Relion® 615 series

Motor Protection and Control REM615 Application Manual

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Disclaimer

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 the result of tests conducted by ABB in accordance 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.

Table of contents

Section 1 Introduction

1.1 This manual

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.

1.2 Intended audience

This manual addresses the protection and control engineer responsible for planning, pre-engineering and engineering.

The protection and control engineer must be experienced in electrical power engineering and have knowledge of related technology, such as communication and protocols.

1.3 Product documentation

1.3.1 Product documentation set

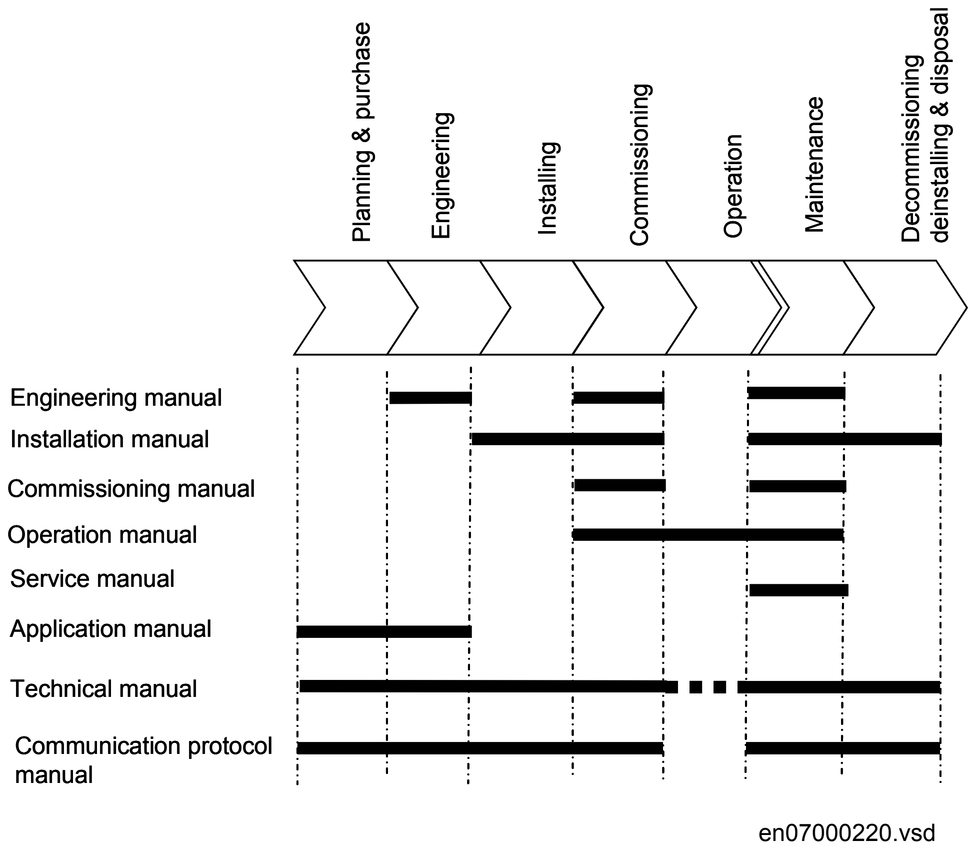


Figure 1: The intended use of manuals in different lifecycles

Engineering Manual contains instructions on how to engineer the IEDs. 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 IEDs 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 chronological order in which the 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 chronological order in which the IED should be commissioned.

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 network data 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.

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

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.

Some of the manuals are not available yet.

1.3.2 Document revision history

Document revision/date	Product version	History
A/03.07.2009	2.0	First release

Download the latest documents from the ABB web site http://www.abb.com/substationautomation.

1.3.3 Related documentation

Name of the document	Document ID
Modbus Communication Protocol Manual	1MRS756468
DNP3 Communication Protocol Manual	1MRS756709
IEC 60870-5-103 Communication Protocol Manual	1MRS756710
IEC 61850 Engineering Guide	1MRS756475
Installation Manual	1MRS756375
Operation Manual	1MRS756708
Technical Manual	1MRS756887

1.4 Document symbols and conventions

1.4.1 Safety indication symbols

This publication includes 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 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 Document conventions

- 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/Information**.
- 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.
- 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: REM615 Functions, codes and symbols

Functionality	IEC 61850	IEC 60617	IEC-ANSI
Protection			
Three-phase non-directional overcurrent protection, low stage, instance 1	PHLPTOC1	3I> (1)	51P-1 (1)
Three-phase non-directional overcurrent protection, instantaneous stage, instance 1	PHIPTOC1	3I>>> (1)	50P/51P (1)
Directional earth-fault protection, low stage, instance 1	DEFLPDEF1	I_0> → (1)	67N-1 (1)
Non-directional earth fault protection, using calculated I0	EFHPTOC1	I_0>>	51N-2
Three-phase undervoltage protection, instance 1	PHPTUV1	3U< (1)	27 (1)
Positive-sequence undervoltage protection	PSPTUV1	U1<	47U+
Negative-sequence overvoltage protection	NSPTOV1	U_2>	47O-
Negative-sequence overcurrent protection for motors, instance 1	MNSPTOC1	I_2>M (1)	46M (1)
Negative-sequence overcurrent protection for motors, instance 2	MNSPTOC2	I_2>M (2)	46M (2)
Table continues on next page			

Functionality	IEC 61850	IEC 60617	IEC-ANSI
Loss of load supervision	LOFLPTUC1	3I<	37
Motor load jam protection	JAMPTOC1	Ist>	51LR
Motor start-up supervision	STTPMSU1	Is2t n<	49,66,48,51LR
Phase reversal protection	PREVPTOC	I_2>>	46R
Thermal overload protection for motors	MPTTR1	3Ith>M	49M
Circuit breaker failure protection	CCBRBRF1	3I>/I_0>BF	51BF/51NBF
Master trip, instance 1	TRPPTRC1	Master Trip (1)	94/86 (1)
Master trip, instance 2	TRPPTRC2	Master Trip (2)	94/86 (2)
Arc protection, instance 1	ARCSARC1	ARC (1)	50L/50NL (1)
Arc protection, instance 2	ARCSARC2	ARC (2)	50L/50NL (2)
Arc protection, instance 3	ARCSARC3	ARC (3)	50L/50NL (3)
Control			
Circuit-breaker control	CBXCBR1	I ↔ O CB	I ↔ O CB
Disconnector position indication, instance 1	DCSXSWI1	I ↔ O DC (1)	I ↔ O DC (1)
Disconnector position indication, instance 2	DCSXSWI2	I ↔ O DC (2)	I ↔ O DC (2)
Disconnector position indication, instance 3	DCSXSWI3	I ↔ O DC (3)	I ↔ O DC (3)
Earthing switch indication	ESSXSWI1	I ↔ O ES	I ↔ O ES
Emergency start-up	ESMGAPC1	ESTART	ESTART
Condition Monitoring			
Circuit-breaker condition monitoring	SSCBR1	CBCM	CBCM
Trip circuit supervision, instance 1	TCSSCBR1	TCS (1)	TCM (1)
Trip circuit supervision, instance 2	TCSSCBR2	TCS (2)	TCM (2)
Current circuit supervision	CCRDIF1	MCS 3I	MCS 3I
Fuse failure supervision	SEQRFUF1	FUSEF	60
Motor runtime counter	MDSOPT1	OPTS	OPTM
Measurement			
Disturbance recorder	RDRE1	-	-
Three-phase current measurement, instance 1	CMMXU1	3I	3I
Sequence current measurement	CSMSQI1	I_1, I_2, I_0	I_1, I_2, I_0
Residual current measurement, instance 1	RESCMMXU1	I_0	I_n
Three-phase voltage measurement	VMMXU1	3U	3U
Residual voltage measurement	RESVMMXU1	U_0	V_n
Sequence voltage measurement	VSMSQI1	U_1, U_2, U_0	U_1, U_2, U_0
Three-phase power and energy measurement	PEMMXU1	P, E	P, E

Section 2 REM615 overview

2.1 Overview

REM615 is a dedicated motor protection and control IED (intelligent electronic device) designed for the protection, control, measurement and supervision of asynchronous motors in manufacturing and process industry. REM615 is a member of ABB's Relion® product family and part of its 615 protection and control product series. The 615 series IEDs are characterized by their compactness and withdrawable design.

Re-engineered from the ground up, the 615 series has been designed to unleash the full potential of the IEC 61850 standard for communication and interoperability between substation automation devices. Once the standard configuration IED has been given the application-specific settings, it can directly be put into service.

The 615 series IEDs support a range of communication protocols including IEC 61850 with GOOSE messaging, IEC 60870-5-103, Modbus® and DNP3.

2.1.1 Product version history

Product version	Product history
2.0	Product released

2.1.2 PCM600 and IED connectivity package version

- Protection and Control IED Manager PCM600 Ver. 2.0 SP2 or later
- REM615 Connectivity Package Ver. 2.5 or later
    - Parameter Setting
    - Firmware Update
    - Disturbance Handling
    - Signal Monitoring
    - Lifecycle Traceability
    - Signal Matrix
    - Communication Management
    - Configuration Wizard
    - Label Printing
    - IED User Management

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

2.2 Operation functionality

2.2.1 Optional functions

- Arc protection
- Modbus TCP/IP or RTU/ASCII
- IEC 60870-5-103
- DNP3 TCP/IP or serial

2.3 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 2: Plug-in unit and case

Main unit	Slot ID	Content options	
Plug-in unit	-	HMI	Small (4 lines, 16 characters) Large (8 lines, 16 characters)
	X100	Auxiliary power/BO module	48-250 V DC/100-240 V AC; or 24-60 V DC 2 normally-open PO contacts 1 change-over SO contact 1 normally-open SO contact 2 double-pole PO contacts with TCS 1 dedicated internal fault output contact
	X110	BIO module	8 binary inputs 4 signal output contacts
	X120	AI/BI module	3 phase current inputs (1/5A) 1 residual current input (1/5A or 0.2/1A)[1)] 4 binary inputs
Case	X130	AI/BI module	3 phase voltage inputs (100, 110, 115 or 120 V) 1 residual voltage input (100, 110, 115 or 120 V) 4 binary inputs
	X000	Optional communication module	See the technical manual for details about different types of communication modules.

1) The 0.2/1A input is normally used in applications requiring sensitive earth-fault protection and featuring core-balance current transformers.

Rated values of the current and voltage inputs are basic setting parameters of the IED. The binary input thresholds are selectable within the range 18…176 V DC by adjusting the binary input setting parameters.

The connection diagrams of different hardware modules are presented in this manual.

See the installation manual for more information about the case and the plug-in unit.

