


**DIGITAL INPUT  
DUAL NC RELAY OUTPUT  
ISOLATED CAN CONTROLLER  
with DUAL LED**

**SAEJ1939®**


**USER MANUAL**

**P/N: AX031901 (250kbps)  
P/N: AX031901-01 (500kbps)  
P/N: AX031901-02 (1Mbps)**

## ACCRONYMS

ACK	Positive Acknowledgement (from SAE J1939 standard)
DM	Diagnostic Message (from SAE J1939 standard)
RLYOUT	Relay Output, C-Form Normally Closed Relays capable of up to 2A current
DTC	Diagnostic Trouble Code (from SAE J1939 standard)
EA	Electronic Assistant <sup>®</sup>  , p/n AX070502 (A Service Tool for Axiomatic ECUs)
ECU	Electronic Control Unit (from SAE J1939 standard)
NAK	Negative Acknowledgement (from SAE J1939 standard)
PDU1	A format for messages that are to be sent to a destination address, either specific or global (from SAE J1939 standard)
PDU2	A format used to send information that has been labeled using the Group Extension technique, and does not contain a destination address.
PGN	Parameter Group Number (from SAE J1939 standard)
PropA	Message that uses the Proprietary A PGN for peer-to-peer communication
PropB	Message that uses a Proprietary B PGN for broadcast communication
PWM	Pulse Width Modulation
RPM	Rotations per Minute
SPN	Suspect Parameter Number (from SAE J1939 standard)
DIN	Digital Frequency Input, digital, frequency, RPM or PWM type

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## REFERENCES

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J1939/21	Data Link Layer, SAE, December 2010
J1939/71	Vehicle Application Layer, SAE, March 2011
J1939/73	Application Layer-Diagnostics, SAE, February 2010
J1939/81	Network Management, SAE, May 2003
TDAX031901	Technical Datasheet, Dual Input, Dual Output Controller

***This document assumes the reader is familiar with the SAE J1939 standard. Terminology from the standard is used, but is not described in this document.***



NOTE: This product is supported by Electronic Assistant ® V4.2.40.1 and higher



NOTE: When a description is in “**double-quotes**” and bolded, this refers to the name of a user configurable setpoint (variable). If it is in ‘*single-quotes*’ and italicized, it refers to an option for the associated setpoint.

For example: “**Output Type**” set to ‘*Digital On/Off*’

# 1. OVERVIEW OF CONTROLLER

## 1.1. Description of Controller

The Digital Input, Dual Form C NC Relay Output Isolated CAN (DIN-2RO-ICAN-LED) consists of a single digital input which is internally pulled high, dual normally closed Form C relays capable of 2A sourcing and once galvanically isolated CAN. The control algorithms allow the user to configure the controller for a wide range of applications without the need for custom software.

Its relay outputs have on/off behaviour, however, they can be configured for different digital responses through the service tool, Electronic Assistant® (EA). These relay outputs are capable of handling 2A continuous and are independent from one another and thus can be controlled by different control signals.

The controller supports an external dual LED which can be configured to react to different events or faults the controller undergoes. It is used as a means of providing visual feedback to the user of the controller's operation.

The DIN-2RO-ICAN-LED is a highly configurable controller which can be used in all types of applications without the need for custom firmware. It must be integrated into a CAN J1939 network of controllers. All logical function blocks on the unit are inherently independent from one another, but can be configured to interact in a large number of ways. Figure 1 shows the hardware features of the controller.

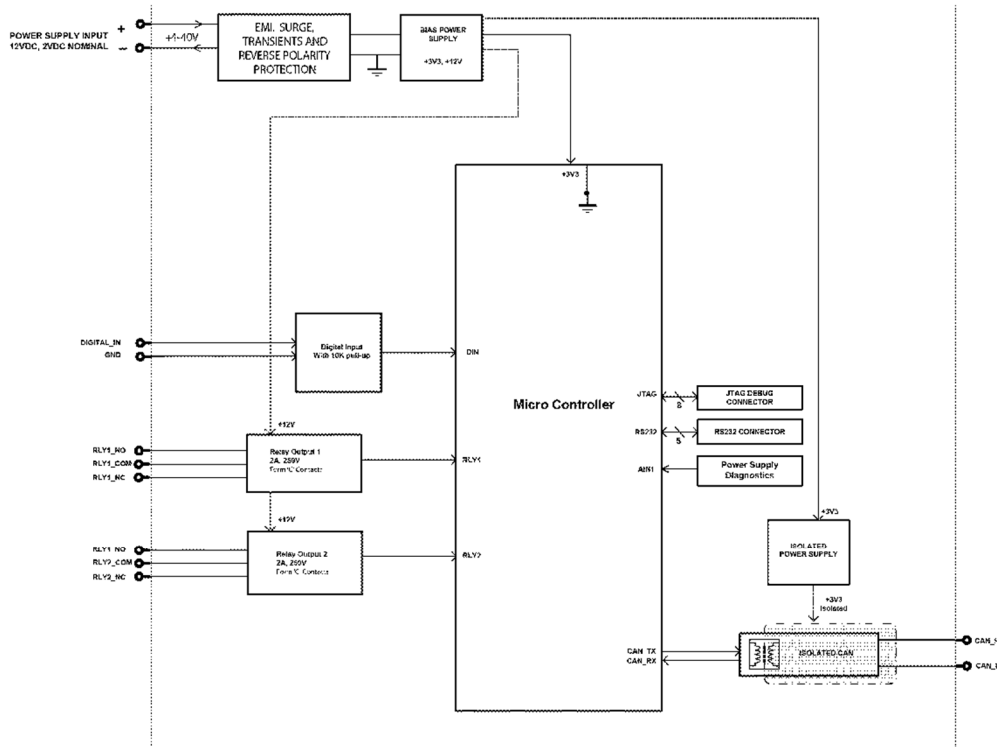


Figure 1: Hardware Functional Block Diagram

The DIN-2RO-ICAN-LED has several built-in protection features that can shut off the outputs in adverse conditions. These features are described in detail in section 1.8 Table 14 and they include hardware shutoffs to protect the circuits from being damaged as well as software shutdown features that can be enabled in safety critical systems.

## 1.2. Digital Input Function Block

The controller consists of single digital input which is internally pulled high. Therefore, the input needs to be grounded in order to trigger a state change within the controller. The digital input can be configured for normal on/off response; however, it can also be configured for frequency/RPM or PWM input types as shown in Table 1:

0	<i>Input Not Used</i>
40	<i>0.5Hz to 50Hz Frequency</i>
41	<i>10Hz to 1kHz Frequency</i>
42	<i>100Hz to 10kHz Frequency</i>
50	<i>PWM Duty Cycle (Low Frequency)</i>
51	<i>PWM Duty Cycle (High Frequency)</i>
60	<b>Digital (Normal Logic)</b>
61	<i>Digital (Inverse Logic)</i>
62	<i>Digital (Latched Logic)</i>

Table 1: Digital Input Types

### 1.2.1. Minimum and Maximum Errors and Ranges

The **Minimum Range** and **Maximum Range** setpoints must not be confused with the measuring range. These setpoints are used when the input is selected as a control input for another function block. They become the Xmin and Xmax values used in the slope calculations. When these values are changed, other function blocks using the input as a control source are automatically updated to reflect the new X-axis values.

The **Minimum Error** and **Maximum Error** setpoints are used with the Diagnostic function block – please refer to Section 1.8 for more details on Diagnostic function block. The values for these setpoints are constrained such that

$$0 \leq \text{Minimum Error} \leq \text{Minimum Range} \leq \text{Maximum Range} \leq \text{Maximum Error} \leq 1.1 \times \text{Max}^*$$

\* The maximum value for any input is dependent on type. The error range can be set up to 10% above this value. The Digital Input makes use of the **Minimum Error** and **Maximum Error** only when the *Sensor Type* selected is not a digital on/off input type.

To avoid causing false faults, adding software filtering can be used to measure the input signals.

### 1.2.2. Input Software Filter Types

Input of the DIN-2RO-ICAN-LED controller can be filtered using **Filter Type** and **Filter Constant** setpoints. There are three (3) filter types available as listed in Table 2.

0	<i>No Filtering</i>
1	<i>Moving Average</i>
2	<i>Repeating Average</i>

Table 2: Input Filtering Types

The first filter option *No Filtering*, provides no filtering to the measured data. Thus the measured data will be directly used to the any function block which uses this data.

The second option, *Moving Average*, applies ‘Equation 1’ below to the measured input data, where  $Value_N$  represents the current input measured data while  $Value_{N-1}$  represents the previous filtered data. The Filter Constant is the **Filter Constant** setpoint.

Equation 1 - Moving Average Filter Function:

$$Value_N = Value_{N-1} + \frac{(Input - Value_{N-1})}{Filter\ Constant}$$

Option three, *Repeating Average*, applies ‘Equation 2’ below to the measured input data, where N is the value of **Filter Constant** setpoint. The filtered input, Value, is the average of all input measurements taken in N (**Filter Constant**) number of samples. When the average is taken, the filtered input will remain until the next average is ready.

Equation 2 - Repeating Average Transfer Function:

$$Value = \frac{\sum_0^N Input_N}{N}$$

### 1.2.3. Digital Input and Frequency Input De-bounce

The different input types will use its own filtering. This is due to the frequency input being able to reach frequencies of up to 10kHz. Therefore, the de-bounce time cannot be too long as to measure a different frequency signal. For this reason, any input type dependent on frequency (frequency, RPM, PWM) will have the filtering options highlighted in Table 3:

0	<i>No Filter</i>
1	<i>111ns</i>
2	<i>1.78us</i>
3	<i>14.22us</i>

Table 3: Frequency Input Filtering Types

On the other hand, the de-bounce time configuration for a digital input is more flexible allowing large de-bounce times (up to seconds). The advantage that this setting provides is that it allows the user to set a large de-bounce time either due to a noisy push-button or due to a requirement that a button needs to

be pressed for a certain amount of seconds before triggering a command. This parameter can be entered freely by the user to suit the needs of the application at hand.

### 1.3. Dual LED Output Function Block

The DIN-2RO-ICAN-LED supports a dual LED (Green and Red). The dual LED output can be used to inform the user of the status the controller is in.

The structure of the output block for the dual LED output is based on stages. The DIN-2RO-ICAN-LED provides the user with up to four different stages in order to provide more flexibility to the dual LED output functionality.

Each of the four stages consists of its independent control source and digital response. However, only one stage can be active at a time. For this reason, the 4-stage structure is based on priority in which the 6<sup>th</sup> stage has the lowest priority and the 1<sup>st</sup> stage has the highest priority. In other words: if all 6 stages are true, the response set for stage 1 will be used to drive the LED. In the instance when none of the stages is active (ON), the Dual LED function block has another group which is the default stage. The user can also configure the parameters of the default stage. The default stage is useful in the case when no other stage is active; providing the user with visual feedback of normal operation if chosen to have the default stage enabled.

The control sources that can be used to command each of the four stages are listed in section 1.12 Table 21. The control sources available for the dual LED output consist of the same control source options as Table 20 with the addition of controller fault options to drive the LED. Hence, the dual LED can be configured to be driven when a (selected) fault occurs.

The output types available for the dual LED for each stage are listed in Table 4 below

<b>Value</b>	<b>Meaning</b>
0	<i>LEDs Disabled</i>
1	<i>Green</i>
2	<i>Yellow</i>
3	<i>Red</i>
4	<i>Toggle Green/Red</i>

*Table 4: LED Output Types*

The LED Responses that are available for each stage in the DIN-2RO-ICAN-LED are listed in Table 5 below

<b>Value</b>	<b>Meaning</b>
0	<i>Normal On/Off</i>
1	<i>Blinking Logic</i>
2	<i>Dim On/Off</i>

*Table 5: LED Response Options*

In 'Normal On/Off' response type, the output command state will follow the control input command: when the control input command is ON, the output will be turned ON and vice-versa.

In 'Blinking Logic' response type, the output will toggle at a period of 'Digital Blink Rate' for as long as the input command is ON.

The "Control Source" setpoint together with "Control Number" setpoint determine which signal is used to drive the output. For example setting "Control Source" to 'Digital Input Measured' and "Control Number" to '1', connects signal measured from Universal Input 1 to the output in question. The input signal is scaled per input type range between 0 and 1 to form control signal.

#### 1.4. Output Function Blocks

The Output Control Logic and the Output Drive function blocks are linked. The control signal, (whether from a CAN command, a Digital Input, a Lookup Table, or a Logic or Math block) will have associated with it a minimum and maximum value. Regardless of what type of control input is selected, the output will always respond in a linear fashion to changes in the input per the calculation in Figure 2.

$$y = mx + a$$

$$m = \frac{Y_{\max} - Y_{\min}}{X_{\max} - X_{\min}}$$

$$a = Y_{\min} - m * X_{\min}$$

Figure 2: Linear Slope Calculations

In the case of the Output Control Logic function block, X and Y are defined as

Xmin = Control Input Minimum      Ymin = "Output at Minimum Command"  
Xmax = Control Input Maximum      Ymax = "Output at Maximum Command"

In all cases, while the x-axis has the constraint that Xmin < Xmax, there is no such limitation on the Y-axis. This allows for a negative slope so that as the control input signal increases, the target output value decreases.

By default, the Output x "Control Source" is setup to be 'Received CAN J1939 Message.' Therefore, the behaviour of the Relay Output is to follow a digital response from an analog range as shown in Figure 4.

In addition to the Control input, the function block also supports an enable input which can be setup as either an enable or disable signal. If multiple enable/disable inputs are required, select the "Enable Source" to be the 'Math Function Block', and setup the desired logic response as described in Section 1.7.

When an Enable input is used, the output will be shutoff as per the "Enable Response". If the response is selected as a disable signal (2 or 3), when the input is ON, the output will be shutoff.

0	<i>Enable When On, Else Shutoff</i>
1	<i>Enable When Off, Else Shutoff</i>

*Table 6: Enable Response Options*

A useful feature of the Enable input is that it can be mapped to react to a diagnostic trouble code (DTC) sent by another ECU on the network via a DM1. In this case, the “**Enable Source**” would be a ‘*Diagnostic Trouble Code (Rxd)*’, and the response would be setup as a disable signal.

The Override option allows the user to have the output drive go to a default value in the case of the override input being engaged/disengaged, depending on the logic selected in “**Override Response.**” When active, the output will be driven to the value in “**Output at Override Command**” regardless of the value of the Control input.

The Enable and Override commands can be mapped to either a CAN message or any other input. By default the DIN-2RO-ICAN-LED assumes a digital input will be used for all of these inputs. If a non-digital control is selected, the input will be interpreted per the hysteresis logic shown in Figure 4.

If a fault is detected at any active input (Enable/Override/Control), then the output will respond per the “**Control Fault Response**” setpoint as outlined in Table 7. This is also true when controlled by a CAN message that is not received within the expected update timeframe (lost communication error). Should a fault response occur the output drive will remain in the corresponding state until the condition(s) causing the fault reaction has disappeared.

0	<i>Shutoff Output</i>
1	<i>Apply Fault Value</i>
2	<i>Hold Last Value</i>

*Table 7: Fault Response Options*

Another fault response that can be enabled is that a power supply over voltage or under voltage will automatically disable ALL outputs. Note: this setpoint is associated with the **Power Supply Diag** function block. Also, if the **Over Temperature Diag** function block is enabled, then a microprocessor over-temperature reading disables all the outputs until it has cooled back to the operating range.

Fault conditions are checked for first, and only if they are not present are the control signal then evaluated. If Enable, Override and Control inputs are all used, the Enable logic is evaluated first, then the Override, and lastly the Control. The logic flow chart for evaluating the output drive is shown in Figure 3 below.

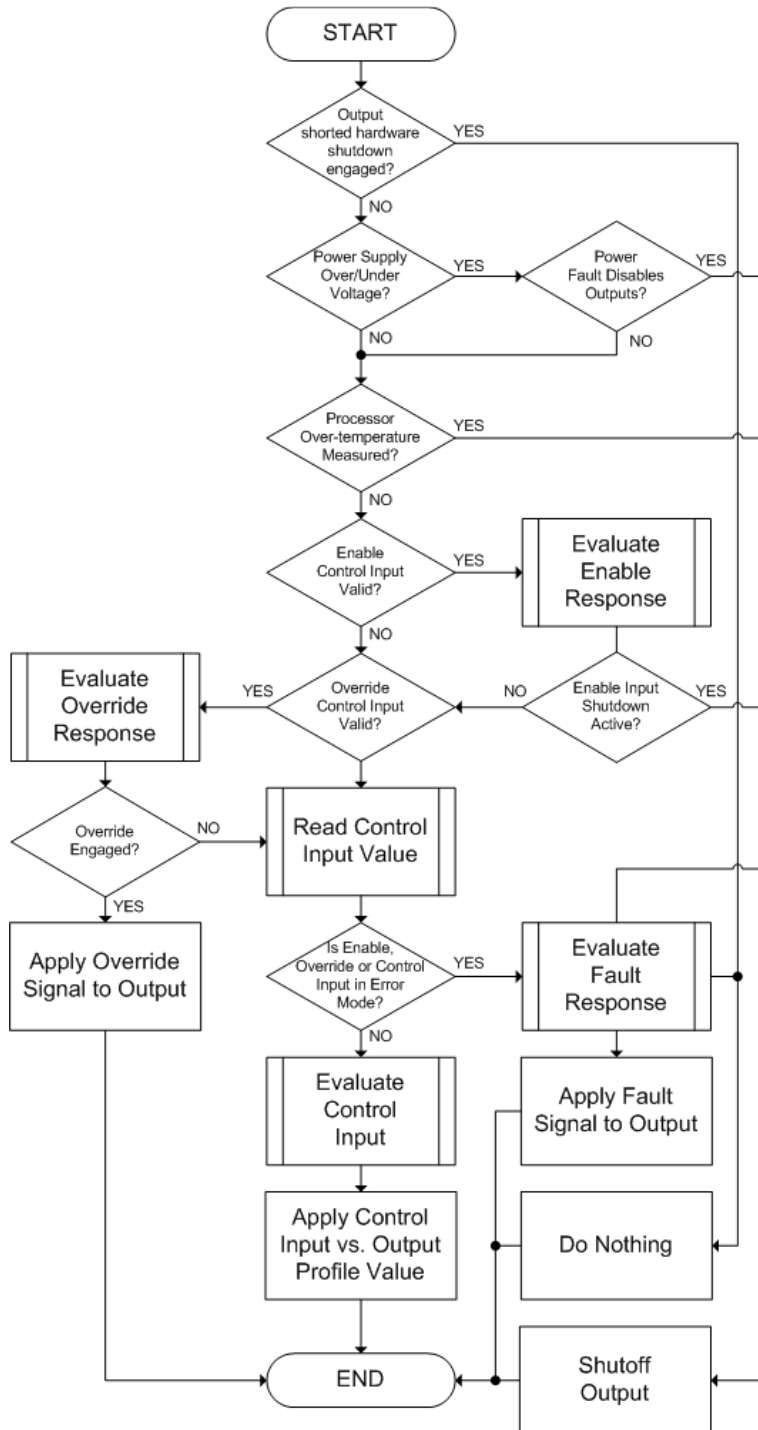


Figure 3: Output Logic Flowchart

The other type of function block associated with an output is the drive block itself.

The “**Output Type**” is the most important setpoint associated with this function block, and it should be selected first. Changing it will result in other setpoints being automatically updated by the DIN-2RO-ICAN-LED to match the new type. There are several output types supported, as outlined in Table 8.

0	<i>Output Disabled</i>
1	<i>Digital On/Off</i>

Table 8: Output Type Options

There are two types of digital responses possible. With the ‘*Digital On/Off*’ type, should the control require the output to be on, it will enable its relay to connect to the normally-opened lead to the common.

If a non-digital control is selected, the command state will be OFF at or below the minimum input, ON at or above the maximum input, and it will not change in between those points. In other words, the input will have built in hysteresis, as shown in Figure 4. This relationship is true for any function block that has a non-digital input mapped to a digital control.

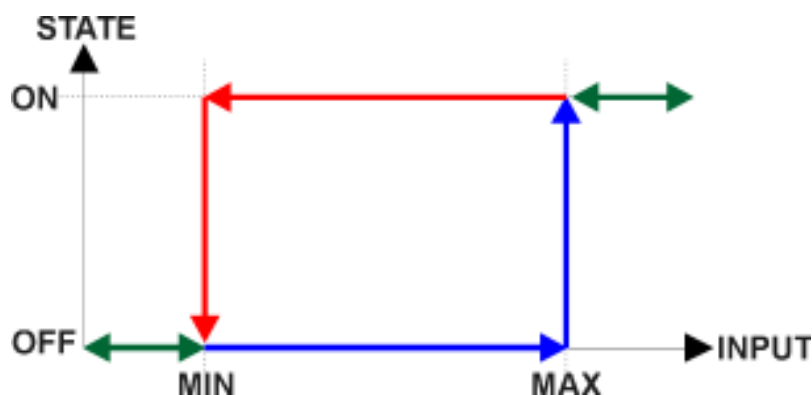


Figure 4: Analog to Digital Input

If a digital “**Output Type**” has been selected the “**Digital Response**” setpoint will be enabled as shown in Table 9. Also, the “**Digital Override State**” setpoint will be enabled which will hold the state to which to set the relays when the Override source is triggered on.

