Landis+Gyr Inc.

Implementation of
DNP V3.00 Protocol Level 2 & 3

Document Number MKB-524011500

Revision E

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Document History

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Document Number: MKB-524011300

Revision Level	Date Issued	Description of Revision
Original	5/24/01	Initial issue.
Revision A	8/02/01	Add set-up information on all protocol board jumpers
Revision B	7/08/02	Table 50 set-up and defaults
Revision C	11/18/02	Additional error code information Updated Device Profile
Revision D	3/12/03	Removed unsolicited responses for certification
Revision E	5/27/03	Added DNP Certification Label and changed Siemens to Landis+Gyr.

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1 Communications

The DNP protocol converter card supports RS232 and two-wire RS485 communications. The standard DNP data link layer and application layer services are supported.

1.1 Baud Rate

There are seven-baud rates supported. The protocol converter card always communicates with the meter at 9600 baud. However, the protocol converter card can be configured through table 32 to communicate with the DNP host at 300, 600, 1200, 2400, 4800, 9600, or 19200 baud.

1.2 UART setup

The parity, number of data bits, and number of stop bits are fixed at none, 8, and 1 respectively. These parameters are not adjustable.

1.3 Data Link Layer Services

The DNP firmware supports data link confirmations, data link retries, and collision avoidance, all as configurable parameters in table 32.

1.3.1 Data Link Confirmations

The DNP firmware can be configured to request data link confirmations on all primary messages that are sent. This is a data link layer service and is transparent to the application layer. This service provides a level of guaranteed delivery for all primary data link frames to the host. This parameter works with the data link retries parameter (see next section).

This service is configured through table 32.

1.3.2 Data Link Retries

The DNP firmware can be configured to retry unconfirmed data link primary frames. The retry is attempted when the confirmation has not arrived within 300 milliseconds after sending the primary frame. The 300-millisecond timeout is fixed. Retries are not attempted unless data link confirmations are enabled.

The number of retries is fixed at 2 if they are enabled. If the confirmation fails after two retries, the communication link is considered failed, and a reset sequence is required before a new primary frame can be sent.

This service is configured through table 32.

1.3.3 Collision Avoidance

The DNP firmware can be configured to enable or disable collision avoidance through table 32. The collision avoidance method used is “Detection of Transmitted Data”. The back-off algorithm used is defined in the DNP Basic 4 documentation set. The fixed delay is taken from the bottom byte of the meter’s DNP address. This value is multiplied by 10 milliseconds to arrive at the fixed delay portion of the back-off time. The maximum random delay in units of 10’s of milliseconds is a configurable parameter stored in table 32.

Collision avoidance should never be enabled on a point-to-point connection since the algorithm inserts additional delays in the transmit state machine. Also, if there are no DNP end devices that send unsolicited responses attached to the communication line, then collisions are impossible and collision avoidance should be disabled.

1.3.4 Data Link Layer Transport Receive Buffer

The data link layer can string several frames together (each one being a transport segment) before reporting the entire data buffer to the application layer. This is referred to as the DNP transport function.

The data link layer maintains one transport buffer of 1024 bytes dedicated to receiving host primary messages. The DNP application layer also maintains a second buffer that it uses to operate on received data. The DNP firmware can thus receive two 1024 byte messages from the host in rapid succession without rejecting the data. A third message would be “NAK’d” unless the application layer could dispatch one or both of the previous messages before the first frame of the third message arrived.

1.3.5 Data Link Layer Transport Transmit Buffer

The data link layer does not maintain a transport buffer for sending application layer fragments. However, the application layer maintains two 2048 byte fragment buffers so that it can build a new response message while the data link layer is busy sending a previously generated response message.

The data link layer will break up the 2048 byte application layer fragment into several transport segments and send them to the host one frame at a time.

1.4 Time Synchronization

Time synch is available through the DNP protocol. The meter’s time may be modified only within the restrictions of the “Modify Clock Time” X command (X 13). This command allows the meter time to be changed within the range of –32768 to +32767 seconds (roughly +/- 9 hours). In no case however can the clock be modified to cross a midnight boundary.

2 Data Point Mapping

The DNP protocol defines three major types of data points: binary, analog, and counter. Of those three, the binary and analog types can be inputs or outputs. The counter type is always an input. All of the above types are supported in the MAXsys and Quad4+ meters with the exception of analog outputs.

2.1 Binary Inputs

Binary inputs are fully supported. The number of binary inputs available to a meter is dependent on the specific version of firmware, but all versions have some of each of the following types.

2.1.1 Error Status Bits

All versions keep an error status word. This word contains 4 bits that may be of interest to the user. The error status bits are configurable as a group, that is, either all four are configured in, or none are. If the error bits are configured in, then they map to binary points 0 through 3 as follows:

```
0      RAM Failure
1      Program Malfunction
2      ROM Failure
3      Recording
```

The error status bits are taken from Table 3, unit_status, bits 0, 3, 4, and 10.

2.1.2 Status Input Bits

All meter versions have some number of status inputs. The actual number is defined in Table 0 under the name MAX_SENSE_INPUTS. A typical number of status inputs is 11. As with the error status bits, the status input bits are configurable as a group. All status inputs are configured in, or none are. If the error bits are configured in, then the first status input binary data point is 4. If the error status bits are not mapped, then the first status input is mapped to binary data point 0.

Note: Typically the first status input is phase C presence, followed by phases B then A, and all other status inputs are unused. However, if any of the meter's Aux Inputs have been programmed as status inputs, then the lowest number Aux Input becomes the first status input, followed by all remaining aux inputs. The phase presence indicators are tacked on to the end of the list after the last aux input.

The status input bits are taken from Table 3, sense_input_status, bits 0 through MAX_SENSE_INPUTS–1.

2.1.3 Relay Output Status

All meter versions also have some number of relay outputs. The actual number is defined in Table 0 under the name MAX_OUTPUTS. A typical number of relay outputs is 12. These should not be confused with binary outputs, which are also available. The entire lot of relays are available as inputs because under many circumstances, they are used as alarms, and therefore behave as inputs.

As with the error status bits and the status input bits, the relay status bits are configurable as a group. All relay output status bits are configured in, or none are. The starting number of the first relay status binary data point is dependent upon whether the error bits and status bits have been configured in. The table below shows the starting position based on other bit inclusion:

Errors Included	Status Inputs Included	Relay 1 binary data point number
No	No	0
Yes	No	4
No	Yes	MAX_SENSE_INPUTS
Yes	Yes	MAX_SENSE_INPUTS + 4

The relay output status bits are taken from Table 3, output_status, bits 0 through MAX_OUTPUTS–1.

2.2 Binary Outputs

Binary outputs are also fully supported. Binary outputs are, of course, the relay outputs. The number of relay outputs available to a meter is dependent upon the specific version of firmware. Binary outputs are configured in as a group, just like the binary inputs. Meter relay 1 corresponds with binary output point 0, and so on up to the number of relays defined in table 0.

In order for relay outputs to be available to the DNP host, two configuration requirements must be satisfied. First, the relay control type must be configured in table 32. This configuration specifies the control methodology for the relays: Select Before Operate, Direct Operate with Acknowledgement, or Direct Operate, No ACK. If none of these is selected, then no binary output data points will exist.

Second, any relay that will be actually operated by the DNP host must be programmed in Table 19 as being sourced from the Miscellaneous Buss, with the line corresponding to the “Operate relay via X command”. The actual miscellaneous buss line number is different from meter version to meter version.

If any relay output is programmed other than “Operate relay via X command”, then the local flag will be set on in the internal indications word. Only if all of the meter’s relays are programmed for control via X command will the local flag be cleared in the internal indications.

Note: There is no restriction on the configuration of relays as inputs and outputs. Relays may be included in the binary input list independently of their inclusion in the binary output list. Relays can be defined as inputs, outputs, both, or neither.

2.3 Analog Inputs

Analog inputs are also fully supported. These values trace their source back to table 3, either from the rate_projection array, or the latest_rates array. Analog inputs can be read directly from table 3, or taken from tables 15 or 36 where rate values are stored in the data blocks. Basically any rate value is reported back to the DNP host as an analog input.

Analog inputs are configured using the external display list in table 32. The mapping of a specific rate value to a given analog input point is based solely on its relative position in the external display list. The first rate value found in the list becomes the first analog input data point. Additional analog input points are assigned as they are found in the display list. They need not be contiguous in the list, nor do they need to be grouped by table source. Any order of external display list items is acceptable.

If there is not enough space in table 32 to define all of the required data points, then the external display lists in table 31 or table 30 can also be used. If the table 31 list is used, then all analog data points found in that list are tacked onto the DNP data point list after the table 32 items. Likewise, if the table 30 list is used, then all analog data points found in that list are tacked onto the DNP data point list after table 31 items (if any).

Analog inputs have a scaling factor applied immediately upon receipt from the meter. The scale factor, which is a power of 10 from .00000001 to 10000000, is specified in the external display item list for each individual item.

Analog input values are read from the meter as floating point values, so they must be converted to 16 or 32 bit signed integers. The conversion process is applied after the value has been scaled. If the analog value is being converted to a 16-bit integer, then it is divided by 65536.0, which is 2.0 raised to the 16^{th} power, and the remainder is reported as the analog value. The same operation is performed if the analog value is being converted to a 32-bit integer, except that the divisor is 2.0 raised to the 32^{nd} power.

2.4 Analog Outputs

Analog outputs are not supported in any way.

2.5 Binary Counter Inputs

Binary counter inputs are also fully supported. These values are basically any register or counter object in the meter that can be accessed via a display item.

2.5.1 Register Data

Any summation register in the data block array can be configured as a binary counter input. Other counters include the Table 9 input registers, and some certain values in table 2 and table 3. Basically any data table item that counts anything in the meter can be specified as a binary counter.

Registers are configured using the external display list in table 32. The mapping of a specific register to a given binary counter input point is based solely on its relative position in the external display list. The first register value found in the list becomes the first counter input data point. The registers need not be contiguous in the list, nor do they need to be grouped by table source. Any order of external display list items is acceptable.

If there is not enough space in table 32 to define all of the required data points, then the external display lists in table 31 or table 30 can also be used. If the table 31 list is used, then all counter data points found in that list are tacked onto the DNP data point list after the table 32 items. Likewise, if the table 30 list is used, then all counter data points found in that list are tacked onto the DNP data point list after table 31 items (if any).

Register values have a scaling factor applied immediately upon receipt from the meter. The scale factor, which is a power of 10 from .00000001 to 10000000, is specified in the external display item list for each individual register item. Scale factors specified for binary registers (such as table 9 input registers) are ignored. The scale factor is applied only to floating point register values.

Summation register values are read from the meter as floating point values, so they must be converted to 16 or 32 bit unsigned integers. The conversion process is applied after the value has been scaled. If the summation register value is being converted to a 16-bit integer, then it is divided by 65536.0, which is 2.0 raised to the 16^{th} power, and the remainder is reported as the register value. The same operation is performed if the summation register value is being converted to a 32-bit integer, except that the divisor is 2.0 raised to the 32^{nd} power.

3 Event Storage

An important part of the DNP protocol involves the ability to record changes in the values of data points. All static input data types supported can be configured to generate event data.

Event data is stored in a RAM buffer on the protocol converter card. This buffer is approximately 100 Kbytes in length, and allows for a total storage of between 5000 and 6000 events or freeze data points. The allocation of the buffer space is dynamic and based on the type of data that can generate events, as well as the number of different data points of each type.

Each data point that can generate events is given a minimum number of buffers for its exclusive use. Once that minimum is exceeded, then additional buffers are allocated from the general event buffer allocation until no more event buffer space is available. After that an “any-purpose” buffer allocation is tapped. The any-purpose buffer space is shared with freeze data events on a first-come-first-served basis. In any event though, no one data point will be allowed to use up all of the event data space.

NOTE: The protocol converter card’s buffer memory *does not* survive a power failure. As such, unless the meter is powered by an un-interruptible power supply (UPS), no reliance should be placed on the ability to read event or freeze event data.

