SATEC

Phasor Measurement Unit

PMU PRO

IEC 60870-5-101/104 Communications Protocol

Reference Guide

BG0652 Rev. A3

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For further information regarding a particular installation, operation or maintenance of equipment, contact the manufacturer or your local representative or distributor.

REVISION HISTORY

A1	Mar 2024	Initial release.
A2	Oct 2024	Added address settings for the second Ethernet interface.
A3	Dec 2024	Updated PMU time quality field.

Table of Contents

1 General

This document specifies a subset of the IEC60780-5-101/104 communications protocol used to transfer data between a master controlling station and the PMU. The document provides the complete information necessary to develop third-party communications software capable of communication with PMU devices.

IEC 60870-5-101/104 references:

IEC 60870-5-1:1990, Telecontrol Equipment and Systems - Part 5, Transmission Protocols - Section 1: Transmission frame formats

IEC 60870-5-2:1991, Telecontrol Equipment and Systems - Part 5, Transmission Protocols - Section 2: Link transmission procedures

IEC 60870-5-3:1992, Telecontrol Equipment and Systems - Part 5, Transmission Protocols - Section 3: General structure of application data

IEC 60870-5-4:1993, Telecontrol Equipment and Systems - Part 5, Transmission Protocols - Section 4: Definition and coding of application information elements

IEC 60870-5-5:1995, Telecontrol Equipment and Systems - Part 5, Transmission Protocols - Section 5: Basic application functions.

IEC 60870-5-101:2003-02, Telecontrol Equipment and Systems - Part 5, Transmission Protocols - Section 101: Companion standard for basic telecontrol tasks

IEC 60870-5-104:2006-06, Telecontrol Equipment and Systems - Part 5, Transmission Protocols - Section 104: Network access for IEC 60870-5-101 using standard transport profiles

2 Protocol Implementation

2.1 Configuring IEC 60870-5

The PMU protocol stack is implemented in a flexible manner. Most of IEC 60870-5-101/104 features are user-configurable allowing easy adaptation for use in different IEC 60870-5 installations. To keep maximum interoperability with master RTU and SCADA systems, the PMU supports all standard ASDU types for data interrogation, event reporting and control.

The support PAS configuration software supplied with the device provides all necessary tools for remote configuration of the device via serial ports or via a TCP/IP Internet connection using either IEC 60870-5-101/104, or Modbus protocol.

See Chapter 6 for instructions on how to configure IEC 60870-5 options in the device for your particular installation.

See the PMU Installation and Operation Manual for more information on configuring the device via PAS.

The protocol implementation details are explained in the following sections.

2.2 Communicating via IEC 60870-5 Ports

The PMU supports unbalanced IEC 60870-5-101 communications via serial ports and multiple balanced IEC 60870-5-104 TCP/IP connections via Ethernet ports.

Serial IEC 60870-5-101 Connections

The PMU has one 485 and one IR port, which can operate in IEC 60870-5-101 mode.

TCP/IP IEC 60870-5-104 Connections

The PMU has two Ethernet ports with the ability to support up to 8 simultaneous TCP connections each. Both ports provide IEC 60870-5-104 servers on TCP port 2404, which are configured and operate independently of each other.

Each port can be configured for two redundant logic connections with the controlling station using two different IP addresses for spontaneous/cyclic transmission. Selecting the same IP address for both connections disables redundancy mode (see Section 2.9 for details). In any case, both IP addresses must be defined to enable spontaneous/cyclic transmission.

Keepalive Probes

The PMU uses TCP keepalive probes to detect dead connections and prevent resource leaks. If the connection is idle longer than configured, the device sends a keepalive request to check if the connection is alive. If no response is received after 5 successive keepalive retransmissions, the connection is considered dead and will be closed.

The TCP keepalive idle time can be configured from 1 to 60 seconds or set to 0 to disable keepalive probes (see the PMU Installation and Operation Manual). The default value is 20 seconds.

Client Connection Timeout

The client connection idle timeout can be used to terminate a connection if it has been inactive for too long. It can be configured from 30 to 300 seconds, or set to 0 to inactivate it (see the PMU Installation and Operation Manual). The default value is 120 seconds.

If the idle timeout is enabled, then the controlling station should either periodically send test APDU to the device, or configure cyclic data transmission in the device to maintain some kind of activity on the connection socket to keep the connection open.

Outstanding Messages

The controlling station must acknowledge receipt of all ASDUs as frequently as possible. The maximum number of outstanding (unacknowledged) messages allowed can be configured from 1 to 32. The default value is 12. When the number of unacknowledged messages reaches the maximum, the device pauses transmission until the controlling station sends an acknowledgement or restarts data transfer.

For testing purposes, you can set the maximum number of unacknowledged ASDUs to zero so that the device never suspends data transmission.

2.3 Device Addressing

The data link address field in IEC 60870-5-101 and the COMMON ADDRESS OF ASDU represents the device address assigned in the device to an IEC 60870-5-101 communication port. See the PMU Installation and Operation Manual on how to configure the device address in your device.

The data link address and COMMON ADDRESS OF ASDU length are configurable for IEC 60870-5-101 ports (see Section 6.1).

2.4 Information Object Addressing and Mapping

Information object address length is configurable for IEC 60870-5-101 ports and is fixed to 3 octets in IEC 60870-5-104. See Section 6.1 for more information on selecting the object address length in the device.

Information object addressing scheme normally uses structured two-octet (three-octet in IEC 60870-5-104) addresses. See Chapter 3 for the full list of the available object points and their addresses.

The PMU allocates a special configurable address space in the range of 1 to 4095 for user-assignable point addresses called mapped points. Mapped points can be used as aliases of the original point addresses to provide a more convenient and faster way for polling and interrogating data. Event reporting in the PMU is only available for mapped points.

You can remap any of 64 general object points listed in Section 3.2 to a single range or a number of ranges in the configurable address space. See Section 6.2 for more information on remapping object addresses.

Different classes of objects - measurement values, single points, double points and integrated totals – can be remapped to separate ranges with a configurable starting object address. See Section 6.1 on how to configure the starting address for mapped object points.

When required, one-octet addresses can be used for IEC 60870-5-101 ports by remapping points to the address range of 1 to 255.

2.5 Interrogation

The PMU supports general and group interrogation commands for binary and analog objects. Address ranges for general and group interrogation are configurable via the IEC 60870-5 Class 2 Data and Counters Setup (see Section 6.3).

Up to 15 groups can be arranged for group interrogation. Any compatible ASDU data type can be separately selected for each range of points regardless of the configured default object type.

Interrogated data are sent in the order they are listed in the Class 2 Data Setup. The device always responds to interrogation requests with a sequence of information objects ASDU with the SQ bit in the variable structure qualifier set to 0.

2.6 Cyclic Data Transmission

Object address ranges for periodic/cyclic data transmission are configurable via the IEC 60870-5 Class 2 Data and Counters Setup (see Section 6.3). Any compatible ASDU data type can be separately selected for each range of points regardless of the configured default object type.

Cyclic data is sent in the order they are listed in the Class 2 Data Setup. The device always transmits cyclic data using a sequence of information objects ASDU with the SQ bit in the variable structure qualifier set to 0.

IEC 60870-5-101 Cyclic Transmission

In IEC 60870-5-101, the device responds to class 2 data requests with data configured for cyclic transmission if there are no higher priority messages ready for transmission. An interrogation command interrupts a cyclic transmission sequence, which is automatically restarted after the interrogation command has been responded.

IEC 60870-5-104 Cyclic Transmission

In IEC 60870-5-104, configured cyclic data is transmitted periodically to the selected controlling station after it confirms start of data transfer. The cyclic transmission period can be set from 100 to 30,000 ms, or set to 0 (default) to disable cyclic transmission.

An interrogation command interrupts cyclic transmission in progress, which is automatically restarted after the interrogation command has been responded.

See Section 6.1 on how to set up a client IP address for cyclic data transmission and the cyclic transmission period.

2.7 Transmission of Integrated Totals

The PMU supports modes A, B, C and D of acquisition of integrated totals – local freeze (with or without reset) with spontaneous transmission, local freeze (with or without reset) with counter interrogation, counter interrogation with/without remote freeze (with or without reset), and counter freeze by an interrogation command with spontaneous transmission of frozen values.

Object address ranges for counter transmission are configurable via the IEC 60870-5 Class 2 Data and Counters Setup (see Section 6.3). Up to 4 groups can be arranged for counter group interrogation. Any compatible ASDU data type can be separately selected for each range of points regardless of the configured default counter object type.

Interrogated data is sent in the order they are listed in the Class 2 Data and Counters Setup. The device always transmits counters using a sequence of information objects ASDU with the SQ bit in the variable structure qualifier set to 0.

NOTES:

The sequence number in the counter qualifier is incremented modulo 32 after each local or remote freeze.

The counter overflow is indicated in case the actual counter rolls over to zero since last counter reading. The counter adjustment is indicated when the counter has been preset or cleared outside of the standard sequence controlled by local freeze and remote interrogation commands.

When using multiple connections via IEC60870-5 ports, only one client should use counter interrogation commands with FRZ qualifiers 1-3 to maintain consistency of the counter freeze buffers.

Do not apply interrogation commands with FRZ qualifiers 1-2 to counters with local freeze, as they will disturb frozen counter buffers.

2.7.1 Transmission Counters with Local Freeze

Integrated totals configured for mode A or B transmission (those checked for local freeze in the IEC 60870-5 Class 2 Data and Counters Setup, see Section 6.3), are locally frozen at configurable intervals synchronized with the device clock. If the local freeze period is evenly divisible into an hour, the counter freeze/transmission intervals will be synchronized with the beginning of the hour. See Section 6.1 on how to set up the local freeze period for mode A or B transmission.

If the counter range is checked for freeze with reset, the actual counters are reset to zero after current counter values are frozen in the freeze buffers.

Frozen values signed for spontaneous transmission are transmitted with spontaneous cause of transmission <3> in response to class 1 requests in IEC 60870-5-101 and spontaneously to the selected client IP address in IEC 60870-5-104.

Interrogation commands with FRZ=0 for ranges of counters signed for local freeze return locally frozen counter values.

2.7.2 Counter Interrogation with/without Remote Freeze

The PMU supports general and group counter interrogation commands with FRZ qualifiers 0-3:

<0> - read (no freeze or reset)

<1> - counter freeze without reset

<2> - counter freeze with reset

<3> - counter reset

Interrogation commands with remote freeze qualifiers FRZ=1 and FRZ=2 cause the specified counters' values to be locally frozen to the freeze buffers, optionally followed by the reset of the actual counter values for commands with FRZ=2. Commands with FRZ=1-3 do not cause the counter values to be transmitted.

Interrogation commands with FRZ=0 (no freeze, no reset) are responded either with the frozen counter values if the command was preceded by a remote or local freeze, or with the actual counter values for counters that were not frozen.

For mode D of spontaneous counter transmission with remote freeze, check the required counters for spontaneous transmission without local freeze (see Section 6.3). They will be transmitted with cause of transmission <3> in response to class 1 requests in IEC 60870-5-101 and spontaneously to the client IP address selected for spontaneous data transmission in IEC 60870-5-104.

NOTE:

Integrated totals checked for spontaneous transmission without local freeze that have not been frozen by a remote freeze command will be periodically reported at specified local freeze/transmission intervals with the actual counter values.

2.8 Event Reporting

The PMU provides up to 64 configurable setpoints for reporting events when a measured value exceeds a predefine threshold or changes by a certain percentage, or a binary point status changes. The scan period for events is one power frequency cycle time for binary events, and 200 ms for analog events.

Events can only be reported for mapped static object points in the address range of 1 to 4095. Default data types for event reporting are configurable via the IEC 60870-5 Options Setup (see Section 6.1) for supported classes of objects. See Section 6.2 on how to select object point addresses and configure thresholds for event reporting.

The device always reports events in a chronological order by a sequence of information objects ASDU with the SQ bit in the variable structure qualifier set to 0.

The device data change buffers can hold up to 128 unreported events.

IEC 60870-5-101 Event Reporting

In IEC 60870-5-101, collected events are transmitted in response to class 1 requests. The device can also respond with class 1 data to class 2 requests if there is no class 2 data in transmission and this option is enabled in the IEC 60870-5 Options Setup (see Section 6.1).

IEC 60870-5-104 Event Reporting

In IEC 60870-5-104, collected events are transmitted spontaneously over the active connection after the controlling station confirms start of data transfer (called started connection). See Section 6.1 on how to configure client IP addresses for spontaneous event transmission. See Section 2.9 for information on configuring and operating redundant connections.

NOTES:

Event reports on counter change events always follow the actual counter changes and are reported with the actual counter values.

Since the PMU maintains a single set of data change buffers, only one master connected to the device can receive spontaneous event reports. You should not send class 1 requests over a serial connection if you have configured spontaneous event transmission over the TCP/IP connection.

2.9 Redundant Connections

For installations where high availability of the process data is required, the PMU provides two redundant groups for communication with two controlling stations, one for each Ethernet port. Each redundant group maintains two redundant connections to the controlling station for spontaneous/cyclic data transmission.

See IEC 60870-5-104, Section 10, for details on how redundant connections operate. The following general rules apply to redundant connections:

- The controlling station should be able to handle two logical connections on different IP addresses.
- Two logical connections on the same Ethernet port represent one redundancy group.
- Only one logical connection is in the started state and is sending data at a time for one redundancy group.
- The controlling station decides which one of the two connections should be in started state.
- The TESTFR test frames ("keep alive" frames) should be used to maintain redundancy connections in active state.
- Each redundancy group uses one process database and event queue.

After connection establishment by the controlling station, the connection is in stopped state and no data is transmitted. The logical connection which is enabled for data transfer is started by issuing a STARTDT command from the controlling station.

Redundancy is activated depending on the selected redundancy mode: in mode 1, redundancy is activated when both redundant connections are established by the controlling station; in mode 2, redundancy is activated once at least one of the connections is established.

If communication fails on the currently started connection, the controlling station must detect the failure and perform a connection switchover to the stopped redundant connection by issuing a STARTDT command so that the pending event is retransmitted over this connection.

