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1. Introduction

This document contains the Power Xpert® Meter (PXM Meter) 4000/6000/8000 Series device Distributed Network Protocol (DNP) 3 ethernet communication Level-2 device profile along with a detailed explanation of the web utility to configure DNP3 parameters of the PXM Meter.

Note: The PXM 4/6/8K supports DNP3 ethernet communication. DNP3 serial communication is not supported.

2. DNP3 Protocol Primer

Acknowledgment: Base materials used in Section 2 of this manual were provided by and used with the permission of the DNP Users Group www.dnp.org.

This is a primer for Users who want a quick understanding of DNP3 without having to comb through the tedious details of a complex specification. The writing style is meant to be informal and personal.¹

Let us start with what it is. Protocols define the rules by which devices talk with each other, and DNP3 is a protocol for transmission of data from point A to point B using serial and IP communications. It has been used primarily by utilities such as the electric and water companies, but it functions well for other areas.

A typical electric company may have a common operations center that monitors all of the equipment at each of its substations. In the operations center, a powerful computer stores all of the incoming data and displays the system for the human operators. Substations have many devices that need monitoring (Are circuit breakers opened or closed?), current sensors (How many amperes are flowing?) and voltage transducers (What is the line potential?). That only scratches the surface. A utility is interested in monitoring many parameters, too numerous to discuss here. The operations personnel often need to switch sections of the power grid into or out of service. Computers are situated in substations to collect the data for transmission to the master station in the operations center. The substation computers are also called upon to energize or de-energize the breakers and voltage regulators.

DNP3 uses the term outstation to denote remote computers as are found in the field. The term master is used for the computers in the control centers.

DNP3 provides the rules for remotely located computers and master station computers to communicate data and control commands. DNP3 is a non-proprietary protocol that is available to anyone by visiting the web site www.dnp.org. Only a nominal fee is charged for documentation, but otherwise it is available worldwide with no restrictions. This means a utility can purchase master station and outstation computing equipment from any manufacturer and be assured that they will reliably talk to each other. Vendors compete based upon their computing equipment’s features, costs and quality factors instead of who has the best protocol. Utilities are not bound to one manufacturer after the initial sale.

What do the computers talk about? Outstation computers gather data for transmission to the master.

- Binary input data that is useful to monitor two-state devices. For example, a circuit breaker is closed or tripped; a pipeline pressure alarm shows normal or excessive.
- Analog input data that conveys voltages, currents, power, reservoir water levels, and temperatures.
- Count input data that reports energy in kilowatt hours or fluid volume.
- Files that contain configuration data.

The master station issues control commands that take the form of:

- Close or trip a circuit breaker, start or stop a motor, and open or close a valve; and/or
- Analog output values to set a regulated pressure or a desired voltage level.

Other things the computers talk to each other about are synchronizing the time and date, sending historical or logged data, waveform data, and on and on.

2.1 Why DNP3?

DNP3 was designed to optimize the transmission of data acquisition information and control commands from one computer to another. It is not a general purpose protocol like those found on the Internet for transmitting email, hypertext documents, SQL queries, multimedia, and huge files. It is intended for Supervisory Control and Data Acquisition (SCADA) applications.

¹ Readers should not assume this document contains formal rules, which are only provided by the DNP3 Specification volumes.
2. DNP3 Protocol Primer

2.1.1 Master and Outstation Databases

Figure 1 shows the master-outstation relationship and gives a simplistic view of the databases and software processes involved. The master is on the left side of Figure 1, and the outstation is on the right side.

A series of square blocks at the top of the outstation depict data stored in its database and output devices. The various data types are conceptually organized as arrays. An array of binary input values represents states of physical or logical Boolean devices. Values in the analog input array represent input quantities that the outstation measured or computed. An array of counters represents count values, such as kilowatt hours, that are ever increasing until they reach a maximum and then roll over to zero and start counting again. Control outputs are organized into an array representing physical or logical on-off, raise-lower, and trip-close points. Lastly, the array of analog outputs represents physical or logical analog quantities such as those used for set points.

The elements of the arrays are labeled 0 through N - 1 where N is the number of blocks shown for the respective data type. In DNP3 terminology, the element numbers are called the point indexes. Indexes are zero-based in DNP3, that is, the lowest element is always identified as zero. Indexes are zero-based in DNP3, that is, the lowest element is always identified as zero.

Notice that the DNP3 master also has a similar database for the input data types (binary, analog and counter.) The master uses values in its database for the specific purposes of displaying system states, closed-loop control, alarm notification, billing, and much, much more. An objective of the master is to keep its database updated. It accomplishes this by sending requests to the outstation asking it to return the values in the outstation's database. This is termed polling. The outstation responds to the master’s request by transmitting the contents of its database. Arrows are drawn at the bottom of Figure 1 showing the direction of the requests (toward the outstation) and the direction of the responses (toward the master). Later, we will discuss systems whereby the outstations transmit responses without being asked.
2.1.2 Layering
The master and the outstation shown in Figure 1 each have two software layers. The top layer is the DNP3 user layer. In the master, it is the software that interacts with the database and initiates the requests for the outstation’s data. In the outstation, it is the software that fetches the requested data from the outstation’s database for responding to master requests. It is interesting to note that if no physical separation of the master and outstation existed, eliminating the DNP3 might be possible by connecting these two upper layers together. However, since physical, or possibly logical separation of the master and outstation exists, DNP3 software is placed at a lower level. The DNP3 User’s code uses the DNP3 software for transmission of requests or responses to the matching DNP3 User’s code at the other end. More will be said about data types and software layers later, but first we want to examine a few typical system architectures where DNP3 is used.

2.1.3 System Architecture
Figure 2 shows common system architectures in use today. At the top is a simple one-on-one system having one master station and one outstation. The physical connection between the two is typically a dedicated or dial-up telephone line. The second type of system is known as a multi-drop design. One master station communicates with multiple outstation devices. Conversations are typically between the master and one outstation at a time. The master requests data from the first outstation, then moves onto the next outstation for its data, and continually interrogates each outstation in a round robin order. The communication media is a multi-dropped telephone line, fiber optic cable, or radio. Each outstation can hear messages from the master and is only permitted to respond to messages addressed to it. Outstations may or may not be able to hear each other.
In some multi-drop forms, communications are peer-to-peer. A station may operate as a master for gathering information or sending commands to the outstation in another station. And then, it may change roles to become an outstation to another station.

