Operation Manual

Feeder Protection Relay
REF615

Document ID: 1MRS756376
Issued: 08.02.2008
Revision: B
IED product version: 1.0

Copyright

Trademarks

Guarantee

Please inquire about the terms of guarantee from your nearest ABB representative.

ABB Oy

Distribution Automation

P.O. Box 699

FI-65101 Vaasa, Finland

Telephone: +358 10 2211

Facsimile: +358 10 22 41094

http://www.abb.com/substationautomation

Disclaimer

The data, examples and diagrams in this manual are included solely for the concept or product description and are not to be deemed as a statement of guaranteed properties. All persons responsible for applying the equipment addressed in this manual must satisfy themselves that each intended application is suitable and acceptable, including that any applicable safety or other operational requirements are complied with. In particular, any risks in applications where a system failure and/or product failure would create a risk for harm to property or persons (including but not limited to personal injuries or death) shall be the sole responsibility of the person or entity applying the equipment, and those so responsible are hereby requested to ensure that all measures are taken to exclude or mitigate such risks.

This document has been carefully checked by ABB but deviations cannot be completely ruled out. In case any errors are detected, the reader is kindly requested to notify the manufacturer. Other than under explicit contractual commitments, in no event shall ABB be responsible or liable for any loss or damage resulting from the use of this manual or the application of the equipment.

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 Council Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95/EC). This conformity is the result of a test conducted by ABB in accordance with Article 10 of the directive in agreement with the product standards EN 50263 and EN 60255-26 for the EMC directive, and with the product standards EN 60255-6 and EN 60255-27 for the low voltage directive. The IED 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 device 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 relay case internals may contain high voltage potential and touching these may cause personal injury.

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

Table of contents

Section 1 Introduction....7
This manual....7
Intended audience....7
Product documentation....8
Product documentation set....8
Document revision history....9
Related documentation....9
Document symbols and conventions....10
Safety indication symbols....10
Document conventions....10
Functions, codes and symbols....11

Section 2 Environmental aspects....13
Sustainable development....13
Disposing of the IED....13

Section 3 REF615 overview....15
Overview....15
Product version history....15
Operation functionality....16
Standard configurations....16
Optional functions....17
Physical hardware....17
LHMI....19
LCD....19
LEDs....21
Keypad....21
LHMI functionality....23
Protection and alarm indication....23
Parameter management 24
Front communication....25
WHMI....25
Command buttons....26
Authorization....27
Communication....27
PCM600 configuration tool....28
Connectivity packages....28
PCM600 and IED connectivity package version....29

Section 4 Using HMI locally or via web interface....31

Table of contents

Using LHMI....31
Logging in....31
Logging out....32
Turning display backlight on....33
Selecting local or remote use....33
Identifying the device....34
Adjusting display contrast....34
Changing LHMI language....35
Changing display symbols....35
Navigating in the menu....36
Menu structure....36
Scrolling the LCD view....36
Changing the default view....37
Browsing setting values....37
Editing values....38
Editing numerical values....38
Editing string values....39
Editing enumerated values....39
Committing settings....40
Clearing and acknowledging....40
Using LHMI help....41
Using WHMI....41
Logging in....41
Logging out....42
Identifying the device....43
Navigating in the menu....44
Menu structure....45
Showing all parameters....45
Editing values....46
Committing settings....48
Clearing and acknowledging....49
Selecting alarm view....51
Selecting event view....52
Selecting phasor diagrams....53
Using WHMI help....55

Section 5 IED operation 57

Operation in normal case....57
Function settings....57
Test data 57
Disturbance case operation....57
Disturbance case identification....58
Operation in tripping case 58
Internal IED errors....58

Disturbance recording triggering....59
Disturbance record analyzation....59
Disturbance reports....59
Fault determination....60
Application problem verification....60
IED parametrization....60
IED settings for IED functionality....60
IED settings for different operating conditions....60

Section 6 Operating procedures....61
Monitoring....61
Indications....61
Monitoring indication messages....61
Monitoring internal IED fault 61
Monitoring condition monitoring data....62
Measured and calculated values....62
Measured values....62
Using LHMI for monitoring....63
Recorded data....63
Creating disturbance recordings....63
Monitoring disturbance recorder data....64
Controlling and uploading disturbance recorder data....64
Monitoring event recorder data....65
Monitoring events....65
Remote monitoring....65
Operating IED remotely....66
Controlling....66
Controlling circuit breakers and disconnectors....66
Resetting IED....67
Clearing and acknowledging via LHMI....67
Changing IED functionality....68
Creating blockings....68
Selecting test mode....68
Connecting to trip and disturbance recorder functions....69
Defining channel settings....69
Defining setting group....69
Activating a setting group....69
Selecting a setting group for editing....70
Browsing and editing setting group values....71
Activating LEDs....72

Section 7 Troubleshooting 73
Fault tracing....73
Identifying hardware errors....73

Identifying runtime errors....73
Identifying communication errors....74
Checking communication LEDs....74
Running the display test....74
Indication messages....75
Internal faults....75
Warnings....77
LED and display messages....78
Corrections procedures....78
Rebooting software....78
Setting password....78
Identifying IED application problems....78
Inspecting wiring....79
Inspecting configuration connection....79
Sample data interruptions....79

Section 8 Commissioning....81
Commissioning checklist....81
Checking installation....81
Checking power supply....81
Checking CT circuits....82
Checking VT circuits....82
Checking binary input and output circuits....83
Binary input circuits....83
Binary output circuits....83
Authorizations....83
User authorization....83
Using PCM600....84
Setting communication between IEDs and PCM600....84
Communication options....84
Setting communication parameters....85
Setting IED and communication....90
Setting communication....90
Setting LHMI....90
Changing LHMI language....90
Adjusting display contrast....91
Changing display symbols....91
Changing the default view....91
Setting system time and time synchronization....92
Setting IED parameters....92
Defining setting groups....92
IED parametrization....95
Configuring analog inputs....95
Testing IED operation....95

Selecting test mode....95
Testing digital I/O interface....96
Testing functions....96
Selecting internal fault test....97
Life cycle traceability....97

Section 9 Glossary....99

Section 1 Introduction

1.1 This manual

Operation Manual contains instructions on how to operate the IED during normal service once it has been commissioned. The manual can be used to find out how to handle disturbances or how to view calculated and measured network data in order to determine the cause of a fault.

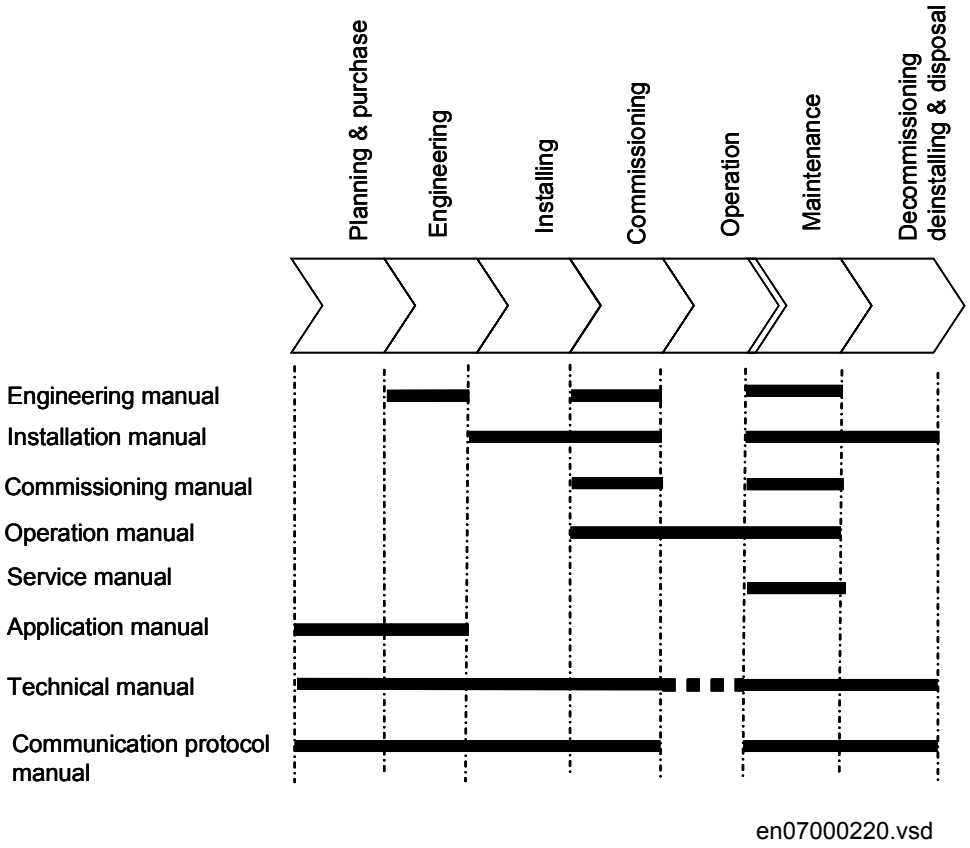
1.2 Intended audience

This manual addresses the operator, who operates the IED on a daily basis.

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



Engineering Manual contains instructions on how to engineer the IED products. The manual provides instructions on how to use the different tools for IED engineering. It also includes instructions on how to handle the tool component available to read disturbance files from the IEDs on the basis of the IEC 61850 definitions. It further introduces the diagnostic tool components available for IED products and the PCM600 tool.

Installation Manual contains instructions on how to install the IED. The manual provides procedures for mechanical and electrical installation. The chapters are organized in the chronological order in which the protection IED should be installed.

Commissioning Manual contains instructions on how to commission the IED. The manual can also be used as a reference during periodic testing. The manual provides procedures for energizing and checking of external circuitry, setting and configuration as well as verifying settings and performing directional tests. The chapters are organized in the chronological order in which the IED should be commissioned.

Operation Manual contains instructions on how to operate the IED during normal service once it has been commissioned. The manual can be used to find out how to handle disturbances or how to view calculated and measured network data in order to determine the cause of a fault.

Service Manual contains instructions on how to service and maintain the IED. The manual also provides procedures for de-energizing, de-commissioning and disposal of the IED.

Application Manual contains application descriptions and setting guidelines sorted per function. The manual can be used to find out when and for what purpose a typical protection function can be used. The manual can also be used when calculating settings.

Technical Manual contains application and functionality descriptions and lists function blocks, logic diagrams, input and output signals, setting parameters and technical data sorted per function. The manual can be used as a technical reference during the engineering phase, installation and commissioning phase, and during normal service.

The Communication Protocol manuals describe the different communication protocols supported by the IED. The manuals concentrate on vendor-specific implementations.

All manuals are not available yet.

1.3.2 Document revision history

Document revision/date	Product version	History
A/20.12.2007	1.0	First release
B/08.02.2008	1.0	Content updated

The latest version of the document can be downloaded from the ABB web site http://www.abb.com/substationautomation

1.3.3 Related documentation

Name of the document	Document ID
Application Manual	1MRS756378
Modbus Communication Protocol Manual	1MRS756468
Installation Manual	1MRS756375
Technical Manual	1MRS756377

1.4 Document symbols and conventions

1.4.1 Safety indication symbols

This publication includes the following icons that point out safety-related conditions or other important information:

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 to relevant 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 should be understood that operation of damaged equipment could, under certain operational conditions, 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

The following conventions are used for the presentation of material:

- Abbreviations in this manual are spelled out in the section "Glossary". In addition, the section contains descriptions on several terms.
- Push button navigation in the HMI menu structure is presented by using the push button icons, for example:
  To navigate between the options, use  and  .
- HMI menu paths are presented as follows:
  Select **Main menu/Configuration/HMI**.

- Menu names are shown in bold in WHMI, for example:
  Click **Information** in the WHMI menu structure.

- HMI messages are shown in Courier font, for example:
  To save the changes in non-volatile memory, select `Yes` and press 
- Parameter names are shown in italics, for example:
  The function can be enabled and disabled with the *Operation* setting.
- Parameter values are indicated with quotation marks, for example:
  The corresponding parameter values are "On" and "Off".
- IED input/output messages and monitored data names are shown in Courier font, for example:
  When the function starts, the `START` output is set to TRUE.

1.4.3 Functions, codes and symbols

Table 1: Functions included in the REF615 standard configuration

Function	IEC 61850	IEC	ANSI
Three-phase non-directional overcurrent protection, low stage	PHLPTOC1	3I>	51P-1
Three-phase non-directional overcurrent protection, high stage, instance 1	PHHPTOC1	3I>> (1)	51P-2 (1)
Three-phase non-directional overcurrent protection, high stage, instance 2	PHHPTOC2	3I>> (2)	51P-2 (2)
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC1	3I>>>	50P/51P
Arc protection	ARCPSARC1 ARCPSARC2 ARCPSARC3	ARC (1) ARC (2) ARC (3)	50L/50NL (1) 50L/50NL (2) 50L/50NL (3)
Non-directional earth-fault protection, low stage	EFLPTOC1	I_0> (1)	50N-1 (1)
Non-directional earth-fault protection, low stage	EFLPTOC2	I_0> (2)	50N-1 (2)
Non-directional earth-fault protection, high stage	EFHPTOC1	I_0>>	50N-2
Non-directional earth-fault protection, instantaneous stage	EFIPTOC1	I_0>>>	50N/51N
Directional earth-fault protection, low stage, instance 1	DEFLPDEF1	I_0> → (1)	67N-1 (1)
Directional earth-fault protection, low stage, instance 2	DEFLPDEF2	I_0> → (2)	67N-1 (2)
Directional earth-fault protection, high stage	DEFHPDEF1	I_0>> →	67N-2
Transient/Intermittent earth-fault protection	INTRPTEF1	I_0> → IEF	67NIEF
Non-directional earth-fault protection, high stage (calculated I_0 current)	EFHPTOC1	I_0>>	50N-2
Negative-sequence overcurrent protection, instance 1	NSPTOC1	I_2> (1)	46 (1)
Negative-sequence overcurrent protection, instance 2	NSPTOC2	I_2> (2)	46 (2)
Phase discontinuity	PDNSPTOC1	I_2/I_1>	46PD
Table continued on next page			

Function	IEC 61850	IEC	ANSI
Three-phase inrush detector	INRPHAR1	3I2f>	68
Three-phase thermal protection for feeders, cables and distribution transformers	T1PTTR1	3Ith>	49F
Autoreclosure	DARREC1	O → I	79
Circuit breaker failure protection	CCBRBRF1	3I>/I_0>BF	51BF/51NBF
Master Trip	TRPPTRC1 TRPPTRC2	Master Trip (1) Master Trip (2)	94/86 (1) 94/86 (2)
Trip circuit supervision, instance 1	TCSSCBR1	TCS (1)	TCM (1)
Trip circuit supervision, instance 2	TCSSCBR2	TCS (2)	TCM (2)
Disturbance recorder	-	-	-
Circuit breaker condition monitoring	MSCBR1	CBCM	CBCM
Three-phase current measurement	CPHMMXU1	3I	3I
Sequence current measurement	CSMSQI1	I_1, I_2, I_0	I_1, I_2, I_0
Residual current measurement	RESCMMXU1	I_0	I_N
Residual voltage measurement	RESVMMXU1	U_0	V_N

Section 2 Environmental aspects

2.1 Sustainable development

Sustainable development has been taken into account from the beginning of the product design process. Extended lifecycle and reliability to use are basis of the design. Reliability has been assured with different kind of tests during the design and manufacturing processes. Long lifecycle can be achieved due to the quality of maintenance and repair services, constant availability of the spare parts and possibility to make software updates.

The choice of the materials and the supplier has been made by following the principles of sustainable development and RoHS directive (EU directive 2002/96/EC/175). The RoHS directive restricts hazardous substances. The pro-environmental manufacturing process, energy consumption and disposing of the IED has been taken into account since the design of the IED.

The RoHS directive limits the use of the following substances:

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%

Design and manufacturing has been done under the certificated environmental system. Functioning and usefulness of the system is under evaluation of external evaluator. ABB follows environmental rules and regulations systematically, and evaluate the effect of them on our products and processes. ABB concern requires a regular environmental reporting.

2.2 Disposing of the IED

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

All parts used in this product are recyclable including plastics. When disposing cast-off IEDs or its parts, contact the local enterprisers who are authorized to handle and recycle metal, electrical/electronics and plastics waste. These partners can sort the material by using dedicated sorting processes and dispose the product according to the local requirements.

Table 3: Materials of the IED parts

IED	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 front panel module	Various
	Plastic parts	PC, PBT[3)], LCP, PA[4)]
	Metallic plate	Steel
Package	Box	Cardboard
Attached material	Manuals	Paper

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

Section 3 REF615 overview

3.1 Overview

REF615 is a native IEC 61850 feeder protection relay for selective short-circuit, overcurrent and earth-fault protection. It is applicable to all types of radial isolated neutral networks, resistant earthed networks and compensated networks. REF615 is part of a product family that will cover main protection applications for utility and industry customers.

The relay features draw-out-type design, compact size and ease of use. Depending on the IED variant, the protection functions may include:

- Three-phase non-directional overcurrent protection, 4 stages
- Double earth-fault protection (cross-country earth-fault protection)
- Non-directional earth-fault, 3 stages
- Non-directional sensitive earth-fault
- Directional earth-fault protection, 3 stages
- Transient/intermittent earth-fault protection
- Negative-phase-sequence protection, 2 stages
- Phase discontinuity
- Three-phase transformer inrush detector
- Three-phase thermal overload, lines and cables
- Circuit breaker failure protection
- Electrically latched lockout relay

Depending on the IED variant, the optional functions may include:

- Auto-reclose
- Arc protection, three lens sensors for arc detection

3.2 Product version history

IED version	Release date	Product history
1.0	20.12.2007	Product released

3.3 Operation functionality

3.3.1 Standard configurations

The IED is available with four alternative standard configurations. The table below indicates the functions supported by the different IED configurations.