See Section 6.1 on how to configure redundant connections in the PMU.

2.10 Clock Synchronization

The device clock time is local time.

The IV Invalid bit in the binary time elements is set to 1 after the device loses power and is reset to 0 when the device time is updated by the C_CS_NA_1 Clock synchronization command.

The device can periodically request clock synchronization by setting the IV Invalid bit in the time tag of the information objects to 1 if the Time sync period in the IEC 60870-5 Options setup is configured to a non-zero value. See Section 6.1 on how to configure the Time sync period in your device.

In case of using a tree octet CP24Time2a time tag in event ASDU types, the device sends spontaneous clock synchronization messages to the controlling station at the beginning of each hour. In IEC 60870-5-104 using CP24Time2a time tags should be avoided.

2.11 Single and Double Commands

The PMU supports single and double commands addressed to device relay outputs.

See the following table for description of relay output operation using single commands.

Single Command State (SCS)	Qualifier of Command (QU)	Relay Output Operation
0 (Not permitted)	Any	No action
1 (OFF)	0 (No additional definitions)	Short pulsed ON
	1 (Short pulse duration)	Short pulsed ON
	2 (Long pulse duration)	Long pulsed ON
	3 (Persistent output)	Latched OFF
2 (ON)	0 (No additional definitions)	Short pulsed ON
	1 (Short pulse duration)	Short pulsed ON
	2 (Long pulse duration)	Long pulsed ON
	3 (Persistent output)	Latched ON
3 (Not permitted)	Any	No action

Double commands must always be sent to the first relay output address between two adjacent addresses occupied by a double point object. See the following table for description of relay output operation using double commands.

Double Command State (DCS)	Qualifier of Command (QU)	Relay Output Operation	
		RO2	RO3
0 (Not permitted)	Any	No action	No action
1 (OFF)	0 (No additional definitions)	Short pulsed ON	No action
	1 (Short pulse duration)	Short pulsed ON	No action
	2 (Long pulse duration)	Long pulsed ON	No action
	3 (Persistent output)	Latched ON	Latched OFF
2 (ON)	0 (No additional definitions)	No action	Short pulsed ON
	1 (Short pulse duration)	No action	Short pulsed ON
	2 (Long pulse duration)	No action	Long pulsed ON
	3 (Persistent output)	Latched OFF	Latched ON
3 (Not permitted)	Any	No action	No action

The short and long pulse duration for pulsed operations are configurable via the IEC 60870-5 Options Setup (see Section 6.1).

NOTE:

Single and double commands with QU=0 are executed using a configured short pulse duration by default.

Command execution is always confirmed by C_SC_ACTTERM or C_DC_ACTTERM.

Single and double commands with qualifiers QU=0-2 (pulse operation) will not have effect unless device relay outputs are configured for pulse mode operation, and commands with qualifier QU=3 (persistent output) will not be effective unless relay outputs are configured for operation in either unlatched, or latched mode (both modes provide latched operations on remote commands).

See the device Installation and Operation manual on how to configure relay outputs for operation in pulse or latched mode. The IEC 60870-5 pulse duration settings override the default relay pulse width configured for relay outputs in the device.

2.12 Read Command

Default data types for responses to a C_RD_NA_1 Read command for general and mapped object points listed in Sections 3.1 and 3.2 are configurable via the IEC 60870-5 Options

Setup for supported classes of objects (see Sections 6.1 and 6.2). System and configuration parameters are read in a fixed format indicated for each parameter in Sections 3.3 through 3.6.

The PMU allows a non-standard interpretation of the Read command variable structure qualifier: a master can request more than one information element starting from the specified information object address by setting the SQ bit to 1 and the number of elements N to a value more than 1.

When a single value is requested, or the object type of the requested values has a time tag, the device responds to a read request with a sequence of information objects ASDU with the SQ bit in the variable structure qualifier set to 0. If more than one value is requested and the object type does not have a time tag, the device responds with a sequence of information elements ASDU with the SQ bit set to 1.

2.13 Parameter Loading

System and configuration parameters are written with either P_ME_NB_1, or P_ME_NC_1 ASDU type indicated for each parameter in Sections 3.3 through 3.6 with KPA = 32 (private range) in the qualifier of a parameter, and are reported to a Read command with the same object type and attributes.

The PMU allows a non-standard interpretation of the P_ME_NB_1 and P_ME_NC_1 ASDU variable structure qualifier: a master can write more than one information element starting from the specified information object address by using a sequence of information elements ASDU with the SQ bit set to 1 and the number of elements N more than 1.

2.14 Data Types

2.14.1 Single Point Information

See the following table for decoding the status of a binary input accessed as a single point object.

Single Point Info Qualifier (SPI)	Digital Input Status
0 (OFF)	OFF (Open)
1 (ON)	ON (Closed)

2.14.2 Double Point Information

Double point objects occupy two adjacent object addresses and should always be accessed by addressing the first address of the pair. See the following table for decoding the status of binary inputs accessed as double point objects.

Double Point Info Qualifier (DPI)	Digital Inputs Status	
	DI1	DI2
0 (Intermediate state)	OFF (Open)	OFF (Open)
1 (OFF)	ON (Closed)	OFF (Open)
2 (ON)	OFF (Open)	ON (Closed)
3 (Indeterminate state)	ON (Closed)	ON (Closed)

2.14.3 Normalized Values

A normalized value represents per unit scaled reading of a measured value. Normalized values are transmitted as 16-bit signed fixed point numbers (F16, Type 4.1 IEC 60870-5-4) in the range of $-1..+1-2^{-15}$. On integer platforms, they can be taken as 16-bit signed integer numbers in the range of –32768..+32767 by dividing a value by 32767 to provide same conversion results.

Per unit normalization allows transmission of any measured value within its measurement range being scaled to a 16-bit fixed-point binary number, where $-1+2^{-15}$ corresponds to the minimum negative value measurement and $1-2^{-15}$ corresponds to the maximum value

measurement. The actual measurement range and reading resolution are indicated in the object address map for all measured values (see Chapter 3).

To get a true measurement, a normalized value should be converted using the following formula:

Y = Raw_reading × Max_Measurement_Range/32767

When over-range occurs, a positive value is reported as $1–2^{-15}$ and a negative value as -1 with the OV bit in the quality descriptor byte QDS set to 1.

Conversion Example:

If the value you have read at object address 20736, which represents a phase I1 current reading (see Section 3.1), is 201×2^{-15}, the CT ratio is 200A : 5A = 40, and the secondary current scale is 10A, then the current reading in engineering units is as follows:

Max_Measurement_Range (see Section 4) = 40 × 10A = 400A

Value_Resolution = 0.01A

True value reading = 201×400/32767 = 2.45A

2.14.4 Scaled Values

A scaled value represents the reading of a measured value scaled to a 16-bit integer number. Scaled values are transmitted as 16-bit signed integer numbers (I16, Type 2.1 IEC 60870-5-4) in the range of –32768..+32767.

Integer scaling allows transmission of any measured value within its measurement range being scaled to a 16-bit integer number by dividing by a fixed scale factor.

To get a true measurement, a scaled value should be converted using the following formula:

Y = Raw_reading × Scale_Factor

The scale factor depends on the maximum measurement range and resolution of a measured value as follows:

a) if (Max_Measurement_Range/Value_Resolution) <= 32767 then

Scale_Factor = 1 × Value_Resolution

b) if (Max_Measurement_Range/Value_Resolution) > 32767 then

Scale_Factor = Max_Measurement_Range/32767

The actual scale factor and measurement resolution are indicated in the object address map for all measured values (see Chapter 3).

When over-range occurs, a positive value is reported as 32767 and a negative value as -32768 with the OV bit in the quality descriptor byte QDS set to 1.

Conversion Example:

If the value you have read at object address 20736, which represents a phase I1 current reading (see Section 3.1), is 201, the CT ratio is 200A : 5A = 40, and the secondary current scale is 10A, then the current reading in engineering units is as follows:

Max_Measurement_Range (see Section 4) = 40 × 10A = 400A

Value_Resolution = 0.01A

Max_Measurement_Range/Value_Resolution = 400/0.01 = 40000 > 32767

True value reading = 201 × (400/32767) = 2.45A

2.14.5 Floating Point Numbers

A floating point number represents the true readings of a measured value. Floating point numbers are transmitted in an IEEE single precision floating point format (R32.23, Type 5 IEC 60870-5-4).

The actual measurement resolution is indicated in the object address map for all measured values (see Chapter 3).

2.14.6 Packed Long Integer and Octet String Formats

Some of system and configuration parameters are stored in the device in 32-bit signed or unsigned integer format or in octet strings that cannot be scaled or represented using floating point numbers. Since IEC-60870-101/104 do not offer compatible ASDU types, the PMU uses standard scaled value parameter format P_ME_NB_1 for transferring these data types that requires following interpretation in application software.

32-bit integer numbers are packed in two adjacent scaled 16-bit integer numbers in UI32 UNSIGNED INTEGER or I32 SIGNED INTEGER format (Type 1.1 and Type 2.1, IEC 60870-5-4).

Octet strings are packed in continuous 16-bit unsigned integer numbers, two octets in a scaled value, in OCTETSTRING OS8i or OS8iASCII format (Type 7, IEC 60870-5-4).

2.15 Password Protection

System and configuration parameters in the PMU are password protected from unauthorized changes via communications. Refer to the device Installation and Operation Manual for details.

A user password must be written to the device authorization register before changing device parameters. If a correct password is not supplied, the device will respond to write requests with the cause of transmission "unknown information object address".

2.16 Interoperability

See Appendix A for the device interoperability profile.

3 Information Object Map

3.1 Mapped Information Objects

IO Address	Point ID	Description	Measurement Range	Units and Resolution	Type	R/W	Notes
1-4095		**Mapped Object Points**					
1		Mapped point				R/W	
2		Mapped point				R/W	
…		…				R/W	
4095		Mapped point				R/W	

NOTE:

Up to 64 general object points can be remapped to addresses 1-4095. See Section 3.2 for the measurement range, resolution and scale factors of the original object points. See Section 6.2 on how to remap object addresses in the device.

3.2 General Information Objects

3.2.1 Single Point Objects

IO Address	Point ID	Description [2]	Measurement Range [1]	Units and Resolution [1]	Type [3]	R/W	Notes
		Digital Inputs					
17920-18044		Digital inputs DI1–DI125					
+0	0x0600	Digital Input DI1	0/1		M_SP	R	
+1	0x0601	Digital Input DI2	0/1		M_SP	R	
		…					
+24	0x0618	Digital Input D25	0/1		M_SP	R	
		Relay Outputs					
18432-18444							
+0	0x0800	RO1	0/1		M_SP, C_SC	R/W	
+1	0x0801	RO2	0/1		M_SP, C_SC	R/W	
		…					
+12	0x080C	RO13	0/1		M_SP, C_SC	R/W	
		Setpoint Status			M_SP	R	
48128-48159							
+0	0x7C00	Setpoint SP1	0/1		M_SP	R	
+1	0x7C01	Setpoint SP2	0/1		M_SP	R	
…		…					
+31	0x7C1F	Setpoint SP32	0/1		M_SP	R	

3.2.2 Double Point Objects

IO Address	Point ID	Description [2]	Measurement Range [1]	Units and Resolution [1]	Type [3]	R/W	Notes
64512-64638		**Digital Inputs**					
+0	0xBC00	Digital Inputs DI1:2	00/01/10/11		M_DP	R	
+1	0xBC01	Digital Inputs DI2:3	00/01/10/11		M_DP	R	
		…					
+23	0xBC17	Digital Inputs DI24:25	00/01/10/11		M_DP	R	
64640-64702		**Relay Outputs**					
+0	0xBC80	RO1:2	00/01/10/11		M_DP, C_DC	R/W	
+1	0xBC81	RO2:3	00/01/10/11		M_DP, C_DC	R/W	
		…					
+11	0xBC8B	RO12:13	00/01/10/11		M_DP, C_DC	R/W	

NOTE: Double point objects occupy two adjacent object addresses and should always be accessed by addressing the first address of the pair.

3.2.3 Measured Values

IO Address	Point ID	Description [2]	Measurement Range [1]	Units and Resolution [1]	Type [3]	R/W	Notes
16384	0x0000	**None**	0		M_ME	R	Zero object reference
19456-19488		**RT Phase Values**					
+0	0x0C00	V1 voltage	0-Vmax	U1	M_ME	R	
+1	0x0C01	V2 voltage	0-Vmax	U1	M_ME	R	
+2	0x0C02	V3 voltage	0-Vmax	U1	M_ME	R	
+3	0x0C03	I1 current	0-Imax	U2	M_ME	R	
+4	0x0C04	I2 current	0-Imax	U2	M_ME	R	
+5	0x0C05	I3 current	0-Imax	U2	M_ME	R	
+6	0x0C06	kW L1	-Pmax-Pmax	U3	M_ME	R	
+7	0x0C07	kW L2	-Pmax-Pmax	U3	M_ME	R	
+8	0x0C08	kW L3	-Pmax-Pmax	U3	M_ME	R	
+9	0x0C09	kvar L1	-Pmax-Pmax	U3	M_ME	R	
+10	0x0C0A	kvar L2	-Pmax-Pmax	U3	M_ME	R	
+11	0x0C0B	kvar L3	-Pmax-Pmax	U3	M_ME	R	
+12	0x0C0C	kVA L1	0-Pmax	U3	M_ME	R	
+13	0x0C0D	kVA L2	0-Pmax	U3	M_ME	R	
+14	0x0C0E	kVA L3	0-Pmax	U3	M_ME	R	
+15	0x0C0F	Power factor L1	-1000-1000	×0.001	M_ME	R	
+16	0x0C10	Power factor L2	-1000-1000	×0.001	M_ME	R	
+17	0x0C11	Power factor L3	-1000-1000	×0.001	M_ME	R	
+18-29	0x0C12-0x0C1D	Not used	0		M_ME	R	
+30	0x0C1E	V12 voltage	0-Vmax	U1	M_ME	R	
+31	0x0C1F	V23 voltage	0-Vmax	U1	M_ME	R	
+32	0x0C20	V31 voltage	0-Vmax	U1	M_ME	R	
20096-20111		**Average Analog Inputs**					
+0	0x0E80	Analog input AI1	AI1min-AI1max		M_ME	R	
+1-15	0x0E81-0x0E8F	Reserved			M_ME	R	
20224-20227		**RT Total Values**					
+0	0x0F00	Total kW	-Pmax-Pmax	U3	M_ME	R	
+1	0x0F01	Total kvar	-Pmax-Pmax	U3	M_ME	R	
+2	0x0F02	Total kVA	0-Pmax	U3	M_ME	R	
+3	0x0F03	Total PF	-1.000-1.000	0.001	M_ME	R	
20480-20488		**RT Auxiliary Values**					
+0	0x1000	Not used	0		M_ME	R	
+1	0x1001	In current	0-Imax	U2	M_ME	R	
+2	0x1002	Frequency	0-Fmax	0.01Hz	M_ME	R	

