DNP 3.0 – Slave Communication Protocol

Version 2016.2.1

Reference Manual

00052.02
March 2019

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Tip. Indicates helpful, timely information for minor problems that the user may encounter.

This symbol indicates that the user should proceed exactly as described in this manual, at the risk of shock or electrical discharge.

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1. GENERAL INFO

1.1 Summary

Communication Driver Name: DNP30S

Implementation DLL: T.ProtocolDriver.DNP30S.dll.

Protocol: DNP3.0 Slave standard protocol.

Interface: TCP/IP or Serial.

Description: This driver is used for slave (or server) mode communication with remote IEDs (Intelligent Electronic Devices) using Level 2 DNP 3.0 protocol in master (or client) mode. Communication can be established through a multi-point serial channel or a LAN using Ethernet and TCP-IP. In the latter case, each IED has an IP address.

IEDs types supported: Any DNP 3.0-compatilble IED in master (or client) mode.

Communication block size: Maximum 250 bytes, FT 1.2 format.

Protocol Options: "LinkConfirm" mode and master station address.

Multi-threading: User defined, five threads per communication node by default.

Max number of nodes: User defined.

PC Hardware requirements: Standard PC Ethernet interface board, RS485 or RS232 port.

1.2 Data Objects Supported

The table below shows the DNP objects and variants supported by this implementation.

Object			Requisition (Master)		Response (Server)	
Obj.	Var.	Description	Function Codes (decimal)	Qualifier Codes (Hex)	Function Codes (decimal)	Qualifier Codes (Hex)
1	0	Binary Input (any variation)	1	00,01,06		
			22	00,01,06	129	
1	1	Single Bit Binary Input (packed)	1	00,01,06	129	00, 01
1	2	Binary Input with status			129	00, 01
2	0	Binary Input event (any variation)	1	06,07,08		
2	1	Binary Input change without time	1	06,07,08	129,130	17,18
2	2	Binary Input change with absolute time	1	06,07,08	129,130	17,18
2	3	Binary Input change with relative time	1	06,07,08	129,130	17,18
3	0	Double-bit Binary input – Any variation	22	00,01,06		
3	1	Double-bit Binary Input – Packed	1	00,01,06	129	00, 01
3	2	Double-bit Binary Input – With flags	1	00,01,06	129	00, 01
4	0	Double-bit Binary Input Event – Any Variation	1	06,07,08		

4	1	Double-bit Binary Input Event – without time	1	06,07,08	129,130	17,18
4	2	Double-bit Binary Input Event- with absolute time	1	06,07,08	129,130	17,18
4	3	Double-bit Binary Input Event - with relative time	1	06,07,08	129,130	17,18
10	1	Binary Output – Any Variation	1	00,01,06		
10	2	Binary Output – Status with flags	1	00,01,06	129	
12	1	Control relay output block	3,4,5	17,28	129	Echo of request
20	0	Binary Counter – All variations				
20	1	Counter – 32-bit with flag	1	00,01,06	129	00, 01
20	2	Counter – 16-bit with flag	1	00,01,06	129	00, 01
20	5	Counter – 32-bit without flag	1	00,01,06	129	00, 01
20	6	Counter – 16-bit without flag	1	00,01,06	129	00, 01
21	0	Frozen counter – All variations				
21	1	Frozen Counter – 32-bit with flag	1	00,01,06	129	00, 01
21	2	Frozen Counter – 16-bit with flag	1	00,01,06	129	00, 01
21	3	Frozen Counter – 32-bit without flag	1	00,01,06	129	00, 01
21	4	Frozen Counter – 16-bit without flag	1	00,01,06	129	00, 01
22	0	Counter Event – Any Variation	1	06		
22	1	Counter Event – 32-bit with flag	1	06,07,08	129,130	17,18
22	2	Counter Event – 16-bit with flag	1	06,07,08	129,130	17,18
23	0	Frozen Counter Event – Any Variation	1	06,07,08		
23	1	Frozen Counter Event – 32-bit with flag	1	06,07,08	129,130	17,18
23	2	Frozen Counter Event – 16-bit with flag	1	06,07,08	129,130	17,18
30	0	Analog Input – All variations	1, 22	00,01,06		
30	1	32 Bits Analog Input	1	00,01,06	129	00, 01
30	2	16 Bit Analog input with flag	1	00,01,06	129	00, 01
30	3	32 Bits Analog Input without flag	1	00,01,06	129	00, 01
30	4	16 Bit Analog input without flag	1	00,01,06	129	00, 01
30	5	Short Floating Point (32bits)	1	00,01,06	129	00, 01
32	0	Analog Input event – All variations	1	06,07,08		
32	1	32 Bits Analog Input event	1	06,07,08	129,130	17,18

