Relion® Protection and Control

650 series
Operation Manual

Power and productivity
for a better world™

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Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95/EC).

This conformity is proved by tests conducted by ABB AB in accordance with the generic standard EN 50263 for the EMC directive, and with the standards EN 60255-5 and/or EN 50178 for the low voltage directive.

This product is designed and produced for industrial use.

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 IED has to be carefully earthed.

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

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

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Section 1 Introduction

1.1 This manual

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

1.2 Intended audience

This manual addresses the operator, who operates the 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

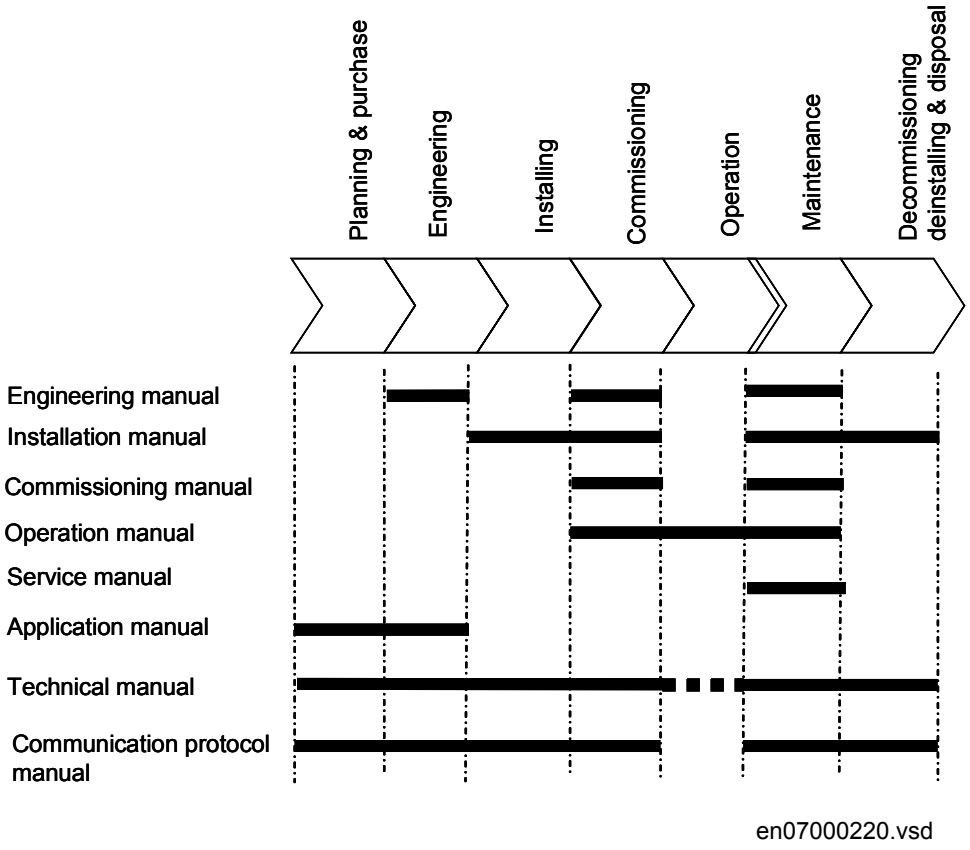

Figure 1: The intended use of manuals in different lifecycles

The engineering manual contains instructions on how to engineer the IEDs using the different tools in PCM600. The manual provides instructions on how to set up a PCM600 project and insert IEDs to the project structure. The manual also recommends a sequence for engineering of protection and control functions, LHMI functions as well as communication engineering for IEC 61850 and DNP3.

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

The commissioning manual contains instructions on how to commission the IED. The manual can also be used by system engineers and maintenance personnel for assistance during the testing phase. The manual provides procedures for checking of external circuitry and energizing the IED, parameter setting and configuration as well as verifying settings by secondary injection. The manual describes the process

of testing an IED in a substation which is not in service. The chapters are organized in chronological order in which the IED should be commissioned.

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

The 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.

The 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.

The 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 manual describes a communication protocol supported by the IED. The manual concentrates on vendor-specific implementations.

The point list manual describes the outlook and properties of the data points specific to the IED. The manual should be used in conjunction with the corresponding communication protocol manual.

The service manual is not available yet.

1.3.2 Document revision history

Document revision/date	Product series version	History
-/September 2009	1.0	First release

1.3.3 Related documents

Documents related to REC650	Identity number
Commissioning manual	1MRK 511 209-UEN
Technical manual	1MRK 511 204-UEN
Application manual	1MRK 511 203-UEN

Table continues on next page

Documents related to REC650	Identity number
Product Guide, configured	1MRK 511 211-BEN
Type test certificate	1MRK 511 211-TEN

Documents related to REL650	Identity number
Commissioning manual	1MRK 506 307-UEN
Technical manual	1MRK 506 304-UEN
Application manual	1MRK 506 305-UEN
Product Guide, configured	1MRK 506 308-BEN
Type test certificate	1MRK 506 308-TEN

Documents related to RET650	Identity number
Commissioning manual	1MRK 504 109-UEN
Technical manual	1MRK 504 106-UEN
Application manual	1MRK 504 107-UEN
Product Guide, configured	1MRK 504 110-BEN
Type test certificate	1MRK 504 110-TEN

650 series manuals	Identity number
Operation manual	1MRK 500 088-UEN
Communication protocol manual, DNP3	1MRK 511 224-UEN
Communication protocol manual, IEC 61850	1MRK 511 205-UEN
Engineering manual	1MRK 511 206-UEN
Installation manual	1MRK 514 013-UEN
Point list manual, DNP3	1MRK 511 225-UEN

1.4 Symbols and conventions

1.4.1 Safety indication symbols

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

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

The caution icon indicates important information or warning related to the concept discussed in the text. It might indicate the presence

of a hazard which could result in corruption of software or damage to equipment or property.

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

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

Although warning hazards are related to personal injury, it 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 Manual conventions

Conventions used in IED manuals. A particular convention may not be used in this manual.

- Abbreviations and acronyms in this manual are spelled out in Glossary. Glossary also contains definitions of important terms.
- Push button navigation in the LHMI menu structure is presented by using the push button icons, for example:
  To navigate between the options, use  and  .
- HMI menu paths are presented in bold, for example:
  Select **Main menu/Settings**.
- LHMI 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.
- The ^ character in front of an input or output signal name in the function block symbol given for a function, indicates that the user can set an own signal name in PCM600.
- The * character after an input or output signal name in the function block symbol given for a function, indicates that the signal must be connected to another function block in the application configuration to achieve a valid application configuration.

1.4.3 Functions included in 650 series IEDs

Table 1: Main protection functions

IEC 61850	ANSI	Function description
Differential protection		
T2WPDIF	87T	Transformer differential protection, two winding
T3WPDIF	87T	Transformer differential protection, three winding
REFPDIF	87N	Restricted earth fault protection, low impedance
Impedance protection		
ZQDPDIS	21	Five zone distance protection, quadrilateral characteristic
FDPSPDIS	21	Phase selection with load enchroachment, quadrilateral characteristic
ZMOPDIS	21	Five zone distance protection, mho characteristic
FMPSPDIS	21	Faulty phase identification with load enchroachment for mho
ZDNRDIR	21	Directional impedance quadrilateral and mho
PPLPHIZ		Phase preference logic
ZMRPSB	68	Power swing detection
ZCVPSOF		Automatic switch onto fault logic, voltage and current based

Table 2: Back-up protection functions

IEC 61850	ANSI	Function description
Current protection		
PHPIOC	50	Instantaneous phase overcurrent protection
OC4PTOC	51/67	Four step directional phase overcurrent protection
EFPIOC	50N	Instantaneous residual overcurrent protection
EF4PTOC	51N/67N	Four step directional residual overcurrent protection
SDEPSDE	67N	Sensitive directional residual overcurrent and power protection
UC2PTUC	37	Time delayed 2-step undercurrent protection
LPTTR	26	Thermal overload protection, one time constant
TRPTTR	49	Thermal overload protection, two time constants
CCRBRF	50BF	Breaker failure protection
CCRPLD	52PD	Pole discordance protection
BRCPTOC	46	Broken conductor check
GUPPDUP	37	Directional underpower protection
GOPPDOP	32	Directional overpower protection
DNSPTOC	46	Negative sequence based overcurrent function
Voltage protection		
UV2PTUV	27	Two step undervoltage protection
OV2PTOV	59	Two step overvoltage protection
ROV2PTOV	59N	Two step residual overvoltage protection

Table continues on next page

IEC 61850	ANSI	Function description
OEXPVPH	24	Overexcitation protection
LOVPTUV	27	Loss of voltage check
Frequency protection		
SAPTUF	81	Underfrequency function
SAPTOF	81	Overfrequency function
SAPFRC	81	Rate-of-change frequency protection

Table 3: Control and monitoring functions

IEC 61850	ANSI	Function description
Control		
SESRSYN	25	Synchrocheck, energizing check, and synchronizing
SMBRREC	79	Autorecloser
SCILO	3	Logical node for interlocking
BB_ES	3	Interlocking for busbar earthing switch
A1A2_BS	3	Interlocking for bus-section breaker
A1A2_DC	3	Interlocking for bus-section disconnector
ABC_BC	3	Interlocking for bus-coupler bay
BH_CONN	3	Interlocking for 1 1/2 breaker diameter
BH_LINE_A	3	Interlocking for 1 1/2 breaker diameter
BH_LINE_B	3	Interlocking for 1 1/2 breaker diameter
DB_BUS_A	3	Interlocking for double CB bay
DB_BUS_B	3	Interlocking for double CB bay
DB_LINE	3	Interlocking for double CB bay
ABC_LINE	3	Interlocking for line bay
AB_TRAFO	3	Interlocking for transformer bay
SCSWI		Switch controller
SXCBR		Circuit breaker
SXSWI		Circuit switch
POS_EVAL		Evaluation of position indication
SELGGIO		Select release
QCBAY		Bay control
LOCREM		Handling of LR-switch positions
LOCREMCTRL		LHMI control of PSTO
TR1ATCC	90	Automatic voltage control for tapchanger, single control
TR8ATCC	90	Automatic voltage control for tapchanger, parallell control
TCMYLTC	84	Tap changer control and supervision, 6 binary inputs
SLGGIO		Logic Rotating Switch for function selection and LHMI presentation
VSGGIO		Selector mini switch extension

Table continues on next page

IEC 61850	ANSI	Function description
DPGGIO		IEC61850 generic communication I/O functions double point
SPC8GGIO		Single point generic control 8 signals
AUTOBITS		AutomationBits, command function for DNP3.0
Secondary system supervision		
CCSRDIF	87	Current circuit supervision
SDDRFUF		Fuse failure supervision
TCSSCBR		Breaker close/trip circuit monitoring
Logic		
SMPPTRC	94	Tripping logic
TMAGGIO		Trip matrix logic
OR		Configurable logic blocks, OR
INVERTER		Configurable logic blocks, Inverter
PULSETIMER		Configurable logic blocks, PULSETIMER
GATE		Configurable logic blocks, Controllable gate
XOR		Configurable logic blocks, exclusive OR
LOOPDELAY		Configurable logic blocks, loop delay
TimeSet		Configurable logic blocks, timer
AND		Configurable logic blocks, AND
SRMEMORY		Configurable logic blocks, set-reset memory
RSMEMORY		Configurable logic blocks, reset-set memory
ANDQT		Configurable logic Q/T, ANDQT
ORQT		Configurable logic Q/T, ORQT
INVERTERQT		Configurable logic Q/T, INVERTERQT
XORQT		Configurable logic Q/T, XORQT
SRMEMORYQT		Configurable logic Q/T, set-reset with memory
RSMEMORYQT		Configurable logic Q/T, reset-set with memory
TIMERSETQT		Configurable logic Q/T, settable timer
PULSETIMERQT		Configurable logic Q/T, pulse timer
INVALIDQT		Configurable logic Q/T, INVALIDQT
INDCOMBSPQT		Configurable logic Q/T, single indication signal combining
INDEXTSPQT		Configurable logic Q/T, single indication signal extractor
FSDSIGN		Fixed signal function block
B16I		Boolean 16 to Integer conversion
B16IFCVI		Boolean 16 to integer conversion with logic node representation
IB16A		Integer to Boolean 16 conversion
IB16FCVB		Integer to boolean 16 conversion with logic node representation
Monitoring		
CVMMXN		Measurements
CMMXU		Phase current measurement

Table continues on next page

IEC 61850	ANSI	Function description
VMMXU		Phase-phase voltage measurement
CMSQI		Current sequence component measurement
VMSQI		Voltage sequence measurement
VNMMXU		Phase-neutral voltage measurement
CNTGGIO		Event counter
DRPRDRE		Disturbance report
AxRADR		Analog input signals
BxRBDR		Binary input signals
SPGGIO		IEC61850 generic communication I/O functions
SP16GGIO		IEC61850 generic communication I/O functions 16 inputs
MVGGIO		IEC61850 generic communication I/O functions
MVEXP		Measured value expander block
LMBRFLO		Fault locator
SPVNZBAT		Station battery supervision
SSIMG	63	Insulation gas monitoring function
SSIML	71	Insulation liquid monitoring function
SSCBR		Circuit breaker condition monitoring
Metering		
PCGGIO		Pulse counter logic
ETPMMTR		Function for energy calculation and demand handling

Table 4: Designed to communicate

IEC 61850	ANSI	Function description
Station communication		
		IEC61850 communication protocol
		DNP3.0 for TCP/IP communication protocol
GOOSEINTLKRCV		Horizontal communication via GOOSE for interlocking
GOOSEBINRCV		GOOSE binary receive
Scheme communication		
ZCPSCH	85	Scheme communication logic for distance or overcurrent protection
ZCRWPSCH	85	Current reversal and weak-end infeed logic for distance protection
ZCLCPLAL		Local acceleration logic
ECPSCH	85	Scheme communication logic for residual overcurrent protection
ECRWPSCH	85	Current reversal and weak-end infeed logic for residual overcurrent protection

Table 5: Basic IED functions

IEC 61850	Function description
Basic functions included in all products	
INTERRSIG	Self supervision with internal event list
	Time synchronization
SETGRP	Setting group handling
ACTVGRP	Parameter setting groups
TESTMODE	Test mode functionality
CHNGLCK	Change lock function
ATHSTAT	Authority status
ATHCHCK	Authority check

Section 2 Environmental aspects

2.1 Sustainable development

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

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

Table 6: Maximum concentration values by weight per homogeneous material

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

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

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

2.2 Disposing of the IED

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

All parts used in this product are recyclable. When disposing cast-off IEDs or its parts, contact the local entrepreneurs who are authorized and specialized in

handling electrical/electronics waste. These partners can sort the material by using dedicated sorting processes and dispose of the product according to the local requirements.