0	<i>Normal On/Off</i>
1	<i>Inverse Logic</i>
2	<i>Latched Logic</i>
3	<i>Blinking Logic</i>

Table 9: Digital Response Options

In a ‘*Normal*’ response, when the Control input commands the output ON, then the output will be turned ON. However, in an ‘*Inverse*’ response, the output will be ON unless the input commands the output ON, in which case it turns OFF.

If a ‘*Latched*’ response is selected, when the input commands the state from OFF to ON, the output will change state.

If a *'Blinking'* response is selected, then while the input command the output ON, it will blink at the rate in the **“Digital Blink Rate”** setpoint. When commanded OFF, the output will stay off. A blinking response is only available with a *'Digital On/Off'* type of output.

## 1.5. Lookup Table Function Block

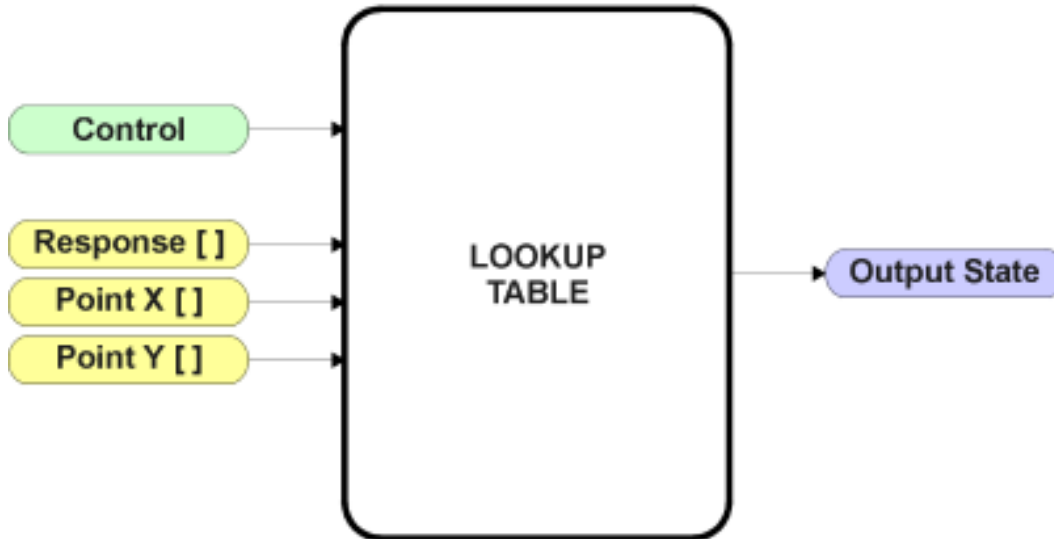


Figure 5: Lookup Table Function Block

**Lookup Tables are used to give an output response of up to 10 slopes per input.** The array size of the Response [], Point X [] and Point Y [] setpoints shown in the block diagram above is therefore 11.

Note: If more than 10 slopes are required, a Programmable Logic Block can be used to combine up to three tables to get 30 slopes, as is described in Section 1.6.

There are two key setpoints that will affect this function block. The first is the “**X-Axis Source**” and “**X-Axis Number**” which together define the Control Source for the function block. When it is changed, the table is automatically updated with new defaults based on the X-Axis source selected if “**Auto update when control changes**” in the Miscellaneous block is *TRUE*.

As stated earlier if “**Auto update when control changes**” is *TRUE*, should the selected Control Source change (i.e. the Min or Max values of the function block are updated), the associated table will also be automatically updated with default settings, based on the new X-Axis limits.



Initialize the Control Source of a Lookup Table **BEFORE** changing the table values, as the new settings **WILL** get erased when the control is updated if the “**Auto update when control changes**” in the Miscellaneous function block is set to *TRUE*.

The second setpoint that will affect the function block (i.e. reset to defaults), is the “**X-Axis Type**”. By default, the tables have a ‘*Data Response*’ output. Alternatively, it can be selected as a ‘*Time Response*’, which is described later in Section 1.5.5.

### 1.5.1. X-Axis, Input Data Response

In the case where the **X-Axis Type** = *'Data Response'*, the points on the X-Axis represents the data of the control source.

**For most *'Data Responses'*, the default value at point (0,0) is [0,0].**

However, should the minimum input be less than zero, for example a CAN message that is reflecting temperature in the range of -40°C to 210°C, then the **"Point 0 – X Value"** will be set to the minimum instead, in this case -40°C.

The constraint on the X-Axis data is that the next index value is greater than or equal to the one below it, as shown in the equation below. Therefore, when adjusting the X-Axis data, it is recommended that X<sub>10</sub> is changed first, then lower indexes in descending order.

$$\text{MinInputRange} \leq X_0 \leq X_1 \leq X_2 \leq X_3 \leq X_4 \leq X_5 \leq X_6 \leq X_7 \leq X_8 \leq X_9 \leq X_{10} \leq \text{MaxInputRange}$$

As stated earlier, MinInputRange and MaxInputRange will be determined by the X-Axis Source that has been selected.

If some of the data points are *'Ignored'* as described in Section 1.5.4, they will not be used in the X-Axis calculation shown above. For example, if points X<sub>4</sub> and higher are ignored, the formula becomes MinInputRange ≤ X<sub>0</sub> ≤ X<sub>1</sub> ≤ X<sub>2</sub> ≤ X<sub>3</sub> ≤ MaxInputRange instead.

### 1.5.2. Y-Axis, Lookup Table Output

The Y-Axis has no constraints on the data that it represents. This means that inverse, or increasing/decreasing or other responses can be easily established.

For example, should the X-Axis of a table be a resistive value (as read from another controller), the output of the table could be temperature from an NTC sensor in the range Y<sub>0</sub>=125°C to Y<sub>10</sub>= -20°C. If this table is used as the control source for another function block (i.e. transmitted over CAN), then Xmin would be -20 and Xmax would be 125 when used the linear formula.

In all cases, the controller looks at the **entire range** of the data in the Y-Axis setpoints, and selects the lowest value as the MinOutRange and the highest value as the MaxOutRange. They are passed directly to other function blocks as the limits on the Lookup Table output. (i.e used as Xmin and Xmax values in linear calculations.)

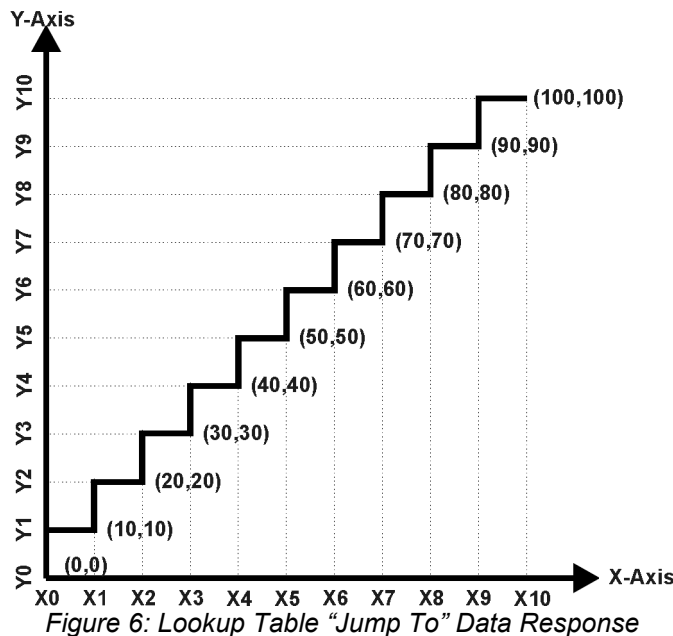
However, if some of the data points are *'Ignored'* as described in Section 1.5.4, they will not be used in the Y-Axis range determination. Only the Y-Axis values shown on EA will be considered when establishing the limits of the table when it is used to drive another function block, such as an Output Drive.

### 1.5.3. Point To Point Response

By default, the X and Y axes are setup for a linear response from point (0,0) to (10,10), where the output will use linearization between each point. To get the linearization, each **"Point N – Response"**, where N = 1 to 10, is setup for a *'Ramp To'* output response.

Alternatively, the user could select a ‘Jump To’ response for “Point N – Response”, where N = 1 to 10. In this case, any input value between  $X_{N-1}$  to  $X_N$  will result in an output from the Lookup Table function block of  $Y_N$ .

An example of a CAN message (0 to 100) used to control a default table (0 to 100) but with a ‘Jump To’ response instead of the default ‘Ramp To’ is shown in Figure 6.



Lastly, any point except (0,0) can be selected for an ‘Ignore’ response. If “Point N – Response” is set to ignore, then all points from  $(X_N, Y_N)$  to  $(X_{10}, Y_{10})$  will also be ignored. For all data greater than  $X_{N-1}$ , the output from the Lookup Table function block will be  $Y_{N-1}$ .

#### 1.5.4. X-Axis, Time Response

As mentioned in Section 1.6, a Lookup Table can also be used to get a custom output response where the “X-Axis Type” is a ‘Time Response.’ When this is selected, the X-Axis now represents time, in units of milliseconds, while the Y-Axis still represents the output of the function block.

In this case, the “X-Axis Source” is treated as a digital input. If the signal is actually an analog input, it is interpreted like a digital input per Figure 4. When the control input is ON, the output will be changed over a period of time based on the profile in the Lookup Table. Once the profile has finished (i.e. index 10, or ‘Ignored’ response), the output will remain at the last output at the end of the profile until the control input turns OFF.

When the control input is OFF, the output is always at zero. When the input comes ON, the profile ALWAYS starts at position  $(X_0, Y_0)$  which is 0 output for 0ms.

When using the Lookup Table to drive an output based on **time**, it is mandatory that setpoints “**Ramp Up (min to max)**” and “**Ramp Down (max to min)**” in the Output X Drive function block be set to **zero**. Otherwise, the output result will not match the profile as expected. Recall, also, that the Y-Axis range of the table should be set to match the Output Drive range in order to get a 1:1 response of table output versus drive output.

In a time response, the interval time between each point on the X-axis can be set anywhere from 1ms to 24 hours. [86,400,000 ms]

One final note about the Lookup Tables is that if a digital input is selected as the control source for the X-Axis, only a 0 (Off) or 1 (On) will be measured. Ensure that the data range for the X-Axis on the table is updated appropriately in this condition.

## 1.6. Programmable Logic Function Block

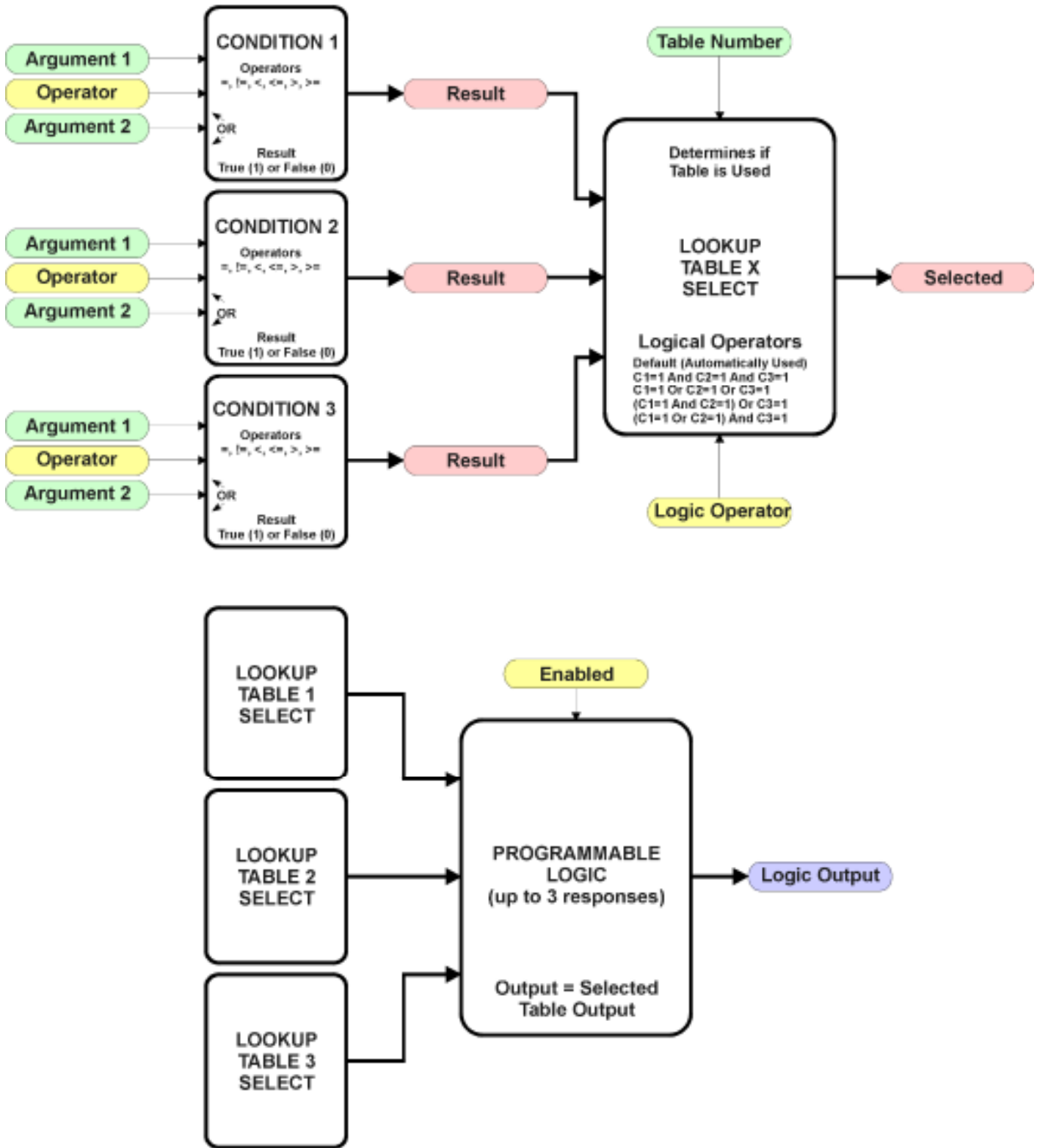


Figure 7: Programmable Logic Function Block

This function block is obviously the most complicated of them all, but very powerful. The Programmable Logic can be linked to up to three tables, any one of which would be selected only under given conditions. Any three tables (of the available 8) can be associated with the logic, and which ones are used is fully configurable.

Should the conditions be such that a particular table (1, 2 or 3) has been selected as described in Section 1.6.2, then the output from the selected table, at any given time, will be passed directly to the Logic Output.

Therefore, up to three different responses to the same input, or three different responses to different inputs, can become the input to another function block, such as an Output X Drive. To do this, the “**Control Source**” for the reactive block would be selected to be the *‘Programmable Logic Function Block.’*

In order to enable any one of Programmable Logic blocks, the “**Programmable Logic Block Enabled**” setpoint must be set to True. They are all disabled by default.

Logic is evaluated in the order shown in Figure 8. Only if a lower number table has not been selected will the conditions for the next table be looked at. **The default table is always selected as soon as it is evaluated. It is therefore required that the default table always be the highest number in any configuration.**

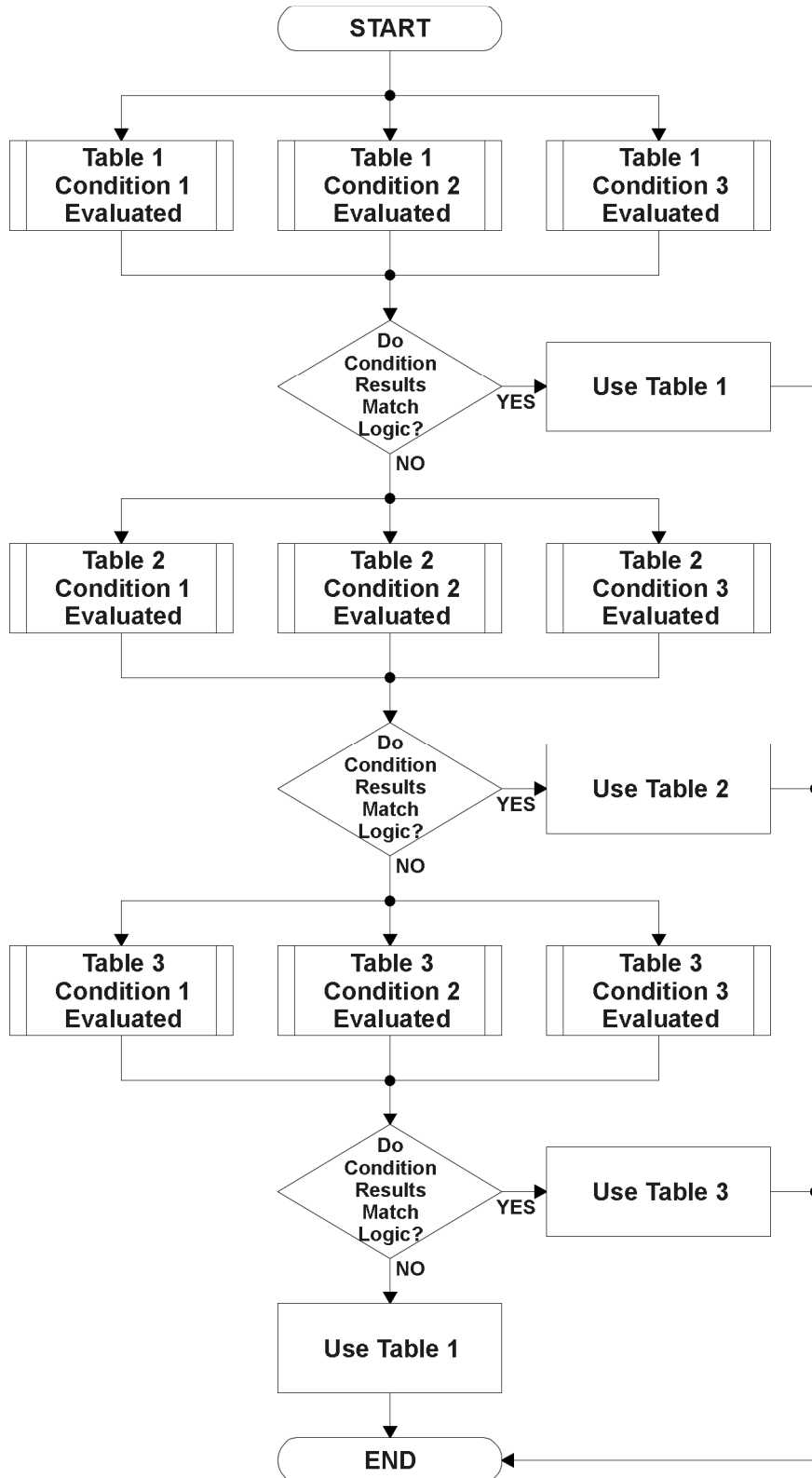


Figure 8: Programmable Logic Flowchart

### 1.6.1. Conditions Evaluation

The first step in determining which table will be selected as the active table is to first evaluate the conditions associated with a given table. Each table has associated with it up to three conditions that can be evaluated.

Argument 1 is always a logical output from another function block, as listed in Section 1.12. As always, the source is a combination of the functional block type and number, setpoints “**Table X, Condition Y, Argument 1 Source**” and “**Table X, Condition Y, Argument 1 Number**”, where both X = 1 to 3 and Y = 1 to 3.

Argument 2 on the other hand, could either be another logical output such as with Argument 1, OR a constant value set by the user. To use a constant as the second argument in the operation, set “**Table X, Condition Y, Argument 2 Source**” to ‘*Control Constant Data.*’ Note that the constant value has no unit associated with it in EA, so the user must set it as needed for the application.

The condition is evaluated based on the “**Table X, Condition Y Operator**” selected by the user. It is always ‘=, *Equal*’ by default. The only way to change this is to have two valid arguments selected for any given condition. Options for the operator are listed in Table 10.

0	=, <i>Equal</i>
1	!=, <i>Not Equal</i>
2	>, <i>Greater Than</i>
3	>=, <i>Greater Than or Equal</i>
4	<, <i>Less Than</i>
5	<=, <i>Less Than or Equal</i>

Table 10: Condition Operator Options

By default, both arguments are set to ‘*Control Source Not Used*’ which disables the condition, and automatically results in a value of N/A as the result. Although Figure 8 shows only True or False as a result of a condition evaluation, the reality is that there could be four possible results, as described in Table 11.

Value	Meaning	Reason
0	False	(Argument 1) Operator (Argument 2) = False
1	True	(Argument 1) Operator (Argument 2) = True
2	Error	Argument 1 or 2 output was reported as being in an error state
3	Not Applicable	Argument 1 or 2 is not available (i.e. set to ‘ <i>Control Source Not Used</i> ’)

Table 11: Condition Evaluation Results

## 1.6.2. Table Selection

In order to determine if a particular table will be selected, logical operations are performed on the results of the conditions as determined by the logic in Section 1.6.1. There are several logical combinations that can be selected, as listed in Table 12.

0	<i>Default Table</i>
1	<i>Cnd1 And Cnd2 And Cnd3</i>
2	<i>Cnd1 Or Cnd2 Or Cnd3</i>
3	<i>(Cnd1 And Cnd2) Or Cnd3</i>
4	<i>(Cnd1 Or Cnd2) And Cnd3</i>

Table 12: Condition Logical Operator Options

Not every evaluation is going to need all three conditions. The case given in the earlier section, for example, only has one condition listed, i.e. that the Engine RPM be below a certain value. Therefore, it is important to understand how the logical operators would evaluate an Error or N/A result for a condition.

