RELION® 630 SERIES

Motor Protection and Control REM630

Application Manual

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Table of contents

Section 1 Introduction

1.1 This manual

The application manual contains descriptions of preconfigurations. The manual can be used as a reference for configuring control, protection, measurement, recording and LED functions. The manual can also be used when creating configurations according to specific application requirements.

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 protection schemes and principles.

1.3 Product documentation

1.3.1 Product documentation set

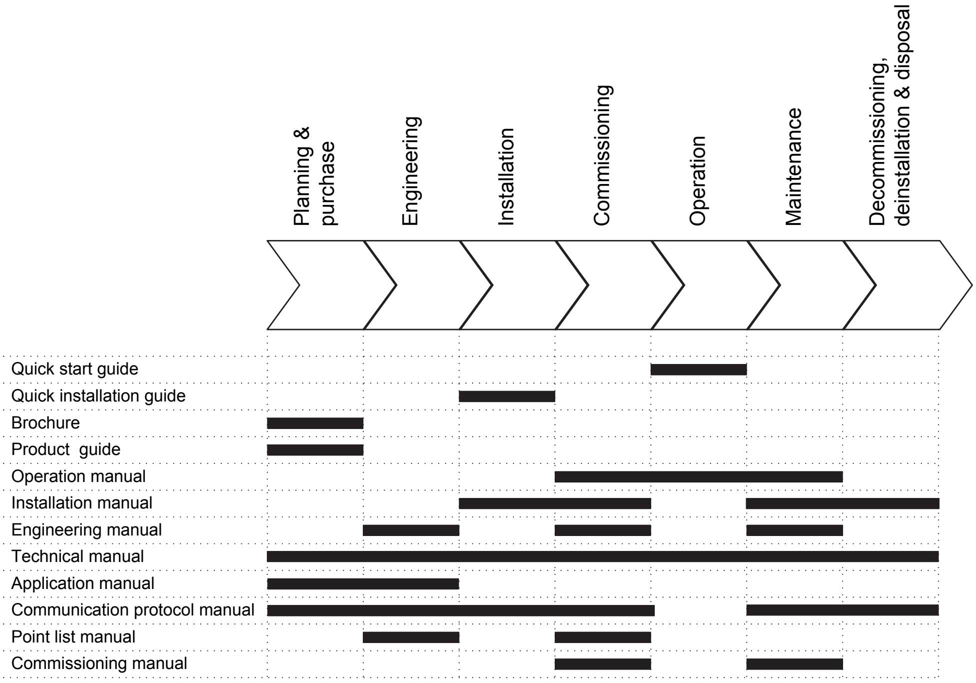


Figure 1: The intended use of documents during the product life cycle

Product series- and product-specific manuals can be downloaded from the ABB Web site http://www.abb.com/relion.

1.3.2 Document revision history

Document revision/date	Product version	History
A/2009-09-15	1.0	First release
B/2009-12-23	1.0	Content updated
C/2011-02-23	1.1	Content updated to correspond to the product version
D/2012-08-29	1.2	Content updated to correspond to the product version
E/2014-11-28	1.3	Content updated to correspond to the product version
F/2016-05-26	1.3	Content updated
G/2019-02-25	1.3	Content updated

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
DNP3 Communication Protocol Manual	1MRS756789
IEC 61850 Communication Protocol Manual	1MRS756793
IEC 60870-5-103 Communication Protocol Manual	1MRS757203
Installation Manual	1MRS755958
Operation Manual	1MRS756509
Technical Manual	1MRS756508
Engineering Manual	1MRS756800
Commissioning Manual	1MRS756801

1.4 Symbols and conventions

1.4.1 Symbols

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

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

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

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

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

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

1.4.2 Document conventions

A particular convention may not be used in this manual.

- Abbreviations and acronyms are spelled out in the glossary. The glossary also contains definitions of important terms.
- Push button navigation in the LHMI menu structure is presented by using the push button icons.
  To navigate between the options, use  and .
- Menu paths are presented in bold.
  Select **Main menu/Settings**.
- WHMI menu names are presented in bold.
  Click **Information** in the WHMI menu structure.
- LHMI messages are shown in Courier font.
  To save the changes in nonvolatile memory, select `Yes` and press .
- Parameter names are shown in italics.
  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, codes and symbols

Table 1: Functions included in the relay

Description	IEC 61850	IEC 60617	ANSI
Protection			
Three-phase non-directional overcurrent protection, low stage	PHLPTOC	3I>	51P-1
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC	3I>>>	50P/51P
Non-directional earth-fault protection, low stage	EFLPTOC	I0>	51N-1
Non-directional earth-fault protection, high stage	EFHPTOC	I0>>	51N-2
Non-directional earth-fault protection, instantaneous stage	EFIPTOC	I0>>>	50N/51N

Table continues on next page

Description	IEC 61850	IEC 60617	ANSI
Directional earth-fault protection, low stage	DEFLPDEF	I0> ->	67N-1
Directional earth-fault protection, high stage	DEFHPDEF	I0>> ->	67N-2
Rotor earth-fault protection	MREFPTOC	Io>R	64R
Negative-sequence overcurrent protection for machines	MNSPTOC	I2>G/M	46G/46M
Phase-reversal protection	PREVPTOC	I2>>	46R
Three-phase thermal overload protection for motors	MPTTR	3Ith>M	49M
Motor startup supervision	STTPMSU	Is2t n<	48,66,14,51LR
Motor load jam protection	JAMPTOC	Ist>	51LR
Emergency start	ESMGAPC	ESTART	ESTART
Loss of load supervision	LOFLPTUC	3I<	37
High-impedance or flux-balance based differential protection for machines	MHZPDIF	3dIHi>G/M	87GH/87MH
Stabilized differential protection for machines	MPDIF	3dI>G/M	87G/87M
Three-phase overvoltage protection	PHPTOV	3U>	59
Three-phase undervoltage protection	PHPTUV	3U<	27
Positive-sequence overvoltage protection	PSPTOV	U1>	47O+
Positive-sequence undervoltage protection	PSPTUV	U1<	47U+
Negative-sequence overvoltage protection	NSPTOV	U2>	47O-
Residual overvoltage protection	ROVPTOV	U0>	59G
Reverse power/directional overpower protection	DOPPDPR	P>	32R/32O
Frequency gradient protection	DAPFRC	df/dt>	81R
Overfrequency protection	DAPTOF	f>	81O
Underfrequency protection	DAPTUF	f<	81U
Three-phase underexcitation protection	UEXPDIS	X<	40
Circuit breaker failure protection	CCBRBRF	3I>/I0>BF	51BF/51NBF
Tripping logic	TRPPTRC	I -> O	94
Multipurpose analog protection	MAPGAPC	MAP	MAP
Control			
Bay control	QCCBAY	CBAY	CBAY
Interlocking interface	SCILO	3	3
Circuit breaker/disconnector control	GNRLCSWI	I <-> O CB/DC	I <-> O CB/DC
Circuit breaker	DAXCBR	I <-> O CB	I <-> O CB
Disconnector	DAXSWI	I <-> O DC	I <-> O DC
Local/remote switch interface	LOCREM	R/L	R/L

Table continues on next page

Description	IEC 61850	IEC 60617	ANSI
Generic process I/O			
Single point control (8 signals)	SPC8GGIO	-	-
Double point indication	DPGGIO	-	-
Single point indication	SPGGIO	-	-
Generic measured value	MVGGIO	-	-
Logic Rotating Switch for function selection and LHMI presentation	SLGGIO	-	-
Selector mini switch	VSGGIO	-	-
Pulse counter for energy metering	PCGGIO	-	-
Event counter	CNTGGIO	-	-
Supervision and monitoring			
Runtime counter for machines and devices	MDSOPT	OPTS	OPTM
Circuit breaker condition monitoring	SSCBR	CBCM	CBCM
Fuse failure supervision	SEQRFUF	FUSEF	60
Current circuit supervision	CCRDIF	MCS 3I	MCS 3I
Trip-circuit supervision	TCSSCBR	TCS	TCM
Station battery supervision	SPVNZBAT	U<>	U<>
Energy monitoring	EPDMMTR	E	E
Measured value limit supervision	MVEXP	-	-
Measurement			
Three-phase current measurement	CMMXU	3I	3I
Three-phase voltage measurement (phase-to-earth)	VPHMMXU	3Upe	3Upe
Three-phase voltage measurement (phase-to-phase)	VPPMMXU	3Upp	3Upp
Residual current measurement	RESCMMXU	I0	I0
Residual voltage measurement	RESVMMXU	U0	U0
Power monitoring with P, Q, S, power factor, frequency	PWRMMXU	PQf	PQf
Sequence current measurement	CSMSQI	I1, I2	I1, I2
Sequence voltage measurement	VSMSQI	U1, U2	V1, V2
Analog channels 1-10 (samples)	A1RADR	ACH1	ACH1
Analog channels 11-20 (samples)	A2RADR	ACH2	ACH2
Analog channels 21-30 (calc. val.)	A3RADR	ACH3	ACH3
Analog channels 31-40 (calc. val.)	A4RADR	ACH4	ACH4
Binary channels 1-16	B1RBDR	BCH1	BCH1
Binary channels 17 -32	B2RBDR	BCH2	BCH2
Binary channels 33 -48	B3RBDR	BCH3	BCH3
Binary channels 49 -64	B4RBDR	BCH4	BCH4
Station communication (GOOSE)			
Table continues on next page			

Description	IEC 61850	IEC 60617	ANSI
Binary receive	GOOSEBINRCV	-	-
Double point receive	GOOSEDPRCV	-	-
Interlock receive	GOOSEINTLKRCV	-	-
Integer receive	GOOSEINTRCV	-	-
Measured value receive	GOOSEMVRCV	-	-
Single point receive	GOOSESPRCV	-	-

Section 2 REM630 overview

2.1 Overview

REM630 is a comprehensive motor management relay for protection, control, measuring and supervision of medium and large synchronous and asynchronous motors in medium voltage industrial power systems. REM630 is a member of ABB's Relion® product family and a part of its 630 series characterized by functional scalability and flexible configurability. REM630 also features necessary control functions required for the management of industrial motor feeder bays. The protection relay can be used with both circuit-breaker controlled and contactor controlled drives.

The supported communication protocols including IEC 61850 offer seamless connectivity to industrial automation systems.

2.1.1 Product version history

Product version	Product history
1.0	First release
1.1	• Support for IEC 60870-5-103 communication protocol • Analog GOOSE • RTD module • New analog input modules • Stabilized three-phase differential protection for motors and generators • High-impedance/flux-balance-based differential protection for motors and generators • Synchronized motor protections
1.2	No new functions
1.3	• Operation time counter • Comparison functions • AND and OR gates with 20 inputs

2.1.2 PCM600 and IED connectivity package version

- Protection and Control IED Manager PCM600 Ver. 2.5 or later
- ABB REM630 Connectivity Package Ver. 1.3 or later
    - Application Configuration
    - Parameter Setting
    - Signal Matrix
    - Signal Monitoring
    - Disturbance Handling
    - Event Viewer
    - Graphical Display Editor

- Hardware Configuration
- IED Users
- IED Compare
- Communication Management
- Configuration Migration

Download connectivity packages from the ABB Web site http://www.abb.com/substationautomation or directly with Update Manager in PCM600.

2.2 Operation functionality

2.2.1 Product variants

The IED capabilities can be adjusted by selecting a product variant. The IED capabilities can be extended by adding HW and/or SW options to the basic variant. For example, the physical communication connector can be either an electrical or optical Ethernet connector.

The number of binary inputs and outputs depends on the amount of the optional BIO modules selected. For a 4U IED, it is possible to take 2 additional BIO modules at the maximum, and for a 6U IED, it is possible to take 4 additional BIO modules at the maximum.

- Basic variant: 14 binary inputs and 9 binary outputs
- With one optional BIO module: 23 binary inputs and 18 binary outputs
- With two optional BIO modules: 32 binary inputs and 27 binary outputs
- With three optional BIO modules: 41 binary inputs and 36 binary outputs
- With four optional BIO modules: 50 binary inputs and 45 binary outputs

2.2.2 Optional functions

Some of the available functions are optional, that is, they are included in the delivered product only when defined by the order code.

- Frequency protection
  - Overfrequency protection
  - Underfrequency protection
  - Frequency gradient
- Phase sequence voltage functions

    - Positive-sequence overvoltage protection
    - Positive-sequence undervoltage protection
    - Negative-sequence overvoltage protection
- Stabilized differential protection for motors
- Additional functions for synchronous motor
    - Reverse power/directional overpower protection
    - Three-phase underexcitation protection
    - Rotor E/F protection

2.3 Physical hardware

The mechanical design of the IED is based on a robust mechanical rack. The HW design is based on the possibility to adapt the HW module configuration to different customer applications.

Table 2: IED contents

Content options	
LHMI	
Communication and CPU module	1 electrical Ethernet connector for the detached LHMI module (the connector must not be used for any other purpose)
	1 Ethernet connector for communication (selectable electrical or optical connector)
	IRIG-B (external time synchronization) connector
	1 fibre-optic connector pair for serial communication (selectable plastic or glass fibre)
	14 binary control inputs
Auxiliary power/binary output module	48-125 V DC or 100-240 V AC/110-250 V DC
	Input contacts for the supervision of the auxiliary supply battery level
	3 normally open power output contacts with TCS
	3 normally open power output contacts
	1 change-over signalling contact
	3 additional signalling contacts
	1 dedicated internal fault output contact
Analog input module	4, 7 or 8 current inputs (1/5 A)
	4, 3 or 2 voltage inputs (100/110/115/120 V)
	With 4 current inputs (1/5 A) also max. 1 accurate current input for sensitive earth fault protection (0.1/0.5 A)
Table continues on next page	

Content options	
Binary input and output module	3 normally open power output contacts 1 change-over signalling contact 5 additional signalling contacts 9 binary control inputs
RTD input and mA output module	8 RTD-inputs (sensor/R/V/mA) 4 outputs (mA)

All external wiring, that is CT and VT connectors, BI/O connectors, power supply connector and communication connections, can be disconnected from the IED modules with wiring, for example, in service situations. The CT connectors have a build-in mechanism which automatically short-circuits CT secondaries when the connector is disconnected from the IED.

2.4 Local HMI

The LHMI is used for setting, monitoring and controlling the protection relay. The LHMI comprises the display, buttons, LED indicators and communication port.