The middle row in Figure 2 shows a hierarchical type system where the device in the middle is an outstation to the master at the left and is a master with respect to the outstation on the right. The middle device is often termed a sub-master.

Both lines at the bottom of Figure 2 show data concentrator applications and protocol converters. A device may gather data from multiple outstations on the right side of the figure and store this data in its database where it is retrievable by a master station on the left side of the figure. This design is often seen in substations where the data concentrator collects information from local intelligent devices for transmission to the master station.

### 2.1.4 TCP/IP

Many vendors offer products that operate using TCP/IP to transport DNP3 messages in lieu of the media discussed above. Link layer frames, which we have not talked about yet, are embedded into TCP/IP packets. This approach has enabled DNP3 to take advantage of Internet technology and permitted economical data collection and control between widely separated devices.

### 2.1.5 More On Layering

Communication circuits between the devices are often imperfect. They are susceptible to noise and signal distortion. DNP3 software is layered to provide reliable data transmission and to affect an organized approach to the transmission of data and commands. Figure 3 shows the layering that was not shown in Figure 1.
2.2 Link Layer Responsibility

The link layer has the responsibility of making the physical link reliable. It does this by providing error detection and duplicate frame detection. The link layer sends and receives packets, which in DNP3 terminology are called frames. Sometimes transmission of more than one frame is necessary to transport all of the information from one device to another.

A DNP3 frame consists of a header and data section. The header specifies the frame size, contains data link control information and identifies the DNP3 source and destination device addresses. The data section is commonly called the payload and contains data passed down from the layers above.

```
DNP3 Frame
<table>
<thead>
<tr>
<th>Header</th>
<th>Data Section</th>
</tr>
</thead>
</table>
```

<table>
<thead>
<tr>
<th>Header</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sync</td>
</tr>
<tr>
<td>Length</td>
</tr>
<tr>
<td>Link Control</td>
</tr>
<tr>
<td>Destination</td>
</tr>
<tr>
<td>Source</td>
</tr>
<tr>
<td>CRC</td>
</tr>
</tbody>
</table>

Figure 4. DNP3 Header and Data Sections.

Every frame begins with two sync bytes that help the receiver determine where the frame begins. The length specifies the number of octets in the remainder of the frame, not including CRC check octets. The link control octet is used for the sending and receiving link layers to coordinate their activities.

2.2.1 Addressing

The destination address specifies which DNP3 device should process the data, and the source address identifies which DNP3 device sent the message. Having both destination and source addresses satisfies at least one requirement for peer-to-peer communications because the receiver knows where to direct its responses. 65,520 individual addresses are available. Every DNP3 device must have a unique address within the collection of devices sending and receiving messages to and from each other. Three destination addresses are reserved by DNP3 to denote an all-call message; that is, the frame should be processed by all receiving DNP3 devices. One address is a universal address, the details of which are not given here, and twelve addresses are reserved for special needs in the future.

2.2.2 CRC Checks

The data payload in the link frame contains a pair of CRC octets for every 16 data octets. This provides a high degree of assurance that communication errors can be detected. The maximum number of octets in the data payload is 250, not including CRC octets. (The maximum length link layer frame is 292 octets if all the CRC and header octets are counted.)

2.2.3 Link Layer Confirmation

One often hears the term ”link layer confirmation” when DNP3 is discussed. A feature of DNP3’s link layer is the ability for the transmitter of the frame to request the receiver to confirm that the frame arrived. Using this feature is optional, and it is often not employed because there are other methods for confirming receipt of data. It provides an extra degree of assurance of reliable communications. If a confirmation is not received, the link layer may retry the transmission. Some disadvantages to using link layer confirmation are the extra time required for confirmation messages and waiting for multiple timeouts when retries are configured.

2.2.4 Transport Layer

The transport layer has the responsibility of breaking long application layer messages into smaller packets sized for the link layer to transmit, and, when receiving, to reassemble frames into longer application layer messages. In DNP3 the transport layer is incorporated into the application layer. The transport layer requires only a single octet overhead to do its job. Therefore, since the link layer can handle only 250 data octets, and one of those is used for the transport function, each link layer frame can hold as many as 249 application layer octets.

2.2.5 Application Layer Fragments

Application layer messages are broken into fragments. Maximum fragment size is determined by the size of the receiving device’s buffer. The normal range is 2048 to 4096 bytes. A message that is larger than one fragment requires multiple fragments. Fragmenting messages is the responsibility of the application layer.

Note that an application layer fragment of size 2,048 must be broken into 9 frames by the transport layer, and a fragment size of 4,096 needs 17 frames. Interestingly, it has been learned by experience that communications are sometimes more successful for systems operating in high noise environments if the fragment size is significantly reduced.
2. DNP3 Protocol Primer

2.3 Static and Event Data

The application layer works together with the transport and link layers to enable reliable communications. It provides standardized functions and data formatting with which the user layer above can interact. Before functions, data groups, and variations can be discussed, the terms static, events, and classes need to be covered.

In DNP3, the term static is used with data and refers to the present value. Thus static binary input data refers to the present On or Off state of a b-state device. Static analog input data contains the value of an analog at the instant it is transmitted. One possibility DNP3 allows is requesting some or all of the static data in an outstation device.

DNP3 events are associated with something significant happening. Examples are state changes, values exceeding some threshold, snapshots of varying data, transient data, and newly available information. An event occurs when a binary input changes from an On to an Off state or when an analog value changes by more than its configured dead-band limit. DNP3 provides the ability to report events with and without time stamps so that, if desired, the master will have the information to generate a time sequence report.

The master’s user layer can direct DNP3 to request events. Usually, a master is updated more rapidly if it spends most of its time polling for events from the outstation and only occasionally asks for static data as an integrity measure. The reason updates are faster is because the number of events generated between outstation interrogations is small and, therefore, less data must be returned to the master.

DNP3 goes a step further by classifying events into three classes. When DNP3 was conceived, class 1 events were considered as having higher priority than class 2 events, and class 2 were higher than class 3 events. While that scheme can be still be configured, some DNP3 Users have developed other strategies more favorable to their operation for assigning events into the classes. The user layer can request the application layer to poll for class 1, 2, or 3 events or any combination of them.

2.3.1 Variations

DNP3 has provisions for representing data in different formats. Examination of analog data formats is helpful to understand the flexibility of DNP3. Static, present value, analog data can be represented by variation numbers as follows:

1. A 32-bit integer value with flag;
2. A 16-bit integer value with flag;
3. A 32-bit integer value;
4. A 16-bit integer value;
5. A 32-bit floating point value with flag; and
6. A 64-bit floating point value with flag.

Note: The flag referred to is a single octet with bit fields indicating whether the data source is on-line, the data source restarted, communications are lost with a downstream source, the data is forced and the value is over range.

Not all DNP3 devices can transmit or interpret all six variations. Later, DNP3 levels are discussed, but for now, suffice it to say that DNP3 devices must be able to transmit the simplest variations so that any receiver can interpret the contents.

Event analog data can be represented by these variations:

1. A 32-bit integer value with flag;
2. A 16-bit integer value with flag;
3. A 32-bit integer value with flag and event time;
4. A 16-bit integer value with flag and event time;
5. A 32-bit floating point value with flag;
6. A 64-bit floating point value with flag;
7. A 32-bit floating point value with flag and event time; and
8. A 64-bit floating point value with flag and event time.

The flag has the same bit fields as for the static variations.

2.3.2 Group

It appears by looking at the above variations that variation 1 and 2 analog events cannot be differentiated from variation 1 and 2 static analog values. DNP3 solves this predicament by assigning group numbers. Static analog values are assigned as group 30, and event analog values are assigned as group 32. Static analog values, group 30, can be formatted in one of 6 variations, and event analog values, group 32, can be formatted in one of 8 variations.

When a DNP3 outstation transmits a message containing response data, the message identifies the group number and variation of every value within the message. Group and variation numbers are also assigned for counters, binary inputs, controls and analog outputs. In fact, all valid data types and formats in DNP3 are identified by group and variation numbers. Defining the allowable groups and variations helps DNP3 assure interoperability between devices. DNP3’s basic documentation contains a library of valid groups and their variations.

2.3.3 Objects

When data from an index is transmitted across the wire, the sender must suitably encode the information to enable a receiving device to parse and properly interpret this data. The bits and bytes for each index appearing in the message are called an object. That is, objects in the message are the encoded representation of the data from a point, or other structure, and the object format depends upon which group and variation number are chosen.
2.3.4 Reading Data

The master’s user layer formulates its request for data from the outstation by telling the application layer what function to perform, such as reading, and by specifying the data types it wants or it can specify specific objects or a range of objects from index number X through index number Y. The application layer then passes the request down through the transport layer to the link layer that, in turn, sends the message to the outstation. The link layer at the outstation checks the frames for errors and passes them up to the transport layer where the complete message is assembled in the outstation’s application layer. The application layer then tells its user layer which groups and variations were requested.

Responses work similarly, in that the outstation’s user layer fetches the desired data and presents it to the application layer that, in turn, uses the group and variation numbers to format user layer data into objects. Data is then passed downward, across the communication channel and upward to the master’s application layer. Here the data objects are then presented to the master’s user layer.

2.3.5 Other Functions

Reading data was briefly described in Section 2.3.4, but DNP3 software is designed to handle other functions. For one, the master can set the time in the outstation. The master can transmit freeze accumulator requests, and it can transmit requests for control operations and setting of analog output values using select-before-operate or direct-operate sequences.

2.4 Unsolicited Responses

One area that has not been covered yet is transmission of unsolicited messages. This is a mode of operating where the outstation spontaneously transmits a response without having received a specific request for the data. Not all outstations have this capability. This mode is useful when the system has many outstations and the master requires notification as soon as possible after a change occurs. Rather than waiting for a master station polling cycle to get around to it, the outstation simply transmits the change.

Before configuring a system for unsolicited messages, a few basics need to be considered. First, spontaneous transmissions should generally occur infrequently, otherwise, too much contention can occur, and controlling media access via master station polling would be better. The second basic issue is that the outstation should have some way of knowing whether it can transmit without stepping on another outstation’s message. DNP3 leaves specification of algorithms to the system implementer.

2.5 Implementation Levels

One last area of discussion involves implementation levels. The DNP3 organization recognizes that supporting every feature of DNP3 is not necessary for every device. Some devices are limited in memory and speed and do not need specific features, while other devices must have the more advanced features to accomplish their task. DNP3 organizes complexity into three levels. At the lowest level, level 1, only very basic functions must be provided and all others are optional. Level 2 handles more functions, groups, and variations, and level 3 is even more sophisticated. Within each level, only certain combinations of request formats and response formats are required. This was done to limit software code in masters and outstations while still assuring interoperability.

2.6 Summary

It should be apparent by now that DNP3 is a protocol that fits well into the data acquisition world. It transports data as generic values, it has a rich set of functions, and it was designed to work in a wide area communications network. The standardized approach of groups and variations, and link, transport and application layers, plus public availability makes DNP3 a protocol to be regarded.
3. DNP Device Profile

<table>
<thead>
<tr>
<th>DNP V3.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEVICE PROFILE DOCUMENT</td>
</tr>
<tr>
<td>This document must be accompanied by a table having the following headings:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Object Group Request</th>
<th>Function Codes</th>
<th>Response Function Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object Variation</td>
<td>Request Qualifiers</td>
<td>Response Qualifiers</td>
</tr>
<tr>
<td>Object Name (optional)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Vendor Name: **Eaton**

Device Name: **Power Expert Meter 4k/6k/8k**

Highest DNP Level Supported:

<table>
<thead>
<tr>
<th>For Requests</th>
<th>Level 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>For Responses</td>
<td>Level 2</td>
</tr>
</tbody>
</table>

Device Function:

- Master
- **Slave**

Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported.

For static (non-change-event) object requests, request qualifier codes 07 and 08 (limited quantity), and 17 and 28 (index) are supported.

16-bit and 32-bit Analog Change Events with Time are supported.

Floating Point Analog Output Status and Output Block Objects 40 are supported.

The read function code for Object 50 (Time and Date), variation 1, is supported.

Maximum Data Link Frame Size (octets):

- Transmitted: **292**
- Received: **292**

Maximum Application Fragment Size (octets):

- Transmitted: **Configurable up-to 2048**
- Received: **2048**

Maximum Data Link Re-tries:

- None
- Fixed at ____
- **Configurable from 0 to 15**

Maximum Application Layer Re-tries:

- None
- **Configurable**
3. DNP Device Profile

Requires Data Link Layer Confirmation:

- Never
- Always
- Sometimes
- **Configurable as:**
  - When reporting Event Data.
  - When sending multi-fragment responses.

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 and multi fragment messages”.

Timeouts while waiting for:

<table>
<thead>
<tr>
<th></th>
<th>None</th>
<th>Fixed at ____</th>
<th>Variable</th>
<th>Configurable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Link Confirm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete Appl. Fragment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Application Confirm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete Appl. Response</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Others:

- Transmission Delay, configurable
- Select/Operate Arm Timeout, configurable 0 sec to 30 sec
- Need Time Interval, configurable 1 sec to 86400 sec (1 day)
- Data Link Confirm Timeout, configurable 0.1 sec to 30 sec
- Binary Change Event Scan Period, fixed at 1 sec
- Analog Change Event Scan Period, fixed at 1 sec
- Counter Change Event Scan Period, fixed at 1 sec
- Frozen Counter Change Event Scan Period, fixed at 1 sec
3. DNP Device Profile

### Sends/Executes Control Operations:

<table>
<thead>
<tr>
<th>Operation</th>
<th>Never</th>
<th>Always</th>
<th>Sometimes</th>
<th>Configurable</th>
</tr>
</thead>
<tbody>
<tr>
<td>WRITE Binary Outputs</td>
<td>![X] Never</td>
<td>![ ] Always</td>
<td>![ ] Sometimes</td>
<td>![ ] Configurable</td>
</tr>
<tr>
<td>SELECT/OPERATE</td>
<td>![ ] Never</td>
<td>![ ] Always</td>
<td>![ ] Sometimes</td>
<td>![ ] Configurable</td>
</tr>
<tr>
<td>DIRECT OPERATE</td>
<td>![ ] Never</td>
<td>![ ] Always</td>
<td>![ ] Sometimes</td>
<td>![ ] Configurable</td>
</tr>
<tr>
<td>DIRECT OPERATE-NACK</td>
<td>![ ] Never</td>
<td>![ ] Always</td>
<td>![ ] Sometimes</td>
<td>![ ] Configurable</td>
</tr>
<tr>
<td>Count &gt; 1:</td>
<td>![ ] Never</td>
<td>![ ] Always</td>
<td>![ ] Sometimes</td>
<td>![ ] Configurable</td>
</tr>
<tr>
<td>Pulse Off:</td>
<td>![ ] Never</td>
<td>![ ] Always</td>
<td>![ ] Sometimes</td>
<td>![ ] Configurable</td>
</tr>
<tr>
<td>Latch Off:</td>
<td>![ ] Never</td>
<td>![ ] Always</td>
<td>![ ] Sometimes</td>
<td>![ ] Configurable</td>
</tr>
<tr>
<td>Queue:</td>
<td>![ ] Never</td>
<td>![ ] Always</td>
<td>![ ] Sometimes</td>
<td>![ ] Configurable</td>
</tr>
<tr>
<td>Clear Queue:</td>
<td>![ ] Never</td>
<td>![ ] Always</td>
<td>![ ] Sometimes</td>
<td>![ ] Configurable</td>
</tr>
</tbody>
</table>

### Reports Binary Input Change Events when no specific variation requested:

- ![ ] Never
- ![ ] Only time-tagged
- ![ ] Only non-time-tagged
- ![X] Configurable to send both, 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
- ![X] Configurable to Binary Input Change With Time and Binary Input Change With Relative Time

### Sends Unsolicited Responses:

- ![X] Never
- ![ ] Configurable
- ![ ] Only certain objects
- ![ ] Sometimes
- ![ ] ENABLE/DISABLE UNSOLICITED

### Sends Static Data in Unsolicited Responses:

- ![X] Never
- ![ ] When Device Restarts
- ![ ] When Status Flags Change

No other options are permitted.
### Default Counter Object/Variation:
- No Counters Reported
- Configurable
- Default
  - Object
  - Variation
- Point-by-point list attached

### Counters Roll Over at:
- No Counters Reported
- Configurable
- 16 Bits
- 32 Bits
- Other Value: _____
- Point-by-point list attached

### Sends Multi-Fragment Responses:
- Yes
- No
- Configurable as: “Always” or “When reporting Event Data”

### 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
The following table identifies which object variations, function codes, and qualifiers the PXM 4/6/8 K meter supports in both request messages and in response messages.

For static (non-change-event) objects, requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01. Requests sent with qualifiers 17 or 28 will be responded with qualifiers 17 or 28. For change-event objects, qualifiers 17 or 28 are always responded.

Table 1. Object Variations, Function Codes, and Qualifiers.

<table>
<thead>
<tr>
<th>Object Number</th>
<th>Variation Number</th>
<th>Description</th>
<th>REQUEST</th>
<th>RESPONSE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Master May Issue</td>
<td>Outstation Must Parse</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>Binary Input – Any Variation</td>
<td>1 (read)</td>
<td>00, 01 (start-stop)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>06 (no range, or all)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>07, 08 (limited qty)</td>
</tr>
<tr>
<td>1</td>
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<td>7 (freeze)</td>
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## 4. Implementation Table

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<tr>
<th>Object Number</th>
<th>Variation Number</th>
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<th>Function Codes (dec)</th>
<th>Qualifier Codes (hex)</th>
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<th>Qualifier Codes (hex)</th>
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### 4. Implementation Table

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<td>06 (no range, or all) 07, 08 (limited qty)</td>
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<tr>
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<td>1 (read)</td>
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<td>1 (read)</td>
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<tr>
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<tr>
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<td>Short floating point</td>
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<tr>
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### 4. Implementation Table

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<th>Object Number</th>
<th>Variation Number</th>
<th>Description</th>
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<th>Qualifier Codes (hex)</th>
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<th>Qualifier Codes (hex)</th>
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<td>00, 01 (start-stop)</td>
<td>17, 28 (index)</td>
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<td>07, 08 (limited qty)</td>
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<td>00, 01 (start-stop)</td>
<td>00, 01 (start-stop)</td>
<td>17, 28 (index)</td>
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<td>07, 08 (limited qty)</td>
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<td>129 (response)</td>
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<td>2 (write)</td>
<td>00, 01 (start-stop)</td>
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<td>17, 28 (index)</td>
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<td>07, 08 (limited qty)</td>
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<td>00, 01 (start-stop)</td>
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<td>17, 28 (index)</td>
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<td>07, 08 (limited qty)</td>
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<td>00, 01 (start-stop)</td>
<td>17, 28 (index)</td>
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<td>07, 08 (limited qty)</td>
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<td>00, 01 (start-stop)</td>
<td>17, 28 (index)</td>
</tr>
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<td>06 (no range, or all)</td>
<td>07, 08 (limited qty)</td>
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<td>00, 01 (start-stop)</td>
<td>17, 28 (index)</td>
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<td>07, 129</td>
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<td>2 (write)</td>
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<td>07, 129</td>
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<td>Time and Date</td>
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<td>07, 129</td>
<td>1 (limited qty = 1)</td>
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<td>00, 01 (start-stop)</td>
<td>00, 01 (start-stop)</td>
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</tbody>
</table>

Note 1: A default variation refers to the variation responded when variation 0 is requested and/or in class 0, 1, 2, or 3 scans. Default variations are configurable; however, default settings for the configuration parameters are indicated in the table above.

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. (For change-event objects, qualifiers 17 or 28 are always responded.)

Note 3: Writes of Internal Indications are only supported for index 4 or 7 (Need Time IIN1-4 or Restart IIN1-7)
5. DNP3 Ethernet Communication Setup Configuration Utility

It is necessary to configure DNP parameters and DNP database to match specific requirements/needs of an application. A simple, easy to use web based interface is provided to configure DNP parameters and database as per user requirement. Installer can get connected to meter by entering IP address of meter in a web browser. No separate software installation is required to configure DNP3 stack. Below sections explain each steps of DNP3 configuration in detail.

DNP3 configuration setup is located at Setup -> Meter Setup & commissioning -> Communication -> Ethernet / LAN Setup -> DNP3 Setup.

DNP3 setup is divided in subpages as per category explained below.

<table>
<thead>
<tr>
<th>DNP3 Node Identification</th>
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<tbody>
<tr>
<td>DNP Master Address</td>
</tr>
<tr>
<td>DNP Slave Address</td>
</tr>
<tr>
<td>DNP User Assigned Code</td>
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Null Proxy Element

<table>
<thead>
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<th>Global Settings</th>
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</thead>
<tbody>
<tr>
<td>Communication</td>
</tr>
<tr>
<td>Input/Output</td>
</tr>
</tbody>
</table>

Figure 5. DNP3 Setup Page.
5.1 DNP3 Node Identification

If the User wishes to change parameters’ then the User first needs to press “Edit” option and “Authenticate” self to avoid unauthorized access. After Authentication, the parameters shall be editable as shown in Figure 7.

Figure 6. DNP3 Node Identification Page.

Figure 7. DNP3 Setup Edit Page.
The User can set three parameters:

1. **DNP Master Address**
   
   It is the address of DNP master with which the PXM meter shall exchange DNP3 data. This address shall be validated by PXM meter and responses shall be sent ONLY if a request is sent by the DNP master with this address. This address shall be used in DNP3 source field in DNP frames from master to slave.

2. **PXM Meter Address**
   
   This is the DNP3 address with which the DNP3 master device shall identify the specific PXM meter in the DNP network. This address shall be used in the DNP3 destination field in DNP frames from master to slave. The PXM meter shall match the destination address in the received frame and the User assigned PXM meter address. If a match is found, then the frame shall be processed further.

3. **User Assigned ID/Code**
   
   The User can assign a name to the PXM meter for identification. This helps in easy identification of the PXM meter location by the user instead of remembering the meter by the DNP3 address.

**Note:** PXM DNP3 implementation uses port 20,000 for its communication. This port is not configurable and is fixed. To communicate with PXM meter over TCP/IP DNP, the master must use 20,000 as port number.

### 5.2 Global Settings

When this page is selected, the User can configure the following parameters.

1. **DNP Select Operation Timeout**
   
   This parameter is used for Select-Before-Operate (SBO) operation on digital outputs (relays). If the SBO mode is used by the master to operate meter’s digital outputs, then “DNP Select operation timeout” parameter is used. In this particular operation, the DNP3 master first sends a select request for particular digital output. When this request is received, the PXM meter starts a timer for duration specified by “DNP Select operation timeout” parameter. If the operate command is received from DNP3 master before this timer elapses, then that digital output is operated as per the master request.

   If this timer expires before the operate request is received, then the operate request is rejected by PXM meter.

   **Note:** It is necessary that the digital I/O card is installed in the PXM meter to use this option. SBO operation is supported only on relays R1, R2, and R3 and these relays should be selected in the DNP input output section as explained later in this document.

2. **DNP Default Object X Variation (X = 1, 2, 10, 20, 21, 22, 23, 30, 32, 34, 40)**
   
   The DNP3 master may send requests to get the DNP3 slave data (PXM data) objects with variation 0. In this case, the meter can send responses with the default variation. It is possible to configure object wise default variation for the PXM meter on web page. The User can select the default variation from the drop down list given against each object.
### 5.3 Communication

The User can set the DNP3 stack communication related parameter in this web page. There are layer wise sections for easy parameter settings.

#### Figure 8. DNP3 Global Settings Setup Edit Page.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNP3 Node Identification</td>
<td></td>
</tr>
<tr>
<td>Global Settings</td>
<td></td>
</tr>
<tr>
<td>Select Before Operation</td>
<td></td>
</tr>
<tr>
<td>DNP select Operation Timeout</td>
<td>5</td>
</tr>
<tr>
<td>Define Variation Settings</td>
<td></td>
</tr>
<tr>
<td>DNP default Object 1 Variation</td>
<td>1</td>
</tr>
<tr>
<td>DNP default Object 2 Variation</td>
<td>2</td>
</tr>
<tr>
<td>DNP default Object 10 Variation</td>
<td>2</td>
</tr>
<tr>
<td>DNP default Object 20 Variation</td>
<td>5</td>
</tr>
<tr>
<td>DNP default Object 21 Variation</td>
<td>9</td>
</tr>
<tr>
<td>DNP default Object 22 Variation</td>
<td>1</td>
</tr>
<tr>
<td>DNP default Object 23 Variation</td>
<td>1</td>
</tr>
<tr>
<td>DNP default Object 30 Variation</td>
<td>3</td>
</tr>
<tr>
<td>DNP default Object 32 Variation</td>
<td>1</td>
</tr>
<tr>
<td>DNP default Object 34 Variation</td>
<td>2</td>
</tr>
<tr>
<td>DNP default Object 40 Variation</td>
<td>2</td>
</tr>
</tbody>
</table>
5.3.1 DNP Application Layer

In this section, the User can set the parameters related to DNP Application Layer that follow.

1. Application Layer Multiple Layer Confirmation

   If the checkbox is selected, it means that a confirmation message is expected from DNP master in response to an application layer frame sent by PXM meter. For example, assume that the application frame from the PXM meter to DNP master consists of events data which are stored in PXM meter buffer. If this option is selected and if the PXM meter does not receive an application layer confirmation from the DNP master, then the PXM meter shall not delete currently stored events from its buffer.

   If the checkbox is not selected, then it means that a confirmation message is not expected from the DNP master in response of an application layer frame sent by the PXM meter.

2. Application Layer Multiple Fragment Responses Allowed

3. Application Layer Multiple Fragment Length

   This parameter indicates the maximum length of an application frame which the PXM meter shall transmit. It is possible in certain cases that the buffer reserved in the DNP master for reception of data is less than what the PXM meter can transmit. To match the reception requirement of a DNP master, this parameter is configurable in the PXM meter. The range provided is from 50 to 2,048 bytes.
### 5.3.2 DNP Data Link Layer

In this section, the User can set the parameters related to the DNP Data Link layer that follows.

1. **DNP Link Layer Confirmation**
   - **Never**
     - The PXM meter shall never expect or wait for a confirmation message from the DNP master in response to the data link layer frame sent to the master.
   - **Sometimes**
     - The PXM meter shall expect or wait for a confirmation message from the DNP master in response to the data link layer frame sent to the master in certain cases only.
     - If the data link frame contains events or related data, then the PXM meter shall expect a data link confirmation from the DNP master. If the data link frame contains static information, then the PXM meter shall not expect a data link confirmation from the DNP master.
   - **Always**
     - Choosing this option may add overhead at the DNP master. Therefore, it needs to be selected carefully.

2. **Link Layer Retries**
   - This parameter indicates how many times the PXM meter shall attempt to retransmit the DNP link frame in case of failure of DNP link layer confirmation from the DNP master. Range of this parameter is from 0 to 15.
   - It is obvious that if the link layer confirmation parameter is set to the option “Never,” then the link layer retries parameter does not hold any significance since the PXM meter shall never attempt retransmission of link frame.

![Figure 10. Link Layer Confirmation Choices.](image)
3. Link Layer Confirmation Time Out

It is the time duration between two successive DNP link layer frames in case of link layer retries from the PXM meter. The range for this parameter is 100 ms to 30,000 ms.

It is the time duration for which the PXM meter will wait before attempting retransmission of the link layer frame if the link layer confirmation message is not received from the DNP master.

4. Link Layer Time Out

It is the maximum amount of time to wait for a complete frame after receiving valid frame sync characters. The range for this parameter is 10 ms to 60,000 ms.

5.3.3 DNP Time Sync

It may be required to synchronize the DNP master and the PXM meter real time clock (RTC). This parameter is configurable and has options as explained below.

1. Time Synchronization Type
   - None
     There will be no time synchronization between the DNP master and PXM meter. The PXM meter shall never set the time sync flag in IIN bytes.
   - Interval
     The PXM meter will periodically set the time sync flag to request time synchronization to match the time/date of the master.
     When the time sync flag is set by the PXM meter, it is up to the DNP master to achieve time synchronization by sending a time write request to the PXM meter. When time sync is successful, the PXM meter shall clear the time sync flag in it IIN bytes and shall restart a timer. Duration of the timer will be decided by the “Interval” parameter. Once this timer elapses, the PXM meter will again set the time sync flag in it IIN bytes. This will indicate to the DNP master that the PXM meter is requesting time sync and it will repeat the procedure as explained above.
     This frequent time synchronization makes sure that time in the DNP master and PXM meter is same.

2. Time Synchronization Interval

   It is amount of time in seconds the PXM meter will wait before setting a time sync flag after the successful clearing of time sync flag.
5.4 DNP3 Input/Output Setup

As explained in Section 2, it is necessary to create a DNP slave database in PXM meter so that data can be exchanged with the DNP master. Organization of this database may vary from application to application depending on needs of the situation. Therefore, it is up to installer to correctly configure this database to get appropriate results. Appendix A provides a list of PXM meter parameters / variables which can be added to the PXM DNP slave database. Using the DNP Input/Output web page, the User can select and configure the required meter parameters for the specific requirement. List in Appendix A has been prepared by keeping reference to the MODBUS address and length. For the encoding of these parameters, the User should refer to the MODBUS section.