Logical Operator	Select Conditions Criteria
Default Table	Associated table is automatically selected as soon as it is evaluated.
Cnd1 And Cnd2 And Cnd3	<p><b>Should be used when two or three conditions are relevant, and all must be true to select the table.</b></p> <p>If any condition equals False or Error, the table is not selected. An N/A is treated like a True. If all three conditions are True (or N/A), the table is selected.</p> <p>If((Cnd1==True) &amp;&amp;(Cnd2==True)&amp;&amp;(Cnd3==True)) Then Use Table</p>
Cnd1 Or Cnd2 Or Cnd3	<p><b>Should be used when only one condition is relevant. Can also be used with two or three relevant conditions.</b></p> <p>If any condition is evaluated as True, the table is selected. Error or N/A results are treated as False</p> <p>If((Cnd1==True)    (Cnd2==True)    (Cnd3==True)) Then Use Table</p>
(Cnd1 And Cnd2) Or Cnd3	<p><b>To be used only when all three conditions are relevant.</b></p> <p>If both Condition 1 and Condition 2 are True, OR Condition 3 is True, the table is selected. Error or N/A results are treated as False</p> <p>If( ((Cnd1==True)&amp;&amp;(Cnd2==True))    (Cnd3==True) ) Then Use Table</p>
(Cnd1 Or Cnd2) And Cnd3	<p><b>To be used only when all three conditions are relevant.</b></p> <p>If Condition 1 And Condition 3 are True, OR Condition 2 And Condition 3 are True, the table is selected. Error or N/A results are treated as False</p> <p>If( ((Cnd1==True)  ((Cnd2==True)) &amp;&amp; (Cnd3==True) ) Then Use Table</p>

Table 11 – Conditions Evaluation Based on Selected Logical Operator

The default “**Table X, Conditions Logical Operator**” for Table 1 and Table 2 is ‘*Cnd1 And Cnd2 And Cnd3*,’ while Table 3 is set to be the ‘*Default Table*.’

### 1.6.3. Logic Block Output

Recall that Table X, where X = 1 to 3 in the Programmable Logic function block does NOT mean Lookup Table 1 to 3. Each table has a setpoint “**Table X – Lookup Table Block Number**” which allows the user to select which Lookup Tables they want associated with a particular Programmable Logic Block. The default tables associated with each logic block are listed in Table 13.

<b>Programmable Logic Block Number</b>	<b>Table 1 – Lookup Table Block Number</b>	<b>Table 2 – Lookup Table Block Number</b>	<b>Table 3 – Lookup Table Block Number</b>
1	1	2	3
2	4	5	6
3	1	2	3
4	4	5	6

*Table 13: Programmable Logic Block Default Lookup Tables*

If the associated Lookup Table does not have an “**X-Axis Source**” selected, then the output of the Programmable Logic block will always be “Not Available” so long as that table is selected. However, should the Lookup Table be configured for a valid response to an input, be it Data or Time, the output of the Lookup Table function block (i.e. the Y-Axis data that has been selected based on the X-Axis value) will become the output of the Programmable Logic function block so long as that table is selected.

Unlike all other function blocks, the Programmable Logic does NOT perform any linearization calculations between the input and the output data. Instead, it mirrors exactly the input (Lookup Table) data. Therefore, when using the Programmable Logic as a control source for another function block, it is HIGHLY recommended that all the associated Lookup Table Y-Axes either be (a) Set between the 0 to 100% output range or (b) all set to the same scale.

## 1.7. Math Function Block

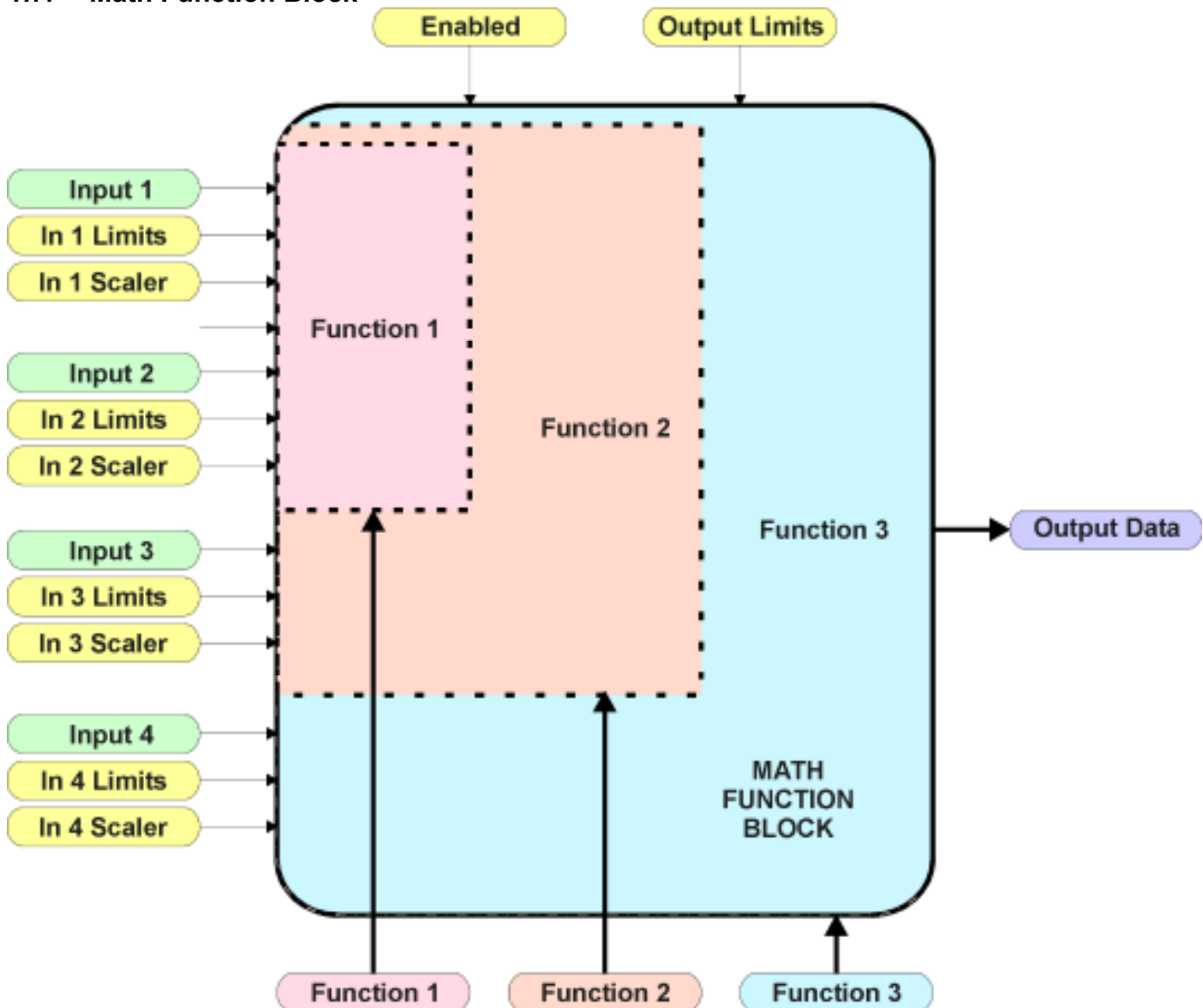


Figure 9: Math Function Block

There are four mathematic function blocks that allow the user to define basic algorithms. A math function block can take up to four input signals, as listed in Table 19 in Section 1.12. Each input is then scaled according to the associated limit and scaling setpoints.

Inputs are converted into a percentage value based on the “**Math Input X Minimum**” and “**Math Input X Maximum**” values selected, where  $X = 1$  to  $4$ . For additional control, the user can also adjust the “**Math Input X Scaler**.” By default, each input has a scaling ‘weight’ of  $1.0$ . However, each input can be scaled from  $-1.0$  to  $1.0$  as necessary before it is applied in the function.

For example, in the case where the user may want to combine two inputs such that a joystick (Input 1) is the primary control of an output, but the speed can be incremented or decremented based on a potentiometer (Input 2), it may be desired that 75% of the scale is controlled by the joystick position, while the potentiometer can increase or decrease the min/max output by up to 25%. In this case, Input 1 would be scaled with  $0.75$ , while Input 2 uses  $0.25$ . The resulting addition will give a command from 0 to 100% based on the combined positions of both inputs.

The appropriate arithmetic or logical operation is performed on the two inputs, InA and InB, according to the associated function. The list of selectable function operations is defined in Table 14.

0	=	True when InA Equals InB
1	!=	True when InA Not Equal InB
2	>	True when InA Greater Than InB
3	>=	True when InA Greater Than or Equal InB
4	<	True when InA Less Than InB
5	<=	True when InA Less Than or Equal InB
6	OR	True when InA or InB is True
7	AND	True when InA and InB are True
8	XOR	True when InA/InB is True, but not both
9	+	Result = InA plus InB
10	-	Result = InA minus InB
11	x	Result = InA times InB
12	/	Result = InA divided by InB
13	MIN	Result = Smallest of InA and InB
14	MAX	Result = Largest of InA and InB

Table 14: Math Function Operators

For Function 1, InA and InB are Inputs 1 and 2 respectively.

For Function 2, InA is the result of Function 1, and InB is Input 3.

For Function 3, InA is the result of Function 2, and InB is Input 4.

For a valid result, the control source for an input must be a non-zero value, i.e. something other than 'Control Source Not Used.' Otherwise, the corresponding function is ignored, and the "Output Data" for the math function block is the result of the earlier function scaled according to the output limit setpoints. For example, if Input 4 is not used, the math output would be the result of the Function 2 operation.

For logical operators (6, 7 or 8), any SCALED input greater than or equal to 0.5 is treated as a TRUE input. For logic output operators (0 to 8), the result of the calculation for the function will always be 0 (FALSE) or 1 (TRUE).

Error data (i.e. input measured out of range) is always treated as a 0.0 input into the function.

For the arithmetic functions (9 to 14), it is recommended to scale the data such that the resulting operation will not exceed full scale (0 to 100%) and saturate the output result.

When dividing, a zero InB value will always result in a zero output value for the associated function. When subtracting, a negative result will always be treated as a zero, unless the function is multiplied by a negative one, or the inputs are scaled with a negative coefficient first.

The resulting mathematical calculation, represented as a percentage value, can be scaled into the appropriate physical units using the "Math Output Minimum Range" and "Math Output Maximum Range" setpoints. These values are also used as the limits when the Math Function is selected as the input source for another function block.

## 1.8. Diagnostic Function Block

There are several types of diagnostics supported by the DIN-2RO-ICAN-LED Controller. As described in Section 1.2, fault detection can be associated with a digital input set up as frequency or PWM input types. In addition, the DIN-2RO-ICAN-LED can also detect/react to power supply over/under voltage measurements, a processor over-temperature, or lost communication events.

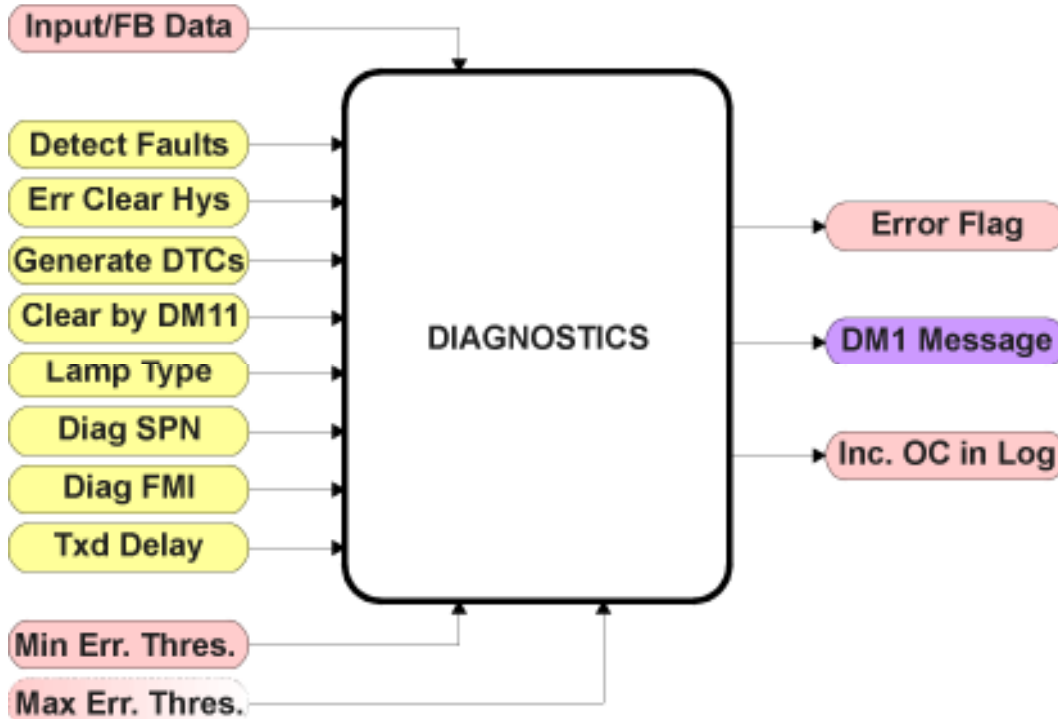


Figure 10: Diagnostics Function Block

The “**Fault Detection is Enabled**” is the most important setpoint associated with this function block, and it should be selected first. Changing it will result in other setpoints being enabled/disabled as appropriate. When disabled, all diagnostic behaviour associated with the output or event in question is ignored (i.e. this type of fault will not disable the output.)

In the case of a power supply error, it can be selected to disable the relay outputs. By default, a power supply under or over voltage condition will not shutoff the outputs.

In most cases, faults can be flagged as either a low or high occurrence. The min/max thresholds for all diagnostics supported by the DIN-2RO-ICAN-LED are listed in Table 15. Bolded values are user configurable setpoints. Some diagnostics react only to a single condition, in which case a N/A is listed in one of the columns.

Function Block	Minimum Threshold	Maximum Threshold
Digital Input	Minimum Error	Maximum Error
Power Supply	Power Undervoltage Threshold	Power Overvoltage Threshold
Over Temperature	N/A	Over Temperature Shutdown
Lost Communication	N/A	Received Message Timeout (any)

Table 15: Fault Detect Thresholds

When applicable, a hysteresis setpoint is provided to prevent the rapid setting and clearing of the error flag when an input or feedback value is right near the fault detection threshold. For the low end, once a fault has been flagged, it will not be cleared until the measured value is greater than or equal to the Minimum Threshold + **“Hysteresis to Clear Fault.”** For the high end, it will not be cleared until the measured value is less than or equal to the Maximum Threshold – **“Hysteresis to Clear Fault.”** The minimum, maximum and hysteresis values are always measured in the units of the fault in question.

The next setpoint in this function block is the **“Event Generates a DTC in DM1.”** If and only if this is set to true will the other setpoints in the function block be enabled. They are all related to the data that is sent to the J1939 network as part of the DM1 message, Active Diagnostic Trouble Codes.

A Diagnostic Trouble Code (DTC) is defined by the J1939 standard as a four byte value which is a combination of:

SPN	Suspect Parameter Number	(first 19 bits of the DTC, LSB first)
FMI	Failure Mode Identifier	(next 5 bits of the DTC)
CM	Conversion Method	(1 bit, always set to 0)
OC	Occurrence Count	(7 bits, number of times the fault has happened)

In addition to supporting the DM1 message, the DIN-2RO-ICAN-LED Controller also supports

DM2	Previously Active Diagnostic Trouble Codes	<b>Sent only on request</b>
DM3	Diagnostic Data Clear/Reset of Previously Active DTCs	<b>Done only on request</b>
DM11	Diagnostic Data Clear/Reset for Active DTCs	<b>Done only on request</b>

So long as even one Diagnostic function block has **“Event Generates a DTC in DM1”** set to True, the DIN-2RO-ICAN-LED Controller will send the DM1 message every one second, regardless of whether or not there are any active faults, as recommended by the standard. While there are no active DTCs, the DIN-2RO-ICAN-LED will send the “No Active Faults” message. If a previously inactive DTC becomes active, a DM1 will be sent immediately to reflect this. As soon as the last active DTC goes inactive, it will send a DM1 indicating that there are no more active DTCs.

If there is more than one active DTC at any given time, the regular DM1 message will be sent using a multipacket Broadcast Announce Message (BAM). If the controller receives a request for a DM1 while this is true, it will send the multipacket message to the Requester Address using the Transport Protocol (TP).



At power up, the DM1 message will not be broadcasted until after a 5 second delay. This is done to prevent any power up or initialization conditions from being flagged as an active error on the network.

When the fault is linked to a DTC, a non-volatile log of the occurrence count (OC) is kept. As soon as the controller detects a new (previously inactive) fault, it will start decrementing the **“Delay Before Sending DM1”** timer for that Diagnostic function block. If the fault has remained present during the delay

time, then the controller will set the DTC to active, and will increment the OC in the log. A DM1 will immediately be generated that includes the new DTC. The timer is provided so that intermittent faults do not overwhelm the network as the fault comes and goes, since a DM1 message would be sent every time the fault shows up or goes away.

Previously active DTCs (any with a non-zero OC) are available upon request for a **DM2** message. If there is more than one previously active DTC, the multipacket DM2 will be sent to the Requester Address using the Transport Protocol (TP).

Should a **DM3** be requested, the occurrence count of all previously active DTCs will be reset to zero. The OC of currently active DTCs will not be changed.

The Diagnostic function block has a setpoint “**Event Cleared only by DM11.**” By default, this is always set to False, which means that as soon as the condition that caused an error flag to be set goes away, the DTC is automatically made Previously Active, and is no longer included in the DM1 message. However, when this setpoint is set to True, even if the flag is cleared, the DTC will not be made inactive, so it will continue to be sent on the DM1 message. Only when a DM11 has been requested will the DTC go inactive. This feature may be useful in a system where a critical fault needs to be clearly identified as having happened, even if the conditions that caused it went away.

In addition to all the active DTCs, another part of the DM1 message is the first byte which reflects the Lamp Status. Each Diagnostic function block has the setpoint “**Lamp Set by Event in DM1**” which determines which lamp will be set in this byte while the DTC is active. The J1939 standard defines the lamps as ‘*Malfunction*’, ‘*Red, Stop*’, ‘*Amber, Warning*’ or ‘*Protect*’. By default, the ‘*Amber, Warning*’ lamp is typically the one set by any active fault.

By default, every Diagnostic function block has associated with it a proprietary SPN. However, this setpoint “**SPN for Event used in DTC**” is fully configurable by the user should they wish it to reflect a standard SPN define in J1939-71 instead. If the SPN is changed, the OC of the associate error log is automatically reset to zero.

Every Diagnostic function block also has associated with it a default FMI. The only setpoint for the user to change the FMI is “**FMI for Event used in DTC,**” even though some Diagnostic function blocks can have both high and low errors as shown in Table 16. In those cases, the FMI in the setpoint reflect that of the low-end condition, and the FMI used by the high fault will be determined per Table 15. If the FMI is changed, the OC of the associate error log is automatically reset to zero.

<b>FMI for Event used in DTC – Low Fault</b>	<b>Corresponding FMI used in DTC – High Fault</b>
FMI=1, Data Valid but Below Normal Operational Range – Most Severe Level	FMI=0, Data Valid but Above Normal Operational Range – Most Severe Level
FMI=4, Voltage Below Normal, or Shorted to Low Source	FMI=3, Voltage Above Normal, Or Shorted to High Source
FMI=5, Current Below Normal or Open Circuit	FMI=6, Current Above Normal or Grounded Circuit
FMI=17, Data Valid but Below Normal Operating Range – Least Severe Level	FMI=15, Data Valid but Above Normal Operating Range – Least Severe Level
FMI=18, Data Valid but Below Normal Operating Range – Moderately Severe Level	FMI=16, Data Valid but Above Normal Operating Range – Moderately Severe Level
FMI=21, Data Drifted Low	FMI=20, Data Drifted High

Table 16: Low Fault FMI vs High Fault FMI



If the FMI used is anything other than one of those in Table 16, then both the low and high faults will be assigned the same FMI. This condition should be avoided, as the log will still used different OC for the two types of faults, even though they will be reported the same in the DTC. It is the user's responsibility to make sure this does not happen.

### 1.9. DTC React Function Block

The DTC React function block is a very simple function which will allow a received DTC, sent from another ECU on a DM1 message, to disable an output or be used as input to another type of logic block. Up to five SPN/FMI combinations can be selected.

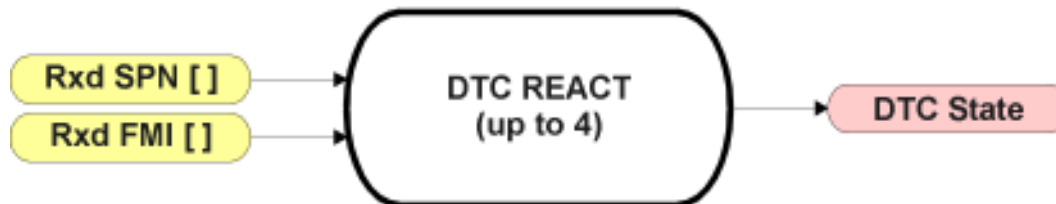


Figure 11: DTC React Function Block

Should a DM1 message be received with the SPN/FMI combination defined, the corresponding DTC State will be set to ON. Once ON, if the same SPN/FMI combination has not been received again after 3 seconds, the DTC State will be reset to OFF.

The DTC could be used as a digital input for any function block as appropriate.

