
GRID AUTOMATION PRODUCTS

MicroSCADA X SYS600 10.2

IEC 60870-5-101 Master Protocol





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Table of contents

Section 1	Copyrights.....	3
Section 2	Introduction.....	5
2.1	This manual.....	5
2.1.1	IEC 60870-5-101 Master Protocol.....	5
2.2	Use of symbols.....	5
2.3	Document conventions.....	6
2.4	Related documents	6
2.4.1	Other referenced manuals.....	7
2.5	Document revisions.....	7
Section 3	Safety information.....	9
3.1	Backup copies.....	9
3.1.1	Taking backup copies.....	9
3.1.2	System backup.....	9
3.1.3	Application backup.....	9
3.2	Fatal errors.....	9
3.2.1	Handling.....	9
3.2.2	Status codes.....	10
Section 4	Instructions.....	11
4.1	Communication.....	11
4.2	Installation.....	11
4.3	Configuration.....	11
4.3.1	Base system configuration.....	11
4.3.2	Communication system configuration.....	12
4.3.2.1	Setting the attribute values.....	13
4.3.2.2	Network topologies.....	13
4.3.2.3	IEC 60870-5-101 line layer.....	14
4.3.2.4	IEC 60870-5-101 station object.....	26
4.3.2.5	Authentication attributes.....	34
4.3.2.6	Autodialing attributes.....	42
4.3.2.7	File transfer attributes.....	45
4.4	After configuration.....	50
4.5	How to test the configuration.....	50
4.6	Serial cable wiring diagram.....	51
4.7	Communication adjustment guidelines.....	51
4.7.1	Basic checks.....	51
4.7.2	Message sending.....	52
4.7.3	Message reception.....	52
4.7.4	Data updating.....	52

Section 5	Technical description.....	55
5.1	IEC 60870-5-101 Protocol.....	55
5.2	Level of implementation.....	55
5.3	Communication.....	55
5.3.1	Communication modes.....	55
5.3.2	Protocol converter.....	56
5.3.3	Addressing.....	56
5.3.4	Device communication attributes.....	57
5.3.5	Data in monitoring direction.....	59
5.3.5.1	Binary inputs and double binary inputs.....	61
5.3.5.2	Analog inputs and digital inputs.....	61
5.3.5.3	Pulse counters.....	61
5.3.5.4	Bit streams.....	61
5.3.6	Data in control direction.....	62
5.3.6.1	Command handling in IEC 60870-5-101 protocol.....	62
5.3.6.2	Data commands.....	63
5.3.6.3	Application commands.....	66
5.3.6.4	System commands.....	67
5.3.7	Transparent data commands.....	67
5.3.8	Parameter in control direction.....	69
5.4	Signal engineering.....	70
5.5	Status codes.....	71
5.6	Interoperability.....	71
5.6.1	Interoperability.....	71
5.6.1.1	System or device.....	71
5.6.1.2	Network configuration.....	72
5.6.1.3	Physical layer.....	72
5.6.1.4	Link layer.....	72
5.6.1.5	Application layer.....	73
5.6.1.6	Basic application functions.....	79
5.7	Description of the SPA bus messages.....	82
5.8	Description of parameter/byte string messages.....	84
Appendix A	Examples of communication system configuration.....	87
Index.....		91

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Section 2 Introduction

2.1 This manual

This manual provides thorough information on the use of IEC 60870-5-101 Master Protocol and information related to it. It describes how to configure the base system and the communication system to establish communication to IEC 60870-5-101 slave devices.

In addition to this configuration, the base system needs to be configured for data storage and processing. For information on this subject, see other manuals, for example, SYS600 Application Objects and SYS600 System Objects.

2.1.1 IEC 60870-5-101 Master Protocol

The IEC 60870-5-101 Master protocol is mainly used for upper level communication between SYS600 and a Substation Control System (SCS) as illustrated by [Figure 1](#).

This protocol can also be used for communication between SYS600 and a remote-controlled line disconnector.

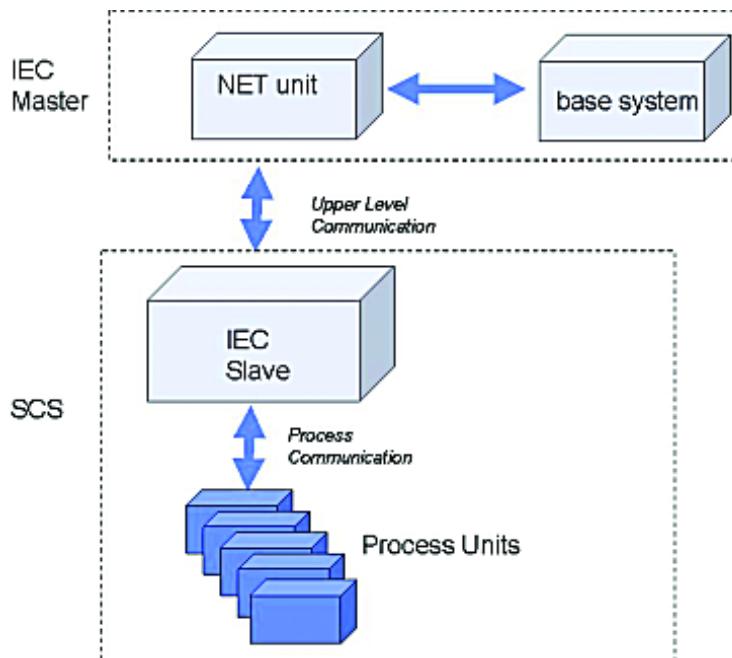


Figure 1: The IEC master sees the Substation Control System (SCS) as an IEC slave

2.2 Use of symbols

This publication includes warning, caution and information symbols where appropriate to point out safety-related or other important information. It also includes tips to point out useful hints to the reader. The corresponding symbols should be interpreted as follows:



Warning icon indicates the presence of a hazard which could result in personal injury.



Caution icon indicates important information or a warning related to the concept discussed in the text. It might indicate the presence of a hazard, which could result in corruption of software or damage to equipment/property.



Information icon alerts the reader to relevant factors and conditions.



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

Although warning hazards are related to personal injury, and caution hazards are associated with equipment or property damage, it should be understood that operation of damaged equipment could, under certain operational conditions, result in degraded process performance leading to personal injury or death. Therefore, comply fully with all warnings and caution notices.

2.3 Document conventions

The following conventions are used for the presentation of material:

- The words in names of screen elements (for example, the title in the title bar of a dialog, the label for a field of a dialog box) are initially capitalized.
- Capital letters are used for file names.
- Capital letters are used for the name of a keyboard key if it is labeled on the keyboard. For example, press the CTRL key. Although the Enter and Shift keys are not labeled, they are written in capital letters, for example, press ENTER.
- Lowercase letters are used for the name of a keyboard key that is not labeled on the keyboard. For example, the space bar, comma key and so on.
- Press CTRL+C indicates that the user must hold down the CTRL key while pressing the C key (in this case, to copy a selected object).
- Press ALT E C indicates that the user presses and releases each key in sequence (in this case, to copy a selected object).
- The names of push and toggle buttons are boldfaced. For example, click **OK**.
- The names of menus and menu items are boldfaced. For example, the **File** menu.
 - The following convention is used for menu operations: **Menu Name/Menu Item/Cascaded Menu Item**. For example: select **File/Open/New Project**.
 - The **Start** menu name always refers to the **Start** menu on the Windows Task Bar.
- System prompts/messages and user responses/input are shown in the Courier font. For example, if the user enters a value that is out of range, the following message is displayed:
Entered value is not valid.
The user may be told to enter the string MIF349 in a field. The string is shown as follows in the procedure: **MIF349**
- Variables are shown using lowercase letters: sequence name

2.4 Related documents

The following SYS600 manuals should be available for reference during the use of this manual:

Name of the manual	Document ID
SYS600 10.2 IEC 60870-5-101 Slave Protocol	1MRK 511 490-UEN
SYS600 10.2 System Configuration	1MRK 511 481-UEN
SYS600 10.2 System Objects	1MRK 511 482-UEN
SYS600 10.2 Application Objects	1MRK 511 467-UEN

2.4.1 Other referenced manuals

The IEC 60870-5-101 protocol is based on the following documents by the IEC Technical Committee 57:

IEC 60870-5-1	Transmission Frame Formats
IEC 60870-5-2	Data Link Transmission Services
IEC 60870-5-3	General Structure of Application Data
IEC 60870-5-4	Definition and Coding of Information Elements
IEC 60870-5-5	Basic Application Functions
IEC 60870-5-101	Companion standard for the IEC 60870-5-101 Protocol

2.5 Document revisions

Revision	Version number	Date	History
A	10.2	31.03.2021	New document for SYS600 10.2

Section 3 Safety information

This section has information on the prevention of hazards and taking backups from the system.

3.1 Backup copies

3.1.1 Taking backup copies

We recommend taking backup copies before making any changes, especially ones that might have side effects. Software and data need to be copied to another place.

Backup copying makes it easier to restore the application software in case of disk crash or other severe failure where stored data is lost. It is therefore recommended that backup copies are taken regularly.

There should be at least two system backup copies and two application copies. A new backup is copied over the oldest backup. This way the latest version is always available, even if the backup procedure fails.

Detailed information on how to take backup copies should be delivered to the customer with the application.

3.1.2 System backup

Usually a system back up is taken after the application is made. It should be taken again when changes are made to the SYS600 system. This is required when the driver configuration or the network setup is changed.

3.1.3 Application backup

An application backup is also taken at the same time with the system backup, after the application is made. It should be taken again when changes are made to the application, for example, if pictures or databases are edited or new pictures are added.

3.2 Fatal errors

A fatal error is an error that causes a breakdown or a locked situation in the SYS600 program execution.

3.2.1 Handling

In case of a fatal error:

1. Write down the possible SYS600 error messages.
2. Shut down the SYS600 main program. If this cannot be done in the SYS600 Control Panel, try to end the task in Windows Task Manager.



Files may be damaged if the base system computers are shut down by switching the power off.

3. The data kept in the main memory at the moment of a fatal error is placed in the drwtsn32.log file with Windows 2003 Server, Windows XP and earlier. By default, it is placed under %SYSTEMDRIVE%\Documents And Settings\All Users\Application Data\Microsoft\Dr Watson. Log and dump file paths can be checked with the drwtsn32 application. (Start -> run -> drwtsn32.exe). Analyze and copy the data in these files. Starting with Windows Server 2008 and Windows 7 the crash handling has changed. The location of the dump files can be read from the registry under the key HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows\Windows Error Reporting\LocalDumps. The DumpFolder value tells the location of the dump files. Collect the data from this location.
4. Restart the system.

Report the program break-down together with the possible SYS600 error messages and the information from the drwtsn32.log file to the SYS600 supplier.

3.2.2 Status codes

Error messages in SCIL are called status codes. A list of status codes and short explanations for them can be found in SYS600 Status Codes.

Section 4 Instructions

4.1 Communication

In SYS600 the IEC 60870-5-101 Master protocol is implemented only in the PC-NET software. PC-NET unit communicates over an INTEGRATED link and via the serial or LAN ports of the base system computer.

Setting the attributes of SYS600 system objects can modify the communication parameters.

The base system sees each IEC device as a station (STA object) that has been created to a line of a NET unit. Each IEC station works as a protocol converter that converts data between the internal protocol of SYS600 and the IEC 60870-5-101 protocol.

The protocol can be used with virtual serial ports by using a special setting of the line attributes. See NET line attribute CM for more information.

4.2 Installation

The SYS600 installation is required.

4.3 Configuration

Configuration can be made either by using the System Configuration Tool or by using SCIL statements. For more information on the System Configuration Tool, see SYS600 System Configuration manual, chapter "PC-NET start-up with System Configuration Tool" and "System Configuration Tool". The usage of the System Configuration Tool is recommended, but if there is a need to create the communication configuration using SCIL, it is instructed in the following chapters. In this case, the configuration can be divided into two parts:

The configuration can be divided into two parts:

- Base system configuration
- Communication system configuration

The attribute descriptions presented in chapter 'Communication system configuration' are the same for configurations created with System Configuration Tool or with SCIL.

4.3.1 Base system configuration

It is assumed here that the base system configuration for objects other than the communication has been made according to the instructions in the System Configuration manual.

The extra steps needed to configure the communication are:

1. Define a node number for a PC_NET instance.
2. Reserve a link number for a PC_NET instance. Creating the link as instructed in step 6 starts the PC_NET instance.
3. Create the base system STA object for each remote IED (master function) or for each NCC connection (slave function).

- IEC 60870-5-101 Master protocol uses the station type IEC (STY type 29)

The STA objects are created to SYS_BASCON.COM using the template or with a separate creation sequence. If the template is not used, the sequence should contain the line:

```
#create STA'Sta_Nb':B = %Sta
```

where 'Sta_Nb' is the number of the station object in the base system. %Sta is a list object which should contain at least the following settings: TT = "EXTERNAL", ST = station type, ND = node number defined in step 1 and TN = translated object number (usually the same as 'Sta_Nb'). See SYS600 System Objects manual for more information on the base system object attributes for STA object).

4. Edit the PC_NET.CF1 according to the description in chapter "Start-up definition file PC_NET.CF1" in the SYS600 System Configuration manual
5. Create a command procedure which creates the lines and stations to the NET object (= pc_net instance) using the S-attributes.
See [Section 4.3.2](#) for more information on the attribute setting. A sample creation script is presented at the end of this manual.
6. Create a command procedure which creates the link of type 'INTEGRATED' to the base system. This procedure should contain the line:

```
#set LIN'i_Integrated_Link_Number':BLT = "INTEGRATED"
```

where 'i_Integrated_Link_Number' is the number of the link reserved in step 2. The PC_NET executable is defined with the SC attribute of the link and it must set before setting of the LT attribute.

The testing of the communication system can be done as follows:

1. Execute the procedure created in step 6. This starts the PC_NET instance and enable the setting of the S-attributes.
2. Execute the procedure created in step 5. If the lines and stations are set to IU = 1 (that is, they are in use) and the configuration is correct and complete in both ends, the communication starts.

For automatic start-up of the communication, the created command procedures must be attached to the APL_INIT_1:C procedure.

4.3.2 Communication system configuration

Each NET instance contains a set of system objects which specify the existence and the usage of the communication lines and the station objects connected to those lines. These objects can be created, modified, and deleted by SCIL, and setting the attributes defines the functionality of these objects.

Access to the attributes can be one of the following:

- **Read-only:** The attribute can only be read. There are still a few exceptions in which the values can be reset.
- **Write-only:** The attribute can only be written (set).
- **Read, conditional write:** The attribute can be both read and written, but the object must be set out of use (IU = 0) before writing.
- **No limitations:** The attribute can be both read and written without limitations.

The configuration of the communication system in SYS600 can be divided into two layers: line layer and station layer. Both of these layers have a specific functionality and a set of attributes of their own.

The purpose of the communication system configuration is to:

- Create all the system objects needed to establish communication between the master and the slave. Related attributes for creation are PO (Line) and DV (Station).
- Adjust the values of the system object attributes to match the physical communication channel and the properties of the remote partner/partners. The menu selection 'Configuration->Preview->PC_NET' in the System Configuration Tool may provide an example of the SCIL based configuration script of any setup.

4.3.2.1 Setting the attribute values

All the line and station attributes have sensible default values, but the value of each attribute must be checked against the requirements of the actual communication system.

The attribute values depend on:

- The physical communication media (for example leased telephone line, radio link, power line carrier), which affects the attributes of the line, such as the baud rate and parity.
- The network topology used (point-to-point, multi-drop), which affects the link type.
- The size (number of stations) of the system, which affects the timeout parameters; the slower the media and larger the system, the longer timeouts are needed.
- The remote system(s), which affects both the line and station attributes, and the message types used.

4.3.2.2 Network topologies

The implementation of the IEC 60870-5-101 Master protocol in SYS600 supports direct and serial bus topologies. The direct topology (point-to-point) can be a direct physical cable from point-to-point, a two-node radio, or modem network. The serial bus topology (multi-drop) is commonly made up of many modems with their outputs/inputs tied together or connected using a star-coupler. The IEC 60870-5-101 protocol supports one master on a line. [Figure 2](#) illustrates the network topologies.

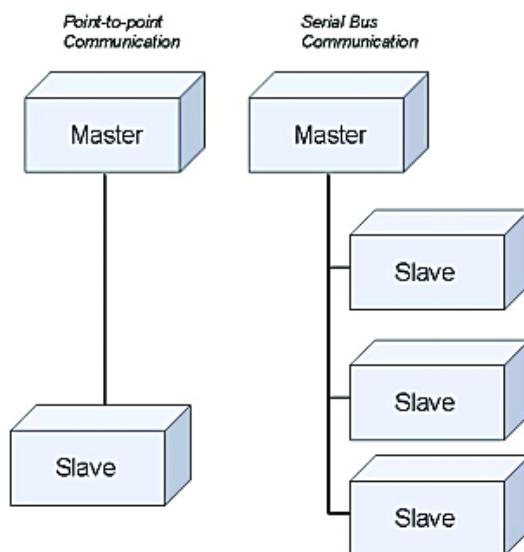


Figure 2: Network topologies



When the serial bus (multi-drop) network topology is used, only the unbalanced mode of the IEC 60870-5-101 protocol can be used.

When making the IEC connection, an agreement about the used communication parameters should be made with the supplier or owner of the master system.

4.3.2.3 IEC 60870-5-101 line layer

The line process of a NET unit performs the functions of the line layer. The purpose of the line layer is to send and receive messages to/from external devices using the IEC 60870-5-101 protocol. The line layer provides frame synchronization and link control.

According to the IEC 60870 standards, the line layer performs the following functions:

- Provides access to the transmission medium.
- Serializes and deserializes frames.
- Adds and removes frame delimiters, if this is not performed by data circuit terminating equipment.
- Detects frame synchronization errors.
- Detects frame size errors.
- Monitors signal distortion, if this is not performed by data circuit terminating equipment.
- Recognizes frames addressed to a designated station.
- Prevents the station transmitting without pause.
- Protects messages against loss and errors within predetermined limits.
- Reports on persistent transmission errors.
- Reports on the status of link configuration.
- Supports initiation and maintenance functions.

Line layer attributes

The following attributes can be used for configuring IEC 60870-5-101 master lines in SYS600.

IU	In Use
	Indicates whether the line is in use (value 1) or not in use (value 0).
PO	Protocol
Data type:	Integer
Value:	0 or 1
Index range:	1...12 (NET line numbering)
Default value:	0
Access:	No limitations
Data type:	Integer
Value:	0...45 Value with IEC 60870-5-101 Master protocol: 31 (unbalanced mode) or 32 (balanced mode).
Index range:	1...12 (NET line numbering)
Access:	Read, conditional write

SD	System Device Name
Associates the NET line numbers of PC-NET with the device names of the physical channels of serial ports. By default, the line number 1 is connected to the COM1, the line 2 to the COM2 and so on. By using the SD attribute, it is possible to override these default values. This may be necessary if the COM ports are used as NET lines or if, for example, a RocketPort card is used.	
Data type:	Text
Value:	See above
Index range:	1...12 (NET line numbering)
Access:	Read, conditional write
PS	Buffer Pool Size
Specifies the number of message buffers reserved for the line. Fixed buffer poll sizes are used in versions 9.3 FP1 and newer and this attribute is retained because of the backward compatibility. Setting the value for PS is not possible anymore. See the attributes PS, NB and PB from the System Objects manual for more information.	
Data type:	Integer
Value:	1...250
Index range:	1...12 (NET line numbering)
Access:	Read (conditional write accepted but has no effect)
BR	Baud Rate
Transmission rate used on the line.	
Data type:	Integer
Value:	1...19200 (384 = 38400 bauds, 576 = 57600 bauds)
Unit:	Bits / s
Index range:	1...12 (NET line numbering)
Default value:	9600
Access:	Read, conditional write
PY	Parity
Specifies the parity check (if any) used for the characters transferred on the line.	
Data type:	Integer
Value:	0 = no parity check 1 = odd parity 2 = even parity
Index range:	1...12 (NET line numbering)
Default value:	2
Access:	Read, conditional write
RD	Receiver Data Bit Count
Specifies the number of data bits in each received character.	
Data type:	Integer
Value:	5, 6, 7 or 8
Unit:	Data bits
Index range:	1...12 (NET line numbering)
Default value:	8
Access:	Read, conditional write

SB Stop Bits

Specifies the number of stop bits attached to each transmitted character.

Data type:	Integer
Value:	1 or 2
Unit:	Stop bits
Index range:	1...12 (NET line numbering)
Default value:	1
Access:	Read, conditional write

TD Transmitter Data Bit Count

Specifies the number of data bits in each transmitted character.

Data type:	Integer
Value:	5, 6, 7 or 8
Unit:	Data bits
Index range:	1...12 (NET line numbering)
Default value:	8
Access:	Read, conditional write

PD Polling Delay

Delay between polling messages. The purpose of this attribute depends on the communication mode. In the unbalanced mode the master sends the polling messages (for class 1 or class 2) with an interval defined by this attribute. In the balanced mode the line layer of the protocol checks the state of the communication, if the time between two consecutive messages is more than the value of the PD attribute.

Data type:	Integer
Value:	0... 65535
Unit:	Milliseconds
Index range:	1...12 (NET line numbering)
Default value:	50 (unbalanced mode) or 5000 (balanced mode)
Access:	Read, conditional write

PP Polling Period

The polling frequency of suspended stations. This attribute specifies how often the suspended stations of the line are polled with the link initialization message. PP value is the value of transmitted messages before a new link initialization message is sent. Each suspended station has a counter of its own, which means that the sending may take place more often, if there are more than one suspended station. If all the stations are suspended, the value of PP is meaningless. Value PP=1 may be used but is not recommended. The attribute is meaningful only in the unbalanced mode.

Data type:	Integer
Value:	1..255
Index range:	1...12 (NET line numbering)
Default:	10
Access:	Read, conditional write

PL Polling Limit

This attribute is used for controlling the polling sequence of IEC stations. The purpose of the PL attribute is to limit the number of successive polls of one station (link address). Normally one station is polled until all the data is read. This attribute is used only in the unbalanced mode.

Data type:	Integer
Value:	2...100

Table continues on next page

PL	Polling Limit
Index range:	1...12 (NET line numbering)
Default value:	10
Access:	Read, conditional write

RP	Reply Polling
This attribute specifies the number of successive polls to a station where the master has sent a command.	
This attribute is used only in the unbalanced mode.	
Data type:	Integer
Value:	1...20
Index range:	1...12 (NET line numbering)
Default value:	1
Access:	Read, conditional write

SL	Secondary polling Limit
This attribute is used to control the class 2 polling of IEC stations. The purpose of the SL attribute is to limit the number of successive class 2 polls of one station (link address). If a value of zero is given, the attribute is meaningless and the value of PL applies to class 2 polls. The value of SL is limited to be less or equal to PL.	
This attribute is used only with the unbalanced mode.	
Value:	0 .. 100 (less or equal to PL)
Indexing:	1..12 (NET line numbering)
Access:	Read, conditional write
Default:	1

TW	Transmission Wait Delay
Specifies the transmission delay in milliseconds. The transmission delay is the time that the NET must wait after receiving a CTS (Clear to Send) signal until starting the transmission of a message.	
Data type:	Integer
Value:	0...65535
Unit:	Milliseconds
Index range:	1...12 (NET line numbering)
Default value:	0
Access:	Read, conditional write

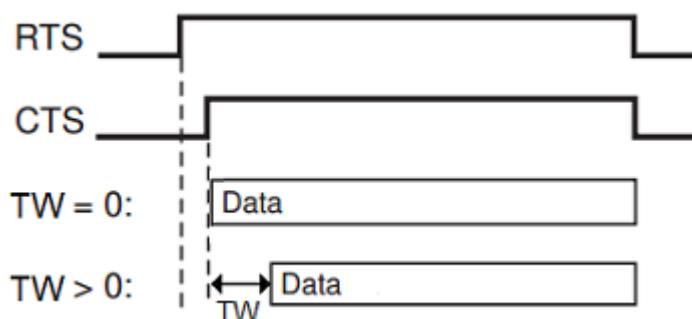


Figure 3: TW attribute

DE **CTS Delay**

The maximum waiting time of the rising edge of the CTS signal after the activation of the RTS signal. If CTS is low after the timeout, it causes a CTS error and the transmission does not start. A line disconnection often leads to a CTS error. If value = 0 is given, 500 msec waiting time is applied. If simulated CTS high is used (serial only, line attribute CM, bit 1), there is no rising edge and transmission starts after the waiting time.

Data type: Integer
Value: 0...65535
Unit: Milliseconds
Index range: 1...12 (NET line numbering)
Default value: 50
Access: Read, conditional write

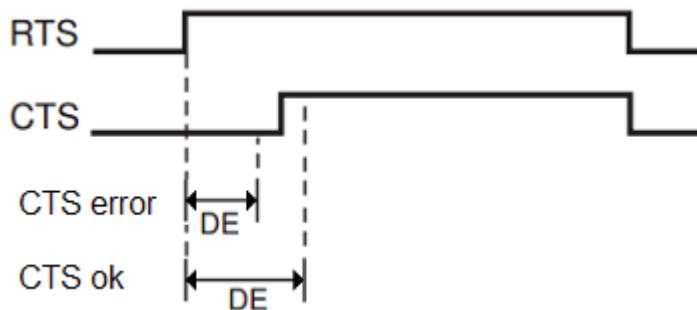


Figure 4: DE attribute



In the [Figure 4](#) the smaller DE value causes a CTS error. A suitable DE value varies with each system.

HT **Header Timeout**

Specifies the maximum waiting time in milliseconds within which the first byte of a line layer response from the IEC slave should have been received after the transmission of a message. If no response has been received within this time, new attempts are performed the number of times specified by the Enquiry limit. If a response is still not obtained, the station is suspended.

Data type: Integer
Value: 0...65535
Unit: Milliseconds
Index range: 1...12 (NET line numbering)
Default value: 2000
Access: Read, conditional write

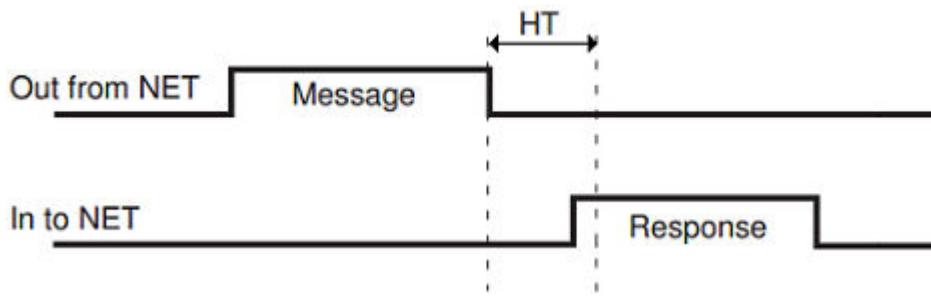


Figure 5: HT attribute

TI	Response Timeout
-----------	-------------------------

The time in seconds that the IEC link waits for the end of the line layer response.

Data type: Integer

Value: 0...255

Unit: Seconds

Index range: 1...12 (NET line numbering)

Default value: 2

Access: No limitations

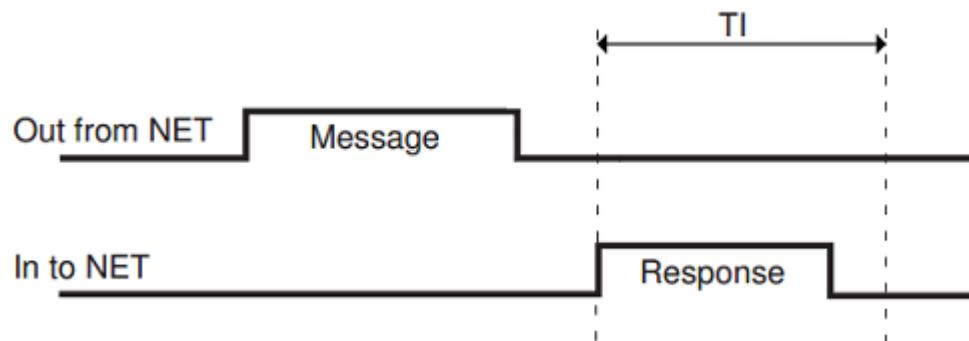


Figure 6: *TI attribute*



A slow communication speed and a long response might cause error with too small TI attribute value.

RY	RTS Keepup Delay
-----------	-------------------------

This attribute defines how long time the RTS-pin of the RS232-port is kept in the signal state after the serial driver completes the write operation. The write operation here means a transmission of any message. See also line attribute CM (Com Port Mode), bit 3.

Data type: Integer

Value: 0...20

Unit: Bytes (absolute time depends on baud rate)

Index range: 1...12 (NET line numbering)

Default value: 1

Access: Read, conditional write

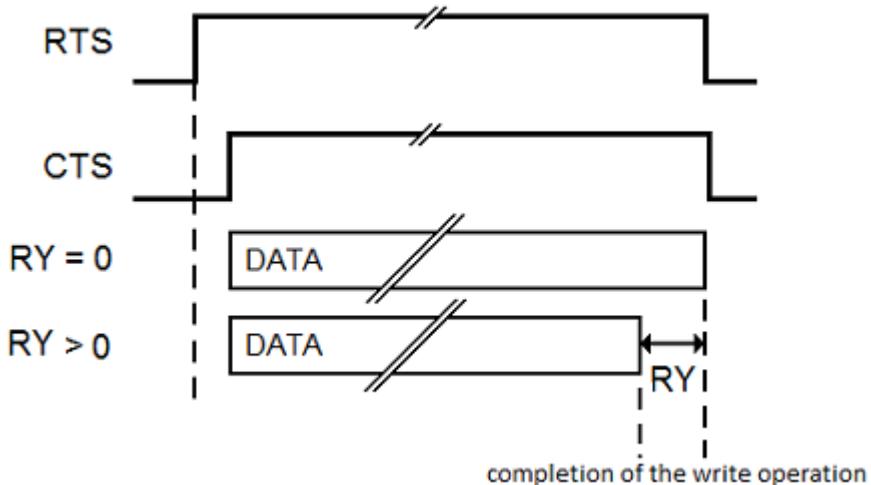


Figure 7: RY attribute

RK **RTS Keep Up Padding Characters**

The number of padding characters (null characters) inserted to the end of a telegram to delay the passivation of the RTS (Request To Send) signal.

Data type:	Integer
Value:	0...255
Index range:	1...12 (NET line numbering)
Default value:	0
Access:	Read, conditional write

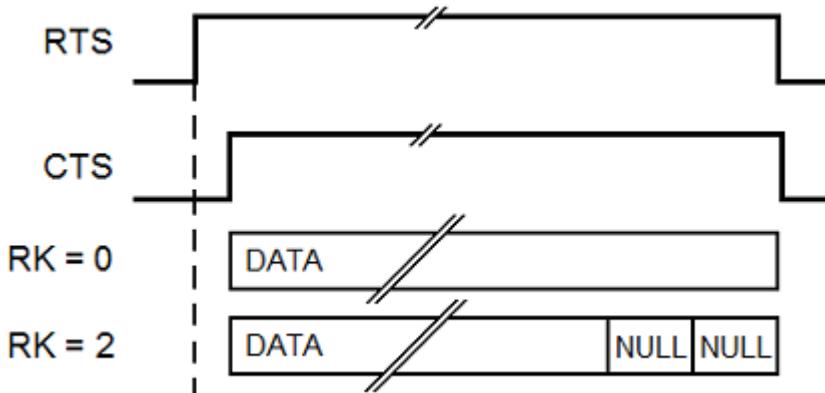


Figure 8: RK attribute



Instead of using RK attribute, the RTS Keepup Delay (RY) attribute can be used.

RI	Receive Interrupt Enable Delay
Defines the delay in milliseconds after which the receiver of a NET line is enabled after a message has been issued. If the given value is too big, the first characters of the response are not necessarily received.	
Data type:	Integer
Value:	0...255 0 = receiver is always enabled 1...9 = receiver enabled right after transmission 10... = receiver enabled as stated by the value
Unit:	Milliseconds
Index range:	1...12 (NET line numbering)
Default value:	0
Access:	No limitations

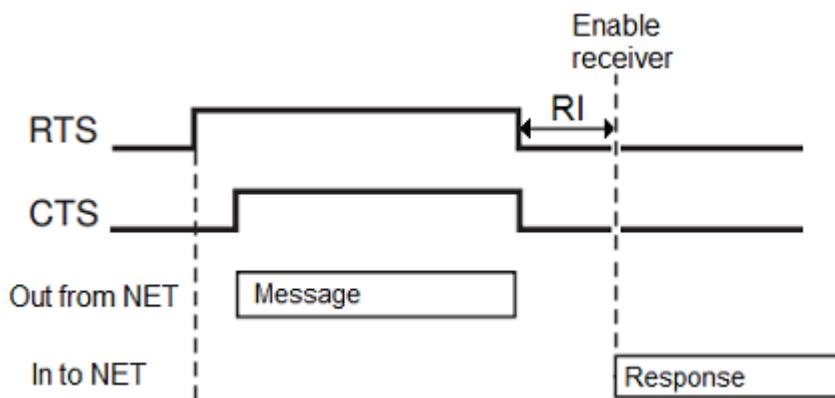


Figure 9: RI attribute

EN	Enquiry Limit
Specifies the maximum number of times that a message is retransmitted after a timeout.	
Data type:	Integer
Value:	1...255
Index range:	1...12 (NET line numbering)
Default value:	3
Access:	Read, conditional write

SG	Modem Signal
An attribute for direct supervision and control of the state of the modem signal. This attribute applies to all protocols. It is used for diagnostics and testing.	
If the incoming signal DCD or CTS is wanted to have a simulated high value all the time, value = 1 can be written to these signals. This feature may be necessary for easier cabling or with virtual serial ports. If value = 0 is written to these signals, the actual state of signal is used. The default mode of operation is the actual state. See also attribute CM Com Port Mode.	
Data type:	Integer
Value:	0 = Passive signal 1 = active signal
Incoming:	DCD and CTS signals
Outgoing:	DTR signal
Index range:	100 * line no + signal no. Signal no. 5 = CTS, 8 = DCD, 20 = DTR

Table continues on next page

SG	Modem Signal
Access:	Read-only, write possible to signals 5 = CTS and 8 = DCD
Examples:	<pre>#SET NET1:SSG208 = 1 ; line 2 of NET1 should behave as DCD is 'high' all the time #SET NET1:SSG205 = 1 ; line 2 of NET1 should behave as CTS is 'high' all the time #SET NET1:SSG208 = 0 ; line 2 of NET1 should use the actual state of the DCD #SET NET1:SSG205 = 0 ; line 2 of NET1 should use the actual state of the CTS</pre>

CM	COM Port Mode
This attribute consists of a set of flags which control the behavior and functionality of the serial port of the line. Each flag is one bit of this attribute.	
Data type:	Integer
Value:	0 ... 15 (see below)
Default value	0
Index range:	1...12 (NET line numbering)
Access:	Read, conditional write
Bit 0:	UART error handling When this bit is 0, the UART errors are read before the bytes are read from the serial port. This is the default mode. When the bit is 1, the UART errors are read as a separate operation after the bytes are read from the serial port. This mode is similar to PC_NETs older than 9.2SP2 and it does not detect all errors detected by the serial port hardware. If the line has a lot of disturbances, this mode may result in better performance than the default mode.
Bit 1:	Simulated high of the CTS signal When this bit is 0, the actual state of the CTS signal is used in the protocol. This is the default mode. When this bit is 1, the CTS signal is simulated to be in the high state all the time and the line behaves according to that. This setting may be necessary with a virtual serial port or for easier cabling. See line attribute DE how transmission starts when CTS is constantly 'high'.

Table continues on next page

CM	COM Port Mode
Bit 2:	<p>Simulated high of the DCD signal When this bit is 0, the actual state of the DCD signal is used in the protocol. This is the default mode.</p> <p>When this bit is 1, the DCD signal is simulated to be in the high state all the time and the line behaves according to that. This setting may be necessary with a virtual serial port or for easier cabling.</p>
Bit 3:	<p>Calculated RTS Keep up time When this bit is 0, the keep up time of the RTS signal is not calculated using the length of the message but it is assumed that the driver of the serial port blocks the execution of the sending process until the message is actually sent. This setting should be used if the setting 'Wait on physical transmission before completing write' or similar is selected in the driver for the port in question. The tuning of the RTS keep up time should be done with line attribute RY. This is the default setting.</p> <p>When this bit is 1, the keep up time of the RTS signal is calculated using the length of the sent message and the baud rate of the port. The RTS keep up time defined with the line attribute RY is added to the calculated time. This setting is not needed if the setting 'Wait on physical transmission before completing write' or similar is selected in the driver for the port in question. This setting is the most common with the virtual serial ports, too.</p> <p>If the serial driver does not provide setting 'Wait on physical transmission before completing write' or similar and RTS signal is actively used by the modem hardware, it is worth to test both alternatives. For accurate analysis using protocol analyzer function, see also the description of the bit 2 of the line attribute AU Analyzer Usage.</p>



Having a simulated value in CTS or DCD may have an effect on how a RS-232 line disconnection is detected and reported to the MicroSCADA application.

MI	Message Identification
Object address of system messages.	
Data type:	Integer
Value:	1...32760
Index range:	1...12 (NET line numbering)
Default value:	6000 + (100 * NET number) + line number
Access:	Read, conditional write

MS	Message Application
The number of the application that is the receiver of the system messages generated by the line.	
Data type:	Integer
Value:	1...250
Default value:	1
Index range:	1...12 (NET line numbering)
Access:	Read, conditional write

LK	Link Type
The type of data link connection used on the line.	
The states of the CTS and DCD signals of the serial port can have simulated values. The usage of this feature may be necessary, if the line uses a virtual serial port or the hardware connected to the serial port requires a special cable. See the description of the line attribute CM for more information.	
Data type:	Integer
Value:	4: Radio link 12: Ready to Send (RTS) signal always set, balanced mode 13: RTS/CTS controlling, balanced mode
Index range:	1...12 (NET line numbering)

Table continues on next page

LK	Link Type
Default value:	4 (unbalanced mode), 12 (balanced mode)
Access:	Read, conditional write
With values 0..10, the behavior is similar to 4: Radio Link, in which RTS/CTS controlling is used and the messages are received in unbalanced fashion. This value should be used in the unbalanced mode. In the balanced mode, the value must be 12 or 13.	
CB	Carrier Blocking
This attribute determines whether the incoming Carrier Detect (DCD) signal of the serial port must be set in order for the IEC line to receive messages. If Carrier Detect is expected (CB=1), the incoming bytes of the messages are discarded while the DCD signal is not set. Historically, the Carrier Detect was used with modems (for example, V.23) in order to indicate the direction of the data flow and filter out corrupted characters when the data flow direction changes. A hardware solution is to connect the DCD pin to the DTR pin in the RS-232 cable. In this case the messages are always received when the line is in use (IU=1). In versions 9.3FP2 and newer, the line attribute CM, bit 2 can be used to achieve the same effect. The usage of the line attribute CM is recommended, since it is supported by all serial protocols.	
Data type:	Integer
Value:	0 = Carrier blocking not used, messages are received regardless of the DCD state 1 = Carrier blocking used, DCD must be signaled in order to receive messages
Default value:	1
Index range:	1...12 (NET line numbering)
Access:	Read, conditional write
DC	Diagnostic Counters
The line protocols gather statistical information about the events on the lines by incrementing a number of diagnostic counters. All the major events and error situations of the communication have their own counters. When accessing diagnostic counters, the attribute is indexed according to the formula: $100 * (\text{line number}) + (\text{diagnostic counter number})$ The IEC 60870-5-101 Master protocol supports the following counters:	
<ul style="list-style-type: none">1. Transmitted telegrams2. Failed transmissions4. Transmitted commands5. Transmitted replies11. Received messages12. Parity errors13. Overrun errors14. Check sum errors15. Framing errors16. Buffer overflow errors	
Data type:	Integer
Value:	0...30000
Index range:	See above
Access:	Read-only, the values can be reset
OM	Operating Mode
This attribute consists of a set of flags which control the behavior and functionality of the IEC line. Each flag is one bit of this attribute. The bits are the following:	
Data type:	Integer
Value:	0..65535
Index range:	1...12 (NET line numbering)

Table continues on next page

OM	Operating Mode
Default value:	0
Access:	Read, conditional write
Bit 0:	Balanced mode handshake When this bit is 0, the sending of the handshaking messages (request, status of link, reset of remote link) are NOT restarted when a Request status of link message is received from the remote end.
Bit 1:	The polling method when a remote station sets the DFC bit on. When this bit is 0, the master sends the Request status of link until the remote station clears the DFC bit (this is the default operation). When this bit is 1, the master continues polling normally. The bit is meaningful only in unbalanced mode.
Bit 2:	One link, one station poll. When this bit is 1, the master infinitely polls the first link that responds. Only the station from which the first data is received is set to OK status and in case of communication failure, only this station is set to suspended state. This configuration is especially useful in a multistation configuration with dial-up, in which the remote station makes the call and there is only station behind the link. This bit should be set only in the unbalanced mode. When this bit is 0, all the links are polled normally (this is the default operation).
Bit 3:	When this bit 1 and a dial-up connection is used, the station object is set to the suspended state when an incoming call is hanged up. When this bit is 0, the hang-up does not cause suspension.
Bit 4:	Polling of the commanded station. When this bit is 1, the commanded station is always polled with the number of data polls defined with the RP attribute. Both class 1 and class 2 polls are made with this configuration. With this configuration, a value that is too big in the RP attribute can cause inefficiency in polling. When this bit is 0, the commanded station is polled with the number of data polls defined with the RP attribute only if the device requests for class 1 polling. This is the default. This bit is meaningful only in the unbalanced mode.

BA	Backup operation
	This attribute determines whether the line should operate in normal or in backup mode. When set to 1, the line operates as the backup line according to the document "Norwegian User Conventions for IEC 60870-5-101".
	The statuses of the station objects are set to OK_STATUS, if the remote device responds to Request status of link requests from the master (unbalanced mode) or if the link initialization is successful (balanced mode). Sending commands to the line operating as backup line is not possible.
	When set to 0, the behavior is returned to normal, that is, data is received and sending the commands is possible. This is the default mode of operation.
Data type:	Integer
Value:	0 = normal operation 1 = backup operation
Default value:	0
Index range:	1...12 (NET line numbering)
Access:	Read, write
Example:	#set net3:sba1=1 ; set line 1 of NET3 to operate as a backup line #set net3:sba2=0 ; set line 2 of NET3 to operate as a main line #set sta20:sg1=1 ; send GI to STA20 (connected to line 2) . . #set net3:sba1=0 ; set line 1 of NET3 to operate as a main line #set net3:sba2=1 ; set line 2 of NET3 to operate as a backup line #set sta10:sg1=1 ; send GI to STA10 (connected to line 1)

UI	UAL event Identification
The UI attribute is used to define the name for the line object, and it is used to identify the source of the UAL (user activity logging) events. This string is added to the identification information of all user activity events from this line object. A unique value within the node is preferred. The node level module name (also in attribute UI) is added to form the full identification information for the user activity event. If a line identifier is not needed, an empty string should be assigned to this attribute.	
Data type:	String
Value:	String containing a line level identifier with maximum length of 16 characters
Indexing:	1..12 (if not used, node attribute will be referred)
Default value:	".LINEx", where x = line number
Access:	Read, write

4.3.2.4 IEC 60870-5-101 station object

The main purpose of the station layer is the protocol conversion between the IEC 60870-5-101 and the internal protocol of SYS600. The station objects also take care of the application level communication with the slave.

The STA objects created in a NET unit perform the functions of the station object. Several STA objects of the type IEC devices are allowed on the same line. It is also possible that multiple stations share the same remote IP address.

The STA objects created in a NET unit perform the functions of the station object. Some attributes are used for the station configuration and others are used for device communication. The configuration attributes are presented in this chapter and the communication attributes are presented in the next one.

Station objects can be configured to use secure authentication using the attributes described in chapter 'Authentication attributes'. IEC 60870-5-101 Secure Authentication is based on IEC technical specifications 62351-5 and 60870-5-7. Users and their roles and keys are created to slave device on-line with IEC 60870-5-101 using symmetric or asymmetric methods.

The databases for user sets and necessary keys are created using separate tools (see SYS600 System Configuration manual, chapter 'Secure authentication using IEC/TS 62351-5' for more information). This database is called "key storage" in the descriptions of the authentication attributes. The key storage which is used by the PC-NET instance is defined with NET Node attribute KS (see System Objects manual for a detailed description). Key storage file is always encrypted.

Station attributes

The following attributes can be used for configuring the IEC 60870-5-101 Master stations in SYS600.

IU	In Use
Indicates whether the station is in use (value 1) or not in use (value 0).	
Data type:	Integer
Value:	0 or 1
Default value:	0
Access:	No limitations

LI **Line Number**

The number of the NET line the station is connected to.

Data type: Integer

Value: 1...12 (NET line numbering)

Access: Read, conditional write



Setting this attribute is not needed, when the station is created by using the DV attribute.

PA **Polling Address**

The link address of the IEC 60870-5-101 station.

Data type: Integer

Value: 0...254, when PL attribute = 1
0...65535, when PL attribute = 2

Default value: 1

Access: Read, conditional write



Address 255 is reserved for broadcast messages (PL=1).
Address 65535 is reserved for broadcast messages (PL=2).

SA **Station Address**

The station address of the IEC 60870-5-101 station, the common address of ASDU in an IEC message.

Data type: Integer

Value: 0...255 , when SL attribute = 1
0...65535, when SL attribute = 2

Default value: 1

Access: Read, conditional write

DR **Direction**

States if the IEC Master station acts as the station A (primary station) or as the station B (secondary station).

Data type: Integer

Value: 0 or 1

Default value: 1 (primary station)

Access: Read, conditional write

PL **Polling Address Length**

The length of the link address in octets.

Data type: Integer

Value: 1 or 2

Default value: 1

Access: Read, conditional write (line IU must also be 0 when writing)

SL Station Address Length

The length of the station address (common address of ASDU) in octets.

Data type: Integer
Value: 1 or 2
Default value: 1
Access: No limitations

IL Information Address Length

The length of the information object address in octets.

Data type: Integer
Value: 1...3
Default value: 2
Access: Read, conditional write

CL Length of Cause of Transmission Information

The length of the cause of transmission field in an IEC 60870-5-101 message in octets. If the originator addresses are used, the value of this attribute should be set to 2.

Data type: Integer
Value: 1 or 2
Default value: 1
Access: No limitations

AL Allocation

Allocates the station to an application. When the AL attribute has the value 1, the station is reserved by the application specified by the AS attribute. All spontaneous messages from the station are sent to this application.

Data type: Integer
Value: 0 or 1
Access: No limitations

AS Allocating Application

Specifies the allocating application of the station (see the AL attribute). The allocating application gets all spontaneous process data from the station. This application is also the only one that is allowed to set the device communication attributes.

Data type: Integer
Value: 0...250,
 0 = no application
Access: Read-only, conditional write



When the AL attribute is set to 0, AS also gets the value 0.

MI **Message Identification**

Object address of system messages.

Data type: Integer
 Value: 1...32760
 Default value: 29000 + station number
 Access: No limitations

MS **Message Application**

The number of the application, that is the receiver of the system messages generated by the station.

Data type: Integer
 Value: 1...250
 Default value: 1
 Access: No limitations

SE **System Messages Enabled**

Specifies whether the system messages generated by the NET and related to the station are sent to applications (value 1) or not (value 0). By using this attribute, it is possible to disable the system messages related to the station.

Data type: Integer
 Value: 0 or 1
 Default value: 1
 Access: No limitations

CA **Command Address**

The object address of the bit stream process object in the SYS600 process database, where unidentified messages are sent. If the value of the CA attribute is 0, the address of the updated bit stream process object is the first IOA (information object address) of each received unknown message.

Data type: Integer
 Value: 0...65535
 Default value: 32000
 Access: No limitations



The unit number (UN attribute) of the bit stream process object must be the same as the STA object number.

ML **Maximum Message Length**

The maximum length of a transmitted message in octets.

Data type: Integer
 Value: 20...253
 Default value: 230
 Access: Read, conditional write

In practice, this attribute is meaningless in the IEC 60870-5-101 master. The length of the incoming messages can always be at their maximum.

SR **Single Char Response**

Enables or disables single char responses. If single char responses are enabled, the station object replies with a 0xE5 character as a link layer acknowledgment. This attribute is meaningful only in the balanced mode.

Data type:	Integer
Value:	0 or 1
Default value:	0 (single char responses disabled)
Access:	Read, conditional write

CF **ConFirmation Mode**

The wait for the activation termination message. With value 0, the timer defined with the CT attribute is not started. Value 0 is needed with some IEC 60870-5-101 Master implementations, which do not send activation termination messages at all. With value 2, the activation termination message is not waited for with setpoint and bitstring commands, that is, with ASDU types 48..51 and 61..64.

Data type:	Integer
Value:	0 = Activation termination is not waited 1 = Activation termination is waited 2 = Activation termination is waited, excluding ASDUs 48..51 and 61..64
Default value:	1
Access:	No limitations

RM **Running Mode**

Consists of a set of flags that control the behavior and functionality of the IEC Master station. Each flag is one bit of this attribute. The bits are as follows:

Bit 0:	The hour transmission method of events to the master. When this bit is 0, the master gets the year, date and hour from the slave as an hourly clock synchronization (ASDU 103). When this bit is 1, the master adds the year, date and hour from its internal clock to the events. Minutes and seconds should be provided in time-tagged events by the slave.
Bit 3:	Handling of unrecognized commands. When this bit is 0, unrecognized command messages are ignored. When this bit is 1, unrecognized messages sent by the slave are forwarded to a bit stream process object with an address as defined by the CA attribute.
Bit 4:	Sending of the general interrogation command when the master receives ASDU 70. When this bit is 0, a general interrogation command is always sent when the end of initialization message (ASDU 70) is received from the IEC slave. When this bit is 1, a general interrogation is not sent automatically when receiving ASDU 70.
Bit 5:	Sending of the general interrogation command when the master gets the zero (OK) status. When this bit is 0, a general interrogation command is always sent when the object status of the IEC master station gets the value zero, for example, when it is set in use or after a suspension. When this bit is 1, a general interrogation is not sent automatically at zero status.
Bit 6:	Parallel commands. When this bit is 1, sending parallel commands is possible. The control is returned immediately back to SCIL and the return status of a command must be checked from the command termination process object. When this bit is 0, sending another command is not possible before the previous command has been completed or a confirmation timeout has occurred. This is the default way of operation.
Bit 7:	Private ASDU handling. When this bit is 1, the private range ASDUs 146, 148 and 160 are handled as unknown ASDUS. The contents of these ASDUs are sent to a bitstream process object, if the bit 3 of RM is set. When bit 7 is 0, the ASDUs are interpreted in the following way: ASDU 146 is similar to ASDU 30, single point information with full time tag, ASDU 148 is similar to ASDU 31, double point information with full time tag, ASDU 160 is similar to ASDU 37, integrated totals with full time tag. The default value for this bit is 0.

Data type:	Integer
Value:	0...65535, see above
Default value:	0
Access:	Read, conditional write

Example:

Enable general interrogation at zero status and disable other features, RM value = $0*8+1*16+0*32=16$.

DC**Diagnostic Counters**

The values of the diagnostic counters which the NET unit keeps for the station. The counters have the following meaning:

1. Suspension information (0 = OK, 1 = suspended)
2. Suspension counter
3. Transmitted data messages
4. Transmitted command messages
5. Transmitted confirmation messages
6. Received data messages
7. Received command messages
8. Received confirmation messages
9. Received unknown messages
10. Received too long messages
15. Application response timeouts

Data type:	Integer
Value:	1...65535
Index range:	1...15
Access:	No limitations

OS**Object Status**

The current status of the IEC station object. When value 1 is written to this attribute, the station object retransmits its current status code .

Data type:	Integer
Value:	when Read, 0 = OK_STATUS or non-zero value = communication is not normal at the moment
Access:	No limitations (write is possible only with value 1)

ST**SYS Waiting Time**

The maximum time that the slave station waits for a reply from the base system.

Data type:	Integer
Value:	0...60000
Unit:	Milliseconds
Default value:	5000
Access:	No limitations

RT**Activation Reply Timeout**

The maximum time the IEC master station waits for an activation confirmation message from the IEC slave.

Data type:	Integer
Value:	0...255
Unit:	Seconds
Default value:	10
Access:	No limitations

CT Activation Termination Timeout

The maximum time the IEC master station waits for an activation termination message from the IEC slave.

Data type:	Integer
Value:	0...255
Unit:	Seconds
Default value:	60
Access:	No limitations

SO Synchronization Offset

This attribute is used to define a station specific time compensation to the synchronization message initiated with SY attribute. If the used hardware delays the transmission of the message to the IEC slave stations, a value close to this delay should be assigned to this attribute. Some tuning work or a good knowledge of the used hardware is needed when this attribute is used.

Data type:	Integer
Value:	-32768..32767
Access:	No restrictions
Default:	0
Unit:	10'th of milliseconds

Example:

If the average transmission delay to the station STA1 is known to be 60 milliseconds, the station object should be configured with the following SCIL command:

```
#SET STA1:SSO=600
```

The attribute can be modified while the system is running. It is possible for the SCIL application to retune, if the feedback of the synchronization accuracy is available. Negative values cause the RTU time to be behind the actual time. Also, a value that is too big compared to the actual transmission delay, causes the RTU time to be ahead of the actual time.

CE Connection Event

Defines the information object address of the data item which is used to indicate the connection loss or recovery to the logical remote unit. The usage of this feature is needed when the actual IED is connected through a gateway or a converter, and the converter reports the connection state with a separate data message. If the information object address defined with CE (index=1) is non-zero and the data value in the message matches the given value (index=2) meaning "connected", the station object is reported to be RUNNING. All other values cause reporting of SUSPENDED and process objects are set to OS=2 state. If the information object address defined with the CE index 1 is 0, this feature is not used (default behavior). The mode defined with index 3 controls whether command sending is allowed to the suspended station or the automatic GI is sent when the station object is taken into use. Any ASDU type used to transfer analog or binary data can be used, but the possible timestamp in the message is not used.

Value: 0..16777215

Indexing

- 1: Information object address of the data (0=feature not used)
- 2: Value meaning 'connected'
- 3: Mode as bit pattern

Table continues on next page

CE	Connection Event
Bit 0 = 0 : Commands from application are not allowed when station is suspended because of the connection event	
Bit 0 = 1 : Commands from application are allowed when station is suspended because of the connection event	
Bit 1 = 0 : If automatic GI is enabled, it is sent when STA is taken into use even though the STA has been suspended because of the connection event	
Bit 1 = 1 : Although automatic GI is enabled, it is not sent when STA is taken into use and it has been suspended because of the connection event	
Bit 2 = 0 : Station is not set to running state if process data is received when the station has been suspended because of the connection event	
Bit 2 = 1 : Station is set to running state if process data is received when the station has been suspended because of the connection event	
4: Initial status of the station (until reported by the converter)	
0 = Running	
1 = Suspended	
Default values:	
1: 0 (=feature not used)	
2: 0 (=value = 0 means 'connected')	
3: 0	
4: 0 (= connection to the station is ok when connection to the converter is established)	
Access:	No limitations

Example 1:

```
#SET STA1:SCE1 = 20000 ; data item with IOA=20000, default value = 0
means 'connected'
```

Example 2:

```
#SET STA1:SCE1 = 5001 ;data item with IOA=5001,
#SET STA1:SCE2 =1 ;value = 1 means 'connected'
#SET STA1:SCE3 =6 ;automatic GI is not sent when STA:SIU->1, next data
sets to RUNNING
#SET STA1:SCE4 =1 ;status is SUSPENDED until reported by converter (or
data is received, index 3 bit 2 is set)
```

SU	Summer Time
States whether summer time is used or not.	
Data type:	Integer
Value:	0 or 1
Default value:	0 (summertime not used)
Access:	No limitations

UA	UAL Event Used
Attribute UA defines whether the UAL (User activity logging) events are generated by the station object. Generation of the UAL events are recommended if the secure authentication is used, see attribute ZA. With 'Standard logging', all user status changes are logged. With 'Special logging', also all successful authentications, key change negotiations, authorization failures and error situations are logged. The event codes with 'Special logging' are supported by SYS600 but not necessarily, for example, with SDM600 product. In case the secure authentication is used and more detailed information from the system behaviour is needed, the usage of value 3 = 'Special logging' is recommended.	
Data type:	Integer
Value:	0 = Disabled 1 = Standard logging 2 = Extended logging 3 = Special logging
Access:	No limitations

Table continues on next page

UA	UAL Event Used
Indexing:	No indexing
Default value:	1 (Enabled)
Access:	No limitations

UI UAL Event Identification

The UI attribute is used to define the name for the station object, and it is used to identify the source of the UAL (user activity logging) events. This string is added to the identification information of all UAL events from this station object. A unique value within the node is preferred. The node level module name (also in attribute UI) is added to form the full identification information for the user activity event. The default value of the string is based on the translated station number which is equal to B-attribute TN (Translated Object Number) in the base system. If a station identifier is not needed, an empty string should be assigned to this attribute.

Data type:	String
Value:	String containing a station level identifier with maximum length of 16 characters
Indexing:	No indexing
Default value:	".STA(TN=x)", where x = translated station number
Access:	No limitations

4.3.2.5 Authentication attributes

This chapter describes only the attribute interface related to secure authentication. See SYS600 System Configuration Manual, chapter 'Secure authentication using IEC/TS 62351-5' for detailed steps for configuring the system for secure authentication according to IEC/TS 62351-5.

ZA Authentication Used

The ZA attribute defines whether secure authentication is used by the station object or not.

Value:	0 = Disabled 1 = Enabled, pre-shared update keys 2 = Enabled, update key negotiation
Indexing:	No indexing
Default value:	0 (Disabled)
Access:	Read/write

ZG Aggressive Mode

The ZG attribute defines whether the aggressive mode of authentication is used by the station object. The aggressive mode uses less bandwidth and using it is recommended. The value of this attribute is meaningless if authentication is disabled (see attribute ZA). Modifying this attribute is possible only if it is enabled in the key storage using the setting 'Allow external modification of security attributes' (see attribute DZ, index 255).

Value:	0 = Aggressive mode disabled 1 = Aggressive mode enabled
Indexing:	No indexing
Default value:	1 (Enabled)
Access:	Read, write possible if the modification is enabled in the key storage

ZT Key Storage Id

The ZT attribute is used to define the keys and user set of the STA object in the key storage. In case there is a need to change the station number and/or its translated number TN and the corresponding user set and key configuration is already configured, keeping the original value in the ZT attribute associates the existing user set with the new station object. The ZT value must be unique within the STA objects accessing the same key storage. Error is returned when setting to a reserved value is attempted. Value = 0 means that the station object is not attached to any user set and the enabling of the authentication using attribute ZA is not possible.

Value: Identification of the STA object in the key storage, range 0..65535
 Default value: Same as the TN of the STA object
 Indexing: No Indexing
 Access: Read/write

ZU Default User

The ZU attribute is used to define the user in case the user is not or cannot be received from the MicroSCADA application. This user is used in requests generated with station the attribute CO, SY or GI.

Value: When read, the number of the active user is returned
 When written, number or the name of the wanted active user
 Default value: 1 (Default user)
 Indexing: No indexing
 Access: Read/write

Example:

Issue an output command using user 2

```
@P_USER = STA1:SZU
#SET STA1:SZU=2
;close select command, double command, address 1000
#SET STA1:SCO=(46,1000,6,128+1)
#SET STA1:SZU=%P_USER
```

ZR Authenticated Users

The ZR attribute is used to read the user numbers and names defined in the key storage for the station. See also the ZU attribute for defining the default user. This attribute is indexed using the user number and it is not supported by the System Configuration tool.

Value: String containing a user name with the maximum length of 32 characters.
 Indexing: 1..65535 (User number)
 If index = 0 is given when read, a vector of configured user numbers for the STA object is returned. If only one user is configured, the returned value is a scalar of type integer.
 If ZA is 0 or no users is configured, no object is returned.
 Access: Read

ZI Association Id

The ZI attribute is used to define the association identification value of the user. This attribute is used to fully identify the user. The attribute is indexed using the user number and is not supported by the System Configuration tool.

Value: The association id of the user defined by the index
 Default value: 0
 Indexing: 1..65535 (User number)

ZV	Authentication Vector
	The ZV attribute defines the constants used by the specific user of the station object. Modifying these constants is possible but it may require some testing to be usable with the remote IED and its configuration. The given index defines the user, value 0 has a special meaning. The values of the vector cannot be modified one-by-one but when written, only a vector containing all values is accepted. If the third parameter is defined, at least one user with role 'Operator' (Value=2) need to be configured. Setting of third parameter for ZV0 is possible only when setting 'Allow external modification of security attributes' flag is set for the keystore in use. This flag is defined in the 'System' level in the Authority Tool.
	Fourth parameter of ZV0 is a bitmask which defines compatibility flags due to different interpretations of IEC62351-5 standard. Bit 0 affects MAC calculation of critical messages and bit 1 affects the handling of CSQ (Challenge sequence number) field. When bits 0 and 1 are set, the functionality is similar to DNP3 SAv5. In case the remote system or its software is North American originated, setting of bits 0 and 1 may be necessary. When bit 2 of the fourth parameter of ZV0 is set, a pre-defined update key for a user is used, instead of generating a random new key in every update key negotiation. This feature is useful if the IED in question uses this key, for example, as a user specific password in its HMI or remote access.
	When index is >0, values of Key wrap algorithm of the session key in ZV(2), HMAC algorithm of the critical requests in ZV(4) and HMAC length of critical requests in ZV(5) are updated automatically as requested by the outstation.
	If the count of the received authentication error messages reaches ZV(6), session keys are renegotiated. ZV(11) is Maximum Session Key Status request count ZV(11), value is meaningless in master. The attribute is indexed using the user number and is not supported by the System Configuration tool. Index 0 contains special compatibility flags applied for all users.
Value:	<p>For index 0, vector of max 4 integers</p> <p>ZV(1) User name null termination (1 = User name transmitted without null termination (default)) (2 = User 'Common' with null termination, others without) (3 = User names transmitted with null termination)</p> <p>ZV(2) Authority certification key length with SHA-1 Update Key Change Method (16 = First 16 bytes used in MAC calculation) (32 = All 32 bytes used in MAC calculation (default))</p> <p>ZV(3) Mapping of user when command is originated from process object (0 = Command sender is logged user (default)) (1 = Command sender is user defined with ZU) (2 = Command sender is first user with role 'Operator')</p> <p>ZV(4) Compatibility bitmask (Bit 0 not set = European interpretation of IEC62351-5 MAC calculation (default)) (Bit 0 set = North American interpretation of IEC62351-5 MAC calculation, same as in DNP3) (Bit 1 not set = European interpretation of IEC62351-5 CSQ handling (default)) (Bit 1 set = North American interpretation of IEC62351-5 CSQ handling, same as in DNP3) (Bit 2 not set = Random update key is generated during negotiation (default)) (Bit 2 set = Update key is not generated during negotiation but taken as pre-defined from the keystore)</p> <p>For indices > 0, vector of 11 integers</p> <p>ZV(1) Session key length</p> <p>ZV(2) Key wrap algorithm of the session keys (2=AES-256)</p> <p>ZV(3) Challenge data length critical request</p> <p>ZV(4) HMAC algorithm of the critical requests (2 = SHA-256)</p> <p>ZV(5) HMAC length (8 = SHA-256 serial) (16 = SHA-256 network)</p> <p>ZV(6) Not used, see DZ(11) and ZH(11)</p> <p>ZV(7) Session key change count</p> <p>ZV(8) Key change interval in seconds</p> <p>ZV(9) Challenge data length session key status</p> <p>ZV(10) Challenge data length update key reply</p> <p>ZV(11) Maximum Session Key Status Count (meaningful in slave only)</p>

Table continues on next page

ZV	Authentication Vector
Default values:	Index 0: ZV(1) : 1 ZV(2) : 32 ZV(3) : 0 ZV(4) : 0 Indices >0: ZV(1) : 16 ZV(2) : 2 (AES-256) ZV(3) : 8 ZV(4) : 2 (SHA-256) ZV(5) : 8 (SHA-256 Serial) ZV(6) : 2 ZV(7) : 1000 ZV(8) : 900 ZV(9) : 8 ZV(10) : 32 ZV(11) : 5
Indexing	1.65535 (User number), 0 (compatibility flags)
Access:	Read-only

Example 1:

```

@USERS = STA1:SZR
#LOOP_WITH I=1..LENGTH(%USERS)
    ; Change each user to use SHA-256 and AES-256 in TCP mode, session
    key change interval 120 secs
@USER=%USERS(%I)

#SET STA1:SZV'USER'=(16,2,8,2,16,2,1000,120,8,32,5)

#LOOP_END

```

ZS	Authentication Status
The ZS attribute returns the current values of the authentication parameters and states of the specific user. This attribute is implemented only for debugging purposes and modifying these values directly is not possible.	
The attribute is indexed using the user number and is not supported by the System Configuration tool.	
Value:	Vector of 8 integers ZS(1) State of the authentication ZS(2) Not used at the moment ZS(3) Not used at the moment ZS(4) Challenge sequence number CSQ ZS(5) Key change sequence number KSQ ZS(6) Key status KST ZS(7) Last error in ZS(8) Last error out Values of Key Status in ZS(6) are : 1 = OK 2 = Not initialized 3 = Communication failure 4 = Authentication failure
Default value:	ZS(1) : 0 ZS(2) : 0 ZS(3) : 0 ZS(4) : 0 ZS(5) : 0 ZS(6) : 2 ZS(7) : 0 ZS(8) : 0

Table continues on next page

ZS	Authentication Status
Values of ZS(1)	0 : Initial State 10 : Wait for Key Status 11 : Wait for Key Change Confirmation 12 : Security Idle 13 : Wait for Reply 14 : Wait for User Change Response 15 : Wait for Update Key Reply 16 : Wait for Update Key Confirm
Indexing:	1..65535 (User number)
Access:	Read-only
ZO	User Roles
	The ZO attribute is used to return user numbers and their roles for the authentication. The user set for the station is created using the authority tool and stored to the key storage file.
Value:	String containing a user role with maximum length of 32 characters. Standard roles are: 0 = 'Viewer' (has 'Monitor Data' permission) 1 = 'Operator' (has 'Monitor Data' and 'Operate Controls' permissions) 2 = 'Engineer' (has 'Monitor Data', 'Change Config', 'File access' and 'Local login' permissions) 3 = 'Installer' (has 'Monitor Data', 'Change Config', 'Change code', 'File Access' and 'Local login' permissions) 4 = 'SecAdm' (has 'Change Security Config', 'Change code' and 'Local login' permissions) 5 = 'SecAud' (has 'Monitor Data' and 'Local login' permissions) 6 = 'RBacMnt' (has 'Monitor Data', 'Change Config' and 'Change Security Config' (roles only) permissions See attribute CR for more information.
Default value:	Empty string
Indexing:	1..65535 (User number)
Access:	Read-only
ZN	Outstation Name
	The ZN attribute is used to return the name of the outstation. This attribute is preconfigured using the Authority Tool and must match the value configured to master/slave.
Value:	String containing an outstation name with maximum length of 128 characters
Default value:	Empty string
Indexing:	No indexing
Access:	Read-only

ZD	Authentication Diagnostics
The ZD attribute provides user specific counters for diagnostic purposes. These counters can be used to verify the activity of each user and to give information in problem situations. The same counters for all users can be read from the attribute DZ.	
Value:	Vector of 17 integers (0..65535) ZD(1) Unexpected Messages ZD(2) Authorization Failures ZD(3) Authentication Failures ZD(4) Reply Timeouts ZD(5) Rekeys Due to Authentication Failure ZD(6) Total Messages Sent ZD(7) Total Messages Received ZD(8) Critical Messages Sent ZD(9) Critical Messages Received ZD(10) Discarded Messages ZD(11) Error Messages Sent ZD(12) Error Messages Received ZD(13) Successful Authentications ZD(14) Session Key Changes ZD(15) Failed Session Key Changes ZD(16) Update Key Changes ZD(17) Failed Update Key Changes
Default values:	ZD(1) ..ZD(17) : 0
Indexing:	1..65535 (User number)
Access:	Read/write (write only value 0)

ZP	Authentication Parameters
The ZP attribute defines authentication parameters which has an effect on all users configured for the station object. The given index specifies the parameter.	
ZP(1)	defines the amount of critical or non-critical ASDUs received which will trigger the session key negotiation for all users, function 'Session Key change Count' in 62351-5 standard. Session key negotiation is triggered also because of the timer defined with ZV(8) (for each user), whichever reason occurs first. The default value for ZP(1) is 1000. In case the ASDU reception rate is high, bigger value is worth to be considered but the value should still be in line with the slave configuration. If ZP(1) value is 0, function is not used, that is, the session keys are negotiated only using a timer based triggering. Slave devices usually have corresponding configuration parameter to invalidate session keys after certain amount of transmitted ASDUs. If this parameter is smaller than ZP(1) in master, it is possible that the keys are invalidated unexpectedly and next critical request such as a control command is rejected. Slave device does not explicitly report when it has invalidated the session keys.
The attribute is not supported by the System Configuration tool. No other indices but 1 is used the moment.	
Value:	ZP(1) Session Key change count
Default values:	ZP(1) : 1000 (range 0..2147483647, value=0 means disabled)
Indexing	1..1
Access:	Read/Write

DZ Diagnostics of Authentication

The DZ attribute provides diagnostic counters of authentication related functions. These counters can be used to verify the activity of communication concerning data which requires authentication. The same counters can be read as user specific from the attribute ZD.

Index 255 has a special meaning. If DZ(255) returns 1, the editing of the attributes CR and ZG is allowed by a special setting in the key storage.

Special sets of the same counter are provided using indices 101..117 and 201..217. Indices 101..117 return the same diagnostic counters calculated from the beginning of the PC_NET start-up, without resetting.

Value: Vector of 17 integers (0..2147483647)

DZ(1) Unexpected Messages

DZ(2) Authorization Failures

DZ(3) Authentication Failures

DZ(4) Reply Timeouts

DZ(5) Rekeys Due to Authentication Failure

DZ(6) Total Messages Sent

DZ(7) Total Messages Received

DZ(8) Critical Messages Sent

DZ(9) Critical Messages Received

DZ(10) Discarded Messages

DZ(11) Error Messages Sent

DZ(12) Error Messages Received

DZ(13) Successful Authentications

DZ(14) Session Key Changes

DZ(15) Failed Session Key Changes

DZ(16) Update Key Changes

DZ(17) Failed Update Key Changes

Default values: DZ(1) ..DZ(17) : 0

DZ(255) : 0 (attribute editing not allowed)

Indexing : 255 : editing of the attributes CR and ZG is allowed by a special setting in the key storage

1..17 : Diagnostic counters mentioned above, is reset

101..117 : Diagnostic counters mentioned above, is unreset

201..217 : Diagnostic counters mentioned above, next threshold value for special action

Access: Read/write (write only value 0 for indices 1..17)

CR	Critical Requests
	The CR attribute defines which requests are critical. The modification of this vector is possible but not recommended.
	The default values follow the IEC TS 60870-5-7. Modifying this attribute is possible only if it is enabled in the key storage using the setting 'Allow external modification of security attributes' (see attribute DZ, index 255). In IEC 60870-5-101, control commands are sent using ASDUs 45..51 (without time tag). The required permissions for a user are 'Operate Controls', see attribute ZO for more information. Index of the CR attribute defines the ASDU number in question.
	This attribute is not supported by the System Configuration Tool.
Value:	Vector of 255 integers with values 0 = not critical 1 = critical 128 = not applicable
Default values:	CR(1..44) : 0 (Indication ASDUs) CR(45..51) : 1 (Non-timestamped command ASDUs) CR(52..57) : 0 (ASDUs not defined) CR(65..69) : 0 (ASDUs not defined) CR(70) : 0 (End of initialization ASDU) CR(71..80) : 0 (ASDUs not defined) CR(81..95) : 128 (Authentication ASDUs) CR(96..99) : 0 (ASDUs not defined) CR(100..102) : 0 (Interrogation and read commands) CR(103) : 1 (Time synchronization command) CR(104) : 0 (Test command without time tag) CR(105) : 1 (Reset process command) CR(106) : 0 (Delay acquisition command) CR(108..109) : 0 (ASDUs not defined) CR(110..113) : 1 (Parameter setting and activation) CR(114..119) : 0 (ASDUs not defined) CR(120..126) : 1 (File Transfer) CR(127..255) : 0 (ASDUs not defined or private range)
Indexing :	Index 1..255 (defines the ASDU number)
Access:	Read, write if allowed by the key storage config

NU	New Keys
The NU attribute is used to renegotiate the update keys for specific user. When a user name is given, user status is set using 'ADD' operation and a new update key is negotiated. The role, role expiry interval and the used algorithm is read from the keystore. In case the slave device has lost its user information, or the session key negotiation fails systematically, it may be necessary to use the special strings described below. "*DELETE" operation is allowed only when setting 'Allow external modification of security attributes' flag is set for the keystore in use. This flag is defined in the 'System' level in the Authority tool. Special string "*ADD" makes an 'ADD' operation to all existing user users and their roles. If asymmetric mode is used and all necessary users are present in the slave device, the usage of "*UPDATE" may be considered since the recalculation of the private/public key pairs consumes a lot of CPU resources. Option "*UPDATE" renegotiates the update keys but does not change the user status.	
Value:	When written, the name of the user to be negotiated again
	Special strings: "*ADD" : Add all users "*DELETE" Delete all users "*UPDATE" Negotiate update keys of all existing users
Indexing:	No indexing
Access:	Write

Example 1:

Renegotiate the update key for user "Mark"

```
#SET STA1:SNU="Mark" ; operation = add, role is read from keystore
```

Example 2:

Delete and add all users. A new update key is negotiated when user is added.

```
#SET STA1:SNU="*DELETE" ; delete all users, takes few seconds per user
#PAUSE 30
#SET STA1:SNU="*ADD" ; add all users, takes few seconds per user
(symmetric mode)

#SET STA1:SNU="*UPDATE" ; renegotiate update key but do not change user
status
```

4.3.2.6 Autodialing attributes

SYS600 provides support for the Autocaller functionality of the IEC 60870-5-101 Master protocol. Autocaller is a modem with functions for automatic dial-up. The dial-up can be initiated by the IEC master or the IEC slave.

The Autocaller must use the AT (Hayes) command set. Note that when using odd or even parity, the modem must support 11-bit word length. In some cases, this feature must be enabled by using the AT commands. Refer to the documentation of the modem in use for further details.

The following Autocaller attributes are valid for the IEC 60870-5-101 Master lines:

AC	Autocaller Enabled
The AC attribute states whether an Autocaller is connected to the line (value 1) or not (value 0).	
Data type:	Integer
Value:	0 or 1
Default value:	0
Access:	No limitations

AS Autocaller State

This attribute indicates the state of the Autocaller.

Data type:

Integer

Value:

0...4

0 = IDLE, ready to make a call

1 = CONNECTED, transmission is activated

2 = BUSY, Autocaller is dialing

3 = INITIAL, Autocaller is uninitialized

4 = CONFIGURE, the IU attribute of the line is set to 0

Default value:

0

Access:

Read-only

CL Connection Time Limited

This attribute determines whether a time limit has been set to the connection (value 1) or not (value 0). The maximum duration of the connection is determined by the CT attribute.

Data type:

Integer

Value:

0 or 1

Default value:

1

Suggested value:

A time limit is necessary on certain radio telephone lines. Limiting the connection time may also be good practice in other cases, if there is a risk that the connection is not otherwise broken.

Access:

No limitations

CT Connection Time

The maximum time that a connection is allowed to last (in seconds). This attribute is significant only if time limiting is activated (CL = 1).

Data type:

Integer

Value:

0...600

Unit:

Seconds

Default value:

120

Access:

No limitations

CN Connection

The CN attribute is used for dialing devices from the NET and for breaking telephone connections.

A call to a station or workplace is initiated by writing the phone number to the CN attribute. The NET unit then commands the autodialing modem to dial the number. The success of the dialing is reported as a system message. Writing an empty string to CN breaks the connection. When dialing a station, the link address of the station should be given at the end of the phone number string, preceded by the letter S. This option is normally used to increase the communication performance on multidrop lines. The station number is only significant in the unbalanced mode (several stations on one line).

Data type:

Text

Value:

Text string of maximum 25 characters

Default value:

Empty text string

Access:

No limitations

Example:

#SET NET1:SCN5 = "123456789S11"

CS **Connected Station**

The link address of the station a NET unit is communicating with.

Data type: Integer
Value: 0...65535
0 = Autocaller not defined or no communication
Default value: 0
Access: Read-only

DD **Radio Disconnection Delay**

Delay between the last data transfer and the line disconnection.

Data type: Integer
Value: 0...32767
Unit: Seconds
Default value: 0
Access: No limitations

MC **Modem Command**

Using this attribute, a modem can be controlled directly from SCIL with the AT/Hayes commands. When an AT command is written to the MC attribute, it is transmitted to the modem on the line. The response from the modem is read using the same attribute.

Data type: Text
Value: Text string, an AT/Hayes command
Default value: 0
Access: No limitations

Example:

#SET NET1:SMC3 = ("AS0?") '

PU **Pulse Dialing**

This attribute determines the dialing principle used.

Data type: Integer
Value: 0 = tone dialing
1 = pulse dialing
Default value: 0
Access: No limitations

RC **Remote Calls Enabled**

The RC attribute states whether remote calls are enabled on a line, meaning that the NET unit can be called from the stations connected to the line in question. This attribute applies to lines with autocaller (AC = 1).

Data type: Integer
Value: 0 = remote calls not enabled
1 = remote calls enabled
Default value: 0
Access: No limitations

RW	Radio Connection Wait Time
Normally, the DCD (Data Carrier Detect) signal is used to indicate an active connection. However, there are cases where this is not possible, for example, on radiotelephone lines using half-duplex links. The RW attribute defines the waiting time in seconds in such a situation from the finishing of the dialing until the transmission is started.	
Data type:	Integer
Value:	0...32767
Unit:	Seconds
Default value:	0
Access:	No limitations

SR	Autocaller AT S Register
The S registers used by the Autocallers follow the AT (Hayes) de facto standard.	
All the Autocallers that use the AT command set have a number of S registers. The number of registers used and the meaning of the individual registers varies slightly from one Autocaller model to another. The contents of the S registers are therefore not described in this document. Refer to the modem manuals.	
Using the SR attribute, the S register number 2, 6, 7, 8, 9, 10, 11 and 12 are accessed. By using the MC attribute (see above), other S registers can also be accessed. The S registers 11 and 12 cannot be set.	
<p>Data type: Integer</p> <p>Value: See the modem manuals</p> <p>Indexing: Seconds</p> <p>Access: 100 * line number + register number</p>	
Example: The S register number 6 of line 2 in NET1 is set = 4: #SET NET1:SSR206 = 4	

4.3.2.7 File transfer attributes

The IEC file transfer feature transmits all types of files between the relay and the SYS600 computer. Only one transmission per one STA object can be active at any one time. If another file transfer request is made while the first file transfer is in progress, the status code is returned and the second file transfer progress does not start.

FI	File Information
The FI attribute initializes the file transfer system with the required base information.	
Value:	Vector of 5 integers 1 = internally used 2 = SEGMENTCOUNT 3 = internally used 4 = QUEUE (unbalanced slave) 5 = PRIORITY (slave) 6 = Section request delay IN (0.1 seconds) 7 = Section filling delay OUT (0.1 seconds)
Indexing:	1..7
Access:	Read/Write
Default value:	1 = 0 2 = 8 3 = 0 4 = 2 5 = 3 (1 is lowest value) 6 = 0 (0 milliseconds) 7 = 10 (1000 milliseconds)

Example:

The following example defines five segments in each file section.

```
#SET STA'sta':SFI(2)=5
```

FD	File Directory
-----------	-----------------------

The FD attribute defines to which directory the received files are stored. PC_NET interrupts file receiving if the directory does not exist or if it is write-protected.

Value: The string contains a valid directory name with the maximum length of 50 characters.
Access: Read/Write
Default: C:\TEMP

Example:

The following example defines C:\SC\DATA to the active directory.

```
#SET STA'sta':SFD="C:\SC\DATA"
```

FF	File Transmission Status
-----------	---------------------------------

The FF attribute indicates the status of file transmission.

Value: 0 = Free to start or the previous transmission is completed
1 = Transmit in progress
2 = Timeout in PC_NET
3 = Not used
4 = Invalid directory or file name
5 = File is not available in the remote end
6 = Service is not available, internal error
7 = Transfer aborted
8 = File reading or writing failed

Access: Read, Write is allowed when the value is not 6.
Default value: 0

If transmission is in progress when the FF attribute is written, the transmission is aborted, and the file is closed. It does not have any other effects, except the value is set to zero (0).

FT	File Timeout
-----------	---------------------

The FT attribute defines the maximum delay for incoming ack section or ack file request. If the time expires, PC_NET interrupts the file transmission.

Value: 0.255
Unit: Seconds
Access: Read/Write
Default value: 30 seconds

FB **File Bytes**

The FB attribute returns both counts of received or transmitted bytes from the beginning of the file transfer session (index 1) and the file size (index 2). At the beginning of the file reception, the value of index 1 is automatically set to zero (0). The value of index 2 is updated when the FB attribute is written, and the correct file index is given.

Value: 0..4294967295

Indexing: When read
 1 = Number of bytes (DWORD), out
 2 = File size in bytes (DWORD), out
 3 = File name in relay (DWORD), out
 4 = Number of bytes (DWORD), in
 5 = File size in bytes (DWORD), in
 6 = File name in relay (DWORD), in

Access: Read

Default: 0

FN **File Name**

The FN attribute collects the information address of a certain file in the file system. When the remote end requests the directory, the information address is reported as a real file, not as a subdirectory (FOR = 0).

Value: When written
 IOA
 NAMEOFFILE
 FILETYPE
 STATUSOFFILE
 NAMEINFILESYSTEM
 SIZEINFILESYSTEM
 DATEINFILESYSTEM
 MSECSSINFILESYSTEM
 When read
 NAMEINFILESYSTEM
 When read

Indexing: When read, (0..299)
 Queue out: index = 100+FILENUM
 Queue in: index = 200+FILENUM

If the FILENUM offset is bigger than the number of files in the list, status code 13887 ICCC_NO_SUCH_FILE is returned.

For more information about status codes, see [Section 5.5](#).

Access: Read/write

Where when writing

IOA

Information object address.

Type: DWORD

NAMEOFFILE

Defines the name of file field in the file transfer messages.

Type: WORD

FILETYPE

Type: WORD

Values: 1 = Transparent file

Other types are not supported at the moment.

STATUSOFFILE

Type: BYTE

Values: 0 = File waits for transfer

NAMEINFILESYSTEM

String contains a valid file name in the disk with maximum length of 100 characters. If the string is empty, the file is deleted from the list.

SIZEINFILESYSTEM (optional)

The file size.

Type: DWORD

DATEINFILESYSTEM (optional)

Creates file's timestamp (seconds from 1.1.78).

Type: TIME

MSECSINFILESYSTEM (optional)

Creates file's timestamp (milliseconds).

Type: WORD

Example of writing:

```
#SET STA'sta':SFN=(1000, 1,1,0, "error.log", 5000, clock)
```

Example of reading:

The second file is read from the outgoing file list and returns the error.log file.

```
STA'sta':SFN(102)
```

FV	File Values
The FV attribute checks the status of the defined file. During the reading process, the attribute's index defines where the file value is taken, either from the outgoing files list or from the incoming files list.	
Value:	Vector IOA NAMEOFFILE FILETYPE CTRLANDSTATUSOFFILE SIZEINFILESYSTEM DATEINFILESYSTEM MSECSINFILESYSTEM
Indexing:	When read, word (0..65535) Queue out: index = 100+FILENUM Queue in: index = 200+FILENUM If the FILENUM offset is bigger than the number of files in the list, the returned data type is "NONE"

Table continues on next page

FV	File Values
Access:	<p>Read For more information about status codes, see Section 5.5.</p> <p>IOA Information object address</p> <p>NAMEOFFILE Defines the name of file field in the file transfer messages.</p> <p>Type: WORD If value = 0 is given for both IOA and NAMEOFFILE, a unique value is assigned.</p> <p>FILETYPE Type: WORD Values: 1 = Transparent file Other types are not supported at the moment.</p> <p>CTRLANDSTATUSOFFILE Type: WORD. The upper byte is a control byte. Bit 0 : Internally used Bit 1=0: Not yet transmitted Bit 1=1: All sections transmitted Bit 2=0: Transmission not acknowledged by remote Bit 2=1: Transmission acknowledged by remote The lower byte is equal to status of file (SOF) Bit 7=0: File waits for transfer (FA) Bit 7=1 Transfer of this file is active (FA)</p> <p>SIZEINFILESYSTEM Type: DWORD The file size.</p> <p>DATEINFILESYSTEM Type: TIME Creates file's timestamp.</p>

Example:

Reading the second file from the outgoing file list.

```
STA'sta':SFV(102)
3 ;Information object address
3 ;Name of file
1 ;Transparent file
1536 ;CTRL=(transmitted, acknowledged), SOF=0
10006 ;Filesize=10006 bytes
847636153 ;Timestamp
```

Example 2:

Initiating of the reception of the first file from remote device.

```
@STA=1
#IF STA'STA':SFF<>1 #THEN #BLOCK
    #SET STA'STA':SCO=(122,0,5,0,0,0,1) ; request directory
    #PAUSE 3
    @FV=STA'STA':SFV(201)
    #IF DATA_TYPE(%FV) == "VECTOR" #THEN #BLOCK
        ; at least one file available
        @NOF_L = %FV(2) mod 256
        @NOF_H = %FV(2) div 256
        #SET STA'STA':SCO=(122, %FV(1), 13, %NOF_L, %NOF_H,
        0,1) ;request file
        #BLOCK_END
    #BLOCK_END
#BLOCK_END
```

Example 3:

Initiating of the reception without directory request. The IOA and NAMEOFFILE of the file in the remote device need to be known in advance.

```
@STA=1
#IF STA'STA':SFF<>1 #THEN #BLOCK
    ; no on-going file transfer
    @NOF_L = %NAMEOFFILE mod 256
    @NOF_H = %NAMEOFFILE div 256
    #SET STA'STA':SCO=(122, %IOA, 13, %NOF_L, %NOF_H,
    0,1) ;request file
#BLOCK_END
```

For more information about status codes, see [Section 5.5](#).

For more examples on communication system configuration, see [Appendix A](#).

4.4 After configuration

For each input signal received from the process device the process database should contain a process object whose value changes after process data is received. For each command there should be an output process object. The bit stream process object that receives unrecognized IEC messages from the slave should also be created.

Besides the configuration of the base system and the communication system, the IEC slave also needs to be configured.

4.5 How to test the configuration

When the slave and master stations have been physically tested and the configuration has been completed, the connection and configuration can be tested based on the following methods:

- With the IEC 60870-5-101 protocols Request to Send (RTS) is set to the active state before transmission and the transmission starts from the raising edge of the Clear to Send (CTS) signal. If the raising edge of Clear to Send (CTS) does not occur and the CTS signal stays inactive within specified time, a line error is reported. If Clear to Send (CTS) is active all the time, the transmission starts after DE+TW milliseconds from the raising edge of the RTS signal. DE and TW are line attributes of unit milliseconds.
- In order to receive messages, the Carrier Detect (DCD) signal should be in the active state or the line attribute CB should be set to 0 to ignore the state of the DCD signal.
- The Data Terminal Ready (DTR) signal is kept in signaled state when the line is used. This signal can be used to control the fallback switches in a HSB configuration
- Diagnostic counters. When the communication between the slave and master is running properly and data is moving on the line, the diagnostic counters indicating the number of received and transmitted data messages should be incrementing.
- Object status. The OS attribute of the IEC slave station should be 0.
- By connecting a protocol analyzer supporting the IEC 60870-5-101 standard to the line.

For MicroSCADA version 9.3 and newer, the protocol analyzer included in PC-NET can be used. See the NET line attributes AO and AU in the SYS600 System Objects manual.

One possible way to test the configuration is to use SYS600 as the IEC master/slave. In this case the base system and communication system configuration for the IEC 60870-5-101 Master line and station(s) have to be made. One IEC slave can be in the same computer.

4.6 Serial cable wiring diagram

When connecting a remote partner to a IEC line using a direct serial cable, the wiring is illustrated in [Figure 10](#). If the used port is a virtual COM port or easier cabling is needed, the line attribute CM provides the possibility to simulate DCD and CTS changes. The line attribute CM is available in SYS600 version 9.3 FP2 and newer.

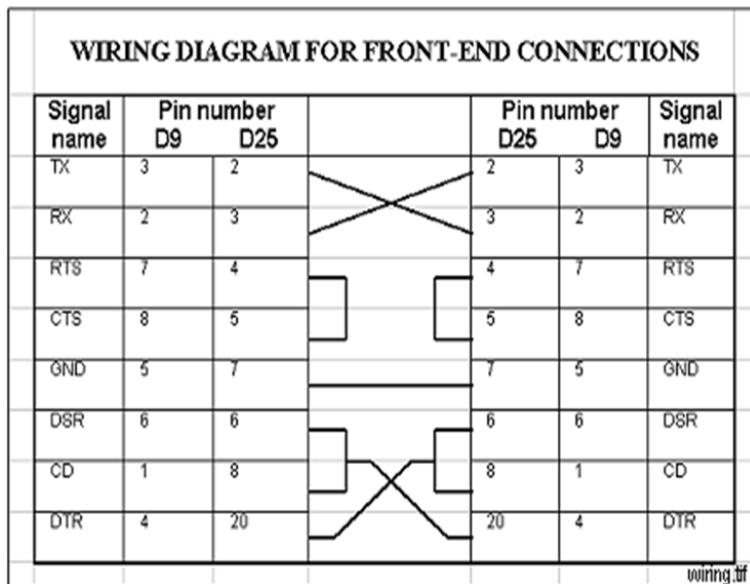


Figure 10: Serial cable wiring diagram

4.7 Communication adjustment guidelines

MicroSCADA has multiple adjustable attributes that affect the communication. The default values might not be suitable for each system and can sometimes cause communication problems. Here are listed the steps of what should be done when the communication is not working correctly.

4.7.1 Basic checks

In case of a communication does not start properly, following checks are worth to do before any further investigation:

- Check that the serial port defined with line attribute SD matches with the computer's serial port. Check also that no error is reported to the notify window when the system or PC_NET is started.
- Check that the stations addresses match in master and slave.
- Check that the baud rates and other Data Transmission Attributes (in MicroSCADA System Configuration Tool) match in master and slave.
- Check that the master and slave stations Polling Addresses (PA) match
- Check that the stations Polling Address Length (PL), Length of Cause of Transmission Information (CL), Station Address Length (SL) and Information Address Length (IL) attribute values are correct

4.7.2 Message sending

If the remote end does not receive the messages sent from the line in question, following hints may help:

- Check if CTS errors exist. The DE attribute sets how long time the CTS signal is waited after the RTS signal has been raised. If the rising edge of the CTS does not occur at all (line disconnected) or if the DE attribute value is too small, timeout occurs, and the line enters to a CTS error state. The status point of the line is updated correspondingly
- Check the FIFO buffers of the used serial port. If RTS signal is used to control the data carrier, communication may function better if the FIFO buffers are disabled (or set to 1).
- Check the RTS Keepup Delay (RY) attribute value. If the RTS signal is used to control the data carrier and it is reset too early, the end of the message might be left out when the message is sent. With RY attribute the closing of the RTS signal can be delayed. On the other hand, if the RY delay is too long, the remote device may start transmission when the data carrier is not available. This causes an error.
- Check the COM Port Mode (CM) attribute. With the bit 3 setting the length of the message is used to calculate the RTS keep up time. See attribute documentation for more information.

4.7.3 Message reception

If the remote end send message but those are not received correctly by the line in question, following hints may help:

- Carrier Block (CB) attribute might be blocking the incoming messages. If the CB attribute is 0, carrier blocking is not used and messages are received regardless of the DCD state. If the CB attribute is 1, carrier blocking is used and the DCD must be signaled while characters belonging to the message is received.
- Check the TW attribute value. The TW attribute delays the sending of the message after the RTS and CTS signals are raised. If the beginning of a message is missing when it is received (recorded) in the other end, increasing the TW attribute value might help.
- Check the RI attribute values. The RI attribute delays the enabling of the message reception. If RI is too big, the first bytes of the message to be received are not accepted and the whole message is lost. If RI is short and the modem hardware generates corrupted characters when the direction of the data carriers changes, slightly bigger RI may cause less timeouts. This advice applies only in the unbalanced mode.
- Check that the Header Timeout (HT) and Response Timeout (TI) attributes lengths are long enough for the communication. The TI time could be too short in cases when the response is long and the baud rate small.
- If the messages are sent and received correctly but are not processed, check CRC or other errors from the Diagnostic Counters in System Configuration Tools online-mode.
- The usage of the protocol analyzer and the bit 1 or line attribute AU (Analyzer usage) will help in the tuning of the attributes DE, HT, TI, RI and RY. If bit 2 of the attribute AU is set, internal information related to completion of the write operation to the serial driver is display in the analyzer output.

4.7.4 Data updating

If the remote end sends messages and it seems like those are received correctly by the line in question, but the process objects are not updating, following hints may help:

- Check that the attached process objects addresses are correct.
- Check that the STA object is allocated to the MicroSCADA application in which the process objects are located. Related STA object attributes are AL (Allocation) and AS (Allocating application).
- If the base system attribute TN (Translated Number) or ND (Node number) for the STA object has been modified by the SCIL application, check that those refer to correct STA object in correct PC_NET node.

Section 5 Technical description

5.1 IEC 60870-5-101 Protocol

The IEC Technical Committee 57 (Working Group 03) has developed a protocol standard for telecontrol, teleprotection and associated telecommunications for electric power systems. The result of this work is IEC 60870-5. The first five documents listed in [Section 2.4](#) specify the base of IEC 60870-5.

The IEC Technical Committee 57 has also generated a companion standard IEC 60870-5-101 for telecontrol equipment and systems with coded bit serial data transmission for monitoring and controlling geographically widespread processes. This standard utilizes the series of documents for IEC 60870-5.

IEC is designed according to the Enhanced Protocol Architecture (EPA) and it specifies the following Open Systems Interconnection (OSI) layers:

- Physical layer
- Data link layer
- Application layer

The physical layer can be any bit-serial physical layer, for example RS-232 C, RS-485, a fiber transceiver In SYS600, the communication takes place using the serial port(s) of the base system computer. The interface used is RS-232 C.

5.2 Level of implementation

In IEC 60870-5-101 the application level messages are called Application Service Data Units (ASDUs). Each ASDU consists of one or several information objects that contain the actual user data. SYS600 supports the ASDUs presented in [Section 5.6](#) Private ASDUs, that is, the ones not included in the IEC 60870-5-101 companion standard, are indicated with an asterisk (*).

For more information, see [Section 5.6](#).

5.3 Communication

This section gives a more detailed description of the implementation of the IEC 60870-5-101 Master protocol in SYS600, describing also the attributes that can be used for device communication. Examples of how to exchange data between the master and the slave are also given in this section along with information of the IEC 60870-5-101 Master status codes.

5.3.1 Communication modes

The IEC 60870-5-101 protocol has two modes or link layer transmission procedures: unbalanced mode and balanced mode. In the unbalanced mode a master station controls the data traffic by polling the outstations sequentially. In this case the master is the primary station that initiates all the message transfer. The outstations are secondary stations (slaves) that can transmit only when they are polled.

In the balanced mode each station, master and slave, can initiate message transfers. The communication mode of a NET line can be selected by using the PO attribute when the line is created, and must be matched with the communication mode of the master station.



The serial bus topology (multi-drop) can be used only in the unbalanced mode.

5.3.2 Protocol converter

Each IEC 60870-5-101 Master station configured on a line of a NET unit acts as a protocol converter between the IEC 60870-5-101 protocol and a base system. An internal protocol of SYS600 is used in communication between the SYS600 nodes, for example, between a base system and a NET unit.

In IEC 60870-5-101, the data sent from the slave to the master can be divided into two classes: class 1 or class 2. The data from the classes is sent to the master either by polling (unbalanced mode) or spontaneously (balanced mode).

5.3.3 Addressing

In IEC 60870-5-101, there are three kinds of addresses:

- **Link address:** The address of the IEC link. This address is defined by the PA (Polling Address) attribute of the IEC station. In most cases it is the same as the station address.
- **Station address:** A common address of an ASDU. There can be several common addresses of an ASDU with the same link address. This address is defined by the SA (Station Address) attribute of the IEC station.
- **Signal address:** An information object address. This address is unique for each signal with the same common address of an ASDU. The Information object address can be given in two ways:
 - As an unstructured address, which is basically just an integer within the range of the information object address.
 - As a structured address which is given byte-wise so that each byte usually represents a level in a hierarchical structure. For example, upper byte = unit number and lower byte = signal address.

SYS600 supports only unstructured addresses. However, this does not prevent communication with the IEC 60870 slaves using structured addresses, since the two types of addresses just demonstrate two different ways of presenting the same address. For example, a two-byte address can be represented as follows:

$$\text{unstructured} = 256 * \text{upper byte} + \text{lower byte}$$

The station attributes SL, CL and IL define the lengths of station address, cause of transmission and information object address, and these values must match the configuration in the slave devices.

See attribute descriptions for more information.

In SYS600 both the input and output process objects share the same address range, which means that there cannot be two process objects with overlapping addresses. If the same address is needed for an input and output object, it can be achieved by using offsets that are outside the information address range limited by the IL attribute. The offset used must be large enough to set only the bits of the information object address that are more significant than the bits within the IL range. The recommended offset is 2000000 (hex) = 33554432 (decimal).

Example:

STAn:SIL = 3, 24 bit addresses

Overlapping information object address 2000 (decimal)

Offset = 33554432 (decimal) = 2000000 (hex)

Address for indication = 2000 (decimal)

Address for command = 2000 + 33554432 = 33556432 (decimal)

5.3.4 Device communication attributes

GI**General Interrogation**

Setting this attribute sends a general/group interrogation command (ASDU 100) to the IEC slave station. In IEC 60870-5-101, analog and binary data can be divided into 16 groups which can be interrogated separately. General interrogation covers all groups. By setting 1 to the GI attribute a general interrogation message is generated. By using the vector value, an interrogation command can be deactivated, that is, cancelled, or a group interrogation command generated.

Data type: Integer or vector

Value: Vector (ENA,[QOI]) or integer 1

Access: No limitations

Description of the vector parameters:

ENA: Activate (value 1) or deactivate (value 0) interrogation

QOI: Qualifier of interrogation

Value 20: General interrogation

Values 21...36: Interrogation for groups 1...16

SY**Synchronize**

The SY attribute is used to make an accurate time synchronization of the IEC 60870 stations. No time arguments are needed since the time sent in the synchronization message is taken from the internal clock of SYS600. Stations can be synchronized one by one or by using a broadcast synchronization message, which synchronizes all the stations configured on a IEC 60870-5-101 line.

The usage of time synchronization with secure authentication according to IEC/TS 62351-5 is not recommended because of significantly lower accuracy.

Data type: Vector

Value: Vector (COT, [BRO,[ADDR]])

Access: Write only

Description of the vector parameters:

COT: Cause of transmission of the synchronization messages. Valid values: 6 = activate, 8 = deactivate.

BRO: Broadcast determines whether the synchronization message is a broadcast message (value 1) or not (value 0). If omitted, value 0 is assumed.

ADDR: Information object address of the synchronization message. In most cases value 0 is correct. If omitted, value 0 is assumed.

CO Command Out

The CO attribute can be used for generating command messages, that is, requests, to IEC 60870 slave stations. All kinds of commands can be generated data commands, application commands and system commands. Parameters in the command direction are also sent by using the CO attribute. The data content of the command is given as transparent data octet by octet. Note that the user is responsible for the validity of the data content. For more information, refer to the IEC 60870-5-101 standards listed in [Section 2.1](#).

Data type:	Vector
Value:	Vector (TYPE, ADDR,COT,DATA)
Value range:	0...255, when IL attribute = 1 0...65535, when IL attribute = 2 0...16777215, when IL attribute = 3
Access:	Write-only

Description of the vector parameters:

TYPE:	Type identification of the ASDU, integer. This parameter can be a type identification given in the IEC 60870-5-101 companion standard or a private one. All ASDU types listed in the interoperability list are valid values for TYPE.
ADDR:	Information object address of the command, integer.
COT:	Cause of transmission of the message, integer. This parameter describes the reason why a message is sent. The causes of transmission shown in Table 1 are commonly used when using the CO attribute.

Table 1: The causes of transmission valid for the CO attribute

COT	Description
3	Spontaneous
5	Request
6	Activation
8	Deactivation

DATA: The set of information objects of the command as integers. Each integer corresponds to one octet in the IEC message.

Some examples of the use of the CO attribute are presented below. See also the examples of the data, application and system commands later in this document.

```
; general interrogation
#SET STA'STA_NR':SCO = (100,0,6,20)
;close select command, double command, address 1000
#SET STA'STA_NR':SCO = (46,1000,6,128+1)
;test command
#SET STA'STA_NR':SCO = (104,0,6,170,85)
```

TD Transparent Data

The TD attribute is used for sending transparent data (for example SPA messages) to the IEC slave.

Data type:	Vector Value Vector (TYPE, ADDR, COT, TDT)
Value range:	0...255, for other parameters but ADDR

Table continues on next page

TD	Transparent Data
Access:	Write-only
Description of the vector parameters:	
TYPE:	Type identification of the ASDU, integer. The type identifications shown in Table 2 are allowed when transparent data is sent to the IEC master/slave by using the TD attribute.

Table 2: The type identifications allowed when using the TD attribute

Type id	ASDU	Description
131	C_SR_NA_1	Parameter, byte string
133	C_SB_NA_1	101 Encapsulated SPA bus message

ADDR:	Information object address, integer
Value range:	0...255, when IL attribute = 1 0...65535, when IL attribute = 2 0...16777215, when IL attribute = 3
COT:	Cause of transmission of the message, integer.
TDT:	Transparent data (for example SPA message) as a text string

For more detailed information, see the examples and the interoperability list later in this document.

5.3.5 Data in monitoring direction

Data in the monitoring direction, that is, from the slave to the master, is received by IEC type process objects. Data in the monitoring direction includes, for example double indications and measured values. The relation between the IEC 60870-5-101 ASDUs and SYS600 process object types is presented in tables below.

Table 3: Relations between the SYS600 process object types and IEC 60870-5-101 ASDUs

Type id	Description	Process Object Type
1, 2, 30	Single point information	Binary input
3, 4, 31	Double point information	Double binary input
5, 6, 32	Step position information	Analog input
9...14, 34, 35, 36	Measured value	Analog inputs
15, 16, 37	Integrated totals	Pulse counter
7 ,8, 33	32-bit bitstring	Bit stream

Both static data (non-time-tagged data) and events (time-tagged data) with the same information object address are received by the same process object. When SYS600 receives an IEC 60870-5-101 message, the process object attributes in [Table 4](#) are updated based on the information in the IEC 60870-5-101 message:

Table 4: Process object attributes updated from an IEC 60870-5-101 message

Attribute	Values	Description
TY	0...44	Type identification of the ASDU.
OV	-	Value of the information object. Data type depends on the ASDU.
OS	0...10	Object status, calculated from the qualifier descriptor bits of the information object.

Table continues on next page

Attribute	Values	Description
QL	0...255	Qualifier byte of the information object.
IV (OS=1)	0, 1	Invalid bit of the qualifier.
NT(OS=2)	0, 1	Not topical bit of the qualifier.
BL	0, 1	Blocked bit of the qualifier.
SB	0, 1	Substituted bit of the qualifier.
OR	0, 1	Overflow bit of the qualifier. Only with analog input process objects.
OF	0, 1	Counter overflow bit of the qualifier. Only with pulse counter process objects.
CT	0...63	Cause of transmission of the message.
OG	0...255	Originator address of the message.
RT	Time	Time tag of the information object (time-tagged data), or system time (non-time-tagged data).
RM	0...999	Milliseconds of the information object (time-tagged data), or system time (non-time-tagged data).

For each information object in the received message, there is a qualifier octet that consists of a set of qualifier descriptor bits each of which indicates a property of the information object. Each qualifier descriptor bit updates a process object attribute as shown in [Table 5](#). The whole qualifier octet is set to the QL attribute of the process object. The qualifier descriptor bits and their descriptions along with related process object types are given in the table below.

Table 5: Qualifier descriptor bits

Bit	Name	Description	Process Object Type
IV	Invalid	The value is valid, if it was acquired correctly. After the acquisition function recognizes abnormal conditions of the information source (missing or non-operating updating devices) the value is marked invalid. The value of the information object is not defined under this condition. The mark Invalid is used to indicate to the master that the value may be incorrect and cannot be used.	All
NT	Not topical	A value is topical if the most recent update was successful. It is not topical, if it was not successfully updated during a specified time interval or it is unavailable.	All
SB	Substituted	The value of the information object is provided by input of an operator (dispatcher) or by an automatic source.	All
BL	Blocked	The value of the information object is blocked for transmission; the value remains in the state that was acquired before it was blocked. Blocking and deblocking may be initiated, for example, by a local lock or a local automatic cause.	All
CA	Counter adjusted	Counter was / was not adjusted since the last reading.	PC
OV	Overflow	The value of the information object is beyond a predefined range of value (mainly applicable to analogue values).	AI
CY	Carry	Counter overflow occurred / did not occur in the corresponding integration period	PC

A timestamp included in the timestamped data messages contains a status bit where the slave can mark the timestamp as invalid. Usually this means that the slave should be synchronized by the master. The value of the OS (Object Status) attribute of an input process object is calculated from the qualifier descriptor bits as in the following:

```
if IEC_IV then (*invalid bit set*)
OS := 1
elsif IEC_NT then (*not topical bit set*)
OS := 2
elsif IEC_Timetag_IV then (*time invalid bit set*)
OS := 3
end_if
```

The following sections give a brief description of each SYS600 input process object type and the corresponding IEC ASDUs.

5.3.5.1 Binary inputs and double binary inputs

Single indications (ASDUs 1, 2 and 30) are received by binary input, and double indications (ASDUs 3, 4, 31) by double binary indication process objects.

5.3.5.2 Analog inputs and digital inputs

Measured values (ASDUs 9...14, 34, 35 and 36) and step position information (ASDUs 6 and 32) can be received by analog input process objects.

Table 6: Value ranges of measured value and step position ASDUs

Type id	Value type	Value range	Value in SYS600
6, 32	Step position	-64...63	Integer -128...127
9, 10, 34	Normalized	-1...(1-2^-15)	Integer -32768...32767
11, 12, 35	Scaled	-32768...32767	Integer -32768...32767
13, 14, 36	Short floating point	32-bit float	Real

If the value of the measured value sent from the IEC 60870 slave is larger than the value range of the ASDU, the value is limited to the range and the overflow bit of the quality descriptor is set. This bit is sent to the OR attribute of the process object.

Step position information can also be received by digital input process objects. Note that the value range of the step position information is larger in SCIL, since it also contains the transient state bit, which is the second most significant bit of the octet.

5.3.5.3 Pulse counters

Integrated totals (ASDUs 15, 16 and 37) can be received by pulse counter process objects. In IEC 60870-5-101, the pulse counters are 32-bit counters, which have a 5-bit sequence number as the five least significant bits of their qualifier octet. The qualifier octet is set to the QL attribute of the process object.

5.3.5.4 Bit streams

32-bit strings (ASDUs 7, 8 and 33) and transparent data (ASDUs 130 and 131) can be received by bit stream process objects.

```
;convert an unrecognized IEC message to a vector of bytes and find ASDU id
@IEC_MSG = UNPACK_STR('LN':POV'IX',8)
@ASDU_ID = %IEC_MSG(3)
```

```
; convert a transparent SPA reply message to text
@SPA_MSG = TYPE_CAST('LN':POV' IX', "TEXT")
```

A special case of the IEC bit stream objects is the one receiving unrecognized messages from the IEC slave. The address of this process object is the same as the CA attribute of the IEC master station.

5.3.6 Data in control direction

Data that is sent from the IEC master to the IEC slave or slaves is called data in control direction. This data includes the data command, application command and system command messages. These messages are described in this section.

5.3.6.1 Command handling in IEC 60870-5-101 protocol

Command confirmation

The IEC 60870-5-101 protocol includes the concept of command confirmations. A confirmation is a message sent by the slave indicating that a command has been received, executed or rejected. Commands are confirmed in two steps as follows:

- A command is **confirmed** when it is received. An activation confirmation can be positive (command accepted) or negative (command rejected). The status ICCC_NEGATIVE_CONFIRMATION indicates of the latter.
- A command is **terminated** when its execution is finished. Activation termination can also be positive (command successfully completed) or negative (command failed).

The following exceptions apply:

- Select-type data commands, Reset process commands (ASDU 105) and Clock synchronization commands (ASDU 103) are only confirmed, not terminated.
- Read commands (ASDU 102) are not confirmed or terminated.

Confirmation and termination messages can be received by analog input or IEC command termination process objects with the UN attribute equal to the STA object number of the IEC master station and the OA attribute equal to command address + offset. Offset is 1000000 hexadecimal = 16777216 decimal. The updating of this process object can be used to indicate the completion of a sent command such as interrogation command, object command or an analog setpoint command. The OV attribute of the process object provides the following information presented in [Table 7](#):

Table 7: Values of the process object receiving activation confirmations and terminations

Values	Description
0	Positive activation confirmation or termination
1	Negative activation confirmation
2	Activation confirmation timeout
3	Activation termination timeout
4	Negative activation termination

The ASDU identification number of the command is updated to the TY attribute of the command process object. This can be used to separate the result of a general interrogation command and the result of a counter interrogation command, both of which can have the same information object address. The length of the activation confirmation and termination timeouts is determined by the RT and CT attributes of the IEC master station, respectively.

Termination messages can be received by analog input or IEC command termination process objects with the UN attribute equal to the STA object number of the IEC 60870-5-103 master

station and the OA attribute equal to command address + offset. Offset is 1000000 hexadecimal = 16777216 decimal. The OV attribute of the process object provides the following information presented in [Table 8](#):

Table 8: Values of the process object receiving activation confirmations and terminations

Values	Description
0	Positive acknowledgement
1	Link layer negative acknowledgement received
2	No link layer acknowledgement
3	No command acknowledgement received
4	Negative acknowledgement

The lengths of the activation confirmation and termination timeouts are determined by the RT and CT attributes of the IEC 60870-5-103 master station, respectively.

Command transactions

In the SYS600 implementation of the IEC 60870-5-101 master protocol, one command transaction can be open at the same time. This means that while an IEC master station waits for a termination to a data, application or system command, a new command cannot be issued. The status

13867 ICCC_CONFIRMATION_OF_CMD_IS_NOT_READY

is returned in this situation.

If the RM attribute bit 6 is set, the user can execute parallel commands without having to wait for confirmation of the foregoing commands. The result of the executed command can be read from the process object with command confirmation offset.

5.3.6.2 Data commands

Object commands

Object commands (for example switching device open/close commands, tap changer raise/lower commands) include the ASDUs shown in [Table 9](#). They are sent to the IEC slave by setting a binary output process object or by using the CO attribute of the IEC station. The unit number (UN attribute) of the output process object must be the same as the STA object number of the corresponding IEC master station. The address of the process object must also equal the address of the command in the IEC slave. IEC object commands are usually select-before-execute commands.

Table 9: Object command ASDUs

Type id	Description	Process Object Type
45	Single command	Binary output
46	Double command	Binary output
47	Regulating step commands	Binary output

The value set to the process object is a list of attributes. The attributes included in the list are shown in [Table 10](#). Optional attributes are indicated with an asterisk (*).

Table 10: Process object attributes included in an IEC object command

Attr.	Values	Default	Description
SE	-	-	If select command is sent, the parameter list is set to the SE attribute. Otherwise excluded.
TY	45...47	-	Type identification of the ASDU.
OV	0,1,2	-	Value of the command 0 = off, 1 = on (single command, double command), 0 = lower, 1 = higher (regulating step command).
QL*	0...255	0	Qualifier of the command: 0 = do definition, 1 = short pulse, 2 = long pulse, 3 = persistent output.
CT	6, 8	-	Cause of transmission of the command: 6 = activate, 8 = deactivate.
OG*	0...255	0	Originator address of the command.

Examples:

```
; single command, select off, short pulse
#SET 'LN':PSE'IX' = LIST(OV=0,CT=6,OG=100,TY=45,QL=1)
; single command, execute offn, short pulse
#SET 'LN':POV'IX' = LIST(OV=0,CT=6,OG=100,TY=45,QL=1)
; single command, cancel (deactivate) off, short pulse
#SET 'LN':POV'IX' = LIST(OV=0,CT=8,OG=100,TY=45,QL=1)
; double command, execute on, long pulse
#SET 'LN':POV'IX' = LIST(OV=1,CT=6,OG=100,TY=46,QL=2)
; regulating step command, execute lower, persistent output
#SET 'LN':POV'IX' = LIST(OV=0,CT=6,OG=100,TY=47,QL=3)
```

Analog setpoints

Analog setpoints (ASDUs 48, 49 and 50) can be sent by using the CO attribute or by setting an analog output process object. The unit number (UN attribute) of the process object must be the same as the STA object number of the corresponding IEC slave station. The address of the process object must also equal the address of the command in the IEC slave. IEC setpoint commands are usually direct (only execute sent) commands.

There are three different types of analog setpoint values as presented in [Table 11](#). Note that both the normalized and scaled values are handled as signed 16-bit integers in SYS600.

Table 11: Value ranges of setpoint ASDUs

Type id	Value type	Value range	Value in SYS600
48	Normalized	-1...(1-2^-15)	Integer -32768...32767
49	Scaled	-32768...32767	Integer -32768...32767
50	Short floating point	32-bit float	Real

The value set to the process object is a list of attributes. The attributes included in the list are shown in [Table 12](#). Optional attributes are indicated with an asterisk (*).

Table 12: Process object attributes included in an IEC 60870 setpoint command

Attr.	Values	Default	Description
TY	48... 50	-	Type identification of the ASDU
OV	0, 1, 2	-	Value of the command depending on the ASDU
QL*	0... 255	0	Qualifier of the command (no standard definitions yet)
CT	6, 8	-	Cause of transmission of the command: 6 = activate, 8 = deactivate
OG*	0... 255	0	Originator address of the command

Examples:

```
;normalised setpoint command, execute
#SET 'LN':POV'IX' = LIST(OV=5000,CT=6,OG=100,TY=48,QL=0)
;scaled command, cancel (deactivate)
#SET 'LN':POV'IX' = LIST(OV=100,CT=8,OG=100,TY=49,QL=0)
```

Bitstring commands

Bitstring command (ASDU 51) can be sent by setting a process object of type bitstream. The unit number (UN attribute) of the process object must be the same as the STA object number of the corresponding IEC slave station. The address of the process object must also equal the address of the command in the IEC slave. IEC bitstring commands are always direct (only execute sent) commands.

Sending of the bitstring commands is possible using the CO-attribute, too.

The value set to the process object is a list of attributes. The attributes included in the list are shown in [Table 13](#). Optional attributes are indicated with an asterisk (*).

Table 13: Process object attributes included in an IEC 60870 bitstring command

Attr.	Values	Default	Description
TY	51	-	Type identification of the ASDU
BS	bitstring of max. 32 bits	-	Value of the command depending on the ASDU
CT	6	-	Cause of transmission of the command: 6 = activate
OG*	0... 255	0	Originator address of the command

Examples:

```
;non-timetagged bitstring command
#SET 'LN':POV'IX' =
list(BS=pack_str((1,0,0,1,1,0,1,1,0,0,1,1,0,1,1,1,0,0,1,1,0,1,1,1,0,0,1,
1,0,1,1),
"BIT_STRING",1),TY=51,CT=6)
```

5.3.6.3 Application commands

Application commands include the ASDUs shown in [Table 14](#). All application commands are sent with address zero.

Table 14: IEC 60870-5-101 application commands

Type id	ASDU	Description
100	C_IC_NA_1	Interrogation command
101	C_CI_NA_1	Counter interrogation command
102	C_RD_NA_1	Read command
105	C_RP_NA_1	Reset process command

General interrogation command

When the IEC slave station receives a general interrogation command (ASDU 100) from the master, it must send all the input signals except the pulse counters to the master without a time tag. The cause of transmission is set to 20. IEC 60870-5-101 also includes a group interrogation function. When this function is used, the signals to be sent to the IEC master are divided into groups which can be interrogated one at the time. The cause of transmission is set to 20 + group number. Interrogation commands can be sent by using the GI or CO attributes of the IEC master station as shown in the examples below.

```
;activate general interrogation
#SET STA'STA_NR':SGI = 1
;activate group interrogation
@GROUP = 1 ; 1..16
#SET STA'STA_NR':SCO = (100,0,6,20+%GROUP)
```

Counter interrogation command

The counter interrogation command is like a general interrogation but only for integrated totals (pulse counters). A counter interrogation can also be a group interrogation. In this case, the number of the groups is four. The cause of transmission of the interrogated pulse counters are 37 in the case of a counter interrogation, or 37 + group number in the case of a group counter interrogation. A counter interrogation command can be sent by using the CO attribute as shown below:

```
;activate counter interrogation
#SET STA'STA_NR':SCO = (101,0,6,5)
;activate group counter interrogation
@GROUP = 1 ; 1..4
#SET STA'STA_NR':SCO = (101,0,6,%GROUP)
```

The meaning of the fourth byte comes directly from the standard:

Bits 0...5:

0 = no counter requested

1 = request counter group 1

2 = request counter group 2

3 = request counter group 3

4 = request counter group 4

5 = general request counter

Bits 6...7:

0 = no freeze or reset

- 1 = counter freeze without reset
- 2 = counter freeze with reset
- 3 = counter reset

Read command

By using the read command (ASDU 102), the user can request the value of an individual signal from the IEC master. The requested signal is sent with the cause of transmission value 5. Note that pulse counters are not included in the read command.

A read command can be sent by using the CO attribute as shown below:

```
;read of user data command
@ADDR = 255 ; information object address
#SET STA'STA_NR':SCO = (102,%ADDR,5)
```

Reset process command

The purpose of the reset process command (ASDU 105) is to re-initialize the application level of the IEC slave station. It can be sent by using the CO attribute as shown below:

```
;activate reset process command
#SET STA'STA_NR':SCO = (105,0,6,1)
```

5.3.6.4 System commands

System commands include the ASDUs presented in [Table 15](#). All the application commands are sent with address zero by default. The address of the clock synchronization command can be changed by using the ADDR parameter of the SY (Synchronize) attribute.

Table 15: IEC 60870-5-101 system command ASDUs

Type id	ASDU	Description
103	C_CS_NA_1	Clock synchronization command
104	C_RP_NA_1	Test command

Clock synchronization command

The clock synchronization commands (ASDU 103) are used for synchronizing IEC slave stations. This command can be sent by using the SY attribute of the IEC master station as shown below:

```
;activate synchronization for one station
#SET STA'STA_NR':SSY = 6
;deactivate synch to one station
#SET STA'STA_NR':SSY = (8,0)
```

Test command

By sending a test command (ASDU 104) to the IEC slave, the IEC master can check that the connection to the application level of the slave is working properly. A test command can be sent by using the CO attribute as shown below:

```
;test command
#SET STA'STA_NR':SCO = (104,0,6,170,85)
```

5.3.7 Transparent data commands

It is possible to exchange transparent messages between a SYS600 IEC slave and an IEC master. SPA messages are an example of these kinds of messages. Transparent SPA messages are sent as commands to the slave by using the TD attribute of the IEC master station and received in bit stream process objects.

The example shown in [Figure 11](#) has two SYS600 base systems, one as the network control system (IEC master) and one as the substation control system (IEC slave). The latter also acts as the master for several SPA devices. In this example a transparent SPA command is sent from the IEC master to the SPA unit via the SYS600 IEC slave and the answer from the SPA unit is sent back to the IEC master. The following steps are taken according to [Figure 11](#).

- Step 1:** The SPA command "RF:" is sent from the IEC master to the IEC slave as an encapsulated SPA message (ASDU 133) to address 12345 by using the TD attribute as in the following:

```
#SET STA1:STD = (133,12345,6,"RF:")
```

- Step 2 and 3:** The SPA reply message is received by the IEC slave in a bit stream process object with the UN attribute equal to the STA object number of the IEC slave station and the OA attribute value equal to the address of the command, which is 12345 in this case. Attached to this process object is an event channel, which activates a command procedure. The SPA message is parsed by the command procedure as in the following:

```
@SPA_MSG = TYPE_CAST(%BS, "TEXT")
```

The SPA message is sent to the SPA unit and the corresponding answer is read by using the SM attribute of the SPA station as in the following:

```
#SET STA2:SSM = %SPA_MSG
@SPA_ANSW = STA2:SSM
```

- Step 4:** The answer is sent back to the IEC master as an activation confirmation of the command, that is, the encapsulated SPA reply message, as in the following:

```
@IEC_STA_NR = 'LN':PUN'IX'
@ORIG = 'LN':POG'IX'
@CMD_ADDR = 'LN':POA'IX'
@CMD_TYPE = 'LN':PTY'IX'
#SET STA'IEC_STA_NR':SCF = -
(256*%ORIG+7,%CMD_ADDR,%CMD_TYPE,%SPA_ANSW)
```

The message is received by the IEC master in a bit stream process object with the UN attribute equal to the STA object number of the IEC slave station and the OA equal to the address of the command. In this case, the message can also be interpreted using the TYPE_CAST function to convert the message into text.

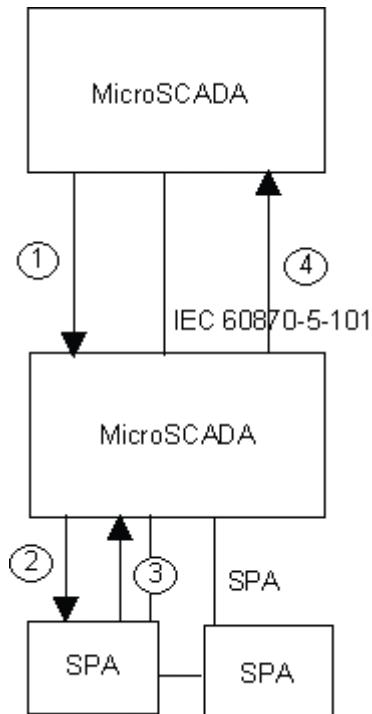


Figure 11: Flow of the transparent SPA messages

By using a mechanism like the one described above, it is possible to read and write the parameters of SPA units over an IEC 60870-5-101 line. The same kind of mechanism can also be used for other purposes, for example exchanging free-format text messages between the master and the slave.

5.3.8 Parameter in control direction

In the IEC 60870-5-101 protocol it is possible for the master to set and activate parameters of information objects of the IEC slave. This kind of action is, for example, setting the limits of a measured value. The following ASDUs presented in [Table 16](#) are provided by the protocol:

Table 16: ASDUs for parameters in the control direction

Type id	ASDU	Description
110	P_ME_NA_1	Parameter of measured values, normalized value.
111	P_ME_NB_1	Parameter of measured values, scaled value.
112	P_ME_NC_1	Parameter of measured values, short floating point number.
113	P_AC_NA_1	Parameter activation.

All of these ASDUs can be sent using the CO attribute of the IEC master station. See the description of the CO attribute in [Section 5.3.4](#) for more details.

ASDUs 110...112 are for setting the parameters of measured values. The syntax is as in the following:

```
#SET STAn:SCO = (TYPE, ADDR, COT, VALUE, QUAL)
```

The elements of the argument vector set to the CO attribute are shown in [Table 17](#).

Table 17: The arguments used when sending parameters of the measured value ASDUs

Argument	Description
TYPE	Type identification of the ASDU, integer 110...112.
ADDR	Information object address of the target measured value object.
COT	Cause of transmission, integer 6.
VALUE	Value of the parameter as normalized value (ASDU 110), scaled value (ASDU 111) or short floating point number (ASDU 113).
QUAL	Qualifier of the ASDU as follows: 1 = threshold value, 2 = smoothing factor, 3 = low limit, 4 = high limit.

When sending a parameter activation message (ASDU 113), the syntax of the CO attribute is in the following. [Table 18](#) describes the values of the elements in the argument vector.

```
#SET STA1:SCO = (TYPE, ADDR, COT, QUAL)
```

Table 18: The arguments used when sending the parameter activation ASDUs

Argument	Description
TYPE	Type identification of the ASDU, integer 113.
ADDR	Information object address of the target object.
COT	Cause of transmission, integer 6 = activate, 8 = deactivate.
QUAL	Qualifier of the ASDU as follows: 1 = act/deact of the previously loaded parameters (addr 0), 2 = act/deact of the parameter of the addressed object, 3 = act/deact of persistent cyclic or periodic transmission of the addressed object.

Examples:

```
; send the low limit 100 of the object with address 1500 as scaled value
#SET STA1:SCO = (111,1500,6,100,3)
; deactivate the previous parameter setting
#SET STA1:SCO = (113,1500,8,2)
```

5.4 Signal engineering

The term signal engineering here means the engineering needed to establish communication to the IEDs using the IEC protocol. In order to create the process object database, the data types and the addresses of the data points used by each remote device need to be identified. When system configuration is completed, communication to the IEDs is possible but the utilization of the functions of the IEDs is not possible until the process object database is created. The principal sequence for the signal engineering is:

1. Make a list of all signals that are to be transferred between the master and the slave. Create the corresponding process objects.
2. Determine the communication mode, balanced or unbalanced and update the system configuration correspondingly. No data poll definitions are needed since IEC60870-5-101 uses link layer polling (unbalanced mode) or data is updated spontaneously (balanced mode).
3. Determine the need for the general interrogations and time synchronizations and make the necessary application changes.
4. Test each signal.

5.5 Status codes

The status codes for the IEC 60870-5-101 Master protocol are defined in the SYS600 Status Codes manual. Some typical reasons for some of the status codes are also given.

Status codes are sent as system messages which can be received by analog input project objects with a unit number (UN) 0 and an object address (OA) as determined by the MI attribute of the line or station, or alternatively, they are returned as a response to a SCIL command accessing a IEC station object.

5.6 Interoperability

5.6.1 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 the 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 different manufacturers' equipment, it is necessary that all the partners agree on the selected parameters.

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

- Function or ASDU is not used
- Function or ASDU is used as standardized (default)
- Function or ASDU is used in reverse mode
- Function or ASDU is used in standard and reverse mode
- Function or ASDU may need some additional application level work

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



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.

5.6.1.1 System or device

(system-specific parameter)

- System definition
- Controlling station definition (Master)
- Controlled station definition (Slave)

5.6.1.2 Network configuration

(network-specific parameter)

<input checked="" type="checkbox"/>	Point-to-point	<input checked="" type="checkbox"/>	Multipoint-partyline
<input type="checkbox"/>	Multiple point-to-point	<input type="checkbox"/>	Multipoint-star

5.6.1.3 Physical layer

(network-specific parameter)

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				
<input type="checkbox"/>	100 bit/s	<input checked="" type="checkbox"/>	2400 bit/s	<input checked="" type="checkbox"/>	2400 bit/s	<input type="checkbox"/> 56000 bit/s
<input type="checkbox"/>	200 bit/s	<input checked="" type="checkbox"/>	4800 bit/s	<input checked="" type="checkbox"/>	4800 bit/s	<input type="checkbox"/> 64000 bit/s
<input checked="" type="checkbox"/>	300 bit/s	<input checked="" type="checkbox"/>	9600 bit/s	<input checked="" type="checkbox"/>	9600 bit/s	
<input checked="" type="checkbox"/>	600 bit/s			<input checked="" type="checkbox"/>	19200 bit/s	
<input checked="" type="checkbox"/>	1200 bit/s			<input checked="" type="checkbox"/>	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				
<input type="checkbox"/>	100 bit/s	<input checked="" type="checkbox"/>	2400 bit/s	<input checked="" type="checkbox"/>	2400 bit/s	<input type="checkbox"/> 56000 bit/s
<input type="checkbox"/>	200 bit/s	<input checked="" type="checkbox"/>	4800 bit/s	<input checked="" type="checkbox"/>	4800 bit/s	<input type="checkbox"/> 64000 bit/s
<input checked="" type="checkbox"/>	300 bit/s	<input checked="" type="checkbox"/>	9600 bit/s	<input checked="" type="checkbox"/>	9600 bit/s	
<input checked="" type="checkbox"/>	600 bit/s			<input checked="" type="checkbox"/>	19200 bit/s	
<input checked="" type="checkbox"/>	1200 bit/s			<input checked="" type="checkbox"/>	38400 bit/s	

5.6.1.4 Link layer

(network-specific parameter)

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

Link transmission produce		Address field of the link	
<input checked="" type="checkbox"/>	Balanced transmission	<input checked="" type="checkbox"/>	Not present (balanced transmission only)
<input checked="" type="checkbox"/>	Unbalanced transmission	<input checked="" type="checkbox"/>	One octet
Frame length		Two octets	
255	Maximum length L	<input checked="" type="checkbox"/>	Structured
		<input checked="" type="checkbox"/>	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>

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

Type identification	Cause of transmission



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

5.6.1.5 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)

- One octet Two octets

Information object address

(system-specific parameter)

- | | |
|--|--|
| <input checked="" type="checkbox"/> One octet | <input checked="" type="checkbox"/> Structured |
| <input checked="" type="checkbox"/> Two octets | <input checked="" type="checkbox"/> Unstructured |
| <input checked="" type="checkbox"/> Three octets | |

Cause of transmission

(system-specific parameter)

<input checked="" type="checkbox"/>	One octet	<input checked="" type="checkbox"/>	Two octets Set to zero in case of no originator address
-------------------------------------	-----------	-------------------------------------	--

Selection of standard ASDUs
Process information in monitor direction

(station-specific parameter)

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

Table continues on next page

<input checked="" type="checkbox"/>	<33> := Bitstring of 32 bit with time tag CP56Time2a	M_BO_TB_1
<input checked="" type="checkbox"/>	<34> := Measured value, normalized value with time tag CP56Time2a	M_ME_TD_1
<input checked="" type="checkbox"/>	<35> := Measured value, scaled value with time tag CP56Time2a	M_ME_TE_1
<input checked="" type="checkbox"/>	<36> := Measured value, short floating point value with time tag CP56Time2a	M_ME_TF_1
<input checked="" type="checkbox"/>	<37> := Integrated totals with time tag CP56Time2a	M_IT_TB_1
<input type="checkbox"/>	<38> := Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
<input type="checkbox"/>	<39> := Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
<input type="checkbox"/>	<40> := Packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1
<input checked="" type="checkbox"/>	<128> := Parameter byte string	M_SR_NA_1
<input checked="" type="checkbox"/>	<130>:=101 Encapsulated SPA reply message	M_SB_NA_1

Process information in control direction (station-specific parameter)

<input checked="" type="checkbox"/>	<45> := Single command	C_SC_NA_1
<input checked="" type="checkbox"/>	<46> := Double command	C_DC_NA_1
<input checked="" type="checkbox"/>	<47> := Regulating step command	C_RC_NA_1
<input checked="" type="checkbox"/>	<48> := Set point command, normalized value	C_SE_NA_1
<input checked="" type="checkbox"/>	<49> := Set point command, scaled value	C_SE_NB_1
<input checked="" type="checkbox"/>	<50> := Set point command, short floating point value	C_SE_NC_1
<input checked="" type="checkbox"/>	<51> := Bitstring of 32 bit	C_BO_NA_1
<input checked="" type="checkbox"/>	<131>:=Parameter byte string	C_SR_NA_1
<input checked="" type="checkbox"/>	<133>:=101 Encapsulated SPA bus message	C_SB_NA_1

System information in monitor direction (station-specific parameter)

<input checked="" type="checkbox"/>	<70> := End of initialization	M_EI_NA_1
-------------------------------------	-------------------------------	-----------

System information in control direction (station-specific parameter)

<input checked="" type="checkbox"/>	<100>:= Interrogation command	C_IC_NA_1
<input checked="" type="checkbox"/>	<101>:= Counter interrogation command	C_CI_NA_1
<input checked="" type="checkbox"/>	<102>:= Read command	C_RD_NA_1
<input checked="" type="checkbox"/>	<103>:= Clock synchronization command	C_CS_NA_1
<input checked="" type="checkbox"/>	<104>:= Test command	C_TS_NA_1
<input checked="" type="checkbox"/>	<105>:= Reset process command	C_RP_NA_1
<input type="checkbox"/>	<106>:= Delay acquisition command	C_CD_NA_1

Parameter in control direction

(station-specific parameter)

<input checked="" type="checkbox"/>	<110>:= Parameter of measured value, normalized value	P_ME_NA_1
<input checked="" type="checkbox"/>	<111>:= Parameter of measured value, scaled value	P_ME_NB_1
<input checked="" type="checkbox"/>	<112>:= Parameter of measured value, short floating point value	P_ME_NC_1
<input checked="" type="checkbox"/>	<113>:= Parameter activation	P_AC_NA_1

File transfer

(station-specific parameter)

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

Type identifier 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																			
		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	<input checked="" type="checkbox"/>																			
<2>	M_SP_TA_1	<input checked="" type="checkbox"/>																			
<3>	M_DP_NA_1	<input checked="" type="checkbox"/>																			
<4>	M_DP_TA_1	<input checked="" type="checkbox"/>																			
<5>	M_ST_NA_1	<input checked="" type="checkbox"/>																			
<6>	M_ST_TA_1	<input checked="" type="checkbox"/>																			
<7>	M_BO_NA_1	<input checked="" type="checkbox"/>																			
<8>	M_BO_TA_1	<input checked="" type="checkbox"/>																			
<9>	M_ME_NA_1	<input checked="" type="checkbox"/>																			
<10>	M_ME_TA_1	<input checked="" type="checkbox"/>																			
<11>	M_ME_NB_1	<input checked="" type="checkbox"/>																			
<12>	M_ME_TB_1	<input checked="" type="checkbox"/>																			
<13>	M_ME_NC_1	<input checked="" type="checkbox"/>																			
<14>	M_ME_TC_1	<input checked="" type="checkbox"/>																			
<15>	M_IT_NA_1	<input checked="" type="checkbox"/>																			
<16>	M_IT_TA_1	<input checked="" type="checkbox"/>																			
<17>	M_EP_TA_1	<input checked="" type="checkbox"/>																			
<18>	M_EP_TB_1	<input checked="" type="checkbox"/>																			
<19>	M_EP_TC_1	<input checked="" type="checkbox"/>																			
<20>	M_PS_NA_1	<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>																
<21>	M_ME_ND_1				<input checked="" type="checkbox"/>																
<30>	M_SP_TB_1	<input checked="" type="checkbox"/>																			
<31>	M_DP_TB_1	<input checked="" type="checkbox"/>																			

Table continues on next page

Type identification		Cause of transmission																				
<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													X		
<38>	M_EP_TD_1																					
<39>	M_EP_TE_1																					
<40>	M_EP_TF_1																					
<45>	C_SC_NA_1																			X	X	X
<46>	C_DC_NA_1																			X	X	X
<47>	C_RC_NA_1																			X	X	X
<48>	C_SE_NA_1																			X	X	X
<49>	C_SE_NB_1																			X	X	X
<50>	C_SE_NC_1																			X	X	X
<51>	C_BO_NA_1																			X	X	X
<70>	M_EI_NA_1							X														
<100>	C_IC_NA_1								X	X	X	X	X							X	X	X
<101>	C_CI_NA_1								X	X	X	X	X							X	X	X
<102>	C_RD_NA_1								X											X	X	X
<103>	C_CS_NA_1									X		X	X							X	X	X
<104>	C_TS_NA_1									X	X									X	X	X
<105>	C_RP_NA_1									X	X									X	X	X
<106>	C_CD_NA_1																					
<110>	P_ME_NA_1									A	A								A	A	A	A

Table continues on next page

Type identification		Cause of transmission																						
<111>	P_ME_NB_1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> A	<input checked="" type="checkbox"/> A	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> A	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> A					
<112>	P_ME_NC_1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> A	<input checked="" type="checkbox"/> A	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> A	<input type="checkbox"/>	<input checked="" type="checkbox"/> A						
<113>	P_AC_NA_1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> X	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> X														
<120>	F_FR_NA_1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> X			
<121>	F_SR_NA_1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> X			
<122>	F_SC_NA_1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> X			
<123>	F_LS_NA_1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> X			
<124>	F_AF_NA_1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> X			
<125>	F_SG_NA_1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> X			
<126>	F_DR_TA_1 *	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> X	<input type="checkbox"/>	<input checked="" type="checkbox"/> X	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	* Blank or X only.																							

5.6.1.6 Basic application functions

Station initialization

(station-specific parameter)



Remote initialization

Cyclic data transmission

(station-specific parameter)



Cyclic data transmission

Read procedure

(station-specific parameter)



Read procedure

Spontaneous transmission

(station-specific parameter)



Spontaneous transmission

Double transmission of information objects with cause of transmission spontaneous

(station-specific parameter)

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)
- 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)

<input checked="" type="checkbox"/>	global				
<input checked="" type="checkbox"/>	group 1	<input checked="" type="checkbox"/>	group 7	<input checked="" type="checkbox"/>	group 13
<input checked="" type="checkbox"/>	group 2	<input checked="" type="checkbox"/>	group 8	<input checked="" type="checkbox"/>	group 14
<input checked="" type="checkbox"/>	group 3	<input checked="" type="checkbox"/>	group 9	<input checked="" type="checkbox"/>	group 15
<input checked="" type="checkbox"/>	group 4	<input checked="" type="checkbox"/>	group 10	<input checked="" type="checkbox"/>	group 16
<input checked="" type="checkbox"/>	group 5	<input checked="" type="checkbox"/>	group 11		Information object addresses assigned to each group must be shown in a separate table
<input checked="" type="checkbox"/>	group 6	<input checked="" type="checkbox"/>	group 12		

Clock synchronization (station-specific parameter)

- Clock synchronization

Command transmission (station-specific parameter)

- 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

Table continues on next page

- 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-specific parameter)

- 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

(station-specific parameter)

- A Threshold value
- A Smoothing factor
- A Low limit for transmission of measured value
- A High limit for transmission of measured value

Parameter activation

(station-specific parameter)

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

Test procedure
(station-specific parameter)



Test procedure

File transfer
(station-specific parameter)

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)



Background scan

Acquisition of transmission delay
(station-specific parameter)



Acquisition of transmission delay

5.7 Description of the SPA bus messages

In distribution automation systems, the SPA-bus protocol may be required to access device information that is not mapped to the IEC 60870-5-101 protocol. This information includes several device specific parameters and recorded disturbance data. Two ASDU types from the private range have been selected to enable transparent transfer of the SPA-bus messages.

ASDU 133 - SPA-bus message

TYPE IDENT 133: C_SB_NA_1

SPA-bus message

Single information object (SQ = 1)

Table 19: ASDU C_SB_NA_1 – SPA-bus message

1	0	0	0	0	1	0	1	TYPE IDENTIFICATION	
1				N*				VARIABLE STRUCTURE QUALIFIER	DATA UNIT
								CAUSE OF TRANSMISSION	IDENTIFIER
								COMMON ADDRESS OF ASDU	
								INFORMATION OBJECT ADDRESS	INFORMATION OBJECT
								SPA-bus command message (in control direction) or SPA-bus reply message (in monitor direction)	

* N defines, in binary format, the number of information elements (characters) in the ASDU. N is a value between 0 and 127.

CAUSES OF TRANSMISSION used with TYPE IDENT 133: = C_SB_NA_1

CAUSE OF TRANSMISSION

In control direction: <6>:=activation

In monitor direction: <7>:=activation confirmation

ASDU 130 - SPA-bus reply message

TYPE IDENT 130: M_SB_NA_1

SPA-bus reply message

Single information object (SQ = 0)

Table 20: ASDU M_SB_NA_1 – SPA-bus reply message

1	0	0	0	0	0	1	0	TYPE IDENTIFICATION	
0	0	0	0	0	0	0	1	VARIABLE STRUCTURE QUALIFIER	DATA UNIT
								CAUSE OF TRANSMISSION	IDENTIFIER
								COMMON ADDRESS OF ASDU	
								INFORMATION OBJECT ADDRESS	INFORMATION OBJECT
								SPA-bus reply message	

CAUSES OF TRANSMISSION used with TYPE IDENT 130: = M_SB_NA_1

CAUSE OF TRANSMISSION

In monitor direction: <5>:= requested

Transfer procedure

Transparent transfer of the SPA-bus messages can be initiated by the controlling station by sending a SPA command message to the controlled station using C_SB_NA_1 ASDU with the

"activation" cause of transmission. The controlled station returns a corresponding SPA reply message using C_SB_NA_1 ASDU with the "activation confirmation" cause of transmission.

The last SPA reply message can also be requested by the controlling station using the Read application function. The controlled station returns the latest SPA reply message using M_SB_NA_1 ASDU with the "requested" cause of transmission. The transfer procedure is presented in [Figure 12](#).

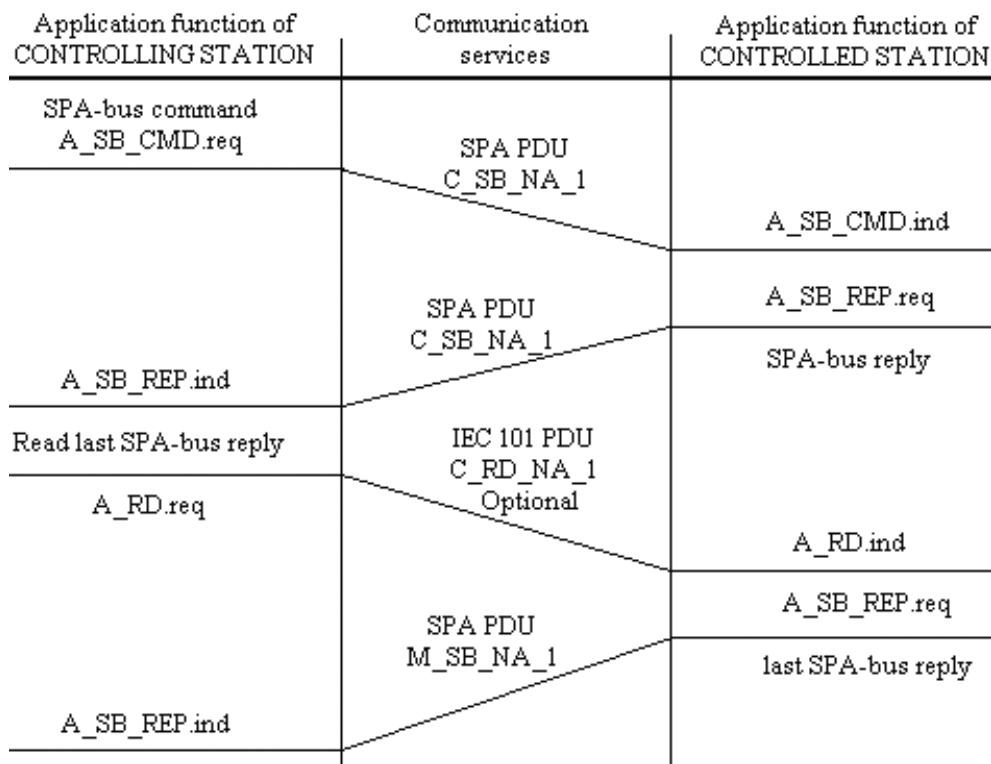


Figure 12: The transfer procedure of transparent SPA-bus protocol

5.8 Description of parameter/byte string messages

In distribution automation systems, several outstation parameters may be accessed as unstructured byte strings (for example, configuration data, device description texts, modem control strings). Two ASDU types from the private range have been selected to enable the parameter setting and parameter reading operations.

ASDU 131 – Parameter, byte string

TYPE IDENT 131: C_SR_NA_1

Parameter, byte string

Single information object (SQ = 0)

Table 21: ASDU C_SR_NA_1 – Parameter, byte string

1	0	0	0	0	0	1	1	TYPE IDENTIFICATION	
0	0	0	0	0	0	0	1	VARIABLE STRUCTURE QUALIFIER	DATA UNIT
								CAUSE OF TRANSMISSION	IDENTIFIER
								COMMON ADDRESS OF ASDU	
								INFORMATION OBJECT ADDRESS	INFORMATION OBJECT
								Character string or byte array	

CAUSES OF TRANSMISSION used with TYPE IDENT 131: = C_SR_NA_1

CAUSE OF TRANSMISSION

In control direction: <6>:=activation

In monitor direction: <7>:=activation confirmation

ASDU 128 – Parameter data, byte string

TYPE IDENT 128: M_SR_NA_1

Parameter, byte string

Single information object (SQ = 0)

Table 22: ASDU M_SR_NA_1 – Parameter data, byte string

1	0	0	0	0	0	1	1	TYPE IDENTIFICATION	
0	0	0	0	0	0	0	1	VARIABLE STRUCTURE QUALIFIER	DATA UNIT
								CAUSE OF TRANSMISSION	IDENTIFIER
								COMMON ADDRESS OF ASDU	INFORMATION OBJECT
								INFORMATION OBJECT ADDRESS	
								Character string or byte array	

CAUSES OF TRANSMISSION used with TYPE IDENT 128: = M_SR_NA_1

CAUSE OF TRANSMISSION

In control direction: <6>:=activation

In monitor direction: <7>:=activation confirmation

Parameter setting and reading procedure

String parameter setting is initiated by the controlling station by sending a parameter value to the controlled station using C_SR_NA_1 ASDU with the "activation" cause of transmission. The controlled station returns an acknowledgement using C_SB_NA_1 ASDU with the "activation confirmation" cause of transmission.

The string parameter value can also be requested by the controlling station by using the Read (ASDU 102, C_RD_NA_1) application function. The controlled station returns the addressed parameter value using M_SR_NA_1 ASDU with the "requested" cause of transmission.

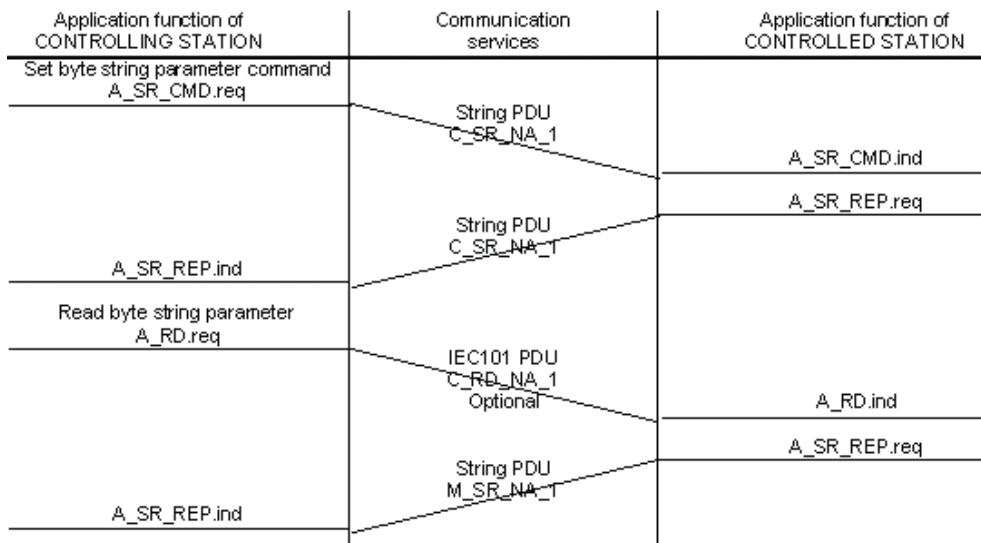


Figure 13: The parameter setting and reading procedure

Appendix A Examples of communication system configuration

The following SCIL procedures make the communication system configuration which is related to the base system configuration example presented earlier in this document. The first procedure creates an IEC 60870-5-101 Master line and two stations on this line.

```

;*****
; INPUT PARAMETERS
@NET = 3 ; NODE NUMBER OF THE PC-NET
@MODE = 0 ; BALANCED MODE
@LINE = 1 ; LINE NUMBER
@STATIONS = (1,2) ; MASTER STATION NUMBERS
@APPLIC = 1 ; APPLICATION NUMBER
;*****
; CREATE A IEC 60870-5-101 MASTER LINE TO NET
#IF NET'NET':SPO'LINE'==0 #THEN #BLOCK
#IF %MODE==0 #THEN #BLOCK
    #SET NET'NET':SPO'LINE' = 32 ;balanced IEC 60870-5-101
;master
    #SET NET'NET':SLK'LINE' = 12 ;link type
    #SET NET'NET':SPD'LINE' = 5000 ;polling delay (ms)
    #SET NET'NET':SRI'LINE' = 0 ;receiver disabling time (ms)
#BLOCK_END
#ELSE_IF %MODE==1 #THEN #BLOCK
    #SET NET'NET':SPO'LINE' = 31 ;unbalanced IEC 60870-5-101
;master
    #SET NET'NET':SLK'LINE' = 4 ;link type
    #SET NET'NET':SPD'LINE' = 500 ;polling delay (ms)
    #SET NET'NET':SRI'LINE' = 5 ;receiver disabling time(ms)
    #SET NET'NET':SPL'LINE' = 10 ;polling limit
    #SET NET'NET':SPP'LINE' = 10 ;polling period(ms)
    #SET NET'NET':SRP'LINE' = 1 ;reply polling
#BLOCK_END
    #SET NET'NET':SSD'LINE' = "COM1" ;system device name
    #SET NET'NET':SMS'LINE' = %APPLIC ;message application
    #SET NET'NET':SMI'LINE' = %LINE+(6000+(%NET*100)) ;message identifier
    #SET NET'NET':SBR'LINE' = 9600 ;baud rate
    #SET NET'NET':SPY'LINE' = 2 ;parity
    #SET NET'NET':SRD'LINE' = 8 ;receive bit count
    #SET NET'NET':STD'LINE' = 8 ;transmit bit count
    #SET NET'NET':SSB'LINE' = 1 ;stop bit count
    #SET NET'NET':SPS'LINE' = 20 ;buffer pool size
    #SET NET'NET':SDE'LINE' = 50 ;CTS delay (ms)
    #SET NET'NET':SHT'LINE' = 2000 ;header timeout (ms)
    #SET NET'NET':STI'LINE' = 2 ;timeout interval (s)
    #SET NET'NET':STW'LINE' = 0 ;transmission wait delay (ms)
    #SET NET'NET':SRK'LINE' = 0 ;RTS keep up padding characters
    #SET NET'NET':SEN'LINE' = 3 ;enquiry limit
#BLOCK_END
;*****
; CREATE IEC 60870-5-101 MASTER STATIONS TO NET
#LOOP_WITH I = 1..LENGTH(%STATIONS)
@STA=%STATIONS(%I)
    #SET NET'NET':SDV(29) = (%STA,%LINE) ;create station to line
    #SET STA'STA':SAL = 1 ;allocated
    #SET STA'STA':SAS = %APPLIC ;allocating application
    #SET STA'STA':SMI = 1000+%STA ;message identification
    #SET STA'STA':SMS = %APPLIC ;message application
    #SET STA'STA':SSE = 1 ;system messages enabled
    #SET STA'STA':SSA = %STA ;station address

```

```

#SET STA'STA':SSL = 2 ;station address length (bytes)
#SET STA'STA':SPA = %STA ;polling address link (address)
#SET STA'STA':SPL = 1 ;polling address length (bytes)
#SET STA'STA':SIL = 3 ;info addr. length (bytes)
#SET STA'STA':SCL = 1 ;COT length (bytes)
#SET STA'STA':SCA = 32000 ;command address
#SET STA'STA':SST = 5000 ;SYS waiting time (ms)
#SET STA'STA':SRT = 10 ;application reply timeout (s)
#SET STA'STA':SCT = 60 ;application termin. timeout(s)
#SET STA'STA':SSU = 0 ;summer time (0=no, 1=yes)
#SET STA'STA':SRW = 10 ;reply window size
#SET STA'STA':SML = 230 ;max. message length
#SET STA'STA':SDR = 0 ;direction
#SET STA'STA':SSR = 0 ;single char response
#SET STA'STA':SRM = 0 ;running mode
#SET STA'STA':SIU = 1 ;set station in use
#LOOP-END
; Set line in use
#SET NET'NET':SIU'LINE' = 1

```

The second example is for an IEC 60870-5-101 Master line with dial-up and two IEC stations.

```

;*****
; INPUT PARAMETERS
@NET = 3 ; NODE NUMBER OF THE PC-NET
@MODE = 1 ; 0 = BALANCED MODE, 1 = UNBALANCED MODE
@LINE = 2 ; LINE NUMBER
@STATIONS = (1,2) ; MASTER STATION NUMBERS
@APPLIC = 1 ; APPLICATION NUMBER
;*****
; CREATE A IEC 60870-5-101 MASTER DIAL-UP LINE TO NET
#IF NET'NET':SPO'LINE'==0 #THEN #BLOCK
#IF %MODE==0 #THEN #BLOCK
    #SET NET'NET':SPO'LINE' = 32 ;balanced IEC 60870-5-101
;master
    #SET NET'NET':SLK'LINE' = 12 ;link type
    #SET NET'NET':SPD'LINE' = 5000;polling delay (ms)
    #SET NET'NET':SRI'LINE' = 0 ;receiver disabling time (ms)
#BLOCK-END
#ELSE-#IF %MODE==1 #THEN #BLOCK
    #SET NET'NET':SPO'LINE' = 31 ;unbalanced IEC 60870-5-10
;master
    #SET NET'NET':SLK'LINE' = 1 ;link type
    #SET NET'NET':SPD'LINE' = 500 ;polling delay (ms)
    #SET NET'NET':SRI'LINE' = 5 ;receiver disabling time (ms)
    #SET NET'NET':SPL'LINE' = 1 ;polling limit
    #SET NET'NET':SPP'LINE' = 10 ;polling period(ms)
    #SET NET'NET':SRP'LINE' = 1 ;reply polling
#BLOCK-END
#SET NET'NET':SSD'LINE' = "COM1" ;system device name
#SET NET'NET':SMS'LINE' = %APPLIC ;message application
#SET NET'NET':SMI'LINE' = %LINE+(6000+(%NET*100)) ;message identifier
#SET NET'NET':SBR'LINE' = 9600 ;baud rate
#SET NET'NET':SPY'LINE' = 2 ;parity
#SET NET'NET':SRD'LINE' = 8 ;receive bit count
#SET NET'NET':STD'LINE' = 8 ;transmit bit count
#SET NET'NET':SSB'LINE' = 1 ;stop bit count
#SET NET'NET':SPS'LINE' = 20 ;buffer pool size
#SET NET'NET':SDE'LINE' = 50 ;CTS delay (ms)
#SET NET'NET':STW'LINE' = 0 ;transmission wait delay (ms)
#SET NET'NET':SHT'LINE' = 50 ;header timeout (ms)
#SET NET'NET':STI'LINE' = 50 ;timeout interval (ms)
#SET NET'NET':SRK'LINE' = 0 ;RTS keep up padding
;characters
#SET NET'NET':SEN'LINE' = 3 ;enquiry limit
#SET NET'NET':SAC'LINE' = 1 ;autocaller enabled
#SET NET'NET':SIU'LINE' = 1 ;set line in use, initialize
;modem

```

```

#BLOCK_END
;***** Configure Autocaller *****
#SET NET'NET':SIU'LINE' = 0
#SET NET'NET':SCL'LINE' = 0 ;connection time limited
#SET NET'NET':SCT'LINE' = 0 ;connection time
#SET NET'NET':SDD'LINE' = 0 ;radio disc. delay
#SET NET'NET':SPU'LINE' = 0 ;pulse dialing
#SET NET'NET':SRC'LINE' = 0 ;remote calls enabled
#SET NET'NET':SRW'LINE' = 0 ;radio connecton wait time
#SET NET'NET':SIU'LINE' = 1
;***** *****
; CREATE IEC 60870-5-101 MASTER STATIONS TO NET
#LOOP WITH I = 1..LENGTH(%STATIONS)
@STA=%STATIONS(%I)
#SET NET'NET':SDV(29) =(%STA,%LINE) ;create station to line
#SET STA'STA':SAL = 1 ;create station to line
#SET STA'STA':SAS = %APPLIC ;allocating application
#SET STA'STA':SMI = 1000+%STA ;message identification
#SET STA'STA':SMS = %APPLIC ;message application
#SET STA'STA':SSE = 1 ;system messages enabled
#SET STA'STA':SSA = %STA ;station address
#SET STA'STA':SSL = 2 ;station address length (bytes)
#SET STA'STA':SPA = %STA ;polling address link address
#SET STA'STA':SPL = 1 ;polling address length (bytes)
#SET STA'STA':SIL = 3 ;info addr. length (bytes)
#SET STA'STA':SCL = 1 ;COT length (bytes)
#SET STA'STA':SCA = 32000 ;command address
#SET STA'STA':SST = 5000 ;SYS waiting time (ms)
#SET STA'STA':SRT = 10 ;application reply timeout (s)
#SET STA'STA':SCT = 60 ;application term. timeout (s)
#SET STA'STA':SSU = 0 ;summer time (0=no, 1=yes)
#SET STA'STA':SRW = 10 ;reply window size
#SET STA'STA':SML = 230 ;max. message length
#SET STA'STA':SDR = 0 ;direction
#SET STA'STA':SSR = 0 ;single char response
#SET STA'STA':SRM = 0 ;running mode
#SET STA'STA':SIU = 1 ;set station in use
#LOOP-END
;dial number 123456789 and start polling link address 1
#SET NET'NET':SCN'LINE' = "123456789S1" ;connection

```


Index

A	
AC.....	42
Activation Reply Timeout.....	31
Activation Termination Timeout.....	32
Addressing.....	56
Aggressive Mode.....	34
AL.....	28
Allocating Application.....	28
Allocation.....	28
Analog	
inputs.....	61
Setpoints.....	64, 65
Analog inputs.....	59
Application commands.....	58, 62, 66, 67
Application Service Data Units (ASDUs)	27, 28, 55, 63
AS.....	28, 43
Association Id.....	35
AT command.....	42, 44, 45
Authenticated users.....	35
Authentication Diagnostics.....	39
Authentication Parameters.....	39
Authentication Status.....	37
Authentication used.....	34
Authentication Vector.....	36
Autocaller AT S Register.....	45
Autocaller Enabled.....	42
Autocaller State.....	43
B	
BA.....	25
Backup operation.....	25
Balanced mode.....	55
Baud Rate.....	15
Binary inputs.....	59, 61
BL.....	60
BR.....	15
Buffer Pool Size.....	15
C	
CA.....	29, 30, 60, 62
Carrier Blocking.....	24
Cause of Transmission (COT)....	28, 57, 64, 66, 83
CB.....	24
CE.....	32
CF.....	30
CL.....	28, 43
Clock synchronisation.....	30, 62
CM.....	22
CN.....	43
CO.....	58, 63
Command Address.....	29
Command Out.....	58
Command	
Transactions.....	63
Command transactions.....	63
Common address of ASDU.....	56
COM Port Mode.....	22
Configuration.....	11
ConFirmation Mode.....	30
Connected Station.....	44
Connection.....	43
Connection Event.....	32
Connection Time.....	43
D	
Connection Time Limited.....	43
Counter interrogation.....	66
CR.....	41
Critical Requests.....	41
CS.....	44
CT.....	30, 32, 43, 60, 62, 64, 65
CTS.....	18, 21
CTS Delay.....	18
CTS signal.....	17, 50
CY.....	60
E	
EN.....	21
End of initialisation.....	30
Enhanced Protocol Architecture (EPA).....	55
Enquiry Limit.....	21
F	
FB.....	47
FD.....	46
FF.....	46
FI.....	45
File Bytes.....	47
File Directory.....	46
File Information.....	45
File Name.....	47
File Timeout.....	46
File Transmission Status.....	46
File Values.....	48
FN.....	47
FT.....	46
FV.....	48
G	
General Interrogation.....	57, 66
GI.....	57, 66
H	
Header Timeout.....	18
HT.....	18
I	
IEC 60870-5-101 master protocol.....	5
IEC 60870-5-101 slave protocol.....	11
IL.....	28, 56
Information Address Length.....	28
Information object address.....	56

Integrated link.....	11
In Use.....	14, 26
IU.....	14, 26, 43
IU attribute.....	14, 26
IV.....	60
K	
Key storage Id.....	35
L	
Length of Cause of Transmission Information.....	28
Level of implementation.....	55
LI.....	27
Line Layer.....	14
Line Layer Attributes.....	14
Line Number.....	27
Link Address.....	56
Link layer.....	14
Link Type.....	23
LK.....	23
M	
Maximum Message Length.....	29
MC.....	44, 45
Message Application.....	23, 29
Message Identification.....	23, 29
MI.....	23, 29, 71
ML.....	29
Modem Command.....	44
Modem Signal.....	21
MS.....	23, 29
Multidrop network topology.....	13
Multi-drop network topology.....	13, 56
N	
NET.....	31, 56
Network topologies.....	13
New Keys.....	42
No limitations.....	12
NT.....	60
NU.....	42
O	
OA.....	62
Object commands.....	63
Object Status.....	31
OF.....	60
OG.....	60, 64, 65
OM.....	24
Open Systems Interconnection.....	55
Open Systems Interconnection (OSI).....	55
Operating Mode.....	24
Operator.....	36
OR.....	60, 61
OS.....	31, 59
Outstation Name.....	38
OV.....	59, 60, 62, 64, 65
P	
PA.....	27, 56
Parameter in control direction.....	69
Parity.....	15
PC.....	44
PC-NET.....	55
PD.....	16
Physical layer.....	55
PL.....	16, 27
PO.....	14, 56
Point-to-point network topology.....	13
Polling Address.....	27
Polling Address Length.....	27
Polling Delay.....	16
Polling Limit.....	16
Polling Period.....	16
PP.....	16
Process object types.....	59, 60
Protocol.....	14
Protocol converter.....	11, 56
PS.....	15
PU.....	44
Pulse counters.....	61, 66
Pulse Dialing.....	44
PY.....	15
Q	
QL.....	60, 64, 65
R	
Radio Connection Wait Time.....	45
Radio Disconnection Delay.....	44
RC.....	44
RD.....	15
Read command.....	62, 67
Read-only.....	12
Receive Interrupt Enable Delay.....	21
Receiver Data Bit Count.....	15
Remote Calls Enabled.....	44
Reply Polling.....	17
Reset process command.....	62
Response Timeout.....	19
RI.....	21
RK.....	20
RM.....	30, 60
RM attribute.....	63
RP.....	17
RT.....	31, 60, 62
RTS.....	18, 20
RTS Keepup Delay.....	19
RTS Keep up Padding Characters.....	20
RTS signal.....	18
Running Mode.....	30
RW.....	45
RY.....	19
S	
SA.....	27, 56
SB.....	16, 60
SD.....	15
SE.....	29, 64
Secondary polling Limit.....	17
Serial cable.....	51
Session Key change Count.....	39
SG.....	21
Signal address.....	56
Single Char Response.....	30
Single indications.....	61
SL.....	17, 28
SM.....	68
SO.....	32
SR.....	30, 45
ST.....	31
STA objects.....	26
Station Address.....	27, 56
Station Address Length.....	28
Station attributes.....	26
Station object.....	26
Status codes	
Line Layer.....	71
Station Layer.....	71
Stop Bits.....	16
Structured address.....	56

SU.....	33
Substation Control System (SCS).....	5
Summer Time.....	33
SY.....	57, 67
Synchronization Offset.....	32
Synchronize.....	57
SYS_BASCON.COM.....	12
SYS600.....	5
System commands.....	58, 62, 67
System Device Name.....	15
System Messages Enabled.....	29
System	
Commands.....	58, 62, 63, 67
Messages.....	23, 29, 71
Objects.....	12, 13
SYS Waiting Time.....	31
T	
TD.....	16, 58, 67, 68
TI.....	19
Transmission Wait Delay.....	17
Transmitter Data Bit Count.....	16
Transparent Data.....	58, 67
Transparent SPA.....	67, 82
TW.....	17
TY.....	59, 62, 64, 65
U	
UA.....	33
UAL event Identification.....	26, 34
UAL Event used.....	33
UI.....	26, 34
UN.....	29, 62, 63, 71
Unbalanced mode.....	55
Unstructured address.....	56
User Roles.....	38
W	
Wiring.....	51
Write-only.....	12
Z	
ZA.....	34
ZD.....	39
ZG.....	34
ZI.....	35
ZN	38
ZO	38
ZP.....	39
ZR.....	35
ZS	37
ZT.....	35
ZU.....	35
ZV.....	36

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