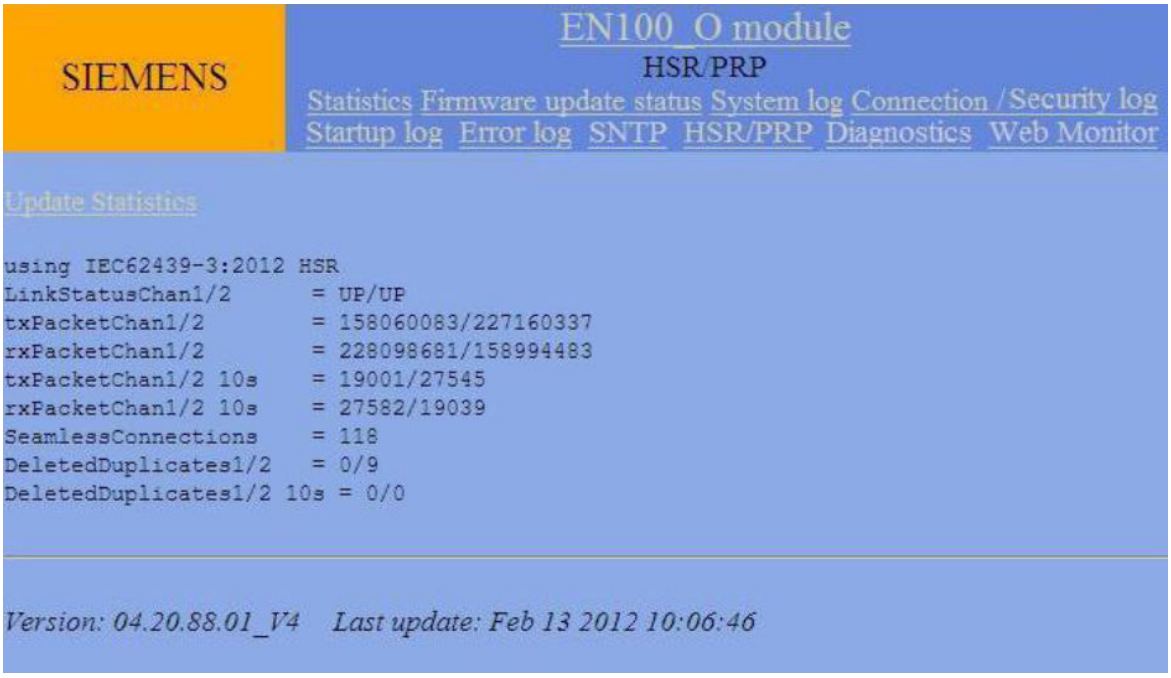
Figure 8-23 PRP Homepage

Table 8-6 Contents of PRP Homepage

Entry	Meaning
LinkStatusChan1/2	Link status message
txPacketChan1/2	Number of data packages sent from the port
rxPacketChan1/2	Number of data packages received by the port
txPacketChan1/2 10s	Number of data packages sent from the port within the last 10 seconds
rxPacketChan1/2 10s	Number of data packages received by the port within the last 10 seconds
SeamlessConnections	Number of modules, that have an active seamless connection. The value must be < 512
CorrectLanChan1/2	Number of PRP-packages, that have been received with a correct PRPLAN-ID
WrongLanChan1/2	Number of PRP-packages, that have been received with a wrong PRPLAN-ID. If this counter is unequal to 0 there may be a wiring error. A wiring error is present, if for example not all modules on the network have channel 1 connected to LAN A and channel 2 to LAN B
CorrectLanChan1/2 10s	Number of PRP-packages, that have been received with a correct PRPLAN-ID within the last 10 seconds
WrongLanChan1/2 10s	Number of PRP-packages, that have been received with a wrong PRPLAN-ID within the last 10 seconds

HSR

The following figure shows the HSR homepage. The relevant values of the HSR homepage are described in *Table 8-7*.



[sc_7SR5_HSRHomepage, 1, --_--]

Figure 8-24 HSR Homepage

Table 8-7 Contents of HSR Homepage

Entry	Meaning
LinkStatusChan1/2	Indication of link status
txPacketChan1/2	Number of data packages transmitted through the port
rxPacketChan1/2	Number of data packages received through the port
txPacketChan1/2 10s	Number of data packages transmitted through the port in the last 10 seconds
rxPacketChan1/2 10s	Number of data packages received through the port in the last 10 seconds
SeamlessConnections	Number of modules with an existing seamless connection. This value must be < 512
DeletedDuplicates1/2	Number of packages that were removed from the ring via the HSR duplicate filter
DeletedDuplicates1/2 10s	Number of packages that were removed from the ring via the HSR duplicate filter st 10 seconds