## 1.10. CAN Transmit Function Block

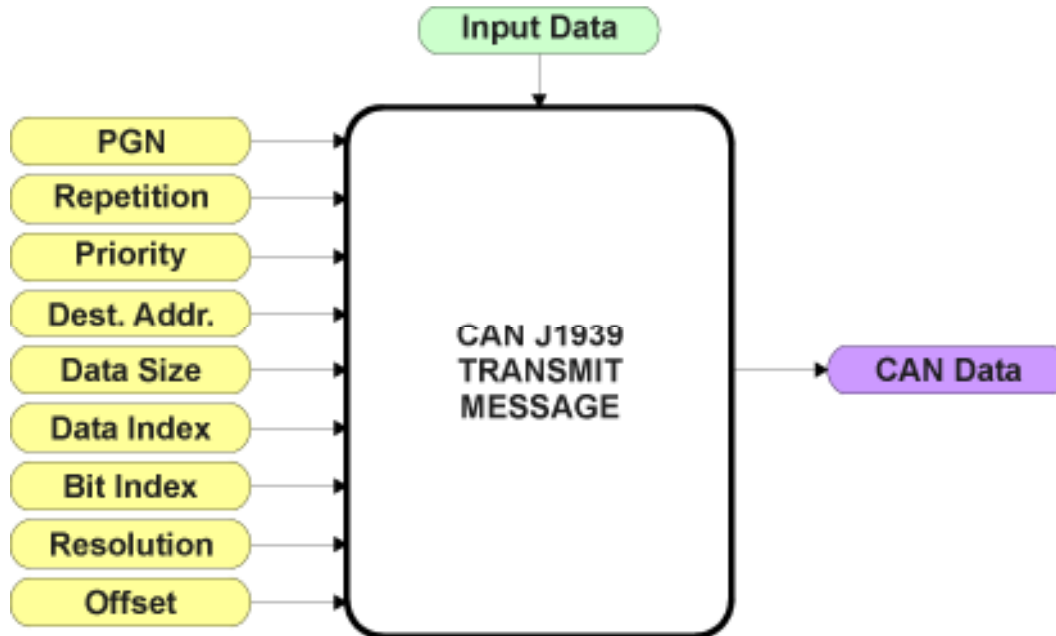


Figure 12: CAN Transmit Function Block

The CAN Transmit function block is used to send any output from another function block (i.e. input, status or feedback signals) to the J1939 network.

Normally, to disable a transmit message, the “**Transmit Repetition Rate**” is set to zero. However, should message share its Parameter Group Number (PGN) with another message, this is not necessarily true. In the case where multiple messages share the same “**Transmit PGN**”, the repetition rate selected in the message with the LOWEST number will be used for ALL the messages that use that PGN.

By default, all messages are sent on Proprietary B PGNs as broadcast messages. The default settings do ‘bundle’ multiple messages onto a PGN, as outlined in Section 3. If all of the data is not necessary, disable the entire message by setting the lowest channel using that PGN to zero. If some of the data is not necessary, simply change the PGN of the superfluous channel(s) to an unused value in the Proprietary B range.



At power up, transmitted message will not be broadcasted until after a 5 second delay. This is done to prevent any power up or initialization conditions from creating problems on the network.

Since the defaults are PropB messages, the “**Transmit Message Priority**” is always initialized to 6 (low priority) and the “**Destination Address (for PDU1)**” setpoint is not used. This setpoint is only valid when a PDU1 PGN has been select, and it can be set either to the Global Address (0xFF) for broadcasts, or sent to a specific address as setup by the user.

The “**Transmit Data Size**”, “**Transmit Data Index in Array (LSB)**”, “**Transmit Bit Index in Byte (LSB)**”, “**Transmit Resolution**” and “**Transmit Offset**” can all be use to map the data to any SPN supported by the J1939 standard. The defaults used by the DIN-2RO-ICAN-LED are all for proprietary SPNs, and are defined in detail in Section 3.3.

Note: CAN Data = (Input Data – Offset)/Resolution

The DIN-2RO-ICAN-LED Controller supports up to 8 unique CAN Transmit Messages, all of which can be programmed to send any available data to the CAN network. By default, only the first two messages are pre-configured to send the output feedback data. The details are outlined in Section 3.3, and the default list is shown in Table 17below.

<b>Block #</b>	<b>Default Transmit Data</b>	<b>(PGN)</b>
1	Digital Input Measured	(0xFF00)
2	Relay Output 1 State	(0xFF00)
3	Relay Output 2 State	(0xFFFF)
4	Control Source Not Used	(0xFFFF)
5	Control Source Not Used	(0xFFFF)
6	Control Source Not Used	(0xFFFF)
7	Control Source Not Used	(0xFFFF)
8	Control Source Not Used	(0xFFFF)

*Table 17: Default CAN Transmit Messages*

### 1.11. CAN Receive Function Block

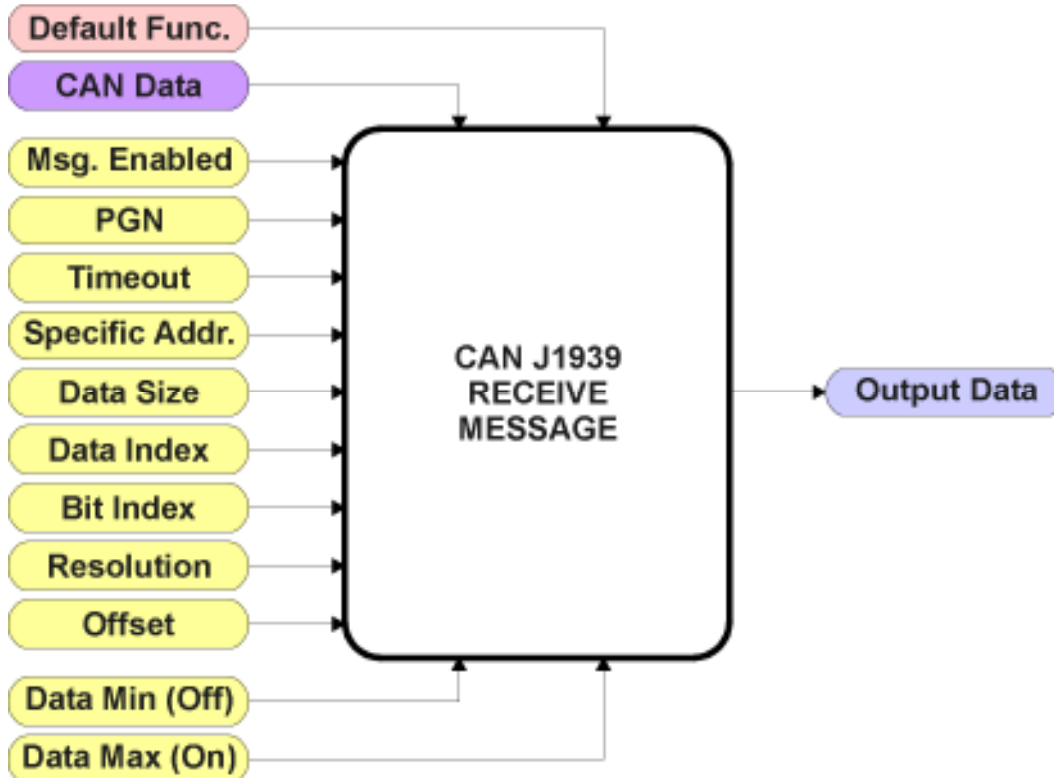



Figure 13: CAN Receive Function Block

The CAN Receive function block is designed to take any SPN from the J1939 network, and use it as an input to any another function block (i.e. Lookup Table or Output Control).

The “**Received Message Enabled**” is the most important setpoint associated with this function block, and it should be selected first. Changing it will result in other setpoints being enabled/disabled as appropriate. By default ALL received messages are disabled.



Since the DIN-2RO-ICAN-LED can support up to 8 received messages, it can get confusing as to what message performs what function. Therefore, the intended “**Default Receive Function**” is available as a read-only value for each message. Change functions with CAUTION!

Once a message has been enabled, a Lost Communication fault will be flagged if that message is not received off of the bus within the “**Receive Message Timeout**” period. This could trigger a Lost Communication event as described in Section 1.8. In order to avoid timeouts on a heavily saturated network, it is recommended to set it at least three times larger than the expected update rate. To disable the timeout feature, simply set this value to zero, in which case the received message will never trigger a Lost Communication fault.

By default, all control messages are expected to be sent to the DIN-2RO-ICAN-LED on Proprietary B PGNs. However, should a PDU1 message be selected, the DIN-2RO-ICAN-LED can be setup to receive it from any ECU by setting the “**Specific Address that sends the PGN**” to the Global Address (0xFF). If a specific address is selected instead, then any other ECU sending data on the PGN will be ignored.

The “**Receive Data Size**”, “**Receive Data Index in Array (LSB)**”, “**Receive Bit Index in Byte (LSB)**”, “**Receive Resolution**” and “**Receive Offset**” can all be use to map any SPN supported by the J1939 standard to the output data of the Received function block. The defaults used by the DIN-2RO-ICAN-LED are all for proprietary SPNs, and are defined in detail in Section 3.4.

Note: Output Data = CAN Data \* Resolution + Offset

As mentioned earlier, a CAN Receive function block can be selected as the source of the control input for the output function blocks. When this is the case, the “**Received Data Min (Off Threshold)**” and “**Received Data Max (On Threshold)**” setpoints become the minimum and maximum values of the X-axis used in the linear calculations. As the names imply, they are also used as the On/Off thresholds for digital input types. These values are in whatever units the output data is AFTER the resolution and offset is applied to the CAN data.

The DIN-2RO-ICAN-LED Controller supports up to 8 unique CAN Receive Messages. By default, each message is pre-configured to read a particular type of data. The details are outlined in Section 3.4, and the default list is shown in Table 18below.

<b>Block #</b>	<b>Default Receive Data</b>
1	Relay Output 1 Command Data
2	Relay Output 2 Command Data
3	Not Used
4	Not Used
5	Not Used
6	Not Used
7	Not Used
8	Not Used

*Table 18: Default CAN Receive Messages*

## 1.12. Available Control/Input Sources

Throughout Section 1, there have been numerous mentions of ‘mapping’ an output of one function block to a control or input of another. Any time an input is programmable, as shown by the green bubbles in the figures above, it consists of two setpoints. One is the “[Name] Source” and the other the “[Name] Number.” Together, these two setpoints uniquely select how the I/O of the various function blocks are linked together in the custom application.

Below is the full list of the programmable inputs supported by the DIN-2RO-ICAN-LED Controller.

Function Block	Input Name
Relay Output x (where x = 1 to 2)	Control
	Enable
	Override
Lookup Table X (where X = 1 to 8)	X-Axis
Programmable Logic	Table 1 – Lookup Table Block Number
	Table 1 – Condition 1, Argument 1
	Table 1 – Condition 1, Argument 2
	Table 1 – Condition 2, Argument 1
	Table 1 – Condition 2, Argument 2
	Table 1 – Condition 3, Argument 1
	Table 1 – Condition 3, Argument 2
	Table 2 – Lookup Table Block Number
	Table 2 – Condition 1, Argument 1
	Table 2 – Condition 1, Argument 2
	Table 2 – Condition 2, Argument 1
	Table 2 – Condition 2, Argument 2
	Table 2 – Condition 3, Argument 1
	Table 2 – Condition 3, Argument 2
	Table 3 – Lookup Table Block Number
	Table 3 – Condition 1, Argument 1
	Table 3 – Condition 1, Argument 2
	Table 3 – Condition 2, Argument 1
	Table 3 – Condition 2, Argument 2
	Table 3 – Condition 3, Argument 1
	Table 3 – Condition 3, Argument 2
Math Function X (where X = 1 to 4)	Input 1, Input 2, Input 3 and Input 4
CAN Transmit X (where X = 1 to 8)	Transmit Data

Table 19: Configurable Inputs

For each of the inputs listed in Table 19, the options for the Source and Number are listed below. Note, not all options would make sense for any particular input, and it is up to the user to program the controller in a logical and functional fashion.

Sources	Range	Notes
Control Source Not Used	N/A	When this is selected, it disables all other setpoints associated with the input in question.
Received CAN J1939 Message	1 to 8	The CAN Receive Messages each have a unique default assigned to them as outlined in Section 1.11
Digital Input Measured	1 to 1	This provides the state of a digital input or the frequency or duty cycle measured depending on the <i>Sensor Type</i> selected
Lookup Table Function Block	1 to 8	User must enable the function block, as it is disabled by default
Programmable Logic Function Block	1 to 4	User must enable the function block, as it is disabled by default
Math Function Block	1 to 4	User must enable the function block, as it is disabled by default
Control Constant Data	1 to 14	1 = Always FALSE, 2 = Always TRUE, 3 to 14 = User Selectable
Diagnostic Trouble Code (Rxd)	1 to 4	Will only be valid if the corresponding DTC has a non-zero SPN
Note: Control sources below this line are meant for feedback and diagnostics, and are not suitable for use as controls for other logic blocks		
Universal Output Target Value	1 to 2	Can be mapped to a CAN Txd
Universal Output Feedback Value	1 to 2	Input to Output X Drive Diagnostics Can be mapped to a CAN Txd
Power Supply Measured	N/A	Input to Power Supply Diagnostics Can be mapped to a CAN Txd
Processor Temperature Measured	N/A	Input to Over Temperature Diagnostics Can be mapped to a CAN Txd

Table 20: Input Sources and Numbers

Sources	Range	Notes
Control Source Not Used	N/A	When this is selected, it disables all other setpoints associated with the input in question.
Digital Input Fault	1 to 1	A fault event of the digital input will command the LED
Power Supply Fault	N/A	Power Supply fault event will command the LED
Processor Temperature Fault	N/A	Processor Temperature fault event will command the LED
CAN Fault	N/A	CAN Receive fault event will command the LED
Received CAN J1939 Message	1 to 8	The CAN Receive Messages each have a unique default assigned to them as outlined in Section 1.11
Lookup Table Function Block	1 to 8	User must enable the function block, as it is disabled by default

Programmable Logic Function Block	1 to 4	User must enable the function block, as it is disabled by default
Math Function Block	1 to 4	User must enable the function block, as it is disabled by default
Control Constant Data	1 to 14	1 = Always FALSE, 2 = Always TRUE, 3 to 14 = User Selectable
Diagnostic Trouble Code (Rxd)	1 to 4	Will only be valid if the corresponding DTC has a non-zero SPN
Note: Control sources below this line are meant for feedback and diagnostics, and are not suitable for use as controls for other logic blocks		
Universal Output Target Value	1 to 2	Can be mapped to a CAN Txd
Universal Output Feedback Value	1 to 2	Input to Output X Drive Diagnostics Can be mapped to a CAN Txd
Power Supply Measured	N/A	Input to Power Supply Diagnostics Can be mapped to a CAN Txd
Processor Temperature Measured	N/A	Input to Over Temperature Diagnostics Can be mapped to a CAN Txd

*Table 21: Dual LED Command Sources and Numbers*

## 2. INSTALLATION INSTRUCTIONS

### 2.1. Dimensions and Pinout

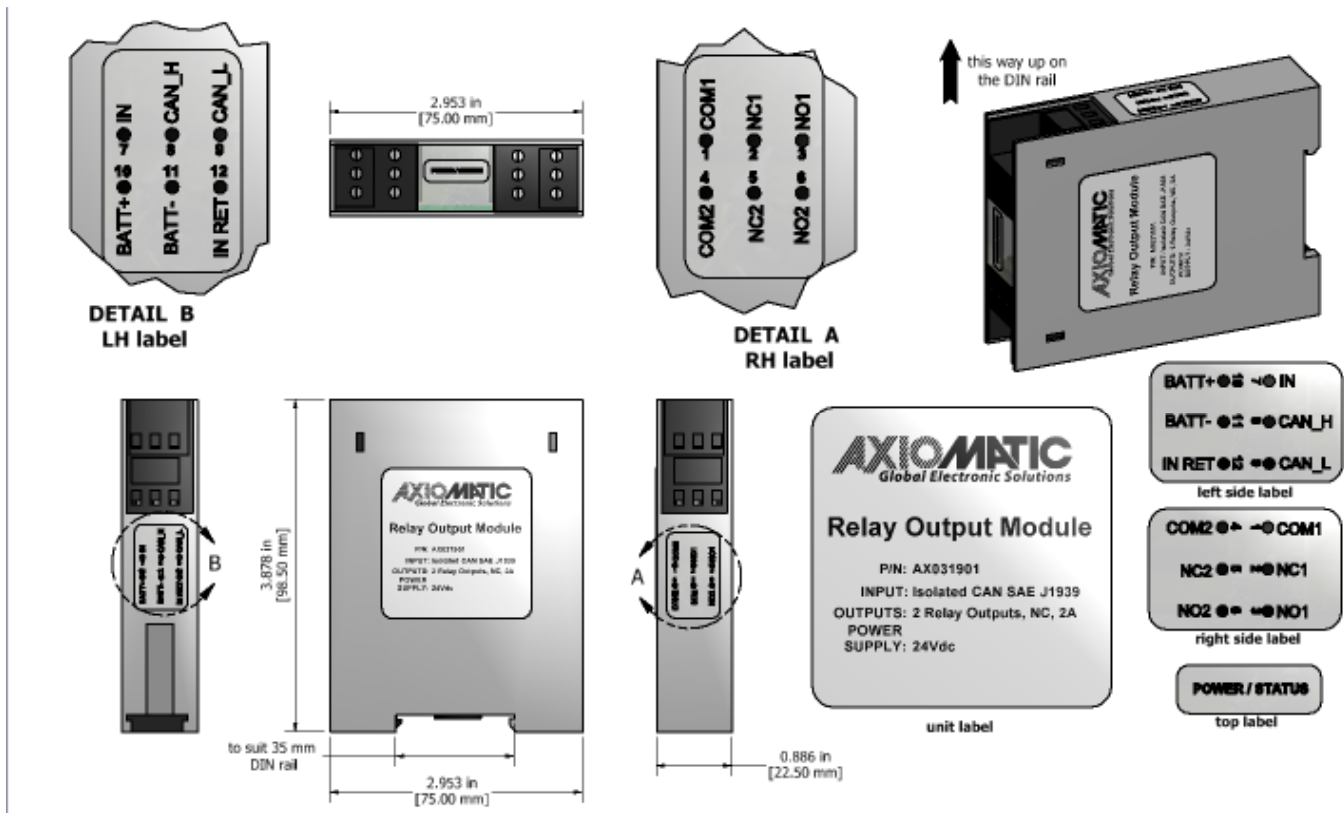


Figure 14: Dimension Drawing

Screw Terminal #	Function
1	Relay Output COM 1
2	Relay Output NC 1
3	Relay Output NO 1
4	Relay Output COM 2
5	Relay Output NC 2
6	Relay Output NO 2
7	Digital Input
8	CANH
9	CANL
10	Power+
11	Power-
12	Digital Input GND

Table 22: Connector Pinout

## 2.2. Mounting Instructions

### NOTES & WARNINGS

- Do not install near high-voltage or high-current devices.
- Ground the chassis for safety purposes and proper EMI shielding.
- Note the operating temperature range. All field wiring must be suitable for that temperature range.
- Install the unit with appropriate space available for servicing and for adequate wire harness access (15 cm) and strain relief (30 cm).
- Do not connect or disconnect the unit while the circuit is live, unless the area is known to be non-hazardous.

### MOUNTING

The enclosure is standard 35mm DIN rail mount. Top of the rail is gripped by a fixed clip and a movable clip. The housing clips on the rail with no tools required, the movable clip slides back under pressure.

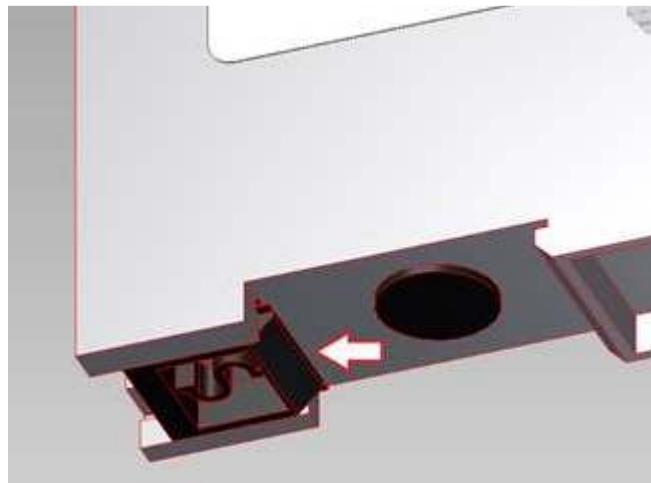


Figure 15: DIN rail mount movable clip

To remove the housing from the rail the black spring clip element is retracted with a small screwdriver and swings the unit off the rail.

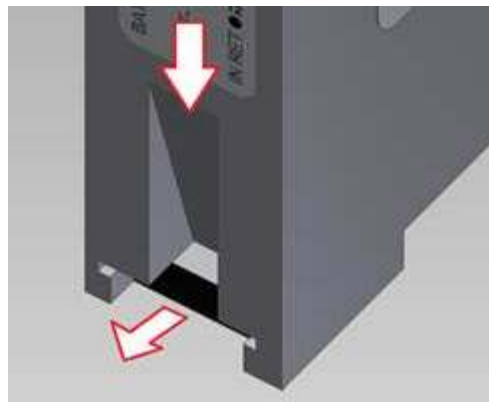


Figure 16: DIN rail mount retraction

## **NOISE – ELECTRICAL CONNECTIONS AND SHIELDING**

To reduce noise, separate all power and output wires from those of the input and CAN. Shielded wires will protect against injected noise. Shield wires should be connected at the power or input source, or at the output load.

