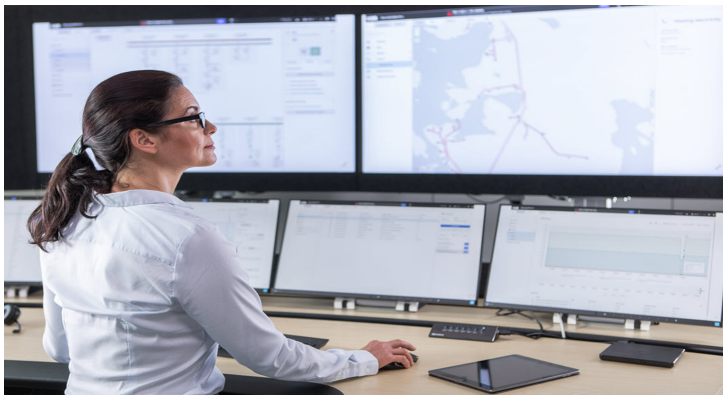
GRID AUTOMATION PRODUCTS

MicroSCADA X SYS600 10.2

IEC 60870-5-103 Master Protocol



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Section 2 Introduction

2.1 This manual

This manual provides thorough information on the use of IEC 60870-5-103 Master Protocol and information related to it. It describes how to configure the base system and the communication system to establish communication to IEC 60870-5-103 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 60870-5-103 Master Protocol

The IEC 60870-5-103 Master protocol is mainly used for process level communication between SYS600 and process units as presented in Figure 1.

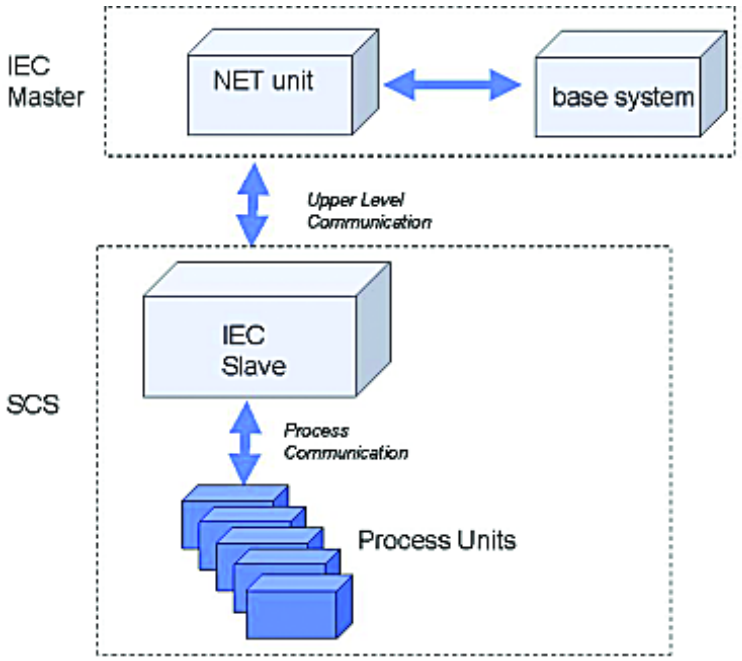

Figure 1: The IEC master sees the Substation Control System (SCS) as an IEC slave

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, e.g. 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 System Configuration	1MRK 511 481-UEN
SYS600 10.2 System Objects	1MRK 511 482-UEN
SYS600 10.2 Application Objects	1MRK 511 467-UEN
SYS600 10.2 Status Codes	1MRK 511 480-UEN

2.4.1 Other referenced manuals

The IEC 60870-5-103 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 60870-5-103	Companion standard for the IEC 60870-5-103 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 60870-5-103 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 60870-5-103 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 60870-5-103 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 (i.e. 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 also the message types used.

4.3.2.2 Network topologies

The implementation of the IEC 60870-5-103 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 60870-5-103 protocol supports one master on a line. Figure 2 illustrates the network topologies.

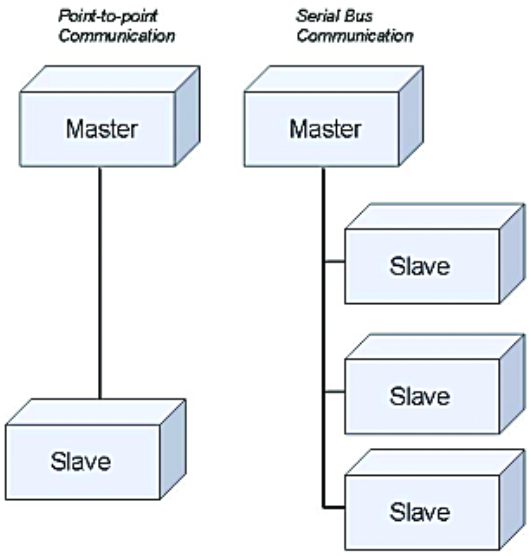

Figure 2: Network topologies

4.3.2.3 IEC 60870-5-103 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 60870-5-103 protocol.

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 60870-5-103 master lines in SYS600.

IU	In Use
Indicates whether the line is in use (value 1) or not in use (value 0).	
Data type:	Integer
Value:	0 or 1
Index range:	1...12 (NET line numbering)
Default value:	0
Access:	No limitations

PO	Protocol
The data transfer protocol used on the line. The line is defined to the NET by setting this attribute. By setting the attribute to 0 the line definition including all the line attributes are deleted.	
Data type:	Integer
Value:	Value with IEC 60870-5-103 Master 0...35 Value with IEC 60870-5-103 Master protocol: 33
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. The master sends the polling messages (for class 1 or class 2) with an interval defined by this attribute.

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

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.

Data type:	Integer
Value:	2...100
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.

Data type:	Integer
Value:	1...20

Table continues on next page

RP	Reply Polling
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.

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)

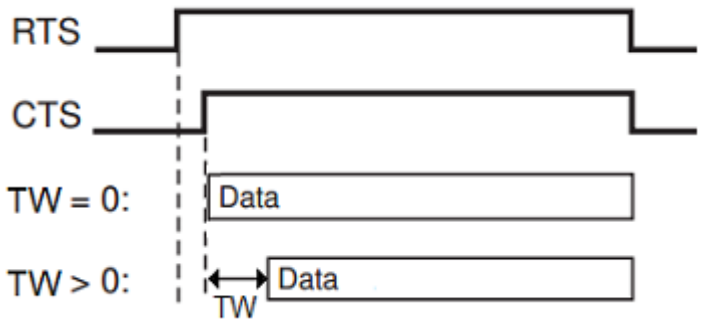

Figure 3: TW attribute

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

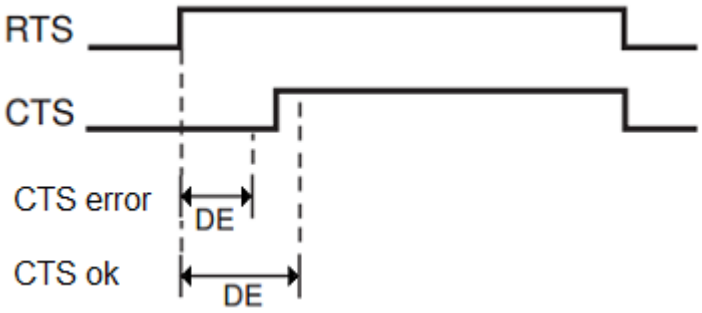

Figure 4: DE attribute

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

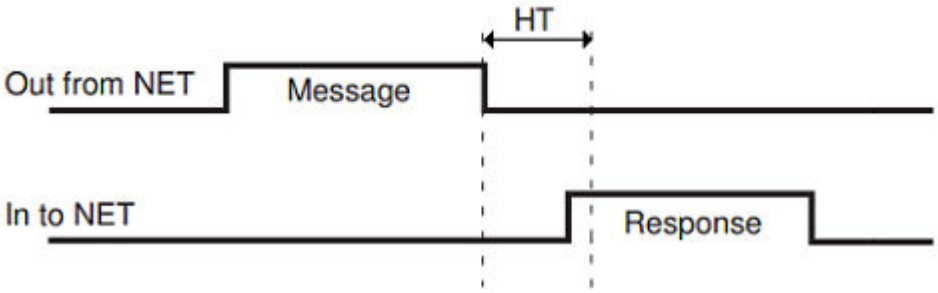

Figure 5: HT attribute

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

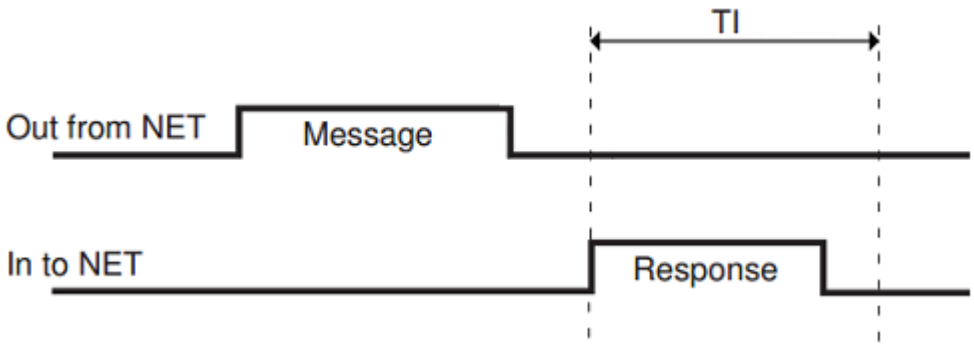

Figure 6: TI attribute

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 baudrate)
Index range:	1...12 (NET line numbering)
Default value:	1
Access:	Read, conditional write

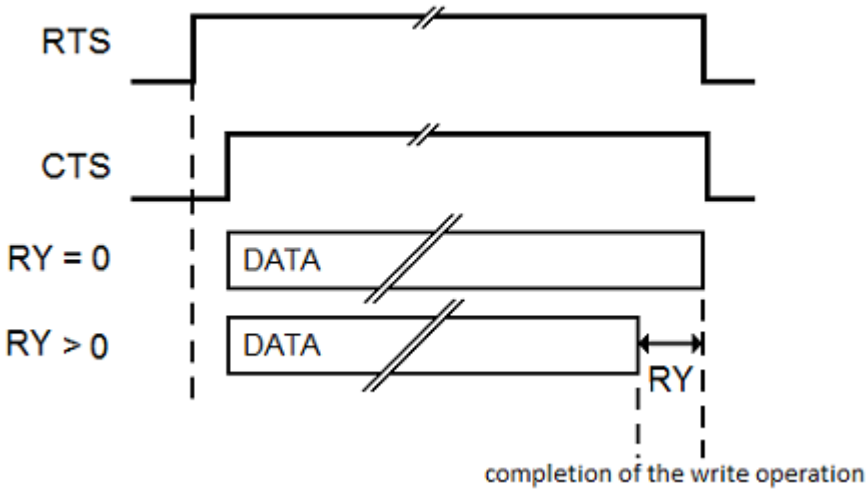

Figure 7: RY attribute

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

Table continues on next page

RK	RTS Keep Up Padding Characters
Index range:	1...12 (NET line numbering)
Default value:	0
Access:	Read, conditional write

