RELION® PRODUCT FAMILY

Grid Automation
REC615 and RER615
IEC 60870-5-101/104 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

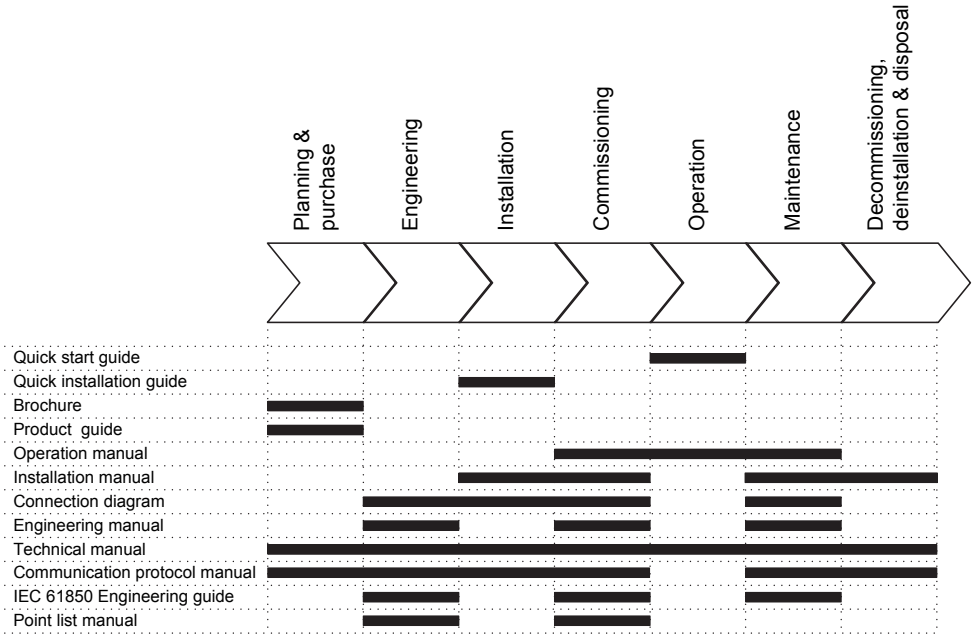

Figure 1: The intended use of documents during the product life cycle

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

1.3.2 Document revision history

Document revision/date	Product version	History
A/2018-08-31	2.0	First release

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

1.3.3 Related documentation

Name of the document	Document ID
Modbus Communication Protocol Manual	1MRS758758
DNP3 Communication Protocol Manual	1MRS758757
IEC 61850 Engineering Guide	1MRS757809
Engineering Manual	1MRS757810
Installation Manual	1MRS757799
Operation Manual	1MRS758754
Technical Manual	1MRS758755

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

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.
- The example figures illustrate the IEC display variant.
- 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.

Section 2 IEC 60870-5 overview

2.1 IEC 60870-5 protocol

The companion standards IEC 60870-5-101 and IEC 60870-5-104 are derived from the IEC 60870-5 protocol standard definition. It specifies a functional profile for basic telecontrol tasks.

The IEC 60870-5 protocol stack is based on the reduced reference model called enhanced performance architecture (EPA). EPA includes three layers of the ISO-OSI model.

- Application layer
- Link layer
- Physical layer

The IEC 60870-5 protocol is described by standard documents.

Table 1: Selected standard provision of the defined telecontrol companion standard

Selected application functions of IEC 60870-5-5	User process
Selected application information elements of IEC 60870-5-4 Selected application service data units of IEC 60870-5-3	Application layer (7)
Selected link transmission procedures of IEC 60870-5-2 Selected transmission frame formats of IEC 60870-5-1	Link layer (2)
Selected ITU-T recommendations	Physical layer (1)

Application layer defines the information elements for structuring application data and the communication service functions. The user process describes an assortment of basic application functions.

Link layer defines the frame formats and the transmission procedures of the IEC communication.

Physical layer defines the hardware-dependent specifications of the IEC 60870-5-101/IEC 60870-5-104 communication interfaces.

2.2 Transmission

IEC 60870-5-101 allows two alternative transmission procedures, an unbalanced and balanced, to be used in the communication between the controlling station (SCADA system) and the controlled outstation.

