GE MDS, LLC.

NETio™ Series

DNP V3 Protocol Communications Supplement

GE MDS

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DNP Protocol

NETio Implementation Summary

This document summarizes the implementation of the DNP V3.00 protocol in NETio. There are a number of important considerations about the DNP implementation in NETio that a user should understand.

1. NETio implementation of DNP is Poll/Response, sometimes also referred to as Master/Slave. NETio modules never initiate communication on their own. They communicate only in response to messages and commands issued by host DNP devices.
2. NETio supports serial DNP and DNP over UDP/TCP, sometimes referred to as DNP Ethernet. **DNP over UDP/TCP requires the use of a NETio AP or an entraNET Access point** with the NETio firmware support option.
3. NETio Remotes (Base and Expansion Modules) only support the direct interrogation of connected I/O using DNP over UDP/TCP when the host device is connected to the Ethernet port of the NETio Access Point or entraNET Access Point.
4. NETio requires that DNP messages and commands must be issued to each NETio module, Remote Base Module, Expansion Module or wireless Expansion Module. Range requests and commands cannot include more than one module; each module must be accessed individually. The DNP ID is assigned to a NETio Remote Base Module and shared by all Expansion Modules physically connected or wirelessly associated with it via WeXP. **IMPORTANT: Make sure the DNP driver you are using in the host device support non-contiguous addressing**.

Reading and understanding the remainder of this document will simplify the configuration of DNP3 in your NETio system.

DNP Protocol

NETio Architectural Implementation

As described in detail below, the DNP V3.00 protocol is a master/slave protocol. A NETio Base Module and its associated Expansion Modules each have unique DNP addresses. Accessing all I/O points from a NETio unit will require separate DNP messages for the base and it's expansions.

A NETio Base Module will process DNP messages that come from one of three sources depending upon how the user has configured it:

a) The source is over-the-air from a NETio AP or entraNET AP. This method allows a NETio Base Module to wirelessly communicate with a DNP Master device or system via the NETio AP or entraNET Access Point. The Access Point is where the physical connection to the DNP host is made. The connection can be serial or DNP over UDP/TCP; see the NETio Manual for instructions on how to configure these options.

b) The source is local. This method allows a NETio Base Module to communicate with a DNP Master device or system physically connected to the **serial** communication port on the NETio Base Module. See Local-Master-Mode, Protocol-Pass-Through and Direct Mode in the NETio Manual for additional details.

c) The source is over-the-air from a Direct Mode root or Direct Mode node. This method allows a NETio Base Module to wirelessly communicate with a DNP Master device or system via another NETio Base Module. One of the NETio Base Modules is where the physical connection from the DNP host is made to the **serial** port of the Direct Mode root. See Local-Master-Mode, Protocol-Pass-Through and Direct Mode in the NETio Manual for additional details.

Electrical Interface (Access Point)

The hardware or electrical interface is either the COM2 RS232 connection or the LAN Ethernet interface on the front faceplate of the Access Point module. Data flow is half-duplex. That is, data is never transmitted and received at the same time. Shielded wire should always be used to minimize noise. Refer to the EntraNET Access Point User Manual for correct serial and Ethernet port wiring.

Electrical Interface (NETio Base Module)

The hardware or electrical interface is the COM1 (RJ45) RS232 connection on the front panel of the NETio module. Data flow is half-duplex. That is, data is never transmitted and received at the same time. Shielded wire should always be used to minimize noise. Refer to the NETio User Manual for correct serial port wiring.

Device Profile Document

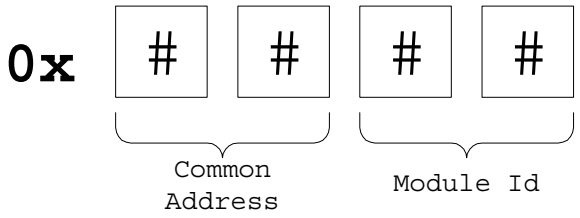
When configured as a DNP device, the NETio Base Module supports the features listed in the Level 1 DNP V3.00 Implementation (DNP-L1) described in Chapter 2 of the subset definitions. See the DNP protocol website at http://www.dnp.org/ for details.

