DNP 3.0 PROTOCOL

DNP 3.0 Protocol for MiCOM Px3x

Px3x-DNP3/EN M/C11

Version 1

Technical Manual

Schneider Electric

Note

The operating manual for this device gives instructions for its installation, commissioning and operation. However, the manual cannot cover all conceivable circumstances or include detailed information on all topics. In the event of questions or specific problems, do not take any action without proper authorization. Contact the appropriate Schneider Electric technical sales office and request the necessary information.

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1 General

The Distributed Network Protocol (DNP) Version 3.0 was developed by Harris, Distributed Automation Products. In November 1993, responsibility for defining further DNP3 specifications and ownership of the DNP3 specifications was handed over to the DNP3 Users Group, a group consisting of utilities and vendors who are using the protocol.

1.1 Standardization

For standardization purposes the DNP Users Group has published the document 'DNP V3.00 Subset Definitions'. This document defines three implementation levels with respect to:

- Supported objects and variations,
- Supported function codes,
- Supported qualifier codes.

The three possible implementation levels are:

Level 1: Simplest level, suitable for intelligent electronic devices (IED).
Level 2: Enhanced implementation, suitable for intelligent electronic devices and remote stations (RTU).
Level 3: Enhanced implementation for remote stations and data concentrators.

1.2 Certification

Certification procedures are being prepared by the DNP Users Group, but at the time of publishing of this document certification is not yet possible. However, there are companies who offer compatibility checking of DNP3.0 implementations, for instance Demand Side Solutions Inc (http://www.demandside.com).

1.3 Device Profile

The following information is an extract from the device profile document for the MiCOM 30 series device implementation of DNP 3.0. This information summarizes the configuration and level of conformity of the implementation to the DNP 3.0 standard:

<table>
<tr><td>Highest DNP Level supported:
For requests:
For responses:</td><td>
Level 2
Level 2</td></tr>
<tr><td colspan="2">Notable support for objects, functions, and/or qualifiers above level 2 (see 1.4 Implementation Table for complete list):
For static object requests, request qualifier codes 00 and 01 (start-stop), 07 and 08 (limited quantity), and 17 and 28 (index) are supported in addition to request qualifier code 06 (no range).
Static object requests sent with qualifiers 00, 01, 06, 07, or 08, will get response with qualifier 00 or 01.
Static object requests sent with qualifiers 17 or 28 will get response with qualifiers 17 or 28.
Object 34, Analog Input Reporting Deadband read and write is supported.
For objects 30, 32, 34, 40, 41 short floating point variations are supported.
For change-event object requests, qualifiers 17 or 28 get a response.
16-bit, 32-bit or short floating point Analog Change Events with Time may be requested.
‘Assign Class’ function is supported for Binary and Analog Input Events.
The read function code for Object 50 (Time and Date), variation 1, is supported.</td></tr>
<tr><td>Maximum Data Link Frame Size (octets):
Transmitted : 292
Received: 292</td><td>Max. Application Frag. Size (octets):
Transmitted: 2048
Received: 2048</td></tr>
<tr><td>Maximum Data Link Retries:
Configurable</td><td>Maximum Allocation Layer Retries:
Configurable</td></tr>
<tr><td colspan="2">Requires Data Link Layer Confirmation:
Configurable</td></tr>
</table>

Requires Application Layer Confirmation:		
When reporting Event Data		
When sending multi-fragment responses		
Timeouts while waiting for:		
Data Link Confirm	-	Configurable
Complete Appl. Fragment	-	None
Application Confirm	-	Configurable
Complete Appl. Response	-	None
Inter-character Delay	-	Default: 4 character times at selected baud rate, configurable
Select/Operate Arm Timeout		Default: 30 s, configurable
Need Time Interval	-	Default: 1 min, configurable
Sends/Executes Control Operations:		
WRITE Binary Outputs	-	Never
SELECT/OPERATE	-	Always
DIRECT OPERATE	-	Always
DIRECT OPERATE - NO ACK	-	Always
Count > 1	-	Never
Pulse On	-	Always
Pulse Off	-	Never
Latch On	-	Always
Latch Off	-	Always
Queue	-	Never
Clear Queue	-	Never

Reports Binary Input Change Events when no specific variation requested:	Reports time-tagged Binary Input Change Events when no specific variation requested:
Only time-tagged, variation 2	Binary Input Change With Time
Sends Unsolicited Responses:	Sends Static Data in Unsolicited Responses:
Never	Never
Default Counter Object/Variation:	Counters Roll Over at:
Default Object 20	16 Bits
Default Variation 6	
Sends Multifragment Responses - Yes	