Figure 12 shows simple steps to prepare the DNP slave database in the PXM meter. DNP3 database configuration can be done with the User interface provided on DNP3 Setup -> DNP3 Input/Output web page. The DNP3 database is arranged in tabs as explained in the following

Figure 12. Steps to Prepare the DNP Slave Database in the PXM Meter.

Figure 13. DNP3 Input/Output Page.
1. **Analog Input: (DNP Object 30, 32)**
   Static analog inputs are configured under Object 30 whereas analog change events are configured under Object 32.

2. **Analog Output: (DNP Object 40)**
   Analog output status is configured under Object 40. Please note that current DNP3 implementation in PXM meter allows only the read operation on analog outputs.

3. **Binary Input: (DNP Object 1, 2)**
   Static digital inputs are configured under Object 1 whereas digital input change events are configured under Object 2.

4. **Binary Output: (DNP Object 10, 12)**
   Digital output status is configured under Object 10 whereas CROB operations are configured under Object 12.

5. **Binary Counter: (DNP Object 20, 21, 22, 23)**
   Static binary counters are configured under Group 20, counter change events are configured under Object 21, frozen counters are configured under Object 22, and frozen counter events are configured under Object 23.

The User has options to Load & Save DNP3 database configuration from the meter or a file. Each of these options can accessed using the File Options dropdown at the top of the Settings page.

**Note:** Unless the User authenticates him/herself by valid User name and password, these buttons will not be operational. The User needs to press the Edit button and enter credentials to access these options.

---

**Load Config**

The User can load a pre-configured DNP database configuration from a file into the User interface to save efforts. This file must be generated using the web interface and must be present on the computer where the web interface is being used.

Upon selecting this option, the User will be prompted to select a configuration file. The User needs to select an appropriate configuration file for loading into web interface.

All configuration data will be available in the file will be loaded into the web interface and displayed for the User for further operations. File data shall be loaded automatically into the individual sections for each category. For example, if a file has analog data (Object 30, 32), then it will be loaded into the Analog Input section and if the file has binary counter data (Object 20, 21, 22, 23) then it will be loaded into the Counter input section of the web interface.

**Save Config**

When the User completes configuration of the DNP3 database, the User may wish to save the configuration into a file on computer for future use and reference. By using “Save Config” option on the web interface, the User can save it on computer. The User will be prompted to select a location and provide a file name for the configuration file.
3. Get From Meter

If the meter is already configured with a DNP database, then the User may transfer an existing DNP database configuration into the web interface by using the “Get From Meter” option. This option is particularly useful when the User wants to modify an existing configuration.

4. Save To Meter

When the User completes the configuration of the DNP database on the web interface, the User must transfer this configuration into the PXM meter. By using the “Save To Meter” option, this operation is achieved.

Note: Unless the meter reboots after using the “Save to Meter” option, the newly configured database will not be effective. After using this option, the web interface will prompt the User if the PXM meter needs to be rebooted or not. The User may choose to reboot immediately or must reboot meter manually later so that the modified DNP database becomes effective.

5.5 Procedure to Create the DNP3 Database Configuration

Appendix A provides a list of meter parameters which can be added to the DNP database. The User needs to select parameters from the list and add them to the DNP3 database. For easy selection, the meter parameters are arranged as per DNP object groups in the Input Output web page.

The procedure for selecting and adding parameters to the DNP3 database is same for all objects. Each tab is assigned to particular DNP3 objects. Each tab has buttons and there functionality is explained in the following.

Figure 16. Adding a New Parameter to the DNP3 Database.
5. DNP3 Ethernet Communication Setup Configuration Utility

![Image](image.png)

Figure 17. Binary Counter Button.

1. Add
   Adds a new parameter to the DNP3 database. When the User selects this option, the new pop-up window allows the User to select the new meter parameter and set the properties of parameter. For example, add a binary counter when the User selects the Add option below the pop-up window.

2. Delete All
   Deletes all parameters present in the selection list on a particular tab. For example, if the Delete All button is pressed on the binary counter tab, then all parameters (i.e. binary counters) in the selection list are deleted.

3. Delete
   Deletes selected parameters in the selection list on particular a tab. For example, if the Delete button is pressed on Binary Counter tab, then a particular selected parameter (i.e. binary counter) in the selection list is deleted.

4. Up
   Moves a particular parameter to a higher DNP index than its existing position. When the list is populated and it is required to change the order (i.e. DNP index) of a particular point to fulfill a field requirement, then using the UP button will achieved this goal.

5. Down
   Move a particular parameter to a lower DNP index than its existing position. When the list is populated and it is required to change the order (i.e. DNP index) of a particular point to fulfill a field requirement, then using the DOWN button will achieved this goal.

The following is an example of UP and Down button movement of a binary counter.
### Input/Output

#### Analog Input

<table>
<thead>
<tr>
<th>DNP Point</th>
<th>Parameter Name</th>
<th>Modbus Address</th>
<th>Length</th>
<th>Deadband</th>
<th>Event Class</th>
</tr>
</thead>
</table>

#### Analog Output

<table>
<thead>
<tr>
<th>DNP Point Number</th>
<th>Parameter Name</th>
<th>Modbus Address</th>
<th>Length</th>
</tr>
</thead>
</table>

#### Binary Input

<table>
<thead>
<tr>
<th>DNP Point Number</th>
<th>Parameter Name</th>
<th>Modbus Address</th>
<th>Length</th>
<th>Event Class</th>
</tr>
</thead>
</table>

#### Binary Output

<table>
<thead>
<tr>
<th>DNP Point Number</th>
<th>Parameter Name</th>
<th>Modbus Address</th>
<th>Length</th>
</tr>
</thead>
</table>

#### Counter Input

<table>
<thead>
<tr>
<th>DNP Point</th>
<th>Parameter Name</th>
<th>Modbus Address</th>
<th>Length</th>
<th>Scaling</th>
<th>Deadband</th>
<th>Counter Length</th>
<th>Frozen</th>
</tr>
</thead>
</table>

Figure 18. Delete Button.
5.6 Assigning a Dead Band

PXM DNP implementation uses a fixed dead banding method for event detection. If a static value of a meter parameter changes beyond the assigned dead band limit, then the event is triggered and stored in the internal event buffer. Dead band value indicates the number of counts used for event comparison.