NETio Point Addressing

Within the scope of a DNP network, a NETio Base Module along with its Expansion Modules will appear as independent DNP devices (although communication with the Expansion Modules is only possible through the Base Module). In terms of DNP, each Base Module and Expansion Module(s) has an independent and static I/O point list.

To address a specific I/O point, DNP uses addresses, Object numbers, Variation numbers and Index numbers. The definition of Objects, Variations and Indexes are described in the DNP specifications.

DNP uses 16-bit addressing, ranging from 0x0000 to 0xFFFF. The NETio, however, does not make use of the multicast addresses 0xFFF0 to 0xFFFF. The NETio usage of the remaining Unicast address range is that the upper byte is common to a Base Module and it's Expansions (call this the DNP Id of the NETio unit), while the lower byte is used to select the Base Module or a particular Expansion Module. The Base Module is addressed by using a lower byte value of 0x0 (zero), while Expansion Modules are addressed by using the module's Id as the lower byte value.



Each NETio module (Base or Expansion) acts as an independent DNP device; therefore I/O points start at index 0x0 (zero) for each module.

Examples:

A NETio Base Module has one Type 3 Expansion Module with a Module ID configured to 0x39. The NETio Base Modules has been configured to use the value 0x05 as the upper byte of DNP addresses (the DNP ID).

In order to access digital output 1 on the **NETio Base Module**, send a DNP message with the following:

DNP Destination Address	Object Id*	Point Index*
0x0500	0x0A	0x00

In order to access digital output 6 on the **NETio Expansion Module**, send a DNP message with the following:

DNP Destination Address	Object Id*	Point Index*
0x0539	0x0A	0x05

** See the NETio DNP Device Profile for a list of supported Objects, Variations and Indexes for each module type.*

DNP V3.0 Device Profile Document

Supported Functions

<table>
<tr><td colspan="2">DNP V3.0
DEVICE PROFILE DOCUMENT
(Also see the DNP 3.0 Implementation Table)</td></tr>
<tr><td colspan="2">Vendor Name: GEMDS</td></tr>
<tr><td colspan="2">Device Name: NETio EB</td></tr>
<tr><td>Highest DNP Level Supported:

For Requests: Level 1
For Responses: Level 1</td><td>Device Function:

☐ Master
☒ Slave</td></tr>
<tr><td colspan="2">Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table):

For static (non-change-event) object requests, request qualifier codes 07 and 08 (limited quantity), and 17 and 28 (index) are supported. Static object requests sent with qualifiers 07, or 08, will be responded with qualifiers 00 or 01.</td></tr>
<tr><td>Maximum Data Link Frame Size (octets):

Transmitted: 292
Received 292</td><td>Maximum Application Fragment Size (octets):

Transmitted: 249
Received 249</td></tr>
<tr><td>Maximum Data Link Re-tries:

☒ None
☐ Fixed
☐ Configurable from 0 to 255</td><td>Maximum Application Layer Re-tries:

☒ None
☐ Configurable, 0-3</td></tr>
<tr><td colspan="2">Requires Data Link Layer Confirmation:

☒ Never
☐ Always
☐ Sometimes
☐ Configurable as: Never, Only for multi-frame messages, or Always</td></tr>
<tr><td colspan="2">Requires Application Layer Confirmation:

☒ Never
☐ Always
☐ When reporting Event Data
☐ When sending multi-fragment responses
☐ Sometimes
☐ Configurable as: “Only when reporting event data”, or “When reporting event data or multi-fragment messages.”</td></tr>
</table>

DNP V3.0
DEVICE PROFILE DOCUMENT
(Also see the DNP 3.0 Implementation Table)

Timeouts while waiting for:

Data Link Confirm:	☒ None	☐ Fixed at ____	☐ Variable	☐ Configurable.
Complete Appl. Fragment:	☒ None	☐ Fixed at ____	☐ Variable	☐ Configurable
Application Confirm:	☒ None	☐ Fixed at ____	☐ Variable	☐ Configurable.
Complete Appl. Response:	☒ None	☐ Fixed at ____	☐ Variable	☐ Configurable

Others:

Sends/Executes Control Operations:

WRITE Binary Outputs	☐ Never	☐ Always	☐ Sometimes	☒ Configurable
SELECT/OPERATE	☐ Never	☐ Always	☐ Sometimes	☒ Configurable
DIRECT OPERATE	☐ Never	☐ Always	☐ Sometimes	☒ Configurable
DIRECT OPERATE – NO ACK	☐ Never	☐ Always	☐ Sometimes	☒ Configurable
Count > 1	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
Pulse On	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
Pulse Off	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
Latch On	☐ Never	☐ Always	☐ Sometimes	☒ Configurable
Latch Off	☐ Never	☐ Always	☐ Sometimes	☒ Configurable
Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
Clear Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable

Explanation of Configurable: an output must be set to 'Protocol Mode' (via menu configuration) for any output control operations to be successfully performed. The On/Off times and Count value are ignored.

Reports Binary Input Change Events when no specific variation requested:

- ☒ Never
- ☐ Only time-tagged
- ☐ Only non-time-tagged
- ☐☐Configurable to send one or the other

Reports time-tagged Binary Input Change Events when no specific variation requested:

- ☒ Never
- ☐ Binary Input Change With Time
- ☐ Binary Input Change With Relative Time
- ☐ Configurable

Sends Unsolicited Responses:

- ☒ Never
- ☐ Configurable
- ☐ Only certain objects
- ☐ Sometimes (attach explanation)
- ☐ ENABLE/DISABLE UNSOLICITED Function codes supported

Sends Static Data in Unsolicited Responses:

- ☒ Never
- ☐ When Device Restarts
- ☐ When Status Flags Change

No other options are permitted.

DNP V3.0
DEVICE PROFILE DOCUMENT
(Also see the DNP 3.0 Implementation Table)

Default Counter Object/Variation:	Counters Roll Over at:
☒ No Counters Reported ☐ Configurable ☐ Default Object Default Variation: ☐ Point-by-point list attached	☒ No Counters Reported ☐ Configurable (attach explanation) ☐ 16 Bits ☐ 32 Bits ☐ Other Value: _____ ☐ Point-by-point list attached

Sends Multi-Fragment Responses:

☐ Yes
☒ No
☐ Configurable

Sequential File Transfer Support:

Append File Mode	☐ Yes	☒ No
Custom Status Code Strings	☐ Yes	☒ No
Permissions Field	☐ Yes	☒ No
File Events Assigned to Class	☐ Yes	☒ No
File Events Send Immediately	☐ Yes	☒ No
Multiple Blocks in a Fragment	☐ Yes	☒ No
Max Number of Files Open	0	

DNP V3.0 Implementation Table

Supported Objects

OBJECT			REQUEST		RESPONSE	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
1	0	Binary Input – Any Variation	1 (read)	00, 01 (start-stop) 06 (no range, or all)		
1	1 (default – see note 1)	Binary Input	1 (read)	00, 01 (start-stop) 06 (no range, or all)	129 ( )	00, 01 (start-stop)
1	2	Binary Input with Status	1 (read)	00, 01 (start-stop) 06 (no range, or all)	129 (response)	00, 01 (start-stop)
10	0	Binary Output – Any Variation	1 (read)	00, 01 (start-stop) 06 (no range, or all)		
10	1	Binary Output	1 (read)	00, 01 (start-stop) 06 (no range, or all)	129 (response)	00, 01 (start-stop)
10	2 (default – see note 1)	Binary Output Status	1 (read)	00, 01 (start-stop) 06 (no range, or all)	129 (response)	00, 01 (start-stop)
12	0	Control Relay Output Block				
12	1 (default – see note 1)	Control Relay Output Block	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, noack)	17, 28 (index)	129 (response)	echo of request
30	0	Analog Input - Any Variation	1 (read)	00, 01 (start-stop) 06 (no range, or all)		
30	2	16-Bit Analog Input	1 (read)	00, 01 (start-stop) 06 (no range, or all)	129 (response	00, 01 (start-stop)
30	4 (default – see note 1)	16-Bit Analog Input without Flag	1 (read)	00, 01 (start-stop) 06 (no range, or all)	129 (response	00, 01 (start-stop)
40	0	Analog Output Status	1 (read)	00, 01 (start-stop) 06 (no range, or all)		
40	2 (default – see note 1	16-Bit Analog Output Status	1 (read)	00, 01 (start-stop) 06 (no range, or all)	129 (response	00, 01 (start-stop)
41	0	Analog Output Block				
41	2 (default – see note 1)	16-Bit Analog Output Block	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, noack)	17, 28 (index)	129 (response	echo of request
60	0	Class 0 Data* (default to class 0)				
60	1	Class 0 Data	1 (read)	06 (no range, or all)		
80	1	Internal Indications	1 (read)	00, 01 (start-stop)	129 (response)	00, 01 (start-stop)
			2 (write) (see note 3)	00 (start-stop) index=7		
No Object (function code only)			13 (cold restart)			
No Object (function code only)			14 (warm restart)			

Note 1: A Default variation refers to the variation responded when variation 0 is requested and/or in class 0 scans.

Note 2: For static (non-change-event) objects, qualifiers 17 or 28 are only responded when a request is sent with qualifiers 17 or 28, respectively. Otherwise, static object requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01.

Note 3: Writes of Internal Indications are only supported for index 7 (Restart IIN1-7)

Note 4: For binary and analog objects (Objects 1, 10, 30, 40), the value of the requested point defaults to 0 (zero) when an error has occurred during a read operation.

DNP Point Lists

Supported Functions

The tables below identify all the default data points provided by the NETio base module and expansion modules.

1.1 Binary Input Points

Binary Input Points Static (Steady-State) Object Number: **1** Change Event Object Number: **N/A** Static Variation reported when variation 0 requested: **1 (Binary Input without status)** Change Event Variation reported when variation 0 requested: **N/A**		
Point Index	**Name/Description**	**Default Change Event Assigned Class (1, 2, 3 or none)**
0	NETio Base Module Type 1 Expansion Module Type 2 Expansion Module Type 4 Expansion Module Type 6 Expansion Module Type 7 Expansion Module	None
1	NETio Base Module Type 1 Expansion Module Type 2 Expansion Module Type 4 Expansion Module Type 6 Expansion Module	None
2	Type 2 Expansion Module Type 4 Expansion Module	None
3	Type 2 Expansion Module Type 4 Expansion Module	None
4	Type 2 Expansion Module	None
5	Type 2 Expansion Module	none

1.2 Binary Output Status Points and Control Relay Output Blocks

The following table lists both the Binary Output Status Points (Object 10) and the Control Relay Output Blocks (Object 12). Although writes can be performed directly on Binary Output Status Points, Control Relay Output Blocks (CROB) have been included for completeness. Performing select/operate commands on CROBs has the same effect as performing write commands to Binary Output Status Points and vice versa. Reading a CROB has the same effect as reading the corresponding Binary Output Status Point and vice versa.

Binary Output Status Points
Object Number: **10**
Default Variation reported when variation 0 requested: **2 (Binary Output Status)**
Control Relay Output Blocks
Object Number: **12**

Point Index	Name/Description	Supported Control Relay Output Block Fields
0	NETio Base Module Type 1 Expansion Module Type 3 Expansion Module Type 6 Expansion Module Type 7 Expansion Module	LATCH_ON, LATCH_OFF
1	NETio Base Module Type 1 Expansion Module Type 3 Expansion Module Type 6 Expansion Module Type 7 Expansion Module	LATCH_ON, LATCH_OFF
2	Type 3 Expansion Module Type 7 Expansion Module	LATCH_ON, LATCH_OFF
3	Type 3 Expansion Module	LATCH_ON, LATCH_OFF
4	Type 3 Expansion Module	LATCH_ON, LATCH_OFF
5	Type 3 Expansion Module	LATCH_ON, LATCH_OFF

1.3 Analog Inputs

The following table lists Analog Inputs (Object 30). It is important to note that Analog Inputs are transmitted through DNP as signed numbers. Scaling is not available.

Analog Inputs
Static (Steady-State) Object Number: **30**
Change Event Object Number: **N/A**
Static Variation reported when variation 0 requested: **4 (16-Bit Analog Input without Flag)**
Change Event Variation reported when variation 0 requested: **N/A**

Point Index	Name/Description	Default Deadband	Default Change Event Assigned Class (1, 2, 3 or none)
0	NETio Base Module Type 1 Expansion Module Type 4 Expansion Module Type 6 Expansion Module Type 7 Expansion Module	N/A	none
1	Type 4 Expansion Module Type 6 Expansion Module Type 7 Expansion Module	N/A	none

1.4 Analog Output Status Points and Analog Output Control Blocks

The following table lists both the Analog Output Status Points (Object 40) and the Analog Output Control Blocks (Object 41). It is important to note that Analog Output Control Blocks and Analog Output Statuses are transmitted through DNP as signed numbers. Scaling is not available.

Analog Output Status Points
Object Number: **40**
Default Variation reported when variation 0 requested: **2 (16-Bit Analog Output Status)**
Analog Output Blocks
Object Number: **41**

Point Index	Name/Description
0	NETio Base Module Type 1 Expansion Module Type 6 Expansion Module
1	Type 6 Expansion Module

Converting NETio A/D Counts in Full Scale Mode

All NETio Analog Input and Output values are represented internally in A/D counts. The actual value represented by the counts is based upon whether the analog point is configured as a current or voltage signal.

4-20 mA Signals

For 4-20 mA current inputs or outputs the conversion factor is .00024414. In addition, because the range of the signal is offset from zero (0) by 4 mA, the number 4 must be added to the converted number to get actual milliamps. Therefore:

A count value of 31534 read from NETio equals:

31584 X .00024414 = 7.71 milliamps
7.70 + 4.0 (Zero Offset) = 11.71 milliamps

A DNP command to generate a 12.6 milliamp would use the following count value:

12.6 Milliamps – 4.0 (Zero Offset) = 8.6 milliamps
8.6 / .00024414 = 35246 counts

0-5 Volt and 0-10 Volt Signals

For 0-5 Volt inputs and outputs the conversion factor is .000076295. For 0-10 Volt I/O the conversion factor is .00015259. Since the range begins a zero (0) there is not offset needed. Therefore:

A count value of 54320 read from NETio equals:

For a 0-5 Volt Input: 54320 X .000076295 = 4.14 Volts
For a 0-10 Volt Input: 54320 X .00015259* = 8.28 Volts

A DNP command to generate a 3.4 Volt would use the following count value:

For a 0-5 Volt Output: 3.4 / .000076295* = 44564 counts
For a 0-10 Volt Output: 3.4 / .00015259* = 22295 counts

* This level of resolution is for mathematical/calculation purposes only. The NETio does not support the use all of the digits displayed in these examples.

Converting NETio A/D Counts with Analog Half Scaling Enabled

When the Analog Half Scaling variable is enabled to allow DNP messages to utilize the 16-bit variation of analog read/write requests**, the full A/D range of NETio is 0-32767**. All NETio Analog Input and Output values are represented internally in A/D counts. The actual value represented by the counts is based upon whether the analog point is configured as a current or voltage signal.

4-20 mA Signals

For 4-20 mA current inputs or outputs the conversion factor is .00048829. In addition, because the range of the signal is offset from zero (0) by 4 mA, the number 4 must be added to the converted number to get actual milliamps. Therefore:

A count value of 31534 read from NETio equals:

31584 X .00048829 = 15.42 milliamps
15.41 + 4.0 (Zero Offset) = 19.41 milliamps

A DNP command to generate a 12.6 milliamp would use the following count value:

12.6 Milliamps – 4.0 (Zero Offset) = 8.6 milliamps
8.6 / .00048829 = 17613 counts

0-5 Volt and 0-10 Volt Signals

For 0-5 Volt inputs and outputs the conversion factor is .00015259. For 0-10 Volt I/O the conversion factor is .00030518. Since the range begins a zero (0) there is not offset needed. Therefore:

A count value of 24320 read from NETio equals:

For a 0-5 Volt Input: 24320 X .00015259= 3.72 Volts
For a 0-10 Volt Input: 24320 X .00030518* = 7.44 Volts

A DNP command to generate a 3.4 Volt would use the following count value:

For a 0-5 Volt Output: 3.4 / .00015259* = 22281 counts
For a 0-10 Volt Output: 3.4 / .00030518* = 11141 counts

* This level of resolution is for mathematical/calculation purposes only. The NETio does not support the use all of the digits displayed in these examples.