GRID AUTOMATION PRODUCTS

MicroSCADA X SYS600 10.2

DNP 3.0 Master Protocol

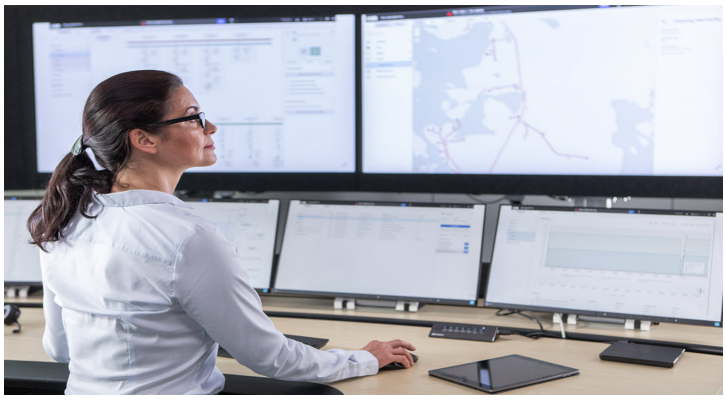

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Table of contents

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Section 2 Introduction

2.1 This manual

This manual provides thorough information on the use of DNP 3.0 Master Protocol and information related to it. It describes how to configure the base system and the communication system to establish communication to DNP 3.0 slave devices. DNP 3.0 protocol is standardized as IEEE standard 1815 - IEEE Standard for Electric Power Systems Communications -- Distributed Network Protocol (DNP3). Term DNP 3.0 is used in this manual and in the referenced tools.

2.1.1 DNP 3.0 master

The DNP 3.0 master is mainly used for a communication protocol between a SYS600 and remotely controlled process devices (RTUs) acting as DNP 3.0 slaves.

This protocol is also commonly used in NCC as upper level communication between SYS600 and a substation control system, as illustrated in Figure 1. In SYS600, the COM500*i* application is used to set up a Substation Control System.

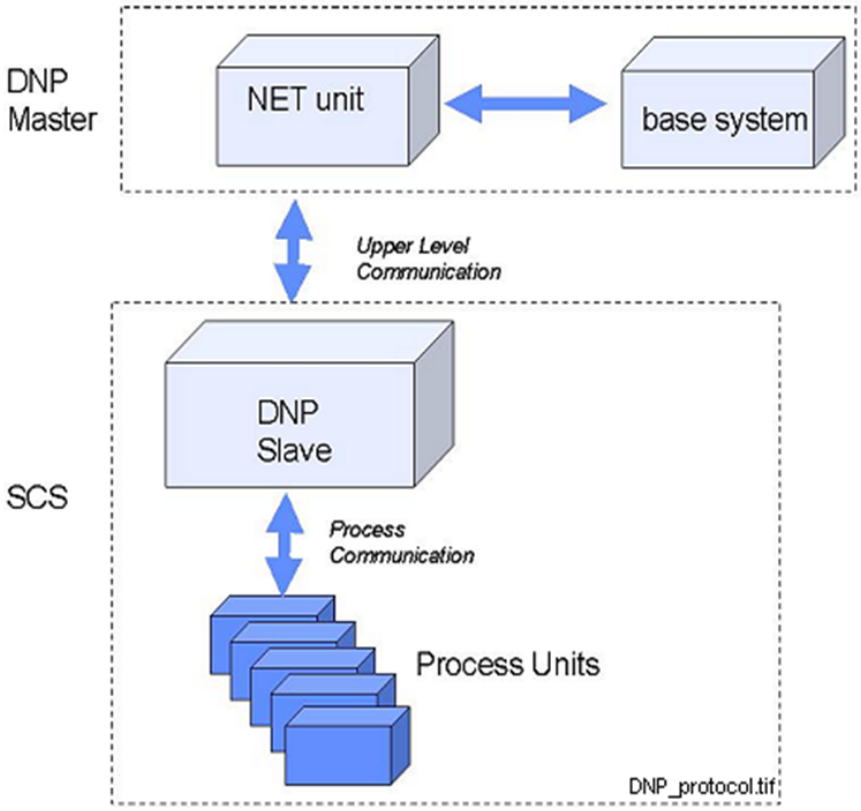

Figure 1: DNP master sees the Substation Control System (SCS) as an DNP slave

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 DNP 3.0 Slave Protocol	1MRK 511 487-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

The following documents of the DNP 3.0 protocol are available via the DNP Users Group:

- DNP 3.0 DATA LINK LAYER
- DNP 3.0 APPLICATION LAYER
- DNP 3.0 DATA OBJECT LIBRARY
- DNP 3.0 TRANSPORT FUNCTIONS
- DNP 3.0 SUBSET DEFINITIONS

The same information is presented in IEEE Standard 1815.

Other related documents:

- Product documentation of the used modem

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 DNP 3.0 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 considers each DNP 3.0 Master device as a station that has been created to a line of a NET unit. Each DNP 3.0 station works as a protocol converter that converts data between the internal protocol of SYS600 and the DNP 3.0 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).

- DNP 3.0 Master protocol uses the station type DNP (STY type 30)

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 DNP 3.0 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 DNP 3.0 protocol supports one master on a line. Figure 2 illustrates the network topologies.

The DNP 3.0 link layer supports the multiple-slave and peer-to-peer communication methods. In peer-to-peer communication, all the stations act as slave data links and collisions are possible as no station has a higher priority, and all of them can transmit spontaneously. SYS600 uses random delay of retransmission as a collision avoidance method. When DNP 3.0 over LAN/WAN is used (TCP/IP or UDP/IP), the same topologies are used. In version 9.3 FP2 and newer, it is also possible that multiple station objects are sharing the same internet address in the configuration.

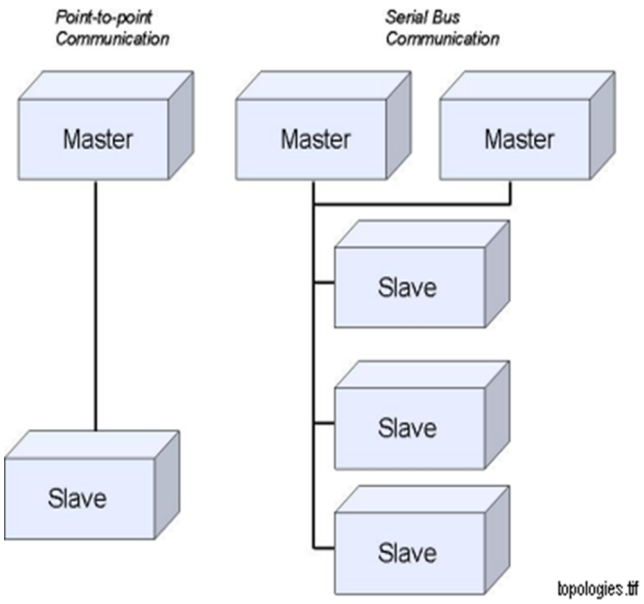

Figure 2: Point-to-point and serial bus topologies

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

4.3.2.3 DNP 3.0 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 DNP 3.0 protocol. By using the DNP 3.0 terminology, this means that the data link layer provides transfer of Link Service Data Units (LSDU) across the physical link. LSDUs are user data fragments small enough to fit into the FT3 frame format. The application layer of a NET unit is responsible for assembling and disassembling messages into LSDUs. The line layer provides frame synchronization and link control.

According to the DNP 3.0 documentation, the link layer performs the following functions:

- Exchange of LSDUs between peer DNP 3.0 data links
- Error notification to data link user
- Sequencing of LSDUs
- Prioritized LSDU delivery
- Quality LSDU delivery
- Performing message retries
- Frame Count Bit (FCB)
- Data Flow Control (DFC)
- Synchronizing and handling of the Frame Count Bit in the control word
- Setting and clearing the Data Flow Control bit based on buffer availability
- Packing user data into the defined frame format and transmitting the data to the physical layer
- Unpacking the frames that are received from the physical layer into user data
- Controlling all aspects of the physical layer
- Responding to all valid frames (function codes) received from the physical layer

Line layer attributes
The following attributes can be used for configuring DNP 3.0 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

LD	Local Address

The IP address that is used locally. It is necessary to set this attribute when the computer has multiple IP addresses and it is defined which address the created line must use. This attribute must be set before the line has been taken into use for the first time. An empty string in LD means that the default IP address of the computer is used. The value of LD cannot be modified after the line has been taken into use for the first time. This attribute is used only in LAN mode of the protocol.

Data type:	Text
Value:	String containing a valid IP address, max 230 characters.
Default value:	Empty string
Index range:	1... 12 (NET line numbering)
Access:	Read, conditional write

This attribute accepts the IP address in form:

```
#SET NET1:SLD1="192.168.1.10"
```

There is an internal limitation which prohibits the use of the same local IP address and the same line number multiple times. This applies to all PC_NET protocols using LAN.

Example:

It is not possible to have

IEC104 master in Line 1 in PC_NET 1 with LD="192.168.1.1"

and

DNP3.0 slave in Line 1 in PC_NET 2 with LD="192.168.1.1"

the configuration must be changed to

IEC104 master in Line 2 in PC_NET 1 with LD="192.168.1.1"

and

DNP3.0 slave in Line 1 in PC_NET 2 with LD="192.168.1.1"

or to

IEC104 master in Line 1 in PC_NET 1 with LD="192.168.1.1"

and

DNP3.0 slave in Line 1 in PC_NET 2 with LD="192.168.1.2"

The limitation is present only when the same local IP address is used. An easy workaround is to configure multiple IP-addresses which are using the same adapter. If this is not possible,

setting a unique value for the NET node attribute LP redefines the internally used ports for the NET node and no conflict takes place. See SYS600 System Objects manual for more information about the NET Node attribute LP.

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:	0...45 Value with DNP 3.0 Master protocol: 43
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

When using DNP 3.0 over LAN, the SD attribute defines the used connection type. Possible types are TCP and UDP.

```
#SET NET'NET':SSD'LINE' = "TCP" ;line uses TCP connection

#SET NET'NET':SSD'LINE' = "UDP" ;line uses UDP connection
```

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. The attribute is meaningless if the line operates in LAN/WAN mode.

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. The attribute is meaningless if the line operates in LAN/WAN mode.

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. The attribute is meaningless if the line operates in LAN/WAN mode.

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. The attribute is meaningless if the line operates in LAN/WAN mode.

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. The attribute is meaningless if the line operates in LAN/WAN mode.

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 (in milliseconds) between "test function of link" commands. The purpose of this command is to ensure that the communication to the slave/master is open. If this attribute is set to zero, the "test function of link" command is not sent. The link testing can also be controlled with the line attribute OM, bit 2.

Data type:	Integer
Value:	0... 65535

Table continues on next page

PD	Polling Delay
Unit:	Milliseconds
Index range:	1...12 (NET line numbering)
Default value:	5000
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

ML	Maximum Message Length

Maximum length of an outgoing data link fragment (LPDU). This length is the amount of user data without checksums.

Data type:	Integer
Value:	50...249
Unit:	Octets
Index range:	1...12 (NET line numbering)
Default value:	230
Access:	No limitations

XR	Maximum Random Delay for Retransmission

Random transmission delay is a simple collision avoidance method used in DNP 3.0 lines. When unsolicited responses are enabled for slave stations on a multi-drop line, there is a possibility that several slave devices send messages at the same time. This message collision is seen as a timeout in a slave station since the master is not responding. The XR attribute limits the possibility that two devices retransmit messages at the same time.
This attribute can also be used for setting the priorities of the slave stations: the station with the smallest retransmission delay has the highest priority. The attribute is meaningless if the line operates in LAN/WAN mode.

Data type:	Integer
Value:	0...65535
Unit:	Milliseconds
Index range:	1...12 (NET line numbering)
Default value:	0
Access:	No limitations

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

Table continues on next page

TW	Transmission Wait Delay
Index range:	1...12 (NET line numbering)
Default value:	5
Access:	No limitations

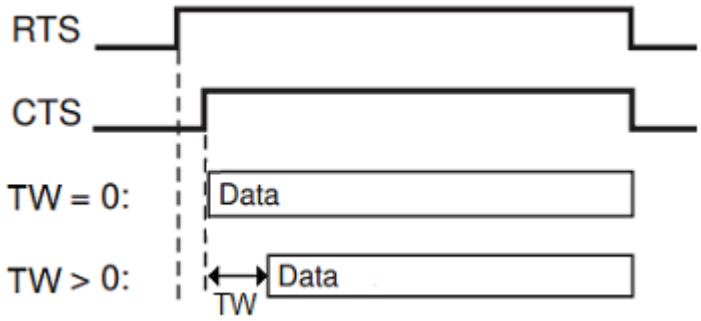

Figure 3: TW attribute

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. The attribute is meaningless if the line operates in LAN/WAN mode.

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

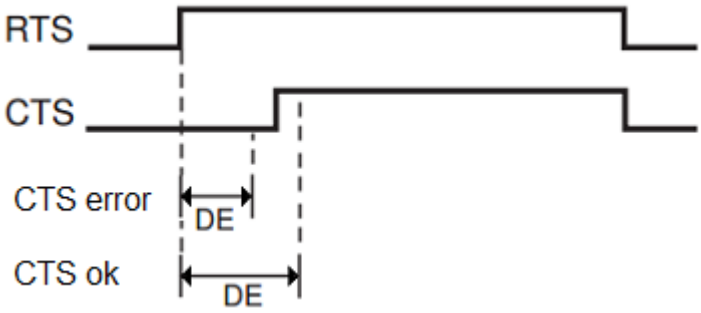

Figure 4: DE attribute

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 link layer response should have been received after the transmission of a message. If no response has been received within this time, new attempts are made the number of times specified by the Enquiry Limit (EN) attribute. 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

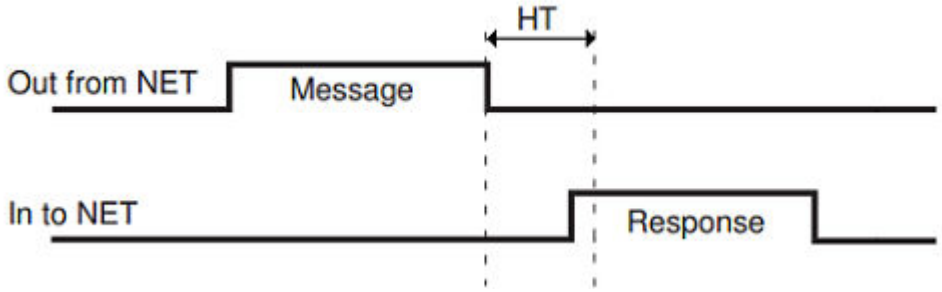

Figure 5: HT attribute

TI	Response Timeout

The time in seconds that the DNP 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

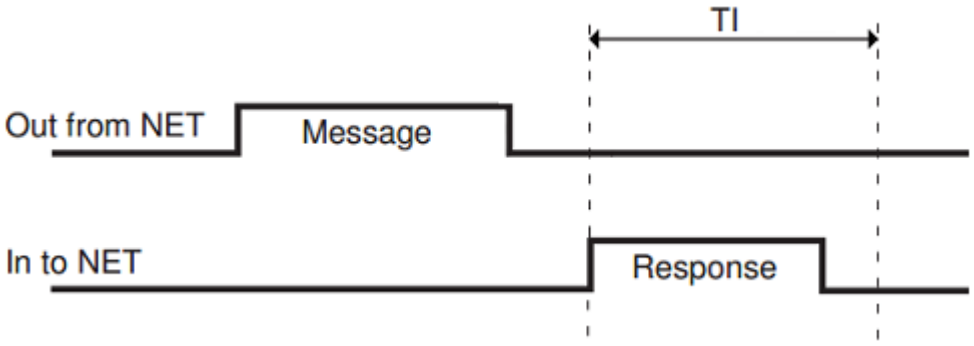

Figure 6: TI attribute

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. The attribute is meaningless if the line operates in LAN/WAN mode.

