USER MANUAL
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PACSystems™ RX3i

IEC 61850 ETHERNET COMMUNICATION MODULE
USER MANUAL

EMERSON

Contents

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In situations where inattention could cause either personal injury or damage to equipment, a Warning notice is used.

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Chapter 1: Introduction

This chapter introduces the PACSystems RX3i IEC 61850 Ethernet Communication Module, or ECM850 for short. The final pages of this chapter are a glossary that define many of the terms and acronyms used in the manual.

Chapter 2, Installation explains how to install an ECM850, how to complete port connections, and how to update the module firmware. It also explains how to install the ECM850's Universal Serial Bus (USB) port driver and describes how the module synchronizes its internal clock with the RX3i CPU.

Chapter 3, Configuration explains how to complete and download the configuration for ECM850s, (IEC 61850 Clients), add Intelligent Electronic Devices (IEDs). and select protocol variables for monitoring and control. This chapter describes how to use PLC Protocol Variables (PPVs) in RX3i controller applications. It also describes different configuration mechanisms: online and offline configuration, configuring specific protocol features like report control block, polling etc.

Chapter 4, IEC 61850 Client System Operation describes I/O scan operation and application program blocks for use with the ECM850. This chapter also provides an overview of IEC 61850 communications between the ECM850 and IEDs (IEC 61850 servers). This chapter defines system constraints with regard to PPV usage, memory usage, and other criteria for using the ECM850 in control applications.

Chapter 5, Diagnostics explains the power-up and reset process, LED blink patterns, status reporting, and fatal error reporting. It also describes faults and corrective actions.

The **Appendices** provide reference information about the ECM850 not required for typical applications.

Appendix A, ECM850 Command Line Interface Support describes an interface to the ECM850 used primarily for diagnostics and troubleshooting.

Appendix B, IEC 61850 I/O Performance Examples presents several IEC 61850 network I/O configurations with the measured I/O performance for each as an aid to computing estimated I/O performance in other scenarios.

Appendix C, Protocol Implementation Conformance Statements (PICS),

Appendix D, Model Implementation Conformance Statement (MICS), and

Appendix E, Protocol Implementation eXtra Information for Testing (PIXIT) collectively provide details of the ECM850's abstract communication service interface (ACSI) and other information required to demonstrate conformance to the IEC 61850 standard.

For additional information, please refer to the manuals listed below. Manuals can be downloaded from the Support website referenced in Contact Information at the front of this manual.

PACSystems CPU Reference Manual, GFK-2222

PACSystems RX3i System Manual, GFK-2314.

PACSystems RX3i PROFINET Controller Command Line Interface Manual, GFK 2572

For detailed information about the IEC 61850 standard, contact the International Electrotechnical Commission Technical Committee 57, Power Systems Management and Associated Information Exchange: www://tc57.iec.ch/

1.1 Description

The PACSystems RX3i IEC 61850 Ethernet Communication Module, catalog number IC695ECM850, or ECM850, connects a PACSystems RX3i controller to an IEC 61850 network, enabling the controller to act as an IEC 61850 Client and communicate with Intelligent Electronic Devices (IEDs, IEC 61850 servers[1]) on the network using the IEC 61850 protocol. (IEC 61850 is a standard for the design of electrical substation automation.) The ECM850 provides the functions and services required for an IEC 61850 Client, as described in the PICS and MICS in the appendices.

The ECM850 supports 10/100/1000 Mbps copper, 100/1000 Mbps multi-mode fiber, and 100/1000 Mbps single-mode fiber Ethernet connections. The network can include media interfaces of more than one type.

Figure 1

[1] Virtually all IEC 61850 Intelligent Electronic Devices (IEDs) function as servers, so within the context of this manual, the term IED may be understood to be an IEC 61850 server device.

Features of the ECM850 include:

- Supports the following IEC 61850 client features
  - Multiple connections to IEDs
  - Read and write of data values
  - Control model – all models
  - Report by exception – reporting buffered and un-buffered
  - Browse data model – logical devices, nodes, data objects & attributes
  - Self-description support – reads data model from IED over IEC 61850 network

Note: *Refer to the appendices for details.*

- Full programming and configuration services for the IEC 61850 Client, including reading of device Substation Configuration Language (SCL) files and reading configuration data online directly from IEDs using the Machine Edition programming and configuration application.
- Supports operation in hot standby redundant systems.
- Firmware upgrades using the WinLoader software utility.
- Built-in command-line interface function that supports direct monitoring and partial configuration by means of the module's Micro USB port or Telnet over Ethernet.

Note: *The USB port is intended for system setup and diagnostics only. It must not remain permanently connected.*

- Support for both star (switched) and linear (daisy-chained) network topologies.
- Four switched Ethernet ports — two eight-conductor RJ-45 shielded twisted pair 10/100/1000 Mbps copper interfaces and two Small Form-factor Pluggable (SFP) cages for user-supplied SFP devices.
- Internal clock synchronized with the RX3i CPU for time-stamped diagnostics
- Multicast Simple Network Time Protocol (SNTP) client support for synchronizing the module's internal clock with an external clock using SNTP over Ethernet.
- Restart pushbutton to manually restart the module without power cycling the system.
- Indicator LEDs: OK, LAN, STATUS, CONN, ACTIVE, USB, and four port active LEDs (1-4).

1.2 Specifications

ECM850 Specifications

Protocol Support	IEC 61850 Client as per PICs and MICs specifications
CPU Compatibility	RX3i CPUs with firmware version 8.05 or higher (CRU320, CPU320, CPU315, CPE305, CPE310)
PAC Machine Edition Compatibility	Machine Edition 8.0 SIM 7
Power Requirements	3.3V: 1.2 A with no SFP devices installed 1.9 A maximum (2 SFP devices installed, 0.35 A per SFP device)
	5V: 1.1 A maximum
Operating Temperature Range	0 to 60°C Derated to 57°C: • if 100 MB Fiber SFPs installed, or • if Copper SFPs operating at 1 GB.
Number of Port Connectors	Two RJ-45 and Two SFP Cages (SFP devices not included, available separately.)
Micro USB Connector	One, for communication with a computer using Command Line Interface.
Local Area Network (LAN	IEEE 802.2 Logical Link Control Class I IEEE 802.3 CSMA/CD Medium Access Control 10/100/1000 Mbps
CPU Status Bits	32
Polling Rate[2]	Configurable for every IED connection from 0 to 31267 msec (default is 1000 msec).
Number of IP Addresses	One
Number of MAC Addresses	Five. One per external port and one internal.
Network Topologies Supported	Star (switched), linear (daisy-chain)
Time Synchronization	SNTP Client – Multicast and Broadcast
System Maximum Limits	
ECM850s per RX3i CPU	Four (4). All must be located in main rack. (Use in remote or expansion racks not supported).
No of IED connections supported per ECM850	32
No of IED connections supported per RX3i CPU	128
Maximum I/O Memory per ECM850	32 Kbytes of combined Input/ Output memory
Maximum I/O Memory per RX3i CPU	128 Kbytes of combined Input/ Output memory
No of PLC Protocol Variables[1] (PPVs) per ECM850	5000
No of PPVs per RX3i CPU	20000
Hot-swappable	Yes

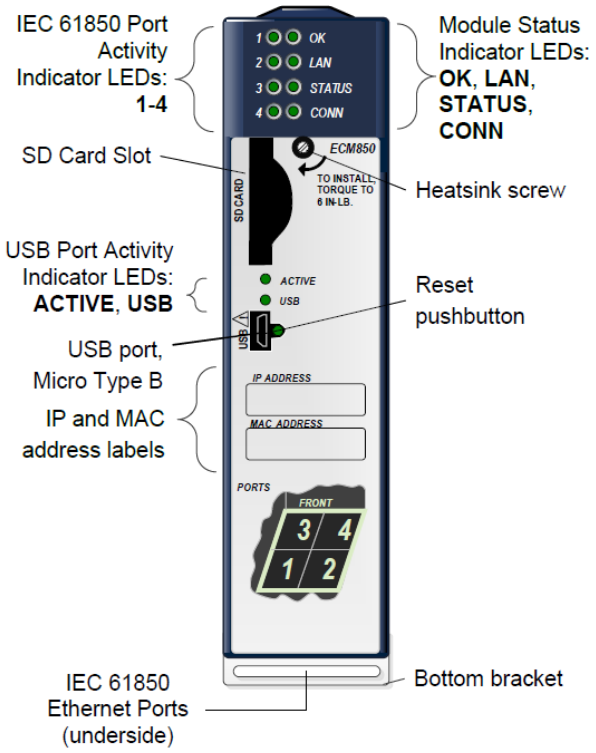
1. "PLC Protocol Variables" is defined as the set of RX3i controller variables which represent the IEC 61850 protocol data attributes in a structured format in a variable list. This typically includes the additional variables which are required to perform "WRITE" operations to an IED. See section 3.3.9 Generate PLC Protocol Variables (PPVs) for each ECM850, for more details.
2. The polling rate for each IED connection can be configured by the IEC 61850 Configurator. ECM850 also supports unsolicited communication using report control blocks (RCB). The RCB can be used for faster updates irrespective of polling rate, based on RCB trigger options. The configuration of polling rate and RCBs is described in Chapter 3, and polling mechanisms are described in section 4.3 ECM850 I/O Scan Mechanism

For product standards, general operating specifications, and installation requirements, refer to the PACSystems RX3i System Manual, GFK-2314.

1.3 Controls and Indicators

The illustration below shows the front of the ECM850 and identifies its controls and indicators.

Figure 2



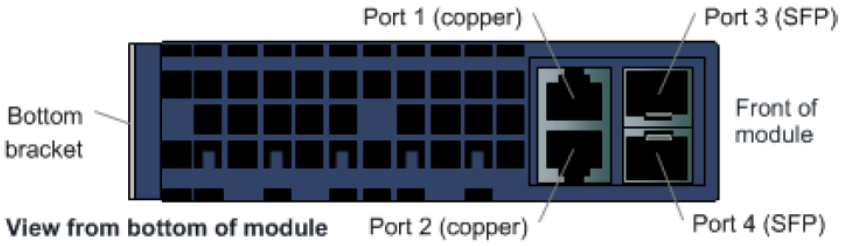
1.3.1 Secure Digital (SD) Card Slot

The SD card slot is designed to support non-volatile memory cards in both standard capacity (SD) and high-capacity (SDHC) formats. It is provided for future use.

1.3.2 Switched {XE Switch} Ethernet {XE Ethernet} Ports {XE Ports}

The ECM850 connects to an IEC 61850 network by means of one or more of its four switched external Ethernet ports. Two 8-conductor RJ-45 shielded twisted pair 10/100/1000 Mbps copper interfaces and two Small Form-factor Pluggable (SFP) cages provide flexibility in media selection.

Figure 3



The module is assigned five Ethernet MAC addresses: one for each of the four external Ethernet ports and one for the internal switch.

1.3.3 Port Status Indicators

Each external Ethernet port has an associated link-up/link-down status bit that can be monitored by the RX3i CPU to check the operating status of the port (see "Status Reporting" in Chapter 5:, "Diagnostics," for information about the ECM850 status bits). In addition, the four Port LEDs on the front of the module provide a visual indication of the port status.

1.3.4 Small Form-factor Pluggable (SFP) Modules for Ethernet Ports

Each SFP cage on the bottom of an ECM850 is capable of accepting a 10/100/1000 Mbps copper SFP module, 100 Mbps Single-Mode Fiber SFP, 100 Mbps Multi-Mode Fiber SFP, 1000 Mbps Single-Mode Fiber SFP, or 1000 Mbps Multi-Mode Fiber SFP device. SFP devices can be removed and replaced during module operation. The ECM850 supports the SFP devices listed below. An SFP type other than those listed below may be configured as a GENERIC SFP in Machine Edition. The ECM850 will attempt to operate with a generic SFP that identifies itself as an Ethernet SFP. Since SFP types other than those listed below have not been validated, correct operation cannot be guaranteed.

SFP Type	Wavelength (nm)	Media Type	Core Size (µm)	Modal Bandwidth (MHz – Km)	Distance (m)
100BASE-FX[1]	1300	MMF	62.5	500	2 – 2,000 (Full-Duplex) 2 – 400 (Half-Duplex)
			50	400	
			50	500	
100BASE-LX10	1300	SMF	9	–	2 – 10,000
1000BASE-SX	850	MMF	62.5	160	2 – 220
				200	2 – 275

SFP Type	Wavelength (nm)	Media Type	Core Size (µm)	Modal Bandwidth (MHz – Km)	Distance (m)
			50	400	2 – 500
				500	2 – 550
1000BASE-LX	1300	SMF	9	–	2 – 10,000
1000BASE-ZX	1550	SMF	9	–	2 – 70,000
10/100/1000 BASE-T[2]	–	CAT5/ CAT5e/ CAT6	–	–	100 (maximum)

[1] Emerson part number IC695SPF002

[2] Emerson part number IC695SPC100

1.3.5 Micro USB Port {XE Micro USB Port}

The ECM850 has a USB Micro-B socket for connection to a computer running Windows Vista or Windows 7. The USB port can be used to access the ECM850's Command Line Interface (CLI) function using a terminal emulation application such as HyperTerminal. The Command Line Interface function can be used to monitor an ECM850 and check its operation. If a problem occurs, the Command Line Interface can be used to help determine the cause. A driver installation application is provided to configure a Windows computer to communicate with the ECM850 through its USB port. See Chapter 2:, Installation, for instructions.

1.3.6 Restart Pushbutton {XE Restart Pushbutton}

The Restart pushbutton on an ECM850 can be used to manually restart the module without cycling power. The restart operation begins when the pushbutton is released.

1.3.7 Indicator LEDs

The table below summarizes the light-emitting diode (LED) indicator functions. More detailed information about error indications and blink patterns is given in Chapter 2:, Installation and Chapter 5:, Diagnostics.

OK	Indicates whether the module can perform normal operation.
LAN	indicates access to and activity on the Ethernet local area network (LAN). The LAN LED indicates network packets are being processed by the network interface (not just passing through the embedded switch)
STATUS	Indicates the condition of the ECM850 during normal operation. It indicates whether an entry other than the startup event is present in the module's local log. STATUS can also indicate whether any of the MAC addresses are invalid.
CONN	Indicates whether the module has received its configuration from the RX3i CPU.
ACTIVE	Indicates the status of IED connections.
USB	Indicates activity on the USB port.

1, 2, 3, 4	Indicate link speed, link connection and link activity corresponding to the four external Ethernet ports.

1.4 IEC 61850 Networks for PACSystems

IEC 61850 is an international standard for the design of electrical substation automation that defines the communication between electrical switchgear and substation control equipment. An IEC 61850 Client connects to and communicates with multiple Intelligent Electronic Devices (IEDs, or IEC 61850 Servers) over an IEC 61850 network. This enables configuration, parameterization, and diagnostics communication between controllers and devices.

Note: *The ECM850 operates only in auto negotiate mode. All bus devices and switches that are connected to the module should be configured to use auto negotiation.*

1.4.1 PAC Machine Edition Configuration and Programming

Machine Edition is used to configure the ECM850's IEC 61850 client system. The IEC 61850 connectivity configuration with IEDs and selection of IEC 61850 data objects and attributes can be done using an integrated IEC 61850 Configurator in the Machine Edition. The Machine Edition application automatically generates PLC Protocol Variables (PPVs) in the object-oriented model. These PPVs are available in controller programs as CPU symbolic variables, enabling the RX3i controller to control, monitor, and sequence the operation of IEDs using these variables.

Machine Edition provides two methods of configuring an ECM850: online and offline.

Online Configuration: The IEC 61850 data model can be directly read from the IED over the IEC 61850 network if the IED is connected to same network as the computer on which Machine Edition is installed. The Configurator provides a mechanism to then browse the data model of the device and select data objects and data attributes (DO/DA) for the RX3i controller.

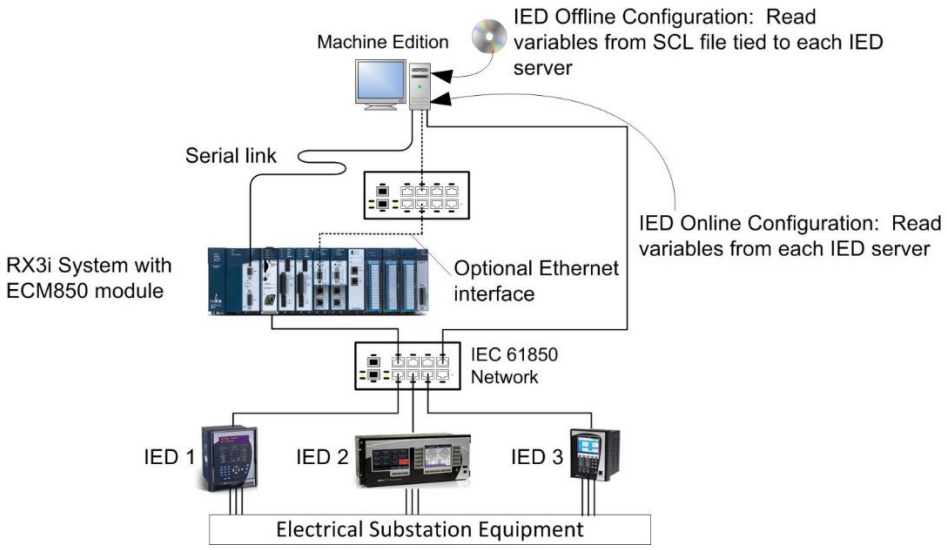
Offline Configuration: The IEC 61850 data model can be directly read or imported from an IED configuration file (ICD or CID file). The Configurator provides a mechanism to then browse the data model of the device and select data objects/attributes for the controller.

Note: *Adding variables manually in the IEC 61850 Configurator is not recommended, as this may result in incorrect configuration and validation errors.*

The detailed configuration procedure and mechanism is described in Chapter 3 and is also available in Machine Edition online help.

The next illustration shows a programmer connection (for configuration, user logic programming, and monitoring), the concept of variable Configuration import, an optional external Ethernet switch, and the ability of ECM850 to connect to an IEC 61850 IED

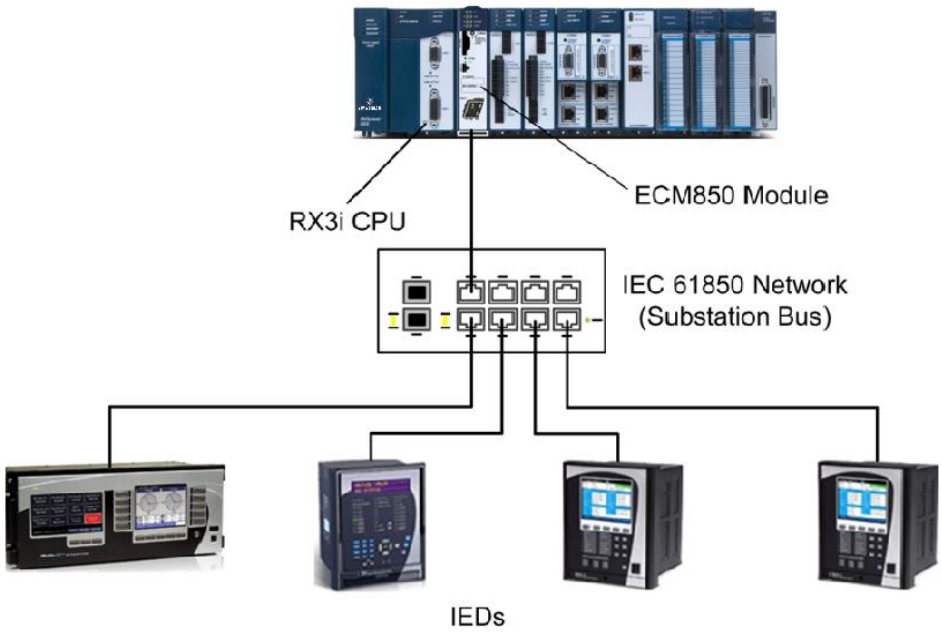
Figure 4: Programmer Connection



1.5 Basic System: One RX3i CPU and One ECM850 Using a Single Port

Components of an RX3i IEC 61850 network consist of an ECM850 in the RX3i main rack communicating with IEDs on an IEC 61850 Substation bus (an Ethernet LAN). The main RX3i rack can include up to four ECM850s, each communicating with its own high-speed network(s). IEDs on the network can include Emerson IEDs and a wide range of third-party devices which provide IEC 61850 server functionality. For example, the illustration below shows a basic system with one PACSystems RX3i CPU node having one ECM850, and one IEC 61850 network with three Emerson IEDs and one third-party IED. Up to 32 IEDs can be installed on a single RX3i IEC 61850 network.

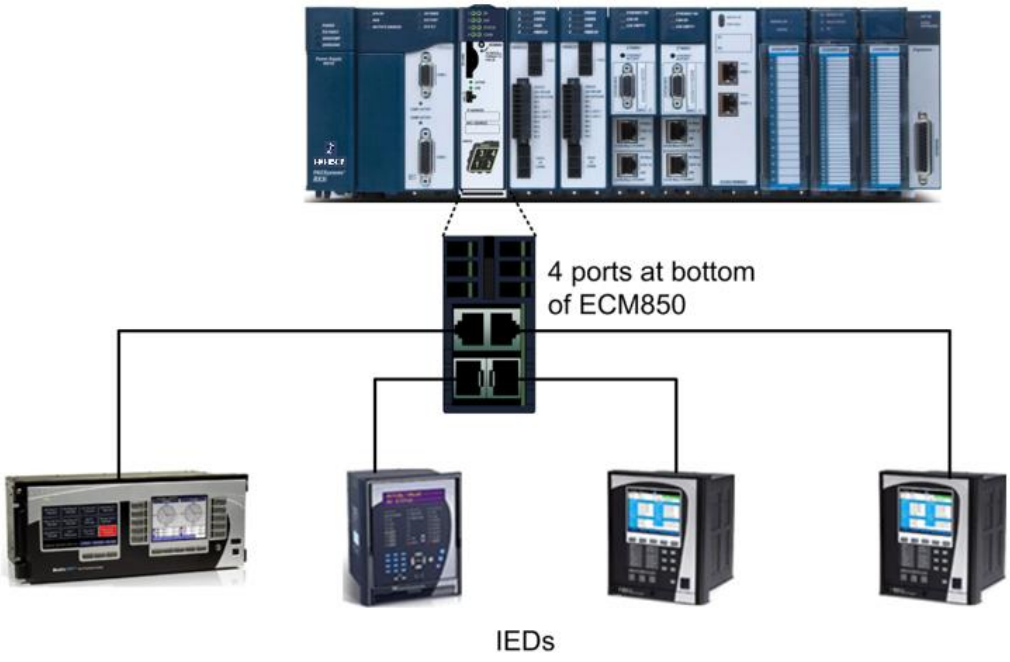
Figure 5: RX3i CPU with one ECN850 and One IEC61850 Network and three IED's



1.5.1 Basic System: One RX3i CPU and ECM850 Using Multiple Ports

The illustration below shows the same basic system as before, with one RX3i CPU with one ECM850 acting as an IEC 61850 client on a single IEC 61850 network, but this example shows the ECM850 directly connected to each separate IED in a star topology. Although each IED is connected to a separate Ethernet port on the ECM850, they are all on the same network segment, LAN 1.

Figure 6: Basic System with Rx3i CPU and ECM850



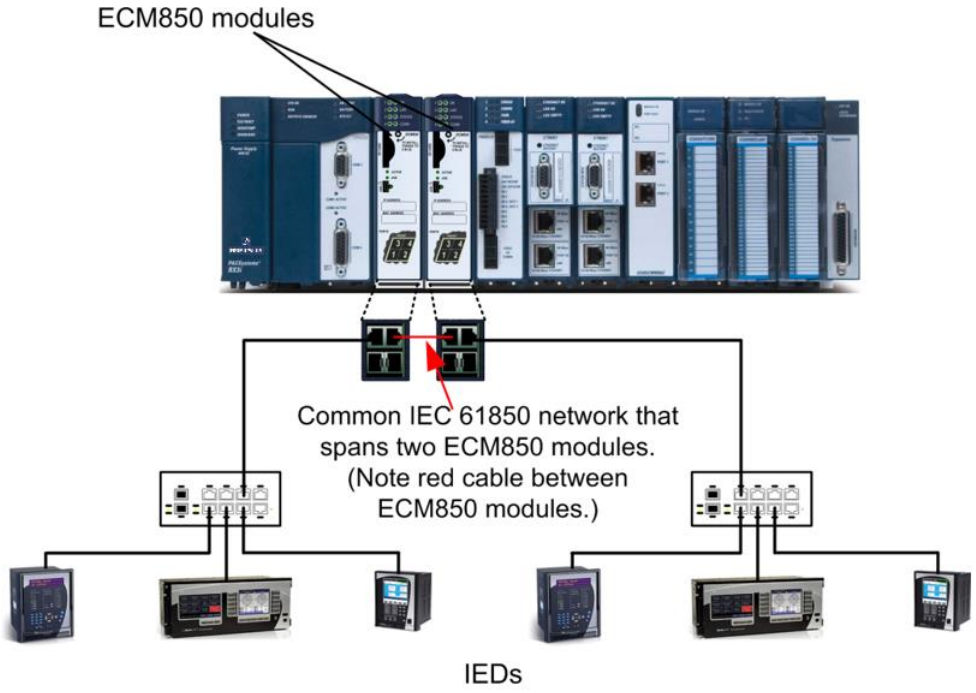
1.5.2 Systems with One RX3i CPU and Two ECM850s

Both examples in this section show systems with one RX3i CPU that has two ECM850s. The IEC 61850 network can serve up to 128 IEDs (in star topology).

Note that multiple ECM850s in the same rack are not synchronized such that all ECM850s are guaranteed to power up at the same time. ECM850 configuration differences (SFPs, etc.) can cause variations in ECM850 power up times.

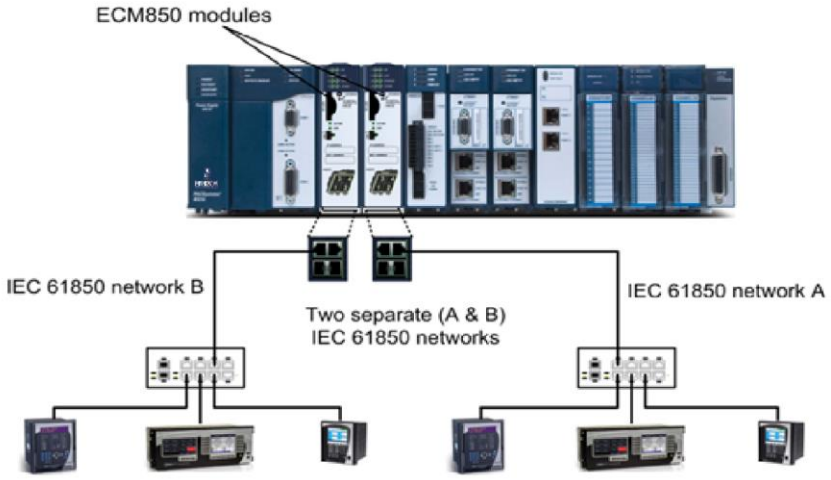
In the following example, both ECM850s are connected to the same network.

Figure 7



In the next example, the two ECM850s are connected to separate networks.

Figure 8

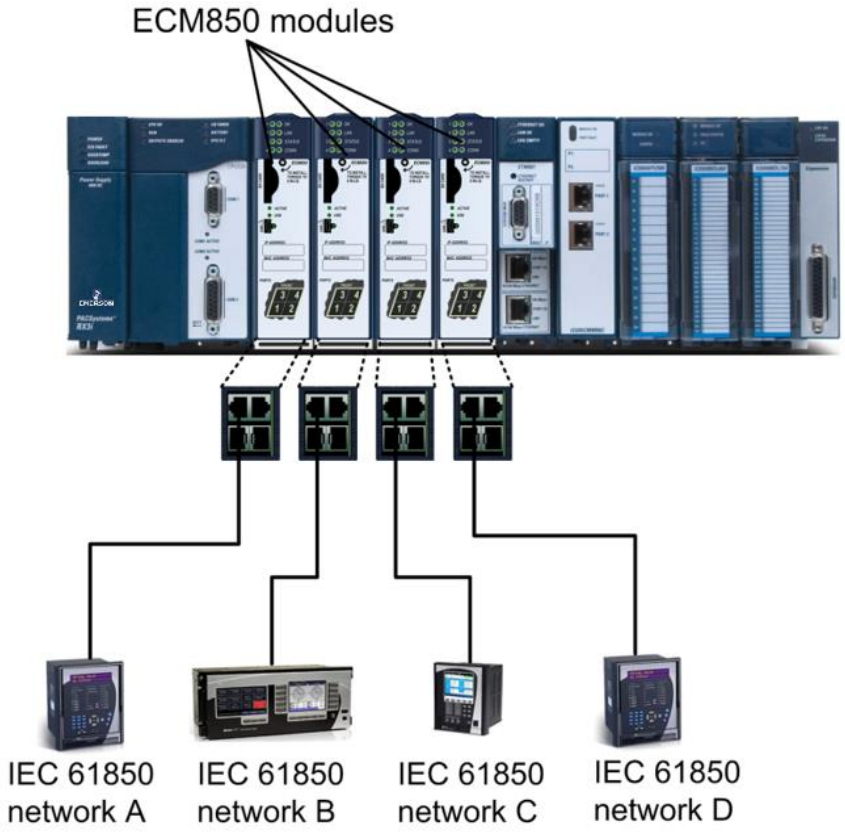


1.5.3 One RX3i CPU with Four ECM850s on Separate Networks

This example shows a system with one RX3i CPU node containing the maximum of four ECM850s, with each ECM850 connected to a different network. In this architecture, up to 128 IEDs are allowed, spread across the four networks. Up to 32 IEDs can be controlled by an ECM850.

Note that multiple ECM850s in the same rack are not synchronized to ensure that all ECM850s are guaranteed to power up at the same time. ECM850 configuration differences (SFPs, etc.) can cause variations in ECM850 power up times.

Figure 9

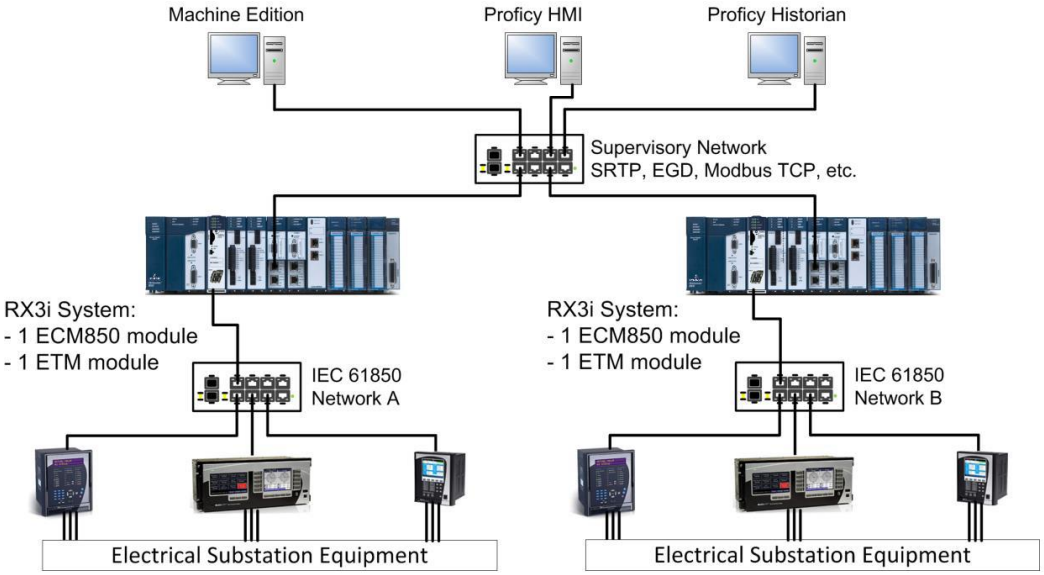


1.5.4 Two RX3i CPUs, Two IEC 61850 Networks, and One Supervisory Network

The example on this page shows two RX3i CPU nodes, each with one ECM850 and one RX3i Ethernet Transmitter Module (ETM). The ECM850s are connected to separate networks (LAN1 and LAN 2 in the illustration). Network A and Network B are used for IEC 61850 traffic.

The RX3i Ethernet Transmitter Modules are connected to the Supervisory Network. PACSystems Machine Edition, HMI and Historian use this network to configure and monitor the application. The Supervisory Network is also used for inter-node communication using protocols such as Ethernet Global Data (EGD), Service Request Transport Protocol (SRTP), and Modbus/TCP. The three separate networks do not compete for network bandwidth or interfere with one another.

Figure 10



1.6 Glossary

Glossary	
ACSE	Abstract Communication Service Event
ACSI	Abstract Communication Service Interface
SCSM	Specific Communication Service Mapping
Broadcast	In Ethernet, the transmission of a network message to all hosts on the network.
CID File	Configured IED Description (CID) files: Type of SCL file as defined in IEC 61850-6standards
CPU	Central Processing Unit. In the context of this manual, CPU refers to an RX3i controller
CPU Node	In a PACSystems RX3i IEC 61850 network, a CPU Node is a node that has a PACSystems RX3i CPU in its rack and is connected to the IEC 61850 network.
DA	Data Attribute
DO	Data Object
ECM	Ethernet Communication Module
EGD	Ethernet Global Data, a client-server protocol that allows controllers to exchange data with HMI workstations, historian systems, and other supervisory software
ECM850	IEC 61850 Ethernet Communication Module
FC	Functional Constraints
Gbps	Gigabits per second, or 1,000,000,000 bits per second, a measure of a communication channel's (such as Ethernet) signaling rate; 1 Gbps = 1000 Mbps
Gratuitous ARPs	An Address Resolution Protocol (ARP) request sent by the host to resolve its own IP address.
HMI	Human-Machine Interface; typically, a graphical display that displays a system's status and alarms and allows operators to monitor and control system operation

ICD File	IED Capability Description (ICD) files: Type of SCL file as defined in IEC 61850-6 standards
IED	Intelligent Electronic Device supporting the IEC 61850 client-server protocol
LD	Logical Device
LN	Logical Node
Mbps	Megabits per second, or 1,000,000 bits per second, a measure of a communication channel's (such as Ethernet) signaling rate
MICS	Model Implementation Conformance Statement for IEC 61850
MMS	Manufacturing Message Specification
Modbus/TCP	An Ethernet-based implementation of the Modbus protocol used to allow supervisory computers to exchange data with controllers.
Multicast	In Ethernet, the transmission of a network message to all hosts within a host group.
NMS	Network Management System. Executes applications that monitor and control managed devices in an SNMP-managed network.
NSAU	Non-Synchronized Active Unit. In the event of redundancy link failure in a hot-standby system, both of the controllers in the system become NSAUs.
PICS	Protocol Implementation Conformance Statement for IEC 61850
PIXIT	Protocol Implementation extra Information for Testing as per IEC 61850 standards
PLC	Programmable Logic Controller; in the context of this manual, the PACSystems RX3i controller
PPV	PLC Protocol Variables. RX3i controller symbolic variables which represents variable data from an IED. This also includes additional variables that are required for performing write operations to the IED.
RCB	Report Control Block
Remote Node	For an RX3i IEC 61850 network, a Remote Node is any IED.
SCL	Substation Configuration description Language (SCL) as defined in IEC 61850-6
SFP	Small Form-factor Pluggable. Pluggable, hot-swappable Ethernet transceivers.
SRTP	Service Request Transport Protocol, an Ethernet-based client-server protocol that allow clients to read and write system memory of SRTP-capable Emerson devices
Status Bits	Module status data in RX3i CPU reference memory.
SVC_REQ	Service Request Function Block. A control system service initiated by the RX3i CPU.
Unicast	In Ethernet, the transmission of a network message to an individual host.
Update Period	The time between cyclic data transfers between an ECM850 and an IED.

Chapter 2: Installation

This chapter provides instructions for installing the ECM850. The following topics are covered.

- Pre-Installation check
- Removing the backplane knockout
- Module installation and removal
- Hot insertion and removal
- Port connections
- Installing SFP devices
- LED indications
- Installing the USB Port Driver
- Firmware updates
- Time synchronization with RX3i CPU

For additional information about system installation, also see the PACSystems RX3i System Manual, catalog number GFK-2314.

2.1 Pre-Installation Check

Upon receiving your RX3i equipment, carefully inspect all shipping containers for damage. If any part of the system is damaged, notify the carrier immediately. The damaged shipping container should be saved as evidence for inspection by the carrier.

As the consignee, it is your responsibility to register a claim with the carrier for damage incurred during shipment. Emerson will fully cooperate with you, however, should such action be necessary.

After unpacking the RX3i equipment, record all serial numbers. Serial numbers are required if you should need to contact Customer Care during the warranty period. All shipping containers and all packing material should be saved should it be necessary to transport or ship any part of the system.

Verify that all components of the system have been received and that they agree with your order. If the system received does not agree with your order, contact Customer Care.

If you need technical help, contact Technical Support. For phone numbers and email addresses, see the Contact Information page in the last of this manual.

2.2 Installation Location

This product is intended for use with the RX3i system. Its components are considered open equipment (having live electrical parts that may be accessible to users) and must be installed in an ultimate enclosure that is manufactured to provide safety. As a minimum, the enclosure shall provide a degree of protection against solid objects as small as 12mm (e.g. fingers). This equates to a NEMA/UL Type 1 enclosure or an IP20 rating (IEC 60529) providing

at least a pollution degree 2 environment. For details about installing RX3i rack systems, refer to GFK-2314, PACSystems RX3i System Manual.

2.3 Installation in Hazardous Areas

The following information is for products bearing the UL marking for Hazardous Areas or ATEX marking for explosive atmospheres:

CLASS 1 DIVISION 2 GROUPS ABCD

- This equipment is an open-type device and is meant to be installed in an enclosure suitable for the environment that is only accessible with the use of a tool.
- Suitable for use in Class I, Division 2, Groups A, B, C and D Hazardous Locations, or nonhazardous locations only.

⚠ WARNING

- EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION 2.
- WHEN IN HAZARDOUS LOCATIONS, TURN OFF POWER BEFORE REPLACING OR WIRING MODULES; AND
- DO NOT CONNECT OR DISCONNECT EQUIPMENT UNLESS POWER HAS BEEN SWITCHED OFF OR THE AREA IS KNOWN TO BE NONHAZARDOUS.

⚠ WARNING

- EXPLOSION HAZARD - USB PORT IS ONLY FOR USE IN NONHAZARDOUS LOCATIONS, DO NOT USE UNLESS AREA IS KNOWN TO BE NON-HAZARDOUS

2.3.1 ATEX Zone 2

The ECM850 must be mounted in an enclosure certified in accordance with EN60079-15 for use in Zone 2, Group IIC and rated IP54. The enclosure shall only be able to be opened with the use of a tool.

2.3.2 ATEX Marking

Ex II 3 G Ex nA IIC T5 X Ta: 0 - 60C

2.4 Module Installation

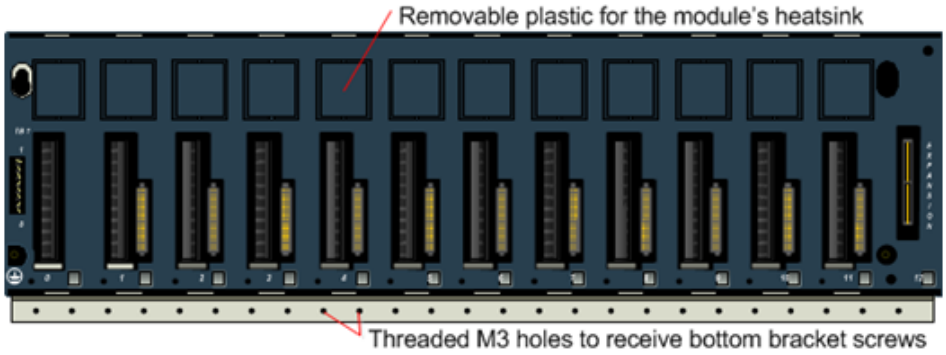
The ECM850 must be installed in the main (CPU) rack of an RX3i system, using a Universal Backplane such as IC695CHS007, CHS012 or CHS016. The ECM850 supports insertion/removal while power is applied to the system (hot swap). This module is compatible with RX3i CPU models CPU320, CPU315, CPE305,CPE310 and CRU320.

