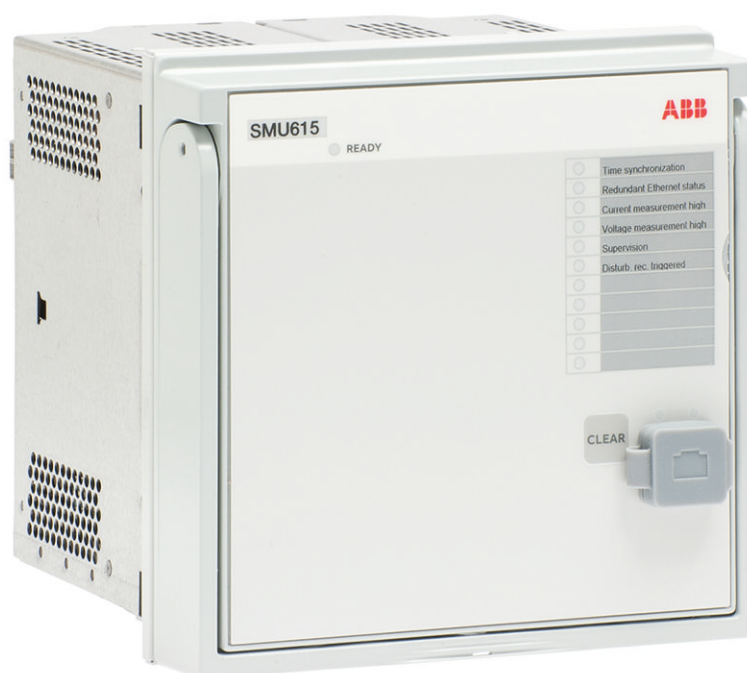


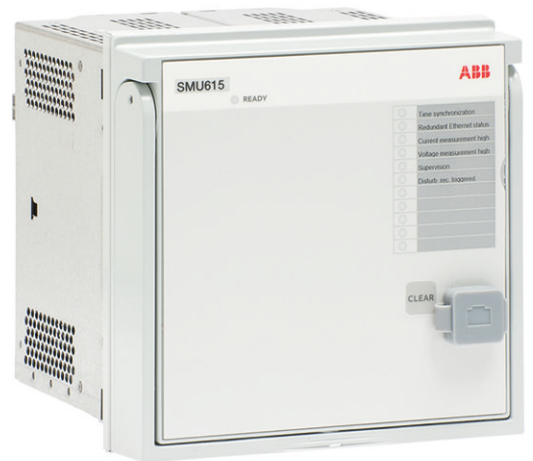
RELION®

Substation Merging Unit

SMU615

Operation Manual





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This product has been designed to be connected and communicate data and information via a network interface which should be connected to a secure network. It is the sole responsibility of the person or entity responsible for network administration to ensure a secure connection to the network and to take the necessary measures (such as, but not limited to, installation of firewalls, application of authentication measures, encryption of data, installation of anti virus programs, etc.) to protect the product and the network, its system and interface included, against any kind of security breaches, unauthorized access, interference, intrusion, leakage and/or theft of data or information. ABB is not liable for any such damages and/or losses.

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Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2014/30/EU) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2014/35/EU). This conformity is the result of tests conducted by ABB in accordance with the product standard EN 60255-26 for the EMC directive, and with the product standards EN 60255-1 and EN 60255-27 for the low voltage directive. The product is designed in accordance with the international standards of the IEC 60255 series.

Safety information



Dangerous voltages can occur on the connectors, even though the auxiliary voltage has been disconnected.



Non-observance can result in death, personal injury or substantial property damage.



Only a competent electrician is allowed to carry out the electrical installation.



National and local electrical safety regulations must always be followed.



The frame of the merging unit has to be carefully earthed.



When the plug-in unit has been detached from the case, do not touch the inside of the case. The merging unit case internals may contain high voltage potential and touching these may cause personal injury.



The merging unit contains components which are sensitive to electrostatic discharge. Unnecessary touching of electronic components must therefore be avoided.



Whenever changes are made in the merging unit, measures should be taken to avoid inadvertent tripping.

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Section 1 Introduction

1.1 This manual

The operation manual contains instructions on how to operate the merging unit once it has been commissioned. The manual provides instructions for monitoring, controlling and setting the merging unit. The manual also describes how to identify disturbances and how to view calculated and measured power grid data to determine the cause of a fault.

1.2 Intended audience

This manual addresses the operator who operates the merging unit frequently.

The operator must be trained in and have a basic knowledge of how to operate protection equipment. The manual contains terms and expressions commonly used to describe this kind of equipment.

1.3

Product documentation

1.3.1

Product documentation set

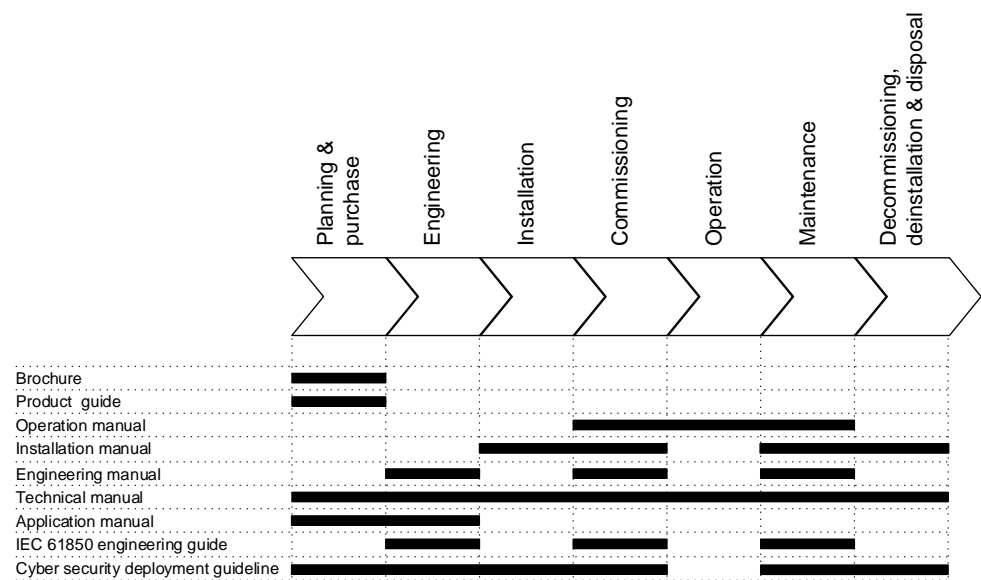


Figure 1: The intended use of documents during the product life cycle

1.3.2

Document revision history

Document revision/date	Product version	History
A/2017-09-26	1.0	First release
B/2019-05-17	1.0	Content updated

1.3.3

Related documentation



Contact ABB for information on SMU615 related documentation.

1.4 Symbols and conventions

1.4.1 Symbols



The electrical warning icon indicates the presence of a hazard which could result in electrical shock.



The warning icon indicates the presence of a hazard which could result in personal injury.



The caution icon indicates important information or warning related to the concept discussed in the text. It might indicate the presence of a hazard which could result in corruption of software or damage to equipment or property.



The information icon alerts the reader of important facts and conditions.



The tip icon indicates advice on, for example, how to design your project or how to use a certain function.

Although warning hazards are related to personal injury, it is necessary to understand that under certain operational conditions, operation of damaged equipment may result in degraded process performance leading to personal injury or death. Therefore, comply fully with all warning and caution notices.

1.4.2 Document conventions

A particular convention may not be used in this manual.

- Abbreviations and acronyms are spelled out in the glossary. The glossary also contains definitions of important terms.
- Menu paths are presented in bold.
Select **Main menu/Settings**.
- WHMI menu names are presented in bold.
Click **Information** in the WHMI menu structure.
- Parameter names are shown in italics.
The function can be enabled and disabled with the *Operation* setting.
- Parameter values are indicated with quotation marks.

The corresponding parameter values are "On" and "Off".

- Input/output messages and monitored data names are shown in Courier font.
- This document assumes that the parameter setting visibility is "Advanced".

1.4.3

Functions, codes and symbols

Table 1: *Functions included in the merging unit*

Function	IEC 61850	IEC 60617	IEC-ANSI
Measurement			
Disturbance recorder	RDRE1	DR (1)	DFR (1)
Three-phase current measurement	CMMXU1	3I (1)	3I (1)
Sequence current measurement	CSMSQI1	I1, I2, I0 (1)	I1, I2, I0 (1)
Residual current measurement	RESCMMXU1	Io (1)	In (1)
Three-phase voltage measurement	VMMXU1	3U (1)	3V (1)
Sequence voltage measurement	VSMSQI1	U1, U2, U0 (1)	V1, V2, V0 (1)
Three-phase power and energy measurement	PEMMXU1	P, E (1)	P, E (1)
Frequency measurement	FMMXU1	f (1)	f (1)
IEC 61850-9-2 LE sampled value sending	SMVSENDER	SMVSENDER	SMVSENDER
Condition monitoring and supervision			
Circuit-breaker condition monitoring	SSCBR1	CBCM (1)	CBCM (1)
Trip circuit supervision	TCSSCBR1	TCS (1)	TCM (1)
	TCSSCBR2	TCS (2)	TCM (2)
Current circuit supervision	CCSPVC1	MCS 3I (1)	MCS 3I (1)
Fuse failure supervision	SEQSPVC1	FUSEF (1)	60 (1)
Arc detection	ARCDSARC1	ARCD (1)	AFD (1)
	ARCDSARC2	ARCD (2)	AFD (2)
	ARCDSARC3	ARCD (3)	AFD (3)
Control			
Circuit-breaker control	CBXCBR1	I <-> O CB (1)	I <-> O CB (1)
Disconnecter control	DCXSWI1	I <-> O DCC (1)	I <-> O DCC (1)
	DCXSWI2	I <-> O DCC (2)	I <-> O DCC (2)
Earthing switch control	ESXSWI1	I <-> O ESC (1)	I <-> O ESC (1)
Disconnecter position indication	DCSXSWI1	I <-> O DC (1)	I <-> O DC (1)
	DCSXSWI2	I <-> O DC (2)	I <-> O DC (2)
Earthing switch indication	ESSXSWI1	I <-> O ES (1)	I <-> O ES (1)
Other			
Table continues on next page			

Function	IEC 61850	IEC 60617	IEC-ANSI
Minimum pulse timer (2 pcs)	TPGAPC1	TP (1)	TP (1)
	TPGAPC2	TP (2)	TP (2)
	TPGAPC3	TP (3)	TP (3)
	TPGAPC4	TP (4)	TP (4)
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC1	TPS (1)	TPS (1)
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC1	TPM (1)	TPM (1)
Pulse timer (8 pcs)	PTGAPC1	PT (1)	PT (1)
	PTGAPC2	PT (2)	PT (2)
Time delay off (8 pcs)	TOFGAPC1	TOF (1)	TOF (1)
	TOFGAPC2	TOF (2)	TOF (2)
	TOFGAPC3	TOF (3)	TOF (3)
	TOFGAPC4	TOF (4)	TOF (4)
Time delay on (8 pcs)	TONGAPC1	TON (1)	TON (1)
	TONGAPC2	TON (2)	TON (2)
	TONGAPC3	TON (3)	TON (3)
	TONGAPC4	TON (4)	TON (4)
Set-reset (8 pcs)	SRGAPC1	SR (1)	SR (1)
	SRGAPC2	SR (2)	SR (2)
	SRGAPC3	SR (3)	SR (3)
	SRGAPC4	SR (4)	SR (4)
Move (8 pcs)	MVGAPC1	MV (1)	MV (1)
	MVGAPC2	MV (2)	MV (2)
Generic control point (16 pcs)	SPCGAPC1	SPC (1)	SPC (1)
	SPCGAPC2	SPC (2)	SPC (2)
Master trip	TRPPTRC1	Master Trip (1)	94/86 (1)
	TRPPTRC2	Master Trip (2)	94/86 (2)
	TRPPTRC3	Master Trip (3)	94/86 (3)
	TRPPTRC4	Master Trip (4)	94/86 (4)
	TRPPTRC5	Master Trip (5)	94/86 (5)

Section 2 Environmental aspects

2.1 Sustainable development

Sustainability has been taken into account from the beginning of the product design including the pro-environmental manufacturing process, long life time, operation reliability and disposing of the merging unit.

The choice of materials and the suppliers have been made according to the EU RoHS directive (2002/95/EC). This directive limits the use of hazardous substances which are the following:

Table 2: *Maximum concentration values by weight per homogeneous material*

Substance	Proposed maximum concentration
Lead - Pb	0.1%
Mercury - Hg	0.1%
Cadmium - Cd	0.01%
Hexavalent Chromium Cr (VI)	0.1%
Polybrominated biphenyls - PBB	0.1%
Polybrominated diphenyl ethers - PBDE	0.1%

Operational reliability and long life time have been assured with extensive testing during the design and manufacturing processes. Moreover, long life time is supported by maintenance and repair services as well as by the availability of spare parts.

Design and manufacturing have been done under a certified environmental system. The effectiveness of the environmental system is constantly evaluated by an external auditing body. We follow environmental rules and regulations systematically to evaluate their effect on our products and processes.

2.2 Disposal of a merging unit

Definitions and regulations of hazardous materials are country-specific and change when the knowledge of materials increases. The materials used in this product are typical for electric and electronic devices.

All parts used in this product are recyclable. When disposing of a merging unit or its parts, contact a local waste handler who is authorized and specialized in disposing of electronic waste. These handlers can sort the material by using dedicated sorting processes and dispose of the product according to the local requirements.

Table 3: *Materials of the merging unit parts*

Merging unit	Parts	Material
Case	Metallic plates, parts and screws	Steel
	Plastic parts	PC ¹⁾ , LCP ²⁾
	Electronics plug in module	Various
Plug-in unit	Electronics plug in modules	Various
	Electronics LHMI module	Various
	Plastic parts	PC, PBT ³⁾ , LCP, PA ⁴⁾
	Metallic parts	Aluminium
Package	Box	Cardboard
Attached material	Manuals	Paper

- 1) Polycarbonate
- 2) Liquid crystal polymer
- 3) Polybutylene terephthalate
- 4) Polyamide

Section 3 SMU615 overview

3.1 Overview

SMU615 is a dedicated substation merging unit intended for measuring current and voltage signals from the instrument transformers and merging them into the standard digital output format that other devices can further use for various power system protection application purposes. SMU615 itself includes no protection functionality but it offers the physical interface into the switchgear primary equipment, that is, circuit breaker, disconnector and earthing switch. SMU615 is a member of ABB's Relion® product family and is characterized by the compactness, simplicity and withdrawable-unit design.

SMU615 has been designed to unleash the full potential of the IEC 61850 standard for communication and interoperability in the digital substations. SMU615 supports process bus according to IEC 61850-9-2 LE with IEEE 1588 v2 time synchronization and both conventional CT/VT inputs and sensor inputs.

3.2 Local HMI

The LHMI is used for monitoring the merging unit. The LHMI comprises the push button, LED indicators and communication port.



Figure 2: Example of the LHMI

3.2.1

LEDs

The LHMI includes a dedicated Ready LED indicator and 11 matrix programmable LEDs on front of the LHMI.

The LEDs can be configured with PCM600 and the operation mode can be selected via WHMI or PCM600.

3.2.2

Keypad

The LHMI keypad contains a push button which is used to acknowledge alarms.

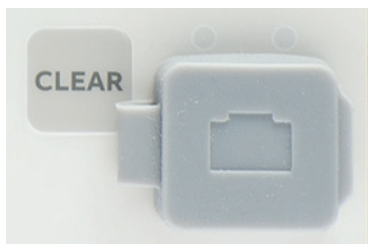



Figure 3: LHMI command push button and RJ-45 communication port

Commands

Table 4: Command push button

Name	Description
 Clear	<ul style="list-style-type: none"> Clearing programmable LEDs. After an initial three-second press, the following three-second press clears the programmable LEDs.

3.2.3

Local HMI functionality

3.2.3.1

LED indications

Ready LED indicator

Table 5: Ready LED indications

LED state	Description
Off	Auxiliary supply voltage is disconnected.
On	Normal operation
Flashing	Internal fault has occurred or the merging unit is in test mode. Internal faults are accompanied by an indication message.

Alarm indicators

The 11 matrix programmable LEDs are used for alarm indication.

Table 6: Alarm indications

LED state	Description
Off	Normal operation. All activation signals are off.
On	<ul style="list-style-type: none"> Non-latched mode: activation signal is still on. Latched mode: activation signal is still on, or it is off but has not been acknowledged. Latched flashing mode: activation signal is still on but has been acknowledged.
Flashing	<ul style="list-style-type: none"> Non-latched flashing mode: activation signal is still on. Latched flashing mode: activation signal is still on, or it is off but has not been acknowledged.

3.2.3.2

Front communication

The RJ-45 port in the LHMI enables front communication. Two LEDs are located above the communication port.

- The green uplink LED on the left is lit when the cable is successfully connected to the port.
- The yellow communication LED on the right flashes when the merging unit communicates with the connected device.

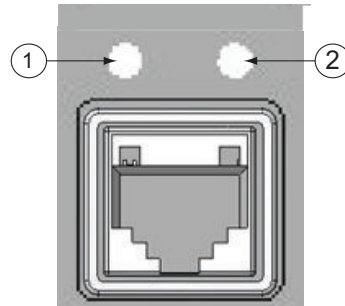


Figure 4: RJ-45 communication port and indication LEDs

- 1 Uplink LED
- 2 Communication LED

When a computer is connected to the merging unit, the merging unit's DHCP server for the front interface assigns an IP address to the computer. The fixed IP address for the front port is 192.168.0.254.

3.3

Web HMI

The WHMI allows secure access to the merging unit via a Web browser. When the *Secure Communication* parameter in the merging unit is activated, the Web server is forced to take a secured (HTTPS) connection to WHMI using TLS encryption. The WHMI is verified with Internet Explorer 8.0, 9.0, 10.0 and 11.0.

WHMI offers several functions.