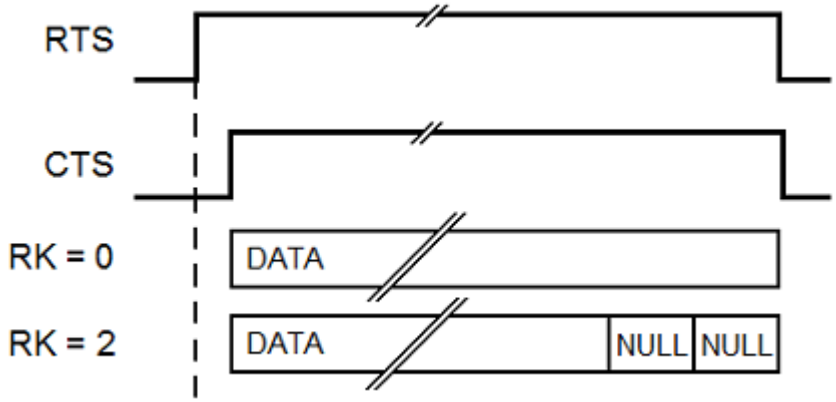

Figure 8: RK attribute

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:	5 (unbalanced mode)
Access:	No limitations Read, conditional write

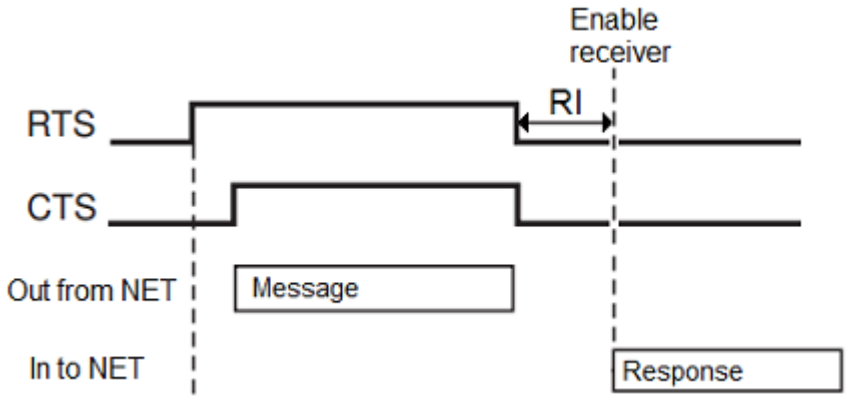

Figure 9: RI attribute

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
Access:	Read-only, write possible to signals 5 = CTS and 8 = DCD

Examples:

```
#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
```

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.

Table continues on next page

CM	COM Port 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'.
Bit 2:	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. 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.
Bit 3:	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. When this bit is 1, the keep up time of the RTS signal is calculated using the length of the sent message and the baudrate 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. 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.

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. This attribute controls the behavior of the RTS-control 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
Index range:	1...12 (NET line numbering)
Default value:	4
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 the unbalanced fashion. LK values 12 and 13 should not be used by the IEC60870-5-103 protocol.

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 (e.g. 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:	0
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 * (line number) + (diagnostic counter number)
The IEC 60870-5-103 Master protocol supports the following counters:

1. Transmitted telegrams
2. Failed transmissions
4. Transmitted commands
5. Transmitted replies
11. Received messages
12. Parity errors
13. Overrun errors
14. Check sum errors
15. Framing errors
16. 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:	
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.
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 the 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 one 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...15:	Not used, do not set.
Data type:	Integer
Value:	0...65535
Value range:	1...12 (NET line numbering)
Default value:	0
Access:	Read, conditional write

4.3.2.4 IEC 60870-5-103 station object

The main purpose of the station layer is the protocol conversion between the IEC 60870-5-103 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 application layer. Several STA objects of the IEC device type are allowed on the same line. Some of the application layer attributes are used for configuration of the station 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 attributes
The following attributes can be used for configuring the IEC 60870-5-103 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 60870-5-103 station.

Data type:	Integer
Value:	0...254
Default value:	1
Access:	Read, conditional write

Address 255 is reserved for broadcast messages

SA	Station Address

The station address of the IEC 60870-5-103 station, the common address of ASDU in an IEC message.

Data type:	Integer
Value:	0...255
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 (the value should always be 1)
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 (the value should always be 1)
Default value:	1
Access:	Read

IL	Information Address Length

The length of the information object address in octets.

Data type:	Integer
Value:	2 (the value should always be 2)
Default value:	2
Access:	Read

CL	Length of Cause of Transmission Information

The length of the cause of transmission field in an IEC 60870-5-103 message in octets.

Data type:	Integer
Value:	1 (the value should always be 1)
Default value:	1
Access:	Read

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:	Read, conditional write

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:	Read, conditional write

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.

Data type:	Integer
Value:	1...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 60870-5-103 master.

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 method for adding year and date for timestamped event data. When this bit is 0, the master gets the year and date from the slave as a clock synchronization (ASDU 6,COT8). When this bit is 1, the master does not expect a clock synchronization (ASDU 6,COT8) from the slave. The master adds the year and date from its internal clock to the events. Hours, minutes and seconds should be provided in time-tagged events by the slave.
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, e.g. 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.

Data type:	Integer
Value:	0...65535, see above
Default value:	1
Access:	Read, conditional write

Example:

Disable general interrogation at zero status, RM value = 0*1+1*32=32.

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

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.

4.3.2.5 Autodialing attributes

SYS600 provides support for the Autocaller functionality of the IEC 60870-5-103 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 60870-5-103 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.

Data type:	Integer
Value:	See the modem manuals
Indexing:	Seconds
Access:	100 * line number + register number

Example:
The S register number 6 of line 2 in NET1 is set = 4:

```
#SET NET1:SSR206 = 4
```

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 60870-5-103 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 in use. This signal can be used to control the fall-back 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 60870-5-103 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.

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.

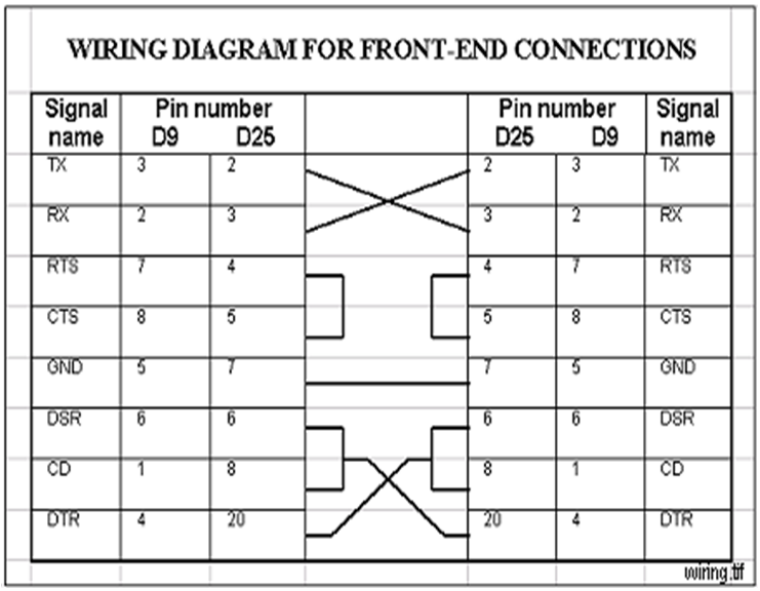

Figure 10: Serial cable wiring diagram

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 computes 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

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.
- 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 60870-5-103 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 60870-5-103 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 60870-5-103 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 Table 1.

Table 1: Application Service Data Units supported by SYS600

Type id	Description
Monitoring Direction	
1	Time-tagged messages
2	Time-tagged messages with relative time
3	Measurands I
4	Time-tagged measurands with relative time
5	Identification
6	Time synchronisation
8	General interrogation termination
9	Measurands II
10	Generic data
11	Generic identification
23	List of recorded disturbance
26	Ready for transmission of disturbance data
27	Ready for transmission of a channel

Table continues on next page

Type id	Description
28	Ready for transmission of tags
29	Transmission of tags
30	Transmission of disturbance values
31	End of transmission
Controlling Direction	
6	Time synchronization
7	General interrogation
47	Generic data
48	General command
49	Generic command
50	Acknowledgement for disturbance data transmission

Private range ASDUs 32-255 can be received to a bitstream process object whose address is defined with the CA station attribute.

Each application level message contains one or more information objects. The information object address is constructed from the function type and the information number codes. The first octet of the information object defines the function type of the protection equipment used. The user can also define private function types. Standard function types are defined in the following table.

Table 2: Standard function types

Function type	Parameter in Controlling Direction
128	Distance protection
160	Overcurrent protection
176	Transformer differential protection
192	Line differential protection
254	Generic function type
255	Global function type

It is also possible to use function types from a private range. The use of such functions is left open in this document.

The information number of the protection equipment is defined by the second object of the information object. It is defined in the following tables.

Table 3: Information number ranges

Monitoring direction	
0... 15	System functions
16... 31	Status
32... 47	Supervision
48... 63	Earth fault
128... 143	Auto-reclosure
144... 159	Measurands
240... 255	Generic functions
Controlling direction	
Table continues on next page	

Monitoring direction	
0... 15	System functions
16... 31	General command
240... 255	Generic functions

Table 4: Data in monitor direction

Informationnumber	ASDU Type	Description
System functions in monitoring direction		
0	8	End of general interrogation
0	6	Time synchronisation
2	5	Reset FCB
3	5	Reset CU
4	5	Start/Reset
5	5	Power On
Status indications in Monitoring Direction		
16	1	Auto-recloser active
17	1	Teleprotection active
18	1	Protection active
19	1	LED reset
20	1	Monitor direction blocked
21	1	Test mode
22	1	Local parameter setting
23	1	Characteristic 1
24	1	Characteristic 2
25	1	Characteristic 3
26	1	Characteristic 4
27	1	Auxiliary input 1
28	1	Auxiliary input 2
29	1	Auxiliary input 3
30	1	Auxiliary input 4
Supervision indications in Monitoring direction		
32	1	Measurand supervision I
33	1	Measurand supervision V
35	1	Phase sequence supervision
36	1	Trip circuit supervision
37	1	I >> back-up supervision
38	1	Voltage transformer fuse failure
39	1	Teleprotection disturbed
46	1	Group warning
47	1	Group alarm
Earth fault indications in monitoring direction		
48	1	Earth fault 1

Table continues on next page

Informationnumber	ASDU Type	Description
49	1	Earth fault 2
50	1	Earth fault 3
51	1	Earth fault forward
52	1	Earth fault reverse
Fault indications in monitoring direction		
64	2	Start/pick-up L1
65	2	Start/pick-up L2
66	2	Start/pick-up L3
67	2	Start/pick-up N
68	2	General trip
69	2	Trip L1
70	2	Trip L2
71	2	Trip L3
72	2	Trip I>>
73	4	Fault location in X ohms
74	2	Fault forward/line
75	2	Fault reverse/busbar
76	2	Teleprotection signal transmitted
77	2	Teleprotection signal received
78	2	Zone 1
79	2	Zone 2
80	2	Zone 3
81	2	Zone 4
82	2	Zone 5
83	2	Zone 6
84	2	General start/pick-up
85	2	Breaker failure
86	2	Trip measuring system L1
87	2	Trip measuring system L2
88	2	Trip measuring system L3
89	2	Trip measuring system E
90	2	Trip I>
91	2	Trip I>>
92	2	Trip IN>
93	2	Trip IN>>
Auto-reclosure indications in monitoring direction		
128	1	Circuit breaker ‘on’ by auto-recloser
129	1	Circuit breaker ‘on’ by long-time auto-recloser
130	1	Auto-recloser locked
Measurands in monitoring direction		
144	3	Measurand I

Table continues on next page

Informationnumber	ASDU Type	Description
145	3	Measurand I, V
146	3	Measurand I, V, P, Q
147	3	Measurand In, Ven
148	9	Measurand $I_{L1,2,3}$, $V_{L1,2,3}$, P, Q, F

Table 5: Data in control direction

Information	ASDU Type	Description
System functions		
0	7	Initialisation of general interrogation command
0	6	Time synchronisation
Supervision indications in monitoring direction		
16	20	Auto-recloser on/off
17	20	Teleprotection on/off
18	20	Protection on/off
19	20	LED reset
23	20	Activate characteristic 1
24	20	Activate characteristic 2
25	20	Activate characteristic 3
26	20	Activate characteristic 4
Response is with the same information number	1	Response

For further details, see the IEC 60870-5-103 interoperability list for SYS600 at the end of this document.

5.3 Communication

This section gives a more detailed description of the implementation of the IEC 60870-5-103 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 60870-5-103 Master status codes.

IEC 60870-5-103 uses an unbalanced communication mode where 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 transfers. The outstations are secondary stations (slaves) that can transmit only when they are polled.

5.3.1 Protocol converter

Each IEC 60870-5-103 Master station configured on a line of a NET unit acts as a protocol converter between the IEC 60870-5-103 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 IEC60870-5-103, the data sent from the slave to the master can be divided into two classes: class 1 and class 2. By default, the master polls class 2 and the slave replies when it has data for request in class 1.

5.3.2 Addressing

In IEC 60870-5-103, 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 identifier. This address is unique for each signal with the same common address of an ASDU. The information object identifier is constructed from two octets:
    - The first octet is for Function Type, 0... 255. It defines the type of the protection equipment used.
    - The second octet is for Information Number, 0... 255. It defines the type of the information within a given function type.

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:

unstructured = 256*upper byte + lower byte (Function Type).

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 0..65535. The recommended offset is 20000 (hex) = 131072 (decimal).

Example:

Overlapping information object address 2000 (decimal)

Offset = 131072 (decimal) = 20000 (hex)

Address for indication = 2000 (decimal)

Address for command = 2000 + 131072 = 133072 (decimal)

The NET unit interprets both addresses as 2000, since bits above the information object identifier range are left out

5.3.3 Device communication attributes

GI	General Interrogation

Setting this attribute sends a general interrogation command (ASDU 7) to the IEC 60870-5-103 slave station. By setting 1 to the GI attribute a general interrogation message is generated. By using the vector value, the user can definethe scan number (SCM) byte value in the given vector parameter. The received confirmation must have the same value in the supplementary information (SIN) field. In this case the first parameter of the vector is unused.

Data type:	Integer or vector
Value:	Vector (ENA,[SCM]) or integer 1
Access:	No limitations

Description of the vector parameters:

ENA:	Activate (value 1) or deactivate (value 0) interrogation
SCM:	Scan number

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 60870-5-103 line.

Data type:	Vector
Value:	Vector (COT, [BRO])
Access:	Write only

Description of the vector parameters:

COT:	Cause of transmission of the synchronization messages. Valid values: 8 = time synchronization
BRO:	Broadcast determines whether the synchronization message is a broadcast message (value 1) or not (value 0). If omitted, value 0 is assumed.

CO	Command Out

The CO attribute can be used for generating command messages, i.e. 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 60870-5-103 standards listed in Section 2.1.

Data type:	Vector
Value:	Vector (TYPE, ADDR,COT,DATA)
Value range:	0...65535
Access:	Write-only
Indexing:	RID; this parameter specifies which response ASDU ID (data in monitoring direction) is used as a reply message to the command sent by the CO attribute. This response message is also sent to the bitstream process object of the base system (where OA = CA attribute). The termination process object is not updated. If RID is not given or its value is 0, the CO command behaves as it was an ASDU 20 general command. If a non-blocking bit is set in RID, the process commands are possible to send, although the NET waits for a reply to a CO command. If the private response bit is set in RID, the expected reply ASDU is from the private range, i.e. transparent SPA commands.

Table 6: RID Parameter

RID:	set of bits <abnnnnnnnn> where		
	n	<0>	ASDU 1 with COT 20/21 or ASDU 10 with COT 40/ 41 is a reply to the CO-command
		<1...255>	response ASDU ID
	b	<0>	blocking mode
		<1>	non-blocking mode
	a	<1>	next private range response (ASDU ID <32-255>) is a valid reply to the CO-command

Description of the vector parameters:

TYPE: Type identification of the ASDU, integer. This parameter can be a type identification given in the IEC 60870-5-103 companion standard or a private one. Examples of type identifications of command messages are given in the table below.
If the Type Identification octet is 255 (0xFF), the value is used as a 16 bits WORD whose upper byte is set to VSQ byte of message.
Sending the Transparent SPA messages in the IEC 60870-5-103 message format is described in Section 5.3.6.

Table 7: Examples of type identifications of command messages

Type id	Description
6	Time synchronization
7	General interrogation
47	Generic data
48	General command
49	Generic command
50	Acknowledgement for disturbance data transmission

ADDR: Information object address of the command, integer. Consists of Function Type and Information Number.

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 8 are commonly used when using the CO attribute.

Table 8: The causes of transmission valid for the CO attribute

COT	Description
8	Time synchronisation
9	Initialization of general interrogation
20	General command
31	Transmission of disturbance data
40	Generic write command
42	Generic read command

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, scan number 0
#SET STA'STA_NR':SCO = (7,(255+256*0),9,0)

;auto-recloser off command, address 4256
;return information identifier 0 (obligatory)
#SET STA'STA_NR':SCO = (20,(160+256*16),20,1,0)
```

5.3.4 Data in monitoring direction

Data in the monitoring direction, i.e. 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 60870-5-103 ASDUs and SYS600 process object types is presented in tables below.

Table 9: Relations between the SYS600 process object types and IEC 60870-5-103 ASDUs

Type id	Description	Process Object Type
1,2	Double point information	Double binary input
3, 4, 9, 205	Measured value	Analog inputs
10, 11, 23, 27, 28, 29, 30, 31	Generic functions, disturbance data handling	Bit stream

5.3.4.1 Binary inputs

Binary indications are always double binary information in IEC 60870-5-103. Double indications (ASDUs 1, 2) are received by double binary indication process objects. Note that in SYS600 the double indication values 1 and 2 are reverse compared to the ones in the IEC message, in order to make them equal to the double binary values of other master protocols implemented in SYS600.

5.3.4.2 Analog inputs and digital inputs

Measured values (ASDUs 3, 4, 9 and private range ASDU 205) can be received by analog input process objects. The value ranges of the ASDUs are as shown in Table 10.

Table 10: Value ranges of measured value and step position ASDUs

Type id	Value type	Value range	Value in SYS600
3, 9	Measured	-1... +1^-12	Integer -4096...4096
4	Measured	Short floating point	32-bit real
205	Measured	0... 2^32-1	32-bit signed integer

ASDUs 3 and 9 are for normal measurands. ASDU 4 is for fault location and ASDU205 is for pulsed energy values. Fault location and energy values do not set status (OS) or overflow (OF) attributes in process objects.

If the value of the measure and the value sent from the IEC 60870-5-103 slave is larger than the value range of the ASDUs 3 or 9, 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. The value also has an invalid flag, which is shown as an invalid value in the process object's OS attribute.

Frames within ASDUs 3 or 9, where there are several information elements, e.g. measurements, only the first information element uses the base address. The rest of the information elements are addressed as follows.

Measurement address = basic address+ (n-1) x 1000000(hex)

n = n'th information element (measurement) in frame.

The maximum value of the information elements supported by the implementation is 32 per frame, that is n = max. 32.

ASDU 4 represents fault location information where short-circuit location is written to the OV attribute. Relative time at the beginning of a short circuit is written to the RA attribute and fault number to the RB attribute of the process object. This event has also a normal time tag, which is written to the RT and the RM attributes of the process object.

In the polling schema of the IEC 60870-5-103 protocol, device responses always contain data. The data usually consists of current analog input values. The continuous polling of analog input process objects generates load in the SYS600 base system and some delta value should be used in the process objects.

5.3.4.3 Disturbance and generic data

It is possible to receive disturbance data and generic data to process the database. However, it is left out of this document. For more information related to this subject, contact the local supplier.

5.3.5 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.

5.3.5.1 Command handling in IEC 60870-5-103 protocol

Command confirmation
The IEC 60870-5-103 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 **acknowledged** when its execution is finished. An acknowledgement can be positive (command successfully completed) or negative (command failed).

The following exceptions apply:

- The slave device does not respond a clock synchronization command (ASDU 6).

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 11:

Table 11: 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 60870-5-103 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.

5.3.5.2 Data commands

Object commands
Object commands (e.g. switching device open/close commands) are sent to the IEC 60870-5-103 slave by setting a binary output process object or by using the CO attribute of the IEC station. The used ASDU is 20 (generic command). The unit number (UN attribute) of the output process object must be the same as the STA object number of the corresponding IEC 60870-5-103 master station. The address of the process object must equal the address of the command in the IEC 60870-5-103 slave. IEC object commands are direct commands.

The value set to the process object is a list of attributes. The attributes included in the list are shown in Table 12.

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

Attr.	Values	Default	Description
TY			The TY attribute is calculated from the equation 256*ASDU number + information number. The ASDU value for general binary commands is 20. The information number depends on the command type and it is calculated from the object address.
OV			Value of the command 0 = off, 1 = on
CT			Cause of Transmission. With the general commands this attribute has always the value 20.

Examples:

```
;binary command, protection on
#SET 'LN':POV'IX' = LIST(OV=1,CT=20,TY=256*20+16)
```

5.3.5.3 General interrogation command

When the IEC 60870-5-103 slave station receives a general interrogation command (ASDU 7) from the master, it must send all the selected input signals to the master without a time tag.

The cause of transmission is set to 9. Interrogation commands can be sent by using the GI or CO attributes of the IEC 60870-5-103 master station as shown in the examples below.

```
;activate general interrogation
#SET STA'STA_NR':SGI = 1

;activate general interrogation with scan number 0
#SET STA'STA_NR':SCO = (7,65365,9,0)
```

For a general interrogation command the NET needs only the ASDU type and possibly the scan number. Other values in the vector are not used.

5.3.5.4 Clock synchronization command

The clock synchronization commands (ASDU 6) are used to synchronize the IEC 60870-5-103 slave stations. This command is sent by using the SY attribute of the IEC 60870-5-103 master station as shown below:

```
;activate broadcast synch
#SET STA'STA_NR':SSY = (8,1)

;activate station synch
#SET STA'STA_NR':SSY = (8,0)
```

5.3.6 Transparent data commands

It is possible to exchange transparent messages between a SYS600 IEC slave and an IEC master. Transparent messages are used for the transmission of SPA-bus messages or any ASCII format messages to a device that understands these messages. Transparent SPA messages are sent as commands to the slave by using the CO attribute of the IEC master station and received by a bit stream process object.

Transparent messages use a non-IEC 60870-5-103 defined data unit with a special structure and function type. SPA-bus messages are in the data unit of the message in the same format as they are sent and received from the SPA-bus devices.

The example shown in Figure 11 has a SYS600 base system as a master, and one device as the IEC 60870-5-103 slave. The following steps are taken according to Figure 11.

Step **1**: The SPA command "RF:" is sent from the IEC 60870-5-103 master to the IEC 60870-5-103 slave as an encapsulated SPA message (ASDU 255) to address 56565 by using the TD attribute as in the following:

```
#SET STA1:SCO(512) = (65535,(245+256*220),255,82,70,58)
```

Index 512 indicates that the private range response is valid. The first vector value sets the value 255 to the type and VSQ fields. These must always be the same. The COT value can be anything. The values 82, 70, 58 are the ASCII-letters "RF:" changed to a decimal format.

Step **2** : The SPA reply message is received by a bit stream process object with the UN attribute equal to the STA object number of the IEC 60870-5-103 slave station. 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")
```

In this case, the message can also be interpreted using the TYPE_CAST function to convert the message to text.

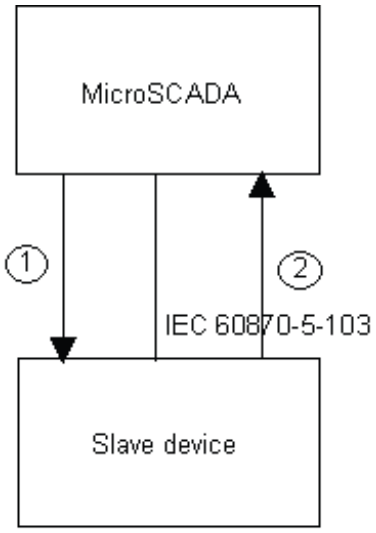

Figure 11: Flow of the transparent SPA messages

By using a mechanism like the one described above, it is possible to read and write the parameters of the SPA units over an IEC 60870-5-103 line. The same kind of mechanism can also be used for other purposes, for example exchanging free-format text messages between the master and slave.

Table 13: Example: IEC_103 transparent message sent by SYS600

START CHARACTER 68H
LENGTH 13H
LENGTH 13H
START CHARACTER 68H
CONTROL 43H
ADDRESS
STRUCTURE TYPE FFH FFH
TRANSMISSION CAUSE N/A
ADDRESS
FUNCTION TYPE F5H
INFORMATION NUMBER DCH
SPA message. An example: Read message >21R1I1:XXcr
CHECKSUM
END CHARACTER 16H

Table 14: Example: Transparent reply message sent by IEC_103 device

START CHARACTER 68H
LENGTH 15H
LENGTH 15H
START CHARACTER 68H
CONTROL 08H
ADDRESS
Table continues on next page

STRUCTURE TYPE FFH FEH
TRANSMISSION CAUSE 20H
ADDRESS
FUNCTION TYPE FFH
INFORMATION NUMBER DCH
SPA-reply message. An example: <21D:2.13:XXcr
CHECKSUM
END CHARACTER 16H

The end character "lf" in the SPA-bus reply is left out of the data unit.

5.4 Status codes

The status codes for the IEC 60870-5-103 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.

5.5 Interoperability list

5.5.1 for SYS600 IEC 60870-5-103 Master

☐ Not supported

■ Supported both by the SYS600 base system and LIB 5xx application software.

▣ Supported by the SYS600 base system, but may need additional application engineering.

5.5.2 Physical layer

5.5.2.1 Electrical interface

☐ EIA RS-485

☐ Number of loads..... for one protection equipment

☐ RS-232

EIA RS-485 standard defines unit loads so that 32 of them can be operated on one line. For detailed information refer to clause 3 of the EIA RS-485 standard.

5.5.2.2 Optical interface

☐ Glass fiber

☐ Plastic fiber

☐ F-SMA type connector

☐ BFOC/2,5 type connector

■ Depends on transceiver

5.5.2.3 Transmission speed

■ 9 600 bit/s

■ 19 200 bit/s

5.5.3 Link layer

There are no choices for the link layer.

5.5.4 Application layer

5.5.4.1 Transmission mode for application data

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

5.5.4.2 Common Address of ASDU

■ One COMMON ADDRESS OF ASDU (identical with station address)

☐ More than one COMMON ADDRESS OF ASDU

5.5.4.3 Selection of standard information numbers in monitor direction

System functions in monitor direction
INF Semantics

☐ <0> End of general interrogation

☐ <0> Time synchronization

☐ <2> Reset FCB

☐ <3> Reset CU

☐ <4> Start/restart

☐ <5> Power on

Status indications in monitor direction
INF Semantics

■ <16> Auto-recloser active

■ <17> Teleprotection active

■ <18> Protection active

- <19> LED reset
- <20> Monitor direction blocked
- <21> Test mode
- <22> Local parameter setting
- <23> Characteristic 1
- <24> Characteristic 2
- <25> Characteristic 3
- <26> Characteristic 4
- <27> Auxiliary input 1
- <28> Auxiliary input 2
- <29> Auxiliary input 3
- <30> Auxiliary input 4

Supervision indications in monitor direction
INF Semantics

- <32> Measurand supervision I
- <33> Measurand supervision V
- <35> Phase sequence supervision
- <36> Trip circuit supervision
- <37> I>> backup operation
- <38> VT fuse failure
- <39> Teleprotection disturbed
- <46> Group warning
- <47> Group alarm

Earth fault indications in monitor direction
INF Semantics

- <48> Earth fault L_1
- <49> Earth fault L_2
- <50> Earth fault L_3
- <51> Earth fault forward, i.e. line
- <52> Earth fault reverse, i.e. busbar

Pulsed Energy values in monitor direction (ASDU 205, FUN=133)
INF Semantics

- <51> Wp Forward
- <52> Wq Forward
- <53> Wp Reverse
- <54> Wq Reverse
- <55> Pulsed Energy Wp (active)
- <56> Pulsed Energy Wq (reactive)

Fault indications in monitor direction
INF Semantics

- <64> Start /pick-up L_1
- <65> Start /pick-up L_2
- <66> Start /pick-up L_3
- <67> Start /pick-up N
- <68> General trip
- <69> Trip L_1
- <70> Trip L_2
- <71> Trip L_3
- <72> Trip I>> (backup operation)
- <73> Fault location X in ohms
- <74> Fault forward/line
- <75> Fault reverse/busbar
- <76> Teleprotection signal transmitted
- <77> Teleprotection signal received
- <78> Zone 1
- <79> Zone 2
- <80> Zone 3
- <81> Zone 4
- <82> Zone 5
- <83> Zone 6
- <84> General start/pick-up

■ <85> Breaker failure

■ <86> Trip measuring system L_1

■ <87> Trip measuring system L_2

■ <88> Trip measuring system L_3

■ <89> Trip measuring system E

■ <90> Trip I>

■ <91> Trip I>>

■ <92> Trip IN>

■ <93> Trip IN>>

Auto-reclosure indications in monitor direction
INF Semantics

■ <128> CB 'on' by AR

■ <129> CB 'on' by long-time AR

■ <130> AR blocked

Measurands in monitor direction
INF Semantics

■ <144> Measurand I

■ <145> Measurands I, V

■ <146> Measurands I, V, P, Q

■ <147> Measurands I_N, V_{EN}

■ <148> Measurands $I_{L1,2,3}$, $V_{L1,2,3}$, P, Q, f

Generic functions in monitor direction
INF Semantics

□ <240> Read headings of all the defined groups

□ <241> Read values or attributes of all the entries of one group

□ <243> Read directory of a single entry

□ <244> Read value or attribute of a single entry

□ <245> End of general interrogation of generic data

□ <249> Write entry with confirmation

□ <250> Write entry with execution

□ <251> Write entry aborted

5.5.4.4 Selection of standard information numbers in control directions

System functions in control direction
INF Semantics

■ <0> Initiation of general interrogation

■ <0> Time synchronization

General commands in control direction
INF Semantics

■ <16> Auto-recloser on/off

■ <17> Teleprotection on/off

■ <18> Protection on/off

■ <19> LED reset

■ <23> Activate characteristic 1

■ <24> Activate characteristic 2

■ <25> Activate characteristic 3

■ <26> Activate characteristic 4

Generic functions in control direction
INF Semantics

☐ <240> Read headings of all the defined groups

☐ <241> Read values or attributes of all the entries of one group

☐ <243> Read directory of a single entry

☐ <244> Read value or attribute of a single entry

☐ <245> General interrogation of generic data

☐ <248> Write entry

☐ <249> Write entry with confirmation

☐ <250> Write entry with execution

☐ <251> Write entry abort

5.5.4.5 Basic application functions

☐ Test mode

■ Blocking of monitor direction

☐ Disturbance data

☐ Generic services

■ Private data

5.5.4.6 Miscellaneous

Measurands are transmitted with ASDU 3, as well as with ASDU 9. As defined in Section 7.2.6.8 of the protocol specification, the maximum MVAL can either be 1,2 or 2,4 times the rated value. No different rating shall be used in ASDU 3 and ASDU 9, since there is only one choice for each measurand.

Measurand	Max. MVAL = rated value times		
	1,2	or	2,4
Current L_1	■		■
Current L_2	■		■
Current L_3	■		■
Voltage L_{1-E}	■		■
Voltage L_{2-E}	■		■
Voltage L_{3-E}	■		■
Active power P	■		■
Active power Q	■		■
Frequency f	■		■
Voltage L_1 - L_2	■		■

Remarks
The following things should be noted when using SYS600 with the IEC 60870-5-103 master protocol:

1. The SU (Summer Time) of synchronization messages (Telegram Type 6) bit is not used in SYS600.
2. In the initialization sequence, SYS600 sends a general interrogation command to the IEC 60870-5-103 slave right after a confirmation to a SEND RESET message has been received. Sending of the general interrogation can be disabled by setting the RM attribute of the IEC 60870-5-103 master station.
3. The accuracy of the IEC 60870-5-103 time synchronization depends on the CPU load of the system and on the hardware used, and should be measured in each system.

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