SNTP

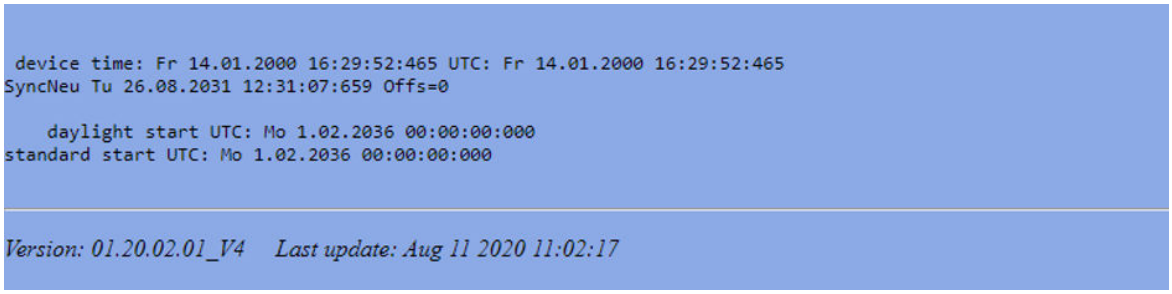
The 1st lines includes:

- Detail on the primary or currently active (primary or secondary) NTP server
- IP-address of the NTP server if connected
- Current time of the device which receives the synchronization from the module. Within the first minutes after start-up of the device the time can differ from the time of the module for some milliseconds since the device tries to bring the current time into line jump free.

The 2nd and 3rd lines are not relevant.

The 5th and 6th line contain some variables in table form from the received NTP telegrams of the primary and secondary server as well as the time since the last received telegram and the time at the moment arising from the synchronization of the module.

The 2 tables for the max. 16 last received NTP telegrams and a short legend follow to this.

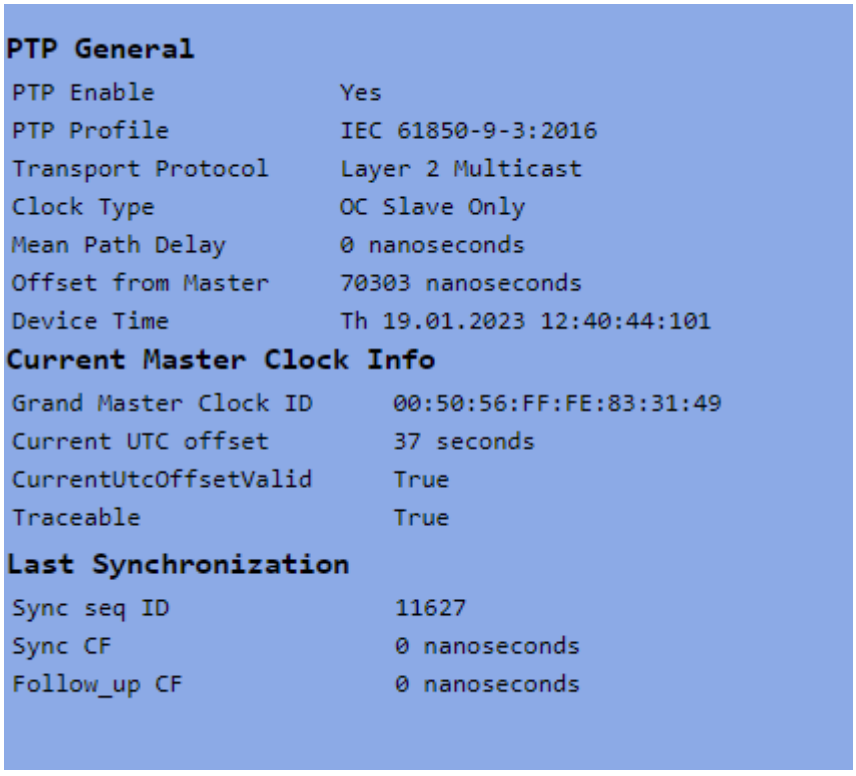


[sc_7SR5_SNTP, 1, --_--]

Figure 8-25 SNTP

PTP

Provides status, Clock Type and protocol information. Provides Offset time information and current device time. Provides Grand Master ID and other information. Provides Last Synchronization information.



[sc_7SR5_PTP, 1, en_US]

Figure 8-26 PTP

Modbus TCP

The device will only display the information for the protocol that is enabled in the configuration, either DNP3 TCP or Modbus TCP.

DNP3 TCP

The device will only display the information for the protocol that is enabled in the configuration, either DNP3 TCP or Modbus TCP.

RSTP

The 1st and 2nd line show the current values of role and status of the ports 1 and 2.