- Programmable LEDs and event lists
- System supervision
- Parameter settings
- Measurement display
- Disturbance records

- Phasor diagram
- Importing/Exporting parameters
- Report summary

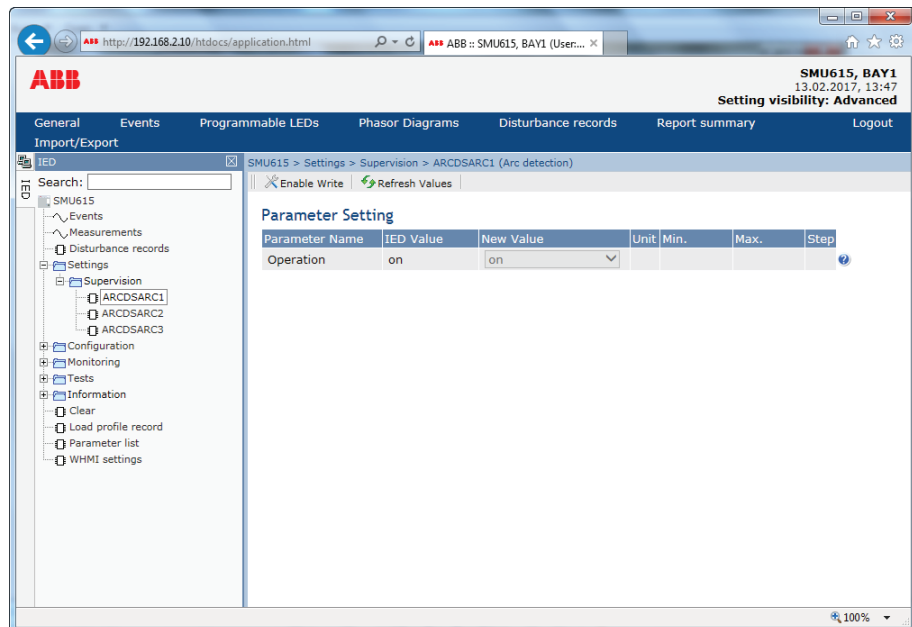


Figure 5: Example view of the WHMI

The WHMI can be accessed locally and remotely.

- Locally by connecting the laptop to the merging unit via the front communication port.
- Remotely over LAN/WAN.

WHMI is enabled by default on the rear port and always enabled (cannot be disabled) on the front port.
























If the WHMI is accessed locally via the front communication port, the following features are available.

- Setting the merging unit to test mode and testing of outputs
- Trip circuit lockout reset
- Restoring factory settings

3.3.1 Command buttons

Command buttons can be used to edit parameters and control information via the WHMI.

Table 7: *Command buttons*

Name	Description
 Enable Write	Enabling parameter editing
 Disable Write	Disabling parameter editing
 Write to IED	Writing parameters to the merging unit
 Refresh Values	Refreshing parameter values
 Print	Printing out parameters
 Commit	Committing changes to merging unit's non-volatile flash memory
 Reject	Rejecting changes
	Showing context sensitive help messages
	Error icon
 Clear events	Clearing events
 Manual trigger	Triggering the disturbance recorder manually
 Save	Saving values to TXT or CSV file format
 Freeze	Freezing the values so that updates are not displayed
 Continue	Receiving continuous updates to the monitoring view
 Delete	Deleting the disturbance record
 Delete all	Deleting all disturbance records
	Saving the disturbance record files
 View all	Viewing all fault records
 Clear records	Clearing all fault records
Import Settings	Importing settings
Export Settings	Exporting settings
 Select all	Selecting all
 Clear all	Clearing all selections
 Clear	Clearing load profile record
 Refresh	Refreshing the parameter list view

3.4 Authorization

Four user categories have been predefined for the WHMI, each with different rights and default passwords.

The default passwords in the merging unit delivered from the factory can be changed with Administrator user rights.

Table 8: *Predefined user categories*

Username	User rights
VIEWER	Read only access
OPERATOR	<ul style="list-style-type: none"> Clearing indications
ENGINEER	<ul style="list-style-type: none"> Changing settings Clearing event list Clearing disturbance records Changing system settings such as IP address, serial baud rate or disturbance recorder settings Setting the merging unit to test mode Selecting language
ADMINISTRATOR	<ul style="list-style-type: none"> All listed above Changing password Factory default activation



For user authorization for PCM600, see PCM600 documentation.

3.4.1 Audit trail

The merging unit offers a large set of event-logging functions. Critical system and merging unit security-related events are logged to a separate nonvolatile audit trail for the administrator.

Audit trail is a chronological record of system activities that allows the reconstruction and examination of the sequence of system and security-related events and changes in the merging unit. Both audit trail events and process related events can be examined and analyzed in a consistent method with the help of Event List in WHMI and Event Viewer in PCM600.

The merging unit stores 2048 audit trail events to the nonvolatile audit trail. Additionally, 1024 process events are stored in a nonvolatile event list. Both the audit trail and event list work according to the FIFO principle. Nonvolatile memory is based on a memory type which does not need battery backup nor regular component change to maintain the memory storage.

Audit trail events related to user authorization (login, logout, violation remote and violation local) are defined according to the selected set of requirements from IEEE 1686. The logging is based on predefined user names or user categories. The user audit trail events are accessible with IEC 61850-8-1, PCM600 and WHMI.

Table 9: *Audit trail events*

Audit trail event	Description
Configuration change	Configuration files changed
Firmware change	Firmware changed
Firmware change fail	Firmware change failed
Attached to retrofit test case	Unit has been attached to retrofit case
Removed from retrofit test case	Removed from retrofit test case
Control remote	DPC object control remote
Test on	Test mode on
Test off	Test mode off
Reset trips	Reset latched trips (TRPPTRC*)
Time change	Time changed directly by the user. Note that this is not used when the merging unit is synchronised properly by the appropriate protocol (IEEE 1588 v2).
View audit log	Administrator accessed audit trail
Login	Successful login from IEC 61850-8-1 (MMS), WHMI or FTP.
Logout	Successful logout from IEC 61850-8-1 (MMS), WHMI or FTP.
Password change	Password changed
Firmware reset	Reset issued by user or tool
Audit overflow	Too many audit events in the time period
Violation remote	Unsuccessful login attempt from IEC 61850-8-1 (MMS), WHMI or FTP.
Violation local	Unsuccessful login attempt from IEC 61850-8-1 (MMS), WHMI or FTP.

PCM600 Event Viewer can be used to view the audit trail events and process related events. Audit trail events are visible through dedicated Security events view. Since only the administrator has the right to read audit trail, authorization must be used in PCM600. The audit trail cannot be reset, but PCM600 Event Viewer can filter data. Audit trail events can be configured to be visible also in WHMI Event list together with process related events.



To expose the audit trail events through Event list, define the *Authority logging* level parameter via **Configuration/Authorization/Security**. This exposes audit trail events to all users.

Table 10: *Comparison of authority logging levels*

Audit trail event	Authority logging level			
	None	Configuration change	Settings edit	All
Configuration change		•	•	•
Firmware change		•	•	•
Firmware change fail		•	•	•
Attached to retrofit test case		•	•	•
Removed from retrofit test case		•	•	•
Control remote			•	•
Test on			•	•
Test off			•	•
Reset trips			•	•
Time change				•
View audit log				•
Login				•
Logout				•
Password change				•
Firmware reset				•
Violation local				•
Violation remote				•

3.5 Communication

The merging unit supports a range of communication protocols including IEC 61850 and IEC 61850-9-2 LE. Operational information and controls are available through these protocols. However, some communication functionality, for example, horizontal communication between the merging units, is only enabled by the IEC 61850 communication protocol.

The IEC 61850 communication implementation supports all monitoring and control functions. Additionally, parameter settings and disturbance recordings can be accessed using the IEC 61850 protocol. Disturbance recordings are available to any Ethernet-based application in the IEC 60255-24 standard COMTRADE file format. The merging unit can send and receive binary signals from other devices (so-called horizontal communication) using the IEC 61850-8-1 GOOSE profile, where the highest performance class with a total transmission time of 3 ms is supported. Furthermore, the merging unit supports sending of analog values using GOOSE messaging. The merging unit meets the GOOSE performance requirements for tripping applications in distribution substations, as defined by the IEC 61850 standard.

The merging unit can support five simultaneous clients. If PCM600 reserves one client connection, only four connections are left for other clients.

All communication connectors, except for the front port connector, are placed on integrated optional communication modules. The merging unit can be connected to Ethernet-based communication systems via the RJ-45 connector (100Base-TX) or the fiber-optic LC connector (100Base-FX).

3.5.1

Ethernet redundancy

IEC 61850 specifies a network redundancy scheme that improves the system availability for substation communication. It is based on two complementary protocols defined in the IEC 62439-3:2012 standard: parallel redundancy protocol PRP-1 and high-availability seamless redundancy HSR protocol. Both protocols rely on the duplication of all transmitted information via two Ethernet ports for one logical network connection. Therefore, both are able to overcome the failure of a link or switch with a zero-switchover time, thus fulfilling the stringent real-time requirements for the substation automation horizontal communication and time synchronization.

PRP specifies that each device is connected in parallel to two local area networks. HSR applies the PRP principle to rings and to the rings of rings to achieve cost-effective redundancy. Thus, each device incorporates a switch element that forwards frames from port to port.



IEC 62439-3:2012 cancels and replaces the first edition published in 2010. These standard versions are also referred to as IEC 62439-3 Edition 1 and IEC 62439-3 Edition 2. The merging unit supports IEC 62439-3:2012 and it is not compatible with IEC 62439-3:2010.

PRP

Each PRP node, called a doubly attached node with PRP (DAN), is attached to two independent LANs operated in parallel. These parallel networks in PRP are called LAN A and LAN B. The networks are completely separated to ensure failure independence, and they can have different topologies. Both networks operate in parallel, thus providing zero-time recovery and continuous checking of redundancy to avoid communication failures. Non-PRP nodes, called single attached nodes (SANs), are either attached to one network only (and can therefore communicate only with DANs and SANs attached to the same network), or are attached through a redundancy box, a device that behaves like a DAN.

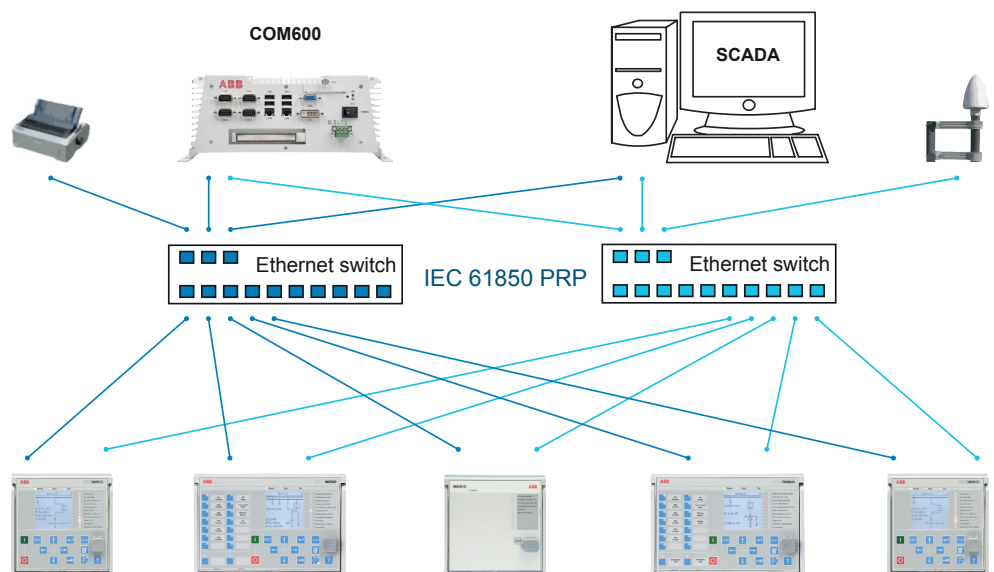


Figure 6: PRP solution

In case a laptop or a PC workstation is connected as a non-PRP node to one of the PRP networks, LAN A or LAN B, it is recommended to use a redundancy box device or an Ethernet switch with similar functionality between the PRP network and SAN to remove additional PRP information from the Ethernet frames. In some cases, default PC workstation adapters are not able to handle the maximum-length Ethernet frames with the PRP trailer.

There are different alternative ways to connect a laptop or a workstation as SAN to a PRP network.

- Via an external redundancy box (RedBox) or a switch capable of connecting to PRP and normal networks
- By connecting the node directly to LAN A or LAN B as SAN
- By connecting the node to the merging unit's interlink port

HSR

HSR applies the PRP principle of parallel operation to a single ring, treating the two directions as two virtual LANs. For each frame sent, a node, DAN, sends two frames, one over each port. Both frames circulate in opposite directions over the ring and each node forwards the frames it receives, from one port to the other. When the originating node receives a frame sent to itself, it discards that to avoid loops; therefore, no ring protocol is needed. Individually attached nodes, SANs, such as laptops and printers, must be attached through a “redundancy box” that acts as a ring element. For example, a merging unit with HSR support can be used as a redundancy box.

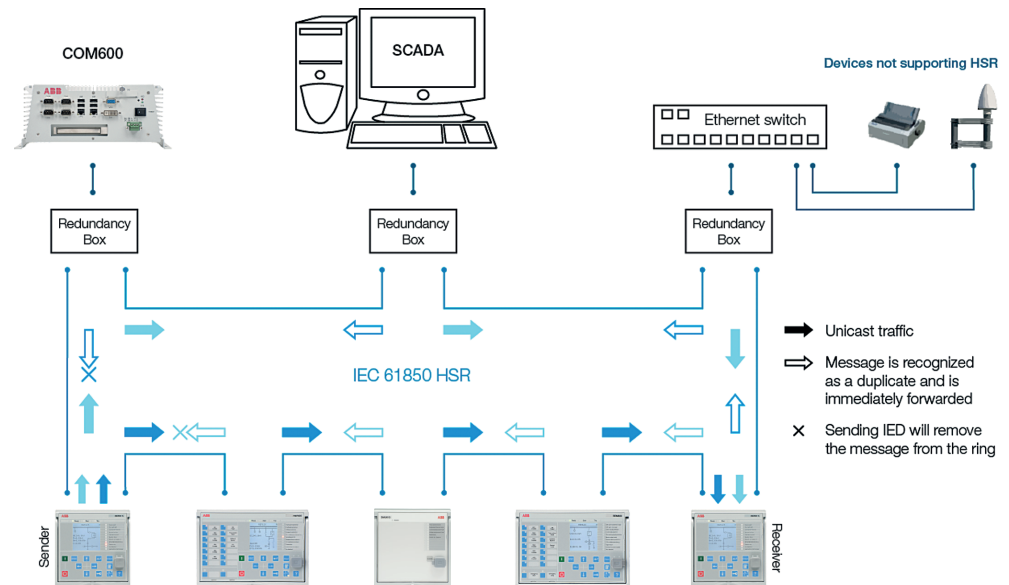


Figure 7: HSR solution

3.5.2

Process bus

Process bus IEC 61850-9-2 defines the transmission of Sampled Measured Values within the substation automation system. International Users Group created a guideline IEC 61850-9-2 LE that defines an application profile of IEC 61850-9-2 to facilitate implementation and enable interoperability. Process bus is used for distributing process data from the primary circuit to all process bus compatible devices in the local network in a real-time manner. The data can then be processed by any protection relay to perform different protection, automation and control functions.

With process bus the galvanic wiring for sharing busbar voltage value can be replaced with Ethernet communication. Transmitting measurement samples over process bus brings also higher error detection because the signal transmission is automatically supervised. Additional contribution to the higher availability is the possibility to use redundant Ethernet network for transmitting SMV signals.

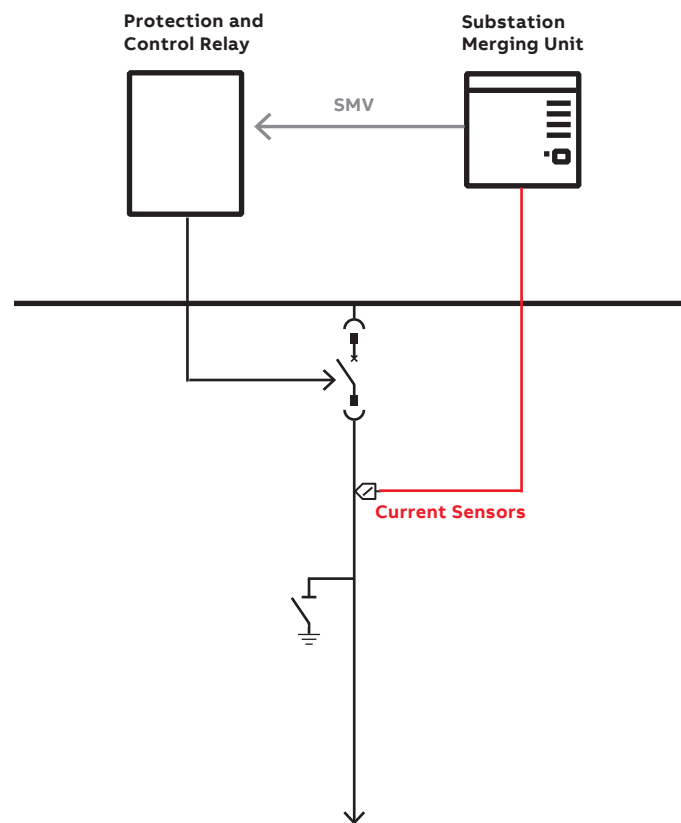


Figure 8: SMU615 sending current measurements as sampled measured values to a protection relay

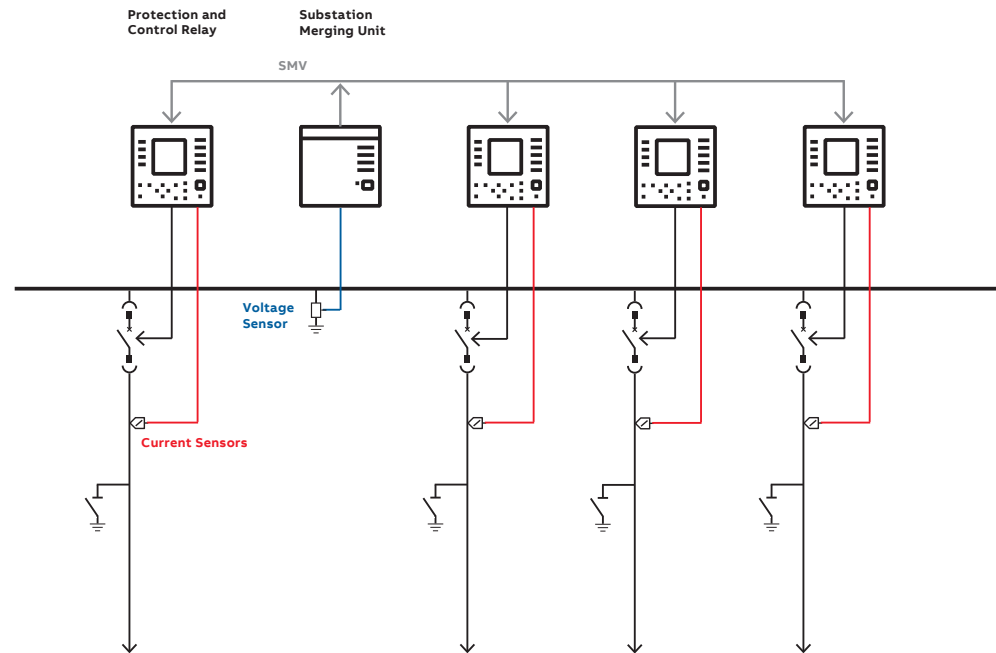


Figure 9: SMU615 sending voltage measurements as sampled measured values to protection relays

