Relion® 620 series

RER620
IEC 60870-5-101/104 Communication Protocol Manual

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Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95/EC). This conformity is the result of tests conducted by ABB in accordance with the product standards EN 50263 and EN 60255-26 for the directive, and with the product standards EN 60255-6 and EN 60255-27 for the directive. The protective relay is designed in accordance with the international standards of the IEC 60255 series and ANSI C37.90

Table of Contents

Section 1 Introduction

1.1 This manual

The communication protocol manual describes a communication protocol supported by the protective 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 for communication setup in a substation from a protective relay 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

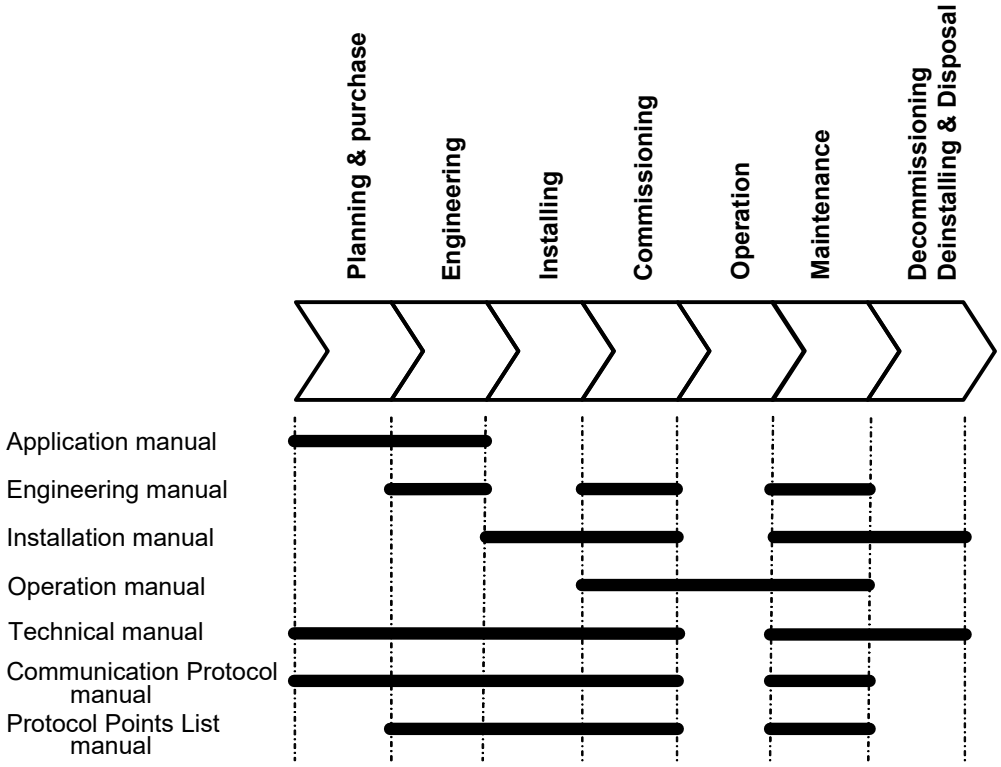

Figure 1: The intended use of manuals in different lifecycles

The engineering manual contains instructions on how to engineer the protective relay using the different tools in PCM600. The manual provides instructions on how to set up a PCM600 project and insert protective relays in the project structure. The manual also recommends a sequence for engineering of protection and control functions, LHMI functions, and communication engineering for IEC 61850 and DNP3.

The installation manual contains instructions on how to install the protective relay. The manual provides procedures for mechanical and electrical installation. The chapters are organized in chronological order in which the protective relay should be installed.

The operation manual contains instructions on how to operate the protective relay once it has been commissioned. The manual provides instructions for monitoring, controlling and setting the protective relay. The manual also describes how to identify disturbances and how to view calculated and measured power grid data to determine the cause of a fault.

The application manual contains application descriptions and setting guidelines sorted per function. The manual can be used to find out when and for what purpose a typical protection function can be used. The manual can also be used when calculating settings.