The 4th line shows the detected neighbors of the module detected in the ring at port 1 and 2 over RSTP telegrams.

A listing of important RSTP information about the bridge and the 2 ports follows.

```
Port Role  Chan1/2    = Root/Alternate
Port State Chan1/2    = Forwarding/Discarding
RSTP-dt/2*HelloTime   = 6/4
NeighbourMAC Chan1/2  = 00-0a-dc-0b-92-c6 / 00-0a-dc-0b-92-c7

RSTP-Bridge:
============
Bridge Priority       = 32768 (8000H)
Bridge Id             = 2048 (800H)
Topology Change Count = 0

Bridge              Learned / Configured
Hello Time            =  02 / 02
Max Age               =  40 / 40
Forward Delay         =  21 / 21
Transmit Count        =   0 / 100 /   2(Max)

RSTP-Port 1:
============
State                 = Forwarding
PathCost              = 200000
Designated Root       = 0000-000adc0b92c0
Designated Bridge     = 0000-000adc0b92c0
Port Role             = Root

RSTP-Port 2:
============
State                 = Discarding
PathCost              = 200000
Designated Root       = 0000-000adc0b92c0
Designated Bridge     = 0000-000adc0b92c0
Port Role             = Alternate


Version: 04.03.07.01_V4    Last update: Mar 18 2009 13:08:55
```

[sc_7SR5_RSTP, 1, --_--]

Figure 8-27 RSTP

Topology Change Count

A counter is available which registers changes of the network topology. Increases are generated during the phase of commissioning typically. In a stable network the counter doesn't change. Ramp up counters are showing bad connections (e.g. loose connection). They show instability in the network and the operator has to analyze the situation and resolve the problems.

NOTE

Under Actual of the bridge information the RSTP parameters obtained by the root are listed. These parameters must be identical with them adjusted on the module.

The current transmit count usually is 0 durably. If it increases or already had reached a high value before (> 20) then it indicates that the ring had changed down on the slower RSTP algorithm.

8.12 Secure MMS

Description

The product does not support Secure MMS and the following message is displayed in the information page.

[sc_7SR5_SecureMMS, 1, --_--]

Figure 8-28 Secure MMS Message

8.13 Syslog

The 7SR5 devices and Reydisp Manager 2 provide a security audit trail which chronologically acquires and categorizes security-relevant events according to the origin and severity.

The 7SR5 devices automatically send the security-relevant events to an external syslog-server. The transmission of the security events to the configured syslog server(s) takes place spontaneously and without a conformation via UDP (User Datagram Protocol) when the security event occurs.

A later readout of the recorded security-events from the device-local security event buffer is possible.

The security events are in English. For further information please refer to the 7SR5 Security manual C53000-H7050-C027-1.

8.14 Modbus Client

Description

Some models in the 7SR5 device range can be connected to an external 7XV5662-6AD10 Temperature measuring unit for temperature sensor information. If the device has the feature enabled the Modbus Client setting is available for selection from the RS485 protocol parameter options.

This protocol can be set to use the RS485 port.