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

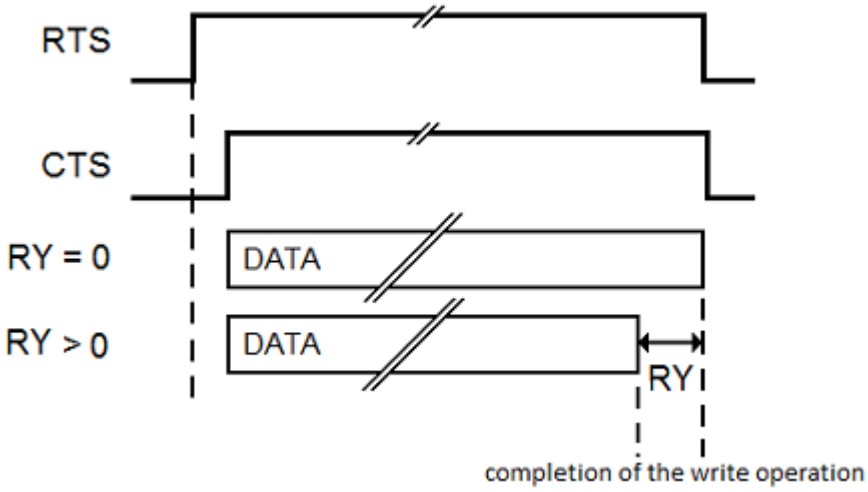

Figure 7: RY attribute

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

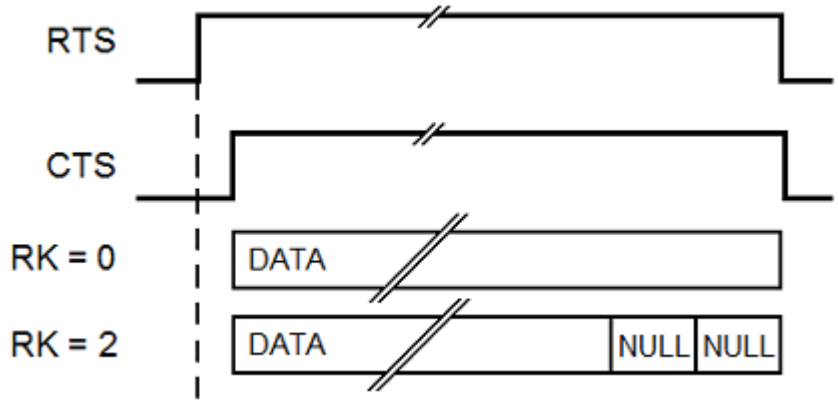

Figure 8: RK attribute

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
Unit:	Milliseconds
Index range:	1...12 (NET line numbering)
Default value:	0
Access:	No limitations

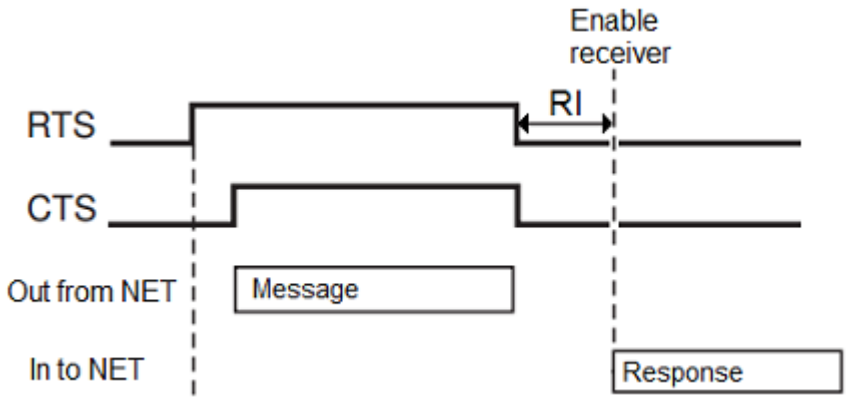

Figure 9: RI attribute

EN	**Enquiry Limit**
Specifies the maximum number of times that a message is retransmitted after a timeout.	
Data type:	Integer
Value:	1...10

Table continues on next page

EN	Enquiry Limit
Index range:	1...12 (NET line numbering)
Default value:	1
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. This attribute is meaningless if the line operates in LAN/WAN mode.

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:	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 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. 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. 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:	14: Collision detection in use, transmission when the Data Carrier Detect (DCD) signal of the line is not set. 15: No collision detection, Data Carrier Detect (DCD) signal is handled as in other protocols.
Index range:	1...12 (NET line numbering)

Table continues on next page

LK	Link Type
Default value:	15
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.

LA	Link Layer Confirmations Enabled

Determines whether the link layer confirmations are 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:	1
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 DNP 3.0 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
20. TCP connect
21. TCP accept
22. TCP close

Data type:	Integer
Value:	0...30000
Index range:	See above
Access:	Read-only, the values can be reset

OM	Operating Mode

A bit pattern, which defines the operating mode of the line.

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

Table continues on next page

OM	Operating Mode
Bit 1:	When this bit is 1, only one application layer command from the connected STA objects may be active at any one time. This configuration is useful when the collision detection is not done by the hardware. The poll intervals defined with the DP attribute define the interval with which the STA object is ready to transmit the poll. When multiple stations are connected, the real polling interval may be longer. When this bit is 0, the command's transmission is not related to the state of the other STA objects connected to a line (default). This mode of operation can be used in systems with collision detection and in the LAN configurations.
Bit 2:	When this bit is 1, the transmission of the "Test function for link" frame is disabled. This configuration may be useful when the collision detection is not done by the hardware. When this bit is 0, the transmission of the "Test function for link" frame is enabled as a default.
Bit 3:	When this bit is 1, the transmission of the "Reset of the remote link" frame is disabled. This configuration is useful when the link initialization is not needed in both directions, or if it is possible that this message collides with other transmitted frames from the other devices sharing the line. When this bit is 0, the transmission of the "Reset of the remote link" frame is enabled.
Bit 4:	When this bit is 1, the "Test function for link" messages are sent also when there is other activity on the line. In order to detect disconnections of the devices correctly, this setting may be necessary especially when the remote devices use unsolicited transmission and no frequent polls are configured for the station objects. When this bit is 0, the "Test function for link" messages are sent only when there is no line activity within the time specified by the line attribute PD. This is the default mode and it is recommended when the remote devices are polled continuously.
Bit 5:	When this bit is 1, the TCP connection to the slave device is not closed although no responses are received from the IEDs having the same IP-address. Setting this bit is needed when a serial terminal server is used and multiple STA objects are sharing the same address in IA. When this bit is 0, the TCP connection is closed by the master, if the IEDs are not responding. This is the default mode.

Example:
The "one command mode" is used when OM is given a value 2^1=2.

IT	Minimum Idle Time

This attribute is important only when LK=14, that is, the DCD signal is used to indicate if the line is busy. The IT attribute defines the minimum time from the DCD low state to the start of the transmission. When the defined time has expired and DCD is still low, the random time from 0 to XR is waited before the transmission takes place. The attribute is meaningless if the line operates in LAN/WAN mode.

Value:	0 .. 255 milliseconds
Indexing:	Line number
Access:	Read/write
Default:	0

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 DNP 3.0 station object

The main purpose of the station layer is the protocol conversion between the DNP 3.0 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 DNP 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 device communication attributes are presented in Section 5. By using the device communication attributes, messages can be sent and they can, for example, synchronize the slaves on the line.

Station objects can be configured to use DNP 3.0 Secure Authentication v2 or v5 using the attributes described in chapter 'Authentication attributes'. DNP 3.0 Secure Authentication v2 and v5 is based on IEC/TS 62351 and standards IEEE1815-2010 (v2) and IEEE1815-2012 (v5). Version v2 uses pre-shared update keys and does not contain roles for users. Version v5 is able to define users and their roles and keys on-line using DNP 3.0.

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.

Chapter 'Security attributes' describes available options for communication encryption and certificate validation using TLS (Transport layer security). Functionality follows IEC technical specification 62351-3 and IEEE1815-2012. This function is applicable only in TCP/IP mode and should be used only together with the application layer secure authentication.

Station attributes
The following attributes can be used for configuring the DNP 3.0 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.

SA	Slave Address

The station address of the DNP 3.0 slave.

Data type:	Integer
Value:	0...65534
Access:	Read, conditional write

Example:

In the example of the communication system configuration, the slave addresses are 1 and 2.

MA	Master Address

The station address of the master station. In the DNP protocol, this is the source address of each request from the master.
If multiple station objects are connected to the same line, the value of the last connected object is used. This means that all the station objects connected to a line are using the same MA value.

Data type:	Integer
Value:	0...65534
Access:	Read, conditional write

IA	Internet Address

The IP address or the hostname of the remote host. The connection is established with a device in this address using port number 20000.
If the line operates in UDP mode, it is possible to define fixed port numbers for the local port receiving responses and the remote port number to which requests are sent. See examples below.

The line needs to have been taken into use at least once before writing to this attribute. If routers/firewalls are used, it must be ensured that the defined port number is left open for connection.

Value:	Any string, max 29 characters
Access:	Read/write

When IA is read, the configured IP address is returned, but the special remote and local port numbers are not.

When written, this attribute accepts the IP address in the following form:

```
#SET STA1:SIA=”192.162.1.120”
```

or as an alias name:

```
#SET STA1:SIA=”GRACE”
```

When an alias name is used, it must be defined in the TCP host file: %windir\system32\drivers \etc\hosts.

If the remote slave device uses a non-standard port for communication in TCP mode, it can be specified as follows:

```
#SET STA1:SIA="192.168.1.120;20001" ; remote device uses port 20001
```

No spaces are allowed between the address and the port number. The port number must be in the range 1..65535.

In the UDP mode, a fixed local port is used, if it has been defined on the left side of a > separator. A fixed remote port is used, if it has been defined on the right side of the; separator. The listened IP address is defined with the line attribute LD.

```
#SET STA1:SIA="3113>192.168.0.1;3114"    ; responses are received to port
3113 and requests are sent to port 3114 (UDP only)
```

If the local or remote port is not defined, the default value 20000 is used. The local port is freely selectable, but it is not allowed to be used by any other application.

DR **Direction**

States if the DNP 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

IL **Information Address Length**

The length of the data object address (index) used in the DNP 3.0 messages.

Data type:	Integer
Value:	1 or 2
Unit:	Octets
Default value:	2
Access:	Read, conditional write

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

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:	30000 + STA object 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. If the value of the CA attribute is 0, the unidentified messages are not sent, and the bit stream object is not updated.
This process object is also updated when the object in the IED response is the time and date object (object 50 var 1).

Data type:	Integer
Value:	0...65534
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 an application data fragment (APDU).

Data type:	Integer
Value:	249...2048
Unit:	Octets
Default value:	2048
Access:	No limitations

PC **Process Data Confirmation**

By setting the value of this attribute to 0, application level confirmations can be disabled. They can be enabled and by setting the value to 1.

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

AR	Application Message Data Retries

The maximum number of retransmissions of an application data fragment (APDU). It is recommended to keep this setting at 0 and use link layer retries instead. This is also the recommended configuration of dnp.org.

Data type:	Integer
Value:	0...5
Default value:	0
Access:	No limitations

PT	Pulse Length for Control Relay Output Block

The length of the pulse used in the output commands of the control relay.

Data type:	Integer
Value:	1…4294967295
Indexing:	0 = Pulse Off time 1 = Pulse On time
Unit:	Milliseconds
Default value:	0
Access:	No limitations

EO	Event Offset

The address offset between the process objects for static data and events with the same DNP 3.0 address (index). The address of the event process object is the address of the process object for static data added with the value of this attribute. If both static data and events are wanted to be received by the same process object, this attribute must be set to 0.

Data type:	Integer
Value:	0…65535
Default value:	0
Access:	Read, conditional write

RM	Running Mode

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

Bit 1:	When this bit is 1, consequent application layer response timeouts set the station to the suspended state and the corresponding process objects are set to invalid state. The first application layer response within a timeout sets the station object state back to OK. This is the default mode of operation, and it may be needed with the command mode defined by the line attribute OM, bit 1. The limit of the consecutive timeouts is defined with the line attribute EN, the same value which is used, if the link layer responses are waited for. When this bit is 0, application layer timeouts do not set the station to the suspended state, and only an informative status message 13915 DNPC_RESPONSE_TIMEOUT is transmitted in this situation.
Bit 2:	Sending static data poll at zero (OK) status. When this bit is 0, a static data (class 0) poll request is always sent when the communication to the station is established and the object status changes to the running state. When this bit is 0, the automatic resetting (see bit 3) of the RESTART bit also causes the static data poll. When this bit is 1, a static data poll is not sent automatically at any situation.
Bit 3:	Automatic reset of the RESTART bit. When this bit is 0, the master station resets the RESTART bit of the internal indications bit of the slave station after this bit has been set by the slave. If bit 2 enables the automatic transmission of the static data poll (class 0), it is also sent after the restart bit is cleared. When this bit is 1, the RESTART bit is not reset automatically.

Table continues on next page

Bit 4: When this bit is 0, automatic time synchronization of the slave is enabled in the master mode. If the slave sets the synchronization required bit of internal indications (bit 1.4), SYS600 performs the synchronization automatically. When this bit is 1, an automatic synchronization of the slave is disabled in the master mode. The master does not send a synchronization message to the slave at all.

Bit 6: Internal indication (IIN) processing. When this bit is 0, the internal indication word included in each application layer response is not transmitted to a process object, but can only be read from the IN attribute. When this bit is 1, the internal indication word is transmitted to an analog input process object with OA=(2^24)*80 (the data object type of internal indication is 80).

Bit 7: When this bit is 0, the time synchronization is sent to the slave in local time. When this bit is 1, the time synchronization is sent to the slave in UTC time.

Data type: Integer

Value: 0...65535, see above

Default value: 2

Access: No limitations

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. APDU in queue length
11. APDU out queue length
12. TSDU in queue length
13. TSDU out queue length
14. WAIT CONFIRM queue length
15. SYS transition queue length
16. Confirmation transition queue length
17. Select transition queue length
18. Free APDUs queue length
19. Free events queue length
20. Free SYS transitions queue length
21. WAIT RESPONSE queue length
22. Unsolicited enabled bitmask
23. WAIT RESPONSE timeouts
24. WAIT CONFIRM timeouts
25. LINK CONFIRM timeouts
26. SYS transition timeouts
27. APDU receive timeouts
28. Delayed scm timeouts
29. Select timeouts
30. Cf write timeouts
31. Commanded station address
32. TCP connects
33. AUTH out queue length
34. WAIT AUTH REPLY queue length
35. WAIT PROCESSING queue length

Data type: Integer

Value: 1...65535

Index range: 1...35

Access: Read-only, the values can be reset

OS	Object Status

The current status of the DNP 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

ST	SYS Waiting Time

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

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

RT	Reply Timeout

The maximum time in seconds that the DNP 3.0 application layer waits for the first application layer fragment of the response from the slave.

Data type:	Integer
Value:	0...600
Unit:	Seconds
Default value:	10
Access:	No limitations

IN	Internal Indications

The current value of the internal indications of the DNP 3.0 Master station. See the DNP 3.0 protocol documentation for details of the internal indications. It is also possible that the internal indication word updates a process object, see attribute RM, bit 6 for more information.

Data type:	Integer
Value:	0...65535
Access:	Read

CT	Confirmation Timeout

The maximum time in seconds that the master station waits for an application layer confirmation from the slave.

Data type:	Integer
Value:	0...600
Unit:	Seconds
Default value:	10
Access:	No limitations

AT	Application Response Timeout

The time in seconds within which the application layer response from the slave must be completed. This is the maximum time from the beginning of the first fragment of the response to the end of the last fragment of the response.

Data type:	Integer
Value:	0...600

Table continues on next page

AT	Application Response Timeout
Unit:	Seconds
Default value:	30
Access:	No limitations

TT	Transport Layer Timeout

The maximum time in seconds that the transport layer is allowed to assemble one application message fragment.

Data type:	Integer
Value:	0...600
Unit:	Seconds
Default value:	10
Access:	No limitations

MT	Maximum Delayed Response Time

The maximum time that a request from SCIL is pending while some other request (such as a poll) is processed and responded by the slave device. The DNP 3.0 protocol allows one application layer transaction to be on-going at any time. If a response for a poll or some other transaction is waiting when a new request is issued from SCIL, the SCIL execution is blocked for max. MT seconds for the previous transaction to be completed.

Data type:	Integer
Value:	0...600
Unit:	Seconds
Default value:	15
Access:	No limitations

OT	Connecting Timeout

The maximum time of the TCP connect operation. The value of this attribute depends on the speed of the LAN, the remote station, and possible routers between SYS600 and the substation. It should be smaller than the HT attribute of the line, but it should be big enough to enable reliable reconnecting of the substation. In a multi-drop configuration, a too big value may cause communication disturbances, if some of the stations are not available.

Value:	0... 60000
Unit:	Milliseconds
Access:	Read, write
Default:	500 ms

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

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 (v2) 2 = Enabled, update key negotiation (v5)
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, GI or FZ.

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 analog output command using user 2

```
@P_USER = STA1:SZU
#SET STA1:SZU=2
;direct 16-bit analog output block command to index 100
#SET STA1:SCO=(5, 41, 2, 23, 1, 100, 255, 255, 255)
#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) or 'SingleUser' (Value=3) 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 keystorage in use. This flag is defined in the 'System' level in the Authority Tool.

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.
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:	For index 0, vector of max 3 integers 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) 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)) 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') (3 = Command sender is first user with role 'SingleUser') For indices > 0, vector of 10 ZV(1) Session key length ZV(2) Key wrap algorithm of the session keys (1=AES-128) (2=AES-256) ZV(3) Challenge data length critical request ZV(4) HMAC algorithm of the critical requests (1 = SHA-1) (2 = SHA-256) ZV(5) HMAC length (4 = SHA-1 serial) (10 = SHA-1 network) (8 = SHA-256 serial) (16 = SHA-256 network) ZV(6) Max error count ZV(7) Session key change count ZV(8) Key change interval in seconds ZV(9) Challenge data length session key status ZV(10) Challenge data length update key reply
Default values:	Index 0: ZV(1) : 1 ZV(2) : 32 ZV(3) : 0 Indices >0: ZV(1) : 16 ZV(2) : 1 (AES-128) ZV(3) : 8 ZV(4) : 1 (SHA-1) ZV(5) : 10 (SHA-1 network) ZV(6) : 2 ZV(7) : 1000 ZV(8) : 900 ZV(9) : 8 ZV(10) : 32
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)

#LOOP_END
```

Example 2:

```
#SET STA1:SZV0=(1,32,3); No null termination, 32 bytes certification key
for SHA-1 (Triangle Microworks configuration), commands sent using first
'SingleUser'
#SET STA1:SZV0=(3,16,2); Null termination, 16 bytes certification key for
SHA-1 (ASE2000 configuration), commands using first 'Operator'
```

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
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 32768 = 'Singleuser' (has all 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)

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.

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 DNP3.0 standard. Modifying this attribute is possible only it is enabled in the key storage using the setting 'Allow external modification of security attributes' (see attribute DZ, index 255). Modifying this attribute is not possible for functions which are not applicable. In DNP3, control commands are sent using functions 3..6 which are critical as default. With v5 authentication, the required permissions for a user are 'Operate Controls', see attribute ZO for more information. Index of the CR attribute defines the DNP3 function in question.
This attribute is not supported by the System Configuration Tool.

Value: Vector of 131 integers with values
0 = not critical
1 = critical
2 = critical only remotely (applies to function 0x00 Confirm only)
3 = critical only locally (applies to function 0x00 Confirm only)
128 = not applicable

Default values:
CR(0) : 0 (Function 0x00 Confirm)
CR(1) : 0 (Function 0x01 Read)
CR(2) : 1 (Function 0x02 Write)
CR(3) : 1 (Function 0x03 Select)
CR(4) : 1 (Function 0x04 Operate)
CR(5) : 1 (Function 0x05 Direct Operate)
CR(6) : 1 (Function 0x06 Direct Operate - no ack)
CR(7) : 0 (Function 0x07 Immediate Freeze)
CR(8) : 0 (Function 0x08 Immediate Freeze - no ack)
CR(9) : 0 (Function 0x09 Freeze and Clear)
CR(10) : 0 (Function 0x0A Freeze and Clear - no ack)
CR(11) : 0 (Function 0x0B Freeze-at-time)
CR(12) : 0 (Function 0x0C Freeze-at-time - no ack)
CR(13) : 1 (Function 0x0D Cold restart))
CR(14) : 1 (Function 0x0E Warm restart)
CR(15) : 0 (Function 0x0F Initialize Data)
CR(16) : 1 (Function 0x10 Initialize Application)
CR(17) : 1 (Function 0x11 Start Application)
CR(18) : 1 (Function 0x12 Stop Application)
CR(19) : 0 (Function 0x13 Save Configuration)
CR(20) : 1 (Function 0x14 Enable Unsolicited Responses)
CR(21) : 1 (Function 0x15 Disable Unsolicited Responses)
CR(22) : 0 (Function 0x16 Assign Class)
CR(23) : 0 (Function 0x17 Delay Measurement)
CR(24) : 1 (Function 0x18 Record Current Time)
CR(25) : 0 (Function 0x19 Open File)
CR(26) : 0 (Function 0x1A Close File)
CR(27) : 0 (Function 0x1B Delete File)
CR(28) : 0 (Function 0x1C Get File Information)
CR(29) : 1 (Function 0x1D Authenticate File)
CR(30) : 0 (Function 0x1E Abort File)
CR(31) : 1 (Function 0x1F Activate Configuration)
CR(32) : 128 (Function 0x20 Authentication request)
CR(33) : 128 (Function 0x21 Authentication request - no ack)
CR(34)..CR(128) : 128 (Functions 0x34 .. 0x80 not defined by the standard)
CR(129) : 0 (Function 0x81 Response)
CR(130) : 0 (Function 0x82 Unsolicited Response)
CR(131) : 128 (Function 0x83 Authentication Response)

Indexing : Index 0..131 (defines the function code)

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 keystorage. 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 keystorage 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. Attribute NU is used only with the v5 authentication.

Value:	When written, the name of the user to be negotiated again Special strings: "*ADD" : Add all users "*DELETE" Delete all 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 keystorage
```

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)
```

4.3.2.6 Security attributes

This chapter describes only the attribute interface related to encryption using TLS (IEC62351-3). These attributes should only be used together with the secure authentication, see Section 'Authentication attributes' and SYS600 System Configuration manual.

All TLS connections in one PC-NET instance must use same certificate and key and trusted certificate authority files, see attribute CI Certificate Information. Furthermore, all TLS connections in one PC-NET instance must use same min/max values of TLS version, see attribute CV Certificate Handling Vector

CI	Certificate Information

The CI attribute is used to define the certificate/key file and the trusted certificate authority file for the TLS communication. When set, it has an effect on all STA objects that have the same remote IP-address in attribute IA. Also, by setting both CI indices the TLS functionality is started. The certificate files location can be chosen freely, but it is recommended to place them in a folder with limited access rights to improve the security of the system. For example, use a folder where only the MicroSCADA user has access rights. Same certificate and trusted certificate authority file should be used in all STA objects configured to one PC-NET instance. This attribute is only used in TCP mode.

Value:	String containing the directory and the name of the certificate file. Only certificate file type .PEM is supported.
Indexing:	1 : Certificate and Key file 2 : Trusted certificate authority file

Table continues on next page

CI	Certificate Information
Default value:	Empty string
Access:	Read/conditional write

Example:
```
#SET STA1:SCI1="C:\Users\MicroSCADA\AppData\Roaming\ABB\MicroSCADA Pro
\Device_STA1.pem"
#SET STA1:SCI2="C:\Users\MicroSCADA\AppData\Roaming\ABB\MicroSCADA Pro
\CA_list.pem"
```

The TLS functionality is activated when both CI attribute indices are set.

CP	Certificate Passphrase

The CP attribute is used to define the passphrase to open the private key in the certificate file defined with attribute CI(1). If the certificate does not require passphrase, this attribute may be an empty string. If the creation of the self-signed certificates is enabled using attribute CV(2), the contents of this attribute is included to the passphrase of the private key of the created certificate. When set, it operates like attribute CI, that is, it has an effect on all STA objects that have the same remote IP-address in attribute IA. This attribute is used only in TCP mode.

Value:	String containing the passphrase with maximum length of 16 characters
Indexing:	No indexing
Default value:	Empty string
Access:	Read/conditional write

Example:
```
#SET STA1:SCP="96gd21"
```

CN	Common Name

The CN indices 1, 2 and 4 are used to define the Common Name, the Country Code and the Organization name of a self-signed certificate. All 3 values must be set when creating a self-signed certificate. The CN(1), the Common Name, should be the IP address of the station. In CN(2) the Country Code should be given with two capital letters. The CN(4), the Organization name, should be a single name without spaces. The name and location of the created certificate is defined using attribute CI(1). When self-signed certificate is used, the CN attribute operates like CI attribute, that is, it has an effect on all STA objects that have the same remote IP-address in attribute IA. CN indices 5 and 6 refer to Organization Unit and Domain Component and can be left empty. If set, corresponding OU and DC strings must be found from CN(3). For detailed instructions for creating a self-signed certificate, see SYS600 System Configuration manual.

If the certificate file contains multiple certificates, the CN index 3 is used for selecting a certain certificate that will be used. In CN(3), the CN(1), CN(2) and CN(4) needs to be listed and they must have the exact values that were set to the certain certificate. The format of CN(3) can be seen in the example below. If only one certificate exists in the certificate file, CN(3) can be left empty. CN attribute is used only in TCP mode.

The CN attribute indices 1, 2 and 4 are needed only when a self-signed certificate is created. The creation of self-signed certificate is selected with CV attribute bit 2 values 1 or 2.

Value:	String
Indexing:	1 : Common name of the certificate with maximum length of 64 characters 2 : Country code with maximum length of 2 characters 3 : Certificate name with maximum length of 228 characters 4 : Organization name with maximum length of 64 characters 5 : Organization Unit name with maximum length of 64 characters 6 : Domain Component with maximum length of 64 characters

Table continues on next page

CN	Common Name

Default value: Empty string

Access: Read/conditional write

Example:

```
#SET STA1:SCN1="10.10.10.1"
#SET STA1:SCN2="FI"
#SET STA1:SCN4="ABB"

#SET STA1:SCN3="CN=10.10.10.1 O=ABB C=FI"
```

Example 2:

```
#SET STA1:SCN1="10.10.10.1"
#SET STA1:SCN2="FI"
#SET STA1:SCN4="ABB"
#SET STA1:SCN5="PSS1" ; optional
#SET STA1:SCN6="COM" ; optional

#SET STA1:SCN3="CN=10.10.10.1 O=ABB C=FI OU=PSS1 DC=COM"
```

CV	Certificate Handling Vector

The CV attribute defines a set of values which control error logging and certificate handling, creation and accepting. The modification of these attributes from the defaults may decrease the total security of the system. When set, it operates like attribute CI, that is, it has an effect on all STA objects that has the same remote IP-address in attribute IA. Attribute is used only in TCP mode.
CV(1) indicates if possible error messages are logged into the MicroSCADA Notify window. If given value is 2, all SCA printouts are directed to Notify Window. This mode should be used only temporarily.
CV(2) indicates if self-signed certificates are created when the communication is started. 0, 'Never', should be used when certificates already exist. This also applies to situations in which self-signed certificates are used. With option 1, 'If not found', a self-signed certificate is created in case the certificate set in CI(1) doesn't already exist. With setting 2, 'Always', a self-signed certificate is always created even if the certificate file set in CI(1) already exists. In this case the existing file is replaced with a new file.
CV(3) indicates the action that will occur when the remote certificate validation fails. With value 0, 'Ignore, continue communication', the communication is not terminated even though the remote certificate is found faulty or cannot be authenticated. This option should only be used in special situations, for example in testing. Value 1, 'Close connection', terminates the connection when the remote certificate validation fails. This is the default behavior and it is recommended to be used. Functionality with value 3 is similar to value 1 but the certificate from remote system does not require to have the IP-address in its 'Common Name' field.
CV(4) defines the accepted certificate file type. Currently only type .pem files are supported.
CV(5) defines the minimum TLS protocol version that is accepted from the remote certificate. In case the remote device uses TLS version lower than what is defined in CV(5) the communication is terminated (unless the CV(3) is set to 0). For highest security it is recommended to use the highest TLS version possible.
CV(6) defines the maximum TLS protocol version that is accepted from the remote certificate. In case the remote device uses TLS version higher than what is defined in CV(6) the communication is terminated (unless the CV(3) is set to 0). For highest security it is recommended to use the highest TLS version possible.

Value:	Integer
Indexing:	CV(1) Error logging (0 = No error logging) (1 = Error logging to Notify window) (2 = All SCA printouts to Notify window) CV(2) Self-signed certificate generation (0 = Never) (1 = If not found) (2 = Always) CV(3) Operation when the remote certification validation fails (0 = Ignore, continue communication) (1 = Close connection) (2 = Not used) (3 = Close connection, no IP-address checking) CV(4) Type of the certificate store (0 = .pem file) CV(5) Minimum TLS version (31 = TLS 1.0/SSL 3.1) (32 = TLS 1.1/SSL 3.2) (33 = TLS 1.2/SSL 3.3) CV(6) Maximum TLS version (31 = TLS 1.0/SSL 3.1) (32 = TLS 1.1/SSL 3.2) (33 = TLS 1.2/SSL 3.3)

Table continues on next page

CV	Certificate Handling Vector
Default values:	CV(1) : 0 CV(2) : 0 CV(3) : 1 CV(4) : 0 CV(5) : 33 CV(6) : 33
Access:	Read/conditional write

For the configured TLS versions to become valid, they must be set before the station and the line are taken into use for the first time. If the TLS versions are changed afterwards, the PC-NET must be restarted for the changes to become valid.

The minimum TLS version must be equal or lower than the maximum TLS version.

```
#SET STA1:SCV1=1 ; enable error logging to notify window
#SET STA1:SCV5=31 ; Set minimum TLS version to 1.0
Example:
#SET STA1:SCV6=33 ; Set maximum TLS version to 1.2
```

EE	Encryption Error

The EE attribute is used to return the last error code occurred in encryption. The value is the same for all STA objects that have the same remote IP-address in attribute IA. See Status Codes manual for error descriptions, chapter CSA SCA error codes. Attribute is used only in TCP mode.

