



User Manual UMAX100310

Universal 25A DC Motor Controller

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VERSION HISTORY

Version	Date	Author	Modification
1.00	June 8, 2020	Erik Sasse	Initial Draft

ACRONYMS

CAN	Controller Area Network
DM	Diagnostic message. Defined in J1939/73 standard
EA	Electronic Assistant. PC application software from Axiomatic, primarily designed to view and program Axiomatic control configuration parameters (setpoints) through CAN bus using J1939 Memory Access Protocol
ECU	Electronic control unit
EMI	Electromagnetic Interference
LIN	Local Interconnect Network. Automotive network maintained by the LIN Consortium
LSB	Less Significant Byte
PC	Personal Computer
PGN	Parameter Group Number. Defined in J1939/73 standard
P/N	Part Number
RS-232	PC serial port interface
CANopen	CAN-based higher level protocol designed and supported by CAN in Automation (CiA)
USB	Universal Serial Bus
UTP	Un-shielded twisted pair
BCD	Binary Code Decimal

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1 INTRODUCTION

The following user manual describes architecture, functionality, configuration parameters and flashing instructions for the Universal 25A DC Motor Controller. It also contains technical specifications and installation instructions to help users build a custom solution on the base of this controller.

The user should check whether the application firmware installed in the controller is covered by this user manual. The user manual is valid for application firmware with the same major version number as the user manual. For example, this user manual is valid for any controller application firmware V1.xx. Updates specific to the user manual are done by adding letters: A, B, ..., Z to the user manual version number.

The motor controller supports one motor output, one Encoder Input with three input signals for A, b, and Z, as well as two universal inputs. Its flexible hardware design allows the controller to have a wide range of input-types for each of the inputs. The sophisticated control algorithms/logical function blocks allow the user to configure the controller for a wide range of applications without the need for custom firmware. ... shows the hardware functional block diagram of the Universal 25A DC Motor Controller.

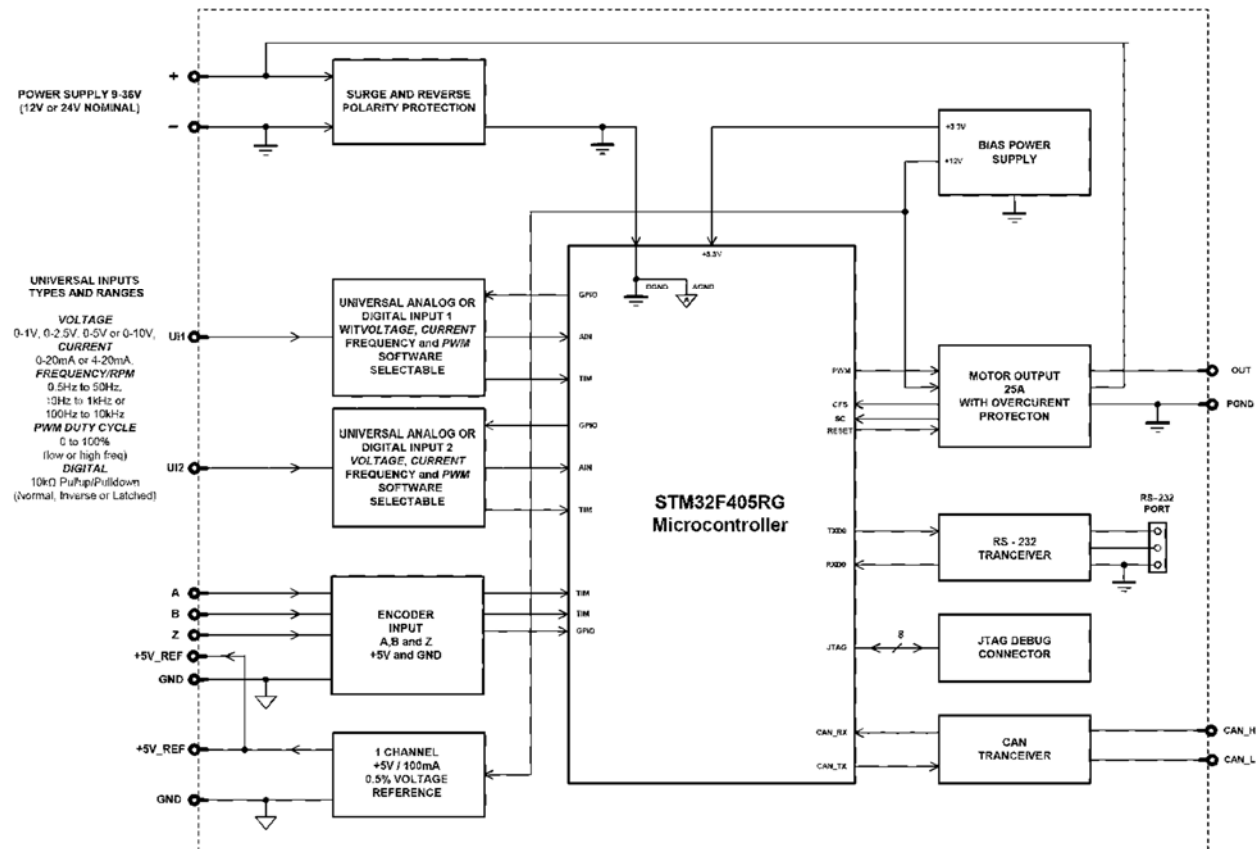


Table 1: Hardware Functional Block Diagram

This unit uses the CANJ1939 standard protocol to transmit and receive data, which operates with auto baud rate detection by default.

This controller accepts power supply voltages from 9 to 36 VDC.

2 CONTROLLER DESCRIPTION

The motor converter is internally organized as a set of function blocks, which can be individually configured and arbitrarily connected to achieve the required system functionality.

The Universal Motor Controller can drive one motor and has additionally two Universal Inputs as well as three inputs to connect an incremental encoder. Furthermore, the motor controller has several function blocks to use the motor controller in a wider spectrum of applications. All these function blocks are explained in more detail in the upcoming subchapters.

Measured input data can be sent to a SAE J1939 CAN Network as is or used in the motor controller function blocks for controlling how the motor is driven. A Windows-based Axiomatic Electronic Assistant® (EA) is used to configure the controller via an USB-CAN (AX070501) device. Configurable properties, EA setpoints, are outlined in chapter 4. Setpoint configuration can be saved in a file which can be used to easily program the same configuration into another Universal 25A DC Motor Controller. Throughout this document EA setpoint names are referred with bolded text and the setpoint option is referred with italicized. For example **Input Sensor Type** setpoint set to option *Frequency/RPM 1.3kHz to 15kHz*.

2.1 Motor Drive Function Block

The motor control output can drive a DC motor or other load with continuous 25A current. The maximum instantaneous current can go beyond this limit up to 35A. The shunt monitor on the board will detect any current value above 35A and shut off the output. This is a fixed value and is not adjustable through software.

The Motor Drive is equipped with several setpoint parameter to adjust its performance. Each parameter is explained in more detail below.

2.1.1 Motor Type

The Motor Output Type determines the output signal related to its input signal. Changing this setpoint causes other setpoints in the group to update to match the selected type, thus the **Output Type** should be selected before configuring other setpoints within the setpoint group. The Output Type setpoint options are listed in

Value	Output Type
0	Output Not Used
1	Proportional Current
2	PWM Duty Cycle
3	Proportional Voltage

Table 2: Motor Output Types

The *Proportional Current* sets the output signal corresponding to its input signal and the current feedback value measured at the output. An internal PID controller can be used for better output control which can be set with the Setpoints **Gain**, **Integral Value**, and **Derivative Value**. The PID-controller is only available for the *Proportional Current* since there is no voltage feedback. The input and output

values of the *Proportional Current* are set and measure in milli Ampere. Therefore, the Minimum and Maximum value of the output must be set in Milli Ampere as well.

The *PWM Duty Cycle* allows the user to run the output at a fixed frequency configured by the setpoint **PWM Output Frequency**, while the duty cycle changes depending on the control signal.

The *Proportional Voltage* uses the measured value of the power supply and adjusts the duty cycle of the output such that the average value will match the target output voltage.

For Proportional outputs signal minimum and maximum values are configured with **Output at Minimum Command** and **Output at Maximum Command** setpoints. Their value range is limited its by selected **Output Type**.

Regardless of what type of control input is selected, the output will always respond in a linear fashion to changes in the input per Equation

$$y = mx + a$$

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

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

Equation 1: Linear Slope Calculations

X is defined by its control input minimum and maximum ranges. Therefore, X_{min} = Control Input Minimum and X_{max} = Control Input Maximum. The Y in Equation 1 is defined by Y_{min} = **Output at Minimum Command** and Y_{max} = **Output at Maximum Command**. While X-axis has the constraint that $X_{min} < X_{max}$, the Y-axis does not have such limitation. Thus, configuring **Output At Minimum Command** to be greater than **Output At Maximum Command** allows the output to follow the control signal inversely.

2.1.2 Motor Drive Control/Enable/Override/ Sources

The Motor Drive output can be configured to be commanded and/or enabled/overridden by the control sources listed in Table 3. This table also displays the number associated to the control sources which can be selected. The default control source is highlighted in Table 3 while the default Enable Source and Override Source is configured to *Source Not Used*.

Value	Meaning	Source Range
0	Source Not Used	[0]
1	Universal Input Data	[1...2]
2	Universal Input Frequency	[1...2]
3	Encoder Data A	[1]
4	Encoder Data B	[1]
5	Encoder Direction	[1]

6	Encoder Counter	[1]
7	Encoder Z Data	[1]
8	Power Supply Voltage Fault State	[1]
9	Temperature Fault State	[1]
10	CAN Receive	[1...10]
11	Conditional Block	[1...10]
12	Global Power Supply Voltage	[1]
13	Global Temperature	[1]
14	Look Up Table	[1...6]
15	Math Function	[1...4]
16	Programmable Logic	[1...2]
17	Lookup Table	[1...6]
18	Constant Data	[1...10]
19	Current Feedback	[1]
20	PID Control	[1]

Table 3: Motor Drive Output Control/Enable/Override/Unlatch Source

The selected control source in the **Control Source** parameter in combination with its **Control Number** is the main commanding source of the motor output based on the **Motor Type** parameter.

For example, setting **Control Source** to *Universal Input* and **Control Number** to '1', connects signal measured from Universal Input 1 to the output in question. Is the input signal an analog input with a voltage between 0V and 5V, for instance, and 1V is measured at this input, the output signal would be 20% in case the **Motor Type** is set to *PWM Output*. That means that the output signal is always responding linear to changes in the control signal.

2.1.3 Motor Drive Enable

In addition to the Control input, the Motor Drive also supports an Enable and Override input. The **Enable Source** setpoint together with **Enable Number** setpoint determine the enable signal for the output in question. The **Enable Response** setpoint is used to select how output will respond to the selected Enable signal. **Enable Response** setpoint options are listed in Table 4.

Value	Meaning
0	Enable When On, Else Shutoff
1	Enable When On, Else Rampoff
2	Enable When Off, Else Shutoff
3	Enable When Off, Else Rampoff
4	Enable When On, Else Ramp To Minimum
5	Enable When On, Else Ramp To Maximum

Table 4: Enable Response Options

2.1.4 Motor Drive Override

The override input allows the motor drive to be configured to go to a default value in the case of the override input being engaged/disengaged, depending on the logic selected in **Override Response**, presented in Table 5. When active, the output will be driven to the value in **Output at Override**

Command regardless of the value of the Control input. The **Override Source** and **Override Number** together determine the Override input signal.

Value	Meaning
0	Override When OFF
1	Override When ON

Table 5: Override Response Options

Fault detection is available for all output types. A current feedback signal, for example, is measured and compared to the desired output current value. Fault detection and associated setpoints are presented in section 2.12.3.

The outputs are inherently protected against a short to GND or +Vps by circuitry. In case of a dead short, the hardware will automatically disable the output drive, regardless of what the processor is commanding for the output. When this happens, the processor detects output hardware shutdown and commands off the output in question. It will continue to drive non-shortened outputs normally and periodically depending on the time set by **Over Current Reset Time** and try to re-engage the short load, if still commanded to do so. If the fault has gone away since the last time the output was engaged while shorted, the controller will automatically resume normal operation.

In the case of an open circuit, there will be no interruption of the control for any of the outputs. The processor will continue to attempt to drive the open load. The measured current through the load is available to be broadcasted on a CAN message if desired. It is also used as the input to the diagnostic function block for the output, and an open or shorted output can be broadcasted in a DM1 message on the CAN network.

2.2 Encoder Input Function Block

The controller provides an Encoder input, which has three physical inputs to support the incremental encoder's A, B, and Z signal. In case no encoder is connected to the unit, these inputs can be used for other purposes. Signal A and B can be used as digital on/off signals and signal Z can measure frequency, PWM and digital on/off signals. The available Input Types are listed in Table 6.

Setpoint Value	Input Type	Supported by Encoder A, B	Supported by Encoder Z
0	Not Implemented	X	X
1	Digital Input	X	X
2	Encoder Input	X	
2	Frequency input		X
3	PWM: 0 to 100%		X
4	16-Bit Counter		X
5	Time Window		X
6	Pulse Window		X

Table 6: Encoder Input Types

The encoder signals A and B on the motor controller unit are detecting the pulses generated by the incremental encoder. The two measurements, step count and direction, are determined using these two

input signals. The Z signal of the encoder works like a common frequency input and measures the input signal every time a rising edge, or falling edge dependent on the configurations, occurs.

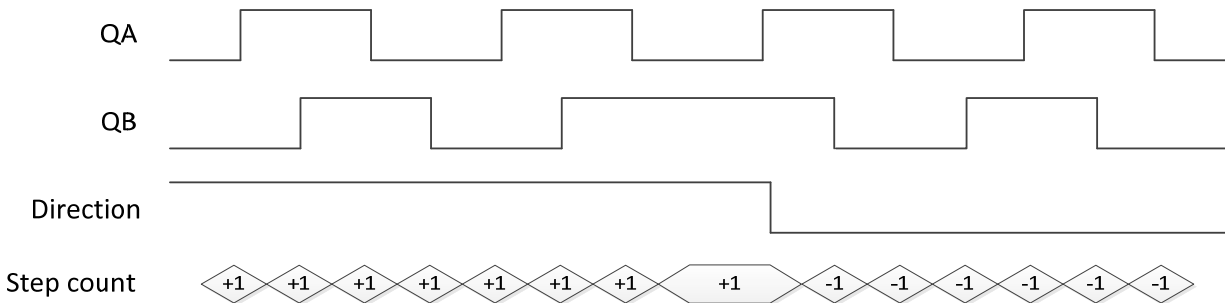


Figure 1: Incremental Decoder Signals (QA&QB) and resulting Direction and Step count

A positive direction is indicated when the edge of signal A is rising before the edge of signal B is rising. If the encoder rotates in a positive direction, the **Encoder Counter value** increases. In case the signal changes and input B becomes the leading signal, the counter value decreases, and the direction is indicated as negative.

As discussed before, the encoder inputs can be configured to different input types for various applications. Signal A and B can only be set to Digital ON/OFF other than Encoder Input which is shown in Table 7.

Value	Meaning
0	Input OFF
1	Digital ON/OFF
2	Encoder Input

Table 7: Encoder Signal A and B Input Types

Signal Z, on the other hand, has more available input types listed in Table 8.

Setpoint Value	Sensor Type/ Input Range
0	Not Implemented
1	Digital Input
2	Frequency input
3	PWM: 0 to 100%
4	16-Bit Counter
5	Time Window
6	Pulse Window

Table 8: Encoder Signal Z Input Types

2.2.1 Encoder Operating Mode

If input type *Encoder Input* is selected, the output value will be between 0 to 2 which represents the direction of rotation. Table 9 shows the meaning of each value.

Value	Direction
-------	-----------

0	Stationary
1	Negative (Anticlockwise)
2	Positive (Counterclockwise)

Table 9: Encoder Directions

2.2.2 Encoder Stationary Delay

The **Encoder Stationary Delay** parameter decides after how many milliseconds the direction is set to stationary (0) if no rising edge or falling edge is detected on signal A or B on the encoder input. This way, the performance of the encoder input can be adjusted for slower and faster rotating encoders. The default value for this parameter is set to 100[ms] by default.

2.2.3 Minimum and Maximum Errors/Ranges

The **Minimum Range** and **Maximum Range** setpoints are used to create the overall useful range of the inputs. For example, if **Minimum Range** is set to 100 RPM and **Maximum Range** is set to 1900 RPM, the overall useful range (0-100%) is between 100 to 1900 RPM. Anything below the **Minimum Range** will saturate at **Minimum Range**. Similarly, anything above the **Maximum Range** will saturate at **Maximum Range**. The other two setpoints, **Minimum Error** and **Maximum Error** must be lower than the **Minimum Range** and the **Maximum Range** setpoints, respectively. Anything below the **Minimum Error** or above the **Maximum Error** will create a fault. If that input is commanding an output, the output will shut off. If requiring the output to remain active, the **Minimum Error/Minimum Range** and **Maximum Range/Maximum Error** should be set to the same values.

All other input types will automatically be set to their default ranges shown in Table 10

Setpoint Value	Sensor Type/ Input Range	Error Min	Range Min	Range Max	Error Max	Hysteresis
0	Not Implemented	-	-	-	-	-
1	Digital Input	OFF	OFF	ON	ON	0
2	Frequency input	-	-	-	-	-
3	PWM: 0 to 100%	1	5	95	99	1
4	16-Bit Counter	OFF	OFF	ON	ON	0
5	Time Window	-	-	-	-	-
6	Pulse Window	-	-	-	-	-

Table 10: Input Type Defaults Based on Sensor Type and Input Range

Refer to section 2.12.3 for diagnostics that can be associated with Input Function Block

2.2.4 Input Software Filter Types

All input types can be filtered using **Filter Type** and **Filter Constant** setpoints. There are three (3) filter types available as listed in Table 11.

0	No Filtering
1	Moving Average
2	Repeating Average

Table 11: 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 the 'Equation 1' below to 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 2 - Moving Average Filter Function:

$$\text{Value}_N = \text{Value}_{N-1} + \frac{(\text{Input} - \text{Value}_{N-1})}{\text{Filter Constant}}$$

The third option, *Repeating Average*, applies the 'Equation 2' below to 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 reads. When the average is taken, the filtered input will remain until the next average is ready.

Equation 3 - Repeating Average Transfer Function:

$$\text{Value} = \frac{\sum_0^N \text{Input}_N}{N}$$

2.2.5 Debounce Filter

This filter is applied to the input before the state is read by the processor. The options for the debounce filter are shown in Table 12, with the default bolded.

Value	Meaning
0	Filter Disabled
1	Filter 111ns
2	Filter 1.78 us
3	Filter 14.22 us

Table 12: Debounce Filter Options

2.2.6 Input Logic Type

This parameter is used to set the logical input type of the corresponding input. The Digital Input Type parameter allows flexibility in the response of the input. Table 13 shows the options available for this parameter.

Value	Meaning
0	Normal Logic
1	Inverse Logic
2	Latched Logic

Table 13: Digital Input logic Types

Normal Logic Type is used for the inputs by default.

In *Normal Logic* mode, the input state is 1 in case the input signal is interpreted as an ON-signal. The input state turns 0 if the input signal is interpreted as an OFF-signal.

For the *Inverse Logic* type, the opposite behavior applies. If the input signal is ON, the state turns 0 and if the input signal is OFF, the state turns 1.

Setting the Input to *Latched Logic*, the input state is toggled between 1 and 0 every time the input signal of the respective digital input changes from OFF to ON.

2.2.7 Active High/Low

This parameter allows the user to select how the controller responds to the behaviour of the digital input. Table 14 shows the different Active High/Low options with the default being highlighted.

Value	Meaning
0	Active High
1	Active Low

Table 14: Active High/Low

The inputs of the Digital Inputs have a fixed 10kOhm pull-down resistor. Given that by default, the inputs are configured to *Active High*, an OFF response by the input is achieved when the input is grounded. The opposite applies if the parameter is set to Active Low.