Table 3: Number of physical connections in standard configurations

Conf.	Analog channels		Binary channels	
	CT	VT	BI	BO
C	4	5 1)	12	10

1) One of the five channels reserved for future applications

2.4 Local HMI

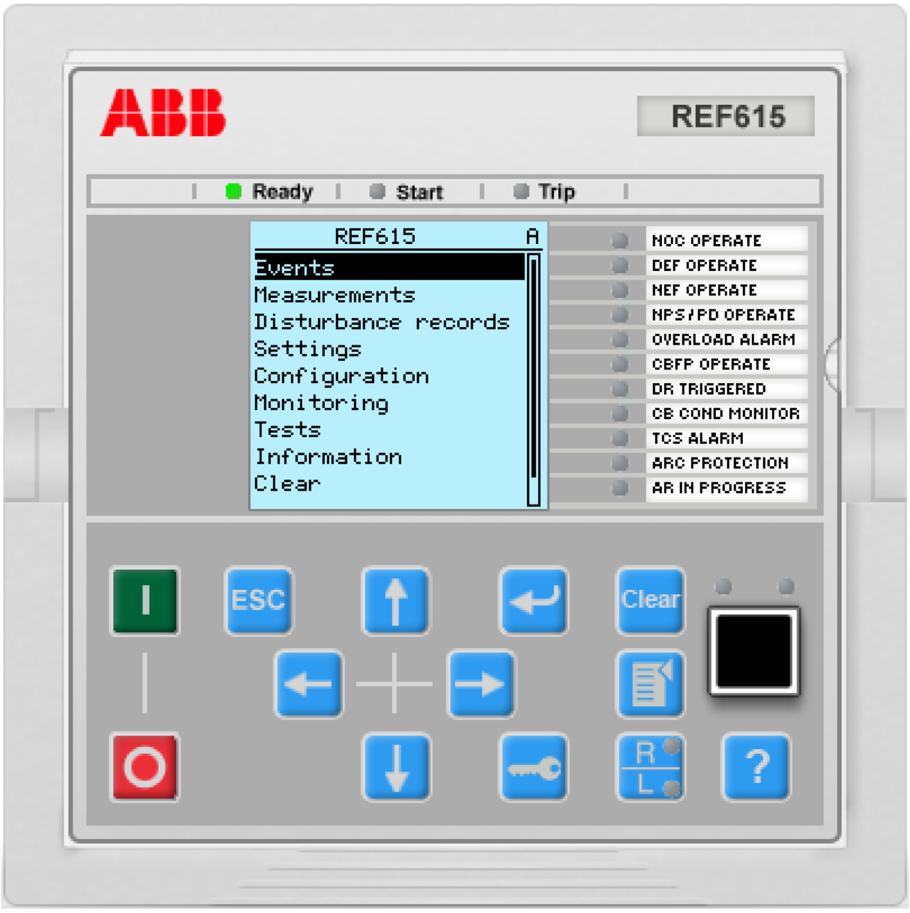


Figure 2: LHMI

The LHMI of the IED contains the following elements:

- Display
- Buttons
- LED indicators
- Communication port

The LHMI is used for setting, monitoring and controlling.

2.4.1 LCD

The LHMI includes a graphical LCD that supports two character sizes. The character size depends on the selected language. The amount of characters and rows fitting the view depends on the character size.

Table 4: Characters and rows on the view

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.

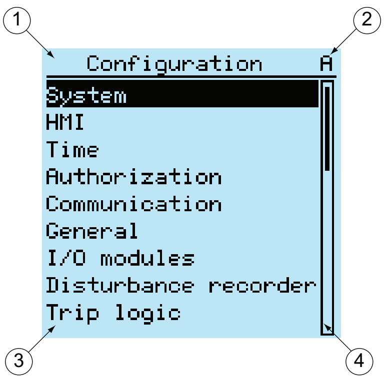


Figure 3: Display layout

1 Header

2 Icon

3 Content

4 Scroll bar (displayed when needed)

2.4.2 LEDs

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

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

2.4.3 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 switch. The push-buttons are also used to acknowledge alarms, reset indications, provide help and switch between local and remote control mode.

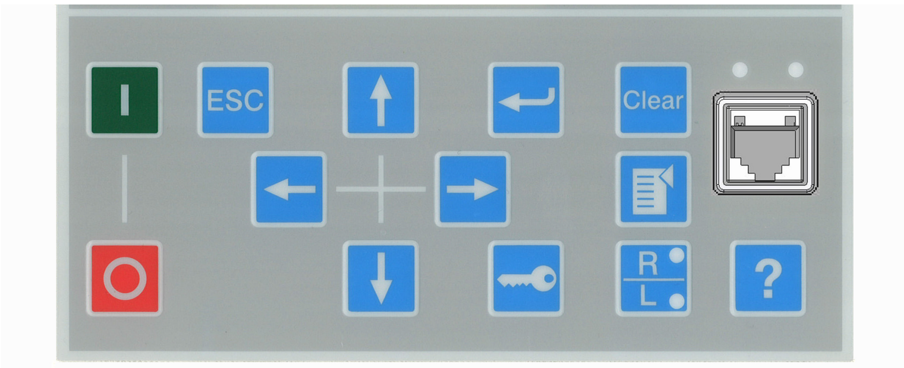


Figure 4: LHMI keypad with object control, navigation and command push-buttons and RJ-45 communication port

2.5 Web HMI

The WHMI enables the user to access the IED via a web browser. The supported web browser version is Internet Explorer 7.0 or later.

WHMI is disabled by default.

WHMI offers several functions.

- Alarm indications and event lists
- System supervision
- Parameter settings

- Measurement display
- Disturbance records
- Phasor diagram

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

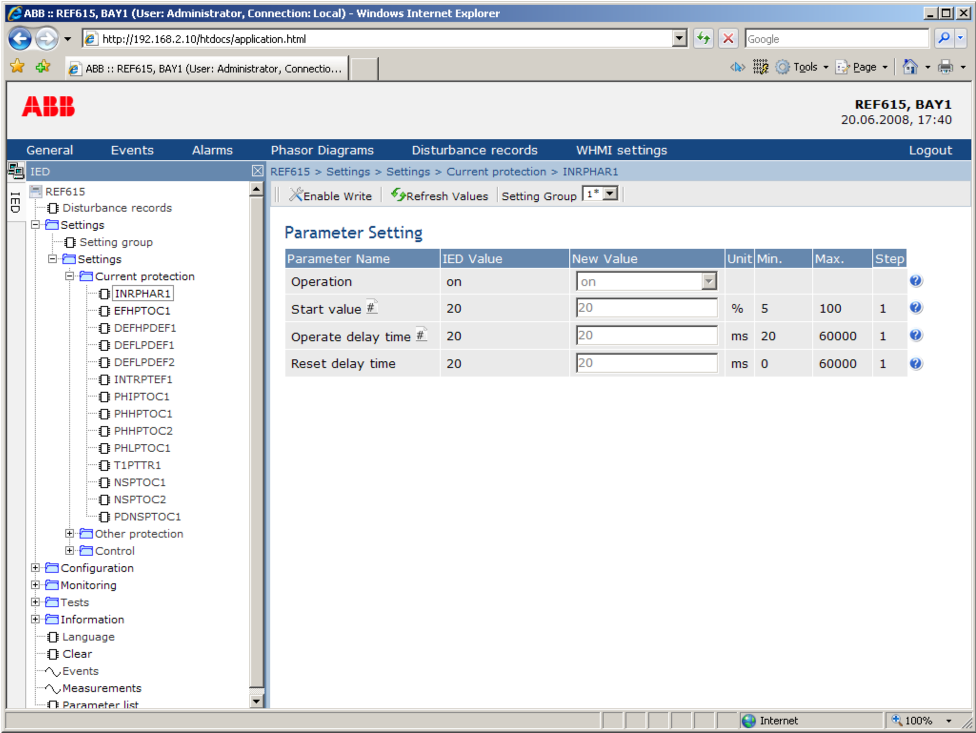


Figure 5: Example view of the WHMI

The WHMI can be accessed locally and remotely.

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

2.6 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 but WHMI always uses authorization.

Table 5: Predefined user categories

Username	User rights
VIEWER	Read only access
OPERATOR	• Selecting remote or local state with R/L (only locally) • Changing setting groups • Controlling • Clearing alarm and indication LEDs and textual indications
ENGINEER	• Changing settings • Clearing event list • Clearing disturbance records • Changing system settings such as IP address, serial baud rate or disturbance recorder settings • Setting the IED to test mode • Selecting language
ADMINISTRATOR	• All listed above • Changing password • Factory default activation

For user authorization for PCM600, see PCM600 documentation.

2.7 Communication

The IED supports a range of communication protocols including IEC 61850, IEC 60870-5-103, Modbus® and DNP3. Operational information and controls are available through these protocols.

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 protocol. Disturbance files are available to any Ethernet-based application in the standard COMTRADE format. 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 meets the GOOSE performance requirements for tripping applications in distribution substations, as defined by the IEC 61850 standard. The IED can simultaneously report events to five different clients on the station bus.

The IED can support five simultaneous clients. If PCM600 reserves one client connection, only four client connections are left, for example, for IEC 61850 and Modbus.

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).

Section 3 REM615 variants

3.1 REM615 variant list

3.2 Presentation of standard configurations

Functional diagrams

The functional diagrams describe the IED's functionality from the protection, measuring, condition monitoring, disturbance recording, control and interlocking perspective. Diagrams show the default functionality with simple symbol logics forming principle diagrams. The external connections to primary devices are also shown, stating the default connections to measuring transformers. The positive measuring direction of directional protection functions is towards the outgoing feeder.

The functional diagrams are divided into sections which each constitute one functional entity. The external connections are also divided into sections. Only the relevant connections for a particular functional entity are presented in each section.

Protection function blocks are part of the functional diagram. They are identified based on their IEC 61850 name but the IEC based symbol and the ANSI function number are also included. Some function blocks, such as PHHPTOC, are used several times in the configuration. To separate the blocks from each other, the IEC 61850 name, IEC symbol and ANSI function number are appended with a running number, that is an instance number, from one upwards. If the block has no suffix after the IEC or ANSI symbol, the function block has been used, that is, instantiated, only once. The IED’s internal functionality and the external connections are separated with a dashed line presenting the IED’s physical casing.

Signal Matrix

With Signal Matrix the user can modify the standard configuration according to the actual needs. The IED is delivered from the factory with default connections described in the functional diagrams for BI's, BO's, function to function connections and alarm LEDs. Signal Matrix has a number of different page views, designated as follows:

- Binary input
- Binary output
- Functions

The functions in different page views are identified by the IEC 61850 names with analogy to the functional diagrams.

3.2.1 Standard configuration

The motor protection and control IED REM615 is available with one standard configuration.

Table 6: Standard configuration

Description	Std.conf.
Motor protection with current and voltage based protection and measurements functions	C

Table 7: Supported functions

Functionality	C
Protection [1)]	
Thermal overload protection for motors	•
Motor start-up supervision	•
Negative-sequence overcurrent protection for motors, instance 1	•
Negative-sequence overcurrent protection for motors, instance 2	•
Directional earth-fault protection, low stage, instance 1	•
Non-directional earth-fault protection, using calculated I_0	•
Motor load jam protection	•
Three-phase non-directional overcurrent protection, low stage, instance 1	•
Three-phase non-directional overcurrent protection, instantaneous stage, instance 1	•
Loss of load supervision	•
Phase reversal protection	•
Three-phase undervoltage protection, instance 1	•
Positive-sequence undervoltage protection	•
Negative-sequence overvoltage protection	•
Circuit breaker failure protection	•
Master trip, instance 1	•
Master trip, instance 2	•
Arc protection, instance 1	o
Arc protection, instance 2	o
Arc protection, instance 3	o
Control	
Circuit-breaker control with interlocking	•
Disconnector position indication, instance 1	•
Disconnector position indication, instance 2	•
Disconnector position indication, instance 3	•
Table continues on next page	

Functionality	C
Earthing switch indication	•
Emergency start-up	•
Condition monitoring	
Circuit-breaker condition monitoring	•
Trip circuit supervision, instance 1	•
Trip circuit supervision, instance 2	•
Current circuit supervision	•
Fuse failure supervision	•
Motor runtime counter	•
Measurement	
Disturbance recorder	•
Three-phase current measurement	•
Sequence current measurement	•
Residual current measurement	•
Three-phase voltage measurement	•
Residual voltage measurement	•
Sequence voltage measurement	•
Three-phase power and energy measurement	•
• = included, o = optional at the time of order	

1) Note that all directional protection functions can also be used in non-directional mode.

3.2.2 Terminal diagrams

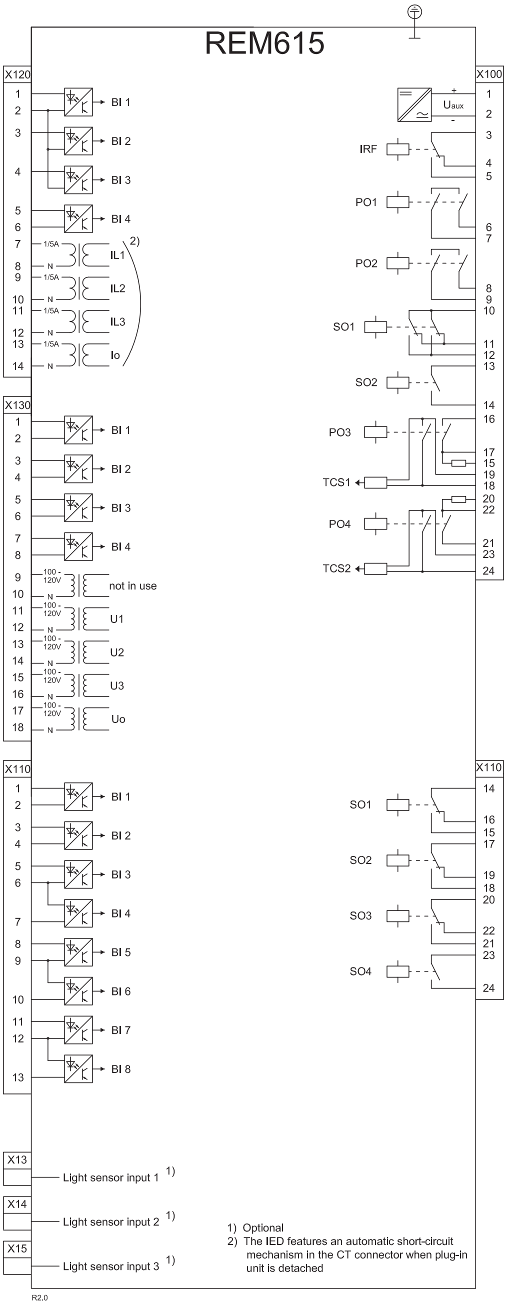


Figure 6: Terminal diagram of standard configuration C

3.2.3 Connection diagrams

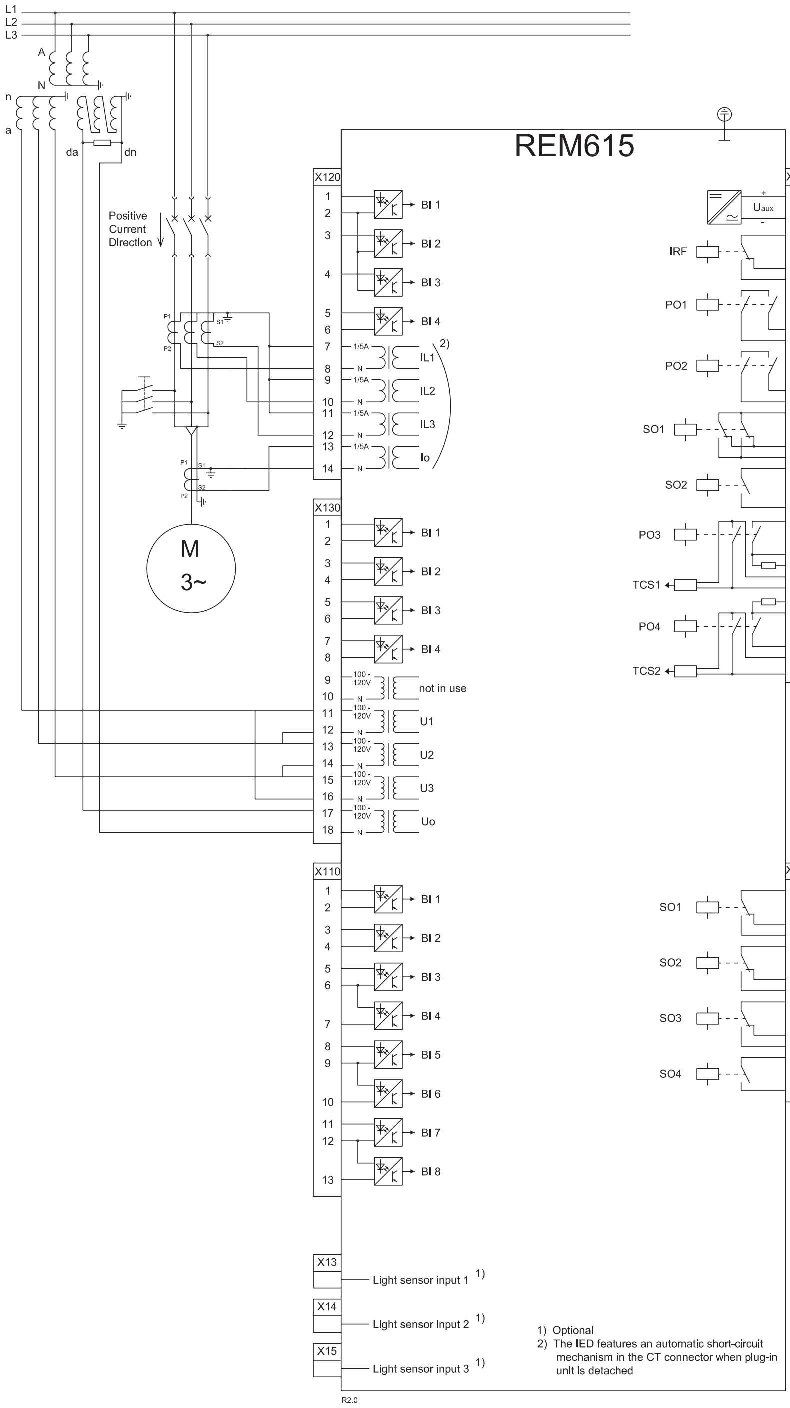


Figure 7: Connection diagram for configuration C (asynchronous motor)

3.3 Standard configuration C for motor protection with current and voltage based protection and measurements functions

3.3.1 Applications

The standard configuration is mainly intended for comprehensive protection and control functionality of circuit breaker controlled asynchronous motors. With minor modifications this standard configuration can be applied also for contactor controlled motors.

The IED with this standard configuration is delivered from the factory with default settings and parameters. The end-user flexibility for incoming, outgoing and internal signal designation within the IED enables this configuration to be further adapted to different primary circuit layouts and the related functionality needs by modifying the internal functionality using PCM600.

3.3.2 Functions

Table 8: Functions included in the REM615 standard configuration with voltage protection and circuit-breaker condition monitoring

Function	IEC 61850	IEC	ANSI
Three-phase non-directional overcurrent protection, low stage	PHLPTOC1	3I>	51P-1
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC1	3I>>>(1)	50P/51P (1)
Directional earth-fault protection, low stage	DEFLPDEF1	I_0> → (1)	67N-1 (1)
Non-directional earth-fault protection, high stage	EFHPTOC1	I_0>>(1)	51N-2 (1)
Negative-sequence overcurrent protection for motors	MNSPTOC1	I_2> (1)	46M (1)
	MNSPTOC2	I_2> (2)	46M (2)
Loss of load supervision	LOFLPTUC1	3I<	37
Motor load jam protection	JAMPTOC1	Ist>	51LR
Motor startup supervision	STTPMSU1	Is2t n<	49,66,48,51LR
Phase reversal protection	PREVPTOC	I_2>>	46R
Thermal overload protection for motors	MPTTR1	3Ith>M	49M
Positive-sequence undervoltage	PSPTUV1	U1<	47U+
Negative-sequence overvoltage	NSPTOV1	U2>	47O-
Three-phase undervoltage protection	PHPTUV1	3U< (1)	27 (1)
Circuit breaker failure protection	CCBRBRF1	3I>/I_0>BF	51BF/51NBF
Arc protection	ARCSARC1	ARC (1)	50L/50NL (1)

Table continues on next page

Function	IEC 61850	IEC	ANSI
	ARCSARC2	ARC (2)	50L/50NL (2)
	ARCSARC3	ARC (3)	50L/50NL (3)
Circuit-breaker control	CBXCBR1	I ↔ O CB	I ↔ O CB
Disconnector position indication	DCSXSWI1	I ↔ O DC (1)	I ↔ O DC (1)
	DCSXSWI2	I ↔ O DC (2)	I ↔ O DC (2)
	DCSXSWI3	I ↔ O DC (3)	I ↔ O DC (3)
Earthing switch indication	ESSXSWI1	I ↔ O ES	I ↔ O ES
Emergency startup	ESMGAPC1	ESTART	ESTART
Circuit breaker condition monitoring	SSCBR1	CBCM	CBCM
Trip circuit supervision	TCSSCBR1	TCS (1)	TCM (1)
	TCSSCBR2	TCS (2)	TCM (2)
Current circuit supervision	CCRDIF1	MCS 3I	MCS 3I
Fuse failure supervision	SEQRFUF1	FUSEF	60
Motor runtime counter	MDSOPT1	OPTS	OPTM
Disturbance recorder	RDRE1	-	-
Three-phase current measurement	CMMXU1	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_0
Three-phase voltage measurement	VMMXU1	3U	3U
Sequence voltage measurement	VSMSQI1	U_1, U_2, U_0	U_1, U_2, U_0
Residual voltage measurement	RESVMMXU1	U_0	V_0
Three-phase power and energy measurement	PEMMXU1	P, E	P, E

3.3.2.1 Default I/O connections

Table 9: Default connections for binary inputs

Binary input	Description	Connector pins
X120-BI1	Emergency start enable	X120-1,2
X120-BI2	Circuit breaker closed	X120-3,2
X120-BI3	Circuit breaker open	X120-4,2
X120-BI4	Lock-out reset	X120-5,6
X110-BI1	MCB open	X110-1,2
X110-BI2	Setting group change	X110-3,4
X110-BI3	Rotation direction	X110-5,6
X110-BI4	Speed switch (motor running)	X110-7,6
X110-BI5	Disconnector close/circuit breaker truck in	X110-8,9
X110-BI6	Disconnector open/circuit breaker truck out	X110-10,9
X110-BI7	Earth switch close	X110-11,12

Table continues on next page

Binary input	Description	Connector pins
X110-BI8	Earth switch open	X110-13,12
X130-BI1	External restart inhibit	X130-1,2
X130-BI2	External trip	X130-3,4
X130-BI3	Gas pressure alarm	X130-5,6
X130-BI4	Circuit breaker spring charged	X130-7,6

Table 10: Default connections for binary outputs

Binary output	Description	Connector pins
X100-PO1	Restart enable	X100-6,7
X100-PO2	Breaker failure backup trip to upstream breaker	X100-8,9
X100-SO1	Open command (for contactor applications)	X100-10,11,(12)
X100-SO2	Operate indication	X100-13,14
X100-PO3	Open circuit breaker/trip	X100-15-19
X100-PO4	Close circuit breaker	X100-20-24
X110-SO1	Motor startup indication	X110-14,15,16
X110-SO2	Thermal overload alarm	X110-17,18,19
X110-SO3	Protection start indication	X110-20,21,22
X110-SO3	Voltage protection alarm	X110-23,24

Table 11: Default connections for LEDs

LED	Description
1	Short circuit protection operate
2	Earth fault protection operate
3	Thermal overload protection operate
4	Combined operate indication of the other protection functions
5	Motor restart inhibit
6	Breaker failure protection operate
7	Disturbance recorder triggered
8	Circuit breaker condition monitoring alarm
9	TCS, fuse failure, measuring circuit fault or runtime counter alarm
10	ARC protection operate
11	Emergency start enabled

3.3.3 Functional diagrams

The functional diagrams describe the default input, output, alarm LED and function-to-function connections. The default connections can be viewed and changed with PCM600 according to the application requirements, if necessary.

The analog channels have fixed connections towards the different function blocks inside the IED's standard configuration. Exceptions from this rule are the 12 analog channels available for the disturbance recorder function. These channels are freely selectable and a part of the disturbance recorder's parameter settings, thus not included in the PCM600 functionality.

The analog channels are assigned to different functions as shown in the functional diagrams. The common signal marked with 3I represents the three phase currents and 3U the three phase voltages. The signal marked with I_0 represents the measured residual current via a core balance current transformer. The signal marked with U_0 represents the measured residual voltage via open delta connected voltage transformers.

The EFHPTOC protection function block for non-directional earth-faults uses the calculated residual current originating from the measured phase currents.

3.3.3.1 Functional diagrams for protection

The functional diagrams describe the IED's protection functionality in detail and according to the factory set default connections.

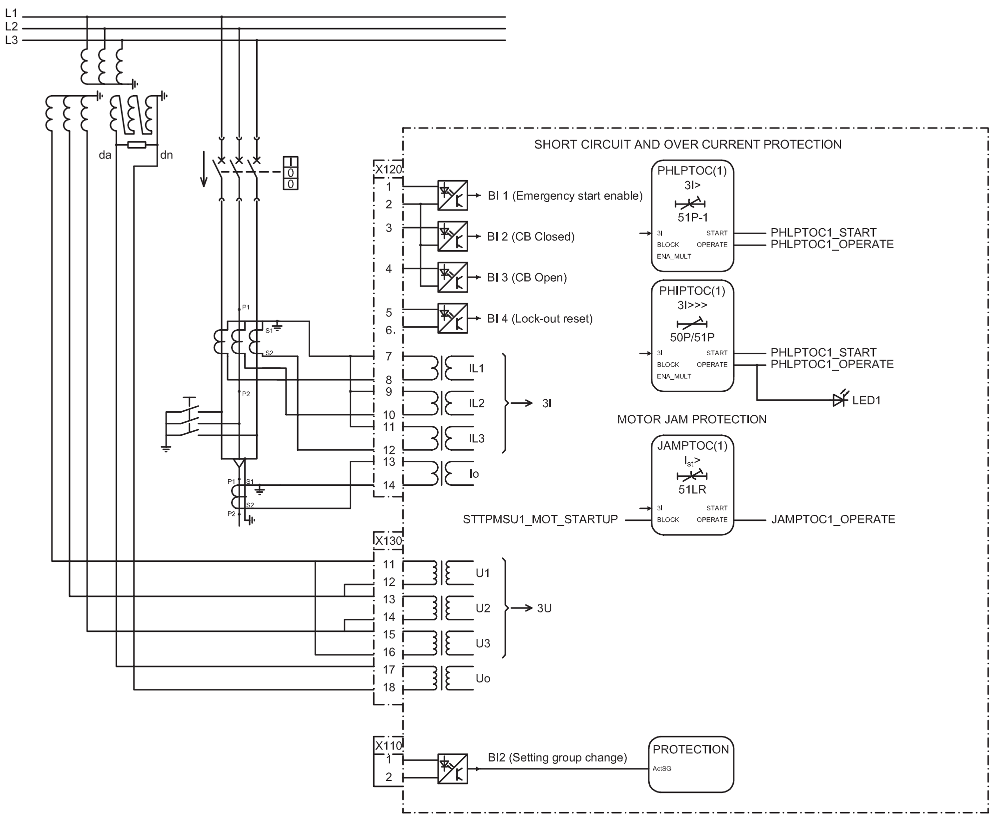


Figure 8: Overcurrent protection

Three overcurrent stages are offered for overcurrent and short-circuit protection. The motor jam protection function (JAMPTOC1) is blocked by the motor startup protection function. PHLPTOC1 can be used for overcurrent protection and PHIPTOC1 for the short-circuit protection. The operation of PHIPTOC1 is not blocked as default by any functionality and it should be set over the motor start current level to avoid unnecessary operation.

There are four IED variant-specific setting groups. Parameters can be set independently for each setting group.

The active setting group (1...4) can be changed with a parameter. The active setting group can also be changed via a binary input if the binary input is enabled for this. To enable the change of the active setting group via a binary input, connect a free binary input with PCM600 to the ActSG input of the SGCB-block.

Table 12: Binary input states and corresponding active setting groups

BI state	Active setting group
OFF	1
ON	2

The active setting group defined by a parameter is overridden when a binary input is enabled for changing the active setting group.

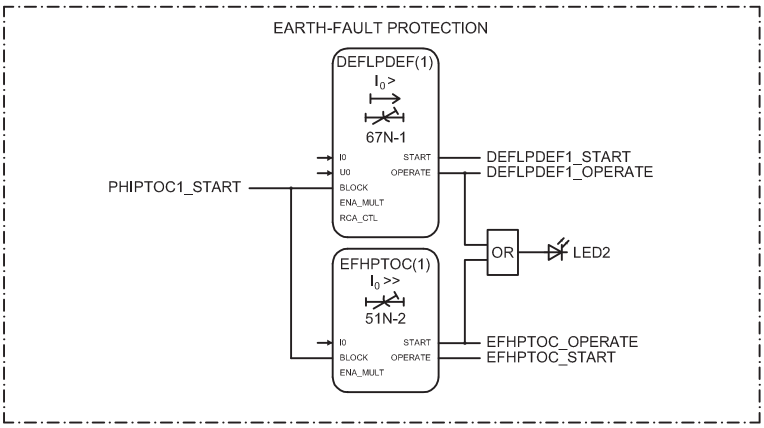


Figure 9: Non-directional earth-fault protection

One stage non-directional earth-fault protection (EFHPTOC1) is offered to detect phase-to-earth faults that may be a result of, for example, insulation ageing. In addition, there is a directional protection stage (DEFLPDEF1) which can be also used as a low stage non-directional earth-fault protection without residual voltage requirement. However, the residual voltage can help to detect earth faults at a low fault current level selectively and to discriminate the apparent residual current caused, for example, by partial current transformer saturation at motor startup.

The earth- fault protection is blocked when the short circuit protection (PHIPTOC1) is started. The operation of the earth-fault protection functions is connected to alarm LED 2.

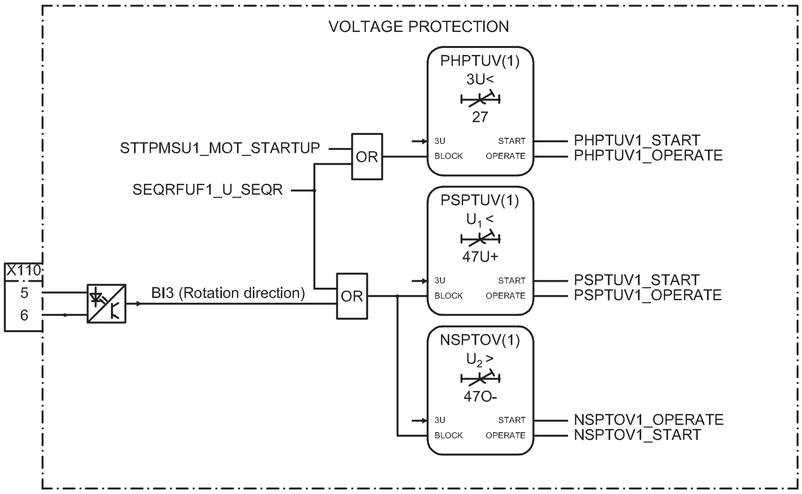


Figure 10: Voltage protection

For voltage protection three-phase undervoltage (PHPTUV1), positive-sequence undervoltage (PSPTUV1) and negative-sequence overvoltage (NSPTOV1) protection functions are offered. The three-phase undervoltage protection is blocked during motor startup to prevent unwanted operation in case there is a short voltage drop. Also if the fuse failure is detected, the undervoltage function is blocked.

The positive-sequence undervoltage and negative-sequence overvoltage protections are included to protect the machine against single-phasing, excessive unbalance between phases and abnormal phase order. The positive-sequence undervoltage and negative-sequence overvoltage functions are blocked by default when the network rotation direction changes (X110_BI3 is active) or if the fuse failure is detected.

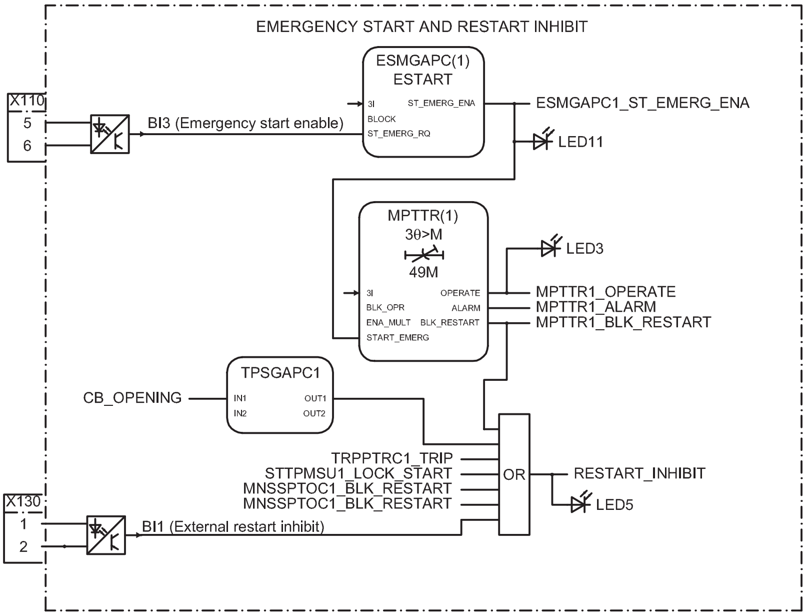


Figure 11: Emergency start and restart inhibit

The emergency start function (ESMGAPC1) allows motor startups although the restart inhibit is activated. The emergency start is enabled for ten minutes after the selected binary input (X120:BI1) is energized. On the rising edge of the emergency start signal:

- Calculated thermal level is set slightly below the restart inhibit level to allow at least one motor startup
- Value of the cumulative startup time counter STTPMSU1 is set slightly below the set restart inhibit value to allow at least one motor startup
- Set operate values of the temperature stages in MPTTR1 function is increased by 10 percent
- External restart inhibit signal (X100:PO1) is ignored
- Alarm LED 11 is activated

The external restart inhibit signal is ignored for as long as the emergency start is activated. A new emergency start cannot be made until the emergency start signal has been reset and the emergency start time of 10 minutes has expired.

The thermal overload protection function (MPTTR1) detects short- and long term overloads under varying load conditions. When the emergency start request is issued for the emergency start function, it activates the corresponding input of the thermal overload function. When the thermal overload function has issued a restart blocking, which inhibits the closing of the breaker when the machine is overloaded, the emergency start request removes this blocking and enables the user to start the motor again.

The restart inhibit is activated for a set period when a circuit breaker is opened. This is called remanence voltage protection where the motor has damping remanence voltage after circuit breaker opening and reclosing after a too short period of time. This can lead to stress for the machine and other apparatuses. The remanence voltage protection waiting time can be set to a timer function TPSGAPC1.

The restart inhibit is also activated when there is

- An active trip command or
- Motor startup supervision has issued lockout or
- Motor unbalance function has issued restart blocking or
- An external restart inhibit is activated by a binary input (X130:BI1).

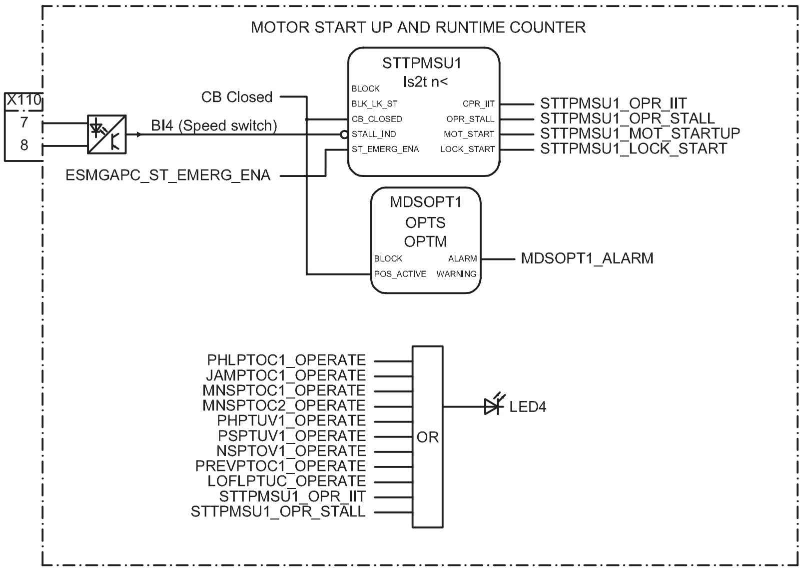


Figure 12: Motor startup supervision

With the motor startup supervision function (STTPMSU1) the starting of the motor is supervised by monitoring three-phase currents or the status of the energizing circuit breaker of the motor. The motor speed switch indication can be used to determine the locked rotor situation. If the motor is running, the speed switch activates the binary input (X110:6-7).

When the emergency start request is activated by ESMCAPC1 and STTPMSU1 is in lockout state, which inhibits motor starting, the lockout is deactivated and emergency starting is available.

The upstream blocking from the motor startup is connected to the output SO1 (X110:14-15-16). The output is used for sending a blocking signal to the relevant overcurrent protection stage of the IED at the infeeding bay.

The motor running time counter (MDSOPT1) provides history data since last commissioning. The counter counts the total number of motor running hours and is incremented when the energizing circuit breaker is closed. The alarm of the runtime counter is connected to alarm LED 9.

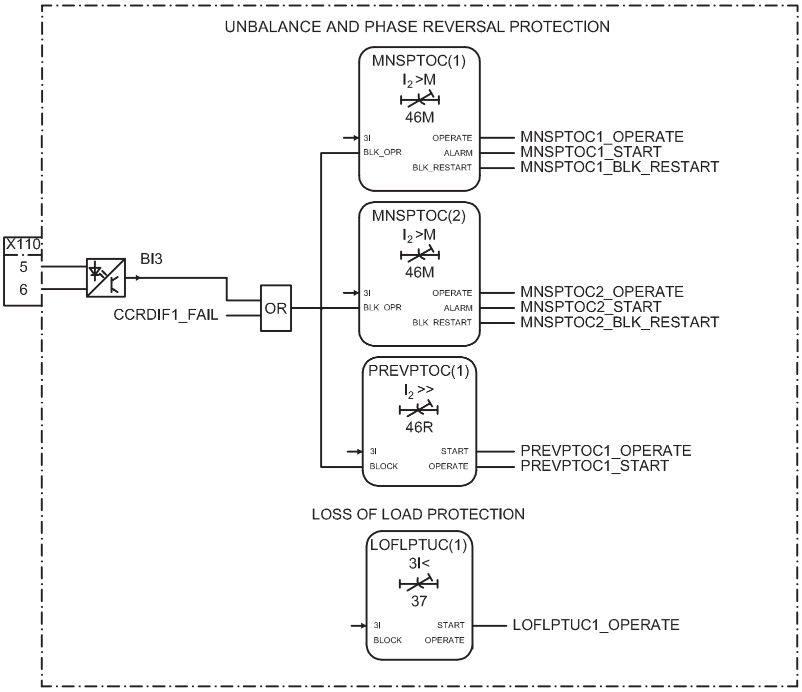


Figure 13: Phase unbalance protection

Two negative-sequence overcurrent stages (MNSPTOC1 and MNSPTOC2) are offered for phase unbalance protection. These functions are used to protect the motor against phase unbalance caused by, for example, a broken conductor. Phase unbalance in network feeding of the motor causes overheating of the motor.

The phase reversal protection (PREVPTOC1) is based on the calculated negative phase-sequence current. It detects too high NPS current values during motor start up, caused by incorrectly connected phases, which in turn causes the motor to rotate in the opposite direction.

The negative-sequence protection and phase reversal protection is blocked if the current circuit supervision detects failure in current measuring circuit or if the external information of reverse network rotation is activated by a binary input (X110:5-6).

The loss of load situation is detected by LFLPTUC1. The loss of load situation can happen, for example, if there is damaged pump or a broken conveyor.

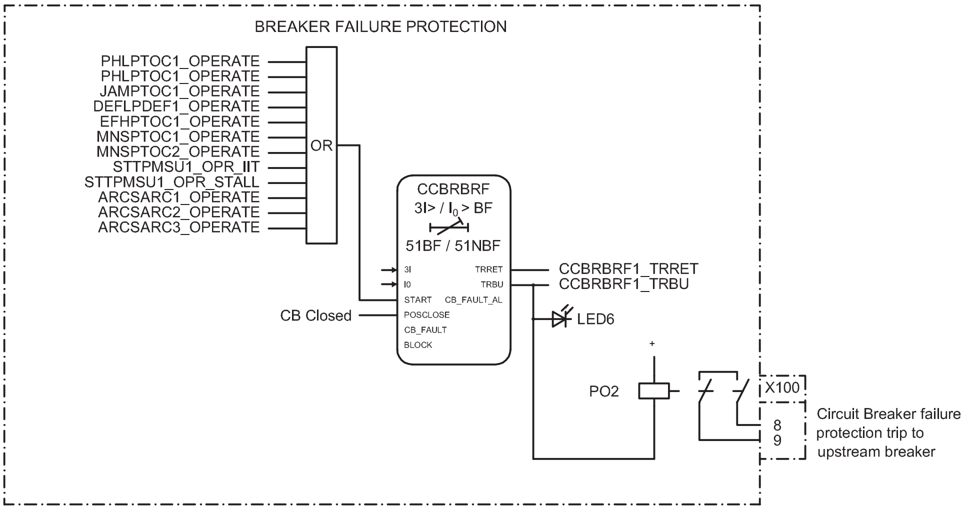


Figure 14: Circuit breaker failure protection

The circuit-breaker failure protection (CCBRBRF1) is initiated via the start input by a number of different protection stages in the IED. CCBRBRF1 offers different operating modes associated with the circuit-breaker position and the measured phase and residual currents.

CCBRBRF1 has two operating outputs: TRRET and TRBU. The TRRET operate output is used for retripping its own circuit breaker through the Master Trip 1 again. The TRBU output is used to give a backup trip to the circuit breaker feeding upstream. For this purpose, the TRBU operate output signal is connected to the output PO2 (X100: 8-9). LED 6 is used for backup (TRBU) operate indication.

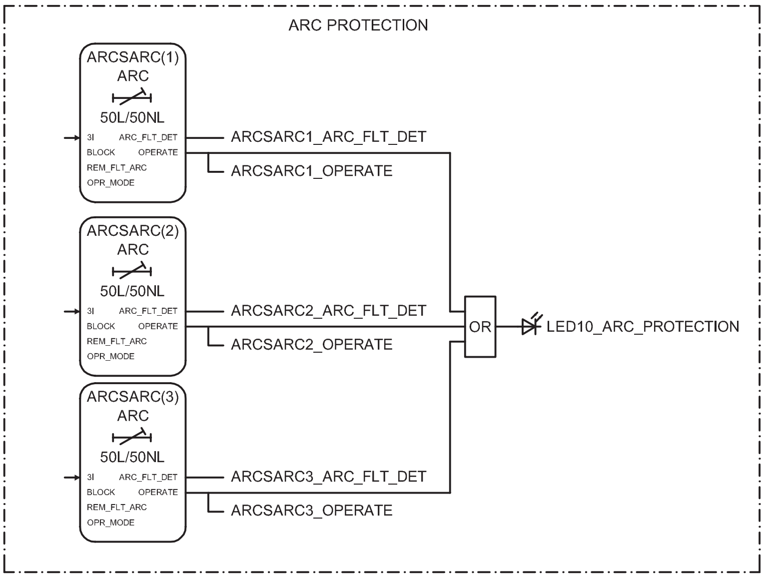


Figure 15: Arc protection

Arc protection (ARCSARC1...3) is included as an optional function.

The arc protection offers individual function blocks for three ARC sensors that can be connected to the IED. Each arc protection function block has two different operation modes, with or without the phase and residual current check. Operate signals from the arc protection function blocks are connected to the Master Trip and also to the alarm LED 10 as a common operate indication.

3.3.3.2 Functional diagrams for disturbance recorder and supervision functions

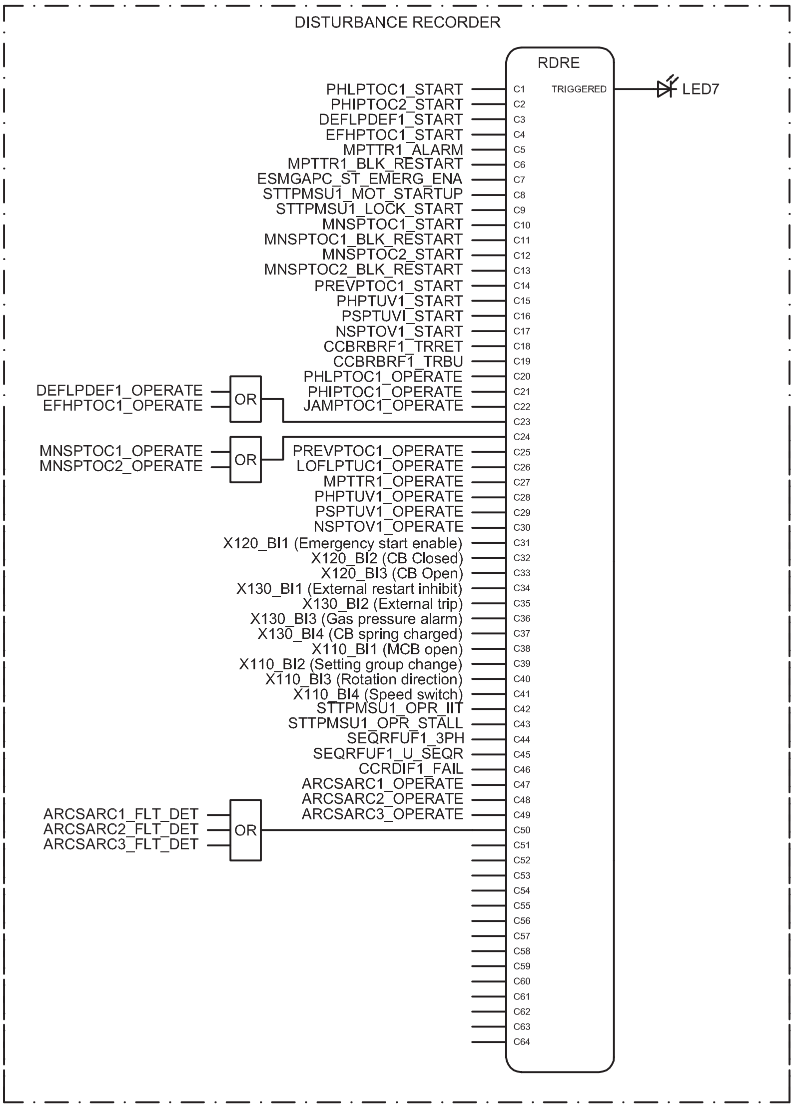


Figure 16: Disturbance recorder

The disturbance recorder has 64 digital inputs out of which 50 are connected as a default. All start and operate signals from the protection stages are routed to trigger the disturbance recorder or alternatively only to be recorded by the disturbance recorder depending on the parameter settings. Additionally, the ARC protection signals and 11 binary inputs are also connected.

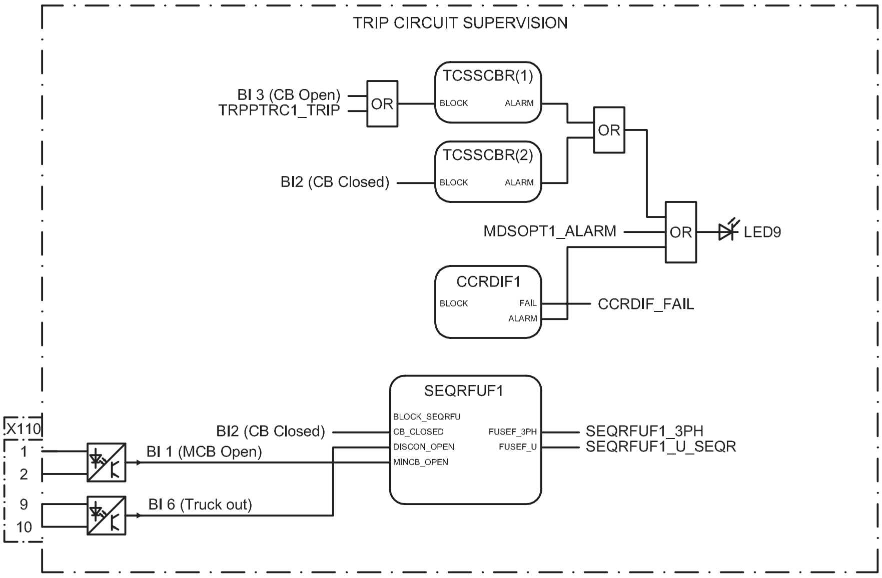


Figure 17: Supervision functions

Two separate trip circuit supervision functions are included, TCSSCBR1 for PO3 (X100:16-19) for Master Trip and TCSSCBR2 for PO4 (X100:20-23) for circuit breaker closing. The trip circuit supervision 1 is blocked by the Master Trip (TRPPTRC1) and the circuit-breaker open position signal. The trip circuit supervision 2 is used for circuit breaker closing and therefore blocked when the circuit breaker is closed. The TCS alarm indication is connected to LED 9.

By default it is expected that there is no external resistor in the circuit breaker tripping/closing coil circuit connected parallel with circuit breaker normally open/closed auxiliary contact.

The motor runtime counter alarm is connected also to the alarm LED 9.

The fuse failure supervision SEQRFUF1 detects failures in voltage measurement circuits. Failures such as open miniature circuit breaker are detected and the alarm is connected to the alarm LED 9.

Failures in current measuring circuits are detected by CCRDIF. When a failure is detected, blocking signal is activated in current protection functions which are measuring calculated sequence component currents, and unnecessary operation can be avoided. The alarm signal is connected to the alarm LED 9.

3.3.3.3 Functional diagrams for control and interlocking

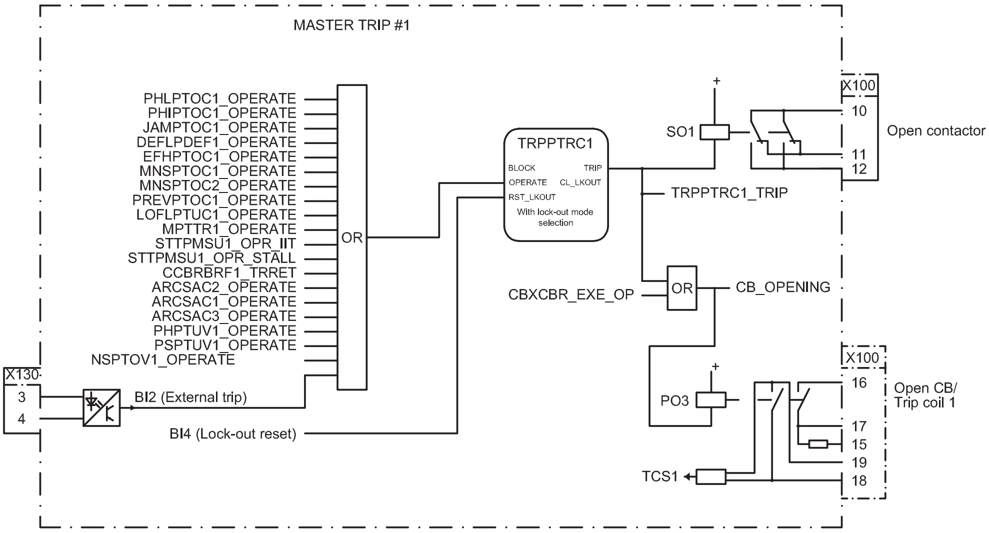


Figure 18: Master Trip

The operate signals from the protections are connected to the trip output contact PO3 (X100:16-19) via the corresponding Master Trip (TRPPTRC1). Open control commands to the circuit breaker from the local or remote CBXCBR1-exe_op are connected directly to the output PO3 (X100:16-19).

TRPPTRC1 provides the lockout/latching function, event generation and the trip signal duration setting. If the lockout operation mode is selected, one binary input can be reassigned to the RST_LKOUT input of the Master Trip to enable external reset with a push button.

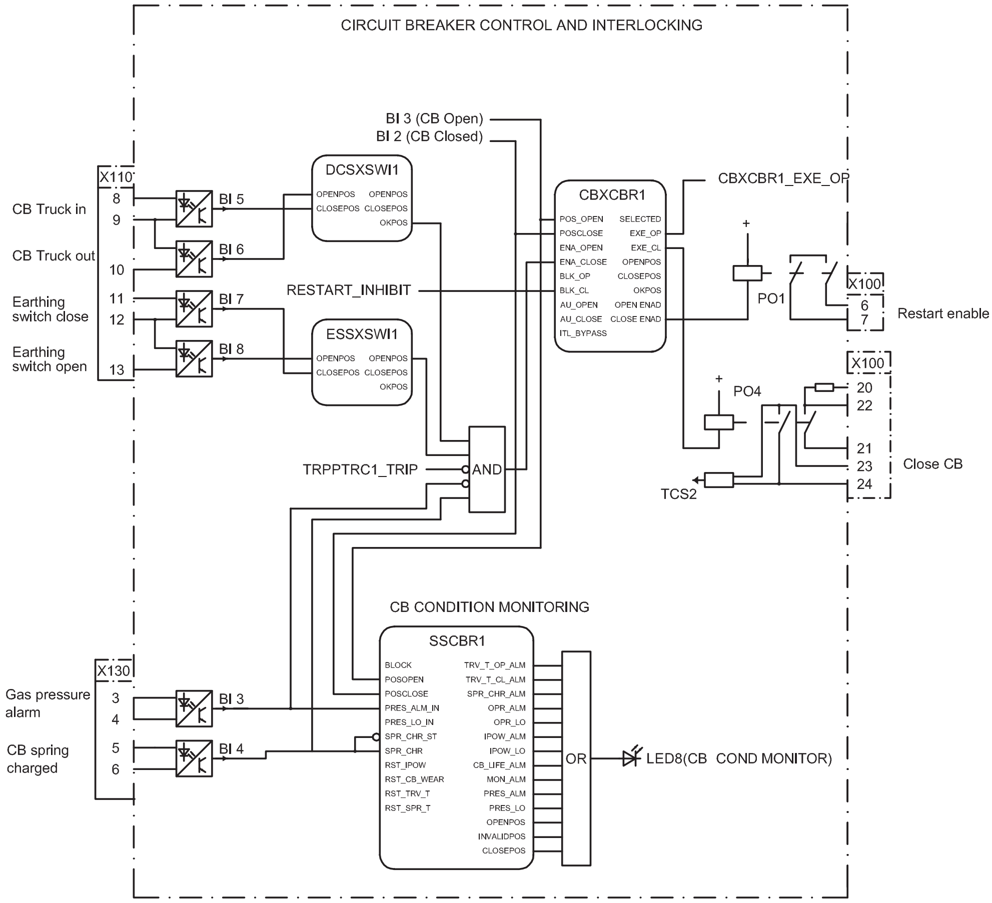


Figure 19: Disconnector position indication

There are three disconnector status blocks (DCSXSWI1…3) available in the IED. The remaining two not described in the functional diagram are available in PCM600 for connection where applicable.

The binary inputs 5 and 6 of the additional card X110 are used for busbar disconnector (DCSXSWI1) or circuit-breaker truck position indication.

Table 13: Device positions indicated by binary inputs 5 and 6

Primary device position	Input to be energized	
	Input 5 (X110:8-9)	Input 6 (X110:10-9)
Busbar disconnector closed	x	
Busbar disconnector open		x
Circuit breaker truck in service position	x	
Circuit breaker truck in test position		x

The binary inputs 7 and 8 (X110:1-13) are designed for the position indication of the line-side earthing switch.

The circuit breaker closing is enabled when the ENA_CLOSE input is activated. The input can be activated by the configuration logic, which is a combination of the disconnector or breaker truck and earth switch position statuses and the statuses of the Master Trip logics and gas pressure alarm and circuit-breaker spring charging. The OKPOS output from the DCSXSWI block defines if the disconnector or the breaker truck is definitely either open/in test position or close/ in service position. This, together with the open earth switch and non-active trip signal, activates the close-enable signal to the circuit breaker control function block. The open operation is always enabled.

When the motor restart is inhibited, the BLK_CLOSE input is activated and closing of the breaker is not possible. When all conditions of the circuit breaker closing are fulfilled, the CLOSE_ENAD output of the CBXCBR1 is activated and PO1 output (X100:6-7) is closed.

The ITL_BYPASS input can be used, for example, to always enable the closing of the circuit breaker when the circuit breaker truck is in the test position, despite of the interlocking conditions being active when the circuit breaker truck is closed in service position.

If the ENA_CLOSE and BLK_CLOSE signals are completely removed from the breaker control function block CBXCBR with PCM600, the function assumes that the breaker close commands are allowed continuously.

The circuit breaker condition monitoring function (SSCBR) supervises the circuit breaker status based on the binary input information connected and measured current levels. The function introduces various supervision methods. The corresponding supervision alarm signals are routed to LED 8.

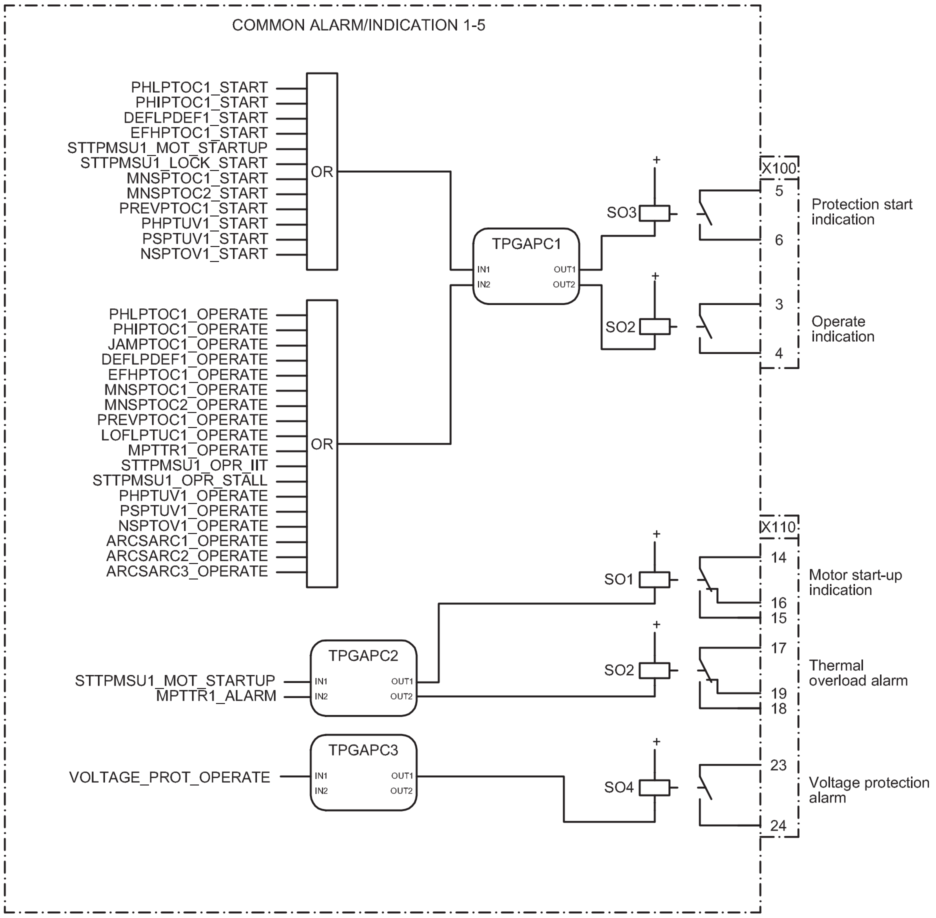


Figure 20: Common alarm/indication 1-5

The signal outputs from the IED are connected to give dedicated information on:

- Start of any protection function SO1 (X100:10-12)
- Operation (trip) of any protection function SO2 (X100:13-15)
- Motor startup indication to upstream level SO1 (X110:14-16)
- Motor thermal overload alarm indication SO2 (X110:17-19)
- Operation (trip) of any voltage protection function SO3 (X110:20-22)

TPGAPC are timers and used for setting the minimum pulse length for the outputs. There are four generic timers (TPGAPC1..4) available in the IED. The remaining ones not described in the functional diagram are available in PCM600 for connection where applicable.

Section 4 Requirements for measurement transformers

4.1 Current transformers

4.1.1 Current transformer requirements for non-directional overcurrent protection

For reliable and correct operation of the overcurrent protection, the CT has to be chosen carefully. The distortion of the secondary current of a saturated CT may endanger the operation, selectivity, and co-ordination of protection. However, when the CT is correctly selected, a fast and reliable short circuit protection can be enabled.

The selection of a CT depends not only on the CT specifications but also on the network fault current magnitude, desired protection objectives, and the actual CT burden. The protection relay settings should be defined in accordance with the CT performance as well as other factors.

4.1.1.1 Current transformer accuracy class and accuracy limit factor

The rated accuracy limit factor (F_n) is the ratio of the rated accuracy limit primary current to the rated primary current. For example, a protective current transformer of type 5P10 has the accuracy class 5P and the accuracy limit factor 10. For protective current transformers, the accuracy class is designed by the highest permissible percentage composite error at the rated accuracy limit primary current prescribed for the accuracy class concerned, followed by the letter "P" (meaning protection).

Table 14: Limits of errors according to IEC 60044-1 for protective current transformers

Accuracy class	Current error at rated primary current (%)	Phase displacement at rated primary current		Composite error at rated accuracy limit primary current (%)
		minutes	centiradians	
5P	±1	±60	±1.8	5
10P	±3	-	-	10

The accuracy classes 5P and 10P are both suitable for non-directional overcurrent protection. The 5P class provides a better accuracy. This should be noted also if there are accuracy requirements for the metering functions (current metering, power metering, and so on) of the relay.

The CT accuracy primary limit current describes the highest fault current magnitude at which the CT fulfils the specified accuracy. Beyond this level, the secondary current of the CT is distorted and it might have severe effects on the performance of the protection relay.

In practise, the actual accuracy limit factor (F_a) differs from the rated accuracy limit factor (F_n) and is proportional to the ratio of the rated CT burden and the actual CT burden.

The actual accuracy limit factor is calculated using the formula:

$$F_a \approx F_n \times \frac{|S_{in} + S_n|}{|S_{in} + S|}$$

F_n	the accuracy limit factor with the nominal external burden S_n
S_{in}	the internal secondary burden of the CT
S	the actual external burden

4.1.1.2 Non-directional overcurrent protection

The current transformer selection

Non-directional overcurrent protection does not set high requirements on the accuracy class or on the actual accuracy limit factor (F_a) of the CTs. It is, however, recommended to select a CT with F_a of at least 20.

The nominal primary current I_{1n} should be chosen in such a way that the thermal and dynamic strength of the current measuring input of the relay is not exceeded. This is always fulfilled when

$I_{1n} > I_{kmax} / 100$,

I_{kmax} is the highest fault current.

The saturation of the CT protects the measuring circuit and the current input of the relay. For that reason, in practice, even a few times smaller nominal primary current can be used than given by the formula.

Recommended start current settings

If I_{kmin} is the lowest primary current at which the highest set overcurrent stage of the relay is to operate, then the start current should be set using the formula:

Current start value < 0.7 x (I_{kmin} / I_{1n})

I_{1n} is the nominal primary current of the CT.

The factor 0.7 takes into account the protection relay inaccuracy, current transformer errors, and imperfections of the short circuit calculations.

The adequate performance of the CT should be checked when the setting of the high set stage O/C protection is defined. The operate time delay caused by the CT saturation is typically small enough when the relay setting is noticeably lower than F_a.

When defining the setting values for the low set stages, the saturation of the CT does not need to be taken into account and the start current setting is simply according to the formula.

Delay in operation caused by saturation of current transformers

The saturation of CT may cause a delayed relay operation. To ensure the time selectivity, the delay must be taken into account when setting the operate times of successive relays.

With definite time mode of operation, the saturation of CT may cause a delay that is as long as the time the constant of the DC component of the fault current, when the current is only slightly higher than the starting current. This depends on the accuracy limit factor of the CT, on the remanence flux of the core of the CT, and on the operate time setting.

With inverse time mode of operation, the delay should always be considered as being as long as the time constant of the DC component.

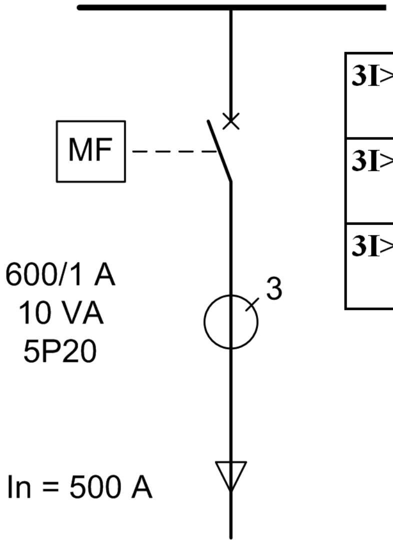
With inverse time mode of operation and when the high-set stages are not used, the AC component of the fault current should not saturate the CT less than 20 times the starting current. Otherwise, the inverse operation time can be further prolonged. Therefore, the accuracy limit factor F_a should be chosen using the formula:

$F_a > 20 \cdot$ *Current start value* $/ I_{1n}$

The *Current start value* is the primary pickup current setting of the relay.

4.1.1.3 Example for non-directional overcurrent protection

The following figure describes a typical medium voltage feeder. The protection is implemented as three-stage definite time non-directional overcurrent protection.



3I>	**1200 A**	**2.00 x I_{2n}**
	0.75 s	**0.75 s**
3I>>	**1800A**	**3.00 x I_{2n}**
	0.50 s	**0.50 s**
3I>>>	**3500 A**	**5.83 x I_{2n}**
	0.20 s	**0.20 s**

Figure 21: Example of three-stage overcurrent protection

The maximum three-phase fault current is 41.7 kA and the minimum three-phase short circuit current is 22.8 kA. The actual accuracy limit factor of the CT is calculated to be 59.

The start current setting for low-set stage (3I>) is selected to be about twice the nominal current of the cable. The operate time is selected so that it is selective with the next relay (not visible in the figure above). The settings for the high-set stage and instantaneous stage are defined also so that grading is ensured with the downstream protection. In addition, the start current settings have to be defined so that the relay operates with the minimum fault current and it does not operate with the maximum load current. The settings for all three stages are as in the figure above.

For the application point of view, the suitable setting for instantaneous stage (I>>>) in this example is 3 500 A (5.83 x I_{2n}). For the CT characteristics point of view, the criteria given by the current transformer selection formula is fulfilled and also the relay setting is considerably below the F_a. In this application, the CT rated burden could have been selected much lower than 10 VA for economical reasons.

Section 5 IED physical connections

5.1 Inputs

5.1.1 Energizing inputs

5.1.1.1 Phase currents

The IED can also be used in single or two-phase applications by leaving one or two energizing inputs unoccupied. However, at least terminals X120/7-8 must be connected.

Table 15: Inputs for phase currents

Terminal	Description
X120-7, 8	I_{L1}
X120-9, 10	I_{L2}
X120-11, 12	I_{L3}

5.1.1.2 Residual current

Table 16: Inputs for residual current

Terminal	Description
X120-13, 14	I_0

5.1.1.3 Phase voltages

Table 17: Inputs for phase voltage

Terminal	Description
X130-11, 12	U1
X130-13, 14	U2
X130-15, 16	U3

5.1.1.4 Residual voltage

Table 18: Inputs for residual voltage

Terminal	Description
X130-17, 18	U_0

5.1.2 Auxiliary supply voltage input

The auxiliary voltage of the IED is connected to terminals X100/1-2. At DC supply, the positive lead is connected to terminal X100-1. The permitted auxiliary voltage range (AC/DC or DC) is marked on the top of the LHMI of the IED.

Table 19: Auxiliary voltage supply

Terminal	Description
X100-1	+ Input
X100-2	- Input

5.1.3 Binary inputs

The binary inputs can be used, for example, to generate a blocking signal, to unlatch output contacts, to trigger the disturbance recorder or for remote control of IED settings.

Table 20: Binary input terminals X110-1...13

Terminal	Description
X110-1 X110-2	BI1, + BI1, -
X110-3 X110-4	BI2, + BI2, -
X110-5 X110-6	BI3, + BI3, -
X110-6 X110-7	BI4, - BI4, +
X110-8 X110-9	BI5, + BI5, -
X110-9 X110-10	BI6, - BI6, +
X110-11 X110-12	BI7, + BI7, -
X110-12 X110-13	BI8, - BI8, +

Table 21: Binary input terminals X120-1...6

Terminal	Description
X120-1 X120-2	BI1, + BI1, -
X120-3 X120-2	BI2, + BI2, -
X120-4 X120-2	BI3, + BI3, -
X120-5 X120-6	BI4, + BI4, -

Table 22: Binary input terminals X130-1...9

Terminal	Description
X130-1 X130-2	BI1, + BI1, -
X130-2 X130-3	BI2, - BI2, +
X130-4 X130-5	BI3, + BI3, -
X130-5 X130-6	BI4, - BI4, +
X130-7 X130-8	BI5, + BI5, -
X130-8 X130-9	BI6, - BI6, +

5.1.4 Optional light sensor inputs

If the IED is provided with the optional communication module with light sensor inputs, the pre-manufactured lens-sensor fibres are connected to inputs X13, X14 and X15, see the terminal diagrams.For further information, see arc protection.

The IED is provided with connection sockets X13, X14 and X15 only if the optional communication module with light sensor inputs has been installed. If the arc protection option is selected when ordering an IED, the light sensor inputs are included in the communication module.

Table 23: Light sensor input connectors

Terminal	Description
X13	Input Light sensor 1
X14	Input Light sensor 2
X15	Input Light sensor 3

5.2 Outputs

5.2.1 Outputs for tripping and controlling

Output contacts PO1, PO2, PO3 and PO4 are heavy-duty trip contacts capable of controlling most circuit breakers. On delivery from the factory, the trip signals from all the protection stages are routed to PO3 and PO4.

Table 24: Output contacts

Terminal	Description
X100-6	PO1, NO
X100-7	PO1, NO
X100-8	PO2, NO
X100-9	PO2, NO
X100-15	PO3, NO (TCS resistor)
X100-16	PO3, NO
X100-17	PO3, NO
X100-18	PO3 (TCS1 input), NO
X100-19	PO3 (TCS1 input), NO
X100-20	PO4, NO (TCS resistor)
X100-21	PO4, NO
X100-22	PO4, NO
X100-23	PO4 (TCS2 input), NO
X100-24	PO4 (TCS2 input), NO

5.2.2 Outputs for signalling

Output contacts SO1 and SO2 in slot X100 or SO1, SO2, SO3 and SO4 in slot X110 or SO1, SO2 and SO3 in slot X130 (optional) can be used for signalling on start and tripping of the IED. On delivery from the factory, the start and alarm signals from all the protection stages are routed to signalling outputs.

Output contacts of slot X130 are available in the optional BIO module (BIOB02A).

Table 25: Output contacts X100-10...14

Terminal	Description
X100-10	SO1, common
X100-11	SO1, NC
X100-12	SO1, NO
X100-13	SO2, NO
X100-14	SO2, NO

Table 26: Output contacts X110-14...24

Terminal	Description
X110-14	SO1, common
X110-15	SO1, NO
X110-16	SO1, NC
X110-17	SO2, common
X110-18	SO2, NO
X110-19	SO2, NC
X110-20	SO3, common
X110-21	SO3, NO
X110-22	SO3, NC
X110-23	SO4, common
X110-24	SO4, NO

Table 27: Output contacts X130-10...18

Terminal	Description
X130-10	SO1, common
X130-11	SO1, NO
X130-12	SO1, NC
X130-13	SO2, common
X130-14	SO2, NO
X130-15	SO2, NC
X130-16	SO3, common
X130-17	SO3, NO
X130-18	SO3, NC

5.2.3 IRF

The IRF contact functions as an output contact for the self-supervision system of the protection IED. Under normal operating conditions, the IED is energized and the contact is closed (X100/3-5). When a fault is detected by the self-supervision system or the auxiliary voltage is disconnected, the output contact drops off and the contact closes (X100/3-4).

Table 28: IRF contact

Terminal	Description
X100-3	IRF, common
X100-4	Closed; IRF, or U_{aux} disconnected
X100-5	Closed; no IRF, and U_{aux} connected

Section 6 Glossary

100BASE-FX	A physical media defined in the IEEE 802.3 Ethernet standard for local area networks (LANs) that uses fibre-optic cabling
100BASE-TX	A physical media defined in the IEEE 802.3 Ethernet standard for local area networks (LANs) that uses twisted-pair cabling category 5 or higher with RJ-45 connectors
ANSI	American National Standards Institute
ASCII	American Standard Code for Information Interchange
BI	Binary input
BO	Binary output
CT	Current transformer
DNP3	A distributed network protocol originally developed by Westronic. The DNP3 Users Group has the ownership of the protocol and assumes responsibility for its evolution.
EMC	Electromagnetic compatibility
GOOSE	Generic Object Oriented Substation Event
HMI	Human-machine interface
IEC	International Electrotechnical Commission
IEC 60870-5-103	Communication standard for protective equipment; A serial master/slave protocol for point-to-point communication
IEC 61850	International standard for substation communication and modelling
IED	Intelligent electronic device
IP address	A set of four numbers between 0 and 255, separated by periods. Each server connected to the Internet is assigned a unique IP address that specifies the location for the TCP/IP protocol.
LAN	Local area network
LC	Connector type for glass fibre cable
LCD	Liquid crystal display
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 TCP/IP	Modbus RTU protocol which uses TCP/IP and Ethernet to carry data between devices
NPS	Negative phase sequence
PCM600	Protection and Control IED Manager
RJ-45	Galvanic connector type
RTU	Remote terminal unit
WAN	Wide area network
WHMI	Web human-machine interface

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