32	2	16 Bit Analog event without flag	1	06,07,08	129,130	17,18
32	3	32 Bit Analog event with flag	1	06,07,08	129,130	17,18
32	4	16 Bit Analog event with flag	1	06,07,08	129,130	17,18
32	5	Analog input event single float –without time	1	06,07,08	129,130	17,18
32	7	Analog input event single float –with time	1	06,07,08	129,130	17,18
40	0	Analog Output Status – Any variation	1			
40	1	Analog Output Status – 32bits with flag	1	00,01,06	129	00, 01
40	2	Analog Output Status - 16bits with flag	1	00,01,06	129	00, 01
40	3	Analog output status – Single float with flag	1	00,01,06	129	00, 01
41	1	32Bit 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
41	3	Analog output block – Single float	3,4,5,6	17,28	129	Echo of request
50	1	Time and Data – Absolute time	1,2	0x07	129	07
51	1	Time and Date CTO – Absolute ti me, synchronized			129,130	07
51	2	Time and Date CTO – Absolute ti me, unsynchronized			129,130	07
52	1	Time Delay – Coarse			129	07
52	2	Time Delay – Fine			129	07
60	1	Class 0 data	1	0x06		
60	2	Class 1 data	1,20,21	06,07,08		
60	3	Class 2 data	1,20,21	06,07,08		
60	4	Class 3 data	1,20,21	06,07,08		
80	1	Internal indications	1,2	00,01	129	01

In master mode protocol implementation, the master only performs the requests highlighted in blue. The server equipment responds using the answers highlighted in yellow. Note that it is up to the server equipment to decide how to respond and the master must support all the features of level 2 to be used as a possible answer.

The objects, object variations, function codes and qualifiers have their standard meanings in DNP. Tables with the function code and qualifiers are shown below:

Function Code	Description	Origin
1	Read	Master
2	Write	Master
3	Select	Master
4	Operate	Master
5	Direct Operate (without selection)	Master
6	Direct Operate (without ack)	Master
7	Freeze Immediately	Master
8	Freeze Immediately (without ack)	Master
9	Freeze and Clear	Master
10	Freeze and Read	Master
13	Restart (Cold)	Master
14	Restart (Warm)	Master
20	Enable non-requested messages	Master
21	Disable non-requested messages	Master
22	Assigns class for an object	Master
23	Measurement with delay	Master
129	Response	Slave
130	Non-Requested Response (doesn´t exist on level 2)	Slave

Qualifier Code	Use on Request	Use on Response
00,01	Static Points range (class 0) or a single point with a number	Static Object
06	All points	Invalid
07,08	A limited number of events A single point without number (this is a timestamp)	A single point without number (this is a timestamp)
17, 28	Controls (one or more unrelated points)	Event Objects (one or more unrelated points)

DNP has the concept of data classes, with four classes defined:

Class 0: Corresponds to the static points, analog or digital. Its content is the value of an

analog or digital variable, input or output in a given time;

Class 1, 2 and 3: Events corresponding to class 0 variable transitions, state transitions or internal relay situations that causes an event.

A common practice in DNP IEDs is to associate the state variation of digital variables or the dead band pass of analog variables with class 1, 2 or 3 events. Thus, modifying the state/value of these variables will cause events to be transmitted at the request of the respective classes of events (60/2, 60/3 and 60/4). Periodically, a class 0 reading (60/1) may be requested for checking integrity.

Notes:

1) In this implementation, it is automatically assumed that BI-type digital variables, when altered, will be sent as Class 1, in Object 2 with variation 2 format (Binary input with time stamp).
2) In this implementation, it is automatically assumed that AI and AIF analog variables, when altered, will be sent as Class 2, in Object 30 with variation 3 format for AI and in Object 30 with variation 5 format for AIF.

1.3 General Operation

The normal slave sequence operation is shown below.

- If necessary during installation, the master must send a synchronization message (50,1) periodically. The date and time received will be interpreted as UCT (or GMT) and will be used to change the host computer's clock;
- When starting execution, IIN flags will be sent on the first answer messages to indicate IED restarted. The master must then execute a "clear device flag" (80/1) to clear this indication;
- Every time there is an alteration of the digital or analog state configured in the POINTS table, with *AcessType* set as *ReadWrite*, an event message will be sent as Class 1 or Class 2. If there is a point in which no event is desired, use *AcessType = Read* for it.
- When slave mode receives a digital or analog output command request, it sends the respective requisition to the IED through software (12/1 or 41/2);

2. CHANNEL SETTINGS

2.1 Protocol Options

LinkConfirmMode – Protocol mode in which, in link layer, all requests should be confirmed by the remote IED. The default content is "Enabled."