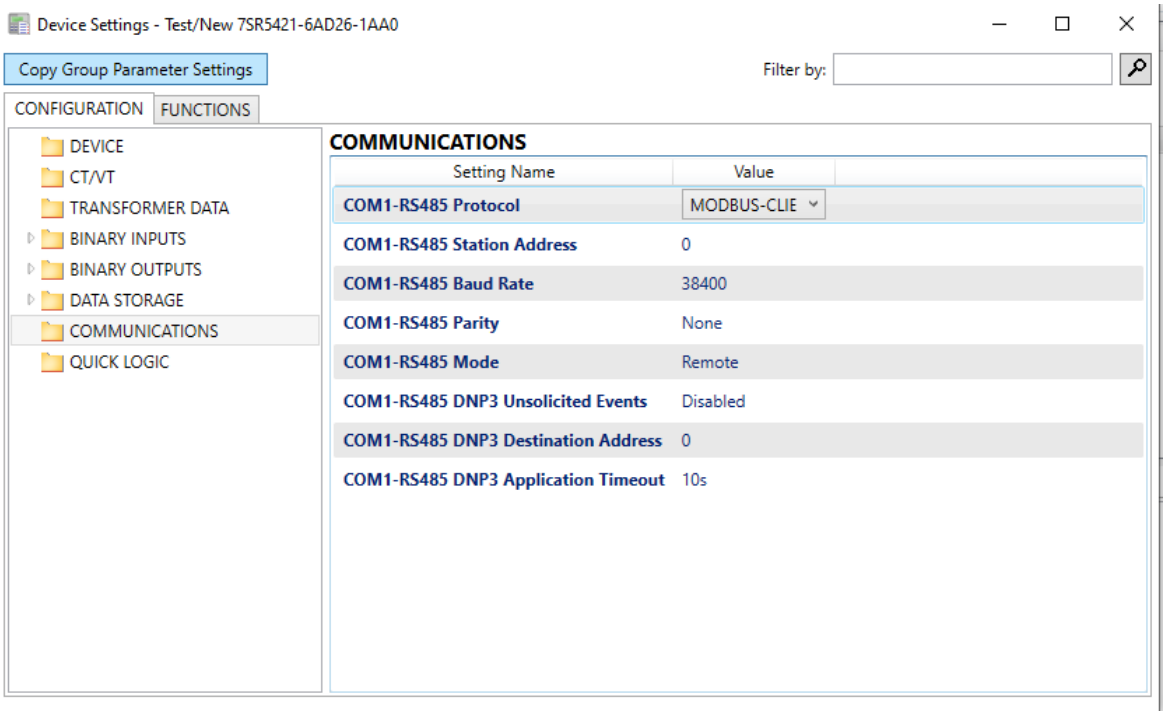
Settings and Properties

The settings for the rear RS485 communications are located in the communication menu of the setting tree.

Modbus-Client is implemented on the device specifically for connection to the external RTD box. The connection is designed to connect to a single 7XV5662-6AD10 Temperature measuring unit (RTD box).

NOTE

The 49TS function must be enabled in the Function configuration for the setting parameter to be visible.



[sc_7SR5_ModbusClient, 2, --_--]

Figure 8-29 Modbus Client

Table 8-8 Settings Menu

Configuration > Data Storgae				
Parameter	**Range**	**Default**	**Setting**	**Notes**
COM1-RS485 Protocol	IEC 60870-5-103, Modbus RTU, DNP3, Off, Modbus Client	Off	Modbus Client	Set the protocol for RTD box connec-tion
COM1-RS485 Station address	0 to 254 for IEC 60870-5-103 1 to 247 for Modbus RTU 0 to 65534 for DNP3	0	As required	Set the address of the RTD box
COM1-RS485 Baud rate	75, 110, 150, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200, 230400	38400	9600 or 19200	Set the baud rate to the same as RTD box
COM1-RS485 Parity	NONE, ODD, EVEN	NONE	As required	Set the parity to the same as the RTD box
COM1-RS485 Mode	Local, Remote, Local or Remote	Remote	Remote	

The setting parameters must match those selected on the RTD equipment, the RTD box options are shown in *Table 8-9*. For further information on the RTD box refer to TR1200 Operating Instructions.

Table 8-9 RTD Box Options

Baud Rate	Data Bits	Parity	Stop Bit
9600, 19200	8	Even, Odd, None	1 (at parity None: 2)

The interface parameters are factory set to 9600 baud, 8 bits, even parity, 1 stop bit.

The RTU mode is used.

The TR 1200 acts in the BUS system as a slave with an adjustable address from 1 to 247.

9 Commissioning and Diagnostics

9.1	Prerequisite	212
9.2	Settings of the Internal Switches	214
9.3	Diagnostic Information for DNP3 or Modbus	215
9.4	Diagnostic Information for Time Synchronization	220
9.5	Further Checks	221

9.1 Prerequisite

NOTE

In this chapter, the commissioning procedure is presented in compressed form. All components must be installed and operating properly.

Creating a List of Addresses

NOTE

With the aid of an address list, you can obtain an overview of the network topology. This list contains all important information about the devices. In this way, you can find any errors quickly.

Siemens thus recommends that you first create a list of component addresses immediately. The list must contain the following information at a minimum:

- Device type
- Product code
- Serial number
- Firmware version in the device
- Firmware version in the module
- IP address – when configured

When the serial communication port is connected the following information should also be recorded. When the RS485 is not to be used the port should be set to **`Off`** in the device configuration/communications/COM1-RS485 Protocol parameters.

- Com 1-RS485 station address
- Com-1 Baud rate
- Com-1 Parity

IP settings can be read only after the devices have been initialized, that is, the parameter sets have been loaded into the devices Subnet mask.

- Standard gateway
- MAC address

The MAC addresses can be read directly on the display of the device in the communications meters.

- IED name under IEC 61850 for each device

It makes sense to also obtain the above-mentioned information for third-party devices, for example, switches.

Supplement this list with a description of the network topology. This topology description explains how the devices are connected to one another.

To obtain information about devices from the competition, follow the procedure in the Manuals.

Once the list is complete, check whether any IP addresses or Com-1 address appear twice. MAC addresses do not appear twice when network components are identified unambiguously.