3.1 Binary Input Change Events

Binary input change events are fully supported. Each time the binary data point list is updated with new data, the values that are changed can be recorded along with the time of the change.

Binary input change events are enabled or disabled as a group. If change events are required on any one binary input, then change events will be recorded on all binary inputs. Binary input change events are enabled via table 32.

When change events are enabled for binary inputs, each input is guaranteed buffer space for several change events. Beyond that, each data point competes for buffer space against all other data points that generate events within the limits defined in section 3.

If binary input change event collection is disabled, then the memory allocation for event storage is redistributed between event storage and freeze event storage.

3.2 Analog Input Change Events

Analog input change events are fully supported. Each time the analog input data point list is updated with new data, the values that exceed the analog input dead band can be recorded along with the time of the change.

Analog input change events are enabled or disabled as a group. If change events are required on any one analog input, then change events will be recorded on all analog inputs. Analog input change events are enabled via table 32.

When change events are enabled for analog inputs, each input is guaranteed buffer space for several change events. Beyond that, each data point competes for buffer space against all other data points that generate events within the limits defined in section 3.

If analog input change event collection is disabled, then the memory allocation for event storage is redistributed between event storage and freeze event storage.

3.2.1 Analog Dead Band

Analog data change events rely on a value known as the dead band. This value is the amount of change required, in the plus or minus direction, that will cause an analog change event to be generated and stored.

The analog dead band is a global value for all analog inputs, and is configured in table 32 of the meter. The units are in tenths of a percent, and any value can be selected from 0.0 percent to

25.5 percent. A change event is generated when the analog value changes by more than the dead band percentage from the previously reported change.

3.3 Binary Counter Change Events

Binary counter change events are fully supported. Each time the binary counter data point list is updated with new data, the values that are changed can be recorded along with the time of the change.

Binary counter change events are enabled or disabled as a group. If change events are required on any one binary counter, then change events will be recorded on all binary counters. Binary counter change events are enabled via table 32.

When change events are enabled for binary counters, each counter is guaranteed buffer space for several change events. Beyond that, each data point competes for buffer space against all other data points that generate events within the limits defined in section 3.

If binary counter change event collection is disabled, then the memory allocation for event storage is redistributed between event storage and freeze event storage.

4 Object and Variation Support

This section details the DNP objects and variations that are supported.

4.1 Object 1 – Binary Input Object (Static)

This object is read-only. The application layer function codes that apply to this object are:

- Read (1) of variations 0, 1, or 2. Variation 0 read requests are honored with variation 1 response data.

4.2 Object 2 – Binary Input Change Object (Event)

This object is read-only. The application layer function codes that apply to this object are:

- Read (1) of variations 0, 1, 2, or 3. Variation 0 read requests are honored with variation 1 response data.
- Enable Unsolicited Messages (20) of variations 0, 1, 2, or 3. Only one variation may be specified.
- Disable Unsolicited Messages (21) of any variation.
- Assign Class (22) of variations 1, 2, or 3. Only one variation may be specified.

4.3 Object 10 – Binary Output Object (Static)

This object is read-only. The application layer function codes that apply to this object are:

- Read (1) of variations 0 or 2. Variation 0 read requests are honored with variation 2 response data.

4.4 Object 12 – Control Block Object (Static)

This object is write-only. The application layer function codes that apply to this object are:

- Select (3), Operate (4), Direct Operate (5), and Direct Operate, no ACK (6) may be issued depending on the table 32 relay output configuration. Only variation 1 is supported. There is no support for pattern control.

4.5 Object 20 – Binary Counter Object (Static)

This object is read-write. The application layer function codes that apply to this object are:

- Read (1) of variations 0 through 8. Variation 0 read requests are honored with either variation 5 or variation 6 response data depending on the state of the default counter size bit in table 32.
- Immediate Freeze (7 or 8) of variations 0 through 8.
- Freeze and Clear (9 or 10) of variations 0 through 8.
- Freeze with Time (11 or 12) of variations 0 through 8.

4.6 Object 21 – Frozen Counter Object (Frozen Static)

This object is read-only. The application layer function codes that apply to this object are:

- Read (1) of variations 0 through 12. Variation 0 read requests are honored with either variation 1 or variation 2 response data depending on the state of the default counter size bit in table 32.

4.7 Object 22 – Counter Change Event Object (Event)

This object is read-only. The application layer function codes that apply to this object are:

- Read (1) of variations 0 through 8. Variation 0 read requests are honored with either variation 1 or variation 2 response data depending on the state of the default counter size bit in table 32.
- Enable Unsolicited Messages (20) of variations 0 through 8. Only one variation may be specified.
- Disable Unsolicited Messages (21) of any variation.
- Assign Class (22) of variations 0 through 8. Only one variation may be specified.

4.8 Object 23 – Frozen Counter Event Object (Frozen Event)

This object is read-only. The application layer function codes that apply to this object are:

- Read (1) of variations 0 through 8. Variation 0 read requests are honored with either variation 1 or variation 2 response data depending on the state of the default counter size bit in table 32.
- Enable Unsolicited Messages (20) of variations 0 through 8. Only one variation may be specified.
- Disable Unsolicited Messages (21) of any variation.
- Assign Class (22) of variations 0 through 8. Only one variation may be specified.

4.9 Object 30 – Analog Input Object (Static)

This object is read-only. The application layer function codes that apply to this object are:

- Read (1) of variations 0 through 4. Variations 5, 6, and 7 are not supported. Variation 0 read requests are honored with either variation 3 or variation 4 response data depending on the state of the default analog register size bit in table 32.
- Immediate Freeze (7 or 8) of variations 0 through 4.
- Freeze with Time (11 or 12) of variations 0 through 4.

4.10 Object 31 – Frozen Analog input Object (Frozen Static)

This object is read-only. The application layer function codes that apply to this object are:

- Read (1) of variations 0 through 6. Variations 7, 8, and 9 are not supported. Variation 0 read requests are honored with either variation 1 or variation 2 response data depending on the state of the default analog register size bit in table 32.

4.11 Object 32 – Analog Change Event Object (Event)

This object is read-only. The application layer function codes that apply to this object are:

- Read (1) of variations 0 through 4. Variations 5, 6, and 7 are not supported. Variation 0 read requests are honored with either variation 1 or variation 2 response data depending on the state of the default analog register size bit in table 32.
- Enable Unsolicited Messages (20) of variations 0 through 4. Only one variation may be specified.
- Disable Unsolicited Messages (21) of any variation.
- Assign Class (22) of variations 0 through 4. Only one variation may be specified.

4.12 Object 33 – Frozen Analog Event Object (Frozen Event)

This object is read-only. The application layer function codes that apply to this object are:

- Read (1) of variations 0 through 4. Variation 0 read requests are honored with either variation 1 or variation 2 response data depending on the state of the default analog register size bit in table 32.
- Enable Unsolicited Messages (20) of variations 0 through 4. Only one variation may be specified.
- Disable Unsolicited Messages (21) of any variation.
- Assign Class (22) of variations 0 through 4. Only one variation may be specified.

4.13 Object 34 – Analog Event Deadband Object

No support is provided for this object.

4.14 Object 40 – Analog Output Status Object (Static)

No support is provided for this object.

4.15 Object 41 – Analog Output Block Object (Static)

No support is provided for this object.

4.16 Object 50 – Time and Date Object

This object is used to set or get the meter time, and to apply timing information to freeze requests. The meter time has a resolution of 10 milliseconds, but an accuracy of only one or two seconds depending on the firmware version.

This object is read-write. The application layer function codes that apply to this object are:

- Read (1) of variations 0 or 1. Variation 2 is not supported for the read function. Variation 0 read requests are honored with variation 1 response data.
- Write (2) of variations 1 or 2.

4.17 Object 51 – Time and Date CTO Object

This object is supported as part of the Object 2 Variation 3 data response.

4.18 Object 52 – Time Delay Object

No support is provided for this object.

4.19 Object 60 – Class Data Object

This object is read-only. The application layer function codes that apply to this object are:

- Read (1) of variations 1 through 4.

4.20 Object 70 – File Object

No support is provided for this object.

4.21 Object 80 – Internal Indications Object

This object is read-write. The application layer function codes that apply to this object are:

- Read (1) of variation 1.
- Write (2) of variation 1.

4.22 Objects 81 and Above

No support is provided for these objects.

5 Power Up and System Initialization

The DNP firmware configures itself according to the data stored in the meter's control tables. The DNP configuration is valid until one of the critical control tables have been modified. If that happens, then the DNP firmware must re-initialize itself.

5.1 First Power Up

The first time that a DNP protocol converter card is powered up, it sees that it has not been set up yet. The firmware then reads the control tables that apply to the protocol converter, and stores them in its non-volatile memory. Periodically, these same control tables will be re-read and checked for changes. If a change has occurred, then the first power up initialization sequence is re-executed.

At first power up no event or freeze commands are in force.

Counters that are associated with data block summation registers are initialized to whatever counts those summation registers currently contain.

5.2 Power Fail

A power failure in the meter causes the protocol converter card to shut down. The DNP firmware stores event and freeze data on the protocol converter card, so all of that data is completely lost. The register data is maintained because it stored in the meter, not on the protocol converter card. Only the freeze and change event history is lost.

5.3 Idle Mode

If the meter ever enters idle mode, then data polling will stop. When the meter re-enters record mode, then all of the data points are re-initialize with current data, and the event and freeze buffers are cleared.

6 LED's

The Protocol Converter Card has six LED's labeled LED1 through LED6. These LED's indicate the status of the host and meter communications, and the error status.

LED 1: On when data is being received from the DNP host.

LED 2: On when data is being transmitted to the DNP host.

LED 3: On when data is being received from the meter.

LED 4: On when data is being transmitted to the meter.

LED 5: On when DNP communications to the host are not possible, due to an error or due to the protocol converter card booting up. This LED turns off when the protocol converter card finishes its boot-up process, and is ready to communicate to the DNP host.

LED 6: Displays error codes by blinking on and off. The tens digit of the error code is a "long" on, while the units digit is a "short" on. A solid on, scintillating, condition indicates a "line break" has been detected and a recovery effort is underway. A very short on condition upon power up, reset by command or table reload is normal.

6.1 Error Codes

The following error codes are defined:

11	Error communicating on meter port
12	Error communicating on DNP host port
13	Overrun error on DNP host port
14	Framing error on DNP host port
15	Parity error on DNP host port
21	Watchdog timer timeout
22	Configuration of RS-485 enables is wrong
23	Configuration of SCMX enables is wrong
24	RX not enabled correctly
25	Interface buffer to DNP host port is full
31	Meter is in Idle Mode
32	Invalid Table 0
33	Invalid Table 32
34	EEPROM failure
4X	Internal stack overflow
5X	Trace buffer alert

6.1.1 Error Code 11 – Meter Comm Error

This error code is displayed when a communication error occurs between the protocol converter card and the meter. This error may occur from time to time but may recover immediately. In that event, there is no corrective action needed since this is a normal occurrence.

6.1.2 Error Code 12 – DNP Host Comm Error

This error code is displayed when a communication error occurs between the protocol converter card and the DNP host. The current revision of DNP firmware (V016R00) does not set this error.

6.1.3 Error Codes 13, 14 & 15 – DNP Host Comm Errors

These error codes are displayed when a communication error occurs between the protocol converter card and the DNP host. If these errors persist, they should be reported to Landis+Gyr Inc. customer service. The current revision of DNP firmware (V016R00) does not set this error.

6.1.4 Error Code 21 – Watchdog Timer Fail

This error code is displayed when the protocol converter card boots up, and discovers that the watchdog timer had triggered the preceding reset. This error should be reported to Landis+Gyr Inc. customer service.

6.1.5 Error Codes 22, 23, 24 & 25 – Internal Configuration Errors

These error codes are internal to the system. These errors should be reported to Landis+Gyr Inc. customer service.