IO Address	Point ID	Description [2]	Measurement Range [1]	Units and Resolution [1]	Type [3]	R/W	Notes
+3	0x1003	Voltage unbalance	0-300	1%	M_ME	R	
+4	0x1004	Current unbalance	0-300	1%	M_ME	R	
+5-7	0x1005-0x1007	Not used	0		M_ME	R	
+8	0x1008	Frequency (3 decimals)	0-100000	×0.001Hz	M_ME	R	
20608-20623		**RT Phasor Values**					
+0	0x1080	V1 voltage magnitude	0-Vmax	U1	M_ME	R	
+1	0x1081	V2 voltage magnitude	0-Vmax	U1	M_ME	R	
+2	0x1082	V3 voltage magnitude	0-Vmax	U1	M_ME	R	
+3	0x1083	Not used	0		M_ME	R	
+4	0x1084	I1 current magnitude	0-Imax	U2	M_ME	R	
+5	0x1085	I2 current magnitude	0-Imax	U2	M_ME	R	
+6	0x1086	I3 current magnitude	0-Imax	U2	M_ME	R	
+7	0x1087	Not used	0		M_ME	R	
+8	0x1088	V1 voltage angle	-1800-1800	0.1º	M_ME	R	
+9	0x1089	V2 voltage angle	-1800-1800	0.1º	M_ME	R	
+10	0x108A	V3 voltage angle	-1800-1800	0.1º	M_ME	R	
+11	0x108B	Not used	0		M_ME	R	
+12	0x108C	I1 current angle	-1800-1800	0.1º	M_ME	R	
+13	0x108D	I2 current angle	-1800-1800	0.1º	M_ME	R	
+14	0x108E	I3 current angle	-1800-1800	0.1º	M_ME	R	
+15	0x108F	Not used	0		M_ME	R	
20736-20768		**Average Phase Values**					
+0	0x1100	V1 voltage	0-Vmax	U1	M_ME	R	
+1	0x1101	V2 voltage	0-Vmax	U1	M_ME	R	
+2	0x1102	V3 voltage	0-Vmax	U1	M_ME	R	
+3	0x1103	I1 current	0-Imax	U2	M_ME	R	
+4	0x1104	I2 current	0-Imax	U2	M_ME	R	
+5	0x1105	I3 current	0-Imax	U2	M_ME	R	
+6	0x1106	kW L1	-Pmax-Pmax	U3	M_ME	R	
+7	0x1107	kW L2	-Pmax-Pmax	U3	M_ME	R	
+8	0x1108	kW L3	-Pmax-Pmax	U3	M_ME	R	
+9	0x1109	kvar L1	-Pmax-Pmax	U3	M_ME	R	
+10	0x110A	kvar L2	-Pmax-Pmax	U3	M_ME	R	
+11	0x110B	kvar L3	-Pmax-Pmax	U3	M_ME	R	
+12	0x110C	kVA L1	0-Pmax	U3	M_ME	R	
+13	0x110D	kVA L2	0-Pmax	U3	M_ME	R	
+14	0x110E	kVA L3	0-Pmax	U3	M_ME	R	
+15	0x110F	Power factor L1	-1000-1000	×0.001	M_ME	R	
+16	0x1110	Power factor L2	-1000-1000	×0.001	M_ME	R	

IO Address	Point ID	Description [2]	Measurement Range [1]	Units and Resolution [1]	Type [3]	R/W	Notes
+17	0x1111	Power factor L3	-1000-1000	×0.001	M_ME	R	
+18-29	0x1112-0x111D	Not used	0		M_ME	R	
+30	0x111E	V12 voltage	0-Vmax	U1	M_ME	R	
+31	0x111F	V23 voltage	0-Vmax	U1	M_ME	R	
+32	0x1120	V31 voltage	0-Vmax	U1	M_ME	R	
21504-21517		**Average Total Values**					
+0	0x1400	Total kW	-Pmax-Pmax	U3	M_ME	R	
+1	0x1401	Total kvar	-Pmax-Pmax	U3	M_ME	R	
+2	0x1402	Total kVA	0-Pmax	U3	M_ME	R	
+3	0x1403	Total PF	-1000-1000	×0.001	M_ME	R	
21760-21771		**Average Auxiliary Values**					
+0	0x1500	Not used	0		M_ME	R	
+1	0x1501	In current	0-Imax	U2	M_ME	R	
+2	0x1502	Frequency	0-10000	×0.01Hz	M_ME	R	
+3	0x1503	Voltage unbalance	0-3000	×0.1%	M_ME	R	
+4	0x1504	Current unbalance	0-3000	×0.1%	M_ME	R	
+5-8	0x1505-0x1508	Not used	0		M_ME	R	
+9	0x1509	Internal temperature	-2000 to 2000	×0.1ºC	M_ME	R	
+10	0x150A	Frequency (3 decimals)	0-100000	×0.001Hz	M_ME	R	
+11	0x150B	Lithium battery voltage	0-100000	×0.001V	M_ME	R	
22656-22665		**RT Symmetrical Components**					
+0	0x1880	Positive sequence voltage	0-Vmax	U1	M_ME	R	
+1	0x1881	Negative sequence voltage	0-Vmax	U1	M_ME	R	
+2	0x1882	Zero sequence voltage	0-Vmax	U1	M_ME	R	
+3	0x1883	Negative sequence voltage unbalance	0-3000	×0.1%	M_ME	R	
+4	0x1884	Zero sequence voltage unbalance	0-3000	×0.1%	M_ME	R	
+5	0x1885	Positive sequence current	0-Imax	U2	M_ME	R	
+6	0x1886	Negative sequence current	0-Imax	U2	M_ME	R	
+7	0x1887	Zero sequence current	0-Imax	U2	M_ME	R	
+8	0x1888	Negative sequence current unbalance	0-3000	×0.1%	M_ME	R	
+9	0x1889	Zero sequence current unbalance	0-3000	×0.1%	M_ME	R	
19328-19359		**RT Analog Inputs**					
+0	0x3B00	Analog input AI1	AI1min-AI1max		M_ME	R	
+1-15	0x3B01-0x3B0F	Reserved			M_ME	R	
19392-19423		**RT Raw Analog Inputs**					
+0	0x3B80	Analog input AI1	0-65535		M_ME_NC_1	R	
+1-15	0x3B81-	Reserved			M_ME_NC_1	R	

IO Address	Point ID	Description [2]	Measurement Range [1]	Units and Resolution [1]	Type [3]	R/W	Notes
	0x3B8F						
52480-52527		**Synchrophasor**					
+0	0x8D00	Frame number	0-239		M_ME_NC_1	R	
+1	0x8D01	Frame timestamp, UTC seconds since 1/1/1970		sec	M_IT	R	
+2	0x8D02	Frame timestamp, fraction of second	0-999999	µsec	M_ME_NC_1	R	
+3	0x8D03	Time quality, bitmap	F39		M_ME_NC_1	R	
+4	0x8D04	Data source/stream ID number	1-65534		M_ME_NC_1	R	
+5	0x8D05	Frame status, bitmap	F40		M_ME_NC_1	R	
+6	0x8D06	Frequency deviation from nominal or actual frequency, Hz	-32767 to 32767, or 0 to 100000	×0.001 Hz	M_ME_NC_1	R	
+7	0x8D07	Rate of change of frequency (ROCOF), Hz/s	-32767 to 32767	×0.01 Hz/s	M_ME_NC_1	R	
+8	0x8D08	V1 phasor magnitude	0-Vmax	U1	M_ME_NC_1	R	
+9	0x8D09	V1 phasor angle	-179999 to 180000	×0.001 deg	M_ME_NC_1	R	
+10	0x8D0A	V2 phasor magnitude	0-Vmax	U1	M_ME_NC_1	R	
+11	0x8D0B	V2 phasor angle	-179999 to 180000	×0.001 deg	M_ME_NC_1	R	
+12	0x8D0C	V3 phasor magnitude	0-Vmax	U1	M_ME_NC_1	R	
+13	0x8D0D	V3 phasor angle	-179999 to 180000	×0.001 deg	M_ME_NC_1	R	
+14	0x8D0E	I1 phasor magnitude	0-Imax	U2	M_ME_NC_1	R	
+15	0x8D0F	I1 phasor angle	-179999 to 180000	×0.001 deg	M_ME_NC_1	R	
+16	0x8D10	I2 phasor magnitude	0-Imax	U2	M_ME_NC_1	R	
+17	0x8D11	I2 phasor angle	-179999 to 180000	×0.001 deg	M_ME_NC_1	R	
+18	0x8D12	I3 phasor magnitude	0-Imax	U2	M_ME_NC_1	R	
+19	0x8D13	I3 phasor angle	-179999 to 180000	×0.001 deg	M_ME_NC_1	R	
+20	0x8D14	V1 phasor, Re	0-Vmax	V	M_ME_NC_1	R	
+21	0x8D15	V1 phasor, Im	0-Vmax	V	M_ME_NC_1	R	
+22	0x8D16	V2 phasor, Re	0-Vmax	V	M_ME_NC_1	R	
+23	0x8D17	V2 phasor, Im	0-Vmax	V	M_ME_NC_1	R	
+24	0x8D18	V3 phasor, Re	0-Vmax	V	M_ME_NC_1	R	
+25	0x8D19	V3 phasor, Im	0-Vmax	V	M_ME_NC_1	R	
+26	0x8D1A	I1 phasor, Re	0-Imax	A	M_ME_NC_1	R	
+27	0x8D1B	I1 phasor, Im	0-Imax	A	M_ME_NC_1	R	
+28	0x8D1C	I2 phasor, Re	0-Imax	A	M_ME_NC_1	R	
+29	0x8D1D	I2 phasor, Im	0-Imax	A	M_ME_NC_1	R	
+30	0x8D1E	I3 phasor, Re	0-Imax	A	M_ME_NC_1	R	
+31	0x8D1F	I3 phasor, Im	0-Imax	A	M_ME_NC_1	R	
+32	0x8D20	V1seq positive sequence voltage phasor magnitude	0-Vmax	U1	M_ME_NC_1	R	
+33	0x8D21	V1seq positive sequence voltage phasor angle	-179999 to 180000	×0.001 deg	M_ME_NC_1	R	
+34	0x8D22	I1seq positive sequence current phasor magnitude	0-Imax	U2	M_ME_NC_1	R	
+35	0x8D23	I1seq positive sequence current phasor angle	-179999 to 180000	×0.001 deg	M_ME_NC_1	R	

IO Address	Point ID	Description [2]	Measurement Range [1]	Units and Resolution [1]	Type [3]	R/W	Notes
+36	0x8D24	V1seq positive sequence voltage phasor, Re	0-Vmax	V	M_ME_NC_1	R	
+37	0x8D25	V1seq positive sequence voltage phasor, Im	0-Vmax	V	M_ME_NC_1	R	
+38	0x8D26	I1seq positive sequence current phasor, Re	0-Imax	A	M_ME_NC_1	R	
+39	0x8D27	I1seq positive sequence current phasor, Im	0-Imax	A	M_ME_NC_1	R	
+40	0x8D20	V2seq negative sequence voltage phasor magnitude	0-Vmax	U1	M_ME_NC_1	R	
+41	0x8D21	V2seq negative sequence voltage phasor angle	-179999 to 180000	×0.001 deg	M_ME_NC_1	R	
+42	0x8D22	I2seq negative sequence current phasor magnitude	0-Imax	U2	M_ME_NC_1	R	
+43	0x8D23	I2seq negative sequence current phasor angle	-179999 to 180000	×0.001 deg	M_ME_NC_1	R	
+44	0x8D24	V2seq negative sequence voltage phasor, Re	0-Vmax	V	M_ME_NC_1	R	
+45	0x8D25	V2seq negative sequence voltage phasor, Im	0-Vmax	V	M_ME_NC_1	R	
+46	0x8D26	I2seq negative sequence current phasor, Re	0-Imax	A	M_ME_NC_1	R	
+47	0x8D27	I2seq negative sequence current phasor, Im	0-Imax	A	M_ME_NC_1	R	

3.2.4 Integrated Totals

IO Address	Point ID	Description [2]	Measurement Range [1]	Units and Resolution [1]	Type [3]	R/W	Notes
18944-18975		**Counters**					
+0	0x0A00	Counter #1	0-999,999,999		M_IT, C_CI	R/W	
+1	0x0A01	Counter #2	0-999,999,999		M_IT, C_CI	R/W	
		…					
+31	0x0A1F	Counter #32	0-999,999,999		M_IT, C_CI	R/W	

NOTES:

1 For volts, amps, power and frequency measurement range, resolution and scale factors refer to Section 4 ”Data Scales and Units”.

2 All AC measurements are fundamental frequency values. Real-time (RT) measurements are synchronized with the PMU frame rate. All average measurements are one-second average values updated at the UTC second rollover.

3 Object types: M_ME – measured value, M_SP – single point information, M_DP – double point information, M_IT – integrated total (counter), C_SC – single command, C_CI – counter interrogation command. See F3 through F10 in Section 5 for compatible object types.