2.2.8 Debounce Time

When Encoder Signal A/B/Z is set to Digital ON/OFF, further setpoints are available.

The Digital Input Debounce Time parameter is a useful parameter in case the digital input signal is noisy. Figure 2 shows how the Debounce Time helps detect a correct input signal.

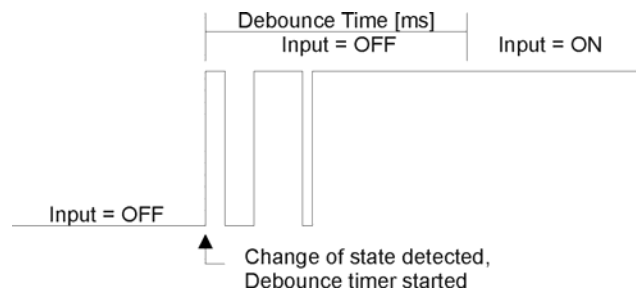


Figure 2: Digital Input Debounce Time

2.2.9 Frequency/RPM Input

Note: This parameter is only available for Signal Z of the Encoder.

There is another type of 'digital' input that can be selected which are connected to the microcontroller timers when the Encoder Z Input Type is set to Frequency Input. This input type can be automatically turned into an RPM measurement by setting parameter *Number of Pulses per Revolution* to a non-zero value. This means when **Pulses per Revolution** setpoint is set to 0, the measurements taken will be in

units of [Hz]. If Pulses per Revolution setpoint is set to higher than 0, the measurements taken will be in units of [RPM]. All other input types ignore this object.

2.2.10 Counter Input Type

The 16-Bit counter has three different types of a Counter input modes: Counter (Pulse Count Reset), Counter (Time Window), Counter (Pulse Window).

Counter (Pulse Count Reset) is a Counter input type in which the output data of the input function block is the number of pulses measured. The pulses will continue to increment in count as they are measured until the **Pulse Count to Reset Counter** value is reached at which the counter will reset back to 0.

Counter (Time Window) is a Counter input type in which parameter **Pulse Count in Time Window** is selected (in milliseconds). The output of the input block will be the amount of pulses measured within that time frame.

Counter (Pulse Window) is a Counter input type in which a 'Pulse Window', is selected in number of pulses **Pulse window in number of pulses**. The output of the input block will be the amount of time elapsed to reach the number of pulses set in the Elapsed Time to Each Pulse Count setpoint.

2.3 Universal Input Function Block

The universal Inputs on the motor controller can be configured to an even wider range of input types compared to the Encoder Z Signal. The available input types are listed in Table 15.

Setpoint Value	Sensor Type/ Input Range	Error Min	Range Min	Range Max	Error Max	Hysteresis
0	Not Implemented	-	-	-	-	-
1	Digital Input	OFF	OFF	ON	ON	0
2	Frequency input	-	-	-	-	-
3	PWM: 0 to 100%	1	5	95	99	1
4	16-Bit Counter	OFF	OFF	ON	ON	0
5	Time Window	-	-	-	-	-
6	Pulse Window	-	-	-	-	-
7	Voltage: 0 to 5V	100 [mV]	200 [mV]	4800 [mV]	4900 [mV]	100 [mV]
8	Voltage: 0 to 10V	200 [mV]	500 [mV]	9500 [mV]	9800 [mV]	100 [mV]
9	Current: 0 to 20mA	0 [uA]	0 [uA]	20000 [uA]	20000 [uA]	500 [uA]
10	Current: 4 to 20mA	1000 [uA]	4000 [uA]	20000 [uA]	21000 [uA]	500 [uA]
11	Encoder Input	-	-	-	-	-

Table 15: Input Type Options for Universal Input

Since the universal input can be used as a type of Digital ON/OFF, Frequency, PWM, and Counter input, the parameters explained in the previous chapter, Encoder Input Function Block, are also available for the Universal Input.

Each universal input can measure an analog input from 0V to 5V or from 0V to 10V. It is advisable to use input type *Voltage 0V to 5V* when the analog input is not exceeding 5V since the analog-digital converter

uses a 12-bit value. Additionally, there are two input types, *Current 0mA to 20 mA* and *Current 0mA to 20 mA*, available to measure a current at the input.

2.3.1 Pull Up/Down Options

Conversely, Frequency, PWM and Counter inputs use setpoint **UNI Pullup/Down Mode** (see Table 1) while **voltage and current inputs set this object to zero**. The options for this parameter are listed in Table 16.

0	<i>Pullup/Pulldown Off</i>
1	<i>10kΩ Pullup</i>
2	<i>10kΩ Pulldown</i>

Table 16: Pull Up/Down Options

Note: Please make sure to set the Pull Up/Down type parameter after changing the input type from analog to any digital input type since this parameter will not be automatically updated for digital input types.

2.4 CAN Receive Signal

There are five *CAN Receive* function blocks available to the user. Each function block represents one CAN Receive that can be received from the CAN bus. The function block has one signal output with a user-defined signal type.

The *CAN Receive* function block reads single-frame application specific CAN messages and extracts CAN signal data presented in a user-defined data format. Different *CAN Receive* function blocks can read and process the same CAN message to extract different CAN signal data.

The CAN messages transmitted by the unit itself are also processed by *CAN Receive* function blocks. The only difference in processing of the internal messages is that they are not sampled from the CAN bus and therefore their processing does not depend on the state of the bus.

The CAN Receive position is defined within the CAN message data frame by the **Data Position Byte** and **Data Position Bit** configuration parameters the same way as in the J1939 standard. The start and stop bits of the CAN signal in the 64-bit CAN message data frame are calculated using the formulas:

$$\begin{aligned}
 StartBit &= (DataPositionByte - 1) \cdot 8 + (DataPositionBit - 1), \\
 StopBit &= StartBit + Size - 1, \text{ where: } StartBit, StopBit \in [0 \dots 63].
 \end{aligned}$$

Equation 4: CAN Receive Position

Resolution and **Offset** configuration parameters are set for continuous CAN input signals. They are not used with discrete CAN signals.

The following rules apply when converting the CAN signal data to the function block output signal:

- It is assumed that the CAN signal code with all bits set to 1 represents an undefined signal. The undefined signal is ignored by the function block;

- Discrete signals can take any value except the one reserved for the undefined signal (all bits set to 1);
- Continuous signals can take only values from the range reserved for continuous signals in the J1939 standard. If the CAN signal code is outside of the range reserved for the continuous signal, the signal is ignored.

When the **Autoreset Time** is not equal to 0, the function block will auto-reset the output signal to the undefined state if the output signal has not been updated within the auto-reset time frame by the new CAN message data.

2.5 CAN Transmit Function Block

There are five *CAN Transmit* function blocks available to the user. Each function block represents one single frame CAN transmit message that can be sent on the CAN bus. The message can contain up to four CAN transmit signals. Each CAN transmit signal is presented by its own signal input in the function block.

The following rules apply when converting function block signal data to the CAN output signal code:

- *Undefined signals* are presented in the signal code with all bits set to 1.
- *Discrete signals* are directly assigned to the signal code without any conversion.
- *Continuous signals* are converted to the signal code based on the *Signal #1...4 Resolution* and *Signal #1...4 Offset* configuration parameters. They are saturated to the continuous signal code range defined in the J1939 standard when they go out of range.

2.6 PID Control Function Block

The PID Control function block is an independent logic block, but it is normally intended to be associated with proportional output control blocks described in the chapters before. When the **Control Source** for an output has been setup as a *PID Function Block*, the command from the selected PID block drives the physical output on the motor controller unit.

The **PID Target Command Source** and **PID Target Command Number** setpoints determine control input and the **PID Feedback Input Source** and **PID Feedback Input Number** setpoints determine the established the feedback signal to the PID function block. The **PID Response Profile** will use the selected inputs as per the options listed in Table 17. When active, the PID algorithm will be called every **PID Loop Update Rate** in milliseconds.

0	Single Output
1	Setpoint Control
2	On When Over Target
3	On When Below Target

Table 17: PID Response Options

When a *'Single Output'* response is selected, the Target and Feedback inputs do not have to share the same units. In both cases, the signals are converted to a percentage values based on the minimum and maximum values associated with the source function block.

For example, a CAN command could be used to set the target value, in which case it would be converted to a percentage value using **Receive Data Min** and **Receive Data Max** setpoints in the appropriate *CAN Receive X* function block. The closed-loop feedback signal, i.e. a Current Feedback from the motor controller output, could be selected as the feedback source. In this case the value of the input would be converted to a percentage based on the **Minimum Range** and **Maximum Range** setpoints in the input block. The output of the PID function would depend on the difference between the commanded target and the measured feedback as a percentage of each signals range. In this mode, the output of the block would be a value from -100% to 100%.

In Order to allow the output to stabilize, the user can select a non-zero value for **PID Delta Tolerance**. If the absolute value of $Error_k$ is less than this value, $Error_k$ in the formula below will be set to zero.

The PID algorithm used is shown below, where G , K_i , T_i , K_d , T_d and $Loop_Update_Rate$ are configurable parameters.

$$PIDOutput_k = P_k + I_k + D_k$$

$$P_k = P_Gain * Error_k$$

$$I_k = I_Gain * ErrorSum_k$$

$$D_k = D_Gain * (Error_k - Error_{k-1})$$

$$Error_k = Target - Feedback$$

$$ErrorSum_k = ErrorSum_{k-1} + Error_k$$

$$P_Gain = G$$

$$I_Gain = G * K_i * T / T_i \text{ (Note: If } T_i \text{ is zero, } I_Gain = 0)$$

$$D_Gain = G * K_d * T_d / T$$

$$T = Loop_Update_Rate * 0.001$$

Note: Each system will have to be turned for the optimum output response. Response times, overshoots and other variables will have to be decided by the customer using an appropriate PID tuning strategy. Axiomatic is not responsible for tuning the control system.

2.7 Lookup Table Function Block

Lookup Tables are used to give an output response of up to 10 slopes per Lookup Table. There are two types of Lookup Table response based on **X-Axis Type**: *Data Response* and *Time Response* Sections 2.7.2 through 2.7.6 will describe these two **X-Axis Types** in more detail. 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 2.8

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 on Setpoint Changes** in the **Miscellaneous** block is *TRUE*.

2.7.1 Auto Update on Setpoint Changes

If **Auto Update on Setpoint Changes** is set to *TRUE*, the **X-Values** of the Lookup Tables are updated based on the **X-Axis Source** and **X-Axis Number** (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. However, if **Auto Update on Setpoint Changes** is set to *FALSE* then the **X-Values** will not get automatically updated on a setpoint change, but the minimum and maximum allowable ranges will be adjusted which Electronic Assistant may give warnings for out-of-range setpoints. For example, if **Encoder Input** is configured with **Minimum Range: 100 RPM (X_{min})** and **Maximum Range: 9800 RPM (X_{max})** and is the **X-Axis Source** to **Lookup Table 1** with maximum **X Value** of *9800 RPM (X_{max})*, if **Encoder Input 1** is then changed to **Maximum Range: 5500 RPM**, **Lookup Table 1** will not update its **X-Values** however, the maximum command (X_{max}) will be set to *5500 RPM* so editing the maximum **X Value** to something higher than *5500 RPM* Electronic Assistant will display a warning. It is up to the user's discretion to appropriately select the values in the Lookup Tables when **Auto Update on Setpoint Changes** is set to *FALSE*.

2.7.2 X-Axis, Input Data Response

In case where the **X-Axis Type** = *Data Response*, the points on the X-Axis represents the data of the control source. These values must be selected within the range of the control source.

When selecting X-Axis data values, there are no constraints on the value that can be entered into any of the X-Axis points. The user should enter values in increasing order to be able to utilize the entire table. Therefore, when adjusting the X-Axis data, it is recommended that X_{10} is changed first, then lower indexes in descending order as to maintain the below:

$$X_{min} \leq X_0 \leq X_1 \leq X_2 \leq X_3 \leq X_4 \leq X_5 \leq X_6 \leq X_7 \leq X_8 \leq X_9 \leq X_{10} \leq X_{max}$$

As stated earlier, X_{min} and X_{max} will be determined by the X-Axis Source that has been selected.

If some of the data points are '*Ignored*' as described in Section 2.7.4, they will not be used in the X-Axis calculation shown above. For example, if points X_4 and higher are ignored, the formula becomes $X_{min} \leq X_0 \leq X_1 \leq X_2 \leq X_3 \leq X_{max}$ instead.

2.7.3 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.

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 Y_{min} and the highest value as the Y_{max} . They are passed directly to other function blocks as the limits on the Lookup Table output. (i.e used as X_{min} and X_{max} values in linear calculations.)

However, if some of the data points are 'Ignored' as described in Section 2.7.4, 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 a Math Function Block.

2.7.4 Default Configuration, Data Response

By default, all Lookup Tables in the ECU are disabled (**X-Axis Source** equals *Control Not Used*). Lookup Tables can be used to create the desired response profiles. If a Universal Input is used as the X-Axis, the output of the Lookup Table will be what the user enters in **Y-Values** setpoints.

Recall, any controlled function block which uses the Lookup Table as an input source will also apply a linearization to the data. **Therefore, for a 1:1 control response, ensure that the minimum and maximum values of the output correspond to the minimum and maximum values of the table's Y-Axis.**

All tables (1 to 2) are disabled by default (no control source selected). However, should an **X-Axis Source** be selected, the **Y-Values** defaults will be in the range of 0 to 100% as described in the "Y-Axis, Lookup Table Output" section above. X-Axis minimum and maximum defaults will be set as described in the "X-Axis, Data Response" section above.

By default, the X and Y axes data is setup for an equal value between each point from the minimum to maximum in each case.

2.7.5 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, as shown in Figure 4. To get the linearization, each "**Point N – Response**", where N = 1 to 10, is setup for a 'Ramp To' output response.

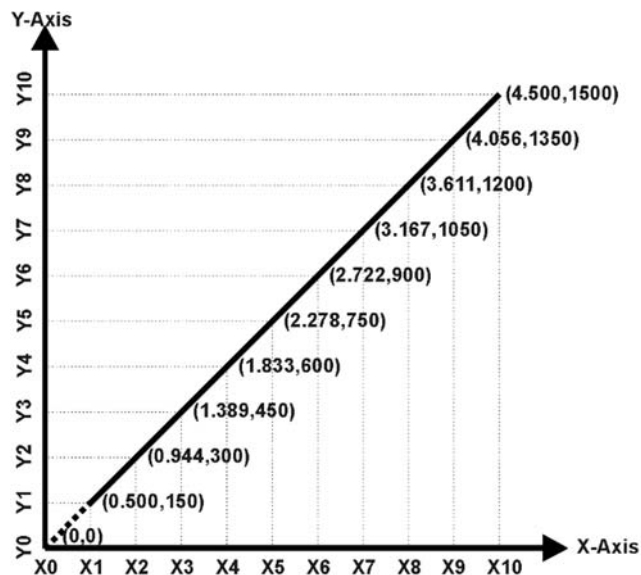


Figure 3: Lookup Table with "Ramp To" Data Response

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 Math function block (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 5.

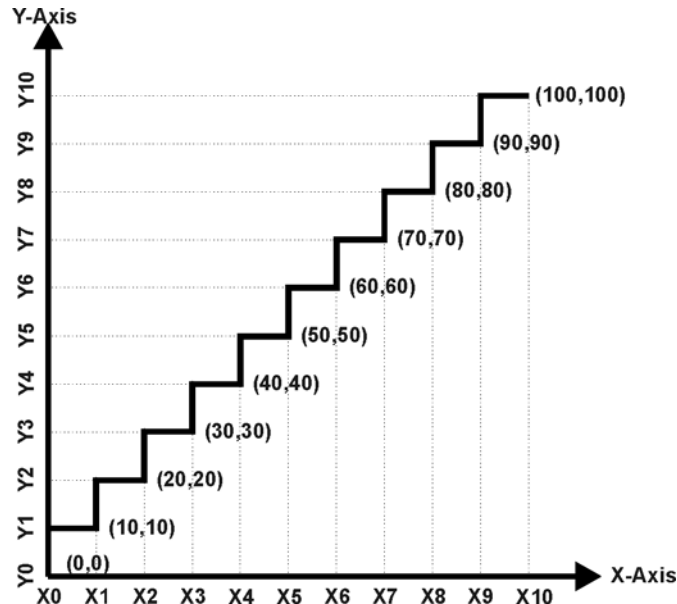


Figure 4: Lookup Table with "Jump To" Data Response

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} .

A combination of *Ramp To*, *Jump To* and *Ignore* responses can be used to create an application specific output profile.

2.7.6 X-Axis, Time Response

As mentioned in Section 2.7, 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. There is also another setpoint associated to the Lookup Table when configured to *Time Response* which is the **Table Auto-Cycle** setpoint.

In this case, the **X-Axis Source** is treated as a digital input. When the control input is ON, the output will be changed over a period of time based on the profile in the Lookup Table. There are two different scenarios on how the Lookup Table will react once the profile is finished. The first option is when **Table Auto-Cycle** is set to *FALSE* in which case, 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. The second option is when **Table Auto-Cycle** is set to *TRUE* in which case, once the profile has finished (i.e. index 10, or *Ignored* response), the Lookup Table will automatically return to the 1st response and will continually be auto-cycling for as long as the input remains in the ON state.

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.

In a time response, the interval time between each point on the X-axis can be set anywhere from 1ms to 1min. [60,000 ms]

2.8 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 two tables, either one of which would be selected only under given conditions. Either one of the tables can be associated with the logic, and which ones are used is fully configurable.

Should the conditions be such that a particular table (1 or 2) has been selected as described in Section 2.7.2, then the output from the selected table, at any given time, will be passed directly to the Logic Output.

Therefore, up to two different responses to the same input, or two 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 the Programmable Logic block, the **Programmable Logic Block Enabled** setpoint must be set to True. The block is disabled by default.

Logic is evaluated in the order shown in Figure 5. 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.**

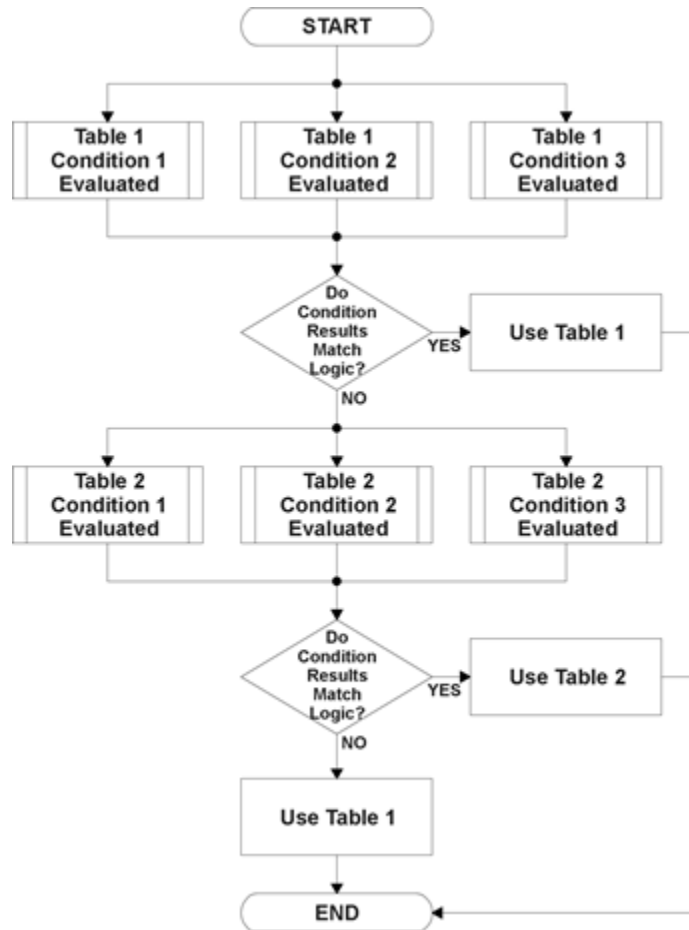


Figure 5: Programmable Logic Flowchart

2.8.1 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 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 18.

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

Table 18: 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 5 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 19.

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 'Control Source Not Used')

Table 19: Condition Evaluation Results

2.8.2 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 2.8.1. There are several logical combinations that can be selected, as listed in Table 20.

0	Default Table
1	Cnd1 And Cnd2 And Cnd3
2	Cnd1 Or Cnd2 Or Cnd3
3	(Cnd1 And Cnd2) Or Cnd3
4	(Cnd1 Or Cnd2) And Cnd3

Table 20: Conditions' 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>Should be used when two or three conditions are relevant, and all must be true to select the table.</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) &&(Cnd2==True)&&(Cnd3==True)) Then Use Table</p>
Cnd1 Or Cnd2 Or Cnd3	Should be used when only one condition is relevant. Can also be used with two or three relevant conditions.

	<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>To be used only when all three conditions are relevant.</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)&&(Cnd2==True)) (Cnd3==True)) Then Use Table</p>
(Cnd1 Or Cnd2) And Cnd3	<p>To be used only when all three conditions are relevant.</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)) && (Cnd3==True)) Then Use Table</p>

Table 21: 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*.

2.8.3 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 22.

Programmable Logic Block Number	Table 1 – Lookup Table Block Number	Table 2 – Lookup Table Block Number	Table 3 – Lookup Table Block Number
1	1	2	3

Table 22: 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.

Note: 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.

2.9 Math Function Block

There are two mathematical function blocks that allow the user to define basic algorithms. A math function block can take up to four input signals. Each input is then scaled according to the associated limit and scaling setpoints.

Inputs are converted into percentage value based on the **Function X Input Y Minimum** and **Function X Input Y Maximum** values selected. For additional control, the user can also adjust the **Function X Input Y 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.

A mathematical function block includes four selectable functions, which each implements equation $A \text{ operator } B$, where A and B are function inputs and operator is function selected with setpoint **Math function X Operator**. Setpoint options are presented in the table below. The functions are connected, so that result of the preceding function goes into Input A of the next function. Thus Function 1 has both Input A and Input B selectable with setpoints, where Functions 2 to 3 have only Input B selectable. Input is selected by setting **Function X Input Y Source** and **Function X Input Y Number**. If **Function X Input B Source** is set to 0 *Control not use'* signal goes through function unchanged.

$$\text{Math Block Output} = \left(((\text{InA } Op1 \text{ InB1}) op2 \text{ InB2}) op3 \text{ InB3} \right)$$

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 23: Math Function Operators

For logic operations (6, 7, 8) scaled input greater or equal to 1 is treated as TRUE. For logic operations (0 to 8), the result of the function will always be 0 (FALSE) or 1 (TRUE). 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 divider will always result in a 100% output value for the associated function.

Lastly the resulting mathematical calculation, presented 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 selected as the input source for another function block.

2.10 Simple Conditional Function Block

This function block is a simple version of the Programmable Logic Function Block and compares up to four different input sources with different logical or relational operators. The result of each block can therefore only be true (1) or false (0). Figure 6 demonstrates the connections between all parameters.

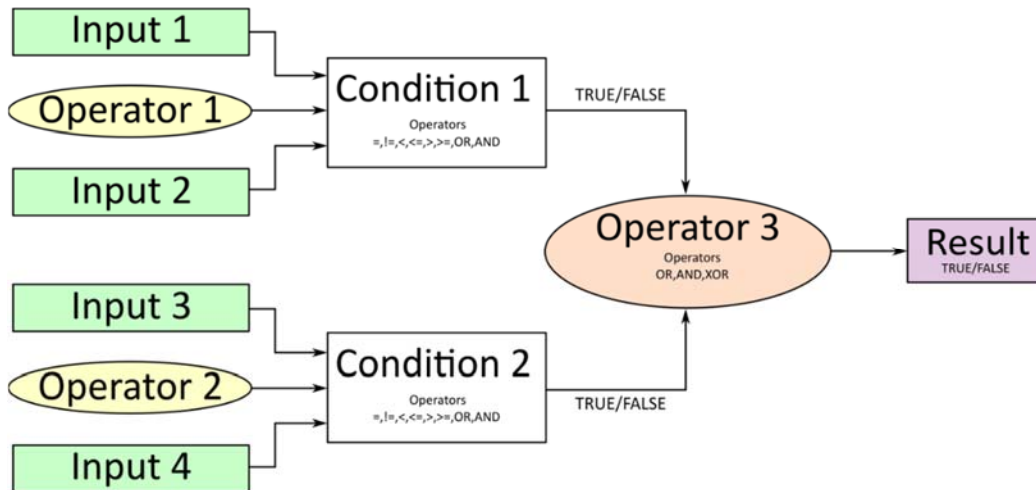


Figure 6: Conditional Block Diagram

Each Conditional Block offers two conditions. Both compare two inputs, which can either be a logical value or an integer value. The result of the conditions can, therefore, only be true or false and will be compared by Operator 3 with a logical operator. This comparison is the result of the Conditional Block and can control any output source.

The value of Input 1 to Input 4 depends on the configured control source and control number. All Inputs are set to No Source as an input source by default.

The value of each source will then be compared to each other with an operator of *Table 24*. If no source is selected, the output value of an Input will be zero.

Value	Meaning
0	==, True when Argument 1 is equal to Argument 2
1	!=, True when Argument 1 is not equal to Argument 2
2	>, True when Argument 1 is greater than Argument 2
3	>=, True when Argument 1 is greater than Argument 2
4	<, True when Argument 1 is less than Argument 2
5	<=, True when Argument 1 is less than or equal Argument 2
6	OR, True when Argument 1 or Argument 2 is True
7	AND, True when Argument 1 and Argument 2 are True

Table 24: Input Operator Options

Operator 1 and Operator 2 are configured to AND by default. The table above cannot be used for comparing the conditions because they can only be compared with logical operators, which are listed in Table 25.

Value	Meaning
0	OR, True when Argument 1 or Argument 2 is True
1	AND, True when Argument 1 and Argument 2 are True
2	XOR, True when Argument 1 is not equal to Argument 2

Table 25: Condition Operator Options

If only one condition is used, it is to make sure that Operator 3 is set to **OR** so that the result is based solely on the condition which has been chosen.

2.11 LED Control Function Block

The motor controller has two red LEDs and one green LED mounted on the front panel. Table 26 describes their position on the front panel when the LEDs facing down.

Name	Position
LED 1 (Red)	Right
LED 2 (Red)	Middle
Heartbeat (Green)	Left

Table 26: LED Positions on the front Panel

The LEDs are reflecting internal states in five different stages, which can be set through Electronic Assistant. Stage 1 has the highest priority and Default Stage has the lowest. While Table 27 shows the settings for stage 1 to 4, the Default stage has no Control Source or Number because its purpose is to indicate the motor controller runs without any issues as well as it informs the user if the unit is powered on.

Stage Settings
Control Source
Output Type
Response Type
Blink Rate

Table 27: LED Stages Settings

2.11.1 LED Control Sources

Each LED can be controlled individually and their LED stages can be configured to be commanded by the LED control sources listed in Table 28. This table displays the control sources which can be selected.

Table 28: LED Control Sources

Value	Meaning
0	Control Source Not Used
1	Input Fault
2	Output Fault
3	Power Supply Fault

4	Temperature Fault
5	CAN Receive Timeout
6	Global Fault
7	PID Control
8	Lookup Table
9	Programmable Logic
10	Math Function
11	Constant Data
12	Output Feedback
13	Power Supply Measured
14	Temperature Measured

Setting the stage to **Control Source Not Used** has no affect to the LED. There are several fault-sources to indicate certain errors during runtime which can become 0(false) or 1(true). The Input Fault triggers when any of the Universal Inputs or Encoder Input shows an error. This also applies to the Output Fault in case any error is indicated on the Motor Drive. An overvoltage or undervoltage error can be shown with the source **Power Supply Fault**, while an overheating can be detected with the **Temperature Fault**. Another fault which can be used to turn on any LED is the CAN Receive Fault which triggers after configured Reset Time. In case any of these errors should trigger an LED, the Global Fault source can be used for this purpose.

All other sources can have other values than true or false and therefore need a minimum limit and maximum limit. If the maximum limit is reached or exceeded, the LED will behave as configured for this stage.

The default configuration for each stage is listed in section 4.17

2.11.2 LED Output/Response Type

The LED behavior can be configured by the **LED Response Type**. **Error! Reference source not found.** shows the possible settings for this setpoint.

Table 29: LED Response Types

Value	Response Type
0	Normal OFF
1	Normal ON
2	Blinking Logic

The LED can be simple turned off or on in case the source value becomes true but also set to *Blinking Logic* to make the LED turn on and off in a certain frequency. How fast the toggle frequency is can be set by the **Blink Rate**, which is declared in milliseconds.

2.12 Diagnostics

2.12.1 General Diagnostics

The diagnostic messages of the Motor Controller can be enabled or disabled by the Setpoint Name **Disable All Diagnostics Checking** in group General Diagnostics. In case there is an empty DM1 message required, **Send empty DM1 message** can be enabled. Both Setpoints are Disabled by default.

2.12.2 Power Supply – Temperature – CAN - Diagnostics

By using the setpoint **Power Supply Diagnostics**, an undervoltage and/or overvoltage error of the Motor Controller can be detected in case the setpoint **Fault Detection is Enabled** is set to true. The **Undervoltage Threshold** and the **Overvoltage Threshold** can be set in range of 9 to 36 Volts by the **Power Supply Diagnostics**. To clear these errors, the Setpoint **Hysteresis to Clear Voltage Fault** can be configured. The undervoltage error clears, if the voltage reaches the defined clear voltage value plus the undervoltage threshold. This principle is also valid for the overvoltage. In this case, the clear voltage value will be subtracted of the overvoltage threshold. When the power supply reaches one of these values, the error will be cleared if **Event Cleared Only by DM11** is set to False.

An overheating can be detected with the **Temperature Diagnostics**. The settings can be enabled by the Setpoint **Fault Detection is Enabled**. If it is set to true, an error will be detected when the temperature reaches a value equal or higher than the configured **Over Temperature Threshold**. The detected error will be cleared if the temperature value is equal or smaller than the over temperature threshold subtracted by the **Hysteresis to Clear Temperature Fault**.

Both diagnostics, Power Supply and Temperature, have a parameter to disable all outputs. In case all outputs should be disabled when an overvoltage or undervoltage is measured, the parameter **Power Fault Disables Outputs** must be set to true. Whereas the parameter **Over Temperature Shutdown** disables the outputs when the unit is overheating.

In the **CAN Diagnostics**, an error will be detected when a CAN receive timeout appears. The error will be cleared if a new CAN receive message occurs.

By default, none of the Diagnostics sends a DTC on the network when one of the errors above is detected. If **Event Generates a DTC in DM1** is set to *TRUE*, the user has access to a full configuration of the DTC parameters. When **Event Cleared Only by DM11** parameter is set to *False*, the DTC is cleared when the controller no longer detects an error message at its respective diagnostic. However, when **Event Cleared Only by DM11** is *True*, the DTC will remain active after the controller no longer detects an error at its respective diagnostic until a DM11 message is sent to the controller. Upon reception of a DM11 message, if the controller is detecting an error at its respective diagnostic, the DTC **will not** be cleared. If, however, the controller no longer detects an error at its respective diagnostic upon reception of a DM11 message, the DTC will be cleared but the occurrence count **will** remain the same. If desired to clear the occurrence count, it is necessary for a DM3 message to be sent to the controller.

The setting for the for **Lamp Set by Event in DM1** and **Failure Mode Identifiers (FMI)** are the same as for the Digital Inputs and Outputs. Therefore Table 31: Lamp Set by Event in DM11 and Table 32: FMI for Event used in DTC are also valid for the discussed parameters in this subchapter.

2.12.3 Diagnostic Trouble Code Trigger Universal/Encoder Input and Motor Drive

The Motor Controller is able to send Diagnostic Trouble Codes *DTCs* to be sent on the CAN-J1939 network upon an ON-signal detection.

Event Generates a DTC in DM1 parameter determines whether or not a configured DTC is sent on the network upon an ON-signal detection. Table 30 shows the different options for this parameter.

Table 30: Event Generates a DTC in DM1

Value	Meaning
0	<i>False</i>
1	<i>True</i>

By default, **Event Generates a DTC in DM1** is set to true for the Motor Drive, but not for the Universal Input and not for the Encoder Input, which sends a DTC-message on the network in case of an open circuit or short circuit at the output. If this parameter is set to *TRUE*, the user has access to a full configuration of the DTC parameters. When **Event Cleared Only by DM11** parameter is set to *FALSE*, the DTC is cleared when the controller no longer detects a fault at the corresponding input or output. However, when **Event Cleared Only by DM11** is *TRUE*, the DTC will remain active after the controller no longer detects a fault at its respective input or output until a DM11 message is sent to the controller. Upon reception of a DM11 message, if the controller is detecting a fault at its respective input or output, the DTC **will not** be cleared. If, however, the controller no longer detects a fault at its respective input or output upon reception of a DM11 message, the DTC will be cleared but the occurrence count **will** remain the same. If desired to clear the occurrence count, it is necessary for a DM3 message to be sent to the controller.

Table 31 shows the available options for **Lamp Set by Event in DM1** that can be configured.

Table 31: Lamp Set by Event in DM11

Value	Meaning
0	<i>Protect</i>
1	<i>Amber, Warning</i>
2	<i>Red, Stop</i>
3	<i>Malfunction</i>

Table 32 below shows the available options for the **Failure Mode Identifiers (FMI)** used in the DTC.

Table 32: FMI for Event used in DTC

Value	Meaning
0	<i>Data Valid But Above Normal Operational Range - Most Severe Level</i>
1	<i>Data Valid But Below Normal Operational Range - Most Severe Level</i>
2	<i>Data Intermittent</i>
3	<i>Voltage Above Normal, Or Shorted To High Source</i>
4	<i>Voltage Below Normal, Or Shorted To Low Source</i>
5	<i>Current Below Normal Or Open Circuit</i>
6	<i>Current Above Normal Or Grounded Circuit</i>
7	<i>Mechanical Error</i>
8	<i>Abnormal Frequency Or Pulse Width Or Period</i>
9	<i>Abnormal Update Rate</i>
10	<i>Abnormal Rate Of Change</i>
11	<i>Root Cause Not Known</i>
12	<i>Bad Component</i>

13	<i>Out Of Calibration</i>
14	<i>Special Instructions</i>
15	<i>Data Valid But Above Normal Operating Range – Least Severe Level</i>
16	<i>Data Valid But Above Normal Operating Range – Moderately Severe Level</i>
17	<i>Data Valid But Below Normal Operating Range – Least Severe Level</i>
18	<i>Data Valid But Below Normal Operating Range – Moderately Severe Level</i>
19	<i>Network Error</i>
20	<i>Data Drifted High</i>
21	<i>Data Drifted Low</i>
31	<i>Condition Exists</i>

When the DIO controller has detected an ON signal at the digital input, which has been configured to send a DTC, the parameter **Delay Before Sending DM1** determines how long the controller will wait in milliseconds before sending a DTC in a DM1 message. If the digital input has turned OFF before **Delay Before Sending DM1** the DTC will not become active and will not be sent on the network. If the controller is sending a DM1 message and the state of the digital input turns OFF, the error will be cleared after the configured time in milliseconds of the parameter **Delay Before Clearing DM1**.

3 OVERVIEW OF J1939 FEATURES

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	PGN
• Request59904	59904 (\$00EA00)
• Acknowledgment	59392 (\$00E800)
• Transport Protocol – Connection Management	60416 (\$00EC00)
• Transport Protocol – Data Transfer Message	60160 (\$00EB00)
• PropB Transmit, Default Measured Inputs Feedback Message	65280 (\$00FF00)
• PropB Transmit, Default Proportional Outputs Target Message	65296 (\$00FF10)
• PropB Transmit, Default Proportional Outputs Feedback Message	65312(\$00FF20)
• PropB Transmit, Default Digital I/O State Feedback Message	65328 (\$00FF30)
• PropB Receive, Default Output Control Data Message	65408 (\$00FF80)
• PropB Receive, Default Output Enable Data Message	65424 (\$00FF90)
• PropB Receive, Default Output Override Data Message	65440 (\$00FFA0)
• PropB Receive, Default PID Feedback Data Message	65456 (\$00FFB0)

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

Note: The Proprietary A PGN 61184 (\$00EF00) can also be selected for any of the messages

From J1939-73 - Diagnostics	PGN
• 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	PGN
• Address Claimed/Cannot Claim	60928 (\$00EE00)
• Commanded Address	65240 (\$00FED8)

From J1939-71 – Vehicle Application Layer	PGN
• 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 [®] (EA) allows for quick and easy configuration of the unit over the CAN network.

3.2 NAME, Address and Software ID

J1939 NAME

The Universal 25A DC Motor 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	132, Motor Controller
Function Instance	10, Universal 25A DC Motor Controller
ECU Instance	0, First Instance
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 [®]) when they are all connected on the same network.

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 High Temperature Quadrature Decoder Input 2 Output Valve controller will continue select the next highest address until it find one that it can claim. See J1939/81 for more details about address claiming.

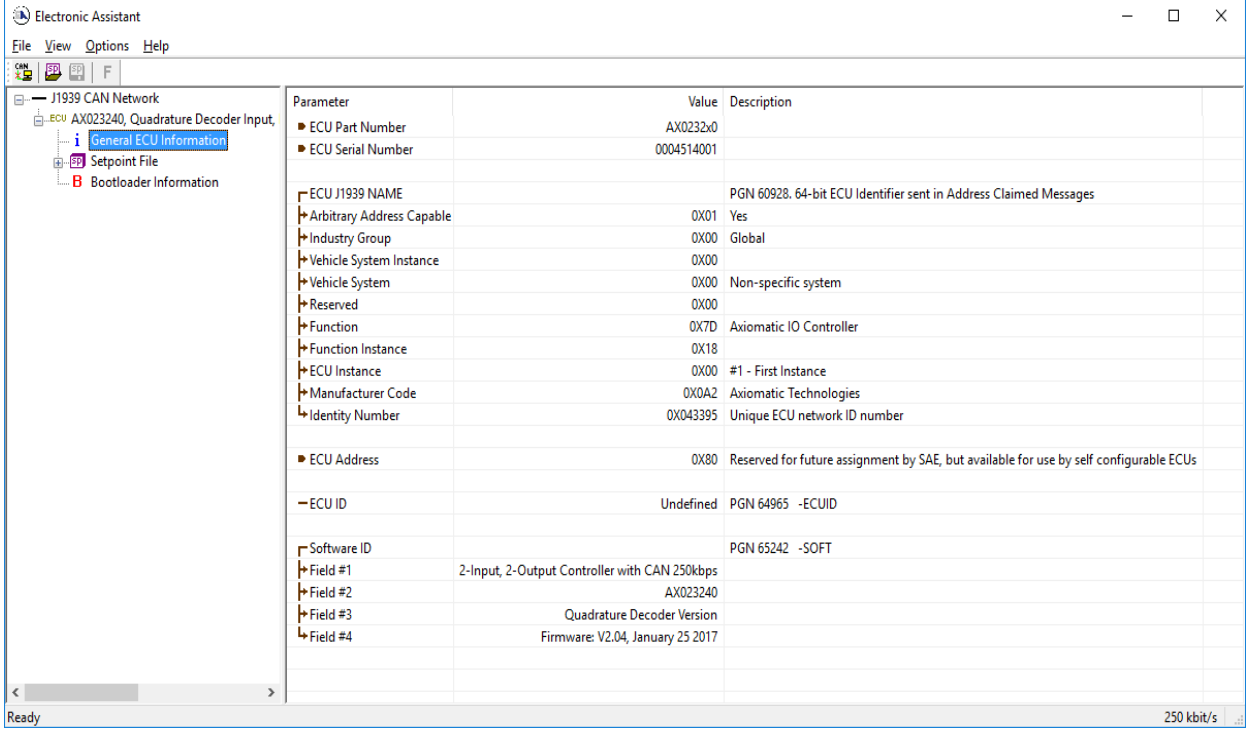
Software Identifier

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 Universal 25A Motor 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.

4 ECU SETPOINTS ACCESSED WITH ELECTRONIC ASSISTANT

Many setpoints have been reference throughout this manual. This section describes in detail each setpoint, their defaults and ranges. For more information on how each setpoint is used by the Universal 25A DC Motor Controller, refer to the relevant section of the User Manual.

4.1 J1939 Network Setpoints

The J1939 Network setpoints deal with the setpoints such as *ECU Instance Number* and *ECU Address*. Figure 7 and Table 33 below will explain these setpoints and their ranges.

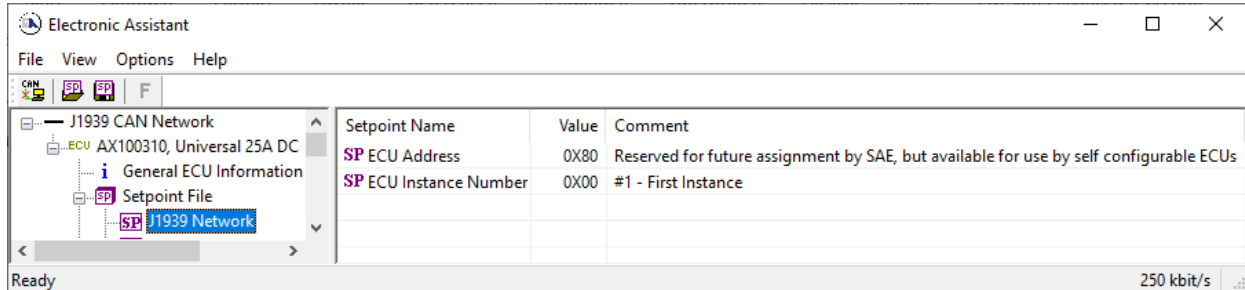


Figure 7: Screen Capture of Default J1939 Network Setpoints

Table 33: Default J1939 Network Setpoints

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

4.2 Motor Drive Setpoints

The Motor Drive setpoints are defined in section 2.1. Refer to that section for detailed information on how these setpoints are used. The screen capture below in Figure 8 displays the available setpoints for the motor drive output. The table below highlights the allowable ranges for each setpoint.

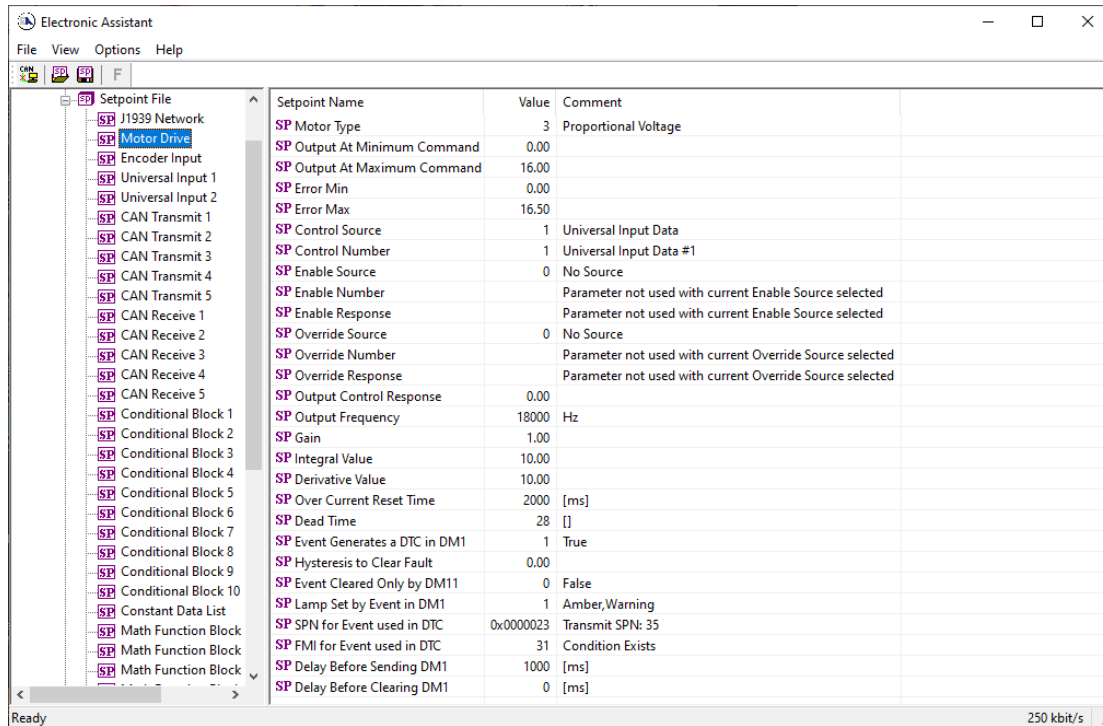


Figure 8: Screen Capture of Motor Drive Setpoints

Name	Range	Default	Notes
Motor Type	Drop List	Normal Logic	Refer to 2.1.1
Output At Minimum Command	Depends on Motor Type Selected	0	Units depending on Motor Type
Output At Maximum Command	Depends on Motor Type Selected	16.0	Units depending on Motor Type
Error Min	Depends on Motor Type Selected	0	Units depending on Motor Type
Error Max	Depends on Motor Type Selected	16.5	Units depending on Motor Type
Control Source	Drop List	Universal Input	Refer to 2.1.2
Control Number	Depends on Source Selected	1	
Enable Source	Drop List	Source not Used	Refer to 2.1.2
Enable Number	Depends on Source Selected	-	
Enable Response	Drop List	Enable When ON	Refer to 2.1.3
Override Source	Drop List	Source not Used	Refer to 2.1.2
Override Number	Depends on Source Selected	-	

Override Response	Drop List	Override When ON	Refer to 2.1.4
Output Control Response	/	0	Refer to 2.1.4
Output Frequency	4,000...24,000	0	
Gain	/	1	
Integral Value	/	10	
Derivative Value	/	10	
Over Current Reset Time	100...60,000	2000	
Dead Time	28...63	28	
Event Generates a DTC in DM1	Drop List	False	Default changed to <i>True</i> for illustration purposes. When <i>False</i> , the Digital Input will not trigger a fault on a DM1
Hysteresis To Clear Fault	0...1,000	0	
Event Cleared Only by DM11	Drop List	False	When set to <i>True</i> , only DM11 messages will clear the fault if the input is no longer active. Refer to subsection 2.12.3
Lamp Set by Event in DM1	Drop List	Protect	Refer to Table 31
SPN for Event used in DTC	0...524,287	0x23	
FMI for Event used in DTC	Drop List	Condition Exists	Refer to Table 32
Delay Before Sending DM1	0...84,600,000	1000	If digital input remains ON after this time, a DTC will be sent on a DM1
Delay Before Clearing DM1	0...84,600,000	0	If digital output OFF after this time, a DTC will not be sent on a DM1 message anymore.

Table 34: Default Motor Drive Setpoints

4.3 Encoder Input Setpoints

The Encoder Input setpoints are defined in Section 2.2.. Refer to that section for detailed information on how these setpoints are used. The screen capture below in Figure 9 displays the available setpoints for each of the Encoder Inputs. Table 35 below highlights the allowable ranges for each setpoint.

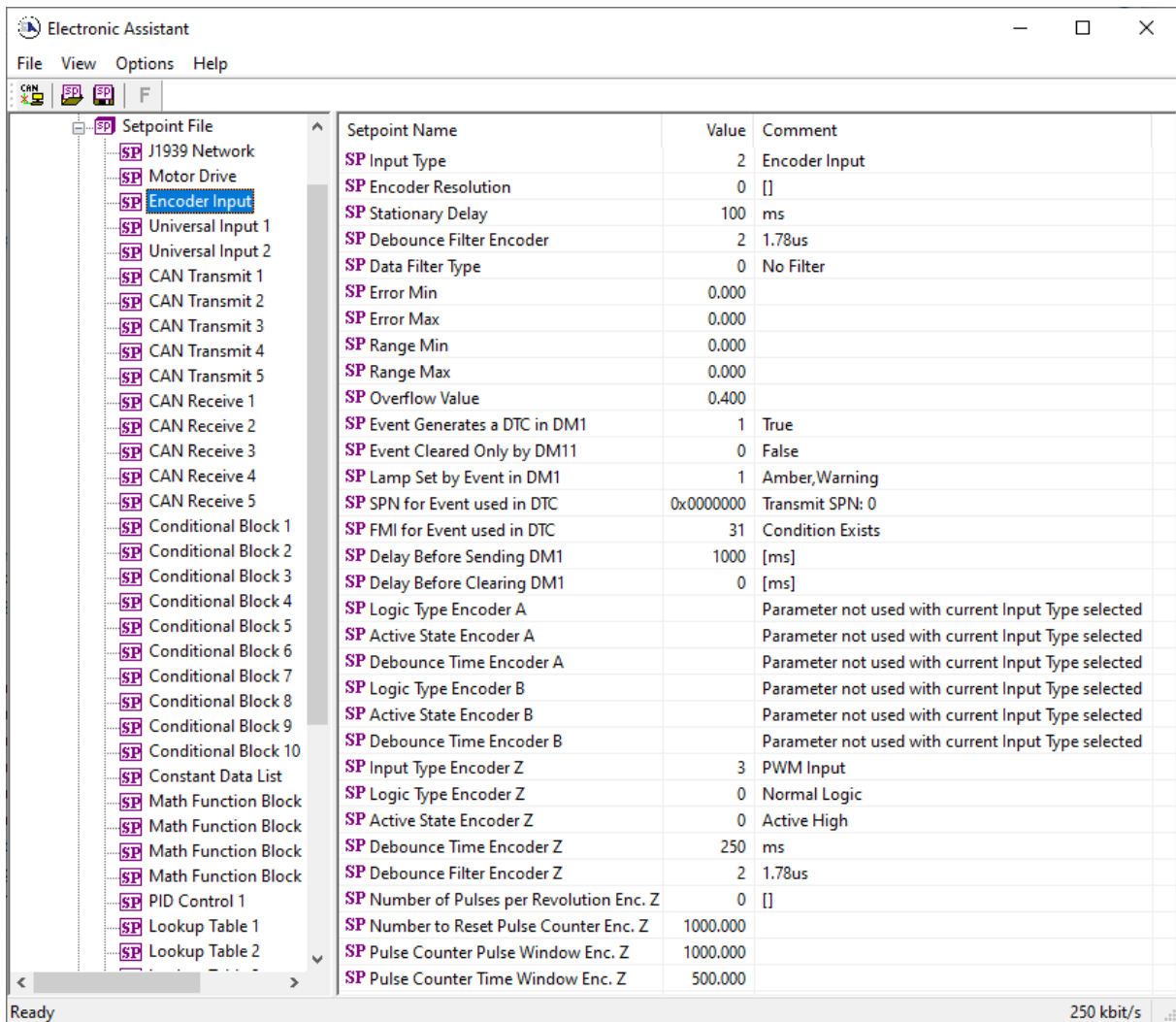


Figure 9: Screen Capture of Default Digital Input Setpoints

Name	Range	Default	Notes
Input Type	Drop List	Encoder Input	Refer to Table 6
Encoder Resolution	0...65000	0	
Stationary Delay	0...65000	100	
Debounce Filter	Drop List	1.78 us	Refer to 2.2.5
Data Filter Type	Drop List	No Filter	Refer to 2.2.4
Error Min	0...100,000	0	Refer to 2.2.3
Error Max	0...100,000	0	Refer to 2.2.3
Range Min	0...100,000	0	Refer to 2.2.3
Range Max	0...100,000	0	Refer to 2.2.3
Overflow Value	/	0.4	
Event Generates a DTC in DM1	Drop List	False	Default changed to <i>True</i> for illustration purposes. When <i>False</i> , the Digital Input will not trigger a fault on a DM1
Hysteresis To Clear Fault	0...1,000	0	

Event Cleared Only by DM11	Drop List	False	When set to <i>True</i> , only DM11 messages will clear the fault if the input is no longer active. Refer to subsection 2.12.3
Lamp Set by Event in DM1	Drop List	Protect	Refer to Table 31
SPN for Event used in DTC	0...524,287	0	
FMI for Event used in DTC	Drop List	Condition Exists	Refer to Table 32
Delay Before Sending DM1	0...84,600,000	1000	If digital input remains ON after this time, a DTC will be sent on a DM1
Delay Before Clearing DM1	0...84,600,000	0	If digital output OFF after this time, a DTC will not be sent on a DM1 message anymore.
Logic Type Encoder A	Drop List	Normal Logic	Refer to 2.2.6
Active State Encoder A	Drop List	Active High	Refer to 2.2.7
Debounce Time Encoder A	0...60,000	250	Unit in millisecond [ms]
Logic Type Encoder B	Drop List	Normal Logic	Refer to 2.2.6
Active State Encoder B	Drop List	Active High	Refer to 2.2.7
Debounce Time Encoder B	0...60,000	250	Unit in millisecond [ms]
Input Type Enc. Z	Drop List	PWM Input	Refer to Table 6
Logic Type Enc. Z	Drop List	Normal Logic	Refer to 2.2.6
Active State Enc. Z	Drop List	Active High	Refer to 2.2.7
Debounce Time Enc. Z	0...60,000	250	Unit in millisecond [ms]
Debounce Filter Enc. Z	Drop List	1.78 us	
Number of Pulses per Revolution Enc. Z	0...65000	0	
Number to Reset Pulse Counter Enc. Z	0...100,000	1000	Refer to 2.2.10
Pulse Counter Pulse Window Enc. Z	0...100,000	1000	Refer to 2.2.10
Pulse Counter Time Window Enc. Z	0...100,000	500	Refer to 2.2.10

Table 35: Default Digital Input Setpoints

4.4 Universal Input Setpoints

The Universal Input setpoints are defined in Section 2.3 Refer to that section for detailed information on how these setpoints are used. The screen capture below in Figure 10 displays the available setpoints for each of the Digital Inputs. Table 35 below highlights the allowable ranges for each setpoint.

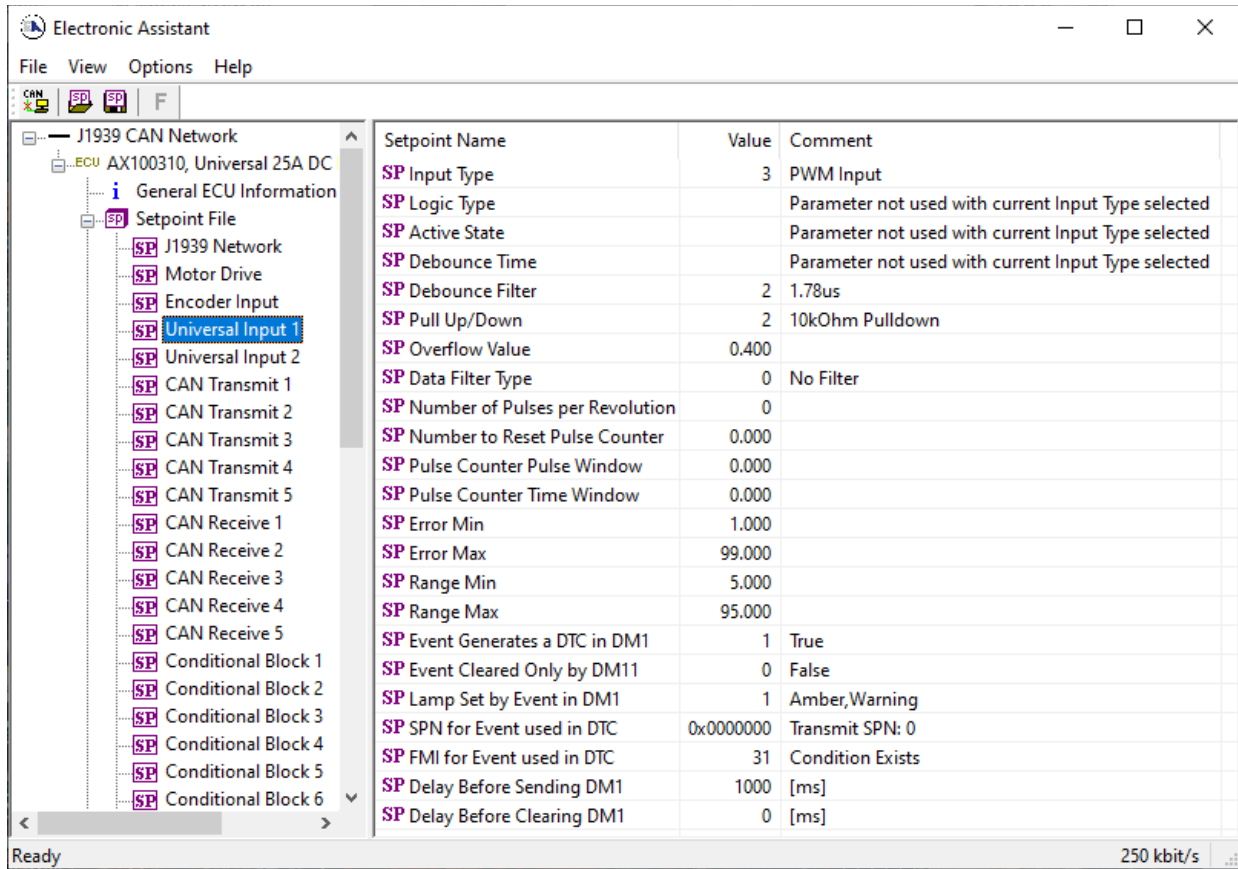


Figure 10: Screen Capture of Default Universal Input Setpoints

Name	Range	Default	Notes
Input Type	Drop List	PWM Input	Refer to Table 6
Logic Type	Drop List	Normal Logic	Refer to 2.2.6
Active State	Drop List	Active High	Refer to 2.2.7
Debounce Time	0...60,000	250	Unit in millisecond [ms]
Debounce Filter	Drop List	1.78 us	Refer to 2.2.5
Pull U/Down	Drop List	10kOhm Pulldown	Refer to 2.3.1
Overflow Value			
Data Filter Type			Refer to 2.2.4
Number of Pulses per Revolution	0...65000	0	Refer to 2.2.10
Number to Reset Pulse Counter	0...100,000	1000	Refer to 2.2.10
Pulse Counter Pulse Window	0...100,000	1000	Refer to 2.2.10
Pulse Counter Time Window	0...100,000	500	Refer to 2.2.10
Error Min	0...100,000	0	Refer to 2.2.3
Error Max	0...100,000	0	Refer to 2.2.3
Range Min	0...100,000	0	Refer to 2.2.3
Range Max	0...100,000	0	Refer to 2.2.3
Event Generates a DTC in DM1	Drop List	False	Default changed to <i>True</i> for illustration purposes. When <i>False</i> , the Digital Input will not trigger a fault on a DM1

Hysteresis To Clear Fault	0...1,000	0	
Event Cleared Only by DM11	Drop List	False	When set to <i>True</i> , only DM11 messages will clear the fault if the input is no longer active. Refer to subsection 2.12.3
Lamp Set by Event in DM1	Drop List	Protect	Refer to Table 31
SPN for Event used in DTC	0...524,287	0	
FMI for Event used in DTC	Drop List	Condition Exists	Refer to Table 32
Delay Before Sending DM1	0...84,600,000	1000	If digital input remains ON after this time, a DTC will be sent on a DM1
Delay Before Clearing DM1	0...84,600,000	0	If digital output OFF after this time, a DTC will not be sent on a DM1 message anymore.

Table 36: Default Digital Input Setpoints

4.5 CAN Transmit Setpoints

The CAN Transmit setpoints are defined in Section 2.5. The screen capture below in Figure 11 displays the available setpoints for the CAN Transmit setpoints. Table 37 below highlights the allowable ranges for the first CAN Transmit setpoint.

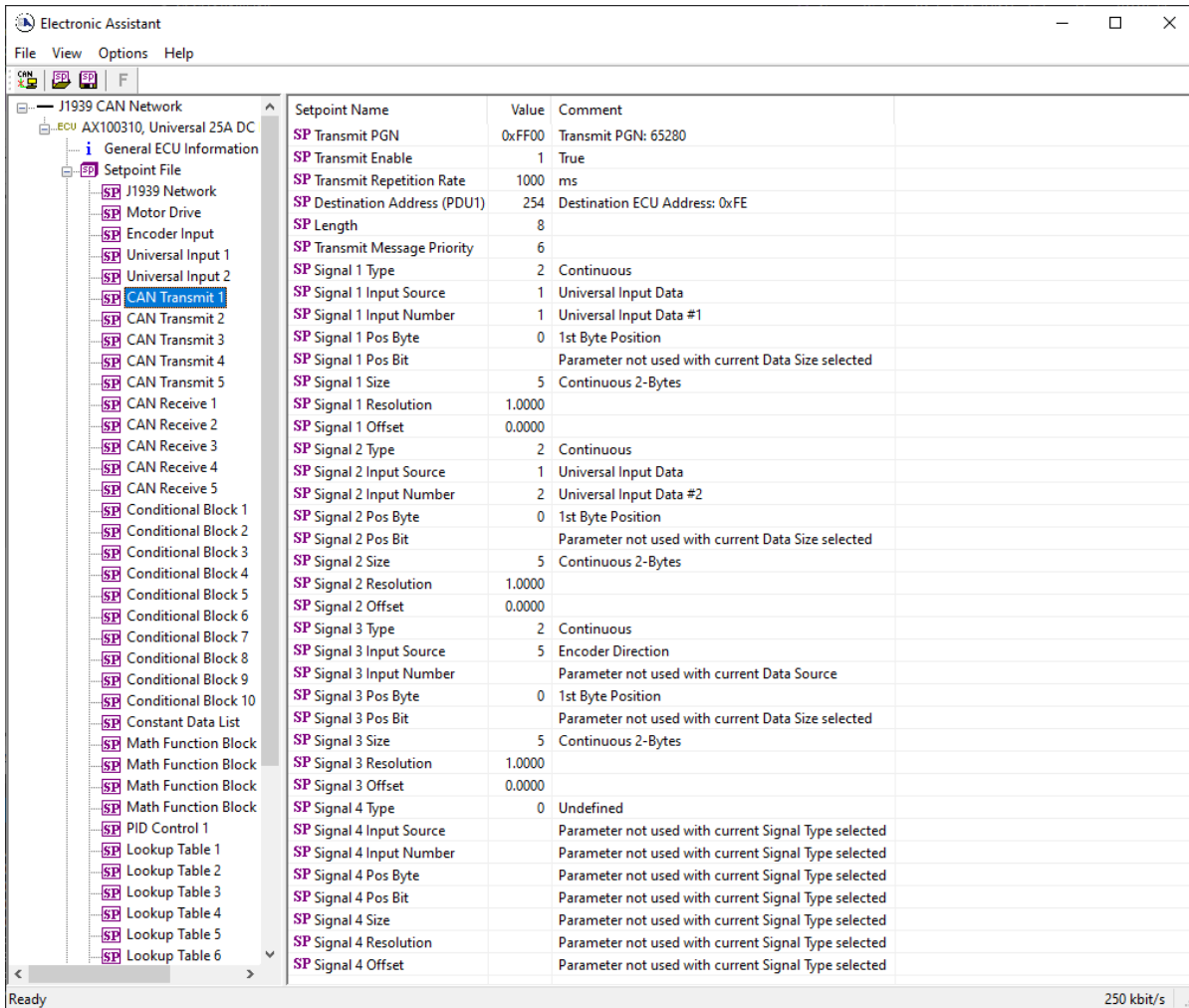


Figure 11: Screen Capture of Default CAN Transmit Setpoints

Name	Default Value ¹	Range	Units	Description
PGN	61459	Any J1939 PGN value	–	CAN message PGN.
Transmission Enable	No	{Yes, No}	–	Enables the CAN output message transmission.
Transmission Rate	10	[0;10000]	ms	CAN output message transmission rate. If 0 – transmission is upon request.
Destination Address	255	[0; 255]	–	Destination address of the PDU1 PGN messages.
Length	8	[0...8]	byte	CAN message data frame length.
Priority	3	[0...7]	–	CAN message priority.
Signal #1 Type	Continuous	{Undefined, Discrete, Continuous}	–	Type of the 1-st CAN output signal.

Name	Default Value ¹	Range	Units	Description
Signal #1 Source	Pitch Angle	Any signal output of any function block or <i>Not Connected</i>	–	Input signal source of the 1-st CAN output signal.
Signal #1 Byte Position	1	[1...8]	–	Byte position of the 1-st CAN output signal.
Signal #1 Bit Position	1	[1...8]	–	Bit position of the 1-st CAN output signal.
Signal #1 Size	16	[1...32]	bit	Size of the 1-st CAN output signal.
Signal #1 Resolution	0.002	Any value	signal units / bit	Resolution of the 1-st CAN continuous output signal.
Signal #1Offset	-64	Any value	signal units	Offset of the 1-st CAN continuous output signal.
Signal #2 Type	Continuous	{Undefined, Discrete, Continuous}	–	Type of the 2-nd CAN output signal.
Signal #2 Source	Roll Angle	Any signal output of any function block or <i>Not Connected</i>	–	Input signal source of the 2-nd CAN output signal.
Signal #2 Byte Position	3	[1...8]	–	Byte position of the 2-nd CAN output signal.
Signal #2 Bit Position	1	[1...8]	–	Bit position of the 2-nd CAN output signal.
Signal #2 Size	16	[1...32]	bit	Size of the 2-nd CAN output signal.
Signal #2 Resolution	0.002	Any value	signal units / bit	Resolution of the 2-nd CAN continuous output signal.
Signal #2Offset	-64	Any value	signal units	Offset of the 2-nd CAN continuous output signal.
...
Signal #4 Type	Undefined	{Undefined, Discrete, Continuous}	–	Type of the 4-th CAN output signal.
Signal #4 Source	Not Connected	Any signal output of any function block or <i>Not Connected</i>	–	Input signal source of the 4-th CAN output signal.
Signal #4 Byte Position	1	[1...8]	–	Byte position of the 4-th CAN output signal.
Signal #4 Bit Position	1	[1...8]	–	Bit position of the 4-th CAN output signal.
Signal #4 Size	1	[1...32]	bit	Size of the 4-th CAN output signal.
Signal #4 Resolution	1	Any value	signal units / bit	Resolution of the 4-th CAN continuous output signal.

Name	Default Value ¹	Range	Units	Description
Signal #4 Offset	0	Any value	signal units	Offset of the 4-th CAN continuous output signal.

Table 37. CAN Transmit Function Block Configuration Parameters

¹ For CAN Output Message #1.

Configuration parameters: *Signal #1...10 Byte Position* and *Signal #1...10 Bit Position*, together with the *Signal #1...10 Size* have the same meaning as in the *CAN Input Signal* function block. The user should be careful not to overlap the output signals.

4.6 CAN Receive Setpoints

The CAN Receive setpoints are defined in Section 2.4. Refer to that section for detailed information on how these setpoints are used. The screen capture below in Figure 12 displays the available setpoints for the CAN Receive setpoints. Table 38 below highlights the allowable ranges for each setpoint.

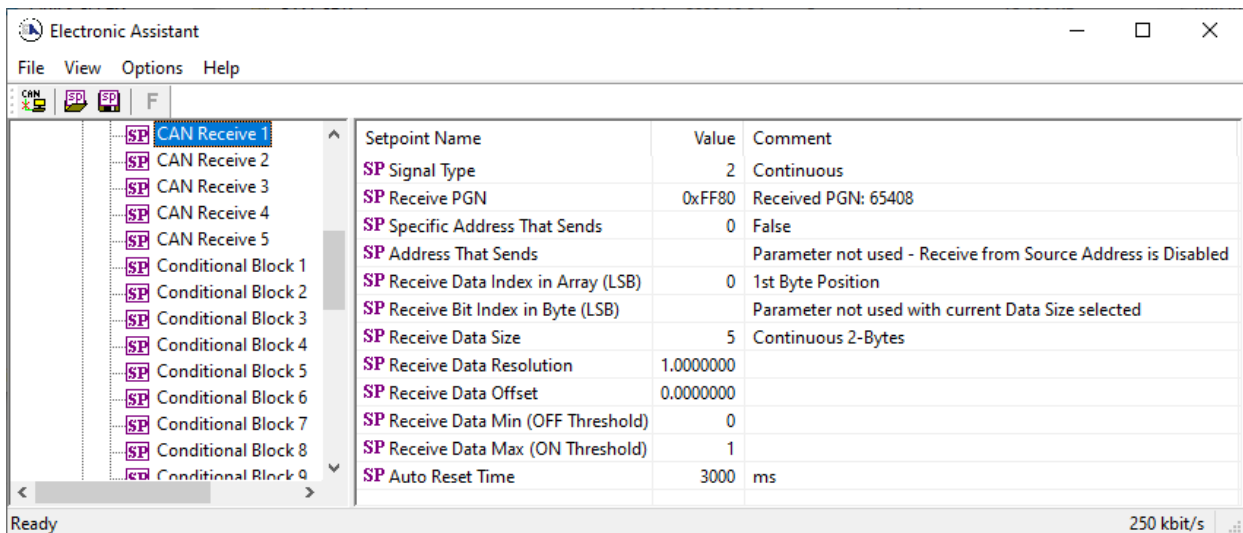


Figure 12: Screen Capture of Default CAN Receive Setpoints

Name	Default Value	Range	Units	Description
Signal Type	Undefined	Drop List	–	CAN input signal type
PGN	65535	Any J1939 PGN value	–	Signal message PGN value.
PGN From Selected Address	No	{No, Yes}	–	Only CAN messages from the selected address will be accepted, if Yes.
Selected Address	0	[0; 253]	–	Address of the ECU transmitting CAN messages if <i>PGN From Selected Address</i> is set to Yes.

Name	Default Value	Range	Units	Description
Data Position Byte	1	[1; 8]	–	Start byte of the CAN input signal in the CAN message data frame.
Data Position Bit	1	[1; 8]	–	Start bit of the CAN input signal in the <i>Data Position Byte</i> .
Size	1	[1...32]	bit	CAN input signal size.
Resolution	1	Any value	signal units / bit	CAN input signal resolution for continuous input signals.
Offset	0	Any value	signal units	CAN input signal offset for continuous input signals.
Autoreset Time	500	[0; 10000]	ms	Function block signal output auto-reset time. If <i>Autoreset Time</i> is 0, the auto-reset is disabled.

Table 38. CAN Input Signal Function Block Configuration Parameters

4.7 Conditional Block

The Conditional Block setpoints are defined in Section 2.10. Refer to that section for detailed information on how these setpoints are used. The screen capture in Figure 13 displays the available setpoints for each of the Conditional Blocks. The table below the screen capture highlights the allowable ranges for each setpoint.

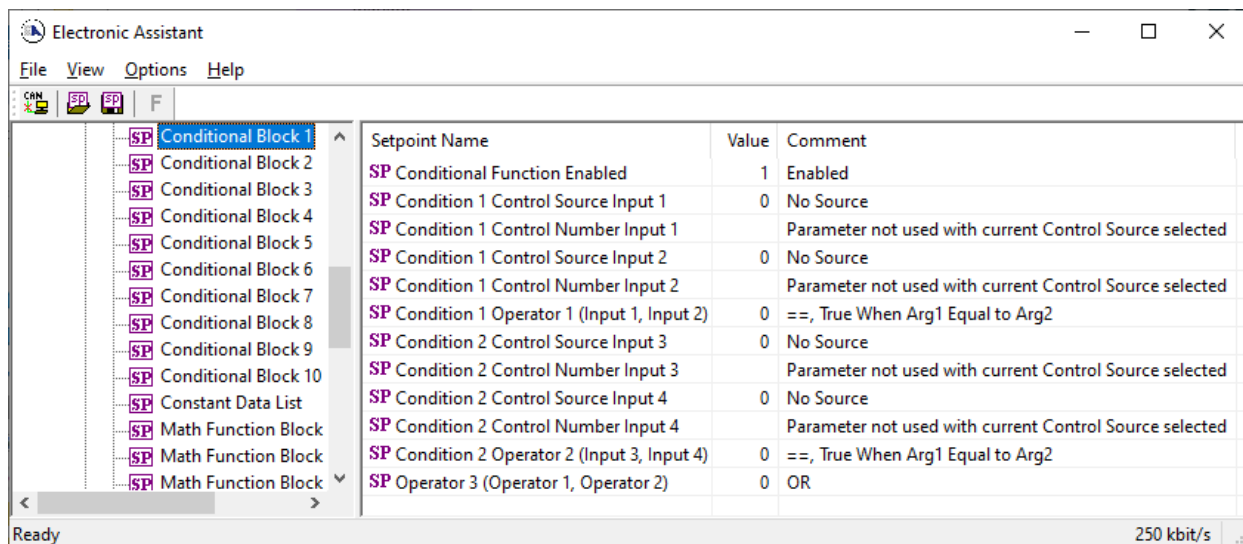


Figure 13: Screen Capture of Conditional Block Setpoints

Name	Range	Default	Notes
Conditional Function Enabled	Drop List	Disabled	Default changed to <i>Enabled</i> for illustration purposes.

Condition 1 Control Source Input 1	Drop List	Digital Input	
Condition 1 Control Number Input 1	Depends on Source Selected	1	
Condition 1 Control Source Input 2	Drop List	Digital Input	
Condition 1 Control Number Input 2	Depends on Source Selected	1	
Condition 1 Operator 1(Input 1, Input 2)	0...7	7	Refer to Table 24
Condition 2 Control Source Input 3	Drop List	Digital Input	
Condition 2 Control Number Input 3	Depends on Source Selected	1	
Condition 2 Control Source Input 4	Drop List	Digital Input	
Condition 2 Control Number Input 4	Depends on Source Selected	1	
Condition 2 Operator 2(Input 3, Input 4)	0...7	7	Refer to Table 24
Operator 3 (Condition 1, Condition 2)	0...2	1	Refer to Table 25

Table 39: Default Conditional Block Setpoints

4.8 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 8 constants are fully user configurable to any value between +/- 1,000,000. The default values are displayed in the screen capture below.

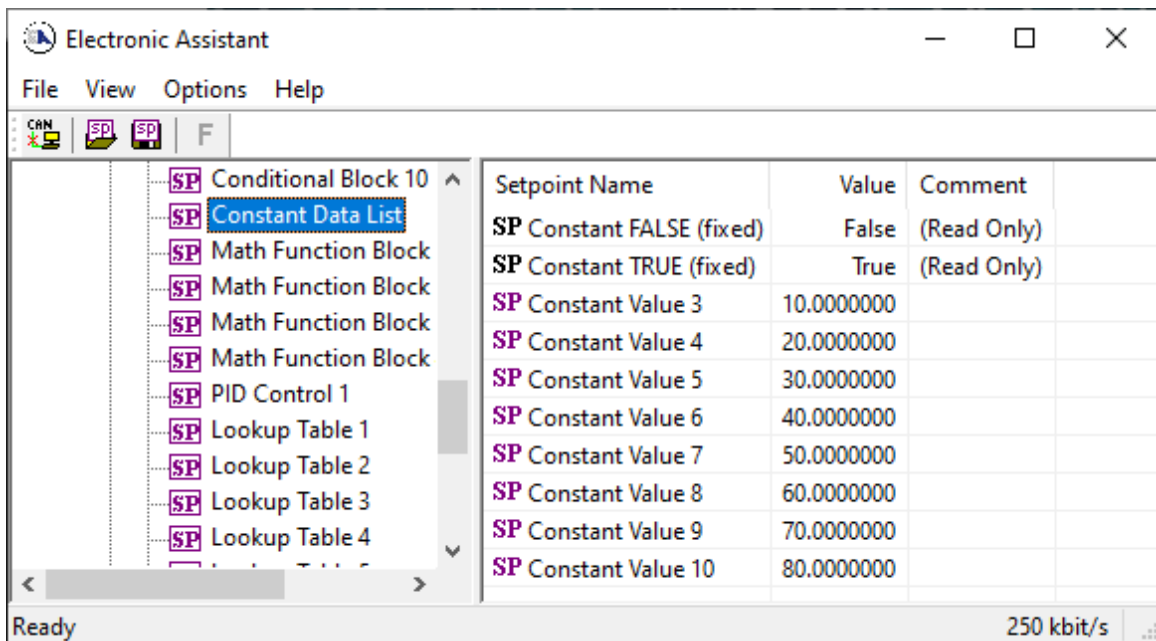


Figure 14: Screen Capture of Constant Data Setpoints

4.9 Math Function Setpoints

The Math Function block is defined in Section 2.9. Please refer there for detailed information about how all these setpoints are used.

Setpoint Name	Value	Comment
SP Math Enabled	1	True
SP Math Output Minimum Range	0.00	
SP Math Output Maximum Range	100.00	
SP Input 1 Source	1	Universal Input Data
SP Input 1 Number	1	Universal Input Data #1
SP Input 1 Minimum	0.00	
SP Input 1 Maximum	100.00	
SP Input 1 Gain	1.00	
SP Input 2 Source	1	Universal Input Data
SP Input 2 Number	2	Universal Input Data #2
SP Input 2 Minimum	0.00	
SP Input 2 Maximum	100.00	
SP Input 2 Gain	1.00	
SP Input 3 Source	0	No Source
SP Input 3 Number		Parameter not used with current Control Source selected
SP Input 3 Minimum		Parameter not used with current Control Source selected
SP Input 3 Maximum		Parameter not used with current Control Source selected
SP Input 3 Gain		Parameter not used with current Control Source selected
SP Input 4 Source	0	No Source
SP Input 4 Number		Parameter not used with current Control Source selected
SP Input 4 Minimum		Parameter not used with current Control Source selected
SP Input 4 Maximum		Parameter not used with current Control Source selected
SP Input 4 Gain		Parameter not used with current Control Source selected
SP Math Function 1	12	/, Result = InA divided by InB
SP Math Function 2	12	/, Result = InA divided by InB
SP Math Function 3		Parameter not used with current Control Source selected

Figure 15: 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.

Name	Range	Default	Notes
Math Function Enabled	Drop List	0, False	True or False
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	Converts calculation from a percentage value to the desired physical unit.
Math Input X Source (X = 1 to 4)	Drop List	0, Control Source Not Used	
Math Input X Number	Per Source	0	
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 Gain	-1.00 to 1.00	1.00	

4.10 PID Control

The PID Control function block is defined in Section 2.6. Please refer there for detailed information about how all these setpoints are used.

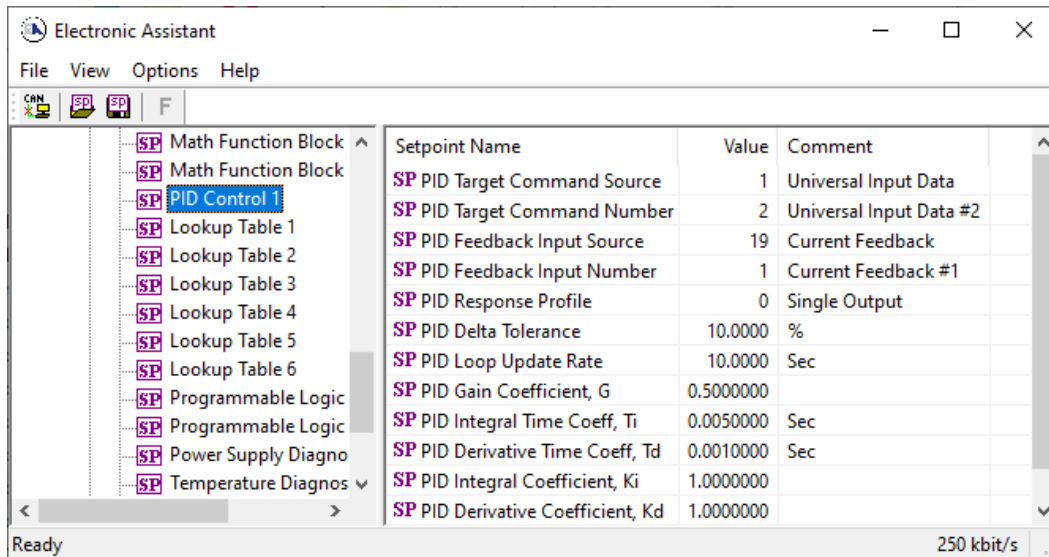


Figure 16: Screen Capture of Default PID Control 1 Setpoints

Note: In the screen capture shown above, the “PID Target Command Source” has been changed from its default value in order to enable the function block.

Name	Range	Default	Notes
PID Target Command Source	Drop List	0, Control Source Not Used	
PID Target Command Number	Per Source	1, Receive Message 1	
PID Feedback Input Source	Drop List	1, Received CAN J1939 Message	
PID Feedback Input Number	Per Source	3, Receive Message 3	
PID Response Profile	Drop List	0, Single Output	
PID Delta Tolerance	0 to 100	1.00	%
PID Loop Update Rate	1 to 60,000 ms	10 ms	1 ms resolution
PID Gain Coefficient, G	0.1 to 10	0.5	
PID Integral Time Coeff, Ti	0.001 to 10 Sec	0.005 Sec	0.001 Sec (1ms) resolution
PID Derivative Time Coeff, Td	0.001 to 10 Sec	0.001 Sec	0.001 Sec (1ms) resolution

PID Integral Coefficient, Ki	0 to 10	1.0	0 disables integral, PD ctrl
PID Derivative Coefficient, Kd	0 to 10	1.0	0 disables derivative, PI ctrl

4.11 Lookup Table Setpoints

The Lookup Table function block is defined in Section 2.7. 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 3, there is nothing further to define in terms of defaults and ranges beyond that which is described in Section 2.7.2 Recall, the X-Axis values will be automatically updated if the min/max range of the selected source is changed if **Auto-update on Setpoint Change** setpoint is *TRUE*. Otherwise, there will be no changes to the X-Axis values and is the user's responsibility to ensure the values are appropriately selected.

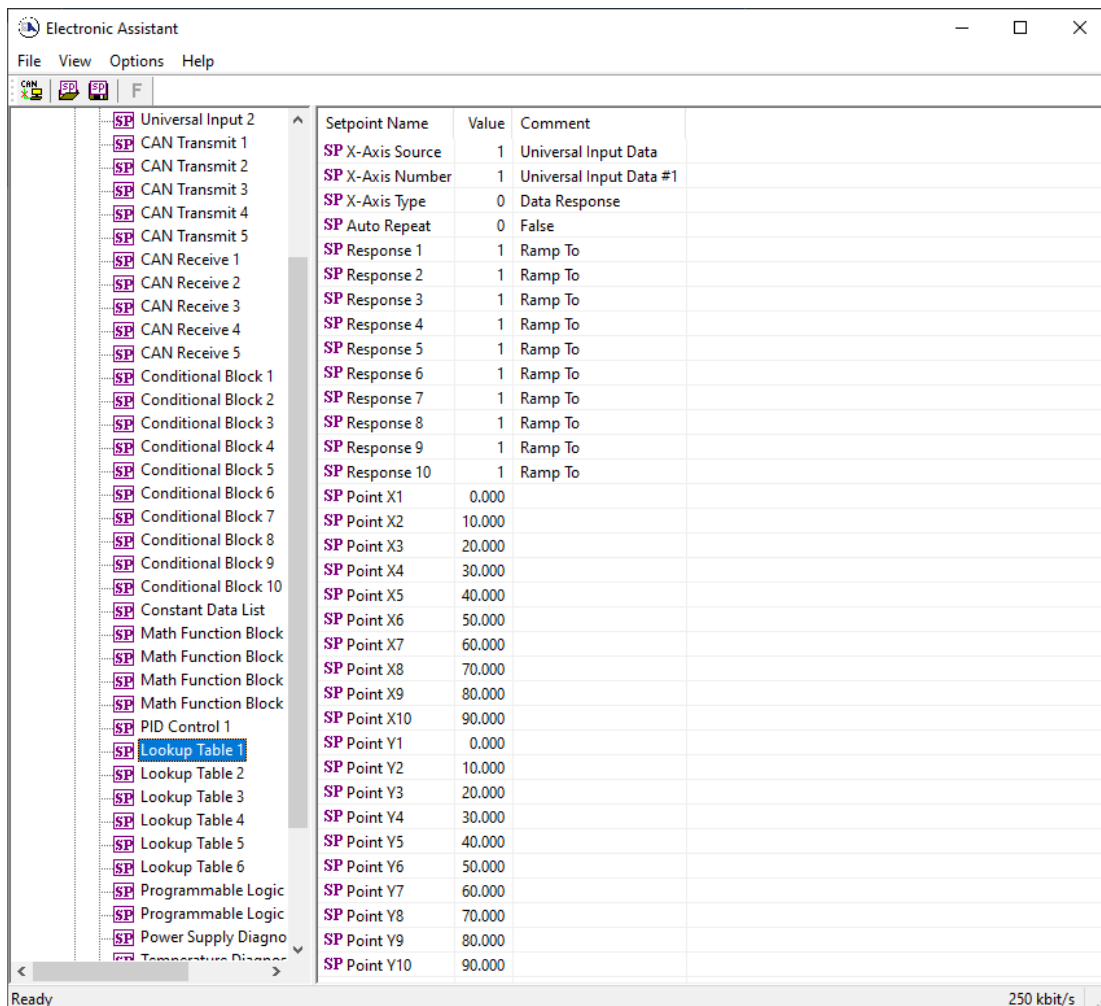


Figure 17: Screen capture of Default Lookup Table 1 Setpoints

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.

4.12 Programmable Logic Setpoints

The Programmable Logic function block is defined in Section 2.8. 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 2.8.2. The screen capture below shows how the setpoints referenced in that section appear on EA.

Setpoint Name	Value	Comment
SP Logic Enabled	1	True
SP Table Number 1	0	Lookup Table 0
SP Logical Operator 1	1	Cnd1 And Cnd2 And Cnd3
SP Table 1 - Condition 1 Argument 1 Source	10	CAN Receive
SP Table 1 - Condition 1 Argument 1 Number	3	CAN Receive #3
SP Table 1 - Condition 1 Argument 2 Source	18	Constant Data
SP Table 1 - Condition 1 Argument 2 Number	1	Constant Data #1
SP Table 1 - Condition 1 Operator	0	=, Equal
SP Table 1 - Condition 2 Argument 1 Source	10	CAN Receive
SP Table 1 - Condition 2 Argument 1 Number	4	CAN Receive #4
SP Table 1 - Condition 2 Argument 2 Source	18	Constant Data
SP Table 1 - Condition 2 Argument 2 Number	5	Constant Data #5
SP Table 1 - Condition 2 Operator	0	=, Equal
SP Table 1 - Condition 3 Argument 1 Source	10	CAN Receive
SP Table 1 - Condition 3 Argument 1 Number	5	CAN Receive #5
SP Table 1 - Condition 3 Argument 2 Source	18	Constant Data
SP Table 1 - Condition 3 Argument 2 Number	10	Constant Data #10
SP Table 1 - Condition 3 Operator	0	=, Equal
SP Table Number 2	1	Lookup Table 1
SP Logical Operator 2	1	Cnd1 And Cnd2 And Cnd3
SP Table 2 - Condition 1 Argument 1 Source	10	CAN Receive
SP Table 2 - Condition 1 Argument 1 Number	3	CAN Receive #3
SP Table 2 - Condition 1 Argument 2 Source	18	Constant Data
SP Table 2 - Condition 1 Argument 2 Number	1	Constant Data #1
SP Table 2 - Condition 1 Operator	0	=, Equal
SP Table 2 - Condition 2 Argument 1 Source	10	CAN Receive
SP Table 2 - Condition 2 Argument 1 Number	4	CAN Receive #4
SP Table 2 - Condition 2 Argument 2 Source	18	Constant Data
SP Table 2 - Condition 2 Argument 2 Number	5	Constant Data #5
SP Table 2 - Condition 2 Operator	0	=, Equal
SP Table 2 - Condition 3 Argument 1 Source	10	CAN Receive
SP Table 2 - Condition 3 Argument 1 Number	5	CAN Receive #5
SP Table 2 - Condition 3 Argument 2 Source	18	Constant Data
SP Table 2 - Condition 3 Argument 2 Number	10	Constant Data #10
SP Table 2 - Condition 3 Operator	0	=, Equal
SP Table Number 3	2	Lookup Table 2
SP Logical Operator 3	0	Default Table
SP Table 3 - Condition 1 Argument 1 Source	10	CAN Receive
SP Table 3 - Condition 1 Argument 1 Number	3	CAN Receive #3
SP Table 3 - Condition 1 Argument 2 Source	18	Constant Data
SP Table 3 - Condition 1 Argument 2 Number	1	Constant Data #1
SP Table 3 - Condition 1 Operator	0	=, Equal
SP Table 3 - Condition 2 Argument 1 Source	10	CAN Receive
SP Table 3 - Condition 2 Argument 1 Number	4	CAN Receive #4
SP Table 3 - Condition 2 Argument 2 Source	18	Constant Data
SP Table 3 - Condition 2 Argument 2 Number	5	Constant Data #5
SP Table 3 - Condition 2 Operator	0	=, Equal
SP Table 3 - Condition 3 Argument 1 Source	10	CAN Receive
SP Table 3 - Condition 3 Argument 1 Number	5	CAN Receive #5
SP Table 3 - Condition 3 Argument 2 Source	18	Constant Data
SP Table 3 - Condition 3 Argument 2 Number	10	Constant Data #10
SP Table 3 - Condition 3 Operator	0	=, Equal

Figure 18: Screen capture of Default Programmable Logic 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.

4.13 Power Supply Diagnostics

The Power Supply Diagnostic setpoints are defined in subsection 2.12.2. Refer to that subsection for detailed information on how these setpoints are used. The screen capture below in Figure 19 displays the available setpoints for the Power Supply Diagnostic setpoints. **Error! Reference source not found.** below highlights the allowable ranges for each setpoint.

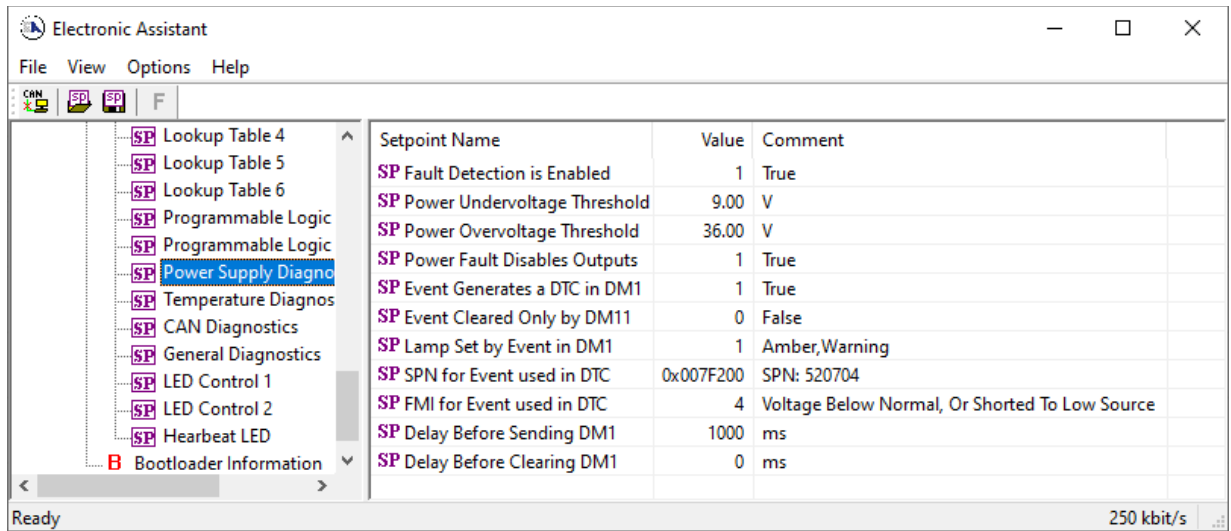


Figure 19: Screen Capture of Default Power Supply Diagnostic Setpoints

Name	Range	Default	Notes
Fault Detection is Enabled	Drop List	True	Refer to Subsection 2.12.2
Power Undervoltage Threshold	8...Power Overvoltage Threshold	9	Units in [volts]
Power Overvoltage Threshold	Power Undervoltage Threshold...36	36	Units in [volts]
Hysteresis to Clear Voltage Fault	0.01...30	1.00	Units in [volts]
Power Fault Disables Outputs	Drop List	True	Refer to Subsection 2.12.2
Event Generates a DTC in DM1	Drop List	False	Default changed to <i>True</i> for illustration purposes, Refer to Subsection 2.12.2
Event Cleared Only by DM11	Drop List	False	Refer to Subsection 2.12.2
Lamp Set by Event in DM1	Drop List	Amber, Warning	Refer to Table 31
SPN for Event used in DTC	0...524,287	520704	Refer to Subsection 2.12.2

FMI for Event used in DTC	Drop List	Voltage Below Normal, Or Shorted to Low Source	Refer to Table 32
Delay Before Sending DM1	0...84,600,000	1000	Units in [milliseconds]
Delay Before Clearing DM1	0...84,600,000	0	If digital output OFF after this time, a DTC will not be sent on a DM1 message anymore.

Table 40: Default Power Supply Diagnostic Setpoints

4.14 Temperature Diagnostics

The Temperature Diagnostic setpoints are defined in subsection 2.12.2. Refer to that subsection for detailed information on how these setpoints are used. The screen capture below in Figure 20 displays the available setpoints for the Temperature Diagnostic setpoints. Table 41 below highlights the allowable ranges for each setpoint.

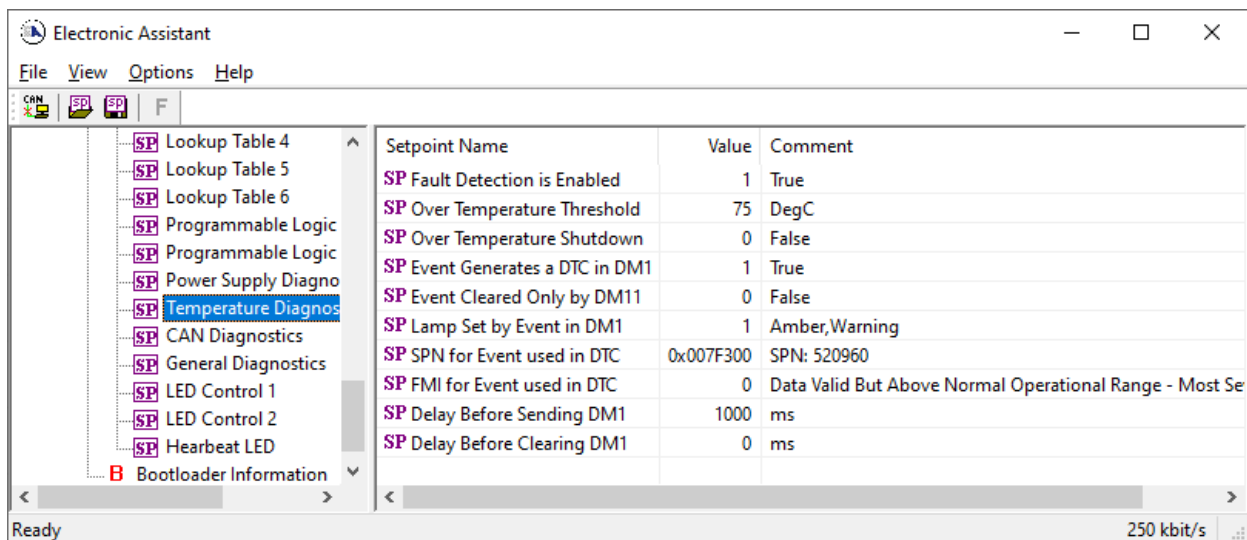


Figure 20: Screen Capture of Default Temperature Diagnostic Setpoints

Name	Range	Default	Notes
Fault Detection is Enabled	Drop List	True	Refer to Subsection 2.12.2
Over Temperature Threshold	50...150	125	Units in [degree in C]
Hysteresis to Clear Voltage Fault	1.00...50	5.00	Units in [degree in C]
Over Temperature Shutdown	Drop List	True	Refer to Subsection 2.12.2
Event Generates a DTC in DM1	Drop List	False	Default changed to <i>True</i> for illustration purposes, Refer to Subsection 2.12.2
Event Cleared Only by DM11	Drop List	False	Refer to Subsection 2.12.2
Lamp Set by Event in DM1	Drop List	Amber, Warning	Refer to Table 31
SPN for Event used in DTC	0...524,287	520,960	Refer to Subsection 2.12.2
FMI for Event used in DTC	Drop List	Data Valid But Above Normal Operational Range – Most Severe Level	Refer to Table 32

Delay Before Sending DM1	0...84,600,000	1,000	Units in [milliseconds]
Delay Before Clearing DM1	0...84,600,000	0	If digital output OFF after this time, a DTC will not be sent on a DM1 message anymore.

Table 41: Default Temperature Diagnostic Setpoints

4.15 CAN Diagnostics

The CAN Diagnostic setpoints are defined in subsection 2.12.2. Refer to that subsection for detailed information on how these setpoints are used. The screen capture below in Figure 21 displays the available setpoints for the Temperature Diagnostic setpoints. Table 42 below highlights the allowable ranges for each setpoint.

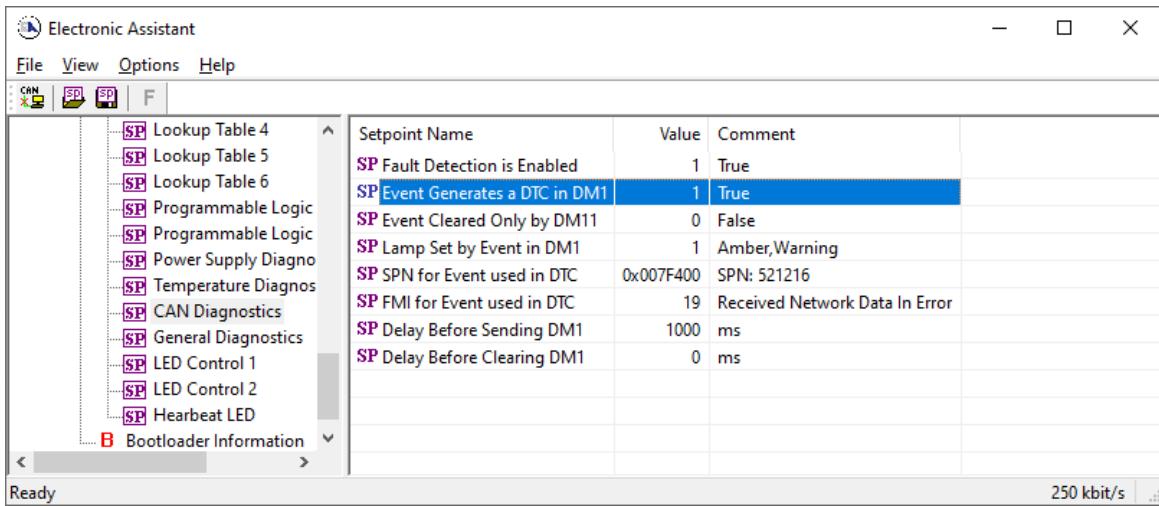


Figure 21: Screen Capture of Default CAN Diagnostic Setpoints

Table 42: Default CAN Diagnostic Setpoints

Name	Range	Default	Notes
Fault Detection is Enabled	Drop List	True	Refer to Subsection 2.12.2
Event Generates a DTC in DM1	Drop List	False	Default changed to <i>True</i> for illustration purposes, Refer to Subsection 2.12.2
Event Cleared Only by DM11	Drop List	False	Refer to Subsection 2.12.2
Lamp Set by Event in DM1	Drop List	Amber, Warning	Refer to Table 31
SPN for Event used in DTC	0...524,287	521,216	Refer to Subsection 2.12.2
FMI for Event used in DTC	Drop List	Voltage Below Normal, Or Shorted to Low Source	Refer to Table 32
Delay Before Sending DM1	0...84,600,000	1,000	Units in [milliseconds]
Delay Before Clearing DM1	0...84,600,000	0	If digital output OFF after this time, a DTC will not be sent on a DM1 message anymore.

4.16 General Diagnostics

The General Diagnostic setpoints are defined in subsection 2.12.1. Refer to that subsection for detailed information on how these setpoints are used. The screen capture below in Figure 22 displays the available setpoints for the Temperature Diagnostic setpoints. Table 43 below highlights the allowable ranges for each setpoint.

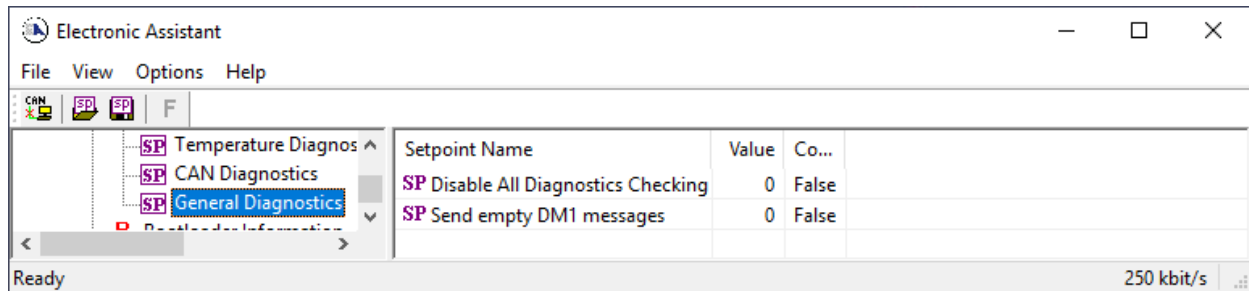


Figure 22: Screen Capture of Default General Diagnostic Setpoints

Table 43: Default General Diagnostic Setpoints

Name	Range	Default	Notes
Disable All Diagnostic Checking	Drop List	False	Refer to Subsection 2.12.1
Send empty DM1 messages	Drop List	False	Refer to Subsection 2.12.1

4.17 LED Control Setpoints

The LED Control setpoints are defined in section 2.11. Refer to that section for detailed information on how these setpoints are used. The screen capture below in Figure 23 displays the available setpoints for each of the LED Control stages. Table 44 below highlights the allowable ranges for each setpoint.

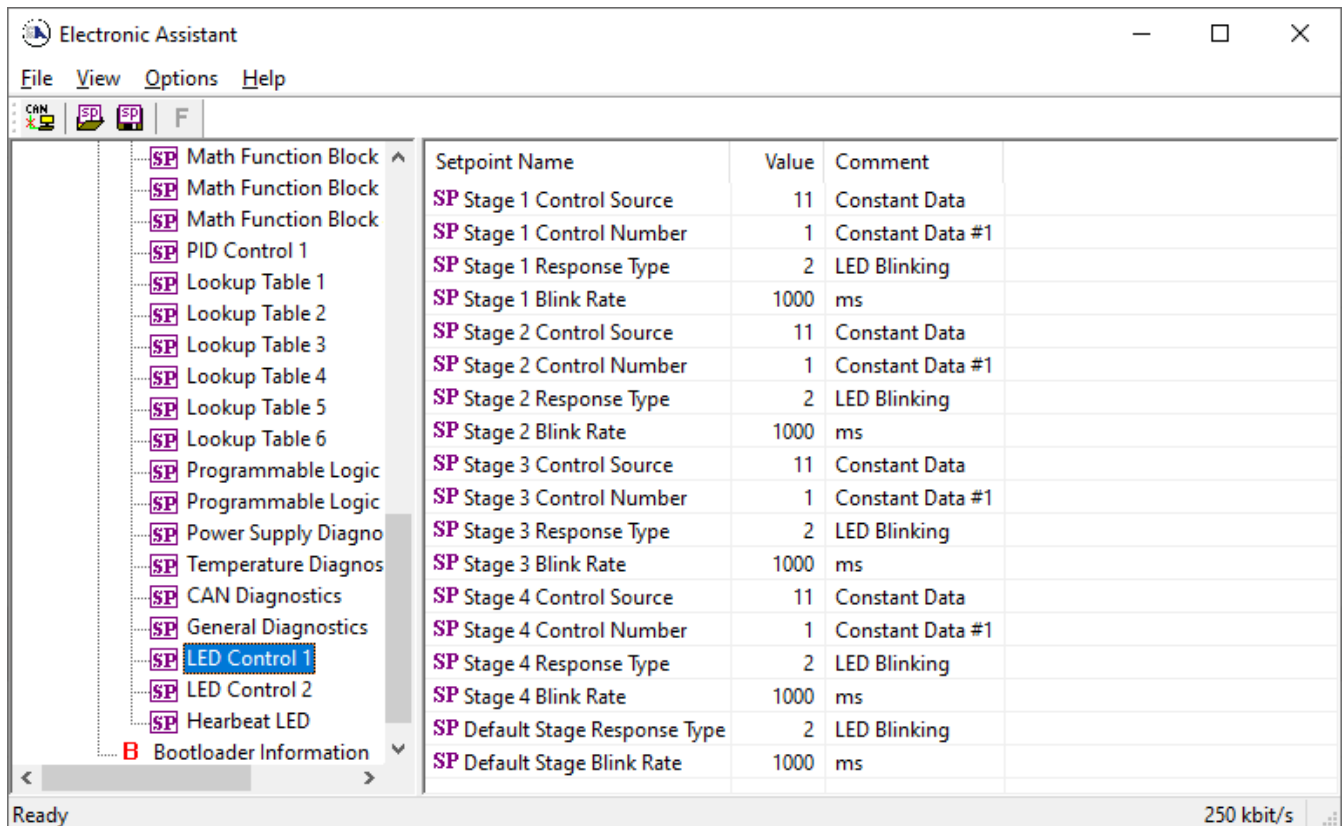


Figure 23: Screen Capture of Default LED Control Setpoints

Name	Range	Default	Notes
Stage 1 Control Source	Drop List	LED Control Power Supply Fault	Refer to Section 2.11.1
Stage 1 Control Number	Depends on Control Source selected		
Stage 1 Response Type	Drop List	LED Blinking	Refer to Section 2.11.2
Stage 1 Blink Rate	0...60,000	500	Units in [milliseconds]
Stage 2 Control Source	Drop List	LED Control Temperature Fault	Refer to Section 2.11.1
Stage 2 Control Number	Depends on Control Source selected		
Stage 2 Response Type	Drop List	LED ON	Refer to Section 2.11.2
Stage 2 Blink Rate	0...60,000	-	
Stage 3 Control Source	Drop List	LED Control CAN Receive Fault	Refer to Section 2.11.1
Stage 3 Control Number	Depends on Control Source selected		
Stage 3 Response Type	Drop List	LED Blinking	Refer to Section 2.11.2
Stage 3 Blink Rate	0...60,000	500	Units in [milliseconds]
Stage 4 Control Source	Drop List	LED Control Source Not Used	Refer to Section 2.11.1
Stage 4 Control Number	Depends on Control Source selected		
Stage 4 Response Type	Drop List	-	Refer to Section 2.11.2

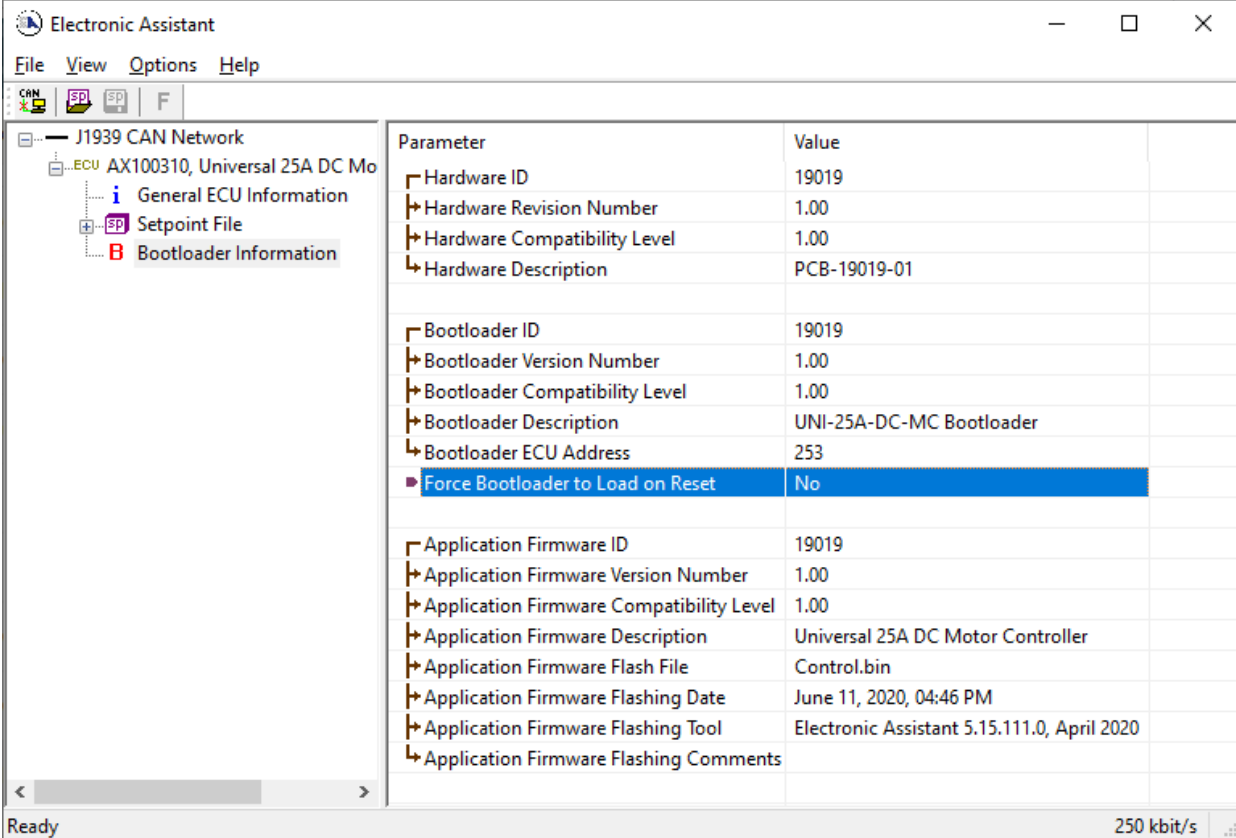
Stage 4 Blink Rate	0...60,000	-	Refer to Section 2.11.2
Default Stage Response Type	Drop List	LED Blinking	Refer to Section 2.11.2
Default Stage Blink Rate	0...60,000	1000	Refer to Section 2.11.2

Table 44: Default LED Control Setpoints

5 REFLASHING OVER CAN WITH EA® BOOTLOADER

The AX100310 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.

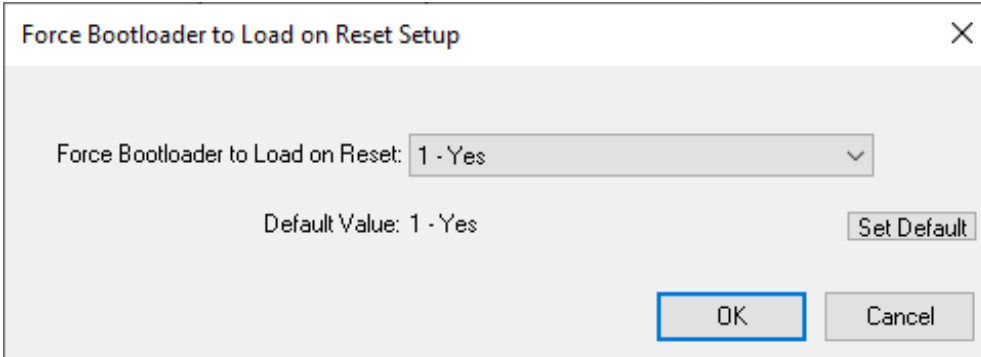
1. When EA first connects to the ECU, the **Bootloader Information** section will display the following information.



The screenshot shows the Electronic Assistant software window. The left sidebar displays a tree view with the following items: J1939 CAN Network, ECU AX100310, Universal 25A DC Mo, General ECU Information, Setpoint File, and Bootloader Information. The main area displays a table of parameters and their values.

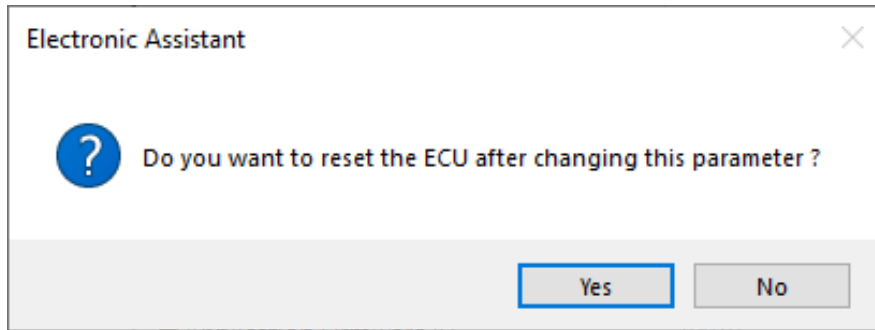
Parameter	Value
Hardware ID	19019
Hardware Revision Number	1.00
Hardware Compatibility Level	1.00
Hardware Description	PCB-19019-01
Bootloader ID	19019
Bootloader Version Number	1.00
Bootloader Compatibility Level	1.00
Bootloader Description	UNI-25A-DC-MC Bootloader
Bootloader ECU Address	253
Force Bootloader to Load on Reset	No
Application Firmware ID	19019
Application Firmware Version Number	1.00
Application Firmware Compatibility Level	1.00
Application Firmware Description	Universal 25A DC Motor Controller
Application Firmware Flash File	Control.bin
Application Firmware Flashing Date	June 11, 2020, 04:46 PM
Application Firmware Flashing Tool	Electronic Assistant 5.15.111.0, April 2020
Application Firmware Flashing Comments	

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

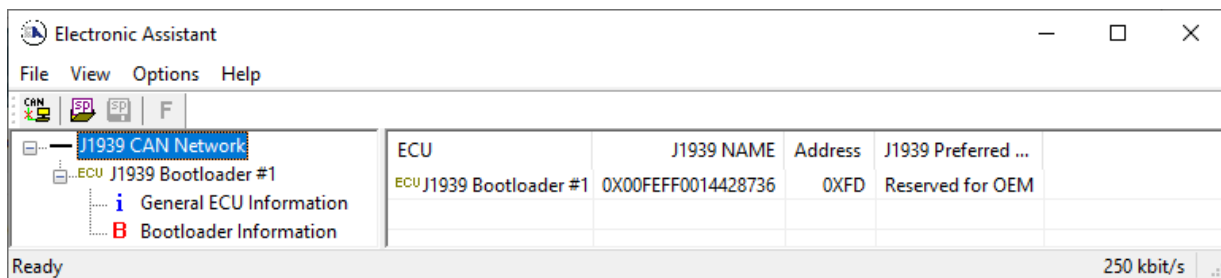


The dialog box titled "Force Bootloader to Load on Reset Setup" contains a dropdown menu for "Force Bootloader to Load on Reset:" with the value "1 - Yes" selected. Below the dropdown, it shows "Default Value: 1 - Yes" and a "Set Default" button. At the bottom, there are "OK" and "Cancel" buttons.

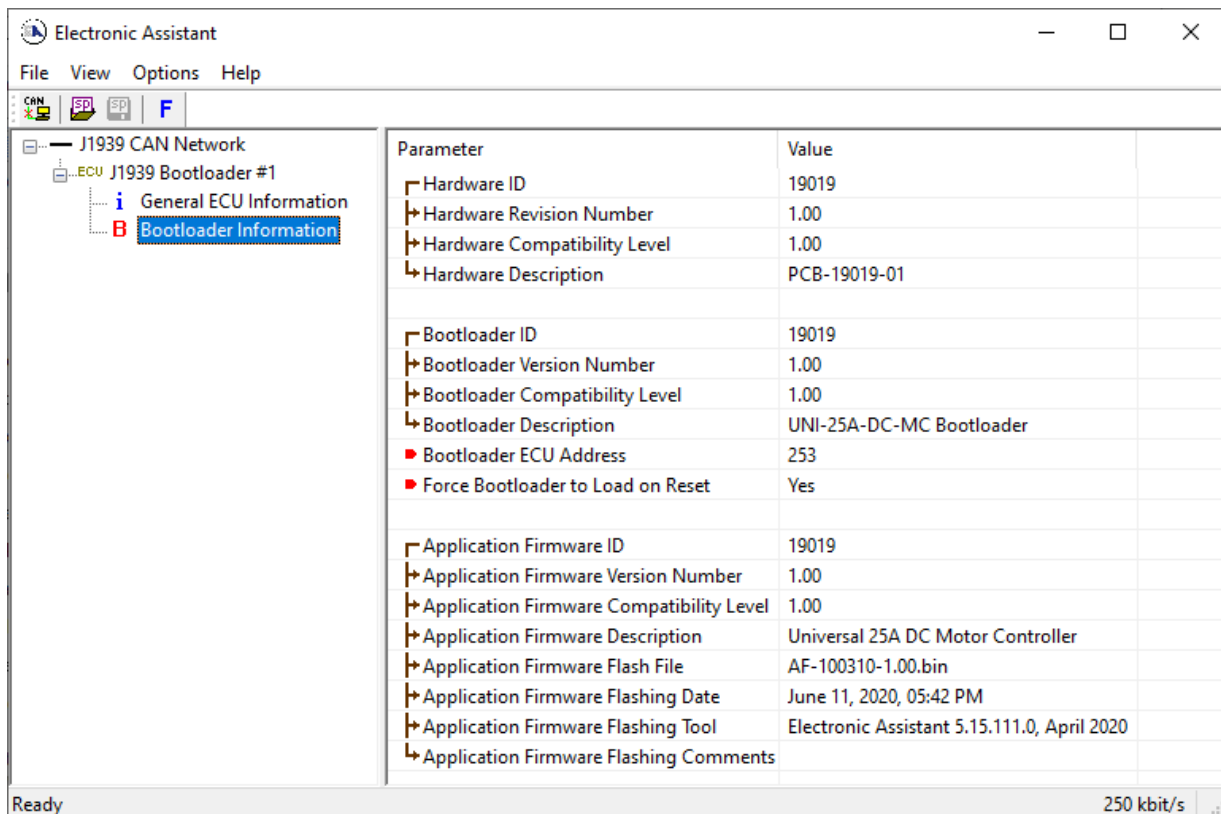
3. When the prompt box asks if you want to reset the ECU, select **Yes**.



- Upon reset, the ECU will no longer show up on the J1939 network as an AX100310 but rather as **J1939 Bootloader #1**.

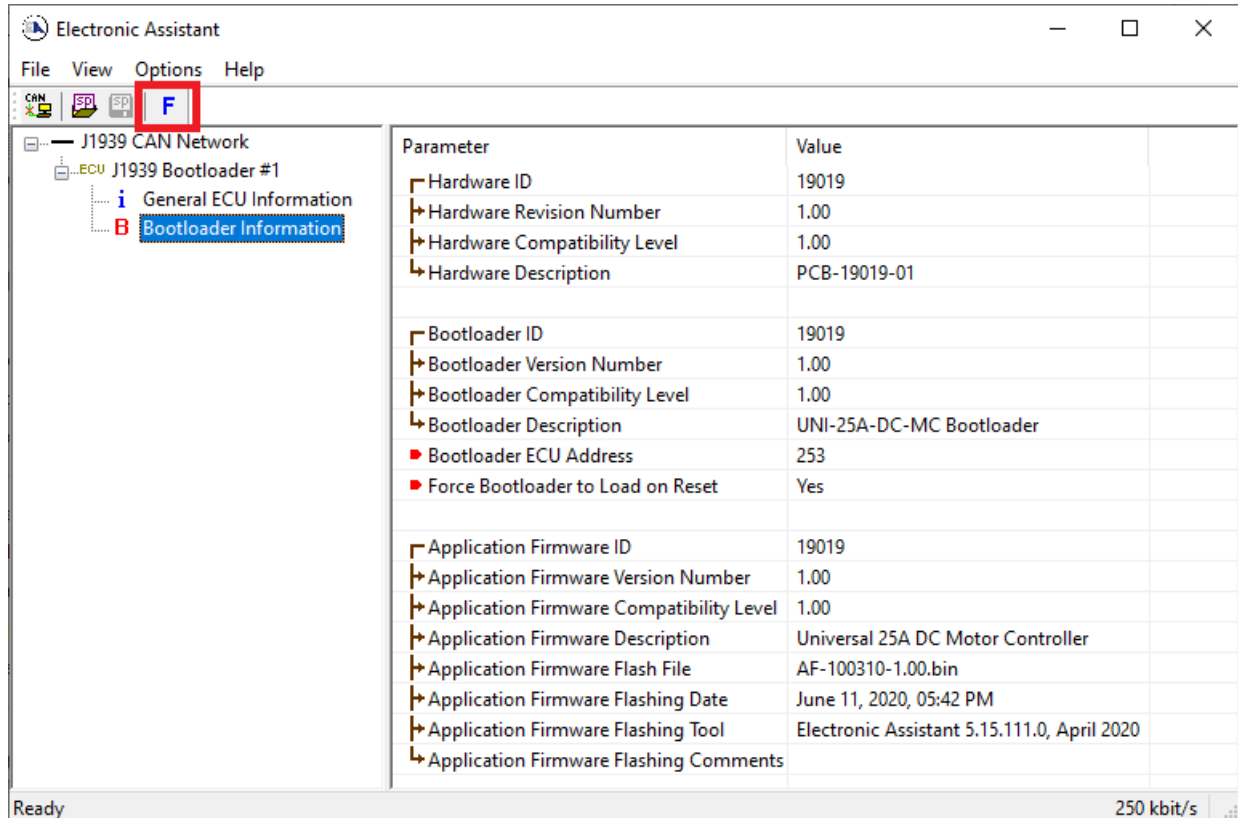


Note: It is recommended to **Close the CAN Port** after the unit was set to Bootloader Mode and afterwards, to **Open the CAN Port again**.



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.

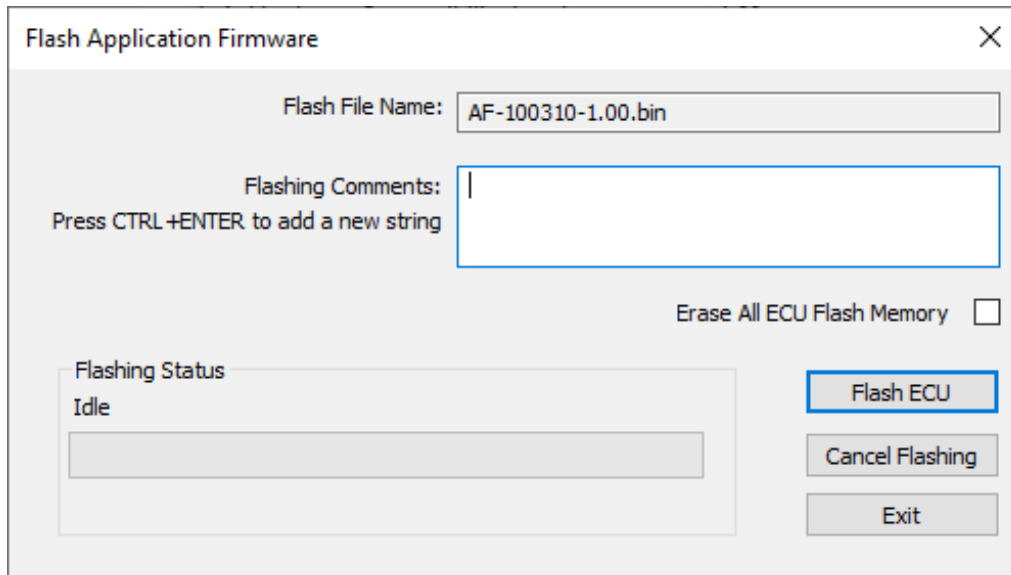
- When the **Bootloader Information** section is selected, the same information is shown as when it was running the AX100310 firmware, but in this case the **Flashing** feature has been enabled.



- Select the **Flashing** button and navigate to where you had saved the **AF-100310-x.yy.bin** file sent from Axiomatic. (Note: only binary (.bin) files can be flashed using the EA tool)

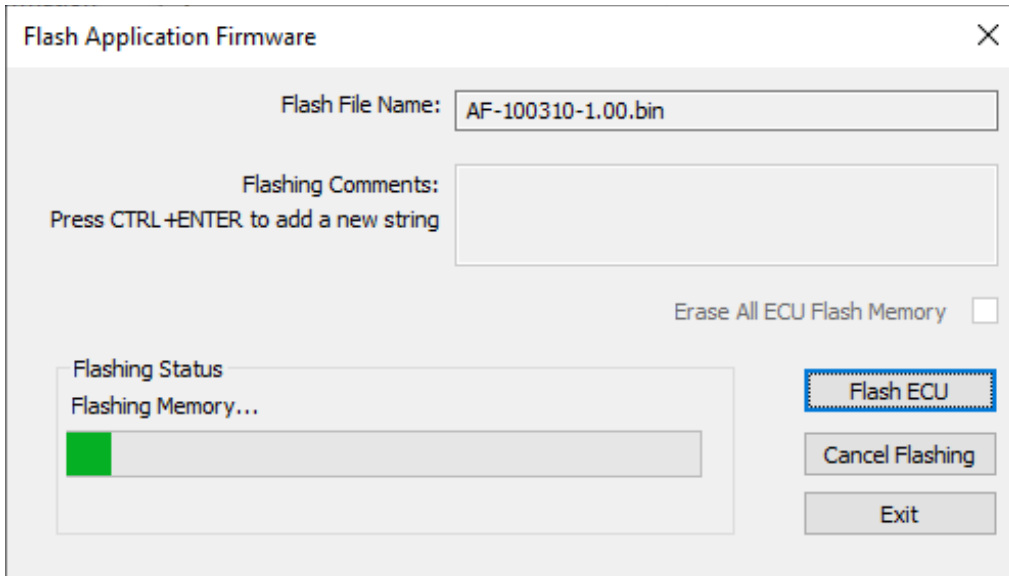
- Once the Flash Application Firmware window opens, you can enter comments such as “Firmware upgraded by [Name]” if you so desire. This is not required, and you can leave the field blank if you do not want to use it.

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.

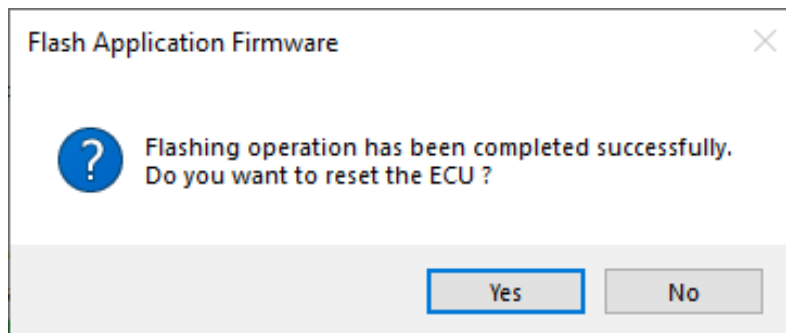


WARNING: Do not check the “Erase All ECU Flash Memory” box unless instructed to do so by your Axiomatic contact. Selecting this will erase ALL data stored in non-volatile flash, including the calibration done by Axiomatic during factory testing. It will also erase any configuration of the setpoints that 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 AX100310 application will start running, and the ECU will be identified as such by EA. Otherwise, the next time the ECU is power-cycled, the AX100310 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

All specifications are typical at nominal input voltage and 25 degrees C unless otherwise specified.

6.1 Power Input

Power Supply Input - Nominal	12V or 24V nominal 9...36 VDC power supply range Transient surge protection is provided. WARNING: This unit is designed for a battery power source. Back EMF from a motor could damage the controller if a bench power supply without voltage regulation is used.
Surge Protection	Provided
Reverse Polarity Protection	Provided
Quiescent Current	61mA @ 12V; 31mA @ 24V Typical

6.2 Input Specifications

CAN Interface CAN_HI CAN_LO	The user can select to control the motor using either a command received from the J1939 bus or a wired command input.																																												
Command Signal Input	Two signal inputs Speed command input is universal and user selectable through software configuration. Choose from one of the following signals: <ul style="list-style-type: none"> ▪ a digital input from a switch or other source (10 kΩ pull-up/pull down – normal, inverted or latched); ▪ potentiometer, 0-1V; 0-2.5V; 0-5V; 0-10Vdc, 0-20 mA or 4-20 mA analog input for machine controls; or ▪ PWM signal input (0.5 Hz to 50 Hz; 10 Hz to 1 kHz; 100 Hz to 10 kHz, 0-100%) for interface to a PLC or engine control module (ECM). 																																												
Input GND	Isolated GND connection provided																																												
Quadrature Encoder Input	A, B, Z, +5V and GND connections Maximum Input Frequency 100 kHz <i>(Input ‘Encoder Z’, which measures the speed, is not able to measure a frequency higher than 60KHz.)</i> Input Amplitude: 0 to Vps. 20kΩ pulldown resistor Rising/Falling edge threshold 4.0V/1.0V +/- 0.1V Number or pulses per revolution are configurable. Custom scaler for encoder steps counter value. There is a configurable polarity of direction of rotation.																																												
Minimum and Maximum Ratings	<table border="1"> <thead> <tr> <th colspan="4">Table 1.0. Absolute Maximum and Minimum Ratings</th> </tr> <tr> <th>Characteristic</th> <th>Min</th> <th>Max</th> <th>Units</th> </tr> </thead> <tbody> <tr> <td>Power Supply</td> <td>8</td> <td>60</td> <td>V dc</td> </tr> <tr> <td>Voltage Input</td> <td>0</td> <td>43</td> <td>V dc</td> </tr> <tr> <td>Current Input</td> <td>0</td> <td>21</td> <td>mA</td> </tr> <tr> <td>Current Input – Voltage Level</td> <td>0</td> <td>12</td> <td>Vdc</td> </tr> <tr> <td>Digital Type Input – Voltage Level</td> <td>0</td> <td>43</td> <td>Vdc</td> </tr> <tr> <td>PWM Duty Cycle</td> <td>0</td> <td>100</td> <td>%</td> </tr> <tr> <td>PWM Frequency</td> <td>50</td> <td>20 000</td> <td>Hz</td> </tr> <tr> <td>PWM Voltage pk - pk</td> <td>0</td> <td>43</td> <td>V dc</td> </tr> <tr> <td>RPM Frequency</td> <td>50</td> <td>20 000</td> <td>Hz</td> </tr> </tbody> </table>	Table 1.0. Absolute Maximum and Minimum Ratings				Characteristic	Min	Max	Units	Power Supply	8	60	V dc	Voltage Input	0	43	V dc	Current Input	0	21	mA	Current Input – Voltage Level	0	12	Vdc	Digital Type Input – Voltage Level	0	43	Vdc	PWM Duty Cycle	0	100	%	PWM Frequency	50	20 000	Hz	PWM Voltage pk - pk	0	43	V dc	RPM Frequency	50	20 000	Hz
Table 1.0. Absolute Maximum and Minimum Ratings																																													
Characteristic	Min	Max	Units																																										
Power Supply	8	60	V dc																																										
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Digital Type Input – Voltage Level	0	43	Vdc																																										
PWM Duty Cycle	0	100	%																																										
PWM Frequency	50	20 000	Hz																																										
PWM Voltage pk - pk	0	43	V dc																																										
RPM Frequency	50	20 000	Hz																																										

Input Accuracy	Table 2.0. Input Accuracy		
	Input Type	Accuracy	Resolution
	Voltage	+/- 1%	1 [mV]
	Current	+/- 1%	1 [uA]
	PWM	+/- 1% (<5kHz) +/- 2% (>5kHz)	0.1 [%]
	Frequency/RPM	+/- 1%	0.01 [Hz]
Input Impedance	0-5V: 1 MOhm 0-10V: 170 kOhm 0(4)-20mA: 249 Ohm Frequency/Digital Input: Pull Up/Pull Down 1 MOhm		
Scan Rate	Each input is scanned in 100uS. A complete scan of 10 inputs occurs with new measured values every 1mS.		
Analog GND	1 Analog GND connections is provided.		

6.3 Output Specifications

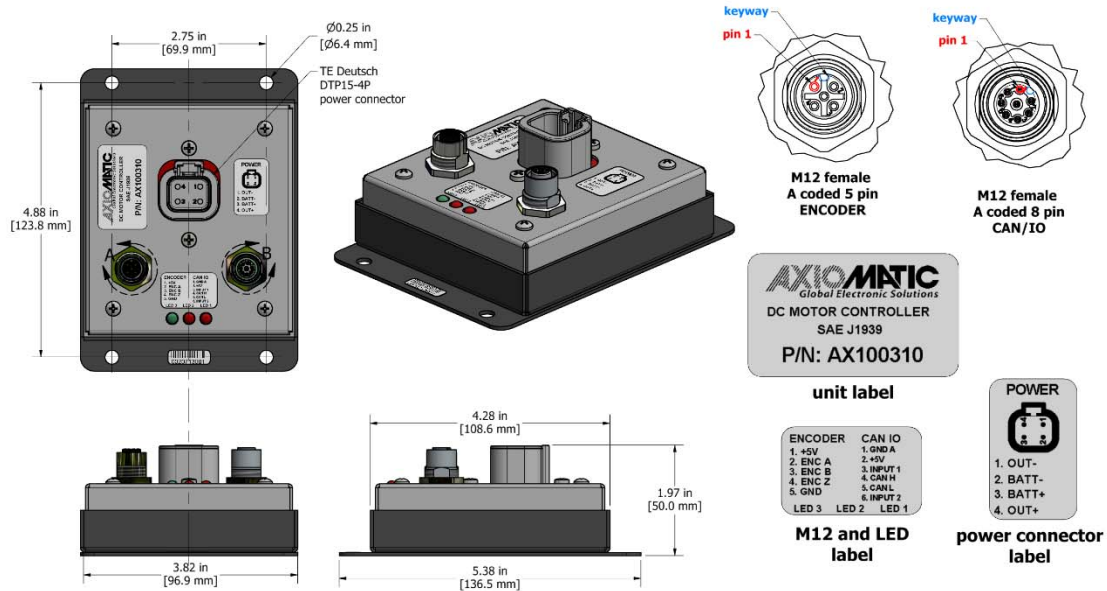
Drive Output	Outputs to a unidirectional, brushed DC motor (other DC motors, contact manufacturer) Half H-Bridge Driver Standard model – 12V or 24V, Up to 25 Amps continuous
Resolution	15-bit PWM
Accuracy	+/- 1% (Duty Cycle)
Protection	Overcurrent and short circuit protection are provided.
+5V Reference	+5V, 100 mA, 0.5%

6.4 General Specifications

Microprocessor	STM32F405RG
CAN Interface	Model AX100310: SAE J1939 The SAE J1939 model has auto baud rate detection and support the following baud rates. 250 kbit/s, 500 kbit/s, 667kbit/s, 1 Mbit/s Model AX100311: CANopen®
Monitoring (options)	The controller can monitor the current drawn by the motor and transmits this information at a constant interval over the CAN bus. Other monitoring options include input measured and % Duty Cycle applied to the motor.
Quiescent Current	61 mA @ 12Vdc; 31 mA @ 24Vdc typical
LED Indication	LED1 – Red LED Flashing LED2 – Red LED Flashing Heartbeat – Green LED (Flashing)
Control Logic	Configurable properties of the controller are divided into function blocks. They include: input function block; diagnostic function block; lookup table function block; programmable logic function block; math function block; constant data block; conditional block; CAN receive message function block; and CAN transmit message function block. The Input function block includes properties used to select input sensor functionality. The Diagnostic function block properties are used to configure fault detection and reaction functionalities. The Math function block gives user an opportunity to process inputs with basic mathematics of the logical functions. The CAN transmit message function block configures properties of the messages sent to the CAN bus. All logic blocks are implemented. Refer to the user manual for details.
CAN Termination	120Ω should be connected between CAN_HI and CAN_LO in a mating wire harness assembly (not supplied).

Electrical Connections	<p>1 8-pin M12, A coded connector 1 5-pin M12, A coded connector 1 4 pin TE Deutsch DTP15-4P connector</p> <p>See pin out below in Table 2.0.</p>
Mating Wire Harness	<p>The mating plug kits for the M12 connectors are not supplied.</p> <p>1 4 pin TE Deutsch DTP15-4P connector mates with wire harness AX070149 (The mating plug assembly is comprised of Deutsch P/N: DTP06-4S, WP4S and four contact sockets 0462-203-12141 with 2 meters (6.5 ft.) of 12 AWG lead wire, unterminated.)</p> <p><u>Wire Harness Pin out:</u> 1 Output - Black/White 2 Battery – Black 3 Battery + Red 4 Output + Red/White</p>
Enclosure and Dimensions	<p>Encapsulated unit enclosed in a stainless-steel casing with powder coated steel base Refer to the <i>dimensional drawing</i>.</p>
Operating Conditions	<p>-40 to +75°C (-40 to 167°F) 0 to 95% relative humidity</p>
Storage Temperature	<p>-40 to 100°C (-40 to 212°F)</p>
Weight	<p>1.80 lb. (0.816 kg)</p>
Vibration	<p>Vibration compliance is suitable for mobile equipment applications.</p>
Protection	<p>IP67</p>

6.5 Dimensions and Typical Connections



Connector	PIN#	Function
Command and CAN 8-pin M12 Female, A coded	1	Input GND
	2	+5V Reference
	3	Input 1
	4	CAN_H
	5	CAN_L
	6	Input 2
	7	Not Used
	8	Not Used
Power and Output TE Deutsch DTP15-4P	1	Output -
	2	Battery -
	3	Battery +
	4	Output +
Encoder Input 5-pin M12, A coded P/N: 09-3442-126-05	1	+5V
	2	ENC_A
	3	ENC_B
	4	ENC_Z
	5	GND

Note: CANopen® is a registered community trademark of CAN in Automation e.V.

Specifications are indicative and subject to change. Actual performance will vary depending on the application and operating conditions. 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.

OUR PRODUCTS

AC/DC Power Supplies
Actuator Controls/Interfaces
Automotive Ethernet Converters
Battery Chargers
CAN Controls, Routers, Repeaters
CAN/WiFi, CAN/Bluetooth
Current/Voltage Converters
DC/DC Power Converters
Engine Temperature Scanners
Ethernet/CAN Converters,
Gateways, Switches
Fan Drive Controllers
Gateways, CAN/Modbus Protocols
Gyroscope Inclinometers
Hydraulic Valve Controllers
Inclinometers, Triaxial
I/O Controls
LVDT Signal Converters
Machine Controls
Modbus Controls
Motor Controls
Power Supplies, DC/DC, AC/DC
PWM Signal Converters/Isolators
Resolver Signal Conditioners
Service Tools
Signal Conditioners, Converters
Strain Gauge CAN Controls
Surge Suppressors

OUR COMPANY

Axiomatic provides electronic machine control components to the off-highway, commercial vehicle, electric vehicle, power generator set, material handling, renewable energy and industrial OEM markets. ***We innovate with engineered and off-the-shelf machine controls that add value for our customers.***

QUALITY DESIGN AND MANUFACTURING

Axiomatic in Canada has an ISO 9001:2015 design and manufacturing facility.

SERVICE

All products to be returned to Axiomatic require a Return Materials Authorization Number (RMA#) from sales@axiomatic.com. Please provide the following information when requesting an RMA number:

- Serial number, part number
- Hours of operation, description of problem
- Wiring set up diagram, application and other comments as needed

SAFE USE

All products should be serviced by Axiomatic. Do not open the product and perform the service yourself.



This product can expose you to chemicals which are known in the State of California, USA to cause cancer and reproductive harm. For more information go to www.P65Warnings.ca.gov.

DISPOSAL

Axiomatic products are electronic waste. Please follow your local environmental waste and recycling laws, regulations and policies for safe disposal or recycling of electronic waste.

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.

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