1.4 Implementation Table

The implementation table defines the objects and variations supported and the implemented functions and qualifier codes for requests (from the master) and responses (from the slave device):

Object			REQUEST		RESPONSE	
Object Number (decimal)	Variation Number (decimal)	Description	Function Codes (decimal)	Qualifier Codes (hex)	Function Codes (decimal)	Qualifier Codes (hex)
1	0	Binary Input - Any Variation	1,22	00,01,06,07,08,17,28		
1	1	Binary Input	1,22	00,01,06,07,08,17,28	129	00,01,17,28
1	2	Binary Input with Status	1,22	00,01,06,07,08,17,28	129	00,01,17,28
2	0	Binary Input Change - Any Variation	1	06,07,08	129	
2	1	Binary Input Change without Time	1	06,07,08	129	17,28
2	2	Binary Input Change with Time	1	06,07,08	129	17,28
10	0	Binary Output - All Variations	1	00,01,06,07, 08,17,28		
10	2	Binary Output Status	1	00,01,06,07, 08,17,28	129	00,01,17,28
12	1	Control Relay Output Block	3,4,5,6	00,01,07,08, 17,28	129	echo
20	0	Binary Counter	1,7,8	00,01,06,07, 08,17,28		
20	1	32-Bit Binary Counter with Flag	1,7,8	00,01,06,07, 08,17,28	129	00,01,17,28
20	2	16-Bit Binary Counter with Flag	1,7,8	00,01,06,07, 08,17,28	129	00,01,17,28
20	5	32-Bit Binary Counter without Flag	1,7,8	00,01,06,07, 08,17,28	129	00,01,17,28
20	6	16-Bit Binary Counter Without Flag	1,7,8	00,01,06,07, 08,17,28	129	00,01,17,28
21	0	Frozen Counter	1	00,01,06,07, 08,17,28		
21	1	32-Bit Frozen Counter with Flag	1	00,01,06,07, 08,17,28	129	00,01,17,28
21	2	16-Bit Frozen Counter with Flag	1	00,01,06,07, 08,17,28	129	00,01,17,28
21	9	32-Bit Frozen Counter without Flag	1	00,01,06,07, 08,17,28	129	00,01,17,28
21	10	16-Bit Frozen Counter without Flag	1	00,01,06,07, 08,17,28	129	00,01,17,28
30	0	Analog Input - All Variations	1	00,01,06,07, 08,17,28		
30	1	32-Bit Analog Input	1	00,01,06,07, 08,17,28	129	00,01,17,28
30	2	16-Bit Analog Input	1	00,01,06,07, 08,17,28	129	00,01,17,28
30	3	32-Bit Analog Input without Flag	1	00,01,06,07, 08,17,28	129	00,01,17,28
30	4	16-Bit Analog Input without Flag	1	00,01,06,07, 08,17,28	129	00,01,17,28
30	5	Short Float Analog Input	1	00,01,06,07, 08,17,28	129	00,01,17,28
32	0	Analog Change Event - All Variations	1,22	06,07,08		
32	1	32-Bit Analog Change Event without Time	1,22	06,07,08	129	17,28
32	2	16-Bit Analog Change Event without Time	1,22	06,07,08	129	17,28
32	3	32-Bit Analog Change Event with Time	1,22	06,07,08	129	17,28
32	4	16-Bit Analog Change Event with Time	1,22	06,07,08	129	17,28
32	5	Short Float Ana. Change Ev. without Time	1	06,07,08	129	17,28
32	7	Short Float Ana. Change Event with Time	1	06,07,08	129	17,28