3.3 Device Status and Control Parameters

IO Address	Point ID	Description	Options/Range	Units and Resolution	Type	R/W	Notes
Device Port Identification							
6144		Active serial port number	0=serial port COM1, 5=USB port, 6...=Ethernet/TCP port		P_ME_NB_1	R	
Device Diagnostics							
6145		Internal device diagnostics (bits 0:15). Read: bits set to 1 indicate diagnostics failed at least once since last reset. Write: preset bits to 0 to clear corresponding diagnostics flags; bits set to 1 have no effect.	F2		P_ME_NB_1	R/W	
6146		Internal device diagnostics (bits 16:32). Not used	0		P_ME_NB_1	R/W	
Reference Device Time							
6175		Scaled zero value followed by a device clock time For example [6175: 0 Q00 t 24.03.2015 15:48:50:524]	0		M_ME_TE_1	R	
Device Reset/Clear Registers							
6176-6186					P_ME_NB_1		
6180		Clear pulse counters	0 = Clear all counters 1-31 = Clear counter #1-#32			W	
6182		Clear operation/event counters	6 = clear communication counters			W	
Device Authorization Register							
6208-6209		Read: 0 = access permitted, -1 = authorization required. Write: 8-digit password.	0 - 99999999 (write) 0/-1 (read)		P_ME_NB_1 UI32	R/W	

3.4 System Parameters

IO Address	Point ID	Description	Options/Range	Units and Resolution	Type	R/W	Notes
Device Identification							
4224-4255					P_ME_NB_1		
+0,1		Device serial number	0-99999999		UI32	R	
+2,3		Device model ID	23000		UI32	R	
+4-11		Device model name	"PMU"		OS128ASCII	R	Null-terminated octet string
+12-13		Device options (bitmap)	0		UI32	R	
+14-19		Reserved				R	
+20		Device firmware version number	4801-4899			R	Two higher decimal digits = major version number, two lower decimal digits = minor version number
+21		Device firmware build number	1-99			R	
+22-23		Reserved				R	
+24		Boot loader version number	101-999			R	
+25		Boot loader build number	1-99			R	
+26-31		Reserved				R	
Factory Device Settings							
4256-4322					P_ME_NB_1		
+0		V1-V3 input range	120, 480	V		R	
+1		V1-V3 input overload	120	%		R	
+2-3		Reserved				R	
+4		I1-I3 input range	1, 5	A		R	
+5		I1-I3 input overload	200	%		R	
+6-63		Reserved				R	
+64-66		Ethernet 1 MAC address	0x0005F0000000-x0005F0FFFFFF		OS48	R	
+67-69		Ethernet 2 MAC address	0x0005F0000000-x0005F0FFFFFF		OS48	R	

3.5 Device Setup Parameters

IO Address	Point ID	Description	Options/Range	Units and Resolution	Type	R/W	Notes
Communication Port Setup Parameters							
4096-4111					P_ME_NB_1		
+0		Communication protocol	0 = Modbus RTU, 1 = Modbus ASCII, 2 = DNP3.0, 7=IEC 60870-5			R/W	
+1		Interface	2 = RS-485			R/W	
+2		Device address	Modbus: 1-247 DNP3.0: 0–65532 IEC 60870-5: 1-254 (1 octet), 1-65532 (2 octets)			R/W	
+3		Baud rate	4 = 2400 bps, 5 = 4800 bps, 6 = 9600 bps, 7 = 19200 bps, 8 = 38400 bps, 9 = 57600 bps, 10 = 115200 bps			R/W	
+4		Data format	0 = 7 bits/even parity, 1 = 8 bits/no parity, 2 = 8 bits/even parity			R/W	
+5-6		Reserved				R	
+7		Minimum delay before sending data	0-1000 (default = 5)			R/W	
+8		Inter-character timeout	1-1000 (default = 4)				Added to standard 4-character time
+9-15		Reserved				R	
Basic Device Setup Parameters							
5120-5182					P_ME_NC_1		
+0		Not used				R/W	
+1		PT ratio (primary to secondary ratio)	10-65000	×0.1		R/W	
+2		PT secondary (Line-to-Line)	500-7000	×0.1		R/W	
+3-4		Reserved				R	
+5		CT primary current	1-30000	A		R/W	
+6-16		Reserved				R	
+17		Nominal line frequency	50, 60	Hz		R/W	
+18		Phase order	0 = ABC, 1 = CBA			R/W	
+19-22		Reserved				R	
+23		Data rate, frames/s	1,2,3,4,5,6,10,12,15,20,25,30,50, 60,100,120,200,240			R/W	
+24-59		Reserved				R	
+60		L1 current direction	0=regular, 1=reverse			R/W	
+61		L2 current direction	0=regular, 1=reverse			R/W	
+62		L3 current direction	0=regular, 1=reverse			R/W	

IO Address	Point ID	Description	Options/Range	Units and Resolution	Type	R/W	Notes
Device Data Scales							
4418-4419					P_ME_NC_1		
+0		Voltage scale, secondary volts	60-600	1V		R/W	
+1		Current scale, secondary amps	10-200	×0.1A		R/W	

3.6 Protocol Setup Parameters

IO Address	Point ID	Description	Options/Range	Units and Resolution	Type	R/W	Notes
IEC 60870-5 Options Setup							
4480-4515		**Network 1**			P_ME_NB_1		
5504-5539		**Network 2**			P_ME_NB_1		
+0		Maximum length of variable frame, octets	32-255			R/W	Fixed to 253 in IEC 60870-5-104
+1		Link address length, octets	1-2			R/W	Not used in IEC 60870-5-104
+2		Cause of transmission length, octets	1-2			R/W	Fixed to 2 in IEC 60870-5-104
+3		Length of common address of ASDU, octets	1-2			R/W	Fixed to 2 in IEC 60870-5-104
+4		Length of information object address, octets	1-3			R/W	Fixed to 3 in IEC 60870-5-104
+5		Select-before-operate timeout, s	0-30			R/W	
+6		Short pulse duration, ms	100-3000	ms		R/W	
+7		Long pulse duration, ms	100-3000	ms		R/W	
+8,9		Time synchronization period, s	1-86400, 0=not active	s	UI32	R/W	
+10		Local counter freeze period, min	1-60, 0=not active	min		R/W	
+11		Cyclic data transmission period, ms	100-30000, 0=not active	ms		R/W	Effective in IEC 60870-5-104 only
+12,13		IP address 1 for spontaneous/cyclic transmission	0-0xFFFFFE, 0=not active		UI32	R/W	
+14,15		IP address 2 for spontaneous/cyclic transmission	0-0xFFFFFE, 0=not active		UI32	R/W	
+16,17		Not used	0		UI32	R/W	
+18		Not used	0			R/W	
+19		Respond with class 1 data to class 2 requests	0=disabled, 1=enabled			R/W	
+20		Single point start mapped address	1-4095			R/W	
+21		Single point default static object type	F3			R/W	
+22		Single point default event object type	F4			R/W	
+23		Double point start mapped address	1-4095			R/W	
+24		Double point default static object type	F5			R/W	
+25		Double point default event object type	F6			R/W	
+26		Measured value start mapped address	1-4095			R/W	
+27		Measured value default static object type	F7			R/W	
+28		Measured value default event object type	F8			R/W	
+29		Integrated totals start mapped address	1-4095			R/W	
+30		Integrated totals default static object type	F9			R/W	
+31		Integrated totals default event object type	F10			R/W	
+32		Voltage units	0=V, 1=kV			R/W	
+33		Current units	0=A, 1=kA			R/W	
+34		Power units	0=kW, 1=MW			R/W	
+35		Redundancy mode	1, 2			R/W	

IO Address	Point ID	Description	Options/Range	Units and Resolution	Type	R/W	Notes
IEC 60870-5 Class 2 Data and Counters Setup							
4544-4639		**Network 1**			P_ME_NB_1		
5568-5663		**Network 2**			P_ME_NB_1		
+0		Information object type and flags	Bits 0:7 – static object type identification (F3, F5, F7, F9), Bit 8=1 – freeze with reset, Bit 9=1 – local freeze, Bit 10=1 – cyclic data transmission, Bit 11=1 – general interrogation, Bits 12:15 – interrogation group = 0-15 (0=no group assigned)			R/W	See Section 3.2 for compatible object types.
+1		Start information object address	1-65535			R/W	
+2		Number of elements in the range	1-128			R/W	
+0-2		**Object address range #1**					
+3-5		**Object address range #2**					
…		**…**					
+93-95		**Object address range #32**					
IEC 60870-5 Assignable Point Map and Events Setup							
5248-5503		**Network 1**			P_ME_NB_1		
5760-6015		**Network 2**			P_ME_NB_1		
+0		Point ID	See Section 3.2			R/W	
+1		Information object type and flags	Bits 0:7 – static object type identification (F3, F5, F7), Bits 8:9 – relation (0=delta, 1= more than, 2 = less than) Bit 10=1 – class 1 assignment			R/W	See Section 3.2 for compatible object types.
+2,3		Deadband/threshold	See Section 3.2 for the point range and resolution			R/W	
+0-3		**Mapped static/event point #1**					
+4-7		**Mapped static/event point #2**					
…		**…**					
+252-255		**Mapped static/event point #64**					

4 Data Scales and Units

Code	Condition	Value/Range	Notes
Data Scales			
Vmax		Voltage Scale × PT Ratio, V	2
Imax		Current Scale × CT Ratio, A,	1, 3
Pmax	PT Ratio = 1	Vmax × Imax × 2, W	4
	PT Ratio > 1	(Vmax × Imax × 2)/1000, kW	4
AImin AImax	+/-1mA	AImin = -AI full scale (at -2 mA) AImax = AI full scale (at +2 mA)	5
	0-20mA	AImin = AI zero scale AImax = AI full scale	5
	4-20mA	AImin = AI zero scale AImax = AI full scale	5
	0-1mA	AImin = AI zero scale AImax = AI full scale (at 2 mA)	5
Data Units			
U1	PT Ratio = 1	0.1V	
	PT Ratio > 1	1V	
U2		0.01A	
U3	PT Ratio = 1	1W/Var/VA	
	PT Ratio > 1	1kW/kvar/kVA	

1 CT Ratio = CT primary current/CT secondary current

2 The Voltage Scale is configurable via the Device Setup Parameters (see Section 3.5) or via the Basic Setup in PAS. The default value is 144V.

3 The Current Scale is configurable via the Device Setup Parameters (see Section 3.5) or via the Basic Setup in PAS. The default value is 2×CT secondary current.

4 Pmax is rounded to whole kilowatts. When PT=1.0, Pmax is limited to 9,999,000 watts and is truncated to this value if greater.

5 AI zero and full scales are engineering scales configurable via the Analog Input Setup in PAS (see the PMU Installation and Operation Manual).

5 Data Formats

Format Code	Value	Description	Notes
Device Diagnostics			
F2	Bit 0	Reserved	
	Bit 1	Reserved	
	Bit 2 = 1	RAM/Data error	
	Bit 3 = 1	CPU watchdog reset	
	Bit 4 = 1	Sampling fault	
	Bit 5 = 1	CPU exception	
	Bit 6	Reserved	
	Bit 7 = 1	Software watchdog reset	
	Bit 8 = 1	Power down	
	Bit 9 = 1	Device reset	
	Bit 10 = 1	Configuration reset	
	Bit 11 = 1	RTC fault	
	Bit 12	Reserved	
	Bit 13	Reserved	
	Bit 14	Reserved	
	Bit 15 = 1	EEPROM fault	
Single Point Info Static Type			
F3	1	M_SP_NA_1	
	2	M_SP_TA_1 (CP24Time2a)	
	30	M_SP_TB_1 (CP56Time2a)	
Single Point Info Event Type			
F4	2	M_SP_TA_1 (CP24Time2a)	
	30	M_SP_TB_1 (CP56Time2a)	
Double Point Info Static Type			
F5	3	M_DP_NA_1	
	4	M_DP_TA_1 (CP24Time2a)	
	31	M_DP_TB_1 (CP56Time2a)	
Double Point Info Event Type			
F6	4	M_DP_TA_1 (CP24Time2a)	
	31	M_DP_TB_1 (CP56Time2a)	
Measured Value Static Type			
F7	9	M_ME_NA_1	
	10	M_ME_NB_1	
	11	M_ME_NC_1	
	12	M_ME_TA_1 (CP24Time2a)	
	13	M_ME_TB_1 (CP24Time2a)	
	14	M_ME_TC_1 (CP24Time2a)	
	34	M_ME_TD_1 (CP56Time2a)	
	35	M_ME_TE_1 (CP56Time2a)	
	36	M_ME_TF_1 (CP56Time2a)	
Measured Value Event Type			
F8	12	M_ME_TA_1 (CP24Time2a)	
	13	M_ME_TB_1 (CP24Time2a)	
	14	M_ME_TC_1 (CP24Time2a)	
	34	M_ME_TD_1 (CP56Time2a)	
	35	M_ME_TE_1 (CP56Time2a)	
	36	M_ME_TF_1 (CP56Time2a)	
Integrated Totals Static Type			
F9	15	M_IT_NA_1	
	16	M_IT_TA_1 (CP24Time2a)	
	37	M_IT_TB_1 (CP56Time2a)	
Integrated Totals Event Type			
F10	16	M_IT_TA_1 (CP24Time2a)	
	37	M_IT_TB_1 (CP56Time2a)	

Format Code	Value	Description	Notes
PMU Time Quality (bitmap)			
F39	Bits 0:3	0xF = clock failure, time not reliable 0xB = time within 10 s 0xA = time within 1 s 0x9 = time within 100 ms 0x8 = time within 10 ms 0x7 = time within 1 ms 0x6 = time within 100 µs 0x5 = time within 10 µs 0x4 = time within 1 µs 0x3 = time within 100 ns 0x2 = time within 10 ns 0x1 = time within 1 ns 0x0 = locked to UTC traceable source	
	Bit 4	Leap second pending	
	Bit 5	Leap second occurred	
	Bit 6	Leap second direction, 0 = add, 1=delete	
PMU Frame Status (bitmap)			
F40	Bits 0:3	Trigger reason	
	Bits 4:5	Unlocked time: 0 = sync locked or unlocked time < 10 s (best quality) 1 = unlocked time < 100 s 2 = unlocked time <= 1000 s 3 = unlocked time > 1000 s	
	Bits 6:8	PMU time quality: 1 = maximum time error < 100 ns 2 = maximum time error < 1 µs 3 = maximum time error < 10 µs 4 = maximum time error < 100 µs 5 = maximum time error < 1 ms 6 = maximum time error < 10 ms 7 = maximum time error > 10 ms or time error unknown	
	Bit 9	1 = data modified by post processing, 0 = otherwise	
	Bit 10	Configuration change, set to 1 for 1 min to advise configuration will change, and cleared to 0 when change effected	
	Bit 11	1 = PMU trigger detected, 0 = no trigger	
	Bit 12	Data sorting, 0 = by timestamp, 1 = by arrival	
	Bit 13	0 = PMU in sync with a UTC traceable time source	
	Bits 14:15	Data error: 0 = good measurement data 1 = PMU error (no information about data) 2 = PMU in test mode or absent data tags inserted (do not use values) 3 = PMU error (do not use values)	