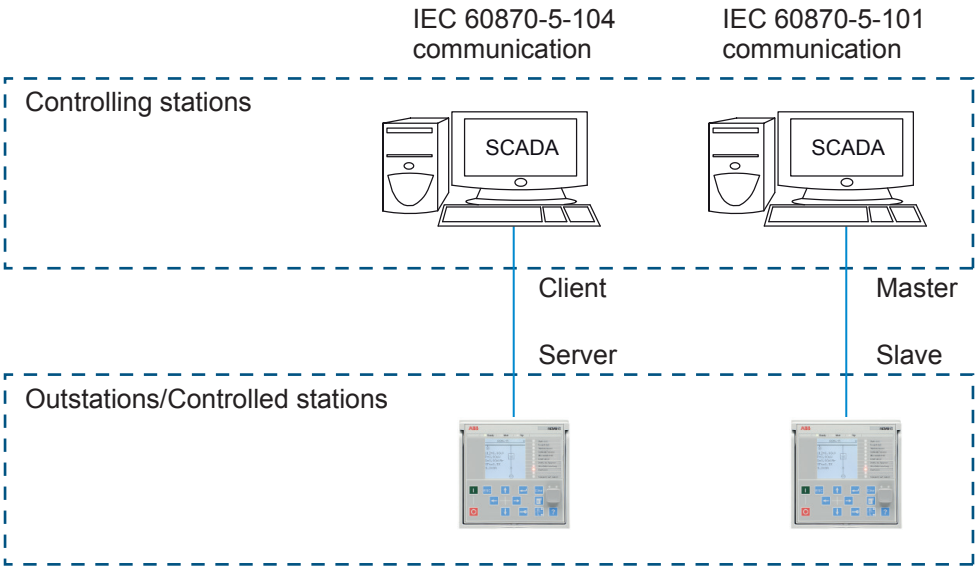

Figure 2: Controlling stations and controlled stations in IEC 60870-5-101/104 communication

In this manual the master device is referred to as the controlling station or the client and the slave. The slave device in turn as the outstation, controlled station or server. Terms vary depending on the IEC 60870-5-101 or IEC 60870-5-104 communication or on the balanced or unbalanced mode.

2.2.1 Unbalanced transmission

When using unbalanced transmission, the controlling station controls the data traffic by polling the controlled outstations sequentially. In this case, the controlling station initiates all the message transfers while the controlled outstations can transmit only in response to the message from the controlling station.

Table 2: Supported transmission services initiated by the controlling station

Service	Purpose
SEND/NO REPLY	For global messages and for cyclic set-point commands from the controlling station
SEND/CONFIRM	For control commands and set-point commands from the controlling station
REQUEST/RESPOND	For polling data from the controlled outstations

2.2.2 Balanced transmission

When using balanced transmission, each station can initiate message transfer. The stations may act simultaneously as controlling stations and controlled outstations.

Therefore they are called combined stations. In this manual, a combined station is called either a controlling station or a controlled outstation according to its function in the message exchange.

The balanced transmission is restricted to point-to-point and to multiple point-to-point configurations.

The balanced transmission supports SEND/CONFIRM and SEND/NO REPLY transmission services. The SEND/NO REPLY transmission service can be initiated only by a controlling station with a broadcast address in a multiple point-to-point configuration.

2.3 Basic application functions

2.3.1 Data acquisition

The data delivered by a controlled outstation can be replies to commands or process values which are collected cyclically, upon change, or upon request from the controlling station.

All the data is buffered in the controlled outstation because the data may appear faster than the communication link is able to transfer it to the controlling station.

When unbalanced transmission is used on the link layer, the buffered data must be polled by the controlling station. The controlled outstation must always wait for a request for transmission from the controlling station.

When balanced transmission is used on the link layer, the buffered data is transmitted by the controlled outstation to the controlling station without a delay.

2.3.2 Event acquisition

Events occur spontaneously at the controlled outstation's application level. The events are buffered in the controlled outstation because the events may appear faster than the communication link is able to transfer them.

When unbalanced transmission is used on the link layer, the buffered events must be polled by the controlling station. The controlled outstation must always wait for a request for transmission from the controlling station.

When balanced transmission is used on the link layer, the buffered events are sequentially, without a delay, transmitted by the controlled outstation to the controlling station.

2.3.3 Interrogation

The controlled outstation's interrogation function is used for updating the controlling station after an internal station initialization, or when the controlling station detects loss of information.