MasterStationID - A univocal number between 1 and 65534 corresponding to the master station address. This way, the master informs its own address to the slave when sending it a message. Some slaves reply to the master disregarding this number, while others demand that the address declared on the slave match the one from the master. The default for this field is "65534."

Password for commands: In order to increase the security in sending commands, normally initiated only by a change in the state of a tag, it is possible to specify in the Client modules a password of up to 9 digits for the command. Here in this server module you must specify the password to generate the command for the Client module that will actually send the

command to the field. This password must be the same as that used by the module sender of this command.

Logging Level – You can choose from this list the logging mode created by the communication module.

Logging level	Debug	All messages are registered in the LOG.
	Info	Only Info, Warning and Error messages are registered in the LOG.
	Warning	Only Warning and Error messages are registered in the LOG.
	Error	Only Error messages are registered in the LOG.

Get analog changes by sample - Alternatively to the mode of receiving changes of tag values, by using AccessType with WriteEventEnable, there's an option to use, by the communication module, the sampling mode of changes occurred in tags. In this mode, the current values are checked against the last values sent periodically. This way only the change is considered, and the new value is sent to the client, if the absolute difference between the current value and the last one sent is greater than the Deadband attribute of the tag. To use this mode you must use the AccessType in the Points table, for these measurement tags, with WriteEventEnable disabled.

Max time to send analog changes (ms) - If you use the Get analog changes by sampling mode, this is the time to be used as the interval between two samples. The default time is set to 3 seconds.

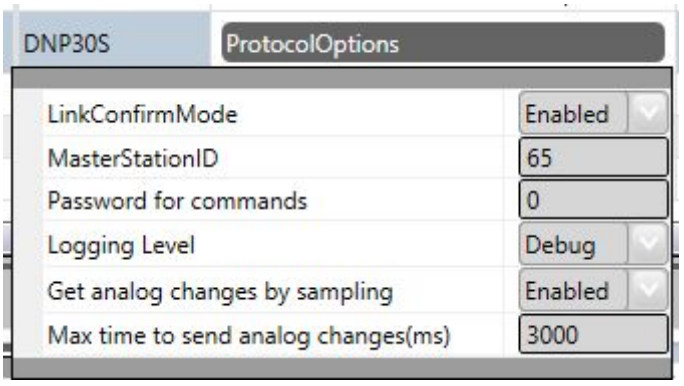


Figure 1 – Protocol Options

2.2 Settings

Serial Channel:

Com: Communication Port used on the computer;

BaudRate

DataBits: 8

StopBits: 1 or 2

Parity: None, Even, Odd;

DTR: on, off

RTS: on, off

CTS: on, off;

Port configuration must be compatible between master and slave IEDs.

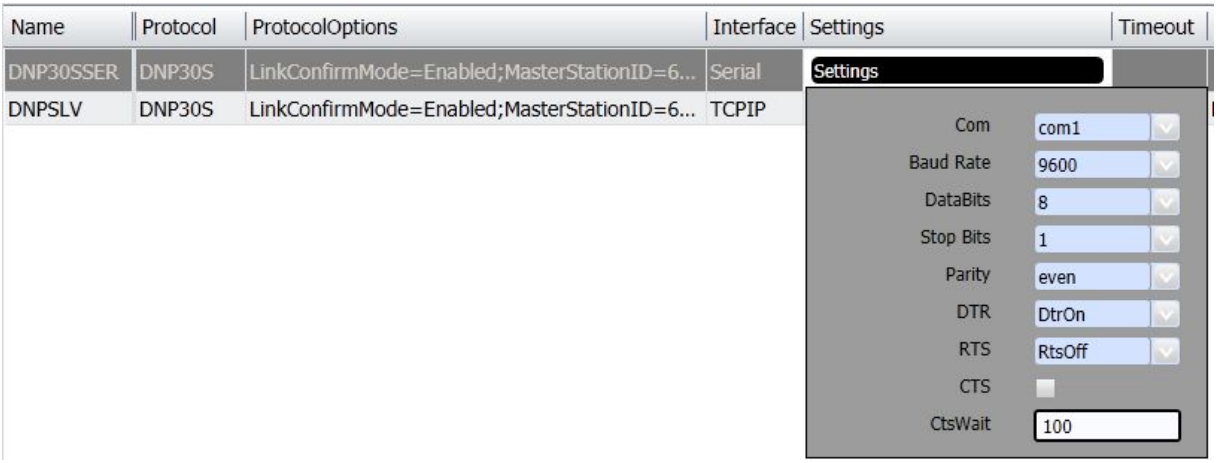


Figure 2 – Serial Channel Settings

TCP/IP channels:

- **ServerMode and AcceptUnsolicited**: Preset and cannot be changed;
- **ListeningPort:** The port of the computer where this slave channel will accept connections is defined here.
- **MaxSimultaneousConnections:** Must be 1.
- **ShareNodeSameIP**: Accepts IED with the same IP.

