RELION® PROTECTION AND CONTROL

REX610

Modbus Communication Protocol Manual

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Section 1 Introduction

1.1 This manual

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

1.2 Intended audience

This manual addresses the communication system engineer or system integrator responsible for pre-engineering and engineering the communication setup in a substation from a protection relay's perspective.

The system engineer or system integrator must have a basic knowledge of communication in protection and control systems and thorough knowledge of the specific communication protocol.

1.3 Product documentation

1.3.1 Product documentation set

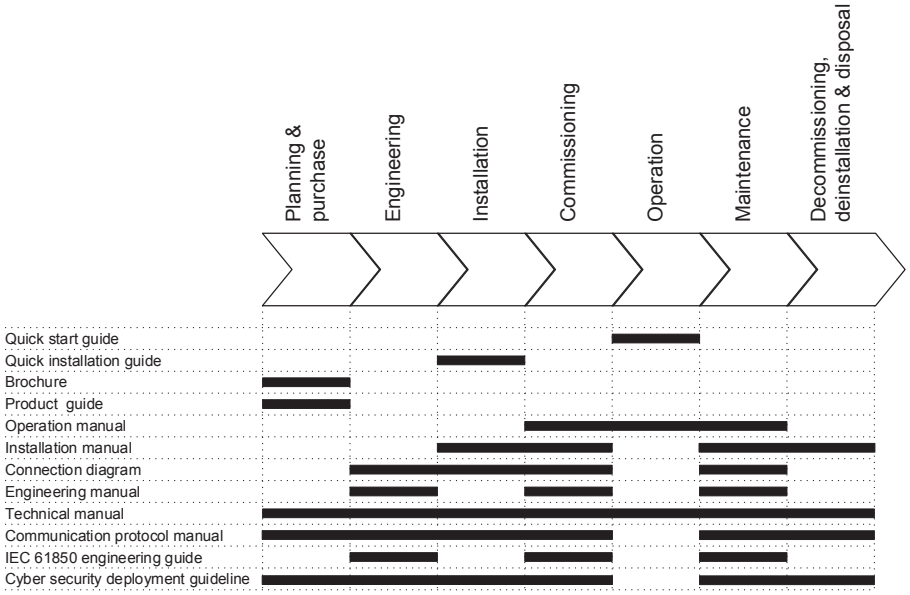

Figure 1: The intended use of documents during the product life cycle

1.3.2 Document revision history

Document revision/date	Product version	History
A/2022-04-21	1.0	First release

1.3.3 Related documentation

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.
- Push button navigation in the LHMI menu structure is presented by using the push button icons.
  To navigate between the options, use ^ and v.
- Menu paths are presented in bold.
  Select **Main menu/Settings**.
- LHMI messages are shown in Courier font.
  To save the changes in nonvolatile memory, select `Yes` and press ↵.
- Parameter names are shown in italics.
  The function can be enabled and disabled with the *Operation* setting.
- Parameter values are indicated with quotation marks.
  The corresponding parameter values are "On" and "Off".
- Input/output messages and monitored data names are shown in Courier font.
  When the function starts, the `START` output is set to TRUE.
- Values of quantities are expressed with a number and an SI unit. The corresponding imperial units may be given in parentheses.
- This document assumes that the parameter setting visibility is "Advanced".
- A functional earth terminal is indicated in figures with the symbol ⏚.
- Equipment protected throughout by double insulation or reinforced insulation (equivalent to class II of IEC 61140) is indicated in figures with the symbol ⧈.

1.4.3 Functions, codes and symbols

All available functions are listed in the table. All of them may not be applicable to all products.

Table 1: Functions included in the relay

Function	IEC 61850	IEC 60617	IEC-ANSI
Protection			
Three-phase non-directional overcurrent protection, low stage	PHLPTOC	3I>	51P-1
Three-phase non-directional overcurrent protection, high stage	PHHPTOC	3I>>	51P-2
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC	3I>>>	50P
Three-phase directional overcurrent protection, low stage	DPHLPDOC	3I> ->	67P/51P-1
Three-phase directional overcurrent protection, high stage	DPHHPDOC	3I>> ->	67P/51P-2
Non-directional earth-fault protection, low stage	EFLPTOC	Io>	51G/51N-1
Non-directional earth-fault protection, high stage	EFHPTOC	Io>>	51G/51N-2
Non-directional earth-fault protection, instantaneous stage	EFIPTOC	Io>>>	50G/50N
Directional earth-fault protection, low stage	DEFLPDEF	Io> ->	67G/N-1 51G/N-1
Directional earth-fault protection, high stage	DEFHPDEF	Io>> ->	67G/N-1 51G/N-2
Three-phase inrush detector	INRPHAR	3I2f>	68HB
Three-phase thermal protection for feeders, cables and distribution transformers	T1PTTR	3Ith>F	49F
Negative-sequence overcurrent protection	NSPTOC	I2>M	46M
Phase discontinuity / Single phasing protection for motor	PDNSPTOC	I2/I1>	46PD
Loss of phase, undercurrent	PHPTUC	3I<	37
Three-phase undervoltage protection	PHPTUV	3U<	27
Three-phase overvoltage protection	PHPTOV	3U>	59
Residual overvoltage protection	ROVPTOV	Uo>	59G/59N
Circuit breaker failure protection	CCBRBRF	3I>/Io>BF	50BF
Master trip	TRPPTRC	Master Trip	94/86
Multipurpose protection	MAPGAPC	MAP	MAP
Control			
Circuit-breaker control	CBXCBR	I <-> O CB	52
Disconnector position indication	DCSXSWI	I <-> O DC	29DS
Earthing switch position indication	ESSXSWI	I <-> O ES	29GS
Autoreclosing	DARREC	O -> I	79
Condition monitoring and supervision			
Trip circuit supervision	TCSSCBR	TCS	TCM
Table continues on next page			

Function	IEC 61850	IEC 60617	IEC-ANSI
Fuse failure supervision	SEQSPVC	FUSEF	VCM, 60
Circuit-breaker condition monitoring	SSCBR	CBCM	52CM
Current circuit supervision	CCSPVC	MCS 3I	CCM
Measurement			
Three-phase current measurement	CMMXU	3I	IA, IB, IC
Residual current measurement	RESCMMXU	Io	IG
Sequence current measurement	CSMSQI	I1, I2, I0	I1, I2, I0
Three-phase voltage measurement	VMMXU	3U	VA, VB, VC
Residual voltage measurement	RESVMMXU	Uo	VG/VN
Traditional LED indication			
Programmable LED control	LED	LED	LED
Logging functions			
Disturbance recorder (common functionality)	RDRE	DR	DFR
Disturbance recorder, analog channels 1…8	A1RADR	A1RADR	A1RADR
Disturbance recorder, binary channels 1...32	B1RBDR	B1RBDR	B1RBDR
Communication protocols			
IEC 61850-8-1 MMS	MMSLPRT	MMSLPRT	MMSLPRT
IEC 61850-8-1 GOOSE	GSELPRT	GSELPRT	GSELPRT
Modbus protocol	MBSLPRT	MBSLPRT	MBSLPRT

Section 2 Modbus overview

2.1 Modbus standard

Modbus is a communication protocol developed by the Modicon company in the 1970s. Originally it was used for communication in PLCs and RTU devices. Later on the Modbus protocol was used in a variety of different device applications. Today the Modbus protocol is mainly used over serial communication networks and Ethernet.

The Modbus serial communication and the Ethernet-based Modbus TCP/IP communication in this protection relay follow the specifications maintained by Modbus Organization.

Modbus communication reference guides are downloadable from Technical Resources at www.modbus.org.

2.1.1 Serial communication

Modbus is a master-slave protocol when it is used over serial communication networks. This protection relay implements the slave side of the protocol. Depending on the chosen physical serial interface, it is possible to build multidrop networks or point-to-point communication connections.

There can only be one Modbus master unit on a Modbus serial network. The Modbus master unit communicates with one Modbus slave unit at a time. Usually the master reads, or scans, data from the slaves cyclically. The master can also write data or give commands to the slave units. Each slave unit has a unique unit address. Thus, the master can identify the slave with which it communicates. The Modbus standard also supports Master broadcast transmissions.

The Modbus serial protocol uses two link modes: Modbus RTU and Modbus ASCII. Only Modbus RTU mode is supported by this protection relay.

2.1.2 Ethernet communication

Modbus communication over Ethernet TCP/IP is of client-server type. This protection relay operates as a Modbus server.

The Modbus TCP/IP connection is established when the Modbus client opens a TCP socket connection to the Modbus server. The socket port 502 on the TCP/IP

stack is reserved for Modbus. If the connection request is accepted by the server, the client can start communicating with the server unit.

This protection relay can accept simultaneously two Modbus TCP/IP client connections. The protection relay can be configured to only accept socket connection requests from known client IP addresses.

2.1.3 Application data implementation

This protection relay is designed to operate with a wide range of different Modbus masters and clients. The Modbus memory map shows the protection relay's internal process data in a simple I/O map which is mainly aimed at PLC masters and other process automation devices. This data is more suitable for SCADA Modbus masters.

The Modbus standard defines four main memory areas for mapping protection relay's process data. Due to its open nature, the Modbus standard does not define exactly what type of data should be mapped to each memory area. The Modbus mapping approach of the protection relay ensures that the same process data are readable from as many Modbus memory areas as possible. The users may then choose the memory areas that are most suitable for their Modbus master systems.

2.1.4 Terms and definitions

Modbus data appear in different memory areas in the Modbus device. The four most common areas are coils, digital inputs, input registers and holding registers. These are also referred to as 0X, 1X, 3X and 4X areas respectively.

Modbus defines addressing in two ways: PLC addressing starts from address 1 and regular Modbus data addressing starts from 0. For example, a holding register at PLC address 234 can be referred to either as 4X register 234 or as 40234. The regular Modbus address, that is the PLC address decremented by one, is shown when analyzing the Modbus traffic on the physical network.

Listings and references to the Modbus data in this documentation follow the PLC addressing scheme. Addresses start from 1.

See also the Modbus protocol standard documentation that can be found for free at www.modbus.org.

Section 3 Vendor-specific implementation

3.1 Protocol server instances

The word "client" refers to the protocol master. The protection relay is referred to as "server" or a slave device.

The protection relay can communicate with maximum three protocol clients simultaneously. The protection relay provides one protocol data and data outlook for different clients. A protocol server communication entity which is configured to operate with a specific master or client is called an instance.

There are three server instance scenarios.

1. One client - One protocol instance - One protocol mapping (if the instance is configured to COM1). The protection relay is intended to operate toward one protocol client. The default protocol data mapping or data outlook can be modified freely.
2. Two clients - One protocol instance - One protocol mapping (if the instance is configured to TCP). The protection relay is intended to operate toward two protocol clients. The default protocol data mapping or data outlook can be modified freely.
3. Three clients - Two protocol instances - One protocol mapping. The protection relay is intended to operate toward two TCP protocol clients and one COM1. All the clients can access the same data or similar data outlook. The default protocol mapping or data outlook can be modified freely.

The protection relay supports a maximum of 3 clients at any point in time. This number includes the MMS client and other communication protocol clients.

3.1.1 Connection to clients

In the relay it is possible to activate one protocol server instance out of two. The protocol server instances are represented by a function block in the relay configuration: MBSLPRT1 and MBSLPRT2. For each connected client, a protocol instance has to be activated by dragging the function block into the relay configuration. When a function block is present in the configuration, its setting and monitoring parameters are visible in the HMI.

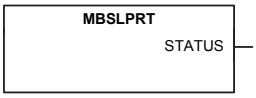

Figure 2: Function block

The two available Modbus instances may be freely activated. However, it is recommended to activate the instances in chronological order. For example, instance 1 is to be used if there is only one client connection and instances 1 and 2 when there are two clients.

Each Modbus instance supports two TCP/IP clients. When both instances are configured in Application Configuration, both cannot be configured to TCP.

If both instances are configured as TCP or COM, only the first instance configuration is supported.

First setup and configuration upload

Dragging a protocol instance function block into the relay configuration is only the first step of the protocol activation. When a protocol instance is added for the first time, it is inactive and unconfigured by default, meaning that it has not been assigned to a physical link port. Neither has any Modbus data point configuration been loaded for the instance. Next step is to do these setups.

When a configuration containing Modbus instances is uploaded to the relay, the *Operation* setting is "Off". After the upload is done, the Modbus instances restart, still with *Operation* being in "Off" state. Thereafter, Parameter Setting in PCM600 uploads the new settings to all applications, including the *Operation* "On" values for the protocol instances.

3.1.2 Protocol server attachment to a client

After its activation, an instance should be attached to the intended client.

If the client is in a serial connection, the instance must be attached to the intended serial port.

In case of a TCP client, the instance must be first attached to the physical Ethernet port. If there are several TCP client connections, the protection relay must be able to distinguish between the clients. There are two setting parameters in an instance.