6.1.6 Error Code 31 – Meter Idle

This error code is displayed when the protocol converter card detects that the meter has been placed in idle mode. This event causes the DNP communications to stop, and for the protocol converter card to reboot. LED 5 staying on continuously indicates the reboot condition. Once the meter is placed back in record mode, the boot process completes and the DNP communications resume.

6.1.7 Error Code 32 – Invalid Table 0

This error code is displayed when the protocol converter card boots up and discovers that it is incompatible with the meter's firmware version. Any meter version that does not support table 32 is incompatible with the DNP firmware.

6.1.8 Error Code 33 – Invalid Table 32

This error code is displayed when the protocol converter card boots up and discovers that the mode word stored in table 32 is NOT 000C (hex).

6.1.9 Error Code 34 – EEPROM Failure

This error code is displayed when the protocol converter card attempts to write to the EEPROM, and cannot do so successfully.

6.1.10 Error Code 4X – Internal Stack Overflow

These error codes are internal to the system. These errors should be reported to Landis+Gyr Inc. customer service.

6.1.11 Error Code 5X – Trace Buffer Alert

These error codes are used for development purposes internal to the system. These errors should be reported to Landis+Gyr Inc. customer service.

6.2 Error Code Display

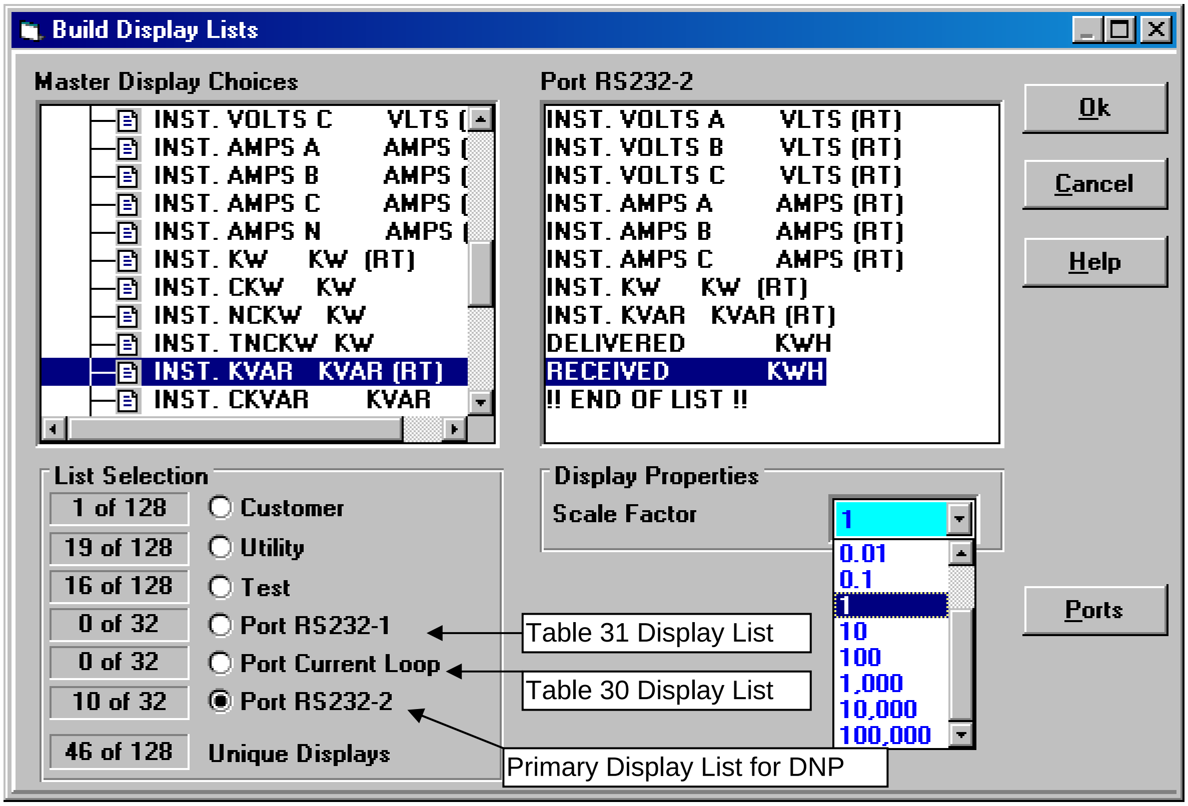
The error codes listed above are displayed by blinking LED 6. Multiple error codes can be displayed by cycling through each one in turn.

Error codes are displayed by first blinking a long pulse for each count of the tens digit, followed by a short pulse for each count of the units digit. There is a moderate delay after the last pulse of each units digit.

For example, assume that there is a watchdog time failure and an EEPROM failure. LED 6 would blink two long pulses followed by one short pulse to indicate error code 21 (watchdog timer), then after a moderate pause, three long pulses followed by four short pulses to indicate error code 34 (EEPROM failure). If the error corrects itself, then that error code will be removed from the display cycle. If there are no errors to display, then LED 6 remains off.

7 Mapper Set-up

7.1 *Display Configuration*



7.1.1 Master Display Choices:

Provides a list of Analogs & counters which can be selected as DNP information.

7.1.2 Port RS232 List:

This list will allow a total of 32 Counters & Analogs to be selected as DNP information. This is the first list that will be looked at for numbering outputs. The first Analog will become 0 and will continue as they are in the list. The same will take place with counters. The next list that will be ordered, will come from table 31 and then table 30.

7.1.3 List Selection:

This allows the user to select a location to store information to be sent back via DNP.

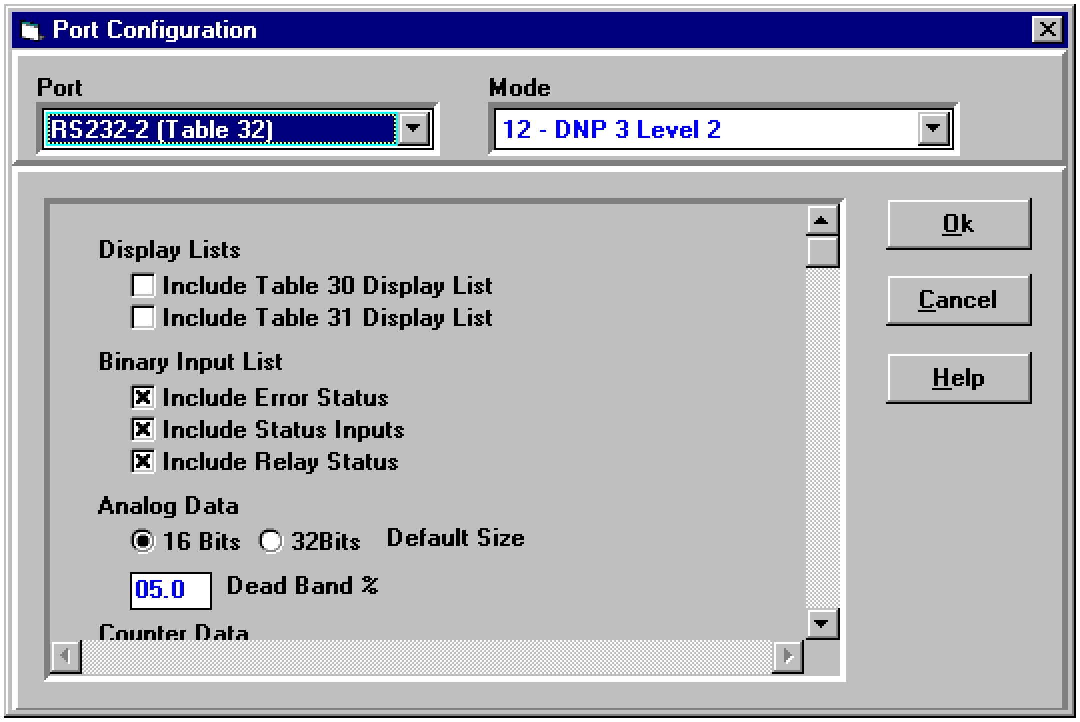
7.1.4 Scale Factors:

The scale factor allows values to be scaled up or down to meet the customer and the DNP requirements. Example a value of 25.5 would be sent back as 25. The number could of been scaled up by 10, a value of 255 would then be returned.

7.1.5 Ports Button:

This allows for switching to Port Configuration.

7.2 Port Configuration 1(Display Lists, Binary Input List & Analog Data)



7.2.1 Displays Lists (Analog or counter values to be returned to the host.)

Include Table 30 Display: Refers to the Current Loop List.

Include Table 31 Display: Refers to the RS232-1 List.

7.2.2 Binary Input List (Errors, Input or Relay status reported back to host.)

Include Error Status: When selected, the errors will be reported as status 0-3. See 2.11 for more detail.

Include Status Inputs: When selected, the status will be reported on the auxiliary inputs, which are set to NO UNIT OF MEASURE. See 2.1.2 for more detail.

Include Relay Status: When selected the status of each output relay will be report. See 2.1.3 for more detail.

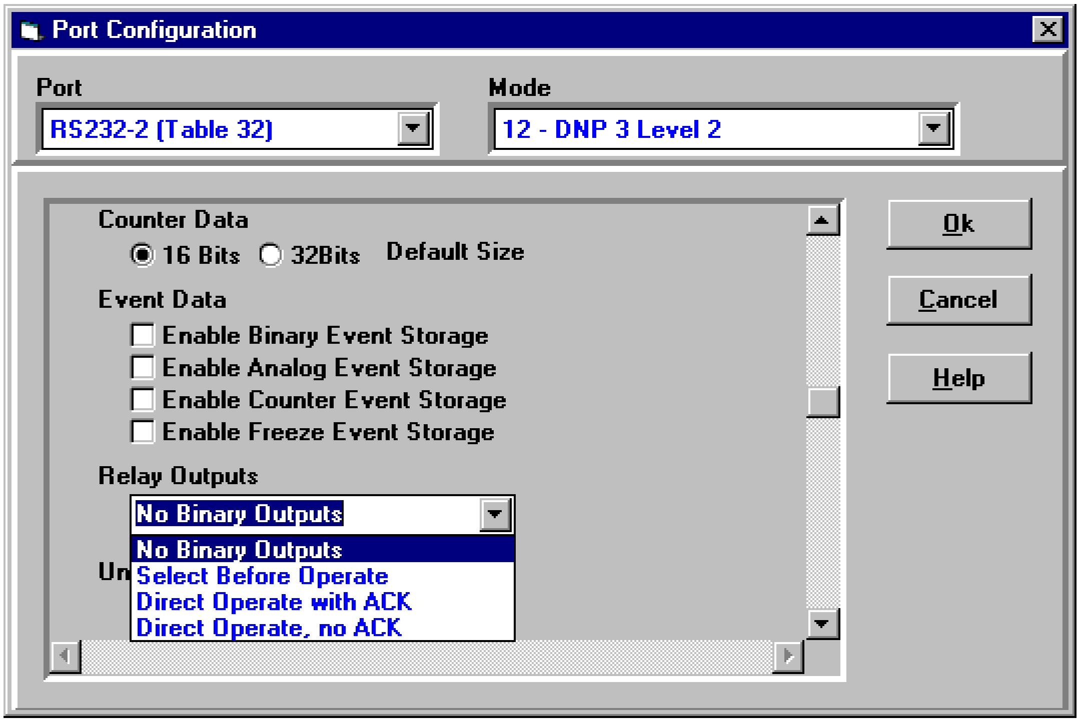
7.2.3 Analog Data

16 Bits: A request to read, will cause data to be reported back to the host as 16 bit numbers.

32 Bits: A request to read, will cause data be reported back to the host as 32 bit numbers.

Dead Band %: The amount of change required causing an analog change event to accrue.

7.3 Port Configuration 2 (Counter Data, Event Data Storage & Relay Outputs)



7.3.1 Counter Data

16 Bits: A request to read, will cause data to be reported back to the host as 16 bit numbers.

32 Bits: A request to read, will cause data to be reported back to the host as 32 bit numbers.

7.3.2 Event Data

Enable Binary Event Storage: Allows Binary event storage on event change.

Enable Analog Event Storage: Allows Analog event storage on Analog change.

Enable Counter Event Storage: Allows Counter event storage on Counter change.

Enable Freeze Event Storage: Allows the meter to perform Freeze event storage when the parameters are sent to the meter from the Host.

Note: The Event Storage should only be enabled for the data that will be used. The data storage will allow a total of 5000 events to be stored. The 5000 buffers are allocated based on the number of event types and number of values for each event. Example: If you enabled all of the event storage types but only planed on using Freeze Event Storage, the number of Freeze events which can be stored will be reduced because part of the 5000 buffers will be allocated to the other event types and will NOT be available for Freeze storage.

7.3.3 Relay Outputs

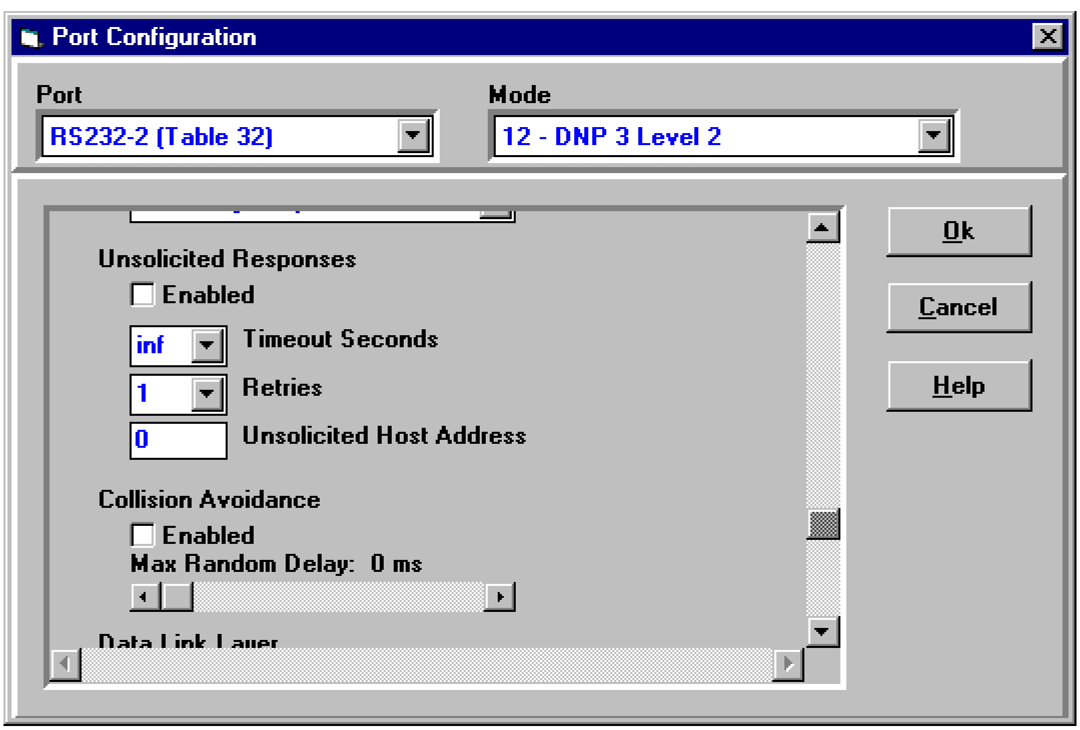
No Binary Outputs: Selecting No Binary Output will prevent any of the relays from being controlled with DNP commands.

Select Before Operate: Select Before Operate requires the host to send two commands with the same data packet. The first command must be Select followed by the second command Operate with the same data packet that was sent with the Select command.

Direct Operate with ACK: When this function is selected the meter will send the host an acknowledgement after the meter has received operate the relay command and the relay has operated.

Direct Operate, no ACK: With this selection there will be no response from the meter after the meter receives the Operate command and the relay has operated.

7.4 Port Configuration 3 (Unsolicited Responses & Collision Avoidance)



7.4.1 Unsolicited Responses

Enabled: Selecting Unsolicited Responses from the meter to the host. This will allow a master to set-up Unsolicited Responses within this meter. The response will only be sent to the unsolicited host address.

Timeout Seconds: The time seconds will be supplied by the SCADA group if Unsolicited Response is enabled.

Retries: The number of Retries will be supplied by the SCADA group if Unsolicited Response is enabled.

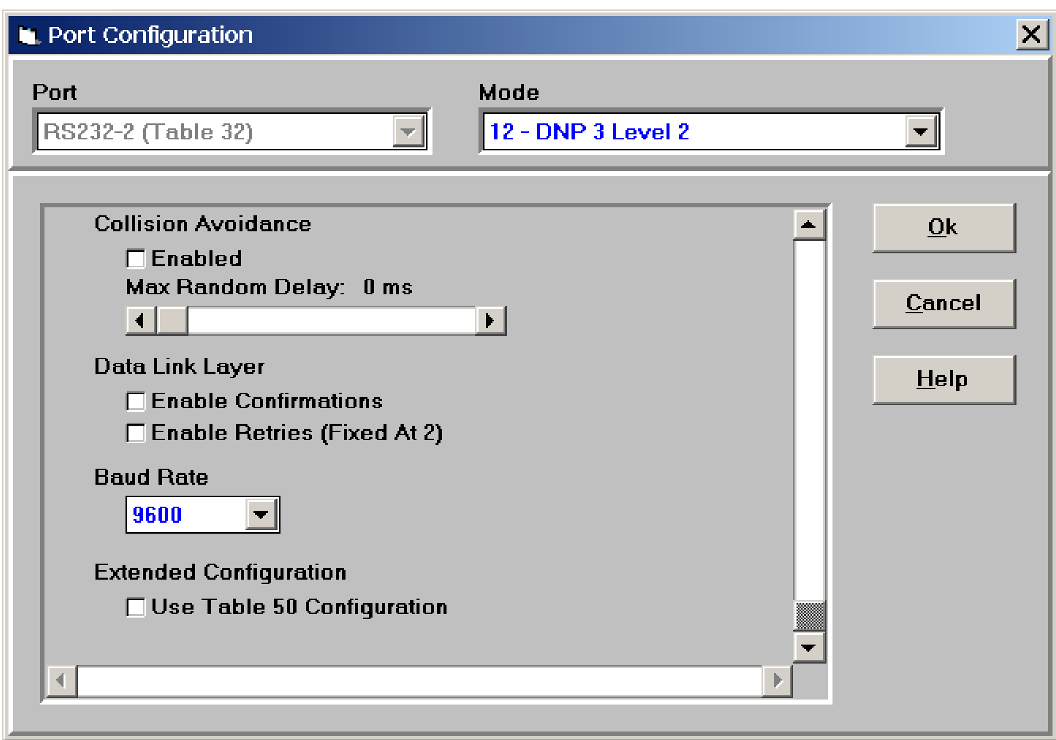
Unsolicited Host Address: This is the address to which the unsolicited response will be sent. The Address will be supplied by the SCADA group if Unsolicited Response is enabled.

7.4.2 Collision Avoidance

Enabled: Collision Avoidance should not be used for point to point communication.

Max Random Delay: The delay time will be supplied by the SCADA group if Collision Avoidance is enabled.

7.5 Port Configuration 4 (Data Link Layer & Baud Rate)



7.5.1 Data Link Layer

Enable Confirmations: This will be enabled if used by the SCADA Department. See section 1.3.1

Enable Retries (Fixed at 2): If retries will be used is a function if used by the SCADA Department. See section 1.3.2

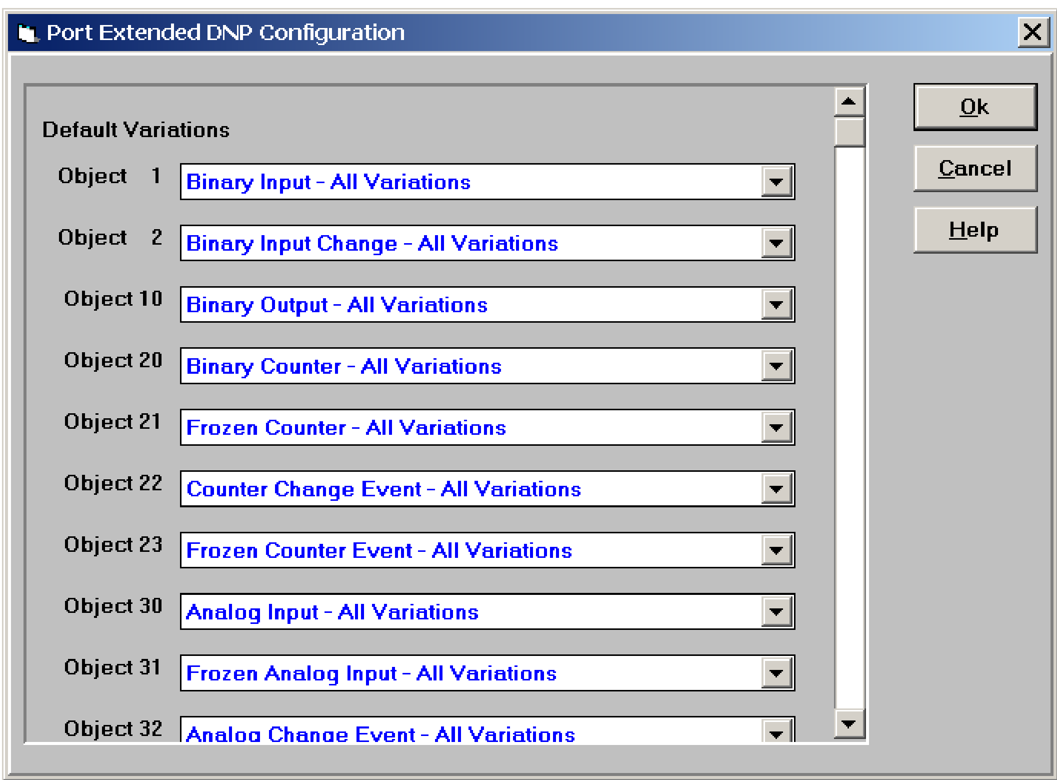
7.5.2 Baud Rate

The baud rate will be selected based on the communication system. This information would normally be supplied by the SCADA Department.

7.5.3 Extended Configuration

Table 50 allows the user to set or change defaults with using a DNP master or a DNP test set.

7.6 Port Configuration 5 Extended DNP Configuration (Table 50)

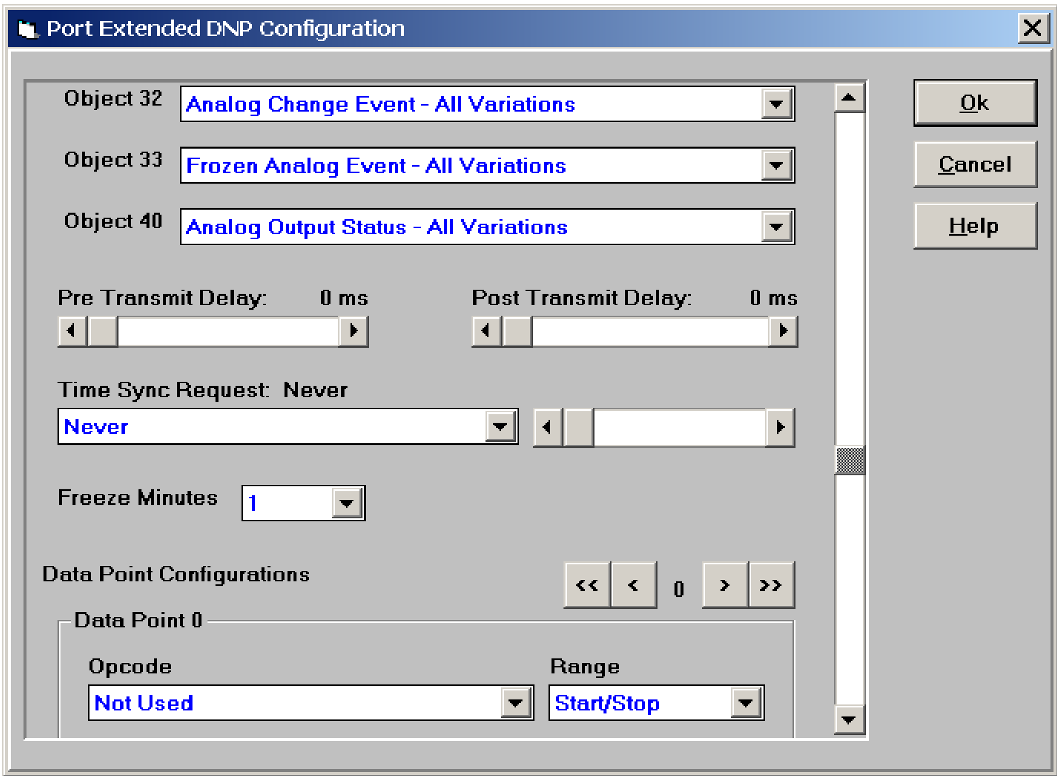


7.6.1 Default Variations

The fields allow the user to change the default variations for each of the "Objects". This screen allows the user to set or change defaults without using a

DNP master or a DNP test set.Note: Table 50 is only available in firmware versions 2751, 2752 and 57xx.

7.7 Port Configuration 6 Extended DNP Configuration (Table 50)



7.7.1 Pre Transmit Delay

The field will allow the user to set the Pre Transmit Delay after asserting RTS, before the first byte of a message is transmitted. The minimum value is zero (no delay) and the maximum value is 255 (2550 milliseconds, or 2.55 seconds). This field is ignored if collision avoidance is enabled, since collision avoidance has its own delay rules. CTS is ignored if the field is non-zero. The transmit will began as soon as the specified delay is complete, rather than waiting for CTS to be asserted.

7.7.2 Post Transmit Delay

The field will allow the user to set the Post Transmit Delay, forces a delay before de-asserting RTS, after the last byte of a message is transmitted. The minimum value is zero (no delay) and the maximum value is 255 (2550 milliseconds, or 2.55 seconds). This field is ignored if the pre-transmit delay is zero.

7.7.3 Time Sync Request & Time Sync Period

These fields specify a time sync is requested and the frequency, which the time sync is requested. The “Protocol Converter Card” (RTU) will never request a time sync, or it can request time sync every “X” minutes, “X” hours, “X” days, “X” weeks and “X” months.

7.7.4 Time Sync Request & Time Sync Period

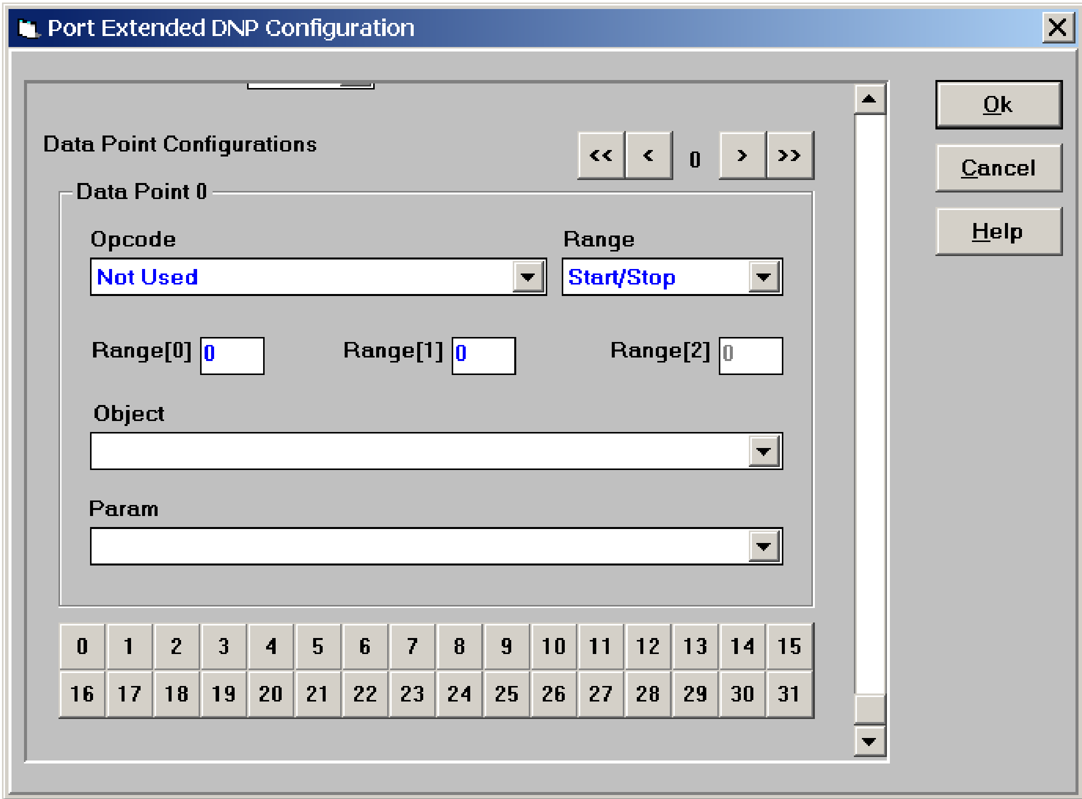
These fields specify a time sync is requested and the frequency, which the time sync is requested. The “Protocol Converter Card” (RTU) will never request a time sync, or it can request time sync every “X” minutes, “X” hours, “X” days, “X” weeks and “X” months.

7.7.5 Freeze Minutes

This field sets the freeze interval in the meter (Protocol Card). If this field is set to zero, then no freeze is generated. Otherwise, the valid values for this field are any number of minutes that is an even factor of 60: 1, 2, 3, 4, 5, 6, 10,12, 15,20, 30 or 60. Additionally, any even factor of 24 hours may be used: 60,120,180, 360, 480, 720 or 1440.

In all cases, the freeze will occur on the even interval minute or hour. An example, if 20 minutes is specified, the freeze will occur on the hour, on the 20-minute mark and on the 40-minute mark. If 720-minutes was specified, than the freeze will occur at midnight and noon.

7.8 Port Configuration 7 Extended DNP Configuration (Table 50)



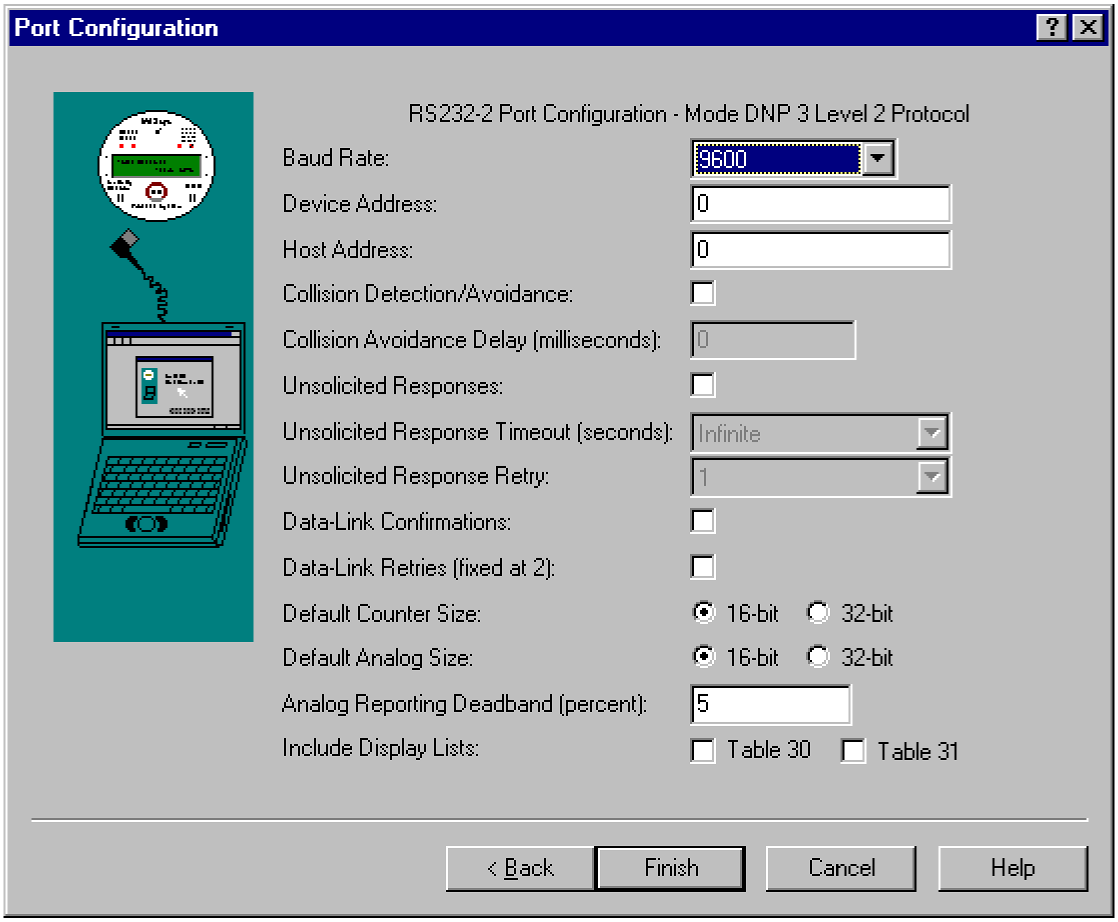
7.8.1 Data Point Configurations

This set of fields allow the customer to configure a particular set of data points in a specific way.

8 Maxcom Set-up Program Mode

8.1 Download list - Port Configuration

The list of items on the screen below can be changed or set at the time of programming.



8.1.1 Baud Rate

See section 7.5.2

8.1.2 Device Address

This is the SCADA address of the meter. This address is normally provide by the SCADA Department.

8.1.3 Host Address

See section 7.4.1

8.1.4 Collision Detection / Avoidance & Delays

See section 7.4.2

8.1.5 Unsolicited Responses, Timeouts & Retries

See section 7.4.1

8.1.6 Data Link Layer, Confirmations & Retries

See section 7.5.1

8.1.7 Counter & Analog Data Size

See section 7.3.1

8.1.8 Analog Dead Band %:

See section 7.2.3

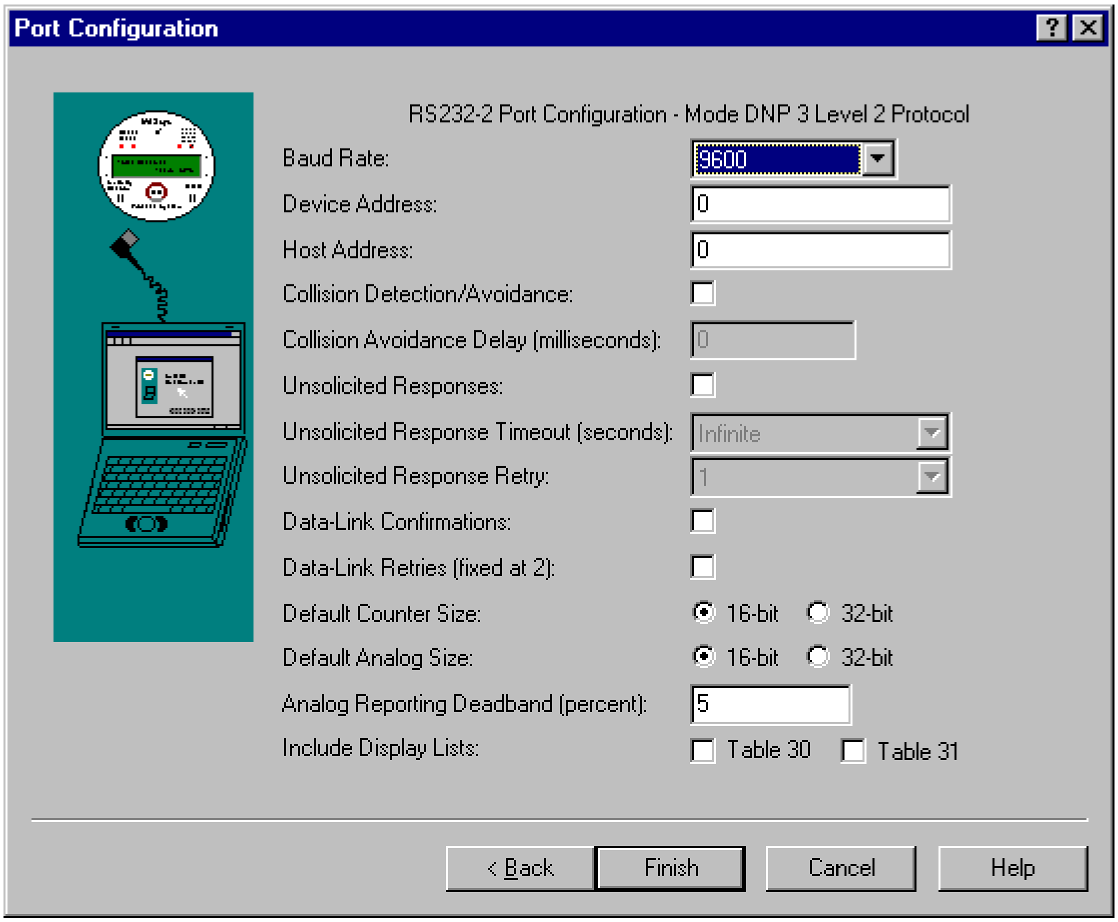
8.1.9 Include Display Lists

This allows lists for tables 30 & 31 to be used as one output list for DNP Analog and Counter (Allowing a total of 96 variables to be selected) Values. See section 7.1.2 for more information.

9 Maxcom Edit Program Mode

9.1 Edit Mode List - Port Configuration

The list of items on the screen below can be edited after the meter has been programming.



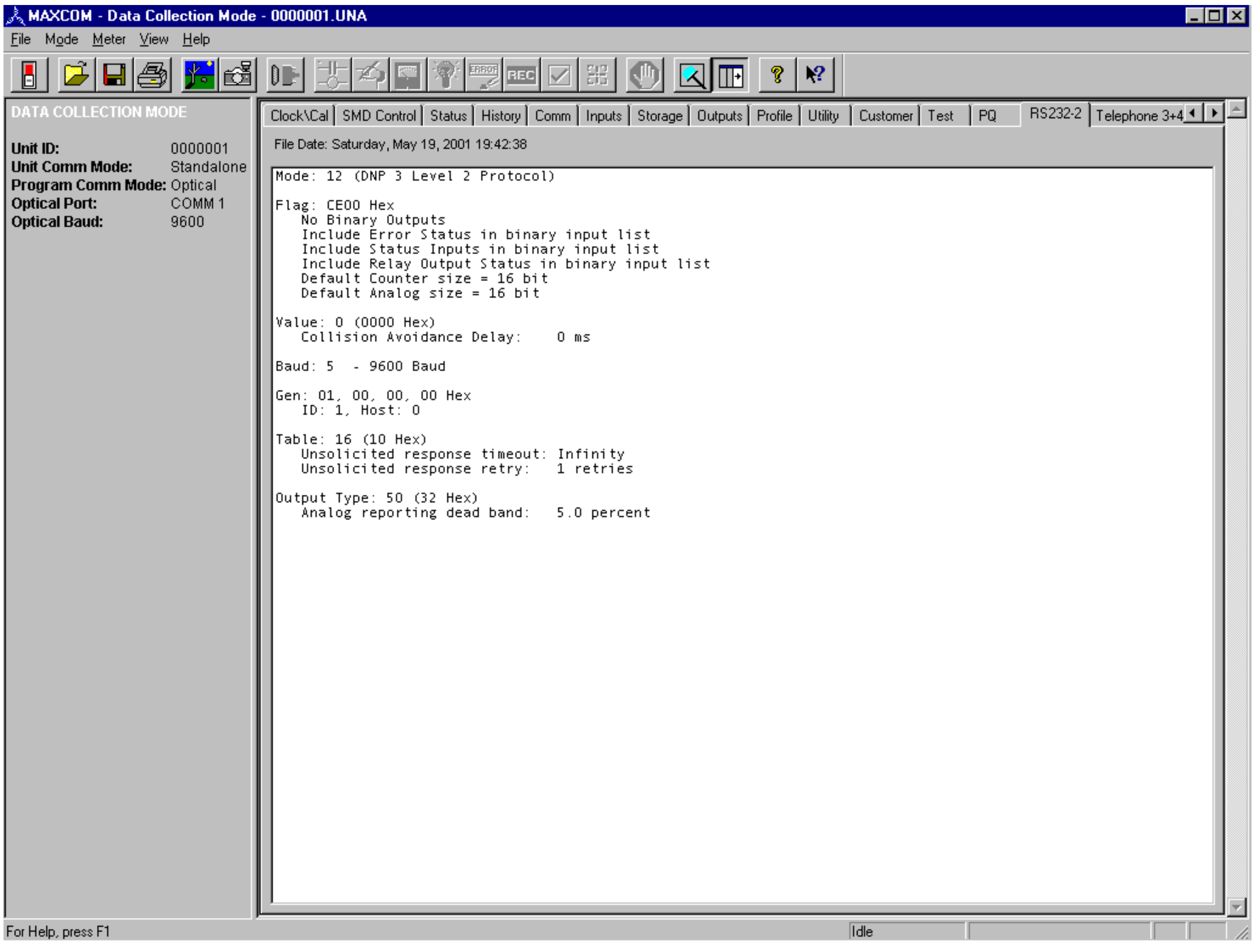
9.1.1 Edit Variables:

See section 8 for details of each variable.

10 Maxcom Data Collection Mode

10.1 Table RS232 Data Collection Mode

The information on the screen below can be used to verify the DNP setting in the meter.



10.1.1 Mode:

This is the protocol the meter firmware expects on the protocol converter board. Note: DNP 3.0 Level 2 will be mode “12”.

The mode field is used by the MAXsys or Quad4+ firmware to determine the function of the RS232-2 serial port. The DNP level 2 firmware uses mode value 0x000C. The other mode values are listed below for reference. Any value not listed is undefined and causes the port to be disabled.

0x0003	PGE protocol
0x0004	DNP (older version; not level 2)
0x0005	CEBUS protocol
0x0006	External RS232 (Type 7 protocol)

0x0007	External RS232 (Type 7 protocol with master/slave)
0x0008	SES-92 protocol
0x0009	MMS protocol
0x000A	External RS232 (Type 7 protocol with master/slave, RTS)
0x000B	MODBUS protocol
0x000C	DNP 3 Level 2 protocol

10.1.2 Flag:

This is the list of 16 bits which will be set based on the option which have been selected, see the following list for selected options.

The following flags are defined:

Bit 0	1 = Enable Freeze Event data colection
Bits 1 & 2	00 = No Binary outputs
	01 = Binary outputs are Select Before Operate
	10 = Binary outputs are Direct Operate with Acknowledge
	11 = Binary outputs are Direct Operate, No ACK
Bit 3	1 = Enable “Binary Input Change Event” data collection
Bit 4	1 = Enable “Analog Input Change Event” data collection
Bit 5	1 = Enable “Counter Change Event” data collection
Bit 6	1 = Enable Collision detection/avoidance
Bit 7	1 = Enable Unsolicited responses
Bit 8	1 = Include Profile data in counter list
Bit 9	1 = Include Error Status in binary input list
Bit 10	1 = Include Status Inputs in binary input list
Bit 11	1 = Include Relay Output Status in binary input list
Bit 12	1 = Enable Data-Link confirmations when sending
Bit 13	1 = Enable Data-Link retries (fixed at 2)
Bit 14	Default Counter size: 1 = 16 bit, 0 = 32 bit
Bit 15	Default Analog size: 1 = 16 bit, 0 = 32 bit

10.1.3 Value:

This field, “value” Field (Collision Avoidance Max Random Delay)

The value field is a 16-bit word, only the bottom byte of which is used. The upper byte should be set to zero for future compatibility purposes.

The bottom byte holds the maximum random delay used in the collision avoidance function. The units are 10's of milliseconds. The minimum value is zero (no random delay), and the maximum value is 255 (2550 milliseconds, or 2.55 seconds).

The least significant byte of the "gen" field is used as the fixed collision avoidance delay value, as well as its primary purpose which is the low byte of the device address.

10.1.4 Baud:

This field tells you at what communications speed the protocol board expects the host to communicate at.

The baud field holds a 16-bit code for the baud rate at which the DNP host channel should operate. The values defined below apply to all protocols, not just DNP:

0 = 300 baud

1 = 600 baud

2 = 1200 baud

3 = 2400 baud

4 = 4800 baud

5 = 9600 baud

6 = 19200 baud

10.1.5 Gen:

This field, gen" Field (DNP Device Address and DNP Host Address)

The gen field is a 4-element array of bytes. This field is reserved for a "unit-id" in whatever protocol is selected. The DNP firmware splits this field into two 16-bit words.

The bottom word (bytes 0 and 1) of this field contains the meter's DNP address. The DNP address is a 16-bit binary value in the range of 0 to 0xffef. Addresses 0xfff0 through 0xffff are reserved for host generated broadcast messages and are not allowed to be used as unit addresses.

Byte 0 plays a dual role. Besides being the bottom byte of the meter's DNP device address, this byte is also used as the "fixed" collision avoidance delay time. The delay time is the byte 0 value multiplied by 10 milliseconds.

The upper word (bytes 2 and 3) of this field is used for the master destination address when sending unsolicited messages. This address is also in the range of 0 to 0xffef.

10.1.6 Table :

This field, "table_no" Field (Unsolicited Response Timeout and Retries)

The table_no field is a single byte. This field was intended to define the table number where the display items could be found. However, since that table is *always* table 16, this field can be used for something else. In this case it is used define unsolicited response confirmation retries and timeouts.

The bottom 4 bits (bits 0-3) of this byte define the unsolicited response timeout according to the following table:

Value	Timeout
0	Infinity
1-10	1 to 10 seconds
11	15 seconds
12	20 seconds
13	30 seconds
14	45 seconds
15	60 seconds

The upper 4 bits (bits 4-7) of this byte define the unsolicited response retry count according to the following table:

Value	Number of Retries
0	None
1-14	1 to 14 retries
15	Infinite retries

10.1.7 Output Type:

output_type" Field (Analog Reporting Deadband)

The output_type field is a single byte. This field also has limited usefulness as it was originally intended, so its definition has changed for DNP.

This field is used to define the "deadband" for reporting analog input change events. The deadband defines how far the input may stray from its last reported value before a new event should be generated.

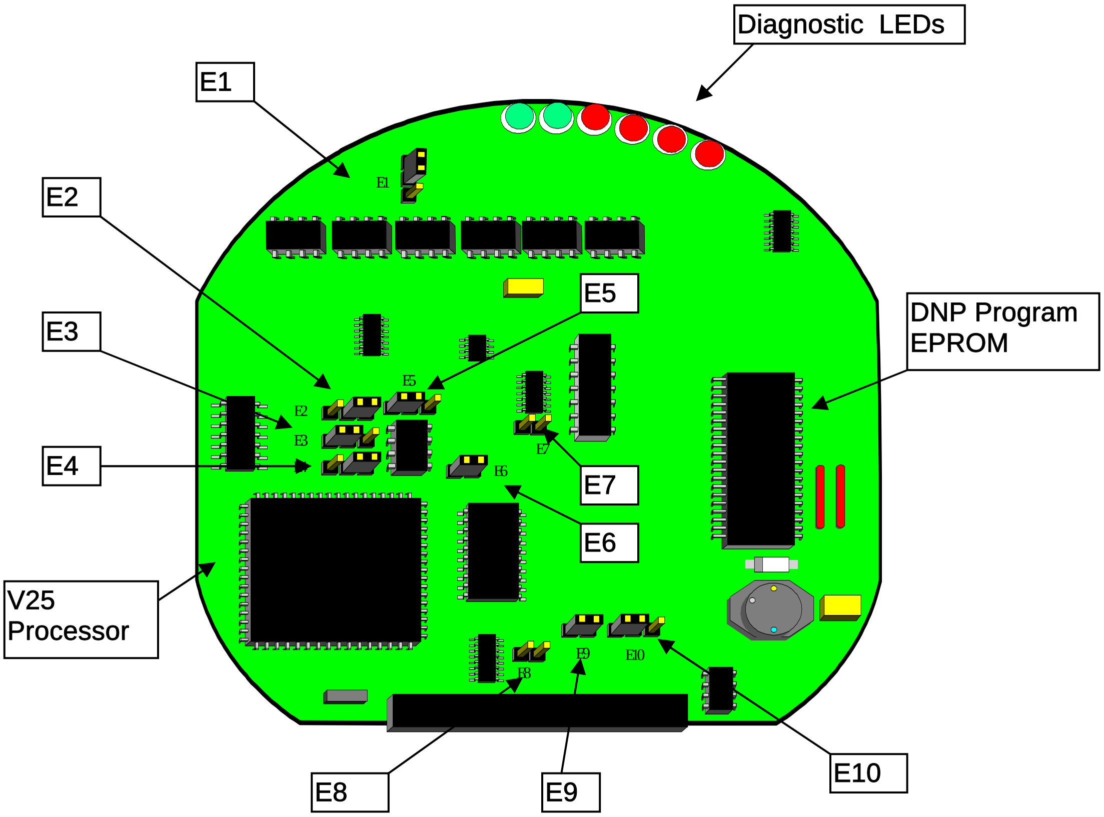
The units of this field are in tenths of a percent. The minimum value is zero (0.0 percent), and the maximum value is 255 (25.5 percent).

This field affects *all* analog input values. However, the deadband reporting may be modified by the use of object 34 for specific analog data points.

11 Hardware

11.1 Protocol Converter Board

Protocol Converter Board:



11.1.1 Jumper Installations Protocol Board

Host Serial Ports (connection from Protocol Board to host computer):

Port	Jumper	Position	Function
	E1	Not Used	On Standard Board
****	E1	A	Common Ground
****	E1	B	Isolated Ground
RS-232 (J2)	E2	A	RX data
RS-485 (J2)	E2	B	RX data

****	E2	B	Isolated RS232
	E3	*Not Used	Ring indicate
	E4	A	RS232 CTS used, signal from external source
	E4	B	RS232 CTS not used & RS485
	E5	Don't Care	RS232
RS485	E5	A	RX data Recommended
****	E5	B	RX data Isolated RS232
	E6	In	RS485 Terminated Not Recommended
	E6	Out	RS485 Un-terminated Recommended
	E7	N/A	Not customer configurable
	E8	N/A	Not customer configurable

Meter Serial Port (connection from Protocol Board to CPU of meter):

Jumper	Position	Function
E9	In	TXD connected to backplane (standard)RS232-2
E9	Out	RXD connected to RS-232 external RS232-1
E10	A	RXD connected to backplane (standard)RS232-2
E10	B	RXD connected to RS-232 external RS232-1

Example of jumper settings:

Application:

Configured to talk to the meter processor on the SuperBoard over the backplane (i.e., bus) on the Mother Board. The host interface is RS-232 with CTS not used.

Jumpers on Protocol Converter Board:

For meter serial port: E9 In; E10 on A.

For host connection: E2 on A, , E4 on B, E5 on A.

NOTE: You can convert from RS232 to RS485 by moving E2 from the jumper from "A" to "B".

**** Indicates position NOT USED on standard board.

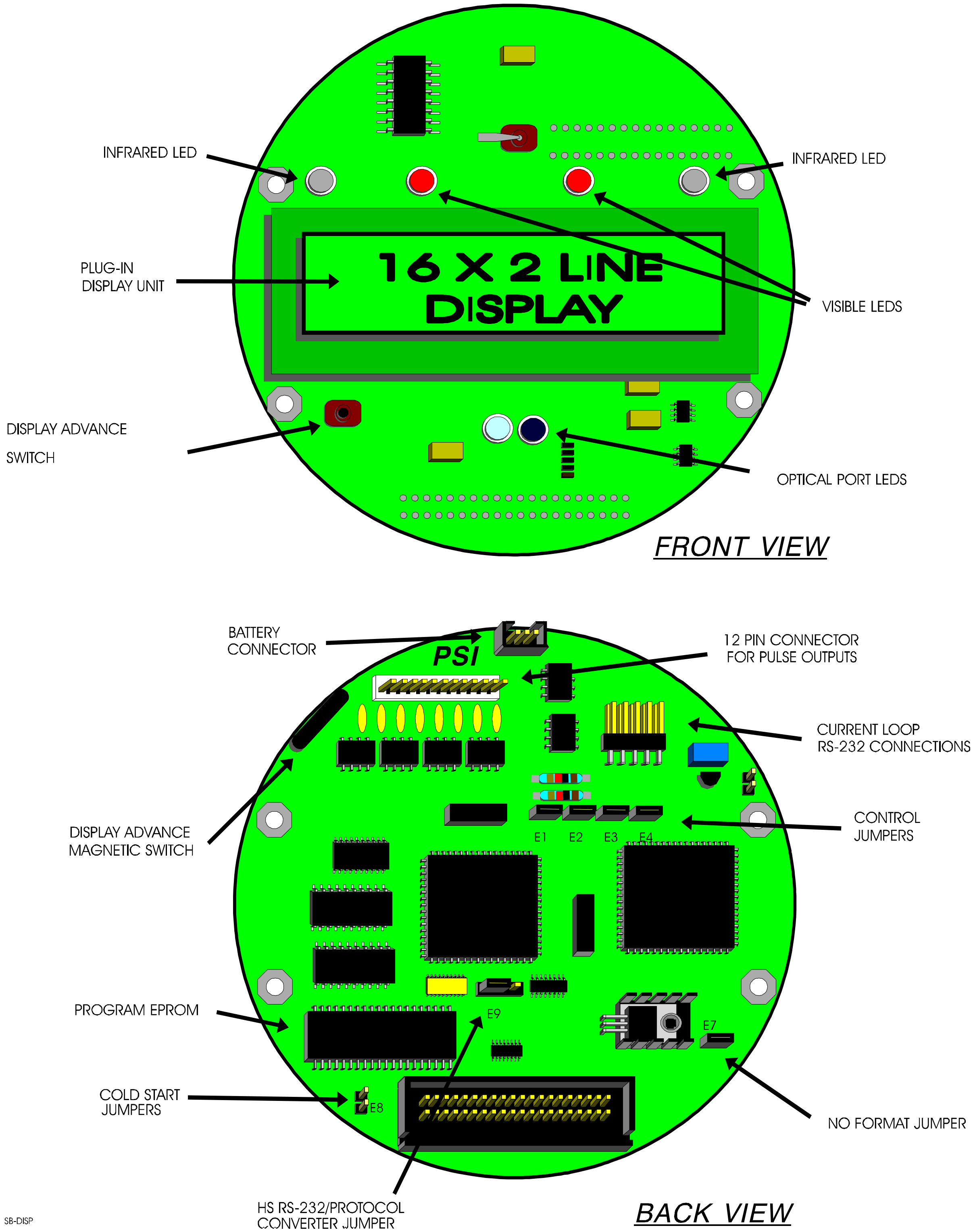
Jumpers on SuperBoard:

E9 in position 2-3 for operation with Protocol Converter

Note: If E9 is in position 1-2, RS-232 port #2 is active for other purposes.

11.2 Display Board

SuperBoard, Component and Solder Side:



11.2.1 Jumper Installations Display Board

E9 in position 2-3 for operation with Protocol Converter

12 Device Profile Document

DNP V3.00

DEVICE PROFILE DOCUMENT

Vendor Name: Landis + Gyr Inc.

Device Name: MAXsys 2510 Solid State Meter with optional Protocol Converter Board;
Protocol Converter Board firmware version V016, revision R07.

Highest DNP Level Supported: For Requests : 2 For Responses : 2	Device Function: ☐ Master ☒ Slave

Notable objects, functions, and / or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table):
See attached

Maximum Data Link Frame Size (octets): Transmitted 292 Received (must be 292)	Maximum Application Fragment Size (octets): Transmitted 2048 (if >2048, must be configurable Received 1024 (must be >= 249)
Maximum Data Link Re-tries: ☐ None ☐ Fixed at ________________________ ☒ Configurable, range: 0 or 2	Maximum Application Layer Re-tries: ☒ None ☐ Configurable, range _______ to _______ (Fixed is not permitted)

Requires Data Link Layer Confirmation:

☐ Never
☐ Always
☐ Sometimes If 'Sometimes', when? ______________________________
☒ Configurable If 'Configurable', how? Table32 Flag1.Bit12

Requires Application Layer Confirmation:

☐ Never
☐ Always (not recommended)
☒ When reporting Event Data (Slave devices only)
☒ When sending multi-fragment responses (Slave devices only)
☐ Sometimes If 'Sometimes', when? ______________________________
☐ Configurable If 'Configurable', how? ______________________________

Timeouts while waiting for:

Data Link Confirm	☐ None	☒ Fixed at 1 second	☐ Variable	☐ Configurable
Complete Appl. Fragment	☒ None	☐ Fixed at ________	☐ Variable	☐ Configurable
Application Confirm	☐ None	☒ Fixed at 3 seconds	☐ Variable	☐ Configurable
Complete Appl. Response	☒ None	☐ Fixed at ________	☐ Variable	☐ Configurable

Others The baud field in table 32 holds a 2-bit code in bits 5 and 4 of the 16-bit field for DNP transmit timeout. If the value is programmed, the DNP firmware will cause a reset after the defined period if it has not responded to DNP activity. The timeout needs a first DNP activity. 0 = No timeout resets, 1 = Two minute timeout resets, 2 = One hour timeout resets and 3 = One day timeout reset.______________________________

Attach explanation if 'Variable' or 'Configurable' was checked for any timeout

Sends/Executes Control Operations:

WRITE Binary Outputs	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
SELECT/OPERATE	☐ Never	☐ Always	☐ Sometimes	☒ Configurable†
DIRECT OPERATE	☐ Never	☐ Always	☐ Sometimes	☒ Configurable†
DIRECT OPERATE - NO ACK	☐ Never	☐ Always	☐ Sometimes	☒ Configurable†
Count > 1	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
Pulse On	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
Pulse Off	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
Latch On	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
Latch Off	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
Trip/Close	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
Raise/Lower	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
Clear Queue	☐ Never	☒ Always	☐ Sometimes	☐ Configurable

† To support control operations and conform to the Subset Definitions, either 'Always' or 'Configurable' must be selected.

WRITE Analog Outputs	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
SELECT/OPERATE	☒ Never	☐ Always	☐ Sometimes	☐ Configurable†
DIRECT OPERATE	☒ Never	☐ Always	☐ Sometimes	☐ Configurable†
DIRECT OPERATE - NO ACK	☒ Never	☐ Always	☐ Sometimes	☐ Configurable†

Maximum Select/Execute Delay Time:

☐ Not Applicable
☒ Fixed at 4 seconds
☐ Configurable, range _______ to _______ seconds

Attach explanation if 'Sometimes' or 'Configurable' was checked for any operation.