Value:	Integer
Indexing:	No indexing
Default value:	0
Access:	Read-only

4.3.2.7 Autodialing attributes

SYS600 provides support for the Autocaller functionality of the DNP 3.0 Master protocol. Autocaller is a modem with functions for automatic dial-up. The dial-up can be initiated by the DNP master or the DNP 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 DNP 3.0 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.

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 DNP 3.0 slave the process database should contain a process object whose value changes after process data is received.

Besides the configuration of the base system and the communication system, the DNP 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:

- For serial lines, Clear to Send (CTS) and Data Carrier Detect (DCD) signals. With the DNP 3.0 Master protocols, both of these signals should be active in the slave end of the line as follows:
- When collision detection is not in use (the LK attribute of the line is 15), the Carrier Detect signal is always active and the Clear to Send signal is active when the master station is transmitting.
- When collision detection is in use (the LK attribute of the line is 14), the Clear to Send signal is active when the master station is transmitting, and the master station transmits only when the Carrier Detect signal is inactive, which means that no other station on the line is transmitting.
  The Data Terminal Ready (DTR) signal is kept in signaled state when the line in use. 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 DNP slave station should be 0.
- By connecting a serial line analyzer to the DNP line (serial mode) or listening to the LAN using a network analyzer software (TCP and UDP modes).

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 DNP 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 11 should be used if collision detection is used (the LK attribute of the line is 14).

When connecting several remote devices to one line when collision detection is used, a more sophisticated wiring is needed. The connections should be made in a way that when the Request to Send signal of any slave device is set as an indication that the station is transmitting, the Carrier Detect signal in all other slave IEDs are set.

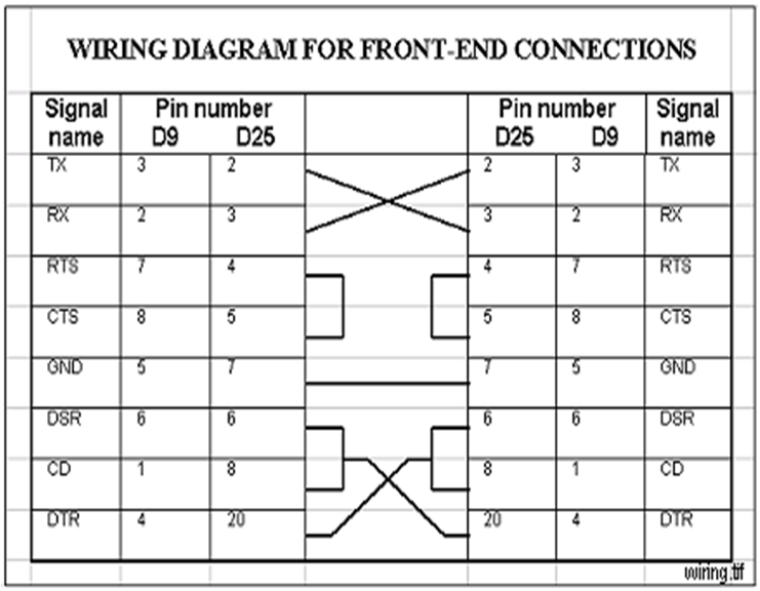

Figure 10: Serial cable wiring diagram when collision detection is not used

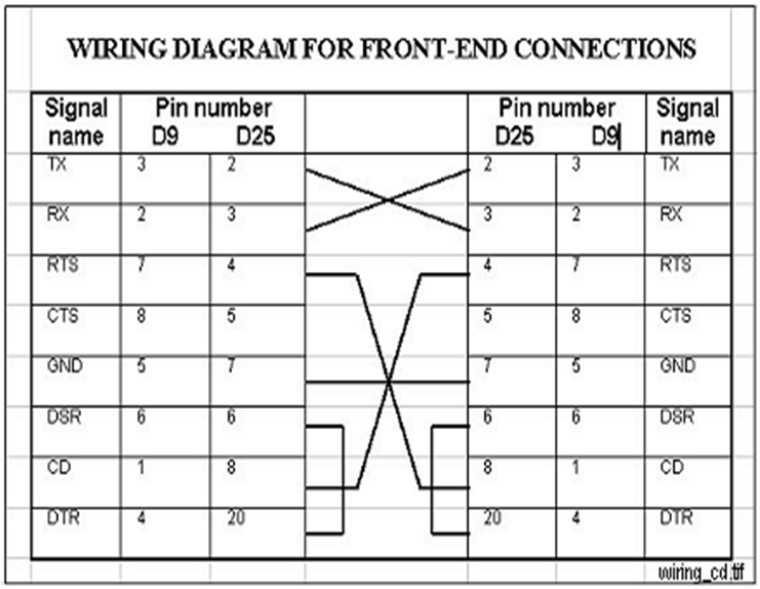

Figure 11: Serial cable wiring diagram when collision detection is used

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. Note that these advices are for serial line only.

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.

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:

- 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 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 DNP 3.0 Protocol

The Distributed Network Protocol (DNP) 3.0 is a standard-based communication protocol designed for electric utility, water, oil and gas, and security systems. DNP is hardware-independent and works with a variety of networks enabling communication between substation computers, Remote Terminal Units (RTUs), Intelligent Electronic Devices (IEDs) and master stations over serial or LAN-based systems. DNP3 is standardized as IEEE standard 1815.

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

- Physical layer
- Data link layer
- Transport layer
- Application layer

The DNP 3.0 transport layer is a pseudo-transparent layer that provides minimum message assembly and disassembly. The purpose of the transport layer is to provide support for application messages larger than the frame length of the data link.

The physical layer can be any bit-serial physical layer, for example RS-232 C, RS-485, a fiber transceiver or Ethernet. 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

DNP 3.0 has three subset levels from 1 to 3, which each include a specific subset of DNP message types and functionality. In SYS600 the DNP 3.0 protocol has been implemented according to the Subset Level 2 of the protocol (DNP 3.00–L2) as presented in Table 19

Each DNP 3.0 message contains a function code that describes the purpose of the messages. The function codes in Table 1 are supported in SYS600:

Table 1: The function code describes the purpose of the message

Code	Function	Description
Transfer Function Codes		
0	Confirm	Message Fragment confirmation.
1	Read	Request objects from outstation.
2	Write	Store specified objects to outstation.
Control Function Codes		
3	Select	Select the output point of outstation.
4	Operate	Set the output that has previously been selected.
5	Direct operate	Set the output directly.
6	Direct operate, no ack	Set the output directly.
Freeze Function Codes		
Table continues on next page		

Code	Function	Description
7	Immediate Freeze	Copy the specified objects to freeze buffer. Respond with status of operation.
8	Immediate Freeze, no ack	Copy the specified objects to freeze buffer.
9	Freeze and Clear	Copy the specified objects to freeze buffer and clear objects.
10	Freeze and Clear, no ack	Copy the specified objects to freeze buffer and clear objects. No response.
Application Control Function Codes		
13	Cold Restart	Perform desired reset sequence.
14	Warm Restart	Perform desired partial reset operation.
Time Synchronization Function Codes		
23	Delay Measurement	Perform propagation delay measurement.
32	Authentication Request	Authentication message to outstation
Response Function Codes		
0	Confirm	Message fragment confirmation.
129	Response	Response to requested message.
130	Unsolicited Message	Spontaneous message without request.
131	Authentication Response	Authentication message from outstation

For more details about the implementation of the DNP 3.0 protocol in SYS600, see the device profile in the end of this document.

5.3 Communication

This section gives a more detailed description of the implementation of the DNP 3.0 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 DNP 3.0 Master status codes.

5.3.1 Communication modes

A communication mode describes how messages are sent between the DNP 3.0 master and the slave by polling, by means of unsolicited messages, or by both methods. The following four cases can be identified:

- Quiescent Operation. In this mode the master does not poll the slave, all the communication is based on unsolicited (spontaneous) report-by-exception messages. The master can send application layer confirmations to the slave.
- Unsolicited Report-by-Exception Operation. The communication is basically unsolicited but the master occasionally sends integrity polls for Class 0 data to verify that its database is up-to-date.
- Polled Report-by-Exception Operation. The master frequently polls for event data and occasionally for Class 0 data.
- Static Report-by-Exception Operation. The master polls only for Class 0 data or the specific data it requires.

When connecting SYS600 to a DNP 3.0 slave or slaves, the operation mode of the slaves should be identified and the configuration of the DNP 3.0 line and station in SYS600, especially the data polling, should be modified to fit the communication mode in question. This is described in detail in Section 5.4.

5.3.2 Protocol converter

Each DNP 3.0 Master station configured on a line of a NET unit acts as a protocol converter between the DNP 3.0 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 DNP, there are basically two kinds of data: static data and event data. Static data in DNP is called class 0 data. Event data can have three different classes or priorities: 1 (high priority), 2 (medium priority) and 3 (low priority). In DNP terminology static data objects are called by their data type. For example, binary input and analog input. Corresponding events are called by adding "change" to the static data object. For example, "binary input change" and "analog change".

Both the static and event data, can be sent from the slave to the master in two ways:

1. The master polls it cyclically or when needed.
2. It is sent to the master spontaneously as unsolicited messages.

A combination of these two ways is also possible. From this point of view DNP 3.0 implements both the balanced and unbalanced transmission procedures.

5.3.3 Handshaking

By default, NET sends spontaneous "test function of link" messages to the DNP 3.0 line in order to check that the communication link is open. The message is sent at intervals specified by the PD attribute of the line. If the DNP 3.0 master does not acknowledge this message, the communication is marked as broken.

Sending the "test function of link" messages can be disabled by setting both the PD and LA attributes of the line to zero or by setting the line attribute OM, bit 2. It must be noted that in this case the state of the communication link is not supervised at regular intervals.

5.3.4 DNP 3.0 in LAN/WAN

The DNP V3.0/LAN protocol is used in LAN and WAN networks to connect central stations and outstations to each other. Since the stations use an open TCP/IP interface as a connection to the network, the structure and characteristics of the network used are invisible to the application. The transferred data messages are equal to the ones used in the serial line based on the DNP 3.0 protocol. When operating as a DNP 3.0 master, SYS600 is the client-end of the connection.

SYS600 is able to keep several connections to controlled stations open at the same time. In the TCP mode, multiple DNP 3.0 master lines can be created in the same computer. In the UDP mode, only one DNP 3.0 master or slave line can be created. The connection type is defined with the line attribute SD. The host internet address (server) is defined with the station attribute IA. Configuration examples for the LAN connection are given in Appendix A.

5.3.5 Addressing

In the DNP 3.0 protocol each link layer message has two addresses: SOURCE address indicates from which station the message is coming and DESTINATION address tells to which station the message is going. When configuring a DNP 3.0 Master station in SYS600, the MA (Master Address) attribute should be equal to the SOURCE address and the SA (Slave Address) equal to the DESTINATION address.

In the DNP 3.0 terminology a data point address is called an index. Several data points of the different data object type, for example, binary input and analog input, can have the same index. An individual data point is identified with the combination of data object type and index.

Since in SYS600 the process object addresses are unique within one application, the different data object types are separated into index ranges by giving each data object type an address offset. The addresses of two process objects of different types do not overlap even if the corresponding DNP 3.0 indices are equal. The address (OA attribute) of a process object is calculated as follows:

OA = OFFSET + INDEX

The address offsets used in SYS600 are calculated as follows:

OFFSET = (2^24)* DATA_OBJECT_TYPE

Address offset for different data object types are given in Table 2.

Table 2: Address offsets of data object types

Data Object Type	Process Object Type	Offset
Binary input	Binary input, double binary indication (sent as two consequent binary inputs)	16777216
Double bit binary input	Double bit binary input	50331648
Binary output status	Binary input	167772160
Control relay output block	Binary output	201326592
Binary counter Frozen counter	Pulse counter Pulse counter	335544320 352321536
Analog input	Analog input	503316480
Analog output status	Analog input	671088640
Analog output block	Analog output	687865856
Security statistics	Analog input	2030043136

The object type double binary indication reserves two addresses.

By default, a static data object and the corresponding event has the same address. The static data object type always determines the address offset. If static data and events are wanted to be received in separate process objects, it can be achieved by giving the EO (Event Offset) attribute a non-zero value. In this case the addresses of the static data object and the corresponding event is calculated as follows:

STATIC_OA = OFFSET + INDEX

EVENT_OA = OFFSET + INDEX + STAn:SEO

The process object address of an analog input process object with index 1255 would be: OA = 503316480 + 1255 = 503317735

For security statistic objects, INDEX is between 1..17, that is, the values read from the outstation are the same as the diagnostic counters described with attribute DZ.

When using the Process Object Tool of the SYS600 base tools, the due address offset is added automatically and the address given in the tool is the index. The size of the address range (one

or two bytes) is determined by the IL (Information Address Length) attribute of the DNP 3.0 master station.

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 user wants this feature, for example, a command and the corresponding indication having the same address, 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.

5.3.6 Internal indications

Each response message sent by the slave contains a two-octet field called internal indications, which indicates the current state of the slave device. This information can be used to monitor the state of the slave or for troubleshooting purposes.

The internal indications sent by the DNP 3.0 slave can be read by using the IN attribute of the DNP 3.0 master station and if the bit 6 of the RM attribute is set, the reading can be done from a process object as well. See the RM attribute description for more information.

The bits of the internal indications are as presented in Table 3.

Table 3: Bits of the internal indications

Octet	Bit	Description
1	0	All stations message received
1	1	Class 1 data available
1	2	Class 2 data available
1	3	Class 3 data available
1	4	Time-synchronization required from the master
1	5	Some or all of the Outstation's digital output points are in local state
1	6	Device trouble
1	7	Device restart
2	0	Function code not implemented
2	1	Requested object(s) unknown
2	2	Parameters in the qualifier, range or data fields are not valid or out of range
2	3	Event buffer(s), or other application buffers overflow
2	4	Request understood but the requested operation is already executing
2	5	The current configuration in the slave is corrupt
2	6	Currently always returned as zero (0)
2	7	Currently always returned as zero (0)

For example, if the value of the IN attribute is 144 = 0000000010010000, it means that the slave should be synchronized (octet 1, bit 4) and the slave device has restarted (octet 1, bit 7).

5.3.7 Device communication attributes

GI	General Interrogation

By using the GI attribute a request for all static (class 0) data can be made. This corresponds to a general interrogation command used in other protocols.

Data type:	Integer
Value:	1
Access:	Write only

SY	Synchronize

The SY attribute is used to make an accurate time synchronization of the DNP 3.0 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 DNP 3.0 line.
By using the "do the first delay" measurement option (FUNC = 2), the synchronization can be corrected with the delay of the application layer of the slave. This can be done by sending a command to the slave to measure its delay. This information is then used for correcting the actual synchronization. FUNC=2 is not recommended in LAN/WAN mode because of the inconsistent transmission delays in the network.

Data type:	Vector
Value:	(FUNC, [BRO])
Access:	No limitations

Description of the vector parameters:

FUNC:	Function code as follows: 1 = direct time setting 2 = time setting with preceding delay measurement 3 = time setting using func 24, record current time
BRO:	Broadcast determines whether the synchronization message is a broadcast message (value 1) or not (value 0). If omitted, value 0 is assumed. Broadcast is not possible with FUNC value 2 and is not currently supported with FUNC value 3. Broadcast is not possible in LAN/WAN mode.

CO	Command Out

The CO attribute can be used for generating command messages, that is, requests, to DNP 3.0 slave stations. All kinds of commands can be generated
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 DNP 3.0 standards listed in Section 2.1.

Data type:	Vector
Value:	(FNC, [TYPE, VAR, QUAL, [TDT]])
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:	
FNC:	Function code of the command, integer
TYPE:	Data object type of the command, integer
VAR:	Variation of the command, integer

Table continues on next page

Description of the vector parameters:

QUAL: Qualifier of the command, integer

TDT: The set of information objects of the command as integers. Each integer corresponds to one octet in the DNP 3.0 message.

Example:

```
;direct 16-bit analog output block command to index 100
#SET STA1:SCO=(5, 41, 2, 23, 1, 100, 255, 255, 255)
```

FZ Freeze Counters

The FZ attribute can be used for freezing the binary counters of the DNP 3.0 slave.

Data type: Integer

Value:
7 = immediate freeze
8 = immediate freeze, no acknowledgement
9 = freeze and clear
10 = freeze and clear, no acknowledgement

Access: Write-only

DP Data Poll

By using the DP attribute the user can configure the data polling of the DNP 3.0 master station.

Data type: Vector

Value:
When writing:
Index 0: vector (PI, NUM)
Other indices: vector (PI, TYPE, VAR, FIRST, LAST)
When reading:
Index 0: vector (PI, NUM, STATUS, TIME)
Other indices: vector (PI, TYPE, VAR, FIRST, LAST,

Index range:
0...50
0 = event poll
1..50 = freely defined polls

Access: No limitations

Description of the vector parameters:

PI: Polling interval as hundreds of milliseconds (0,1s).

NUM: Number of events to be polled. Value 0 = all events.

TYPE: Data object type to be polled, integer.

VAR: Variation to be polled. Value 0 = all variations
Special values with data object type 60, Class Data:
VAR= 255 -> Class 1/2/3 poll is issued
VAR= 0 -> Class 1/2/3/0 poll is issued.

FIRST: Lower limit of the index range. If 0, all data points with the given data object type and variation are polled. If data object type 60, Class Data, is polled, this value is 0.

LAST: Upper limit of the index range, integer. If 0, all data points with the given data object type and variation are polled. If data object type 60, Class Data, is polled, this value is 0.

STATUS: The result of the polling as a bit mask. The bits of the STATUS parameter are as in the table below.

TIME: Time left until the next request.

Table 4: Bits of the STATUS parameter

Bit	Description
0	Data not polled yet
1	No connection to the slave
2	Response timeout

Table continues on next page

Bit	Description
6	Device trouble
8	Function code not implemented in the slave
9	Requested object(s) unknown, meaning that the requested data does not exist in the slave
10	Parameters in the qualifier, range or data fields are not valid or they are out of range
11	Event buffer(s), or other application buffers overflow
12	Request understood but requested operation is already executing
13	Current configuration in the slave is corrupt

For example, if the value of the status parameter is 512 = 0001000000000, the parameter error bit (bit 10) is set.

Data object types and variations supported by SYS600 are listed in Table 1. It is possible to poll all static data (class 0) and events (classes 1…3) by using the DP attribute by setting the TYPE parameter to 60 and variation to class number + 1.

The following examples illustrate the use of the DP attribute.

```
;1,5 second event poll, all events
#SET STA1:SDP0 = (15,0)
;2 second poll for binary inputs, all variations, all objects
#SET STA1:SDP1 = (20,1,0,0,0)
;3 second poll for 32-bit analog inputs (var 3) with index 100…500
#SET STA1:SDP1 = (30,30,3,100,500)
```

5.4 Configuring data polling

The DNP 3.0 protocol provides versatile possibilities for data polling: data can be polled based on the data object type, variation, index range, class and count. It can also be polled, with certain restrictions, based on a combination of these parameters.

The way the data polling is executed is also different in the DNP 3.0 protocol compared to many other protocols. While for example in the IEC 60870-5-101 polling is fixed and standard background operations, the data polls, or requests, are application level messages, in the DNP 3.0 protocol and they can be configured in a different way in each DNP 3.0 master device. For this reason SYS600 does not send any cyclical data polls by default, requests must be configured using the DP attribute of the DNP 3.0 master station. The only automatic poll is a request for static (class 0) data when the device gets the OK status, that is, at start-up or after a communication disturbance, unless this feature is disabled by the RM (Running Mode) attribute of the DNP 3.0 master station.

Another dimension of the data polling is the fact that some DNP 3.0 slaves are able to send some or all of their data as unsolicited spontaneous messages, while some slave devices require all the data to be polled. One example could be a device that sends all the binary events as unsolicited messages while all static data, binary and analog, must be requested by the master. In this case, polling the binary events would be unnecessary and cause unnecessary transmissions on the DNP 3.0 line.

All the facts mentioned above lead to the conclusion that it is very important to configure the data polling of the DNP 3.0 master according to the functionality of the slave or slaves. If not, it may result in decreased performance or missing data.

The following examples give instructions on how to configure the data polling for the four different communication modes listed in Section 5.3.1. These are only examples, in each project the data polling must be matched to the actual slave device. The implementation of the slave can be checked from the device profile or other documentation of the slave.

5.4.1 Quiescent operation

All the communication is based on unsolicited messages; no data polling is needed.

In this case no configuration using the DP attribute is needed. The automatic class 0 poll at OK status can be disabled by using the RM attribute of the DNP 3.0 master station.

5.4.2 Unsolicited report-by-exception operation

Communication is basically unsolicited, only integrity poll is needed.

Cyclical integrity poll for static (class 0) data can be configured as follows:

```
;request class 0 data every 5 minutes
#SET STA1:SDP1 = (3000,60,1,0,0)
```

5.4.3 Polled report-by-exception operation

Event data (classes 1...3) is polled frequently and static data occasionally.

This poll configuration can be made as follows:

```
;request all events every 2 seconds
#SET STA1:SDP0 = (20,0)
;request class 0 data every 20 seconds
#SET STA1:SDP1 = (200,60,1,0,0)
```

Events can also be polled class by class:

```
;request class 1..3 data every 2 seconds
#SET STA1:SDP2 = (20,60,2,0,0)
#SET STA1:SDP3 = (20,60,3,0,0)
#SET STA1:SDP4 = (20,60,4,0,0)
```

5.4.4 Static report-by-exception operation

The master polls only for Class 0 data or the specific data it requires.

This poll configuration can be made as follows:

```
;request binary inputs every 5 seconds
#SET STA1:SDP1 = (50,1,0,0,0)
;request analog inputs and binary counters every 15 seconds
#SET STA1:SDP2 = (150,30,0,0,0)
#SET STA1:SDP3 = (150,20,0,0,0)
```

Another example shows how to poll a certain variation or index range:

```
;request binary inputs with status (var 2) every 5 seconds
#SET STA1:SDP1 = (50,1,2,0,0)
;request analog inputs with index 1…100 and 150…200 every 15 seconds
#SET STA1:SDP2 = (150,30,0,1,100)
#SET STA1:SDP3 = (150,20,0,150,200)
;request binary counters every 15 seconds
#SET STA1:SDP3 = (150,20,0,0,0)
```

In the quiescent operation mode static data is sent to the master as unsolicited messages only at start-up and when the status of a data point changes. Besides these situations, data must be sent as change events or by means of polling.

5.4.5 Input data

Input data, such as binary inputs and analog inputs, are received in input process objects. Table 5 lists the process object attributes that are updated when a message is received from a DNP 3.0 slave.

Table 5: Process object attributes updated from a DNP message

Attribute	Values	Description
OV	-	Value of the information object. Data type depends on the data object type.
OS	0…10	Object status, calculated from the bits of the flag byte and the internal indications.
QL	0…255	Flag byte of the data object.
IV	0, 1	On-line bit of the flag byte.
NT	0, 1	Communication lost bit of the flag byte.
BL	0, 1	Chatter filter bit of the flag byte. Only with binary objects.
SB	0, 1	Local forced and remote forced bits of the flag byte.
OR	0, 1	Overflow bit of the qualifier. Only with analog objects.
OF	0, 1	Roll-over bit of the flag byte. Only with binary counter objects.
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).

In DNP 3.0 there are variations with and without flag, that is, status information. The status of a data object is indicated by using a flag byte that consists of eight bits, each of which represents a property of the data object. The bits used depend on the data object type and are shown in Table 6. The attributes that are updated based on the flag byte are shown in Table 5.

Table 6: Bits of the flag byte

Bit	Description	Pobj. type
On-line (Bit 0)	The on-line bit indicates that the binary input point has been read successfully (bit is set). If this field is set to off-line (bit is not set), the state of the digital point may not be correct.	All
Restart (Bit 1)	The restart bit set indicates that the field device which originated the data object is currently restarting. This can be the device reporting this data object.	All
Communication lost (bit 2)	The communication lost bit set indicates that the device reporting this data object has lost communication with the originator of the data object.	All
Remote forced data (Bit 3)	The remote forced data bit indicates that the state of the binary input has been forced to its current state at a device other than the end device.	All
Local forced data (Bit 4)	The local forced data bit indicates that the state of the binary input has been forced to its current state at the end device.	All
Table continues on next page		

Bit	Description	Pobj. type
Chatter filter (Bit 5)	The chatter filter bit indicates that the binary input point has been filtered in order to remove unneeded transitions in the state of the point.	Binary input
Roll-over (Bit 5)	When set, the roll-over bit indicates that the accumulated value has exceeded the last reported recordable. The counter value has been reset to 0 upon the roll-over and counting has resumed as normal. This bit is cleared when the counter value (plus the roll-over state) is reported.	Pulse counter
Over range (Bit 5)	The out of range field indicates that the digitized signal or calculation has exceeded the value range.	Analog input

The internal indications parameter sent by the DNP 3.0 slave contains a status bit which the slave can use to indicate that it needs synchronization and the time stamps it is sending may be invalid. The value of the OS (Object Status) attribute of an input process object is calculated from the bits of the flag byte and the internal indications as in the following:

```
if “off-line” then (*on-line bit is not set*)
OS = 1
Elseif “communication lost" then (*communication lost bit set*)
OS = 2
Elseif “Timesync required bit set in IIN” then (*need time bit of IIN
set*)
OS = 3
Else
OS = 0
```

The following sections give a brief description of each SYS600 input process object type and the corresponding DNP 3.0 data object types.

By default, both static data objects and events with the same index are received in the same process object. If these are to be separated, it can be done by using the EO (Event Offset) attribute of the DNP 3.0 master station.

Events in the DNP 3.0 protocol can be sent in one of the following three ways:

- Without time. This kind of event does not contain a time stamp and it can be considered as a notification of a change in the value of the static data point.
- With time. This kind of event contains a time coded as milliseconds from 1 January 1970 00:00:00.000.
- With relative time. Relative time means that first the slave sends a base time object and the events sent after the base time contain a timestamp relative to the base time.

5.4.5.1 Analog inputs

Analog inputs and analog change events are received in the DNP 3.0 analog input process objects. The data object types and variations listed in Table 7 are supported by SYS600.

Table 7: Analog input data object types and variations

Obj	Var	Description	Value
30	1	32-bit analog input	S32
30	2	16-bit analog input	S16
30	3	32-bit analog input without flag	S32
30	4	16-bit analog input without flag	S16
30	5	32-bit single precision floating point analog input	F32
32	1	32-bit analog change event without time	S32

Table continues on next page

Obj	Var	Description	Value
32	2	16-bit analog change event without time	S16
32	3	32-bit analog change event with time	S32
32	4	16-bit analog change event with time	S16
32	5	32-bit single precision floating point analog change event without time	F32
32	7	32-bit single precision floating point analog change event with time	F32

In DNP 3.0, analog values are integers. Value ranges are as follows:

S16 = signed 16-bit integer = -32768…32767

S32 = signed 32-bit integer = - 2147483648…2147483647

F32 = 32-bit floating point number = -3.4x10^38 ... 3.4x10^38 (approximately)

5.4.5.2 Single and double indications

The DNP 3.0 protocol has a somewhat exceptional approach to the handling of binary data. Binary data in a DNP 3.0 application is considered as a sequence of bits and it is up to the application to decide how they are used (as single or double indications or even as a bit mask).

SYS600 supports binary input and double binary input process objects for DNP. A binary input is a one-bit signal and a double binary is a two-bit signal whose bits are two binary inputs with consecutive indices (DNP addresses). These two bits can be sent from the DNP 3.0 slave in separate messages and the connection to one process object is done internally in SYS600. The following data object types and variations are supported:

Table 8: Binary input data object types and variations

Obj	Var	Description
1	1	Binary input.
1	2	Binary input with status.
2	1	Binary input change without time.
2	2	Binary input change with time.
2	3	Binary input change with relative time.
3	1	Double-Bit binary input
3	2	Double-Bit binary input with status.
4	1	Double-Bit binary input change without time.
4	2	Double-Bit binary input change with time.
4	3	Double-Bit binary input change with relative time.

Process object of type DNP/Double indication must be used, if the remote IED sends double indications using two consequent data items with object 1 or 2. Process objects of type DNP/Double-bit binary input must be used, if the double indications are sent using object 3 or 4. See the device profile or the manual of the slave device for more information on the object types used by the IED.

If a process object of type DNP/Double indication is used, the Alarm Delay must be set. This is because two bits are received in two different messages and there may be a delay between them. To prevent faulty values, a small alarm delay must be added to the process object. See the attribute definition of the AD process object in SYS600 Application Objects.

Each process object of type DNP/Double Indication reserves two consecutive addresses in the SYS600 process database. This should be taken into account when giving addresses.

Both bits of a process object of type DNP/Double Indication must be updated by static data, for example by a class 0 request, before the object is updated by a change event.

5.4.5.3 Pulse counters

Pulse counters are termed binary counters in the DNP 3.0 protocol. Counters can be either 16-bit or 32-bit. The DNP 3.0 protocol also has a data object type called frozen counter, which is a binary counter frozen to the value it had when the master sent a freeze counters command. This is a way get a snapshot of the counters.

Binary counters and counter events are received by DNP 3.0 pulse counter process objects. Frozen counters are received by DNP frozen binary counter process objects. SYS600 supports the data object types and variations listed in Table 9.

Table 9: Binary counter data object types and variations

Obj	Var	Description	Value
20	1	32-bit binary counter	U32
20	2	16-bit binary counter	U16
20	3	32-bit delta counter	U32
20	4	16-bit delta counter	U16
20	5	32-bit binary counter without flag	U32
20	6	16-bit binary counter without flag	U16
20	7	32-bit delta counter without flag	U32
20	8	16-bit delta counter without flag	U16
21	1	32-bit frozen counter	U32
21	2	16-bit frozen counter	U16
21	9	32-bit frozen counter without flag	U32
21	10	16-bit frozen counter without flag	U16
22	1	32-bit counter change event without time	U32
22	2	16-bit counter change event without time	U16
22	5	32-bit counter change event with time	U32
22	6	16-bit counter change event with time	U16

Value ranges are as follows:

U16 = unsigned 16-bit integer = 0…65535

U32 = unsigned 32-bit integer = 0…4294967295

5.4.6 Status of output objects

DNP 3.0 provides data object types for the status of binary and analog output objects. These data objects indicate the value and status of the corresponding output objects and can be requested as any other data from the slave. The following data object types and variations are supported:

Table 10: Data object types and variations for status of output objects

Object	Variation	Description
10	2	Binary Output Status
40	1	32-bit Analog Output Status
40	2	16-bit Analog Output Status
40	3	32-bit floating point Analog Output Status

Status of an output object is the status of a binary or analog output object of the DNP 3.0 slave, not the DNP 3.0 master.

5.4.7 Output data

5.4.7.1 Command handling in DNP protocol

Requests and responses
Messages from the master to the slave are called requests in the DNP 3.0 protocol. A request can be a request for data or a latch relay command. The slave replies to a request with a response that can contain the requested user data or the status of a command.

Unlike in some other protocols in DNP 3.0 all data polling is handled by application layer requests. Since only one request can be open, that is, waiting for a response, at any one time, a new request cannot be issued before the previous request has received its response or a time-out has occurred. This means that if a data poll configured by using the DP attribute is waiting for a response, a command sent from SCIL is not issued until the handling of the poll is completed.

Overlapping requests are handled in SYS600 as follows: if a new request is issued from SCIL while another is waiting for the response, execution of SCIL is paused until the previous request is completed or the time defined by the MT (Maximum Delayed Response Time) expires. The latter results in the status DNPC_ANOTHER_COMMAND_ALREADY_PENDING.

By default, SYS600 sends a clock synchronization request, a reset restart bit request and class 0 data request when the DNP master station gets the OK status, for example at start-up. While these requests are open, no commands can be issued from SCIL.

5.4.7.2 Data commands

Object commands
Object command, such as switching device open/close commands and tap changer raise/lower commands, are sent as control relay output block messages. This message is a multi-purpose command that contains the following control functions:

- Latching commands
- Momentary relay commands
- Breaker or transformer tap commands (pulse operation)

The first two commands are usually used for setting and latching output relays and the third for tripping and closing breakers or raising and lowering tap changers. Object commands are usually select-before-operate commands.

The function code is selected using the TY attribute, see Table 11 and Table 13. The TY value 255 must be used if the controlled device does not accept other application layer requests (for example polls) between select and operate commands. The operate command is sent

automatically, if the Status field of the response to the select command is 0: "Request accepted or initiated". This functionality applies to both binary and analog outputs.

The data object type of the binary output block is 12 and its variation is 1. The implementation in SYS600 has the following limitations:

- The CLEAR and QUEUE fields of the command are always 0. This means that SYS600 does not support queued commands.
- The COUNT field of the command is always 1. This means that the command is executed only once.
- The STATUS field of the command is set to 0.

Control relay output messages are sent by setting a list to a DNP 3.0 Control Relay Block process object or by using the CO attribute of the DNP 3.0 station. The unit number (UN attribute) of the output process object must be the same as the STA object number of the corresponding DNP 3.0 master station. The address (index) of the process object must also be equal to the address of the command in the DNP 3.0 slave. Process Object Tool automatically adds the due offset to the DNP index.

The values of the attributes set to the list depend on the control function and are presented in the following three tables. A few examples are given for each control function.

Table 11: Process object attributes included in a control relay output command

Attribute	Values	Description
SE	-	If a select command is sent, the parameter list is set to the SE attribute. Otherwise not included.
TY	3, 4, 5, 6, 255	Function code of the command, 3 = select, 4 = operate, 5 = direct operate, 6 = direct operate, no ack, special value 255= select and automatic operate
QL	0, 1, 2	Qualifier of the command, 0 = momentary relay operation, 1 = latching operation, 2 = pulse operation
OV	0, 1	Direction of the command, 0 = OFF/TRIP/RAISE, 1 = ON/CLOSE/LOWER

Examples:

```
;select, latch ON
#SET 'LN':PSE'IX' = LIST(OV=1,QL=1,TY=3)
;operate, latch OFF
#SET 'LN':POV'IX' = LIST(OV=0,QL=1,TY=4)
;direct, relay ON
#SET 'LN':POV'IX' = LIST(OV=1,QL=0,TY=5)
;direct, no ack, relay OFF
#SET 'LN':POV'IX' = LIST(OV=1,QL=0,TY=6)
;select, trip breaker
#SET 'LN':PSE'IX' = LIST(OV=0,QL=2,TY=3)
;operate, close breaker
#SET 'LN':POV'IX' = LIST(OV=1,QL=2,TY=4)
;select and automatic operate, close breaker
#SET 'LN':POV'IX' = LIST(OV=1,QL=2,TY=255)
```

Analog setpoints

Analog setpoints are sent analog output block messages to the DNP 3.0 slave. The data object type of the analog output block is 41. The SYS600 implementation supports three analog output variations as specified in Table 12.

Table 12: Data object types and variations for analog output objects

Object	Variation	Description
41	1	32-bit Analog Output
41	2	16-bit Analog Output
41	3	32-bit floating point Analog Output

The requested variation is defined using the attribute QL, see the examples below. In case QL is not defined, the used variation is var2, 16-bit Analog output.

The unit number (UN attribute) of the output process object must be the same as the STA object number of the corresponding DNP 3.0 master station, and the address of the process object must be equal to the address of the command in the DNP 3.0 slave. The Process Object Tool automatically adds the due offset to the DNP 3.0 index.

Analog output block messages are sent by setting a list to a process object of the DNP 3.0 analog output block. The attributes included in the list are presented in Table 13. Setpoint commands are usually direct commands.

Table 13: Process object attributes included in a control relay output command

Attribute	Values	Description
OV	depends on requested variation	Value.
TY	3,4,5,6, 255	Function code of the command: 3 = select, 4 = operate, 5 = direct operate, 6= direct operate, no ack, special value 255 = select and automatic operate
QL	1..3	Requested variation

When 32-bit variations 1 and 3 are used, the value ranges for DNP Analog output commands are dependent on the setting of the IR (Integer Representation) of the used process object. See Table 14 and Table 15 for details.

Table 14: Value ranges when output process object has setting IR=0 (no 32-bit integer representation)

QL	Description
1	-2147483000..2147483000 (accuracy of the transmitted value is lost with big absolute values).
2	-32768..32767
3	limits of single precision float, approximately -3.4x10^38 .. 3.4x10^38

Table 15: Value ranges when output process object has setting IR=1 (32-bit integer representation)

QL	Description
1	-2147483647..2147483647
2	-32768..32767
3	-2147483647..2147483647 (accuracy of the transmitted value is lost with big absolute values)

If 32-bit variations 1 or 3 are used, it recommended to use setting IR=1 for process objects with QL=1 and setting IR=0 for process objects with QL=3. The manual of the controlled device should define which variation should be used with each index (=address).

The following examples illustrate the use of the analog output block command.

```
;select, value 100, 16 bit integer variation
#SET 'LN':P'IX' = LIST(OV=100,TY=3)
;operate, value 100, 16 bit integer variation
#SET 'LN':P'IX' = LIST(OV=100,TY=4, QL=2)
;direct, value 200, 32 bit integer variation
#SET 'LN':P'IX' = LIST(OV=200,TY=5, QL=1)
;select and automatic operate, value 100.1, 32-bit floating point
#SET 'LN':P'IX' = LIST(OV=100.1,TY=255, QL=3)
```

Response to a data command

The DNP 3.0 slave sends a corresponding response to each control relay output block and analog output block request containing information about the status of the execution of the command. This response message updates an analog input process object with the UN attribute equal to the STA object number of the DNP 3.0 master station and OA equal to 209715200 + DNP 3.0 address (index) of the corresponding output process object. This applies only to object commands.

For analog setpoints the offset for the command response indication is 696254464 (= 41.5 * 2^24). The process object for the response information can be created as a DNP 3.0 command termination object by using the Process Object Tool, which automatically adds the due address offset. Note that the index given in the Process Object Tool is the index of the command. The values of the OV attribute of the response process object have the following meaning:

Table 16: Values of the process object receiving response to a command

Value	Description
0	Request accepted or initiated.
1	Request not accepted, the time between select and operate was too long.
2	No previous select message.
3	Request not accepted because of a formatting error.
4	Control operation is not supported for this point.
5	Request not accepted because the point is already active.
6	Request not accepted because of control hardware problems.
128	Response timeout.

Values 0…6 are sent by the slave and value 128 is set by SYS600 after a time determined by the MT attribute of the DNP 3.0 master station has expired while waiting for a response from the slave.

5.4.8 Application and system commands

5.4.8.1 Restart commands

The DNP 3.0 protocol has two restart commands, cold restart, and warm restart. When receiving a cold restart command, the DNP 3.0 slave should perform a complete reset sequence to its application level. Warm restart should launch only a partial reset sequence.

Both restart commands can be sent by using the CO attribute of the DNP 3.0 master station as shown in the following examples:

```
;send cold restart command
#SET STA1:SCO = VECTOR(13)
;send warm restart command
#SET STA1:SCO = VECTOR(14)
```

5.4.8.2 Time synchronization

DNP 3.0 slaves can be synchronized by using the SY attribute of the DNP 3.0 master station. Synchronization can take place station by station or as a broadcast message which synchronizes all the stations on the line. It is possible to first measure the delay caused by the application layer of the slave and use this delay to correct the actual synchronization. The synchronization is sent automatically when the master station gets the OK status, if not prevented by the RM attribute, it is always a message corrected with the measured delay.

Broadcast delay measurement is not possible. It is also not possible to make broadcast time synchronization across LAN/WAN. Furthermore, the usage delay measurement is not recommended in LAN/WAN since the transmission delays are rarely consistent.

Examples:

```
;send synch to station 1, no broadcast, no delay measurement
#SET STA1:SSY = (1,0)
;send synch broadcast to the line of station 1, include delay measurement
#SET STA1:SSY = (1,1)
```

5.4.8.3 Freeze Counters command

The DNP 3.0 protocol provides a function, which can be used to freeze the binary counters of a slave, meaning that they can be copied to another buffer in the slave. These frozen counters have the same indices (DNP 3.0 addresses) as the original counters but a different data object type and they can be requested independently. The Freeze Counters function provides a snapshot of the binary counters of the DNP 3.0 slave at a specific moment of time.

The Freeze Counters command has two options:

- Immediate freeze, which only freezes the counters.
- Freeze and clear, which both freezes the counters and resets the values of the original counters.

Both these options can be sent with or without a request for acknowledgement from the slave.

The Freeze Counters command can be sent by using the FZ attribute of the DNP 3.0 master station as shown in the following examples:

```
;immediate freeze
#SET STA1:SFZ = 7
;freeze and clear, no ack
#SET STA1:SFZ = 10
```

Binary counters and frozen counters have different data object types and thus different address offsets in SYS600, which means that a binary counter and a frozen counter cannot be received in the same process object.

5.5 Signal engineering

The term signal engineering here means the engineering needed to establish communication to the IEDs using the DNP 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, that is, whether polling or unsolicited messages are used for sending data to the master, based on the information about the behavior of the slave device.
3. Configure data polling based on the communication mode and update the system configuration correspondingly.
4. Determine the need for the class 0 polls and time synchronizations and make the necessary application changes.
5. Test each signal.

5.6 Status codes

The status codes for the DNP 3.0 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 DNP station object.

5.7 Device profile

Table 17: The device profile that describes the implementation of the DNP 3.0 master protocol in SYS600

DNP 3.0 **DEVICE PROFILE DOCUMENT**	
Vendor Name: Hitachi Power Grids, Grid Automation Products	
Device Name: SYS600 version 10	
Highest DNP Level Supported: For Requests: Subset Level 2 For Responses: Subset Level 2	**Device Function:** [x] Master [ ] Slave
Maximum Data Link Frame Size (octets): Transmitted: <292 Received: (must be 292)	**Maximum Application Fragment Size (octets):** Transmitted: <250 (Single fragments only) Received: 2048
Maximum Data Link Re-tries: [ ] None [ ] Fixed at _____ [x] Configurable, range 0 to 10, line attribute EN	**Maximum Application Layer Re-tries:** [x] None [] Configurable
Requires Data Link Layer Confirmation: [ ] Never [ ] Always [ ] Sometimes. If 'Sometimes', when?_____ [x] Configurable, line attribute LA	
Requires Application Layer Confirmation: [ ] Never [ ] Always (not recommended) [ ] When reporting Event Data (Slave devices only) [ ] When sending multi-fragment responses (Slave devices only) [ ] Sometimes. If 'Sometimes', when?_____ [x] Configurable, station attribute PC	
Table continues on next page	

Timeouts while waiting for: Data Link Confirm [ ] None [ ] Fixed at _____ [ ] Variable [x] Configurable, line attribute HT Complete Appl. Fragment [ ] None [ ] Fixed at _____ [ ] Variable [x] Configurable, station attribute TT/RT Application Confirm [ ] None [ ] Fixed at _____ [ ] Variable [x] Configurable, station attribute CT Complete Appl. Response [ ] None [ ] Fixed at _____ [ ] Variable [x] Configurable, station attribute AT **Others:** Retransmission after a collision, STA attribute XR (random delay if collision detection used). Complete data link frame: line attribute TI Response to a request: station attribute RT (first APDU), station attribute AT (last APDU).	
Sends/Executes Control Operations: WRITE Binary Outputs [x] Never [ ] Always [ ] Sometimes [ ] Configurable SELECT/OPERATE [ ] Never [ ] Always [ ] Sometimes [x] Configurable, process object attribute TY DIRECT OPERATE [ ] Never [ ] Always [ ] Sometimes [x] Configurable, process object attribute TY DIRECT OPERATE - NO ACK [ ] Never [ ] Always [ ] Sometimes [x] Configurable, process object attribute TY Count > 1 [x] Never [ ] Always [ ] Sometimes [ ] Configurable Pulse On [ ] Never [ ] Always [ ] Sometimes [x] Configurable, process object attribute QL Pulse Off [ ] Never [ ] Always [ ] Sometimes [x] Configurable, process object attribute QL Latch On [ ] Never [ ] Always [ ] Sometimes [x] Configurable, process object attribute QL Latch Off [ ] Never [ ] Always [ ] Sometimes [x] Configurable, process object attribute QL Queue [x] Never [ ] Always [ ] Sometimes [ ] Configurable Clear Queue [x] Never [ ] Always [ ] Sometimes [ ] Configurable	
FILL OUT THE FOLLOWING ITEM FOR MASTER DEVICES ONLY:	
Expects Binary Input Change Events: [x] Either time-tagged or non-time-tagged for a single event [ ] Both time-tagged and non-time-tagged for a single event [ ] Configurable (attach explanation)	

5.7.1 Supported function codes

Table 18: Supported function codes, (= CO attribute is needed)*

CODE	FUNCTION	DESCRIPTION	Supported
Transfer Function Codes			
0	Confirm	Message fragment confirmation No Response	Yes
1	Read	Request objects from outstation Respond with requested objects	Yes
2	Write	Store the specified objects to outstation Respond with status of the operation	Yes
Control Function Codes			
3	Select	Select the output point of outstation Respond with status of control point	Yes
4	Operate	Set the output that has previously been selected Respond with status of control point	Yes
5	Direct operate	Set the output directly Respond with status of control point	Yes
6	Direct operate - no ack	Set the output directly No response	Yes
Freeze Function Codes			
7	Immediate Freeze	Copy the specified objects to freeze buffer Respond with status of operation	Yes
8	Immediate Freeze - no ack	Copy the specified objects to freeze buffer No response	Yes
9	Freeze and Clear	Copy the specified objects to freeze buffer and clear objects Respond with status of operation	Yes
10	Freeze and Clear - no ack	Copy the specified objects to freeze buffer and clear objects No response	Yes
11	Freeze with time	Copy the specified objects to freeze buffer at specified time Respond with status of operation	No
12	Freeze with time - no ack	Copy the specified objects to freeze buffer at specified time No response	No
Application Control Function Codes			
13	Cold Restart	Perform the desired reset sequence Respond with a time object	Yes (*)
14	Warm Restart	Perform the desired partial reset operation Respond with a time object	Yes (*)
15	Initialize Data to Defaults	Initialize the specified data to default Respond with the status of operation	No
16	Initialize Application	Prepare the specified application to run Respond with the status of operation	No

Table continues on next page

CODE	FUNCTION	DESCRIPTION	Supported
17	Start Application	Start the specified application to run Respond with the status of operation	No
18	Stop Application	Stop the specified application to run Respond with the status of operation	No
Configuration Function Codes			
19	Save configuration	Save the configuration Respond with the status of operation	No
20	Enable Unsolicited Messages	Enable Unsolicited Messages Respond with the status of operation	Yes (*)
21	Disable Unsolicited Messages	Disable Unsolicited Messages Respond with the status of operation	Yes (*)
22	Assign Class	Assign specified objects to a class Respond with the status of operation	Yes (*)
Time Synchronization Function Codes			
23	Delay Measurement	Perform propagation delay measurement	Yes
24	Record current time	Used in a network application to allow the Master station and the Out station to record their time at the same instant	Yes
Authentication Request Function Codes			
32	Authentication Request	Authentication Request	Yes
33	Authentication Error	Authentication Error	No
Response Function Codes			
0	Confirm	Message fragment confirmation	Yes
129	Response	Response to requested message	Yes
130	Unsolicited Message	Spontaneous message without request	Yes
131	Authentication Response	Authentication Response	Yes

5.7.2 Supported Objects

Table 19: Supported Objects

		OBJECT GROUP and VARIATION	Request, master may issue, outstation shall parse	Request, master may issue, outstation shall parse	Response Master shall parse, outstation may issue	Response Master shall parse, outstation may issue
Obj	**Var**	**Description**	**Func Codes**	**Qual Codes**	**Func Codes**	**Qual Codes**
1	0	Binary Input - All Variations	1, 22	00, 01, 06		
1	1	Binary Input	1	00,01,06	129, 130	00, 01
1	2	Binary Input with Status	1	00,01,06	129, 130	00, 01

Table continues on next page

		OBJECT GROUP and VARIATION	Request, master may issue, outstation shall parse	Request, master may issue, outstation shall parse	Response Master shall parse, outstation may issue	Response Master shall parse, outstation may issue
Obj	Var	Description	Func Codes	Qual Codes	Func Codes	Qual Codes
2	0	Binary Input Change - All Variations	1	06,07,08		
2	1	Binary Input Change without Time	1	06,07,08	129, 130	17, 28
2	2	Binary Input Change with Time	1	06,07,08	129, 130	17, 28
2	3	Binary Input Change with Relative Time	1	06,07,08	129, 130	17, 28
3	0	Double bit binary input - All Variations	1,22	00,01,06		
3	1	Double bit binary input	1	00,01,06	129, 130	00, 01
3	2	Double bit binary input with status.	1	00,01,06	129, 130	00, 01
4	0	Double bit binary input change without time - All Variations	1	06,07,08		
4	1	Double bit binary input change without time.	1	06,07,08	129, 130	17, 28
4	2	Double bit binary input change with time.	1	06,07,08	129, 130	17, 28
4	3	Double bit binary input change with relative time.	1	06,07,08	129, 130	17, 28
10	0	Binary Output – All Variations	1	00,01,06		
10	1	Binary Output				
10	2	Binary Output Status	1	00,01,06	129, 130	00, 01
12	0	Control Block – All Variations				
12	1	Control Relay Output Block	3, 4, 5, 6	17, 28	129	echo of request
12	2	Pattern Control Block	5, 6	17, 28	129	echo of request
12	3	Pattern Mask	5, 6	00,01	129	echo of request
20	0	Binary Counter - All Variations	1, 7, 8, 9, 10, 22	00,01,06		
20	1	32-Bit Binary Counter	1	00,01,06	129, 130	00, 01
20	2	16-Bit Binary Counter	1	00,01,06	129, 130	00, 01
20	3	32-Bit Delta Counter	1	00,01,06	129, 130	00, 01
20	4	16-Bit Delta Counter	1	00,01,06	129, 130	00, 01
20	5	32-Bit Binary Counter without Flag	1	00,01,06	129, 130	00, 01
20	6	16-Bit Binary Counter without Flag	1	00,01,06	129, 130	00, 01
20	7	32-Bit Delta Counter without Flag	1	00,01,06	129, 130	00, 01
20	8	16-Bit Delta Counter without Flag	1	00,01,06	129, 130	00, 01
21	0	Frozen Counter - All Variations	1,22	00,01,06		
21	1	32-Bit Frozen Counter	1	00,01,06	129, 130	00, 01
21	2	16-Bit Frozen Counter	1	00,01,06	129, 130	00, 01
21	3	32-Bit Frozen Delta Counter	1	00,01,06	129, 130	00, 01
21	4	16-Bit Frozen Delta Counter	1	00,01,06	129, 130	00, 01
21	5	32-Bit Frozen Counter with Time of Freeze				
21	6	16-Bit Frozen Counter with Time of Freeze				

Table continues on next page

		OBJECT GROUP and VARIATION	Request, master may issue, outstation shall parse	Request, master may issue, outstation shall parse	Response Master shall parse, outstation may issue	Response Master shall parse, outstation may issue
Obj	Var	Description	Func Codes	Qual Codes	Func Codes	Qual Codes
21	7	32-Bit Frozen Delta Counter with Time of Freeze				
21	8	16-Bit Frozen Delta Counter with Time of Freeze				
21	9	32-Bit Frozen Counter without Flag	1	00,01,06	129, 130	00, 01
21	10	16-Bit Frozen Counter without Flag	1	00,01,06	129, 130	00, 01
21	11	32-Bit Frozen Delta Counter without Flag				
21	12	16-Bit Frozen Delta Counter without Flag				
22	0	Counter Change Event - All Variations	1	06,07,08		
22	1	32-Bit Counter Change Event without Time	1	06,07,08	129, 130	17, 28
22	2	16-Bit Counter Change Event without Time	1	06,07,08	129, 130	17, 28
22	3	32-Bit Delta Counter Change Event without Time	1	06,07,08	129, 130	17, 28
22	4	16-Bit Delta Counter Change Event without Time	1	06,07,08	129, 130	17, 28
22	5	32-Bit Counter Change Event with Time	1	06,07,08	129, 130	17, 28
22	6	16-Bit Counter Change Event with Time	1	06,07,08	129, 130	17, 28
22	7	32-Bit Delta Counter Change Event with Time				
22	8	16-Bit Delta Counter Change Event with Time				
23	0	Frozen Counter Event - All Variations	1	06,07,08		
23	1	32-Bit Frozen Counter Event without Time	1	06,07,08	129, 130	17, 28
23	2	16-Bit Frozen Counter Event without Time	1	06,07,08	129, 130	17, 28
23	3	32-Bit Frozen Delta Counter Event without Time	1	06,07,08	129, 130	17, 28
23	4	16-Bit Frozen Delta Counter Event without Time	1	06,07,08	129, 130	17, 28
23	5	32-Bit Frozen Counter Event with Time				
23	6	16-Bit Frozen Counter Event with Time				
23	7	32-Bit Frozen Delta Counter Event with Time				
23	8	16-Bit Frozen Delta Counter Event with Time				
30	0	Analog Input - All Variations	1,22	00, 01, 06		
30	1	32-Bit Analog Input	1	00,01,06	129, 130	00, 01

Table continues on next page

		OBJECT GROUP and VARIATION	Request, master may issue, outstation shall parse	Request, master may issue, outstation shall parse	Response Master shall parse, outstation may issue	Response Master shall parse, outstation may issue
Obj	Var	Description	Func Codes	Qual Codes	Func Codes	Qual Codes
30	2	16-Bit Analog Input	1	00,01,06	129, 130	00, 01
30	3	32-Bit Analog Input without Flag	1	00,01,06	129, 130	00, 01
30	4	16-Bit Analog Input without Flag	1	00,01,06	129, 130	00, 01
30	5	32-Bit floating point Analog Input	1	00,01,06	129, 130	00, 01
31	0	Frozen Analog Input - All Variations				
31	1	32-Bit Frozen Analog Input				
31	2	16-Bit Frozen Analog Input				
31	3	32-Bit Frozen Analog Input with Time of Freeze				
31	4	16-Bit Frozen Analog Input with Time of Freeze				
31	5	32-Bit Frozen Analog Input without Flag				
31	6	16-Bit Frozen Analog Input without Flag				
32	0	Analog Change Event - All Variations	1	06,07,08		
32	1	32-Bit Analog Change Event without Time	1	06,07,08	129,130	17,28
32	2	16-Bit Analog Change Event without Time	1	06,07,08	129,130	17,28
32	3	32-Bit Analog Change Event with Time	1	06,07,08	129,130	17,28
32	4	16-Bit Analog Change Event with Time	1	06,07,08	129,130	17,28
32	5	32-Bit floating point Analog Change Event without Time	1	06,07,08	129,130	17,28
32	7	32-Bit floating point Analog Change Event with Time	1	06,07,08	129,130	17,28
33	0	Frozen Analog Event - All Variations				
33	1	32-Bit Frozen Analog Event without Time				
33	2	16-Bit Frozen Analog Event without Time				
33	3	32-Bit Frozen Analog Event with Time				
33	4	16-Bit Frozen Analog Event with Time				
40	0	Analog Output Status - All Variations	1	00, 01, 06		
40	1	32-Bit Analog Output Status	1	00, 01, 06	129,130	00,01
40	2	16-Bit Analog Output Status	1	00, 01, 06	129, 130	00, 01
40	3	32-Bit floating point Analog Output Status	1	00, 01, 06	129, 130	00, 01
41	0	Analog Output Block - All Variations				
41	1	32-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	2	16-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request

Table continues on next page

		OBJECT GROUP and VARIATION	Request, master may issue, outstation shall parse	Request, master may issue, outstation shall parse	Response Master shall parse, outstation may issue	Response Master shall parse, outstation may issue
Obj	Var	Description	Func Codes	Qual Codes	Func Codes	Qual Codes
41	3	32-Bit floating point Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
50	0	Time and Date - All Variations				
50	1	Time and Date	2	07 quantity = 1		
			1	07 quantity = 1	129	07 quantity = 1
50	2	Time and Date with Interval				
51	0	Time and Date CTO - All Variations				
51	1	Time and Date CTO			129, 130	07, quantity=1
51	2	Unsynchronized Time and Date CTO			129, 130	07, quantity=1
52	0	Time Delay - All Variations				
52	1	Time Delay Coarse			129	07, quantity=1
52	2	Time Delay Fine			129	07, quantity=1
60	1	Class 0 Data	1	06		
60	2	Class 1 Data	1	06,07,08		
			20, 21, 22	06		
60	3	Class 2 Data	1	06,07,08		
			20, 21, 22	06		
60	4	Class 3 Data	1	06,07,08		
			20, 21, 22	06		
70	1	File Identifier				
80	1	Internal Indications	1	00,01		
			2	00 index=7		
81	1	Storage Object				
82	1	Device Profile				
83	1	Private Registration Object				
83	2	Private Registration Object Descriptor				
90	1	Application Identifier				
100	1	Short Floating Point				
100	2	Long Floating Point				
100	3	Extended Floating Point				
101	1	Small Packed Binary-Coded Decimal				
101	2	Medium Packed Binary-Coded Decimal				

Table continues on next page

		OBJECT GROUP and VARIATION	Request, master may issue, outstation shall parse	Request, master may issue, outstation shall parse	Response Master shall parse, outstation may issue	Response Master shall parse, outstation may issue
Obj	Var	Description	Func Codes	Qual Codes	Func Codes	Qual Codes
101	3	Large Packed Binary-Coded Decimal				
		No Object	13			
		No Object	23			

If the remote device sends double binary input using object type 1 and 2, each process object of type "Double indication" reserves two consecutive addresses in the SYS600 process database. This should be taken into account when giving addresses. Furthermore, if the process object is of type "Double indication", Alarm Delay must be used. This is because it is possible that two bits are received in two different messages and there may be a delay between them. To prevent faulty values, a small alarm delay must be added to the process object. See the attribute definition of the AD process object in SYS600 Application Objects.

Explanations:

- Obj. is the data object type.
- Var. is the variation.
- Func. is the function code of the message.
- Qual. is the qualifier code of the message in hexadecimal.
- Echo means that the response is the request mirrored.

5.7.3 TCP/UDP additions for LAN/WAN network

SYS600 LAN/WAN DNP uses the default IP address provided by the operating system.

A created DNP Master line reserves a port number

```
2501+linenumber
```

for its internal use.

In TCP/IP mode (connection-oriented), the connection is established to port

```
20000 (default)
```

of the slave device. Only one connection to each master station is established at the any one time. The IP address of the master is configured using the IA attribute of the station object. The remote port number can be configured using an option in the station attribute IA.

In UDP/IP mode (connectionless) all data is sent and received through port

```
20000
```

The slave device must receive messages from this port only. All messages which are sent by the slave device must be sent to this port of the master. The IP address of the slave is configured with the IA attribute of the station object. The multidrop configuration requires redefinition of local ports though all communication goes through port 20000. This configuration has been explained in the description of the IA attribute.

5.7.4 Secure authentication

DNP 3.0 in SYS600 supports secure authentication versions v2 and v5. For secure authentication version v2, the supported message types are of object type 120 (Authentication), variations 1-7 and 9. For secure authentication version v5, the supported message types are of object type 120 (Authentication), variations 1-7 and 9-15. The function codes used with these object types are 32 = Authentication Request and 131 = Authentication Response. The supported qualifiers are fixed in DNP 3.0 standard.

5.7.5 Example topologies:

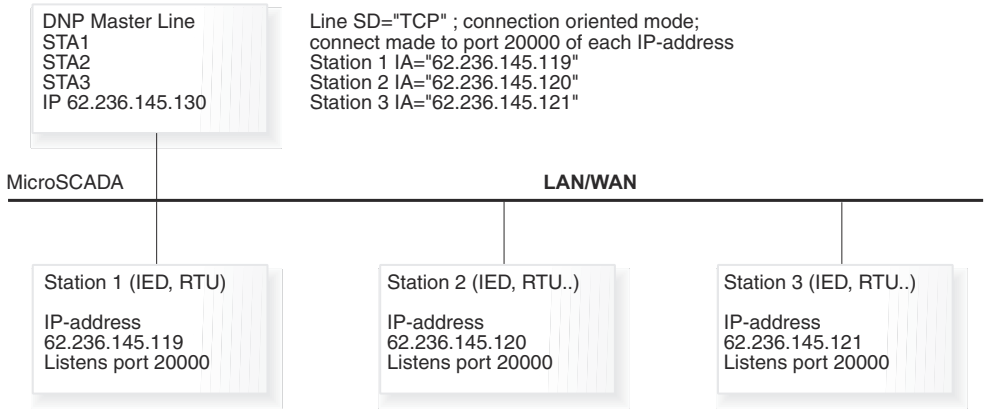

Figure 12: SYS600 as DNP3.0 TCP master in multidrop environment

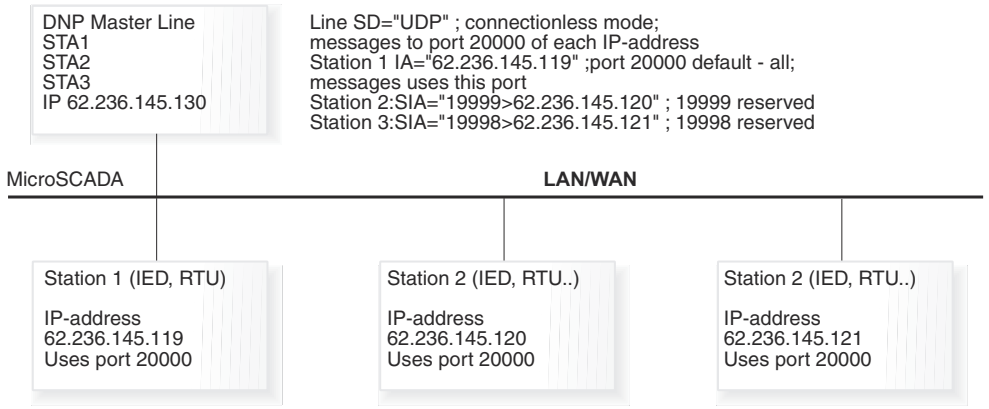

Figure 13: SYS600 as DNP3.0 UDP master in multidrop environment

Appendix A Configuration Examples

1.1 One station in TCP mode

```
@NET=2
@STA=1
@LINE=1
#SET NET'NET':SPO'LINE'=43
#SET NET'NET':SDV(30)=('STA','LINE')
#SET NET'NET':SSD'LINE'="TCP"
#SET NET'NET':SEN'LINE'=3
#SET NET'NET':SMS'LINE'='NET'
#SET NET'NET':SPD'LINE'=0
#SET NET'NET':SHT'LINE'=300
#SET NET'NET':STI'LINE'=4
#SET NET'NET':SLA'LINE'=0
#SET NET'NET':SPS'LINE'=190
#SET NET'NET':SLK'LINE'=15
#SET NET'NET':SIU'LINE'=1
#SET NET'NET':SIU'LINE'=0
#SET STA'STA':SAL=1
#SET STA'STA':SDR=1
#SET STA'STA':SSA=1
#SET STA'STA':SIA="GRACE"
#SET STA'STA':SMA=10
#SET STA'STA':STT=25
#SET STA'STA':SCT=10
#SET STA'STA':SRT=30
#SET STA'STA':SAT=60
#SET STA'STA':SPC=1
#SET STA'STA':SRM=28
#SET STA'STA':SIU=1
#SET NET'NET':SIU'LINE'=1
```

1.2 Multiple stations in TCP mode

```
@NET=2
@STA=1
@LINE=1
#SET NET'NET':SPO'LINE'=43
#SET NET'NET':SDV(30)=('STA','LINE')
#SET NET'NET':SDV(30)=(2,'LINE')
#SET NET'NET':SDV(30)=(3,'LINE')
#SET NET'NET':SSD'LINE'="TCP"
#SET NET'NET':SEN'LINE'=3
#SET NET'NET':SMS'LINE'='NET'
#SET NET'NET':SPD'LINE'=0
#SET NET'NET':SHT'LINE'=1000
#SET NET'NET':STI'LINE'=4
#SET NET'NET':SLA'LINE'=0
#SET NET'NET':SPS'LINE'=190
#SET NET'NET':SLK'LINE'=15
#SET NET'NET':SPP'LINE'=3
#SET NET'NET':SIU'LINE'=1
#SET NET'NET':SIU'LINE'=0
#SET STA'STA':SAL=1
#SET STA'STA':SDR=1
#SET STA'STA':SSA=1
#SET STA'STA':SIA="192.168.1.120"

#SET STA'STA':SMA=10
```

```
#SET STA'STA':STT=25
#SET STA'STA':SCT=10
#SET STA'STA':SRT=30
#SET STA'STA':SAT=60
#SET STA'STA':SPC=1
#SET STA'STA':SRM=28
#SET STA'STA':SIU=1
@STA=2
#SET STA'STA':SAL=1
#SET STA'STA':SDR=1
#SET STA'STA':SSA=2
#SET STA'STA':SIA="192.168.1.120"
#SET STA'STA':SMA=10
#SET STA'STA':STT=25
#SET STA'STA':SCT=10
#SET STA'STA':SRT=30
#SET STA'STA':SAT=60
#SET STA'STA':SPC=1
#SET STA'STA':SRM=28
#SET STA'STA':SIU=1
@STA=3
#SET STA'STA':SAL=1
#SET STA'STA':SDR=1
#SET STA'STA':SSA=3
#SET STA'STA':SIA="192.168.1.122"
#SET STA'STA':SMA=10
#SET STA'STA':STT=25
#SET STA'STA':SCT=10
#SET STA'STA':SRT=30
#SET STA'STA':SAT=60
#SET STA'STA':SPC=1
#SET STA'STA':SRM=28
#SET STA'STA':SIU=1
#SET NET'NET':SIU'LINE'=1
```

1.3 One station in UDP mode

```
@NET=2
@STA=1
@LINE=1
#SET NET'NET':SPO'LINE'=43
#SET NET'NET':SDV(30)=('STA','LINE')
#SET NET'NET':SSD'LINE'="UDP"
#SET NET'NET':SEN'LINE'=3
#SET NET'NET':SMS'LINE'='NET'
#SET NET'NET':SPD'LINE'=0
#SET NET'NET':SHT'LINE'=300
#SET NET'NET':STI'LINE'=4
#SET NET'NET':SLA'LINE'=1
#SET NET'NET':SPS'LINE'=190
#SET NET'NET':SLK'LINE'=15
#SET NET'NET':SIU'LINE'=1
#SET NET'NET':SIU'LINE'=0
#SET STA'STA':SAL=1
#SET STA'STA':SDR=1
#SET STA'STA':SSA=1
#SET STA'STA':SIA="192.168.1.120"
#SET STA'STA':SMA=10
#SET STA'STA':STT=25
#SET STA'STA':SCT=10
#SET STA'STA':SRT=30
#SET STA'STA':SAT=60
#SET STA'STA':SPC=1
#SET STA'STA':SRM=28
```

```
#SET STA'STA':SIU=1
#SET NET'NET':SIU'LINE'=1
```

1.4 Multiple stations in UDP mode

```
@NET=2
@STA=1
@LINE=1
#SET NET'NET':SPO'LINE'=43
#SET NET'NET':SDV(30)=('STA','LINE')
#SET NET'NET':SDV(30)=(2,'LINE')
#SET NET'NET':SDV(30)=(3,'LINE')
#SET NET'NET':SSD'LINE'="UDP"
#SET NET'NET':SEN'LINE'=3
#SET NET'NET':SMS'LINE'='NET'
#SET NET'NET':SPD'LINE'=0
#SET NET'NET':SHT'LINE'=1000
#SET NET'NET':STI'LINE'=4
#SET NET'NET':SLA'LINE'=1
#SET NET'NET':SPS'LINE'=190
#SET NET'NET':SLK'LINE'=15
#SET NET'NET':SPP'LINE'=3
#SET NET'NET':SIU'LINE'=1
#SET NET'NET':SIU'LINE'=0
#SET STA'STA':SAL=1
#SET STA'STA':SDR=1
#SET STA'STA':SSA=1
#SET STA'STA':SIA="20000>192.168.1.120"
#SET STA'STA':SMA=10
#SET STA'STA':STT=25
#SET STA'STA':SCT=10
#SET STA'STA':SRT=30
#SET STA'STA':SAT=60
#SET STA'STA':SPC=1
#SET STA'STA':SRM=28
#SET STA'STA':SIU=1
@STA=2
#SET STA'STA':SAL=1
#SET STA'STA':SDR=1
#SET STA'STA':SSA=2
#SET STA'STA':SIA="19999>192.168.1.121"
#SET STA'STA':SMA=10
#SET STA'STA':STT=25
#SET STA'STA':SCT=10
#SET STA'STA':SRT=30
#SET STA'STA':SAT=60
#SET STA'STA':SPC=1
#SET STA'STA':SRM=28

#SET STA'STA':SIU=1
@STA=3
#SET STA'STA':SAL=1
#SET STA'STA':SDR=1
#SET STA'STA':SSA=3
#SET STA'STA':SIA="19998>192.168.1.122"
#SET STA'STA':SMA=10
#SET STA'STA':STT=25
#SET STA'STA':SCT=10
#SET STA'STA':SRT=30
#SET STA'STA':SAT=60
#SET STA'STA':SPC=1
#SET STA'STA':SRM=28
#SET STA'STA':SIU=1
#SET NET'NET':SIU'LINE'=1
```

Appendix B 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 DNP 3.0 Master line and two stations on this line.

```
;*************************************************************************
; INPUT PARAMETERS
@NET = 3 ; NODE NUMBER OF THE PC-NET
@LINE = 1 ; LINE NUMBER
@STATIONS = VECTOR(1,2) ; MASTER STATION NUMBERS
@SLAVE_STATIONS = VECTOR(1,2) ; SLAVE STATION NUMBERS
@MASTER_ADDRESS = %STATIONS(1)
@APPLIC = 1
;*************************************************************************
; CREATE A DNP 3.0 LINE TO NET
#IF NET'NET':SPO'LINE'==0 #THEN #BLOCK
 #SET NET'NET':SPO'LINE' = 36 ;DNP 3.0 master
 #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':SLK'LINE' = 14 ;link type (coll. detection in use)
 #SET NET'NET':SPS'LINE' = 20 ;buffer pool size
 #SET NET'NET':SML'LINE' = 249 ;maximum message length (bytes)
 #SET NET'NET':SXR'LINE' = 0 ;max. random delay for retransm.(ms)
 #SET NET'NET':SDE'LINE' = 50 ;CTS delay (ms)
 #SET NET'NET':STW'LINE' = 0 ;transmission wait delay (ms)
 #SET NET'NET':SHT'LINE' = 2000 ;header timeout (ms)
 #SET NET'NET':STI'LINE' = 2 ;response timeout (ms)
 #SET NET'NET':SRK'LINE' = 0 ;RTS keep up padding characters
 #SET NET'NET':SRI'LINE' = 0 ;receiver disabling time (ms)
 #SET NET'NET':SPD'LINE' = 5000 ;polling delay (ms)
 #SET NET'NET':SEN'LINE' = 3 ;retransmission limit
 #SET NET'NET':SLA'LINE' = 1 ;link layer conf. enabled
#BLOCK_END
;*************************************************************************
; CREATE DNP 3.0 STATIONS TO NET
#LOOP_WITH I = 1..LENGTH(%STATIONS)
@STA=%STATIONS(%I)
@SLAVE = %SLAVE_STATIONS(%I)
 #SET NET'NET':SDV(30) = (%STA,%LINE) ;create station to line
 #SET STA'STA':SIU = 0 ;set station out of use
 #SET STA'STA':SAL = 1 ;allocation
 #SET STA'STA':SAS = %APPLIC ;allocating application
 #SET STA'STA':SMI = 30000 +%STA ;message identification
 #SET STA'STA':SMS = %APPLIC ;message application
 #SET STA'STA':SSE = 1 ;system messages enabled
 #SET STA'STA':SSA = %SLAVE ;slave address
 #SET STA'STA':SMA = %MASTER_ADDRESS ;master address
 #SET STA'STA':SIL = 2 ;info address length (bytes)
 #SET STA'STA':SCA = 32000 ;command address
 #SET STA'STA':SPC = 0 ;process data confirmation
 #SET STA'STA':SAT = 30 ;appl. response timeout (s)
 #SET STA'STA':SRT = 10 ;reply timeout (s)
 #SET STA'STA':SST = 5000 ;SYS waiting time (ms)
```

```
 #SET STA'STA':SCT = 10 ;confirmation timeout (s)
 #SET STA'STA':STT = 10 ;transport layer timeout (s)
 #SET STA'STA':SDR = 1 ;direction
 #SET STA'STA':SAR = 0 ;appl. message data retries
 #SET STA'STA':SML = 2048 ;max. message length
 #SET STA'STA':SPT0 = 0 ;pulse off time
 #SET STA'STA':SPT1 = 0 ;pulse on time
 #SET STA'STA':SEO = 0 ;event offset
 #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 DNP 3.0 Master line with dial-up and two DNP stations.

```
;*********************************************************************
; INPUT PARAMETERS
@NET = 3 ; NODE NUMBER OF THE PC-NET
@LINE = 1 ; LINE NUMBER
@STATIONS = VECTOR(1,2) ; MASTER STATION NUMBERS
@SLAVE_STATIONS = VECTOR(1,2) ; SLAVE STATION NUMBERS
@APPLIC = 1
;*********************************************************************
; CREATE A DNP 3.0 LINE TO NET
#IF NET'NET':SPO'LINE'==0 #THEN #BLOCK
 #SET NET'NET':SPO'LINE' = 36 ;DNP 3.0 master
 #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':SLK'LINE' = 14 ;link type (coll. detection in use)
 #SET NET'NET':SPS'LINE' = 20 ;buffer pool size
 #SET NET'NET':SML'LINE' = 249 ;maximum message length (bytes)
 #SET NET'NET':SXR'LINE' = 0 ;max. random delay for retransm.(ms)
 #SET NET'NET':SDE'LINE' = 50 ;CTS delay (ms)
 #SET NET'NET':STW'LINE' = 0 ;transmission wait delay (ms)
 #SET NET'NET':SHT'LINE' = 2000 ;header timeout (ms)
 #SET NET'NET':STI'LINE' = 2 ;response timeout (ms)
 #SET NET'NET':SRK'LINE' = 0 ;RTS keep up padding characters
 #SET NET'NET':SRI'LINE' = 0 ;receiver disabling time (ms)
 #SET NET'NET':SPD'LINE' = 5000 ;polling delay (ms)
 #SET NET'NET':SEN'LINE' = 3 ;retransmission limit
 #SET NET'NET':SLA'LINE' = 1 ;link layer conf. enabled
#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 DNP 3.0 STATIONS TO NET
#LOOP_WITH I = 1..LENGTH(%STATIONS)
@STA=%STATIONS(%I)
@SLAVE = %SLAVE_STATIONS(%I)
 #SET NET'NET':SDV(30) = (%STA,%LINE) ;create station to line
 #SET STA'STA':SIU = 0 ;set station out of use
 #SET STA'STA':SAL = 1 ;allocation
 #SET STA'STA':SAS = %APPLIC ;allocating application
 #SET STA'STA':SMI = 30000 +%STA ;message identification
```

```
 #SET STA'STA':SMS = %APPLIC ;message application
 #SET STA'STA':SSE = 1 ;system messages enabled
 #SET STA'STA':SSA = %SLAVE ;slave address
 #SET STA'STA':SMA = %STA ;master address
 #SET STA'STA':SIL = 2 ;info address length (bytes)
 #SET STA'STA':SCA = 32000 ;command address
 #SET STA'STA':SPC = 0 ;process data confirmation
 #SET STA'STA':SAT = 30 ;appl. response timeout (s)
 #SET STA'STA':SRT = 10 ;reply timeout (s)
 #SET STA'STA':SST = 5000 ;SYS waiting time (ms)
 #SET STA'STA':SCT = 10 ;confirmation timeout (s)
 #SET STA'STA':STT = 10 ;transport layer timeout (s)
 #SET STA'STA':SDR = 1 ;direction
 #SET STA'STA':SAR = 0 ;appl. message data retries
 #SET STA'STA':SML = 2048 ;max. message length
 #SET STA'STA':SPT0 = 0 ;pulse off time
 #SET STA'STA':SPT1 = 0 ;pulse on time
 #SET STA'STA':SEO = 0 ;event offset
 #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
```

Index

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