Table 7: Materials of the IED parts

IED	Parts	Material
Unit	Metallic plates, parts and screws	Steel
	Plastic parts	PC[1], LCP[2]
	LHMI display module	Various
Package	Box	Cardboard
Attached material	Manuals	Paper

1) Polycarbonate
2) Liquid crystal polymer

Section 3 650 series overview

3.1 Local HMI

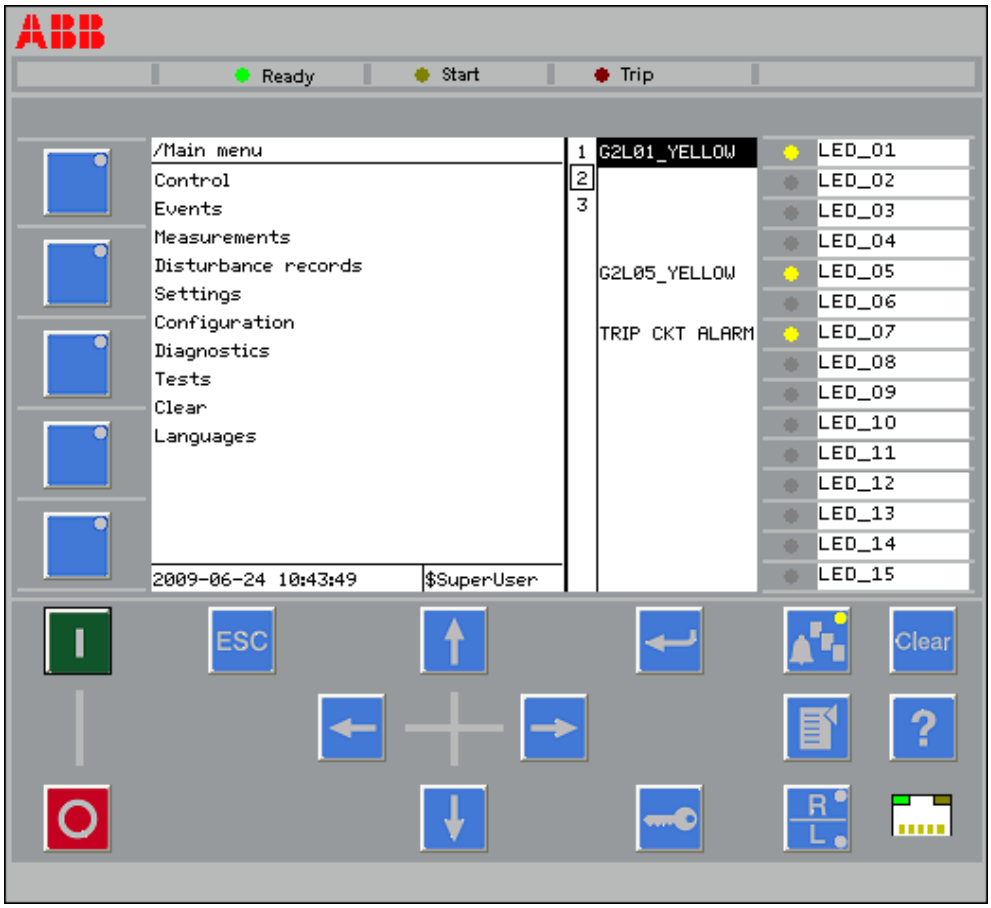

Figure 2: Local human-machine interface

The LHMI of the IED contains the following elements:

- Display (LCD)
- Buttons
- LED indicators
- Communication port

The LHMI is used for setting, monitoring and controlling.

3.1.1 LCD

The LHMI includes a graphical monochrome LCD with a resolution of 320 x 240 pixels. The character size can vary. The amount of characters and rows fitting the view depends on the character size and the view that is shown.

The display view is divided into four basic areas.

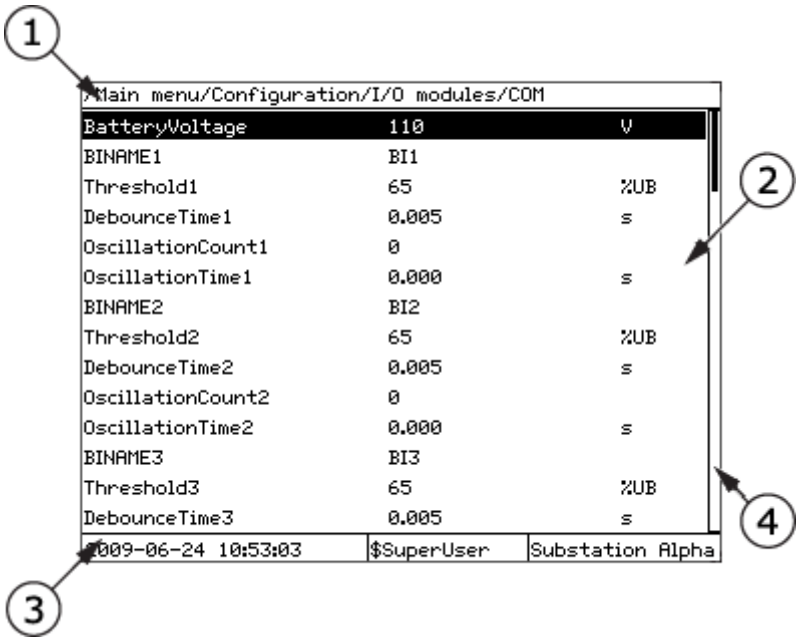

Figure 3: Display layout

1 Path
2 Content
3 Status
4 Scroll bar (appears when needed)

- The path shows the current location in the menu structure. If the path is too long to be shown, it is truncated from the beginning, and the truncation is indicated with three dots.
- The content area shows the menu content.
- The status area shows the current IED time, the user that is currently logged in and the object identification string which is settable via the LHMI or with PCM600.
- If text, pictures or other items do not fit in the display, a vertical scroll bar appears on the right. The text in content area is truncated from the beginning if it does not fit in the display horizontally. Truncation is indicated with three dots.

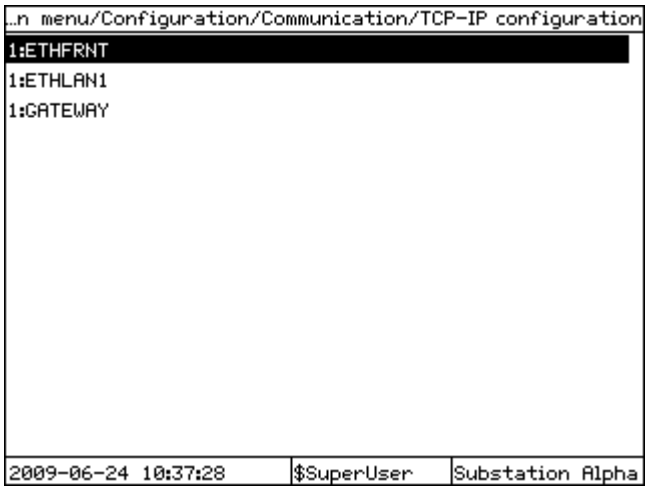

Figure 4: Truncated path

The number before the function instance, for example `1:ETHFRNT`, indicates the instance number.

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

The function button panel shows on request what actions are possible with the function buttons. Each function button has a LED indication that can be used as a feedback signal for the function button control action. The LED is connected to the required signal with PCM600.

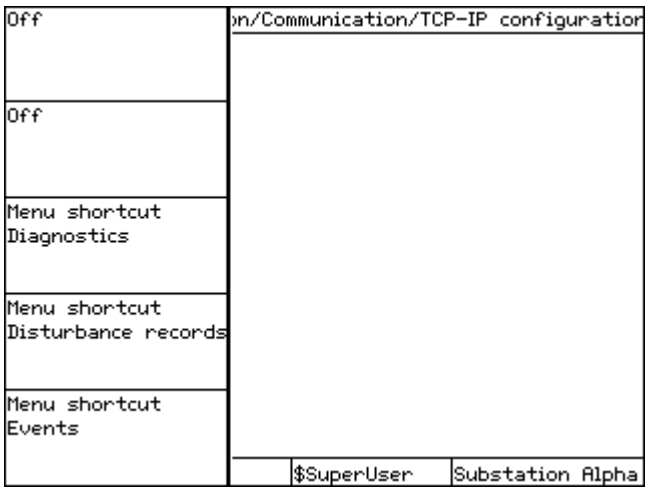

Figure 5: Function button panel

The alarm LED panel shows on request the alarm text labels for the alarm LEDs.

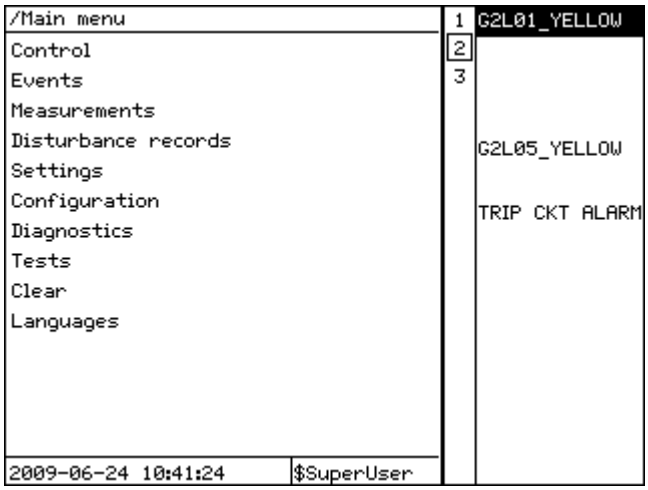

Figure 6: Alarm LED panel

The function button and alarm LED panels are not visible at the same time. Each panel is shown by pressing one of the LCD function buttons or the Multipage button. Pressing the ESC button clears the panel from the display. Both the panels have dynamic width that depends on the label string length that the panel contains.

3.1.2 LEDs

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

There are also 15 matrix programmable alarm LEDs on front of the LHMI. Each LED can indicate three states with the colors: green, yellow and red. The alarm texts related to each three-color LED are divided into three pages and can be browsed with the Multipage button. The 15 physical three-color LEDs in one LED group can indicate 45 different signals. Altogether, 135 signals can be indicated since there are three LED groups. The LEDs can be configured with PCM600 and the operation mode can be selected with the LHMI or PCM600.

3.1.3 Keypad

The LHMI keypad contains push-buttons which are used to navigate in different views or menus. With push-buttons you can give open or close commands to one primary object, for example, a circuit breaker, disconnector or an earthing switch. The push-buttons are also used to acknowledge alarms, reset indications, provide help and switch between local and remote control mode.

The keypad also contains programmable push-buttons that can be configured either as menu shortcut or control buttons.

