IEC 60870-5-101 Master Driver Help

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IEC 60870-5-101 Master Driver Help

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Overview

IEC 60870 is a commonly used substation communication protocol similar to DNP. The IEC 60870-5-101 protocol uses specific terms to describe the communications pathway. Descriptions are as follows:

- **Channel:** This describes a communications path between two endpoints.
- **Session:** This describes a logical connection between a 101 master node (server channel) and a 101 slave node (server device). It comprises one or more 101 Sectors.
- **101 Sector:** This groups related data. It has its own Information Object Address (IOA) space. In the IEC 60870-5-101 Master Driver, a 101 session/sector pair is represented as server devices for each channel.

Thus, the server channel describes the communications pathway over which the master and slave will communicate. The other endpoint of the 101 channel may have one or more slave nodes and sectors available. A server device must be created for each sector in the endpoint.

Channel Setup

60870 Settings

The 60870 Settings dialog is used to specify the IEC 60870-5-101 Master Driver's settings for communications with a specific channel on a 101 slave. Descriptions of the parameters are below.
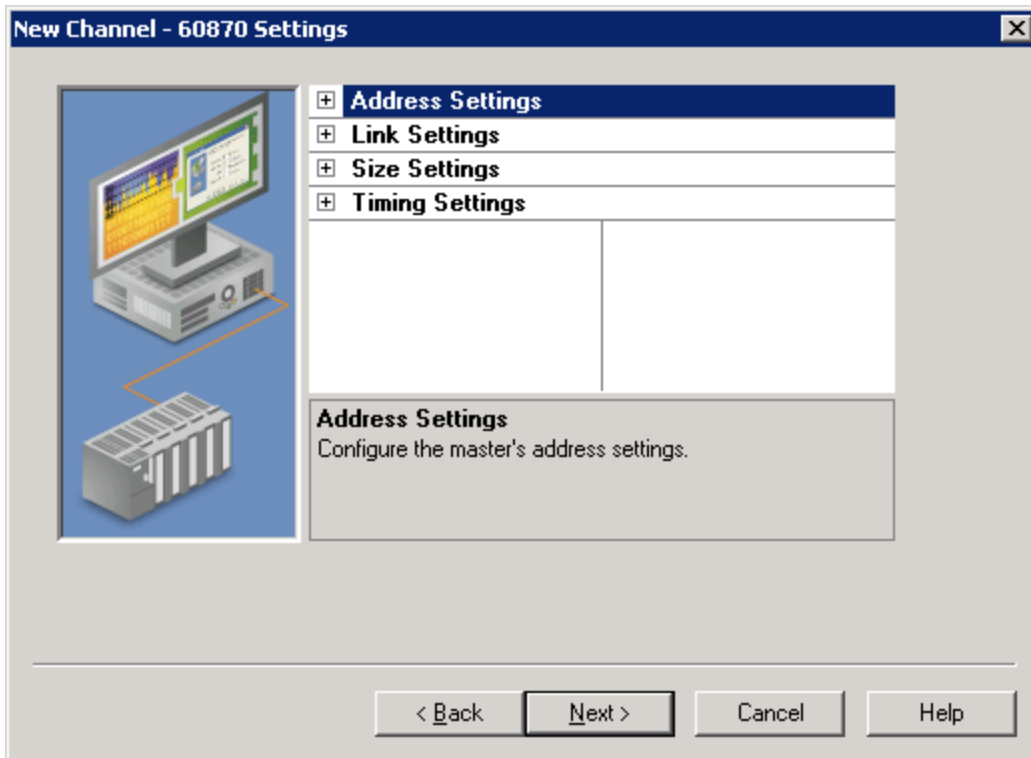
Address Settings

- **Cause of Transmission (COT) Size** This parameter specifies the number of octets in an ASDU COT field. When Two Octets is selected, the master's originator address is included in messages sent to the slave. When One Octet is selected, the originator address is not included and is disabled in the configuration. The default setting is Two Octets.
- **Originator Address:** This parameter specifies the second byte of the Cause of Transmission (COT) field, which is used by a dual-mode device to route responses from a slave to the correct master. The valid range is 0 to 254. The default setting is 0.

Link Settings

- **Link Mode:** This parameter specifies the mode in which the device will be configured. Options include Unbalanced Transmission and Balanced Transmission. The default setting is Unbalanced Transmission. Descriptions of the options are as follows:
    - **Balanced Transmission:** This mode allows a master to communicate with one device, and allows the device to send unsolicited updates.
    - **Unbalanced Transmission:** This mode allows a master to communicate with multiple devices. It does not support unsolicited updates; as such, all data from each device must be polled.
- **RX Buffer Size:** This parameter specifies the maximum data size it is possible to receive. Messages containing more than the specified size are discarded. This value can range between 6 and 255. The default setting in 255 bytes.
- **Link Confirm Timeout:** This parameter specifies the maximum amount of time (in milliseconds) to wait for a confirmation of a link frame. The default setting is 2000 ms.
- **Class 1 Poll Interval:** This parameter specifies the time (in milliseconds) between each Class 1 data poll when the master is not expecting data. It is used by the unbalanced transmission link mode to acquire high-priority data, such as events, periodically. The default value is 0, which disables it. Most devices do not require periodic Class 1 polling because Class 2 polling notifies the driver when class 1 data exists.

- **Class 2 Poll Interval:** This parameter specifies the time (in milliseconds) between each Class 2 data poll when the master is not expecting data. It is used by the unbalanced transmission link mode to acquire low-priority data, such as cyclic data, periodically. The default value is 500. Many devices notify the driver of Class 1 data during Class 2 polling. When this occurs, a Class 1 poll is automatically scheduled, regardless of the Class 1 poll interval. Class 2 polling cannot be disabled.
- **Class 1 Pending Delay:** This parameter specifies the time (in milliseconds) between each Class 1 data poll when the master is expecting data. The default value is 0.
- **Class 2 Pending Delay:** This parameter specifies the time (in milliseconds) between each Class 2 data poll when the master is expecting data. The default value is 0.