The technical manual contains application and functionality descriptions and lists function blocks, logic diagrams, input and output signals, setting parameters and technical data

sorted per function. The manual can be used as a technical reference during the engineering phase, installation and commissioning phase, and during normal service.

The communication protocol manuals describe the communication protocols supported by the protective relay. Each manual concentrates on vendor-specific implementations.

The point list manual describes the outlook and properties of the data points specific to the protective relay. The manual should be used in conjunction with the corresponding communication protocol manual.

1.3.2 Document revision history

Document revision/date	Product version	History
A/11/23/2010	1.0	First release
B/10/31/2011	1.1	Content updated to correspond to the product series version
C/07/20/2017	1.3	Content updated to correspond to the product series version

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

1.3.3 Related documentation

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 Safety indication 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 to important facts and conditions.

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

Although warning hazards are related to personal injury, it should be understood that operation of damaged equipment could, under certain operational conditions, result in

degraded process performance leading to personal injury or death. Therefore, comply fully with all warning and caution notices.

1.4.2 Manual conventions

Conventions used in protective relay manuals. A particular convention may not be used in this manual.

- Abbreviations and acronyms in this manual 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, for example:

  To navigate between the options, use  and  .
- HMI menu paths are presented in bold, for example:

  Select **Main Menu > Settings**.
- LHMI messages are shown in Courier font, for example:

  To save the changes in non-volatile memory, select `Yes` and press  .
- Parameter names are shown in italics, for example:

  The function can be enabled and disabled with the *Operation* setting.
- Parameter values are indicated with quotation marks, for example:

  The corresponding parameter values are "Enabled" and "Disabled".
- Protective relay input/output messages and monitored data names are shown in Courier font, for example:

  When the function picks up, the `PICKUP` output is set to TRUE.
- Dimensions are provided both in inches and mm. If it is not specifically mentioned then the dimension is in mm.

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, unbalanced and balanced, to be used in the communication between the controlling station (SCADA system) and the controlled outstation. IEC 60870-5-104 ignores this setting. After receiving STARTDT command from the controlling station, the controlled station will start reporting events immediately to the controlling station without requests.

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. Synchronizing of the clocks provides a correct chronological sequence of time-tagged events or information objects that are transmitted to the controlling station, or that are logged locally.

After system initialization, the clocks are initially synchronized by the controlling station. Then, 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 time tag is received. A delay acquisition command can be used to define the measured or estimated transmission delay in the outstation. The command corrects the time on the outstation side when sending.

2.3.5 Command transmission

A command is used in telecontrol systems to change the state of operational equipment, for example, a circuit breaker. 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 a Direct command or a 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 by the controlling station to:

- 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 execute 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 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.

2.3.7 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.

2.3.8 Analog Value Deadband

In certain situations, the user might want to reduce the number of unnecessary events by using the deadband feature. This feature is available for analog measurements for each point and may be configured in the configuration tool by setting the Range and Interval parameters.

The range can, for example, be 0.05 (5%). If the data point value changes beyond the set value of 0.05 (5%) from the previously sent value, the data will be sent spontaneously as deadband data. The interval, however, limits the deadbanded value to be sent once per configured time window which

is defined of the order of seconds. The interval can be set to zero to disable the time window limiting feature.

Section 3 Vendor-specific implementation

3.1 615/620 series implementation

3.1.1 Internal IEC 61850 data modeling

The protective 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 dataset 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 gets only the most important data.

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

It is assumed that all the other settings have their default values. Avoid changing the other settings unless something is clearly wrong by default.

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.

  ICheck the communication card jumpers. Refer to applicable manual for details.

- *Device Address*
  Set to match the address set in the master.
- *ASDU Address*
  Usually ASDU Address is the same as link 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 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 master.

- *COT Length*
  Should be set to 2. The standard requires COT Length set to 2 in both the master and the slave devices.
- *IOA Length*
  Usually, set to 3. This setting must have the same value in the master and slave devices.
- *Link Address Length*
  Usually set to 2. This setting must have the same value in the master and slave devices.
- *ASDU Address Length*
  Usually set to 2. This setting must have the same value in the master and slave devices.

