Remote I/O
RIO600
Installation and Commissioning Manual

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Warranty

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

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Conformity

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

Safety information

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

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

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

National and local electrical safety regulations must always be followed.

The DIN rail of the device has to be carefully earthed.

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

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

Table of contents

Section 1 Introduction

1.1 This manual

The installation and commissioning manual contains information on how to install and commission the device. The manual provides an introduction to engineering tasks and a description of the basic operations.

1.2 Intended audience

This manual addresses application engineers, who install and configure the device.

The application engineer must have basic knowledge of the IEC 61850 client and server architectures in general.

Understanding the communication properties of the IED is a prerequisite before making any connections to RIO600. The connection details of the IED are available in the respective manuals.

1.3 Product documentation

1.3.1 Product documentation set

The installation and commissioning manual contains information on how to install and commission the device. The manual provides an introduction to engineering tasks and a description of the basic operations.

The communication configuration manual contains information on how to engineer the device using the different tools in PCM600. The manual provides information for IEC 61850 engineering with PCM600 and IET600. For more details on tool usage, see the PCM600 documentation.

The user manual (online help) contains instructions on how to use the RIO600 Configuration Wizard. The Configuration Wizard helps configure RIO600 for different system products and tools with the help of the connectivity package. See the product documentation for more information on handling the connectivity packages in different system products and tools.

1.3.2 Document revision history

Document revision/date	Product version	History
A/2011-12-23	1.0	First release
B/2012-12-18	1.1	Content updated to correspond to the product version
C/2013-09-30	1.2	Content updated to correspond to the product version
D/2014-09-29	1.5	Content updated to correspond to the product version
E/2015-08-31	1.6	Content updated to correspond to the product version
F/2016-06-09	1.7	Content updated to correspond to the product version
G/2019-05-17	1.7	Content updated
H/2019-12-16	1.8	Content updated to correspond to the product version
K/2020-09-23	1.8	Content updated to correspond to patch version 1.8.2
L/2021-08-05	1.8	Content updated to correspond to patch version 1.8.3
M/2021-11-30	1.8	Content updated to correspond to patch version 1.8.4
N/2022-07-22	1.8	Content updated to correspond to patch version 1.8.5

1.3.3 Related documentation

Name of the document	Document ID
RIO600 Communication Configuration Manual	1MRS757489
Specific Communication Service Mapping (SCSM) – Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3	IEC 61850-8-1

Download the latest documents from the ABB Web site abb.com/mediumvoltage.

1.4 Symbols and conventions

1.4.1 Symbols

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

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

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

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

1.4.2 Document conventions

A particular convention may not be used in this manual.

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

Section 2 General security deployment guidelines

2.1 General security

Technological advancements and breakthroughs have caused a significant evolution in the electric power grid. As a result, the emerging “smart grid” and “Internet of Things” are quickly becoming a reality. At the heart of these intelligent advancements are specialized IT systems – various control and automation solutions such as distribution automation systems. To provide end users with comprehensive real-time information, enabling higher reliability and greater control, automation systems have become ever more interconnected. To combat the increased risks associated with these interconnections, ABB offers a wide range of cyber security products and solutions for automation systems and critical infrastructure.

The new generation of automation systems uses open standards such as IEC 61850 GOOSE, Modbus and commercial technologies, in particular Ethernet and TCP/IP based communication protocols. They also enable connectivity to external networks, such as office intranet systems and the Internet. These changes in technology, including the adoption of open IT standards, have brought huge benefits from an operational perspective, but they have also introduced cyber security concerns previously known only to office or enterprise IT systems.

To counter cyber security risks, open IT standards are equipped with cyber security mechanisms. These mechanisms, developed in a large number of enterprise environments, are proven technologies. They enable the design, development and continuous improvement of cyber security solutions for control systems, including distribution automation applications.

ABB understands the importance of cyber security and its role in advancing the security of distribution networks. A customer investing in new ABB technologies can rely on system solutions where reliability and security have the highest priority. At ABB, we are addressing cyber security requirements on a system level as well as on a product level to support cyber security standards or recommendations.

Reporting of vulnerability or cyber security issues related to any ABB product can be done via cybersecurity@ch.abb.com.

2.2 System hardening rules

Today's distribution automation systems are basically specialized IT systems. Therefore, several rules of hardening an automation system apply to these systems, too. RIO600 is designed to expand the digital and analog I/O of ABB’s Relion® protection and control relays. Protection and control relays are from the automation system perspective on the lowest level and closest to the actual primary process. It is important to apply defense-in- depth information assurance concept where each layer in the system is capable of protecting the automation system and therefore RIO600s are also part of this concept. The following should be taken into consideration when planning the system protection.

- Recognizing and familiarizing all parts of the system and the system's communication links
- Removing all unnecessary communication links in the system
- Rating the security level of remaining connections and improving with applicable methods
- Hardening the system by removing or deactivating all unused processes, communication ports and services
- Checking that the whole system has backups available from all applicable parts
- Collecting and storing backups of the system components and keeping those up-to-date
- Changing default passwords and using strong enough passwords
- Separating public network from automation network
- Segmenting traffic and networks
- Using firewalls and demilitarized zones
- Assessing the system periodically
- Using antivirus software in workstations and keeping those up-to-date

It is important to utilize the defence-in-depth concept when designing automation system security. It is not recommended to connect a device directly to the Internet without adequate additional security components. The different layers and interfaces in the system should use security controls. Robust security means, besides product features, enabling and using the available features and also enforcing their use by company policies. Adequate training is also needed for the personnel accessing and using the system.

Section 3 RIO600 overview

3.1 Overview

RIO600 is designed to expand the digital and analog I/O of ABB's Relion® protection and control relays and to provide I/O for the COM600 substation automation unit using the IEC 61850 and Modbus TCP communication. Both galvanic RJ-45 and optical LC connectors are supported for Ethernet station bus communication. RIO600 can also be used in secondary substations for fault passage indication and power measurements reporting values directly to a peer protection relay or to an upper level system. RIO600 accepts three-phase sensor signals (voltage and current) and provides fault detection and metering functions.

RIO600 allows flexible I/O assignment and provides seamless IEC 61850 connectivity between the substation's input and output signals and the protection relay or the COM600 substation gateway ensuring improved functionality and performance. RIO600 supports both Edition 1 and Edition 2 versions of the IEC 61850 standard. RIO600 can also be used as a standalone device in grid automation applications.

Figure 1: RIO600

RIO600 helps in simplifying and decreasing the wiring inside the substation by digitizing the hardwired signals. The fully hardwired traditional medium-voltage switchgear/substation control and protection system results in extensive I/O wiring, connecting devices in switchgear signaling to the external systems, for example, to the remote terminal unit (RTU) or other higher-level automation systems.

RIO600 provides additional I/O within the switchgear using Ethernet communication. The I/O signals can be efficiently transmitted between the protection relay or COM600 with fast, high performance IEC 61850 GOOSE communication. Alternatively, RIO600 can communicate with an upper level automation system using the widely accepted Modbus TCP automation protocol.

The binary input module can be used for sending binary input values from primary equipment or secondary systems to peer protection relays or an upper-level system. The binary output modules can be used to control equipment based on the control signal received from communication.

The smart control module (SCM) can be used for different switchgear applications to drive primary switches. The module enables the control of a combined three-position switch (disconnector and earthing switch) used in gas insulated switchgears or standard two-position switches such as disconnector or earthing switches. Alternatively, the heavy-duty output contacts of the SCM can be used as power outputs for circuit breaker trip circuits to make, carry and break the belonging trip coil current. The trip circuit supervision function is designed to supervise the control circuit of the circuit breaker. Furthermore, the SCM can be used as a generic module with four binary inputs and four fast power outputs.

With the RTD/mA module, RIO600 can be used in different monitoring applications. RIO600 can receive temperatures (°C) via RTDs or analog input signals (mA) from various transducers or devices. The input current (mA) can be linearly scaled for various applications, for example, transformer tap changer position indication. The input value is forwarded to a peer protection relay or to an upper-level system. With the analog output module (AOM), RIO600 can control an external device having an mA input.

RIO600 also includes a measurement module with fault passage indication (FPI) functionality. This module is intended for grid automation applications where RIO600 enables accurate current and voltage measurements or only current measurement from a MV network using ABB's accurate and lightweight sensor technology. With this measurement module, RIO600 can be used as a stand-alone fault passage indicator unit. Based on the measured MV values, it can give voltage presence and directional FPI and report them to an upper-level system. This also enables power flow and power quality monitoring. The typical accuracy of line voltages, currents and active power is better than 0.5% and for other power measurements better than 1%.

The FPI functionality can be based on phase current measurements only. It provides a selective fault passage indicator for single phase earth faults in high-impedance earth networks, that is, in compensated, unearthed and high-resistance earthed systems. It can be applied as single-phase earth-fault FPI in case of overhead lines and underground cables, regardless of the earth-fault type (continuous, transient or intermittent) or the fault resistance value (low or high ohmic).

The FPI module incorporates the latest fault-detection algorithms used in the Relion family. With an easy-to-use multifrequency admittance-based (MFA) earth-fault detection algorithm, it accurately detects solid, resistive and intermittent earth faults. Practical sensitivity of up to 10 kΩ of the fault resistance can be achieved in symmetrical networks. This new functionality is suitable for high-impedance earthed networks, and especially for compensated and unearthed networks where accurate and selective earth-fault detection is more challenging due to low fault currents. With the use of the negative-sequence overcurrent protection function, it is easier to detect single-phase and phase-to-phase faults or unbalanced loads which are due to broken conductors or unsymmetrical feeder voltages, for example. The selective FPI functionality for single-phase earth faults in high-impedance earthed networks (that is, in compensated, unearthed and high-resistance earthed systems) is available. FPI functionality can be applied as single-phase earth-fault FPI in case of overhead lines and underground cables and is based on phase current measurements only which can be done with non-conventional current transformers (LPCTs) or with sensors (Rogowski coils). With the fault passage information, the faulted line section can be quickly identified, and manual or automatic fault isolation and supply restoration can be initiated. The three-phase inrush detector function INRPHAR can be used to coordinate transformer inrush situations in distribution networks. The fuse failure supervision function SEQSPVC can be used to block the voltage measuring functions when failure occurs in the secondary circuits between the voltage transformer (or combi sensor or voltage sensor) and the protection relay to avoid misoperations of the voltage protection functions.

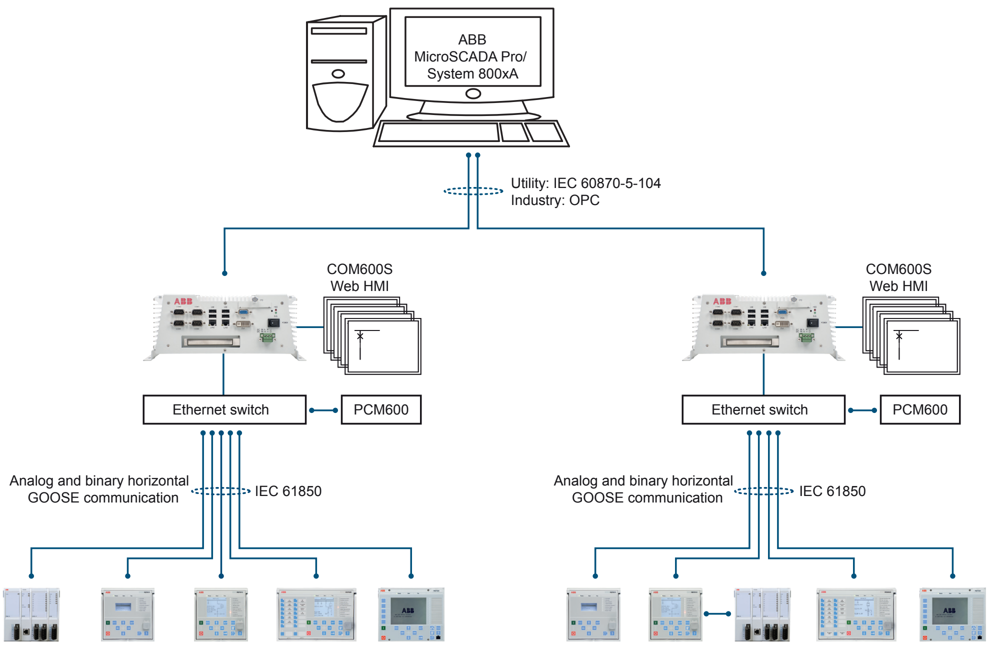

Figure 2: Conceptual picture of a typical system setup

- IEC 61850 connectivity with support of standard versions Edition 1 and Edition 2
- IEC 61850 GOOSE for real-time information exchange on the Ethernet station bus
- Modbus TCP/IP support for one client
- Standard RJ-45 interface with 10/100 Mbits/s or 100 Mbit/s multimode fiber-optic LC Ethernet interface
- Auxiliary power supply
- Easy-to-use configuration tool for the IEC 61850 data mapping
- Reduced conventional cabling
- Up to 40 configurable binary and analog I/O channels
- DIN rail mountable modules
- Support of two SNTP servers
- WHMI-based monitoring
- Subscribes and publishes GOOSE messages from/to multiple IEDs as configured
- "Stand-alone" operation, with support of intermodule logic

3.1.1 Product version history

Product version	Modules supported	Product history
1.0	MOD600ALECMIR MOD600APSMH MOD600ADIM8H MOD600ADOM4	• Communication module with RJ-45 port • High power supply module • Digital input module with eight inputs high-power supply • Digital output module with four outputs
1.1	MOD600BLECMIR MOD600APSML MOD600ADIM8H MOD600APSMH MOD600ADIM8L MOD600ADOM4	New module support added to RIO600 Ver.1.0 • New version for communication module to support modules below • Low power supply module • Digital input module with eight inputs low-power supply
1.2	MOD600CLECMIR MOD600ARTD4 MOD600AAOM4 MOD600APSMH MOD600APSML MOD600ADIM8H MOD600ADIM8L MOD600ADOM4	New module support added to RIO600 Ver.1.1 • New version for communication module to support modules below • RTD/mA input module with four channels • Analog output module with four channels
1.5	MOD600DLECMIR MOD600ASIM8F MOD600ARTD4 MOD600AAOM4 MOD600APSMH MOD600APSML MOD600ADIM8H MOD600ADIM8L MOD600ADOM4	New module support added to RIO600 Ver.1.2 • New version for communication module to support above features • SIM8F sensor input module with three-phase voltage and current input signals • Modbus TCP/IP support

Table continues on next page

Product version	Modules supported	Product history
1.6	MOD600ELECMIR MOD600ALECMFO MOD600ASCM8H MOD600ASCM8L MOD600ASIM8F MOD600ARTD4 MOD600AAOM4 MOD600APSMH MOD600APSML MOD600ADIM8H MOD600ADIM8L MOD600ADOM4	New module support added to RIO600 Ver.1.5 • New version for communication module with IEC 61850 Edition 2 support and standalone functionality • LECMFO communication module with multimode fiber-optic LC interface • SCM8H smart control module with four inputs and four solid state power outputs, high voltage range • SCM8L smart control module with four inputs and four solid state power outputs, low voltage range
1.7	MOD600FLECMIR MOD600BLECMFO MOD600ASCM8H MOD600ASCM8L MOD600ASIM8F MOD600ARTD4 MOD600AAOM4 MOD600APSMH MOD600APSML MOD600ADIM8H MOD600ADIM8L MOD600ADOM4	New functionality added • Multifrequency admittance-based earth-fault indication in SIM8F
1.8	MOD600GLECMIR MOD600CLECMFO MOD600ASCM8H MOD600ASCM8L MOD600ASIM8F MOD600ASIM4F MOD600ARTD4 MOD600AAOM4 MOD600APSMH MOD600APSML MOD600ADIM8H MOD600ADIM8L MOD600ADOM4	New module support added to RIO600 Ver.1.8 • SIM4F sensor module with three-phase current input signals New functionality added • FPIPTOC • INRPHAR • SEQSPVC • NSPTOC • Trip circuit supervision

3.2 Module configuration

RIO600 uses a modular architecture where the I/O control functionality is built on modules. The modules can be stacked on a standard DIN rail to achieve the required configuration. The minimum configuration required for RIO600 contains a power supply module, a communication module and an I/O module.

Table 1: RIO600 module types

Module type		Description
Power supply modules	PSMH	High-voltage range power supply module
	PSML	Low-voltage range power supply module
Communication modules	LECM	Communication module with Ethernet port
	LECM	Communication module with optical Ethernet port

Table continues on next page

Module type			Description
I/O modules	Digital input module	DIM8H	High-voltage range, eight optically isolated binary inputs with common return for two inputs
		DIM8L	Low-voltage range, eight optically isolated binary inputs with common return for two inputs
	Digital output module	DOM4	Four output contacts in each digital output module with two pairs of potential free contacts with common return
	RTD module	RTD4	Four optically isolated channels supporting RTD sensors (Pt100, Pt250, Ni100, Ni120 and Ni250) and an mA input (0...20 mA configurable). Individual channels are non-isolated from each other.
	Analog output module	AOM4	Four individually isolated channels of configurable mA outputs driving 0...20 mA signals
	Sensor input module	SIM8F	Sensor input module with combined three-phase current and voltage signals
	Sensor input module	SIM4F	Sensor input module with three-phase current signals
	Smart control module	SCM8H	High-voltage range, SCM with five application types • 4I4O – four input and four output channels • Three-position switch • Disconnector • Circuit breaker • Earthing switch
		SCM8L	Low-voltage range, SCM with five application types • 4I4O – four input and four output channels • Three-position switch • Disconnector • Circuit breaker • Earthing switch

The availability and combination of RIO600 modules and channels depend on the number of power supplies connected.

Table 2: Maximum number of modules and channels available when one power supply module is connected

	LECM with copper interface		LECM with fiber interface	
Description	Modules	Channels	Modules	Channels
Digital input modules (DIM8H/ DIM8L)	5	40	5	40
Digital output modules	5	20	4	16
RTD4 modules	5	20	4	16

Table continues on next page

	LECM with copper interface		LECM with fiber interface	
Description	Modules	Channels	Modules	Channels
Analog output modules	2	8	1	4
SIM8F/SIM4F modules	5	-	4	-
Smart control module (SCM8H/ SCM8L)	3	24	2	16

Table 3: Maximum number of modules and channels available when two power supply modules are connected

	LECM with copper interface		LECM with fiber interface	
Description	Modules	Channels	Modules	Channels
Digital input modules (DIM8H/ DIM8L)	5	40	5	40
Digital output modules	10	40	9	36
RTD4 modules	10	40	9	36
Analog output modules	4	16	3	12
SIM8F/SIM4F modules	5	-	5	-
Smart control module (SCM8H/ SCM8L)	5	40	5	40

A combination of all the modules can be used in a single RIO600 stack. The number of modules supported by a number of power supply modules is automatically checked by PCM600. If the selected combination of modules exceeds the number of supported modules related to power consumption, the configuration tool gives an indication and does not configure the stack.

3.3 Web HMI

The WHMI allows accessing the present status information of RIO600 via a Web browser. The supported Web browser version is Internet Explorer 9.0 or later and the preferred version is Internet Explorer 10.

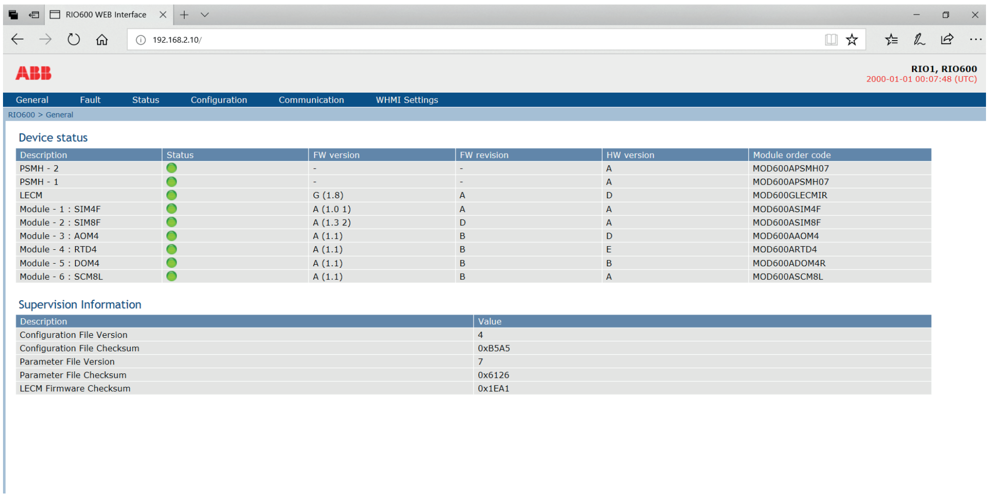

Figure 3: General view of the RIO600 WHMI

WHMI provides information about RIO600.

- Module hardware version
- Module software version
- RIO600 modules and their statuses
- Latest GOOSE transmitting and receiving information
- Modbus TCP/IP and connection information
- Fault indication and description
- Channel statuses of input/output modules
- RIO600 configuration
- Communication parameters

3.4 PCM600 tool

PCM600 with the RIO600 connectivity package is used for configuring RIO600.

- Configuring RIO600 in the online and offline modes
- Setting the operating parameters for the modules using Parameter Setting
- Performing the I/O mapping across the modules using Signal Matrix
- Reading and writing the configuration and the parameter file to RIO600
- Setting the password using IED Users
- Establishing the GOOSE communication between the devices configured in PCM600 using IEC 61850 configuration
- Configuring the Modbus communication settings for connection with Modbus TCP client
- Updating composition of existing RIO600 in online and offline modes
- Migrating from older version of RIO600 to the higher version using IED Configuration Migration
- Generating Modbus address point list for the configured modules
- Creating graphical logic configuration with Application Configuration

- Support for IEC 61850 Edition 1 and Edition 2 enabling the creation of IED objects in PCM600 with the selected protocol standard version
- Exporting configuration files to a local machine
- Establishing GOOSE communication between the devices configured in PCM600 using IEC 61850 Configuration or Goose Engineering through Application Configuration or both

3.4.1 PCM600 and RIO600 connectivity package version

- Protection and Control IED Manager PCM600 Ver.2.9 Hotfix 2 or later
- RIO600 Connectivity Package Ver.1.8 or later

3.5 Communication

RIO600 supports horizontal Generic Object Oriented Substation Event (GOOSE) communication according to the IEC 61850 substation automation standard versions Edition 1 and Edition 2. It meets the horizontal communication performance criteria for protection and fault detection defined by IEC 61850-5, that is, peer-to-peer communication <10 ms. Currently, the IEC 61850 MMS profile for vertical TCP/IP communication is not supported.

Modbus TCP communication to one Modbus TCP client is also supported. IEC 61850 GOOSE and Modbus TCP can be used in parallel in the same Ethernet-based station bus.

RIO600 sends and receives binary and analog signals to or from the ABB Relion® series protection relays and the COM600 station automation unit/RTU using the IEC 61850-8-1 GOOSE profile or Modbus TCP. Any RTU supporting these protocols can be used. RIO600 subscribes to a GOOSE message from up to five peer protection relays and publishes to multiple protection relays as configured. Up to seven GOOSE data sets can be published. It is possible to send time-stamped events using the GOOSE service with a T0 class accuracy.

RIO600 also supports Modbus TCP communication used in Ethernet networks. The communication type is client-server where RIO600 acts as a Modbus TCP server. RIO600 Modbus TCP server supports connection to one Modbus TCP client.

RIO600 communication module includes a galvanic RJ-45 port with 10/100 Mbits/s or fiber-optic LC Ethernet for IEC 61850 GOOSE and Modbus TCP communication. The used cable must be a shielded twisted pair cable CAT5e at the minimum or a multimode fiber-optic cable with an LC connector.

Using the same Ethernet port, RIO600 can be connected in parallel to PCM600 and a Web browser over the same communication bus.

3.5.1 TCP/IP-based protocols and used IP ports

The RIO600 device supports FTP, HTTP, Modbus TCP and the network time management protocols.

Table 4: Supported ports in the RIO600 device

Port number	Type	Default state	Description
20, 21	TCP	Open	File transfer protocol (FTP)
123	UDP	Open	Network time management protocol
80	TCP	Open	Web server HTTP
502	TCP	Closed	Modbus TCP

FTP and HTTP protocols are not secure. Ensure general security in the substation is considered as described in General security deployment guidelines.
FTP and HTTP are always enabled and cannot be disabled.

For the FTP protocol, it is strongly recommended to change the default password using IED Users Management in PCM600 as described in the communication configuration manual. The default password in RIO600 for the ADMINISTRATOR user credential is “ABB_RIO600”==/”.

RIO600 supports only one user credential for ADMINISTRATOR.

Modbus is disabled by default and can be enabled with Parameter Settings in PCM600. In the plant structure, go to **RIO600/IED Configuration/Configuration/Station Communication/ MODBUS: 0** to set the Modbus configuration parameters.

Section 4 Unpacking, inspecting and storing

4.1 Removing transport packaging

Products require careful handling.

1. Examine the delivered products to ensure that they have not been damaged during the transport.
2. Remove the transport packing carefully without force.

The cardboard packaging material is 100% recyclable.

4.2 Inspecting the product

4.2.1 Identifying the product

1. Locate the product's order number from the label on the bottom.
2. Compare the order number to the ordering information to verify that the received product is correct.

4.2.2 Checking delivery items

Check that all items are included in the delivery in accordance with the delivery documents.

4.2.3 Inspecting the product

The product requires careful handling before installation on site.

- Check the product to see if any damage occurred during transportation.

If the product has damaged during transportation, make a claim against the transport contractor and notify the local ABB representative.

4.2.4 Returning a product damaged in transportation

If damage has occurred during transportation, appropriate actions must be taken against the latest carrier.

Inform the nearest ABB office or representative. ABB should be notified immediately if there are any discrepancies in relation to the delivery documents.

4.3 Storing

If the product is stored before installation, it must be done in the original transport packaging in a dry and dust-free place. Observe the environmental requirements stated in the technical manual.

Section 5 Installing

5.1 Mounting modules

RIO600 is designed to be mounted on the standard DIN rail. The modules can be easily stacked and removed.

1. Mount the modules on the DIN rail.
   - The modules can be stacked in the DIN rail as per configuration and in a predefined order depending on the module type.
   - After the power supply and communication modules are mounted, the order of the DIM8H/DIM8L/DOM4/RTD4/AOM4/SIM8F/SIM4F/SCM8H/SCM8L modules is user configurable.

   Mount the RTD4 module in the extreme right side to provide optimally short grounding arrangement to the RTD cable shields.

   Table 5: Predefined order of the modules

Number of power supply modules	Order of different modules
1	1.1. PSMH or PSML 1.2. LECM 1.3. DIM8H, DIM8L, DOM4, RTD4, AOM4, SIM8F, SIM4F, SCM8H or SCM8L
2	1.1. PSMH or PSML 1.2. PSMH or PSML 1.3. LECM 1.4. DIM8H, DIM8L, DOM4, RTD4, AOM4, SIM8F, SIM4F, SCM8H or SCM8L

2. Plug in the rubber caps on the first and the last module in the stack.
3. Install the end clamps at the first and the last module in the stack.
4. Connect the Ethernet cable before connecting the auxiliary power.

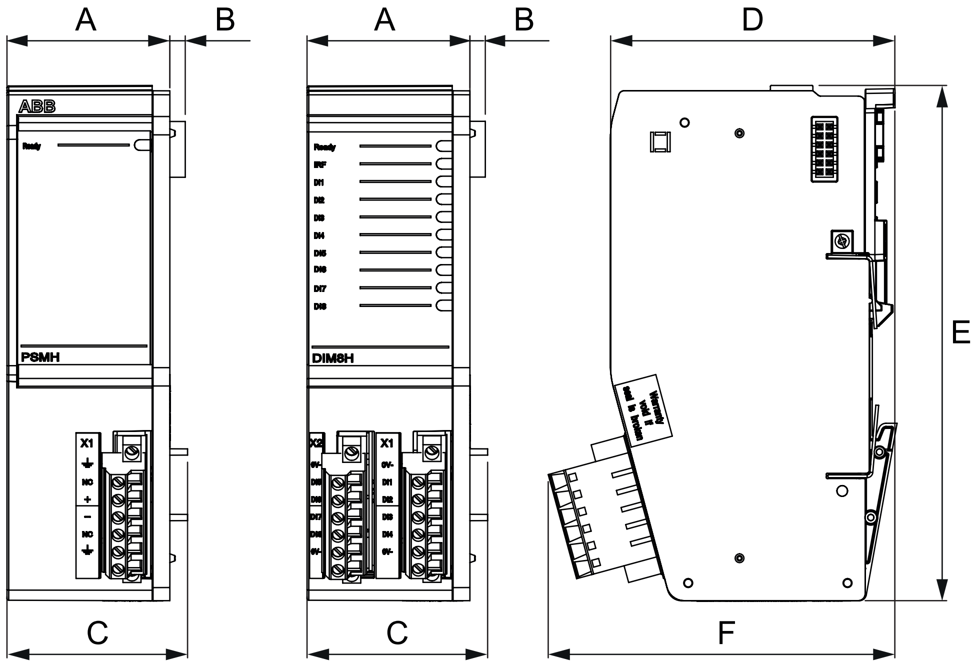

Figure 4: Dimension and mounting details of the PSMH/PSMLDIM8H/DIM8L/RTD4/AOM4/SCM8H/SCM8L modules

A	46 mm
B	4.5 mm
C	51 mm
D	81 mm
E	146 mm
F	99 mm

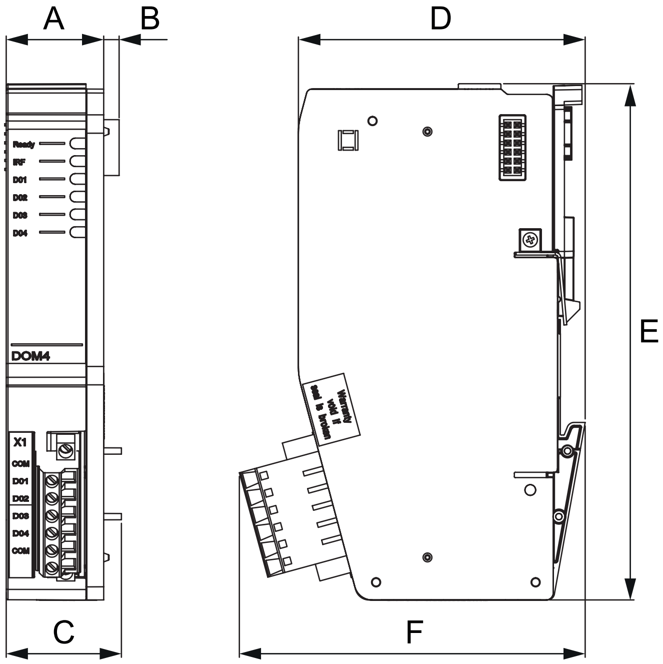

Figure 5: Dimension and mounting details of the digital output module DOM4

A 27.5 mm

B 4.5 mm

C 33 mm

D 81 mm

E 146 mm

F 99 mm

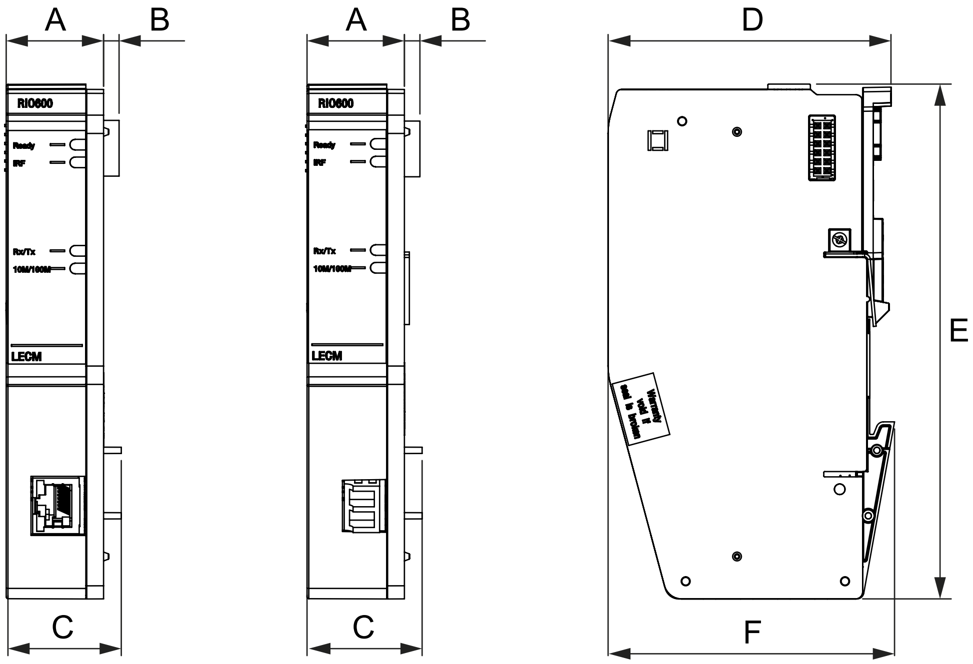

Figure 6: Dimension and mounting details of the communication module LECM

A 27.5 mm

B 4.5 mm

C 33 mm

D 81 mm

E 146 mm

F 81 mm

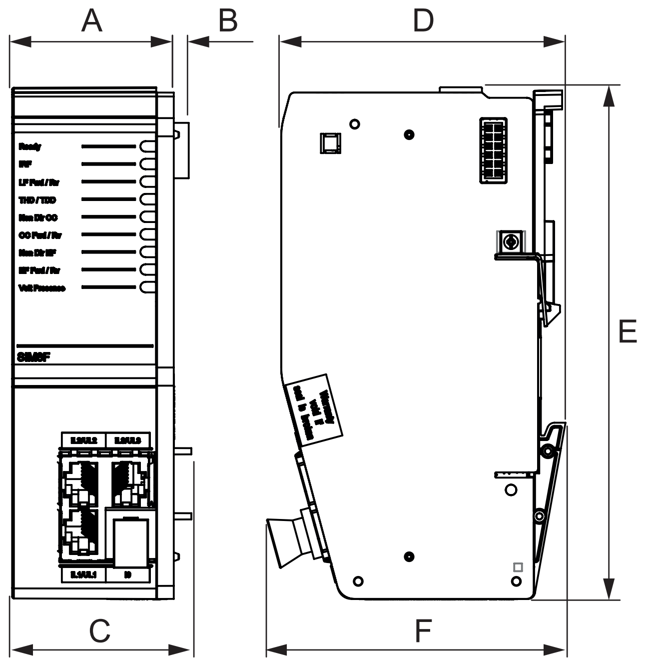

Figure 7: Dimension and mounting details of the SIM8F module

A	46 mm
B	4.25 mm
C	51 mm
D	81 mm
E	145.5 mm
F	85 mm

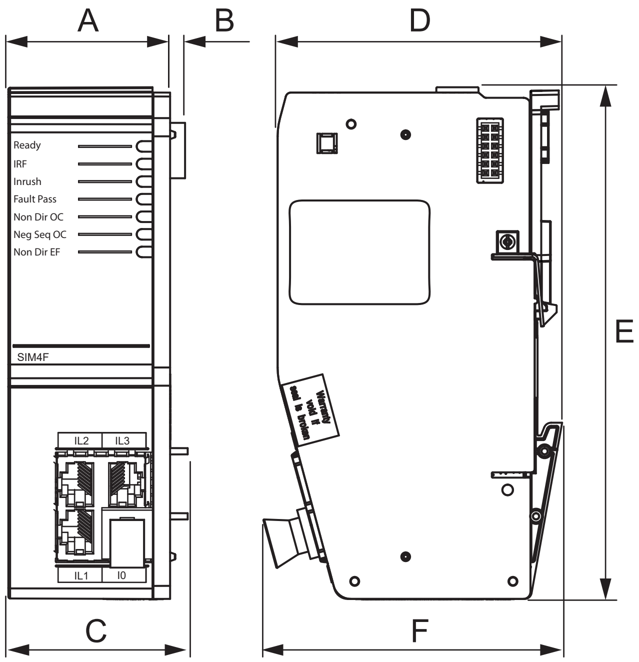

Figure 8: Dimension and mounting details of the SIM4F module

A	46 mm
B	4.25 mm
C	51 mm
D	81 mm
E	145.5 mm
F	85 mm

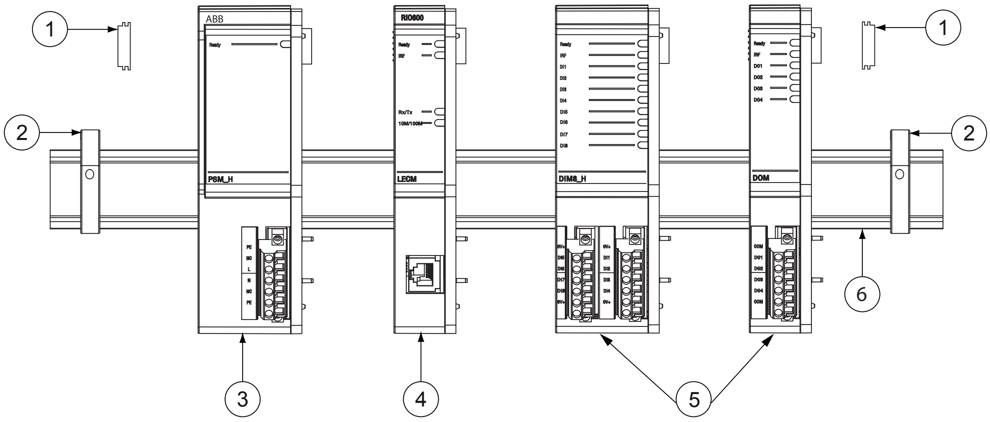

Figure 9: Assembly drawings of the RIO600 modules

1 Rubber cap

2 End clamp

3 PSM module

4 LECM module

5 DIM8H, DIM8L, DOM4, RTD4, AOM4, SIM8F, SIM4F, SCM8H, or SCM8L module

6 DIN rail

Disconnect the power supply to the module stack before any configuration update, position change or during the addition or removal of modules. The modules are not hot-swappable/pluggable. Earthing of the used DIN rail should be arranged properly.

5.1.1 Configuration examples

The user-specific configuration can be adapted according to application requirements by combining different modules.

RIO600 can be configured with a combination of low-voltage and high-voltage modules, for example, PSMH-LECM-DIM8L, PSML-LECM-DIM8H or PSML-PSMH-LECM-DIM8H-DIM8L-DOM4.

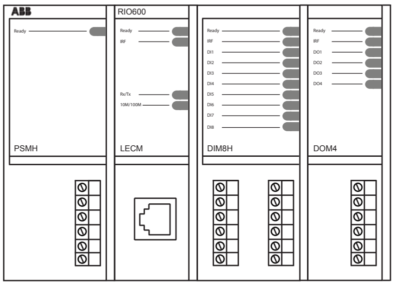

Figure 10: RIO600 configuration with 12 channels with 8 DI and 4 DO (1 × DIM8H + 1 × DOM4)

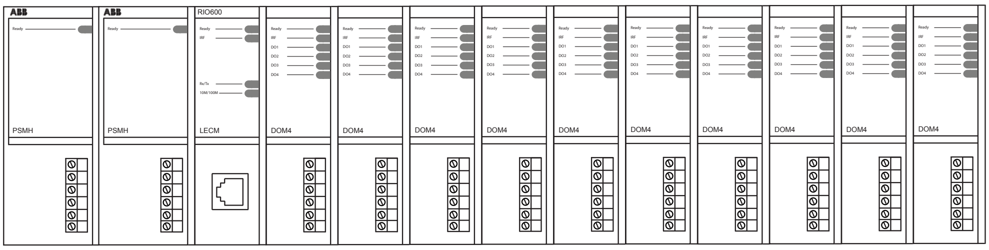

Figure 11: RIO600 configuration: 40 channels with 40 DO (10 × DOM4)

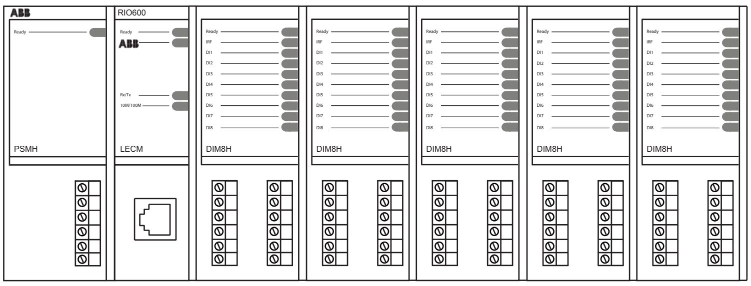

Figure 12: RIO600 configuration: 40 channels with 40 DI (5 × DIM8H)

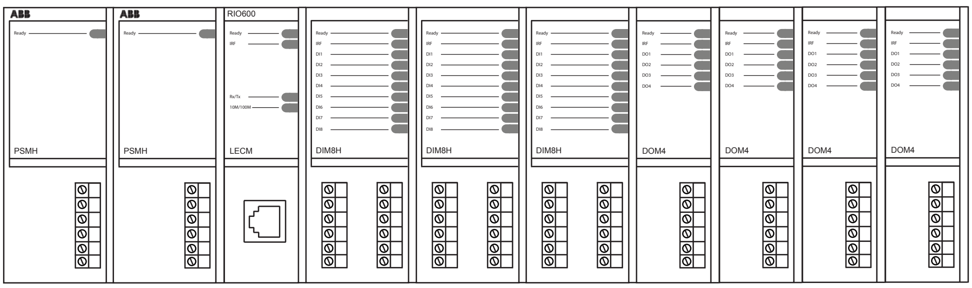

Figure 13: RIO600 configuration: 40 channels with 24 DI and 16 DO (3 × DIM8H + 4 × DOM4)

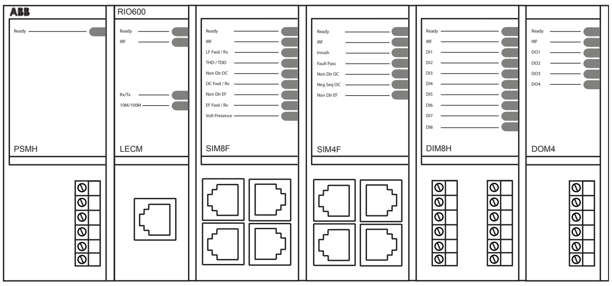

Figure 14: RIO600 configuration: 1 × SIM8F + 1 × SIM4F + 1 × DIM8H + 1 × DOM4

5.2 Connecting wires

5.2.1 Connecting power supply

RIO600 supports power supply modules PSMH and PSML.

With the PSMH module, the voltage range for the external power connection is 110...250 V DC (±20%) and 100...240 V AC (-15% to +10%).

With the PSML module, the voltage range for the external power connection is U_{aux} nominal 24, 30, 48, 60 V DC (with variation of 50...120% of Un) and the startup threshold is 19.2 V DC (24 V DC * 80%).

1. Fasten the power connector through the upper and lower screw terminals.
2. Connect the power supply cable to the power supply module.

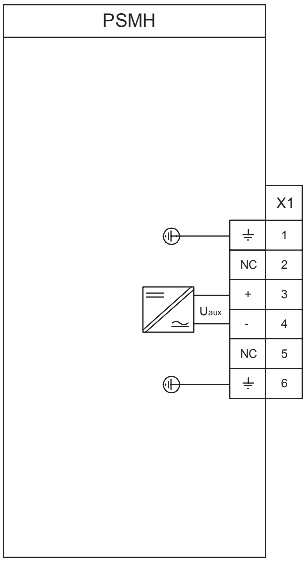

Figure 15: PSMH terminals

Table 6: PSMH screw terminal of power connection

X1	Terminal	Description
1	⏚	Power earth
2	NC	Not connected
3	+	Line/positive
4	-	Neutral/negative
5	NC	Not connected
6	⏚	Power earth

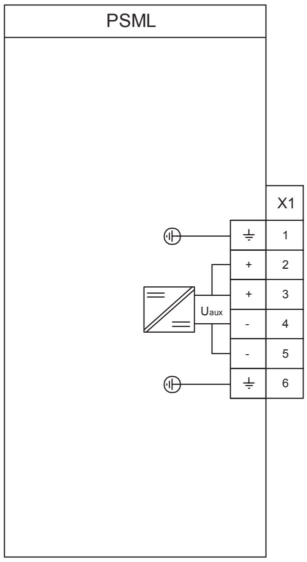

Figure 16: PSML terminals

Table 7: PSML screw terminal of power connection

X1	Terminal	Description
1	⏚	Power earth
2	+	Positive
3	+	Positive
4	-	Negative
5	-	Negative
6	⏚	Power earth

+ terminals of the PSML module are internally shorted.

- terminals of the PSML module are internally shorted.

Check the source polarity of the terminal connections. Reverse polarity can withstand only 60 seconds at the maximum.

5.2.2 Connecting Ethernet cable

Check that the proper power supply and LECM modules are mounted on the DIN rail. The LECM module is supplied with two end caps and end clamps which must be mounted at both ends of the RIO600 stack.

The communication module works as a RIO600 main module and communicates with different digital I/O modules over backplane for achieving functionality based on the output activation commands received through the communication services.

1. Connect the Ethernet cable to the LECM module in RIO600.
   The RJ-45 cable type must be shielded twisted cable, CAT5e at minimum.
   The fiber-optic cable must be multimode type with LC connector.
2. Connect the other end of the cable to the IEC 61850 station bus through the Ethernet switch.

Ensure that the fiber-optic cable is connected on both ends of the device. Looking directly at the LC connector may damage eyes.

Change the default IP address of the LECM module by using the Parameter Setting tool in PCM600.

Table 8: Default settings of the LECM module

Setting	Value
IP	192.168.2.10
Subnet mask	255.255.255.0
Default gateway	192.168.2.1
Time Synch source	none
Technical key	RIO1

In case of incomplete settings, the push button switch on the LECM module can be used to restore the default settings.

During a configuration mismatch when the power is on, the LECM module communicates through the previously configured IP address.

5.2.3 Connecting binary input signals

Check that the proper power supply and LECM modules are mounted on the DIN rail.

DIM8H module has two sets of connectors. Each set of connectors accept four binary input connections with two isolated pairs of inputs per connection. The voltage range for DIM8H binary input connection is 110...250 V DC (±20%). The threshold is 78 V DC.

DIM8L module has two sets of connectors. Each set of connectors accept four binary input connections with two isolated pairs of inputs per connection. The voltage range for DIM8L binary input connection is 24, 30, 48, 60 V DC (±20%) variation. The threshold is 13 V DC.

1. Fasten the input connectors through the upper and lower screw terminals.
2. Connect wires to the DI and 0V- signals.

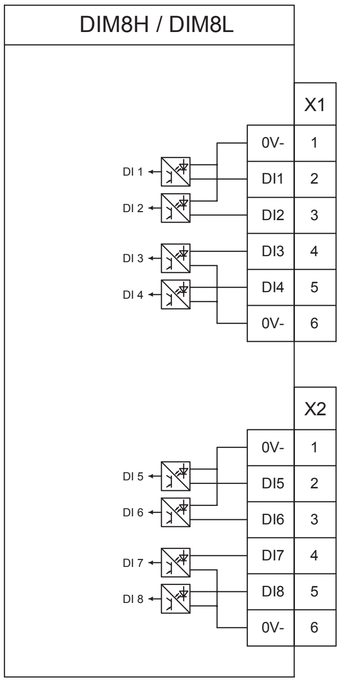

Figure 17: DIM8H/DIM8L terminals

Table 9: Screw terminal of the DIM8H/DIM8L connection

X2	Binary input terminal	Description	LED	X1	Binary input terminal	Description	LED
1	0 V-	Isolated input pair 3		1	0 V-	Isolated input pair 1	
2	DI5		DI5	2	DI1		DI1
3	DI6		DI6	3	DI2		DI2
Table continues on next page							

X2	Binary input terminal	Description	LED	X1	Binary input terminal	Description	LED
4	DI7	Isolated input pair 4	DI7	4	DI3	Isolated input pair 2	DI3
5	DI8		DI8	5	DI4		DI4
6	0 V-			6	0 V-		

5.2.4 Connecting binary output signals

Check that the proper power supply and LECM modules are mounted on the DIN rail.

The DOM4 module has four signaling outputs with a common return for a pair of two outputs. The default contact status during auxiliary shutdown and startup phase is “Opened”. Once a valid configuration is accepted, the contacts operate based on the output activation commands received via communication services.

The rated voltage for binary output connection is 250 V AC or 250 V DC. The binary output contact operation time is 5...7 ms.

1. Fasten the output connector through the upper and lower screw terminals.
2. Connect wires to the DO and COM signals.

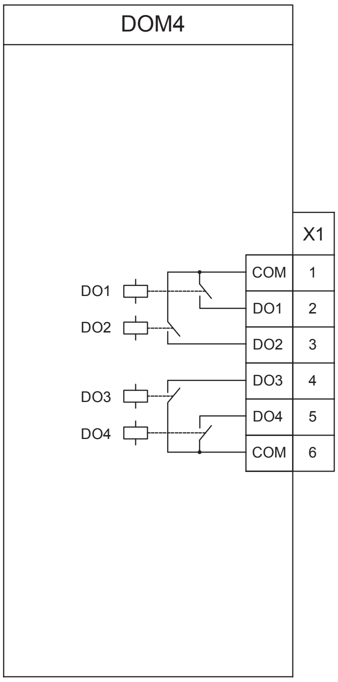

Figure 18: DOM4 terminals

Table 10: Screw terminal of the DOM4 connection

X1	Binary output terminal	Description	LED
1	COM	Isolated output pair 1	
2	DO1		DO1
3	DO2		DO2
4	DO3	Isolated output pair 2	DO3
5	DO4		DO4
6	COM		

5.2.5 Connecting RTD/mA signals

Use a shielded cable for the connection of RTD/mA signals. Connect the shield of the cable to the DIN rail through an earthing clamp, for example, Weidmuller Earthing Clamp: 1252520000 (KLBUE 4-13.5 FM4).

Check that the proper power supply and LECM modules are mounted on the DIN rail. The RTD4 module has two sets of connectors where each set accepts two RTD/mA signals.

1. Fasten the input connector through the upper and lower screw terminals.
2. Connect the signals based on the type of configuration.
    - For 2-wire RTD configuration, connect the RTD signals between - and + terminals and short - and C terminals, else there will be an IRF.

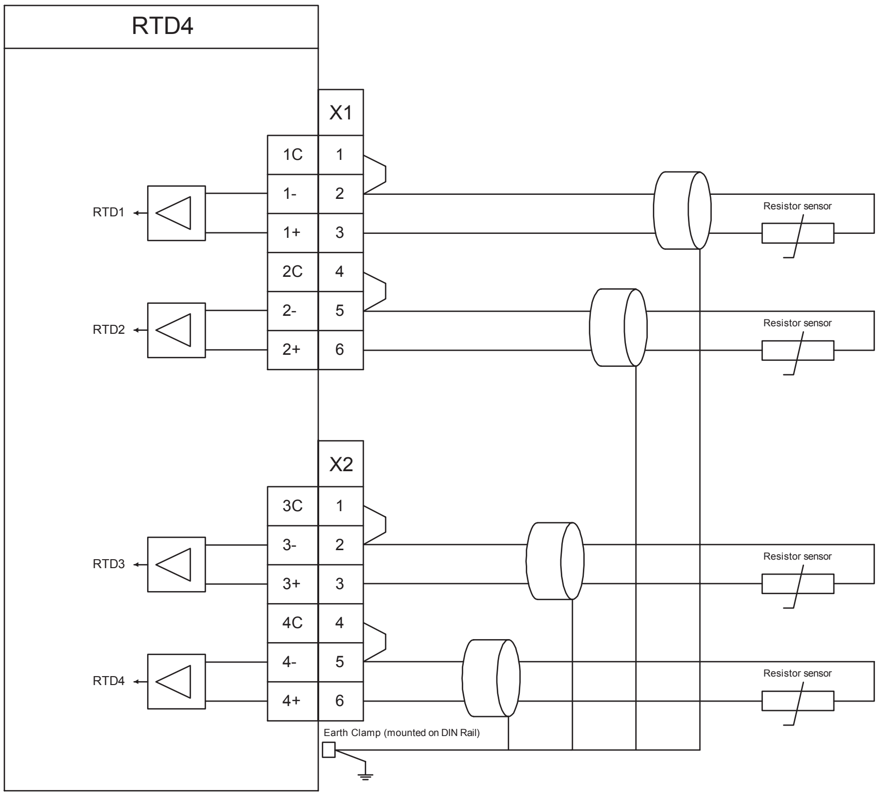

Figure 19: 2-wire RTD

- For 3-wire RTD configuration, connect the three terminals of RTD sensor between C, - and + terminals.

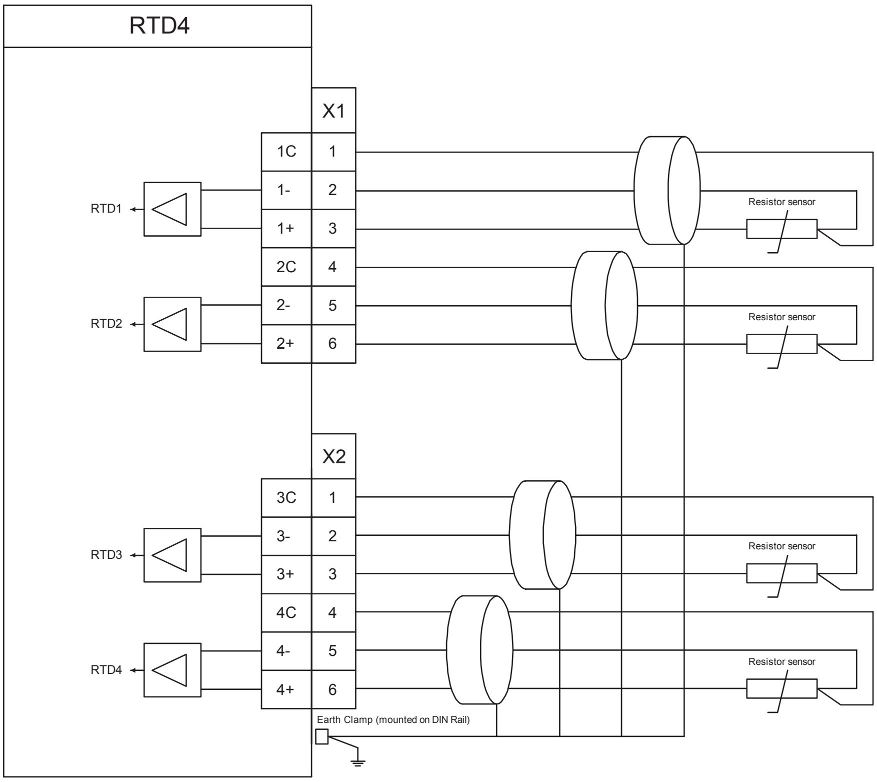

Figure 20: 3-wire RTD

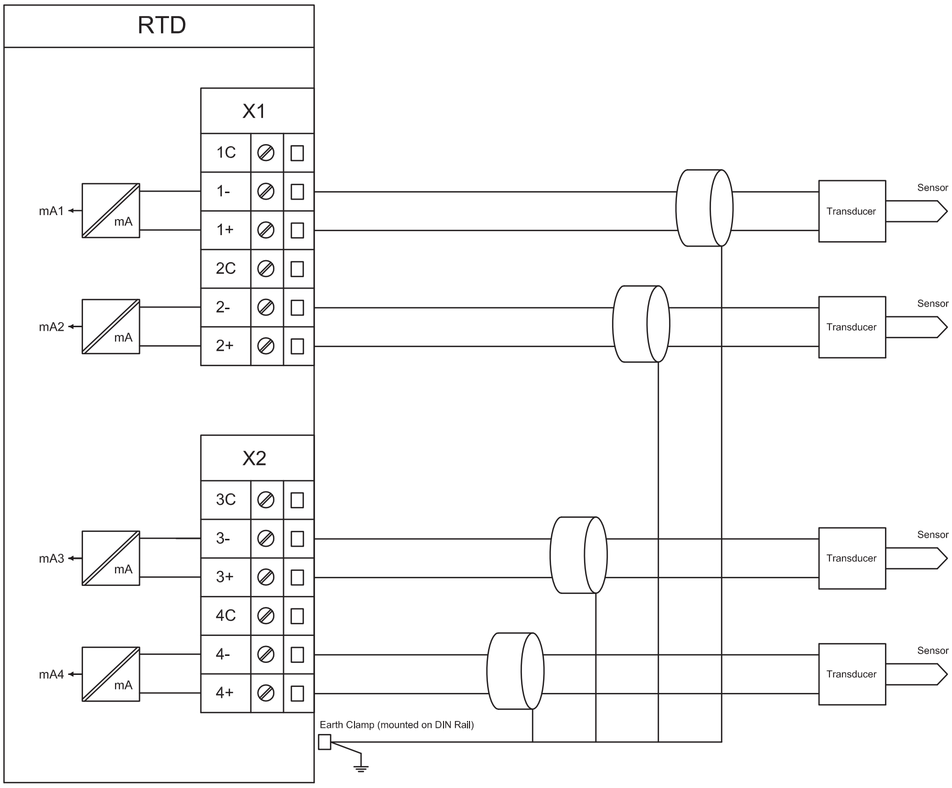

Figure 21: mA input connection

The recommended connection method is 3-wire RTD as it allows compensation of connection lead (connection wire) resistance and the results are more accurate.

Table 11: Screw terminal of RTD/mA connection

X2	RTD/mA input terminal	Description	X1	RTD/mA input terminal	Description
1	3C	Ch3 compensation	1	1C	Ch1 compensation
2	3-	Ch3 return path (negative terminal)	2	1-	Ch1 return path (negative terminal)
3	3+	Ch3 positive terminal	3	1+	Ch1 positive terminal

Table continues on next page

X2	RTD/mA input terminal	Description	X1	RTD/mA input terminal	Description
4	4C	Ch4 compensation	4	2C	Ch2 compensation
5	4-	Ch4 return path (negative terminal)	5	2-	Ch2 return path (negative terminal)
6	4+	Ch4 positive terminal	6	2+	Ch2 positive terminal

5.2.6 Connecting AOM4 signals

Use a shielded cable for the connection of RTD/mA signals. Connect the shield of the cable to the DIN rail through an earthing clamp, for example, Weidmuller Earthing Clamp: 1252520000 (KLBUE 4-13.5 FM4).

Check that the proper power supply and LECM modules are mounted on the DIN rail. The AOM4 module has two sets of connectors where each set provides two AOM4 signals.

1. Fasten the input connector through the upper and lower screw terminals.
2. For AOM4 configuration, connect the wires between - and + terminals.

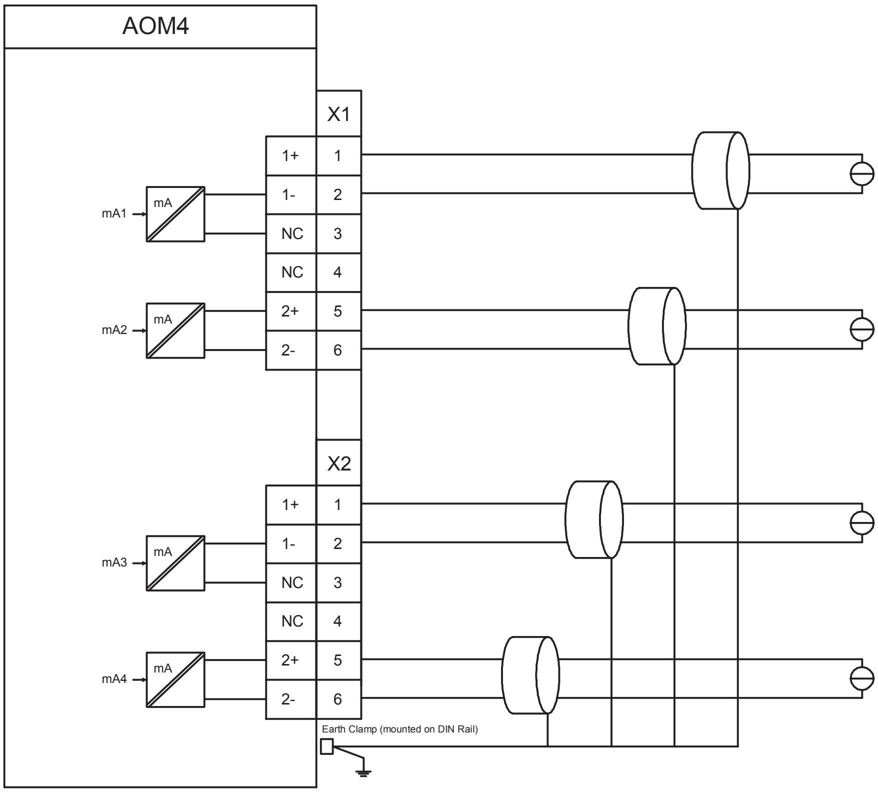

Figure 22: mA output connection

Table 12: Screw terminal of AOM4 connection

X2	AOM output terminal	Description	X1	AOM output terminal	Description
1	3+	Ch3 out	1	1+	Ch1 out
2	3-	Ch3 return path (negative terminal)	2	1-	Ch1 return path (negative terminal)
3	NC	Not connected	3	NC	Not connected
4	NC	Not connected	4	NC	Not connected
5	4+	Ch4 out	5	2+	Ch2 out
6	4-	Ch4 return (negative terminal)	6	2-	Ch2 return (negative terminal)

5.2.7 Connecting SIM8F sensor signals

RIO600 accepts three phase voltage and current signals to RJ-45 connectors.

The input signals are fed from combined non-conventional instrument transformers (NCIT) which have both a current sensor based on Rogowski coil principle and a voltage sensor based on capacitive divider principle. The sensor is equipped with current and voltage signal cable with RJ-45 connector for connection with SIM8F module. There are also separate current and voltage sensors which are wired to a single RJ-45 connector with adapter.

- Use the cable connector type RJ-45 for connecting the sensors with SIM8F.
- Connect both current and voltage signals to the sensor input for proper operation.

Preferred ABB combined sensor for RIO600 is KEVCY 24 RE1, KEVCY 36 RE1, KEVCY 40.5 RE1 or KEVCD A.

Preferred combination of ABB current sensors is KECA 80 C85 and ABB voltage sensor KEVA 24 C10, 24 C21, 24 C22, 24 C23, 17.5 B20, 17.5 B21, 24 B20, or 24 B21.

RIO600 supports also split-core current sensor type for retro-fit purposes. Preferred split-core sensor is KECA 80 D85.

From RIO600 Ver.1.8.3 onwards (along with SIM8F Ver.1.3.3), RIO600 supports non-conventional current transformers (LPCT).

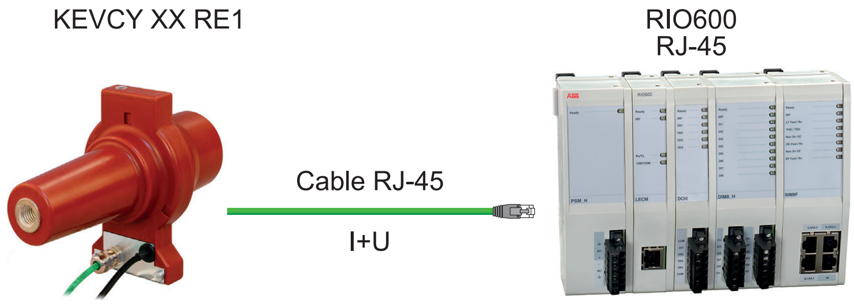

Figure 23: Connecting combisensor to RIO600 RJ-45

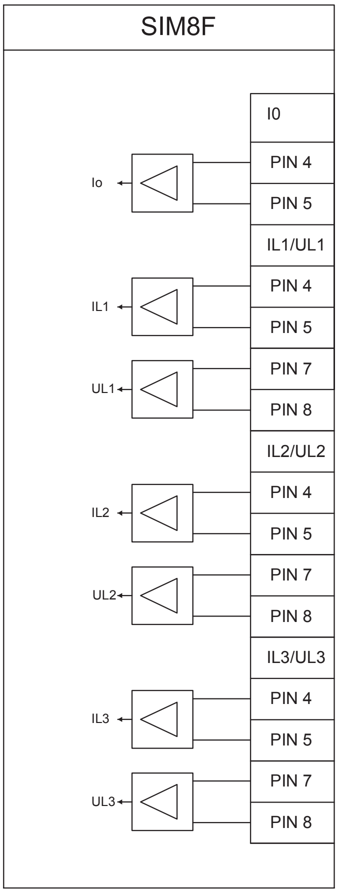

Figure 24: SIM8F terminals

Table 13: SIM8F connection terminal

Connector	Pin #	Sensor terminal connection	Description
I0	4, 5	S1, S2	Analog input connection for neutral/Io (earth current connection)
IL1/UL1	4,5 7,8	S1, S2 a, n	Analog input connector for phase 1 current and voltage signals
IL2/UL2	4,5 7,8	S1, S2 a, n	Analog input connector for phase 2 current and voltage signals
IL3/UL3	4,5 7,8	S1, S2 a, n	Analog input connector for phase 3 current and voltage signals

5.2.8 Connecting SIM4F sensor signals

In RIO600, SIM4F accepts three phase current signals to RJ-45 connectors.

The input signals are fed from a current sensor based on the Rogowski coil principle. The sensor should be equipped with an RJ-45 connector for connection with the SIM4F module. There are current sensors which are wired to a single RJ-45 connector with adapter.

- Use the cable connector type RJ-45 for connecting the sensors with SIM4F.
- Connect current signals to the sensor input for proper operation.

Preferred ABB current sensor is KECA 80 C85.

RIO600 supports also split-core current sensor type for retro-fit purposes. Preferred split-core sensor is KECA 80 D85.

From RIO600.Ver.1.8.3 onwards (along with SIM4F Ver.1.0.3), RIO600 supports non-conventional current transformers (LPCT).

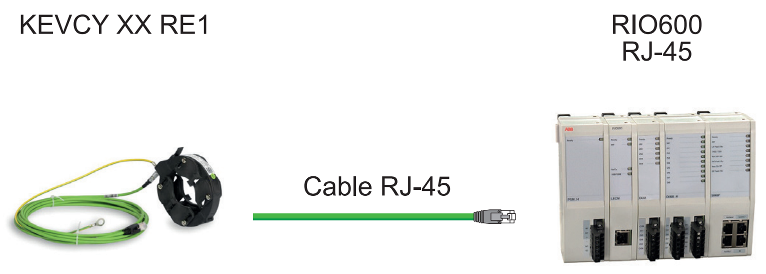

Figure 25: Connecting split-core current sensor to RIO600 RJ-45

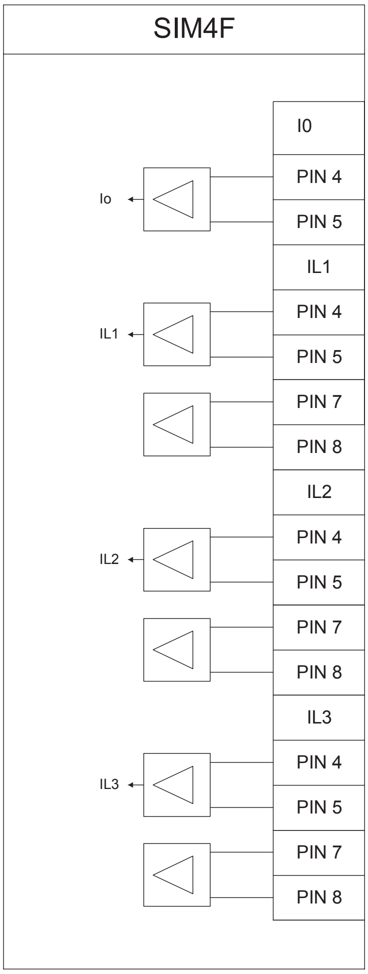

Figure 26: SIM4F terminals

Table 14: SIM4F connection terminal

Connector	Pin #	Sensor terminal connection	Description
I0	4, 5	S1, S2	Analog input connection for neutral/Io (earth current connection)
IL1	4,5	S1, S2 a, n	Analog input connector for phase 1 current signal
IL2	4,5	S1, S2 a, n	Analog input connector for phase 2 current signal
IL3	4,5	S1, S2 a, n	Analog input connector for phase 3 current signal

5.2.9 Connecting smart control module signals

Smart control module supports different switchgear application types such as managing two-position or three-position switches or managing circuit breaker trip commands or generic four binary inputs and four fast power outputs.

Check that the proper power supply and LECM modules are mounted on the DIN rail.

SCM8H/SCM8L modules have two sets of connectors. X1 is used for the binary inputs and X2 for the solid state outputs. X1 connectors accept four binary input connections with two isolated pairs of inputs per connection. X2 connectors have four outputs with a common return for a pair of two outputs.

The voltage range for SCM8H binary input connection is 110...250 V DC (±20%). The threshold is 78 V DC.

The voltage range for SCM8L binary input connection is 24...60 V DC (±20%). The threshold is 13 V DC.

The operation time of the high-speed output contact is <200 µs.

1. Fasten the input and output connectors through the upper and lower screw terminals.
2. Connect wires to the signals according to the used application.
   The functionality of the four digital inputs is equal to the standard input board DIM8. Each application type has different wiring requirements and a specific connection diagram.

Check that the polarity of the solid state power outputs is correct.

Check the direction of motor rotation/moving switch, if applicable, and ensure the right polarity of the high-speed outputs.

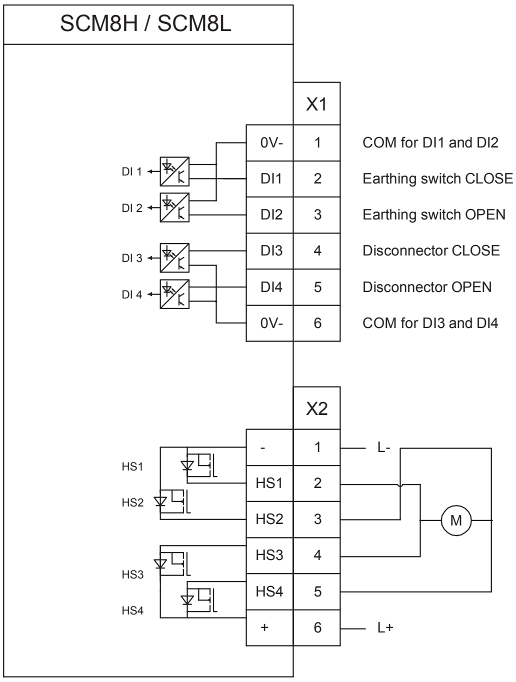

Figure 27: Connection diagram for three-position switch application (rod type with DC motor)

Table 15: SCM connection for three-position switch application

X1	Connector inputs	Description	X2	Connector outputs	Description
OV-	1	Common return for DI1 and DI2	-	1	AUX. DC voltage L-
DI1	2	Earthing switch CLOSE position signal	HS1	2	DC motor connection
DI2	3	Earthing switch OPEN position signal	HS2	3	DC motor connection
DI3	4	Disconnector switch CLOSE position signal	HS3	4	DC motor connection
DI4	5	Disconnector switch OPEN position signal	HS4	5	DC motor connection
OV-	6	Common return for DI3 and DI4	+	6	AUX. DC voltage L+

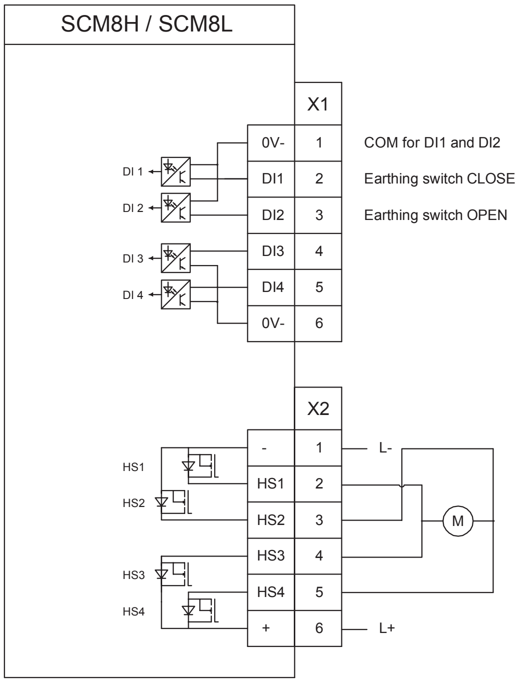

Figure 28: Connection diagram for two-position earthing switch application (rod type with DC motor)

Table 16: SCM connection for two-position earthing switch application

X1	Connector inputs	Description	X2	Connector outputs	Description
OV-	1	Common return for DI1 and DI2	-	1	AUX. DC voltage L-
DI1	2	Earthing switch CLOSE position signal	HS1	2	DC motor connection
DI2	3	Earthing switch OPEN position signal	HS2	3	DC motor connection
DI3	4	Digital input 3	HS3	4	DC motor connection
DI4	5	Digital input 4	HS4	5	DC motor connection
OV-	6	Common return for DI3 and DI4	+	6	AUX. DC voltage L+

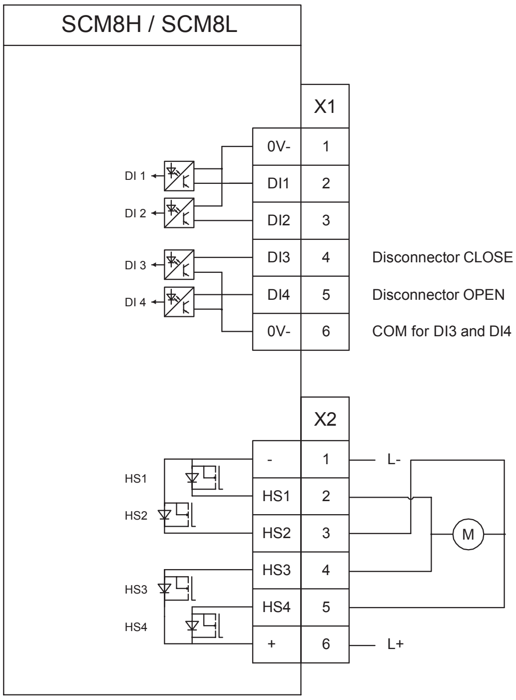

Figure 29: Connection diagram for two-position disconnector switch application (rod type with DC motor)

Table 17: SCM connection for two-position disconnector switch application

X1	Connector inputs	Description	X2	Connector outputs	Description
OV-	1	Common return for DI1 and DI2	-	1	AUX. DC voltage L-
DI1	2	Digital input 1	HS1	2	DC motor connection
DI2	3	Digital input 2	HS2	3	DC motor connection
DI3	4	Disconnector switch CLOSE position signal	HS3	4	DC motor connection
DI4	5	Disconnector switch OPEN position signal	HS4	5	DC motor connection
OV-	6	Common return for DI3 and DI4	+	6	AUX. DC voltage L+

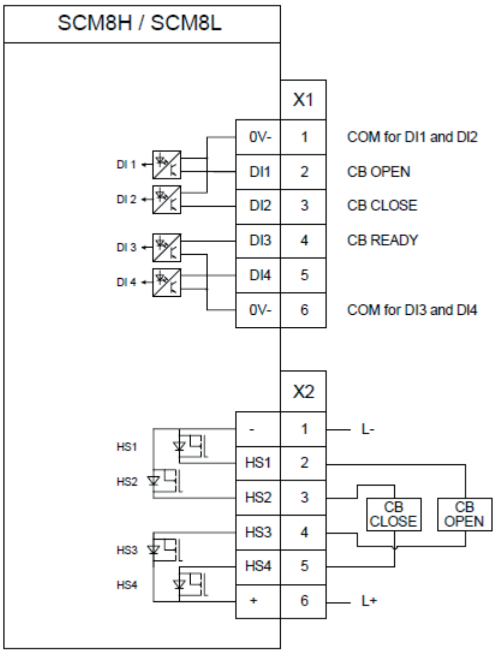

Figure 30: Connection diagram for circuit breaker application (direct tripping – double pole)

Table 18: SCM connection for circuit breaker application

X1	Connector inputs	Description	X2	Connector outputs	Description
OV-	1	Common return for for DI1 and DI2	-	1	AUX. DC voltage L-
DI1	2	Position indication for CB Open	HS1	2	CB OPEN Trip coil
DI2	3	Position indication for CB Close	HS2	3	CB CLOSE coil
DI3	4	CB READY status	HS3	4	CB OPEN Trip coil
DI4	5	Digital input 4	HS4	5	CB CLOSE coil
OV-	6	Common return for DI3 and DI4	+	6	AUX. DC voltage L+

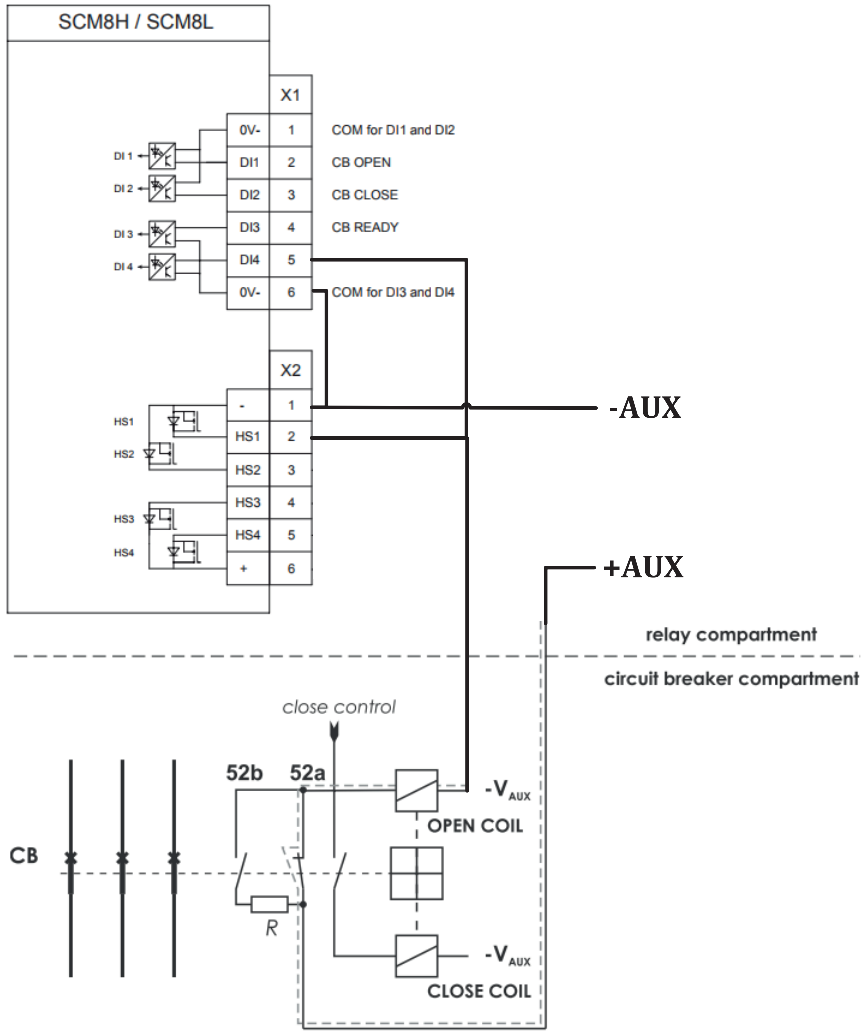

Figure 31: Connection diagram for circuit breaker application with trip circuit supervision (direct tripping - double pole)

Table 19: SCM connection for circuit breaker application with trip circuit supervision

X1	Connector inputs	Description	X2	Connector outputs	Description
OV-	1	Common return for DI1 and DI2	-	1	AUX. DC voltage L-
DI1	2	Position indication for CB Open	HS1	2	CB OPEN Trip coil
DI2	3	Position indication for CB Close	HS2	3	CB CLOSE coil

Table continues on next page

X1	Connector inputs	Description	X2	Connector outputs	Description
DI3	4	CB READY status	HS3	4	NC
DI4	5	TCS	HS4	5	CB CLOSE coil
OV-	6	Common return for DI3 and DI4	+	6	AUX. DC voltage L+

Table 20: Values recommended for the external resistor Rext

Description	Value
Operating voltage Vaux	Recommended shunt resistor Rext
SCM_L	
24 V	1.2 kΩ, 5 W
SCM_H	
110 V DC	5.6 kΩ, 5 W
220 V DC	33 kΩ, 5 W

Uc – (Rext + Rs) X Ic ≥ 13 V for SCM8L

Uc – (Rext + Rs) X Ic ≥ 78 V for SCM8H

Where,

Uc is Operating voltage over the supervised trip circuit

Ic is Measuring current through the trip circuit, 2 mA for SCM8L and 3 mA for SCM8H

Rext is external shunt resistance

Rs is trip coil resistance

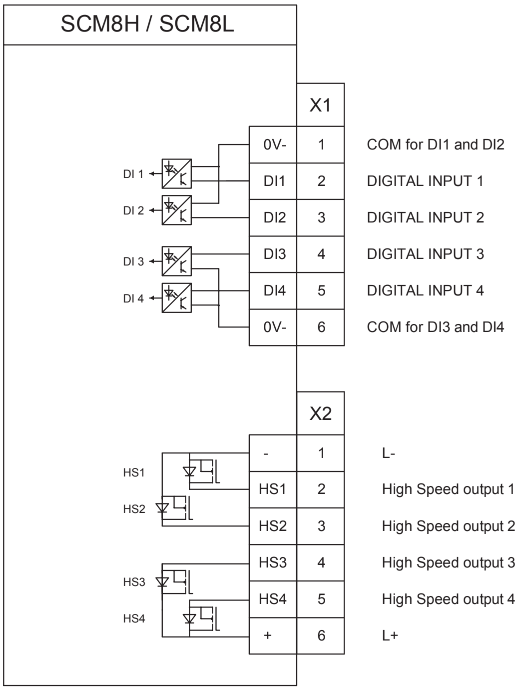

Figure 32: Connection diagram for generic four DI and four high-speed power outputs (HS)

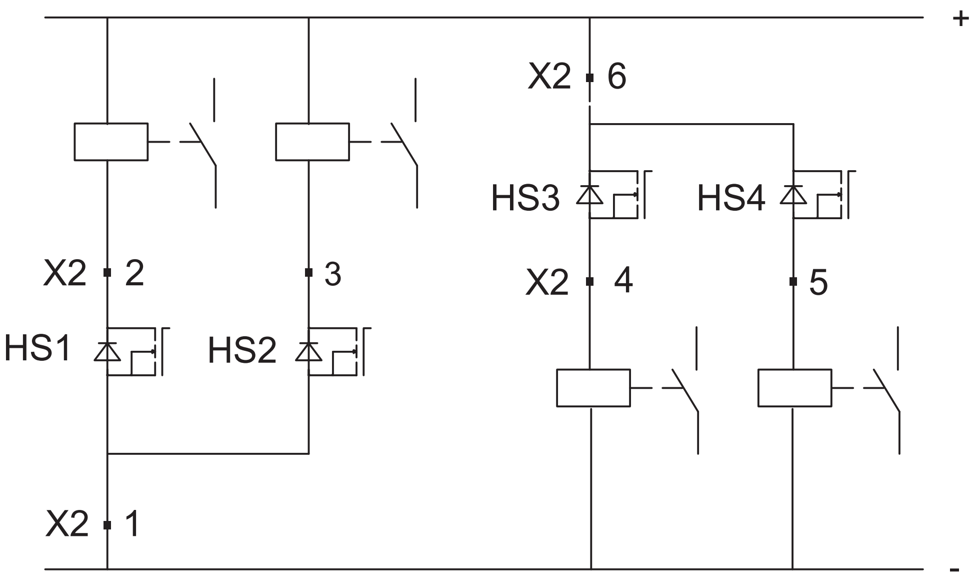

Figure 33: 4I4O connection

HS3 and HS4 need to be connected as the negative terminal of the voltage source.