Size Settings

- **Link Address Size:** This parameter specifies the number of octets in a device link address. Options include Zero, One Octet, and Two Octets. Balanced communications support zero, one, or two octets. Unbalanced communications support one or two octets. The number of octets that are selected determines the maximum link address allowed in the device setup. The default setting is One Octet.
- **Common Address (ASDU) Size:** This parameter specifies the number of octets in a device common address. Options include One Octet and Two Octets. The number of octets that are selected determines the maximum common address allowed in the device. The default setting is Two Octets.
- **Information Object Address (IOA) Size:** This parameter specifies the number of octets in a tag information object address. Options include One Octet, Two Octets, or Three Octets. The number of octets that are selected determines the maximum address allowed as a tag IOA. The default setting is Two Octets.

Timing Settings

- **Incremental Timeout (ms):** This defines the maximum time to wait for a response from a device when a command is outstanding. The default setting is 30000 ms.
- **First Char Wait (ms):** This parameter specifies how long to wait (in milliseconds) after receiving a character before attempting to transmit a character. The default setting is 0 ms.

Device Setup

Communication Protocol
IEC 60870-5-101 Master

Note: For more information, refer to **IEC 60870-5-101 Interoperability Guide**.
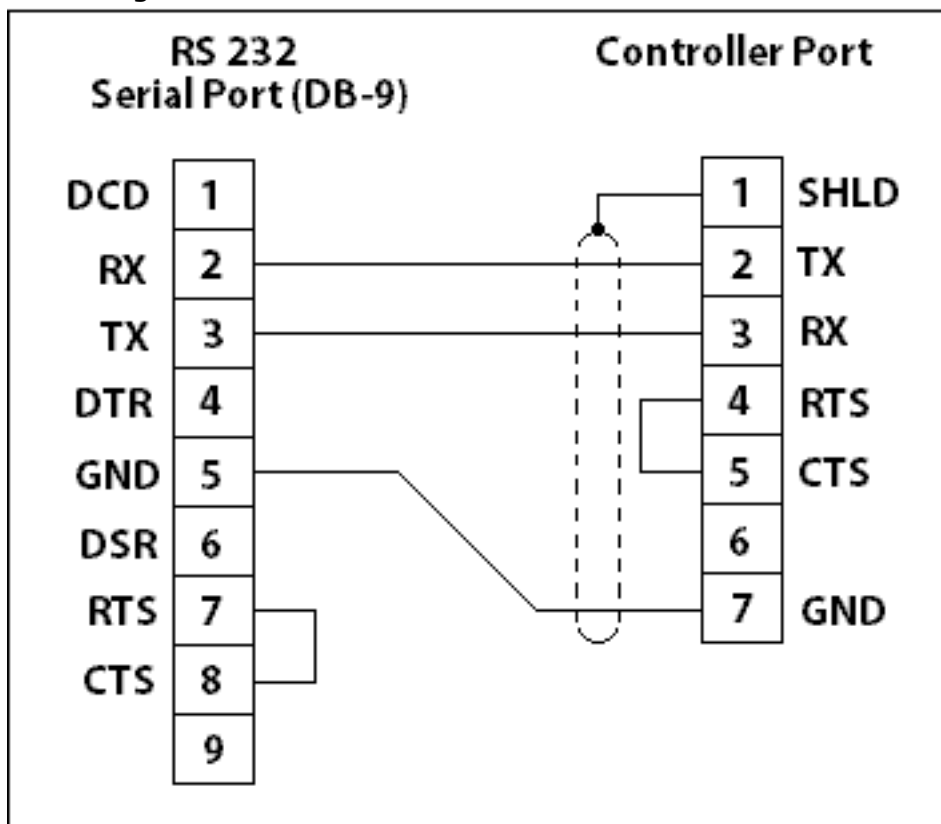
Supported Devices
Any IEC 60870-5-101 slave device or gateway.

Maximum Channels and Devices
The maximum number of channels supported is 256. The maximum number of devices supported per channel is 1024.

Note: When using Ethernet Encapsulation, this driver uses one socket per channel.

Cable Diagram

Timing

Timing settings come in two varieties: link-layer timing and application-layer timing. Link-layer timing settings are used to control or time out the acquisition of application layer data. Application-layer data contains the individual commands to read or write. For example, General Interrogation is performed as an application-layer command, but the acquisition of individual data is accomplished through the link layer.

Device-level application-layer timeouts are controlled through the request timeout device settings. These settings are the only timing parameters that can affect tag quality.

The channel-level timing settings affect the link layer. They do not directly affect the quality of a tag, but they can be tuned to allow for delays or timeouts during the acquisition of individual data pieces. These settings can introduce complex interactions in data acquisition and should not be changed without a compelling reason.

Note: If Link Confirm Timeout is less than Request Timeout, the first communication timeout to a device fails based on the Link Confirm Timeout. The device error state is not set because it is not an application-layer failure. However, subsequent failures are treated as application-layer timeouts. To ensure that communications timeouts always result in the device entering error state, the device Attempt Count should be greater than 1.