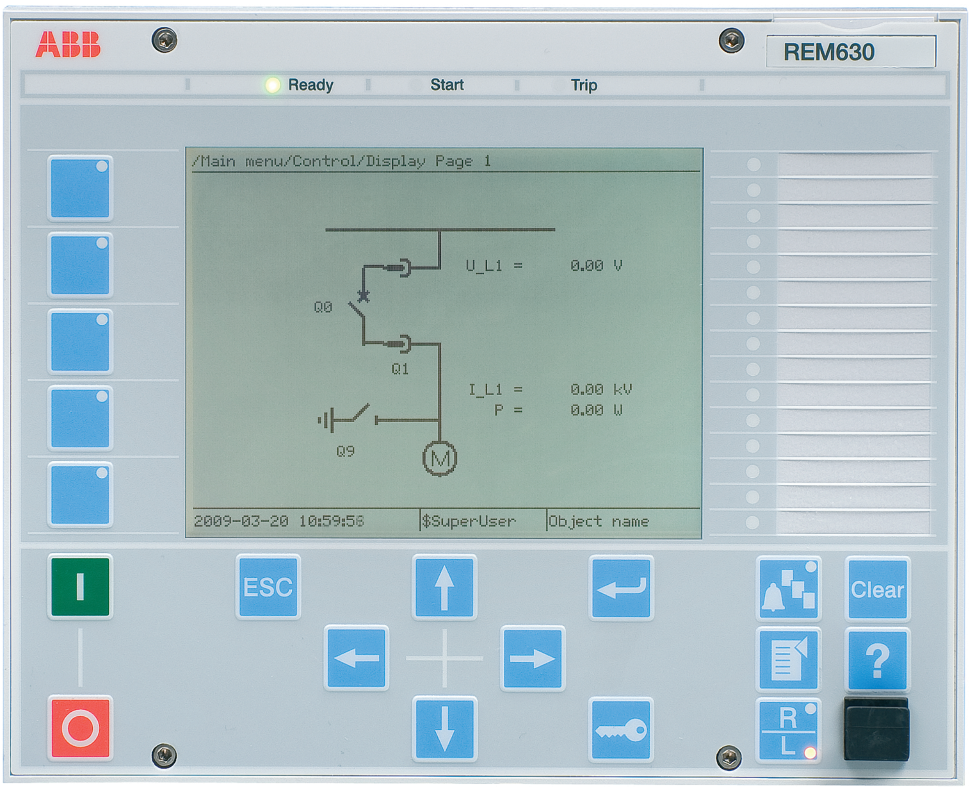


Figure 2: LHMI

2.4.1 Display

The LHMI includes a graphical monochrome display 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.

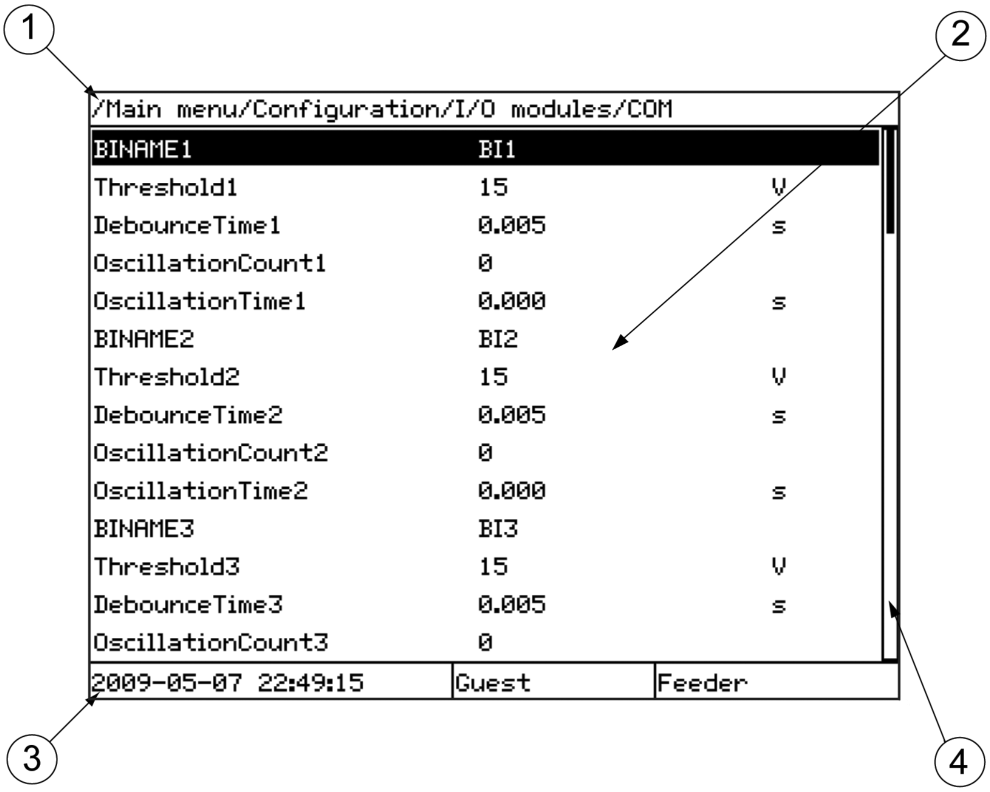


Figure 3: Display layout

1 Path

2 Content

3 Status

4 Scroll bar (appears when needed)

The 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.

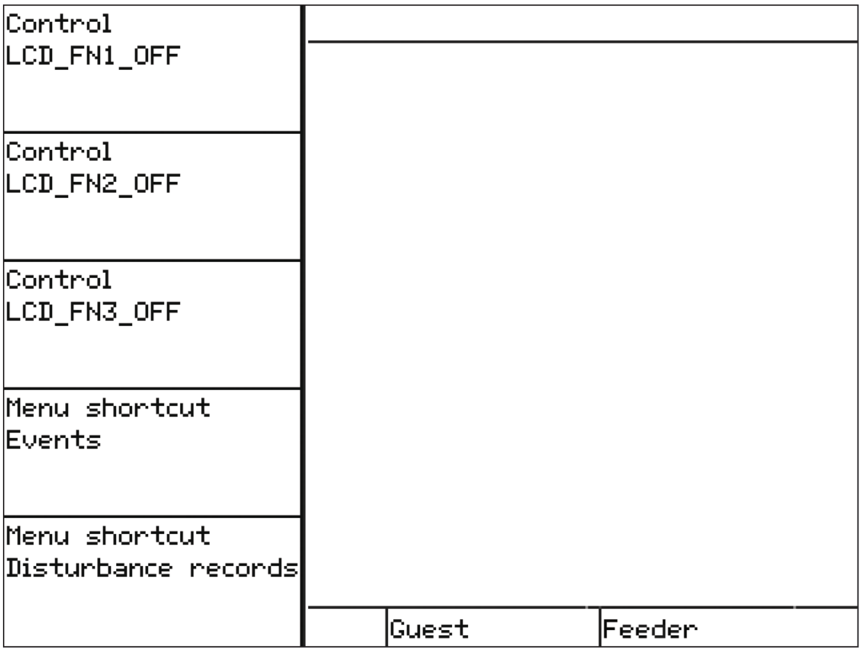


Figure 4: Function button panel

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

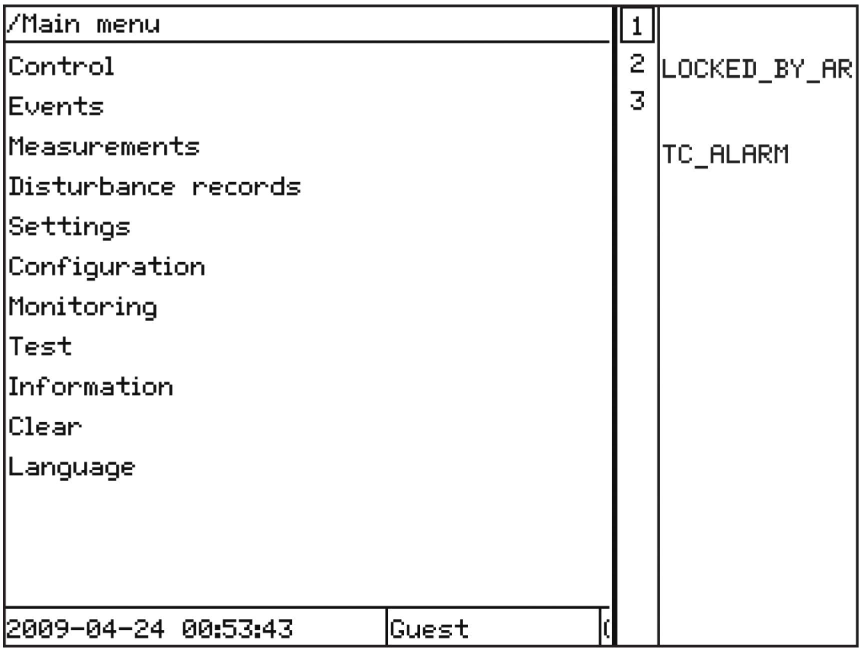


Figure 5: Alarm LED panel

The function button and alarm LED panels are not visible at the same time. Each panel is shown by pressing one of the 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.

2.4.2 LEDs

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

There are 15 programmable alarm LEDs on the 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. Altogether, the 15 physical three-color LEDs can indicate 45 different alarms. 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 the push-buttons you can control objects in the single-line diagram, for example, circuit breakers or disconnectors 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.

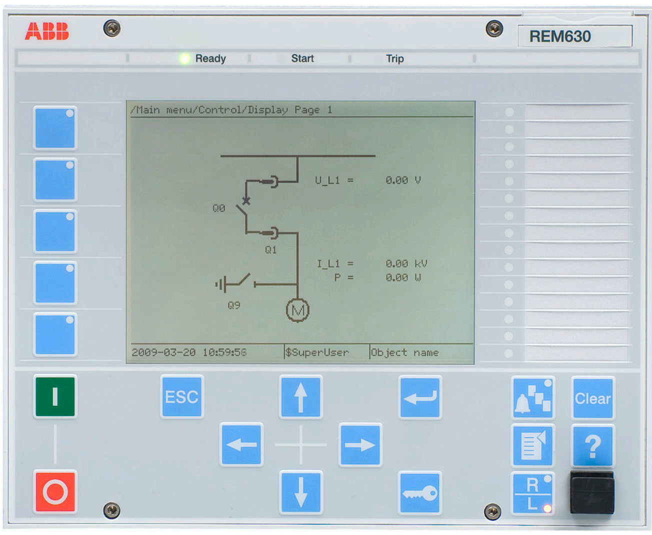


Figure 6: LHMI keypad with object control, navigation and command push-buttons and RJ-45 communication port

2.5 Web HMI

The WHMI enables the user to access the IED via a web browser. The supported Web browser versions are Internet Explorer 8.0, 9.0 and 10.0.

WHMI is disabled by default. To enable the WHMI, select **Main menu/Configuration/HMI/Web HMI/Operation** via the LHMI.

WHMI offers several functions.

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

Viewing phasor diagram with WHMI requires downloading a SVG Viewer plugin.

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

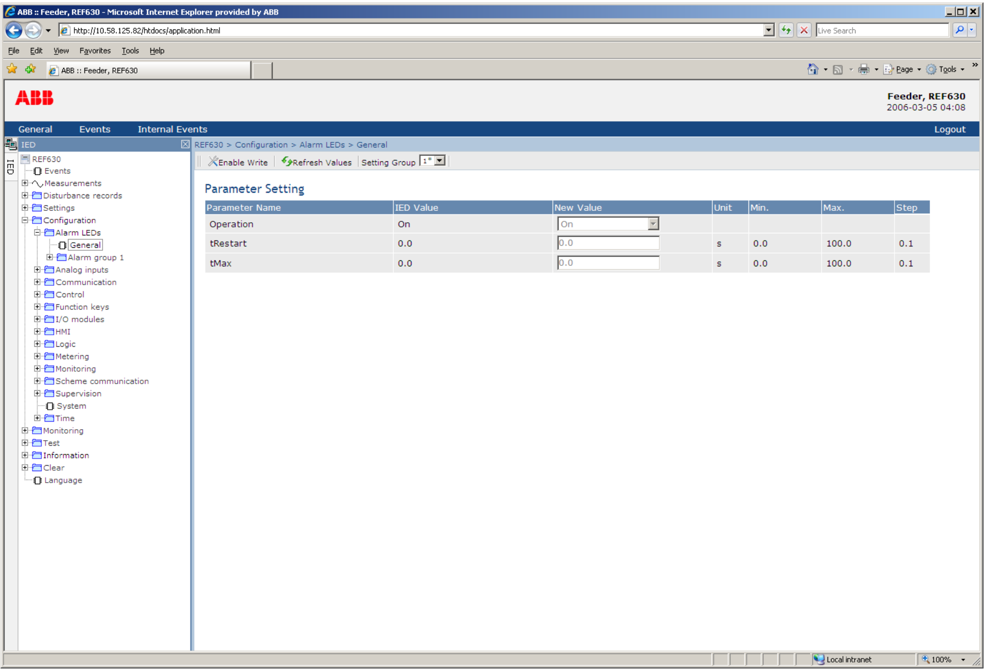


Figure 7: Example view of the WHMI

The WHMI can be accessed locally and remotely.

- Locally by connecting the user's computer to the IED via the front communication port.
- Remotely over LAN/WAN.

2.6 Authorization

At delivery, logging on to the IED is not required to be able to use the LHMI. The IED user has full access to the IED as a SuperUser until users and passwords are created with PCM600 and written into the IED.

The available user categories are predefined for LHMI and WHMI, each with different rights.

Table 3: Available user categories

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

All changes in user management settings cause the IED to reboot.

2.7 Communication

The protection relay supports communication protocols IEC 61850-8-1, IEC 60870-5-103 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 protection relays, is only enabled by the IEC 61850-8-1 communication protocol.

Disturbance files are accessed using the IEC 61850 or IEC 60870-5-103 protocols. Disturbance files are also available to any Ethernet based application in the standard COMTRADE format. The protection relay can send binary signals to other protection relays (so called horizontal communication) using the IEC 61850-8-1 GOOSE (Generic Object Oriented Substation Event) profile. Binary GOOSE messaging can, for example, be employed for protection and interlocking-based protection schemes. The protection relay meets the GOOSE performance requirements for tripping applications in distribution substations, as defined by the IEC 61850 standard. Further, the protection relay supports the sending and receiving of analog values using

GOOSE messaging. Analog GOOSE messaging enables fast transfer of analog measurement values over the station bus, thus facilitating for example sharing of RTD input values, such as surrounding temperature values, to other relay applications. The protection relay interoperates with other IEC 61850 compliant devices, 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. For systems using IEC 60870-5-103, the protection relay can be connected to one master in a station bus with star-topology.

All communication connectors, except for the front port connector, are placed on integrated communication modules. The protection relay is connected to Ethernet-based communication systems via the RJ-45 connector (10/100BASE-TX) or the fibre-optic multimode LC connector (100BASE-FX).

IEC 60870-5-103 is available from optical serial port where it is possible to use serial glass fibre (ST connector) or serial plastic fibre (snap-in connector).

The protection relay supports the following time synchronization methods with a timestamping resolution of 1 ms.

Ethernet communication based

- SNTP (simple network time protocol)
- DNP3

With special time synchronization wiring

- IRIG-B

IEC 60870-5-103 serial communication has a time-stamping resolution of 10 ms.

Section 3 REM630 variants

3.1 Presentation of preconfigurations

The 630 series protection relays are offered with optional factory-made preconfigurations for various applications. The preconfigurations contribute to faster commissioning and less engineering of the protection relay. The preconfigurations include default functionality typically needed for a specific application. Each preconfiguration is adaptable using the Protection and Control IED Manager PCM600. By adapting the preconfiguration the protection relay can be configured to suit the particular application.

The adaptation of the preconfiguration may include adding or removing of protection, control and other functions according to the specific application, changing of the default parameter settings, configuration of the default alarms and event recorder settings including the texts shown in the HMI, configuration of the LEDs and function buttons, and adaptation of the default single-line diagram.

In addition, the adaptation of the preconfiguration always includes communication engineering to configure the communication according to the functionality of the protection relay. The communication engineering is done using the communication configuration function of PCM600.

If none of the offered preconfigurations fulfill the needs of the intended area of application, 630 series protection relays can also be ordered without any preconfiguration. In this case the protection relay needs to be configured from the ground up.