Object			REQUEST		RESPONSE	
Object Number (decimal)	Variation Number (decimal)	Description	Function Codes (decimal)	Qualifier Codes (hex)	Function Codes (decimal)	Qualifier Codes (hex)
34	0	Analog Input Reporting Deadband – All V.	1	06,07,08		
34	1	16 Bit Analog Input Reporting Deadband	1,2	00,01,06,07,08	129	00,01,17,28
34	2	32 Bit Analog Input Reporting Deadband	1,2	00,01,06,07,08	129	00,01,17,28
34	3	Short Float Analog Input Rep. Deadband	1,2	00,01,06,07,08	129	00,01,17,28
40	0	Analog Output Status – All Variations	1	06,07,08		
40	1	32-Bit Analog Output Status	1	06,07,08	129	00,01,17,28
40	2	16-Bit Analog Output Status	1	06,07,08	129	00,01,17,28
40	3	Short Float Analog Output Status	1	06,07,08	129	00,01,17,28
41	1	32-Bit Analog Output Block	3,4,5,6	00,01,07,08, 17,28	129	echo
41	2	16-Bit Analog Output Block	3,4,5,6	00,01,07,08, 17,28	129	echo
41	3	Short Float Analog Output Block	3,4,5,6	00,01,07,08, 17,28	129	echo
50	0	Time and Date - All Variations	1	00,01,06,07, 08,17,28		00,01,17,28
50	1	Time and Date	1,2	00,01,06,07, 08,17,28	129	00,01,17,28
52	2	Time Delay Fine				7
60	0	Class 0,1,2,3 Data	1	06		
60	1	Class 0 Data	1	06	129	00,01
60	2	Class 1 Data	1,22	06,07,08	129	17, 28
60	3	Class 2 Data	1,22	06,07,08	129	17, 28
60	4	Class 3 Data	1,22	06,07,08	129	17, 28
80	1	Internal Indications	2	00 (index = 7)		
		No Object (function code only)	13 Cold Restart			
		No Object (function code only)	14 Warm Restart			
		No Object (function code only)	23 Delay Measure-ment			

2 Layer Model

The DNP 3.0 protocol layer model has the following structure:

User Layer
Application Layer
Transport Layer
Data Link Layer
Physical Layer

In order to guarantee as far as possible that MiCOM 30 series devices conform to the DNP 3.0 standard, a library from Triangle MicroWorks Inc. has been used in the implementation of the software. This library supports DNP 3.0 Level 2 (see '1.1 Standardization').

2.1 Physical Layer

The physical layer is either:

- Fiber optic,
- RS 485 bus, two-wire or four-wire

2.2 Data Link Layer

The data link layer is responsible for telegram framing.

The data link layer uses the FT3 telegram format as defined in the IEC 870-5-1 specification. Telegrams have a secure hamming distance of 6.

This document describes the specifics of the DNP 3.0 implementation for MiCOM 30 series devices. The document 'DNP V3.00 Data Link Layer Protocol Description' and the IEC 870-5-1 specification contain a detailed description of the data link layer and telegram framing.

2.3 Transport Layer

The transport layer is responsible for fragmentation of data over multiple telegrams.

This layer is responsible for disassembling one Transport Service Data Unit (TSDU) into multiple Transport Protocol Data Units (TPDUs), or frames, and assembling multiple (more than one) TPDUs into one TSDU.

This document describes the specifics of the DNP 3.0 implementation for MiCOM 30 series devices. The document 'DNP V3.00 Transport Functions' contains a detailed description of the transport layer.

2.4 Application Layer

The master sends ‘Application Layer Requests’ to the slave device. The device replies with ‘Application Layer Responses’.

The application layer is responsible for decoding the command and data information from request telegrams (from the master) and writing data to response telegrams (from the slave device).

Each request telegram contains a header and optionally data fields (information objects). The header contains an application control byte, and a function code defining the action to be taken by the slave device (see '5.1.1 Request Function Codes - Master to Slave').

The header in a response telegram contains an application control byte, a response function code (see '5.1.2 Response Function Codes - Slave to Master'), and a field containing internal indications from the slave device (see '4.3.11 Data Object 80 – Internal Indications').

Each item of data in a telegram is prefixed by an object header which defines the data type (e.g. binary input) and data variation (e.g. binary input with status) contained in the data field (see '4 Data Objects'). Qualifier and range fields in the object header specify how the data objects are packed in the message - range, quantity, index size (see '1.4 Implementation Table').

This document describes the specifics of the DNP 3.0 implementation for MiCOM 30 series devices. The document ‘DNP V3.00 Application Layer Protocol Description’ contains a detailed description of the application layer.

3 Configuring the DNP 3.0 Protocol

It is important to note that activation and configuration of the DNP 3.0 protocol for MiCOM 30 series devices must be done via the local control panel or over the PC interface. Device data items do not have fixed indices but instead the user may configure the data items which are to be made available to the DNP 3.0 master by selecting items from 'm out of n' selection tables.

The protocol is available on the 'logical' common interface 1 (COMM1) only.

Configuration is done in the menu tree branch

Parameters\Config. parameters\COMM1

The DNP 3.0 protocol must be activated and the device address and parity must be correctly configured.

Two parameters are used to configure the behavior of the device when refreshing measurement values:

COMM1: Delta meas.v. (DNP3) (003 250)

The value of this parameter is used as the default reporting deadband for all measurements. The master can change the reporting deadband value for each measurement individually (see '5.3 Function 2 - Write and 4.3.8 Data Object 34 – Analog Input Reporting Deadband'). A measurement is reported only when its value changes by a magnitude greater than the configured value.

COMM1: Delta t (DNP3) (003 248)

This parameter defines the time in seconds after which measurement values are refreshed by the device. The value of this parameter should be chosen carefully because changes to a measurement within the configured time period are not registered.

All values in the device data model which are to be made available to the DNP 3.0 protocol must be configured using the following parameters:

COMM1: Ind./cl. bin. inputs (003 232)

This parameter is used to select from an 'm out of n' selection table all the binary signals (read only) which are to be made available to the DNP 3.0 master. A data class may be assigned to each selected item (no class, or class 0 to 3).

COMM1: Ind./cl. bin. outputs (003 233)

This parameter is used to select from an 'm out of n' selection table all the binary commands (read/write) from the device data model which are to be made available to the DNP 3.0 master. Since all 'm out of n' parameters use the same software mechanism, a data class may be assigned to each selected item, but data classes 1 to 3 are not evaluated.

COMM1: Ind./cl. bin. count. (003 234)

This parameter is available only in MiCOM 30 series devices with control functions. It is used to select from an ‘m out of n’ selection table all the binary counters (read only) from the device data model which are to be made available to the DNP 3.0 master. Since all ‘m out of n’ parameters use the same software mechanism, a data class may be assigned to each selected item, but data classes 1 to 3 are not evaluated.

COMM1: Ind./cl. analog inp (003 235)

This parameter is used to select from an ‘m out of n’ selection table all the analog measurements (read only) from the device data model which are to be made available to the DNP 3.0 master. A data class may be assigned to each selected item (no class, or class 0 to 3).

COMM1: Ind./cl. analog outp (003 236)

This parameter is used to select from an ‘m out of n’ selection table all the analog parameters (read/write) from the device data model which are to be made available to the DNP 3.0 master. Since all ‘m out of n’ parameters use the same software mechanism, a data class may be assigned to each selected item, but data classes 1 to 3 are not evaluated.

The data class defines the event reporting behavior and allows the user to retrieve data by class as well as by data type (see '6.4 Data Class Handling').

4 Data Objects

4.1 General

DNP 3.0 uses the concept of data objects as an interface for devices which support the DNP 3.0 protocol. These objects have been defined in such a way that any device should be able to map the data which it wants to make available to a DNP 3.0 master to the data objects which are defined in the protocol specification.

The master specifies variations when handling data objects (see '1.4 Implementation Table' for a complete list of implemented data objects, variations, and function and qualifier codes which use these objects).

This document describes the specifics of the DNP 3.0 implementation for MiCOM 30 series devices. The document ‘DNP V3:00 Data Object Library’ contains a detailed description of the data objects and their variations.

In the implementation for MiCOM 30 series devices only 2 types of data objects are supported:

- **Static objects**

  Static objects reflect the current value of data items.

- **Event objects**

  Event objects are generated as a result of a data change, e.g. a signal or fault measurement. Event data reflects the value of data at some time in the past, and is stored in a queue in the device.

4.2 Data Objects Supported

The following table lists the data objects which are supported in MiCOM 30 series devices, the data object type, and which functions use the data objects.

Object Number (decimal)	Description	Type	Functions Using This Object (decimal)
1	Binary Input	static	1
2	Binary Input Change	event	1
10	Binary Output	static	1
12	Control Relay Output Block	static	3, 4, 5, 6
20	Binary Counter	static	1, 7, 8, 9, 10
21	Frozen Counter	static	1
30	Analog Input	static	1
32	Analog Change Event	event	1
34	Analog Input Reporting Deadband	static	1, 2
40	Analog Output	static	1
41	Analog Output Block	static	3, 4, 5, 6
50	Time and Date	static	1, 2
52	Time Delay Fine	static	
60	Class 0, 1, 2, 3 Data	event	1
80	Internal Indications	static	2

4.3 Assigning Data to Data Objects

4.3.1 General

Switchgear, Single Signals and Single Commands

MiCOM 30 series switchgear units are mapped to two data objects:

Data Object 1 – Binary Input

- Status signal OPEN
- Status signal CLOSE

Data Object 10 – Binary Output

- Command OPEN
- Command CLOSE

The device data to be made available to the DNP 3.0 master is mapped to the binary input and binary output objects by configuring them from ‘m out of n’ selection tables (see '3 Configuring the DNP 3.0 Protocol').

Tap Changer Signals and Commands

Tap changer signals are mapped to data object 30 (analog input).

For tap changer commands, 2 bits are used in data object 10 (binary output):

- ‘Raise one step’ command
- ‘Lower one step’ command.

The device data to be made available to the DNP 3.0 master is mapped to the analog input and binary output objects by configuring them from ‘m out of n’ selection tables (see '3 Configuring the DNP 3.0 Protocol').

4.3.1.1 Protection Data and General Device Information

The addresses to be made available to the DNP 3.0 master are selected using ‘m out of n’ selection tables.

4.3.1.2 Special Handling for Transient Signals

MiCOM 30 series devices support the following transient signals:

- Binary input signals which have been configured to be handled as transient (see function group SIG_1),
- Fault signals generated by protection functions which are defined in the device data model as 'start' only,
- Fault measurements generated by protection functions.

Transient signals are reset at the end of a fault.

4.3.2 Data Object 1 – Binary Input

The scope and contents of data object 1 vary greatly within the MiCOM 30 series device family. Bay units have only information from the control functions, protection devices only protection information, while combined protection and control units have both.

The number of binary inputs generated by the control functions depends on the device type and design version.

A simple bay unit may have as few as 10 signals, whereas a fully equipped combined protection and control unit may have nearly 300 signals.

Depending on the bay type, inputs are used for 2-pole switchgear units (for example a circuit breaker). In some cases, a large number of switchgear units may be configured. Reserving an area especially for a large number of units in data object 1 would not be the best solution because the reserved area would not be used by less complex devices.

For this reason, all binary signals which are generated by protection and control functions which are to be mapped to data object 1 are available in 'm out of n' selection tables instead of a fixed place being reserved. The index of each signal is the position in the list of selected signals, i.e. the order in which the signals are selected from the selection list implicitly assigns the index to the signal.

Data object 1 is allocated as follows:

Index (decimal)	Index (hex)	Description
0-63	00-3F	'm out of n' selection of binary signals

The software reduces the size of data object 1 to the number of values selected from the 'm out of n' selection tables.

Every value can be assigned data class 0 (static) and data classes 1,2 or 3 for the corresponding event telegram. Assigning of the data class is done in the 'm out of n' selection list. If an event data class (1,2 or 3) is selected, data class 0 is set implicitly. The master can change the data class using the 'Assign Class' function.

For the physical states of the LED's, digital inputs and digital outputs, no event information is available. All these values are only updated cyclically with a period ranging from 1 to 120 seconds depending on the set value
COMM1: Delta t (DNP3).
If a change is detected, the corresponding time stamp is that of the last update. Multiple transitions during the update cycle are not transmitted.

4.3.3 Data Object 10 – Binary Output

The number of binary outputs depends on the device type and design version. The number of signals may be anything from 2 up to over 150.

There are two types of binary outputs:

- Binary outputs to coils

  These outputs may be controlled by pulses. The state of the output is therefore not represented in the binary output object.

- Logical binary outputs

  These outputs represent binary settings (e.g. MAIN: Device on-line.) The state of these signals can be read in the binary output object.

In addition, a distinction is made between:

- Single pole electrical devices (see function group CMD_1)

  These have only one contact and can be controlled with latch on/off or pulse on.

  and

- 2-pole electrical devices (see function group DEVxx)

  These have two contacts – for instance one to switch the breaker on and another to switch it off. 2-pole devices are represented by two indices in the binary output object and the state of the device is represented by two indices in the binary input object.

Data object 10 is allocated as follows:

Index (decimal)	Index (hex)	Description
0-31	00-1F	'm out of n' selection of binary commands

The software reduces the size of data object 10 to the number of values selected from the 'm out of n' selection tables.

Data class assignment is not relevant for data object 10.

4.3.4 Data Object 12 – Control Relay Output Block

The following table shows the structure of data object 12 and the use of the individual fields:

Field	Description	Use/Comments
Control Code	8 bit control code Bits 0-3 (code): 0 – NUL operation 1 – Pulse On 2 – Pulse Off 3 – Latch On 4 – Latch Off Bit 4 – Queued Bit 5 – Clear Bit 6/7 – Trip/Close: 1 – Close/Lower .....2 – Trip/Raise	 Response only Pulse ON Not implemented Latch the output ON Latch the output OFF Not implemented, 0 Not implemented, 0 Close / lower tap changer Trip / raise tap changer
Count	Number of control executions	1
On Time	Duration of ON state	2000 – short command time 20000 – long command time
Off Time	Duration of OFF state	Not implemented, 0
Status	Control operation status: 0 – Request accepted 1 – *Operate* too late after *select* 2 – No matching *select* before *operate* 3 – Format error in request 4 – Control operation not supported 5 – Queue full or already active 6 – Hardware error 7 – Device in 'local' mode (*) 8 – Too many operations (*) 9 – Not authorized (*) 10 to 126 – Reserved (*) 127 – Unspecified error (*)	

(*) Note: These codes are currently only documented in a recommendation by the technical committee.

The control relay output block information object offers a wide variety of possibilities for controlling outputs. Among DNP vendors there are discussions about the interpretation of control operations. The technical committee of the DNP Users Group has published a number of recommendations in an attempt to improve compatibility.

The discussions have made clear that DNP masters on the market differ greatly in their implementation of the control relay output block. An attempt has therefore been made to offer as many possibilities as possible in order to achieve compatibility to as many masters as possible.

Conventions:

- Only one control operation is accepted per request.
- Pulse OFF, Queued, Clear, Count and Off Time are not supported (Count will always be 1).
- If On Time from the master ≤ 2000 ms, the short time parameter (MAIN Cmd. dur. short cmd.) of the device is used (e.g. 2000 ms), otherwise the long time parameter (MAIN Cmd. dur.long cmd.) is used (e.g. 20000 ms).
- If the Trip/Close field is used, all other fields are ignored. The standard control procedure to control an (air) circuit breaker is used (terminate command when the return information or timeout occurs).
- The Trip/Close command can be sent either to the ON-contact or the OFF-contact of a 2-pole device and the control operation to be performed depends only on the Trip/Close field. This means that the slave is compatible to both addressing modes from the master (1 or 2 points per index). Where possible, Trip/Close should be used for 2-pole devices.
- 2-pole devices can also be controlled by Latch ON / Pulse ON commands, making them compatible with masters which do not use Trip/Close operations. Trip/Close has priority, i.e. the control code is ignored, but Pulse ON should be set to conform to the convention as defined by the Users Group.
- Use of the control code is preferred when controlling single pole devices.
- The type of each command (pulse, persistent or switch command) is configured in the device.

Operation	Destination of Operation			
	Single Pole Device	**Logical Output (e.g. setting)**	**2-Pole OFF-contact / transformer raise**	**2-Pole ON-contact / transformer lower**
Pulse ON	pulse on	set persistent logical 1	switch off / raise	switch on / lower
Pulse OFF	not supported	not supported	not supported	not supported
Latch ON	persistent output on	set persistent logical 1	switch off / raise	switch on / lower
Latch OFF	persistent output off	set persistent logical 0	not supported	not supported
Trip/Raise	not supported	not supported	switch off / raise	switch off / raise
Close/Lower	not supported	not supported	switch on / lower	switch on / lower

4.3.5 Data Object 20 – Binary Counters

Data object 20 is allocated as follows:

Index (decimal)	Index (hex)	Description
0-15	00-F	'm out of n' selection of counters

The software reduces the size of data object 10 to the number of values selected from the 'm out of n' selection tables.

The method of data class assignment is the same as for data object 1, except that only static data class 0 may be assigned. This is because counter events are not supported.

4.3.6 Data Object 21 – Frozen Counters

Frozen counters are counter values which have been frozen at a definite point in time so they can be read at a later time. The method of data class assignment is the same as for data object 1, except that only static data class 0 may be assigned. This is because frozen counter events are not supported.

4.3.7 Data Object 30 – Analog Inputs

Data object 30 is allocated as follows:

Index (decimal)	Index (hex)	Description
0-31	00-1F	'm out of n' selection of analog inputs

The software reduces the size of data object 30 to the number of values selected from the 'm out of n' selection tables.

The method of data class assignment is the same as for data object 1.

Event Handling

- 'Normal' Measurements

  Event handling is done using CURRENT mode, i.e. for each measurement only one entry per change is made in the queue and identical entries are overwritten. An analog event has the current value and timestamp at the time of the request.

- Fault Measurements (function groups GF_DA, FT_DA, OL_DA, 103 protocol ID 4)

  For measurements generated by a fault, SOE mode is used, i.e. all events are stored in a queue and overwriting of identical entries does not take place.

Reporting Deadband and Update Cycle Time

Two parameters are available allowing the user to configure a simple smoothing of all measurement values and a refresh rate for all the measurement values (see '3 Configuring the DNP 3.0 Protocol').

In addition, the master can define a reporting deadband for each individual measurement.

4.3.8 Data Object 34 – Analog Input Reporting Deadband

Each individual measurement has its own deadband. In CURRENT mode, an event telegram is generated when a deadband is exceeded.

Deadband values can be read and written by the master. The values are lost when a device is restarted and must be reconfigured by the master. This is in keeping with the DNP philosophy.

4.3.9 Data Object 40 – Analog Output Status

Index (decimal)	Index (hex)	Description
0-15	00-F	'm out of n' selection of analog outputs

The software reduces the size of data object 40 to the number of selected data points.

Data class assignment is not relevant to data object 40.

4.3.10 Data Object 41 – Analog Output Block

Data object 41 can be sent as 32 bit or 16 bit and has the following structure:

Field	Description	Use/Comments
Value	32/16 bit analog value	
Status	Status	Identical to control relay output block

The analog output block is used for changing settings in a device. This is done in a similar way to the control of a logical binary output, i.e. the command is echoed with status code set.

4.3.11 Data Object 80 – Internal Indications

Internal indications are reported in every response message. The master can write to the internal indications to reset the restart bit. No other bits may be written to. The following table describes the meaning of each bit:

Bit	Description and Conditions	
0	IIN1-0	All Stations – set after a broadcast message (any message using a destination address of 0xfff0 or above) has been received.
1	IIN1-1	Class 1 event data available.
2	IIN1-2	Class 2 event data available.
3	IIN1-3	Class 3 event data available.
4	IIN1-4	Time synchronization required.
5	IIN1-5	Local mode. Set when control is in local mode or command direction is blocked.
6	IIN1-6	Device Trouble. Set when the group alarm condition is active.
7	IIN1-7	Device restart. Set after device restart.
8	IIN2-0	Function Unknown. Generally means that the function code (octet 2 of the request header) cannot be processed.
9	IIN2-1	Object Unknown. Generally means that the function code could be processed but the object group / variation could not be processed.
10	IIN2-2	Parameter Error. Generally indicates that both the function code and object group / variation could be processed but that the qualifier / range field is in error.
11	IIN2-3	Buffer Overflow. Indicates that an event buffer has overflowed, and that change events, of at least one type, have been lost.
12	IIN2-4	Already Executing. – not supported, always 0
13	IIN2-5	Bad configuration. – not supported, always 0
14	IIN2-6	Reserved. Always 0.
15	IIN2-7	Reserved. Always 0.

5 Function Codes

5.1 Function Codes Implemented

5.1.1 Request Function Codes - Master to Slave

The following function codes are sent by the master to the slave device:

Code (decimal)	Function
1	Read
2	Write
3	Select
4	Operate
5	Direct Operate
6	Direct Operate No Acknowledgement
7	Immediate Freeze
8	Immediate Freeze No Acknowledgement
9	Freeze and Clear (*)
10	Freeze and Clear No Acknowledgement (*)
13	Cold Start
14	Warm Start
22	Assign Class
23	Delay Measurement

(*) Note: Freeze and clear functions are currently not implemented.

5.1.2 Response Function Codes - Slave to Master

The following function codes are sent by the slave device to the master:

Code (decimal)	Function
129	Response

5.2 Function 1 – Read

Reading of the following data objects is implemented:

Object Number (decimal)	Description
1	Binary Input
10	Binary Output
20	Binary Counter
21	Frozen Counter
30	Analog Input
34	Analog Input Reporting Deadband
40	Analog Output

Any read errors are flagged in the internal indications in the response.

5.3 Function 2 - Write

Writing of the following data objects is implemented:

Object Number (decimal)	Description
34	Analog Input Reporting Deadband
50	Time and Date
80	Internal Indications

Analog Input Reporting Deadband

Deadband values may be written for each individual measurement.

Time and Date – Time Synchronization

The transmission time from the master (depending on the baud rate) is taken into consideration before setting the date and time in the device.

Internal Indications

In data object 80 it is possible to introduce additional internal indications. This functionality has not been implemented. The master can write to the internal indications to reset the restart bit. No other bits may be written to.

5.4 Function 3, 4, 5, 6 – Select, Operate, Direct Operate, Direct Operate No Ack.

These commands may be used with the following data objects:

Object Number (decimal)	Description
12	Control Relay Output Block
41	Analog Output Block

The following functionality is implemented:

- Select a combination of bits which indicate the operations supported by a binary output.
- Select a binary output for control.
- Execute a control operation for a binary output.
- Select a combination of bits which indicate the operations supported by an analog output.
- Select an analog output for control.

5.5 Functions 7, 8, 9, 10 – Immediate Freeze (with/without Acknowledge), Freeze and Clear (with/without Acknowledge) (*)

(*) Implementation of freeze and clear functions planned but not yet implemented.

These functions can be used with data object 20 (binary counters).

5.6 Function 13 – Cold Start

DNP defines a cold start as a restart of the application as occurs when a device is switched on. This corresponds to a warm start in Schneider Electric terminology.

A warm start be made only if the device is in offline mode.

The device informs the master in a response telegram what period of time will elapse before the device is available again.

5.7 Function 14 – Warm Start

DNP defines a warm start as a restart of the DNP protocol, i.e. clearing of buffers and queues.

The device informs the master in a response telegram what period of time will elapse before the device is available again.

5.8 Function 22 – Assign Class

The master can use function 22 to change the data class of event telegrams. This has been implemented for data objects 1 (binary inputs) and 30 (analog inputs).

The data class setting values are lost when a device is restarted and must be reconfigured by the master. This is in keeping with the DNP philosophy.

5.9 Function 23 – Delay measurement

The master uses function 23 to calculate the path delay for a device. This is done by sending the command to the device and measuring the elapsed time until a response is received. The elapsed time can be used to adjust the time of day when setting the device time.

6 Notes on Communication Functions

6.1 Startup

It is important to note that changes in the ‘m out of n’ selection tables will result in the initialization of the communications module of a device.

6.2 Time and Date Handling and Synchronization

The transmission time from the master (depending on the baud rate) is taken into consideration before setting the date and time in the device. Conversion from DNP time and date to the device’s native format is done.

6.3 Event Handling

6.3.1 Binary Events

Binary events are queued in the device. An event telegram is generated only if the data is configured in one of the data classes 1 to 3. The allocation of data classes is done during configuration of the signals in the ‘m out of n’ selection lists (see '4.3 Assigning Data to Data Objects').

6.3.2 Analog Events

In MiCOM 30 series devices there are 3 different types of analog values:

- Constant values (e.g. device characteristics).
  This data does not change and there are therefore no events.

- ‘Normal’ measurements, which can change at any time.
  The master can define a reporting deadband for each individual measurement. Event handling is done using CURRENT mode, i.e. for each measurement only one entry per change is made in the queue and identical entries are overwritten. An analog event has the current value and timestamp at the time of the request.

- Fault measurements.
  These are measurements which are calculated when a fault occurs (e.g. fault duration). SOE mode is used, i.e. all events are stored in the queue.

An event telegram is generated only if the data is configured in one of the data classes 1 to 3. The allocation of data classes is done during configuration of the signals in the ‘m out of n’ selection lists (see '4.3 Assigning Data to Data Objects').

6.4 Data Class Handling

The DNP 3.0 protocol defines the following data classes:

- Class 0 – static data
- Class 1 – high priority events
- Class 2 – medium priority events
- Class 3 – low priority events

Data classes can be assigned to signals in two ways:

- By configuring the class of a configured signal in the ‘m out of n’ selection lists (see '4.3 Assigning Data to Data Objects').
- By the master sending the ‘Assign Class’ command (function code 22).

Assignment of classes 1, 2 and 3 (used for event telegrams) is mutually exclusive. All data which is assigned a class 1, 2 or 3 is also implicitly assigned class 0.

The possible data classes are ‘without function’, ‘class 0’, ‘class 1’, ‘class 2’ or ‘class 3’. Below is a list of the default configuration and valid values for each data object:

Object Number (decimal)	Description	Default Data Class	Valid Data Classes
1	Binary Input	1	none, 0, 1, 2, 3
10	Binary Output	none	none
20	Binary Counter	none	none, 0
21	Frozen Counter	none	none, 0
30	Analog Input	2	none, 0, 1, 2, 3
40	Analog Output	none	none

6.5 File Transfer

The DNP 3.0 protocol specifies data object 70 (file identifier) for transferring files.

File transfer support (required for fault data transfer) is currently not implemented in MiCOM 30 series devices.

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