Communications

The Communications dialog is used to specify the IEC 60870-5-101 Master Driver settings for communications with a specific sector on a 101 slave. Descriptions of the parameters are below.
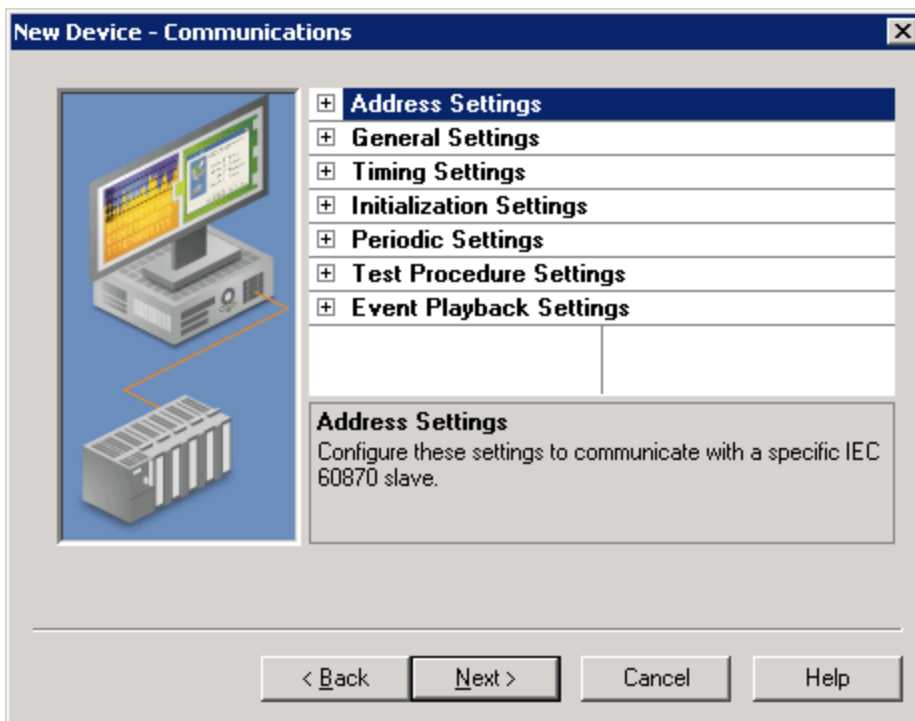
Address Settings

- **Common Address:** This parameter specifies whether to permit the addressing of the whole station and, optionally, a particular sector within a station. A station represents a physical device; a sector represents a set of data within a device. Sectors are commonly used by pass-through devices (which must separate data from the multiple devices they represent) and by devices that want to segment their data based on type. The valid range is 0 to 254 or 65534, depending on whether the Common Address (ASDU) Size setting is set to one or two octets. The default setting is 3.
- **Link Address:** This parameter identifies a session, which is a physical or logical device in the network. The valid range is 0 to 254 or 0 to 65534, depending on whether the Link Address Size setting is set to one or two octets. The default setting is 0. In Balanced Transmission mode, this setting is not used when the Link Address Size is set to zero octets.

Notes:
1. Devices within a channel must have unique link/common address pairs because the master must have unique sector references within a channel.

2. When a channel link mode is set to Balanced Transmission, all devices are required to use the same Link Address because this link mode requires the channel be connected to a single slave (point-to-point) connection.

General Settings

- **Polled Reads:** When enabled, unbuffered tags perform polled reads when last-read data is older than the scan rate. When disabled, only previously received cyclic and background scan data is reported. If polled reads are disabled, the driver reports "Uncertain" quality until cyclic or background scan updates have been received. Default is enabled.
- **Delay Acquisition:** Acquisition is used to account for transmission delay between the master and slave. When enabled, the master performs Delay Acquisition before issuing Time Sync commands to the device. Delay Acquisition is disabled by default.

Timing Settings

- **Request Timeout (ms):** This parameter specifies an interval that determines how long the driver waits for a general response from the target device to complete. The default setting is 10000 ms. General Interrogation and Counter Interrogation use their own timeout setting: Interrogation Request Timeout.
- **Interrogation Request Timeout (ms):** This parameter specifies the General and Counter Interrogation request timeouts. Having a separate timeout for interrogation enables larger timeouts for these longer requests.
- **Attempt Count:** This parameter specifies how many times the driver tries a communication request before considering the request to have failed and the device to be in error. The valid range is 1 to 10. The default setting is 3. General Interrogation and Counter Interrogation use their own setting for the number of attempts: Interrogation Attempt Count.
- **Interrogation Attempt Count:** This parameter specifies the number of General and Counter Interrogation attempts.

Initialization Settings

- **Time Sync Initialization**: Specifies if and when a time synchronization should be sent to the slave during initialization. The default settings is "End of Initialization." This parameter is independent of the Synchronization setting of the Time Synchronization page and Command.Timesync tag.
  - **End of Initialization**: Perform Time Sync when the device notifies the master that it has ended initialization.
  - **Connect/Reconnect**: Perform Time Sync when a connection is established. This occurs any time the master reestablishes communication with the slave.
  - **None**: Do not perform an initial Time Sync.
- **GI Initialization**: Specifies if and when a General Interrogation (GI) should be sent to the slave during initialization. The default setting is "End of Initialization." This parameter is independent of the Periodic GI Interval setting and the Command.GI command tag.
  - **End of Initialization**: Perform GI when the device notifies the master that it has ended initialization.
  - **Connect/Reconnect**: Perform GI when a connection is established. This occurs any time the master reestablishes communication with the slave.
  - **None**: Do not perform an initial GI.
- **CI Initialization**: Specifies if and when a Counter Interrogation (CI) should be sent to the slave during initialization. The default setting is "End of Initialization." This parameter is independent of the Periodic CI Interval setting and the Command.CI command tag.
  - **End of Initialization**: Perform CI when the device notifies the master that it has ended initialization.
  - **Connect/Reconnect**: Perform CI when a connection is established. This occurs any time the master reestablishes communication with the slave.
  - **None**: Do not perform an initial CI.

Periodic Settings

- **Periodic GI Interval (minutes)**: Configures the master to perform a General Interrogation based on a specified time interval. The default setting is 720 minutes (12 hours). When clients are connected, General Interrogations are sent every time the specified period elapses. Specifying an interval of 0 disables periodic GI.
- **Periodic CI Interval (minutes)**: Configures the master to perform a Counter Interrogation based on a specified time interval. When clients are connected, Counter Interrogations are sent every time the specified period elapses. The default setting is 0 minutes (disabled). Specifying an interval of 0 disables periodic CI.

Test Procedure Settings

- **Test Procedure**: Specifies whether or not test command is enabled. When enabled, the master periodically sends a test command ASDU. This command can be used to determine device error state. It is recommended to use this when devices are expected to go long periods without communicating. The default setting is enabled.
- **Test Procedure Period (seconds)**: Test commands are sent at the specified rate. The default setting is 15 seconds.