When the function is used, the controlling station requests the controlled outstations to transmit the actual values of all their process variables. Normally, the amount of information is known by the application functions in both the controlling stations and controlled outstations. The interrogation can be done either by an interrogation group (1…16) at a time or all groups at once (general).

2.3.4 Clock synchronization

The clock of the controlled outstation has to be synchronized with the clock of the controlling station. Clock synchronization provides accurate time tags for events and information objects that are transmitted to the controlling station or logged locally.

After system initialization, the clocks are initially synchronized by the controlling station. After that, the clocks are periodically resynchronized by transmission of a clock synchronization command (C_CS ACT).

The time information must always be corrected either by the controlling station before sending or by the outstation when an ASDU with a time tag is received. A delay acquisition command can be used to define the measured or estimated transmission delay in the outstation. The command provides time compensation for the transmission time on the outstation.

2.3.5 Command transmission

A command is used in telecontrol systems to change the state of operational equipment, for example, a circuit breaker or a disconnector. A command may be initiated by an operator or by automatic supervisory procedures in the controlling station. Provision against unauthorized access or against unwanted actions are system- or process-dependent.

The two standard procedures for command transmission are Direct command and Select and execute command.

Direct commands are used by the controlling station to immediately control operations in the controlled outstations. For safety reasons, the controlled outstation's application function checks the permissibility and the validity of the received command message and operates if the check results are positive.

The two-step command Select and execute is used for a number of things.

- Prepare a specified control operation in a controlled outstation
- Check that the correct control operation is prepared
- Execute the command

The preparation is checked by an operator or by an application procedure. The controlled outstation does not start the control operation until it has received the correct execution indication. The command transmission is confirmed to the controlled outstation by an activation confirmation response. After the command is executed, an activation termination response is sent to the controlling station.

2.3.6 Transmission of integrated totals

An integrated total is a value that is integrated over a specified time period. The specific clock times and the periodic time interval of successive acquisitions of the integrated totals are system parameters. There are two methods for acquiring counter information.

- Acquisition of integrated totals (Freeze-and-Read)
- Acquisition of incremental information (Clear-and-Read)

2.3.7 Changes in protocol and link parameters

When the values of the protocol and link parameters are changed, the new values take effect after they have been committed.

2.3.8 Acquisition of transmission delay

The value of time correction is determined by the sum of the transmission delay and the internal equipment delay. The transmission delay is a value which can be acquired either separately by parameterization, or via a dynamic procedure initiated by the controlling station.

Section 3 Vendor-specific implementation

3.1 Product series implementation

3.1.1 Internal IEC 61850 data modeling

The protection relay is natively using the IEC 61850 data model for data processing. In practice, some data which is not used by the system database might not be available. Furthermore, the data must be enabled in an IEC 61850 data set to be able to be reported by IEC 60870-5-101/104.

3.1.2 Instances

The protocol can be run as multiple instances. Each instance has its own database and therefore all the data accesses are independently managed. For example, if a client is not available for event receiving, that does not affect the data buffering for other clients.

Every instance has independent configuration and data object mapping. It is possible to build a configuration where the amount of information objects is different for the clients. For example, a client with slow connection receives only the most important data.

Currently the maximum number of instances is two.

3.1.3 Selecting between IEC 60870-5-101 and IEC 60870-5-104

All available protocol instances support both the IEC 60870-5-101 and IEC 60870-5-104 communication. The communication is selected in the *Port configuration* parameter.

Some parameters are applicable only to either one of the protocols.

3.2 Configuring

In this document it is assumed that all unmentioned setting parameters remain at their default values.

3.2.1 Configuring IEC 60870-5-101

To configure one protocol instance to work as IEC 60870-5-101 slave, configure the parameters to enable basic communication.

- *Port*
  According to the physical wiring, set either to "IEC101-COM1" or "IEC101-COM2". Set the correct serial mode and communication baud rate under COM1/COM2 settings.
  Check the communication card jumpers. See the technical manual for details.
- *Device Address*
  Set to match the address set in the master.
- *ASDU Address*
  Usually *ASDU Address* is the same as device address.
- *Link Mode*
  If the system is configured to use unbalanced communication, set *Link Mode* to "Unbalanced". Otherwise, no change is needed.
- *COT Length*
  Usually set to 1. This setting must have the same value in the master and slave devices.
- *IOA Length*
  Usually, set to 2. This setting must have the same value in the master and slave devices.
- *Link Address Length*
  Usually set to 1. This setting must have the same value in the master and slave devices.
- *ASDU Address Length*
  Usually set to 1. This setting must have the same value in the master and slave devices.