RS485 Connection

The RS485 should be connected and all wiring checked. The RS485 data comms link will be broken for that particular device element if it is withdrawn from the case or is not powered but the chain of communication to the other devices is maintained.

A suitable PC software test tool may be used to confirm communication to the devices and check data points and signals. Data points can be edited in the Communications editor tool in the device configuration and the

preferred configuration uploaded to the devices. Each of the 3 serial protocols supported in the 7SR5 device allow different parameterization according with the standard.

All signals used by the SCADA system over the RS485 connection should be initiated in the device and confirmed as received by the SCADA system.

Ethernet Communication Ring Structure

Start-up Ring Structure

The system is correctly set up and can now be switched on. Before power on, the ring containing the devices must be interrupted at one point[6]. The power-on sequence is as follows:

- Break ring structure at one point.[7]
- Energize switch. After power on wait for about 20 seconds.
- Energize devices. Siemens recommends to energize the devices in the order in which they are arranged in the ring. After power on, you should wait for each device to start up before the next device is energized.[8]
- Close the ring.

Check the accessibility

After commissioning of the network, the accessibility of the components in the ring must be checked. After connecting a PC to an external switch, all IP addresses can be accessed using the PC browser. The IP address is entered directly. This connection allows checking of the external switches. The settings of the modules integrated in the devices can be found on the respective device home page.

The home page address always has the format **`https://IP-address/home`**.

One example of a setting is **`https://172.16.52.55/home`**.

For commissioning and supervision supported tools are available from *http://www.siprotec.com*.

NOTE

Modules can work both in line and in switch mode. Their home page is therefore different. The mode is set in Reydisp Manager 2 device configuration.

After these preliminary steps have been completed, you have an operational ring structure in which further settings can be made.

6 This is strongly recommended in order to build up a stable ring structure.

7 Interrupting the ring can speed up the startup; if this is not done, effects similar to those described in the next footnote can occur.

8 Generally, neither the order of energizing nor the wait time are relevant. With RSTP, however, time-outs can cause a delay in building up the connection.

9.2 Settings of the Internal Switches

Activate RSTP

Activate the RSTP mode using Reydisp Manager 2. This invokes a menu that contains all RSTP-relevant settings.

`Set the bridge priority` – The internal switches should be set to the lowest bridge priority (i.e. the highest priority number) in the system.

The setting is the same for all switches. Siemens recommends a value of 32768.

`Port Priority` – This setting does not exist in internal switches.

`Age Time` – This value is set to 2 seconds.

`Max Age Time` – Here a value of 40 seconds is set. This ensures that even rings with up to 30 devices will work.

`Transmit Count` – Must be set to 100.

`Set the edge ports Further Checks` – Setting not available.

`Port Security` – Setting not available.

`Far Error Fault Indication` – This feature is set by default, no setting by the user is required.

NOTE

Please note that the basic default settings may differ. You should make the settings recommended here.

9.3 Diagnostic Information for DNP3 or Modbus

The device will only display the information for the protocol that is enabled in the configuration, either DNP3 TCP or Modbus TCP.

Diagnostic Information DNP 3 TCP or Modbus TCP

Table 9-1 Instrumentation – Communication Meters

Name	Value
DNP1/Modbus1	Connected/Disconnected
IP1 - Master 1	IP address
Send x Recieve x	Quantity of sent messages to master 1 Quantity of received messages from master 1
Errors	Quantity error messages
DNP2/Modbus2	Connected/Disconnected
IP2	Master 2 IP address
Send x Recieve x	Quantity of sent messages to master 2 Quantity of received messages from master 2
Ethernet Time Source	No Time Source or which source the Ethernet channel is receiving the time source

Diagnostic Data at the Device

Table 9-2 Displayed Values and their Description

Name	Values	Description
Channel name	Text	Internal channel description
Protocol State	Running/Stopped	State display for the protocol (current state)
Received Bytes	Number of bytes	Received Bytes
Sent Bytes	Number of bytes	Sent Bytes
Master Address	Number	Address of the master
Slave Address	Number	Address of the slave
Unsolicited Message	On/off	Unsolicited transmission
ReportDealed	Number	Telegrams arranged from device to module
ReportGot	Number	Telegrams sent from device to module
TCP or Uart	TCP or Uart	Connection via Ethernet or serial
Baud rate	Number	Set baud rate (for serial communication only)
Parity	EVEN/ODD/NONE	Set parity (for serial communication only)
DataBit	7/8	Set data bits (for serial communication only)
StopBit	1 or 2	Set stop bits (for serial communication only)
IPPort	Number	Number of the IP port (for Ethernet communication only)

Name	Values	Description
SubNetMask	Number	Subnet mask (for Ethernet communication only)
Gateway	Number	Gateway (for Ethernet communication only)