2.4.1 Removing the Backplane Knockout

The ECM850 must be installed in the main (CPU) rack of an RX3i system, using a Universal Backplane such as IC695CHS007, CHS012 or CHS016.

The back of the ECM850 has an exposed heat sink and backplane connector. Before inserting the module into the backplane, remove the plastic knockout in the slot where the module will be placed. The installation slot must match the slot that is selected in the module's hardware configuration.

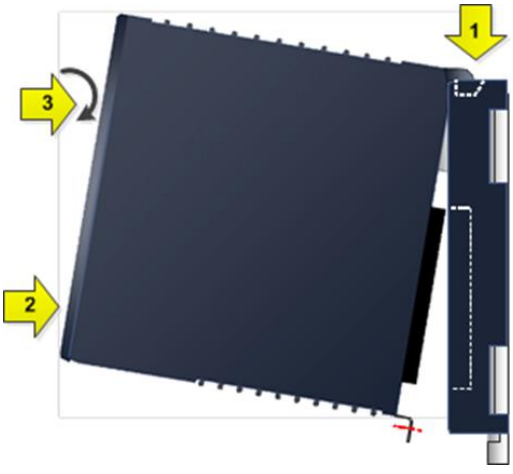
Figure 11



2.4.2 Module Insertion

- RX3i rack power may be off or on (see Section 2.4.4, Hot Insertion and Removal).
- Holding the module firmly, align the module with the correct slot and connector.
- Engage the module's rear pivot hook in the notch on the top of the backplane (1).
- Swing the module down until the module's connector engages the backplane connector (2).
- Visually inspect the module to be sure it is properly seated.
- Turn the heat sink screw on the front of the module several turns into the threaded hole in the backplane using a flat-tip screwdriver (3), but do not tighten.

Figure 12

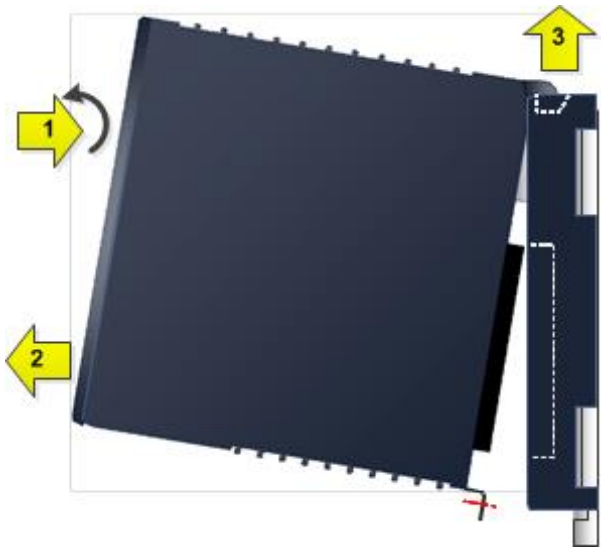


- Insert the two provided M3x5 machine screws through the module's bottom bracket into threaded holes in the bottom of the backplane and screw them several turns using a #1 Phillips screwdriver, but do not tighten.
- Tighten the heat sink screw to 6 in-lbs (0.7 N m).
- Tighten the bottom bracket screws.

2.4.3 Module Removal

- RX3i rack power may be off or on (see section 2.4.4-Hot Insertion & Removal for relevant warnings).
- Loosen the heat sink screw on the front of the module to release the heat sink from the backplane's aluminum backplate (1).
- While holding the module firmly, pivot the module upward until its connector is out of the backplane (2).
- Lift the module up and away from the backplane to disengage the pivot hook (3).

Figure 13



2.4.4 Hot Insertion and Removal

Modules in a Universal Backplane can be installed or removed while power is applied to the system. This includes backplane power and field power supplied to the module.

The ECM850 must be properly seated with the latch engaged and all pins connected within 2 seconds. For removal, the module must be completely disengaged within 2 seconds. It is important that the module not remain partially inserted during the insertion or removal process. There must be at a minimum of two seconds between the removal and insertion of modules.

⚠ WARNING

Inserting or removing a module with power applied to the system may cause an electrical arc. This can result in unexpected and potentially dangerous action by field devices. Arcing is an explosion risk in hazardous locations. Be sure that the area is non-hazardous or remove system power appropriately before removing or inserting a module.

If the surrounding air operating temperature of the ECM850 is greater than 40°C (104°F), SFP devices could have operating temperatures over 70°C (158°F). Under these conditions, for your safety, do not use bare hands to remove an SFP device from the SFP cage. Use protective gloves or a tool (needle-nose pliers) to avoid handling the hot SFP device directly when removing the SFP device.

⚠CAUTION

If an ECM850 is extracted from a powered RX3i backplane, it loses power immediately, which may result in data loss. Do not remove or insert the device while downloading hardware configuration to the system.

When the module is plugged back into a powered backplane, the ECM850 restores data from the internal non-volatile memory. If, however, the RX3i CPU has configuration data for the ECM850, it re-delivers the data to the module, superseding parameters previously stored in non-volatile memory.

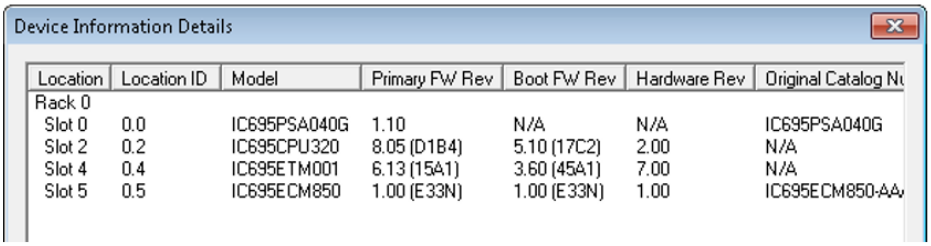
2.4.5 Fault Notifications

Removing an ECM850 causes a Loss of IOC fault in the RX3i CPU's I/O fault table and inserting an ECM850 causes an Addition of IOC fault in the I/O Fault table.

2.5 Confirm ECM850 Communication with the CPU

1. Start the Machine Edition application, then open or create the project to contain the ECM850.
2. Configuring the rack, power supply, and CPU in the Project tab of the Navigator
3. Go online with the target, right-click on the target and select **Online Commands ▸**, **Show Status...**, **Details**, to display the **Device Information Details** window. This queries the CPU and all modules present on all racks in the system, whether configured or not.
4. If the ECM850 is displayed in the list similar to the following screenshot, it indicates that the module has powered up as expected, is communicating with the CPU over the rack backplane, and that it is ready for further configuration.

Figure 14



2.6 Next Steps

The full configuration of the ECM850 is covered in detail in the following chapters of this manual, but in brief, the steps are the following:

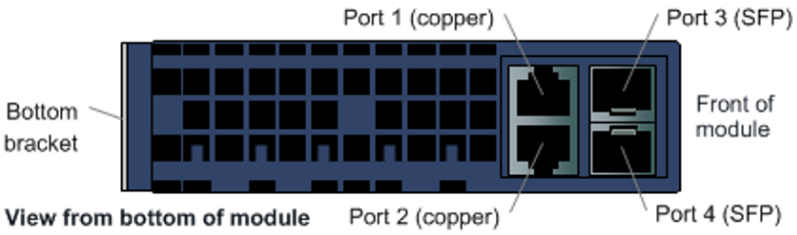
1. **Add the ECM850 to the RX3i Target Hardware Configuration.** Select the slot in which the ECM850 is installed, right-click and select **Add Module**. From the Communications tab of the Module Catalog, select the IC695ECM850. Double-clicking the slot with the IC695ECM850 displays a Settings grid where you can enter (among others) the module's IEC 61850 network IP address, subnet mask, and Status Address.
2. **Add IEDs and select IEC 61850 Data Objects/Data Attributes (DO/DA).** Right-click the slot with the IC695ECM850 and select Configure **IEC61850 Client** to display the integrated **IEC 61850 Configurator** to define and configure the IEDs with which the ECM850 will communicate. The IEC 61850 Configurator supports both online and offline configuration. Online, you can connect to the IED and browse the device's data model to select objects of interest. Offline, you can import an IED Capability Description (ICD) or Configured IED Description (CID) file preconfigured by the IED vendor to browse and select the device's data objects. Machine Edition automatically generates "PLC Protocol Variables" (PPVs) from these objects for use in the ladder application.
3. **Create the RX3i application**. Finally, you use the variables created in the previous step to develop an RX3i application program. You will then download this program along with the hardware configuration and network configuration to the RX3i controller for validation and deployment.

2.7 Ethernet Port Connections

Each port on an ECM850 operates independently, so devices that operate at different speeds and/or duplex modes may be attached to the ports. Each port automatically detects the attached cable and functions properly with either straight-through or crossover cables.

Note: *The ECM850 operates only in autonegotiate mode. All IEC 61850 devices and switches that are connected to the ECM850 should be configured to use autonegotiation.*

Figure 15



2.7.1 IEC 61850 Network Connections

Connections to the ECM850 can be made using standard cables. Each ECM850 can be connected to only one IEC 61850 network. Different devices on the same LAN, however, can be connected via more than one port.

Note: *Shielded cable is required for 1 Gbps operation.*

⚠CAUTION

Do not connect two or more ports on the ECM850 to the same device, either directly or indirectly to create network ring. This may result in packets continuously cycle on the network, preventing normal operation.

2.7.2 RJ-45 Port Connections

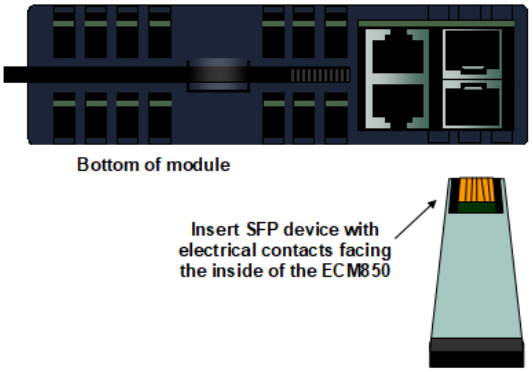
The ECM850's two RJ-45 ports can be used for IEC 61850 network connections or for general Ethernet communications on a 10BaseT, 100BaseTX, or 1000Base-T IEEE 802.3 network. If the port is connected to an external switch, hub, or repeater, up to 12 IEC 61850 nodes may be connected in a star wiring topology. Cables may be up to 100 meters in length. Cables for 100BaseTX or 1000BaseT must be data grade Category 5 or better unshielded twisted pair (UTP) or shielded twisted pair (STP). 10BaseT may be used for the general Ethernet traffic, but not for IEC 61850 communications.

2.7.3 Installing Small Form-factor Pluggable (SFP) Devices

SFP devices can be installed in Port 3 and Port 4 of the ECM850. See Chapter 1: for a list of supported SFP devices, media types and distances. The specific SFP module installed in each cage must be defined in the Machine Edition configuration of the ECM850.

When inserting the SFP device into the ECM850, keep its protective plug installed. Following the manufacturer's installation instructions, insert the device with its electrical contacts oriented toward the inside of the ECM850 until it clicks into place.

Figure 16



⚠ WARNING

Optical SFPs use an invisible laser to generate a fiber-optic signal. Always keep the port covered when a cable is not installed. DO NOT look into the open port if a cable is not installed.

Remove the protective plug to install the cable.

When the ECM850 powers up, it automatically detects devices plugged into the SFP cages, their type (fiber, copper, etc.) and their link speed. If an SFP device has been included in the configuration but is not present in the specified cage, the ECM850 logs a Loss of Network Port entry to its Local Log Table. If possible, the ECM850 also logs a fault to the associated RX3i I/O Fault Table. The module continues to operate with a loss of network port fault.

If the installed SFP device is different from what has been configured, the ECM850 logs a mismatch entry to its local log table. If possible, it also logs an informational fault to the associated RX3i controller's fault table. The module tries to configure and use the SFP if it is compatible (as listed in chapter 1). If the ECM850 detects an unsupported SFP type on powerup or when the SFP is inserted, the ECM850 adds an entry into its Local Log Table and the RX3i I/O Fault Table (if possible) and turns the associated port LED red.

2.7.4 Removing SFP Devices

Remove the cable from the SFP device. If the device has a latching mechanism such as a bale clasp, open it gently. Do not pull on the latching mechanism. Hold the sides of the SFP device and pull it out of the ECM850 port.

⚠ WARNING

If the surrounding air operating temperature of the ECM850 is greater than 40 °C, SFP devices could have operating temperatures over 70 °C (158 °F). Under these conditions, for your safety, do not use bare hands to remove an SFP device from the SFP cage. Use protective gloves or a tool (needle-nose pliers) to avoid handling the hot SFP device directly when removing the SFP device.

2.8 Powerup Indicator LED Patterns

At powerup, the indicator LEDs show the blink patterns described below. The LEDs also blink diagnostic patterns for certain operating errors and for module identification. See "Chapter 5:, Diagnostics" for a description of the blink patterns.

Step	LED/ Blink pattern	Description
1	All LEDs off	Normal operation, unpowered state
2	STATUS LED solid Green	Normal operation, power on
	OK LED blinks Amber with coded blink pattern	Fatal Initialization or Diagnostics Failure, H/W Module Identity Information not available
	OK, LAN, and STATUS LEDs blink green in unison (0.5 second ON/ 0.5 second OFF)	Invalid firmware detected. Module is waiting for firmware update. Blink pattern continues during firmware update.
3	LAN and STATUS LED solid Green	Normal operation
4	LAN LED solid Green	Normal operation
	LAN and STATUS LED blink Green (0.5 second ON and 0.5 second OFF)	Update of module firmware. After the automatic update completes, the LEDs blink Amber and the module resets, which restarts the powerup process.
5	OK LED blinks Green (0.5 second ON and 0.5 second OFF)	Module powerup completed, but communication not yet established over the RX3i backplane.
	OK LED solid Green	Normal operation. Powerup completed and backplane communications established.

Note: *Under certain ambient operating temperatures, the ECM850 may momentarily display the overtemperature pattern during power up, while it is calibrating its thermal protection functions. This indication may be ignored, and no overtemperature entry is added to the Local Log table, the Controller Fault table or I/O Fault table*

2.8.1 Detailed Indicator LED Descriptions

OK LED

The OK LED indicates whether the module is able to perform normal operation.

	Green, ON steady	OK
	Green, blink pattern	Fatal error. Flashes once between error codes blinked on the STATUS LED.
	OFF	Not OK

LAN LED

The LAN LED indicates access to and activity on the Ethernet network. The LAN LED indicates network packets are being processed by the network interface (not just passing through the embedded switch).

	Blinking ON	The module's network interface is active
	Blink pattern	Fatal error. Flashes once between error codes blinked on the STATUS LED

○	OFF	No network activity

STATUS LED

The STATUS LED indicates the condition of the ECM850 during normal operation. It indicates whether an entry other than the startup event is present in the module's local log. STATUS can also indicate whether any of the MAC addresses are invalid.

The STATUS LED state is reset when the local log is cleared. For more information see the Command Line Interface clear log command.

●	Green, ON	No new local log table entries
○	OFF	New local log table entry
◐	Green, blink pattern	Fatal error. Error codes are blinked on this LED
◐	Red, blinking	Invalid MAC address (all MAC addresses are validated; error indicates if any address is bad)

CONN LED

The CONN LED indicates whether the module has received its configuration from the RX3i CPU.

●	Green, ON	Configured
○	OFF	Not configured
◐	Green, blink pattern	Fatal error. Flashes once between error codes blinked on the STATUS LED

ACTIVE LED

The active LED indicates the status of IEC 61850 connections.

●	Green, ON	All configured IEC 61850 IEDs have established IEC 61850 connections
●	Amber, ON	At least one configured IEC 61850 IED has established a connection, but at least one configured IED is not connected
○	OFF	No configured IEDs have established connections to the ECM850, or hardware configuration is cleared.

USB LED

The USB LED indicates activity on the USB port.

◐	Green, Blinking	USB port activity
○	OFF	No USB port activity

Port LEDs

The ECM850 has four Port Indicator LEDs, 1, 2, 3, and 4 that indicate link speed, link connection and link activity corresponding to the four possible external Ethernet ports.

	Blue, ON	Link connected, 1000 Mbps
	Blue, blinking	Port active, 1000 Mbps
	Green, ON	Link connected, 100 Mbps
	Green, blinking	Port active, 100 Mbps
	Purple, ON	Link connected, 10 Mbps
	Purple, blinking	Port active, 10 Mbps
	Green, blink pattern	Fatal error. Flashes once between error codes blinked on the STATUS LED
	OFF	The associated Ethernet port is not connected to an active link
	Red, ON	Port 3 and port 4 only. Incompatible SFP plugged into port.

2.9 Installing the USB Port Driver

Set up use of the module's USB port in either of these ways:

1. Run the provided driver installation application before connecting the computer's USB port to the ECM850's USB port the first time.
2. With the provided installation files accessible on either a local or network drive, attach the computer's USB port to the ECM850's USB port.
    a. Windows opens a New Hardware Found Wizard dialog. Within the wizard application, enter the location of the provided installation files.
    b. Windows then installs the USB driver compatible with the USB port.

The computer automatically assigns a serial port name for the ECM850's USB port. A unique serial port number will be used for each ECM850. The serial port name is COM followed by the next available number from 1 to 256. After the computer assigns the module's USB port a COM port name, it uses the same name each time it connects to the module (except for a special case described below).

If the computer has already assigned all its available port names (COM1 through COM256), the next device to attach is assigned a previously-used COM Port name:

1. If the last assigned COM port name was COM256, the next COM port name assigned is the first unconnected COM port after the physical serial communications ports.
2. If the last assigned COM port name was not COM256, the next COM port name assigned is the first unconnected COM port in sequence.

After the initial installation process, the same computer can be attached to other ECM850s without additional installation steps. The virtual serial port name is automatically assigned when the device is attached to the computer.

2.10 Firmware Updates

The Winloader utility is used to update the firmware on an ECM850.

The current firmware version of the ECM850 may be obtained using either the Machine Edition programmer (Online Commands->Show Status->Details), or the module's Command Line Interface node command.

Connect Winloader to the RX3i CPU's serial port and specify the desired target module by its Rack/Slot location. The CPU must be placed in STOP/OUTPUTS DISABLED mode to update module firmware. The Winloader utility displays the update completion status as the update progresses. When the update has completed, the ECM850 will restart, completing the update and activating the updated firmware.

2.11 Time Synchronization with the RX3i CPU

The internal clock value of an ECM850 is displayed in Command Line Interface commands, and it is used to timestamp entries in the ECM850 Local Fault Log as they occur.

The ECM850's internal clock is synchronized with the RX3i CPU clock whenever the ECM850 is:

- powered up, or
- hot-inserted, or
- reset with the Reset pushbutton or on command from the Command Line Interface.

Storing hardware configuration to the ECM850 does not cause clock synchronization.

If the CPU's time is changed after the ECM850 synchronizes its own internal clock, the ECM850's internal clock is not automatically synchronized until the ECM850 is again powered up, hot-inserted, or reset.

The ECM850's internal clock may be set from the Command Line Interface at any time, using the time command.

Chapter 3: Configuration

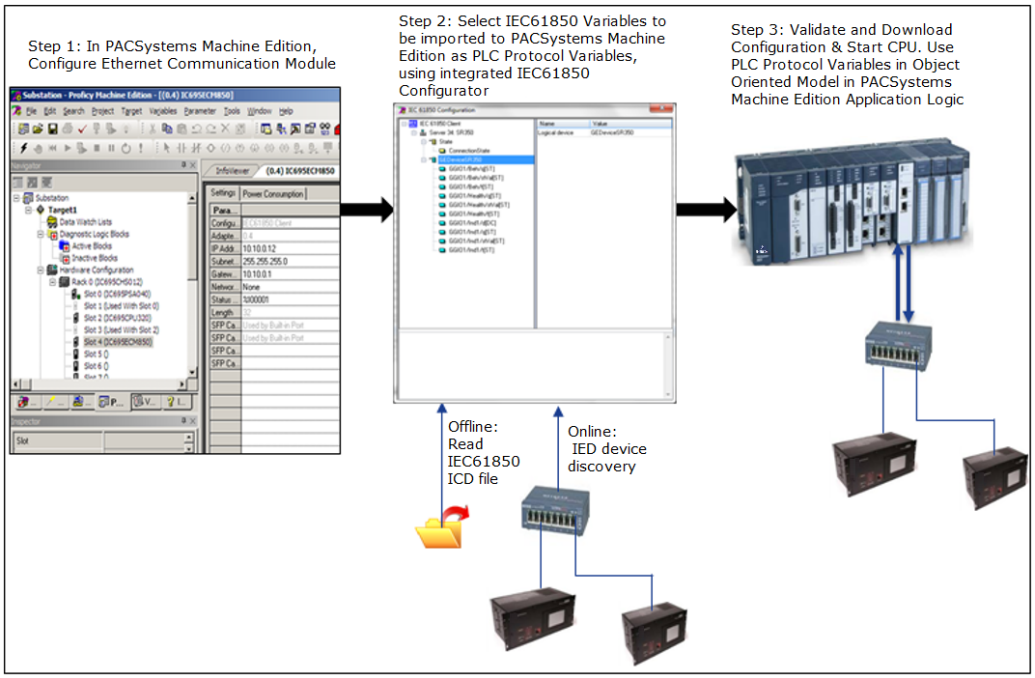
This chapter explains procedure to configure an ECM850 with IEC 61850 client system, and also explains how to add IEDs and select PPVs for monitoring and control in RX3i controller applications.

3.1 Configuration Overview

The Machine Edition programmer is used to create and download the configuration for an RX3i IEC 61850 network and its devices.

The illustration below shows a simplified view of user level configuration approach for an ECM850.

Figure 17



3.2 Configuration Tools

Machine Edition is the primary tool used to configure the ECM850. Machine Edition has an integrated “IEC 61850 Configurator”, which supports the configuration of IEDs. This tool also allows browsing of the devices’ IEC 61850 object data model for selecting PPVs.

In addition, certain parameters can be set from a computer through the ECM850’s Command Line Interface. The Command Line Interface can be used to set the ECM850’s non-volatile parameters, which are listed below. These parameters are initially set up in the Machine Edition configuration. If any of these parameters is subsequently changed from the Command Line Interface, the module uses the new setting. Regardless of their source, the module retains these non-volatile parameter settings over power cycles.

3.2.1 Non-Volatile Configuration Parameters

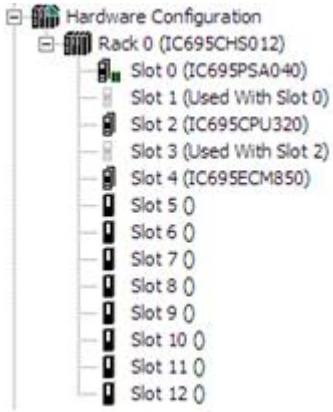
Parameter	Default Value
IP Address	0.0.0.0
Subnet Mask	0.0.0.0
Default Gateway	0.0.0.0
Device Name	ecm

3.3 Basic Configuration Steps

3.3.1 Add one or more ECM850s

1. In the Project tab of the Navigator, expand the Hardware Configuration and the main rack.
2. Right-click the slot in which you want to add the ECM850 and choose Add Module.
3. In the Catalog dialog box that appears, select the Communications tab.
4. Select IC695ECM850 - RX3i IEC 61850 Ethernet Communication Module and click OK.
5. The ECM850 is placed in the rack and its parameters are displayed in the Parameter Editor window. Its communications properties appear in the Inspector pane. Edit the ECM850's parameters and its communications properties as described in next steps.

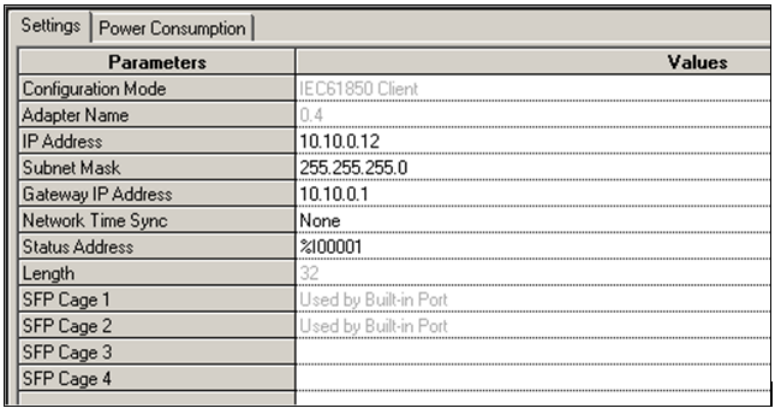
Figure 18



3.3.2 Configure each ECM850 Parameters (Settings Tab)

Edit ECM850 parameters in the Settings Tab as appropriate.

Figure 19



The parameters are described below:

IP Address

ECM850's IP address. Default is 0.0.0.0

⚠CAUTION

If the IP Address is set such that its domain is different that the IP addresses of the IEDs (as set in "IEC 61850 Configurator"), then module will be unable to communicate on the network and might disrupt network communications. Contact your network administrator to assign values that work with an existing network.

Subnet Mask

The Subnet Mask filters network communications so that they are routed only to subnets to which they are addressed. The value defined here propagates through the ECM850 to IEDs throughout the network.

⚠CAUTION

If the subnet mask is improperly set, devices may be unable to communicate on the network and might disrupt network communications. Contact your network administrator to assign values that work with an existing network.

The ECM850 can only communicate to nodes in the local subnet. All nodes on the IEC 61850 LAN must be in the same subnet.

Gateway IP Address

The Gateway IP address of the ECM850 is configured using this parameter. This is the IP Address of a device that connects two (sub) networks that can use different communications protocols, enabling them to communicate with each other. The value defined here propagates to the ECM850 and IEDs throughout the IEC 61850 network.

⚠CAUTION

If the gateway is improperly set, devices may be unable to communicate on the network, disrupting network communications. Contact your network administrator to assign values that work with an existing network.

Network Time Synch

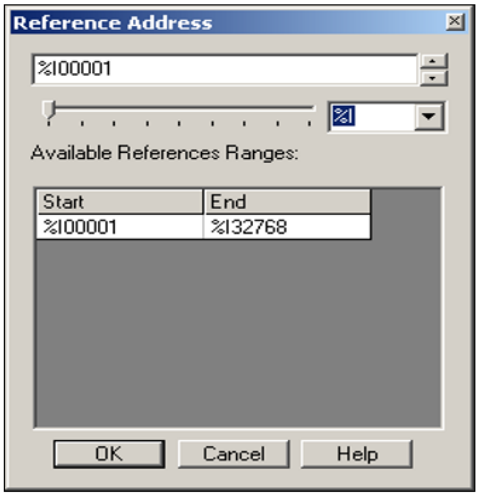
Network Time Synchronization mode which user can select. The current option provides two selections: “None” and “SNTP”. If the user selects SNTP, the ECM850 acts as an SNTP client.

Status Address, Length

This is Status Address is the reference memory location for the ECM850’s 32 bits of status data. The Status address can be assigned to valid %I, %Q, %R, %AI, %AQ, %W, %G, %T or %M memory by right-clicking on the Status Address field and selecting the Data Entry tool. The default value is the next available %I address. See Chapter 5:, Diagnostics, for definitions of the status bits that the module writes to this address.

Note	*Because point faults are not supported with %G, %T and %M, the other memory types or I/O Symbolics are preferred.*

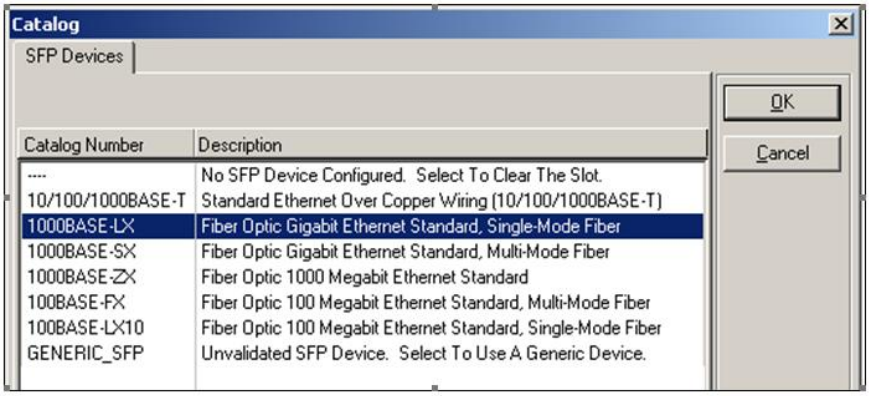
Figure 20



SFP Cage 1 / 2 / 3 / 4

If the module will use plug–in Small Form-factor Pluggable devices as ports 3 and/or 4, specify the SFP devices in the appropriate field(s). On the Settings tab, right-click in the Values field for the port, and select Data Entry Tool to open the Catalog window. In the Catalog window, select the type of SFP device for the port, like the example shown below, and click OK. If the device is not listed, choose GENERIC_SFP to add it to the configuration.

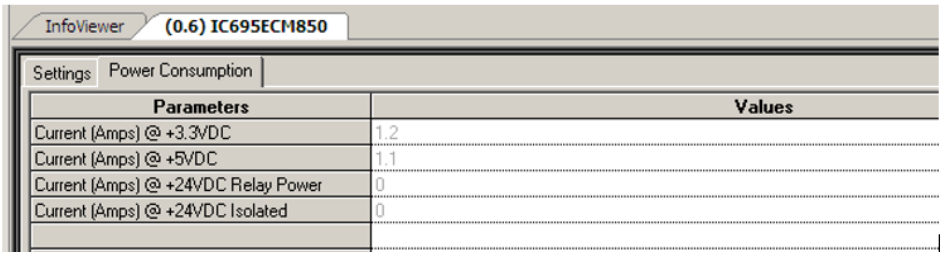
Figure 21



ECM850 (Power Consumption Tab)

The Power consumption tab provides details of the power consumption of the ECM850.

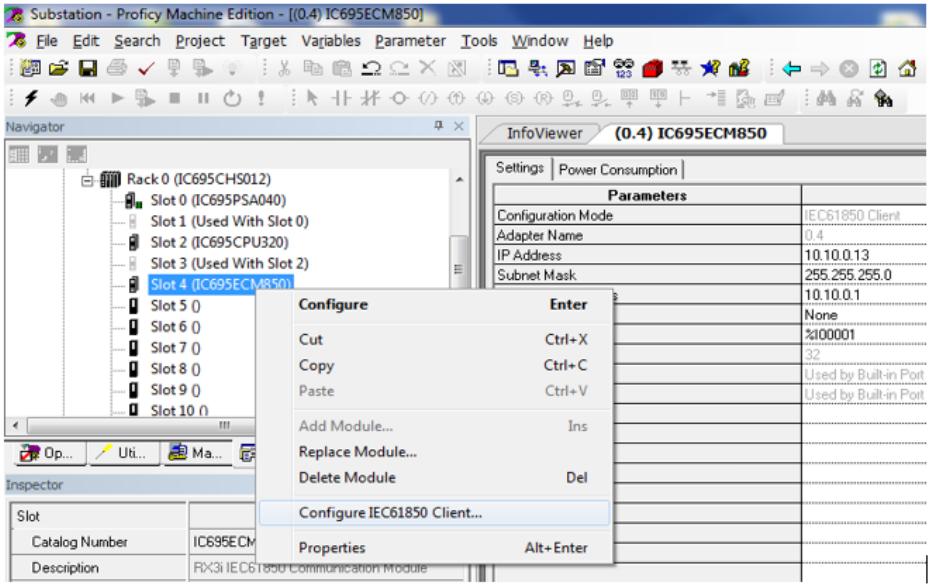
Figure 22



3.3.3 Open IEC 61850 Configurator for each ECM850

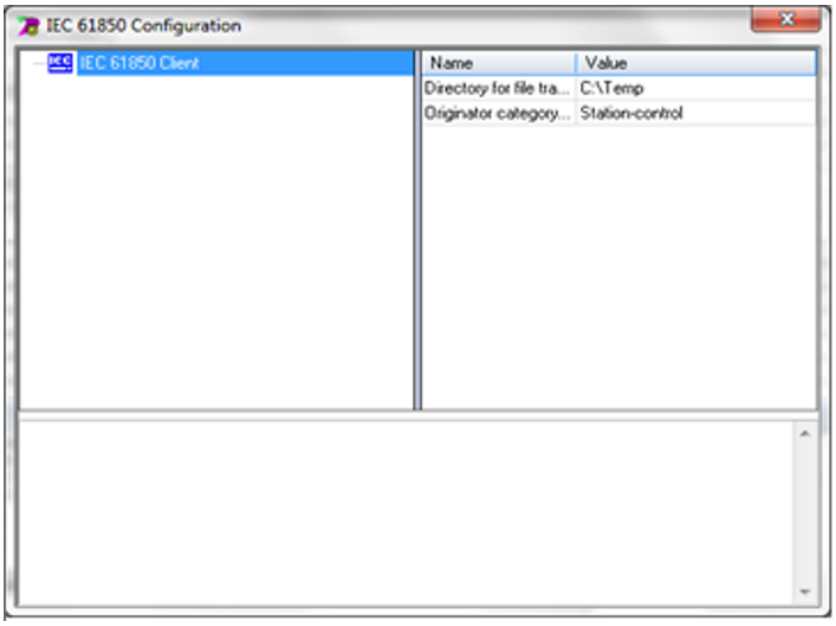
1. Right click on ECM850 in which you want to configure IEC 61850 Client system and choose Configure IEC 61850 Client.

Figure 23



2. This opens a model dialogue as an Integrated “IEC 61850 Configurator”, which provides the required user interface for protocol specific configuration of IEC 61850 Client.

Figure 24

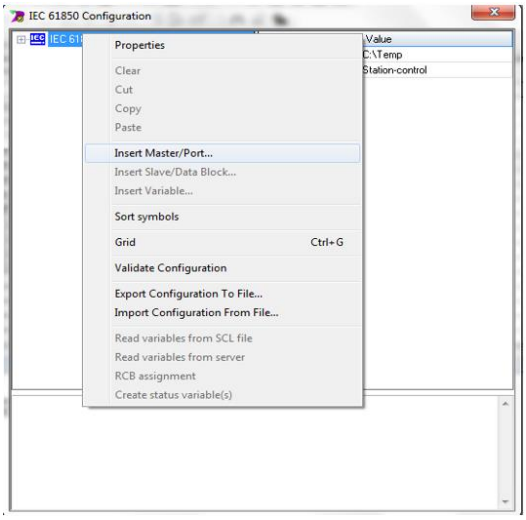


Note *The “IEC 61850 Configurator” cannot be opened when Machine Edition is online with the RX3i controller.*

3.3.4 Add IEDs to each ECM850

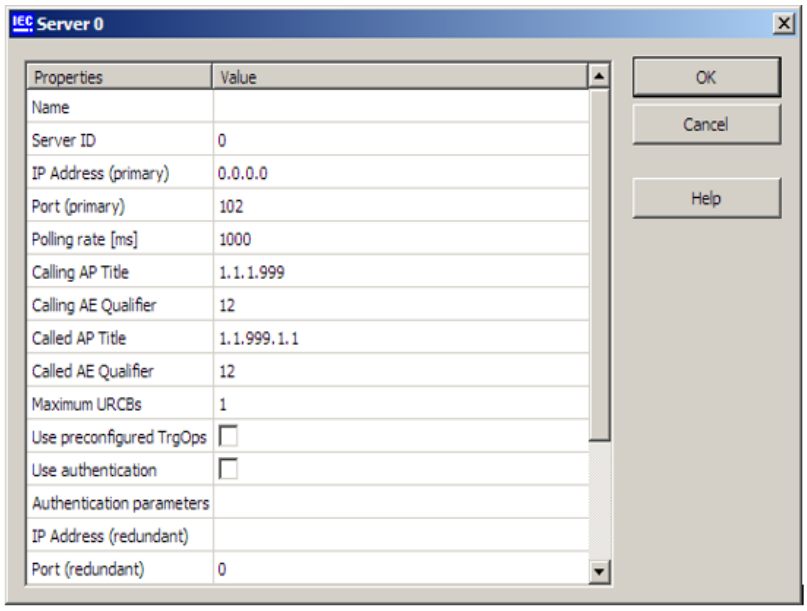
1. In the IEC 61850 Configurator window that appears, right click on **IEC 61850 Client** and choose **Insert Master/port**.

Figure 25



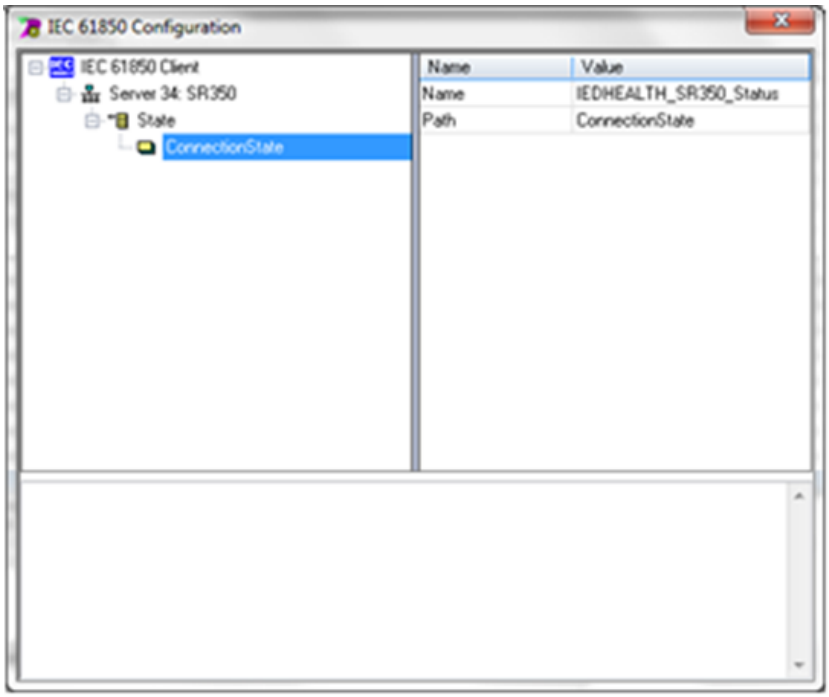
2. In the Server dialogue box that appears, add **Name** and **IP Address (primary)** of the IED and click **OK**.

Figure 26



3. The new server device will appear under **IEC 61850 Client**.

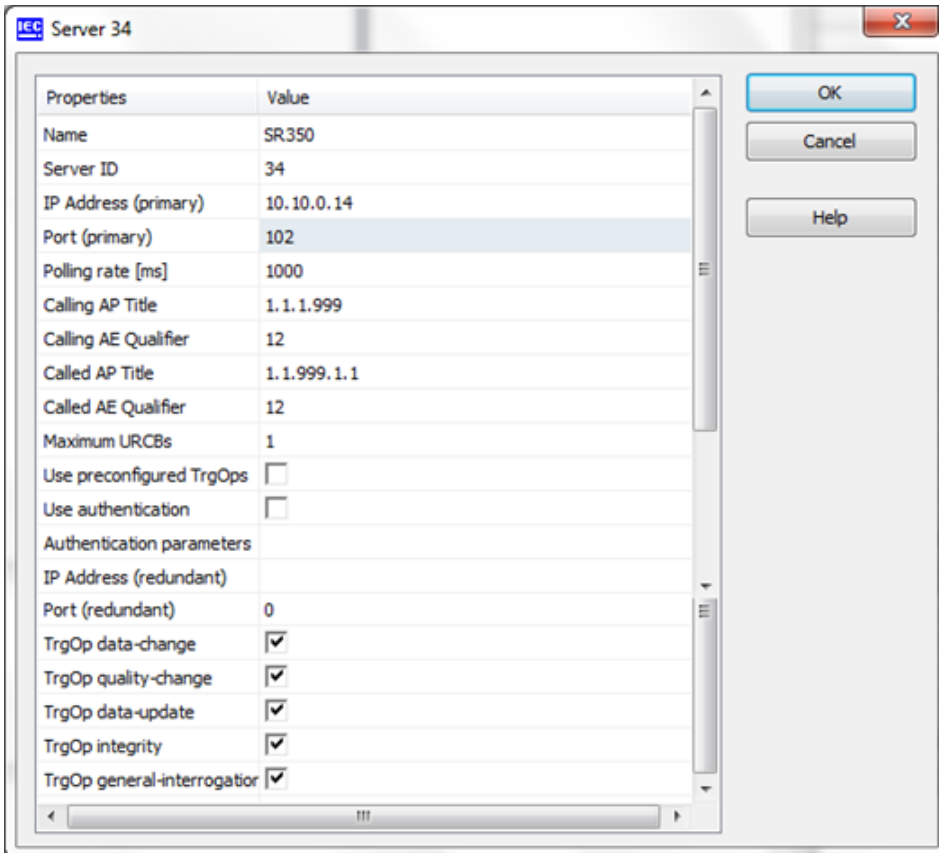
Figure 27



3.3.5 Configure each IED parameters

1. Select Server device in the IEC 61850 Configurator, to get the server device parameters in right window pane.
2. Under right window pane, configure Server device parameters as per definitions given below.