Playback Settings

- **Playback Events**: Specifies whether or not event playback is enabled. When disabled, all tags associated with event playback report the most recent data and no data is buffered. When enabled, events are played back based on the buffer size and playback rate. The default setting is Enabled. See **Event Playback**.
- **Playback Buffer Size**: Maximum number of events buffered for each Information Object Address (IOA) buffer. The default setting is 100.
- **Playback Rate (ms)**: Rate at which events are played back. The default setting is 2000 ms.

Event Playback

A device may send many updates in one transaction. To address this, event playback handles multiple value changes for data points that are then displayed (played back) in the client. For example, if a device sends a set of packed events that represent some history of an analog event (such as voltage values during a fault), the data is played back in the historical sequence. The driver plays back each data point at a set interval to allow the client to read each update in the order it was received from the device.

Event playback also guarantees that each change to a data point is read. If the playback interval expires before the data has been accessed, the data is maintained until the client references it.

To guarantee that no data is missed, it is recommended that client update rates be at least as fast as the event playback interval. This is not required with a single client because data is held until at least one read has occurred; however, it is required in the case of multiple clients reading the same data point to ensure that each client receives all the data.

The quality of a buffered tag is "uncertain" until data associated with the tag is received. If a DNR occurs during event playback, all buffered events are played back before reporting "bad" quality.

Notes:

1. Please see the OPC DA Compliance note for OPC DA Compliance settings that can affect event playback.

2. The OPC timestamp is based on the device time (if available) or the server time. When the OPC timestamp is based on server time, it represents the time of the data arrival.

Data Type Descriptions

Data Type	Description
Boolean	Single bit
Float	32-bit floating-point value
Byte	Unsigned 8-bit value Bit 0 is the low bit Bit 7 is the high bit
Date	64-bit value representing the number of milliseconds since December 31, 1899
Char	Signed 8-bit data
Word	Unsigned 16-bit data
Dword	Unsigned 32-bit data
Short	Signed 16-bit data
Long	Signed 32-bit data

Address Descriptions

There are two forms of tag addressing. The first is information object address (IOA) based tag addressing, which allows access to each individual data point on a device. IOA-based tag addressing includes monitor ASDUs and control ASDUs. The second form is device-level command-based tag addressing, which allows control of device-specific commands.

IOA-Based Tag Addressing
  Monitor ASDUs
  Control ASDUs
Command-Based Tag Addressing

IOA-Based Tag Addressing

Tag addressing takes the form *TYPEID.IOA.SUB-TYPE.OPTIONAL.OPTIONAL*, where:

- *TYPEID* is the ASDU type.
- *IOA* is the Information Object Address (IOA).
- *SUB-TYPE* is the point's driver-specific attribute.
- *OPTIONAL* is an attribute that is not required.

Note: The Information Object Address (IOA) represents a slave device's point address. It is an integer between 1 and 254, 65535, or 16777215; depending on whether the Information Object Address Size property is set to one, two, or three octets (respectively).

TYPEID
The TYPEID represents the ASDU type as defined by the protocol. Types include monitor or control. Each monitor TYPEID supports multiple protocol-defined ASDU numbers. Monitor types represent data that is read only. Control types represent data that can be written.

  Monitor ASDUs
  Control ASDUs

Monitor ASDUs

Monitor TYPEID	Data Type	ASDU	Description
M_SP	Boolean	1, 2, 30	Single-Point Information
M_DP	Char	3, 4, 31	Double-Point Information: Possible values are 0, 1, 2, and 3. 0: Indeterminate or Intermediate State 1: Determined State OFF 2: Determined State ON 3: Indeterminate State
M_ST	Char	5, 6, 32	Step Position Information: Possible values are -64 to +63. Supports the Transient sub-type.
M_BO	Dword	7, 8, 33	Bit string of 32 bit. Support bit indexing into the following sub-types: Value and CurrentValue.
M_ME_NV	Float	9, 10, 21, 34	Measured Value, Normalized Value: This represents a value between -1 and 0.999969482421875. Devices transmit this value and the driver converts this into its appropriate floating-point value.
M_ME_SV	Short	11, 12, 35	Measured Value, Scaled Value. Possible values are -32768 to +32767.
M_ME_FV	Float	13, 14, 36	Measured Value, Short Floating Point Number.
M_IT	Long	15, 16, 37	Integrated Totals. Supports the SQ sub-type. Does not support the unbuffered "Current" sub-types.

SUB-TYPE
The SUB-TYPEs that are available are determined by the TYPEID. Monitor TYPEIDs can only use monitor SUB-TYPEs. For more information, refer to the table below.

SUB-TYPE	Data Type	Description
Value	See TYPEID	The Event Playback value. Values received during General Interrogation (GI) and event acquisition are played back with this tag. If the quality descriptor IV (invalid) bit is set, this tag shows bad quality. When used with M_BO, this supports bit indexing. For example, to access bit 0 in the value tag, use the sub-type Value with .0 appended: Value.0.
CurrentValue*	See TYPEID	This reports all unbuffered data; which includes cyclic, background scan, and polled reads. If the quality descriptor IV (invalid) bit is set, this tag shows bad quality. When used with M_BO, this supports bit indexing. For example, to access bit 0 in the value tag, use the sub-type CurrentValue with .0 appended: CurrentValue.0. Not supported for M_IT. Polled reads are performed with the read command: C_RD Type ID 102. Although the standard considers this a control operation, the physical reads are performed with the monitor TYPEIDs.
Timestamp	Date	The Event Playback timestamp. Timestamps received during GI, event acquisition, cyclic updates, and background scans are played back with this tag. If the device provides data without a timestamp, the Timestamp tag value is set to 1899-12-30T00:00:00.000 and it is set to bad quality.
CurrentTimestamp*	Date	Same as Timestamp, but with unbuffered data.
QualityDesc	Byte	The Event Playback quality description field. Quality descriptions received during GI, event acquisition, cyclic updates, and background scans will be played back with this tag.
CurrentQualityDesc*	Byte	Same as QualityDesc, but with unbuffered data.
COT	Word	The Event Playback Cause of Transmission (COT) field. For COT values as specified in 60870-5-101, section 7.2.3, refer to the table below.
CurrentCOT*	Word	Same as COT, but with unbuffered data.
Transient	Boolean	The Event Playback Transient bit associated with M_ST ASDU type. 0: Equipment is not in transient state. 1: Equipment is in transient state.
CurrentTransient*	Boolean	The same as the Transient, but with unbuffered data.
SQ	Char	The event playback sequence field associated with the M_IT ASDU type. A number between 0 and 31 represents the sequence notation.