3.2.2 Configuring IEC 60870-5-104

To configure one protocol instance to work as the IEC 60870-5-104 server, configure the parameters to enable basic communication.

- *Port*
  Set to "IEC104 - Ethernet".
- *Client IP*
  Set to match the IP address of the client device.
- *ASDU Address*

Set to match the address set in the client.

- *COT Length*
  Usually set to 2. This setting must have the same value in the client and server devices.
- *IOA Length*
  Usually, set to 3. This setting must have the same value in the client and server devices.
- *Link Address Length*
  Usually set to 2. This setting must have the same value in the client and server devices.
- *ASDU Address Length*
  Usually set to 2. This setting must have the same value in the client and server devices.

3.2.3 Troubleshooting

After setting the communication parameters correctly, check the communication.

- Use the communication card LEDs to diagnose if the messages are transmitted and received.
- Check the diagnostics counters available in the protection relay's Monitoring section.
- Check also that the other settings for the protocol instance match the controlling station database configuration.

3.3 Event overflow handling

The IEC 60870-5-101/104 standard does not specify any particular method for detecting event overflows. In this protection relay, special single-point indication objects have been defined for this purpose.

The protection relay can store up to 500 IEC 60870-5-101/104 events per object type.

3.3.1 Overflow mode

The protocol instance can be configured to keep either the newest or the oldest events in case of buffer overflow. The event buffer overflows typically in a situation where a lot of signals change at the same time and the controlling station is not able to fetch all the event reports quickly enough. In these cases, the events that occurred in that critical moment are the most important. It is recommended to use the mode for keeping the oldest events. In addition, in this mode the protection relay can be configured to generate an event buffer overflow indication. After receiving overflow

indication, the controlling station can interrogate the protection relay to ensure data integrity.

3.3.2 Overflow indication addresses

If the mode for keeping the oldest events is enabled, the protection relay sends an event buffer overflow indication. If the lost event is included in the interrogation list, the protection relay sends the indication event with the address configured as “OvInd IOA”. If the data is not available for interrogation, the protection relay uses address configured as “OvInd NoGI IOA”. Both indications are sent if there are multiple events lost fulfilling both of the criteria.

Knowing that the missed data is not included in the interrogation list, the controlling station can skip interrogation. If the addresses are configured as same (default), only one indication is sent regardless if the data is included in the interrogation or not.

3.3.3 Overflow situation clearing

Overflow situation clearing is applicable only for the mode for keeping oldest events.

After the event buffer overflow is cleared, the protection relay discards new events for three seconds to allow the controlling station to start fetching the events and to free space in the event buffer. Otherwise, the event buffer overflows immediately again and the communication is disturbed more.

3.4 Supported data types

The available IEC 60870-5-101/104 application data objects in this protection relay have been premapped to some default addresses. In any case, by using the Communication Management tool in PCM600, the objects inside the 16 bit protocol address space can be freely removed, added or relocated.

3.4.1 Indications (MSP, MDP)

The protection relay supports both single and double-bit indications with a configurable time stamp format.

Table 3: Information type for point indications

Type	Label	Information object	Time stamp format
1	M_SP_NA_1	Single-point information	
2	M_SP_TA_1	Single-point information with time	Short
30	M_SP_TB_1	Single-point information with CP56Time2a time	Full
3	M_DP_NA_1	Double-point information	
4	M_DP_TA_1	Double-point information with time	Short
31	M_DP_TB_1	Double-point information with CP56Time2a time	Full

3.4.2 Measurements (MMENA, MMENB, MMENC, MMEND)

Measurements related to current and voltage values are transmitted as primary values by default. However, with the Communication Management tool in PCM600 it is possible to change the measurements into relative pu values. Additionally, the Communication Management tool also provides a separate rescaling option for all of the analog values.

Futhermore, it is possible to define how the data is to be transmitted, that is, either as change events or cyclical data. With change event, it is possible to add an additional deadband and a sending interval for the transmission. The sending interval guarantees that data is not transmitted more often than defined by the interval setting.

Table 4: Information type for measured values

Type	Label	Information object	Time stamp format
13	M_ME_NC_1	Measured value, short float32 value	
36	M_ME_TC_1	Measured value, short float32 value with CP56Time2a time	Full
9	M_ME_NA_1	Measured value, normalized value	
10	M_ME_TA_1	Measured value, normalized value with time	Short
34	M_ME_TD_1	Measured value, normalized value with CP56Time2a time	Full
Table continues on next page			

Type	Label	Information object	Time stamp format
11	M_ME_NB_1	Measured value, scaled value	
12	M_ME_TB_1	Measured value, scaled value with time	Short
35	M_ME_TE_1	Measured value, scaled value with CP56Time2a time	Full

The time format can be changed to "short time" in case of an older IEC 60870-5-101 system that does not support floating-point measured values or full CP56Time2a time.

3.4.3 Control objects (CSC, CDC)

Two types of control objects are available. Single-bit controls are normally used for setting group selection and clearing the indication LEDs or recorded data.

Double-bit controls relate to circuit breaker or disconnector controlling. The controllable object can be configured to be in the direct or the select-before-operate (SBOW) mode. The IEC 60870-5-101/104 implementation allows both controlling mechanisms in both cases.

A command can be rejected for several reasons.

- Control direction is wrong.
- Legal values for double-bit controls are 1 and 2. Both 0 and 3 are rejected.
- Control object is set to "Status-only".
- Control operation is rejected by the controllable object itself because of, for example, interlocking.

Table 5: Information type for control objects

Type	Label	Information object
45	C_SC_NA_1	Single command
46	C_DC_NA_1	Double command

3.4.4 Packed protection events (MEPTB, MEPTC)

The protection pickup/trip signals are reported as packed protection events.

3.4.5 Integrated totals (MIT)

The values of the integrated totals' counter follow the range of the IEC 61850 level source counters. Therefore, the counter rollover value may not be the maximum integer value, which usually is assumed in this protocol.

Through the Communication Management tool in PCM600, the integrated totals' counters may freely be located to any integrated totals' group. Counters within the same group can be reset at the same time. On the IEC 61850 level, several counters can be tied to the same reset command point. If this is the case, the counters are reset as one group, even if they reside in different integrated totals' groups. Information about the reset being done point-wise or for the whole LN at a time can be found in the IEC 61850 data model.

Table 6: Commands

Operation	Description
Read	The reading operation causes the integrated totals to be interrogated. The protection relay sends the values after the Read command.
Reset	The integrated totals can be cleared by the Reset command. The Reset command is not only for IEC 60870-5-101/104. It clears the counter values globally in the protection relay.
Freeze	With the Freeze command, the protection relay copies the momentary values and stores them as frozen. Later, the frozen values can be read with the Read command.

Table 7: Information type for integrated totals

Type	Label	Information object	Time stamp format
15	M_IT_NA_1	Integrated totals	
16	M_IT_TA_1	Integrated totals with time	Short
37	M_IT_TB_1	Integrated totals with CP56Time2a time	Full

The counters can be configured to be reset one group at a time. However, the grouping might be limited internally so that multiple counters are tied to the same reset command point. In this case, those counters are reset as one group, even if they are set to different groups in the Communication Management tool. Information about the reset being done point-wise or for the whole LN at a time can be found in the IEC 61850 data model.

3.5 Addressing scheme

3.5.1 Default addresses

There are some protection functions which are not available in this protection relay, but might be available in other protection relays in the product series. The main principle is to keep the data mapped in a consistent way in the whole product series, which means that there are some gaps in the address range. The addresses are laid in a structured form to have a different address range for the different information object types. Some data points may be unused by default and thus no default address is defined for them.

3.5.2 Configuring communication options

- Configure the communication options by using LHMI, WHMI or PCM600 to set the parameters in **Configuration/Communication/IEC60870-5-101/104**.
- For remapping the data object, use the Communication Management tool in PCM600.

3.6 Communication parameters

All the parameter names have a number in the end of the caption. The setting affects only to the protocol instance marked by the number.

3.6.1 Port

- NONE (default)
- IEC101 - COM1
- IEC101 - COM2
- IEC104 - Ethernet

The setting enables/disables the protocol instance and defines the link layer.

3.6.2 ClientIP

Applicable for IEC 60870-5-104 only.

The setting defines the IP address of the client. If the protocol instance is enabled, the *ClientIP* setting must be different from other instances' ClientIPs. The meaning of the parameter depends on the link mode.

In the balanced mode, *ClientIP* is the address where the protection relay tries to connect when the communication is started. Once connected, the communication continues with that client.

In the unbalanced mode, *ClientIP* defines the address from where the client's communication initiative is accepted. If the protocol instance's *ClientIP* setting does not match with the client's, the protection relay does not respond.

3.6.3 End delay

Applicable for IEC 60870-5-101 only.

- Min: 0
- Max: 20
- Default: 4
- Unit: characters at the current baud rate

The setting defines the maximum allowed time between the characters in the IEC101 frame. If this setting is too low, the protection relay may interpret incoming message as multiple frames, which causes discarding of the frame. If the link uses, for example, radio modem, it might be needed to adjust the *End delay* setting to a higher value. The delay time is defined in characters at the current baud rate.

3.6.4 Device address

- Min: 1
- Max: 255/65535
- Default: 1

The *address* setting is the identification number of the device. This setting must match the address defined in the controlling station configuration. The maximum value of this setting depends on the link address length.

3.6.5 ASDU address

- Min: 1
- Max: 255/65535
- Default: 1

Each device on the communication network has a common address of ASDU. The *ASDU address* setting must match the address defined in the controlling station configuration. The maximum value of this setting depends on the ASDU address length.

3.6.6 Link mode

- Unbalanced (default)
- Balanced

The setting defines the link mode. In the unbalanced mode, the protection relay listens for the controlling station commands and responds when needed. In the balanced mode, the protection relay opens the connection and sends a spontaneous report when something happens.

3.6.7 COT length

- Min: 1
- Max: 2
- Default: 1
- Unit: bytes

Many communication frames include the cause of transmission information (COT). The length of COT element is configurable and should be set to same value throughout the network. Typical values are ‘1’ for IEC 60870-5-101 and ‘2’ for IEC 60870-5-104.

3.6.8 IOA length

- Min: 1
- Max: 3
- Default: 2
- Unit: bytes

For the communication frames, the information object address (IOA) length is configurable and should be set to the same value throughout the network. Typical values are “2” for IEC 60870-5-101 and “3” for IEC 60870-5-104.

3.6.9 Link address length

- Min: 1
- Max: 2
- Default: 1
- Unit: bytes

In a communication frame, the destination address is defined. The length of a link address element is configurable and should be set to same value throughout the network. Typical values are “1” for IEC 60870-5-101 and “2” for IEC 60870-5-104.

3.6.10 ASDU address length

- Min: 1
- Max: 2
- Default: 1
- Unit: bytes

In some communication frames, the ASDU address is defined. The length of an ASDU address element is configurable and should be set to the same value throughout the network. Typical values are “1” for IEC 60870-5-101 and “2” for IEC 60870-5-104.

3.6.11 Single-character response

Applicable only for IEC 60870-5-101.

- Enabled
- Disabled (default)

The setting allows the protection relay to respond with a single-character response for some acknowledgement frames. If used, the master must also support this feature.

3.6.12 Show bad time

- Enabled (default)
- Disabled

If the protection relay time is not synchronized properly, the time quality is marked as bad or inaccurate. The time quality is indicated as a flag in the changed data report. If the *Show bad time* setting is set to "Disabled", the protection relay does not indicate the bad time flag, which may be useful in some systems. If the time quality indication is disabled, the controlling station is not able to trust the time-stamped event correctness.

3.6.13 Time format

- Short: 24 bit
- Full: 56 bit
- Default: 56 bit

There are two different time stamp formats used in the IEC 60870-5 standard. The shorter format includes only the time, and the full format includes both the date and the time. The changed data reports include the time stamp in the format specified with the *Time format* setting.

Select the time format which is supported by the controlling station.

Both time formats are supported for IEC 60870-5-101. However, only the 56-bit format is supported for IEC 60870-5-104.

3.6.14 Event time

- Local
- UTC (default)

The setting selects between the time stamp modes for event reporting.

3.6.15 Overflow mode

- Oldest+Indication (default)
- Keep newest

The setting defines the handling of the event buffer overflow situation. In the oldest +indication mode, the protection relay discards the newest events to protect the older ones. In that mode, the protection relay generates an overflow indication event. The keep newest mode is added for compatibility for the systems that prefer latest information. In that case, the oldest events in the buffer are discarded.

3.6.16 OvInd IOA

Applicable only if the *Overflow mode* setting is set to “Oldest +Indication”.

- Min: 0
- Max: 255/65535/16777215
- Default: 60000

The protection relay generates an overflow indication event with this address if the lost event is included in any of the interrogation groups. Based on this information, the controlling station requests for interrogation to get the latest momentary values.

- If the *OvInd IOA* setting is set to 0, the overflow indication is disabled for the points that are part of some interrogation groups.
- If the *OvInd IOA* setting is set to the same value as the *OvInd NoGI IOA* setting, only one indication event is generated regardless of the point being included in the interrogation group or not.
- The maximum value depends on the *IOA length* setting.

3.6.17 OvInd NoGI IOA

Applicable only if the *Overflow mode* setting is set to “Oldest +Indication”.

- Min: 0
- Max: 255/65535/16777215
- Default: 60000

The protection relay generates an overflow indication event with this address if the lost event is not included in any of the interrogation groups. Based on this information, the controlling station knows that the interrogation is not needed because the missed data is not updated anyway.

- If the *OvInd NoGI IOA* setting is set to zero, the overflow indication is disabled for the points that are not part of some interrogation groups.
- If the *OvInd NoGI IOA* setting is set to the same value as the *OvInd IOA* setting, only one indication event is generated regardless of the point being included in the interrogation group or not.
- The maximum value depends on the *IOA length* setting.

3.6.18 Event order

- Accurate time (default)
- Preserve chronology

The protection relay has accurate time stamps for every data attribute which is part of an IEC 61850 data set. Most of them are updated in a chronological manner. However, there may be some special data items that do not have system-level time stamp available, such as circuit breaker control return indication. If the controlling station needs strictly chronological event buffering, the *Event order* setting should be set to "Preserve chronology". If the events are collected to a SCADA system, which is able to buffer and sort the received events at the system level, it is recommended to use "Accurate time"instead.

3.6.19 Selection time-out

- Min: 1
- Max: 65
- Default: 30
- Unit: seconds

This is the maximum time between the Select and Execute commands for the circuit breaker controlling in the select-before-operate mode. The controllable object's IEC 61850-level *Selection time-out* parameter is not used when the control is made from the IEC 60870-5-101/104 protocol.

3.6.20 Cyclical period

- Min: 1
- Max: 604800
- Default: 10
- Unit: seconds

Cyclical period is the periodical timer for the cyclical data sending. The maximum of 604800 seconds means one week.

The cyclical period only affects the data that has been configured as cyclical in the Communication Management tool in PCM600.

3.7 Diagnostics

All of the counters, with the exception of the Status point, show value "-1" when no connection is established after the protection relay's restart.

3.7.1 Status

The *Status* setting value is “True” when the communication is active, that is, a controlling station has been connected within the last 30 seconds. Otherwise it is “False”.

It is possible to reset the diagnostic counters by setting the *Status* setting value to "True".

3.7.2 Received frames

The Received frames counter shows the number of accepted frames received by the protection relay since the last start-up or a diagnostic reset.

3.7.3 Transmitted frames

The Transmitted frames counter shows the number of frames transmitted by the protection relay since last the start-up or a diagnostic reset.

3.7.4 Physical errors

The Physical errors counter shows the number of detected errors on the physical layer since last the startup or a diagnostic reset.

3.7.5 Link errors

The Link errors counter shows the number of detected errors on the link layer since the last startup or a diagnostic reset.

3.7.6 Transport errors

The Transport errors counter shows the number of detected errors on the transport layer since the last startup or a diagnostic reset.