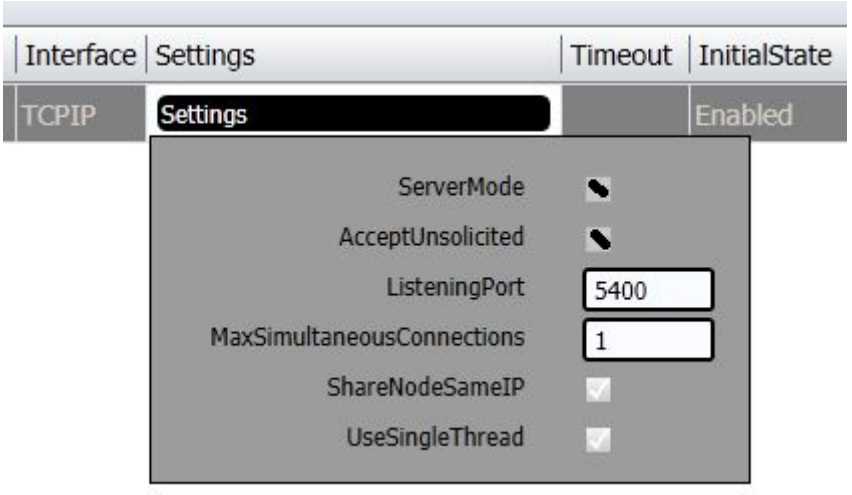


Figure 3 – TCP/IP Settings

2.3 Timeout

Defines limit times for transmission and reception of message characters and the number of retries.

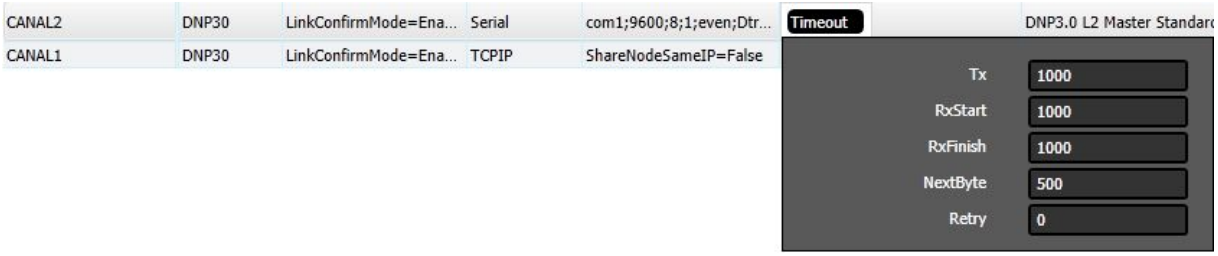


Figure 4 –Timeout Attributes

2.4 Initial State

Defines how the channel will initiate: enabled or disabled. If the channel is disabled, no message will be sent or received through it. In other words, the channel will be deactivated.

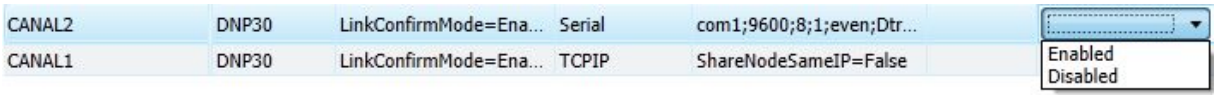


Figure 5 – Channel Initial State

3. NODES SETTINGS

Each node represents a remote station (IED). The user can configure multiple workstations into a single channel for serial communication. In the case of TCP-IP communication, only one node is supported for each channel. In this case, you must set as many channels as there are nodes.

