GE VERNOVA

8 Series

Instruction Manual

Communications System

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Firmware Version: 4.30
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Copyright statement

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Warranty

GE Vernova warrants most of its manufactured products for 10 years.

For warranty details including any limitations and disclaimers, see the Terms and Conditions at http://www.gevernova.com/gegridsolutions.com/multilin/warranty.htm

Major changes

For information on the updates included in this release of the manual, please refer to the latest release notes.

Contents

CHAPTER 1

INTRODUCTION

1.1 CHAPTER OVERVIEW

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

This chapter contains the following sections:

1.2 FOREWORD

This technical manual provides a functional and technical description of the relay, as well as a comprehensive set of instructions for using it. The level at which this manual is written assumes that you are already familiar with protection engineering and have experience in this discipline. The description of principles and theory is limited to that which is necessary to understand the product. For further details on general protection engineering theory, we refer you to the publication, Protection and Automation Application Guide, which is available online.

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

1.2.1 TARGET AUDIENCE

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

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

1.2.2 TYPOGRAPHICAL CONVENTIONS

The following typographical conventions are used throughout this manual.

- Description of software menu items, buttons, labels or hardware keys and buttons written in bold type and colored in Vernova dark green.
  For example: Select **Save** from the file menu
- The names for special keys, appear in in upper case bold type and colored in Vernova dark green.
  For example: **ENTER**
- Filenames, paths, code, and text that appears on a command line interface use the courier font
  For example: `Example\File.text`
- Special terminology is written with leading capitals
  For example: Line Differential Relay
- If reference is made to the relay's internal settings database on the relay's LCD screen, the menu items are written in bold italics
  For example: ***SECURITY*** (on the relay's LCD screen), or ***Security*** (in the EnerVista D&I Setup software)
- Menu paths are shown with **>** separators. This applies to both software menu paths and relay menu paths
  For example: ***SETTINGS > SYSTEM SETUP > AC INPUTS*** (for relay path), or **File > Save** (for software path)
- Setting values are written with the courier font and are italicized
  For example: *`Enabled`*
- The products, use Flexlogic operands. Flexlogic operands are written in dark Vernova green uppercase courier font
  For example: PUSHBUTTON 1 ON
- Sometimes it is beneficial to emphasize some words. Depending on the case in question, this may be done with bold, italic or upper case font attributes.
- Notes are written in italic in, and are surrounded by a border.
  For example:

Note:
This is a note

1.2.3 NOMENCLATURE

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

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

- The word *relay* and *IED* (Intelligent Electronic Device) are both used to describe the protection device. The term *IED* is associated with the IEC61850 standard, whereas the term *relay* is the long-used traditional term. It may also be referred to simply as the *device* or the *product*.
- American English and spelling is used throughout this manual.
- The term 'Earth' and American term 'Ground' are equivalent. You may find either used in the manual.
- When depicting a generic instance of a number of items, this manual uses <n> where n can be any integer.

1.3 GENERAL DESCRIPTION

The Multilin 8 Series protective relay platform includes five different relays, the 845, 850, 859, 869 and 889. Information in this manual applies to all 8 series relays unless otherwise indicated.

The Multilin 845 relay is a microprocessor-based unit intended for the management and primary protection of the medium to large size medium voltage (MV) and high voltage (HV) power transformers. Both 2-winding and 3-winding transformers are supported. The 845 relay provides a number of primary and backup current and voltage based protection functions. This system allows for control of the circuit breakers at each winding plus a number of monitoring and control functions are also provided.

The Multilin 850 relay is a microprocessor-based unit intended for the management and primary protection of distribution feeders, as well as for the management and backup protection of buses, transformers, and transmission lines. The 850 relay is particularly suited to overhead feeders, where automatic reclosing is normally applied.

The Multilin 859 relay is a microprocessor-based unit intended for the management and primary protection of medium and large sized motors. Base relay models provide thermal overload and overcurrent protection plus a number of current and voltage based backup functions. It has a different form factor from the rest of the 8-series.

The Multilin 869 relay is a microprocessor-based unit intended for the management and primary protection of medium and large sized motors. Base relay models provide thermal overload and overcurrent protection plus a number of current and voltage based backup functions.

The Multilin 889 relay is a microprocessor-based unit intended for the primary protection of small, medium and large sized generators. Base relay models provide standard generator protection functions plus a number of current and voltage based backup functions.

1.4 FOR FURTHER ASSISTANCE

For product support, contact us as follows:

GE Vernova

650 Markland Street

Markham, Ontario

Canada L6C 0M1

Worldwide telephone: +1 905 927 7070

Europe/Middle East/Africa telephone: +34 94 485 88 54

North America toll-free: 1 800 547 8629

Fax: +1 905 927 5098

Worldwide e-mail: ga.support@gevernova.com

Website: https://www.gevernova.com

1.4.1 REPAIRS

The firmware and software can be upgraded without return of the device to the factory.

For issues not solved by troubleshooting, the process to return the device to the factory for repair is as follows:

- Contact a GE Vernova Grid Solutions Technical Support Center. Contact information is found in the first chapter.
- Obtain a Return Materials Authorization (RMA) number from the Technical Support Center.
- Verify that the RMA and Commercial Invoice received have the correct information.
- Tightly pack the unit in a box with bubble wrap, foam material, or styrofoam inserts or packaging peanuts to cushion the item(s). You may also use double boxing whereby you place the box in a larger box that contains at least 5 cm of cushioning material.
- Ship the unit by courier or freight forwarder, along with the Commercial Invoice and RMA, to the factory.
- Customers are responsible for shipping costs to the factory, regardless of whether the unit is under warranty.
- Fax a copy of the shipping information to the GE Vernova Grid Solutions service department.

Use the detailed return procedure outlined at

https://www.gevernova.com/grid-solutions/return-procedures

The current warranty and return information are outlined at

https://www.gevernova.com/grid-solutions/multilin/warranty

CHAPTER 2

COMMUNICATION PORTS

2.1 CHAPTER OVERVIEW

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

This chapter contains the following sections:

2.2 RS485

On the rear, the relay is equipped with two RS485 serial communication ports. The RS485 port has settings for baud rate and parity. It is important that these parameters agree with the settings used on the computer or other equipment connected to this port. A maximum of 32 relays can be daisy-chained and connected to a DCS, PLC or a PC using the RS485 port.

Path: ***Setpoints*** > ***Device*** > ***Communications*** > ***RS485***

BAUD RATE

Range: 2400, 4800, 9600, 1200, 19200, 38400, 57600, 115200

Default: 115200

PARITY

Range: None, Odd, Even

Default: None

PORT PROTOCOL

Range: Modbus, DNP 3.0, IEC 60870-5-103

Default: Modbus

2.3 USB

The USB parameters are as follows:

IP Address: 172.16.0.2

IP Subnet Mask: 255.255.255.0

IP GWY IP Address: 172.16.0.1

Note:
Whenever the device is rebooted, the USB cable needs to be unplugged and plugged in again for proper communication to be established over USB.

Connecting multiple relays over USB to a single PC is not possible because in the case of USB, the IP address of the device 172.16.0.2 is constant.

2.3.1 USING THE QUICK CONNECT FEATURE VIA THE USB PORT

From the EnerVista D&I Setupsoftware the **Quick Connect** button can be used to establish a fast connection through the front panel USB port of an relay.

Before starting, verify that the standard USB cable is properly connected from the laptop computer to the front panel USB port.

1. Verify that the latest version of the EnerVista D&I Setup software is installed (available from the GE Vernova website). See the software installation section in the *relay* Instruction Manual for installation details.
2. Open the 8-Series Setup.
3. Select the device to start the software.
4. Click the **Quick Connect** button to open the Quick Connect dialog box
5. Set the **Interface** to **USB-8Series**, then click **Connect**.
6. The software creates a site named **Quick Connect** with a corresponding device also named **Quick Connect** and displays them on the upper-left corner of the screen. Expand the sections to view data directly from the device.

2.4 ETHERNET PORTS

The following communication offerings are available.

Base Offering

- 2x Copper (RJ45) Ports
- Modes: 10/100 Mbps
- Protocols: Modbus TCP, DNP 3.0, IEC 61850 GOOSE, SNTP, IEC 62439-3 clause 4 (PRP)

Advanced Offering

- 4x Copper (RJ45) Ports or 2x Fiber
- Modes: 10/100 Mbps (copper)
- 100Mbps (Fiber)
- Protocols: Modbus TCP, DNP 3.0, IEC 61850 GOOSE, SNTP, IEC 62439-3 clause 4 (PRP), HSR

Note:
Always use Shielded Twisted Pair (STP) cable when connecting to RJ45 Ethernet ports

2.4.1 NETWORK SETTINGS MENU

This section describes the network settings menu. If the communications card is installed network port 1 is no longer available. When using more than one Ethernet port, configure each to belong to a different network or subnet using the IP addresses and mask, else communication becomes unpredictable when more than one port is configured to the same subnet.

Note:
*Use the softkeys and **Down/Up** key to enter an IP address. When entering an IP address you must press the **BACK** key first to switch between softkey mode and the **Down/Up** key mode.*

NETWORK 1, 2, 4, 5

Range: Standard IPV4 Address format

Default: 192.168.11.11 (Port 1)

Default: 192.168.11.12 (Port 2)

Default: 192.168.11.13 (Port 4)

Default: 192.168.11.14 (Port 5)

The setting sets the port's IPV4 address in standard IPV4 format.

Note:
The setting is valid on Port 2(5) if Prt1(4) is set to Independent

Note:
*The setting is valid on Port 2 if **Prt1 Operation** is set to* `Independent`.

Note:
172.17.X.X/16 and 172.18.X.X/16 are reserved IPs.

PRT1<n> SUBNET IP MASK

Range: Standard IPV4 mask format

Default: 255.255.255.0 (Port 1, 2, 4, 5)

This setting specifies the IPv4 mask associated with the corresponding port IP address.

PRT<n> OPERATION

Range: Independent, LLA, PRP, HSR, RSTP

Default: Independent

This setting determines the mode of operation for ports 1 and 2: `Independent`, `LLA`, `PRP`, `HSR`, `RSTP`

Independent operation: Ports 1, 2, 4 and 5 operate independently with their own MAC and IP address.

LLA operation: Ports 1, 2, 4 and 5 use port 1's MAC and IP address settings while port 2 is in standby mode in that it does not actively communicate on the Ethernet network but monitors its link. If port 1 is active and the link loss problem is detected, communications is switched to port 2 immediately. Port 2 is, in effect, acting as a redundant or backup link to the network for port 1.

LLA (Link Loss Alert)*:** is a proprietary feature supported by the fiber optic ports. When enabled, this feature is able to detect a failure of the fiber link. If ***Prt1 Operation is set to `LLA`, the detection of a link failure by this feature triggers the transfer of communications. If LLA is enabled on a port with a non-fiber SFP, the target message `LLA not supported by Prt (1 or 2)` is displayed on the keypad and an event is logged.

Note:
LLA is not available on port 4,5 copper (RJ45). When the port operation is selected, the relay requires a reboot for the setting to be applied.

Parallel Redundancy Protocol (PRP) operation: Ports 1 and 2 use the same MAC address and combine information at the link layer. It is intended to only be used if the two ports are connected to separate parallel LAN's. In this mode of operation, both ports cannot be connected to the same LAN. The receiving devices (8 Series) process the first frame received and discard the duplicate through a link redundancy entity (LRE) or similar service that operates below layer 2. Aside from LRE, PRP uses conventional Ethernet hardware but both ports must know they are in PRP. Ports of PRP devices operating with the same Internet Protocol (IP) addresses for traffic that uses IP Management protocols such as Address Resolution Protocol (ARP) must operate correctly.

Duplicate Discard mode: This is the normal setting for PRP operation and once set it allows the sender LRE to append a six-octet field that contains a sequence number, the Redundancy Control Trailer (RCT) to both frames it sends. The receiver LRE uses the sequence number of the RCT and the source MAC address to detect duplicates. It forwards only the first frame of a pair to its upper layers.

HSR operation: When set to HSR (High-availability Seamless Redundancy Protocol), PRT1 is paired with PRT2, or PRT4 is paired with PRT5. Each pair of ports use the same MAC address. In this mode, all the participating devices are connected in ring topology. In normal condition (fault-free state), both identical frames will reach the destination device within a certain interval. The first frame will be sent up the OSI stack to the destination application, while the second one will be discarded.

For more information, see the Communications Guide.

Note:
NOTE: redundancy operations work in pairs Port1/2 and Port4/5 only. It is not interchangeable between all ports.

Note:
Always use Shielded Twisted Pair (STP) cable when connecting to RJ45 Ethernet ports

BRIDGE PRIORITY

Range: 0 to 61440 in steps of 4096

Default: 32768

This setting specifies the switch (bridge) priority value. The bridge priority value is used to along with the port MAC address to determine the root device in the network. Lower values mean the higher priority.

Note:
When assigning the bridge priority, it is recommended to configure the Ethernet switch as the root device of the network. This reduces the number of hops to reach all devices in the network.

RSTP PORT 1 PRIORITY

Range: 0 to 240 in steps of 16

Default: 128

This setting specifies the Network Port 1 RSTP priority to select as root port. Lower the number means higher priority.

RSTP PORT 1 PATHCOST

Range: 0 to 2000000 in steps of 1

Default: 200000

This setting specifies the port cost value used for the switch to determine the forwarding path. The lower the value, the lower the cost and hence the preferred route.

RSTP PORT 2 PRIORITY

Range: 0 to 240 in steps of 16

Default: 128

This setting specifies the Network Port 1 RSTP priority to select as root port. Lower the number means higher priority.

RSTP PORT 2 PATHCOST

Range: 0 to 2000000 in steps of 1

Default: 200000

This setting specifies the port cost value used for the switch to determine the forwarding path. The lower the value, the lower the cost and hence the preferred route.

Note:
Please note that the PTP feature is not functional on Network Ports with RSTP enabled.

Note:
Always use Shielded Twisted Pair (STP) cable when connecting to RJ45 Ethernet ports

2.4.2 ROUTING

When the configuration card is present, a default route and a maximum number of 6 static routes can be configured. The default route is used as the last choice, if no other route towards a given destination is found.

Path: *Setpoints* > *Device* > *Communications* > *Routing* > *Default Route*

GATEWAY ADDRESS

Range: Standard IPV4 unicast address format (0.0.0.1 to 223.255.255.254)

Default: 127.0.0.1

This setting sets the gateway of the default route to be used by IP traffic sent from the relay, if no other route towards a given IP destination is found.

This setting is available only if the communications card is present.

Path: *Setpoints* > *Device* > *Communications* > *Routing* > *Static RT1 (2 to 6)*

RT1 (2,3,4,5,6) DESTINATION

Range: Standard IPV4 network address format (0.0.0.1 to 223.255.255.254)

Default: 127.0.0.1

This setting sets the destination IPv4 route. This setting is available only if the communications card is present.

RT1 (2,3,4,5,6) MASK

Range: Standard IPV4 network mask format

Default: 255.0.0.0

This setting sets the IP mask associated with the route. This setting is available only if the communications card is present.

RT1 (2,3,4,5,6) GATEWAY

Range: Standard IPV4 unicast address format (0.0.0.1 to 223.255.255.254)

Default: 127.0.0.1

This setting sets the destination IP route. This setting is available only if the communications card is present.

RULES FOR ADDING AND DELETING STATIC ROUTES

1. By default, the value of the destination field is 127.0.0.1 for all static routes (1 to 6). This is equivalent to saying that the static routes are not configured. When the destination address is 127.0.0.1, the mask and gateway must also be kept as default values.
2. By default, the value of the default route gateway address is 127.0.0.1. This means the default route is not configured.
3. Use any of the static network route entries numbered 1 to 6 to configure a static network route. Once a route destination is configured for any of the entries 1 to 6, that entry becomes a static route and it must meet all the rules listed in *Important Notes* below.
4. To configure the default route, enter a default gateway address. A default gateway address configured must be validated against Rule #5, the next rule.
5. Routes are deleted by replacing the route destination with the default address (127.0.0.1). When deleting a route, the mask and gateway must also be put back to their default values.
6. The default route is deleted by replacing the default gateway with the default value 127.0.0.1.

Note:
Host routes are not supported at present.
The route mask has IPv4 mask format. In binary this is a set of contiguous bits of 1 from left to right, followed by one or more contiguous bits of 0.
The route destination and mask must match. This can be verified by checking that RtDestination & RtMask == RtDestination
This is an example of a good configuration: RtDestination= 10.1.1.0; Rt Mask= 255.255.255.0
This is an example of a bad configuration: RtDestination = 10.1.1.1; Rt Mask= 255.255.255.0
The route destination must not be a connected network.
The route gateway must be on a connected network. This rule applies to the gateway address of the default route as well. This can be verified by checking that: RtGwy & Prt4Mask) == (Prt4IP & Prt4Mask) || (RtGwy & Prt5Mask) == (Prt5IP & Prt5Mask)

TARGETS

Wrong Route Config

Description: A route with mismatched destination and mask has been configured.

Message: Wrong route configuration.

Solution: Rectify the IP address and mask of the mis-configured route.

TOPOLOGY

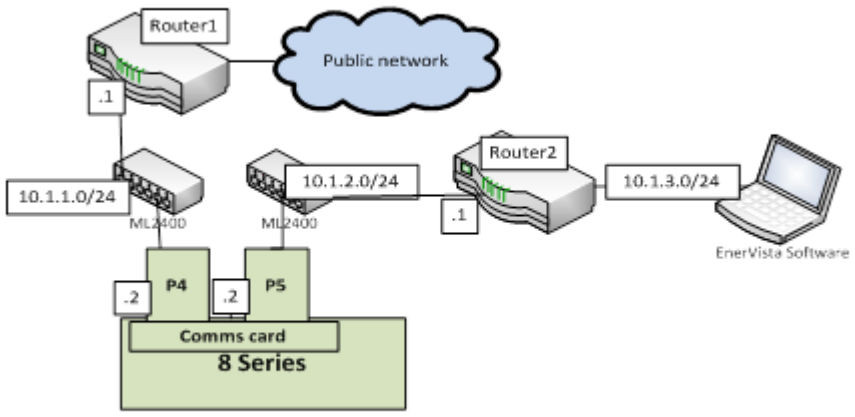


Figure 1: Topology Example

In the topology example above, the device is connected through the two Ethernet ports available on the communications card.

Note:
Always use Shielded Twisted Pair (STP) cable when connecting to RJ45 Ethernet ports

Port 4 (IP address 10.1.1.2) connects to LAN 10.1.1.0/24 and to the Internet through Router1. Router 1 has an interface on 10.1.1.0/24 and the IP address of this interface is 10.1.1.1.

Port 5 (IP address 10.1.2.2) connects to LAN 10.1.2.0/24 and to EnerVista D&I Setup through Router 2. Router 2 has an interface on 10.1.2.0/24 and the IP address of this interface is 10.1.2.1.

Network addresses:

- PRT4 IP ADDRESS = 10.1.1.2
- PRT4 SUBNET IP MASK = 255.255.255.0
- PRT5 IP ADDRESS = 10.1.2.2
- PRT5 SUBNET IP MASK = 255.255.255.0

Routing Settings:

IPV4 DEFAULT ROUTE: GATEWAY ADDRESS = 10.1.1.1

STATIC NETWORK ROUTE 1: RT1 DESTINATION = 10.1.3.0/24RT1 NET MASK = 255.255.255.0RT1 GATEWAY = 10.1.2.1

Behavior:

One static network route was added to the destination 10.1.3.0/24, where a laptop running EnerVista D&I Setup is located. This static route uses a different gateway (10.1.2.1) than the default route. This gateway is the address of Router 2, which is aware of destination 10.1.3.0 and is able to route packets coming from the device and destined to EnerVista D&I Setup.

2.5 STATUS

2.5.1 TCP CONNECTIONS STATUS

These values specify the maximum and the remaining number of TCP connections still available for each protocol. Depending on the order code, some protocols may be hidden.

Each time a connection is used, the remaining number of connections decrements. When a connection is released, the remaining number of connections increments. If no connection is made over the specific protocol, the number remaining equals the maximum number available for the specific protocol.

For example, the maximum number of Modbus TCP connections is 5. Once an EnerVista session is opened on a computer connected to the 8series over Ethernet, the Modbus TCP status shows 4. If the EnerVista application is closed, the Modbus TCP status shows 5.

The following are the Maximum TCP connections per protocols for the “SE” communications order code option:

Modbus TCP - Maximum	3*
DNP TCP - Maximum	2 (Depends on number of configured channels)

* With USB or WiFi connections, this number decreases as follows:

- 1 USB or 1 WiFi connection: Modbus TCP - Maximum = 2
- 1 USB and 1 WiFi connection: Modbus TCP - Maximum = 1

The following are the Maximum TCP connections per protocols for the Advanced communications order code options:

MMS TCP - Maximum	8
Modbus TCP - Maximum	5
DNP TCP - Maximum	2 (Depends on the number of configured channels)
IEC-104 TCP -Maximum	2 (Depends on the number of configured channels)
SFTP - Maximum*	8 (2 x 1 Administrator, 2 x 3 Observers)

* SFTP is only available with the Advanced security option.

Path: ***Status*** > ***Communications*** > ***Connections***

MMS TCP - Maximum

Default: 0 (SE), 8 (Advanced)

MMS TCP - Remaining

Modbus TCP - Maximum

Default: 3 (SE), 5 (Advanced)

> *Note:*
> *For the “SE” communications option, a USB or WiFi connection decreases the number of remaining Modbus TCP connections, by up to two (one for USB and one for WiFi).*

Modbus TCP - Remaining

DNP TCP - Maximum

Default: 2 (Depends on the number of configured channels)

DNP TCP - Remaining

IEC - 104 - Maximum

Default: 0 (SE), 2 (Advanced. Depends on the number of configured channels)

IEC - 104 - Remaining

SFTP - Maximum

Default: 0 (SE), 8 (Advanced. 2 x 1 Administrator, 2 x 3 Observers)

> *Note:*
> *SFTP is only available with the Advanced security option.*

SFTP - Remaining

2.5.2 ACTIVITY STATUS

The communication state for each enabled communication type is shown by its value. The main CPU and Comms software sets/resets the active bits for all enabled communication types. The communication state bits are not latched.

Path: ***Status*** > ***Communications*** > ***Activity Status***

SERIAL MODBUS

Range: NONE, ACTIVE

Default: NONE

ETHERNET MODBUS

Range: NONE, ACTIVE

Default: NONE

CHAPTER 3

PROTOCOLS

3.1 CHAPTER OVERVIEW

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

This chapter contains the following sections:

3.2 TIME PROTOCOLS

3.2.1 REAL-TIME CLOCK

Path: ***Setpoints*** > ***Device*** > ***Real Time Clock***

The relay is capable of receiving a time reference from several time sources in addition to its own internal clock. An accurate time reference is necessary for time-stamping events, transient recorders and other occurrences within the relay. The accuracy of the time stamp is based on the time reference that is used. The relay supports an internal clock, SNTP (Simple network Time Protocol), IRIG-B (Inter-range Instrumentation Group) and PTP IEEE 1588 v.2 (Precision Time Protocol) as potential time references.

If two or more time sources are available, the time source with the highest priority is used (where 1 is considered to be the highest priority). Please note, you can interchange the time source priority of PTP and IRIG-B. If both PTP and IRIG-B are available to the relay, the relay clock synchronizes to PTP over IRIG-B. If PTP is not available the relay's CPU synchronizes its internal clock to IRIG-B.

Time Sources

Time Source	Priority
PTP (IEEE1588)	1*
IRIG-B	2*
SNTP	3
Internal Clock	4

* The priority of IRIG-B and PTP can be swapped.

Note:
Synchronization by IEC103, DNP, Modbus and IEC104 is not valid if there is a source from IRIG-B, SNTP or PTP.

3.2.1.1 IEEE 1588 PRECISION TIME PROTOCOL

The 8 series products support the IEEE C37.238 (Power Profile) of IEEE 1588 Precision Time Protocol (PTP) as a slave-only clock. This can be used to replace or supplement IRIG-B and SNTP time synchronization so

that the relay can be synchronized using Ethernet messages from the substation LAN without any additional physical connections being required.

3.2.1.1.1 PTP STATUS

The present values of the PTP protocol are displayed here.

Path:***Status*** > ***PTP***

Grandmaster ID is the grandmaster Identity code being received from the present PTP grandmaster, if any. When the relay is not using any PTP grandmaster, this actual value is zero. The grandmaster Identity code is specified by PTP to be globally unique, so one can always know which clock is grandmaster in a system with multiple grandmaster-capable clocks.

RTC Accuracy is the estimated maximum time difference at present in the Real Time Clock (RTC), considering the quality information imbedded in the received time signal, how long the relay has had to lock to the time source, and in the case of time signal interruptions, the length of the interruption. The value 999,999,999 indicates that the magnitude of the estimated difference is one second or more, or that the difference cannot be estimated.

Port 4 (5) PTP State is the present state of the port's PTP clock. The PTP clock state is:

- DISABLED If the port's function setting is Disabled
- NO SIGNAL If enabled but no signal from an active master has been found and selected

- CALIBRATING If an active master has been selected but lock is not at present established
- SYNCH'D (NO PDELAY) If the port is synchronized, but the peer delay mechanism is non-operational
- SYNCHRONIZED If the port is synchronized

3.2.1.1.2 PTP CONFIGURATION

Path: ***Setpoints*** > ***Device*** > ***Real Time Clock*** > ***Precision Time***

PORT 4(5) PTP FUNCTION

Range: Disabled, Enabled

Default: Enabled

When the port setting is selected as `Disabled` PTP is disabled on the port. The relay does not generate, or listen to, PTP messages on the port.

PORT 4(5) PATH DELAY ADDER

Range: 0 to 60000 ns in steps of 1 ns

Default: 0 ns

The time delivered by PTP is advanced by the time value in the setting prior to the time being used to synchronize the relay's real time clock. This is to compensate for time delivery delays not compensated for in the network. In a fully compliant Power Profile (PP) network, the peer delay and the processing delay mechanisms compensate for all the delays between the grandmaster and the relay. In such networks, the setting is zero.

In networks containing one or more switches and/or clocks that do not implement both of these mechanisms, not all delays are compensated, so the time of message arrival at the relay is later than the time indicated in the message. The setting can be used to approximately compensate for the delay. Since the relay is not aware of network switching that dynamically changes the amount of uncompensated delay, there is no setting that always completely corrects for uncompensated delay. A setting can be chosen that reduces worst-case error to half of the range between minimum and maximum uncompensated delay if these values are known.

PORT 4(5) PATH DELAY ASYMMETRY

Range: -1000 to +1000 ns in steps of 1 ns

Default: 0 ns

The setting corresponds to Delay Asymmetry in PTP, which is used by the peer delay mechanism to compensate for any difference in the propagation delay between the two directions of a link. Except in unusual cases, the two fibers are of essentially identical length and composition, so the setting is set to zero.

In unusual cases where the length of link is different in different directions, the setting is to be set to the number of nanoseconds longer the Ethernet propagation delay is to the relay compared with the mean of path propagation delays to and from the relay. For instance, if it is known say from the physical length of the fibers and the propagation speed in the fibers that the delay from the relay to the Ethernet switch it is connected to is 9000 ns and that the delay from the switch to the relay is 11000 ns, then the mean delay is 10000 ns, and the path delay asymmetry is +1000 ns.

STRICT POWER PROFILE

Range: Enabled, Disabled

Default: Enabled

Power profile (IEEE Std C37.238™ 2011) requires that the grandmaster clock be power profile compliant, that the delivered time have a worst-case error of ±1 µs, and that the peer delay mechanism be implemented. With the strict power profile setting enabled, the relay selects as master only clocks displaying the IEEE_C37_238 identification codes. It uses a port only when the peer delay mechanism is operational. With the strict power

profile setting disabled, the relay uses clocks without the power profile identification when no power profile clocks are present, and uses ports even if the peer delay mechanism is non-operational.

The setting applies to all of the relay's PTP-capable ports.

PTP DOMAIN NUMBER

Range: 0 to 255

Default: 0

The setting is set to the domain number of the grandmaster-capable clock(s) to which they can be synchronized. A network may support multiple time distribution domains, each distinguished with a unique domain number. More commonly, there is a single domain using the default domain number zero.

The setting applies to all of the relay's PTP-capable ports.

PTP VLAN PRIORITY

Range: 0 to 7

Default: 4

The setting selects the value of the priority field in the 802.1Q VLAN tag in request messages issued by the relay's peer delay mechanism. In compliance with PP (Power Profile) the default VLAN priority is 4, but it is recommended that in accordance with PTP it be set to 7.

Depending on the characteristics of the device to which the relay is directly linked, VLAN Priority may have no effect.

The setting applies to all of the relay's PTP-capable ports.

PTP VLAN ID

Range: 0 to 4095

Default: 0

The setting selects the value of the ID field in the 802.1Q VLAN tag in request messages issued by the relay's peer delay mechanism. It is provided in compliance with PP (Power Profile). As these messages have a destination address that indicates they are not to be bridged, their VLAN ID serves no function, and so may be left at its default value.

Depending on the characteristics of the device to which the relay is directly linked, VLAN ID may have no effect.

The setting applies to all of the relay's PTP-capable ports.

PTP PRIORITY

Range: 1, 2

Default: 1

The setting sets the priority of PTP time for the relay.

3.2.1.2 IRIG-B

IRIG-B is available in all 8 Series relays. A failure on IRIG-B triggers an event and a target message.

> *Note:*
> *Note that IRIG-B is auto detected. The signal type is detected in the hardware, so there are no configurable options.*

3.3 FILE TRANSFER PROTOCOLS

The base offering supports Trivial File Transfer Protocol (TFTP). The default port 69 is always used. No configuration setting is available.

When the communications module is present, the SSH File Transfer Protocol (SFTP) is also available. The default TCP port 22 for SSH is also used for SFTP.

3.3.1 READING EVENT RECORDER

To read the entire event recorder contents (the only available format), use the following filename:

Evt.txt

Event Record retrieval example:

tftp -i 172.16.0.2 get evt.txt

3.3.2 READING TRANSIENT RECORDER

Familiarity with the Transient recorder feature is required to understand the following description.

The *Oscillography Number of Triggers* register is incremented by one every time a new oscillography file is triggered (captured) and cleared to zero when oscillography data is cleared. When a new trigger occurs, the associated oscillography file is assigned a file identifier number equal to the incremented value of the register; the newest file number is equal to the *Oscillography Number of Triggers* register. This register can be used to determine if any new data has been captured by periodically reading it to see if the value has changed; if the number has increased then new data is available.

The *Oscillography Number of Records* register specifies the maximum number of files (and the number of cycles of data per file) that can be stored in the memory of the relay.

The *Oscillography Available Records* register specifies the actual number of files that are stored and still available to be read out of the relay. Writing `Yes` (i.e. the value 1) to the Oscillography Clear Data register clears oscillography data files, clears both the Oscillography Number of Triggers and Oscillography Available Records registers to zero, and sets the Oscillography Last Cleared Date to the present date and time.

To read binary COMTRADE oscillography files, read the following filenames:

OSCnnnn.CFG and OSCnnn.DAT

Transient Record retrieval example:

tftp -i 172.16.0.2 get COMTRADE/osc1.cfg

tftp -i 172.16.0.2 get COMTRADE/osc1.dat

> *Note:*
> *The COMTRADE Version used on 8 Series relays is C37.111-1999.*

3.3.3 READING FAULT REPORTS

Fault report data is available via the file retrieval mechanism in each relay. The filename is `FaultReport1_#####.txt`. The `#####` refers to the fault report record number.

The fault report number is a counter that indicates how many fault reports have ever occurred. Only the last fifteen fault reports are available for retrieval; a request for a non-existent fault report file yields a null file.

The total amount of available reports since the last clear command is found in *Number of Reports*, Modbus register (32690).

Report retrieval example:

tftp -i 172.16.0.2 get FaultReport1_1.txt

3.4 DNP PROTOCOL

3.4.1 DNP COMMUNICATION

The relay supports Distributed Network Protocol (DNP) version 3.0 operating as a DNP slave device. Two DNP masters can actively communicate with the relay at one time, because the relay maintains two sets of DNP data change buffers and connection information. The following is a detailed explanation of the DNP 3 implementation.

Note:
Both DNP and IEC104 protocol can work at the same time, but you have to consider that there is only one point map. So, the two protocols will use the same data mapping, i.e. the same point index and same point source.

Note:
The relay supports two DNP3.0 client connections simultaneously.

Note:
When configuring DNP do not use port 20057 since this is reserved for internal purposes.

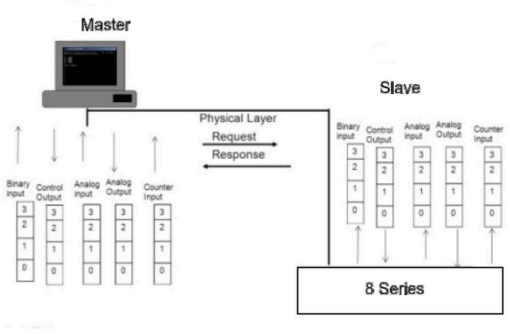
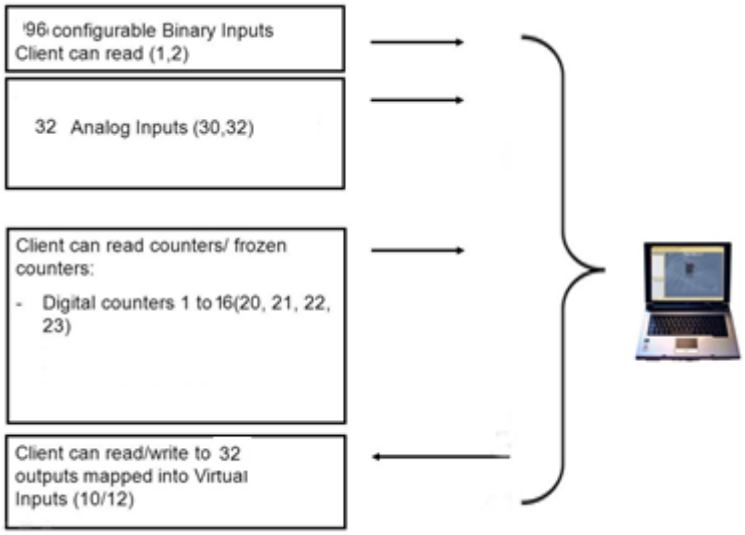


Figure 2: DNP Data Types

DATA TYPES

- **Binary input data**: Binary input data is used to monitor two-state device operations such as the position of a circuit breaker. The user can configure up to 255 Binary inputs. All binary inputs are configured from FlexLogic operands. For a complete list, see Format Code FC142.
- **Binary output data**: Binary output data is used to control two-state devices such as the tripping or circuit closing of a circuit breaker. The relay can be configured to support up to 16 Binary outputs. The slave's Binary outputs are automatically mapped into the virtual inputs starting at virtual input 1. Please note that the number of Binary/ Control outputs is configurable. The user can configure a subset that supports dual point control. This subset starts at address 0.
- **Analog input data**: Analog input data is used to monitor analog signals such as voltages, currents, and power. Up to 255 analog points can be mapped to the master.
- **Analog output data**: Not supported..
- **Time stamps**
- **Count input data**: Count input data could represent a cumulative quantity such as kilowatt-hours of energy. Up to 16 counter points can be mapped to the master.



Supported Object Numbers

Object	DNP Data Type	Relay
1	Binary Input Status	User Assigned FlexLogic Operands
2	Binary Input Change since last read	
10	Binary Output Status for monitoring	User assigned Virtual Inputs and/or Commands (client looks at status only)
12	Control Relay Output Block	User assigned Virtual inputs and/or Commands (client can write to the user specified number of control relay outputs)
20	Counter Value	Digital counters 1 through 16.
21	Frozen Counter Value	
22	Counter Value Change since last read	
23	Frozen Counter Value Change since last read by client	
30	User configured Analog Input value	
32	User configured Analog Input value changed since last time read by client	

Analog Variation Numbers	Data Format
1	32-bit integer value with flag
2	16-bit integer value with flag
3	32-bit integer value without flag
4	16-bit integer value without flag
5	32-bit floating point value with flag

3.4.2 DNP PROTOCOL SETTINGS

Path: *Setpoints* > *Device* > *Communications* > *DNP protocol*

DNP CHANNEL 1(2) PORT

Range: None, Network - TCP, Network - UDP

Default: None

The ***DNP Channel 1 Port*** and ***DNP Channel 2 Port*** settings select the communications port assigned to the DNP protocol for each channel. When set to *Network - TCP*, the DNP protocol can be used over TCP/IP on channels 1 or 2. When set to *Network - UDP*, the DNP protocol can be used over UDP/IP.

DNP ADDRESS

Range: 0 to 65519 in steps of 1

Default: 65519

The DNP address sets the DNP slave address. This number identifies the device on a DNP communications link. Each DNP slave must be assigned a unique address.

DNP CLIENT ADDRESS 1(2)

Range: standard IP address

Default: 0.0.0.0

The DNP Client Address settings can force the device to respond to a maximum of two specific DNP masters.

DNP TCP/UDP PORT 1(2)

Range: 1 to 65535 in steps of 1

Default: 2000

> *Note:*
> ***DNP Channel 1 Port*** *will take the* ***DNP TCP/UDP Port 1*** *and* ***DNP Client Address 1*** *to allow/reject connections. The same relation is used by channel 2.*

DNP UNSOL RESP FUNCTION

Range: Enabled, Disabled

Default: Disabled

This setting will take effect for Ethernet communication only if the main card is present or a comms card is available in the device. This setting enables/disables the unsolicited response functionality. It is disabled for RS485 applications since there is no collision avoidance mechanism.

DNP UNSOL RESP TIMEOUT

Range: 0 to 60 s in steps of 1

Default: 5 s

Sets the time the relay waits for a DNP master to confirm an unsolicited response.

UNSOL RESP MAX RETRIES

Range: 1 to 255 in steps of 1

Default: 10

Sets the number of times the device retransmits an unsolicited response without receiving confirmation from the master; a value of *255* allows infinite re-tries.

UNSOL RESP AT STARTUP

Range: Enabled, Disabled

Default: Disabled

When relay is rebooting, unsolicited responses work without an Enable message needed, but this is only possible once the Master resets the communications with the relay. This happens with both Reset Link or Class 1 request messages.

DNP UNSOL RESP DEST ADDRESS

Range: 1 to 65519 in steps of 1

Default: 1

Sets the DNP address to which all unsolicited responses are sent. The IP address to which unsolicited responses are sent is determined by the device from the current TCP connection or the most recent UDP message.

DNP TIME SYNC IIN PERIOD

Range: 1 to 10080 min. in steps of 1

Default: 1440 min

This setting determines how often the Need Time Internal Indication (IIN) bit is set by the device. Changing this time allows the DNP master to send time synchronization commands more or less often, as required.

DNP MESSAGE FRAGMENT SIZE

Range: 30 to 2048 in steps of 1

Default: 240

This setting determines the size, in bytes, at which message fragmentation occurs. Large fragment sizes allow for more efficient throughput; smaller fragment sizes cause more application layer confirmations to be necessary which can provide for more robust data transfer over noisy communication channels.

DNP OBJECT DEFAULT VARIATION SETTINGS

These settings allow selection of the DNP default variation number for object types 1, 2, 20, 21, 22, 23, 30, and 32. The default variation refers to the variation response when variation 0 is requested and/or in class 0, 1, 2, or 3 scans. The DNP binary outputs typically map one-to-one to IED data points. That is, each DNP binary output controls a single physical or virtual control point in an IED. In the 8 Series relay, DNP binary outputs are mapped to virtual inputs. See below for details

DNP OBJECT 1(2) DEFAULT VARIATION

Range: 1, 2

Default: 2

DNP OBJECT 20(22) DEFAULT VARIATION

Range: 1, 2, 5, 6

Default: 1

DNP OBJECT 21 DEFAULT VARIATION

Range: 1, 2, 9, 10

Default: 1

DNP OBJECT 23 DEFAULT VARIATION

Range: 1, 2, 5, 6

Default: 2

DNP OBJECT 30 DEFAULT VARIATION

Range: 1, 2, 3, 4, 5

Default: 1

TCP CONNECTION TIMEOUT

Range: 10 to 300 s in steps of 1

Default: 120 s

This setting specifies a time delay for the detection of dead network TCP connections. If there is no data traffic on a DNP TCP connection for greater than the time specified by this setting, the connection will be aborted.. This frees up the connection to be re-used by a client.

3.4.3 DNP DEVICE PROFILE

DNP 3.0 Device Profile	
(Also see the IMPLEMENTATION TABLE in the following section)	
Vendor Name: **General Electric Multilin**	
Device Name:	
Highest DNP Level Supported: For Requests: **Level 2** For Responses: **Level 2**	
Device Function: □ Master ☒ **Slave**	
Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table): **Binary Inputs (Object 1)** **Binary Input Changes (Object 2)** **Binary Outputs (Object 10)** **Control Relay Output Block (Object 12)** **Binary Counters (Object 20)** **Frozen Counters (Object 21)** **Counter Change Event (Object 22)** **Frozen Counter Event (Object 23)** **Analog Inputs (Object 30)** **Analog Input Changes (Object 32)** **Analog Deadbands (Object 34)**	
Time and Date (Object 50) **Time Delay Fine (Object 52)** **Class Data (Object 60)** **Internal Indications (Object 80)**	
Maximum Data Link Frame Size (octets):	**Maximum Application Fragment Size (octets):**
Transmitted: **292**	Transmitted: **configurable up to 2048**
Received: **292**	Received: **2048**
Maximum Data Link Re-tries:	**Maximum Application Layer Re-tries:**
☒ **None**	☒ **None**
□ Fixed at 3	□ Configurable
□ Configurable	

DNP 3.0 Device Profile	
Requires Data Link Layer Confirmation: ☒ **Never** □ Always □ Sometimes □ Configurable	
Requires Application Layer Confirmation: □ Never □ Always ☒ **When reporting Event Data** ☒ **When sending multi-fragment responses** □ Sometimes □ Configurable	
Timeouts while waiting for: Data Link Confirm: ☒ **None** □ Fixed □ Variable □ Configurable Complete Appl. Fragment: ☒ **None** □ Fixed □ Variable □ Configurable Application Confirm: □ None ☒ **Fixed at 10 s** □ Variable □ Configurable Complete Appl. Response: ☒ **None** □ Fixed at ___ □ Variable □ Configurable	
Others: Transmission Delay: **No intentional delay** Need Time Interval: **Configurable (default = 24 hrs.)** Select/Operate Arm Timeout: **10 s** Binary input change scanning period: **8 times per power system cycle** Analog input change scanning period: **500 ms** Counter change scanning period: **500 ms** Frozen counter event scanning period: **500 ms**	
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	
Explanation of 'Sometimes': Object 12 points are mapped to Virtual Inputs and Commands (Force Coils). Both "Pulse On" and "Latch On" operations perform the same function in the relay; that is, the appropriate Virtual Input or Coil is put into the "On" state. The On/Off times and Count value are ignored. "Pulse Off" and "Latch Off" operations put the appropriate Virtual Input or Coil into the "Off" state. "Trip" and "Close" operations both put the appropriate Virtual Input or coil into the "On" state if a paired mapping is set, otherwise "Trip" will put into "Off" and "Close" will put into "On".	
Reports Binary Input Change Events when no specific variation requested: □ Never ☒ **Only time-tagged** □ Only non-time-tagged □ Configurable	**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 (attach explanation)

DNP 3.0 Device Profile	
Sends Unsolicited Responses: □ Never □ Configurable □ Only certain objects ☒ **Sometimes** ☒ **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.
Explanation of 'Sometimes': It will be disabled for RS-485 applications, since there is no collision avoidance mechanism. For Ethernet communication it will be available and it can be disabled or enabled with the proper function code.	
Default Counter Object/Variation: □ No Counters Reported □ Configurable (attach explanation) ☒ **Default Object: 20** **Default Variation: 1** ☒ **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	

3.4.4 DNP IMPLEMENTATION

OBJECT			REQUEST		RESPONSE	
OBJECT NO.	**VARIATION NO.**	**DESCRIPTION**	**FUNCTION CODES (DEC)**	**QUALIFIER CODES (HEX)**	**FUNCTION CODES (DEC)**	**QUALIFIER CODES (HEX)**
1	0	Binary Input (Variation 0 is used to request default variation)	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	---	---
	1	Binary Input	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
	2	Binary Input with Status	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
2	0	Binary Input Change (Variation 0 is used to request default variation)	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	---	---
	1	Binary Input Change without Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	2	Binary Input Change with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	3	Binary Input Change with Relative Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	---	---

OBJECT			REQUEST		RESPONSE	
OBJECT NO.	VARIATION NO.	DESCRIPTION	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)
10	0	Binary Output Status (Variation 0 is used to request default variation)	1 (read)	00, 01(start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	---	---
	2	Binary Output Status	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
12	1	Control Relay Output Block	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, noack)	00, 01 (start-stop) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	echo of request
20	0	Binary Counter (Variation 0 is used to request default variation)	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	---	---
	1	32-Bit Binary Counter	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
	2	16-Bit Binary Counter	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
	5	32-Bit Binary Counter without Flag	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
	6	16-Bit Binary Counter without Flag	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
21	0	Frozen Counter(Variation 0 is used to request defaultvariation)	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	---	---

OBJECT			REQUEST		RESPONSE	
OBJECT NO.	VARIATION NO.	DESCRIPTION	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)
	1	32-Bit Frozen Counter	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
	2	16-Bit Frozen Counter	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
	9	32-Bit Frozen Counter without Flag	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
	10	16-Bit Frozen Counter without Flag	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
22	0	Counter Change Event (Variation 0 is used to request default variation)	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	---	---
	1	32-Bit Counter Change Event	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	2	16-Bit Counter Change Event	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	5	32-Bit Counter Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	6	16-Bit Counter Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
23	0	Frozen Counter Event (Variation 0 is used to request default variation)	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	---	---
	1	32-Bit Frozen Counter Event	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	2	16-Bit Frozen Counter Event	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	5	32-Bit Frozen Counter Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	6	16-Bit Frozen Counter Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)

OBJECT			REQUEST		RESPONSE	
OBJECT NO.	VARIATION NO.	DESCRIPTION	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)
30	0	Analog Input (Variation 0 is used to request default variation)	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	---	---
	1	32-Bit Analog Input	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
	2	16-Bit Analog Input	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
	3	32-Bit Analog Input without Flag	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
	4	16-Bit Analog Input without Flag	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
	5	short floating point	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
32	0	Analog Change Event (Variation 0 is used to request default variation)	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	---	---
	1	32-Bit Analog Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	2	16-Bit Analog Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	3	32-Bit Analog Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	4	16-Bit Analog Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	5	short floating point Analog Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	7	short floating point Analog Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)

OBJECT			REQUEST		RESPONSE	
OBJECT NO.	VARIATION NO.	DESCRIPTION	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)
34	0	Analog Input Reporting Deadband (Variation 0 is used to request default variation)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	---	---
	1	16-bit Analog Input Reporting Deadband (default - see Note 1)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
			2 (write)	00, 01 (start-stop) 07, 08 (limited quantity) 17, 28 (index)	---	---
	2	32-bit Analog Input Reporting Deadband	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
			2 (write)	00, 01 (start-stop) 07, 08 (limited quantity) 17, 28 (index)	---	---
50	1	Time and Date (default - see Note 1)	1 (read) 2 (write)	00, 01 (start-stop) 06 (no range, or all) 07 (limited qty=1) 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
52	2	Time Delay Fine (quantity = 1)	129 (response)	07 (limited quantity)	---	---
60	0	Class 0, 1, 2, and 3 Data	1 (read) 20 (enable unsol) 21 (disable unsol) 22 (assign class)	06 (no range, or all)	---	---
	1	Class 0 Data	1 (read) 22 (assign class)	06 (no range, or all)	---	---
	2	Class 1 Data	1 (read) 20 (enable unsol)	06 (no range, or all) 07, 08 (limited quantity)	---	---
	3	Class 2 Data	21 (disable unsol)		---	---
	4	Class 3 Data	22 (assign class)		---	---
80	1	Internal Indications	1 (read)	00, 01 (start-stop) (index =7)	129 (response)	00, 01 (start-stop)
			2 (write) (see Note 3)	00 (start-stop) (index =7)	---	---
		No Object (function code only) see Note 3	13 (cold restart)	---	---	---
		No Object (function code only)	14 (warm restart)	---	---	---

OBJECT			REQUEST		RESPONSE	
OBJECT NO.	VARIATION NO.	DESCRIPTION	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)
		No Object (function code only)	23 (delay meas.)	---	---	---

1. A default variation refers to the variation response when variation 0 is requested and/or in class 0, 1, 2, or 3 scans. The default variations for object types 1, 2, 20, 21, 22, 23, 30, and 32 are selected via relay settings. This optimizes the class 0 poll data size.
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 changeevent objects, qualifiers 17 or 28 are always responded.)
3. Cold restarts are implemented the same as warm restarts – the relay is not restarted, but the DNP process is restarted.