Diagnostic Data via Device Home Page

EN100 has a homepage which you can open by entering the IP address of the device. To open the HTML page, proceed as follows:

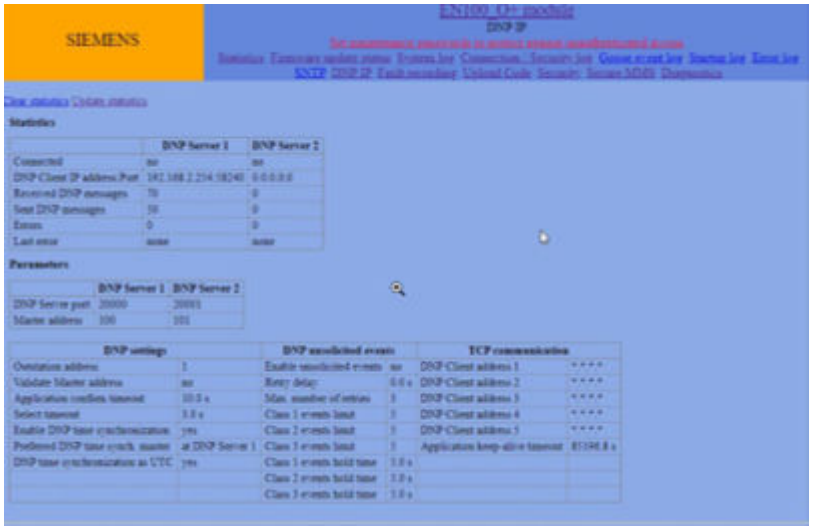
Enter the IP address of the device in the browser according to the following rule: https://IP address/home. For example: https://192.168.2.1/home. The EN100 homepage opens.

[sc_7SR5_EthernetEN100Homepage, 2, --_--]

Figure 9-1 EN100 Homepage

In the navigation pane (menu at the top), click the entry **DNP TCP**.

The DNP3 TCP diagnosis page opens.



[sc_7SR5_DNP3IPDiagnosisPage, 1, --_--]

Figure 9-2 DNP3 TCP Diagnosis Page

This page offers statistic data that is useful for communication diagnosis (e.g. telegram and error counters as well as the IP of the connected DNP3 TCP master). Additionally, the main protocol-specific settings made during DNP3 TCP configuration in the mapping file are shown and give an overview with which parameters DNP3 TCP is running on the module.

The parameters displayed on the diagnosis page correspond to the DNP3 TCP-specific parameters and the DNP3 TCP networking parameters.

Table 9-3 Additional Remarks to Links

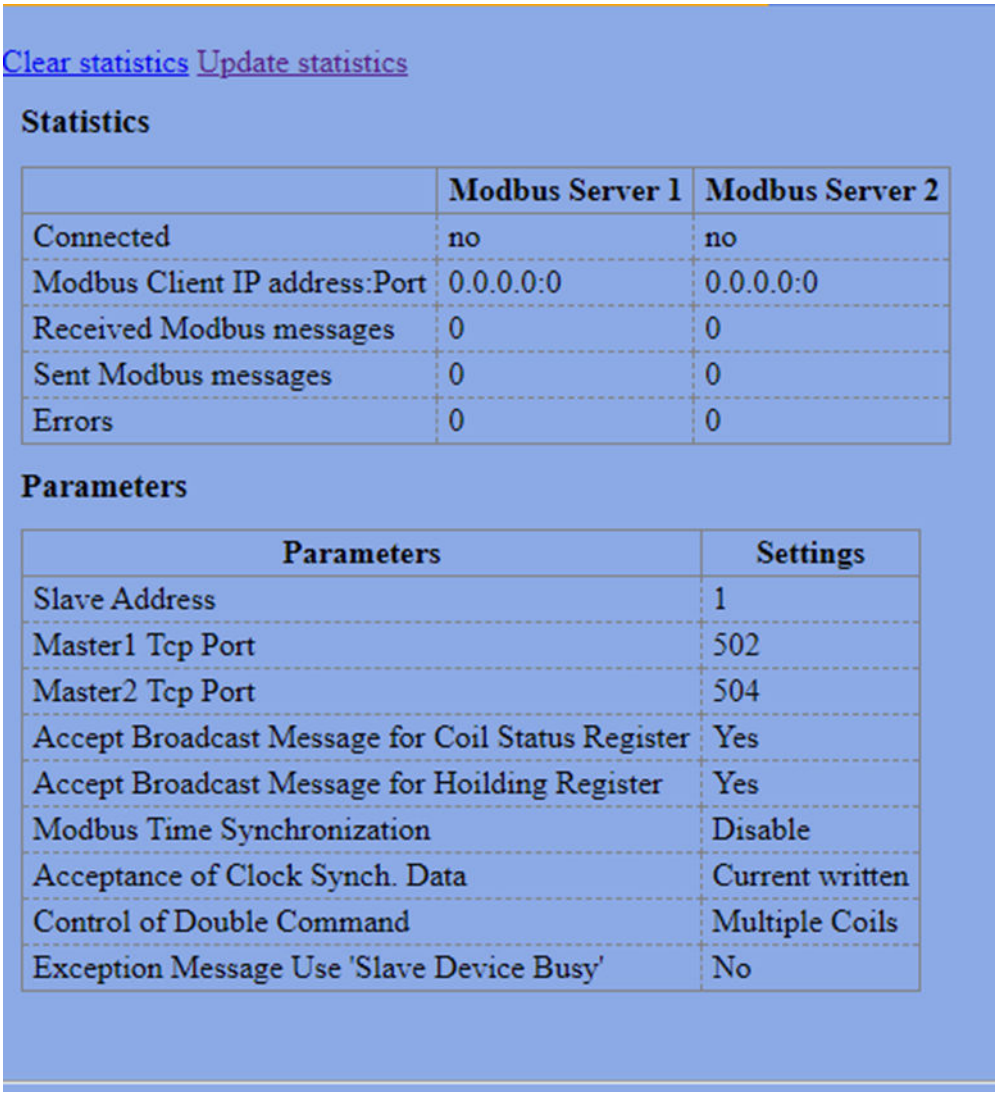
Clear statistics (link)	Pressing this link resets all statistic values (telegram and error counters) to zero.
Update statistics (link)	The HTML page is not updated automatically. Press this link to update the statistic values (all values will then be read again from the EN100 module).