Table 21: SCM connection for generic four inputs and four high-speed power outputs

X1	Connector inputs	Description	X2	Connector outputs	Description
OV-	1	Common return for DI1 and DI2	-	1	AUX. DC voltage L-
DI1	2	Digital input 1	HS1	2	High speed output 1
DI2	3	Digital input 2	HS2	3	High speed output 2
DI3	4	Digital input 3	HS3	4	High speed output 3
DI4	5	Digital input 4	HS4	5	High speed output 4
OV-	6	Common return for DI3 and DI4	+	6	AUX. DC voltage L+

5.3 Connecting RIO600 to a PC

Connect RIO600 to a PC within the same IP subnet.

The default IP address of the LECM module is 192.168.2.10.

5.3.1 Checking the connection to RIO600

The connection to RIO600 can be checked either with ICMP Ping messages or by connecting to RIO600 via a Web browser.

1. To check the connection between the PC and RIO600 with ICMP Ping messages, open the **Run** dialog box.
2. Type `cmd` in the **Open** box.
3. Click **OK** to access the command prompt.

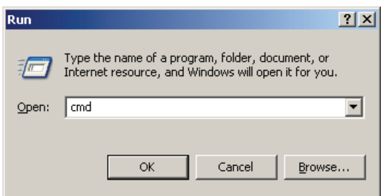

Figure 34: Starting command prompt

4. Ping the IP address of RIO600 by typing, for example, `ping 192.168.2.10`.

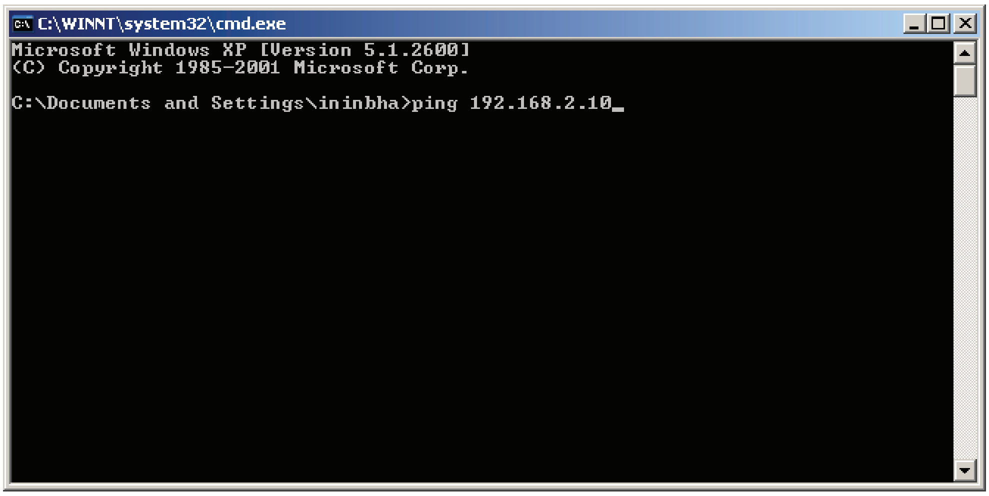

Figure 35: Type ping command

RIO600 responds with valid Ping replies if the connection and used IP address are correct.

Section 6 Commissioning

6.1 Parameter setting

The operating parameters of the LECM, DIM8H, DIM8L,DOM4, RTD4, AOM4, SIM8F and SIM4F modules.

6.1.1 Operating parameter settings LECM

Table 22: Operating parameter settings for LECM

Parameter name	Range	Unit	Step	Default value	Description
General Parameters					
Test Mode	Disable/Enable			Disable	This parameter enables or disables the *Test mode* parameter in RIO600.
Standalone configuration	False/True			False	If enabled, RIO600 operates in standalone mode without any GOOSE/Modbus commands
Communication					
IP Address				192.168.2.10	IP address for RIO600
Subnet Mask				255.255.255.0	Subnet mask address for RIO600
Default Gateway				192.168.2.1	Gateway address for RIO600
Synch Source	None/SNTP/ Modbus			None	Time synchronization (SNTP) selection. None: SNTP functionality not selected. If the SNTP time synchronization is not required or available, the *Synch Source* parameter must be set to “None". RIO600 displays the default time on the WHMI in red to indicate that time is not synchronized. SNTP: SNTP functionality selected. If two separate SNTP servers are available, their IP addresses can be configured with parameters *IP SNTP Primary* and *IP SNTP Secondary*. If a single SNTP server is used, its IP address can be configured in the *IP SNTP Primary* parameter, and the *IP SNTP Secondary* parameter can be configured as "0.0.0.0". Modbus: Syncronization by unsigned 16 bit UTC time.
IP SNTP Primary				10.58.125.165	IP address for SNTP server 1
IP SNTP Secondary				192.168.2.165	IP address for SNTP server 2 If the second SNTP server is not required, configure this field with the value "0.0.0.0" to disable the server.
Table continues on next page					

Parameter name	Range	Unit	Step	Default value	Description
Time Synch Interval	15...36000	s	15		SNTP polling time interval Values can be entered from 15 s to 10 h with a step value of 15.[1)]
Physical MAC Address Check	Disabled/Enabled			Disabled	Disabled = Physical MAC address check disabled Enabled = Physical MAC address check enabled If this parameter is enabled, then RIO600 checks physical MAC address of the publisher IED and will only accept GOOSE message subscribed by RIO600. In this way, RIO600 can do an additional security verification of peer IED. To be used with care as this parameter does not update if the system configuration is updated or peer IED is replaced.
Physical MAC address				00:00:00:00:00:00	Physical MAC address of the publisher IED.

1) Feature available from RIO600 Ver.1.8.2 onwards

6.1.1.1 Standalone configuration

RIO600 can be configured to operate in a standalone mode. During this mode, RIO600 ignores all events from the publisher. It also does not check for any communication errors or warnings and the modules can be configured as desired. With the parameter default value "false", the Ethernet cable is expected to be connected, otherwise RIO600 indicates a warning due to communication failure.

6.1.1.2 Intermodule communication

Binary signals in RIO600 can be configured to operate the outputs within the same RIO600 stack. Any binary signal can be mapped to any of the output contacts. RIO600 supports the one-input NOT logic function and four-input OR and AND logic functions through which signals can be passed and mapped to one output contact. A logic output can also be available on GOOSE through the MVGAPC block. RIO600 supports up to two MVGAPC blocks, 20 OR, 20 AND, and 20 NOT logic blocks per RIO600 stack.

6.1.2 Operating parameter settings DIM8H and DIM8L

The parameters for DIM8H and DIM8L are the same.

Table 23: Operating parameter settings for DIM8H and DIM8L

Parameter name	Range	Unit	Default value	Description
Debounce Time	5...4095	ms	10	This parameter is the debounce time for the DIM8 module in ms.
Oscillation Upper Limit	2...63	Counts	63	This parameter is the oscillation suppression upper limit. The parameter value acts as the count for upper limit.
Oscillation Suppression Hysteresis	1...62	Counts	62	This parameter is the oscillation suppression Hysteresis. The parameter value acts as the count for Hysteresis.
Oscillation Time	0...4095	ms	4095	This parameter is the oscillation suppression time limit. The parameter value acts as the time window for the oscillation detection in ms. 0 means that no oscillation suppression is active.
Description			Digital Input 1...8	User defined channel name not exceeding 30 characters
Channel 1 Inversion	Non-Inverted/Inverted		Non Inverted	channel 1 input type: non-inverted/inverted
Channel 2 Inversion	Non-Inverted/Inverted		Non Inverted	channel 2 input type: non-inverted/inverted
Channel 3 Inversion	Non-Inverted/Inverted		Non Inverted	channel 3 input type: non-inverted/inverted
Channel 4 Inversion	Non-Inverted/Inverted		Non Inverted	channel 4 input type: non-inverted/inverted
Channel 5 Inversion	Non-Inverted/Inverted		Non Inverted	channel 5 input type: non-inverted/inverted
Channel 6 Inversion	Non-Inverted/Inverted		Non Inverted	channel 6 input type: non-inverted/inverted
Channel 7 Inversion	Non-Inverted/Inverted		Non Inverted	channel 7 input type: non-inverted/inverted
Channel 8 Inversion	Non-Inverted/Inverted		Non Inverted	channel 8 input type: non-inverted/inverted
Input Channel 1 Enabled/Disabled	Enabled/Disabled		Enabled	channel 1: enabled/disabled
Input Channel 2 Enabled/Disabled	Enabled/Disabled		Enabled	channel 2 : enabled/disabled
Input Channel 3 Enabled/Disabled	Enabled/Disabled		Enabled	channel 3: enabled/disabled
Input Channel 4 Enabled/Disabled	Enabled/Disabled		Enabled	channel 4: enabled/disabled
Input Channel 5 Enabled/Disabled	Enabled/Disabled		Enabled	channel 5: enabled/disabled
Input Channel 6 Enabled/Disabled	Enabled/Disabled		Enabled	channel 6: enabled/disabled
Input Channel 7 Enabled/Disabled	Enabled/Disabled		Enabled	channel 7: enabled/disabled
Input Channel 8 Enabled/Disabled	Enabled/Disabled		Enabled	channel 8: enabled/disabled

6.1.2.1 Binary input debounce time (filter time)

The filter time eliminates debounces and short disturbances on a binary input. The filter time is set for each binary input.

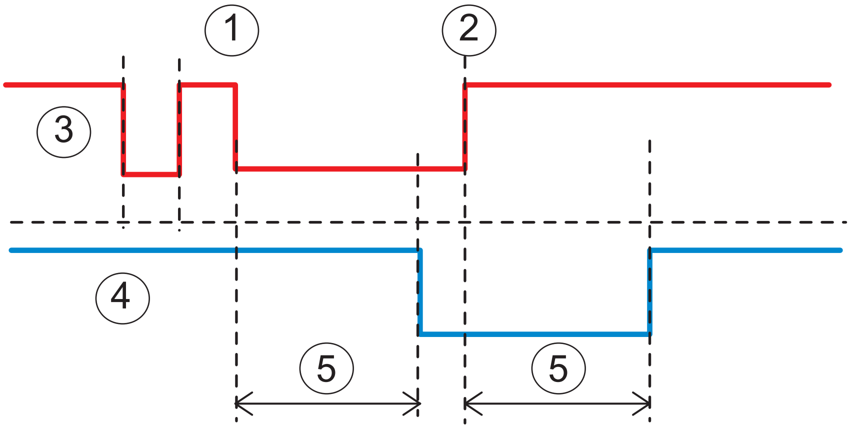

Figure 36: Binary input filtering

1	t_0
2	t_1
3	Input signal
4	Filtered input signal
5	Filter time

At the beginning, the input signal is at the high state, the short low state is filtered and no input state change is detected. The low state starts when the time t_0 exceeds the filter time, which means that the change in the input state is detected and the time tag attached to the input change is t_0. The high state starts when t_1 is detected and the time tag t_1 is attached.

6.1.2.2 Binary input inversion

When a binary input is inverted, the state of the input is TRUE (1) when no control voltage is applied to its terminals. Accordingly, the input state is FALSE (0) when a control voltage is applied to the terminals of the binary input.

LEDs and WHMI reflect the physical input signal present on the binary input terminal.

6.1.2.3 Oscillation suppression

Oscillation suppression is used to reduce the load from the system when a binary input starts oscillating. A binary input is regarded as oscillating if the number of valid state changes (= number of events after filtering) during configured time period (as per oscillation time parameter) is equal to or greater than the set oscillation level value. During oscillation, the binary input is blocked (the status is invalid) and an event is generated. The state of the input does not change when it is blocked, that is, its state depends on the condition before blocking.

The binary input is regarded as non-oscillating if the number of valid state changes during configured time period is less than the set oscillation level value minus the set oscillation hysteresis value. The oscillation hysteresis must be set lower than the oscillation level to enable the input to be restored from oscillation. When the input returns to a non-oscillating state, the binary input is deblocked (the status is valid) and an event is generated.

6.1.3 Operating parameter settings DOM4

Table 24: Operating parameter settings for DOM4

Parameter name	Range	Unit	Default value	Description
Description			Digital Output 1...4	User defined channel name not exceeding 30 characters
Pulse Length	10 to 65535	ms	10	The integer value in this parameter indicates the pulse length for the output channels in milliseconds (ms). This parameter is configurable separately for each output channel.
Signal Type	Static/Pulse		Static	output signal type: static/pulse This parameter is configurable separately for each output channel.
Output Channel 1 Inversion	Non-Inverted/Inverted		Non Inverted	channel 1 output type: non-inverted/inverted
Output Channel 2 Inversion	Non-Inverted/Inverted		Non Inverted	channel 2 output type: non-inverted/inverted
Output Channel 3 Inversion	Non-Inverted/Inverted		Non Inverted	channel 3 output type: non-inverted/inverted
Output Channel 4 Inversion	Non-Inverted/Inverted		Non Inverted	channel 4 output type: non-inverted/inverted
Output Channel 1 Enabled	Enabled/Disabled		Enabled	channel 1: enabled/disabled
Output Channel 2 Enabled	Enabled/Disabled		Enabled	channel 2: enabled/disabled
Output Channel 3 Enabled	Enabled/Disabled		Enabled	channel 3: enabled/disabled
Output Channel 4 Enabled	Enabled/Disabled		Enabled	channel 4: enabled/disabled

Table 25: Details of output channels on a DOM4 board configured for IRF

Status	Contact condition	LED status
Power-on	Open	OFF
Normal operating condition	Closed	ON
IRF condition	Open	OFF

It is possible to map IRF condition to any binary output via Signal Matrix in PCM600.

Certain parameters, for example, signal type, inversion and disabling, are not applicable to the channel that is configured for the IRF operation. OR logic function should not be used with the contact used for IRF operation.

6.1.4 Operating parameter settings of RTD/mA module

Table 26: Operating parameter settings

Parameter name	Range		Unit	Default value	Description
Description				Analog Input 1...4	User defined channel name not exceeding 30 characters
Input mode	Pt100 Pt250 Ni100 Ni120 Ni250 0…20mA Not in Use			Not in use	Input channel type selection. “Not in Use” indicates that the channel is disabled.
All the below parameters depend on the selected input mode (RTD/mA)					
Conn Type	Input mode - RTD	Input mode - mA			Connection type based on the selected input mode.
	2-wire 3-wire				
Input Max	-40...200 °C	0.0...20.0 mA			Maximum range of input based on the selected input mode. For example, if the selected input mode is “0…20 mA” and the channel has to be configured for 4...20 mA, *Input Max* is 20.0.
Input Min	-40...200 °C	0.0...20.0 mA			Minimum range of input based on the selected input mode. For example, if the selected Input Mode is “0…20 mA” and the channel has to be configured for 4...20 mA, *Input Min* is 4.0.
SuperVision time	0...5		s	5	The rate at which value of measurements is reported.
Tolerance Low		0...4	%	0	Tolerance in percentage on lower value of mA input range. For RTD, this is not applicable. For example, if the channel is configured for 4 to 20 mA and selected *Tolerance Low* is 4, then 4% (= 0.64) of range (= 16 mA) is applied to *Input Min Value*. Thus, if measured value is less than *Input Min* by *Tolerance Low* % (= 3.36) of configured range (*Input Max* – *Input Min*), the value is considered “out of range”.
Tolerance High		0...4	%	0	Tolerance in percentage on higher value of mA input range. For RTD, this is not applicable. For example, if the channels are configured for 4...20 mA and selected *Tolerance High* is 4, then 4% (= 0.64) of range (= 16 mA) is applied to *Input Max Value*. Thus, if measured value is more than *Input Max* by *Tolerance High* % (= 20. 64) of configured range (*Input Max* – *Input Min*), the value is considered “out of range”.

Table continues on next page

Parameter name	Range	Unit	Default value	Description
Value Unit	Degree Celsius, Dimensionless, mA			Value unit is based on type of configuration.
Value Max	Degree Celsius: -40...+200 Dimensionless: -10000...+10000 mA: 0...20		20	Upper limit of range
Value Min	Degree Celsius: -40...+200 Dimensionless: -10000...+10000 mA: 0...20		0	Lower limit of range
Value High High	Degree Celsius: -40…+200 Dimensionless: -10000...+10000 mA: 0...20 .		18	High high alarm limit
Value High	Degree Celsius: -40...+200 Dimensionless: -10000...+10000 mA: 0...20		17	High alarm limit
Value Low	Degree Celsius: -40….+200 Dimensionless: -10000...+10000 mA: 0...20		3	Low alarm limit
Value Low Low	Degree Celsius: -40...+200 Dimensionless: -10000...+10000 mA: 0...20		2	Low low alarm limit
Deadband Value	0.1…10	%	0.5	Deadband value in percentage or range

Configure the input mode of unused RTD channels as "Not in use".

6.1.4.1 Selection of output value format

Each channel has individual *Value unit* settings for selecting the unit for the channel output. The default setting is “Dimensionless”. The other settings like *Input minimum*, *Input maximum, Value maximum* and *Value minimum* have to be adjusted according to the input channel selected.

When the channel is selected for the RTD input type, the *Value unit* setting should be set to “Degree Celsius” and linear scaling is not possible.

When the channel is selected for the mA input signal and *Value unit* is set to “mA”, linear scaling is not possible, but the default range (0…20 mA) can be set smaller with the *Input maximum* and *Input minimum* parameters. If the application requires linear scaling of the input range, the *Value unit* parameter must be set to "Dimensionless", where the input range can be scaled linearly with the parameters *Input minimum* and *Input maximum* to *Value minimum* and *Value maximum.*

6.1.4.2 Linear input scaling

Each channel can be scaled linearly when the *Input Mode* parameter is set to "0…20 mA" and the *Value Unit* parameter is set to "Dimensionless".

The scaling is defined by a curve consisting of two points, where the y-axis (*Input minimum* and *Input maximum*) defines the input range and the x-axis (*Value minimum* and *Value maximum*) is the range of the scaled value of the input.

The input scaling can be bypassed by selecting *Value unit* to be "mA" when *Input mode* is "0...20 mA".

Example of linear scaling

The mA input is used as tap changer position information. The sensor information is from 4...20 mA, which is equivalent to the tap changer position from -36...+36 respectively.

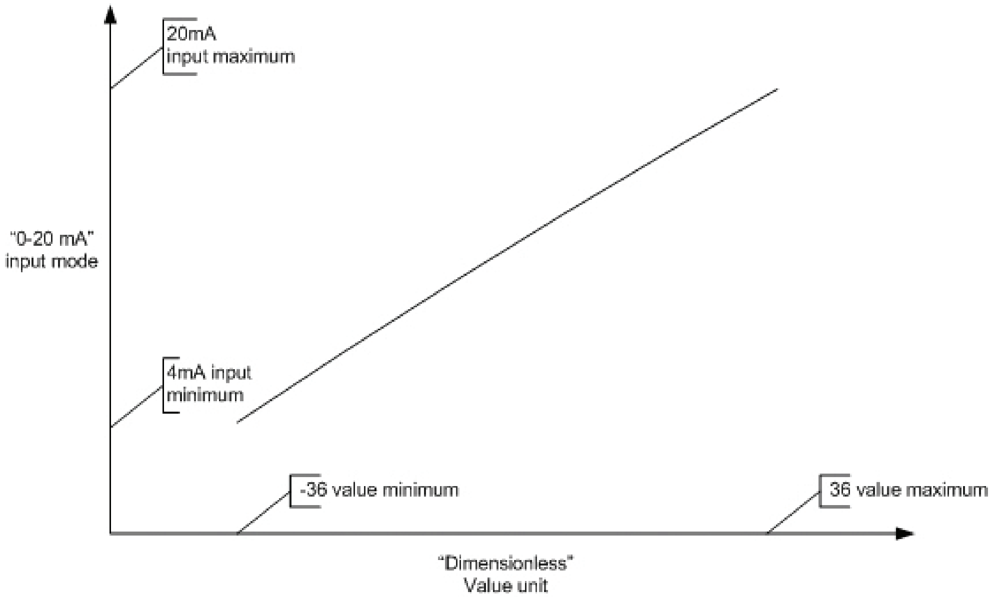

Figure 37: Example of linear scaling

6.1.4.3 Measurement chain supervision

Each channel is monitored continuously for any break of circuitry in any enabled channel. If the RTD input cable is damaged or broken, the channel value in

GOOSE is set to zero and the quality bit is set to invalid after the supervision filter time has elapsed. Also, the IRF LED on the module flashes a warning and WHMI shows "Ext HW fault". If the mA input cable is damaged or broken, the channel value in GOOSE is set to zero and the quality remains good. If the measured input value goes beyond the limits, the value gets saturated to the limits and the quality bits of the corresponding output are set accordingly.

Table 27: Limits for the RTD/mA inputs

Input	Limit value
RTD temperature, high	>200 °C
RTD temperature, low	<-40 °C
Current, high	>20 mA
Current, low	< Minimum of "Input Min" parameter value

One supervisory circuitry is shared between two input channels. If the supervisory circuitry detects failure, both input channels are declared faulty.

6.1.4.4 Calibration

The RTD and mA input channel is calibrated at the factory.

6.1.4.5 Limit value supervision

The limit value supervision indicates whether the measured value of channel exceeds or falls below the set limits. All the channels have an individual limit parameter setting. The measured value contains the corresponding range information in GOOSE parameter “range” and has a value of 0...4.

- 0: “normal”
- 1: “high”
- 2: “low”
- 3: “high-high”
- 4: “low-low”

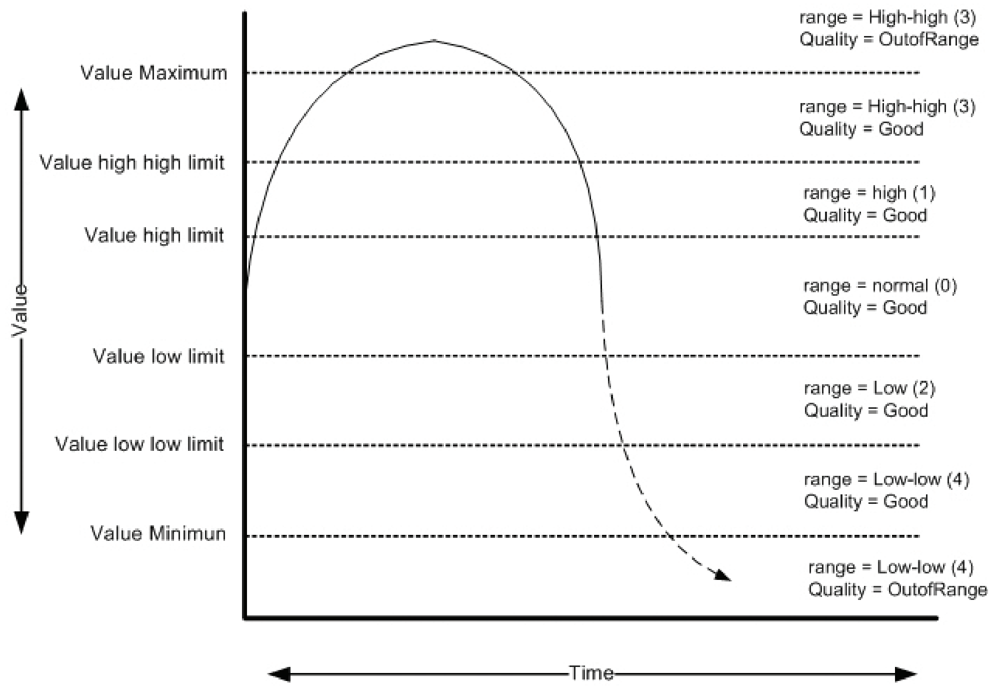

Figure 38: Limit value supervision

Table 28: Settings for RTD/mA input limit value supervision

Function	Settings for limit value supervision	
RTD/mA input	Out of range	Value maximum
	High-high limit	Val high-high limit
	High limit	Val high limit
	Low limit	Val low limit
	Low-low limit	Val low-low limit
	Out of range	Value minimum

When the measured value exceeds either the *Value maximum* parameter or the *Value minimum* parameter, the corresponding quality is set to “Out of range”.

6.1.4.6 Deadband supervision

Deadband settings are used to select how sensitively RIO600 sends the updated measurements to data subscriber over the GOOSE and Modbus communication. The deadband settings must be sensitive enough to report events fast enough but also insensitive enough not to load the Ethernet network with unnecessary events.

The deadband functionality decides the percentage change in the input values that needs to be reported to the application. If the percentage change between the current measured values and the last reported values is greater than the set *DeadBand Value* (in %) of the measured range, the current measurement is reported to the application. Otherwise, the last reported measurement value is continued to be made available for the application.

Deadband formula:

[ABS (new value – last reported value) > (% of Deadband value × Measured range)]

The measured range is the difference between the parameters *Input Max value* and *Input Min value*.

Measured range = ABS (Input Max – Input Min)

For example, if Input Min = 0, Input Max = 20, Deadband value = 1% and Last reported value = 10 and if the new measured value is less than 9.8 or greater than 10.2, the measured value should be reported.

If the value remains unchanged, it is reported after every 30 seconds.

Since the functionality can be utilized in various measurement modes, the default values are set to minimum. Thus, it is very important to set correct limit values to suit the application before the deadband supervision works properly.

6.1.5 Operating parameter settings of AOM4

Table 29: Operating parameter settings of AOM4

Parameter name	Range	Unit	Default value	Description
Description			Analog Output 1...4	User-defined channel name not exceeding 30 characters
Output Mode	0...20 Not in use	mA	Not in use	Mode of configuration When "Not in use" is selected, the channel is disabled.
Output Max	0...20		20	Maximum value of mA output
Output Min	0...20		0	Minimum value of mA output
Value Unit	Dimensionless mA		Dimensionless	Value unit depends on the configuration type.
Value Max	Dimensionless: -100000.0…+100000.0 mA: 0...20		20.0	Upper limit of the range for GOOSE For Modbus the range is -32768...+32768
Value Min	Dimensionless: -100000.0…+100000.0 mA: 0...20		0.0	Lower limit of the range for GOOSE For Modbus the range is -32768...+32768
Deadband Value	0…10	%	0	Deadband value in percentage Deadband not applicable when set to 0

At power-up, AOM4 channel drives the minimum configured mA value.

If setting *Value Unit* is in mA, settings *Value Min* and *Value Max* are not relevant.

6.1.5.1 Calibration

The calibration of the mA output channels and read-back channels is done at the factory.

6.1.5.2 Output channel supervision

Each output channel is continuously monitored for its health. If an output cable is damaged, broken or if the connections are open, the IRF LED on the module flashes a warning and WHMI shows “Ext HW fault”. As a main part of self-supervision, the module continuously reads back the value driven as an output. If this readback value deviates by 1% of range with respect to driven value, the IRF LED is steady and WHMI shows “Supervision fault”.

6.1.5.3 Deadband supervision

Deadband settings are used to select how sensitively AOM4 module operates the output based on the information received over GOOSE or Modbus communication.

The deadband functionality decides the percentage change in the output value that needs to be generated at the AOM4 output terminals. If the percentage change between the newly received value and the last driven value is greater than the set *Deadband Value* (in %) of the output range, then the newly received value drives the output. Otherwise, the last driven value is continued at the output terminals.

Deadband formula:

[ABS (new value – last output driven value) > (% of Deadband value × Output range)]

The output range is the difference between the parameters *Output Max value* and *Output Min value*.

Output range = ABS (Output Max – Output Min)

For example, if Output Min = 0, Output Max = 20, Deadband value = 1% and Last output value = 10 and if the new received output value is less than 9.8 or greater than 10.2, the new output value should be driven.

6.1.6 Operating parameter settings of SIM8F module

Table 30: Operating parameter settings of SIM8F module

Parameter name		Range	Unit	Step	Default	Description
Frequency		50 60	Hz	-	50 Hz	Rated system frequency
Nominal current		50…630	A	1	400	Nominal phase current[1)]
Nominal current Io		50…630	A	1	400	Nominal current – Io channel[1)]
Nominal voltage		500…48000	V	1	15000	Nominal phase-to-phase voltage
Current sensor type		Rogowski coil LP CT	-	-	Rogowski coil	Selection of current sensor type[1)]
Rated sensor current	Phase CT	50...500	A	1	80	Rated primary current of sensor – Phase CT[1)]
	Neutral CT	50...500	A	1	80	Rated primary current of sensor – Neutral CT[1)]
Secondary output voltage	Phase CT	100...300	mV	1	150	Rated secondary output voltage of sensor – Phase CT[1)]
	Neutral CT	100...300	mV	1	150	Rated secondary output voltage of sensor – Neutral CT[1)]
Io signal sel		Calculated Io Measured Io	-	-	Calculated Io	Selection used for Io signal
Phase Rotation		ABC ACB	-	-	ABC	Phase rotation order
Sensor Correction Factors						
Phase A	Current Amplitude	0.7000…1.3000	-	0.0001	1.0000	Amplitude correction factor for current sensor, phase A
	Current Phase	-3.0000… +3.0000	deg	0.00025	0.000	Phase correction factor for current sensor, phase A
	Voltage Amplitude	0.7000…1.3000	-	0.0001	1.0000	Amplitude correction factor for voltage sensor, phase A
	Voltage Phase	-3.0000… +3.0000	deg	0.00025	0.000	Phase correction factor for voltage sensor, phase A

Table continues on next page

Parameter name		Range	Unit	Step	Default	Description
Phase B	Current Amplitude	0.7000…1.3000	-	0.0001	1.0000	Amplitude correction factor for current sensor, phase B
	Current Phase	-3.0000… +3.0000	deg	0.00025	0.000	Phase correction factor for current sensor, phase B
	Voltage Amplitude	0.7000…1.3000	-	0.0001	1.0000	Amplitude correction factor for voltage sensor, phase B
	Voltage Phase	-3.0000… +3.0000	deg	0.00025	0.000	Phase correction factor for voltage sensor, phase B
Phase C	Current Amplitude	0.7000…1.3000	-	0.0001	1.0000	Amplitude correction factor for current sensor, phase C
	Current Phase	-3.0000… +3.0000	deg	0.00025	0.000	Phase correction factor for current sensor, phase C
	Voltage Amplitude	0.7000…1.3000	-	0.0001	1.0000	Amplitude correction factor for voltage sensor, phase C
	Voltage Phase	-3.0000… +3.0000	deg	0.00025	0.000	Phase correction factor for voltage sensor, phase C
Residual	Current Amplitude	0.7000…1.3000	-	0.0001	1.0000	Amplitude correction factor for current sensor, residual
	Current Phase	-3.0000… +3.0000	deg	0.00025	0.000	Phase correction factor for current sensor, residual
LED Reset Time Delay		1…1440	min	1	60	LEDs Reset delay time (incase no external signal received for resetting). This is applicable to THD/TDD, OC and EF fault indication LEDs.
Default Load Flow Direction		Forward, Reverse	-	-	Forward	Load flow direction selection. The load flow direction LED color for Forward selection is, Forward = Green, Reverse = Red and vice versa.
Table continues on next page						

Parameter name	Range	Unit	Step	Default	Description
THD & TDD LED colors	THD = Red, TDD = Green THD = Green, TDD = Red	-	-	THD = Green TDD = Red	THD & TDD LED indication
Protection LED Colors	Forward = Red, Reverse = Green Forward = Green, Reverse = Red	-	-	Forward = Green Reverse = Red	Over Current Direction LED indication Common setting for DOC and DEF
Fault Indication Reset Method	Self Reset Method, Definite Time, Voltage Presence, DT or Voltage Presence	-	-	Definite Time	Self Reset Method: Flashing protection indication LED is reset immediately once the fault is cleared. Definite Time: Flashing protection indication LED is reset after the definite time set by LED reset time delay. Voltage Presence: Flashing protection indication LED is reset after the presence of 3 ph voltage. DT or Voltage Presence: ORing of above two methods.
Update Interval for Metering Values	1...15	-	1	4	Update interval for metering values × 500 ms
New installation	-	-	-	-	Performs reset of energy counter and internal statistics information

1) Feature available from RIO600 Ver.1.8.3 and SIM8F Ver.1.3.3 onwards

From RIO600 Ver.1.8.3 and SIM8F Ver.1.3.3 onwards, current sensor parameters (primary current and secondary voltage) are user-configurable. Configure the parameters based on the sensor used with the SIM8F module.

From RIO600 Ver.1.8.3 and SIM8F Ver.1.3.3 onwards, configure phase current sensor and neutral current sensor individually. If current sensors with different CT ratios are used for phase and neutral channels, configure them accordingly.

For versions preceding RIO600 Ver.1.8.3 and SIM8F Ver.1.3.3, *Rated sensor current* set as 80 A refers to 150 mV at 50 Hz and 180 mV at 60 Hz when 80 A is injected. Similarly, *Rated sensor current* set as 250 A refers to 150 mV at 50 Hz and 180 mV at 60 Hz when 250 A is injected.

6.1.6.1 Functions available in SIM8F

Table 31: Functions available in SIM8F

Function	IEC 61850		IEC 60617	IEC-ANSI
	Edition 1	Edition 2		
Measurement functions				
Three-phase current measurement	CMMXU	CMMXU	3I	3I
Three-phase voltage measurement	VMMXU	VMMXU	3U	3U
Residual current measurement	RESCMMXU	RESCMMXU	Io	Io
Residual voltage measurement	RESVMMXU	RESVMMXU	Uo	Uo
Three-phase power and energy measurement	PEMMXU	PEMMXU	P	P
Three-phase power direction	PWRRDIR	PWRRDIR	-	-
Energy monitoring	EMMTR	EMMTR	E	E
Current, voltage and power average and peak measurement	CMSTA	CAVMMXU CMAMMXU RCAVMMXU	-	-
	VMSTA	VAVMMXU VMAMMXU		
	PEMSTA	PEAVMMXU PEMAMMXU		
Power quality measurement functions (harmonics)				
Current total demand distortion monitoring	CMHAI	CMHAI	PQM3I	PQM3I
Voltage total demand distortion monitoring	VMHAI	VMHAI	PQM3U	PQM3V
Detection and indication functions				
Three-phase non-directional overcurrent fault detection	PHPTOC	PHPTOC	3I>	51P
Three-phase directional overcurrent fault detection	DPHPTOC	DPHPTOC	3I>->	67P
Non-directional earth-fault fault detection	EFPTOC	EFPTOC	I0>	51N
Table continues on next page				

Function	IEC 61850		IEC 60617	IEC-ANSI
	Edition 1	Edition 2		
Directional earth-fault fault detection	DEFPTOC	DEFPTOC	I0>->	67N
Multifrequency admittance-based earth-fault indication	MFAPSDE	MFAPSDE	I0>->Y	67YN
Voltage presence indication	PHSVPR	PHSVPR	PHSVPR	PHSVPR
Negative-sequence overcurrent protection	NSPTOC	NSPTOC	I2>	46
Three-phase inrush detector	INRPHAR	INRPHAR	3I2f>	68
Fuse failure protection	SEQSPVC	SEQSPVC	FUSEF	60

6.1.6.2 Measurement functions

Three-phase current measurement CMMXU

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Three-phase current measurement	CMMXU	3I	3I

Function block

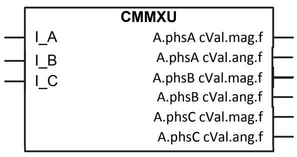

Figure 39: Function block

Signals

Table 32: CMMXU Input signals

Name	Type	Default	Description
I_A	SIGNAL	-	Phase A current
I_B	SIGNAL	-	Phase B current
I_C	SIGNAL	-	Phase C current

Table 33: CMMXU Output signals

Name	Type	Description
A.phsA cVal.mag.f	REAL	Current amplitude, for phase A
A.phsA cVal.ang.f	REAL	Current phase angle, for phase A
A.phsB cVal.mag.f	REAL	Current amplitude, for phase B
A.phsB cVal.ang.f	REAL	Current phase angle, for phase B
A.phsC cVal.mag.f	REAL	Current amplitude, for phase C
A.phsC cVal.ang.f	REAL	Current phase angle, for phase C

Table 34: CMMXU Technical data

Characteristic	Value
Operation accuracy	At frequency f = f_n
	±5% or ±1 A in the range of 1...80 A for Rogowski coil and LPCT ±1% in the range of 80...3000 A for Rogowski coil ±1% in the range of 80...6000 A for LPCT
Suppression of harmonics	RMS: No suppression

Three-phase voltage measurement VMMXU

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Three-phase voltage measurement	VMMXU	3U	3U

Function block

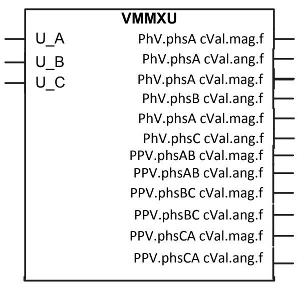

Figure 40: Function block

Signals

Table 35: VMMXU Input signals

Name	Type	Default	Description
U_A	SIGNAL	-	Phase to earth voltage A
U_B	SIGNAL	-	Phase to earth voltage B
U_C	SIGNAL	-	Phase to earth voltage C

Table 36: VMMXU Output signals

Name	Type	Description
PhV.phsA cVal.mag.f	REAL	Phase to ground voltage amplitude, for phase A
PhV.phsA cVal.ang.f	REAL	Voltage phase angle, for Phase A
PhV.phsB cVal.mag.f	REAL	Phase to ground voltage amplitude, for phase B
PhV.phsB cVal.ang.f	REAL	Voltage phase angle, for Phase B
PhV.phsC cVal.mag.f	REAL	Phase to ground voltage amplitude, for phase C
PhV.phsC cVal.ang.f	REAL	Voltage phase angle, for Phase C
PPV.phsAB cVal.mag.f	REAL	Phase to ground voltage amplitude, for phase A and B
PPV.phsAB cVal.ang.f	REAL	Voltage phase angle, for Phase A and B
PPV.phsBC cVal.mag.f	REAL	Phase to ground voltage amplitude, for phase B and C
PPV.phsBC cVal.ang.f	REAL	Voltage phase angle, for Phase B and C
PPV.phsCA cVal.mag.f	REAL	Phase to ground voltage amplitude, for phase C and A
PPV.phsCA cVal.ang.f	REAL	Voltage phase angle, for Phase C and A
PhRotSt.stVal	STATUS	Phase Rotation Status value[1)] 0 = Invalid 1 = Positive 2 = Negative

1) Feature available from RIO600 Ver.1.8.2 onwards

From LECM Ver.1.8.2 and SIM8F Ver.1.3.2 onwards, the Phase Rotation Status (PhRotSt) signal has been introduced. The signal can be monitored via GOOSE and Modbus.

Signal PhRotSt is of Enum type with values 0 (Invalid), 1 (Positive) and 2 (Negative). The status is updated based on the Positive and Negative Sequence components of phase voltages.
The threshold limit for signal PhRotSt is 60 % of the nominal Ph-earth voltage.

Table 37: VMMXU Technical data

Characteristic	Value
Operation accuracy	At frequency f = f_n
	±5% in the range of 480 V...9.6 kV ±0.5% in the range of 9.6...28.8 kV ±1% in the range of 28.8...48 kV
Suppression of harmonics	RMS: No suppression

Residual current measurement RESCMMXU

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Residual current measurement	RESCMMXU	Io	Io

Function block

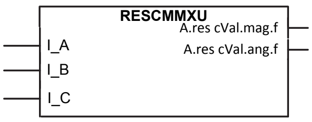

Figure 41: Function block

Signals

Table 38: RESCMMXU Input signals

Name	Type	Default	Description
I_A	SIGNAL	-	Phase A current
I_B	SIGNAL	-	Phase B current
I_C	SIGNAL	-	Phase C current

Table 39: RESCMMXU Output signals

Name	Type	Description
A.res cVal.mag.f	REAL	Residual current RMS, magnitude of reported value
A.res cVal.ang.f	REAL	Residual current angle

Table 40: RESCMMXU Technical data

Characteristic	Value
Operation accuracy	At frequency f = f_n 1. When *Io signal sel*[1)] = "Calculated Io", ±5.0% (when all three phase currents are in the range of 50...630 A) 2. When *Io signal sel*[1)] = "Measured Io" ±5% or ±1 A in the range of 1...50 A ±1% in the range of 50...630 A
Suppression of harmonics	RMS: No suppression

1) See Chapter Operating parameter settings of SIM8F module

Residual voltage measurement RESVMMXU

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Residual voltage measurement	RESVMMXU	Uo	Uo

Function block

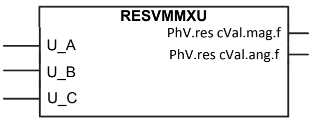

Figure 42: Function block

Signals

Table 41: RESVMMXU Input signals

Name	Type	Default	Description
U_A	SIGNAL	-	Phase to earth voltage A
U_B	SIGNAL	-	Phase to earth voltage B
U_C	SIGNAL	-	Phase to earth voltage C

Table 42: RESVMMXU Output signals

Name	Type	Description
PhV.res cVal.mag.f	REAL	Calculated magnitude of residual voltage
PhV.res cVal.ang.f	REAL	Calculated residual voltage angle

Table 43: RESVMMXU Technical data

Characteristic	Value
Operation accuracy	At frequency f = f_n ±5.0% (when all three voltages are in the range of 9.6...14.4 kV or 19.2...28.8 kV)
Suppression of harmonics	RMS: No suppression

Three-phase power and energy measurement PEMMXU

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Three-phase power and energy measurement	PEMMXU	P	P

Function block

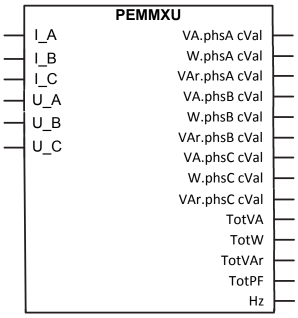

Figure 43: Function block

Power and energy calculation

The three-phase power is calculated from the phase-to-earth voltages and currents. The power measurement function is capable of calculating a complex power based on the fundamental frequency component (DFT).

Once the complex apparent power is calculated, P, Q, S and pf are calculated using equations.

$$P = Re(\vec{S})$$

(Equation 1)

$$Q = Im(\vec{S})$$

(Equation 2)

$$S = \left|\vec{S}\right| = \sqrt{P^2 + Q^2}$$

(Equation 3)

The calculated power values are presented in units of W/VA/VAr, kW/kVA/kVAr or MW/MVA/MVAr.

$$\cos\phi = \frac{P}{S}$$

(Equation 4)

From LECM Ver.1.8.2 and SIM8F Ver.1.3.2 onwards, the scaling parameter *Power Unit Mult* for calculated power values can be selected in Parameter Setting as "None", "Kilo" or "Mega". GOOSE and Modbus support power value scaling in the W/VA/VAr, kW/kVA/kVAr and MW/MVA/MVAr ranges whereas the WHMI supports power value scaling in the kW/kVA/kVAr and MW/MVA/MVAr ranges.

Up to LECM Ver.1.7 (latest patch) and SIM8F Ver.1.2.2, GOOSE and Modbus support power values given in the W/VA/VAr range whereas the WHMI supports power value scaling in the kW/kVA/kVAr range.

From RIO600 Ver.1.8.2 onwards, per phase power factor values are available in GOOSE and Modbus.

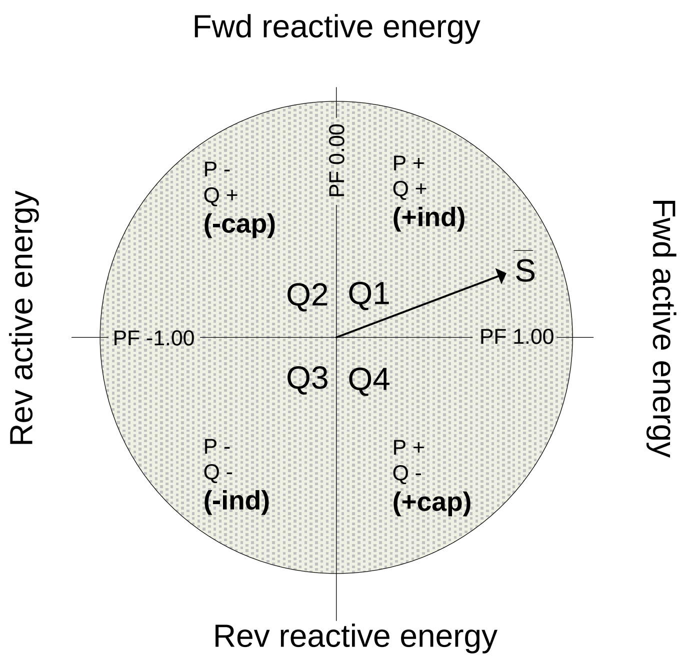

Figure 44: Power quadrants

Table 44: Complex Power quadrants

Quadrant	Current	P	Q	PF	Power
Q1	Lagging	+	+	0…+1.00	+ind
Q2	Lagging	-	+	0…-1.00	-cap
Q3	Leading	-	-	0…-1.00	-ind
Q4	Leading	+	-	0…+1.00	+cap

Signals

Table 45: PEMMXU Input signals

Name	Type	Default	Description
I_A	SIGNAL	-	Phase A current
I_B	SIGNAL	-	Phase B current
I_C	SIGNAL	-	Phase C current
U_A	SIGNAL	-	Phase to earth voltage A
U_B	SIGNAL	-	Phase to earth voltage B
U_C	SIGNAL	-	Phase to earth voltage C

Table 46: PEMMXU Output signals

Name	Type	Description
VA.phsA cVal	REAL	Apparent power Phase A
W.phsA cVal	REAL	Active power Phase A
VAr.phsA cVal	REAL	Reactive power Phase A
VA.phsB cVal	REAL	Apparent power Phase B
W.phsB cVal	REAL	Active power Phase B
VAr.phsB cVal	REAL	Reactive power Phase B
VA.phsC cVal	REAL	Apparent power Phase C
W.phsC cVal	REAL	Active power Phase C
VAr.phsC cVal	REAL	Reactive power Phase C
TotVA	REAL	Total Apparent power
TotW	REAL	Total Active power
TotVAr	REAL	Total Reactive power
TotPF	REAL	Total Power Factor
Hz	REAL	System frequency
PF.phsA.cVal	REAL	Power Factor Phase A[1)]
PF.phsB.cVal	REAL	Power Factor Phase B[1)]
PF.phsC.cVal	REAL	Power Factor Phase C[1)]

1) Feature available from RIO600 Ver.1.8.2 onwards

Table 47: PEMMXU Technical data

Characteristic	Value
Operation accuracy	At frequency $f = f_n$ All three voltages are in the range of 9.6...14.4 kV or 19.2...28.8 kV. All three currents are in the range of 80...630 A. Active power and energy are in the range |PF| > 0.71. Reactive power and energy are in the range |PF| < 0.71.
	±1.0% for active power P (±0.5% at +25ºC) ±3.0% for reactive Q and apparent power S (±1% at +25ºC) ±0.03 for power factor
Suppression of harmonics	RMS: No suppression

Three-phase power direction PWRRDIR

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Three-phase power direction	PWRRDIR	-	-

Function block

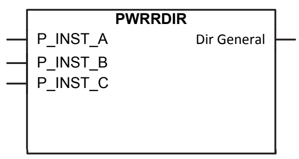

Figure 45: Function block

Signals

Table 48: PWRRDIR Input signals

Name	Type	Default	Description
P_INST_A	SIGNAL	-	Active power Phase A
P_INST_B	SIGNAL	-	Active power Phase B
P_INST_C	SIGNAL	-	Active power Phase C

Table 49: PWRRDIR Output signals

Name	Type	Description
Dir General	BOOLEAN	Direction of load flow (forward or reverse)

Energy monitoring EMMTR

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Energy monitoring	EMMTR	E	E

Function block

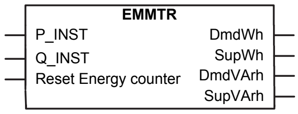

Figure 46: Function block

Functionality

The energy monitoring function EMMTR is used to calculate the active and reactive energy from the respective power inputs P and Q.

Operation principle

The operation of EMMTR can be described using a module diagram.

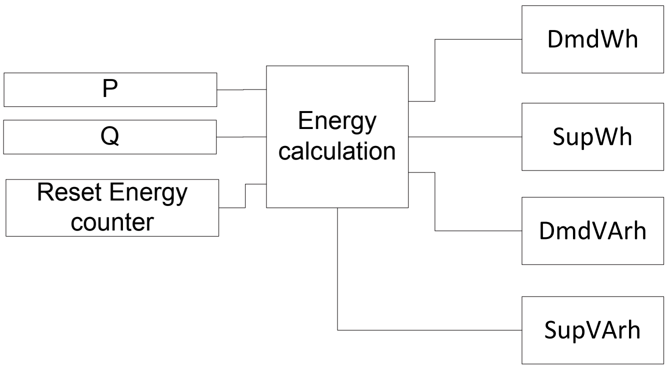

Figure 47: Functional module diagram

Energy Calculation

Based on the measured powers, the linear average of the active and reactive energies over a preset time interval of 500 ms is calculated.

The accumulated forward and reverse active energy value is available at `DmdWh` and `SupWh` and the accumulated forward and reverse reactive energy value is available at `DmdVArh` and `SupVArh`, respectively.

The binary signal `RESET ENERGY COUNTER` from external IED is used to reset the accumulation.

From RIO600 Ver.1.8 onwards, the scaling parameter *Energy Unit Mult* for calculated energy values can be selected in Parameter Setting as "Kilo" or "Mega". GOOSE, Modbus and the WHMI support energy values in the kWh/kVArh or MWh/MVArh ranges.

Signals

Table 50: EMMTR Input signals

Name	Type	Default	Description
P_INST	REAL	-	Measured active power
Q_INST	REAL	-	Measured reactive power
RESET ENERGY COUNTER	BOOLEAN	-	Reset of accumulated energy reading

Table 51: EMMTR Output signals

Name	Type	Description
DmdWh	REAL	Accumulated forward active energy value in kWh
SupWh	REAL	Accumulated reverse active energy value in kWh
DmdVArh	REAL	Accumulated forward reactive energy value in kVArh
SupVArh	REAL	Accumulated reverse reactive energy value in kVArh

Table 52: EMMTR Technical data

<table>
<tr><th>Characteristic</th><th>Value</th></tr>
<tr><td rowspan="2">Operation accuracy</td><td>At frequency f = fn
All three voltages are in the range of 9.6...14.4 kV or 19.2...28.8 kV.
All three currents are in the range of 80...630 A.
Active power and energy are in the range |PF| > 0.71.
Reactive power and energy are in the range |PF| < 0.71.</td></tr>
<tr><td>±3.0% for energy</td></tr>
<tr><td>Suppression of harmonics</td><td>RMS: No suppression</td></tr>
</table>

Current, voltage and power average and peak measurement CMSTA, VMSTA, PEMSTA

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Current, voltage and power average and peak measurement	CMSTA, VMSTA, PEMSTA	-	-

Function block

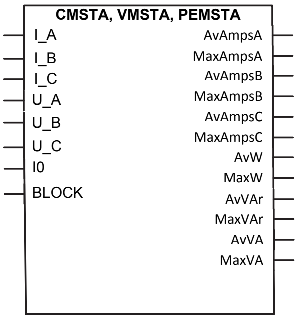

Figure 48: Function block

Functionality

The current, voltage and power average and peak measurement functions CMSTA, VMSTA and PEMSTA are used to calculate the average and peak value of current, voltage and power. The functions can be enabled and disabled with the *Operation* setting.

The corresponding parameter values are "On" and "Off". The average interval can be set to "3","10", "15", "60", "120", or "1440" minutes and the peak interval to "1 day", "1 week", "1 month", or "1 year".

Signals

Table 53: CMSTA, VMSTA & PEMSTA Input signals

Name	Type	Default	Description
I_A	REAL	-	Phase A current
I_B	REAL	-	Phase B current
I_C	REAL	-	Phase C current
U_A	REAL	-	Phase to earth voltage A
U_B	REAL	-	Phase to earth voltage B

Table continues on next page

Name	Type	Default	Description
U_C	REAL	-	Phase to earth voltage C
Io	REAL	-	Residual current
BLOCK	-	-	Block through settings only

Table 54: CMSTA, VMSTA & PEMSTA Output signals

Name	Type	Description
AvAmpsA	REAL	Phase A average current
MaxAmpsA	REAL	Phase A peak current
AvVoltsA	REAL	Phase to earth voltage A - average value
MaxVoltsA	REAL	Phase to earth voltage A - peak value
AvAmpsB	REAL	Phase B average current
MaxAmpsB	REAL	Phase B peak current
AvVoltsB	REAL	Phase to earth voltage B - average value
MaxVoltsB	REAL	Phase to earth voltage B - peak value
AvAmpsC	REAL	Phase C average current
MaxAmpsC	REAL	Phase C peak current
AvVoltsC	REAL	Phase to earth voltage C - average value
MaxVoltsC	REAL	Phase to earth voltage C - peak value
AvAmpsI0	REAL	Average Residual current Applicable if "Io signal sel" is "Measured Io"
MaxAmpsI0	REAL	Peak Residual current - Applicable if "Io signal sel" is "Measured Io"
AvW	REAL	Average total Active power
MaxW	REAL	Peak total Active power
AvVAr	REAL	Average total reactive power
MaxVAr	REAL	Peak total reactive power
AvVA	REAL	Average total apparent power
MaxVA	REAL	Peak total apparent power

Settings

Table 55: CMSTA, VMSTA, PEMSTA Settings

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Off/On
Avg Cal Time Interval	3 min 10 min 15 min 1 hour 2 hours 24 hours	-	-	1 hour	Time internal over which average current, voltage and power are calculated
Peak Cal Time Interval	1 day 1 week 1 month 1 year	-	-	1 day	Time internal over which peak current, voltage and power are calculated

The measured quantities provided by the function blocks are updated every 500 ms.

6.1.6.3 Power quality measurement functions (harmonics)

Current total demand distortion monitoring CMHAI

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Current total demand distortion monitoring	CMHAI	PQM3I	PQM3I

Function block

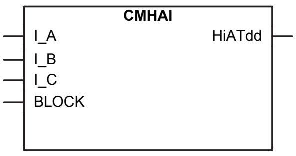

Figure 49: Function block

Functionality

The distortion monitoring function CMHAI is used for monitoring the current total demand distortion (TDD). The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off". The operation of the current distortion monitoring function can be described with a module diagram. All the modules in the diagram are explained in the next sections.

Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of CMHAI can be described with a module diagram. All the modules in the diagram are explained in the next sections.

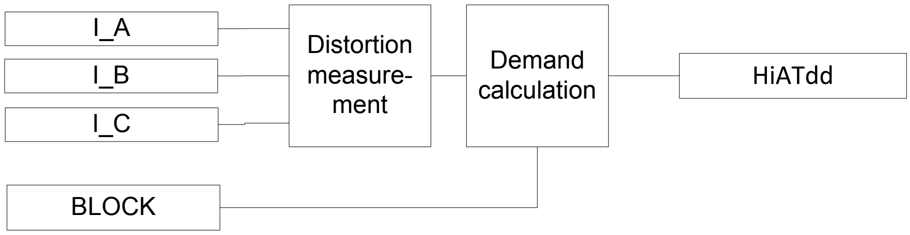

Figure 50: Functional module diagram

Distortion measurement

The distortion measurement module measures harmonics up to the 8^{th} harmonic. The total demand distortion (TDD) is calculated from the measured harmonic components with the formula.

$$TDD = \frac{\sqrt{\sum_{k=2}^{L} I_k^2}}{I_N}$$

(Equation 5)

I_N Nominal current amplitude

The nominal current amplitude is available from the *Nominal Current* setting under the SIM8F operation parameter.

Demand calculation

The demand value for TDD is calculated separately for each phase. If any of the calculated total demand distortion values is above the set *TDD alarm limit* value, the `HiATdd` output is activated.

Application

The power quality standards are defined through the characteristics of the supply voltage. The key characteristics describing power quality are transients, short-duration and long-duration voltage variations, unbalance and waveform distortions. Power quality is a customer-driven issue and any power problem concerning voltage or current that results in a failure or misoperation of customer equipment is a power quality problem.

Harmonic distortion in a power system is caused by nonlinear devices. Electronic power converter loads constitute the most important class of nonlinear loads in a power system. The switch mode power supplies in a number of single-phase electronic equipment, such as personal computers, printers and copiers, have very high third-harmonic content in the current. Three-phase electronic power converters, that is, dc/ac drives, do not generate third-harmonic currents but they can be significant sources of harmonics.

Power quality monitoring is an essential service that utilities can provide for their industrial and key customers. Not only can a monitoring system provide information about system disturbances and their possible causes, it can also detect problem conditions throughout the system before they cause customer complaints, equipment malfunctions and even equipment damage or failure. Power quality problems are not limited to the utility side of the system. In fact, the majority of power quality problems are localized within customer facilities. Thus, power quality monitoring is not only an effective customer service strategy but also a way to protect a utility's reputation for quality power and service.

CMHAI provides a method for monitoring the power quality by means of the current waveform distortion.

Signals

Table 56: CMHAI Input signals

Name	Type	Default	Description
I_A	SIGNAL	-	Phase A current
I_B	SIGNAL	-	Phase B current
I_C	SIGNAL	-	Phase C current
BLOCK		-	Block through settings only

Table 57: CMHAI Output signals

Name	Type	Description
HiATdd	BOOLEAN	Alarm signal for TDD

Settings

Table 58: CMHAI Settings

Name	Values (Range)	Unit	Step	Default	Description
Operation	On Off	-	-	On	Operation Off/On
TDD Alarm Limit	5.0…100.0	%	0.1	10%	Limit of TDD
Measuring Mode	Worst case Phase A Phase B Phase C	-	-	Worst case	Specifies the monitored phase

Voltage total demand distortion monitoring VMHAI

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Voltage total demand distortion monitoring	VMHAI	PQM3U	PQM3V

Function block

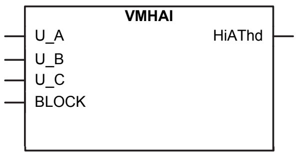

Figure 51: Function block

Functionality

The distortion monitoring function VMHAI is used for monitoring the voltage total harmonic distortion THD.

Operation principle

The function can be enabled and disabled with the *Operation* setting. The corresponding parameter values are "On" and "Off".

The operation of VMHAI can be described with a module diagram. All the modules in the diagram are explained in the next sections.

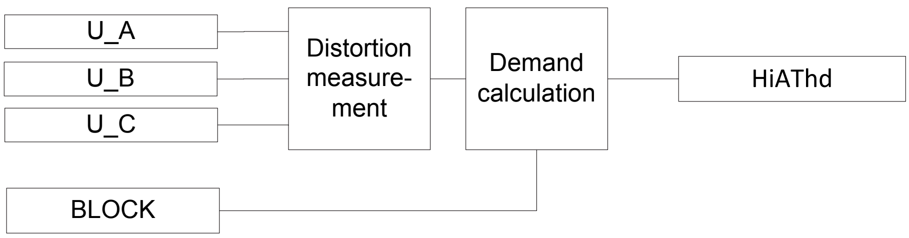

Figure 52: Functional module diagram

Distortion measurement

The distortion measurement module measures harmonics up to the 8^{th} harmonic. The total harmonic distortion (THD) is calculated from the measured harmonic components with the formula.

$$THD = \frac{\sqrt{\sum_{k=2}^{N} Uk^2}}{U1}$$

(Equation 6)

Uk = k^{th} harmonic component

U1 = the voltage fundamental component amplitude

Demand calculation

The demand value for THD is calculated separately for each phase. If any of the calculated total demand distortion values is above the *THD alarm limit* setting, the `HiAThd` output is activated.

Application

VMHAI provides a method for monitoring the power quality by means of the voltage waveform distortion.

Signals

Table 59: VMHAI Input signals

Name	Type	Default	Description
U_A	SIGNAL	-	Phase to earth voltage A
U_B	SIGNAL	-	Phase to earth voltage B
U_C	SIGNAL	-	Phase to earth voltage C
BLOCK		-	Block through settings only

Table 60: VMHAI Output signals

Name	Type	Description
HiAThd	BOOLEAN	Alarm signal for THD

Settings

Table 61: VMHAI Settings

Name	Values (Range)	Unit	Step	Default	Description
Operation	On Off	-	-	On	Operation Off/On
THD Alarm Limit	5.0…100.0	%	0.1	10%	Limit of THD
Measuring Mode	Worst case Phase A Phase B Phase C	-	-	Worst case	Specifies the monitored phase

6.1.6.4 Three-phase current fault detection

Three-phase non-directional overcurrent fault detection PHPTOC

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Three-phase non-directional overcurrent fault detection	PHPTOC	3I>	51P

Functionality

The three-phase non-directional overcurrent fault detection function PHPTOC is used as one-phase, two-phase or three-phase non-directional overcurrent and short circuit fault detection. The function starts when the current exceeds the set limit. PHPTOC operates with definite time characteristic, that is, the function operates after a predefined operate time and resets immediately when the fault current disappears.

Operation principle

The *Operation* setting is used to enable or disable the function. The corresponding parameter values are "On" and "Off".

The operation of PHPTOC can be described by using a module diagram. All modules in the diagram are explained in the next sections.

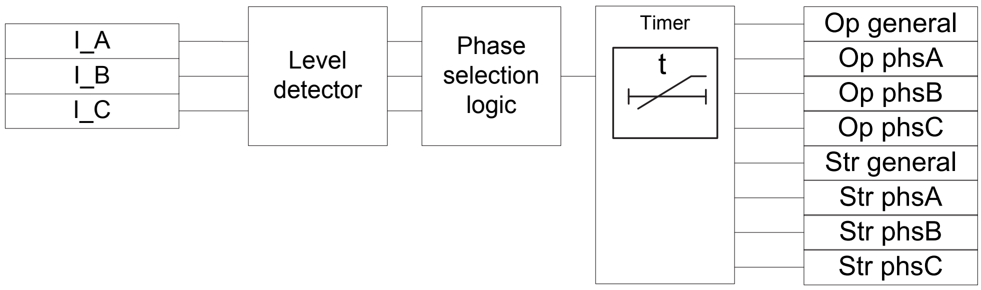

Figure 53: Functional module diagram

Level detector

The fundamental component of phase currents is compared phase-wise with the *Start value* setting. If the measured value exceeds the *Start value* setting, the Level detector reports the exceeding value to the phase selection logic.

The *Absolute hysteresis* setting can be used for preventing unnecessary oscillations in the `START` and `OPERATE` output signals, if the input current is slightly above or below the *Start value* setting. After leaving the hysteresis area, the start condition has to be met again and if it is not sufficient, the signal returns to the hysteresis area.

Phase selection logic

If the fault criteria are fulfilled in the Level detector, the phase selection logic detects the phase or phases in which the measured current exceeds the setting. If the phase information matches the *No. of start phases* setting, the phase selection logic activates the timer module.

Timer

Once the Timer is activated, it activates the `STR GENERAL` output. The `STR PHSA`, `STR PHSB` and `STR PHSC` outputs indicate which phases are started. The time characteristic is according to the Definite time. When the operation timer has reached the value set by *Operate delay time*, the `OP GENERAL` output signal is activated. The `OP PHSA`, `OP PHSB` and `OP PHSC` outputs indicate which phases are operated. If the fault disappears before the module operates, the reset is instantaneous and `STR GENERAL` is deactivated.

The `OP GENERAL` output is available at LED 5 of the SIM8F module.

The phase segregated as well as general start and operate outputs `STR GENERAL`, `STR PHSA`, `STR PHSB`, `STR PHSC`, `OP GENERAL`, `OP PHSA`, `OP PHSB` and `OP PHSC` are available over communication.

Signals

Table 62: PHPTOC Output signals

Name	Type	Description
Op general	Boolean	General operate signal
Op phsA	Boolean	Operate signal for phase A
Op phsB	Boolean	Operate signal for phase B
Op phsC	Boolean	Operate signal for phase C
Str general	Boolean	General start signal
Str phsA	Boolean	Start signal for phase A
Str phsB	Boolean	Start signal for phase B
Str phsC	Boolean	Start signal for phase C

Settings

Table 63: PHPTOC Settings

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Off/On
No. of Start Phases	1 out of 3 2 out of 3 3 out of 3	-	-	1 out of 3	Number of phases required for operate activation
Start Value	50…2000	A	10	480	Start value for overcurrent fault detection
Operate Delay Time	40…60000	ms	10	40	Operate delay time
Absolute Hysteresis	0.0…100.0	A	0.1	3.0	Absolute hysteresis for current

Table 64: PHPTOC Technical data

Charateristic	Value
Operation accuracy	Depending on the frequency of the current measured: f = f_n ±1.5% of the set value
Operate time accuracy (DMT)	±1.0% of the set value or ±20 ms

Three-phase directional overcurrent fault detection DPHPTOC

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Three-phase directional overcurrent fault detection	DPHPTOC	3I>->	67P

Functionality

The three-phase directional overcurrent fault detection function DPHPTOC is used as one-phase, two-phase or three-phase directional overcurrent and short circuit fault detection. The function starts when the current exceeds the set limit and directional criterion is fulfilled. DPHPTOC operates with definite time characteristic, that is, the function operates after a predefined operate time and resets immediately when the fault current disappears.

Operation principle

The *Operation* setting is used to enable or disable the function. The corresponding parameter values are "On" and "Off".

The operation of DPHPTOC can be described by using a module diagram. All modules in the diagram are explained in the next sections.

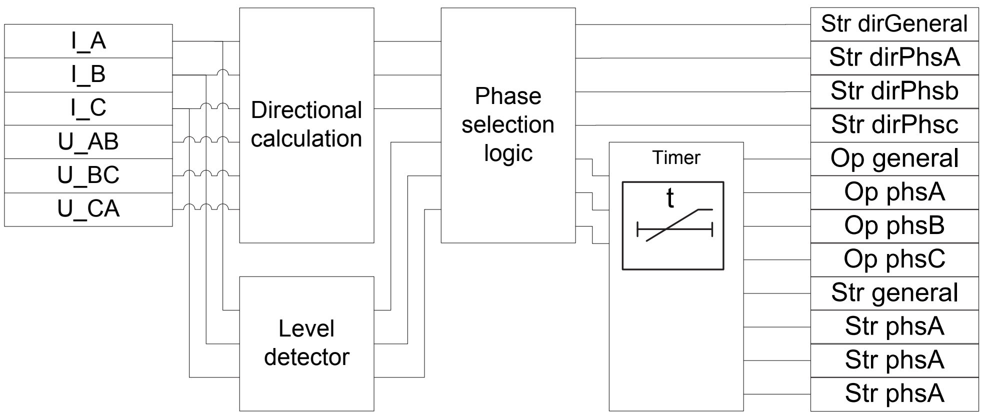

Figure 54: Functional module diagram

Directional calculation

The directional calculation module compares the current phasor with the polarizing phasor. Cross polarizing voltage quantities are used as polarizing phasors. The directional operation can be selected with the *Directional mode* setting. "Forward" or "Reverse" or “Non directional” operation can be selected.

The *Characteristic angle* setting is used to turn the directional characteristic. The value of *Characteristic angle* should be selected in such a way that all faults in the operating direction are seen in the operating zone and all faults in the opposite direction are seen in the non-operating zone. The value of *Characteristic angle* depends on the network configuration.

Reliable operation requires both the operating and polarizing quantities to be above certain minimum amplitude levels. The minimum amplitude level for the operating quantity (current) is fixed to 50 A. The minimum amplitude level for the polarizing quantity (voltage) is fixed to 500 V. If the amplitude level of the operating quantity or polarizing quantity is below minimum operate voltage and current, the direction information of the corresponding phase is set to "Unknown".

The polarizing quantity validity remains valid even if the amplitude of the polarizing quantity falls below the minimum level of 500 V. In this case, the directional information is provided by a special memory function for a defined time of 100 ms.

DPHPTOC is provided with a memory function to secure a reliable and correct directional IED operation in case of a close short circuit or an earth-fault characterized by a low voltage. At sudden loss of the polarization quantity, the angle difference is calculated on the basis of a fictive voltage. The fictive voltage is calculated using the polarizing quantity measured before the fault occurred.

When the voltage of one or more phases falls below minimum operate voltage of 500 V at a close fault, the corresponding phase-related fictive voltage is used to determine the phase angle. The measured voltage is applied again when the voltage is above 500 V. The fictive voltage is also discarded if the measured voltage stays below *Min operate voltage* of 500 V longer than the *Voltage Mem time* of 100 ms or if the fault current disappears while the fictive voltage is in use. When the voltage is below *Min operate voltage* of 500 V and the fictive voltage is unusable, the fault direction cannot be determined.

The fictive voltage cannot be used for different reasons.

- The fictive voltage is discarded after *Voltage Mem time* of 100 ms
- The phase angle cannot be reliably measured before the fault situation

Level detector

The fundamental component of phase currents is compared phase-wise with the *Start value* setting. If the measured value exceeds the *Start value* setting, the Level detector reports the exceeding value to the phase selection logic.

The *Abs Hyst Oper Qty* and *Abs Hyst Pol Qty* setting can be used for preventing unnecessary oscillations in `START` and `OPERATE` output if the operating and/or polarizing quantity is slightly above or below the *Start value* setting. After leaving the hysteresis area, the start condition has to be met again and if it is not sufficient, the signal returns to the hysteresis area.

Phase selection logic

If the fault criteria is fulfilled in the Level detector and the directional calculation, the phase selection logic detects the phase or phases in which the measured current exceeds the setting. If the phase information matches the *No. of start phase* setting, the phase selection logic activates the timer module.

The phase selection logic also provides the information about the phase specific fault directions. The `STR DIRPHSA`, `STR DIRPHSB` and `STR DIRPHSC` outputs indicates the direction of the fault in phase A, B and C respectively. The general fault direction information is provided by the `STR DIRGENERAL` output. The information is available over GOOSE communication.