3.1 Nodes Data (Primary and Backup)

Attribute set associated with the node (channel), which refers to its address and other attributes presented below:

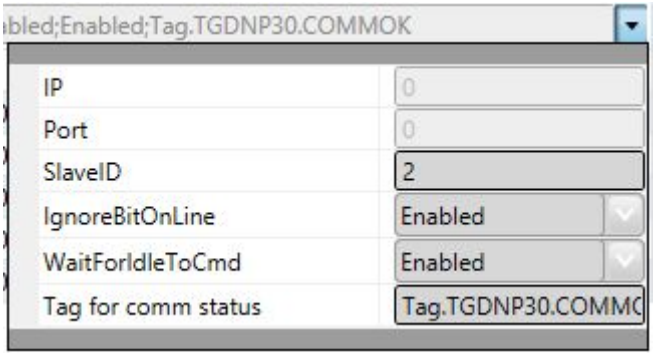


Figure 6 – Channel Data

For TCP-IP Communication:
IP Address – Not used
Port – Not used

For both TCP-IP and Serial:
SlaveID – Slave station address, defined by this channel.

IgnoreBitOnLine – If "enabled," it indicates the driver must ignore the "BitOnLine" indication which is inserted by the IED when a failure or normality occurs at a point, according to the IED criteria.

WaitForIdleToCmd – If "enabled," it indicates that a command should only be sent when the sampled communication is at rest, i.e., is not happening.

Tag for Comm status - This field can indicate the name of an existing tag in the project to show success/failure in communication from a functional point of view. The module waits for a maximum of **Timeout** milliseconds (defined in Protocol Options, above) for receiving a request from the client. In case of failure, the value of this tag will be set to ZERO. In case of success, the value will be set as ONE.

4. POINTS SETTINGS

4.1 General

Points can be input or output points.

Entry points, i.e. points that are acquired through the protocol, have basically two main parameters: point type and address.

Output points, used for remote controls, have besides the type and address, a parameter (ControlCode) for specifying the output operation. On SCADA, given an IED address map, address numbers must be unique for points of the same type.

Point states or point values are reported by IED through Information Objects defined in the standard. These objects have variations such as with or without "timestamp." Every time the IED reports an Information Object with a "timestamp," this will be listed on SCADA as an attribute of the point that corresponds to this object. When there is no "timestamp," SCADA will fill it with the current time of the computer hosting SCADA.

SCADA communication module on Server mode implements:

- Responses to requests to read digital points;
- Responses to requests to read analog variables;
- Responses to requests for meter reading;
- Command request execution of digital and analog points.

4.2 Point Types

The implemented SCADA point types, listed below, are defined based on the data objects set out in the standard. For each type of point, whichever the object variation received on the IED might be, with or without a flag or a timestamp, the values acquired will be placed in points with the types listed below. In the **Points** table, the "**Address**" field is used to choose the type of point and to specify its address.

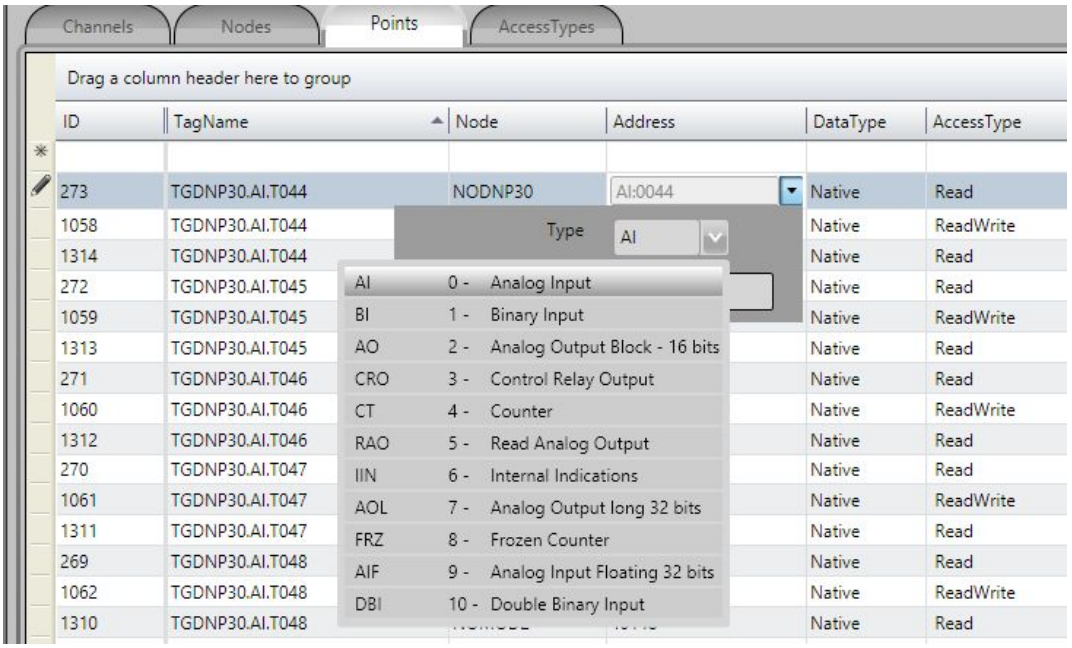


Figure 7 – Options for Point Types

AI - Analog Input

Scalar analog measurement used for transmission of analog quantities. The tag data with this type of point is sent through object 32 variation 1, when sent as events; when sending by class 0 (static), it uses object 30 variation 1.They are 32-bit integer numbers without timestamp.