6 Configuring IEC 60870-5

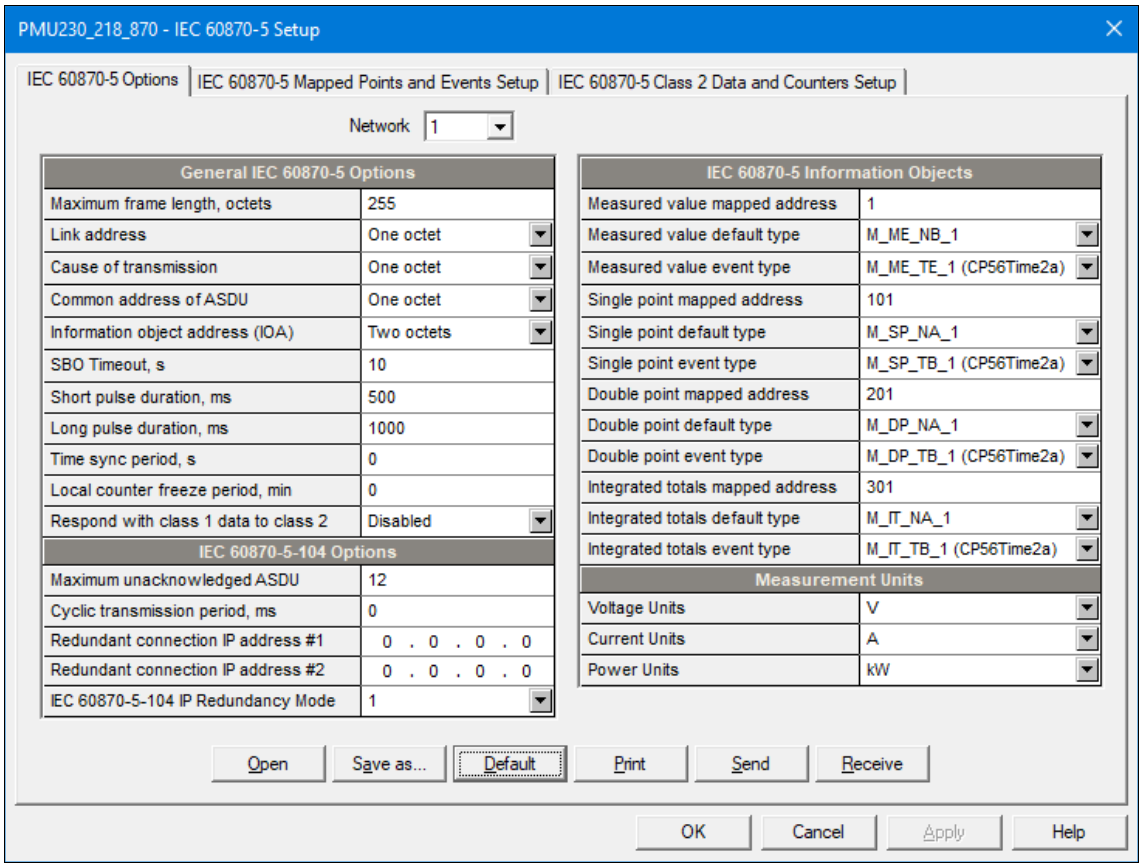
Use the PAS software provided with your device to configure IEC 60870-5 options. See the PMU Installation and Operation Manual for more information on installation and operating PAS on your computer.

Configuring IEC 60870-5 is available via both Modbus and IEC 60870-5 ports.

6.1 Configuring IEC 60870-5 Options

To configure the IEC 60870-5 options:

1. Select IEC 60870-5 Setup from the Device Setup menu.



2. Select the network port you want to configure and configure desired options.
3. Click Save as… to store your setup in the device site database, and click Send to send the setup to the device.

See the following table for available options.

Parameter	Options	Default	Description
General IEC 60870-5 Options			
Maximum frame length	32-255 octets	255	The maximum length of the transmission frame. In IEC 60870-5-104 it is fixed to 253 octets.
Link address	1-2 octets	1	Link address length
Cause of transmission	1-2 octets	1	Cause of transmission length. In IEC 60870-5-104 it is fixed to 2 octets.

Parameter	Options	Default	Description
Common address of ASDU	1-2 octets	1	Length of common address of ASDU. In IEC 60870-5-104 it is fixed to 2 octets.
Information object address	1-3 octets	2	Length of information object address In IEC 60870-5-104 it is fixed to 3 octets.
SBO Timeout, s	0-30 s	10	Select-before-operate (SBO) timeout for single point commands with a select qualifier
Short pulse duration, ms	100-3000 ms	500	Short pulse duration for single point commands with a short pulse qualifier
Long pulse duration, ms	100-3000 ms	1000	Long pulse duration for single point commands with a long pulse qualifier
Time sync period, s	1-86400 s, 0=not active	0	The time interval between periodic time synchronization requests
Local counter freeze period, min	1-60 min, 0=not active	0	The period of local counter freeze and spontaneous transmission of integrated totals
Respond with class 1 data to class 2	0=disabled, 1=enabled	Disabled	If enabled, the device will respond with class 1 data to class 2 requests when there is no class 2 data in transmission
IEC 60870-5-104 Options			
Maximum unacknowledged ASDU	1-32, 0=unlimited	12	The maximum number of unacknowledged ASDU allowed before suspending data transmission. Unlimited when set to 0.
Cyclic transmission period, ms	100-30000 ms, 0=not active	0	The period of cyclic/periodic data transmission via the IEC 60870-5-104 port
Redundant connection IP address #1	0.0.0.0 =not active	0.0.0.0	First IP address for spontaneous/cyclic transmission. Can be a member of a redundant connection group (see Notes 3-4).
Redundant connection IP address #2	0.0.0.0 =not active	0.0.0.0	Second IP address for spontaneous/cyclic transmission. Can be a member of a redundant connection group (see Notes 3-4).
Redundancy mode	1, 2	1	Mode 1 = both connections must be established to activate redundancy Mode 2 = at least one connection must be established to activate redundancy
IEC 60870-5 Information Objects			
Measured value mapped address	1-4095	1	Starting address for mapped static measured value objects

Parameter	Options	Default	Description
Measured value default type	M_ME_NA_1 M_ME_NB_1 M_ME_NC_1 M_ME_TA_1 M_ME_TB_1 M_ME_TC_1 M_ME_TD_1 M_ME_TE_1 M_ME_TF_1	M_ME_NB_1	The default type of static measured value objects for Read requests
Measured value event type	M_ME_TA_1 M_ME_TB_1 M_ME_TC_1 M_ME_TD_1 M_ME_TE_1 M_ME_TF_1	M_ME_TE_1	The default type of measured value objects for event reporting
Single point mapped address	1-4095	101	Starting address for mapped static single point objects
Single point default type	M_SP_NA_1 M_SP_TA_1 M_SP_TB_1	M_SP_NA_1	The default type of static single point objects for Read requests
Single point event type	M_SP_TA_1 M_SP_TB_1	M_SP_TB_1	The default type of single point objects for event reporting
Double point mapped address	1-4095	201	Starting address for mapped static double point objects
Double point default type	M_DP_NA_1 M_DP_TA_1 M_DP_TB_1	M_DP_NA_1	The default type of static double point objects for Read requests
Double point event type	M_DP_TA_1 M_DP_TB_1	M_DP_TB_1	The default type of double point objects for event reporting
Integrated totals mapped address	1-4095	301	Starting address for mapped static integrated totals objects
Integrated totals default type	M_IT_NA_1 M_IT_TA_1 M_IT_TB_1	M_IT_NA_1	The default type of static integrated totals for Read requests
Integrated totals event type	M_IT_TA_1 M_IT_TB_1	M_IT_TB_1	The default type of integrated totals for event reporting
Measurement Units			
Voltage units	0=V, 1=kV	V	Units of voltage measured values
Current units	0=A, 1=kA	A	Units of current measured values
Power units	0=kW, 1=MW	kW	Units of power measured values

NOTES:

1. In IEC 60870-5-104, the maximum length of the variable frame, the common address of ASDU, information object address and cause of transmission length are permanently set to values indicated in the table and the optional settings are ignored.
2. Selecting the one-octet information object address length for IEC 60870-5-101 will limit the range of objects to only mapped points in the range of 1 to 255 and will make impossible configuring IEC 60870-5 in the device via IEC 60870-5-101 ports.

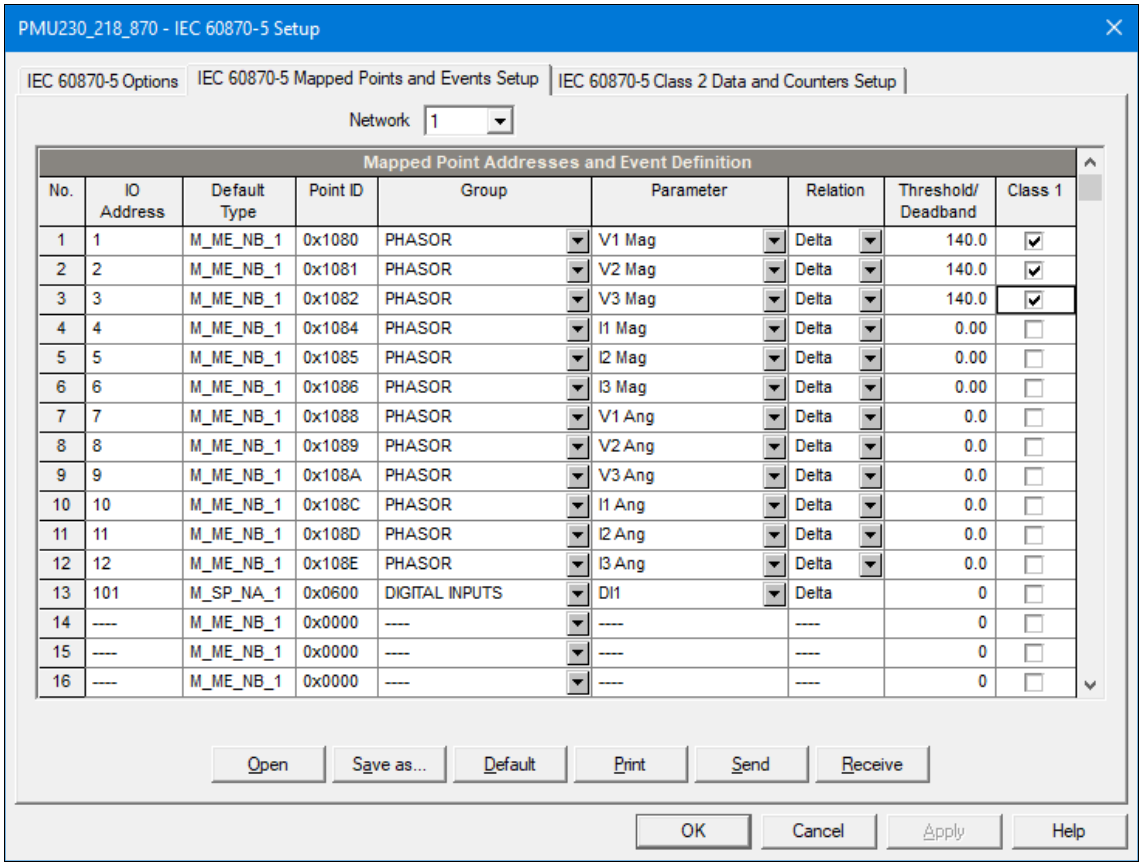
3. The two IP addresses must be defined to activate spontaneous/cyclic transmission. To operate over a single connection without redundancy, set both to the same IP address.
4. If the two IP addresses are set to different, the selected redundancy mode is activated for the redundancy group on the current Ethernet port, allowing a controlling station to run two redundant logical connections for spontaneous/cyclic transmission. See Section 2.9 for details.
5. The mapped I/O object addresses, default types and measurement units are common to both networks. Changes made to one network are automatically applied to the other network.

6.2 Remapping Point Addresses and Event Reporting

NOTE: The process measurement scales for most analog values depend on your external PT and CT settings and on the voltage and current scales defined in the device. Configure them in your device and save to the device site database before configuring event deadbands. See Basic Setup in the PMU Installation and Operation Manual on how to configure these parameters in your device.

To remap static object point addresses to the configurable address space and to configure corresponding event objects:

1. Select IEC 60870-5 Setup from the Device Setup menu, and then click on the IEC 60870-5 Mapped Points and Events Setup tab.



2. Select an object group and parameter for the points you want to remap. Object types and addresses are assigned automatically based on the initial mapped address and the default static type you selected for the object type in the IEC 60870-5 Options Setup (See Section 6.1).

   If you want to use a static point to report events, select the relation and operating threshold or deadband that will be used to detect events, and check the Class 1

box for this point. See Section 2.8 for more information on event reporting. The following options are available:

- Delta – a new event is reported when the absolute value of the difference between the last reported point value and its current value exceeds the specified deadband value, or the status of a binary point changes. Measured values with a zero deadband will not be checked for events;
- More than (over) - a new event is reported when the point value rises over the specified threshold, and then when it returns below the threshold minus a predefined return hysteresis – applicable for measured values;
- Less than (under) - a new event is reported when the point value drops below the specified threshold, and then when it returns above the threshold plus a predefined return hysteresis – applicable for measured values.

Hysteresis of the return threshold for measured values is 0.05 Hz for frequency and 2% of the operating threshold for other points.

All thresholds/deadbands for measured values should be specified in primary units.

3. Click Save as… to store your setup in the device site database, and click Send to send the setup to the device.

   When the setup is saved to the device database or sent to the device, all points are automatically arranged in the following order: measured values, single point objects, double point objects, integrated totals. See Section 3.2 for a complete list of available information objects.

6.3 Configuring Class 2 Data and Counter Transmission

This setup allows you to configure object address ranges for interrogation, cyclic/periodic data transmission, and spontaneous counter transmission with or without local freeze/reset.

To configure object address ranges for data transmission:

1. Select IEC 60870-5 Setup from the Device Setup menu, and then click on the IEC 60870-5 Class 2 Data and Counters Setup tab.
2. Select an object type and specify the ranges of points to be included into interrogation responses or/and cyclic/spontaneous data transfers. For interrogation and cyclic/spontaneous transmission, only mapped point addresses (see Section 6.2) and general object addresses listed in Section 3.2 can be used. See Section 3.2 for information on compatible object types.

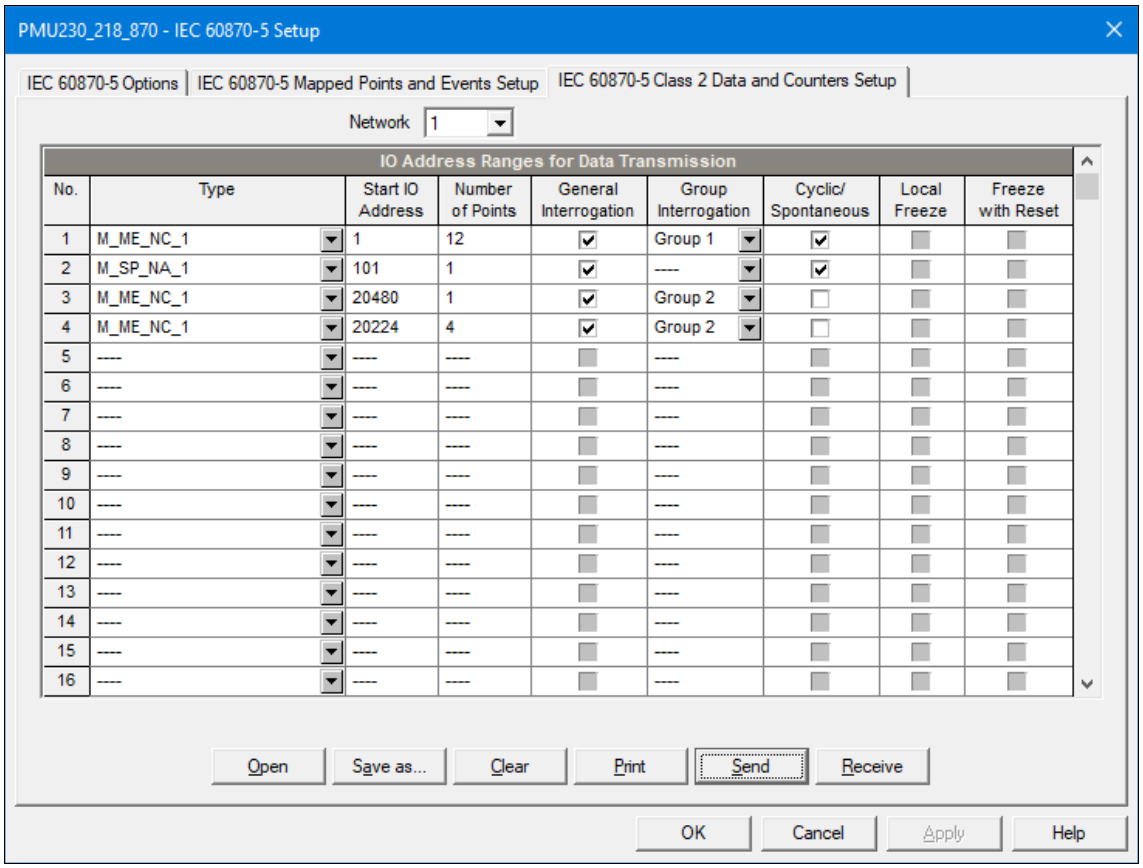
   Up to 32 address ranges can be selected. Fill in the lines sequentially without gaps. The first empty line will be considered the end of a range list.

   NOTE:

   Although double point objects occupy two adjacent addresses, always specify the actual number of requested double points as you define other object ranges.

   Class 2 interrogated and cyclic/spontaneous data are always transmitted in the order they are listed in the setup. If you place ranges of point of the same type in continuous rows, they will be packed together and transmitted using a minimum number of frames.
3. Check the "General Interrogation" box for ranges you want to include into the general station interrogation.

4. In the "Group Interrogation" box, select the appropriate groups for the ranges you want to include into group interrogation. Each range of points can be allocated for both general and group interrogation.



5. Check the "Cyclic/Spontaneous" box for the ranges you want to include in the cyclic/spontaneous data transmission.

   Analog and binary data selected for cyclic transmission will be transmitted as cyclic messages. The cyclic data transmission period is configurable via the IEC 60870-5 Options setup (see Section 6.1).

   Integrated totals selected for spontaneous transmission will be transmitted as spontaneous messages at configurable local counter freeze/transmission intervals (see Section 6.1).

6. Check the "Local Freeze" box for modes A and B of transmission of integrated totals with local freeze. See Section 6.1 on how to configure the local counter freeze period. See Section 2.7 for more information on the operation and transmission of frozen counters.

   NOTE:

   Counters selected for spontaneous transmission without local freeze will be periodically reported at specified counter freeze/transmission intervals either with the frozen counter values if a remote freeze command was issued before (mode D of acquisition of integrated totals), or with the actual counter values for counters that were not frozen.

7. Check the "Freeze with Reset" box for the integrated totals for which a local freeze with reset should be applied.

8. Click Save as… to store your setup in the device site database, and click Send to send the setup to the device.

7 IEC 60870-5 Interoperability Profile

The following sections contain the device interoperability profile in a form derived from IEC 60870-5-101:2003 and IEC 60870-5-104:2006.

7.1 IEC 60870-5-101 Protocol Implementation Conformance Statement (PICS)

The selected parameters are marked in the white boxes as follows:

☐ Function or ASDU is not used

☒ Function or ASDU is used as standardized (default)

R Function or ASDU is used in reverse mode

B Function or ASDU is used in standard and reverse mode

The possible selection (blank, X, R, or B) is specified for each specific Clause or parameter.

NOTE: In addition, the full specification of a system may require individual selection of certain parameters for certain parts of the system, such as the individual selection of scaling factors for individually addressable measured values.

G.1.1 System or device

(system-specific parameter, indicate the definition of a system or a device by marking one of the following with an "×")

☐ System definition

☐ Controlling station definition (master)

☒ Controlled station definition (slave)

G.1.2 Network configuration

(network-specific parameter, all configurations that are used are to be marked with an "×")

☒ Point-to-point

☒ Multiple point-to-point

☒ Multipoint-partyline

☐ Multipoint-star

G.1.3 Physical layer

(network-specific parameter, all interfaces and data rates that are used are to be marked with an "×")

Transmission speed (control direction)

Unbalanced interchange Circuit V.24/V.28 Standard	Unbalanced interchange Circuit V.24/V.28 Recommended if >1 200 bit/s		Balanced interchange Circuit X.24/X.27
☐ 100 bit/s	☒ 2 400 bit/s	☒ 2 400 bit/s	☐ 56 000 bit/s
☐ 200 bit/s	☒ 4 800 bit/s	☒ 4 800 bit/s	☐ 64 000 bit/s
☐ 300 bit/s	☒ 9 600 bit/s	☒ 9 600 bit/s	
☐ 600 bit/s		☒ 19 200 bit/s	
☐ 1 200 bit/s		☒ 38 400 bit/s	

* Additionally supported baud rates: 57600 bit/s, 115200 bit/s.

Transmission speed (monitor direction)

Unbalanced interchange Circuit V.24/V.28 Standard	Unbalanced interchange Circuit V.24/V.28 Recommended if >1 200 bit/s	Balanced interchange Circuit X.24/X.27	
☐ 100 bit/s	☒ 2 400 bit/s	☒ 2 400 bit/s	☐ 56 000 bit/s
☐ 200 bit/s	☒ 4 800 bit/s	☒ 4 800 bit/s	☐ 64 000 bit/s
☐ 300 bit/s	☒ 9 600 bit/s	☒ 9 600 bit/s	
☐ 600 bit/s		☒ 19 200 bit/s	
☐ 1 200 bit/s		☒ 38 400 bit/s	

* Additionally supported baud rates: 57600 bit/s, 115200 bit/s.

G.1.4 Link layer

(network-specific parameter, all options that are used are to be marked with an "×". Specify the maximum frame length. If a non-standard assignment of class 2 messages is implemented for unbalanced transmission, indicate the type ID and COT of all messages assigned to class 2.)

Frame format FT 1.2, single character 1 and the fixed time out interval are used exclusively in this companion standard.

	Link transmission procedure		**Address field of the link**
☐	Balanced transmission	☐	Not present (balanced transmission only)
☒	Unbalanced transmission	☒	One octet
	Frame length	☒	Two octets
255	Maximum length L (control direction)	☐	Structured
255	Maximum length L (monitor direction)	☒	Unstructured
	Time during which repetitions are permitted (Trp) or number of repetitions		

When using an unbalanced link layer, the following ASDU types are returned in class 2 messages (low priority) with the indicated causes of transmission:

☐ The standard assignment of ASDUs to class 2 messages is used as follows:

Type identification	**Cause of transmission**
9, 11, 13, 21	<1>

☒ A special assignment of ASDUs to class 2 messages is used as follows:

Type identification	Cause of transmission
1, 2, 9-16, 30, 34-37	<20> to <35>, <37> to <41>

NOTE: In response to a class 2 poll, a controlled station may respond with class 1 data when there is no class 2 data available.

G.1.5 Application layer

Transmission mode for application data

Mode 1 (least significant octet first), as defined in 4.10 of IEC 60870-5-4, is used exclusively in this companion standard.

Common address of ASDU

(system-specific parameter, all configurations that are used are to be marked with an "×")

☒ One octet ☒ Two octets

Information object address

(system-specific parameter, all configurations that are used are to be marked with an "×")

☒ One octet ☒ Structured
☒ Two octets ☐ Unstructured
☒ Three octets

Cause of transmission

(system-specific parameter, all configurations that are used are to be marked with an "×")

☒ One octet ☒ Two octets (with originator address)
Originator address is set to zero if not used

Selection of standard ASDUs

Process information in monitor direction

(station-specific parameter, mark each type ID with an "×" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

☒	<1> := Single-point information	M_SP_NA_1
☒	<2> := Single-point information with time tag	M_SP_TA_1
☒	<3> := Double-point information	M_DP_NA_1
☒	<4> := Double-point information with time tag	M_DP_TA_1
☐	<5> := Step position information	M_ST_NA_1
☐	<6> := Step position information with time tag	M_ST_TA_1
☐	<7> := Bitstring of 32 bit	M_BO_NA_1
☐	<8> := Bitstring of 32 bit with time tag	M_BO_TA_1
☒	<9> := Measured value, normalized value	M_ME_NA_1
☒	<10> := Measured value, normalized value with time tag	M_ME_TA_1
☒	<11> := Measured value, scaled value	M_ME_NB_1
☒	<12> := Measured value, scaled value with time tag	M_ME_TB_1
☒	<13> := Measured value, short floating point value	M_ME_NC_1
☒	<14> := Measured value, short floating point value with time tag	M_ME_TC_1
☒	<15> := Integrated totals	M_IT_NA_1
☒	<16> := Integrated totals with time tag	M_IT_TA_1
☐	<17> := Event of protection equipment with time tag	M_EP_TA_1
☐	<18> := Packed start events of protection equipment with time tag	M_EP_TB_1
☐	<19> := Packed output circuit information of protection equipment with time tag	M_EP_TC_1
☐	<20> := Packed single-point information with status change detection	M_PS_NA_1
☐	<21> := Measured value, normalized value without quality descriptor	M_ME_ND_1
☒	<30> := Single-point information with time tag CP56Time2a	M_SP_TB_1
☒	<31> := Double-point information with time tag CP56Time2a	M_DP_TB_1
☐	<32> := Step position information with time tag CP56Time2a	M_ST_TB_1
☐	<33> := Bitstring of 32 bit with time tag CP56Time2a	M_BO_TB_1
☒	<34> := Measured value, normalized value with time tag CP56Time2a	M_ME_TD_1
☒	<35> := Measured value, scaled value with time tag CP56Time2a	M_ME_TE_1

☒	<36> := Measured value, short floating point value with time tag CP56Time2a	M_ME_TF_1
☒	<37> := Integrated totals with time tag CP56Time2a	M_IT_TB_1
☐	<38> := Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
☐	<39> := Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
☐	<40> := Packed output circuit information of protection equipment with time tag P56Time2a	M_EP_TF_1

Either ASDUs of the set <2>, <4>, <6>, <8>, <10>, <12>, <14>, <16>, <17>, <18>, <19> or of the set <30–40> are used.

Process information in control direction

(station-specific parameter, mark each type ID with an "×" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

☒	<45> := Single command	C_SC_NA_1
☒	<46> := Double command	C_DC_NA_1
☐	<47> := Regulating step command	C_RC_NA_1
☐	<48> := Set point command, normalized value	C_SE_NA_1
☐	<49> := Set point command, scaled value	C_SE_NB_1
☐	<50> := Set point command, short floating point value	C_SE_NC_1
☐	<51> := Bitstring of 32 bit	C_BO_NA_1

System information in monitor direction

(station-specific parameter, mark with an "×" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

☒	<70> := End of initialization	M_EI_NA_1

System information in control direction

(station-specific parameter, mark each type ID with an "×" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

☒	<100> := Interrogation command	C_IC_NA_1
☒	<101> := Counter interrogation command	C_CI_NA_1
☒	<102> := Read command	C_RD_NA_1
☒	<103> := Clock synchronization command	C_CS_NA_1
☐	<104> := Test command	C_TS_NA_1
☐	<105> := Reset process command	C_RP_NA_1
☐	<106> := Delay acquisition command	C_CD_NA_1

Parameter in control direction

(station-specific parameter, mark each type ID with an "×" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

☐	<110> := Parameter of measured value, normalized value	P_ME_NA_1
☒	<111> := Parameter of measured value, scaled value	P_ME_NB_1
☒	<112> := Parameter of measured value, short floating point value	P_ME_NC_1
☐	<113> := Parameter activation	P_AC_NA_1

File transfer

(station-specific parameter, mark each type ID with an "×" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

- ☐ <120> := File ready F_FR_NA_1
- ☐ <121> := Section ready F_SR_NA_1
- ☐ <122> := Call directory, select file, call file, call section F_SC_NA_1
- ☐ <123> := Last section, last segment F_LS_NA_1
- ☐ <124> := Ack file, ack section F_AF_NA_1
- ☐ <125> := Segment F_SG_NA_1
- ☐ <126> := Directory {blank or X, only available in monitor (standard) direction} F_DR_TA_1

Type identification and cause of transmission assignments

(station-specific parameters)

Blank = function or ASDU is not used.

Mark type identification/cause of transmission combinations:

"×" if used only in the standard direction;

"**R**" if used only in the reverse direction;

"**B**" if used in both directions.

Type identification		**Cause of transmission**																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<1>	M_SP_NA_1	×				×									×					
<2>	M_SP_TA_1	×		×		×									×					
<3>	M_DP_NA_1	×				×									×					
<4>	M_DP_TA_1	×		×		×									×					
<5>	M_ST_NA_1																			
<6>	M_ST_TA_1																			
<7>	M_BO_NA_1																			
<8>	M_BO_TA_1																			
<9>	M_ME_NA_1	×				×									×					
<10>	M_ME_TA_1	×		×		×									×					
<11>	M_ME_NB_1	×				×									×					
<12>	M_ME_TB_1	×		×		×									×					
<13>	M_ME_NC_1	×				×									×					
<14>	M_ME_TC_1	×		×		×									×					
<15>	M_IT_NA_1	×				×										×				
<16>	M_IT_TA_1	×		×		×										×				
<17>	M_EP_TA_1																			
<18>	M_EP_TB_1																			
<19>	M_EP_TC_1																			
<20>	M_PS_NA_1																			
<21>	M_ME_ND_1																			
<30>	M_SP_TB_1	×		×		×									×					
<31>	M_DP_TB_1	×		×		×									×					
<32>	M_ST_TB_1																			
<33>	M_BO_TB_1																			
<34>	M_ME_TD_1	×		×		×									×					
<35>	M_ME_TE_1	×		×		×									×					
<36>	M_ME_TF_1	×		×		×									×					

Type identification		Cause of transmission																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<37>	M_IT_TB_1	×		×		×										×				
<38>	M_EP_TD_1																			
<39>	M_EP_TE_1																			
<40>	M_EP_TF_1																			
<45>	C_SC_NA_1						×	×	×	×	×							×	×	×
<46>	C_DC_NA_1						×	×	×	×	×							×	×	×
<47>	C_RC_NA_1																			
<48>	C_SE_NA_1																			
<49>	C_SE_NB_1																			
<50>	C_SE_NC_1																			
<51>	C_BO_NA_1																			
<70>	M_EI_NA_1				×															
<100>	C_IC_NA_1						×	×			×							×	×	
<101>	C_CI_NA_1						×	×			×							×	×	
<102>	C_RD_NA_1					×												×	×	×
<103>	C_CS_NA_1						×	×										×	×	
<104>	C_TS_NA_1																			
<105>	C_RP_NA_1																			
<106>	C_CD_NA_1																			
<110>	P_ME_NA_1																			
<111>	P_ME_NB_1					×														
<112>	P_ME_NC_1					×														
<113>	P_AC_NA_1																			
<120>	F_FR_NA_1																			
<121>	F_SR_NA_1																			
<122>	F_SC_NA_1																			
<123>	F_LS_NA_1																			
<124>	F_AF_NA_1																			
<125>	F_SG_NA_1																			
<126>	F_DR_TA_1																			
* Blank or × only																				

G.1.6 Basic application functions

Station initialization

(station-specific parameter, mark with an "×" if function is used)

☐ Remote initialization

Cyclic data transmission

(station-specific parameter, mark with an "×" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☒ Cyclic data transmission

Read procedure

(station-specific parameter, mark with an "×" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☒ Read procedure

Spontaneous transmission

(station-specific parameter, mark with an "×" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☒ Spontaneous transmission

Double transmission of information objects with cause of transmission spontaneous

(station-specific parameter, mark each information type with an "**X**" where both a type ID without time and corresponding type ID with time are issued in response to a single spontaneous change of a monitored object)

The following type identifications may be transmitted in succession caused by a single status change of an information object. The particular information object addresses for which double transmission is enabled are defined in a project-specific list.

☐ Single-point information M_SP_NA_1, M_SP_TA_1, M_SP_TB_1 ~~and M_PS_NA_1~~

☐ Double-point information M_DP_NA_1, M_DP_TA_1 and M_DP_TB_1

☐ Step position information M_ST_NA_1, M_ST_TA_1 and M_ST_TB_1

☐ Bitstring of 32 bit M_BO_NA_1, M_BO_TA_1 and M_BO_TB_1 (if defined for a specific project, see 7.2.1.1)

☐ Measured value, normalized value M_ME_NA_1, M_ME_TA_1, ~~M_ME_ND_1~~ and M_ME_TD_1

☐ Measured value, scaled value M_ME_NB_1, M_ME_TB_1 and M_ME_TE_1

☐ Measured value, short floating point number M_ME_NC_1, M_ME_TC_1 ~~and M_ME_TF_1~~

Station interrogation

(station-specific parameter, mark with an "×" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☒ global

☒ group 1	☒ group 7	☒ group 13
☒ group 2	☒ group 8	☒ group 14
☒ group 3	☒ group 9	☒ group 15
☒ group 4	☒ group 10	☐ group 16
☒ group 5	☒ group 11	Information object addresses assigned to each group are configurable (see Section 6.3 in this guide)
☒ group 6	☒ group 12	

Clock synchronization

(station-specific parameter, mark with an "×" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☒ Clock synchronization

☐ Day of week used

☐ RES1, GEN (time tag substituted/ not substituted) used

☐ SU-bit (summertime) used

Command transmission

(object-specific parameter, mark with an "×" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☒ Direct command transmission

☐ Direct set point command transmission

☒ Select and execute command

☐ Select and execute set point command

☒ C_SE ACTTERM used

☒ No additional definition

☒ Short-pulse duration (duration determined by a system parameter in the controlled station)

☒ Long-pulse duration (duration determined by a system parameter in the controlled station)

☒ Persistent output

Transmission of integrated totals

(station- or object-specific parameter, mark with an "×" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☒ Mode A: local freeze with spontaneous transmission

☒ Mode B: local freeze with counter interrogation

☒ Mode C: freeze and transmit by counter interrogation commands

☐ Mode D: freeze by counter-interrogation command, frozen values reported spontaneously

☒ Counter read

☒ Counter freeze without reset

☒ Counter freeze with reset

☒ Counter reset

☒ General request counter

☒ Request counter group 1

☒ Request counter group 2

☒ Request counter group 3

☒ Request counter group 4

Parameter loading

(object-specific parameter, mark with an "×" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☒ Threshold value

☐ Smoothing factor

☐ Low limit for transmission of measured value

☐ High limit for transmission of measured

Parameter activation

(object-specific parameter, mark with an "×" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☐ Act/deact of persistent cyclic or periodic transmission of the addressed object

Test procedure

(station-specific parameter, mark with an "×" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☐ Test procedure

File transfer

(station-specific parameter, mark with an "×" if function is used)

File transfer in monitor direction

☐ Transparent file

☐ Transmission of disturbance data of protection equipment

☐ Transmission of sequences of events

☐ Transmission of sequences of recorded analogue values

File transfer in control direction

☐ Transparent file

Background scan

(station-specific parameter, mark with an "×" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☐ Background scan

Acquisition of transmission delay

(station-specific parameter, mark with an "×" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☐ Acquisition of transmission delay

7.2 IEC 60870-5-104 Protocol Implementation Conformance Statement (PICS)

The interoperability list is defined as in IEC 60870-5-101 and extended with parameters used in this standard. The text descriptions of parameters, which are not applicable to this companion standard, are strike-through (corresponding check box is marked black).

NOTE: In addition, the full specification of a system may require individual selection of certain parameters for certain parts of the system, such as the individual selection of scaling factors for individually addressable measured values.

The selected parameters are marked in the white boxes as follows:

☐ Function or ASDU is not used

☒ Function or ASDU is used as standardized (default)

R Function or ASDU is used in reverse mode

B Function or ASDU is used in standard and reverse mode

The possible selection (blank, X, R, or B) is specified for each specific clause or parameter.

A black check box indicates that the option cannot be selected in this companion standard.

G.2.1 System or device

(system-specific parameter, indicate definition of a system or a device by marking one of the following with "**X**")

☐ System definition

☐ Controlling station definition (master)

☒ Controlled station definition (slave)

G.2.2 Network configuration

(network-specific parameter, all configurations that are used are to be marked "×")

- ~~Point-to-point~~
- ~~Multiple point-to-point~~
- ~~Multipoint-partyline~~
- ~~Multipoint-star~~

G.2.3 Physical layer

(network-specific parameter, all interfaces and data rates that are used are to be marked "×")

Transmission speed (control direction)

Unbalanced interchange Circuit V.24/V.28 Standard	Unbalanced interchange Circuit V.24/V.28 Recommended if >1 200 bit/s		Balanced interchange Circuit X.24/X.27
■ ~~100 bit/s~~	■ ~~2 400 bit/s~~	■ ~~2 400 bit/s~~	■ ~~56 000 bit/s~~
■ ~~200 bit/s~~	■ ~~4 800 bit/s~~	■ ~~4 800 bit/s~~	■ ~~64 000 bit/s~~
■ ~~300 bit/s~~	■ ~~9 600 bit/s~~	■ ~~9 600 bit/s~~	
■ ~~600 bit/s~~		■ ~~19 200 bit/s~~	
■ ~~1 200 bit/s~~		■ ~~38 400 bit/s~~	

Transmission speed (monitor direction)

Unbalanced interchange	Unbalanced interchange	Balanced interchange

Circuit V.24/V.28
Standard

- ~~100 bit/s~~
- ~~200 bit/s~~
- ~~300 bit/s~~
- ~~600 bit/s~~
- ~~1 200 bit/s~~

Circuit V.24/V.28
Recommended if >1 200 bit/s

- ~~2 400 bit/s~~
- ~~4 800 bit/s~~
- ~~9 600 bit/s~~

Circuit X.24/X.27

- ~~2 400 bit/s~~
- ~~4 800 bit/s~~
- ~~9 600 bit/s~~
- ~~19 200 bit/s~~
- ~~38 400 bit/s~~

Circuit X.24/X.27

- ~~56 000 bit/s~~
- ~~64 000 bit/s~~

G.2.4 Link layer

(network-specific parameter, all options that are used are to be marked "×". Specify the maximum frame length. If a non-standard assignment of class 2 messages is implemented for unbalanced transmission, indicate the Type ID and COT of all messages assigned to class 2.)

~~Frame format FT 1.2, single character 1 and the fixed time out interval are used exclusively in this companion standard.~~

Link transmission

- ~~Balanced transmission~~
- ~~Unbalanced transmission~~

Frame length

- ~~Maximum length L (number of octets)~~

Address field of the link

- ~~Not present (balanced transmission only)~~
- ~~One octet~~
- ~~Two octets~~
- ~~Structured~~
- ~~Unstructured~~

When using an unbalanced link layer, the following ASDU types are returned in class 2 messages (low priority) with the indicated causes of transmission:

- ~~The standard assignment of ASDUs to class 2 messages is used as follows:~~

Type identification	**Cause of transmission**
9, 11, 13, 21	<1>

- ~~A special assignment of ASDUs to class 2 messages is used as follows:~~

Type identification	Cause of transmission

Note: (In response to a class 2 poll, a controlled station may respond with class 1 data when there is no class 2 data available).

G.2.5 Application layer

Transmission mode for application data

Mode 1 (Least significant octet first), as defined in 4.10 of IEC 60870-5-4, is used exclusively in this companion standard.

Common address of ASDU

(system-specific parameter, all configurations that are used are to be marked "×")

- ~~One octet~~
- ☒ Two octets

Information object address

(system-specific parameter, all configurations that are used are to be marked "×")

- ~~One octet~~
- ☒ Structured

■ ~~Two octets~~ ☐ Unstructured

☒ Three octets

Cause of transmission

(system-specific parameter, all configurations that are used are to be marked "×")

■ ~~One octet~~ ☒ Two octets (with originator address)
Originator address is set to zero if not used

Length of APDU

(system-specific parameter, specify the maximum length of the APDU per system)

The maximum length of APDU for both directions is 253. It is a fixed system parameter.

253	Maximum length of APDU per system in control direction
253	Maximum length of APDU per system in monitor direction

Selection of standard ASDUs

Process information in monitor direction

(station-specific parameter, mark each Type ID "×" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☒	<1> := Single-point information	M_SP_NA_1
■	~~<2> := Single-point information with time tag~~	M_SP_TA_1
☒	<3> := Double-point information	M_DP_NA_1
■	~~<4> := Double-point information with time tag~~	M_DP_TA_1
☐	<5> := Step position information	M_ST_NA_1
■	~~<6> := Step position information with time tag~~	M_ST_TA_1
☐	<7> := Bitstring of 32 bit	M_BO_NA_1
■	~~<8> := Bitstring of 32 bit with time tag~~	M_BO_TA_1
☒	<9> := Measured value, normalized value	M_ME_NA_1
■	~~<10> := Measured value, normalized value with time tag~~	M_ME_TA_1
☒	<11> := Measured value, scaled value	M_ME_NB_1
■	~~<12> := Measured value, scaled value with time tag~~	M_ME_TB_1
☒	<13> := Measured value, short floating point value	M_ME_NC_1
■	~~<14> := Measured value, short floating point value with time tag~~	M_ME_TC_1
☒	<15> := Integrated totals	M_IT_NA_1
■	~~<16> :=Integrated totals with time tag~~	M_IT_TA_1
■	~~<17> := Event of protection equipment with time tag~~	M_EP_TA_1
■	~~<18> := Packed start events of protection equipment with time tag~~	M_EP_TB_1
■	~~<19> := Packed output circuit information of protection equipment with time tag~~	M_EP_TC_1
☐	<20> := Packed single-point information with status change detection	M_PS_NA_1
☐	<21> := Measured value, normalized value without quality descriptor	M_ME_ND_1
☒	<30> := Single-point information with time tag CP56Time2a	M_SP_TB_1
☒	<31> := Double-point information with time tag CP56Time2a	M_DP_TB_1
☐	<32> := Step position information with time tag CP56Time2a	M_ST_TB_1
☐	<33> := Bitstring of 32 bit with time tag CP56Time2a	M_BO_TB_1
☒	<34> := Measured value, normalized value with time tag CP56Time2a	M_ME_TD_1
☒	<35> := Measured value, scaled value with time tag CP56Time2a	M_ME_TE_1

☒	<36> := Measured value, short floating point value with time tag CP56Time2a	M_ME_TF_1
☒	<37> := Integrated totals with time tag CP56Time2a	M_IT_TB_1
☐	<38> := Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
☐	<39> := Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
☐	<40> := Packed output circuit information of protection equipment with time tag P56Time2a	M_EP_TF_1

In this companion standard only the use of the set <30> – <40> for ASDUs with time tag is permitted.

Process information in control direction

(station-specific parameter, mark each Type ID "×" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☒	<45> := Single command	C_SC_NA_1
☒	<46> := Double command	C_DC_NA_1
☐	<47> := Regulating step command	C_RC_NA_1
☐	<48> := Set point command, normalized value	C_SE_NA_1
☐	<49> := Set point command, scaled value	C_SE_NB_1
☐	<50> := Set point command, short floating point value	C_SE_NC_1
☐	<51> := Bitstring of 32 bit	C_BO_NA_1
■	~~<58> := Single command with time tag CP56Time2a~~	C_SC_TA_1
■	~~<59> := Double command with time tag CP56Time2a~~	C_DC_TA_1
■	~~<60> := Regulating step command with time tag CP56Time2a~~	C_RC_TA_1
■	~~<61> := Set point command, normalized value with time tag CP56Time2a~~	C_SE_TA_1
■	~~<62> := Set point command, scaled value with time tag CP56Time2a~~	C_SE_TB_1
■	~~<63> := Set point command, short floating point value with time tag CP56Time2a~~	C_SE_TC_1
■	~~<64> := Bitstring of 32 bit with time tag CP56Time2a~~	C_BO_TA_1

Either the ASDUs of the set <45> – <51> or of the set <58> – <64> are used.

System information in monitor direction

(station-specific parameter, mark with an "×" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☒	<70> := End of initialization	M_EI_NA_1

System information in control direction

(station-specific parameter, mark each Type ID "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☒	<100> := Interrogation command	C_IC_NA_1
☒	<101> := Counter interrogation command	C_CI_NA_1
☒	<102> := Read command	C_RD_NA_1
☒	<103> := Clock synchronization command	C_CS_NA_1
■	~~<104> := Test command~~	C_TS_NA_1
☐	<105> := Reset process command	C_RP_NA_1
☐	<106> := Delay acquisition command	C_CD_NA_1
■	~~<107> := Test command with time tag CP56Time2a~~	C_TS_TA_1

Parameter in control direction

(station-specific parameter, mark each Type ID "×" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☐	<110> := Parameter of measured value, normalized value	P_ME_NA_1
☒	<111> := Parameter of measured value, scaled value	P_ME_NB_1
☒	<112> := Parameter of measured value, short floating point value	P_ME_NC_1
☐	<113> := Parameter activation	P_AC_NA_1

File transfer

(station-specific parameter, mark each Type ID "×" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☐	<120> := File ready	F_FR_NA_1
☐	<121> := Section ready	F_SR_NA_1
☐	<122> := Call directory, select file, call file, call section	F_SC_NA_1
☐	<123> := Last section, last segment	F_LS_NA_1
☐	<124> := Ack file, ack section	F_AF_NA_1
☐	<125> := Segment	F_SG_NA_1
☐	<126> := Directory {blank or X, only available in monitor (standard) direction}	F_DR_TA_1
☐	<127> := Query Log – Request archive file	F_SC_NB_1

Type identifier and cause of transmission assignments

(station-specific parameters)

Blank: functions or ASDU not used.

Mark Type Identification/Cause of transmission combinations:

"×" if only used in the standard direction;

"**R**" if only used in the reverse direction;

"**B**" if used in both directions.

Type identification		**Cause of transmission**																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<1>	M_SP_NA_1	×		×		×									×					
~~<2>~~	~~M_SP_TA_1~~																			
<3>	M_DP_NA_1	×		×		×									×					
~~<4>~~	~~M_DP_TA_1~~																			
<5>	M_ST_NA_1																			
~~<6>~~	~~M_ST_TA_1~~																			
<7>	M_BO_NA_1																			
~~<8>~~	~~M_BO_TA_1~~																			
<9>	M_ME_NA_1	×		×		×									×					
~~<10>~~	~~M_ME_TA_1~~																			
<11>	M_ME_NB_1	×		×		×									×					
~~<12>~~	~~M_ME_TB_1~~																			
<13>	M_ME_NC_1	×		×		×									×					
~~<14>~~	~~M_ME_TC_1~~																			
<15>	M_IT_NA_1	×		×		×										×				
~~<16>~~	~~M_IT_TA_1~~																			

Type identification		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
~~<17>~~	~~M_EP_TA_1~~																			
~~<18>~~	~~M_EP_TB_1~~																			
~~<19>~~	~~M_EP_TC_1~~																			
<20>	M_PS_NA_1																			
<21>	M_ME_ND_1																			
<30>	M_SP_TB_1	×		×		×									×					
<31>	M_DP_TB_1	×		×		×									×					
<32>	M_ST_TB_1																			
<33>	M_BO_TB_1																			
<34>	M_ME_TD_1	×		×		×									×					
<35>	M_ME_TE_1	×		×		×									×					
<36>	M_ME_TF_1	×		×		×									×					
<37>	M_IT_TB_1	×		×		×										×				
<38>	M_EP_TD_1																			
<39>	M_EP_TE_1																			
<40>	M_EP_TF_1																			
<45>	C_SC_NA_1						×	×	×	×	×							×	×	×
<46>	C_DC_NA_1						×	×	×	×	×							×	×	×
<47>	C_RC_NA_1																			
<48>	C_SE_NA_1																			
<49>	C_SE_NB_1																			
<50>	C_SE_NC_1																			
<51>	C_BO_NA_1																			
<58>	C_SC_TA_1																			
<59>	C_DC_TA_1																			
<60>	C_RC_TA_1																			
<61>	C_SE_TA_1																			
<62>	C_SE_TB_1																			
<63>	C_SE_TC_1																			
<64>	C_BO_TA_1																			
<70>	M_EI_NA_1*				×															
<100>	C_IC_NA_1						×	×			×							×	×	
<101>	C_CI_NA_1						×	×			×							×	×	
<102>	C_RD_NA_1					×												×	×	×
<103>	C_CS_NA_1																	×	×	
~~<104>~~	~~C_TS_NA_1~~																			
<105>	C_RP_NA_1																			
~~<106>~~	~~C_CD_NA_1~~																			
<107>	C_TS_TA_1																			
<110>	P_ME_NA_1																			
<111>	P_ME_NB_1					×														
<112>	P_ME_NC_1					×														
<113>	P_AC_NA_1																			
<120>	F_FR_NA_1																			
<121>	F_SR_NA_1																			

Type identification		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<122>	F_SC_NA_1																			
<123>	F_LS_NA_1																			
<124>	F_AF_NA_1																			
<125>	F_SG_NA_1																			
<126>	F_DR_TA_1*																			
<127>	F_SC_NB_1*																			
* Blank or × only																				

G.2.6 Basic application functions

Station initialization

(station-specific parameter, mark "×" if function is used)

☒ Remote initialization

Cyclic data transmission

(station-specific parameter, mark "×" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

☒ Cyclic data transmission

Read procedure

(station-specific parameter, mark "×" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

☒ Read procedure

Spontaneous transmission

(station-specific parameter, mark "×" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

☒ Spontaneous transmission

Double transmission of information objects with cause of transmission spontaneous

(station-specific parameter, mark each information type "×" where both a Type ID without time and corresponding Type ID with time are issued in response to a single spontaneous change of a monitored object)

The following type identifications may be transmitted in succession caused by a single status change of an information object. The particular information object addresses for which double transmission is enabled are defined in a project-specific list.

☐ Single-point information M_SP_NA_1, M_SP_TA_1, M_SP_TB_1 ~~and M_PS_NA_1~~

☐ Double-point information M_DP_NA_1, M_DP_TA_1 and M_DP_TB_1

☐ Step position information M_ST_NA_1, M_ST_TA_1 and M_ST_TB_1

☐ Bitstring of 32 bit M_BO_NA_1, M_BO_TA_1 and M_BO_TB_1 (if defined for a specific project, see 7.2.1.1)

☐ Measured value, normalized value M_ME_NA_1, M_ME_TA_1, ~~M_ME_ND_1~~ and M_ME_TD_1

☐ Measured value, scaled value M_ME_NB_1, M_ME_TB_1 and M_ME_TE_1

☐ Measured value, short floating point number M_ME_NC_1, M_ME_TC_1 ~~and M_ME_TF_1~~

Station interrogation

(station-specific parameter, mark "×" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☒ global

☒ group 1	☒ group 7	☒ group 13
☒ group 2	☒ group 8	☒ group 14
☒ group 3	☒ group 9	☒ group 15
☒ group 4	☒ group 10	☐ group 16
☒ group 5	☒ group 11	Information object addresses assigned to each group are configurable (see Section 6.3 in this guide)
☒ group 6	☒ group 12	

Clock synchronization

(station-specific parameter, mark "×" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☒ Clock synchronization

☐ Day of week used

☐ RES1, GEN (time tag substituted/ not substituted) used

☐ SU-bit (summertime) used

optional, see 7.6

Command transmission

(object-specific parameter, mark "×" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☒ Direct command transmission

☐ Direct set point command transmission

☒ Select and execute command

☐ Select and execute set point command

☒ C_SE ACTTERM used

☒ No additional definition

☒ Short-pulse duration (duration determined by a system parameter in the controlled station)

☒ Long-pulse duration (duration determined by a system parameter in the controlled station)

☒ Persistent output

☒ Supervision of maximum delay in command direction of commands and set point commands

30 s Maximum allowable delay of commands and set point commands

Transmission of integrated totals

(station- or object-specific parameter, mark "×" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☒ Mode A: local freeze with spontaneous transmission

☒ Mode B: local freeze with counter interrogation

☒ Mode C: freeze and transmit by counter interrogation commands

☐ Mode D: freeze by counter-interrogation command, frozen values reported spontaneously

☒ Counter read

☒ Counter freeze without reset

☒ Counter freeze with reset

☒ Counter reset

☒ General request counter

☒ Request counter group 1

☒ Request counter group 2

☒ Request counter group 3

☒ Request counter group 4

Parameter loading

(object-specific parameter, mark "×" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☒ Threshold value

☐ Smoothing factor

☐ Low limit for transmission of measured value

☐ High limit for transmission of measured

Parameter activation

(object-specific parameter, mark "×" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☐ Act/deact of persistent cyclic or periodic transmission of the addressed object

Test procedure

(station-specific parameter, mark "×" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☐ Test procedure

File transfer

(station-specific parameter, mark "×" if function is used).

File transfer in monitor direction

☐ Transparent file

☐ Transmission of disturbance data of protection equipment

☐ Transmission of sequences of events

☐ Transmission of sequences of recorded analogue values

File transfer in control direction

☐ Transparent file

Background scan

(station-specific parameter, mark "×" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

☐ Background scan

Acquisition of transmission delay

(station-specific parameter, mark "×" if function is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions).

■ ~~Acquisition of transmission delay~~

Definition of time outs

Parameter	Default value	Remarks	Selected value
t_0	30 s	Time-out of connection establishment	Not used
t_1	15 s	Time-out of send or test APDUs	Not used
t_2	10 s	Time-out for acknowledges in case of no data messages $t_2 < t_1$	Not used
t_3	20 s	Time-out for sending test frames in case of a long idle state	5 min

Maximum range for timeouts t_0 to t_2: 1 s to 255 s, accuracy 1 s.
Recommended range for timeout t_3: 1 s to 48 h, resolution 1 s.
Long timeouts for t_3 may be needed in special cases where satellite links or dialup connections are used (for instance to establish connection and collect values only once per day or week).

Maximum number of outstanding I format APDUs *k* and latest acknowledge APDUs (*w*)

Parameter	Default value	Remarks	Selected value
k	12 APDUs	Maximum difference receive sequence number to send state variable	Configurable from 1 to 32. Can be set to 0 for unlimited number of ASDUs.
w	8 APDUs	Latest acknowledge after receiving *w* I format APDUs	Not used

Maximum range of values *k*: 1 to 32767 ($2^{15}-1$) APDUs, accuracy 1 APDU

Maximum range of values *w*: 1 to 32767 APDUs, accuracy 1 APDU (Recommendation: *w* should not exceed two-thirds of *k*).

Port number

Parameter	Value	Remarks
Portnumber	2404	In all cases

Redundant connections

[2] Number N of redundancy group connections used

RFC 2200 suite

RFC 2200 is an official Internet Standard, which describes the state of standardization of protocols used in the Internet as determined by the Internet Architecture Board (IAB). It offers a broad spectrum of actual standards used in the Internet. The suitable selection of documents from RFC 2200 defined in this standard for given projects has to be chosen by the user of this standard.

☒ Ethernet 802.3

☐ Serial X.21 interface

☐ Other selection from RFC 2200: