DNP 3.0

Slave Communication Protocol

Summary

1. GENERAL INFO

1.1 Summary

Communication Driver Name: DNP30S.
Current Version: 1.0.
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 Eletronic Devices) using Level 2 DNP 3.0 Level 2 protocol in master (or client) mode. Communication can be done through multi-point serial channel or LAN using Ethernet and TCP-IP. In the last case, each IED has an IP address.
IEDs types supported: Any compatilble DNP 3.0 IED in master (or client) mode.
Communication block size: Maximum 250 bytes, FT 1.2 format.
Protocol Options: Mode "LinkConfirm" and master station address.
Multi-threading: User defined, five threads per comunication 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.

Objeto			Requisição (Mestre)		Resposta (Escravo)	
Obj.	Var	Descrição	Func. Code (decimal)	Qual. Code (Hex)	Func. Codes (decimal)	Qual. Code (Hex)
1	1	Single Bit Binary Input			129	00
1	2	Binary Input with status			129	00
2	1	Binary Input change without time			129	17
2	2	Binary Input change with time			129	17
12	1	Control relay output block	3,4,5	0x17	129	17
20	0	Binary Counter – all variation				
21	0	Frozen counter – all variations				
30	0	Analog Input – all variations				
30	1	32 Bits Analog Input			129	00
30	2	16 Bit Analog input with flag			129	00
30	3	32 Bits Analog Input without flag			129	00
30	4	16 Bit Analog input without flag			129	00
30	5	Short Floating Point (32bits)				
32	0	Analog Input change event – all variations				
32	1	32 Bits Analog Input change event			129	17
32	2	16 Bit Analog change event without flag			129	17
32	3	32 Bit Analog change event with flag				
32	4	16 Bit Analog change event with				

		flag				
40	2	16 Bit Analog output status			129	00
41	1	32Bit Analog output block	5	0x17	129	17
41	2	16 Bit Analog output block	5	0x17	129	17
50	1	Time and Data	1,2	0x07		
60	1	Class 0 data	1	0x06		
60	2	Class 1 data	1	0x06		
60	3	Class 2 data	1	0x06		
60	4	Class 3 data	1	0x06		
80	1	Internal indications	2	0x06		

In the master mode protocol implementation, 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 deciding 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	Descrição	Origem
1	Read	Master
2	Write	Master
3	Select	Master
4	Oper	Master
5	Direct Oper (without selection)	Master
6	Direct Oper (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, defined four classes:

Class 0: Corresponds to the static points, analog or digital. Its content is the value of a variable analog or digital, input or output in a given time;
Class 1, 2 e 3: Events corresponding to class 0 variables transitions, state transitions or internal relay situations that causes an event.

A common practice in the DNP IEDs is to associate the state variation of digital variables or dead band pass of analog variable to classes 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, it may be requested a class 0 reading (60 / 1), for checking integrity.

Comments:

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 an in Object 30 with variation 5 format for AIF.

1.3 General operation

The normal slave sequence operation is showed below.

- If it's necessary, when installing, the master shall 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 restart. The master shall then execute a writing of "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 - Number between 1 and 65534, univocal and correspondent to the master station address. This way, the master informs his own address to the slave when sending him a message. Some slaves reply to the master disregarding this number, others demand that the address declared on the slave matches the one from the master. The default for this field is "65534".

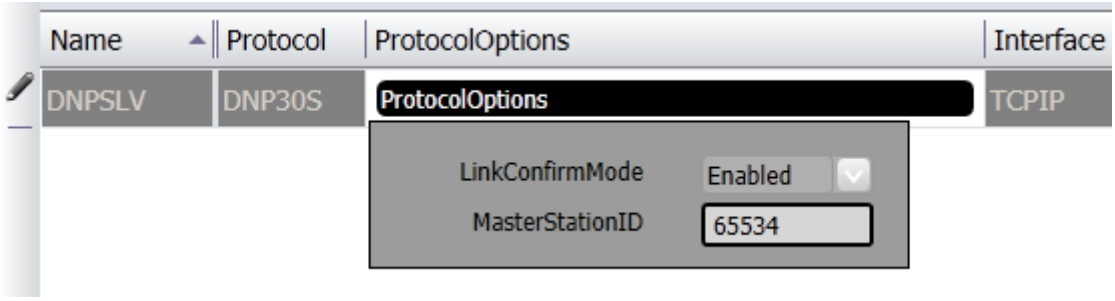


Figure 1 – Protocol Options

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.