Figure 28



Name

This is identification name for IED.

Server ID

This is a unique Identification number for the IED. The default value is 0.

IP Address (primary)

This is primary IP address of IED. Default is 0.0.0.0

Port (primary)

This is the primary port number of the IED on which the connection needs to be established. Default is 102.

Polling rate [ms]

This is defined as update rate for every connection in milliseconds, with a range of 0 to 31267. The default value is 1000 (= 1 second).

Calling AP Title

This setting is according to ISO 8650-1(ACSE) and should not be used in standard cases. The default value is 1.1.1.999

Calling AE Qualifier

This setting is according to ISO 8650-1(ACSE) and should not be used in standard cases. The default value is 12

Called AP Title

This setting is according to ISO 8650-1(ACSE) and should not be used in standard cases. The default value is 1.1.999.1.1

Called AE Qualifier

This setting is according to ISO 8650-1(ACSE) and should not be used in standard cases. The default value is 12.

Maximum URCBs

The maximum number of Un-buffered Report Control Blocks (URCBs) that you can activate. The URCBs are accessed in an order related to their importance and are analyzed for the variables in that URCB. The more variables related to a URCB that are used, the higher the priority for accessing this URCB. If you need to configure a specific URCB instead of relying on this parameter, then you can select the specific URCB using the "RCB configuration". For more information, see section 3.4.2,

Configuring URCBs – Direct **Method**. The default value is 1.

Use Preconfigured TrgOps

If this option is enabled, then the "Trigger options" as set by the IED are used by ECM850 client. Otherwise the specific trigger option values defined in the ECM850 configuration are used. This is set to disabled by default. For more information refer to Trigger **Options**.

Use Authentication

This is used to enable the authentication of IED. The default value is disabled.

Authentication parameters

This is authentication parameters set for the IED, which will be validated if authentication is enabled. The default value is not set.

IP Address (redundant)

This is a redundant IP address of the IED that you can set. Default is not set.

Note	*If the IED supports a redundant IP feature and provides a redundant IP address which will be activated on failure of the primary IP, then the ECM850 will automatically connect to the redundant IP address on primary IP address failure.*

Port (redundant)

This is a redundant port number for the IED that you can set. Default is 0.

Note	*If the IED supports redundant port feature and provides a redundant port number which will be activated on failure of primary port, then the ECM850 will automatically connect to the redundant IP port number on primary port failure.*

Trigger Options

In a Report Control Block (RCB), the data are pushed by the server on a trigger. The trigger support several options:

- **TrgOp data-change**

  The enabling of this option will ensure that data will be available on Data value change.

- **TrgOp quality-change**

  The enabling of this option will ensure that data will be available Quality change.

- **TrgOp data-update**

  The enabling of this option will ensure that data will be available only on Timestamp change.

- **TrgOp integrity**

  The enabling of this option will ensure that data will be available on integrity poll as defined in “bufTm” in respective RCB.

- **TrgOp general-interrogation**

  The enabling of this option will enable general interrogation on request by the client (GI).

3.3.6 Read Variables of Each IED

Use either of the two options below to read variables of each IED.

a. Offline configuration:

b.

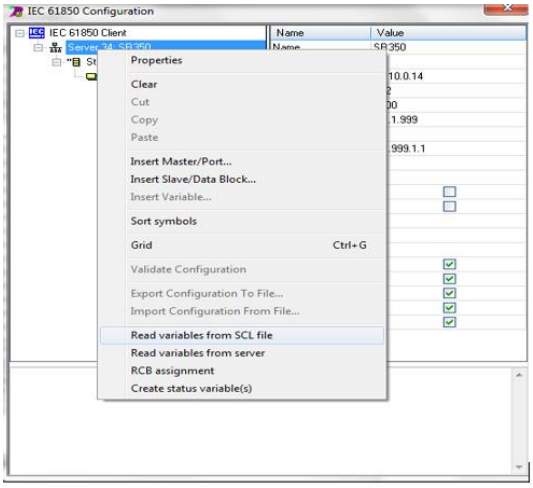
c. Read variables from SCL file for **each IED**

d. Online configuration: Read variables from server for each IED

Read variables from SCL file for each IED

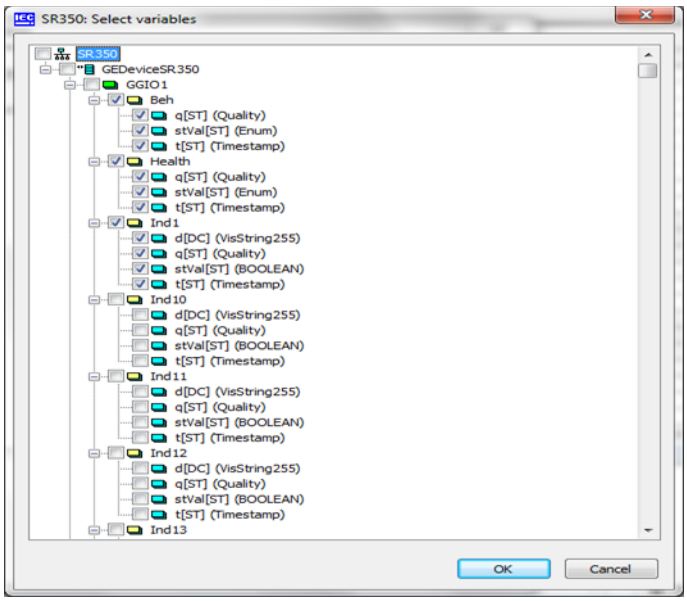
1. Right click on Server device in the IEC 61850 Configurator and choose **Read variables from SCL file.**

Figure 29



2. In the Open dialogue box that appears, browse and select SCL (.icd or .cid) file for the Server device and click Open.
3. In the dialogue box that appears <server name>: Select variables, displays IEC 61850 data model for the IED.

Figure 30

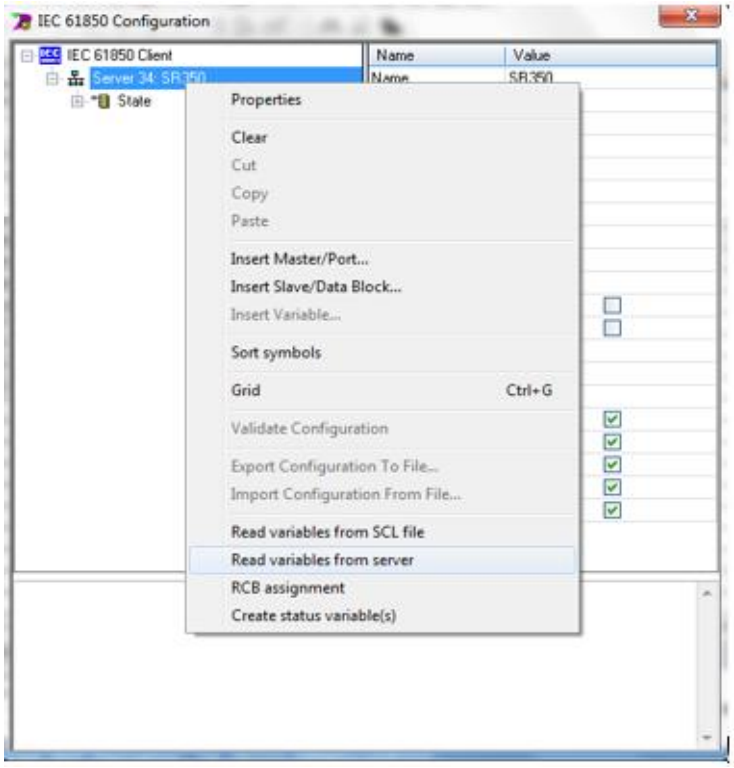


Note *The IEC 61850 protocol specifies the configuration file schema for an "SCL" file, which is used for IED description.*

Read variables from server for each IED

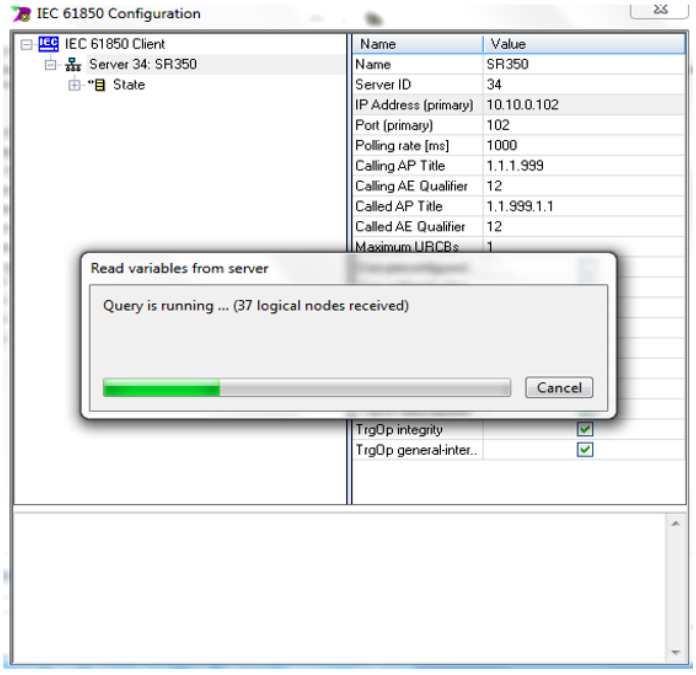
1. Right click on Server device in the IEC 61850 Configurator and choose **Read variables from server.**

Figure 31



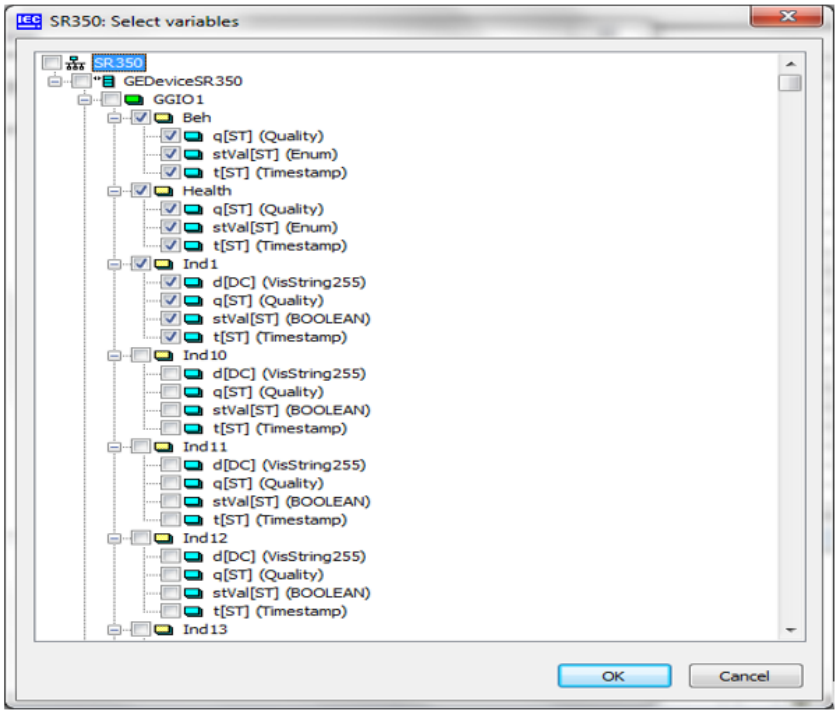
2. A pop up **Read variables from server** appears, showing **Query is running... (x logical nodes received)**. Click **Cancel** to cancel this operation.

Figure 32



3. In the dialogue box that appears, **<server name>: Select variables** displays the IEC 61850 data model for the IED.

Figure 33

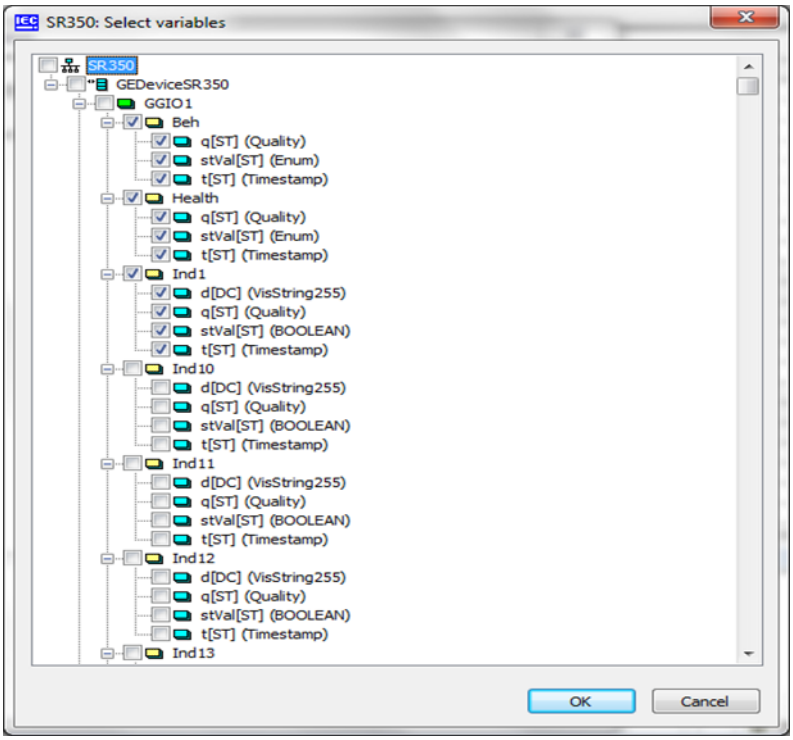


Note	*Be sure to set the IP Address of the IED correctly and ensure that Machine Edition is connected over the network*

3.3.7 Select Variables for Each IED

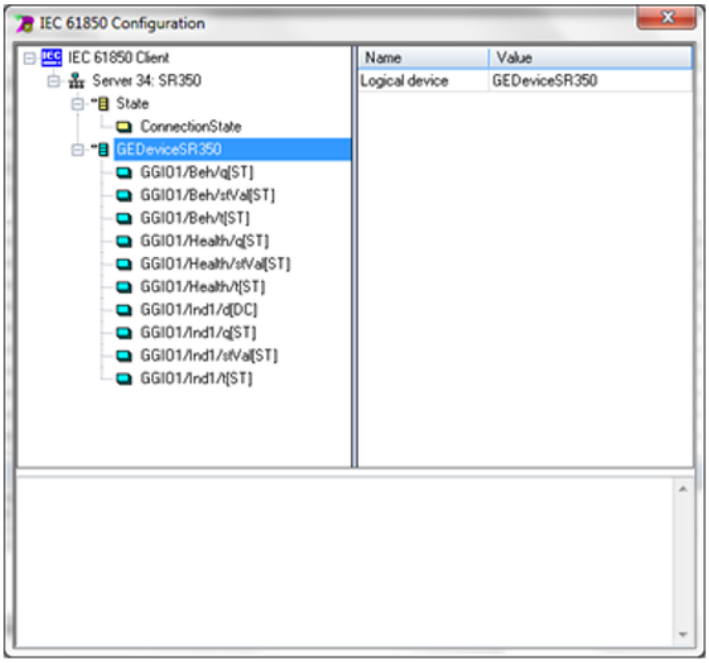
1. In the dialogue box that appears, **<server name>: Select variables** allows selection of variables by means of check boxes.

Figure 34



2. Click **OK**, to import selected variables under Server device or click **Cancel** to cancel import of variables.

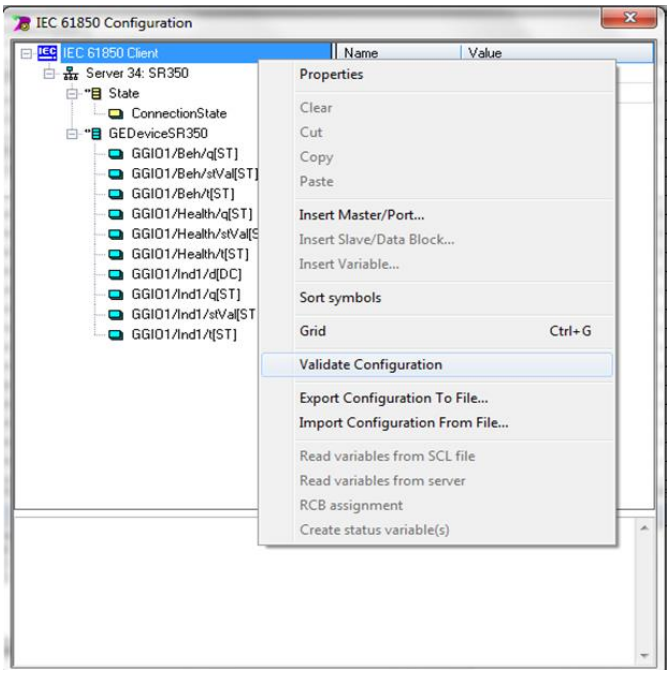
Figure 35



3.3.8 Validate Configuration of IEC 61850 Client for each ECM850

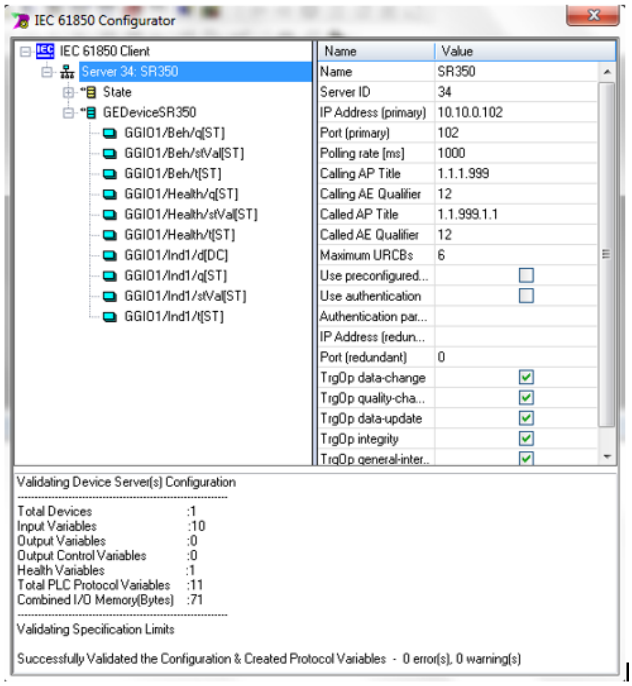
1. In the IEC 61850 Configurator window, right click on **IEC 61850 Client** and choose **Validate Configuration**.

Figure 36



2. In the bottom pane messages appear, indicating results of validation. The messages provide details of variable configuration information as defined below.

Figure 37



Total Devices

The total number of IEC 61850 Server devices (IEDs) added to the configuration.

Input Variables

The total number of attributes which are of Input type. These are attributes which are "Read only" from the device. Variables with functional constraints [ST], like stVal, q, t etc., are examples of such variable.

Output Variables

The total number of Output type attributes. These are attributes which can be written to the device. The examples of such variables with functional constraints [CF]/[CO] etc.

Output Control Variables

The total number of control variables required for performing the "Write" operation from the RX3i controller to the device. Each "writeable" attribute in IEC 61850 is associated with a set of control variables, based on the operation.

Health Variables

The total number of IED status variables. These variables are "Read only" and provide connection status of the IED.

Total PLC Protocol Variables (PPVs)

The total number of PPVs generated for the configuration.

Total PPVs = Input Variables + Output Variables + Output Control variables + Health variables.

For more information on PPVs, refer to section 4.4.1 PPV Description.

Combined I/O Memory (Bytes)

The total I/O memory consumed in bytes for IEC 61850 configuration of ECM850.

Validation messages

On successful validation, the message "**Successfully Validated the Configuration**..." appears. If the validation fails, the message "**Validation & Protocol Variable Creation Aborted...**" appears.

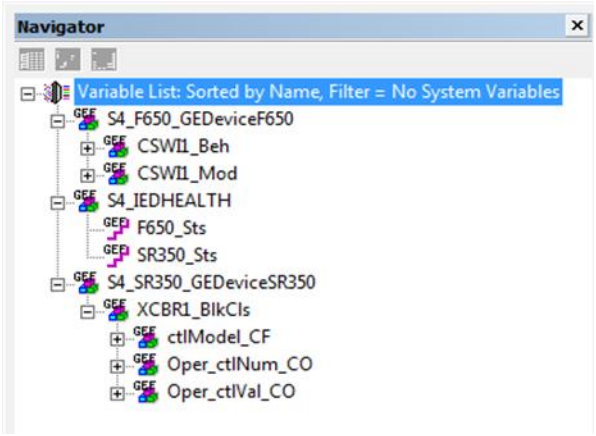
The messages provide details of configuration errors or warnings. You need to remove the error conditions, before you can proceed. However, you can proceed further with configuration, if your configuration has warnings.

Note*:** *Some configuration error handling scenarios are described in* ***section 3.6 IEC 61850 Configurator - Scenarios and Techniques*. Some error handling scenarios are described in* ***section 3.6.4 IEC 61850 Configurator Error Handling***

3.3.9 Generate PLC Protocol Variables (PPVs) for each ECM850

1. In the IEC 61850 Configurator window, click on cross button **X** to close the Configurator.
2. A pop up showing a message "**Creating ECM module Protocol variables…**" appears, showing that PPVs are being generated in the project for the ECM850.
3. Check for PPVs under the Variable List page.

Figure 38



3.3.10 Validate configuration

1. In the Machine edition, click on the **Target** menu and select **Validate "<Target name>"**
2. Look in the **Feedback zone** for validation messages to see if the validation succeeded.

3.3.11 Download configuration

1. Connect to RX3i controller using Serial or Ethernet connection and go online with the target.
2. In Machine Edition, click on the **Target** menu and select **Download and start "<Target name>"**
3. See the **Feedback zone**, for messages
4. See the Controller and I/O fault tables for any faults.

If the configuration is stored to non-volatile memory or is battery-backed, the CPU maintains configuration data through power cycles.

- The RX3i CPU transfers configuration data to the ECM850 over the backplane.
- After successfully processing and applying its configuration data, the ECM850 turns on its CONN LED.
- The ECM850 then connects with IED over the IEC 61850 network and starts exchanging data as per the configuration.

If the ECM850 cannot connect to an IED, the ECM850 logs a Loss of Device fault in its local log table and provides the information to the RX3i CPU controller fault tables. The ECM850 periodically attempts to establish communications with IED. When one of these subsequent connect/configuration attempts is successful, the ECM850 logs an Addition of Device fault for that IED in its local log table and provides the information to the RX3i CPU controller fault tables.

Note: *It may take up to 5–30 seconds for the ECM850 to establish a connection to an IED, including one that previously existed, but was lost.*

Clearing the RX3i CPU Configuration

If the programmer clears the configuration for an RX3i CPU containing a ECM850, the ECM850 clears its configuration (excluding non-volatile parameters, which are retained), closes all opened IED connections, and turns OFF its CONN LED.

3.4 Advanced Configuration for IEC 61850 Client

Several advanced configuration topics for the IEC 61850 Client are described in this section: report control blocks for buffered and un-buffered reports, plus the configuration of the Client's Originator Category.

3.4.1 Report Control Block (RCB) overview

The IEC 61850 Client gets the data from the server device using polling technique by default. The definition of RCB control block optimizes the communication by using an event-based communication. This functionality is for supporting – "Unsolicited" communication or "Report by Exception" mechanism of updating data for IED variables.

URCB (Un-buffered Report Control Blocks)

An Un-buffered Report Control Block (URCB) is associated with a DATA-SET. URCB data is sent immediately to the connected IEC-61850 Client. If the transport data flow is not fast enough to support the movement of this data, some may be lost. The IED can have multiple instances of the URCB data and manages the separation of the instances to the IEC-61850 Clients.

a. The un-buffered reports are sent to the client and destroyed immediately by the server after sending without any acknowledgment.

b. The server sends a block immediately after value or quality change.

BRCB (Buffered Report Control Blocks)

A Buffered Report Control Block (BRCB) is associated with a DATASET. BRCB data is queued up, or buffered, in the IED and sent sequentially to the ECM850 client. The size of the buffer is defined by the IED. A BRCB is used so that data will not be lost due to communication control or loss of connection. There are procedures required around the reporting, and the IED may only report to one client.

a. The BRCBs are sent to the client till the reception of an acknowledgment from the client.

b. They are re-sent as long as the client accepts them.

c. They are stored (up to the specified limit for each server) in case communication between server and client fails.

d. The client asks for buffered reports only if it detects a connection failure or lost report, otherwise the BRCBs act like URCBs and the server sends a block immediately after a value or quality change.

Trigger options

a. In an RCB, the data are pushed by the server on a trigger. The trigger supports several options:

   1. TrgOps data-change: Data value change
   2. TrgOps quality-change: Quality change
   3. TrgOps data-update: Timestamp change
   4. TrgOps Integrity: Minimum every bufTm (bufTm is define in the RCB)
   5. TrgOps general-interrogation: On request by the client (GI)

b. These options are set by the server, if the “Use preconfigured TrgOps” in “IEC 61850 Configurator” is set. Otherwise the defined values in the client configuration are used. For more information refer to **section 3.3.5 Use Preconfigured TrgOps**

3.4.2 Configuring URCBs

You can use either or both of the options below for configuring URCBs in the ECM850:

a. Configuring URCB - Indirect Method : Refer Configuring URCB - Indirect Method

b. Configuring URCB – Direct Method : Refer

c. Configuring URCBs – Direct **Method**

Configuring URCB - Indirect Method

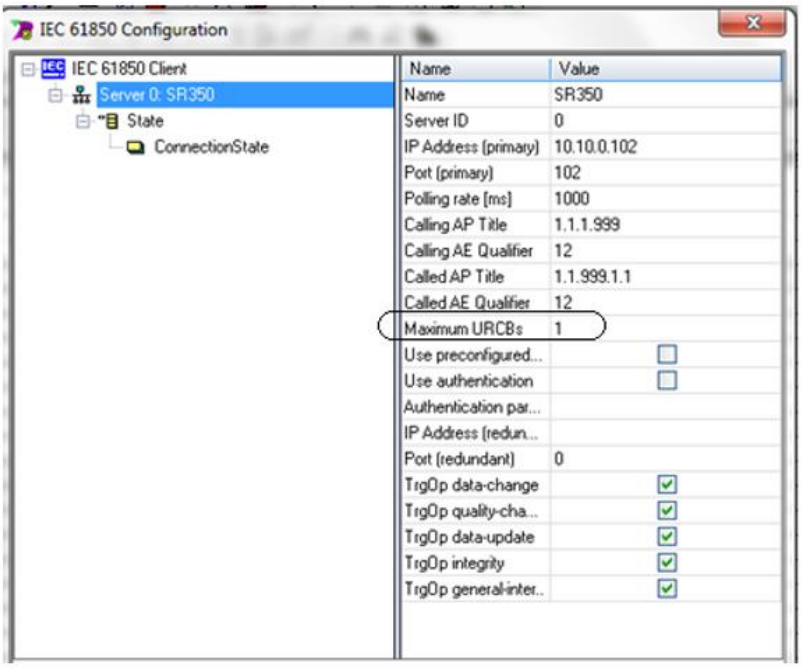
The RCB assignment can be done automatically by the IEC 61850 client driver in ECM850; in that case the maximum of URCBs can be set in the configuration for each IED.

The URCBs are accessed in an order related to their importance. the more variables related to a URCB that are used, the higher the priority for accessing the URCB.

The ECM850 browses all URCBs and their corresponding DATASETs. The driver will prioritize connections to the URCBs that contain the most data to be read by the client. Other data will be read by polling according to the Polling time configured.

Refer to the screenshot below and check the server parameter – **Maximum URCBs**. This value can be increased for this feature. However, this is an indirect way of handling reports.

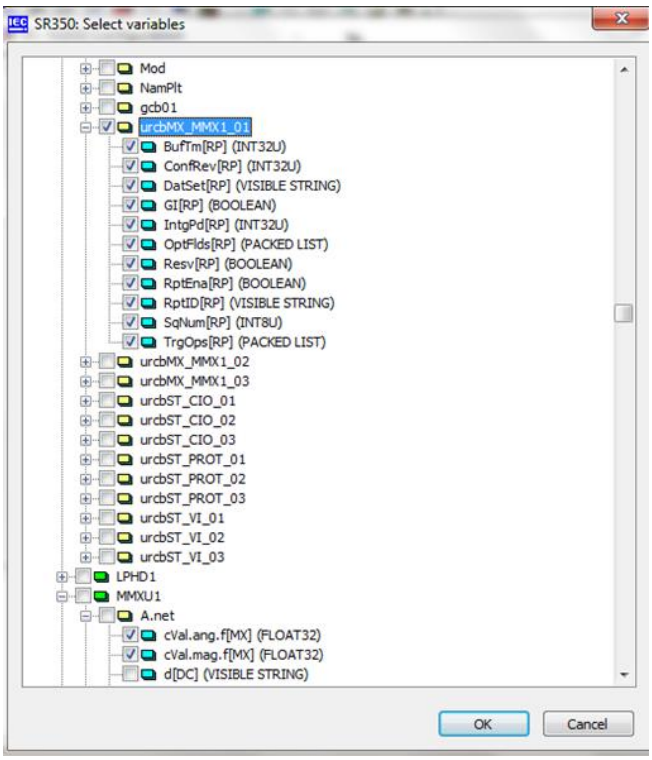
Figure 39



Configuring URCBs – Direct Method

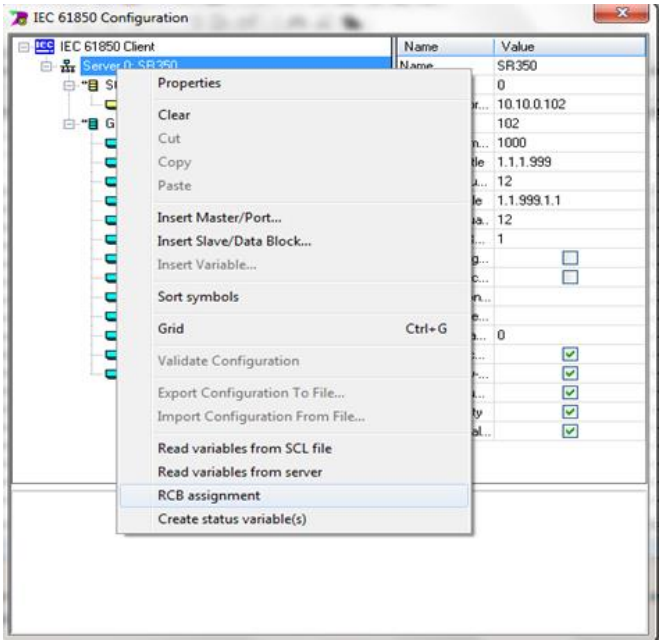
1. Add IED.
2. Read variables from the server, select IEC 61850 variables of required RCB - Logical Node: **LLN0** and Data Object: **<report name><report number>.**

Figure 40



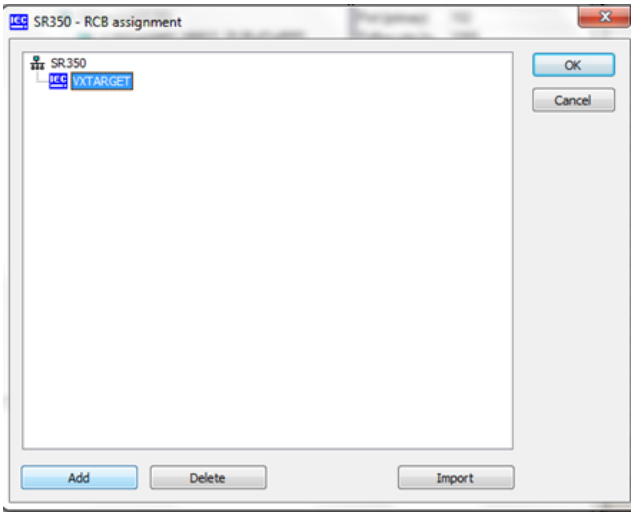
3. Right click on the server device in the IEC 61850 Configurator and choose **RCB Assignment.**

Figure 41



4. In the dialogue box that appears **<server name> RCB Assignment**, click **Add** and name the IEC target as “VXTARGET”.

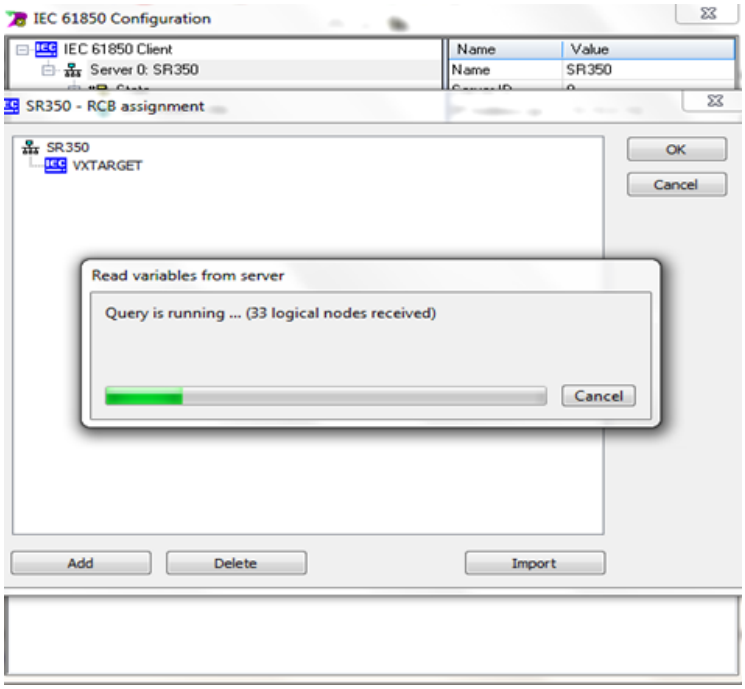
Figure 42



5. In the dialogue box **<server name> RCB Assignment**, Click **Import** to get the reports from the IEC 61850 Server device.
6. pop up **Read variables from server** appears, showing **Query is running ... (x logical nodes received)**. Click **Cancel** to cancel this operation.

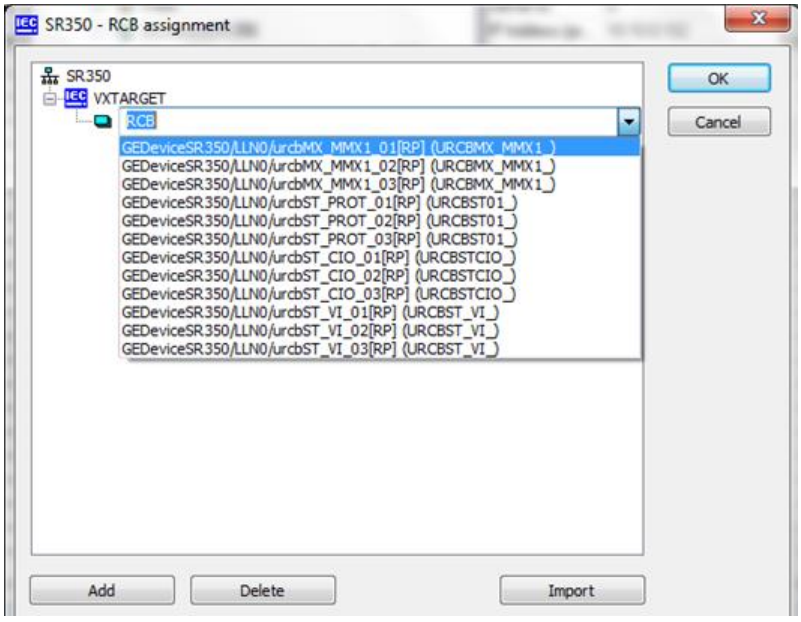
7.

Figure 43



8. In the dialogue box **<server name> RCB Assignment**, Click Add and select the required **Report [<server name>/LLN0/<report name><report number>[RP]<report name>]** from the drop-down menu.

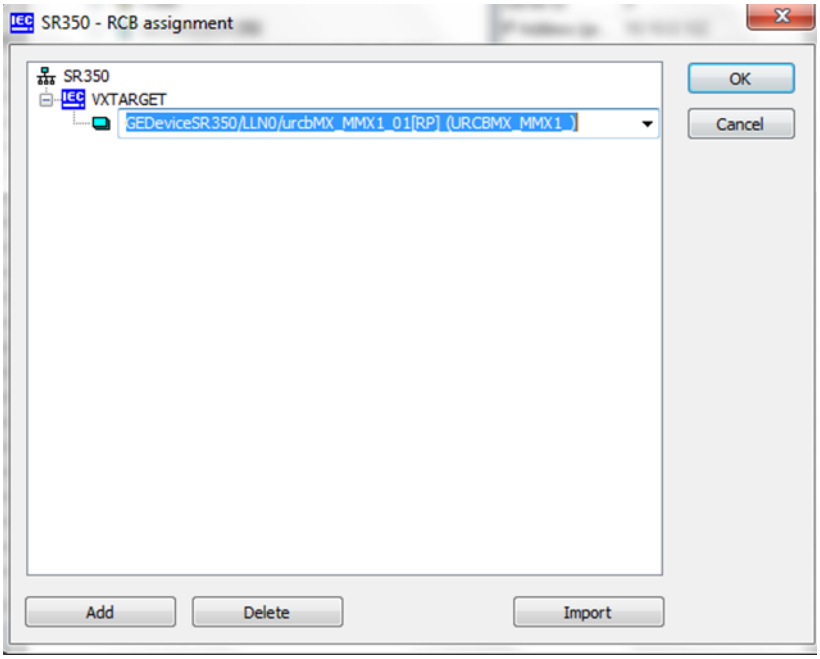
Figure 44



9. Click **Add** to add multiple reports.

10.

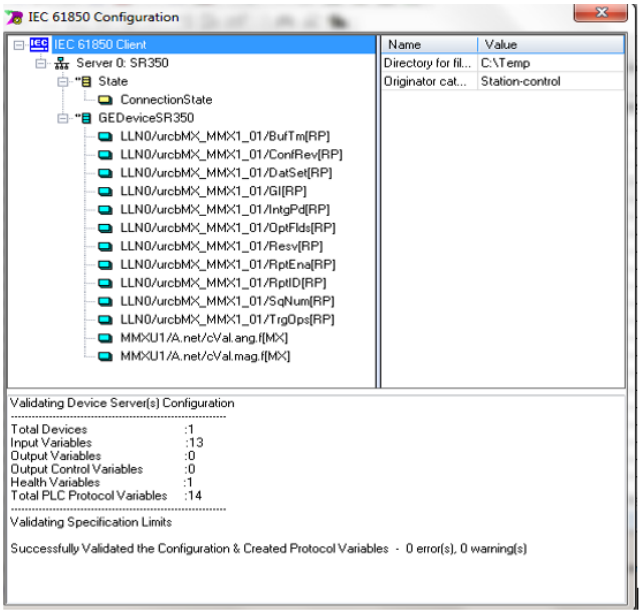
Figure 45



11. In the dialogue box **<server name> RCB Assignment**, click **OK** to close.

12. In the IEC 61850 Configurator window, right click on **IEC 61850** Client and choose **Validate Configuration**. If there are no errors, you can proceed to the next step.

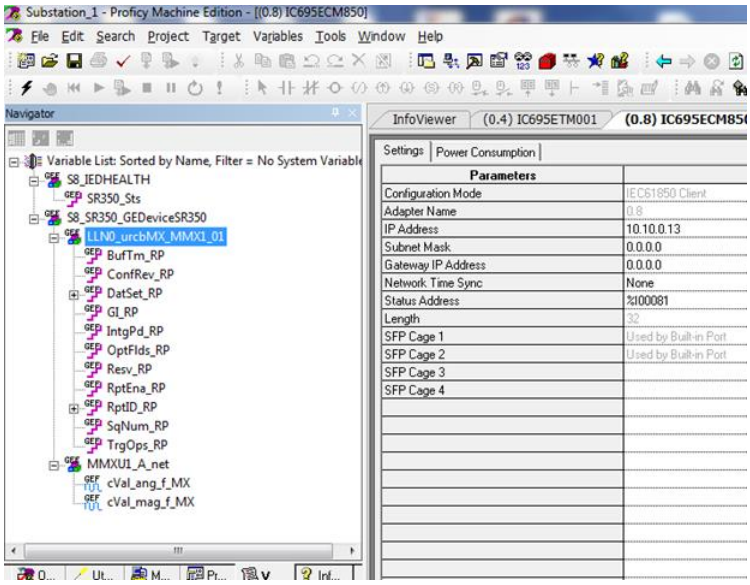
Figure 46



Note: *Set the IP Address of IEC 61850 Server device correctly and ensure that machine edition is connected to the Server device over network.*

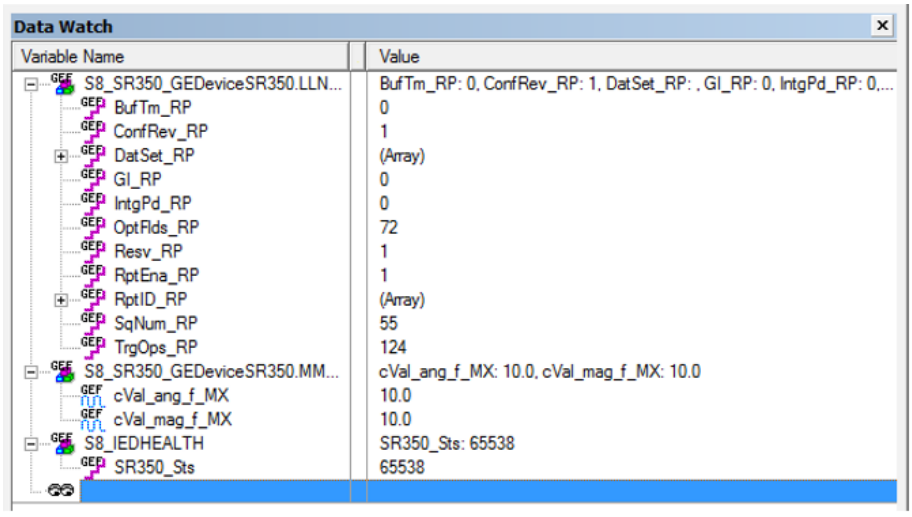
13. In the dialogue box **<server name> RCB Assignment**, click **OK** to close. On closure of the IEC 61850 Configurator, required PPVs are generated automatically in the project. This is shown in the screenshot below, where report-related parameters are shown as variables. It also includes the normal DO/DA variables, which are part of the report.

Figure 47



14. In the dialogue box **<server name> RCB Assignment**, click **OK** to close. The configuration can be downloaded to the RX3i Controller and the controller can be put in RUN mode. Reports get enabled (see RptEna_RP = 1), if the configuration is valid. The DO/DA data in the report gets updated based don the trigger options as set in the client configuration.

Figure 48



Reports-related Parameters for URCB

The important report related parameters available as PPVs are defined below:

BufTm_RP Buffer time parameter for the report.

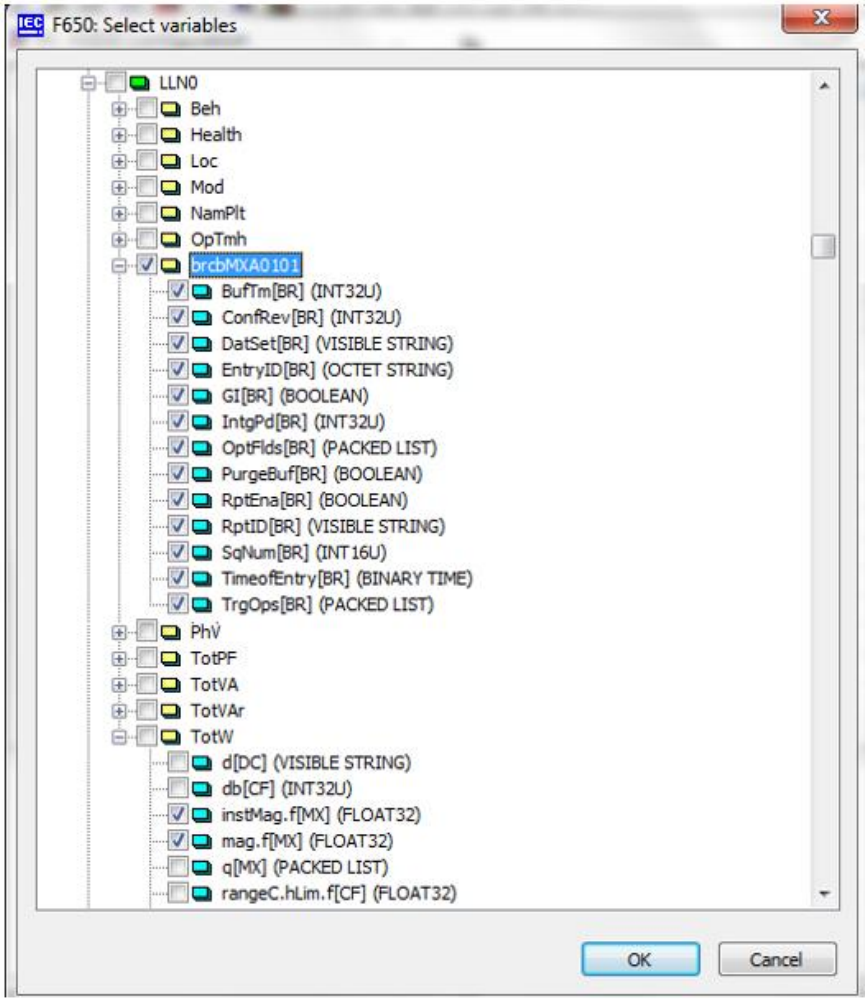
ConfRev_RP	Configuration revision parameter for the report.
Dataset_RP	Dataset, as a string data array type with a limit of 32 elements.
GI_RP	General Interrogation" parameter for the report.
IntgPd_RP	Integrity period shows the time period for the "Integrity poll" of data objects.
OptFlds_RP	Optional fields, per the IEC 61850 specifications on which the report is functioning.
Resv_RP	Reserved parameters for the report.
RptEna_RP	Report Enabled Flag, set to "1" if the report is enabled and is operational.
SqNum_RP	Sequence number for the report, updated on every report received.
TrgOps_RP	Trigger options, per the IEC 61850 specifications on which the report is functioning

3.4.3 Configuring BRCBs

You can right click on the server and “RCB assignment” for configuring a Buffered RCB or statically assigned RCB. You can directly import from a server or enter the name of the RCB in appropriate format. It is recommended that you connect to the IED and browse through the reports available to ensure that reports are subscribed by the client correctly.

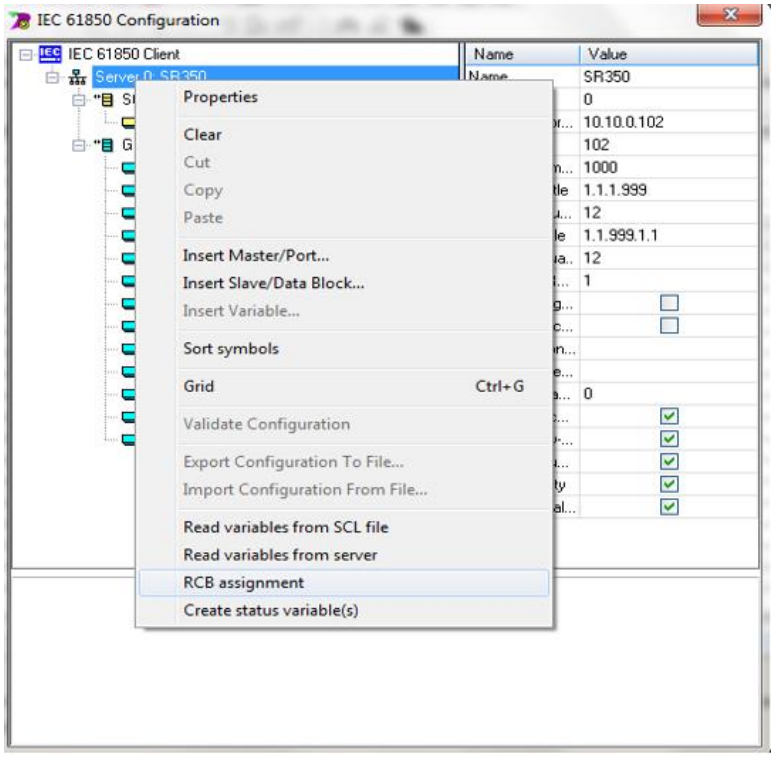
1. Add IED.
2. Read variables from server, select IEC 61850 variables of required RCB - Logical Node: **LLN0** and Data Object: **<report name><report number>**.

Figure 49



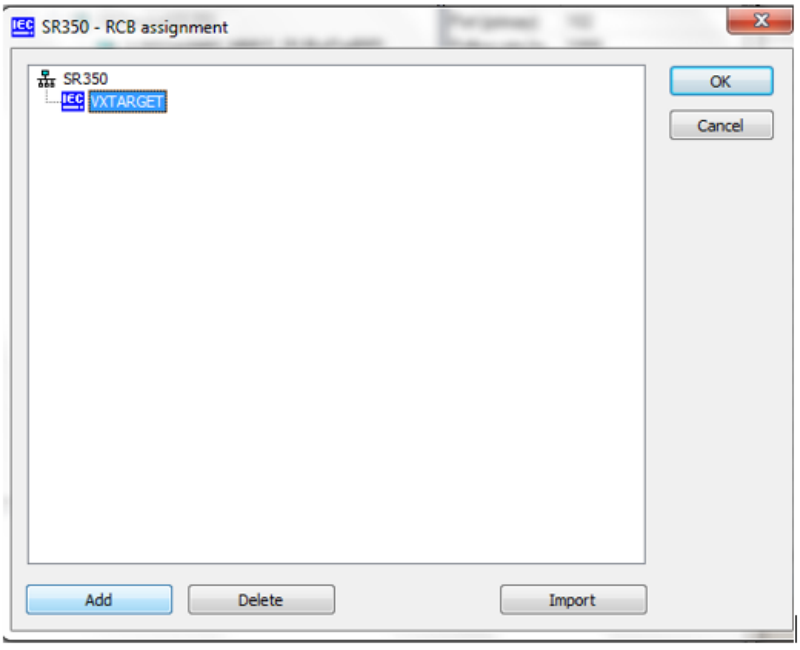
3. Right click on Server device in the IEC 61850 Configurator and choose **RCB Assignment.**

Figure 50



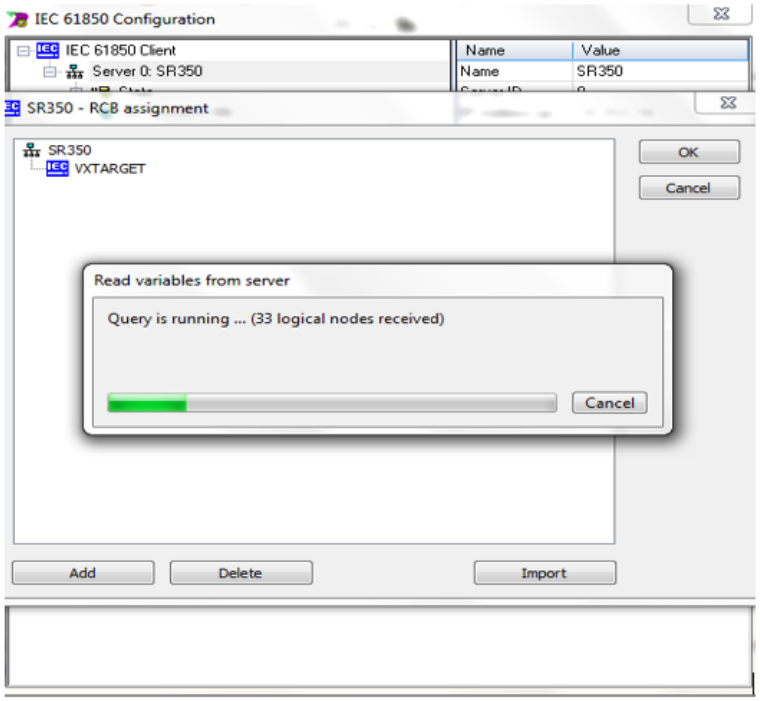
4. In the dialogue box that appears **<server name> RCB Assignment**, click **Add** and name the IEC target as “VXTARGET”.

Figure 51



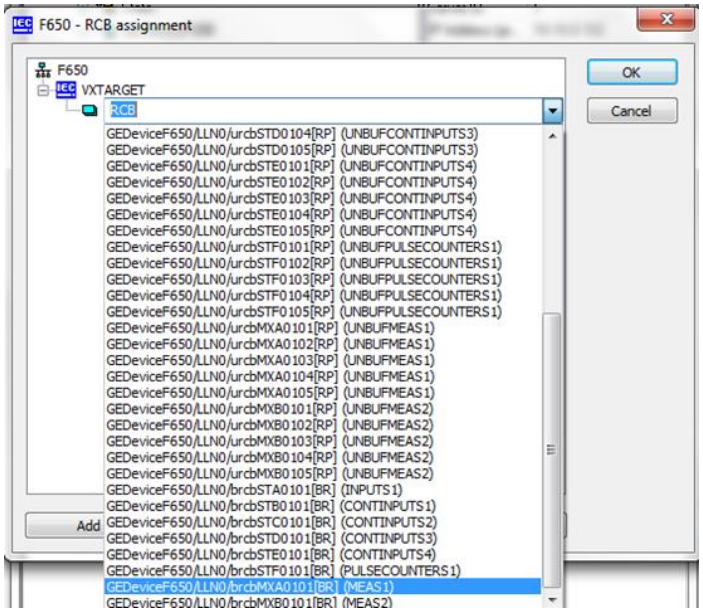
5. In the dialogue box **<server name> RCB Assignment**, Click **Import** to get the reports from the IEC 61850 Server device
6. A pop up **Read variables from server** appears, showing **Query is running ... (x logical nodes received)**. Click **Cancel** to cancel this operation.

Figure 52



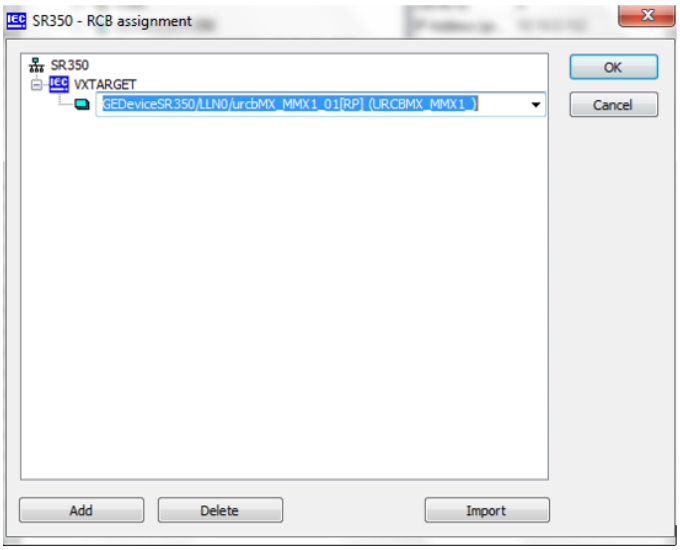
7. In the dialogue box **<server name> RCB Assignment**, Click **Add** and select the required Report **[<server name>/LLN0/<report name><report number>[RP]<report name>]** from the drop-down menu.

Figure 53



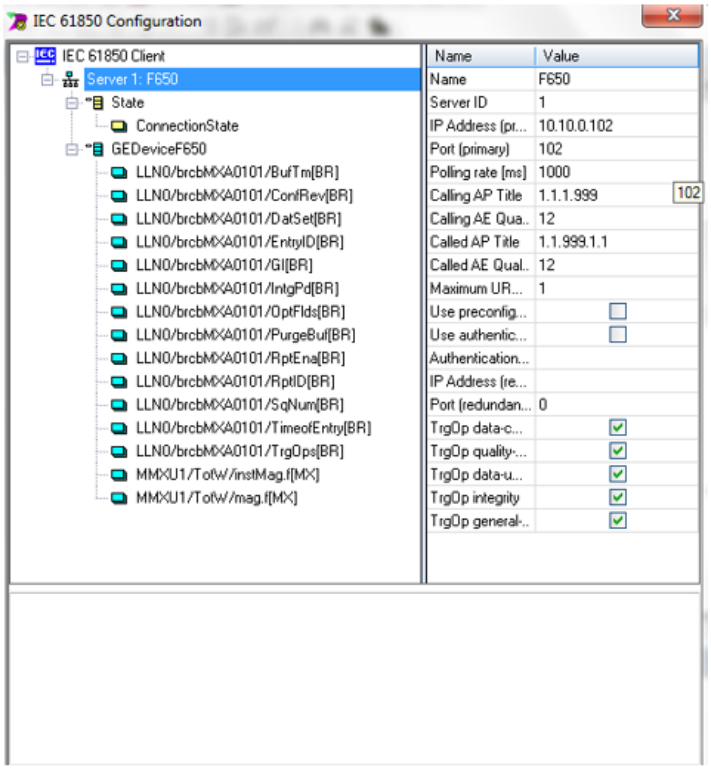
8. Click **Add** to add multiple reports.

Figure 54



9. In the dialogue box **<server name> RCB Assignment**, click **OK** to close.
10. In the IEC 61850 Configurator window, right click on **IEC 61850 Client** and choose **Validate Configuration**. If there are no errors, then you can proceed to the next step.

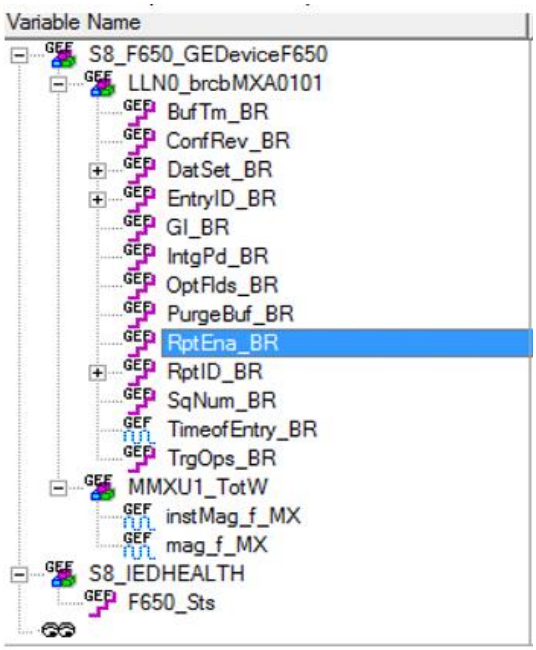
Figure 55



Note: *After setting the IP Address of an IEC 61850 server device, ensure that Machine Edition is connected to it over the network.*

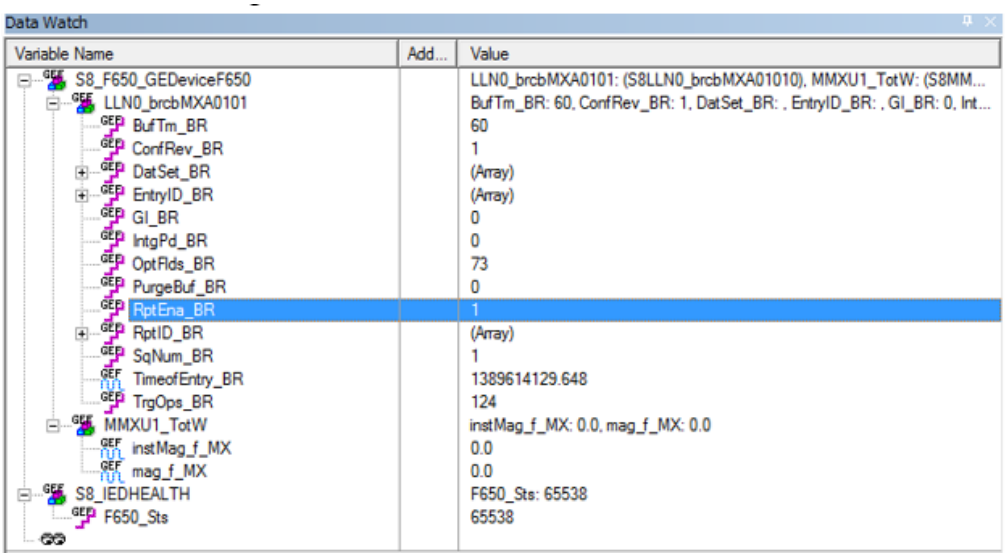
11. In the dialogue box **<server name> RCB Assignment**, click OK to close. On closure of the IEC 61850 Configurator, all required PPVs are generated automatically in the project. This is shown in the screenshot below, where report-related parameters are shown as variables. It also includes the normal DO/DA variables, which are part of the report.

Figure 56



12. In the dialogue box **<server name> RCB Assignment**, click OK to close. The configuration can be downloaded to the RX3i Controller and the controller can be put in RUN mode. Reports get enabled (see RptEna_RP = 1), if the configuration is valid. The DO/DA data in the report gets updated based don the trigger options as set in the client configuration.

Figure 57



Reports-related Parameters for URCB

- **BufTm_BR**

  This is buffer time parameter for report.

- **ConfRev_BR**

  This is a Configuration revision parameter for the configured report.

- **Dataset_BR**

  This provides the name of Dataset as a string data type in array. The limit is 32 elements.

- **EntryID_BR**

  This provides the Entry ID for the incoming report as a string data type in array. The limit is 32 elements.

- **GI_BR**

  This parameter is “General Interrogation” parameter for the report.

- **IntgPd_BR**

  The Integrity period parameters show the time value set for “Integrity poll” of data objects.

- **OptFlds_BR**

  This shows the optional fields, as per IEC 61850 specifications on which the report is functioning.

- **Resv_RP**

  This is reserved parameters for the report.

- **RptEna_RP**

  This is a Report Enabled Flag. This gets set to “1” if the configured report is enabled and is operational.

- **SqNum_BR**

  This is Sequence number for the report. This gets updated on every report received.

- **TrgOps_BR**

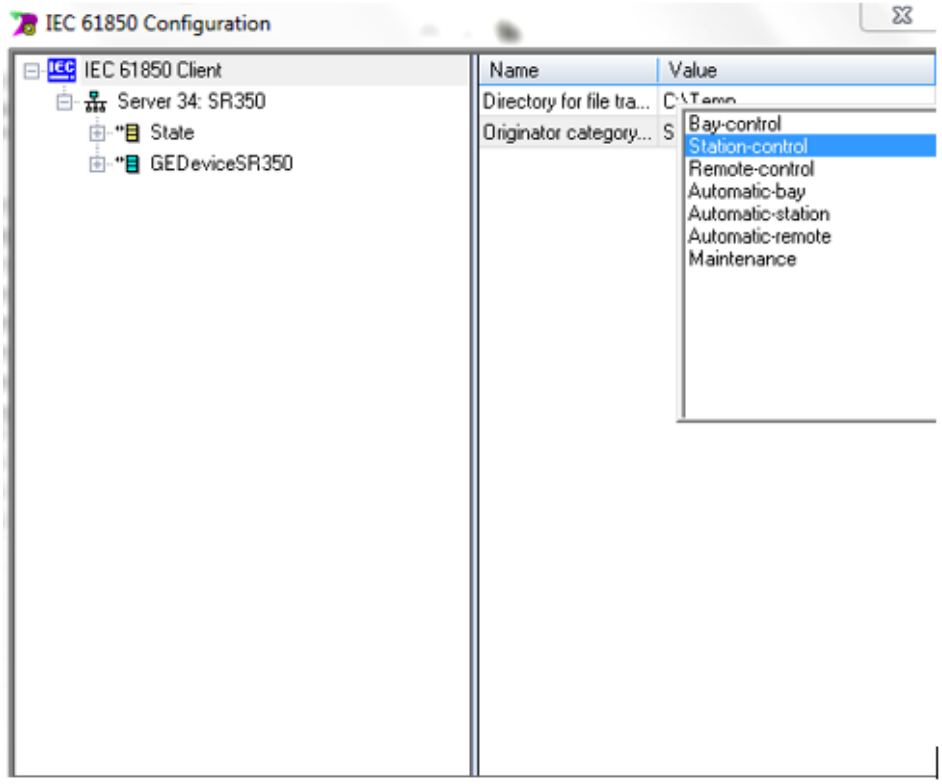
  This shows the trigger options, as per IEC 61850 specifications on which the report is functioning.

3.4.4 Configuring Originator Category for ECM850

The "orCat" is defined in the "IEC 61850 Configurator" dialogue in Machine Edition. (Default = Station control).

1. In the IEC 61850 Configurator window, click on **IEC 61850 Client**.
2. In the right pane of the Configurator window, double click on **Originator category (orCat)** and select the required category type.

Figure 58



Note: *The "orIdent" is defined internally in the ECM850 and is fixed to '**GEIPECM: VXTARGET**'. This also includes the apostrophe at the start and end of the name.*

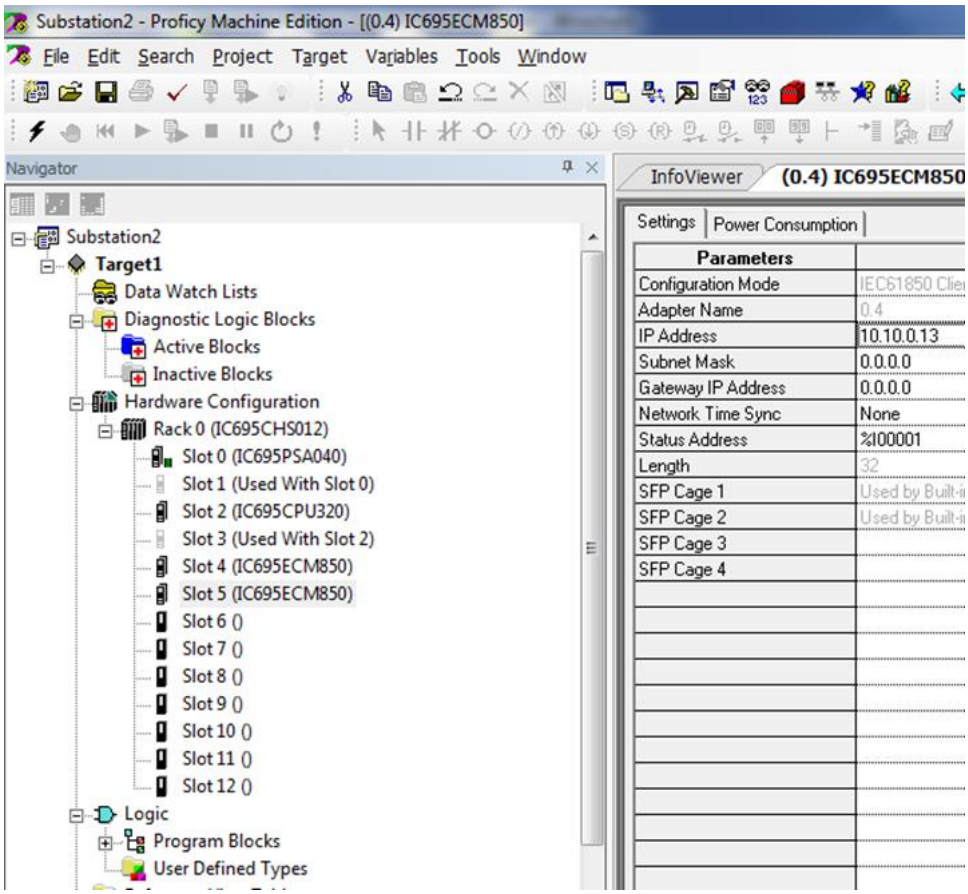
3.5 Configuration Features for the ECM850

This section describes features for handing ECM850 configuration in a Machine Edition project.

3.5.1 Configuring Multiple Modules and Multiple Devices

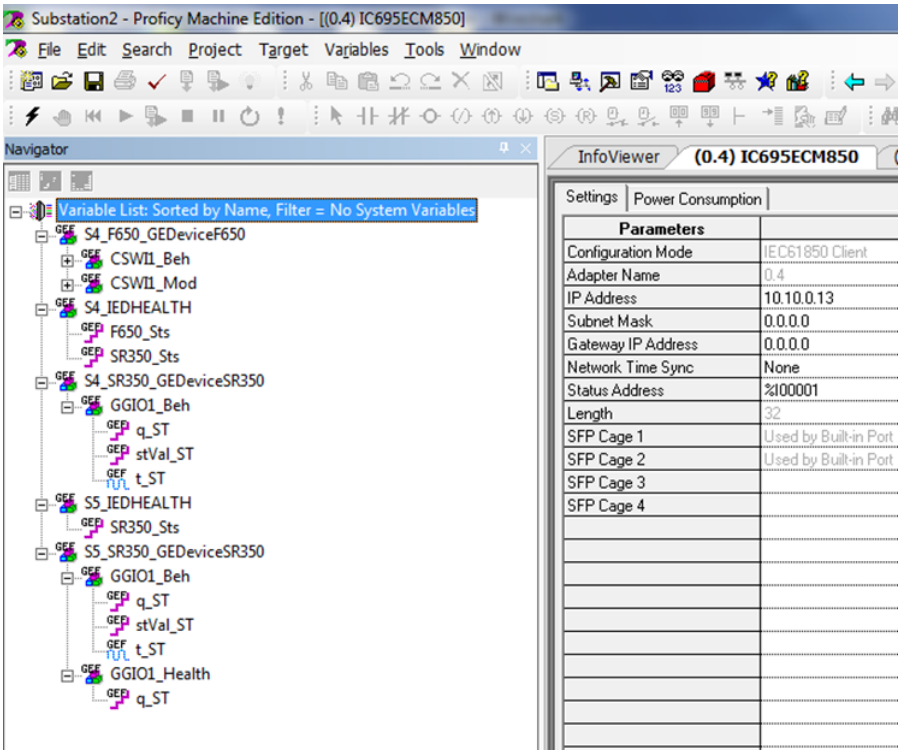
You can configure multiple ECM805 modules in an RX3i target, up to four. Each ECM850 can be configured to connect with multiple IEDs, not exceeding 32 devices. Refer to the specifications for constraints and limitations with regard to combined I/O memory and limitation on the number of PPVs. Each ECM850 can be configured separately. The screenshot below shows an example of two ECM850s in a single RX3i target.

Figure 59



The PPVs from each ECM850 are identified by a 'Slot Number prefix' followed by an underscore. This is shown below.

Figure 60



3.5.2 Copy, Paste, and Movement of ECM850s Within a Target

Machine Edition supports copy and paste of an ECM850 within a target across different slots. The drag and drop option is also available for the ECM850. The renaming of PPVs is automatically taken care in the background during the paste operation.

3.5.3 Copy, Paste, and Movement of ECM850s Between Targets

Machine Edition supports copy and paste of ECM850 within a project between different targets.The drag and drop option is also available for the ECM850. The renaming of the PPVs is automatically taken care in the background.

3.5.4 Download and Upload of ECM850 Configuration to/from the RX3i Controller

Machine Edition supports the download of Hardware configuration to the RX3i Controller. It also supports the upload of ECM850 configuration stored within an RX3i Controller back to a Machine Edition project.

3.6 IEC 61850 Configurator - Scenarios and Techniques

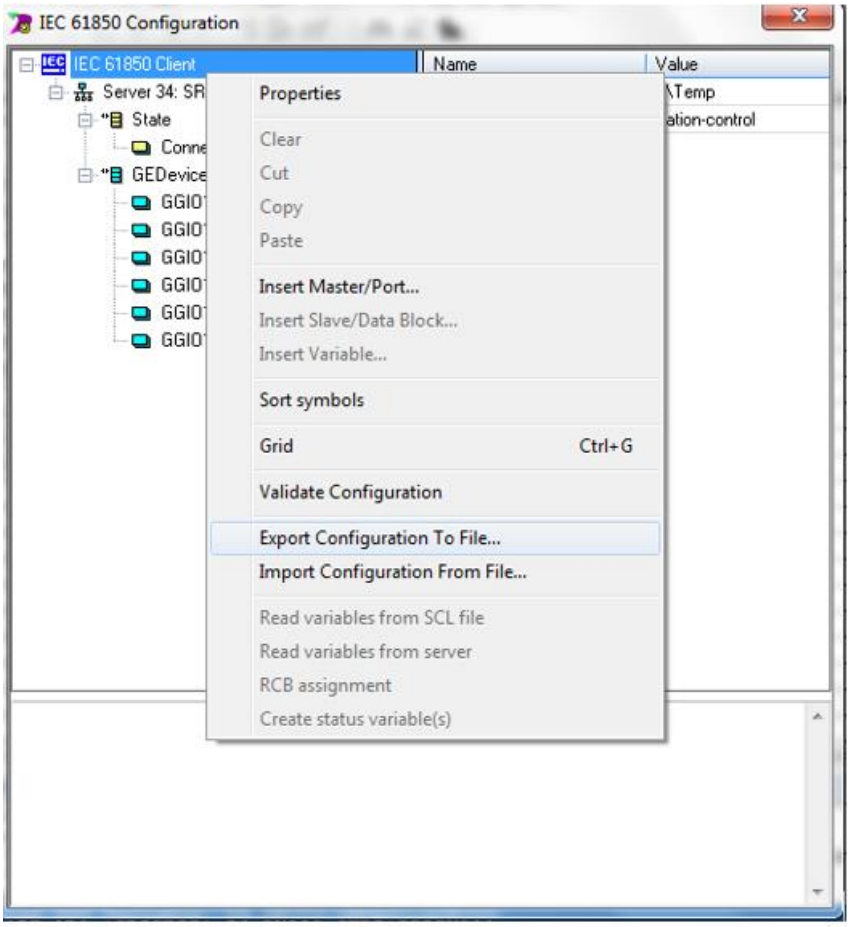
This section describes the different scenarios for configuration using the “IEC 61850 Configurator” and also details of techniques for exporting and importing IEC 61850 configurations.

3.6.1 Exporting complete configurations

The “IEC 61850 Configurator” provides ability to export a configuration to a file and then import such a configuration file to retrieve configuration information. This is useful for re-using a standard configuration for IED in the same ECM850 or across different slots in a Machine Edition project. This also helps to save or store the configuration in a file for future use.

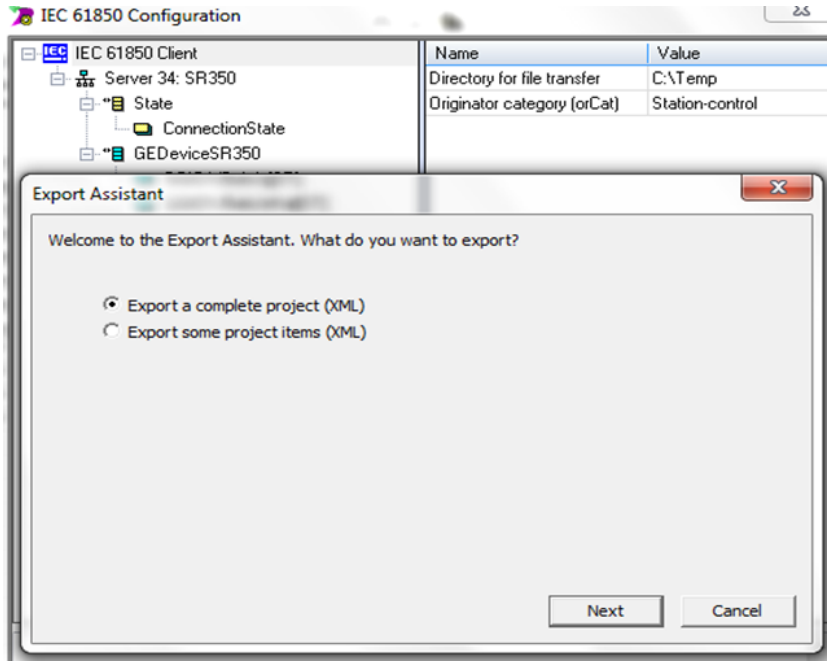
1. In the IEC 61850 Configurator window, right click on **IEC 61850 Client** and choose **Export Configuration To File...**

Figure 61



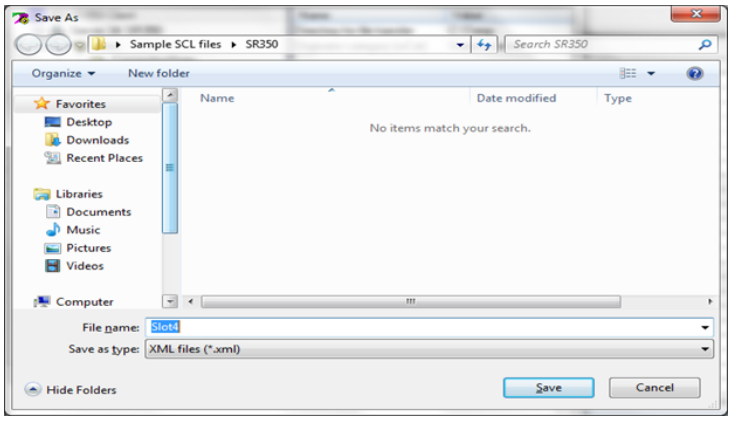
2. In the dialogue box that appears **Export Assistance**, select **Export a complete project (XML)** and click Next.

Figure 62



3. In the dialogue box **Save As**, browse to the required path, name the export file and click **Save**.

Figure 63



4. Click **Finish** to close the dialogue.

Figure 64

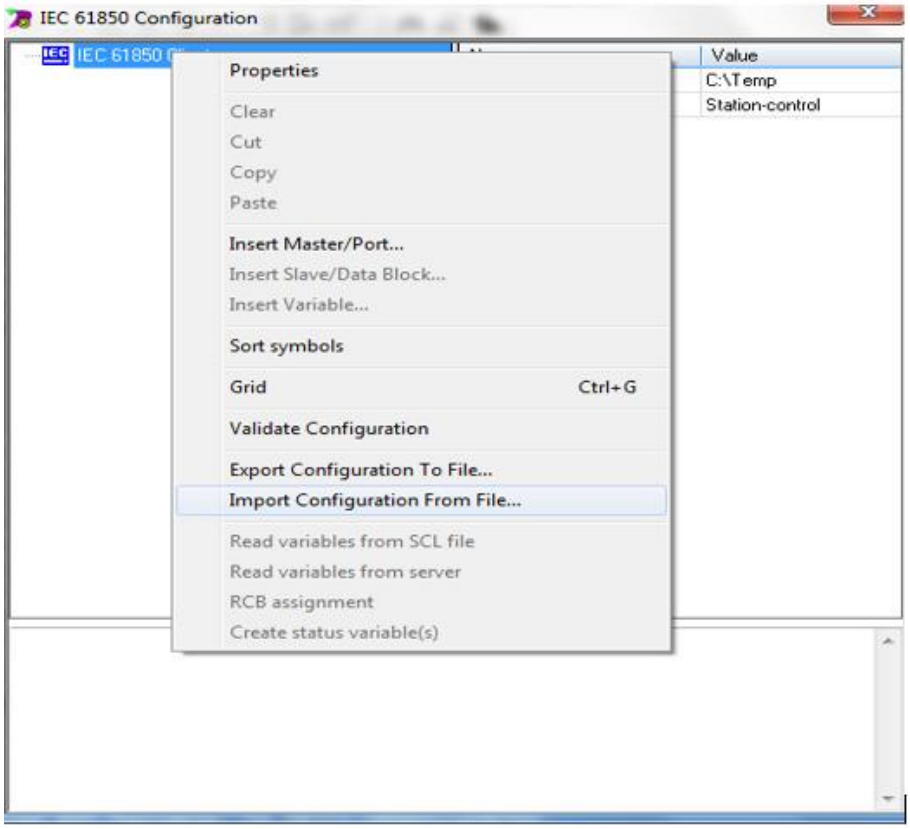
Note: *This is the recommended option for exporting a configuration from "IEC 61850 Configurator". Do not use the 'Export some project (XML) option.*

3.6.2 Importing Configuration from a File

A configuration saved in an XML file (schema as exported by the export tool) can be imported into the IEC 61850 Configurator.