Table 9-4 Additional Remarks to Statistics and Parameters

Connected	It is shown whether a DNP client is connected to this DNP server – **yes** or **no** – and additionally if time synchronization via DNP3 TCP is executed, the text **Time synch.** shows which client acts as time master.
DNP Client IP address: Port	IP address and TCP port number of the client which is currently connected to the server or was connected last to the server.
Enable DNP time synchronization	The value **yes** is shown if on the one hand the parameter **EnableDnpTimeSynch** is set to 1, but on the other hand no SNTP server is configured in the Ethernet interface SNTP configurator. no – Enable DNP time synchronization = no yes – Enable DNP time synchronization = yes and SNTP server is configured yes – Enable DNP time synchronization = yes but no SNTP server is configured

In the navigation pane (menu at the top), click the entry **Modbus TCP**.

The Modbus TCP diagnosis page opens.



Clear statistics Update statistics

Statistics

	Modbus Server 1	Modbus Server 2
Connected	no	no
Modbus Client IP address:Port	0.0.0.0:0	0.0.0.0:0
Received Modbus messages	0	0
Sent Modbus messages	0	0
Errors	0	0

Parameters

Parameters	Settings
Slave Address	1
Master1 Tcp Port	502
Master2 Tcp Port	504
Accept Broadcast Message for Coil Status Register	Yes
Accept Broadcast Message for Hoilding Register	Yes
Modbus Time Synchronization	Disable
Acceptance of Clock Synch. Data	Current written
Control of Double Command	Multiple Coils
Exception Message Use 'Slave Device Busy'	No

[sc_7SR5_ModbusTCPDiagnosisPage, 1, --_--]

Figure 9-3 Modbus TCP Diagnosis Page

This page offers statistic data that is useful for communication diagnosis (e.g. telegram and error counters as well as the TCP of the connected Modbus TCP master). Additionally, the main protocol-specific settings made during Modbus TCP configuration in the mapping file are shown and give an overview with which parameters Modbus TCP is running on the module.

NOTE

The entry Connection/Security log in the navigation pane is also relevant for Modbus TCP and DNP3 TCP. The following events are entered:

- Establishing a new connection with a client
- Closing a connection
- Rejecting a connection (unknown IP address or server already connected)

[sc_7SR5_EthernetEN100ConnectionSecurityLog, 1, --_--]

Figure 9-4 EN100 Module – Connection/Security Log

9.4 Diagnostic Information for Time Synchronization

These meters are under the **Communication Meters** menu.

SNTP Meter

This is 1 meter that scrolls across the display.