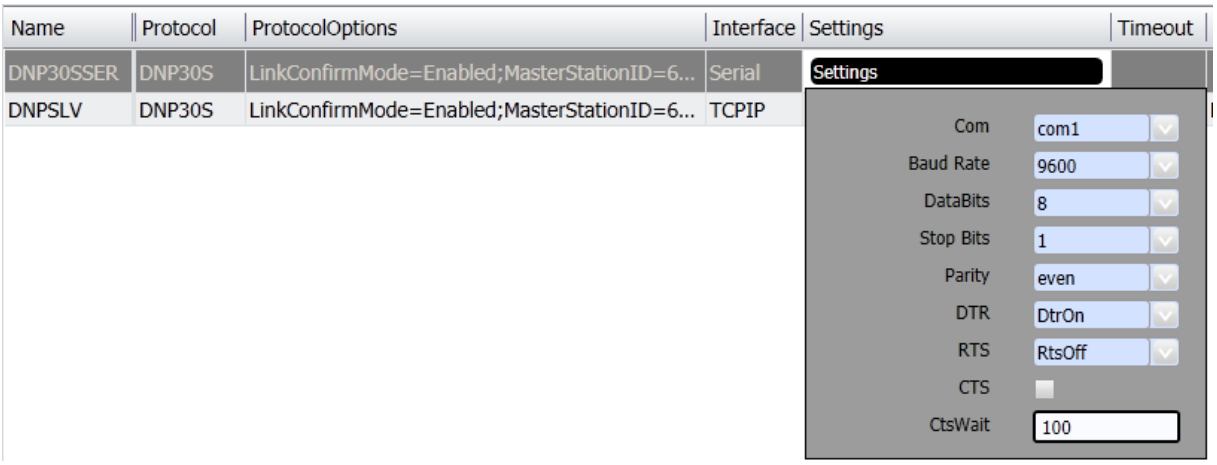


Figure 2 – Serial Channel Settings

TCP/IP channels:

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

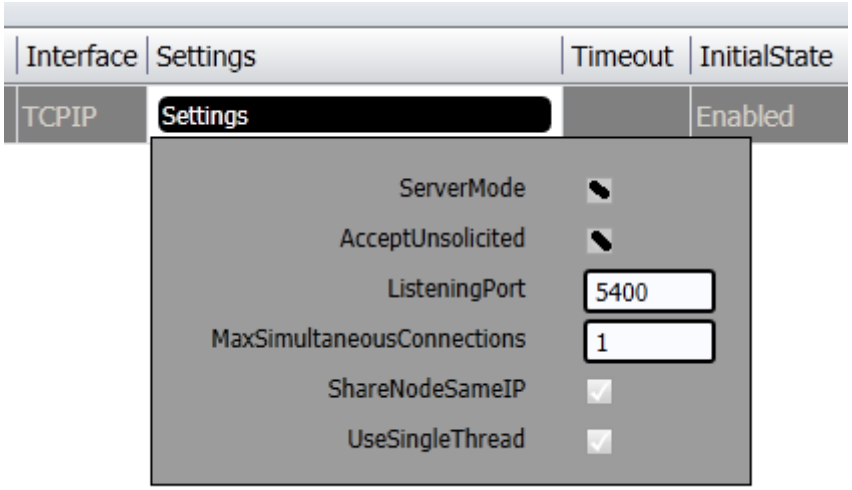


Figure 3 – TCP/IP Settings

2.3 Timeout

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

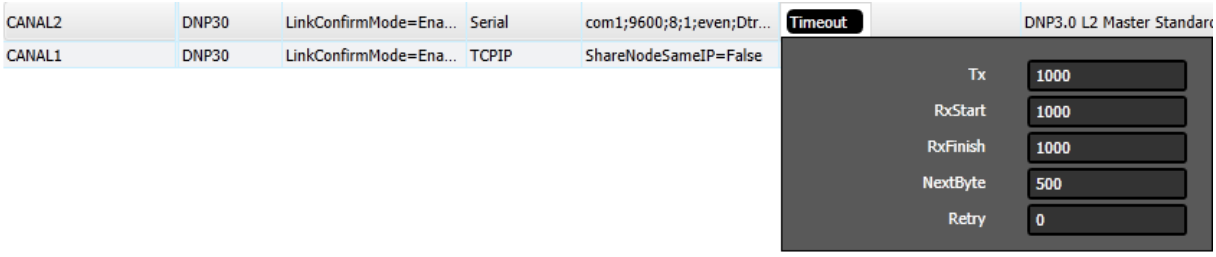


Figure 4 –Timeout Attributes

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.

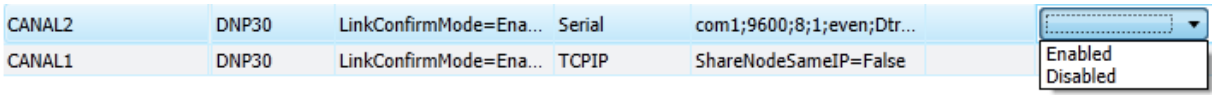


Figure 5 – Channel Initial State

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, there must be set as many channel as there are nodes.

3.1 Channel Data (Primary and Backup)

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

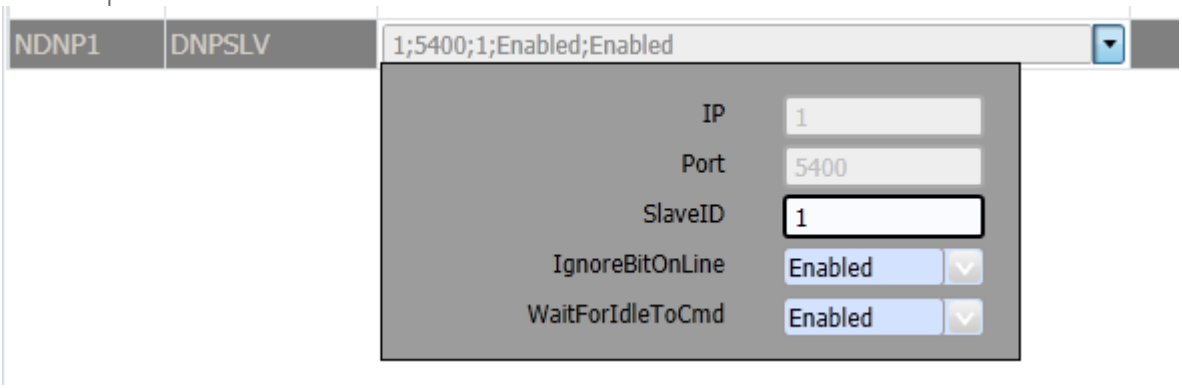


Figure 6 – Channel Data

In case of 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", indicates the driver must ignore the "BitOnLine" indication which is inserted by the IED when normality failure occurs at a point, according to the IED criteria.

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

4. POINTS SETTINGS

4.1 General

The points can be input or output.

The entry points, i.e. points that are acquired through the protocol have basically two main parameters: The 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 Action.NET, given an IED address map, for points of the same type, address numbers must be unique.

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 "timestamp", this will be listed in Action.Net as an attribute of the point that corresponds to this object. When there is no "timestamp", Action.Net will fill it with the current time of the computer hosting Action.Net.

Action.Net communication module on master mode, implements:

- Digital points read;
- Analog points read;
- Counters read;
- Analog and Digital points commands;
- Select Before Operate commands;

4.2 Point Types

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

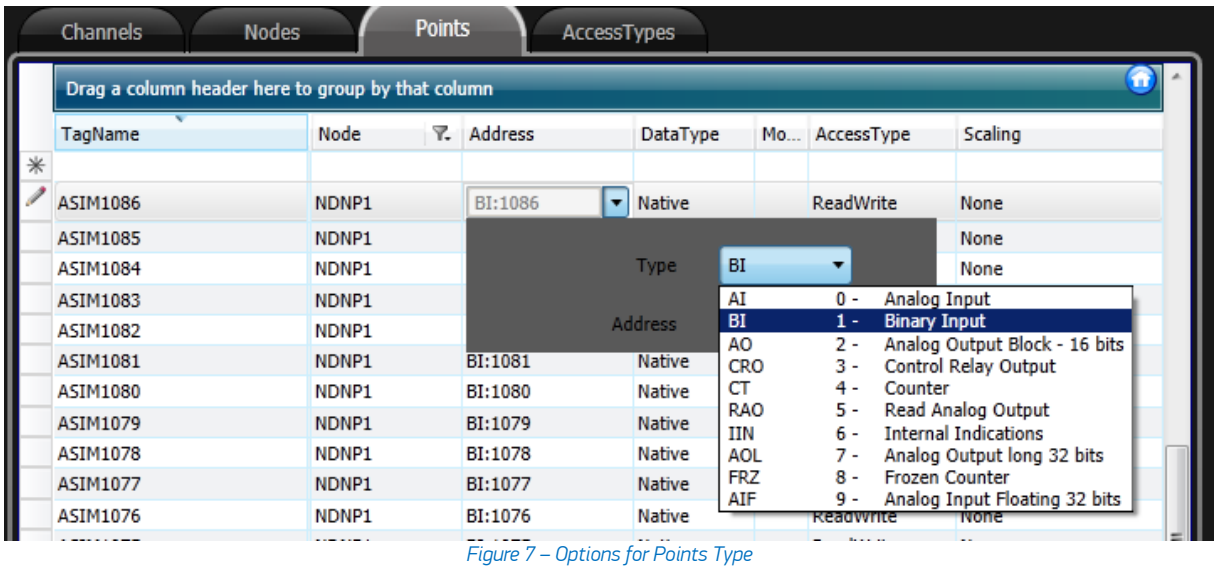


Figure 7 – Options for Points Type

AI- Analog Input

Scalar Analog measurement used for transmission of analog quantities. Used to receive data sent through objects 30 and 32 and all its variations. They are 32-bit integers numbers.

BI - Binary Input

Simple binary entry point, value 0 or 1. Used to receive data sent through objects 1 and 2 and all its variations.

RAO –Read Analog Output

Not used in slave mode implementation.

CRO - Control Relay Output

Digital output point used to control the switches and circuit breakers. The DNP object 12, including a Control Code (8 bits), is used to indicate the type of command and execution details. When enrolling these points in slave mode, there is no need to define the control code, since only the Action.NET point value alteration is executed. For this alteration to serve as a trigger of a client protocol command that will execute the command as a real IED.

For controlling switches and circuit breakers, it is recommended to use two Tags: one for Trip and other for Close.

The possible values are presented in the table below with the respective associated actions:

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

FRZ - Frozen Counter

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

AO - Analog Output Satus or Block (16bits)

When this slave mode receives a message with Function Code of writing (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 wrote 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 Function Code of writing (2 = Write) and this object 41(required value to be reached on the analog output) on its 1 variations (32 bits), this value is wrote 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 Action.NET. Their value is sent through object 30 with variation 5. They are floating point numbers are 32 or 64-bit IEEE-754 format.

IIN - Internal Indications

As 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 has not certain object at all or in a specific class
10	IIN	Inavalid 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 answer to a command. Address: 65001

BIT	Origin	Description	Content
0	Status	Accepted Command	Returns 1 after a correct command
1	Status	Not Accepted Command	Returns 1 if occurred a timeout between select and operate
2	Status	Select Fault	Returns 1 if occurred a operate without prior select
3	Status	Format Error	Returns 1 if command has en 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 occurred a hardware error while the command was processed
7		Not used	

4.3 Point Address

The **Address** field to be filled in the registration of a point is what the standard calls “Index”. It means 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.

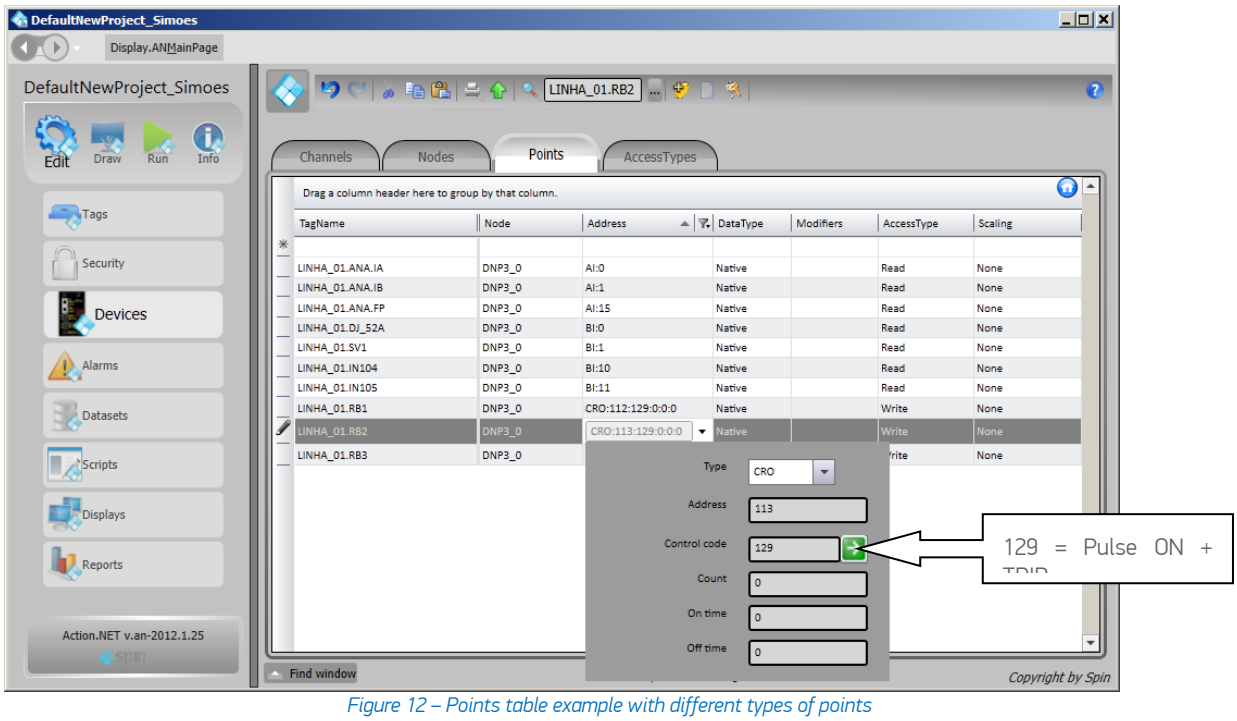
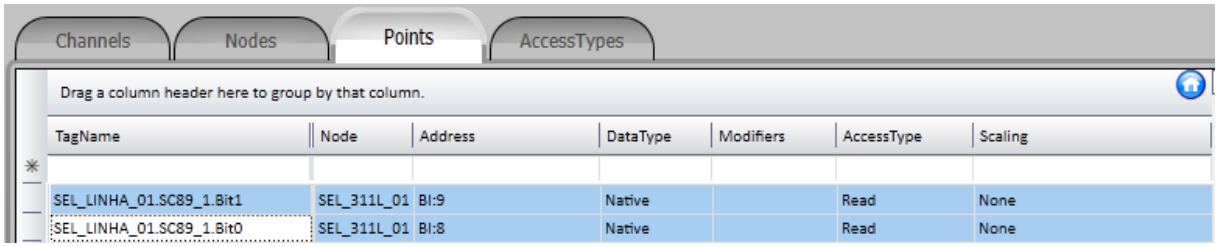


Figure 12 – Points table example with different types of points

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

It is defined as an AnalogInt Tag and the Bit attribute of this 16-bits 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 it is a communication module in client mode, there is need for a few own characteristics for parametrization of the **Access Type** field on the **Points** table:

For points with reading or command reception types (CRO, AO and AOL):
ReadOnStartup= On;
ReadPooling= Never;
WriteEvent= Changed;
AccepUnsolictited = On;

For reading type points, for which there is no intent to generate events, the Access Type must be defined the same way as mentioned above, but with:
WriteEnable = Off
WriteEvent= none;