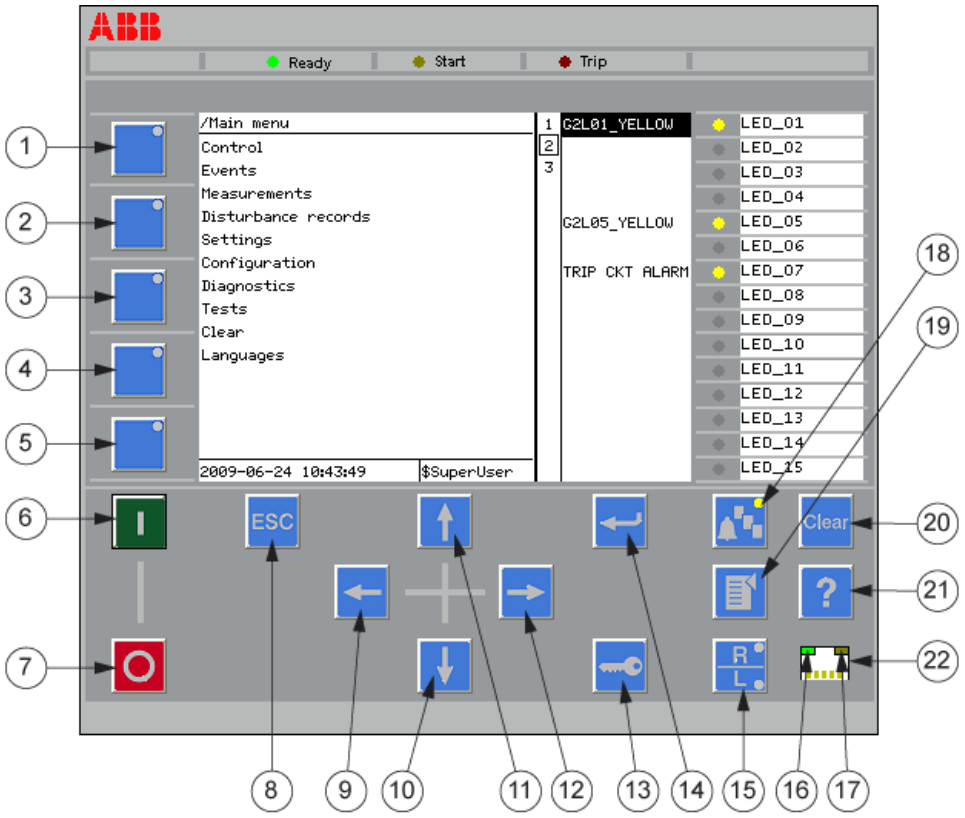

Figure 7: LHMI keypad with object control, navigation and command push-buttons and RJ-45 communication port

1...5 Function button
6 Close
7 Open
8 Escape
9 Left
10 Down
11 Up
12 Right
13 Key
14 Enter
15 Remote/Local
16 Uplink LED
17 Not in use
18 Multipage
19 Menu
20 Clear
21 Help

22 Communication port

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.

Object to be controlled is selected from the single line diagram.

Table 8: Object control push-buttons

Name	Description
Close	Closing the object.
Open	Opening the 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 9: 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 ← or →. • Running the display test in combination with . • Deleting a character in combination with Clear when editing a string. • Inserting a space in combination with ↵ when editing a string.
Enter	• Entering parameter setting mode. • Confirming a new value of a setting parameter. • Confirming selection in dialogs and alarm panel.
Up Down	• Moving up and down in menus. • Selecting objects in the SLD. • Moving selection in dialogs and alarm panel. • Scrolling active digits of a parameter when entering a new setting value.
Left Right	• Moving left and right in menus. • Selecting pages in the SLD. • 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 10: Command push-buttons

Name	Description
Menu	• Moving directly to Main menu, if currently in any other menu or view. • 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 the help menu.
Multipage	Opening alarm panel and selecting alarm page from the view.

Function buttons

Table 11: Function buttons

Name	Description
LCD function button	Executing the defined function: OFF, menu short cut or binary control.

3.1.4 Local HMI functionality

3.1.4.1 Protection and alarm indication

Protection indicators

Protection indicator LEDs are Ready, Start and Trip.

Configure the disturbance recorder to enable the start and trip LEDs.

Table 12: Ready LED (green)

LED state	Description
Off	Auxiliary supply voltage is disconnected.
On	Normal operation.
Flashing	Internal fault has occurred.

Table 13: Start LED (yellow)

LED state	Description
Off	Normal operation.
On	A protection function has started and an indication message is displayed. • The start indication is latching and must be reset via communication or by pressing Clear.
Flashing	A flashing yellow LED has a higher priority than a steady yellow LED. The IED is in test mode and protection functions are blocked. • The indication disappears when the IED is no longer in test mode and blocking is removed.

Table 14: Trip LED (red)

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.

Alarm indicators

The 15 programmable three-color LEDs are used for alarm indication. An individual alarm/status signal, connected to any of the LED function blocks, can be assigned to one of the three LED colors when configuring the IED.

Table 15: Alarm indications

LED state	Description
Off	Normal operation. All activation signals are off.
On	• Follow-S sequence: The activation signal is on. • LatchedColl-S sequence: The activation signal is on, or it is off but the indication has not been acknowledged. • LatchedAck-F-S sequence: The indication has been acknowledged, but the activation signal is still on. • LatchedAck-S-F sequence: The activation signal is on, or it is off but the indication has not been acknowledged. • LatchedReset-S sequence: The activation signal is on, or it is off but the indication has not been acknowledged.
Flashing	• Follow-F sequence: The activation signal is on. • LatchedAck-F-S sequence: The activation signal is on, or it is off but the indication has not been acknowledged. • LatchedAck-S-F sequence: The indication has been acknowledged, but the activation signal is still on.

3.1.4.2 Parameter management

The LHMI is used to access the IED parameters. Three types of parameters can be read and written.

- 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.

3.1.4.3 Front communication

The RJ-45 port in the LHMI enables front communication.

- The green uplink LED on the left is lit when the cable is successfully connected to the port.

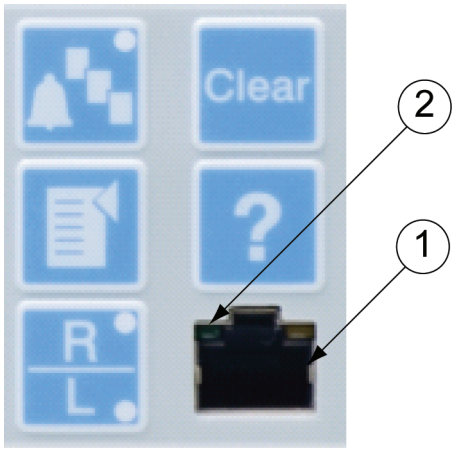

Figure 8: RJ-45 communication port and green indicator LED

1 RJ-45 connector
2 Green indicator LED

When a computer is connected to the IED front port with a crossed-over cable, the IED's DHCP server for the front interface assigns an IP address to the computer if *DHCPServer* = *On*. The default IP address for the front port is 10.1.150.3 .

Do not connect the IED front port to LAN. Connect only a single local PC with PCM600 to front port.

3.1.4.4 Single-line diagram

Single-line diagram is used for bay monitoring and/or control. It shows a graphical presentation of the bay which is configured with PCM600.

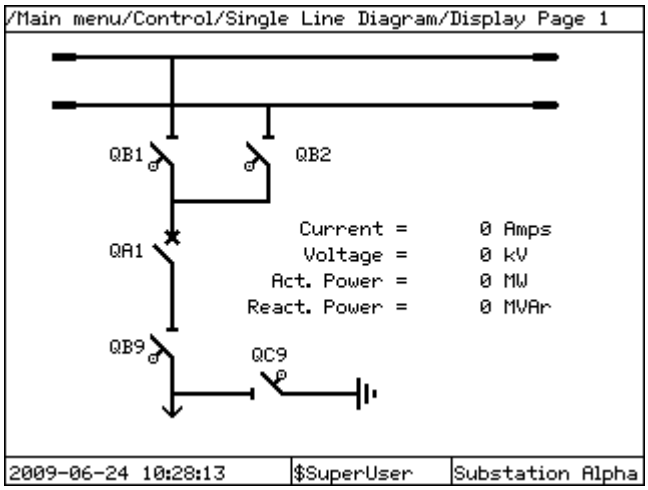

Figure 9: Single-line diagram

3.2 Authorization

The user categories are predefined for the LHMI with different rights.

The IED users can be created, deleted and edited only with PCM600. One user can belong to one or several user categories.

At delivery, the user has full access until users are created with PCM600. Logging on is not required for the LHMI.

Table 16: Predefined user categories

Username	User rights
SystemOperator	Control from LHMI, no bypass
ProtectionEngineer	All settings
DesignEngineer	Application configuration
UserAdministrator	User and password administration

For more information, see PCM600 documentation.

3.3 Communication

The IED supports communication protocols IEC 61850-8-1 and DNP3 over TCP/IP.

All operational information and controls are available through these protocols. However, some communication functionality, for example, horizontal communication (GOOSE) between the IEDs, is only enabled by the IEC 61850-8-1 communication protocol.

Disturbance files are accessed using the IEC 61850 protocol. Disturbance files are available to any Ethernet based application in the standard COMTRADE format. Further, the IED sends and receives binary signals from other IEDs using the IEC 61850-8-1 GOOSE profile. The IED meets the GOOSE performance requirements for tripping applications in substations, as defined by the IEC 61850 standard. The IED interoperates with other IEC 61850 compliant IEDs, tools and systems and simultaneously reports events to five different clients on the IEC 61850 station bus. For a system using DNP3 over TCP/IP, events can be sent to four different masters.

All communication connectors, except for the front port connector, are placed on integrated communication modules. The IED is connected to Ethernet-based communication systems via the fibre-optic multimode LC connector (100BASE-FX).

The IED supports SNTP, DNP3 and IRIG-B time synchronization methods with a time-stamping resolution of 1 ms.

Ethernet based:

- SNTP (Simple Network Time Protocol)
- DNP3

With special time synchronization wiring:

- IRIG-B

3.4 PCM600 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, see PCM600 documentation.

3.4.1 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.

3.4.2 PCM600 and IED connectivity package version

- Protection and Control IED Manager PCM600 Ver. 2.1 or later
- ABB IED Connectivity Package RE_630/RE_650 Ver. 1.0 or later
- ABB REC650 Module Ver. 1.0 or later
- ABB REL650 Module Ver. 1.0 or later
- ABB RET650 Module Ver. 1.0 or later

Download connectivity packages from the ABB web site http://www.abb.com/substationautomation

Section 4 Using the HMI

4.1 Using the local HMI

At delivery, logging on is not required and the user has full access until users and passwords are created with PCM600 and written into the IED.

Commands, changing parameter values and resetting indications, for example, are actions requiring password when the password protection is activated. Reading information on the LHMI is always allowed without password.

Utility security policies and practical consideration should always be taken on the feasibility of using passwords. In emergency situations, the use of passwords could delay urgent actions. On the other hand when security issues must be met, the two factors must be seriously considered.

4.1.1 Logging on

1. Press to activate the logon procedure.
   The logon is also activated when attempting a password-protected operation.
2. Select the user name from the list.

Figure 10: Selecting the user name

3. Enter the password when prompted digit by digit and select OK.
   - Activate the digit to be entered with and .
   - Enter the character with and .

   Upper and lower case letters are also found by scrolling with the vertical arrows.

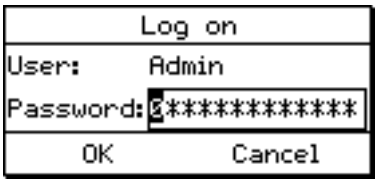

Figure 11: Entering the password

Passwords are case sensitive.

4. Press to confirm the logon or ESC to cancel the procedure.
If the logon fails, a message is displayed on the LCD.

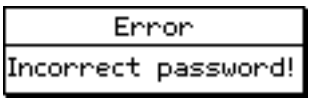

Figure 12: Error message indicating an incorrect password

The logon dialog will open if the attempted operation requires another level of user rights.

Once a user is created and downloaded into the IED, logon is possible with the password assigned in the tool. If there is no user created, an attempt to log on causes the display to show a corresponding message.

Figure 13: No user defined

4.1.2 Logging off

The user is automatically logged off after the display timeout. The IED then returns to a state where only reading is enabled. Manual logoff is also possible.

1. Press .
2. To confirm logoff, select `Yes` and press .

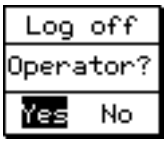

Figure 14: Logging off

4.1.3 Turning the display backlight on

The display backlight is normally off. It turns on 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 after the display backlight has turned off. The factory default for display timeout is 60 minutes.

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

Change the backlight timeout period in .**Main menu/ Configuration/HMIScreen/1:SCREEN/DisplayTimeout**

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 or 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.

- Press .
  - 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 neither of the LEDs is 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.

To control the IED, log in with the appropriate user rights.