- *Client IP*: When the client makes the TCP connection, its IP address is checked. This instance is given to the client with this IP address. It is also possible to use the address “0.0.0.0” if no client IP address is to be defined. In this case, the client's IP address is ignored.
- *TCP port*: This parameter can be used in conjunction with the *Client IP* setting, thus allowing only a certain IP address at a specific TCP socket port number.

Each Modbus instance supports two client IPs: *Client IP 1* and *Client IP 2*.

3.1.3 Several identical client connections

Maximum two clients can access the same protocol data. Also, one instance can be used for maximum two clients, so that when there are problems with communication, the line diagnostic data for instances follows the same instance number rule.

If multiple client connections are used, they must be distinguished by using *Client IP 1* and *Client IP 2*.

3.1.4 Protocol data mapping to server instances

By default, Modbus communication supports one data mapping for the protocol.

In PCM600, it is necessary to always define the mappings to be edited or viewed.

3.2 Modbus link alternatives

Modbus communication is possible over the serial communication interface, over the Ethernet interface, or over both interfaces simultaneously.

Depending on the protection relay type, either only serial communication or only Ethernet communication may be supported.

3.2.1 Serial link

Modbus serial communication requires that the protection relay variant is equipped with a serial interface card. The serial interface card can contain one serial interface.

The Modbus link mode is Modbus RTU.

Documentation on the Modbus serial link messages and the Modbus standard can be obtained from www.modbus.org.

3.2.1.1 Modbus serial link parameters

Serial link setting parameters can be accessed with Parameter Setting in PCM600 or via the LHMI path **Configuration/Communication/COM1**.

Address

Each serial link can be given a separate unit address.

Port

This protection relay supports only one serial port COM1. By default, the port is selected as "Ethernel TCP 1" and it must be changed to "COM1".

If this protocol does not operate as expected, ensure that only one instance is configured to the COM1 port.

The baud rate is defined on the serial driver side and is therefore located via the HMI path **Configuration/Communication/COM1**.

3.2.1.2 Modbus serial diagnostic counters

Modbus serial diagnostic counters can be viewed via the HMI path **Monitoring/ Communication/Protocols/Modbus/MBS0 (n)**.

The counters show complete Modbus protocol link frames and Modbus errors. The serial communication driver (COM1) maintains its own counters for lower level serial communication diagnostics.

Table 2: Serial diagnostic counters

Counter	Description
Status	Shows the value "True" if the serial instance is in use. This indicates that the Modbus client is connected and Modbus messages, which are addressed to the device, are received regularly at least at 15-second intervals or faster. In all other cases this value is "False".
Reset counters	True = Reset all diagnostic counters
Received frames	Total amount of received Modbus frames. For example, the Modbus frames that are addressed to this instance.
Transmitted frames	Total amount of transmitted Modbus responses

Table continues on next page

Counter	Description
Transmitted exc A	Total amount of exception responses 1 and 2. These exception responses usually reveal configuration errors on the Modbus client side. Either the client uses a request function code which is not supported or the requested Modbus points do not exist.
Transmitted exc B	Total amount of exception responses 3. These exceptions usually reveal the protection relay's application level rejections. That is, the protection relay application rejects the request at this moment, under the current circumstances. The exception can also mean that the value in the Modbus write request is out of range.
Checksum errors	Total amount of detected Modbus checksum errors. The Modbus instance only calculates checksums of Modbus frames that contain a proper link address. All other incoming Modbus frames are discarded.

3.2.1.3 Troubleshooting serial communication

The diagnostic capabilities can be used for investigating communication problems. If communication cannot be established to the relay, then proceed in this order.

1. Reset the serial driver and Modbus protocol diagnostic counters to make it easier to view the changes.
2. Check the serial driver diagnostic counters. If serial characters are not received, check the cable (Rx line) and the link setup parameters, also on the Master side.
3. If serial characters are received, check the Received frame counter via the path **Monitoring/Communication/Protocols/Modbus/MBS0 (n)**.
4. Go over to Modbus diagnostics and check if Modbus link frames are internally received. The serial driver detects every link frame on the line, but the Modbus protocol only reacts to Modbus link frames, which are addressed to its own protocol instance.
5. Check for receive errors, checksum errors or several retransmissions. If these are found, the line may be noisy.
6. If Modbus link messages are received, check that the response messages are sent to the master.
7. Check the serial driver's transmitted character counter. If it is running, then the relay is transmitting. If the master receives nothing, then check the cable (Tx line).

3.2.1.4 Character framing in Modbus RTU mode

According to the Modbus standard, the character length in the Modbus RTU mode should be 11 bits. It is possible to freely define the character parity: even, odd or no parity. No parity means that the bit length of the serial character is reduced by one. Thus, the character is compensated with an additional stop bit.

Table 3: RTU characters

Coding system	8-bit binary
Bits per character	1 start bit 8 data bits, the least significant bit is sent first 1 bit for even/odd parity; no bit if parity is not used 1 stop bit if parity is used; 2 stop bits if parity is not used

3.2.2 TCP/IP link

The protection relay operates as a Modbus TCP/IP server. A Modbus TCP/IP client can establish a connection to the protection relay through the standardized TCP socket port 502.

The Modbus TCP/IP interface of the protection relay can be configured to accept two simultaneous Modbus client connections. It is possible to grant connections only to the predefined TCP/IP clients. The write authority of the Modbus TCP/IP client is configurable.

Modbus TCP usually shares the Ethernet connection with the other Ethernet-based protocols of the protection relay. The number of Ethernet-based clients that can be simultaneously connected to the protection relay is restricted.

3.2.2.1 Modbus TCP/IP diagnostic counters

Modbus TCP/IP counters can be viewed via the LHMI path **Monitoring/ Communication/Protocols/Modbus/MBS0 (n)**.

The counters show the complete Modbus protocol link frames and Modbus errors. The Ethernet communication driver maintains its own counters for lower level communication diagnostics.

Table 4: TCP/IP diagnostic counters

Counter	Description
Status	Shows the value "True" if the TCP/IP or serial instance is in use. This means that a Modbus client has connected to the TCP socket and Modbus TCP messages are received regularly at least at 15-second intervals or faster. In all other cases this value shows "False".
Reset counters	True = Reset all diagnostic counters
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 protection relay's application level rejections.

Table 5: Common (instance independent) Modbus TCP/IP diagnostic counters

Counter	Description
CnReject unregistered	The amount of connection requests that are rejected since the client is not registered

3.3 Supported Modbus function codes

3.3.1 Application functions

Table 6: Supported application functions

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	Diagnostics	Checks the communication system between the master and the slave
15	Force multiple coils	Sets the status of multiple discrete outputs
16	Preset multiple registers	Sets the value of multiple holding registers
23	Read/write holding registers	Exchanges holding registers in one query

3.3.2 Diagnostic functions

The diagnostic functions are only intended for serial communication. However, the serial diagnostic counters can be read, but not reset, via the Modbus TCP/IP interface. The serial line cannot be forced to the listen mode via the Modbus TCP/IP interface.

Table 7: Supported diagnostic subfunctions

Function code	Name	Description
00	Return query data	The data in the query data field is returned (looped back) in the response. The entire response is identical to the query.
01	Restart communication option	The slaves' peripheral port is initialized and restarted and the communication event counters are cleared. Before this, a normal response is sent provided that the port is not in the listen-only mode. If the port is in the listen only mode, no response will be sent.
10	Clear counters and diagnostic register	All counters and the diagnostic register are cleared.
11	Return bus message count	The response returns the number of messages in the communication system detected by the slave since its last restart, clear counters operation or power-up.
12	Return bus communication error count	The response returns the number of CRC errors encountered by the slave since its last restart, clear counters operation or power up.
13	Return bus exception error count	The response returns the number of Modbus exception responses sent by the slave since its last restart, clear counters operation or power up.
14	Return slave message count	The response returns the number of messages addressed to the slave or broadcast which the slave has processed since its last restart, clear counters operation or power up.
18	Return bus character overrun count	The response returns the number of messages addressed to the slave for which it has not been able to send a response due to a character overrun since its last restart, clear counters operation or power-up.

3.3.3 Exception codes

Table 8: Supported exception codes

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 is incorrect.
03	Illegal data value	A value contained in the query data field is out of range.

3.4 Modbus application data

3.4.1 Modbus data implementation

The protection relay is internally modeled according to the 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 a protection relay application. The usage depends on the protection relay implementation.

As REX610 is a freely configurable device, almost all internal IEC 61850 data objects can be mapped to Modbus. The internal IEC 61850 data objects in this device are assigned with potential (empty) Modbus mappings according to the general rules based on the IEC 61850 common data classes (CDC).

The Beh and Mod attributes of every logical node and some redundant data objects within the generic function blocks are unmapped.

Table 9: Mapping rules

CDC	Description	Attribute[1)]	Modbus data type	Areas
SPS	Singe point status	stVal	Mom	0x1x3x4x
SPC	Controllable single point status	stVal	Mom	0x1x3x4x
		Oper.ctlVal	One writable bit	0x4x
DPC	Controllable double point status	stVal	Open/Close/Fault bits	0x1x3x4x
		Oper.ctlVal	Direct and SBO writable bits	0x
ACD	Protection activation detection (Start)	general	Mom	0x1x3x4x
		dirGeneral[2)]	Readable enumeral AI	3x4x
		phsA	Mom	0x1x3x4x
		phsB	Mom	0x1x3x4x
		phsC	Mom	0x1x3x4x
ACT	Protection activation (Operate)	general	Mom	0x1x3x4x
		phsA	Mom	0x1x3x4x
		phsB	Mom	0x1x3x4x
		phsC	Mom	0x1x3x4x
		neut	Mom	0x1x3x4x

Table continues on next page

CDC	Description	Attribute[1)]	Modbus data type	Areas
INS	Integer value	stVal	Readable integer AI	3x4x
INC	Controllable integer value	stVal	Readable integer AI	3x4x
		Oper.ctlVal	Writable integer AI	4x
ENS	Enumeral value	stVal	Readable integer AI	3x4x
ENC	Controllable enumeral value	stVal	Readable integer AI	3x4x
		Oper.ctlVal	Writable integer AI	4x
MV	Meas value	mag.f	Readable integer AI	3x4x
		instMag.f		
CMV	Complex meas value	cVal.mag.f	Readable integer AI	3x4x
DEL	Phase-to-phase measurements	phsAB.instCVal.mag.f	Readable integer AI	3x4x
		phsBC.instCVal.mag.f	Readable integer AI	3x4x
		phsCA.instCVal.mag.f	Readable integer AI	3x4x
WYE	Phase-to-ground measurements (filtered)	phsA.instCVal.mag.f	Readable integer AI	3x4x
		phsB.instCVal.mag.f	Readable integer AI	3x4x
		phsC.instCVal.mag.f	Readable integer AI	3x4x
		neut.instCVal.mag.f	Readable integer AI	3x4x
		net.instCVal.mag.f	Readable integer AI	3x4x
		res.instCVal.mag.f	Readable integer AI	3x4x
WYE[3)]	Phase-to-ground measurements (instantaneous)	phsA.instCVal.mag.f	Readable integer AI	3x4x
		phsB.instCVal.mag.f	Readable integer AI	3x4x
		phsC.instCVal.mag.f	Readable integer AI	3x4x
		neut.instCVal.mag.f	Readable integer AI	3x4x
		net.instCVal.mag.f	Readable integer AI	3x4x
		res.instCVal.mag.f	Readable integer AI	3x4x

Table continues on next page

CDC	Description	Attribute[1)]	Modbus data type	Areas
SEQ	Sequence of components	c1.instCVal.mag.f	Readable integer AI	3x4x
		c1.instCVal.ang.f	Readable integer AI	3x4x
		c2.instCVal.mag.f	Readable integer AI	3x4x
		c2.instCVal.ang.f	Readable integer AI	3x4x
		c3.instCVal.mag.f	Readable integer AI	3x4x
		c3.instCVal.ang.f	Readable integer AI	3x4x

1) A data object need not contain all data attributes listed for the object class in question.
2) The enumeral values for the ACD class dirGeneral attribute are 1=Unknown, 2=Forward, 3=Backward, 4=Both.
3) WYE class measurands can be obtained as filtered values and, in some cases, also as instantaneous values. If values are polled fast, instantaneous values show more ripples.

Update rate of analog value protocol data

The protocol offers almost all internal IEC 61850 data objects to be mapped. Some special analog data values are not updated to the protocol database spontaneously by default. A symptom may be that these analog values are updated slowly through the protocol because they are updated by the protocol's own background scanning task.

32-bit-wide integer data

The generic pre-mapping of integer analog values (INS, INC) is generally defined to be 16-bit-wide registers. If the user instead defines a 32-bit register, then the option "Use UDR Register size (v2)" should be used to map the register as 32 bits.

Control operations

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

Control operations include automatic checking for authorization and local and remote blockings as well as preventing simultaneous controlling by multiple clients.

Application data compatibility

This protection relay 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. Digital data is readable as bits or packed bits in registers.
- Primarily 16-bit register sizes are used for measurands. 32 bits are used only in some rare cases.
- By default, measurands are scaled by value 1000.
- The addressing of the application data in the documentation and tools follows the Modbus-PLC addressing principle, where the base address 1 is used.
- The Modbus memory-mapped data in the monitoring direction is assembled into user-definable registers or bits in a specific UDR memory area. The data can then be scanned from this area.