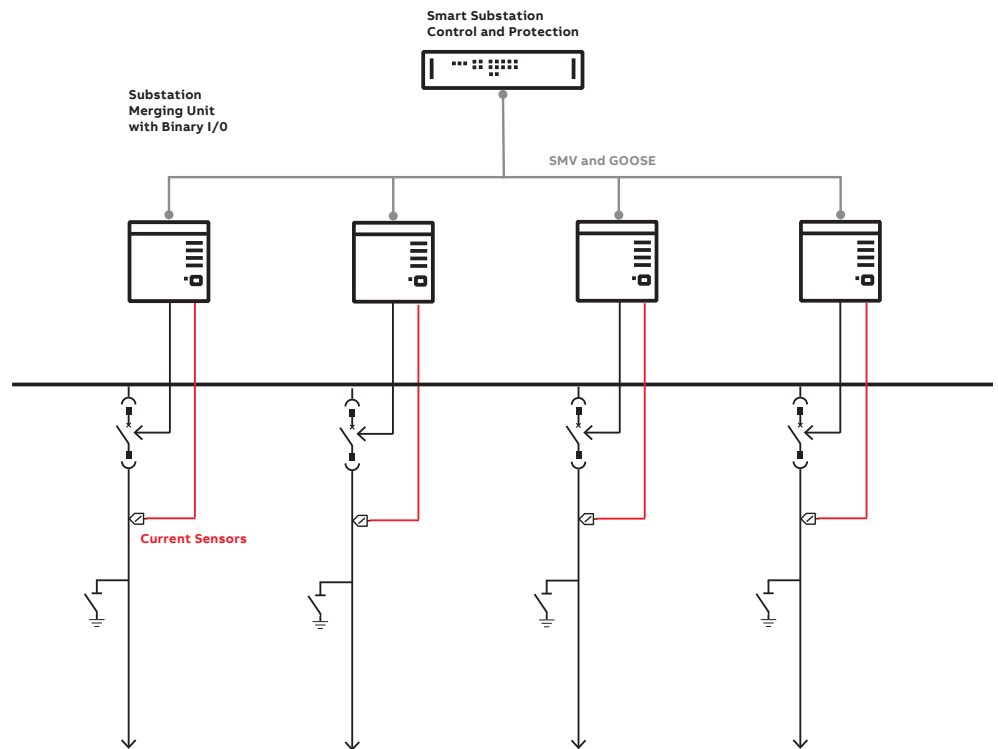


Figure 10: Smart substation control and protection SSC600 with SMU615

The merging unit supports IEC 61850 process bus with sampled values of analog currents and voltages. The measured values are transferred as sampled values using the IEC 61850-9-2 LE protocol which uses the same physical Ethernet network as the IEC 61850-8-1 station bus. The intended application for sampled values is sharing the measured voltages and currents from the merging unit to other devices with 9-2 support.

The merging units with process bus based applications use IEEE 1588 v2 Precision Time Protocol (PTP) according to IEEE C37.238-2011 Power Profile for high accuracy time synchronization. With IEEE 1588 v2, the cabling infrastructure requirement is reduced by allowing time synchronization information to be transported over the same Ethernet network as the data communications.

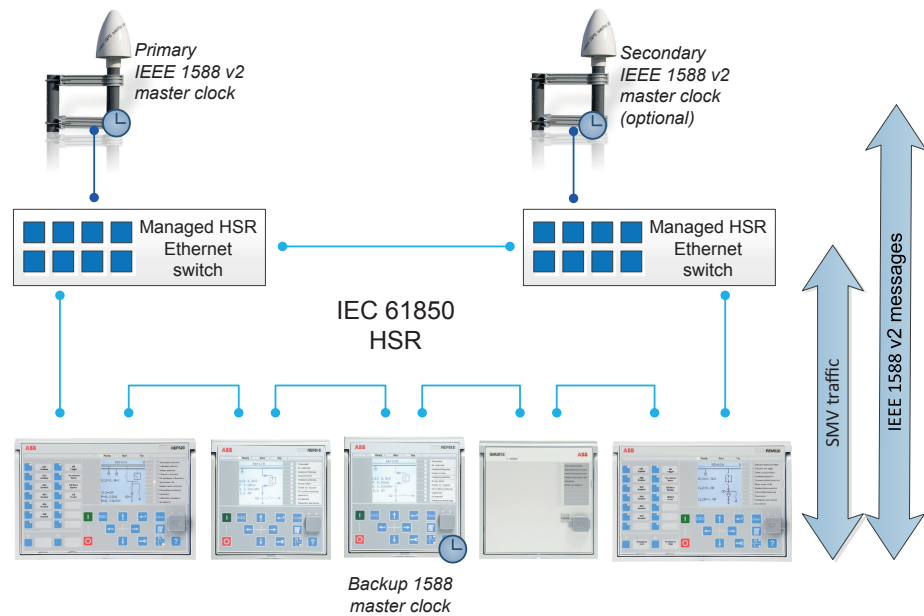


Figure 11: Example network topology with process bus, redundancy and IEEE 1588 v2 time synchronization

The process bus is available for all merging units. See the IEC 61850 engineering guide for detailed system requirements and configuration details.

3.5.3 Secure communication

The merging unit supports secure communication for WHMI and file transfer protocol. If the *Secure Communication* parameter is activated, protocols require TLS based encryption method support from the clients. In this case WHMI must be connected from a Web browser using the HTTPS protocol and in case of file transfer the client must use FTPS.

3.6 PCM600 tool

Protection and Control IED Manager PCM600 offers all the necessary functionality to work throughout all stages of the merging unit life cycle.

- Planning
- Engineering
- Commissioning
- Operation and disturbance handling
- Functional analysis

The whole substation can be controlled and different tasks and functions can be performed with the individual tool components. PCM600 can operate with many different topologies, depending on the customer needs.



For more information, see the PCM600 documentation.

3.6.1

Connectivity packages

A connectivity package is a software component that consists of executable code and data which enables system tools to communicate with a merging unit. Connectivity packages are used to create configuration structures in PCM600. The latest PCM600 and connectivity packages are backward compatible with older merging unit versions.

A connectivity package includes all of the data which is used to describe the merging unit, for example, it contains a list of the existing parameters, data format used, units, setting range, access rights and visibility of the parameter. In addition, it contains code which allows software packages that consume the connectivity package to properly communicate with the merging unit. It also allows for localization of text even when its read from the merging unit in a standard format such as COMTRADE.

Update Manager is a tool that helps in defining the right connectivity package versions for different system products and tools. Update Manager is included with products that use connectivity packages.

3.6.2

PCM600 and merging unit's connectivity package version

- Protection and Control IED Manager PCM600 2.7 or later
- SMU615 Connectivity Package Ver.1.0 or later




Contact ABB for information on the latest connectivity package.

Section 4 Using HMI

4.1 Using local HMI

4.1.1 Clearing and acknowledging

The Clear button is used to reset and acknowledge latched programmable LED indications. It is a shortcut for clearing.

- Press  for three seconds to clear the latched programmable LEDs.

4.2 Using Web HMI

- As secure communication is enabled by default, access the WHMI from a Web browser using the HTTPS protocol.



To establish a remote WHMI connection to the merging unit, contact the network administrator to check the company rules for IP and remote connections.



Disable the Web browser proxy settings or make an exception to the proxy rules to allow the merging unit's WHMI connection, for example, by including the merging unit's IP address in **Internet Options/Connections/LAN Settings/Advanced/Exceptions**.

4.2.1 Logging in

1. Open Internet Explorer.
2. Type the merging unit's IP address in the Address bar and press ENTER.
3. Type the username with capital letters.
4. Type the password.

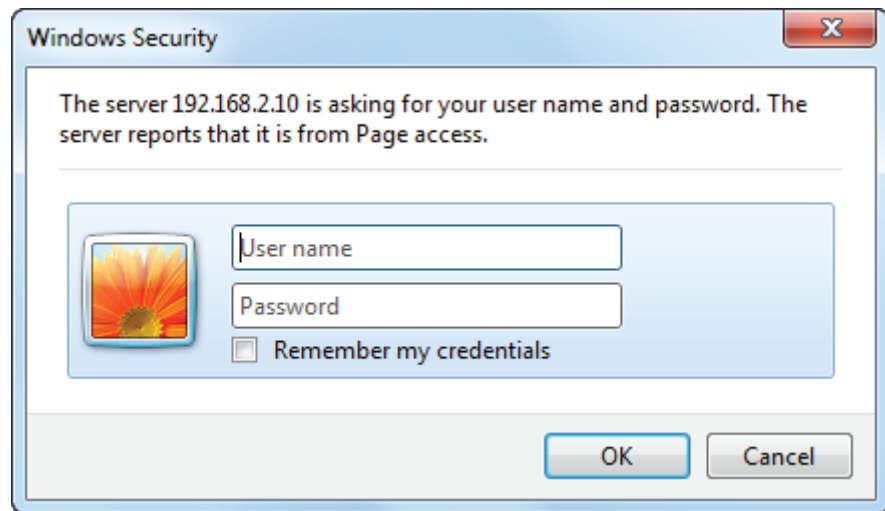


Figure 12: Entering username and password to use the WHMI

5. Click **OK**.
The language file starts loading and the progress bar is displayed.

4.2.2 Logging out

The user is logged out after session timeout. The timeout can be set in **Main menu/Configuration/HMI/Web HMI timeout**.

- To log out manually, click **Logout** on the menu bar.

4.2.3 Identifying device

The Information menu includes detailed information about the device, for example, revision and serial number.

1. Click the **Information** menu in the left navigation bar.
2. Click a submenu to see the data.

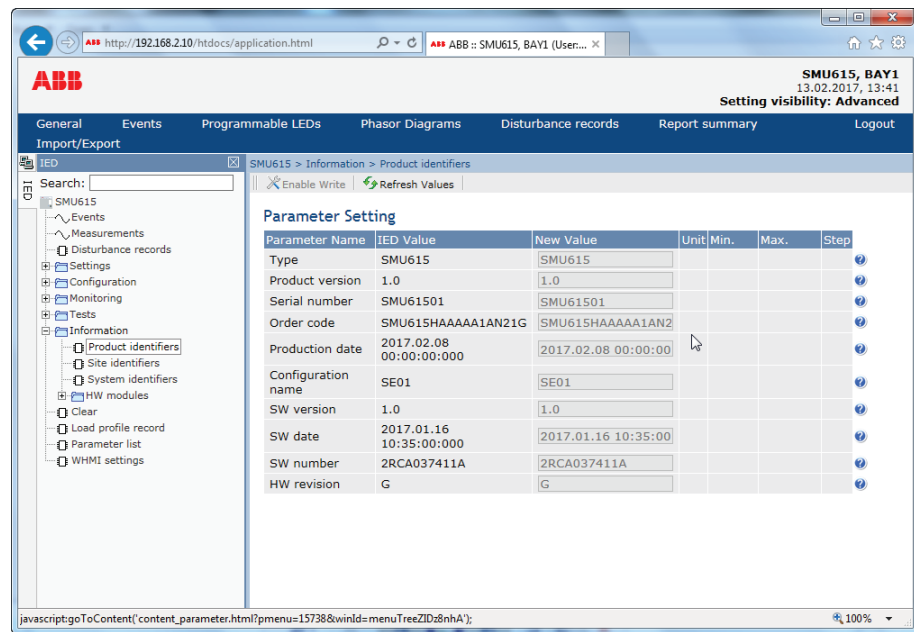


Figure 13: Device information

4.2.4 Navigating in menus

- Use the menu bar to access different views.
 - The **General** view shows the merging unit version and status.
 - The **Events** view contains a list of events produced by the application configuration.
 - The **Programmable LEDs** view shows the status of programmable LEDs.
 - The **Phasor diagrams** view shows phasor diagrams.
 - The **Disturbance records** view shows the list of disturbance records.
 - The **Report summary** page allows to save events, fault records, disturbance records, the load profile record and the parameter list.
 - The **Import/Export** page allows to import and export parameters settings.
 - **Logout** ends the session.

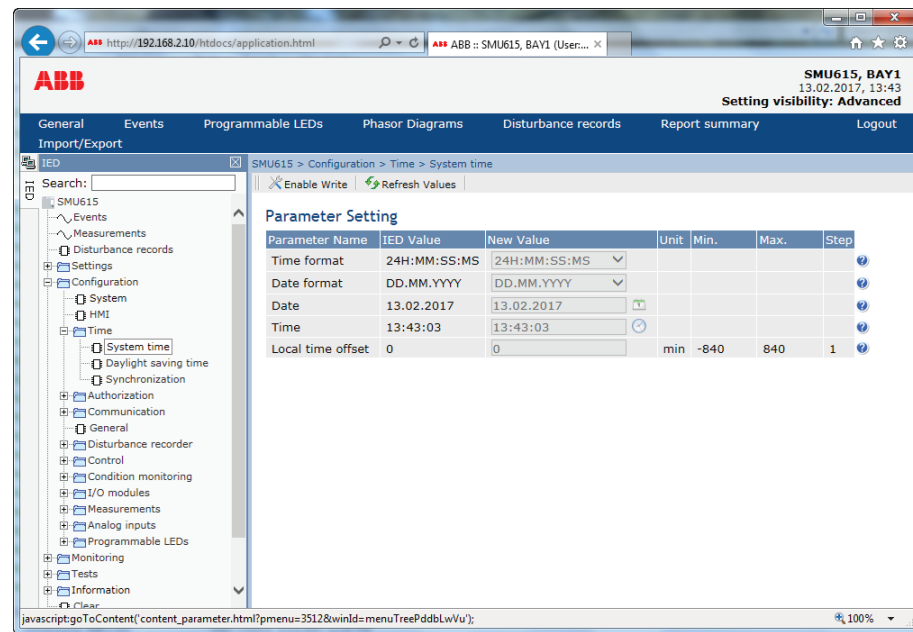


Figure 14: Navigating in Web HMI menus

4.2.4.1

Menu structure

The Main menu contains main groups which are divided further into more detailed submenus.

- Control
- Events
- Measurements
- Disturbance records
- Configuration
- Monitoring
- Tests
- Information
- Clear
- Language
- Load profile record
- Parameter list
- WHMI settings

4.2.5

Showing parameters

Some function blocks have a function-specific On/Off setting. When the function setting is “Off”, all settings are hidden and when the function setting is “On”, all settings are visible based on the other visibility and hiding rules.



Switch a function block on or off via the *Operation* parameter under the required function block.

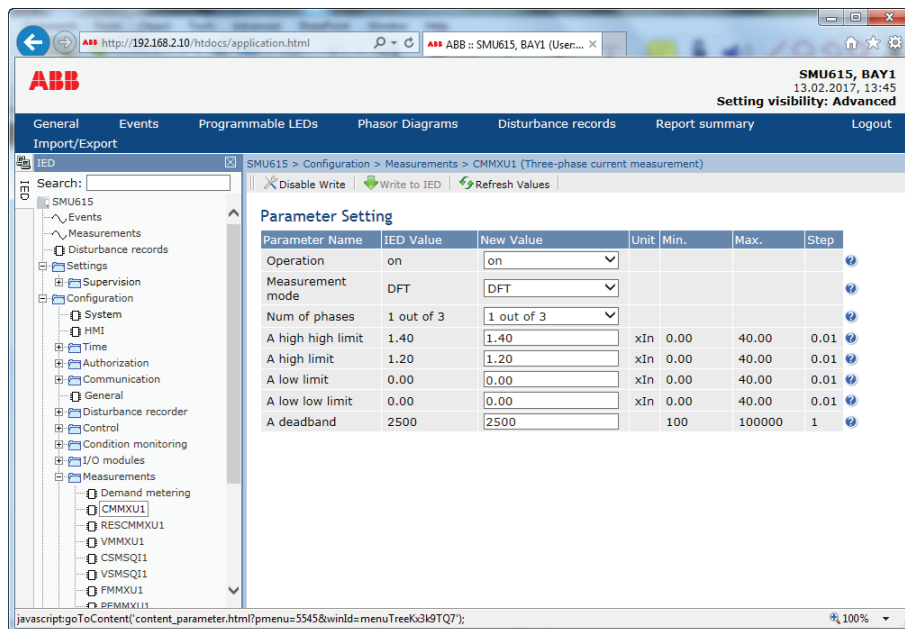


Figure 15: Function block On

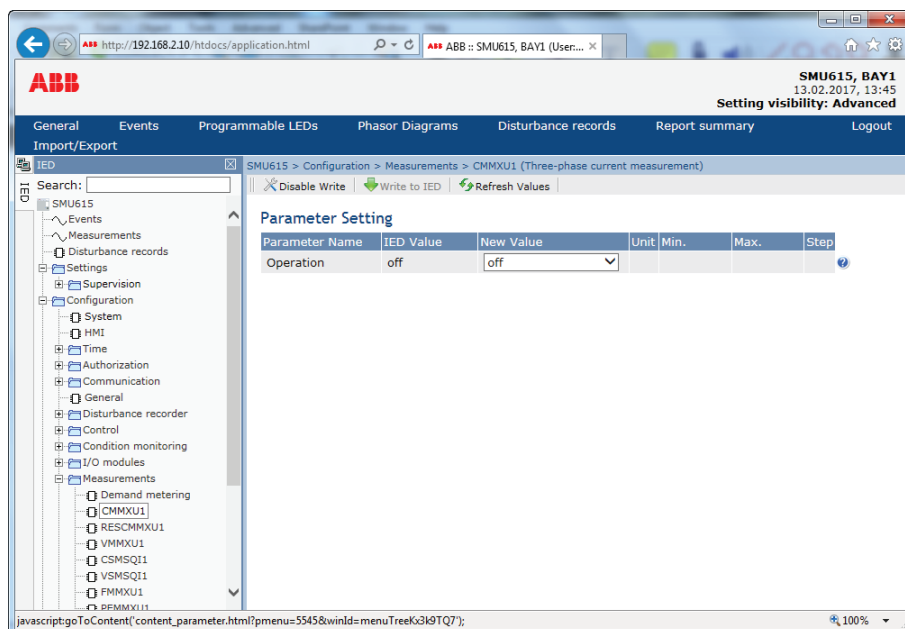


Figure 16: Function block Off

The Parameter list page offers filtering functionality where only chosen parameters are displayed, saved or printed. There are various options for filtering.

- Enabled settings hides settings of disabled function blocks.
- Writable settings displays only writable settings. This option is checked by default.
- Basic settings displays only basic settings.
- Setting group displays only settings of the selected setting group. With “All” selected, all setting groups are displayed.

Options can be combined. For example, with the Enabled settings and Writable settings selected, only enabled and writable settings are displayed. If none of the options is selected, all settings are displayed.



The values “Basic” or “Advanced” of the *Setting visibility* parameter in **Main Menu/Configuration/HMI** have no effect on the Parameter list page. This page has its own Basic settings option which can be used to hide or show the advanced settings on the Parameter list page.

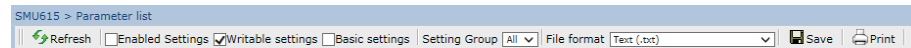


Figure 17: Parameter list filter

1. Click **Parameter list** in the left navigation bar.

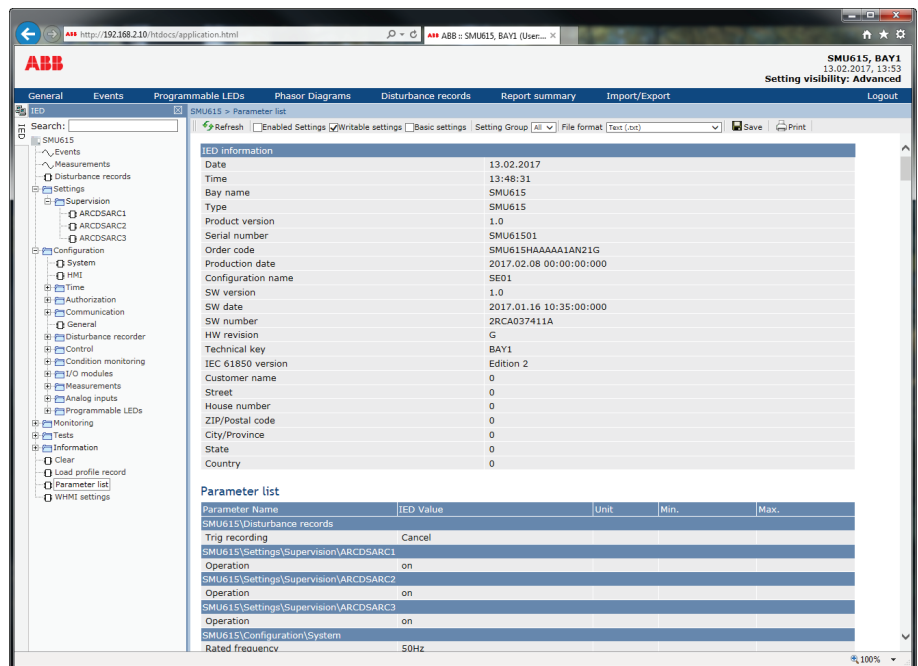


Figure 18: Displaying parameters

2. Select only those settings that are wanted to be shown and click **Refresh**. If nothing is selected, all settings are shown.

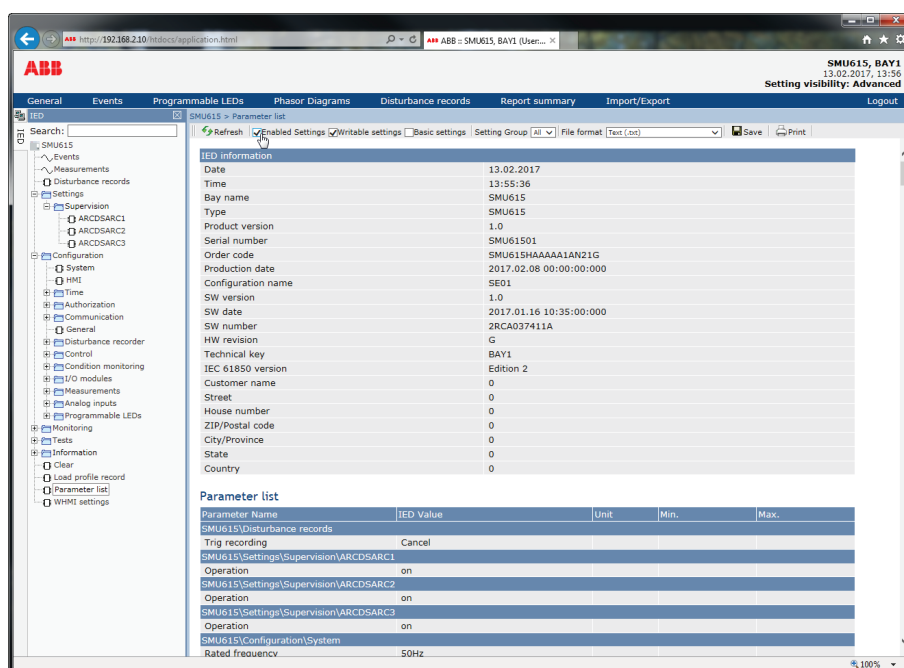


Figure 19: Enabled settings

3. Select text (.txt) or comma separated values (.csv) file format and click **Save** to save the settings.
4. Click **Print** to print all the selected parameters.

4.2.6

Editing values

1. Select a menu in the left navigation bar.
2. Click a submenu to see function blocks.
3. Click a function block to see the setting values.
4. Click **Enable Write**.



Some parameters, for example the Web HMI mode, cannot be set via the WHMI.

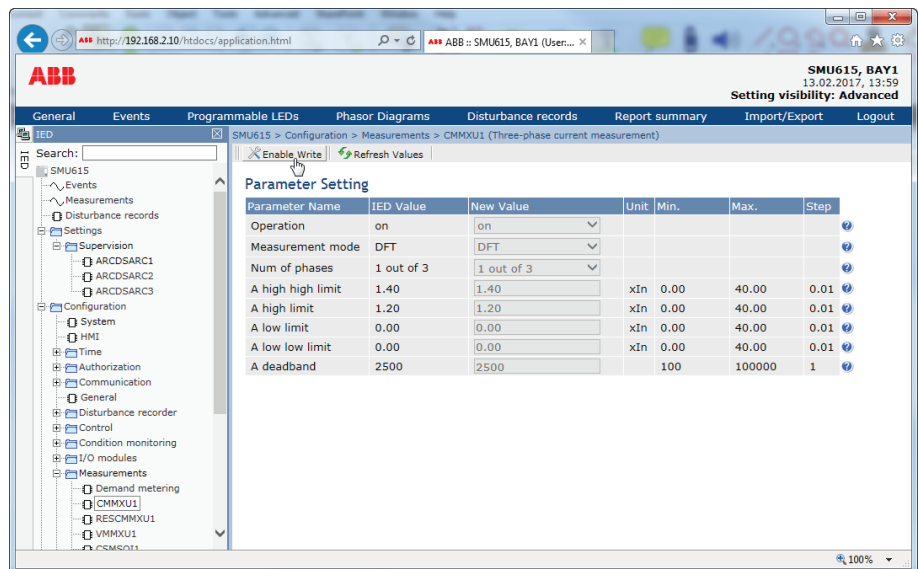


Figure 20: Enable writing to edit a value

5. Edit the value.

- The minimum, maximum and step values for a parameter are shown in the Min., Max. and Step columns.

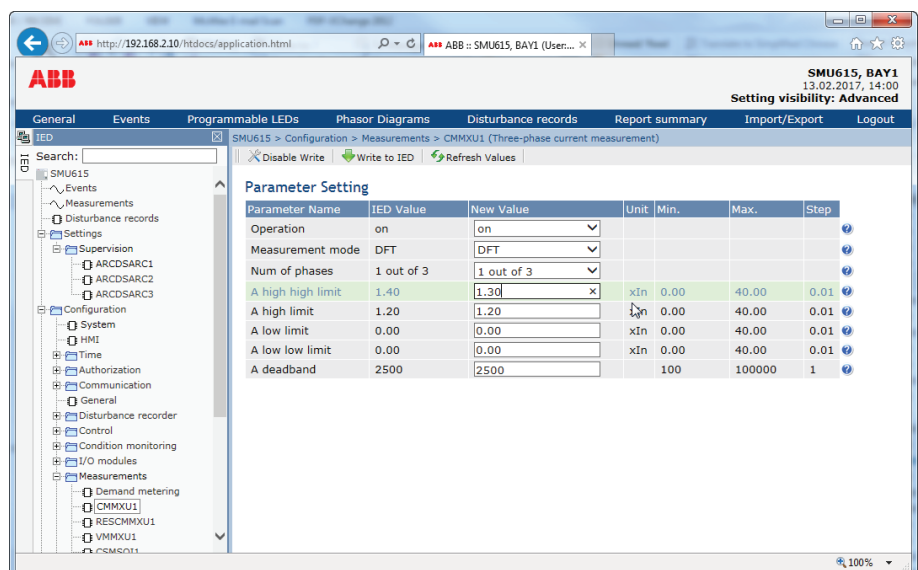


Figure 21: Editing a value

- If the entered value is within the accepted value range, the selection is highlighted in green. If the value is out of range, the row is highlighted in red and a warning dialog box is displayed. **Write to IED** is unavailable.

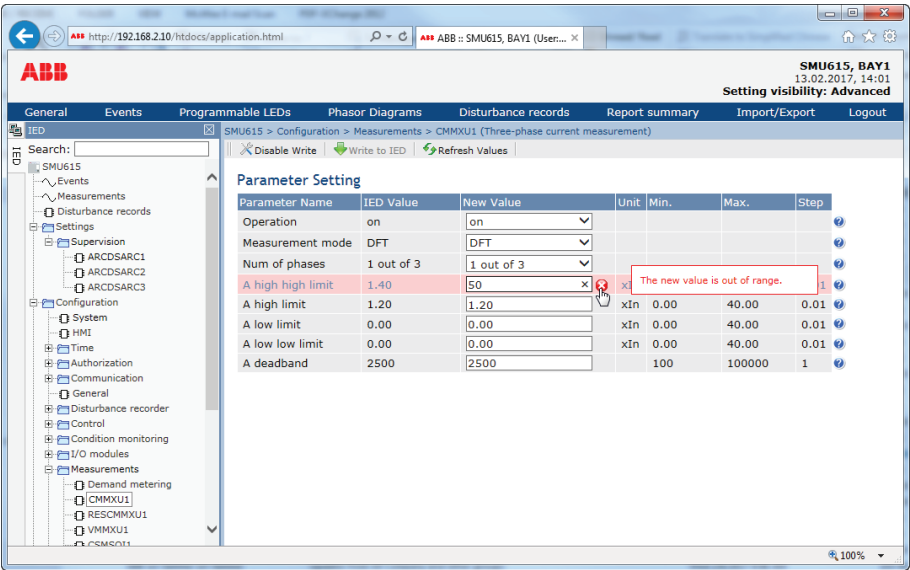


Figure 22: Warning indicating that the entered value is incorrect

- If writing values fails, a warning dialog box is displayed.

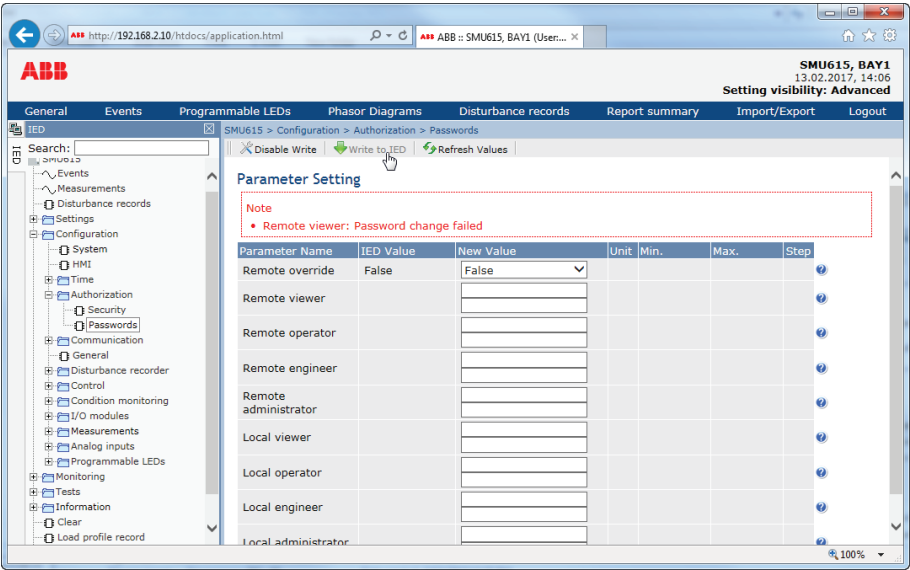


Figure 23: Warning indicating that the values were not written to the merging unit



If writing is enabled accidentally, click **Disable Write**. **Disable Write** cannot be selected when a value has already been written to the merging unit. After clicking **Write to IED**, click either **Commit** or **Reject**.

4.2.7 Committing settings

Editable values are stored either in RAM or a nonvolatile flash memory. Values stored in the flash memory are in effect also after a reboot.

Some parameters have an edit-copy. If editing is cancelled, the values with an edit-copy are immediately restored to the original value. The values without an edit-copy, such as string values, are restored to the original value only after a reboot even though the edited value is not stored in the flash memory.

1. Click **Write to IED** after editing parameter values to put the values into merging unit's database for use.

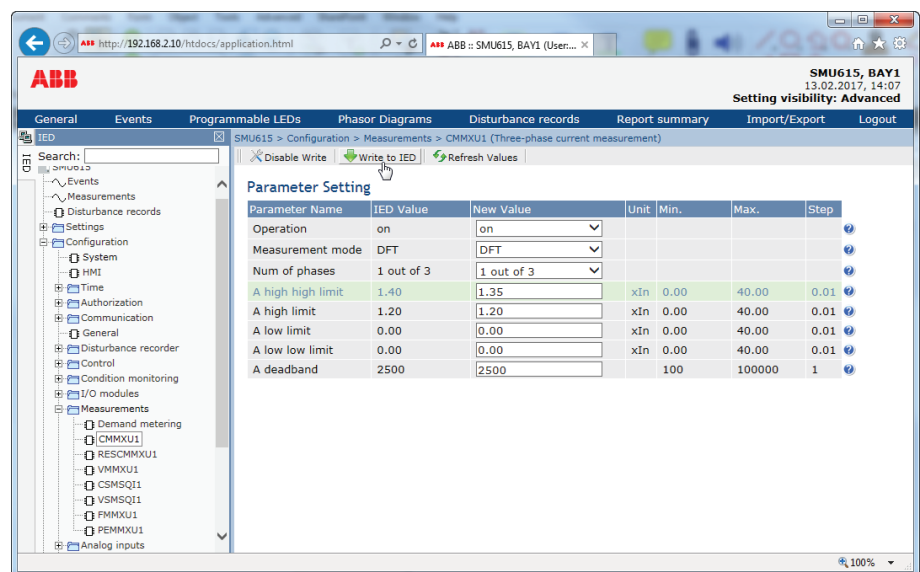


Figure 24: Writing values to merging unit

The values are not stored to the flash memory.

2. Click **Commit** to write the values to the flash memory.
 - Click **Reject** to cancel saving settings.
 - If the parameter has an edit-copy, the original parameter value is restored.
 - If the parameter does not have an edit-copy, the edited parameter value remains visible until the merging unit is rebooted. However, the edited value is not stored in the nonvolatile memory and thus the reboot restores the original value.

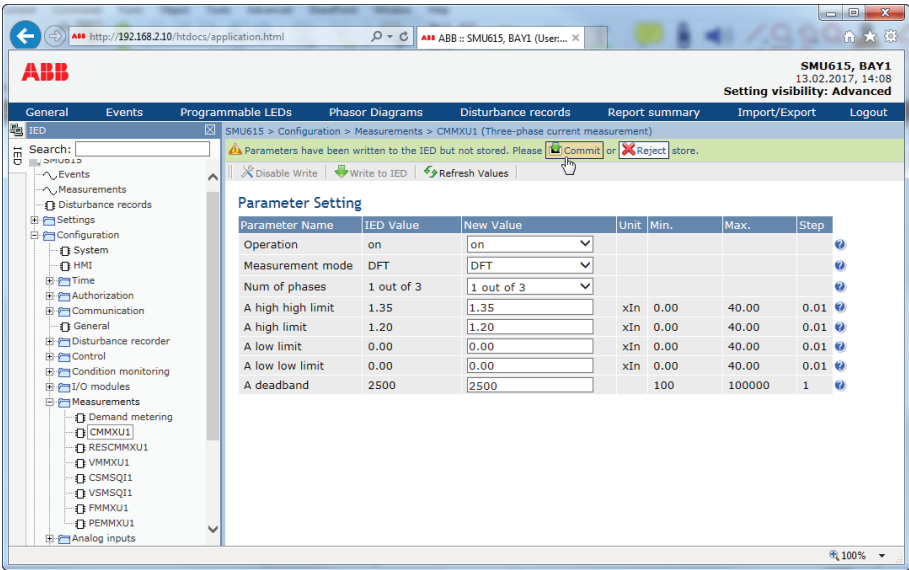


Figure 25: Committing changes



Committing values takes a few seconds.



If the values are not committed, they are not taken into use and they are lost after a reboot.

4.2.8

Clearing and acknowledging

All messages and indications, including LEDs and latched outputs as well as registers and recordings, can be reset, acknowledged or cleared using the Clear menu.

1. Click **Clear** in the left navigation bar.

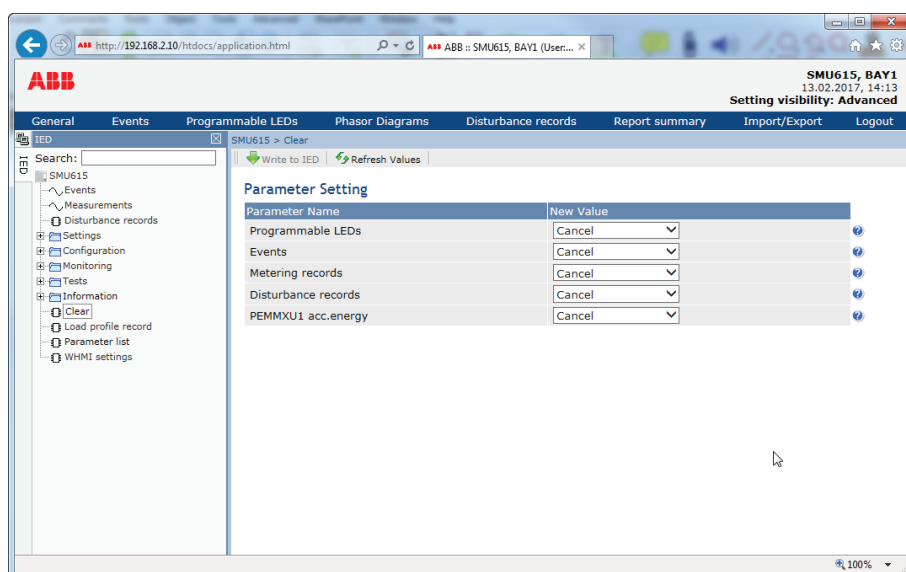


Figure 26: Selecting clear menu

2. In the **New Value** list, select **Clear** to choose the item to be cleared.
3. Click **Write to IED**.

4.2.9

Selecting programmable LEDs view

The programmable LEDs view shows the status of the programmable LEDs. These are the same LEDs that are located on the upper right side of the LHMI panel.

- Click **Programmable LEDs** on the menu bar.

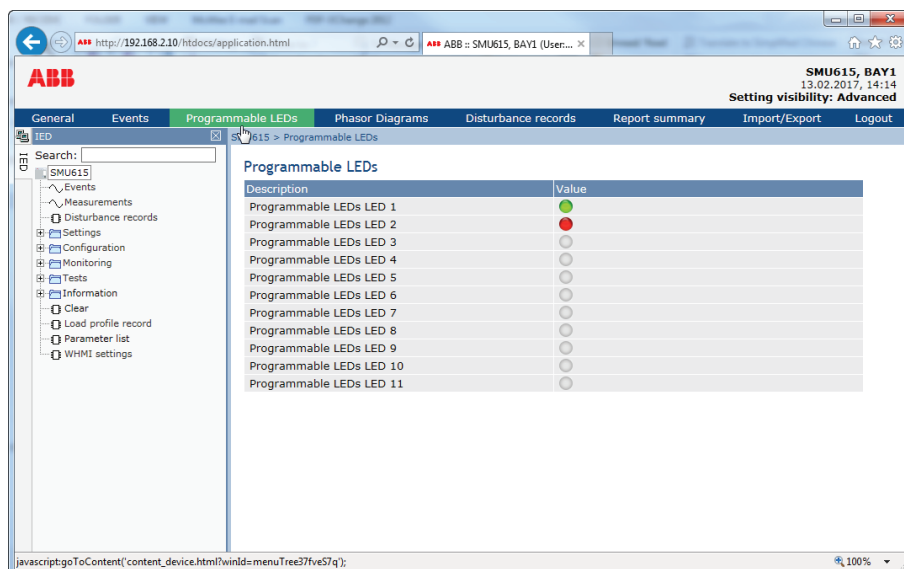


Figure 27: Monitoring programmable LEDs

4.2.10 Selecting event view

The event view contains a list of events produced by the application configuration. When the event page is opened, it displays up to 100 latest events at one time. The event list is updated automatically.

1. Click **Events** on the menu bar.

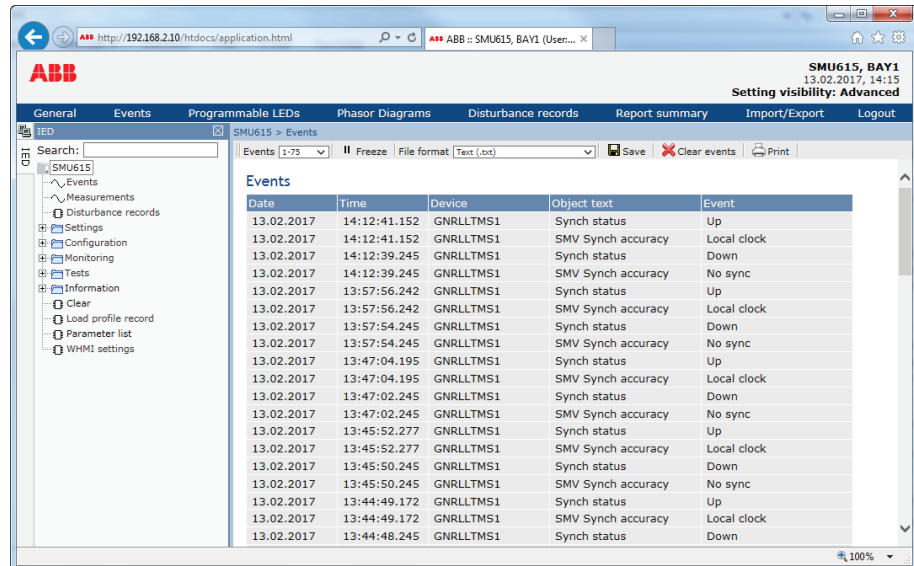


Figure 28: Monitoring events

2. Click **Freeze** to stop updating the event list.
3. Select a page from the drop-down list to view older events or select **View all** to show all events on the same page.

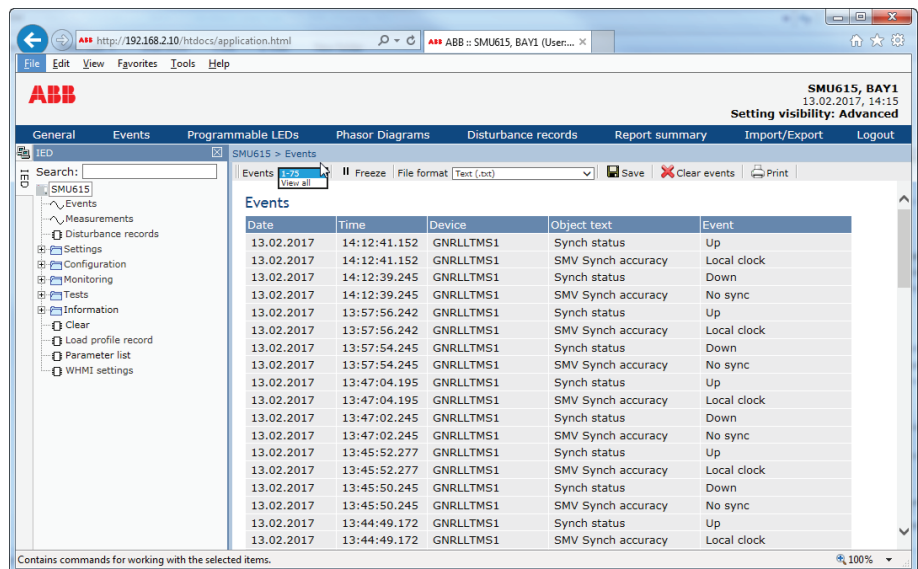


Figure 29: Events view

- To save the events in TXT or CSV file formats, select the file format from the drop-down list and click **Save**.



The CSV file can be opened with a spreadsheet program such as OpenOffice.org Calc or Microsoft Excel.

- Click **Clear events** to clear all events from the merging unit.
- Click **Print** to print all the selected events.

4.2.11

Selecting disturbance records view

Disturbance records are listed in the disturbance records view.

- Click **Disturbance records** on the menu bar.

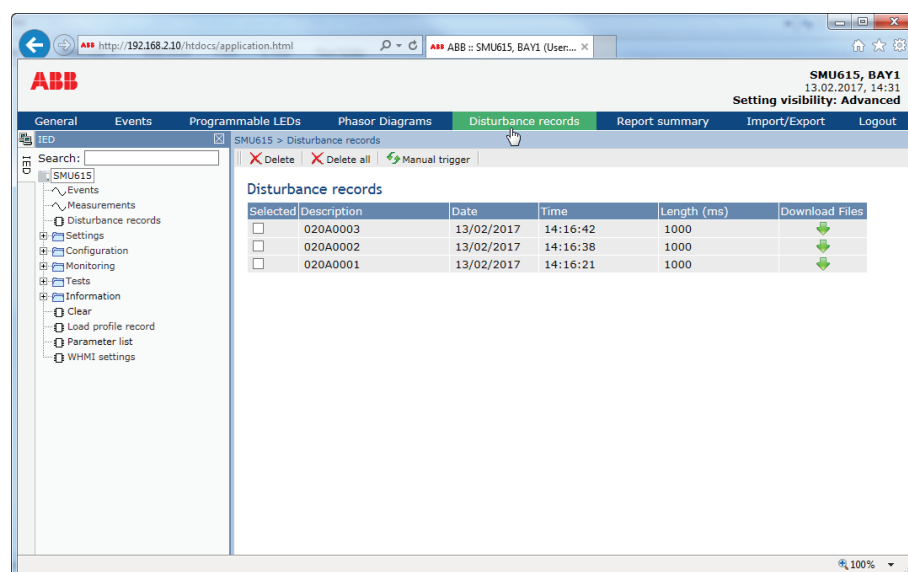


Figure 30: Selecting disturbance records view

4.2.11.1

Saving disturbance records

1. Click **Disturbance records** on the menu bar.
2. To save the disturbance record files, click the icon in the **Download Files** column of the record.
Both the disturbance record files CFG and DAT are saved at once.
3. Open the disturbance record files with a suitable program.

4.2.11.2

Triggering disturbance recorder manually

1. Click **Disturbance records** on the menu bar.
2. Click **Manual trigger**.

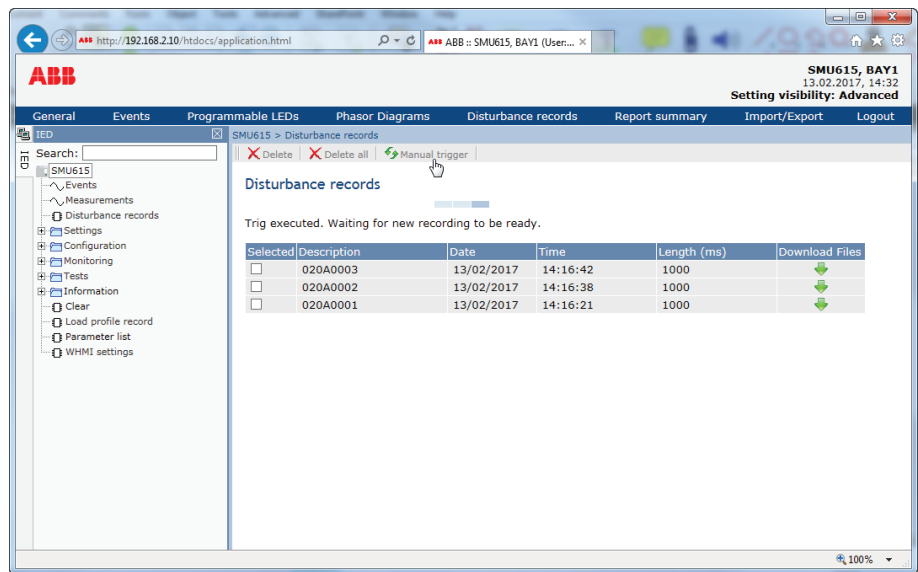


Figure 31: Manual triggering

4.2.11.3

Deleting disturbance records

1. Click **Disturbance records** on the menu bar.
2. Delete records.
 - Click **Delete all** to delete all records.
 - Select one or more recordings and click **Delete** to delete selected records.

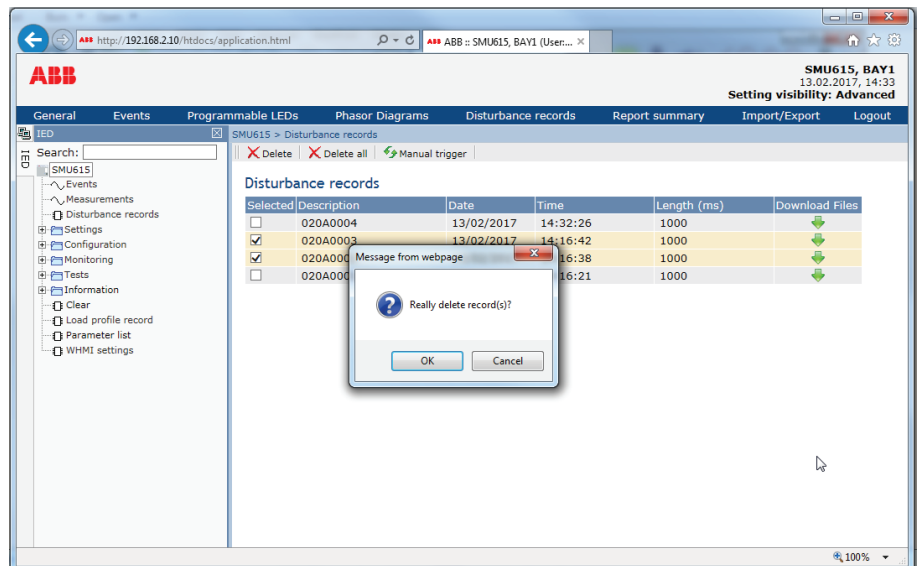


Figure 32: Deleting disturbance records

3. Click **OK** to confirm or **Cancel** to cancel the deletion.

4.2.12

Selecting phasor diagrams



Install or enable the SVG plugin to view the phasor diagrams, if needed.

1. Click **Phasor diagrams** on the menu bar.

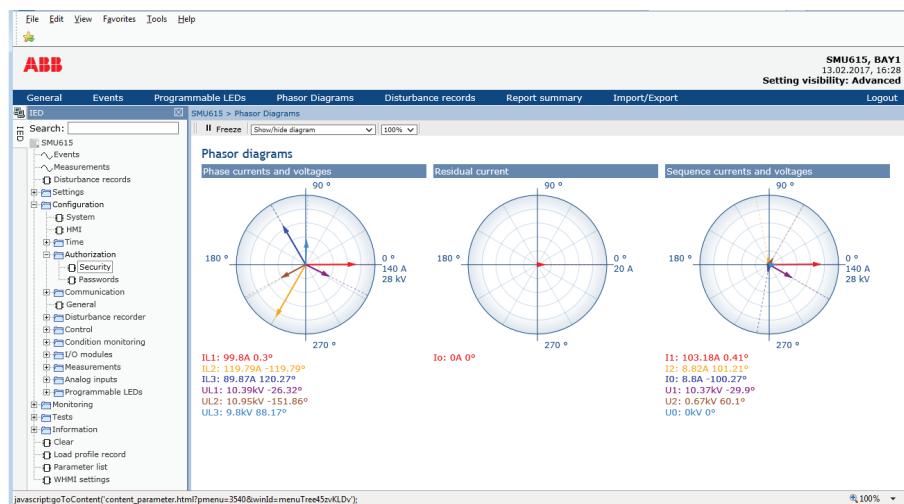


Figure 33: Monitoring phasors

2. Toggle the diagram visibility by selecting the diagram from the drop-down menu.

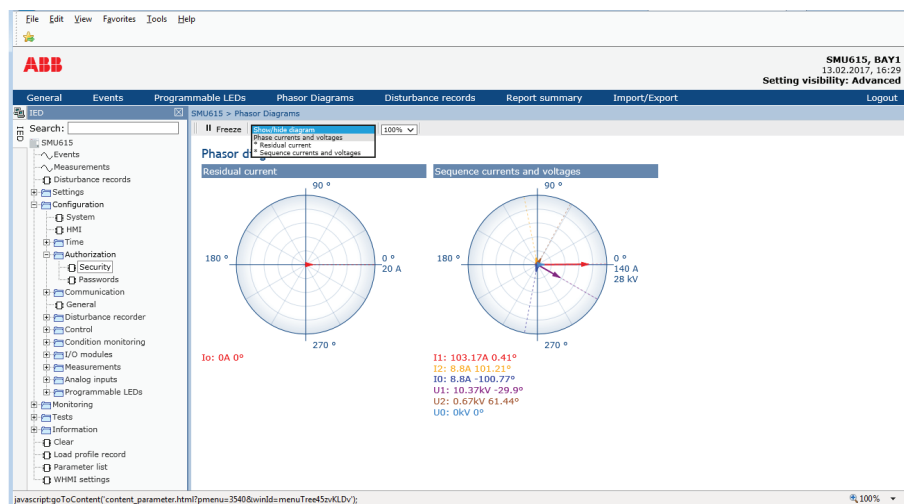


Figure 34: Toggling the diagram visibility

Visible diagrams are indicated with an asterisk *.

3. Change the size of the diagram by changing the zoom value.

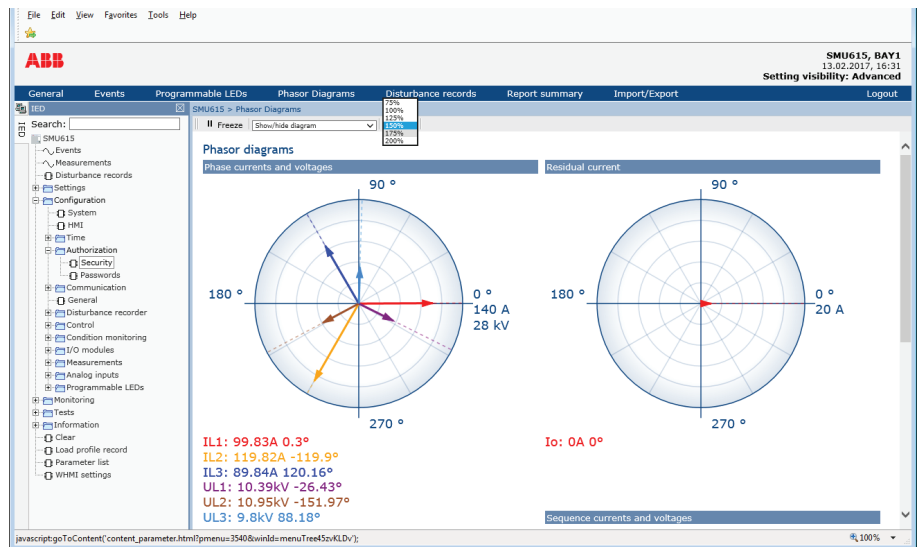


Figure 35: Zooming the diagram

- Click **Freeze** to stop updating the phasor diagram. No updates are displayed in the diagram.

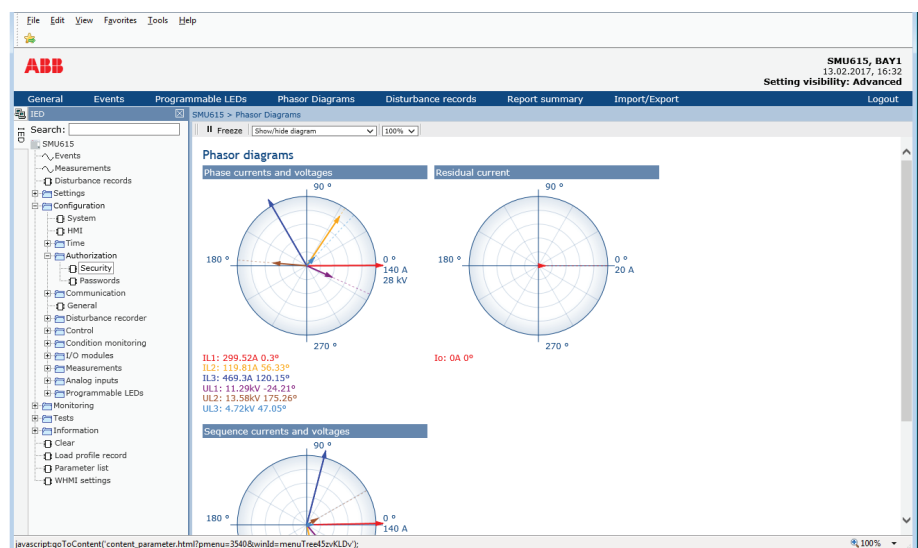


Figure 36: The arrow extends outside the circle if the current value is too high

4.2.13

Exporting load profile records

- Click **Load profile record** in the left navigation bar.
- To export the load profile record files, click the icon in the **Download Files** column.

- Both the load profile record files CFG and DAT are saved at once.
3. Save the CFG and DAT files in the same folder on the computer.
4. Open the load profile record COMTRADE files with a suitable program.



Open the load profile files, for example, with the Wavewin tool included in PCM600.

4.2.14 Import and export of settings

Merging unit's setting parameters can be imported and exported in the XRIO file format.

4.2.14.1 Exporting settings

Merging unit's setting parameters can be exported in XRIO file format.

1. Click **Import/Export** on the menu bar.
2. Click **Export Settings**. The export file includes all parameters except status parameters.

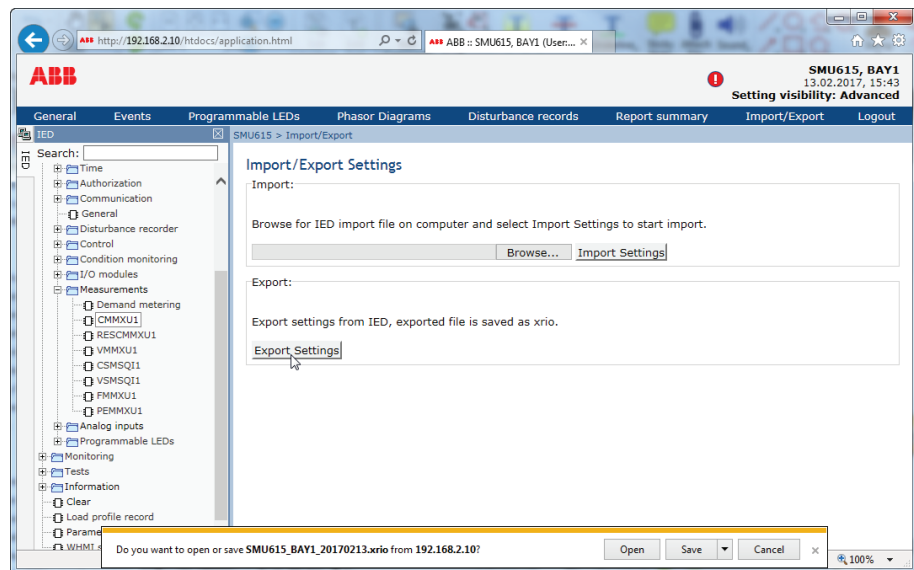


Figure 37: Exporting settings

3. Click **Save** to export the settings to the computer.

4.2.14.2 Importing settings

The parameter export and import function can be utilized, for example, when the merging unit parameters are set using the WHMI instead of PCM600. The merging

unit settings engineered with PCM600 can be exported to XRIO files and imported to the WHMI. The WHMI can be used to write the settings to the merging units. The WHMI can also be used to read the merging unit setting parameters and to export those to files, which can be used by PCM600. WHMI imports all parameters from the import file except lockable and read only parameters.



The exporting and importing of settings is sensitive to the merging unit contents. Settings are exported and imported for one merging unit at a time. The export files of a specific merging unit can be exchanged between PCM600, WHMI and the actual physical merging unit. To avoid errors and to efficiently manage the exporting and importing of settings, for example, in a substation with several devices, ensure that the names of the export files identify the merging unit to which the file should be imported.



Ensure that the correct settings are imported to the correct merging unit. Wrong settings may cause the merging unit to malfunction.

1. Click **Import/Export** on the menu bar.
2. Click **Browse** and choose the file to be imported.

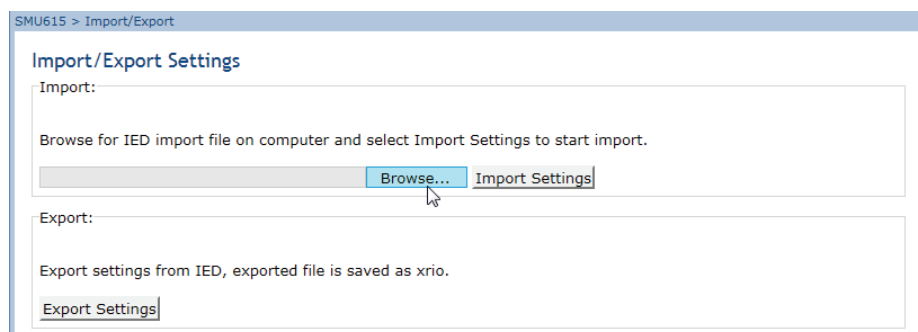


Figure 38: Browsing import settings

3. Click **Import Settings**.
Wait until the file transfer is complete.

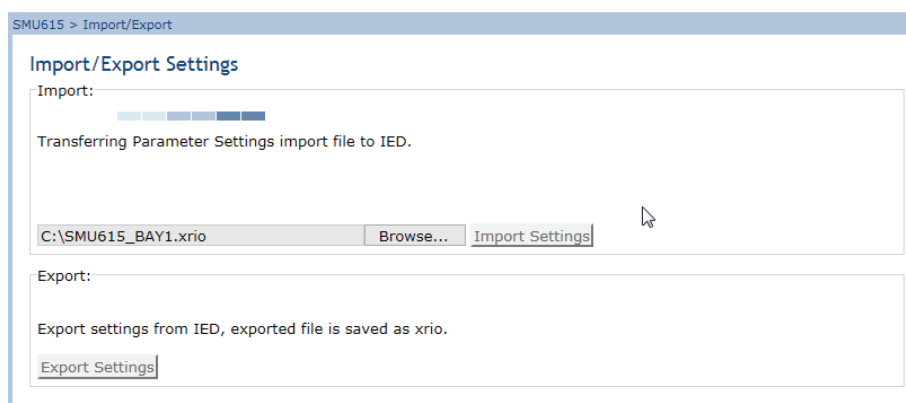


Figure 39: Importing settings

4. Click **OK** to commit the imported settings to the merging unit. Wait until the import is complete.
 - Click **Cancel** to cancel the importing. Both the WHMI and the merging unit revert to the settings in use prior to the import.

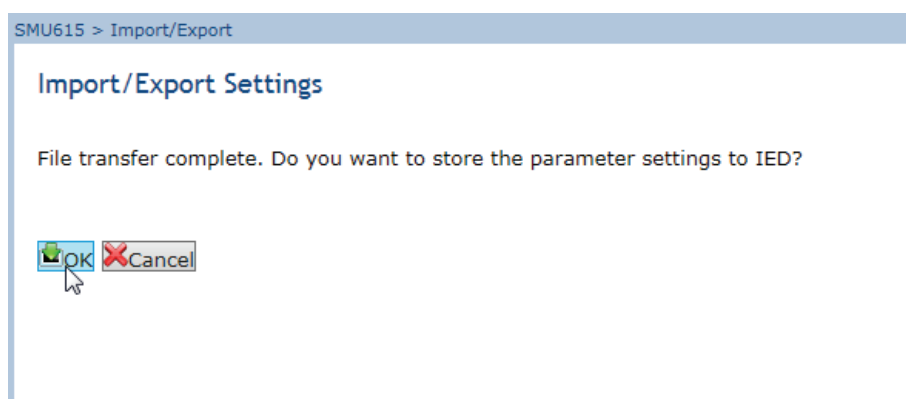


Figure 40: Writing parameter settings

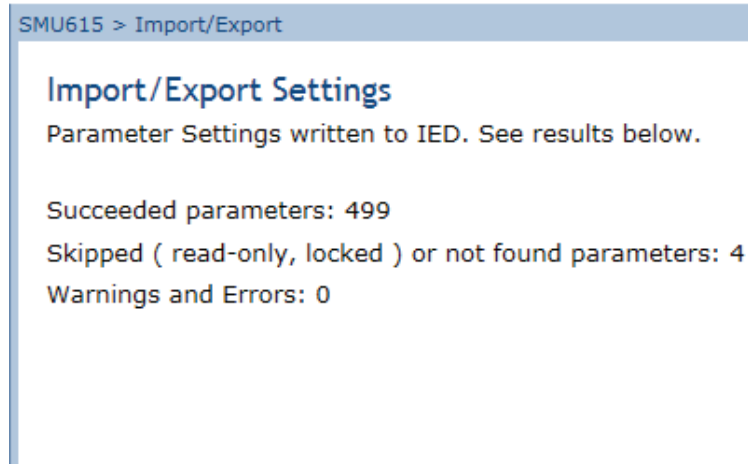


Figure 41: Parameter settings written to merging unit



Only editable parameters are written to the merging unit during the import. If part of the import fails, the faulty parameters are listed separately.

4.2.15

Exporting report summary

The Report summary page allows exporting events, disturbance records, the load profile record and the parameter list. Events and the parameter list are saved in TXT format. Saved files contain all events and settings. Disturbance records and load profile record files are saved in CFG and DAT formats.

1. Click **Report summary** on the menu bar.
2. Select the items to be exported.
Click **Select all** to select all items and click **Clear all** to clear all selections.
3. From the **Disturbance records** drop-down list, select the amount of records to be saved.
 - All
 - Last 1
 - Last 10
4. Click **Save** to export the ZIP file with the selected files.

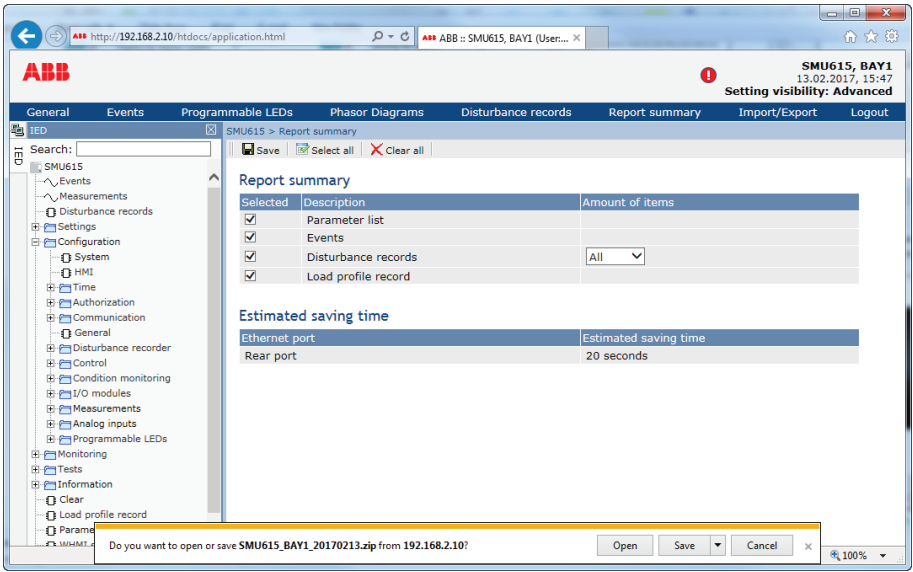


Figure 42: Report summary page

4.2.16

Using Web HMI help

The context-sensitive WHMI help provides information on a single parameter, for example.

- Move the mouse over the  to display the help dialog box.

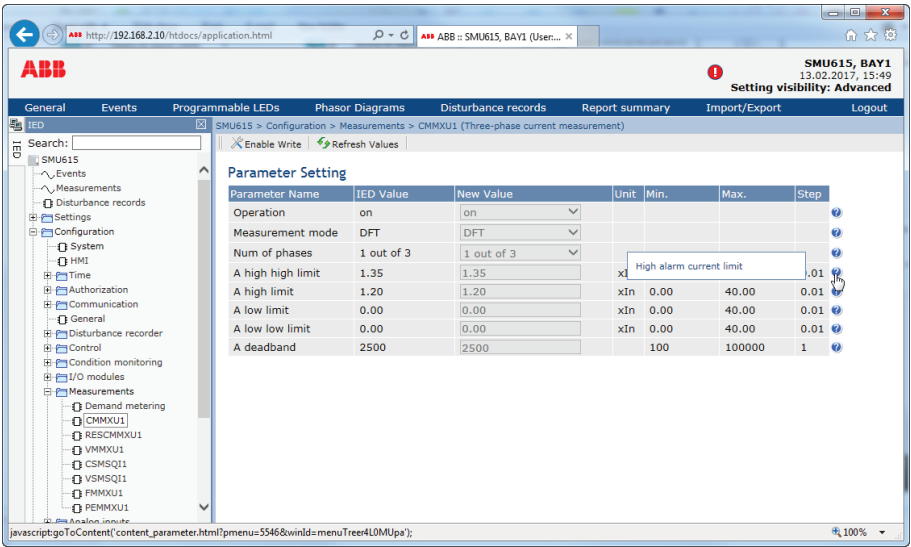


Figure 43: Opening the WHMI help

Section 5 Merging unit operation

5.1 Normal operation

In a normal merging unit use situation, the basic operation includes monitoring and checking procedures.

- Monitoring measured values
- Checking object states
- Checking function setting parameters
- Checking events and alarms

All basic operations can be performed via the WHMI or with PCM600.



For more information, see the PCM600 documentation.

5.2 Disturbance identification

Disturbances and their causes can be identified by the Ready indicator LED. During normal operation, the Ready LED is steady green.

Table 11: *Disturbance indications*

LED	State	Description
Ready LED	Green, flashing	Internal fault

Further actions to be taken to identify the disturbance:

- Checking programmable LEDs
- Reading event history
- Checking fault records
- Analyzing disturbance recordings



Document the disturbance before clearing the information from the merging unit.



Only authorized and skilled personnel should analyze possible errors and decide on further actions. Otherwise, stored disturbance data can be lost.

5.2.1 Disturbance recording triggering

Disturbance recordings are normally triggered by merging unit applications when they detect fault events. Disturbance recordings can also be triggered manually or periodically. The manual trigger generates an instant disturbance report. Use this function to get a snapshot of the monitored signals.

5.2.2 Disturbance record analysis

The merging unit collects disturbance records of fault events which are set to trigger the disturbance recorder. Disturbance data is collected and stored for later viewing and analysis. The disturbance recorder data can be read and analyzed with PCM600.



For more information, see the PCM600 documentation.

5.2.3 Disturbance reports

PCM600 can be used for creating reports of disturbance recorder data.



For more information, see the PCM600 documentation.

5.2.4 Merging unit self-supervision

The merging unit self-supervision handles internal run-time fault situations. The main indication of an internal fault is a flashing green Ready LED.

Internal faults can be divided to hardware errors, run-time errors in the application or operating system and communication errors. Further actions always depend on the cause of the error.



Only authorized and skilled personnel should analyze the errors and decide on further actions.

The merging unit records system registrations, merging unit status data and events.



Document all the recorded data from the merging unit before resetting the tripping and lockout functions.

5.3

Merging unit parametrization

Merging unit parameters are set via the WHMI or PCM600.

Setting parameters need to be calculated according to the electrical network conditions and the electrical characteristics of the protected equipment. The merging unit's settings need to be verified before the merging unit is connected to a system.



Document all changes to parameter settings.



For more information, see the PCM600 documentation.

Section 6 Operating procedures

6.1 Monitoring

6.1.1 Indications

The operation of the merging unit can be monitored via two different indications on the LHMI.

- One indicator LED with fixed functionality: Ready
- 11 programmable LEDs

6.1.1.1 Monitoring merging unit's internal fault

The flashing green LED indicates an internal fault.

- Use the WHMI to monitor the internal fault of the merging unit.



See the troubleshooting section for more details.

6.1.2 Measured and calculated values

Measurement view in **Main Menu/Measurements** shows the momentary actual values for various power system measurements.

All values show the momentary measurement value and some include demand values calculated from a set period.



Invalid or questionable measurement values are presented in parentheses.

6.1.2.1 Measured values

Measured values can be accessed through the WHMI or PCM600.

Table 12: *Examples of the measured values*

Indicator	Description
IL1-A	Current measured on phase L1
IL2-A	Current measured on phase L2
IL3-A	Current measured on phase L3
I_0 -A	Measured earth-fault current
U_0 -kV	Measured residual voltage
U12-kV	Measured phase-to-phase voltage U12
U23-kV	Measured phase-to-phase voltage U23
U31-kV	Measured phase-to-phase voltage U31
f-Hz	Measured frequency
S-MVA	Total apparent power
P-MW	Total active power
Q-MVar	Total reactive power
PF	Average power factor
Ng-Seq-A	Negative-phase-sequence current
Ps-Seq-A	Positive-phase-sequence current
Zro-Seq-A	Zero-phase-sequence current
Ng-Seq-kV	Negative-phase-sequence voltage
Ps-Seq-kV	Positive-phase-sequence voltage
Zro-Seq-kV	Zero-phase-sequence voltage

6.1.3

Recorded data

The merging unit is provided with intelligent and flexible functionality that collects different kinds of data. The recorded data gives substantial information for post fault analysis.

- Disturbance records
- Events

6.1.3.1

Creating disturbance recordings

Normally disturbance recordings are triggered by the merging unit applications but the recording can also be triggered manually via the WHMI.

1. Click **Disturbance records** on the menu bar.
2. Click **Manual trigger**.
The disturbance recorder is now triggered.

6.1.3.2 Monitoring disturbance recorder data

Disturbance recorder data can be monitored via the WHMI.

- Click **Disturbance records** on the menu bar.
All the disturbance recorder information is listed.
 - Number of recordings currently in the merging unit's memory
 - Remaining amount of recordings that fit into the available recording memory
 - Recording memory used in percentage
 - If the periodic triggering function is used, the time to trigger which indicates the remaining time to the next periodic triggering of the disturbance recorder.

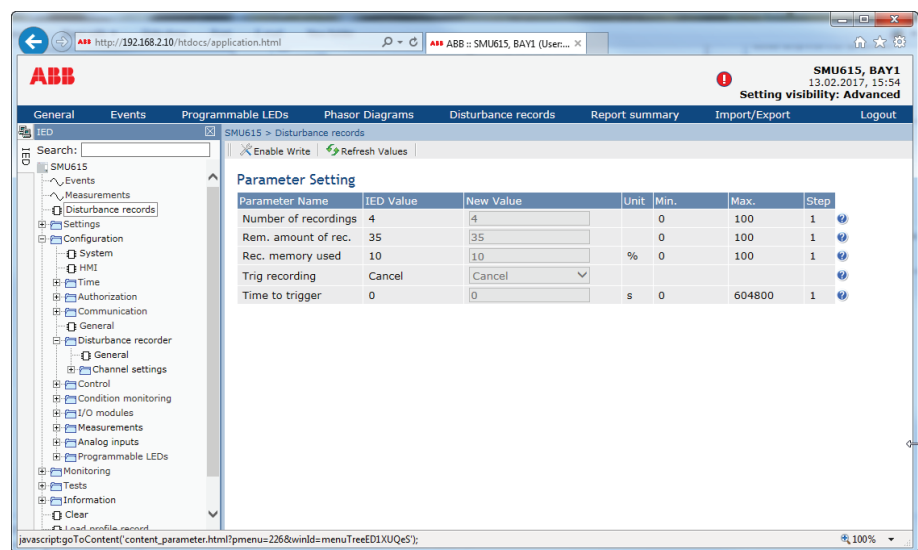


Figure 44: Monitoring disturbance recorder via Web HMI

Individual disturbance recordings can be uploaded from the merging unit with the PCM600 software to monitor disturbance recorder data.

6.1.3.3 Controlling and reading of disturbance recorder data

Disturbance recorder data can be controlled and read with PCM600. It can also be read via WHMI.



For more information, see the PCM600 documentation.

6.1.4 Remote monitoring

The merging unit supports comprehensive remote monitoring.

6.1.4.1 Monitoring merging units remotely

Use the PCM600 tool and WHMI to operate the merging unit remotely.

- Read maintenance record and version log.
- Analyze disturbance record data.
- Create disturbance records.
- Monitor merging unit values.



For more information, see the PCM600 documentation.


6.2 Resetting merging unit

6.2.1 Clearing and acknowledging

All messages and indications, including LEDs and latched outputs as well as registers and indications, including recordings can be reset, acknowledged or cleared via the WHMI using the Clear menu.

- Click **Clear** in the left navigation bar.
All the items that can be cleared are shown.
 - Programmable LEDs
 - Events
 - Metering records
 - Disturbance records
 - Master trip
 - Acc. energy of three-phase power and energy measurement



Use the  button as a shortcut for clearing. The first three-second press clears the indications. The second three-second press clears the programmable LEDs.

6.3 Changing merging unit functionality

6.3.1 Activating programmable LEDs

Programmable LEDs can be activated via the WHMI.

1. Click the **Configuration** menu in the left navigation bar and select **Programmable LEDs**.
2. Select a programmable LED to change its mode.
3. Click **Enable Write**.
4. In the **New Value** list, select the LED mode.
5. Click **Write to IED**.

Section 7 Troubleshooting

7.1 Fault tracing

7.1.1 Identifying hardware errors

1. Check the module with an error.
Check the supervision events via the Web HMI for a faulty hardware module.
2. Inspect the merging unit visually.
 - Inspect the merging unit visually to find any physical error causes.
 - If you can find some obvious physical damage, contact ABB for repair or replacement actions.
3. Check whether the error is external or internal.
 - Check that the error is not caused by external origins.
 - Remove the wiring from the merging unit and test the input and output operation with an external test device.
 - If the problem remains, contact ABB for repair or replacement actions.

7.1.2 Identifying runtime errors

1. Check the error origin from the merging unit's supervision events via the Web HMI.
2. Reboot the merging unit and recheck the supervision events to see if the fault has cleared.
3. In case of persistent faults, contact ABB for corrective actions.

7.1.3 Identifying communication errors

Communication errors are normally communication interruptions or synchronization message errors due to communication link breakdown.

- In case of persistent faults originating from merging unit's internal faults such as component breakdown, contact ABB for repair or replacement actions.

7.1.3.1 Checking front communication link operation

- To verify front communication, check that both LEDs above the RJ-45 communication port are lit.

Table 13: *Front communication LEDs*

LED	Communication ok
Uplink	Steady green light
Communication	Flashing yellow light

7.1.3.2 Checking time synchronization

1. Click the **Monitoring** menu in the left navigation bar and select **IED status**.
2. Check **Time synchronization**.

7.2 Indication messages

7.2.1 Internal faults

An event about the fault is stored as a message on the WHMI. The text *Internal Fault* with an additional text message, a code, date and time, is stored to indicate the fault type.

Different actions are taken depending on the severity of the fault. The merging unit tries to eliminate the fault by restarting. After the fault is found to be permanent, the merging unit stays in the internal fault mode. All other output contacts are released and locked for the internal fault. The merging unit continues to perform internal tests during the fault situation.

The internal fault code indicates the type of internal fault. When a fault appears, the code must be recorded so that it can be reported to ABB customer service.

Table 14: *Internal fault indications and codes*

Fault indication	Fault code	Additional information
Internal Fault System error	2	An internal system error has occurred.
Internal Fault File system error	7	A file system error has occurred.
Internal Fault Test	8	Internal fault test activated manually by the user.
Internal Fault SW watchdog error	10	Watchdog reset has occurred too many times within an hour.
Internal Fault SO-relay(s),X100	43	Faulty Signal Output relay(s) in card located in slot X100.
Internal Fault SO-relay(s),X110	44	Faulty Signal Output relay(s) in card located in slot X110.
Internal Fault PO-relay(s),X100	53	Faulty Power Output relay(s) in card located in slot X100.
Internal Fault PO-relay(s),X110	54	Faulty Power Output relay(s) in card located in slot X110.
Table continues on next page		

Fault indication	Fault code	Additional information
Internal Fault Conf. error,X000	62	Card in slot X000 is wrong type, is missing, does not belong to original configuration or card firmware is faulty.
Internal Fault Conf. error,X100	63	Card in slot X100 is wrong type or does not belong to the original composition.
Internal Fault Conf. error,X110	64	Card in slot X110 is wrong type, is missing or does not belong to the original composition.
Internal Fault Conf. error,X120	65	Card in slot X120 is wrong type, is missing or does not belong to the original composition.
Internal Fault Conf.error,X130	66	Card in slot X130 is wrong type, is missing or does not belong to the original composition.
Internal Fault Card error,X000	72	Card in slot X000 is faulty.
Internal Fault Card error,X100	73	Card in slot X100 is faulty.
Internal Fault Card error,X110	74	Card in slot X110 is faulty.
Internal Fault Card error,X120	75	Card in slot X120 is faulty.
Internal Fault Card error,X130	76	Card in slot X130 is faulty.
Internal Fault LHMI module	79	LHMI module is faulty. The fault indication may not be seen on the LHMI during the fault.
Internal Fault RAM error	80	Error in the RAM memory on the CPU card.
Internal Fault ROM error	81	Error in the ROM memory on the CPU card.
Internal Fault EEPROM error	82	Error in the EEPROM memory on the CPU card.
Internal Fault FPGA error	83	Error in the FPGA on the CPU card.
Internal Fault RTC error	84	Error in the RTC on the CPU card.
Internal Fault COM card error	116	Error in the COM card.

7.2.2

Warnings

An event about the warnings are stored with the text `Warning` additionally provided with the name of the warning, a numeric code and the date and time on the WHMI.



If a warning appears, record the name and code so that it can be provided to ABB customer service.

Table 15: *Warning indications and codes*

Warning indication	Warning code	Additional information
Warning Watchdog reset	10	A watchdog reset has occurred.
Warning Power down det.	11	The auxiliary supply voltage has dropped too low.
Warning IEC61850 error	20	Error when building the IEC 61850 data model.
Warning Dataset error	24	Error in the Data set(s).
Warning Report cont. error	25	Error in the Report control block(s).
Warning GOOSE contr. error	26	Error in the GOOSE control block(s).
Warning SCL config error	27	Error in the SCL configuration file or the file is missing.
Warning Logic error	28	Too many connections in the configuration.
Warning SMT logic error	29	Error in the SMT connections.
Warning GOOSE input error	30	Error in the GOOSE connections.
ACT error	31	Error in the ACT connections.
Warning GOOSE Rx. error	32	Error in the GOOSE message receiving.
Warning AFL error	33	Analog channel configuration error.
Warning SMV config error	34	Error in the SMV configuration.
Warning Comm. channel down	35	Redundant Ethernet (HSR/PRP) communication interrupted.
Warning Unack card comp.	40	A new composition has not been acknowledged/accepted.

7.3 Correction procedures

7.3.1 Rebooting software

1. Click the **Configuration** menu in the left navigation bar and select **General**.
2. Click **Enable Write**.
3. Edit the **Software reset** parameter.
 - In the **New Value** list, select **Activate**.
4. Click **Write to IED**.

7.3.2 Restoring factory settings

In case of configuration data loss or any other file system error that prevents the merging unit from working properly, the whole file system can be restored to the original factory state. All default settings and configuration files stored in the factory are restored. Only the administrator can restore the factory settings.

1. Click the **Configuration** menu in the left navigation bar and select **General**.
2. Click **Enable Write**.
3. Edit the **Factory setting** parameter.
 - In the **New Value** list, select **Activate**.
4. Click **Write to IED**.

The merging unit restores the factory settings and restarts. Restoring takes 1...3 minutes. Confirmation of restoring the factory settings is shown on the display a few seconds, after which the merging unit restarts.



Avoid the unnecessary restoring of factory settings, because all the parameter settings that are written earlier to the merging unit will be overwritten with the default values.

7.3.3 Restoring administrator password

If authentication is enabled in the merging unit and the administrator password is lost, it is no longer possible to change passwords or operate the merging unit with full access rights.

The administrator password can be restored to the default value using a one-time password. The OTP functionality is only available via the merging unit's front port.

Contact ABB technical customer support to retrieve the administrator level access to the merging unit.

1. Using the front RJ-45 port, connect a PC to the merging unit.
2. Open the Web browser and go to <https://192.168.0.254/otp.html>.
3. Forward the displayed OTP related information to ABB technical customer support to receive a one-time password.
4. Reset the administrator password.
 - 4.1. Type the ADMINISTRATOR username with capital letters.
 - 4.2. Type the one-time password.
 - 4.3. Click **Reset**.

- If the password is successfully reset, restart the browser and log in as administrator using the default password.
- If the password reset fails, try again or contact ABB technical customer support again.

7.3.4 Setting passwords

If user authorization is off or the user is logged in as an administrator, user passwords can be set via the WHMI or with PCM600.

Local passwords can be changed in WHMI only via the merging unit's front RJ-45 port. Remote passwords can be changed via the WHMI or with PCM600.

1. Click **Configuration** in the left navigation bar and select **Authorization**.
2. Select the **Passwords** submenu and edit the values.
3. Click **Write to IED**.



If the administrator password is lost, contact ABB's technical customer support to retrieve the administrator level access.

7.3.5 Identifying merging unit application problems

- Check that the function is on.
- Check the blocking.
- Check the mode.
- Check the measurement value.
- Check the connection to trip and disturbance recorder functions.
- Check the channel settings.

7.3.5.1 Inspecting wiring

The physical inspection of wiring connections often reveals the wrong connection for phase currents or voltages. However, even though the phase current or voltage connections to merging unit terminals might be correct, wrong polarity of one or more measurement transformers can cause problems.

- Check the current or voltage measurements and their phase information from **Main menu/Measurements**.
- Check that the phase information and phase shift between phases is correct.
- Correct the wiring if needed.
- Check the actual state of the connected binary inputs from **Main menu/Monitoring/I/O status/Binary input values**.
- Test and change the relay state manually in **Main menu/Tests/Binary outputs**.

7.3.5.2

Sample data interruptions

Occasionally merging units can receive corrupted or faulty measurement data during runtime. In these cases the operation system halts the corresponding application execution until correct data is received. In case of permanent faults, the measurement chain should be checked to remove the origin of the faulty measurement data.



In case of persistent faults originating from merging unit's internal faults, contact ABB for repair or replacement actions.

Section 8 Commissioning

8.1 Commissioning checklist

Familiarize yourself with the merging unit and its functionality before you start the commissioning work.

- Ensure that your version of the technical manual applies to the merging unit version you test.
- Ensure that your setting software and connectivity packages work with the merging unit version you test.
- Find out if you need any additional software.
- Ensure that you have the merging unit settings either on paper or in electronic format. The settings and logic should be well documented.
- Inspect the settings to ensure that they are correct.
- Ensure that you have the correct cable to connect your PC to the merging unit's communication port. The RJ-45 port supports any CAT 5 Ethernet cable but the recommendation is STP.
- Test your PC's communication port before you go to the site.
- Find out who to contact if you have trouble and make sure you have a means to contact them.
- Find out who is responsible for the settings.
- Ensure that you have with you the proper test equipment and all needed connection cables.
- Ensure that the owner of the switchgear familiarizes you with the work site and any special aspects of it.
- Ensure that you know how to operate in emergency situations. Find out where the first aid and safety materials and exit routes are.

8.2 Checking installation

8.2.1 Checking power supply

- Check that the auxiliary supply voltage remains within the permissible input voltage range under all operating conditions.
- Check that the polarity is correct before powering the merging unit.

8.2.2 Checking CT circuits



Check that the wiring is in strict accordance with the supplied connection diagram.

The CTs must be connected in accordance with the terminal diagram provided with the merging unit, both with regards to phases and polarity. The following tests are recommended for every primary CT or CT core connected to the merging unit.

- Primary injection test to verify the current ratio of the CT, the correct wiring up to the merging unit and correct phase sequence connection (that is L1, L2, L3.)
- Polarity check to prove that the predicted direction of the secondary current flow is correct for a given direction of the primary current flow. This is an essential test for the proper operation of the directional function, protection or measurement in the merging unit.
- CT secondary loop resistance measurement to confirm that the current transformer secondary loop DC resistance is within specification and that there are no high resistance joints in the CT winding or wiring.
- CT excitation test to ensure that the correct core in the CT is connected to the merging unit. Normally only a few points along the excitation curve are checked to ensure that there are no wiring errors in the system, for example, due to a mistake in connecting the CT's measurement core to the merging unit.
- CT excitation test to ensure that the CT is of the correct accuracy rating and that there are no short circuited turns in the CT windings. Manufacturer's design curves should be available for the CT to compare the actual results.
- Earthing check of the individual CT secondary circuits to verify that each three-phase set of main CTs is properly connected to the station earth and only at one electrical point.
- Insulation resistance check.
- Phase identification of CT shall be made.



Both the primary and the secondary sides must be disconnected from the line and the merging unit when plotting the excitation characteristics.



If the CT secondary circuit is opened or its earth connection is missing or removed without the CT primary being de-energized first, dangerous voltages may be produced. This can be lethal and cause damage to the insulation. The re-energizing of the CT primary should be prohibited as long as the CT secondary is open or unearthed.

8.2.3 Checking VT circuits

Check that the wiring is in strict accordance with the supplied connection diagram.



Correct possible errors before continuing to test the circuitry.

Test the circuitry.

- Polarity check
- VT circuit voltage measurement (primary injection test)
- Earthing check
- Phase relationship
- Insulation resistance check

The polarity check verifies the integrity of circuits and the phase relationships. The polarity must be measured as close to the merging unit as possible to ensure that most of the wiring is also checked.

The primary injection test verifies the VT ratio and the wiring all the way from the primary system to the merging unit. Injection must be performed for each phase-to-neutral circuit and each phase-to-phase pair. In each case, voltages in all phases and neutral are measured.

8.2.4 Checking binary input and output circuits

8.2.4.1 Checking binary input circuits

- Preferably, disconnect the binary input connector from the binary input cards.
- Check all the connected signals so that both the input level and the polarity are in accordance with the merging unit specifications.



Do not use AC voltage. Binary inputs are rated for DC voltage only.

8.2.4.2 Checking binary output circuits

- Preferably, disconnect the binary output connector from the binary output cards.
- Check all connected signals so that both load and voltage are in accordance with the merging unit specifications.

8.3 Authorizations

8.3.1 User authorization

The user categories have been predefined for the WHMI via front port RJ-45 and rear port RJ-45, each with different rights and default passwords.

Passwords are settable for all predefined user categories. The WHMI password via the front port RJ-45 must be at least four characters and the WHMI password via the rear port RJ-45 at least nine characters. The maximum number of characters is 8 for the WHMI front port password and 20 for the WHMI rear port password. Only the following characters are accepted.

- Numbers 0-9
- Letters a-z, A-Z
- Space
- Special characters !"#\$%&'()*+,-./:;<=>?@[\]^_`{|}~



User authorization is disabled by default and can be enabled via the WHMI path **Main Menu/Configuration/Authorization/Passwords**.

Table 16: *Predefined user categories and default passwords*

Username	Front panel WHMI password	Rear panel WHMI password	User rights
VIEWER	0001	remote0001	Only allowed to view
OPERATOR	0002	remote0002	Authorized to make operations
ENGINEER	0003	remote0003	Allowed to change merging unit parameters, but no operation rights
ADMINISTRATOR	0004	remote0004	Full access



For user authorization for PCM600, see PCM600 documentation.