For analog inputs, if a reference value goes above or below the dead band limit, then an event is triggered. For example, if IA is assigned with a dead band value of 10 and reference value of IA is 500 Amps, then an event will be triggered in the case of the static value of IA is less than 490 Amps or greater than 510 Amps. When this particular event is triggered, the value of IA which caused the event becomes reference for next event comparison.

For binary counters, if the difference/delta between reference value and current value is greater than the dead band, then an event is triggered. This is because the counter value cannot decrement. When an event is triggered, the value which caused the event becomes reference for the next event comparison.

For binary inputs, state stage causes an event generation, therefore it is not required to assign a dead band to the binary inputs.

Below are limits for different types of event storages in the PXM meter.

- Analog input change events: 500
- Binary input change events: 250
- Binary counter input change events: 250
- Frozen binary counter change events: 250

Note: If the User selects an event class as 0, then the dead band cannot be programmed. Similarly, if the User assigns class 1, 2, or 3, then the dead band value cannot be zero.
## Appendix A Points List

<table>
<thead>
<tr>
<th>#</th>
<th>Parameter Name</th>
<th>Eng. Unit</th>
<th>DNP3 Category</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Floating-Point Word Order Setting</td>
<td>Encoded</td>
<td>Analog Output</td>
<td>16 Bit</td>
</tr>
<tr>
<td>2</td>
<td>Fixed-Point Word Order Setting</td>
<td>Encoded</td>
<td>Analog Output</td>
<td>16 Bit</td>
</tr>
<tr>
<td>3</td>
<td>Product ID</td>
<td>0</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>4</td>
<td>Primary/Secondary Status</td>
<td>Encoded</td>
<td>Analog Input</td>
<td>16 Bit</td>
</tr>
<tr>
<td>5</td>
<td>Cause Of Status</td>
<td>Encoded</td>
<td>Analog Input</td>
<td>16 Bit</td>
</tr>
<tr>
<td>6</td>
<td>IA</td>
<td>Amps</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>7</td>
<td>IB</td>
<td>Amps</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>8</td>
<td>IC</td>
<td>Amps</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>9</td>
<td>IG</td>
<td>Amps</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>10</td>
<td>IN</td>
<td>Amps</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>11</td>
<td>Iavg</td>
<td>Amps</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>12</td>
<td>VAB</td>
<td>Volts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>13</td>
<td>VBC</td>
<td>Volts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>14</td>
<td>VCA</td>
<td>Volts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>15</td>
<td>VLavg</td>
<td>Volts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>16</td>
<td>VAN</td>
<td>Volts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>17</td>
<td>VBN</td>
<td>Volts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>18</td>
<td>VCN</td>
<td>Volts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>19</td>
<td>VLNavg</td>
<td>Volts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>20</td>
<td>VNG</td>
<td>Volts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>21</td>
<td>Real Power (Watts)</td>
<td>Watts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>22</td>
<td>Reactive Power (VAr)</td>
<td>VAr</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>23</td>
<td>Apparent Power (VA)</td>
<td>VA</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>24</td>
<td>Pfd [Displacement Power Factor]</td>
<td>0</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>25</td>
<td>Pfa [Apparent/True Power Factor]</td>
<td>0</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>26</td>
<td>Frequency</td>
<td>Hz</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>27</td>
<td>K-factor</td>
<td>0</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>28</td>
<td>Transformer Harmonic Derating Factor (sqrt2/CrestFactor)</td>
<td>0</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>29</td>
<td>Phase A Watts</td>
<td>Watts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>30</td>
<td>Phase B Watts</td>
<td>Watts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>31</td>
<td>Phase C Watts</td>
<td>Watts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>32</td>
<td>Phase A VAr</td>
<td>VAr</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>33</td>
<td>Phase B VAr</td>
<td>VAr</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>34</td>
<td>Phase C VAr</td>
<td>VAr</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>35</td>
<td>Phase A VA</td>
<td>VA</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>36</td>
<td>Phase B VA</td>
<td>VA</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>37</td>
<td>Phase C VA</td>
<td>VA</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>38</td>
<td>Phase A Pfd [Displacement Power Factor]</td>
<td>0</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>39</td>
<td>Phase B Pfd</td>
<td>0</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>40</td>
<td>Phase C Pfd</td>
<td>0</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
</tbody>
</table>
# Appendix A Points List

<table>
<thead>
<tr>
<th>#</th>
<th>Parameter Name</th>
<th>Eng. Unit</th>
<th>DNP3 Category</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>41</td>
<td>Phase A PFa [Apparent/True Power Factor]</td>
<td>0</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>42</td>
<td>Phase B PFa</td>
<td>0</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>43</td>
<td>Phase C PFa</td>
<td>0</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>44</td>
<td>Source1 VAB (AUX)</td>
<td>Volts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>45</td>
<td>Source1 VBC (AUX)</td>
<td>Volts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>46</td>
<td>Source1 VCA (AUX)</td>
<td>Volts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>47</td>
<td>Phase A Direct (V)</td>
<td>Volts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>48</td>
<td>Phase A Quadrature (V)</td>
<td>Volts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>49</td>
<td>Phase B Direct (V)</td>
<td>Volts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>50</td>
<td>Phase B Quadrature (V)</td>
<td>Volts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>51</td>
<td>Phase C Direct (V)</td>
<td>Volts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>52</td>
<td>Phase C Quadrature (V)</td>
<td>Volts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>53</td>
<td>Positive Sequence Direct (V)</td>
<td>Volts</td>
<td>Analog Input</td>
<td>32 Bit</td>
</tr>
<tr>
<td>54</td>
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