Section 4 IEC 60870-5-101 and IEC 60870-5-104 parameters

4.1 Parameter list

Table 8: IEC 60870-5-101/104 settings

Parameter	Values (Range)	Unit	Step	Default	Description
Operation	1=on 5=off			5=off	Selects if this protocol instance is enabled or disabled
Port	1=IEC101 - COM 1 2=IEC101 - COM 2 3=IEC104 - Ethernet			3=IEC104 - Ethernet	Port selection
ClientIP				0.0.0.0	IP address of the client
TCP Port	0...65535		1	2404	Server TCP port
Start Delay	0...20	char	1	4	Frame start delay for serial communication
End Delay	0...20	char	1	4	Frame end delay for serial communication
Device Address	1...65535		1	1	Device address
ASDU Address	1...65535		1	1	Common address of ASDU
Link Mode	0=Balanced 1=Unbalanced			0=Balanced	Link mode setting
COT Length	1...2		1	1	Cause of transmission length
IOA Length	1...3		1	2	Information Object Address length
Link Address Length	1...2		1	1	Link Address Length
ASDU Address Length	1...2		1	1	ASDU Address Length
Single Char Resp	0=False 1=True			0=False	Single character response enabled/ disabled
Show Bad Time	0=False 1=True			1=True	Enable/disable bad time quality indication in events
Time Format	0=Short 24bit 1=Full 56bit			1=Full 56bit	Time stamp format 3 or 7 octet
Event Time	0=Local 1=UTC			1=UTC	Selects between UTC/Local time
Overflow Mode	0=Oldest +indication 1=Keep newest			0=Oldest +indication	Event buffer overflow handling mechanism
OvInd IOA	0...16777215		1	60000	Overflow indication address for interrogated data
OvInd NoGI IOA	0...16777215		1	60000	Overflow indication address for non-interrogated data

Table continues on next page

Parameter	Values (Range)	Unit	Step	Default	Description
Event Order	0=Accurate time 1=Preserve chronology			0=Accurate time	Selects the event ordering principle
Selection Timeout	1...65	s	1	30	Selection timeout for control SBO operations
Counter Reporting	0=Read by master 1=Spontaneous			0=Read by master	Counter reporting after freeze
Freeze mode	0=Not in use 1=Freeze only 2=Freeze and Reset			0=Not in use	Periodic freezing mode for integrated totals
TX window (k)	1...20		1	12	IEC60870-5-104 transmit window (k)
RX window (w)	1...20		1	8	IEC60870-5-104 receive window (w)
TX timeout (t1)	1...60000	ms	1	30000	IEC60870-5-104 transmit timeout (t1)
RX timeout (t2)	1...60000	ms	1	10000	IEC60870-5-104 receive timeout (t1)
Test interval (t3)	1...60000	ms	1	20000	IEC60870-5-104 link test interval (t3)
Cyclical Period	1...604800		1	10	Cyclical period in seconds
IT_FRZ	0=False 1=True			0=False	Control point for freezing integrated totals
Inverted DIR bit	0=False 1=True			0=False	Special mode for masters that require inverted DIR bit on Balanced IEC101 line. If enabled, this protocol instance will be non-compliant with the IEC 60870-5-101 standard.

4.2 Monitored data

Table 9: Protocol diagnostic counters

Name	Type	Values (range)	Unit	Description
Status 1	BOOLEAN	0=False 1=True		Status
Received frames 1	INT32	-1...2147483646		Received frames
Transmitted frames 1	INT32	-1...2147483646		Transmitted frames
Physical errors 1	INT32	-1...2147483646		Physical layer errors
Link errors 1	INT32	-1...2147483646		Link layer errors
Transport errors 1	INT32	-1...2147483646		Transport layer errors
Status 2	BOOLEAN	0=False 1=True		Status
Received frames 2	INT32	-1...2147483646		Received frames
Transmitted frames 2	INT32	-1...2147483646		Transmitted frames
Physical errors 2	INT32	-1...2147483646		Physical layer errors
Link errors 2	INT32	-1...2147483646		Link layer errors
Transport errors 2	INT32	-1...2147483646		Transport layer errors

Section 5 Glossary

ASDU	Application-layer service data unit
Data set	The content basis for reporting and logging containing references to the data and data attribute values
EMC	Electromagnetic compatibility
EPA	Enhanced performance architecture
Ethernet	A standard for connecting a family of frame-based computer networking technologies into a LAN
IEC	International Electrotechnical Commission
IEC 60870-5	IEC standard for telecontrol equipment and systems. Part 5 defines transmission protocols.
IEC 60870-5-101	Companion standard for basic telecontrol tasks
IEC 60870-5-104	Network access for IEC 60870-5-101
IEC 61850	International standard for substation communication and modeling
LHMI	Local human-machine interface
PCM600	Protection and Control IED Manager
SCADA	Supervision, control and data acquisition
WHMI	Web human-machine interface

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