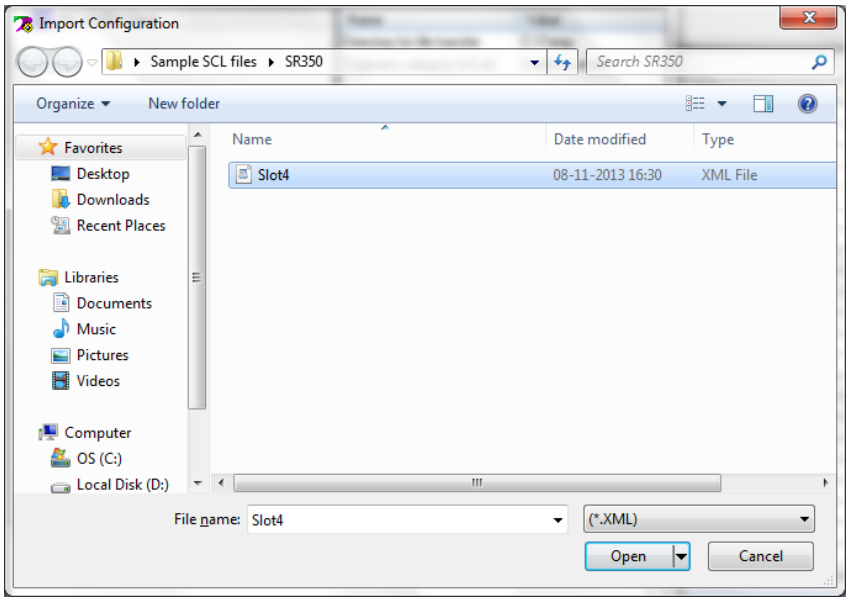
1. In the IEC 61850 Configurator window, right click on **IEC 61850 Client** and choose **Import Configuration From File...**

Figure 65



2. In the dialogue box that appears **Import Configuration,** browse and select the exported file and click **Open.**

Figure 66

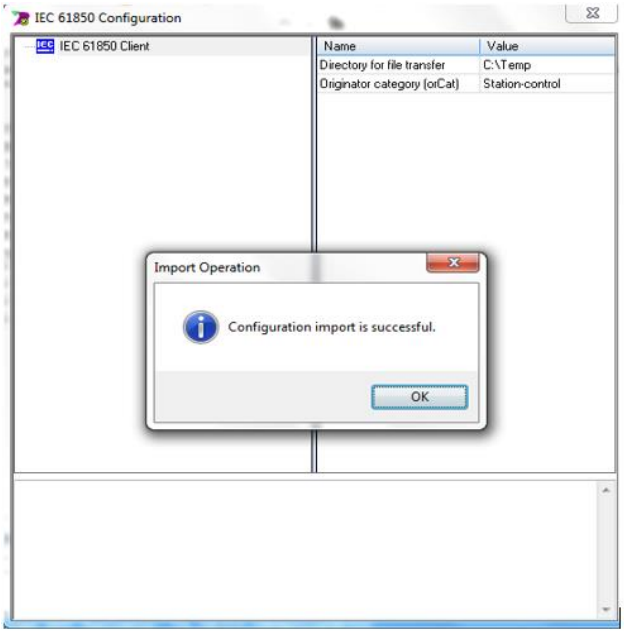


⚠CAUTION

If you corrupt the XML file contents and attempt to import, there may be errors during validation of the configuration. It is recommended that you start with a known good XML file and modify it according to the XML schema to ensure that entries are consistent with IEC 61850 standards.

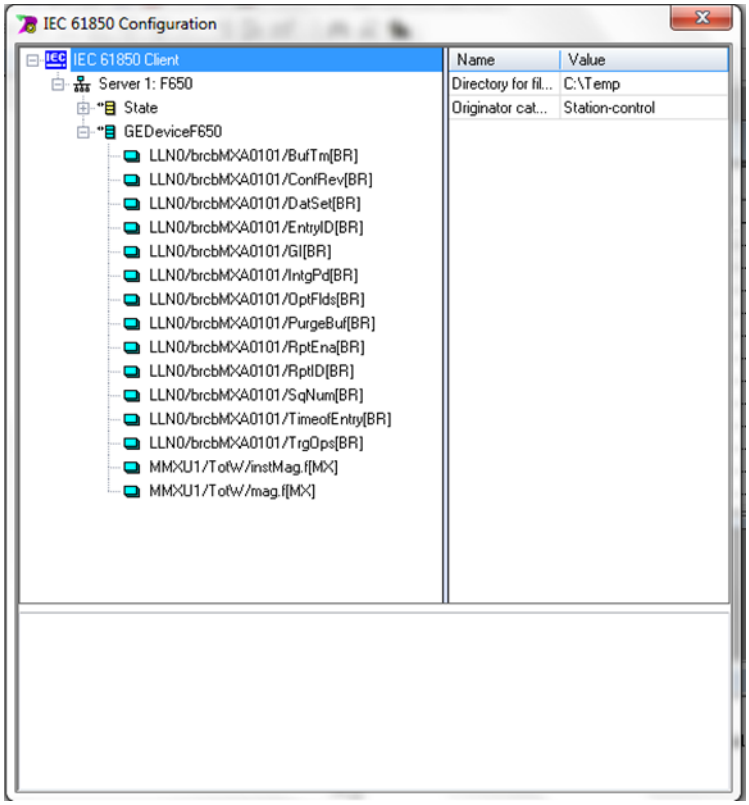
3. In the pop-up dialogue box **Import Operation**, click **OK.**

Figure 67



4. You can see the configuration under **IEC 61850 Client.**

Figure 68



Note: *If you don't find logical device "state" after the configuration import, you can manually create the IED (server) status variables by using the option* ***Create status variable(s)****, available by right clicking on the server device.*

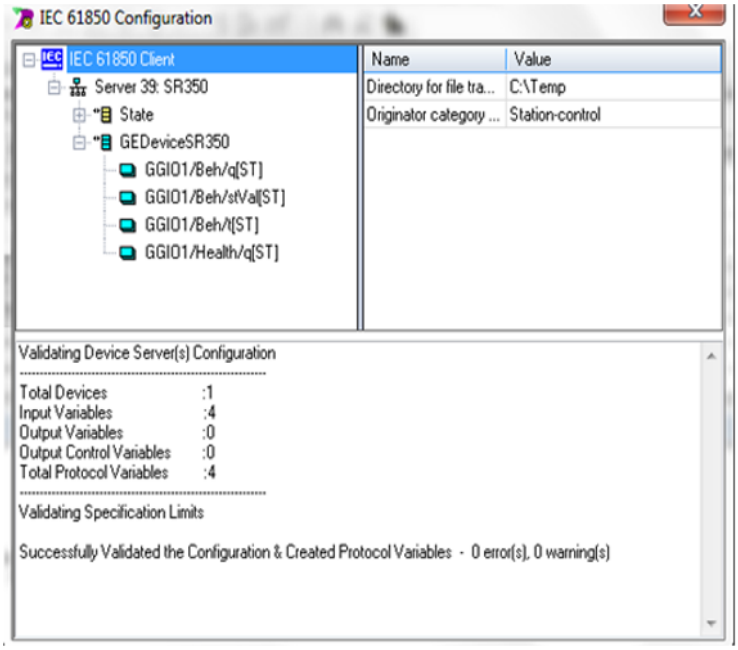
3.6.3 Configuration Scenarios for IEC 61850 Configurator

Some of the common use case configuration scenarios for "*IEC 61850 Configurator*" are described in this section.

Use case 1: Configure, and validate for successful validation

1. Perform a successful configuration in "IEC 61850 Configurator" and validate the same. The example below shows the screenshot of a successful validation.

Figure 69

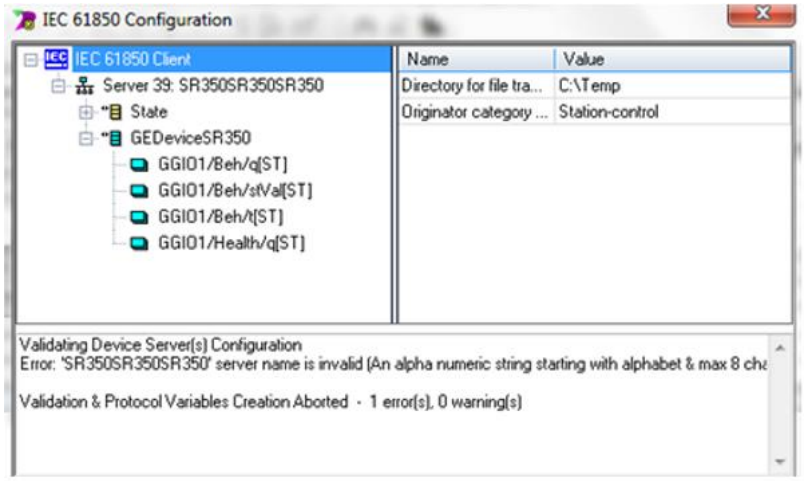


2. On Closure of the "IEC 61850 Configurator", PPVs are successfully generated in the PACSystems Machine Edition project as shown in the Variable list.

Use case 2: Configure and Validate for Failed Validation

In this use case, the validation finds errors as illustrated below. The feedback zone of the "IEC 61850 Configurator" shows an appropriate message describing the error condition.

Figure 70

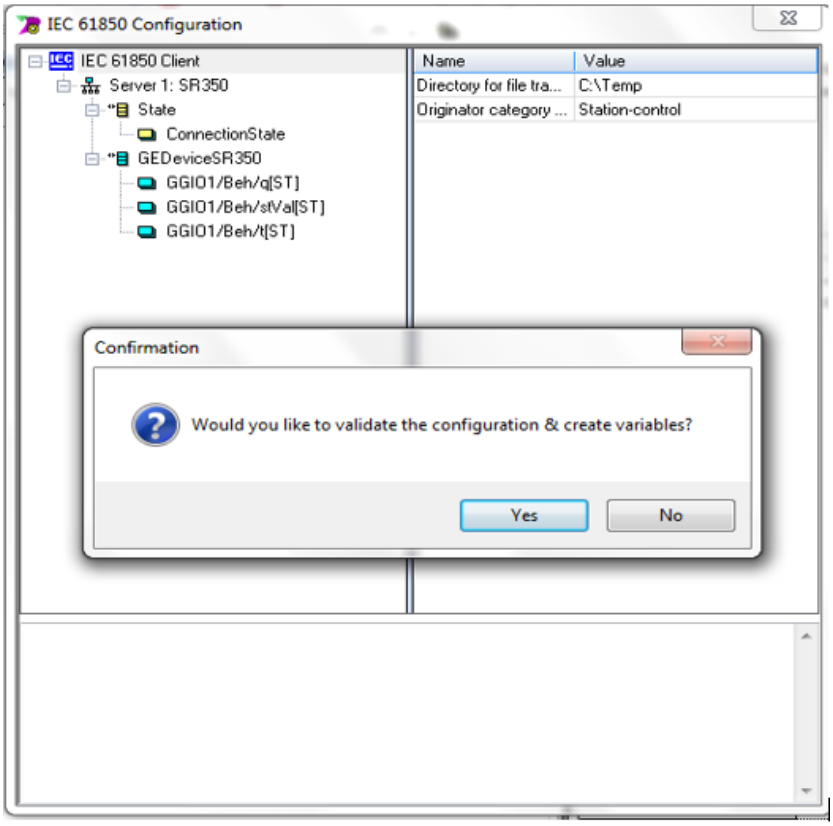


Note: *The different error and warning conditions for the "IEC 61850 Configurator" are described in the table* ***IEC 61850 Configurator*** Error Handling

Use case 3: Configure and Exit with Successful Validation

1. Following a successful validation of a configuration, you can choose to close the "IEC 61850 Configurator" dialogue without performing any further validation. In this use case, the message displayed is illustrated below:

Figure 71

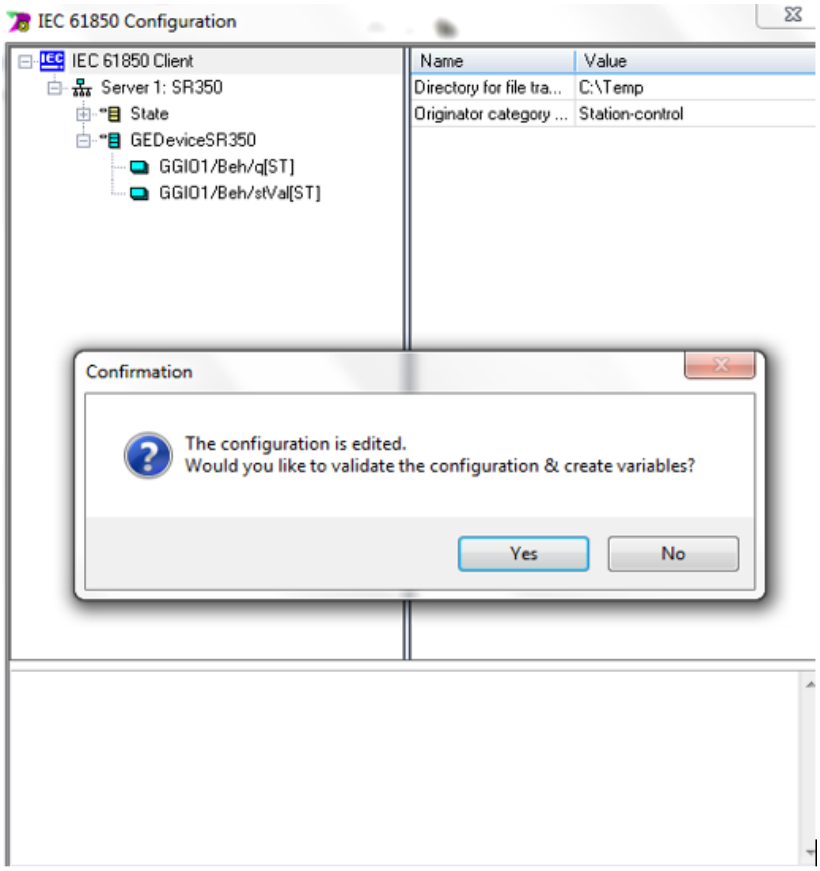


2. In the window that appears, if you select “Yes”, then PPVs are created in the RX3i controller project. If you select “No”, then the dialogue is closed and PPVs are not generated.

Use case 4: Re-configure, and Exit with successful validation

1. Modify the existing configuration (e.g. added or deleted DO/DA variables) and choose to directly close the Configurator: In this use case, the below illustrated message is displayed:

Figure 72

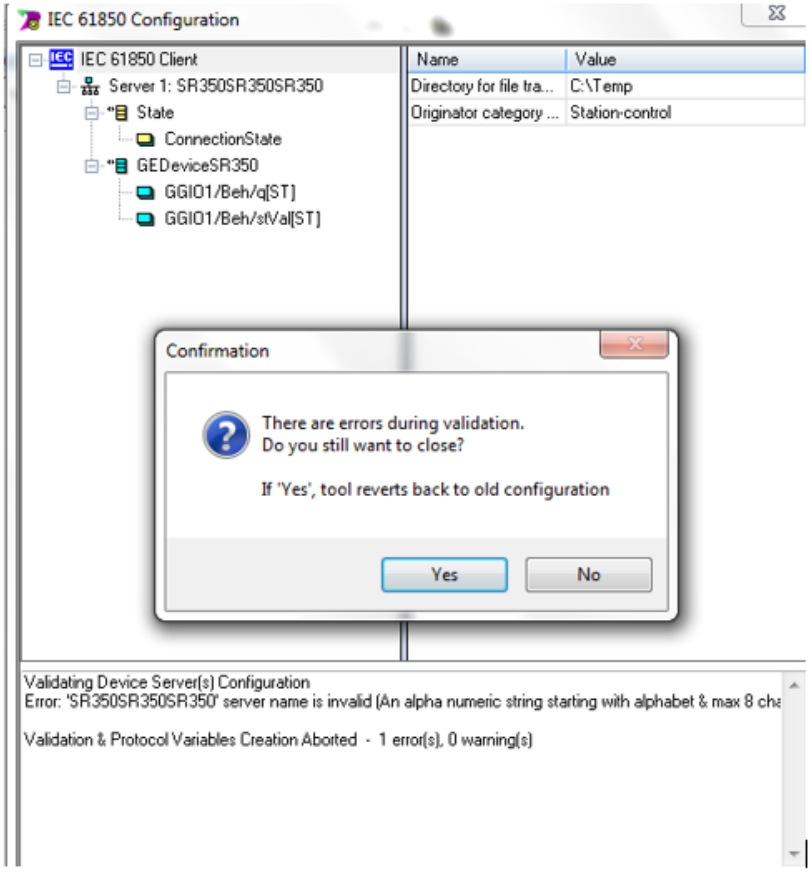


2. In the window that appears, if you select “Yes”, then a new set of PPVs are generated according to the edited configuration. If you select “No”, the existing configuration is retained and the PPVs in PACSystems Machine Edition project do not change.

Use case 5: Re-configure and Exit with a Failed Validation

1. Modify the existing configuration wrongly (e.g. Server IP address set to 0.0.0.0) and choose to directly close the Configurator. In this use case, the message displayed is illustrated below:

Figure 73

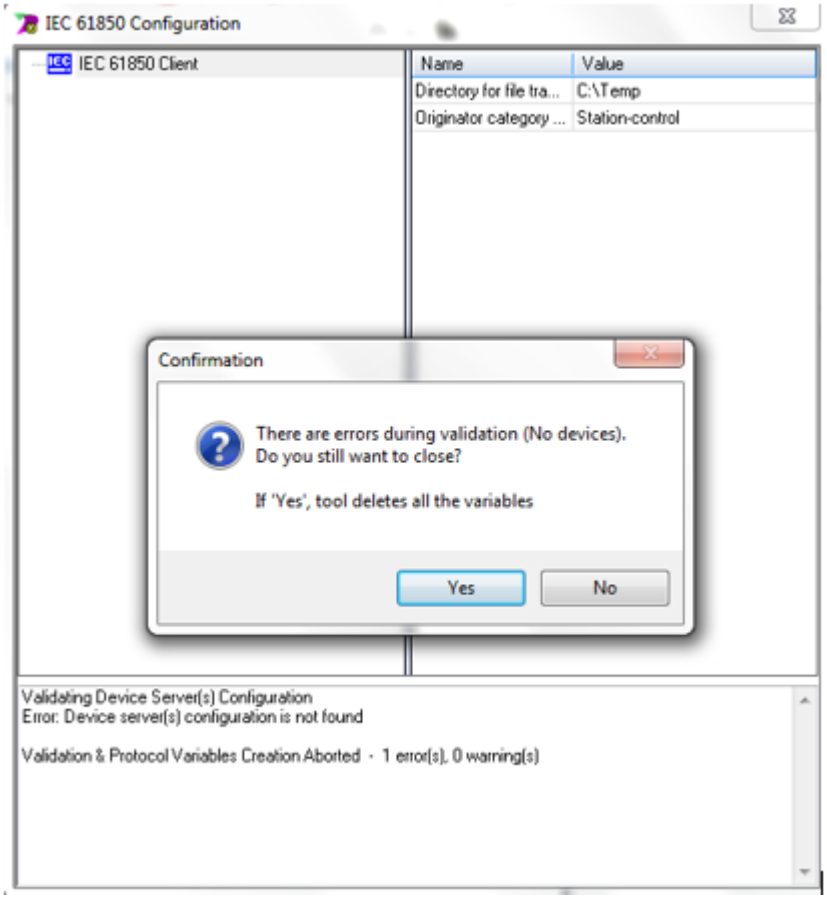


2. In the window that appears, if you select “Yes”, the Configurator reverts to the last successful configuration. If you select “No”, you will remain in the Configurator window until you resolve the invalid configuration issue

Use case 6: Clear Configuration and Exit

1. Right click on an IED in the IEC 61850 Configurator and click **Clear**, so that no IEDs are selected.
2. Right click on **IEC 61850 Client** and click **Validate Configuration.**
3. In the feedback zone, error message appears.
4. Close the IEC 61850 Configurator directly and exit. The message shown below appears:

Figure 74



5. In the window, if you select “Yes”, then the entire configuration is cleared and all previous PPVs are deleted. If you select “No”, then the Configurator window remains open for further configuration.

3.6.4 IEC 61850 Configurator Error Handling

The IEC 61850 Configurator provides a mechanism to validate the configuration and report warning or error messages. The feedback zone of the Configurator displays appropriate messages to explain any configuration errors or warnings or announce the successful validation of the configuration.

In case of validation failure, you can go through the error or warning list and change the configuration to fix issues and correct the configuration. The table below provides the list of

errors and warnings that you may get on validation failures. You can proceed to generate PPVs in case of warnings. If there are errors, however, the configuration must be fixed before PPVs can be generated.

IEC 61850 Configurator Errors

If the "Path" property exceeds the variable name size limit, the name is truncated. If after truncating, the name is same as another variable name, then a unique number is added (Eg: q0001_ST) to the next structure level for retaining the uniqueness of the variable name.

Example: IEC 61850 variables with Path as shown below:

GGIO1/Beh12345678910111213141516171819202122232425262728293O/q[ST]

GIO1/Beh12345678910111213141516171819202122232425262728293O/q[ST]

Validation truncates the variables above and displays this warning:

⚠ WARNING

Truncated: GGIO1_Beh12345678910111213141516171819202l to:

GGIO1_Beh1234567891011121314

The PPVs in the Variables tab will be represented in this case as:

GGIO1_Beh1234567891011121314.q_ST

GGIO1_Beh1234567891011121314.q0001_ST

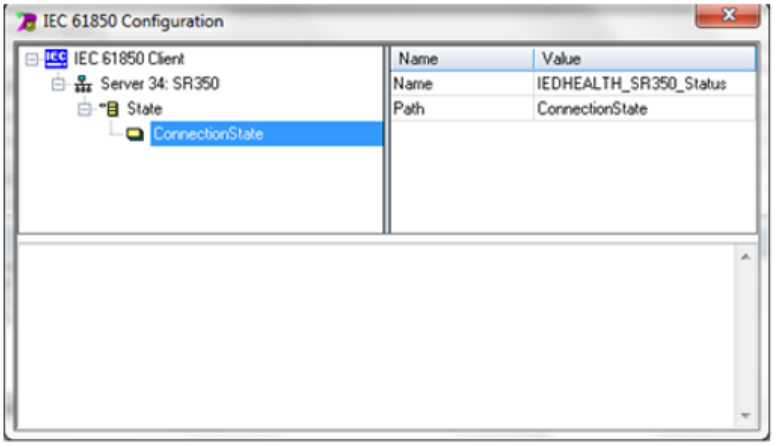
3.7 IEC 61850 Data Types and Attributes

The sections below describe the configuration of IED connection-state variables, the mapping of IEC 61850 data types to RX3i variable types, and the mapping of quality and timestamp attributes to PPVs.

3.7.1 Configuring the IED Connection State Variable

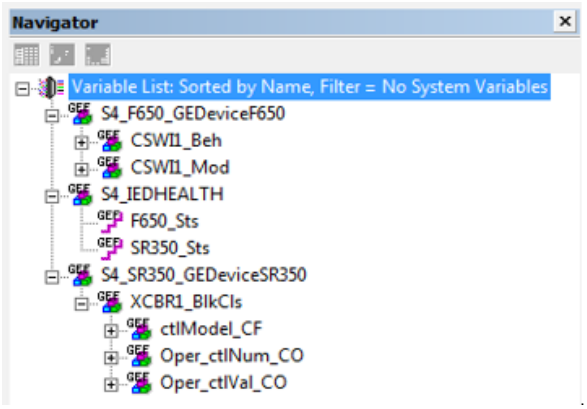
A **ConnectionState** status variable gets automatically created by the IEC 61850 Configurator for each device when you add a new Master/port or Server Device. This **ConnectionState** variable is represented in the RX3I controller variable list as the health status variable **Sxx_IEDHEALTH.nnn_Status**, where **xx** = Slot number and **nnn** = the name of the IED. These variables provide connection status for each configured IED.

Figure 75



The equivalent PPV for this is shown in the screenshot below:

Figure 76



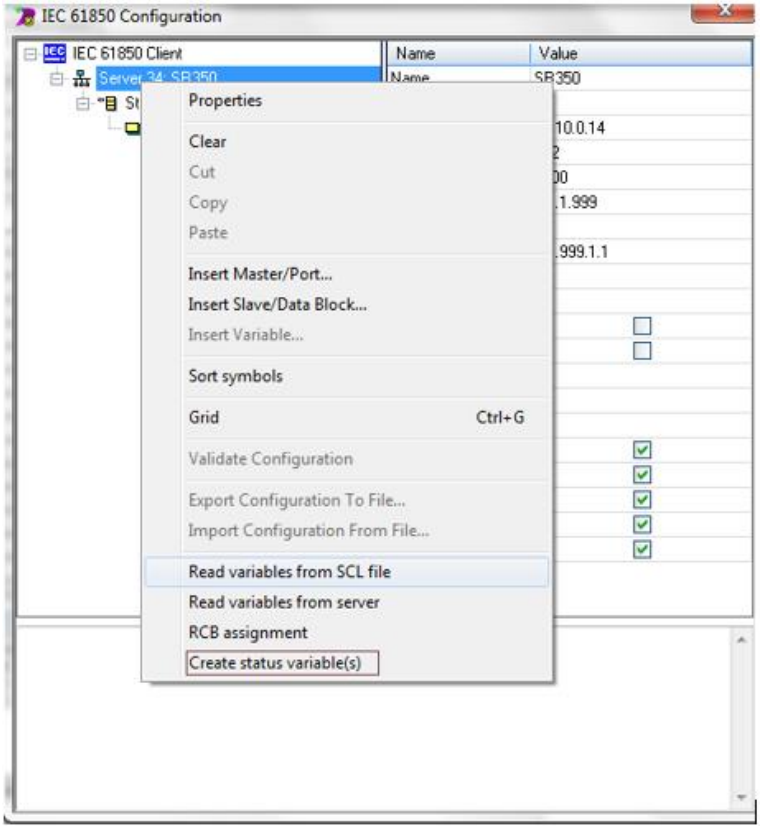
Note: *For more information on connection status, refer to section* ***5.3.1 IED Connection Status****.*

Explicit Creation of ConnectionState

You can also explicitly create the "ConnectionState" variable by using the "Create status variable(s)" option. This may be required, if you import a previously-created configuration using "Import Configuration From File..." and the state variable has been manually removed.

Note: *Each IED has only one "ConnectionState" variable and PPV associated with it. If you click the "Create status variable(s)" multiple times, the Configurator will only create one variable per IED.*

Figure 77



3.7.2 Data Type Mapping – IEC 61850

The data type mapping between the IEC 61850 data types and data types supported in Machine Edition is provided in the following table.

IEC 61850 Standard		**Machine Edition**	
Data Type	**Size (Bytes)**	**Data Type**	**Size (Bytes)**
BOOLEAN	0,1 (bits)	INT	2(LSBit usable)
INT32	4	DINT	4
INT32U	4	DWORD	4
INT8	1	INT	2(LSB usable)
FLOAT32	4	REAL	4
OCTET / VISIBLE / UNICODE STRING nn	nn	BYTE	32
INT8U	1	UINT	2(LSB usable)
INT16	2	INT	2
INT16U	2	UINT	2
INT24U	3	DINT	4
INT64	8	DINT(2)	8

IEC 61850 Standard		Machine Edition	
Data Type	**Size (Bytes)**	**Data Type**	**Size (Bytes)**
Enumerated	Varies & handled based on child variables		
CODED ENUM	4	DWORD	4
Currency	Not Supported		
Time Stamp	8	LREAL	8

3.7.3 Quality Type Mapping – IEC 61850

The Quality attributes can be selected during configuration using the "IEC 61850 Configurator" dialogue in Machine Edition. On validation of configuration, equivalent Protocol Variables (PPVs) are automatically created for Quality. These quality variables get updated in the RX3i controller and can be read as normal RX3i controller variables.

An example of a quality PPV variable in RX3i controller project with data type as DWORD (4 Bytes):

S5_SR350. Emerson DeviceSR350.GGIO1_Beh.q_ST

The equivalent IEC 61850 Configurator DA:

SR350. Emerson DeviceSR350.GGIO1\Beh\q[ST]

The quality bit of IEC 61850 data "q" is mapped according to the following table

Attribute name	Attribute type Value / Value range	Bit Map
Validity	CODED ENUM good | invalid | reserved | questionable	6,7
detailQual	PACKED LIST	
Overflow	BOOLEAN DEFAULT FALSE	5
Out Of Range	BOOLEAN DEFAULT FALSE	4
Bad Reference	BOOLEAN DEFAULT FALSE	3
Oscillatory	BOOLEAN DEFAULT FALSE	2
Failure	BOOLEAN DEFAULT FALSE	1
Old Data	BOOLEAN DEFAULT FALSE	0
Inconsistent	BOOLEAN DEFAULT FALSE	15
Inaccurate	BOOLEAN DEFAULT FALSE	14
Source	CODED ENUM process | substituted	13
Test	BOOLEAN DEFAULT FALSE	11
Operator Blocked	BOOLEAN DEFAULT FALSE	12

3.7.4 Timestamp Type Mapping – IEC 61850

The Timestamp attributes can be selected during configuration using the "IEC 61850 Configurator" dialogue in Machine Edition. On validation of configuration, equivalent Protocol Variables (PPVs) are automatically created for Timestamp. These Timestamp variables get updated in the RX3i controller and can be read as normal RX3i controller variables.

The following is an example of timestamp PPV variable in the RX3i controller project with data type as LREAL (8 Bytes) in Unix-Time format:

S5_SR350. Emerson DeviceSR350.GGIO1_Beh.t_ST

The equivalent IEC 61850 Configurator DA:

SR350. Emerson DeviceSR350.GGIO1\Beh\t[ST]

The ECM850 supports SNTP Client (multicast and broadcast). However, note that the Client module does not send timestamp quality to control object.

Chapter 4: System Operation

This chapter describes:

- IEC 61850 System Overview
  - IEC 61850 Communications
  - RX3i IEC 61850 Client System
  - Types of IEC 61850 Communications
  - External Switch VLAN Priority Settings
- ECM850 Operations in RX3i System
  - Duplicate ECM850 IP Address Detection
  - Resolving Duplicate IP Addresses
- ECM850 I/O Scan Mechanism
  - RX3i CPU Sweep
  - Input Scan
  - Output Scan
  - IEC 61850 Server connection
- Protocol Variable Operations in RX3i controller Applications
  - Protocol Variable Description
  - IEC 61850 Operation and Protocol Variable mapping
  - Read Operations
  - Write Operations
  - Control Operations
- Performance factors
- RX3i CPU operations for ECM850
  - SVC for enabling or disabling Protocol outputs
  - Reset Smart Module for ECM850
  - Unsupported features
- Hot Standby (HSB) operation for ECM850
  - Basic System overview
  - Protocol Output control for HSB System
  - Enabling or Disabling Protocol Outputs
  - Status Reporting for Protocol Outputs State
  - Application logic for handling HSB System
  - Non-Synchronized Active Unit (NSAU) Scenarios
  - HSB Configuration Using Machine Edition

4.1 IEC 61850 System Overview

4.1.1 IEC 61850 Communications

IEC 61850 is primarily focused on electrical utility stations and substations. Substations can be categorized as distribution or transmission substations. Although IEC 61850 applications are primarily in electrical substations, there are applications in other industries as well (co-gen sites). The PACSystems RX3i supports IEC 61850 Clients by providing connectivity to substation devices like IEDs, relays, and other components.

The ECM850 uses IEC 61850 communications protocols for data exchange. The same network can also be used for basic Ethernet communications, but use of a separate Ethernet LAN and RX3i Ethernet interface is recommended for most applications.

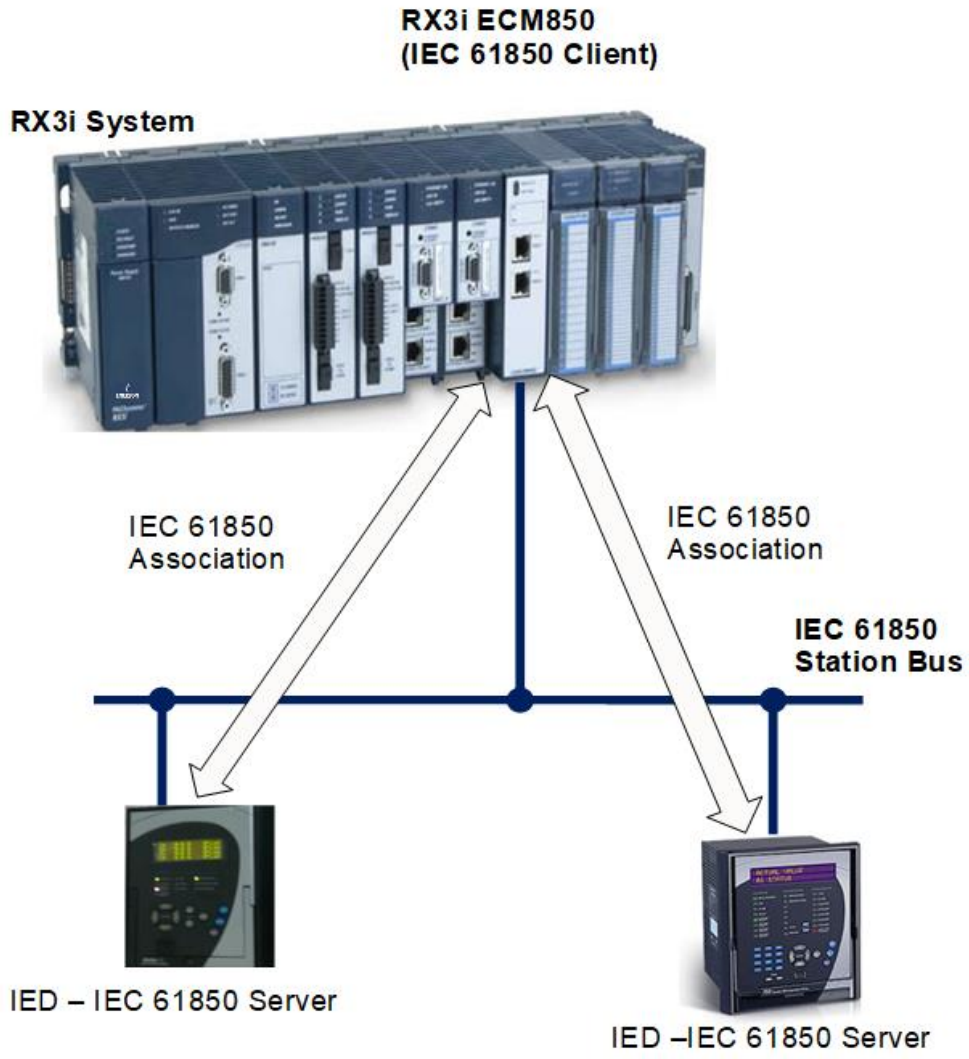
An IEC 61850 network can include three types of devices:

IEC 61850 Client	In an RX3i system, the ECM850 operates as an IEC 61850 Client. It establishes an association with one or more IEDs (IEC 61850 Server devices).
IEC 61850 Server	IEC 61850 Server devices are typically IEDs or Relays which are distributed throughout a substation. They are connected over an IEC 61850 network to IEC 61850 Client(s).
IEC 61850 Configurator	An IEC 61850 device which may be required to connect to IEDs for browsing the Data model in the devices.

4.1.2 RX3i IEC 61850 Client System

The ECM850 implements IEC 61850 Client as specified in the PICS and MICS. The ECM805 establishes application association with IEC 61850 Server devices for data exchange. The ECM850 communicates with the IEDs and exchanges IED variable data with the RX3i CPU. This data is available as symbolic variables and RX3i controller application program can use this data for monitoring and control. This data can also be put to higher level systems like HMI and SCADA.

Figure 78



4.2 ECM850 Operations in RX3i System

The ECM850 in the RX3i controller system performs the following operations:

- Receives IEC 61850 IED configuration from the RX3i controller CPU.
- Establish association with IEDs using the configuration over IEC 61850 network.
- Consumes input data from each IED and makes that data available to the CPU during the CPU's input scan.
- Receives output data from the CPU during the output scan and transfers the outputs to IEDs.
- Processes connection information from IEDs and converts them to a PACSystems format.
- Maintains a Local Log Table of its own alarms and the diagnostic information it receives. It also forwards some of the information to the CPU as I/O or Controller Faults.

- Checks for duplicate IP addresses as described below.

4.2.1 Duplicate ECM850 IP Address detection

The ECM850 detects that a network device has the same IP address as its own during powerup, when a new hardware configuration is downloaded from the programmer, and during operation when a device with a conflicting IP address announces its presence[2] on the network.

When a duplicate is detected during powerup, ECM850 reset, or new hardware configuration store, the ECM850:

- logs a Duplicate IP Address Detected fault for itself,
- does not connect to any configured IEDs,
- periodically queries the network for resolution of the IP address conflict.

When the IP conflict is resolved, the ECM850:

- logs a Duplicate IP Address Resolved fault for itself,
- attempts to re-connect all configured IEDs

Note: *Power cycling a rack that has a ECM850 with the same IP address as another node on the network will result in two Duplicate IP Address Detected faults in the I/O Fault table. This is normal behavior that occurs because the ECM850 retains IP parameters through a power cycle and attempts to exist on the network before receiving a new configuration from the CPU. The first fault occurs before the ECM850 receives the new configuration and the second fault occurs after the ECM850 receives its new configuration. Both faults result in the ECM850 not attempting to connect to the network.*

4.2.2 Resolving Duplicate IP Addresses

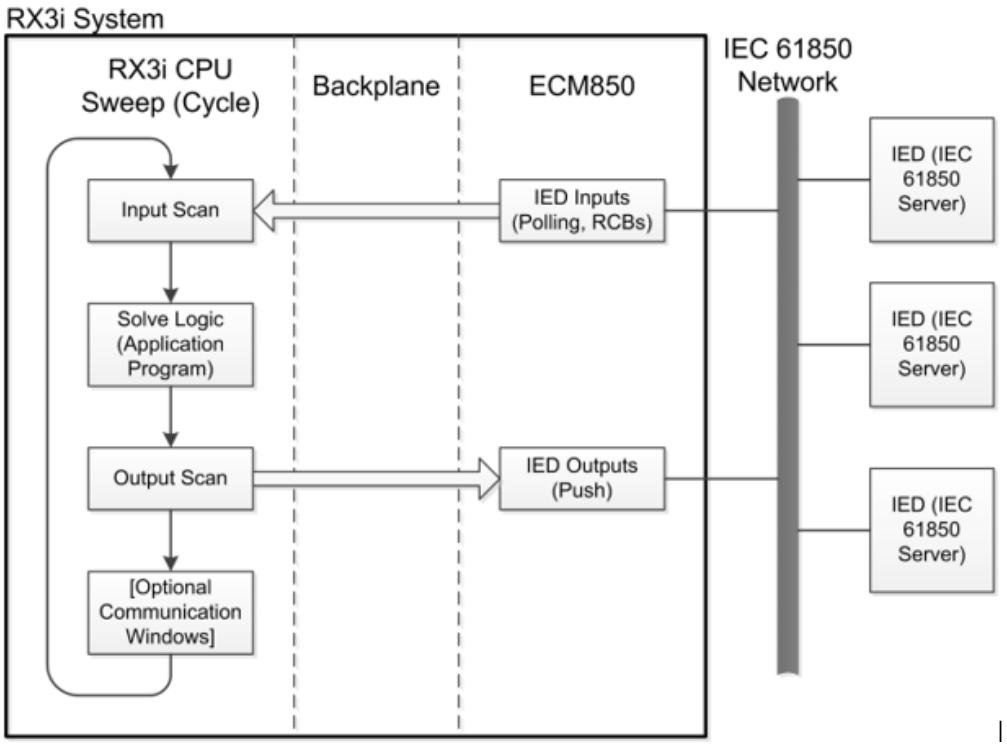
When an IP address conflict exists, IP-based network communication with the device(s) may be disrupted. The IP address conflict should be resolved by disconnecting one of the offending devices from the network or assigning each a unique address. The Duplicate IP Address Detected fault lists the MAC address of the offending devices in bytes 8 – 13 and 14 – 19 of the Fault Extra Data.

4.3 ECM850 I/O Scan Mechanism

The movement of input data from IEDs through the ECM850 to the RX3i CPU and output data from the CPU through the ECM850 and out to IEDs involves multiple data transfers using a variety of mechanisms described in the following sections. At a high level, however, inputs from IEDs are received by the CPU asynchronous to the CPU sweep, while outputs are sent from the CPU to IED synchronous to the sweep. Refer to **Appendix B: IEC 61850 I/O Performance Examples** for ECM850 IED polling performance data. The data flow among IEDs, the ECM850, and RX3i controller is illustrated in the following figure.

[2] The ECM850 uses the ARP protocol to detect duplicate IP addresses. Devices that issue a gratuitous ARP to announce their presence on the network are detected.

Figure 79



4.3.1 RX3i CPU Sweep

The RX3i CPU Sweep illustrated above is a repeating sequence that includes an input scan, logic solution, and an output scan. The CPU input scan retrieves the latest input data collected from the IEDs and buffered in the ECM850. After this, the input data is used by the application logic to determine new output data. During the RX3i output scan, the CPU writes the newly computed outputs to the ECM850, which in turn pushes this output data immediately to the IEDs.

4.3.2 RX3i Input Scan

At the start of every input scan, the RX3i CPU sends a request to the ECM850 for its input data. On receipt of this notification from CPU, the ECM850 unconditionally sends its latest input data from the IEDs to the CPU. The age of the data in the ECM850's input data buffer will depend on the configuration of each IED, as described in Chapter 3. By default, each IED is polled by the ECM850 for input data every second (although this period is configurable). Alternately, the IEDs can be configured to report certain data immediately on change, as described in section **3.4.1 Report Control Block (RCB) overview** Except in the latter case, the updating of IED input data in the RX3i is essentially asynchronous to the CPU sweep.

4.3.3 RX3i Output Scan

The CPU sends IED output data to the ECM850 during every output scan. At the end of the output scan, the ECM850 sends the latest output data unconditionally to IEDs through its

IEC 61850 Client interface. This means that RX3i outputs to IEDs are sent synchronous to the CPU sweep.

4.3.4 IEC 61850 Server Connections

The ECM850 connects with IEDs (IEC 61850 server devices) as an IEC 61850 client. The IEC 61850 client establishes associations with all configured IEDs. The ECM850 connects with the devices and fetches data by polling at the configured polling rate or receives unsolicited reports from the device based on the configuration of RCBs. These variable data are available to the ECM850's IEC 61850 client interface and is exchanged with RX3i CPU.

The IEC 61850 client interface operates asynchronously within the ECM850's multitasking environment, along with other firmware processes. The interface independently processes the commands and messages for IEDs. Since the interface runs asynchronously, depending upon how often IEDs send data and the CPU's sweep period, it is possible that a variable may be updated more than one time by the IEC 61850 client interface before the RX3i CPU sees the update. It may be possible in some cases that the ECM850 may not be able to transfer every data change. Only the data most recently stored in the IEC 61850 client interface will be available for the RX3i CPU. It is possible that some of the changes in variables in some IEDs may be lost in the process, especially during times of high volume IED data traffic.

4.4 PPV Operations in RX3i Controller Applications

The IEC 61850 variables from the selected IEDs appear in the Machine Edition variable list as PPVs. These variables can be used in the RX3i control application subject to normal variable validation and download to the RX3i controller. The controller can be put in RUN mode to run its application with IEC 61850 variables.

4.4.1 PPV Description

The PLC Protocol Variables, or PPVs, are variables available in the Machine Edition project for use in RX3i controller application programs.

General Format of IEC 61850 Variables

The high-level IEC 61850 data model hierarchy for IED variables is shown below, depicting the data model:

– Physical Device (SR350)

– Logical Device (GEDeviceSR350)

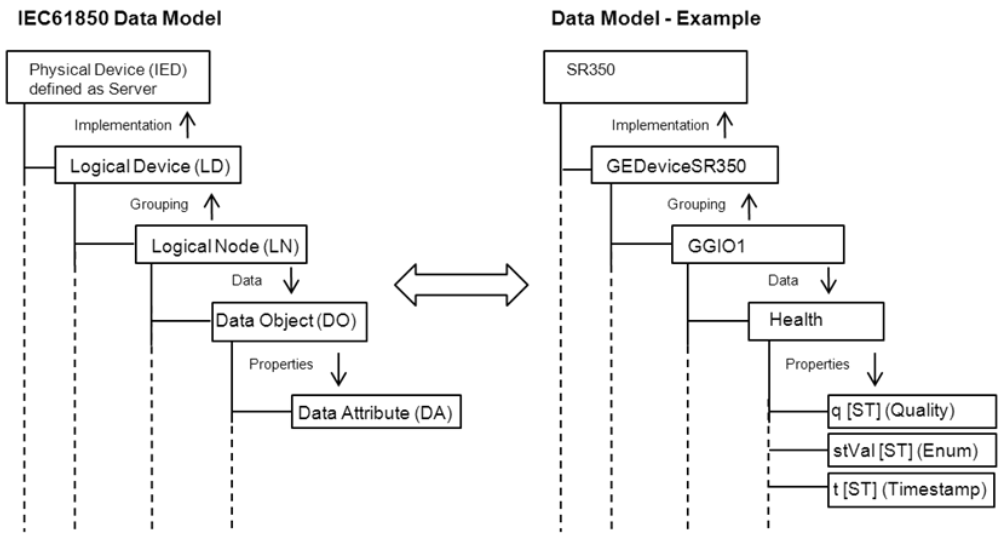
– Logical cNode (LLN0)

– Data Objects (Beh, Health etc)

– Data Attributes (Q, stval, t).

The **IEC 61850 Configurator** displays the variables in the above format. The functional constraints are shown in square bracket [e.g. [ST]/[CF] attached at the end of the variable name.

Figure 80



General Format of PPVs

The general PPV format for representation in RX3i controller variable lists is shown below:

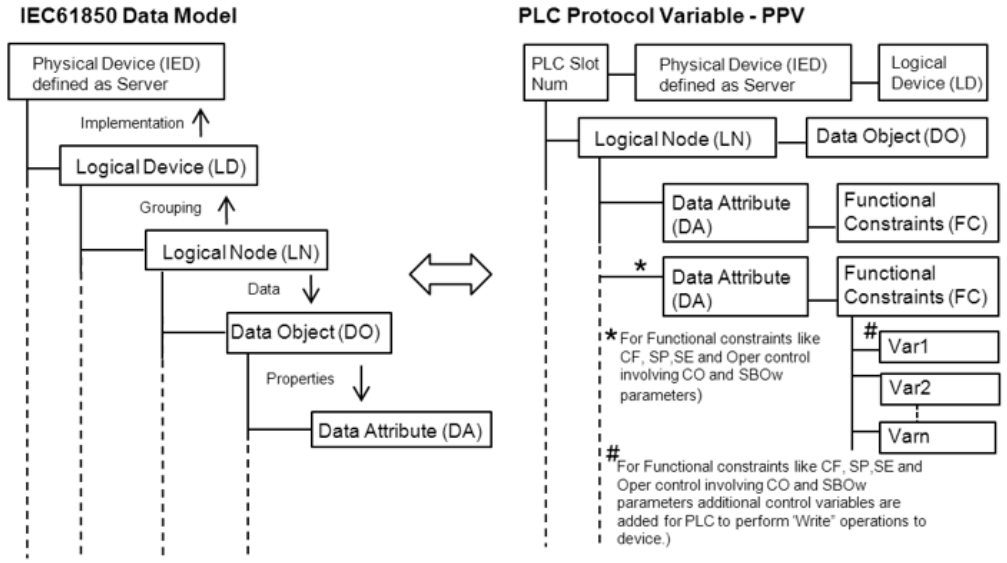
– SlotNum_Physical Device_Logical Device

– Logical Node_ Data Object

– Data Attribute_Functional Constraints

This is illustrated below.

Figure 81



Examples: The following examples show the equivalent PPVs for an IEC 61850 DO/DA variable.

Example#1-Read Variables:

IEC 61850 – Configurator: SR350_DevSR350.LPHD1/Proxy/stVal[ST]

PPV(s) :S4_SR350_DevSR350.LPHD1_proxy.stVal_ST

Example#2-Write Variables:

IEC 61850 – Configurator: Dev.IEDDevice. PTOV1/Mod/subVal[SV] PPV(s):

S8_Dev_IEDDevice.PTOV1_Mod.subEna_SV. WRITEVal

S8_Dev_IEDDevice.PTOV1_Mod.subEna_SV. WRITECmd

S8_Dev_IEDDevice.PTOV1_Mod.subEna_SV. WRITERslt

S8_Dev_IEDDevice.PTOV1_Mod.subEna_SV. ReadVal

Note*:** *These variables are structured variables of symbolic type. These variables can be treated as normal symbolic variables for RX3i controller application programming purposes and all rules of symbolic variables apply to these variables. For more information on PPV mapping , refer to section **4.4.2 IEC 61850 Operation and PPV Mapping.

Creating PPVs

PPVs are automatically created by Machine Edition on successful validation. This action happens when the "IEC 61850 Configurator" dialogue is closed.

The various configuration scenarios related to this dialogue are described in section **3.6.3 Configuration Scenarios for IEC 61850 Configurator.**

4.4.2 IEC 61850 Operation and PPV Mapping

This section describes the mapping between IEC 61850 attributes and PPVs, based on the Functional constraints and operation type.

IEC 61850 Operation Table

Depending of the functional constraints, several operations can be performed. Each operation type except the "Direct Map" operation type has an associated variable set.

Functional Constraints	Identifier	Operation
Status information	†[ST]	Direct Map
Measurands	†[MX]	Direct Map
Control	†.Oper.ctlVal[CO]	Operate
Control	†.SBOw.ctlVal[CO]	Select
Control	†.Cancel.ctlVal[CO]	Cancel
Control	†[CO]	Direct Map (+)
Setpoint	†[SP]	Write
Parameters	†[SE]	Write
Substitution	†[SV]	Write
Configuration	†[CF]	Write
Description	†[DC]	Direct Map(x)

(+) This denotes PPVs which have †.ReadVal extensions

(x) This denotes PPVs which are represented as arrays; string data types, for example

Operation Types

The following operations are performed based on the functional constraints in the table above.

- **Write**

  This operation has different behavior depending of the variable type. A variable set is created with the variable name plus the key word “WRITE”. The variable set includes WRITEVal, WRITECmd, WRITERslt, ReadVal.

- **Operate**

  This operation has different behavior depending of the variable type. A variable set is created with the variable name plus the key word “OPER”. The variable set includes †.OPERVal, †.OPERCmd, †.OPERSts, †.OPERRslt, †.ReadVal.

- **Select**

  This operation has different behavior depending of the variable type. A variable set is created with the variable name plus the key word “SELECT”. The variable set includes †.SELECTCmd, †.SELECTSts, †.SELECTRslt, †.ReadVal.

- **Cancel**

  This operation has different behavior depending of the variable type. A variable set is created with the variable name plus the key word “CANCEL”. The variable set includes †.CANCELCmd, †.CANCELSts, †.CANCELRslt, †.ReadVal.

- **Direct Map**

  The variable is directly mapped to the given variable.

IEC 61850 Attribute and PPV Mapping –Table

The following table provides mapping between IEC 61850 attributes and its mapping with PPVs and associated operation type.

IEC 61850 Attribute and PPV Mapping

Functional Constraints	Identifier	Operation	Variable Examples
Status info	†[ST]	Direct Map	IEC 61850 - Configurator SR350_DevSR350.LPHD1/Proxy/stVal[ST] PLC Protocol Variable(s) S4_SR350_DevSR350.LPHD1_proxy.stVal_ST
Measurands	†[MX]	Direct Map	IEC 61850 - Configurator SR350_DevSR350.MMXU1/A.net/cVal.ang.f[MX] PLC Protocol Variable(s) S4_SR350_DevSR350.MMXU1_A_net.cval_ang_f_MX
Control	†.Oper.ctlVal[CO]	Operate	IEC 61850 - Configurator

Functional Constraints	Identifier	Operation	Variable Examples
			SR350.DevSR350.XCBR1/Pos/Oper.ctlVal [CO] PLC Protocol Variable(s) S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERChk S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERVal S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERCmd S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERSts S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERRslt S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.ReadVal
Control	†.SBOw.ctlVal[CO]	Select	IEC 61850 - Configurator SR350.DevSR350.XCBR1/Pos/SBOw.ctlVal[CO] PLC Protocol Variable(s) S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.SELECTVal S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.SELECTCmd S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.SELECTSts S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.SELECTRslt S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.ReadVal
Control	†.Cancel.ctlVal[CO]	Cancel	IEC 61850 - Configurator SR350.DevSR350.XCBR1/Pos/Cancel.ctlVal[CO] PLC Protocol Variable(s) S4_SR350_DevSR350.XCBR1_Pos.Cancel_ctlVal_CO.CANCELCmd S4_SR350_DevSR350.XCBR1_Pos.Cancel_ctlVal_CO.CANCELSts S4_SR350_DevSR350.XCBR1_Pos.Cancel_ctlVal_CO.CANCELRslt S4_SR350_DevSR350.XCBR1_Pos.Cancel_ctlVal_CO.ReadVal
Control	†[CO]	Direct Map+	IEC 61850 - Configurator SR350.DevSR350.XCBR1/Pos/SBOw.ctlNum[CO] PLC Protocol Variable(s)

Functional Constraints	Identifier	Operation	Variable Examples
			S4_SR350_DevSR350.XCBR1_Pos.SBO_CO.ReadVal
Setpoint	†[SP]	Write	IEC 61850 - Configurator Dev.DevF650.auxPTOV2/PTOVEna/setVal[SP] PLC Protocol Variable(s) S8_Dev_DevF650.auxPTOV2_PTOVEna.setVal_SP.WRITEVal S8_Dev_DevF650.auxPTOV2_PTOVEna.setVal_SP.WRITECmd S8_Dev_DevF650.auxPTOV2_PTOVEna.setVal_SP.WRITERslt S8_Dev_DevF650.auxPTOV2_PTOVEna.setVal_SP.ReadVal
Parameters	†[SE]	Write	IEC 61850 - Configurator Dev.IEDDevice.PTOV1/OpDlTmms/setVal[SE] PLC Protocol Variable(s) S8_Dev_IEDDevice.PTOV1_OpDITmms.setVal_SE.WRITEVal S8_Dev_IEDDevice.PTOV1_OpDITmms.setVal_SE.WRITECmd S8_Dev_IEDDevice.PTOV1_OpDITmms.setVal_SE.WRITERslt S8_Dev_IEDDevice.PTOV1_OpDITmms.setVal_SE.ReadVal
Substitution	†[SV]	Write	IEC 61850 - Configurator Dev.IEDDevice.PTOV1/Mod/subVal[SV] PLC Protocol Variable(s) S8_Dev_IEDDevice.PTOV1_Mod.subEna_SV.WRITEVal S8_Dev_IEDDevice.PTOV1_Mod.subEna_SV.WRITECmd S8_Dev_IEDDevice.PTOV1_Mod.subEna_SV.WRITERslt S8_Dev_IEDDevice.PTOV1_Mod.subEna_SV.ReadVal
Configuration	†[CF]	Write	IEC 61850 - Configurator Dev.IEDDevice.PTOV1/Mod/subVal[SV] PLC Protocol Variable(s) S4_SR350_DevSR350.XCBR1_Pos.ctlModel_CF.WRITEVal S4_SR350_DevSR350.XCBR1_Pos.ctlModel_CF.WRITECmd

Functional Constraints	Identifier	Operation	Variable Examples
			S4_SR350_DevSR350.XCBR1_Pos.ctlModel_CF.WRITERslt S4_SR350_DevSR350.XCBR1_Pos.ctlModel_CF.ReadVal
Description	†[DC]	Direct Map	IEC 61850 - Configurator SR350.DevSR350.MMXU1/A.net/d[DC] PLC Protocol Variable(s) S4_SR350_DevSR350.MMXU1_A_net.d_DC[32]
Parameters	†[SG]	Direct Map	IEC 61850 - Configurator Dev.IEDDevice.PTOV1/TmMult/setMag.f[SG] PLC Protocol Variable(s) S8_Dev_IEDDevice.PTOV1_TmMult.setMag_f_SG

(+) – This refers to the PPV which have †.ReadVal extensions

(x) – This refers to the PPV which are represented as array. E.g. string data types

4.4.3 Read Operations

The PPVs created as described in the section above can be monitored and used in the application logic as normal symbolic variables.

4.4.4 Write Operations

WRITE Operation

You can perform the write operations to IED from the RX3i controller in two steps:

1. Write the command value to the specified **value** variable (†.WRITEVal)
2. Force a rising edge to activate the operation in a specified **command** variable (†.WRITECmd).
3. Check the result of operation is in specified **result** variable (†.WRITERslt).

The above steps can be performed in RX3i controller application using ladder logic.

For each attribute with FC=SP/SV/SE/CF, as seen in the "**IEC 61850 Configurator**

" dialogue, Machine Edition automatically creates a set of PPVs in the PACSystems Machine Edition project with the extensions shown below:

a. †.WRITEVal (Value to be written: Type – Write)
b. †.WRITECmd (Command to transfer value in †.WRITEVal to device: Type – Write)
c. †.WRITERslt (Result of operation – BUSY, ERROR,DONE : Type – Read)
d. †.ReadVal (Value of parameter read from device: Type – Read)

WRITE Operation Example

The example below is for attributes with FC=SP, used for write operation:

IEC 61850 Configurator

The IEC 61850 variable as seen in the Configurator dialogue:

Dev.DevF650.auxPTOV2/PTOVEna/setVal[SP]

PPV (set)

The PPV set that gets created automatically in the RX3i project for the above IEC 61850 variable:

a. S8_Dev_DevF650.auxPTOV2_PTOVEna.setVal_SP.WRITEVal
b. S8_Dev_DevF650.auxPTOV2_PTOVEna.setVal_SP.WRITECmd
c. S8_Dev_DevF650.auxPTOV2_PTOVEna.setVal_SP.WRITERslt
d. S8_Dev_DevF650.auxPTOV2_PTOVEna.setVal_SP.ReadVal

WRITE Operation with PPV

The following steps needs to be performed in RX3i controller application:

1. Step1: Write value to be written to device in the PPV with extension (†.WRITEVal). e.g. S8_Dev_DevF650.auxPTOV2_PTOVEna.setVal_SP.WRITEVal
2. Step2: Issue a transition from "0" to "1" in the PPV with extension (†.WRITECmd) to trigger the transfer of written value in step#1 to the IED.

   e.g. S8_Dev_DevF650.auxPTOV2_PTOVEna.setVal_SP.WRITECmd
3. Step3: Check the PPV with extension (†.WRITERslt) for success (1).

   e.g. S8_Dev_DevF650.auxPTOV2_PTOVEna.setVal_SP.WRITERslt

   [WRITERslt returns code:

   0: BUSY

   1: DONE

   2: ERROR]
4. Step4: Check that the written value has been updated in device by reading the PPV with extension (†.ReadVal)

   e.g. S8_Dev_DevF650.auxPTOV2_PTOVEna.setVal_SP.ReadVal

4.4.5 Control Operations

The control operations include operation like Operate, Select, Cancel. These are typically used for IED controls. The ECM850 supports the command 'direct operate' and 'select before operate' (SBO) in normal and in enhanced security.

In operation-"Operate", the ECM850 automatically checks the actual Control Model and executes the command in the corresponding way.

Commands and Control Models

For this, first attribute †/ctlModel[CF] of the Data Object is read out internally by ECM850 and depending on the value of this attribute, the corresponding command is executed using the respective Control model:

- Value 0: no action, execute command not possible (status only)

- Value 1: an 'Operate' service (direct control with normal security) is executed.
- Value 2: 'Select' and 'Operate' services (select before operate with normal security) are executed.
- Value 3: an 'Operate' service (direct control with enhanced security) is executed.
- Value 4: 'SelectWithValue' and 'Operate' services (select before operate with enhanced security) are executed.

Command Details

Operate command: The value is set directly to †/Oper[CO].

Select commands are processed sequentially:

- Select command normal security: read from †/SBO[CO], write to †/Oper[CO].
- Select command enhanced security: write to †/SBOw[CO], write to †/Oper[CO].

The required command sequences are automatically performed in the right sequence by the ECM850. No further configuration steps are necessary.

In addition to this, the ECM850 supports manual **Select** and **Cancel**. The ECM850, according to the ctlModel of the Data Object, executes the **Select** (only when ctlModel=2 or 4).

The values of ctlModel=0, 1 or 3 are treated as negative answer of Select.

When the IEC 61850 server responds, as Select positive, the client module stores information about selected Data Object and in the following command (in the following "OPERATE" operation) executes only the Operate

OPERATE operation

The control operations can executed using "Operate operation on PPV" for (†.Oper.ctlVal[CO]). This is described in detail with example as below:

For the attribute with (†.Oper.ctlVal[CO]), as seen in the IEC 61850 Configurator, Machine Edition on validation automatically creates a set of PPVs in the RX3i project with extensions as below:

a. †.OPERChk (Check for interlock & Synchrocheck to be written: Type - Write)
b. †.OPERVal (Value to be written: Write)
c. †.OPERCmd (Trigger cmd to transfer value in †.OPERVal to device: Type - Write)
d. †.OPERSts (Result of operation –Success or failure with error code: Type - Read)
e. †.OPERRslt (Result of operation –Success or failure with error code: Type - Read)
f. †.ReadVal (Actual value of parameter from Device: Type - Read)

These PPVs can be used to perform control operations to the device.

OPERATE Operation Example

The example below is describes "Operate Operation with PPV":

IEC 61850 Configurator

The IEC 61850 variable as seen in the Configurator dialogue:

SR350.DevSR350.XCBR1/Pos/Oper.ctlVal[CO]

PPV (set)

The PPV set that gets created automatically in the RX3i project for the above IEC 61850 variable:

a. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERChk
b. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERVal
c. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERCmd
d. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERSts
e. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERRslt
f. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.ReadVal

OPERATE with PPV

If the user application needs to write a value to such a writable data attribute, the following steps must be performed in the RX3i controller:

1. Step1: Write value in PPV with extension (†.OPERChk) as required:

   0: No check

   1: Interlock check

   2: Synchro check

   3: Interlock and Synchro check

   e.g. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERChk

2. Step2: Write value to be written to device in the PPV with extension (†.OPERVal).

   e.g. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERVal

3. Step3: Provide a transition from “0” to “1” in the PPV with extension (†.OPERCmd) to trigger the transfer of written value to the IED.

   e.g. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERCmd

4. Step4: Check the PPV with extension (†.OPERSts) for status code.

   e.g. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERSts

   [OPERSts returns code:

   0: BUSY

   1: DONE

   2: ERROR]

5. Step5: Check the PPV with extension (†.OPERRslt) for success (1).

   e.g S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERRslt

   [WRITERslt > 0, it returns IEC 61850 AddCause

   WRITERslt < 0 internal error code:

   -1, wrong parameter in (†.WRITEVal)

   -2, driver not loaded

   -3, write command cannot be issued (e.g. not valid server)]

   Refer to **Table for Add Cause**, below.

6. Step6: check that the written value has been updated in the PPV with extension (†.ReadVal)

   e.g. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.ReadVal

SELECT Operation

The control operations can executed using "SELECT operation on PPV" for (†.Oper.ctlVal[CO]). This is described in detail with example as below:

For the attribute with (†.SBOw.ctlVal[CO]), as seen in the IEC 61850 Configurator, Machine Edition on validation automatically creates a set of PPVs in the project with extensions as below:

a. †.SELECTVal (Value to be written: Write)
b. †.SELECTCmd (Trigger cmd to transfer value in †.SELECTCmd to device: Write)
c. †.SELECTSts (Result of operation –Success or failure with error code: Read)
d. †.SELECTRslt (Result of operation –Success or failure with error code: Read)
e. †.ReadVal (Actual value of parameter from Device: Read)

These PPVs can be used to perform SELECT operation to the device.

SELECT Operation Example

The below is example describing Select operation using "Select Operation with PPV":

IEC 61850 - Configurator

The IEC 61850 variable as seen in the Configurator dialogue:

SR350.DevSR350.XCBR1/Pos/SBOw.ctlVal[CO]

PPVs (set)

The PPV set that gets created automatically in the project for the variable above is:

a. S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.SELECTVal
b. S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.SELECTCmd
c. S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.SELECTSts
d. S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.SELECTRslt
e. S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.ReadVal

SELECT operation on PPV

If the user has to write a value to such a data attribute, then the following steps need to be performed in logic:

1. Step1: Write value to be written to device in the PPV with extension (†.SELECTVal).

   e.g. S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.SELECTVal

2. Step2: Provide a transition from "0" to "1" in the PPV with extension (†.SELECTCmd) to trigger the transfer of written value to the IED.

   e.g. S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.SELECTCmd

3. Step3: Check the PPV with extension (†.SELECTSts) for status code.

   e.g. S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.SELECTSts

[SELECTSts returns code:

0: BUSY

1: DONE

2: ERROR]

4. Step4: Check the PPV with extension (†.SELECTRslt) for success (1).

   e.g S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.SELECTRslt

   [SELECTRslt > 0, it returns IEC 61850 AddCause

   SELECTRslt < 0 internal error code:

   -1, wrong parameter in (†.SELECTVal)

   -2, driver not loaded

   -3, write command cannot be issued (e.g. not valid server)]

   Refer to **Table for Add Cause**, below

5. Step5: check that the written value has been updated in the PPV with extension (†.ReadVal)

   e.g. S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.ReadVal

CANCEL Operation

The control operations can executed using "CANCEL operation on PPV" for (†.Cancel.ctlVal[CO]). This is described in detail with example as below:

For the attribute with (†.Cancel.ctlVal[CO]), as seen in the IEC 61850 Configurator, Machine Edition on validation automatically creates a set of PPVs in the project with extensions as below:

a. †.CANCELCmd (Trigger command to Cancel the operation to device: Type - Write)
b. †.CANCELSts (Status of operation –with code: Type - Read)
c. †.CANCELRslt (Result of operation –Success or failure with error code: Type - Read)
d. †.ReadVal (Actual value of parameter from Device: Type - Read)

These PPVs can be used to perform CANCEL operation to the device.

CANCEL Operation Example

The below is example describing Cancel operation using "Cancel Operation with PPV":

IEC 61850 - Configurator

The IEC 61850 variable as seen in the Configurator dialogue:

SR350.DevSR350.XCBR1/Pos/Cancel.ctlVal[CO]

PPV (set)

The PPV set that gets created automatically in the project for the variable above:

a. S4_SR350_DevSR350.XCBR1_Pos.Cancel_ctlVal_CO.CANCELCmd
b. S4_SR350_DevSR350.XCBR1_Pos.Cancel_ctlVal_CO.CANCELSts
c. S4_SR350_DevSR350.XCBR1_Pos.Cancel_ctlVal_CO.CANCELRslt
d. S4_SR350_DevSR350.XCBR1_Pos.Cancel_ctlVal_CO.ReadVal

CANCEL operation on PPV

If the user has to write a value to a data attribute, the following steps need to be performed in logic:

1. Step1: Provide a transition from "0" to "1" in the PPV with extension (†.CANCELCmd) to trigger the transfer of written value to the IED.

   e.g. S4_SR350_DevSR350.XCBR1_Pos.Cancel_ctlVal_CO.CANCELCmd

2. Step2: Check the PPV with extension (†.CANCELSts) for status code.

   e.g. S4_SR350_DevSR350.XCBR1_Pos.Cancel_ctlVal_CO.CANCELSts

   [CANCELSts returns code:

   0: BUSY

   1: DONE

   2: ERROR]

3. Step3: Check the PPV with extension (†.CANCELRslt) for success (1).

   e.g S4_SR350_DevSR350.XCBR1_Pos.Cancel_ctlVal_CO.CANCELRslt

   [CANCELRslt > 0, it returns IEC 61850 AddCause

   CANCELRslt < 0 internal error code:

   -1, wrong parameter

   -2, driver not loaded

   -3, write command cannot be issued (e.g. not valid server)]

   Refer table - **Table for Add Cause**

4. Step5: check that the written value has been updated in the PPV with extension (†.ReadVal)

   e.g. S4_SR350_DevSR350.XCBR1_Pos.Cancel_ctlVal_CO.ReadVal

Table for Add Cause

The value given by the Result variable is defined in the following table.

Add Cause

Value	State
1	state_not_supported
2	state_blocked_by_switching_hierarchy
3	state_select_failed
4	state_invalid_position
5	state_position_reached
6	state_parameter_change_in_execution
7	state_step_limit
8	state_blocked_by_mode
9	state_blocked_by_process
10	state_blocked_by_interlocking

Value	State
11	state_blocked_by_synchrocheck
12	state_command_already_in_execution
13	state_blocked_by_health
14	state_1_of_n_control
15	state_abortion_by_cancel
16	state_time_limit_over
17	state_abortion_by_trip
18	state_object_not_selected

4.5 Performance Factors

There are many factors that affect the timing of I/O as it flows through the system. Primary factors include:

- CPU Sweep Time
- Configured Polling rate for each IED
- Configured Reports (unsolicited communication)
- Number of IEDs connections
- Amount of Protocol I/O data exchanges (in Kbytes)
- Network latency and loading (for example, switching hardware, additional non-IEC 61850 network traffic)

When designing an IEC 61850 IO system, consider and weigh these factors appropriately to achieve an optimal system for the application.

The size of the combined protocol I/O memory (Kbytes) has direct impact on the CPU sweep time. Hence refer to sweep impact data when designing IEC 61850 systems (**Appendix B: IEC 61850 I/O Performance Examples**).

The constraints related to CPU memory needs to be taken into account, especially for CPE305/CPE310 which has comparatively less user memory. It should also be noted that the IEC 61850 variables consume the symbolic memory spaces, hence system design should incorporate such factor and check to ensure that CPU has sufficient memory for performing logic operations.

4.6 RX3i CPU Operations for ECM850

This section describes several RX3i CPU functions as related to their operation when used with an ECM850.

4.6.1 SVC REQ for Enabling or Disabling Protocol Outputs

SVC REQ 47 block is provided for enabling or disabling Protocol Outputs.

The application can be used to trigger “Enabling” or “Disabling” of Protocol outputs. If the Protocol outputs are enabled, then output commands coming from RX3i CPU to the

ECM850 will be given to the IEDs over wire. If the Protocol outputs are disabled for an EMC850 module, then output commands coming from Rx3i CPU will be blocked and commands or controls will not reach the IEDs.

Bit:10 in the “ModuleStatus” for each ECM850 (Outputs Disabled) provides the status of Protocol outputs.

This SVC REQ block is available for all PACSystems RX3i CPUs on which ECM850 is supported. However, this can be used to disable protocol outputs on standby units in HSB system to handle HSB scenarios like SAU/SBU, NSAU, Mode transitions. Refer to the Hot standby operation for ECM850 for details.

Instructions for Usage

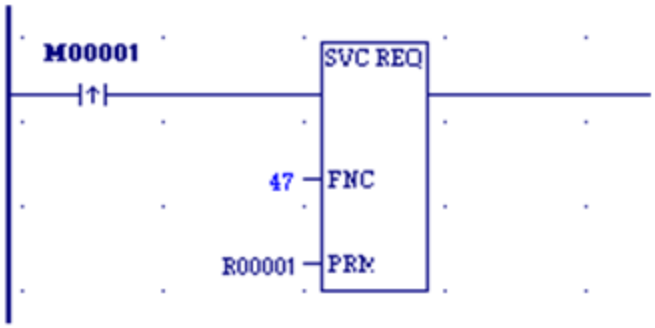
The parameter block has a length of 2 WORDs. It is an input parameter block only.

address	Module Slot (low byte)
	Module Rack (high byte)
address + 1	0 = Enable Protocol Outputs
	1 = Disable Protocol Outputs

Example

A switch on a control console is wired to %M00001, the input to the SVC_REQ 47 instruction. When closed, the switch will activate the SVC_REQ 47, causing the ECM850 output production to be enabled or disabled.

Figure 82



Instruction Timing

The execution times of the SVC_REQ 47 block in RX3i CPUs is given in the table below.

SVC_REQ	CPE305, CPE310		CPU310		CPU315		CPU320, CRU320[1]	
	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)
47	5.343	1.149	NA	NA	3.583	0.832	3.377	0.818

NA = not applicable (CPU310 does not support SVC_REQ 47).

[1] Due to Error Checking and Correction (ECC), the CRU320’s times are approximately 5% slower on average than the CPU320’s.

4.6.2 Reset Smart Module for ECM850

Service Request 24, Reset Smart Module can be used to reset an ECM850 in the RX3i CPU rack. The result is the same as extracting the ECM850 from the rack then re-inserting it.

When the RX3i CPU encounters the Reset Smart Module service request in the application logic, it issues a reset command to the specified module (in this case, a ECM850). The ECM850 terminates all connections to IEC 61850 devices. When the ECM850 powers up and re-establishes communications with the CPU, the CPU sends the ECM850 its configuration, and the ECM850 re-establishes connections with all its configured IEC 61850 devices.

The Reset Smart Module request cannot be used to reset modules located in remote nodes.

4.6.3 Unsupported Features

The following are features that are not supported by ECM850

- Run Mode Store
- DO IO
- SCAN SET
- Remote Operation

4.7 Network Time Synchronization

4.7.1 Configuring SNTP for ECM850

In Machine Edition's Hardware Configuration for the ECM850 on the Settings tab, configure the items as described in the following sections.

Network Time Sync:
The location that the time stamp value for a ECM850 Local Log and IEC 61850 outputs is obtained from.

- None: The time stamp value for an ECM850 Local Log and IEC 61850 outputs is obtained from the ECM850 local time (which is synchronized at power-up/restart with controller's local clock). Time stamps of IEC 61850 outputs obtained by an ECM850 with this setting (None) will not be in synchronization with the time stamps of IED.
- SNTP (Simple Network Timing Protocol): The time stamp value for a Local Log and IEC 61850 outputs is obtained from the ECM850 which is synchronized to a central clock, located on a user-supplied SNTP time server on the network. All ECM850s configured with this setting (SNTP) have synchronized time stamps. Synchronized time stamps enable you to compare groups of data to determine the order in which they were written or to determine when outputs written to IED.

4.7.2 SNTP Operation

An SNTP network server sends out a periodic timing message to all SNTP-capable Ethernet interfaces on the network. The presence of an SNTP server on the network this allows the ECM850 synchronize its internal clock with this SNTP timing message. The default mode of SNTP operation is Broadcast and Multicast.

Note: *The use of SNTP Servers dated before January 1, 1989 is not supported.*

4.7.3 Multiple SNTP Servers in a Network

To guard against loss of SNTP timing messages, multiple SNTP servers can be tracked on a network. The ECM850 maintains timing information from up to four SNTP servers. Each server assigns a stratum number that determines its priority. ECM850 uses the message from the server with the lowest stratum number until communication with that server is lost. (A server is considered lost if more than 150 seconds elapse between its timing messages.) If communication with a server is lost, the ECM850 synchronizes with the server with the next lowest stratum number as soon as two of its timing messages are received within a 150-second period.

4.7.4 Loss or absence of SNTP Timing Signals

If the ECM80 is configured for SNTP, but fails to receive timing messages from an SNTP network time server within a 150 second period, the ECM850 does the following:

1. A fault is logged in the RX3i Controller Fault Table.
2. A fault is logged in the Local Log of the ECM850.
3. The ECM850 continues to use the time synchronized at power-up/restart with the controller's local clock, or
4. it continues to use the most recently synchronized time from SNTP Server before that signal was lost.

For more information on SNTP events, refer to **SNTP Events** in **section 5.6.2** .

For more information on the SNTP CLI command, refer to section **A-3 ECM850 Commands, Show Sntpstat.**

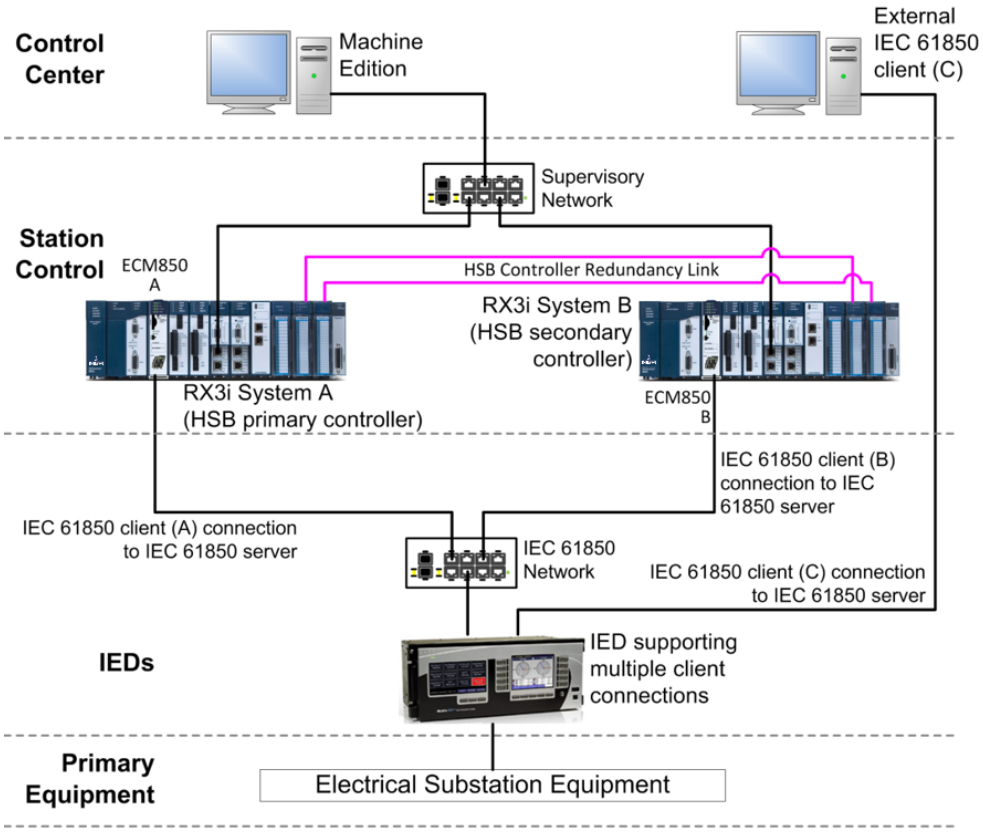
4.8 Hot Standby (HSB) Operation for ECM850

The ECM850 can be used with PACSystems RX3i Hot standby system with RX3i CRU320. This section describes how the ECM850 can be used in such system. Refer to the PACSystems Hot Standby CPU Redundancy User's Manual, GFK-2308 for details of Hot standby operation.

4.8.1 Basic HSB System Overview

The basic system architecture for an HSB system with an ECM850 and IEC 61850 network is shown in the diagram.

Figure 83



The ECM850 can be configured in each CRU system. Each ECM850 communicates with the same IED and establishes an association. The IED must be configured for connecting with two or more IEC 61850 client devices. In this example, there are three IEC 61850 Client devices (ECM850-A in the Primary RX3i controller, ECM850-B in the Secondary RX3i controller and a third client, Machine-C), The server publishes data to all three clients over the IEC 61850 network.