Timer

Once the Timer is activated, it activates the `START` output. The `STR PHSA`, `STR PHSB` and `STR PHSC` outputs indicate which phases are started. The time characteristic is according to the definite time. When the operation timer has reached the value set by *Operate delay time*, the `OP GENERAL` output is activated. The `OP PHSA`, `OP PHSB` and `OP PHSC` outputs indicate which phases are operated. If the fault disappears before the module operates, the reset is instantaneous and `STR GENERAL` output is deactivated.

When *Directional mode* is set to “Non-directional”, outputs `OpFwd` and `OpRev` are activated when a fault is detected in the “Forward” or “Reverse” direction respectively. However, these outputs are also available when *Directional mode* is set to “Forward” or “Reverse”.

When *Directional mode* is set to “Non-directional” and PHPTOC operates in unknown direction, none of the LEDs show fault inditation.

The `OP GENERAL` output is available at LED 6 of SIM8F module.

The phase segregated as well as general start and operate outputs `STR GENERAL`, `STR PHSA`, `STR PHSB`, `STR PHSC`, `OP GENERAL`, `OP PHSA`, `OP PHSB`, `OP PHSB`, `OpFwd` and `OpRev` are available over communication.

Directional overcurrent characteristics

The forward and reverse sectors are defined separately. The forward operation area is limited with the *Min forward angle* and *Max forward angle* settings. The reverse operation area is limited with the *Min reverse angle* and *Max reverse angle* settings.

The sector limits are always defined as positive degree values.

In the forward operation area, the *Max forward angle* setting defines the counterclockwise sector and the *Min forward angle* setting defines the corresponding clockwise sector, measured from the *Characteristic angle* setting.

In the backward operation area, the *Max reverse angle* setting defines the counterclockwise sector and the *Min reverse angle* setting defines the corresponding clockwise sector, measured from the *Characteristic angle* setting set to 180°.

Relay characteristic angle (RCA) is set to positive if the operating current lags the polarizing quantity and negative if the operating current leads the polarizing quantity.

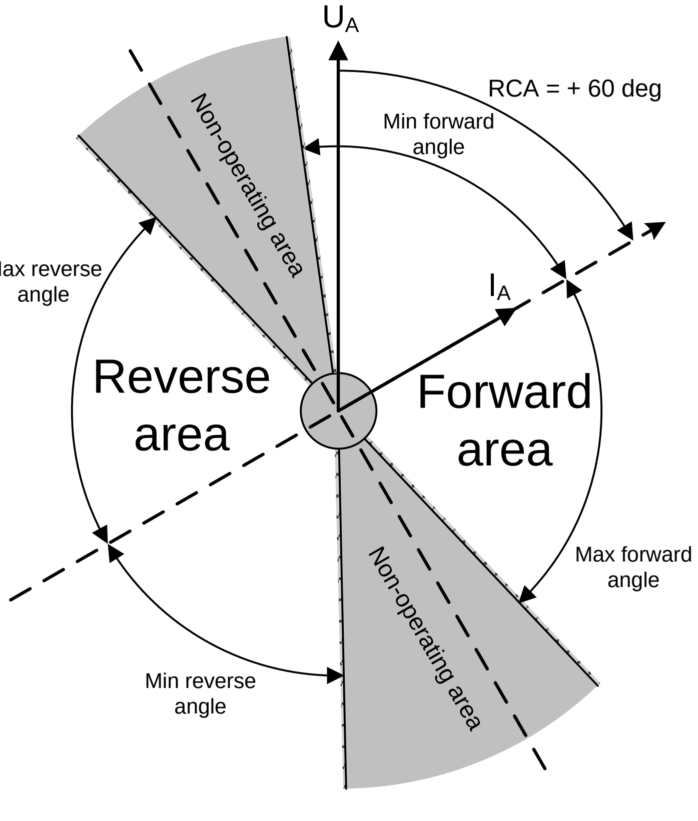

Figure 55: Configurable operating sectors

Table 65 and Table 66 describe conditions under which per phase fault direction and combined fault directions values are calculated.

Table 65: Per phase fault direction indication

Criterion for per phase fault direction information	Value for fault direction FLT_A, FLT_B, FLT_C
Angle between the polarizing and operating quantity is not in any of the defined sectors	0 = unknown
Angle between the polarizing and operating quantity is in the forward sector	1 = forward
Angle between the polarizing and operating quantity is in the reverse sector	2 = backward
Angle between the polarizing and operating quantity is in both the forward and the reverse sectors, that is, the sectors are overlapping	3 = both

Table 66: Phase combined fault direction value

Criterion for combined fault direction information	Value for fault direction FAULT_DIR
The fault direction information for all phases is unknown	0 = unknown
The fault direction information for at least one phase is forward, no phase in reverse	1 = forward
The fault direction information for at least one phase is reverse, no phase in forward	2 = backward
The fault direction information for some phase is forward and for some phase is reverse	3 = both

Cross-polarizing as polarizing quantity

When cross polarizing is used as a polarizing method, the directional information is calculated with formulas defined in Table 67.

Table 67: Equations for calculating angle difference for cross polarizing method

Faulted phases	Used fault current	Used polarizing voltage	Angle difference
A	I_A	U_{BC}	$\phi(U_{BC}) - \phi(I_A) - \phi_{RCA} + 90°$
B	I_B	U_{CA}	$\phi(U_{CA}) - \phi(I_B) - \phi_{RCA} + 90°$
C	I_C	U_{AB}	$\phi(U_{AB}) - \phi(I_C) - \phi_{RCA} + 90°$

Table continues on next page

Faulted phases	Used fault current	Used polarizing voltage	Angle difference
A - B	$\overline{I_A} - \overline{I_B}$	$\overline{U_{BC}} - \overline{U_{CA}}$	$\phi(\overline{U_{BC}} - \overline{U_{CA}}) - \phi(\overline{I_A} - \overline{I_B}) - \phi_{RCA} + 90°$
B - C	$\overline{I_B} - \overline{I_C}$	$\overline{U_{CA}} - \overline{U_{AB}}$	$\phi(\overline{U_{CA}} - \overline{U_{AB}}) - \phi(\overline{I_B} - \overline{I_C}) - \phi_{RCA} + 90°$
C - A	$\overline{I_C} - \overline{I_A}$	$\overline{U_{AB}} - \overline{U_{BC}}$	$\phi(\overline{U_{AB}} - \overline{U_{BC}}) - \phi(\overline{I_C} - \overline{I_A}) - \phi_{RCA} + 90°$

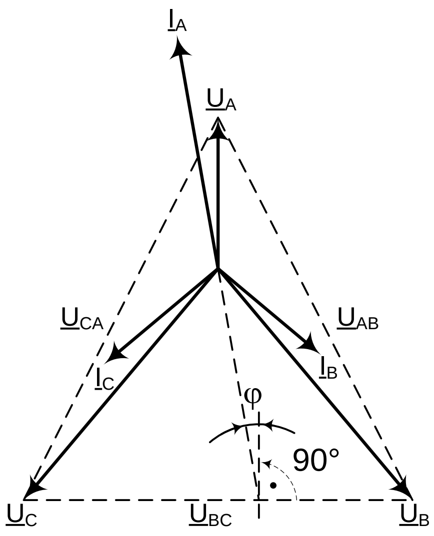

Figure 56: Single-phase earth-fault of phase A

Figure 56 shows phasors in single-phase earth-fault, where the faulted phase is phase A. The angle difference between the polarizing quantity U_{BC} and operating quantity I_A is marked as ϕ. Note that the polarizing quantity is rotated with 90°. The *Characteristic angle* is assumed to be 0°.

Figure 57 shows phasors in two-phase short circuit failure, where the fault is between phase B and phase C. The angle difference between the polarizing quantity $\overline{U_{CA}} - \overline{U_{AB}}$ and operating quantity $\overline{I_B} - \overline{I_C}$ is marked as ϕ.

Figure 56 and Figure 57 are valid if the phase rotation is ABC.

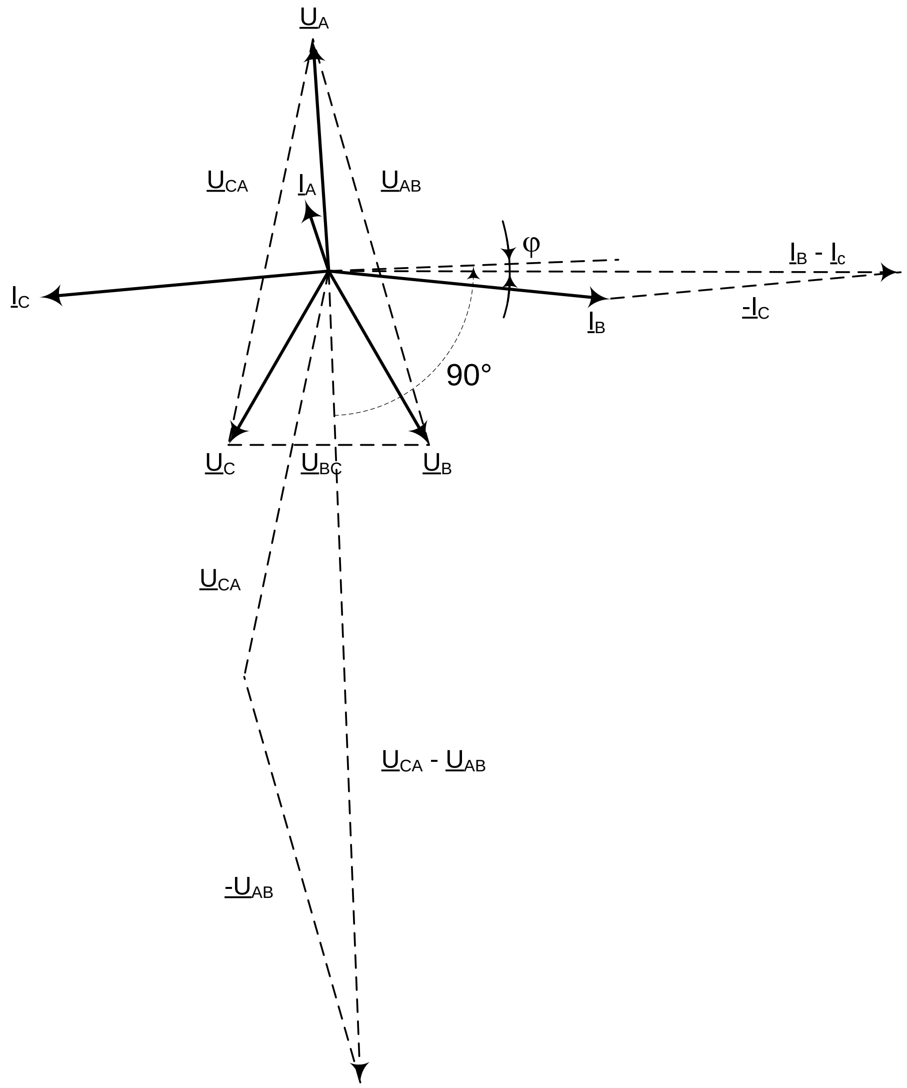

Figure 57: Two-phase short circuit and short circuit between phase B and C

Signals

Table 68: DPHPTOC Output signals

Name	Type	Description
Op general	Boolean	General operate signal
Op phsA	Boolean	Operate signal for phase A
Op phsB	Boolean	Operate signal for phase B
Op phsC	Boolean	Operate signal for phase C
OpFwd	Boolean	Operate signal indicating fault in forward direction when *Directional mode* is set to “Non Directional”.
Table continues on next page		

Name	Type	Description
OpRev	Boolean	Operate signal indicating fault in reverse direction when *Directional mode* is set to "Non Directional".
Str general	Boolean	General start signal
Str phsA	Boolean	Start signal for phase A
Str phsB	Boolean	Start signal for phase B
Str phsC	Boolean	Start signal for phase C
Str dirGeneral	Integer	General detected fault direction
Str dirPhsA	Integer	Detected fault direction for phase A
Str dirPhsB	Integer	Detected fault direction for phase B
Str dirPhsC	Integer	Detected fault direction for phase C

Settings

Table 69: DPHPTOC Settings

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Off/On
No. of Start Phases	1 out of 3 2 out of 3 3 out of 3	-	-	1 out of 3	Number of phases required for operate activation
Start Value	50…2000	A	10	480	Start value for overcurrent fault detection
Operate Delay Time	40…60000	ms	10	40	Operate delay time
Directional Mode	Forward Reverse Non-directional	-	-	Forward	Directional mode
Characteristics Angle	-179…180	Deg	1	0	Characteristics angle
Max Forward Angle	0…90	Deg	1	80	Maximum phase angle in forward direction
Max Reverse Angle	0…90	Deg	1	80	Maximum phase angle in reverse direction
Min Forward Angle	0…90	Deg	1	80	Minimum phase angle in forward direction
Min Reverse Angle	0…90	Deg	1	80	Minimum phase angle in reverse direction
Min Operate Current	-	A	-	50	Minimum operating current to allow directional criteria

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
Min Operate Voltage	-	V	-	500	Minimum operating voltage to allow directional criteria
Voltage Mem Time	-	ms	-	100	Voltage memory time
Abs Hyst Oper Qty	0.0…100.0	A	0.1	3	Absolute hysteresis for operating quantity
Abs Hyst Pol Qty	0…2500	V	0.1	200	Absolute hysteresis for polarizing quantity

Table 70: DPHPTOC Technical data

Characteristic	Value
Operation accuracy	Depending on the nominal frequency of the current measured: $f = f_n$ Current: ±1.5% of the set value Voltage: ±1.5% of the set value Phase angle: ±2º
Operate time accuracy (DMT)	±1.0% of the set value or ±20 ms

6.1.6.5 Earth-fault fault detection

Non-directional earth-fault fault detection EFPTOC

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Non-directional earth-fault fault detection	EFPTOC	I0>	51N

Functionality

The earth-fault overcurrent fault detection function EFPTOC is used as a non-directional phase-to-earth fault detection. The function starts when the residual current exceeds the set limit. Function operates with definite time characteristic, that is, the function operates after a predefined operate time and resets when the fault current disappears.

Operation principle

The *Operation* setting is used to enable or disable the function. The corresponding parameter values are "On" and "Off".

The operation of EFPTOC can be described by using a module diagram. All modules in the diagram are explained in the next sections.

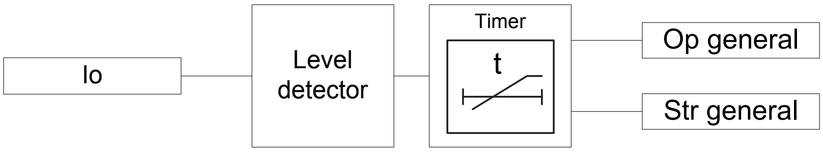

Figure 58: Functional module diagram

Level detector

The fundamental component of residual currents is compared with the *Start value* setting. If the measured value exceeds the *Start value* setting, the Level detector sends an enable signal to the timer module. The direct measured residual current or calculated residual current can be used for fault detection. The selection can be set with *Io signal Sel* available in the general parameter setting.

The *Absolute hysteresis* setting can be used for preventing unnecessary oscillations in `STR GENERAL` and `OP GENERAL` output if the input current is slightly above or below the *Start value* setting. After leaving the hysteresis area, the start condition has to be fulfilled again and if it is not sufficient, the signal returns to the hysteresis area.

Timer

Once the Timer is activated, it activates the `STR GENERAL` output. The time characteristic is according to the definite time. When the operation timer has reached the value set by *Operate delay time*, the `OP GENERAL` output is activated. If the fault disappears before the module operates, the reset is instantaneous and `STR GENERAL` output is deactivated.

The `OP GENERAL` output is available at LED 7 of SIM8F module.

The `STR GENERAL` and `OP GENERAL` output signals are available over communication.

Signals

Table 71: EFPTOC Output signals

Name	Type	Description
Op general	Boolean	Operate signal
Str general	Boolean	Start signal

Settings

Table 72: EFPTOC Settings

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Off/On
Start Value	4…200 200…1000	A A	1 5	4	Start value for earth-fault detection
Operate Delay Time	40..60000	ms	10	40	Operate delay time
Absolute Hysteresis	0.0…50.0	A	0.1	0.1	Absolute hysteresis for current

Table 73: EFPTOC Technical data

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: $f = f_n$ ±10% of the set value in the range of 4...25 A ±1.5% of the set value in the range of 26...1000 A (Current measurement based on internal calculation)
Operate time accuracy (DMT)	±1.0% of the set value or ±20 ms

Directional earth-fault fault detection DEFPTOC

Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Directional earth-fault fault detection	DEFPTOC	I0>->	67N

Functionality

The earth-fault function DEFPTOC is used as a directional earth-fault detection for feeders.

The function starts when the operating quantity (residual current, Io) and polarizing quantity (zero sequence voltage, Uo) exceed the set limits and the angle between them is inside the set operating sector. Function operates with the definite time characteristic, that is, the function operates after a predefined operate time of 40 ms and resets when the fault current disappears.

Operation principle

The *Operation* setting is used to enable or disable the function. The corresponding parameter values are "On" and "Off".

The operation of DEFPTOC can be described by using a module diagram. All modules in the diagram are explained in the next sections.

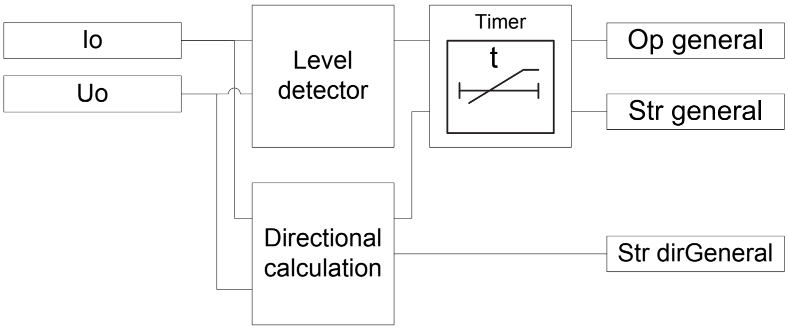

Figure 59: Functional module diagram

Level detector

The magnitude of the operating quantity is compared with the *Start value* setting and the magnitude of the polarizing quantity is compared with the *Voltage start value*. If both limits are exceeded, the Level detector sends an enabling signal to the timer module.

The direct measured residual current or calculated residual current can be used for fault detection. The selection can be set with *Io signal Sel* available in the general parameter setting.

The *Abs Hyst Oper Qty* and *Abs Hyst Pol Qty* settings can be used for preventing unnecessary oscillations in `STR GENERAL` and `OP GENERAL` output if the operating and/or polarizing quantity is slightly above or below the *Start value* setting. After leaving the hysteresis area, the start condition has to be fulfilled again and if it is not sufficient, the signal returns to the hysteresis area.

Directional calculation

The directional calculation module monitors the angle between the polarizing quantity and operating quantity. When the angle is in the operation sector, the module sends the enabling signal to the timer module.

The minimum signal level which allows the directional operation is fixed to *Min operate current* as 1 A and *Min operate voltage* as 500 V.

The convention used in the phasor diagrams representing the operation of DEFPTOC is reversed, that is, the polarizing quantity Uo in the phasor diagrams is -Uo.

For defining the operation sector, there are three modes available through the *Operation mode* setting.

Table 74: Operation modes

Operation mode	Description
Phase angle	The operating sectors for forward and reverse are defined with the settings *Min forward angle*, *Max forward angle*, *Min reverse angle* and *Max reverse angle*.
IoSin	The operating sectors are defined as "forward" when $\|Io\| \times \sin(\phi)$ has a positive value and "reverse" when the value is negative. Θ is the angle difference between -Uo and Io.
IoCos	As "IoSin" mode. Only cosine is used for calculating the operation current.

The directional of the operation can be selected with the *Directional mode* setting. Either "Non-directional", "Forward" or "Reverse" operation can be selected. The operation criterion is selected with the *Operation mode* setting.

The *Characteristic angle* setting is used in the "Phase angle" mode to adjust the operation according to the method of neutral point earthing so that in an isolated network, the *Characteristic angle* (ϕ_{RCA}) = (-90°) and in a compensated network ϕ_{RCA} = 0°.

For definitions of different directional earth-fault characteristics, see the Directional earth-fault characteristics section.

The directional calculation module also provides the information about the direction of fault `STR DIRGENERAL` during fault situation. The information is available over GOOSE communication.

Timer

Once the Timer is activated, it activates the `STR GENERAL` output. The time characteristic is according to the definite time. When the operation timer has reached the value set by *Operate delay time*, the `OP GENERAL` output is activated. If the fault disappears before the module operates, the reset is instantaneous and `STR GENERAL` output is deactivated.

When *Directional mode* is set to “Non Directional”, outputs `OpFwd` and `OpRev` are activated when a fault is detected in the “Forward” or “Reverse” direction respectively. However, these outputs are also available when *Directional mode* is set to “Forward” or “Reverse”.

The `OP GENERAL` output is available at LED 8 of SIM8F module.

The `STR GENERAL` and `OP GENERAL` outputs are available over communication.

Directional earth-fault principle

In an isolated neutral network or Peterson earthed networks it is difficult to achieve selective earth-fault detection based on the magnitude of residual current. Such applications demand the use of directional earth-fault detection. They are also used in the network where overcurrent fault detection supports the directional overcurrent principle. To determine the direction of fault, directional earth-fault requires a reference, known as polarizing quantity against which residual current can be compared. This polarizing quantity can be either a zero sequence voltage or negative sequence voltage, depending on the network. SIM8F module supports zero sequence voltage.

Relay characteristic angle

The *Characteristic angle* known as Relay Characteristic Angle (RCA), Relay Base Angle or Maximum Torque Angle (MTA), is used in the "Phase angle" mode to turn the directional characteristic, if the expected fault current angle does not coincide with the polarizing quantity to produce the maximum torque. That is, RCA is the angle between the maximum torque line and polarizing quantity. If the polarizing quantity is in phase with the maximum torque line, RCA is 0°. The angle is positive if operating current lags the polarizing quantity and negative if it leads the polarizing quantity.

Example 1

If the "Phase angle" mode is selected, the compensated network ($\phi_{RCA} = 0°$) and *Characteristic angle* = 0°.

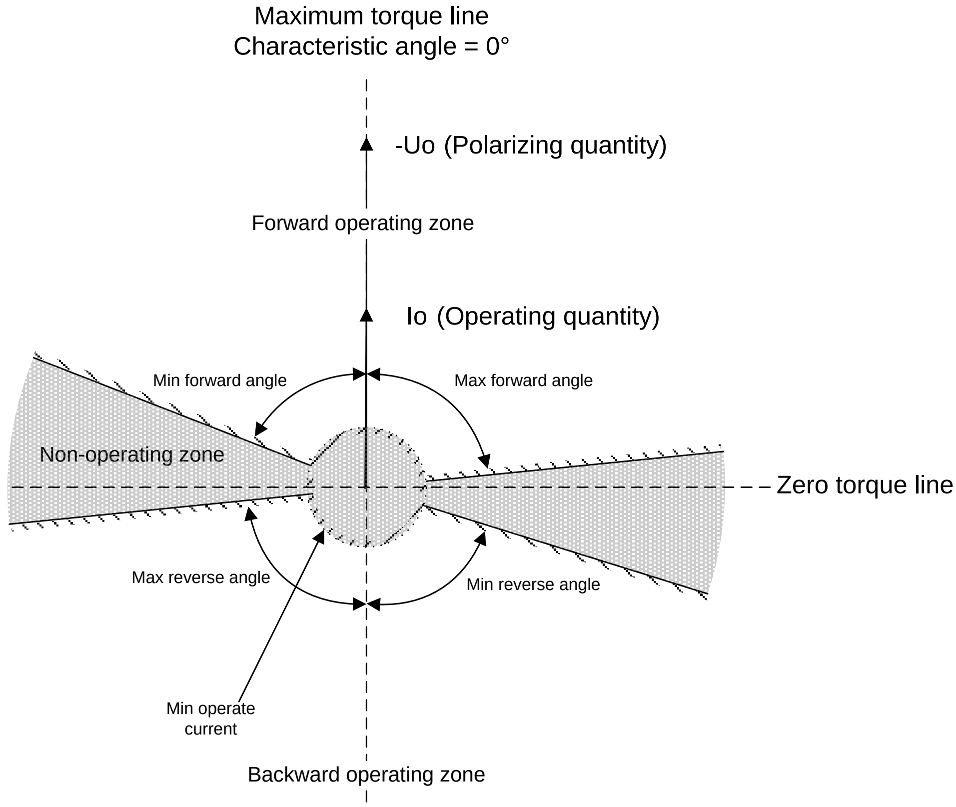

Figure 60: Definition of the relay characteristic angle, RCA = 0° in a compensated network

Example 2

If the "Phase angle" mode is selected, the solidly earthed network (ϕ_{RCA} = +60°) and *Characteristic angle* = +60°.

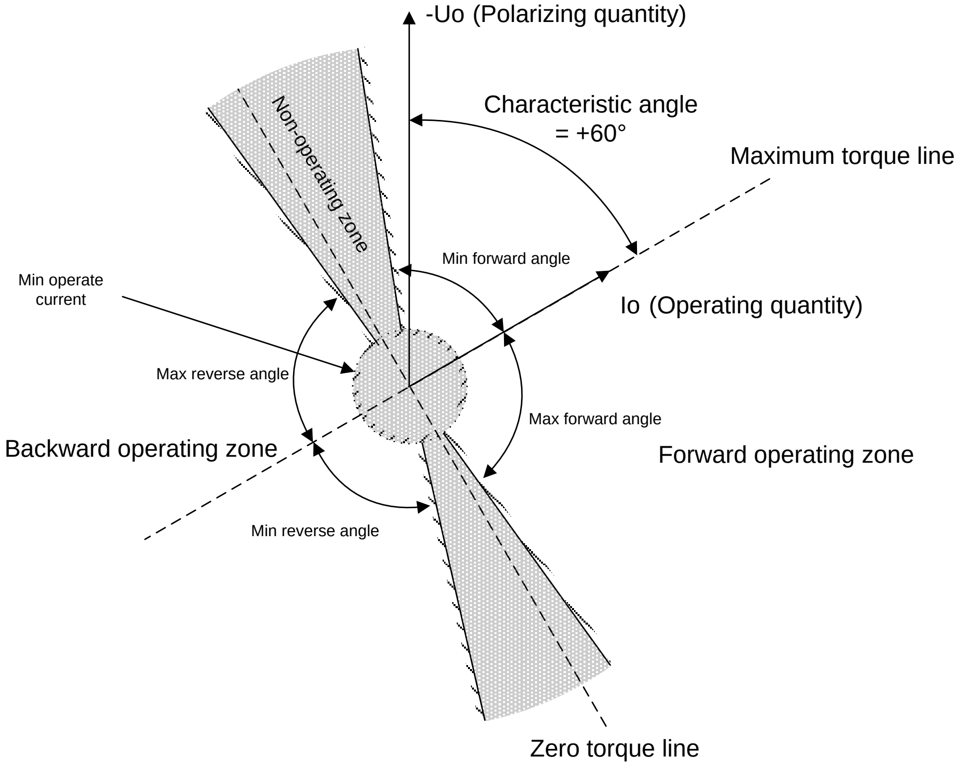

Figure 61: Definition of the relay characteristic angle, RCA = +60° in a solidly earthed network

Example 3

If the "Phase angle" mode is selected, the solidly earthed network (ϕ_{RCA} = -90°) and *Characteristic angle* = -90°.

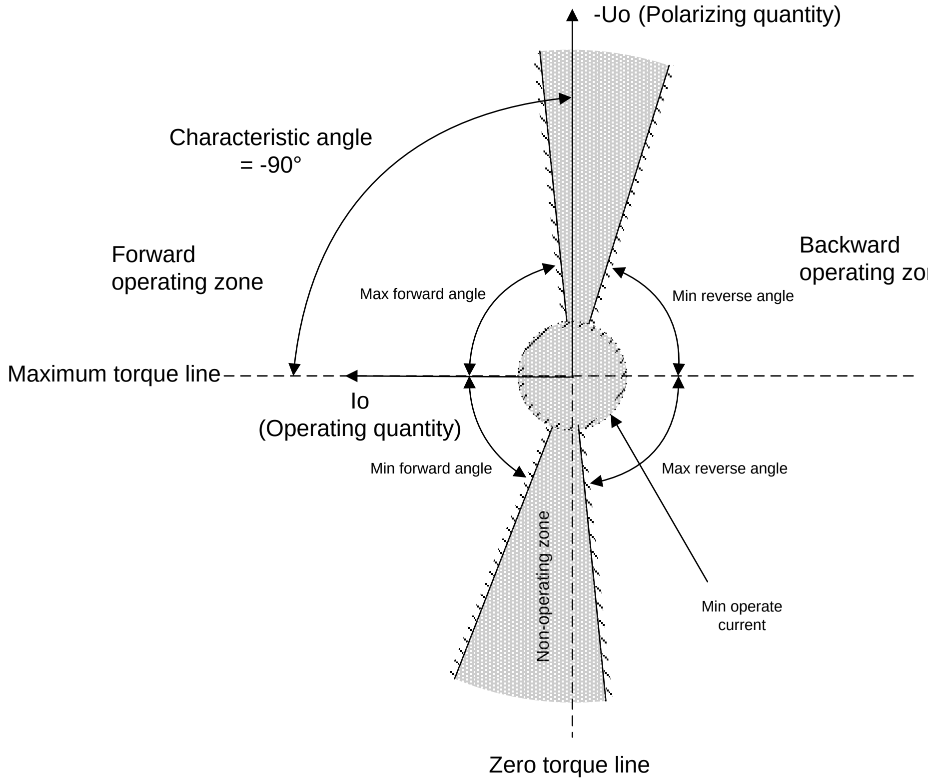

Figure 62: Definition of the relay characteristic angle, RCA = -90° in an isolated network

Directional earth-fault detection in an isolated neutral network

In isolated networks, there is no intentional connection between the system neutral point and earth. The only connection is through the phase-to-earth capacitances (C0) of phases and leakage resistances (R0). This means that the residual current is mainly capacitive and has a phase shift of -90° compared to the polarizing voltage. Consequently, the relay characteristic angle (RCA) should be set to -90° and the operation criteria to "IoSin" or "Phase angle". The width of the operating sector in the phase angle criteria can be selected with the settings *Min forward angle*, *Max forward angle*, *Min reverse angle* or *Max reverse angle*. Figure 63 illustrates a simplified equivalent circuit for an unearthed network with an earth-fault in phase C.

For definitions of different directional earth-fault characteristics, see Directional earth-fault principles.

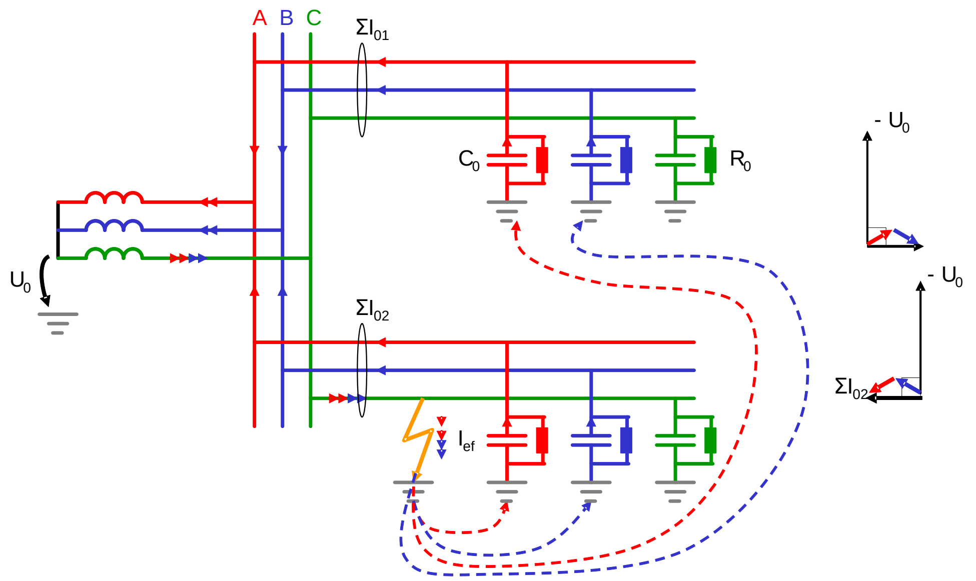

Figure 63: Earth-fault in an isolated network

Directional earth-fault detection in a compensated network

In compensated networks, the capacitive fault current and the inductive resonance coil current compensate each other. The fault detection cannot be based on the reactive current measurement, since the current of the compensation coil would disturb the operation of the relays. In this case, the selectivity is based on the measurement of the active current component. The magnitude of this component is often small and must be increased by a parallel resistor in the compensation equipment. When measuring the resistive part of the residual current, the relay characteristic angle (RCA) should be set to 0° and the operation criteria to "IoCos" or "Phase angle". Figure 64 illustrates the simplified equivalent circuit for a compensated network with an earth-fault in phase C.

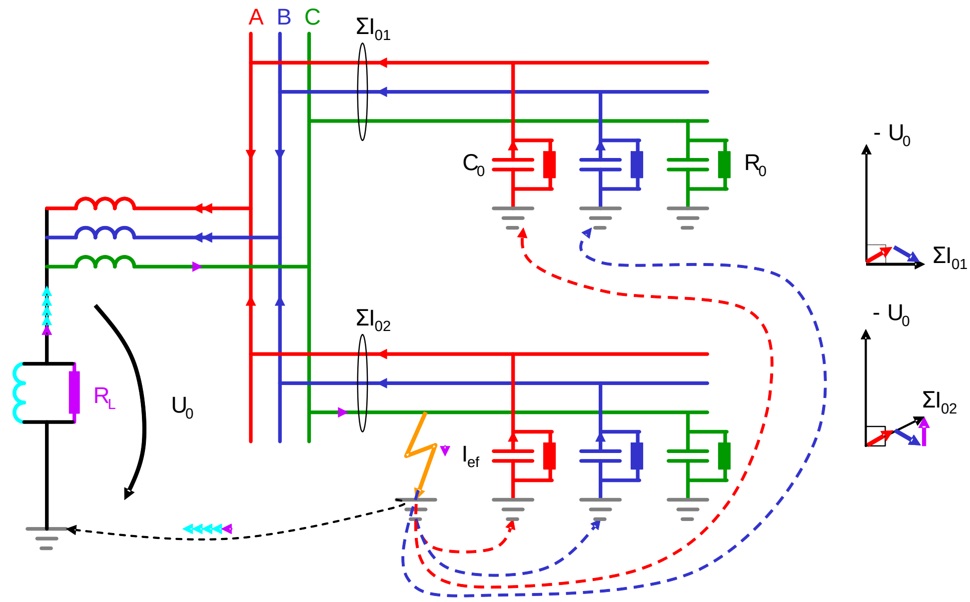

Figure 64: Earth-fault in a compensated network

Directional earth-fault characteristic

Phase angle characteristic

The operation criterion phase angle is selected with the *Operation mode* setting using the value "Phase angle".

The forward and reverse sectors are defined separately. The forward operation area is limited with the *Min forward angle* and *Max forward angle* settings. The reverse operation area is limited with the *Min reverse angle* and *Max reverse angle* settings.

The sector limits are always defined as positive degree values.

In the forward operation area, the *Max forward angle* setting defines the clockwise sector and the *Min forward angle* setting defines the counter clockwise sector, measured from the *Characteristic angle* setting.

In the reverse operation area, the *Max reverse angle* setting defines the clockwise sector and the *Min reverse angle* setting defines the counter clockwise sector, measured from the complement of the *Characteristic angle* setting (180° phase shift).

RCA is set to positive if the operating current lags the polarizing quantity. It is set to negative if it leads the polarizing quantity.

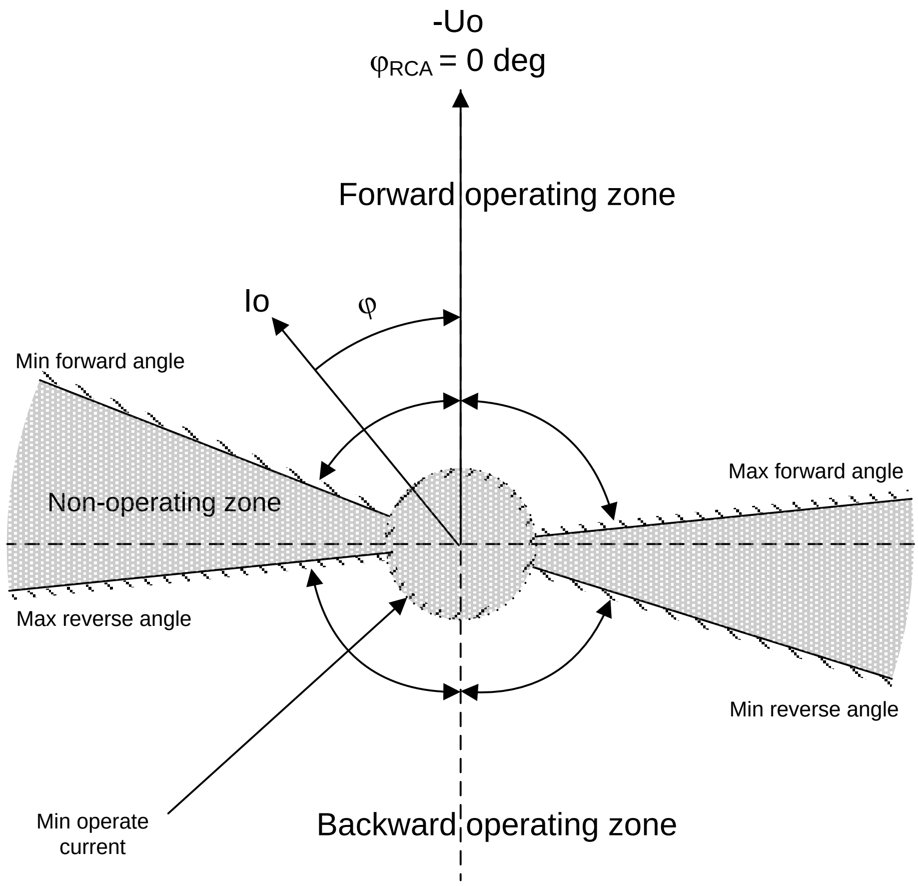

Figure 65: Configurable operating sectors in phase angle characteristic

Table 75: Fault direction indication

Fault direction	Value
Angle between the polarizing and operating quantity is not in any of the defined sectors	0 = unknown
Angle between the polarizing and operating quantity is in the forward sector	1 = forward
Angle between the polarizing and operating quantity is in the reverse sector	2 = backward
Angle between the polarizing and operating quantity is in both the forward and the reverse sectors, that is, the sectors are overlapping.	3 = both

The directional operations forward and reverse are not allowed when the measured polarizing or operating quantities are invalid, that is, their magnitude is below the minimum operate values. In case of low magnitudes, the `STR DIRGENERAL` output is set to 0=unknown. This means the function is allowed to operate in the directional mode as non-directional, since the directional information is invalid.

Iosin and Iocos criteria

A modern approach to directional fault detection is the active or reactive current measurement. The operating characteristic of the directional operation depends on the earthing principle of the network. The Iosin(ϕ) criterion is used in an isolated network, measuring the reactive component of the fault current caused by the earth capacitance. The Iocos(ϕ) criterion is used in the compensated network, measuring the active component of the fault current.

The operation criteria Iosin(ϕ) and Iocos(ϕ) are selected with the *Operation mode* setting using the values "IoSin" or "IoCos" respectively.

When the Iosin(ϕ) or Iocos(ϕ) criterion is used, the component indicates a forward or reverse-type fault through the `STR DIRGENERAL` output, where 1 = forward fault and 2 = reverse fault.

In case of low magnitude, the `STR DIRGENERAL` output is set to 0 = unknown. The function is allowed to operate in the directional mode as non-directional, since the directional information is invalid.

The following examples show the characteristics of different operation criteria.

Example 1

If Iosin(ϕ) criterion is selected in forward-type fault, the `STR DIRGENERAL` = 1.

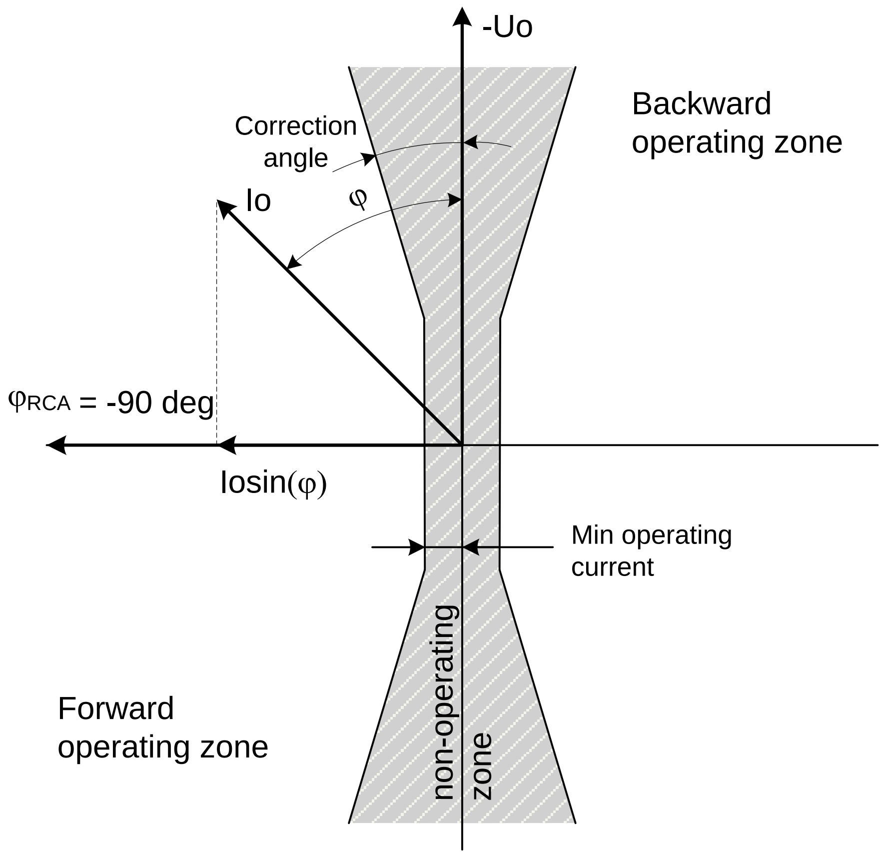

Figure 66: Operating characteristic Iosin(ϕ) in forward fault

Example 2

If Iosin(ϕ) criterion is selected in reverse-type fault, the `STR DIRGENERAL` = 2.

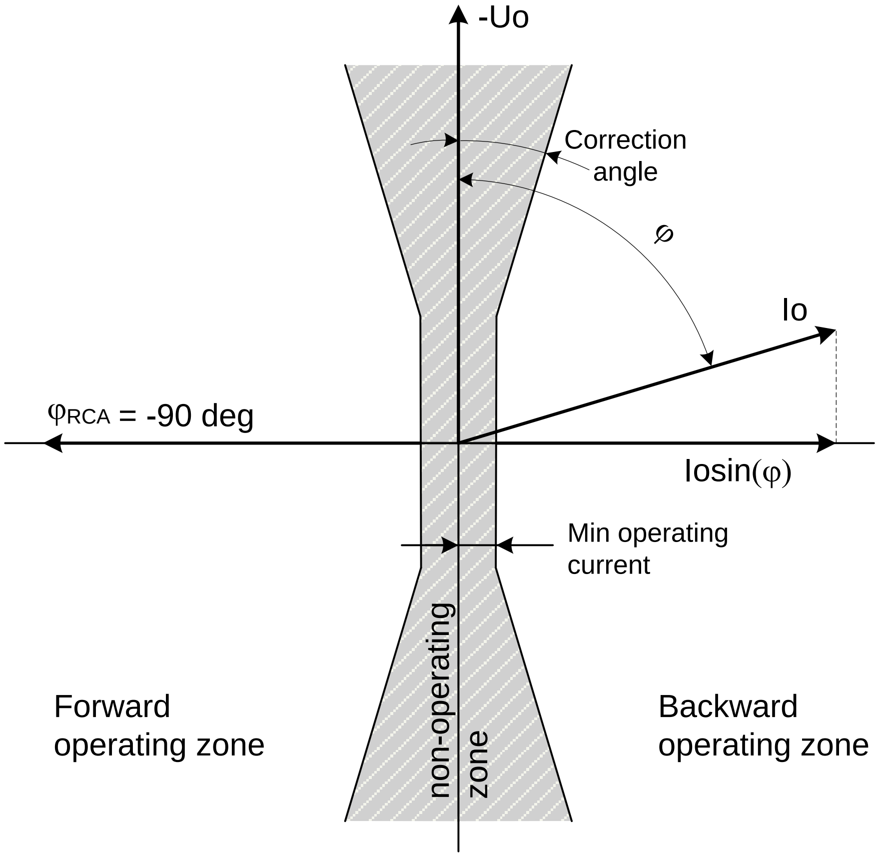

Figure 67: Operating characteristic Iosin(ϕ) in reverse fault

Example 3

If Iocos(ϕ) criterion is selected in forward-type fault, the STR DIRGENERAL = 1.

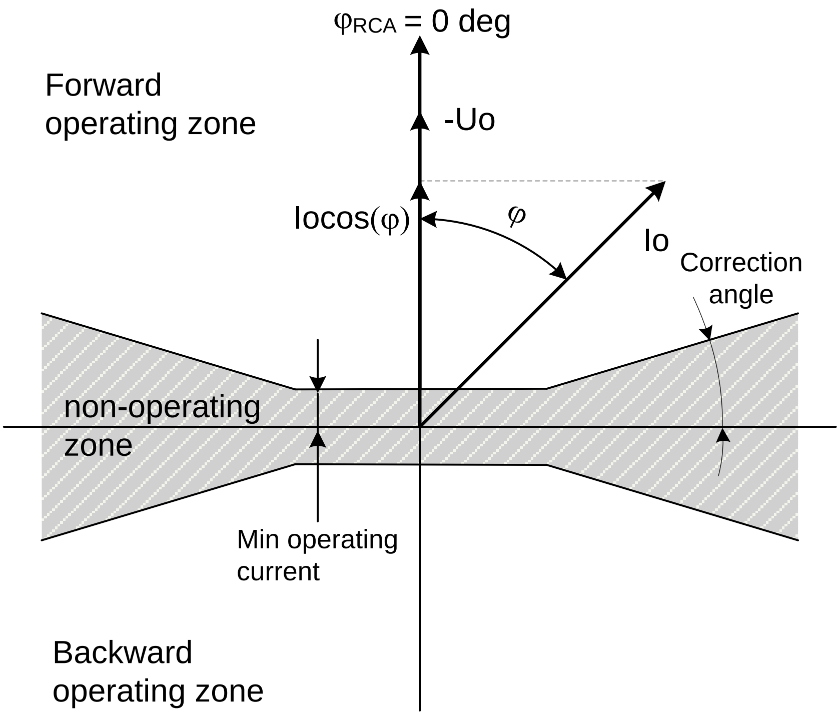

Figure 68: Operating characteristic Iocos(ϕ) in forward fault

Example 4

If Iocos(ϕ) criterion is selected in reverse-type fault, the `STR DIRGENERAL` = 2.

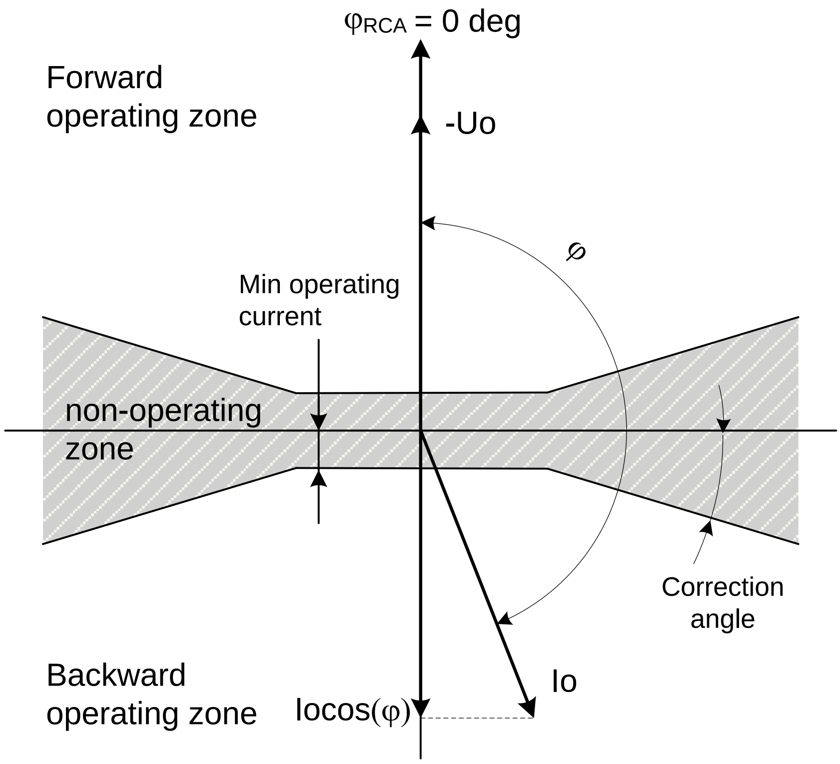

Figure 69: Operating characteristic Iocos(ϕ) in reverse fault

Signals

Table 76: DEFPTOC Output signals

Name	Type	Description
Op general	Boolean	Operate signal
OpFwd	Boolean	Operate signal indicating fault in forward direction when *Directional mode* is set to “Non Directional”.
OpRev	Boolean	Operate signal indicating fault in reverse direction when *Directional mode* is set to “Non Directional”.
Str general	Boolean	Start signal
Str dirGeneral	Integer	Detected fault direction

Settings

Table 77: DEFPTOC Settings

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Off/On
Start Value	4…200 200…1000	A A	1 5	4	Start value for earth-fault detection
Voltage Start Value	500..1000	V	1	500	Voltage start value
Operate Delay Time	40…60000	ms	10	80	Operate delay time
Enable Voltage Limit	No Yes	-	-	Yes	Additional check for voltage before issuing trip
Directional Mode	Forward Reverse Non Directional	-	-	Forward	Directional mode
Operation Mode	Phase angle IoSin IoCos	-	-	Phase angle	Operation criteria
Characteristics Angle	-179…180	Deg	1	0	Characteristics angle
Max Forward Angle	0…180	Deg	1	80	Maximum phase angle in forward direction
Max Reverse Angle	0…180	Deg	1	80	Maximum phase angle in reverse direction
Min Forward Angle	0…180	Deg	1	80	Minimum phase angle in forward direction
Min Reverse Angle	0…180	Deg	1	80	Minimum phase angle in reverse direction
Min Operate Current	-	A	-	1	Minimum operating current to allow directional criteria
Min Operate Voltage	-	V	-	500	Minimum operating voltage to allow directional criteria
Abs Hyst Oper Qty	0.0…50.0	A	0.1	0.1	Absolute hysteresis for operating quantity
Abs Hyst Pol Qty	0…2500	V	0.1	200	Absolute hysteresis for polarizing quantity

Table 78: DEFPTOC Technical data

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: $f = f_n$ Current: ±10% of the set value in the range of 4...25 A ±1.5% of the set value in the range of 26...1000 A Voltage: ±1.5% of the set value Phase angle: ±3° (Current measurement based on internal calculation)
Operate time accuracy (DMT)	±1.0% of the set value or ±20 ms

Multifrequency admittance-based earth-fault indication MFAPSDE

Identification

Description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Multifrequency admittance-based earth-fault indication	MFAPSDE	I0>->Y	67YN

Functionality

The multifrequency admittance-based earth-fault indication function MFAPSDE provides selective directional earth-fault protection for high-impedance earthed networks, that is, for compensated, unearthed and high-resistance earthed systems. It can be applied for the earth-fault protection of overhead lines and underground cables.

The operation of MFAPSDE is based on multifrequency neutral admittance measurement, utilizing cumulative phasor summing technique. This concept provides extremely secure, dependable and selective earth-fault protection also in cases where the residual quantities are highly distorted and contain non-fundamental frequency components.

Besides faults with dominantly fundamental frequency content, MFAPSDE is capable of detecting transient and intermittent (restriking) earth faults.

MFAPSDE supports fault direction indication both in operate and non-operate direction, which may be utilized during the fault location process. The inbuilt transient detector may be used to identify intermittent earth faults, and discriminate them from permanent or continuous earth faults.

The operation characteristic is defined by a tilted operation sector, which is universally valid for unearthed and compensated networks.

The operating time characteristic is according to the definite time (DT).

Operation principle

The *Operation* setting is used to enable or disable the function. The corresponding parameter values are “On” and “Off”.

The operation of MFAPSDE can be described using a module diagram. All modules in the diagram are explained in the next sections.

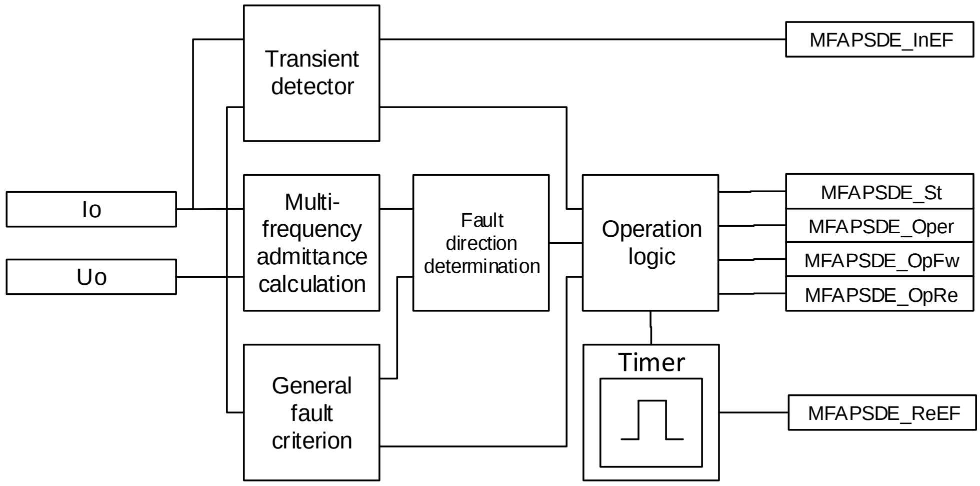

Figure 70: Functional module diagram

General fault criterion

The General fault criterion (GFC) module monitors the presence of earth fault in the network and it is based on the value of the fundamental frequency zero-sequence voltage defined as the vector sum of fundamental frequency phase voltage phasors divided by three.

$$\overline{U_0^1} = \frac{\overline{U_A^1} + \overline{U_B^1} + \overline{U_C^1}}{3}$$

(Equation 7)

When the magnitude of $\overline{U_0^1}$ exceeds the *Voltage start value* setting, an earth fault is detected. The GFC module reports the exceeded value to the Fault direction determination module and Operation logic. The reporting is referenced as General Fault Criterion release.

Set the correct system phase-to-phase voltage with the *Nominal Voltage* setting under the SIM8F operating parameter. The function uses this value internally for calculation.

The *Voltage start value* setting defines the basic sensitivity of the MFAPSDE function. To avoid unselective start or operation, *Voltage start value* must always be set to a value which exceeds the maximum healthy state zero-sequence voltage value, taking into consideration the possible network topology changes, compensation coil and parallel resistor switching status and compensation degree variations.

Multi-frequency admittance calculation

Multi-frequency admittance calculation module calculates neutral admittances utilizing fundamental frequency and the 2nd, 3rd, 5th, 7th and 9th harmonic components of residual current and zero-sequence voltage. The following admittances are calculated, if the magnitudes of a particular harmonic in residual current and zero-sequence voltage are measurable by the IED.

Fundamental frequency admittance (conductance and susceptance)

$$\overline{Y_0^1} = \frac{3 \cdot \overline{I_0^1}}{-\overline{U_0^1}} = G_o^1 + j \cdot B_o^1$$

(Equation 8)

$\overline{Y_0^1}$	Fundamental frequency neutral admittance phasor
$\overline{I_0^1}$	Fundamental frequency zero-sequence current phasor $\left(\frac{\overline{I_A^1} + \overline{I_B^1} + \overline{I_C^1}}{3}\right)$
$\overline{U_0^1}$	Fundamental frequency zero-sequence voltage phasor $\left(\frac{\overline{U_A^1} + \overline{U_B^1} + \overline{U_C^1}}{3}\right)$
G_0^1	Fundamental frequency conductance, $\mathrm{Re}(\overline{Y_0^1})$
B_0^1	Fundamental frequency susceptance, $\mathrm{Im}(\overline{Y_0^1})$

Harmonic susceptances

$$\text{Im}\left[\overline{Y_0^n}\right] = \text{Im}\left[\frac{3 \cdot \overline{I_0^n}}{-\overline{U_0^n}}\right] = j \cdot B_o^n$$

(Equation 9)

$\overline{Y_0^n}$	nth harmonic frequency neutral admittance phasor
$\overline{I_0^n}$	nth harmonic frequency zero-sequence current phasor
$\overline{U_0^n}$	nth harmonic frequency zero-sequence voltage phasor
B_0^n	nth harmonic frequency susceptance, $\text{Im}(\overline{Y_0^n})$
n	2, 3, 5, 7 and 9

For fault direction determination, the fundamental frequency admittance and harmonic susceptances are summed together in phasor format. The result is the sum admittance phasor defined in Equation 10.

$$\overline{Y}_{osum} = \text{Re}\left[\overline{Y_0^1}\right] + j \cdot \text{Im}\left[\overline{Y_0^1} + \sum_{n=2}^{9} \overline{Y_0^n}\right] = G_o^1 + j \cdot B_{osum}$$

(Equation 10)

Fault direction determination

If an earth-fault is detected by the GFC module, the fault direction is evaluated based on the calculated sum admittance phasor $\overline{Y}_{osum}$ obtained from the Multi-frequency admittance calculation module. To obtain dependable and secure fault direction determination regardless of the fault type (transient, intermittent, permanent, high or low ohmic), the fault direction is calculated using a special filtering algorithm, that is, the Cumulative Phasor Summing (CPS) technique. This filtering method is advantageous during transient and intermittent earth faults with dominantly non-sinusoidal or transient content. It is equally valid during continuous (stable) earth faults.

The concept of CPS is illustrated in Figure 71. It is the result of adding values of the measured sum admittance phasors together in phasor format in chronological order during the fault. The corresponding accumulated sum admittance phasor $\overline{Y}_{osum\_CPS}$ is calculated using the discrete sum admittance phasors $\overline{Y}_{osum}$ in different time instants (t1...t5). This phasor is used as directional phasor in determining the direction of the fault.

$$\overline{Y}_{osum\_CPS}(t_1) = \overline{Y}_{osum}(t_1)$$

(Equation 11)

$$\overline{Y}_{osum\_CPS}(t_2) = \overline{Y}_{osum}(t_1) + \overline{Y}_{osum}(t_2)$$

(Equation 12)

$$\overline{Y}_{osum\_CPS}(t_3) = \overline{Y}_{osum}(t_1) + \overline{Y}_{osum}(t_2) + \overline{Y}_{osum}(t_3)$$

(Equation 13)

$$\overline{Y}_{osum\_CPS}(t_4) = \overline{Y}_{osum}(t_1) + \overline{Y}_{osum}(t_2) + \overline{Y}_{osum}(t_3) + \overline{Y}_{osum}(t_4)$$

(Equation 14)

$$\overline{Y}_{osum\_CPS}(t_5) = \overline{Y}_{osum}(t_1) + \overline{Y}_{osum}(t_2) + \overline{Y}_{osum}(t_3) + \overline{Y}_{osum}(t_4) + \overline{Y}_{osum}(t_5)$$

(Equation 15)

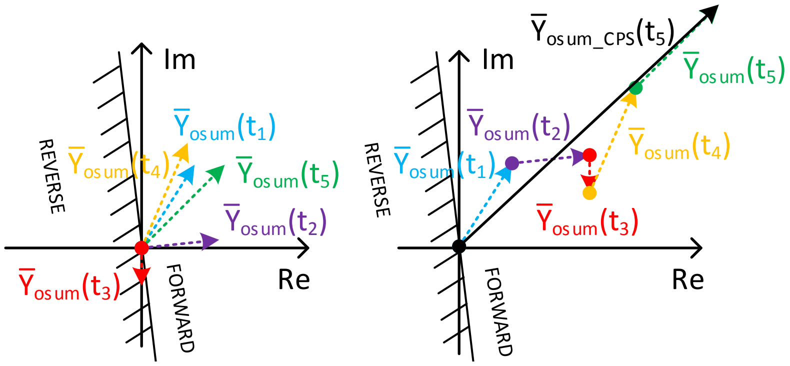

Figure 71: Cumulative Phasor Summing (CPS) principle

The CPS technique provides a stable directional phasor quantity despite of individual phasors varying in magnitude and phase angle in time due to non-stable fault type such as an intermittent earth fault. This is also true for harmonic components included in the sum admittance phasor. Harmonics have typically a highly fluctuating character.

Harmonic components provide a more distinctive directional determination in compensated networks than the fundamental frequency components. With higher frequencies the compensation coil appears as a very high impedance and the harmonics are not affected by the compensation coil and degree of compensation. When harmonics are present, they cause the sum admittance phasor to behave as in case of an unearthed network, where directional phasors point in fully opposite directions in the faulty and healthy feeders.

The direction of the MFAPSDE function is defined by setting *Directional mode* to “Forward” or “Reverse”. The operation characteristic is defined by tilted operation sector as illustrated in Figure 72. The characteristic provides universal applicability, that is, it is valid both in compensated and unearthed networks, also if the compensation coil is temporarily switched off. The tilt of the operation sector is defined with setting *Tilt angle* to compensate the measurement errors of residual current and voltage measurement.

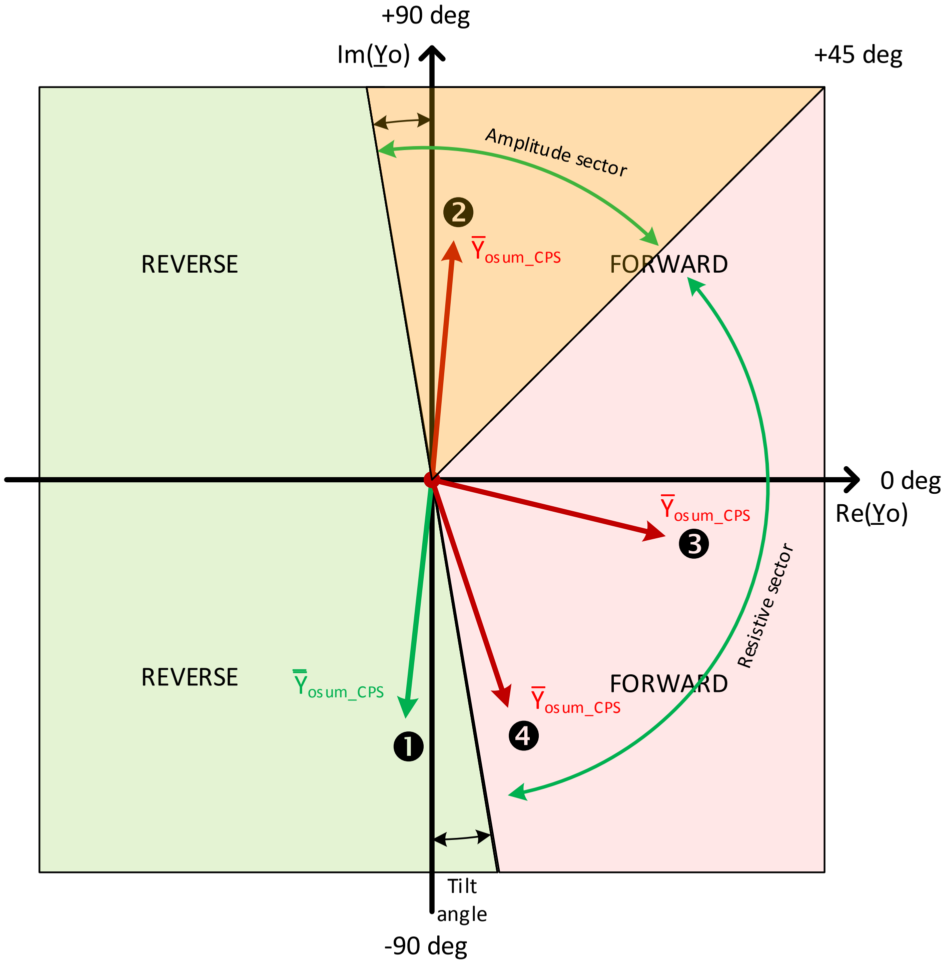

Figure 72: Directional characteristic of the MFAPSDE function

In case of unearthed network operation, adequate tilt angle must be allowed to ensure dependable operation of MFAPSDE.

In Figure 72, phasors 1…4 demonstrate the behavior of the directional phasor in different network fault conditions.

- Phasor 1 depicts the direction of accumulated sum admittance phasor in case of an earth fault outside the protected feeder (assuming that the admittance of the protected feeder is dominantly capacitive). The result is valid regardless of the fault type (low ohmic, high(er) ohmic, permanent or intermittent). In case harmonic components are present in the fault quantities, they turn the phasor align to the negative Im($\overline{Y}_o$) axis.

- Phasor 2 depicts the direction of accumulated sum admittance phasor in case of an earth fault inside the protected feeder when the network is unearthed. The result is also valid in compensated networks when there are harmonic components present in the fault quantities (typically low ohmic permanent or intermittent fault). In this case, the result is valid regardless of the network's actual compensation degree. Harmonics turn the phasor align to the positive Im($\overline{Y}_o$) axis.
- Phasors 3 and 4 depict the direction of accumulated sum admittance phasor in case of a higher-ohmic earth fault in the protected feeder without harmonics in the fault quantities when the network is compensated. As no harmonic components are present, the phase angle of the accumulated phasor is determined by the compensation degree of the network. With high degree of overcompensation, the phasor turns towards the negative Im($\overline{Y}_o$) axis (as phasor 4).

The characteristic *Tilt angle* should reflect the measurement errors, that is, the larger the measurement errors, the larger the *Tilt angle* setting should be. Typical setting value of 10 degrees is recommended.

The detected fault direction is available as GOOSE outputs `MFAPSDE_OpFw` and `MFAPSDE_OpRe`. Outputs `MFAPSDE_OpFw` and `MFAPSDE_OpRe` provide the fault direction irrespective of settings *Power direction logic* and *Directional mode*.

To adapt the fault direction determination to possible fault direction change during the fault, for example, during manual fault location process, a cyclic accumulation of sum admittance phasors is conducted. The duration of this directional evaluation cycle is 1.2 · *Reset delay time* (minimum of 600 ms). If the fault direction based on the cyclic phasor accumulation is opposite to the function direction output for *Reset delay time* or 500 ms (minimum of 500 ms), the function is reset and fault direction calculation of MFAPSDE is restarted.

The direction of the MFAPSDE function is supervised by a settable current magnitude threshold. The operate current used in the magnitude supervision is measured with a special filtering method, which provides very stable residual current estimate regardless of the fault type. This stabilized current estimate is the result from fundamental frequency admittance calculation utilizing the CPS technique. The stabilized current value is obtained (after conversion) from the corresponding admittance value by multiplying it with the system nominal phase-to-earth voltage value (=1/sqrt(3) which is entered as Nominal voltage). The stabilized values of the fundamental frequency admittance and the corresponding current are calculated with Equation 16 and Equation 17.

$$\overline{Y^1_{0\ stab}} = \frac{3 \cdot \overline{I^1_{0\ CPS}}}{-\overline{U^1_{0\ CPS}}} = \text{Re}\left[\overline{Y^1_{0\ stab}}\right] + j\,\text{Im}\left[\overline{Y^1_{0\ stab}}\right] = G^1_{ostab} + j \cdot B^1_{ostab}$$

(Equation 16)

$\overline{Y^1_{0\ stab}}$	Stabilized fundamental frequency admittance estimate, which is result from fundamental frequency admittance calculation utilizing the Cumulative Phasor Summing (CPS) technique
$\overline{I^1_{0\ CPS}}$	Fundamental frequency zero-sequence current phasor calculated utilizing the Cumulative Phasor Summing (CPS) technique
$\overline{U^1_{0\ CPS}}$	Fundamental frequency zero-sequence votlage phasor calculated utilizing the Cumulative Phasor Summing (CPS) technique
G^1_{ostab}	Real part of stabilized fundamental frequency conductance estimate
B^1_{ostab}	Imaginary part of stabilized fundamental frequency susceptance estimate

$$\overline{I^1_{0\ stab}} = \left(G^1_{ostab} + j \cdot B^1_{ostab}\right) \cdot U_{baseres} = I^1_{oCosstab} + j \cdot I^1_{oSinstab}$$

(Equation 17)

G^1_{ostab}	Real part of stabilized fundamental frequency conductance estimate
B^1_{ostab}	Imaginary part of stabilized fundamental frequency susceptance estimate
$\overline{I^1_{0\ stab}}$	Stabilized fundamental frequency residual current estimate, which is obtained (after conversion) from the corresponding admittance value by multiplying it with the system nominal phase-to-earth voltage value
$I^1_{oCosstab}$	Real part of stabilized fundamental frequency residual current estimate
$I^1_{oSinstab}$	Imaginary part of stabilized fundamental frequency residual current estimate

The main advantage of the filtering method is that due to the admittance calculation, the resulting current value does not depend on the value of fault resistance, that is, the estimated current magnitude equals the value that would be measured during a solid earth fault (Rf = 0 Ω). Another advantage of the algorithm is that it is capable of estimating the correct current magnitude during intermittent earth faults.

The setting *Min Forward Operate current* defines the minimum operate current if the operation direction is set to “Forward”. The *Min Reverse Operate current* setting defines the minimum operate current if the operation direction is set to “Reverse”.

With the previously described special filtering technique, the settings *Min Forward Operate current* and *Min Reverse Operate current* are based on fundamental frequency residual current values.

Setting *Operating Quantity* defines whether the current magnitude supervision is based on the "Adaptive", "Amplitude", or "Resistive" methods. When *Operating Quantity* is set to "Adaptive", the method adapts the principle of current magnitude supervision to the system earthing condition. This is done by monitoring the phase angle of the accumulated sum admittance phasor. In case the phase angle of accumulated sum admittance phasor is greater than 45 degrees, the set minimum operate current threshold is compared to the amplitude of $\overline{I_{0\,stab}^{1}}$ (Figure 73). In case the phase angle of accumulated admittance phasor is below 45 degrees, the set minimum operate current threshold is compared to the resistive component of $\overline{I_{0\,stab}^{1}}$. This automatic adaptation of the magnitude supervision enables secure and dependable directional determination in compensated networks, and it is also valid when network is unearthed (compensation coil is switched off).

If the operation direction is set to “Reverse”, the resistive and amplitude sectors are mirrored in the operation characteristics.

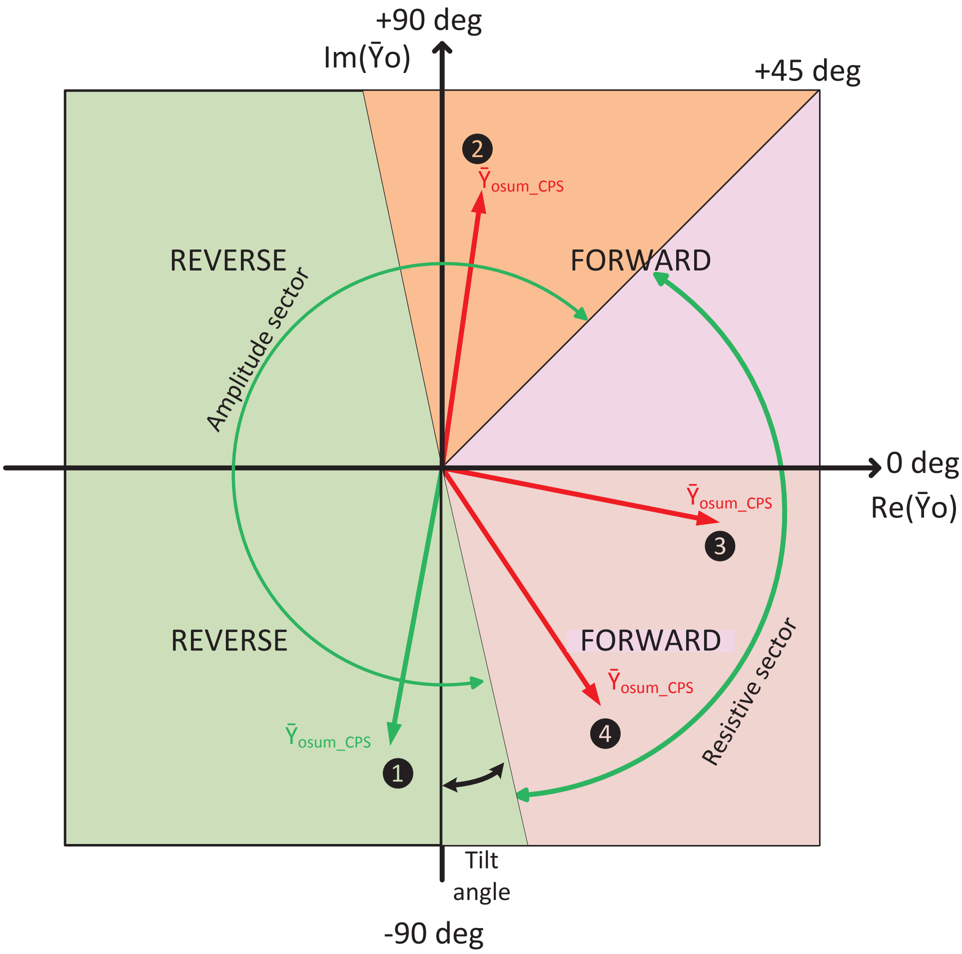

Figure 73: Illustration of amplitude and resistive current sectors when directional mode is set to "Forward" and setting operating quantity="Adaptive"

Setting *Operating Quantity* should be set to "Adaptive" in resonant earthed systems, except when protected feeders are overcompensated by distributed coils. In such a case, *Operating Quantity* should be set to "Resistive".

Setting *Operating Quantity* to "Adaptive" enables secure and dependable directional determination in compensated networks, which is also valid when the compensation coil is switched off and the network becomes unearthed. In case of an unearthed network, the minimum operate current (settings *Min Forward Operate Current* and *Min Reverse Operate Current*) is automatically compared to the amplitude of $\overline{I_{0\ stab}^{1}}$. In case of restriking earth faults, harmonics created by the fault type make the accumulated sum admittance phasor behave as in case of an unearthed network. Therefore, operation can be achieved without the need for resistive part of $\overline{I}^{1}_{0\,stab}$. This also means that in compensated networks during earth faults with rich harmonic content in residual quantities, operation can be achieved without the parallel resistor of the centralized compensation coil.

When *Operating Quantity* is set to "Resistive", settings *Min Forward Operate Current* and *Min Reverse Operate Current* are compared to the resistive component of $\overline{I}^{1}_{0\,stab}$ in the whole defined operate sector (see Figure 74).

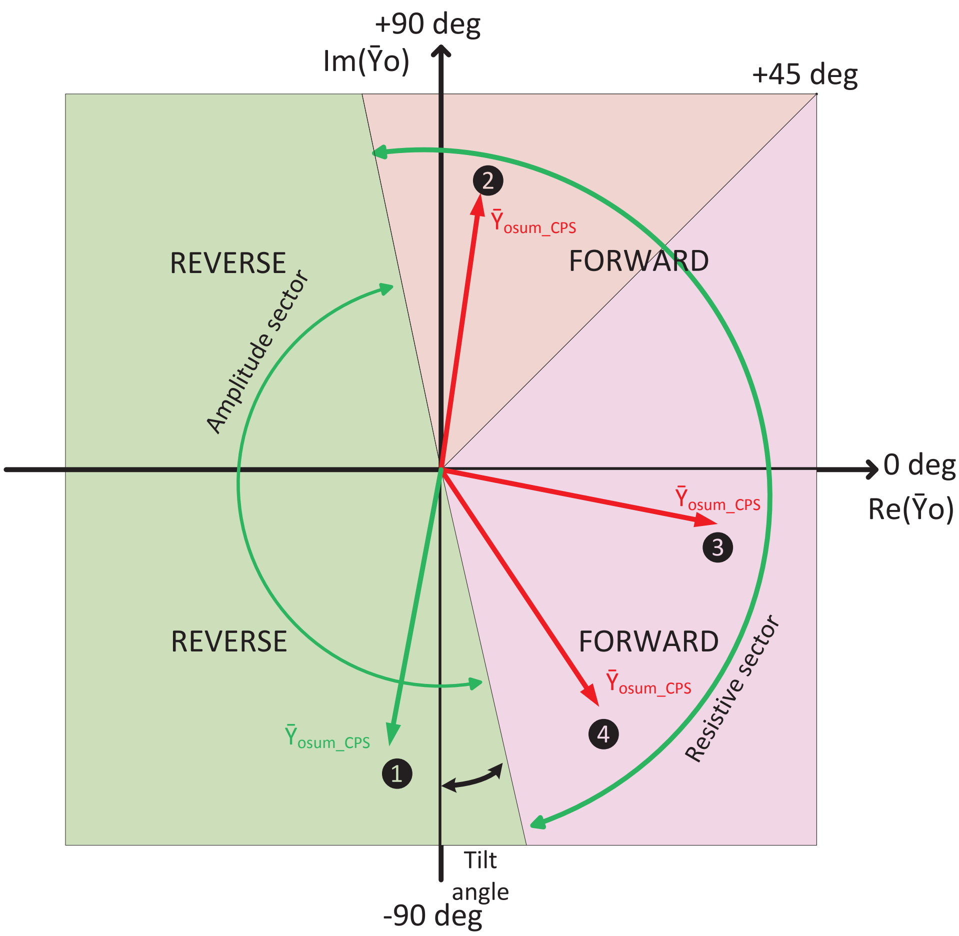

Figure 74: Illustration of amplitude and resistive current sectors when directional mode is set to "Forward" and setting operating quantity = "Resistive"

The resistive mode is valid for resonant earthed networks and high-resistance earthed systems, but not in case of unearthed networks. The resistive mode must be selected when there is a risk of local overcompensation of a protected feeder, that is, when the earth-fault current is compensated with distributed compensation coil and their inductive current exceeds the amount of capacitive current produced by the phase-to-earth capacitance of the feeder.

In compensated networks, where distributed compensation coils are also used to compensate earth-fault current, setting *Operating Quantity* should be set to "Resistive". This enables secure and dependable directional determination also in case of local overcompensation where the earth-fault current produced by the healthy feeder can become inductive.

When *Operating Quantity* is set to "Amplitude", settings *Min Forward Operate Current* and *Min Reverse Operate Current* are compared to the amplitude of $\overline{I}^{1}_{0\ stab}$ in the whole defined operate sector (see Figure 75). This selection can be used in unearthed networks.

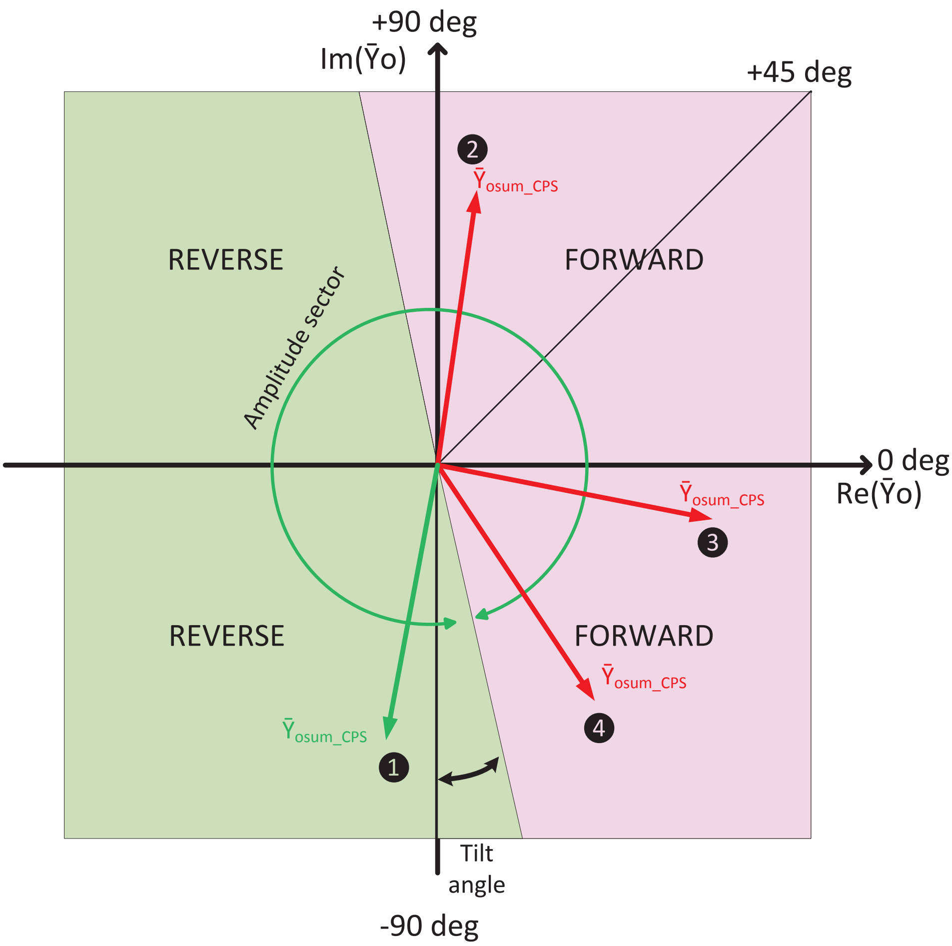

Figure 75: Illustration of amplitude and resistive current sectors when directional mode is set to "Forward" and setting operating quantity = "Amplitude"

If the “Adaptive” or “Resistive” operating quantity is selected, setting *Min Forward Operate Current* should be set to a value less than $p \cdot IR_{tot}$.

IR_{tot} is the total resistive earth-fault current of the network corresponding to the resistive current of the parallel resistor of the coil and the network losses of the system (typically in order of 1…5% of the total capacitive earth-fault current of the network).

p is the security factor (0.5…0.7).

This setting should be set based on the total resistive earth-fault current of the network including the parallel resistor of the coil and the network losses. It must be set to a value, which is lower than the total resistive earth-fault current to enable dependable operation.

For example, if the resistive current of the parallel resistor is 10 A (at primary voltage level), then a value of 0.5 · 10 A = 5 A could be used. If *Operating Quantity* is set to "Adaptive", the same setting value is also applicable if the coil is disconnected and the network becomes unearthed. In this case, the current magnitude supervision is automatically based on the amplitude of $\overline{I}^{1}_{0\,stab}$). The selected setting value must never exceed the ampere value of the parallel resistor to allow the operation of the faulted feeder. In case of a smaller ampere value of a parallel resistor, for example 5 A, the recommended security factor should be larger, for example 0.7.

If *Operating Quantity* is set to "Amplitude", the set minimum operate current threshold (settings *Min Forward Operate Current* and *Min Reverse Operate Current*) should be selected based on the capacitive earth-fault current values produced by the background network in case of a solid earth fault with a security margin.

The main task of the current magnitude supervision is to secure the correct directional determination of an earth fault, so that only the faulty feeder is disconnected or alarmed. Therefore, the threshold values should be selected carefully and not set too high as this can inhibit the disconnection of the faulty feeder.

Transient detector

The transient detector module is used for detecting transients in the residual current and residual voltage signals. When the number of detected transients equals or exceeds the *Peak Counter Limit* setting (without the function being reset, depending on the drop-off time set with the *Reset delay time* setting), the `MFAPSDE_InEF` output is activated over GOOSE. This indicates the detection of intermittent earth fault in the network. The operation of transient detector is illustrated in Figure 76.

Several factors, such as the fault moment on the voltage wave, fault location, fault resistance and the parameters of the feeders and the supplying transformers, affect the magnitude and frequency of fault transients. If the fault is permanent (non-transient) in nature, only the initial fault transient in current and voltage can be measured, whereas the intermittent fault creates repetitive transients. The practical sensitivity of transient detection is limited to approximately few hundreds of ohms of fault resistance. Therefore, the application of transient detection is limited to low ohmic earth faults.

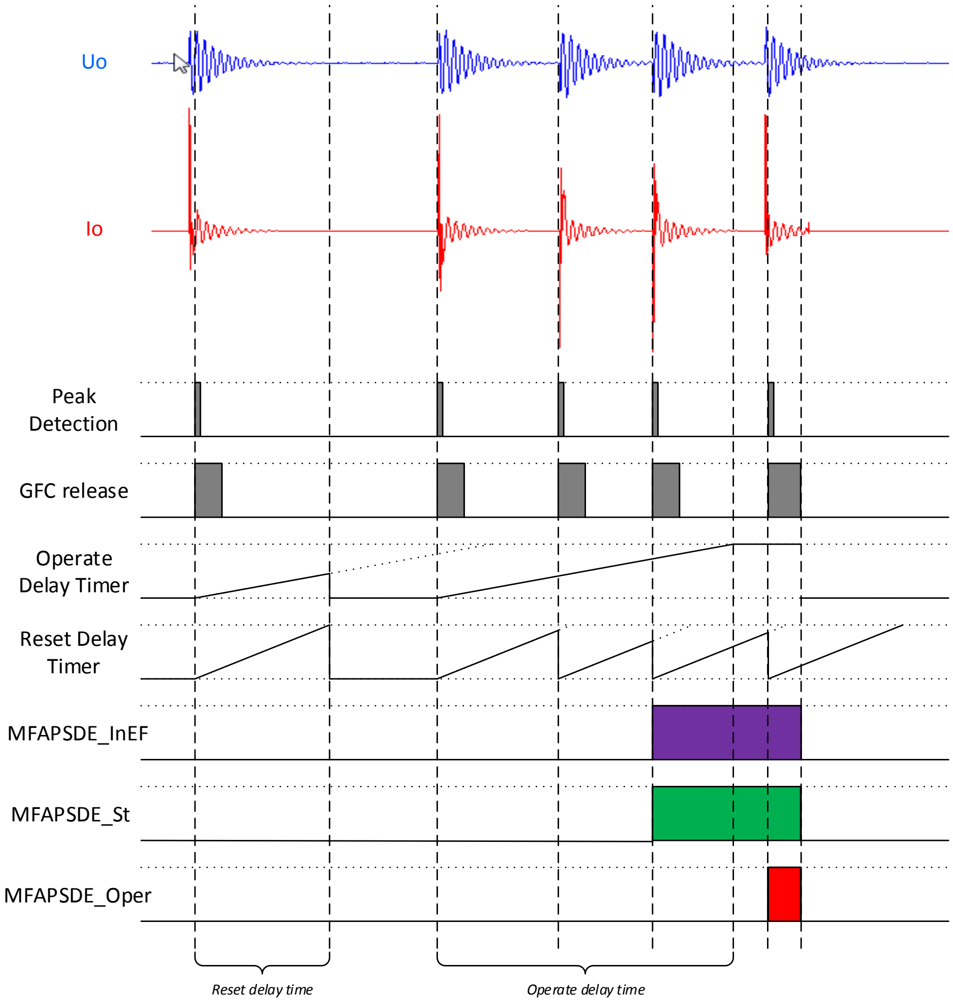

Figure 76: Example of operation of Transient detector: indication of detected detection of intermittent earth fault by MFAPSDE_InEF output (setting Peak Counter Limit = "3")

Operation logic

Operation of MFAPSDE is applicable to all kinds of earth faults in unearthed and compensated networks. It is intended to detect all kinds of earth faults regardless of their type (transient, intermittent, permanent, high or low ohmic). The *Voltage start value* setting defines the basic sensitivity of the MFAPSDE function.

The operate timer is started in the following conditions.

- Earth fault is detected by the General fault criteria (GFC).
- Fault direction equals the *Directional mode* setting.
- If the *Power direction logic* setting is set to “Enable”, the active power flow direction must equal the *Directional mode* setting.
- Estimated stabilized fundamental frequency residual current exceeds the set minimum operate current level (forward direction *Min Forward Operate Current* and reverse direction *Min Reverse Operate Current*), which is applied in current magnitude threshold supervision, and which is further defined with setting *Operating Quantity*. Available options are "Adaptive", "Amplitude" and "Resistive".

When the above four conditions are satisfied, the `MFAPSDE_St` output is activated once *Start Delay Time* has elapsed. `MFAPSDE_Oper` output activates after *Operate delay time* has elapsed. Reset timer is started if any of the above four conditions is not valid. In case the fault is transient and self-extinguishing, `MFAPSDE_St` output stays active until the elapse of reset timer (*Reset Delay Time*). After the `MFAPSDE_Oper` output activation, `MFAPSDE_St` and `MFAPSDE_Oper` outputs are immediately reset, if any of the above four conditions are not valid. In addition, the `MFAPSDE_OpFw` and `MFAPSDE_OpRe` outputs are activated based on the fault direction.

The start and operate of fault are also available as GOOSE outputs `MFAPSDE_St` and `MFAPSDE_Oper`.

Output `MFAPSDE_Oper` is configured to LED 8 of the SiM8F module. The LED turns ON when this signal becomes high. The LED color depends on setting *Directional mode* of the MFAPSDE function. The LED is green for forward setting and red for reverse setting.

If the detection of temporary earth faults is not desired, the activation of `MFAPSDE_St` output may be delayed with the *Start Delay Time* setting. The same setting can also be used to avoid restarting of the function during long lasting post-fault oscillations, if time constants of post-fault oscillations are very long (network losses and thus Low damping).

The Fwd/Rev requirement affects the behavior of MFA panel LED, ACT output and WHMI as defined in Table 79.

Table 79: Behavior of MFA panel LED, ACT output and WHMI status for various fault conditions

Sl.No	PCM600 setting	Fault direction	ACT outputs				SIM8F panel LED	WHMI			Remarks
			Start	Operate	OpFwd	OpRev		Start	Operate	Direction	
1	Forward	Forward	Yes	Yes	Yes	No	Green	ON	ON	Forward	
2		Reverse	No	No	No	Yes	-	-	-	Unknown	
3		Reverse with previous forward[1)]	No	No	No	Yes	Green (Flashing)	Latched since a forward fault occurred in prior		Reverse	WHMI direction is updated with instantaneous value since Str and Op are latched.
4	Reverse	Forward	No	No	Yes	No	-	-	-	Unknown	
5		Reverse	Yes	Yes	No	Yes	Red	ON	ON	Reverse	
6		Forward with previous reverse	No	No	Yes	No	Red (Flashing)	Latched since a reverse fault occurred in prior		Forward	WHMI direction is updated with instantaneous value since Str and Op are latched.

1) In the third case, start and operate are latched in the WHMI because of a forward fault. If the fault direction changes before the previous fault is cleared, the WHMI shows the direction as reverse since its direction variable is updated with the latest condition in SIM and start and operate are not cleared as they are latched. In the second case, the WHMI shows Unknown direction because it ignores the direction information if start and operate are not triggered.

To keep the operate timer active between current spikes during intermittent earth fault, *Reset delay time* should be set to a value exceeding the maximum expected time interval between fault spikes (obtained at full resonance condition). The recommended value is at least 300 ms.

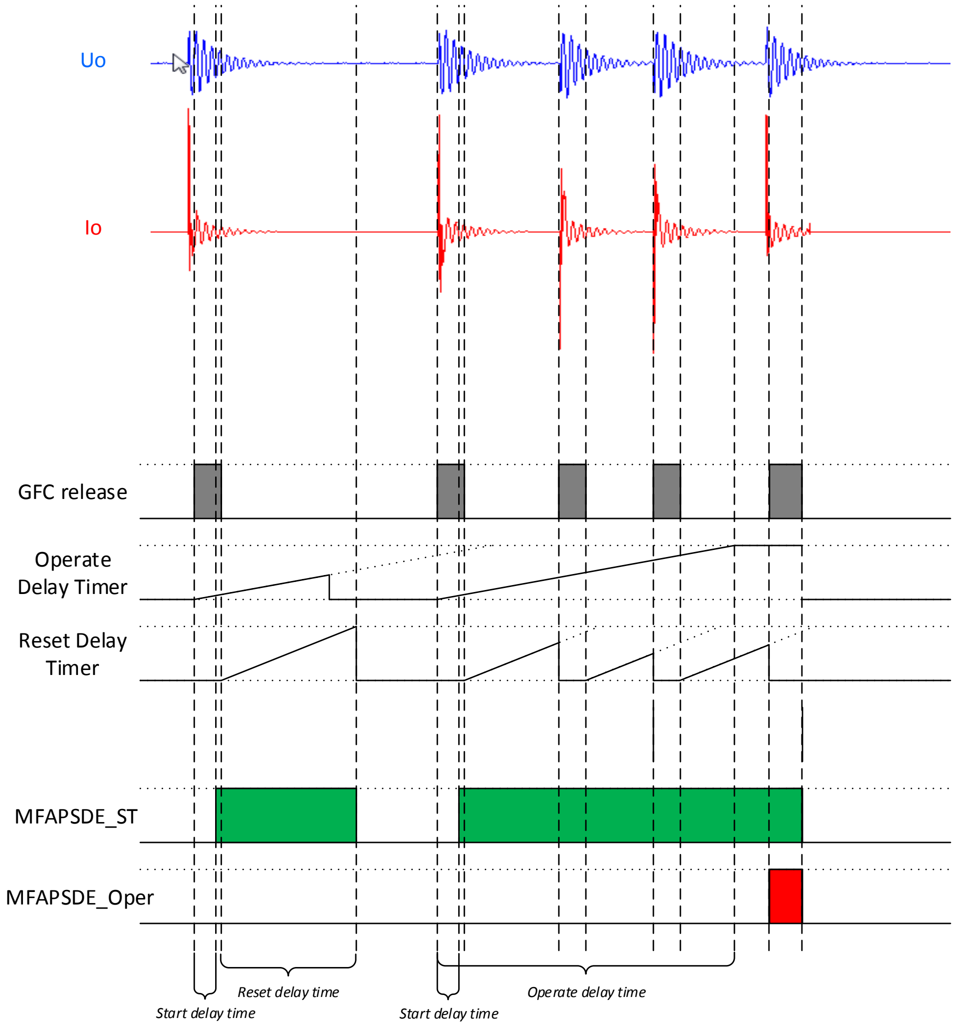

Figure 77: Operation of function

Timer

If the detected fault direction is opposite to the set directional mode and GFC release is active, `MFAPSDE_ReEF` output is activated once *Start delay time* has elapsed. Reset timer is activated at the falling edge of General Fault Criterion release, that is, when zero-sequence voltage falls below *Voltage start value*. `MFAPSDE_ReEF` is reset once the reset delay time elapses. `MFAPSDE_ReEF` is also available as a GOOSE output. If the *Power direction logic* setting is set to “Enable”, the active power flow direction must be opposite to the set directional mode to activate `MFAPSDE_ReEF`.

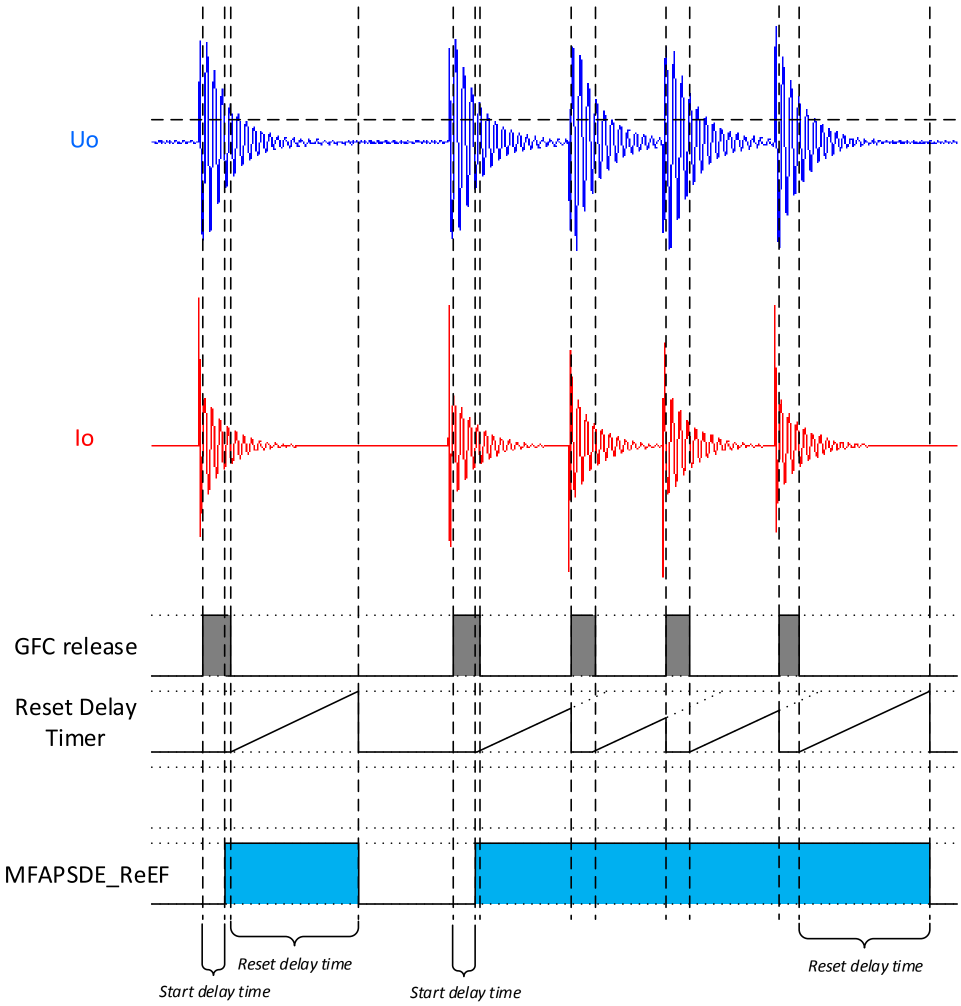

Figure 78: Activation of MFAPSDE_EF output (indication that the fault is located opposite to set operate direction)

Signals

Table 80: MFAPSDE Output signals

Name	Type	Description
MFAPSDE_Oper	Boolean	Operate signal
MFAPSDE_St	Boolean	Start signal
MFAPSDE_ReEF	Boolean	Signal for EF to indicate opposite fault direction
MFAPSDE_InEF	Boolean	Intermittent earth-fault indication
MFAPSDE_OpFw	Boolean	Operate in forward direction
MFAPSDE_OpRe	Boolean	Operate in reverse direction

Settings

Table 81: MFAPSDE Settings

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Off/On
Power direction logic	Disable Enable	-	-	Enable	Power direction logic
Peak Counter Limit	3...20	-	-	3	Peak counter limit for intermittent (restriking) EF detection
Operating Quantity	Adaptive Amplitude Resistive	-	-	Adaptive	Operating quantity selection
Voltage Start Value	500...10000	V	1	500	Voltage start value
Operate Delay Time	60...60000	ms	1	500	Operate delay time
Directional Mode	Forward Reverse	-	-	Forward	Directional mode
Tilt Angle	5...20	Deg	1	10	Characteristics tilt angle
Reset Delay Time	0...60000	ms	1	500	Reset delay time
Start Delay Time	30...60000	ms	1	30	Start delay time
Min Forward Operate Current	1.0...20.0	A	0.1	1	Minimum operate current in forward direction
Min Reverse Operate Current	1.0...20.0	A	0.1	1	Minimum operate current in reverse direction

Table 82: MFAPSDE Technical data

Characteristic	Value
Operation accuracy	At frequency f = f_n ±5% in the range of 480 V...9.6 kV ±0.5% in the range of 9.6...28.8 kV
Operate time accuracy	±1.0% of the set value or ±20 mS

6.1.6.6 Voltage presence indication

Voltage presence indication PHSVPR

Identification

Description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Voltage presence indication	PHSVPR	PHSVPR	PHSVPR

Functionality

The voltage presence indication function PHSVPR supervises the voltage presence status. The function is used for indicating the voltage presence status of a load break switch or a circuit breaker.

Operation principle

The *Operation setting* is used to enable or disable the function. The corresponding parameter values are “On” and “Off”.

The operation of PHSVPR can be described by using a module diagram. All modules in the diagram are explained in the next sections.

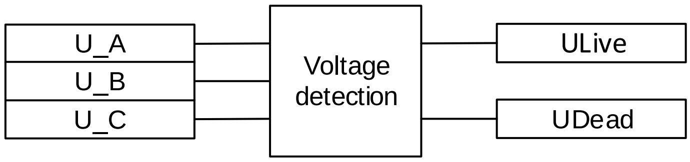

Figure 79: Functional module diagram

Voltage detector

This module supervises phase-to-earth voltage. The *Alive Phase Supervision* and *Dead Phase Supervision* settings define which phase or phases are monitored for voltage presence and voltage absence respectively. The measured phase-to-earth voltages are compared with the threshold settings.

If the measured phase-to-earth voltage remains above the set *Voltage Live Value* for 1 second for the phases defined under *Alive Phase Supervision*, the `PHSVPR_ULive` output activates indicating the voltage presence. Similarly, if the measured phase-to-earth voltage remains below the set *Voltage Dead Value* for 1 second for the phases defined under *Dead Phase Supervision*, the `PHSVPR_UDead` output activates indicating voltage absence.

However, if the phase-to-earth voltage for the phase under supervision drops below the set *Voltage Live Value* or rises above the *Voltage Dead Value*, outputs `PHSVPR_ULive` and `PHSVPR_UDead` are deactivated.

The hysteresis is used for preventing unnecessary oscillations if the input signal varies slightly above or below the threshold setting. After leaving the hysteresis area, the start condition has to be fulfilled again and it is not sufficient for the signal to only return back to the hysteresis area. The hysteresis setting is not freely configurable.

The activation of `PHSVPR_ULive` is indicated with LED 8 of the SIM8F module in green color whereas the activation of `PHSVPR_UDead` is indicated with the same LED 8 of the SIM8F module in red color.

Signals

Table 83: PHSVPR Output signals

Name	Type	Description
PHSVPR_ULive	Boolean	Indicating voltage presence
PHSVPR_UDead	Boolean	Indicating voltage absence

Settings

Table 84: PHSVPR Settings

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Off/On
Alive Phase Supervision	1 out of 3 2 out of 3 3 out of 3	-	-	1 out of 3	Number of phases required for voltage presence detection
Dead Phase Supervision	1 out of 3 2 out of 3 3 out of 3	-	-	3 out of 3	Number of phases required for voltage absence detection
Voltage Live Value	300…25000	V	1	6000	Limit for phase to neutral voltage presence detection
Voltage Dead Value	300…25000	V	1	300	Limit for phase to neutral voltage absence detection

Table 85: PHSVPR Technical data

Characteristic	Value
Operation accuracy	At frequency $f = f_n$ ±5% in the range of 480 V...9.6 kV ±0.5% in the range of 9.6...28.8 kV

6.1.6.7 Negative-sequence overcurrent indication NSPTOC

Identification

Description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Negative-sequence overcurrent protection	NSPTOC	I2>	46

Functionality

The negative-sequence overcurrent protection function NSPTOC is used to increase sensitivity to detect single-phase and phase-to-phase faults or unbalanced loads due to, for example, broken conductors or unsymmetrical feeder voltages.

NSPTOC can also be used to detect broken conductors.

The operating time characteristic is according to the definite time (DT).

Operation principle

The *Operation* setting is used to enable or disable the function. The corresponding parameter values are "On" and "Off".

The operation of NSPTOC can be described with a module diagram. All the modules in the diagram are explained in the next sections.

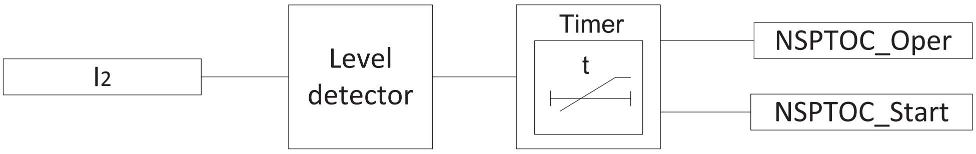

Figure 80: Functional module diagram

Level detector

The measured negative-sequence current is compared to the set *Start Value*. If the measured value exceeds the set *Start Value*, Level detector activates the Timer module.

Timer

Once activated, Timer activates the `NSPTOC_Start` output. When the operation time has reached the value of *Operate Delay Time*, the `NSPTOC_Oper` output is activated.

Signals

Table 86: NSPTOC Input signals

Name	Type	Default	Description
I_2	SIGNAL	0	Negative phase sequence current

Table 87: NSPTOC Output signals

Name	Type	Description
NSPTOC_Start	BOOLEAN	General start of function
NSPTOC_Oper	BOOLEAN	General operate of function

Settings

Table 88: NSPTOC Settings

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Off/On
Start Value	4...1000	A	1	12	Start value
Reset Delay Time	0...60000	ms	5	20	Reset delay time
Operate Delay Time	40…200000	ms	1	40	Operate delay time

From RIO600 Ver.1.8.3, SIM8F Ver.1.3.3 and SIM4F Ver.1.0.3 onwards, NSPTOC inputs and setting values are dependent on the *Nominal current* setting parameter. See Chapter Operating parameter settings of SIM8F module.

Table 89: NSPTOC Technical data

Characteristic	Value
Operation accuracy	Depending on the nominal frequency of the current measured: $f = f_n$ Current: ±1.5% of the set value or ±0.02 A I_{Fault} = 2 × set value = <36 ms I_{Fault} = 10 × set value = <30 ms
Operate time accuracy	±1.0% of the set value or ±20 ms

6.1.6.8 Fuse failure supervision SEQSPVC

Identification

Description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Fuse failure supervision	SEQSPVC	FUSEF	60

Functionality

The fuse failure supervision function SEQSPVC is used to block the voltage-measuring functions when failure occurs in the secondary circuits between the voltage transformer (or combi sensor or voltage sensor) and the protection relay to avoid malfunctions of the voltage protection functions.

SEQSPVC has two algorithms, a negative sequence-based algorithm and a delta current and delta voltage algorithm.

A criterion based on the delta current and the delta voltage measurements can be activated to detect three-phase fuse failures which usually are more associated with the voltage transformer switching during station operations.

Operation principle

The *Operation* setting is used to enable or disable the function. The corresponding parameter values are "On" and "Off".

The operation of SEQSPVC can be described with a module diagram. All modules in the diagram are explained in the next sections.

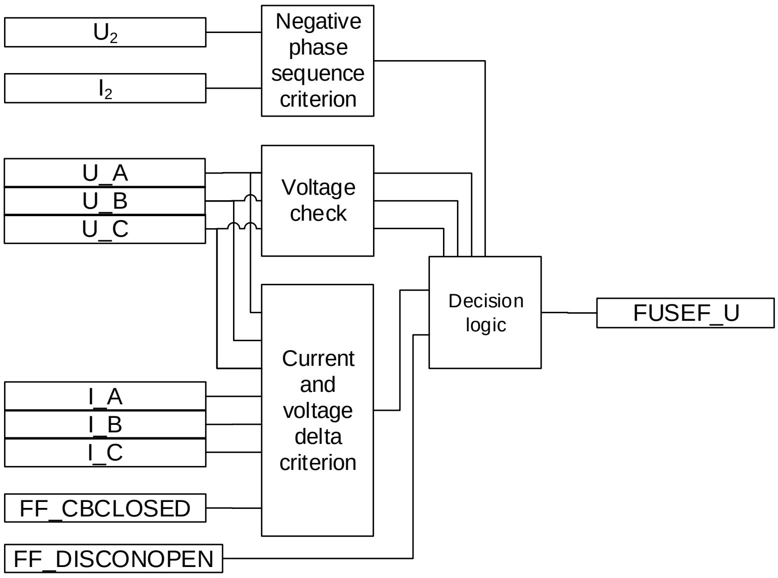

Figure 81: Functional module diagram

Negative phase-sequence criterion

A fuse failure based on the negative-sequence criterion is detected if the measured negative-sequence voltage exceeds the set *Neg Seq Voltage Lev* value and the measured negative-sequence current is below the set *Net Seq Current Lev* value. The detected fuse failure is reported to the Decision logic module.

Voltage check

The module makes a phase-specific comparison between each voltage input and the *Seal in Voltage* setting. If the input voltage is lower than the setting, the corresponding phase is reported to the Decision logic module.

Current and voltage delta criterion

The delta function can be activated by setting the *Change Rate Enable* parameter to "True". Once the function is activated, it operates in parallel with the negative sequence-based algorithm. The current and voltage are continuously measured in all three phases to calculate:

- Change of voltage dU/dt
- Change of current dI/dt

The calculated delta quantities are compared to the respective set values of the *Current Change Rate* and *Voltage Change Rate* settings.

The delta current and delta voltage algorithms detect a fuse failure if there is a sufficient negative change in each phase separately. This is performed when the circuit breaker is closed. Information about the circuit breaker position is connected to the `FF_CBCLOSED` input.

There are two conditions for activating the current and voltage delta function.

- The magnitude of dU/dt exceeds the corresponding value of the *Voltage Change Rate* setting and the magnitude of dI/dt is below the value of the *Current Change Rate* setting in any phase at the same time due to the closure of the circuit breaker (`FF_CBCLOSED` = TRUE).
- The magnitude of dU/dt exceeds the value of the *Voltage Change Rate* setting and the magnitude of dI/dt is below the *Current Change Rate* setting in any phase at the same time and the magnitude of the phase current in the same phase exceeds the *Min Op Current Delta* setting.

The first condition requires the delta criterion to be fulfilled in any phase at the same time as the circuit breaker is closed. Opening the circuit breaker at one end and energizing the line from the other end onto a fault could lead to an improper operation of SEQSPVC with an open breaker. If this is considered to be an important disadvantage, the `FF_CBCLOSED` input is to be connected to FALSE. In this way only the second criterion can activate the delta function.

The second condition requires the delta criterion to be fulfilled in one phase together with a high current for the same phase. The measured phase current is used to reduce the risk of a false fuse failure detection. If the current on the protected line is low, a voltage drop in the system (not caused by the fuse failure) is not followed by a current change and a false fuse failure can occur. To prevent this, the minimum phase current criterion is checked.

The fuse failure detection is active until the voltages return above the *Min Op Voltage Delta* setting. If a voltage in a phase is below the *Min Op Voltage Delta* setting, a new fuse failure detection for that phase is not possible until the voltage returns above the setting value.

Decision logic

The fuse failure detection output `FUSEF_U` is controlled according to the detection criteria or external signals.

Table 90: Fuse failure output control

Fuse failure detection criterion	Conditions and function response
Negative-sequence criterion	If a fuse is detected based on the negative-sequence criterion, the FUSEF_U output is activated.
	The FUSEF_U output signal is also activated if all the phase voltages are above the *Seal in Voltage* setting for more than 60 seconds and at the same time the negative-sequence voltage is above *Neg Seq Voltage Lev* for more than 5 seconds, all the phase currents are below the *Current Dead Lin Val* setting and the circuit breaker is closed, that is, FF_CBCLOSED is TRUE.
Current and voltage delta function criterion	If the current and voltage delta criterion detects a fuse failure condition, but all the voltages are not below the *Seal in Voltage* setting, only the FUSEF_U output is activated.
External fuse failure detection	The FF_DISCONOPEN input signal is supposed to be connected through a protection relay binary input to the N.C. auxiliary contact of the line disconnector. The FF_DISCONOPEN signal sets the FUSEF_U output signal to block the voltage-related functions when the line disconnector is in the open state.

It is recommended to always set *Enable Seal* in to "True". This secures that the blocked protection functions remain blocked until normal voltage conditions are restored if the fuse failure has been active for 5 seconds, that is, the fuse failure outputs are deactivated when the normal voltage conditions are restored.

Signals

Table 91: SEQSPVC Input signals

Name	Type	Default	Description
IA	SIGNAL	0	Phase A current
IB	SIGNAL	0	Phase B current
IC	SIGNAL	0	Phase C current
I_2	SIGNAL	0	Negative-sequence current
U_A	SIGNAL	0	Phase A voltage
U_B	SIGNAL	0	Phase B voltage
U_C	SIGNAL	0	Phase C voltage
U2	SIGNAL	0	Negative phase sequence voltage
FF_CBCLOSED	BOOLEAN	0 = False	Active when circuit breaker is closed
FF_DISCONOPEN	BOOLEAN	0 = False	Active when line disconnector is open

Table 92: SEQSPV Output signals

Name	Type	Description
FUSEF_U	BOOLEAN	General start of function

Settings

Table 93: SEQSPVC Settings

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Off/On
Neg Seq Current Lev	4…1000	A	1	12	Operate level of neg seq undercurrent element
Neg Seq Voltage Lev	300…10000	V	5	1500	Operate level of neg seq overvoltage element
Current Change Rate	4…1000	A	1	60	Operate level of change in phase current
Voltage Change Rate	300…10000	V	5	6000	Operate level of change in phase voltage
Change Rate Enable	FALSE TRUE	-	-	FALSE	Enabling operation of change based function
Min Op Voltage Delta	300…10000	V	5	7500	Minimum operate level of phase voltage for delta calculation
Min Op Current Delta	4…1000	A	1	40	Minimum operate level of phase current for delta calculation
Seal in Voltage	300…10000	V	5	7500	Operate level of seal-in phase voltage
Enable Seal In	FALSE TRUE	-	-	FALSE	Enabling seal in functionality
Current Dead Lin Val	4…1000	A	1	20	Operate level for open phase current detection

From RIO600 Ver.1.8.3 and SIM8F Ver.1.3.3 onwards, SEQSPVC inputs and setting values are dependent on the *Nominal current* and *Nominal current Io* setting parameters. See Chapter Operating parameter settings of SIM8F module.

Table 94: SEQSPVC Technical data

Characteristic	Value
Operate time accuracy	Depending on the nominal frequency of the current measured: f_n NPS function: Typically, 37 ms for U_{Fault} = 1.1 × set value Typically, 23 ms for U_{Fault} = 5 × set value Delta function: Typically, 35 ms for ΔU = 1.1 × set value Typically, 28 ms for ΔU = 5 × set value

6.1.6.9 Inrush detector INRPHAR

Identification

Description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Three-phase inrush detector	INRPHAR	3I2f>	68

Functionality

The three-phase inrush detector function INRPHAR is used to coordinate transformer inrush situations in distribution networks. Transformer inrush detection is based on the following principle: the output signal `BLK2H` is activated once the numerically derived ratio of second harmonic current I_2H and the fundamental frequency current I_1H exceeds the set value.

The operating time characteristic is according to the definite time (DT).

Operation principle

The *Operation* setting is used to enable or disable the function. The corresponding parameter values are "On" and "Off".

The operation of INRPHAR can be described with a module diagram. All modules in the diagram are explained in the next sections.

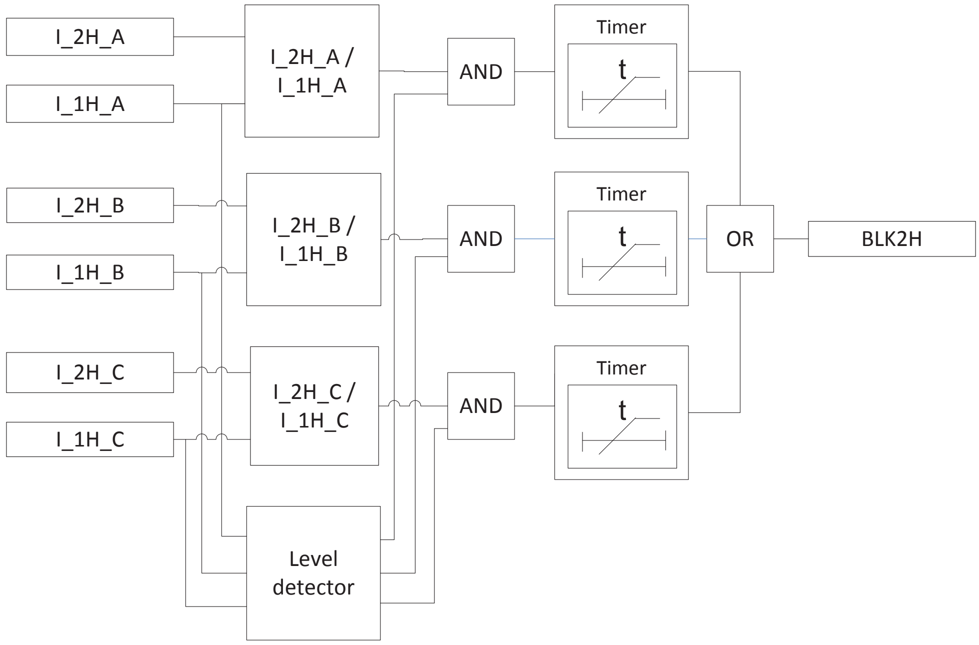

Figure 82: Functional module diagram

I_2H/I_1H

This module calculates the ratio of the second harmonic (I_2H) and fundamental frequency (I_1H) phase currents. The calculated value is compared to the set *Start Value*. If the calculated value exceeds the set *Start Value*, the module output is activated.

Level detector

The output of the phase-specific level detector is activated when the fundamental frequency current I_1H exceeds five percent of the nominal current.

Timer

Once activated, Timer runs until the set *Operate Delay Time* value. The time characteristics is according to DT. When the operation timer has reached the *Operate Delay Time* value, the `BLK2H` output is activated. After the timer has elapsed and the inrush situation still exists, the `BLK2H` signal remains active until the I_2H/I_1H ratio drops below the value set for the ratio in all phases, that is, until the inrush situation is over.

Signals

Table 95: INRPHAR Input signals

Name	Type	Default	Description
I_2H_A	SIGNAL	0	Second harmonic phase A current
I_1H_A	SIGNAL	0	Fundamental frequency phase A current
I_2H_B	SIGNAL	0	Second harmonic phase B current
I_1H_B	SIGNAL	0	Fundamental frequency phase B current
I_2H_C	SIGNAL	0	Second harmonic phase C current
I_1H_C	SIGNAL	0	Fundamental frequency phase C current

Table 96: INRPHAR Output signals

Name	Type	Description
BLK2H	BOOLEAN	Second harmonic based block

Settings

Table 97: INRPHAR Settings

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Off/On
Start Value	5...100	%	1	20	Start value
Reset Delay Time	0...60000	ms	5	100	Reset delay time
Operate Delay Time	20…60000	ms	1	500	Operate delay time

Table 98: INRPHAR Technical data

Characteristic	Value
Operation accuracy	Depending on the nominal frequency of the current measured: f_n Current: ±1.5% of the set value or ±0.02 A Ratio I2f/I1f measurement: ±5.0% of the set value
Operate time accuracy	±35 ms

6.1.6.10 UPS power failure monitoring

The Sensor Input Module (SIM8F) stores the measured and derived time related statistics information in its non-volatile memory. After the SIM8F module reboots or is powered up, the stored information is used to continue the updating of measured and derived statistics.

SIM8F aims at storing and recovering the information stored in its non-volatile memory. After a sudden loss of power supply to RIO600, data can be corrupted in the non-volatile memory of the SIM8F module. This leads to the loss of stored information. All time related information used for statistics is lost and statistics calculation restarts.

To avert the loss of data, the UPS power failure output signal from UPS should be connected to any one of the DIM8H/L input channels or the subscribed Boolean GOOSE data set element can be used as an indication for UPS power failure. When the binary input is detected by the DIM module or the Boolean value in the subscribed GOOSE data set element is set to "TRUE", it is considered as an indication of UPS power failure and SIM8F stores the statistics information in its non-volatile memory. This guarantees successful storage of statistics information in SIM8F module's memory and the statistics calculations resume from this point after a reboot. If UPS power failure indication indicates that the UPS power is healthy, SIM8F continues its normal operation.

The UPS power failure input channel for DIM8H/L module can be configured in Signal Matrix in PCM600.

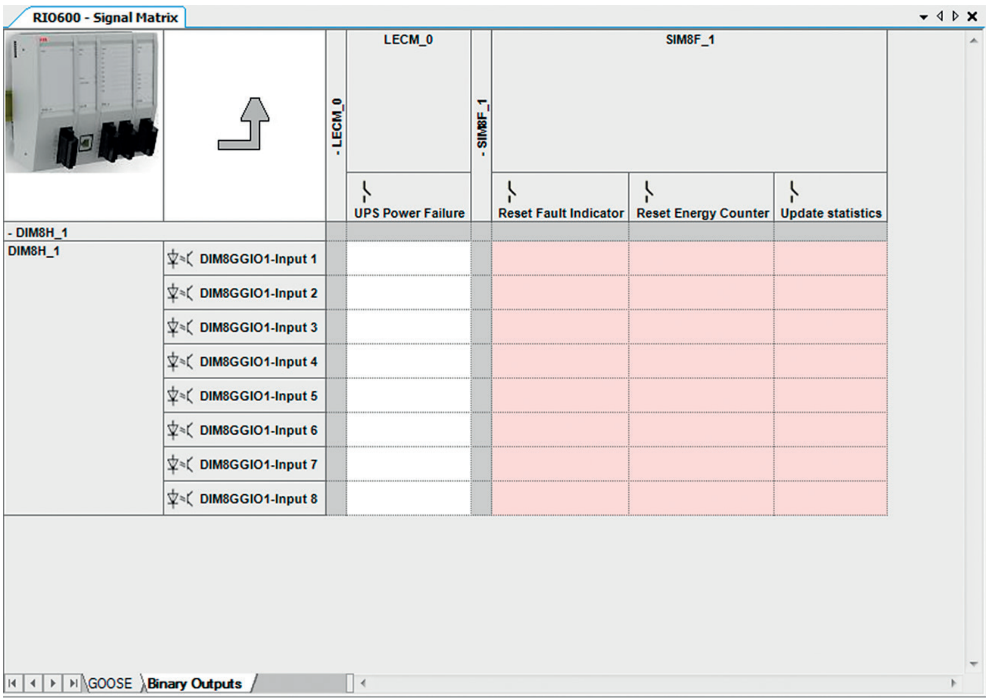

Figure 83: Configuring the UPS power failure input channel

6.1.6.11 Calibration

The SIM8F module is factory calibrated.

6.1.7 Operating parameter settings of SIM4F module

Table 99: Operating parameter settings of SIM4F module

Parameter name		Range	Unit	Step	Default	Description
Frequency		50 60	Hz	-	50 Hz	Rated system frequency
Nominal current		50…630	A	1	400	Nominal phase current[1)]
Nominal current Io		50…630	A	1	400	Nominal current – Io channel[1)]
Current sensor type		Rogowski coil LP CT	-	-	Rogowski coil	Selection of current sensor type[1)]
Rated sensor current	Phase CT	50...500	A	1	80	Rated primary current of sensor – Phase CT[1)]
	Neutral CT	50...500	A	1	80	Rated primary current of sensor – Neutral CT[1)]
Secondary output voltage	Phase CT	100...300	mV	1	150	Rated Secondary output voltage of sensor – Phase CT[1)]
	Neutral CT	100...300	mV	1	150	Rated Secondary output voltage of sensor – Neutral CT[1)]
Io signal sel		Calculated Io Measured Io	-	-	Calculated Io	Selection used for Io signal
Phase Rotation		ABC ACB	-	-	ABC	Phase rotation order
Sensor Correction Factors						
Phase A	Current Amplitude	0.7000…1.3000	-	0.0001	1	Amplitude correction factor for current sensor, phase A
	Current Phase	-3.0000… +3.0000	deg	0.0003	0	Phase correction factor for current sensor, phase A
Phase B	Current Amplitude	0.7000…1.3000	-	0.0001	1	Amplitude correction factor for current sensor, phase B
	Current Phase	-3.0000… +3.0000	deg	0.0003	0	Phase correction factor for current sensor, phase B

Table continues on next page

Parameter name		Range	Unit	Step	Default	Description
Phase C	Current Amplitude	0.7000…1.3000	-	0.0001	1	Amplitude correction factor for current sensor, phase C
	Current Phase	-3.0000…+3.0000	deg	0.0003	0	Phase correction factor for current sensor, phase C
Residual	Current Amplitude	0.7000…1.3000	-	0.0001	1	Amplitude correction factor for current sensor, residual
	Current Phase	-3.0000…+3.0000	deg	0.0003	0	Phase correction factor for current sensor, residual
LED reset time delay		1…1440	min	1	60	LEDs Reset delay time (incase no external signal received for resetting). This is applicable to OC fault detection & EF Protection LEDs.
Fault Indication Reset Method		Self Reset Method Definite Time	-	-	Definite Time	Self Reset Method: Flashing protection indication LED is reset immediately once the fault is cleared. Definite Time: Flashing protection indication LED is reset after the definite time set by LED reset time delay.
Update interval for Metering values		1...15	-	1	4	Update interval for metering values x500mSec

1) Feature available from RIO600 Ver.1.8.3 and SIM8F Ver.1.3.3 onwards

From RIO600 Ver.1.8.3 and SIM4F Ver.1.0.3 onwards, current sensor parameters (primary current and secondary voltage) are user-configurable. Configure the parameters based on the sensor used with the SIM8F module.

From RIO600 Ver.1.8.3 and SIM4F Ver.1.0.3 onwards, configure phase current sensor and neutral current sensor individually. If current sensors with different CT ratios are used for phase and neutral channels, configure them accordingly.

For versions preceding RIO600 Ver.1.8.3 and SIM4F Ver.1.0.3, *Rated sensor current* set as 80 A refers to 150 mV at 50 Hz and 180 mV at 60 Hz when 80 A is injected. Similarly, *Rated sensor current* set as 250 A refers to 150 mV at 50 Hz and 180 mV at 60 Hz when 250 A is injected.

6.1.7.1 Functions available in SIM4F

Table 100: Functions available in SIM4F

Function	IEC 61850		IEC 60617	IEC-ANSI
	Edition 1	Edition 2		
Measurement functions				
Three-phase current measurement	CMMXU	CMMXU	3I	3I
Residual current measurement	RESCMMXU	RESCMMXU	Io	Io
Current average and peak measurement	CMSTA	CAVMMXU CMAMMXU RCAVMMXU	-	-
Detection and indication functions				
Three-phase non-directional overcurrent fault detection	PHPTOC	PHPTOC	3I>	51P
Non-directional earth-fault detection	EFPTOC	EFPTOC	I0>	51N
Negative-sequence overcurrent protection	NSPTOC	NSPTOC	I2>	46
Three-phase inrush detector	INRPHAR	INRPHAR	3I2f>	68
Fault passage indicator	FPIPTOC	FPIPTOC	-	-

6.1.7.2 Measurement functions

Three-phase current measurement CMMXU

See Measurement functions.

Residual current measurement RESCMMXU

See Measurement functions.

Current peak measurement CMSTA

See Measurement functions.

6.1.7.3 Three-phase current fault detection

Three-phase non-directional overcurrent fault detection PHPTOC

See Three-phase non-directional overcurrent fault detection PHPTOC.

6.1.7.4 Earth-fault detection

Non-directional earth-fault detection EFPTOC

See Non-directional earth-fault detection EFPTOC.

6.1.7.5 Negative-sequence overcurrent indication NSPTOC

See Negative-sequence overcurrent indication NSPTOC.

6.1.7.6 Inrush detector INRPHAR

See Inrush detector INRPHAR.

6.1.7.7 Fault passage indicator FPIPTOC

Identification

Description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Fault passage indicator	FPIPTOC		

Functionality

The fault passage indicator function FPIPTOC provides selective Fault Passage Indicator (FPI) functionality for single-phase earth faults in high-impedance earthed networks, that is, in compensated, unearthed and high resistance earthed systems. It can be applied as single-phase earth fault FPI in case of overhead lines and underground cables, regardless of actual earth-fault type (continuous, transient or intermittent) or fault resistance value (low or high(er) ohmic).

FPIPTOC is based only on phase current measurements, thus it is applicable in cases where voltage measurements are not available. Current measurement can be done with conventional current transformers (CTs) or with sensors (Rogowski coils).

Accurate and reliable fault location information is the key for effective fault isolation and supply restoration. With the fault passage information from the FPIPTOC, the faulted line section can be quickly identified, and manual or automatic fault isolation and supply restoration can be initiated.

The operating time characteristic is according to the definite time (DT).

Operation principle

The *Operation* setting is used to enable or disable the function. The corresponding parameter values are "On" and "Off".

The operation of FPIPTOC can be described with a module diagram. All modules in the diagram are explained in the next sections.

FPIPTOC is based on DFT-phasor calculation.

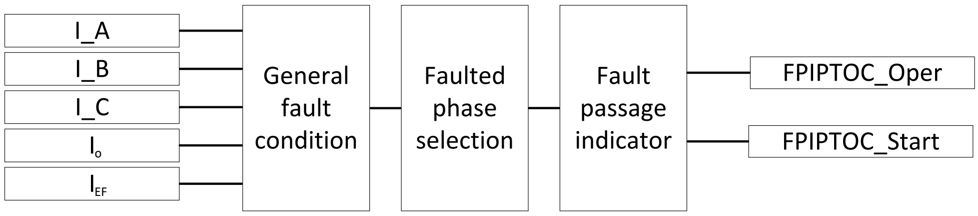

Figure 84: Functional module diagram

General fault criterion (GFC)

The General fault criterion (GFC) module monitors the presence of earth fault in the network. There are two fault detection methods evaluated in parallel based on residual current (I_o) and earth-fault current (I_{EF}).

Residual current amplitude I_o can be derived from phase currents as:

$I_o = 3 \cdot abs(\underline{I}_0) = 3 \cdot abs(I_A + I_B + I_C)/3$

where

$\underline{I}_0$ = Zero-sequence current phasor

In order to estimate single-phase earth-fault current, threefold negative-sequence current component due to earth fault is used (phase A as reference, a=cos(120°) + j·sin(120°), phase rotation: A-B-C). Estimated fundamental frequency earth-fault current amplitude can be derived from phase currents as:

$\underline{I}_{EF} = 3 \cdot \underline{I}_2 = \underline{I}_A + \underline{a}^2 \cdot \underline{I}_B + \underline{a} \cdot \underline{I}_C$

$I_{EF} = abs(\underline{I}_{EF})$

where

$\underline{I}_2$ = Negative-sequence current phasor

Earth-fault detection is based on monitoring the amplitude of residual current (I_o) and earth fault current (I_{EF}) and by comparing them to setting values, *Residual Start Cur* and *EF Start Cur*, respectively.

$I_o > Residual\ Start\ Cur$ (Equation 18)

I_{EF}>*EF Start Cur*

(Equation 19)

Setting *Residual Start Cur* must be set above the highest residual current value measured during the healthy state.

Setting *EF Start Cur* must be set above the highest threefold negative-sequence current value measured during the healthy state.

In order to provide reliable and selective earth-fault detection, the previously described earth-fault detection conditions, Equation 18 and Equation 19, must be fulfilled for the minimum duration as defined with setting *Start Delay Time*. The pick-up timer is, however, overridden, if simultaneously the residual current amplitude and the estimated earth-fault current amplitude exceeds setting *Inst Start Cur*:

I_o AND I_{EF}>*Inst Start Cur*

Setting *Inst Start Cur* should be set to high value, which indicates single-phase earth fault with abnormal high earth-fault current value. Such a condition could be due to, for example, malfunction of the Arc suppression Coil itself or the coil tuner. Setting value should be based on magnitude of the uncompensated earth fault current of the network. Setting *Inst Start Cur* is set lower value than the uncompensated earth fault current of the network with sufficient margin.

After an earth fault is detected by the General fault criterion module, calculation of 'delta' quantities for residual current and earth-fault current is conducted. Calculation of change in the amplitude of residual current (ΔI_o) and in the earth-fault current (ΔI_F) due to earth fault is done by comparing the present value of residual current phasor ($\underline{I}_o$) and earth fault current phasor ($\underline{I}_F$) to value *Revert Time* earlier and calculating its amplitude:

$\Delta I_o = abs(\underline{I}_o(t_{FLT}) - \underline{I}_o(t_{PRE\_FLT}))$

$\Delta I_{EF} = abs(\underline{I}_{EF}(t_{FLT}) - \underline{I}_{EF}(t_{PRE\_FLT}))$

where

t_{FLT} is the time during the earth fault

t_{PRE_FLT} is the time prior to the earth fault and it represents pre-fault or healthy-state conditions. This pre-fault operation point is determined based on user setting *Revert Time* as follows:

$t_{PRE\_FLT} = t_{FLT}(1) - \textit{Revert Time}$

where

$t_{FLT}(1)$ equals the first time instance, when the earth fault is internally detected by FPIPTOC, based on Equation 18 and Equation 19. Pre-fault time moment is at least *Revert Time* before earth fault occurrence moment.

In case of high(er) ohmic earth-fault, due to slow increase of Io and I_F magnitude, it may take several hundreds of milliseconds until setting thresholds are exceeded and an earth fault is detected after actual earth-fault ignition moment. Therefore, setting *Revert Time* should have sufficient big value, at least 300 ms.

Faulted phase selection

The Faulted phase selection module provides information about the faulted phase (A, B or C) during a single-phase earth fault.

The faulted phase is identified by evaluation of the following equations:

$$FAULTED\ PHASE\ A = abs\left(\frac{\Delta \underline{I}_B^1 - \Delta \underline{I}_C^1}{\Delta \underline{I}_A^1 - \frac{\left(\Delta \underline{I}_B^1 + \Delta \underline{I}_C^1\right)}{2}}\right)$$

(Equation 20)

$$FAULTED\ PHASE\ B = abs\left(\frac{\Delta \underline{I}_C^1 - \Delta \underline{I}_A^1}{\Delta \underline{I}_B^1 - \frac{\left(\Delta \underline{I}_C^1 + \Delta \underline{I}_A^1\right)}{2}}\right)$$

(Equation 21)

$$FAULTED\ PHASE\ C = abs\left(\frac{\Delta \underline{I}_A^1 - \Delta \underline{I}_B^1}{\Delta \underline{I}_C^1 - \frac{\left(\Delta \underline{I}_A^1 + \Delta \underline{I}_B^1\right)}{2}}\right)$$

(Equation 22)

where

$\Delta \underline{I}_A = \underline{I}_A(t_{FLT}) - \underline{I}_A(t_{PRE\_FLT})$ = change of phase A current phasor due to earth fault

$\Delta \underline{I}_B = \underline{I}_B(t_{FLT}) - \underline{I}_B(t_{PRE\_FLT})$ = change of phase B current phasor due to earth fault

$\Delta \underline{I}_C = \underline{I}_C(t_{FLT}) - \underline{I}_C(t_{PRE\_FLT})$ = change of phase C current phasor due to earth fault

Faulted phase is identified by comparing the magnitudes of Equations 20 - 22. If Equation 20 has a minimum value, the faulted phase is A. If Equation 21 has a minimum value, the faulted phase is B. If Equation 22 has a minimum value, the faulted phase is C.

Actual implementation uses Cumulative Phasor Summing (CPS) calculation. This filtering method is especially advantageous during transient, intermittent and re-striking earth faults with dominantly non-sinusoidal or transient content. But it is equally valid during continuous (stable) earth faults. The concept of CPS is illustrated in the figure below.

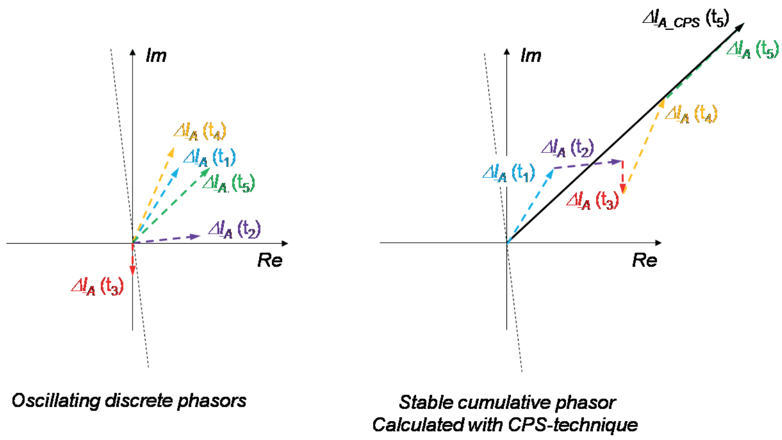

Figure 85: Principle of CPS

Cumulative phasor sum is the result of adding the values of the measured current phasors together in phasor format in chronological order during the fault. Using the discrete current phasors in different time instants (t1...t5), the corresponding accumulated current phasor is calculated:

$$\Delta \underline{I}_{A\_CPS}(t1) = \Delta \underline{I}_A\,(t1)$$

$$\Delta \underline{I}_{A\_CPS}(t2) = \Delta \underline{I}_A\,(t1)+\Delta \underline{I}_A\,(t2)$$

$$\Delta \underline{I}_{A\_CPS}(t3) = \Delta \underline{I}_A\,(t1)+\Delta \underline{I}_A\,(t2)+\Delta \underline{I}_A\,(t3)$$

$$\Delta \underline{I}_{A\_CPS}(t4) = \Delta \underline{I}_A\,(t1)+\Delta \underline{I}_A\,(t2)+\Delta \underline{I}_A\,(t3)+\Delta \underline{I}_A\,(t4)$$

$$\Delta \underline{I}_{A\_CPS}(t5) = \Delta \underline{I}_A\,(t1)+\Delta \underline{I}_A\,(t2)+\Delta \underline{I}_A\,(t3)+\Delta \underline{I}_A\,(t4)+\Delta \underline{I}_A\,(t5)$$

By dividing two CPS-based current quantities, CPS1/CPS2, a stable magnitude or phase angle estimate regardless of the fault type is obtained. This is demonstrated in Figure 86 and Figure 87.

The main advantage of the CPS method is that it can estimate stable magnitude and phase angle also during intermittent or re-striking earth faults. Accumulation of phasors is started when the presence of an earth fault in the network is confirmed and accumulation of phasors is reset when the fault condition is over, and after *Reset Delay Time* has elapsed.

Fault passage indicator

After the presence of the earth fault in the network and the faulted phase is confirmed, then it is the task to validate whether the fault current has flown though the measurement point of FPIPTOC. There are two criteria for detection of fault passage based on the theory of admittances valid for high impedance earthed network during a single-phase earth fault.

First condition for detection of fault passage is based on evaluation simultaneously the phase angles of three ratios of changes in phase current phasors (fundamental frequency) due to the earth fault:

$$FPI\_AtoB = angle\left(\frac{\Delta \underline{I}_A^1}{\Delta \underline{I}_B^1}\right)$$

(Equation 23)

$$FPI\_BtoC = angle\left(\frac{\Delta \underline{I}_B^1}{\Delta \underline{I}_C^1}\right)$$

(Equation 24)

$$FPI\_CtoA = angle\left(\frac{\Delta \underline{I}_C^1}{\Delta \underline{I}_A^1}\right)$$

(Equation 25)

where

$\Delta\underline{I}_A = \underline{I}_A(t_{FLT}) - \underline{I}_A(t_{PRE\_FLT})$ = change of phase A current phasor due to earth fault

$\Delta\underline{I}_B = \underline{I}_B(t_{FLT}) - \underline{I}_B(t_{PRE\_FLT})$ = change of phase B current phasor due to earth fault

$\Delta\underline{I}_C = \underline{I}_C(t_{FLT}) - \underline{I}_C(t_{PRE\_FLT})$ = change of phase C current phasor due to earth fault

Actual implementation uses CPS calculation. Accumulation of phasors is started when the presence of earth fault in the network is confirmed and accumulation of phasors is reset when fault condition is over, and after *Reset Delay Time* has elapsed.

The indication of fault passage is declared when:

- the maximum phase angle is above setting *Angle Sector* AND
- the minimum phase angle is below setting -*Angle Sector*

Additionally, the absolute values of maximum and minimum phase angles of Equations 23 - 25 in the faulted feeder should be equal. Their difference, that is, the phase angle offset (= maximum – minimum phase angle) must not exceed setting threshold *Angle Offset Sector*.

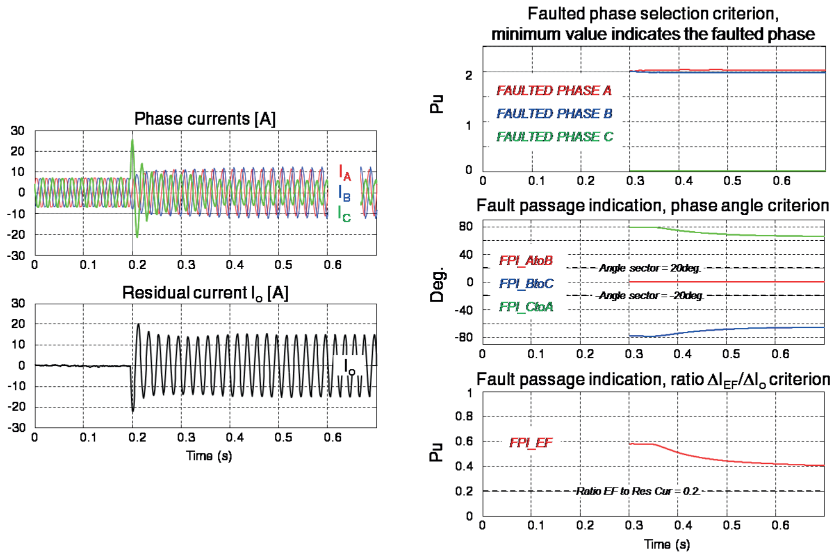

Figure 86: Stable phase C-to-earth fault current flowing through the measuring point of FPIPTOC in a compensated network

In Figure 86, the fault occurs at time 0.2 sec. On the right-hand side, the result of faulted phase selection (Equations 20 - 22) and fault passage indication (phase angles of Equations 23 - 25 and $\Delta I_{EF}/\Delta I_o$ ratio of Equation 26) are shown.

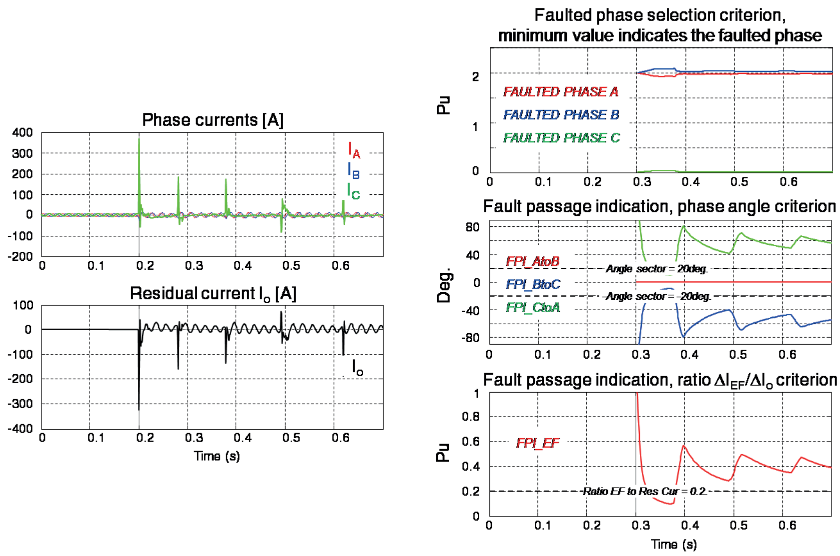

Figure 87: Re-striking phase C-to-earth fault current flowing through the measuring point of FPIPTOC in a compensated network

In Figure 87, the fault occurs at time 0.2 sec. On the right-hand side, the result of faulted phase selection (Equations 20 - 22) and fault passage indication (phase angles of Equations 23 - 25 and $\Delta I_{EF}/\Delta I_o$ ratio of Equation 26) are shown.

Typical setting for *Angle Sector* is 15…30 deg.

Typical setting for *Angle Offset Sector* is 45…65 deg.

Second condition for detection of fault passage is based on evaluation simultaneously ratio of change due to earth fault in earth-fault current to residual current (fundamental frequency):

$$FPI\_EF = abs\left(\frac{\Delta \underline{I}_{EF}^{1}}{\Delta \underline{I}_{o}^{1}}\right)$$

(Equation 26)

The indication of fault passage is declared when the current ratio of Equation 26 is above setting *Ratio EF to Res Cur*.

Actual implementation uses CPS calculation. Accumulation of phasors is started when the presence of earth fault in the network is confirmed and accumulation of phasors is reset when the fault condition is over, and after *Reset Delay Time* has elapsed.

Typical setting for *Ratio EF to Res Cur* is 0.2.

When all conditions for detection of fault passage are fulfilled, then FPIPTOC functions starts. This is indicated by activation of `FPIPTOC_Start` output. The `FPIPTOC_Oper` output is activated when *Operate Delay Time* has elapsed.

The `FPIPTOC_ Start` signal is prolonged with setting *Reset Delay Time*. Proper setting is 350...500 ms. In order to prevent unwanted function, reset between the current spikes during intermittent earth fault, *Reset Delay Time* should have typical value of 300…500 ms. After `FPIPTOC_Oper` is activated, then *Reset Delay Time* is no longer active.

Start criteria of general earth-fault detection have a user settable *Start Delay Time*, which is overridden in case instantaneous GFC-module start condition is fulfilled.

Raising edge of general earth fault criteria starts CPS calculation. Falling edge of general earth fault criteria resets CPS calculation.

Signals

Table 101: FPIPTOC Input signals

Name	Type	Default	Description
IA	SIGNAL	0	Phase A current, IA
IB	SIGNAL	0	Phase B current, IB
IC	SIGNAL	0	Phase C current, IC

Table 102: FPIPTOC Output signals

Name	Type	Description
FPIPTOC_Oper	BOOLEAN	Fault passage indication function is started.
FPIPTOC_Start	BOOLEAN	Fault passage indication function is operated.

Settings

Table 103: FPIPTOC Settings

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Off/On
Residual Start Cur	1…100	A	0.1	4	Residual current start threshold
EF Start Cur	1…100	A	0.1	4	Earth-fault current start threshold
Inst Start Cur	10…100	A	1	50	Earth-fault current threshold for instantaneous start condition
Angle Sector	10…90	Deg	1	15	Phase angle sector boundary threshold for fault passage
Operate Delay Time	100…60000	ms	10	500	Operate delay time
Ratio EF to Res Cur	0.1-1.0		0.1	0.1	Ratio earth-fault current to residual current
Start Delay Time	0...1000	ms	10	20	Start delay
Angle Offset Sector	10…90	Deg	1	45	Phase angle offset threshold for fault passage indication
Reset Delay Time	20…6000	ms	1	20	Reset Delay Time
Revert Time	300…1500	ms	10	300	Revert time for delta-calculation

In RIO600 Ver.1.8, the FPIPTOC setting values (*Residual Start Cur*, *EF Start Cur* and *Inst Start Cur*) are dependent on a fixed value (400 A RMS). In RIO600 Ver.1.8.2 and SIM4F Ver.1.0.2, these values are dependent on the *Rated sensor current* setting in SIM4F. From RIO600 Ver.1.8.3 and SIM4F Ver.1.0.3 onwards, the FPIPTOC settings and input values are dependent on the *Nominal current* and *Nominal current Io* settings in SIM4F. See Chapter Operating parameter settings of SIM4F module.

From RIO600 Ver.1.8.3 and SIM4F Ver.1.0.3 onwards, FPIPTOC input from Io channel is based on the *Io Signal sel* parameter setting. See Chapter Operating parameter settings of SIM4F module.

Table 104: FPIPTOC Technical data

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: $f = f_n$ ±1.5% of the set value
Start time accuracy	±1.0% of the set value or ±70 ms
Operate time accuracy[1)]	±1.0% of the set value or ±30 ms

1) f_n = 50 Hz, results based on statistical distribution of 1000 measurements

6.1.7.8 Calibration

The SIM4F module is factory calibrated.

6.1.8 Operating parameter settings of SCM module

Smart control module can be configured for different applications. Application types can be set during the configuration wizard operation. Because of solid state outputs, the module allows a direct making, carrying and breaking of motor and coil currents. This technical characteristic offers the capability to control three-position switches or two-position switches of, for example, gas-insulated switchgears, which requires a so called “4-4H bridge” in order to turn a DC motor in both directions.

6.1.8.1 Functions available in SCM

Table 105: Functions available in SCM

Function	IEC 61850		IEC 60617	IEC-ANSI
	Edition 1	Edition 2		
Supervision function				
Trip circuit supervision	TCSHSCBR/ TCSLSCBR	TCSHSCBR/ TCSLSCBR	TCS	TCM

6.1.8.2 Three-position earthing switch or two-position earthing switch or two-position disconnector switch or circuit breaker control application

The RIO600 smart control module is able to handle the following.

- Motor driven switches
- Three-position switch (combined earthing switch and disconnector switch)
- Two-position earthing switch
- Two-position disconnector switch
- Circuit breaker
- Interlocking rules to control coils

Each smart control module can handle one motor driven switch or one circuit breaker.

Table 106: Operation parameters for three-position earthing switch, two-position earthing switch, two-position disconnector switch or circuit breaker control application

Parameter name	Range	Unit	Default value	Description
Motor Parameters				
Motor start time out	0...32000	ms	0	Maximum time from Starting motor to definitely leave defined Start position
Motor braking	Not used/used		Not used	Motor braking
Motor $U_{nominal}$	24…250	VDC	110	Motor nominal voltage
Motor(s) duty cycle	1…100	%	100	Duty cycle to run motor(s)
Earthing switch parameters				
Earthing switch close time-out	0…32000	ms	25000	Maximum time from Earthing switch opened to Earthing switch closed
Earthing switch open time-out	0…32000	ms	25000	Max time from Earthing switch closed to Earthing switch opened
Disconnector parameters				
Disconnector close time-out	0…32000	ms	25000	Maximal time from Disconnector opened to Disconnector closed
Disconnector open time-out	0…32000	ms	25000	Maximal time from Disconnector closed to Disconnector opened
CB parameters				
Trip coil pulse time	1...500	ms	100	Pulse time for trip coil
				Pulse ends if start position leaved or end position reached
Closing coil pulse time	1...500	ms	100	Pulse time for closing coil
Table continues on next page				

Parameter name	Range	Unit	Default value	Description
				Pulse ends if start position leaved or end position reached
Input channels				
Debounce Time (Filter time)	5...4095	ms	10	This parameter is the debounce time for the input signal in ms.
Oscillation Upper Limit	2...63	Counts	63	This parameter is the oscillation suppression upper limit. The parameter value acts as the count for upper limit.
Oscillation Suppression Hysteresis	1...62	Counts	62	This parameter is the oscillation suppression hysteresis. The parameter value acts as the count for hysteresis.
Oscillation Time	0...4095	ms	4095	This parameter is the oscillation suppression time limit. The parameter value acts as the time window for the oscillation detection in ms. 0 means that no oscillation suppression is active.
Description			Digital Input 1...4	User defined channel name not exceeding 30 characters
Channel 1 Inversion	Non-inverted/inverted		Non Inverted	channel 1 input type: non-inverted/inverted
Channel 2 Inversion	Non-inverted/inverted		Non Inverted	channel 2 input type: non-inverted/inverted
Channel 3 Inversion	Non-inverted/inverted		Non Inverted	channel 3 input type: non-inverted/inverted
Channel 4 Inversion	Non-inverted/inverted		Non Inverted	channel 4 input type: non-inverted/inverted
Output channels				
Description			High speed output 1..4	User defined channel name not exceeding 30 characters

Interlocking rules for motor driven switch (earthing switch, disconnector)

When configured for motor driven switch control, the smart control module runs on different interlocking rules which helps the switchgear to function safely. It checks different stages of the motor based on different input signals and controls the operation of the motor. The panel and substation interlocking has to be handled by the connected protection and control device.

RIO600 ignores commands to operate the motor to its current position. For example, if the Disconnector is in the OPEN position when RIO600 receives an OPEN command, no motor operation is performed and the command is ignored.

Table 107: Interlocking rules for motor driven switches

Operation	Position of switch	Command allowed
	If Earthing switch is between OPEN and CLOSE positions (intermediate position) and the disconnector is in OPEN position	Open earthing switch
	If Disconnector is between OPEN and CLOSE positions (intermediate position) and the earthing switch is in OPEN position	Open disconnector
Close earthing switch	Earthing switch is in OPEN position and disconnector is in OPEN position	Allowed to CLOSE
Close disconnector	Disconnector is in OPEN position and earthing switch is in OPEN position	Allowed to CLOSE
Input status	Unexpected (wrong) position indication	Stop motor immediately

Interlocking rules for circuit breaker control

Smart control module configured for a circuit breaker application controls two double poled coils. The circuit breaker interlocking has to be realized inside the belonging protection and control device.

Table 108: Interlocking rules for circuit breaker control

Operation	Position of switch	Allowed state
CB Open	Circuit breaker ready	Close circuit breaker
CB Close	Circuit breaker close	No action

Irrespective of the circuit breaker's current position, if a command comes to an open circuit breaker, it will be always executed.

Binary input debounce time (filter time)

The filter time eliminates debounces and short disturbances on a binary input. The filter time is set for each binary input.