3.2.3 Troubleshooting

After setting the communication parameters correctly, check the communication.

- Use the communication card LED's to diagnose if the messages are properly transmitted and received. There are diagnostic counters available in the protective relay's Monitoring section.
- Check also that the other settings for the protocol instance match the master configuration, as they affect the data interpretation.

3.3 Event overflow handling

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 client 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 keep oldest events mode. In addition, in this mode the protective relay can be configured to generate an event buffer overflow indication. After receiving overflow indication, the client can interrogate the protective relay to ensure data integrity.

3.3.2 Overflow indication addresses

If the keep oldest events mode is enabled, the protective relay sends an event buffer overflow indication. If the lost event is included in the interrogation list, the protective relay sends the indication event with the address configured as "OvInd IOA". If the data is not available for interrogation, the protective 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 client can skip interrogation. If the addresses are configured to 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 keep oldest events mode.

After the event buffer overflow is cleared, the protective relay discards new events for 3 seconds to allow the client to start fetching the events and to free some space in the event buffer. Otherwise, the event buffer overflows immediately again and the communication is disturbed more.

3.4 Supported data types

3.4.1 Indications (MSP, MDP)

The protective relay supports both single and double-bit indications with configurable timestamp format.

3.4.2 Measurements (MMENA, MMENB, MMENC, MMEND)

By default, analog measurements are transmitted in primary units, such as A, V or Hz. The scaling is based on the measuring transformer ratio.

3.4.3 Control objects (CSC, CDC)

Two types of control objects are available. The double bit controls are employed for circuit breaker control points. The C_DC_XX (46, 59) type commands should be issued to control the double bit points.

The single bit controls are used for all the other control points, e.g., setting group selection, clearing the indication LED's or recorded data and etc. The C_SC_XX (45, 58) type commands should be used to control the single bit points.

If the command type and point type do not match, the Negative Confirmation with COT 47 UKIOA_NEGA (Unknown IOA Origin) response will be sent.

Both select-before-operate command and direct operate command can be used for all control points regardless the configuration of the SCBXCR control mode.

A command is rejected because of:

- 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 denied by the circuit breaker itself because of, for example, interlocking.
- Remote Mode is not enabled.

3.5 Addressing scheme

3.5.1 Default addresses

There are some protection functions, which are not available in this protective relay, but might be available in other protective relays in the 615/620 series. The main principle is to keep the data mapped in a consistent way in the whole 615/620 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.

3.5.2 Configuring communication options

- Configure the communication options by using LHMI 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 protective 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 protective 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 protective 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 Device address is the identification number of the device. This setting must match the address defined in the client 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. *ASDU address* must match the address defined in the client configuration. The maximum value of this setting depends on the ASDU address length.

3.6.6 Link mode

- Unbalanced
- Balanced (default)[1]

The settings defines the link mode. In the unbalanced mode, the protective relay listens for the client's commands and responds when needed. In the balanced mode, the protective 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 OA 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.

1. STARTDT must always be sent before any user data transfer from the controlled station (for example, general interrogated information) is initiated. Any pending user data in the controlled station is sent only after the STARTDT con

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 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 protective relay to respond with the single character response for some acknowledgment frames. If used, the client must also support this feature.

3.6.12 Show bad time

- Enabled (default)
- Disabled

If the protective 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 *Show bad time* is set to "Disabled", the protective relay does not indicate the bad time flag which may be useful in some systems. If the time quality indication is disabled, the client 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 client.

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 protective relay discards the newest events to protect the older ones. In that mode, the protective 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 *Overflow mode* is set to "Oldest+Indication".

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

The protective 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 client requests for interrogation to get the latest momentary values.

- If OvInd IOA is set to 0, the overflow indication is disabled for the points that are part of some interrogation groups.
- If *OvInd IOA* is set to the same value as *OvInd NoGI IOA*, only one indication event is generated regardless whether the point is 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 Overflow mode is set to "Oldest+Indication".

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

The protective 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 client knows that the interrogation is not needed because the missed data is not updated anyway.