The CAN shield can be connected at the controller using the CAN Shield pin provide on the connector. However the other end should not be connected in this case.

All wires used must be 16 or 18 AWG.

## **GROUNDING**

Chassis ground should be connected to the module's Frame GND pin to improve the EMI response of the unit.

All chassis grounding should go to a single ground point designated for the machine and all related equipment. Axiomatic recommends that the ground strap that provides a low impedance path for EMI should be a ½ inch wide, flat, hollow braid, no more than 12 inches long .

## **CAN NETWORK CONSTRUCTION**

Axiomatic recommends that multi-drop networks be constructed using a “daisy chain” or “backbone” configuration with short drop lines.

## **CAN TERMINATION**

It is necessary to terminate the network; therefore an external CAN termination is required. No more than two network terminators should be used on any one single network. A terminator is a 121Ω, 0.25 W, 1% metal film resistor placed between CAN\_H and CAN\_L terminals at the end two nodes on a network.

### 3. OVERVIEW OF J1939 FEATURES

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The software was designed to provide flexibility to the user with respect to messages sent to and from the ECU by providing:

- Configurable ECU Instance in the NAME (to allow multiple ECUs on the same network)
- Configurable Transmit PGN and SPN Parameters
- Configurable Receive PGN and SPN Parameters
- Sending DM1 Diagnostic Message Parameters
- Reading and reacting to DM1 messages sent by other ECUs
- Diagnostic Log, maintained in non-volatile memory, for sending DM2 messages

#### 3.1. Introduction To Supported Messages

The ECU is compliant with the standard SAE J1939, and supports the following PGNs

##### From J1939-21 - Data Link Layer

- |  |                  |
|--|------------------|
| • Request                                    | 59904 (\$00EA00) |
| • Acknowledgment                             | 59392 (\$00E800) |
| • Transport Protocol – Connection Management | 60416 (\$00EC00) |
| • Transport Protocol – Data Transfer Message | 60160 (\$00EB00) |

Note: Any Proprietary B PGN in the range 65280 to 65535 (\$00FF00 to \$00FFFF) can be selected

##### From J1939-73 - Diagnostics

- |  |                  |
|--|------------------|
| • DM1 – Active Diagnostic Trouble Codes                        | 65226 (\$00FECA) |
| • DM2 – Previously Active Diagnostic Trouble Codes             | 65227 (\$00FECB) |
| • DM3 – Diagnostic Data Clear/Reset for Previously Active DTCs | 65228 (\$00FECC) |
| • DM11 - Diagnostic Data Clear/Reset for Active DTCs           | 65235 (\$00FED3) |
| • DM14 – Memory Access Request                                 | 55552 (\$00D900) |
| • DM15 – Memory Access Response                                | 55296 (\$00D800) |
| • DM16 – Binary Data Transfer                                  | 55040 (\$00D700) |

##### From J1939-81 - Network Management

- |                                |                  |
|--------------------------------|------------------|
| • Address Claimed/Cannot Claim | 60928 (\$00EE00) |
| • Commanded Address            | 65240 (\$00FED8) |

##### From J1939-71 – Vehicle Application Layer

- |                           |                  |
|---------------------------|------------------|
| • Software Identification | 65242 (\$00FEDA) |
|---------------------------|------------------|

None of the application layer PGNs are supported as part of the default configurations, but they can be selected as desired for either transmit or received function blocks.


Setpoints are accessed using standard Memory Access Protocol (MAP) with proprietary addresses. The Electronic Assistant<sup>®</sup> (EA) allows for quick and easy configuration of the unit over the CAN network.

## 3.2. Name, Address and Software ID

### 3.2.1. J1939 Name

The DIN-2RO-ICAN-LED Controller ECU has the following defaults for the J1939 NAME. The user should refer to the SAE J1939/81 standard for more information on these parameters and their ranges.

Arbitrary Address Capable	Yes
Industry Group	0, Global
Vehicle System Instance	0
Vehicle System	0, Non-specific system
Function	125, Axiomatic I/O Controller
Function Instance	23, Axiomatic AX031901, Single Digital Input, Dual NC Relay Output Controller with Isolated CAN
<b>ECU Instance</b>	<b>0, First Instance</b>
Manufacture Code	162, Axiomatic Technologies Corporation
Identity Number	Variable, uniquely assigned during factory programming for each ECU

The ECU Instance is a configurable setpoint associated with the NAME. Changing this value will allow multiple ECUs of this type to be distinguishable by other ECUs (including the Electronic Assistant<sup>®</sup> ) when they are all connected on the same network.

### 3.2.2. ECU Address

The default value of this setpoint is 128 (0x80), which is the preferred starting address for self-configurable ECUs as set by the SAE in J1939 tables B3 to B7. The EA will allow the selection of any address between 0 to 253, and ***it is the user's responsibility to select an address that complies with the standard***. The user must also be aware that since the unit is arbitrary address capable, if another ECU with a higher priority NAME contends for the selected address, the DIN-2RO-ICAN-LED will continue select the next highest address until it find one that it can claim. See J1939/81 for more details about address claiming.

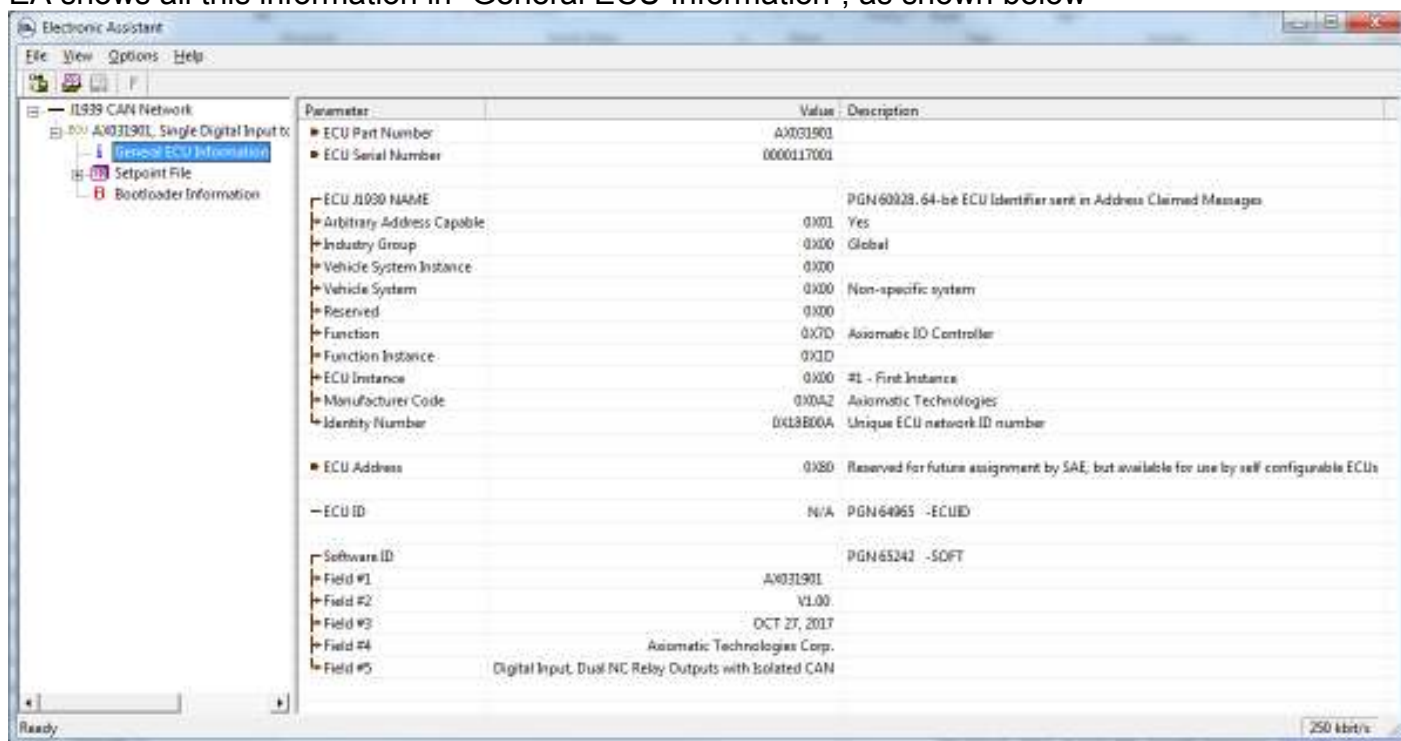
### 3.2.3. Software Identifier

PGN 65242	Software Identification	- SOFT	
Transmission Repetition Rate:	On request		
Data Length:	Variable		
Extended Data Page:	0		
Data Page:	0		
PDU Format:	254		
PDU Specific:	218 PGN Supporting Information:		
Default Priority:	6		
Parameter Group Number:	65242 (0xFEDA)		
Start Position	Length	Parameter Name	SPN
1	1 Byte	Number of software identification fields	965
2-n	Variable	Software identification(s), Delimiter (ASCII “*”)	234

For the DIN-2RO-ICAN-LED Controller ECU, Byte 1 is set to 5, and the identification fields are as follows

**(Part Number)\*(Version)\*(Date)\*(Owner)\*(Description)**

EA shows all this information in “General ECU Information”, as shown below



*Note: The information provided in the Software ID is available for any J1939 service tool which supports the PGN -SOFT.*

### 3.3. CAN Transmit Message Defaults

This section outlines the **default** settings of the DIN-2RO-ICAN-LED Controller CAN transmissions. Recall, however, that this is a fully programmable unit, such that all these SPNs can be sent on different PGNs if so desired.

In all the messages shown below, not all the transmitted values have an SPN assigned to them, as this ECU only uses the SPNs for diagnostic trouble codes. If the SPN is shown as N/A, this means that the associated value cannot be used to generate DTCs.

The “Controller Status Message” has the following default configuration.

PGN 65280		Controller Status Message	
Transmission Repetition:	0s (not sent by default, configurable)		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	GE PGN Supporting Information:		
Default Priority:	6		
Parameter Group Number:	65280 (0xFF00)		
Start Position	Length	Parameter Name	SPN
1	1 byte	Digital Input Measured	520192
2	1 byte	Relay Output 1 State	N/A
3	1 byte	Relay Output 2 State	N/A

### 3.4. CAN Receive Message Defaults

This section outlines the **default** settings of the DIN-2RO-ICAN-LED Controller CAN receive channels, used as inputs to the various function blocks supported by this ECU. Recall, however, that this is a fully programmable unit, such that all these SPNs can be received on different PGNs if so desired.

In all the messages shown below, none of the received values have an SPN assigned to them, as this ECU only uses the SPNs for diagnostic trouble codes. To have the DIN-2RO-ICAN-LED react to a DTC sent by another ECU on the network on a DM1, use the DTC React Function block instead.

The “Relay Output Control Data Message” has the following default configuration.

PGN 65408		Relay Output Control Data	
Transmission Repetition:	100ms (default, configurable)		
Data Length:	8		
Data Page:	0		
PDU Format:	254		
PDU Specific:	GE	PGN Supporting Information:	
Default Priority:	6		
Parameter Group Number:	65408 (0xFF80)		
Start Position	Length	Parameter Name	SPN
1	1 byte	Relay Output 1 Command Data	N/A
2	1 byte	Relay Output 2 Command Data	N/A

#### Relay Output x Command Data, where X = 1 to 2

Default value used when a ‘*Received CAN J1939 Message*’ is used as the control source for the Output Control logic function block (or another block that is linked to the output control.)

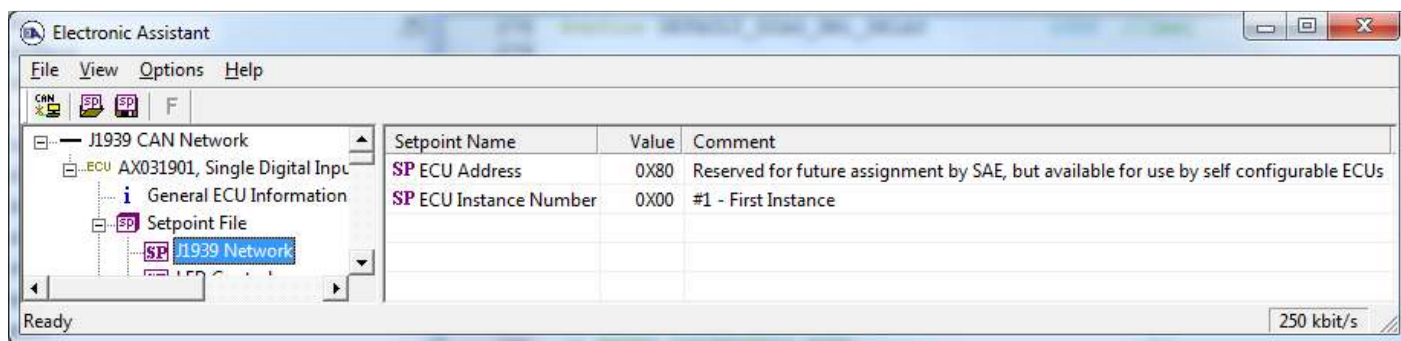
Data Length: 1 byte  
Resolution: 0.4%/bit, 0 offset  
Data Range: 0 to 100 %  
Type: Input  
Suspect Parameter Number: N/A  
Parameter Group Number: 65408

## 4. ECU SETPOINTS ACCESSED WITH ELECTRONIC ASSISTANT

Many setpoints have been reference throughout this manual. This section describes in detail each setpoint, and their defaults and ranges. For more information on how each setpoint is used by the DIN-2RO-ICAN-LED Controller, refer to the relevant section of the User Manual.

### 4.1. Miscellaneous Setpoints

The Miscellaneous setpoints primarily deal with the CAN Network. Refer to the notes for more information about each setpoint.



**Screen Capture of Default Miscellaneous Setpoints**

Name	Range	Default	Notes
ECU Instance Number	Drop List	0, #1 – First Instance	Per J1939-81
ECU Address	0 to 253	128 (0x80)	Preferred address for a self-configurable ECU

If non-default values for the “**ECU Instance Number**” or “**ECU Address**” are used, they will be mirrored during a setpoint file flashing, and will only take effect once the entire file has been downloaded to the unit. After the setpoint flashing is complete, the unit will claim the new address and/or re-claim the address with the new NAME. If these setpoints are changing, it is recommended to close and re-open the CAN connection on EA after the file is loaded so that only the new NAME and address are showing in the J1939 CAN Network ECU list.

## 4.2. LED Control Setpoints

The LED Control function block is defined in Section 1.2. Please refer to that section for detailed information about how the following parameters are used.

Setpoint Name	Value	Comment
SP Stage 1 Control Source	0	Control Not Used
SP Stage 1 Control Number		Parameter not used with current Control Source selected
SP Stage 1 Output Type		Parameter not used with current Control Source selected
SP Stage 1 Response Type		Parameter not used with current Control Source selected
SP Stage 1 Blink Rate		Parameter not used with current Control Source selected
SP Stage 2 Control Source	11	DTC React
SP Stage 2 Control Number	1	DTC React #2
SP Stage 2 Output Type	2	Yellow
SP Stage 2 Response Type	0	Normal On/Off
SP Stage 2 Blink Rate		Parameter not used with Selected Response
SP Stage 3 Control Source	2	Power Supply Fault
SP Stage 3 Control Number	0	Power Supply Fault #1
SP Stage 3 Output Type	3	Red
SP Stage 3 Response Type	1	Blinking Logic
SP Stage 3 Blink Rate	250	ms
SP Stage 4 Control Source	3	Temperature Fault
SP Stage 4 Control Number	0	Temperature Fault #1
SP Stage 4 Output Type	3	Red
SP Stage 4 Response Type	2	Dimming Response
SP Stage 4 Blink Rate		Parameter not used with Selected Response
SP Stage 5 Control Source	1	Input Fault
SP Stage 5 Control Number	0	Input Fault #1
SP Stage 5 Output Type	2	Yellow
SP Stage 5 Response Type	1	Blinking Logic
SP Stage 5 Blink Rate	1000	ms
SP Stage 6 Control Source	4	CAN Receive Timeout
SP Stage 6 Control Number	0	CAN Receive Timeout #1
SP Stage 6 Output Type	2	Yellow
SP Stage 6 Response Type	2	Dimming Response
SP Stage 6 Blink Rate		Parameter not used with Selected Response
SP Default Stage Output Type	1	Green
SP Default Stage Response Type	2	Dimming Response
SP Default Stage Blink Rate		Parameter not used with Selected Response

**Screen Capture of LED Control Setpoints**

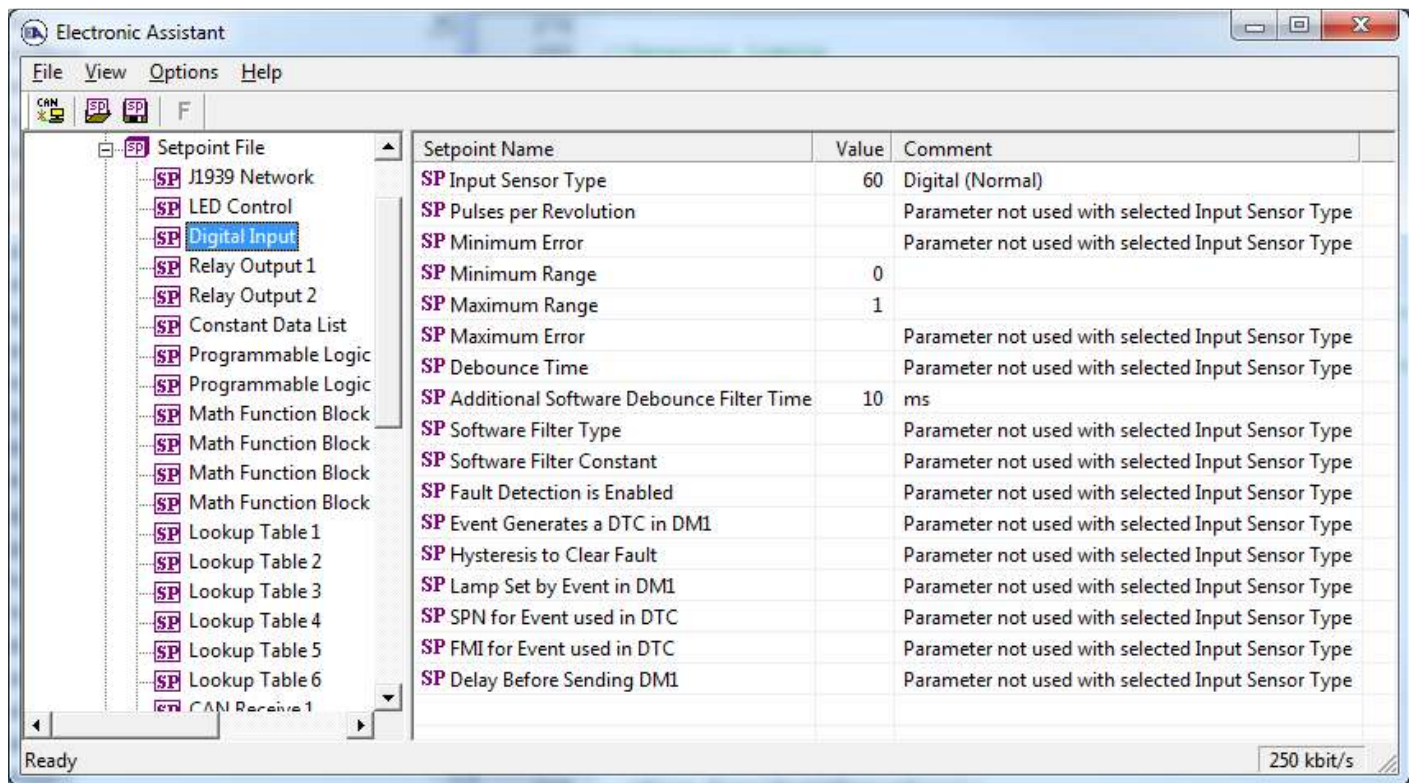
Please note that the setpoints in the above screen capture have been changed from their default values for description purposes in user manual.

Name	Range	Default	Notes
Stage 1 Control Source	Drop List	0, Control Not Used	See Table 21
Stage 1 Control Number	Depends on Source	Not Used	See Table 21
Stage 1 Output Type	Drop List	Not Used	See Table 4
Stage 1 Response Type	Drop List	Not Used	See Table 5

Stage 1 Blink Rate	0 to 60000 ms	Not Used	
Stage 2 Control Source	Drop List	0, Control Not Used	See Table 21
Stage 2 Control Number	Depends on Source	Not Used	See Table 21
Stage 2 Output Type	Drop List	Not Used	See Table 4
Stage 2 Response Type	Drop List	Not Used	See Table 5
Stage 2 Blink Rate	0 to 60000 ms	Not Used	
Stage 3 Control Source	Drop List	0, Control Not Used	See Table 21
Stage 3 Control Number	Depends on Source	Not Used	See Table 21
Stage 3 Output Type	Drop List	Not Used	See Table 4
Stage 3 Response Type	Drop List	Not Used	See Table 5
Stage 3 Blink Rate	0 to 60000 ms	Not Used	
Stage 4 Control Source	Drop List	0, Control Not Used	See Table 21
Stage 4 Control Number	Depends on Source	Not Used	See Table 21
Stage 4 Output Type	Drop List	Not Used	See Table 4
Stage 4 Response Type	Drop List	Not Used	See Table 5
Stage 4 Blink Rate	0 to 60000 ms	Not Used	
Stage 5 Control Source	Drop List	0, Control Not Used	See Table 21
Stage 5 Control Number	Depends on Source	Not Used	See Table 21
Stage 5 Output Type	Drop List	Not Used	See Table 4
Stage 5 Response Type	Drop List	Not Used	See Table 5
Stage 5 Blink Rate	0 to 60000 ms	Not Used	
Stage 6 Control Source	Drop List	0, Control Not Used	See Table 21
Stage 6 Control Number	Depends on Source	Not Used	See Table 21
Stage 6 Output Type	Drop List	Not Used	See Table 4
Stage 6 Response Type	Drop List	Not Used	See Table 5
Stage 6 Blink Rate	0 to 60000 ms	Not Used	
Default Stage Output Type	Drop List	Green	See Table 4
Default Stage Response Type	Drop List	Dim On/OFF	See Table 5
Default Stage Blink Rate	0 to 60000 ms	Not Used	

### 4.3. Digital Input Setpoints

The Digital Input function block is defined in Section 1.3. Please refer there for detailed information about how all these setpoints are used.