3.5 DNP AND IEC104 POINT LISTS

The menu path for the DNP/IEC104 point lists is shown below.

Path: ***Setpoints*** > ***Device*** > ***Communications*** > ***DNP/IEC104 Point Lists***

Binary Input/MSP Points

Analog Input/MME Points

Binary Outp/CSC/CDC Pnts

Binary input points (DNP) or MSP points (IEC 60870-5-104)

You can configure the binary inputs points for the DNP protocol, or the MSP points for IEC 60870-5-104 protocol to a maximum of 96 points. The data source for each point is user-programmable and can be configured by assigning FlexLogic operands. For a complete list, see Format Code FC142.

The menu path for the binary input points (DNP) or MSP points (IEC 60870-5-104) is shown below.

Path: ***Setpoints*** > ***Device*** > ***Communications*** > ***DNP/IEC104 Point Lists*** > ***Binary Input/MSP Points***

Point 0 Entry

...

Point 255 Entry

Analog input points (DNP) or MME points (IEC 60870-5-104)

You can configure up to 255 analog input points for the DNP or IEC 60870-5-104 protocols. The menu path for the analog input point (DNP) or MME points (IEC 60870-5-104) is shown below.

Path: *Setpoints* > ***Device*** > ***Communications*** > ***DNP/IEC104 Point Lists*** > ***Analog Input / MME Points***

Analog IP Point 0 Entry

Point 0 Scale Factor

Point 0 Deadband

DNP ANALOG INPUT POINT 0(255) SCALE FACTOR

Range: / 0.001, / 0.01, / 0.1, / 1, / 10, / 100, / 1000, / 10000, / 100000

Default: /1

These are numbers used to scale analog input point values. Each setting represents the scale factor for the analog input point. For example, if the ***DNP PHASE A VOLTAGE SCALE FACTOR*** setting is set to `/ 1000`, and the Phase A voltage is 72000 V, the Phase A voltage sent on to the relay is 72 V. The settings are useful when analog input values must be adjusted to fit within certain ranges in DNP masters.

> *Note:*
> *A scale factor of `/ 0.1` is equivalent to a multiplier of 10.*

DNP ANALOG INPUT POINT 0(255) DEADBAND

Range: 1 to 100000000 in steps of 1

Default: 30000

The setting is the threshold value to define the condition to trigger unsolicited responses containing analog input data. Each setting represents the default deadband value for the associated analog input. For example, to trigger unsolicited responses from the relay when phase A current changes by 15 A, the DNP Current Deadband

for Phase A current should be set to `15`. Note that these settings are the deadband default values. DNP object 34 points can be used to change deadband values from the default for each individual DNP analog input point. Whenever power is removed and re-applied, the new deadbands are in effect.

Binary output points (DNP) or CSC/CDC points (IEC 60870-5-104)

You can configure the binary output points for the DNP protocol, or the CSC/CDC points for IEC 60870-5-104 protocol to a maximum of 16 points. The data source for each point is user-programmable and can be configured by assigning FlexLogic operands. The menu path for the binary output points (DNP) or CSC/CDC points (IEC 60870-5-104) is shown below.

Path: ***Setpoints*** > ***Device*** > ***Communications*** > ***DNP/IEC104 Point Lists*** > ***Binary Output / CSC/CDC Points***

Binary Output Point 0 ON

Binary Output Point 0 OFF

...

Binary Output Point 31 ON

Binary Output Point 31 OFF

Note:
The DNP/IEC 60870-5-104 point lists always begin with point 0 and end at the first `Off` value. Since DNP / IEC 60870-5-104 point lists must be in one continuous block, any points assigned after the first `Off` point are ignored.

BINARY INPUT POINTS

The DNP binary input data points are configured through the **DNP/IEC104 POINT LISTS BINARY INPUT/MSP POINTS** menu. When a freeze function is performed on a binary counter point, the frozen value is available in the corresponding frozen counter point.

- Static (Steady-State) Object Number: **1**
- Change Event Object Number: **2**
- Request Function Codes supported: **1 (read), 22 (assign class)**
- Static Variation reported when variation 0 requested: **2 (Binary Input with status), Configurable**
- Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time), Configurable**
- Change Event Scan Rate: **8 times per power system cycle**
- Change Event Buffer Size: **1024**
- Default Class for All Points: **1**

POINT NAME/DESCRIPTION COUNTERS

The following details lists both Binary Counters (Object 20) and Frozen Counters (Object 21). When a freeze function is performed on a Binary Counter point, the frozen value is available in the corresponding Frozen Counter point. Digital Counter values are represented as 16 or 32-bit integers. The DNP 3.0 protocol defines counters to be unsigned integers. Care should be taken when interpreting negative counter values.

BINARY COUNTERS

- Static (Steady-State) Object Number: **20**
- Change Event Object Number: **22**
- Request Function Codes supported: **1 (read), 7 (freeze), 8 (freeze noack), 9 (freeze and clear), 10 (freeze and clear, noack), 22 (assign class)**
- Static Variation reported when variation 0 requested: **1 (32-Bit Binary Counter with Flag)**

- Change Event Variation reported when variation 0 requested: **1 (32-Bit Counter Change Event without time)**
- Change Event Buffer Size: **10**
- Default Class for all points: **3**

FROZEN COUNTERS

- Static (Steady-State) Object Number: **21**
- Change Event Object Number: **23**
- Request Function Codes supported: **1 (read)**
- Static Variation reported when variation 0 requested: **1 (32-Bit Frozen Counter with Flag)**
- Change Event Variation reported when variation 0 requested: **1 (32-Bit Counter Change Event without time)**
- Change Event Buffer Size: **10**
- Default Class for all points: **3**

BINARY AND FROZEN COUNTERS POINT INDEX NAME/DESCRIPTION

- 0 Digital Counter 1
- 1 Digital Counter 2
- 2 Digital Counter 3
- 3 Digital Counter 4
- 4 Digital Counter 5
- 5 Digital Counter 6
- 6 Digital Counter 7
- 7 Digital Counter 8
- 8 Digital Counter 9
- 9 Digital Counter 10
- 10 Digital Counter 11
- 11 Digital Counter 12
- 12 Digital Counter 13
- 13 Digital Counter 14
- 14 Digital Counter 15
- 15 Digital Counter 16

ANALOG INPUTS

It is important to note that 16-bit and 32-bit variations of analog inputs are transmitted through DNP as signed numbers. Even for analog input points that are not valid as negative values, the maximum positive representation is 32767 for 16-bit values and 2147483647 for 32-bit values. This is a DNP requirement. The deadbands for all Analog Input points are in the same units as the Analog Input quantity. For example, an Analog Input quantity measured in volts has a corresponding deadband in units of volts. Relay settings are available to set default deadband values according to data type. Deadbands for individual Analog Input Points can be set using DNP Object 34.

A default variation refers to the variation response when variation 0 is requested and/or in class 0, 1, 2, or 3 scans. The default variations for object types 1, 2, 20, 21, 22, 23, 30, and 32 are selected via relay settings. This optimizes the class 0 poll data size.

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, are responded with qualifiers 00 or 01. For change event objects, qualifiers 17 or 28 are always responded.

Cold restarts are implemented the same as warm restarts – the relay is not restarted, but the DNP process is restarted.

3.6 IEC60870-5-103

The point map for the 103 is different from the one shared by the IEC104 and DNP protocols. IEC 60870-5-103 serial communications protocol is supported on the rear RS485 port only.

The DNP, IEC 103 and Modbus cannot be enabled simultaneously. Only one instance of DNP 3.0, IEC 103 or Modbus can run on the RS485 serial port.

Path: *SETPOINTS* > *DEVICE* > *COMMUNICATIONS* > *IEC 60870-5-103 PROTOCOL*

IEC103 Common ASDU Addrs

Range: 0 to 254 in steps of 1

Default: 0

IEC103 Sync Timeout

Range: 0 to 1440 minutes in steps of 1 min

Default: 0 min

All binary inputs are configured from FlexLogic operands. For a complete list, see Format Code FC142.

Note:
Pay attention when configuring the function type and information number of the different points, because they must be unique. There is no mechanism in the EnerVista D&I Setup or the front panel HMI to detect duplication of the information index. The IEC 60870-5-103 point lists always begin with point `0` and end at the first `Off` value. Since IEC 60870-5-103 point lists must be in one continuous block, any points assigned after the first `Off` point are ignored.

3.6.1 CAUSE OF TRANSMISSION

The cause of transmission is an unsigned integer which takes one of the values specified in the following tables.

Cause of Transmission in the Monitor Direction

Value	Description
<1>	Spontaneous
<2>	Cyclic
<3>	Reset frame count bit (FCB)
<4>	Reset communications unit (CU)
<5>	Start/Restart
<6>	Power on
<8>	Time synchronization
<9>	General interrogation
<10>	Termination of general interrogation
<20>	Positive acknowledgment of command
<21>	Negative acknowledgment of command

Cause of Transmission in the Control Direction

Value	Description
<8>	Time synchronization
<9>	Initiation of general interrogation

Value	Description
<20>	General command

3.6.2 IEC 60870-5-103 MENUS

PATH: *SETPOINTS* > *DEVICE* > *COMMUNICATIONS* > *IEC103 POINT LISTS* > *BINARY INPUTS*

BINARY INPUT POINT X

FUNC TYPE

Range: 0 to 255 in steps of 1

Default: 0

INFO NUM

Range: 0 to 255 in steps of 1

Default: 0

POINT X

Range: 0 to 255 in steps of 1

Default: 0

PRESENT IN GEN INTERROGATION

Range: YES, NO

Default: NO

Select YES to send the binary input in response to a general interrogation request. By default, the binary input is not sent.

There are five measurand ASDUs available. The Fifth ASDU supports more metering values as shown below.

PATH: *SETPOINTS* > *DEVICE* > *COMMUNICATIONS* > *IEC103 POINT LISTS* > *MEASURANDS* > *FIRST ASDU...FIFTH ASDU*

IDENT TYPE

Range: 3, 9

Default: 3

First/Second/Third/Fourth ASDU:

If Ident Type=3 , 4 Measurands are sent to the master

If Ident Type=9, 4 Measurands are sent to the master

Fifth ASDU:

If Ident Type=3 , 4 Measurands are sent to the master

If Ident Type=9 , 16 Measurands are sent to the master

PATH: *SETPOINTS* > *DEVICE* > *COMMUNICATIONS* > *IEC103 POINT LISTS* > *COMMANDS*

The IEC 60870-5-103 Disturbance Recorder supports disturbance data transmission. For full functionality, the 64 Digital Channels need to be configured according to the Digital Inputs configured in the Transient Recorder.

PATH: *SETPOINTS* > *DEVICE* > *COMMUNICATIONS* > *IEC103 DISTURBANCE RECORDER*

DIGITAL CHANNEL 1...64

FUNC TYPE

Range: 0 to 255 in steps of 1

Default: 0

INFO NUM

Range: 0 to 255 in steps of 1

Default: 0

3.6.3 IEC 60870-5-103 INTEROPERABILITY

3.6.3.1 IEC 60870-5-103 PHYSICAL LAYER

Electrical interface

☒	EIA RS-485
32	Number of loads for one protection equipment

Optical interface

☐	Glass fibre
☐	Plastic fibre
☐	F-SMA type connector
☐	BFOC/2,5 type connector

Transmission speed

☒	9600 bits/s
☒	19200 bits/s

3.6.3.2 IEC 60870-5-103 LINK LAYER

There are no choices for the Link Layer.

3.6.3.3 IEC 60870-5-103 APPLICATION LAYER

Transmission mode for application data

Mode 1 (least significant octet first), is used exclusively in this companion standard.

Common address of ASDU

☒	One COMMON ADDRESS OF ASDU (identical with station address)
	More than one COMMON ADDRESS OF ASDU

Selection of standard information numbers in monitor direction

System functions in monitor direction

	INF	Semantics
☒	<0>	End of general interrogation
☒	<0>	Time synchronization
☒	<2>	Reset FCB
☒	<3>	Reset CU
☒	<4>	Start/restart
☒	<5>	Power on

Status indications in monitor direction

	INF	Semantics	Identifier	Data Text
☐	<16>	Auto-recloser active		
☐	<17>	Teleprotection active		
☐	<18>	Protection active		
☐	<19>	LED reset		
☐	<20>	Monitor direction blocked		
☐	<21>	Test mode		
☐	<22>	Local parameter setting		
☐	<23>	Characteristic 1		
☐	<24>	Characteristic 2		
☐	<25>	Characteristic 3		
☐	<26>	Characteristic 4		
☐	<27>	Auxiliary input 1		
☐	<28>	Auxiliary input 2		
☐	<29>	Auxiliary input 3		
☐	<30>	Auxiliary input 4		

Supervision indications in monitor direction

	INF	Semantics	Identifier	Data Text
☐	<32>	Measurand supervision I		
☐	<33>	Measurand supervision V		
☐	<35>	Phase sequence supervision		
☐	<36>	Trip circuit supervision		
☐	<37>	I>> back-up operation		

	INF	Semantics	Identifier	Data Text
☐	<38>	VT fuse failure		
☐	<39>	Teleprotection disturbed		
☐	<46>	Group warning		
☐	<47>	Group alarm		

Earth fault indications in monitor direction

	INF	Semantics	Identifier	Data Text
☐	<48>	Earth fault L1		
☐	<49>	Earth fault L2		
☐	<50>	Earth fault L3		
☐	<51>	Earth fault forward, i.e. line		
☐	<52>	Earth fault reverse, i.e. busbar		

Fault indications in monitor direction

	INF	Semantics	Identifier	Data Text
☐	<64>	Start / pick-up L1		
☐	<65>	Start / pick-up L2		
☐	<66>	Start / pick-up L3		
☐	<67>	Start / pick-up N		
☐	<68>	General trip		
☐	<69>	Trip L1		
☐	<70>	Trip L2		
☐	<71>	Trip L3		
☐	<72>	Trip I>> (back-up operation)		
☐	<73>	Fault location X in ohms		
☐	<74>	Fault forward / line		
☐	<75>	Fault reverse / busbar		
☐	<76>	Teleprotection signal transmitted		
☐	<77>	Teleprotection signal received		

	INF	Semantics	Identifier	Data Text
☐	<78>	Zone 1		
☐	<79>	Zone 2		
☐	<80>	Zone 3		
☐	<81>	Zone 4		
☐	<82>	Zone 5		
☐	<83>	Zone 6		
☐	<84>	General start / pick-up		
☐	<85>	Breaker failure		
☐	<86>	Trip measuring system L1		
☐	<87>	Trip measuring system L2		
☐	<88>	Trip measuring system L3		
☐	<89>	Trip measuring system E		
☐	<90>	Trip I>		
☐	<91>	Trip I>>		
☐	<92>	Trip IN>		
☐	<93>	Trip IN>>		

Auto-reclosure indications in monitor direction

	INF	Semantics	Identifier	Data Text
☐	<128>	CB ‘on’ by AR		
☐	<129>	CB ‘on’ by long-time AR		
☐	<130>	AR blocked		

Measurands in monitor direction

	INF	Semantics	Identifier	Data Text
☐	<144>	Measurand I		
☐	<145>	Measurands I, V		
☐	<146>	Measurands I, V, P, Q		
☐	<147>	Measurands In, Ven		

	INF	Semantics	Identifier	Data Text
☐	<148>	Measurands IL123, VL123, P, Q, f		

Generic functions in monitor direction

	INF	Semantics
☐	<240>	Read headings of all defined groups
☐	<241>	Read values or attributes of all entries of one group
☐	<243>	Read directory of a single entry
☐	<244>	Read value or attribute of a single entry
☐	<245>	End of general interrogation of generic data
☐	<249>	Write entry with confirmation
☐	<250>	Write entry with execution
☐	<251>	Write entry aborted

Selection of standard information numbers in control direction

System functions in control direction

	INF	Semantics
☒	<0>	Initiation of general interrogation
☒	<0>	Time synchronization

General commands in control direction

	INF	Semantics
☐	<16>	Auto-recloser on / off
☐	<17>	Teleprotection on / off
☐	<18>	Protection on / off
☐	<19>	LED reset
☐	<23>	Activate characteristic 1
☐	<24>	Activate characteristic 2
☐	<25>	Activate characteristic 3
☐	<26>	Activate characteristic 4

General functions in control direction

	INF	Semantics
☐	<240>	Read headings of all defined groups
☐	<241>	Read values or attributes of all entries of one group
☐	<243>	Read directory of a single entry
☐	<244>	Read value or attribute of a single entry
☐	<245>	General interrogation of generic data
☐	<248>	Write entry
☐	<249>	Write entry with confirmation
☐	<250>	Write entry with execution
☐	<251>	Write entry abort

Basic application functions

☐	Test mode
☐	Blocking of monitor direction
☐	Disturbance data
☐	Generic services
☐	Private data

Miscellaneous

Measurand	Max. MVAL = times rated value		
	1,2	or	2,4
Current L1	☐		☒
Current L2	☐		☒
Current L3	☐		☒
Voltage L1-E	☐		☒
Voltage L2-E	☐		☒
Voltage L3-E	☐		☒
Active power P	☐		☒
Reactive power Q	☐		☒
Frequency f	☐		☒

Measurand	Max. MVAL = times rated value		
	1,2	or	2,4
Voltage L1-L2	☐		☒

3.7 MODBUS PROTOCOL

All Ethernet ports and serial communication ports support the Modbus protocol. The only exception is if the serial port has been configured for DNP or IEC 60870-5-103 operation (see descriptions below). This allows the EnerVista D&I Setup (which is a Modbus master application) to communicate with the relay.

The relay implements a subset of the Modicon Modbus RTU serial communication standard. The Modbus protocol is hardware-independent. That is, the physical layer can be any of a variety of standard hardware configurations. This includes USB, RS485, fiber optics, etc. Modbus is a single master / multiple slave type of protocol suitable for a multi-drop configuration.

The relay is always a Modbus slave with a valid slave address range 1 to 254.

DATA FRAME FORMAT AND DATA RATE

One data frame of an asynchronous transmission to or from a relay typically consists of 1 start bit, 8 data bits, and 1 stop bit. This produces a 10-bit data frame. This is important for transmission through modems at high bit rates. Modbus protocol can be implemented at any standard communication speed. The relay supports operation at 9600, 19200, 38400, 57600, and 115200 bps baud rate. The USB interface supports Modbus TCP/IP.

FUNCTION CODE SUPPORTED

The following functions are supported:

- FUNCTION CODE 03H - Read Setpoints
- FUNCTION CODE 04H - Read Actual Values
- FUNCTION CODE 05H - Execute Operation
- FUNCTION CODE 06H - Store Single Setpoint
- FUNCTION CODE 07H - Read Device Status
- FUNCTION CODE 08H - Loopback Test
- FUNCTION CODE 10H - Store Multiple Setpoints
- FUNCTION CODE 42H - Group Settings Read
- FUNCTION CODE 43H - Group Settings Write

When a Modbus master such as the EnerVista D&I Setup communicates with the relay over Ethernet, the relay slave address, TCP port number and IP address for the associated port must be configured and are also configured within the Master for this device. The default Modbus TCP port number is 502.

3.7.1 MODBUS CONFIGURABLE PARAMETERS

The following Modbus parameters are configurable:

Path:*Setpoints* > *Device* > *Communications* > *Modbus Protocol*

MODBUS SLAVE ADDRESS

Range: 1 to 254 in steps of 1

Default: 254

For the RS485 ports each 8 Series must have a unique address from 1 to 254. Address 0 is the broadcast address to which all Modbus slave devices listen. Addresses do not have to be sequential, but no two devices can have the same address, otherwise conflicts resulting in errors occur. Generally, each device added to the link uses the next higher address starting at 1.

MODBUS TCP PORT NUMBER

Range: 1 to 65535 in steps of 1

Default: 502

The TCP port number used with Modbus over Ethernet. Note that the maximum number of simultaneous Modbus connections supported over Ethernet is three for an 8 Series without the communications card and five for an 8 Series with the communications card.

COMPATIBILITY

Range: Disabled, FlexMap

Default: Disabled

Compatibility mode changes the Modbus actual value registers to emulate the SR relay. The emulation supports typical actual value data for common data items.

See the *8 Series Protective Relay Communications guide* for the list.

FLEXMAP FILE

Range: Up to 13 alphanumeric characters

Default: Depends on the type of the relay and order code options:

SR735XAFlexMap.000 for Current protection option "S"

SR750XAFlexMap.000 for Current Protection option "M", "D" or "A"

SR469XAFlexMap.000

SR745XAFlexMap.000

SR489XAFlexMap.000

369XAFlexMap.000

The ***Flexmap File*** describes the translation from the Modbus memory map to the target Modbus memory map.

The default Flexmap File can be changed by entering the filename. In the case where the default `SR735XAFlexMap.000` file requires to be changed to SR750 then enter `SR750XAFlexMap.000` file.

RS485 Port1

Range: Off, On

Default: Off

RS485 Port2

Range: Off, On

Default: Off

RS485 Port3 (only 859)

Range: Off, On

Default: Off

Ethernet Port1

Range: Off, On

Default: Off

Ethernet Port2

Range: Off, On

Default: Off

Ethernet Port4 (not 859)

Range: Off, On

Default: Off

Ethernet Port5 (not 859)

Range: Off, On

Default: Off

MODBUS ACTIVITY TIMEOUT

Range: 0 to 3600 s in steps of 1 s

Default: 0 s

The ***Modbus Activity Timeout*** specifies the minimum time without Modbus communication. This timeout is used to declare the Modbus **Loss of Communication** state.

The Modbus state is always Active if the ***Modbus Activity Timeout*** is `0 s`.

MODBUS 485 READ ACTUALS

Range: Function Code 03h, Function Code 04h

Default: Function Code 04h

The ***Modbus 485 Read Actuals*** setting configures the Function Code that the relay responds to from a Modbus Master when Actual Values are requested. Use this setting in scenarios where the Modbus Master can only communicate using Function Code 03h for requesting Actual Values.

Note:
This setting applies only to the RS485 connection.
When this setting is changed to Function Code 03h, retrieving configuration settings through the RS485 port is not possible.

MODBUS ERROR RESPONSES

The following exception response codes are implemented.

Error ID	Exception	Description
01	ILLEGAL FUNCTION	The function code transmitted is not one of the functions supported by the 8 Series.
02	ILLEGAL DATA ADDRESS	The address referenced in the data field transmitted by the master is not an allowable address for the 8 Series.
03	ILLEGAL DATA VALUE	The value referenced in the data field transmitted by the master is not within range for the selected data address.

3.7.2 FUNCTION CODE 03H (READ SETPOINTS)

Modbus Implementation: Read Holding Registers

Relay Implementation: Read Setpoints

For the relay implementation of Modbus, the function code can be used to read any setpoints (holding registers). Holding registers are 16 bit values transmitted high order byte first. As a result all relay Setpoints are sent as two bytes. The maximum number of registers that can be read in one transmission is 125.

The slave response to this function code is the slave address, function code, a count of the number of data bytes to follow, the data itself and the CRC. Each data item is sent as a two byte number with the high order byte sent first.

For example, consider a request for slave 17 to respond with 3 registers starting at address 006B. For this example the register data in these addresses is as follows:

Address	Data
006B	022B
006C	0000
006D	0064

The master/slave packets have the following format:

Master Packet Format for Function Code 03H

MASTER TRANSMISSION	BYTES	EXAMPLE	DESCRIPTION
SLAVE ADDRESS	1	FE	message for slave 254
FUNCTION CODE	1	03	read registers
DATA STARTING ADDRESS	2	4A 8A	data starting at 4A8A
NUMBER OF SETPOINTS	2	00 04	4 registers = 8 bytes total
CRC (low, high)	2	67 F4	CRC error code

Slave Packet Format for Function Code 03H

SLAVE RESPONSE	BYTES	EXAMPLE	DESCRIPTION
SLAVE ADDRESS	1	FE	message from slave 254
FUNCTION CODE	1	03	read registers
BYTE COUNT	1	08	4 registers = 8 bytes total
DATA 1	2	00 00	value in address 4A8A (16-bit)
DATA 2	2	04 B0	value in address 4A8B (16-bit)
DATA 3	2	00 00	value in address 4A8C (32-bit)
DATA 4	2	00 64	
CRC (low, high)	2	E7 75	CRC error code

ASE 2000 V2 Example

```
--> 00 00 00 00 00 06 FE 03 4A 8A 00 04

--> 00 00 00 00 00 0B FE 03 08 00 00 04 B0 00 00 00 64
```

3.7.3 FUNCTION CODE 04H (READ ACTUAL VALUES)

Modbus Implementation: Read Input Registers

Relay Implementation: Read Actual Values

For the relay implementation of Modbus, the function code can be used to read any actual values (input registers). Input registers are 16 bit values transmitted high order byte first. Thus all relay Actual Values are sent as two bytes. The maximum number of registers that can be read in one transmission is 125.

The slave response to this function code is the slave address, function code, a count of the data bytes to follow, the data itself and the CRC. Each data item is sent as a two byte number with the high order byte sent first.

For example, request slave 17 to respond with 1 register starting at address 0008. For this example the value in this register (0008) is 0000.

Master Packet Format for Function Code 04H

MASTER TRANSMISSION	BYTES	EXAMPLE	DESCRIPTION
SLAVE ADDRESS	1	FE	message for slave 254
FUNCTION CODE	1	04	read registers
DATA STARTING ADDRESS	2	05 95	data starting at 0595
NUMBER OF ACTUAL VALUES	2	00 02	2 registers = 4 bytes total
CRC (low, high)	2	75 24	CRC error code

Slave Packet Format for Function Code 04H

SLAVE RESPONSE	BYTES	EXAMPLE	DESCRIPTION
SLAVE ADDRESS	1	FE	message from slave 254
FUNCTION CODE	1	04	read registers
BYTE COUNT	1	04	2 register = 4 bytes total
DATA 1	2	00 00	value in address 0595 (32-bit)
DATA 2	2	27 0F	
CRC (low, high)	2	AF 7F	CRC error code

ASE 2000 V2 Example

```
--> 00 00 00 00 00 06 FE 04 05 95 00 02
--> 00 00 00 00 00 07 FE 04 04 00 00 27 0F
```

3.7.4 FUNCTION CODE 05H (EXECUTE OPERATION)

Modbus Implementation: Force Single Coil

Relay Implementation: Execute Operation

The function code allows the master to request a relay to perform specific command operations.

For example, to request slave 17 to execute operation code 1 (reset), we have the following master/slave packet format:

Master Packet Format for Function Code 05H

MASTER TRANSMISSION	BYTES	EXAMPLE	DESCRIPTION
SLAVE ADDRESS	1	FE	message for slave 254
FUNCTION CODE	1	05	execute operation
OPERATION CODE	2	00 01	operation code 1
CODE VALUE	2	FF 00	perform function
CRC (low, high)	2	C9 F5	CRC error code

Slave Packet Format for Function Code 05H

SLAVE RESPONSE	BYTES	EXAMPLE	DESCRIPTION
SLAVE ADDRESS	1	FE	message from slave 17
FUNCTION CODE	1	05	execute operation
OPERATION CODE	2	00 01	operation code 1
CODE VALUE	2	FF 00	perform function
CRC (low, high)	2	C9 F5	CRC error code

ASE 2000 V2 Example

```
--> 00 00 00 00 00 06 FE 05 00 01 FF 00
--> 00 00 00 00 00 06 FE 05 00 01 FF 00
```

3.7.5 FUNCTION CODE 06H (STORE SINGLE SETPOINT)

Modbus Implementation: Preset Single Register

Relay Implementation: Store Single Setpoint

The command allows the master to store a single setpoint into the memory of a relay. The slave response to this function code is to echo the entire master transmission.

For example, request slave 17 to store the value 2 in setpoint address 04 5C. After the transmission in this example is complete, setpoints address 04 5C contains the value 0002. The master/slave packet format is shown next.

Master Packet Format for Function Code 06H

MASTER TRANSMISSION	BYTES	EXAMPLE	DESCRIPTION
SLAVE ADDRESS	1	FE	message for slave 254
FUNCTION CODE	1	06	store single setpoint
DATA STARTING ADDRESS	2	4A 44	setpoint address 4A 44
DATA	2	03 E8	data for setpoint address 4A 44
CRC (low, high)	2	CB 76	CRC error code

Slave Packet Format for Function Code 06H

SLAVE RESPONSE	BYTES	EXAMPLE	DESCRIPTION
SLAVE ADDRESS	1	FE	message from slave 254
FUNCTION CODE	1	06	store single setpoint
DATA STARTING ADDRESS	2	4A 44	setpoint address 4A 44
DATA	2	03 E8	data for setpoint address 04A 44
CRC (low, high)	2	CB 76	CRC error code

ASE 2000 V2 Example

```
--> 00 00 00 00 00 06 FE 06 4A 44 03 E8
--> 00 00 00 00 00 06 FE 06 4A 44 03 E8
```

3.7.6 FUNCTION CODE 07H (READ DEVICE STATUS)

Modbus Implementation: Read Exception Status

Relay Implementation: Read Device Status

The function used to quickly read the status of a selected device. A short message length allows for rapid reading of status. The status byte returned has individual bits set to 1 or 0 depending on the status of the slave device. For this example, consider the following relay general status byte:

Master Packet Format for Function Code 07H

MASTER TRANSMISSION	BYTES	EXAMPLE	DESCRIPTION
SLAVE ADDRESS	1	FE	message for slave 254
FUNCTION CODE	1	07	read device status
CRC (low, high)	2	00 12	CRC error code

Slave Packet Format for Function Code 07H

SLAVE RESPONSE	BYTES	EXAMPLE	DESCRIPTION
SLAVE ADDRESS	1	FE	message from slave 254
FUNCTION CODE	1	07	read device status
DEVICE STATUS (see following table)	1	28	status = 00101000 (in binary)
CRC (low, high)	2	12 1E	CRC error code

ASE 2000 V2 Example

```
--> 00 00 00 00 00 02 FE 07
--> 00 00 00 00 00 03 FE 07 28
```

Function code 07H includes the following bit masks:

Device Table Status

Bit mask	Description
Bit 0	SP Group 3 Active
Bit 1	SP Group 2 Active
Bit 2	Pickup State
Bit 3	Breaker Connected
Bit 4	Breaker Closed
Bit 5	Breaker Tripped
Bit 6	Alarm
Bit 7	Trip

3.7.7 FUNCTION CODE 08H (LOOPBACK TEST)

Modbus Implementation: Loopback

Relay Implementation: Loopback Test

The function is used to test the integrity of the communication link. The relay echos the request.

For example, consider a loopback test from slave 254:

Master Packet Format for Function Code 08H

MASTER TRANSMISSION	BYTES	EXAMPLE	DESCRIPTION
SLAVE ADDRESS	1	FE	message for slave 254
FUNCTION CODE	1	08	loopback test
DIAGNOSTICS CODE	2	00 00	must be 00 00
DATA	2	00 00	must be 00 00
CRC (low, high)	2	F4 04	CRC error code

Slave Packet Format for Function Code 08H

SLAVE RESPONSE	BYTES	EXAMPLE	DESCRIPTION
SLAVE ADDRESS	1	FE	message from slave 17
FUNCTION CODE	1	08	loopback test
DIAGNOSTICS CODE	2	00 00	must be 00 00
DATA	2	00 00	must be 00 00

SLAVE RESPONSE	BYTES	EXAMPLE	DESCRIPTION
CRC (low, high)	2	F4 04	CRC error code

ASE 2000 V2 Example

```
--> 00 00 00 00 00 06 FE 08 00 00 00 00
--> 00 00 00 00 00 06 FE 08 00 00 00 00
```

3.7.8 FUNCTION CODE 10H (STORE MULTIPLE SETPOINTS)

Modbus Implementation: Preset Multiple Registers

Relay Implementation: Store Multiple Setpoints

The function code allows multiple Setpoints to be stored into the relay memory. Modbus registers are 16-bit values transmitted high order byte first. Thus all relay setpoints are sent as two bytes. The maximum number of Setpoints that can be stored in one transmission is dependent on the slave device. Modbus allows up to a maximum of 60 holding registers to be stored. The relay response to this function code is to echo the slave address, function code, starting address, the number of Setpoints stored, and the CRC.

For example, consider a request for slave 254 to store the value 00 0A to setpoint address 41 DB and the value 00 64 to setpoint address 41 DC. After the transmission in this example is complete, relay slave 254 will have the following setpoints information stored:

Address	Data
41 DB	00 0A
41 DC	00 64

Master Packet Format for Function Code 10H

MASTER TRANSMISSION	BYTES	EXAMPLE	DESCRIPTION
SLAVE ADDRESS	1	FE	message for slave 254
FUNCTION CODE	1	10	store setpoints
DATA STARTING ADDRESS	2	41 DB	setpoint address 41 DB
NUMBER OF SETPOINTS	2	00 02	2 setpoints – 4 bytes total
BYTE COUNT	1	04	4 bytes of data
DATA 1	2	00 0A	data for setpoint address 41 DB
DATA 2	2	00 64	data for setpoint address 41 DC
CRC (low, high)	2	91 ED	CRC error code

Slave Packet Format for Function Code 10H

SLAVE RESPONSE	BYTES	EXAMPLE	DESCRIPTION
SLAVE ADDRESS	1	FE	message from slave 254
FUNCTION CODE	1	10	store setpoints
DATA STARTING ADDRESS	2	41 DB	setpoint address 41 DB
NUMBER OF SETPOINTS	2	00 02	2 setpoints
CRC (low, high)	2	31 C0	CRC error code

ASE 2000 V2 Example

```
--> 00 00 00 00 00 0B FE 10 41 DB 00 02 04 00 0A 00 64
--> 00 00 00 00 00 06 FE 10 41 DB 00 02
```

3.7.9 ADMINISTRATOR LOGIN AND COMMANDS VIA MODBUS FOR 8 SERIES RELAYS

Logging in as Administrator

Logging in as Administrator is demonstrated in the example below. The process requires writing 44 bytes which consist of the Role ID and Password. Password characters are 22 bytes and role characters are also 22 bytes. The logging in must be done using a single Modbus command using Function 10H (Store Multiple Setpoints).

The following table shows data to be written to the relay to login as Administrator. The relay password in this example is 0.

Data Written to Relay to Login as Administrator

Description	Memory Map Address		Value to be written	
	DEC	HEX	DEC	HEX
Role Characters 1 and 2	62242	F322	16740	4164
Role Characters 3 and 4	62243	F323	28009	6D69
Role Characters 5 and 6	62244	F324	28265	6E69
Role Characters 7 and 8	62245	F325	29556	7374
Role Characters 9 and 10	62246	F326	29281	7261
Role Characters 11 and 12	62247	F327	29807	746F
Role Characters 13 and 14	62248	F328	29184	7200
Role Characters 15 and 16	62249	F329	0	0000
Role Characters 17 and 18	62250	F32A	0	0000
Role Characters 19 and 20	62251	F32B	0	0000
Role Characters 21 and 22	62252	F32C	0	0000
Password Characters 1 and 2	62253	F32D	12288	3000
Password Characters 3 and 4	62254	F32E	0	0000
Password Characters 5 and 6	62255	F32F	0	0000
Password Characters 7 and 8	62256	F330	0	0000
Password Characters 9 and 10	62257	F331	0	0000
Password Characters 11 and 12	62258	F332	0	0000
Password Characters 13 and 14	62259	F333	0	0000
Password Characters 15 and 16	62260	F334	0	0000
Password Characters 17 and 18	62261	F335	0	0000
Password Characters 19 and 20	62262	F336	0	0000
Password Characters 21 and 22	62263	F337	0	0000

Login as Administrator Function Format

Slave#	Function	Data Starting Address	Number of Setpoints	Byte Count	Data 1	Data 2	Data 3	Data 4	Data 5	Data 6	Data 7	Data 8	Data 9
FE	10	F322	0016	2C	4164	6D69	6E69	7374	7261	746F	7200	0	0

Login as Administrator Function Format continued

Data 10	Data 11	Data 12	Data 13	Data 14	Data 15	Data 16	Data17	Data 18	Data 19	Data 20	Data 21	Data 22
0	0	3000	0	0	0	0	0	0	0	0	0	0

Commands using Modbus Function 10H (Store Multiple Setpoints)

Sending commands requires writing 4 bytes to the Command address register using the Modbus Function 10H (Store Multiple Setpoints). The 4 bytes are the function and the command values. The function value is always 05.

Modbus Commands registers

Description	Memory Map Address	
	DEC	HEX
Command Register	40129	0x0080
Command Function Register	40130	0x0081

Examples of Command values

Command Value	Value Description
1	Reset
96	Clear All Records
98	Clear Events
105	Clear Energy Use Data
4096	Force Virtual Input 1

Function Format for ***Clear All*** command:

Function Format for *Clear All* command

Slave #	Function	Data Starting Address	Number of Setpoints	Byte count	Data 1	Data 2
FE	10	0080	0002	04	0005	0060

Function Format for *Clear Energy Use Data* command

Slave #	Function	Data Starting Address	Number of Setpoints	Byte count	Data 1	Data 2
FE	10	0080	0002	04	0005	0069

Function Format for *Force Virtual Input 1* command

Slave #	Function	Data Starting Address	Number of Setpoints	Byte count	Data 1	Data 2
FE	10	0080	0002	04	0005	1000

Commands using Modbus Function 05H (Execute Operation)

Specific command operations such as described above can also be performed using function code 05H.

Format for Function Code 05H

Master Transmission	Byte#	Example	Description
Slave Address	1	FE	message for slave # 254
Function Code	1	05	execute operation
Operation Code	2	00 01	operation code
Code Value	2	FF 00	perform function
CRC	2	DF 6A	CRC error code

Examples of Command values

Command Value	Value Description
1	Reset
96	Clear All Records
98	Clear Events
105	Clear Energy Use Data
4096	Force Virtual Input 1

Function Format for Reset command

Slave #	Function	Operation Code	Code Value
FE	05	0001	FF00

3.8 MODBUS MEMORY MAP

Refer to the Modbus Maps spreadsheet package located online under Support Documents on the webpage for each 8 Series relay:

https://www.gevernova.com/grid-solutions

Press the button below to open the Modbus Memory Map of 8 Series Version 4.30

8Series v430 Modbus Memory Map

Note:
Modbus Maps and Format Codes for all 8 Series relays are included in the same package. There are several versions of the Modbus Map and corresponding Format Codes available, and the one matching the relay firmware version should be used.

3.8.1 ACCESSING DATA VIA THE USER MAP

The relay has a powerful feature, called the User Map, which allows a computer to read up to 125 non-consecutive data registers (setpoints or actual values) by using one Modbus packet. It is often necessary for a master computer to continuously poll various values in each of the connected slave relays. If these values are scattered throughout the memory map, reading them would require numerous transmissions and would burden the communication link. The User Map can be programmed to join any memory map address to one in the block of consecutive User Map locations, so that they can be accessed by reading these consecutive locations.

The relay contains a user-definable area in the Modbus memory map. This area allows re-mapping of the addresses of any Actual Values registers. The User Definable area has two sections.

1. A Register Index area (40524 to 40648) that contains 125 Actual Values register addresses
2. A Register area (30524 to 30648) that contains the data at the addresses in the Register Index

Register data that is separated in the rest of the memory map may be re-mapped to adjacent register addresses in the user-definable registers area. This is accomplished by writing to register addresses in the user-definable register index area. This allows for improved throughput of data and can eliminate the need for multiple read command sequences. The user-definable register index is stored as a setpoint and therefore it is remembered even when the power is removed.

Default User Map

Common actual values have been defaulted for the user. Below are the default registers. (This is the general Default User Map; some features are not supported in all relays resulting in some blank addresses. View the Modbus User Map in the EnerVista D&I Setup for specific relays.)

Default User Map

User Map Address	Description	Modbus Address	
User Map Address 1,2	Device Status	30714	30715
User Map Address 3,4	LED1 1-16	30710	30711
User Map Address 5,6	Contact Inputs 1-32	30700	30701
User Map Address 7,8	Contact Outputs 1-32	30708	30709
User Map Address 9,10	Virtual Inputs 1-32	30716	30717
User Map Address 11, 12	Virtual Outputs 1-32	30724	30725
User Map Address 13,14	Remote Inputs 1-32	30736	30737
User Map Address 15,16	GGIO1 Indications 1-32	30752	30753
User Map Address 17,18	J1 Ia	34420	34421

User Map Address	Description	Modbus Address	
User Map Address 19,20	J1 Ib	34422	34423
User Map Address 21,22	J1 Ic	34424	34425
User Map Address 23,24	J1 In	34428	34429
User Map Address 25,26	J1 I AVG	34445	34446
User Map Address 27,28	J1 Ig	34426	34427
User Map Address 29,30	J2 Van RMS	34646	34647
User Map Address 31,32	J2 Vbn RMS	34648	34649
User Map Address 33,34	J2 Vcn RMS	34650	34651
User Map Address 35,36	J2 Vab RMS	34652	34653
User Map Address 37,38	J2 Vbc RMS	34654	34655
User Map Address 39,40	J2 Vca RMS	34656	34657
User Map Address 41,42	J2 V AVG L-L	34670	34671
User Map Address 43,44	J2 V AVG L-N	34672	34673
User Map Address 45,46	Pwr1 Real	35690	35691
User Map Address 47,48	Pwr1 Apparent	35694	35695
User Map Address 49	Pwr1 PF	35714	
User Map Address 50	Product Code	30001	
User Map Address 51	J2-CT Frq Rate of Chge	34931	
User Map Address 52,53	Sync1 Line Volts Magnitude	35585	35586
User Map Address 54	Sync1 Line Volts Angle	35587	
User Map Address 55,56	Sync1 Line Volts Frequency	35588	35589
User Map Address 57,58	Pwr1 Pos WattHours	35854	35855
User Map Address 59,60	Pwr1 Ph A Real	35696	35697
User Map Address 61,62	Pwr1 Ph A Apparent	35708	35709
User Map Address 63	Pwr1 Ph A PF	35715	
User Map Address 64,65	Pwr1 Ph B Real	35698	35699
User Map Address 66,67	Pwr1 Ph B Apparent	35710	35711
User Map Address 68	Pwr1 Ph B PF	35716	
User Map Address 69,70	Pwr1 Ph C Real	35700	35701
User Map Address 71,72	Pwr1 Ph C Apparent	35712	35713
User Map Address 73	Pwr1 Ph C PF	35717	
User Map Address 74,75	Pwr1 Reactive	35692	35693
User Map Address 76,77	Pwr1 Ph A Reactive	35702	35703
User Map Address 78,79	Pwr1 Ph B Reactive	35704	35705
User Map Address 80,81	Pwr1 Ph C Reactive	35706	35707

The relay supports 32-bit Modbus items to be configured in the user map. When such an address is configured in the user map for example at user map address 1, user map address 2 is also consumed by the same item irrespective of the address assigned in address 2.

Note:
The User Map supports memory map addresses within the range of 30001 to 65534. Some of the data registers containing setpoints reside in memory map addresses that are greater than 65534, thus those addresses can't be programmed into user map.

3.8.2 MEMORY MAP ORGANIZATION

The relay Memory Map describes all the data registers that can be accessed via serial communications. The Memory Map address range is grouped into several categories as outlined in the following table. All memory map locations are two byte (16 bit) values. The remaining pages of this chapter list all locations of the Memory Map. Addresses for all locations are shown in hexadecimal. Consult the range, step, units, and the data format (listed after the memory map) to interpret register values.

Note:
Many Modbus drivers add 40001 (for settings) or 30001 (for actual values) to the actual address of the register addresses. For example, if settings address 0h was to be read, then 40001d would be the address required by the Modbus communications driver; similarly, if settings address 320h (800d) was to be read, then 40801d would be the address required by the Modbus communications driver.

Memory Map Section	Address Range	Description
Product ID	30001 to 30104	Identification and revision information.
Actual Values	30193 to 30391	Actual values. Read Only.
	30660 to 38923	
User Map Values	30524 to 30648	User Map Values. See the previous section for details.
Setpoints	40001 to 40008	Setpoints data. Read and Write.
	40230 to 40477	
	40660 to 95523	
Commands	40129 to 40140	Substitute command locations. Read and write.
User Map Setpoints	40524 to 40648	User map setpoints. Configures user map values
Simulation	102550 to 102896	Simulation

3.8.3 COMPATIBILITY MODE

The relay supports emulation of the SR735/SR745/SR750/SR469/SR489/369 Modbus memory map for retrofit applications. The emulation supports typical actual value data for common data items. When enabled, the relay responds to Modbus packets from a PLC as if it were a legacy SR relay.

The compatibility mode is only available for RS485 and rear Ethernet ports. (The USB and Wifi always respond using the 8 Series memory map.)

The Ethernet ports can be configured individually for compatibility mode.

When in compatibility mode, the rear Ethernet ports support setting changes for Compatibility mode, Set date and time, Clear events, and Event retrieval.

User Map

When using the default user map in compatibility mode, the user is required to enter the Modicon format for the address that is being read in the user map. The Modicon format has an offset of 30001, and thus is different from the values found in the SR publications. For convenience, the translated values have been included in the tables below. The user map can only be entered in an offline file, and the compatibility mode must be set to SR469 or SR750, depending on the product being used.

The user map implementation is the same function as covered in the section *Accessing Data via the User Map*. The only difference is that the read function starts at 0100h (256 Dec) to correspond to the SR469/SR750 map.Range: User Map #1 (0100h) to User Map #125 (017Ch)

Example:

PLC requests Phase A current from SR469 = 0300h (HEX) using User Map #1 = 0100h

Default User Map #1 in 8 Series PC SW = 30769 (Dec) => SR469 = 768 (Dec) = 0300h(HEX)

The following tables list the addresses supported in compatibility mode for compatible products : SR735, SR745, SR750, SR469, SR489 and 369.

Press the button below to open the Compatibility Mode Tables

Compatibility Mode Tables

3.8.4 USING THE MEMORY MAP

3.8.4.1 READING DEVICE STATUS REGISTER BITS

Values in this Communications Guide show bit position by hexadecimal value, for example '0x00100000 In Service'. The following tables show equivalent 32-bit assignments, using Device Status values as an example.

Modbus Map entry, Device Status

Modbus Address	Hex Address	Description	Min	Max	Step	Units	Format Code	Factory Default	Size in Words	850	869	889	845
30714	0x02C9	Device Status	0	0xFFFFFFFF	1		FC135	0	2	Y	Y	Y	Y

Format Code entries, Device Status (FC 135)

Code	Type	Definition	850	869	889	845
FC135	unsigned 32 bits	Device Status				
	0x00040000	Self-Test Fault	Y	Y	Y	Y
	0x00080000	Maintenance	Y	Y	Y	Y
	0x00100000	In Service	Y	Y	Y	Y
	0x00200000	SP Group 6 Active	Y	Y	Y	Y
	0x00400000	SP Group 5 Active	Y	Y	Y	Y
	0x00800000	SP Group 4 Active	Y	Y	Y	Y
	0x01000000	SP Group 3 Active	Y	Y	Y	Y
	0x02000000	SP Group 2 Active	Y	Y	Y	Y
	0x04000000	Pickup State	Y	Y	Y	Y
	0x40000000	Alarm	Y	Y	Y	Y
	0x80000000	Trip	Y	Y	Y	Y

The following table shows a Modbus Read from Device of two registers, starting with 02C9.

Address	Modbus type	# of	Selection	Modbus group	values
02C9	Actual value	2	Binary	0xFFFFFFFF	1010-1100-0001-0000, 0000-0000-0000-0000
	Actual value		Hex		

The following table gives the equivalent 32-bit values.