FILL OUT THE FOLLOWING ITEM FOR MASTER DEVICES ONLY:

Expects Binary Input Change Events:

☐ Either time-tagged or non-time-tagged for a single event
☐ Both time-tagged and non-time-tagged for a single event
☐ Configurable (attach explanation)

FILL OUT THE FOLLOWING ITEMS FOR SLAVE DEVICES ONLY:

TimeSync Information :

a.) TimeSync Period
☐Never
☐ Fixed at _______ seconds
☒Configurable, range _1 minute_ to _255 Months (4 weeks per month)

b.) Maximum time base drift over a 10 minute interval : < 1 ms
c.) Maximum Internal Time Reference Error when set via DNP : 2000 ms
d.) Maximum Delay Measurement error : 20 ms
e.) Maximum response time : 1000 ms
f.) Event data time-tag error - if different than (c) :
Binary Input Change Events _________ ms
Counter Change Events _________ ms
Frozen Counter Change Events _________ ms
Analog Change Events _________ ms
Frozen Analog Change Events _________ ms

Reports Binary Input Change Events when no specific variation requested: ☐ Never ☐ Only time-tagged ☐ Only non-time-tagged ☒ Configurable to send both, one or the other (attach explanation) Table 50 default variation configuration	Reports time-tagged Binary Input Change Events when no specific variation requested: ☐Never ☐ Binary Input Change With Time ☐ Binary Input Change With Relative Time ☒ Configurable (attach explanation) Table 50 default variation configuration
Sends Unsolicited Responses: ☒ Never ☐ Configurable (attach explanation) ☐ Only certain objects ☐ Sometimes (attach explanation) ☒ ENABLE/DISABLE UNSOLICITED Function codes supported	Sends Static Data in Unsolicited Responses: ☒ Never ☐ When Device Restarts ☐ When Status Flags Change No other options are permitted.
Supports Collision Avoidance: ☐ Never ☐ Always ☒ Configurable (attach explanation)	Collision Avoidance Detection Method: ☐ Not Applicable ☒ Link Activity ☐ DCD - with aid of external device ☐ DCD - without aid of external device

Default Counter Object/Variation: ☐ No Counters Reported ☒ Configurable (attach explanation) ☐ Default Object ______________ Default Variation ______________ ☐ Point-by-point list attached	Counters Roll Over at: ☐ No Counters Reported ☐ Configurable (attach explanation) ☐ 16 Bits ☐ 32 Bits ☒ Other Value _Depends on counter size_ ☐ Point-by-point list attached
Source Address Filtering: ☒ Not Supported ☐ Configurable (attach explanation)	
Sends Multi-Fragment Responses: ☒ Yes ☐ No	

13 DNP 3.00 Implementation Table

DNP 3.00 - IMPLEMENTATION TABLE

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes**	**Qual Codes (hex)**
1	0	Binary Input – All Variations	1(Read)	00,01(Start-Stop) 06(All Data)		
1	1*	Binary Input	1(Read)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
1	2	Binary Input with Status	1(Read)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
2	0	Binary Input Change – All Variations	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)		
2	1*	Binary Input Change without Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
2	2	Binary Input Change with Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
2	3	Binary Input Change with Relative Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
10	0	Binary Output – All Variations	1(Read)	00,01(Start-Stop) 06(All Data)		
10	1	Binary Output	None			
10	2*	Binary Output Status	1(Read)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
12	0	Control Block – All Variations	None			
12	1	Control Relay Output Block	3(Select) 4(Operate) 5(Dir Operate) 6(Dop/NoAck	17,28 (Index)	129 (Resp)	Echo of Request
12	2	Pattern Control Block	None			
12	3	Pattern Mask	None			

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes**	**Qual Codes (hex)**
20	0	Binary Counter - All Variations	1(Read) 7(Imm Freeze) 8(Imm Freeze, NoAck) 9(Frz & Clr) 10(Frz & Clr, NoAck) 11(Frz/Time) 12(Frz/Time, NoAck)	00,01(Start-Stop) 06(All Data)		
20	1	32-Bit Binary Counter	1(Read) 7(Imm Freeze) 8(Imm Freeze, NoAck) 9(Frz & Clr) 10(Frz & Clr, NoAck) 11(Frz/Time) 12(Frz/Time, NoAck)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
20	2	16-Bit Binary Counter	1(Read) 7(Imm Freeze) 8(Imm Freeze, NoAck) 9(Frz & Clr) 10(Frz & Clr, NoAck) 11(Frz/Time) 12(Frz/Time, NoAck)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
20	3	32-Bit Delta Counter	1(Read) 7(Imm Freeze) 8(Imm Freeze, NoAck) 9(Frz & Clr) 10(Frz & Clr, NoAck) 11(Frz/Time) 12(Frz/Time, NoAck)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
20	4	16-Bit Delta Counter	1(Read) 7(Imm Freeze) 8(Imm Freeze, NoAck) 9(Frz & Clr) 10(Frz & Clr, NoAck) 11(Frz/Time) 12(Frz/Time, NoAck)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes**	**Qual Codes (hex)**
20	5*	32-Bit Binary Counter without Flag	1(Read) 7(Imm Freeze) 8(Imm Freeze, NoAck) 9(Frz & Clr) 10(Frz & Clr, NoAck) 11(Frz/Time) 12(Frz/Time, NoAck)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
20	6	16-Bit Binary Counter without Flag	1(Read) 7(Imm Freeze) 8(Imm Freeze, NoAck) 9(Frz & Clr) 10(Frz & Clr, NoAck) 11(Frz/Time) 12(Frz/Time, NoAck)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
20	7	32-Bit Delta Counter without Flag	1(Read) 7(Imm Freeze) 8(Imm Freeze, NoAck) 9(Frz & Clr) 10(Frz & Clr, NoAck) 11(Frz/Time) 12(Frz/Time, NoAck)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
20	8	16-Bit Delta Counter without Flag	1(Read) 7(Imm Freeze) 8(Imm Freeze, NoAck) 9(Frz & Clr) 10(Frz & Clr, NoAck) 11(Frz/Time) 12(Frz/Time, NoAck)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes**	**Qual Codes (hex)**
21	0	Frozen Counter - All Variations	1(Read)	00,01(Start-Stop) 06(All Data)		
21	1*	32-Bit Frozen Counter	1(Read)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
21	2	16-Bit Frozen Counter	1(Read)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
21	3	32-Bit Frozen Delta Counter	1(Read)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
21	4	16-Bit Frozen Delta Counter	1(Read)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
21	5	32-Bit Frozen Counter with Time of Freeze	1(Read)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
21	6	16-Bit Frozen Counter with Time of Freeze	1(Read)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
21	7	32-Bit Frozen Delta Counter with Time of Freeze	1(Read)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
21	8	16-Bit Frozen Delta Counter with Time of Freeze	1(Read)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
21	9	32-Bit Frozen Counter without Flag	1(Read)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
21	10	16-Bit Frozen Counter without Flag	1(Read)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
21	11	32-Bit Frozen Delta Counter without Flag	1(Read)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
21	12	16-Bit Frozen Delta Counter without Flag	1(Read)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes	Qual Codes (hex)
22	0	Counter Change Event – All Variations	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)		
22	1*	32-Bit Counter Change Event without Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
22	2	16-Bit Counter Change Event without Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
22	3	32-Bit Delta Counter Change Event without Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
22	4	16-Bit Delta Counter Change Event without Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
22	5	32-Bit Counter Change Event with Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
22	6	16-Bit Counter Change Event with Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
22	7	32-Bit Delta Counter Change Event with Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
22	8	16-Bit Delta Counter Change Event with Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes**	**Qual Codes (hex)**
23	0	Frozen Counter Event – All Variations	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)		
23	1*	32-Bit Frozen Counter Event without Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
23	2	16-Bit Frozen Counter Event without Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
23	3	32-Bit Frozen Delta Counter Event without Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
23	4	16-Bit Frozen Delta Counter Event without Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
23	5	32-Bit Frozen Counter Event with Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
23	6	16-Bit Frozen Counter Event with Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
23	7	32-Bit Frozen Delta Counter Event with Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
23	8	16-Bit Frozen Delta Counter Event with Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes**	**Qual Codes (hex)**
30	0	Analog Input – All Variations	1(Read) 7(Imm Freeze) 8(Imm Freeze, NoAck) 11(Frz/Time) 12(Frz/Time, NoAck)	00,01(Start-Stop) 06(All Data)		
30	1	32-Bit Analog Input	1(Read) 7(Imm Freeze) 8(Imm Freeze, NoAck) 11(Frz/Time) 12(Frz/Time, NoAck)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
30	2	16-Bit Analog Input	1(Read) 7(Imm Freeze) 8(Imm Freeze, NoAck) 11(Frz/Time) 12(Frz/Time, NoAck)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
30	3*****	32-Bit Analog Input without Flag	1(Read) 7(Imm Freeze) 8(Imm Freeze, NoAck) 11(Frz/Time) 12(Frz/Time, NoAck)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
30	4	16-Bit Analog Input without Flag	1(Read) 7(Imm Freeze) 8(Imm Freeze, NoAck) 11(Frz/Time) 12(Frz/Time, NoAck)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
31	0	Frozen Analog Input – All Variations	1(Read)	00,01(Start-Stop) 06(All Data)		
31	1	32-Bit Frozen Analog Input	1(Read)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
31	2	16-Bit Frozen Analog Input	1(Read)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
31	3	32-Bit Frozen Analog Input with Time of Freeze	1(Read)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
31	4	16-Bit Frozen Analog Input with Time of Freeze	1(Read)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
31	5*****	32-Bit Frozen Analog Input without Flag	1(Read)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)
31	6	16-Bit Frozen Analog Input without Flag	1(Read)	00,01(Start-Stop) 06(All Data)	129 (Resp)	00 (Start-Stop)

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes**	**Qual Codes (hex)**
32	0	Analog Change Event - All Variations	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)		
32	1*	32-Bit Analog Change Event without Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
32	2	16-Bit Analog Change Event without Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
32	3	32-Bit Analog Change Event with Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
32	4	16-Bit Analog Change Event with Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
33	0	Frozen Analog Event - All Variations	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)		
33	1*	32-Bit Frozen Analog Event without Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
33	2	16-Bit Frozen Analog Event without Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
33	3	32-Bit Frozen Analog Event with Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
33	4	16-Bit Frozen Analog Event with Time	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes**	**Qual Codes (hex)**
40	0	Analog Output Status - All Variations	None			
40	1	32-Bit Analog Output Status	None			
40	2	16-Bit Analog Output Status	None			
41	0	Analog Output Block - All Variations	None			
41	1	32-Bit Analog Output Block	None			
41	2	16-Bit Analog Output Block	None			
50	0	Time and Date - All Variations	1(Read)	07,08 (Qty = 1)		
50	1*	Time and Date	1(Read) 2(Write)	07,08 (Qty = 1)	129 (Resp)	07 (Qty = 1)
50	2	Time and Date with Interval	11(Frz/Time) 12(Frz/Time, NoAck)	07,08 (Qty = 1)	129 (Resp)	07 (Qty = 1)
51	0	Time and Date CTO - All Variations	None			
51	1	Time and Date CTO	None		Part of Obj 2 Var 3 Resp.	07 (Qty = 1)
51	2	Unsynchronized Time and Date CTO	None			
52	0	Time Delay - All Variations	None			
52	1	Time Delay Coarse	None			
52	2	Time Delay Fine	None			
60	0					
60	1	Class 0 Data	1(Read)	06(All Data)	129 (Resp)	00 (Start-Stop)
60	2	Class 1 Data	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
60	3	Class 2 Data	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)
60	4	Class 3 Data	1(Read) 20(En Unsol) 21(Dis Unsol) 22(Assign Cl)	06(All Data) 07,08(Limited Qty)	129 (Resp)	28 (Index)

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
Obj	**Var**	**Description**	**Func Codes (dec)**	**Qual Codes (hex)**	**Func Codes**	**Qual Codes (hex)**
70	1	File Identifier	None			
80	1	Internal Indications	2(Write)	00,01(Start-Stop)	129 (Resp)	Null
81	1	Storage Object	None			
82	1	Device Profile	None			
83	1	Private Registration Object	None			
83	2	Private Registration Object Descriptor	None			
90	1	Application Identifier	None			
100	1	Short Floating Point	None			
100	2	Long Floating Point	None			
100	3	Extended Floating Point	None			
101	1	Small Packed Binary-Coded Decimal	None			
101	2	Medium Packed Binary-Coded Decimal	None			
101	3	Large Packed Binary-Coded Decimal	None			
		No Object (Cold Restart)	13(Cold-Restart)		129 (Resp)	Null
		No Object (Warm Restart)	14(Warm-Restart)		129 (Resp)	Null
		No Object (Delay Measurement)	None			