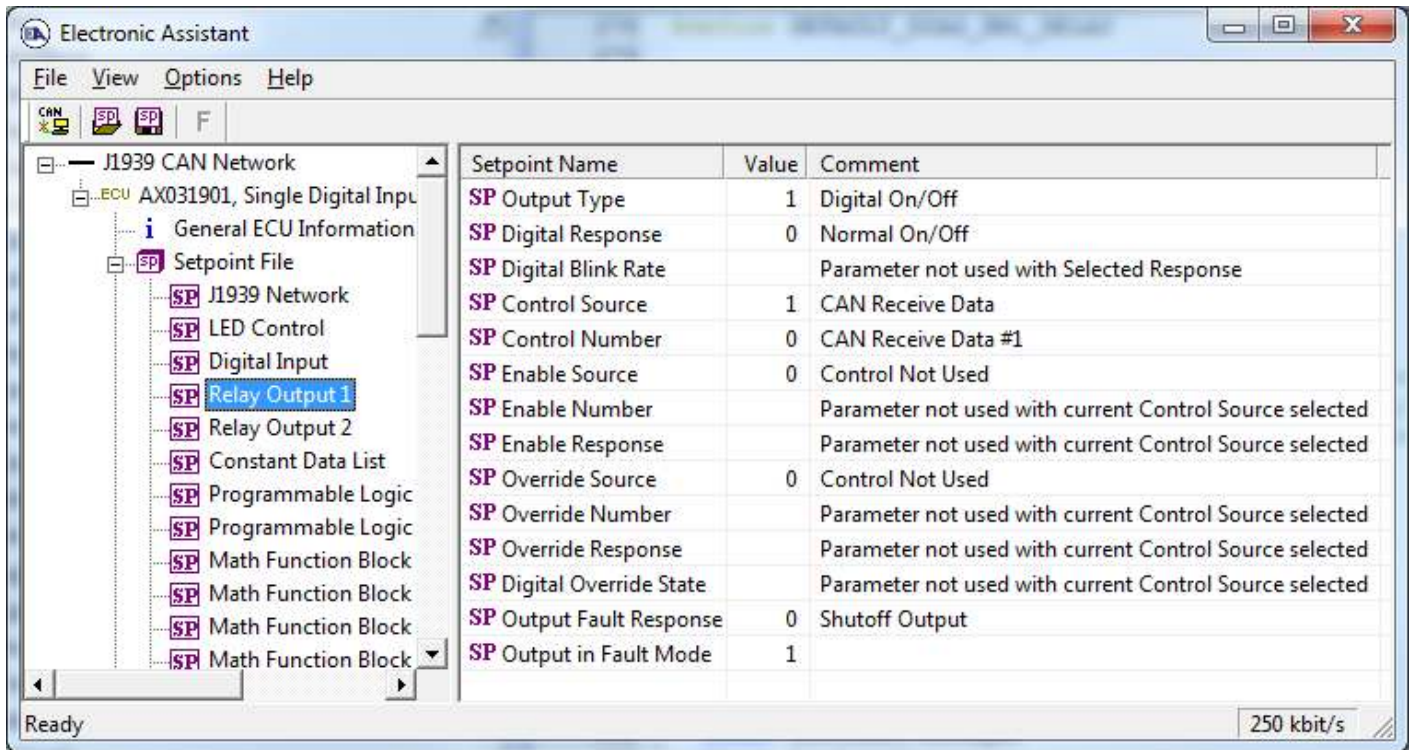
**Screen Capture of Default Digital Input Setpoints**

Name	Range	Default	Notes
Input Sensor Type	Drop List	60 – Digital (Normal)	Refer to Section 1.2
Pulses per Revolution	0 to 60000	0	If set to 0, measurements are taken in Hz. If value is set greater than 0, measurements are taken in RPM
Minimum Error	Depends on Sensor Type	Not used with default sensor type	Refer to Section 1.2.1
Minimum Range	Depends on Sensor Type	0, OFF	Refer to Section 1.2.1
Maximum Range	Depends on Sensor Type	1, ON	Refer to Section 1.2.1
Maximum Error	Depends on Sensor Type	Not used with default sensor type	Refer to Section 1.2.1
Debounce Time	Drop List	Not used with default sensor type	
Digital Input Type Software Debounce Filter Type	0 to 60000	10 (ms)	Debounce time for Digital On/Off input type
Software Filter Type	Drop List	Not used with default sensor type <i>r</i>	Refer to Section 1.2.2. This function is not used in Digital and Counter input types
Software Filter Constant	0 to 60000	Not used with default sensor type	Refer to Section 1.2.3
Fault Detection is Enabled	Drop List	Not used with default sensor type	Refer to Section 1.8

Event Generates a DTC in DM1	Drop List	Not used with default sensor type	Refer to Section 1.8
Hysteresis to Clear Fault	Depends on Sensor Type	Not used with default sensor type	Refer to Section 1.8
Lamp Set by Event in DM1	Drop List	Not used with default sensor type	Refer to Section 1.8
SPN for Event used in DTC	0 to 0x1FFFFFFF	Not used with default sensor type	Refer to Section 1.8
FMI for Event used in DTC	Drop List	Not used with default sensor type	Refer to Section 1.8
Delay Before Sending DM1	0 to 60000	Not used with default sensor type	Refer to Section 1.8

#### 4.4. Relay Output Setpoints

The Relay Output function block is defined in Section 1.3. Please refer there for detailed information about how all these setpoints are used.



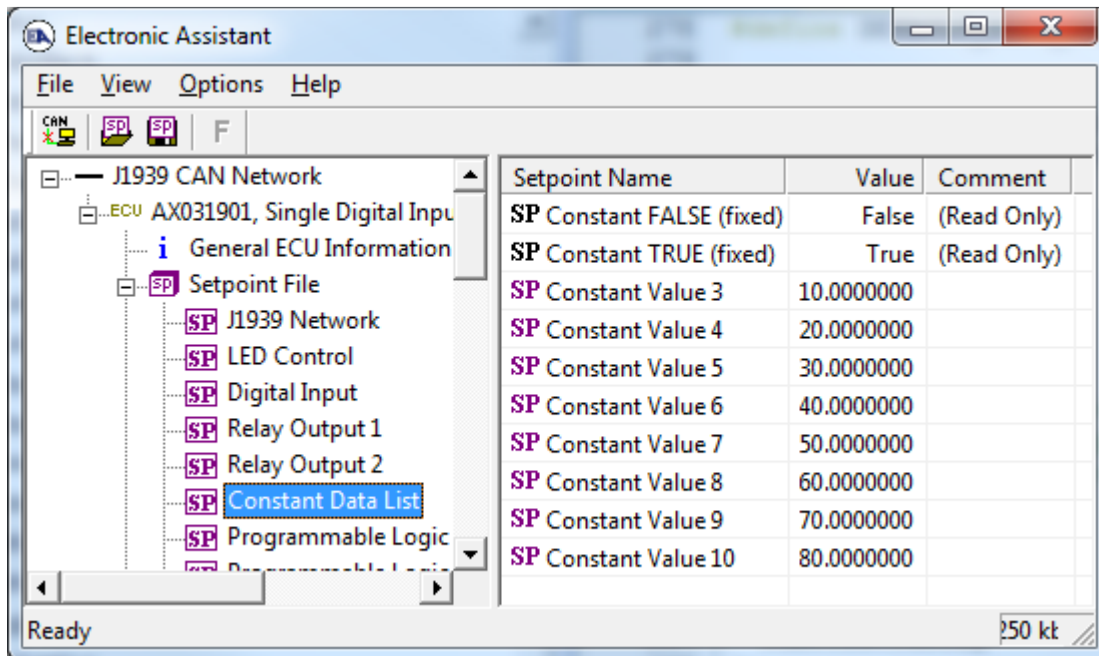
**Screen Capture of Default Relay Output 1 Setpoints**

<b>Name</b>	<b>Range</b>	<b>Default</b>	<b>Notes</b>
Output Type	Drop List	1, Digital On/Off	See Table 8
Digital Response	Drop List	0, Normal On/Off	See Table 9
Digital Blink Rate	10 to 5000 ms	500 ms	Only used with 'Blinking' response
Control Source	Drop List	1, Received CAN J1939 Message	See Table 20
Control Number	Per Source	0, Received CAN J1939 Message # 1	See Table 20
Enable Source	Drop List	0, Control Source Not Used	See Table 20
Enable Number	Per Source	N/A	See Table 20
Enable Response	Drop List	N/A	See Table 6
Override Source	Drop List	0, Control Source Not Used	See Table 20
Override Number	Per Source	N/A	See Table 20
Override Response	Drop List	N/A	0 = Override When On 1 = Override When Off
Digital Override State	0 or 1	1, ON	
Control Fault Response	Drop List	0, Shutoff Output	See Table 7
Output in Fault Mode	Depends on Output Type	1, ON	See limits on ranges per output type outlined above

## 4.5. Constant Data List Setpoints

The Constant Data List function block is provided to allow the user to select values as desired for various logic block functions.

The first two constants are fixed values of 0 (False) and 1 (True) for use in binary logic. The remaining 12 constants are fully user programmable to any value between +/- 1,000,000. The default values (shown below) are arbitrary and should be configured by the user as appropriate for their application.



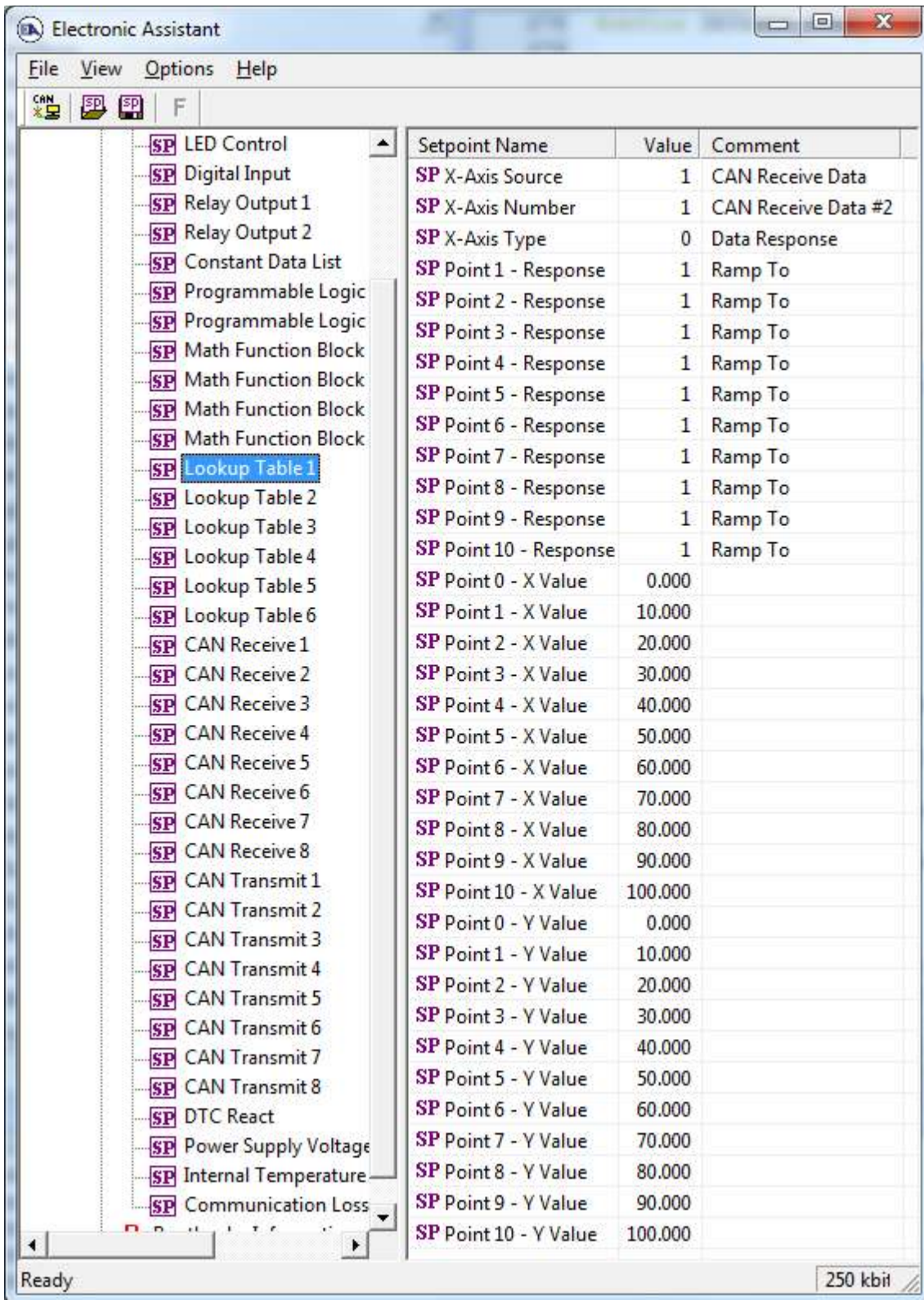
The screenshot shows the 'Electronic Assistant' software window. The left pane displays a tree view of the CAN network configuration, with 'Constant Data List' selected. The right pane shows a table of setpoints.

Setpoint Name	Value	Comment
SP Constant FALSE (fixed)	False	(Read Only)
SP Constant TRUE (fixed)	True	(Read Only)
SP Constant Value 3	10.0000000	
SP Constant Value 4	20.0000000	
SP Constant Value 5	30.0000000	
SP Constant Value 6	40.0000000	
SP Constant Value 7	50.0000000	
SP Constant Value 8	60.0000000	
SP Constant Value 9	70.0000000	
SP Constant Value 10	80.0000000	

*Screen Capture of Default Constant Data List Setpoints*

## 4.6. Lookup Table Setpoints

The Lookup Table function block is defined in Section 1.5. Please refer there for detailed information about how all these setpoints are used. As this function block's X-Axis defaults are defined by the “**X-Axis Source**” selected from Table 19, there is nothing further to define in terms of defaults and ranges beyond that which is described in Section 1.5. Recall, the X-Axis values will be automatically updated if the min/max range of the selected source is changed.



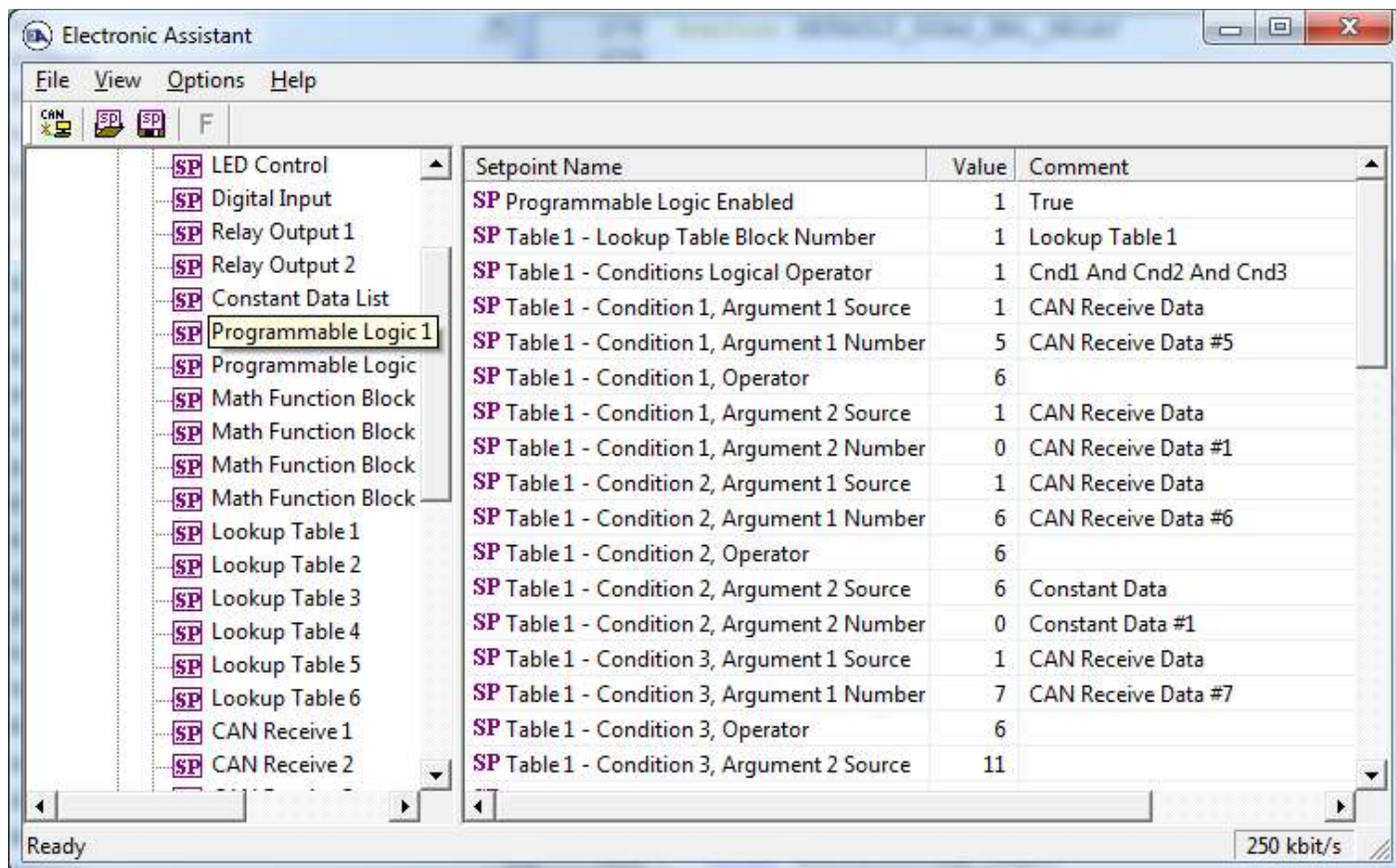
**Screen Capture of Example Lookup Table 1 Setpoints**

*Note: In the screen capture shown above, the “X-Axis Source” has been changed from its default value in order to enable the function block.*

## 4.7. Programmable Logic Setpoints

The Programmable Logic function block is defined in Section 1.6. Please refer there for detailed information about how all these setpoints are used.

As this function block is disabled by default, there is nothing further to define in terms of defaults and ranges beyond that which is described in Section 1.6. The screen capture below shows how the setpoints referenced in that section appear on EA.



**Screen Capture of Default Programmable Logic 1 Setpoints**

*Note: In the screen capture shown above, the “Programmable Logic Block Enabled” has been changed from its default value in order to enable the function block.*

*Note: The default values for the Argument1, Argument 2 and Operator are all the same across all the Programmable Logic function blocks, and must therefore be changed by the user as appropriate before this can be used.*

## 4.8. Math Function Setpoints

The Math Function block is defined in Section 1.7. Please refer there for detailed information about how all these setpoints are used.