* For all the SUB-TYPES with "Current" in the name, cyclic or background data is reported if it has been recently received. If there has not been an update for a significant period of time and polled reads are enabled, a polled read with the read command ASDU is performed. This is accomplished by monitoring a tag's scan rate. Cyclic and background scan data is reported only if it is newer than a tag's scan rate. If the quality descriptor IV (invalid) bit is set, this tag shows bad quality.

Cause of Transmission(COT)
The Cause of Transmission field is enumerated according to the table below, which is based on the IEC 60870-5-101 specification.

Note: All causes of transmission (with the exception of requested transmission, background scan, and periodic / cyclic) are handled by event playback. Users can access events, general interrogation, and counter interrogation by utilizing the Value tag, Timestamp tag, QualityDesc tag, and COT tag. Requested, background scan, and cyclic unbuffered data can be accessed by utilizing the CurrentValue tag, CurrentTimestamp tag, CurrentQualityDesc tag, and CurrentCOT tag.

COT Value	Cause
0	Not used
1	Periodic, cyclic
2	Background scan
3	Spontaneous
4	Initialized
5	Request or requested
6	Activation
7	Activation confirmation

COT Value	Cause
8	Deactivation
9	Deactivation confirmation
10	Activation termination
11	Return information caused by a remote command
12	Return information caused by a local command
13	File transfer
14-19	Reserved for further compatible definitions
20	Interrogated by station interrogation
21-36	Interrogated by group 1-16 interrogation
37	Requested by general counter request
38-41	Requested by group 1-4 counter request
42-43	Reserved for further compatible definitions
44	Unknown type identification
45	Unknown Cause of Transmission
46	Unknown Common Address (ASDU)
47	Unknown Information Object Address (IOA)
48-63	For special use (private range)

Buffered, Monitor ASDUs Examples

If a client needs access to double-point data in IOA 200 to capture events generated for this point. Events (COT = Spontaneous) are buffered so that all events are captured and played back to the client in chronological order. The following tags expose all the data related to IOA 200.

M_DP.200.VALUE
M_DP.200.TIMESTAMP
M_DP.200.COT
M_DP.200.QUALITYDESC

ASDUs that contain structured data expose additional sub-types to expose the data. For example, integrated totals (M_IT) contain a count (exposed in the VALUE sub-type) and sequence (exposed in the SQ sub-type). The following tags expose all data related to integrated total data in IOA 800.

M_IT.800.VALUE
M_IT.800.SQ
M_IT.800.TIMESTAMP
M_IT.800.COT
M_IT.800.QUALITYDESC

Unbuffered, Monitor ASDUs

If a client needs access to measured, floating-point data in IOA 700 and the slave is configured to transmit data periodically (COT = Cyclic) every 60 seconds. The clients should access "current" (unbuffered) tags. All ASDUs and sub-type are available with "current" sub-types, except integrated totals (M_IT) because the protocol does not support polled reads or cyclic transmission of integrated totals. The following tags expose all the data related to IOA 700.

M_ME_FV.700.CURRENTVALUE
M_ME_FV.700.CURRENTTIMESTAMP
M_ME_FV.700.CURRENTCOT
M_ME_FV.700.CURRENTQUALITYDESC

If the client update rate is greater than or equal to the slave's configured cyclic transmission rate (60 seconds in this example), the driver only performs a polled read to determine the tag's initial value. After the initial read, the driver receives cyclic updates and provides the client the latest cyclic slave transmission. If the client update rate is faster than the slave cyclic transmission rate, the driver performs a polled read anytime the data is older than the client scan rate. For example, if the client update rate is 10 seconds, the driver performs a polled read every 10 seconds unless the cyclic data is less than 10 seconds old. Polled reads can be disabled in the device configuration.

Control ASDUs

These Control ASDUs are write only.

Control TYPEID	Data Type	ASDU	Description
C_SC	Boolean	45	Single Command
C_DC	Char	46	Double Command. Possible values are 1 and 2. 0: Not Permitted 1: Determined State OFF 2: Determined State ON 3: Not Permitted
C_RC	Char	47	Regulating Step Command. Possible values are 1 and 2. 0: Not Permitted 1: Next Step LOWER 2: Next Step HIGHER 3: Not Permitted
C_SE_NV	Float	48	Measured Value, Normalized Value: This represents a value between -1 and 0.999969482421875. Values outside the range fail and report bad quality.
C_SE_SV	Short	49	Set point command, scaled value.
C_SE_FV	Float	50	Set point command, Short Floating Point Number.
C_BO	Dword	51	Bit string of 32 bits. Does not support bit indexing.

SUB-TYPE
The SUB-TYPEs that are available are determined by the TYPEID. Control TYPEIDs can only use control SUB-TYPEs. For more information, refer to the table below.

SUB-TYPE	Data Type	Description
SelectExecuteValue	See TYPEID	The two-step write value. Writing to this causes the associated command ASDU to write to a device using select-and-execute. In this mode, writes occur with a dual command/response from the device.
DirectValue	See TYPEID	The single-step write value. Writing to this causes the associated command ASDU to write to a device using direct execute. In this mode, writes occur with a single command/response with the device.

OPTIONAL
The below parameters can be included with select Control TYPEIDs, but are not required. These allow access to additional Control SUB-TYPE options. Optional addressing can be used in any order.