4.1.5 Identifying the device

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

1. Select **Main menu/Diagnostics/IED Status/Product identifiers**.
2. Select a submenu with and .

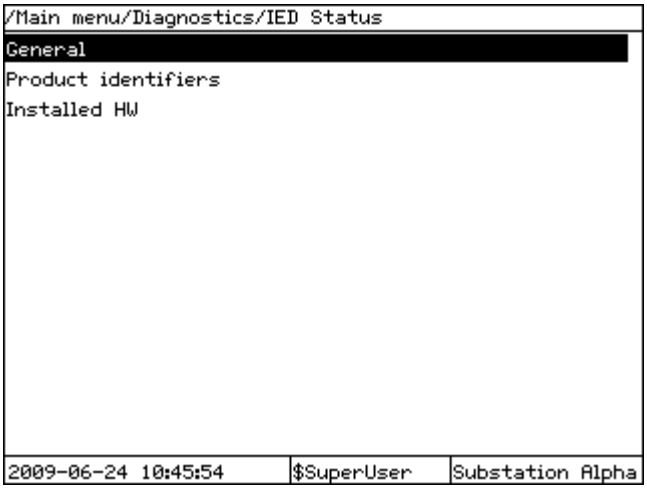

Figure 15: Selecting a submenu

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

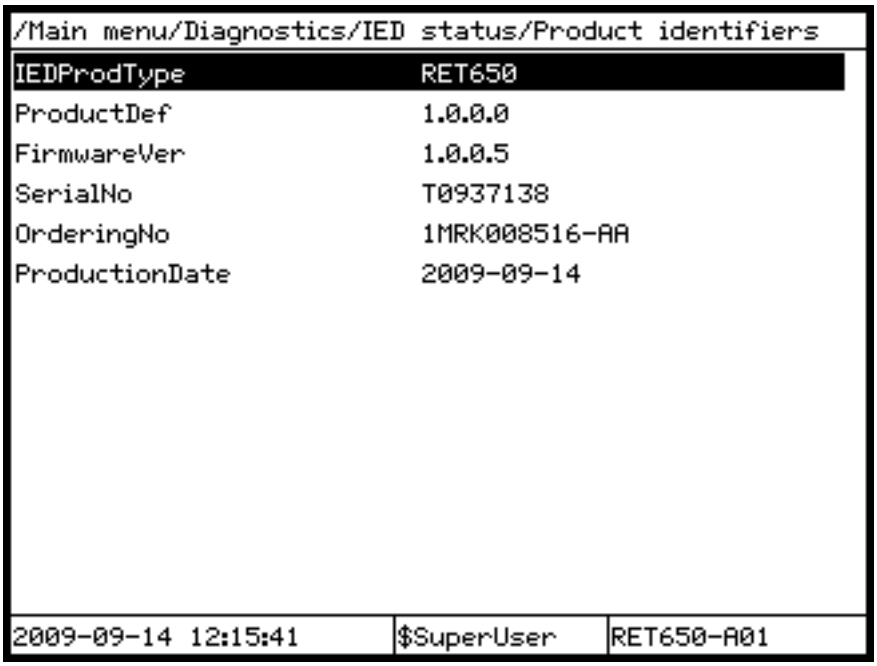

Figure 16: IED information

4.1.6 Adjusting the display contrast

Adjust the display contrast anywhere in the menu structure to obtain optimal readability.

- 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 if you are logged in and authorized to control the IED. After an auxiliary power failure, the contrast is restored.

4.1.7 Changing the local HMI language

1. Select **Main menu/Languages/1:LANGUAGE** and press ↵.
2. Change the language using ↑ or ↓.
3. Press ↵ to confirm the selection.
4. Commit the changes.

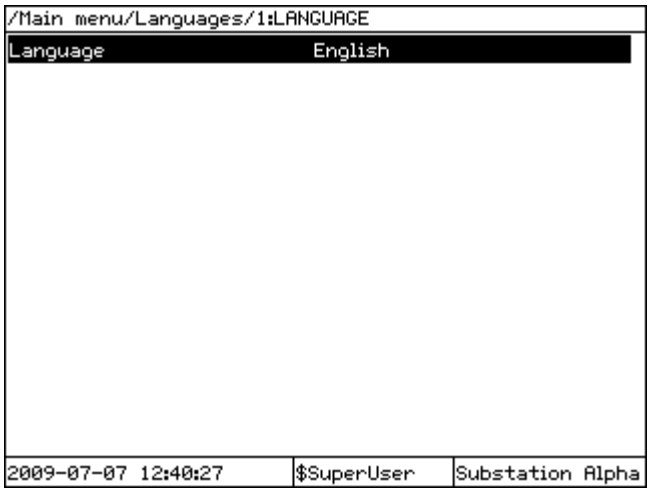

Figure 17: Changing the LHMI language

To change the language using a shortcut, press ESC and ← or → simultaneously anywhere in the menu.

4.1.8 Navigating in the menu

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.

4.1.8.1 Menu structure

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

- Control
- Events
- Measurements
- Disturbance records
- Settings
- Configuration
- Diagnostics

- Tests
- Clear
- Languages

4.1.8.2 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.

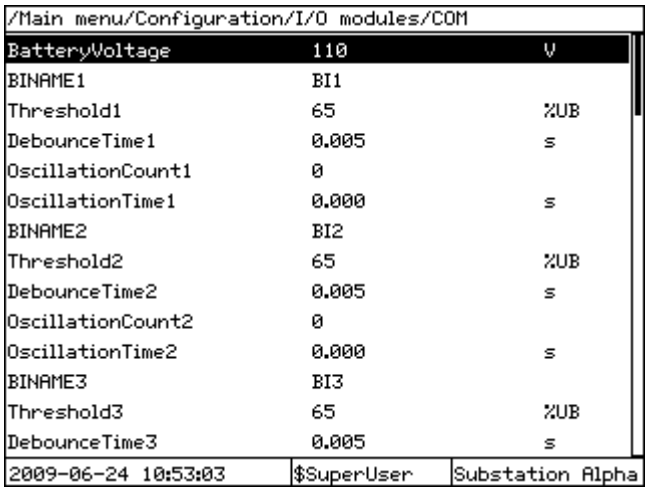

Figure 18: Scroll bar on the right

- To scroll the view upwards, press .
- To scroll the view downwards, press .
- To jump from the last row to the first row, press again.
  - Press to jump from the first row to the last row.

4.1.8.3 Changing the default view

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

1. Select **Main menu/Configuration/HMI/Screen/1:SCREEN** and press .
2. Change the default view with or .
3. Press to confirm the selection.

4.1.9 Using function buttons

The LCD function buttons can be configured either as menu shortcut or control buttons. The buttons are functional only when the function button panel is visible.

1. Press any function button to open the function button panel.
   On the first press of a button, the panel opens but no other action is taken.

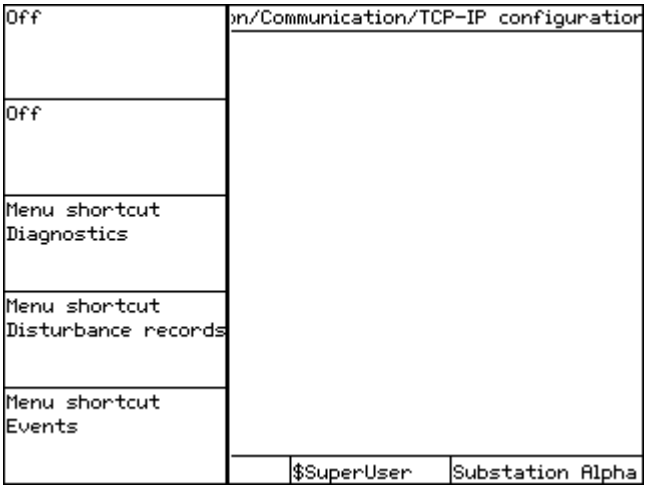

Figure 19: Function button panel

2. Press the wanted function button.
   - Press the wanted function button to jump to a certain menu item.
     The menu will open immediately upon pressing the button.
   - Press the wanted function button for at least 0.5 s to initiate a control signal. The action is taken once.
     To repeat the action, press the button again. If the button is pressed less that 0.5 s, no action is taken.
3. Press ESC to close the function button panel.
   The panel is also closed after pressing a function button configured for a menu shortcut.

The LCD function buttons are configured with PCM600.

For more information, see PCM600 documentation.

4.1.10 Using the single-line diagram

The single-line diagram is created with PCM600.

1. Select **Main menu/Control/Single line diagram**.
   The single-line diagram view is displayed.

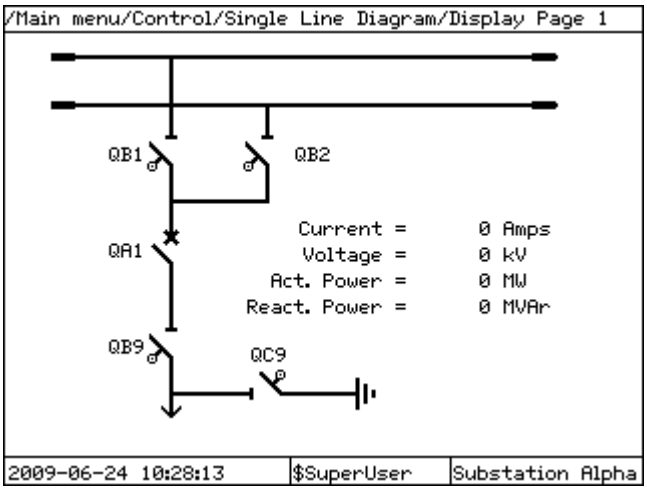

Figure 20: Example of a single-line diagram

2. Select an object with ↑ or ↓.
   Selection of an object is indicated with a square border that moves when ↑ and ↓ are used.
   Breaker objects can have additional icons that present the breaker states.
   - ! = Circuit breaker is in substituted state.
   - 🔒 = Circuit breaker is interlocked.
3. Press O to select open or I to select close the object.
4. Confirm the control operation in the dialog that opens.
5. To move between the single-line diagram pages, press ← or →.

Select the single-line diagram for the default view in **Main menu/Configuration/HMI/Screen/1:SCREEN/DefaultScreen**.

4.1.11 Browsing setting values

1. Select **Main menu/Settings/IED Settings** and press →.
2. Press ↑ and then ↵ to activate the setting group number selection.

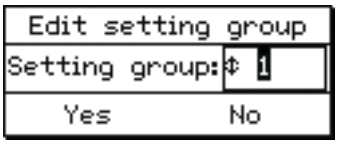

Figure 21: Selecting the setting group number

3. Press ↑ or ↓ to select the setting group number.

4. Press to confirm the setting group selection and to return to the Edit setting group dialog.
5. Press to select Yes and to view the setting group values.
   - Press or to select No and to exit.

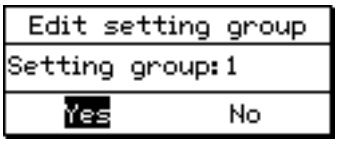

Figure 22: Selecting a setting group

6. To browse the settings, scroll the list with and and to select a setting press . To move back to the list, press .

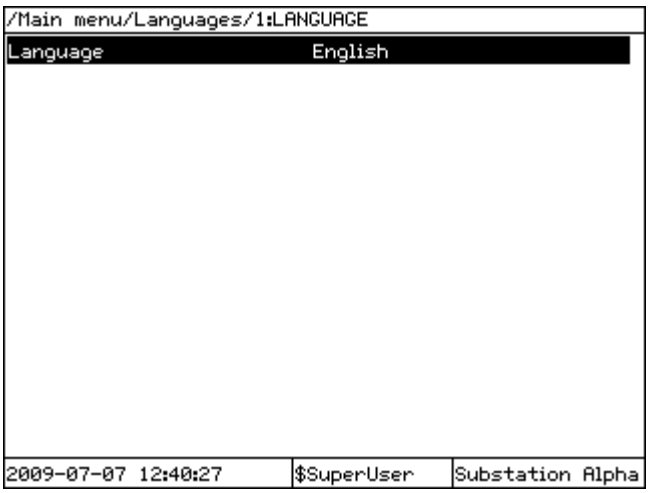

Figure 23: Setting alternatives in the selected setting group

The content of the list depends on the pre-configuration or on the functions configured with PCM600.

4.1.12 Editing values

- To edit values, log in with the appropriate user rights.
  If the user rights are not sufficient for editing values, the login dialog opens.

4.1.12.1 Editing numerical values

1. Select **Main menu/Settings** and then a setting.
   The last digit of the value is active.

- When the symbol in front of the value is ↑, increase the active value.
- When the symbol is ↓, decrease the active value.
- When the symbol in front of the value is ↕, either increase or decrease the active value.

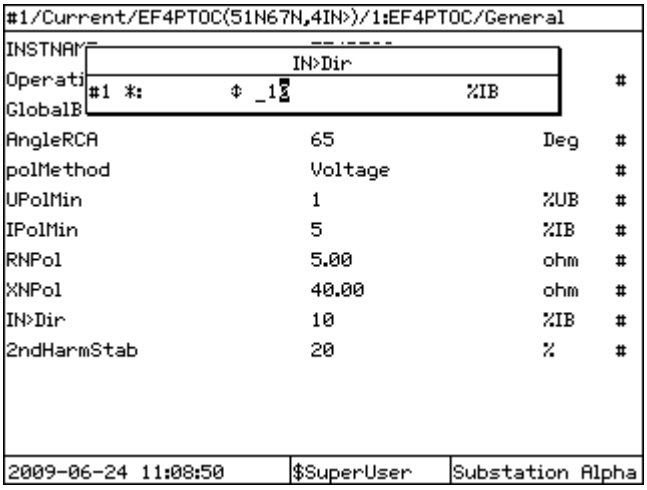

Figure 24: Last digit is active and it can be increased or decreased

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. For decimal values, the change can be fractions 0.1, 0.01, 0.001 (...) depending on the active digit.

   For parameters with defined steps, digits smaller than the step value cannot be edited.

3. Press ← or → to move the cursor to another digit.
4. To select the minimum or maximum value, select the arrow symbol in front of the value.
   - To set the value to the maximum, press ↑.
   - To set the value to the minimum, press ↓.

   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.

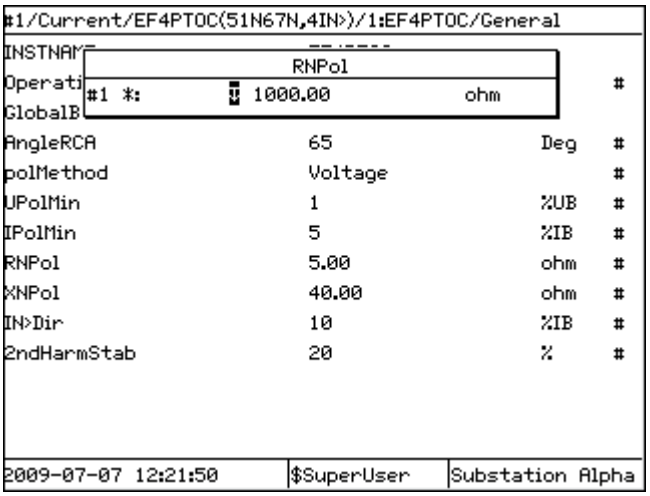

Figure 25: Restoring the previous value

4.1.12.2 Editing string values

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.
3. Press ← or → to move the cursor to another character.
   - To insert characters or space, press simultaneously ESC and ↵.
   - To delete characters, press simultaneously ESC and Clear.

PCM600 supports Unicode characters.

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

4.1.13 Saving settings

Editable values are stored in the non-volatile flash memory. Most of the parameter changes take effect immediately after storing, but some parameter changes require

application restart. Values stored in the flash memory remain in effect after reboot as well.

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 .

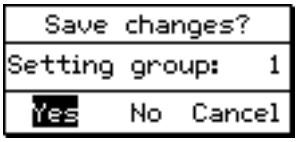

Figure 26: Confirming settings

- To exit without saving changes, select `No` and press .
- To cancel saving settings, select `Cancel` and press . The value returns to editing mode.

After changing the parameters marked with !, the IED restarts automatically for the changes to take effect.

4.1.14 Clearing and acknowledging

The Clear button is used to reset, acknowledge or clear all messages and indications, including LEDs and latched outputs as well as registers and recordings. Press the Clear button to activate a selection menu, and select the wanted clearance or reset function. Events and alarms assigned to alarm LEDs are cleared with the Clear button as well.

1. Press Clear to activate the Clear view.

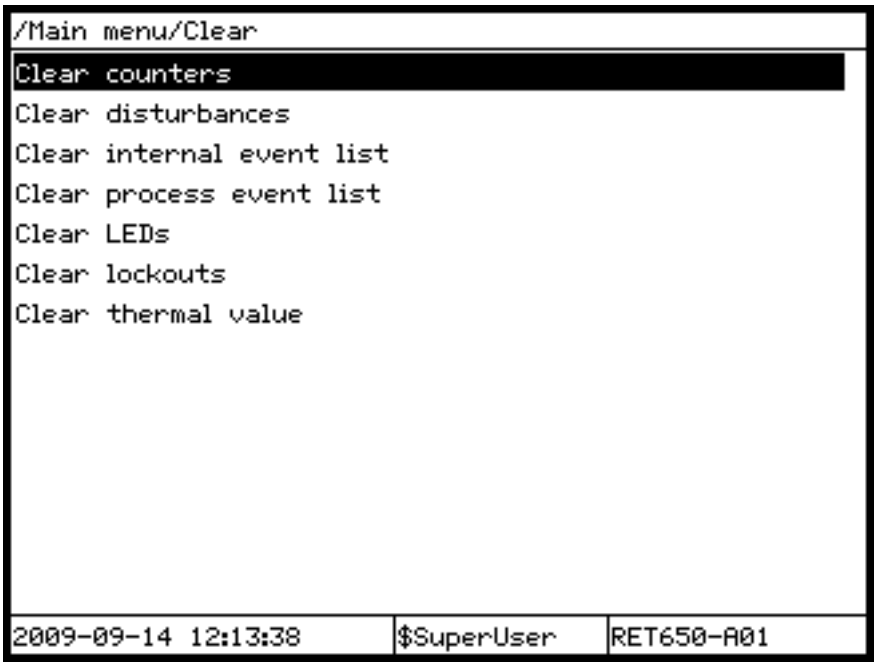

Figure 27: Clear view

The content of the Clear menu depends on the configuration configured with PCM600.

2. Select the item to be cleared with or .
3. Press , select OK to confirm the selection or Cancel to cancel the selection, and press .
4. Repeat steps 2 and 3 to clear other items.

4.1.15 Using the local HMI help

1. Press to open the help view.
2. Scroll the text with or if the help text exceeds the display area.
3. To close the help, press ESC.
   The help dialog is also closed when the display timeout expires.

Section 5 IED operation

5.1 Normal operation

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

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

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

For more information, see PCM600 documentation.

5.2 Disturbance identification

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

For the LEDs to operate, the disturbance recorder has to be defined in the configuration.

Table 17: Disturbance indications

LED	State	Description
Start LED	Yellow, steady	Protection started
Trip LED	Red, steady	Protection operated

Further actions to be taken to identify the disturbance:

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

Document the disturbance before clearing the information from the IED.

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

5.2.1 Disturbance recording triggering

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

5.2.2 Disturbance record analysis

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 with PCM600.

For more information, see PCM600 documentation.

5.2.3 Disturbance reports

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

For more information, see PCM600 documentation.

5.2.4 Internal IED errors

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

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

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

The IED records IED status data and events.

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

5.3 IED parametrization

IED parameters are set via the LHMI or PCM600.

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.

Document all changes to parameter settings.

For more information, see PCM600 documentation.

5.3.1 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.

5.3.2 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 or PCM600.

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
- 15 programmable three-color alarm LEDs which can present 45 virtual LED states
  - For each on state LED color and for the LED off state, texts can be programmed with PCM600 and via LHMI. These texts are displayed on the LHMI.
- A text message on the display.

6.1.1.1 Monitoring indication messages

Indication messages are shown in a dialog box that is displayed when the disturbance recorder is triggered. The indication dialog box shows a list of current disturbance recordings one by one. To scroll the dialog, use  and  .

To activate the indication message function, the disturbance recorder function has to be activated and properly configured. Check also that the setting **Main menu/Configuration/HMI/ Screen/1:SCREEN1/AutoIndicationDRP** is set to *On*.

1. Read the indication message in the dialog box.
   The message contains the same information that is available for disturbance recordings.
2. Press  to see more detailed information.
3. Press  to close the indication message without clearing it or press  to activate the Clear view and to clear messages.

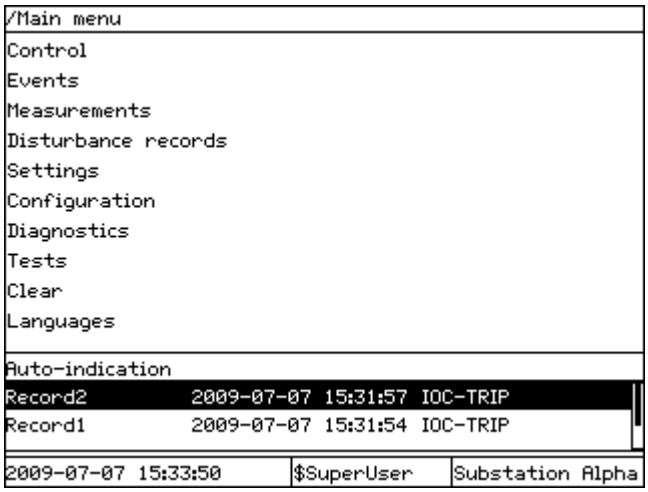

Figure 28: Indication message

6.1.1.2 Monitoring alarm data

Active alarms are indicated by the alarm LEDs and the LED in the Multipage button. The alarms are configured with PCM600. The alarm type and information depend on the application configuration.

1. Press to open the alarm view.
2. Press or to move between active alarms in the page, or press to switch between the three alarm pages.
3. Press to open a dialog box that shows more detailed information about the selected alarm.

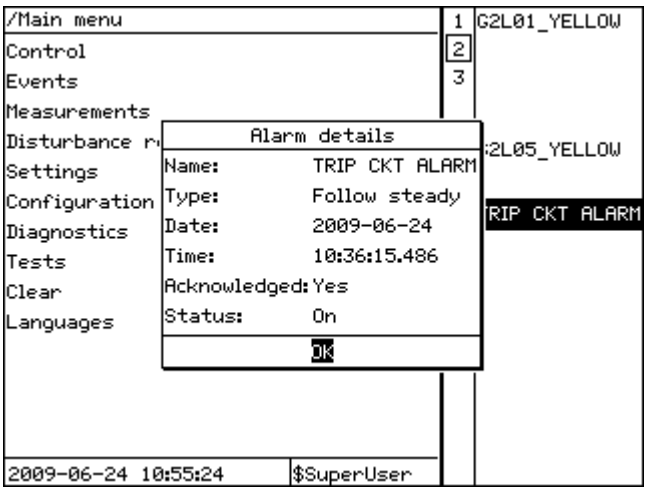

Figure 29: Alarm details

Press ↵ or ESC to close the dialog box.

4. Press ESC to close the alarm view.
5. Press Clear to activate the Clear view and to clear alarms.

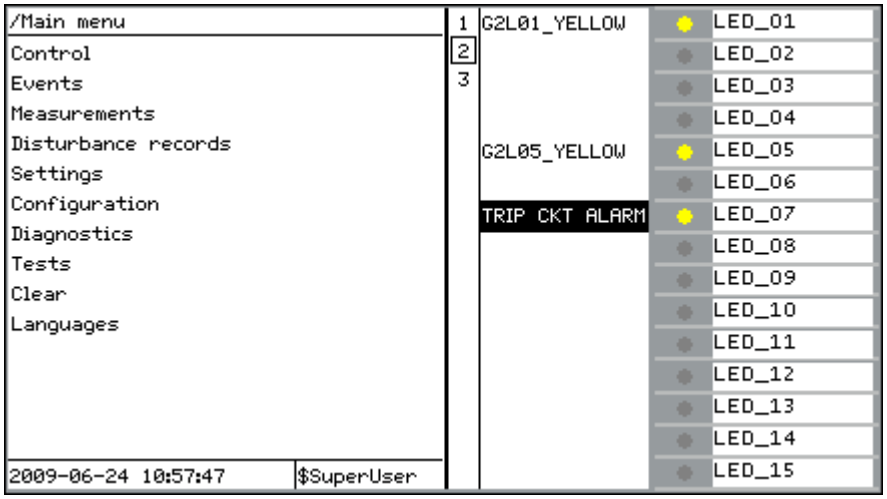

Figure 30: Alarm data

6.1.1.3 Monitoring an internal IED fault

The flashing green LED indicates an internal IED fault. The fault messages are found in the LHMI menu.

1. Select **Main menu/Diagnostics/Internal events** or **IED status** to monitor the latest fault indication.
2. Press ↑ or ↓ to scroll the view.

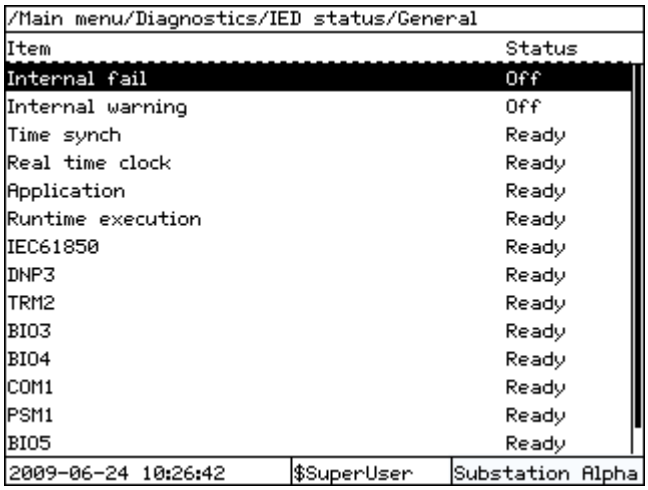

Figure 31: Fault indication

The internal event list is not updated dynamically. To update the list, leave the **Internal events** menu and then select it again.

6.1.1.4 Monitoring condition monitoring data

1. Select **Main menu/Diagnostics/IED status/General**.
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

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.

6.1.2.2 Using the local HMI for monitoring

1. Select **Main menu/Measurements** to monitor measured and calculated values. 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 a fault event. The data gives substantial information for the post fault analysis.

- Disturbance records
- Events

6.1.3.1 Creating disturbance recordings

Normally disturbance recordings are triggered by the IED applications but the recording can also be triggered manually.

1. Select **Main menu/Disturbance records**.
2. Select **Manual Trig** with or .
3. Press to execute manual triggering.

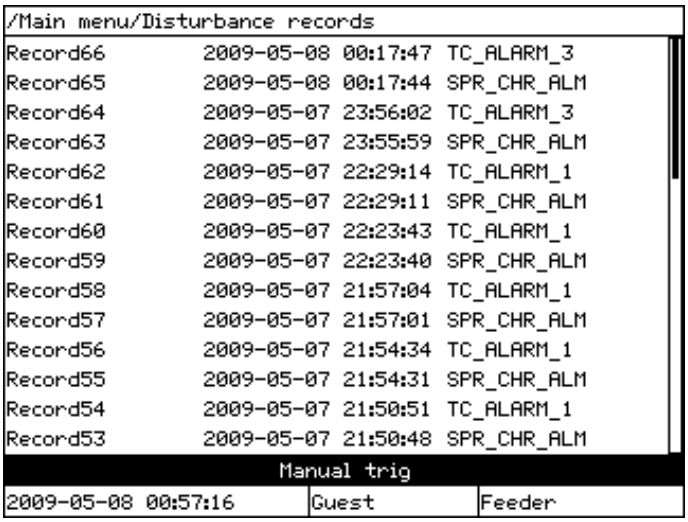

Figure 32: Manual triggering

The disturbance recorder is now triggered.

6.1.3.2 Monitoring disturbance recorder data

Upload individual disturbance recordings from the IED with the PCM600 software to monitor disturbance recorder data.

1. Select **Main menu/Disturbance records**.
   All disturbance records are listed.
2. Scroll the view with or .

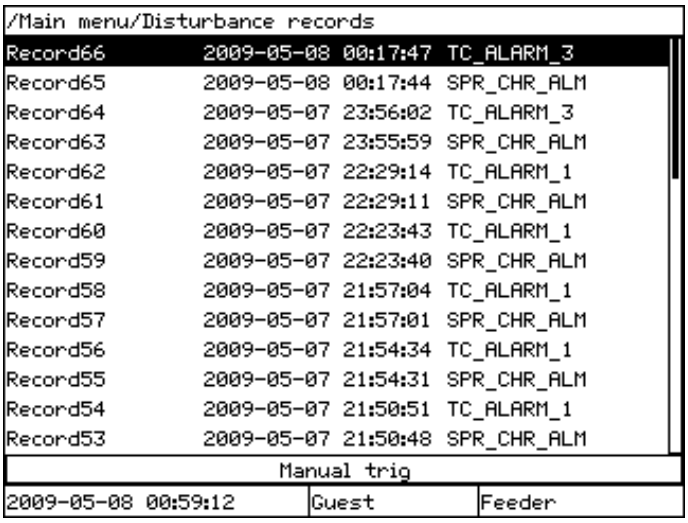

Figure 33: Monitoring disturbance recorder via the LHMI

3. To view a specific disturbance record, press .
A list of detail categories is displayed.

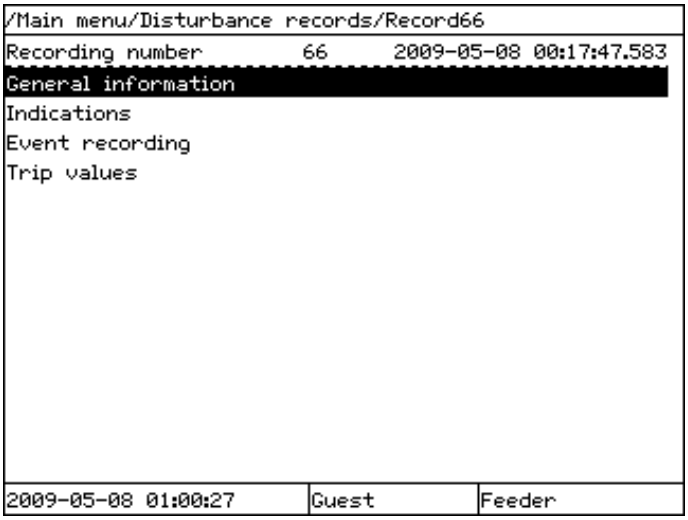

Figure 34: Disturbance record data categories

4. To select a category and view the items under it, press or and then .

6.1.3.3 Controlling and uploading disturbance recorder data

Disturbance recorder data can be controlled and read with PCM600.

For more information, see PCM600 documentation.

6.1.3.4 Monitoring events

The event view contains a list of events produced by the application configuration. The events are grouped by day, and each event takes one line. Select the order of events with the setting **Main menu/Configuration/HMI/Screen/1:SCREEN/ EvListSrtOrder**.

1. Select **Main menu/Events**.
2. Press → to open the event list.
   Events are shown grouped by date.
   Time, channel, signal name and value of the event are shown.
3. Press ↑ or ↓ to scroll the view.

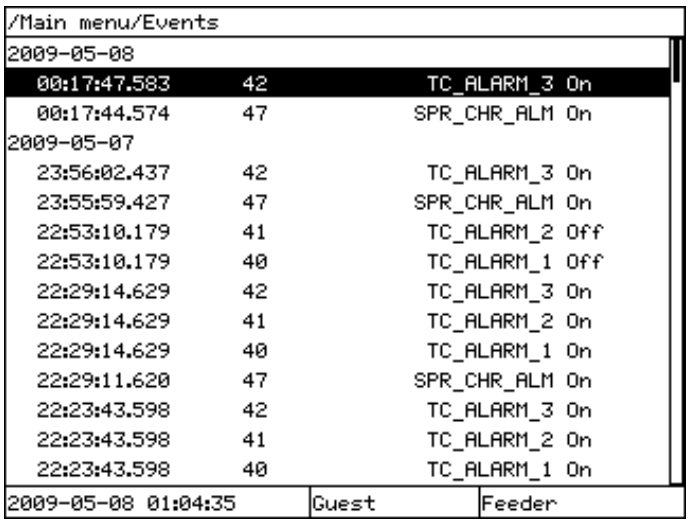

Figure 35: Monitoring events

The event list is not updated dynamically. To update the list, leave the Events menu and then select it again.

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 the user is authorized to access control operations.

1. Select **Main menu/Control/Single line diagram**.

The SLD displays all controllable objects.

2. Select an object with ↑ or ↓.
   Selection of object is indicated with a square border that moves when ↑ and ↓ are used.
   Breaker objects can have additional icons that present the breaker states.
   ! Circuit breaker is in substituted state.
   Circuit breaker is interlocked.
3. Press ○ to select open or | to select close the object.

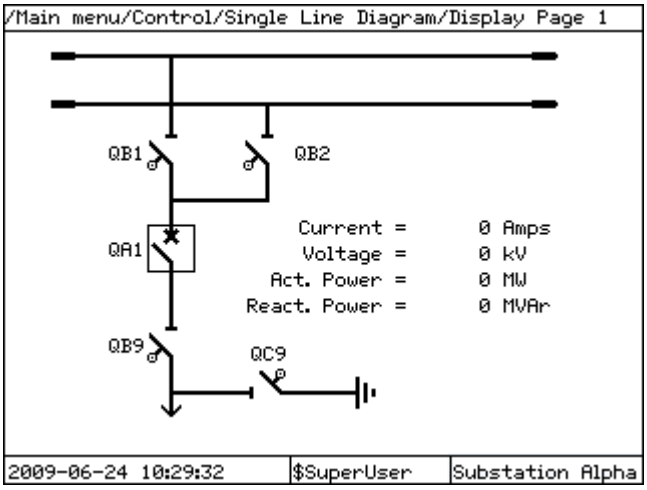

Figure 36: Selecting an object

4. Press ↵ to confirm the operation.

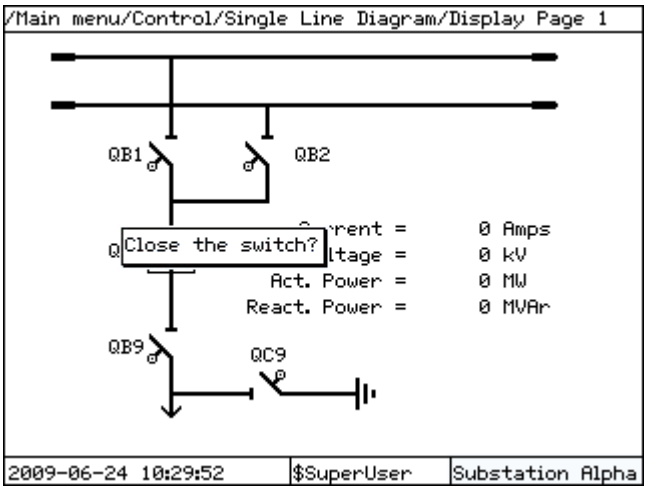

Figure 37: Closing a circuit breaker

- Press ESC to cancel the operation.

5. Press ← or → to move between single-line diagram pages.

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 the IED

6.3.1 Clearing and acknowledging via the local HMI

Use the Clear button to reset, acknowledge or clear all messages and indications, including LEDs and latched outputs as well as registers and recordings. Pressing the Clear button activates a view for selecting the reset function. Events and alarms assigned to alarm LEDs can also be cleared with the Clear button.

1. Press Clear to activate the Clear view.
   All the items that can be cleared are shown.

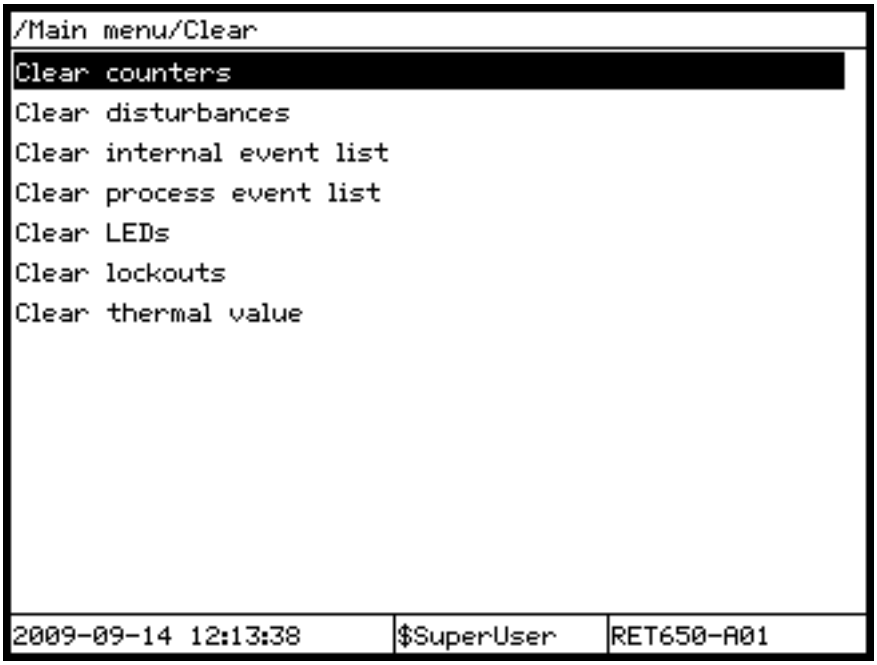

Figure 38: Clear view

   The content of the Clear menu depends on the configuration configured with PCM600.
2. Select the item to be cleared with ↑ or ↓.
3. Press →, select `OK` to confirm the selection or `Cancel` to cancel the selection.
4. To clear other items, repeat the steps.

6.4 Changing the IED functionality

6.4.1 Defining the setting group

6.4.1.1 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.

1. Select **Main menu/Settings/Activate setting group/1:SETGRPS** and press .

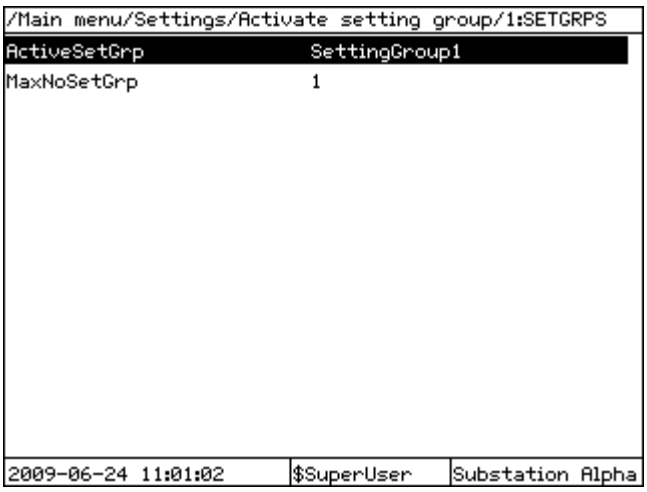

Figure 39: Active setting group

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

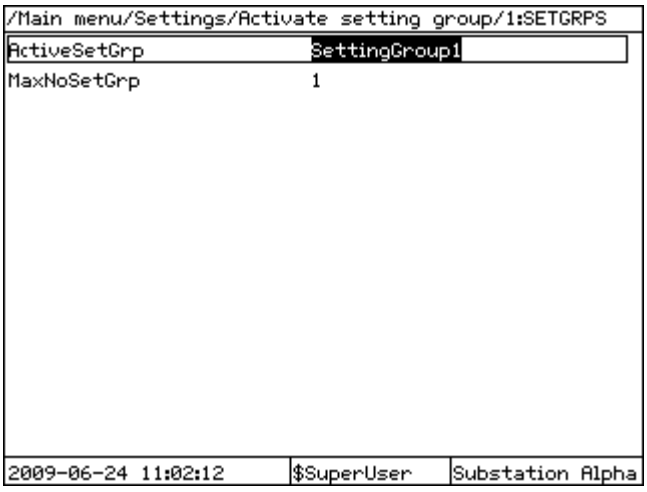

Figure 40: Selecting the active setting group

4. Commit the settings.

Remember to document the changes you make.

6.4.1.2 Browsing and editing setting group values

1. Select **Main menu/Settings/IED setting** and press .
   Setting group 1 is the default setting group to be edited.

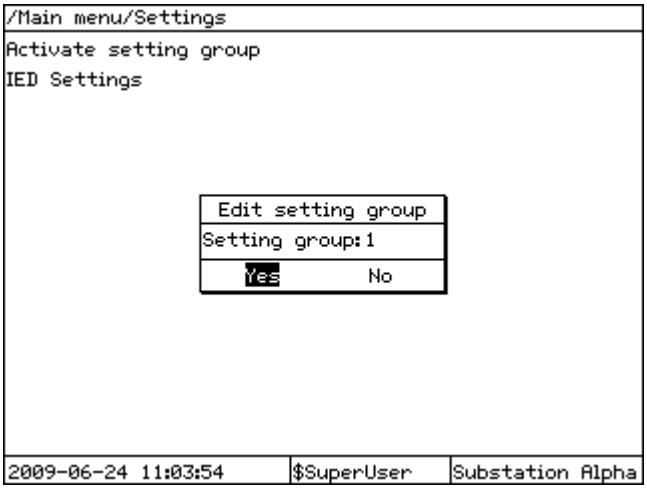

Figure 41: Selecting a setting group for editing

2. Press on the `Setting group` line in the dialog box to activate selection mode.
3. Select the wanted setting group with or and press .

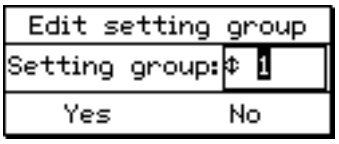

Figure 42: Changing the setting group

4. Select `Yes` in the dialog, and press ↵ to continue.
   The current setting group is displayed on the left in the header.
5. Select the application function category in the list with ↑ or ↓, and press → to see the function blocks in that category.
   Categories available in the list depend on the configuration configured with PCM600.

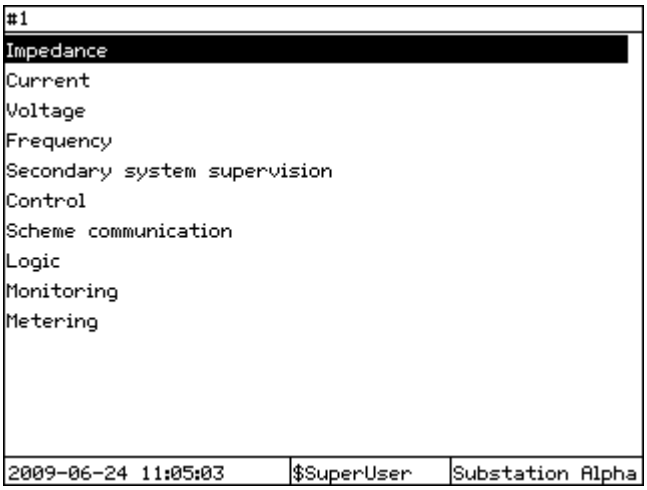

Figure 43: Selecting the function category

6. To browse the function blocks, scroll the list with ↑ and ↓.
   Function blocks available depend on the application configuration. To move back to the list, press ←.
7. To select a function block, press →.

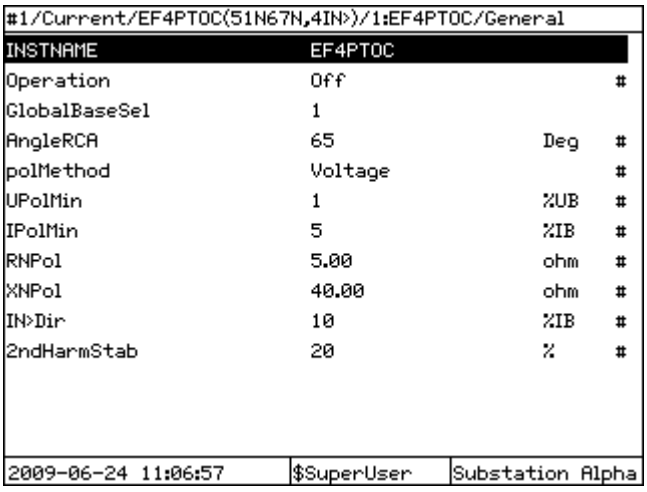

Figure 44: Function block settings

The # character on the right indicates that the parameter belongs to a setting group.

8. To browse the settings, scroll the list with and .
9. To edit the selected setting, press .
   - In case of a parameter that is not part of a setting group, the parameter is activated for editing.
   - In case of a setting group parameter, the editing dialog shows the value of the setting in all available setting groups, but you can edit only the value in the selected setting group. The active setting group is marked with an asterisk *.

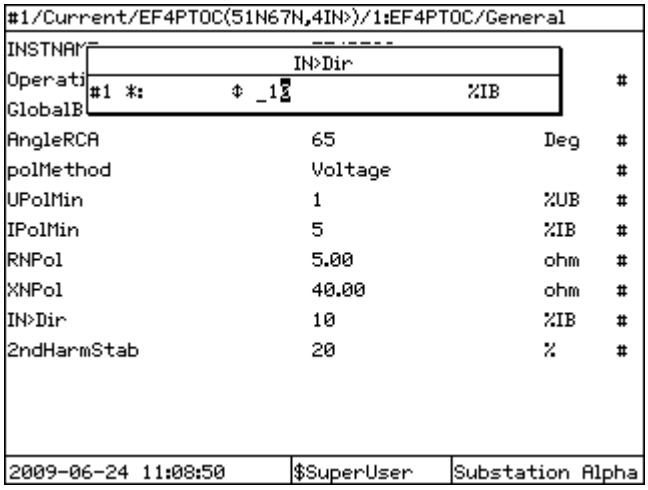

Figure 45: Changing the setting value

10. Press or to change the value.
11. Confirm the change with .

6.4.2 Activating LEDs

To be able to activate the LEDs, they have to be configured with PCM600.

1. Select **Main menu/Configuration/HMI/LEDs** and press .

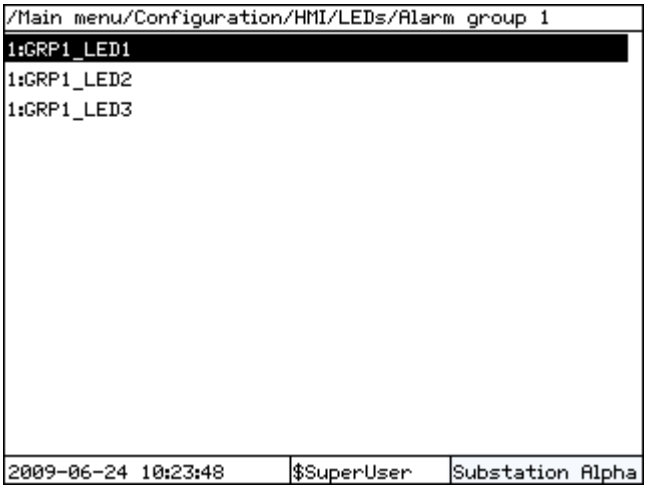

Figure 46: Alarm groups

The list can contain three alarm groups at the maximum. The amount of groups depends on the amount of LEDs taken into use.

2. Select an alarm group with or and press .
3. Select an Alarm LED with or .
4. Press to confirm the selection and to change the Alarm LED mode.
5. Press or to change the value and to confirm the selection.

For more information, see PCM600 documentation.

Section 7 Troubleshooting

7.1 Fault tracing

7.1.1 Identifying hardware errors

1. Check the module with an error.
   - Check the general IED status in **Main menu/Diagnostics/IED status/General** for a faulty hardware module.
   - Check the history of changes in internal event list in **Main menu/Events**.
2. Inspect the IED visually.
   - Inspect the IED visually to find any physical error causes.
   - If you can find some obvious physical damage, contact ABB for repair or replacement actions.
3. Check whether the error is external or internal.
   - Check that the error is not caused by external origins.
   - Remove the wiring from the 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

1. Check the error origin from IED's internal event list **Main menu/Diagnostics/IED status/General**.
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.

- Check the IEC61850 and DNP3 communication status in internal event list in **Main menu/Diagnostics/IED Status/General**.
- In case of persistent faults originating from IED's internal faults such as component breakdown, contact ABB for repair or replacement actions.

7.1.3.1 Checking the communication link operation

There are several different communication links on the product. First check that all communication ports that are used for communication are turned on.

1. Check the front communication port RJ-45.
   1.1. Check that the uplink LED is lit with a steady green light.
   The uplink LED is located on the LHMI above the RJ-45 communication port on the left. The port is used for direct electrical communication to a PC connected via a crossed-over Ethernet cable.
   1.2. Check the communication status of the front port via the LHMI in **Main menu/Test/Function status/Communication/1:DOSFRNT/Outputs**.
   Check that the *LINKUP* value is 1, that is, the communication is working. When the value is 0, there is no communication link.

The rear port connector X0 is used for connecting an external HMI to the IED. If the *LINKUP* value is 0 for front port, there is no communication link via port X0. Do not use rear port connector X0 if the IED is equipped with an LHMI.

2. Check the communication status of the rear port X1 via the LHMI in **Main menu/Test/Function status/Communication/1:DOSLAN1/Outputs**.
   The X1 communication port on the rear side of the IED is for optical Ethernet via LC connector or electrical via RJ-45 connector of the IEC 61850-8-1 station bus communication.
   - Check that the *LINKUP* value is 1, that is, the communication is working. When the value is 0, there is no communication link.

7.1.3.2 Checking the time synchronization

- Select **Main menu/Diagnostics/IED status/General** and check the status of the time synchronization on **Time Synch**.
  The *Time synch* value is *Ready* when the synchronization is in order. Note that the time synchronization source has to be activated. Otherwise the value is always *Ready*.

7.1.4 Running the display test

To run the display test, either use the push buttons or start the test via the menu.

- Select **Main menu/Tests/LED test**.
- Press → or simultaneously ESC and ☰.

All 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

When the Ready LED indicates an internal fault by flashing, the message associated with the fault is found in the internal event list in the LHMI menu **Main menu/Diagnostics/Internal events**. The message includes the date, time, description and signal state for the fault. The internal event list is not updated dynamically. The list is updated by leaving the **Internal events** menu and then selecting it again. The current status of the internal fault signals can also be checked via the LHMI in **Main menu/Diagnostics/IED status**.

Different actions are taken depending on the severity of the fault. After the fault is found to be permanent, the IED stays in internal fault mode. The IED continues to perform internal tests during the fault situation.

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

Table 18: Internal fault indications

Fault indication	Additional information
Internal Fault Real Time Clock Error	Hardware error with the real time clock.
Internal Fault Runtime Exec. Error	One or more of the application threads are not working properly.
Internal Fault SW Watchdog Error	This signal will be activated when the terminal has been under too heavy load for at least 5 minutes.
Internal Fault Runtime App Error	One or more of the application threads are not in an expected state.
Internal Fault File System Error	A file system error has occurred.
Internal Fault TRM-Error	A TRM card error has occurred. The instance number is displayed at the end of the fault indication.
Internal Fault BIO-Error	A BIO card error has occurred. The instance number is displayed at the end of the fault indication.
Internal Fault COM-Error	A COM card error has occurred. The instance number is displayed at the end of the fault indication.
Internal Fault PSM-Error	A PSM card error has occurred. The instance number is displayed at the end of the fault indication.

7.2.2 Warnings

The warning message associated with the fault is found in the internal event list in the LHMI menu **Main menu/Diagnostics/Internal events**. The message includes the date, time, description and signal state for the fault. The current status of the internal fault signals can also be checked via the LHMI in **Main menu/Diagnostics/IED status/General**.

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

Table 19: Warning indications

Warning indication	Additional information
Warning IEC 61850 Error	IEC 61850 has not succeeded in some actions such as reading the configuration file, startup etc.
Warning DNP3 Error	Error in DNP3 communication.

7.2.3 Additional indications

The additional indication messages do not activate internal fault or warning.

The messages are listed in the LHMI menu under the event list. The signal status data is found under the IED status and in the internal event list.

Table 20: Additional indications

Warning indication	Additional information
Time Synch Error	Source of the time synchronization is lost or time system has made a time reset.
BATTERY1 Error	BATTERY1 Error status.
Settings Changed	Settings have been changed.
Setting Groups Changed	Setting group has been changed.

7.3 Correction procedures

7.3.1 Resetting the configuration

The configuration is reset with PCM600.

For more information, see PCM600 documentation.

7.3.2 Changing and setting the password

The password can only be set with PCM600.

For more information, see PCM600 documentation.

7.3.3 Identifying IED application problems

Navigate to the appropriate menu in the LHMI to identify possible problems.

- Check that the function is on.
- Check that the correct setting group (1 to 4) is activated.
- Check the blocking.
- Check the mode.
- Check the measurement value.
- Check the connection to trip and disturbance recorder functions.
- Check the channel settings.

7.3.3.1 Inspecting the wiring

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

- Check the current or voltage measurements and their phase information from **Main menu/Measurements/Analog primary values** or **Analog secondary voltages**.
- Check that the phase information and phase shift between phases is correct.
- Correct the wiring if needed.
  - Change the parameter *Negation* in **Configuration/Analog modules/ 3PhaseAnalogGroup/1:SMAI_20_n** (n= the number of the SMAI used).

    Changing the *Negation* parameter is not recommended without special skills.

  - Change the parameter in PCM600, see PCM600 documentation.
- Check the actual state of the connected binary inputs.
  - In LHMI, select **Main menu/Tests/Binary input values/Binary input modules**. Then navigate to the board with the actual binary input to be checked.
  - Check the actual state of the connected binary inputs through PCM600, see PCM600 documentation.

- Measure output contacts using the voltage drop method of applying at least the minimum contact load given for the output relays in the technical data, for example 100 mA at 24 V AC/DC.

  Output relays, especially power output relays, are designed for breaking high currents. Due to this, layers of high resistance may appear on the surface of the contacts. Do not determine proper functionality of connectivity or contact resistance by measuring with a regular hand-held ohm meter.

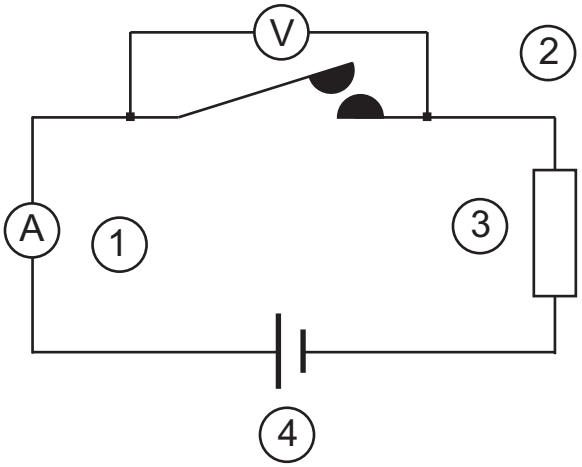

Figure 47: Testing output contacts using the voltage drop method

1 Contact current
2 Contact voltage drop
3 Load
4 Supply voltage

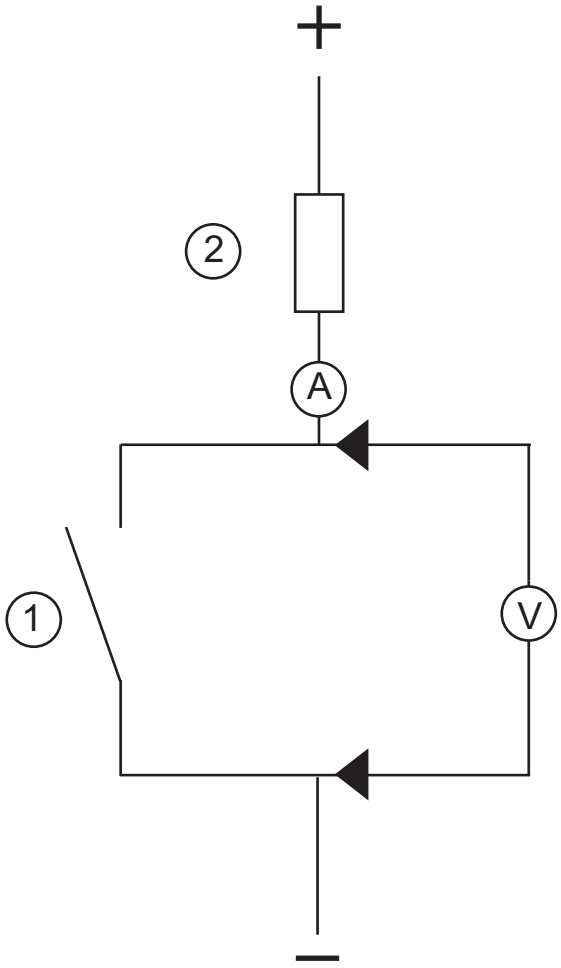

Figure 48: Testing a trip contact

1 Trip contact under test
2 Current limiting resistor

- To check the status of the output circuits driving the output relay via the LHMI, select **Main menu/Tests/Binary output values/Binary output modules** and then navigate to the board with the actual binary output to be checked.
- Test and change the relay state manually.
  1. To set the IED to test mode, select **Main menu/Tests/IED testmode1:TESTMODE/TestMode** and set the parameter to *On*.
  2. To operate or force the output relay to operate, select **Main menu/Tests/ Forcing/Binary output values** and then navigate to the board with the actual binary output relay to be operated/forced.
  3. Select the BOn_PO to be operated/forced and use and or to operate the actual output relay.

Each BOn_PO is represented by two signals. The first signal in LHMI is the actual value 1 or 0 of the output, and in PCM600 a lit or dimmed diode. The second signal is the status Normal or Forced. Forced status is only achieved when the BO is set to *Forced* or operated on the LHMI.

Set the parameter *TestMode* to *Off* after completing these tests. The Start LED will stop flashing when the relay is no longer in test mode.

An initially high contact resistance will not cause problems as it will be reduced quickly by the electrical cleaning effect of fritting and thermal destruction of layers, bringing the contact resistance back to the mOhm range. As a result, practically the full voltage is available at the load.

Section 8 Glossary

AC	Alternating current
ACT	Application configuration tool within PCM600
A/D converter	Analog to digital converter
ADBS	Amplitude dead-band supervision
ANSI	American National Standards Institute
AR	Autoreclosing
ASCT	Auxiliary summation current transformer
ASD	Adaptive signal detection
AWG	American Wire Gauge standard
BR	External bi-stable relay
BS	British standard
CAN	Controller Area Network. ISO standard (ISO 11898) for serial communication
CB	Circuit breaker
CCITT	Consultative Committee for International Telegraph and Telephony. A United Nations sponsored standards body within the International Telecommunications Union.
CCVT	Capacitive Coupled Voltage Transformer
Class C	Protection Current Transformer class as per IEEE/ ANSI
CMPPS	Combined mega pulses per second
CO cycle	Close-open cycle
Co-directional	Way of transmitting G.703 over a balanced line. Involves two twisted pairs making it possible to transmit information in both directions
COMTRADE	Standard format according to IEC 60255-24
Contra-directional	Way of transmitting G.703 over a balanced line. Involves four twisted pairs of with two are used for transmitting data in both directions, and two pairs for transmitting clock signals
CPU	Central processor unit
CR	Carrier receive
CRC	Cyclic redundancy check
CS	Carrier send

CT	Current transformer
CVT	Capacitive voltage transformer
DAR	Delayed auto-reclosing
DARPA	Defense Advanced Research Projects Agency (The US developer of the TCP/IP protocol etc.)
DBDL	Dead bus dead line
DBLL	Dead bus live line
DC	Direct current
DFT	Discrete Fourier transform
DIP-switch	Small switch mounted on a printed circuit board
DLLB	Dead line live bus
DNP	Distributed Network Protocol as per IEEE/ANSI Std. 1379-2000
DR	Disturbance recorder
DRAM	Dynamic random access memory
DRH	Disturbance report handler
DSP	Digital signal processor
DTT	Direct transfer trip scheme
EHV network	Extra high voltage network
EIA	Electronic Industries Association
EMC	Electro magnetic compatibility
EMF	Electro motive force
EMI	Electro magnetic interference
EnFP	End fault protection
ESD	Electrostatic discharge
FOX 20	Modular 20 channel telecommunication system for speech, data and protection signals
FOX 512/515	Access multiplexer
FOX 6Plus	Compact, time-division multiplexer for the transmission of up to seven duplex channels of digital data over optical fibers
G.703	Electrical and functional description for digital lines used by local telephone companies. Can be transported over balanced and unbalanced lines
GCM	Communication interface module with carrier of GPS receiver module
GDE	Graphical display editor within PCM600

GI	General interrogation command
GIS	Gas insulated switchgear
GOOSE	Generic object oriented substation event
GPS	Global positioning system
HDLC protocol	High level data link control, protocol based on the HDLC standard
HFBR connector type	Plastic fiber connector
HMI	Human machine interface
HSAR	High speed auto reclosing
HV	High voltage
HVDC	High voltage direct current
IDBS	Integrating dead band supervision
IEC	International Electrical Committee
IEC 60044-6	IEC Standard, Instrument transformers – Part 6: Requirements for protective current transformers for transient performance
IEC 61850	Substation Automation communication standard
IEEE	Institute of Electrical and Electronics Engineers
IEEE 802.12	A network technology standard that provides 100 Mbits/s on twisted-pair or optical fiber cable
IEEE P1386.1	PCI Mezzanine card (PMC) standard for local bus modules. References the CMC (IEEE P1386, also known as Common mezzanine card) standard for the mechanics and the PCI specifications from the PCI SIG (Special Interest Group) for the electrical EMF Electro Motive Force.
IED	Intelligent electronic device
I-GIS	Intelligent gas insulated switchgear
Instance	When several occurrences of the same function are available in the IED they are referred to as instances of that function. One instance of a function is identical to another of the same kind but will have a different number in the IED user interfaces. The word instance is sometimes defined as an item of information that is representative of a type. In the same way an instance of a function in the IED is representative of a type of function.
IP	1. Internet protocol. The network layer for the TCP/IP protocol suite widely used on Ethernet networks. IP is a connectionless, best-effort packet switching protocol. It

	provides packet routing, fragmentation and re-assembly through the data link layer. 2. Ingression protection according to IEC standard
IP 20	Ingression protection, according to IEC standard, level 20
IP 40	Ingression protection, according to IEC standard, level 40
IP 54	Ingression protection, according to IEC standard, level 54
IRF	Internal fail signal
IRIG-B:	InterRange Instrumentation Group Time code format B, standard 200
ITU	International Telecommunications Union
LAN	Local area network
LIB 520	High voltage software module
LCD	Liquid crystal display
LDD	Local detection device
LED	Light emitting diode
MCB	Miniature circuit breaker
MCM	Mezzanine carrier module
MVB	Multifunction vehicle bus. Standardized serial bus originally developed for use in trains.
NCC	National Control Centre
OCO cycle	Open-close-open cycle
OCP	Overcurrent protection
OLTC	On load tap changer
OV	Over voltage
Overreach	A term used to describe how the relay behaves during a fault condition. For example a distance relay is over-reaching when the impedance presented to it is smaller than the apparent impedance to the fault applied to the balance point, i.e. the set reach. The relay “sees” the fault but perhaps it should not have seen it.
PCI	Peripheral component interconnect, a local data bus
PCM	Pulse code modulation
PCM600	Protection and control IED manager
PC-MIP	Mezzanine card standard
PISA	Process interface for sensors & actuators
PMC	PCI Mezzanine card
POTT	Permissive overreach transfer trip

Process bus	Bus or LAN used at the process level, that is, in near proximity to the measured and/or controlled components
PSM	Power supply module
PST	Parameter setting tool within PCM600
PT ratio	Potential transformer or voltage transformer ratio
PUTT	Permissive underreach transfer trip
RASC	Synchrocheck relay, COMBIFLEX
RCA	Relay characteristic angle
REVAL	Evaluation software
RFPP	Resistance for phase-to-phase faults
RFPE	Resistance for phase-to-earth faults
RISC	Reduced instruction set computer
RMS value	Root mean square value
RS422	A balanced serial interface for the transmission of digital data in point-to-point connections
RS485	Serial link according to EIA standard RS485
RTC	Real time clock
RTU	Remote terminal unit
SA	Substation Automation
SC	Switch or push-button to close
SCS	Station control system
SCT	System configuration tool according to standard IEC 61850
SMA connector	Subminiature version A, A threaded connector with constant impedance.
SMT	Signal matrix tool within PCM600
SMS	Station monitoring system
SNTP	Simple network time protocol – is used to synchronize computer clocks on local area networks. This reduces the requirement to have accurate hardware clocks in every embedded system in a network. Each embedded node can instead synchronize with a remote clock, providing the required accuracy.
SRY	Switch for CB ready condition
ST	Switch or push-button to trip
Starpoint	Neutral point of transformer or generator
SVC	Static VAr compensation
TC	Trip coil

TCS	Trip circuit supervision
TCP	Transmission control protocol. The most common transport layer protocol used on Ethernet and the Internet.
TCP/IP	Transmission control protocol over Internet Protocol. The de facto standard Ethernet protocols incorporated into 4.2BSD Unix. TCP/IP was developed by DARPA for internet working and encompasses both network layer and transport layer protocols. While TCP and IP specify two protocols at specific protocol layers, TCP/IP is often used to refer to the entire US Department of Defense protocol suite based upon these, including Telnet, FTP, UDP and RDP.
TNC connector	Threaded Neill Concelman, A threaded constant impedance version of a BNC connector
TPZ, TPY, TPX, TPS	Current transformer class according to IEC
Underreach	A term used to describe how the relay behaves during a fault condition. For example a distance relay is under-reaching when the impedance presented to it is greater than the apparent impedance to the fault applied to the balance point, i.e. the set reach. The relay does not “see” the fault but perhaps it should have seen it. See also Overreach.
U/I-PISA	Process interface components that deliver measured voltage and current values
UTC	Coordinated universal time. A coordinated time scale, maintained by the Bureau International des Poids et Mesures (BIPM), which forms the basis of a coordinated dissemination of standard frequencies and time signals. UTC is derived from International Atomic Time (TAI) by the addition of a whole number of "leap seconds" to synchronize it with Universal Time 1 (UT1), thus allowing for the eccentricity of the Earth"s orbit, the rotational axis tilt (23.5 degrees), but still showing the Earth"s irregular rotation, on which UT1 is based. The Coordinated Universal Time is expressed using a 24-hour clock and uses the Gregorian calendar. It is used for aeroplane and ship navigation, where it also sometimes known by the military name, "Zulu time". "Zulu" in the phonetic alphabet stands for "Z" which stands for longitude zero.
UV	Undervoltage
WEI	Weak end infeed logic
VT	Voltage transformer
X.21	A digital signalling interface primarily used for telecom equipment

$3I_O$	Three times zero-sequence current. Often referred to as the residual or the earth-fault current
$3U_O$	Three times the zero sequence voltage. Often referred to as the residual voltage or the neutral point voltage

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