Setpoint Name	Value	Comment
SP Math Function Enabled	1	True
SP Function 1 Input A Source	1	CAN Receive Data
SP Function 1 Input A Number	2	CAN Receive Data #3
SP Function 1 Input A Minimum	0.00	
SP Function 1 Input A Maximum	100.00	
SP Function 1 Input A Scaler	1.00	
SP Function 1 Input B Source	1	CAN Receive Data
SP Function 1 Input B Number	5	CAN Receive Data #6
SP Function 1 Input B Minimum	0.00	
SP Function 1 Input B Maximum	100.00	
SP Function 1 Input B Scaler	1.00	
SP Math Function 1 Operation	9	+, Result = InA plus InB
SP Function 2 Input B Source	0	Control Not Used
SP Function 2 Input B Number		Parameter not used with current Control Source selected
SP Function 2 Input B Minimum		Parameter not used with current Control Source selected
SP Function 2 Input B Maximum		Parameter not used with current Control Source selected
SP Function 2 Input B Scaler		Parameter not used with current Control Source selected
SP Math Function 2 Operation (Input A = Result of Function 1)		Parameter not used with current Control Source selected
SP Function 3 Input B Source	0	Control Not Used
SP Function 3 Input B Number		Parameter not used with current Control Source selected
SP Function 3 Input B Minimum		Parameter not used with current Control Source selected
SP Function 3 Input B Maximum		Parameter not used with current Control Source selected
SP Function 3 Input B Scaler		Parameter not used with current Control Source selected
SP Math Function 3 Operation (Input A = Result of Function 2)		Parameter not used with current Control Source selected
SP Math Output Minimum Range	0.00	
SP Math Output Maximum Range	200.00	

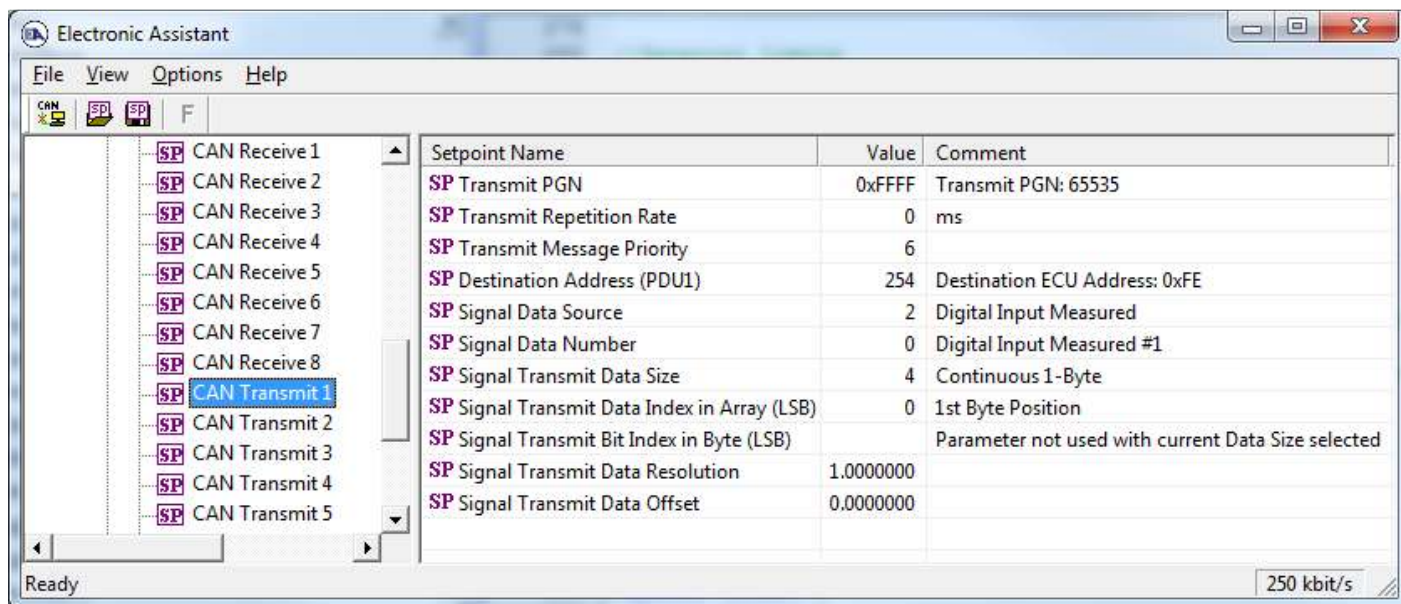
Screen Capture of Example Math Function 1 Setpoints

Note: In the screen capture shown above, the “Math Function Enabled” has been changed from its default value in order to enable the function block. Other setpoints have also been changed from default values in order to illustrate how the block might look when functional, as per the example outlined in Section 1.8.

Name	Range	Default	Notes
Math Function Enabled	Drop List	0, False	True or False
Math Input X Source (X = 1 to 4)	Drop List	0, Control Source Not Used	See Table 20
Math Input X Number	Per Source	0	See Table 20
Math Input X Minimum	$-10^6$ to $10^6$	0.0	Converts input to a percentage before use in the calculation.
Math Input X Maximum	$-10^6$ to $10^6$	100.0	
Math Input X Scaler	-1.00 to 1.00	1.00	See Section 1.7
Math Output Minimum Range	$-10^6$ to $10^6$	0.0	Converts calculation from a percentage value to the desired physical unit.
Math Output Maximum Range	$-10^6$ to $10^6$	100.0	

## 4.9. CAN Transmit Setpoints

The CAN Transmit function block is defined in Section 1.10, with additional information in Section 3.3. Please refer there for detailed information about how all these setpoints are used.



**Screen Capture of Default CAN Transmit 1 Setpoints**

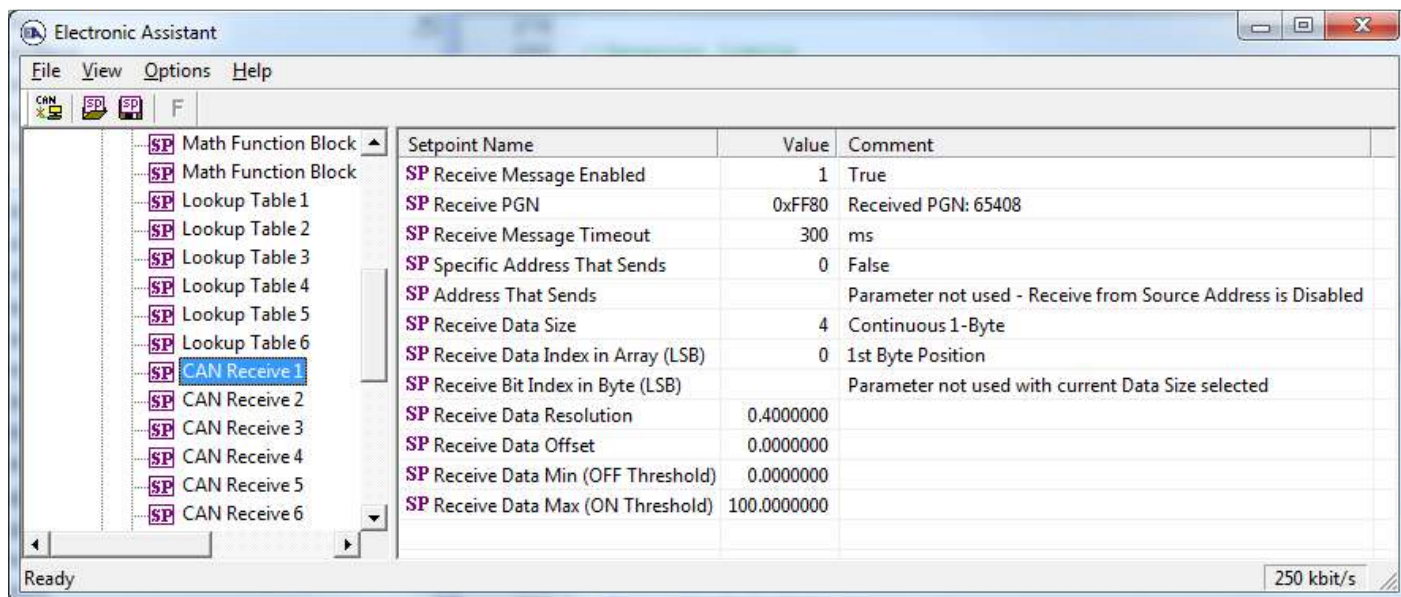
Name	Range	Default	Notes
Transmit Data Source	Drop List	Different for each	See Table 20 for defaults
Transmit Data Number	Per Source	Different for each	See Table 20 for defaults
Transmit PGN	0 to 65535	65280 (\$FF00) Txd1 to 2	See Section 3.3 for defaults
Transmit Repetition Rate	0 to 60,000 ms	0	0ms disables transmit
Transmit Message Priority	0 to 7	6	Proprietary B Priority
Destination Address (for PDU1)	0 to 255	254 (0xFE, Null Address)	Not used by default
Transmit Data Size	Drop List	Different for each	0 = Not Used (disabled) 1 = 1-Bit 2 = 2-Bits 3 = 4-Bits 4 = 1-Byte 5 = 2-Bytes 6 = 4-Bytes See Section 3.3 for defaults
Transmit Data Index in Array (LSB)	1 to 9-DataSize	Different for each	See Section 3.3 for defaults
Transmit Bit Index in Byte (LSB)	1 to 9-BitSize	Different for each	Only used with Bit Data Types
Transmit Data Resolution	$-10^6$ to $10^6$	Different for each	See Section 3.3 for defaults
Transmit Data Offset	$-10^4$ to $10^4$	Different for each	See Section 3.3 for defaults



Recall that when multiple messages are sent on the same PGN, only the **LOWEST** Indexed channel's *Repetition Rate* will be used. This means that even if a non-zero value is selected on a higher channel, but the lowest is still 0, no message will be sent.

## 4.10. CAN Receive Setpoints

The CAN Receive function block is defined in Section 1.11, with additional information in Section 3.4. Please refer there for detailed information about how all these setpoints are used.



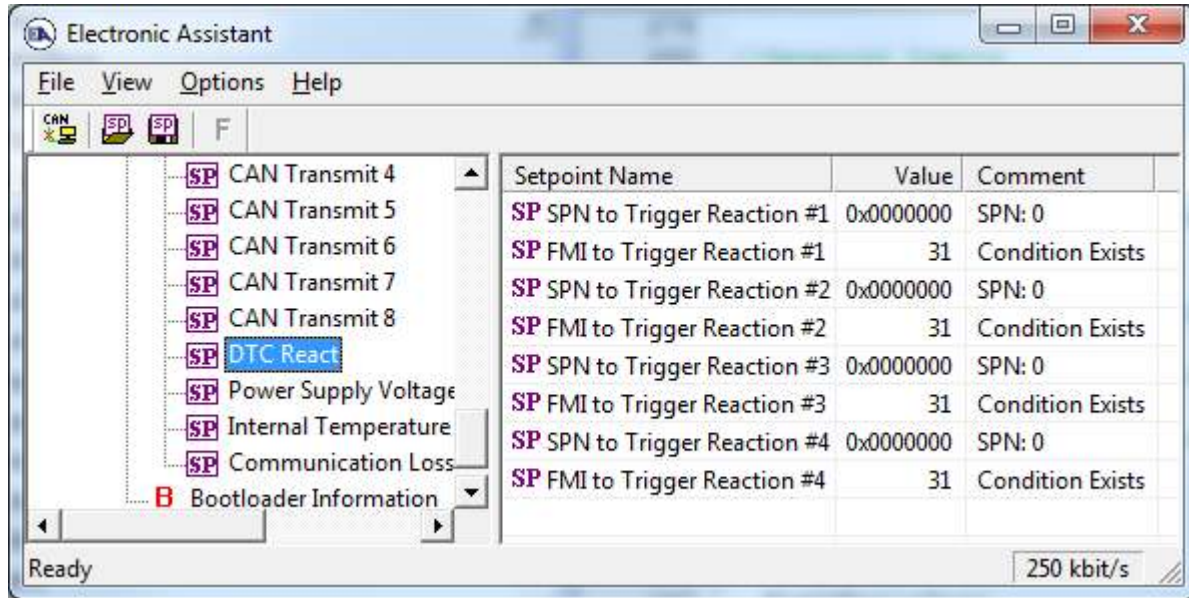
Screen Capture of Default CAN Receive 1 Setpoints

*Note: If the "Received Message Enabled" setpoint is False all other setpoints read "No Control Source, Function Block Disabled"*

Name	Range	Default	Notes
Received Message Enabled	False or True	False	See note above
Received PGN	0 to 65535	65408 (\$FF80)	See Section 3.4 for defaults
Received Message Timeout	0 to 60,000 ms	300 ms	Expects all data at 100ms
Specific Address that sends PGN	0 to 255	254 (0xFE, Null Addr)	Not used by default
Receive Data Size	Drop List	Different for each	0 = Not Used (disabled) 1 = 1-Bit 2 = 2-Bits 3 = 4-Bits 4 = 1-Byte 5 = 2-Bytes 6 = 4-Bytes See Section 3.4 for defaults
Receive Data Index in Array (LSB)	1 to 9-DataSize	Different for each	See Section 3.4 for defaults
Receive Bit Index in Byte (LSB)	1 to 9-BitSize	Different for each	Only used with Bit Data Types
Receive Data Resolution	$-10^6$ to $10^6$	Different for each	See Section 3.4 for defaults
Receive Data Offset	-10,000 to 10,000	Different for each	See Section 3.4 for defaults
Received Data Min (Off Threshold)	$-10^6$ to Max	0.0	See Section 3.4 for defaults
Received Data Max (On Threshold)	$-10^4$ to $10^4$	100.0	See Section 3.4 for defaults

#### 4.11. DTC React Setpoints

The DTC React function block is defined in Section 1.9. Please refer there for detailed information about how all these setpoints are used.



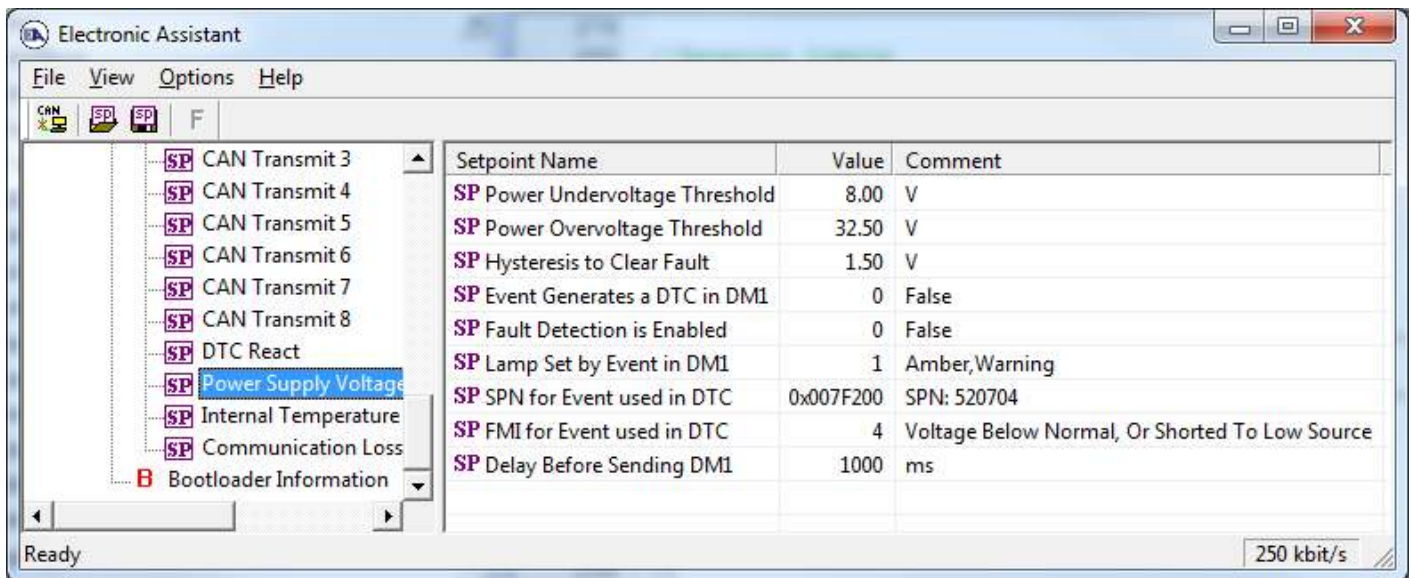
**Screen Capture of Default DTC React Setpoints**

Name	Range	Default	Notes
SPN to Trigger Reaction #X	0 to 524287	0	0 is an illegal value, and disables the DTC
FMI to Trigger Reaction #X	Drop List	31, Condition Exists	Supports all FMIs in the J1939 standard

Where X = 1 to 4

#### 4.12. [Additional] Diagnostic Setpoints

Here, the [Additional] diagnostics are Power Supply, Over Temperature and Lost Communication. The Diagnostic function block is defined in Section 1.8. Please refer there for detailed information about how all these setpoints are used.



**Screen Capture of Default Power Supply Diag Setpoints**

*Note: By default, the “Event Generates at DTC in DM1” is actually False, but it was changed to get the screen capture.*

<b>Name</b>	<b>Range</b>	<b>Default</b>	<b>Notes</b>
Fault Detection is Enabled	False or True	True	See Section 1.8
Power Undervoltage Threshold *	7.5V to Over V	8.00 V	
Power Overvoltage Threshold *	Under V to 65V	30.00 V	
Over Temperature Shutdown **	0 to 125 DegC	125.00 Deg C	
Hysteresis to Clear Fault	0.01 to 250.00	1.50 V 5.00 DegC N/A	Power Temp Comm See Section 1.8
Power Fault Disables Outputs *	False or True	False	
Event Generates a DTC in DM1	False or True	False	See Section 1.8
Event Cleared Only by DM11	False or True	False	See Section 1.8
Lamp Set by Event in DM1	Drop List	1, Amber, Warning	See Section 1.8
SPN for Event used in DTC	1 to 524287	520704 (\$7F200) 520960 (\$7F300) 521216 (\$7F400)	Power Temp Comm See Section 1.8
FMI for Event used in DTC	Drop List	4, Voltage Below Normal 0, Data Above Normal–Most Sever 19, Received Data Error	Power Temp Comm See Section 1.8
Delay Before Sending DM1	0 to 60,000 ms	1000 ms	See Section 1.8

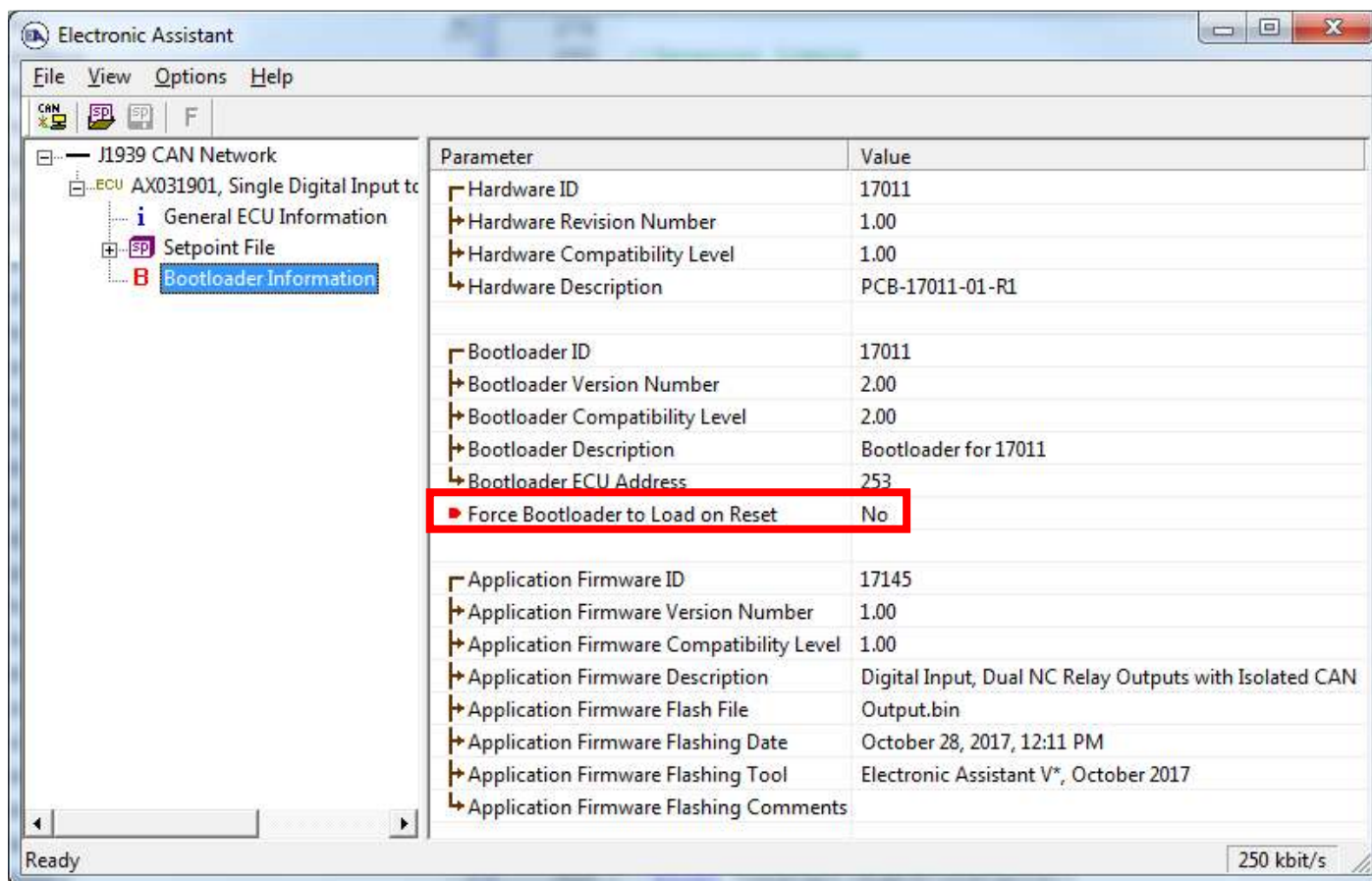
\* Only used with Power Supply Diag group

\*\* Only used with Over Temperature Diag group

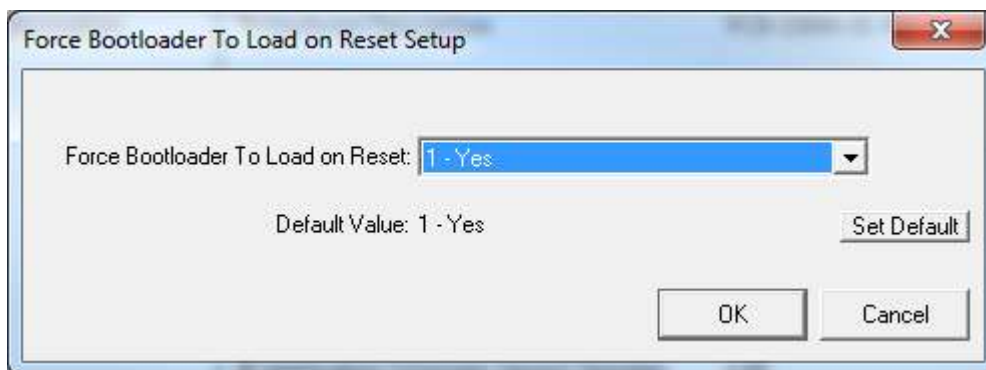
## 5. REFLASHING OVER CAN WITH EA® BOOTLOADER

The AX031901 can be upgraded with new application firmware using the **Bootloader Information** section. This section details the simple step-by-step instructions to upload new firmware provided by Axiomatic onto the unit via CAN, without requiring it to be disconnected from the J1939 network.

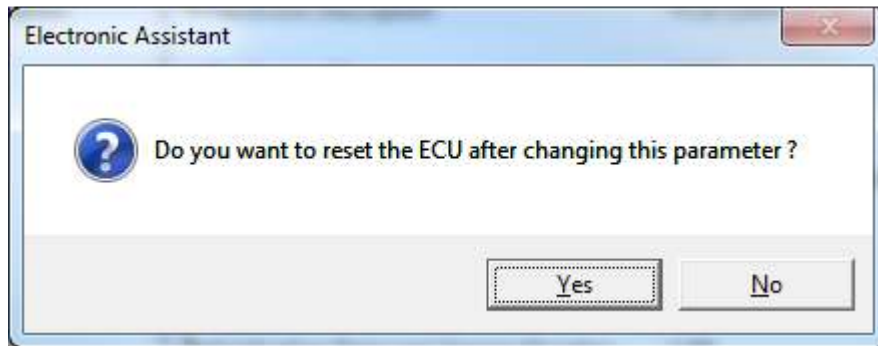
1. When EA first connects to the ECU, the **Bootloader Information** section will display the following information.



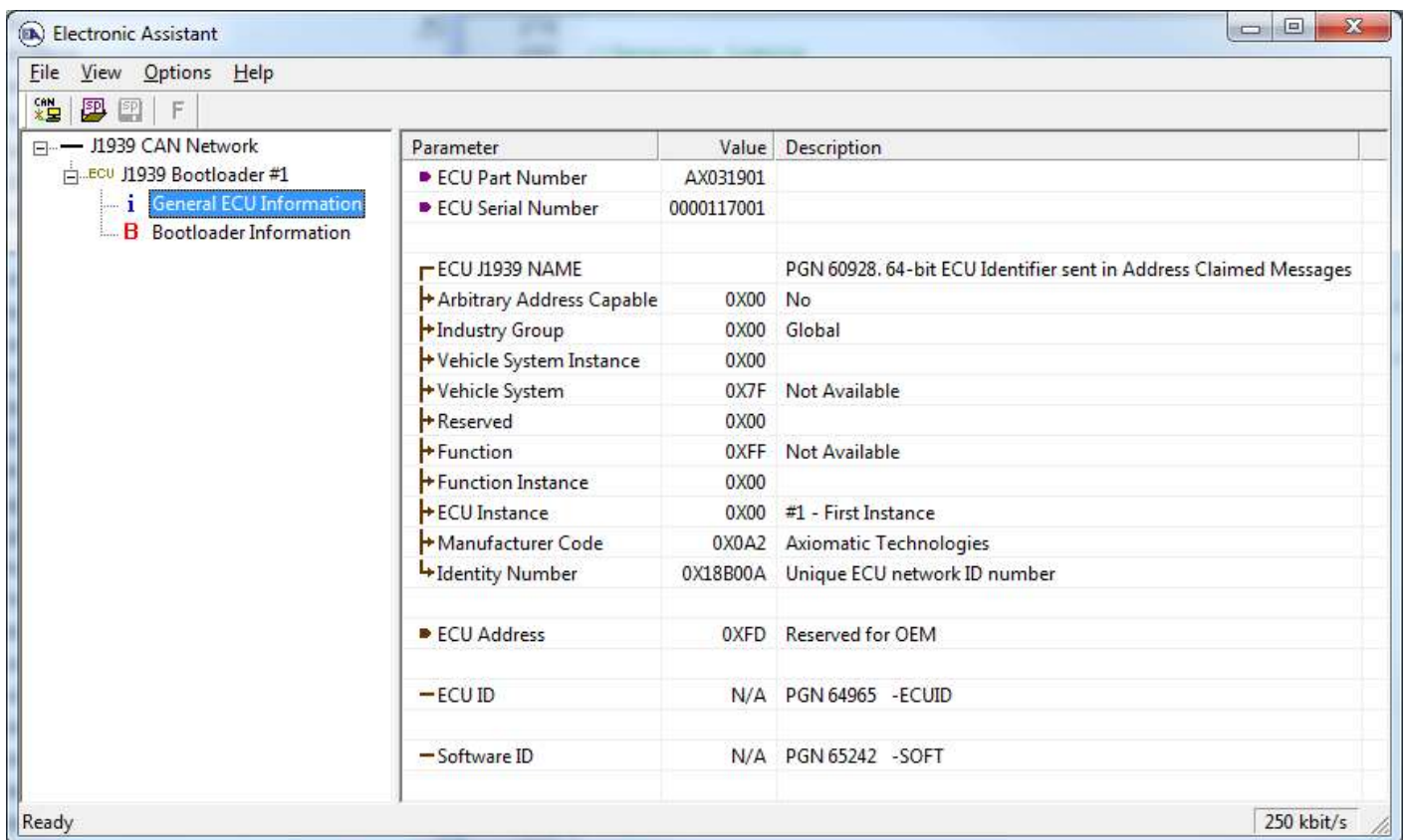
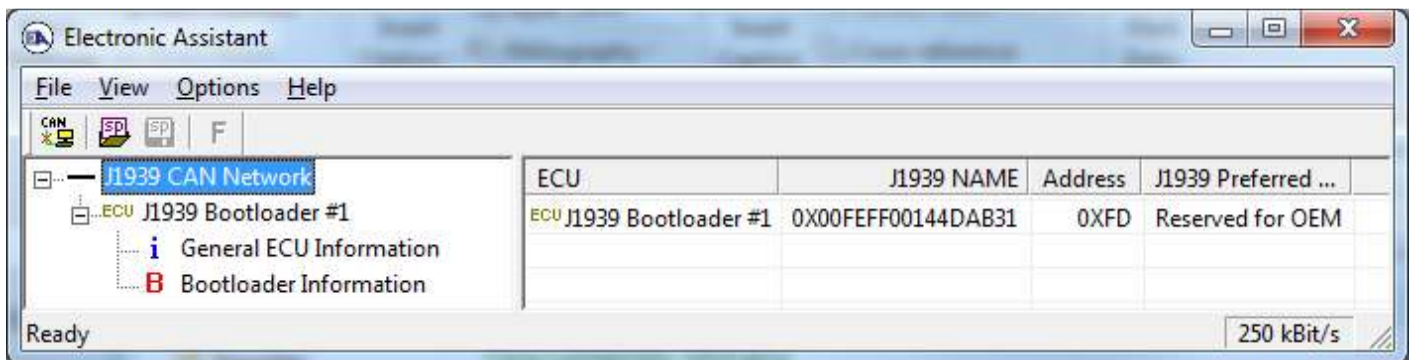
2. To use the bootloader to upgrade the firmware running on the ECU, change the variable **“Force Bootloader To Load on Reset”** to Yes.



3. When the prompt box asks if you want to reset the ECU, select Yes.

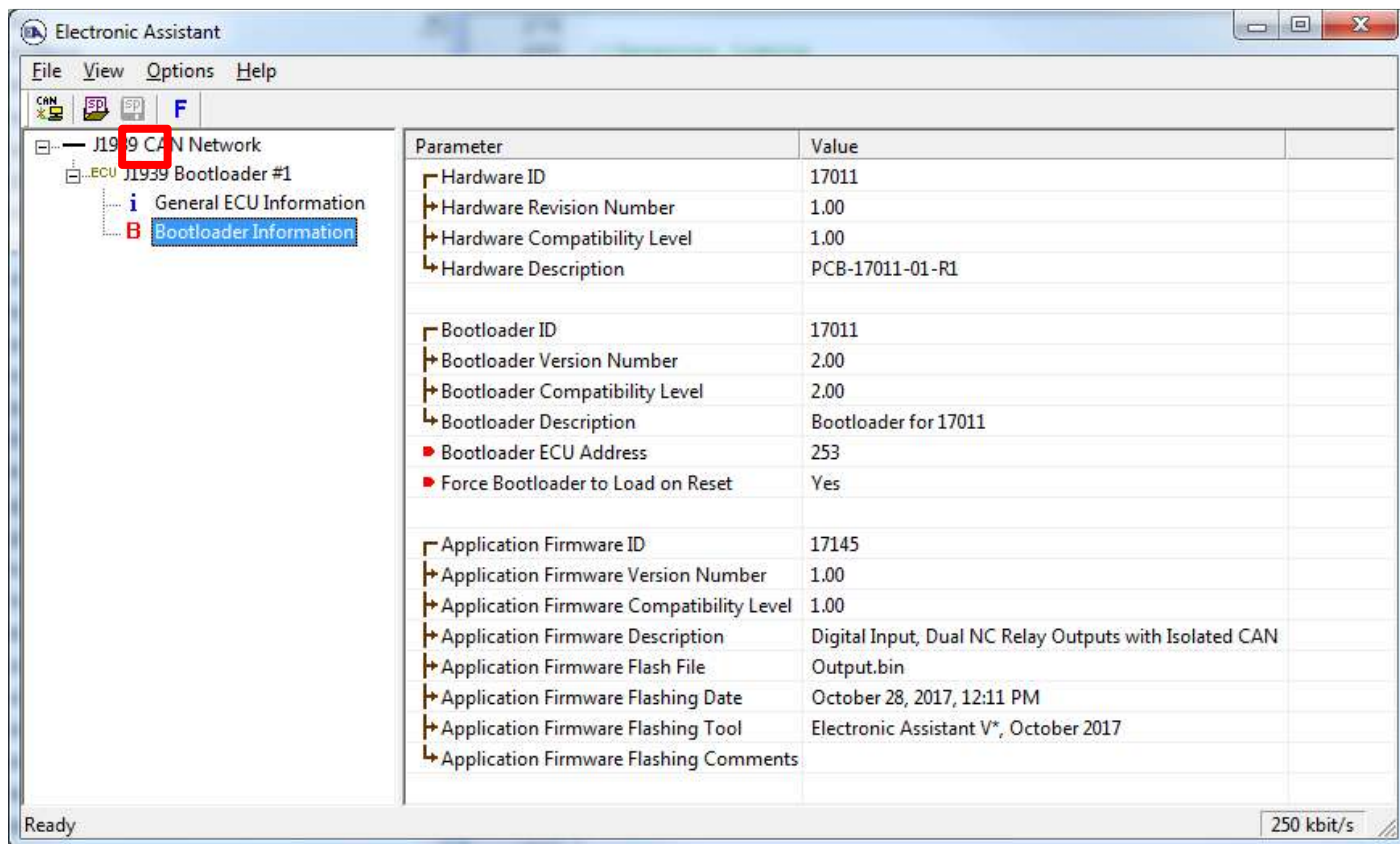


- Upon reset, the ECU will no longer show up on the J1939 network as an AX031901 but rather as **J1939 Bootloader #1**.



Note that the bootloader is NOT Arbitrary Address Capable. This means that if you want to have multiple bootloaders running simultaneously (not recommended) you would have to manually change the address for each one before activating the next, or there will be address conflicts, and only one ECU would show up as the bootloader. Once the 'active' bootloader returns to regular functionality, the other ECU(s) would have to be power cycled to re-activate the bootloader feature.

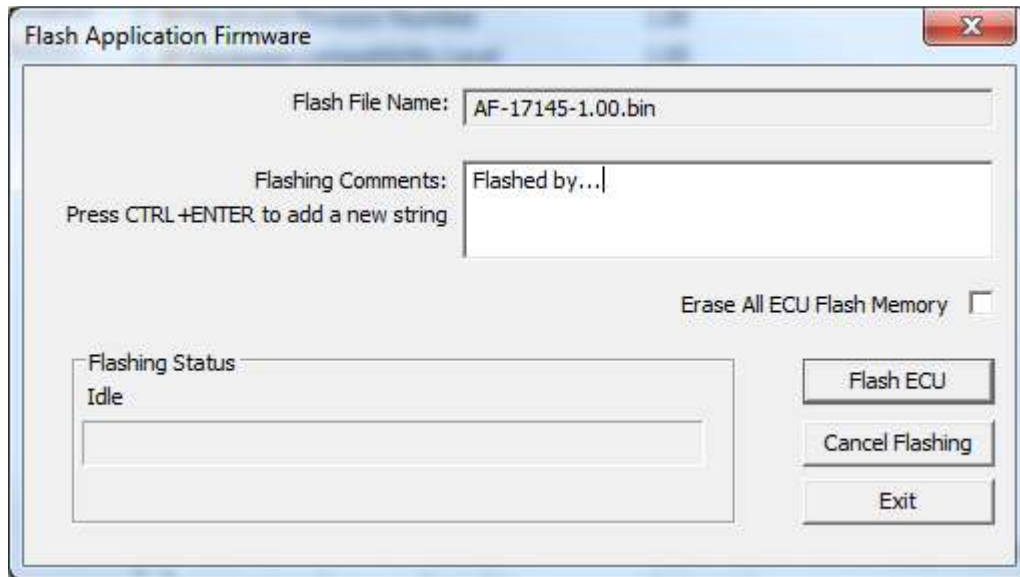
- When the **Bootloader Information** section is selected, the same information is shown as when it was running the AX031901 firmware, but in this case the **Flashing** feature has been enabled.



- Select the **Flashing** button and navigate to where you had saved the **AF-17145\_x.yy.bin** file sent from Axiomatic. (Note: only binary (.bin) files can be flashed using the EA tool)

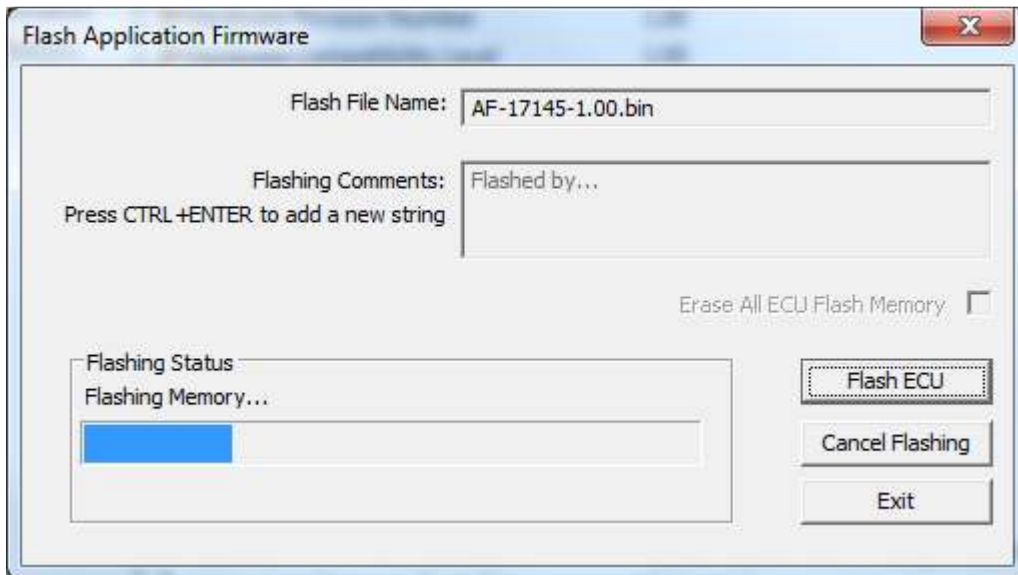
- Once the Flash Application Firmware window opens, you can enter comments such as “Firmware upgraded by [Name]” if you so desire. This is not required, and you can leave the field blank if you do not want to use it.

Note: You do not have to date/time-stamp the file, as this is done automatically by the EA tool when you upload the new firmware.



**WARNING:** Do not check the “Erase All ECU Flash Memory” box unless instructed to do so by your Axiomatic contact. Selecting this will erase ALL data stored in non-volatile flash, including the calibration done by Axiomatic during factory testing. It will also erase any configuration of the setpoints that might have been done to the ECU and reset all setpoints to their factory defaults. By leaving this box unchecked, none of the setpoints will be changed when the new firmware is uploaded.

- A progress bar will show how much of the firmware has been sent as the upload progresses. The more traffic there is on the J1939 network, the longer the upload process will take.



9. Once the firmware has finished uploading, a message will popup indicating the successful operation. If you select to reset the ECU, the new version of the AX031901 application will start running, and the ECU will be identified as such by EA. Otherwise, The next time the ECU is power-cycled, the AX031901 application will run rather than the bootloader function.



Note: If at any time during the upload the process is interrupted, the data is corrupted (bad checksum) or for any other reason the new firmware is not correct, i.e. bootloader detects that the file loaded was not designed to run on the hardware platform, the bad or corrupted application will not run. Rather, when the ECU is reset or power-cycled the **J1939 Bootloader** will continue to be the default application until valid firmware has been successfully uploaded into the unit.

## 6. TECHNICAL SPECIFICATIONS

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### 6.1. Power

Power Supply Input	12Vdc or 24 Vdc nominal 4...36 Vdc power supply range
Protection	Reverse polarity protection up to -100V. Under-voltage protection is down to 3.5V. Overvoltage protection is up to 40 V.
Voltage Sags	0.5V for 0.2 seconds 4V continuous

### 6.2. Input

Digital Input	Internal fixed pull up
Frequency Input	Frequency types: 0.5Hz to 50Hz, 10Hz to 1kHz, 100Hz to 10kHz; RPM; and PWM %DC
Input Accuracy	< 1%
Input Resolution	16-bit Timer

### 6.3. Relay Outputs

Relay Outputs	2 Form C Relays NC 3 contact pins per output Max. 2A @ 250Vac or 2A @ 30Vdc per contact
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### 6.4. General Specifications

Microprocessor	STM32F103CBT7, 32-bit, 128 Kbytes Flash Program Memory
Isolation	300 Vrms CAN bus Isolation
Typical Quiescent Current	18.47mA @ 12Vdc; 10.28mA @ 24Vdc (During Normal Operation)
Control Logic	Standard embedded software is provided.
Communications	1 Isolated CAN port (SAE J1939)
LED Indicators	Red and Green LEDs with application-specific responses
Operating Conditions	-40 to 85 °C (-40 to 185 °F)
Storage Temperature	-55 to 125 °C (-67 to 257°F)
Protection	IP40 (housing), Terminals IP20
Weight	0.20 lbs. (0.091 kg)

## 7. VERSION HISTORY

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<b>Version</b>	<b>Date</b>	<b>Author</b>	<b>Comments</b>
V1A	October 28, 2017	Gustavo Del Valle	Initial Draft



## OUR PRODUCTS

Actuator Controls  
Battery Chargers  
CAN bus Controls, Gateways  
CAN/Wifi, CAN/Bluetooth  
Current Converters  
DC/DC Power Converters  
DC Voltage/Current Signal Converters  
Engine Temperature Scanners  
Ethernet/CAN Converters  
Fan Drive Controllers  
Hydraulic Valve Controllers  
I/O Controls  
LVDT Simulators  
Machine Controls  
Motor Controls  
PID Controls  
Position Sensors, Angle Measurement Inclinometers  
Power Supplies  
PWM Signal Converters/Isolators  
Resolver Signal Conditioners  
Service Tools  
Signal Conditioners  
Strain Gauge CAN Controls  
Surge Suppressors

## OUR COMPANY

Axiomatic provides electronic machine controls, components, and systems to the off-highway, commercial vehicle, electric vehicle, power generator set, material handling, renewable energy and industrial OEM markets.

We provide efficient, innovative solutions that focus on adding value for our customers.

We emphasize service and partnership with our customers, suppliers, and employees to build long term relationships and mutual trust.

## QUALITY DESIGN AND MANUFACTURING

Axiomatic is an ISO 9001:2008 registered facility.

## SERVICE

All products to be returned to Axiomatic require a Return Materials Authorization Number (RMA#).

Please provide the following information when requesting an RMA number:

- Serial number, part number
- Axiomatic invoice number and date
- Hours of operation, description of problem
- Wiring set up diagram, application
- Other comments as needed

When preparing the return shipping paperwork, please note the following. The commercial invoice for customs (and packing slip) should state the harmonized international HS (tariff code), valuation and return goods terminology, as shown in italics below. The value of the units on the commercial invoice should be identical to their purchase price.

*Goods Made In Canada (or Finland)  
Returned Goods for Warranty Evaluation, HS: 9813.00  
Valuation Identical Goods  
Axiomatic RMA#*

## WARRANTY, APPLICATION APPROVALS/LIMITATIONS

Axiomatic Technologies Corporation reserves the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. Users should satisfy themselves that the product is suitable for use in the intended application. All our products carry a limited warranty against defects in material and workmanship. Please refer to our Warranty, Application Approvals/Limitations and Return Materials Process as described on [www.axiomatic.com/service.html](http://www.axiomatic.com/service.html).

## CONTACTS

**Axiomatic Technologies Corporation**  
5915 Wallace Street  
Mississauga, ON  
CANADA L4Z 1Z8  
TEL: +1 905 602 9270  
FAX: +1 905 602 9279  
[www.axiomatic.com](http://www.axiomatic.com)

**Axiomatic Technologies Oy**  
Höytämöntie 6  
33880 Lempäälä  
FINLAND  
TEL: +358 3 3595 600  
FAX: +358 3 3595 660  
[www.axiomatic.fi](http://www.axiomatic.fi)