Standard configuration functionality	Overcurrent and directional earth-fault protection		Overcurrent and non-directional earth-fault protection	
	Std. conf.	Std. conf.	Std. conf.	Std. conf.
	A	B	C	D
Protection				
Three-phase non-directional overcurrent, low-set stage	●	●	●	●
Three-phase non-directional overcurrent, high-set stage, instance 1	●	●	●	●
Three-phase non-directional overcurrent, high-set stage, instance 2	●	●	●	●
Three-phase non-directional overcurrent, instantaneous stage	●	●	●	●
Directional earth-fault, low-set stage, instance 1	●	●	-	-
Directional earth-fault, low-set stage, instance 2	●	●	-	-
Directional earth-fault, high-set stage	●	●	-	-
Double earth-fault protection (cross-country earth-fault)	●	●	-	-
Transient/intermittent earth-fault	●	●	-	-
Non-directional earth-fault, low-set stage	-	-	●	●
Non-directional earth-fault, high-set stage	-	-	●	●
Non-directional earth-fault, instantaneous stage	-	-	●	●
Non-directional sensitive earth-fault	-	-	●	●
Negative-sequence overcurrent, instance 1	●	●	●	●
Negative-sequence overcurrent, instance 2	●	●	●	●
Phase discontinuity	●	●	●	●
Thermal overload	●	●	●	●
Circuit breaker failure protection	●	●	●	●

Table continued on next page

Three-phase inrush current detection	●	●	●	●
Arc protection with three sensors	○	○	○	○
Control				
Circuit breaker control with basic interlocking[1)]	●	●	●	●
Circuit breaker control with extended interlocking[2)]	-	●	-	●
Auto-reclosing of one circuit breaker	○	○	○	○
Supervision and Monitoring				
Circuit breaker condition monitoring	-	●	-	●
Trip-circuit supervision of two trip circuits	●	●	●	●
Measurement				
Transient disturbance recorder	●	●	●	●
Three-phase current measurement	●	●	●	●
Current sequence components	●	●	●	●
Residual current measurement	●	●	●	●
Residual voltage measurement	●	●	-	-

1) **Basic interlocking functionality**: Closing of the circuit breaker can be enabled by a binary input signal. The actual interlocking scheme is implemented outside the relay. The binary input serves as a "master interlocking input" and when energized it will enable circuit breaker closing.
2) **Extended interlocking functionality**: The circuit breaker interlocking scheme is implemented in the relay configuration, based on primary equipment position information (via binary inputs) and the logical functions available. The signal matrix tool of PCM600 can be used for modifying the interlocking scheme to suit your application.

● = Included, ○ = Optional at the time of the order

3.3.2 Optional functions

The optional functions available in the IED are:

- Arc protection
- Auto-reclosing
- IEC 61850-8-1
- Modbus TCP/IP or RTU/ASCII

3.4 Physical hardware

The IED consists of two main parts: plug-in unit and case. The plug-in unit content depends on the ordered functionality.

Table 4: Plug-in unit and case

Main unit	Content options		
Plug-in unit	HMI		
	CPU module		
	Auxiliary power/ binary output module	48-250V DC / 100-240 Vac; or 24-60 Vdc 2 normally-open PO contacts 2 change-over SO contacts 2 double-pole PO contacts with TCS 1 dedicated internal fault output contact	
	AI module [1]	Option 1:	3 phase current inputs (1/5A) 1 residual current input for non-directional earth-fault protection (1/5A or 0.2/1A[2]) 4 BIs
		Option 2:	3 phase current inputs (1/5A) 1 residual current input (1/5A or 0.2/1A) 1 residual voltage input for directional earth-fault protection (100, 110, 115 or 120 V) 3 BIs
	BI/O module	7 BIs 3 SO contacts	
Case	AI module interface connectors Auxiliary power/binary output module interface connectors BI/O module interface connectors Communication module		

1) The analog input module option depends on the selected standard configuration.
2) The 0.2/1A input is normally used in applications requiring sensitive earth-fault protection and featuring core-balance current transformers.

The rated input levels are selected in the IED software for phase current, residual current and residual voltage. The binary input thresholds 18...176 V DC are selected by adjusting the IED's parameter settings.

The additional BI/O module is included in the IED with standard configurations B and D.

The connection diagrams of different hardware modules are presented in the REF615 Application manual.

Refer to the RE_615 Installation manual for more information about the case and the plug-in unit.

3.5 LHMI

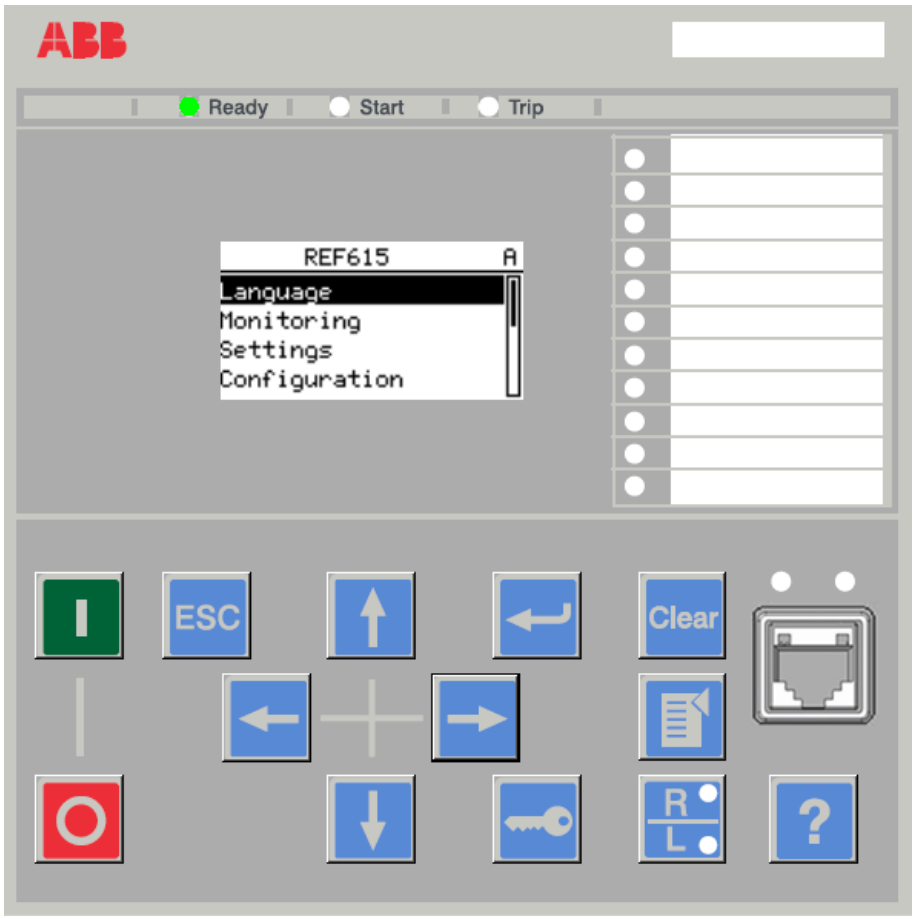


Figure 1: LHMI

The LHMI of the IED contains the following elements:

- Display
- Buttons
- LED indicators
- Communication port

The LHMI is used for setting, monitoring and controlling.

3.5.1 LCD

The LHMI includes a graphical LCD that supports two character sizes.

The amount of characters and rows fitting the view depends on the character size:

Character size	Rows in view	Characters on row
Small, mono-spaced (6x12 pixels)	5 rows 10 rows with large screen	20
Large, variable width (13x14 pixels)	4 rows 8 rows with large screen	min 8

The display view is divided into four basic areas:

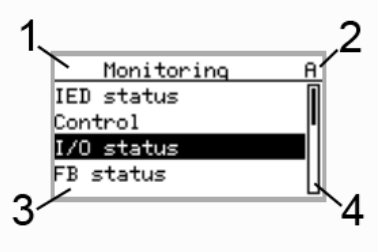


Figure 2: Display layout

1 Header
2 Icon
3 Content
4 Scroll bar (appears when needed)

- The header area at the top of the display view shows the current location in the menu structure.
- The icon area at the upper right corner of the display shows the current action or user level.
  Current action is indicated by the following characters:
  - U: Font/Firmware is being updated
  - S: Parameters are being stored
  - !: Warning and/or indication

  Current user level is indicated by the following characters:
  - V: Viewer
  - O: Operator
  - E: Engineer
  - A: Administrator
- The content area with four rows shows the menu content. With larger character size, the content area has only three rows.
- If the menu contains more rows than the display can show at a time, a scroll bar appears on the right.

The display is updated either cyclically or based on changes in the source data such as parameters or events.

3.5.2 LEDs

The LHMI includes three protection indicators above the display: Ready, Start and Trip.

There are also 11 matrix programmable indicator LEDs on front of the LHMI. The LEDs can be configured with PCM600 and the operation mode can be selected with the LHMI.

3.5.3 Keypad

The LHMI keypad consists of push buttons which are used to navigate in different views or menus. With push buttons you can give open or close commands to, for example, circuit breakers, disconnectors and switches. The push buttons are also used to acknowledge alarms, reset indications, provide help and switch between local and remote control mode.

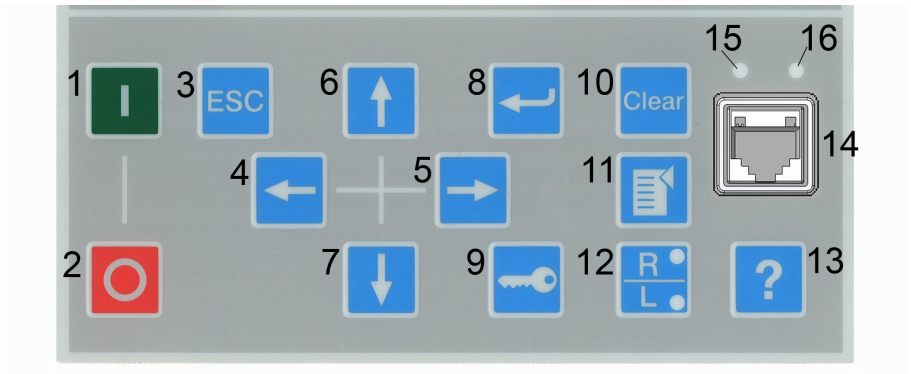


Figure 3: LHMI keypad with object control, navigation and command push buttons and RJ-45 communication port

1 Close
2 Open
3 Escape
4 Left
5 Right
6 Up
7 Down
8 Enter
9 Key
10 Clear
11 Menu
12 Remote/Local
13 Help
14 Communication port
15 Uplink LED
16 Communication LED

Object control

If the control position of the IED is set to local with the R/L button, the IED can be controlled using the object control buttons.

As a default, breaker 1 is always the first to be controlled. If other controllable objects are available, the user can select them in the control menu.

Table 5: Object control push buttons

Name	Description
Close	Closing the selected object.
Open	Opening the selected object.

Navigation

The arrow buttons are used for navigation. To scroll information, press the arrow button several times or simply keep it pressed down.

Table 6: Navigation push buttons

Name	Description
ESC ESC	• Leaving setting mode without saving the values. • Cancelling certain actions. • Adjusting the display contrast in combination with or . • Changing the language in combination with . • Running the display test in combination with .
Enter	• Entering parameter setting mode. • Confirming a new value of a setting parameter.
Up Down	• Moving up and down in menus. • Scrolling active digits of a parameter when entering a new setting value.
Left Right	• Moving left and right in menus. • Changing the active digit of a parameter when entering a new setting value.
Key	• Activating the authorization procedure, when the user is not logged in. • Logging out, when the user is currently logged in.

Commands

Table 7: Command push buttons

Name	Description
Menu	• Moving directly to the Main Menu, if currently in default view or in any menu. • Moving to the default view, if currently in Main Menu.
R/L	Changing the control position (remote or local) of the device. • When the R LED is lit, remote control is enabled and local control disabled. • When the L LED is lit, local control is enabled and remote control disabled. • When none of the LEDs are lit, both control positions are disabled.
Clear	Activating the Clear/Reset view.
Help	Showing context sensitive help messages.

3.5.4 LHMI functionality

3.5.4.1 Protection and alarm indication

Protection indicators

Protection indicator LEDs are called Ready, Start and Trip.

Table 8: Ready LED

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

Table 9: Start LED

LED state	Description
Off	Normal operation.
On	A protection function has started and an indication message is displayed. • If several protection functions start within a short time, the last start is indicated on the display.
Blinking	A protection function is blocked. • The blocking indication disappears when the blocking is removed or when the protection function is reset.

Table 10: Trip LED

LED state	Description
Off	Normal operation.
On	A protection function has tripped and an indication message is displayed. • The trip indication is latching and must be reset via communication or by pressing Clear. • If several protection functions trip within a short time, the last trip is indicated on the display.

Alarm indicators

The 11 matrix programmable LEDs are used for alarm indication.

Table 11: Alarm indications

LED state	Description
Off	Normal operation. All alarms are OFF.
On	• Non-latched mode (Follow-S): alarm is still on. • Latched mode (Latched-S): alarm is still on or it is off but has not been acknowledged. • Latched blinking mode (LatchedAck-F-S): alarm is still on but has been acknowledged.
Blinking	• Non-latched blinking mode (Follow-F): alarm is still on. • Latched blinking mode (LatchedAck-F-S): alarm is still on or it is off but has not been acknowledged.

3.5.4.2 Parameter management

The LHMI enables you to access the IED parameters. It is possible to read and write three types of parameters:

- Numerical values
- String values
- Enumerated values

Numerical values are presented either in integer or in decimal format with minimum and maximum values. Character strings can be edited character by character. Enumerated values have a predefined set of selectable values.

The IED does not support Scandinavian characters.

3.5.4.3 Front communication

The RJ-45 port in the LHMI enables front communication. There are two LEDs 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 blinks when the IED communicates with the connected device.

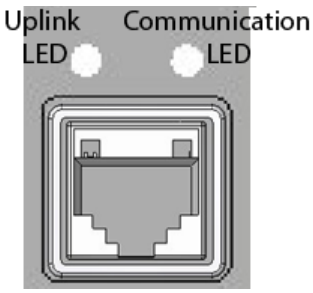


Figure 4: RJ-45 communication port and indication LEDs

When a computer is connected to the IED, the IED'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.

3.6 WHMI

The WHMI enables the user to access the IED via a web browser.

WHMI is disabled by default and can be enabled via the LHMI **Main Menu/Configuration/HMI/Web HMI mode**.

WHMI offers the following functions:

- Alarm indications and event lists
- System supervision
- Parameter settings
- Measurement display
- Phasor diagram

The menu tree structure on the WHMI is identical to the one on the LHMI.

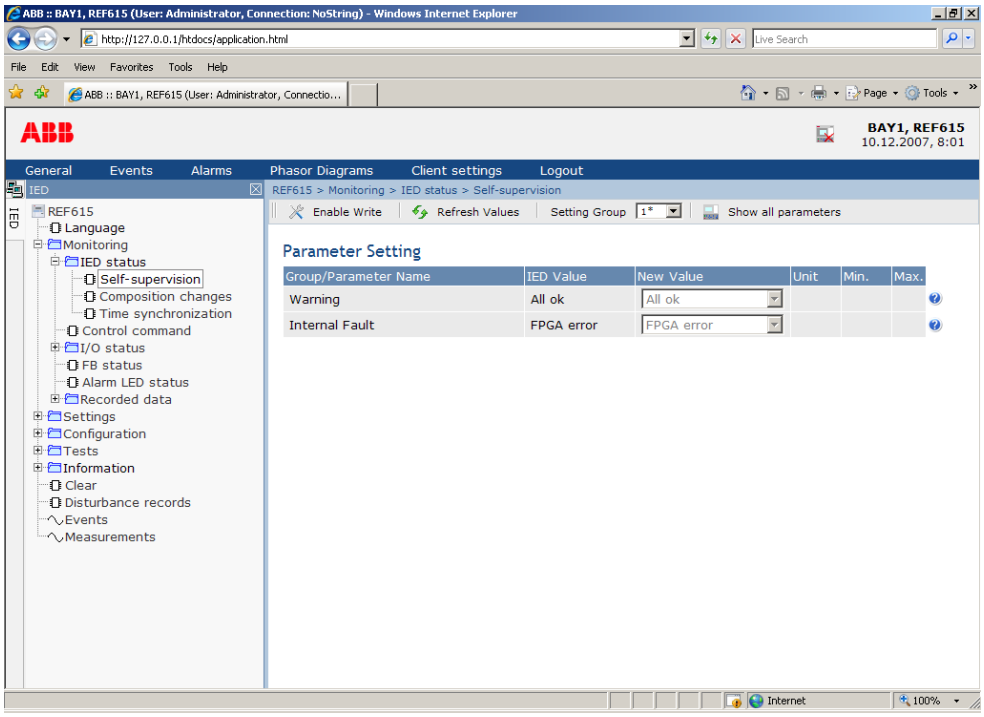


Figure 5: Example view of the WHMI

The WHMI can be accessed:

- Locally by connecting your laptop to the IED via the front communication port.
- Remotely through the Internet or over LAN/WAN.

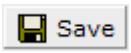
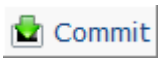
3.6.1 Command buttons

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

Table 12: Command buttons

Name	Description
Enable Write	Enabling parameter editing.
Disable Write	Disabling parameter editing.
Write to IED	Writing parameters to the IED.
Refresh Values	Refreshing parameter values.
Show all parameters	Showing all parameters.
Print	Printing out parameters.

Table continued on next page

Name	Description
	Saving values to CSV file format.
	Freezing the values so that updates are not displayed.
	Committing changes to IED's non-volatile flash memory.
	Rejecting changes.
	Showing context sensitive help messages.

3.7 Authorization

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

The default passwords can be changed with Administrator user rights.