SNTP	Meter [9]	Meter [10]	Meter [11]
Not configured	No primary NTP server	No secondary NTP server	NTP1/2 sync 999/999
Configured	NT1*<IpAddress>	NT2<IpAddress>	NTP1/2 sync 036/019

IEEE 1588 (PTP) Meters

There are 2 meters

IEEE 1588 Synch ID	Meter
Not configured	Time source from <source e.g. SNTP>
Configured	Time from PTP <Sync sequence ID e.g. 12345>

IEEE 1588 Grand Master Clock ID	Meter
Not configured	–
Configured	<64 bit ID of form xx:xx:xx:xx:xx:xx:xx:xx>

9 Shows details of Primary Server
10 Shows details of Secondary Server
11 Shows seconds since last time synch recieved from each server

9.5 Further Checks

Check the Accessibility

After making all settings and loading the parameters, all components must be accessible through their IP address.

This must be possible both with a closed and an interrupted ring.

If a device cannot be accessed, the reasons might be:

- A device connected by a line link to an external switch is connected.
- A device integrated into a ring is not available.
- A ring structure is broken at more than one point, so that some of the devices are not available.

Check the Home Pages

The home page of the devices is available at address **`https://IP address/home`**. For further details see *8.11 EN100 Homepage*. To be on the safe side, you should check with the statistic page the for the most important points as listed:

- RSTP-Role Chan1/2 = Alternate/Root
  If the devices are arranged in a ring, and the ring is closed and connected to the external switches which are also on, one device on the statistic page must always display this text. If none of the devices in the ring does, the ring is physically broken.
- FilterSymErrCntChan1/2 = 0/2753
  If these 2 counters are incremented during stable operation of the device, and with neither of the 2 adjacent devices turned off, there is a poor FO connection. This can be due to an excessive attenuation by the coupling devices, or to a defective cable.
- FNS queue overflow = 0
  If this display is not equal zero, this suggests that there are circulating broadcast telegrams.
- Frames Loss = 0
  A value that is not zero indicates circulating multicast telegrams.

10 Troubleshooting

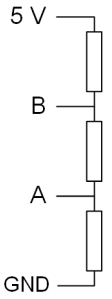
10.1	RS485 Serial Communication	224
10.2	7SR5 to Reydisp Manager 2 from USB port	225
10.3	Ethernet Communication	226

10.1 RS485 Serial Communication

Devices do not Communicate in a Multidrop Network

Siemens recommends proceeding as follows:

- Check that all relays are powered up with auxiliary power supply.
- Check the polarity of rear communication terminal and connection.
- Check that all relays have unique addresses.
  - Modbus in the range 1 to 247
  - IEC 60870-5-103 in the range 1 to 254
  - DNP3 Serial in the range 1 to 65534
- Check if RS485 terminating resistor is required and in circuit.
- Fit pull up/pull down resistors if required.
- Check no more than 64 devices are connected to the bus.
- The bus polarity for the connection is shown in *Figure 10-1*.



[dw_7SR5_RS485PortComm, 1, en_US]

Figure 10-1 Communication to Multiple Devices using RS485 (Standard Port)

- Check the communication settings are set on the device parameter settings.
  - Correct Protocol
  - Parity
  - Baud rate
- Check protocol settings match those on the communication master device or SCADA system.

Signals are not Received by Master

- Check the communication parameters are configured in the Reydisp Manager 2 communication file for the particular protocol.
- Check polling for correct address point.
- For Modbus ensure polling is for adjacent points.

10.2 7SR5 to Reydisp Manager 2 from USB port

Siemens recommends proceeding as follows:

- Check the communication cable is connected properly.
- Check that the USB driver is installed correctly.
- Check there is not a conflict between the Reydisp Manager 2 port IP address and another IP address on the PC in the PC Network connections configuration.

10.3 Ethernet Communication

The subject of this chapter is troubleshooting problems with the Ethernet interface. First, here are the essential points that can prevent correct working.

No link established

If the device does not connect, first check the installation. Has the link to the switch been correctly established and have the right cables been used (no crossover cables!)? Has the correct cable been used for a direct link with the PC (crossover cables must be used in this case!)? Is the switch functioning correctly and is its supply voltage OK? Correct functioning of a link can be seen by the link status LED.

IP address

Has an IP address been set in the device? If this setting has not been made and there is also no DHCP server in the network, it will not be possible to establish a link. To validate the IP address, it is possible to execute a ping from the network to the device's IP address.

Subnet mask

Has the subnet mask been correctly set? The subnet mask results from the addressing scheme used in the network segment.

Remote access not possible

Has the gateway address been correctly set in the device? If it is not correct, it will not be possible to access a device via 2 or more networks.

No time synchronization via Ethernet

Is there a time server in the network and what is its address? Has the address been correctly set in the device? Is the device correctly parameterized for use of time synchronization via Ethernet? If the time server is a PC, is the Windows time service deactivated and the correct NTP service started? Ensure the Modbus TCP or DNP3 TCP is not active when the SNTP server is being used and vise versa.