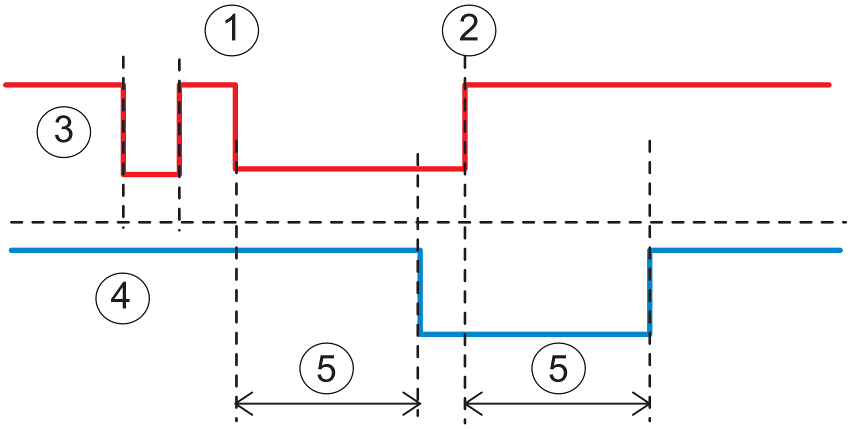

Figure 88: Binary input filtering

1	t_0
2	t_1
3	Input signal
4	Filtered input signal
5	Filter time

At the beginning, the input signal is at the high state, the short low state is filtered and no input state change is detected. The low state starts when the time t_0 exceeds the filter time, which means that the change in the input state is detected and the time tag attached to the input change is t_0. The high state starts when t_1 is detected and the time tag t_1 is attached.

Binary input inversion

When a binary input is inverted, the state of the input is TRUE (1) when no control voltage is applied to its terminals. Accordingly, the input state is FALSE (0) when a control voltage is applied to the terminals of the binary input.

LEDs and WHMI reflect the physical input signal present on the binary input terminal.

Oscillation suppression

Oscillation suppression is used to reduce the load from the system when a binary input starts oscillating. A binary input is regarded as oscillating if the number of valid state changes (= number of events after filtering) during configured time period (as per oscillation time parameter) is equal to or greater than the set oscillation level value. During oscillation, the binary input is blocked (the status is invalid) and an event is generated. The state of the input does not change when it is blocked, that is, its state depends on the condition before blocking.

The binary input is regarded as non-oscillating if the number of valid state changes during configured time period is less than the set oscillation level value minus the set oscillation hysteresis value. The oscillation hysteresis must be set lower than the oscillation level to enable the input to be restored from oscillation. When the input returns to a non-oscillating state, the binary input is deblocked (the status is valid) and an event is generated.

6.1.8.3 Generic four inputs and four high speed power outputs

Smart control module has four inputs with common return for a pair and four power outputs with common return for a pair. These channels can be used for generic purposes, for example, position indications or status information.

Table 109: Operation parameters for generic inputs and high-speed power outputs

Parameter name	Range	Unit	Default value	Description
Input channels				
Debounce Time (Filter time)	5...4095	ms	10	This parameter is the debounce time for the input signal in ms.
Oscillation upper limit	2...63	Counts	63	This parameter is the oscillation suppression upper limit. The parameter value acts as the count for upper limit.
Oscillation suppression hysteresis	1...62	Counts	62	This parameter is the oscillation suppression hysteresis. The parameter value acts as the count for hysteresis.
Oscillation time	0...4095	ms	4095	This parameter is the oscillation suppression time limit. The parameter value acts as the time window for the oscillation detection in ms. 0 means that no oscillation suppression is active.
Description			Digital input 1...4	User defined channel name not exceeding 30 characters.
Channel 1 Inversion	Non-inverted/inverted		Non-inverted	Channel 1 input type: non-inverted/inverted
Channel 2 Inversion	Non-inverted/inverted		Non-inverted	Channel 2 input type: non-inverted/inverted
Channel 3 Inversion	Non-inverted/inverted		Non-inverted	Channel 3 input type: non-inverted/inverted
Channel 4 Inversion	Non-inverted/inverted		Non-inverted	Channel 4 input type: non-inverted/inverted
Output channels				
Description			High speed output 1..4	User defined channel name not exceeding 30 characters.

Table continues on next page

Parameter name	Range	Unit	Default value	Description
Pulse length	10 to 65535	ms	10	The integer value in this parameter indicates the pulse length for the output channels in ms.
Signal type	Static/Pulse		Static	Output signal type: static/pulse
Output Channel 1 Enabled	Enabled/Disabled		Enabled	Output channel 1: enabled/disabled
Output Channel 2 Enabled	Enabled/Disabled		Enabled	Output channel 2: enabled/disabled
Output Channel 3 Enabled	Enabled/Disabled		Enabled	Output channel 3: enabled/disabled
Output Channel 4 Enabled	Enabled/Disabled		Enabled	Output channel 4: enabled/disabled
Output Channel 1 Inversion	Non-inverted/inverted		Non-inverted	Output channel 1: non-inverted/inverted
Output Channel 2 Inversion	Non-inverted/inverted		Non-inverted	Output channel 2: non-inverted/inverted
Output Channel 3 Inversion	Non-inverted/inverted		Non-inverted	Output channel 3: non-inverted/inverted
Output Channel 4 Inversion	Non-inverted/inverted		Non-inverted	Output channel 4: non-inverted/inverted

6.1.8.4 Trip circuit supervision TCSHSCBR/TCSLSCBR

Identification

Description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Trip circuit supervision	TCSHSCBR/ TCSLSCBR	TCS	TCM

Functionality

The trip circuit supervision function TCSHSCBR/TCSLSCBR supervises the control circuit of the circuit breaker. The invalidity of a control circuit is detected by using a dedicated input (Input 4) contact. The failure of a circuit is reported to the corresponding function block in the IED configuration.

When using one digital input, no extra wiring is required from the relay to the circuit breaker. An external resistor needs to be included for supervising the trip circuit in both closed and open positions of the circuit breaker.

The operating time characteristic is according to the definite time (DT). The function activate alarm after a predefined operating time and resets when the fault disappears.

Operation principle

The *Operation setting* is used to enable or disable the function. The corresponding parameter values are “On” and “Off”.

The operation of TCSLSCBR can be described by using a module diagram. All modules in the diagram are explained in the next sections.

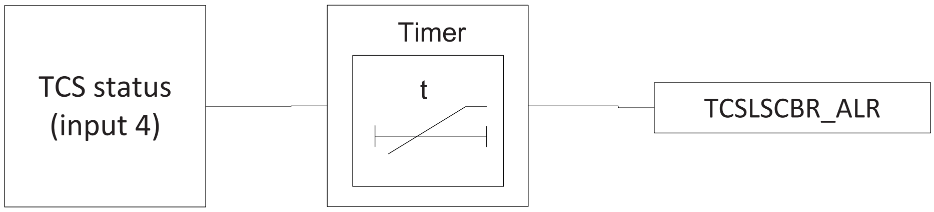

Figure 89: Functional module diagram

TCS status

This module receives the trip circuit status from binary input 4. A detected failure in trip circuit activates the timer.

Timer

Once activated, the timer runs until the set value of *Operate Delay Time* has elapsed. The time characteristic is according to DT. When the operation timer has reached the maximum time value, the `TCSLSCBR_ALR` output is activated. If a drop-off situation occurs during the operate time up counting, the reset timer is activated. If the reset timer reaches the value set by *Reset Delay Time*, the operation timer resets and the `TCSLSCBR_ALR` output is deactivated.

TCSHSCBR is available for high-voltage circuit breaker and TCSLSCBR for low-voltage circuit breaker configuration

Signals

Table 110: TCSHSCBR Output signals

Name	Type	Description
TCSHSCBR_ALR	Boolean	Alarm output

Table 111: TCSLSCBR Output signals

Name	Type	Description
TCSLSCBR_ALR	Boolean	Alarm output

Settings

Table 112: TCSHSCBR/TCSLSCBR settings

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Off / On
Operate Delay Time	20…300000	ms	1	3000	Operate delay time
Reset Delay Time	0…60000	ms	1	1000	Reset Delay Time

Table 113: TCSHSCBR/TCSLSCBR Technical data

Characteristic	Value
Operate time accuracy	±1.0% of the set value or ±20 ms

6.2 Test mode handling

Use PCM600 to set the device in test mode.

In the test mode, RIO600 publishes GOOSE messages with the test bit activated (bit 11 of quality byte, as per IEC 61850-8-1) in the quality data attribute of the corresponding data object. If RIO600 is configured for IEC 61850 Edition 1, the global test bit in the GOOSE frame header is also set to “TRUE”.

RIO600 detects the test bit in the received message and operates the output for the subscribed GOOSE messages.

Table 114: Test mode operation

Test mode in subscriber RIO600	Test mode in publisher IED	Output contact on subscriber RIO600 according to received data
Off	Off	Operate
On	Off	Not operate
Off	On	Not operate
On	On	Operate

When RIO600 is in the test mode, the Ready LED of the LECM module flashes.

RIO600 does not support Simulation mode of IEC61850 Edition 2.

6.3 Channel output value handling

The channel values of the binary output modules follow the value in the subscribed GOOSE message if the output is connected to the subscribed data. In case of communication disturbances such as a broken Ethernet cable or GOOSE timeout, the output values are restored to default, that is, set to failsafe values. When designing the application, the failsafe value is “0” as the outputs are normally open contacts (NO). For example, the blocking signals are enabled and the interlocking is released in the failsafe state. Also, when RIO600 is powered off, the outputs go to the normal state, which is open (“0”).

For Analog Output Module (AOM4), in case of failsafe condition, the module continues to drive the old value. In case of power-off condition, the module drives 0 mA current.

6.4 Local/Remote mode

RIO600 can be set to Local/Remote mode using any of the binary input signals, GOOSE signal or through a Modbus command. The Local/Remote mode can be instantiated using Signal Matrix tool. Different combinations are possible based on the Local/Remote setting.

Table 115: Local/Remote mode options

Local/ Remote mode	OR Logic	Local	Remote			
		Intermodule communication support (commands from DIM8)	Binary Goose subscribing	Binary Goose publishing	Binary Modbus write operations	Binary Modbus read operations
-	NO	YES	YES	YES	YES	YES
Remote	NO	YES	YES	YES	YES	YES
Local	NO	YES	NO	YES	NO	YES
-	YES	YES	YES	YES	N/A	N/A
Remote	YES	YES	YES	YES	N/A	N/A
Local	YES	YES	NO	YES	N/A	N/A

6.5 Time synchronization

RIO600 can be synchronized to an NTP time server or the time synchronization can be achieved using Modbus TCP client.

Time synchronization is used to synchronize the device's real time clock. Using time synchronization, RIO600 can show the correct time in its WHMI and time stamp the header and data events of GOOSE messages properly.

Time synchronization is not mandatory. The time stamp attribute is not included by default in GOOSE data sets.

RIO600 does not support DST and therefore the used time is always UTC in WHMI and events. When RIO600 uses the NTP server or Modbus client for time synchronization, the WHMI displays the real time from the time synchronization source.

6.5.1 SNTP time synchronization

RIO600 supports up to two SNTP servers (primary SNTP server and secondary SNTP server) for time synchronization. RIO600 uses only one of the SNTP servers at a time. The primary server is used mainly, whereas the secondary server is used (when configured) if the primary server cannot be reached. While using the secondary SNTP server, RIO600 tries to reach the primary server and switches back to the primary server if it is available. If both SNTP servers are offline, the event time stamps have a time invalid status and a warning is activated. RIO600 supports the NTP/SNTP version 4.

From RIO600 Ver.1.8.2 onwards, time synchronization requests are sent to the SNTP server based on the time synchcronization interval configured in Parameter Settings. *Time Synch Interval* has a minimum value of 15 s and a maximum of 10 hrs (36000 s). The time interval can be entered in steps of 15 (15, 30, 45...36000 seconds).

RIO600 supports T0 class performance for time tagging of events.

If the time sync source is not configured, LECM internal reference clock is used for RIO600 internal operation.

An increase in the time synchronization interval reduces the time synchronization accuracy. Thus, *Time Synch Interval* for SNTP is fixed at 15 seconds for applications, such as GOOSE, where the time synchronization accuracy is strictly required. The user-defined value is overridden if the RIO600 device is configured as a GOOSE Publisher. For applications, such as Modbus, where the time synchronization accuracy requirement is less strict, the time interval can be configured according to the user requirements.

6.5.2 Modbus time synchronization

RIO600 can be synchronized by Modbus TCP client. The Modbus client should send an unsigned 16-bit value range for setting the time value.

Modbus time synchronization can be used only if it is enabled in Parameter Setting through the configuration and the time synchronization source is made as Modbus or an exception code 4 is sent. The time synchronization registers can only be written with data within the valid range of each parameter. In case the data to be written is outside the valid range, time is not updated and an exception code 4 is sent to the master to indicate an error in writing to time registers. If master tries to poll for the time registers and read their data, the actual time stored in IED is reported.

The accuracy class is not guaranteed for time synchronization with Modbus commands.

Table 116: Time synchronization with Modbus commands

Modbus address (in decimal for 3X and 4X range)	Information	Scale factor	Data type	Valid range
8	Year	1	Unsigned 16	2000...9999
9	Month	1	Unsigned 16	1...12
10	Day	1	Unsigned 16	1...31
11	Hour	1	Unsigned 16	0...23
12	Minute	1	Unsigned 16	0...59
13	Seconds	1	Unsigned 16	0...59

6.6 GOOSE performance

RIO600 meets the horizontal communication performance criteria for protection purposes defined by IEC61850-5, device-to-device communication under 10 ms.

RIO600 also supports sending and receiving analog values using GOOSE messaging. In case of an mA/RTD input, transferring the event via GOOSE requires 250 ms. It takes 50 ms to drive the mA ouput signal in AOM after receiving the GOOSE command.

In case of SIM8F, the metering values are sent over GOOSE based on the set parameter *Update interval for Metering values*.

Section 7 Modbus TCP communication

7.1 Modbus TCP/IP

Modbus is a communication protocol developed by Modicon Company in 1970s. It was used originally for communication in PLCs and RTU devices but later the Modbus protocol has been used in a variety of different device applications.

The Ethernet based Modbus TCP/IP communication in this IED follows the specifications maintained by Modbus Organization. The Modbus communication reference guides can be downloaded from Technical Resources on www.modbus.org. RIO600 is designed to operate with a wide range of different Modbus masters and clients. The word "client" refers to the protocol master. RIO600 is referred to as "server" or a slave device. RIO600 can communicate with one Modbus protocol client at a time.

Modbus TCP can be used in parallel with IEC 61850 GOOSE.

7.1.1 Connection to client

In RIO600, it is possible to activate one Modbus protocol server instance. Modbus TCP server is activated by setting the *Modbus operation* parameter to "ON" and selecting Write to IED in PCM600. Modbus TCP can be used in parallel with the IEC 61850 GOOSE.

7.1.2 Protocol server attachment to a client

After protocol activation, RIO600 should be connected to the intended client. When the client makes a TCP connection, its IP address is checked. Protocol reservation is given to the client with this IP address. Modbus TCP client must use the Slave ID in its data requests to ensure responses from RIO600. The Slave ID is set through Parameter Setting in PCM600.

7.1.3 TCP/IP link

RIO600 operates as a ModbusTCP/IP server. A Modbus TCP/IP client can establish a connection to RIO600 through the standardized TCP socket port 502. The Modbus TCP/IP interface of RIO600 can be configured to accept one Modbus client IP address. The analog output and binary output write authority for the Modbus TCP/IP client is configurable, for example, if Modbus TCP is used only for monitoring and RIO600 outputs are operated using IEC 61850 GOOSE.

7.1.4 Modbus TCP/IP diagnostic counters over Web HMI

Modbus TCP/IP diagnostic counters can be viewed via the WHMI. These counters show the sent and received Modbus protocol link frames and Modbus errors.

Table 117: TCP/IP diagnostic counters

Counter	Description
Received frames	Total amount of received Modbus frames.
Transmitted frames	Total amount of transmitted Modbus responses.
Transmitted Exc A	Total amount of exception responses 1 and 2. These exception responses usually reveal configuration errors on the Modbus client's side.
Transmitted Exc B	Total amount of exception responses 3. These exceptions reveal the application level rejections.
TCP connection status	Shows the value "Green" via LED on WHMI, if TCP/IP instance is in use. A Modbus client has connected to the TCP socket and Modbus TCP messages are received regularly. In all other cases, it shows the value "Red" via a LED.

The counters and status are reset when the client makes a TCP socket disconnection or if the live TCP socket connection times out.

7.1.5 Common Modbus TCP/IP diagnostic counters

Table 118: TCP/IP diagnostic counters (client independent)

Counter	Description
CnReject No sockets	Amount of connection requests rejected due to unavailable TCP sockets
CnReject Not reg	Amount of connection requests rejected since the client is not registered

7.1.6 Supported Modbus function codes

Table 119: Function codes supported by RIO600

Function code	Name	Description
01	Read coil status	Reads the status of discrete outputs
02	Read digital input status	Reads the status of discrete inputs
03	Read holding registers	Reads the contents of output registers
04	Read input registers	Reads the contents of input registers
05	Force single coil	Sets the status of a discrete output
06	Preset single register	Sets the value of a holding register
08 sub function code 00	Diagnostics: Request query data	The data in the query data field is returned (looped back) in the response. The entire response is identical to the query.

Table 120: Exception codes supported by RIO600

Function code	Name	Description
01	Illegal function	The slave does not support the requested function.
02	Illegal data address	The slave does not support the data address or the number of items in the query if incorrect.
03	Illegal data value	A value contained in the query data field is out of range.
04	Slave device failure	An un-recoverable error occurred while the server (or slave) was attempting to perform the requested action.

7.1.7 Modbus data implementation

RIO600 is internally modelled according to IEC 61850 standard. The Modbus protocol is implemented on top of this model. However, not all features of the IEC 61850 data model are available through the Modbus interface.

The Modbus protocol standard defines one-bit digital data and 16-bit register data as RTU application data alternatives. The protocol does not define how this protocol application data should be used by an application.

7.1.8 Change events and time synchronization

The Modbus standard does not define event reporting or time synchronization procedures. Proprietary solutions are introduced in RIO600 to support these functionalities and are depicted later in this document.

7.1.9 Control operations

The Modbus standard defines data types 0X for coils and 4X for holding registers to be used for control operations. RIO600 supports both data types.

7.1.10 Application data compatibility

RIO600 is designed to operate with a wide range of Modbus masters spanning from industrial PLCs to substation SCADA devices. The application solutions have been chosen to achieve the highest possible level of compatibility with the systems.

- Application data is readable in many different Modbus memory areas while digital data is readable as bits or packed bits in registers.
- Addressing the application data in the documentation and tools follows the Modbus addressing principle, where the base address 0 is used.

7.1.11 Data mapping principles

Modbus data is organized sequentially. This is the most efficient organization method since the master normally scans the Modbus data in blocks.

7.1.12 Default data organization

The available Modbus data in RIO600 is always mapped to a Modbus location. The Modbus points that are pre-mapped are only cached from the application by the stack when there is a read poll for the corresponding data point.

7.1.13 Data in monitoring direction

All data in the monitoring direction is available through the 3X and 4X memory areas. This includes the digital indication data which is also readable in the 1X and 0X areas. All register structures are located in the 4X area. The Modbus data may contain empty bits or registers within the sequential data areas. These bits and registers are intended for possible future expansion. Reading this data does not result in any Modbus exception response. The value in these bits or registers is always zero.

7.1.14 One-bit data mapping

All one-bit data is readable either from the 0X or 1X memory area. The Modbus bit point addresses are similar regardless of the memory area. The same one-bit data can also be read either from the 3X or the 4X area. In this case, the bit values are packed into 16 bit 3X and 4X registers. Controls and set points are mapped to Modbus 0X data (coils). Only one coil can be operated at a time. Some control bits are packed bits in the 4X control register structures.

7.1.15 Digital input data

As the indication signals related to fault detection applications often change rapidly, the Modbus master may not detect all the changes. The Modbus protocol implementation in RIO600 supports the latching concept for binary input data points. The *Binary Input Read Method*, found under Parameter Setting in PCM600, can be configured either as "Instantaneous" or "Latched".

In instantaneous mode, the Modbus master receives the latest values of binary data points for every read poll. In latched mode, the Modbus master receives the first changed value of the corresponding data point since the last read poll has been made for the same data point. The actual present value is reported in the next read poll.

In this way, a missed event between data polls can be detected. The latching concept is applicable only for all the binary channels of DIM module, all the binary readable points of SIM8F/SIM4F module and all the binary channels of SCM module for the 4I4O application type.

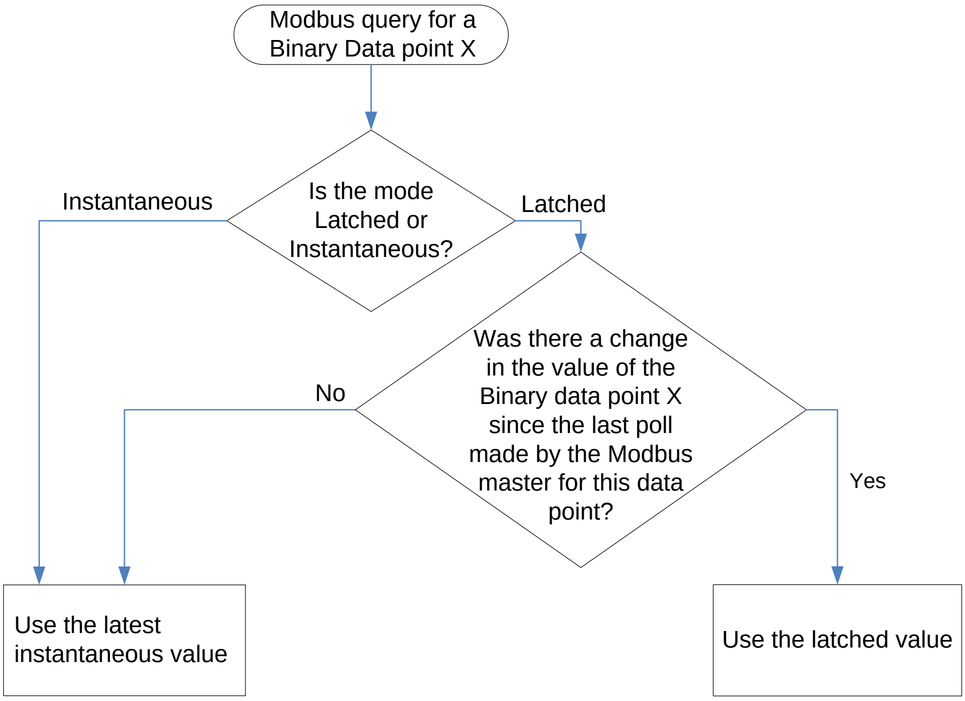

Figure 90: Latching mechanism for reading binary input data

7.1.16 Measurand registers

The Modbus measurands are located in the Modbus register area. The measurands are readable from 3X and 4X areas from the same register addresses. The Modbus measurands derive from the IEC 61850 filtered measurand values. Modbus register values are always in integer format. Since the internal IEC 61850 values are represented as decimal numbers, the Modbus stack needs to scale these values to integer format. Thus, a scale factor always exists for each Modbus register value and the same is mentioned against each Modbus addressable data point in the Modbus point list manual.

7.1.17 Register value update

The Modbus register values can be updated in different ways. The update method is predefined and fixed.

- The Modbus register values are available so that the Modbus stack directly reads the momentary value of the mapped source object. These values are never cached in the Modbus database. They are only fetched from the source

object at the time of the Modbus client reading. Most of the registers are mapped in this way.
- If the binary input read mode is latched, the Modbus stack reads the value cached in the Modbus database, in case there is a change in value of the queried binary input data point since its last poll.

7.1.18 Primary values

Measurands originating from sensor measurements can be obtained from RIO600 in only one way. They can be viewed as primary values. The primary values are represented internally as decimal numbers. The primary units are [A] for current and [kV] for voltage.

For each of these values mapped to the Modbus address, a scale factor is associated for each of the values mapped to the Modbus address. The measurands are sent over two Modbus registers using 32 bits for each measurand value. The Modbus master must use the scale factor associated with each of these data points (mentioned in the point list) and divide the value received over Modbus with the scale factor of that measurand. For example, a value of 23.33 with a scale factor of 1000 is sent as 23330 to the Modbus master.

7.1.19 Register size

In most cases, the channel values of counters RTD4 and AOM4 are located in single 16-bit registers. In some cases, the measurands for SIM8F/SIM4F module are located in two consecutive registers forming a single 32-bit integer value. The 32-bit value is always coded so that the high word part, that is, the higher 16 bits, is located first in this register address. The low word part, that is, the lower 16 bits, is always in the next register address. Register sizes and types are stated in the Modbus memory map list.

7.1.20 Control operations

RIO600 outputs can be controlled either through the 0X coil objects or 4X holding register control structures. See the Modbus control objects' memory map for the available control objects. The control objects in RIO600 are single point control objects. Single point control objects can be either pulse outputs or persistent outputs.

The Modbus client should only write "1" to the pulse outputs. This write operation activates the control operation and there is no need for the Modbus client to write "0" to the object. However, writing "0" is not forbidden. The result is that nothing happens to the control object. The Modbus client can write both "1" and "0" to the persistent outputs. Therefore, the persistent outputs have two defined levels: "0" and "1".

7.1.21 Control functions

The output objects are controlled one at a time. RIO600 accepts only functions 05 (force single coil) when the 0X coils control structure is used for the control operation. The same can also be handled using the 4X register writes, that is, by using the feature called direct control. The IED's analog output can be written only through function code 06 (write single register).

RIO600 accepts force single coil (function code 05) when the 0X coil control structure is used and write single register (function code 06) when the 4X register control structure is used for the control operation. Analog output of RIO600 can be written only by using the write single register function.

7.1.22 Exception codes

Only a few exception code alternatives exist for the write coil and write register requests in Modbus. If the write permission has not been provided for the client to write a value to either binary or analog outputs, RIO600 does not consider the write request but responds with an exception code for the respective operation.

7.1.23 System status register

SSR1

The device health status SSR1 register is located at 3X/4X address 0. The bits in SSR1 give an overview of the RIO600 health.

Table 121: System status register 1 (Device health status)

Bit	Value	Description
0	0 = Healthy 1 = Warning or error	LECM warning
1	0 = Healthy 1 = Warning or error	LECM error
2	0 = Healthy 1 = Warning or error	Module 1 health
3	0 = Healthy 1 = Warning or error	Module 2 health
4	0 = Healthy 1 = Warning or error	Module 3 health
5	0 = Healthy 1 = Warning or error	Module 4 health
6	0 = Healthy 1 = Warning or error	Module 5 health
7	0 = Healthy 1 = Warning or error	Module 6 health
8	0 = Healthy 1 = Warning or error	Module 7 health
9	0 = Healthy 1 = Warning or error	Module 8 health
Table continues on next page		

Bit	Value	Description
10	0 = Healthy 1 = Warning or error	Module 9 health
11	0 = Healthy 1 = Warning or error	Module 10 health
12	0 = Healthy 1 = UPS power failure	-
13	0 = Remote 1 = Local	-
14	-	-
15	-	-

SSR2

The device alive counter SSR2 register is located at 3X/4X address 01. SSR2 counts upwards from 0 to 65535 and starts over. The meaning of this register is to assure that the device is actually operating.

7.1.24 Module information

The 3X/4X Modbus address range 16...26 is reserved for providing the module identification values to the Modbus master or client. The 3X/4X register address 16 should indicate the presence of LECM and the addresses 17...26 should display the information about Module 1...10 respectively.

Table 122: Module identification for RIO600

Module name	Module identifier value reported to Modbus master
DOM4	66
DIM8H/DIM8L	67
RTD4	68
AOM4	69
SIM8F	70
SIM4F	72
SCMH/SCM8L	71
LECM	76

The Modbus master can be informed about the RIO600 stack configuration by polling for the addresses corresponding to the Module identification address range.

For example, in a RIO600 stack with the configuration LECM-DIM8H-DIM8L-DOM4-RTD4, the addresses 16, 17, 18, 19 and 20 show the values 76, 67, 67, 66 and 68 respectively.

7.1.25 Modbus time synchronization

RIO600’s internal UTC time structure can be synchronized using the Modbus time synch implementation. For this, *Synch source* should be set as “Modbus” in the parameter settings for LECM. The time sent by the time synch source (Modbus master) must be in UTC format.

3X/4X register addresses 8...13 can be read in a 3X/4X read poll to retrieve the time stored in RIO600’s internal time structures. Using 4X register addresses 8...13, a Modbus master or client can synchronize RIO600’s time by writing the appropriate values to these addresses. When RIO600 time is synchronized, that is, all the time elements are updated with the proper values, the LECM’s time synch warning is turned off and the time synch status in WHMI indicates “Good”.

- If any of the time element has not been updated, the time synch warning is turned on and the time synch status in WHMI indicates “Bad”.
- If the value written in a time element is out of the acceptable value range for the corresponding time element, the particular time element’s value is not updated and an exception code 4 is sent to the Modbus client.
- If the Modbus master/client disconnects from RIO600, a time sync warning is raised again in LECM and the time sync status in WHMI indicates “Bad”.
- If Modbus time sync command has not been received from the Modbus master/client for a minimum time period of half an hour, a time sync warning is raised again in LECM and the time sync status in WHMI indicates “Bad”.

Table 123: Time synchronization in RIO600

Modbus address (in decimal)	Attribute name	Information	Scale factor	Data type	More information (Valid range)
8	Time synchronisation	Year	1	Unsigned 16	2000...9999
9	Time synchronisation	Month	1	Unsigned 16	1...12
10	Time synchronisation	Day	1	Unsigned 16	1...31
11	Time synchronisation	Hour	1	Unsigned 16	0...23
12	Time synchronisation	Minute	1	Unsigned 16	0...59
13	Time synchronisation	Seconds	1	Unsigned 16	0...59

7.1.26 Parameter settings

Modbus communication needs to be enabled via the PCM600 path **Configuration/ Station communication/MODBUS**. The station communication parameters need to be set to use Modbus communication in RIO600.

Table 124: Station communication parameters for Modbus

Parameter name	Range	Unit	Default value	Description
Modbus operation	ON/OFF	-	Off	Select “ON” to enable Modbus communication with client.
Modbus connection timeout	1...100	Sec	10	If there is no request from other client within this timeout, RIO600 closes the TCP connection.
TCP Client Modbus operation	ON/OFF	-	Off	Select “ON” to enable Modbus communication with the client.
Slave ID	1...254	-	-	Slave ID of RIO600
Client IP	-	-	000.000.000 .000	IP address of the Modbus client
Binary input read method	Latched	-	Latched	Binary input signal information is stored until a Modbus request command is received.
-	Instantaneo us	-	-	The current binary signal information would be provided to the client upon request.
Binary Output Write	Allowed	-	Not allowed	Binary output should be allowed to be operated irrespective of the GOOSE communication.
-	Not allowed	-	-	-
Analog Output Write	Allowed		Not allowed	Analog output should be allowed to be operated irrespective of the GOOSE communication.
-	Not allowed	-	-	-

Modbus slave in RIO600 communicates with one master and the IP address of the Modbus master is configurable through PCM600.

- If a Modbus request comes from an unregistered master (the master's IP address differs from the one configured in PCM600 or RIO600 has not been configured with a zero IP address), RIO600 Modbus slave does not connect to the unregistered master/client and the master/client status LED on WHMI remains red.
- If a Modbus master’s IP address is correct (the masters' IP address is identical with the one configured in PCM600 or RIO600 has been configured with a zero IP address), the Master status LED in WHMI turns green. However, the RIO600 Modbus slave still searches for the Slave ID in the Modbus master’s request.
- If the slave ID is not identical with the one configured in PCM600, the RIO600 Modbus slave does not respond to the Modbus master’s poll request even if it is in connected state with the master.

For the RIO600 Modbus slave to respond to a master's request, the IP addresses of both the master and the slave ID must be the same as configured in PCM600 or RIO600 must be configured with a zero IP address (default IP address) and the slave ID should be the same as configured in PCM600.

The moment the RIO600 slave is connected to a Modbus master, *Connection timeout* parameter comes into consideration.

If the duration of inactivity between the RIO600 Modbus slave and the connected Master reaches the connection timeout value configured through PCM600, the RIO600 Modbus slave is disconnected from the master and the WHMI status LED turns red. To establish further communication between RIO600 Modbus slave and Modbus Master, the master has to reconnect to the RIO600 Modbus slave. For RIO600 Modbus slave to communicate with Modbus Master, the Modbus operation and TCP Client operation must be “ON”.

- If the binary input read method is set to “Instantaneous”, the RIO600 Modbus slave responds with the instantaneous or real-time values for a Modbus poll that requests the status of binary input channels of the DIM8 H or DIM8 L module and the binary input readable points, that is points mentioned in the point list, of the SIM8F/SIM4F module and the SCM module of 4I4O application type.
- If the binary input read method is set to “Latched”, the RIO600 Modbus slave responds with the first status change value between the polls for a Modbus poll that requests the status of binary input channels of the DIM8 H or DIM8 L module and the binary input readable points of the SIM8F/SIM4F module and the SCM module of 4I4O application type. For example, if the value for a particular binary input changes from status "0" to status "1" between two consecutive Modbus polls and then back to status "0", the RIO600 Modbus shows value "1" to the Modbus master. The value here is latched to the first status change between the polls.
- If the binary output write is set to “Not Allowed” and the Modbus master tries to write a value to either DOM channels, SIM8F/SIM4F’s or SCM’s writeable channels, this results in exception code 4.
- If the analog output write is set to “Not Allowed” and the Modbus master tries to write a value to either AOM channels, this results in exception code 4.
- If the time synch source is not selected as “Modbus” and the Modbus master tries to write a value to the time registers, an exception code 4 is sent from the RIO600 Modbus slave to the Modbus master.

7.1.27 Module reserved channel concept

Keeping the future expansion in consideration, RIO600 Modbus implementation reserves a few channel numbers.

7.1.28 RTD range information

RIO600 Modbus implementation can be used to retrieve the range information for each of the RTD channels. Modbus address 704 onwards can be used in a 3X/4X read poll to retrieve the range information of any RTD channel present in the stack. Table 125 shows the manner in which the RTD range information for RTD channels should be interpreted.

Table 125: Reporting of RTD range information

Range	Value reported
normal	0
high	1
low	2
high high	3
low low	4

In case a channel is reserved for future use, value “0” should be reported for it.

7.1.29 Reporting reserved addresses

Considering RIO600 expansion, the Modbus point list depicts several addresses reserved for future use. In the current implementation, if a 3X/4X read poll is made for a Modbus address which is reserved for future use, the value “0” is reported to the Modbus master. The Modbus master must be able to poll for a maximum number of data points in one single poll and it should not return an exception in case a reserved address region falls between two unreserved or currently assigned Modbus address regions. However, during a write poll (4X), if a Modbus master is trying to write the value to a Modbus address which is reserved for future use, an exception is returned to the Modbus master.

Table 126: Correlation between the function code and address range

Module name	Data type	0X		1X		3X		4X	
		Readable (FC 01)	Writeable (FC 05)	Readable (FC 02)	Writeable	Readable (FC 04)	Writeable	Readable (FC 03)	Writeable (FC 06)
DOM4	Boolean	Yes	Yes	No	No	Yes	No	Yes	Yes
DIM8H/ DIM8L	Boolean	No	No	Yes	No	Yes	No	Yes	No
RTD4	Signed 16 bit channel status informatio n	No	No	No	No	Yes	No	Yes	No
	Channel range informatio n (unsigned 16)	No	No	No	No	Yes	No	Yes	No
AOM4	Signed 16 bit channel status informatio n	No	No	No	No	Yes	No	Yes	Yes

Table continues on next page

Module name	Data type	0X		1X		3X		4X	
SIM8F/ SIM4F	Readable data Boolean	No	No	Yes	No	Yes	No	Yes	No
	Writeable data Boolean	Yes	Yes		No	Yes	No	Yes	Yes
	Signed 32 bit Analog data and Signed 16 bit enum	No	No	No	No	Yes	No	Yes	No
SCM	Boolean	Yes	Yes	Yes	No	Yes	No	Yes	Yes
SSR	SSR1 and SSR 2 unsigned 16 bit information	No	No	No	No	Yes	No	Yes	No
Module information	Unsigned 16 bit information	No	No	No	No	Yes	No	Yes	No
Time Synchronization	Unsigned 16 bit information	No	No	No	No	Yes	No	Yes	Yes
Supervision Data	Unsigned 16 bit information	No	No	No	No	Yes	No	Yes	No

7.1.30 Function code and addressing region mapping

Table 127: Correlation between the function code and address range

Module name	Data type			1X		3X		4X	
		Readable (FC 01)	Writeable (FC 05)	Readable (FC 02)	Writeable	Readable (FC 04)	Writeable	Readable (FC 03)	Writeable (FC 06)
DOM4	Boolean	Yes	Yes	No	No	Yes	No	Yes	Yes
DIM8H/DIM8L	Boolean	No	No	Yes	No	Yes	No	Yes	No
RTD4	Signed 16 bit channel status information	No	No	No	No	Yes	No	Yes	No
	Channel range information (unsigned 16)	No	No	No	No	Yes	No	Yes	No
AOM4	Signed 16 bit channel status information	No	No	No	No	Yes	No	Yes	Yes

Table continues on next page

Module name	Data type			1X		3X		4X	
		Readable (FC 01)	Writeable (FC 05)	Readable (FC 02)	Writeable	Readable (FC 04)	Writeable	Readable (FC 03)	Writeable (FC 06)
SIM8F/SIM4F	Readable data Boolean	No	No	Yes	No	Yes	No	Yes	No
	Writeable data Boolean	Yes	Yes	No	No	Yes	No	Yes	Yes
	Signed 32 bit Analog data and Signed 16 bit enum	No	No	No	No	Yes	No	Yes	No
SSR	SSR1 and SSR 2 unsigned 16 bit information	No	No	No	No	Yes	No	Yes	No
Module information	Unsigned 16 bit information	No	No	No	No	Yes	No	Yes	No
Time Synchronization	Unsigned 16 bit information	No	No	No	No	Yes	No	Yes	Yes
Supervision Data	Unsigned 16 bit information	No	No	No	No	Yes	No	Yes	No

7.2 Modbus point list

Modbus data points and structures available in RIO600 modules are described here. Some of the addresses are reserved and unused, that is, data points always return value “0” when they are read.

There are two alternatives for Modbus addressing. PLC addressing starts from address 1 while regular Modbus addressing starts from 0. For example, in PLC addressing a holding register address 234 can be referred to either as 4X register 234 or as 40234. Similarly, regular Modbus addressing at 234 can be referred to either as 4X register 233 or as 40233.

Modbus addresses in the documentation follow regular Modbus addressing scheme with addresses starting from 0. For PLC based addressing scheme the regular Modbus data addresses should be incremented by one.

Modbus point list can be exported from the connectivity package.

7.2.1 SSR1 System status register (1) device health

System status register address provides information about the health status of the RIO600 system and all individual modules present in its stack. It also provides status of the UPS power failure and local/remote mode.

Table 128: SSR1 System status register (1) device health

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
0	Bit				LECM Warning	0 = Ok, 1 = Warning or error
0.01	Bit				LECM Error	0 = Ok, 1 = Warning or error
0.02	Bit				Module 1 Health	0 = Ok, 1 = Warning or error
0.03	Bit				Module 2 Health	0 = Ok, 1 = Warning or error
0.04	Bit				Module 3 Health	0 = Ok, 1 = Warning or error
0.05	Bit				Module 4 Health	0 = Ok, 1 = Warning or error
0.06	Bit				Module 5 Health	0 = Ok, 1 = Warning or error
0.07	Bit				Module 6 Health	0 = Ok, 1 = Warning or error
0.08	Bit				Module 7 Health	0 = Ok, 1 = Warning or error
0.09	Bit				Module 8 Health	0 = Ok, 1 = Warning or error
0.1	Bit				Module 9 Health	0 = Ok, 1 = Warning or error
0.11	Bit				Module 10 Health	0 = Ok, 1 = Warning or error
0.12	Bit				UPS Power Failure Status	0 = Ok, 1 = Warning or error
0.13	Bit				Local/Remote Mode Status	0 = Remote, 1 = Local
0.14	Bit				<reserved>	0
0.15	Bit				<reserved>	0

7.2.2 SSR2 System status register (2) device alive register

This register provides information about the Modbus device alive counter.

Table 129: SSR2 System status register (2) device alive register

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
1	u16	1			Device Alive Counter	0...65535

7.2.3 Time synchronization

RIO600 time can be synchronized with the Modbus client by writing to the register addresses in Table 22. The time can also be read from the same register addresses.

Table 130: Time synchronization

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
8	u16	1			Year	2000...2999
9	u16	1			Month	1...12
10	u16	1			Day	1...31
11	u16	1			Hour	0...23
12	u16	1			Minute	0...59
13	u16	1			Second	0...59

7.2.4 Module identification

RIO600 modules can be identified with following register addresses. This information can be useful to identify the information about modules connected on the stack.

Table 131: Module identification

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values[1)]
16	u16	1			LECM Module Identification	DOM = 66 DIM8 = 67 RTD = 68 AOM = 69 SIM8F = 70 SIM4F = 72 SCM = 71 LECM = 76
17	u16	1			Module 1 Identification	
18	u16	1			Module 2 Identification	
19	u16	1			Module 3 Identification	
20	u16	1			Module 4 Identification	
21	u16	1			Module 5 Identification	
22	u16	1			Module 6 Identification	
23	u16	1			Module 7 Identification	
24	u16	1			Module 8 Identification	
25	u16	1			Module 9 Identification	
26	u16	1			Module 10 Identification	

1) Modbus master can be informed about the RIO600 stack configuration by polling for the addresses corresponding to the module identification address range

7.2.5 LD0.DIM8GGIO/LD0.DIM8LGGIO physical I/O states

Status of binary input information can be accessed using the following addresses of DIM8H/DIM8L module.

Table 132: LD0.DIM8GGIO/LD0.DIM8LGGIO physical I/O states

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
		LD0.DIM8GGIO1/ LD0.DIM8LGGIO1			
0	32.00	.Ind1.stVal		DIM8H 1-Input 1 State	0/1=Off/On
1	32.01	.Ind2.stVal		DIM8H 1-Input 2 State	0/1=Off/On
2	32.02	.Ind3.stVal		DIM8H 1-Input 3 State	0/1=Off/On
3	32.03	.Ind4.stVal		DIM8H 1-Input 4 State	0/1=Off/On
4	32.04	.Ind5.stVal		DIM8H 1-Input 5 State	0/1=Off/On
5	32.05	.Ind6.stVal		DIM8H 1-Input 6 State	0/1=Off/On
6	32.06	.Ind7.stVal		DIM8H 1-Input 7 State	0/1=Off/On
7	32.07	.Ind8.stVal		DIM8H 1-Input 8 State	0/1=Off/On
8	32.08	<reserved>		<reserved>	0=Off
9	32.09	<reserved>		<reserved>	0=Off
10	32.1	<reserved>		<reserved>	0=Off
11	32.11	<reserved>		<reserved>	0=Off
12	32.12	<reserved>		<reserved>	0=Off
13	32.13	<reserved>		<reserved>	0=Off
14	32.14	<reserved>		<reserved>	0=Off
15	32.15	<reserved>		<reserved>	0=Off
		LD0.DIM8GGIO2/ LD0.DIM8LGGIO2			
16	33.00	.Ind1.stVal		DIM8H 2-Input 1 State	0/1=Off/On
17	33.01	.Ind2.stVal		DIM8H 2-Input 2 State	0/1=Off/On
18	33.02	.Ind3.stVal		DIM8H 2-Input 3 State	0/1=Off/On
19	33.03	.Ind4.stVal		DIM8H 2-Input 4 State	0/1=Off/On
20	33.04	.Ind5.stVal		DIM8H 2-Input 5 State	0/1=Off/On
21	33.05	.Ind6.stVal		DIM8H 2-Input 6 State	0/1=Off/On
22	33.06	.Ind7.stVal		DIM8H 2-Input 7 State	0/1=Off/On
23	33.07	.Ind8.stVal		DIM8H 2-Input 8 State	0/1=Off/On
24	33.08	<reserved>		<reserved>	0=Off
25	33.09	<reserved>		<reserved>	0=Off
26	33.10	<reserved>		<reserved>	0=Off
27	33.11	<reserved>		<reserved>	0=Off
28	33.12	<reserved>		<reserved>	0=Off
29	33.13	<reserved>		<reserved>	0=Off
30	33.14	<reserved>		<reserved>	0=Off

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
31	33.15	<reserved>		<reserved>	0=Off
		LD0.DIM8GGIO3/ LD0.DIM8LGGIO3			
32	34.00	.Ind1.stVal		DIM8H 3-Input 1 State	0/1=Off/On
33	34.01	.Ind2.stVal		DIM8H 3-Input 2 State	0/1=Off/On
34	34.02	.Ind3.stVal		DIM8H 3-Input 3 State	0/1=Off/On
35	34.03	.Ind4.stVal		DIM8H 3-Input 4 State	0/1=Off/On
36	34.04	.Ind5.stVal		DIM8H 3-Input 5 State	0/1=Off/On
37	34.05	.Ind6.stVal		DIM8H 3-Input 6 State	0/1=Off/On
38	34.06	.Ind7.stVal		DIM8H 3-Input 7 State	0/1=Off/On
39	34.07	.Ind8.stVal		DIM8H 3-Input 8 State	0/1=Off/On
40	34.08	<reserved>		<reserved>	0=Off
41	34.09	<reserved>		<reserved>	0=Off
42	34.10	<reserved>		<reserved>	0=Off
43	34.11	<reserved>		<reserved>	0=Off
44	34.12	<reserved>		<reserved>	0=Off
45	34.13	<reserved>		<reserved>	0=Off
46	34.14	<reserved>		<reserved>	0=Off
47	34.15	<reserved>		<reserved>	0=Off
		LD0.DIM8GGIO4/ LD0.DIM8LGGIO4			
48	35.00	.Ind1.stVal		DIM8H 4-Input 1 State	0/1=Off/On
49	35.01	.Ind2.stVal		DIM8H 4-Input 2 State	0/1=Off/On
50	35.02	.Ind3.stVal		DIM8H 4-Input 3 State	0/1=Off/On
52	35.04	.Ind5.stVal		DIM8H 4-Input 5 State	0/1=Off/On
53	35.05	.Ind6.stVal		DIM8H 4-Input 6 State	0/1=Off/On
54	35.06	.Ind7.stVal		DIM8H 4-Input 7 State	0/1=Off/On
55	35.07	.Ind8.stVal		DIM8H 4-Input 8 State	0/1=Off/On
56	35.08	<reserved>		<reserved>	0=Off
57	35.09	<reserved>		<reserved>	0=Off
58	35.10	<reserved>		<reserved>	0=Off
59	35.11	<reserved>		<reserved>	0=Off
60	35.12	<reserved>		<reserved>	0=Off
61	35.13	<reserved>		<reserved>	0=Off
62	35.14	<reserved>		<reserved>	0=Off
63	35.15	<reserved>		<reserved>	0=Off
		LD0.DIM8GGIO5/ LD0.DIM8LGGIO5			
64	36.00	.Ind1.stVal		DIM8H 5-Input 1 State	0/1=Off/On
65	36.01	.Ind2.stVal		DIM8H 5-Input 2 State	0/1=Off/On
66	36.02	.Ind3.stVal		DIM8H 5-Input 3 State	0/1=Off/On

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
67	36.03	.Ind4.stVal		DIM8H 5-Input 4 State	0/1=Off/On
68	36.04	.Ind5.stVal		DIM8H 5-Input 5 State	0/1=Off/On
69	36.05	.Ind6.stVal		DIM8H 5-Input 6 State	0/1=Off/On
70	36.06	.Ind7.stVal		DIM8H 5-Input 7 State	0/1=Off/On
71	36.07	.Ind8.stVal		DIM8H 5-Input 8 State	0/1=Off/On
72	36.08	<reserved>		<reserved>	0=Off
73	36.09	<reserved>		<reserved>	0=Off
74	36.10	<reserved>		<reserved>	0=Off
75	36.11	<reserved>		<reserved>	0=Off
76	36.12	<reserved>		<reserved>	0=Off
77	36.13	<reserved>		<reserved>	0=Off
78	36.14	<reserved>		<reserved>	0=Off
79	36.15	<reserved>		<reserved>	0=Off
		LD0.DIM8GGIO6/ LD0.DIM8LGGIO6			
80	37.00	.Ind1.stVal		DIM8H 6-Input 1 State	0/1=Off/On
81	37.01	.Ind2.stVal		DIM8H 6-Input 2 State	0/1=Off/On
82	37.02	.Ind3.stVal		DIM8H 6-Input 3 State	0/1=Off/On
83	37.03	.Ind4.stVal		DIM8H 6-Input 4 State	0/1=Off/On
84	37.04	.Ind5.stVal		DIM8H 6-Input 5 State	0/1=Off/On
85	37.05	.Ind6.stVal		DIM8H 6-Input 6 State	0/1=Off/On
86	37.06	.Ind7.stVal		DIM8H 6-Input 7 State	0/1=Off/On
87	37.07	.Ind8.stVal		DIM8H 6-Input 8 State	0/1=Off/On
88	37.08	<reserved>		<reserved>	0=Off
89	37.09	<reserved>		<reserved>	0=Off
90	37.10	<reserved>		<reserved>	0=Off
91	37.11	<reserved>		<reserved>	0=Off
92	37.12	<reserved>		<reserved>	0=Off
93	37.13	<reserved>		<reserved>	0=Off
94	37.14	<reserved>		<reserved>	0=Off
95	37.15	<reserved>		<reserved>	0=Off
		LD0.DIM8GGIO7/ LD0.DIM8LGGIO7			
96	38.00	.Ind1.stVal		DIM8H 7-Input 1 State	0/1=Off/On
97	38.01	.Ind2.stVal		DIM8H 7-Input 2 State	0/1=Off/On
98	38.02	.Ind3.stVal		DIM8H 7-Input 3 State	0/1=Off/On
99	38.03	.Ind4.stVal		DIM8H 7-Input 4 State	0/1=Off/On
100	38.04	.Ind5.stVal		DIM8H 7-Input 5 State	0/1=Off/On
101	38.05	.Ind6.stVal		DIM8H 7-Input 6 State	0/1=Off/On
102	38.06	.Ind7.stVal		DIM8H 7-Input 7 State	0/1=Off/On

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
103	38.07	.Ind8.stVal		DIM8H 7-Input 8 State	0/1=Off/On
104	38.08	<reserved>		<reserved>	0=Off
105	38.09	<reserved>		<reserved>	0=Off
106	38.10	<reserved>		<reserved>	0=Off
107	38.11	<reserved>		<reserved>	0=Off
108	38.12	<reserved>		<reserved>	0=Off
109	38.13	<reserved>		<reserved>	0=Off
110	38.14	<reserved>		<reserved>	0=Off
111	38.15	<reserved>		<reserved>	0=Off
		LD0.DIM8GGIO8/ LD0.DIM8LGGIO8			
112	39.00	.Ind1.stVal		DIM8H 8-Input 1 State	0/1=Off/On
113	39.01	.Ind2.stVal		DIM8H 8-Input 2 State	0/1=Off/On
114	39.02	.Ind3.stVal		DIM8H 8-Input 3 State	0/1=Off/On
115	39.03	.Ind4.stVal		DIM8H 8-Input 4 State	0/1=Off/On
116	39.04	.Ind5.stVal		DIM8H 8-Input 5 State	0/1=Off/On
117	39.05	.Ind6.stVal		DIM8H 8-Input 6 State	0/1=Off/On
118	39.06	.Ind7.stVal		DIM8H 8-Input 7 State	0/1=Off/On
119	39.07	.Ind8.stVal		DIM8H 8-Input 8 State	0/1=Off/On
120	39.08	<reserved>		<reserved>	0=Off
121	39.09	<reserved>		<reserved>	0=Off
122	39.10	<reserved>		<reserved>	0=Off
123	39.11	<reserved>		<reserved>	0=Off
124	39.12	<reserved>		<reserved>	0=Off
125	39.13	<reserved>		<reserved>	0=Off
126	39.14	<reserved>		<reserved>	0=Off
127	39.15	<reserved>		<reserved>	0=Off
		LD0.DIM8GGIO9/ LD0.DIM8LGGIO9			
128	40.00	.Ind1.stVal		DIM8H 9-Input 1 State	0/1=Off/On
129	40.01	.Ind2.stVal		DIM8H 9-Input 2 State	0/1=Off/On
130	40.02	.Ind3.stVal		DIM8H 9-Input 3 State	0/1=Off/On
131	40.03	.Ind4.stVal		DIM8H 9-Input 4 State	0/1=Off/On
132	40.04	.Ind5.stVal		DIM8H 9-Input 5 State	0/1=Off/On
133	40.05	.Ind6.stVal		DIM8H 9-Input 6 State	0/1=Off/On
134	40.06	.Ind7.stVal		DIM8H 9-Input 7 State	0/1=Off/On
135	40.07	.Ind8.stVal		DIM8H 9-Input 8 State	0/1=Off/On
136	40.08	<reserved>		<reserved>	0=Off
137	40.09	<reserved>		<reserved>	0=Off
138	40.10	<reserved>		<reserved>	0=Off

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
139	40.11	<reserved>		<reserved>	0=Off
140	40.12	<reserved>		<reserved>	0=Off
141	40.13	<reserved>		<reserved>	0=Off
142	40.14	<reserved>		<reserved>	0=Off
143	40.15	<reserved>		<reserved>	0=Off
		LD0.DIM8GGIO10/ LD0.DIM8LGGIO10			
144	41.00	.Ind1.stVal		DIM8H 10-Input 1 State	0/1=Off/On
145	41.01	.Ind2.stVal		DIM8H 10-Input 2 State	0/1=Off/On
146	41.02	.Ind3.stVal		DIM8H 10-Input 3 State	0/1=Off/On
147	41.03	.Ind4.stVal		DIM8H 10-Input 4 State	0/1=Off/On
148	41.04	.Ind5.stVal		DIM8H 10-Input 5 State	0/1=Off/On
149	41.05	.Ind6.stVal		DIM8H 10-Input 6 State	0/1=Off/On
150	41.06	.Ind7.stVal		DIM8H 10-Input 7 State	0/1=Off/On
151	41.07	.Ind8.stVal		DIM8H 10-Input 8 State	0/1=Off/On
152	41.08	<reserved>		<reserved>	0=Off
153	41.09	<reserved>		<reserved>	0=Off
154	41.10	<reserved>		<reserved>	0=Off
155	41.11	<reserved>		<reserved>	0=Off
156	41.12	<reserved>		<reserved>	0=Off
157	41.13	<reserved>		<reserved>	0=Off
158	41.14	<reserved>		<reserved>	0=Off
159	41.15	<reserved>		<reserved>	0=Off

7.2.6 LD0.DOMGGIO physical I/O states

The binary output (DOM4) module can be accessed with the addresses listed in Table 133.

Table 133: LD0.DOMGGIO physical I/O states

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
		LD0.DOMGGIO1			
256	48.00	.SPCSO1.stVal		DOM 1-Output 1 State	0/1=Off/On
257	48.01	.SPCSO2.stVal		DOM 1-Output 2 State	0/1=Off/On
258	48.02	.SPCSO3.stVal		DOM 1-Output 3 State	0/1=Off/On
259	48.03	.SPCSO4.stVal		DOM 1-Output 4 State	0/1=Off/On
260	48.04	<reserved>		<reserved>	0=Off
261	48.05	<reserved>		<reserved>	0=Off
262	48.06	<reserved>		<reserved>	0=Off
263	48.07	<reserved>		<reserved>	0=Off

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
264	48.08	<reserved>		<reserved>	0=Off
265	48.09	<reserved>		<reserved>	0=Off
266	48.10	<reserved>		<reserved>	0=Off
267	48.11	<reserved>		<reserved>	0=Off
268	48.12	<reserved>		<reserved>	0=Off
269	48.13	<reserved>		<reserved>	0=Off
270	48.14	<reserved>		<reserved>	0=Off
271	48.15	<reserved>		<reserved>	0=Off
		LD0.DOMGGIO2			
272	49.00	.SPCSO1.stVal		DOM 2-Output 1 State	0/1=Off/On
273	49.01	.SPCSO2.stVal		DOM 2-Output 2 State	0/1=Off/On
274	49.02	.SPCSO3.stVal		DOM 2-Output 3 State	0/1=Off/On
275	49.03	.SPCSO4.stVal		DOM 2-Output 4 State	0/1=Off/On
276	49.04	<reserved>		<reserved>	0=Off
277	49.05	<reserved>		<reserved>	0=Off
278	49.06	<reserved>		<reserved>	0=Off
279	49.07	<reserved>		<reserved>	0=Off
280	49.08	<reserved>		<reserved>	0=Off
281	49.09	<reserved>		<reserved>	0=Off
282	49.10	<reserved>		<reserved>	0=Off
283	49.11	<reserved>		<reserved>	0=Off
284	49.12	<reserved>		<reserved>	0=Off
285	49.13	<reserved>		<reserved>	0=Off
286	49.14	<reserved>		<reserved>	0=Off
287	49.15	<reserved>		<reserved>	0=Off
		LD0.DOMGGIO3			
288	50.00	.SPCSO1.stVal		DOM 3-Output 1 State	0/1=Off/On
289	50.01	.SPCSO2.stVal		DOM 3-Output 2 State	0/1=Off/On
290	50.02	.SPCSO3.stVal		DOM 3-Output 3 State	0/1=Off/On
291	50.03	.SPCSO4.stVal		DOM 3-Output 4 State	0/1=Off/On
292	50.04	<reserved>		<reserved>	0=Off
293	50.05	<reserved>		<reserved>	0=Off
294	50.06	<reserved>		<reserved>	0=Off
295	50.07	<reserved>		<reserved>	0=Off
296	50.08	<reserved>		<reserved>	0=Off
297	50.09	<reserved>		<reserved>	0=Off
298	50.10	<reserved>		<reserved>	0=Off
299	50.11	<reserved>		<reserved>	0=Off
300	50.12	<reserved>		<reserved>	0=Off

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
301	50.13	<reserved>		<reserved>	0=Off
302	50.14	<reserved>		<reserved>	0=Off
303	50.15	<reserved>		<reserved>	0=Off
		LD0.DOMGGIO4			
304	51.00	.SPCSO1.stVal		DOM 4-Output 1 State	0/1=Off/On
305	51.01	.SPCSO2.stVal		DOM 4-Output 2 State	0/1=Off/On
306	51.02	.SPCSO3.stVal		DOM 4-Output 3 State	0/1=Off/On
307	51.03	.SPCSO4.stVal		DOM 4-Output 4 State	0/1=Off/On
308	51.04	<reserved>		<reserved>	0=Off
309	51.05	<reserved>		<reserved>	0=Off
310	51.06	<reserved>		<reserved>	0=Off
311	51.07	<reserved>		<reserved>	0=Off
312	51.08	<reserved>		<reserved>	0=Off
313	51.09	<reserved>		<reserved>	0=Off
314	51.10	<reserved>		<reserved>	0=Off
315	51.11	<reserved>		<reserved>	0=Off
316	51.12	<reserved>		<reserved>	0=Off
317	51.13	<reserved>		<reserved>	0=Off
318	51.14	<reserved>		<reserved>	0=Off
319	51.15	<reserved>		<reserved>	0=Off
		LD0.DOMGGIO5			
320	52.00	.SPCSO1.stVal		DOM 5-Output 1 State	0/1=Off/On
321	52.01	.SPCSO2.stVal		DOM 5-Output 2 State	0/1=Off/On
322	52.02	.SPCSO3.stVal		DOM 5-Output 3 State	0/1=Off/On
323	52.03	.SPCSO4.stVal		DOM 5-Output 4 State	0/1=Off/On
324	52.04	<reserved>		<reserved>	0=Off
325	52.05	<reserved>		<reserved>	0=Off
326	52.06	<reserved>		<reserved>	0=Off
327	52.07	<reserved>		<reserved>	0=Off
328	52.08	<reserved>		<reserved>	0=Off
329	52.09	<reserved>		<reserved>	0=Off
330	52.10	<reserved>		<reserved>	0=Off
331	52.11	<reserved>		<reserved>	0=Off
332	52.12	<reserved>		<reserved>	0=Off
333	52.13	<reserved>		<reserved>	0=Off
334	52.14	<reserved>		<reserved>	0=Off
335	52.15	<reserved>		<reserved>	0=Off
		LD0.DOMGGIO6			
336	53.00	.SPCSO1.stVal		DOM 6-Output 1 State	0/1=Off/On

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
337	53.01	.SPCSO2.stVal		DOM 6-Output 2 State	0/1=Off/On
338	53.02	.SPCSO3.stVal		DOM 6-Output 3 State	0/1=Off/On
339	53.03	.SPCSO4.stVal		DOM 6-Output 4 State	0/1=Off/On
340	53.04	<reserved>		<reserved>	0=Off
341	53.05	<reserved>		<reserved>	0=Off
342	53.06	<reserved>		<reserved>	0=Off
343	53.07	<reserved>		<reserved>	0=Off
344	53.08	<reserved>		<reserved>	0=Off
345	53.09	<reserved>		<reserved>	0=Off
346	53.10	<reserved>		<reserved>	0=Off
347	53.11	<reserved>		<reserved>	0=Off
348	53.12	<reserved>		<reserved>	0=Off
349	53.13	<reserved>		<reserved>	0=Off
350	53.14	<reserved>		<reserved>	0=Off
351	53.15	<reserved>		<reserved>	0=Off
		LD0.DOMGGIO7			
352	54.00	.SPCSO1.stVal		DOM 7-Output 1 State	0/1=Off/On
353	54.01	.SPCSO2.stVal		DOM 7-Output 2 State	0/1=Off/On
354	54.02	.SPCSO3.stVal		DOM 7-Output 3 State	0/1=Off/On
355	54.03	.SPCSO4.stVal		DOM 7-Output 4 State	0/1=Off/On
356	54.04	<reserved>		<reserved>	0=Off
357	54.05	<reserved>		<reserved>	0=Off
358	54.06	<reserved>		<reserved>	0=Off
359	54.07	<reserved>		<reserved>	0=Off
360	54.08	<reserved>		<reserved>	0=Off
361	54.09	<reserved>		<reserved>	0=Off
362	54.10	<reserved>		<reserved>	0=Off
363	54.11	<reserved>		<reserved>	0=Off
364	54.12	<reserved>		<reserved>	0=Off
365	54.13	<reserved>		<reserved>	0=Off
366	54.14	<reserved>		<reserved>	0=Off
367	54.15	<reserved>		<reserved>	0=Off
		LD0.DOMGGIO8			
368	55.00	.SPCSO1.stVal		DOM 8-Output 1 State	0/1=Off/On
369	55.01	.SPCSO2.stVal		DOM 8-Output 2 State	0/1=Off/On
370	55.02	.SPCSO3.stVal		DOM 8-Output 3 State	0/1=Off/On
371	55.03	.SPCSO4.stVal		DOM 8-Output 4 State	0/1=Off/On
372	55.04	<reserved>		<reserved>	0=Off
373	55.05	<reserved>		<reserved>	0=Off

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
374	55.06	<reserved>		<reserved>	0=Off
375	55.07	<reserved>		<reserved>	0=Off
376	55.08	<reserved>		<reserved>	0=Off
377	55.09	<reserved>		<reserved>	0=Off
378	55.10	<reserved>		<reserved>	0=Off
379	55.11	<reserved>		<reserved>	0=Off
380	55.12	<reserved>		<reserved>	0=Off
381	55.13	<reserved>		<reserved>	0=Off
382	55.14	<reserved>		<reserved>	0=Off
383	55.15	<reserved>		<reserved>	0=Off
		LD0.DOMGGIO9			
384	56.00	.SPCSO1.stVal		DOM 9-Output 1 State	0/1=Off/On
385	56.01	.SPCSO2.stVal		DOM 9-Output 2 State	0/1=Off/On
386	56.02	.SPCSO3.stVal		DOM 9-Output 3 State	0/1=Off/On
387	56.03	.SPCSO4.stVal		DOM 9-Output 4 State	0/1=Off/On
388	56.04	<reserved>		<reserved>	0=Off
389	56.05	<reserved>		<reserved>	0=Off
390	56.06	<reserved>		<reserved>	0=Off
391	56.07	<reserved>		<reserved>	0=Off
392	56.08	<reserved>		<reserved>	0=Off
393	56.09	<reserved>		<reserved>	0=Off
394	56.10	<reserved>		<reserved>	0=Off
395	56.11	<reserved>		<reserved>	0=Off
396	56.12	<reserved>		<reserved>	0=Off
397	56.13	<reserved>		<reserved>	0=Off
398	56.14	<reserved>		<reserved>	0=Off
399	56.15	<reserved>		<reserved>	0=Off
		LD0.DOMGGIO10			
400	57.00	.SPCSO1.stVal		DOM 10-Output 1 State	0/1=Off/On
401	57.01	.SPCSO2.stVal		DOM 10-Output 2 State	0/1=Off/On
402	57.02	.SPCSO3.stVal		DOM 10-Output 3 State	0/1=Off/On
403	57.03	.SPCSO4.stVal		DOM 10-Output 4 State	0/1=Off/On
404	57.04	<reserved>		<reserved>	0=Off
405	57.05	<reserved>		<reserved>	0=Off
406	57.06	<reserved>		<reserved>	0=Off
407	57.07	<reserved>		<reserved>	0=Off
408	57.08	<reserved>		<reserved>	0=Off
409	57.09	<reserved>		<reserved>	0=Off
410	57.10	<reserved>		<reserved>	0=Off

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
411	57.11	<reserved>		<reserved>	0=Off
412	57.12	<reserved>		<reserved>	0=Off
413	57.13	<reserved>		<reserved>	0=Off
414	57.14	<reserved>		<reserved>	0=Off
415	57.15	<reserved>		<reserved>	0=Off

7.2.7 LD0.RTDGGIO physical I/O values

RTD/mA input (RTD4) module can be accessed with addresses listed in Table 134.

Table 134: LD0.RTDGGIO physical I/O values

Reg A	Scale	IEC 61850 name	SA name	Description	Values
		LD0.RTDGGIO1		16 Bit Signed Integer	
64	Value reported with a scale factor of "1" when channel configured as dimensionless and with a scale factor of "100" when channel configured as either mA or RTD	.AnIn1.mag.f		RTD 1-Channel 1 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
65		.AnIn2.mag.f		RTD 1-Channel 2 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
66		.AnIn3.mag.f		RTD 1-Channel 3 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
67		.AnIn4.mag.f		RTD 1-Channel 4 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
68		<reserved>		<reserved>	0
69		<reserved>		<reserved>	0
70		<reserved>		<reserved>	0
71		<reserved>		<reserved>	0
72		.AnIn1.range/.AnIn2.range		RTD 1-Channel Range Information Channel - 2 (High Byte) Channel - 1 (Low Byte)	Normal – 0; High – 1; Low – 2; High High – 3; Low Low – 4;
73		.AnIn3.range/.AnIn4.range		RTD 1-Channel Range Information Channel - 4 (High Byte) Channel - 3 (Low Byte)	Normal – 0; High – 1; Low – 2; High High – 3; Low Low – 4;
74		<reserved>		<reserved>	0
75		<reserved>		<reserved>	0
76		<reserved>		<reserved>	0
77		<reserved>		<reserved>	0
78		<reserved>		<reserved>	0
79		<reserved>		<reserved>	0
		LD0.RTDGGIO2			

Table continues on next page

Reg A	Scale	IEC 61850 name	SA name	Description	Values
80	Value reported with a scale factor of "1" when channel configured as dimensionless and with a scale factor of "100" when channel configured as either mA or RTD	.AnIn1.mag.f		RTD 2-Channel 1 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000 1)
81		.AnIn2.mag.f		RTD 2-Channel 2 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000 1)
82		.AnIn3.mag.f		RTD 2-Channel 3 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000 1)
83		.AnIn4.mag.f		RTD 2-Channel 4 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000 1)
84		<reserved>		<reserved>	0
85		<reserved>		<reserved>	0
86		<reserved>		<reserved>	0
87		<reserved>		<reserved>	0
88		.AnIn1.range/.AnIn2.range		RTD 2- Channel Range Information Channel - 2 (High Byte) Channel - 1 (Low Byte)	Normal – 0; High – 1; Low – 2; High High – 3; Low Low – 4;
89		.AnIn3.range/.AnIn4.range		RTD 2- Channel Range Information Channel - 4 (High Byte) Channel - 3 (Low Byte)	Normal – 0; High – 1; Low – 2; High High – 3; Low Low – 4;
90		<reserved>		<reserved>	0
91		<reserved>		<reserved>	0
92		<reserved>		<reserved>	0
93		<reserved>		<reserved>	0
94		<reserved>		<reserved>	0
95		<reserved>		<reserved>	0
		LD0.RTDGGIO3			
96	Value reported with a scale factor of "1" when channel configured as dimensionless and with a scale factor of "100" when channel configured as either mA or RTD	.AnIn1.mag.f		RTD 3-Channel 1 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000 1)
97		.AnIn2.mag.f		RTD 3-Channel 2 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000 1)
98		.AnIn3.mag.f		RTD 3-Channel 3 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000 1)
99		.AnIn4.mag.f		RTD 3-Channel 4 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000 1)
100		<reserved>		<reserved>	0
101		<reserved>		<reserved>	0
102		<reserved>		<reserved>	0
103		<reserved>		<reserved>	0
104		.AnIn1.range/.AnIn2.range		RTD 3- Channel Range Information Channel - 2 (High Byte) Channel - 1 (Low Byte)	Normal – 0; High – 1; Low – 2; High High – 3; Low Low – 4;

Table continues on next page

Reg A	Scale	IEC 61850 name	SA name	Description	Values
105		.AnIn3.range/.AnIn4.range		RTD 3- Channel Range Information Channel - 4 (High Byte) Channel - 3 (Low Byte)	Normal – 0; High – 1; Low – 2; High High – 3; Low Low – 4;
106		<reserved>		<reserved>	0
107		<reserved>		<reserved>	0
108		<reserved>		<reserved>	0
109		<reserved>		<reserved>	0
110		<reserved>		<reserved>	0
111		<reserved>		<reserved>	0
		LD0.RTDGGIO4			
112	Value reported with a scale factor of "1" when channel configured as dimensionless and with a scale factor of "100" when channel configured as either mA or RTD	.AnIn1.mag.f		RTD 4-Channel 1 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
113		.AnIn2.mag.f		RTD 4-Channel 2 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
114		.AnIn3.mag.f		RTD 4-Channel 3 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
115		.AnIn4.mag.f		RTD 4-Channel 4 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
116		<reserved>		<reserved>	0
117		<reserved>		<reserved>	0
118		<reserved>		<reserved>	0
119		<reserved>		<reserved>	0
120		.AnIn1.range/.AnIn2.range		RTD 4- Channel Range Information Channel - 2 (High Byte) Channel - 1 (Low Byte)	Normal – 0; High – 1; Low – 2; High High – 3; Low Low – 4;
121		.AnIn3.range/.AnIn4.range		RTD 4- Channel Range Information Channel - 4 (High Byte) Channel - 3 (Low Byte)	Normal – 0; High – 1; Low – 2; High High – 3; Low Low – 4;
122		<reserved>		<reserved>	0
123		<reserved>		<reserved>	0
124		<reserved>		<reserved>	0
125		<reserved>		<reserved>	0
126		<reserved>		<reserved>	0
127		<reserved>		<reserved>	0
		LD0.RTDGGIO5			
Table continues on next page					

Reg A	Scale	IEC 61850 name	SA name	Description	Values
128	Value reported with a scale factor of "1" when channel configured as dimensionless and with a scale factor of "100" when channel configured as either mA or RTD	.AnIn1.mag.f		RTD 5-Channel 1 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
129		.AnIn2.mag.f		RTD 5-Channel 2 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
130		.AnIn3.mag.f		RTD 5-Channel 3 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
131		.AnIn4.mag.f		RTD 5-Channel 4 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
132		<reserved>		<reserved>	0
133		<reserved>		<reserved>	0
134		<reserved>		<reserved>	0
135		<reserved>		<reserved>	0
136		.AnIn1.range/.AnIn2.range		RTD 5- Channel Range Information Channel - 2 (High Byte) Channel - 1 (Low Byte)	Normal – 0; High – 1; Low – 2; High High – 3; Low Low – 4;
137		.AnIn3.range/.AnIn4.range		RTD 5- Channel Range Information Channel - 4 (High Byte) Channel - 3 (Low Byte)	Normal – 0; High – 1; Low – 2; High High – 3; Low Low – 4;
138		<reserved>		<reserved>	0
139		<reserved>		<reserved>	0
140		<reserved>		<reserved>	0
141		<reserved>		<reserved>	0
142		<reserved>		<reserved>	0
143		<reserved>		<reserved>	0
		LD0.RTDGGIO6			
144	Value reported with a scale factor of "1" when channel configured as dimensionless and with a scale factor of "100" when channel configured as either mA or RTD	.AnIn1.mag.f		RTD 6-Channel 1 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
145		.AnIn2.mag.f		RTD 6-Channel 2 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
146		.AnIn3.mag.f		RTD 6-Channel 3 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
147		.AnIn4.mag.f		RTD 6-Channel 4 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
148		<reserved>		<reserved>	0
149		<reserved>		<reserved>	0
150		<reserved>		<reserved>	0
151		<reserved>		<reserved>	0
152		.AnIn1.range/.AnIn2.range		RTD 6- Channel Range Information Channel - 2 (High Byte) Channel - 1 (Low Byte)	Normal – 0; High – 1; Low – 2; High High – 3; Low Low – 4;

Table continues on next page

Reg A	Scale	IEC 61850 name	SA name	Description	Values
153		.AnIn3.range/.AnIn4.range		RTD 6- Channel Range Information Channel - 4 (High Byte) Channel - 3 (Low Byte)	Normal – 0; High – 1; Low – 2; High High – 3; Low Low – 4;
154		<reserved>		<reserved>	0
155		<reserved>		<reserved>	0
156		<reserved>		<reserved>	0
157		<reserved>		<reserved>	0
158		<reserved>		<reserved>	0
159		<reserved>		<reserved>	0
		LD0.RTDGGIO7			
160	Value reported with a scale factor of "1" when channel configured as dimensionless and with a scale factor of "100" when channel configured as either mA or RTD	.AnIn1.mag.f		RTD 7-Channel 1 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
161		.AnIn2.mag.f		RTD 7-Channel 2 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
162		.AnIn3.mag.f		RTD 7-Channel 3 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
163		.AnIn4.mag.f		RTD 7-Channel 4 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
164		<reserved>		<reserved>	0
165		<reserved>		<reserved>	0
166		<reserved>		<reserved>	0
167		<reserved>		<reserved>	0
168		.AnIn1.range/.AnIn2.range		RTD 7- Channel Range Information Channel - 2 (High Byte) Channel - 1 (Low Byte)	Normal – 0; High – 1; Low – 2; High High – 3; Low Low – 4;
169		.AnIn3.range/.AnIn4.range		RTD 7- Channel Range Information Channel - 4 (High Byte) Channel - 3 (Low Byte)	Normal – 0; High – 1; Low – 2; High High – 3; Low Low – 4;
170		<reserved>		<reserved>	0
171		<reserved>		<reserved>	0
172		<reserved>		<reserved>	0
173		<reserved>		<reserved>	0
174		<reserved>		<reserved>	0
175		<reserved>		<reserved>	0
		LD0.RTDGGIO8			

Table continues on next page

Reg A	Scale	IEC 61850 name	SA name	Description	Values
176	Value reported with a scale factor of "1" when channel configured as dimensionless and with a scale factor of "100" when channel configured as either mA or RTD	.AnIn1.mag.f		RTD 8-Channel 1 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1]
177		.AnIn2.mag.f		RTD 8-Channel 2 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1]
178		.AnIn3.mag.f		RTD 8-Channel 3 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1]
179		.AnIn4.mag.f		RTD 8-Channel 4 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1]
180		<reserved>		<reserved>	0
181		<reserved>		<reserved>	0
182		<reserved>		<reserved>	0
183		<reserved>		<reserved>	0
184		.AnIn1.range/.AnIn2.range		RTD 8- Channel Range Information Channel - 2 (High Byte) Channel - 1 (Low Byte)	Normal – 0; High – 1; Low – 2; High High – 3; Low Low – 4;
185		.AnIn3.range/.AnIn4.range		RTD 8- Channel Range Information Channel - 4 (High Byte) Channel - 3 (Low Byte)	Normal – 0; High – 1; Low – 2; High High – 3; Low Low – 4;
186		<reserved>		<reserved>	0
187		<reserved>		<reserved>	0
188		<reserved>		<reserved>	0
189		<reserved>		<reserved>	0
190		<reserved>		<reserved>	0
191		<reserved>		<reserved>	0
		LD0.RTDGGIO9			
192	Value reported with a scale factor of "1" when channel configured as dimensionless and with a scale factor of "100" when channel configured as either mA or RTD	.AnIn1.mag.f		RTD 9-Channel 1 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1]
193		.AnIn2.mag.f		RTD 9-Channel 2 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1]
194		.AnIn3.mag.f		RTD 9-Channel 3 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1]
195		.AnIn4.mag.f		RTD 9-Channel 4 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1]
196		<reserved>		<reserved>	0
197		<reserved>		<reserved>	0
198		<reserved>		<reserved>	0
199		<reserved>		<reserved>	0
200		.AnIn1.range/.AnIn2.range		RTD 9- Channel Range Information Channel - 2 (High Byte) Channel - 1 (Low Byte)	Normal – 0; High – 1; Low – 2; High High – 3; Low Low – 4;

Table continues on next page

Reg A	Scale	IEC 61850 name	SA name	Description	Values
201		.AnIn3.range/.AnIn4.range		RTD 9- Channel Range Information Channel - 4 (High Byte) Channel - 3 (Low Byte)	Normal – 0; High – 1; Low – 2; High High – 3; Low Low – 4;
202		<reserved>		<reserved>	0
203		<reserved>		<reserved>	0
204		<reserved>		<reserved>	0
205		<reserved>		<reserved>	0
206		<reserved>		<reserved>	0
207		<reserved>		<reserved>	0
		LD0.RTDGGIO10			
208	Value reported to user with a scale factor of "1" when channel configured as dimensionless and with a scale factor of "100" when channel configured as either mA or RTD	.AnIn1.mag.f		RTD 10-Channel 1 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
209		.AnIn2.mag.f		RTD 10-Channel 2 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
210		.AnIn3.mag.f		RTD 10-Channel 3 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
211		.AnIn4.mag.f		RTD 10-Channel 4 Input Value	-40...200 [°C]/0.0...20.0 [mA]/-10000...10000[1)]
212		<reserved>		<reserved>	0
213		<reserved>		<reserved>	0
214		<reserved>		<reserved>	0
215		<reserved>		<reserved>	0
216		.AnIn1.range/.AnIn2.range		RTD 10- Channel Range Information Channel - 2 (High Byte) Channel - 1 (Low Byte)	Normal – 0; High – 1; Low – 2; High High – 3; Low Low – 4;
217		.AnIn3.range/.AnIn4.range		RTD 10- Channel Range Information Channel - 4 (High Byte) Channel - 3 (Low Byte)	Normal – 0; High – 1; Low – 2; High High – 3; Low Low – 4;
218		<reserved>		<reserved>	0
219		<reserved>		<reserved>	0
220		<reserved>		<reserved>	0
221		<reserved>		<reserved>	0
222		<reserved>		<reserved>	0
223		<reserved>		<reserved>	0

1) As per the configuration

7.2.8 LD0.RTDGGIO RTD channel range information

RTD input channel range information can be accessed with addresses listed in the table.

Table 135: LD0.RTDGGIO RTD channel range information

Reg A	Type	Scale	IEC61850 name	SA name	Description	Values
			LD0.RTDGGIO1		RTD-1	
704	u16	1	.AnIn1.range / .AnIn2.range		RTD Channel Range Information Channel - 2 (High Byte) Channel - 1 (Low Byte)	Normal = 0 High = 1 Low = 2 High High = 3 Low Low = 4
705	u16	1	.AnIn3.range / .AnIn4.range		RTD Channel Range Information Channel - 4 (High Byte) Channel - 3 (Low Byte)	
			LD0.RTDGGIO2		RTD-2	
712	u16	1	.AnIn1.range / .AnIn2.range		RTD Channel Range Information Channel - 2 (High Byte) Channel - 1 (Low Byte)	
713	u16	1	.AnIn3.range / .AnIn4.range		RTD Channel Range Information Channel - 4 (High Byte) Channel - 3 (Low Byte)	
			LD0.RTDGGIO3		RTD-3	
720	u16	1	.AnIn1.range / .AnIn2.range		RTD Channel Range Information Channel - 2 (High Byte) Channel - 1 (Low Byte)	Normal = 0 High = 1 Low = 2 High High = 3 Low Low = 4
721	u16	1	.AnIn3.range / .AnIn4.range		RTD Channel Range Information Channel - 4 (High Byte) Channel - 3 (Low Byte)	
			LD0.RTDGGIO4		RTD-4	
728	u16	1	.AnIn1.range / .AnIn2.range		RTD Channel Range Information Channel - 2 (High Byte) Channel - 1 (Low Byte)	
729	u16	1	.AnIn3.range / .AnIn4.range		RTD Channel Range Information Channel - 4 (High Byte) Channel - 3 (Low Byte)	
			LD0.RTDGGIO5		RTD-5	
Table continues on next page						

Reg A	Type	Scale	IEC61850 name	SA name	Description	Values
736	u16	1	.AnIn1.range / .AnIn2.range		RTD Channel Range Information Channel - 2 (High Byte) Channel - 1 (Low Byte)	Normal = 0 High = 1 Low = 2 High High = 3 Low Low = 4
737	u16	1	.AnIn3.range / .AnIn4.range		RTD Channel Range Information Channel - 4 (High Byte) Channel - 3 (Low Byte)	
			LD0.RTDGGIO6		RTD-6	
744	u16	1	.AnIn1.range / .AnIn2.range		RTD Channel Range Information Channel - 2 (High Byte) Channel - 1 (Low Byte)	
745	u16	1	.AnIn3.range / .AnIn4.range		RTD Channel Range Information Channel - 4 (High Byte) Channel - 3 (Low Byte)	
			LD0.RTDGGIO7		RTD-7	
752	u16	1	.AnIn1.range / .AnIn2.range		RTD Channel Range Information Channel - 2 (High Byte) Channel - 1 (Low Byte)	Normal = 0 High = 1 Low = 2 High High = 3 Low Low = 4
753	u16	1	.AnIn3.range / .AnIn4.range		RTD Channel Range Information Channel - 4 (High Byte) Channel - 3 (Low Byte)	
			LD0.RTDGGIO8		RTD-8	
760	u16	1	.AnIn1.range / .AnIn2.range		RTD Channel Range Information Channel - 2 (High Byte) Channel - 1 (Low Byte)	
761	u16	1	.AnIn3.range / .AnIn4.range		RTD Channel Range Information Channel - 4 (High Byte) Channel - 3 (Low Byte)	
			LD0.RTDGGIO9		RTD-9	

Table continues on next page

Reg A	Type	Scale	IEC61850 name	SA name	Description	Values
768	u16	1	.AnIn1.range / .AnIn2.range		RTD Channel Range Information Channel - 2 (High Byte) Channel - 1 (Low Byte)	Normal = 0 High = 1 Low = 2 High High = 3 Low Low = 4
769	u16	1	.AnIn3.range / .AnIn4.range		RTD Channel Range Information Channel - 4 (High Byte) Channel - 3 (Low Byte)	
			LD0.RTDGGIO10		RTD-10	
776	u16	1	.AnIn1.range / .AnIn2.range		RTD Channel Range Information Channel - 2 (High Byte) Channel - 1 (Low Byte)	
777	u16	1	.AnIn3.range / .AnIn4.range		RTD Channel Range Information Channel - 4 (High Byte) Channel - 3 (Low Byte)	

7.2.9 LD0.AOMGGIO physical I/O values

mA output (AOM4) module information can be accessed with the addresses listed in the table.

Table 136: LD0.AOMGGIO physical I/O values

Reg A	Scale	IEC 61850 name	SA name	Description	Values
		LD0.AOMGGIO1		16 bit signed Integer	
224	Value reported with a scale factor of "1" when channel configured as dimensionless and with a scale factor of "100" when channel configured as mA	.AnOut1.mxVal.f		AOM 1-Channel 1 Output Value	0.0...20.0 [mA] / -32768...+32768[1)]
225		.AnOut2.mxVal.f		AOM 1-Channel 2 Output Value	0.0...20.0 [mA] / -32768...+32768[1)]
226		.AnOut3.mxVal.f		AOM 1-Channel 3 Output Value	0.0...20.0 [mA] / -32768...+32768[1)]
227		.AnOut4.mxVal.f		AOM 1-Channel 4 Output Value	0.0...20.0 [mA] / -32768...+32768[1)]
228		<reserved>		<reserved>	0
229		<reserved>		<reserved>	0
230		<reserved>		<reserved>	0
231		<reserved>		<reserved>	0
232		<reserved>		<reserved>	0
233		<reserved>		<reserved>	0
234		<reserved>		<reserved>	0
235		<reserved>		<reserved>	0
236		<reserved>		<reserved>	0
237		<reserved>		<reserved>	0
238		<reserved>		<reserved>	0

Table continues on next page

Reg A	Scale	IEC 61850 name	SA name	Description	Values
239		<reserved>		<reserved>	0
		LD0.AOMGGIO2			
240	Value reported with a scale factor of "1" when channel configured as dimensionless and with a scale factor of "100" when channel configured as mA	.AnOut1.mxVal.f		AOM 2-Channel 1 Output Value	0.0...20.0 [mA] / -32768...+32768 1)
241		.AnOut2.mxVal.f		AOM 2-Channel 2 Output Value	0.0...20.0 [mA] / -32768...+32768 1)
242		.AnOut3.mxVal.f		AOM 2-Channel 3 Output Value	0.0...20.0 [mA] / -32768...+32768 1)
243		.AnOut4.mxVal.f		AOM 2-Channel 4 Output Value	0.0...20.0 [mA] / -32768...+32768 1)
244		<reserved>		<reserved>	0
245		<reserved>		<reserved>	0
246		<reserved>		<reserved>	0
247		<reserved>		<reserved>	0
248		<reserved>		<reserved>	0
249		<reserved>		<reserved>	0
250		<reserved>		<reserved>	0
251		<reserved>		<reserved>	0
252		<reserved>		<reserved>	0
253		<reserved>		<reserved>	0
254		<reserved>		<reserved>	0
255		<reserved>		<reserved>	0
		LD0.AOMGGIO3			
256	Value reported with a scale factor of "1" when channel configured as dimensionless and with a scale factor of "100" when channel configured as mA	.AnOut1.mxVal.f		AOM 3-Channel 1 Output Value	0.0...20.0 [mA] / -32768...+32768 1)
257		.AnOut2.mxVal.f		AOM 3-Channel 2 Output Value	0.0...20.0 [mA] / -32768...+32768 1)
258		.AnOut3.mxVal.f		AOM 3-Channel 3 Output Value	0.0...20.0 [mA] / -32768...+32768 1)
259		.AnOut4.mxVal.f		AOM 3-Channel 4 Output Value	0.0...20.0 [mA] / -32768...+32768 1)
260		<reserved>		<reserved>	0
261		<reserved>		<reserved>	0
262		<reserved>		<reserved>	0
263		<reserved>		<reserved>	0
264		<reserved>		<reserved>	0
265		<reserved>		<reserved>	0
266		<reserved>		<reserved>	0
267		<reserved>		<reserved>	0
268		<reserved>		<reserved>	0
269		<reserved>		<reserved>	0
270		<reserved>		<reserved>	0

Table continues on next page

Reg A	Scale	IEC 61850 name	SA name	Description	Values
271		<reserved>		<reserved>	0
		LD0.AOMGGIO4			
272	Value reported with a scale factor of "1" when channel configured as dimensionless and with a scale factor of "100" when channel configured as mA	.AnOut1.mxVal.f		AOM 4-Channel 1 Output Value	0.0...20.0 [mA] / -32768...+32768[1)]
273		.AnOut2.mxVal.f		AOM 4-Channel 2 Output Value	0.0...20.0 [mA] / -32768...+32767[1)]
274		.AnOut3.mxVal.f		AOM 4-Channel 3 Output Value	0.0...20.0 [mA] / -32768...+32768[1)]
275		.AnOut4.mxVal.f		AOM 4-Channel 4 Output Value	0.0...20.0 [mA] / -32768...+32768[1)]
276		<reserved>		<reserved>	0
277		<reserved>		<reserved>	0
278		<reserved>		<reserved>	0
279		<reserved>		<reserved>	0
280		<reserved>		<reserved>	0
281		<reserved>		<reserved>	0
282		<reserved>		<reserved>	0
283		<reserved>		<reserved>	0
284		<reserved>		<reserved>	0
285		<reserved>		<reserved>	0
286		<reserved>		<reserved>	0
287		<reserved>		<reserved>	0

1) As per user configuration

7.2.10 LD0.PHPTOC phase overcurrent fault detection

Table 137: LD0.PHPTOC phase overcurrent fault detection

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
		LD0.PHPTOC1		SIM8F-1/SIM4F-1	
516	384.04	.Str.general	START	General Start	1 = Start
517	384.05	.Str.phsA		Phase A Start	1 = Start
518	384.06	.Str.phsB		Phase B Start	1 = Start
519	384.07	.Str.phsC		Phase C Start	1 = Start
520	384.08	.Op.general	Operate	General Operate	1 = Operate
521	384.09	.Op.phsA		Phase A Operate	1 = Operate
522	384.10	.Op.phsB		Phase B Operate	1 = Operate
523	384.11	.Op.phsC		Phase C Operate	1 = Operate
		LD0.PHPTOC2		SIM8F-2/SIM4F-2	
548	386.04	.Str.general	START	General Start	1 = Start
549	386.05	.Str.phsA		Phase A Start	1 = Start

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
550	386.06	.Str.phsB		Phase B Start	1 = Start
551	386.07	.Str.phsC		Phase C Start	1 = Start
552	386.08	.Op.general	Operate	General Operate	1 = Operate
553	386.09	.Op.phsA		Phase A Operate	1 = Operate
554	386.10	.Op.phsB		Phase B Operate	1 = Operate
555	386.11	.Op.phsC		Phase C Operate	1 = Operate
		LD0.PHPTOC3		SIM8F-3/SIM4F-3	
644	800.04	.Str.general	START	General Start	1 = Start
645	800.05	.Str.phsA		Phase A Start	1 = Start
646	800.06	.Str.phsB		Phase B Start	1 = Start
647	800.07	.Str.phsC		Phase C Start	1 = Start
648	800.08	.Op.general	Operate	General Operate	1 = Operate
649	800.09	.Op.phsA		Phase A Operate	1 = Operate
650	800.10	.Op.phsB		Phase B Operate	1 = Operate
651	800.11	.Op.phsC		Phase C Operate	1 = Operate
		LD0.PHPTOC4		SIM8F-4/SIM4F-4	
676	802.04	.Str.general	START	General Start	1 = Start
677	802.05	.Str.phsA		Phase A Start	1 = Start
678	802.06	.Str.phsB		Phase B Start	1 = Start
679	802.07	.Str.phsC		Phase C Start	1 = Start
680	802.08	.Op.general	Operate	General Operate	1 = Operate
681	802.09	.Op.phsA		Phase A Operate	1 = Operate
682	802.10	.Op.phsB		Phase B Operate	1 = Operate
683	802.11	.Op.phsC		Phase C Operate	1 = Operate
		LD0.PHPTOC5		SIM8F-5/SIM4F-5	
708	804.04	.Str.general	START	General Start	1 = Start
709	804.05	.Str.phsA		Phase A Start	1 = Start
710	804.06	.Str.phsB		Phase B Start	1 = Start
711	804.07	.Str.phsC		Phase C Start	1 = Start
712	804.08	.Op.general	Operate	General Operate	1 = Operate
713	804.09	.Op.phsA		Phase A Operate	1 = Operate
714	804.10	.Op.phsB		Phase B Operate	1 = Operate
715	804.11	.Op.phsC		Phase C Operate	1 = Operate

7.2.11 LD0.DPHPTOC three-phase directional overcurrent fault detection

Table 138: LD0.DPHPTOC three-phase directional overcurrent fault detection

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
		LD0.DPHPTOC1		SIM8F-1	
524	384.12	.Str.general	START	General Start	1 = Start
525	384.13	.Str.phsA		Phase A Start	1 = Start
526	384.14	.Str.phsB		Phase B Start	1 = Start
527	384.15	.Str.phsC		Phase C Start	1 = Start
528	385.00	.Op.general	Operate	General Operate	1 = Operate
529	385.01	.Op.phsA		Phase A Operate	1 = Operate
530	385.02	.Op.phsB		Phase B Operate	1 = Operate
531	385.03	.Op.phsC		Phase C Operate	1 = Operate
538	385.10	.OpFwd.general		Forward Operate	1 = Operate
539	385.11	.OpRev.general		Reverse Operate	1 = Operate
		LD0.DPHPTOC2		SIM8F-2	
556	386.12	.Str.general	START	General Start	1 = Start
557	386.13	.Str.phsA		Phase A Start	1 = Start
558	386.14	.Str.phsB		Phase B Start	1 = Start
559	386.15	.Str.phsC		Phase C Start	1 = Start
560	387.00	.Op.general	Operate	General Operate	1 = Operate
561	387.01	.Op.phsA		Phase A Operate	1 = Operate
562	387.02	.Op.phsB		Phase B Operate	1 = Operate
563	387.03	.Op.phsC		Phase C Operate	1 = Operate
570	387.10	.OpFwd.general		Forward Operate	1 = Operate
571	387.11	.OpRev.general		Reverse Operate	1 = Operate
		LD0.DPHPTOC3		SIM8F-3	
652	800.12	.Str.general	START	General Start	1 = Start
653	800.13	.Str.phsA		Phase A Start	1 = Start
654	800.14	.Str.phsB		Phase B Start	1 = Start
655	800.15	.Str.phsC		Phase C Start	1 = Start
656	801.00	.Op.general	Operate	General Operate	1 = Operate
657	801.01	.Op.phsA		Phase A Operate	1 = Operate
658	801.02	.Op.phsB		Phase B Operate	1 = Operate
659	801.03	.Op.phsC		Phase C Operate	1 = Operate
666	801.10	.OpFwd.general		Forward Operate	1 = Operate
667	801.11	.OpRev.general		Reverse Operate	1 = Operate
		LD0.DPHPTOC4		SIM8F-4	
684	802.12	.Str.general	START	General Start	1 = Start

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
685	802.13	.Str.phsA		Phase A Start	1 = Start
686	802.14	.Str.phsB		Phase B Start	1 = Start
687	802.15	.Str.phsC		Phase C Start	1 = Start
688	803.00	.Op.general	Operate	General Operate	1 = Operate
689	803.01	.Op.phsA		Phase A Operate	1 = Operate
690	803.02	.Op.phsB		Phase B Operate	1 = Operate
691	803.03	.Op.phsC		Phase C Operate	1 = Operate
698	803.10	.OpFwd.general		Forward Operate	1 = Operate
699	803.11	.OpRev.general		Reverse Operate	1 = Operate
		LD0.DPHPTOC5		SIM8F-5	
716	804.12	.Str.general	START	General Start	1 = Start
717	804.13	.Str.phsA		Phase A Start	1 = Start
718	804.14	.Str.phsB		Phase B Start	1 = Start
719	804.15	.Str.phsC		Phase C Start	1 = Start
720	805.00	.Op.general	Operate	General Operate	1 = Operate
721	805.01	.Op.phsA		Phase A Operate	1 = Operate
722	805.02	.Op.phsB		Phase B Operate	1 = Operate
723	805.03	.Op.phsC		Phase C Operate	1 = Operate
730	805.10	.OpFwd.general		Forward Operate	1 = Operate
731	805.11	.OpRev.general		Reverse Operate	1 = Operate

7.2.12 LD0.CMHAI current total demand distortion

Table 139: LD0.CMHAI current total demand distortion

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
		LD0.CMHAI1		SIM8F-1	
532	385.04	.HiATdd.stVal		Current TDD Upto 8th Harmonics	1 = Operate
		LD0.CMHAI2		SIM8F-2	
564	387.04	.HiATdd.stVal		Current TDD Upto 8th Harmonics	1 = Operate
		LD0.CMHAI3		SIM8F-3	
660	801.04	.HiATdd.stVal		Current TDD Upto 8th Harmonics	1 = Operate
		LD0.CMHAI4		SIM8F-4	
692	803.04	.HiATdd.stVal		Current TDD Upto 8th Harmonics	1 = Operate
		LD0.CMHAI5		SIM8F-5	
724	805.04	.HiATdd.stVal		Current TDD Upto 8th Harmonics	1 = Operate

7.2.13 LD0.VMHAI voltage total demand distortion

Table 140: LD0.VMHAI voltage total demand distortion

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
		LD0.VMHAI1		SIM8F-1	
533	385.05	.HiAThd.stVal		Voltage THD	1 = Operate
		LD0.VMHAI2		SIM8F-2	
565	387.05	.HiAThd.stVal		Voltage THD	1 = Operate
		LD0.VMHAI3		SIM8F-3	
661	801.05	.HiAThd.stVal		Voltage THD	1 = Operate
		LD0.VMHAI4		SIM8F-4	
693	803.05	.HiAThd.stVal		Voltage THD	1 = Operate
		LD0.VMHAI5		SIM8F-5	
725	805.05	.HiAThd.stVal		Voltage THD	1 = Operate

7.2.14 LD0.EFPTOC non-directional earth-fault detection

Table 141: LD0.EFPTOC non-directional earth-fault detection

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
		LD0.EFPTOC1		SIM8F-1/SIM4F-1	
534	385.06	.Str.general	START	General Start	1 = Start
535	385.07	.Op.general	Operate	General Operate	1 = Operate
		LD0.EFPTOC2		SIM8F-2/SIM4F-2	
566	387.06	.Str.general	START	General Start	1 = Start
567	387.07	.Op.general	Operate	General Operate	1 = Operate
		LD0.EFPTOC3		SIM8F-3/SIM4F-3	
662	801.06	.Str.general	START	General Start	1 = Start
663	801.07	.Op.general	Operate	General Operate	1 = Operate
		LD0.EFPTOC4		SIM8F-4/SIM4F-4	
694	803.06	.Str.general	START	General Start	1 = Start
695	803.07	.Op.general	Operate	General Operate	1 = Operate
		LD0.EFPTOC5		SIM8F-5/SIM4F-5	
726	805.06	.Str.general	START	General Start	1 = Start
727	805.07	.Op.general	Operate	General Operate	1 = Operate

7.2.15 LD0.DEFPTOC directional earth-fault detection

Table 142: LD0.DEFPTOC directional earth-fault detection

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
		LD0.DEFPTOC1		SIM8F-1	
536	385.08	.Str.general	START	General Start	1 = Start
537	385.09	.Op.general	Operate	General Operate	1 = Operate
540	385.12	.OpFwd.general		Forward Operate	1 = Operate
541	385.13	.OpRev.general		Reverse Operate	1 = Operate
		LD0.DEFPTOC2		SIM8F-2	
568	387.08	.Str.general	START	General Start	1 = Start
569	387.09	.Op.general	Operate	General Operate	1 = Operate
572	387.12	.OpFwd.general		Forward Operate	1 = Operate
573	387.13	.OpRev.general		Reverse Operate	1 = Operate
		LD0.DEFPTOC3		SIM8F-3	
664	801.08	.Str.general	START	General Start	1 = Start
665	801.09	.Op.general	Operate	General Operate	1 = Operate
668	801.12	.OpFwd.general		Forward Operate	1 = Operate
669	801.13	.OpRev.general		Reverse Operate	1 = Operate
		LD0.DEFPTOC4		SIM8F-4	
696	803.08	.Str.general	START	General Start	1 = Start
697	803.09	.Op.general	Operate	General Operate	1 = Operate
700	803.12	.OpFwd.general		Forward Operate	1 = Operate
701	803.13	.OpRev.general		Reverse Operate	1 = Operate
		LD0.DEFPTOC5		SIM8F-5	
728	805.08	.Str.general	START	General Start	1 = Start
729	805.09	.Op.general	Operate	General Operate	1 = Operate
732	805.12	.OpFwd.general		Forward Operate	1 = Operate
733	805.13	.OpRev.general		Reverse Operate	1 = Operate

7.2.16 LD0.MFAPSDE multifrequency admittance protection (earth-fault indication)

Table 143: LD0.MFAPSDE multifrequency admittance protection

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
		LD0.MFAPSDE1		SIM8F-1	
736	806	.Str.general	Start	General Start	1 = Start
737	806.01	.Op.general	Operate	General Operate	1 = Operate
738	806.02	.RevEF.stVal		Reverse Earth Fault	1 = Fault
Table continues on next page					

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
739	806.03	.ItmEFInd.stVal		Intermittent Earth Fault Indication	1 = Fault
740	806.04	.OpFwd.general		Forward Operate	1 = operate
741	806.05	.OpRev.general		Reverse Operate	1 = operate
		LD0.MFAPSDE 2		SIM8F-2	
768	808	.Str.general	Start	General Start	1 = Start
769	808.01	.Op.general	Operate	General Operate	1 = Operate
770	808.02	.RevEF.stVal		Reverse Earth Fault	1 = Fault
771	808.03	.ItmEFInd.stVal		Intermittent Earth Fault Indication	1 = Fault
772	808.04	.OpFwd.general		Forward Operate	1 = operate
773	808.05	.OpRev.general		Reverse Operate	1 = operate
		LD0.MFAPSDE3		SIM8F-3	
800	810	.Str.general	Start	General Start	1 = Start
801	810.01	.Op.general	Operate	General Operate	1 = Operate
802	810.02	.RevEF.stVal		Reverse Earth Fault	1 = Fault
803	810.03	.ItmEFInd.stVal		Intermittent Earth Fault Indication	1 = Fault
804	810.04	.OpFwd.general		Forward Operate	1 = operate
805	810.05	.OpRev.general		Reverse Operate	1 = operate
		LD0.MFAPSDE4		SIM8F-4	
832	812	.Str.general	Start	General Start	1 = Start
833	812.01	.Op.general	Operate	General Operate	1 = Operate
834	812.02	.RevEF.stVal		Reverse Earth Fault	1 = Fault
835	812.03	.ItmEFInd.stVal		Intermittent Earth Fault Indication	1 = Fault
836	812.04	.OpFwd.general		Forward Operate	1 = operate
837	812.05	.OpRev.general		Reverse Operate	1 = operate
		LD0.MFAPSDE5		SIM8F-5	
864	814	.Str.general	Start	General Start	1 = Start
865	814.01	.Op.general	Operate	General Operate	1 = Operate
866	814.02	.RevEF.stVal		Reverse Earth Fault	1 = Fault
867	814.03	.ItmEFInd.stVal		Intermittent Earth Fault Indication	1 = Fault
868	814.04	.OpFwd.general		Forward Operate	1 = operate
869	814.05	.OpRev.general		Reverse Operate	1 = operate

7.2.17 LD0.PHSVPR voltage presence

Table 144: LD0.PHSVPR Voltage Presence

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
		LD0.PHSVPR1		SIM8F-1	
744	806.08	.VLiv.stVal		Indication For Voltage Presence	1 = Presence
745	806.09	.VDea.stVal		Indication For Voltage Not Presence	1 = Non-Presence
		LD0.PHSVPR2		SIM8F-2	
776	808.08	.VLiv.stVal		Indication For Voltage Presence	1 = Presence
777	808.09	.VDea.stVal		Indication For Voltage Not Presence	1 = Non-Presence
		LD0.PHSVPR3		SIM8F-3	
808	810.08	.VLiv.stVal		Indication For Voltage Presence	1 = Presence
809	810.09	.VDea.stVal		Indication For Voltage Not Presence	1 = Non-Presence
		LD0.PHSVPR4		SIM8F-4	
840	812.08	.VLiv.stVal		Indication For Voltage Presence	1 = Presence
841	812.09	.VDea.stVal		Indication For Voltage Not Presence	1 = Non-Presence
		LD0.PHSVPR5		SIM8F-5	
872	814.08	.VLiv.stVal		Indication For Voltage Presence	1 = Presence
873	814.09	.VDea.stVal		Indication For Voltage Not Presence	1 = Non-Presence

7.2.18 LD0.NSPTOC negative-sequence overcurrent fault detection

Table 145: LD0.NSPTOC negative-sequence overcurrent fault detection

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
		LD0.NSPTOC1		SIM8F-1/SIM4F-1	
752	807	.Str.general	START	General Start	1 = Start
753	807.01	.Op.general	Operate	General Operate	1 = Operate
		LD0.NSPTOC2		SIM8F-2/SIM4F-2	
784	809	.Str.general	START	General Start	1 = Start
785	809.01	.Op.general	Operate	General Operate	1 = Operate
		LD0.NSPTOC3		SIM8F-3/SIM4F-3	
816	811	.Str.general	START	General Start	1 = Start
817	811.01	.Op.general	Operate	General Operate	1 = Operate
Table continues on next page					

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
		LD0.NSPTOC4		SIM8F-4/SIM4F-4	
848	813	.Str.general	START	General Start	1 = Start
849	813.01	.Op.general	Operate	General Operate	1 = Operate
		LD0.NSPTOC5		SIM8F-5/SIM4F-5	
880	815	.Str.general	START	General Start	1 = Start
881	815.01	.Op.general	Operate	General Operate	1 = Operate

7.2.19 LD0.FPIPTOC fault direction indication

Table 146: LD0.FPIPTOC fault direction indication

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
		LD0.FPIPTOC1		SIM4F-1	
754	807.02	.Str.general	START	General Start	1 = Start
755	807.03	.Op.general	Operate	General Operate	1 = Operate
		LD0.FPIPTOC2		SIM4F-2	
786	809.02	.Str.general	START	General Start	1 = Start
787	809.03	.Op.general	Operate	General Operate	1 = Operate
		LD0.FPIPTOC3		SIM4F-3	
818	811.02	.Str.general	START	General Start	1 = Start
819	811.03	.Op.general	Operate	General Operate	1 = Operate
		LD0.FPIPTOC4		SIM4F-4	
850	813.02	.Str.general	START	General Start	1 = Start
851	813.03	.Op.general	Operate	General Operate	1 = Operate
		LD0.FPIPTOC5		SIM4F-5	
882	815.02	.Str.general	START	General Start	1 = Start
883	815.03	.Op.general	Operate	General Operate	1 = Operate

7.2.20 LD0.SEQSPVC fuse failure supervision

Table 147: LD0.SEQSPVC fuse failure supervision

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
		LD0.SEQSPVC1		SIM8F-1	
757	807.05	.Str.general	START	General Start	1 = Start
		LD0.SEQSPVC2		SIM8F-2	
789	809.05	.Str.general	START	General Start	1 = Start
		LD0.SEQSPVC3		SIM8F-3	
821	811.05	.Str.general	START	General Start	1 = Start
		LD0.SEQSPVC4		SIM8F-4	

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
853	813.05	.Str.general	START	General Start	1 = Start
		LD0.SEQSPVC5		SIM8F-5	
885	815.05	.Str.general	START	General Start	1 = Start

7.2.21 LD0.INRPHAR inrush detector

Table 148: LD0.INRPHAR inrush detector

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
		LD0.INRPHAR1		SIM8F-1/SIM4F-1	
758	807.06	.Str.general	START	General Start	1 = Start
		LD0.INRPHAR2		SIM8F-2/SIM4F-2	
790	809.06	.Str.general	START	General Start	1 = Start
		LD0.INRPHAR3		SIM8F-3/SIM4F-3	
822	811.06	.Str.general	START	General Start	1 = Start
		LD0.INRPHAR4		SIM8F-4/SIM4F-4	
854	813.06	.Str.general	START	General Start	1 = Start
		LD0.INRPHAR5		SIM8F-5/SIM4F-5	
886	815.06	.Str.general	START	General Start	1 = Start

7.2.22 Binary writable signals for SIM8F

Table 149: Binary writable signals for SIM8F

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
				SIM8F-1	
576	391			Reset Fault Indicator	1 = Reset
577	391.01			Reset Energy Counter	1 = Reset
578	391.02			Update Statistics	1 = Update statistics
				SIM8F-2	
592	392			Reset Fault Indicator	1 = Reset
593	392.01			Reset Energy Counter	1 = Reset
594	392.02			Update Statistics	1 = Update statistics
				SIM8F-3	
896	816			Reset Fault Indicator	1 = Reset
897	816.01			Reset Energy Counter	1 = Reset
898	816.02			Update Statistics	1 = Update statistics
				SIM8F-4	
912	817			Reset Fault Indicator	1 = Reset

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
913	817.01			Reset Energy Counter	1 = Reset
914	817.02			Update Statistics	1 = Update statistics
				SIM8F-5	
928	818			Reset Fault Indicator	1 = Reset
929	818.01			Reset Energy Counter	1 = Reset
930	818.02			Update Statistics	1 = Update statistics

7.2.23 Binary writable signals for SIM4F

Table 150: Binary writable signals for SIM4F

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
				SIM4F-1	
576	391			Reset Fault Indicator	1 = Reset
				SIM4F-2	
592	392			Reset Fault Indicator	1 = Reset
				SIM4F-3	
896	816			Reset Fault Indicator	1 = Reset
				SIM4F-4	
912	817			Reset Fault Indicator	1 = Reset
				SIM4F-5	
928	818			Reset Fault Indicator	1 = Reset

7.2.24 LD0.PWRRDIR phase load flow direction

Table 151: LD0.PWRRDIR phase load flow direction

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.PWRRDIR1		SIM8F-1	0 = unknown 1 = forward 2 = reverse 3 = both
400	u16	1	.Dir.dirgeneral		General Load Flow Direction	
401	u16	1	.Dir.dirphsA		Phase A Per Phase Load Flow Direction	
402	u16	1	.Dir.dirphsB		Phase B Per Phase Load Flow Direction	
403	u16	1	.Dir.dirphsC		Phase C Per Phase Load Flow Direction	
			LD0.PWRRDIR2		SIM8F-2	
532	u16	1	.Dir.dirgeneral		General Load Flow Direction	
533	u16	1	.Dir.dirphsA		Phase A Per Phase Load Flow Direction	
534	u16	1	.Dir.dirphsB		Phase B Per Phase Load Flow Direction	
535	u16	1	.Dir.dirphsC		Phase C Per Phase Load Flow Direction	
			LD0.PWRRDIR3		SIM8F-3	
864	u16	1	.Dir.dirgeneral		General Load Flow Direction	
865	u16	1	.Dir.dirphsA		Phase A Per Phase Load Flow Direction	
866	u16	1	.Dir.dirphsB		Phase B Per Phase Load Flow Direction	
867	u16	1	.Dir.dirphsC		Phase C Per Phase Load Flow Direction	
			LD0.PWRRDIR4		SIM8F-4	
996	u16	1	.Dir.dirgeneral		General Load Flow Direction	
997	u16	1	.Dir.dirphsA		Phase A Per Phase Load Flow Direction	
998	u16	1	.Dir.dirphsB		Phase B Per Phase Load Flow Direction	
999	u16	1	.Dir.dirphsC		Phase C Per Phase Load Flow Direction	
			LD0.PWRRDIR5		SIM8F-5	
1128	u16	1	.Dir.dirgeneral		General Load Flow Direction	
1129	u16	1	.Dir.dirphsA		Phase A Per Phase Load Flow Direction	
1130	u16	1	.Dir.dirphsB		Phase B Per Phase Load Flow Direction	
1131	u16	1	.Dir.dirphsC		Phase C Per Phase Load Flow Direction	

7.2.25 LD0.PHPTOC phase overcurrent fault detection

Table 152: LD0.PHPTOC phase overcurrent fault detection

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.PHPTOC1		SIM8F-1/SIM4F-1	0 = unknown 1 = forward 2 = reverse 3 = both
404	u16	1	.Str.dirgeneral		General Start	
405	u16	1	.Str.dirphsA		Phase A Start	
406	u16	1	.Str.dirphsB		Phase B Start	
407	u16	1	.Str.dirphsC		Phase C Start	
			LD0.PHPTOC2		SIM8F-2/SIM4F-2	
536	u16	1	.Str.dirgeneral		General Start	
537	u16	1	.Str.dirphsA		Phase A Start	
538	u16	1	.Str.dirphsB		Phase B Start	
539	u16	1	.Str.dirphsC		Phase C Start	
			LD0.PHPTOC3		SIM8F-3/SIM4F-3	
868	u16	1	.Str.dirgeneral		General Start	
869	u16	1	.Str.dirphsA		Phase A Start	
870	u16	1	.Str.dirphsB		Phase B Start	
871	u16	1	.Str.dirphsC		Phase C Start	
			LD0.PHPTOC4		SIM8F-4/SIM4F-4	
1000	u16	1	.Str.dirgeneral		General Start	
1001	u16	1	.Str.dirphsA		Phase A Start	
1002	u16	1	.Str.dirphsB		Phase B Start	
1003	u16	1	.Str.dirphsC		Phase C Start	
			LD0.PHPTOC5		SIM8F-5/SIM4F-5	
1132	u16	1	.Str.dirgeneral		General Start	
1133	u16	1	.Str.dirphsA		Phase A Start	
1134	u16	1	.Str.dirphsB		Phase B Start	
1135	u16	1	.Str.dirphsC		Phase C Start	

7.2.26 LD0.DPHPTOC three-phase directional overcurrent fault detection

Table 153: LD0.DPHPTOC three-phase directional overcurrent fault detection

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.DPHPTOC1		SIM8F-1	0 = unknown 1 = forward 2 = reverse 3 = both
408	u16	1	.Str.dirgeneral		General Start	
409	u16	1	.Str.dirphsA		Phase A Start	
410	u16	1	.Str.dirphsB		Phase B Start	
411	u16	1	.Str.dirphsC		Phase C Start	
			LD0.DPHPTOC2		SIM8F-2	
540	u16	1	.Str.dirgeneral		General Start	
541	u16	1	.Str.dirphsA		Phase A Start	
542	u16	1	.Str.dirphsB		Phase B Start	
543	u16	1	.Str.dirphsC		Phase C Start	
			LD0.DPHPTOC3		SIM8F-3	
872	u16	1	.Str.dirgeneral		General Start	
873	u16	1	.Str.dirphsA		Phase A Start	
874	u16	1	.Str.dirphsB		Phase B Start	
875	u16	1	.Str.dirphsC		Phase C Start	
			LD0.DPHPTOC4		SIM8F-4	
1004	u16	1	.Str.dirgeneral		General Start	
1005	u16	1	.Str.dirphsA		Phase A Start	
1006	u16	1	.Str.dirphsB		Phase B Start	
1007	u16	1	.Str.dirphsC		Phase C Start	
			LD0.DPHPTOC5		SIM8F-5	
1136	u16	1	.Str.dirgeneral		General Start	
1137	u16	1	.Str.dirphsA		Phase A Start	
1138	u16	1	.Str.dirphsB		Phase B Start	
1139	u16	1	.Str.dirphsC		Phase C Start	

7.2.27 LD0.EFPTOC non-directional earth-fault detection

Table 154: LD0.EFPTOC non-directional earth-fault detection

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
412	u16		LD0.EFPTOC1		SIM8F-1/SIM4F-1	0 = unknown 1 = forward 2 = reverse 3 = both
		1	.Str.dirgeneral		General Start	
544	u16		LD0.EFPTOC2		SIM8F-2/SIM4F-2	
		1	.Str.dirgeneral		General Start	
876	u16		LD0.EFPTOC3		SIM8F-3/SIM4F-3	
		1	.Str.dirgeneral		General Start	
1008	u16		LD0.EFPTOC4		SIM8F-4/SIM4F-4	
		1	.Str.dirgeneral		General Start	
1140	u16		LD0.EFPTOC5		SIM8F-5/SIM4F-5	
		1	.Str.dirgeneral		General Start	

7.2.28 LD0.DEFPTOC directional earth-fault detection

Table 155: LD0.DEFPTOC directional earth-fault detection

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.DEFPTOC1		SIM8F-1	0 = unknown 1 = forward 2 = reverse 3 = both
413	u16	1	.Str.dirgeneral		General Start	
			LD0.DEFPTOC2		SIM8F-2	
545	u16	1	.Str.dirgeneral		General Start	
			LD0.DEFPTOC3		SIM8F-3	
877	u16	1	.Str.dirgeneral		General Start	
			LD0.DEFPTOC4		SIM8F-4	
1009	u16	1	.Str.dirgeneral		General Start	
			LD0.DEFPTOC5		SIM8F-5	
1141	u16	1	.Str.dirgeneral		General Start	

7.2.29 LD0.CMMXU phase current measurements

Table 156: LD0.CMMXU phase current measurements

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
			LDO.CMMXU1		SIM8F-1/SIM4F-1	
414	i32	10	.A.phsA.cVal.mag.f		Phase A Current Magnitude	
415						
416	i32	1	.A.phsA.cVal.ang.f		Phase A Current Angle	
417						
418	i32	10	.A.phsB.cVal.mag.f		Phase B Current Magnitude	
Table continues on next page						

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
419						
420	i32	1	.A.phsB.cVal.ang.f		Phase B Current Angle	
421						
422	i32	10	.A.phsC.cVal.mag.f		Phase C Current Magnitude	
423						
424	i32	1	.A.phsC.cVal.ang.f		Phase C Current Angle	
425						
			LD0.CMMXU2		SIM8F-2/SIM4F-2	
546	i32	10	.A.phsA.cVal.mag.f		Phase A Current Magnitude	
547						
548	i32	1	.A.phsA.cVal.ang.f		Phase A Current Angle	
549						
550	i32	10	.A.phsB.cVal.mag.f		Phase B Current Magnitude	
551						
552	i32	1	.A.phsB.cVal.ang.f		Phase B Current Angle	
553						
554	i32	10	.A.phsC.cVal.mag.f		Phase C Current Magnitude	
555						
556	i32	1	.A.phsC.cVal.ang.f		Phase C Current Angle	
557						
			LD0.CMMXU3		SIM8F-3/SIM4F-3	
878	i32	10	.A.phsA.cVal.mag.f		Phase A Current Magnitude	
879						
880	i32	1	.A.phsA.cVal.ang.f		Phase A Current Angle	
881						
882	i32	10	.A.phsB.cVal.mag.f		Phase B Current Magnitude	
883						
884	i32	1	.A.phsB.cVal.ang.f		Phase B Current Angle	
885						
886	i32	10	.A.phsC.cVal.mag.f		Phase C Current Magnitude	
887						
888	i32	1	.A.phsC.cVal.ang.f		Phase C Current Angle	
889						
			LD0.CMMXU4		SIM8F-4/SIM4F-4	
1010	i32	10	.A.phsA.cVal.mag.f		Phase A Current Magnitude	
1011						
1012	i32	1	.A.phsA.cVal.ang.f		Phase A Current Angle	
1013						
1014	i32	10	.A.phsB.cVal.mag.f		Phase B Current Magnitude	

Table continues on next page

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
1015						
1016	i32	1	.A.phsB.cVal.ang.f		Phase B Current Angle	
1017						
1018	i32	10	.A.phsC.cVal.mag.f		Phase C Current Magnitude	
1019						
1020	i32	1	.A.phsC.cVal.ang.f		Phase C Current Angle	
1021						
			LD0.CMMXU5		SIM8F-5/SIM4F-5	
1142	i32	10	.A.phsA.cVal.mag.f		Phase A Current Magnitude	
1143						
1144	i32	1	.A.phsA.cVal.ang.f		Phase A Current Angle	
1145						
1146	i32	10	.A.phsB.cVal.mag.f		Phase B Current Magnitude	
1147						
1148	i32	1	.A.phsB.cVal.ang.f		Phase B Current Angle	
1149						
1150	i32	10	.A.phsC.cVal.mag.f		Phase C Current Magnitude	
1151						
1152	i32	1	.A.phsC.cVal.ang.f		Phase C Current Angle	
1153						

7.2.30 LD0.VMMXU voltage measurements

Table 157: LD0.VMMXU voltage measurements

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.VMMXU1		SIM8F-1	
426	i32	1	.PPV.phsAB.cVal.mag.f		V_{ab} Magnitude	
427						
428	i32	1	.PPV.phsAB.cVal.ang.f		V_{ab} Angle	
429						
430	i32	1	.PPV.phsBC.cVal.mag.f		V_{bc} Magnitude	
431						
432	i32	1	.PPV.phsBC.cVal.ang.f		V_{bc} Angle	
433						
434	i32	1	.PPV.phsCA.cVal.mag.f		V_{ca} Magnitude	
435						
436	i32	1	.PPV.phsCA.cVal.ang.f		V_{ca} Angle	
437						

Table continues on next page

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
438	i32	1	.PhV.phsA.cVal.mag.f		Phase A Voltage Magnitude	
439						
440	i32	1	.PhV.phsA.cVal.ang.f		Phase A Voltage Angle	
441						
442	i32	1	.PhV.phsB.cVal.mag.f		Phase B Voltage Magnitude	
443						
444	i32	1	.PhV.phsB.cVal.ang.f		Phase B Voltage Angle	
445						
446	i32	1	.PhV.phsC.cVal.mag.f		Phase C Voltage Magnitude	
447						
448	i32	1	.PhV.phsC.cVal.ang.f		Phase C Voltage Angle	
449						
1261	U16	1	.PhRotSt.stVal		Phase Rotation Status[1)]	0 = Invalid 1 = Positive 2 = Negative
			LD0.VMMXU2		SIM8F-2	
558	i32	1	.PPV.phsAB.cVal.mag.f		V_{ab} Magnitude	
559						
560	i32	1	.PPV.phsAB.cVal.ang.f		V_{ab} Angle	
561						
562	i32	1	.PPV.phsBC.cVal.mag.f		V_{bc} Magnitude	
563						
564	i32	1	.PPV.phsBC.cVal.ang.f		V_{bc} Angle	
565						
566	i32	1	.PPV.phsCA.cVal.mag.f		V_{ca} Magnitude	
567						
568	i32	1	.PPV.phsCA.cVal.ang.f		V_{ca} Angle	
569						
570	i32	1	.PhV.phsA.cVal.mag.f		Phase A Voltage Magnitude	
571						
572	i32	1	.PhV.phsA.cVal.ang.f		Phase A Voltage Angle	
573						
574	i32	1	.PhV.phsB.cVal.mag.f		Phase B Voltage Magnitude	
575						
576	i32	1	.PhV.phsB.cVal.ang.f		Phase B Voltage Angle	
577						
578	i32	1	.PhV.phsC.cVal.mag.f		Phase C Voltage Magnitude	
579						
580	i32	1	.PhV.phsC.cVal.ang.f		Phase C Voltage Angle	
581						

Table continues on next page

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
1309	U16	1	.PhRotSt.stVal		Phase Rotation Status[1)]	0 = Invalid 1 = Positive 2 = Negative
			LD0.VMMXU3		SIM8F-3	
890	i32	1	.PPV.phsAB.cVal.mag.f		V_{ab} Magnitude	
891						
892	i32	1	.PPV.phsAB.cVal.ang.f		V_{ab} Angle	
893						
894	i32	1	.PPV.phsBC.cVal.mag.f		V_{bc} Magnitude	
895						
896	i32	1	.PPV.phsBC.cVal.ang.f		V_{bc} Angle	
897						
898	i32	1	.PPV.phsCA.cVal.mag.f		V_{ca} Magnitude	
899						
900	i32	1	.PPV.phsCA.cVal.ang.f		V_{ca} Angle	
901						
902	i32	1	.PhV.phsA.cVal.mag.f		Phase A Voltage Magnitude	
903						
904	i32	1	.PhV.phsA.cVal.ang.f		Phase A Voltage Angle	
905						
906	i32	1	.PhV.phsB.cVal.mag.f		Phase B Voltage Magnitude	
907						
908	i32	1	.PhV.phsB.cVal.ang.f		Phase B Voltage Angle	
909						
910	i32	1	.PhV.phsC.cVal.mag.f		Phase C Voltage Magnitude	
911						
912	i32	1	.PhV.phsC.cVal.ang.f		Phase C Voltage Angle	
913						
1357	U16	1	.PhRotSt.stVal		Phase Rotation Status[1)]	0 = Invalid 1 = Positive 2 = Negative
			LD0.VMMXU4		SIM8F-4	
1022	i32	1	.PPV.phsAB.cVal.mag.f		V_{ab} Magnitude	
1023						
1024	i32	1	.PPV.phsAB.cVal.ang.f		V_{ab} Angle	
1025						
1026	i32	1	.PPV.phsBC.cVal.mag.f		V_{bc} Magnitude	
1027						
1028	i32	1	.PPV.phsBC.cVal.ang.f		V_{bc} Angle	
1029						

Table continues on next page

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
1030	i32	1	.PPV.phsCA.cVal.mag.f		V_{ca} Magnitude	
1031						
1032	i32	1	.PPV.phsCA.cVal.ang.f		V_{ca} Angle	
1033						
1034	i32	1	.PhV.phsA.cVal.mag.f		Phase A Voltage Magnitude	
1035						
1036	i32	1	.PhV.phsA.cVal.ang.f		Phase A Voltage Angle	
1037						
1038	i32	1	.PhV.phsB.cVal.mag.f		Phase B Voltage Magnitude	
1039						
1040	i32	1	.PhV.phsB.cVal.ang.f		Phase B Voltage Angle	
1041						
1042	i32	1	.PhV.phsC.cVal.mag.f		Phase C Voltage Magnitude	
1043						
1044	i32	1	.PhV.phsC.cVal.ang.f		Phase C Voltage Angle	
1045						
1405	U16	1	.PhRotSt.stVal		Phase Rotation Status[1)]	0 = Invalid 1 = Positive 2 = Negative
			LD0.VMMXU5		SIM8F-5	
1154	i32	1	.PPV.phsAB.cVal.mag.f		V_{ab} Magnitude	
1155						
1156	i32	1	.PPV.phsAB.cVal.ang.f		V_{ab} Angle	
1157						
1158	i32	1	.PPV.phsBC.cVal.mag.f		V_{bc} Magnitude	
1159						
1160	i32	1	.PPV.phsBC.cVal.ang.f		V_{bc} Angle	
1161						
1162	i32	1	.PPV.phsCA.cVal.mag.f		V_{ca} Magnitude	
1163						
1164	i32	1	.PPV.phsCA.cVal.ang.f		V_{ca} Angle	
1165						
1166	i32	1	.PhV.phsA.cVal.mag.f		Phase A Voltage Magnitude	
1167						
1168	i32	1	.PhV.phsA.cVal.ang.f		Phase A Voltage Angle	
1169						
1170	i32	1	.PhV.phsB.cVal.mag.f		Phase B Voltage Magnitude	
1171						
1172	i32	1	.PhV.phsB.cVal.ang.f		Phase B Voltage Angle	
1173						

Table continues on next page

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
1174	i32	1	.PhV.phsC.cVal.mag.f		Phase C Voltage Magnitude	
1175						
1176	i32	1	.PhV.phsC.cVal.ang.f		Phase C Voltage Angle	
1177						
1453	U16	1	.PhRotSt.stVal		Phase Rotation Status[1)]	0 = Invalid 1 = Positive 2 = Negative

1) Feature available from RIO600 Ver.1.8.2 onwards

7.2.31 LD0.PEMMXU power measurements

Table 158: LD0.PEMMXU power measurements

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.PEMMXU1		SIM8F-1	
450	i32	1	.W.phsA.cVal.mag.f		Phase A Active Power	
451						
452	i32	1	.W.phsB.cVal.mag.f		Phase B Active Power	
453						
454	i32	1	.W.phsC.cVal.mag.f		Phase C Active Power	
455						
456	i32	1	.TotW.mag.f		Total Active Power	
457						
458	i32	1	.VAr.phsA.cVal.mag.f		Phase A Reactive Power	
459						
460	i32	1	.VAr.phsB.cVal.mag.f		Phase B Reactive Power	
461						
462	i32	1	.VAr.phsC.cVal.mag.f		Phase C Reactive Power	
463						
464	i32	1	.TotVAr.mag.f		Total Reactive Power	
465						
466	i32	1	.VA.phsA.cVal.mag.f		Phase A Apparent Power	
467						
468	i32	1	.VA.phsB.cVal.mag.f		Phase B Apparent Power	
469						
470	i32	1	.VA.phsC.cVal.mag.f		Phase C Apparent Power	
471						
472	i32	1	.TotVA.mag.f		Total Apparent Power	
473						
474	i32	100	.Hz.mag.f		Frequency	
475						

Table continues on next page

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
476	i32	1000	.TotPF.mag.f		Average Power Factor	
477						
1274	i32	1000	.PF.phsA.cVal.mag.f		Phase A Power Factor1)	
1275						
1276	i32	1000	.PF.phsB.cVal.mag.f		Phase B Power Factor1)	
1277						
1278	i32	1000	.PF.phsC.cVal.mag.f		Phase C Power Factor1)	
1279						
			LD0.PEMMXU2		SIM8F-2	
582	i32	1	.W.phsA.cVal.mag.f		Phase A Active Power	
583						
584	i32	1	.W.phsB.cVal.mag.f		Phase B Active Power	
585						
586	i32	1	.W.phsC.cVal.mag.f		Phase C Active Power	
587						
588	i32	1	.TotW.mag.f		Total Active Power	
589						
590	i32	1	.VAr.phsA.cVal.mag.f		Phase A Reactive Power	
591						
592	i32	1	.VAr.phsB.cVal.mag.f		Phase B Reactive Power	
593						
594	i32	1	.VAr.phsC.cVal.mag.f		Phase C Reactive Power	
595						
596	i32	1	.TotVAr.mag.f		Total Reactive Power	
597						
598	i32	1	.VA.phsA.cVal.mag.f		Phase A Apparent Power	
599						
600	i32	1	.VA.phsB.cVal.mag.f		Phase B Apparent Power	
601						
602	i32	1	.VA.phsC.cVal.mag.f		Phase C Apparent Power	
603						
604	i32	1	.TotVA.mag.f		Total Apparent Power	
605						
606	i32	100	.Hz.mag.f		Frequency	
607						
608	i32	1000	.TotPF.mag.f		Average Power Factor	
609						
1322	i32	1000	.PF.phsA.cVal.mag.f		Phase A Power Factor1)	
1323						
Table continues on next page						

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
1324	i32	1000	.PF.phsB.cVal.mag.f		Phase B Power Factor1)	
1325						
1326	i32	1000	.PF.phsC.cVal.mag.f		Phase C Power Factor1)	
1327						
			LD0.PEMMXU3		SIM8F-3	
914	i32	1	.W.phsA.cVal.mag.f		Phase A Active Power	
915						
916	i32	1	.W.phsB.cVal.mag.f		Phase B Active Power	
917						
918	i32	1	.W.phsC.cVal.mag.f		Phase C Active Power	
919						
920	i32	1	.TotW.mag.f		Total Active Power	
921						
922	i32	1	.VAr.phsA.cVal.mag.f		Phase A Reactive Power	
923						
924	i32	1	.VAr.phsB.cVal.mag.f		Phase B Reactive Power	
925						
926	i32	1	.VAr.phsC.cVal.mag.f		Phase C Reactive Power	
927						
928	i32	1	.TotVAr.mag.f		Total Reactive Power	
929						
930	i32	1	.VA.phsA.cVal.mag.f		Phase A Apparent Power	
931						
932	i32	1	.VA.phsB.cVal.mag.f		Phase B Apparent Power	
933						
934	i32	1	.VA.phsC.cVal.mag.f		Phase C Apparent Power	
935						
936	i32	1	.TotVA.mag.f		Total Apparent Power	
937						
938	i32	100	.Hz.mag.f		Frequency	
939						
940	i32	1000	.TotPF.mag.f		Average Power Factor	
941						
1370	i32	1000	.PF.phsA.cVal.mag.f		Phase A Power Factor1)	
1371						
1372	i32	1000	.PF.phsB.cVal.mag.f		Phase B Power Factor1)	
1373						
1374	i32	1000	.PF.phsC.cVal.mag.f		Phase C Power Factor1)	
1375						

Table continues on next page

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.PEMMXU4		SIM8F-4	
1046	i32	1	.W.phsA.cVal.mag.f		Phase A Active Power	
1047						
1048	i32	1	.W.phsB.cVal.mag.f		Phase B Active Power	
1049						
1050	i32	1	.W.phsC.cVal.mag.f		Phase C Active Power	
1051						
1052	i32	1	.TotW.mag.f		Total Active Power	
1053						
1054	i32	1	.VAr.phsA.cVal.mag.f		Phase A Reactive Power	
1055						
1056	i32	1	.VAr.phsB.cVal.mag.f		Phase B Reactive Power	
1057						
1058	i32	1	.VAr.phsC.cVal.mag.f		Phase C Reactive Power	
1059						
1060	i32	1	.TotVAr.mag.f		Total Reactive Power	
1061						
1062	i32	1	.VA.phsA.cVal.mag.f		Phase A Apparent Power	
1063						
1064	i32	1	.VA.phsB.cVal.mag.f		Phase B Apparent Power	
1065						
1066	i32	1	.VA.phsC.cVal.mag.f		Phase C Apparent Power	
1067						
1068	i32	1	.TotVA.mag.f		Total Apparent Power	
1069						
1070	i32	100	.Hz.mag.f		Frequency	
1071						
1072	i32	1000	.TotPF.mag.f		Average Power Factor	
1073						
1418	i32	1000	.PF.phsA.cVal.mag.f		Phase A Power Factor[1)]	
1419						
1420	i32	1000	.PF.phsB.cVal.mag.f		Phase B Power Factor[1)]	
1421						
1422	i32	1000	.PF.phsC.cVal.mag.f		Phase C Power Factor[1)]	
1423						
			LD0.PEMMXU5		SIM8F-5	
1178	i32	1	.W.phsA.cVal.mag.f		Phase A Active Power	
1179						
Table continues on next page						

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
1180	i32	1	.W.phsB.cVal.mag.f		Phase B Active Power	
1181						
1182	i32	1	.W.phsC.cVal.mag.f		Phase C Active Power	
1183						
1184	i32	1	.TotW.mag.f		Total Active Power	
1185						
1186	i32	1	.VAr.phsA.cVal.mag.f		Phase A Reactive Power	
1187						
1188	i32	1	.VAr.phsB.cVal.mag.f		Phase B Reactive Power	
1189						
1190	i32	1	.VAr.phsC.cVal.mag.f		Phase C Reactive Power	
1191						
1192	i32	1	.TotVAr.mag.f		Total Reactive Power	
1193						
1194	i32	1	.VA.phsA.cVal.mag.f		Phase A Apparent Power	
1195						
1196	i32	1	.VA.phsB.cVal.mag.f		Phase B Apparent Power	
1197						
1198	i32	1	.VA.phsC.cVal.mag.f		Phase C Apparent Power	
1199						
1200	i32	1	.TotVA.mag.f		Total Apparent Power	
1201						
1202	i32	100	.Hz.mag.f		Frequency	
1203						
1204	i32	1000	.TotPF.mag.f		Average Power Factor	
1205						
1466	i32	1000	.PF.phsA.cVal.mag.f		Phase A Power Factor[1)]	
1467						
1468	i32	1000	.PF.phsB.cVal.mag.f		Phase B Power Factor[1)]	
1469						
1470	i32	1000	.PF.phsC.cVal.mag.f		Phase C Power Factor[1)]	
1471						

1) Feature available from RIO600 Ver.1.8.2 onwards

7.2.32 LD0.RESCMMXU residual current measurement

Table 159: LD0.RESCMMXU residual current measurement

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.RESCMMXU1		SIM8F-1/SIM4F-1	
478	i32	10	.A.res.cVal.mag.f		Residual Current Magnitude	
479						
480	i32	1	.A.res.cVal.ang.f		Residual Current Angle	
481						
			LD0.RESCMMXU2		SIM8F-2/SIM4F-2	
610	i32	10	.A.res.cVal.mag.f		Residual Current Magnitude	
611						
612	i32	1	.A.res.cVal.ang.f		Residual Current Angle	
613						
			LD0.RESCMMXU3		SIM8F-3/SIM4F-3	
942	i32	10	.A.res.cVal.mag.f		Residual Current Magnitude	
943						
944	i32	1	.A.res.cVal.ang.f		Residual Current Angle	
945						
			LD0.RESCMMXU4		SIM8F-4/SIM4F-4	
1074	i32	10	.A.res.cVal.mag.f		Residual Current Magnitude	
1075						
1076	i32	1	.A.res.cVal.ang.f		Residual Current Angle	
1077						
			LD0.RESCMMXU5		SIM8F-5/SIM4F-5	
1206	i32	10	.A.res.cVal.mag.f		Residual Current Magnitude	
1207						
1208	i32	1	.A.res.cVal.ang.f		Residual Current Angle	
1209						

7.2.33 LD0.RESVMMXU residual voltage measurement

Table 160: LD0.RESVMMXU residual voltage measurement

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.RESVMMXU1		SIM8F-1	
482		10	.PhV.res.cVal.mag.f		Residual Voltage Magnitude	
483	i32					
484		1	.PhV.res.cVal.ang.f		Residual Voltage Angle	
485	i32					
			LD0.RESVMMXU2		SIM8F-2	
Table continues on next page						

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
614		10	.PhV.res.cVal.mag.f		Residual Voltage Magnitude	
615	i32					
616		1	.PhV.res.cVal.ang.f		Residual Voltage Angle	
617	i32					
			LD0.RESVMMXU3		SIM8F-3	
946		10	.PhV.res.cVal.mag.f		Residual Voltage Magnitude	
947	i32					
948		1	.PhV.res.cVal.ang.f		Residual Voltage Angle	
949	i32					
			LD0.RESVMMXU4		SIM8F-4	
1078		10	.PhV.res.cVal.mag.f		Residual Voltage Magnitude	
1079	i32					
1080		1	.PhV.res.cVal.ang.f		Residual Voltage Angle	
1081	i32					
			LD0.RESVMMXU5		SIM8F-5	
1210		10	.PhV.res.cVal.mag.f		Residual Voltage Magnitude	
1211	i32					
1212		1	.PhV.res.cVal.ang.f		Residual Voltage Angle	
1213	i32					

7.2.34 LD0.CAVMMXU average current measurements

Table 161: LD0.CAVMMXU average current measurements

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.CAVMMXU1		SIM8F-1/SIM4F-1	
486	i32	10	.A.phA.cVal.mag.f		Phase A Average Operating Current	
487						
488	i32	10	.A.phB.cVal.mag.f		Phase B Average Operating Current	
489						
490	i32	10	.A.phC.cVal.mag.f		Phase C Average Operating Current	
491						
			LD0.CAVMMXU2		SIM8F-2/SIM4F-2	
618	i32	10	.A.phA.cVal.mag.f		Phase A Average Operating Current	
619						
620	i32	10	.A.phB.cVal.mag.f		Phase B Average Operating Current	
621						

Table continues on next page

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
622	i32	10	.A.phC.cVal.mag.f		Phase C Average Operating Current	
623						
			LD0.CAVMMXU3		SIM8F-3/SIM4F-3	
950	i32	10	.A.phA.cVal.mag.f		Phase A Average Operating Current	
951						
952	i32	10	.A.phB.cVal.mag.f		Phase B Average Operating Current	
953						
954	i32	10	.A.phC.cVal.mag.f		Phase C Average Operating Current	
955						
			LD0.CAVMMXU4		SIM8F-4/SIM4F-4	
1082	i32	10	.A.phA.cVal.mag.f		Phase A Average Operating Current	
1083						
1084	i32	10	.A.phB.cVal.mag.f		Phase B Average Operating Current	
1085						
1086	i32	10	.A.phC.cVal.mag.f		Phase C Average Operating Current	
1087						
			LD0.CAVMMXU5		SIM8F-5/SIM4F-5	
1214	i32	10	.A.phA.cVal.mag.f		Phase A Average Operating Current	
1215						
1216	i32	10	.A.phB.cVal.mag.f		Phase B Average Operating Current	
1217						
1218	i32	10	.A.phC.cVal.mag.f		Phase C Average Operating Current	
1219						

7.2.35 LD0.RCAVMMXU average current measurements

Table 162: LD0.RCAVMMXU average current measurements

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.RCAVMMXU1		SIM8F-1/SIM4F-1	
492	i32	10	.A.res.cVal.mag.f		Residual Average Operating Current	
493						
			LD0. RCAVMMXU2		SIM8F-2/SIM4F-2	
Table continues on next page						

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
624	i32	10	.A.res.cVal.mag.f		Residual Average Operating Current	
625						
			LD0. RCAVMMXU3		SIM8F-3/SIM4F-3	
956	i32	10	.A.res.cVal.mag.f		Residual Average Operating Current	
957						
			LD0. RCAVMMXU4		SIM8F-4/SIM4F-4	
1088	i32	10	.A.res.cVal.mag.f		Residual Average Operating Current	
1089						
			LD0. RCAVMMXU5		SIM8F-5/SIM4F-5	
1220	i32	10	.A.res.cVal.mag.f		Residual Average Operating Current	

7.2.36 LD0.CMAMMXU peak current measurements

Table 163: LD0.CMAMMXU peak current measurements

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.CMAMMXU1		SIM8F-1/SIM4F-1	
494	i32	10	.A.phA.cVal.mag.f		Phase A Peak Current	
495						
496	i32	10	.A.phB.cVal.mag.f		Phase B Peak Current	
497						
498	i32	10	.A.phC.cVal.mag.f		Phase C Peak Current	
499						
			LD0.CMAMMXU2		SIM8F-2/SIM4F-2	
626	i32	10	.A.phA.cVal.mag.f		Phase A Peak Current	
627						
628	i32	10	.A.phB.cVal.mag.f		Phase B Peak Current	
629						
630	i32	10	.A.phC.cVal.mag.f		Phase C Peak Current	
631						
			LD0.CMAMMXU3		SIM8F-3/SIM4F-3	
958	i32	10	.A.phA.cVal.mag.f		Phase A Peak Current	
959						
960	i32	10	.A.phB.cVal.mag.f		Phase B Peak Current	
961						
962	i32	10	.A.phC.cVal.mag.f		Phase C Peak Current	
963						
			LD0.CMAMMXU4		SIM8F-4/SIM4F-4	

Table continues on next page

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
1090	i32	10	.A.phA.cVal.mag.f		Phase A Peak Current	
1091						
1092	i32	10	.A.phB.cVal.mag.f		Phase B Peak Current	
1093						
1094	i32	10	.A.phC.cVal.mag.f		Phase C Peak Current	
1095						
			LD0.CMAMMXU5		SIM8F-5/SIM4F-5	
1222	i32	10	.A.phA.cVal.mag.f		Phase A Peak Current	
1223						
1224	i32	10	.A.phB.cVal.mag.f		Phase B Peak Current	
1225						
1226	i32	10	.A.phC.cVal.mag.f		Phase C Peak Current	
1227						

7.2.37 LD0.VAVMMXU average voltage measurements

Table 164: LD0.VAVMMXU average voltage measurements

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.VAVMMXU1		SIM8F-1	
500	i32	1	.PhsV.phsA.cVal.mag.f		Phase A Average Operating Voltage	
501						
502	i32	1	.PhsV.phsB.cVal.mag.f		Phase B Average Operating Voltage	
503						
504	i32	1	.PhsV.phsC.cVal.mag.f		Phase C Average Operating Voltage	
505						
			LD0.VAVMMXU2		SIM8F-2	
632	i32	1	.PhsV.phsA.cVal.mag.f		Phase A Average Operating Voltage	
633						
634	i32	1	.PhsV.phsB.cVal.mag.f		Phase B Average Operating Voltage	
635						
636	i32	1	.PhsV.phsC.cVal.mag.f		Phase C Average Operating Voltage	
637						
			LD0.VAVMMXU3		SIM8F-3	
964	i32	1	.PhsV.phsA.cVal.mag.f		Phase A Average Operating Voltage	
965						

Table continues on next page

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
966	i32	1	.PhsV.phsB.cVal.mag.f		Phase B Average Operating Voltage	
967						
968	i32	1	.PhsV.phsC.cVal.mag.f		Phase C Average Operating Voltage	
969						
			LD0.VAVMMXU4		SIM8F-4	
1096	i32	1	.PhsV.phsA.cVal.mag.f		Phase A Average Operating Voltage	
1097						
1098	i32	1	.PhsV.phsB.cVal.mag.f		Phase B Average Operating Voltage	
1099						
1100	i32	1	.PhsV.phsC.cVal.mag.f		Phase C Average Operating Voltage	
1101						
			LD0.VAVMMXU5		SIM8F-5	
1228	i32	1	.PhsV.phsA.cVal.mag.f		Phase A Average Operating Voltage	
1229						
1230	i32	1	.PhsV.phsB.cVal.mag.f		Phase B Average Operating Voltage	
1231						
1232	i32	1	.PhsV.phsC.cVal.mag.f		Phase C Average Operating Voltage	
1233						

7.2.38 LD0.VMAMMXU peak voltage measurements

Table 165: LD0.VMAMMXU peak voltage measurements

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.VMAMMXU1		SIM8F-1	
506	i32	1	.PhsV.phsA.cVal.mag.f		Phase A Peak Voltage	
507						
508	i32	1	.PhsV.phsB.cVal.mag.f		Phase B Peak Voltage	
509						
510	i32	1	.PhsV.phsC.cVal.mag.f		Phase C Peak Voltage	
511						
			LD0.VMAMMXU2		SIM8F-2	
638	i32	1	.PhsV.phsA.cVal.mag.f		Phase A Peak Voltage	
639						
Table continues on next page						

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
640	i32	1	.PhsV.phsB.cVal.mag.f		Phase B Peak Voltage	
641						
642	i32	1	.PhsV.phsC.cVal.mag.f		Phase C Peak Voltage	
643						
			LD0.VMAMMXU3		SIM8F-3	
970	i32	1	.PhsV.phsA.cVal.mag.f		Phase A Peak Voltage	
971						
972	i32	1	.PhsV.phsB.cVal.mag.f		Phase B Peak Voltage	
973						
974	i32	1	.PhsV.phsC.cVal.mag.f		Phase C Peak Voltage	
975						
			LD0.VMAMMXU4		SIM8F-4	
1102	i32	1	.PhsV.phsA.cVal.mag.f		Phase A Peak Voltage	
1103						
1104	i32	1	.PhsV.phsB.cVal.mag.f		Phase B Peak Voltage	
1105						
1106	i32	1	.PhsV.phsC.cVal.mag.f		Phase C Peak Voltage	
1107						
			LD0.VMAMMXU5		SIM8F-5	
1234	i32	1	.PhsV.phsA.cVal.mag.f		Phase A Peak Voltage	
1235						
1236	i32	1	.PhsV.phsB.cVal.mag.f		Phase B Peak Voltage	
1237						
1238	i32	1	.PhsV.phsC.cVal.mag.f		Phase C Peak Voltage	
1239						

7.2.39 LD0.PEAVMMXU average power measurements

Table 166: LD0.PEAVMMXU average power measurements

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.PEAVMMXU1		SIM8F-1	
512	i32	1	.TotW.mag.f		Average Active Power	
513						
514	i32	1	.TotVAr.mag.f		Average Reactive Power	
515						
516	i32	1	.TotVA.mag.f		Average Apparent Power	
517						
			LD0.PEAVMMXU2		SIM8F-2	

Table continues on next page

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
644	i32	1	.TotW.mag.f		Average Active Power	
645						
646	i32	1	.TotVAr.mag.f		Average Reactive Power	
647						
648	i32	1	.TotVA.mag.f		Average Apparent Power	
649						
			LD0.PEAVMMXU3		SIM8F-3	
976	i32	1	.TotW.mag.f		Average Active Power	
977						
978	i32	1	.TotVAr.mag.f		Average Reactive Power	
979						
980	i32	1	.TotVA.mag.f		Average Apparent Power	
981						
			LD0.PEAVMMXU4		SIM8F-4	
1108	i32	1	.TotW.mag.f		Average Active Power	
1109						
1110	i32	1	.TotVAr.mag.f		Average Reactive Power	
1111						
1112	i32	1	.TotVA.mag.f		Average Apparent Power	
1113						
			LD0.PEAVMMXU5		SIM8F-5	
1240	i32	1	.TotW.mag.f		Average Active Power	
1241						
1242	i32	1	.TotVAr.mag.f		Average Reactive Power	
1243						
1244	i32	1	.TotVA.mag.f		Average Apparent Power	
1245						

7.2.40 LD0.PEMAMMXU peak power measurements

Table 167: LD0.PEMAMMXU peak power measurements

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.PEMAMMXU1		SIM8F-1	
518	i32	1	.TotW.mag.f		Peak Active Power	
519						
520	i32	1	.TotVAr.mag.f		Peak Reactive Power	
521						
522	i32	1	.TotVA.mag.f		Peak Apparent Power	
523						

Table continues on next page

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.PEMAMMXU2		SIM8F-2	
650	i32	1	.TotW.mag.f		Peak Active Power	
651						
652	i32	1	.TotVAr.mag.f		Peak Reactive Power	
653						
654	i32	1	.TotVA.mag.f		Peak Apparent Power	
655						
			LD0.PEMAMMXU3		SIM8F-3	
982	i32	1	.TotW.mag.f		Peak Active Power	
983						
984	i32	1	.TotVAr.mag.f		Peak Reactive Power	
985						
986	i32	1	.TotVA.mag.f		Peak Apparent Power	
987						
			LD0.PEMAMMXU4		SIM8F-4	
1114	i32	1	.TotW.mag.f		Peak Active Power	
1115						
1116	i32	1	.TotVAr.mag.f		Peak Reactive Power	
1117						
1118	i32	1	.TotVA.mag.f		Peak Apparent Power	
1119						
			LD0.PEMAMMXU5		SIM8F-5	
1246	i32	1	.TotW.mag.f		Peak Active Power	
1247						
1248	i32	1	.TotVAr.mag.f		Peak Reactive Power	
1249						
1250	i32	1	.TotVA.mag.f		Peak Apparent Power	
1251						

7.2.41 LD0.EMMTR energy measurement

Table 168: LD0.EMMTR energy measurement

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.EMMTR1		SIM8F-1	
524	i32	1	.DmdWh.actVal		Real Energy Demand	
525						
526	i32	1	.SupWh.actVal		Real Energy Supply	
527						

Table continues on next page

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
528	i32	1	.DmdVArh.actVal		Reactive Energy Demand	
529						
530	i32	1	.SupVArh.actVal		Reactive Energy Supply	
531						
			LD0.EMMTR2		SIM8F-2	
656	i32	1	.DmdWh.actVal		Real Energy Demand	
657						
658	i32	1	.SupWh.actVal		Real Energy Supply	
659						
660	i32	1	.DmdVArh.actVal		Reactive Energy Demand	
661						
662	i32	1	.SupVArh.actVal		Reactive Energy Supply	
663						
			LD0.EMMTR3		SIM8F-3	
988	i32	1	.DmdWh.actVal		Real Energy Demand	
989						
990	i32	1	.SupWh.actVal		Real Energy Supply	
991						
992	i32	1	.DmdVArh.actVal		Reactive Energy Demand	
993						
994	i32	1	.SupVArh.actVal		Reactive Energy Supply	
995						
			LD0.EMMTR4		SIM8F-4	
1120	i32	1	.DmdWh.actVal		Real Energy Demand	
1121						
1122	i32	1	.SupWh.actVal		Real Energy Supply	
1123						
1124	i32	1	.DmdVArh.actVal		Reactive Energy Demand	
1125						
1126	i32	1	.SupVArh.actVal		Reactive Energy Supply	
1127						
			LD0.EMMTR5		SIM8F-5	
1252	i32	1	.DmdWh.actVal		Real Energy Demand	
1253						
1254	i32	1	.SupWh.actVal		Real Energy Supply	
1255						

Table continues on next page

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
1256	i32	1	.DmdVArh.actVal		Reactive Energy Demand	
1257						
1258	i32	1	.SupVArh.actVal		Reactive Energy Supply	
1259						

7.2.42 LD0.MFAPSDE multifrequency admittance protection (earth-fault indication)

Table 169: LD0.MFAPSDE multifrequency admittance protection

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.MFAPSDE1		SIM8F-1	0 = unknown 1 = forward 2 = reverse 3 = both
1260	u16	1	.Str.dirGeneral		General Start	
			LD0.MFAPSDE2		SIM8F-2	
1308	u16	1	.Str.dirGeneral		General Start	
			LD0.MFAPSDE3		SIM8F-3	
1356	u16	1	.Str.dirGeneral		General Start	
			LD0.MFAPSDE4		SIM8F-4	
1404	u16	1	.Str.dirGeneral		General Start	
			LD0.MFAPSDE5		SIM8F-5	
1452	u16	1	.Str.dirGeneral		General Start	

7.2.43 SCM Application types

Table 170: IEC 61850 name for SCM application types

SCM application type	IEC 61850 name	
	Low voltage	High voltage
Four Input/Four Output	LD0.SCMLGGIO	LD0.SCMHGGIO
Three Position Switch	LD0.SCMLPGGIO	LD0.SCMHPGGIO
Two Position Disconnector	LD0.SCMLDGGIO	LD0.SCMHDGGIO
Two Position Earth	LD0.SCMLEGGIO	LD0.SCMHEGGIO
Circuit Breaker	LD0.SCMLCGGIO	LD0.SCMHCGGIO

Table 171: SCM application types

Reg A	Type	IEC 61850 name	SA name	Description	Values
				SCM	
1500	i16			Application Type	(Application type – Value) 4I4O – 128; Three position switch – 129; Two position disconnector – 130; Two position earth – 131; Circuit breaker – 132;
1501	i16			Application Type	
1502	i16			Application Type	
1503	i16			Application Type	
1504	i16			Application Type	
1505	i16			Application Type	
1506	i16			Application Type	
1507	i16			Application Type	
1508	i16			Application Type	
1509	i16			Application Type	

7.2.44 Binary readable signals of SCM

Table 172: Binary readable signals of SCM

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
		1) 1. LD0.SCMLGGIO1/ LD0.SCMHGGIO1 2. LD0.SCMLPGGIO1/ LD0.SCMHPGGIO1 3. LD0.SCMLDGGIO1/ LD0.SCMHDGGIO1 4. LD0.SCMLEGGIO1/ LD0.SCMHEGGIO1 5. LD0.SCMLCGGIO1/ LD0.SCMHCGGIO1 6. LD0.TCSLSCBR1/ LD0.TCSHSCBR1		SCM-1	
1664	1516	.Ind1.stVal		Digital Input Channel 1	0/1 = Off/On
1665	1516.01	.Ind2.stVal		Digital Input Channel 2	0/1 = Off/On
1666	1516.02	.Ind3.stVal		Digital Input Channel 3	0/1 = Off/On
1667	1516.03	.Ind4.stVal		Digital Input Channel 4	0/1 = Off/On
1668	1516.04	RELEASE_ES		Release Earth Switch Information	0/1 = Off/On
1669	1516.05	RELEASE_DS		Release Disconnector Information	0/1 = Off/On
1670	1516.06	REED_ES		REED Earth Switch Information	0/1 = Off/On
1671	1516.07	RELEASE_CB		Release Circuit Breaker Information	0/1 = Off/On
1672	1516.08	.Ind10.stVal		Error Code: No Fault	0/1 = Off/On
1673	1516.09	.Ind11.stVal		Error Code: Device Error	0/1 = Off/On
1674	1516.1	.Ind12.stVal		Error code: Release	0/1 = Off/On

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
1675	1516.11	.Ind13.stVal		Error Code: No Act	0/1 = Off/On
1676	1516.12	.Ind14.stVal		Error Code: Interlocking Error	0/1 = Off/On
1677	1516.13	.Ind15.stVal		Error Code: REED/ Release Error	0/1 = Off/On
1678	1516.14	.Ind16.stVal		Error Code: Position Error	0/1 = Off/On
1679	1516.15	.Ind17.stVal		Error Code: Time-out Error	0/1 = Off/On
1680	1517	.CircAlm.stVal		Trip Circuit Supervision Alarm Status	0/1 = Off/On
1681	1517.01	.CircAlm.stVal		Trip Circuit Supervision Alarm Status	0/1 = Off/On
		1) 1. LD0.SCMLGGIO2/ LD0.SCMHGGIO2 2. LD0.SCMLDGGIO2/ LD0.SCMHDGGIO2 3. LD0.SCMLDGGIO2/ LD0.SCMHDGGIO2 4. LD0.SCMLEGGIO2/ LD0.SCMHEGGIO2 5. LD0.SCMLCGGIO2/ LD0.SCMHCGGIO2 6. LD0.TCSLSCBR2/ LD0.TCSHSCBR2		SCM-2	
1696	1518	.Ind1.stVal		Digital Input Channel 1	0/1 = Off/On
1697	1518.01	.Ind2.stVal		Digital Input Channel 2	0/1 = Off/On
1698	1518.02	.Ind3.stVal		Digital Input Channel 3	0/1 = Off/On
1699	1518.03	.Ind4.stVal		Digital Input Channel 4	0/1 = Off/On
1700	1518.04	RELEASE_ES		Release Earth Switch Information	0/1 = Off/On
1701	1518.05	RELEASE_DS		Release Disconnector Information	0/1 = Off/On
1702	1518.06	REED_ES		REED Earth Switch Information	0/1 = Off/On
1703	1518.07	RELEASE_CB		Release Circuit Breaker Information	0/1 = Off/On
1704	1518.08	.Ind10.stVal		Error Code: No Fault	0/1 = Off/On
1705	1518.09	.Ind11.stVal		Error Code: Device Error	0/1 = Off/On
1706	1518.1	.Ind12.stVal		Error code: Release	0/1 = Off/On
1707	1518.11	.Ind13.stVal		Error Code: No Act	0/1 = Off/On
1708	1518.12	.Ind14.stVal		Error Code: Interlocking Error	0/1 = Off/On
1709	1518.13	.Ind15.stVal		Error Code: REED/ Release Error	0/1 = Off/On
1710	1518.14	.Ind16.stVal		Error Code: Position Error	0/1 = Off/On
1711	1518.15	.Ind17.stVal		Error Code: Time-out Error	0/1 = Off/On
1712	1519	.CircAlm.stVal		Trip Circuit Supervision Alarm Status	0/1 = Off/On
1713	1519.01	.CircAlm.stVal		Trip Circuit Supervision Alarm Status	0/1 = Off/On

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
		1) 1. LD0.SCMLGGIO3/ LD0.SCMHGGIO3 2. LD0.SCMLPGGIO3/ LD0.SCMHPGGIO3 3. LD0.SCMLDGGIO3/ LD0.SCMHDGGIO3 4. LD0.SCMLEGGIO3/ LD0.SCMHEGGIO3 5. LD0.SCMLCGGIO3/ LD0.SCMHCGGIO3 6. LD0.TCSLSCBR3/ LD0.TCSHSCBR3		SCM-3	
1728	1520	.Ind1.stVal		Digital Input Channel 1	0/1 = Off/On
1729	1520.01	.Ind2.stVal		Digital Input Channel 2	0/1 = Off/On
1730	1520.02	.Ind3.stVal		Digital Input Channel 3	0/1 = Off/On
1731	1520.03	.Ind4.stVal		Digital Input Channel 4	0/1 = Off/On
1732	1520.04	RELEASE_ES		Release Earth Switch Information	0/1 = Off/On
1733	1520.05	RELEASE_DS		Release Disconnector Information	0/1 = Off/On
1734	1520.06	REED_ES		REED Earth Switch Information	0/1 = Off/On
1735	1520.07	RELEASE_CB		Release Circuit Breaker Information	0/1 = Off/On
1736	1520.08	.Ind10.stVal		Error Code: No Fault	0/1 = Off/On
1737	1520.09	.Ind11.stVal		Error Code: Device Error	0/1 = Off/On
1738	1520.1	.Ind12.stVal		Error code: Release	0/1 = Off/On
1739	1520.11	.Ind13.stVal		Error Code: No Act	0/1 = Off/On
1740	1520.12	.Ind14.stVal		Error Code: Interlocking Error	0/1 = Off/On
1741	1520.13	.Ind15.stVal		Error Code: REED/ Release Error	0/1 = Off/On
1742	1520.14	.Ind16.stVal		Error Code: Position Error	0/1 = Off/On
1743	1520.15	.Ind17.stVal		Error Code: Time-out Error	0/1 = Off/On
1744	1521	.CircAlm.stVal		Trip Circuit Supervision Alarm Status	0/1 = Off/On
1745	1521.01	.CircAlm.stVal		Trip Circuit Supervision Alarm Status	0/1 = Off/On
		1) 1. LD0.SCMLGGIO4/ LD0.SCMHGGIO4 2. LD0.SCMLPGGIO4/ LD0.SCMHPGGIO4 3. LD0.SCMLDGGIO4/ LD0.SCMHDGGIO4 4. LD0.SCMLEGGIO4/ LD0.SCMHEGGIO4 5. LD0.SCMLCGGIO4/ LD0.SCMHCGGIO4 6. LD0.TCSLSCBR4/ LD0.TCSHSCBR4		SCM-4	

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
1760	1522	.Ind1.stVal		Digital Input Channel 1	0/1 = Off/On
1761	1522.01	.Ind2.stVal		Digital Input Channel 2	0/1 = Off/On
1762	1522.02	.Ind3.stVal		Digital Input Channel 3	0/1 = Off/On
1763	1522.03	.Ind4.stVal		Digital Input Channel 4	0/1 = Off/On
1764	1522.04	RELEASE_ES		Release Earth Switch Information	0/1 = Off/On
1765	1522.05	RELEASE_DS		Release Disconnector Information	0/1 = Off/On
1766	1522.06	REED_ES		REED Earth Switch Information	0/1 = Off/On
1767	1522.07	RELEASE_CB		Release Circuit Breaker Information	0/1 = Off/On
1768	1522.08	.Ind10.stVal		Error Code: No Fault	0/1 = Off/On
1769	1522.09	.Ind11.stVal		Error Code: Device Error	0/1 = Off/On
1770	1522.1	.Ind12.stVal		Error code: Release	0/1 = Off/On
1771	1522.11	.Ind13.stVal		Error Code: No Act	0/1 = Off/On
1772	1522.12	.Ind14.stVal		Error Code: Interlocking Error	0/1 = Off/On
1773	1522.13	.Ind15.stVal		Error Code: REED/ Release Error	0/1 = Off/On
1774	1522.14	.Ind16.stVal		Error Code: Position Error	0/1 = Off/On
1775	1522.15	.Ind17.stVal		Error Code: Time-out Error	0/1 = Off/On
1776	1523	.CircAlm.stVal		Trip Circuit Supervision Alarm Status	0/1 = Off/On
1777	1523.01	.CircAlm.stVal		Trip Circuit Supervision Alarm Status	0/1 = Off/On
		1) 1. LD0.SCMLGGIO5/ LD0.SCMHGGIO5 2. LD0.SCMLPGGIO5/ LD0.SCMHPGGIO5 3. LD0.SCMLDGGIO5/ LD0.SCMHDGGIO5 4. LD0.SCMLEGGIO5/ LD0.SCMHEGGIO5 5. LD0.SCMLCGGIO5/ LD0.SCMHCGGIO5 6. LD0.TCSLSCBR5/ LD0.TCSHSCBR5		SCM-5	
1792	1524	.Ind1.stVal		Digital Input Channel 1	0/1 = Off/On
1793	1524.01	.Ind2.stVal		Digital Input Channel 2	0/1 = Off/On
1794	1524.02	.Ind3.stVal		Digital Input Channel 3	0/1 = Off/On
1795	1524.03	.Ind4.stVal		Digital Input Channel 4	0/1 = Off/On
1796	1524.04	RELEASE_ES		Release Earth Switch Information	0/1 = Off/On
1797	1524.05	RELEASE_DS		Release Disconnector Information	0/1 = Off/On
1798	1524.06	REED_ES		REED Earth Switch Information	0/1 = Off/On

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
1799	1524.07	RELEASE_CB		Release Circuit Breaker Information	0/1 = Off/On
1800	1524.08	.Ind10.stVal		Error Code: No Fault	0/1 = Off/On
1801	1524.09	.Ind11.stVal		Error Code: Device Error	0/1 = Off/On
1802	1524.1	.Ind12.stVal		Error code: Release	0/1 = Off/On
1803	1524.11	.Ind13.stVal		Error Code: No Act	0/1 = Off/On
1804	1524.12	.Ind14.stVal		Error Code: Interlocking Error	0/1 = Off/On
1805	1524.13	.Ind15.stVal		Error Code: REED/ Release Error	0/1 = Off/On
1806	1524.14	.Ind16.stVal		Error Code: Position Error	0/1 = Off/On
1807	1524.15	.Ind17.stVal		Error Code: Time-out Error	0/1 = Off/On
1808	1525	.CircAlm.stVal		Trip Circuit Supervision Alarm Status	0/1 = Off/On
1809	1525.01	.CircAlm.stVal		Trip Circuit Supervision Alarm Status	0/1 = Off/On
		[1] 1. LD0.SCMLGGIO6/ LD0.SCMHGGIO6 2. LD0.SCMLPGGIO6/ LD0.SCMHPGGIO6 3. LD0.SCMLDGGIO6/ LD0.SCMHDGGIO6 4. LD0.SCMLEGGIO6/ LD0.SCMHEGGIO6 5. LD0.SCMLCGGIO6/ LD0.SCMHCGGIO6 6. LD0.TCSLSCBR6/ LD0.TCSHSCBR6		SCM-6	
1824	1526	.Ind1.stVal		Digital Input Channel 1	0/1 = Off/On
1825	1526.01	.Ind2.stVal		Digital Input Channel 2	0/1 = Off/On
1826	1526.02	.Ind3.stVal		Digital Input Channel 3	0/1 = Off/On
1827	1526.03	.Ind4.stVal		Digital Input Channel 4	0/1 = Off/On
1828	1526.04	RELEASE_ES		Release Earth Switch Information	0/1 = Off/On
1829	1526.05	RELEASE_DS		Release Disconnector	0/1 = Off/On
				Information	
1830	1526.06	REED_ES		REED Earth Switch Information	0/1 = Off/On
1831	1526.07	RELEASE_CB		Release Circuit Breaker Information	0/1 = Off/On
1832	1526.08	.Ind10.stVal		Error Code: No Fault	0/1 = Off/On
1833	1526.09	.Ind11.stVal		Error Code: Device Error	0/1 = Off/On
1834	1526.1	.Ind12.stVal		Error code: Release	0/1 = Off/On
1835	1526.11	.Ind13.stVal		Error Code: No Act	0/1 = Off/On
1836	1526.12	.Ind14.stVal		Error Code: Interlocking Error	0/1 = Off/On
1837	1526.13	.Ind15.stVal		Error Code: REED/ Release Error	0/1 = Off/On

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
1838	1526.14	.Ind16.stVal		Error Code: Position Error	0/1 = Off/On
1839	1526.15	.Ind17.stVal		Error Code: Time-out Error	0/1 = Off/On
1840	1527	.CircAlm.stVal		Trip Circuit Supervision Alarm Status	0/1 = Off/On
1841	1527.01	.CircAlm.stVal		Trip Circuit Supervision Alarm Status	0/1 = Off/On
		1) 1. LD0.SCMLGGIO7/ LD0.SCMHGGIO7 2. LD0.SCMLPGGIO7/ LD0.SCMHPGGIO7 3. LD0.SCMLDGGIO7/ LD0.SCMHDGGIO7 4. LD0.SCMLEGGIO7/ LD0.SCMHEGGIO7 5. LD0.SCMLCGGIO7/ LD0.SCMHCGGIO7 6. LD0.TCSLSCBR7/ LD0.TCSHSCBR7		SCM-7	
1856	1528	.Ind1.stVal		Digital Input Channel 1	0/1 = Off/On
1857	1528.01	.Ind2.stVal		Digital Input Channel 2	0/1 = Off/On
1858	1528.02	.Ind3.stVal		Digital Input Channel 3	0/1 = Off/On
1859	1528.03	.Ind4.stVal		Digital Input Channel 4	0/1 = Off/On
1860	1528.04	RELEASE_ES		Release Earth Switch Information	0/1 = Off/On
1861	1528.05	RELEASE_DS		Release Disconnector Information	0/1 = Off/On
1862	1528.06	REED_ES		REED Earth Switch Information	0/1 = Off/On
1863	1528.07	RELEASE_CB		Release Circuit Breaker Information	0/1 = Off/On
1864	1528.08	.Ind10.stVal		Error Code: No Fault	0/1 = Off/On
1865	1528.09	.Ind11.stVal		Error Code: Device Error	0/1 = Off/On
1866	1528.1	.Ind12.stVal		Error code: Release	0/1 = Off/On
1867	1528.11	.Ind13.stVal		Error Code: No Act	0/1 = Off/On
1868	1528.12	.Ind14.stVal		Error Code: Interlocking Error	0/1 = Off/On
1869	1528.13	.Ind15.stVal		Error Code: REED/ Release Error	0/1 = Off/On
1870	1528.14	.Ind16.stVal		Error Code: Position Error	0/1 = Off/On
1871	1528.15	.Ind17.stVal		Error Code: Time-out Error	0/1 = Off/On
1872	1529	.CircAlm.stVal		Trip Circuit Supervision Alarm Status	0/1 = Off/On
1873	1529.01	.CircAlm.stVal		Trip Circuit Supervision Alarm Status	0/1 = Off/On

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
		1) 1. LD0.SCMLGGIO8/ LD0.SCMHGGIO8 2. LD0.SCMLPGGIO8/ LD0.SCMHPGGIO8 3. LD0.SCMLDGGIO8/ LD0.SCMHDGGIO8 4. LD0.SCMLEGGIO8/ LD0.SCMHEGGIO8 5. LD0.SCMLCGGIO8/ LD0.SCMHCGGIO8 6. LD0.TCSLSCBR8/ LD0.TCSHSCBR8		SCM-8	
1888	1530	.Ind1.stVal		Digital Input Channel 1	0/1 = Off/On
1889	1530.01	.Ind2.stVal		Digital Input Channel 2	0/1 = Off/On
1890	1530.02	.Ind3.stVal		Digital Input Channel 3	0/1 = Off/On
1891	1530.03	.Ind4.stVal		Digital Input Channel 4	0/1 = Off/On
1892	1530.04	RELEASE_ES		Release Earth Switch Information	0/1 = Off/On
1893	1530.05	RELEASE_DS		Release Disconnector Information	0/1 = Off/On
1894	1530.06	REED_ES		REED Earth Switch Information	0/1 = Off/On
1895	1530.07	RELEASE_CB		Release Circuit Breaker Information	0/1 = Off/On
1896	1530.08	.Ind10.stVal		Error Code: No Fault	0/1 = Off/On
1897	1530.09	.Ind11.stVal		Error Code: Device Error	0/1 = Off/On
1898	1530.1	.Ind12.stVal		Error code: Release	0/1 = Off/On
1899	1530.11	.Ind13.stVal		Error Code: No Act	0/1 = Off/On
1900	1530.12	.Ind14.stVal		Error Code: Interlocking Error	0/1 = Off/On
1901	1530.13	.Ind15.stVal		Error Code: REED/ Release Error	0/1 = Off/On
1902	1530.14	.Ind16.stVal		Error Code: Position Error	0/1 = Off/On
1903	1530.15	.Ind17.stVal		Error Code: Time-out Error	0/1 = Off/On
1904	1531	.CircAlm.stVal		Trip Circuit Supervision Alarm Status	0/1 = Off/On
1905	1531.01	.CircAlm.stVal		Trip Circuit Supervision Alarm Status	0/1 = Off/On
		1) 1. LD0.SCMLGGIO9/ LD0.SCMHGGIO9 2. LD0.SCMLPGGIO9/ LD0.SCMHPGGIO9 3. LD0.SCMLDGGIO9/ LD0.SCMHDGGIO9 4. LD0.SCMLEGGIO9/ LD0.SCMHEGGIO9 5. LD0.SCMLCGGIO9/ LD0.SCMHCGGIO9 6. LD0.TCSLSCBR9/ LD0.TCSHSCBR9		SCM-9	

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
1920	1532	.Ind1.stVal		Digital Input Channel 1	0/1 = Off/On
1921	1532.01	.Ind2.stVal		Digital Input Channel 2	0/1 = Off/On
1922	1532.02	.Ind3.stVal		Digital Input Channel 3	0/1 = Off/On
1923	1532.03	.Ind4.stVal		Digital Input Channel 4	0/1 = Off/On
1924	1532.04	RELEASE_ES		Release Earth Switch Information	0/1 = Off/On
1925	1532.05	RELEASE_DS		Release Disconnector Information	0/1 = Off/On
1926	1532.06	REED_ES		REED Earth Switch Information	0/1 = Off/On
1927	1532.07	RELEASE_CB		Release Circuit Breaker Information	0/1 = Off/On
1928	1532.08	.Ind10.stVal		Error Code: No Fault	0/1 = Off/On
1929	1532.09	.Ind11.stVal		Error Code: Device Error	0/1 = Off/On
1930	1532.1	.Ind12.stVal		Error code: Release	0/1 = Off/On
1931	1532.11	.Ind13.stVal		Error Code: No Act	0/1 = Off/On
1932	1532.12	.Ind14.stVal		Error Code: Interlocking Error	0/1 = Off/On
1933	1532.13	.Ind15.stVal		Error Code: REED/ Release Error	0/1 = Off/On
1934	1532.14	.Ind16.stVal		Error Code: Position Error	0/1 = Off/On
1935	1532.15	.Ind17.stVal		Error Code: Time-out Error	0/1 = Off/On
1936	1533	.CircAlm.stVal		Trip Circuit Supervision Alarm Status	0/1 = Off/On
1937	1533.01	.CircAlm.stVal		Trip Circuit Supervision Alarm Status	0/1 = Off/On
		[1)] 1. LD0.SCMLGGIO10/ LD0.SCMHGGIO10 2. LD0.SCMLPGGIO10/ LD0.SCMHPGGIO10 3. LD0.SCMLDGGIO10/ LD0.SCMHDGGIO10 4. LD0.SCMLEGGIO10/ LD0.SCMHEGGIO10 5. LD0.SCMLCGGIO10/ LD0.SCMHCGGIO10 6. LD0.TCSLSCBR10/ LD0.TCSHSCBR10		SCM-10	
1952	1534	.Ind1.stVal		Digital Input Channel 1	0/1 = Off/On
1953	1534.01	.Ind2.stVal		Digital Input Channel 2	0/1 = Off/On
1954	1534.02	.Ind3.stVal		Digital Input Channel 3	0/1 = Off/On
1955	1534.03	.Ind4.stVal		Digital Input Channel 4	0/1 = Off/On
1956	1534.04	RELEASE_ES		Release Earth Switch Information	0/1 = Off/On
1957	1534.05	RELEASE_DS		Release Disconnector Information	0/1 = Off/On
1958	1534.06	REED_ES		REED Earth Switch Information	0/1 = Off/On

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
1959	1534.07	RELEASE_CB		Release Circuit Breaker Information	0/1 = Off/On
1960	1534.08	.Ind10.stVal		Error Code: No Fault	0/1 = Off/On
1961	1534.09	.Ind11.stVal		Error Code: Device Error	0/1 = Off/On
1962	1534.1	.Ind12.stVal		Error code: Release	0/1 = Off/On
1963	1534.11	.Ind13.stVal		Error Code: No Act	0/1 = Off/On
1964	1534.12	.Ind14.stVal		Error Code: Interlocking Error	0/1 = Off/On
1965	1534.13	.Ind15.stVal		Error Code: REED/ Release Error	0/1 = Off/On
1966	1534.14	.Ind16.stVal		Error Code: Position Error	0/1 = Off/On
1967	1534.15	.Ind17.stVal		Error Code: Time-out Error	0/1 = Off/On
1968	1535	.CircAlm.stVal		Trip Circuit Supervision Alarm Status	0/1 = Off/On
1969	1535.01	.CircAlm.stVal		Trip Circuit Supervision Alarm Status	0/1 = Off/On

1) Applicable (read only) data attributes are mentioned under their respective data objects.
LD0.SCMLGGIO/LD0.SCMHGGIO
- .Ind1.stVal
- .Ind2.stVal
- .Ind3.stVal
- .Ind4.stVal

LD0.SCMLPGGIO/LD0.SCMHPGGIO
- .Ind1.stVal
- .Ind2.stVal
- .Ind3.stVal
- .Ind4.stVal
- RELEASE_ES
- RELEASE_DS
- REED_ES
- .Ind10.stVal
- .Ind11.stVal
- .Ind12.stVal
- .Ind13.stVal
- .Ind14.stVal
- .Ind15.stVal
- .Ind16.stVal
- .Ind17.stVal

LD0.SCMLDGGIO/LD0.SCMHDGGIO
- .Ind1.stVal
- .Ind2.stVal
- .Ind3.stVal
- .Ind4.stVal
- RELEASE_DS
- .Ind10.stVal
- .Ind11.stVal
- .Ind12.stVal
- .Ind13.stVal
- .Ind14.stVal
- .Ind16.stVal
- .Ind17.stVal

LD0.SCMLEGGIO/LD0.SCMHEGGIO
- .Ind1.stVal
- .Ind2.stVal
- .Ind3.stVal
- .Ind4.stVal
- RELEASE_ES
- REED_ES
- .Ind10.stVal
- .Ind11.stVal

- .Ind12.stVal
- .Ind13.stVal
- .Ind14.stVal
- .Ind15.stVal
- .Ind16.stVal
- .Ind17.stVal

LD0.SCMLCGGIO/LD0.SCMHCGGIO
- .Ind1.stVal
- .Ind2.stVal
- .Ind3.stVal
- .Ind4.stVal
- RELEASE_CB
- .Ind10.stVal
- .Ind11.stVal
- .Ind12.stVal
- .Ind13.stVal
- .Ind14.stVal
- .Ind15.stVal
- .Ind16.stVal
- .Ind17.stVal

LD0.TCSLSCBR/LD0.TCSHSCBR
- .CircAlm.stVal

7.2.45 Binary writable signals for SCM

Table 173: Binary writable signals for SCM

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
		1) 1. LD0.SCMLGGIO1/ LD0.SCMHGGIO1 2. LD0.SCMLPGGIO1/ LD0.SCMHPGGIO1 3. LD0.SCMLDGGIO1/ LD0.SCMHDGGIO1 4. LD0.SCMLEGGIO1/ LD0.SCMHEGGIO1 5. LD0.SCMLCGGIO1/ LD0.SCMHCGGIO1		SCM-1	
2496	1568.00	.SPCSO1.stVal		Digital Output Channel 1	0/1 = Off/On
2497	1568.01	.SPCSO2.stVal		Digital Output Channel 2	0/1 = Off/On
2498	1568.02	.SPCSO3.stVal		Digital Output Channel 3	0/1 = Off/On
2499	1568.03	.SPCSO4.stVal		Digital Output Channel 4	0/1 = Off/On
2500	1568.04	<reserved>		<reserved>	
2501	1568.05	<reserved>		<reserved>	
2502	1568.06	<reserved>		<reserved>	
2503	1568.07	<reserved>		<reserved>	
2504	1568.08	CLOSE_ES		Earth Switch Close Command	0/1 = Off/On
2505	1568.09	OPEN_ES		Earth Switch Open Command	0/1 = Off/On
2506	1568.10	CLOSE_DS		Disconnector Close Command	0/1 = Off/On
2507	1568.11	OPEN_DS		Disconnector Open Command	0/1 = Off/On
2508	1568.12	<reserved>		<reserved>	
2509	1568.13	<reserved>		<reserved>	

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
2510	1568.14	<reserved>		<reserved>	
2511	1568.15	OPEN_CB		Circuit Breaker Open Command	0/1 = Off/On
2512	1569.00	CLOSE_CB		Circuit breaker Close Command	0/1 = Off/On
2513	1569.01	<reserved>		<reserved>	
		1) 1. LD0.SCMLGGIO2/ LD0.SCMHGGIO2 2. LD0.SCMLPGGIO2/ LD0.SCMHPGGIO2 3. LD0.SCMLDGGIO2/ LD0.SCMHDGGIO2 4. LD0.SCMLEGGIO2/ LD0.SCMHEGGIO2 5. LD0.SCMLCGGIO2/ LD0.SCMHCGGIO2		SCM-2	
2528	1570.00	.SPCSO1.stVal		Digital Output Channel 1	0/1 = Off/On
2529	1570.01	.SPCSO2.stVal		Digital Output Channel 2	0/1 = Off/On
2530	1570.02	.SPCSO3.stVal		Digital Output Channel 3	0/1 = Off/On
2531	1570.03	.SPCSO4.stVal		Digital Output Channel 4	0/1 = Off/On
2532	1570.04	<reserved>		<reserved>	
2533	1570.05	<reserved>		<reserved>	
2534	1570.06	<reserved>		<reserved>	
2535	1570.07	<reserved>		<reserved>	
2536	1570.08	CLOSE_ES		Earth Switch Close Command	0/1 = Off/On
2537	1570.09	OPEN_ES		Earth Switch Open Command	0/1 = Off/On
2538	1570.10	CLOSE_DS		Disconnector Close Command	0/1 = Off/On
2539	1570.11	OPEN_DS		Disconnector Open Command	0/1 = Off/On
2540	1570.12	<reserved>		<reserved>	
2541	1570.13	<reserved>		<reserved>	
2542	1570.14	<reserved>		<reserved>	
2543	1570.15	OPEN_CB		Circuit Breaker Open Command	0/1 = Off/On
2544	1571.00	CLOSE_CB		Circuit breaker Close Command	0/1 = Off/On
2545	1571.01	<reserved>		Digital Output Channel 1	
		1) 1. LD0.SCMLGGIO3/ LD0.SCMHGGIO3 2. LD0.SCMLPGGIO3/ LD0.SCMHPGGIO3 3. LD0.SCMLDGGIO3/ LD0.SCMHDGGIO3 4. LD0.SCMLEGGIO3/ LD0.SCMHEGGIO3 5. LD0.SCMLCGGIO3/ LD0.SCMHCGGIO3		SCM-3	
2560	1572.00	.SPCSO1.stVal		Digital Output Channel 1	0/1 = Off/On

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
2561	1572.01	.SPCSO2.stVal		Digital Output Channel 2	0/1 = Off/On
2562	1572.02	.SPCSO3.stVal		Digital Output Channel 3	0/1 = Off/On
2563	1572.03	.SPCSO4.stVal		Digital Output Channel 4	0/1 = Off/On
2564	1572.04	<reserved>		<reserved>	
2565	1572.05	<reserved>		<reserved>	
2566	1572.06	<reserved>		<reserved>	
2567	1572.07	<reserved>		<reserved>	
2568	1572.08	CLOSE_ES		Earth Switch Close Command	0/1 = Off/On
2569	1572.09	OPEN_ES		Earth Switch Open Command	0/1 = Off/On
2570	1572.10	CLOSE_DS		Disconnector Close Command	0/1 = Off/On
2571	1572.11	OPEN_DS		Disconnector Open Command	0/1 = Off/On
2572	1572.12	<reserved>		<reserved>	
2573	1572.13	<reserved>		<reserved>	
2574	1572.14	<reserved>		<reserved>	
2575	1572.15	OPEN_CB		Circuit Breaker Open Command	0/1 = Off/On
2576	1573.00	CLOSE_CB		Circuit breaker Close Command	0/1 = Off/On
2577	1573.01	<reserved>		<reserved>	
		1) 1. LD0.SCMLGGIO4/ LD0.SCMHGGIO4 2. LD0.SCMLPGGIO4/ LD0.SCMHPGGIO4 3. LD0.SCMLDGGIO4/ LD0.SCMHDGGIO4 4. LD0.SCMLEGGIO4/ LD0.SCMHEGGIO4 5. LD0.SCMLCGGIO4/ LD0.SCMHCGGIO4		SCM-4	
2592	1574.00	.SPCSO1.stVal		Digital Output Channel 1	0/1 = Off/On
2593	1574.01	.SPCSO2.stVal		Digital Output Channel 2	0/1 = Off/On
2594	1574.02	.SPCSO3.stVal		Digital Output Channel 3	0/1 = Off/On
2595	1574.03	.SPCSO4.stVal		Digital Output Channel 4	0/1 = Off/On
2596	1574.04	<reserved>		<reserved>	
2597	1574.05	<reserved>		<reserved>	
2598	1574.06	<reserved>		<reserved>	
2599	1574.07	<reserved>		<reserved>	
2600	1574.08	CLOSE_ES		Earth Switch Close Command	0/1 = Off/On
2601	1574.09	OPEN_ES		Earth Switch Open Command	0/1 = Off/On
2602	1574.10	CLOSE_DS		Disconnector Close Command	0/1 = Off/On
2603	1574.11	OPEN_DS		Disconnector Open Command	0/1 = Off/On
2604	1574.12	<reserved>		<reserved>	
2605	1574.13	<reserved>		<reserved>	
Table continues on next page					

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
2606	1574.14	<reserved>		<reserved>	
2607	1574.15	OPEN_CB		Circuit Breaker Open Command	0/1 = Off/On
2608	1575.00	CLOSE_CB		Circuit breaker Close Command	0/1 = Off/On
2609	1575.01	<reserved>		<reserved>	
		1) 1. LD0.SCMLGGIO5/ LD0.SCMHGGIO5 2. LD0.SCMLPGGIO5/ LD0.SCMHPGGIO5 3. LD0.SCMLDGGIO5/ LD0.SCMHDGGIO5 4. LD0.SCMLEGGIO5/ LD0.SCMHEGGIO5 5. LD0.SCMLCGGIO5/ LD0.SCMHCGGIO5		SCM-5	
2624	1576.00	.SPCSO1.stVal		Digital Output Channel 1	0/1 = Off/On
2625	1576.01	.SPCSO2.stVal		Digital Output Channel 2	0/1 = Off/On
2626	1576.02	.SPCSO3.stVal		Digital Output Channel 3	0/1 = Off/On
2627	1576.03	.SPCSO4.stVal		Digital Output Channel 4	0/1 = Off/On
2628	1576.04	<reserved>		<reserved>	
2629	1576.05	<reserved>		<reserved>	
2630	1576.06	<reserved>		<reserved>	
2631	1576.07	<reserved>		<reserved>	
2632	1576.08	CLOSE_ES		Earth Switch Close Command	0/1 = Off/On
2633	1576.09	OPEN_ES		Earth Switch Open Command	0/1 = Off/On
2634	1576.10	CLOSE_DS		Disconnector Close Command	0/1 = Off/On
2635	1576.11	OPEN_DS		Disconnector Open Command	0/1 = Off/On
2636	1576.12	<reserved>		<reserved>	
2637	1576.13	<reserved>		<reserved>	
2638	1576.14	<reserved>		<reserved>	
2639	1576.15	OPEN_CB		Circuit Breaker Open Command	0/1 = Off/On
2640	1577.00	CLOSE_CB		Circuit breaker Close Command	0/1 = Off/On
2641	1577.01	<reserved>		<reserved>	
		1) 1. LD0.SCMLGGIO6/ LD0.SCMHGGIO6 2. LD0.SCMLPGGIO6/ LD0.SCMHPGGIO6 3. LD0.SCMLDGGIO6/ LD0.SCMHDGGIO6 4. LD0.SCMLEGGIO6/ LD0.SCMHEGGIO6 5. LD0.SCMLCGGIO6/ LD0.SCMHCGGIO6		SCM-6	
2656	1578.00	.SPCSO1.stVal		Digital Output Channel 1	0/1 = Off/On

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
2657	1578.01	.SPCSO2.stVal		Digital Output Channel 2	0/1 = Off/On
2658	1578.02	.SPCSO3.stVal		Digital Output Channel 3	0/1 = Off/On
2659	1578.03	.SPCSO4.stVal		Digital Output Channel 4	0/1 = Off/On
2660	1578.04	<reserved>		<reserved>	
2661	1578.05	<reserved>		<reserved>	
2662	1578.06	<reserved>		<reserved>	
2663	1578.07	<reserved>		<reserved>	
2664	1578.08	CLOSE_ES		Earth Switch Close Command	0/1 = Off/On
2665	1578.09	OPEN_ES		Earth Switch Open Command	0/1 = Off/On
2666	1578.10	CLOSE_DS		Disconnector Close Command	0/1 = Off/On
2667	1578.11	OPEN_DS		Disconnector Open Command	0/1 = Off/On
2668	1578.12	<reserved>		<reserved>	
2669	1578.13	<reserved>		<reserved>	
2670	1578.14	<reserved>		<reserved>	
2671	1578.15	OPEN_CB		Circuit Breaker Open Command	0/1 = Off/On
2672	1579.00	CLOSE_CB		Circuit breaker Close Command	0/1 = Off/On
2673	1579.01	<reserved>		<reserved>	
		[1)] 1. LD0.SCMLGGIO7/ LD0.SCMHGGIO7 2. LD0.SCMLPGGIO7/ LD0.SCMHPGGIO7 3. LD0.SCMLDGGIO7/ LD0.SCMHDGGIO7 4. LD0.SCMLEGGIO7/ LD0.SCMHEGGIO7 5. LD0.SCMLCGGIO7/ LD0.SCMHCGGIO7		SCM-7	
2688	1580.00	.SPCSO1.stVal		Digital Output Channel 1	0/1 = Off/On
2689	1580.01	.SPCSO2.stVal		Digital Output Channel 2	0/1 = Off/On
2690	1580.02	.SPCSO3.stVal		Digital Output Channel 3	0/1 = Off/On
2691	1580.03	.SPCSO4.stVal		Digital Output Channel 4	0/1 = Off/On
2692	1580.04	<reserved>		<reserved>	
2693	1580.05	<reserved>		<reserved>	
2694	1580.06	<reserved>		<reserved>	
2695	1580.07	<reserved>		<reserved>	
2696	1580.08	CLOSE_ES		Earth Switch Close Command	0/1 = Off/On
2697	1580.09	OPEN_ES		Earth Switch Open Command	0/1 = Off/On
2698	1580.10	CLOSE_DS		Disconnector Close Command	0/1 = Off/On
2699	1580.11	OPEN_DS		Disconnector Open Command	0/1 = Off/On
2700	1580.12	<reserved>		<reserved>	
2701	1580.13	<reserved>		<reserved>	

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
2702	1580.14	<reserved>		<reserved>	
2703	1580.15	OPEN_CB		Circuit Breaker Open Command	0/1 = Off/On
2704	1581.00	CLOSE_CB		Circuit breaker Close Command	0/1 = Off/On
2705	1581.01	<reserved>		<reserved>	
		[1)] 1. LD0.SCMLGGIO8/ LD0.SCMHGGIO8 2. LD0.SCMLPGGIO8/ LD0.SCMHPGGIO8 3. LD0.SCMLDGGIO8/ LD0.SCMHDGGIO8 4. LD0.SCMLEGGIO8/ LD0.SCMHEGGIO8 5. LD0.SCMLCGGIO8/ LD0.SCMHCGGIO8		SCM-8	
2720	1582.00	.SPCSO1.stVal		Digital Output Channel 1	0/1 = Off/On
2721	1582.01	.SPCSO2.stVal		Digital Output Channel 2	0/1 = Off/On
2722	1582.02	.SPCSO3.stVal		Digital Output Channel 3	0/1 = Off/On
2723	1582.03	.SPCSO4.stVal		Digital Output Channel 4	0/1 = Off/On
2724	1582.04	<reserved>		<reserved>	
2725	1582.05	<reserved>		<reserved>	
2726	1582.06	<reserved>		<reserved>	
2727	1582.07	<reserved>		<reserved>	
2728	1582.08	CLOSE_ES		Earth Switch Close Command	0/1 = Off/On
2729	1582.09	OPEN_ES		Earth Switch Open Command	0/1 = Off/On
2730	1582.10	CLOSE_DS		Disconnector Close Command	0/1 = Off/On
2731	1582.11	OPEN_DS		Disconnector Open Command	0/1 = Off/On
2732	1582.12	<reserved>		<reserved>	
2733	1582.13	<reserved>		<reserved>	
2734	1582.14	<reserved>		<reserved>	
2735	1582.15	OPEN_CB		Circuit Breaker Open Command	0/1 = Off/On
2736	1583.00	CLOSE_CB		Circuit breaker Close Command	0/1 = Off/On
2737	1583.01	<reserved>		<reserved>	
		[1)] 1. LD0.SCMLGGIO9/ LD0.SCMHGGIO9 2. LD0.SCMLPGGIO9/ LD0.SCMHPGGIO9 3. LD0.SCMLDGGIO9/ LD0.SCMHDGGIO9 4. LD0.SCMLEGGIO9/ LD0.SCMHEGGIO9 5. LD0.SCMLCGGIO9/ LD0.SCMHCGGIO9		SCM-9	
2752	1584.00	.SPCSO1.stVal		Digital Output Channel 1	0/1 = Off/On

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
2753	1584.01	.SPCSO2.stVal		Digital Output Channel 2	0/1 = Off/On
2754	1584.02	.SPCSO3.stVal		Digital Output Channel 3	0/1 = Off/On
2755	1584.03	.SPCSO4.stVal		Digital Output Channel 4	0/1 = Off/On
2756	1584.04	<reserved>		<reserved>	
2757	1584.05	<reserved>		<reserved>	
2758	1584.06	<reserved>		<reserved>	
2759	1584.07	<reserved>		<reserved>	
2760	1584.08	CLOSE_ES		Earth Switch Close Command	0/1 = Off/On
2761	1584.09	OPEN_ES		Earth Switch Open Command	0/1 = Off/On
2762	1584.10	CLOSE_DS		Disconnector Close Command	0/1 = Off/On
2763	1584.11	OPEN_DS		Disconnector Open Command	0/1 = Off/On
2764	1584.12	<reserved>		<reserved>	
2765	1584.13	<reserved>		<reserved>	
2766	1584.14	<reserved>		<reserved>	
2767	1584.15	OPEN_CB		Circuit Breaker Open Command	0/1 = Off/On
2768	1585.00	CLOSE_CB		Circuit breaker Close Command	0/1 = Off/On
2769	1585.01	<reserved>		<reserved>	
		1) 1. LD0.SCMLGGIO10/ LD0.SCMHGGIO10 2. LD0.SCMLPGGIO10/ LD0.SCMHPGGIO10 3. LD0.SCMLDGGIO10/ LD0.SCMHDGGIO10 4. LD0.SCMLEGGIO10/ LD0.SCMHEGGIO10 5. LD0.SCMLCGGIO10/ LD0.SCMHCGGIO10		SCM-10	
2784	1586.00	.SPCSO1.stVal		Digital Output Channel 1	0/1 = Off/On
2785	1586.01	.SPCSO2.stVal		Digital Output Channel 2	0/1 = Off/On
2786	1586.02	.SPCSO3.stVal		Digital Output Channel 3	0/1 = Off/On
2787	1586.03	.SPCSO4.stVal		Digital Output Channel 4	0/1 = Off/On
2788	1586.04	<reserved>		<reserved>	
2789	1586.05	<reserved>		<reserved>	
2790	1586.06	<reserved>		<reserved>	
2791	1586.07	<reserved>		<reserved>	
2792	1586.08	CLOSE_ES		Earth Switch Close Command	0/1 = Off/On
2793	1586.09	OPEN_ES		Earth Switch Open Command	0/1 = Off/On
2794	1586.10	CLOSE_DS		Disconnector Close Command	0/1 = Off/On
2795	1586.11	OPEN_DS		Disconnector Open Command	0/1 = Off/On
2796	1586.12	<reserved>		<reserved>	
2797	1586.13	<reserved>		<reserved>	

Table continues on next page

Bit A	Reg A	IEC 61850 name	SA name	Description	Values
2798	1586.14	<reserved>		<reserved>	
2799	1586.15	OPEN_CB		Circuit Breaker Open Command	0/1 = Off/On
2800	1587.00	CLOSE_CB		Circuit breaker Close Command	0/1 = Off/On
2801	1587.01	<reserved>		<reserved>	

1) Applicable (read and write) data attributes are mentioned under their respective data objects.
LD0.SCMLGGIO/LD0.SCMHGGIO
- .SPCSO1.stVal
- .SPCSO2.stVal
- .SPCSO3.stVal
- .SPCSO4.stVal

LD0.SCMLPGGIO/LD0.SCMHPGGIO
- CLOSE_ES
- OPEN_ES
- CLOSE_DS
- OPEN_DS

LD0.SCMLDGGIO/LD0.SCMHDGGIO
- CLOSE_DS
- OPEN_DS

LD0.SCMLEGGIO/LD0.SCMHEGGIO
- CLOSE_ES
- OPEN_ES

LD0.SCMLCGGIO/LD0.SCMHCGGIO
- OPEN_CB
- CLOSE_CB

7.2.46 Supervision data

Supervision data register addresses provide information about the file revision and checksum of RIO600’s configuration and IO parameter file. It also provides information about the firmware version (major, minor and patch) and its checksum of the modules present in the RIO600.

Table 174: Supervision data

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
2260	Unsigned 16	1			RIO Configuration File Revision	0...65535
2261	Unsigned 16	1			RIO Configuration File Checksum	0...65535
2262	Unsigned 16	1			Reserved For Future Use	0
2263	Unsigned 16	1			IO Parameters File Revision	0...65535
2264	Unsigned 16	1			IO Parameters File Checksum	0...65535
2265	Unsigned 16	1			Reserved For Future Use	0
:	:	:			:	:
2281	Unsigned 16	1			Reserved For Future Use	0

Table continues on next page

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
2282	Unsigned 16	1			LECM - Firmware Version Major (High byte) Minor (Low byte)	0...65535
2283	Unsigned 16	1			LECM - Firmware Version Patch (Low byte)	0...65535
2284	Unsigned 16	1			LECM - Firmware Checksum	0...65535
2285	Unsigned 16	1			LECM - Reserved For Future Use	0
2286	Unsigned 16	1			Module 1 - Firmware Version Major (High byte) Minor (Low byte)	0...65535
2287	Unsigned 16	1			Module 1 - Firmware Version Patch (Low byte)	0...65535
2288	Unsigned 16	1			Module 1 - Reserved For Future Use	0
2289	Unsigned 16	1			Module 1 - Reserved For Future Use	0
2290	Unsigned 16	1			Module 2 - Firmware Version Major (High byte) Minor (Low byte)	0...65535
2291	Unsigned 16	1			Module 2 - Firmware Version Patch (Low byte)	0...65535
2292	Unsigned 16	1			Module 2 - Reserved For Future Use	0
2293	Unsigned 16	1			Module 2 - Reserved For Future Use	0
2294	Unsigned 16	1			Module 3 - Firmware Version Major (High byte) Minor (Low byte)	0...65535
2295	Unsigned 16	1			Module 3 - Firmware Version Patch (Low byte)	0...65535
2296	Unsigned 16	1			Module 3 - Reserved For Future Use	0
2297	Unsigned 16	1			Module 3 - Reserved For Future Use	0
2298	Unsigned 16	1			Module 4 - Firmware Version Major (High byte) Minor (Low byte)	0...65535
2299	Unsigned 16	1			Module 4 - Firmware Version Patch (Low byte)	0...65535
2300	Unsigned 16	1			Module 4 - Reserved For Future Use	0
2301	Unsigned 16	1			Module 4 - Reserved For Future Use	0
2302	Unsigned 16	1			Module 5 - Firmware Version Major (High byte) Minor (Low byte)	0...65535
2303	Unsigned 16	1			Module 5 - Firmware Version Patch (Low byte)	0...65535

Table continues on next page

Reg A	Type	Scale	IEC 61850 name	SA name	Description	Values
2304	Unsigned 16	1			Module 5 - Reserved For Future Use	0
2305	Unsigned 16	1			Module 5 - Reserved For Future Use	0
2306	Unsigned 16	1			Module 6 - Firmware Version Major (High byte) Minor (Low byte)	0...65535
2307	Unsigned 16	1			Module 6 - Firmware Version Patch (Low byte)	0...65535
2308	Unsigned 16	1			Module 6 - Reserved For Future Use	0
2309	Unsigned 16	1			Module 6 - Reserved For Future Use	0
2310	Unsigned 16	1			Module 7 - Firmware Version Major (High byte) Minor (Low byte)	0...65535
2311	Unsigned 16	1			Module 7 - Firmware Version Patch (Low byte)	0...65535
2312	Unsigned 16	1			Module 7 Reserved For Future Use	0
2313	Unsigned 16	1			Module 7 - Reserved For Future Use	0
2314	Unsigned 16	1			Module 8 - Firmware Version Major (High byte) Minor (Low byte)	0...65535
2315	Unsigned 16	1			Module 8 - Firmware Version Patch (Low byte)	0...65535
2316	Unsigned 16	1			Module 8 - Reserved For Future Use	0
2317	Unsigned 16	1			Module 8 - Reserved For Future Use	0
2318	Unsigned 16	1			Module 9 - Firmware Version Major (High byte) Minor (Low byte)	0...65535
2319	Unsigned 16	1			Module 9 - Firmware Version Patch (Low byte)	0...65535
2320	Unsigned 16	1			Module 9 - Reserved For Future Use	0
2321	Unsigned 16	1			Module 9 - Reserved For Future Use	0
2322	Unsigned 16	1			Module 10 - Firmware Version Major (High byte) Minor (Low byte)	0...65535
2323	Unsigned 16	1			Module 10 - Firmware Version Patch (Low byte)	0...65535
2324	Unsigned 16	1			Module 10 - Reserved For Future Use	0
2325	Unsigned 16	1			Module 10 - Reserved For Future Use	0

Section 8 Using the Web HMI

8.1 Accessing the Web HMI

- Type the IP address of RIO600 in the address bar of the Web browser and press ENTER.
- Ensure that both the computer and RIO600 are configured for the same subnet.

8.2 Navigating in the menu

- Use the menu bar to access different views.
    - The **General** view shows general information about RIO600. The content of the view varies depending on the RIO600 hardware configuration.
    - The **Fault** view shows RIO600-related fault and warning information.
    - The **Status** view shows status information.
    - The **Configuration** view shows information about the configuration.
    - The **Communication** view shows communication parameter settings.

8.3 Selecting the fault view

The fault view shows RIO600-related fault and warning information. The left column lists the modules related to the fault or warning, and the right column shows the fault or warning code with description.

- Click **Fault** in the menu bar.
    - Alternatively click the fault or warning indicator sign (if present) on the page header.

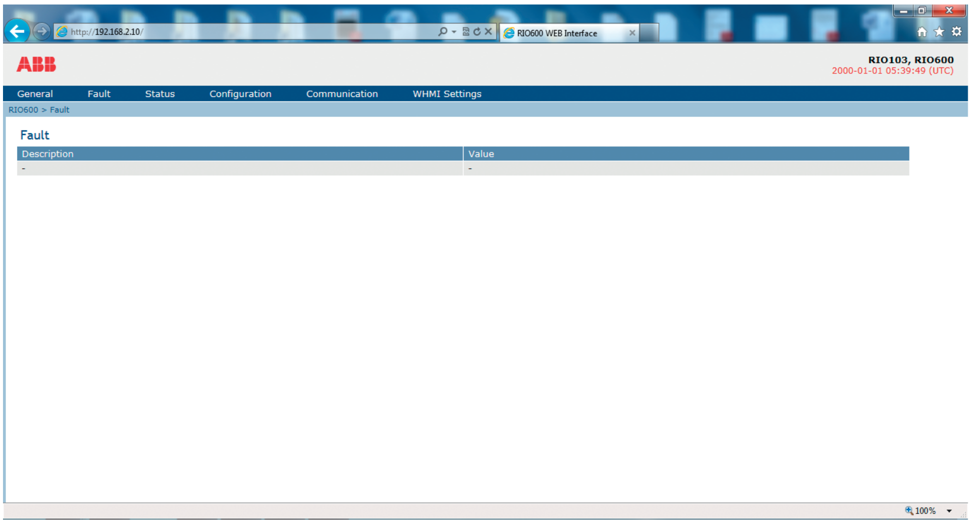

Figure 91: Fault view

8.4 Selecting the status view

The status view shows GOOSE, Modbus, time synchronization and I/O statuses.

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

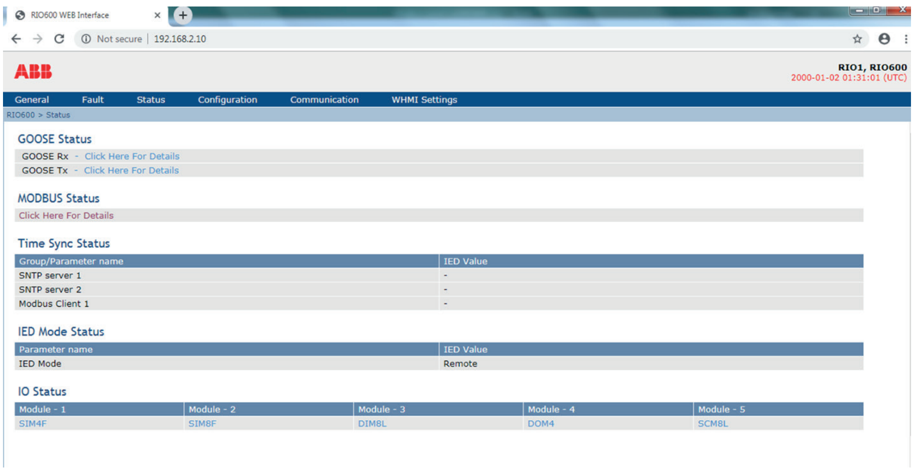

Figure 92: Status page of RIO600 WHMI

- Click the **Click Here For Details** link beside **GOOSE Rx** to view **GOOSE Receive Status**.
  The content area is updated with information related to the last GOOSE frame as received by RIO600 for each GOOSE AppID.

- If no GOOSE messages are received or accepted (if the MAC acceptance filter is enabled) or the GOOSE engineering has not been done, the GOOSE Tx/Rx status is "-".
- If there is an error in the received GOOSE frame, the error information is displayed in the error column of the GOOSE Receive Status table.

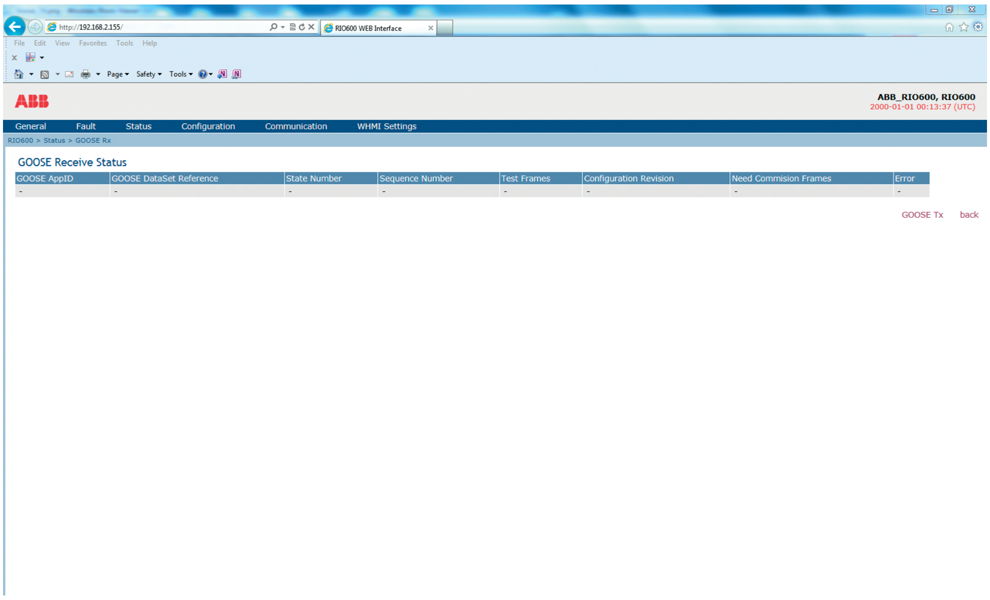

Figure 93: GOOSE Receive Status

- Click the **Click Here For Details** link beside GOOSE Tx to view GOOSE Transmit Status.
  The content area is updated with information related to the last transmitted GOOSE frame for each GOOSE AppID.

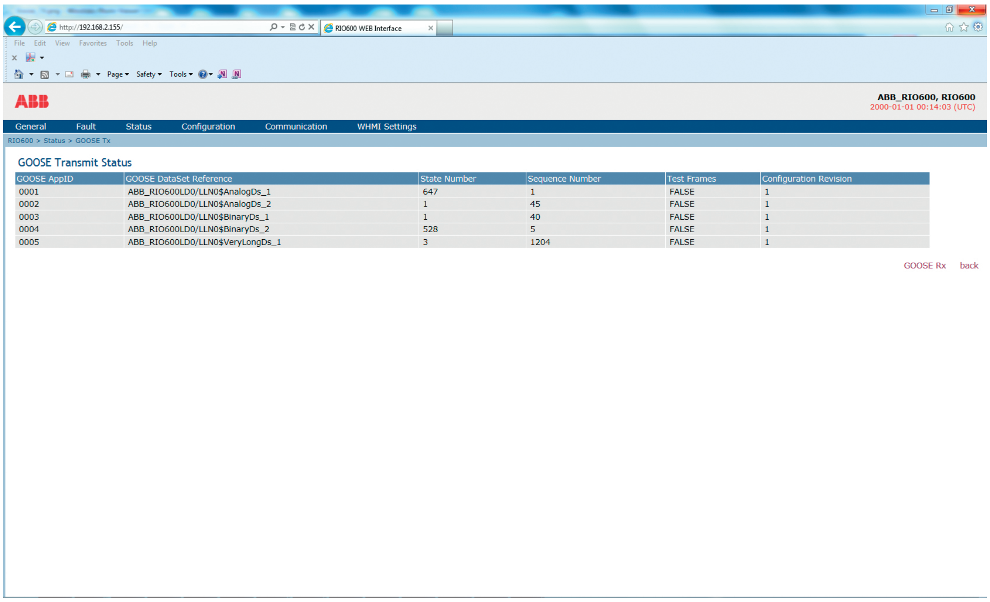

Figure 94: GOOSE Transmit Status

- Click the **Click Here For Details** link under **Modbus status** header for the detailed Modbus status.

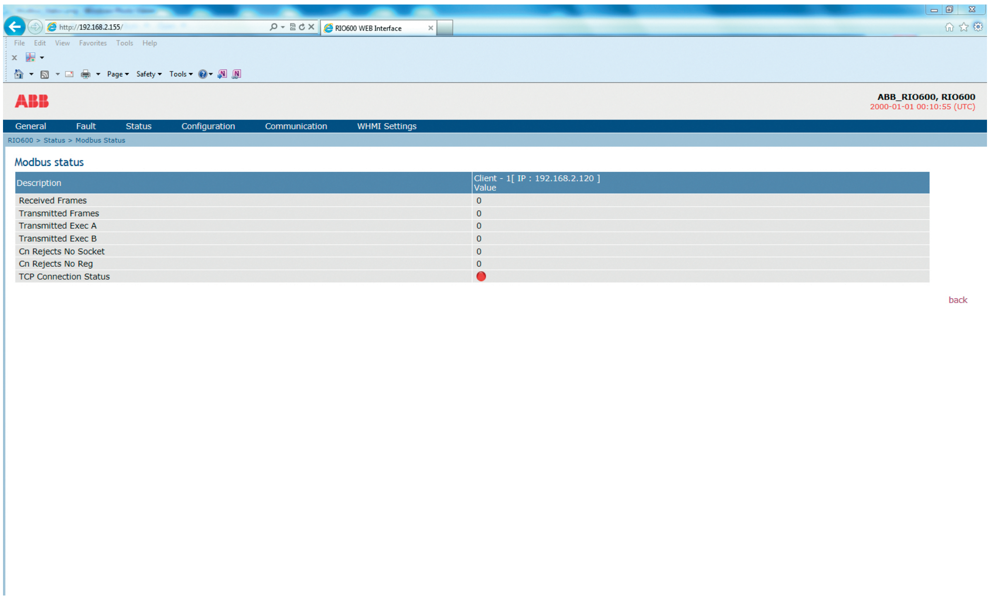

Figure 95: Modbus status

- View **Time Sync Status** to see the statuses of SNTP Server 1 and 2 or Modbus.

- If the time sync source is disabled or not configured, the status is "-".
- If the time sync source is configured as SNTP and if the server is accessible to RIO600, the time sync status is "Good". Otherwise the status is "Bad".
- If the time sync source is configured as Modbus and RIO600 receives the time synch information from the MODBUS master, the time sync status is "Good". Otherwise the status is "Bad".

Select the **Configuration** view in the menu bar to access the configured SNTP server 1 and 2 addresses.

- View **I/O Status** to see the LED statuses of the channels of the binary I/O modules.
  - Grey indicates that the LED is off
  - Yellow color indicates that the LED is on

The LED status does not reflect the actual output if the DOM output is configured as pulse mode or when SCM8H/SCM8L module is configured for application types other than 4 I/O.

In case of SIM8F and SIM4F, click the **Click Here** link to see the detailed status.

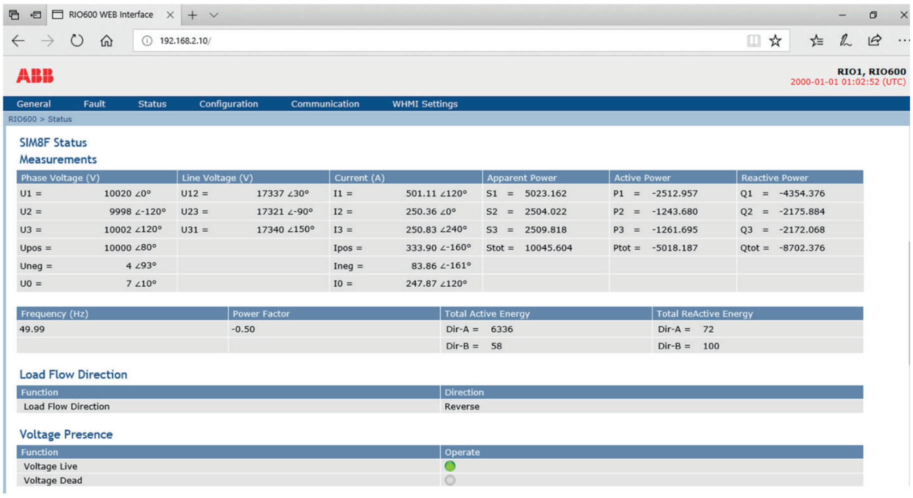

Figure 96: SIM8F status

The direction information for multi-frequency admittance-based earth-fault indication is according to the Start & Operate indication.

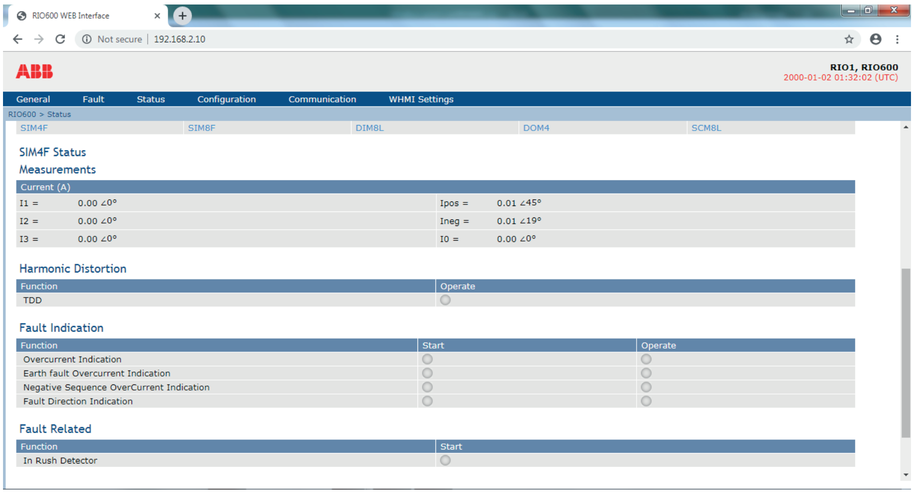

Figure 97: SIM4F status

Pulse output statuses are not updated on the WHMI.

8.5 Selecting the configuration view

The configuration view shows the settings of all modules.

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

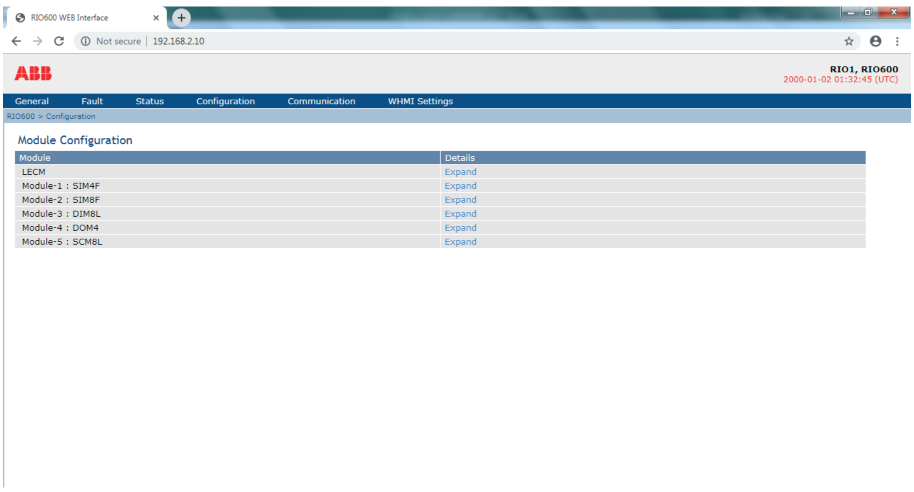

Figure 98: Module configuration

- Click **Click Here For Details** for detailed configuration of each module. The **LECM Configuration** section shows the **General Configuration** and **Modbus Configuration** details.

Figure 99: LECM configuration

- The **DIM Configuration** status section shows the settings for each channel of DIM8H_L module present in RIO600. The row that belongs to the module number gives configuration details common for all channels in that particular module. The configurations that are specific to a particular channel are shown on a row pertaining to that channel.

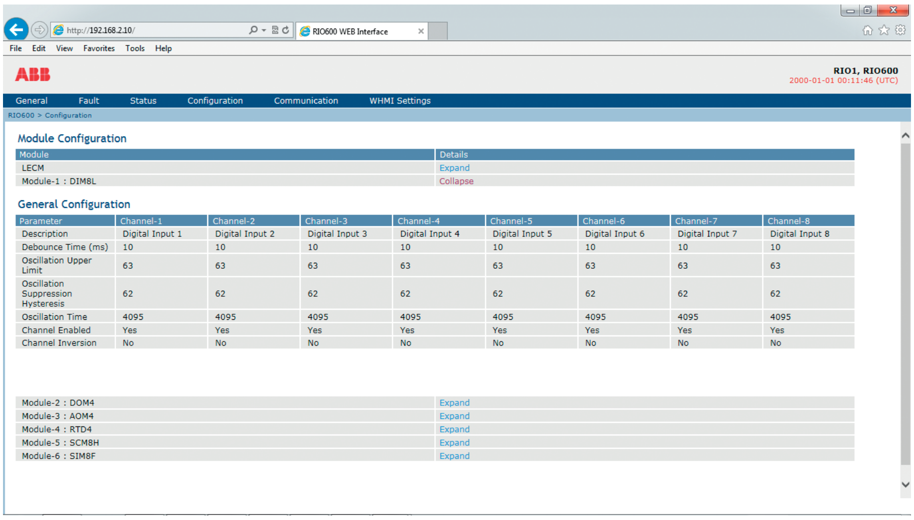

Figure 100: DIM configuration

- The **DOM Configuration** status section shows the settings for each channel of DOM4 module present in RIO600. The row that belongs to the module number gives configuration details common for all channels in that particular module. The configurations specific to a particular channel are shown on a row pertaining to that channel.

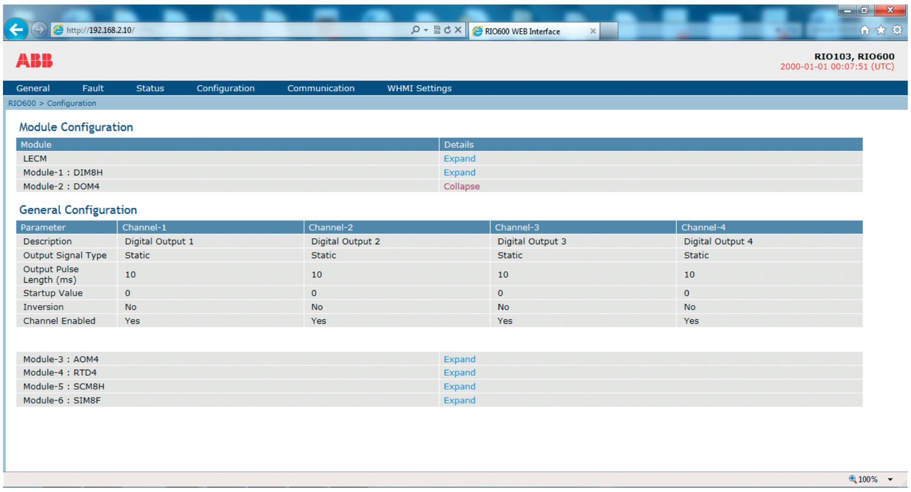

Figure 101: DOM configuration

- The **RTD Configuration** setting section shows the settings for each RTD4 module present in RIO600. The row that belongs to the module number gives the configuration details of all individual channels for that particular module.

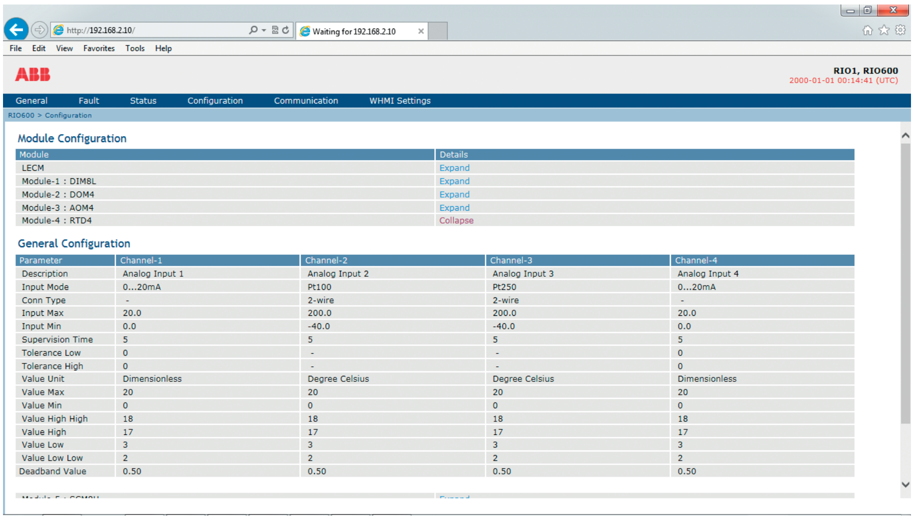

Figure 102: RTD configuration

- The **AOM Configuration** setting section shows the settings for each AOM4 module present in RIO600. The row that belongs to the module number gives the configuration details of all individual channels for that particular module.

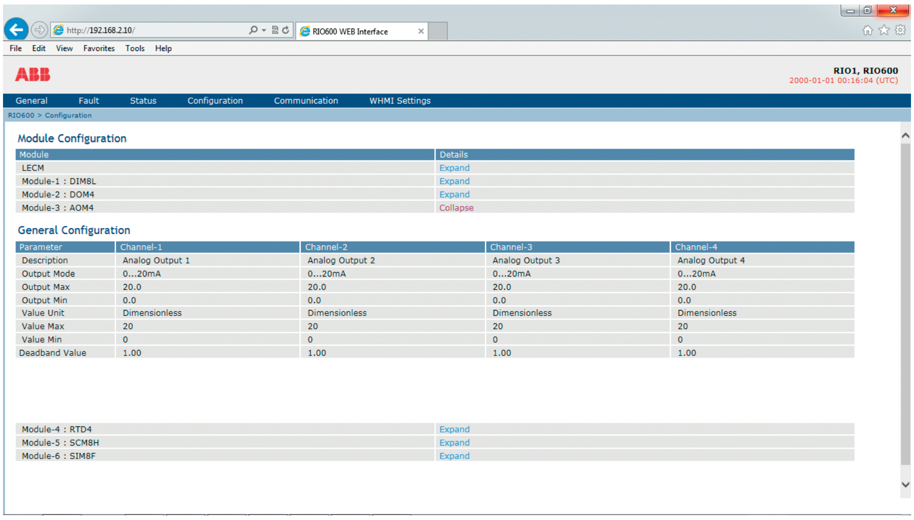

Figure 103: AOM configuration

- The **SIM8F Configuration** setting section shows the SIM8F configuration for the selected SIM8F module. It gives configuration details (in read-only mode) of the SIM8F module as configured by Parameter Setting of RIO600 Connectivity Package.

Figure 104: SIM8F configuration

- The **SIM4F Configuration** setting section shows the SIM4F configuration for the selected SIM4F module. It gives configuration details (in read-only mode) of the SIM4F module as configured by Parameter Setting of RIO600 Connectivity Package.

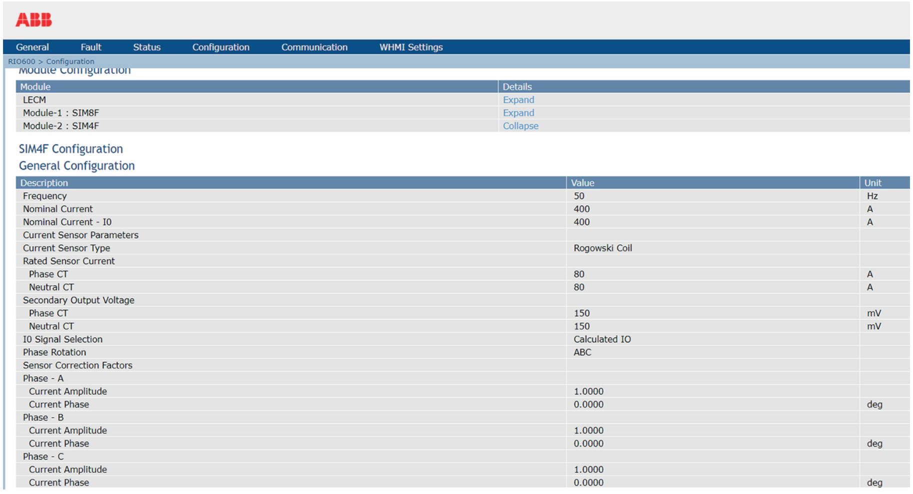

Figure 105: SIM4F configuration

8.6 Selecting the communication view

The communication parameter settings are presented in the communication view.

- Click **Communication** in the menu bar.
    - If the SNTP server is disabled, the SNTP server address is "-".
    - If Modbus is disabled, the Modus client address is "-".
    - The GOOSE publisher and subscriber multicast MAC addresses display the GOOSE publisher and subscriber related information.
    - If the publisher MAC filtering is enabled, it is shown by the **GOOSE Publisher Physical MAC** parameter.
    - If the publisher MAC is not configured, it is not visible under **Communication Parameters**.

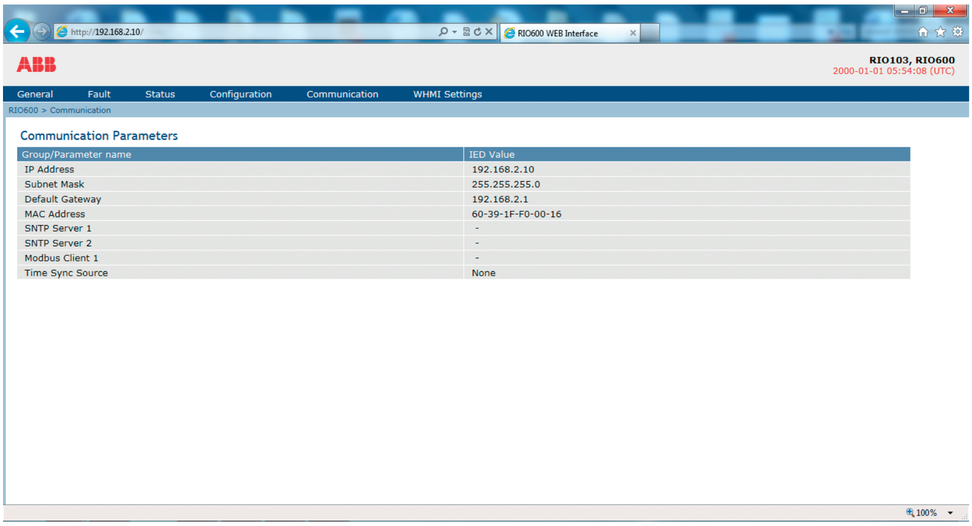

Figure 106: Communication view

Section 9 Troubleshooting

9.1 Checking LED indications

LED indicators describe the state of the RIO600 modules. Each module has indication LEDs showing the state of module functionality. Generally, each module is able to show whether it is functioning properly. Communication and binary I/O states are shown with separate LEDs.

- Check the details of RIO600 WHMI to view the error conditions.

Table 175: LED indicators (PSMH and PSML)

LED	Color	State	Description
Ready	Green	ON	PSMH is healthy
Ready	Green	OFF	Power is not available or PSMH is not working

Table 176: LED indicators (LECM)

LED	Color	State	Description
Ready	Green	ON	LECM is ready
Ready	Green	Flashing	LECM is ready and in test mode or FACTORY reset operation in progress
IRF	Red	OFF	LECM is healthy
IRF	Red	ON	LECM is in error condition
IRF	Red	Flashing	LECM is in warning condition
Ethernet link	Green	ON	Link is established
Ethernett link	Green	OFF	Link broken/not established/connected to 10 Mbps network
Ethernet data	Yellow	Flashing	Data communication
Ethernet data	Yellow	ON	No data on Ethernet link
Ethernet data	Yellow	OFF	Link broken

Table 177: LED indicators (I/O modules)

LED	Color	State	Description
Ready	Green	ON	Module is ready
Ready	Green	Flashing	Module is powered on, configuration is pending
IRF	Red	OFF	Module is healthy
IRF	Red	ON	Module is in error condition
DI1 to DI8 DO1 to DO4	Yellow	ON	Binary I/O signal activated
DI1 to DI8 DO1 to DO4	Yellow	OFF	Binary I/O signal not activated

Table 178: LED indicators (SIM8F modules)

LED	Color	State	Description
Ready	Green	ON	Module is ready
Ready	Green	Flashing	Module is powered on, configuration is pending
IRF	Red	OFF	Module is healthy
IRF	Red	ON	Module is in error condition
IRF	Red	Flashing	Module is in warning condition
LF Fwd/Rv	Green	ON	Power direction indication as per configuration
LF Fwd/Rv	Red	ON	Power direction indication as per configuration
LF Fwd/Rv	Orange	ON	Power direction indication as per configuration
THD/TDD	Green/Red	OFF	THD/TDD is not present
THD/TDD	Green/Red	ON	THD/TDD is present. LED color indication is as per configuration. Dual color if both are present.
Non Dir Oc	Green	OFF	Non-directional overcurrent fault detection condition is not detected
Non Dir Oc	Green	ON	Non-directional overcurrent fault detection condition is detected

Table continues on next page

LED	Color	State	Description
OC Fwd/Rv	Green/Red	OFF	Directional overcurrent fault detection condition is not detected
OC Fwd/Rv	Green/Red	ON	Directional overcurrent fault detection condition is detected. LED color indication is as per configuration and fault detection direction.
Non Dir EF	Red	OFF	Non-directional earth-fault detection condition is not detected
Non Dir EF	Red	ON	Non-directional earth-fault detection condition is detected
EF Fwd/Rv	Green/Red	OFF	Directional earth-fault detection condition is not detected
EF Fwd/Rv	Green/Red	ON	Directional earth-fault condition is detected. LED color indication is as per configuration and fault detection direction.

Table 179: LED indicators (SIM4F modules)

LED	Color	State	Description
Ready	Green	ON	Module is ready
Ready	Green	Flashing	Module is powered on, configuration is pending
IRF	Red	OFF	Module is healthy
IRF	Red	ON	Module is in error condition
IRF	Red	Flashing	Module is in warning condition
Inrush	Green	OFF	Inrush fault condition is not detected
Inrush	Green	ON	Inrush fault condition is detected
Fault Direction Indication	Green	OFF	Fault direction indication fault condition is not detected
Fault Direction Indication	Green	ON	Fault direction indication fault condition is detected

Table continues on next page

LED	Color	State	Description
Non Dir Oc	Green	OFF	Non-directional overcurrent fault detection condition is not detected
Non Dir Oc	Green	ON	Non-directional overcurrent fault detection condition is detected
Neg Seq Oc	Green	OFF	Negative-sequence overcurrent fault condition is not detected
Neg Seq Oc	Green	ON	Negative-sequence overcurrent fault condition is detected
Non Dir EF	Green	OFF	Non-directional earth-fault detection condition is not detected
Non Dir EF	Green	ON	Non-directional earth-fault detection condition is detected

The binary input LED is ON if the input signal is HIGH (DIM8H: ~100 V DC, DIM8L: ~24 V DC) and OFF if the signal is LOW (~0 V DC). The operation is independent of normal/inverted parameter.

The binary output LED is ON if the output contact is closed and OFF if the output contact is open. The operation is independent of normal/inverted parameter.

Flashing protection indication LEDs signify that the fault has been cleared and is waiting for reset according to the *Fault indication reset method* setting.

Table 180: LED indicators (SCM module)

LED	Color	State	Description
Ready	Green	ON	Module is ready
Ready	Green	Flashing	Module is powered on, configuration is pending
IRF	Red	OFF	Module is healthy

Table continues on next page

LED	Color	State	Description
IRF	Red	ON	Module is in error condition
DI1 to DI4 HS1 to HS4	Yellow	ON	Binary I/O signal activated
DI1 to DI4 HS1 to HS4	Yellow	OFF	Binary I/O signal not activated

9.1.1 Behavior during IRF condition

Table 181: Behavior during IRF in LECM module

Module IRF	Behavior in an IRF condition		
	RIO600 as a whole	LECM	DIM8L/DIM8H, DOM4, AOM4, RTD4
IRF in LECM module	Normal functionality is compromised	1. Shows error by steady red LED on LECM module 2. Shows IRF source information on WHMI under faults page 3. Force all DOM4 outputs to default, that is, “0” 4. All AOM4 output continues to drive the last GOOSE received value 5. GOOSE: Update Quality of all data attributes and RIO600 module health as per IEC 61850 6. Open DOM4 IRF output contact, if configured	1. Continues normal operation 2. Shows error in previous module over LECM WHMI (if detected)

Table 182: Behavior during IRF in DIM8L/DIM8H module

Module IRF	Behavior in an IRF condition			
	RIO600 as a whole	LECM	DIM8L/DIM8H	DOM4, AOM4, RTD4
IRF in DIM8L/DIM8H module	Continues normal function with corrective action	1. Shows IRF by steady IRF LED on LECM module 2. Shows IRF source information on WHMI under faults page 3. DIM module under fault's channel values as reported on GOOSE are forced to default, that is "0" 4. GOOSE: Update quality of all module's data attributes as required and RIO600 module health as per IEC 61850 5. Open DOM4 IRF output contact, if configured	Normal functionality is compromised	1. Continues normal operation 2. Shows error in previous module over LECM WHMI (if detected)

Table 183: Behavior during IRF in DOM4 module

Module IRF	Behavior in an IRF condition			
	RIO600 as a whole	LECM	DOM4	DIM8L/DIM8H, RTD4, AOM4
IRF in DOM4 module	Continues normal function with corrective action	1. Shows IRF by steady IRF LED on LECM module 2. DOM4 Module under fault's channel is forced to default i.e. "FALSE" or "OFF" state. The DOM4 module's channel's physical status will be forced to "OFF" state 3. Show IRF on WHMI under Faults page. 4. GOOSE: Updates quality of all modules' data attributes and RIO600 module health as per IEC 61850 5. Opens DOM4 IRF output contact, if it is configured	Normal functionality is compromised	1. Continues normal operation 2. Shows error in previous module over LECM WHMI (if detected)

Table 184: Behavior during IRF in RTD4 module

Module IRF	Behavior in an IRF condition			
	RIO600 as a whole	LECM	RTD4	DIM8L/DIM8H, DOM4, AOM4
IRF in RTD4 module	Continues normal function with corrective action	1. Show IRF to user by steady IRF LED on LECM module 2. The RTD Module under fault's channel values as reported over GOOSE are forced to "0" 3. Show IRF on WHMI under Faults page 4. GOOSE: Updates quality of all modules' data attributes and RIO600 module health as per IEC 61850 5. Opens DOM IRF output contact, if it is configured	Normal functionality is compromised	1. Continues normal operation 2. Shows error in previous module over LECM WHMI (if detected)

Table 185: Behavior during IRF in AOM4 module

Module IRF	Behavior in an IRF condition			
	RIO600 as a whole	LECM	AOM4	DIM8L/DIM8H, DOM4, RTD4
IRF in AOM4 module	Continues normal function with corrective action	1. Show IRF to user by steady IRF LED on LECM module 2. Shows IRF source information on WHMI under Faults page 3. AOM4 module under fault's channels are forced to default, that is, "0" and the AOM module's channel's physical status is forced to "0" 4. GOOSE: Updates quality of all module's data attributes and RIO600 module health as per IEC 61850 5. Opens DOM4 IRF output contact, if it is configured	Normal functionality is compromised	1. Continues normal operation 2. Shows error in previous module over LECM WHMI (if detected)

Table 186: Behavior during IRF in SIM8F module

Module IRF		Behavior in an IRF condition	
	RIO600 as a whole	LECM	DIM8L/DIM8H, DOM4, RTD4, AOM4
IRF in SIM8F module	Continues normal function with corrective action	1. Shows IRF by steady IRF LED on LECM module 2. Shows IRF source information on WHMI under faults page 3. SIM8F module information is sent with bad quality 4. GOOSE: Updates quality of all modules' data attributes and RIO600 module health as per IEC 61850 5. Opens DOM4 IRF output contact, if it is configured	1. Continues normal operation 2. Shows error in previous module over LECM WHMI (if detected)

Table 187: Behavior during IRF in SIM4F module

Module IRF		Behavior in an IRF condition	
	RIO600 as a whole	LECM	DIM8L/DIM8H, DOM4, RTD4, AOM4
IRF in SIM4F module	Continues normal function with corrective action	1. Shows IRF by steady IRF LED on LECM module 2. Shows IRF source information on WHMI under faults page 3. SIM4F module information is sent with bad quality 4. GOOSE: Updates quality of all modules' data attributes and RIO600 module health as per IEC 61850 5. Opens DOM4 IRF output contact, if it is configured	1. Continues normal operation 2. Shows error in previous module over LECM WHMI (if detected)

9.2 Self-supervision

The self-supervision system continuously monitors the software and hardware of various RIO600 modules. The run-time fault situations are indicated via the WHMI and communication channels.

There are two types of fault indications.

- Error indications
- Warning indications

In case of an error or warning in any of the modules available in the RIO600 stack, the red IRF LEDs start flashing. See Behavior during IRF condition.

9.2.1 Error indications

The error indications provided in the WHMI are a combination of a code and a description of the error. Errors can be caused by any of the following:

- Mismatch in the module configuration and the used stack
- Hardware or internal communication failure

The error indications in the LECM module can be divided into user error and internal error indications.

Table 188: Error indications and codes

Module type	Code	Description
LECM (user error indications)	0x00000001	Error in previous module
	0x00000002	GOOSE receive error
	0x00000004	Flash memory failure
	0x00000008	HWCompos file error
	0x00000010	Config files syntax error
	0x00000020	IO modules mismatch
	0x00000040	Config files missing
	0x00000080	Config files exception
	0x00000100	Config data error
	0x00000200	Error while processing rec. GOOSE
LECM (internal error indications)	0x00010000	Tcpnet system error
	0x00020000	CAN controller error
	0x00040000	Mem allocation error
	0x00080000	Mem free error
	0x00100000	Exception ABORT
	0x00200000	OS exception error
Table continues on next page		

Module type	Code	Description
SIM8F/SIM4F	0x00000002	Module IRF
	0x00000004	Module not responding
	0x00000008	Partially calibrated
	0x00000010	Calibration error
	0x00000020	Watchdog timeout
	0x00000040	SPI communication failure
	0x00000080	EEPROM write failure
	0x00000100	Error in previous module
	0x00020000	SPI communication failure – Metering IC
	0x00040000	SPI communication failure – Sampling IC
DIM8H/DIM8L DOM4 SCM8H/SCM8L	0x00000002	Module IRF
	0x00000004	Module not responding
	0x00000100	Error in previous module
RTD AOM	0x00000002	Module IRF
	0x00000004	Module not responding
	0x00000100	Error in previous module
	0x00010000	Channel – 1 Ext. hw. Fault
	0x00020000	Channel – 1 Out of range
	0x00040000	Channel – 1 Supervision fault
	0x00080000	Channel – 1 Ext. wiring fault
	0x00100000	Channel – 2 Ext. hw. Fault
	0x00200000	Channel – 2 Out of range
	0x00400000	Channel – 2 Supervision fault
	0x00800000	Channel – 2 Ext. wiring fault
	0x01000000	Channel – 3 Ext. hw. Fault
	0x02000000	Channel – 3 Out of range
	0x04000000	Channel – 3 Supervision fault
	0x08000000	Channel – 3 Ext. wiring fault
	0x10000000	Channel – 4 Ext. hw. Fault
	0x20000000	Channel – 4 Out of range
	0x40000000	Channel – 4 Supervision fault
	0x80000000	Channel – 4 Ext. wiring fault

9.2.2 Warning indications

The warning indications provided in the WHMI are a combination of a code and a description of the warning.

Table 189: Warning indications and codes

Module type	Code	Description
LECM (user warning indications)	0x00000100	Time synchronization error
	0x00010000	RTC not synched
	0x00080000	Calibration parameter out of range
	0x00100000	Calibration save failed
	0x00200000	EEPROM write failure
	0x00400000	Software internal error

9.3 Restoring communication

1. Check the firewall configuration in the host PC. A firewall may prevent the FTP and ping command from working.
2. Open the TCP/IP and UDP ports by adjusting the firewall settings.
   Windows XP SP2 or later contains a built-in firewall.

   Table 190: TCP/IP and UDP ports

Protocol	TCP/UDP port
FTP file transfer protocol	21, 20
Network time management protocol	123
HTTP	80
Modbus TCP	502

   The FTP timeout period in RIO600 is 100 ms.
3. Check the network if the communication issue persists.
   All devices in the same network should have unique MAC addresses and IP addresses.
4. If an address conflict is detected, separate RIO600 from the network and refresh the PC's ARP table.
   4.1. In the command prompt, type **arp-d**.
   4.2. Press ENTER to flush the ARP table and establish the communication to RIO600.

RIO600 supports only one user credential for FTP with the user name Administrator.

9.4 Restoring factory settings

The LECM board has a push button to restore RIO600 to factory settings. The configuration files in RIO600 are deleted and the communication parameters are changed to the default values.

1. Power off the rack before removing the modules from the stack.
2. Remove the I/O modules from the stack to access the factory reset button on the LECM board.
   If the plastic part cutout is not open, remove the cutout to display the push button.

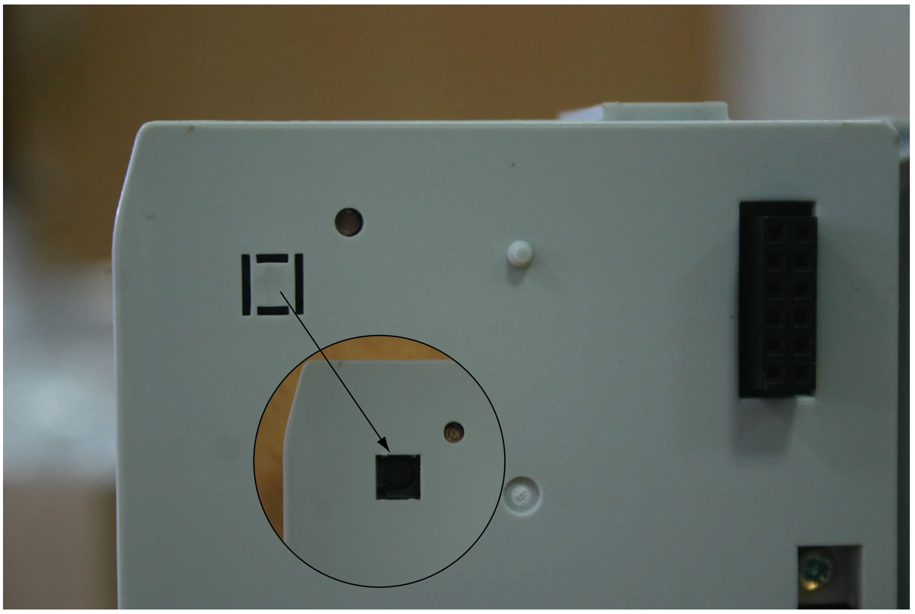

Figure 107: Accessing the reset push button

3. Press the push button and while keeping the button pressed, power up RIO600.
4. Keep the push button pressed for 30 seconds after RIO600 is powered up.
   The IRF LED (red) appears static (continuous ON). If the Ethernet cable is connected, the LEDs for Ethernet link and Ethernet data are static. It takes 50 seconds to delete the stored configuration files and bring the LECM module to its factory default state. The LECM board automatically reboots when the stored configuration files have been deleted. The ready LED turns OFF and then ON once, and the IRF LED turns OFF and back ON to indicate an internal relay fault. The absence of RIO600 configuration files causes this internal relay fault.
5. After reboot, verify the factory default state from the WHMI.
   In WHMI’s General view, the module status LED color is red for LECM. The LED state for all other modules available in the stack is OFF.

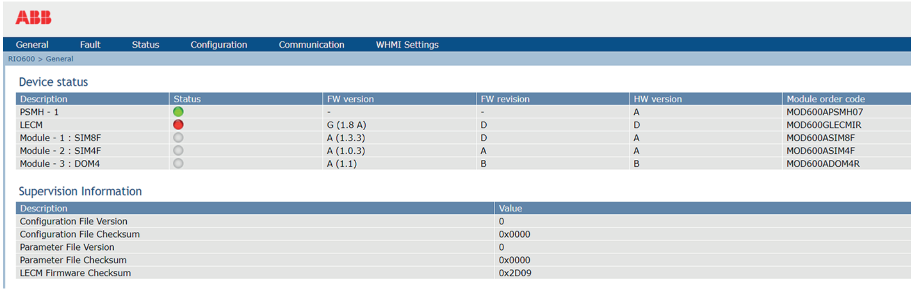

Figure 108: WHMI's General view during factory default state

The reason for an internal relay fault can be verified from the WHMI's Fault view.

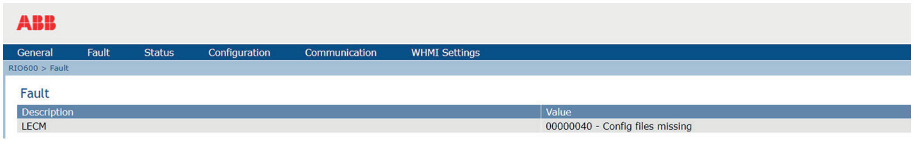

Figure 109: WHMI's Fault view during factory default state

9.5 Ping command response

In the absence of TCP/IP layer activity on the Ethernet network, RIO600 responds to ping command within 1...5 ms depending on the ongoing internal tasks of the device.

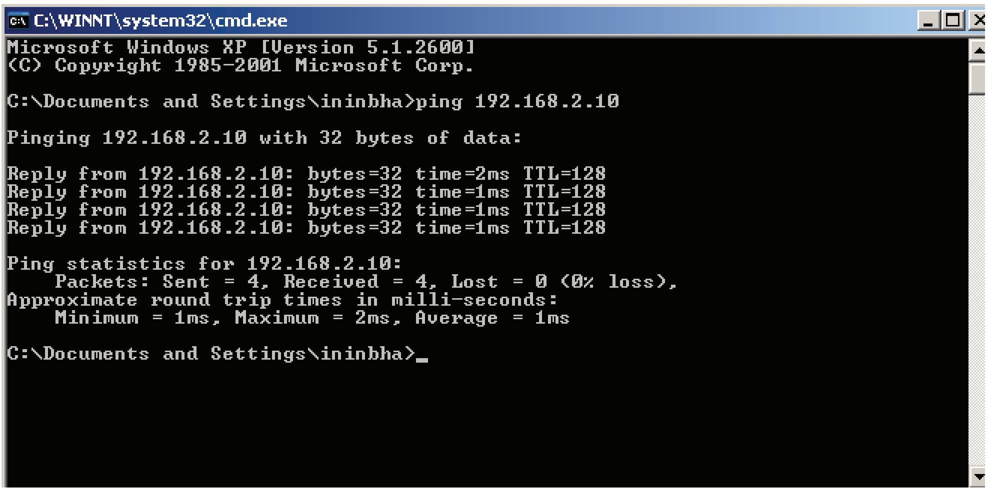

Figure 110: Response to the ping command

When there is network traffic on the TCP/IP layer, the ping command response time varies and may cross the specified limits as the priority is in the I/O and GOOSE functionality.

9.6 Troubleshooting inactive I/O modules

If a valid configuration has been downloaded in RIO600 but the Ready LED of the I/O modules remains off, check the connections between the physical modules. The Ready LED on the binary modules remains off until the configuration is applied.

In the newer modules, the Ready LED flashes indicating that the module has been powered up but the configuration is missing.

1. Separate the modules from each other.
   If the modules are loosely connected with each other or the back plane pins on the modules do not connect exactly between the two modules, the I/O modules are not detected by the communication module. Thus, the configuration is not applied.
2. Reconnect the modules.
   The configuration file is applied after the LECM module verifies the type of the modules and its position which is downloaded in the configuration file along with the physically connected modules and their positions. The lit Ready LED (green) indicates that the configuration is applied.

9.7 SIM8F/SIM4F measurement quality

The quality of the measured or derived electrical quantities provided by SIM8F/SIM4F can be bad due to one of the following reasons.

- Connection between SIM8F/SIM4F and the measurement sensor is incorrect
- Frequency value is not within valid range
- Sensor input signals are not within valid range

For more information on the valid measurement range, see the product guide.

9.8 Updating LECM module using Firmware Update

Replace the LECM module in the installed RIO600 stack with a new one from factory or a neighbor stack. Use PCM600 to configure the LECM module.

1. In the **Plant Structure** view, select the RIO600 device.
2. In the **Object Properties** pane, define the **IP Address** of the replaced LECM. LECM modules delivered from the factory have the default IP Address 192.168.2.10.
3. Right-click the RIO600 device and select **Firmware Update**.
4. In the **Connection** dialog, click **Connect**.
   - Click Cancel to exit the tool.

   The relay enters bootloader mode. The stack information is read from the relay and shown in the tool.

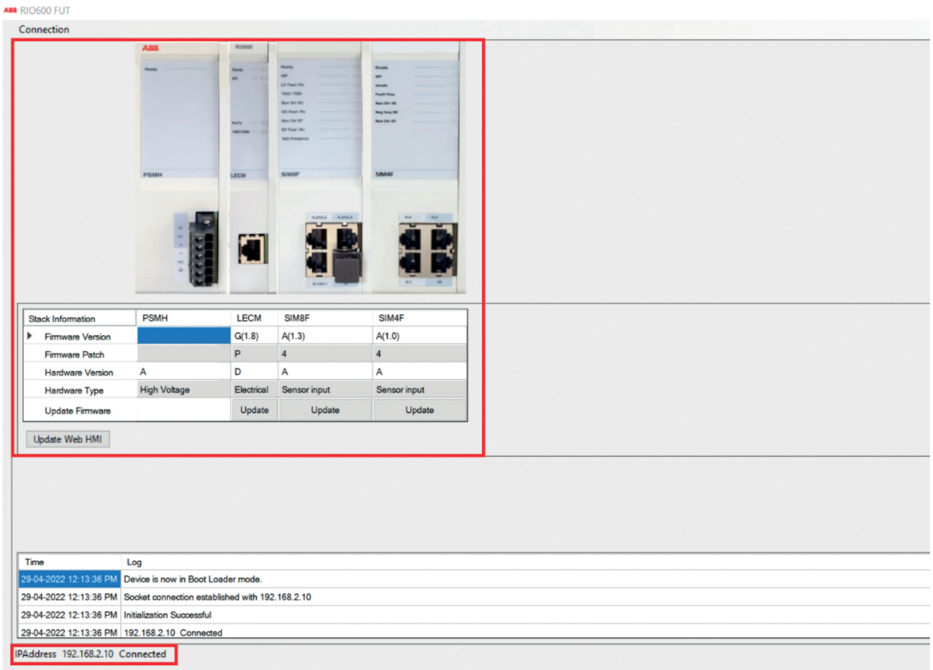

Figure 111: Reading stack information in bootloader mode

5. Under the **LECM** column, click **Update**.

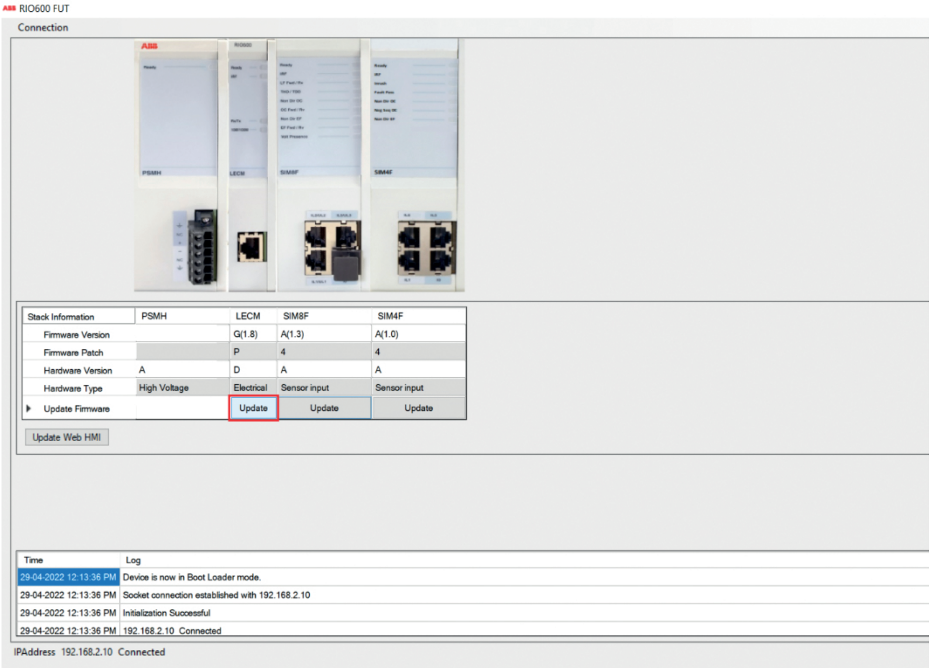

Figure 112: Updating LECM module

6. Select the correct file for LECM and click **Open**.

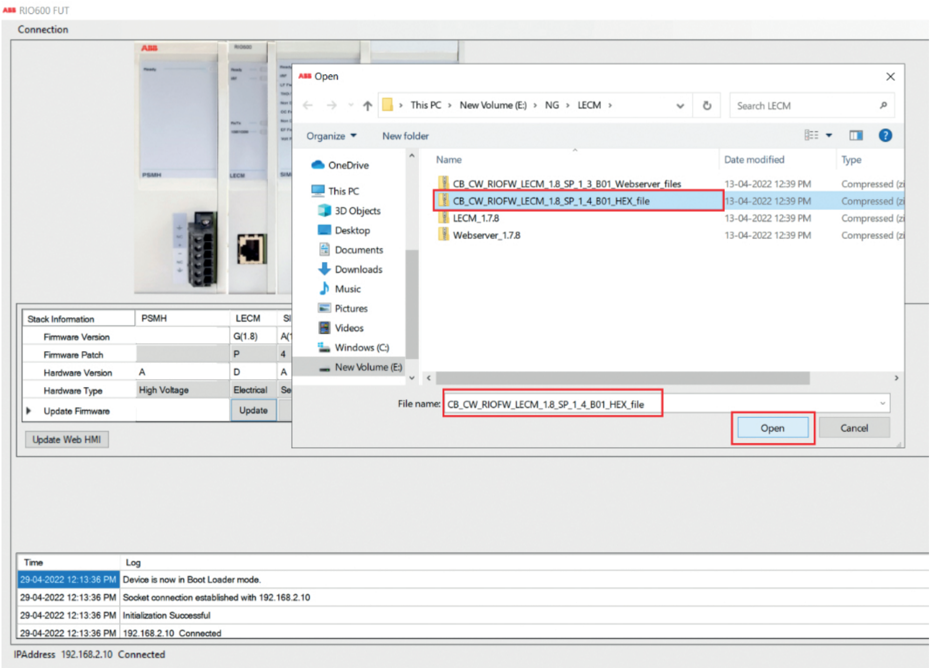

Figure 113: Selecting the file to update LECM module

7. Wait until the updating process is completed and click **OK**.

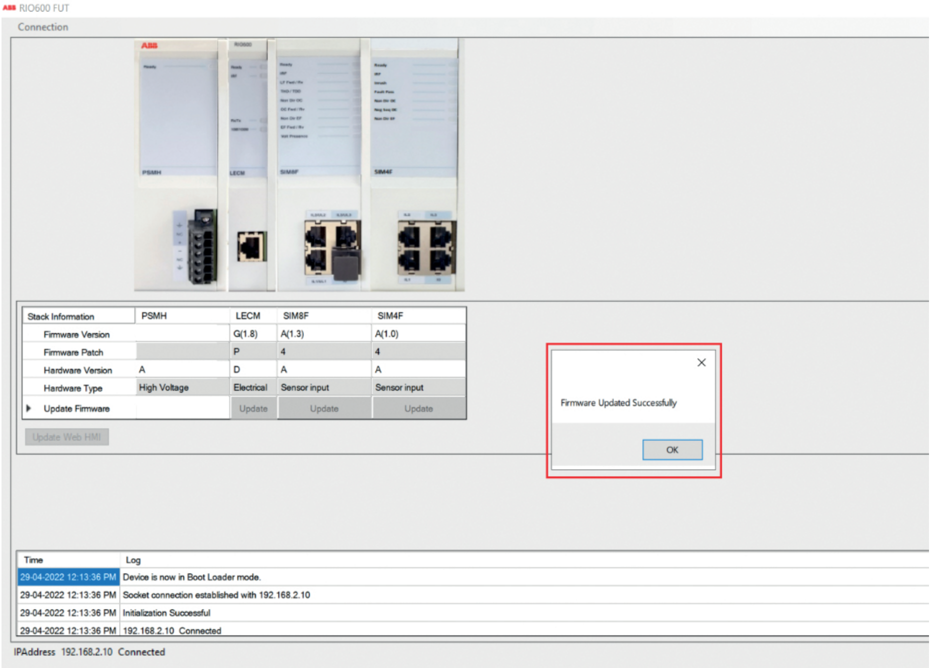

Figure 114: Completing the LECM update successfully

8. To update WHMI corresponding to the LECM version, click **Update Web HMI**.

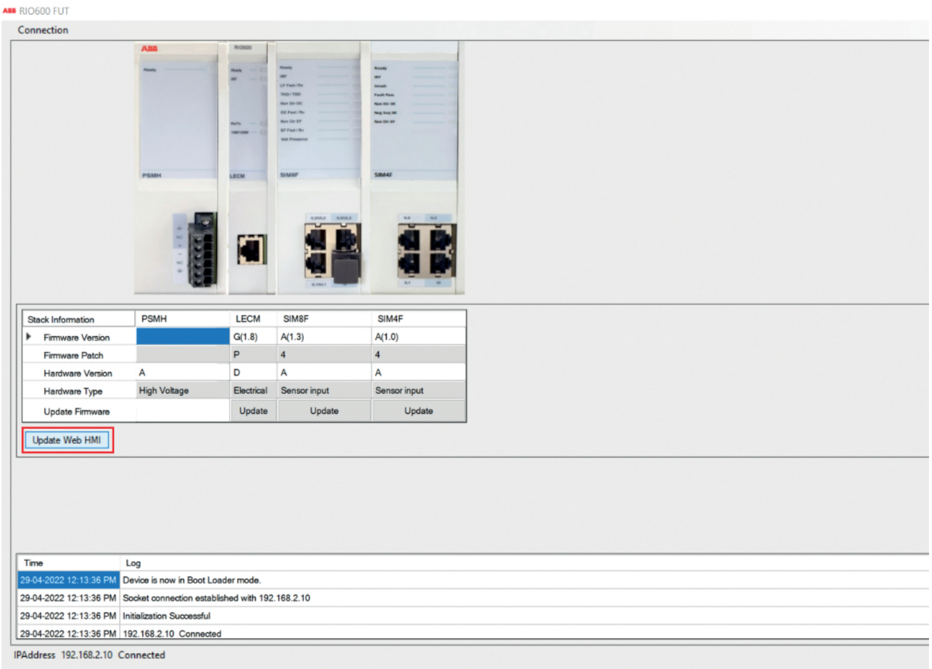

Figure 115: Updating the Web HMI

9. Select the correct file for WHMI and click **Open**.

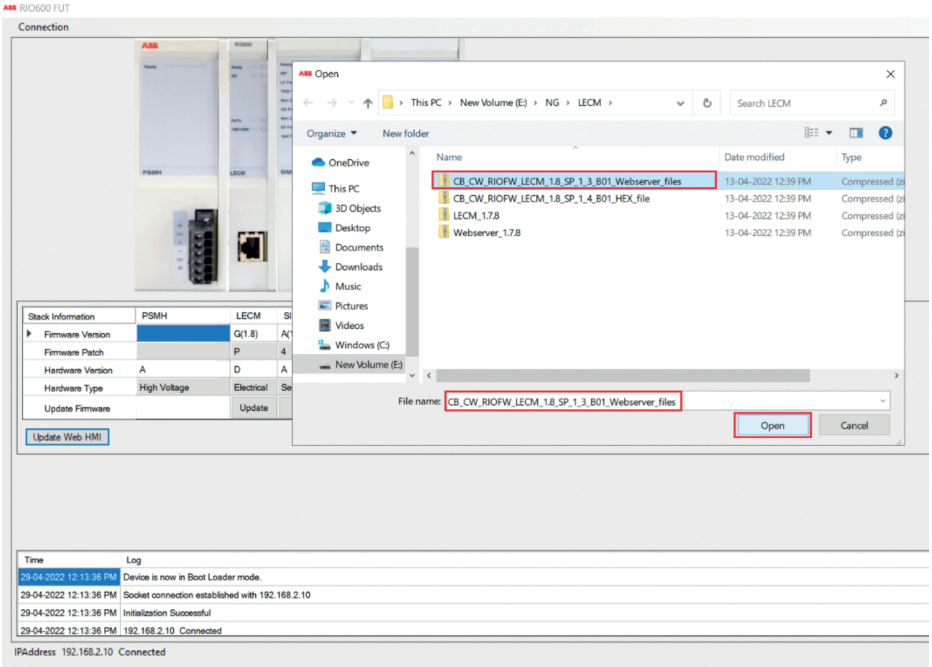

Figure 116: Selecting the file to update Web HMI

10. Wait until the updating process is completed and click **OK**.

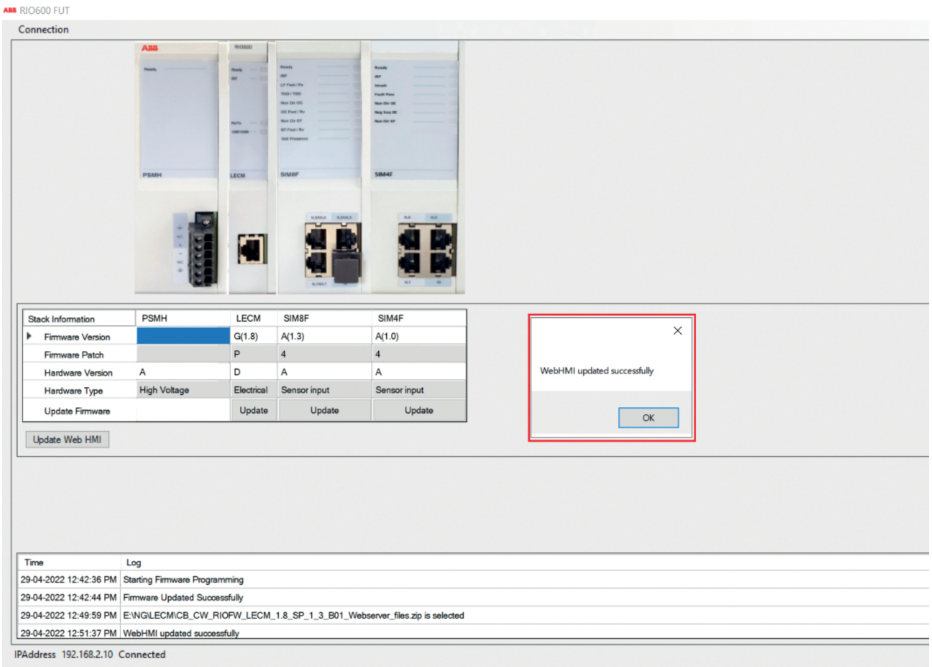

Figure 117: Completing the Web HMI update successfully

To update other modules such as SIM8F, SIM4F or SCM, see Updating SIM8F module using Firmware Update.

11. In the **Connection** menu, select **Disconnect**.
    The relay exits the bootloader mode and its status turns to Disconnected.

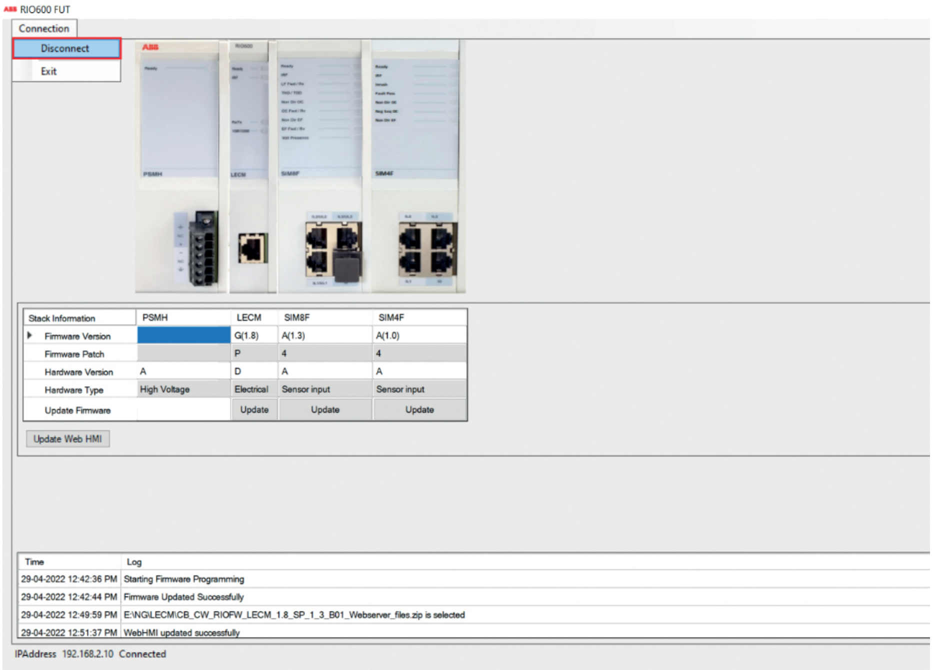

Figure 118: Exiting the bootloader mode

12. In the **Connection** menu, select **Exit** and click **Yes** to confirm.

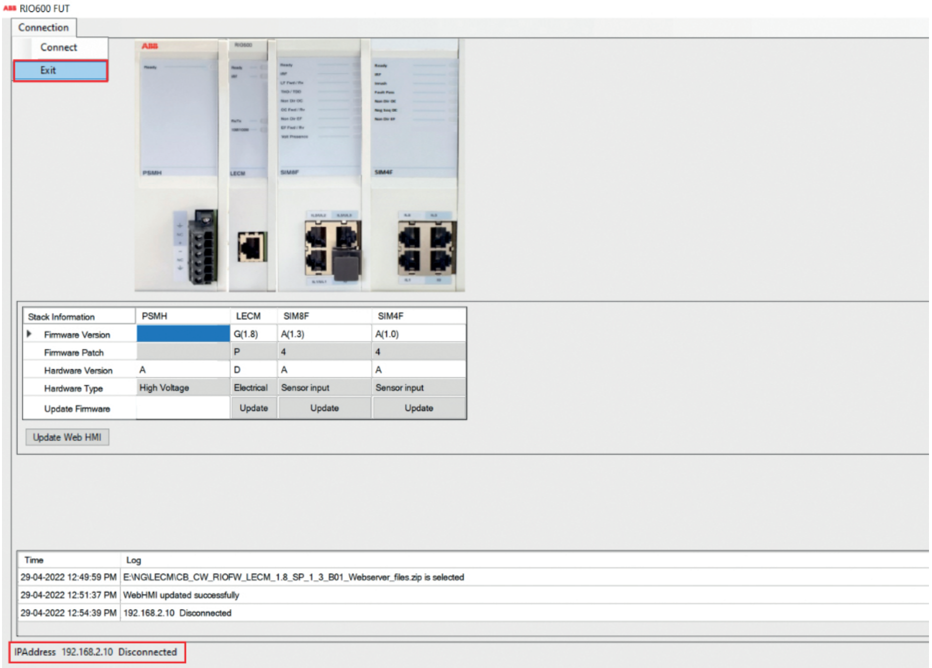

Figure 119: Closing Firmware Update

13. Perform **Common Write** to load the configuration to the relay.

LECM downgrade is supported until Ver.1.5 only.

While using Firmware Update, PCM600 operations such as partial read/write or common read/write do not work as the relay is in bootloader mode.

9.9 Updating SIM8F module using Firmware Update

Same steps can be followed to update SIM4F and SCM modules with PCM600.

1. In the **Plant Structure** view, right-click the RIO600 device and select **Firmware Update**.
2. In the **Connection** dialog, click **Connect**.
   The relay enters bootloader mode. The stack information is read from the relay and shown in the tool.

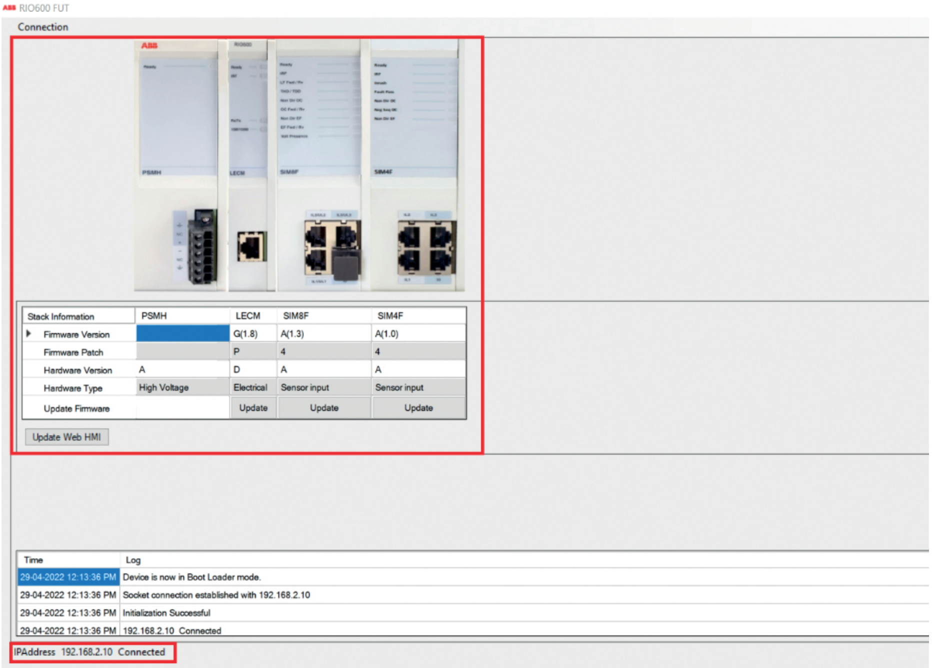

Figure 120: Reading stack information in bootloader mode

3. Under the **SIM8F** column, click **Update**.

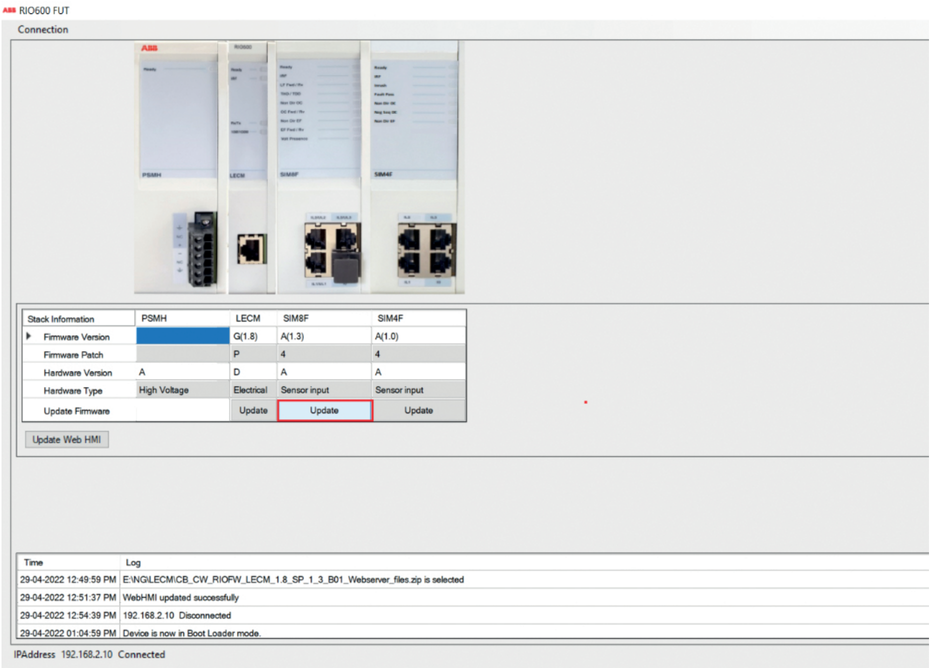

Figure 121: Updating SIM8F module

4. Select the correct file for SIM8F and click **Open**.

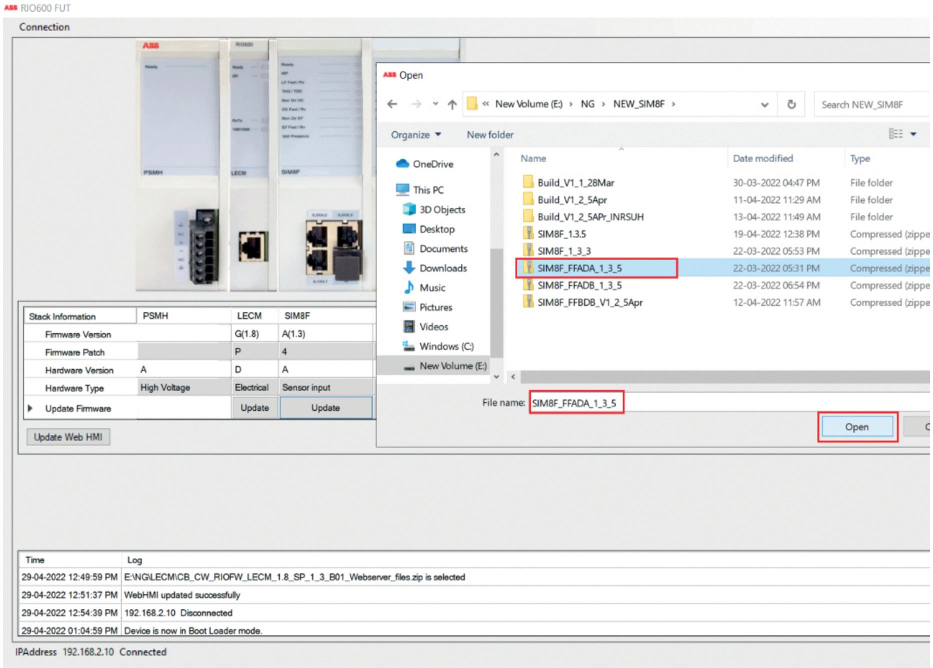

Figure 122: Selecting the file to update SIM8F module

5. Wait until the updating process is completed and click **OK**.

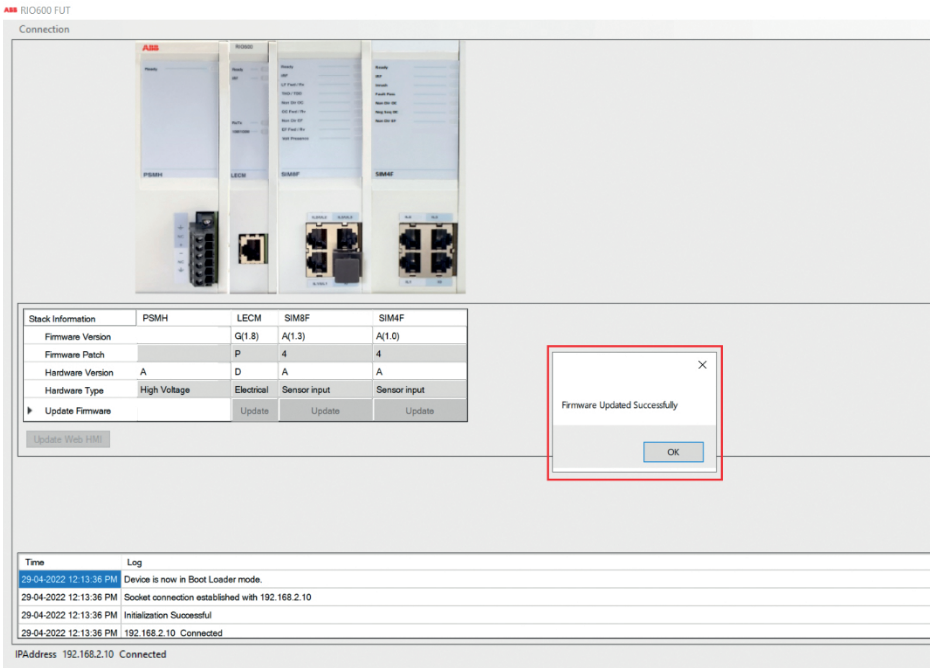

Figure 123: Completing the SIM8F update successfully

6. In the **Connection** menu, select **Disconnect**.
   The relay exits the bootloader mode and its status turns to Disconnected.

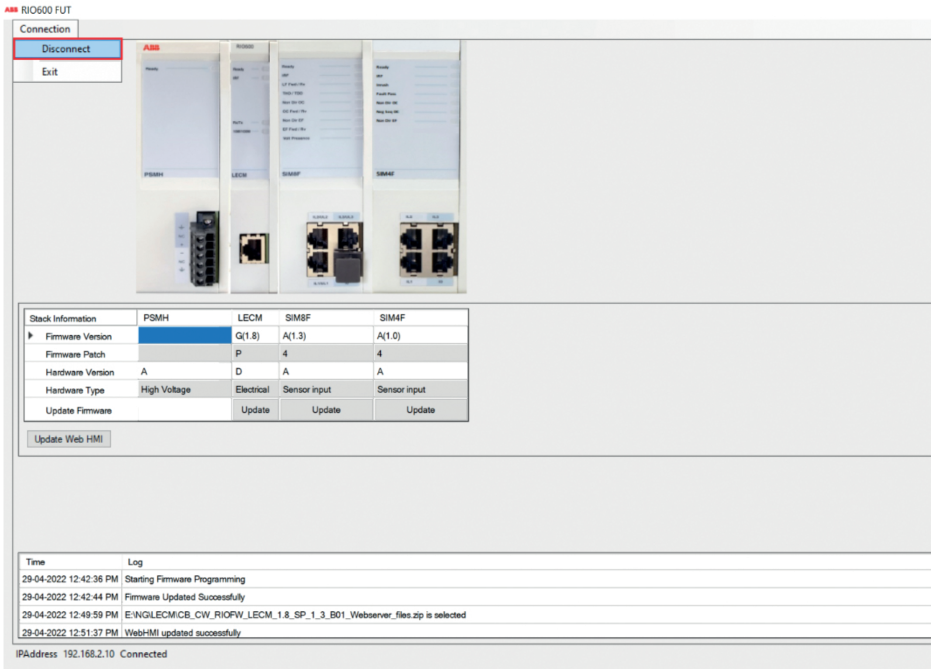

Figure 124: Exiting the bootloader mode

7. In the **Connection** menu, select **Exit** and click **Yes** to confirm.

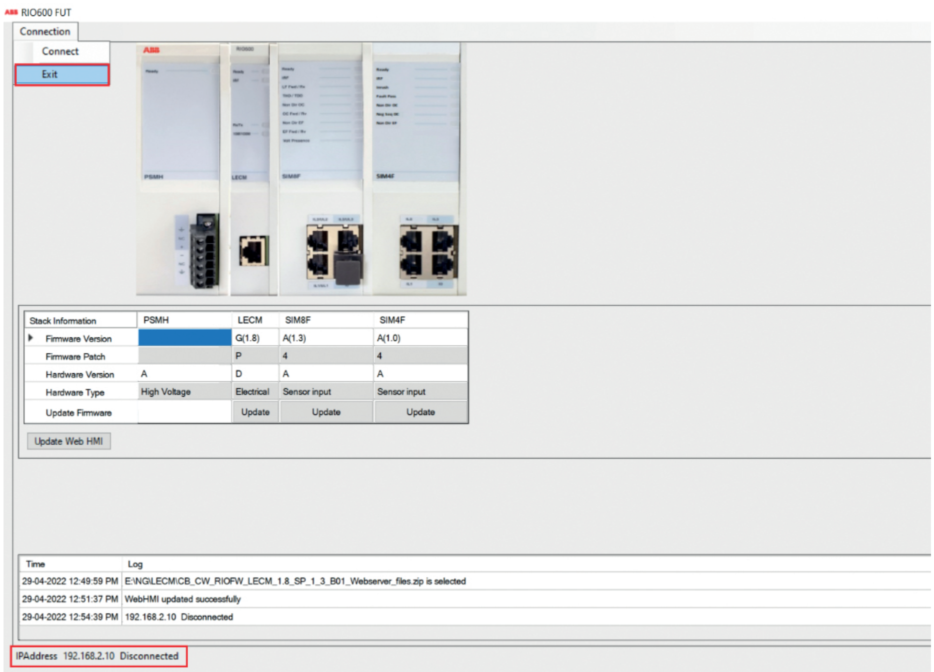

Figure 125: Closing Firmware Update

8. Perform **Common Write** to load the configuration to the relay.

9.10 Contacting customer support

- Before contacting the customer service, gather the required background information.
    - Firmware version for the different modules available in WHMI
    - Connectivity package version
    - PCM600 version

Section 10 Technical data

Table 191: Interfaces

Description	Value
LECM Ethernet interface	RJ-45 (STP CAT5e) galvanic connector Multimode LC fiber-optic connector
Power Supply Module (PSMH/PSML/DIM8H/DIM8L/DOM4/SCM8H/SCM8L) front mating connector	Suggested part: Weidmuller P/N 1844260000
Sensor input module SIM8F/SIM4F	

Table 192: Module weights

Description	Value
PSMH/PSML	235 g
LECM	123 g
DIM8H/DIM8L	206 g
DOM4	163 g
RTD4	206 g
AOM4	206 g
SIM8F/SIM4F	180 g
SCM8H/SCM8L	215 g

Table 193: Dimensions of the end clamp (EW 35, Weidmuller)

Description	Value
Width	8.5 mm (to be fixed at the ends of assembled modules)

Table 194: Power supply

Description	PSMH	PSML
U_{aux} nominal	100, 110, 120, 220, 240 V AC, 50 and 60 Hz	24, 30, 48, 60 V DC
	110, 125, 220, 250 V DC	
U_{aux} variation	85…110% of U_{aux} nominal (85...264 V AC)	50...120% of U_{aux} nominal (12...72 V DC)
	80…120% of U_{aux} nominal (88…300 V DC)	
Start-up threshold		19.2 V DC (24 V DC × 80%)
Table continues on next page		

Description	PSMH	PSML
Maximum interruption time in the auxiliary DC without resetting the RIO600 modules	100 ms at U_{aux} nominal	50 ms at U_{aux} nominal
Ripple in the DC auxiliary voltage	Max. 15% of the DC value (at frequency of 100 Hz)	
Reversal of DC power supply polarity	1 minute for each polarity	
Burden of auxiliary voltage supply • Quiescent (Pq) condition (none of the 20 I/O channels are activated)	<4.0 W nominal	
• Operating condition (20 binary output channels in DOM4 modules are activated)	<12.0 W (maximum)	
Module configuration	**Condition**	**Max. consumption for PSMH and PSML**
PSM + LECM + DIM8H	All DIs activated	2 W
PSM + LECM + DIM8L		
PSM + LECM + DOM4	All DOs activated	4 W
PSM + LECM + DOM4 (5)	All DOs activated	12 W
PSM (2) + LECM + DIM8H (5)	All DIs activated	11 W
PSM (2) + LECM + DIM8L (5)		
PSM (2) + LECM + DOM4 (10)	All DOs activated	22 W

Table 195: Binary inputs

Description	DIM8H	DIM8L
Rated voltage	110…250 V DC	24, 30, 48, 60 V DC
Operating voltage range	±20% of rated voltage	±20% of rated voltage
Current drain	3…3.7 mA	2 mA
Power consumption/input channel	330…925 mW	30…130 mW
Threshold voltage	78 V DC	13 V DC
Reaction time	5 ms...4.0 s filtering time	5 ms...4.0 s filtering time

Table 196: Signal outputs (digital output module DOM4)

Description	Value
Operating time	<5 ms
Nominal coil power	<500 mW
Rated voltage	250 V AC/DC
Continuous contact carry	5 A
Table continues on next page	

Description	Value
Make and carry for 3.0 s	10 A
Make and carry for 0.5 s	15 A
Breaking capacity when the control circuit time constant L/R <40 ms, at 48/110/220 V DC	1 A/0.25 A/0.15 A

Table 197: mA/RTD input (RTD4 module)

Description		Value	
RTD inputs	Supported RTD sensors	100 Ω platinum	TCR 0.00385 (DIN 43760)
		250 Ω platinum	TCR 0.00385
		100 Ω nickel	TCR 0.00618 (DIN 43760)
		120 Ω nickel	TCR 0.00618
		250 Ω nickel	TCR 0.00618
	Maximum lead resistance (three-wire measurement)	100 Ω platinum	200 Ω per lead
		250 Ω platinum	200 Ω per lead
		100 Ω nickel	200 Ω per lead
		120 Ω nickel	200 Ω per lead
		250 Ω nickel	200 Ω per lead
	Isolation	4 kV	Inputs to all other channel outputs and protective earth
	RTD/resistance sensing maximum	0.275 mA rms current	
	Operation accuracy	±1°C	
	Response time	< Filter time + 350 ms	
mA inputs	Supported current range	0…20 mA	
	Current input impedance	44 Ω ± 0.1%	
	Operation accuracy	±0.5% or ±0.1 mA	
	Isolation	4 kV	Inputs to all outputs and protective earth

Table 198: Analog output module (AOM4)

Description		Value
mA output	Supported current range	0.0…20.0 mA
	Operation accuracy	±0.1% or ±0.2 mA
	Isolation	4 kV between each output and protective earth

Table 199: Sensor input module (SIM8F)

Description		Value
Preferred ABB sensors		• Combined sensors KEVCY 24 RE1, KEVCY36 RE1, KEVCY 40.5 RE1, KEVCD A • Combination of current sensor KECA 80 C85 or KECA D85 and voltage sensor KEVA 24 C10, 24 C21, 24 C22, 24 C23, 17.5 B20, 17.5 B21, 24 B20, or 24 B21 • Non-conventional low power CTs (LPCTs)
Current measurement	Range	1...3000 A for Rogowski coil 1...6000 A for LPCT
	Accuracy	±5% or ±1 A in the range of 1...80 A for Rogowski coil and LPCT ± 1% in the range of 80...3000 A for Rogowski coil ± 1% in the range of 80...6000 A for LPCT
Line voltage measurement	Range	480 V...48 kV
	Accuracy	±5% in the range of 480...9600 V ±0.5% in the range of 9.6...48 kV
Power measurements: P, Q, S and PF	Range	9.6...28.8 kV 80...630 A
	Accuracy	±1.0% for active power P (±0.5% at +25ºC) ±3.0% for reactive Q and apparent power S (±1% at +25ºC) ±0.03 for power factor ±3.0% for energy
Line frequency measurement	Range	50 or 60 Hz
	Accuracy	For 50 Hz, ±50 mHz For 60 Hz, ±60 mHz
Average operating current, voltage and power		Average operating current, voltage, power according to selection: 3 min/10 min/15 min/1 hour/2 hours/24 hours
Peak current, voltage and power values		Peak values for 1 day, 1 week, 1 month, 1 year
General detection of the harmonics disturbances		• Current TDD (Total demand distortion) up to the 8th harmonics • Voltage THD (Total harmonic distortion) up to the 8th harmonics
Load flow direction		Forward/reverse
Non-directional overcurrent fault detection	Operating range	50...2000 A
	Accuracy	Depending on the nominal frequency of the current measured: f_n ±1.5% of the set value Operate time: ±1.0% of the set value or ±20 ms
Directional overcurrent fault detection	Operating range	50...2000 A
	Accuracy	Depending on the nominal frequency of the current measured: f_n Current: ±1.5% of the set value Voltage: ±1.5% of the set value Phase angle: ±2º Operate time: ±1.0% of the set value or ±20 ms
Table continues on next page		

Description		Value
Non-directional earth-fault detection	Operating range	4...200 A (isolated/compensated network) 200...1000 A (solidly grounded/low-impedance network)
	Accuracy	Depending on the nominal frequency of the current measured: f_n ±10% of the set value in the range of 4...25 A ±1.5% of the set value in the range of >25...1000 A Operate time: ±1.0% of the set value or ±20 ms (Current measurement based on internal calculation)
Directional earth-fault detection	Operating range	4...200 A (isolated/compensated network) 200...1000 A (solidly grounded/low-impedance network)
	Accuracy	Depending on the nominal frequency of the current measured: f_n Current: • ±10% of the set value in the range of 4...25 A • ±1.5% of the set value in the range of >25...1000 A Voltage: ±1.5% of the set value Phase angle: ±3º Operate time: ±1.0% of the set value or ±20 ms (Current measurement based on internal calculation)
Fuse failure protection	Operating range	4...1000 A (Negative-sequence current level) 300...10000 V (Negative-sequence voltage level)
	Accuracy	Depending on the nominal frequency of the current measured: f_n NPS function: Typically, 37 ms for U_{Fault} = 1.1 × set value Typically, 23 ms for U_{Fault} = 5 × set value Delta function: Typically, 35 ms for ΔU = 1.1 × set value Typically, 28 ms for ΔU = 5 × set value
Three-phase inrush detector	Operating range	5…100% Ratio I2f/I1f measurement
	Accuracy	Depending on the nominal frequency of the current measured: f_n Current: ±1.5% of the set value or ±0.02 A Ratio I2f/I1f measurement: ±5.0% of the set value Operate time: ±35 ms

Table continues on next page

Description		Value
Negative-sequence overcurrent protection	Operating range	4...200 A (isolated/compensated network) 200...1000 A (solidly grounded/low-impedance network)
	Accuracy	Depending on the nominal frequency of the current measured: $f = f_n$ Current: ±1.5% of the set value or ±0.02 A I_{Fault} = 2 × set value = <36 ms I_{Fault} = 10 × set value = <30 ms Operate time: ±1.0% of the set value or ±20 ms
Multifrequency admittance-based earth-fault indication	Operating range	480 V...28.8 kV
	Accuracy	Depending on the nominal frequency of the current measured: f_n Voltage: ±5% in the range of 480 V...9.6 kV ±0.5% in the range of 9.6...28.8 kV Operate time: ±1.0% of the set value or ±20 ms

Table 200: Current sensor module (SIM4F)

Description		Value
Preferred ABB sensors		Current sensors KECA 80 C85 or KECA 80 D85 Non-conventional low power CTs (LPCTs)
Current measurement	Range	1...3000 A for Rogowski coil 1...6000 A for LPCT
	Accuracy	±5% or ±1 A in the range of 1...80 A for Rogowski coil and LPCT ± 1% in the range of 80...3000 A for Rogowski coil ± 1% in the range of 80...6000 A for LPCT
Line frequency measurement	Range	50 or 60 Hz
	Accuracy	For 50 Hz, ±50 mHz For 60 Hz, ±60 mHz
Average operating current		Average operating current according to selection: 3 min/10 min/15 min/1 hour/2 hours/24 hours
Peak current		Peak values for 1 day, 1 week, 1 month, 1 year
Non-directional overcurrent fault detection	Operating range	50...2000 A
	Accuracy	Depending on the nominal frequency of the current measured: f_n ±1.5% of the set value Operate time: ±1.0% of the set value or ±20 ms

Table continues on next page

Description		Value
Non-directional earth-fault detection	Operating range	4...200 A (isolated/compensated network) 200...1000 A (solidly grounded/low-impedance network)
	Accuracy	Depending on the nominal frequency of the current measured: f_n ±10% of the set value in the range of 4...25 A ±1.5% of the set value in the range of >25...1000 A Operate time: ±1.0% of the set value or ±20 ms (Current measurement based on internal calculation)
Fault pass indicator	Operating range	1...100 A (earth-fault and residual current) 10…100 A (instantaneous current)
	Accuracy	Depending on the nominal frequency of the current measured: f_n Current: ±1.5% of the set value Start time :±1.0% of the set value or ±70 ms Operate time: ±1.0% of the set value or ±30 ms
Three-phase inrush detector	Operating range	5…100% Ratio I2f/I1f measurement
	Accuracy	Depending on the nominal frequency of the current measured: f_n Current: ±1.5% of the set value or ±0.02 A Ratio I2f/I1f measurement: ±5.0% of the set value Operate time: ±35 ms
Negative-sequence overcurrent protection	Operating range	4...200 A (isolated/compensated network) 200...1000 A (solidly grounded/low-impedance network)
	Accuracy	Depending on the nominal frequency of the current measured: $f = f_n$ Current: ±1.5% of the set value or ±0.02 A I_{Fault} = 2 × set value = <36 ms I_{Fault} = 10 × set value = <30 ms Operate time: ±1.0% of the set value or ±20 ms

Table 201: Binary inputs (SCM)

Description	SCM8H	SCM8L
Rated voltage	110...250 V DC	24, 30, 48, 60 V DC
Operating voltage range	±20% of rated voltage	±20% of rated voltage
Current drain	3…3.7 mA	2 mA
Power consumption/input channel	330…925 mW	30…130 mW
Threshold voltage	78 V DC	13 V DC
Reaction time	5 ms...4.0 s filtering time	5 ms...4.0 s filtering time

Table 202: High-speed outputs (SCM)

Description	SCM8H	SCM8L
Operating time	<1 ms	<1 ms
Rated voltage	110..250 V DC	24, 30, 48, 60 V DC
Continuous current carry	20 A	20 A
Short time current carry	100 A for 10 ms	200 A for 10 ms

Table 203: Communication interface (communication module LECM)

Connector	Cable	Data transfer	Maximum distance	Wave length	Permitted path attenuation[1)]
RJ-45	Shielded twisted pair cable, at minimum CAT5e	10/100 Mbits/s	30 m	-	-
LC	Multimode 62.5/125 μm or 50/125 μm glass-fiber core	100 Mbits/s	2 km	1310 nm	<8 dB

1) Maximum allowed attenuation caused by connectors and cable together

Table 204: Degree of protection by enclosure

Description	Value
Degree of protection	IP20[1)]

1) If a higher IP class is required, the cabinet where the device is installed should provide proper protection.

Table 205: Environmental conditions

Description	Value
Operating temperature range	-25...+70°C
Relative humidity	<93%
Atmospheric pressure	86...106 kPa
Altitude	up to 2000 m
Transport and storage temperature range	-40...+85°C

Section 11 Device and functionality tests

Table 206: Inspection of mechanical structure

Description	Reference	Result
Markings and mechanical structure	IEC 60255-1 and IEC 60255-27	OK
Enclosure class of the flush-mounted device	IEC 60529	IP 20
Clearances and creepage distances	IEC 60255-27	OK

Table 207: Overload test

Description	Reference	Result
Thermal withstand capability test	IEC 60255-1 and IEC 60255-27	OK

Table 208: Power supply module tests

Test	Type test value	Result
Operating range of auxiliary supply voltage test	80% and 120% of rated value for DC 85% and 110% of rated value for AC, frequency is between 50 Hz for -5% and 60 Hz for +5%	IEC 60255-1 and IEEE C37.90-2005
Power consumption of auxiliary supply • Quiescent load • Maximum load	 <4 W <12 W	IEC 60255-1 and IEEE C37.90-2005
Reversal of DC power supply polarity	1 min for each polarity	IEC60255-27
Start-up time test	<30 s	

Table 209: Contact tests

Description	Type test value	Reference
Make and carry	Signaling contacts • 5 A, continuous • 10 A for 3 s • 15 A for 0.5 s	IEC 60255-1, IEC 61810-1 and IEEE C37.90-2005
Breaking capacity for DC, L/R ≤40 ms	Signaling contacts • 48 V, 1.00 A • 110 V, 0.25 A • 220 V, 0.15 A	IEC 60255-1, IEC 61810-1 and IEEE C37.90-2005
Mechanical durability	10000 operations	IEC 60255-1, IEC 61810-1 and IEEE C37.90-2005

Table 210: Insulation tests

Description1)	Type test value	Reference
Dielectric tests	2 kV, 50 Hz, 1 min 500 V, 50 Hz, 1 min for communication 2.8 kV DC, 1 min 700 V DC, 1 min for communication	IEC 60255-27 and IEEE C37.90-2005
Impulse voltage tests	5 kV, 1.2/50 μs, 0.5 J	IEC 60255-27 and IEEE C37.90-2005
Insulation resistance measurements	>100 MΩ, 500 V DC	IEC 60255-27

1) Insulation tests are not applicable to SIM8F/SIM4F

Table 211: Electromagnetic compatibility and immunity tests

Description	Type test value	Reference
Electrostatic discharge • Air discharge	 8 kV	IEC 60255-26 and IEC 61000-4-2, Level 3
Radio frequency electromagnetic field (amplitude modulated)	10 V/m (RMS) f = 80...1000 MHz and 1.4...2.7 GHz	IEC 60255-26 and IEC 61000-4-3, Level 3
Radio frequency electromagnetic field from digital radio telephones (pulse modulated)	10 V/m (RMS) f = 900 MHz, 1890 MHz	IEC 61000-4-3, Level 3
Power frequency (50 Hz) magnetic field • Continuous • 3 s	 100 A (RMS)/m 300 A (RMS)/m	IEC 60255-26 and IEC 61000-4-8
Table continues on next page		

Description	Type test value	Reference
Pulsed magnetic field	1000 A/m; 6.4/16 μs Tr/Td; 5 pulses positive/negative; 10 s (time interval)	IEC 61000-4-9, Level 5
Conducted disturbance induced by radio frequency fields, Amplitude modulated	0.15...80 MHz - 10 V (unmod, RMS); 80% AM (1 kHz); 150 Ω source impedance 27 and 68 MHz (spot frequencies); 10 V (unmod, RMS); 80% AM (1 kHz); 150 Ω source impedance	IEC 60255-26 and IEC 61000-4-6, Level 3
Fast low-energy transient (EFT) (including functional earth port)	5/50 ns Tr/Td; 5 kHz repetition frequency 4 kV (peak) for power supply input/output ports and 2 kV (peak) for communication port	IEC 60255-26 and IEC 61000-4-4
Damped oscillatory waves (HFD) 100 kHz and 1 MHz burst	100 kHz and 1 MHz frequency; 75 ns Tr; 40 Hz and 400 Hz repetition frequency; 200 Ω source impedance	IEC 60255-26 and IEC 61000-4-18
• Power supply and input/output ports	Differential mode: 1 kV (peak) Common mode: 2.5 kV (peak)	
• Communication port	Differential mode: not applicable Common mode: 1 kV (peak)	
Slow high-energy transient (surge1.2/50 μs voltage pulse)	1.2/50 μs Tr/Th (open circuit) 8/20 μs Tr/Th (short circuit)	IEC 60255-26 and IEC 61000-4-5
• Auxiliary power supply and input/output ports[1)]	±4 kVp (L-Gnd) ±2 kVp (L-L)	
• Communication port	±2 kVp (L-Gnd) while no L-L test is applicable	
Voltage dips, short interruptions and voltage variation immunity tests (AC 50 Hz and 60 Hz)	30% reduction for 25/30 cycles 60% reduction for 10/12 cycles 100% reduction for 0.5, 1.0, 2.5 and 5.0 cycles 100% reduction for 250/300 cycles	IEC 60255-26 and IEC 61000-4-11
Voltage dips, supply interruption and voltage variations on DC input power port (immunity tests)	30% reduction for 500 ms 60% reduction for 200 ms 100% reduction for 10, 20, 30 and 50 ms 100% reduction for 5 s	IEC 60255-26 and IEC 61000-4-29
Ripple voltage	15% U_n frequencies of ripple 100/120 Hz (for 50/60 Hz)	IEC 60255-26, IEC 61000-4-17 and IEEE C37.90-2005
Gradual shut-down/start-up test (for DC power supply)		IEC 60255-26
• Ramp towards shut-down	60 s	
• Wait at power of condition	5 min	
• Ramp towards start-up	60 s	

Table continues on next page

Description	Type test value	Reference
Power frequency voltage 50 Hz and 60 Hz Input/output port • Differential mode • Common mode	 150 V (RMS) 100 Ω coupling resistor 0.1 µF coupling capacitor 300 V (RMS) 220 Ω coupling resistor 0.47 µF coupling capacitor	IEC 60255-26 and IEC 61000-4-16
Emission tests • Radiated 30...230 MHz 230...1000 MHz • Conducted 0.15...0.50 MHz 0.5...30 MHz	 <40 dB (µV/m) quasi-peak, measured at 10 m distance <47 dB (µV/m) quasi-peak, measured at 10 m distance <79 dB (µV) quasi-peak <66 dB (µV) average <73 dB (µV) quasi-peak <60 dB (µV) average	IEC 60255-26

1) When SCM is configured as a generic I/O, the level supported is ±2 kVp (L-Gnd) ±1 kVp (L-L)

Table 212: Electromagnetic compatibility and immunity tests according to ANSI standards

Description	Type test value	Reference
1 MHz oscillatory SWC test	All ports: ±2.5 kV common mode/ differential mode	IEEE C37.90.1-2002
Fast transient SWC test	All ports: ±4 kV common mode/ differential mode	IEEE C37.90.1-2002
Radio frequency interference tests	20 V/m (prior to modulation) f = 80...1000 MHz (AM) f = 900 MHz (PM)	IEEE C37.90.2-2004

Table 213: Mechanical tests

Description	Type test value	Reference
Vibration tests (sinusoidal) • Vibration response test • Vibration endurance test	Class 1 f = 10…150 Hz Peak acceleration: 0.5 g 1 sweep cycle in each axis f = 10…150 Hz Peak acceleration: 1.0 g 20 sweep cycles in each axis	IEC 60255-21-1
Shock and bump test	Class 1	IEC 60255-21-2

Table continues on next page

Description	Type test value	Reference
• Shock response test	Peak acceleration: 5 g Duration of the pulse: 11 ms Number of pulses in each direction: 3	
• Shock withstanding test	Peak acceleration: 15 g Duration of the pulse: 11 ms Number of pulses in each direction: 3	
• Bump test	Peak acceleration: 10 g Duration of the pulse: 16 ms Number of pulses in each direction: 1000	
Seismic test	Class 2	IEC 60255-21-3
• Nominal frequency range	1...35 Hz	
• Zero period acceleration	Horizontal direction: 2.0 gn Vertical direction: 1.0 gn	
• Number of time histories in each axis	Single axis sine sweep	

Table 214: Environmental tests

Description	Type test value	Reference
Dry heat test	• 96 h at +70°C	IEC 60068-2-2 and IEEE C37.90-2005
Dry cold test	• 96 h at -25°C • 16 h at -40°C	IEC 60068-2-1 and IEEE C37.90-2005
Damp heat cyclic test	• 6 cycles (12 h + 12 h) at +25...+55°C, humidity >93%	IEC 60068-2-30
Damp heat steady state test	• Temperature 40°C • Humidity 93% • Duration 96 h	IEC 60068-2-78 and IEEE C37.90-2005
Change of temperature test	• 5 cycles (3 h + 3 h) at -25...+55°C	IEC60068-2-14
Storage test	• 96 h at -40°C • 96 h at +85°C	IEC 60068-2-1, IEC 60068-2-2 and IEEE C37.90-2005

Table 215: EMC compliance

Description	Reference
EMC directive	2004/108/IEC
Standard	EN 50263 (2000) EN 60255-26 (2007)

Table 216: RoHS compliance

Description
Complies with RoHS directive 2002/95/EC

Section 12 Glossary

ACT	1. Application Configuration tool in PCM600 2. Trip status in IEC 61850
AOM	Analog output module
AOM4	Analog output module
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
CPS	Cumulative phasor summing
DIM8H	Binary input module with eight channels, high voltage
DIM8L	Binary input module with eight channels, low voltage
DIN rail	A standardized 35 mm wide metal rail with a hat-shaped cross section
DOM	Binary output module, four channels
DOM4	Binary output module, four channels
DST	Daylight-saving time
DT	Definite time
EF	Earth fault
EMC	Electromagnetic compatibility
Ethernet	A standard for connecting a family of frame-based computer networking technologies into a LAN
FPI	Measured value, short floating point information
FPI	Fault passage indicator
FTP	File transfer protocol
GFC	General fault criteria
GOOSE	Generic Object-Oriented Substation Event
I/O	Input/output
ICMP	Internet Control Message Protocol
IEC	International Electrotechnical Commission
IEC 61850	International standard for substation communication and modeling

IEC 61850-8-1	A communication protocol based on the IEC 61850 standard series
IED	Intelligent electronic device
IP	Internet protocol
IP address	A set of four numbers between 0 and 255, separated by periods. Each server connected to the Internet is assigned a unique IP address that specifies the location for the TCP/IP protocol.
IRF	1. Internal fault 2. Internal relay fault
LC	Connector type for glass fiber cable, IEC 61754-20
LECM	Communication module
LED	Light-emitting diode
LPCT	Low power current transformer
MAC	Media access control
MFA	Multifrequency admittance
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
MTA	Also known as RCA or base angle. Maximum torque angle.
MV	Medium voltage
NTP	Network time protocol
OC	Overcurrent
PC	1. Personal computer 2. Polycarbonate
PCM600	Protection and Control IED Manager
PSMH	Power supply module, high voltage
PSML	Power supply module, low voltage
RCA	Also known as MTA or base angle. Characteristic angle.
RIO600	Remote I/O unit
RJ-45	Galvanic connector type
RTD	Resistance temperature detector
RTD4	Resistance temperature detector

RTU	Remote terminal unit
SCADA	Supervision, control and data acquisition
SCM	Smart control module
SIM4F	Sensor input module (4 currents)
SIM8F	Sensor input module (4 currents and 4 voltages)
SNTP	Simple Network Time Protocol
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol
UDP	User datagram protocol
UTC	Coordinated universal time
WHMI	Web human-machine interface

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