Bits	Word position	Hex value		Bit
2nd 16 bits	Low Order Word of Long Value	0x02CA	0x00000001	Bit 1
2nd 16 bits	Low Order Word of Long Value	0x02CA	0x00000002	Bit 2
2nd 16 bits	Low Order Word of Long Value	0x02CA	0x00000004	Bit 3
2nd 16 bits	Low Order Word of Long Value	0x02CA	0x00000008	Bit 4
2nd 16 bits	Low Order Word of Long Value	0x02CA	0x00000010	Bit 5
2nd 16 bits	Low Order Word of Long Value	0x02CA	0x00000020	Bit 6
2nd 16 bits	Low Order Word of Long Value	0x02CA	0x00000040	Bit 7
2nd 16 bits	Low Order Word of Long Value	0x02CA	0x00000080	Bit 8
2nd 16 bits	Low Order Word of Long Value	0x02CA	0x00000100	Bit 9
2nd 16 bits	Low Order Word of Long Value	0x02CA	0x00000200	Bit 10
2nd 16 bits	Low Order Word of Long Value	0x02CA	0x00000400	Bit 11
2nd 16 bits	Low Order Word of Long Value	0x02CA	0x00000800	Bit 12
2nd 16 bits	Low Order Word of Long Value	0x02CA	0x00001000	Bit 13
2nd 16 bits	Low Order Word of Long Value	0x02CA	0x00002000	Bit 14
2nd 16 bits	Low Order Word of Long Value	0x02CA	0x00004000	Bit 15
2nd 16 bits	Low Order Word of Long Value	0x02CA	0x00008000	Bit 16
1st 16 bits	High Order Word of Long Value	0x02C9	0x00010000	Bit 17
1st 16 bits	High Order Word of Long Value	0x02C9	0x00020000	Bit 18
1st 16 bits	High Order Word of Long Value	0x02C9	0x00040000	Bit 19
1st 16 bits	High Order Word of Long Value	0x02C9	0x00080000	Bit 20
1st 16 bits	High Order Word of Long Value	0x02C9	0x00100000	Bit 21
1st 16 bits	High Order Word of Long Value	0x02C9	0x00200000	Bit 22
1st 16 bits	High Order Word of Long Value	0x02C9	0x00400000	Bit 23
1st 16 bits	High Order Word of Long Value	0x02C9	0x00800000	Bit 24
1st 16 bits	High Order Word of Long Value	0x02C9	0x01000000	Bit 25
1st 16 bits	High Order Word of Long Value	0x02C9	0x02000000	Bit 26
1st 16 bits	High Order Word of Long Value	0x02C9	0x04000000	Bit 27
1st 16 bits	High Order Word of Long Value	0x02C9	0x08000000	Bit 28
1st 16 bits	High Order Word of Long Value	0x02C9	0x10000000	Bit 29
1st 16 bits	High Order Word of Long Value	0x02C9	0x20000000	Bit 30
1st 16 bits	High Order Word of Long Value	0x02C9	0x40000000	Bit 31
1st 16 bits	High Order Word of Long Value	0x02C9	0x80000000	Bit 32

3.8.4.2 READING CO OUTPUTS

CO Outputs are used to show the state of the output relays in the 8-Series device (internal to the device). For example, on the 869 relay the Trip and Close contacts have voltage monitoring inputs. The Trip and Close Circuit Monitoring feature uses the voltage input to monitor the trip and to close coil circuit integrity.

To read the output relay status for all relays, use Modbus address 30708 (0x02C3) where each bit corresponds to a different output relay as described in format code FC198.

Modbus Map entry, CO Outputs

Modbus Address	Hex Address	Description	Min	Max	Step	Units	Format Code	Factory Default	Size in Words	850	869	889	845
30708	0x02C3	CO Outputs	0	0xFFFFFFFF	1		FC198	0	2	Y	Y	Y	Y

Format Code entries, CO Outputs

Code	Type	Definition	850	869	889	845
FC126A	unsigned 16 bits	Off / On Selection				
	0	Off	Y	Y	Y	Y
	1	On	Y	Y	Y	Y
FC198	unsigned 32 bits	Output Relay Operation				
Each bit corresponds to a particular output relay, and uses format FC126A						
	0x00000004	Output Relay 3	Y	Y	Y	Y
	0x00000008	Output Relay 4	Y	Y	Y	Y
	0x00000010	Output Relay 5	Y	Y	Y	Y
	0x00000020	Output Relay 6	Y	Y	Y	Y
	0x00000040	Output Relay 7	Y	Y	Y	Y

3.8.4.3 INTERPRETING ELEMENT STATUS FOR BREAKER CONTACTS

Element Status items with formats FE020 - FE025 are used to sense/verify the state of the breaker contacts, external to the 8 Series device.

The following Modbus registers are assigned to Breaker Contact Element Status:

- 38005 (0x1F44) Element Status 106 (Output Relay 1)
- 38006 (0x1F45) Element Status 107 (Output Relay 2)
- 38007 (0x1F46) Element Status 108 (Output Relay 3)
- 38008 (0x1F47) Element Status 109 (Output Relay 4)
- 38009 (0x1F48) Element Status 110 (Output Relay 5)
- 38010 (0x1F49) Element Status 111 (Output Relay 6)
- 37951 (0x1F0E) Element Status 52 (Critical Fail)

These Modbus Registers are listed in the Modbus memory map table as follows:

Modbus Map entries, Element Status Register for Breaker Control Relays

Modbus Address	Hex Address	Description	Min	Max	Step	Units	Format Code	Factory Default	Size in Words	850	869	889	845
38005	0x1F44	Element Status 106 (Output Relay 1)	0	65535	1		FE106	0		Y	Y	Y	Y
38006	0x1F45	Element Status 107 (Output Relay 2)	0	65535	1		FE107	0		Y	Y	Y	Y
38007	0x1F46	Element Status 108 (Output Relay 3)	0	65535	1		FE108	0		Y	Y	Y	Y

Modbus Address	Hex Address	Description	Min	Max	Step	Units	Format Code	Factory Default	Size in Words	850	869	889	845
38008	0x1F47	Element Status 109 (Output Relay 4)	0	65535	1		FE109	0		Y	Y	Y	Y
38009	0x1F48	Element Status 110 (Output Relay 5)	0	65535	1		FE110	0		Y	Y	Y	Y
38010	0x0301	Element Status 111 (Output Relay 6)	0	65535	1		FE111	0		Y	Y	Y	Y
37951	0x1F0E	Element Status 52 (Critical Fail)	0	65535	1		FE052	0		Y	Y	Y	Y

The format code used for each Modbus register is listed in the Format Code column. In this case, the format codes used are FE052 and FE106 through FE111.

These format codes are described in the Format Code table as follows:

Format Code entries, Element Status Register for Breaker Control Relayss

Code	Type	Definition	850	869	889	845
FE106	unsigned 16 bits	Element Status: Output Relay 1				
	0x0002	Von	Y	Y	Y	Y
	0x0004	Voff	Y	Y	Y	Y
FE107	unsigned 16 bits	Element Status: Output Relay 2				
	0x0002	Von	Y	Y	Y	Y
	0x0004	Voff	Y	Y	Y	Y
FE108	unsigned 16 bits	Element Status: Output Relay 3				
	0x0002	Von				Y
	0x0004	Voff				Y
FE109	unsigned 16 bits	Element Status: Output Relay 4				
	0x0002	Von				Y
	0x0004	Voff				Y
FE110	unsigned 16 bits	Element Status: Output Relay 5				
	0x0002	Von				Y
	0x0004	Voff				Y
FE111	unsigned 16 bits	Element Status: Output Relay 6				
	0x0002	Von				Y
	0x0004	Voff				Y

Code	Type	Definition	850	869	889	845
FE052	unsigned 16 bits	Element Status: Critical Fail				
	0x0002	Critical Fail OP	Y	Y	Y	Y

Note:
From the notes preceding the full Format Code table, notice that Element Status Format Codes (FE1 onwards) contain values that should be masked with 0x01FF to match the bit field values shown in the table.

Element Status 106 monitors the state of the voltage monitor for Output Relay 1.

When the voltage is present on the Trip Contact voltage monitor (Von), the Element Status 106 register will read: 0x2002 (8194). The masked value is then 0x0002, corresponding to Von in the preceding table.

When the voltage is not present on the Trip Contact voltage monitor (Voff), the Element Status 106 register will read: 0x2004 (8196). The masked value is then 0x0004, corresponding to Voff in the preceding table.

Element Status 107 monitors the state of the voltage monitor for Output Relay 2.

When the voltage is present on the Trip Contact voltage monitor (Von), the Element Status 107 register will read: 0x2002 (8194). The masked value is then 0x0002, corresponding to Von in the preceding table.

When the voltage is not present on the Trip Contact voltage monitor (Voff), the Element Status 107 register will read: 0x2004 (8196). The masked value is then 0x0004, corresponding to Voff in the preceding table.

Element Status 52 is used to monitor the Critical Fail contact.

When the relay is in service, the IN SERVICE LED on the front panel is green.

The Element Status 52 (Critical Fail) register reads: 0x2000 (8192). The masked value is then 0x0000, indicating Critical Fail Op is not present.

When the relay is not service, the IN SERVICE LED on the front panel is orange.

The Element Status 52 (Critical Fail) register reads: 0x2002 (8194). The masked value is then 0x0002, corresponding to Critical Fail Op in the preceding table.

3.8.4.4 READING PHASE CURRENT VALUES

In this example a PLC is accessing the 6 sequential values beginning at Modbus address 34420 (Phase A current) in an 850 relay.

The following Modbus registers are assigned to Phase Currents:

- 34420 (0x1143) J1 Ia - Phase A current
- 34422 (0x1145) J1 Ib - Phase B current
- 34424 (0x1147) J1 Ic - Phase C current

These Modbus Registers are listed in the Modbus memory map table as follows:

Modbus Map entries for Phase Currents

Modbus Address	Hex Address	Description	Min	Max	Step	Units	Format Code	Factory Default	Size in Words	850	869	889	845
34420	0x1143	J1 Ia	0	0xFFFFFFFF	1	A	F13	0	2	Y	Y	Y	Y

Modbus Address	Hex Address	Description	Min	Max	Step	Units	Format Code	Factory Default	Size in Words	850	869	889	845
34422	0x1145	J1 Ib	0	0xFFFFFFFF	1	A	F13	0	2	Y	Y	Y	Y
34424	0x1147	J1 Ic	0	0xFFFFFFFF	1	A	F13	0	2	Y	Y	Y	Y

In this case the format code used is F13, which is described in the Format Code table as follows:

Format Code entries for Phase Current

Code	Type	Definition	850	869	889	845
F13	unsigned 32 bits	Unsigned Long Value, 3 Decimal Places				
1st 16 bits		High Order Word of Long Value	Y	Y	Y	Y
2nd 16 bits		Low Order Word of Long Value	Y	Y	Y	Y

The phase current metering values read by the PLC should match the values shown on the relay. Validating the received values in the PLC against the real values observed on the 850 relay front panel or read via EnerVista D&I Setup is recommended.

PLCs can use two different word orders for reading 32-bit registers. As a result, a 32 bit value of aabbccdd may be read as aabb ccdd, or as ccdd aabb.

A word-swap may be necessary to read the proper data from 850 relay current registers.

Once the correct word order is set, the obtained value needs to be divided by 1000 to get the decimal point.

Register: 34420	Register: 34421
1st 16 bits High Order Word of Long Value	2nd 16 bits Low Order Word of Long Value
unsigned 32 bits Unsigned Long Value	
unsigned 32 bits Unsigned Long Value, 3 Decimal Places	

For example:

Phase A Current value on relay display: 183.594 A

Phase current values read from Phase A Current Modbus registers:

04F5 (34420): 0002

04F6 (34421): CD2A

Combine the two 16 bit values into a 32 bit unsigned value: 183594

Apply the decimal point rule (divide by 1000): 183.594 A

Register: 34420	Register: 34421
0002	CD2A
183594	
183.594	

3.8.4.5 READING LAST TRIP TARGET MESSAGES

Target messages are read through the Modbus Target Message registers.

Modbus Map entries, Targets

Modbus Address	Hex Address	Description	Min	Max	Step	Units	Format Code	Factory Default	Size in Words	850	869	889	845
30273	0x0110	Target Count	0	256	1		F0	0	1	Y	Y	Y	Y
30274	0x0111	Target Cause	0	0xFFFFFFFF	1		FC134	0	2	Y	Y	Y	Y

Follow these steps to obtain the Last Trip message:

1. Read address 30273 (0x0110) to obtain the Target Count.
2. Write the value obtained from Target Count register to select the Target Index register at address, for example: 40230 (0x00E5). This will position the Target Message Index at newest Target Message.
3. Read the Target Cause register for the newest Target Message to obtain the Target Message cause.

For example, here are 3 Target Messages, with a Target Count of 3.

Target Index # 3	GND IOC 1 OP
Target Index # 2	GND IOC 1 PKP
Target Index # 1	Link Error Primary

In this example, the following values are read from the Target Registers:

Target Index # 3 Value:	0x00CO, 0xF202
Target Index # 2 Value:	0x00CO, 0xF201
Target Index # 1 Value:	0x0000, 0x0037

In order to interpret the target messages, we need to refer to the appropriate function codes:

For Target Index #1: Link Error Primary

The value in Target Message Register 0111(hex) is 0x0000.

The value in Target Message Register 0112(hex) is 0x0037. 0x0037 = Decimal 55 - Link Error Primary (As per format FC134)

Format FC134 (See full description in Format Code Table)

Code	Type	Definition
FC134	Unsigned 32 bits	Cause of Event
	...	
	54	FLASH Error
	55	**Link Error Primary**
	56	Traffic Error Primary
	...	

For Target Index #2: GND IOC 1 Trip PKP

The value in Target Message Register 0111(hex) is 0x00C0. In the FC134 table below, this corresponds to Trip.

The value in Target Message Register 0112(hex) is 0xF201. In the FC134 table below, F2 corresponds to IOC 1, and 01 corresponds to Pickup.

Format FC134 Byte Assignments

0x00A0 - Alarm
0x00C0 - Trip
0x0080 - Configurable
0xF2xx - IOC 1
0xF4xx - IOC 2

0xF6xx - IOC 3
0xXX01 - Pickup
0xXX02 - Operate
0xXX04 - Dropout

For Target Index #3 - Last Trip: GND IOC 1 Trip OP

In this example, we see the GND IOC 1 Trip OP event logged as the last trip.

Las Trip Data Cause: GND IOC 1 Trip OPEvent Number: 768

Details about the Last Trip can be found in the Last Trip Modbus Registers:

Modbus Map entries, Last Trip

Modbus Address	Hex Address	Description	Min	Max	Step	Units	Format Code	Factory Default	Size in Words	850	869	889	845
31220	0x04C3	Cause	0	0xFFFFFFFF	1		FC134	0	2	Y	Y	Y	Y
31222	0x04C5	Event	0	4294967295	1		F10	0	2	Y	Y	Y	Y

Follow these steps to obtain information about the Last Trip:

1. Read address 31220 (0x04C3) to obtain the Last trip Data Cause. (32 bit).
2. Read address 31222 (0x04C5) to find the Event Number. (32 bit)

In this example, the value in Last Trip Cause Register 0x04C3(hex) is x00C0. In the FC134 table below, this corresponds to Trip.

The value in Last Trip Cause Register 0x04C4(hex) is 0xF202. In the FC134 table below, F2 corresponds to IOC 1, and 02 corresponds to Operate.

Format FC134 Byte Assignments

0x00A0 - Alarm
0x00C0 - Trip
0x0080 - Configurable
0xF2xx - IOC 1
0xF4xx - IOC 2
0xF6xx - IOC 3
0xXX01 - Pickup
0xXX02 - Operate
0xXX04 - Dropout

The value in Last Trip Event Register 0x04C5(hex) is 0x0000.

The value in Last Trip Event Register 0x04C6(hex) is 0x0300. 0x0300 = Decimal 768 - Event Number 768 (As per format F10)

Format F10 (See full description in Format Code Table)

Code	Type	Definition
F10	unsigned 32 bits	Unsigned Long Value
1st 16 bits		High Order Word of Long Value
2nd 16 bits		Low Order Word of Long Value

3.8.5 MODBUS COMMANDS

Command Value	Description	850	869	889	845
0	None	Y	Y	Y	Y
1	Reset	Y	Y	Y	Y
3	Open	Y	Y	Y	Y
4	Close	Y	Y	Y	Y
5	Open2	Y		Y	Y
6	Close2	Y		Y	Y
7	Open3				Y
8	Close3				Y
9	ChangeToSetpointGroup1	Y	Y	Y	Y
10	ChangeToSetpointGroup2	Y	Y	Y	Y
11	ChangeToSetpointGroup3	Y	Y	Y	Y
12	ChangeToSetpointGroup4	Y	Y	Y	Y
13	ChangeToSetpointGroup5	Y	Y	Y	Y
14	ChangeToSetpointGroup6	Y	Y	Y	Y
15	Active Group	Y	Y	Y	Y
18	Local	Y	Y	Y	Y
19	Remote	Y	Y	Y	Y
96	Clear All Records	Y	Y	Y	Y
97	Clear Targets	Y	Y	Y	Y
98	Clear Events	Y	Y	Y	Y
99	Clear Transient Records	Y	Y	Y	Y
100	Clear DataLogger	Y	Y	Y	Y
101	Clear Max Current Demand	Y	Y	Y	Y
102	Clear Min/Max Real Power Demand	Y	Y	Y	Y
103	Clear Min/Max Reactive Power Demand	Y	Y	Y	Y
104	Clear Min/Max Apparent Power Demand	Y	Y	Y	Y
105	Clear Energy Use Data	Y	Y	Y	Y
106	Clear Thermal Capacity	Y			
107	Clear Digital Counters	Y	Y	Y	Y
108	Clear BKR1 Arcing Current	Y	Y	Y	Y
109	Clear BKR1 Health Data	Y	Y	Y	Y
110	Clear BKR2 Arcing Current	Y		Y	Y
111	Clear BKR2 Health Data	Y		Y	Y

Command Value	Description	850	869	889	845
112	Clear BKR3 Arcing Current				Y
113	Clear BKR3 Health Data				Y
122	Reset Motor Info		Y		
123	RTD Maximums		Y	Y	Y
124	Reset Unauthorized Access	Y	Y	Y	Y
126	Clear Fault Reports	Y	Y	Y	Y
134	USER PushButton 1	Y	Y	Y	Y
135	USER PushButton 2	Y	Y	Y	Y
136	USER PushButton 3	Y	Y	Y	Y
137	Start Inhibit		Y		
199	MotorDLogClear		Y		
200	MotorDLogStart		Y		
201	MotorDLogStop		Y		
202	Trigger Waveform	Y	Y	Y	Y
210	Clear Autoreclose 1	Y			
211	Clear Broken Rotor Bar Data		Y		
213	Clear Motor Start Statistics		Y		
214	Clear Motor Learned Data		Y		
215	Clear Xfmr Loss of Life				Y
216	Clear Xfmr Learned Data				Y
217	Clear Xfmr Energization Records				Y
218	Clear Xfmr DFR Records				Y
219	Clear Xfmr Historic Max Record				Y
220	Clear DGA History				Y
222	Clear Running Hours			Y	
223	Clear Last Trip Data	Y	Y	Y	Y
224	Clear Stator Inter-Turn Fault		Y		
227	Clear Autoreclose 2	Y			
229	Clear Energy Log Data	Y	Y	Y	Y
230	Clear PwrQuality Data	Y	Y	Y	Y
240	USER PushButton 4	Y	Y	Y	Y
241	USER PushButton 5	Y	Y	Y	Y
242	USER PushButton 6	Y	Y	Y	Y

Command Value	Description	850	869	889	845
243	USER PushButton 7	Y	Y	Y	Y
244	USER PushButton 8	Y	Y	Y	Y
245	USER PushButton 9	Y	Y	Y	Y
246	USER PushButton 10	Y	Y	Y	Y
247	Reset Annunciator	Y	Y	Y	Y
248	TabPbNavBtn1Pressed	Y	Y	Y	Y
249	TabPbNavBtn2Pressed	Y	Y	Y	Y
250	TabPbNavBtn3Pressed	Y	Y	Y	Y
251	TabPbNavBtn4Pressed	Y	Y	Y	Y
252	TabPbNavBtnReleased	Y	Y	Y	Y
253	Acknowledge Annunciator	Y	Y	Y	Y
254	SW Cmd Open 1	Y	Y	Y	Y
255	SW Cmd Close 1	Y	Y	Y	Y
256	SW Cmd Open 2	Y	Y	Y	Y
257	SW Cmd Close 2	Y	Y	Y	Y
258	SW Cmd Open 3	Y	Y	Y	Y
259	SW Cmd Close 3	Y	Y	Y	Y
260	SW Cmd Open 4	Y	Y	Y	Y
261	SW Cmd Close 4	Y	Y	Y	Y
262	SW Cmd Open 5	Y	Y	Y	Y
263	SW Cmd Close 5	Y	Y	Y	Y
264	SW Cmd Open 6	Y	Y	Y	Y
265	SW Cmd Close 6	Y	Y	Y	Y
266	SW Cmd Open 7	Y	Y	Y	Y
267	SW Cmd Close 7	Y	Y	Y	Y
268	SW Cmd Open 8	Y	Y	Y	Y
269	SW Cmd Close 8	Y	Y	Y	Y
270	SW Cmd Open 9	Y	Y	Y	Y
271	SW Cmd Close 9	Y	Y	Y	Y
278	Clear OHSW Arcing Current	Y			
279	Clear OHSW Health Data	Y			
280	Clear RCL Arcing Current	Y			
281	Clear RCL Health Data	Y			

Command Value	Description	850	869	889	845
282	Clear RCL Wear Data	Y			
283	Clear Auto Sectionalizer	Y			
284	Clear Auto Reclose	Y			
4096	Force Virtual Input 1	Y	Y	Y	Y
4097	Force Virtual Input 2	Y	Y	Y	Y
4098	Force Virtual Input 3	Y	Y	Y	Y
4099	Force Virtual Input 4	Y	Y	Y	Y
4100	Force Virtual Input 5	Y	Y	Y	Y
4101	Force Virtual Input 6	Y	Y	Y	Y
4102	Force Virtual Input 7	Y	Y	Y	Y
4103	Force Virtual Input 8	Y	Y	Y	Y
4104	Force Virtual Input 9	Y	Y	Y	Y
4105	Force Virtual Input 10	Y	Y	Y	Y
4106	Force Virtual Input 11	Y	Y	Y	Y
4107	Force Virtual Input 12	Y	Y	Y	Y
4108	Force Virtual Input 13	Y	Y	Y	Y
4109	Force Virtual Input 14	Y	Y	Y	Y
4110	Force Virtual Input 15	Y	Y	Y	Y
4111	Force Virtual Input 16	Y	Y	Y	Y
4112	Force Virtual Input 17	Y	Y	Y	Y
4113	Force Virtual Input 18	Y	Y	Y	Y
4114	Force Virtual Input 19	Y	Y	Y	Y
4115	Force Virtual Input 20	Y	Y	Y	Y
4116	Force Virtual Input 21	Y	Y	Y	Y
4117	Force Virtual Input 22	Y	Y	Y	Y
4118	Force Virtual Input 23	Y	Y	Y	Y
4119	Force Virtual Input 24	Y	Y	Y	Y
4120	Force Virtual Input 25	Y	Y	Y	Y
4121	Force Virtual Input 26	Y	Y	Y	Y
4122	Force Virtual Input 27	Y	Y	Y	Y
4123	Force Virtual Input 28	Y	Y	Y	Y
4124	Force Virtual Input 29	Y	Y	Y	Y
4125	Force Virtual Input 30	Y	Y	Y	Y

Command Value	Description	850	869	889	845
4126	Force Virtual Input 31	Y	Y	Y	Y
4127	Force Virtual Input 32	Y	Y	Y	Y

3.9 ETHERNET/IP

EtherNet/IP (Ethernet/Industrial Protocol) is a communication system designed for industrial settings. It enables devices such as protection relays to exchange application data. EtherNet/IP uses standard Ethernet (IEEE 802.3) and TCP/IP technologies to transport Common Industrial Protocol (CIP) data packets. The system operates on a producer/consumer model for transferring time-sensitive control information. This model allows a sending device (e.g., a relay) to send data to multiple receiving devices (e.g., control stations, PLCs) without needing to transmit the data to each destination individually. Firmware version 4.3 onwards supports EtherNet/IP.

3.9.1 EDS FILE

Device configuration support is facilitated through a specially formatted, machine-readable ASCII file known as the Electronic Data Sheet (EDS). An EDS provides details regarding the device configuration data, including its context, content, and format. This information enables configuration tools to display informative screens that guide users through the steps required to configure a device. Additionally, an EDS incorporate vendor-specific information alongside the essential device parameter data specified by this documentation. The EDS files of Multilin 8 Series located online under Manuals on the web site for each 8 Series relay:

https://www.gevernova.com/grid-solutions/multilin/catalog/8_series.htm

Note:
EDS files for all 8 Series relays are included in the same package. There are several EDS files available, and the one matching the relay type and firmware version (4.3 onwards) should be used.

3.9.2 CIP DATA MODEL

The Common Industrial Protocol (CIP) is a peer-to-peer, object-oriented protocol designed to establish connections between industrial devices and higher-level devices. Notably, CIP operates independently of the physical media and data link layer. CIP utilizes abstract object modeling to define the range of communication services offered, the observable behavior of a CIP node and a standardized method for accessing and exchanging information within CIP products. Within CIP, a node is represented as a collection of Objects, each offering an abstract depiction of specific components within a product.

3.9.2.1 OBJECT MODEL

CIP Data Model Classes

Class		Number of Instances
Name	ID	
Identity Object	0x01	1
Message Router Object	0x02	1
Assembly Object	0x04	2
Connection Manager object	0x06	1
TCP Object	0xF5	1
Ethernet Link Object	0xF6	1

3.9.2.2 IDENTITY OBJECT

The following tables contain the attribute, status, and common services information for the Identity Object.

Identity Object Attributes

Attribute ID	Name	CIP Data Type	Data Value	Access Rule
1	Revision	UINT	2	Get
2	Max Instance	UINT	1	Get
3	Number of Instances	UINT	1	Get
4	Optional Attribute List	Struct of UINT: number of attributes ARRAY of UINTS: optional Attributes	0	Get
5	Optional Service List	Struct of UINT: Number of services ARRAY of UINT: Optional Services	0	Get
6	Max Number Class Attributes	UINT	7	Get
7	Max Number of Instance Attributes	UINT	7	Get

Identity Object/Instance 1

Attribute ID	Name	CIP Data Type	Data Value	Access Rule
1	Vendor ID	UINT	50	Get
2	Device type	UINT	0x2B	Get
3	Product code number	UINT	50	Get
4	Product major revision Product minor revision	USINT USINT	2 112	Get
5	Status	WORD	See following Table	Get
6	Serial number	UDINT	From Config	Get
7	Product name	SHORT STRING32	EIP	Get

Bit Definitions for Status Instance Attribute of Identity Object

Bit(s)	Called	Definition
0	Owned	TRUE indicates the device (or an object within the device) has an owner. Typically, this will be due to the device being an end point of an I/O connection to an ownable resource within the device, such as output data. A resource may also be owned through explicit messaging. The existence of an I/O connection alone does not indicate ownership, such as may be present through a CIP router.
2	Configured	TRUE indicates the application of the device has been configured to do something different than the "out–of–box" default. This shall not include configuration of the communications.
4-7	Extended Device Status	2 - At least one faulted I/O connection 3 - No I/O connections established 6 - At least one I/O connection in run mode 7 - At least one I/O connection established, all in Idle mode
8	Minor recoverable Fault	True indicates the device detected a problem with itself, which is thought to be recoverable. The problem does not cause the device to go into one of the faulted states.
9	Minor unrecoverable Fault	TRUE indicates the device detected a problem with itself, which is thought to be unrecoverable. The problem does not cause the device to go into one of the faulted states.

Bit(s)	Called	Definition
10	Major recoverable Fault	TRUE indicates the device detected a problem with itself, which caused the device to go into the "Major Recoverable Fault" state.
11	major unrecoverable Fault	TRUE indicates the device detected a problem with itself, which caused the device to go into the "Major Unrecoverable Fault" state.

Identity Object Common Services

Service Code	Class level	Instance level	Service Name
0x01	No	Yes	Get_Attribute_All
0x05	No	Yes	Reset
0x0E	Yes	Yes	Get_Attribute_Single

3.9.2.3 MESSAGE ROUTER OBJECT

The following tables contain the attribute, status, and common services information for the Message Router Object.

Message Router Object Attributes

Attribute ID	Name	CIP Data Type	Data Value	Access Rule
1	Revision	UINT	1	Get
2	Max Instance	UINT	1	Get
3	Number of Instances	UINT	1	Get
4	Optional Attribute List	Struct of UINT: number of attributes ARRAY of UINTS: optional Attributes	0	Get
5	Optional Service List	Struct of UINT: Number of services ARRAY of UINT: Optional Services	0	Get
6	Max Number Class Attributes	UINT	7	Get
7	Max Number of Instance Attributes	UINT	3	Get

Message Router Object / Instance 1

Attribute ID	Name	CIP Data Type	Data Value	Access Rule
1	Class List	Struct of UINT: number of attributes ARRAY of UINTS: optional Attributes		Get
2	Maximum Connections	UINT		Get
3	Number connections	UINT		Get

Message Router Object Common Services

Service Code	Class level	Instance level	Service Name
0x01	No	Yes	Get_Attribute_All
0x0E	Yes	Yes	Get_Attribute_Single

3.9.2.4 ASSEMBLY OBJECT

The following table contains the attribute, instance, data mapping and common services for the Assembly Object.

Assembly Object Attributes

Attribute ID	Name	CIP Data Type	Data Value	Access Rule
1	Revision	UINT	2	Get
2	Max instance	UINT	239 (0xEF)	Get
3	Number of Instances	UINT	2	Get
4	Optional Attribute List	Struct of UINT: number of attributes ARRAY of UINTS: optional Attributes	0	Get
5	Optional Service List	Struct of UINT: Number of services ARRAY of UINT: Optional Services	0	Get
6	Max Number Class Attributes	UINT	7	Get
7	Max Number of Instance Attributes	UINT	3	Get

Assembly Object/ Instance 100 (0x64)- 109 (0x6D)

Attribute ID	Name	CIP Data Type	Data Value	Access Rule
3	T2O (Input)	Array of USINT	Varies	Get

Assembly Object/ Instance 112 (0x70)

Attribute ID	Name	CIP Data Type	Data Value	Access Rule
3	O2T (Output)	Array of USINT	Varies	Get/Set

Assembly Object Common Services

Service Code	Class level	Instance level	Service Name
0x01	No	Yes	Get_Attribute_All
0x0E	Yes	Yes	Get_Attribute_Single
0x10	N00	Yes	Set_Attribute_Single

3.9.2.5 CONNECTION MANAGER OBJECT

The following table contains the attribute, instance, data mapping and common services for the Assembly Object

Connection Manager Object Attributes

Attribute ID	Name	CIP Data Type	Data Value	Access Rule
1	Revision	UINT	1	Get
2	Max Instance	UINT	1	Get
3	Number of Instances	UINT	1	Get
4	Optional Attribute List	Struct of UINT: number of attributes ARRAY of UINTS: optional Attributes	0	Get
5	Optional Service List	Struct of UINT: Number of services ARRAY of UINT: Optional Services	0	Get
6	Max Number Class Attributes	UINT	7	Get
7	Max Number of Instance Attributes	UINT	0	Get

Connection Manager Common Services

Service Code	Class level	Instance level	Service Name
0x01	No	Yes	Get_Attribute_All
0x0E	Yes	Yes	Get_Attribute_Single

3.9.2.6 TCP OBJECT

The following table contains the attributes and common services for the TCP Object.

TCP Object Attributes

Attribute ID	Name	Data Type	Data Value	Access Rule
1	Revision	UINT	4	Get
2	Max Instance	UINT	1	Get
3	Number of Instances	UINT	1	Get
4	Optional Attribute List	Struct of UINT: number of attributes ARRAY of UINTS: optional Attributes	0	Get
5	Optional Service List	Struct of UINT: Number of services ARRAY of UINT: Optional Services	0	Get
6	Max Number Class Attributes	UINT	7	Get
7	Max Number of Instance Attributes	UINT	13	Get

TCP Object / Instance 1

Attribute ID	Name	Data Type	Data Value	Access Rule
1	Status	DWORD	Varies	Get
2	Configuration capability	DWORD	Varies	Get
3	Configuration control*	DWORD	Varies	Get

4	Physical Link Object Structure of Path Size Path	 UINT Array of Word	 Varies	Get
5	Interface configuration Structure of IP Address Network Mask Gateway Address Name Server Name Server 2 Domain Name	 UDINT UDINT UDINT UDINT UDINT STRING	 Varies Varies Varies Varies Varies Varies	Get
6	Host name*	STRING	Varies	Get
13	Encapsulation Inactivity Timeout*	UINT	Varies	Set

TCP Object Common Services

Service Code	Class level	Instance level	Service Name
0x01	No	Yes	Get_Attribute_All
0x0E	Yes	Yes	Get_Attribute_Single

3.9.2.7 ETHERNET LINK OBJECT

The following table contains the attributes and common service information for the Ethernet Link Object.

EtherNet Link Object Attributes

Attribute ID	Name	Data Type	Data Value	Access Rule
1	Revision	UINT	4	Get
2	Max Instance	UINT	1	Get
3	Number of Instances	UINT	1	Get
4	Optional Attribute List	Struct of UINT: number of attributes ARRAY of UINTS: optional Attributes	0	Get
5	Optional Service List	Struct of UINT: Number of services ARRAY of UINT: Optional Services	0	Get
6	Max Number Class Attributes	UINT	7	Get
7	Max Number of Instance Attributes	UINT	11	Get

EtherNet Link Object / Instance 1

Attribute ID	Name	Data Type	Data Value	Access Rule
1	Interface speed*	UDINT	Varies	Get
2	Interface flags*	DWORD	Varies	Get
3	Physical address	USINT Array (6)	Varies	Get

Attribute ID	Name	Data Type	Data Value	Access Rule
11	Interface Capability Structure of Capability Bits Structure of Speed/Duplex Array Count Structure of Interface Speed Interface Duplex Mode	 DWORD USINT UINT USINT	 Varies Varies Varies Varies	Get

Ethernet Link Object Common Services

Service Code	Class level	Instance level	Service Name
0x01	No	Yes	Get_Attribute_All
0x0E	Yes	Yes	Get_Attribute_Single

3.9.3 SIGNAL LIST

Signals available through Ethernet/IP are grouped into three main categories. The first group includes digital signals. Based on the relay order code, digital values of 60 contact inputs (CI), 256 virtual inputs(VI), 256 virtual outputs(VO), and 30 auxiliary relays are available through Ethernet/IP. In addition, the digital signals listed in following Table are also available.

Digital Signals Available through Ethernet/IP

Signal Name	850	869	889	845	859
In-Service	Y	Y	Y	Y	Y
Any Trip	Y	Y	Y	Y	Y
Any Alarm	Y	Y	Y	Y	Y
Any PKP	Y	Y	Y	Y	Y
Local Mode ON	Y	Y	Y	Y	Y
BKR1 Opened	Y	Y	Y	Y	Y
BKR1 Closed	Y	Y	Y	Y	Y
Motor Starting		Y			
Motor Running		Y			
Motor Stopped		Y			
Motor Overload		Y			
Motor Tripped		Y			

For all 8 Series products, three command signals, including “Open”, “Close” and “Reset”, are available through Ethernet\IP.

Moreover, analogue values also publish through Ethernet/IP as following list. Some signals might be unavailable based the relay type and order code.

Analog Signals Available through Ethernet/IP

Signal Name	850	869	889	845	859
J1 Ia	Y	Y	Y	Y	Y
J1 Ib	Y	Y	Y	Y	Y
J1 Ic	Y	Y	Y	Y	Y
J1 Ig	Y	Y	Y	Y	Y

Signal Name	850	869	889	845	859
J1 In	Y	Y	Y	Y	Y
J1 Ia RMS	Y	Y	Y	Y	Y
J1 Ib RMS	Y	Y	Y	Y	Y
J1 Ic RMS	Y	Y	Y	Y	Y
J1 Ig RMS	Y	Y	Y	Y	Y
J1 In RMS	Y	Y	Y	Y	Y
J1 Ia Angle	Y	Y	Y	Y	Y
J1 Ib Angle	Y	Y	Y	Y	Y
J1 Ic Angle	Y	Y	Y	Y	Y
J1 Ig Angle	Y	Y	Y	Y	Y
J1 In Angle	Y	Y	Y	Y	Y
J1 I AVG	Y	Y	Y	Y	Y
J1 I_0	Y	Y	Y	Y	Y
J1 I_1	Y	Y	Y	Y	Y
J1 I_2	Y	Y	Y	Y	Y
J1 I_0 Angle	Y	Y	Y	Y	Y
J1 I_1 Angle	Y	Y	Y	Y	Y
J1 I_2 Angle	Y	Y	Y	Y	Y
J1 Igd	Y		Y	Y	
J1 Igd Angle	Y		Y	Y	
J1 Load	Y	Y	Y	Y	Y
J1 Ia Peak		Y			Y
J1 Ib Peak		Y			Y
J1 Ic Peak		Y			Y
K1 Ia	Y	Y	Y	Y	Y
K1 Ib	Y	Y	Y	Y	Y
K1 Ic	Y	Y	Y	Y	Y
K1 Ig	Y	Y	Y	Y	Y
K1 In	Y	Y	Y	Y	Y
K1 Ia RMS	Y	Y	Y	Y	Y
K1 Ib RMS	Y	Y	Y	Y	Y
K1 Ic RMS	Y	Y	Y	Y	Y
K1 Ig RMS	Y	Y	Y	Y	Y
K1 In RMS	Y	Y	Y	Y	Y
K1 Ia Angle	Y	Y	Y	Y	Y
K1 Ib Angle	Y	Y	Y	Y	Y
K1 Ic Angle	Y	Y	Y	Y	Y
K1 Ig Angle	Y	Y	Y	Y	Y
K1 In Angle	Y	Y	Y	Y	Y
K1 I AVG	Y	Y	Y	Y	Y
K1 I_0	Y	Y	Y	Y	Y
K1 I_1	Y	Y	Y	Y	Y
K1 I_2	Y	Y	Y	Y	Y

Signal Name	850	869	889	845	859
K1 I_0 Angle	Y	Y	Y	Y	Y
K1 I_1 Angle	Y	Y	Y	Y	Y
K1 I_2 Angle	Y	Y	Y	Y	Y
K1 Igd	Y		Y	Y	
K1 Igd Angle	Y		Y	Y	
K1 Load	Y		Y	Y	
K1 Ia Peak		Y			
K1 Ib Peak		Y			
K1 Ic Peak		Y			
K2 Ia	Y		Y	Y	
K2 Ib	Y		Y	Y	
K2 Ic	Y		Y	Y	
K2 Ig	Y		Y	Y	
K2 In	Y		Y	Y	
K2 Ia RMS	Y		Y	Y	
K2 Ib RMS	Y		Y	Y	
K2 Ic RMS	Y		Y	Y	
K2 Ig RMS	Y		Y	Y	
K2 In RMS	Y		Y	Y	
K2 Ia Angle	Y		Y	Y	
K2 Ib Angle	Y		Y	Y	
K2 Ic Angle	Y		Y	Y	
K2 Ig Angle	Y		Y	Y	
K2 In Angle	Y		Y	Y	
K2 I AVG	Y		Y	Y	
K2 I_0	Y		Y	Y	
K2 I_1	Y		Y	Y	
K2 I_2	Y		Y	Y	
K2 I_0 Angle	Y		Y	Y	
K2 I_1 Angle	Y		Y	Y	
K2 I_2 Angle	Y		Y	Y	
K2 Igd	Y		Y	Y	
K2 Igd Angle	Y		Y	Y	
J2 Van	Y	Y	Y	Y	Y
J2 Vbn	Y	Y	Y	Y	Y
J2 Vcn	Y	Y	Y	Y	Y
J2 Vab	Y	Y	Y	Y	Y
J2 Vbc	Y	Y	Y	Y	Y
J2 Vca	Y	Y	Y	Y	Y
J2 Vn	Y	Y	Y	Y	Y
J2 Vaux	Y	Y	Y	Y	Y
J2 Van RMS	Y	Y	Y	Y	Y
J2 Vbn RMS	Y	Y	Y	Y	Y

Signal Name	850	869	889	845	859
J2 Vcn RMS	Y	Y	Y	Y	Y
J2 Vab RMS	Y	Y	Y	Y	Y
J2 Vbc RMS	Y	Y	Y	Y	Y
J2 Vca RMS	Y	Y	Y	Y	Y
J2 Vn RMS	Y	Y	Y	Y	Y
J2 Vaux RMS	Y	Y	Y	Y	Y
J2 Van Angle	Y	Y	Y	Y	Y
J2 Vbn Angle	Y	Y	Y	Y	Y
J2 Vcn Angle	Y	Y	Y	Y	Y
J2 Vab Angle	Y	Y	Y	Y	Y
J2 Vbc Angle	Y	Y	Y	Y	Y
J2 Vca Angle	Y	Y	Y	Y	Y
J2 Vn Angle	Y	Y	Y	Y	Y
J2 Vaux Angle	Y	Y	Y	Y	Y
J2 V AVG L-L	Y	Y	Y	Y	Y
J2 V AVG L-N	Y	Y	Y	Y	Y
J2 V0	Y	Y	Y	Y	Y
J2 V1	Y	Y	Y	Y	Y
J2 V2	Y	Y	Y	Y	Y
J2 V0 Angle	Y	Y	Y	Y	Y
J2 V1 Angle	Y	Y	Y	Y	Y
J2 V2 Angle	Y	Y	Y	Y	Y
K2 Van	Y		Y		
K2 Vbn	Y		Y		
K2 Vcn	Y		Y		
K2 Vab	Y		Y		
K2 Vbc	Y		Y		
K2 Vca	Y		Y		
K2 Vn	Y		Y		
K2 Vaux	Y		Y		
K2 Van RMS	Y		Y		
K2 Vbn RMS	Y		Y		
K2 Vcn RMS	Y		Y		
K2 Vab RMS	Y		Y		
K2 Vbc RMS	Y		Y		
K2 Vca RMS	Y		Y		
K2 Vn RMS	Y		Y		
K2 Vaux RMS	Y		Y		
K2 Van Angle	Y		Y		
K2 Vbn Angle	Y		Y		
K2 Vcn Angle	Y		Y		
K2 Vab Angle	Y		Y		
K2 Vbc Angle	Y		Y		

Signal Name	850	869	889	845	859
K2 Vca Angle	Y		Y		
K2 Vn Angle	Y		Y		
K2 Vaux Angle	Y		Y		
K2 V AVG L-L	Y		Y		
K2 V AVG L-N	Y		Y		
K2 V0	Y		Y		
K2 V1	Y		Y		
K2 V2	Y		Y		
K2 V0 Angle	Y		Y		
K2 V1 Angle	Y		Y		
K2 V2 Angle	Y		Y		
Frequency	Y	Y	Y	Y	Y
Pwr1 Real	Y	Y	Y	Y	Y
Pwr1 Reactive	Y	Y	Y	Y	Y
Pwr1 Apparent	Y	Y	Y	Y	Y
Pwr1 Ph A Real	Y	Y	Y	Y	Y
Pwr1 Ph B Real	Y	Y	Y	Y	Y
Pwr1 Ph C Real	Y	Y	Y	Y	Y
Pwr1 Ph A Reactive	Y	Y	Y	Y	Y
Pwr1 Ph B Reactive	Y	Y	Y	Y	Y
Pwr1 Ph C Reactive	Y	Y	Y	Y	Y
Pwr1 Ph A Apparent	Y	Y	Y	Y	Y
Pwr1 Ph B Apparent	Y	Y	Y	Y	Y
Pwr1 Ph C Apparent	Y	Y	Y	Y	Y
Pwr1 PF	Y	Y	Y	Y	Y
Pwr1 Ph A PF	Y	Y	Y	Y	Y
Pwr1 Ph B PF	Y	Y	Y	Y	Y
Pwr1 Ph C PF	Y	Y	Y	Y	Y
Reset Energy D/T	Y	Y	Y	Y	Y
Reset Energy Time (us)	Y	Y	Y	Y	Y
Pwr1 Pos WattHours	Y	Y	Y	Y	Y
Pwr1 Pos WattHours Cost	Y				
Pwr1 Neg WattHours	Y	Y	Y	Y	Y
Pwr1 Neg WattHours Cost	Y				
Pwr1 Pos VarHours	Y	Y	Y	Y	Y
Pwr1 Neg VarHours	Y	Y	Y	Y	Y
J1 Phase A THD	Y	Y	Y	Y	Y
J1 Phase B THD	Y	Y	Y	Y	Y
J1 Phase C THD	Y	Y	Y	Y	Y
J2 Phase A THD	Y	Y	Y	Y	Y
J2 Phase B THD	Y	Y	Y	Y	Y
J2 Phase C THD	Y	Y	Y	Y	Y
RTD 1	Y	Y	Y	Y	Y

Signal Name	850	869	889	845	859
RTD 2	Y	Y	Y	Y	Y
RTD 3	Y	Y	Y	Y	Y
RTD 4	Y	Y	Y	Y	Y
RTD 5	Y	Y	Y	Y	Y
RTD 6	Y	Y	Y	Y	Y
RTD 7	Y	Y	Y	Y	Y
RTD 8	Y	Y	Y	Y	Y
RTD 9	Y	Y	Y	Y	Y
RTD 10	Y	Y	Y	Y	Y
RTD 11	Y	Y	Y	Y	Y
RTD 12	Y	Y	Y	Y	Y
RTD 13	Y	Y	Y	Y	
Motor Status		Y			Y
Thermal Capacity Used		Y			Y
Estimated Trip Time on OL		Y			Y
Thermal Lockout Time		Y			Y
Max Start Rate LO Time		Y			Y
Time Btwn Starts LO Time		Y			Y
Restart Delay LO Time		Y			Y
Total Motor Lockout Time		Y			Y
Motor Speed		Y			Y
Motor Running Hours		Y			Y
Motor Load		Y			Y
Current Unbalance		Y			Y
Therm Model Biased Load			Y		
Fltd Motor Load		Y			Y
Fltd RMS Cur A		Y			Y
Fltd RMS Cur B		Y			Y
Fltd RMS Cur C		Y			Y
Fltd Mag Cur A		Y			Y
Fltd Mag Cur B		Y			Y
Fltd Mag Cur C		Y			Y
Motor Voltage Unbalance		Y			Y

3.10 OPC UA OVERVIEW

This section describes the implementation process for the OPC-UA (Open Platform Communications - Unified Architecture) in the 8 Series relays.

OPC UA is a platform-independent standard through which various kinds of systems and devices can communicate by sending request and response Messages between Clients and Servers.

3.10.1 OPC UA INTRODUCTION

The OPC Foundation, a consortium of prominent manufacturers dedicated to defining standard interfaces, has developed numerous software interfaces over the years to streamline information flow from the process level to the management level. Historically, various OPC (Open Platform Communications) specifications were crafted to address differing industrial application needs, including Data Access (DA), Alarm & Events (A&E), Historical Data Access (HDA), and Data eXchange (DX).

Building on the insights gained from these traditional OPC interfaces, the OPC Foundation introduced the OPC Unified Architecture (UA), a new platform aimed at providing a generic description and uniform access to all information exchanged between systems or applications. This standard encompasses the functionalities of all preceding OPC interfaces and offers the ability to natively integrate the interface into any system, regardless of the operating system or programming language employed. OPC UA provides a standardized framework for information exchange between components and systems and is recognized as the IEC 62541 standard, forming the basis for other international standards.

OPC UA encompasses several key features:

• Integration of all previous OPC functionalities, such as DA, A&E, and HDA, into a generic interface.

• Utilization of open, platform-independent protocols for interprocess and network communication.

• Capability for Internet access and communication through firewalls.

• Built-in access control and security mechanisms at both protocol and application levels.

• Comprehensive mapping options for object-oriented models, allowing objects to have tags, methods, and event-triggering capabilities.

• Extensible type system accommodating complex data types and objects.

• Transport mechanisms and modeling rules that underpin other standards.

• Scalability from small embedded systems to enterprise applications

3.10.2 OPC UA ADDRESS SPACE

The OPC UA Address Space serves as a hierarchical, object-oriented framework within an OPC UA server. It organizes data, metadata, and services for client access through a network-like structure comprised of nodes. These nodes include Objects, Variables, Methods, Views, DataTypes, References, and ObjectTypes, and are interconnected via references. Nodes can represent both physical and abstract entities, such as devices or process values, and come with attributes like value and description. Clients browse the Address Space to discover and interact with server data. In 8 Series OPC UA, clients only have Read/Monitor Services to access Variable values, guided by the Address Space structure.