3.4.2 Data mapping principles

The available Modbus data in the protection relay can be mapped to a Modbus user-defined area. An unmapped Modbus point does not cause any burden on the protection relay until it is taken into use.

3.4.2.1 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 Mobdus exception response. The value in these bits or registers is always zero.

3.4.2.2 One-bit data mapping

All one-bit data in the protection relay is readable either from the 0X or 1X memory area. The Modbus bit point addresses are similar regardless of the memory area. In addition, 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. The bit locations follow a pattern similar to the 0X and 1X locations.

If a one-bit value is located in the 0X or 1X bit address 1800, the same bit value can also be found in the 3X or 4X register 112 (1800 DIV 16) at register bit 8 (1800 MOD 16). This is easier to understand when the address numbers are expressed in the hexadecimal format: 1800 = 0x708, where the register 112 = 0x70 and bit 8 = 0x8.

3.4.2.3 Data in control direction

The protection relay's controls, set points and acknowledgements are mapped in parallel to both Modbus 0X data (coils) and Modbus 4x data (registers). Control points can only be operated one by one.

3.4.3 Digital input data

As the indication signals related to protection applications often change rapidly, the Modbus master may not detect all the changes.

3.4.3.1 Digital input configuration

Digital input indications are mirrored on several Modbus memory areas. Indications can be accessed in Communication Management in PCM600, under tabs: 1X – discrete inputs, 0X – read-only coils, 3X – input registers and 4X – holding registers. Digital inputs are read-only objects. Writing to the defined 0X and 4X addresses results in an exception response.

The bit address field shows the 1X and 0X Modbus memory addresses on which the data occur as default. The Modbus register address and bit within the register are shown under the 3X and 4X register views. The address field may also be empty, meaning that the object is not located in the Modbus memory at all as default. The indication objects can be taken into use in the user-definable area.

Modbus Communication Management shows only active data objects, that is, the objects that are available in the functions that are activated in the relay configuration.

Table 10: Setting columns in the Modbus CMT view

Setting column	Alternatives	Description
Bit address	Not adjustable	The 0X and 1X bit Modbus memory map address where the object resides as default. If the field is empty, the object is not visible in the Modbus memory map as default. The object can always be further mapped into the user-defined area.

The cards' binary input and output status is mapped to the fixed register which is not available in Communication Management.

3.4.4 Measurand registers

The Modbus measurands are located in the Modbus register area. The measurands are readable from both 3X and 4X areas from the same register addresses.

The Modbus measurands derive from the protection relay's internal, original IEC 61850 filtered measurand values. Modbus register values in this protection relay are always in integer format. Since the internal IEC 61850 values are often represented as decimal numbers, the Modbus stack needs to scale these values to integer format. Thus, there are always a scale factor and an offset parameter for each Modbus register value. The default values of the scale factor and the offset parameter are 1000 and 0, respectively.

The formula for calculating the Modbus register value is:

$$Modbus\ value = (IEC61850Value \times scaleFactor) + Offset$$

(Equation 1)

The range of the original IEC 61850 value can be seen in the Modbus memory map point list.

3.4.4.1 Register sizes

In most cases the measurands or counters are located in single 16-bit registers. The measurands are either unsigned or signed two's complement values while the counters are always unsigned values.

In some cases the measurands or counter values can be located in two consecutive registers, thus 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 then always in the next register address.

Register sizes and types are clearly stated in the Modbus memory map list.

3.4.4.2 Register saturation

After a re-scaling operation the Modbus value may exceed the limit of the Modbus register representation. The Modbus value then saturates to the closest max or min value of the register size in question.

3.4.4.3 Rearranging of register value ranges

The pre-defined original Modbus register does not always fit inside the whole value range of the source value.

Example

A counter in the motor protection relay shows the running hours of the motor. The original system counter value has a range of 0…999999 hours. For Modbus, a 16-bit unsigned register is defined for this value. The default scale factor for this Modbus register is defined as x1.

The value range for the 16-bit register is only 0…65535. This means that when the original counter reaches 65535 hours (about seven and a half years), the Modbus value saturates (remains locked) at 65535.

To overcome this problem, the Modbus register value can be assigned to a 32-bit user-definable register. Even when the original register saturates at 65535, the user-definable register continues calculating upwards from this value.

3.4.4.4 Register configuration

Measurand registers are mirrored on both 3X and 4X Modbus register areas. Registers can be accessed in Modbus Communication Management in PCM600, under tabs: 3X – input registers and 4X – holding registers.

Register values are received from the IEC 61850 system level in two formats. Measurands are usually received as floating point values and counters as integer values. The Modbus register values are always presented as integer values. To make the source floating point value's decimals visible in the Modbus register, the received IEC 61850 value can be multiplied by, for example, 10, 100 or 1000. The Modbus register rounds the integer part and truncates all decimals that are left in the source value.

Table 11: Setting column in the Modbus Communication Management tool in PCM600

Setting column	Alternatives	Description
Register address	Not adjustable	The 3X and 4X Modbus memory map addresses where the register resides as default. If the field is empty, the register is not visible in the Modbus memory map as default. The register can always be further mapped into the user-definable area.

Modbus supports the default scaling factor of 1000 only.

3.4.5 Control operations

The protection relay's 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 this protection relay are either single-point or double-point control objects.

Single point control object output types

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".

Most of the outputs in this protection relay are pulse outputs.

Double point control operation modes on IEC 61850 level

This protection relay supports two control models: direct-operate and select-before-operate. The IEC 61850 single point control objects in this protection relay are of direct-operate type. The IEC 61850 double point control objects can be configured either into the direct-operate or select-before-operate mode.

An IEC 61850 double point output cannot support both direct-operate and select-before-operate modes at the same time.

Double point control operations on Modbus level

The double-point select-before-operate mode is usually used for the circuit breaker operations. Modbus incorporates a 30-second fixed select time-out on protocol level. Four controllable objects exist on the Modbus level.

- Select open
- Select close
- Cancel selection
- Operate (=execute) selection

Direct operate of a double-point object consists of two controllable objects.

- Direct open (writing the value "1" opens the circuit breaker)
- Direct close (writing the value "1" closes the circuit breaker)

Direct operate of a double point object is always possible over Modbus. In addition, select-before-operate control is possible if the controllable object's control model is set to "sbo-with-enhanced-security."

3.4.5.1 Control functions

Generally, output objects are controlled one at a time. The protection relay accepts only functions 05 (force single coil) and 15 (force multiple coils) when the 0X coils control structure is used for control operation.

Only one control bit can be operated at a time when the 4X control structures are used.

Exception codes

Only a few exception code alternatives exist for the write coil and write register requests in Modbus:

- 01 = illegal function
- 02 = illegal address
- 03 = illegal value

The exception code 03 is also returned if a command operation is rejected due to other internal reasons. An additional internal reason code for the exception can be found in the SSR2 register after the command operation.

Internal control rejection reasons with coils may be, for example:

- The client has no write authority.
- The protection relay is in local or OFF state.
- The control operation is already reserved by another client and thus blocked.

If a positive acknowledgement is returned, the control command has been initiated by the protection relay.

3.4.5.2 Additional control operation features

Normal or enhanced security operations

Control objects on the IED system level (IEC 61850 level) always follow a control model. Control model alternatives are referred to as normal security or enhanced security. Some control objects have a fixed control model. Other objects' control models are configurable.

Normal-security object:

- Positive confirmation means that the control has been activated and the application behind the control point has performed successfully.
- Exception 03 response means that either the control is not activated, or the control is activated, but the application behind the control point does not perform successfully.

Enhanced-security object:

- Positive confirmation means that control has been activated. The application behind the control point has started, but has not finished yet. SSR2 state is set to ‘In progress’.
- Exception 03 response means that the control is not activated. SSR2 reason code is updated. After a positive confirmation, SSR6 state is set to ‘Ready’ when the application control eventually is terminated. The SSR2 reason code is updated with either a positive or a negative reason code.

Impact on master’s logic

Only one control sequence can be performed at a time by the IED. A new Modbus control command cannot be accepted by the IED after an enhanced security object control until the SSR2 state is set to ‘Ready’. Enhanced-security objects are always

double-point objects. For example, in the case of control made to a motor-controlled disconnector, the control sequence lasts 10 seconds. The master can monitor the command progress in several ways.

- Polling the SSR2 register and examining the state bits. Control can be in state 'In progress' for 10 seconds.
- Double-point object .stSeld attribute is set to ‘1’ while the control operation is in progress. This lasts 10 seconds.
- The control should result in some input data eventually changing position. This input data can be monitored to determine that the control operation is over. This should take 10 seconds.

3.4.5.3 Control bit configuration

Control bits are write-only coil (0x) data. In addition, some of the control bits are assigned in parallel to holding register (4x) control structures.

Control bits can be accessed in Modbus Communication Management in PCM600, under the tab 0x – writable coils.

Table 12: Control bit settings

Setting column	Alternatives	Description
Bit address	Empty	Control point is not in use. It can be edited with DELETE +ENTER keys.
	1...65535	Control point is not in use on this coil (0x) address. This is a write-only coil. A (read-only) indication can be mapped to the same coil address without the two objects interfering with one another.
Control struct number	Not adjustable	0: Control structure not defined
		1...N: Control structure number defined
Control struct bit	Not adjustable	0...15: Bit definition within the Control structure

The bit address is configurable. It is also possible to completely remove a control point from the Modbus 0x memory map by first deleting the address and then pressing ENTER.

The address mapped to the 0x, 1x, 3x and 4x register should be unique. For example, if 0x10 is mapped in the UDR view for read coil, then 0x10 should not be mapped to any other register type.

3.4.6 System status registers

The Modbus SSRx 16-bit system status registers are by default located at addresses 48001 and 48002. See the Modbus memory map for the actual locations of the SSRx registers. The SSRx registers can also be read from the 3X register area from corresponding register addresses.

Table 13: System status registers

Register	Description	Address
SSR1	Device mode	48001
SSR2	Last command result	48002

3.4.6.1 SSR1

The device mode SSR1 register is located by default at address 48001. The bit values in SSR1 are common for all Modbus clients. The bits give an overview of the protection relay's mode. For example, bit 6 is activated if the protection relay's configured time synchronization source is lost.

Table 14: 16-bit SSR1 register

Bit	Description
0	Test mode (1= Device is set into test mode)
1...2	Local/Remote states (bit 1= LSB) 00 = Remote – Modbus controls allowed 01 = Station – Modbus controls allowed 10 = Local – Modbus controls not allowed 11 = Off – Modbus controls not allowed
3...5	Active setting parameter setting group (bit 3 = LSB) 001 = Setting group 1 010 = Setting group 2 011 = Setting group 3 100 = Setting group 4 101 = Setting group 5 110 = Setting group 6
6	Protection relay time synchronization failure (1 = Failure)
7	0 = not used
8	Last reset cause (1= Power reset)
9	Last reset cause (1= Watchdog reset)
10	Last reset cause (1= Warm reset)
11...15	0 = not used

3.4.6.2 SSR2

The last command result SSR2 register is located by default at address 48002. This client-dependent SSR2 register shows the result of a specific client's last write attempt. This is especially useful if the exception code 03 appears or if the

command initiates a secured control operation. The client will only see its own results, not the results of other clients.

Table 15: 16-bit SSR2 register

ClientCmdSEQNo				Cmd State		Resp Type		CMDResultCode							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

ClientCmdSEQNo

Counts the client's control operations from 0000...1111, that is 0...15, and then starts over.

CmdState

00 = No write command has ever been issued by this client

01 = Command in progress

11 = Response Ready

RespType

01 = Unsecured control response

10 = Secured control response

11 = Modbus 03 exception response valid. CMDResultCode is in this case 0. The reason for the 03 exception is an invalid written value.

Table 16: CMDResultCode

Code	Description
0	OK
201	Device in local mode
202	Control operation reserved by another client
203	Select-timeout or Execute without select
204	Control operation internally blocked
205	Control operation timed out
250	Other reason

3.4.7 User-definable data

There can be several reasons for defining UD data. For example, the user may want to repack a limited amount of important data into sequential addresses and thereafter only scan this smaller set of data. Especially with serial links, this saves bandwidth and improves response times.

User-definable register can be used if more advanced rescaling and re-manipulating of the regular Modbus register is needed. Many of these features are defined for retrofit purposes and are not needed for normal installations. Some rescaling features are redundant at the moment.

3.4.7.1 User-definable registers

The Modbus register areas 3X and 4X from 1 to 127 can be compiled freely by the user. Almost any regular register data in the Modbus memory map can be made to appear as a register copy in this UDR memory area. The regular Modbus source register is not moved away from its original location and thus it can be read also from the original location.

3.4.7.2 User-definable bits

The Modbus bit address areas 0X and 1X from bit 16 to 2047 can be freely compiled by the user. Almost any regular bit data in the Modbus memory map can be made to appear as a bit data copy in this UDB memory area. The regular Modbus source bit data are not moved away from their original location and thus they can be read also from the original location.

Bit 16 is the first valid bit address in the address space because the register and bit addresses overlap and the register addresses start from register location 1. The bit address 16 is the same as register 1, bit 0.

3.4.7.3 Data exceptions

Some exceptions exist for the Modbus source data concerning the UD mapping.

- None of the system status registers or fixed register structures can appear in the UD area.
- UD registers/bits cannot act as source data for other UD data.
- Modbus source data can only be attached to one UD location.

3.4.7.4 Data properties

The UD data inherits all properties from the source data.

- The memory areas on which the source data are located
- Data pre-scaling in case of registers

3.4.7.5 Unmapped data locations

It is possible to partially scan unmapped register or bit locations, also known as gaps. No exception responses are generated. The unmapped locations always return data value 0.

3.4.7.6 UDR data configuration

UDR definitions can be created using Communication Management in PCM600.

3.4.7.7 UDR register value manipulation

UDR values are initially copied from the source register. Thereafter the following manipulations can be applied to the UDR value.

Table 17: Configuration columns in Modbus Communication Management tool in PCM600

Setting	Alternatives	Description
Initial properties		
UDR register size (v2)	Same as the source register[1)]	If the Modbus source register is a 16-bit register, the UDR register is automatically 16-bit. This principle applies to 32-bit registers, too.
	16-bit	The UDR register is forced to 16-bit regardless of the source register size.
	32-bit	The UDR register is forced to 32-bit regardless of the source register size.

1) Default value

3.4.8 Parameter setting group selection

Parameter setting group selection and reading is defined through regular Modbus registers. Formerly this was achieved by a fixed 4x holding register address 2301. See the protection relay documentation for the number of available setting groups. Exception response 3 is given if the written value is out of range or the setting group changing is blocked.

3.4.9 Time synchronization

The real-time clock inside the protection relay runs in UTC time. However, the local time is also known by the protection relay through the time parameter settings. With Modbus the protection relay time can be viewed in local time or UTC time.

Two identical time structures are available in the Modbus memory map: the protection relay's local time at location 49201...49208 and the internal UTC time at the location 49211...49218.

3.4.9.1 Real-time clock structure

Table 18: Modbus real-time clock structure

Modbus address		Register contents	Values
Local time	UTC time		
49201	49211	Reserved	0
49202	49212	Year	2000...9999
49203	49213	Month	1...12
49204	49214	Day	1...31
49205	49215	Hour	0...23
49206	49216	Minutes	0...59
49207	49217	Seconds	0...59
49208	49218	Milliseconds	0...999

Section 4 Modbus parameters and diagnostics

4.1 Parameter list

The Modbus parameters can be accessed with PCM600 or via the HMI path **Configuration/Communication/Modbus/MBS0 (n)**.

Some parameters are not visible in the “Basic” setting visibility mode. To view all parameters, use “Advanced” setting visibility mode in Parameter Setting in PCM600 and HMI.

See the technical manual for baud rate related settings and supported baud rates for serial communication.

Table 19: MODBUS Non group settings (Basic)

Parameter	Values (Range)	Unit	Step	Default	Description
Port	1=COM 1 3=Ethernet - TCP 1			3=Ethernet - TCP 1	Port selection for this protocol instance. Select between serial and Ethernet based communication.
Address	1...254		1	1	Unit address
Write authority	0=Read only 1=Disable 0x write 2=Full access			2=Full access	Selects the control authority scheme
Client1 IP				0.0.0.0	Sets the IP address of the client1. If set to zero, connection from any client is accepted.
ControlStructPWd 1				****	Password for control operations using Control Struct mechanism, which is available on 4x memory area.
ControlStructPWd 2				****	Password for control operations using Control Struct mechanism, which is available on 4x memory area.
Parity	0=none 1=odd 2=even			2=even	Parity for the serial connection.
Operation	1=on 5=off			5=off	Enable or disable this protocol instance
Client2 IP				0.0.0.0	Sets the IP address of the client2. If set to zero, connection from any client is accepted.
Reset counters	0=False 1=True			0=False	Reset counters

Table 20: MODBUS Non group settings (Advanced)

Parameter	Values (Range)	Unit	Step	Default	Description
TCP port	1...65535		1	502	Defines the listening port for the Modbus TCP server. Default

4.2 Monitored data

The Modbus serial and Ethernet monitored data can be accessed with Parameter Setting in PCM600 or via the HMI path **Monitoring/Communication/Modbus/MBS0 (n)**.

Table 21: MODBUS Monitored data

Name	Type	Values (Range)	Unit	Description
Received frames	INT32	-1...2147483646		Number of received frames
Checksum errors	INT32	-1...2147483646		Number of checksum errors
Transmitted frames	INT32	-1...2147483646		Number of transmitted frames
Transmitted exc A	INT32	-1...2147483646		Number of transmitted exception responses 01 and 02
Transmitted exc B	INT32	-1...2147483646		Number of transmitted exception responses 03
Status	BOOLEAN	0=False 1=True		Communication status (True
CnReject unregistered	INT32	-1...2147483646		Connection rejected due to unregistered client

Section 5 Modbus data mappings

5.1 Overview

This chapter describes the Modbus data points and structures available in the protection relay. The point lists describe a superset of all data available through the standard configurations including the optional functionalities.

Most of the Modbus data points are valid for all standard configurations. Some data points are standard configuration-dependent or optional application-dependent and thus not available in each protection relay. The unavailable (unused) data points always return value 0 when they are read. The configuration-dependent and optional data do not overlap.

5.2 Indications

Table 22: Explanations of the indications table columns

Column name	Description
BitA	Default 0X and 1X bit address for the data
RegA	Default 3X and 4X register.bit (00...15) address for the data
IEC 61850 name	Original IED data object identification. Described in the IEC 61850 format as Logical Device.Logical Node and thereafter .Data Object.Data Attribute. Logical Node is the same as the application function block name.
SA name	The signal may have a defined label that is visible, for example, in Application Configuration in PCM600.
Description	Short description of the signal. See the technical manual for more information.
Value	Meaning of the value states

5.2.1 Unmapped indications

Unmapped indications are indication data that has no initial Modbus mapping locations, but can be added to the user-definable Modbus area using Communication Management in PCM600.

5.2.1.1 CTRL.CBCSWI1 Circuit-breaker control (1)

Table 23: CTRL.CBCSWI1 Circuit-breaker control (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		CTRL.CBCSWI1			
		.OpCntRs.Oper.ctlVal		Operation counter reset	1 = Active
		.Pos.stSeld	SELECTED	CB selected for control	1=Selected
		.OpOpn.general	OPEN_CB	Operate (open XCBR)	1=Open CB
		.OpCls.general	CLOSE_CB	Operate (close XCBR)	1=Close CB
		CTRL.CBCSWI1	POSITION		
		.PosOpn.stVal		Position open	1 = Active
		.PosCls.stVal		Position close	1 = Active
		.PosOk.stVal		Position ok	1 = Active
		.OpnEna.stVal		Open Enable	1 = Active
		.ClsEna.stVal		Close Enable	1 = Active
		.InSynOk.stVal	SYNC_OK	In Sync ok	1 = Active
		.SynItlByps.stVal	ITL_BYPASS	Interlock bypass	1 = Active

5.2.1.2 CTRL.LLN0 Local, Remote, Station, Off and Combinations

Table 24: CTRL.LLN0 Local, Remote, Station, Off and Combinations

BitA	RegA	IEC 61850 name	SA name	Description	Values
		CTRL.LLN0.		Function block input based status	
		.LocKeyLoc.stVal		Local	1=ON/0=OFF
		.LocKeyRem.stVal		Remote	1=ON/0=OFF
		.LocKeyAll.stVal		Local+Remote	1=ON/0=OFF
		CTRL.LLN0.		Function block setting based status	
		.LocKeyLoc.stVal		Local	1=ON/0=OFF
		.LocKeyRem.stVal		Remote	1=ON/0=OFF
		.LocKeyAll.stVal		Local+Remote	1=ON/0=OFF
		.LocKey.stVal		Local	1=ON/0=OFF

5.2.1.3 CTRL.DCSXSWI1 Disconnector position indication (1)

Table 25: CTRL.DCSXSWI1 Disconnector position indication (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		CTRL.DCSXSWI1	POSITION		
		.Pos.stVal	-	Close bit	1=Close
		.Pos.stVal	-	Open bit	1=Open
		.Pos.stVal	-	Fault bit	1=Pos(00/11)

5.2.1.4 CTRL.DCSCSWI1 Disconnector switch status (1)

Table 26: CTRL.DCSCSWI1 Disconnector switch status (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		CTRL.DCSCSWI1	POSITION		
		.Pos.stVal	-	close bit	1=close
		.Pos.stVal	-	open bit	1=open
		.Pos.stVal	-	fault bit	1=pos(00/11)
		.PosOpn.stVal	-	CB OPEN	1=open
		.PosCls.stVal	-	CB CLOSE	1=close
		.PosOk.stVal	-	CB OK	1=ok

5.2.1.5 LD0.DEFHPDEF1 Directional earth-fault protection, high stage (1)

Table 27: LD0.DEFHPDEF1 Directional earth-fault protection, high stage (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.DEFHPTOC1			
		.Str.general	START	General start	1=Start
		.Op.general	OPERATE	General operate	1=Operate
		.Blk.stVal	BLOCK	Block signal	1=Active
		.InEnaMult.stVal	ENA_MULT	Enable multiplier	1=Active

5.2.1.6 LD0.DEFLPDEF1 Directional earth-fault protection, low stage (1)

Table 28: LD0.DEFLPDEF1 Directional earth-fault protection, low stage (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.DEFLPTOC1			
		.Str.general	START	General start	1=Start
		.Op.general	OPERATE	General operate	1=Operate
		.Blk.stVal	BLOCK	Block signal	1=Active
		.InEnaMult.stVal	ENA_MULT	Enable multiplier	1=Active

5.2.1.7 LD0.DEFLPDEF2 Directional earth-fault protection, low stage (2)

Table 29: LD0.DEFLPDEF2 Directional earth-fault protection, low stage (2)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.DEFLPTOC2			
		.Str.general	START	General start	1=Start
		.Op.general	OPERATE	General operate	1=Operate
		.Blk.stVal	BLOCK	Block signal	1=Active
		.InEnaMult.stVal	ENA_MULT	Enable multiplier	1=Active

5.2.1.8 LD0.DPHHPDOC1 Three-phase directional overcurrent protection, high stage (1)

Table 30: LD0.DPHHPDOC1 Three-phase directional overcurrent protection, high stage (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.DPHHPTOC1			
		.Str.general	START	General start	1=Start
		.Str.PhsA	-	Phs A start	1=Start
		.Str.PhsB	-	Phs B start	1=Start
		.Str.PhsC	-	Phs C start	1=Start
		.Op.general	OPERATE	General operate	1=Operate
		.Op.PhsA	-	Operate Phase A	1=Operate
		.Op.PhsB	-	Operate Phase B	1=Operate
		.Op.PhsC		Operate Phase C	1=Operate
		.Blk.stVal	BLOCK	Block signal	1 = Active
		.InEnaMult.stVal	ENA_MULT	Enable multiplier	1 = Active
		.NonDir.stVal		Forces protection to non-directional	

5.2.1.9 LD0.DPHLPDOC1: Three-phase directional overcurrent protection, low stage (1)

Table 31: LD0.DPHLPDOC1: Three-phase directional overcurrent protection, low stage (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.DPHLPTOC1			
		.Str.general	START	General start	1=Start
		.Str.PhsA	-	Phs A start	1=Start
		.Str.PhsB	-	Phs B start	1=Start
		.Str.PhsC	-	Phs C start	1=Start
		.Op.general	OPERATE	General operate	1=Operate
		.Op.PhsA	-	Operate Phase A	1=Operate
		.Op.PhsB	-	Operate Phase B	1=Operate
		.Op.PhsC		Operate Phase C	1=Operate
		.Blk.stVal	BLOCK	Block signal	1=Active
		.InEnaMult.stVal	ENA_MULT	Enable multiplier	1=Active
		.NonDir.stVal		Forces protection to non-directional	

5.2.1.10 LD0.DPHLPDOC2 Three-phase directional overcurrent protection, low stage (2)

Table 32: LD0.DPHLPDOC2 Three-phase directional overcurrent protection, low stage (2)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.DPHLPTOC2			
		.Str.general	START	General start	1=Start
		.Str.PhsA	-	Phs A start	1=Start
		.Str.PhsB	-	Phs B start	1=Start
		.Str.PhsC	-	Phs C start	1=Start
		.Op.general	OPERATE	General operate	1=Operate
		.Op.PhsA	-	Operate Phase A	1=Operate
		.Op.PhsB	-	Operate Phase B	1=Operate
		.Op.PhsC		Operate Phase C	1=Operate
		.Blk.stVal	BLOCK	Block signal	1=Active
		.InEnaMult.stVal	ENA_MULT	Enable multiplier	1=Active
		.NonDir.stVal		Forces protection to non-directional	

5.2.1.11 LD0.PHPTUC1 Loss of phase, undercurrent

Table 33: LD0.PHPTUC1 Loss of phase, undercurrent

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.PHPTUC1			
		.Str.general	START	General start	1=Start
		.Str.PhsA	-	Phs A start	1=Start
		.Str.PhsB	-	Phs B start	1=Start
		.Str.PhsC	-	Phs C start	1=Start
		.Op.general	OPERATE	General operate	1=Operate
		.Op.PhsA	-	Operate Phase A	1=Operate
		.Op.PhsB	-	Operate Phase B	1=Operate
		.Op.PhsC		Operate Phase C	1=Operate
		.Blk.stVal	BLOCK	Block signal	1=Active

5.2.1.12 LD0.UL1TVTR1 Three-phase VT supervision (1)

Table 34: LD0.UL1TVTR1 Three-phase VT supervision (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.UL1TVTR1			
		.Alm.stVal	ALARM	Alarm	1=Alarm
		.Wrn.stVal	WARNING	Warning	1=Warning
		.FuFail.stVal	MINCB_OPEN	External MCB opens protected voltage circuit	1=Active

5.2.1.13 LD0.FKEYGGIO1 Function key status (1)

Table 35: LD0.FKEYGGIO1 Function key status (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.FKEYGGIO1			
		.SPCSO1.stVal		FKEY 1 LED status	1= LED ON
		.SPCSO2.stVal		FKEY 2 LED status	1= LED ON

5.2.1.14 CTRL.ESSXSWI1 Earthing switch position indication (1)

Table 36: CTRL.ESSXSWI1 Earthing switch position indication (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		CTRL.ESSXSWI1	POSITION		
		.Pos.stVal.Close	-	Close bit	1=Close
		.Pos.stVal.Open	-	Open bit	1=Open
		.Pos.stVal.Fault	-	Fault bit	1=Pos(00/11)

5.2.1.15 CTRL.ESSCSWI1 Earthing switch status (1)

Table 37: CTRL.ESSCSWI1 Earthing switch status (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		CTRL.ESSCSWI1	POSITION		
		.Pos.stVal	-	close bit	1=close
		.Pos.stVal	-	open bit	1=open
		.Pos.stVal	-	fault bit	1=pos(00/11)
		.PosOpn.stVal	-	CB OPEN	1=open
		.PosCls.stVal	-	CB CLOSE	1=close
		.PosOk.stVal	-	CB OK	1=ok

5.2.1.16 LD0.CCBRBRF1 Circuit breaker failure protection (1)

Table 38: LD0.CCBRBRF1 Circuit breaker failure protection (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.CCBRBRF1			
		.Str.general	CB_FAULT_AL	Timer running	1=Running
		.OpEx.general	TRBU	Fail, external trip	1=Ext.trip
		.OpIn.general	TRRET	Internal re-trip	1=Re-trip
		.Blk.stVal	BLOCK	Block CBFP operation	1=block

5.2.1.17 LD0.CCSPVC1 Current circuit supervision (1)

Table 39: LD0.CCSPVC1 Current circuit supervision (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.CCSPVC1			
		.SigFailAlm.stVal	ALARM	Alarm	1=Alarm
		.FailACirc.general	FAIL	Failure operate	1=Operate

5.2.1.18 LD0.CMMXU1 Three-phase current measurement (1)

Table 40: LD0.CMMXU1 Three-phase current measurement (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.CMMXU1			
		.HiAlm.stVal	HIGH_ALARM	High alarm	1=Alarm
		.HiWrn.stVal	HIGH_WARN	High warning	1=Warning
		.LoWrn.stVal	LOW_WARN	Low warning	1=Warning
		.LoAlm.stVal	LOW_ALARM	Low alarm	1=Alarm

5.2.1.19 LD0.DARREC1 Autoreclosing (1)

Table 41: LD0.DARREC1 Autoreclosing (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.DARREC1			
		.PrgRec.stVal	INPRO	AR in progess	1=In progress
		.PrgRec1.stVal	INPRO_1	1st shot in progess	1=In progress
		.PrgRec2.stVal	INPRO_2	2nd shot in progess	1=In progress
		.PrgRec3.stVal	INPRO_3	3rd shot in progess	1=In progress
		.PrgRec4.stVal	INPRO_4	4th shot in progess	1=In progress
		.PrgRec5.stVal	INPRO_5	5th shot in progess	1=In progress
		.SucRec.stVal	SUC_RECL	Successful AR	1=Success

Table continues on next page

BitA	RegA	IEC 61850 name	SA name	Description	Values
		.UnsRec.stVal	UNSUC_RECL	Unsuccessful AR	1=Unsuccess
		.LO.stVal	LOCKED	Lockout status	1=Lockout
		.RdyRec.stVal	READY	Reclose ready	1=Ready
		.ActRec.stVal	ACTIVE	Reclose active	1=Active
		.PrgDsr.stVal	DISCR_INPRO	Discr.time in progress	1=In progress
		.PrgCutOut.stVal	CUTOUT_INPRO	Cutout time in progress	1=In progress
		.FrqOpAlm.stVal	FRQ_OP_ALM	Frequent op. Alarm	1=Alarm
		.RclTmStr.stVal	-	Reclaim time started	1=started
		.ProCrd.stVal	PROT_CRD	Protection coordination	1=In progress
		.CBManCls.stVal	MAN_CB_CL	CB manually closed	1=CB closed
		.OpCls.general	CLOSE_CB	Operate (close XCBR)	1=Close CB
		.OpOpn.general	OPEN_CB	Operate (open XCBR)	1=Open CB
		.UnsCBCls.stVal	UNSUC_CB	CB closing failed	1=Failed
		.WtMstr.stVal	CMD_WAIT	Master signal to follower	1=Signal
		.InInhRec.stVal	INHIBIT_RECL	Inhibit reclose	1=Inhibit
		.InBlkThm.stVal	BLK_THERM	Thermal block	1=Block

5.2.1.20 LD0.DARREC1 Autoreclosing state (1)

Table 42: LD0.DARREC1 Autoreclosing state (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.DARREC1			
		.AutoRecOn.stVal	AR_ON	AutoRecloser state	0/1=Off/On

5.2.1.21 LD0.EFHPTOC1 Non-directional earth-fault protection, high stage (1)

Table 43: LD0.EFHPTOC1 Non-directional earth-fault protection, high stage (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.EFHPTOC1			
		.Str.general	START	Stage start	1=Start
		.Op.general	OPERATE	Stage operate	1=Operate
		InEnaMult.stVal	ENA_MULT	Enable multiplier	1 = Active
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.22 LD0.EFIPTOC1 Non-directional earth-fault protection, instantaneous stage (1)

Table 44: LD0.EFIPTOC1 Non-directional earth-fault protection, instantaneous stage (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.EFIPTOC1			
		.Str.general	START	Stage start	1=Start
		.Op.general	OPERATE	Stage operate	1=Operate
		.InEnaMult.stVal	ENA_MULT	Enable multiplier	1 = Active
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.23 LD0.EFLPTOC1 Non-directional earth-fault protection, low stage (1)

Table 45: LD0.EFLPTOC1 Non-directional earth-fault protection, low stage (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.EFLPTOC1			
		.Str.general	START	Stage start	1=Start
		.Op.general	OPERATE	Stage operate	1=Operate
		.InEnaMult.stVal	ENA_MULT	Enable multiplier	1 = Active
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.24 LD0.EFLPTOC2 Non-directional earth-fault protection, low stage (2)

Table 46: LD0.EFLPTOC2 Non-directional earth-fault protection, low stage (2)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.EFLPTOC2			
		.Str.general	START	Stage start	1=Start
		.Op.general	OPERATE	Stage operate	1=Operate
		.InEnaMult.stVal	ENA_MULT	Enable multiplier	1 = Active
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.25 LD0.INRPHAR1 Three-phase inrush detector (1)

Table 47: LD0.INRPHAR1 Three-phase inrush detector (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.INRPHAR1			
		.Str.general	BLK2H	General start	1=Start
		.Str.phsA	-	Phs A start	1=Start
		.Str.phsB	-	Phs B start	1=Start
		.Str.phsC	-	Phs C start	1=Start
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.26 LD0.LEDGGIO1 Indication LED states Color1/Color2

These LED indication points interpret the case when a signal is wired to both the OK and ALARM inputs, but inverted to the other. This means that the LED toggles between red and green colors. The default color for ALARM is red and green for OK. Colors can, however, be reconfigured with a setting parameter.

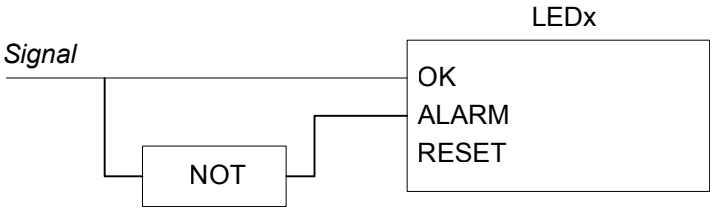

Figure 3: Signal wired to both OK and ALARM inputs – inverted to the other

If the OK and ALARM inputs are wired to separate indication signals, the LED will have three legal states and cannot be expressed with one bit only. In this case, it is possible to combine this LED bit interpretation with the corresponding value from the other LED state interpretation.

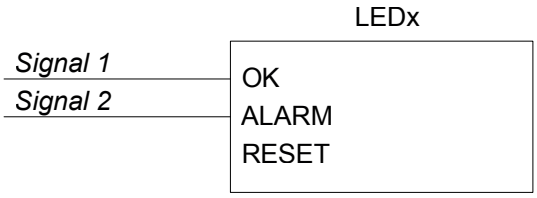

Figure 4: Separate signals wired to OK and ALARM inputs

Table 48: LD0.LEDGGIO1 Indication LED states Color1/Color2

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.LEDGGIO1			
		.LEDSt1.stVal	-	LED 1 state	0/1=Color1/2
		.LEDSt2.stVal	-	LED 2 state	0/1=Color1/2
		.LEDSt3.stVal	-	LED 3 state	0/1=Color1/2
		.LEDSt4.stVal	-	LED 4 state	0/1=Color1/2
		.LEDSt5.stVal	-	LED 5 state	0/1=Color1/2
		.LEDSt6.stVal	-	LED 6 state	0/1=Color1/2
		.LEDSt7.stVal	-	LED 7 state	0/1=Color1/2
		.LEDSt8.stVal	-	LED 8 state	0/1=Color1/2
		.LEDSt9.stVal	-	LED 9 state	0/1=Color1/2
		.LEDSt10.stVal	-	LED 10 state	0/1=Color1/2

5.2.1.27 LD0.LEDGGIO1 Indication LED states OFF/ColorX

These LED indication points interpret the case when an indication signal is wired to either the OK or ALARM input of the LED function block. The default color for ALARM is red and green for OK. Colors can, however, be reconfigured with a setting parameter.

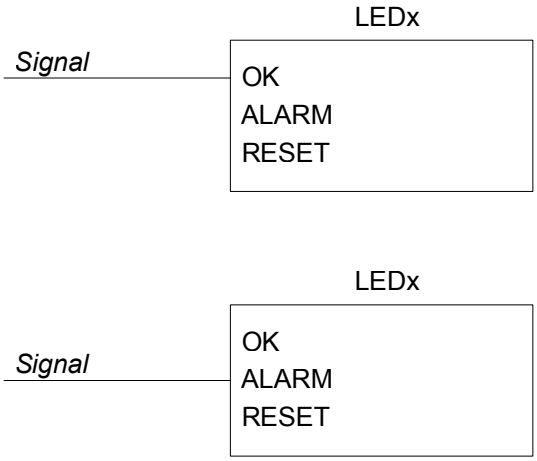

Figure 5: Signal wired to either OK or Alarm input

Table 49: LD0.LEDGGIO1 Indication LED states OFF/ColorX

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.LEDGGIO1			
		.LEDSt1.stVal	-	LED 1 state	0/1=Off/Color
		.LEDSt2.stVal	-	LED 2 state	0/1=Off/Color
		.LEDSt3.stVal	-	LED 3 state	0/1=Off/Color
		.LEDSt4.stVal	-	LED 4 state	0/1=Off/Color
		.LEDSt5.stVal	-	LED 5 state	0/1=Off/Color
		.LEDSt6.stVal	-	LED 6 state	0/1=Off/Color
		.LEDSt7.stVal	-	LED 7 state	0/1=Off/Color
		.LEDSt8.stVal	-	LED 8 state	0/1=Off/Color
		.LEDSt9.stVal	-	LED 9 state	0/1=Off/Color
		.LEDSt10.stVal	-	LED 10 state	0/1=Off/Color

5.2.1.28 LD0.NSPTOC1 Negative-sequence overcurrent protection (1)

Table 50: LD0.NSPTOC1 Negative-sequence overcurrent protection (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.NSPTOC1			
		.Str.general	START	Stage start	1=Start
		.Op.general	OPERATE	Stage operate	1=Operate
		.InEnaMult.stVal	ENA_MULT	Enable multiplier	1 = Active
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.29 LD0.NSPTOC2 Negative-sequence overcurrent protection (2)

Table 51: LD0.NSPTOC2 Negative-sequence overcurrent protection (2)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.NSPTOC2			
		.Str.general	START	Stage start	1=Start
		.Op.general	OPERATE	Stage operate	1=Operate
		.InEnaMult.stVal	ENA_MULT	Enable multiplier	1 = Active
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.30 LD0.PDNSPTOC1 Phase discontinuity / Single phasing protection for motor (1)

Table 52: LD0.PDNSPTOC1 Phase discontinuity / Single phasing protection for motor (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.PDNSPTOC1			
		.Str.general	START	Stage start	1=Start
		.Op.general	OPERATE	Stage operate	1=Operate
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.31 LD0.PHHPTOC1 Three-phase non-directional overcurrent protection, high stage (1)

Table 53: LD0.PHHPTOC1 Three-phase non-directional overcurrent protection, high stage (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.PHHPTOC1			
		.Str.general	START	General start	1=Start
		.Str.phsA	-	Phs A start	1=Start
		.Str.phsB	-	Phs B start	1=Start
		.Str.phsC	-	Phs C start	1=Start

Table continues on next page

BitA	RegA	IEC 61850 name	SA name	Description	Values
		.Op.general	OPERATE	General operate	1=Operate
		.Op.PhsA		Operate phase A	1 = Operate
		.Op.PhsB		Operate phase B	1 = Operate
		.Op.PhsC		Operate phase C	1 = Operate
		.InEnaMult.stVal	ENA_MULT	Enable multiplier	1 = Active
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.32 LD0.PHHPTOC2 Three-phase non-directional overcurrent protection, high stage (2)

Table 54: LD0.PHHPTOC2 Three-phase non-directional overcurrent protection, high stage (2)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.PHHPTOC2			
		.Str.general	START	General start	1=Start
		.Str.phsA	-	Phs A start	1=Start
		.Str.phsB	-	Phs B start	1=Start
		.Str.phsC	-	Phs C start	1=Start
		.Op.general	OPERATE	General operate	1=Operate
		.Op.PhsA		Operate phase A	1 = Operate
		.Op.PhsB		Operate phase B	1 = Operate
		.Op.PhsC		Operate phase C	1 = Operate
		.InEnaMult.stVal	ENA_MULT	Enable multiplier	1 = Active
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.33 LD0.PHIPTOC1 Three-phase non-directional overcurrent protection, instantaneous stage (1)

Table 55: LD0.PHIPTOC1 Three-phase non-directional overcurrent protection, instantaneous stage (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.PHIPTOC1			
		.Str.general	START	General start	1=Start
		.Str.phsA	-	Phs A start	1=Start
		.Str.phsB	-	Phs B start	1=Start
		.Str.phsC	-	Phs C start	1=Start
		.Op.general	OPERATE	General operate	1=Operate
		.Op.PhsA		Operate phase A	1 = Operate
		.Op.PhsB		Operate phase B	1 = Operate
		.Op.PhsC		Operate phase C	1 = Operate
		.InEnaMult.stVal	ENA_MULT	Enable multiplier	1 = Active
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.34 LD0.PHLPTOC1 Three-phase non-directional overcurrent protection, low stage (1)

Table 56: LD0.PHLPTOC1 Three-phase non-directional overcurrent protection, low stage (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.PHLPTOC1			
		.Str.general	START	General start	1=Start
		.Str.phsA	-	Phs A start	1=Start
		.Str.phsB	-	Phs B start	1=Start
		.Str.phsC	-	Phs C start	1=Start
		.Op.general	OPERATE	General operate	1=Operate
		.Op.PhsA		Operate phase A	1 = Operate
		.Op.PhsB		Operate phase B	1 = Operate
		.Op.PhsC		Operate phase C	1 = Operate
		.InEnaMult.stVal	ENA_MULT	Enable multiplier	1 = Active
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.35 LD0.PHPTOV1 Three-phase overvoltage protection (1)

Table 57: LD0.PHPTOV1 Three-phase overvoltage protection (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.PHPTOV1			
		.Str.general	START	General start	1=Start
		.Str.phsA	-	Phs A start	1=Start
		.Str.phsB	-	Phs B start	1=Start
		.Str.phsC	-	Phs C start	1=Start
		.Op.general	OPERATE	General operate	1=Operate
		.Op.PhsA		Operate phase A	1 = Operate
		.Op.PhsB		Operate phase B	1 = Operate
		.Op.PhsC		Operate phase C	1 = Operate
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.36 LD0.PHPTOV2 Three-phase overvoltage protection (2)

Table 58: LD0.PHPTOV2 Three-phase overvoltage protection (2)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.PHPTOV2			
		.Str.general	START	General start	1=Start
		.Str.phsA	-	Phs A start	1=Start
		.Str.phsB	-	Phs B start	1=Start

Table continues on next page

BitA	RegA	IEC 61850 name	SA name	Description	Values
		.Str.phsC	-	Phs C start	1=Start
		.Op.general	OPERATE	General operate	1=Operate
		.Op.PhsA		Operate phase A	1 = Operate
		.Op.PhsB		Operate phase B	1 = Operate
		.Op.PhsC		Operate phase C	1 = Operate
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.37 LD0.PHPTOV3 Three-phase overvoltage protection (3)

Table 59: LD0.PHPTOV3 Three-phase overvoltage protection (3)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.PHPTOV3			
		.Str.general	START	General start	1=Start
		.Str.phsA	-	Phs A start	1=Start
		.Str.phsB	-	Phs B start	1=Start
		.Str.phsC	-	Phs C start	1=Start
		.Op.general	OPERATE	General operate	1=Operate
		.Op.PhsA		Operate phase A	1 = Operate
		.Op.PhsB		Operate phase B	1 = Operate
		.Op.PhsC		Operate phase C	1 = Operate
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.38 LD0.PHPTUV1 Three-phase undervoltage protection (1)

Table 60: LD0.PHPTUV1 Three-phase undervoltage protection (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.PHPTUV1			
		.Str.general	START	General start	1=Start
		.Str.phsA	-	Phs A start	1=Start
		.Str.phsB	-	Phs B start	1=Start
		.Str.phsC	-	Phs C start	1=Start
		.Op.general	OPERATE	General operate	1=Operate
		.Op.PhsA		Operate phase A	1 = Operate
		.Op.PhsB		Operate phase B	1 = Operate
		.Op.PhsC		Operate phase C	1 = Operate
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.39 LD0.PHPTUV2 Three-phase undervoltage protection (2)

Table 61: LD0.PHPTUV2 Three-phase undervoltage protection (2)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.PHPTUV2			
		.Str.general	START	General start	1=Start
		.Str.phsA	-	Phs A start	1=Start
		.Str.phsB	-	Phs B start	1=Start
		.Str.phsC	-	Phs C start	1=Start
		.Op.general	OPERATE	General operate	1=Operate
		.Op.PhsA		Operate phase A	1 = Operate
		.Op.PhsB		Operate phase B	1 = Operate
		.Op.PhsC		Operate phase C	1 = Operate
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.40 LD0.PHPTUV3 Three-phase undervoltage protection (3)

Table 62: LD0.PHPTUV3 Three-phase undervoltage protection (3)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.PHPTUV3			
		.Str.general	START	General start	1=Start
		.Str.phsA	-	Phs A start	1=Start
		.Str.phsB	-	Phs B start	1=Start
		.Str.phsC	-	Phs C start	1=Start
		.Op.general	OPERATE	General operate	1=Operate
		.Op.PhsA		Operate phase A	1 = Operate
		.Op.PhsB		Operate phase B	1 = Operate
		.Op.PhsC		Operate phase C	1 = Operate
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.41 LD0.RESCMMXU1 Residual current measurement (1)

Table 63: LD0.RESCMMXU1 Residual current measurement (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.RESCMMXU1			
		.HiAlm.stVal	HIGH_ALARM	High alarm	1=Alarm
		.HiWrn.stVal	HIGH_WARN	High warning	1=Warning
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.42 LD0.RESVMMXU1 Residual voltage measurement (1)

Table 64: LD0.RESVMMXU1 Residual voltage measurement (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.RESVMMXU1			
		.HiAlm.stVal	HIGH_ALARM	High alarm	1=Alarm
		.HiWrn.stVal	HIGH_WARN	High warning	1=Warning
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.43 LD0.ROVPTOV1 Residual overvoltage protection (1)

Table 65: LD0.ROVPTOV1 Residual overvoltage protection (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.ROVPTOV1			
		.Str.general	START	General start	1=Start
		.Op.general	OPERATE	General operate	1=Operate
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.44 LD0.ROVPTOV2 Residual overvoltage protection (2)

Table 66: LD0.ROVPTOV2 Residual overvoltage protection (2)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.ROVPTOV2			
		.Str.general	START	General start	1=Start
		.Op.general	OPERATE	General operate	1=Operate
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.45 LD0.ROVPTOV3 Residual overvoltage protection (3)

Table 67: LD0.ROVPTOV3 Residual overvoltage protection (3)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.ROVPTOV3			
		.Str.general	START	General start	1=Start
		.Op.general	OPERATE	General operate	1=Operate
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.46 LD0.SEQSPVC1 Fuse failure supervision (1)

Table 68: LD0.SEQSPVC1 Fuse failure supervision (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.SEQSPVC1			
		.Str.general	FUSEF_U	Start	1=Start
		.Str3Ph.general	FUSEF_3PH	3-phase start	1=Start
		.Blk.stVal	BLOCK	Block signal	1 = Active
		.InMCBPsOpn.stVal	MINCB_OPEN	Active when MCB opens protected voltage circuit	1 = MCB open

5.2.1.47 LD0.SSCBR1 Circuit-breaker condition monitoring (1)

Table 69: LD0.SSCBR1 Circuit-breaker condition monitoring (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.SSCBR1			
		.OpnAlm.stVal	TRV_T_OP_ALM	Opn travel time alarm	1=Alarm
		.ClsAlm.stVal	TRV_T_CL_ALM	Cls travel time alarm	1=Alarm
		LD0.SSOPM1			
		.SprChaAlm.stVal	SPR_CHR_ALM	Spring charge alarm	1=Alarm
		LD0.SSCBR1			
		.OpCntAlm.stVal	OPR_ALM	CB operations alarm	1=Alarm
		.OpCntLO.stVal	OPR_LO	CB operations lockout	1=Lockout
		.LonTmAlm.stVal	MON_ALM	CB inactive alarm	1=Alarm
		LD0.SSIGM1			
		.InsAlm.stVal	PRES_ALM	Low pressure alarm	1=Alarm
		.InsBlk.stVal	PRES_LO	Low pressure lockout	1=Lockout
		LD0.SSCBR1			
		.APwrAlm.stVal	IPOW_ALM	Lyt alarm	1=Alarm
		.APwrLO.stVal	IPOW_LO	Lyt lockout	1=Lockout
		.RmnNumOpAlm.stVal	CB_LIFE_ALM	CB lifetime alarm	1=Alarm
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.48 LD0.T1PTTR1 Three-phase thermal protection for feeders, cables and distribution transformers (1)

Table 70: LD0.T1PTTR1 Three-phase thermal protection for feeders, cables and distribution transformers (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.T1PTTR1			
		.Str.general	START	General start	1=Start
		.AlmThm.general	ALARM	Thermal alarm	1=Alarm

Table continues on next page

BitA	RegA	IEC 61850 name	SA name	Description	Values
		.Op.general	OPERATE	General operate	1=Operate
		.InEnaMult.stVal	ENA_MULT	Enable multiplier	1 = Active
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.49 LD0.TCSSCBR1 Trip circuit supervision (1)

Table 71: LD0.TCSSCBR1 Trip circuit supervision (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.TCSSCBR1			
		.CircAlm.stVal	ALARM	Supervision alarm	1=Alarm
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.50 LD0.TCSSCBR2 Trip circuit supervision (2)

Table 72: LD0.TCSSCBR2 Trip circuit supervision (2)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.TCSSCBR2			
		.CircAlm.stVal	ALARM	Supervision alarm	1=Alarm
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.51 LD0.TRPPTRC1 Master trip (1)

Table 73: LD0.TRPPTRC1 Master trip (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.TRPPTRC1			
		.Op.general	OPERATE	Op. input signal	1=Operate
		.Tr.general	TRIP	Trip output signal	1=Trip
		.Blk.stVal	BLOCK	Block signal	1 = ACTIVE
		.ClsLO.stVal	CL_LKOUT	CB lockout output	1 = ACTIVE

5.2.1.52 LD0.TRPPTRC2 Master trip (2)

Table 74: LD0.TRPPTRC2 Master trip (2)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.TRPPTRC2			
		.Op.general	OPERATE	Op. input signal	1=Operate
		.Tr.general	TRIP	Trip output signal	1=Trip
		.Blk.stVal	BLOCK	Block signal	1 = ACTIVE
		.ClsLO.stVal	CL_LKOUT	CB lockout output	1 = ACTIVE