BI - Binary Input

Simple bitwise input point, value 0 or 1. The data of tags with this type of point is sent through object 2 variation 2, when by reason of change (event), with timestamp, or through object 2 var. 1, when for general reading (class 0).

DBI - Double-bit Binary Input

Double binary input point, value between 0 and 3. The tag data with this type of point is sent through object 3 and variation 2, when by reason of change (event), with timestamp, or through object 3 var. 1, when for general reading (class 0).

RAO - Read Analog Output

Not used in the implementation of slave mode.

CRO - Control Relay Output

Digital output point used to receive switch and breaker commands. The DNP 12 object, including the Control Code (8 bits), is expected to indicate the type of command and execution details.

When registering these points in slave mode, it is necessary to define a control code that is identical to the one that will be sent by the Master IED, in order to identify the tag used in the Slave. The slave only executes the change of the value of the SCADA point. In order for

the command to reach its final destination in an IED, the affected tag must be used by another Client protocol, which will send it to the IED.

In the case of control of switches and circuit breakers it is recommended that two tags be used: one for Trip and one for Close.

The possible values received from the client are shown in the table below with their associated actions:

ControlCode	Protocol Action	Action in SCADA tag executed on the slave
1	Output Pulse ON	Changes to 1 and later to zero
2	Output Pulse OFF	Changes to zero and later to 1
3	Output Latch ON	Changes to 1
4	Output Latch OFF	Changes to zero
65	Output Pulse ON + Close	Changes to 1 and later to zero
66	Output Pulse OFF + Close	Changes to zero and later to 1
67	Output Latch ON + Close	Changes to 1
68	Output Latch OFF + Close	Changes to zero
129	Output Pulse ON + Trip	Changes to 1 and later do zero
130	Output Pulse OFF + Trip	Changes to zero and later to 1
131	Output Latch ON + Trip	Changes to 1
132	Output Latch OFF + Trip	Changes to zero
+ 16	Queue + Trip	Does nothing
+ 32	Clear + Trip	Does nothing

CT – Counter

Binary counter of 16 or 32 bits, received from the IEDs through objects 20 and all their variations. This number has the last state of counter, at the instant it is read.

FRZ - Frozen Counter

Binary counter of 32 bits, sent through an object 21 variation 1, which contains the information of a counter used as a tag.

AO - Analog Output Status or Block (16bits)

When this slave mode receives a message with a writing Function Code (2 = Write or 4 = Operate or 5 = DirectOperate) and this object 41 (required value to be reached on the analog output) on its 2 variations (16 bits), this value is written on the tag defined by the POINTS table for the address received on the object.

AOL - Analog Output Long (32 bits)

When this slave mode receives a message with a writing Function Code (2 = Write) and this object 41 (required value to be reached on the analog output) on its 1 variation (32 bits), this value is written on the tag defined by the POINTS table for the address received on the object.

AIF - Analog Input Floating (32 bits)

Measurement used for analog transmission of analog quantities. Tags with this type must be identified as real on SCADA. Their value is sent through object 30 with variation 5, when sending static by class 0, or using object 32 variation 5 when sent as event changes.. These are floating point numbers with 32 or 64 bits, IEEE-754 format.

IIN - Internal Indications

As a standard of this protocol, the Internal Indications statuses or the command answer statuses are sent in every slave answer message, for client use. The following table shows the format of these two 16-bit words.

IIN: 16 bits sent in every slave answer with control data - Address: 65000

BIT	Origin	Description	Content
0	IIN	Broadcast	Returns 1 if slave receives a broadcast message (address = FFFF)
1	IIN	Class 1	Returns 1 if slave has class 1 events
2	IIN	Class 2	Returns 1 if slave has class 2 events
3	IIN	Class 3	Returns 1 if slave has class 3 events
4	IIN	Clock Synchronization	Returns 1 if slave asks for clock synchronization
5	IIN	Outputs set to local	Returns 1 if slave has any output set to local
6	IIN	Problem	Returns 1 if slave has a problem
7	IIN	Restart	Returns 1 if slave has restarted
8	IIN	Function not Implemented	Returns 1 if a function asked by the master was not implemented in the slave
9	IIN	Unknown Object	Returns 1 if slave does not have a certain object at all or in a specific class
10	IIN	Invalid Data	Returns 1 if slave has an invalid parameter in the qualifier or the address range is invalid
11	IIN	Overflow	Returns 1 if slave buffer has an overflow
12	IIN	Busy	Returns 1 if the request was received but is already running
13	IIN	Corrupted Data	Returns 1 if the parametric data was corrupted
14	IIN	Reserved	Always 0
15	IIN	Reserved	Always 0