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

Table 13: Predefined user categories

Username	User rights
VIEWER	Only allowed to view
OPERATOR	Authorized to make operations
ENGINEER	Allowed to change IED parameters, but no operation rights
ADMINISTRATOR	Full access

For user authorization for PCM600, refer to PCM600 documentation.

3.8 Communication

The IED supports two different communication protocols: IEC 61850 and Modbus®. Operational information and controls are available through these protocols. However, some communication functionality, for example, horizontal communication between the IEDs and parameters setting, is only enabled by the IEC 61850 communication protocol.

The IEC 61850 communication implementation supports all monitoring and control functions. Additionally, parameter setting and disturbance file records can be accessed using the IEC 61850-8-1 protocol. Further, the IED can send and receive binary signals from other IEDs (so called horizontal communication) using the IEC61850-8-1 GOOSE profile, where the highest performance class with a total transmission time of 3 ms is supported. The IED can simultaneously report to five different IEC 61850-8-1 clients.

All communication connectors, except for the front port connector, are placed on integrated optional communication modules. The IED can be connected to Ethernet-based communication systems via the RJ-45 connector (100BASE-TX) or the fibre-optic LC connector (100BASE-FX). If connection to a RS-485 network is required, the 10-pin screw-terminal connector can be used.

3.9 PCM600 configuration tool

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

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

With the individual tool components, you can perform different tasks and functions and control the whole substation. PCM600 can operate with many different topologies depending on customer needs.

For more information, refer to PCM600 documentation.

3.9.1 Connectivity packages

Connectivity package is a collection of software and information related to a specific protection and control terminal providing system products and tools to connect and interact with the IED.

Connectivity Package Manager is a tool that helps the user to define the right connectivity package versions for different system products and tools. Connectivity Package Manager is included in products supporting the connectivity concept.

Use the connectivity packages to create configuration structure in PCM600. In addition to other products supporting connectivity concept, the connectivity packages for PCM600 contain:

- Description of IED's internal parameters and their properties such as data format, unit, setting range, visibility and access rights. The description texts can be translated into other languages as well.
- Software components that adapt the IED-specific interfaces to the standard interfaces of system products and tools such as IED-specific dispatchers for tools. This means that there is a protocol-specific adaptation for the parameter setting and disturbance handling tool components, for example disturbance uploading according to COMTRADE.

3.9.2 PCM600 and IED connectivity package version

Supported tools:

- Protection and Control IED Manager PCM600 Ver. 2.0 or later
- REF615 Connectivity Package Ver. 1.0
  - Parameter Setting Tool
  - Disturbance Handling Tool
  - Signal Monitoring Tool
  - Signal Matrix Tool

PCM600 and the necessary connectivity packages can be downloaded from the ABB web site http://www.abb.com/substationautomation

Section 4 Using HMI locally or via web interface

4.1 Using LHMI

You must be logged in and authorized to use the LHMI. Password authorization is disabled by default and can be enabled either via the LHMI or WHMI.

To enable password authorization, select **Main Menu/ Configuration/Authorization**.

4.1.1 Logging in

Log in to use the LHMI:

1. Press any of the following buttons to activate the login procedure
   - 
   - 
   - 

   - 
   - 
2. Press  or  to select the user level.

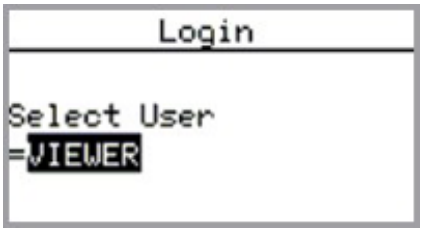


Figure 6: Selecting access level

3. Confirm the selection with  .
4. Enter the prompted password digit by digit.

- Activate the digit to be entered with ← and →.
- Enter the character with ↑ and ↓.

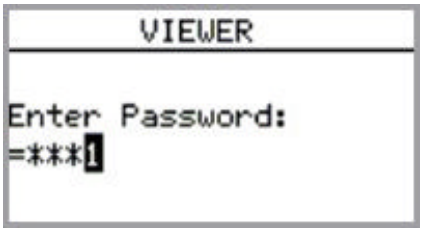


Figure 7: Entering password

5. Press ↵ to confirm the login.
   - To cancel the procedure, press ESC.

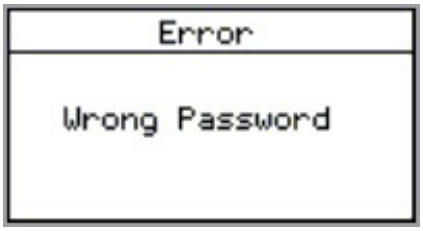


Figure 8: Error message indicating wrong password

The user level you are logged into shows on the LCD's upper right corner in the icon area.

4.1.2 Logging out

The user is automatically logged out 30 seconds after the backlight timeout.

Manual logout is also possible:

1. Press 🔑.
2. To confirm logout, select `Yes` and press ↵.

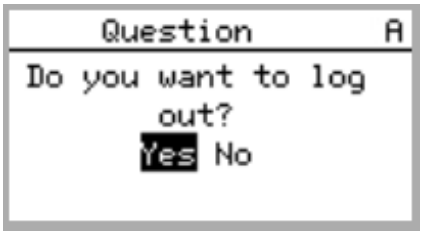


Figure 9: Logging out

- To cancel logout, press ESC.

4.1.3 Turning display backlight on

The display backlight is normally off. It turns on during the display test at power up.

- To turn on the backlight manually, press any LHMI push button.
  The backlight turns on and the panel is ready for further operations.

If the panel has not been used for a predefined timeout period, the backlight is switched off. The user is logged out from the current user level 30 seconds after the display backlight has turned off.

The display returns to the default view and all unconfirmed operations such as parameter editing and breaker selection are cancelled.

You can change the backlight timeout period in **Main Menu/ Configuration/HMI/Backlight timeout**.

4.1.4 Selecting local or remote use

The control position of the IED can be changed with the R/L button. In local position primary equipment, such as circuit breakers and disconnectors, can be controlled via the LHMI. In remote position, control operations are possible only from a higher level, that is from a control center.

To change the IED's control position:

- Press R/L for two seconds.
  - When the L LED is lit, local control is enabled and remote control disabled.
  - When the R LED is lit, remote control is enabled and local control disabled.
  - When none of the LEDs are lit, both control positions are disabled.

The control position cannot be simultaneously local and remote, but it can be disabled when neither of the positions is active.

You must be logged in and authorized to control the IED.

4.1.5 Identifying the device

The IED information includes detailed information about the device, such as revision and serial number. The IED information is shown on the display for a few seconds when the device starts up. The same information is also found in the IED menu.

To view the device information:

1. Select **Main Menu/Information**.
2. Select a submenu with and .

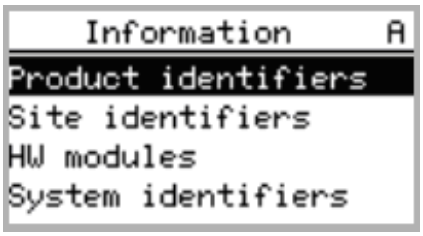


Figure 10: Selecting submenu

3. Enter the submenu with .
4. Browse the information with and .

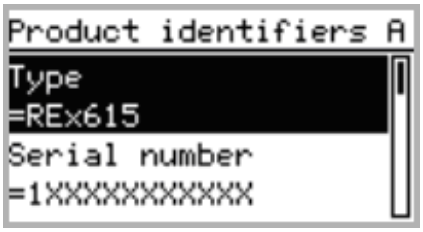


Figure 11: IED information

4.1.6 Adjusting display contrast

To obtain optimal readability, you can adjust the display contrast. The contrast can be adjusted anywhere in the menu structure.

- To increase the contrast, press simultaneously ESC and ↑.
- To decrease the contrast, press simultaneously ESC and ↓.

The selected contrast value is stored in the non-volatile memory. After an auxiliary power failure, the contrast is restored.

4.1.7 Changing LHMI language

To change the LHMI language:

1. Select **Main Menu/Language** and press ↵.
2. Change the language with ↑ or ↓.
3. Press ↵ to confirm the selection.
4. Commit the changes.

Figure 12: Changing the LHMI language

You can change the language also by pressing simultaneously ESC and ←.

4.1.8 Changing display symbols

To switch between the display symbols IEC 61850, IEC and ANSI:

1. Select **Main Menu/Configuration/HMI/FB naming convention** and press ↵.
2. Change the display symbols with ↑ or ↓.
3. Press ↵ to confirm the selection.

The IED has to be rebooted if the WHMI display symbols are changed. With the LHMI, the change takes effect immediately.

4.1.9 Navigating in the menu

You can navigate the menus and change the display views on the screen with the keypad:

- To move to the Main Menu or default view, press .
- To move up or down in a menu, press or .
- To move downwards in the menu tree, press .
- To move upwards in the menu tree, press .
- To enter setting mode, press .
- To leave setting mode without saving, press ESC.

4.1.9.1 Menu structure

The Main Menu contains the following main groups:

- Language
- Monitoring
- Settings
- Configuration
- Tests
- Information
- Clear
- Disturbance records
- Events
- Measurements

Main groups are divided further into more detailed submenus.

4.1.9.2 Scrolling the LCD view

If a menu contains more rows than the display can show at a time, a scroll bar is displayed on the right.

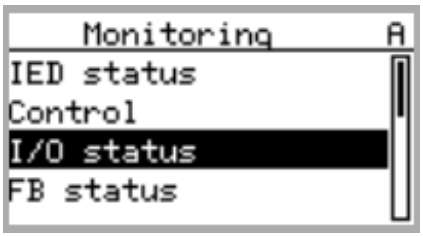


Figure 13: Scroll bar on the right

- To scroll the view upwards, press .
- To scroll the view downwards, press .
- You can jump from the last row to the first row by pressing again. You can also jump from the first row to the last row by pressing .

4.1.9.3 Changing the default view

The default view of the display is the **Measurements** unless set otherwise.

To change the default view:

1. Select **Main Menu/Configuration/HMI/Default view** and press .
2. Change the default view with or .
3. Press to confirm the selection.

4.1.10 Browsing setting values

To browse setting values:

1. Select **Main Menu/Settings/Settings** and press .
2. Select the setting group to be viewed with or .

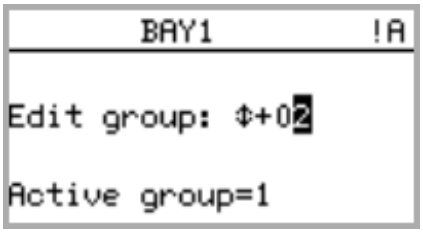


Figure 14: Selecting a setting group

3. Press to confirm selection.
4. To browse the settings, scroll the list with and and to select a setting press . To move back to the list, press .

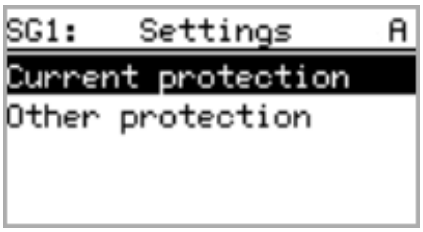


Figure 15: Setting alternatives in the selected setting group

4.1.11 Editing values

You must be logged in and authorized to edit values.

4.1.11.1 Editing numerical values

To edit numerical values:

1. Select **Main Menu/Settings** and then a setting.
   When you start editing numerical values, the last digit is active.
   - When the symbol in front of the value is ↑, you can only increase the active value.
   - When the symbol is ↓ you can only decrease the active value.
   - When the symbol in front of the value is ↕, you can either increase or decrease the active value.

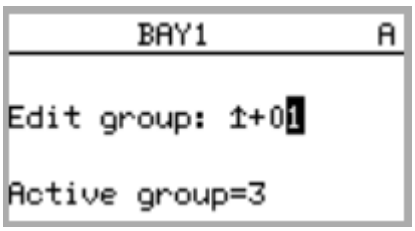


Figure 16: Last digit is active and it can only be increased

2. Press ↑ to increase or ↓ to decrease the value of an active digit.
   One press increases or decreases the value by a certain step. For integer values, the change is 1, 10, 100 or 1000 (...) depending on the active digit. Additionally, for decimal values, the change can be fractions 0.1, 0.01, 0.001 (...) depending on the active digit.
3. Press ← or → to move the cursor to another digit.
4. The minimum or maximum value can be set by selecting the arrow symbol in front of the value:
   - To set the value to the maximum, press ↑.
   - To set the value to the minimum, press ↓.

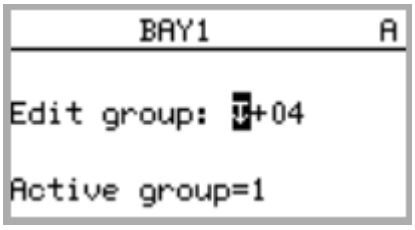


Figure 17: Arrow symbol is active, the value is set to the maximum

After pressing , the previous value can be restored by pressing once, and vice versa. Another press of or sets the value to the lower or higher limit. The symbol in front of the value is ↕, when the previous value is shown.

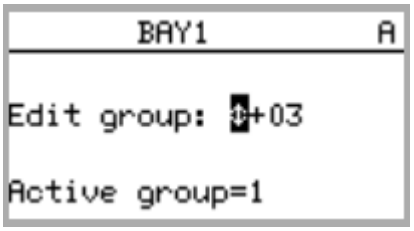


Figure 18: Restoring the previous value

4.1.11.2 Editing string values

To edit string values consisting of ASCII characters:

1. Activate the setting mode and select a setting.
   When editing string values, the cursor moves to the first character.
2. Press or to change the value of an active character.
   One press changes the value by one step in the order the values appear in the ASCII range. The available ASCII characters are 32...126.
3. Press or to move the cursor to another character.
   - To shorten text, replace the unnecessary characters with space. The string will be saved without the spaces at the end.

The IED does not support Scandinavian characters.

The maximum length of strings depends on the parameter. In most cases the screen width limits the string length to 20 characters but for some parameters the maximum length is up to 64 characters.

4.1.11.3 Editing enumerated values

To edit enumerated values:

1. Activate the setting mode and select a setting.
   When editing an enumerated value, the selected value is shown inverted.
2. Press or to change the value of an active character.

One press changes the enumerated value by one step in the parameter specific order.

4.1.12 Committing settings

Editable values are stored either in RAM or in non-volatile flash memory. Values stored in flash memory are in effect also after 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.

To store changes into non-volatile memory:

1. Press to confirm any changes.
2. Press to move upwards in the menu tree or to enter the Main Menu.
3. To save the changes in non-volatile memory, select `Yes` and press .

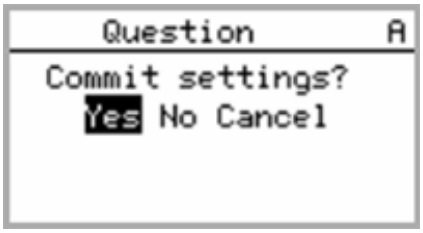


Figure 19: Confirming settings

- To exit without saving changes, select `No` and press .
  - 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 you reboot the IED. However, the edited value is not stored in non-volatile memory and the reboot restores the original value.
- To cancel saving settings, select `Cancel` and press . The value returns to editing mode.

4.1.13 Clearing and acknowledging

You can reset, acknowledge or clear all messages and indications, including LEDs and latched outputs as well as registers and recordings, with the Clear button. Pressing the Clear button activates a selection menu, where you can choose which clearance or reset function you want to make. Events and alarms assigned to alarm LEDs are cleared with the Clear button as well.

To clear, reset or acknowledge messages and indications:

1. Press Clear to activate the Clear view.

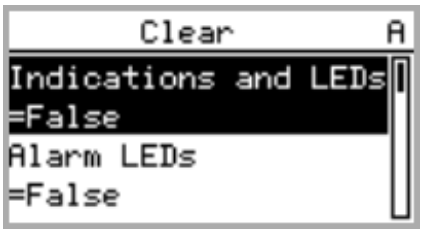


Figure 20: Clear view

2. Select the item to be cleared with ↑ or ↓.
3. Press ↵, change the value from `False` to `True` with ↑ or ↓ and press ↵ again.
   The item is now cleared and the value changes back to `False`.
4. Repeat steps 2 and 3 to clear other items.

4.1.14 Using LHMI help

The LHMI help is used to get information from, for example, the selected view, menu or a single parameter.

To open the context sensitive help:

1. Press ?.
   The help view is displayed.
2. If the help text exceeds the display area, scroll the text with ↑ or ↓.
3. To close the help, press ESC.

4.2 Using WHMI

WHMI is disabled by default. To use it, you must enable it via the LHMI in **Main Menu/Configuration/HMI/Web HMI mode**.

You must be logged in and authorized to use the WHMI.

4.2.1 Logging in

Log in to use the WHMI:

1. Enter the username with capital letters.
2. Enter the password.
3. Click **Log in**.

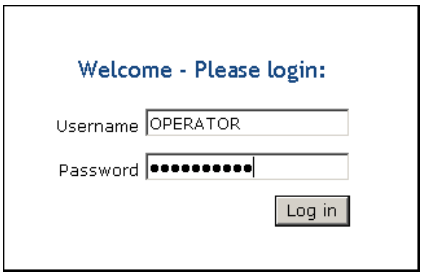


Figure 21: Entering username and password to use the WHMI

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**. The red session timeout bar appears one minute before the timeout expires.