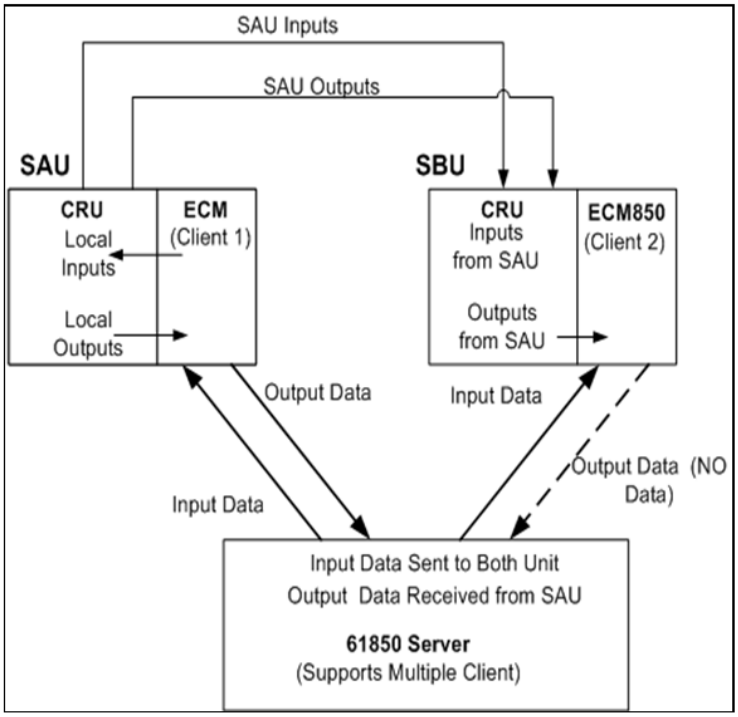
***Note*:**	*IEDs used with the ECM850 must have the capability to connect with multiple IEC 61850 Clients. If an IED is not configured to connect with multiple IEC 61850 clients, then the HSB system with ECM850(s) will not work as described, and one or more of the HSB systems (Primary or Secondary) may not be able to connect with the IED.*

4.8.2 Protocol Output Control for HSB system

The ECM850 acting as IEC 61850 client on both the active and standby units connect to the IED and fetches input data from the device. Only the active unit (SAU), however, controls the application using input data from the ECM850 on the active controller. The active unit (SAU) takes control of the outputs. The input data and output data are transferred as part of the “Transfer List” from the active unit (SAU) to the standby unit (SBU) and hence data is overridden in the SBU. However, the output commands/controls from the SBU should not be issued to the IED. The “Protocol Outputs” should be enabled only for the SAU and disabled for the SBU. This is depicted in the diagram below.

The HSB concept (produce output data on the wire only on the active unit) is illustrated in the figure and explained below:

Figure 84



SAU – Synchronized Active Unit

SBU – Synchronized Backup Unit

- Both ECM850s maintain IEC 61850 connections to the IED (IEC 61850 Server device). Only the ECM850 on the SAU, however, produces outputs on wire. The ECM850 on the SBU unit has a connection with the IED but does not send any write requests to the IED on wire.
- Protocol Input and Output Variables are configured in the Transfer list of the CRU.
- Both Primary and Secondary ECM850s reads Input data from the IED. However, the SBU's Input data is overwritten by the SAU input data via Transfer list synchronization.
- The SAU drives Output data to the IED. The Output Data on the SBU is overwritten by the SAU's output data via Transfer list synchronization. The ECM850 on the SBU, however, will not write this synchronized Output data to the IED on wire.

4.8.3 Enabling or Disabling Protocol Outputs

A SVC REQ block is provided for enabling or disabling Protocol Outputs. This is described in section **4.6.1 SVC REQ for Enabling or Disabling Protocol Outputs**.

4.8.4 Status Reporting for Protocol Outputs State

The ECM850 Protocol Outputs state can be determined from Bit 10 (Outputs Disabled) of the Status information.

Bit 10: “1” indicates Protocol outputs are disabled and outputs not sent on the wire over the protocol

Bit 10: “0” indicates Protocol outputs are enabled and outputs sent on the wire over the protocol

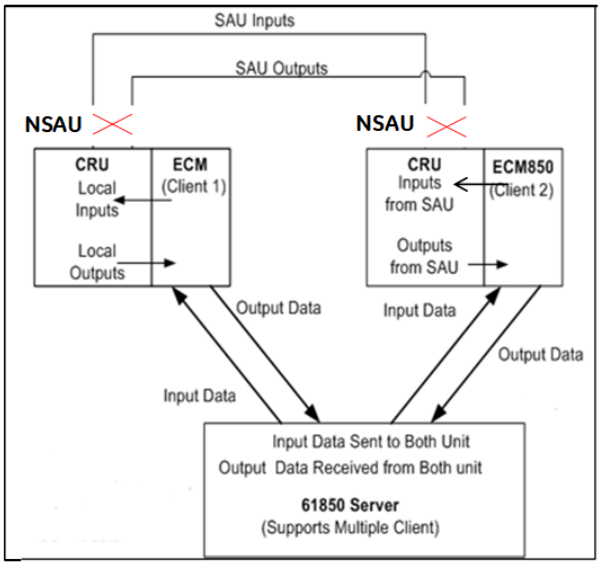
4.8.5 Application logic for handling HSB System

The Application logic needs to implement a control “Enable” or “Disable” of Protocol Outputs for ECM850 by using the SVC REQ block. The SAU should always drive the Protocol Outputs to the IED and the SBU should block or disable Protocol Outputs. The logic should include all required interlocks and check for other important application and system aspects for this control, also it should handle role change scenario and a special scenario, where both RX3i controller units are Non synchronized active units.

4.8.6 Non-Synchronized Active Unit (NSAU) Scenarios

On event of redundancy link failure, both of the units, becomes NSAU. In such scenario, the IED will be controlled by two IEC 61850 clients (ECM850-A and ECM850-B). This is depicted in the diagram below.

Figure 85



- Both units are acting as Non-Synchronized Active Unit in the event of a redundancy link break
- Both ECM850s maintain active IEC 61850 connections to the IED.
- No Transfer list exchanges between CRUs.
- Both ECM850’s in Primary and Secondary will read Input data from IED independently at respective rates.
- Both ECM850’s will Write Output Data to IED as if two separate Clients are controlling a single IED.

The following are options for handling this situation:

- If both are NSAU, then break the IEC 61850 connections for ECM on Secondary CRU, such that protocol Outputs are not driven by Secondary ECM.
- If both are NSAU, then the unit which was Standby before the link break, should be put in STOP mode. This will ensure that protocol Outputs are not driven by two clients at the same time.
- If one of them is NSAU, then protocol Outputs are driven by ECM with NSAU irrespective of Primary or Secondary system. This can be possible if the other CPU is fault mode.

4.8.7 HSB Configuration Using Machine Edition

Machine Edition supports configuring ECM850 in a CRU Target. The mirroring of the hardware configuration (HWC) from Primary to Secondary also includes mirroring of the ECM850 configuration. The transfer list for the ECM850 has to be manually configured for including IEC 61850 PPVs.

Chapter 5: Diagnostics

This chapter describes:

- Powerup and Reset
  - Module Restart
  - Problems During Powerup and Reset
  - Transitioning to Firmware Update Mode
- Special LED Blink Patterns
  - Special LED Patterns - Module Identification
  - Special LED Patterns – Microprocessor Overtemperature
- Fatal Error Reporting
- Status Reporting
  - IED Connection status
- Fatal Error Reporting
- ECM850's Local Log Table
  - Local Log Table-Only Faults
  - Viewing and Clearing the Local Log Table
- ECM850 Faults in the RX3i Fault Tables
  - Clearing the RX3i Fault Tables
  - Faults Reported to the RX3i Controller Fault Table
  - Faults Reported to the RX3i I/O Fault Table

5.1 Powerup and Reset

During powerup and reset, the ECM850 runs diagnostics and initializes its hardware components. When the necessary hardware components have been initialized and tested, the ECM850 transitions to either normal operation or firmware update mode.

As the module transitions to normal operation, it adds a startup entry that provides a reason for the restart in its Local Log table. This entry is normal.

5.1.1 Module Restart

The ECM850 restarts if it receives a Reset signal from the RX3i CPU, if the Restart Pushbutton is pressed, if the restart or default command is issued from the Command Line Interface, or if the hardware watchdog timer expires. More details on each type of restart are given below.

When the ECM850 is restarted, it retains any entries in its Local Log table and its non-volatile configuration parameters. Any debug data in non-volatile storage can be viewed from the Command Line Interface using the log or show log command.

Restart Triggered by Reset Signal from the RX3i CPU

The RX3i CPU resets/restarts the ECM850 if:

- The application logic executes SVC_REQ #24, specifying the rack and slot of an ECM850.
- The RX3i CPU loses communications with the ECM850.
- The ECM850 requests the RX3i CPU to reset / restart it (for example, as a result of a restart or default Command Line Interface command execution).

Restart Triggered by Restart Pushbutton

Pressing and releasing the ECM850's Restart pushbutton resets the hardware, turns OFF all LEDs briefly and initiates the module's power-up sequence. The Restart pushbutton may also be used to restart the module if the STATUS LED is blinking an error code upon hardware or runtime failure or if the module locks up.

Restart Triggered by Restart and Default Command

Issuing a restart or default command from the Command Line Interface causes the ECM850 to restart. Modify-level privileges are required to issue these commands.

Restart Triggered by Hardware Watchdog Timer

The ECM850 maintains a hardware watchdog timer that will restart the module in the event that it is unable to carry out its normal processing. The RX3i CPU is not able to access the ECM850's shared memory while the ECM850 is restarting.

After the restart, the module's Local Log table is restored from NVRAM. The ECM850 logs a Watchdog Timer Expired fault in the RX3i CPU's IO Fault Table, and a Restart Event in its local log table.

5.1.2 Problems during Powerup and Reset

Certain conditions can prevent the module from powering up and becoming operational or entering firmware update mode:

Problem	Indication	Action
Hardware failure	All Indicator LEDs off. Module unresponsive.	Contact Technical Support to arrange for repair and replacement
Invalid bootstrap image		
Invalid boot image	No Indicator LEDs turn on and the module is unresponsive, or The STATUS LED is solid Green and is the only LED that is on.	
Power-up diagnostics/hardware initializations fail that are considered fatal	LED Fatal Error blink code, as described in this chapter.	Note the blink code and contact Customer Service.
Non-Fatal diagnostic/hardware initialization faults	The module continues normal power-up, but an entry is added to the Local Log table and the RX3i CPU's fault table (if backplane communications have been established).	Note the fault and contact Customer Service.
The module does not contain hardware identity information	LED Fatal Error blink pattern, as described in this chapter.	Note the blink code and contact Customer Service.

5.1.3 Transitioning to Firmware Update Mode

The module transitions to firmware update mode for any of the following reasons:

1. Winloader has commanded the module to enter firmware update mode. This is normal when a firmware update has been initiated from Winloader.
2. The ECM850 does not have a valid firmware image at power-up. The ECM850 performs checks to determine the firmware image is valid and has not been corrupted before it begins execution. If the validation fails, firmware update mode is activated until a valid image has been stored.

For more information about firmware update mode and using Winloader, please see Chapter 2:, Installation.

5.2 Special LED Blink Patterns

In addition to the LED blink patterns that indicate a fatal error, the ECM850's LEDs can indicate module location/identification and microprocessor overtemperature conditions, as described below.

5.2.1 Special LED Patterns - Module Identification

The LEDs on an ECM850 can be commanded to repeatedly turn ON and OFF in a special sequence, to help locate or identify the module:

- First the LEDs are turned on in the following order: OK, LAN, STATUS, CONN, PORT 4, PORT 3, PORT 2, PORT 1. There is a short delay between turning on each LED.
- The LEDs are then turned off in the same order. There is a short time delay between turning off each LED.

The command blinkId **<begin/end>** is issued via the Command Line Interface. Issuing the **blinkId begin** command starts the identification blink sequencing, while blinkId end stops the identification blink sequencing. When issued from the Command Line Interface, the last command session that commands the IDENTIFICATION blink pattern determines its state (either blinking or stopped). Note that the blinkId command requires Modify-level access to the Command Line Interface.

5.2.2 Special LED Patterns - Microprocessor Over temperature

If the maximum threshold temperature for the ECM850's microprocessor is crossed, the ECM850 goes into power-saving mode. While the ECM850 is in an over temperature condition, LEDs on the module flash at half-second intervals:

OK green

LAN green

STATUS green

CONN amber,

ACTIVE green, USB red

P1 and P2 green

The ECM850 stays in power-saving mode until the temperature drops to a safer level. Once a safe temperature is reached, the ECM850 restarts. When the ECM850 is restarted, it retains any entries in its Local Log table and its non-volatile configuration parameters. Any debug data in non-volatile storage can be viewed from the Command Line Interface using the log or show log command.

***Note*:** *Under certain ambient operating temperatures, the ECM850 may momentarily display the over temperature pattern during power up, while it is calibrating its thermal protection functions. This indication may be ignored, and no overtemperature entry is added to the Local Log table, the Controller Fault table or I/O Fault table.*

5.3 Status Reporting

The ECM850 provides 32 bits of status information to a configured location in the RX3i CPU's reference memory.

The status data consists of the Module OK bit, which indicates the health of the module itself, a status bit for each external port, and a bit that indicates the connection status of the configured devices.

All Status bits are active high. The status location may be configured in %I, %Q, %AI, %AQ, %R, %G, %T, %M or %W or I/O Variable reference memory in the RX3i CPU.

Bit	Name	Description
1	Module OK	Indicates the health of the ECM850. 1 indicates the module is functioning properly. 0 indicates the module is powering up or has failed.
2	Port1 Link Up	1 indicates the port is connected to another device and is operating correctly. 0 indicates the port is not connected to another device or has an error preventing communications.
3	Port2 Link Up	1 indicates the port is connected to another device and is operating correctly. 0 indicates the port is not connected to another device or has an error preventing communications.
4	Port3 Link Up	1 indicates the port is connected to another device and is operating correctly. 0 indicates the port is not connected to another device or has an error preventing communications, or the SFP cage is empty or has an incompatible SFP device.
5	Port4 Link Up	1 indicates the port is connected to another device and is operating correctly. 0 indicates the port is not connected to another device or the port has an error preventing communications, or the SFP cage is empty or has an incompatible SFP device.
6-8	Reserved	Reserved. Always 0.
9	All Devices Connected†	1 indicates all configured devices are connected and communicating over IEC 61850. 0 indicates no devices are configured or one or more configured devices have not established an IEC 61850connection.
10	Outputs Disabled	1 indicates Protocol outputs are disabled and outputs are not sent on the wire over the protocol 0 indicates Protocol outputs are enabled and outputs are sent on the wire over the protocol
11-32	Reserved	Set to 0

† Individual device status (as reported by the Health status variable for individual IED) are updated prior to the All Devices Connected bit. Therefore, it is possible (depending on ECM850 loading) to see via the Health status variables that every individual device is connected while the All Devices Connected bit is not yet set. To avoid this inconsistency, it is recommended that the All

Devices Connected bit be checked first, before checking individual device connection status using the Health status variables.

5.3.1 IED Connection Status

The communication between an ECM850 and an IED can be verified using the Status Variable of each IED. The IED device status variable (ConnectionState) gets automatically created, when you add a new Master/port or Server Device. This "ConnectionState" variable provides the status of IED connection. Each device has an associated health status variable which is available in PPV format as described below:

In the Variables tab of the Navigator, expand the variable list of the intended target.

1. Expand the UDT instance Sxx[1] _ IEDHealth and find the status variables listed for all the IEDs configured for that ECM module.
2. Check the status of each IED in the Watch window.
3. The Status Variable is of type DWORD with a length of 32 bits. The bit description of the status data is as shown below.

ConnectionState (or) Sxx[1]_IEDHEALTH.nnn[2]_Sts	Primary Connection Status	Redundant Connection Status
TCP CONNECTED	0x0000 0002	0x0000 0020
TCP CONNECTING	0x0000 0004	0x0000 0040
TCP CONNECT FAILED	0x0000 0008	0x0000 0080
MMS[3] INITIALIZED	0x0001 0000	0x0100 0000
MMS RCB[4] ENABLE FAILED	0x0002 0000	0x0200 0000

[1] xx - Slot number where the ECM850 resides

[2] nnn - IED (IEC 61850 Server device) Name

[3] MMS (Manufacturing Message Specification)

[4] RCB (Report Control Block)

Example:
If an IED is connected and communicating in a Primary Connection the status value will be 16#0001 0002. If an IED is connected and communicating in a Redundant Connection the status value will be 16#01000020.

This can be used by the application logic to take a corrective action or turn on an indicator if a specific device fails. It might also be used by a custom HMI to show which IEC 61850 device connections are currently established.

It is recommended that the *All Devices Connected* status bit be checked first in the "Module Status" to determine whether all devices belonging to the ECM850 are functioning. If this bit is 0, indicating that one or more devices is not OK, the specific health status can then be used to determine which specific devices are not communicating. For details on this status bit, refer to "Status Reporting".

5.4 Fatal Error Reporting

If the ECM850 encounters a Fatal error, it tries to save diagnostic information to non-volatile storage. The RX3i CPU then resets the ECM850.

Diagnostic information can be viewed from the Command Line Interface using the show debug fataIInfo command.it, refer to “Status Reporting”.

5.5 ECM850’s Local Log Table

The ECM850’s local log table contains entries indicating events and errors. There can be three types of entries in the local log table:

- Local faults. These are viewable only using the module’s Command Line Interface.
- Controller faults. These can also be seen in the RX3i CPU Controller fault table, if the ECM850 was connected to the RX3i CPU at the time the entry was added to the log.
- I/O faults. These can also be seen in the RX3i CPU I/O Fault table, if the ECM850 was connected to the RX3i CPU at the time the entry was added to the log.

The ECM850 maintains the entries in its local log table until they are cleared from the Command Line Interface. Entries in the local log are preserved across power-cycles.

The Local Log table can only be cleared from the Command Line Interface using the clear log command. Clearing the RX3i CPU fault tables or restarting the ECM850 does NOT clear the local log table.

If the ECM850’s Local Log table overflows, new entries overwrite the oldest entries, which are lost. If that happens, the Command Line Interface indicates the number of entries that have been discarded. The count of discarded entries is reset to zero when the local log table is cleared.

The ECM850’s STATUS LED provides an indication that a new fault has been added to the module’s local log since either the last time the module was restarted, or since the last time the log was cleared. The STATUS LED is ON at powerup, after the Local Log has been cleared, or after executing the *clear statLED* command from the Command Line Interface. When a fault occurs the STATUS, LED turns OFF to indicate that a new fault has been logged.

5.5.1 Local Log Table-Only Faults

The following faults appear only in the local log table of the ECM850. They have an Entry Type of Local Fault, when viewed using the Command Line Interface log details command. The Local Log Table also contains the faults that are reported to the RX3i CPU. Those faults, which are listed later in this chapter, are not repeated here.

Local Log Table-Only Faults

Group-Error Code	Description	Cause	Recommended Action
2-1	ECM850 restarted.	The ECM850 has experienced a restart. Possible causes include: • ECM850 power-cycled • ECM850 reset button pushed • ECM850 command shell command to reset board issued • ECM850 F/W updated • ECM850 exceeded safe operating temperature • H/W watchdog timer expired • Internal fatal error encountered The reason for the reset is indicated by the description shown when displaying the fault.	If the restart is due to a H/W watchdog timer expiration, or internal fatal error, note the fault extra data and contact customer service.
2-2	Time synchronization with RX3i controller failed.	The ECM850 was unable to synchronize its current time with the RX3i controller.	Contact customer service.
4-1	Socket close failed	ECM850 was unable to close an opened OS socket.	Contact customer service.
5-1	CLI null environment pointer	ECM850 encountered a null pointer while processing a command via the CLI.	Contact customer service.
5-3	CLI Ethernet command failure	ECM850 encountered an error while processing an Ethernet related command.	Contact customer service.
5-4	CLI ECM850 specific command failure	ECM850 encountered an error while processing an ECM850-specific CLI command.	Contact customer service.

Group-Error Code	Description	Cause	Recommended Action
5-5	CLI initialization failure	The Command Line Interface functionality on the ECM850 failed to initialize correctly.	Contact customer service.
6-1	Write to nonvolatile memory failure	The ECM850 failed to write data to nonvolatile memory, which could result from configuration store/clear operations from the programmer, or Command Line Interface commands.	Contact customer service.
13-5	Failure occurred while processing configuration.	The ECM850 ran in to a failure while processing a new configuration.	Contact customer service.
9-3	Rejected mail error.	Note: The RX3i controller that delivered the configuration to the ECM850 should also log its own different failure fault in the Controller fault table.	Contact customer service.
9-4	Mail processing error on the ECM850.	The ECM850 received a rejected mail message from the CPU.	None.

5.5.2 Viewing and Clearing the Local Log Table

The only way to view and clear the data in the ECM850's Local Log table is through the Command Line Interface.

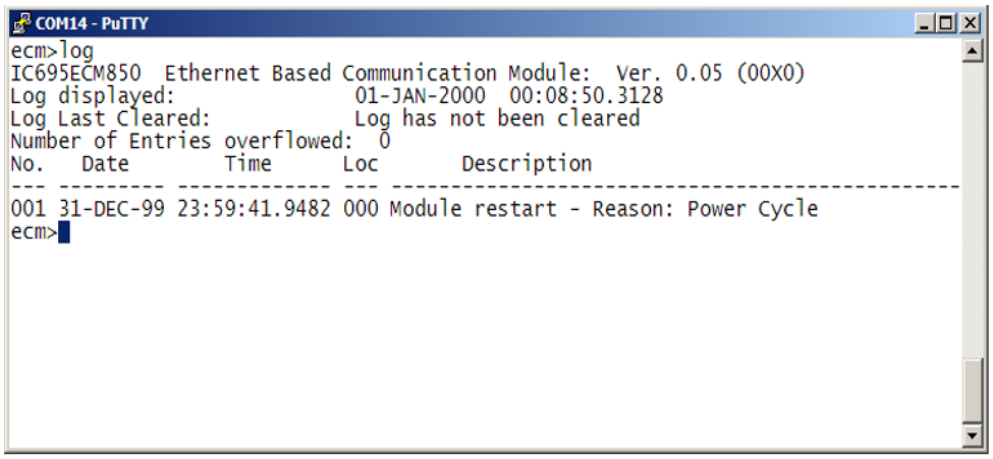
- Log data can be viewed from the Command Line Interface using the log or show log command.
- The local log table can only be cleared from the Command Line Interface using the clear log command, which requires Modify level access. Clearing the RX3i CPU fault tables or restarting the ECM850 does NOT clear the local log table.

If the ECM850's Local Log table overflows, new entries overwrite the oldest entries, which are lost. If that happens, the log or show log command indicates the number of entries that have been lost. The count of lost entries is cleared when the local log table is cleared.

ECM850 Local Log Display

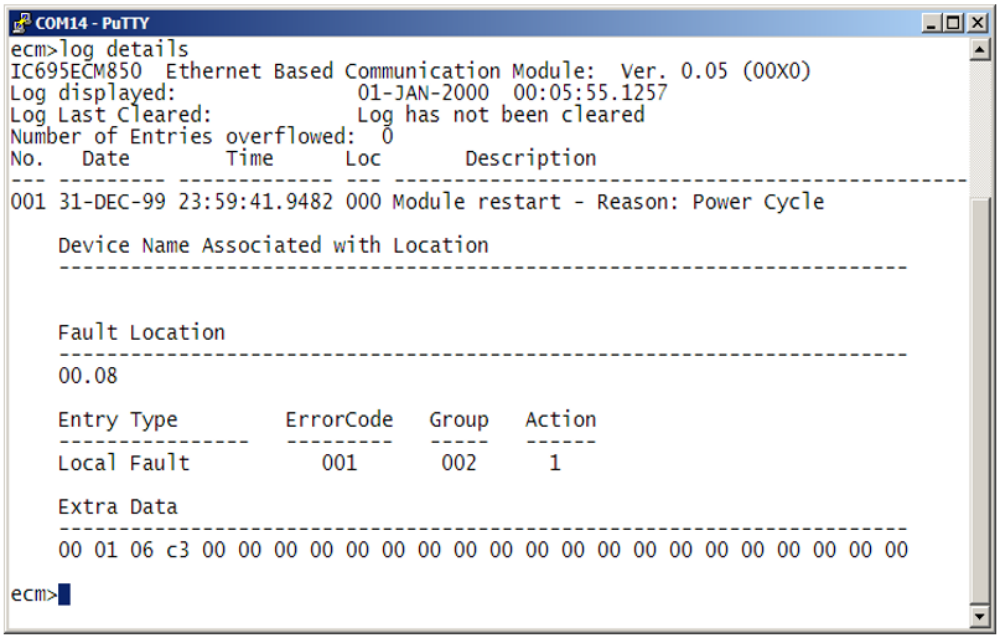
The first illustration below shows a typical display using the log command. The Loc column number for ECM850 is always 000.

Figure 86



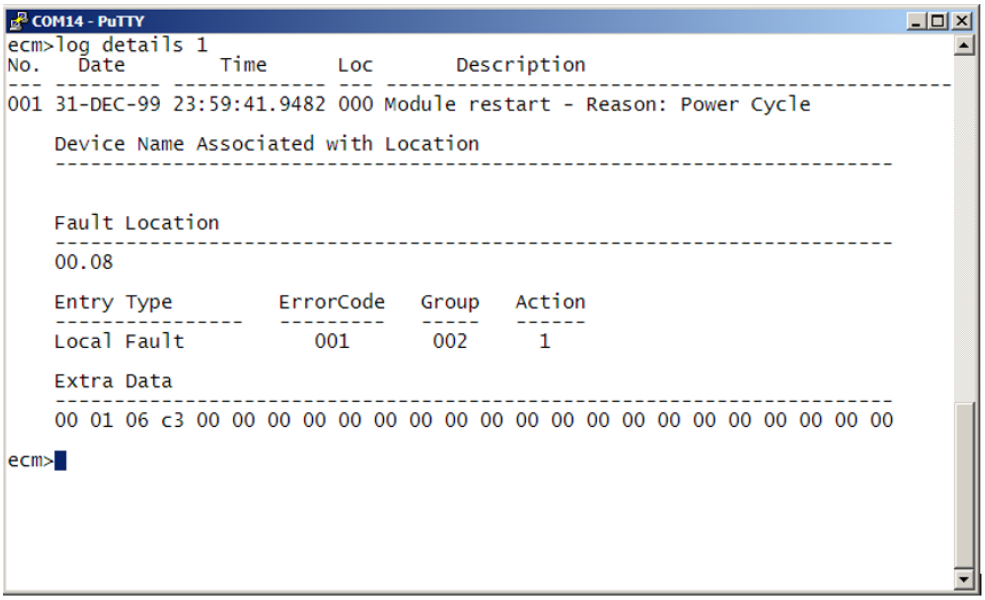
The command log details provide more information about all the entries in the local log, including the Device Names of IEDs that have log entries.

Figure 87



The command log details followed by an entry number display the information for a single entry. The example below shows the information for log entry 1:

Figure 88



5.6 ECM850 Faults in the RX3i Fault Tables

The ECM850 logs all (Local, Controller, I/O) faults in its Local Log. In addition, it logs Controller and I/O faults in the corresponding RX3i CPU's fault tables (the Controller Fault Table or the I/O Fault Table).

5.6.1 Clearing the RX3i Fault Tables

Clearing one or both of the RX3i CPU's fault tables has no effect on the ECM850's Local Log table. The ECM850's Local Log can only be cleared from its Command Line Interface.

Likewise, clearing one or both of the RX3i CPU's fault tables has no effect on the diagnostic conditions maintained by any IO-Device.

5.6.2 Faults Reported to the RX3i Controller Fault Table

The following ECM850 related faults are reported in the Controller Fault Table of the RX3i CPU, in addition to being listed in the ECM850's Local Log Table.

Faults Reported to the RX3i Controller Fault Table

Group- Error Code	Description	Cause	Recommended Action
11-84	Configured SFP mismatch detected.	SFP configured for a port on the ECM850 does not match what is physically present on the ECM850.	The SFP present should operate properly in the presence of this fault. However, to eliminate the fault, either update configuration to match the actual SFP type in use or replace the SFP in use with the same type of SFP configured.

13-h	ECM850 hardware failure.	The ECM850 has encountered a hardware related failure.	Contact customer service.
135-s	ECM850 has encountered a critical fatal error.	A critical fatal error has occurred during normal ECM850 operation from which the ECM850 cannot recover.	Contact customer service.
140-i	ECM850 has encountered a non-critical error.	A non-critical error has occurred on the ECM850.	None. This fault is informational.

h Error code that provides more information about what part of the ECM850's hardware had failure.

i Error code that provides more information about a non-critical error.

s Error code that provides more information about what caused a fatal error on the ECM850.

SNTP Events

The following ECM850 related SNTP Events are reported in the Controller Fault Table of the RX3i CPU, in addition to being listed in the ECM850's Local Log Table.

Event Type 29 indicates an SNTP exception event. Most SNTP events contain an optional Status Code (SCode) value. The command display for Event Type 29 is shown below.

Date	Time	Event	Count	Entry 2	Entry 3	Entry 4	Entry 5	Entry 6	SCode
12-APR-2000	00:00:00.0	29H	1H	0000H	0000H	0000H	0000H	0000H	00000000H

The table below shows SNTP events and corresponding Controller Fault Table entries. Entry 2 identifies the particular SNTP event. Entries 3 and 4 are unused. Entries 5 and 6 contain an internal location identification code.

Entry 2 Event Description

Entry 2	Description
1	"LAN system-software fault; resuming" SNTP client failed to lock onto a valid SNTP time server within the timeout.
2	"LAN system-software fault; resuming" A locked-on SNTP server was lost and the time server was changed.
6	"LAN system-software fault; resuming" An attempt to join the multicast host group failed.
9	"LAN system-software fault; resuming" An invalid timer identification value was detected. This is an internal software error.
b	"LAN system-software fault; resuming" Lock on the time server was lost. The module is no longer synchronized to any time servers
c	"LAN system-software fault; resuming" An internal time computation error was detected.
10	"LAN system-software fault; resuming"

Entry 2	Description
	An error occurred in an operating system request. This is an internal software error.
11	"LAN system-software fault; resuming" An error occurred in registering for configuration. This is an internal software error.
12	"LAN system-software fault; resuming" An error occurred in retrieving configuration. This is an internal software error.
13	"LAN system-software fault; resuming" Internal configuration error.
14	"LAN system-software fault; resuming" Internal messaging error.
17	"LAN system-software fault; resuming" Error in producing tally output.
20	"LAN system-software fault; resuming" This is not an error but represents the change of State of Synchronization

5.6.3 Faults Rep Faults Reported to the RX3i I/O Fault Table

The following ECM850-related faults are reported in the I/O Fault Table of the RX3i CPU, in addition to being listed in the ECM850's Local Log Table.

Faults Reported to the RX3i I/O Fault Table

Group- Category- Type- Description	Description	Cause	Recommended
3-2-0-0	Loss of Device	3-2-0-0	If this is unexpected operation, either re-connect missing IED on the network, or remove the device from the ECM850's configuration.[3]
3-35-1-0	Expected SFP is missing.	SFP configured for a port on the ECM850 is not physically present.	Insert SFP into port of ECM850 to match configuration stored to the ECM850 or remove the SFP from configuration.
3-68-1-0	Unsupported SFP detected.	An unsupported (non-Ethernet) SFP is physically connected to a ECM850 port.	The installed SFP is not supported, replace with supported SFP
3-68-2-0	Invalid SFP detected.	An invalid (non-functional) SFP is	The installed SFP is invalid, replace with a supported SFP

[3] The network connection issue might be in the interconnecting network between the controller and the device, and not necessarily at the device itself. In a network with a large number of clients, storing a configuration that causes all clients to reconfigure (for example, changing the Domain Name) may generate a large number of Loss/Addition of Device faults. This is expected behavior, and all devices should thereafter automatically return to operation.

Group- Category- Type- Description	Description	Cause	Recommended
		physically connected to a ECM850 port.	
7-3-0-0	Addition of Device.	A configured IED that was previously missing has just been re-connected.	None[4]
7-31-1-0	Extra SFP present on the ECM850.	An SFP port on the ECM850 has been configured to be empty, but an SFP is present.	Either update the ECM850 configuration to indicate the SFP is present or remove the extra SFP from the ECM850.
7-34-0-0	Addition of network interface.	A configured IED interface that was previously reported lost has been added to the device.	None.
7-36-0-0	Addition of network port.	A configured ECM850 port that was previously reported lost has been added to the device.	None.
9-11-3-1	Invalid MAC address detected.	ECM850 no longer has a valid MAC address.	Contact customer service.
9-11-5-x	Internal runtime error.	ECM850 has encountered an internal error during its operation.	Contact customer service.
9-18-1-1	ECM850 exceeded its recommended operating temperature.	The temperature detected by the ECM850 has exceeded its safe operating temperature.	Reduce the temperature of the environment where the ECM850 is operating.
9-18-1-2	Watchdog Timeout Error	ECM850 application code restarted due to a hardware watchdog timeout.	Contact customer service.
9-69-0-0	ECM850 has become heavily loaded.	The ECM850 has become heavily loaded with activity (Continued use in this mode may cause	Reduce load on ECM850. One or more of the following can be tried to reduce load:

[4] In a network with a large number of clients, storing a configuration that causes all clients to reconfigure (for example, changing the Domain Name) may generate a large number of Loss/Addition of Device faults. This is expected behavior and all devices should automatically return to operational.

Group- Category- Type- Description	Description	Cause	Recommended
		degradation of system performance (possibly including delayed IO updates) and potential loss of network communications.	• Increase the configured update rate value (i.e. IO received less frequently) of one or more IEDs configured on the ECM850. • Reduce the number of IEDs configured on the ECM850.
9-70-0-0	ECM850 is no longer heavily loaded.	Load applied to ECM850 has been reduced to an acceptable level, after it was previously heavily loaded.	None.
9-71-0-0	Duplicate IP address detected on the network.	ECM850 has detected a duplicate IP address on the network.	Either remove the ECM850 on the network that has the duplicate IP address, or assign a new IP address to conflicting ECM850.[5]
9-72-0-0	Duplicate IP address conflict resolved.	ECM850 has detected that a previously duplicated IP address conflict has been resolved.	None.

[5] The Fault Extra Data displays the MAC addresses of the conflicting devices in the MAC 1 field (bytes 8–13) and the MAC 2 field (bytes 14–19). If the ECM850 is one with a conflicting IP address, MAC 1 will be 0. This data is stored in Big Endian (most significant byte in lowest address) format.

Appendix A: ECM850 Command Line Interface Support

The ECM850 supports a Command Line Interface (CLI) that allows you to monitor and troubleshoot its operation. A computer can access the Command Line Interface using either the module's Micro-B USB port or using Telnet over the IEC 61850 network. The ECM850's CLI is identical in most respects to the RX3i PROFINET Controller's (IC695PNC001), for which the PACSystems RX3i PROFINET Controller Command Line Interface Manual, GFK-2572 is the primary reference. (Manuals can be downloaded from the Support website, referenced in the Contact Information section at the front of this manual.) The command descriptions provided there for the Global, Monitor access level & Modify access level commands are all applicable to this module. The information in the remainder of this chapter will highlight only those features of the ECM850's CLI that differ from the PROFINET Controller's CLI.

***Note*:** *Before attempting to connect to the module using the USB port, you must install the USB driver as described in section 2.9 Installing the USB Port Driver.*

The prompt ecm>, appears on connecting a computer to the Command Line Interface. The prompt appears in the Modify level (not in Configuration mode).

A-1 Monitor Level commands

The commands below are supported by the ECM850. The (†) indicates commands that are added or modified for ECM850 support. Details of these ECM850-specific commands are given in section **A-3 ECM850 Commands**, below

alias	show log
cls	show mac
help	show mem
history	show network
log	show node
login	show port
node†	show sntpstat†
shconfig	show session timeout
show arp	show sm
show config	show tcp
show debug exception	show telnetd
show debug fatalinfo	show time
show icmp	show udp
show ip	terminate

A-2 Modify Level Commands

The commands below are supported by ECM850. The (†) indicates new commands that are added for ECM850 support.

arp	logincfg
blinkld	logout
clear arp	monport
clear counters	ping
clear counters sntp†	restart
clear log	sessiontimeout
clear statled	telnetd
default	time

A-3 ECM850 Commands

node

Global Command

The node command displays device ID and physical module information. This command displays the same information as the show node command without parameters.

Example:

Screen Display

```
ecm>node
20-JAN-2014   03:14:37.0050
<<< Node Info >>>
Device Type:    Ethernet Communication Module
Catalog Number: IC695ECM850
Serial Number:  K582800
Date Code:      05SEP2013

Revision Information:
  Primary FW:  1.00 (E30F)
  Boot FW:     1.00 (E30F)
  FPGA:        0.105 (02A2)
  BIOS:        C305S009 (29-JUL-2010)
  Protocol Stack           : IEC61850 Client
  Protocol Stack Version   : 1.0.20131209
  Protocol Runtime Version : 1.0.20131209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<<< Node ID >>>
Device Name:       ecm
IP Address:        10.10.0.13
Subnet Mask:       255.255.255.0
Default Gateway:   10.10.0.1

ecm>
```

Show Sntpstat

The Show Sntpstat command displays the SNTP status and/or counter

Example 1: Network Time Synchronization is disabled

Screen Display

```
ecm>Show Sntpstat
Network time synchronization is not enabled in the RX3i
controller configuration
```

Example 2: Network Time Synchronization is enabled – SNTP server not available

Screen Display

```
ecm>Show Sntpstat
<<< SRTP Server Status >>>
Current POSIX clock time: 01-JAN-1970 00:33:10.6 (+00:00)
Status:UNSYNCHRONIZED
0 tracked SNTP server(s)
Ntppkt  =00000000H  Nstrater=00000000H  Nverold =00000000H
Nver3   =00000000H

Nver4   =00000000H  Nverbad =00000000H  Nlenbad =00000000H
Nincons =00000000H

Ntimout =00000000H  Nsvrchng=00000000H  Nloktot =00000000H
Nlokcons=00000000H

Nrqpkt  =00000000H

ecm>
```

Example 3: Network Time Synchronization is enabled – SNTP server available and status is unsynchronized

Screen Display

```
ecm>Show Sntpstat
 <<< SRTP Server Status >>>
Current POSIX clock time: 01-JAN-1970 00:34:31.3 (+00:00)
Status:UNSYNCHRONIZED
<<< SNTP TRACKING TABLE >>>
                          Time Since
Server Address  Stratum    Update     Consistent
--------------- -------   -----------  ----------
10.10.0.9           7     5 seconds   NO
1 tracked SNTP server(s)
Ntppkt  =00000002H  Nstrater=00000001H  Nverold =00000000H
Nver3   =00000000H

Nver4   =00000003H  Nverbad =00000000H  Nlenbad =00000000H
Nincons =00000001H

Ntimout =00000000H  Nsvrchng=00000000H  Nloktot =00000000H
Nlokcons=00000000H

Nrqpkt  =00000000H

ecm>
```

Example 4: Network Time Synchronization is enabled – SNTP server available and status is synchronized

Screen Display

```
ecm>Show Sntpstat
 <<< SRTP Server Status >>>
Current POSIX clock time: 20-JAN-2014 07:09:53.5 (+00:00)
Status:SYNCHRONIZED
<<< SNTP TRACKING TABLE >>>
                          Time Since
Server Address  Stratum    Update     Consistent
--------------- -------   -----------  ----------
10.10.0.9           7    11 seconds  YES < LOCK
1 tracked SNTP server(s)
Ntppkt  =00000006H  Nstrater=00000001H  Nverold =00000000H
Nver3   =00000000H

Nver4   =00000007H  Nverbad =00000000H  Nlenbad =00000000H
Nincons =00000001H

Ntimout =00000000H  Nsvrchng=00000000H  Nloktot =00000006H
Nlokcons=00000004H

Nrqpkt  =00000000H

ecm>
```

Appendix B: IEC 61850 I/O Performance Examples

This section presents several IEC 61850 network I/O configurations with the measured I/O performance for each as an aid to computing estimated I/O performance in other scenarios.

Note: *The configurations and performance numbers shown here are examples only. Actual performance timings will vary depending on details of your configuration, program, and network setup.*

B-1 Methodology

The I/O Loopback measurements shown below were performed by wiring the outputs of an RX3i discrete output module to the inputs of Emerson SR350 IED. The computation was done by the RX3i controller, which measured the times from setting output points to the looped-back data transition being reflected in the corresponding input points. When RCBs1 were enabled, the computation was done for the points configured in the report.

Machine Edition was online with the RX3i controller during testing. The average, minimum, and maximum loopback times were captured from a 1-hour sample period. In addition, since the CPU sweep time is a significant factor in the accuracy and precision of the I/O Loopback times recorded, the average CPU sweep times for each configuration are given.

Note: *CPU Sweep time variation is not completely a function of varying IEC 61850 I/O counts. It is also influenced by variability in the logic executed and in hardware configurations.*

CPE310

Combined I/O memory (Kbytes)	CPU Sweep time (msec)	I/O Loop back time in msec with Polling[2] rate = 1000 msec Avg (Min, Max)	I/O Loop back time in msec with RCBs enabled for inputs Avg (Min, Max)
4	8.3	993 (518, 1035)	73 (40, 341)
8	13.5	990 (420,1042)	89 (52, 339)
16	25.1	988 (725, 1028)	165 (73, 580)
32	47.4	946 (858, 1046)	251 (93, 624)

CPU320

Combined I/O memory (Kbytes)	CPU Sweep time (msec)	I/O Loop back time in msec with Polling rate2 = 1000 msec Avg (Min, Max)	I/O Loop back time in msec with RCBs enabled for inputs Avg (Min, Max)
4	7.02	988 (499, 1033)	73 (42, 177)
8	11.9	985 (997,1114)	92 (48, 354)
16	22.5	984 (291, 1038)	161 (65, 562)
32	43.8	972 (261, 1051)	233 (85, 654)

[1]RCBs = Report Control Blocks. The PPVs for loopback are part of RCB with trigger options set as "TrgOp data-change" and other PPVs are configured for polling rate of 1000msec. This can be set in the IEC 61850 Configurator.

[2]The polling rate for each IED connection can be configured in IEC 61850 Configurator.

Appendix C: Protocol Implementation Conformance Statements (PICS)

C-1 General

The following Abstract Communication Service Interface (ACSI) conformance statements are used to provide an overview and details of the IEC 61850 interface of the PACSystems RX3i IEC 61850 Ethernet Communication Module (ECM850) with Firmware version 1.0.

- ASCI basic conformance statement,
- ACSI models conformance statement, and
- ACSI service conformance statement

The statements specify the communication features mapped to IEC 61850-8-1.

C-2 ASCI Basic Conformance Statement

The basic conformance statement is defined in Table 1 below

Table 1: Basic conformance statement

		Client/ Subscriber	Server/ Publisher	Value/ Comments
Client-Server roles				
B11	Server side (of TWO-PARTY-APPLICATION-ASSOCIATION)	—		
B12	Client side of (TWO-PARTY-APPLICATION-ASSOCIATION)	Y	—	
SCSMs supported				
B21	SCSM: IEC 6185-8-1 used	Y		
B22	SCSM: IEC 6185-9-1 used			
B23	SCSM: IEC 6185-9-2 used			
B24	SCSM: other			
Generic substation event model (GSE)				
B31	Publisher side	—		
B32	Subscriber side	N	—	
Transmission of sampled value model (SVC)				
B41	Publisher side	—		
B42	Subscriber side	N	—	
–				
Y = supported				
N or empty = not supported				

C-3 ACSI Models Conformance Statement

The ACSI model's conformance statement is defined in Table 2.

Table 2: 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**	Y		
M6	**Setting group control**	Y		
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		
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		
Logging				
M9	**Log control**	N		
M9-1	IntgPd	N		
M10	**Log**	N		
M11	**Control**	Y		

		Client/ Subscriber	Server/ Publisher	Value/ Comments
If GSE (B31/32) is supported				
M12	**GOOSE**	N		
M13	**GSSE**	N		
If SVC (41/42) is supported				
M14	Multicast SVC	N		
M15	Unicast SVC	N		
If Server or Client side (B11/12) supported				
M16	Time	Y		
M17	**File Transfer**	N		
Y = service is supported N or empty = service is not supported				

C-4 ACSI Service Conformance Statement

The ACSI service conformance statement is defined in Table 3 (depending on the statements in Table A.1).

Table 3: ACSI Service Conformance Statement

	Services	AA: TP/MC	Client (C)	Server (S)	Comments
Server					
S1	GetServerDirectory	TP	Y		
Application association					
S2	Associate	TP	Y		
S3	Abort	TP	Y		
S4	Release	TP	N		
Logical device					
S5	GetLogicalDeviceDirectory	TP	Y		
Logical node					
S6	GetLogicalNodeDirectory	TP	Y		
S7	GetAllDataValues	TP	N		
Data					
S8	GetDataValues	TP	Y		
S9	SetDataValues	TP	Y		
S10	GetDataDirectory	TP	Y		
S11	GetDataDefinition	TP	Y		
Data set					
S12	GetDataSetValues	TP	N		
S13	SetDataSetValues	TP	N		

	Services	AA: TP/MC	Client (C)	Server (S)	Comments
S14	CreateDataSet	TP	N		
S15	DeleteDataSet	TP	N		
S16	GetDataSetDirectory	TP	Y		
Substitution					
S17	SetDataValues	TP	Y		
Setting group control					
S18	SelectActiveSG	TP	Y		
S19	SelectEditSG	TP	Y		
S20	SetSGValues	TP	Y		
S21	ConfirmEditSGValues	TP	Y		
S22	GetSGValues	TP	Y		
S23	GetSGCBValues	TP	Y		
Reporting					
Buffered Report Control Block (BRCB)					
S24	Report	TP	Y		
S24-1	data-change (dchg)		Y		
S24-2	quality-change (qchg)		Y		
S24-3	data-update (dupd)		Y		
S25	GetBRCBValues	TP	Y		
S26	SetBRCBValues	TP	Y		
Unbuffered Report Control Block (URCB)					
S27	Report	TP	Y		
S27-1	data-change (dchg)		Y		
S27-2	quality-change (qchg)		Y		
S27-3	data-update (dupd)		Y		
S28	GetURCBValues	TP	Y		
S29	SetURCBValues	TP	Y		
Logging					
Log control block					
S30	GetLCBValues	TP	N		
S31	SetLCBValues	TP	N		
Log					
S32	QueryLogByTime	TP	N		
S33	QueryLogAfter	TP	N		
S34	GetLogStatusValues	TP	N		
Generic substation event model (GSE)					
GOOSE-CONTROL-BLOCK					

	Services	AA: TP/MC	Client (C)	Server (S)	Comments
S35	SendGOOSEMessage	MC	N		
S36	GetGoReference	TP	N		
S37	GetGOOSEElementNumber	TP	N		
S38	GetGoCBValues	TP	N		
S39	SetGoCBValues	TP	N		
GSSE-CONTROL-BLOCK					
S40	SendGSSEMessage	MC	N		
S41	GetGsReference	TP	N		
S42	GetGSSEDataOffset	TP	N		
S43	GetGsCBValues	TP	N		
S44	SetGsCBValues	TP	N		
Transmission of sampled value model (SVC)					
Multicast SVC					
S45	SendMSVMessage	MC	N		
S46	GetMSVCBValues	TP	N		
S47	SetMSVCBValues	TP	N		
Unicast SVC					
S48	SendUSVMessage	TP	N		
S49	GetUSVCBValues	TP	N		
S50	SetUSVCBValues	TP	N		
Control					
S51	Select	TP	Y		
S52	SelectWithValue	TP	Y		
S53	Cancel	TP	Y		
S54	Operate	TP	Y		
S55	CommandTermination	TP	Y		
S56	TimeActivatedOperate	TP	N		
File transfer					
S57	GetFile	TP	N		
S58	SetFile	TP	N		
S59	DeleteFile	TP	N		
S60	GetFileAttributeValues	TP	N		
Time					
T1	Time resolution of internal clock			10 (1ms)	nearest negative power of 2 in seconds
T2	Time accuracy of internal clock			T1	T0 (10ms) T1 (1ms) T2 (100µs) T3 (25µs) T4 (4µs) T5 (1µs)
T3	Supported TimeStamp resolution			10 (1ms)	nearest negative power of 2 in seconds

Appendix D: Model Implementation Conformance Statement (MICS)

D-1 General

This model implementation conformance statement is applicable to the IEC 61850 interface of the PACSystems RX3i IEC 61850 Ethernet Communication Module (ECM850) with Firmware version 1.0.

D-2 Common Data Class Extensions

D-2.1 Supported common data classes

All logical nodes, common data classes and data attribute types as defined in IEC 61850-7-3 and IEC 61850-7-4 are supported.

D-2.2 Unsupported common data classes

Not Applicable

Appendix E: Protocol Implementation extra Information for Testing (PIXIT)

E-1 Introduction

This document specifies the protocol implementation extra information for testing (PIXIT) for the PACSystems RX3i IEC 61850 Ethernet Communication Module (ECM850) with Firmware version 1.0, hereafter referred to as the client.

Together with the PICS and the MICS, the PIXIT forms the basis for a conformance testing according to IEC 61850-10.

The following sections and tables specify the extra client information needed for each applicable ACSI service model as structured in IEC 61850-10 and the “Conformance Test Procedures for Client System with IEC 61850-8-1 interface”.

E-2 Configuration PIXIT

Configuration PIXIT

Description	Value / Clarification
Describe how the client handles nameplate configuration revision mismatches	The Client reads out data model at each associate and therefore does not need to check configuration revision.
Describe how the client handles report control block configuration revision mismatches	RCB configuration is read out at each associate.
<additional items>	The Client does not use items of predefined data model until reading them from data model from an online server. The SCL file is used only for offline import of variables to the controller project in Machine Edition for the purpose of initial configuration.

E-3 Association Model PIXIT

Association Model PIXIT

Description	Value / Clarification
Guaranteed number of servers that can set-up an association simultaneously (one association per server)	32 Connections
Lost connection detection time range (default range of TCP_KEEPALIVE is 1 – 20 seconds)	The current TCP timeout of Operating System. The connection loss to a Server only detected if at least one of its attributes is currently polled.

Description	Value / Clarification
Lost (abort) connection retry time	30 seconds
Is authentication supported	Yes
What is the maximum and minimum MMS PDU size	Max MMS PDU size 65535 Min MMS PDU size DO(4096)
What is the typical startup time after a power supply interrupt	The module boot time is approximately 40 seconds. Depending on the size of the RX3i controller application, the number of drivers, and link connections for each driver, it will take an additional 1 to 30 seconds to be fully functional.

E-4 Server Model PIXIT

Server Model PIXIT

Description	Value / Clarification
Maximum object identification length	The following specifies the limits in "IEC 61860 Configurator": LD: 128 chars/octets LN: 16 chars/octets DO: 128 chars/octets DA: 128 chars/octets FC: 2 chars/octets The following are limits for PLC Protocol variables (PPV), which are representation of IEC 61850 DO/DA in the RX3i controller project as a variable list. These variables are automatically generated on selecting IEC 61850 attributes from the Configurator. LD: 19-26 chars LN_DO: 32 chars DA_FC: 29 chars (FC: 2 chars) Here is the example for variable representation: IEC 61850 - Configurator The IEC 61850 variable as seen in the Configurator dialogue: SR350.GEDeviceSR350.GGIO1\Beh\q[ST] SR350.GEDeviceSR350.MMXU1\A.neut\cVal.ang.f[MX] PLC Protocol Variable(s) The PPV set that gets created automatically in the RX3i controller project for the above IEC 61850 variable: S8_SR350_GEDeviceSR350.GGIO1_Beh.q_ST

Description	Value / Clarification
	S5_SR350_GEDeviceSR350.MMXU1_A_neut.cVal_ang_f_MX [<SlotNum(3†)>_<ServerName(8†)>_<Logical Device>].[<Logical node>_<Data Objects>].[<Data Attributes>_<Functional Constraints>] † Number of character limits
Does client support auto description?	In the Runtime the Client reads data model only via MMS. The Client does not use data not responded via MMS by association. In Machine Edition there is a dialogue entitled "IEC 61850 Configurator" available for ECM850 configuration. This dialogue provides the IEC 61850 user configuration interface. In this Configurator, user can use option of "Read variables from server" by providing the IP address of the server or IED device. In this option, the Configurator connects to the Device over MMS and read the data model from device over Ethernet network. This support is part of the "auto description" feature. The other option is to read a data model from an SCL file using the "Read variables from SCL file" which is known as Offline configuration.
What analogue value (MX) quality bits are used in the client?	Good Yes Invalid Yes Reserved Yes Questionable Yes Overflow Yes Outofrange Yes Badreference Yes Oscillatory Yes Failure Yes Olddata Yes Inconsistent Yes Inaccurate Yes Process Yes Substituted Yes Test Yes Operatorblocked Yes
Which status value (ST) quality bits are used in the client	Good Yes Invalid Yes Reserved Yes

Description	Value / Clarification
	Questionable Yes Badreference Yes Oscillatory Yes Failure Yes Olddata Yes Inconsistent Yes Inaccurate Yes Process Yes Substituted Yes Test Yes Operatorblocked Yes
Describe how to view/display quality values.	The quality values can be configured to be presented as variables in configuration of the driver.
Describe how to view/display time quality process values from the server.	Not available
Describe how to force a SetDataValues request.	This operation can be forced by using the "WRITE Operation with PPV" for writing values to the device in the RX3i controller application. This is operation is described in detail in the manual with an example. For each attribute with FC=SP/SV/SE/CF, as seen in the "IEC 61850 Configurator" dialogue, Machine Edition validation automatically creates a set of PLC protocol variables (PPVs) in the RX3i controller project with extensions as below: a) †.WRITEVal (Value to be written: Write) b) †.WRITECmd (Command to transfer value in †.WRITEVal to device: Write) c) †.WRITERslt (Result of operation – Success or failure with error code: Read) d) †.ReadVal (Actual value of parameter from Device: Read) The PPV set can be used to write values to the device and force "SetDataValues" request. The below is example for attributes with FC=SP, used for write operation: IEC 61850 Configurator The IEC 61850 variable as seen in the Configurator dialogue: Dev.DevF650.auxPTOV2/PTOVEna/setVal[SP] PLC Protocol Variables (set)

Description	Value / Clarification
	The PPV set that gets created automatically in the RX3i controller project for the above IEC 61850 variable: a) S8_Dev_DevF650.auxPTOV2_PTOVEna.setVal_SP.WRITEVal b) S8_Dev_DevF650.auxPTOV2_PTOVEna.setVal_SP.WRITECmd c) S8_Dev_DevF650.auxPTOV2_PTOVEna.setVal_SP.WRITERslt d) S8_Dev_DevF650.auxPTOV2_PTOVEna.setVal_SP.ReadVal **WRITE Operation with PPV** If the user has to write a value to such a writable data attribute, then the following steps need to be executed in the RX3i controller logic using Machine Edition: 1. Step1: Write value to be written to device in the PPV with extension (†.WRITEVal). e.g. S8_Dev_DevF650.auxPTOV2_PTOVEna.setVal_SP.WRITEVal 2. Step2: Issue a transition from "0" to "1" in the PPV with extension (†.WRITECmd) to trigger the transfer of written value in step#1 to the IED. e.g. S8_Dev_DevF650.auxPTOV2_PTOVEna.setVal_SP.WRITECmd 3. Step3: Check the PPV with extension (†.WRITERslt) for success (1). e.g. S8_Dev_DevF650.auxPTOV2_PTOVEna.setVal_SP.WRITERslt [WRITERslt > 0, it returns IEC61850 AddCause WRITERslt < 0 internal error code as below: -1, wrong parameter in (†.WRITEVal) -2, driver not loaded -3, write command cannot be issued (e.g. not valid server)] 4. Step4: Check that the written value has been updated in device by reading the PPV with extension (†.ReadVal) e.g. S8_Dev_DevF650.auxPTOV2_PTOVEna.setVal_SP.ReadVal

Description	Value / Clarification
Describe how to force a GetAllDataValues request	Not Used
Describe how the client behaves in case of: GetDataDefinition response GetLogicalDeviceDirectory response GetAllDataValues response GetDataValues response SetDataValues response-	 GetDataDefinition response- [I-Bit†] GetLogicalDeviceDirectory response- [I-Bit†] GetAllDataValues response- [not supported] GetDataValues response- [I-Bit†] SetDataValues response- [Error output in WRITE and/or value in variable will not accept change]
	† Status bit INVALID of variables mirroring DO/DA

E-5 Data Set Model PIXIT

Data Set Model PIXIT

Description	Value / Clarification
Describe how to force a GetDataSetValues request.	Not Used
Describe how to force a SetDataSetValues request.	Not Used
Describe how to force a DeleteDataSet request.	Not Used
Describe how the client handles following dataset mismatches between the SCL and the data sets exposed via MMS: 1. new dataset element 2. missing dataset element 3. Reordered dataset members in a dataset of a different data type. 4. Reordered dataset members in a dataset of the same data type.	The SCL file is not used in the Client module during runtime communication. This file can be used to preconfigure IEC 61850 variables [offline configuration] in the RX3i controller project using Machine Edition's "IEC 61850 Configurator" dialogue.
Describe how the client behaves in case of: – GetLogicalNodeDirectory (DATA-SET) response- – GetDataSetDirectory response-	Data will be polled (no reporting)
Does the client support the creation of: – persistent datasets – non-persistent datasets	 No No
Describe how the client behaves in case of: – CreateDataSet response- – DeleteDataSet response-	 Not Used Not Used

Description	Value / Clarification
<additional items>	Not Used

E-6 Substitution Model PIXIT

Substitution Model PIXIT

Description	Value / Clarification
Describe how to substitute a value.	For the attributes with FC=SV ((†/subEna, subQ, subID and e.g. subVal) as seen in the IEC 61850 Configurator, Machine Edition on validation automatically creates a set of PLC Protocol Variables (PPVs) in the RX3i controller project with extensions as shown below: a) †.WRITEVal (Value to be written: Write) b) †.WRITECmd (Command to transfer value in †.WRITEVal to device: Write) c) †.WRITERslt (Result of operation –Success or failure with error code: Read) d) †.ReadVal (Actual value of parameter from Device: Read) These PPVs can be used to write values to the device. The example below shows attributes with FC=SV, used for “write”: IEC 61850 Configurator The IEC 61850 variable as seen in the Configurator dialogue: Dev.IEDDevice.PTOV1/Mod/subVal[SV] PLC Protocol Variables(set) The PPV set that gets created automatically in the RX3i controller project for the above IEC 61850 variable a) S8_Dev_IEDDevice.PTOV1_Mod.subEna_SV.WRITEVal b) S8_Dev_IEDDevice.PTOV1_Mod.subEna_SV.WRITECmd c) S8_Dev_IEDDevice.PTOV1_Mod.subEna_SV.WRITERslt d) S8_Dev_IEDDevice.PTOV1_Mod.subEna_SV.ReadVal
Describe how to substitute a value.	WRITE Operation with PPV If the user has to write a value to such a writable data attribute, then the following steps needs to be execute in Application logic: 1. Step1: Write value to be written to device in the PPV with extension (†.WRITEVal).

Description	Value / Clarification
	e.g. S8_Dev_IEDDevice.PTOV1_Mod.subEna_SV.WRITEVal 2. Step2: Provide a transition from "0" to "1" in the PPV with extension (†.WRITECmd) to trigger the transfer of written value to the IED. e.g. S8_Dev_IEDDevice.PTOV1_Mod.subEna_SV.WRITECmd 3. Step3: Check the PPV with extension (†.WRITERslt) for success (1). e.g. S8_Dev_IEDDevice.PTOV1_Mod.subEna_SV.WRITERslt [WRITERslt returns code: 0: BUSY 1: DONE 2: ERROR] 4. Step4: check that the written value has been updated in the PPV with extension (†.ReadVal) e.g. S8_Dev_IEDDevice.PTOV1_Mod.subEna_SV.ReadVal **Substitution** For the attributes with FC=SV (†/subEna, subQ, subID and e.g. subVal), set values to be substituted in (†/subVal, subQ, subID) using the "write" operation on PPVs as described above. Then set value in (†/subEna) to "TRUE" by using "write" operation on PPV for enabling the substitution.

E-7 Setting Group Control Model PIXIT

Setting Group Control Model PIXIT

Description	Value / Clarification
Describe how to change the active setting group.	The active setting group can be changed by using "Write operation on PPV" to attribute ActSG. This is described in detail with example as below: For the attribute ActSG as seen in the IEC 61850 Configurator, Machine Edition on validation automatically creates a set of PLC Protocol Variables (PPV) in the RX3i controller project with extensions as below: a) †.WRITEVal (Value to be written: Write) b) †.WRITECmd (Command to transfer value in †.WRITEVal to device: Write)

Description	Value / Clarification
	c) †.WRITERslt (Result of operation –Success or failure with error code: Read) d) †.ReadVal (Actual value of parameter from Device: Read)
	These PPVs can be used to write values to the device. Below is an example of ActSG attributes with FC=SP, used for "write": **IEC 61850 Configurator** The IEC 61850 variable as seen in the Configurator dialogue: Dev.IEDDevice.LLN0/SGCB/ActSG[SP] **PLC Protocol Variables(set)** The PPV set that gets created automatically in the RX3i controller project for the above IEC 61850 variable: a) S8_Dev_IEDDevice.LLN0_SGCB.ActSG_SP.WRITEVal b) S8_Dev_IEDDevice.LLN0_SGCB.ActSG_SP.WRITECmd c) S8_Dev_IEDDevice.LLN0_SGCB.ActSG_SP.WRITERslt d) S8_Dev_IEDDevice.LLN0_SGCB.ActSG_SP.ReadVal **WRITE Operation with PPV** If the user has to write a value to such a writable data attribute, then the following steps needs to be execute in RX3i controller logic: 1. Step1: Write value to be written to device in the PPV with extension (†.WRITEVal). e.g. S8_Dev_IEDDevice.LLN0_SGCB.ActSG_SP.WRITEVal 2. Step2: Provide a transition from "0" to "1" in the PPV with extension (†.WRITECmd) to trigger the transfer of written value to the IED e.g. S8_Dev_IEDDevice.LLN0_SGCB.ActSG_SP.WRITECmd 3. Step3: Check the PPV with extension (†.WRITERslt) for success (1). e.g. S8_Dev_IEDDevice.LLN0_SGCB.ActSG_SP.WRITERslt [WRITERslt returns code: 0: BUSY 1: DONE 2: ERROR] 4. Step4: check that the written value has been updated in the PPV with extension (†.ReadVal) e.g. S8_Dev_IEDDevice.LLN0_SGCB.ActSG_SP.ReadVal

Description	Value / Clarification
Describe how to get the actual setting group values	The current value of variables created for SG attributes are directly mapped to the PLC Protocol Variable (PPV). Below is one example of a PPV with SG attributes. IEC 61850 Configurator The IEC 61850 variable as seen in the Configurator dialogue: Dev.IEDDevice.PTOV1/TmMult/setMag.f[SG] PLC Protocol Variable(s) The PPV set that gets created automatically in the RX3i controller project for the above IEC 61850 variable: S8_Dev_IEDDevice.PTOV1_TmMult.setMag_f_SG
Describe how the client behaves in case of: GetSGCBValues response- The configured SG is different than the actual setting group	GetSGCBValues response- [Invalid Bit – (Status bit INVALID of variables mirroring DO/DA)] The configured SG is different than the actual setting group - SGCB is read out via MMS at each associate

E-8 Reporting Model PIXIT

Reporting Model PIXIT

Description	Value / Clarification
Does the client search for RCB in all logical nodes?	Yes: all logical nodes are searched (for automatic allocation of URCBs)
Does the client search for RCB when the logical nodes are not specified?	Yes: logical nodes are searched for static allocation of URCBs and BRCBs. BRCBs are selectable online from Server only.
Which dynamic RCB attributes are/can be configured by the client	RptID No DataSet No Optional fields Yes (fixed†) Trigger conditions Yes (common for all RCBs) Buffer time No Integrity period No † These are pre-configured and cannot be changed dynamically.
Does the client supports IEDs with indexed and non-indexed report control blocks (RCB)	Buffered RCB indexed Yes Buffered RCB not indexed Yes Unbuffered RCB indexed Yes Unbuffered RCB not indexed Yes
The supported trigger conditions are:	Integrity Yes data change Yes

Description	Value / Clarification	
	quality change	Yes
	data update	Yes
	general interrogation	Yes
The minimum required optional fields are:	sequence-number	Yes
	report-time-stamp	No
	reason-for-inclusion	No
	data-set-name	Yes
	data-reference	No
	buffer-overflow	No
	entryID	Yes
	conf-rev	No
Does the client support segmented reports?	Yes	
Does the client support pre-assigned RCB?	Yes	
Does the client support reported data sets containing structured data objects or data attributes?	reporting of data objects	Yes
	reporting of data attributes	Yes (By Polling)
Describe how the client does respond when an URCB is already reserved.	The client tries to use another URCB if dynamically allocated; fallback is polling.	
Describe how the client responds when a BRCB is already reserved.	Variables will be polled	
Describe how the client responds to a SetBRCBValues(EntryID).	The client accepts negative responses internally.	
Describe how the client responds when a report has an unknown: dataset, RptId, unexpected number of dataset entries, and/or unexpected data type format entries.	Dataset directory and RCB configuration is read out at each associate	
Describe how the client detect reporting configuration changes (mismatches). Does it check the “configuration revision” attributes and/or does it check the dataset members?	RCB configuration is read out at each associate, “configuration revision” doesn’t care	
Describe how to force the client to change the RCB buffer time.	Not used	

E-9 Control Model PIXIT

Control Model PIXIT

Description	Value / Clarification
What control modes are supported?	status-only Yes direct-with-normal-security Yes sbo-with-normal-security Yes direct-with-enhanced-security Yes sbo-with-enhanced-security Yes **Note:** *For each use of "Operate operation with PPV", the Client Module automatically checks current †/ctlModel[CF] and depending on the value of that attribute, the corresponding control model is executed. The control mode operation is described in additional items in detail with examples.*
Is Time activated operate (operTm) supported?	No
Is "operate-many" supported?	No
Can the client set the test flag?	No
What check conditions can be set?	synchrocheck Yes interlock-check Yes The check condition can be predefined by setting an appropriate value to a PPV (PLC Protocol Variable) with extension (†.OPERChk) as an USINT variable. The values that can be configured in this variable are given below: 0: No check 1: Interlock check 2: Synchro check 3: Interlock and Synchro check This is described in the <additional items> section below under "**OPERATE Operation with PPV".**
Which originator categories are supported and what is the originator identification?	The "orCat" is defined in the "IEC 61850 Configurator" dialogue in Machine Edition. (Default = Station control). The following originator category (OrCat) can be configured for client: • Bay-control • Station-control • Remote-control • Automatic-bay • Automatic-station • Automatic-remote

Description	Value / Clarification
	• Maintenance The “orIdent” is defined internally in the ECM850 and is fixed to 'GEIPECM: VXTARGET'. Note: This also includes the apostrophe at start and end of the name.
Describe if and how the client sets/increments the ctlNum.	For each use of any ctlVal[CO], the Client increments the PPV (†ctlNum) from 0 to 127 and next turns to 0. The example of such a PPV variable in the RX3i controller project: S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlNum_CO.ReadVal The equivalent IEC 61850 Configurator DA: SR350.DevSR350.XCBR1\Pos\Oper.ctlNum[CO]
What does the client when do if it receives a LastApplicationError and describe how to view the additional cause?	The PPV variable generated for (†.Oper.ctlVal[CO]) with the extension (†.OPERRslt) in RX3i controller reports the current state and success/failure of commands. This also reports the “AddCause” as defined in IEC 61850. This is described in section **4.4 PPV Operations in RX3i Controller Applications.**
What does the client do when it receives a Select, SelectWithValue or Operate respond negative?	The PPV variable generated for (†.Oper.ctlVal[CO]) with the extension (†.OPERRslt) in RX3i controller reports the current state and success/failure of commands. This also reports the “AddCause” as defined in IEC 61850. This is described in section **4.4 PPV Operations in RX3i Controller Applications.**
Can the client change the control model via online services?	No
What does the client do when the ctlModel is not initialized in the SCL?	out of scope The Client reads the ctlModel directly from the Device during runtime communication.
<additional items>	The driver supports the command ‘direct operate’ and ‘select before operate’ (SBO) in normal and in enhanced security. In IEC 61850_OPER the driver automatically checks the actual Control Model and executes the command in the corresponding way. **Commands and Control Models:** For this, first attribute †/ctlModel[CF] of the Data Object is read out. Depending on the value of this attribute, the corresponding command is executed using the respective Control model:

Description	Value / Clarification
	Value 0: no action, execute command not possible (status only) *Value 1:* an 'Operate' service (direct control with normal security) is executed. *Value 2:* 'Select' and 'Operate' services (select before operate with normal security) are executed. *Value 3: an* 'Operate' service (direct control with enhanced security) is executed. *Value 4:* 'SelectWithValue' and 'Operate' services (select before operate with enhanced security) are executed. **Command Details:** Operate command: The value is set directly to †/Oper[CO]. Select commands are processed sequentially: • Select command normal security: read from †/SBO[CO], write to †/Oper[CO]. • Select command enhanced security: write to †/SBOw[CO], write to †/Oper[CO]. The required command sequences are automatically performed in the right sequence by the driver. No further configuration steps are necessary from user perspective in RX3i controller logic. In addition to this, the client Module supports manual Select and Cancel. The client module - according to the ctlModel of the Data Object - executes the Select (only when ctlModel=2 or 4). The values of ctlModel=0, 1 or 3 are treated as negative answer of Select. When the IEC 61850 server responds, as Select positive, the client module stores information about selected Data Object and in the following command (in the following "OPERATE" operation) executes only the Operate.
<additional items>	**A) OPERATE Operation with PPV** The control operations can executed using "Operate operation on PPV" for (†.Oper.ctlVal[CO]). This is described in detail with example as below: For the attribute with (†.Oper.ctlVal[CO]), as seen in the IEC 61850 Configurator, Machine Edition

Description	Value / Clarification
	validation automatically creates a set of PLC Protocol Variables (PPVs) in the RX3i controller project with extensions as below: a. †.OPERChk (Check for interlock & Synchrocheck to be written: Write) b. †.OPERVal (Value to be written: Write) c. †.OPERCmd (Trigger cmd to transfer value in †.OPERVal to device: Write) d. †.OPERSts (Result of operation –Success or failure with error code: Read) e. †.OPERRslt (Result of operation –Success or failure with error code: Read) f. †.ReadVal (Actual value of parameter from Device: Read) These PPVs can be used to perform control operations to the device. The below is example describing control Operation using "Operate Operation with PPV": **IEC 61850 Configurator** The IEC 61850 variable as seen in the Configurator dialogue: SR350.DevSR350.XCBR1/Pos/Oper.ctlVal[CO] **PLC Protocol Variables(set)** The PPV set that gets created automatically in the RX3i controller project for the above IEC 61850 variable: a. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERChk b. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERVal c. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERCmd d. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERSts e. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERRslt f. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.ReadVal

Description	Value / Clarification
<additional items>	OPERATE operation with PPV If the User/Application has to write a value to such a writable data attribute, then the following steps needs to be execute in RX3i controller logic: 1. Step1: Write value in PPV with extension (†.OPERChk) as required: 0: No check 1: Interlock check 2: Synchro check 3: Interlock and Synchro check e.g. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERChk 2. Step2: Write value to be written to device in the PPV with extension (†.OPERVal). e.g. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERVal 3. Step3: Provide a transition from "0" to "1" in the PPV with extension (†.OPERCmd) to trigger the transfer of written value to the IED. e.g. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERCmd 4. Step4: Check the PPV with extension (†.OPERSts) for status code. e.g. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERSts [OPERSts returns code: 0: BUSY 1: DONE 2: ERROR] 5. Step5: Check the PPV with extension (†.OPERRslt) for success (1). e.g S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.OPERRslt [WRITERslt > 0, it returns IEC 61850 AddCause WRITERslt < 0 internal error code: -1: wrong parameter in (†.WRITEVal) -2: driver not loaded -3: write command cannot be issued (e.g. not valid server)]

Description	Value / Clarification
	6. Step6: check that the written value has been updated in the PPV with extension (†.ReadVal) e.g. S4_SR350_DevSR350.XCBR1_Pos.Oper_ctlVal_CO.ReadVal
<additional items>	**B) SELECT Operation with PPV** The control operations can executed using "SELECT operation on PPV" for (†.Oper.ctlVal[CO]). This is described in detail with example as below: For the attribute with (†.SBOw.ctlVal[CO]), as seen in the IEC 61850 Configurator, Machine Edition validation automatically creates a set of PLC Protocol Variables (PPV) in the RX3i controller project with extensions as below: a. †.SELECTVal (Value to be written: Write) b. †.SELECTCmd (Trigger cmd to transfer value in †.SELECTCmd to device: Write) c. †.SELECTSts (Result of operation –Success or failure with error code: Read) d. †.SELECTRslt (Result of operation –Success or failure with error code: Read) e. †.ReadVal (Actual value of parameter from Device: Read) These PPVs can be used to perform SELECT operation to the device. Below is an example illustrating "Select Operation with PPV": **IEC 61850 Configurator** The IEC 61850 variable as seen in the Configurator dialogue: SR350.DevSR350.XCBR1/Pos/SBOw.ctlVal[CO] **PLC Protocol Variables (set)** The PPV set that gets created automatically in the RX3i controller project for the above IEC 61850 variable: a. S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.SELECTVal

Description	Value / Clarification
	b. S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.SELECTCmd c. S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.SELECTSts d. S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.SELECTRslt e. S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.ReadVal
<additional items>	<u>SELECT operation on PPV</u> If the user has to write a value to such a writable data attribute, then the following steps needs to be execute in RX3i controller logic: 1. Step1: Write value to be written to device in the PPV with extension (†.SELECTVal). e.g. S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.SELECTVal 2. Step2: Provide a transition from "0" to "1" in the PPV with extension (†.SELECTCmd) to trigger the transfer of written value to the IED. e.g. S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.SELECTCmd 3. Step3: Check the PPV with extension (†.SELECTSts) for status code. e.g. S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.SELECTSts [SELECTSts returns code: 0: BUSY 1: DONE 2: ERROR] 4. Step4: Check the PPV with extension (†.SELECTRslt) for success (1). e.g S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.SELECTRslt [SELECTRslt > 0, it returns IEC 61850 AddCause SELECTRslt < 0 internal error code: -1, wrong parameter in (†.SELECTVal) -2,driver not loaded -3, write command cannot be issued (e.g. not valid server)]

Description	Value / Clarification
	5. Step5: check that the written value has been updated in the PPV with extension (†.ReadVal) e.g. S4_SR350_DevSR350.XCBR1_Pos.SBOw_ctlVal_CO.ReadVal
<additional items>	<u>C) CANCEL Operation with PPV</u> The control operations can executed using "CANCEL operation on PPV" for (†.Cancel.ctlVal[CO]). This is described in detail with example as below: For the attribute with (†.Cancel.ctlVal[CO]), as seen in the IEC 61850 Configurator, Machine Edition validation automatically creates a set of PLC Protocol Variables (PPVs) in the RX3i controller project with extensions as below: a. †.CANCELCmd (Trigger command to Cancel the operation to device: Write) b. †.CANCELSts (Status of operation –with code: Read) c. †.CANCELRslt (Result of operation –Success or failure with error code: Read) d. †.ReadVal (Actual value of parameter from Device: Read) These PPVs can be used to perform a CANCEL operation in the device. Below is an example illustrating "Cancel Operation with PPV": <u>IEC 61850 Configurator</u> The IEC 61850 variable as seen in the Configurator dialogue: SR350.DevSR350.XCBR1/Pos/Cancel.ctlVal[CO] <u>PLC Protocol Variables(set)</u> The PPV set that gets created automatically in the RX3i controller project for the above IEC 61850 variable: a. S4_SR350_DevSR350.XCBR1_Pos.Cancel_ctlVal_CO.CANCELCmd b. S4_SR350_DevSR350.XCBR1_Pos.Cancel_ctlVal_CO.CANCELSts c. S4_SR350_DevSR350.XCBR1_Pos.Cancel_ctlVal_CO.CANCELRslt

Description	Value / Clarification
	d. S4_SR350_DevSR350.XCBR1_Pos.Cancel_ctlVal_CO.ReadVal
<additional items>	<u>CANCEL operation on PPV</u> If the user has to write a value to such a writable data attribute, then the following steps needs to be execute in RX3i controller logic: 1. Step1: Provide a transition from "0" to "1" in the PPV with extension (†.CANCELCmd) to trigger the transfer of written value to the IED. e.g. S4_SR350_DevSR350.XCBR1_Pos.Cancel_ctlVal_CO.CANCELCmd 2. Step2: Check the PPV with extension (†.CANCELSts) for status code. e.g. S4_SR350_DevSR350.XCBR1_Pos.Cancel_ctlVal_CO.CANCELSts [CANCELSts returns code: 0: BUSY 1: DONE 2: ERROR] 3. Step3: Check the PPV with extension (†.CANCELRslt) for success (1). e. g S4_SR350_DevSR350.XCBR1_Pos.Cancel_ctlVal_CO.CANCELRslt [CANCELRslt > 0, it returns IEC 61850 AddCause CANCELRslt < 0 internal error code: -1, wrong parameter -2, driver not loaded - -3, write command cannot be issued (e.g. not valid server)] 4. Step5: check that the written value has been updated in the PPV with extension (†.ReadVal) e.g. S4_SR350_DevSR350.XCBR1_Pos.Cancel_ctlVal_CO.ReadVal

E-10 Time and Time Synchronization Model PIXIT

Time and Time Synchronization Model PIXIT

<table>
<tr><th>Description</th><th>Value / Clarification</th></tr>
<tr><td>Describe how to view the internal time & quality or how to expose the timestamp and timestamp quality via the IEC 61850 interface.</td><td>The Time and Quality attributes can be selected during configuration using the “IEC 61850 Configurator” dialogue in Machine Edition.
On validation of the configuration, equivalent PPVs are automatically created for Quality and Timestamp. These timestamp and quality variables get updated in the RX3i controller and can be read as normal controller variables.</td></tr>
<tr><td>Describe how to view the internal time & quality or how to expose the timestamp and timestamp quality via the IEC 61850 interface.</td><td><u>Quality</u>
An example of a PPV quality variable in an RX3i controller project with data type as DWORD (4 Bytes):
S5_SR350.GEDeviceSR350.GGIO1_Beh.q_ST
For equivalent IEC 61850 Configurator DA:
SR350.GEDeviceSR350.GGIO1\Beh\q[ST]
The quality bits of IEC 61850 data “q” are mapped according to the following table:
<table>
<tr><th>Attribute name</th><th>Attribute type
Valu0065/Value range</th><th>Bit Map</th></tr>
<tr><td>Validity</td><td>CODED ENUM good | invalid | reserved | questionable</td><td>6,7</td></tr>
<tr><td>DetailQual</td><td>PACKED LIST</td><td></td></tr>
<tr><td>Overflow</td><td>BOOLEAN DEFAULT FALSE</td><td>5</td></tr>
<tr><td>Out of Range</td><td>BOOLEAN DEFAULT FALSE</td><td>4</td></tr>
<tr><td>Bad Reference</td><td>BOOLEAN DEFAULT FALSE</td><td>3</td></tr>
<tr><td>Oscillatory</td><td>BOOLEAN DEFAULT FALSE</td><td>2</td></tr>
<tr><td>Failure</td><td>BOOLEAN DEFAULT FALSE</td><td>1</td></tr>
<tr><td>Old Data</td><td>BOOLEAN DEFAULT FALSE</td><td>0</td></tr>
<tr><td>Inconsistent</td><td>BOOLEAN DEFAULT FALSE</td><td>15</td></tr>
<tr><td>Inaccurate</td><td>BOOLEAN DEFAULT FALSE</td><td>14</td></tr>
<tr><td>Source</td><td>CODED ENUM process | substituted</td><td>13</td></tr>
<tr><td>Test</td><td>BOOLEAN DEFAULT FALSE</td><td>11</td></tr>
<tr><td>Operator Blocked</td><td>BOOLEAN DEFAULT FALSE</td><td>12</td></tr>
</table></td></tr>
<tr><td></td><td><u>Timestamp</u>
Example of timestamp PPV variable in RX3i controller project with data type as LREAL (8 Bytes) in Unix-Time format:
S5_SR350.GEDeviceSR350.GGIO1_Beh.t_ST</td></tr>
</table>

Description	Value / Clarification
	For equivalent IEC 61850 Configurator DA: SR350.GEDeviceSR350.GGIO1\Beh\t[ST] The ECM850 supports SNTP Client (multicast and broadcast). However, note that the Client module does not send timestamp quality to control objects.
What time quality bits are supported?	LeapSecondsKnown No ClockFailure No ClockNotSynchronized No
What is the behavior when the time synchronization signal/messages are lost	Not Applicable
When is the quality bit "Clock failure" set?	The Client does not set any time quality bits.
When is the quality bit "Clock not synchronized" set?	The Client does not set any time quality bits.

Technical Support & Contact Information

Home link: http://www.Emerson.com/Industrial-Automation-Controls

Knowledge Base: https://www.emerson.com/Industrial-Automation-Controls/support

Note: If the product is purchased through an Authorized Channel Partner, please contact the seller directly for any support.

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