OPTION	Applicable TypeIDs	Description
ShortPulse	C_SC C_DC C_RC	Control ASDU includes ShortPulse QoC. Only one of ShortPulse, LongPulse, or Persistent may be used at a time. Not specifying allows the device to use its default setting.
LongPulse	C_SC C_DC C_RC	Control ASDU includes LongPulse QoC. Only one of ShortPulse, LongPulse, or Persistent may be used at a time. Not specifying allows the device to use its default setting.
Persistent	C_SC C_DC C_RC	Control ASDU includes Persistent QoC. Only one of ShortPulse, LongPulse, or Persistent may be used at a time. Not specifying allows the device to use its default setting.

"No additional definition" (value of 0) is used for command tags that support the Qualifier of Command (QoC) syntax, but have no QoC option is specified.

Control ASDUs Examples
If a client must control single-point data monitored with IOA 100, it can be accomplished with control ASDUs. In 60870-5-101, monitor IOAs are read-only (used to transfer data from the slave to the master) and cannot be written. The slave; however, may be configured to expose a single control IOA at point 2100 such that it correlates to the monitor IOA for the same point. When the master changes the value of IOA 2100, the change is reflected in the monitored single-point IOA 100. The following tags can be used to send control ASDUs to the slave for single-point 2100.

C_SC.2100.SELECTEXECUTEVALUE
C_SC.2100.DIRECTVALUE

The client should use the tag that represents the desired write strategy. In addition to the write strategy, an optional write qualifier can be used to specify the slave's behavior. The following tags represent several options that can adjust the write qualifier. The write qualifier can be used with C_SC, C_DC, and C_RC control ASDUs. All write qualifiers are supported for both the DIRECTVALUE and SELECTEXECUTEVALUE sub-types.

C_SC.2100.SELECTEXCECUTEVALUE.PERSISTENT
C_SC.2100.DIRECTVALUE.LONGPULSE
C_SC.2100.DIRECTVALUE.PERSISTENT
C_SC.2100.SELECTEXECUTEVALUE.SHORTPULSE

Command-Based Tag Addressing

Tag addressing takes the form *TYPE.COMMAND*, where:

- *TYPE* is the string: Command.
- *COMMAND* is the command to be run.

COMMAND
An example command address is: "Command.GI".

SUB-TYPE	Description
Command.GI	Global General Interrogation (GI) is issued when a client writes any value to this tag. This asks a device for any data assigned to general interrogation.
Command.CI	Global Counter Interrogation (CI) is issued when a client writes any value to this tag. This asks any integrated totals.
Command.FreezeCounters	Global Freeze Counter Interrogation is issued when a client writes any value to this tag. This stops counting integrated totals.
Command.ResetCounters	Global Reset Counter Interrogation is issued when a client writes any value to this tag. This returns all integrated totals to 0.
Command.FreezeResetCounters	Global Freeze and Reset Counter Interrogation is issued when a client writes any value to this tag. This stops all integrated totals and returns all integrated totals to 0.
Command.TimeSync	Time Sync is issued when a client writes any value to this tag. This synchronizes the master clock with the slave clock.
Command.TestProcedure	Test Procedure is issued when a client writes any value to this tag. This checks a device to see if it is connected.

Error Descriptions

The following messages may be generated. Click on the link for a description of the message.

Error Messages

Device <device name> failed to complete clock synchronization.
Device <device name> failed to complete <procedure name>.
Error loading XML file <Reason>.
Error loading XML file for channel.
Error loading XML file for device. Common address is invalid.
Error loading XML file for device. Link address in invalid.
Error loading XML file for device. Link and common address pair must be unique.
Error loading XML file for device. When the transmission mode is balanced, all devices must have the same link address. The link address of device is <link address>.
Read failed on tag <tag name>.
Read failed on tag <tag name> due to datatype mismatch.
Reverting channel link mode to Unbalanced Transmission. Balanced Transmission is not compatible with communication serialization or port sharing.
Too many events received.
Unable to write to address <address> on device <device>.
Write failed on tag <tag name>.

Device <device name> failed to complete clock synchronization.

Error Type:
Warning

Possible Cause:

1. Communications were lost.

2. Communications timed out.

Solution:

1. Service the device connection.

2. Increase the value of the device's clock synchronization request timeout setting.

Device <device name> failed to complete <procedure>.

Error Type:
Warning

Possible Cause:

1. Communications were lost. This can occur when the time to send all general interrogation data exceeds the request timeout.

2. Communications timed out.

Solution:

1. Service the device connection.

2. Increase the value of the device's interrogation request timeout setting.

Error loading XML file <Reason>.

Error Type:
Error

Possible Cause:

- A link address size of zero has been specified for a device in Unbalanced Mode.
- The common address is invalid.
- The link address is invalid.

Solution:

- The link address specifies the device with which communications are occurring: it must exist in an unbalanced (multi-drop) network. Either configure the device for Balanced Mode or increase the link address size.
- Change the common address to a value within the valid range. This error can also occur when the common address's octet size is too small.
- Change the link address to a value within the valid range. This error can also occur when the link address's octet size is too small.

See Also:
Channel Setup

Error loading XML file for channel <channel name>. Unbalanced mode does not support a link address size of zero.

Error Type:
Error

Possible Cause:
The XML project being loaded specifies a link address size of 0. A link address is required when the link mode is set to Unbalanced Transmission.

Solution:

- Change the link mode to Balanced Transmission.
- Increase Link Address Size to 1 or 2 octets.

See Also:
Channel Setup

Error loading XML file for device <device name>. When the transmission mode is balanced, all devices must have the same link address. The link address of device <device name> is <link address>.

Error Type:
Error

Possible Cause:
Devices don't have the same link address when the link mode is Balanced Transmission. This link mode requires that the channel contain one (1) master and one (1) slave.

Solution:
Verify that every device in the channel has the same link address, but unique common addresses.

See Also:
Channel Setup

Error loading XML file for device <device name>. Common Address is invalid. Valid range is <low limit> to <high limit>.