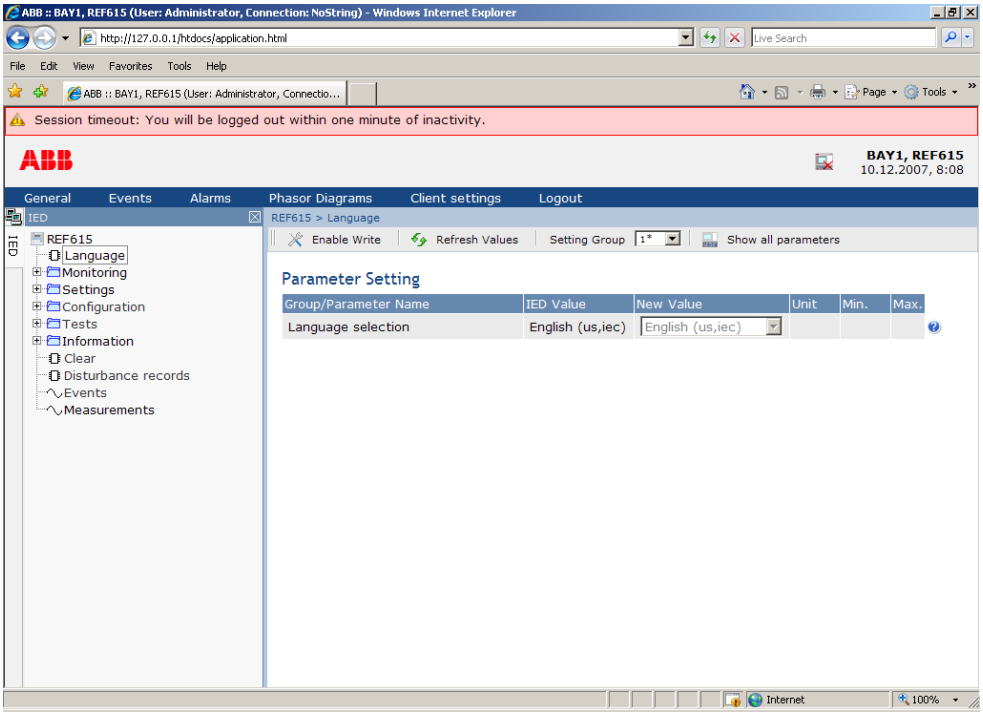


Figure 22: Session timeout

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

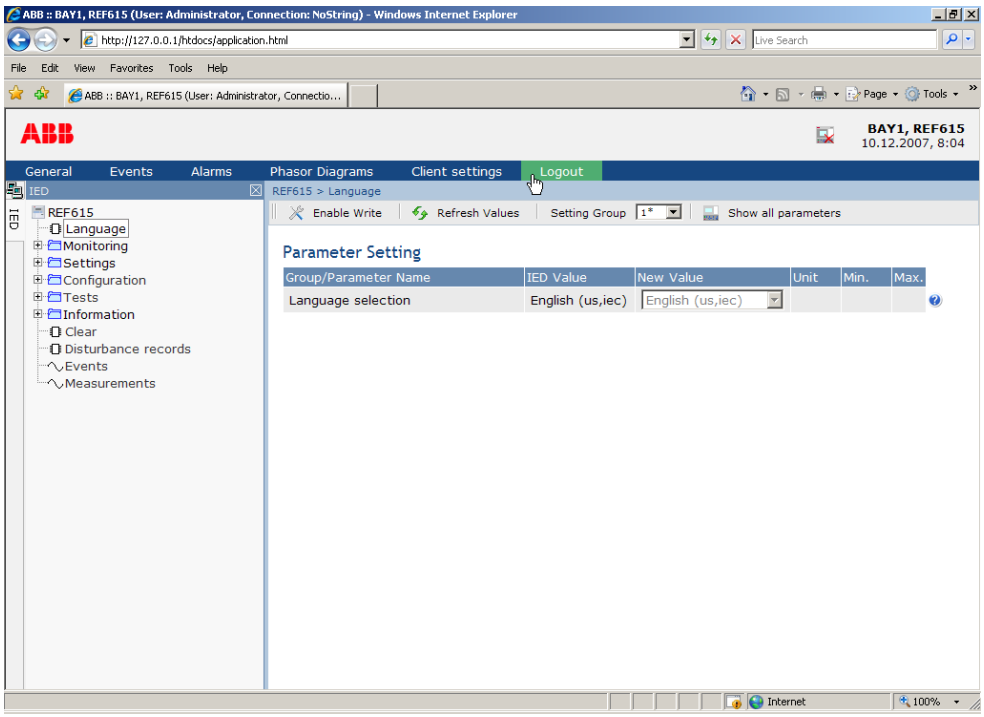


Figure 23: WHMI logout

4.2.3 Identifying the device

The IED information includes detailed information about the device, such as revision and serial number.

To view the device information:

1. Click **Information** in the WHMI menu structure.
2. Click asubmenu to see the data.

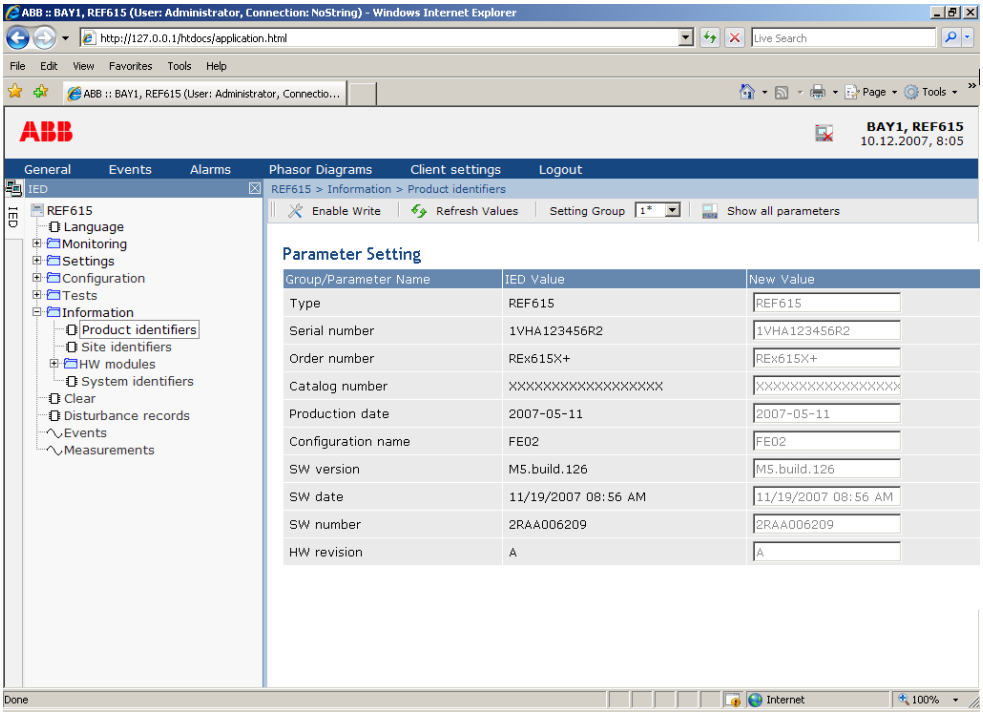


Figure 24: Device information

4.2.4 Navigating in the menu

The menu tree structure on the WHMI is identical to the one on the LHMI.

- Click the menu and submenu names to display the contents.

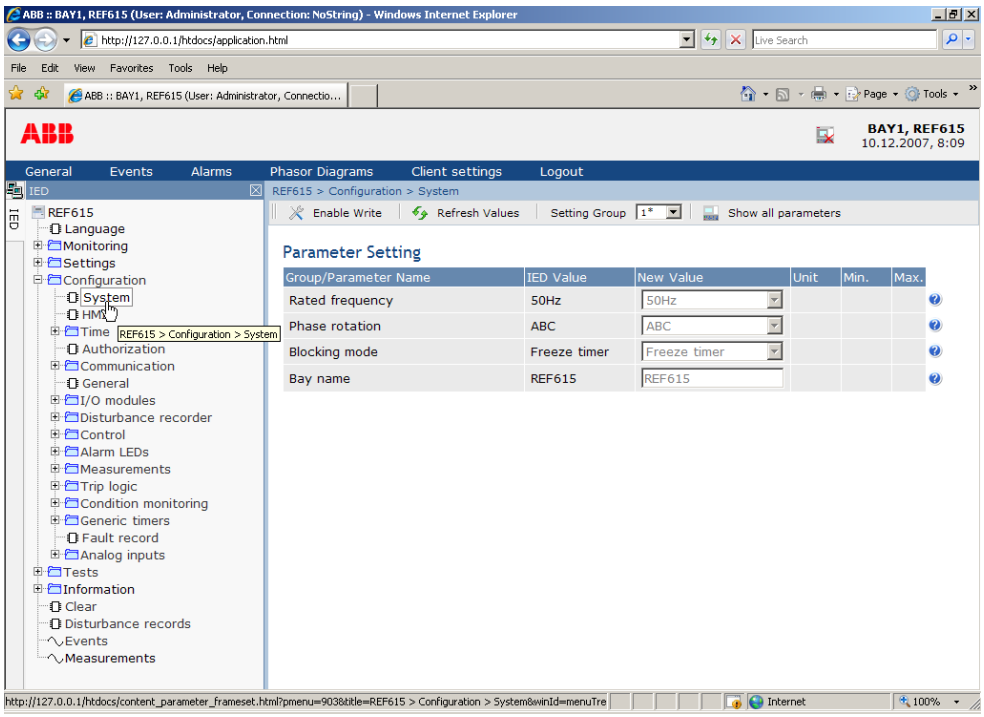


Figure 25: Navigating in the WHMI menus

4.2.4.1 Menu structure

The Main Menu contains the following main groups:

- Language
- Monitoring
- Settings
- Configuration
- Tests
- Information
- Clear
- Disturbance records
- Events
- Measurements

Main groups are divided further into more detailed submenus.

4.2.5 Showing all parameters

To view all parameters:

1. Select **Settings/Setting group**.
2. Click **Show all parameters**.

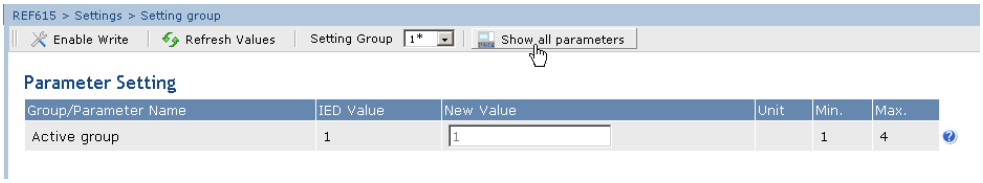


Figure 26: Show all parameters

3. Click **Print** to print out all parameters on paper.

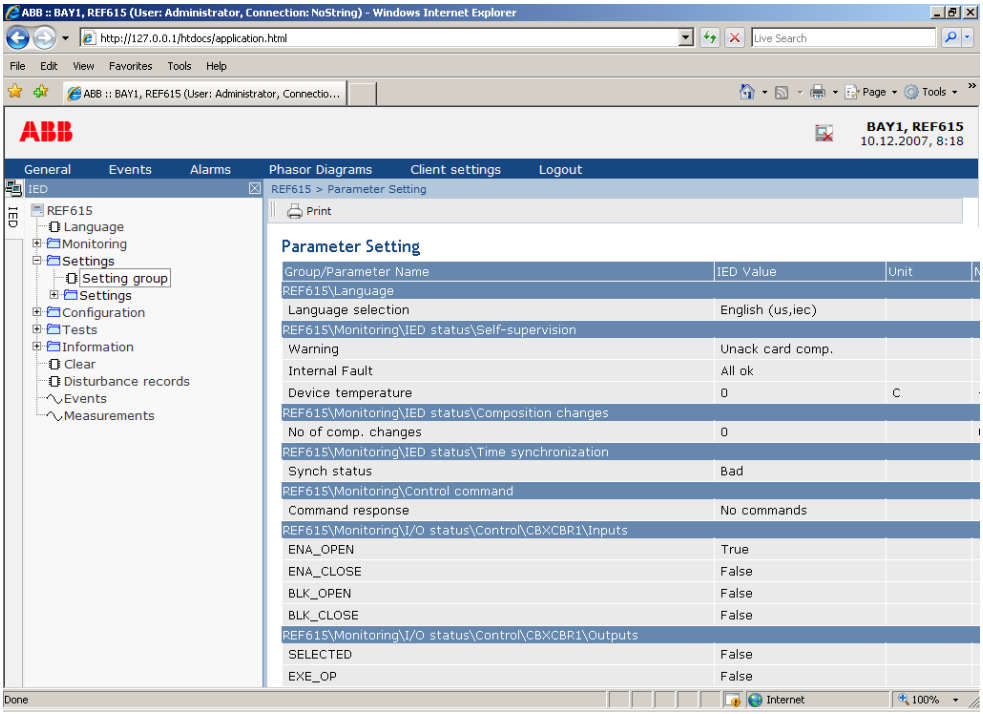


Figure 27: All parameters listed

4.2.6 Editing values

To edit values via the WHMI:

1. Click the menu in the WHMI tree.
2. Click the submenu to see function blocks.
3. Click a function block to see the setting values.
4. Click **Enable Write**.

Some parameters, for example the IED test mode, cannot be set via the WHMI.

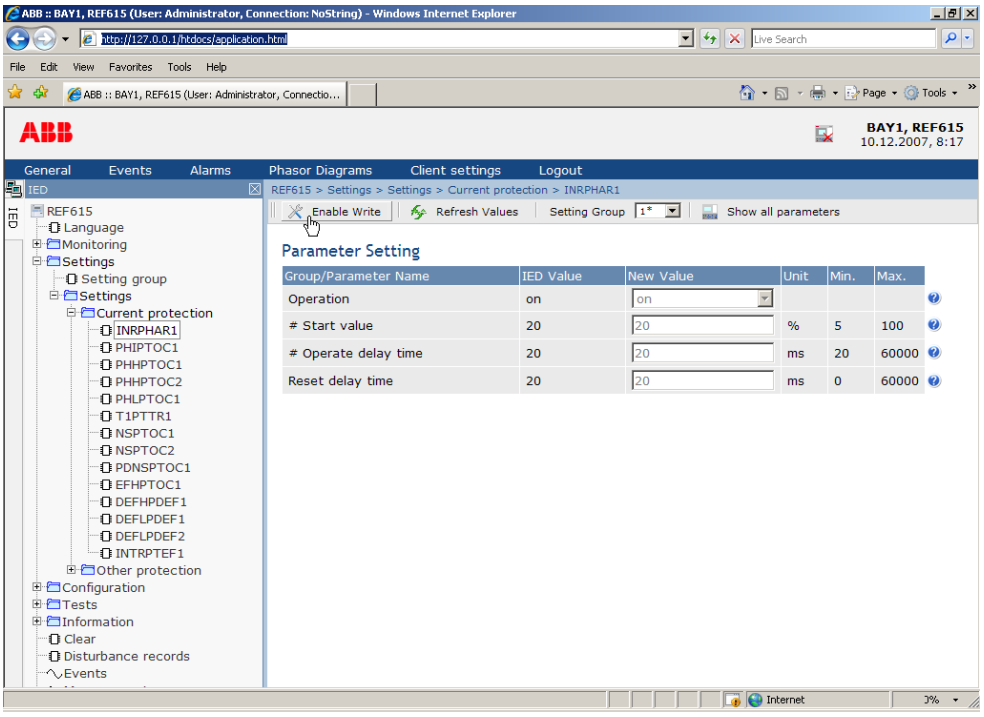


Figure 28: Enable writing to edit a value

The active setting group is shown in the Setting Group drop-down box. The active setting group is indicated with an asterisk *.

5. Edit the value.
   - The minimum and maximum values for a parameter are shown in the Min. and Max. columns.
   - Setting group values are indicated with #.

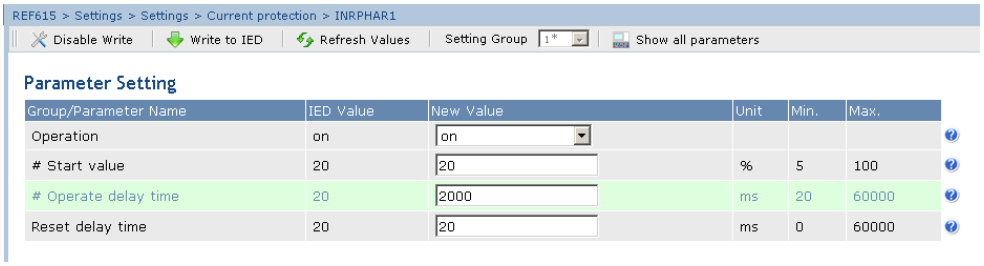


Figure 29: Editing value

- 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 appears.

Figure 30: Warning indicating that the entered value is incorrect

4.2.7 Committing settings

Editable values are stored either in RAM or in non-volatile flash memory. Values stored in flash memory are in effect also after 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.

To store changes into non-volatile memory:

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

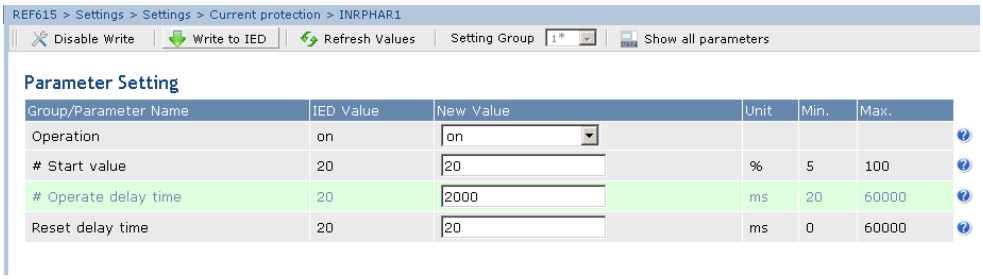


Figure 31: Writing values to IED

   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 you reboot the IED. However, the edited

value is not stored in non-volatile memory and thus the reboot restores the original value.

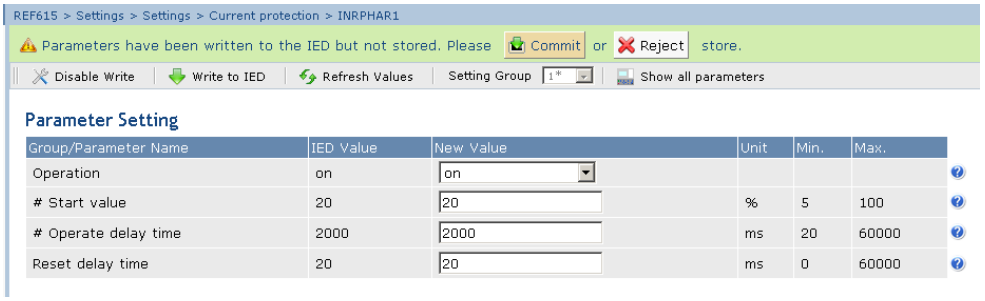


Figure 32: Committing changes

Committing values will take a few seconds.

If you only write values to the IED and then reboot, the old values will resume in the IED as active values and the new values are lost.

4.2.8 Clearing and acknowledging

You can reset, acknowledge or clear all messages and indications, including LEDs and latched outputs as well as registers and recordings, in the Clear menu.

To clear, reset or acknowledge messages and indications:

1. Click the **Clear** menu.

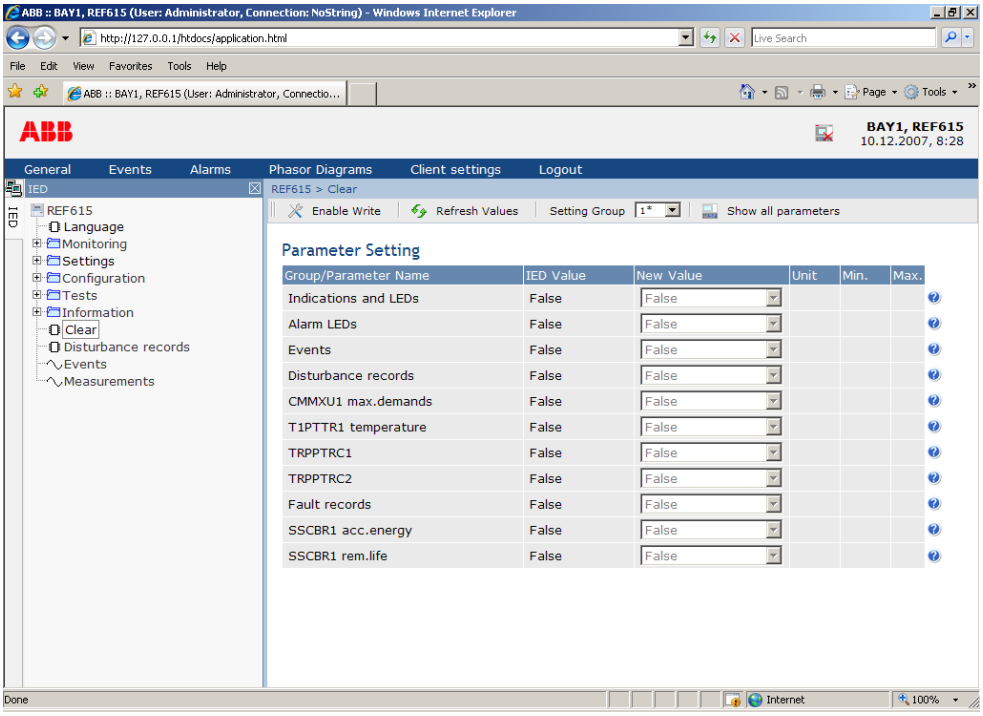


Figure 33: Selecting clear menu

2. Click **Enable write**.
3. In the **New Value** box, click **True** to select the item to be cleared.
4. Click **Write to IED**.
5. Click **Disable IED**.

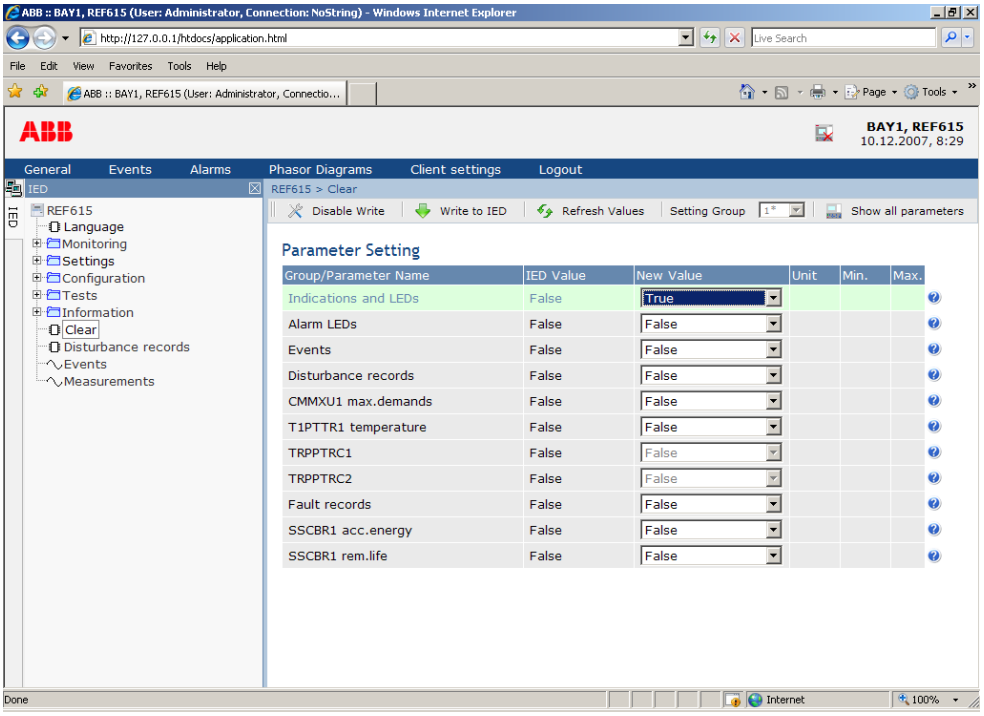


Figure 34: Clearing indications and LEDs

4.2.9 Selecting alarm view

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

To monitor the alarms:

- Click **Alarms** in the menu bar.

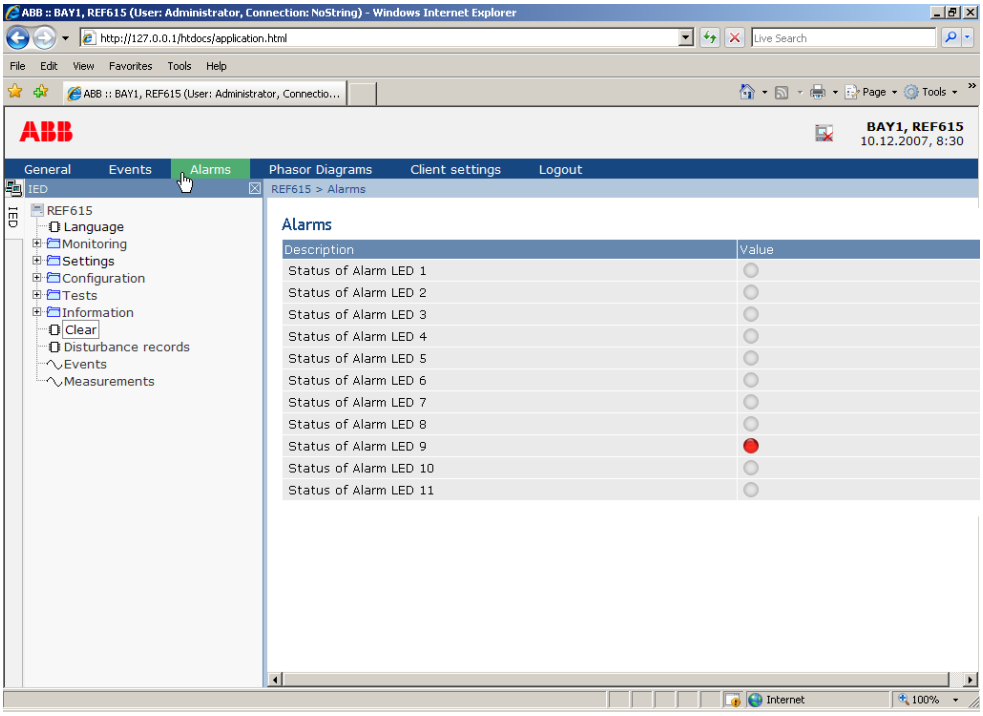


Figure 35: Monitoring alarms

4.2.10 Selecting event view

The event view contains a list of events produced by the application configuration.

To monitor the events:

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

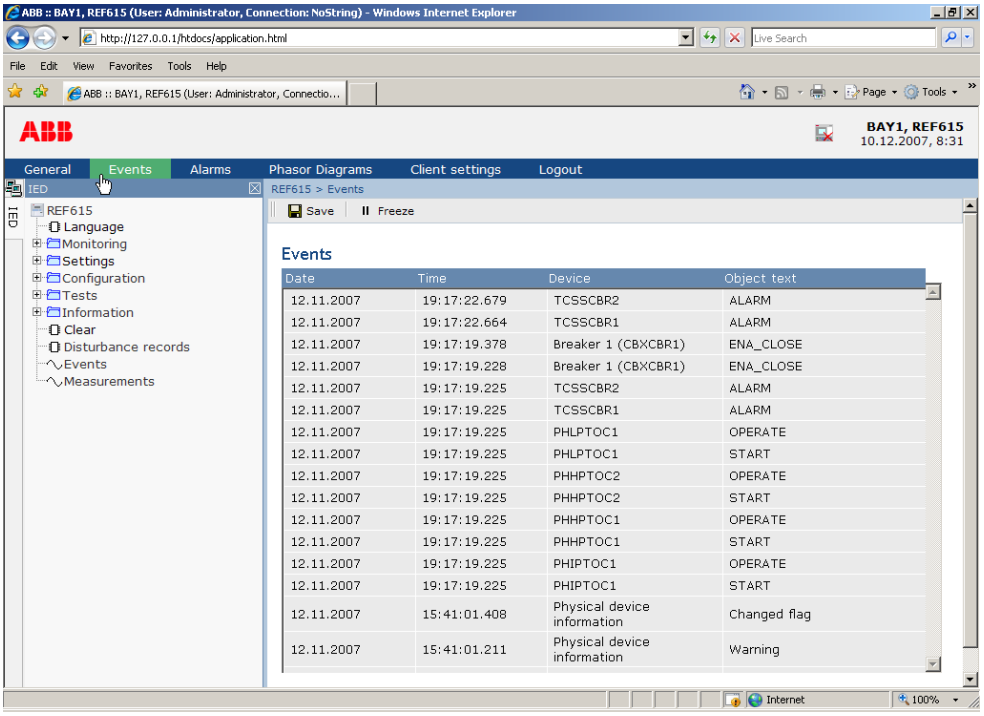


Figure 36: Monitoring events

2. Click **Freeze** to stop updating the event list.
   No new events will appear in the event list.
3. Click **Save** to save the events in CSV file format.
   The CSV file can be opened with a spreadsheet program such as OpenOffice.org Calc or Microsoft Excel.

4.2.11 Selecting phasor diagrams

To view phasor diagrams:

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

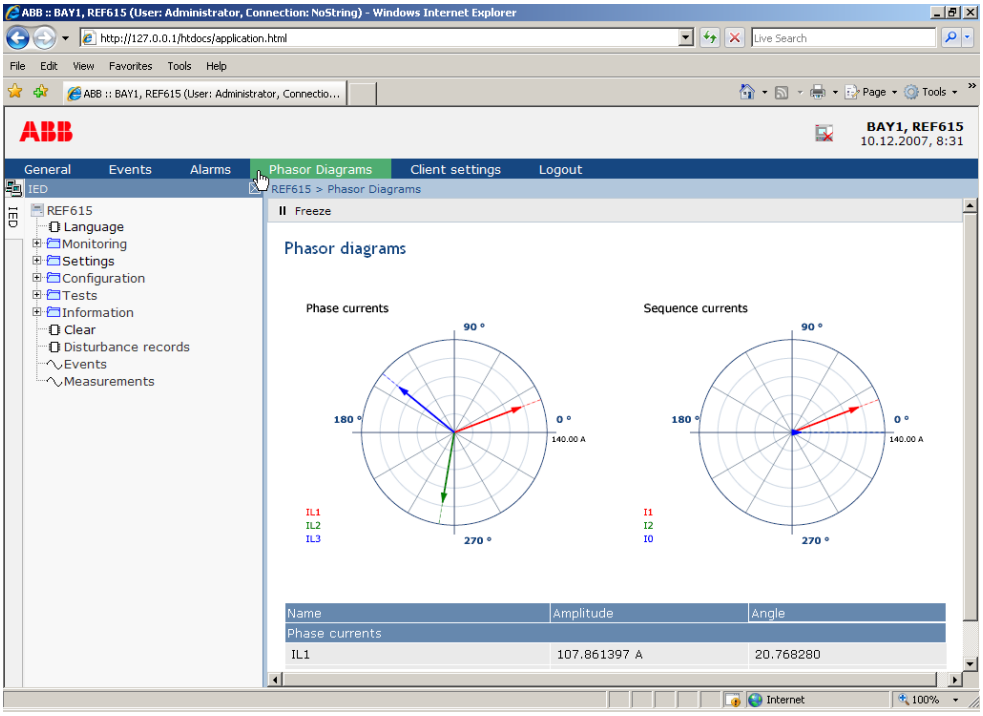


Figure 37: Normal case with symmetrical phase currents

2. Click **Freeze** to stop updating the phasor diagram.
No updates will appear in the diagram.

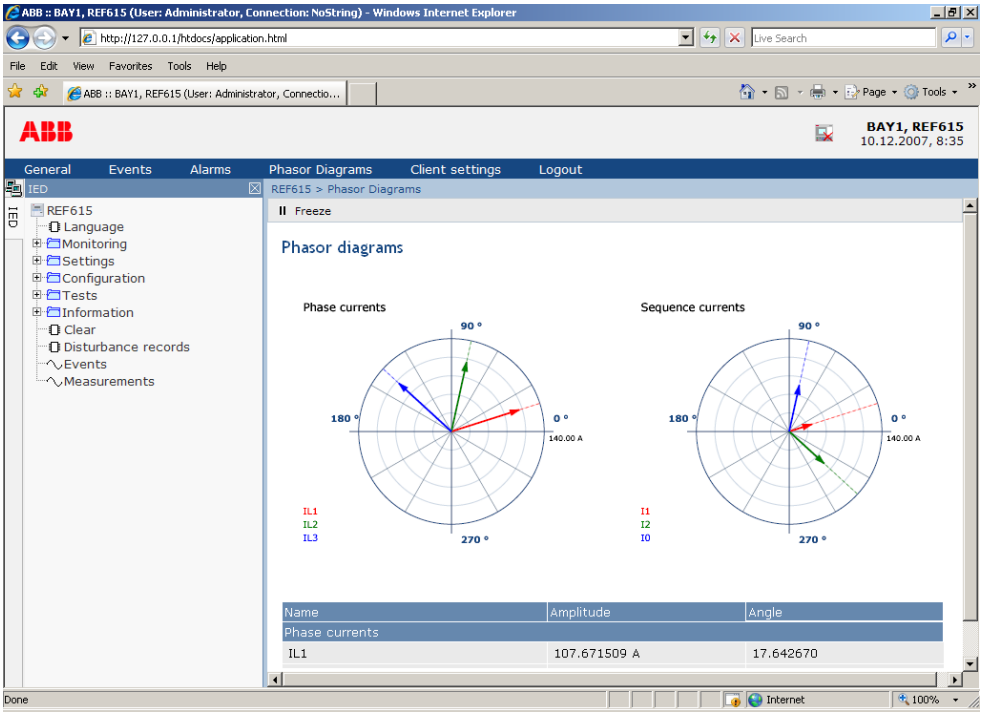


Figure 38: Typical commissioning situation with reversed CT IL2 polarity

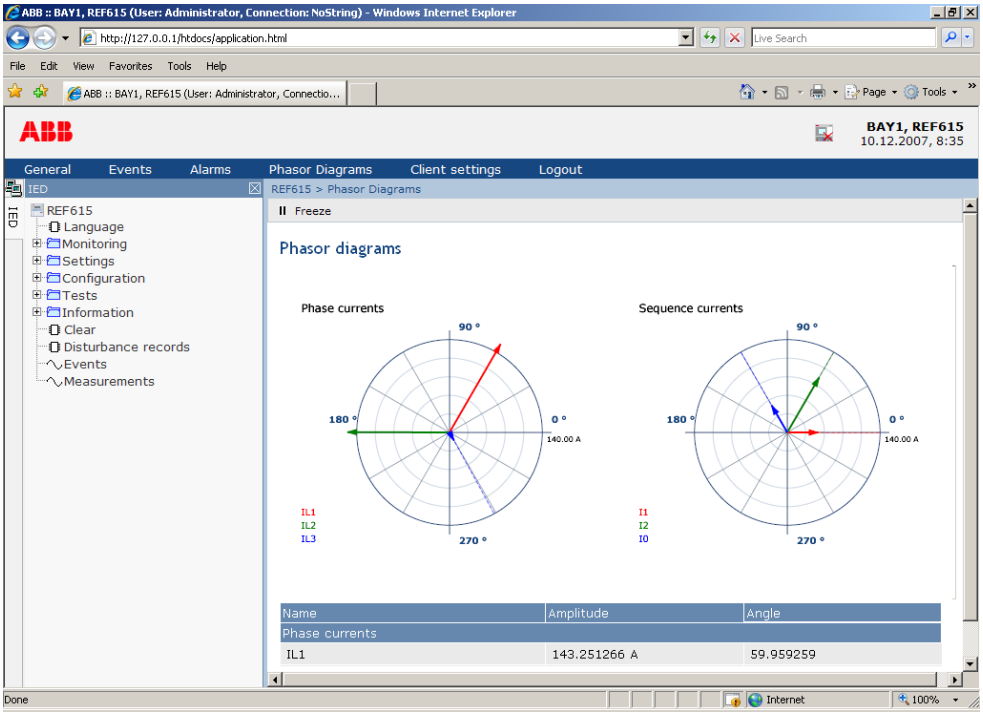


Figure 39: The arrow extends outside the circle if the current value is too high and if the current value is too low, the arrow is continued with a dotted line to better show where it points

4.2.12 Using WHMI help

With the WHMI help you can get information from, for example, a single parameter.

To open the context sensitive help:

1. Click .
   The help dialog box is displayed.

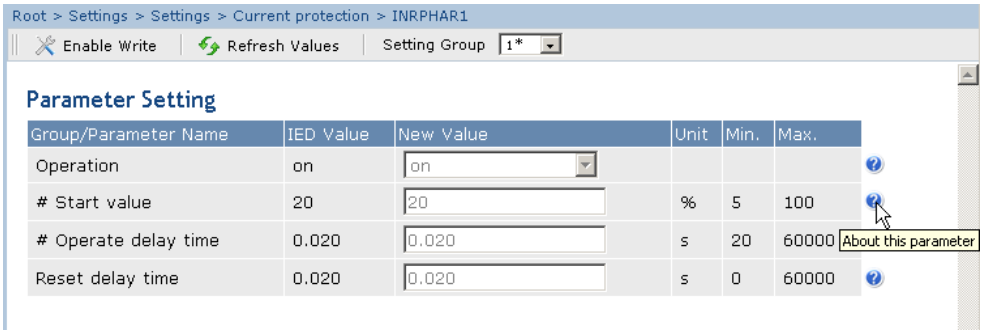


Figure 40: Clicking the help button

2. To close the help dialog box, click **OK**.

Section 5 IED operation

5.1 Operation in normal case

The basic operation procedures in normal IED use situation are:

- Monitoring of measured values
- Checking the function setting parameters
- Checking the test data

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

For more information, refer to PCM600 documentation.

5.1.1 Function settings

To check the correct operation of the IED, check the function settings via the LHMI, WHMI or PCM600.

5.1.2 Test data

The IED's functions can be tested to ensure correct operation. After a specific test, you can analyze the results.

5.2 Disturbance case operation

The IED is designed to identify and indicate several types of disturbances. The main purpose of a protective IED is to identify power system disturbances and operate according to the disturbance to avoid damage for power system equipment and people. In other words, to disconnect the disturbance from the healthy network.

Many disturbance origins are permanent and cannot be automatically cleared. The IED then collects disturbance data for later analysis.

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

Some disturbances can be IED related, for example, external damage to hardware. The IED supervises internal faults and indicates them to ensure that the user can take the right corrective actions. Disturbance data can be read, managed and analyzed with PCM600.

For more information, refer to PCM600 documentation.

5.2.1 Disturbance case identification

Disturbances and their causes can be identified on the basis of indicator LEDs: Ready, Start and Trip. In normal operation case the Ready LED is steady green.

Table 14: Disturbance indications

LED	State	Description
Start LED	Yellow, steady	Protection started
Start LED	Yellow, blinking	Protection function blocked.
Trip LED	Red, steady	Protections operated
Ready LED	Green, blinking	Internal faults

Further actions to be taken to identify the disturbance:

- Analyzing disturbance recordings
- Monitoring recorded data
- Reading internal events
- Finding available functions

5.2.2 Operation in tripping case

If a protection function trip is not cleared automatically, the cause of fault should be checked to identify needs for further actions.

Document the tripping case before clearing the information from the IED.

5.2.3 Internal IED errors

The IED monitors internal software and hardware errors. Internal error information is collected to the IED for later analysis. The main indication of an internal fault is a blinking green Ready LED.

Errors can be caused by external or internal events damaging the IED. Internal supervision functionality monitors different types of internal errors. These can be divided to hardware errors, runtime errors in application or operating system and communication errors. Further actions always depend on the cause of the errors.

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

Internal IED errors may be caused by:

- Hardware errors
- Runtime errors
- Communication errors

The IED records:

- IED self-supervision report
- Event list
- System registrations

Document all the recorded data from the IED before you reset the tripping and IED lockout functions.

5.2.4 Disturbance recording triggering

Disturbance recordings are normally triggered by IED applications when they detect fault events. Disturbance recordings can also be triggered manually or periodically.

5.2.5 Disturbance record analyzation

The IED 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 uploaded and analyzed, for example, with PCM600.

For more information, refer to PCM600 documentation.

5.2.6 Disturbance reports

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

For more information, refer to PCM600 documentation.

5.3 Fault determination

Sometimes the cause of an application fault can be determined via the LHMI. Usually, this is not enough and a more detailed analysis of the application configuration is needed. This can be done with PCM600.

5.3.1 Application problem verification

The faulty operation of application functions is usually related to wrong configuration or incorrect wiring of the external voltage and currents or binary inputs.

5.4 IED parametrization

IED parameters are usually set with a parameter setting tool but it can also be done via the LHMI.

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

For more information, refer to PCM600 documentation.

5.4.1 IED settings for IED functionality

Function settings can be edited one by one by navigating to the individual setting values, for example via the LHMI. The values in other setting groups should be known before editing a certain setting value.

After completing the editing of setting group values, the new values are activated. The user can either commit the edited values or discard them. Setting values can also be copied from one setting group to another.

5.4.2 IED settings for different operating conditions

IED settings can be designed for various operation conditions by defining different setting values to different setting groups. The active setting group can be changed by the IED application or manually via the LHMI.

Section 6 Operating procedures

6.1 Monitoring

6.1.1 Indications

The operation of the IED can be monitored via three different indications on the LHMI:

- Three indicator LEDs with fixed functionality: Ready, Start and Trip
- 11 programmable indicator LEDs
- A text message on the display

6.1.1.1 Monitoring indication messages

Indication messages and tripping data are shown in a dialog box.

To monitor indication messages:

1. Read the indication message in the dialog box.
   The message can indicate the starting or tripping of protection functions or an internal fault in the device.
2. Press ESC to close the indication message without clearing it or press Clear to activate the Clear view and to clear messages.

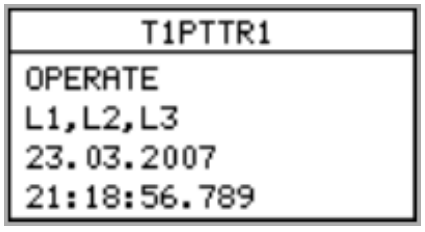


Figure 41: Indication message

6.1.1.2 Monitoring internal IED fault

The blinking green LED indicates an internal IED fault. Internal IED fault messages are shown in a dialog box.

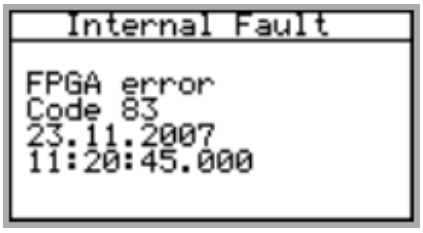


Figure 42: Fault indication

To monitor the latest fault indication:

1. Select **Main Menu/Monitoring/IED status/Self-supervision**.
2. Press ↑ or ↓ to scroll the view.

All internal IED fault messages are collected in `C:\userlog.txt`. The log file can be uploaded and viewed by the user. The timestamp of the fault is included in the log file.

6.1.1.3 Monitoring condition monitoring data

To access condition monitoring related data:

1. Select **Main Menu/Monitoring/I/O status/Condition monitoring**.
2. Press ↑ or ↓ to scroll the view.

With PCM600 the user can map output signals from condition monitoring related function blocks to the appropriate destinations.

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 also demand values calculated from set period.

6.1.2.1 Measured values

Measured values can be accessed through the LHMI or WHMI.

Table 15: Measured values

Indicator	Description
IL1	Current measured on phase L1
IL2	Current measured on phase L2
IL3	Current measured on phase L3
IL1-dem	Current demand value on phase L1
Table continued on next page	

Indicator	Description
IL2-dem	Current demand value on phase L2
IL3-dem	Current demand value on phase L3
I_0	Measured earth-fault current
Ng-Seq	Negative phase sequence
Ps-Seq	Positive phase sequence
Zro-Seq	Zero phase sequence
U_0	Measured residual voltage

6.1.2.2 Using LHMI for monitoring

To monitor measured and calculated values:

1. Select **Main Menu/Measurements**.
   The list of IED's basic measurements is shown.
2. Scroll the view with and .

6.1.3 Recorded data

The IED is provided with intelligent and flexible functionality which collects different kinds of data, for example, in case of fault event. The data gives substantial information for the post fault analysis. These data include:

- Disturbance records
- Fault records
- Events

6.1.3.1 Creating disturbance recordings

Normally disturbance recordings are triggered by the IED applications.

To trigger a disturbance recording manually:

1. Select **Main Menu/Disturbance records**.
2. Select **Trig recording** with or .
3. Press , change the value from `False` to `True` with or and press again. The disturbance recorder is now triggered.

Figure 43: Changing the value

6.1.3.2 Monitoring disturbance recorder data

Individual disturbance recordings must be uploaded from the IED with appropriate software such as PCM600 to monitor disturbance recorder data. All disturbance recordings can be found from the `C:\COMTRADE` directory.

To monitor the state of the disturbance recorder via the LHMI:

1. Select **Main Menu/Disturbance records**.
2. All the disturbance recorder information is listed. To view the following items, scroll the list with ↑ or ↓:
   - Number of recordings currently in IED memory
   - Remaining amount of recordings that can fit into the available recording memory
   - Recording memory used in percentage value
   - If the periodic triggering functionality is used, the time to trigger which indicates the remaining time to next periodic triggering of the disturbance recorder.

Figure 44: Monitoring disturbance recorder via the LHMI

6.1.3.3 Controlling and uploading disturbance recorder data

Disturbance recorder data can be controlled and read with PCM600.

For more information, refer to PCM600 documentation.

6.1.3.4 Monitoring event recorder data

To monitor event recorder data:

1. Select **Main Menu/Monitoring/Recorded data**.
2. To navigate between the fault records, press  and  .
3. To enter or exit a submenu, press  or  .

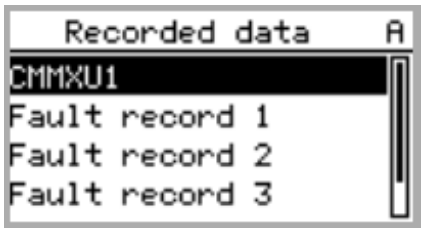


Figure 45: Monitoring event recorder data

6.1.3.5 Monitoring events

Event view contains a list of events produced by the application configuration. Each event takes one view area. The header area shows the currently viewed event index and the total amount of the events. The most recent event is always first.

To monitor events:

1. Select **Main Menu/Events**.
2. Press  to view the first event.
   Date, time, device description, object description and event text elements of the event are shown.
3. Press  or  to scroll the view.

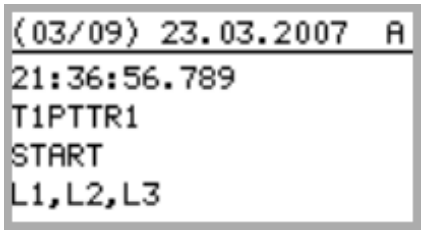


Figure 46: Monitoring events

6.1.4 Remote monitoring

The IED supports comprehensive remote monitoring.

6.1.4.1 Operating IED remotely

With the PCM600 tool you can:

- Read maintenance record and version log
- Analyze disturbance record data
- Create disturbance record
- Read IED values.

For more information, refer to PCM600 documentation.

6.2 Controlling

6.2.1 Controlling circuit breakers and disconnectors

The primary equipment can be controlled via the LHMI with the Open and Close buttons when the IED is set to local control mode and you are authorized to access control operations.

As a default, breaker 1 is always the first to be controlled. If other controllable objects are available, the user can select them in the control menu:

1. Press O to open or I to close the object.

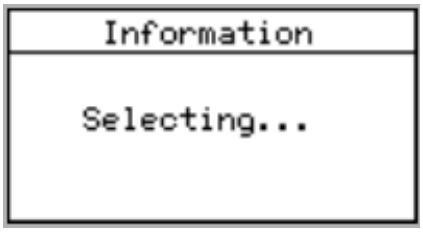


Figure 47: Selecting object

2. To confirm the operation, select Yes and press ↵.

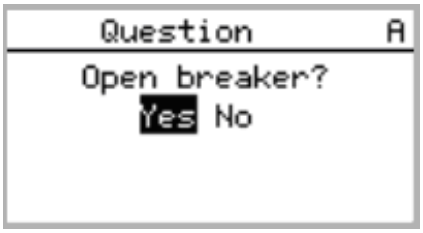


Figure 48: Opening circuit breaker

- To cancel the operation, select No and press .

Figure 49: Cancelling operation

The time between selecting the object and giving a control command is restricted by an adjustable timeout. When an object is selected, the control command has to be given within this time.

6.3 Resetting IED

6.3.1 Clearing and acknowledging via LHMI

You can reset, acknowledge or clear all messages and indications, including LEDs and latched outputs as well as registers and recordings, with the Clear button. Pressing the Clear button activates a selection menu, where you can choose which clearance or reset function you want to make. You can also clear events and alarms assigned to alarm LEDs with the Clear button.

To clear, reset or acknowledge messages and indications:

1. Press Clear to activate the Clear view.
   All the items that can be cleared are shown:
   - Indications and LEDs
   - Alarm LEDs
   - Recorded data
   - Events
   - Disturbance records
   - Temperature functions
   - Trip lockout functions

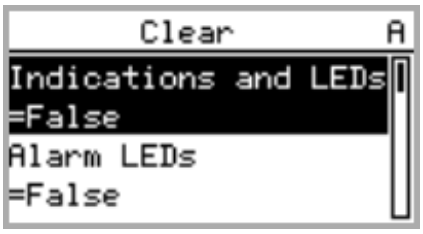


Figure 50: Clear view

2. Select the item to be cleared with ↑ or ↓.
3. Press ↵, change the value from `False` to `True` with ↑ or ↓ and press ↵ again. The item is now cleared and the value changes back to `False`.
4. Repeat steps 2 and 3 to clear other items.

6.4 Changing IED functionality

6.4.1 Creating blockings

PCM600 can be used for creating blockings.

For more information, refer to PCM600 documentation.

6.4.2 Selecting test mode

The test mode can be activated using the LHMI. The green Ready LED will be blinking to indicate that the test mode is activated.

To activate or deactivate the test mode:

1. Select **Main Menu/Tests/IED test/Test mode** and press ↵.

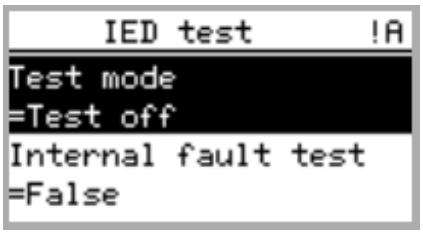


Figure 51: Entering test mode

2. Select `Test off` or `Test on` with ↑ or ↓.
3. Press ↵ to confirm the selection.

If you do not cancel the test mode, it remains on and the Ready LED remains blinking. Test mode does not retain if the IED is reset.

6.4.3 Connecting to trip and disturbance recorder functions

PCM600 can be used for connecting trip and disturbance recorder functions.

For more information, refer to PCM600 documentation .

6.4.4 Defining channel settings

To monitor the settings for each channel of the disturbance recorder:

1. Select **Main Menu/Configuration/Disturbance recorder/Channel settings**.
2. Press or to scroll the view.
3. To change channel settings, press .

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

6.4.5 Defining setting group

6.4.5.1 Activating a setting group

IED settings are planned in advance for different operation conditions by calculating setting values to different setting groups. The active setting group can be changed by the IED application or manually from the menu.

To change the active setting group via the LHMI:

1. Select **Main Menu/Settings/Setting group/Active group** and press .

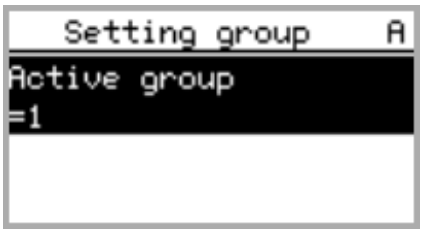


Figure 52: Active setting group

2. Select the setting group with ↑ or ↓.
3. Press ↵ to confirm the selection or ESC to cancel.

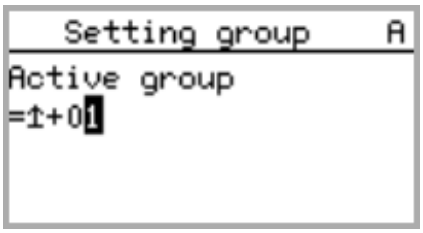


Figure 53: Selecting active setting group

4. Commit the settings.

Remember to document the changes you make.

6.4.5.2 Selecting a setting group for editing

To select a setting group:

1. Select **Main Menu/Settings/Edit setting group**.
2. Select the setting group to be edited with ↑ or ↓.
3. Press ↵ to confirm the selection.
4. Edit the settings.

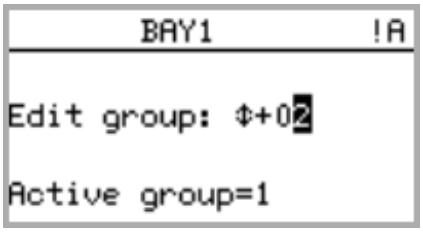


Figure 54: Selecting a setting group

6.4.5.3 Browsing and editing setting group values

To browse setting group values:

1. Select **Main Menu/Settings/Settings** and press →.
2. Select the setting group to be viewed with ↑ or ↓ and press ↵ to confirm the selection.

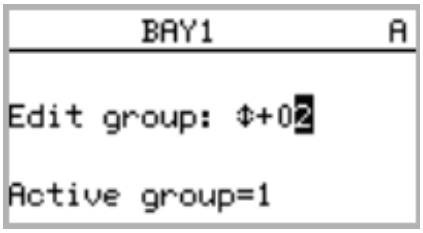


Figure 55: Selecting setting group

3. To browse the settings, scroll the list with ↑ and ↓ and to select a setting press →.
4. To browse different function blocks, scroll the list with ↑ and ↓ and to select a function block press →. To move back to the list, press ←.
   The function block list is shown in the content area of the display. On the left in the header, you see the current setting group, and on the right the menu path.
5. To browse the parameters, scroll the list with ↑ and ↓ and to select a parameter, press →.
   The setting group values are indicated with #.

Figure 56: Setting group parameter

6. To select a setting group value, press → and to edit the value press ↵.

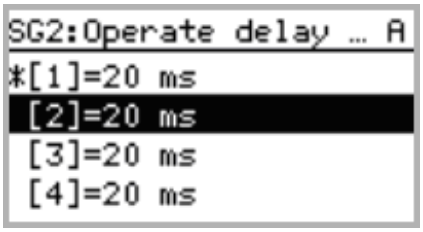


Figure 57: Selecting setting group value

Only values within the selected setting group can be changed.

7. Press ↑ or ↓ to change the value and ↵ to confirm the selection.

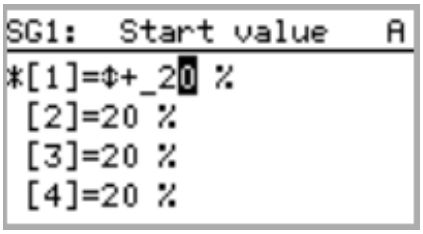


Figure 58: Editing setting group value

The active setting group is indicated with an asterisk * .

6.4.6 Activating LEDs

To change the Alarm LED mode:

1. Select **Main Menu/Configuration/Alarm LEDs** and press →.
2. Select an Alarm LED with ↑ or ↓.
3. Press ↵ to confirm the selection and to change the Alarm LED mode.
4. Press ↑ or ↓ to change the value and enter to confirm the selection.

For more information, refer to PCM600 documentation.

Section 7 Troubleshooting

7.1 Fault tracing

7.1.1 Identifying hardware errors

Most hardware errors are caused by external events which physically damage the IED's hardware. Probable causes are, for example, overvoltage, spikes and short circuits which damage one or several of IED's physical inputs or outputs. Human errors can also cause damage during installation or operation. As a consequence, one or several physical cards, inputs or outputs may stop operating due to the damage.

To identify hardware errors:

1. Check the module with error.
   You can check the IED supervision events in **Main Menu/Monitoring/IED status/Self-supervision** for the hardware module with error.
2. Incpest the IED visually
   - Inspect the IED visually to find the 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 IED 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

Runtime errors may be caused by component failures or software problems. Application errors are sometimes caused by measurement data flow problems like missing samples from measurement data stream.

Some errors are cleared automatically but sometimes, for example in case of a component failure, proper corrective actions are needed.

To identify runtime errors:

1. Check the error origin from IED's supervision events **Main Menu/ Monitoring/IED status/Self-supervision**.
2. Reboot the IED 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.

To identify communication errors:

1. Check the operation of the communication link.
2. Check the time synchronization. On the LHMI, this can be done by navigating from **Main Menu/Monitoring/IED status/Time synchronization**.
3. In case of persistent faults originating from IED's internal faults such as component breakdown, contact ABB for repair or replacement actions.

7.1.4 Checking communication LEDs

There are two LEDs on the LHMI above the RJ-45 communication port.

- To verify communication, check that both LEDs are lit.

Table 16: Communication LEDs

LED	Communication ok
Uplink	Steady green light
Communication	Blinking yellow light

7.1.5 Running the display test

A short display test is always run, when auxiliary voltage is connected to the device. You can also run the display test manually:

- Press simultaneously ESC and .

The LEDs are tested by turning them on simultaneously. The LCD shows a set of patterns so that all the pixels are activated. After the test, the display returns to normal state.

7.2 Indication messages

7.2.1 Internal faults

Internal fault indications have the highest priority on the LHMI. None of the other LHMI indications can override the internal fault indication.

An indication about the fault is also shown as a message on the LHMI. The text `Internal Fault` with an additional text message, a code, date and time, is shown to indicate the fault type.

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

The internal fault code indicates the type of internal IED fault. When a fault appears, document the code and state it when ordering the service.

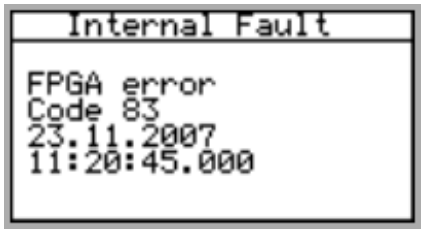


Figure 59: Fault indication

Table 17: 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.
Table continued on next page		

Fault indication	Fault code	Additional information
Internal Fault SO-relay(s),X110	44	Faulty Signal Output relay(s) in card located in slot X110.
Internal Fault SO-relay(s),X130	46	Faulty Signal Output relay(s) in card located in slot X130.
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.
Internal Fault PO-relay(s),X130	56	Faulty Power Output relay(s) in card located in slot X130.
Internal Fault Light sensor error	57	Faulty ARC light sensor input(s).
Internal Fault Conf. error,X000	62	Card in slot X000 is wrong type.
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.

7.2.2 Warnings

Further, a fault indication message, which includes text `Warning` with additional text, a code, date and time, is shown on the LHMI to indicate the fault type. If more than one type of fault occur at the same time, indication of the latest fault appears on the LCD. The fault indication message can be manually cleared.

When a fault appears, the fault indication message is to be recorded and stated when ordering service.

Figure 60: Warning

Table 18: 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 Modbus error	21	Error in the Modbus communication.
Warning DNP3 error	22	Error in the DNP3 communication.
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.
Warning GOOSE rec. error	32	Error in the GOOSE message receiving.
Warning AFL error	33	Analog channel configuration error.

Table continued on next page

Warning indication	Warning code	Additional information
Warning Unack card comp.	40	A new composition has not been acknowledged/accepted.
Warning ARC1 cont. light	85	A continuous light has been detected on the ARC light input 1.
Warning ARC2 cont. light	86	A continuous light has been detected on the ARC light input 2.
Warning ARC3 cont. light	87	A continuous light has been detected on the ARC light input 3.

7.2.3 LED and display messages

Usually when a LED is lit, an indication is shown on the LHMI and event 10 is generated.

7.3 Corrections procedures

7.3.1 Rebooting software

To reboot the software:

1. Select **Main Menu/Configuration/General** and press .
2. Change the value from `False` to `True` with or button and press .

7.3.2 Setting password

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

The password can be set to write mode with engineer or operator rights but the changes to the password are not saved.

To set a password via the LHMI:

1. Select **Main Menu/Configuration/Authorization**.
2. Select the password to be reset with or .
3. Press , change the password with or and press again.
4. Repeat steps 2 and 3 to set the rest of the passwords.

7.3.3 Identifying IED application problems

To identify application problems:

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

7.3.3.1 Inspecting wiring

The physical inspection of wiring connections often reveals the wrong connection for phase currents or voltages. However, even though the phase current connections to IED terminals might be correct, wrong polarity of one or more measurement transformers can cause problems. To verify this problem:

1. Check the current or voltage measurements and their phase information from **Main Menu/Measurements/Load – primary values**.
2. Check that the phase information and phase shift between phases is correct.
3. Correct the wiring if needed.

7.3.3.2 Inspecting configuration connection

The user can sometimes make wrong connections for applications in the ACT. The user might, for example, connect a wrong binary input to an application function. Thus, the IED includes a software testing functionality to force any binary input to active or inactive state. To verify the problem:

1. Activate **Main Menu/Tests/IED test /Test mode**.
2. Activate **Main Menu/Tests/Binary inputs**.
3. Check the function operation from **Main Menu/Monitoring/I/O status/ Function output values**.
4. Check and correct the product configuration, if the input does not create the expected action.

7.3.3.3 Sample data interruptions

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

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

Section 8 Commissioning

8.1 Commissioning checklist

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

- Ensure that you have all the needed stations drawings such as single line and wiring diagrams.
- Ensure that your version of the technical reference manual applies to the IED version you test.
- Ensure that your setting software and connectivity packages work with the IED version you test.
- Find out if you need any additional software.
- Ensure that you have the IED 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 IED's communication port. The RJ-45 port supports any Cat 5Ethernet 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 connections 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.

8.2.2 Checking CT circuits

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

- Primary injection test to verify the current ratio of the CT, the correct wiring up to the protection IED and correct phase sequence connection (that is L1, L2, L3.)
- Polarity check to prove that the predicted direction of secondary current flow is correct for a given direction of primary current flow. This is an essential test for the proper operation of the directional function, protection or measurement in the IED.
- 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 IED. 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 IED.
- Check the earthing 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.

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

If the CT secondary circuit earth connection is removed without the current transformer primary being de-energized, dangerous voltages may result in the secondary CT circuits.

8.2.3 Checking VT circuits

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

Do not continue before any errors are corrected.

Test the circuitry. The following tests are recommended:

- 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 check should be performed as close as possible to the IED.

The primary injection test verifies the VT ratio and the wiring all the way through from the primary system to the IED. 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 Binary input circuits

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

8.2.4.2 Binary output circuits

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

8.3 Authorizations

8.3.1 User authorization

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

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

Table 19: Predefined user categories

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

For user authorization for PCM600, refer to PCM600 documentation.

8.4 Using PCM600

8.4.1 Setting communication between IEDs and PCM600

The communication between the IED 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 communication media is always Ethernet and the protocol is TCP/IP.

Each IED 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 IED. 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 IED 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 IEDs.
2. Set up the PC for a direct link or connect the PC or workstation to the network.
3. Configure the IED IP addresses in the PCM600 project for each IED. The addresses are used for communication by the OPC interface of PCM600.

8.4.1.1 Communication options

Two options are available for the connection of PCM600 to the IED:

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

Point to point link

The IED is provided with an RJ-45 connector on the front panel. The connector is mainly for configuration and setting purposes. Any Ethernet cable can be used but the recommendation is STP.

The IED 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.

8.4.1.2 Setting communication parameters

The IP address and the corresponding mask can be set via the LHMI for the rear port. The front port uses a fixed IP address 192.168.0.254. The front port also uses DHCP.

Each Ethernet interface has a factory default IP address when the complete IED is delivered.

Setting front communication

To set up a standard PC with Microsoft Windows operating system for front communication:

1. To open Network Connections, click **Start**, point to **Settings**, click **Control Panel**, and then double-click **Network Connections**.
2. Double-click the connection that you want to configure, and then click **Properties**.
3. Select the TCP/IP protocol from the list of configured components using this connection and click **Properties**.

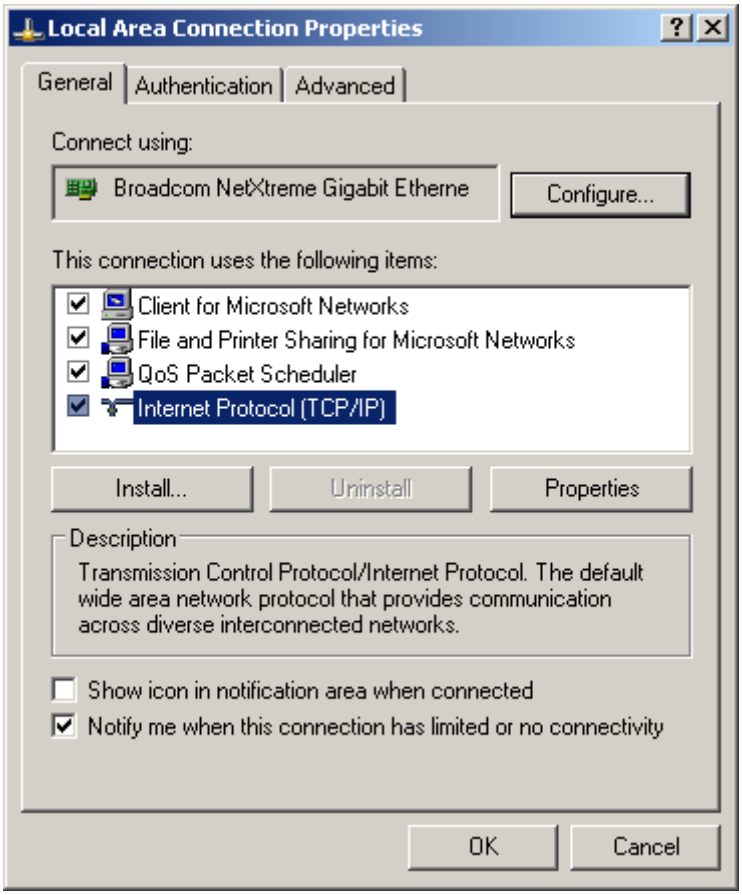


Figure 61: Selecting TCP/IP protocol

4. Select **Obtain an IP address automatically** and **Obtain DNS server address automatically**.

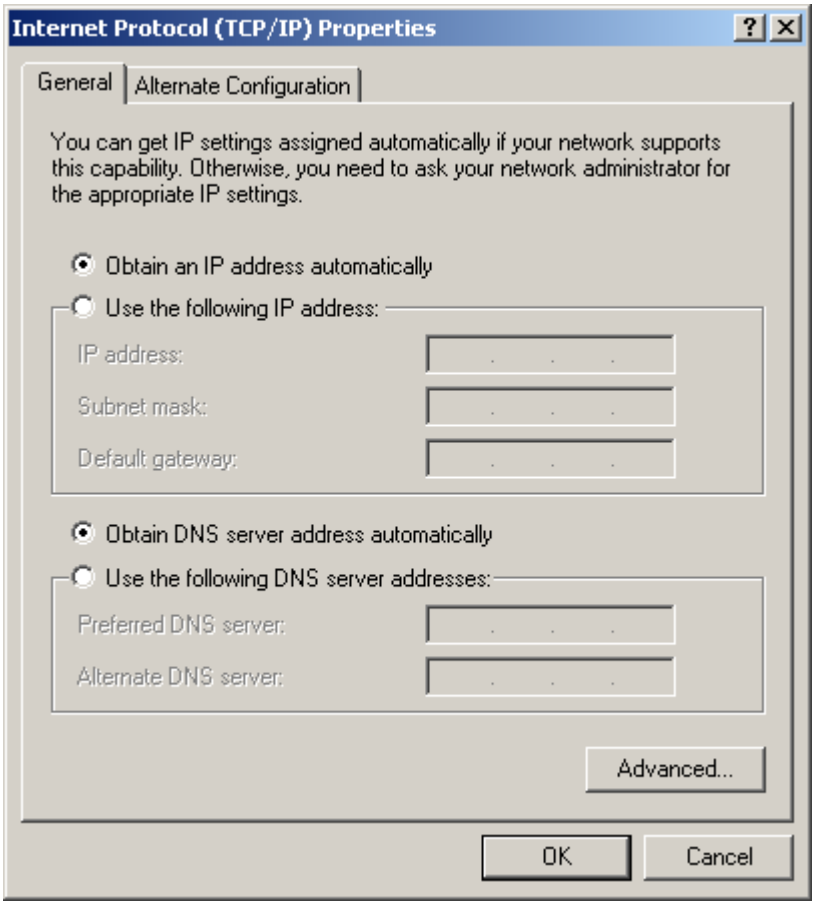


Figure 62: Obtaining IP address automatically

5. Close all open windows by clicking **OK** and start PCM600.

Administrator rights are requested to change the configuration as described above.

Setting rear communication

To set up a standard PC with MicroSoft Windows operating system for rear communication:

1. To open Network Connections, click **Start**, point to **Settings**, click **Control Panel**, and then double-click **Network Connections**.
2. Double-click the connection that you want to configure, and then click **Properties**.
3. Select the TCP/IP protocol from the list of configured components using this connection and click **Properties**.

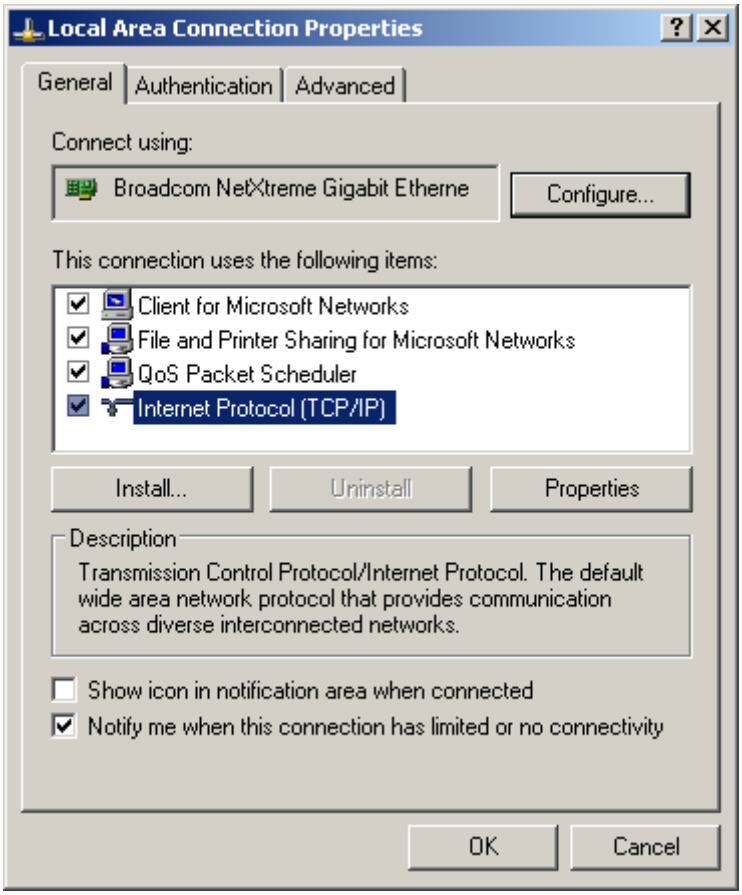


Figure 63: Selecting TCP/IP protocol

4. Choose **Use the following IP address**. Enter an IP address and a subnet mask. Make sure that the IP address is unique, that is not used by any other IED on the network.

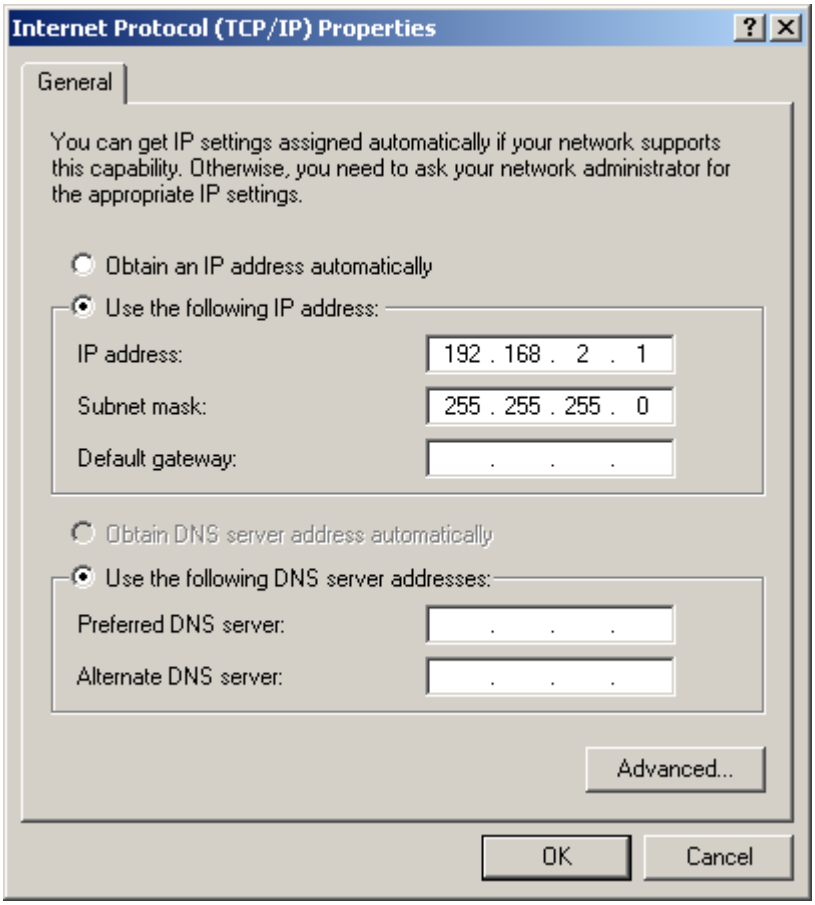


Figure 64: Setting IP address and subnet mask

5. Close all open windows by clicking **OK** and start PCM600.

Administrator rights are requested to change the configuration as described above.

Setting IED's IP address in PCM600

In PCM600 the IED's IP address can be defined either via the first window of the wizard by including a new IED in the project or by entering the IED's IP address in the Object Properties window.

To define the IP address via the Object Properties window:

1. Select the IED to which you want to define the IP address.
2. Open the Object Properties window.
3. Place the cursor in the IP Address row and enter the IP address.

The used method depends on the time at which the IP address is available. Defining IP address in the Object Properties windows allows changing the IP address at any time.

8.5 Setting IED and communication

8.5.1 Setting communication

The IED is provided with an RJ-45 connector on the front panel. The connector is mainly used for configuration and setting purposes. The fixed IP address for the front port is 192.168.0.254.

Different communication ports are available via optional communication modules. There are three options for rear port communication intended mainly for station level communication, that is station bus. The options are galvanic Ethernet (RJ-45), optical Ethernet (LC) and RS-485/RS-232 twisted pair. Communication protocols used via Ethernet ports are IEC 61850-8-1 and Modbus TCP/IP. Protocol available for RS-485/RS-232 serial port is Modbus RTU/Modbus ASCII.

You can set the following communication parameters:

- To define the settings for the Ethernet port, select **Main Menu/Configuration/Communication/Ethernet/Rear port**.
- To define the settings for RS-485/RS-232 serial port, select **Main Menu/Configuration/Communication/COM1** or **Main Menu/Configuration/Communication/COM2**.
- To define Modbus communication parameters, select **Main Menu/Configuration/Communication/Modbus**.

For more information, refer to the Modbus Protocol Manual and the Technical Manual.

8.5.2 Setting LHMI

8.5.2.1 Changing LHMI language

To change the LHMI language:

1. Select **Main Menu/Language** and press  .
2. Change the language with  or  .
3. Press  to confirm the selection.
4. Commit the changes.

Figure 65: Changing the LHMI language

You can change the language also by pressing simultaneously ESC and ←.

8.5.2.2 Adjusting display contrast

To obtain optimal readability, you can adjust the display contrast. The contrast can be adjusted anywhere in the menu structure.

- To increase the contrast, press simultaneously ESC and ↑.
- To decrease the contrast, press simultaneously ESC and ↓.

The selected contrast value is stored in the non-volatile memory. After an auxiliary power failure, the contrast is restored.

8.5.2.3 Changing display symbols

To switch between the display symbols IEC 61850, IEC and ANSI:

1. Select **Main Menu/Configuration/HMI/FB naming convention** and press ↵.
2. Change the display symbols with ↑ or ↓.
3. Press ↵ to confirm the selection.

The IED has to be rebooted if the WHMI display symbols are changed. With the LHMI, the change takes effect immediately.

8.5.2.4 Changing the default view

The default view of the display is the **Measurements** unless set otherwise.

To change the default view:

1. Select **Main Menu/Configuration/HMI/Default view** and press .
2. Change the default view with or .
3. Press to confirm the selection.

8.5.2.5 Setting system time and time synchronization

To edit the date and time and the time synchronization source:

1. Select **Main Menu/Configuration/Time/System time** and press .
2. Select the parameter with or .
3. Press , change the value with or and press again.
4. Repeat steps 2 and 3 to set the rest of the system time parameters.
5. Select **Main Menu/Configuration/Time/Synchronization/Synch source** and press .
6. Set the time synchronization source to `SNTP` or `Modbus` with or .
7. Press to confirm the selection.
   If SNTP is used, the SNTP server's IP address is set in **Main Menu/Configuration/Time/Synchronization/IP SNTP Primary** and **Main Menu/Configuration/Time/Synchronization/IP SNTP Secondary**.

8.5.3 Setting IED parameters

8.5.3.1 Defining setting groups

Selecting a setting group for editing

To select a setting group:

1. Select **Main Menu/Settings/Edit setting group**.
2. Select the setting group to be edited with or .
3. Press to confirm the selection.
4. Edit the settings.

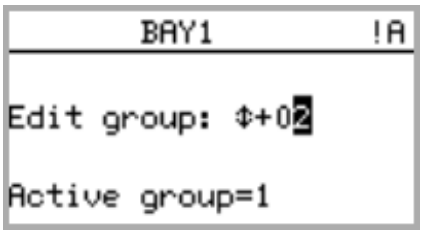


Figure 66: Selecting a setting group

Browsing and editing setting group values

To browse setting group values:

1. Select **Main Menu/Settings/Settings** and press →.
2. Select the setting group to be viewed with ↑ or ↓ and press ↵ to confirm the selection.

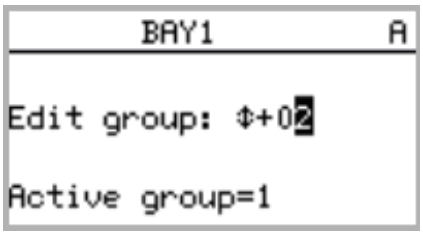


Figure 67: Selecting setting group

3. To browse the settings, scroll the list with ↑ and ↓ and to select a setting press →.
4. To browse different function blocks, scroll the list with ↑ and ↓ and to select a function block press →. To move back to the list, press ←.
   The function block list is shown in the content area of the display. On the left in the header, you see the current setting group, and on the right the menu path.
5. To browse the parameters, scroll the list with ↑ and ↓ and to select a parameter, press →.
   The setting group values are indicated with #.

Figure 68: Setting group parameter

6. To select a setting group value, press → and to edit the value press ↵.

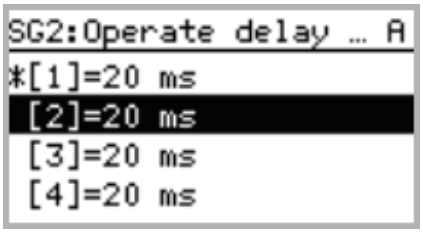


Figure 69: Selecting setting group value

   Only values within the selected setting group can be changed.
7. Press ↑ or ↓ to change the value and ↵ to confirm the selection.

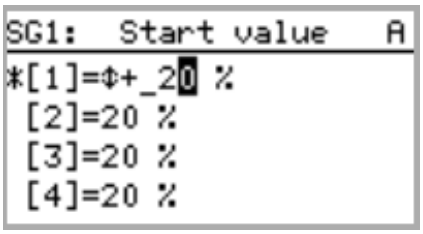


Figure 70: Editing setting group value

The active setting group is indicated with an asterisk * .

Activating a setting group

IED settings are planned in advance for different operation conditions by calculating setting values to different setting groups. The active setting group can be changed by the IED application or manually from the menu.

To change the active setting group via the LHMI:

1. Select **Main Menu/Settings/Setting group/Active group** and press .

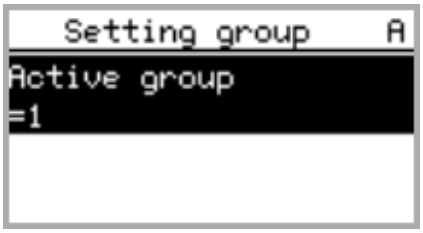


Figure 71: Active setting group

2. Select the setting group with or .
3. Press to confirm the selection or ESC to cancel.

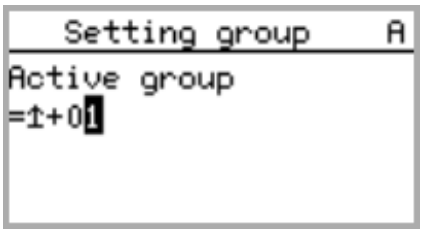


Figure 72: Selecting active setting group

4. Commit the settings.

Remember to document the changes you make.

8.5.3.2 IED parametrization

IED parameters are usually set with a parameter setting tool but it can also be done via the LHMI.

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

For more information, refer to PCM600 documentation.

8.5.3.3 Configuring analog inputs

To configure the CT and VT analog inputs:

1. Select **Main Menu/Configuration/Analog inputs** and press  .
2. Select the analog input to be configured with  or  .
3. Press  , change the value with  or  and press  again.
   - 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.

8.6 Testing IED operation

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

8.6.1 Selecting test mode

The test mode can be activated using the LHMI. The green Ready LED will be blinking to indicate that the test mode is activated.

To activate or deactivate the test mode:

1. Select **Main Menu/Tests/IED test/Test mode** and press  .

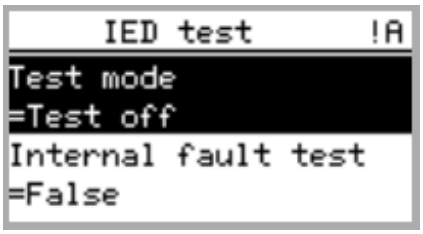


Figure 73: Entering test mode

2. Select `Test off` or `Test on` with ↑ or ↓.
3. Press ↵ to confirm the selection.

If you do not cancel the test mode, it remains on and the Ready LED remains blinking. Test mode does not retain if the IED is reset.

8.6.2 Testing digital I/O interface

To activate or deactivate, for example, a digital output:

1. Select **Main Menu/Tests/Binary Outputs/X100 (PSM)/X100-Output 1** and press ↵.
2. Select `False` or `True` with ↑ or ↓.
3. Press ↵ to confirm the selection.

If the optional BIO-module (X110) is included in the IED, the menu path could also be **Main Menu/Tests/Binary Outputs/X110 (BIO1)/<binary output>**.

8.6.3 Testing functions

To activate or deactivate an output signal for protection or other function:

1. Select **Main Menu/Tests/Function tests/Current protection/PHLPTOC** and press ↵.
2. Select the output signal to be activated or deactivated with ↑ or ↓ and press ↵.
3. To deactivate all output signals for the function, select `Reset` with ↑ or ↓ and press ↵.

8.6.4 Selecting internal fault test

The internal fault may be tested by using the LHMI. When enabling the test, the internal relay fault output contact is activated, the green Ready LED will be blinking and internal fault test indication is shown on the LHMI. Refer to Technical Manual for internal relay fault output contact location.

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.

To activate or deactivate internal fault test:

1. Select **Main Menu/Tests/IED test/Internal fault test** and press .

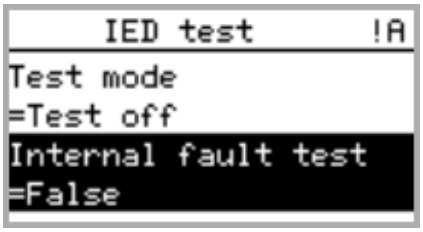


Figure 74: Internal fault test

2. Select `False` or `True` with or .
3. Press to confirm the selection.

8.7 Life cycle traceability

The LCT feature traces the IED's composition changes. If the IED's SW or HW is updated, the LCT feature traces the changes.

After a composition change, an indication is seen on the LHMI at the IED start-up. At this point, PCM600 should be connected to the IED as it reads the changed data from the IED. The LCT indication is cleared in the same way as other indications. If PCM600 is not connected to the IED, the indication is seen again after the IED's reboot.

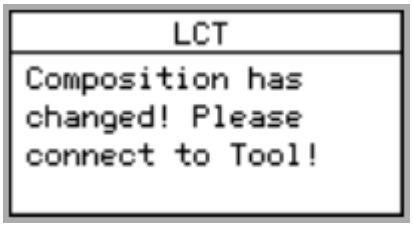


Figure 75: LCT indication

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 the physical media defined in the IEEE 802.3 Ethernet standard for local area networks (LANs). 100BASE-FX uses fiber optic cabling with ST/SC connectors.
100BASE-TX	A physical media defined in the IEEE 802.3 Ethernet standard for local area networks (LANs). 100BASE-TX uses twisted-pair cabling category 5 or higher with RJ-45 connectors.
ACT	Application Configuration Tool in PCM600.
ACT	Trip status
AI	Analog input
ANSI	American National Standards Institute
ASCII	American Standard Code for Information Interchange
BI	Binary input
BI/O	Binary input/output
COMTRADE	COMmon format for Transient Data Exchange for power systems. Defined by the IEEE Standard.
Connectivity Package Manager	Software that helps the user to define right connectivity package versions for different applications and tools.
CPU	Central Processing Unit
CSV	Comma separated values
CT	Current transformer
DHCP	Dynamic Host Control Protocol allows devices joining the network to dynamically receive an IP address from the DHCP server that contains a pool of IP addresses.
EEPROM	Electrically Erasable Programmable Read-Only Memory
Ethernet	A large, diverse family of frame-based computer networking technologies that operate at many speeds for LANs interconnecting computing devices. Ethernet is a trademark of Xerox Corporation, Inc. and defined in the IEEE 802.3 standard in which computers access the network through a CSMA/CD protocol.
FB	Function block.
Firmware	System software or hardware that has been written and stored in a device's memory that controls the device.

FPGA	Field Programmable Gate Array
GOOSE	Generic Object Oriented Substation Event
HMI	Human-machine interface
HW	Hardware
IEC	International Electrotechnical Commission
IEC 61850	International standard for substation communication and modelling.
IEC 61850-8-1	A communication protocol based on the IEC 61850 standard series and a standard for substation modelling.
IED	Intelligent Electronic Device
IP address	Internet protocol address is 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 a location for the TCP/IP protocol.
LAN	Local area network
LC	Connector type for glass fibre cable.
LCD	Liquid crystal display
LCT	Life cycle traceability
LED	Light-emitting diode
LHMI	Local Human-Machine Interface
Modbus	A serial communication protocol developed by the Modicon company in 1979. Originally used for communication in PLCs and RTU devices.
Modbus ASCII	Modbus link mode. Character length 10 bits.
Modbus RTU	Modbus link mode. Character length 11 bits.
Modbus TCP/IP	Modbus RTU protocol which uses TCP/IP and Ethernet to carry data between devices.
NCC	Network control center
OPC	OLE (object linking and embedding) for process control
PC	Personal Computer; Polycarbonate
PCM600	Protection and Control IED Manager
PO	Power output
R/L	Remote/Local
RAM	Random access memory
REF615	Feeder protection relay
RJ-45	Galvanic connector type.

RoHS	Restriction of the use of certain Hazardous Substances in electrical and electronic equipment.
ROM	Read Only Memory
RS-232	Serial interface standard.
RS-485	Serial link according to EIA standard RS485.
RTU	Remote Terminal Unit
SCADA	Supervision, control and data acquisition
SCL	Substation Configuration Language
SMT	Signal Matrix Tool
SNTP	Simple Network Time Protocol
SO	Signal output
STP	Shielded Twisted-Pair
SW	Software
TCP/IP	Transmission Control Protocol / Internet Protocol
TCS	Trip-circuit supervision
VT	Voltage transformer
WAN	Wide area network
WHMI	Web Human-Machine Interface

ABB Oy
Distribution Automation
P.O. Box 699
FI-65101 VAASA, Finland
Phone +358 10 22 11
Fax +358 10 22 41094
www.abb.com/substationautomation

1MRS756376