Status field: 8 bits sent as an answer to a command. Address: 65001

BIT	Origin	Description	Content
0	Status	Command Accepted	Returns 1 after a correct command
1	Status	Command Not Accepted	Returns 1 if a timeout has occurred between select and operate

2	Status	Select Fault	Returns 1 if an operate has occurred without prior select
3	Status	Format Error	Returns 1 if command has an error in format
4	Status	Control not supported	Returns 1 if operation was not supported
5	Status	Full Queue	Returns 1 if the request queue on the slave is full or the point is already active
6	Status	Hardware Error	Returns 1 if a hardware error occurred while the command was being processed
7		Not used	

4.3 Point Address

The **Address** field to be filled in when registering a point is what the standard calls "Index." It consists of a 16-bit number that is the indicative index [0 to n-1] of each of the points of the same type mapped within the IED.

For example purposes, a points table filled with several types of points is presented below. The digital output type points (CRO), as mentioned above, have their control code, besides the address.

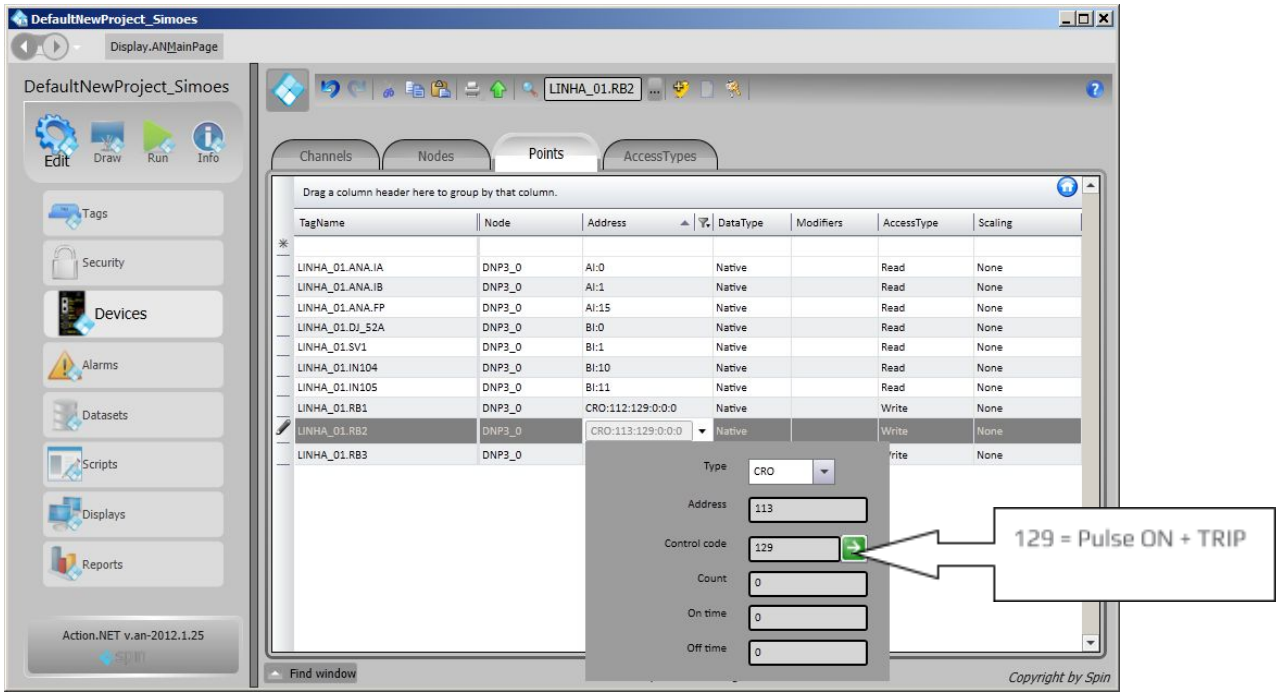
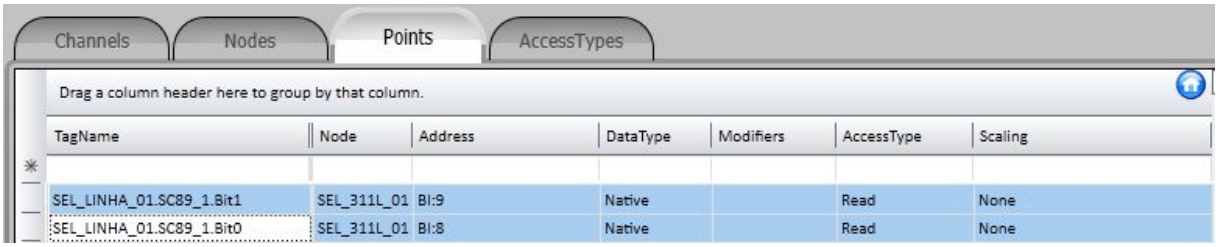