Error Type:
Error

Possible Cause:
The XML project being loaded specifies a common address that is not valid with the Common Address Size setting.

Solution:

- Increase the Common Address Size. Possible values are 1 octet or 2 octets.
- Update the common address so that it is within the allowed range.

Error loading XML file for device <device name>. The link address (<link address>) and common address (<common address>) pair is already in use on device <device name>. Link and common address pairs must be unique.

Error Type:
Error

Possible Cause:
More than one device in the channel is using the same link address / common address pair.

Solution:
Verify that every device in the channel has a unique link address /common address pair.

See Also:
Channel Setup

Error loading XML file for device <device name>. Link address is invalid. Valid range is <low limit> to <high limit>.

Error Type:
Error

Possible Cause:
The XML project being loaded specifies a link address that is not valid with the Link Address Size setting.

Solution:

- Increase the Link Address Size. Possible values are 1 octet or 2 octets.
- Update the link address so that it is within the allowed range.

Read failed on tag <tag name>.

Error Type:
Warning

Possible Cause:
A device is connected, but the tag is not appropriate for the device. For example, the ASDU type or IOA may not be appropriate for the data on the device.

Solution:
Correct the tag address to match the device's configuration.

See Also:
Address Descriptions

Read failed on tag <tag name> due to datatype mismatch.

Error Type:
Warning

Possible Cause:
Tag ASDU type is incorrect. This error occurs when data is received from the device at this IOA, but it represents a different ASDU type.

Solution:
Verify or correct the ASDU type. Correct the tag address to match the device configuration.

See Also:

[Address Descriptions](#)

Reverting channel '%s' link mode to Unbalanced Transmission. Balanced Transmission is not compatible with communication serialization or port sharing.

Error Type:
Warning

Possible Cause:

- The channel was assigned to a virtual network from the Advanced Channel Settings property sheet with the link mode set to Balanced Transmission.
- The channel was added to a com port network that is in used by at least one other channel with the link mode set to Balanced Transmission.

Solution:
The Balanced Transmission link mode is designed to work with a point-to-point serial network configuration. In a point-to-point network, the master and slave may transmit at any time. This link mode is not compatible with communication serialization or port sharing because there is no way to avoid transmit collisions when multiple slaves are connected.

Too many events received in <device name>; the buffer has overflowed. Increase the event playback buffer size.

Error Type:
Warning

Possible Cause:
The slave is producing events faster than the client can consume them.

Solution:
The per-item event buffer size should be large enough to handle the data at the highest per-item event transmission speed. For example, if a slave may transmit 100 events in 5 seconds and the event playback rate is set to 5 seconds, the event buffer will overflow if more than 100 events are received in a 5-second period.

Unable to write to address <address> on device <device>.

Error Type:
Warning

Possible Cause:

1. Incorrect common address; the device is not responding.
2. The point does not exist in the slave.
3. The address has an incorrect data type.

Solution:

1. Correct the common address to match the slave.
2. Correct the Information Object Address(IOA).
3. Correct the data type for the address.

See Also:
[Address Descriptions](#)

Write failed on tag <tag name>.

Error Type:
Warning

Possible Cause:

Attempted to write to a tag outside the supported range.

Solution:
Note the minimum and maximum values and limit writes within the supported range.

See Also:
Address Descriptions

IEC 60870-5-101 Interoperability Guide

The following reference material is from the International Electrotechnical Commission (IEC).

Interoperability

This companion standard presents sets of parameters and alternatives from which subsets have to be selected to implement particular telecontrol systems. Certain parameter values, such as the number of octets in the COMMON ADDRESS of ASDUs represent mutually exclusive alternatives. This means that only one value of the defined parameters is admitted per system. Other parameters, such as the listed set of different process information in command and in monitor direction allow the specification of the complete set or subsets, as appropriate for given applications. This Clause summarizes the parameters of the previous Clauses to facilitate a suitable selection for a specific application. If a system is composed of equipment stemming from different manufacturers, it is necessary that all partners agree on the selected parameters.

The selected parameters should be marked in the white boxes as follows:

The selected parameters should be marked in the white boxes as follows:

☐ Function or ASDU is not used

☒ X 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.

System or device

(system-specific parameter, indicate the station's function by marking one of the following with 'X')

☐ System definition

☒ Controlling station definition (Master)

☐ Controlled station definition (Slave)

Network configuration

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

☒ Point-to-point   ☐ Multipoint-party line

☒ Multiple point-to-point   ☐ Multipoint-star

Physical layer

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

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	☒	2400 bit/s	☒	2400 bit/s	☒	56000 bit/s
☐	200 bit/s	☒	4800 bit/s	☒	4800 bit/s	☐	64000 bit/s
☒	300 bit/s	☒	9600 bit/s	☒	9600 bit/s		
☒	600 bit/s			☒	19200 bit/s		
☒	1200 bit/s			☒	38400 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	☒	2400 bit/s	☒	2400 bit/s	☒	56000 bit/s
☐	200 bit/s	☒	4800 bit/s	☒	4800 bit/s	☐	64000 bit/s
☒	300 bit/s	☒	9600 bit/s	☒	9600 bit/s		
☒	600 bit/s			☒	19200 bit/s		
☒	1200 bit/s			☒	38400 bit/s		

Link layer

(network-specific parameter, all options that are used are to be marked with an "X". 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
☒ Balanced transmission
☒ Unbalanced transmission

Address field of link
☒ Not present (balanced transmission only)
☒ One octet
☒ Two octets
☐ Structured
☐ Unstructured

Frame length
255   Maximum length L (control direction)
255   Maximum length L (monitor direction)

Configurable   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

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.

Application layer

Transmission mode for application data
Mode 1 (Least significant octet first), as defined in clause 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 "X")

☒ One octet   ☒ Two octets

Information object address
(system-specific parameter, all configurations that are used are to be marked "X")

☒ One octet   ☐ structured
☒ Two octets   ☐ unstructured
☒ Three octets

Cause of transmission
(system-specific parameter, all configurations that are used are to be marked "X")

☒ One octet   ☒ Two octets (with originator address)
                      Set to zero in case of no originator address

Selection of standard ASDUs

Process information in monitor direction
(station-specific parameter, mark each type ID with an "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)

☒ <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_TD_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 CP56Time2a   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 '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)

[X] <45> – Single command   C_SC_NA_1

[X] <46> := Double command   C_DC_NA_1

[X] <47> := Regulating step command   C_RC_NA_1

[X] <48> := Set point command, normalized value   C SE NA 1

[X] <49> := Set point command, scaled value   C SE NB 1

[X] <50> := Set point command, short floating point value   C_SE_NC_1

[X] <51> := Bitstring of 32 bit   C_BO_NA_1

System information in monitor direction
(station-specific parameter, mark with an "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).

[X] <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)

[X] <100> := Interrogation command   C IC NA 1

[X] <101> := Counter interrogation command   C_CI_NA_1

[X] <102> := Read command   C_RD_NA_1

[X] <103> – Clock synchronization command   C_CS_NA_1

[X] <104> := Test command   C_TS_ND_1

[ ] <105> := Reset process command   C_RP_NC_1

[X] <106> := Delay acquisition command   C_CD_NA_1

Parameter in control direction
(station-specific parameter, mark each type ID with an '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)

[ ] <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 '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)

[ ] <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   F_DR_TA_1

Type Identification and cause of transmission assignments
(station-specific parameters)

Shaded boxes are not required.

Blank = function or ASDU is not used.

Mark type identification/cause of transmission combinations:

"X" 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																	
		periodic, cyclic	background scan	spontaneous	initialized	request or requested	activation	activation confirmation	deactivation	deactivation confirmation	activation termination	return info caused by a remote cmd	return info caused by a local cmd	file transfer	interrogated by group \<number\>	request by group \<n\> counter request	unknown type identification	unknown cause of transmission	unknown common address of ASDU	unknown information object address
		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			X		X						X	X		X					
\<2\>	M_SP_TA_1			X		X						X	X		X					
\<3\>	M_DP_NA_1			X		X						X	X		X					
\<4\>	M_DP_TA_1			X		X						X	X							
\<5\>	M_ST_NA_1			X		X						X	X		X					
\<6\>	M_ST_TA_1			X		X						X	X							
\<7\>	M_BO_NA_1			X		X									X					
\<8\>	M_BO_TA_1			X		X														
\<9\>	M_ME_NA_1			X		X									X					
\<10\>	M_ME_TA_1			X		X														
\<11\>	M_ME_NB_1			X		X									X					
\<12\>	M_ME_TB_1			X		X														
\<13\>	M_ME_NC_1			X		X									X					
\<14\>	M_ME_TC_1			X		X														
\<15\>	M_IT_NA_1			X																

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
<16>	M_IT_TA_1			X															
<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			X		X								X					
<30>	M_SP_TB_1			X		X				X	X			X					
<31>	M_DP_TB_1			X		X				X	X								
<32>	M_ST_TB_1			X		X				X	X								
<33>	M_BO_TB_1			X		X													
<34>	M_ME_TD_1			X		X													
<35>	M_ME_TE_1			X		X													
<36>	M_ME_TF_1			X		X													
<37>	M_IT_TB_1			X															
<38>	M_EP_TD_1																		
<39>	M_EP_TE_1																		
<40>	M_EP_TF_1																		
<45>	C_SC_NA_1						X												
<46>	C_DC_NA_1						X												
<47>	C_RC_NA_1						X												
<48>	C_SE_NA_1						X												
<49>	C_SE_NB_1						X												
<50>	C_SE_NC_1						X												
<51>	C_BO_NA_1						X												
<70>	M_EI_NA_1*)																		
<100>	C_IC_NA_1						X												
<101>	C_CI_NA_1						X												
<102>	C_RD_NA_1																		
<103>	C_CS_NA_1						X												
<104>	C_TS_NA_1						X												
<105>	C_RP_NA_1																		
<106>	C_CD_NA_1						X												
<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 X only**

Basic application functions

Station initialization
(station-specific parameter, mark with an "**X**" if function is used)

[X]   Remote initialization

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

[X]   Cyclic data transmission

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

[X]   Read procedure

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

[X]   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_TF_1

[ ]   Measured value, short floating point number M_ME_NC_1, M_ME_TC_1 and M_ME_TF_1

Clock synchronization
(station-specific parameter, mark ʺ if function is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' if used in both directions)

[X] Clock synchronization

[ ] Day of week used

[ ] RES1, GEN (time tag substituted/ not substituted) used

[ ] SU-bit (summertime) used

optional, see clause 7.6

Command transmission
(station-specific parameter, mark ʺ if function is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' if used in both directions)

[X] Direct command transmission

[X] Direct set point command transmission

[X] Select and execute command

[X] Select and execute set point command

[ ] C_SE ACTTERM used

[X] No additional definition

[X] Short pulse duration (duration determined by a system parameter in the outstation)

[X] Long pulse duration (duration determined by a system parameter in the outstation)

[X] Persistent output

[X] Supervision of maximum delay in command direction of commands and set point commands

| Configurable | Maximum allowable delay of commands and set point commands |

Transmission of Integrated totals
(station-specific parameter, mark 'X' 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

[ ] Mode B: Local freeze with counter

[ ] Mode C Freeze and transmit by counter interrogation

[ ] Mode C Freeze by counter-interrogation command, frozen values reported

[X] Counter read

[X] Counter freeze without reset

[X] Counter freeze without reset

[X] Counter reset

[X] 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 "X" 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 value

Parameter activation
(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)

☐ 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 analog 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	30s	Time-out of connection establishment	Configurable
t_1	15s	Time-out of send or test APDUs	Configurable
t_2	10s	Time-out for acknowledges in case of no data messages $t_2 < t_1$	Configurable
t_3	20s	Time-out for sending test frames in case of a long idle state	Configurable

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Word 10
Write failed on tag. 19