3.10.3 OPC UA SIGNAL LIST

Thes signals available through OPC UA are categorized in three different type; Analog, Digital and Command. The command in all the 8 Series relays include three signals; Close Breaker, Open Breaker, and Reset. The Digital and Analog signals availability based on relay type are as following tables.

List of Digital Signals Available through OPC UA server

Signal Name	845	850	859	869	889
Contact Input 1	Y	Y	Y	Y	Y
Contact Input 2	Y	Y	Y	Y	Y
Contact Input 3	Y	Y	Y	Y	Y
Contact Input 4	Y	Y	Y	Y	Y
Contact Input 5	Y	Y	Y	Y	Y
Contact Input 6	Y	Y	Y	Y	Y
Contact Input 7	Y	Y		Y	Y
Contact Input 8	Y	Y		Y	Y
Contact Input 9	Y	Y		Y	Y
Contact Input 10	Y	Y		Y	Y
Contact Input 11	Y	Y		Y	Y
Contact Input 12	Y	Y		Y	Y
Contact Input 13	Y	Y		Y	Y
Contact Input 14	Y	Y		Y	Y
Contact Input 15	Y	Y		Y	Y
Contact Input 16	Y	Y		Y	Y
Contact Input 17	Y	Y		Y	Y
Contact Input 18	Y	Y		Y	Y
Contact Input 19	Y	Y		Y	Y
Contact Input 20	Y	Y		Y	Y
Contact Input 21	Y	Y		Y	Y
Contact Input 22	Y	Y		Y	Y
Contact Input 23	Y	Y		Y	Y
Contact Input 24	Y	Y		Y	Y
Contact Input 25	Y	Y		Y	Y
Contact Input 26	Y	Y		Y	Y
Contact Input 27	Y	Y		Y	Y
Contact Input 28	Y	Y		Y	Y
Contact Input 29	Y	Y		Y	Y
Contact Input 30	Y	Y		Y	Y
Contact Input 31	Y	Y		Y	Y
Contact Input 32	Y	Y		Y	Y
Contact Input 33	Y	Y		Y	Y
Contact Input 34	Y	Y		Y	Y
Contact Input 35	Y	Y		Y	Y
Contact Input 36	Y	Y		Y	Y
Contact Input 37	Y	Y		Y	Y
Contact Input 38	Y	Y		Y	Y
Contact Input 39	Y	Y		Y	Y
Contact Input 40	Y	Y		Y	Y

Signal Name	845	850	859	869	889
Contact Input 41	Y	Y		Y	Y
Contact Input 42	Y	Y		Y	Y
Contact Input 43	Y	Y		Y	Y
Contact Input 44	Y	Y		Y	Y
Contact Input 45	Y	Y		Y	Y
Contact Input 46	Y	Y		Y	Y
Contact Input 47	Y	Y		Y	Y
Contact Input 48	Y	Y		Y	Y
Contact Input 49	Y	Y		Y	Y
Contact Input 50	Y	Y		Y	Y
Contact Input 51	Y	Y		Y	Y
Contact Input 52	Y	Y		Y	Y
Contact Input 53	Y	Y		Y	Y
Contact Input 54	Y	Y		Y	Y
Contact Input 55	Y	Y		Y	Y
Contact Input 56	Y	Y		Y	Y
Contact Input 57	Y	Y		Y	Y
Contact Input 58	Y	Y		Y	Y
Contact Input 59	Y	Y		Y	Y
Contact Input 60	Y	Y		Y	Y
Contact Output 1	Y	Y	Y	Y	Y
Contact Output 2	Y	Y	Y	Y	Y
Contact Output 3	Y	Y	Y	Y	Y
Contact Output 4	Y	Y	Y	Y	Y
Contact Output 5	Y	Y		Y	Y
Contact Output 6	Y	Y		Y	Y
Contact Output 7	Y	Y		Y	Y
Contact Output 8	Y	Y		Y	Y
Contact Output 9	Y	Y		Y	Y
Contact Output 10	Y	Y		Y	Y
Contact Output 11	Y	Y		Y	Y
Contact Output 12	Y	Y		Y	Y
Contact Output 13	Y	Y		Y	Y
Contact Output 14	Y	Y		Y	Y
Contact Output 15	Y	Y		Y	Y
Contact Output 16	Y	Y		Y	Y
Contact Output 17	Y	Y		Y	Y
Contact Output 18	Y	Y		Y	Y
Contact Output 19	Y	Y		Y	Y
Contact Output 20	Y	Y		Y	Y
Contact Output 21	Y	Y		Y	Y

Signal Name	845	850	859	869	889
Contact Output 22	Y	Y		Y	Y
Contact Output 23	Y	Y		Y	Y
Contact Output 24	Y	Y		Y	Y
Contact Output 25	Y	Y		Y	Y
Contact Output 26	Y	Y		Y	Y
Contact Output 27	Y	Y		Y	Y
Contact Output 28	Y	Y		Y	Y
Contact Output 29	Y	Y		Y	Y
Contact Output 30	Y	Y		Y	Y
Phase IOC1 Pkp general	Y	Y	Y	Y	Y
Phase IOC1 Op general	Y	Y	Y	Y	Y
Phase IOC1 Pkp phsA	Y	Y	Y	Y	Y
Phase IOC1 Op phsA	Y	Y	Y	Y	Y
Phase IOC1 Pkp phsB	Y	Y	Y	Y	Y
Phase IOC1 Op phsB	Y	Y	Y	Y	Y
Phase IOC1 Pkp phsC	Y	Y	Y	Y	Y
Phase IOC1 Op phsC	Y	Y	Y	Y	Y
Phase IOC2 Pkp general	Y	Y	Y	Y	Y
Phase IOC2 Op general	Y	Y	Y	Y	Y
Phase IOC2 Pkp phsA	Y	Y	Y	Y	Y
Phase IOC2 Op phsA	Y	Y	Y	Y	Y
Phase IOC2 Pkp phsB	Y	Y	Y	Y	Y
Phase IOC2 Op phsB	Y	Y	Y	Y	Y
Phase IOC2 Pkp phsC	Y	Y	Y	Y	Y
Phase IOC2 Op phsC	Y	Y	Y	Y	Y
Neutral IOC1 Pkp	Y	Y	Y	Y	Y
Neutral IOC1 Op	Y	Y	Y	Y	Y
Neutral IOC2 Pkp	Y	Y	Y	Y	Y
Neutral IOC2 Op	Y	Y	Y	Y	Y
Ground IOC1 Pkp	Y	Y	Y	Y	Y
Ground IOC1 Op	Y	Y	Y	Y	Y
Ground IOC2 Pkp	Y	Y			Y
Ground IOC2 Op	Y	Y			Y
Sens ground IOC1 Pkp		Y			
Sens ground IOC1 Op		Y			
Sens ground IOC2 Pkp		Y			
Sens ground IOC2 Op		Y			
Neg Seq IOC1 Pkp	Y	Y	Y	Y	Y
Neg Seq IOC1 Op	Y	Y	Y	Y	Y
Neg Seq IOC2 Pkp	Y	Y			Y
Neg Seq IOC2 Op	Y	Y			Y

Signal Name	845	850	859	869	889
Phase TOC1 Pkp general	Y	Y	Y	Y	Y
Phase TOC1 Op general	Y	Y	Y	Y	Y
Phase TOC1 Pkp phsA	Y	Y	Y	Y	Y
Phase TOC1 Op phsA	Y	Y	Y	Y	Y
Phase TOC1 Pkp phsB	Y	Y	Y	Y	Y
Phase TOC1 Op phsB	Y	Y	Y	Y	Y
Phase TOC1 Pkp phsC	Y	Y	Y	Y	Y
Phase TOC1 Op phsC	Y	Y	Y	Y	Y
Phase TOC2 Pkp general	Y	Y			Y
Phase TOC2 Op general	Y	Y			Y
Phase TOC2 Pkp phsA	Y	Y			Y
Phase TOC2 Op phsA	Y	Y			Y
Phase TOC2 Pkp phsB	Y	Y			Y
Phase TOC2 Op phsB	Y	Y			Y
Phase TOC2 Pkp phsC	Y	Y			Y
Phase TOC2 Op phsC	Y	Y			Y
Neutral TOC1 Pkp	Y	Y	Y	Y	Y
Neutral TOC1 Op	Y	Y	Y	Y	Y
Neutral TOC2 Pkp	Y	Y			Y
Neutral TOC2 Op	Y	Y			Y
Ground TOC1 Pkp	Y	Y	Y	Y	Y
Ground TOC1 Op	Y	Y	Y	Y	Y
Ground TOC2 Pkp	Y	Y			Y
Ground TOC2 Op	Y	Y			Y
Sens ground TOC1 Pkp		Y			Y
Sens ground TOC1 Op		Y			Y
Sens ground TOC2 Pkp		Y			
Sens ground TOC2 Op		Y			
Neg Seq TOC1 Pkp	Y	Y		Y	
Neg Seq TOC1 Op	Y	Y		Y	
Neg Seq TOC2 Pkp	Y	Y			
Neg Seq TOC2 Op	Y	Y			
Phase TOV1 Pkp general	Y	Y	Y	Y	Y
Phase TOV1 Op general	Y	Y	Y	Y	Y
Phase TOV1 Pkp phsA	Y	Y	Y	Y	Y
Phase TOV1 Op phsA	Y	Y	Y	Y	Y
Phase TOV1 Pkp phsB	Y	Y	Y	Y	Y
Phase TOV1 Op phsB	Y	Y	Y	Y	Y
Phase TOV1 Pkp phsC	Y	Y	Y	Y	Y
Phase TOV1 Op phsC	Y	Y	Y	Y	Y
Phase TOV2 Pkp general	Y	Y	Y	Y	Y

Signal Name	845	850	859	869	889
Phase TOV2 Op general	Y	Y	Y	Y	Y
Phase TOV2 Pkp phsA	Y	Y	Y	Y	Y
Phase TOV2 Op phsA	Y	Y	Y	Y	Y
Phase TOV2 Pkp phsB	Y	Y	Y	Y	Y
Phase TOV2 Op phsB	Y	Y	Y	Y	Y
Phase TOV2 Pkp phsC	Y	Y	Y	Y	Y
Phase TOV2 Op phsC	Y	Y	Y	Y	Y
Neg Seq OV1 Pkp	Y	Y	Y	Y	Y
Neg Seq OV1 Op	Y	Y	Y	Y	Y
Neg Seq OV2 Pkp	Y	Y			
Neg Seq OV2 Op	Y	Y			
Voltage Phase Reversal Pkp		Y	Y	Y	Y
Voltage Phase Reversal Op		Y	Y	Y	Y
Phase TUV1 Pkp general	Y	Y	Y	Y	Y
Phase TUV1 Op general	Y	Y	Y	Y	Y
Phase TUV1 Pkp phsA	Y	Y	Y	Y	Y
Phase TUV1 Op phsA	Y	Y	Y	Y	Y
Phase TUV1 Pkp phsB	Y	Y	Y	Y	Y
Phase TUV1 Op phsB	Y	Y	Y	Y	Y
Phase TUV1 Pkp phsC	Y	Y	Y	Y	Y
Phase TUV1 Op phsC	Y	Y	Y	Y	Y
Phase TUV2 Pkp general	Y	Y	Y	Y	Y
Phase TUV2 Op general	Y	Y	Y	Y	Y
Phase TUV2 Pkp phsA	Y	Y	Y	Y	Y
Phase TUV2 Op phsA	Y	Y	Y	Y	Y
Phase TUV2 Pkp phsB	Y	Y	Y	Y	Y
Phase TUV2 Op phsB	Y	Y	Y	Y	Y
Phase TUV2 Pkp phsC	Y	Y	Y	Y	Y
Phase TUV2 Op phsC	Y	Y	Y	Y	Y
Over-Frequency1 Pkp	Y	Y	Y	Y	Y
Over-Frequency1 Op	Y	Y	Y	Y	Y
Over-Frequency2 Pkp	Y	Y	Y	Y	Y
Over-Frequency2 Op	Y	Y	Y	Y	Y
Under-Frequency1 Pkp	Y	Y	Y	Y	Y
Under-Frequency1 Op	Y	Y	Y	Y	Y
Under-Frequency2 Pkp	Y	Y	Y	Y	Y
Under-Frequency2 Op	Y	Y	Y	Y	Y
Phase Dir OC 1 Op general		Y			
Phase Dir OC 1 Op phsA		Y			
Phase Dir OC 1 Op phsB		Y			
Phase Dir OC 1 Op phsC		Y			

Signal Name	845	850	859	869	889
Phase Dir OC 2 Op general		Y			
Phase Dir OC 2 Op phsA		Y			
Phase Dir OC 2 Op phsB		Y			
Phase Dir OC 2 Op phsC		Y			
Frequency Rate of Change 1 Pkp	Y	Y	Y	Y	Y
Frequency Rate of Change 1 Op	Y	Y	Y	Y	Y
Frequency Rate of Change 2 Pkp	Y	Y	Y	Y	Y
Frequency Rate of Change 2 Op	Y	Y	Y	Y	Y
Directional Power 1 Pkp	Y	Y	Y	Y	Y
Directional Power 1 Op	Y	Y	Y	Y	Y
Directional Power 2 Pkp	Y	Y	Y	Y	Y
Directional Power 2 Op	Y	Y	Y	Y	Y
Breaker 1 Closed	Y	Y	Y	Y	Y
Breaker 1 Opened	Y	Y	Y	Y	Y
Breaker 1 Unknown	Y	Y	Y	Y	Y
Breaker 1 Disconnected	Y	Y	Y	Y	Y
Breaker Failure 1 Op	Y	Y	Y	Y	Y
Breaker Failure 1 retrip	Y	Y	Y	Y	Y
Breaker Failure 2 Op	Y	Y			Y
Breaker Failure 2 retrip	Y	Y			Y
Fuse Failure 1 Op		Y			
Fuse Failure 2 Op		Y			
Trip Bus 1 Pkp	Y	Y	Y	Y	Y
Trip Bus 1 Op	Y	Y	Y	Y	Y
Trip Bus 2 Pkp	Y	Y	Y	Y	Y
Trip Bus 2 Op	Y	Y	Y	Y	Y
Trip Bus 3 Pkp	Y	Y	Y	Y	Y
Trip Bus 3 Op	Y	Y	Y	Y	Y
Trip Bus 4 Pkp	Y	Y	Y	Y	Y
Trip Bus 4 Op	Y	Y	Y	Y	Y
Trip Bus 5 Pkp	Y	Y	Y	Y	Y
Trip Bus 5 Op	Y	Y	Y	Y	Y
Trip Bus 6 Pkp	Y	Y	Y	Y	Y
Trip Bus 6 Op	Y	Y	Y	Y	Y
Synch1 OK	Y	Y			Y
Synch1 Live Bus	Y	Y			Y
Synch1 Live Line	Y	Y			Y
Synch1 Dead Bus	Y	Y			Y
Synch1 Dead Line	Y	Y			Y
Synch1 Dead Source OK	Y	Y			Y
Synch1 Close permission	Y	Y			Y

Signal Name	845	850	859	869	889
Neutral TOV1 Pkp	Y		Y	Y	Y
Neutral TOV1 Op	Y		Y	Y	Y
Phase Dir OC Op general	Y		Y	Y	Y
Phase Dir OC Op phsA	Y		Y	Y	Y
Phase Dir OC Op phsB	Y		Y	Y	Y
Phase Dir OC Op phsC	Y		Y	Y	Y
Neutral Dir OC Op FWD	Y		Y	Y	Y
Neutral Dir OC Op REV	Y		Y	Y	Y
Ground Fault Pkp			Y	Y	
Ground Fault Op			Y	Y	
Ground Fault Alarm Pkp			Y	Y	
Ground Fault Alarm Op			Y	Y	
Mechanichal Jam Pkp			Y	Y	
Mechanichal Jam Op			Y	Y	
Short Circuit Pkp			Y	Y	
Short Circuit Op			Y	Y	
Current Unbalance Alarm Pkp			Y	Y	
Current Unbalance Alarm Op			Y	Y	
Current Unbalance Trip Pkp			Y	Y	
Current Unbalance Trip Op			Y	Y	
Acceleration Time Op			Y	Y	
Load Increase Alarm Pkp			Y	Y	Y
Load Increase Alarm Op			Y	Y	Y
Start Inhibited			Y	Y	
Thermal Inhibit PKP			Y	Y	
Thermal Inhibit OP			Y	Y	
Max Starting Rate PKP			Y	Y	
Max Starting Rate OP			Y	Y	
Time Between Start PKP			Y	Y	
Time Between Start OP			Y	Y	
Restart Delay PKP			Y	Y	
Restart Delay OP			Y	Y	
Underpower Pkp			Y	Y	
Underpower Op			Y	Y	
Alarm Underpower Pkp			Y	Y	
Alarm Underpower Op			Y	Y	
Undercurrent Pkp			Y	Y	
Undercurrent Op			Y	Y	
Alarm Undercurrent Pkp			Y	Y	
Alarm Undercurrent Op			Y	Y	
Thermal Model Pkp			Y	Y	

Signal Name	845	850	859	869	889
Thermal Model Op			Y	Y	
Thermal Model Alarm			Y	Y	
Fuse Failure Op	Y		Y	Y	Y
Neutral IOC3 Pkp					Y
Neutral IOC3 Op					Y
Inadvertent Energization Armed					Y
Inadvertent Energization Op					Y
Offline Overcurrent Pkp					Y
Offline Overcurrent Op					Y
Offline Overcurrent PhA Pkp					Y
Offline Overcurrent PhA Op					Y
Offline Overcurrent PhB Pkp					Y
Offline Overcurrent PhB Op					Y
Offline Overcurrent PhC Pkp					Y
Offline Overcurrent PhC Op					Y
Generator Unbalance Pkp					Y
Generator Unbalance Op					Y
Generator Unbalance Alarm Pkp					Y
Generator Unbalance Alarm Op					Y
Auxiliary TOV1 Pkp					Y
Auxiliary TOV1 Op					Y
3rd Harmonic Neutral UV Trip Pkp					Y
3rd Harmonic Neutral UV Trip Op					Y
3rd Harmonic Neutral UV Alarm Pkp					Y
3rd Harmonic Neutral UV Alarm Op					Y
Ground Dir OC Op FWD	Y				Y
Ground Dir OC Op REV	Y				Y
Neg Seq Dir Op FWD					Y
Neg Seq Dir Op REV					Y
Sens Gnd Dir Op FWD					Y
Sens Gnd Dir Op REV					Y
Volts Per Hertz1 Pkp	Y				Y
Volts Per Hertz1 Op	Y				Y
Volts Per Hertz2 Pkp	Y				Y
Volts Per Hertz2 Op	Y				Y
Loss of Excitation 1 Pkp					Y
Loss of Excitation 1 Op					Y
Loss of Excitation 2 Pkp					Y
Loss of Excitation 2 Op					Y
Gnrtr. Percent Dif. Pkp general					Y
Gnrtr. Percent Dif. Op general					Y

Signal Name	845	850	859	869	889
Gnrtr. Percent Dif. Pkp phsA					Y
Gnrtr. Percent Dif. Op phsA					Y
Gnrtr. Percent Dif. Pkp phsB					Y
Gnrtr. Percent Dif. Op phsB					Y
Gnrtr. Percent Dif. Pkp phsC					Y
Gnrtr. Percent Dif. Op phsC					Y
Gnrtr. Overall Percent Dif. Pkp general					Y
Gnrtr. Overall Percent Dif. Op general					Y
Gnrtr. Overall Percent Dif. Pkp phsA					Y
Gnrtr. Overall Percent Dif. Op phsA					Y
Gnrtr. Overall Percent Dif. Pkp phsB					Y
Gnrtr. Overall Percent Dif. Op phsB					Y
Gnrtr. Overall Percent Dif. Pkp phsC					Y
Gnrtr. Overall Percent Dif. Op phsC					Y
Out of Step Left Blinder Pkp					Y
Out of Step Right Blinder Pkp					Y
Out of Step Timer Pkp					Y
Out of Step Op					Y
Frequency OOB Accum 1 Pkp					Y
Frequency OOB Accum 1 Op					Y
Frequency OOB Accum 2 Pkp					Y
Frequency OOB Accum 2 Op					Y
3rd Harmonic Voltage Difference Trip Pkp					Y
3rd Harmonic Voltage Difference Trip Op					Y
3rd Harmonic Voltage Difference Alarm Pkp					Y
3rd Harmonic Voltage Difference Alarm Op					Y
Thermal Overload Pkp					Y
Thermal Overload Op					Y
Restricted Ground Fault 1 PKP	Y				Y
Restricted Ground Fault 1 OP	Y				Y
Restricted Ground Fault 1 supervision	Y				Y
Breaker 2 Closed	Y				Y
Breaker 2 Opened	Y				Y
Breaker 2 Unknown	Y				Y
Breaker 2 Disconnected	Y				Y
Run Hours Op					Y
Generator state					Y
Sequential Shutdown PKP					Y
Sequential Shutdown OP					Y
Field Breaker Discrepancy PKP					Y
Field Breaker Discrepancy OP					Y

Signal Name	845	850	859	869	889
Neutral TOC3 Pkp	Y				
Neutral TOC3 Op	Y				
XFMR Instant Dif. Op general	Y				
XFMR Instant Dif. Op phsA	Y				
XFMR Instant Dif. Op phsB	Y				
XFMR Instant Dif. Op phsC	Y				
XFMR Percent Dif. Pkp general	Y				
XFMR Percent Dif. Op general	Y				
XFMR Percent Dif. Pkp phsA	Y				
XFMR Percent Dif. Op phsA	Y				
XFMR Percent Dif. Pkp phsB	Y				
XFMR Percent Dif. Op phsB	Y				
XFMR Percent Dif. Pkp phsC	Y				
XFMR Percent Dif. Op phsC	Y				
Xfmr Overload - Current Pkp	Y				
W1 Xfmr Overload - Current Pkp	Y				
W2 Xfmr Overload - Current Pkp	Y				
W3 Xfmr Overload - Current Pkp	Y				
Xfmr Overload - Current Op	Y				
Winding Hottest-spot Temp. Pkp	Y				
Winding Hottest-spot Temp. Op	Y				
Restricted Ground Fault 2 PKP	Y				
Restricted Ground Fault 2 OP	Y				
Restricted Ground Fault 2 supervision	Y				
Restricted Ground Fault 3 PKP	Y				
Restricted Ground Fault 3 OP	Y				
Restricted Ground Fault 3 supervision	Y				
Breaker 3 Closed	Y				
Breaker 3 Opened	Y				
Breaker 3 Unknown	Y				
Breaker 3 Disconnected	Y				
Breaker Failure 3 Op	Y				
Breaker Failure 3 retrip	Y				

List of Analog Signals Available through OPC UA server

Signal Name	845	850	859	869	889
Real Power (W)	Y	Y	Y	Y	Y
Reactive Power (VAr)	Y	Y	Y	Y	Y
Apparent Power (VA)	Y	Y	Y	Y	Y
Power Factor	Y	Y	Y	Y	Y
J2 Phase AB voltage magnitude (V)	Y	Y	Y	Y	Y

Signal Name	845	850	859	869	889
J2 Phase AB voltage angle	Y	Y	Y	Y	Y
J2 Phase BC voltage magnitude (V)	Y	Y	Y	Y	Y
J2 Phase BC voltage angle	Y	Y	Y	Y	Y
J2 Phase CA voltage magnitude (V)	Y	Y	Y	Y	Y
J2 Phase CA voltage angle	Y	Y	Y	Y	Y
J2 Phase A voltage magnitude (V)	Y	Y	Y	Y	Y
J2 Phase A voltage angle	Y	Y	Y	Y	Y
J2 Phase B voltage magnitude (V)	Y	Y	Y	Y	Y
J2 Phase B voltage angle	Y	Y	Y	Y	Y
J2 Phase C voltage magnitude (V)	Y	Y	Y	Y	Y
J2 Phase C voltage angle	Y	Y	Y	Y	Y
J2 Neutral voltage magnitude (V)	Y	Y	Y	Y	Y
J2 Neutral voltage angle	Y	Y	Y	Y	Y
J1 Phase A current magnitude (A)	Y	Y	Y	Y	Y
J1 Phase A current angle	Y	Y	Y	Y	Y
J1 Phase B current magnitude (A)	Y	Y	Y	Y	Y
J1 Phase B current angle	Y	Y	Y	Y	Y
J1 Phase C current magnitude (A)	Y	Y	Y	Y	Y
J1 Phase C current angle	Y	Y	Y	Y	Y
J1 Ground current magnitude (A)	Y	Y	Y	Y	Y
J1 Ground current angle	Y	Y	Y	Y	Y
J1 Neutral current magnitude (A)	Y	Y	Y	Y	Y
J1 Neutral current angle	Y	Y	Y	Y	Y
J2 Auxiliary Voltage magnitude (V)	Y	Y		Y	Y
J2 Auxiliary Voltage angle	Y	Y		Y	Y
J1-CT Frequency (Hz)	Y	Y	Y	Y	Y
J1-CT Frq. Rate of Change	Y	Y	Y	Y	Y
J2-3VT Frequency (Hz)	Y	Y	Y	Y	Y
J2-3VT Frq. Rate of Change	Y	Y	Y	Y	Y
J2-Vx Frequency (Hz)	Y	Y		Y	Y
J2-Vx Frq. Rate of Change	Y	Y		Y	Y
Positive Sequence Current magnitude (A)	Y	Y	Y	Y	Y
Positive Sequence Current angle	Y	Y	Y	Y	Y
Negative Sequence Current magnitude (A)	Y	Y	Y	Y	Y
Negative Sequence Current angle	Y	Y	Y	Y	Y
Zero Sequence Current magnitude (A)	Y	Y	Y	Y	Y
Zero Sequence Current angle	Y	Y	Y	Y	Y
Positive Sequence Voltage magnitude (A)	Y	Y	Y	Y	Y
Positive Sequence Voltage angle	Y	Y	Y	Y	Y
Negative Sequence Voltage magnitude (A)	Y	Y	Y	Y	Y
Negative Sequence Voltage angle	Y	Y	Y	Y	Y
Zero Sequence Voltage magnitude (A)	Y	Y	Y	Y	Y
Zero Sequence Voltage angle	Y	Y	Y	Y	Y

Signal Name	845	850	859	869	889
K1 Phase A current magnitude (A)	Y	Y		Y	Y
K1 Phase A current angle	Y	Y		Y	Y
K1 Phase B current magnitude (A)	Y	Y		Y	Y
K1 Phase B current angle	Y	Y		Y	Y
K1 Phase C current magnitude (A)	Y	Y		Y	Y
K1 Phase C current angle	Y	Y		Y	Y
K1 Neutral current magnitude (A)	Y	Y		Y	Y
K1 Neutral current angle	Y	Y		Y	Y
Sensitive ground current magnitude (A)		Y			
Sensitive ground current angle		Y			
RTD Input 1	Y	Y	Y	Y	Y
RTD Input 2	Y	Y	Y	Y	Y
RTD Input 3	Y	Y	Y	Y	Y
RTD Input 4	Y	Y	Y	Y	Y
RTD Input 5	Y	Y	Y	Y	Y
RTD Input 6	Y	Y	Y	Y	Y
RTD Input 7	Y	Y	Y	Y	Y
RTD Input 8	Y	Y	Y	Y	Y
RTD Input 9	Y	Y	Y	Y	Y
RTD Input 10	Y	Y	Y	Y	Y
RTD Input 11	Y	Y	Y	Y	Y
RTD Input 12	Y	Y	Y	Y	Y
RTD Input 13	Y	Y		Y	Y
Pwr1 Pos WattHours	Y	Y	Y	Y	Y
Pwr1 Neg WattHours	Y	Y	Y	Y	Y
Pwr1 Pos VarHours	Y	Y	Y	Y	Y
Pwr1 Neg VarHours	Y	Y	Y	Y	Y
User Map Value 1	Y	Y	Y	Y	Y
User Map Value 2	Y	Y	Y	Y	Y
User Map Value 3	Y	Y	Y	Y	Y
User Map Value 4	Y	Y	Y	Y	Y
User Map Value 5	Y	Y	Y	Y	Y
User Map Value 6	Y	Y	Y	Y	Y
User Map Value 7	Y	Y	Y	Y	Y
User Map Value 8	Y	Y	Y	Y	Y
User Map Value 9	Y	Y	Y	Y	Y
User Map Value 10	Y	Y	Y	Y	Y
User Map Value 11	Y	Y	Y	Y	Y
User Map Value 12	Y	Y	Y	Y	Y
User Map Value 13	Y	Y	Y	Y	Y
User Map Value 14	Y	Y	Y	Y	Y
User Map Value 15	Y	Y	Y	Y	Y
User Map Value 16	Y	Y	Y	Y	Y

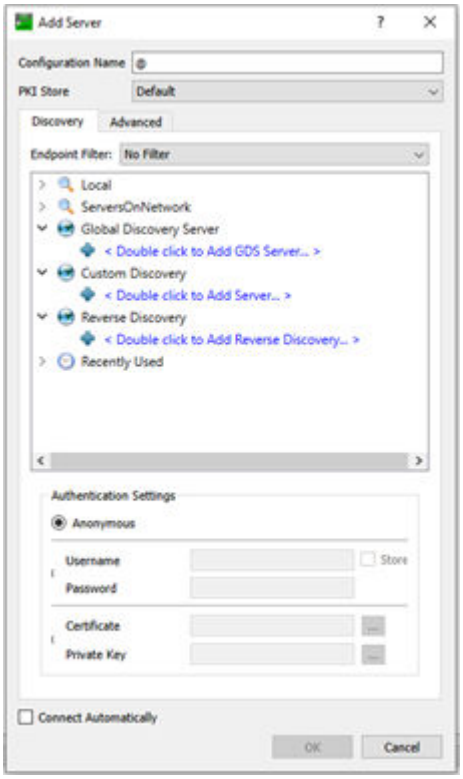
Signal Name	845	850	859	869	889
User Map Value 17	Y	Y	Y	Y	Y
User Map Value 18	Y	Y	Y	Y	Y
User Map Value 19	Y	Y	Y	Y	Y
User Map Value 20	Y	Y	Y	Y	Y
User Map Value 21	Y	Y	Y	Y	Y
User Map Value 22	Y	Y	Y	Y	Y
User Map Value 23	Y	Y	Y	Y	Y
User Map Value 24	Y	Y	Y	Y	Y
User Map Value 25	Y	Y	Y	Y	Y
User Map Value 26	Y	Y	Y	Y	Y
User Map Value 27	Y	Y	Y	Y	Y
User Map Value 28	Y	Y	Y	Y	Y
User Map Value 29	Y	Y	Y	Y	Y
User Map Value 30	Y	Y	Y	Y	Y
User Map Value 31	Y	Y	Y	Y	Y
User Map Value 32	Y	Y	Y	Y	Y
J2 Auxiliary Voltage magnitude (V)	Y			Y	Y
K1-CT Frequency (Hz)	Y			Y	Y
K1-CT Frq. Rate of Change	Y			Y	Y
K1 Ground current magnitude (A)	Y			Y	Y
K1 Ground current angle	Y			Y	Y
K1 Positive Sequence Current magnitude (A)	Y			Y	Y
K1 Positive Sequence Current angle	Y			Y	Y
K1 Negative Sequence Current magnitude (A)	Y			Y	Y
K1 Negative Sequence Current angle	Y			Y	Y
K1 Zero Sequence Current magnitude (A)	Y			Y	Y
K1 Zero Sequence Current angle	Y			Y	Y
K2 Phase AB voltage magnitude (A)					Y
K2 Phase AB voltage angle					Y
K2 Phase BC voltage magnitude (A)					Y
K2 Phase BC voltage angle					Y
K2 Phase CA voltage magnitude (A)					Y
K2 Phase CA voltage angle					Y
K2 Phase A voltage magnitude (A)					Y
K2 Phase A voltage angle					Y
K2 Phase B voltage magnitude (A)					Y
K2 Phase B voltage angle					Y
K2 Phase C voltage magnitude (A)					Y
K2 Phase C voltage angle					Y
K2 Neutral voltage magnitude (A)					Y
K2 Neutral voltage angle					Y
K1 Positive Sequence Voltage magnitude (A)					Y
K1 Positive Sequence Voltage angle					Y

Signal Name	845	850	859	869	889
K1 Negative Sequence Voltage magnitude (A)					Y
K1 Negative Sequence Voltage angle					Y
K1 Zero Sequence Voltage magnitude (A)					Y
K1 Zero Sequence Voltage angle					Y
K2-CT Frequency (Hz)	Y				
K2-CT Frq. Rate of Change	Y				
K2 Phase A current magnitude (A)	Y				
K2 Phase A current angle	Y				
K2 Phase B current magnitude (A)	Y				
K2 Phase B current angle	Y				
K2 Phase C current magnitude (A)	Y				
K2 Phase C current angle	Y				
K2 Neutral current magnitude (A)	Y				
K2 Neutral current angle	Y				
K2 Ground current magnitude (A)	Y				
K2 Ground current angle	Y				
K2 Positive Sequence Current magnitude (A)	Y				
K2 Positive Sequence Current angle	Y				
K2 Negative Sequence Current magnitude (A)	Y				
K2 Negative Sequence Current angle	Y				
K2 Zero Sequence Current magnitude (A)	Y				
K2 Zero Sequence Current angle	Y				

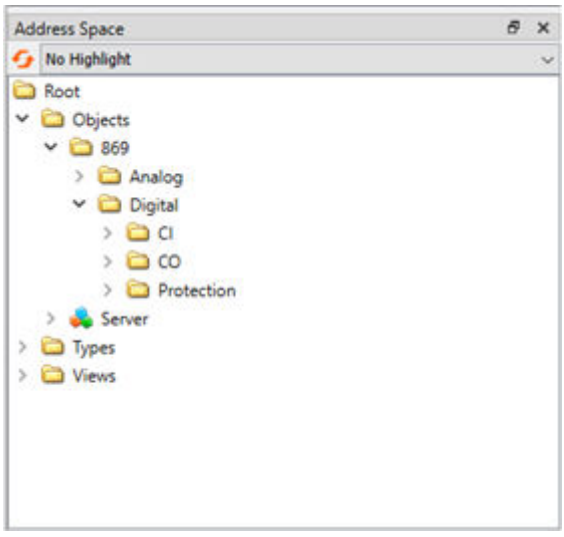
3.10.4 CONNECTING TO MULTILIN 8 SERIES OPC UA SERVER

Getting connected to Relays OPC UA server through OPC UA client platforms are uncomplicated. Several free OPC UA clients are available. Multilin 8 Series are compatible with multiple OPC UA Client software. The guideline in this manual is using “UaExpert®”. This software is available on www.unified-automation.com. For connecting the Multilin 8 Series OPC UA Server, users should take following steps.

- Download and Install UaExpert
- Open UaExpert, navigate to the top-left corner of the window and select "Add" from the "Server" menu. A window like the one shown below will appear.



- Right-click on "ServersOnNetwork" and choose "Edit URL."
- In the opened window, enter the address "opc.tcp://[Relay IP address]:[OPC UA port number]." The IANA registered OPC UA port for TCP communication is 4840. The relay IP address should be the one entered under Setpoint/Device/Communications/Ethernet.
- Expand the server and select the “None”, followed by clicking OK.
- The server will be displayed under the Project section of the window (Project/Servers). Right-click on the server and select "Connect."
- Once connected, the address space will be visible in the relevant section in the middle left of the window. The address space will resemble the figure below, where an 869 relay from the 8 Series is connected as a server.



- Under each folder—Analog, Digital, and subfolders—you can select the signals to be displayed. The values of the signals will update in real-time as they change in the relay. The server includes three data type; Double and Integer which are used for analog values, and Boolean, which is utilized for digital, logic, input, and

output data. It should be noted that these values are real-time, and the 8 Series relays do not support historical data for the values.

Additionally, signals can be added to the Data Access View section of the window. In this regard:

- Right-click on this section and select "Add Custom Node."
- A window will pop up. Enter the NodeId values for the signal (Node) and then click OK. The assigned values are available in the attributes of each signal, which can be viewed from the Attributes section located at the top right of the window.

Multilin 8 Series Relays allow the OPC UA Client connected to the OPC UA server to keep track of digital signals and protection elements through Events and Alarms generated. Events are generated every time a digital signal changes its status. Alarms are generated by functions with Operate elements, such as: Protection functions.

CHAPTER 4

IEC 61850

4.1 CHAPTER OVERVIEW

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

This chapter contains the following sections:

4.2 FUNCTIONALITY

CLIENT CONNECTIONS

The relay supports up to eight IEC61850 concurrent client connections.

LOGICAL DEVICES AND REPORTS

Supported buffered and un-buffered report, the **report triggers** are shown in the *Supported Triggers* list.

Supported Triggers

- Data-change
- Integrity
- General-interrogation

Supported buffered and un-buffered **report option** fields are shown in the *Field* list.

Field

- Sequence number
- Report time stamp
- Reason for inclusion
- Data set name
- Data-ref
- Buffer-overflow (Buffered reports only)
- Entry id (Buffered reports only)
- Conf- revision

Report control block configuration settings are modified by the IEC61850 advanced configurator writing directly in a CID file. There is no Modbus register assigned to those.

The datasets for reports are fully configurable with CDCs from any Logical Node.

The Description field in the logical node is fixed text and it can not be updated from the Modbus settings.

4.3 STATUS

4.3.1 IEC 61850 STATUS

Path: ***Status*** > ***Communications*** > ***IEC 61850 Status***

COMMS NOT VALIDATED OK

Range: NO, YES

Default: NO

COMMS NOT VALIDATED DONE

Range: YES, NO

Default: YES

COMMS VALIDATED OK

Range: YES, NO

Default: YES

COMMS VALIDATED DONE

Range: YES, NO

Default: YES

MAIN NOT VALIDATED OK

Range: NO, YES

Default: NO

MAIN NOT VALIDATED DONE

Range: YES, NO

Default: YES

MAIN VALIDATED OK

Range: YES, NO

Default: YES

MAIN VALIDATED DONE

Range: YES, NO

Default: YES

NOT RUNNING.ERROR CID

Range: NO, YES

Default: NO

RUNNING.DEFAULT CID

Range: NO, YES

Default: NO

RUNNING.SAVING CID TO FLASH

Range: NO, YES

Default: NO

CID HANDLING DONE

Range: YES, NO

Default: YES

NUMBER OF CONNECTED CLIENTS

Range: 0 to 8

Default: 0

CLIENT 1(8) IP ADDRESS

Range: 0, 0XFFFFFFFF

Default: 0

4.3.2 GOOSE STATUS

Path: *Status* > ***Communications*** > ***GGIO1 Indications***

The present state of the 32 GGIO1 Indications are shown here. There are up to 32 GGIO indications that can be used to map any FlexLogic operand into the IED 61850 information model. Default value is Off.

Path: ***Status*** > ***Communications*** > ***GOOSE Status***

GOOSE 1 to 64 Status

Range: OFF, ON

Default: OFF

This setting indicates GOOSE communications are being received. A GOOSE STATUS of ON indicates successful receipt of the last GOOSE packet. A GOOSE STATUS of OFF indicates the communications link has failed, with the speed this setting changes determined by the Update Time setting configured under GOOSE Transmission.

Path: ***Status*** > ***Communications*** > ***GOOSE HDR Status***

GOOSE 1 to 64 H.Status

Range: OFF, ON

Default: OFF

This setting validates the GOOSE packet structure. A GOOSE HEADER STATUS of ON indicates that the structure of the last GOOSE packet was valid.

Path: ***Status*** > ***Communications*** > ***GOOSE Analog AV***

FLOAT 1 to 24

Range:

Default: 0.0

SINT32 1 to 8

Range:

Default: 0

4.4 THE IEC 61850 CONFIGURATOR

The relay supports the IEC 61850 protocol which is identified by order code option 2A, 2E, 3A or 3E.

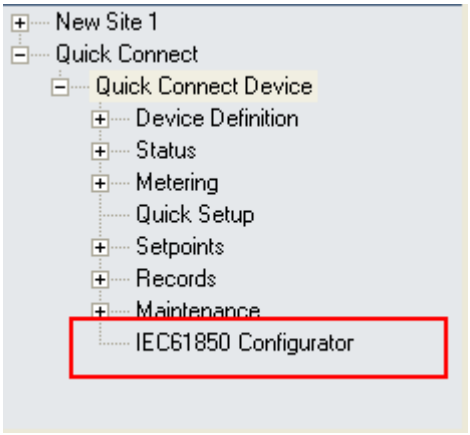
The IEC 61850 configurator is found in both the online and offline section of the EnerVista D&I Setup for configuring the online and offline relay settings file respectively.

4.4.1 ONLINE AND OFFLINE SETUP

ONLINE SETTINGS FILE

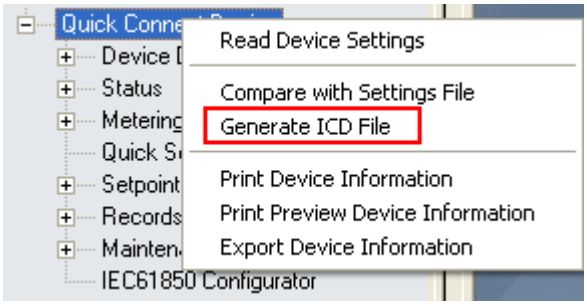
Two options are available to configure the relay's online settings file.

1. Configuration
   - Configure the relay (having order code option: IEC 61850) through the Device Setup or Quick connect screen.
   - The IEC 61850 Configurator item is displayed after Maintenance.



   - Launch the online IEC 61850 configurator screen, by double-clicking on **IEC61850 Configurator**.
   - Select the required settings from the different tab displays (in the configurator screen) to complete the IEC 61850 configuration.
2. Online right-click option
   - Select any online relay and right click on the selected item. More options become available for selection, as described below.

Generate ICD file: The menu option generates a default ICD file with the respective order code option and saves the file to the path selected previously.



Read Device Settings: The menu option reads all the settings from the relay by TFTP and creates an relay file with extension *.CID. The created *.CID file consists of two sections. A private section where all non IEC 61850 settings are available, and a public section in which IEC 61850 related settings are implemented.

When creating a CID file using a 3rd party ICT/SCL tool, ensure the following:

- The order code in the CID file must match the device order code if writing the CID file directly into the relay (without using the <PlatformSoftwareVersion> software). The ***Desc*** value in communication settings of the CID file must match the relay's order code.
- The maximum allowed services must be equal or below the specified limits as in ICD/CID.
- Configure Datasets only in LLN0 logical node.
- Creating new LD, LN, and communication-AP settings is not recommended.

OFFLINE SETTINGS FILE

The **Generate ICD File** menu option generates a default ICD file with the respective order code option and saves the file to the path selected previously.

4.4.2 IEC 61850 CONFIGURATOR DETAILS

The IEC61850 Configurator allows you to edit the IEC 61850 CID and ICD file. You can't do any other operations in the EnerVista D&I Setup if the IEC61850 Configurator is open.

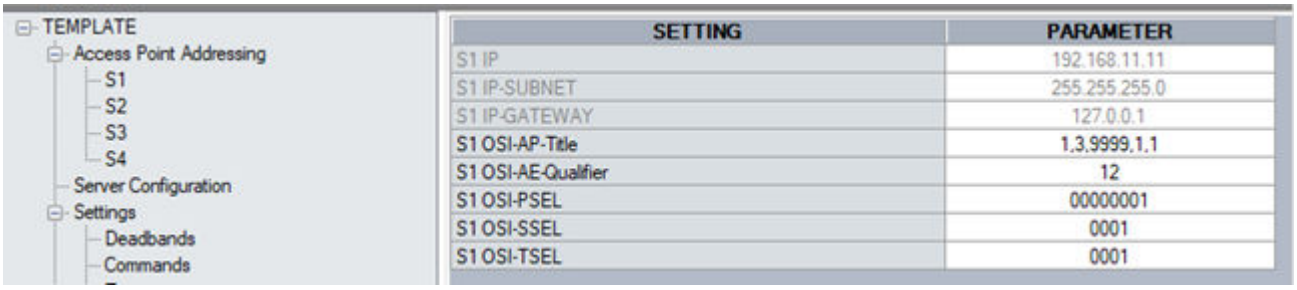
> *Note:*
> *When the IEC 61850 configuration is saved while online, the **DEVICE IN SERVICE** state (**Setpoints** > **Device** > **Installation**) switches to `Not Ready` for the duration of the upload. This ensures that all new settings are applied before the device is operational.*

The IEC61850 Configurator consists of these items in the hierarchy menu:

- Access Point Addressing
- Settings
- DataSets
- Reports
- GOOSE

4.4.2.1 ICD/CID

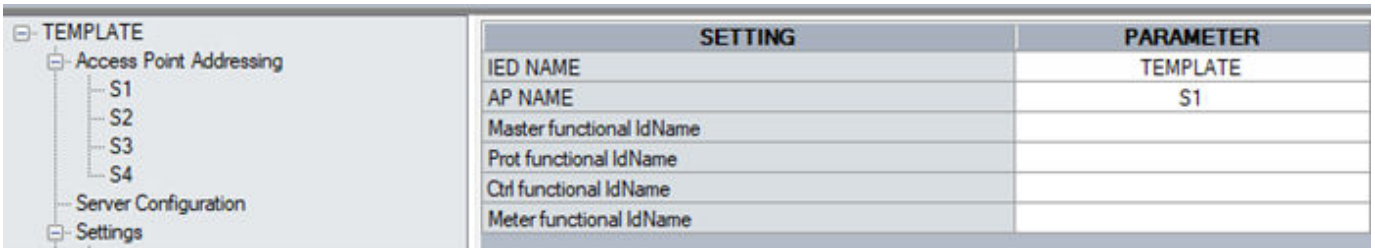
Access Point addressing Represents the network interface through which communication is established. The access point addressing involves setting up network parameters like IP address, subnet mask, and gateway to enable communication between devices.



• S1 IP, S1 IP-SUBNET, S1 IP-GATEWAY: The parameters are the configured ETH_A IP details configured in the device through EnerVista D&I: **Setpoints > Product Setup > Communications > Network**

• S1 OSI-AP-Title, S1 OSI-AE-Qualifier, S1 OSI-PSEL, S1 OSI-SSEL, S1 OSI-TSEL: The parameters must be configured according to the IEC 61850 standard

The **Server Configuration** panel contains IEC 61850 settings relevant to the server functions of the IED implementation.



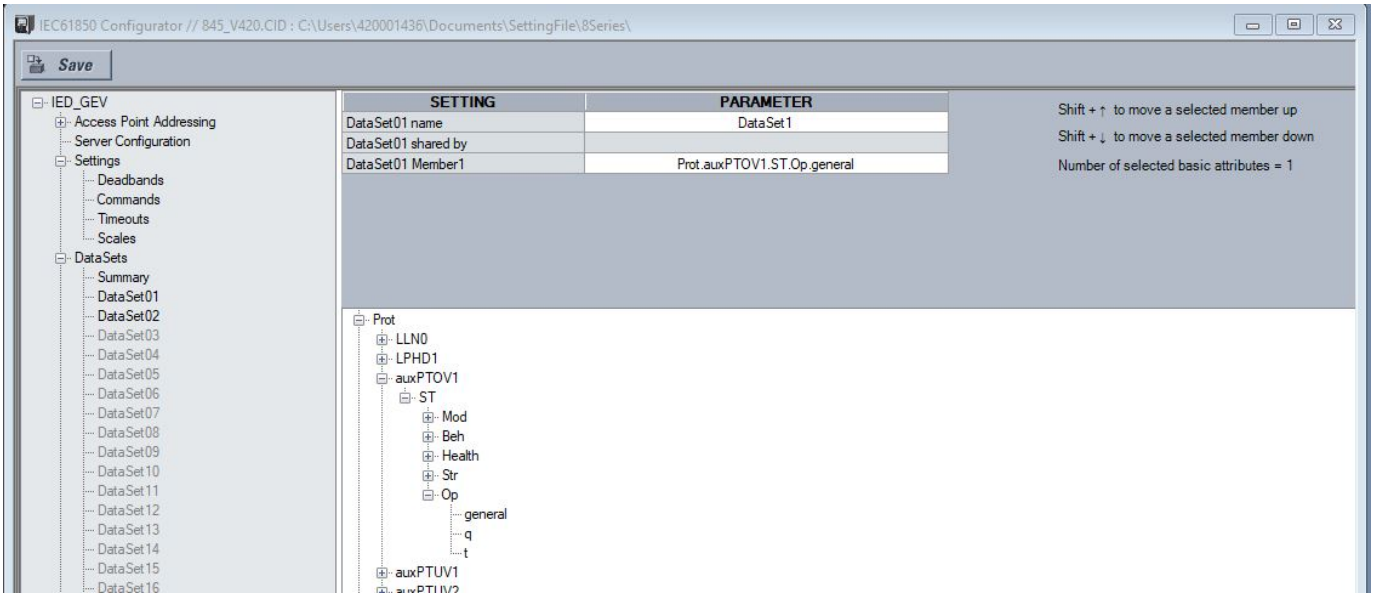
- IED Name sets the name used by IEC 61850 for the 8 Series relay. The IED Name represents the MMS domain name (IEC 61850 logical device) where all IEC/MMS logical nodes are located. An IED name unique within the network must be entered for proper operation. Valid characters are upper and lowercase letters, digits, and the underscore (_) character. The first character must be a letter.
- AP Name stands for Access Point name, and it is the subnetwork.
- The four functional IdName settings can be use to rename the Logical devices of Master, Protection, Control and Meter.

4.4.2.2 SETTINGS

Deadbands

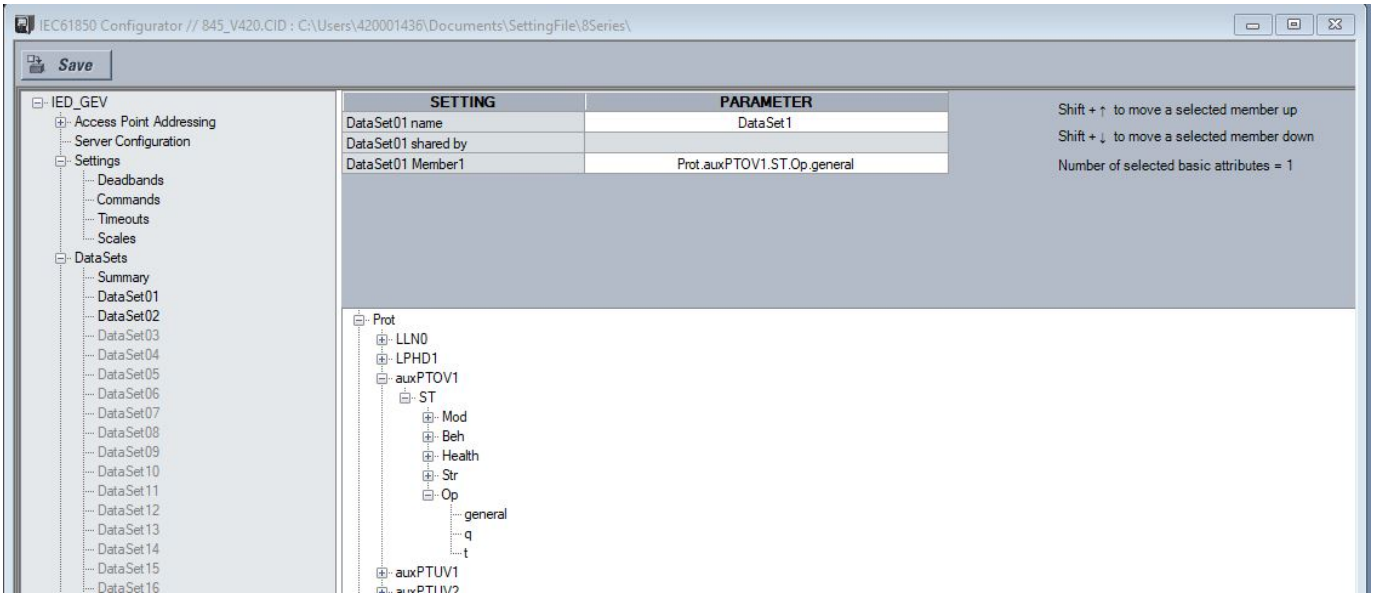
Range: 0 to 100.000 %

The MMXU deadband settings represent the deadband values used to determine when to update the MMXU "mag" and "cVal" values from the associated "instmag" and "instcVal" values. The "mag" and "cVal" values are used for the IEC 61850 buffered and unbuffered reports. The settings correspond to the associated "db" data items in the CF functional constraint of the MMXU logical node, as per the IEC 61850 standard. According to IEC 61850-7-3, the db value "shall represent the percentage of difference between the maximum and minimum in units of 0.001%". Thus, it is important to know the maximum value for each MMXU measured quantity, since this represents the 100.00% value for the deadband and therefore A value of 1000 represents the 1% of the scale.



Commands

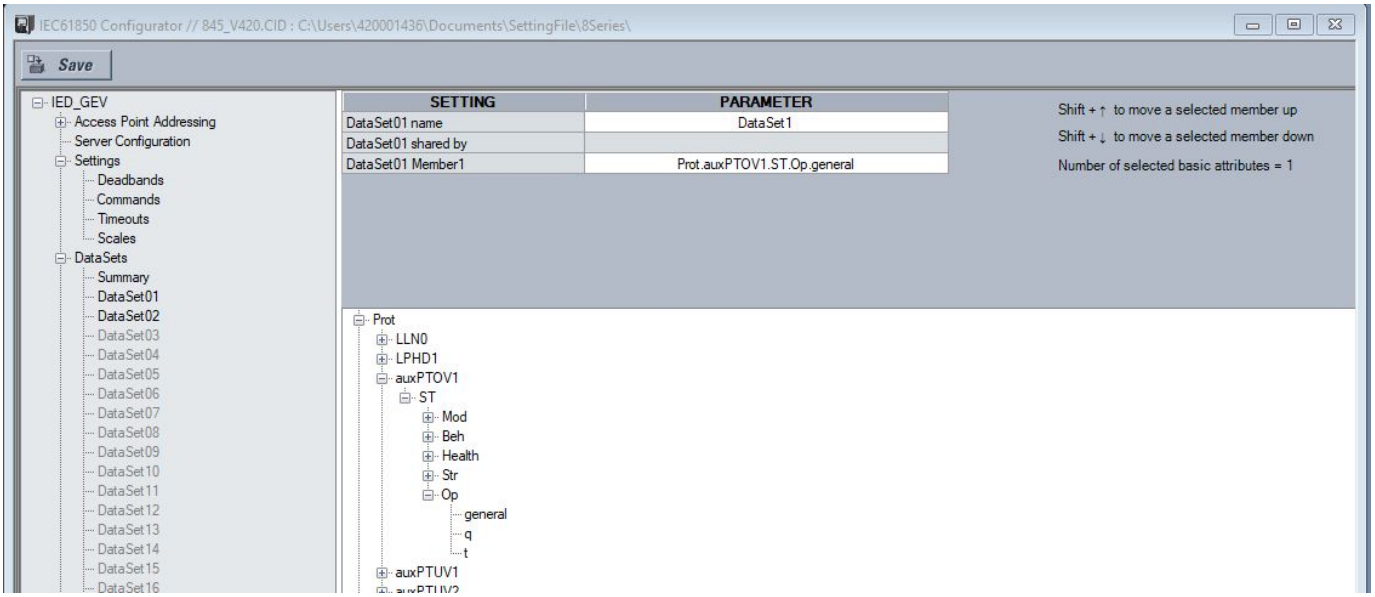
IEC 61850 controllable data exist in logical nodes, GGIO3, XCBR and CSWI:



Timeouts

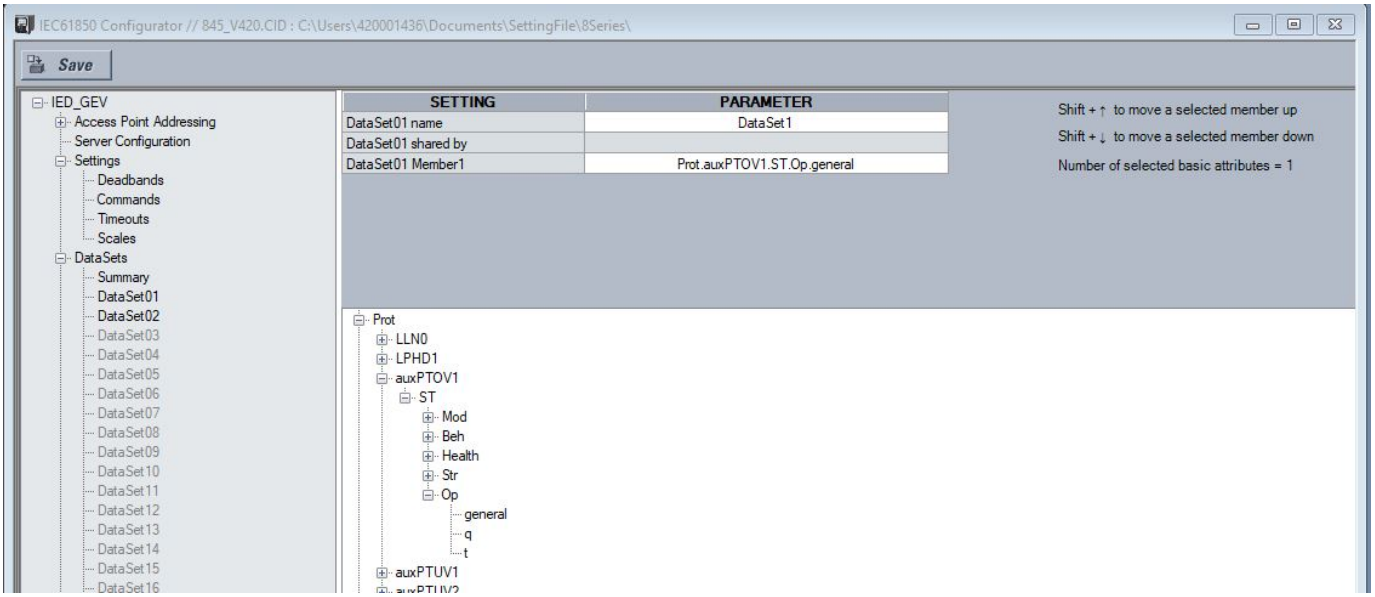
There is a configurable timeout for SBO control modes and for operation in logical nodes listed above. The value range for SBO timeout is 500 ms - 60 seconds.

he sboClass attribute can only have value "operate-once", "operate-many" pattern is not supported in IEC 61850 SBO controls in 8Series relay.attribute can only have value "operate-once", "operate-many" pattern is not supported in IEC 61850 SBO controls in 8Series relay.



Scales

Scales parameter has the options k or M.



4.4.2.3 DATASET

DataSets

Two different sections will be differentiated under this section:

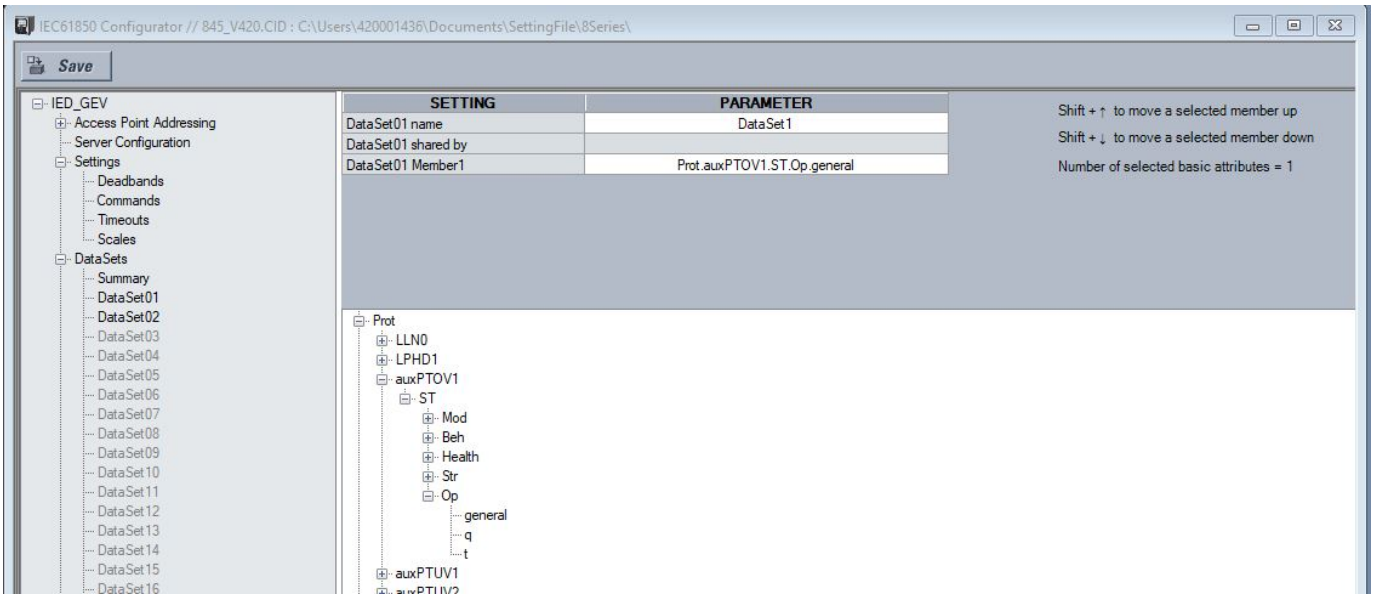
• Summary

• DataSetXX

Summary

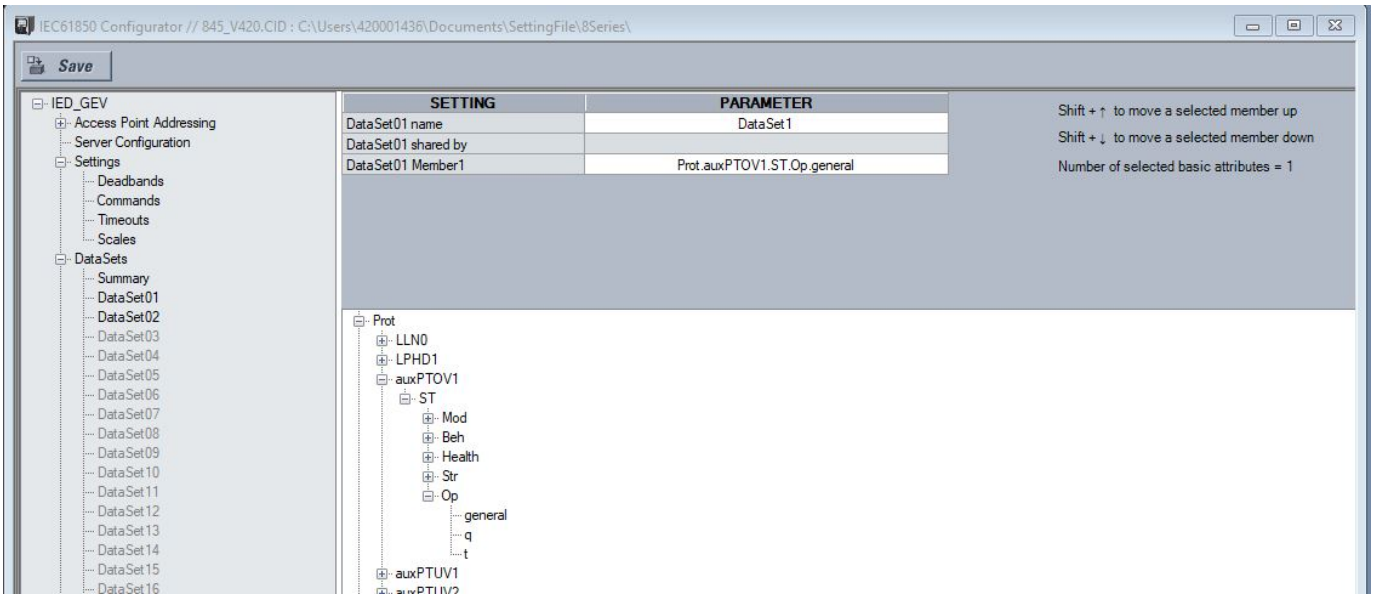
In this screen, user can find a list with information about where a configured DataSetXX has been used (Report and/or GOOSE).

If a DataSetXX is shared by more than one Report/GOOSE, all elements will be listed in DataSetXX Parameter field, separated by commas.



DataSets xx

There are totally 22 DataSets, under each DataSet, there are 64 members, then Logic Nodes can be drag and dropped from the Logic Device below to the members of each DataSet.



4.4.2.4 REPORTS

Reports

Reports in IEC 61580 Configurator permits configuration of data sets and report control blocks for buffered and unbuffered reports.

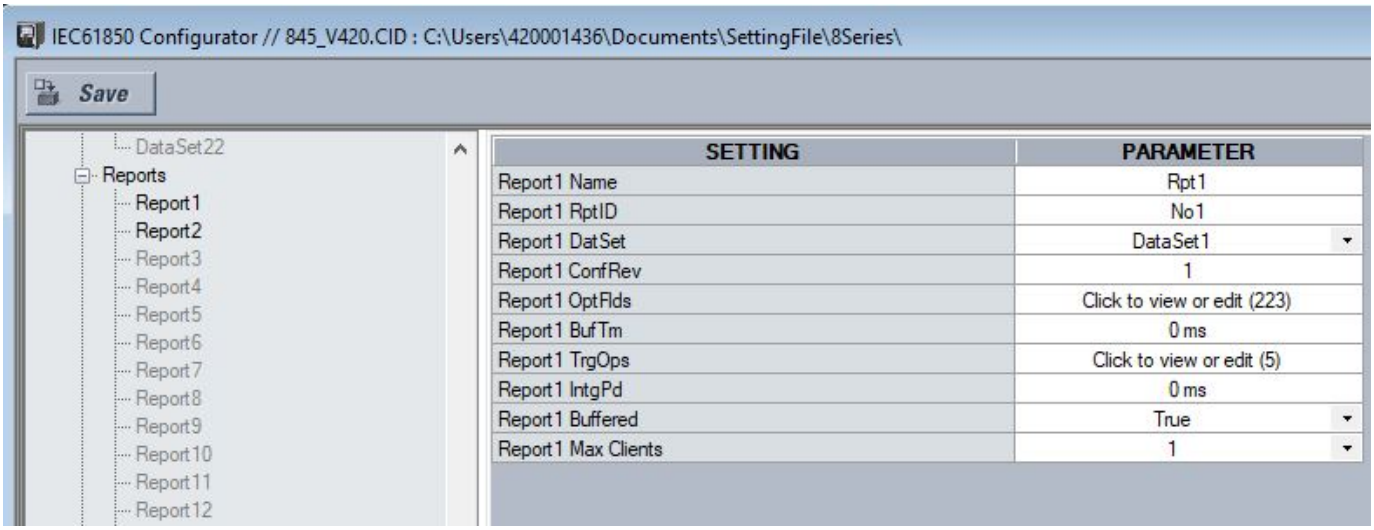


Figure 3: Reports Screen

The screen helps the user to create, modify and delete Report Control Blocks (RCBs) and Datasets. Each Report Control Block must have a maximum of 4 different clients with up to a maximum of 8 Report Control Blocks linked to their Datasets. Each dataset must have a maximum of 64 members in total.

- Report Control Blocks: Report control blocks can be added as required. The first character of Report name in the value of this attribute must be a letter (upper or lower case). The rest of the characters must be a number, a letter (upper or lower case) or a “_”. The maximum number of characters allowed in IEC61850 Configurator

is 30 and IEC61850 MMS Library adds 2 more characters indicating the number of the instance of the RCB depending on the number of IEC61850 clients configured.

- Dataset Sources: Each report control block can be selected from the pull down list with dataset items which should be pre-programmed in DataSets.

4.4.2.5 IEC 61850

The optional communications processor supports both the IEC 61850 GOOSE and IEC 61850 MMS Server service as per IEC 61850 standard Ed. 2. The GOOSE messaging service provides the ability for the relay to Publish/ Subscribe Digital Input and other element statuses and its Quality and Timestamp to/from other IEDs with supporting GOOSE messaging service. Server support allows remote control center, RTU/Gateway, local HMI or other client role devices access to the relay for monitoring and control. The configuration of IEC 61850 services is accomplished using the EnerVista D&I Setup.

The IEC 61850 Server (i.e. the relay) reports information to the IEC 61850 Client, such as the Local HMI, RTU and Gateway. This information consists of logical device data, data sets, data control block, logical nodes and their data attributes.

Appendix B lists the implementation details of IEC 61850, including the logical nodes and number of instances for each that are supported..

Data Obj	data attribute	Type	FC	Name	Description
PhyHealth		ENS			This physical device's health
	stVal	ENUMERATED	ST		3 when ANY MAJOR ERROR ==On; 2 when ANY MINOR ERROR==On; 1 otherwise

4.4.2.6 GOOSE TRANSMISSION

The relay has an IEC 61850 server and supports the GOOSE message scheme. A maximum of 16 GOOSE control blocks can be added. The GOOSE Configuration has two sections:

- TxGOOSE for transmission
- RxGOOSE for reception

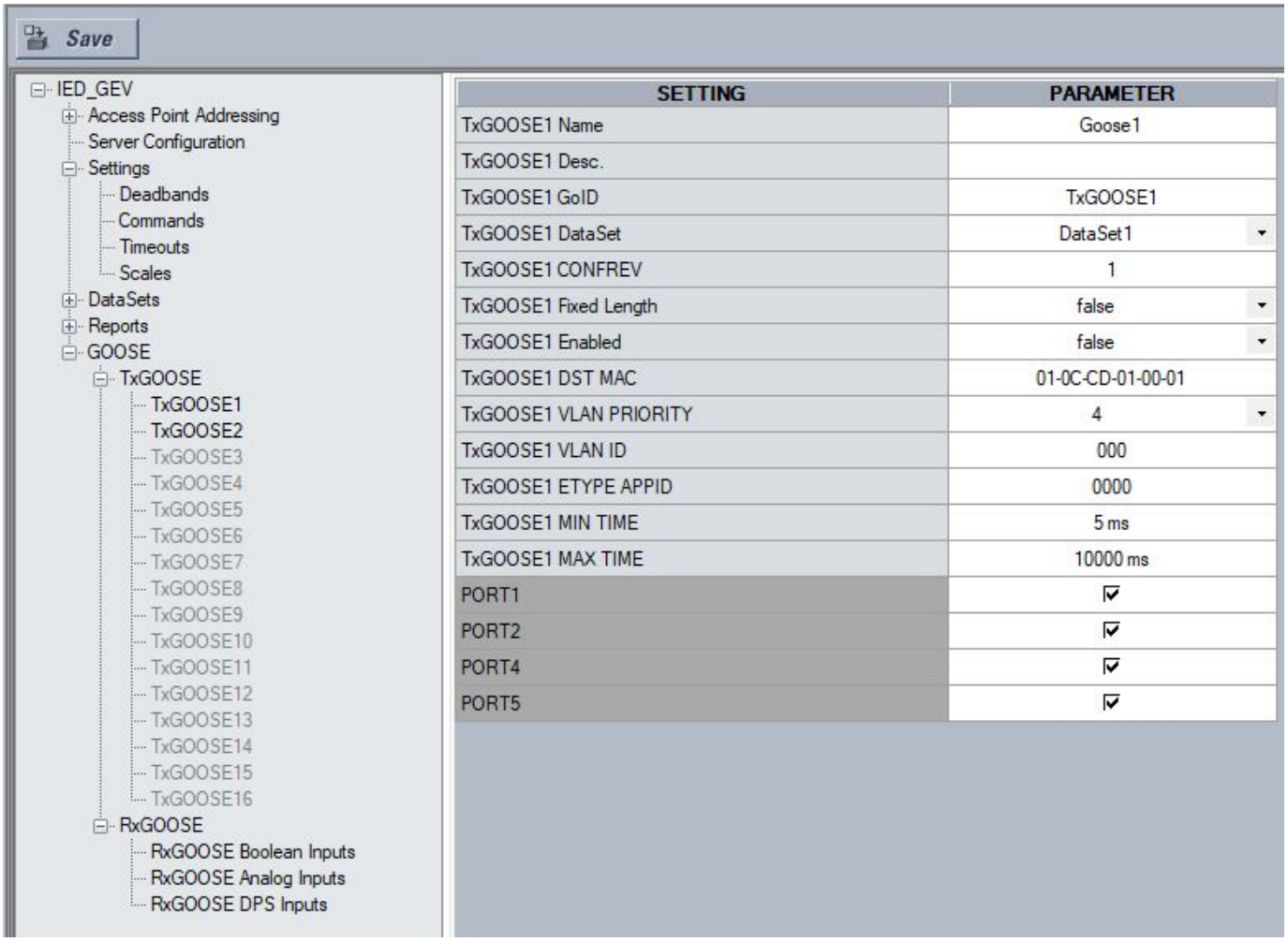


Figure 4: TxGOOSE Screen

- TxGOOSE control blocks: The user can add the required GOOSE control block.
  - **RxGOOSE1 Name:** The first character in the value of this attribute must be a letter (upper or lower case). The rest of the characters must be a number, a letter (upper or lower case) or a "_". The maximum number of characters allowed is 32.
  - **DTxGOOSE1 Desc.:** The maximum number of characters allowed is 32.
  - **TxGOOSE1 GoID:** The maximum number of characters allowed is 129.
  - **TxGOOSE1 DataSet:** Choose from pre-programmed DataSets pulldown list.
  - **TxGOOSE1 CONFREV:** The entered value sets the confRev value in published GOOSE messages and can be used by subscribers to discriminate TxGOOSE messages of the expected configuration revision from messages of a different revision. The standard requires that CONFREV be incremented each time the members or the order of the members published is changed.
  - **TxGOOSE1 Fixed Length:** Choose Fixed Length of TxGOOSE to be true or false
  - **TxGOOSE1 Enabled:** Enable or disable TxGOOSE by set to true or false
  - **TxGOOSE1 DST MAC:** 6 pairs of letters (from A to F, upper case or lower case) or numbers separated by colons.
  - **TxGOOSE1 VLAN priority:** A number from 0 to 7.
  - **TxGOOSE1 VLAN ID:** The maximum number of characters allowed is 3. IEC61850 Configurator allows characters limited to 0 to 9, A to F and it saves in the CID file the hexadecimal value (max FFF).

- **TxGOOSE1 ETYPE APPID:** All characters must be numerical. The maximum number of characters allowed is 4. IEC61850 Configurator allows characters limited to 0 to 9, A to F and it saves in the CID file the hexadecimal value (max FFFF).
- **TxGOOSE1 MIN TIME:** If the entered time is non-zero, when a member value change is detected, four event transmissions are sent, then heartbeat transmissions resume.
- **TxGOOSE1 MAX TIME:** This setting specifies the time interval between heartbeat messages, meaning messages that are sent periodically while no events are detected.

To receive the TxGOOSE from any other IEDs, the CID file should be imported then drag and dropped to each Ind *.

Right click mouse over LGOS *, the choose "Add GOOSE".

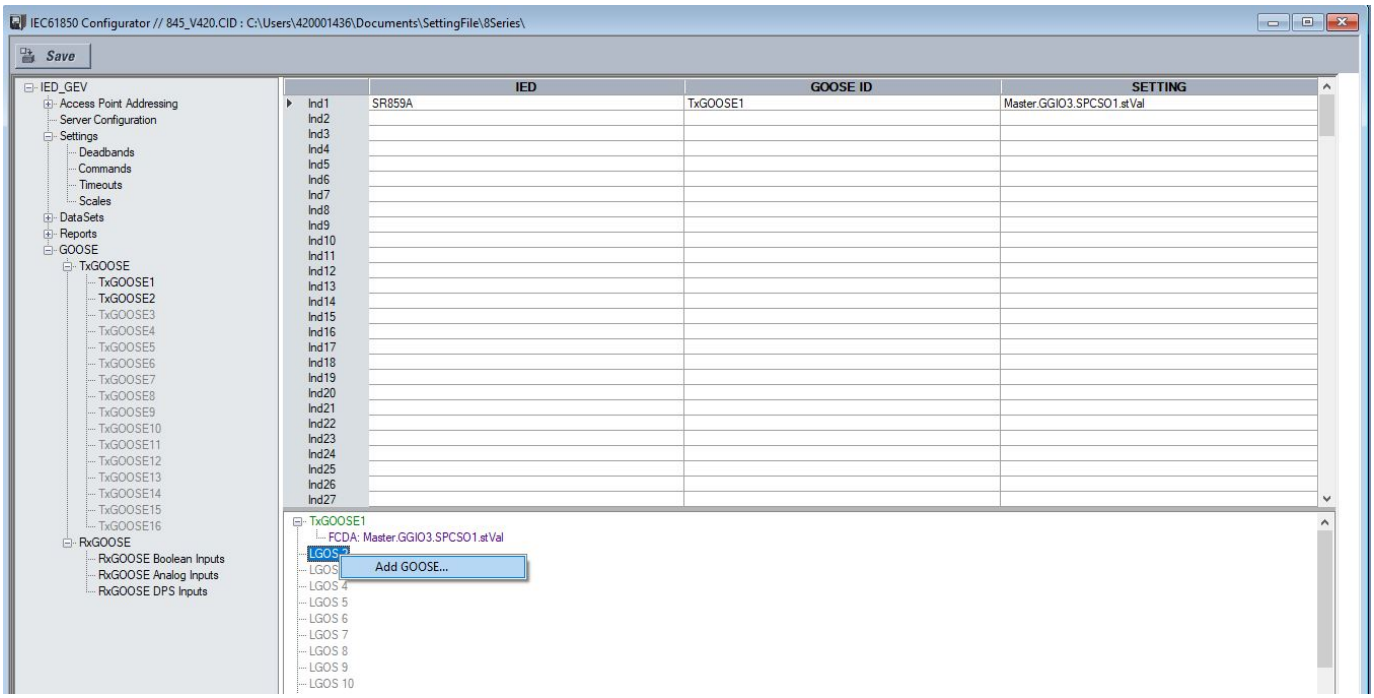


Figure 5: RxGOOSE Screen

4.5 IEC 61850 MMS FILE TRANSFER

The relays support MMS file transfer services based on IEC-61850-7-2. The following files are available for transfer:

- Motor Start Records: Ms1.cfg, ms1.dat. (Comtrade format)
- Oscillography Records: Osc1.cfg, Osc1.dat, Osc1.hdr (Comtrade format)
- Event File: Evt.txt
- Device Configuration File: Default.CID
- Snapshot File: Snapshot.txt

CHAPTER 5

REDUNDANT ETHERNET

5.1 CHAPTER OVERVIEW

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

This chapter contains the following sections:

5.2 REDUNDANT ETHERNET COMMUNICATION

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

The redundancy interface in the device provides paired Ethernet ports, both of which are for the same physical medium (two copper, or two fibre).

Industry standard PRP (Parallel Redundancy Protocol) and HSR (High-availability Seamless Redundancy) protocols, LLA (Link Loss Alert) functionality as well as physical medium selection (copper or fibre) are all available in the ordering options (HSR is only available from revision 4.10 onwards)

PRP addresses the need for seamless switchover and zero recovery time in case of single network failure in substation automation networks. PRP achieve redundancy by using a combination of LAN duplication and frame duplication technique. Identical frames are sent on two completely independent networks that connect source and destination. Under normal circumstances both frames will reach destination and one of them will be sent up the OSI stack to the destination application, while the second one will be discarded.

HSR functionality, like PRP, addresses the need for seamless switchover and zero recovery time in case of single network failure in substation automation networks. A source node in HSR ring receives a frame from its upper layer and sends it over its two ports in different directions. Under normal circumstances (fault-free state) both identical frames will reach destination node within a certain interval and the first frame will be sent up the OSI stack to the destination application, while the second one will be discarded.

LLA (Link Loss Alert) detects a failure in the fibre link. When the link failure is detected, communication is switched to the standby port. When the primary port link detected is good, the communication is switched back to primary and the backup port goes back into standby mode.

Note:
Always use Shielded Twisted Pair (STP) cable when connecting to RJ45 Ethernet ports

5.3 PARALLEL REDUNDANCY PROTOCOL (PRP)

PRP (Parallel Redundancy Protocol) is defined in IEC 62439-3. PRP provides bumpless redundancy and meets the most demanding needs of substation automation. The PRP implementation of the REB is compatible with any standard PRP device.

PRP uses two independent Ethernet networks operating in parallel. PRP systems are designed so that there should be no common point of failure between the two networks, so the networks have independent power sources and are not connected together directly.

Devices designed for PRP applications have two ports attached to two separate networks and are called Doubly Attached Nodes (DAN). A DAN has two ports, one MAC address and one IP address.

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

Devices such as printers that have a single Ethernet port can be connected to either of the networks but will not directly benefit from the PRP principles. Such devices are called Singly Attached Nodes (SAN). For devices with a single Ethernet port that need to connect to both LANs, this can be achieved by employing Ethernet Redundancy Boxes (sometimes abbreviated to RedBox). Devices with a single Ethernet port that connect to both LANs by means of a RedBox are known as Virtual DAN (VDAN).

The figure below summarises DAN, SAN, VDAN, LAN, and RedBox connectivity.

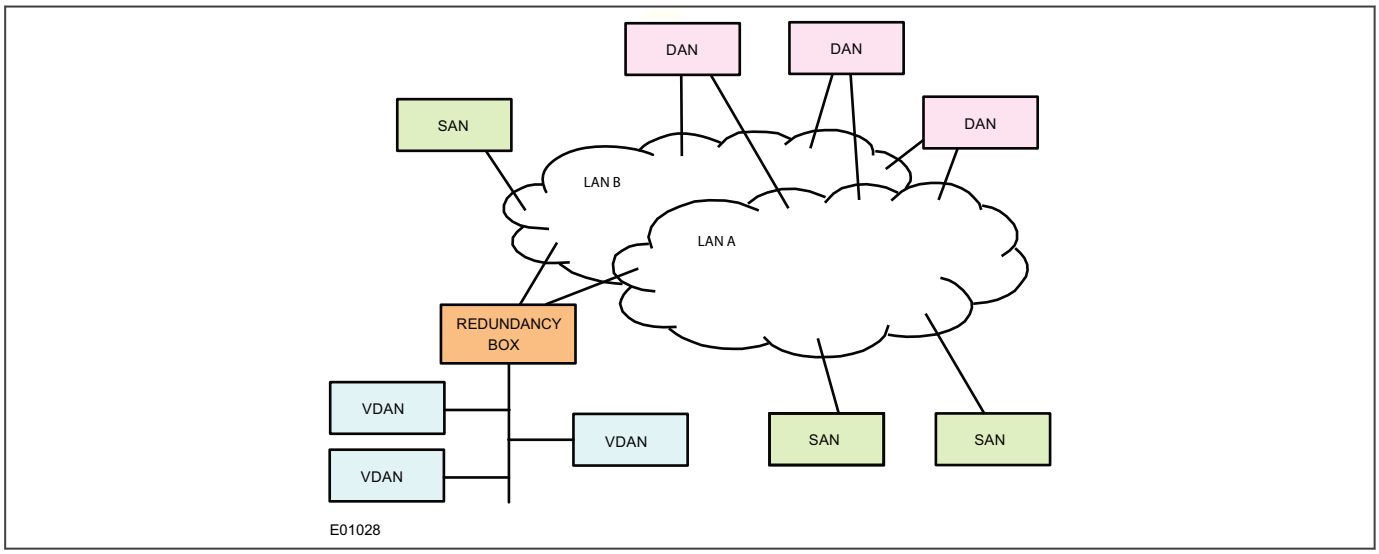


Figure 6: IED attached to separate LANs

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

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

The selection of PRP in the device can be done by selecting *PRP* at the ***ETH2 Operation*** setting at path: ***SETPOINTS\DEVICE\COMMUNICATIONS\ETHERNET\ETHERNET 2***

When set to PRP (Parallel Redundancy Protocol), ETH2 (PortA) and ETH3 (PortB) are the paired ports and use the same MAC address of ETH2 and combine information at the link layer. In this mode of operation both ports are connected two different switches on LANA and LANB. The relay processes the first received frame by forwarding the packet to upper layers and discards the duplicate frame, using the Link Redundancy Entity (LRE) service at

layer 2. When received a frame from the network, LRE forwards the first received frame of a pair to the upper layers after removing the RCT and discards the duplicate. When receiving a frame from the upper layers of the node, LRE appends the RCT and sends the frame through both ports. PRP main mode of operation is Duplicate Discard Mode and Duplicate Accept Mode is not supported.

5.4 HSR ETHERNET REDUNDANCY PROTOCOL

HSR stands for High-Availability Seamless Redundancy. It is standardized in IEC 62439-3 (clause 5) for use in ring topology networks. Similar to PRP, HSR provides bumpless redundancy and meets the most demanding needs of substation automation. HSR has become the reference standard for ring-topology networks in the substation environment. The HSR implementation of the redundancy Ethernet board (REB) is compatible with any standard HSR device. HSR works on the premise that each device connected in the ring is a doubly attached node running HSR (referred to as DANH). Similar to PRP, singly attached nodes such as printers are connected via Ethernet Redundancy Boxes (RedBox).

In HSR mode, all the participating devices are connected in a ring topology. In normal condition (fault-free state), both identical frames will reach destination device within a certain interval. If both frames are received, the relay processes the first, one and removes the HSR tag. The duplicate frame is discarded.

5.4.1 HSR MULTICAST TOPOLOGY

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

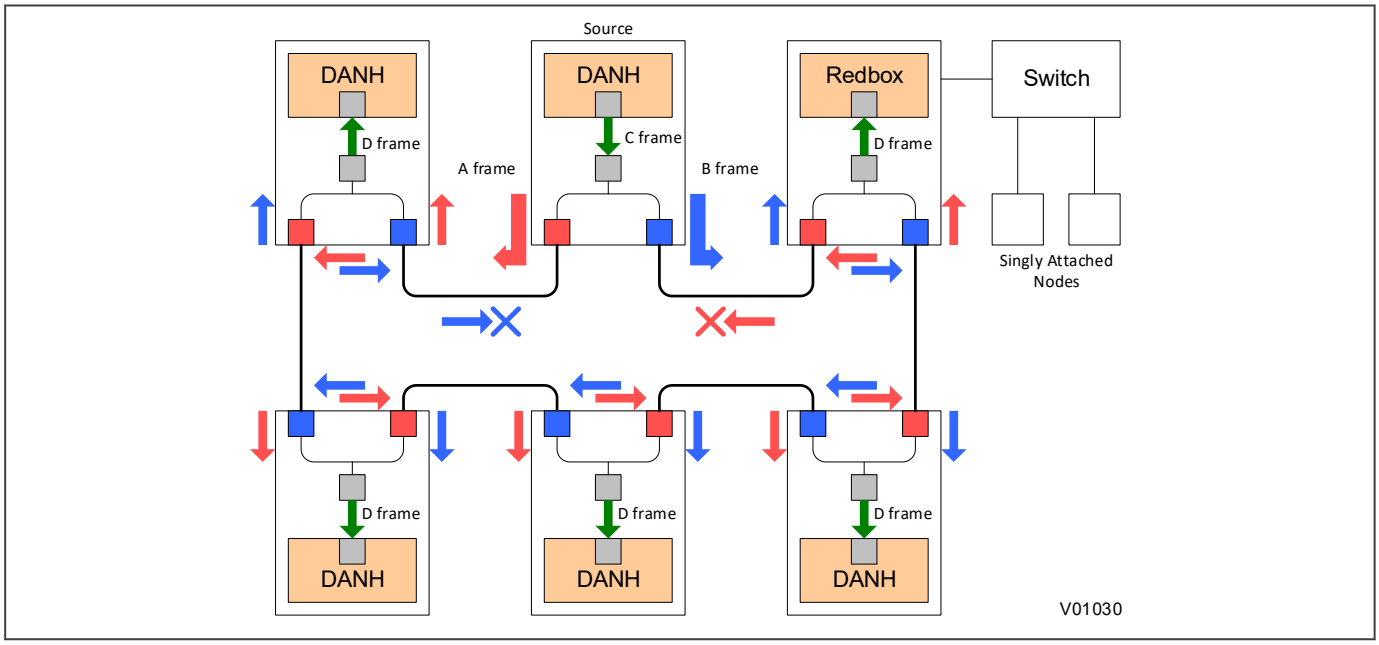


Figure 7: HSR multicast topology

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

5.4.2 HSR UNICAST TOPOLOGY

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

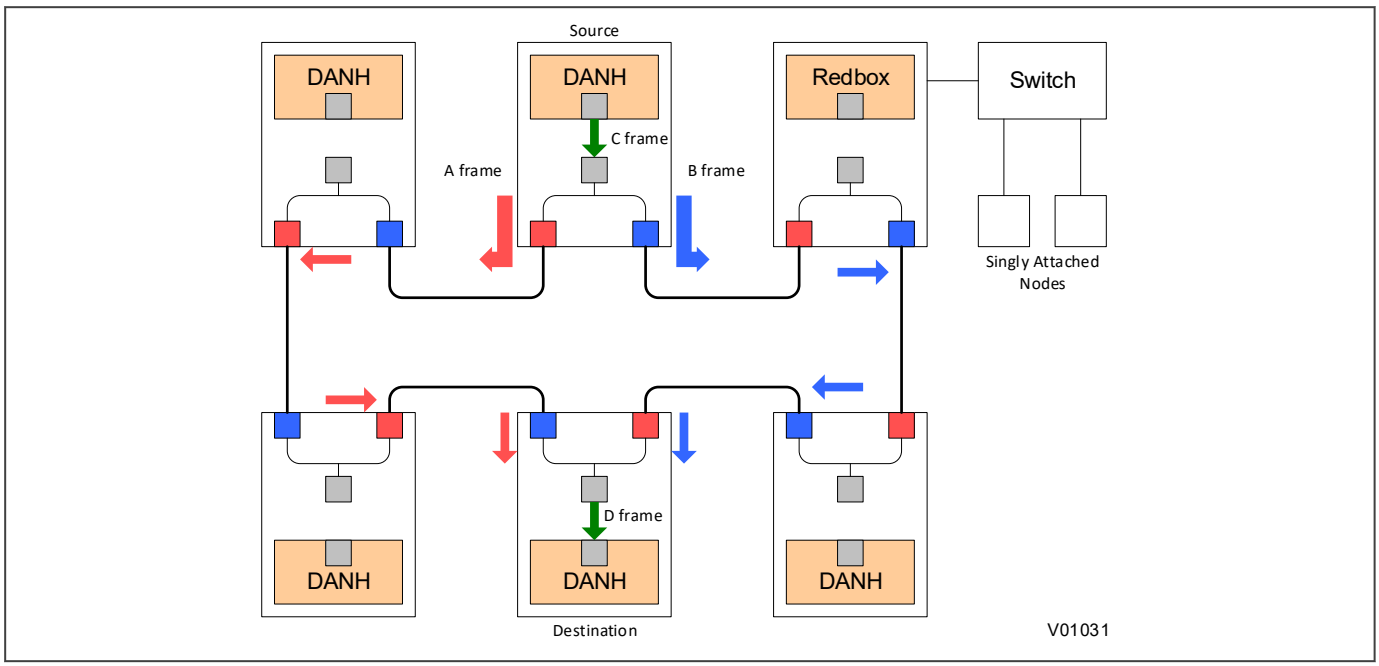


Figure 8: HSR unicast topology

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

5.5 LINK LOSS ALERT FUNCTIONALITY (LLA)

LLA (Link Loss Alert) detects a failure in the fiber link. When the link failure is detected, communication is switched to the standby port. When the primary port link detected is good, the communication is switched back to primary and the backup port goes back into standby mode.

LLA uses paired Ethernet ports, both of which are for the same physical medium (two copper, or two fibre).

LLA uses the MAC and IP address settings of the first Ethernet port. The second Ethernet port is in standby mode. It does not actively communicate on the Ethernet network but monitors the link of the first Ethernet port. If a problem with the link is detected , communication is switched to the second port. It acts as backup link to the network for the first Ethernet port. When it detects that the first Ethernet link is good again communications automatically switches back to the first port and the second port goes into standby mode again.

5.6 RAPID SPANNING TREE PROTOCOL (RTSP)

The Rapid Spanning Tree Protocol (RTSP), like STP, was designed to avoid loops in an Ethernet network. Rapid Spanning Tree Protocol (RSTP) (IEEE 802.1w) is an evolution of the Spanning Tree Protocol (STP) (802.1d standard) and provides for faster spanning tree convergence after a topology change.

The IEEE 802.1d Spanning Tree Protocol (STP) was developed to allow the construction of robust networks that incorporate redundancy while pruning the active topology of the network to prevent loops. While STP is effective, it requires that frame transfer must halt after a link outage until all bridges in the network are sure to be aware of the new topology.

Using STP (IEEE 802.1d) recommended values, this period lasts 30 seconds. The Rapid Spanning Tree Protocol (IEEE 802.1w) is a further evolution of the 802.1d Spanning Tree Protocol. It replaces the settling period with an active handshake between switches (bridges) that guarantees topology information to be rapidly propagated through the network. RSTP converges in less than one second. RSTP also offers a number of other significant innovations.

These include:

- Topology changes in STP must be passed to the root bridge before they can be propagated to the network.
- Topology changes in RSTP can be originated from and acted upon by any designated switch (bridge), leading to more rapid propagation of address information
- STP recognizes one state - blocking for ports that should not forward any data or information. RSTP explicitly recognizes two states or blocking roles - alternate and backup port including them in computations of when to learn and forward and when to block
- STP relays configuration messages received on the root port going out of its designated ports. If an STP switch (bridge) fails to receive a message from its neighbour it cannot be sure where along the path to the root a failure occurred. RSTP switches (bridges) generate their own configuration messages, even if they fail to receive one from the root bridge. This leads to quicker failure detection
- RSTP offers edge port recognition, allowing ports at the edge of the network to forward frames immediately after activation while at the same time protecting them against loops
- An improvement in RSTP allows configuration messages to age more quickly preventing them from “going around in circles” in the event of a loop RSTP has three states. They are discarding, learning and forwarding.

The discarding state is entered when the port is first taken into service. The port does not learn addresses in this state and does not participate in frame transfer. The port looks for STP traffic in order to determine its role in the network. When it is determined that the port plays an active part in the network, the state changes to learning. The learning state is entered when the port is preparing to play an active member of the network. The port learns addresses in this state but does not participate in frame transfer. In a network of RSTP switches (bridges) the time spent in this state is usually quite short. RSTP switches (bridges) operating in STP compatibility mode spend between 6 to 40 seconds in this state. After 'learning' the bridge places the port in the forwarding state. While in this state the port both learn addresses and participates in frame transfer while in this state. The result of these enhanced states is that the IEEE 802.1d version of spanning tree (STP) can take a fairly long time to resolve all the possible paths and to select the most efficient path through the network. The IEEE 802.1w Rapid reconfiguration of Spanning Tree significantly reduces the amount of time it takes to establish the network path. The result is reduced network downtime and improved network robustness. In addition to faster network reconfiguration, RSTP also implements greater ranges for port path costs to accommodate the higher connection speeds that are being implemented.

Proper implementations of RSTP (by switch vendors) is designed to be compatible with IEEE 802.1d STP. GE recommends that you employ RSTP or STP in your network.

CHAPTER 6

RADIUS SERVER

6.1 CHAPTER OVERVIEW

This chapter includes information about the RADIUS server and certificates followed by an example of how to set up a simple RADIUS server and certificate management.

This chapter contains the following sections:

6.2 SIMPLE RADIUS SERVER AND CERTIFICATE MANAGEMENT

The 8 Series unit can act as a RADIUS client and has the ability to authenticate users with a RADIUS server using the EAP-TTLS protocol. Authentication is performed with the help of certificates.

Any cryptography application such as OpenSSL etc. can be used to create certificates. First, a private key and certificate request are created for the server. The certificate request contains the public key, and the server's information (name, email, organization etc.) The certificate request is then sent to a certificate authority (CA) for the authority's digital signature. If the request is sent to a well-known CA, then upon receiving payment from the RADIUS server's administrator, the CA verifies the information and signs the certificate. The administrator can choose not to use an external well-known CA's services and create a local CA instead.

The signed certificate of the server along with CA's public certificate are then sent back to the RADIUS server administrator. Finally, the CA's public certificate is uploaded to the relay.

In this example, a local CA is created and used to sign the server's certificate request.

Authentication:

The user initiates the authentication process by providing user credentials. The 8 Series unit then tries to establish a trust relationship with the RADIUS server. The RADIUS server identifies itself via a certificate which it sends to the 8 Series unit. This certificate holds the server's information:

- version
- public key
- subject
- serial number
- valid from
- valid until
- key-usage
- signature algorithm
- "issuer" (i.e. CA) etc.

The 8 Series unit then validates the server's identity by verifying the server's certificate against the CA certificate that it has. If both the server and CA certificates are signed by the same trusted authority (CA), a client side trust relationship is successfully established.

6.3 SETTING UP A SIMPLE RADIUS SERVER

The following example demonstrates how to set up a test bench RADIUS server. A proper RADIUS server is only to be deployed by qualified IT professionals. The third party tools and services mentioned below are only for demonstration purposes and do not imply endorsement by GE.

This example uses **FreeRADIUS** as the RADIUS server.

Download and install **FreeRADIUS.net** (Windows™ version) from http://freeradius.net/

6.3.1 RADIUS SERVER CERTIFICATE MANAGEMENT

Create a private key for the server

To create a private key by using the command:

```
openssl genrsa -out server.key 4096
```

The RSA based private key is generated. The RSA based private key is not a password protected key.

Create a certificate request for the server

To create a certificate request by using the command:

```
openssl req -new -key server.key -out server.csr
```

While using the command, you are asked to enter the following information that is incorporated into the certificate request.

- Country Name
- State or Province Name
- Locality Name
- Organizational Unit Nae
- Common Name
- Email Address

What you enter here is called a Distinguished Name or a DN. All this information is sent with the certificate request. The two extra attributes ("A challenge password" and "An optional company name") are left blank for this example.

Figure 9: Enter DN information for Certificate request

Create a Signed Certificate for the Server

CA certificates (assuming it to be your root certificate from CA) are created and later used to sign the server's certificate request.

1. Create a private key for the root CA by using the command:

   ```
   openssl genrsa -out ca.key 4096
   ```

2. Create a public certificate and self-sign it, by using the command:

```
openssl req -new -x509 -days 3650 -key ca.key -out ca.crt
```

While using the above command, you are asked to enter information that is incorporated into your certificate. Please make sure that while entering this information (as depicted in the previous step) that the Common Name (CN) of the CA and the Server certificate do NOT match. This avoids naming collisions and other related errors later on.

3. Use the server's certificate request (server.csr) that was created as described in the previous section (see Create a Certificate Request for the Server) and sign it with the CA. Use the following command:

```
openssl x509 -req -days 3650 -in server.csr -CA ca.crt -CAkey ca.key -set_serial 01 -out server.crt
```

Definitions	
x509	This term is used to add a digital signature to the certificate.
-req	With this option, a certificate request is expected instead of the certificate (by default).
-in	Specifies the input file from which the certificate is read.
-CA	Specifies the CA certificate to be used for signing. When the -CA option is present, x509 behaves like a "mini CA". The input file is signed by this CA using this option. The issuer name is set to the subject name of the CA and it is digitally signed using the CA's private key. This option is normally combined with the –req option. Without the –req option, the input is a certificate which must be self-signed.
-CAkey	When the -CA option is used to sign a certificate, it uses a serial number specified in a file. This file consists of one line containing an even number of hex digits with the serial number to use. After each use, the serial number is incremented and written out to the file again.
-set_serial	Specifies the serial number to use.
-out	Specifies the output file to write to.
–days	Specifies the number of days the certificate is valid.

Transfer Certificates to Server

Copy the following files onto the FreeRADIUS.net server under the directory containing the certificates.

- server.key
- server.crt
- ca.crt

In this example the directory is located under the path:

```
<Path_to_Radius>\etc\raddb\certs\FreeRADIUS.net\DemoCerts>
```

6.3.2 RADIUS SERVER CONFIGURATION

Modify the following .GE and .CONF files to configure the RADIUS server.

RADIUSD.CONF

Locate the "bind_address" field and set it to your RADIUS server's IP address in the radiusd.conf file.

USERS.CONF

Add the users in the users.conf file.

The file is available under the directory

```
<Path_to_Radius>\etc\raddb directory.
```

Adding the following text configures a user "Tester" which has an "Administrator" role.

Tester:

```
->User-Password == "Testing1!1"
->GE-UR-Role = Administrator
```

CLIENTS.CONF

Add the clients in the clients.conf file.

The file is available under the directory:

```
<Path_to_Radius>\etc\raddb .
```

The following text defines a RADIUS client 8 Series unit with the assumption that its IP-address is 10.0.0.2 and subnet mask is 255.255.255.0. The "secret" that is specified here is also configured on the 8 Series unit for successful authentication. The "shortname" is a short alias that can be used in place of the IP address and it is optional.

```
client 10.0.0.2/24 {
secret = testing123
shortname = private-network-1
}
```

DICTIONARY.GE

Create a file called "dictionary.ge" under the directory

```
<Path_to_Radius>\etc\raddb
```

Add the following content to it:

```
# ############################################################
# GE VSA's
############################################################
VENDOR GE 2910
# Management authorization
BEGIN-VENDOR GE
# Role ID
ATTRIBUTE GE-UR-Role 1 integer
# GE-UR-ROLE values
VALUE GE-UR-Role Administrator 1
VALUE GE-UR-Role Supervisor 2
VALUE GE-UR-Role Engineer 3
VALUE GE-UR-Role Operator 4
VALUE GE-UR-Role Observer 5
END-VENDOR GE
############################################################
DICTIONARY
```

Add the following line

```
$INCLUDE dictionary.ge
```

to the "dictionary" file present under

```
<Path_to_Radius>\etc\raddb.
```

EAP.CONF

The eap.conf file is available under the directory

```
<Path_to_Radius>\etc\raddb .
```

Locate the "tls" block and add the respective entries as shown in figure A-2 to the "private_key_file", "certificate_file" and "CA_file" fields.

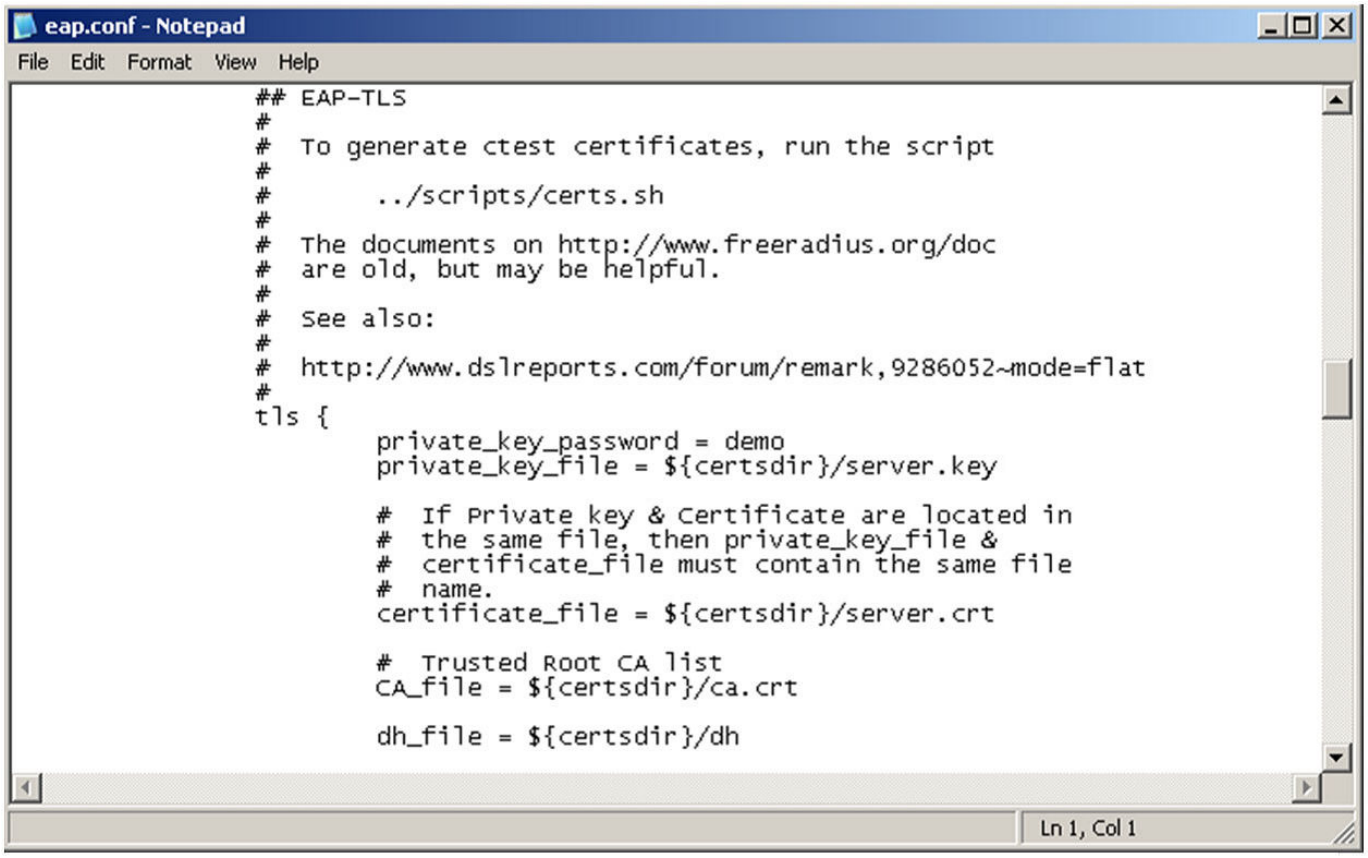


Figure 10: EAP.CONF file

Start the Server

The `<Path_to_Radius>/start_radiusd_debug.bat` file can be used to start the RADIUS server in debug mode.

We recommend to first run the RADIUS server in debug mode, otherwise, you cannot see what is going on and cannot correct any problems.

6.3.3 RADIUS CLIENT CONFIGURATION

Radius settings are configured under ***Setpoints > Device > Security*** on the EnerVista D&I Setup.

1. Configure the IP address and ports for the Radius server.
2. Enter the vendor ID for GE in the field dedicated for this purpose. The GE vendor ID is 2910 and the field is set to this value by default.
3. The CA's public certificate needs to be transferred to the 8 Series unit. Since the 8 Series unit accepts the certificates in DER format, the signed certificate must first be converted from PEM format to DER by using the command:
   `openssl x509 -in ca.crt -inform PEM -out ca.der -outform DER`
4. Move the DER file (`ca.der`) to the 8 Series unit by using SFTP. The path on the 8 Series unit is `/net/MainShare`
5. Finally, update the Remote RADIUS shared secret (as set up in clients.conf) using the EnerVista 8 Series Setup software.

CHAPTER 7

IEC 61850 CONFORMANCE STATEMENTS

7.1 CHAPTER OVERVIEW

This chapter contains the following sections:

7.2 MODEL IMPLEMENTATION CONFORMANCE STATEMENT

This model implementation conformance statement is applicable for 8 Series Family, with firmware 3.00 or later

This MICS document specifies the modeling extensions compared to IEC 61850 Edition 2. For the exact details on the standardized model please compare the ICD substation configuration file: 845.icd, 850.icd, 859.icd, 869.icd and 889.icd.

- Clause 2 contains the list of implemented logical nodes.
- Clause 3 describes the new and extended logical nodes.
- Clause 4 describes the new and extended common data classes.

7.2.1 LOGICAL NODES

The following table is a list of the logical nodes and maximum number of instances supported within the 8 Series relays:

> *Note:*
> *Depending on the relay order code, the number of available logical nodes may change.*

Logical Nodes

Logical Nodes Name	Description	ANSI	850	869	859	845	889
L: Logical Nodes for system							
LPHD1	Physical device information		Yes	Yes	Yes	Yes	Yes
LLN0	Logical node zero		Yes	Yes	Yes	Yes	Yes
LGOS	Goose subscription		Yes	Yes	Yes	Yes	Yes
C: Logical Nodes for control							
CSWI	Switch controller	89	Yes(9)	Yes(9)	No	Yes(9)	Yes(9)
BKRCSWI	Breaker Status	52	Yes(2)	Yes(1)	Yes(1)	Yes(3)	Yes(2)
CBCILO	Circuit Breaker Interlocking		Yes(2)	No	No	Yes(3)	Yes(2)
SWICILO	Switch Interlocking		Yes(9)	No	No	Yes(9)	Yes(9)
CnctCSWI	Contactor Controller		No	Yes(1)	Yes(1)	No	No
RCLCSWI	Recloser controller	79	Yes	No	No	No	No
F: Logical Nodes for functional blocks							
TurnFltFXOT	Stator Inter-Turn Fault		No	Yes	Yes	No	No
RunHrsFXOT	Generator Run Hours		No	No	No	No	Yes
DigCntFCNT	Digital Counters		Yes(16)	Yes(16)	Yes (16)	Yes(16)	Yes (16)
G: Logical nodes for generic references							
GGIO1	Remote Outputs		Yes	Yes	Yes	Yes	Yes
GGIO2	Contact Inputs		Yes	Yes	Yes	Yes	Yes
GGIO3	Virtual Inputs		Yes	Yes	Yes	Yes	Yes
GGIO4	Virtual Outputs		Yes	Yes	Yes	Yes	Yes
GGIO5	Remote Inputs		Yes	Yes	Yes	Yes	Yes
GGIO6	Contact Outputs		Yes	Yes	Yes	Yes	Yes

Logical Nodes Name	Description	ANSI	850	869	859	845	889
GGIO7	Analog Inputs		Yes	Yes	No	Yes	Yes
ColdLodGAPC	Cold Load		Yes(2)	No	No	No	No
SwOntoFltGAPC	Switch Onto Fault	SOTF	Yes(3)	No	No	No	No
PoleDscGAPC	Pole Discordance		Yes(3)	No	No	No	No
CTSupGAPC	CT Supervision		Yes(3)	No	No	No	No
BrknCondGAPC	Broken Conductor	I1/I2	Yes(3)	No	No	No	No
FldBkrDspGAPC	Field Bkr.Discrepancy		No	No	No	No	Yes
I: Logical nodes for interfacing and archiving							
LEDsIHMI	LED status		Yes	Yes	Yes	Yes	Yes
M: Logical nodes for metering and measurement							
J1MHAI	Harmonics		Yes(1)	Yes(1)	Yes(1)	Yes(1)	Yes(1)
J2MHAI	Harmonics		Yes(1)	Yes(1)	Yes(1)	Yes(1)	Yes(1)
K1MHAI	Harmonics		Yes(1)	No	No	Yes(1)	Yes(1)
K2MHAI	Harmonics		Yes(1)	No	No	Yes(1)	Yes(1)
JKMHAI	Harmonics		Yes(1)	No	No	No	No
MMTR	Energy counters		Yes(4)	Yes(1)	Yes(1)	Yes(1)	Yes(3)
EnrLogMMTR	Energy log metering		Yes(4)	Yes(1)	Yes(1)	Yes(1)	Yes(2)
PwrDmdMMTR	Pwr Dmd metering		Yes(4)	Yes(1)	Yes(1)	Yes(1)	Yes(1)
CurDmdMMTR	Cur Dmd metering		Yes(4)	Yes(1)	Yes(1)	Yes(3)	Yes(1)
MMXU1	J metering		Yes	Yes	No	Yes	Yes
MMXU2	Sens. Gnd. current		Yes	Yes	No	No	Yes
JMMXU1	Currents		Yes	No	No	No	No
K1MMXU1	K1 currents		Yes	No	No	No	No
K2MMXU1	K2 currents		No	No	No	Yes	Yes
JKMMXU1	JK currents		Yes	No	No	No	No
K_MMXU1	K metering		No	No	No	No	Yes
FastUFMMXU1	Fast Under Freq.		Yes	No	No	No	No
CTSupMMXU1	CT Supervision		Yes	No	No	No	No
MSQI1	Sequence metering		Yes	Yes	Yes	Yes	Yes
K1MSQI1	K1Seq. metering		No	Yes	No	Yes	Yes
K2MSQI1	K2 Seq. metering		No	No	No	Yes	Yes
K_MSQI1	K Seq. metering		No	No	No	No	Yes
PwrMMXU	Power metering		Yes(4)	Yes(4)	No	Yes(4)	Yes(4)
P: Logical Nodes for protection functions							
PDOP	Directional power	32	Yes(4)	Yes(2)	Yes(2)	Yes(2)	Yes(2)
RctPwrTripPDUP	Reactive power Trip	32	No	Yes	Yes	No	Yes
RctPwrAlmPDUP	Reactive power Alm.	32	No	Yes	Yes	No	Yes
tripPDUP	Underpower Trip	37P	No	Yes	Yes	No	No
almPDUP	Underpower Alarm	37P	No	Yes	Yes	No	No
SeqShtdnPDUP	Sequence Shutdown		No	No	No	No	Yes
PwrLosPDUP	Power Loss		Yes(2)	No	No	No	No
phsPIOC	Ph. Inst. overcurrent	50P	Yes(16)	Yes(2)	Yes(2)	Yes(8)	Yes(6)

Logical Nodes Name	Description	ANSI	850	869	859	845	889
ndPIOC	Neut. Inst. Overcurrent	50N	Yes(16)	Yes(2)	Yes(1)	Yes(6)	Yes(3)
gndPIOC	Gnd. Inst. Overcurrent	50G	Yes(12)	Yes	Yes(1)	Yes(6)	Yes(2)
hsePIOC	Sen. Gnd. Inst. Overc.	50SG	Yes(4)	No	Yes(1)	No	Yes
ngseqPIOC	Neg. Seq. Inst Overc.	50_2	Yes(16)	No	Yes(1)	Yes(3)	Yes(3)
jamPIOC	Mechanical Jam	50LR	No	Yes	Yes(2)	No	No
gndfltripPIOC	Gnd Fault Trip PKP		No	Yes(2)	Yes(2)	No	No
gndfltalmPIOC	Gnd Fault Alarm PKP		No	Yes(2)	Yes(2)	No	No
scPIOC	Short Circuit		No	Yes	Yes(2)	No	No
OfflinePIOC	Offline Overcurrent	50OFL	No	No	No	No	Yes
InadvEnergPIOC	Inadvertent Energiz.	50/27	No	No	No	No	Yes
phsPTOC	Ph. Tim. Overcurrent	51P	Yes(10)	Yes(1)	Yes(1)	Yes(3)	Yes(2)
ndPTOC	Neut. Tim. Overcur.	51N	Yes(8)	Yes	Yes(1)	Yes(3)	Yes(2)
gndPTOC	Gnd. Tim. Overcur.	51G	Yes(6)	Yes(1)	Yes(1)	Yes(3)	Yes(2)
hsePTOC	Sen. Gnd. Tim Overc.	51SG	Yes(2)	Yes(1)	Yes(1)	No	Yes
ngseqPTOC	Neg.Seq.Tim. Overc.	51_2	Yes(8)	No	No	Yes(3)	No
unbalalmPTOC	Current Unbal. Alm.	46	No	Yes	Yes	No	Yes
unbaltripPTOC	Current Unbal. Trip	46	No	Yes	Yes	No	Yes
accelPTOC	Acceleration Time		No	Yes	Yes	No	No
lodincrPTOC	Load Increase alarm		No	Yes	Yes	No	Yes
TrItf0PTOC	Inter-Turn Fault Detection		No	No	No	Yes(1)	No
TrItf1PTOC	Inter-Turn Fault Detection Stage1		No	No	No	Yes(1)	No
TrItf2PTOC	Inter-Turn Fault Detection Stage2		No	No	No	Yes(1)	No
PTOF	OverFrequency	81O	Yes(12)	Yes(4)	Yes(4)	Yes(4)	Yes(2)
phsPTOV	Phase Overvoltage	59P	Yes(4)	No		Yes(2)	Yes(2)
ndPTOV	Neutral Overvoltage	59N	Yes(4)	No	Yes	Yes	Yes
ngseqPTOV	Neg.Seq. OverV.	59_2	Yes(4)	Yes	Yes	Yes	Yes
auxPTOV	Aux. Overvoltage	59X	Yes(4)	No	No	Yes	Yes(2)
phrevPTOV	Ph.Reversal OverV.	47	No	Yes	Yes	No	Yes
PTUF	UnderFrequency	81U	Yes(12)	Yes(4)	Yes(4)	Yes(4)	Yes(4)
FastPTUF	Fast UnderFreq.		Yes(9)	Yes(9)	Yes(9)	No	No
HzBndPTUF	Freq. OOB Accum.		No	No	No	No	Yes(7)
phsPTUV	Phase Undervoltage	27P	Yes(8)	Yes(4)	Yes(4)	Yes(2)	Yes(2)
auxPTUV	Aux. Undervoltage	27X	Yes(4)	Yes(2)	No	Yes(2)	Yes(2)
RctPwrPTUV	React. Pwr. UV.	40Q	Yes(4)	No	No	No	No
TmPTUV	Time Dep.UV	27T	Yes(4)	No	No	No	No
ThHaNeutPTUV	3rd Ha Neut UV.	27TN	No	No	No	No	Yes
ThHaNeutAlmPTUV	3rd Ha Neut Alm UV.	27TN	No	No	No	No	Yes

Logical Nodes Name	Description	ANSI	850	869	859	845	889
RestPTUV	Restoration		Yes(2)	No	No	No	No
ThmOvlPTTR	Thermal Model	49TOL	Yes(2)	No	No	No	No
MotThmPTTR	Thermal Model	49	No	Yes	Yes	No	No
curPTTR	Xfmr. Thrm. Overload	49	No	No	No	Yes	No
GenThmPTTR	Gen. Thrm. Overload	49	No	No	No	No	Yes
PFRC	Freq. ROC	81R	Yes(12)	Yes(2)	Yes(2)	Yes(4)	Yes(2)
trbusPTRC	Trip Bus		Yes(6)	Yes(6)	Yes(6)	Yes(6)	Yes(6)
WatPSDE	Wattmetric Gnd. Fault	32N	Yes(4)	No	No	No	No
NeutAdmPSDE	Neutral Admittance	21YN	Yes(3)	Yes	Yes	No	No
PVPH	Volts per Hertz	24	No	Yes	Yes	Yes(6)	Yes(6)
PTUC	UnderCurrent	37	Yes(3)	Yes	Yes	No	No
tripPTUC	UnderCurrent Trip	37	No	Yes	Yes	No	No
almPTUC	UnderCurrent Alarm	37	No	Yes	Yes	No	No
PMRI	Thermal Inhibit		No	Yes	Yes	No	No
instPDIF	Instant. Differential	50/87	No	No	No	Yes	No
pcntPDIF	Xrfm. Percent. Diff.	87T	No	No	No	Yes	No
PcntPDIF	Percent. Diff.	87	No	Yes	No	No	Yes
OvrlPcntPDIF	Overall Percent. Diff.	87O	No	No	No	No	Yes
RGFPDIF	Restricted Gnd. Fault	87N	Yes(3)	No	No	Yes(3)	Yes
LodEncPDIS	Load Encroachment		Yes(2)	No	No	No	Yes(2)
LosExtPDIS	Loss of Exc. Circle	40	No	Yes	Yes	No	Yes
ThHaVPHIZ	3rd Har. Volt. Diff.		No	No	No	No	Yes
HaDetPHAR	Harmonic Detection		Yes(6)	Yes(6)	Yes(6)	Yes(6)	Yes(6)
OOSPPAM	Out of Step	78	No	Yes	Yes	No	Yes
RestPTUF	UF Restoration		Yes(2)	No	No	No	No
incfltPIOC	Incipient Cable Fault Detection		Yes(2)	No	No	No	No
PTEF	TEFD		Yes(2)	No	No	No	No
Q: Logical Nodes for power quality events							
PQQVVR	power quality events		Yes	Yes	Yes	No	No
R: Logical Nodes for protection related functions							
phsRDIR	Ph. Dir. Overcurrent		Yes(6)	Yes	Yes	Yes	Yes
ndRDIR	Neut. Dir. Overcurrent		Yes(4)	Yes	Yes	Yes	Yes
gndRDIR	Gnd. Dir. Overcurrent		Yes(2)	No	No	Yes	Yes
ngseqRDIR	Neg.Seq.Dir. OverC.		Yes(2)	No	No	No	Yes
hseRDIR	Sens.Gnd.Dir. OverC.		Yes	No	No	No	Yes
RREC	Autoreclosing		Yes(2)	No	No	No	No
RCLRREC	Autoreclosing		Yes	No	No	No	No

Logical Nodes Name	Description	ANSI	850	869	859	845	889
RBRF	Breaker failure		Yes(3)	Yes(1)	Yes(1)	Yes(3)	Yes(2)
RCLRRBRF	Breaker failure		Yes	No	No	No	No
RptRFLO	Fault locator		Yes(25)	Yes(25)	Yes(25)	Yes(25)	Yes(25)
SynChkRSYN	Synchrocheck		Yes(2)	No	No	Yes	Yes
MtrStrtRDRE	Motor Start records		No	Yes	Yes	No	No
TransRcdRDRE	Transient records		Yes	Yes	Yes	Yes	Yes
S: Logical Nodes for supervision and monitoring							
ArcFlsSARC	Arc Flash		Yes(2)	Yes(2)	No	Yes(2)	Yes(2)
RtdSTMP	RTD Inputs		Yes(13)	Yes (13)	Yes (12)	Yes(13)	Yes (13)
RemRtdSTMP	Remote RTD Inputs		Yes(12)	Yes (12)	Yes (12)	Yes(12)	Yes(12)
RtdMaxSTMP	Max RTD		Yes(13)	Yes (13)	Yes (12)	Yes(13)	Yes(13)
RRtdMaxSTMP	Max Remote RTD		Yes(12)	Yes (12)	Yes (12)	Yes(12)	Yes(12)
HotRtdSTMP	Hottest RTD		No	Yes	Yes	No	Yes
RemHotRtdSTMP	Remote Hottest RTD		No	Yes	Yes	Yes	Yes
SPTR	Winding Hottest Spot		No	No	No	Yes	No
DgaSIML	DGA		No	No	No	Yes	No
BknRotSVBR	Broken Rotor Bar		No	Yes	Yes	No	No
T: Logical nodes for instrument transformers and sensors							
TVTR	Fuse Failure		Yes(2)	Yes	Yes	Yes	Yes
X: Logical nodes for switchgear							
XCBR	Breaker		Yes(2)	Yes	Yes	Yes(3)	Yes(2)
XSWI	Switchgear status		Yes(9)	Yes(9)	No	Yes(9)	Yes(9)
OHSWXSWI	Overhead Sw. health		Yes	No	No	No	No
RCLXCBR	Reclose breaker		Yes	No	No	No	No
Y: Logical nodes for power transformers							
YPTR	Harmonic Derating		No	No	No	Yes	No
XfmrYLTC	Tap Changer		No	No	No	Yes	No
Z: Logical nodes for further power system equipment							
GnStZGEN	Generator Status		No	No	No	No	Yes
ZMOT	Motor Status		No	Yes	Yes	No	No

7.2.1.1 SYSTEM LOGICAL NODES LN GROUP L

The tables in this section use the following abbreviations:

- M: Data is mandatory in the IEC 61850-7-4 ED.2
- O: Data is optional in the IEC 61850-7-4 ED.2 and is used in the device.
- E: Data is an extension to the IEC 61850-7-4 ED.2
- C: Data is conditional in the IEC 61850-7-4 ED.2 and is used in the device.

7.2.1.1.1 LPHD (PHYSICAL DEVICE INFORMATION)

LPHD class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
LPHD		Physical device information	M	

LPHD class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Data				
Common Logical Node Information				
PhyNam	DPL_0	Physical device name plate	M	
PhyHealth	ENS_11	Physical device health	M	
Proxy	SPS_0	Indicates if this LN is a proxy	M	
Sim	SPC_1	Receive Simulated GOOSE	O	
SetChang	SPS_2	Setting Change	O	
NotInServ	SPS_2	Device out of service	O	
SetFilRjct	SPS_2	Settings file rejected	O	
MajorErr	SPS_2	Major error	O	
MinorErr	SPS_2	Minor error	O	
Port4EthFail	SPS_2	Port 4 fails	O	
Port5EthFail	SPS_2	Port 5 fails	O	
FWSuccess	SPS_2	Firmware updated	O	

7.2.1.1.2 LLN0 (LOGICAL NODE ZERO)

LLN0 class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
LLN0		Logical node zero		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_0	Name plate	M	
GoCB (ACSI class GOOSE control block)				
GoCB	GoCB			

7.2.1.1.3 LGOS (GOOSE SUBSCRIPTION)

LGOS class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
LGOS		Logical node zero		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_2	Name plate	M	
St	SPS_0	Status of the subscription	M	

LGOS class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
LastStNum	INS_0	Last state number received	O	
ConfRevNum	INS_0	Expected conf revision num.	O	
GoCBRef	ORG_0		O	

7.2.1.1.4 GOCB (GOOSE CONTROL BLOCK CLASS DEFINITION)

GoCB class			
Attribute Name	**Attribute Type**	**FC**	**Notes**
GoEna	BOOLEAN	GO	Enable (TRUE), disable (FALSE)
GoID	VISIBLE STRING65	GO	
DatSet	Object Reference	GO	
ConfRev	INT32U	GO	
NdsCom	BOOLEAN	GO	
DstAddress	PHYCOMADDR	GO	

7.2.1.2 LOGICAL NODES FOR CONTROL FUNCTIONS LN GROUP C

7.2.1.2.1 CSWI SWITCHGEAR CONTROLLER

CSWI class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
CSWI_0				
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Controls				
Pos	DPC_0		M	

7.2.1.2.2 CSWI RECLOSER CONTROLLER

CSWI class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
CSWI_1				
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	

CSWI class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Controls				
Pos	DPC_0		M	
PosA	DPC_1		O	
PosB	DPC_1		O	
PosC	DPC_1		O	
HlthStr	ACD_3	Switch health pickup	O	
HlthOpnStr	ACD_3	Open time sw. health pkp.	O	
HlthClsStr	ACD_3	Close time sw. health pkp.	O	
ArcPhAStr	ACD_3	Arc time PhA sw. health pkp.	O	
ArcPhBStr	ACD_3	Arc time PhB sw. health pkp.	O	
ArcPhCStr	ACD_3	Arc time PhC sw. health pkp.	O	
EngyPhAStr	ACD_3	Arc energy PhA sw. health pkp.	O	
EngyPhBStr	ACD_3	Arc energy PhB sw. health pkp.	O	
EngyPhCStr	ACD_3	Arc energy PhC sw. health pkp.	O	
HlthFail	SPS_2	Sw.open or close failed	O	
ArcFail	SPS_2	Sw. arc time failed	O	

7.2.1.3 LOGICAL NODES FOR GENERIC REFERENCES LN GROUP G

7.2.1.3.1 GGIO (GENERIC PROCESS I/O)

7.2.1.3.1.1 GGIO1: REMOTE OUTPUTS

GGIO class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O/**	**Notes**
GGIO_RO		Generic process I/O		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status information				
Ind1	SPS_0	General Indication (binary input)	O	Remote Output 1
Ind2	SPS_0	General Indication (binary input)	O	Remote Output 2
..	..	..	..	
Ind32	SPS_0	General Indication (binary input)	O	Remote Output 32

7.2.1.3.1.2 GGIO2: CONTACT INPUTS

GGIO class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
GGIO_CI		Generic process I/O		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Ind1	SPS_0	General Indication	O	Contact input 1
Ind2	SPS_0	General Indication	O	Contact input 2
..	..	..	..	
Ind32	SPS_0	General Indication	O	Contact input 32

7.2.1.3.1.3 GGIO3: VIRTUAL INPUTS

GGIO class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
GGIO_VI		Generic process I/O		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status information				
Controls				
SPCSO1	SPC_1	Single point controllable status output	O	Virtual Input 1
SPCSO2	SPC_1	Single point controllable status output	O	Virtual Input 2
..	..	..	..	
SPCSO64	SPC_1	Single point controllable status output	O	Virtual Input 64

7.2.1.3.1.4 GGIO3: VIRTUAL INPUTS

GGIO class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
GGIO_VI		Generic process I/O		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	

GGIO class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status information				
Controls				
SPCSO1	SPC_1	Single point controllable status output	O	Virtual Input 1
SPCSO2	SPC_1	Single point controllable status output	O	Virtual Input 2
..	..	..	..	
SPCSO64	SPC_1	Single point controllable status output	O	Virtual Input 64

7.2.1.3.1.5 GGIO4: VIRTUAL OUTPUTS LOGICAL NODE

GGIO class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
GGIO_VO		Generic process I/O		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status information				
Ind1	SPS_0	General Indication	O	Virtual Output 1
Ind2	SPS_0	General Indication	O	Virtual Output 2
..	..	..	..	
Ind96	SPS_0	General Indication	O	Virtual Output 96

7.2.1.3.1.6 GGIO5: REMOTE INPUTS (GOOSE) LOGICAL NODE FOR 3A/3E OPTION

GGIO class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
GGIO_RI		Generic process I/O		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status information				
Ind1	SPS_0	General Indication	O	Remote input 1
Ind2	SPS_0	General Indication	O	Remote input 2
..	..	..	..	

GGIO class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Ind256	SPS_0	General Indication	O	Remote input 256
AnIn1	MV_2	Analog Input	O	Float type
..	..	..	..	
AnIn24	MV_2	Analog Input	O	Float type
AnIn25	MV_4	Analog Input	O	Integer type
..	..	..	..	
AnIn32	MV_4	Analog Input	O	Integer type

7.2.1.3.1.7 GGIO5: REMOTE INPUTS (GOOSE) LOGICAL NODE FOR 2A/2E OPTION

GGIO class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
GGIO_RI		Generic process I/O		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status information				
Ind1	SPS_0	General Indication	O	Remote input 1
Ind2	SPS_0	General Indication	O	Remote input 2
..	..	..	..	
Ind128	SPS_0	General Indication	O	Remote input 128
AnIn1	MV_2	Analog Input	O	Float type
..	..	..	..	
AnIn6	MV_2	Analog Input	O	Float type
AnIn7	MV_4	Analog Input	O	Integer type
AnIn8	MV_4	Analog Input	O	Integer type

7.2.1.3.1.8 GGIO6: CONTACT OUTPUTS

GGIO class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
GGIO_CO		Generic process I/O		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Ind1	SPS_0	General Indication	O	Contact Output 1
Ind2	SPS_0	General Indication	O	Contact Output 2

GGIO class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Ind3	SPS_0	General Indication	O	
Ind4	SPS_0	General Indication	O	
Ind8	SPS_0	General Indication	O	
Ind9	SPS_0	General Indication	O	
Ind10	SPS_0	General Indication	O	
Ind11	SPS_0	General Indication	O	
Ind12	SPS_0	General Indication	O	
Ind16	SPS_0	General Indication	O	
Ind17	SPS_0	General Indication	O	
Ind18	SPS_0	General Indication	O	
Ind19	SPS_0	General Indication	O	
Ind20	SPS_0	General Indication	O	
Ind24	SPS_0	General Indication	O	

7.2.1.3.1.9 GGIO7: ANALOG INPUTS

GGIO class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
GGIO_AI		Generic process I/O		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
AnIn1	SPS_0	General Indication	O	Analog Input 1
AnIn2	SPS_0	General Indication	O	Analog Input 2
AnIn3	SPS_0	General Indication	O	
AnIn4	SPS_0	General Indication	O	

7.2.1.3.2 GAPC (GENERIC AUTOMATIC PROCESS CONTROL)

7.2.1.3.2.1 COLDLODGAPC: COLD LOAD

GAPC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O/**	**Notes**
ColdLodGAPC		Generic Automatic process control		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	

GAPC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O/**	**Notes**
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status information				
Str	ACD_2		O	
Op	ACT_2		O	

7.2.1.3.2.2 SWONTOFLT: SWITCH ONTO FAULT

GAPC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O/**	**Notes**
SwOntoFltGAPC		Generic Automatic process control		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status information				
Str	ACD_2		O	
Op	ACT_2		O	

7.2.1.3.2.3 FLDBKRDSPGAPC: FIELD BREAKER DISCREPANCY

GAPC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O/**	**Notes**
FldBkrDspGAPC		Generic Automatic process control		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status information				
Str	ACD_2		O	
Op	ACT_2		O	

7.2.1.3.2.4 BRKNCONGAPC: BROKEN CONDUCTOR

GAPC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O/**	**Notes**
BrknConGAPC		Generic Automatic process control		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status information				
Str	ACD_2		O	
Op	ACT_2		O	

7.2.1.3.2.5 POLEDSCGAPC: POLE DISCORDANCE

GAPC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O/**	**Notes**
PoleDscGAPC		Generic Automatic process control		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status information				
Op	ACT_2	Pole Discord [X] OP	O	
OpEx	ACT_3	External PD[X] OP	O	
OpCon	ACT_3	Contact PD[X] OP	O	
OpCur	ACT_3	Current PD[X] OP	O	
PhAFailOpn	SPS_2	PD[X]-A Fail to Open	O	
PhBFailOpn	SPS_2	PD[X]-B Fail to Open	O	
PhCFailOpn	SPS_2	PD[X]-C Fail to Open	O	
PhAFailCls	SPS_2	PD[X]-A Fail to Cls	O	
PhBFailCls	SPS_2	PD[X]-B Fail to Cls	O	
PhCFailCls	SPS_2	PD[X]-C Fail to Cls	O	

7.2.1.3.2.6 CTSUPGAPC: CT SUPERVISION

GAPC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O/**	**Notes**
CTSupGAPC		Generic Automatic process control		

GAPC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O/**	**Notes**
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status information				
Str	ACD_2		O	
Op	ACT_2		O	
StrSeqChk	ACD_3		O	
OpSeqChk	ACT_3		O	
StrDiffChk	ACD_3		O	
OpDiffChk	ACT_3		O	
StrSymChk	ACD_3		O	
OpSymChk	ACT_3		O	

7.2.1.4 LOGICAL NODES FOR INTERFACING AND ARCHIVING LN GROUP I

7.2.1.4.1 LEDSIHMI: STATUS OF THE LEDS

IHMI class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
IHMI		Human Machine Interface		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
InService	SPS_2	In Service LED	O	
TripInd	SPS_2	Trip LED	O	
AlmImd	SPS_2	Alarm LED	O	
StrInd	SPS_2	Pickup LED	O	
UsrPrgmLED5	SPS_2	User-programmable LED 5	O	
...	SPS_2		O	
UsrPrgmLED17	SPS_2	User-programmable LED 17	O	
...	SPS_2		O	
UsrPrgmLED24	SPS_2	User-programmable LED 24	O	

The number of user-programmable LEDs available depends on the order code Faceplet Option:

- M (basic): UserPrgmLED 5 - UsrPrgmLED17
- G (standard): UserPrgmLED 5 - UsrPrgmLED17
- A (advanced): UserPrgmLED 5 - UsrPrgmLED24

7.2.1.5 LOGICAL NODES FOR METERING AND MEASUREMENT LN GROUP M

7.2.1.5.1 MHAI (HARMONICS OR INTERHARMONICS)

Applicable for:

- J1MHAI1
- J2MHAI1
- K1MHAI1
- K2MHAI1
- JKMHAI1

MHAI class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
MHAI		Measurement		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Measured values				
ThdA	WYE_5		O	
HA2	WYE_4	2nd harmonic	O	
...	WYE_4		O	
HA25	WYE_4	25th harmonic	O	

7.2.1.5.2 MMXU (MEASUREMENT)

7.2.1.5.2.1 MMXU1: MEASUREMENT

MMXU class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
MMXU_1		Measurement		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Measured values				

MMXU class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Hz	MV_0	Line Frequency	O	VLFREC
HzRte	MV_1	Frequency Rate of Change	O	
Hz3VT	MV_1	3VT Frequency	O	
Hz3VTRte	MV_1	3VT Frq Rate of Chge	O	
HzVx	MV_1	Vx Frequency	O	
HzVxRte	MV_1	Vx Frq Rate of Chge	O	
PPV	DEL_0	Phase to phase voltages (VL1L2,...)	O	Phase Voltage
PhV	WYE_0	Phase to ground voltages (VL1ER, ...)	O	Ground Voltage
A	WYE_1	Phase currents (IL1, ...)	O	Currents
AuxV	CMV_1	Auxiliary Phase Voltage	O	Aux Voltage
AvAPhs	MV_0	Average Phase Current	O	

7.2.1.5.2.2 MMXU2: MEASUREMENTS (SENSITIVE GROUND)

MMXU class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
MMXU_2		Measurement		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Measured values				
A	WYE_2	Phase currents (IL1, ...)	O	Currents
AvAPhs	MV_0	Average Phase Current	O	

7.2.1.5.2.3 K1MMXU1 AND K2MMXU1

Applicable for:

- K1MMXU1 (845, 869, 889)
- K2MMXU1 (845, 889)

MMXU class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
MMXU_SLOT_K		Measurement		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	

MMXU class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
NamPlt	LPL_1	Name plate	M	
Measured values				
Hz	MV_0	Line Frequency	O	VLFREC
HzRte	MV_1	Frequency Rate of Change	O	VLFREC
A	WYE_2	Phase currents (IL1, ...)	O	Currents
AvAPhs	MV_0	Average Phase Current	O	

7.2.1.5.2.4 MMXU1 CURRENTS

Applicable for:

- JMMXU1: Slot J Currents
- K1MMXU1: K1 Currents
- K2MMXU1: K2 Currents
- JKMMXU1: JK Currents

MMXU class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
MMXU_SLOT_K_2		Measurement		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Measured values				
A	WYE_1	Phase currents (IL1, ...)	O	Currents
AvAPhs	MV_0	Average Phase Current	O	

7.2.1.5.2.5 K2 MMXU1 AND K2MMXU2 FOR 850

Applicable for:

- K2MMXU1 (850)
- K2MMXU2 (850)

MMXU class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
MMXU_SLOT_K_3		Measurement		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	

MMXU class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Measured values				
Hz3VT	MV_1	3VT Frequency	O	
HzVx	MV_1	Vx Frequency	O	
PPV	DEL_0	Phase to Phase Voltage		
AuxV	CMV_1	VAux		

7.2.1.5.2.6 CTSUPMMXU: CT SUPERVISION METERING

MMXU class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
MMXU_CTS		Measurement		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Measured values				
CTS1SymImin	MV_1	CTS1 Symmetric Min. Current	O	
CTS1SymImax	MV_1	CTS1 Symmetric Max. Current	O	
CTS1SymQuot	MV_1	CTS1 Symmetric Quotient	O	
CTS1DiffCur	MV_1	CTS1 Differential Current	O	
CTS2SymImin	MV_1	CTS2 Symmetric Min. Current	O	
CTS2SymImax	MV_1	CTS2 Symmetric Max. Current	O	
CTS2SymQuot	MV_1	CTS2 Symmetric Quotient	O	
CTS2DiffCur	MV_1	CTS2 Differential Current	O	
CTS3SymImin	MV_1	CTS3 Symmetric Min. Current	O	
CTS3SymImax	MV_1	CTS3 Symmetric Max. Current	O	
CTS3SymQuot	MV_1	CTS3 Symmetric Quotient	O	
CTS3DiffCur	MV_1	CTS3 Differential Current	O	

7.2.1.5.2.7 PWRMMXU: POWER METERING

MMXU class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
MMXU_POWER		Measurement		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	

MMXU class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
NamPlt	LPL_1	Name plate	M	
Measured values				
TotW	MV_0	Total active power (P)	O	Real Power
TotVAr	MV_0	Total reactive power (Q)	O	Reactive Power
TotVA	MV_0	Total apparent power (S)	O	Apparent Power
TotPF	MV_0	Average power factor (PF)	O	Power Factor
W	WYE_3	Phase active power	O	Real Power
VAr	WYE_3	Phase reactive power	O	Reactive Power
VA	WYE_3	Phase apparent power	O	Apparent Power
PF	WYE_3	Phase power factor	O	Power Factor

7.2.1.5.3 MSQI SEQUENCE AND IMBALANCE

The tables in this section use the following abbreviations:

- M: Data is mandatory in the IEC 61850-7-4 ED.2
- O: Data is optional in the IEC 61850-7-4 ED.2 and is used in the device.
- E: Data is an extension to the IEC 61850-7-4 ED.2
- C: Data is conditional in the IEC 61850-7-4 ED.2 and is used in the device.

7.2.1.5.3.1 MSQI: SEQUENCE METERING

Applicable for:

- a) MSQI1: Sequence Metering
- b) K_MSQI: K Sequence Metering

MSQI class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O/C**	**Notes**
MSQI_1		Sequence and imbalance		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Measured values				
SeqA	SEQ_0	Pos, Neg and Zero seq Current	C	I0_P, I1_P, I2_P
SeqV	SEQ_0	Pos, Neg and Zero seq Voltage	C	V0_P, V1_P, V2_P

7.2.1.5.3.2 MSQI: K1 & K2 SEQUENCE METERING

Applicable for:

- K1MSQI1: K1 Sequence Metering
- K2MSQI1: K2 Sequence Metering

MSQI class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O/C**	**Notes**
MSQI_2		Sequence and imbalance		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Measured values				
SeqA	SEQ_0	Pos, Neg and Zero seq Current	C	I0_P, I1_P, I2_P

7.2.1.5.4 MMTR

7.2.1.5.4.1 MMTR: ENERGY COUNTERS

MMTR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
MMTR_1		Metering		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Measured values				
CntPsWh	MV_1	Power Pos. WHrs	O	
CntPsWhCst	MV_3	Power Pos. WHrs Cost	O	
CntNgWh	MV_1	Power Neg. WHrs	O	
CntNgWhCst	MV_3	Power Neg. WHrs Cost	O	
CntPsVArh	MV_1	Power Pos. VArHours	O	
CntNgVArh	MV_1	Power Neg. VArHours	O	
RsEnrDT	INS_1	Reset Energy D/T	O	

7.2.1.5.4.2 ENRLOGMMTR: ENERGY LOG METERING

MMTR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
MMTR_2		Measurement		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	

MMTR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Measured values				
PosLEWh	MV_3	Power Last Event Pos. WattHours	O	
NegLEWh	MV_3	Power Last Event Neg. WattHours	O	
PosLEVArh	MV_3	Power Last Event Pos. VarHours	O	
NegLEVArh	MV_3	Power Today Neg. VarHours	O	
PosTdyWh	MV_3	Power Today Pos. WattHours	O	
NegTdyWh	MV_3	Power Today Neg. WattHours	O	
PosTdyVArh	MV_3	Power Today Pos. VarHours	O	
NegTdyVArh	MV_3	Power Yesterday Neg. VarHours	O	
PosYdyWh	MV_3	Power Yesterday Neg. VarHours	O	
NegYdyWh	MV_3	Power Yesterday Pos. WattHours	O	
PosYdyVArh	MV_3	Power Yesterday Neg. WattHours	O	
NegYdyVArh	MV_3	Power Yesterday Pos. VarHours	O	
RsEnrDT	INS_1	Reset Energy Log D/T	O	

7.2.1.5.4.3 PWRDMDMMTR: POWER DEMAND METERING

MMTR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
MMTR_3		Measurement		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Measured values				
PwrRsDmdDT	INS_1	Power Reset Demand D/T	O	
WDmd	MV_1	Power Real Demand	O	
WMaxDmd	MV_3	Power Max Real Demand	O	
WMinDmd	MV_3	Power Min Real Demand	O	
VArDmd	MV_1	Power Reactive Demand	O	
VArMaxDmd	MV_3	Power Max Reactive Demand	O	

MMTR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
VarMinDmd	MV_3	Power Min Reactive Demand	O	
VADmd	MV_1	Power Apparent Demand	O	
VAMaxDmd	MV_3	Power Max Apparent Demand	O	
VAMinDMD	MV_3	Power Min Apparent Demand	O	

7.2.1.5.4.4 CURDMDMMTR: CURRENT DEMAND METERING

MMTR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
MMTR_4		Measurement		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Measured values				
CurRsDmdDT	INS_1	Current Reset Demand D/T	O	
Aamd	MV_1	Current PhA Demand	O	
AbDmd	MV_1	Current PhB Demand	O	
AcDmd	MV_1	Current PhC Demand	O	
AaMaxDmd	MV_3	Current Max PhA Demand	O	
AbMaxDmd	MV_3	Current Max PhB Demand	O	
AcMaxDmd	MV_3	Current Max PhC Demand	O	

7.2.1.6 LOGICAL NODES FOR PROTECTION FUNCTIONS LN GROUP P

7.2.1.6.1 PDOP (DIRECTIONAL OVERPOWER)

PDOP class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
PDOP		Directional Overpower		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	

PDOP class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Op	ACT_2	Operate	M	

7.2.1.6.2 PDOP (DIRECTIONAL UNDERPOWER)

7.2.1.6.2.1 RCTPWRTRIPPDUP: REACTIVE POWER TRIP

PDUP class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
RctPwrTripPDUP		Directional Underpower		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACT_2	Operate	M	
StrPos	ACD_3	Positive pickup	O	
OpPos	ACT_3	Negative pickup	O	
StrNeg	ACD_3	Positive Operate	O	
OpNeg	ACT_3	Negative Operate	O	

7.2.1.6.2.2 RCTPWRALMPDUP: REACTIVE POWER ALARM

PDUP class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
RctPwrAlmPDUP		Directional Underpower		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACT_2	Operate	M	
StrPos	ACD_3	Positive pickup	O	
OpPos	ACT_3	Negative pickup	O	
StrNeg	ACD_3	Positive Operate	O	
OpNeg	ACT_3	Negative Operate	O	

7.2.1.6.2.3 C) SEQSHTDNPDUP: SEQUENTIAL SHUTDOWN

PDUP class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
SeqShtdnPDUP		Directional Underpower		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACT_2	Operate	M	

7.2.1.6.2.4 PWRLOSPDUP: POWER LOSS

PDUP class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
PDUP_2		Directional Underpower		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_0	Start	M	
Op	ACT_0	Operate	M	

7.2.1.6.3 PIOC (INSTANTANEOUS OVERCURRENT)

7.2.1.6.3.1 PHSPIOC: PHASE IOC

PIOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
phsPIOC		Instantaneous overcurrent		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_0	Start	O	
Op	ACT_0	Operate	M	

7.2.1.6.3.2 OFFLINEPIOC: OFFLINE IOC

PIOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Offline PIOC		Instantaneous overcurrent		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_0	Start	O	
Op	ACT_0	Operate	M	

7.2.1.6.3.3 NDPIOC: NEUTRAL IOC

PIOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
ndPIOC		Instantaneous overcurrent		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_1	Start	O	
Op	ACT_1	Operate	M	

7.2.1.6.3.4 GNDPIOC: GROUND IOC

PIOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
gndPIOC		Instantaneous overcurrent		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_1	Start	O	
Op	ACT_1	Operate	M	

7.2.1.6.3.5 HSEPIOC: SENSITIVE GROUND IOC

PIOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
hsePIOC		Instantaneous overcurrent		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_1	Start	O	
Op	ACT_1	Operate	M	

7.2.1.6.3.6 JAMPIOC: MECHANICAL JAM

PIOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
jamPIOC		Instantaneous overcurrent		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_1	Start	O	
Op	ACT_1	Operate	M	

7.2.1.6.3.7 SCPIOC: SHORT CIRCUIT

PIOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
scPIOC		Instantaneous overcurrent		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_1	Start	O	

PIOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Op	ACT_1	Operate	M	

7.2.1.6.3.8 NGSEQPIOC: NEGATIVE SEQUENCE IOC

PIOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
NgSeqPIOC		Instantaneous overcurrent		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	O	Neq Seq IOC PKP
Op	ACT_2	Operate	M	Neq Seq IOC OP

7.2.1.6.3.9 INADVENERGPIOC: INADVERTENT ENERGIZATION

PIOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
InadvEnergPIOC		Inadvertent Energization		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Op	ACD_2	Operate	M	
Armed	ACT_3	Armed	O	

7.2.1.6.4 PTOC (TIME OVERCURRENT)

7.2.1.6.4.1 PHSPTOC: PHASE TOC

PTOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
PhsPTOC		Time overcurrent		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	

PTOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_0	Start	O	TOC PKP
Op	ACT_0	Operate	M	TOC OP

7.2.1.6.4.2 NDPTOC: NEUTRAL TOC

PTOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
ndPTOC		Time overcurrent		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_1	Start	O	PKP
Op	ACT_1	Operate	M	OP

7.2.1.6.4.3 GNDPTOC: GROUND TOC

PTOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
gndPTOC		Time overcurrent		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_1	Start	O	PKP
Op	ACT_1	Operate	M	OP

7.2.1.6.4.4 HSEPTOC: SENSITIVE GROUND TOC

PTOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
hsePTOC		Time overcurrent		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	

PTOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_1	Start	O	PKP
Op	ACT_1	Operate	M	OP

7.2.1.6.4.5 UNBALALMPTOC: CURRENT UNBALANCE ALARM

PTOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
unbalalmPTOC		Time overcurrent		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_1	Start	O	PKP
Op	ACT_1	Operate	M	OP

7.2.1.6.4.6 UNBALTRIPPTOC: CURRENT UNBALANCE TRIP

PTOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
unbaltripPTOC		Time overcurrent		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_1	Start	O	PKP
Op	ACT_1	Operate	M	OP

7.2.1.6.4.7 ACCELPTOC: ACCELERATION

PTOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
accelPTOC		Time overcurrent		
Data				

PTOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_1	Start	O	PKP
Op	ACT_1	Operate	M	OP

7.2.1.6.4.8 LDINCPTOC: LOAD INCREASE ALARM

PTOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
ldincPTOC		Time overcurrent		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_1	Start	O	PKP
Op	ACT_1	Operate	M	OP

7.2.1.6.4.9 NGSEQPTOC: NEGATIVE SEQUENCE TOC

PTOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
NgSeqPTOC		Time overcurrent		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	O	
Op	ACT_2	Operate	M	

7.2.1.6.4.10 PTOC_TRITF: INTER-TURN FAULT DETECTION

PTOC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
TrItf0PTOC/ TrItf1PTOC/ TrItf2PTOC/		Inter-Turn Fault Detection/ Inter-Turn Fault Detection Stage1/ Inter-Turn Fault Detection Stage2		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Inter-Turn Fault Detection PKP	O	
Op	ACT_2	Inter-Turn Fault Detection OP	M	
kFactCalFail	SPS_2	Inter-Turn Flt k Fac Cal Fail operand	O	
kFactCalApld	SPS_2	Inter-Turn Flt k Fac Cal Apld operand	O	
DifARaw	WYE_7	Phase raw percent differential currents	O	
kFact	WYE_7	Inter-Turn k Factors phase related	O	
DifAComp	WYE_8	Phase compensated differential currents	O	

7.2.1.6.5 PTOF: OVERFREQUENCY

PTOF class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
PTOF		OverFrequency		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	PTOF PKP
Op	ACT_2	Operate	M	PTOF OP

7.2.1.6.6 PTOV (OVERVOLTAGE)

7.2.1.6.6.1 PHSPTOV: PHASE OVERVOLTAGE

PTOV class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
phsPTOV		Overvoltage		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_0	Start	M	Phase TOV PKP
Op	ACT_0	Operate	O	Phase TOV OP

7.2.1.6.6.2 NDPTOV: NEUTRAL OVERVOLTAGE

PTOV class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
ndPTOV		Overvoltage		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACT_2	Operate	M	

7.2.1.6.6.3 NGSEQPTOV: NEGATIVE SEQUENCE OVERVOLTAGE

PTOV class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
ngseqPTOV		Overvoltage		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACT_2	Operate	M	

7.2.1.6.6.4 AUXPTOV: AUXILIARY OVERVOLTAGE

PTOV class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
auxPTOV/		Overvoltage		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACT_2	Operate	M	

7.2.1.6.6.5 PHSREVPTOV: PHASE REVERSAL OVERVOLTAGE

PTOV class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
phsrevPTOV		Overvoltage		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACT_2	Operate	M	

7.2.1.6.7 PTUF (UNDERFREQUENCY)

7.2.1.6.7.1 PTUF: UNDERFREQUENCY

PTUF class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
PTUF		UnderFrequency		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				

PTUF class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Str	ACD_2	Start	M	PTUF PKP
Op	ACT_2	Operate	M	PTUF OP

7.2.1.6.7.2 FASTPTUF: FAST UNDERFREQUENCY

PTUF class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
FastPTUF		UnderFrequency		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	PTUF PKP
Op	ACT_2	Operate	M	PTUF OP

7.2.1.6.7.3 HZBNDPTUF: FREQUENCY OUT OF BAND ACCUMULATION

PTUF class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
HzBndPTUF		UnderFrequency		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACD_2	Operate	M	
Measured and metered values				
HzObAccum	MV_3	Frequency OOB Accum	O	

7.2.1.6.8 PTUV (UNDERVOLTAGE)

7.2.1.6.8.1 PHSPTUV: PHASE UNDERVOLTAGE

PTUV class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
phsPTUV		Undervoltage		
Data				

PTUV class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_0	Start	M	Phase PTUV PKP
Op	ACT_0	Operate	M	Phase PTUV OP

7.2.1.6.8.2 AUXPTUV: AUXILIARY UNDERVOLTAGE

PTUV class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
auxPTUV		Undervoltage		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACT_2	Operate	M	

7.2.1.6.8.3 THHANEUTPTUV: THIRD HARMONIC NEUTRAL UNDERVOLTAGE

PTUV class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
ThHaNeutPTUV		Undervoltage		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACT_2	Operate	M	

7.2.1.6.8.4 THHANEUTALMPTUV: THIRD HARMONIC NEUTRAL UNDERVOLTAGE

PTUV class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
ThHaNeutAlmPTUV		Undervoltage		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACT_2	Operate	M	

7.2.1.6.8.5 RCTPWRPTUV: REACTIVE POWER UNDERVOLTAGE

PTUV class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
RectPwrPTUV		Undervoltage		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACT_2	Operate	M	
Restore	SPS_2		O	

7.2.1.6.8.6 TMPTUV: TIME DEPENDENT UNDERVOLTAGE

PTUV class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
TimedPTUV		Undervoltage		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACT_2	Operate	M	
TmCrv	SPS_2	Curve	O	

PTUV class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Cnt	SPS_2	Counter	O	

7.2.1.6.8.7 RESTPTUV: RESTORATION UNDERVOLTAGE

PTUV class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
RestorationPTUV		Undervoltage		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACT_2	Operate	M	
StrAux	ACD_3	Start	O	
OpAux	ACT_3	Operate	O	
Init	SPS_2	Initiate	O	

7.2.1.6.9 PTTR (THERMAL OVERLOAD)

7.2.1.6.9.1 PTTR: THERMAL O/L

PTTR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
PTTR		Thermal Overload		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_0	Start	M	
Op	ACT_0	Operate	M	

7.2.1.6.9.2 MOTTHMPTTR: THERMAL MODE NODE

PTTR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
MotThmPTTR		Thermal Overload		
Data				

PTTR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_0	Start	M	
Op	ACT_0	Operate	M	

7.2.1.6.9.3 CURPTTR: TRANSFORMER O/L

PTTR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
curPTTR		Thermal Overload		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	O	
StrW1	ACT_3	Start W1	O	
StrW2	ACT_3	Start W2	O	
StrW3	ACT_3	Start W3	O	
Op	ACT_2	Operate	M	

7.2.1.6.9.4 TMPPTTR: THERMAL O/L

PTTR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
tmpPTTR		Thermal Overload		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	O	
Op	ACT_2	Operate	M	

7.2.1.6.9.5 GENTHMPTTR: THERMAL O/L

PTTR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
GenThmPTTR		Thermal Overload		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	O	
Op	ACT_2	Operate	M	

7.2.1.6.10 PFRC: RATE OF CHANGE OF FREQUENCY

PFRC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
PFRC		Rate of change of frequency		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACT_2	Operate	M	

7.2.1.6.11 PTRC: TRIP BUS

PTRC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
PFRC		Trip bus		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACT_2	Operate	M	

7.2.1.6.12 PSDE (SENSITIVE DIRECTIONAL EARTH FAULT)

PSDE class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
WatPSDE/ NeutAdm		Sensitive directional earth fault (/ Neutral admittance)		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACT_2	Operate	O	

7.2.1.6.13 PVPH: VOLTS PER HERTZ

PVPH class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
PVPH		Volts per Hertz		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACT_2	Operate	M	

7.2.1.6.14 PTUC (UNDERCURRENT)

7.2.1.6.14.1 TRIPPTUC: UNDERCURRENT TRIP

Applicable for:

- tripPTUC: Undercurrent trip
- almPTUC: Undercurrent alarm

PTUC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
PTUC		Undercurrent		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	

PTUC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACT_2	Operate	M	

7.2.1.6.14.2 ALMPTUC: UNDERCURRENT ALARM

PTUC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
almPTUC		Undercurrent		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACT_2	Operate	M	

7.2.1.6.14.3 PTUC: UNDERCURRENT

PTUC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
PTUC_2		Undercurrent		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACT_2	Operate	M	
StrAlm	ACD_3	Start aux	O	
OpAlm	ACT_3	Operate aux	O	

7.2.1.6.15 PMRI: START INHIBIT

PMRI class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
PMRI		Start inhibit		

PMRI class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
StrInh	SPS_0	Start inhibited	O	

7.2.1.6.16 PDIF (DIFFERENTIAL PROTECTION)

7.2.1.6.16.1 INSTPDIF: INSTANTANEOUS DIFFERENTIAL

PDIF class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
PDIF_2		Differential protection		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Op	ACT_2	Operate	M	

7.2.1.6.16.2 PCNTPDIF: TRANSFORMER PERCENT DIFFERENTIAL AND OVRLPCNTPDIF: OVERALL PERCENT DIFFERENTIAL

Applicable for:

- PcntPDIF: Transformer Percent Differential
- OvrlPcntPDIF: Overall Percent Differential

PDIF class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
PERC_PDIF_1		Differential protection		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_0	Start	o	

PDIF class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Op	ACT_0	Operate	M	
DifACLc	WYE_3	Differential Current	O	
RstA	WYE_3	Restraint Current	O	
Ha2ndA	WYE_4	2nd Harmonic Current	O	
Ha5thA	WYE_4	5th Harmonic Current	O	

7.2.1.6.16.3 PCNTPDIF: MOTOR/GENERATOR PERCENT DIFFERENTIAL

Applicable for:

- PcntPDIF: Generator Percent Differential
- PcntPDIF: Motor Percent Differential

PDIF class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
PERC_PDIF_0		Differential protection		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_0	Start	O	
Op	ACT_0	Operate	M	
DifACLc	WYE_3	Differential Current	O	
RstA	WYE_3	Restraint Current	O	

7.2.1.6.16.4 RGFPDIF: RESTRICTED GROUND FAULT

PDIF class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
RGFPDIF		Differential protection		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_0	Start	O	
Op	ACT_0	Operate	M	
SupervOn	SPS_2	Supervision	O	

7.2.1.6.17 PDIS (DIFFERENTIAL PROTECTION)

7.2.1.6.17.1 LODECRPDIS: LOAD ENCROACHMENT

PDIS class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
PDIS_0		Differential Protection		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	
Op	ACT_2	Operate	M	

7.2.1.6.17.2 LOSEXTPDIS: LOSS OF EXCITATION

PDIS class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
PDIS_1		Differential Protection		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start Circle 1	M	
Op	ACT_2	Operate Circle 1	M	
StrC2	ACD_2	Start Circle 2	O	
OpC2	ACT_2	Operate Circle 2	O	
Z1ResC1	MV_3	Z1 Resistance Circle 1	O	
Z1ReaC1	MV_3	Z1 Reactance Circle 1	O	
Z1MagC1	MV_3	Z1 Magnitude Circle 1	O	
Z1AngC1	MV_3	Z1 Angle Circle 1	O	
Z1ResC2	MV_3	Z1 Resistance Circle 2	O	
Z1ReaC2	MV_3	Z1 Reactance Circle 2	O	
Z1MagC2	MV_3	Z1 Magnitude Circle 2	O	
Z1AngC2	MV_3	Z1 Angle Circle 2	O	

7.2.1.6.18 THHAVPHIZ: THIRD HARMONIC VOLTAGE DIFFERENCE

PHIZ class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
ThHaVTripPHIZ/ ThHaVAlmpPHIZ		Ground detector		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start Trip	O	
Op	ACT_2	Operate Trip	M	
StrAlm	ACD_3	Start Alarm	O	
OpAlm	ACT_3	Operate Alarm	O	

7.2.1.6.19 HADETPHAR: HARMONIC DETECTION

PHAR class				
Attribute Name	Attr. Type	Explanation	M/O	Notes
HaDetPHAR		Harmonic restraint		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	O	
Op	ACT_2	Operate	M	

7.2.1.6.20 OOSPPAM: OUT OF STEP

PPAM class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
OOSPPAM		Out of step		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Start	M	

PPAM class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
StrLftBld	ACT_3	Left blinder pickup	O	
StrRgtBld	ACT_3	Right blinder pickup	O	
StrTimer	ACT_3	Timer pickup	O	
Op	ACT_2	Operate	M	

7.2.1.6.21 PTEF: TRANSIENT EARTH/GROUND FAULT DETECTION

PPAM class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
PTEF		Transient earth/ground fault		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Str	ACD_2	Enabled	M	
TrRv	SPS_2	Reverse	O	
TrFw	SPS_2	Forward	O	
Measured values				
TrReactPwr	MV_3	Transient Reactive Power	M	
TrActPwr	MV_3	Transient Active Power	O	
DyThrPosQ	MV_3	Dynam. Threshold Pos Q	O	
DyThrNegQ	MV_3	Dynam. Threshold Neg Q	O	
DyThrPosP	MV_3	Dynam. Threshold Pos P	O	
DyThrNegQ	MV_3	Dynam. Threshold Pos P	O	

7.2.1.7 LOGICAL NODES FOR POWER QUALITY EVENTS LN GROUP Q

7.2.1.7.1 PQQVVR: POWER QUALITY EVENTS

QVVR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
QVVR_VD		Voltage variation		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				

QVVR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
VarStr	SPS_0	Volt Sag OP or Volt Swell OP	M	
DipStr	SPS_0	Volt Sag OP	O	
SwlStr	SPS_0	Volt Swell OP	O	
Measured and metered values				
RcdSncClr	INS_1	Records Since Clear	O	
RsTms	INS_1	Last Clear Date/time	O	
SrcPh	ENS_8	Source Phase	O	
EvtTyp	ENS_9	Event Type	O	
EvtInst	ENS_10	Element Instance	O	
VVa	MV_2	Volt Variation magnitude	O	
VVaTm	MV_2	Duration	O	
EvtDt	INS_1	Date/Time	O	

7.2.1.8 LOGICAL NODES FOR PROTECTION RELATED FUNCTIONS LN GROUP R

7.2.1.8.1 RDIR (DIRECTIONAL ELEMENT)

7.2.1.8.1.1 PHSRDIR: PHASE DIRECTIONAL OVERCURRENT

RDIR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
PhsRDIR		Directional Element		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Dir	ACD_0	Direction	M	
Op	ACT_0	Operate	O	

7.2.1.8.1.2 NDRDIR: NEUTRAL DIRECTIONAL ELEMENT

RDIR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
ndRDIR		Directional Element		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	

RDIR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Dir	ACD_1	Direction	M	
Op	ACT_3	Operate	O	

7.2.1.8.1.3 GNDRDIR: GROUND DIRECTIONAL ELEMENT (845, 850, 889)

RDIR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
gndRDIR		Directional Element		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Dir	ACD_1	Direction	M	
Op	ACT_3	Operate	O	

7.2.1.8.1.4 NGSEQRDIR: NEGATIVE SEQUENCE DIRECTIONAL ELEMENT (850,889)

RDIR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
ngseqRDIR		Directional Element		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Dir	ACD_2	Directions	M	
Op	ACT_2	Directions	O	

7.2.1.8.1.5 HSERDIR: GROUND DIRECTIONAL OVERCURRENT (850, 889)

RDIR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
hseRDIR		Directional Element		
Data				
Common Logical Node Information				

RDIR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Dir	ACD_2	Directions	M	
Op	ACT_2	Directions	O	

7.2.1.8.2 RREC: AUTORECLOSE ELEMENTS

RREC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
RREC		Autoreclosing element		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
OpCls	ACT_2	AR Close 3P	M	
AutoRecSt	ENS_3	Operate	M	

7.2.1.8.3 RBRF: BREAKER FAILURE

RBRF class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
RBRF		Breaker failure element		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
OpEx	ACT_2	Breaker failure trip	M	
OpIn	ACT_2	Breaker failure operate	M	

7.2.1.8.4 RPTRFLO: FAULT REPORT

RFLO class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
rptRFLO		Fault locator element		
Data				

RFLO class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Measured Values				
FltZ	CMV_2	Fault Impedance	M	
FltDiskm	MV_2	Fault Distance in KM	O	
FltLoop	ENS_4	Fault Type	O	
RecCyc	INS_1	Fault Reclose Shot	O	

7.2.1.8.5 SYNCHKRSYN: SYNCHROCHECK

RSYN class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
SynChkRSYN		Synchronism-check		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Rel	SPS_0	Sync[X] OK	M	
LivBus	SPS_2	Sync[X] Live Bus	O	
LivLin	SPS_2	Sync[X] Live Line	O	
DeaBus	SPS_2	Sync[X] Dead Bus	O	
DeaLin	SPS_2	Sync[X] Dead Line	O	
ClsPerm	SPS_2	Sync[X] Close Perm	O	
Measured values				
DifVClc	MV_2	Sync[X] Voltage Difference	O	
DifHzClc	MV_2	Sync[X] Frequency Difference	O	
DifAngClc	MV_2	Sync[X] Angle Difference	O	
BusVMag	MV_3	Sync[X] Bus Volts Magnitude	O	
BusVHz	MV_3	Sync[X] Bus Volts Frequency	O	
BusVAng	MV_3	Sync[X] Bus Volts Angle	O	
LinVMag	MV_3	Sync[X] Bus Volts Magnitude	O	
LinVHz	MV_3	Sync[X] Line Volts Frequency	O	
LinVAng	MV_3	Sync[X] Bus Volts Angle	O	

7.2.1.8.6 RDRE (DISTURBANCE RECORDER)

7.2.1.8.6.1 MTRSTRTRDRE: MOTOR START RECORDS

RDRE class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
RDRE_MOTOR_START		Motor Start Records		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
RcdMade	SPS_0	Start Records	M	If FltNum>0 true, else false
FltNum	INS_0	Fault number	M	
RsTms	INS_1	Last CLear D/T	O	

7.2.1.8.6.2 TRANSRCDRDRE: TRANSIENT RECORDS

RDRE class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
RDRE_TRANSIENTS		Transient Recorder		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
RcdMade	SPS_0	Transient Records	M	If NumRcd>0 true, else false
FltNum	INS_0	Records since last clear	M	
NumRcd	INS_1	Records available	O	
RsTms	INS_1	Last Clear D/T	O	

7.2.1.9 LOGICAL NODES FOR SUPERVISION AND MONITORING LN GROUP S

7.2.1.9.1 ARCFLSSARC: ARC FLASH

SARC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O/**	**Notes**
ArcFlsSARC		Arc Flash element		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	

SARC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O/**	**Notes**
Status information				
FADet	SPS_0	Arc Flash [X] OP	M	
FADetS1	SPS_2	Arc Flash [X] S1 OP	O	
FADetS2	SPS_2	Arc Flash [X] S2 OP	O	
FADetS3	SPS_2	Arc Flash [X] S3 OP	O	
FADetS4	SPS_2	Arc Flash [X] S4 OP	O	
LT1PKP	SPS_2	AF [X] Light 1 PKP	O	
LT2PKP	SPS_2	AF [X] Light 2 PKP	O	
LT3PKP	SPS_2	AF [X] Light 3 PKP	O	
LT4PKP	SPS_2	AF [X] Light 4 PKP	O	
HsPhAIOCStr	ACD_3	AF [X] HS Ph IOC PKP A	O	
HsPhBIOCStr	ACD_3	AF [X] HS Ph IOC PKP B	O	
HsPhCIOCStr	ACD_3	AF [X] HS Ph IOC PKP C	O	
HsGndIOCStr	ACD_3	AF [X] HS GND IOC PKP A	O	
LTFail	SPS_2	Light Sensor Trouble	O	
LT1Fail	SPS_2	Light Sensor 1 Trouble	O	
LT2Fail	SPS_2	Light Sensor 2 Trouble	O	
LT3Fail	SPS_2	Light Sensor 3 Trouble	O	
LT4Fail	SPS_2	Light Sensor 4 Trouble	O	
Measured values				
HSIa	MV_3	AF[X] Hs Phase Current A	O	
HSIb	MV_3	AF[X] Hs Phase Current B	O	
HSIc	MV_3	AF[X] Hs Phase Current C	O	
HSIg	MV_3	AF[X] Hs Phase Current	O	
Controls				
FACntRs	INC_1	Fault arc counter	M	

7.2.1.9.2 STMP (TEMPERATURE SUPERVISION)

7.2.1.9.2.1 RTDSTMP: RTD TEMPERATURE SUPERVISION AND REMRTDSTMP: REMOTE RTD TEMPERATURE SUPERVISION

STMP class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
STMP		temperature sensor		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				

STMP class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Alm	SPS_0	RRTD/RTD [X] Alarm PKP	O	
Trip	SPS_0	RRTD/RTD [X] Trip PKP	O	
Str	ACD_3	RRTD/RTD [X] Trip has operated	O	
StrAlm	ACD_3	RRTD/RTD [X] Trip	O	
OpnCirc	SPS_2	RRTD/RTD [X] Open	O	
ShrtCirc	SPS_2	RRTD/RTD [X] Shorted	O	
Measured values				
Tmp	MV_4	RRTD/RTD[x] input (Temperature)	O	

7.2.1.9.2.2 HOTRTDSTMP: HOTTEST RTD AND REMHOTRTDSTMP: REMOTE HOTTEST RTD

STMP class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
HOTTEST_STMP		temperature sensor		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
ShrtCirc	SPS_2		O	
Measured values				
HotStaIn	MV_5	Rem. Hot. Sta. RTD Input	O	
HotStaTmp	MV_5	Rem. Hot. Sta. RTD Temp	O	
HotBeaIn	MV_5	Rem.Hot. Bea. RTD Input	O	
HotBeaTmp	MV_5	Rem.Hot.Bea. RTD Temp	O	

7.2.1.9.3 XFMRSPTR: WINDING HOTTEST SPOT (845)

SPTR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
XfmrSPTR		Insulation medium supervision		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
HPTmpStr	SPS_2	Hotst-Spot PKP	O	

SPTR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
HPTmpOp	SPS_0	Hotst-Spot OP	O	
AgeRteStr	SPS_2	Aging Fctr PKP	O	
AgeRteOp	SPS_2	Aging Fctr OP	O	
LOLStr	SPS_2	Xfmr LOL PKP	O	
LOLOp	SPS_2	Xfmr LOL OP	O	
Measured values				
HPTmpClc	MV_2	Wndg Hottest Spot ºC	O	
AgeRte	MV_2	Aging Factor	O	
DlyRatLOL	MV_3	Daily Rate LOL	O	
XfmrLfLst	MV_3	Transformer Life Lost	O	
TopOilTmp	MV_3	Top Oil Temperature	O	
AmbTmp	MV_3	Ambient Temperature	O	

7.2.1.9.4 DGASIML: INSULATION MEDIUM SUPERVISION (LIQUID) (845)

SIML class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
SIML_DGA		Insulation medium supervision		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Measured values				
H2ppm	MV_2	Hydrogen in ppm	O	
N2ppm	MV_2	N2 in ppm	O	
COppm	MV_2	CO in ppm	O	
CO2ppm	MV_2	CO2 in ppm	O	
CH4ppm	MV_2	CH4 in ppm	O	
C2H2ppm	MV_2	C2H2 in ppm	O	
C2H4ppm	MV_2	C2H4 in ppm	O	
C2H6ppm	MV_2	C2H6 in ppm	O	
O2ppm	MV_2	O2 in ppm	O	
MstH2Oppm	MV_3	Moisture H2O in ppm	O	
TDCG	MV_3	TDCG	O	
AmbTmp	MV_5	Ambient temperature	O	
HyH2ppm	MV_5	Hydran H2 in ppm	O	
HyH2HrlTrnd	MV_5	Hydran Hourly Trend	O	
HyH2DlyTrnd	MV_5	Hydran Daily Trend	O	
RHLev	MV_3	Percent RH Level	O	

SIML class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
RHrlAv	MV_3	Percent RH Hourly Average	O	
H2OppmLev	MV_5	H2O ppm Level	O	
H2OppmHrlAv	MV_5	H2O ppm Hourly Average	O	

7.2.1.9.5 BKNROTSVBR: BROKEN ROTOR BAR

SVBR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
SVBR		Vibrationsupervision		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
Alm	SPS_0	Broken Rotor Bar PKP	O	
Trip	SPS_0	Broken Rotor Bar OP	O	
Measured values				
CompLev	MV_3	Component level	O	
CompHz	MV_3	Component frequency	O	
MotLodBRBClc	MV_3	Motor load at BRB	O	
LodDevBRBClc	MV_3	Load Dev. at BRB	O	
MaxCompLev	MV_3	Calculation	O	
MaxCompHz	MV_3	Max. Component frequency	O	
MotLodBRBMax	MV_3	Max. Motor load at BRB Calc.	O	
LodDevBRBMax	MV_3	Max. Load Dev. at BRB Calc.	O	

7.2.1.10 LOGICAL NODES FOR INSTRUMENT TRANSFORMERS AND SENSORS LN GROUP T

7.2.1.10.1 TVTR: FUSE FAILURE

TVTR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
TVTR		Voltage transformer		

TVTR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
FuFail	SPS_0	Fuse failure	O	

7.2.1.11 LOGICAL NODES FOR SWITCHGEAR LN GROUP X

7.2.1.11.1 XCBR (CIRCUIT BREAKER)

7.2.1.11.1.1 XCBR: CIRCUIT BREAKER

XCBR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
XCBR		Circuit breaker		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Loc	SPS_0	Local operation	M	Local / Remote
OpCnt	INS_0	Operation counter	M	Breaker openings
Controls				
Pos	DPC_0	Switch position	M	Breaker open, close, bad state
BlkOpn	SPC_2	Remote Block opening	M	
BlkCls	SPC_2	Remote Block closing	M	
LocBlkOpn	SPC_3	Local Block opening	O	
LocBlkCls	SPC_3	Local Block closing	O	
Status information				
CBOpCap	ENS_2	Circuit breaker operating capability	M	(BKR Openings Cnt - BREAKER Openings)*2

Note:
These states are supported: OFF (01); ON (10); Bad state (11); however, the logic for Intermediate state (00) is not currently available in the Platform.

7.2.1.11.1.2 RCLXCBR: CIRCUIT BREAKER

XCBR class				
Attribute Name	Attr. Type	Explanation	M/O	Notes
XCBR		Circuit breaker		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Loc	SPS_0	Local operation	M	Local / Remote
OpCnt	INS_0	Operation counter	M	Breaker openings
Controls				
Pos	DPC_1	3PH Reclose position	M	
PosA	DPC_2	Single Phase A reclose position	O	
PosB	DPC_2	Single Phase B reclose position	O	
PosC	DPC_2	Single Phase C reclose position	O	
BlkOpn	SPC_2	Remote Block opening	M	
BlkCls	SPC_2	Remote Block closing	M	
LocBlkOpn	SPC_3	Local Block opening	O	
LocBlkCls	SPC_3	Local Block closing	O	

7.2.1.11.2 XSWI (CIRCUIT SWITCH)

7.2.1.11.2.1 XSWI: CIRCUIT BREAKER (850)

XSWI class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
XSWI_0		Circuit switch		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Loc	SPS_0	Local operation	M	
OpCnt	INS_0	Operation counter	M	
Controls				
Pos	DPC_1	Switch position	M	
BlkOpn	SPC_2	Block opening	M	
BlkClr	SPC_2	Block closing	M	
Status information				

XSWI class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
SwTyp	ENS_7	Switch type	M	

7.2.1.11.2.2 OHSHXSWI: CIRCUIT BREAKER (850)

XSWI class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
XSWI_1		Circuit switch		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Loc	SPS_0	Local operation	M	
OpCnt	INS_0	Operation counter	M	
Controls				
Pos	DPC_1	Switch position	M	
BlkOpn	SPC_2	Block opening	M	
BlkCls	SPC_2	Block closing	M	
Status information				
SwTyp	ENS_7	Switch type	M	
HlthStr	ACD_3	Switch health pickup	O	
HlthOpnStr	ACD_3	Open time sw. health pkp.	O	
HlthClsStr	ACD_3	Close time sw. health pkp.	O	
ArcPhAStr	ACD_3	Arc time PhA sw. health pkp.	O	
ArcPhBStr	ACD_3	Arc time PhB sw. health pkp.	O	
ArcPhCStr	ACD_3	Arc time PhC sw. health pkp.	O	
EngyPhAStr	ACD_3	Arc energy PhA sw. health pkp.	O	
EngyPhBStr	ACD_3	Arc energy PhB sw. health pkp.	O	
EngyPhCStr	ACD_3	Arc energy PhC sw. health pkp.	O	
HlthFail	SPS_2	Sw.open or close failed	O	
ArcFail	SPS_2	Sw. arc time failed	O	
OpnLmtRch	SPS_2	Max.number of Open reached	O	
ClsLmtRch	SPS_2	Max.number of Close reached	O	

7.2.1.12 LOGICAL NODES FOR POWER TRANSFORMERS LN GROUP Y

7.2.1.12.1 WFMRYPTR (POWER TRANSFORMER)

7.2.1.12.1.1 XFMRYPTR: HARMONIC DERATING

YPTR class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
XfmrYPTR				
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
W1HaDeratStr	ACD_3	W1 Harmonic Derating PKP	O	
W1HaDeratOp	ACT_3	W1 Harmonic Derating OP	O	
W2HaDeratStr	ACD_3	W2 Harmonic Derating PKP	O	
W2HaDeratOp	ACT_3	W2 Harmonic Derating OP	O	
W3HaDeratStr	ACD_3	W3 Harmonic Derating PKP	O	
W3HaDeratOp	ACT_3	W3 Harmonic Derating OP	O	
LodLimRed	SPS_2	Load Limit Reduced	O	
Measured values				
W1LodFact	MV_3	W1 Load Factor	O	
W1AvPhCur	MV_3	W1 Average Phase Current	O	
W1HaDerat	MV_3	W1 Harmonic Derating Factor	O	
W2LodFact	MV_3	W2 Load Factor	O	
W2AvPhCur	MV_3	W2 Average Phase Current	O	
W2HaDerat	MV_3	W2 Harmonic Derating Factor	O	
W3LodFact	MV_3	W3 Load Factor	O	
W3AvPhCur	MV_3	W3 Average Phase Current	O	
W3HaDerat	MV_3	W3 Harmonic Derating Factor	O	

7.2.1.12.1.2 XFMRYLTC: TAP CHANGER

YLTC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
XfmrYLTC				
Data				
Common Logical Node Information				

YLTC class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
EndPosR	SPS_0	Tap Changer at Max. Tap	M	
EndPosL	SPS_0	Tap Changer at Min. Tap	O	
TapPos	ISC_0	Tap Position	O	
Measured values				
OhmsIn1	MV_3	Ohms in 1	O	
WndgV	MV_3	Winding Voltage	O	
DltVMinTapV	MV_3	Delta V Above Min. Tap V	O	

7.2.1.13 LOGICAL NODES FOR FURTHER POWER SYSTEM EQUIPMENT LN GROUP Z

7.2.1.13.1 GNSTZGEN: GENERATOR STATUS

ZGEN class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
GnStZGEN		Generator		
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
GnSt	ENS_5	Generator state	M	
OpNoLod	SPS_0	Operation at no load (N/A)	M	
RotDir	ENS_6	Phase rotation	M	
OpUnExt	SPS_0	Operation at under excitation (N/A)	M	
OpOvExt	SPS_0	Operation at over excitation (N/A)	M	

7.2.1.13.2 ZMOT: MOTOR STATUS

ZMOT class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
ZMOT				
Data				

ZMOT class				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Common Logical Node Information				
Mod	ENC_0	Mode	M	
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
MotSt	ENS_5	Motor status	O	Included in Tissue 808
Measured values				
MotThCapUsed	MV_5	Motor Thermal Capacity Used	O	
EstTrTmOL	MV_5	Estimated Trip Time on OL	O	
ThLockTm	MV_5	Thermal Lockout Time	O	
MxStrRteLOTm	MV_5	Max Start Rate LO Time	O	
MxCHStRtLOTm	MV_5	Max C/H Start Rate LO Time	O	
TmBtwStrLOTm	MV_5	Time Between Starts LO Time	O	
ReStrDlyLOTm	MV_5	Restart Delay LO Time	O	
TotMotLockTm	MV_5	Total Motor Lockout Time	O	
MotSpeed	MV_5	Motor Speed	O	
MotRunHours	MV_5	Motor Running Hours	O	
MotLoad	MV_1	Motor Load	O	
MotCurrUnb	MV_1	Motor Current Unbalance	O	
MotVoltUnb	MV_1	Motor Voltage Unbalance		
ThModBsdLoad	MV_1	Thermal Model Biased Load	O	
FltdMotLoad	MV_1	Fltd Motor Load	O	
FltdRMSCurA	MV_1	Fltd RMS Current A	O	
FltdRMSCurB	MV_1	Fltd RMS Current B	O	
FltdRMSCurC	MV_1	Fltd RMS Current C	O	
FltdMagCurA	MV_1	Fltd Mag Current A	O	
FltdMagCurB	MV_1	Fltd Mag Current B	O	
FltdMagCurC	MV_1	Fltd Mag Current C	O	
LastStrCur	MV_3	Last Start Current	O	
LastMotStrTrm	INS_1	Last Motor Start D/T	O	
LastAccelTm	MV_3	Last Acceleration Time	O	
MotStrNum	MV_5	Motor Starts since last clear		

7.2.1.13.3 ZBAT: BATTERY HEALTH MONITORING

ZBAT				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
ZBAT				
Data				
Common Logical Node Information				
Mod	ENC_0	Mode	M	

ZBAT				
Attribute Name	**Attr. Type**	**Explanation**	**M/O**	**Notes**
Beh	ENS_0	Behavior	M	
Health	ENS_1	Health	M	
NamPlt	LPL_1	Name plate	M	
Status Information				
BatTestInit	SPS_2	Battery test Initiation	O	
BatTestPass	SPS_2	Battery test pass	O	
BatTestFail	SPS_2	Battery test fail	O	
BatCheck	SPS_2	Battery check	O	
BatChaDis	SPS_2	Battery charger disabled	O	
BatRep	SPS_2	Replace battery	O	
BatTestBlk	SPS_2	Battery test blocked	O	
BatFullChg	SPS_2	Battery full charged	O	
Measured values				
Vol	MV_0	DC Supply volt	O	
Amp	MV_0	DC Supply current	O	
PwrAvg	MV_1	DC Supply Average power	O	
PwrMax	MV_1	DC Supply Maximum power	O	
PwrMin	MV_1	DC Supply Minimum power	O	

7.2.2 COMMON DATA CLASS

The tables in this section use the following abbreviations:

- M: Data is mandatory in the IEC 61850-7-4.
- O: Data is optional in the IEC 61850-7-4 and is used in the device.
- C: Data is conditional in the IEC 61850-7-4 and is used in the device.
- GC_1: At least one of the attributes shall be present for a given instance of DataObject/SubDataObject.
- GC_2: All or none of the data attributes belonging to the same group (n) shall be present for a given instance of DataObject/SubDataObject.
- AC_CO_M: The attribute is mandatory, if the controllable status class supports control.
- AC_CO_O: The attribute is optional, if the controllable status class supports control.
- AC_ST: The attribute is mandatory, if the controllable status class supports status information.
- AC_LN0_M: The attribute shall be present if the data NamPlt belongs to LLN0.

7.2.2.1 COMMON DATA CLASS SPECIFICATIONS FOR STATUS INFORMATION

7.2.2.1.1 POINT STATUS (SPS)

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
SPS_0					
DataAttribute					
status					
stVal	Boolean	ST	dchg		M

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
q	BVstring13	ST	qchg		M
t	Utctime	ST			M
configuration, description and extension					
d	Vstring255	DC			O
SPS_1					
DataAttribute					
status					
stVal	Boolean	ST	dchg		M
q	BVstring13	ST	qchg		M
t	Utctime	ST			M
SPS_2					
DataAttribute					
status					
stVal	Boolean	ST	dchg		M
q	BVstring13	ST	qchg		M
t	Utctime	ST			M
configuration, description and extension					
d	Vstring255	DC			O
dataNs	Vstring255	EX			O

7.2.2.1.2 INTEGER STATUS (INS)

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
INS_0					
DataAttribute					
status					
stVal	INT32	ST	dchg		M
q	BVstring13	ST	qchg		M
t	Utctime	ST			M
d	Vstring255	DC			O
INS_1					
DataAttribute					
status					
stVal	INT32	ST	dchg		M
q	BVstring13	ST	qchg		M
t	Utctime	ST			M
d	Vstring255	DC			O
dataNs	Vstring255	EX			O

7.2.2.1.3 ENUMERATED STATUS (ENS)

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
ENS_0 (Beh)					
DataAttribute					
status					

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
stVal	Enum	ST	dchg	On, blocked, test, test/blocked, Off	M
q	BVstring13	ST	qchg		M
t	Utctime	ST			M
ENS_1 (Health)					
Attribute					
DataAttribute					
status					
stVal	Enum	ST	dchg	Ok, warning, Alarm	M
q	BVstring13	ST	qchg		M
t	Utctime	ST			M
ENS_2 (CBOpCap)					
Attribute					
DataAttribute					
status					
stVal	INT32	ST	dchg	Ok, warning, Alarm	M
q	BVstring13	ST	qchg		M
t	Utctime	ST			M
d	Vstring255	DC			O
ENS_3 (AutoRecSt)					
Attribute					
DataAttribute					
status					
stVal	Enumerated	ST	dchg	1 - Ready 'AR Enabled 2 - InProgress 'AR in Progress 3 - Successful ' Not mapped 4 - Waiting for trip 'AR Initiated 5 - Trip issues by protection 'Not mapped 6 - Fault disappeared ' Not mapped 7 - Wait to complete ' Not mapped 8 - Circuit breaker close ' AR Close 9 - Cycle unsuccessful ' AR Lockout 10 - Unsuccessful ' AR Disabled 11 - Aborted ' Not mapped	M
q	BVstring13	ST	qchg		M
t	Utctime	ST			M
d	Vstring255	DC			O
ENS_4 (Fault Type)					
Attribute					
DataAttribute					
status					
stVal	Enumerated	ST	dchg	1, 2, 3, 4, 5, 6, other	M
q	BVstring13	ST	qchg		M

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
t	Utctime	ST			M
d	Vstring255	DC			O
dataNs	Vstring255	EX			
ENS_5 (GeneratorSt)					
Attribute					
DataAttribute					
status					
stVal	Enumerated	ST	dchg	Stopped, Stopping, Started…	M
q	BVstring13	ST	qchg		M
t	Utctime	ST			M
d	Vstring255	DC			O
ENS_6 (RotDir)					
Attribute					
DataAttribute					
status					
stVal	Enumerated	ST	dchg	Clockwise, Counter-Clockwise...	M
q	BVstring13	ST	qchg		M
t	Utctime	ST			M
d	Vstring255	DC			O
ENS_7 (SwType)					
Attribute					
DataAttribute					
status					
stVal	Enumerated	ST	dchg	Load break, Disconnector...	M
q	BVstring13	ST	qchg		M
t	Utctime	ST			M
ENS_8 (SourcePhase)					
Attribute					
DataAttribute					
status					
stVal	Enumerated	ST	dchg	None, Va, Vb, Vc, Vab, Vbc, Vca	M
q	BVstring13	ST	qchg		M
t	Utctime	ST			M
d	Vstring255	DC			O
dataNs	Vstring255	EX			O
ENS_9 (EventType)					
Attribute					
DataAttribute					
status					
stVal	Enumerated	ST	dchg	None, Volt Sag, Volt Swell	M
q	BVstring13	ST	qchg		M

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
t	Utctime	ST			M
d	Vstring255	DC			O
dataNs	Vstring255	EX			O
ENS_10 (ElementInstance)					
Attribute					
DataAttribute					
status					
stVal	Enumerated	ST	dchg	VD1, VD2, VD3	M
q	BVstring13	ST	qchg		M
t	Utctime	ST			M
d	Vstring255	DC			O
dataNs	Vstring255	EX			O
ENS_11 (Health)					
Attribute					
DataAttribute					
status					
stVal	Enumerated	ST	dchg	OK, Warning, Alarm	M
q	BVstring13	ST	qchg		M
t	Utctime	ST			M
d	Vstring255	DC			O

7.2.2.1.4 PROTECTION ACTIVATION INFORMATION (ACT)

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
ACT_0					
DataAttribute					
control and status					
general	Boolean	ST	dchg		M
phsA	Boolean	ST	dchg		O
phsB	Boolean	ST	dchg		O
phsC	Boolean	ST	dchg		O
q	Bvstring13	ST	qchg		M
t	Utctime	ST			M
configuration, description and extension					
d	Vstring255	DC			O
ACT_1					
DataAttribute					
control and status					
general	Boolean	ST	dchg		M
neut	Boolean	ST	dchg		O
q	Bvstring13	ST	qchg		M
t	Utctime	ST			M
configuration, description and extension					
d	Vstring255	DC			O

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
ACT_2					
DataAttribute					
control and status					
general	Boolean	ST	dchg		M
q	Bvstring13	ST	qchg		M
t	Utctime	ST			M
configuration, description and extension					
d	Vstring255	DC			O
ACT_3					
DataAttribute					
control and status					
general	Boolean	ST	dchg		M
q	Bvstring13	ST	qchg		M
t	Utctime	ST			M
configuration, description and extension					
d	Vstring255	DC			O
dataNs	Vstring255	EX			M

7.2.2.1.5 DIRECTIONAL PROTECTION ACTIVATION INFORMATION (ACD)

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
ACD_0					
DataAttribute					
control and status					
general	Boolean	ST	dchg		M
dirGeneral	Enumerated (Byte)	ST	dchg	unknown | forward | backward | both	M
phsA	Boolean	ST	dchg		GC_2(1)
dirPhsA	Enumerated (Byte)	ST	dchg	unknown | forward | backward	GC_2(1)
phsB	Boolean	ST	dchg		GC_2(2)
dirPhsB	Enumerated (Byte)	ST	dchg	unknown | forward | backward	GC_2(2)
phsC	Boolean	ST	dchg		GC_2(3)
dirPhsC	Enumerated (Byte)	ST	dchg	unknown | forward | backward	GC_2(3)
q	Bvstring13	ST	qchg		M
t	Utctime	ST			M
configuration, description and extension					
d	Vstring255	DC			O
ACD_1					
DataAttribute					
control and status					
general	Boolean	ST	dchg		M
dirGeneral	Enumerated (Byte)	ST	dchg	unknown | forward | backward | both	M

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
neut	Boolean	ST	dchg		GC_2(4)
dirNeut	Enumerated (Byte)	ST	dchg	unknown | forward | backward	GC_2(4)
q	Bvstring13	ST	qchg		M
t	Utctime	ST			M
configuration, description and extension					
d	Vstring255	DC			O
ACD_2					
DataAttribute					
control and status					
general	Boolean	ST	dchg		M
dirGeneral	Enumerated (Byte)	ST	dchg	unknown | forward | backward | both	M
q	Bvstring13	ST	qchg		M
t	Utctime	ST			M
configuration, description and extension					
d	Vstring255	DC			O
ACD_3					
DataAttribute					
control and status					
general	Boolean	ST	dchg		M
dirGeneral	Enumerated (Byte)	ST	dchg	unknown | forward | backward | both	M
q	Bvstring13	ST	qchg		M
t	Utctime	ST			M
configuration, description and extension					
d	Vstring255	DC			O
dataNs	Vstring255	EX			M

7.2.2.2 COMMON DATA CLASS SPECIFICATIONS FOR MEASURAND INFORMATION

7.2.2.2.1 MEASURED VALUE (MV)

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
MV_0					
DataAttribute					
measured attributes					
instMag	FloatAnalogueValue	MX	------		O
f	FLOAT32				GC_1
mag	FloatAnalogueValue	MX	dchg		M
f	FLOAT32				GC_1
range	ENUMERATED(Byte)	MX	dchg		O
q	BVstring13	MX	qchg		M
t	Utctime	MX			M

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
configuration, description and extension					
units	Unit	CF			O
SIUnit	ENUMERATED(Byte)				M
Multiplier	ENUMERATED(Byte)				O
db	INT32U	CF			O
zeroDb	INT32U	CF			O
rangeC	RangeConfig	CF			O
hhLim	FloatAnalogueValue				
f	FLOAT32				GC_1
hlim	FloatAnalogueValue				
f	FLOAT32				GC_1
lLim	FloatAnalogueValue				
f	FLOAT32				GC_1
llLim	FloatAnalogueValue				
f	FLOAT32				GC_1
min	FloatAnalogueValue				
f	FLOAT32				GC_1
max	FloatAnalogueValue				
f	FLOAT32				GC_1
limDb	INT32U				
d	Vstring255	DC			O
MV_1					
DataAttribute					
measured attributes					
instMag	FloatAnalogueValue	MX	------		O
f	FLOAT32				GC_1
mag	FloatAnalogueValue	MX	dchg		M
f	FLOAT32				GC_1
range	ENUMERATED(Byte)	MX	dchg		O
q	BVstring13	MX	qchg		M
t	Utctime	MX			M
configuration, description and extension					
units	Unit	CF			O
SIUnit	ENUMERATED(Byte)				M
Multiplier	ENUMERATED(Byte)				O
db	INT32U	CF			O
zeroDb	INT32U	CF			O
rangeC	RangeConfig	CF			O
hhLim	FloatAnalogueValue				
f	FLOAT32				GC_1
hlim	FloatAnalogueValue				
f	FLOAT32				GC_1
lLim	FloatAnalogueValue				

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
f	FLOAT32				GC_1
IILim	FloatAnalogueValue				
f	FLOAT32				GC_1
min	FloatAnalogueValue				
f	FLOAT32				GC_1
max	FloatAnalogueValue				
f	FLOAT32				GC_1
limDb	INT32U				
d	Vstring255	DC			O
dataNs	Vstring255	EX			M
MV_2					
DataAttribute					
measured attributes					
mag	FloatAnalogueValue	MX	dchg		M
f	FLOAT32				GC_1
q	BVstring13	MX	qchg		M
t	Utctime	MX			M
configuration, description and extension					
units	Unit	CF			O
SIUnit	ENUMERATED(Byte)				M
Multiplier	ENUMERATED(Byte)				O
d	Vstring255	DC			O
MV_3					
DataAttribute					
measured attributes					
mag	FloatAnalogueValue	MX	dchg		M
f	FLOAT32				GC_1
q	BVstring13	MX	qchg		M
t	Utctime	MX			M
configuration, description and extension					
units	Unit	CF			O
SIUnit	ENUMERATED(Byte)				M
Multiplier	ENUMERATED(Byte)				O
d	Vstring255	DC			O
dataNs	Vstring255	EX			M
MV_4					
DataAttribute					
measured attributes					
mag	FloatAnalogueValue	MX	dchg		M
i	INT32				GC_1
q	BVstring13	MX	qchg		M
t	Utctime	MX			M
configuration, description and extension					

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
units	Unit	CF			O
SIUnit	ENUMERATED(Byte)				M
Multiplier	ENUMERATED(Byte)				O
d	Vstring255	DC			O
MV_5					
DataAttribute					
measured attributes					
mag	FloatAnalogueValue	MX	dchg		M
i	INT32				GC_1
q	BVstring13	MX	qchg		M
t	Utctime	MX			M
configuration, description and extension					
units	Unit	CF			O
SIUnit	ENUMERATED(Byte)				M
Multiplier	ENUMERATED(Byte)				O
d	Vstring255	DC			O
dataNs	Vstring255	EX			M

7.2.2.2.2 COMPLEX MEASURED VALUE (MV)

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
CMV_0					
DataAttribute					
measured attributes					
instCVal	FloatVector	MX	------		O
mag	FloatAnalogueValue				
f	FLOAT32				
cVal	FloatVector	MX	dchg		M
mag	FloatAnalogueValue				
f	FLOAT32				
range	ENUMERATED(Byte)	MX	dchg		O
q	BVstring13	MX	qchg		M
t	Utctime	MX			M
configuration, description and extension					
units	Unit	CF			O
SIUnit	Byte				M
Multiplier	Byte				O
db	INT32U	CF			O
dbAng	INT32U	CF			O
zeroDb	INT32U	CF			O
rangeC	RangeConfig	CF			O
d	Vstring255	DC			O
CMV_1					
DataAttribute					

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
measured attributes					
instCVal	FloatVector	MX	------		O
mag	FloatAnalogueValue				
f	FLOAT32				
cVal	FloatVector	MX	dchg		M
mag	FloatAnalogueValue				
f	FLOAT32				
range	ENUMERATED(Byte)	MX	dchg		O
q	BVstring13	MX	qchg		M
t	Utctime	MX			M
configuration, description and extension					
units	Unit	CF			O
SIUnit	Byte				M
Multiplier	Byte				O
db	INT32U	CF			O
dbAng	INT32U	CF			O
zeroDb	INT32U	CF			O
rangeC	RangeConfig	CF			O
d	Vstring255	DC			O
dataNs	Vstring255	EX			M
CMV_2					
DataAttribute					
measured attributes					
cVal	FloatVector	MX	dchg		M
mag	FloatAnalogueValue				
f	FLOAT32				
q	BVstring13	MX	qchg		M
t	Utctime	MX			M
configuration, description and extension					
units	Unit	CF			O
SIUnit	Byte				M
Multiplier	Byte				O
d	Vstring255	DC			O
CMV_3					
Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
DataAttribute					
measured attributes					
cVal	FloatVector	MX	dchg		M
mag	FloatAnalogueValue				
f	FLOAT32				
q	BVstring13	MX	qchg		M
t	Utctime	MX			M
configuration, description and extension					

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
units	Unit	CF			O
SIUnit	Byte				M
Multiplier	Byte				O
d	Vstring255	DC			O
CMV_4					
DataAttribute					
measured attributes					
instCVal	FloatVector	MX	------		O
mag	FloatAnalogueValue				
f	FLOAT32				
cVal	FloatVector	MX	dchg		M
mag	FloatAnalogueValue				
f	FLOAT32				
range	ENUMERATED(Byte)	MX	dchg		O
q	BVstring13	MX	qchg		M
t	Utctime	MX			M
configuration, description and extension					
units	Unit	CF			O
SIUnit	Byte				M
Multiplier	Byte				O
db	INT32U	CF			O
zeroDb	INT32U	CF			O
rangeC	RangeConfig	CF			O
d	Vstring255	DC			O
CMV_5					
DataAttribute					
measured attributes					
cVal	FloatVector	MX	dchg		M
mag	FloatAnalogueValue				
f	FLOAT32				
q	BVstring13	MX	qchg		M
t	Utctime	MX			M
configuration, description and extension					
units	Unit	CF			O
SIUnit	Byte				M
Multiplier	Byte				O
d	Vstring255	DC			O
dataNs	Vstring255	EX			M
CMV_6					
Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
DataAttribute					
measured attributes					
cVal	FloatVector	MX	dchg		M

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
mag	FloatAnalogueValue				
f	FLOAT32				
q	BVstring13	MX	qchg		M
t	Utctime	MX			M
configuration, description and extension					
units	Unit	CF			O
SIUnit	Byte				M
Multiplier	Byte				O
db	INT32U	CF			O
d	Vstring255	DC			O

7.2.2.2.3 PHASE TO GROUND RELATED MEASURED VALUES OF A THREE PHASE SYSTEM (WYE)

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
WYE_0					
Data					
phsA	CMV_0				GC_1
phsB	CMV_0				GC_1
phsC	CMV_0				GC_1
neut	CMV_0				GC_1
configuration, description and extension					
d	Vstring255	DC			O
WYE_1					
Data					
phsA	CMV_0				GC_1
phsB	CMV_0				GC_1
phsC	CMV_0				GC_1
neut	CMV_0				GC_1
net	CMV_0				GC_1
res	CMV_0				GC_1
configuration, description and extension					
d	Vstring255	DC			O
WYE_2					
Data					
phsA	CMV_0				GC_1
phsB	CMV_0				GC_1
phsC	CMV_0				GC_1
neut	CMV_0				GC_1
neut	CMV_0				GC_1
net	CMV_0				GC_1
configuration, description and extension					
d	Vstring255	DC			O
WYE_3					

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
Data					
phsA	CMV_4				GC_1
phsB	CMV_4				GC_1
phsC	CMV_4				GC_1
configuration, description and extension					
d	Vstring255	DC			O
WYE_4					
Data					
phsA	CMV_4				GC_1
phsB	CMV_5				GC_1
phsC	CMV_4				GC_1
configuration, description and extension					
d	Vstring255	DC			O
WYE_5					
Data					
phsA	CMV_6				GC_1
phsB	CMV_6				GC_1
phsC	CMV_6				GC_1
configuration, description and extension					
d	Vstring255	DC			O
WYE_6					
Data					
phsA	CMV_0				GC_1
phsB	CMV_0				GC_1
phsC	CMV_0				GC_1
configuration, description and extension					
d	Vstring255	DC			O

7.2.2.2.4 PHASE TO PHASE RELATED MEASURED VALUES OF A THREE PHASE SYSTEM (DEL)

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
DEL_0					
Data					
phsAB	CMV_0				GC_1
phsBC	CMV_0				GC_1
phsCA	CMV_0				GC_1
configuration, description and extension					
d	Vstring255	DC			O

7.2.2.2.5 SEQUENCE (SEQ)

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
SEQ_0					
Data					
c1	CMV_0				GC_1

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
c2	CMV_0				GC_1
c3	CMV_0				GC_1
Measured attributes					
seqT	enumerated	MX		Pos-neg-zero | dir-quad-zero	O
configuration, description and extension					
d	Vstring255	DC			O

7.2.2.3 COMMON DATA CLASS SPECIFICATIONS FOR CONTROLLABLE STATUS INFORMATION

7.2.2.3.1 CONTROLLABLE SINGLE POINT (SPC)

Attribute Name		Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
SPC_0						
DataAttribute						
control and status						
stVal		Boolean	ST		FALSE | TRUE	AC_ST
q		Quality	ST			AC_ST
t		TimeStamp	ST			AC_ST
control and status						
Oper	ctlVal	Boolean	CO			AC_CO_M
	origin	Originator	CO			AC_CO_M
	orCat	ENUMERATED				M
	orIdent	OCTECT64				M
	ctlNum	INT8U	CO			M
	T	Btime6	CO			M
	Test	Boolean	CO			M
	Check	ENUMERATED	CO			M
configuration, description and extension						
ctlModel		ENUMERATED	CF		ctlModel	M
operTimeout		INT32U	CF			AC_CO_O
d		Vstring255	DC			O
SPC_1						
DataAttribute						
control and status						
stVal		Boolean	ST		FALSE | TRUE	AC_ST
q		Quality	ST			AC_ST
t		TimeStamp	ST			AC_ST
control and status						

Attribute Name		Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
Oper	ctlVal	Boolean	CO			AC_CO_M
	origin	Originator	CO			AC_CO_M
	orCat	ENUMERATED				M
	orIdent	OCTECT64				M
	ctlNum	INT8U	CO			M
	T	Btime6	CO			M
	Test	Boolean	CO			M
	Check	ENUMERATED	CO			M
configuration, description and extension						
ctlModel		ENUMERATED	CF		ctlModel_1	M
operTimeout		INT32U	CF			AC_CO_O
d		Vstring255	DC			O
SPC_2						
DataAttribute						
control and status						
stVal		Boolean	ST		FALSE | TRUE	AC_ST
q		Quality	ST			AC_ST
t		TimeStamp	ST			AC_ST
configuration, description and extension						
ctlModel		ENUMERATED	CF		ctlModel	M
d		Vstring255	DC			O
SPC_3						
DataAttribute						
control and status						
stVal		Boolean	ST		FALSE | TRUE	AC_ST
q		Quality	ST			AC_ST
t		TimeStamp	ST			AC_ST
configuration, description and extension						
ctlModel		ENUMERATED	CF		ctlModel	M
d		Vstring255	DC			O
dataNs		Vstring255	EX			O

7.2.2.3.2 CONTROLLABLE DOUBLE POINT (DPC)

Attribute Name		Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
DPC_0						
DataAttribute						
control and status						
Oper	ctlVal	Boolean	CO			AC_CO_M
	origin	Originator	CO,ST			AC_CO_M
	orCat	ENUMERATED				M
	orIdent	OCTECT64				M
	ctlNum	INT8U	CO,ST			M
	T	Btime6	CO			M

Attribute Name		Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
	Test	Boolean	CO			M
	Check	ENUMERATED	CO			M
Cancel						
SBO						
SBOw						
stVal		CODE ENUM	ST	dchg	intermediate-state | off | on | bad-state	M
q		BVstring13	ST	qchg		AC_ST
t		Utctime	ST			AC_ST
stSeld		Boolean	ST			
configuration, description and extension						
ctlModel		ENUMERATED	CF			M
sboTimeout		INT32U	CF			AC_CO_O
sboClass		ENUMERATED	CF			AC_CO_O
operTimeout		INT32U	CF			AC_CO_O
d		Vstring255	DC			O
DPC_1						
DataAttribute						
control and status						
stVal		CODE ENUM	ST	dchg	intermediate-state | off | on | bad-state	M
q		BVstring13	ST	qchg		AC_ST
t		Utctime	ST			AC_ST
configuration, description and extension						
ctlModel		ENUMERATED	CF			M
d		Vstring255	DC			O
DPC_2						
DataAttribute						
control and status						
stVal		CODE ENUM	ST	dchg	intermediate-state | off | on | bad-state	M
q		BVstring13	ST	qchg		AC_ST
t		Utctime	ST			AC_ST
configuration, description and extension						
ctlModel		ENUMERATED	CF			M
d		Vstring255	DC			O
dataNs		Vstring255	EX			O
DPC_3						
DataAttribute						
control and status						
Oper	ctlVal	Boolean	CO			AC_CO_M
	origin	Originator	CO,ST			AC_CO_M
	orCat	ENUMERATED				M
	orIdent	OCTECT64				M

Attribute Name		Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
	ctlNum	INT8U	CO,ST			M
	T	Btime6	CO			M
	Test	Boolean	CO			M
	Check	ENUMERATED	CO			M
Cancel						
SBO						
SBOw						
stVal		CODE ENUM	ST	dchg	intermediate-state | off | on | bad-state	M
q		BVstring13	ST	qchg		AC_ST
t		Utctime	ST			AC_ST
stSeld		Boolean	ST			
configuration, description and extension						
ctlModel		ENUMERATED	CF			M
sboTimeout		INT32U	CF			AC_CO_O
sboClass		ENUMERATED	CF			AC_CO_O
operTimeout		INT32U	CF			AC_CO_O
d		Vstring255	DC			O

7.2.2.3.3 CONTROLLABLE INTEGER STATUS (INC)

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
INC_0					
DataAttribute					
status					
stVal	Enum	ST	dcgh	On, blocked, test, test/blocked, Off	M
q	BVstring13	ST	qchg		M
t	Utctime	ST			M
configuration, description and extension					
ctlModel	ENUMERATED	CF			M
INC_1					
DataAttribute					
status					
stVal	Enum	ST	dcgh	On, blocked, test, test/blocked, Off	M
q	BVstring13	ST	qchg		M
t	Utctime	ST			M
configuration, description and extension					
ctlModel	ENUMERATED	CF			M

7.2.2.3.4 INTEGER CONTROLLER STEP POSITION INFORMATION (ISC)

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
ISC_0					
DataAttribute					

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
status					
valWTr	ValWithTrans	ST	dcgh		M
q	BVstring13	ST	qchg		M
t	Utctime	ST			M
configuration, description and extension					
ctlModel	ENUMERATED	CF			M
d	Vstring255	DC			O

7.2.2.3.5 CONTROLLABLE ENUMERATED STATUS (ENC)

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
ENC_0 (type Mod)					
DataAttribute					
status					
stVal	Enum	ST	dcgh		M
q	BVstring13	ST	qchg		M
t	Utctime	ST			M
configuration, description and extension					
ctlModel	ENUMERATED	CF		ctlmodel	M
ENC_1 (type Mod)					
DataAttribute					
status					
stVal	Enum	ST	dcgh		M
q	BVstring13	ST	qchg		M
t	Utctime	ST			M
configuration, description and extension					
ctlModel	ENUMERATED	CF		cntmodel 1	M

7.2.2.4 ACSI BASIC CONFORMANCE STATEMENT

Basic conformance statement

		Client/Subscriber	Server/Publisher	Value/Comments
Client-Server roles				
B11	Server side (of TWO-PARTY-APPLICATION-ASSOCIATION)		Y	
B12	Client side of (TWO-PARTY-APPLICATION-ASSOCIATION)			
SCSMs supported				
B21	SCSM: IEC 6185-8-1 used		Y	
B22	SCSM: IEC 6185-9-1 used			Ed2: Deprecated
B23	SCSM: IEC 6185-9-2 used			
B24	SCSM: other			

		Client/Subscriber	Server/Publisher	Value/Comments
Generic substation event model (GSE)				
B31	Publisher side		Y	
B32	Subscriber side	Y		
Transmission of sampled value model (SVC)				
B41	Publisher side			
B42	Subscriber side			
- = not applicable Y = supported N or empty = not supported				

7.2.2.4.1 DEVICE NAME PLATE (DPL)

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
DPL_0 (type Mod)					
DataAttribute					
control and status					
vendor	Vstring255	DC			M
hwRev	Vstring255	DC			O
swRev	Vstring255	DC			O
serNum	Vstring255	DC			O
model	Vstring255	DC			O
location	Vstring255	DC			O
d	Vstring255	DC			M

7.2.2.4.2 LOGICAL NODE NAME PLATE (LPL)

Attribute Name	Attribute Type	FC	TrgOp	Value/Value Range	M/O/C
LPL_0 (type Mod)					
DataAttribute					
control and status					
vendor	Vstring255	DC			M
swRev	Vstring255	DC			M
d	Vstring255	DC			M
configRev	Vstring255	DC			AC_LN0_M
ldNs	Vstring255	EX			O
LPL_1					
DataAttribute					
control and status					
vendor	Vstring255	DC			M
swRev	Vstring255	DC			M
d	Vstring255	DC			M

7.3 TICS TEMPLATE FOR SERVER

This section contains a template for the TISSUES (Technical Issues) Implementation Conformance Statement (TICS). According to the UCA IUG QAP (Quality Assurance Plan) the Tissue conformance statement is required to perform a conformance test and is referenced on the certificate.

This conformance statement template is applicable to the 8 Series relays.

Version 1.0

Date: July 23, 2015

7.3.1 MANDATORY EDITION 2 TISSUES

The following table gives an overview of the applicable mandatory Tissues:

Part 6 Tissue	Description	Implemented Y/N/A
658	Tracking related features	N/A
663	FCDA element cannot be a "functionally constrained logical node"	Y
668	Autotransformer modeling	N/A
687	SGCB ResvTms	N/A
719	ConfDataSet - maxAttributes definition is confusing	Y
721	Log element name	N/A
768	bType VisString65 is missing	Y
770	Goose ID max. length is 129 characters	Y
779	object references	Y
788	SICS S56 from optional to mandatory	N/A
789	ConfLdName as services applies to both server and client	Y
804	valKind and IED versus System configuration	N/A
806	Max length of log name inconsistent between -6 and -7-2	N/A
807	Need a way to indicate if "Owner" present in RCB	N/A
822	Extension of IED capabilities	N/A
823	ValKind for structured data attributes	N/A
824	Short addresses on structured data attributes	N/A
825	Floating point value	N/A
845	SGCB ResvTms	N/A
853	SBO and ProtNs	N/A
855	Recursive SubFunction	N/A
857	Function/SubFunction for ConductingEquipment	N/A
886	Missing 8-1 P-types	N/A
901	tServices as AP or as IED element	N/A
936	SupSubscription parameter usage is difficult	N/A
1168	doName and daName of ExtRef; doName may have one dot (DO.SDO)	N/A
1175	IPv6 address lowercase only	N/A

Part 7 Tissue	Description	Implemented Y / N/A
Part 7-1		
828	Data model namespace revision IEC 61850-7-4:2007[A]	Y
1151	simulated GOOSE disappears after 1st appearance when LPHD.Sim = TRUE	N/A
1196	Extensions to standardized LN classes made by third parties	N/A
Part 7-2		
778	AddCause values – add value not-supported	Y
780	What are unsupported trigger option at a control block?	Y
783	TimOper Resp- ; add Authorization check	N/A
786	AddCause values 26 and 27 are switched	Y
820	Mandatory ACSI services (use for PICS template)	N/A
858	typo in enumeration ServiceType	N/A
861	dchg of ConfRev attribute	N/A
876	GenLogicINodeClass and SGCB, GoCB, MsvCB, UsvCB	N/A
1038	Loss of Info Detection After Resynch	N/A
1050	GTS Phycomaddr definition in SCL	N/A
1062	Entrytime not used in CDC	N/A
1071	Length of DO name	Y
1091	The sentence "The initial value of EditSG shall be 0", has to be stated in part 7.2 not in 8.1	N/A
1127	Missing owner attribute in BTS and UTS	N/A
1163	Old report in URCB	N/A
1202	GI not optional	Y
Part 7-3		
697	persistent command / PulseConfig	N/A
698	Wrong case is BAC.dB attribute	N/A
722	Units for 'h' and 'min' not in UnitKind enumeration.	N/A
919	Presence Condition for sVC	N/A
925	Presence of i or f attribute - Problem with writing	N/A
926	Presence Conditions within RangeConfig	Y
Part 7-4		
671	mistake in definition of Mod & Beh	N/A

Part 7 Tissue	Description	Implemented Y / N/A
674	CDC of ZRRC.LocSta is wrong	N/A
675	SIML LN	N/A
676	Same data object name used with different CDC	N/A
677	MotStr is used with different CDC in PMMS and SOPM LN classes	N/A
679	Remove CycTrMod Enum	N/A
680	SI unit for MHYD.Cndct	N/A
681	Enum PIDAlg	N/A
682	ANCR.ParColMod	N/A
683	Enum QVVR.IntrDetMth	N/A
685	Enum ParTraMod	N/A
686	New annex H - enums types in XML	N/A
694	Data object CmdBlk	N/A
696	LSVS.St (Status of subscription)	N/A
712	interpretation of quality operatorBlocked	N/A
713	DO Naming of time constants in FFIL	N/A
724	ANCR.Auto	N/A
725	Loc in LN A-group	N/A
734	LLN0.OpTmh vs. LPHD.OpTmh	N/A
735	ISAF.Alm and ISAF.AlmReset	N/A
736	PFSign	N/A
742	GAPC.Str, GAPC.Op and GAPC.StrVal	N/A
743	CCGR.PmpCtl and CCGR.FanCtl	N/A
744	LN STMP, EEHealth and EEName	N/A
772	LPHD.PwrUp/PwrDn shall be transient	N/A
773	Loc, LocKey and LocSta YPSH and YLTC	N/A
774	ITCI.LocKey	N/A
775	KVLV.ClsLim and OpnLim	N/A
776	LPHD.OutOv/InOv and LCCH.OutOv/InOv	N/A
800	Misspelling in CSYN	N/A
802	CCGR and Harmonized control authority	N/A

Part 7 Tissue	Description	Implemented Y / N/A
808	Presence condition of ZMOT.DExt and new DOs	N/A
831	Setting of ConfRevNum in LGOS	N/A
838	Testing in Beh=Blocked	N/A
844	MFLK.PhPiMax, MFLK.PhPiLoFil, MFLK.PhPiRoot DEL->WYE	N/A
849	Presence conditions re-assessing in case of derived statistical calculation	N/A
877	QVUB -settings should be optional	N/A
909	Remove ANCR.ColOpR and ColOpL	N/A
920	Resetable Counter is NOT resetable	N/A
932	Rename AVCO.SptVol to AVCO.VolSpt	N/A
939	Change CDC for ANCR.FixCol	N/A
991	LGOS: GoCBRef (as well as LSVS.SvCBRef) should be mandatory	N/A
1007	PTRC as fault indicator - Update of description required	Y
1044	TapChg in AVCO	N/A
1077	Rename DOnames within LTIM	N/A

Part 8-1 Tissue	Description	Implemented Y / N/A
784	Tracking of control (CTS)	N/A
817	Fixed-length GOOSE float encoding	N/A
834	File dir name length 64	Y
951	Encoding of Owner attribute	N/A
1040	More associate error codes	N/A
1178	Select Response+ is non-null value	Y

Compare the TISSUE database for more details: www.tissues.iec61850.com

7.4 PICS

This section contains the Protocol Implementation Conformance Statement (PICS) for the IEC 61850 interface in the 8 Series relays.

Version 1.0

Date: July 23, 2015

he following ACSI conformance statements are used to provide an overview and details about 8 Series relays, with firmware 1.80:

- ACSI basic conformance statement
- ACSI models conformance statement
- ACSI service conformance statement

The statements specify the communication features mapped to IEC 61850-8-1 First Edition and/or Edition 2.

7.4.1 ACSI BASIC CONFORMANCE STATEMENT

Basic conformance statement

		Client/Subscriber	Server/Publisher	Value/Comments
Client-Server roles				
B11	Server side (of TWO-PARTY-APPLICATION-ASSOCIATION)		Y	
B12	Client side of (TWO-PARTY-APPLICATION-ASSOCIATION)			
SCSMs supported				
B21	SCSM: IEC 6185-8-1 used		Y	
B22	SCSM: IEC 6185-9-1 used			Ed2: Deprecated
B23	SCSM: IEC 6185-9-2 used			
B24	SCSM: other			
Generic substation event model (GSE)				
B31	Publisher side		Y	
B32	Subscriber side	Y		
Transmission of sampled value model (SVC)				
B41	Publisher side			
B42	Subscriber side			
- = not applicable Y = supported N or empty = not supported				

7.4.2 ACSI MODELS CONFORMANCE STATEMENT

ACSI models conformance statement

		Client/Subscriber	Server/Publisher	Value/Comments
If Server or Client side (B11/12) supported				
M1	Logical device		Y	
M2	Logical node		Y	
M3	Data		Y	
M4	Data set		Y	
M5	Substitution			
M6	Setting group control			
	Reporting			
M7	Buffered report control		Y	
M7-1	sequence-number		Y	
M7-2	report-time-stamp		Y	
M7-3	reason-for-inclusion		Y	
M7-4	data-set-name		Y	
M7-5	data-reference		Y	
M7-6	buffer-overflow		Y	
M7-7	entryID		Y	
M7-8	BufTm		Y	
M7-9	IntgPd		Y	
M7-10	GI		Y	
M7-11	conf-revision		Y	
M8	Unbuffered report control		Y	
M8-1	sequence-number		Y	
M8-2	report-time-stamp		Y	
M8-3	reason-for-inclusion		Y	
M8-4	data-set-name		Y	
M8-5	data-reference		Y	
M8-6	BufTm		Y	
M8-7	IntgPd		Y	
M8-8	GI		Y	
M8-9	conf-revision		Y	
	Logging			
M9	Log control			
M9-1	IntgPd			
M10	Log			
M11	Control		Y	
M17	File Transfer		Y	
M18	Application association		Y	
M19	GOOSE Control Block		Y	
M20	Sampled Value Control Block			

		Client/Subscriber	Server/Publisher	Value/Comments
If GSE (B31/32) is supported				
M12	GOOSE		Y	
M13	GSSE			Deprecated
If SVC (B41/B42) is supported				
M14	Multicast SVC			
M15	Unicast SVC			
For all IEDs				
M16	Time	Y	Y	
Y = service is supported N or empty = service is not supported				

7.4.3 ACSI SERVICE CONFORMANCE STATEMENT

The ACSI service conformance statement is defined in the following tables.

ACSI service Conformance statement

	Ed	ACSI Service	AA: TP/MC	Client Sub (C)	Server Pub (S)	Comments
Server						
S1	1,2	GetServerDirectory(LOGICAL-DEVICE)	TP		Y	
Application association						
S2	1,2	Associate	TP		Y	
S3	1,2	Abort	TP		Y	
S4	1,2	Release	TP		Y	
Logical device						
S5	1,2	GetLogicalDeviceDirectory	TP		Y	
Logical node						
S6	1,2	GetLogicalNodeDirectory	TP		Y	
S7	1,2	GetAllDataValues	TP		Y	
Data						
S8	1,2	GetDataValues	TP		Y	
S9	1,2	SetDataValues	TP		Y	
S10	1,2	GetDataDirectory	TP		Y	
S11	1,2	GetDataDefinition	TP		Y	
Data set						
S12	1,2	GetDataSetValues	TP		Y	
S13	1,2	SetDataSetValues	TP			
S14	1,2	CreateDataSet	TP			

	Ed	ACSI Service	AA: TP/MC	Client Sub (C)	Server Pub (S)	Comments
S15	1,2	DeleteDataSet	TP			
S16	1,2	GetDataSetDirectory	TP		Y	
Substitution						
S17	1	SetDataValues	TP			Ed1 only
Setting group control						
S18	1,2	SelectActiveSG	TP			
S19	1,2	SelectEditSG	TP			
S20	1,2	SetEditSGValues	TP			
S21	1,2	ConfirmEditSGValues	TP			
S22	1,2	GetEditSGValues	TP			
S23	1,2	GetSGCBValues	TP			
Reporting						
Buffered report control block (BRCB)						
S24	1,2	Report	TP		Y	
S24-1	1,2		data-change (dchg)		Y	
S24-2	1,2		quality-change (qchg)			
S24-3	1,2		data-update (dupd)			
S25	1,2	GetBRCBValues	TP		Y	
S26	1,2	SetBRCBValues	TP		Y	
Unbuffered report control block (URCB)						
S27	1,2	Report	TP		Y	
S27-1	1,2		data-change (dchg)		Y	
S27-2	1,2		quality-change (qchg)			
S27-3	1,2		data-update (dupd)			
S28	1,2	GetURCBValues	TP		Y	
S29	1,2	SetURCBValues	TP		Y	
Logging						
Log control						
S30	1,2	GetLCBValues	TP			
S31	1,2	SetLCBValues	TP			

	Ed	ACSI Service	AA: TP/MC	Client Sub (C)	Server Pub (S)	Comments
Log						
S32	1,2	QueryLogByTime	TP			
S33	1,2	QueryLogAfter	TP			
S34	1,2	GetLogStatusValues	TP			
Generic substation event model (GSE)						
GOOSE						
S35	1,2	SendGOOSEMessage	MC		Y	
GOOSE Control Block						
S36	1,2	GetGoReference	TP			
S37	1,2	GetGOOSEElementNumber	TP			
S38	1,2	GetGoCBValues	TP		Y	
S39	1,2	SetGoCBValues	TP		Y	
GSSE (Ed2:61850-7-2 Annex C)						
S40	1,2	SendGSSEMessage	MC			Deprecated
GSSE Control Block (Ed2:61850-7-2 Annex C)						
S41	1,2	GetGsReference	TP			Deprecated
S42	1,2	GetGSSEDataOffset	TP			Deprecated
S43	1,2	GetGsCBValues	TP			Deprecated
S44	1,2	SetGsCBValues	TP			Deprecated
Transmission of sampled value model (SVC)						
Multicast SV						
S45	1,2	SendMSVMessage	MC			Use for 9-2LE or IEC 61869-9
Multicast Sampled Value Control Block						
S46	1,2	GetMSVCBValues	TP			
S47	1,2	SetMSVCBValues	TP			
Unicast SV						
S48	1,2	SendUSVMessage	TP			
Unicast Sampled Value Control Block						
S49	1,2	GetUSVCBValues	TP			
S50	1,2	SetUSVCBValues	TP			
Control						
S51	1,2	Select	TP		Y	SBO Normal Security
S52	1,2	SelectWithValue	TP		Y	SBO Enhanced Security
S53	1,2	Cancel	TP		Y	
S54	1,2	Operate	TP		Y	
S55	1,2	CommandTermination	TP		Y	
S56	1,2	TimeActivatedOperate	TP			
File transfer						
S57	1,2	GetFile	TP		Y	

	Ed	ACSI Service	AA: TP/MC	Client Sub (C)	Server Pub (S)	Comments
S58	1,2	SetFile	TP			
S59	1,2	DeleteFile	TP			
S60	1,2	GetFileAttributeValues	TP			
S61	1,2	GetServerDirectory (FILE)	TP		Y	
Time						
T1	1,2	Time resolution of internal clock	-		2 ms	nearest negative power of 2 in seconds
T2	2	Time accuracy of internal clock	-			TL (ms) (low accuracy), T3 < 7) (only Ed2)
	1,2		-			T0 (ms) (<= 10 ms), 7 <= T3 < 10)
	1,2		-			T1 (µs) (<= 1 ms), 10 <= T3 < 13
	1,2		-			T2 (µs) (<= 100 µs), 13 <= T3 < 15
	1,2		-			T3 (µs) (<= 25 µs), 15 <= T3 < 18
	1,2		-			T4 (µs) (<= 4 µs), 18 <= T3 < 20
	1,2		-			T5 (µs) (<= 1 µs), T3 >= 20)
T3	1,2	Supported TimeStamp resolution	-		1 µs	nearest negative power of 2 in seconds

7.5 PIXIT

This section contains the Protocol Implementation eXtra Information for Testing (PIXIT) for the IEC 61850 interface in the 8 Series relays.

Version 1.0

Date: July 23, 2015

This document specifies the protocol implementation extra information for testing (PIXIT) of the IEC 61850 interface in 8 Series relays.

Together with the PICS and the MICS, the PIXIT forms the basis for a conformance test according to IEC 61850-10. The PIXIT entries contain information which is not available in the PICS, MICS, TICS documents or SCL file.

Each table specifies the PIXIT for applicable ACSI service model as structured in IEC 61850-10. The "Ed" column indicates if the entry is applicable for IEC 61850 Edition 1 and/or Edition 2.

7.5.1 PIXIT FOR ASSOCIATION MODEL

ID	Ed	Description	Value / Clarification	
As1	1	Maximum number of clients that can set-up an association simultaneously	4	
As2	1,2	TCP_KEEPALIVE value. The recommended range is 1...20s	7200 seconds but if no application message is detected within the As3 value, the device will close the connection.	
As3	1,2	Lost connection detection time	120 seconds (Configurable)	
As4	-	Authentication is not supported yet		
As5	1,2	What association parameters are necessary for successful association	Transport selector Session selector Presentation selector AP Title AE Qualifier	Y Y Y N N
As6	1,2	If association parameters are necessary for association, describe the correct values e.g.	Transport selector Session selector Presentation selector AP Title AE Qualifier	0001 0001 00000001 N/A N/A
As7	1,2	What is the maximum and minimum MMS PDU size	Max MMS PDU size Min MMS PDU size	120000 32000.
As8	1,2	What is the maximum start up time after a power supply interrupt	180 seconds	

7.5.2 PIXIT FOR SERVER MODEL

ID	Ed	Description	Value / Clarification	
Sr1	1,2	Which analogue value (MX) quality bits are supported (can be set by server)	Validity: Y N N N N N N N N N N Source: N N N N	 Good, Invalid, Reserved, Questionable Overflow OutofRange BadReference Oscillatory Failure OldData Inconsistent Inaccurate Process Substituted Test OperatorBlocked
Sr2	1,2	Which status value (ST) quality bits are supported (can be set by server)	Validity: Y N N N N N N N N N N Source: N N N N	 Good, Invalid, Reserved, Questionable BadReference Oscillatory Failure OldData Inconsistent Inaccurate Process Substituted Test OperatorBlocked
Sr3	-	What is the maximum number of data object references in one GetDataValues request	Deprecated	
Sr4	-	What is the maximum number of data object references in one SetDataValues request	Deprecated	
Sr5	1	Which Mode values are supported*	On [On-]Blocked Test Test/Blocked Off	Y N N N N

*IEC 61850-6:2009 clause 9.5.6 states that if only a subrange of the enumeration value set is supported, this shall be indicated within an ICD file by an enumeration type, where the unsupported values are missing.

7.5.3 PIXIT FOR DATA SET MODEL

ID	Ed	Description	Value / Clarification
Ds1	1	What is the maximum number of data elements in one data set (compare ICD setting)	64
Ds2	1	How many persistent data sets can be created by one or more clients (this number includes predefined datasets)	NOT SUPPORTED
Ds3	1	How many non-persistent data sets can be created by one or more clients	NOT SUPPORTED

7.5.4 PIXIT FOR SUBSTITUTION MODEL

ID	Ed	Description	Value / Clarification
Sb1	1	Are substituted values stored in volatile memory	NOT SUPPORTED

7.5.5 PIXIT FOR SETTING GROUP CONTROL MODEL

ID	Ed	Description	Value / Clarification
Sg1	1	What is the number of supported setting groups for each logical device	NOT SUPPORTED
Sg2	1,2	What is the effect of when and how the non-volatile storage is updated (compare IEC 61850-8-1 $16.2.4)	NOT SUPPORTED
Sg3	1	Can multiple clients edit the same setting group	NOT SUPPORTED
Sg4	1	What happens if the association is lost while editing a setting group	NOT SUPPORTED
Sg5	1	Is EditSG value 0 allowed	NOT SUPPORTED
Sg6	2	When ResvTms is not present how long is an edit setting group locked	NOT SUPPORTED

7.5.6 PIXIT FOR REPORTING MODE

ID	Ed	Description	Value / Clarification	
Rp1	1	The supported trigger conditions are (compare PICS)	integrity data change quality change data update general interrogation	Y Y N N Y
Rp2	1	The supported optional fields are	sequence-number report-time-stamp reason-for-inclusion data-set-name data-reference buffer-overflow entryID conf-rev segmentation	Y Y Y Y Y Y Y Y Y
Rp3	1,2	Can the server send segmented reports	Y	
Rp4	1,2	Mechanism on second internal data change notification of the same analogue data value within buffer period (Compare IEC 61850-7-2 $14.2.2.9)	Send report immediately	

ID	Ed	Description	Value / Clarification
Rp5	1	Multi client URCB approach (compare IEC 61850-7-2:2003 $14.2.1)	Each URCB is visible to all clients
Rp6	-	What is the format of EntryID	Deprecated
Rp7	1,2	What is the buffer size for each BRCB or how many reports can be buffered	Buffer size = 50000 Bytes
Rp8	-	Pre-configured RCB attributes that are dynamic, compare SCL report settings	Deprecated
Rp9	1	May the reported data set contain: - structured data objects - data attributes	 Y Y
Rp10	1,2	What is the scan cycle for binary events Is this fixed, configurable	Event Driven Fixed
Rp11	1	Does the device support to pre-assign a RCB to a specific client in the SCL	N
Rp12	2	After restart of the server is the value of ConfRev restored from the original configuration or retained prior to restart	Restored from original configuration

7.5.7 PIXIT FOR LOGGING MODEL

ID	Ed	Description	Value / Clarification
Lg1	1,2	What is the default value of LogEna (Compare IEC 61850-8-1 $17.3.3.2.1, the default value should be FALSE)	NOT SUPPORTED
Lg2	-	What is the format of EntryID	Deprecated
Lg3	1,2	Are there are multiple Log Control Blocks that specify the Journaling of the same MMS NamedVariable and TrgOps and the Event Condition (Compare IEC 61850-8-1 $17.3.3.3.2)	NOT SUPPORTED
Lg4	1	Pre-configured LCB attributes that cannot be changed online	NOT SUPPORTED

7.5.8 PIXIT FOR GOOSE PUBLISH MODEL

ID	Ed	Description	Value / Clarification
Gp1	1,2	Can the test (Ed1) / simulation (Ed2) flag in the published GOOSE be set	N
Gp2	1	What is the Behavior when the GOOSE publish configuration is incorrect	DUT keeps GoEna=F Configuration tool does not allow wrong configuration to be uploaded into device. e.g.: empty dataset.
Gp3	1,2	Published FCD supported common data classes are	SPS, INS, ENS, ACT, ACD, MV, CMV, SAV, WYE, DEL, SEQ, INC, ENC, SPC, DPC, INC, ENC. (Only the elements with FC=ST or MX will be published).
Gp4	1,2	What is the slow retransmission time Is it fixed or configurable	Configured by SCL on GoCB MaxTime
Gp5	1,2	What is the fastest retransmission time Is it fixed or configurable	Fixed. MinTime = 5 ms
Gp6	-	Can the GOOSE publish be turned on / off by using SetGoCBValues(GoEna)	Y
Gp7	1,2	What is the initial GOOSE sqNum after restart	sqNum = 1

ID	Ed	Description	Value / Clarification
Gp8	1	May the GOOSE data set contain: - structured data objects (FCD) - timestamp data attributes	 Y Y (timestamp attributes are not supported)
Gp9	2	How is the retransmission curve after a change.	- sqNum = 0 New change - sqNum = 1 -> 5ms later with TAL = 1000 - sqNum = 2 -> 10ms later with TAL = 1000 - sqNum = 3 -> 15ms later with TAL = 4000 - sqNum = 4 -> 1000ms later with TAL = Update time* x 4 - sqNum = 5 -> Update time* later with TAL = Update time* x 4 - sqNum = 6-> Update time* later with TAL = Update time* x 4 - sqNum = 7 …….. - …… *Update time is configured in the EnerVista 8 Series Setup

7.5.9 PIXIT FOR GOOSE SUBSCRIBE MODEL

ID	Ed	Description	Value / Clarification
Gs1	1,2	What elements of a subscribed GOOSE header are checked to decide the message is valid and the allData values are accepted? If yes, describe the conditions. Notes: - the VLAN tag may be removed by a ethernet switch and shall not be checked - the simulation flag shall always be checked (Ed2) - the ndsCom shall always be checked (Ed2)	Y destination MAC address Y APPID N gocbRef Y timeAllowedtoLive N datSet Y goID N t N stNum N sqNum N simulation / test N confRev Y ndsCom Y numDatSetEntries
Gs2	1,2	When is a subscribed GOOSE marked as lost (TAL = time allowed to live value from the last received GOOSE message)	message does not arrive after TAL
Gs3	1,2	What is the Behavior when one or more subscribed GOOSE messages isn't received or syntactically incorrect (missing GOOSE)	Message will be ignored, but when the next correct message will be received, it will be proceed as normal.
Gs4	1,2	What is the Behavior when a subscribed GOOSE message is out-of-order	Message will be proceeded
Gs5	1,2	What is the Behavior when a subscribed GOOSE message is duplicated	Message will be ignored
Gs6	1	Does the device subscribe to GOOSE messages with/without the VLAN tag	Y, with the VLAN tag Y, without the VLAN tag
Gs7	1	May the GOOSE data set contain: - structured data objects (FCD) - timestamp data attributes	 Y N
Gs8	1,2	Subscribed FCD supported common data classes are	DUT can receive all kinds of data but only digitals can be mapped.
Gs9	1,2	Are subscribed GOOSE with test=T (Ed1) / simulation=T (Ed2) accepted in test/simulation mode	N

ID	Ed	Description	Value / Clarification
Gs10	2	What is the Behavior when a subscribed GOOSE message with TAL = 0 is received by the subscriber.	The message will be ignored. The mechanism applies where the new GOOSE message is not received within a TAL.
Gs11	2	What is the Behavior when a subscribed GOOSE message hasn't the expected data structure.	The message will be ignored. The mechanism applies where the new GOOSE message is not received within a TAL.

7.5.10 PIXIT FOR CONTROL MODEL

ID	Ed	Description	Value / Clarification
Ct1	-	What control models are supported (compare PICS)	Deprecated
Ct2	1,2	Is the control model fixed, configurable and/or dynamic	Configurable & Dynamic
Ct3	-	Is TimeActivatedOperate supported (compare PICS or SCL)	Deprecated
Ct4	-	Is "operate-many" supported (compare sboClass)	Deprecated
Ct5	1	Will the DUT activate the control output when the test attribute is set in the SelectWithValue and/or Operate request (when N test procedure Ctl2 is applicable)	N
Ct6	-	What are the conditions for the time (T) attribute in the SelectWithValue and/or Operate request	Deprecated
Ct7	-	Is pulse configuration supported (compare pulseConfig)	Deprecated
Ct8	1	What is the Behavior of the DUT when the check conditions are set Is this Behavior fixed, configurable, online changeable	N synchrocheck N interlock-check DUT ignores the check value and always perform the check

ID	Ed	Description	Value / Clarification
Ct9	1,2	Which additional cause diagnosis are supported	Y Unknown Y Not-supported Y Blocked-by-switching-hierarchy N Select-failed Y Invalid-position Y Position-reached N Step-limit Y Blocked-by-Mode N Blocked-by-process N Blocked-by-interlocking N Blocked-by-synchrocheck Y Command-already-in-execution N Blocked-by-health N 1-of-n-control N Abortion-by-cancel Y Time-limit-over N Abortion-by-trip Y Object-not-selected Edition 1 specific values: N Parameter-change-in-execution Edition 2 specific values: Y Object-already-selected N No-access-authority N Ended-with-overshoot N Abortion-due-to-deviation N Abortion-by-communication-loss N Blocked-by-command N None Y Inconsistent-parameters Y Locked-by-other-client N Parameter-change-in-execution
Ct10	1,2	How to force a "test-not-ok" respond with SelectWithValue request	Device in local mode
Ct11	1,2	How to force a "test-not-ok" respond with Select request	
Ct12	1,2	How to force a "test-not-ok" respond with Operate request	DOns: Sending T=1 SBOns: Sending T=1 DOes: Sending T=1 SBOes: Sending T=1
Ct13	1,2	Which origin categories are supported / accepted	N bay-control Y station-control Y remote-control N automatic-bay Y automatic-station Y automatic-remote N maintenance N process

ID	Ed	Description	Value / Clarification
Ct14	1,2	What happens if the orCat value is not supported or invalid	DOns: control is rejected (Oper-ObjectAccessDenied). SBOns: control is rejected (Oper-ObjectAccessDenied). DOes: control is rejected (Oper-ServiceError, ObjectAccessDenied). SBOes: control is rejected (SBOw-ServiceError, ObjectAccessDenied).
Ct15	1,2	Does the IED accept a SelectWithValue / Operate with the same control value as the current status value Is this Behavior configurable	DOns: N SBOns: N DOes: N SBOes: N Configurable: N
Ct16	1,2	Does the IED accept a select/operate on the same control object from 2 different clients at the same time	DOns: N SBOns: N DOes: N SBOes: N
Ct17	1	Does the IED accept a Select/SelectWithValue from the same client when the control object is already selected (Tissue #334)	SBOns: N SBOes: N
Ct18	1,2	Is for SBOes the internal validation performed during the SelectWithValue and/or Operate step	SelectWithValue and Operate
Ct19	-	Can a control operation be blocked by Mod=Off or [On-]Blocked (Compare PIXIT-Sr5)	Deprecated
Ct20	1,2	Does the IED support local / remote operation	Y (Only for XCBR)
Ct21	1,2	Does the IED send an InformationReport with LastApplError as part of the Operate response- for control with normal security	SBOns: N DOns: N
Ct22	2	How to force a "parameter-change-in-execution	SBOns: N/A SBOes: N/A

7.5.11 PIXIT FOR TIME SYNCHRONISATION MODEL

ID	Ed	Description	Value / Clarification
Tm1	1,2	What time quality bits are supported (may be set by the IED)	Y LeapSecondsKnown N ClockFailure Y ClockNotSynchronized.
Tm2	1,2	Describe the Behavior when the time server(s) ceases to respond What is the time server lost detection time	On one time server: An event is generated On all time servers: An event is generated 60 seconds
Tm3	1,2	How long does it take to take over the new time from time server	2 seconds
Tm4	1,2	When is the time quality bit "ClockFailure" set	Never
Tm5	1,2	When is the time quality bit "Clock not Synchronized" set	60 seconds after the time server(s) ceases to respond.
Tm6	-	Is the timestamp of a binary event adjusted to the configured scan cycle	Deprecated
Tm7	1	Does the device support time zone and daylight saving	Y

ID	Ed	Description	Value / Clarification
Tm8	1,2	Which attributes of the SNTP response packet are validated	Y Leap indicator not equal to 3 Y Mode is equal to SERVER N Origination is equal to value sent by the SNTP client as Transmit Timestamp Y RX/TX timestamp fields are checked for reasonableness Y SNTP version 3 and/or 4 N other (describe)
Tm9	1,2	Do the COMTRADE files have local time or UTC time and is this configurable	Local N

7.5.12 PIXIT FOR FILE TRANSFER MODEL

ID	Ed	Description	Value / Clarification
Ft1	1	What is structure of files and directories Where are the COMTRADE files stored Are comtrade files zipped and what files are included in each zip file	 /COMTRADE N
Ft2	1,2	Directory names are separated from the file name by	“/”
Ft3	1	The maximum file name size including path (recommended 64 chars)	255 chars
Ft4	1,2	Are directory/file name case sensitive	Case sensitive
Ft5	1,2	Maximum file size for SetFile	
Ft6	1	Is the requested file path included in the MMS fileDirectory respond file name	Y
Ft7	1	Is the wild char supported MMS fileDirectory request	No
Ft8	1,2	Is it allowed that 2 clients get a file at the same time	Y same file Y different files
Ft9	1,2	Which files can be deleted	Not Applicable

7.5.13 PIXIT FOR SERVICE TRACKING MODEL

ID	Ed	Description	Value / Clarification
Tr1	2	Which ACSI services are tracked by LTRK.GenTrk	Not Applicable