- If *OvInd NoGI IOA* is set to zero, the overflow indication is disabled for the points that are not part of some interrogation groups.
- If *OvInd NoGI IOA* is set to same value as *OvInd IOA*, only one indication event is generated regardless whether the point is 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 protective relay has accurate time stamps for every data attribute which is part of an IEC 61850 dataset. Most of them are updated in a chronological manner. However, there may be some special data items that do not have system-level timestamp available, such as circuit breaker control return indication. If the client needs strictly chronological event buffering, *Event order* 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 by the IEC 60870-5-101/104 client.

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.

3.6.21 Transmit window

- Min: 1
- Max: 32767
- Default: 12
- Unit: APDU

The value of k shall indicate the maximum number of sequentially numbered I format APDUs that the DTE may have outstanding (i.e. unacknowledged) at a given time. The transmitter stops the transmission at k unacknowledged I format APDUs.

3.6.22 Receive window

- Min: 1
- Max: 32767
- Default: 8
- Unit: APDU

The receiver acknowledges at the latest after receiving w I format APDUs

Recommendation: w should not exceed two-thirds of k.

3.6.23 Transmit timeout

- Min: 1000
- Max: 255000
- Default: 15000
- Unit: ms

t1 is the timeout of a sent U-frame or I-frame. t1 starts after a U-frame or I-frame message is sent. When t1 timer expires and no ACK for that message was received, the connection termination (active close) will be initiated. The accuracy for t1 is 1 second. The timeout setting should be set as a multiple of 1000ms.

3.6.24 Receive timeout

- Min: 1000

- Max: 255000
- Default: 15000
- Unit: ms

In case of longer data transmission in one direction only, an S format has to be sent in the other direction to acknowledge the APDUs before buffer overflow or time out. t2 is the time-out for acknowledges in case of no data messages. t2 < t1, resolution 1 s. The timeout setting should be set as a multiple of 1000ms.

3.6.25 Link test interval

- Min: 1000
- Max: 172800000 (48 hours)
- Default: 20000
- Unit: ms

Unused, but open, connections may be periodically tested in both directions by sending test APDUs (TESTFR = act) which are confirmed by the receiving station sending TESTFR = con. Both stations may initiate the test procedure after a specified period of time in which no data transfers occur (time out). The reception of every frame - I frame, S frame or U frame - retriggers timer t3. The accuracy for t3 is 1 second. The timeout setting should be set as a multiple of 1000ms.

3.7 Diagnostics

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

3.7.1 Status

The Status value is "True" when the communication is active, that is, a client has been connected within the last 30 seconds. Otherwise it is "False".

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

3.7.2 Received frames

The Received frames counter shows the number of accepted frames received by the protective relay since the last startup or a diagnostic reset.

3.7.3 Transmitted frames

The Transmitted frames counter shows the number of frames transmitted by the protective relay since last the startup 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 3: IEC 60870-5-101 and IEC 60870-5-104 settings

Parameter	Values (range)	Unit	Step	Default	Description
Port 1	0=Not in use 1=IEC101 - COM1 2=IEC101 - COM2 3=IEC104 - Ethernet			0=Not in use	Port selection for instance 1
ClientIP 1				0.0.0.0	IP address of the client
End Delay 1	0...20	char		4	Frame end delay for serial communication
Device Address 1	1...65535			1	Link address of the instance 1
ASDU Address 1	1...65535			1	ASDU address of the instance 1
Link Mode 1	0=Balanced 1=Unbalanced			0=Balanced	Link mode setting for instance 1
COT Length 1	1...2			1	Cause of transmission length
IOA Length 1	1...3			2	Information object address length
Link Address Length 1	1...2			1	Link address length
ASDU Address Length 1	1...2			1	ASDU address length
Single Char Resp 1	0=Disabled 1=Enabled			0=Disabled	Single character response enabled/disabled
Show Bad Time 1	0=Disabled 1=Enabled			1=Enabled	Enable/disable bad time quality indication in events
Time Format 1	0=Short 24bit 1=Full 56bit			1=Full 56bit	Time stamp format 3 or 7 octet
Event Time 1	0=Local 1=UTC			1=UTC	Selects between UTC/local time
Overflow Mode 1	0=Oldest +indication 1=Keep newest			0=Oldest +indication	Event buffer overflow handling mechanism
OvInd IOA 1	0...16777215			60000	Overflow indication address for interrogated data 1
OvInd NoGI IOA 1	0...16777215			60000	Overflow indication address for non-interrogated data 1