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 motor 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, an instance number, from one onwards.

3.1.1 Preconfigurations

Table 4: REM630 preconfiguration ordering options

Description	Preconfiguration		
Preconfiguration A for asynchronous motor	A		
Preconfiguration B for asynchronous motor including differential protection		B	
Number of instances available			n

Table 5: Functions used in preconfigurations

Description	A	B	n
Protection			
Three-phase non-directional overcurrent protection, low stage	1	1	1
Three-phase non-directional overcurrent protection, instantaneous stage	1	1	1
Non-directional earth-fault protection, low stage	1	1	1
Non-directional earth-fault protection, high stage	1	1	1
Non-directional earth-fault protection, instantaneous stage	-	-	1
Directional earth-fault protection, low stage	-	-	1
Directional earth-fault protection, high stage	-	-	1
Rotor earth-fault protection	-	-	1
Negative-sequence overcurrent protection for machines	2	2	2
Phase-reversal protection	1	1	1
Three-phase thermal overload protection for motors	1	1	1
Motor startup supervision	1	1	1
Motor load jam protection	1	1	1
Emergency start	1	1	1
Loss of load supervision	1	1	1
High-impedance or flux-balance based differential protection for machines	-	-	1
Stabilized differential protection for machines	-	1	1
Three-phase overvoltage protection	-	-	2
Three-phase undervoltage protection	-	-	2
Positive-sequence overvoltage protection	1	1	2
Positive-sequence undervoltage protection	1	1	2
Negative-sequence overvoltage protection	1	1	2
Residual overvoltage protection	-	-	3
Reverse power/directional overpower protection	-	-	3
Frequency gradient protection	-	-	6
Overfrequency protection	-	-	3
Underfrequency protection	-	-	3
Table continues on next page			

Description	A	B	n
Three-phase underexcitation protection	-	-	2
Circuit breaker failure protection	1	1	2
Tripping logic	1	1	2
Multipurpose analog protection	-	-	16
Control			
Bay control	1	1	1
Interlocking interface	2	2	10
Circuit breaker/disconnector control	2	2	10
Circuit breaker	1	1	2
Disconnector	1	1	8
Local/remote switch interface	-	-	1
Generic process I/O			
Single point control (8 signals)	-	-	5
Double point indication	-	-	15
Single point indication	-	-	64
Generic measured value	-	-	15
Logic Rotating Switch for function selection and LHMI presentation	-	-	10
Selector mini switch	-	-	10
Pulse counter for energy metering	-	-	4
Event counter	-	-	1
Supervision and monitoring			
Runtime counter for machines and devices	-	-	1
Circuit breaker condition monitoring	1	1	2
Fuse failure supervision	1	1	1
Current circuit supervision	1	1	1
Trip-circuit supervision	3	3	3
Station battery supervision	-	-	1
Energy monitoring	1	1	1
Measured value limit supervision	-	-	40
Measurement			
Three-phase current measurement	1	1	1
Three-phase voltage measurement (phase-to-earth)	-	-	1
Three-phase voltage measurement (phase-to-phase)	1	1	1
Residual current measurement	-	-	1
Residual voltage measurement	-	-	1
Power monitoring with P, Q, S, power factor, frequency	1	1	1
Sequence current measurement	1	1	1
Sequence voltage measurement	1	1	1
Disturbance recorder function			
Table continues on next page			

Description	A	B	n
Analog channels 1-10 (samples)	1	1	1
Analog channels 11-20 (samples)	-	-	1
Analog channels 21-30 (calc. val.)	-	-	1
Analog channels 31-40 (calc. val.)	-	-	1
Binary channels 1-16	1	1	1
Binary channels 17-32	1	1	1
Binary channels 33-48	1	1	1
Binary channels 49-64	1	1	1
Station communication (GOOSE)			
Binary receive	-	-	10
Double point receive	-	-	32
Interlock receive	-	-	59
Integer receive	-	-	32
Measured value receive	-	-	60
Single point receive	-	-	64
n = total number of available function instances regardless of the preconfiguration selected 1, 2, ... = number of included instances			

3.2 Preconfiguration A for asynchronous motor

3.2.1 Application

The preconfiguration is designed to be used for protection of asynchronous motor feeders in single busbar system with a truck circuit breaker.

The apparatus controlled by the IED is the circuit breaker. The earth switch is considered to be operated manually. The open, close and undefined states of the circuit breaker and the earth switch are indicated on the LHMI.

Required interlocking is configured in the IED.

The preconfiguration includes:

- Control functions
- Current protection functions
- Voltage protection functions
- Supervision functions
- Disturbance recorders
- LEDs' configuration
- Measurement functions

3.2.2 Functions

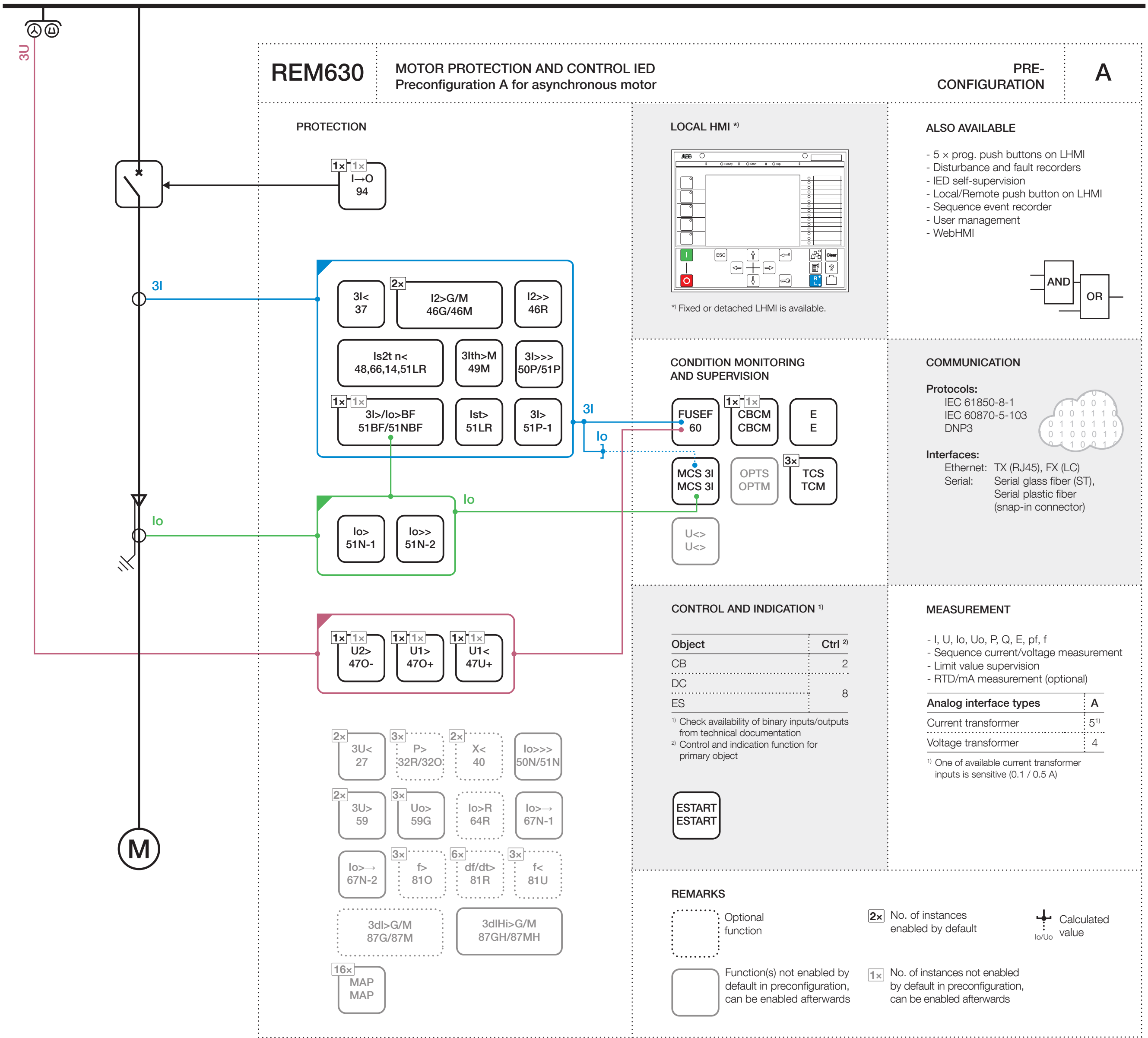


Figure 8: Functionality overview for preconfiguration A

3.2.3 Input/output signal interfaces

Table 6: Interface of binary inputs

Hardware module instance	Hardware channel	Description
COM	BI1	Circuit breaker closed
COM	BI2	Circuit breaker open
COM	BI3	Circuit breaker truck in
COM	BI4	Circuit breaker truck out
COM	BI5	Earth switch closed
COM	BI6	Earth switch open
COM	BI7	External restart inhibit
COM	BI8	Speed switch
COM	BI9	External trip
COM	BI10	Lockout reset
COM	BI11	Allow emergency start
COM	BI12	Circuit breaker gas pressure
COM	BI13	Circuit breaker spring charged
COM	BI14	MCB open

The outputs of the IED are categorized as power outputs (POx) and signal outputs (SOx). The power outputs can be used for starting and stopping the motor. The signal outputs are not heavy-duty outputs. They are used for alarm or signaling purposes.

Table 7: Interface of binary outputs

Hardware module instance	Hardware channel	Description
PSM	BO1_PO	Master Trip 1
PSM	BO2_PO	Motor start
PSM	BO3_PO	Master Trip 2
PSM	BO4_PO	Restart enable
PSM	BO5_PO	Backup trip
PSM	BO6_PO	Not connected
PSM	BO7_SO	Common operate
PSM	BO8_SO	Common start
PSM	BO9_SO	Motor startup

The IED measures the analog signals needed for protection and measuring functions via galvanically isolated matching transformers. The matching transformer input channels 1…4 are intended for current measuring and channels 7...10 for voltage measuring.

Table 8: Interface of analog inputs

Hardware module instance	Hardware channel	Description
AIM_2	CH1	Phase current IL1
AIM_2	CH2	Phase current IL2
AIM_2	CH3	Phase current IL3
AIM_2	CH4	Neutral current I_0
AIM_2	CH5	Not connected
AIM_2	CH6	Not available
AIM_2	CH7	Phase voltage UL1
AIM_2	CH8	Phase voltage UL2
AIM_2	CH9	Phase voltage UL3
AIM_2	CH10	Neutral voltage U_0

3.2.4 Preprocessing blocks and fixed signals

The analog current and voltage signals coming to the IED are processed by preprocessing blocks. There are two types of preprocessing blocks based on 20 samples per cycle and 80 samples per cycle. All function blocks functioning at 5 ms task time need 80 samples per cycle whereas all the rest need 20 samples per cycle.

A fixed signal block providing a logical TRUE and a logical FALSE output has been used. Outputs are connected internally to other functional blocks when needed.

Even if the *AnalogInputType* setting of a SMAI block is set to “Current”, the *MinValFreqMeas* setting is still visible. This means that the minimum level for current amplitude is based on UBase. As an example, if UBase is 20 kV, the minimum amplitude for current is 20000 × 10% = 2000 A.

3.2.5 Control functions

3.2.5.1 Motor bay control QCCBAY

Bay control is used to handle the selection of the operator place per bay. It provides blocking functions that can be distributed to different apparatuses within the bay. Bay control sends information about the permitted source to operate (PSTO) and blocking conditions to other functions within the bay, for example switch control functions.

3.2.5.2 Apparatus control SCILO, GNRLCSWI, DAXCBR, DAXSWI

Apparatus control initializes and supervises proper selection and switches on primary apparatus. Each apparatus requires interlocking function, switch control function and apparatus functions.

Circuit-breaker control function

The circuit breaker is controlled by a combination of switch interlocking (SCILO), switch controller (GNRLCSWI) and circuit breaker controller (DAXCBR) functions.

The position information of the circuit breaker and the truck are connected to DAXCBR. The interlocking logics for the circuit breaker have been programmed to open at any time, provided that the gas pressure inside the circuit breaker is above the lockout limit. Closing of the circuit breaker is always prevented if the gas pressure inside the circuit breaker is below the lockout limit or the truck is open or spring charge time is above the set limit.

SCILO function checks for the interlocking conditions and provides closing and opening enable signals. The enable signal is used by GNRLCSWI function block which checks for operator place selector before providing the final open or close signal to DAXCBR function.

The open, closed and undefined states of the circuit breaker are indicated on the LHMI.

Earth-switch control function

The earth switch is controlled by a combination of SCILO, GNRLCSWI and DAXSWI functions.

The position information of the earth switch is connected to respective DAXSWI via binary inputs. Earth switch interlocking depends on the circuit breaker and the truck position. Opening and closing of the earth switch can be enabled at anytime only if the circuit breaker and the truck are open.

Interlocking for earth switch is provided. However, the earth switch is not controlled by the IED, and is considered to be operated manually.

SCILO function checks for these conditions and provides a closing and opening enable signal. The enable signal is used by GNRLCSWI function blocks which check for the operator place selector before providing the final open or close signal to DAXSWI function.

The open, closed and undefined states of the earth switch are indicated on the LHMI.

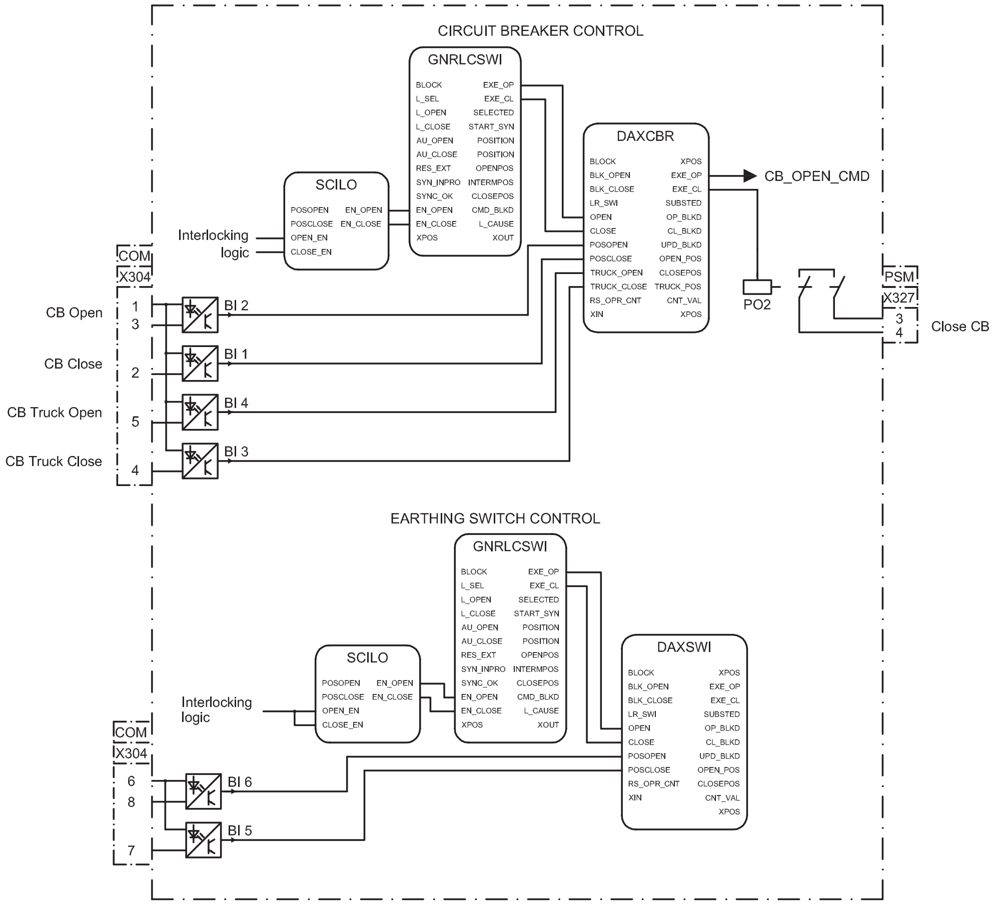


Figure 9: Apparatus control

3.2.6 Protection functions

3.2.6.1 Thermal overload protection MPTTR

The three-phase thermal overload protection function is designed to be used for protecting electric motors from overheating. The function calculates the thermal level on the basis of the measured motor load current, rated motor current, and calculated negative sequence current.

When the thermal level of the motor exceeds a predefined limit, the function generates a thermal overload alarm. If the thermal content continues to rise and reaches 100 percent, the function block generates a trip command to stop the motor. To prevent successive restarting of the motor when the motor temperature is high, restarting of the motor is inhibited if the thermal content exceeds the set restart inhibit level. However it is possible to start the motor in case of an emergency. The set of three phase currents, I3P, is connected to the inputs.

The thermal overload alarm and trip provide an LED indication on the LHMI. The thermal overload alarm, thermal overload trip and restart inhibit signals are connected to the disturbance recorders.

3.2.6.2 Emergency start ESMGAPC

Emergency start function is used in an emergency where motor needs to be started even with a knowledge that it may result into damage to the motor. The function only forces the IED to allow restarting of the motor but it does not actually restart it.

The set of three phase currents, I3P, is connected to the inputs. Emergency start is allowed when binary input COM BI11 is activated.

The emergency output is connected to the disturbance recorder and is used to provide a LED indication on the LHMI.

3.2.6.3 Motor startup supervision STTPMSU

The motor startup supervision function protects against excessive starting time and locked rotor conditions of motors during startup.

Further, on exceeding the specified number of startups within certain duration, the function prevents restarting. After any motor start, further restarts are also inhibited until settable duration of time.

The starting of the motor is supervised by monitoring the true RMS magnitude of all phase currents. During the startup of the motor, the function calculates the integral of I^2t value and if the calculated value exceeds the set value, the operate signal is activated. A speed switch information, which indicates whether the rotor starts to rotate or not, can also be used in this function.

The output signals indicating I^2t operate, motor startup, motor stall condition and motor restart inhibit are connected to the disturbance recorders and used to provide a LED indication on the LHMI. The motor startup information is also available at binary output PSM SO3.

3.2.6.4 Motor stall protection JAMPTOC

The motor load jam protection function is used for protection against mechanical jam when motor is running. The function is blocked during motor startup.

The set of three phase currents, I3P, is connected to the inputs. The function operates when the measured current is above the setting. The operation characteristic is definite time.

The operate signal is used to trigger the disturbance recorder and to provide a LED indication on the LHMI.

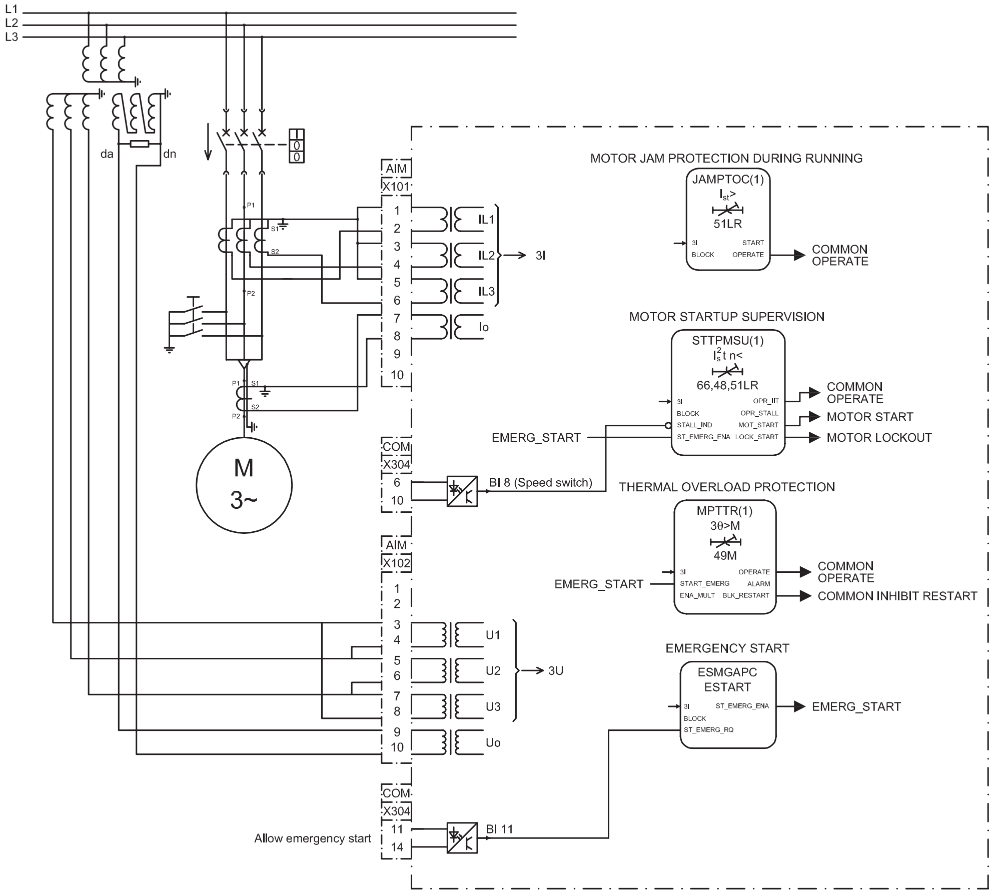


Figure 10: Motor load jam protection

3.2.6.5 Loss of load protection LOFLPTUC

The loss of load protection is used for detecting sudden load loss which is considered as a fault condition.

The set of three phase currents, I3P, is connected to the inputs and the function operates when all the phase currents fall below the set level but stay above the set de-energization level. It operates with definite time (DT) characteristics. The operate signal is used to trigger the disturbance recorder.

3.2.6.6 Phase reversal protection PREVPTOC

The phase reversal protection is used for detecting the reversed connection of the phases to a three-phase motor by monitoring the negative-phase sequence current of the motor.

The operation of the function is based on the detection of very high negative-sequence currents during motor start up due to incorrect phase connections to the motor. The condition causes the motor to rotate in the reverse direction. The function starts and operates when the negative-sequence current exceeds the corresponding set limits. Phase reversal protection is blocked when current circuit supervision detects a failure. Operate signal is used to trigger the disturbance recorder.

3.2.6.7 Motor negative-sequence overcurrent protection MNSPTOC

Two instances of negative-sequence overcurrent detection are provided for protection against single-phasing, unbalance load or unsymmetrical voltage. The set of three phase currents, I3P, is connected to the inputs.

The function operates in two modes, the definite time mode (DT) and the inverse definite minimum time (IDMT) mode, for which two instances of the function block are used. The negative-sequence overcurrent protection is blocked in case of current circuit supervision failure is activated.

The common operate and start signal from the both MNSPTOC functions are connected to an OR-gate to form a combined negative-sequence overcurrent operate and start signal which is used to provide a LED indication on the LHMI. Also a separate start and operate signal from the both MNSPTOC functions is connected to the disturbance recorder.

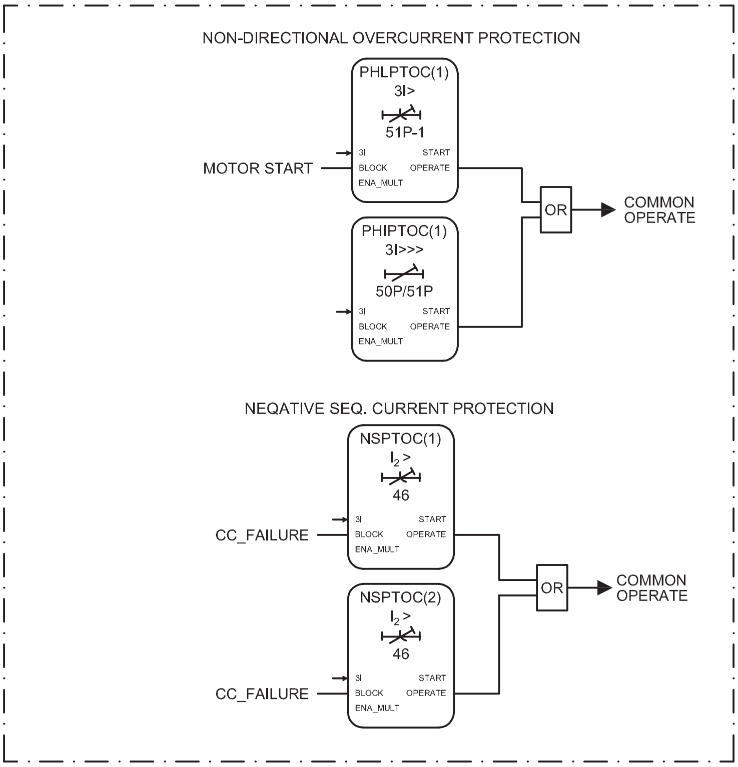


Figure 11: Motor negative-sequence overcurrent protection

3.2.6.8 Non-directional overcurrent protection PHxPTOC

The three-phase non-directional overcurrent functions are used for non-directional one-phase, two-phase and three-phase overcurrent and short-circuit protection with definite time or various inverse definite minimum time (IDMT) characteristic. The operation of a stage is based on three measuring principles: DFT, RMS or peak-to-peak values.

The configuration includes two variants of non-directional overcurrent function blocks: low and instantaneous. The set of three phase currents, I3P, is connected to the inputs. The low stage is blocked during motor startup. It is designed for additional alarming or protection purposes, like supplementing thermal overload protection. The low stage can be used as overcurrent protection whereas instantaneous stages give protection in case of short circuit.

An operate and start signal from the low stage is used to provide a LED indication on the LHMI. Separate start and operate signals from both functions are connected to the disturbance recorder.

3.2.6.9 Non-directional earth-fault protection EFxPTOC

The non-directional earth-fault protection functions are used for protection under earth-fault conditions with definite-time (DT) or with inverse definite minimum time (IDMT) characteristic when appropriate.

The operation of the stage can be based on three measuring principles: DFT, RMS or peak-to-peak values. The configuration includes high stage and low stage non-directional current function blocks. The set of three phase currents, I3P, is connected to the inputs. During the startup, for avoiding unnecessary operations, the start value of both instances is multiplied by a setting parameter *Start value Mult*. Both instances of the earth fault protection are blocked by the start of the instantaneous overcurrent protection.

A common operate and start signal from high stage and low stage earth-fault protection functions are connected to an OR-gate to form a combined non-directional earth-fault operate and start signal which is used to provide a LED indication on the LHMI. Separate start and operate signals from both of these functions are connected to the disturbance recorder.

3.2.6.10 Positive-sequence overvoltage protection PSPTOV

The positive-sequence overvoltage function blocks are used for positive-sequence overvoltage protection with definite-time characteristic. The set of three phase voltages, U3P, is connected to the inputs.

The operate and start signals from the positive-sequence overvoltage function is used to trigger the disturbance recorder.

3.2.6.11 Positive-sequence undervoltage protection PSPTUV

The positive-sequence undervoltage function blocks are used for positive-sequence undervoltage protection with definite-time characteristic. The set of three phase voltages, U3P, is connected to the inputs.

The operate and start signals from the positive-sequence overvoltage function is used to trigger the disturbance recorder. The undervoltage function is blocked by the fuse failure function and during starting condition of the motor.

3.2.6.12 Negative-sequence overvoltage protection NSPTOV

The negative sequence overvoltage function blocks are used for negative-sequence overvoltage protection with definite-time characteristic. The set of three phase voltages, U3P, is connected to the inputs.

The operate and start signals are used to provide a LED indication on the LHMI and they are also connected to the disturbance recorder.

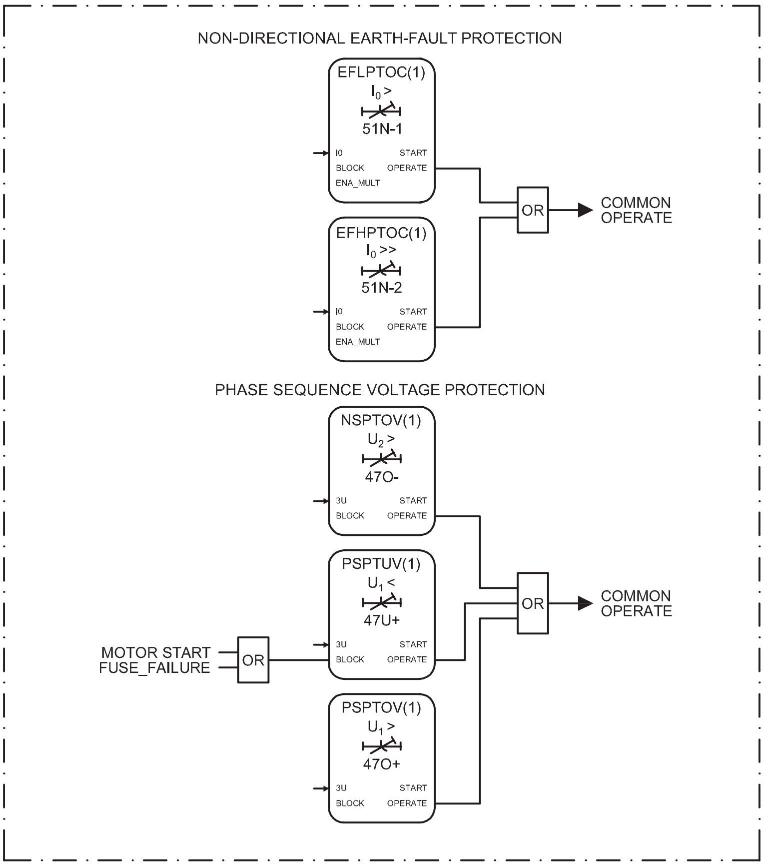


Figure 12: Negative-sequence overvoltage protection

3.2.6.13 Circuit-breaker failure protection CCBRBRF

The function is activated by the common operate command from the protection functions. The breaker failure function issues a backup trip command to adjacent circuit breakers in case the main circuit breaker fails to trip for the protected component. The backup trip is connected at binary output PSM PO5.

A failure of a circuit breaker is detected by measuring the current or by detecting the remaining trip signal. Function also provides retrip. Retrip is used along with the main trip, and is activated before the backup trip signal is generated in case the main breaker fails to open. Retrip is used to increase the operational reliability of the circuit breaker.

3.2.6.14 Tripping logic TRPPTRC

Tripping logic has been configured to provide tripping signal of required duration to Master trip 1 and Master trip 2 circuit. The tripping circuit opens the circuit breaker on

- Receipt of operate signal from the protection function or
- Retrip signal from circuit breaker failure protection.

Two master tripping signals are available at binary output PSM PO1 and PSM PO3. The lockout reset binary input available at COM BI10 is connected to the tripping circuit to reset the circuit-breaker lockout function.

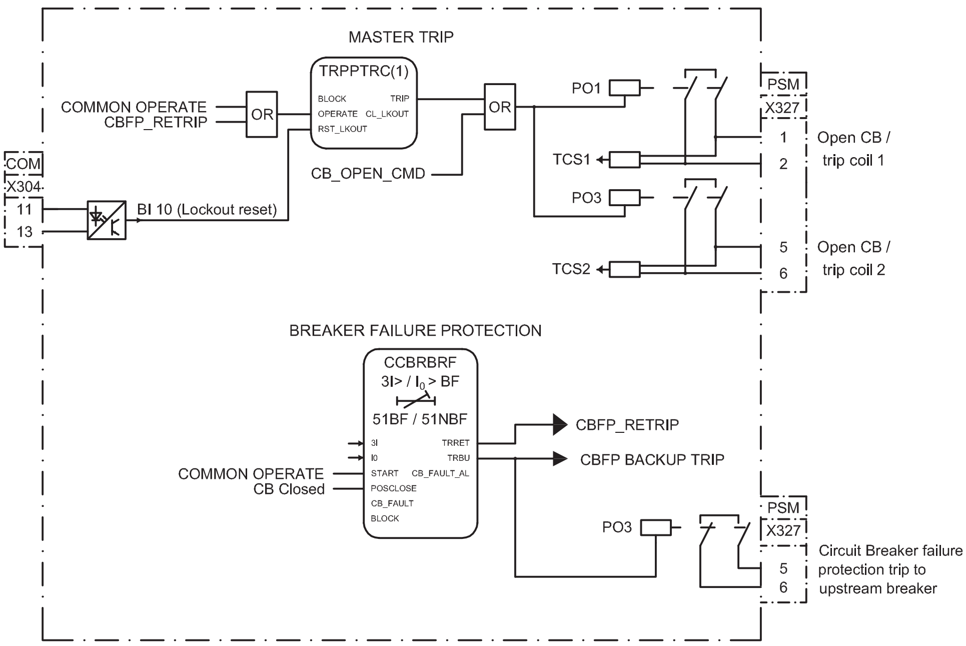


Figure 13: Tripping logic

3.2.6.15 Combined operate and start alarm signal

The operate outputs of all protection functions are combined in an OR-gate to get a common Operate output. This common operate signal is connected to a tripping logic. It is also available as an alarm binary output, PSM SO1, with a settable minimum alarm delay of 80 ms. Also, a common Start output is derived from the start outputs of protection functions combined in an OR-gate. The output is available as an alarm binary output PSM SO2 with a settable minimum alarm delay of 80 ms.

3.2.6.16 Combined restart inhibit and restart enable signal

The restart inhibit signals from the motor thermal protection, negative-sequence overcurrent and motor startup protection function are combined in an OR-gate to obtain a common restart inhibit signal. This signal is also connected to the disturbance recorder and it provides a LED indication on the LHMI.

The restart inhibit signal is inverted to a restart enable signal. The restart enable signal is active, if the emergency start is activated or if both the common operate signal and the common restart inhibit signals are inactive. The restart enable signal is connected to the disturbance recorder. The signal provides a LED indication on the LHMI and is available as an output at PSM PO4 with a minimum alarm time of 80 ms.

3.2.7 Supervision functions

3.2.7.1 Trip circuit supervision TCSSCBR

Two instances of the trip circuit supervision function are used for supervising Master trip 1 and Master trip 2. Function continuously supervises trip circuit and alarms in case of a failure of a trip circuit. The function block does not perform the supervision itself but it is used as an aid for configuration. To prevent unwanted alarms, the function is blocked when any of the protection function's operate signals is active or the circuit breaker is open.

An additional instance of the trip circuit supervision function is used to check the proper functioning of the closing circuit of the motor circuit breaker. To prevent unwanted alarms, the function is blocked when the circuit breaker is in closed position.

The function gives an indication via a LED on the LHMI on detection of any of the trip circuit failure. Also individual trip circuit alarm indications are connected to the disturbance recorders.

3.2.7.2 Fuse failure and current circuit supervision SEQRFUF, CCRDIF

The fuse failure and current circuit supervision functions give an alarm in case of a failure in the secondary circuits between the voltage transformer or current transformer and the IED respectively. The set of three phase currents and voltages, I3P and U3P, are connected to the inputs.

An alarm is available on failure of the secondary circuits. Alarms are recorded by a disturbance recorder.

3.2.7.3 Circuit-breaker condition monitoring SSCBR

The circuit-breaker condition monitoring function checks for the health of the circuit breaker. The circuit breaker status is connected to the function via binary inputs. Function requires also pressure lockout input and spring charged input connected via binary input COM_101.BI12 and COM_101.BI13 respectively. Various alarm outputs from the function are combined in an OR-gate to create a master circuit-breaker monitoring alarm.

All of the alarms are separately connected to the binary recorder and a combined alarm is available as an indication via a LED on the LHMI.

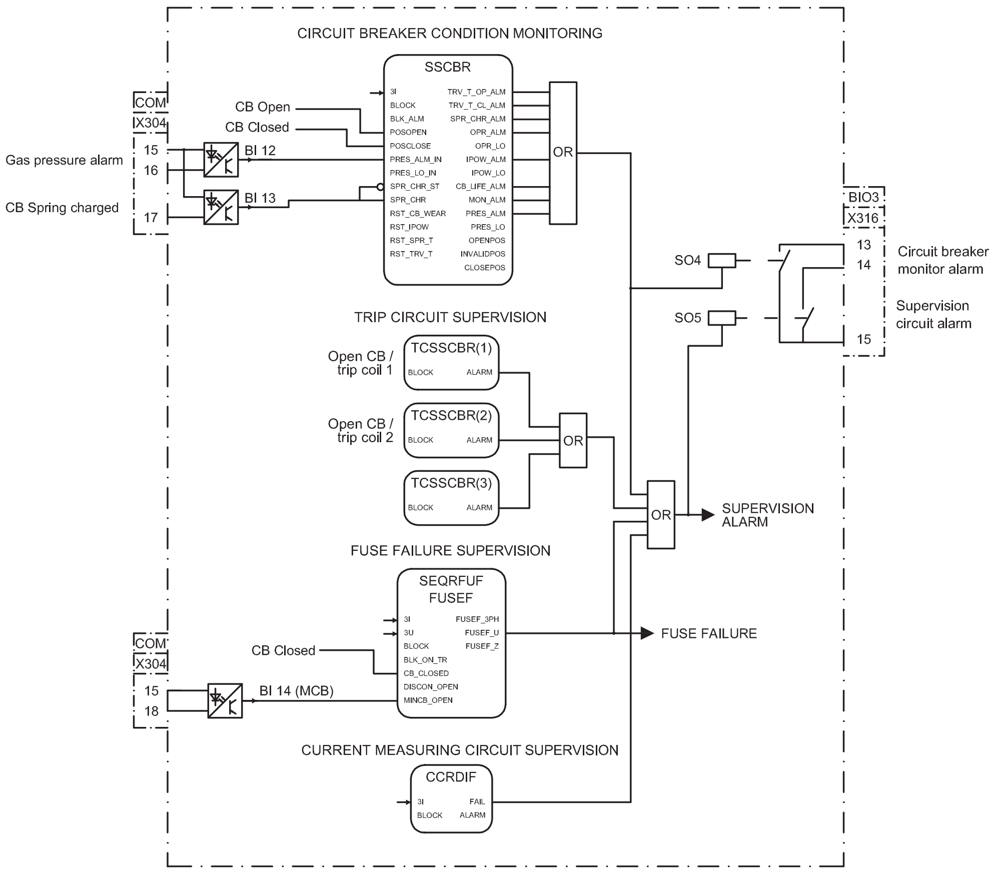


Figure 14: Circuit-breaker condition monitoring

3.2.8 Measurement and analog recording functions

The measured quantities in this configuration are:

- Current
- Current sequence component
- Residual current
- Voltage
- Power
- Energy

The measured quantities can be viewed in the measurement menu on the LHMI.

All analog input channels are connected to the analog disturbance recorder. When any of these analog values violate the upper or lower threshold limits, the recorder unit is triggered which in turn will record all the signals connected to the recorder.

Table 9: Signals connected to the analog recorder

Channel ID	Description
Channel 1	Phase A current
Channel 2	Phase B current
Channel 3	Phase C current
Channel 4	Neutral current
Channel 5	Phase A voltage
Channel 6	Phase B voltage
Channel 7	Phase C voltage
Channel 8	Neutral voltage

Data connected to analog channels contain 20 samples per cycle.

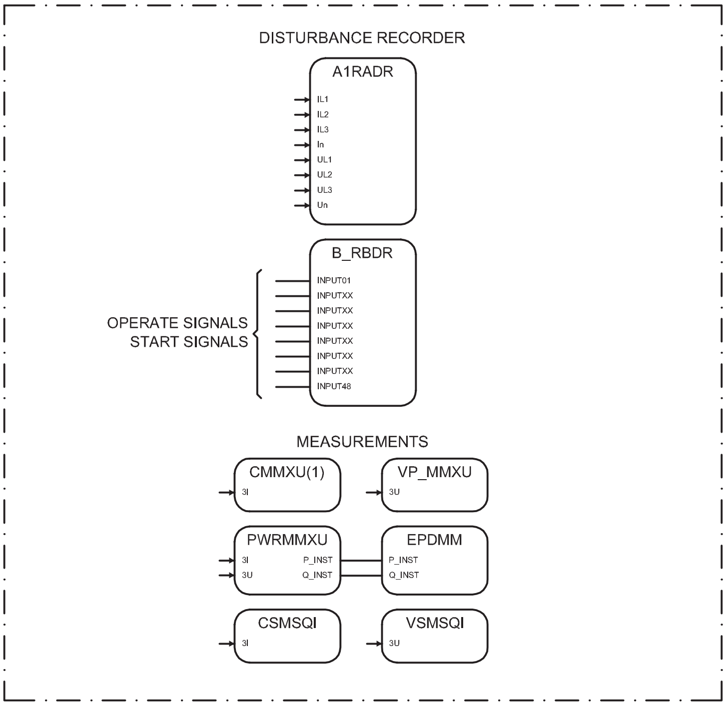


Figure 15: Measurement and analog recording functions

3.2.9 Binary recording and LED configuration

All of the start and operate outputs from the respective protection functions, various alarms from supervision functions, and important signals from control and protective functions are connected to a binary recorder. In case of a fault, the binary recorder is triggered which in turn will record all the signals connected to the recorder.

Table 10: Signals connected tot the binary recorder

Channel ID	Description
Channel 1	Start of overcurrent low stage
Channel 2	Operate of overcurrent low stage
Channel 3	Start of instantaneous overcurrent stage
Channel 4	Operate of instantaneous overcurrent stage
Channel 5	Start of negative-sequence overcurrent stage 1
Channel 6	Operate of negative-sequence overcurrent stage 1
Channel 7	Start of negative-sequence overcurrent stage 2
Channel 8	Operate of negative-sequence overcurrent stage 2
Channel 9	Thermal overload prior alarm
Channel 10	Operate thermal overload
Channel 11	Start of low stage earth-fault protection
Channel 12	Operate of low stage earth-fault protection

Table continues on next page

Channel ID	Description
Channel 13	Start of high stage earth-fault protection
Channel 14	Operate of high stage earth- fault protection operate
Channel 15	Operate of phase reversal protection
Channel 16	Operate of loss of load protection
Channel 17	Start of positive-sequence overvoltage protection
Channel 18	Operate of positive-sequence overvoltage protection
Channel 19	Start of positive-sequence under voltage protection
Channel 20	Operate of positive-sequence under voltage protection
Channel 21	Start of negative-sequence over voltage protection
Channel 22	Operate of negative-sequence over voltage protection
Channel 23	Operate of motor jam protection
Channel 24	Operate signal for stalling protection
Channel 25	Operate signal for thermal stress (IIT)
Channel 26	Restart inhibit for motor
Channel 27	Emergency start of motor activated
Channel 28	Motor restart inhibit due to negative-sequence overcurrent protection stage 1
Channel 29	Motor restart inhibit due to negative-sequence overcurrent protection stage 2
Channel 30	Motor restart inhibit due to thermal overload
Channel 31	Circuit breaker closed
Channel 32	Circuit breaker is open
Channel 33	Backup trip from circuit-breaker failure protection
Channel 34	Retrip from circuit-breaker failure protection
Channel 35	Trip circuit alarm 1 (supervising motor stop circuit 1)
Channel 36	Trip circuit alarm 2 (supervising motor stop circuit 2)
Channel 37	Trip circuit alarm 3 (supervising motor start circuit 3)
Channel 38	Circuit breaker maintenance alarm: accumulated energy exceeds the set limit
Channel 39	Circuit breaker not operated since long
Channel 40	Closing time of circuit breaker exceeded the limit
Channel 41	Opening time of circuit breaker exceeded the limit
Channel 42	Pressure in circuit breaker below the lockout limit
Channel 43	Spring charge time of circuit breaker exceeded the limit
Channel 44	Number of circuit breaker operation exceeded the set limit
Channel 45	Circuit breaker maintenance alarm: number of operations exceeds the set limit
Channel 46	External trip command
Channel 47	External restart inhibit command
Channel 48	MCB open indication
Channel 49	Current circuit failure
Channel 50	Fuse failure
Channel 51	Motor startup in progress

The LEDs are configured for alarm indications.

Table 11: LEDs configured on LHMI alarm page 1

LED No	LED color	Description
LED 1	Yellow	Start from OC
LED 1	Red	Operate from OC
LED 2	Yellow	Combined start from EF
LED 2	Red	Combined operate from EF
LED 3	Red	Operate from motor jam protection
LED 4	Yellow	Combined start from MNSPTOC
LED 4	Red	Combined operate from MNSPTOC
LED 5	Yellow	Thermal overload prior alarm
LED 5	Red	Thermal overload trip
LED 6	Yellow	Retrip from circuit-breaker protection function
LED 6	Red	Backup trip from circuit-breaker protection function
LED 7	Green	Disturbance recorder triggered
LED 8	Yellow	Alarm from circuit-breaker monitoring function
LED 9	Red	Combined trip circuit supervision alarm
LED 10	Yellow	Fuse failure supervision
LED 10	Red	Current circuit failure
LED 11	Red	Operate signal for thermal stress (IIT)
LED 12	Red	Motor stall at start
LED 13	Yellow	Motor startup in progress
LED 14	Green	Restart enabled
LED 14	Red	Restart inhibited
LED 15	Red	Emergency start of motor activated

3.3 Preconfiguration B for asynchronous motor including differential protection

3.3.1 Application

The preconfiguration B is designed to be used as unit protection of asynchronous and synchronous motor feeders in single busbar systems with a truck circuit breaker.

The apparatus controlled by the IED is the circuit breaker. The earth switch is considered to be operated manually. The open, close and undefined states of the circuit breaker and the earth switch are indicated on the LHMI.

Required interlocking is configured in the IED.

The preconfiguration includes:

- Control functions
- Current protection functions including stabilized differential protection
- Voltage protection functions
- Supervision functions
- Disturbance recorders
- LEDs' configuration
- Measurement functions

3.3.2 Functions

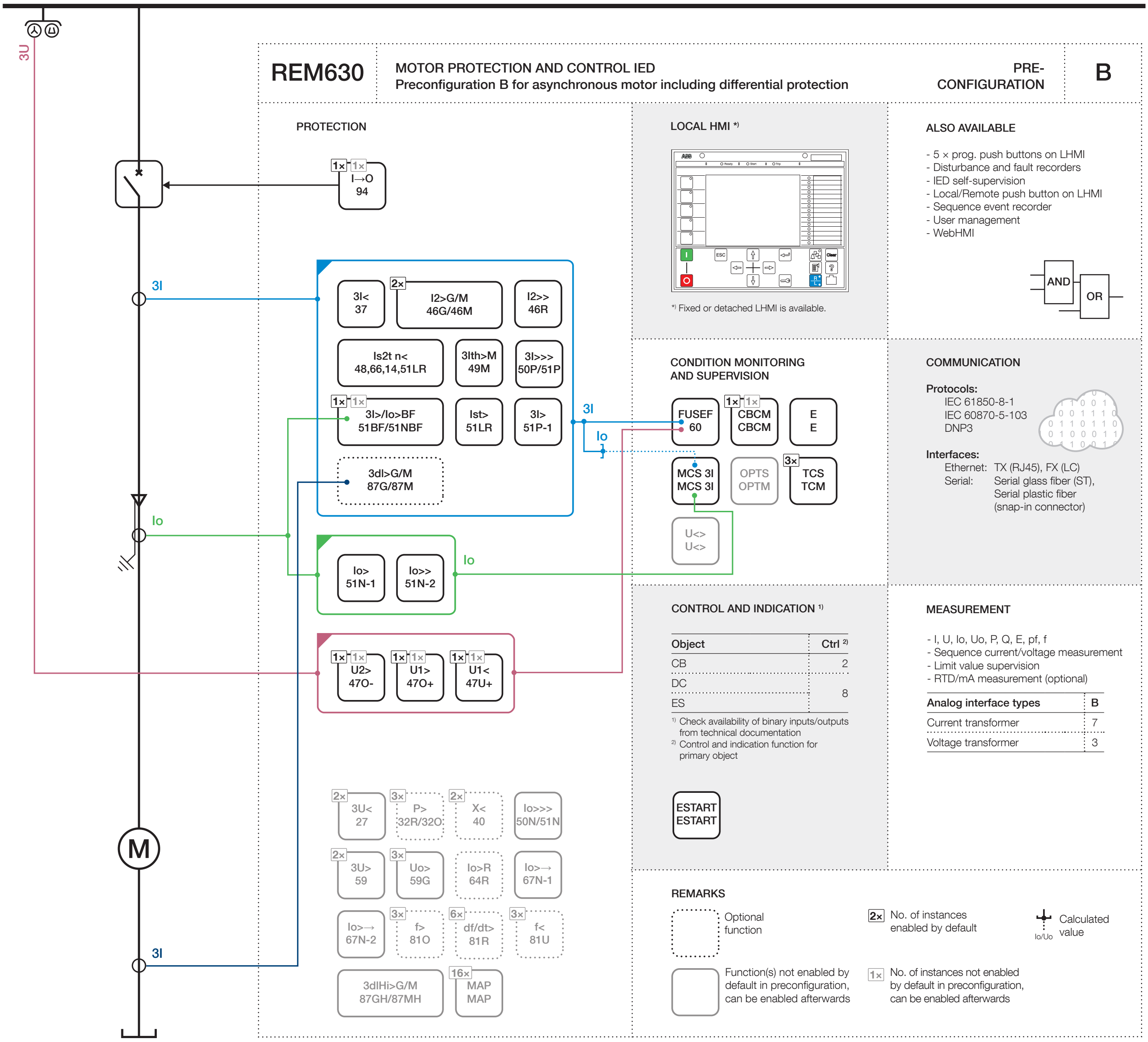


Figure 16: Functionality overview for preconfiguration B

3.3.3 Input/output signal interfaces

Table 12: Interface of binary inputs

Hardware module instance	Hardware channel	Description
COM	BI1	Circuit breaker closed
COM	BI2	Circuit breaker open
COM	BI3	Circuit breaker truck in
COM	BI4	Circuit breaker truck out
COM	BI5	Earth switch closed
COM	BI6	Earth switch open
COM	BI7	External restart inhibit
COM	BI8	Speed switch
COM	BI9	External trip
COM	BI10	Lockout reset
COM	BI11	Allow emergency start
COM	BI12	Circuit breaker gas pressure
COM	BI13	Circuit breaker spring charged
COM	BI14	MCB open

The outputs of the IED are categorized as power outputs (POx) and signal outputs (SOx). The power outputs can be used for starting and stopping the motor. The signal outputs are not heavy-duty outputs. They are used for alarm or signaling purposes.

Table 13: Interface of binary outputs

Hardware module instance	Hardware channel	Description
PSM	BO1_PO	Master Trip 1
PSM	BO2_PO	Motor start
PSM	BO3_PO	Master Trip 2
PSM	BO4_PO	Restart enable
PSM	BO5_PO	Backup trip
PSM	BO6_PO	Not connected
PSM	BO7_SO	Common operate
PSM	BO8_SO	Common start
PSM	BO9_SO	Motor startup

The IED measures the analog signals needed for protection and measuring functions via galvanically isolated matching transformers. The matching transformer input channels 1…7 are intended for current measuring and channels 8...10 for voltage measuring.

Table 14: Interface of analog inputs

Hardware module instance	Hardware channel	Description
AIM_2	CH1	Line-side phase current, IL1
AIM_2	CH2	Line-side phase current, IL2
AIM_2	CH3	Line-side phase current, IL3
AIM_2	CH4	Neutral current, Io
AIM_2	CH5	Neutral-side phase current, IL1_N
AIM_2	CH6	Neutral-side phase current, IL2_N
AIM_2	CH7	Neutral-side phase current, IL3_N
AIM_2	CH8	Voltage U1
AIM_2	CH9	Voltage U2
AIM_2	CH10	Voltage U3

3.3.4 Preprocessing blocks and fixed signals

The analog current and voltage signals coming to the IED are processed by preprocessing blocks. There are two types of preprocessing blocks based on 20 samples per cycle and 80 samples per cycle. All function blocks functioning at 5 ms task time need 80 samples per cycle whereas all the rest need 20 samples per cycle.

A fixed signal block providing a logical TRUE and a logical FALSE output has been used. Outputs are connected internally to other functional blocks when needed.

Even if the *AnalogInputType* setting of a SMAI block is set to “Current”, the *MinValFreqMeas* setting is still visible. This means that the minimum level for current amplitude is based on UBase. As an example, if UBase is 20 kV, the minimum amplitude for current is 20000 × 10% = 2000 A.

3.3.5 Control functions

3.3.5.1 Motor bay control QCCBAY

Bay control is used to handle the selection of the operator place per bay. It provides blocking functions that can be distributed to different apparatuses within the bay. Bay control sends information about the permitted source to operate (PSTO) and blocking conditions to other functions within the bay, for example switch control functions.

3.3.5.2 Apparatus control SCILO, GNRLCSWI, DAXCBR, DAXSWI

Apparatus control initializes and supervises proper selection and switches on primary apparatus. Each apparatus requires interlocking function, switch control function and apparatus functions.

Circuit-breaker control function

The circuit breaker is controlled by a combination of switch interlocking (SCILO), switch controller (GNRLCSWI) and circuit breaker controller (DAXCBR) functions.

The position information of the circuit breaker and the truck are connected to DAXCBR. The interlocking logics for the circuit breaker have been programmed to open at any time, provided that the gas pressure inside the circuit breaker is above the lockout limit. Closing of the circuit breaker is always prevented if the gas pressure inside the circuit breaker is below the lockout limit or the truck is open or spring charge time is above the set limit.

SCILO function checks for the interlocking conditions and provides closing and opening enable signals. The enable signal is used by GNRLCSWI function block which checks for operator place selector before providing the final open or close signal to DAXCBR function.

The open, closed and undefined states of the circuit breaker are indicated on the LHMI.

Earth-switch control function

The earth switch is controlled by a combination of SCILO, GNRLCSWI and DAXSWI functions.

The position information of the earth switch is connected to respective DAXSWI via binary inputs. Earth switch interlocking depends on the circuit breaker and the truck position. Opening and closing of the earth switch can be enabled at anytime only if the circuit breaker and the truck are open.

Interlocking for earth switch is provided. However, the earth switch is not controlled by the IED, and is considered to be operated manually.

SCILO function checks for these conditions and provides a closing and opening enable signal. The enable signal is used by GNRLCSWI function blocks which check for the operator place selector before providing the final open or close signal to DAXSWI function.

The open, closed and undefined states of the earth switch are indicated on the LHMI.

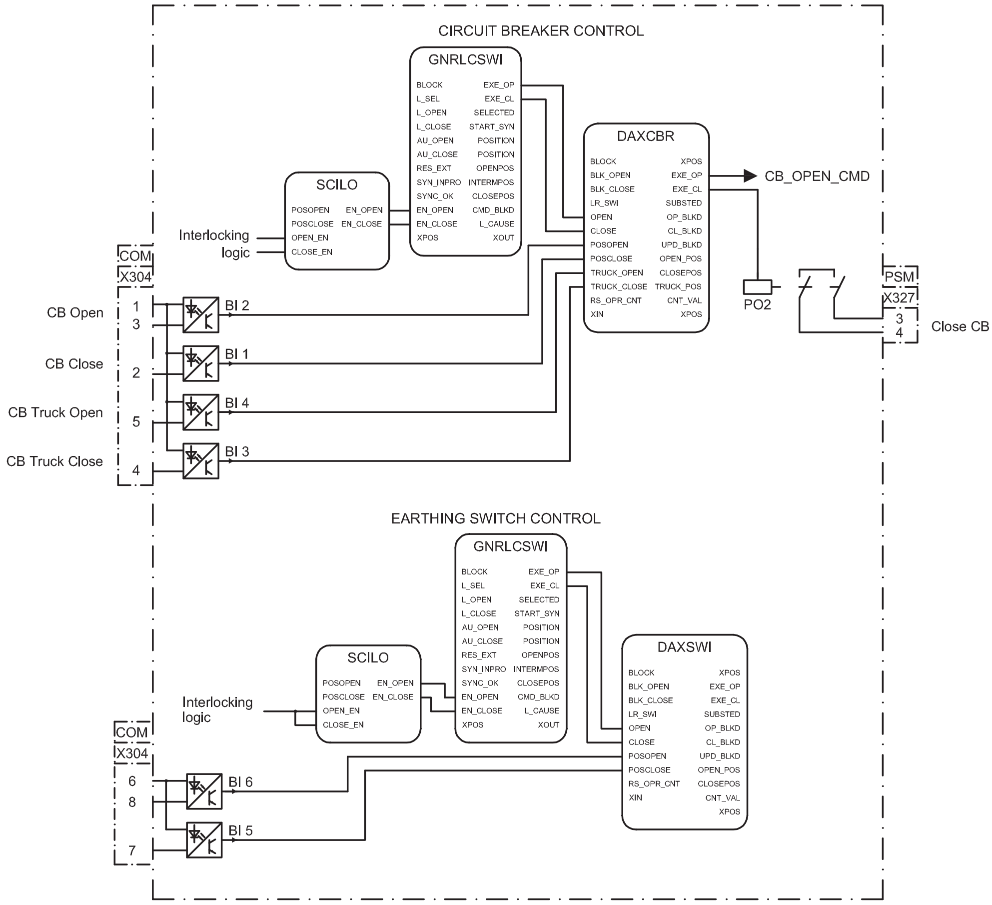


Figure 17: Apparatus control

3.3.6 Protection functions

3.3.6.1 Stabilized three-phase differential protection MPDIF

Stabilized three-phase differential protection with low stage (biased stage) and high stage (instantaneous stage) is used for protecting motor against winding failure. Two sets of three phase currents from the line side, 3I, and neutral side, 3I_N, are connected to the inputs I3P and I3P_N of MPDIF. Possible uneven current transformer saturation creates a challenge for the differential protection. MPDIF includes AC current transformer saturation detection-based blocking which prevents unnecessary tripping in case of magnetizing inrush currents which may be present at switching operations, at overvoltages or during external faults. MPDIF includes also a user-selectable DC restraint feature. The feature decreases the sensitivity of the differential protection for a temporary time period to avoid the motor to be unnecessarily disconnected due to high DC currents during external faults.

The operate signal from the low and high stages are used to provide a LED indication on the LHMI. Low stage and high stage operate outputs are connected to the disturbance recorder. An internal blocking signal available from the function INT_BLKD is connected to the disturbance recorder.

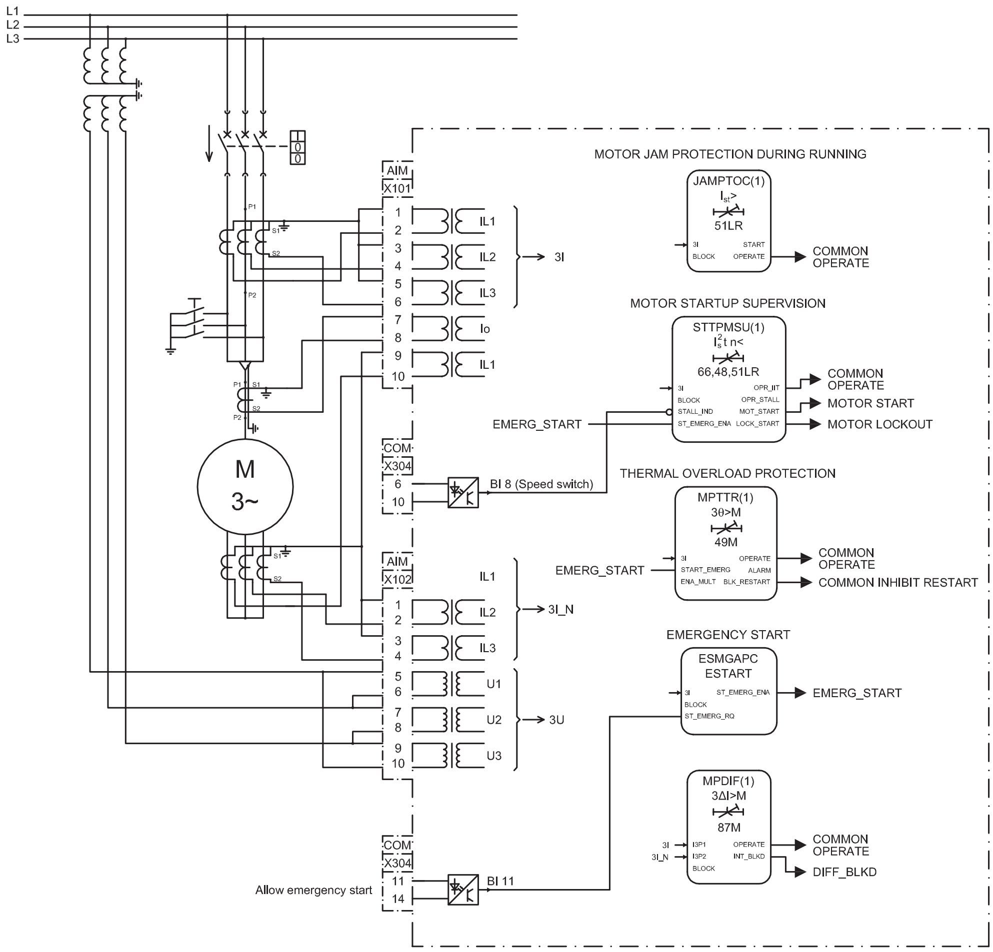


Figure 18: Motor load jam and differential protection

3.3.6.2 Thermal overload protection MPTTR

The three-phase thermal overload protection function is designed to be used for protecting electric motors from overheating. The function calculates the thermal level on the basis of the measured motor load current, rated motor current, and calculated negative sequence current.

When the thermal level of the motor exceeds a predefined limit, the function generates a thermal overload alarm. If the thermal content continues to rise and reaches 100 percent, the function block generates a trip command to stop the motor. To prevent successive restarting of the motor when the motor temperature is high, restarting of the motor is inhibited if the thermal content exceeds the set restart inhibit level. However it is possible to start the motor in case of an emergency. The set of three phase currents, I3P, is connected to the inputs.

The thermal overload alarm and trip provide an LED indication on the LHMI. The thermal overload alarm, thermal overload trip and restart inhibit signals are connected to the disturbance recorders.

3.3.6.3 Emergency start ESMGAPC

Emergency start function is used in an emergency where motor needs to be started even with a knowledge that it may result into damage to the motor. The function only forces the IED to allow restarting of the motor but it does not actually restart it.

The set of three phase currents, I3P, is connected to the inputs. Emergency start is allowed when binary input COM BI11 is activated.

The emergency output is connected to the disturbance recorder and is used to provide a LED indication on the LHMI.

3.3.6.4 Motor startup supervision STTPMSU

The motor startup supervision function protects against excessive starting time and locked rotor conditions of motors during startup.

Further, on exceeding the specified number of startups within certain duration, the function prevents restarting. After any motor start, further restarts are also inhibited until settable duration of time.

The starting of the motor is supervised by monitoring the true RMS magnitude of all phase currents. During the startup of the motor, the function calculates the integral of I^2t value and if the calculated value exceeds the set value, the operate signal is activated. A speed switch information, which indicates whether the rotor starts to rotate or not, can also be used in this function.

The output signals indicating I^2t operate, motor startup, motor stall condition and motor restart inhibit are connected to the disturbance recorders and used to provide a LED indication on the LHMI. The motor startup information is also available at binary output PSM SO3.

3.3.6.5 Motor load jam protection JAMPTOC

The motor load jam protection function is used for protection against mechanical jam when motor is running. The function is blocked during motor startup.

The set of three phase currents, I3P, is connected to the inputs. The function operates when the measured current is above the setting. The operation characteristic is definite time.

The operate signal is used to trigger the disturbance recorder and to provide a LED indication on the LHMI.

3.3.6.6 Loss of load protection LOFLPTUC

The loss of load protection is used for detecting sudden load loss which is considered as a fault condition.

The set of three phase currents, I3P, is connected to the inputs and the function operates when all the phase currents fall below the set level but stay above the set de-energization level. It operates with definite time (DT) characteristics. The operate signal is used to trigger the disturbance recorder.

3.3.6.7 Phase reversal protection PREVPTOC

The phase reversal protection is used for detecting the reversed connection of the phases to a three-phase motor by monitoring the negative-phase sequence current of the motor.

The operation of the function is based on the detection of very high negative-sequence currents during motor start up due to incorrect phase connections to the motor. The condition causes the motor to rotate in the reverse direction. The function starts and operates when the negative-sequence current exceeds the corresponding set limits. Phase reversal protection is blocked when current circuit supervision detects a failure. Operate signal is used to trigger the disturbance recorder.

3.3.6.8 Motor negative-sequence overcurrent protection MNSPTOC

Two instances of negative-sequence overcurrent detection are provided for protection against single-phasing, unbalance load or unsymmetrical voltage. The set of three phase currents, I3P, is connected to the inputs.

The function operates in two modes, the definite time mode (DT) and the inverse definite minimum time (IDMT) mode, for which two instances of the function block are used. The negative-sequence overcurrent protection is blocked in case of current circuit supervision failure is activated.

The common operate and start signal from the both MNSPTOC functions are connected to an OR-gate to form a combined negative-sequence overcurrent operate and start signal which is used to provide a LED indication on the LHMI. Also a separate start and operate signal from the both MNSPTOC functions is connected to the disturbance recorder.

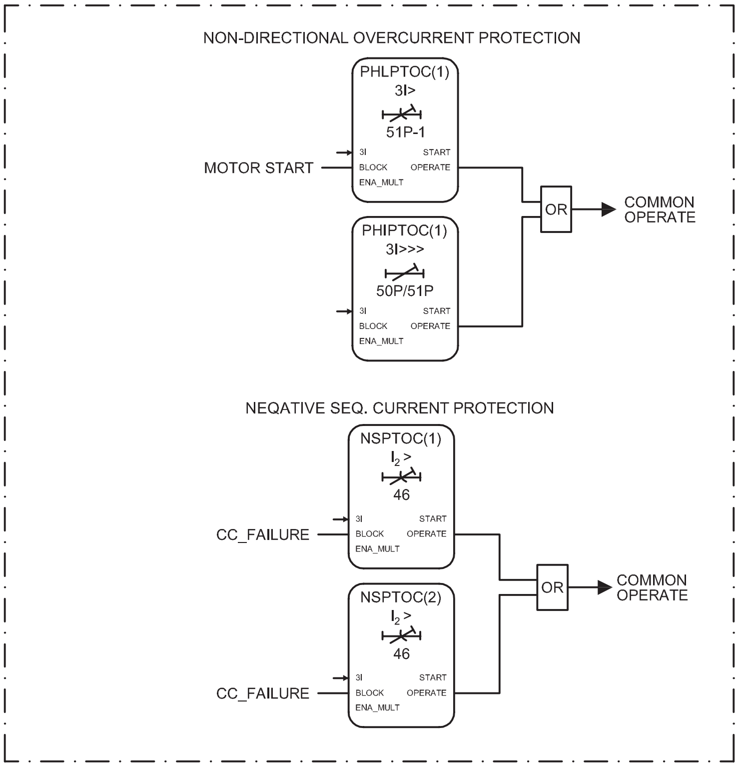


Figure 19: Motor negative-sequence overcurrent protection

3.3.6.9 Non-directional overcurrent protection PHxPTOC

The three-phase non-directional overcurrent functions are used for non-directional one-phase, two-phase and three-phase overcurrent and short-circuit protection with definite time or various inverse definite minimum time (IDMT) characteristic. The operation of a stage is based on three measuring principles: DFT, RMS or peak-to-peak values.

The configuration includes two variants of non-directional overcurrent function blocks: low and instantaneous. The set of three phase currents, I3P, is connected to the inputs. The low stage is blocked during motor startup. It is designed for additional alarming or protection purposes, like supplementing thermal overload protection. The low stage can be used as overcurrent protection whereas instantaneous stages give protection in case of short circuit.

An operate and start signal from the low stage is used to provide a LED indication on the LHMI. Separate start and operate signals from both functions are connected to the disturbance recorder.

3.3.6.10 Non-directional earth-fault protection EFxPTOC

The non-directional earth-fault protection functions are used for protection under earth-fault conditions with definite-time (DT) or with inverse definite minimum time (IDMT) characteristic when appropriate.

The operation of the stage can be based on three measuring principles: DFT, RMS or peak-to-peak values. The configuration includes high stage and low stage non-directional current function blocks. The set of three phase currents, I3P, is connected to the inputs. During the startup, for avoiding unnecessary operations, the start value of both instances is multiplied by a setting parameter *Start value Mult*. Both instances of the earth fault protection are blocked by the start of the instantaneous overcurrent protection.

A common operate and start signal from high stage and low stage earth-fault protection functions are connected to an OR-gate to form a combined non-directional earth-fault operate and start signal which is used to provide a LED indication on the LHMI. Separate start and operate signals from both of these functions are connected to the disturbance recorder.

3.3.6.11 Positive-sequence overvoltage protection PSPTOV

The positive-sequence overvoltage function blocks are used for positive-sequence overvoltage protection with definite-time characteristic. The set of three phase voltages, U3P, is connected to the inputs.

The operate and start signals from the positive-sequence overvoltage function is used to trigger the disturbance recorder.

3.3.6.12 Positive-sequence undervoltage protection PSPTUV

The positive-sequence undervoltage function blocks are used for positive-sequence undervoltage protection with definite-time characteristic. The set of three phase voltages, U3P, is connected to the inputs.

The operate and start signals from the positive-sequence overvoltage function is used to trigger the disturbance recorder. The undervoltage function is blocked by the fuse failure function and during starting condition of the motor.

3.3.6.13 Negative-sequence overvoltage protection NSPTOV

The negative sequence overvoltage function blocks are used for negative-sequence overvoltage protection with definite-time characteristic. The set of three phase voltages, U3P, is connected to the inputs.

The operate and start signals are used to provide a LED indication on the LHMI and they are also connected to the disturbance recorder.

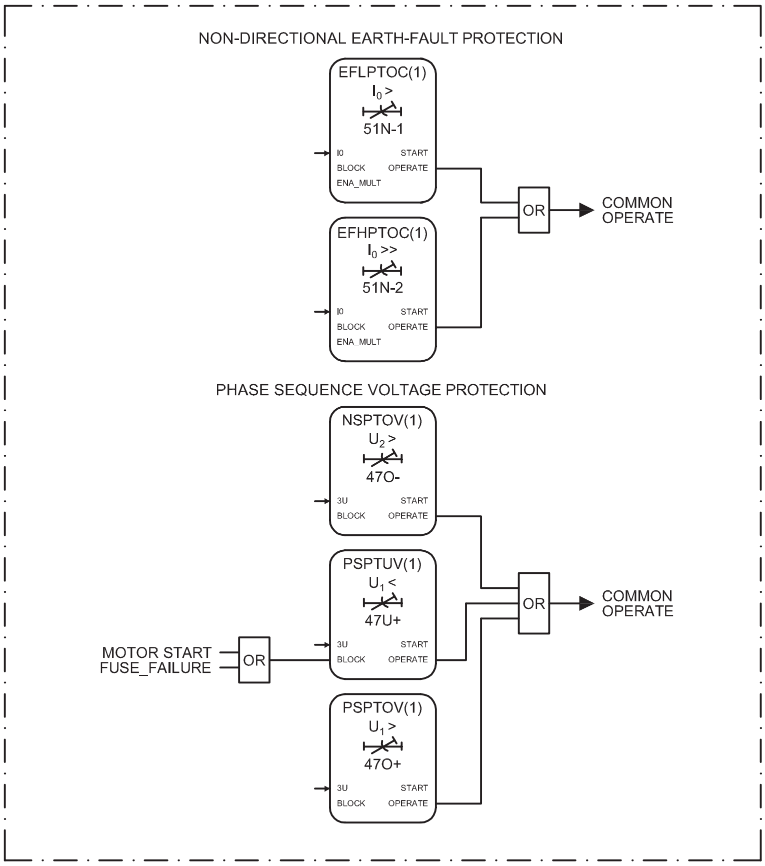


Figure 20: Negative-sequence overvoltage protection

3.3.6.14 Circuit-breaker failure protection CCBRBRF

The function is activated by the common operate command from the protection functions. The breaker failure function issues a backup trip command to adjacent circuit breakers in case the main circuit breaker fails to trip for the protected component. The backup trip is connected at binary output PSM PO5.

A failure of a circuit breaker is detected by measuring the current or by detecting the remaining trip signal. Function also provides retrip. Retrip is used along with the main trip, and is activated before the backup trip signal is generated in case the main breaker fails to open. Retrip is used to increase the operational reliability of the circuit breaker.

3.3.6.15 Tripping logic TRPPTRC

Tripping logic has been configured to provide tripping signal of required duration to Master trip 1 and Master trip 2 circuit. The tripping circuit opens the circuit breaker on

- Receipt of operate signal from the protection function or
- Retrip signal from circuit breaker failure protection.

Two master tripping signals are available at binary output PSM PO1 and PSM PO3. The lockout reset binary input available at COM BI10 is connected to the tripping circuit to reset the circuit-breaker lockout function.

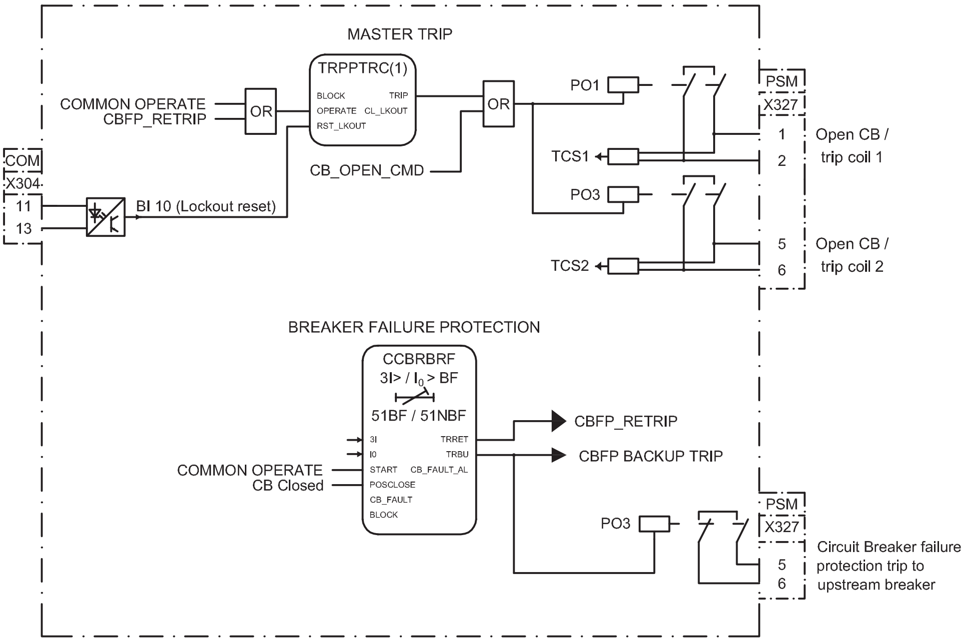


Figure 21: Tripping logic

3.3.6.16 Combined operate and start alarm signal

The operate outputs of all protection functions are combined in an OR-gate to get a common Operate output. This common operate signal is connected to a tripping logic. It is also available as an alarm binary output, PSM SO1, with a settable minimum alarm delay of 80 ms. Also, a common Start output is derived from the start outputs of protection functions combined in an OR-gate. The output is available as an alarm binary output PSM SO2 with a settable minimum alarm delay of 80 ms.

3.3.6.17 Combined restart inhibit and restart enable signal

The restart inhibit signals from the motor thermal protection, negative-sequence overcurrent and motor startup protection function are combined in an OR-gate to obtain a common restart inhibit signal. This signal is also connected to the disturbance recorder and it provides a LED indication on the LHMI.

The restart inhibit signal is inverted to a restart enable signal. The restart enable signal is active, if the emergency start is activated or if both the common operate signal and the common restart inhibit signals are inactive. The restart enable signal is connected to the disturbance recorder. The signal provides a LED indication on the LHMI and is available as an output at PSM PO4 with a minimum alarm time of 80 ms.

3.3.7 Supervision functions

3.3.7.1 Trip circuit supervision TCSSCBR

Two instances of the trip circuit supervision function are used for supervising Master trip 1 and Master trip 2. Function continuously supervises trip circuit and alarms in case of a failure of a trip circuit. The function block does not perform the supervision itself but it is used as an aid for configuration. To prevent unwanted alarms, the function is blocked when any of the protection function's operate signals is active or the circuit breaker is open.

An additional instance of the trip circuit supervision function is used to check the proper functioning of the closing circuit of the motor circuit breaker. To prevent unwanted alarms, the function is blocked when the circuit breaker is in closed position.

The function gives an indication via a LED on the LHMI on detection of any of the trip circuit failure. Also individual trip circuit alarm indications are connected to the disturbance recorders.

3.3.7.2 Fuse failure and current circuit supervision SEQRFUF, CCRDIF

The fuse failure and current circuit supervision functions give an alarm in case of a failure in the secondary circuits between the voltage transformer or current transformer and the IED respectively. The set of three phase currents and voltages, I3P and U3P, are connected to the inputs.

An alarm is available on failure of the secondary circuits. Alarms are recorded by a disturbance recorder.

3.3.7.3 Circuit-breaker condition monitoring SSCBR

The circuit-breaker condition monitoring function checks for the health of the circuit breaker. The circuit breaker status is connected to the function via binary inputs. Function requires also pressure lockout input and spring charged input connected via binary input COM_101.BI12 and COM_101.BI13 respectively. Various alarm outputs from the function are combined in an OR-gate to create a master circuit-breaker monitoring alarm.

All of the alarms are separately connected to the binary recorder and a combined alarm is available as an indication via a LED on the LHMI.

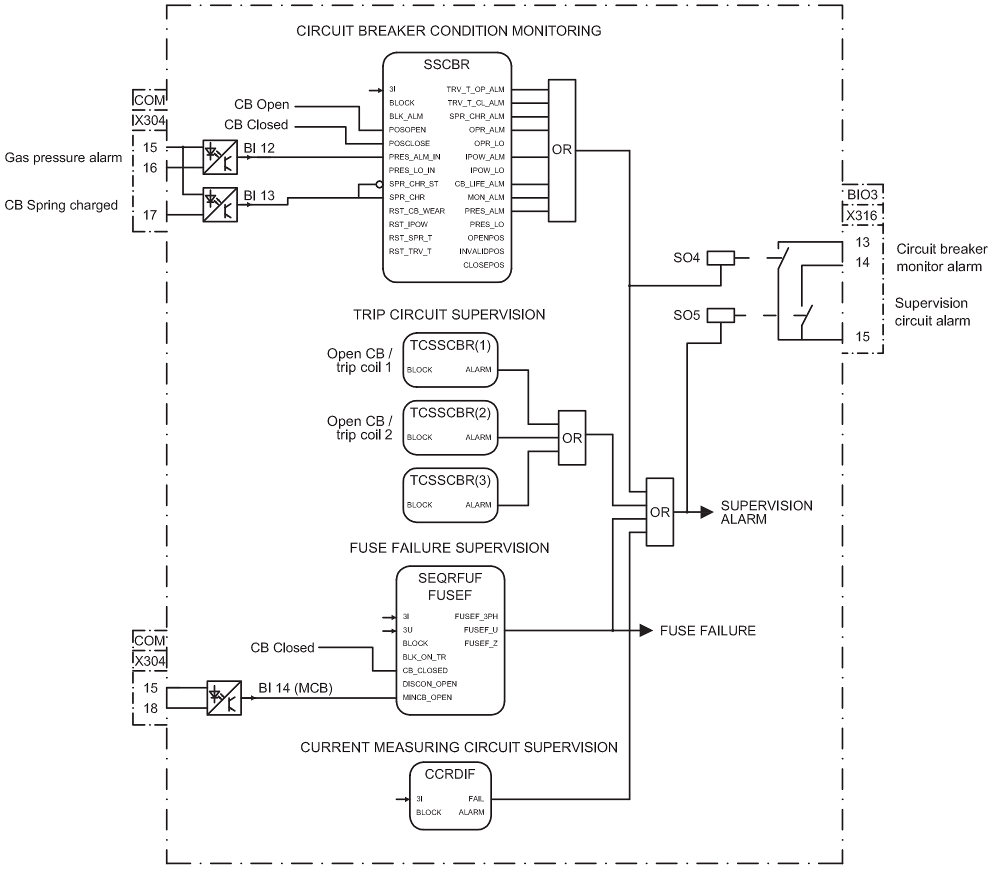


Figure 22: Circuit-breaker condition monitoring

3.3.8 Measurement and analog recording functions

The measured quantities in this configuration are:

- Current
- Current sequence component
- Residual current
- Voltage
- Power
- Energy

The measured quantities can be viewed in the measurement menu on the LHMI.

All analog input channels are connected to the analog disturbance recorder. When any of these analog values violate the upper or lower threshold limits, the recorder unit is triggered which in turn will record all the signals connected to the recorder.

Table 15: Signals connected to the analog recorder

Channel ID	Description
Channel 1	Line-side phase A current
Channel 2	Line-side phase B current
Channel 3	Line-side phase C current
Channel 4	Neutral current
Channel 5	Neutral-side phase A current
Channel 6	Neutral-side phase B current
Channel 7	Neutral-side phase C current
Channel 8	Phase A voltage
Channel 9	Phase B voltage
Channel 10	Phase C voltage

Data connected to analog channels contain 20 samples per cycle.

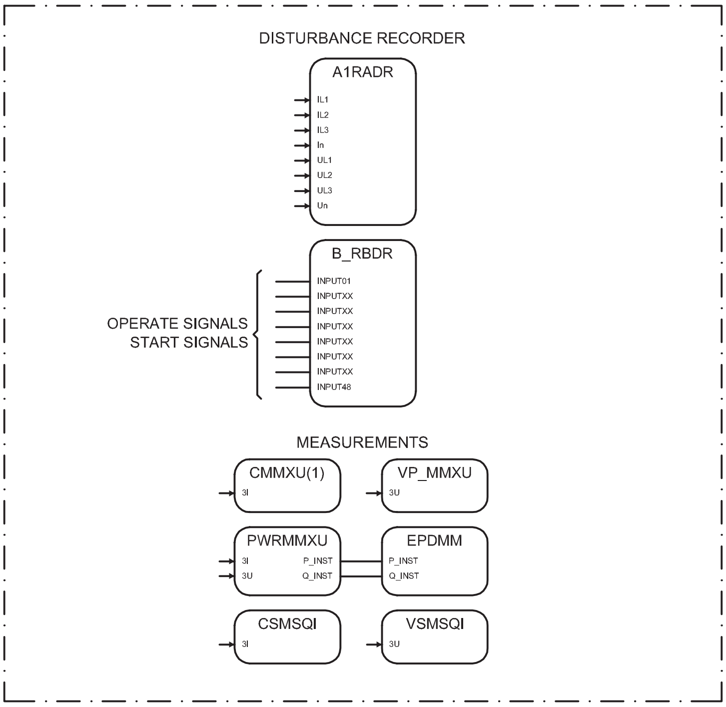


Figure 23: Measurement and analog recording functions

3.3.9 Binary recording and LED configuration

All of the start and operate outputs from the respective protection functions, various alarms from supervision functions, and important signals from control and protective functions are connected to a binary recorder. In case of a fault, the binary recorder is triggered which in turn will record all the signals connected to the recorder.

Table 16: Signals connected to the binary recorder

Channel ID	Description
Channel 1	Operate of differential protection high stage
Channel 2	Operate of differential protection low stage
Channel 3	Differential protection internally blocked
Channel 4	Start of overcurrent low stage
Channel 5	Operate of overcurrent low stage
Channel 6	Start of instantaneous overcurrent stage
Channel 7	Operate of instantaneous overcurrent stage
Channel 8	Start of negative-sequence overcurrent stage 1
Channel 9	Operate of negative-sequence overcurrent stage 1
Channel 10	Start of negative-sequence overcurrent stage 2
Channel 11	Operate of negative-sequence overcurrent stage 2
Channel 12	Thermal overload prior alarm
Channel 13	Operate thermal overload
Channel 14	Start of low stage earth-fault protection
Channel 15	Operate of low stage earth-fault protection
Channel 16	Start of high stage earth-fault protection
Channel 17	Operate of high stage earth-fault protection operate
Channel 18	Operate of phase reversal protection
Channel 19	Operate of loss of load protection
Channel 20	Start of positive-sequence overvoltage protection
Channel 21	Operate of positive-sequence overvoltage protection
Channel 22	Start of positive-sequence undervoltage protection
Channel 23	Operate of positive-sequence undervoltage protection
Channel 24	Start of negative-sequence overvoltage protection
Channel 25	Operate of negative-sequence overvoltage protection
Channel 26	Operate of motor jam protection
Channel 27	Operate signal for stalling protection
Channel 28	Operate signal for thermal stress.
Channel 29	Lock out condition for motor restart
Channel 30	Emergency start of motor
Channel 31	Motor restart inhibit due to negative-sequence overcurrent protection stage 1
Channel 32	Motor restart inhibit due to negative-sequence overcurrent protection stage 2
Channel 33	Motor restart inhibit due to thermal overload
Channel 34	Circuit breaker closed
Channel 35	Circuit breaker opened
Channel 36	Backup trip from circuit-breaker failure protection

Table continues on next page

Channel ID	Description
Channel 37	Retrip from circuit-breaker failure protection
Channel 38	Trip circuit alarm 1 (supervising motor stop circuit trip 1)
Channel 39	Trip circuit alarm 2 (supervising motor stop circuit trip 2)
Channel 40	Trip circuit alarm 3 (supervising motor start circuit)
Channel 41	Accumulated current power exceeds set limit
Channel 42	Circuit breaker not operated since long
Channel 43	Closing time of circuit breaker exceeded the limit
Channel 44	Opening time of circuit breaker exceeded the limit
Channel 45	Pressure in circuit breaker below lockout limit
Channel 46	Spring charge time of circuit breaker exceeded the limit
Channel 47	Number of circuit breaker operation exceeded the set limit
Channel 48	Alarm indicating low life of circuit breaker
Channel 49	External trip command
Channel 50	External restart inhibit command
Channel 51	MCB open indication
Channel 52	Current circuit supervision failure
Channel 53	Fuse failure
Channel 54	Motor startup in progress

The LEDs are configured for alarm indications.

Table 17: LEDs configured on LHMI alarm page 1

LED No	LED color	Description
LED 1	Red	Operate from low stage differential protection
LED 2	Red	Operate from high stage differential protection
LED 3	Yellow	Combine start from OC
LED 3	Red	Combine operate from OC
LED 4	Yellow	Combine start from EF
LED 4	Red	Combine operate from EF
LED 5	Yellow	Start from motor jam protection
LED 5	Red	Operate from motor jam protection
LED 6	Yellow	Combine start from NSOC
LED 6	Red	Combine operate from NSOC
LED 7	Yellow	Thermal overload prior alarm
LED 7	Red	Thermal overload trip
LED 8	Yellow	Retrip from circuit breaker protection function
LED 8	Red	Backup trip from circuit breaker protection function

Table continues on next page

LED No	LED color	Description
LED 9	Red	Combine alarm from circuit breaker monitoring and trip circuit supervision function
LED 10	Yellow	Fuse failure supervision
LED 10	Red	Current circuit failure
LED 11	Red	Motor startup supervision
LED 12	Red	Motor stall at start
LED 13	Yellow	Motor startup in progress
LED 14	Green	Restart enabled
LED 14	Red	Restart inhibited
LED 15	Red	Emergency start made

Section 4 Requirements for measurement transformers

4.1 Current transformers

4.1.1 Current transformer requirements for 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 settings of the protection relay 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 18: 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 protection 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 protection 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 protection 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 is to operate, the start current should be set using the formula:

Current start value < 0.7 × (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 overcurrent protection is defined. The operate time delay caused by the CT saturation is typically small enough when the overcurrent 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 protection relay operation. To ensure the time selectivity, the delay must be taken into account when setting the operate times of successive protection relays.

With definite time mode of operation, the saturation of CT may cause a delay that is as long as the time 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.

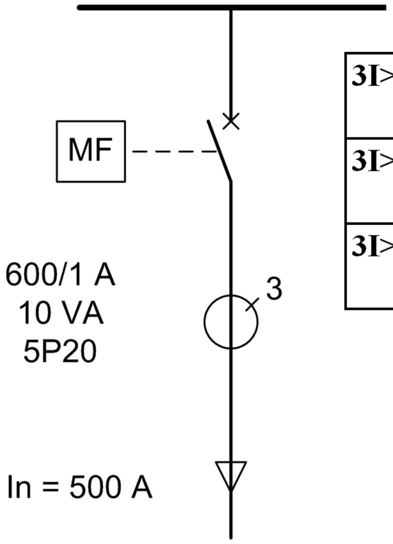
With inverse time mode of operation and when the high-set stages are not used, the AC component of the fault current should not saturate the CT less than 20 times the starting current. Otherwise, the inverse operation time can be further prolonged. Therefore, the accuracy limit factor F_a should be chosen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

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

The *Current start value* is the primary start current setting of the protection 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** **0.75 s**	**2.00 x I_{2n}** **0.75 s**
3I>>	**1800A** **0.50 s**	**3.00 x I_{2n}** **0.50 s**
3I>>>	**3500 A** **0.20 s**	**5.83 x I_{2n}** **0.20 s**

Figure 24: 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 protection relay (not visible in Figure 24). 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 protection 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 Figure 24.

For the application point of view, the suitable setting for instantaneous stage (I>>>) in this example is 3 500 A (5.83 × I_{2n}). I_{2n} is the 1.2 multiple with nominal primary current of the CT. For the CT characteristics point of view, the criteria given by the current transformer selection formula is fulfilled and also the protection 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 Glossary

100BASE-FX	A physical medium defined in the IEEE 802.3 Ethernet standard for local area networks (LANs) that uses fiber optic cabling
ANSI	American National Standards Institute
BI/O	Binary input/output
BIO	Binary input and output
COMTRADE	Common format for transient data exchange for power systems. Defined by the IEEE Standard.
Connectivity package	A collection of software and information related to a specific protection and control IED, providing system products and tools to connect and interact with the IED
CPU	Central processing unit
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.
DT	Definite time
EMC	Electromagnetic compatibility
Ethernet	A standard for connecting a family of frame-based computer networking technologies into a LAN
GOOSE	Generic Object-Oriented Substation Event
HMI	Human-machine interface
HW	Hardware
IDMT	Inverse definite minimum time
IEC	International Electrotechnical Commission
IEC 60870-5-103	1. Communication standard for protective equipment 2. A serial master/slave protocol for point-to-point communication
IEC 61850	International standard for substation communication and modeling
IEC 61850-8-1	A communication protocol based on the IEC 61850 standard series
IED	Intelligent electronic device

LAN	Local area network
LC	Connector type for glass fiber cable, IEC 61754-20
LED	Light-emitting diode
LHMI	Local human-machine interface
PCM600	Protection and Control IED Manager
REM630	Motor protection and control IED
RJ-45	Galvanic connector type
RMS	Root-mean-square (value)
RTD	Resistance temperature detector
SW	Software
TCP/IP	Transmission Control Protocol/Internet Protocol
TCS	Trip-circuit supervision
VT	Voltage transformer
WAN	Wide area network
WHMI	Web human-machine interface

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ABB Distribution Solutions
Distribution Automation
P.O. Box 699
FI-65101 VAASA, Finland
Phone +358 10 22 11

www.abb.com/mediumvoltage
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