5.2.1.53 LD0.VMMXU1 Three-phase voltage measurement (1)

Table 75: LD0.VMMXU1 Three-phase voltage measurement (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.VMMXU1			
		.HiAlm.stVal	HIGH_ALARM	High alarm	1=Alarm
		.HiWrn.stVal	HIGH_WARN	High warning	1=Warning
		.LoWrn.stVal	LOW_WARN	Low warning	1=Warning
		.LoAlm.stVal	LOW_ALARM	Low alarm	1=Alarm

5.2.1.54 LD0.MAPGAPC1 Multipurpose protection (1)

Table 76: LD0.MAPGAPC1 Multipurpose protection (1)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.MAPGAPC1			
		.Str.general	START	Stage start	1 = Start
		.Op.general	OPERATE	Stage operate	1 = Operate
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.55 LD0.MAPGAPC2 Multipurpose protection (2)

Table 77: LD0.MAPGAPC2 Multipurpose protection (2)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.MAPGAPC2			
		.Str.general	START	Stage start	1 = Start
		.Op.general	OPERATE	Stage operate	1 = Operate
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.56 LD0.MAPGAPC3 Multipurpose protection (3)

Table 78: LD0.MAPGAPC3 Multipurpose protection (3)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.MAPGAPC3			
		.Str.general	START	Stage start	1 = Start
		.Op.general	OPERATE	Stage operate	1 = Operate
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.57 LD0.MAPGAPC4 Multipurpose protection (4)

Table 79: LD0.MAPGAPC4 Multipurpose protection (4)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.MAPGAPC4			
		.Str.general	START	Stage start	1 = Start
		.Op.general	OPERATE	Stage operate	1 = Operate
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.58 LD0.MAPGAPC5 Multipurpose protection (5)

Table 80: LD0.MAPGAPC5 Multipurpose protection (5)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.MAPGAPC5			
		.Str.general	START	Stage start	1 = Start
		.Op.general	OPERATE	Stage operate	1 = Operate
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.59 LD0.MAPGAPC6 Multipurpose protection (6)

Table 81: LD0.MAPGAPC6 Multipurpose protection (6)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.MAPGAPC6			
		.Str.general	START	Stage start	1 = Start
		.Op.general	OPERATE	Stage operate	1 = Operate
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.60 LD0.MAPGAPC7 Multipurpose protection (7)

Table 82: LD0.MAPGAPC7 Multipurpose protection (7)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.MAPGAPC7			
		.Str.general	START	Stage start	1 = Start
		.Op.general	OPERATE	Stage operate	1 = Operate
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.61 LD0.MAPGAPC8 Multipurpose protection (8)

Table 83: LD0.MAPGAPC8 Multipurpose protection (8)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.MAPGAPC8			
		.Str.general	START	Stage start	1 = Start
		.Op.general	OPERATE	Stage operate	1 = Operate
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.62 LD0.MAPGAPC9 Multipurpose protection (9)

Table 84: LD0.MAPGAPC9 Multipurpose protection (9)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.MAPGAPC9			
		.Str.general	START	Stage start	1 = Start
		.Op.general	OPERATE	Stage operate	1 = Operate
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.63 LD0.MAPGAPC10 Multipurpose protection (10)

Table 85: LD0.MAPGAPC10 Multipurpose protection (10)

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.MAPGAPC10			
		.Str.general	START	Stage start	1 = Start
		.Op.general	OPERATE	Stage operate	1 = Operate
		.Blk.stVal	BLOCK	Block signal	1 = Active

5.2.1.64 LD0.LLN0

Table 86: LD0.LLN0

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.LLN0			
		.Mod.stVal	-	Device mode	
		.IndLEDRs.Oper.CtlVall	-	Indication LED reset	1 = Active
		.ProgLEDRs.Oper.CtlVall	-	Programmable LED reset	1 = Active
		.ActSetGr.stVal	-	Active Setting group status value	1...4
		.Act1SetGr.stVal	-	Status of Active Setting group 1	1 = Active
		.Act2SetGr.stVal	-	Status of Active Setting group 2	1 = Active

Table continues on next page

BitA	RegA	IEC 61850 name	SA name	Description	Values
		.Act3SetGr.stVal	-	Status of Active Setting group 3	1 = Active
		.Act4SetGr.stVal	-	Status of Active Setting group 4	1 = Active
		.LgcSelSetGr.stVal	-	Logic selection for setting group	1 = Active
		LD0.LPHD1			
		.NumPwrUp.stVal	-	No of power up of device	0...65535

5.2.1.65 LD0.LDEV1

Table 87: LD0.LDEV1

BitA	RegA	IEC 61850 name	SA name	Description	Values
		LD0.LDEV1			
		.ChgAckCnt.stVal		Number of composition changes	0...9999
		.ChgFlg.stVal		Life cycle traceability	1 = Active
		.WrmStrCmd.Oper.ctlVal		Reset of relay	1 = Active
		.FailTest.Oper.ctlVal		Internal fault test mode	1 = Active
		.EvtLstClr.Oper.ctlVal	Events	Clear events in HMI	1 = Active
		.DevWrn.stVal	Warning	Relay warning	1 = Active
		.DevFail.stVal	Internal Fault	Relay internal fault	1 = Active

5.3 Registers

Table 88: Explanations of columns in register tables

Column name	Description
RegA	Default 3X and 4X register address for the data
Type	Type of the register. The alternatives are u16, u32 (unsigned 16- and 32-bit integer) or i16, i32 (signed 16- and 32-bit integer).
Scale	Scale factor by default. Also, an adjustable offset value exists that is set to 0 by default.
IEC 61850 name	Original IED data object identification. Described in the IEC 61850 format as Logical Device.Logical Node and thereafter .Data Object.Data Attribute. Logical Node is the same as the application function block name.
SA name	The signal may have a defined label that is visible, for example, in Application Configuration in PCM600.
Description	Short description of the signal. See the technical manual for more information. Also, if a register is writable, it is stated here.
Values	The value range of the original IEC 61850 value, that is, before scaling

5.3.1 Premapped registers

All the premapped signals listed in this section are not listed in Communication Management in PCM600.

5.3.1.1 Active parameter setting group - write

Table 89: Active parameter setting group - write

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.LLN0			
2301	u16	1	.SGCB.ActSG		Selected Active Group	1...4

Reading the register 2301 results in response 0.

5.3.1.2 Control structure 1 - read and write

Table 90: Control structure 1 - read and write

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
7001	u16	1		-	Password reg 1	acc to setting
7002	u16	1		-	Password reg 2	acc to setting
7003	u16	1		-	Control register	< single bit >
7004	u16	1		-	Confirm register	< single bit >
7005	u16	1		-	Execute register	1

5.3.1.3 Control structure 2 - read and write

Table 91: Control structure 2 - read and write

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
7006	u16	1		-	Password reg 1	acc to setting
7007	u16	1		-	Password reg 2	acc to setting
7008	u16	1		-	Control register	< single bit >
7009	u16	1		-	Confirm register	< single bit >
7010	u16	1		-	Execute register	1

5.3.1.4 Device ID string - read

Table 92: Device ID string - read

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
9001	u16	1		-	ASCII coded string	1)
...		1				
9120	u16	1		-		

1) See the technical manual.

5.3.1.5 Protection relay's real-time clock (in local time mode) - read

Table 93: Protection relay's real-time clock (in local time mode) - read

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
9201	u16	1		-	Reserved	
9202	u16	1		-	Year	2000...2999
9203	u16	1		-	Month	1...12
9204	u16	1		-	Day	1...31
9205	u16	1		-	Hour	0...23
9206	u16	1		-	Minute	0...59
9207	u16	1		-	Second	0...59
9208	u16	1		-	Millisecond	0…999

5.3.1.6 Protection relay's real-time clock (in UTC time mode) - read

Table 94: Protection relay's real-time clock (in UTC time mode) - read

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
9211	u16	1		-	Reserved	
9212	u16	1		-	Year	2000...2999
9213	u16	1		-	Month	1...12
9214	u16	1		-	Day	1...31
9215	u16	1		-	Hour	0...23
9216	u16	1		-	Minute	0...59
9217	u16	1		-	Second	0...59
9218	u16	1		-	Millisecond	0…999

In REX610, the protection relay’s real-time clock on Modbus is restricted to reading the values. Write and synchronize are not supported.

5.3.1.7 SSR1 System status register (1) device health - read

Table 95: SSR1 System status register (1) device health - read

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
8001.00	Bit	1		-	Device global warning	1=Warning
8001.01	Bit	1		-	Device global error	1=Error
8001.02	Bit	1		-	Device test mode	1=Test mode
8001.03	Bit	1		-	00 : Remote 10 : Local 11: Off	
8001.04	Bit	1		-		
8001.05	Bit	1		-	Active setting parameter group(3 = LSB) 001: active setting grp 1 010: active setting grp 2 011: active setting grp 3 100: active setting grp 4	
8001.06	Bit	1				
8001.07	Bit	1				
8001.08	Bit	1		-	IED time synch failure	1=Failure
8001.09	Bit	1		-	Last reset cause a	1=Cold start
8001.10	Bit	1		-	Last reset cause b	1=Watchdog
8001.11	Bit	1		-	Last reset cause c	1=Warm start
8001.12	Bit				< reserved >	0
8001.13	Bit				< reserved >	0
8001.14	Bit				< reserved >	0
8001.15	Bit				< reserved >	0

5.3.1.8 SSR2 System status register (2) protection relay's mode and state - read

Table 96: SSR2 System status register (2) protection relay's mode and state - read

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
				-	Command Result code	
8002.00	Bit	1			-bit 0	
8002.01	Bit	1			-bit 1	
8002.02	Bit	1			-bit 2	
8002.03	Bit	1			-bit 3	
8002.04	Bit	1			-bit 4	
8002.05	Bit	1			-bit 5	
8002.06	Bit	1			-bit 6	
8002.07	Bit	1			-bit 7	
				-	Response Type	
8002.08	Bit	1			-bit 0	
8002.09	Bit	1			-bit 1	
				-	Command State	
8002.10	Bit	1			-bit 0	

Table continues on next page

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
8002.11	Bit	1			-bit 1	
				-	Client Command seq number	
8002.12	Bit	1			-bit 0	
8002.13	Bit	1			-bit 1	
8002.14	Bit	1			-bit 2	
8002.15	Bit	1			-bit 3	

5.3.1.9 LD0.DIOAGGIO1 Physical I/O states (BIO card) - read

Table 97: LD0.DIOAGGIO1 Physical I/O states (BIO card) - read

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.DIOAGGIO1			
8010			.Ind1.stVal		Input 1 State	0= OFF/ 1=ON
8011			.Ind2.stVal		Input 2 State	0= OFF/ 1=ON
8012			.Ind3.stVal		Input 3 State	0= OFF/ 1=ON
8013			.Ind4.stVal		Input 4 State	0= OFF/ 1=ON
8014			.Ind5.stVal		Input 5 State	0= OFF/ 1=ON
8015			.Ind6.stVal		Input 6 State	0= OFF/ 1=ON
8016			.SPCSO1.stVal		Output 1 State	0= OFF/ 1=ON
8017			.SPCSO2.stVal		Output 2 State	0= OFF/ 1=ON
8018			.SPCSO4.stVal		Output 4 State	0= OFF/ 1=ON
8019			.SPCSO5.stVal		Output 5 State	0= OFF/ 1=ON

Registers 8010...8019 should be read as 0X or 1X register (Coil or Discrete Input).

5.3.1.10 LD0.PSUAGGIO1 Physical I/O states (PSM card) - read

Table 98: LD0.PSUAGGIO1 Physical I/O states (PSM card) - read

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.PSUAGGIO1			0= OFF/ 1=ON
8020			.Ind1.stVal		Input 1 State	0= OFF/ 1=ON
8021			.Ind2.stVal		Input 2 State	0= OFF/ 1=ON
8022			.SPCSO1.stVal		Output 1 State	0= OFF/ 1=ON
8023			.SPCSO2.stVal		Output 2 State	

Registers 8020...8023 should be read as 0X or 1X register (Coil or Discrete Input).

5.3.2 Unmapped registers

Unmapped registers are register data that has no initial Modbus mapping locations, but can be added to the user-definable Modbus area using Communication Management in PCM600. The initial register type settings of these objects have little meaning, since it is always possible to redefine the settings completely for the user-definable register.

5.3.2.1 CTRL.LLN0 Local, Remote, Station, Off and Combinations

Table 99: CTRL.LLN0 Local, Remote, Station, Off and Combinations

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
			CTRL.LLN0.			
	u26	1	.LocKeyHMI.stVal		Local remote status	0=OFF/ 1=Local/ 2=Remote/4= L+R

5.3.2.2 LD0.LLN0/LPHD1/LDEV1 System values

Table 100: LD0.LLN0/LPHD1/LDEV1 System values

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.LLN0			
	u16	1	.ParChgCnt.stVal		Num. of setting changes	0…65535

5.3.2.3 System diagnostic values

Table 101: System diagnostic values

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.LDEV1			
	u16	1	.DevWrn.stVal	Warning	Last warning code	1)
	u16	1	.DevFail.stVal	Internal fault	Last internal fault code	1)
			DR.RDRE1			
	u16	1	.FltNum.stVal	-	Num. of DR recordings	0...N
	u16	1	.MemUsed.stVal	-	DR memory used	0...100 [%]
			.RcdMade.stVal		Recording made	
			.RcdTrg.Oper.ctlVal		Manual Trig recording	1=Trigger
			.MemClr.Oper.ctlVal		Record clear	1=Clear
			.RcdStr.stVal		Record started status	1=started
			.RmnRcdCap.stVal		Rem. amount of rec.	0...100
			.PerTmRmn.stVal		Time remaining to the next periodic trigger	0...604800
			.RcdDltInd.stVal		Record deletion indication	1 = deleted
			.MemFullSt.stVal		DR memory full indication	1 = mem full
			.OvWrRcdInd.stVal		Record overwrite indication	1 = overwritten
			.PerTrgInd.stVal		Periodic trigger indication	1 = triggered
			.ManTrgInd. stVal		Manual trigger indication	1 = triggered
			LD0.LPHD1			
	u16	1	.NumPwrUp.stVal	-	Num. of cold starts	0...65535
	u16	1	.WrmStr.stVal	-	Num. of warm starts	0...65535
			LD0.LDEV1			
	u16	1	.ChgAckCnt.stVal	-	Num. of conf. changes	0...65535
			LD0.LLN0			
	u16	1	.ParChgCnt.stVal	-	Num. of setting changes	0…65535

1) See the technical manual

5.3.2.4 CTRL.CBCSWI1 Circuit breaker operation counter (1)

Table 102: CTRL.CBCSWI1 Circuit breaker operation counter (1)

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
			CTRL.CBCSWI1			
	u16	1	.OpCnt.stVal	Operation counter	Operation counter	0…65535

5.3.2.5 LD0.CMMXU1 Three-phase current measurement (1)

Table 103: LD0.CMMXU1 Three-phase current measurement (1)

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.CMMXU1		Phase current (1)	
	u16	1000	.A.phsA.instCVal.mag.f	I_INST_A	Phs A amplitude	0.00...40.0 [xIn]
	u16	1000	.A.phsB.instCVal.mag.f	I_INST_B	Phs B amplitude	0.00...40.0 [xIn]
	u16	1000	.A.phsC.instCVal.mag.f	I_INST_C	Phs C amplitude	0.00...40.0 [xIn]

5.3.2.6 LD0.CSMSQI1 Sequence current measurement (1)

Table 104: LD0.CSMSQI1 Sequence current measurement (1)

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.CSMSQI1		Sequence of currents	
	u16	1000	.SeqA.c1.instCVal.mag	I1_INST	Positive amplitude	0.00...40.0 [xIn]
	u16	1000	.SeqA.c2.instCVal.mag	I2_INST	Negative amplitude	0.00...40.0 [xIn]
	u16	1000	.SeqA.c2.instCVal.mag	I3_INST	Zero amplitude	0.00...40.0 [xIn]

5.3.2.7 LD0.DARREC1 Autoreclosing counters (1)

Table 105: LD0.DARREC1 Autoreclosing counters (1)

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.DARREC1			
	u16	1	.RecCnt1.stVal	CNT_SHOT1	AR 1st shot counter	0...65535
	u16	1	.RecCnt2.stVal	CNT_SHOT2	AR 2nd shot counter	0...65535
	u16	1	.RecCnt3.stVal	CNT_SHOT3	AR 3rd shot counter	0...65535
	u16	1	.RecCnt4.stVal	CNT_SHOT4	AR 4th shot counter	0...65535
	u16	1	.RecCnt5.stVal	CNT_SHOT5	AR 5th shot counter	0...65535
	u16	1	.FrqOpCnt.stVal	FRQ_OPR_CNT	AP freq. op. counter	0...65535

5.3.2.8 LD0.DARREC1 Autoreclosing values (1)

Table 106: LD0.DARREC1 Autoreclosing values (1)

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.DARREC1			
	i16	1	.AutoRecSt.stVal	STATUS	AR state	-2...4[1)]
	u16	1	.ShotPntr.stVal	SHOT_PTR	AR shot pointer value	0...6
	u16	1	.OpCntRs.stVal	COUNTER	AR operation counter	0...65535

1) See the technical manual.

5.3.2.9 LD0.RESCMMXU1 Residual current measurement (1)

Table 107: LD0.RESCMMXU1 Residual current measurement (1)

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.RESCMMXU1		Residual current (1)	
	u16	1000	.A.res.instCVal.mag	I0_INST	- amplitude	0.00...40.0 [xIn]

5.3.2.10 LD0.RESVMMXU1 Residual voltage measurement (1)

Table 108: LD0.RESVMMXU1 Residual voltage measurement (1)

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.RESVMMXU1		Residual voltage (1)	
	u16	1000	.A.res.instCVal.mag	U0_INST	- amplitude	0.00...4.00 [xUn]

5.3.2.11 LD0.SSCBR1 Circuit-breaker condition monitoring (1)

Table 109: LD0.SSCBR1 Circuit-breaker condition monitoring (1)

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.SSCBR1			
	u16	1	.InaTmdCnt.stVal	INA_DAYS	CB inactive days	0...9999
	u16	1	.OpTmOpn.mag	T_TRV_OP	Open travel time	0...60000 [ms]
	u16	1	.OpTmCls.mag	T_TRV_CL	Close travel time	0...60000 [ms]
			.OpCntRs.stVal	NO_OPR	Number of CB operation cycle	0...99999
			LD0.SSOPM1			
	u16	100	.TmsSprCha.mag	T_SPR_CHR	Spring charge time	0.00…99.99 [s]
			LD0.SPH1SCBR1			
	i16	1	.RmnNumOp.stVal	CB_LIFE_A	Remain.life phs A	-/+ 9999

Table continues on next page

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.SPH2SCBR1			
	i16	1	.RmnNumOp.stVal	CB_LIFE_B	Remain.life phs B	-/+ 9999
			LD0.SPH3SCBR1			
	i16	1	.RmnNumOp.stVal	CB_LIFE_C	Remain.life phs C	-/+ 9999
			LD0.SPH1SCBR1			
	u16	1	.AccmAPwr.mag	IPOW_A	Iyt phs A	0...1E6
			LD0.SPH2SCBR1			
	u16	1	.AccmAPwr.mag	IPOW_B	Iyt phs B	0...1E6
			LD0.SPH3SCBR1			
	u16	1	.AccmAPwr.mag	IPOW_C	Iyt phs C	0...1E6

5.3.2.12 LD0.T1PTTR1 Three-phase thermal protection for feeders, cables and distribution transformers (1)

Table 110: LD0.T1PTTR1 Three-phase thermal protection for feeders, cables and distribution transformers (1)

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.T1PTTR1			
	i16	1	.Tmp.mag	TEMP	Object temperature	-100.0… 9999.9 [C]
	u16	1	.TmpRl.mag	TEMP_RL	Relative temperature	0.00…99.99 [C]
	i16	1	.TmpUsed.mag	TEMP_AMB	Ambient temperature	-99…999.99 [C]
	u16	1	.OpTm.stVal	T_OPERATE	Time to operate	0…60000 [s]
	u16	1	.BlkThmRsTm.stVal	T_ENA_CLOSE	Time to deactivate block	0…60000 [s]

5.3.2.13 LD0.VMMXU1 Three-phase voltage measurement (1)

Table 111: LD0.VMMXU1 Three-phase voltage measurement (1)

RegA	Type	Scale	IEC 61850 name	SA name	Description	Values
			LD0.VMMXU1		Phase-ground voltage (1)	
	u16	1000	.phV.phsA.cVal.mag	U_DB_A	- Phs A amplitude	0.00...4.00 [xUn]
	u16	1000	.phV.phsB.cVal.mag	U_DB_B	- Phs B amplitude	0.00...4.00 [xUn]
	u16	1000	.phV.phsC.cVal.mag	U_DB_C	- Phs C amplitude	0.00...4.00 [xUn]

5.4 Controls

Table 112: Explanations of the controls table columns

Column name	Description
0xA	User-defined 0x coil register
CS	Control structure and bit within the structure for control value
IEC 61850 name	Original IED data object identification. Described in the IEC 61850 format as Logical Device.Logical Node and thereafter .Data Object.Data Attribute. Logical Node is the same as the application function block name.
SA name	The signal may have a defined label that is visible, for example, in Application Configuration in PCM600.
Description	Short description of the signal. See the technical manual for more information.
Value	Meaning of the written value

5.4.1 Reset, acknowledge and trigger points

Table 113: Reset, acknowledge and trigger points

0xA	CS	IEC 61850 name	SA name	Description	Values
		LD0.LLN0			
	2	.IndLEDRs.Oper.ctlVal	-	Reset indications and LEDs	1=Reset
	2.01	.ProgLEDRs.Oper.ctlVal	-	Reset Alarm LEDs	1=Reset
		DR.RDRE1			
	2.02	.RcdTrg.Oper.ctlVal	-	Trig DR recording	1=Trig
	2.03	.MemClr.Oper.ctlVal	-	Clear DR memory	1=Clear
		LD0.DARREC1			
	2.04	.RecRs.Oper.ctlVal	-	Reset reclosing	1=Activate
	2.05	.CntRs.Oper.ctlVal	-	Reset reclosing counters	1=Activate
		LD0.SSCBR1			
	2.06	.RsAccmAPwr.Oper.ctlVal	-	Reset accumulation energy	1=Activate
	2.07	.RsCBWear.Oper.ctlVal	-	Reset input for CB remaining life and operation counter	1=Activate
	2.08	.RsTrvTm.Oper.ctlVal	-		
		LD0.SSOPM1		Reset travelling time alarm	1=Activate
	2.09	.RsSprChaTm.Oper.ctlVal	-	Reset spring charge time alarm	1=Activate
	2.1	Reserved			
	2.11	Reserved			
	2.12	Reserved			
	2.13	Reserved			
	2.14	Reserved			
	2.15	Reserved			

Table continues on next page

0xA	CS	IEC 61850 name	SA name	Description	Values
		LD0.LDEV1			
		.EvtLstClr.Oper.ctlVal		Event log clear	1=Active
		LD0.LLN0			
		.Mod.Oper.ctlVal		Test mode	1=Normal mode 2=IED blocked 3=IED test 4=IED test and blocked
		LD0.LDEV1			1=Active
		.WrmStrCmd.Oper.ctlVal		Software reset	1=Active
		LD0.LDEV1			
		.FailTest.Oper.ctlVal		Internal fault test	1=Active
		LD0.TRPPTRC1			
		.LORs.Oper.ctlVal		Lock out reset	1=Active
		.TrRs.Oper.ctlVal		Trip reset	1=Active
		CTRL.CBCSWI1			
		.OpCntRs.Oper.ctlVal		CB operation counter reset	1=Active

5.4.2 CTRL.CBCSWI1 Circuit breaker control (1)

Table 114: CTRL.CBCSWI1 Circuit breaker control (1)

0xA	CS	IEC 61850 name	SA name	Description	Values
		CTRL.CBCSWI1	POSITION		
	1.00	.Pos.Oper.ctlVal	-	Select open	1=Select
	1.01	.Pos.Oper.ctlVal	-	Select close	1=Select
	1.02	.Pos.Oper.ctlVal	-	Cancel selection	1=Cancel
	1.03	.Pos.Oper.ctlVal	-	Execute selection	1=Execute
	1.04	.Pos.Oper.ctlVal	-	Direct open	1=Open
	1.05	.Pos.Oper.ctlVal	-	Direct close	1=Close

Section 6 Glossary

AI	Analog input
EMC	Electromagnetic compatibility
Ethernet	A standard for connecting a family of frame-based computer networking technologies into a LAN
HMI	Human-machine interface
IEC	International Electrotechnical Commission
IEC 61850	International standard for substation communication and modeling
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.
LED	Light-emitting diode
LHMI	Local human-machine interface
LSB	Least significant bit
MCB	Miniature circuit breaker
Modbus	A serial communication protocol developed by the Modicon company in 1979. Originally used for communication in PLCs and RTU devices.
Modbus ASCII	Link mode using 7-bit ASCII characters
Modbus memory map	Allocation of accessible protocol data
Modbus RTU	Link mode using 8-bit binary characters
Modbus TCP/IP	Modbus RTU protocol which uses TCP/IP and Ethernet to carry data between devices
MOM	Momentary position
PCM600	Protection and Control IED Manager
PLC	Programmable logic controller
RTU	Remote terminal unit
Rx	Receive/Received
SBO	Select-before-operate

SCADA	Supervision, control and data acquisition
SI	Sensor input
SSR1	System status register for device health
SSR2	System status register for device mode
SSRx	System status register
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol
Tx	Transmit/Transmitted
UD	User-definable
UDB	User-definable bit
UDR	User-definable register
UTC	Coordinated universal time

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