Table continues on next page

Parameter	Values (range)	Unit	Step	Default	Description
Event Order 1	0=Accurate time 1=Preserve chronology			0=Accurate time	Selects the event ordering principle
Selection Timeout 1	1...65			30	Selection time-out for control SBO operations
Cyclical Period 1	1...604800			10	Cyclical period in seconds
TX window (k) 1	1...32767			12	IEC60870-5-104 transmit window (k)
RX window (w) 1	1...32767			8	IEC60870-5-104 receive window (w)
TX timeout (t1) 1	1...255000	ms		15000	IEC60870-5-104 transmit timeout (t1)
RX timeout (t2) 1	1...255000	ms		10000	IEC60870-5-104 receive timeout (t1)
Test interval (t3) 1	1... 172800000	ms		20000	IEC60870-5-104 link test interval (t3)
Port 2	0=Not in use 1=IEC101 - COM1 2=IEC101 - COM2 3=IEC104 - Ethernet			0=Not in use	Port selection for instance 2
ClientIP 2				0.0.0.0	IP address of the client
End Delay 2	0...20	char		4	Frame end delay for serial communication
Device Address 2	1...65535			1	Link address of the instance 2
ASDU Address 2	1...65535			1	ASDU address of the instance 2
Link Mode 2	0=Balanced 1=Unbalanced			0=Balanced	Link mode setting for instance 2
COT Length 2	1...2			1	Cause of transmission length
IOA Length 2	1...3			2	Information object address length
Link Address Length 2	1...2			1	Link address length
ASDU Address Length 2	1...2			1	ASDU address length
Single Char Resp 2	0=Disabled 1=Enabled			0=Disabled	Single character response enabled/disabled
Show Bad Time 2	0=Disabled 1=Enabled			1=Enabled	Enable/disable bad time quality indication in events
Time Format 2	0=Short 24bit 1=Full 56bit			1=Full 56bit	Time stamp format 3 or 7 octet
Event Time 2	0=Local 1=UTC			1=UTC	Selects between UTC/local time
Overflow Mode 2	0=Oldest +indication 1=Keep newest			0=Oldest +indication	Event buffer overflow handling mechanism
OvInd IOA 2	0...16777215			60000	Overflow indication address for interrogated data 2
OvInd NoGI IOA 2	0...16777215			60000	Overflow indication address for non-interrogated data 2
Event Order 2	0=Accurate time 1=Preserve chronology			0=Accurate time	Selects the event ordering principle
Selection Timeout 2	1...65			30	Selection time-out for control SBO operations
Cyclical Period 2	1...604800			10	Cyclical period in seconds
TX window (k) 1	1...32767			12	IEC60870-5-104 transmit window (k)

Table continues on next page

Parameter	Values (range)	Unit	Step	Default	Description
RX window (w) 1	1...32767			8	IEC60870-5-104 receive window (w)
TX timeout (t1) 1	1...255000	ms		15000	IEC60870-5-104 transmit timeout (t1)
RX timeout (t2) 1	1...255000	ms		10000	IEC60870-5-104 receive timeout (t1)
Test interval (t3) 1	1... 172800000	ms		20000	IEC60870-5-104 link test interval (t3)

4.2 Monitored data

Table 4: 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

ANSI	American National Standards Institute
ASDU	Application-layer service data unit
DNP3	A distributed network protocol originally developed by Westronic. The DNP3 Users Group has the ownership of the protocol and assumes responsibility for its evolution.
DTE	Data terminal equipment
EMC	Electromagnetic compatibility
EPA	Enhanced performance architecture
Ethernet	A standard for connecting a family of frame-based computer networking technologies into a LAN
HMI	Human-machine interface
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 protective relay Manager
SCADA	Supervision, control and data acquisition

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