8.4 Setting merging unit and communication

8.4.1 Setting communication between merging units and PCM600

The communication between the merging unit and PCM600 is independent of the used communication protocol within the substation or to the NCC. It can be seen as a second channel for communication.

The media is always Ethernet and communication is based on TCP/IP.

Each merging unit has an Ethernet front connector for PCM600 access. Depending on the station concept and the used station protocol, additional Ethernet interfaces may be available on the rear side of the merging unit. All Ethernet interfaces can be used to connect PCM600.

When an Ethernet based station protocol is used, the PCM600 communication can use the same Ethernet port and IP address. The merging unit is able to separate the information belonging to the PCM600 dialog.

To configure the physical connection and the IP addresses:

1. Set up or get the IP addresses of the merging units.
2. Set up the PC for a direct link or connect the PC or workstation to the network.
3. Configure the IP addresses in the PCM600 project for each merging unit.
The addresses are used for communication between merging units and PCM600.

8.4.1.1 Communication link options between PCM600 and merging units

Two options are available for the connection of PCM600 to the merging unit.

- Direct point to point link between PCM600 and the merging unit
- Indirect link via a station LAN or from remote via a network

Point to point link

The merging unit is provided with an RJ-45 connector on the LHMI. The front communication port is mainly used for configuration and setting purposes. The front communication port should not be connected to any Ethernet network.

The merging unit has a DHCP server for the front interface. The DHCP server assigns an IP address to the computer connected to the front interface. The computer's LAN interface has to be configured to obtain the IP address automatically.

LAN or WAN network

In TCP/IP networking, a LAN is often but not always implemented as a single IP subnet. A router connects LANs to a WAN. In IP networking, the router maintains both a LAN address and a WAN address. Design considerations for computer

networks cover a wide range of topics including layout, capacity planning, and security. To some extent, the network configuration also depends on user preferences.

8.4.2 Communication settings

The merging unit is provided with an RJ-45 front port on the LHMI. This connector is mainly used for configuration and setting purposes. The rear port IP address and the corresponding subnet masks can be set via the WHMI. The front port uses a fixed IP address 192.168.0.254, and it also provides DHCP server to assign an IP address for the connected computer. The rear Ethernet interface has a factory default IP address 192.168.2.10 when the complete merging unit is delivered.

Different communication ports are available via optional communication modules. Ethernet RJ-45 and optical Ethernet LC are the two rear port Ethernet communication options. Rear port Ethernet is intended for station bus communication. Communication protocols used via Ethernet ports are IEC 61850-8-1 and IEC 61850-9-2 LE.



If the protocol does not operate as expected, check that other serial protocols are not using the COM port.



Use the correct Ethernet connectors in the merging unit with redundant communication protocols like HSR and PRP. merging units with HSR/PRP support have three Ethernet connectors and redundant Ethernet ports are marked as LAN A and LAN B. The third Ethernet port without any LAN marking works as an interlink port. Thus, an additional redundancy box is not needed. For example, laptops with PCM600 must be connected via a redundancy box to access a merging unit which is part of the HSR network.



The redundant communication module has three operation modes: “Normal”, “HSR” and “PRP”. The operation mode can be changed from communication settings.



For more information, see the communication protocol manuals and the technical manual.

8.4.2.1 Defining Ethernet port settings



Change the Ethernet port settings primarily via PCM600 to ensure that PCM600 is able to export a consistent configuration to SYS600.

Ethernet port settings are recommended to be changed only when the device is stand-alone and properly configured.

1. Click **Configuration** in the left navigation bar and select **Communication**.
2. In the **Ethernet** submenu, define the **Rear port** settings.
 - IP address
 - Subnet mask
 - Default gateway of the optional rear port Ethernet connector
3. Click **Write to IED**.

8.4.2.2

Setting communication protocol parameters

1. Click **Configuration** in the left navigation bar and select **Communication**.
2. Change the protocol specific settings.
The possible settings to be changed are, for example, the selected communication port, address and link mode.

8.4.3

Setting system time and time synchronization

1. Click **Configuration** in the left navigation bar and select **Time**.
2. Select a submenu and edit the parameters.
 - **System time**
 - **Daylight saving time**
 - **Synchronization**
3. Click **Write to IED**.

8.4.3.1

Setting daylight saving time

The merging unit can be set to determine the correct date for the DST shift every year. The UTC time is used to set the DST.

1. Set the *DST on day (weekday)* and *DST off day (weekday)* parameters to define on which week day the time shift occurs.
2. Set the *DST on date (day)*, *DST on date (month)* and *DST off date (month)* parameters to define on which month and week the time shift occurs.
The DST on/off date must precede the selected DST on/off day and be within the same week as the DST shift.

Table 17: *Possible date values for DST change on Sunday*

Day of the DST shift	DST on/off date (day)
First Sunday of the month	1
Second Sunday of the month	8
Third Sunday of the month	15
Fourth Sunday of the month	22
Last Sunday, if the month has 30 days	24
Last Sunday, if the month has 31 days	25

For example, if the DST is observed from the last Sunday in March to the last Sunday in October and the time shift occurs at 01:00 UTC, the setting parameters are the following.

DST on time (hours):	2 h
DST on time (minutes):	0 min
DST on date (day):	25
DST on date (month):	March
DST on day (weekday):	Sunday
DST off time (hours):	1 h
DST off time (minutes):	0 min
DST off date (day):	25
DST off date (month):	October
DST off day (weekday):	Sunday



Set the *DST on day (weekday)* and *DST off day (weekday)* to "reserved" to determine the exact date and time for the DST shift. Repeat the setting yearly, as the time for the DST shift is not on the same date every year.



To disable the DST, set the *DST in use* parameter to "False".

8.4.4 Setting merging unit parameters

8.4.4.1 Merging unit parametrization

Merging unit parameters are set via the WHMI or PCM600.

Setting parameters need to be calculated according to the electrical network conditions and the electrical characteristics of the protected equipment. The merging unit's settings need to be verified before the merging unit is connected to a system.



Document all changes to parameter settings.



For more information, see the PCM600 documentation.

8.4.4.2

Defining disturbance recorder channel settings

1. Click **Configuration** in the left navigation bar and select **Disturbance recorder**.
2. Edit the **Channel settings**.

Each analog channel has an equal set of parameters and correspondingly, each binary channel has an equal set of parameters.

8.4.4.3

Configuring analog inputs

- Click **Configuration** in the left navigation bar and select **Analog inputs**.
- Edit the values.
 - For CTs, the secondary current and primary current need to be set to the correct values.
 - For VTs, the secondary voltage and primary voltage need to be set to the correct values.

8.5

Testing merging unit operation

The merging unit has to be in the test mode before the digital outputs and certain output signals of protection and other functions can be activated.

8.5.1

Selecting IED test mode

The test mode can be activated using the WHMI via the front port. The green Ready LED is flashing to indicate that the test mode is activated. By default, the test mode can only be changed from the WHMI via the front port. Activation by remote client is possible, see the technical manual.



The Ready LED also flashes if the merging unit detects a diagnostic failure. Check the test mode setting and the merging unit's IRF alarm contact status to find the reason for the failure.

The test mode is useful for simulated testing of functions and outputs without providing current inputs.

1. Click **Tests** in the left navigation bar and select **IED test**.
2. Click **Enable Write**.
3. Edit the **Test mode** parameter.
 - In the **New Value** list, select **IED test**.

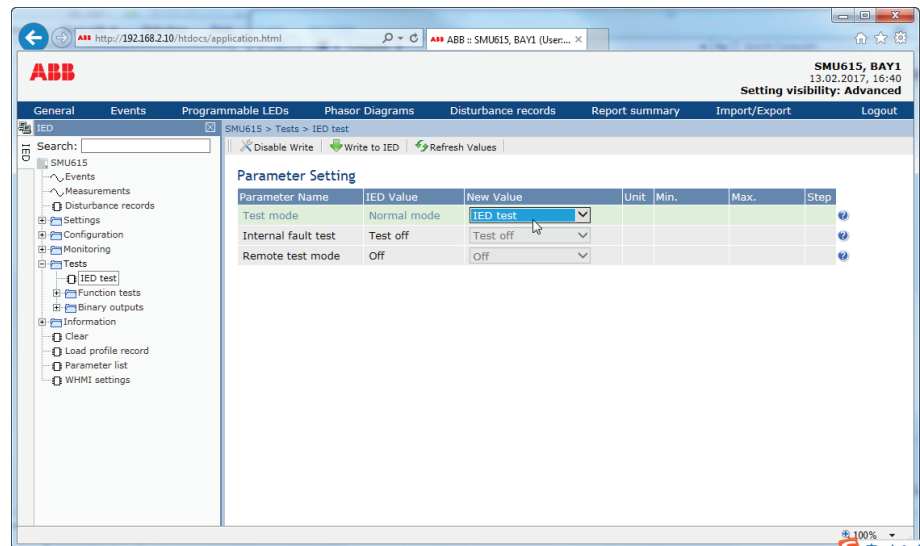


Figure 45: Entering test mode

4. Click **Write to IED**.



If the test mode is not cancelled, it remains on and the Ready LED remains flashing.

8.5.2

Testing digital I/O interface

1. Click **Tests** in the left navigation bar and select, for example, **Binary outputs**.
2. Select the module and output to be edited. For example, **X100 (PSM)** and **X100-PO1**.
3. Select the value to activate or deactivate the digital output.
4. Click **Write to IED**.



If the optional BIO-module (X110) is included in the merging unit, the menu path could also be **Main menu/Tests/Binary Outputs/X110 (BIO)/<binary output>**.

8.5.3 Testing functions

Activate or deactivate an output signal for protection or other function to test the function.

1. Click **Tests** in the left navigation bar and select **Function tests**.
2. In the **Current protection** submenu, select the function block to be tested.
3. Select the output signal to be activated or deactivated.
4. To deactivate all output signals for the function, select reset and confirm the selection.

8.5.4 Selecting internal fault test

The internal fault may be tested by using the WHMI via the front port. When enabling the test, the internal fault output contact is activated, the green Ready LED is flashing. See the technical manual for the internal fault output contact location. The internal fault can only be activated by using the WHMI via the front port.



Differing from real internal fault situation, the other output contacts are not released and locked during the test. In other words, protection functions can operate and trip the outputs when the internal fault is tested.

1. Click **Tests** in the left navigation bar and select **IED test**.
2. Click **Enable Write**.
3. Edit the **Internal fault test** parameter.
 - In the **New Value** list, select **Test on**.

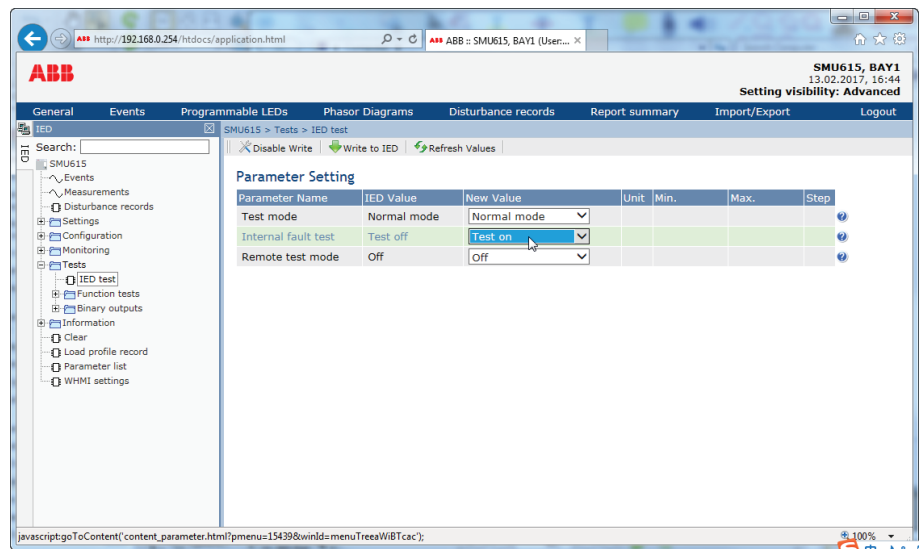


Figure 46: Internal fault test

4. Click **Write to IED**.

8.5.5

Selecting IED blocked or IED test and blocked mode

The IED blocked mode and the IED test and blocked mode can be activated by using the WHMI via the front port. The green Ready LED flashes to indicate that the IED test and blocked mode is activated. By default, the test mode can only be changed from the WHMI via the front port. Activation by remote client is possible, see the technical manual.



The Ready LED also flashes if the merging unit detects a diagnostic failure. Check the test mode setting and the merging unit's IRF alarm contact status to find the reason of the failure.

The test mode can be used for simulated testing of functions and outputs without providing current inputs. The IED blocked mode can be used to block the physical outputs to the process.

1. Click **Tests** in the left navigation bar and select **IED test**.
2. Click **Enable Write**.
3. Edit the **Test mode** parameter.
 - In the **New Value** list, select the test mode status.

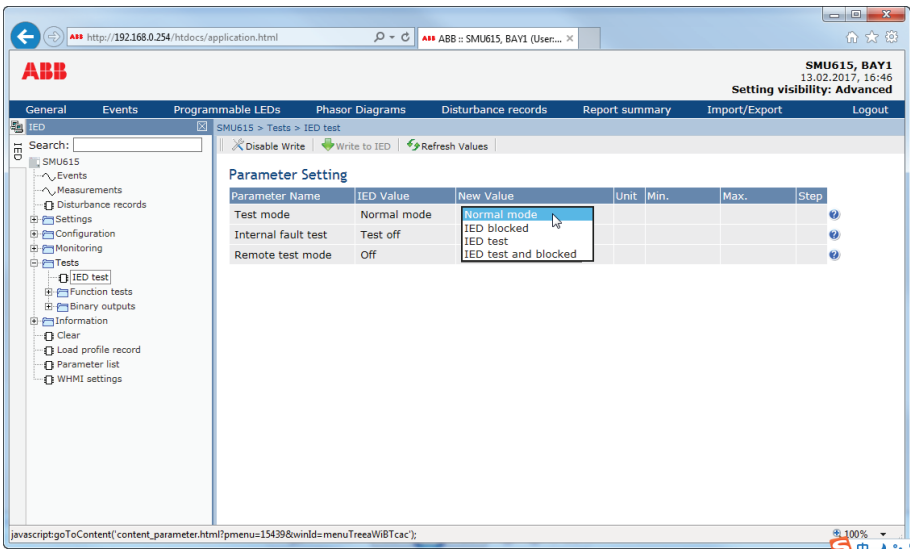


Figure 47: Entering IED blocked or IED test and blocked mode

4. Click **Write to IED**.



If the IED blocked or IED test and blocked mode is not cancelled, it remains on and the Ready LED remains flashing.

8.6 ABB Product Data Registration

The ABB Product Data Registration feature traces composition changes in the merging unit's SW or HW. Traceability allows better support and maintenance possibilities.

The PCM600 reads the changed data from the merging unit. Therefore a connection to the merging unit must be established first. Composition data can be read with PCM600 by enabling LCT during PCM600 installation and activating collection in PCM600 from 'Lifecycle Handling' menu. For detailed information see PCM600 online help.



The LCT composition changed report does not affect the functionality of the merging unit.

The number of composition changes can be seen from the *Composition changes* parameter in **Main Menu/Monitoring/IED status**.

Section 9 Glossary

100BASE-FX	A physical medium defined in the IEEE 802.3 Ethernet standard for local area networks (LANs) that uses fiber optic cabling
100BASE-TX	A physical medium defined in the IEEE 802.3 Ethernet standard for local area networks (LANs) that uses twisted-pair cabling category 5 or higher with RJ-45 connectors
AC	Alternating current
ACT	1. Application Configuration tool in PCM600 2. Trip status in IEC 61850
CAT 5	A twisted pair cable type designed for high signal integrity
COMTRADE	Common format for transient data exchange for power systems. Defined by the IEEE Standard.
CPU	Central processing unit
CSV	Comma-separated values
CT	Current transformer
DAN	Doubly attached node
DC	1. Direct current 2. Disconnecter 3. Double command
DHCP	Dynamic Host Configuration Protocol
DPC	Double-point control
DST	Daylight-saving time
EEPROM	Electrically erasable programmable read-only memory
EMC	Electromagnetic compatibility
Ethernet	A standard for connecting a family of frame-based computer networking technologies into a LAN
FIFO	First in, first out
FPGA	Field-programmable gate array
FTP	File transfer protocol
FTPS	FTP Secure
GOOSE	Generic Object-Oriented Substation Event

HMI	Human-machine interface
HSR	High-availability seamless redundancy
HTTPS	Hypertext Transfer Protocol Secure
HW	Hardware
IEC	International Electrotechnical Commission
IEC 61850	International standard for substation communication and modeling
IEC 61850-8-1	A communication protocol based on the IEC 61850 standard series
IEC 61850-9-2	A communication protocol based on the IEC 61850 standard series
IEC 61850-9-2 LE	Lite Edition of IEC 61850-9-2 offering process bus interface
IED	Intelligent electronic device
IEEE 1686	Standard for Substation Intelligent Electronic Devices' (IEDs') Cyber Security Capabilities
IP address	A set of four numbers between 0 and 255, separated by periods. Each server connected to the Internet is assigned a unique IP address that specifies the location for the TCP/IP protocol.
IRF	1. Internal fault 2. Internal relay fault
LAN	Local area network
LC	Connector type for glass fiber cable, IEC 61754-20
LCP	Liquid crystal polymer
LCT	Life cycle traceability
LE	Light Edition
LED	Light-emitting diode
LHMI	Local human-machine interface
MMS	1. Manufacturing message specification 2. Metering management system
NCC	Network control center
OTP	One-time password
PA	Polyamide
PBT	Polybutylene terephthalate
PC	1. Personal computer 2. Polycarbonate

PCM600	Protection and Control IED Manager
PRP	Parallel redundancy protocol
PTP	Precision Time Protocol
RAM	Random access memory
RJ-45	Galvanic connector type
RoHS	Restriction of hazardous substances
ROM	Read-only memory
RTC	Real-time clock
SAN	Single attached node
SCL	XML-based substation description configuration language defined by IEC 61850
SMT	Signal Matrix tool in PCM600
SMU615	Substation merging unit
SMV	Sampled measured values
STP	Shielded twisted-pair
SVG	Scalable vector graphics
SW	Software
TCP/IP	Transmission Control Protocol/Internet Protocol
UTC	Coordinated universal time
VT	Voltage transformer
WAN	Wide area network
WHMI	Web human-machine interface
XRIO	eXtended Relay Interface by OMICRON



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