Figure 12 – A sample points table with different types of points

To implement discrete digital input points, it is enough to use the "Bit" attribute of a tag for each of the points that define the discrete digital input value. Therefore, for example, a switch with two contacts that define its state:

Tag	ADDRESS	Complement
SEL_LINHA_01.SC89_1	8	Switch Open
SEL_LINHA_01.SC89_1	9	Switch Closed

This is defined as an AnalogInt Tag and the Bit attribute of this 16-bit variable (AnalogInt) is used on the node table to address two points, as in the figure below:



The values assumed by the SEL_LINHA_01.SC89_1 variable will be:

Tag	Bit 0	Bit 1	VALUE	MEANING
SEL_LINHA_01.SC89_1	0	0	0	UNDEFINED
SEL_LINHA_01.SC89_1	1	0	1	OPEN
SEL_LINHA_01.SC89_1	0	1	2	CLOSED
SEL_LINHA_01.SC89_1	1	1	3	ERROR

4.4 Access Type

Since this is a communication module in client mode, it requires a few characteristics of its own for parametrization of the **Access Type** field in the **Points** table:

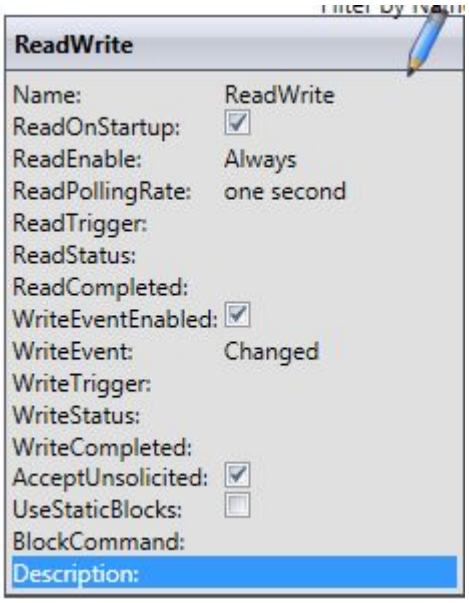
For reading or command reception-type points (using writeEventsEnable, for getting tag changes):

ReadOnStartup= On;

ReadPooling= Never;

WriteEvent= Changed;

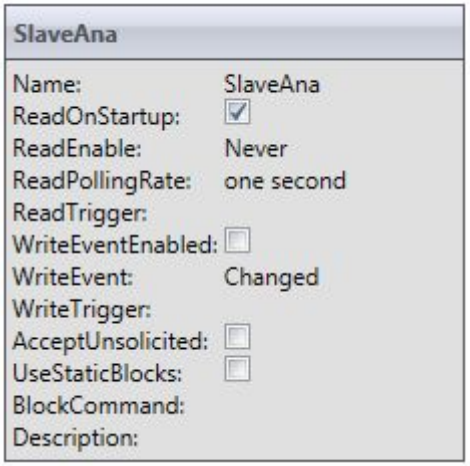
AccepUnsolictited = On;



For measure-type points (analog) - (Using get analog changes by sampling: Option Get analog changes by sampling):

Point type AI. AIF, CT EAO and FRZ.

Use WriteEventEnable = false: as shown in the **SlaveAna** picture below:



For command-type points:

Access Type must be defined (as shown in the **WriteSlave** picture below**)**

ReadPooling = Never;

WriteEventEnable = off

WriteEvent= Changed;


WriteSlave
Name: WriteSlave
ReadOnStartup:
ReadEnable: Never
ReadPollingRate: one second
ReadTrigger:
WriteEventEnabled:
WriteEvent: Changed
WriteTrigger:
AcceptUnsolicited:
UseStaticBlocks:
BlockCommand:
Description: