

UNIVERSAL MOTOR CONTROLLER, 100W WITH J1939

USER MANUAL

P/N: AX100270

P/N: AX100270-01 – J1939 500kbits/s Baud Rate

P/N: AX100270-02 – Custom J1939 Baud Rate, 1Mbits/s

VERSION HISTORY

Version	Date	Author	Modification
1.0.0	Feb 26, 2018	Antti Keränen	Initial Version
1.0.1	Jun 8, 2018	Antti Keränen	Axiomatic EA screen captures in Section 5 & Section 6 updated.
1.0.2	July 19, 2023	Amanda Wilkins	Marketing review. Updated address.
1.0.3	September 1, 2023	Kiril Mojsov	Performed Legacy Updates

ACRONYMS

ACK	Positive Acknowledgement (from SAE J1939 standard)
BATT +/-	Battery positive (a.k.a. Vps) or Battery Negative (a.k.a. GND)
ECU	Electronic Control Unit (from SAE J1939 standard)
GND	Ground reference (a.k.a. BATT-)
SENT	Single Edge Nibble Transmission
BLDC	Brushless DC

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REFERENCES

TDAX100270 Technical Datasheet, Universal Motor Controller, 100W, Axiomatic Technologies 2018

1. Overview of The Motor Controller

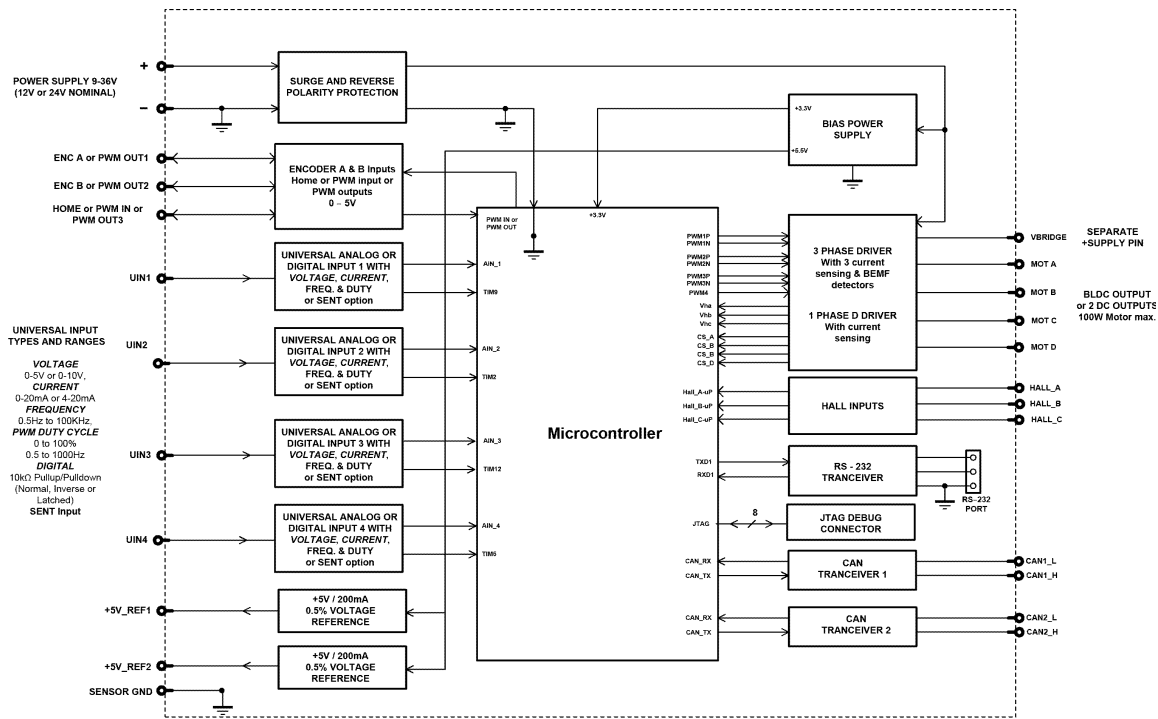


Figure 1 – AX100270 Block Diagram

The universal motor controller, 100W, drives a brushed DC Motor up to 6A or a 3-phase BLDC motor up to 6A. It features two SAE J1939 ports. Interfacing with 12V or 24Vdc power, the controller accepts 4 universal inputs (voltage, current, Frequency, PWM, SENT or digital input types). Hall sensor feedback input is accepted when driving BLDC motor.

In addition, the controller interfaces with one standard A and B phase encoder inputs and one PWM signal or alternatively can read three PWM input signals. The PWM input pins can be configured to provide three PWM signal outputs.

Settings are user configurable to suit many applications. Configuration is via the *Windows*-based Axiomatic Electronic Assistant configuration tool and an USB-CAN converter. The controller is packaged in a TE Deutsch enclosure and has a 24-pin connector.

Setpoint configuration can be saved in a file which can be used to easily program the same configuration into another AX100270 Universal Motor Controller. Throughout this document, Axiomatic EA setpoint names are referred to with bolded text in double-quotes, and the setpoint option is referred to with italicized text in single-quotes. For example, "**Input Sensor Type**" setpoint set to option '*Voltage 0 to 5V*'.

In this document, the configurable properties of the ECU are divided into function blocks, namely Motor Control Function Block, Input Function Block, Output Function Block, Diagnostic Function Block, PID Control Function Block, Lookup Table Function Block, Programmable Logic Function Block, Math Function Block, DTC React Function Block, CAN Transmit Message Function Block and

CAN Receive Message Function Block. These function blocks are presented in detail in next subchapters.

The Universal Motor Controller, 100W, can be ordered using the following part numbers depending on the application.

AX100270	Controller with the default J1939 baud rate (250kbits/s).
AX100270-01	Controller with the 500kbits/s J1939 baud rate.
AX100270-02	Controller with a custom 1Mbits/s J1939 baud rate.

2. Controller Function Blocks

2.1. Motor Controllers

The motor control outputs can drive a motor or other load with continuous 6A current. The maximum instantaneous current can go beyond this limit. The controller is capable of driving one or two DC motors simultaneously or alternatively one BLDC motor.

Most of the setpoints are common for both motor types. The only difference is the Hall sensor sequence setpoints that are only applied for the BLDC motor. When the Motor Drive #1 type is set as BLDC drive, the Motor Drive #2 is disabled automatically by the firmware.

The Motor Control setpoint group has settings for configuring how the motor control output is driven. The **“Output At Minimum Command”** is the output response when the minimum control value (-10A) is fed into the output control block. The **“Output At Maximum Command”** is the equivalent with maximum control value (10A). Both setpoint values are given in milliamps. The motor control algorithm will limit the output current if it tries to rise above these limits.

“Output At Override Command” is the output target current when the override command is used by configuring the **“Override Source”** and **“Override Number”** setpoints. There is a current limiting functionality with this feature too.

“Ramp Up” and **“Ramp Down”** setpoints define the ramp duration for the motor control output current to rise to its target or fall back to zero. Please note if the enable function is used to stop the motor, the ramp function is not applied because the enable functionality utilizes hardware feature for disabling the motor.

“Control Source” and **“Control Number”** setpoints define the control source for motor driving. The allowed values for these setpoints are listed in **Table 20**.

“Direction Source” and **“Direction Number”** define how the direction of motor current flow is controlled. **“Enable Source”** and **“Enable Number”** define the motor driving enable signal source. Both the direction and enable interpret the ‘control signal == 0’ as the one drive value and ‘control signal > 0’ the other.

“Invert Motor Direction” setpoint can be used to change the default direction of motor rotation.

In case there is a need to use a combined direction and enable signaling, for example a CAN message containing both information, this is possible to configure by setting the **“Direction Source”** to *Control Not Used* and **“Enable Source”** to *Received CAN Message*. With this configuration, the received CAN message values are used as listed in Table 1.

0	<i>Disabled</i>
1	<i>Motor enabled in forward direction</i>
2	<i>Motor enabled in reverse direction</i>
3	<i>Reserved</i>

Table 1 – Combined enable and direction signals

“Override Source”, **“Override Number”** and **“Override Response”** allow the user to define an additional control source for overriding the motor output control source set in **“Control Source”** and **“Control Number”** setpoints. The **“Override Response”** can be configured to a negative or to a positive current value. The sign will define the direction of motor driving during override.

The Hall sensor states have the following default values and the phase outputs are driven like shown in Table 2. The column “Hall, combined” shows the value programmed with the Axiomatic EA. The combined Hall state is calculated using:

$$Hall, combined = (Hall_A) \ll 2 + (Hall_B) \ll 1 + Hall_C$$

Hall, combined	Hall C	Hall B	Hall A	Phase A	Phase B	Phase C
2	0	1	0	PWM	OFF	LOW
3	1	1	0	OFF	PWM	LOW
1	1	0	0	LOW	PWM	OFF
5	1	0	1	LOW	OFF	PWM
4	0	0	1	OFF	LOW	PWM
6	0	1	1	PWM	LOW	OFF

Table 2 – Default commutation sequence

2.2. Universal Inputs

The controller has four universal inputs which can be configured to measure voltage, current, frequency, pulse width (PWM) or digital signal. Two out of these four inputs support are decoding SENT signal.

Universal Input setpoint groups have the “**Input Sensor Type**” setpoint, which is used to configure input type. Selecting input type effects on other setpoints and how they are interpreted and should thus be selected first on this block. The input sensor types for Universal Inputs are listed in Table 3.

0	<i>Disabled</i>
12	<i>Voltage 0 to 5 V</i>
13	<i>Voltage 0 to 10 V</i>
20	<i>Current 0 to 20 mA</i>
21	<i>Current 4 to 20 mA</i>
40	<i>Frequency 0.5 to 50 Hz</i>
41	<i>Frequency 10 Hz to 1 kHz</i>
42	<i>Frequency 100 Hz to 10 kHz</i>
50	<i>PWM Low Frequency (<1kHz)</i>
51	<i>PWM High Frequency (>100Hz)</i>
60	<i>Digital (normal)</i>
61	<i>Digital (inverse)</i>
62	<i>Digital (latched)</i>
100	<i>SENT</i>

Table 3 – Universal Input Sensor Type Options

On Universal Inputs, analog voltage (i.e. 0-5V, 0-10V) or current (0-20mA, 4-20mA) signals go directly to a 12-bit analog-to-digital converter (ADC) on the processor. The voltage input is a high impedance input protected against shorts to GND or Vcc. In current mode, a 250Ω resistor is used to measure the input signal.

The SENT input type is available only on Universal Inputs #2 and #4. In this mode, the controller is capable of reading in SENT data in the following format, using 3μs tick time.

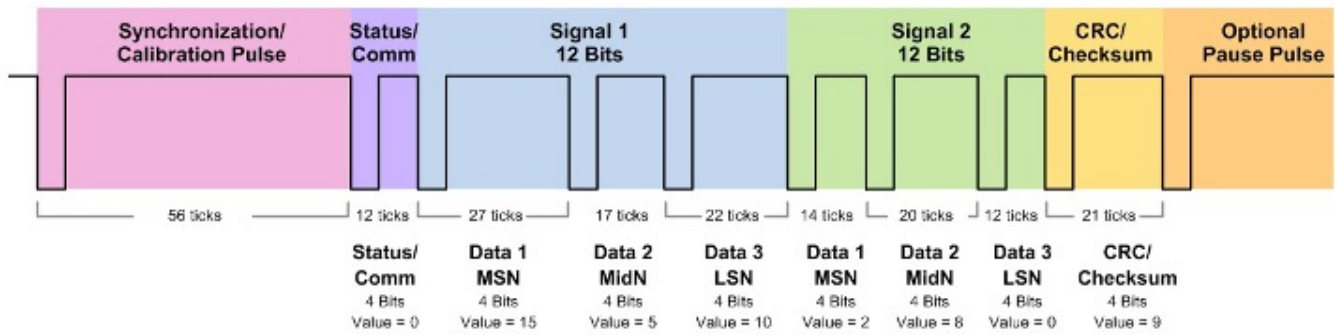


Figure 2 - An example SENT frame

When SENT data is selected as data source for any of the function blocks, the data numbers have the following contents:

1	Status nibble
2	Signal 1 contents (0...4095)
3	Signal 2 contents (0...4095)
4	CRCs (received CRC << 8 + calculated CRC)

Table 4 – Control Numbers associated with SENT

An additional software debounce filter can be used with Universal Input types when configured to detect digital signals for filtering the inputs using longer time constants than with the default debounce filter. The available software implemented debounce times are listed in Table 5.

0	0ms
1	10ms
2	20ms
3	40ms
4	100ms
5	200ms
6	400ms
7	1000ms

Table 5 – Software Debounce Filter Times

Frequency/RPM or Pulse Width Modulated (PWM) “**Input Sensor Type**” options connect an input to 16-bit timer pin on the processor. “**Debounce Time**” setpoint is used to select an input capture filter for the timer pin in question.

The “**Pulses/Units Per Revolution**” setpoint can be used with all input types. If this setpoint is set to a value greater than zero, then the input data will be multiplied by this value, resulting the input to be read in rotations-per-minute (RPM). This feature can be used for scaling the measured input value to RPM reading without having to use a lookup table. If this setpoint is set to zero, the inputs are measured and reported using the corresponding units (volts, milliamps, hertz...).

Universal Inputs have all available three Digital “**Input Sensor Type**” options: Normal, Inverse and Latched. With digital input sensor types, the input measurement is given, either 1 (ON) or 0 (OFF). The Universal inputs measure digital voltage with 3V threshold.

0	<i>None</i>
1	<i>111ns</i>
2	<i>1.78us</i>
3	<i>14.22us</i>

Table 6 – Debounce Time Options

On Frequency, PWM and digital input modes 22kΩ pull-up or pull-down resistors can be enabled or disabled by setting the value of the “**Pullup/Pulldown Resistor**” setpoint. Setpoint options are given in Table 7. By default, pull-down resistors are enabled for all inputs.

0	<i>Pullup/down Off</i>
1	<i>22 kΩ Pullup</i>
2	<i>22 kΩ Pulldown</i>

Table 7 – Pullup/Pulldown Resistor Options

“**Active High/Active Low**” setpoint is used to configure how signal high and low are interpreted. Setpoint options are given in Table 8. By default, all inputs are selected to be Active High, which means that signal high is interpreted as 1(ON) and signal low as 0(OFF).

0	<i>Active High</i>
1	<i>Active Low</i>

Table 8 – Active High/Low Options

Table 9 shows the effect of different digital input types on input signal measurement interpretation with recommended “**Pullup/Pulldown Resistor**” and “**Active High/Low**” combinations. Fault diagnostics are not available for digital input types.

Input Sensor Type		Pulldown Active High	Pullup Active Low	Input measured (state)
6	<i>Digital (normal)</i>	High	Low or Open	1 (ON)
		Low or Open	High	0 (OFF)
61	<i>Digital (inverse)</i>	High or Open	Low	1 (ON)
		Low	High or Open	0 (OFF)
62	<i>Digital (latched)</i>	High to Low	Low to High	0 (no change)
		Low to High	High to Low	1 (state change)

Table 9 – Digital Input Sensor Type versus Input State

The “**Minimum Range**” and “**Maximum Range**” setpoints are used to define range of the signal input outputs as a control source. For example, if “**Maximum Range**” is set to 4V for an input, the control signal is saturated at 4V if input signal rises above 4V. The “**Minimum Range**” and “**Maximum Range**” setpoints are interpreted in input types units, thus they should be re-adjusted after editing “**Input Sensor Type**”.

Software filters can be applied to the measured input signal. Setpoints “**Software Filter Type**” and “**Software Filter Constant**” are used to configure the software filter. By default, no filter is applied to the signal. Software filtering is described in detail in section 2.2.1.

2.2.1. Input Filtering

Measured input data from universal inputs can be filtered to form desired control data. Input filters are configured with “**Filter Type**” and “**Filter Constant**” setpoints. Filters are configured for each input individually.

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

Table 10 – Filter Type Options

“**Filter Type**” setpoint defines the type of software filter used. Setpoint options are ‘*No Filtering*’, ‘*Moving Average*’ and ‘*Repeating Average*’. The ‘*No Filtering*’ option applies no filtering to the measured input data. The ‘*Moving Average*’ option applies the transfer function below to the measured input data, where $Value_N$ is the current value of the control data, $Value_{N-1}$ is the previous control data and Filter Constant is the value of the “**Filter Constant setpoint**”.

Equation 1 - Moving Average Transfer Function:

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

Equation 2 - Repeating Average Transfer Function:

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

The ‘*Repeating Average*’ option applies the transfer function above to the measured input data, where N is value of the “**Filter Constant**” setpoint. At every reading of the input value, the value is added to the sum. At every N^{th} read, the sum is divided by N, and the result is new control data. The sum is set to zero for the next read and summing is started again.

2.3. PWM Inputs / Outputs

The controller has three PWM inputs / outputs. The PWM inputs don’t have as many setpoints for configuration as the Universal Inputs have, however there are some special features.

The “**Input Sensor Type**” setpoint allows to select between different input types as listed in Table 9 above. There is also “**Software Debounce Filter Time**” available, functionality is identical to Universal Inputs’ software debounce filtering. The “**Active High/Active Low**” setpoint defines whether a high or low input reading is interpreted as digital high.

2.3.1. Quadrature Decoder Mode

PWM Input/Output pins #1 and #2 can be configured to decode pulses generated by a quadrature encoder. To use this mode, both PWM Inputs need to have “**Input Sensor Type**” ‘80 - *Quadrature Decoder*’ selected.

When Quadrature Decoder mode is in use, the inputs report the number of encoder pulses read in. The “**Maximum Range**” and “**Minimum Range**” setpoints define the maximum and minimum limits

for the number of read in pulses. These setpoints are also used when scaling the number of pulses to form the control data for other function blocks.

2.3.2. PWM Outputs

The PWM outputs can generate varying PWM signal at a frequency defined using **“PWM Output Frequency”** setpoint. Please note that even if the output is configured as a PWM output, the Control Source option “Digital Input” on other function blocks will reflect the status of the pin signal level.

2.4. PID Controller 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 earlier. 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 Universal Motor Controller.

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 11. When active, the PID algorithm will be called every **“PID Loop Update Rate”** in milliseconds.

0	<i>Single Output</i>
1	<i>Dual Output</i>
2	<i>Setpoint Control</i>
3	<i>On When Over Target</i>
4	<i>On When Below Target</i>

Table 11 – 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 0-5V input) could be connected to *‘Universal Input 1’* and 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 0% to 100%.

To have the block output in range -100% to 100%, the *‘Dual Output’* response needs to be selected. Other than the output range, the *‘Dual Output’* mode is equivalent to the *‘Single Output’* mode.

When a *‘Setpoint Control’* response is selected, the **“PID Target Command Source”** automatically gets updated to *‘Control Constant Data’* and cannot be changed. The value set in the associated constant in the Constant Data List function block becomes the desired target value. In this case, both the target and the feedback values are assumed to be in same units and range. The minimum and

maximum values for the feedback automatically become the constraints on the constant target. In this mode, the output of the block would be a value from 0% to 100%.

For example, if the feedback was setup as a 4-20mA input, a “**Constant Value X**” setpoint set to 14.2 would automatically be converted to 63.75%. The PID function would adjust the output as needed to have the measured feedback to maintain that target value.

The last two response options, ‘*On When Over Target*’ and ‘*On When Under Target*’, are designed to allow the user to combine the two proportional outputs as a push-pull drive for a system. Both outputs must be setup to use the same control input (linear response) and feedback signal to get the expected output response. In this mode, the output would be between 0% to 100%.

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**, **Ki**, **Ti**, **Kd**, **Td** and **Loop_Update_Rate** are configurable parameters.

$$PIDOutput_k = P_k + I_k + D_k$$

$$P_k = P_Gain * Error_k$$

$$I_k = I_Gain * ErrorSum_k$$

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

$$Error_k = Target - Feedback$$

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

$$P_Gain = G$$

$$I_Gain = Ki * T/Ti \text{ (Note: If Ti is zero, I_Gain = 0)}$$

$$D_Gain = Kd * Td/T$$

$$T = Loop_Update_Rate * 0.001$$

Equation 3 - PID Control Algorithm

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.

2.5. Lookup Tables

Lookup Tables are used to give output response up to 10 slopes per input. 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 described in Section 2.6.

Lookup tables have two differing modes defined by “**X-Axis Type**” setpoint, given in Table 12. Option ‘0 – Data Response’ is the normal mode where block input signal is selected with the “**X-Axis Source**” and “**X-Axis Number**” setpoints and X values present directly input signal values. With

option '1 – Time Response' the input signal is time and X values present time in milliseconds. And selected input signal is used as digital enable.

0	<i>Data Response</i>
1	<i>Time Response</i>

Table 12 – X-Axis Type Options

The slopes are defined with (x, y) points and associated point response. X value presents input signal value and Y value corresponding Lookup Table output value. "PointN – Response" setpoint defines type of the slope from preceding point to the point in question. Response options are given in Table 13. 'Ramp To' gives a linearized slope between points, whereas 'Jump to' gives a point to point response, where any input value between X_{N-1} and X_N will result Lookup Table output being Y_N . "Point0 – Response" is always 'Jump To' and cannot be edited. Choosing 'Ignored' response causes associated point and all the following points to be ignored.

0	<i>Ignore</i>
1	<i>Ramp To</i>
2	<i>Jump To</i>

Table 13 – PointN – Response Options

In case Time Response is used, the "**Autocycle**" setpoint can be used for generating a repeating, cyclic output while the selected control source enables the time response output of the lookup table.

The X values are limited by minimum and maximum range of the selected input source if the source is one of the Input Blocks or a Math Function Block. For the fore mentioned sources X-Axis data will be redefined when ranges are changed, therefore inputs should be adjusted before changing X-Axis values. For other sources Xmin and Xmax are 0 and 1000. The X-Axis is constraint to be in rising order, thus value of the next index is greater than or equal to preceding one. Therefore, when adjusting the X-Axis data, it is recommended that X_{10} is changed first, then lower indexes in descending order.

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

The Y-Axis has no constraints on the data it presents, thus inverse, decreasing, increasing or other response can be easily established. The Smallest of the Y-Axis values is used as Lookup Table output min and the largest of the Y-Axis values is used as Lookup Table output max (i.e. used as Xmin and Xmax values in linear calculation. Ignored points are not considered for min and max values.

2.6. Programmable Logic

The Programmable Logic Function Block is very powerful tool. A Programmable Logic can be linked to up to three Lookup Tables, any of which would be selected only under given conditions. Thus, output of a Programmable Logic at any given time will be the output of the Lookup Table selected by defined logic. Therefore, up to three different responses to the same input, or three different responses to different inputs, can become the input to another function block.

To enable any one of the Programmable Logic blocks, the "**Programmable Logic Enabled**" setpoint must be set to 'True'. By default, all Logic blocks are disabled.

The three associated tables are selected by setting “**Table X – Lookup Table Block Number**” setpoint to desired Lookup Table number, for example selecting 1 would set Lookup Table 1 as TableX.

For each TableX there are three conditions that define the logic to select the associated Lookup Table as Logic output. Each condition implements function *Argument1 Operator Argument2* where Operator is logical operator defined by setpoint “**Table X – Condition Y, Operator**”. Setpoint options are listed in Table 14. Condition arguments are selected with “**Table x – Condition Y, Argument Z Source**” and “**Table x – Condition Y, Argument Z Number**” setpoints. If ‘0 – Control not Used’ option is selected as “**Table x – Condition Y, Argument Z Source**” the argument is interpreted as 0.

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

Table 14 – Table X – Condition Y, Operator Options

The three conditions are evaluated and if the result satisfies logical operation defined with “**Table X – Conditions Logical Operator**” setpoint, given in Table 15, the associated Lookup Table is selected as output of the Logical block. Option ‘0 – Default Table’ selects associated Lookup Table in all conditions.

0	<i>Default Table (Table1)</i>
1	<i>Cnd1 And Cnd2 And Cnd3</i>
2	<i>Cnd1 Or Cnd2 Or Cnd3</i>
3	<i>(Cnd1 And Cnd2) Or Cnd3</i>
4	<i>(Cnd1 Or Cnd2) And Cnd3</i>

Table 15 – Table X – Conditions Logical Operator Options

The three logical operations are evaluated in order and the first to satisfy gets selected, thus if Table1 logical operation is satisfied, the Lookup Table associated with Table1 gets selected regardless of two other logical operations. In addition, if none of the logical operations is satisfied the Lookup Table associated with Table1 gets selected.

2.7. Math Function Block

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

The mathematical block’s input signal value can have values in range -1000 to 1000. In case the signal value is larger than that, the “**Function X Input Y Minimum**” and “**Function X Input Y Maximum**” values can be used to rescale the value. 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 Table 16. The functions are connected together, 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 4 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 used’ signal goes through function unchanged.

$$\text{Math Block Output} = \left(\left((A1 \text{ op1 } B1) \text{ op2 } B2 \right) \text{ op3 } B3 \right) \text{ op4 } B4$$

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 either InA or 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
15	MAX-MIN, Result = Absolute value of (InA – InB)
16	SIN, Result = InA * SIN(InB)
17	COS, Result = InA * COS(InB)
18	SQRT, Result = InA * SQRT(InB)

Table 16 – Math function X Operator Options

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 (-1e6 to 1e6) and saturate the output result.

When dividing, a zero divider will always result in a full (1e6) output value for the associated function.

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

2.8. Variable Data

In case run time settable, non-volatile data is required in the control algorithm, the Control Variable Data Blocks offer one possible solution. These function blocks contain a single variable with rules for updating the value at run time, without the need for the user to trigger the variable update process as it is done with the Control Constant Data Blocks.

The **“Variable Value”** setpoint shows the current value for the variable. This setpoint is user configurable, so it is possible to modify the value using the Axiomatic EA.

“Variable Value Data Source” and **“Variable Data Data Number”** define the source from which the new Variable Data value is read at update event.

The variable data update process is controlled using the next five setpoints, namely **“Variable Value Update Trigger Source”**, **“Variable Value Update Trigger Number”**, **“Variable Value Update Trigger Threshold Source”**, **“Variable Value Update Trigger Threshold Number”** and **“Variable Value Update Function”**. The trigger number and source define the control signal to be compared with the trigger threshold control signal. The comparison is done using the logical (or mathematical) operator that can be selected using **“Variable Value Update Function”** setpoint.

In case the logical operation evaluates as *True* (for the Math functions, greater than zero) the variable data value is updated from the selected data source and the new value is stored into Flash memory. The save is done only once per evaluating the update function as *True*. Before the next save can happen, the update function must evaluate as *False* (for the Math functions, equal to zero) at least once. Also, the minimum time between two variable data saving events is set to 10 seconds (not user configurable limit).

2.9. Diagnostics Blocks

The Universal Motor Controller supports diagnostic messaging. DM1 is a message, containing Active Diagnostic Trouble Codes (DTC) that is sent to the J1939 network in case a fault has been detected. A Diagnostic Trouble Code is defined by the J1939 standard as a four-byte value.

In addition to supporting the DM1 message, the following are supported:

SPN	Suspect Parameter Number	(user defined)
FMI	Failure Mode Identifier	(see Table 18 and Table 19)
CM	Conversion Method	(always set to 0)
OC	Occurrence Count	(number of times the fault has happened)
DM2	Previously Active Diagnostic Trouble Codes	Sent only on request
DM3	Diagnostic Data Clear/Reset of Previously Active DTCs	Done only on request
DM11	Diagnostic Data Clear/Reset for Active DTCs	Done only on request

Fault detection and reaction is a standalone functionality that can be configured to monitor and report diagnostics of various controller parameters. The Universal Motor Controller supports 8 Diagnostics Definitions, each freely configurable by the user.

By default, the monitoring of operating voltage, CPU temperature and receive message timeouts is configured to diagnostics blocks 1, 2 and 3., In case any of these three diagnostics blocks are needed for some other use, the user can adjust the default settings to suit the application.

There are 4 fault types that can be used, **“Minimum and maximum error”**, **“Absolute value error”**, **“State error”** and **“Double minimum and maximum error”**.

Minimum and maximum error has two thresholds, “MIN Shutdown” and “MAX Shutdown” that have configurable, independent diagnostics parameters (SPN, FMI, Generate DTCs, delay before flagging status). In case the parameter to monitor stays between these two thresholds, the diagnostic is not flagged.

Absolute value error has one configurable threshold with configurable parameters. In case the parameter to monitor stays below this threshold, the diagnostic is not flagged.

State error is like the Absolute value error, the only difference is that State error does not allow the user to specify specific threshold values; thresholds ‘1’ and ‘0’ are used instead. This is ideal for monitoring state information, such as received message timeouts.

Double minimum and maximum error lets user to specify four thresholds, each with independent diagnostic parameters. The diagnostic status and threshold values is determined and expected as show in Figure 3 below.

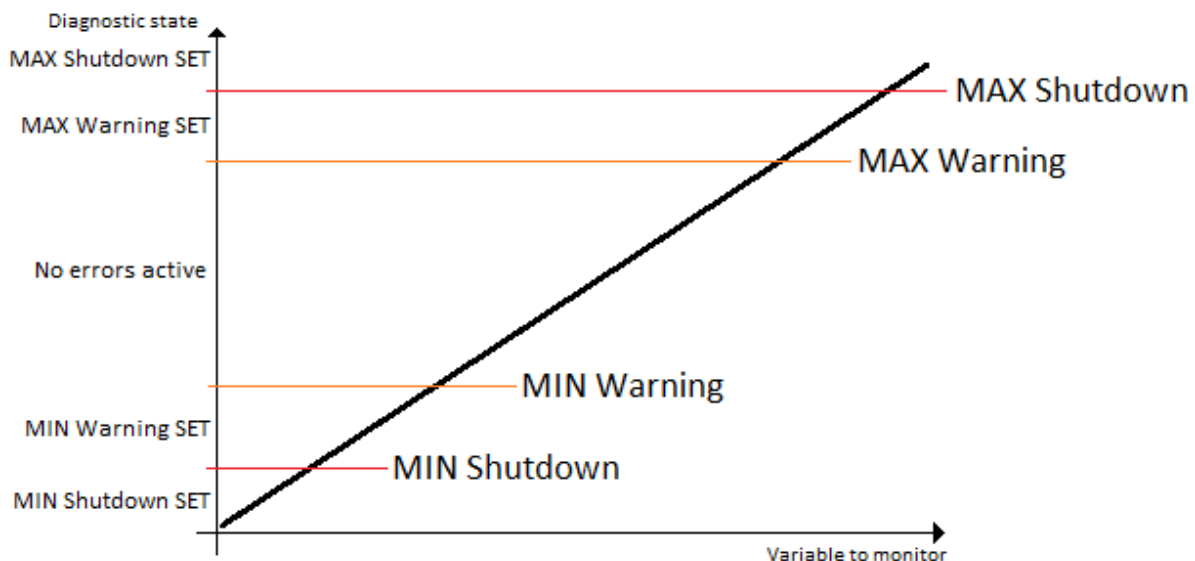


Figure 3 – Double Minimum and Maximum Error Thresholds

In case any of the Diagnostics blocks is configured to monitor Output Current Feedback, there is an internal error status flag maintained automatically for that output. This internal flag can be used for driving the output to a specified state in case of diagnostic event using Proportional Current Output setpoints “Control Fault Response”, “Output in Fault Mode” and “Fault Detection Enabled”.

There is also built in error status flags for power supply and CPU temperature monitoring. In case any of the diagnostics blocks is measuring these two parameters, the corresponding internal error status flags can be used for shutting down the unit in case of failure. The setpoints “**Power Fault Disables Outputs**” and “**Over Temperature Shutdown**” can be used for enabling the shutdown of the unit (shutdown == output driving is turned off).

While there are no active DTCs, the Universal Motor Controller will send “No Active Faults” message. If a previously inactive DTC becomes active, a DM1 will be sent immediately to reflect this. As soon as the last active DTC goes inactive, a DM1 indicating that there are no more active DTCs will be sent.

If there is more than one active DTC at any given time, the regular DM1 message will be sent using a multipacket message to the Requester Address using the Transport Protocol (TP).



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

When the fault is linked to a DTC, a non-volatile log of the occurrence count (OC) is kept. As soon as the controller detects a new (previously inactive) fault, it will start decrementing the **“Delay before Event is flagged”** timer for that Diagnostic function block. If the fault has remained present during the delay time, then the controller will set the DTC to active, and will increment the OC in the log. A DM1 will immediately be generated that includes the new DTC. The timer is provided so that intermittent faults do not overwhelm the network as the fault comes and goes, since a DM1 message would be sent every time the fault shows up or goes away.

By default, the fault flag is cleared when error condition that has caused it goes away. The DTC is made Previously Active and is it is no longer included in the DM1 message. To identify a fault having happened, even if the condition that has caused is one away, the **“Event Cleared only by DM11”** setpoint can be set to *‘True’*. This configuration enables DTC to stay Active, even after the fault flag has been cleared, and be included in DM1 message until a Diagnostic Data Clear/Reset for Active DTCs (DM11) has been requested.

As defined by J1939 Standard the first byte of the DM1 message reflects the Lamp status. **“Lamp Set by Event”** setpoint determines the lamp type set in this byte of DTC. **“Lamp Set by Event”** setpoint options are listed in Table 17. By default, the *‘Amber, Warning’* lamp is typically the one set be any active fault.

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

Table 17 – Lamp Set by Event in DM1 Options

“SPN for Event” defines suspect parameter number used as part of DTC. The default value zero is not allowed by the standard, thus no DM will be sent unless **“SPN for Event”** in is configured to be different from zero. **It is user’s responsibility to select SPN that will not violate J1939 standard.** When the **“SPN for Event”** is changed, the OC of the associated error log is automatically reset to zero.

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>

Table 18 – FMI for Event Options

Every fault has associated a default FMI with them. The used FMI can be configured with “**FMI for Event**” setpoint, presented in Table 18. When an FMI is selected from Low Fault FMIs in Table 19 for a fault that can be flagged either high or low occurrence, it is recommended that the user would select the high occurrence FMI from the right column of Table 19. There is no automatic setting of High and Low FMIs in the firmware, the user can configure these freely.

Low Fault FMIs	High Fault FMIs
<i>FMI=1, Data Valid But Below Normal Operation Range – Most Severe Level</i>	<i>FMI=0, Data Valid But Above Normal Operational Range – Most Severe Level</i>
<i>FMI=4, Voltage Below Normal, Or Shorted to Low Source</i>	<i>FMI=3, Voltage Above Normal, Or Shorted To High Source</i>
<i>FMI=5, Current Below Normal Or Open Circuit</i>	<i>FMI=6, Current Above Normal Or Grounded Circuit</i>
<i>FMI=17, Data Valid But Below Normal Operating Range – Least Severe Level</i>	<i>FMI=15, Data Valid But Above Normal Operating Range – Least Severe Level</i>
<i>FMI=18, Data Valid But Below Normal Operating Level – Moderately Severe Level</i>	<i>FMI=16, Data Valid But Above Normal Operating Range – Moderately Severe Level</i>
<i>FMI=21, Data Drifted Low</i>	<i>FMI=20, Data Drifted High</i>

Table 19 – Low Fault FMIs and corresponding High Fault FMIs

2.10. CAN Transmit Function Block

The CAN Transmit function block is used to send any output from another function block (i.e. input, CAN receive) to the J1939 network. The AX100270 ECU has six CAN Transmit Messages and each message has four completely user defined signals.

2.10.1. CAN Transmit Message Setpoints

Each CAN Transmit Message setpoint group includes setpoints that effect the whole message and are thus mutual for all signals of the message. These setpoints are presented in this section. The setpoints that configure an individual signal are presented in next section.

The “**Transmit PGN**” setpoint sets PGN used with the message. **User should be familiar with the SAE J1939 standard and select values for PGN/SPN combinations as appropriate from section J1939/71.**

“**Repetition Rate**” setpoint defines the interval used to send the message to the J1939 network. If the “**Repetition Rate**” is set to zero, the message is disabled unless it shares its PGN with another message. In case of a shared PGN repetition rate of the LOWEST numbered message are used to send the message ‘bundle’.



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

2.10.2. CAN Transmit Signal Setpoints

Each CAN transmit message has four associated signals, which define data inside the Transmit message. “**Control Source**” setpoint together with “**Control Number**” setpoint define the signal source of the message. “**Control Source**” and “**Control Number**” options are listed in **Table 20**. Setting “**Control Source**” to ‘*Control Not Used*’ disables the signal.

“**Transmit Data Width**” setpoint determines how many bits signal reserves from the message. “**Transmit Data Index in Array**” determines in which of 8 bytes of the CAN message LSB of the signal is located. Similarly, “**Transmit Bit Index in Byte**” determines in which of 8 bits of a byte the LSB is located. These setpoints are freely configurable, thus **it is the User’s responsibility to ensure that signals do not overlap and mask each other.**

“**Transmit Data Resolution**” setpoint determines the scaling done on the signal data before it is sent to the bus. “**Transmit Data Offset**” setpoint determines the value that is subtracted from the signal data before it is scaled. Offset and Resolution are interpreted in units of the selected source signal.

2.11. CAN Receive Function Block

The CAN Receive function block is designed to take any SPN from the J1939 network and use it as an input to another function block (i.e. Outputs).

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

Once a message has been enabled, a Lost Communication fault will be flagged if that message is not received off the bud within the “**Receive Message Timeout**” period. This could trigger a Lost Communication event as described in section 2.9. To avoid timeouts on a heavily saturated network, it is recommended to set the period at least three times longer than the expected update rate. To disable the timeout feature, simply set this value to zero, in which case the received message will never trigger a Lost Communication fault.

The “**Receive Data Width**”, “**Receive Data Index in Array (LSB)**”, “**Receive Bit Index in Byte (LSB)**”, “**Receive Resolution**” and “**Receive Offset**” can all be used to map any SPN supported by the J1939 standard to the output data of the Received function block.

A CAN receive function clock can be selected as the source of the control input for the output function blocks. When this is case, the “**Received Data Min (Off Threshold)**” and “**Received Data Max (On Threshold)**” setpoints determine the minimum and maximum values of the control signal. As the

names imply, they are also used as the On/Off thresholds for digital output types. These values are in whatever units the data is AFTER the resolution and offset is applied to CAN receive signal.

The Universal Motor Controller I/O supports up to eight unique CAN Receive Messages.

2.12. DTC React

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

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

The DTC could be used as a digital (on/off) input for any function block as appropriate.

2.13. Available Control Sources

Many of the Function Blocks have selectable input signals, which are determined with “[Name] Source” and “[Name] Number” setpoints. Together, these setpoints uniquely select how the I/O of the various function blocks are linked together. “[Name] Source” setpoint determines the type of the source and “[Name] Number” selects the actual source if there is more than one of the same type. Available “[Name] Source” options and associated “[Name] Number” ranges are listed in Table 20. All sources, except “CAN message reception timeout”, are available for all blocks, including output control blocks and CAN Transmit messages. Thought input Sources are freely selectable, not all options would make sense for any input, and it is up to the user to program the controller in a logical and functional manner.

Sources	Number Range	Notes
0: Control Not Used	N/A	When this is selected, it disables all other setpoints associated with the signal in question.
1: Received CAN Message	1 to 8	User must enable the function block, as it is disabled by default.
2: Universal Input Measured	1 to 4	
3: Digital Input Detected	1 to 3	State of the PWM Input / Output pins. If the pin is configured as output, it might not source any meaningful data.
4: PID Function Block	1 to 2	User must enable the function block, as it is disabled by default.
5: Lookup Table	1 to 4	
6: Programmable Logic Block	1 to 2	User must enable the function block, as it is disabled by default.
7: Math Function Block	1 to 2	User must enable the function block, as it is disabled by default.
8: Control Constant Data	1 to 15	1 = FALSE, 2 = TRUE, 3 to 15 = User Selectable
9: Diagnostic Trouble Code	1 to 5	Will only be valid if the corresponding DTC has a non-zero SPN
10: Motor Target Drive	1 to 2	Motor drive target value.
11: Measured Motor Current	1 to 2	Measured motor current in mA.
12: Power Supply Measured	0 to 255	Measured power supply value in Volts. The Parameter sets the threshold in Volts to compare with. In case Parameter is set to '0', the measured value is used as is.
13: Processor Temperature Measured	0 to 255	Measured processor temperature in °C. The Parameter sets the threshold in Celcius to compare with. In case Parameter is set to '0', the measured value is used as is.
14: CAN Reception Timeout	N/A	Only available in Output blocks.
15: Control Variable Data	1 to 2	Variable data.
16: SENT Data	1 to 8	Received SENT data, 1-4 SENT interface #1, 5-8 SENT interface #2

Table 20 – Available Control Sources and Numbers

If a non-digital signal is selected to drive a Universal Input in digital input mode, the signal is interpreted to be OFF at or below the minimum of selected source and ON at or above the maximum of the selected source, and it will not change in between those points. Thus, analog to digital interpretation has a built in hysteresis defined by minimum and maximum of the selected source, as shown in Figure 4. A Universal Input signal is interpreted to be ON at or above “**Maximum Range**” and OFF at or below “**Minimum Range**”.

Control Constant Data has no unit nor minimum and maximum assigned to it, thus user must assign appropriate constant values according to intended use.

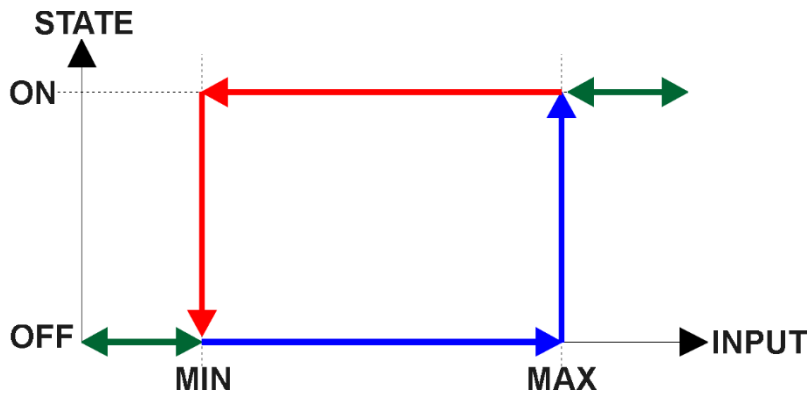


Figure 4 – Analog source to Digital input

3. Installation Instructions

3.1. Dimensions and Pinout

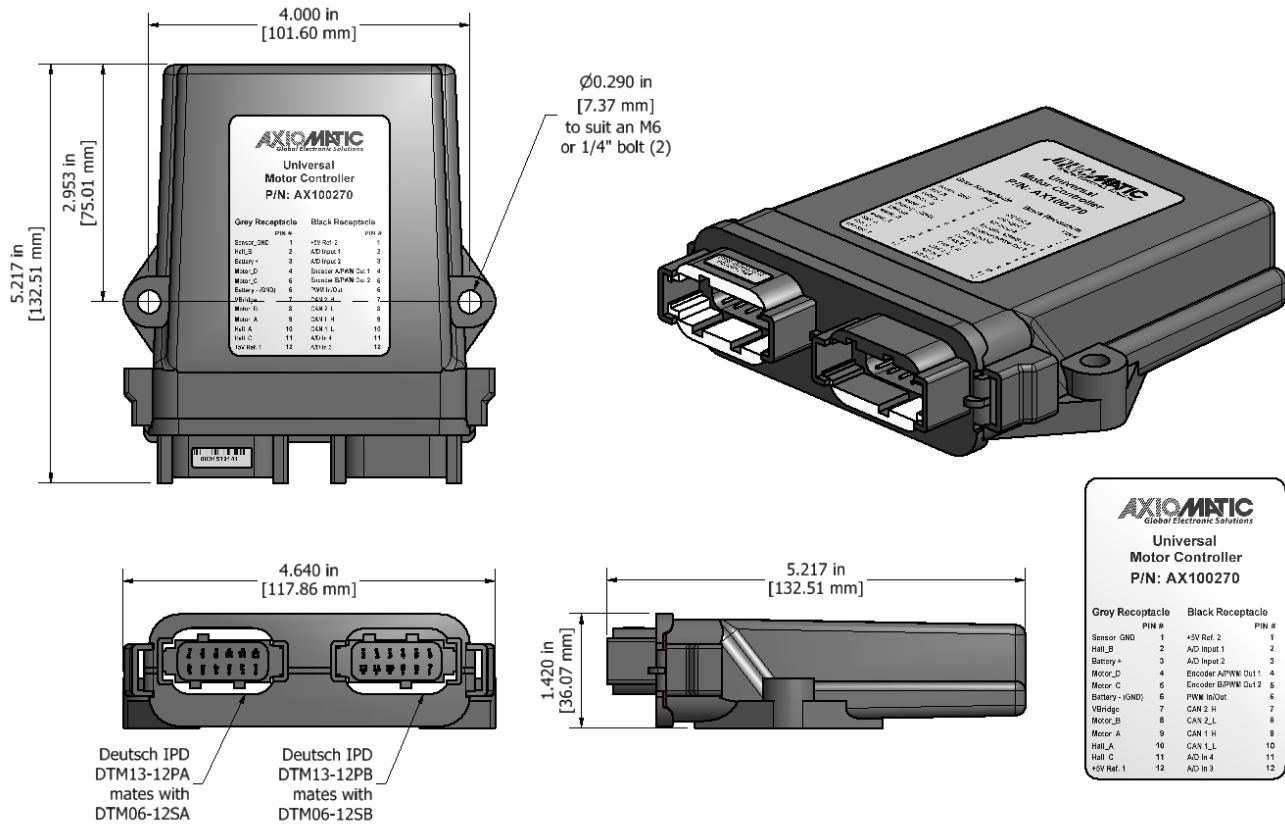


Figure 5 – AX100270 Dimensional Drawing

Grey Connector PIN #	Function	Black Connector PIN #	Function
1	Sensor GND	1	+5V Reference 2
2	Hall B	2	A/D Input 1
3	Battery +	3	A/D Input 2
4	Motor D	4	Encoder A/PWM Out 1
5	Motor C	5	Encoder B/PWM Out 2
6	Battery - (GND)	6	PWM In/Out
7	V Bridge	7	CAN 2_H
8	Motor B	8	CAN 2_L
9	Motor A	9	CAN 1_H
10	Hall A	10	CAN 1_L
11	Hall C	11	A/D Input 4
12	+5V Reference 1	12	A/D Input 3

Table 21 – AX100270 Connector Pinouts

4. Overview of the J1939 Features

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

- Configurable ECU Instance in the NAME (to allow multiple ECUs on the same network)
- Configurable Input Parameters
- Configurable PGN and Data Parameters
- Configurable Diagnostic Messaging Parameters, as required
- Diagnostic Log, maintained in non-volatile memory

4.1. Introduction to Supported Messages

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

From J1939-21 – Data Link Layer

- Request 59904 0x00EA00
- Acknowledgement 59392 0x00E800
- Transport Protocol – Connection Management 60416 0x00EC00
- Transport Protocol – Data Transfer Message 60160 0x00EB00
- Proprietary B from 65280 0x00FF00
to 65535 0x00FFFF

From J1939-73 – Diagnostics

- DM1 – Active Diagnostic Trouble Codes 65226 0x00FECA
- DM2 – Previously Active Diagnostic Trouble Codes 65227 0x00FECB
- DM3 – Diagnostic Data Clear/Reset for Previously Active DTCs 65228 0x00FECC
- DM11 – Diagnostic Data Clear/Reset for Active DTCs 65235 0x00FED3
- DM14 – Memory Access Request 55552 0x00D900
- DM15 – Memory Access Response 55296 0x00D800
- DM16 – Binary Data Transfer 55040 0x00D700

From J1939-81 – Network Management

- Address Claimed/Cannot Claim 60928 0x00EE00
- Commanded Address 65240 0x00FED8

From J1939-71 – Vehicle Application Layer

- Software Identification 65242 0x00FEDA

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

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

4.2. NAME, Address and Software ID

The Universal Motor Controller I/O ECU has the following default for the J1939 NAME. The user should refer to the SAE J1939/81 standard for more information on these parameters and their ranges.

Arbitrary Capable	Address	Yes
Industry Group		0, Global
Vehicle Instance	System	0
Vehicle System		0, Non-specific system
Function		132, Axiomatic Motor Controller
Function Instance		7, Axiomatic AX100270
ECU Instance		0, First Instance
Manufacture Code		162, Axiomatic Technologies
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 from one another when they are connected on the same network.

The default value of the “ECU Address” setpoint is 128 (0x80), which is the preferred starting address for self-configurable ECUs as set by the SAE in J1939 tables B3 and B7. The Axiomatic EA supports the selection of any address between 0 and 253. ***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 universal motor controller will continue select the next highest address until it finds 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

Byte 1 is set to 5, and the identification fields are as follows.

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

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

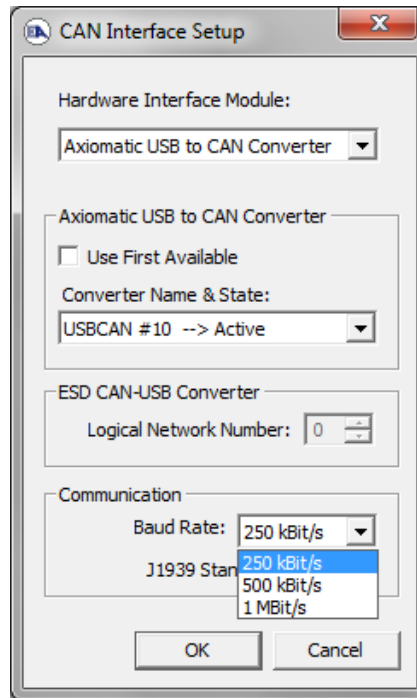
Note: The information provided in the Software ID is available for any J1939 service tool which supports the PGN -SOFT.

5. ECU Setpoints Accessed with the Axiomatic Electronic Assistant

This section describes in detail each setpoint, and their default and ranges. Default values presented in tables are values used when setpoint in question is active. Many of the setpoints are dependent on other setpoints and they may not be active by default. Associated Figures show screen capture of initial operation, however some of the setpoints are not in default condition as they are set differently to activate more setpoints for the image. The setpoints are divided into setpoint groups as they are shown in the Axiomatic EA. For more information on how each setpoint is used by Universal Motor controller, refer to the relevant section in this user manual.

5.1. Accessing the ECU Using the Axiomatic EA

ECU with P/N AX100270 does not need any specific setup for the Axiomatic EA. To access the high-speed versions, AX100270-01 and/or AX100270-02, the CAN bus Baud Rate needs to be set accordingly. The CAN Interface Setup can be found from “Options” menu in the Axiomatic EA.



5.2. J1939 Network Parameters

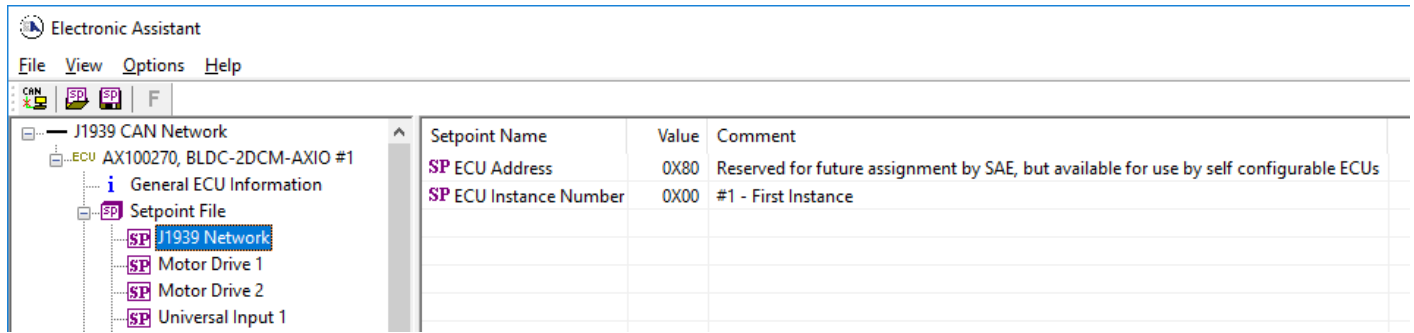


Figure 6 – Screen Capture of J1939 Setpoints

Name	Range	Default	Notes
ECU Address	0x80	0-253	Preferred address for a self-configurable ECU
ECU Instance	0-7	0x00	Per J1939-81

Table 22 – J1939 Network Setpoints

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

5.3. Motor Drive 1 Setpoints

The Motor Control function block is explained in more detail in section 2.1

Setpoint Name	Value	Comment
SP Motor Type	0	DC motor
SP Output At Minimum Command	-10000	mA
SP Output At Maximum Command	10000	mA
SP Output At Override Command	0	mA
SP Invert Motor Direction	0	False
SP Ramp Up (Min to Max)	100	ms
SP Ramp Down (Max to Mix)	100	ms
SP Control Source	0	Control Not Used
SP Control Number		Parameter not used with current Control Source selected
SP Direction Source		Parameter not used with current Control Source selected
SP Direction Number		Parameter not used with current Control Source selected
SP Enable Source		Parameter not used with current Control Source selected
SP Enable Number		Parameter not used with current Control Source selected
SP Enable Response		Parameter not used with current Control Source selected
SP Override Source		Parameter not used with current Control Source selected
SP Override Number		Parameter not used with current Control Source selected
SP Override Response		Parameter not used with current Control Source selected
SP Hall sequence, step 1 (CW)	3	
SP Hall sequence, step 2 (CW)	2	
SP Hall sequence, step 3 (CW)	6	
SP Hall sequence, step 4 (CW)	4	
SP Hall sequence, step 5 (CW)	5	
SP Hall sequence, step 6 (CW)	1	
SP Hall sequence, step 1 (CCW)	4	
SP Hall sequence, step 2 (CCW)	5	
SP Hall sequence, step 3 (CCW)	1	
SP Hall sequence, step 4 (CCW)	3	
SP Hall sequence, step 5 (CCW)	2	
SP Hall sequence, step 6 (CCW)	6	

Figure 7 – Screen Capture of Motor Drive 1 Setpoints

Name	Range	Default	Notes
Motor Type	Drop List	DC motor	
Output At Minimum Command	-10000mA to 0mA	-10000mA	
Output At Maximum Command	0mA to 10000mA	10000mA	
Output At Override Command	-10000mA to 10000mA	0mA	
Invert Motor Direction	Drop List	False	
Ramp Up (Min to Max)	0...60000ms	100ms	
Ramp Down (Max to Min)	0...60000ms	100ms	
Control Source	Drop List	Control Not Used	See Table 20
Control Number	Drop List	1	See Table 20
Direction Source	Drop List	Control Not Used	See Table 20
Direction Number	Drop List	1	See Table 20
Enable Source	Drop List	Control Not Used	See Table 20
Enable Number	Drop List	1	See Table 20
Enable Response	Drop List	0	See Table 20
Override Source	Drop List	Control Not Used	See Table 20
Override Number	Drop List	1	See Table 20
Override Response	Drop List	0	See Table 20
Hall sequence, step 1 (CW)	1-6	3	Each CW step should have unique value

Hall sequence, step 2 (CW)	1-6	2	Each CW step should have unique value
Hall sequence, step 3 (CW)	1-6	6	Each CW step should have unique value
Hall sequence, step 4 (CW)	1-6	4	Each CW step should have unique value
Hall sequence, step 5 (CW)	1-6	5	Each CW step should have unique value
Hall sequence, step 6 (CW)	1-6	1	Each CW step should have unique value
Hall sequence, step 1 (CCW)	1-6	4	Each CCW step should have unique value
Hall sequence, step 2 (CCW)	1-6	5	Each CCW step should have unique value
Hall sequence, step 3 (CCW)	1-6	1	Each CCW step should have unique value
Hall sequence, step 4 (CCW)	1-6	3	Each CCW step should have unique value
Hall sequence, step 5 (CCW)	1-6	2	Each CCW step should have unique value
Hall sequence, step 6 (CCW)	1-6	6	Each CCW step should have unique value

Table 23 – Motor Drive 1 Setpoints

5.4. Motor Drive 2 Setpoints

The Motor Control function block is explained in more detail in section 2.1

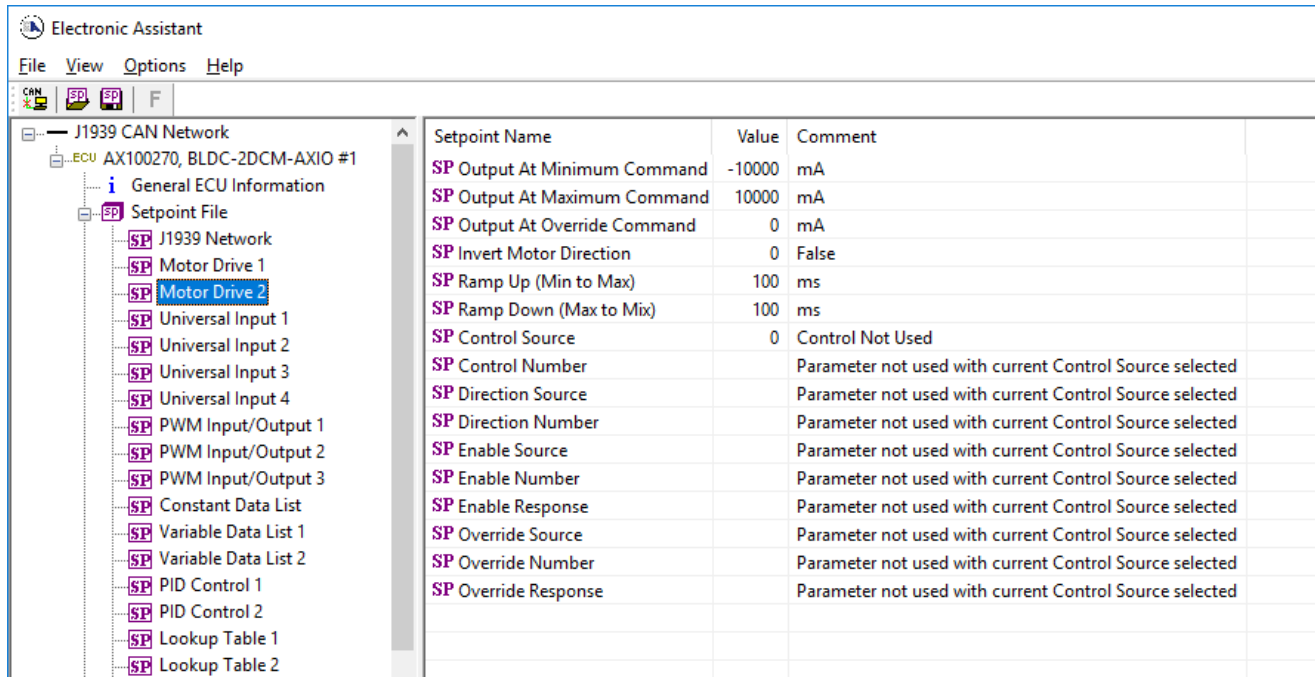


Figure 8 – Screen Capture of Motor Drive 2 Setpoints

Name	Range	Default	Notes
Motor Type	Drop List	DC motor	
Output At Minimum Command	-10000mA to 0mA	-10000mA	
Output At Maximum Command	0mA to 10000mA	10000mA	
Output At Override Command	-10000mA to 10000mA	0mA	
Invert Motor Direction	Drop List	False	
Ramp Up (Min to Max)	0...60000ms	100ms	
Ramp Down (Max to Min)	0...60000ms	100ms	
Control Source	Drop List	Control Not Used	See Table 20
Control Number	Drop List	1	See Table 20
Direction Source	Drop List	Control Not Used	See Table 20
Direction Number	Drop List	1	See Table 20
Enable Source	Drop List	Control Not Used	See Table 20
Enable Number	Drop List	1	See Table 20
Enable Response	Drop List	0	See Table 20
Override Source	Drop List	Control Not Used	See Table 20
Override Number	Drop List	1	See Table 20
Override Response	Drop List	0	See Table 20

Table 24 – Motor Drive 2 Setpoints

5.5. Universal Input Setpoints

The Universal Inputs are defined in Section 2.2

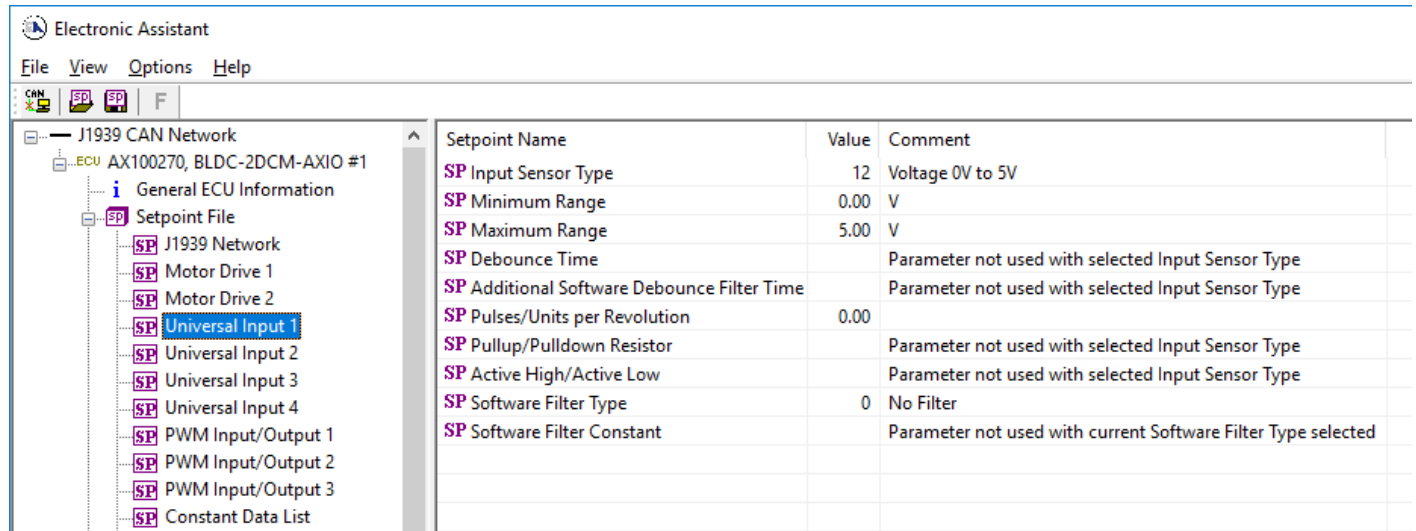


Figure 9 – Screen Capture of Universal Input Setpoints

Name	Range	Default	Notes
Input Sensor Type	Drop List	VOLTAGE 0 TO 5V	See Table 3
Minimum Range	Depends on Input Sensor Type	Depends on Input Sensor Type	
Maximum Range	Depends on Input Sensor Type	Depends on Input Sensor Type	
Debounce Time	Drop List	None	See Table 6
Additional Software Debounce Filter Time	Drop List	0ms	See Table 5
Pulses/Units per Revolution	Drop List	0	See Section 2.2
Pullup/Pulldown Resistor	Drop List	22kΩ Pulldown	See Table 7
Active High/Active Low	Drop List	Active High	See Table 8
Software Filter Type	Drop List	No Filtering	See Table 10
Software Filter Constant	1..1000	1	

Table 25 – Universal Input Setpoints

5.6. PWM Input / Output Setpoints

The PWM Inputs / Outputs are defined in Section 2.3

Setpoint Name	Value	Comment
SP Pin Usage	0	PWM Input
SP Input Sensor Type	60	Digital Normal Logic
SP Minimum Range	0	OFF
SP Maximum Range	4095	
SP Debounce Time		Parameter not used with selected Input Sensor Type
SP Active High/Active Low	0	Active High
SP Output At Minimum Command		Parameter not used - Pin is used as input
SP Output At Maximum Command		Parameter not used - Pin is used as input
SP Ramp Up (Min to Max)		Parameter not used - Pin is used as input
SP Ramp Down (Max to Mix)		Parameter not used - Pin is used as input
SP PWM Output Frequency		Parameter not used - Pin is used as input
SP Control Source		Parameter not used - Pin is used as input
SP Control Number		Parameter not used - Pin is used as input
SP Enable Source		Parameter not used - Pin is used as input
SP Enable Number		Parameter not used - Pin is used as input

Figure 10 – Screen Capture of PWM Input / Output Setpoints

Name	Range	Default	Notes
Pin Usage	Drop List	PWM Input	
Input Sensor Type	Drop List	Digital Normal Logic	See Table 9
Minimum Range	0 – Max Range	0	See Section 2.3
Maximum Range	Min Range - 4095	4095	See Section 2.3
Debounce Time	Drop List	None	
Active High/Active Low	Drop List	Active High	
Output At Minimum Command	0.0% - Output At Max	0.0% DC	
Output At Maximum Command	Output At Min - 100.0% D.C.	100.0% DC	
Ramp Up (Min to Max)	0 – 10000ms	1000ms	
Ramp Down (Max to Min)	0 – 10000ms	1000ms	
PWM Output Frequency	1 – 25000Hz	500Hz	
Control Source	Drop List	Control Not Used	See Table 20
Control Number	Drop List	1	See Table 20
Enable Source	Drop List	Control Not Used	See Table 20
Enable Number	Drop List	1	See Table 20

Table 26 – PWM Input / Output Setpoints

5.7. 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 13 constants are fully user programmable to any value between +/- 1 000 000. The default values are arbitrary and should be configured by the user as appropriate for their application.

The screenshot shows the 'Electronic Assistant' software interface. The 'Constant Data List' setpoint is selected in the left-hand pane. The right-hand pane displays a table with the following data:

Setpoint Name	Value	Comment
SP Constant FALSE (fixed)	False	(Read Only)
SP Constant TRUE (fixed)	True	(Read Only)
SP Constant Value 3	10.0000000	
SP Constant Value 4	20.0000000	
SP Constant Value 5	30.0000000	
SP Constant Value 6	40.0000000	
SP Constant Value 7	50.0000000	
SP Constant Value 8	60.0000000	
SP Constant Value 9	70.0000000	
SP Constant Value 10	80.0000000	
SP Constant Value 11	90.0000000	
SP Constant Value 12	100.0000000	
SP Constant Value 13	25.0000000	
SP Constant Value 14	75.0000000	
SP Constant Value 15	1.0000000	

Figure 11 - Screen Capture of Constant Data List Setpoints

5.8. Variable Data List Setpoints

The Variable Data List Function Block is provided to allow the user to select values as desired for various logic block functions and defining rule for updating this data at run time. This functionality is explained in more detail in section 2.8.

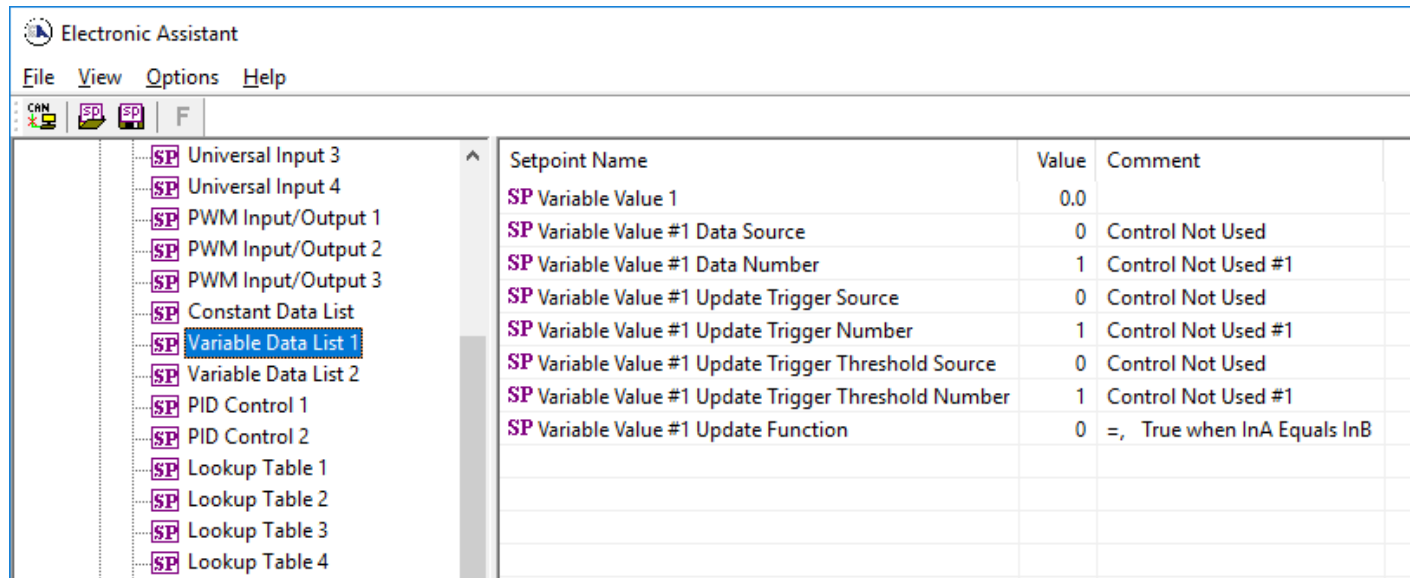


Figure 12 – Screen Capture of Variable Data List Setpoints

Name	Range	Default	Notes
Variable Value		0	
Variable Value Data Source	Drop List	Control Not Used	See Table 20
Variable Value Data Number	Depends on control source	1	See Table 20
Variable Value Update Trigger Source	Drop List	Control Not Used	See Table 20
Variable Value Update Trigger Number	Depends on control source	1	See Table 20
Variable Value Update Trigger Threshold Source	Drop List	Control Not Used	See Table 20
Variable Value Update Trigger Threshold Number	Depends on control source	1	See Table 20
Variable Value Update Function	0...17	0	See Table 16

Table 27 – Variable Data Setpoints

5.9. PID Control

The PID Control Function Block is defined in Section 2.4. Please refer there for detailed information about how all these setpoints are used.

Command Source is set to ‘Control Not Used’ by default. To enable a PID Control, select appropriate “PID Target Command Source” and “PID Feedback Input Source”.

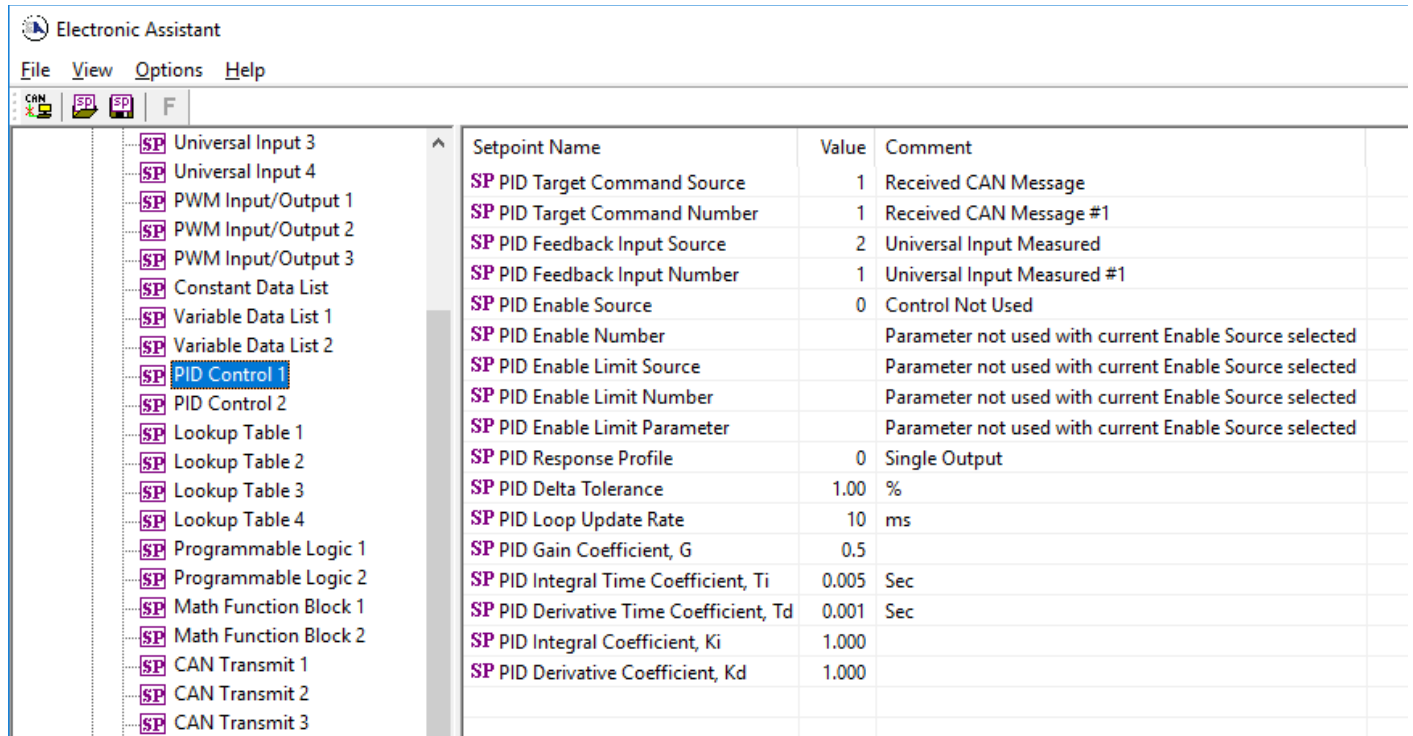


Figure 13 – Screen Capture of PID Control Setpoints

Name	Range	Default	Notes
PID Target Command Source	Drop List	Control Not Used	See Table 20
PID Target Command Number	Depends on control source	1	See Table 20
PID Feedback Input Source	Drop List	Control Not Used	See Table 20
PID Feedback Input Number	Depends on control source	1	See Table 20
PID Enable Source	Drop List	Control Not Used	See Table 20
PID Enable Number	Depends on control source	1	See Table 20
PID Enable Limit Source	Drop List	Control Not Used	See Table 20
PID Enable Limit Number	Depends on control source	1	See Table 20
PID Enable Limit Parameter	Drop List	0	
PID Response Profile	Drop List	Single Output	See Table 11
PID Delta Tolerance	0 to 100	1.00 %	%
PID Loop Update Rate	1 to 60 000 ms	10ms	1 ms resolution
PID Gain Coefficient, G	0.1 to 1000	0.5	See Equation 3
PID Integral Time Coefficient, Ti	0.001 to 10 Sec	0.005 Sec	0.001 Sec (1ms) resolution
PID Derivative Time Coefficient, Td	0.001 to 10 Sec	0.001 Sec	0.001 Sec (1ms) resolution
PID Integral Coefficient, Ki	0 to 10	1.000	0 disables integral, PD ctrl
PID Derivative Coefficient, Kd	0 to 10	1.000	0 disables derivative, PI ctrl

Table 28 – Programmable Logic Setpoints

5.10. Lookup Table

The Lookup Table Function Block is defined in Section 2.5. Please refer there for detailed information about how all these setpoints are used. “**X-Axis Source**” is set to ‘*Control Not Used*’ by default. To enable a Lookup Table, select appropriate “**X-Axis Source**”.

Setpoint Name	Value	Comment
SP X-Axis Source	0	Control Not Used
SP X-Axis Number		Parameter not used with current Control Source selected
SP X-Axis Type		Parameter not used with current Control Source selected
SP Disable limit (X Value)		Parameter not used with current Control Source selected
SP Enable limit (X Value)		Parameter not used with current Control Source selected
SP Output value when disabled		Parameter not used with current Control Source selected
SP Table Auto-Cycle		Parameter not used with current Control Source selected
SP Point 1 - Response		Parameter not used with current Control Source selected
SP Point 2 - Response		Parameter not used with current Control Source selected
SP Point 3 - Response		Parameter not used with current Control Source selected
SP Point 4 - Response		Parameter not used with current Control Source selected
SP Point 5 - Response		Parameter not used with current Control Source selected
SP Point 6 - Response		Parameter not used with current Control Source selected
SP Point 7 - Response		Parameter not used with current Control Source selected
SP Point 8 - Response		Parameter not used with current Control Source selected
SP Point 9 - Response		Parameter not used with current Control Source selected
SP Point 10 - Response		Parameter not used with current Control Source selected
SP Point 0 - X Value		Parameter not used with current Control Source selected
SP Point 1 - X Value		Parameter not used with current Control Source selected
SP Point 2 - X Value		Parameter not used with current Control Source selected
SP Point 3 - X Value		Parameter not used with current Control Source selected
SP Point 4 - X Value		Parameter not used with current Control Source selected
SP Point 5 - X Value		Parameter not used with current Control Source selected
SP Point 6 - X Value		Parameter not used with current Control Source selected
SP Point 7 - X Value		Parameter not used with current Control Source selected
SP Point 8 - X Value		Parameter not used with current Control Source selected
SP Point 9 - X Value		Parameter not used with current Control Source selected
SP Point 10 - X Value		Parameter not used with current Control Source selected
SP Point 0 - Y Value		Parameter not used with current Control Source selected
SP Point 1 - Y Value		Parameter not used with current Control Source selected
SP Point 2 - Y Value		Parameter not used with current Control Source selected
SP Point 3 - Y Value		Parameter not used with current Control Source selected
SP Point 4 - Y Value		Parameter not used with current Control Source selected
SP Point 5 - Y Value		Parameter not used with current Control Source selected
SP Point 6 - Y Value		Parameter not used with current Control Source selected
SP Point 7 - Y Value		Parameter not used with current Control Source selected
SP Point 8 - Y Value		Parameter not used with current Control Source selected
SP Point 9 - Y Value		Parameter not used with current Control Source selected
SP Point 10 - Y Value		Parameter not used with current Control Source selected

Figure 14 – Screen Capture of Lookup table Setpoints

Name	Range	Default	Notes
X-Axis Source	Drop List	Control Not Used	See Table 20
X-Axis Number	Depends on control source	1	See Table 20
X-Axis Type	Drop List	Data Response	See Table 12
Table Auto-Cycle	Drop List	0	
Point 1 - Response	Drop List	Ramp To	See Table 13
Point 2 - Response	Drop List	Ramp To	See Table 13
Point 3 - Response	Drop List	Ramp To	See Table 13
Point 4 - Response	Drop List	Ramp To	See Table 13
Point 5 - Response	Drop List	Ramp To	See Table 13
Point 6 - Response	Drop List	Ramp To	See Table 13
Point 7 - Response	Drop List	Ramp To	See Table 13
Point 8 - Response	Drop List	Ramp To	See Table 13
Point 9 - Response	Drop List	Ramp To	See Table 13
Point 10 - Response	Drop List	Ramp To	See Table 13
Point 0 - X Value	From X-Axis source minimum to Point 1 - X Value	X-Axis source minimum 0.000	See Section 2.5
Point 1 - X Value	From Point 0 - X Value to Point 2 - X Value	0.500	See Section 2.5
Point 2 - X Value	From Point 1 - X Value to Point 3 - X Value	1.000	See Section 2.5
Point 3 - X Value	From Point 2 - X Value to Point 4 - X Value	1.500	See Section 2.5
Point 4 - X Value	From Point 3 - X Value to Point 5 - X Value source	2.000	See Section 2.5
Point 5 - X Value	From Point 4 - X Value to Point 6 - X Value	2.500	See Section 2.5
Point 6 - X Value	From Point 5 - X Value to Point 7 - X Value	3.000	See Section 2.5
Point 7 - X Value	From Point 6 - X Value to Point 8 - X Value	3.500	See Section 2.5
Point 8 - X Value	From Point 7 - X Value to Point 9 - X Value	4.000	See Section 2.5
Point 9 - X Value	From Point 8 - X Value to Point 10 - X Value	4.500	See Section 2.5
Point 10 - X Value	From Point 9 - X Value to X-Axis source maximum	X-Axis source maximum 5.000	See Section 2.5
Point 0 - Y Value	-10 ⁶ to 10 ⁶	0.000	
Point 1 - Y Value	-10 ⁶ to 10 ⁶	10.000	
Point 2 - Y Value	-10 ⁶ to 10 ⁶	20.000	
Point 3 - Y Value	-10 ⁶ to 10 ⁶	30.000	
Point 4 - Y Value	-10 ⁶ to 10 ⁶	40.000	
Point 5 - Y Value	-10 ⁶ to 10 ⁶	50.000	
Point 6 - Y Value	-10 ⁶ to 10 ⁶	60.000	
Point 7 - Y Value	-10 ⁶ to 10 ⁶	70.000	
Point 8 - Y Value	-10 ⁶ to 10 ⁶	80.000	
Point 9 - Y Value	-10 ⁶ to 10 ⁶	90.000	
Point 10 - Value	-10 ⁶ to 10 ⁶	100.000	

Table 29 – Lookup Table Setpoints

5.11. Programmable Logic

The Programmable Logic function block is defined in Section 2.6. Please refer there for detailed information about how all these setpoints are used. **“Programmable Logic Enabled”** is *‘False’* by default. To enable Logic set **“Programmable Logic Enabled”** to *‘True’* and select appropriate **“Argument Source”**.

Setpoint Name	Value	Comment
SP Programmable Logic Enabled	0	False
SP Table 1 - Lookup Table Block Number		Parameter not used - Programmable Logic Disabled
SP Table 1 - Conditions Logical Operator		Parameter not used - Programmable Logic Disabled
SP Table 1 - Condition 1, Argument 1 Source		Parameter not used - Programmable Logic Disabled
SP Table 1 - Condition 1, Argument 1 Number		Parameter not used - Programmable Logic Disabled
SP Table 1 - Condition 1, Operator		Parameter not used - Programmable Logic Disabled
SP Table 1 - Condition 1, Argument 2 Source		Parameter not used - Programmable Logic Disabled
SP Table 1 - Condition 1, Argument 2 Number		Parameter not used - Programmable Logic Disabled
SP Table 1 - Condition 2, Argument 1 Source		Parameter not used - Programmable Logic Disabled
SP Table 1 - Condition 2, Argument 1 Number		Parameter not used - Programmable Logic Disabled
SP Table 1 - Condition 2, Operator		Parameter not used - Programmable Logic Disabled
SP Table 1 - Condition 2, Argument 2 Source		Parameter not used - Programmable Logic Disabled
SP Table 1 - Condition 2, Argument 2 Number		Parameter not used - Programmable Logic Disabled
SP Table 1 - Condition 3, Argument 1 Source		Parameter not used - Programmable Logic Disabled
SP Table 1 - Condition 3, Argument 1 Number		Parameter not used - Programmable Logic Disabled
SP Table 1 - Condition 3, Operator		Parameter not used - Programmable Logic Disabled
SP Table 1 - Condition 3, Argument 2 Source		Parameter not used - Programmable Logic Disabled
SP Table 1 - Condition 3, Argument 2 Number		Parameter not used - Programmable Logic Disabled
SP Table 2 - Lookup Table Block Number		Parameter not used - Programmable Logic Disabled
SP Table 2 - Conditions Logical Operator		Parameter not used - Programmable Logic Disabled
SP Table 2 - Condition 1, Argument 1 Source		Parameter not used - Programmable Logic Disabled
SP Table 2 - Condition 1, Argument 1 Number		Parameter not used - Programmable Logic Disabled
SP Table 2 - Condition 1, Operator		Parameter not used - Programmable Logic Disabled
SP Table 2 - Condition 1, Argument 2 Source		Parameter not used - Programmable Logic Disabled
SP Table 2 - Condition 1, Argument 2 Number		Parameter not used - Programmable Logic Disabled
SP Table 2 - Condition 2, Argument 1 Source		Parameter not used - Programmable Logic Disabled
SP Table 2 - Condition 2, Argument 1 Number		Parameter not used - Programmable Logic Disabled
SP Table 2 - Condition 2, Operator		Parameter not used - Programmable Logic Disabled
SP Table 2 - Condition 2, Argument 2 Source		Parameter not used - Programmable Logic Disabled
SP Table 2 - Condition 2, Argument 2 Number		Parameter not used - Programmable Logic Disabled
SP Table 2 - Condition 3, Argument 1 Source		Parameter not used - Programmable Logic Disabled
SP Table 2 - Condition 3, Argument 1 Number		Parameter not used - Programmable Logic Disabled
SP Table 2 - Condition 3, Operator		Parameter not used - Programmable Logic Disabled
SP Table 2 - Condition 3, Argument 2 Source		Parameter not used - Programmable Logic Disabled
SP Table 2 - Condition 3, Argument 2 Number		Parameter not used - Programmable Logic Disabled
SP Table 3 - Lookup Table Block Number		Parameter not used - Programmable Logic Disabled
SP Table 3 - Conditions Logical Operator		Parameter not used - Programmable Logic Disabled
SP Table 3 - Condition 1, Argument 1 Source		Parameter not used - Programmable Logic Disabled

Figure 15 – Screen Capture of Programmable Logic Setpoints

Setpoint ranges and default values for Programmable Logic Blocs are listed in Table 30. Only “**Table1**” setpoint are listed, because other “**TableX**” setpoints are similar, except for the default value of the “**Lookup Table Block Number**” setpoint, which is X for “**TableX**”.

Name	Range	Default	Notes
Programmable Logic Enabled	Drop List	False	
Table1 - Lookup Table Block Number	1 to 4	Look up Table 1	
Table1 - Conditions Logical Operation	Drop List	Default Table	See Table 15
Table1 - Condition1, Argument 1 Source	Drop List	Control Not Used	See Table 20
Table1 - Condition1, Argument 1 Number	Depends on control source	1	See Table 20
Table1 - Condition1, Operator	Drop List	=, Equal	See Table 14
Table1 - Condition1, Argument 2 Source	Drop List	Control Not Used	See Table 20
Table1 - Condition1, Argument 2 Number	Depends on control source	1	See Table 20
Table1 - Condition2, Argument 1 Source	Drop List	Control Not Used	See Table 20
Table1 - Condition2, Argument 1 Number	Depends on control source	1	See Table 20
Table1 - Condition2, Operator	Drop List	=, Equal	See Table 14
Table1 - Condition2, Argument 2 Source	Drop List	Control Not Used	See Table 20
Table1 - Condition2, Argument 2 Number	Depends on control source	1	See Table 20
Table1 - Condition3, Argument 1 Source	Drop List	Control Not Used	See Table 20
Table1 - Condition3, Argument 1 Number	Depends on control source	1	See Table 20
Table1 - Condition3, Operator	Drop List	=, Equal	See Table 14
Table1 - Condition3, Argument 2 Source	Drop List	Control Not Used	See Table 20
Table1 - Condition3, Argument 2 Number	Depends on control source	1	See Table 20

Table 30 – Programmable Logic Setpoints

5.12. Math Function Block

The Math Function Block is defined in Section 2.7. Please refer there for detailed information about how all these setpoints are used. “**Math Function Enabled**” is ‘False’ by default. To enable a Math Function Block, set “**Math Function Enabled**” to ‘True’ and select appropriate “**Input Source**”.

Setpoint Name	Value	Comment
SP Math Function Enabled	0	False
SP Function 1 Input A Source		Parameter not used - Math Function is Disabled
SP Function 1 Input A Number		Parameter not used - Math Function is Disabled
SP Function 1 Input A Minimum		Parameter not used - Math Function is Disabled
SP Function 1 Input A Maximum		Parameter not used - Math Function is Disabled
SP Function 1 Input A Scaler		Parameter not used - Math Function is Disabled
SP Function 1 Input B Source		Parameter not used - Math Function is Disabled
SP Function 1 Input B Number		Parameter not used - Math Function is Disabled
SP Function 1 Input B Minimum		Parameter not used - Math Function is Disabled
SP Function 1 Input B Maximum		Parameter not used - Math Function is Disabled
SP Function 1 Input B Scaler		Parameter not used - Math Function is Disabled
SP Math Function 1 Operation		Parameter not used - Math Function is Disabled
SP Function 2 Input B Source		Parameter not used - Math Function is Disabled
SP Function 2 Input B Number		Parameter not used - Math Function is Disabled
SP Function 2 Input B Minimum		Parameter not used - Math Function is Disabled
SP Function 2 Input B Maximum		Parameter not used - Math Function is Disabled
SP Function 2 Input B Scaler		Parameter not used - Math Function is Disabled
SP Math Function 2 Operation (Input A = Result of Function 1)		Parameter not used - Math Function is Disabled
SP Function 3 Input B Source		Parameter not used - Math Function is Disabled
SP Function 3 Input B Number		Parameter not used - Math Function is Disabled
SP Function 3 Input B Minimum		Parameter not used - Math Function is Disabled
SP Function 3 Input B Maximum		Parameter not used - Math Function is Disabled
SP Function 3 Input B Scaler		Parameter not used - Math Function is Disabled
SP Math Function 3 Operation (Input A = Result of Function 2)		Parameter not used - Math Function is Disabled
SP Function 4 Input B Source		Parameter not used - Math Function is Disabled
SP Function 4 Input B Number		Parameter not used - Math Function is Disabled
SP Function 4 Input B Minimum		Parameter not used - Math Function is Disabled
SP Function 4 Input B Maximum		Parameter not used - Math Function is Disabled
SP Function 4 Input B Scaler		Parameter not used - Math Function is Disabled
SP Math Function 4 Operation (Input A = Result of Function 3)		Parameter not used - Math Function is Disabled
SP Math Output Minimum Range		Parameter not used - Math Function is Disabled
SP Math Output Maximum Range		Parameter not used - Math Function is Disabled

Figure 16 – Screen Capture of Math Function Block Setpoints

Name	Range	Default	Notes
Math Function Enabled	Drop List	False	
Function 1 Input A Source	Drop List	Control not used	See Table 20
Function 1 Input A Number	Depends on control source	1	See Table 20
Function 1 Input A Minimum	-10 ⁶ to 10 ⁶	0.0	
Function 1 Input A Maximum	-10 ⁶ to 10 ⁶	100.0	
Function 1 Input A Scaler	-1.00 to 1.00	1.00	
Function 1 Input B Source	Drop List	Control not used	See Table 20
Function 1 Input B Number	Depends on control source	1	See Table 20
Function 1 Input B Minimum	-10 ⁶ to 10 ⁶	0.0	
Function 1 Input B Maximum	-10 ⁶ to 10 ⁶	100.0	
Function 1 Input B Scaler	-1.00 to 1.00	1.00	
Math Function 1 Operation	Drop List	=, True when InA Equals InB	See Table 16
Function 2 Input B Source	Drop List	Control not used	See Table 20
Function 2 Input B Number	Depends on control source	1	See Table 20
Function 2 Input B Minimum	-10 ⁶ to 10 ⁶	0.0	
Function 2 Input B Maximum	-10 ⁶ to 10 ⁶	100.0	
Function 2 Input B Scaler	-1.00 to 1.00	1.00	
Math Function 3 Operation	Drop List	=, True when InA Equals InB	See Table 16
Function 3 Input B Source	Drop List	Control not used	See Table 20
Function 3 Input B Number	Depends on control source	1	See Table 20
Function 3 Input B Minimum	-10 ⁶ to 10 ⁶	0.0	
Function 3 Input B Maximum	-10 ⁶ to 10 ⁶	100.0	
Function 3 Input B Scaler	-1.00 to 1.00	1.00	
Math Function 3 Operation	Drop List	=, True when InA Equals InB	See Table 16
Function 4 Input B Source	Drop List	Control not used	See Table 20
Function 4 Input B Number	Depends on control source	1	See Table 20
Function 4 Input B Minimum	-10 ⁶ to 10 ⁶	0.0	
Function 4 Input B Maximum	-10 ⁶ to 10 ⁶	100.0	
Function 4 Input B Scaler	-1.00 to 1.00	1.00	
Math Function 4 Operation	Drop List	=, True when InA Equals InB	See Table 16
Math Output Minimum Range	-10 ⁶ to 10 ⁶	0.0	
Math Output Maximum Range	-10 ⁶ to 10 ⁶	100.0	

Table 31 – Math Function Setpoints

5.13. CAN Transmit Setpoints

CAN Transmit Message Function Block is presented in section 2.10. Please refer there for detailed information how these setpoints are used. **“Transmit Repetition Rate”** is 0ms by default, thus no message will be sent.

Setpoint Name	Value	Comment
SP Transmit PGN	0xFF00	Transmit PGN: 65280
SP Transmit Repetition Rate	100	ms
SP Transmit Message Priority	6	
SP Destination Address (PDU1)	0	Destination ECU Address: 0x0
SP Signal 1 Data Source	2	Universal Input Measured
SP Signal 1 Data Number	1	Universal Input Measured #1
SP Signal 1 Transmit Data Type	2	CAN signal continuous
SP Signal 1 Transmit Data Width	16	
SP Signal 1 Transmit Data Index in Array (LSB)	0	1st Byte Position
SP Signal 1 Transmit Bit Index in Byte (LSB)	0	1st Bit Position
SP Signal 1 Transmit Data Resolution	0.0010000	
SP Signal 1 Transmit Data Offset	0.0000000	
SP Signal 1 Transmit Data Minimum	0.0000000	
SP Signal 1 Transmit Data Maximum	5.0000000	
SP Signal 2 Data Source	2	Universal Input Measured
SP Signal 2 Data Number	2	Universal Input Measured #2
SP Signal 2 Transmit Data Type	2	CAN signal continuous
SP Signal 2 Transmit Data Width	16	
SP Signal 2 Transmit Data Index in Array (LSB)	2	3rd Byte Position
SP Signal 2 Transmit Bit Index in Byte (LSB)	0	1st Bit Position
SP Signal 2 Transmit Data Resolution	0.0010000	
SP Signal 2 Transmit Data Offset	0.0000000	
SP Signal 2 Transmit Data Minimum	0.0000000	
SP Signal 2 Transmit Data Maximum	5.0000000	
SP Signal 3 Data Source	2	Universal Input Measured
SP Signal 3 Data Number	3	Universal Input Measured #3
SP Signal 3 Transmit Data Type	2	CAN signal continuous
SP Signal 3 Transmit Data Width	16	
SP Signal 3 Transmit Data Index in Array (LSB)	4	5th Byte Position
SP Signal 3 Transmit Bit Index in Byte (LSB)	0	1st Bit Position
SP Signal 3 Transmit Data Resolution	0.0010000	
SP Signal 3 Transmit Data Offset	0.0000000	
SP Signal 3 Transmit Data Minimum	0.0000000	
SP Signal 3 Transmit Data Maximum	5.0000000	
SP Signal 4 Data Source	2	Universal Input Measured
SP Signal 4 Data Number	4	Universal Input Measured #4

Figure 17 – Screen Capture of CAN Transmit Message Setpoints

Name	Range	Default	Notes
Transmit PGN	0xffff ... 0xffff	Different for each	See Section Error! Reference source not found.
Transmit Repetition Rate	0 ... 65000 ms	0ms	0ms disables transmit
Transmit Message Priority	0...7	6	Proprietary B Priority
Destination Address	0...255	255	Not used by default
Signal 1 Control Source	Drop List	Different for each	See Table 20
Signal 1 Control Number	Drop List	Different for each	See Table 20
Signal 1 Transmit Data Type	Drop List	0	
Signal 1 Transmit Data Width	1-32	1	
Signal 1 Transmit Data Index in Array	0-7	2	
Signal 1 Transmit Bit Index In Byte	0-7	0	
Signal 1 Transmit Data Resolution	-100000.0 to 100000	0.001	
Signal 1 Transmit Data Offset	-10000 to 10000	0.0	
Signal 2 Control Source	Drop List	Signal undefined	See Table 20
Signal 2 Control Number	Drop List	Signal undefined	See Table 20
Signal 2 Transmit Data Type	Drop List	0	
Signal 2 Transmit Data Width	1-32	1	
Signal 2 Transmit Data Index in Array	0-7	0	
Signal 2 Transmit Bit Index In Byte	0-7	0	
Signal 2 Transmit Data Resolution	-100000.0 to 100000	0.001	
Signal 2 Transmit Data Offset	-10000 to 10000	0.0	
Signal 3 Control Source	Drop List	Signal undefined	See Table 20
Signal 3 Control Number	Drop List	Signal undefined	See Table 20
Signal 3 Transmit Data Type	Drop List	0	
Signal 3 Transmit Data Width	1-32	1	
Signal 3 Transmit Data Index in Array	0-7	0	
Signal 3 Transmit Bit Index In Byte	0-7	0	
Signal 3 Transmit Data Resolution	-100000.0 to 100000	0.001	
Signal 3 Transmit Data Offset	-10000 to 10000	0.0	
Signal 4 Control Source	Drop List	Signal undefined	See Table 20
Signal 4 Control Number	Drop List	Signal undefined	See Table 20
Signal 4 Transmit Data Type	Drop List	0	
Signal 4 Transmit Data Width	1-32	1	
Signal 4 Transmit Data Index in Array	0-7	0	
Signal 4 Transmit Bit Index In Byte	0-7	0	
Signal 4 Transmit Data Resolution	-100000.0 to 100000	0.001	
Signal 4 Transmit Data Offset	-10000 to 10000	0.0	

Table 32 – CAN Transmit Message Setpoints

5.14. CAN Receive Setpoints

The Math Function Block is defined in Section 2.11. Please refer there for detailed information about how these setpoints are used. **“Receive Message Timeout”** is set to 0ms by default. To enable Receive message set **“Receive Message Timeout”** that differs from zero.

Setpoint Name	Value	Comment
SP Receive Message Enabled	1	True
SP Receive PGN	0xFF80	Received PGN: 65408
SP Receive Message Timeout	0	ms
SP Address That Sends	0	False
SP Specific Address That Sends		Parameter not used - Receive from Source Address is Disabled
SP Receive Data Type	2	CAN signal continuous
SP Receive Data Width	8	
SP Receive Data Index in Array	0	1st Byte Position
SP Receive Bit Index in Byte	0	1st Bit Position
SP Receive Data Resolution	1.0000000	
SP Receive Data Offset	0.0000000	
SP Receive Data Min (OFF Threshold)	0.0000000	
SP Receive Data Max (ON Threshold)	255.0000000	

Figure 18 – Screen Capture of CAN Receive Message Setpoints

Name	Range	Default	Notes
Received Message Enabled	Drop List	False	
Received PGN	0 to 65536	Different for each	
Received Message Timeout	0 to 60 000 ms	0ms	
Specific Address That Sends	Drop List	False	
Address That Sends	0 to 255	254 (0xFE, Null Addr)	
Receive Data Type	Drop List	0	
Receive Data Width	1-32	1	
Receive Data Index in Array	0-7	0	
Receive Transmit Bit Index In Byte	0-7	0	
Receive Transmit Data Resolution	-100000.0 to 100000	0.001	
Receive Transmit Data Offset	-10000 to 10000	0.0	
Receive Data Min (Off Threshold)	-1000000 to Max	0.0	
Receive Data Max (On Threshold)	-100000 to 100000	2.0	

Table 33 – CAN Receive Setpoints

5.15. DTC React

The DTC React Function Block is defined in Section 2.12. Please refer there for detailed information about how these setpoints are used.

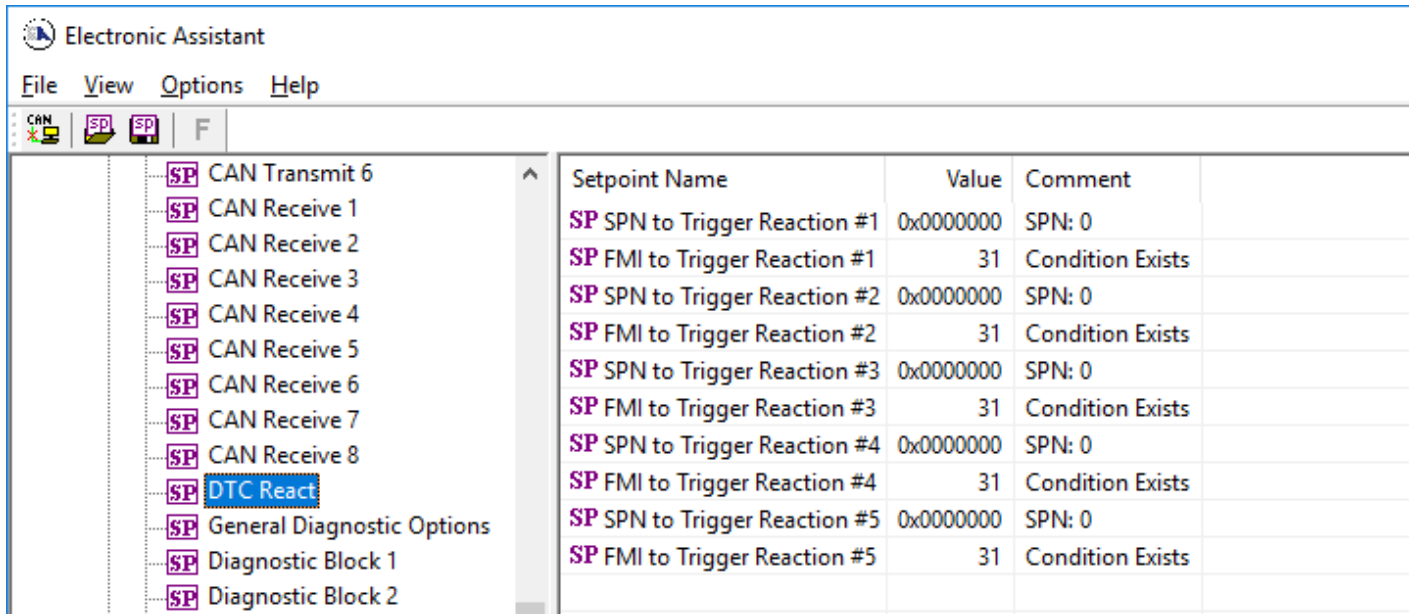


Figure 19 – Screen Capture of DTC React Setpoints

Name	Range	Default	Notes
SPN to Trigger Reaction #1	0 to 524287	0	0 is an illegal value, and disables the DTC
FMI to Trigger Reaction #X	Drop List	31, Condition Exists	Supports all FMIs in the J1939 standard

Table 34 – DTC React Setpoints

5.16. General Diagnostics Options

These setpoints control the shutdown of the ECU in case of a power supply or CPU temperature related errors. Refer to section 2.9 for more info.

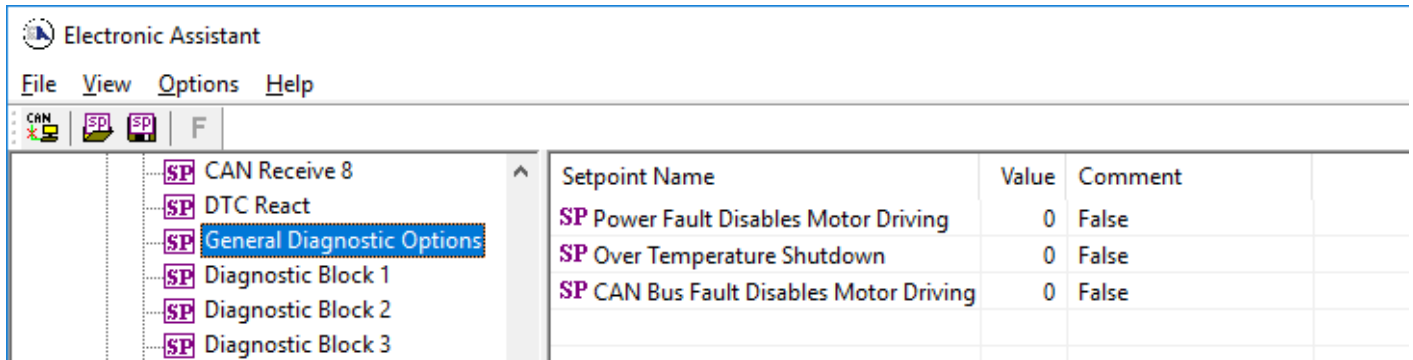


Figure 20 – Screen Capture of General Diagnostics Options Setpoints

Name	Range	Default	Notes
Power Fault Disables Motor Driving	Drop List	0	
Over Temperature Shutdown	Drop List	0	
CAN Bus Fault Disables Motor Driving	Drop List	0	

Table 35 – General Diagnostics Options Setpoints

5.17. Diagnostics Blocks

There are 8 Diagnostics blocks that can be configured to monitor various parameters of the Controller. The Diagnostic Function Block is defined in section 2.9. Please refer there for detailed information how these setpoints are used.

Setpoint Name	Value	Comment
SP Fault Detection is Enabled	1	True
SP Function Type to Monitor	12	Power Supply Measured
SP Function Parameter to Monitor	1	Power Supply Measured
SP Enable Source	0	Control Not Used
SP Enable Number		Parameter not used with current Enable Source selected
SP Enable Response		Parameter not used with current Enable Source selected
SP Fault Detection Type	4	Double Threshold Min and Max Error
SP Maximum Value for Diagnostic Data	54.00	
SP Minimum Value for Diagnostic Data	0.00	
SP Use Hysteresis When Defining Thresholds	1	True
SP Hysteresis	1.00	
SP Event Cleared Only by DM11	0	False
SP Set Limit for MAXIMUM SHUTDOWN	36.00	
SP Clear Limit for MAXIMUM SHUTDOWN		Parameter not used - Hysteresis used when defining thresholds
SP Set Limit for MAXIMUM WARNING	32.00	
SP Clear Limit for MAXIMUM WARNING		Parameter not used - Hysteresis used when defining thresholds
SP Clear Limit for MINIMUM WARNING		Parameter not used - Hysteresis used when defining thresholds
SP Set Limit for MINIMUM WARNING	10.00	
SP Clear Limit for MINIMUM SHUTDOWN		Parameter not used - Hysteresis used when defining thresholds
SP Set Limit for MINIMUM SHUTDOWN	8.00	
SP MAXIMUM SHUTDOWN, Event Generates a DTC in DM1	1	True
SP MAXIMUM SHUTDOWN, Lamp Set by Event	1	Amber,Warning
SP MAXIMUM SHUTDOWN, SPN for Event	0x0000064	SPN: 100
SP MAXIMUM SHUTDOWN, FMI for Event	3	Voltage Above Normal, Or Shorted To High Source
SP MAXIMUM SHUTDOWN, Delay Before Event is Flagged	1000	ms
SP MAXIMUM WARNING, Event Generates a DTC in DM1	1	True
SP MAXIMUM WARNING, Lamp Set by Event	1	Amber,Warning
SP MAXIMUM WARNING, SPN for Event	0x00000C8	SPN: 200
SP MAXIMUM WARNING, FMI for Event	3	Voltage Above Normal, Or Shorted To High Source
SP MAXIMUM WARNING, Delay Before Event is Flagged	1000	ms
SP MINIMUM WARNING, Event Generates a DTC in DM1	1	True
SP MINIMUM WARNING, Lamp Set by Event	1	Amber,Warning
SP MINIMUM WARNING, SPN for Event	0x000012C	SPN: 300
SP MINIMUM WARNING, FMI for Event	4	Voltage Below Normal, Or Shorted To Low Source
SP MINIMUM WARNING, Delay Before Event is Flagged	1000	ms
SP MINIMUM SHUTDOWN, Event Generates a DTC in DM1	1	True
SP MINIMUM SHUTDOWN, Lamp Set by Event	1	Amber,Warning
SP MINIMUM SHUTDOWN, SPN for Event	0x0000190	SPN: 400
SP MINIMUM SHUTDOWN, FMI for Event	4	Voltage Below Normal, Or Shorted To Low Source
SP MINIMUM SHUTDOWN, Delay Before Event is Flagged	1000	ms

Figure 21 – Screen Capture of Diagnostic Block Setpoints

Name	Range	Default	Notes
Fault Detection is Enabled	Drop List	False	
Function Type to Monitor	Drop List	0 – Control not used	
Function parameter to Monitor	Drop List	0 – No selection	
Fault Detection Type	Drop List	1 – Min and Max Error	See section 2.9
Maximum Value for Diagnostic Data	Minimum Value for Diagnostic Data ... 4.28e ⁹	5.0	
Minimum Value for Diagnostic Data	0.0 ... Maximum Value for Diagnostic Data	0.0	
Use Hysteresis When Defining Thresholds	Drop List	False	
Hysteresis	0.0 ... Maximum Value for Diagnostic Data	0.0	
Event Cleared only by DM11	Drop List	False	
Set Limit for MAXIMUM SHUTDOWN	Minimum Value for Diagnostic Data ... Maximum Value for Diagnostics Data	4.8	
Clear Limit for MAXIMUM SHUTDOWN	Minimum Value for Diagnostic Data ... Maximum Value for Diagnostics Data	4.6	
Set Limit for MAXIMUM WARNING	Minimum Value for Diagnostic Data ... Maximum Value for Diagnostics Data	0.0	
Clear Limit for MAXIMUM WARNING	Minimum Value for Diagnostic Data ... Maximum Value for Diagnostics Data	0.0	
Clear Limit for MINIMUM WARNING	Minimum Value for Diagnostic Data ... Maximum Value for Diagnostics Data	0.0	
Set Limit for MINIMUM WARNING	Minimum Value for Diagnostic Data ... Maximum Value for Diagnostics Data	0.0	
Clear Limit for MINIMUM SHUTDOWN	Minimum Value for Diagnostic Data ... Maximum Value for Diagnostics Data	0.4	
Set Limit for MINIMUM SHUTDOWN	Minimum Value for Diagnostic Data ... Maximum Value for Diagnostics Data	0.2	
MAXIMUM SHUTDOWN, Event Generates a DTC in DM1	Drop List	True	
MAXIMUM SHUTDOWN, Lamp Set by Event	Drop List	0 – Protect	See Table 17
MAXIMUM SHUTDOWN, SPN for Event	0...524287	520448 (\$7F100)	It is the user's responsibility to select an SPN that will not violate the J1939 standard.
MAXIMUM SHUTDOWN, FMI for Event	Drop List	3, Voltage Above Normal	See Table 18
MAXIMUM SHUTDOWN, Delay Before Event is Flagged	0...60000 ms	1000	
MAXIMUM WARNING, Event Generates a DTC in DM1	Drop List	True	
MAXIMUM WARNING, Lamp Set by Event	Drop List	0 – Protect	See Table 17
MAXIMUM WARNING, SPN for Event	0...524287	520704 (\$7F200)	It is the user's responsibility to select an SPN that will not violate the J1939 standard.
MAXIMUM WARNING, FMI for Event	Drop List	3, Voltage Above Normal	See Table 18
MAXIMUM WARNING, Delay Before Event is Flagged	0...60000 ms	1000	
MINIMUM WARNING, Event Generates a DTC in DM1	Drop List	True	
MINIMUM WARNING, Lamp Set by Event	Drop List	0 – Protect	See Table 17
MAXIMUM WARNING, SPN for Event	0...524287	520960 (\$7F300)	It is the user's responsibility to select an SPN that will not violate the J1939 standard.
MINIMUM WARNING, FMI for Event	Drop List	4, Voltage Below Normal	See Table 18

MINIMUM WARNING, Delay Before Event is Flagged	0...60000 ms	1000	
MINIMUM SHUTDOWN, Event Generates a DTC in DM1	Drop List	True	
MINIMUM SHUTDOWN, Lamp Set by Event	Drop List	Amber Warning	See Table 17
MINIMUM SHUTDOWN, SPN for Event	0...524287	521216 (\$7F400)	It is the user's responsibility to select an SPN that will not violate the J1939 standard.
MINIMUM SHUTDOWN, FMI for Event	Drop List	4, Voltage Below Normal	See Table 18
MINIMUM SHUTDOWN, Delay Before Event is Flagged	0...60000 ms	1000	

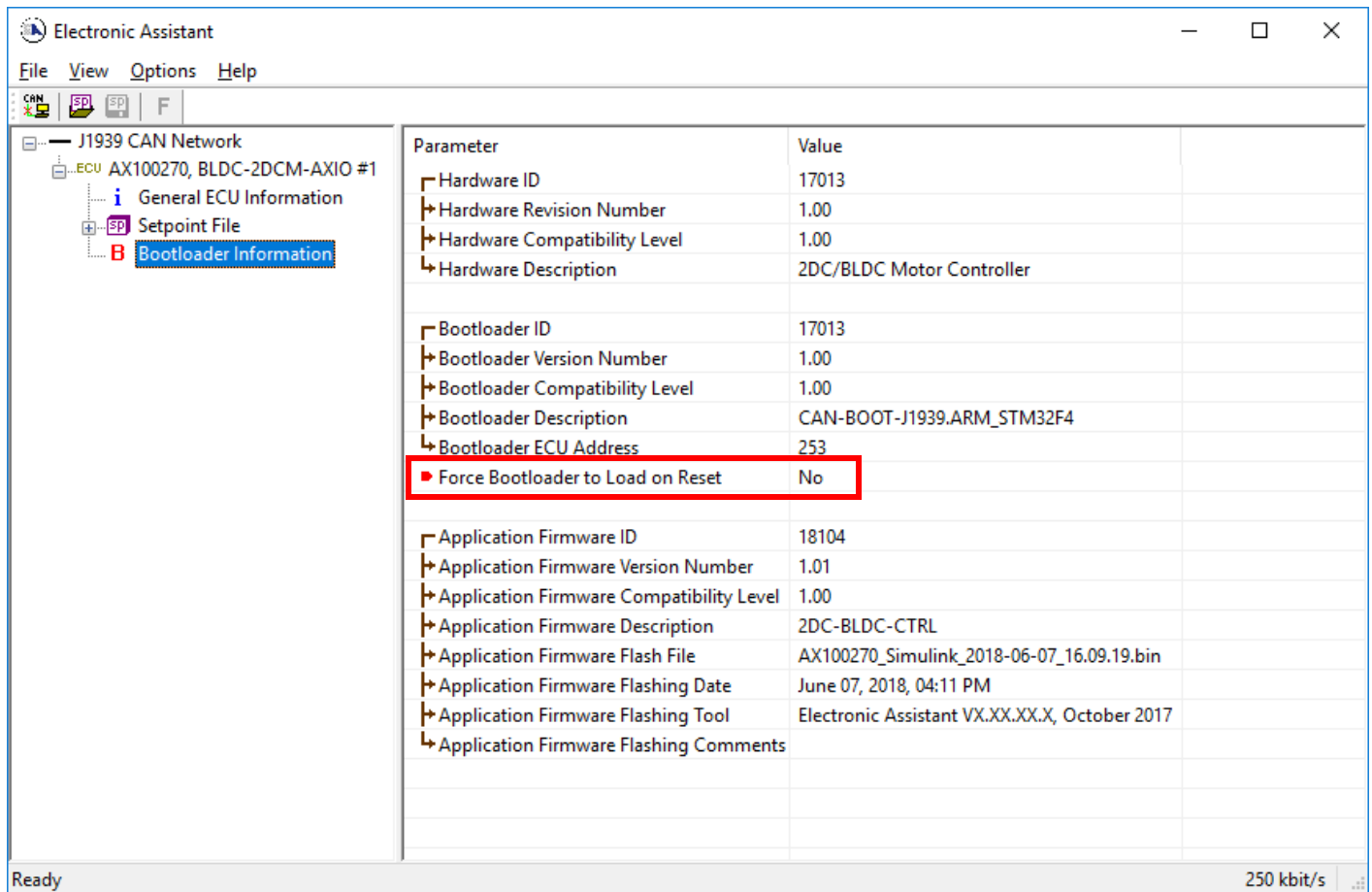
Table 36 – Diagnostic Block Setpoints

6. Reflashing over CAN with the Axiomatic EA Bootloader

The AX100270 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.

Note: To upgrade the firmware use Axiomatic Electronic Assistant V5.13.92.0 or higher.

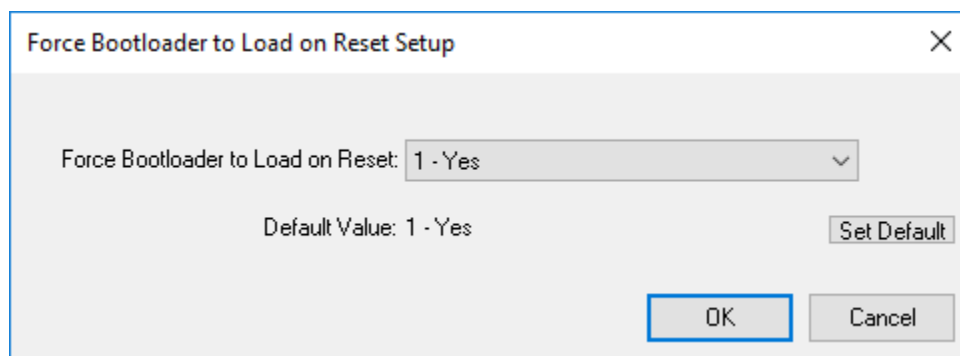
1. When the Axiomatic EA first connects to the ECU, the **Bootloader Information** section will display the following information.



The screenshot shows the Electronic Assistant software interface. The left sidebar displays a tree view with 'J1939 CAN Network' expanded to show 'ECU AX100270, BLDC-2DCM-AXIO #1', which includes 'General ECU Information', 'Setpoint File', and 'Bootloader Information'. The main window displays a table of parameters for the selected ECU. The 'Force Bootloader to Load on Reset' parameter is highlighted with a red box.

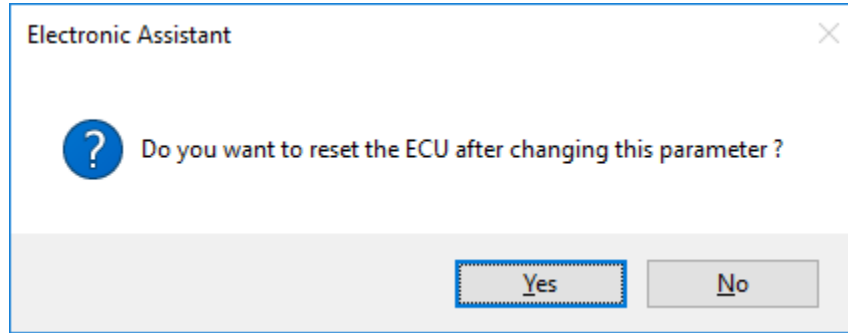
Parameter	Value
Hardware ID	17013
Hardware Revision Number	1.00
Hardware Compatibility Level	1.00
Hardware Description	2DC/BLDC Motor Controller
Bootloader ID	17013
Bootloader Version Number	1.00
Bootloader Compatibility Level	1.00
Bootloader Description	CAN-BOOT-J1939.ARM_STM32F4
Bootloader ECU Address	253
Force Bootloader to Load on Reset	No
Application Firmware ID	18104
Application Firmware Version Number	1.01
Application Firmware Compatibility Level	1.00
Application Firmware Description	2DC-BLDC-CTRL
Application Firmware Flash File	AX100270_Simulink_2018-06-07_16.09.19.bin
Application Firmware Flashing Date	June 07, 2018, 04:11 PM
Application Firmware Flashing Tool	Electronic Assistant VX.XX.XX.X, October 2017
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.

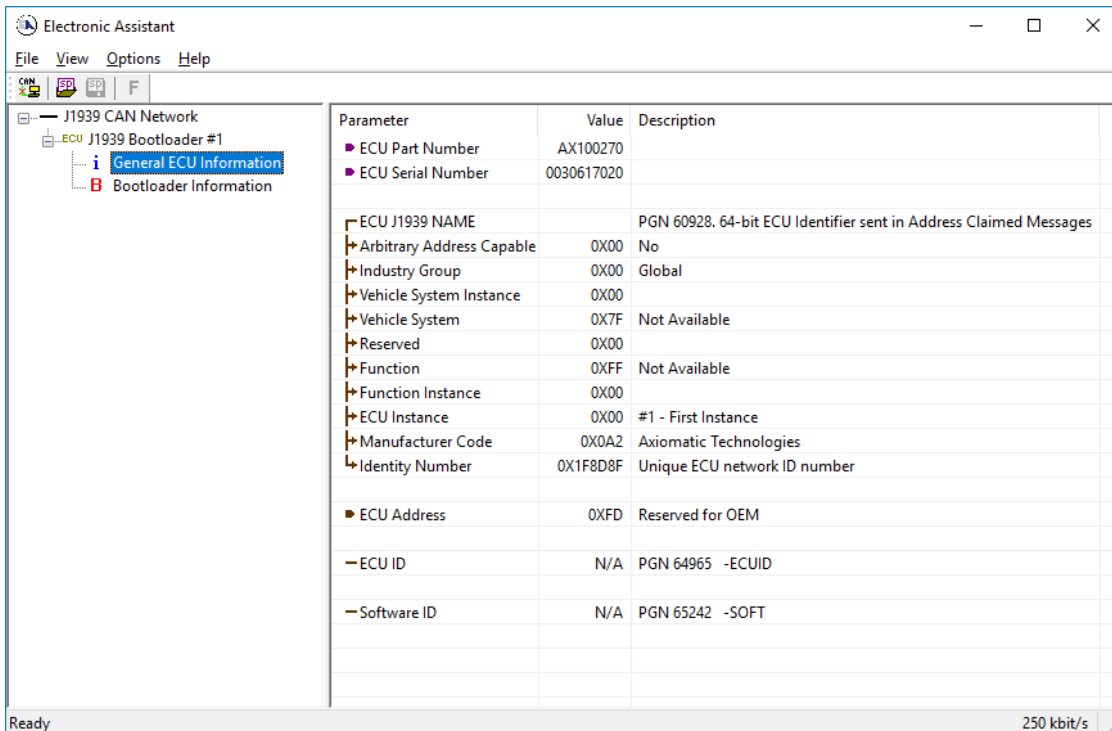
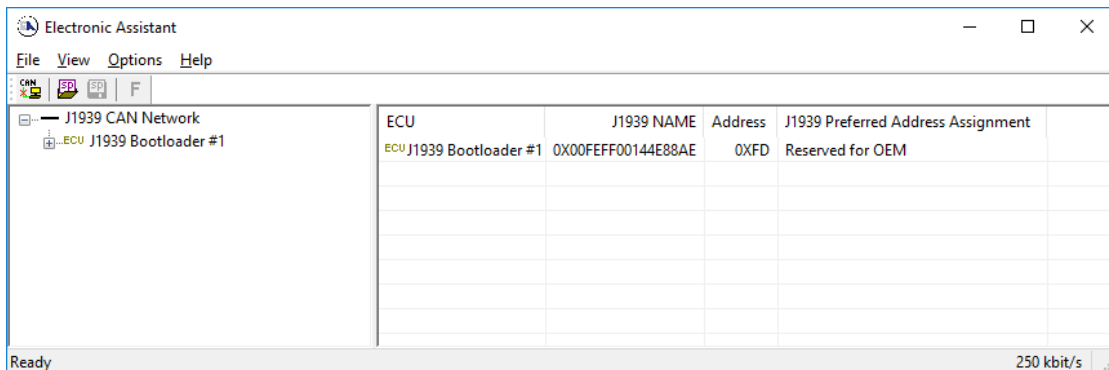


The screenshot shows a dialog box titled 'Force Bootloader to Load on Reset Setup'. The 'Force Bootloader to Load on Reset' dropdown menu is set to '1 - Yes'. The default value is also '1 - Yes'. There are 'Set Default', 'OK', and 'Cancel' buttons.

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



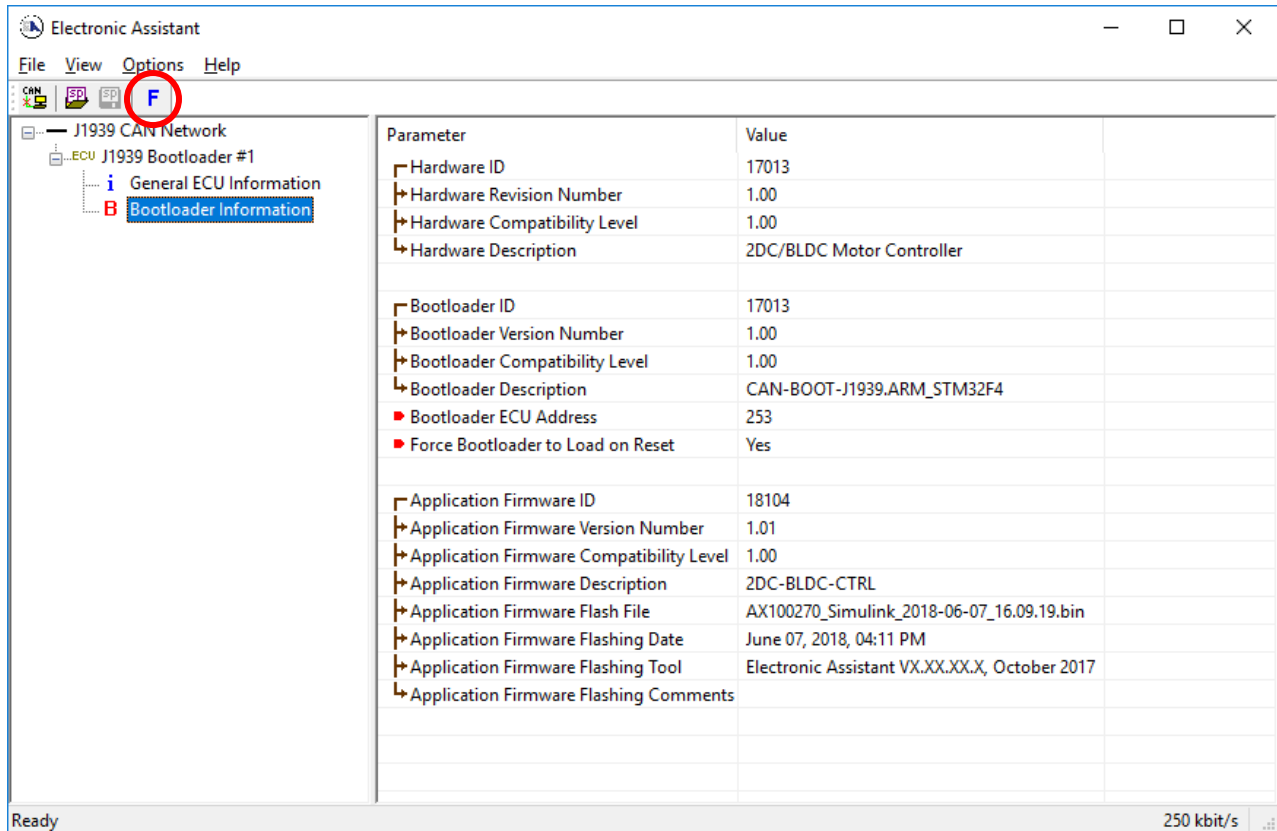
4. Upon reset, the ECU will no longer show up on the J1939 network as an AX100270 but rather as **J1939 Bootloader #1**.



Note that the bootloader is NOT Arbitrary Address Capable. This means that if you want to have multiple bootloaders running simultaneously (not recommended) you would have to manually change the address for each one before activating the next, or there will be address conflicts. And

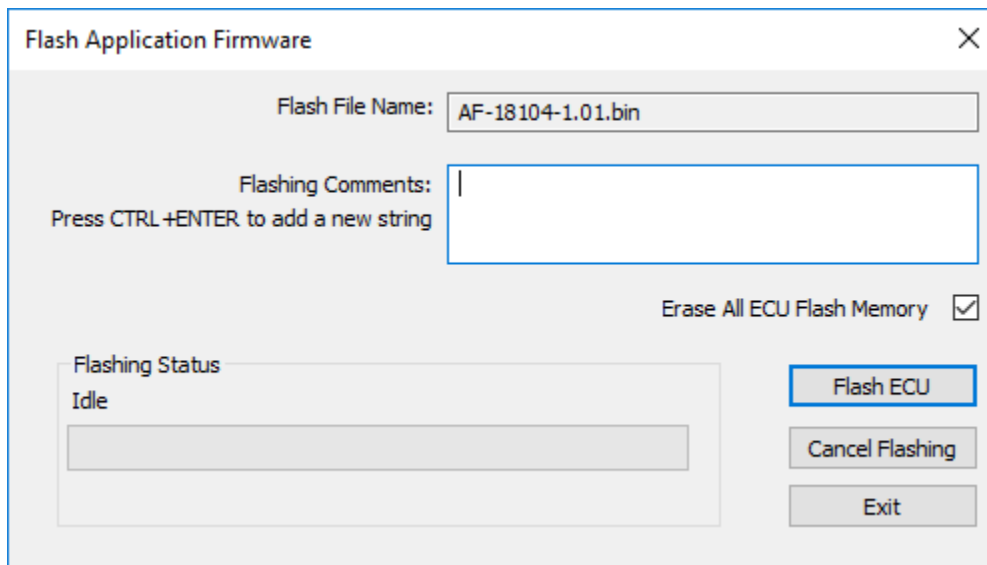
only one ECU would show up as the bootloader. Once the 'active' bootloader returns to regular functionality, the other ECU(s) would have to be power cycled to re-activate the bootloader feature.

- When the **Bootloader Information** section is selected, the same information is shown as when it was running the AX100270 firmware, but in this case the **F**lashing feature has been enabled.



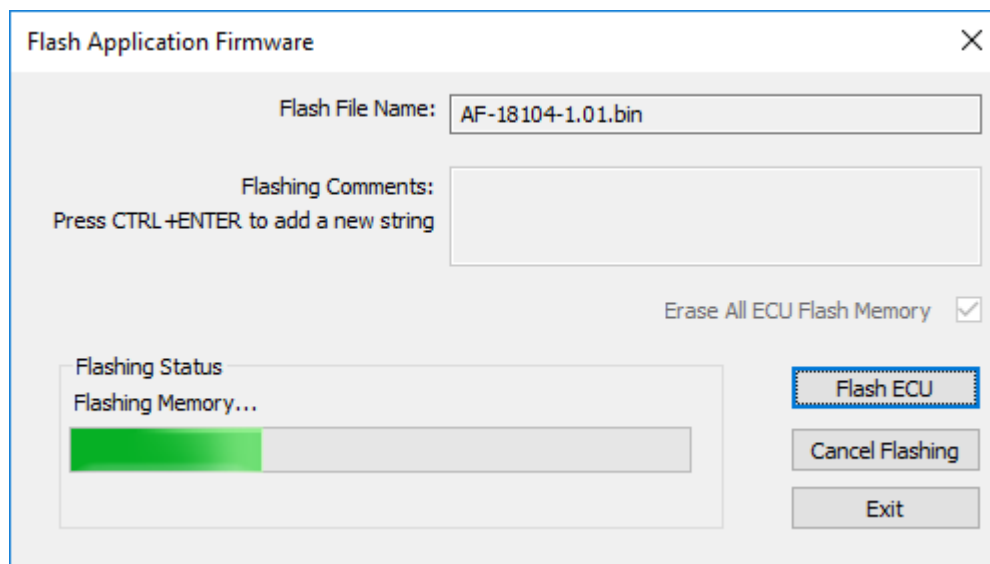
- Select the **F**lashing button and navigate to where you had saved the **AF-18104-1.xx.bin** (or equivalent) file sent from Axiomatic. (Note: only binary (.bin) files can be flashed using the Axiomatic EA tool.)
- Once the Flash Application Firmware window opens, you can enter comments such as "Firmware 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/timestamp the file, as this is done automatically by the Axiomatic EA tool when you upload the new firmware.

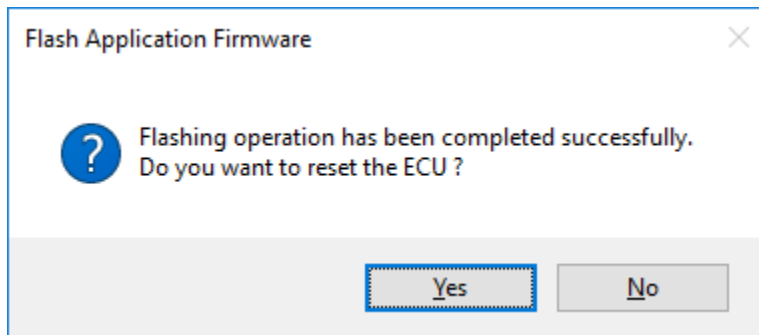


NOTE: It is good practice to tick the “Erase All ECU Flash Memory” box. Please note, that selecting this option will **erase ALL data stored in non-volatile flash**. It will also erase any configuration of the setpoints that might have been done to the ECU and reset all setpoints to their factory defaults. In case the controller contains custom settings, those settings need to be saved to PC before reflashing.

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.



Once the firmware has finished uploading, a message will pop up indicating the successful operation. If you select to reset the ECU, the new version of the AX100270 application will start running, and the ECU will be identified as such by the Axiomatic EA. Otherwise, the next time the ECU is power cycled, the AX100270 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.

APPENDIX A - TECHNICAL SPECIFICATION

Technical Specifications:

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 <https://www.axiomatic.com/service/>.

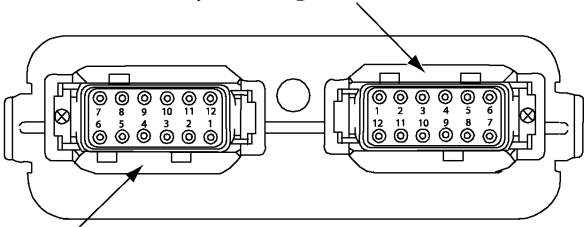
Input Specifications (Refer to the block diagram.)

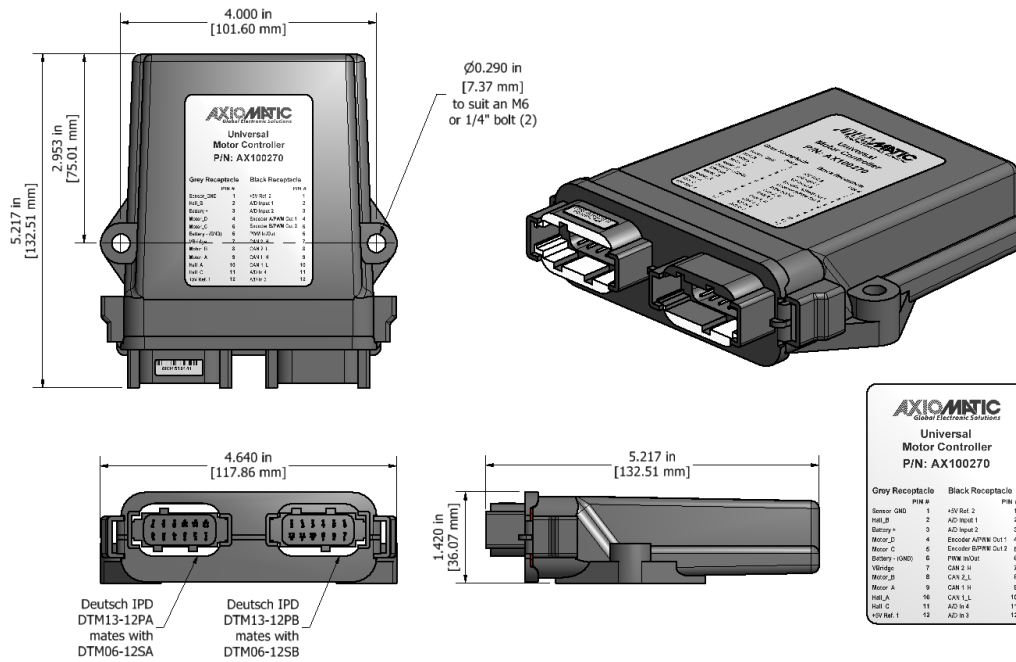
Power Supply Input	12 or 24Vdc nominal (6...36 Vdc power supply range) NB. The maximum total current draw permitted on the power supply input pins is 7.5 Amps @ 24Vdc, at one time.																																												
Reverse Polarity Protection	Provided up to -80Vdc																																												
Surge and Transient Protection	Provided																																												
Under-voltage Protection	Provided (hardware shutdown at 6V)																																												
Overvoltage Protection	Provided (hardware shutdown at 41V)																																												
Universal Signal Inputs	Up to 4 inputs are selectable by the user from the following. Analog Voltage (0-5V, 0-10V), Current (0-20 mA, 4-20mA, 249Ω current sense resistor) Frequency or PWM Inputs Digital Or SENT (option). 12-bit Analog to Digital resolution Amplitude up to +Vsupply Protected against shorts to GND. See Tables 1 and 2. NB.SAE J2716 SENT (Single Edge Nibble Transmission) protocol is a point-to-point scheme for transmitting signal values from a sensor to a controller.																																												
Encoder Inputs	Three (3) Standard A and B phase encoder inputs Additional PWM input or Home Encoder input is provided. Frequency Range: 0-250 kHz Amplitude: 0-5Vdc This feature is user configurable as PWM Outputs (see Output section).																																												
Hall Sensor	Standard open collector/drain HALL EFFECT Sensor Input type (3) 1K Pull-up to +5V per input is provided.																																												
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>6</td> <td>36</td> <td>V dc</td> </tr> <tr> <td>Voltage Input</td> <td>0</td> <td>36</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>36</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>1 000</td> <td>Hz</td> </tr> <tr> <td>PWM Voltage pk - pk</td> <td>0</td> <td>36</td> <td>V dc</td> </tr> <tr> <td>Frequency</td> <td>50</td> <td>10 000</td> <td>Hz</td> </tr> </tbody> </table>	Table 1.0. Absolute Maximum and Minimum Ratings				Characteristic	Min	Max	Units	Power Supply	6	36	V dc	Voltage Input	0	36	V dc	Current Input	0	21	mA	Current Input – Voltage Level	0	12	Vdc	Digital Type Input – Voltage Level	0	36	Vdc	PWM Duty Cycle	0	100	%	PWM Frequency	50	1 000	Hz	PWM Voltage pk - pk	0	36	V dc	Frequency	50	10 000	Hz
Table 1.0. Absolute Maximum and Minimum Ratings																																													
Characteristic	Min	Max	Units																																										
Power Supply	6	36	V dc																																										
Voltage Input	0	36	V dc																																										
Current Input	0	21	mA																																										
Current Input – Voltage Level	0	12	Vdc																																										
Digital Type Input – Voltage Level	0	36	Vdc																																										
PWM Duty Cycle	0	100	%																																										
PWM Frequency	50	1 000	Hz																																										
PWM Voltage pk - pk	0	36	V dc																																										
Frequency	50	10 000	Hz																																										
Input Accuracy and Resolution	<table border="1"> <thead> <tr> <th colspan="3">Table 2.0. Input Accuracy</th> </tr> <tr> <th>Input Type</th> <th>Accuracy</th> <th>Resolution</th> </tr> </thead> <tbody> <tr> <td>Voltage</td> <td>+/- 1%</td> <td>1 [mV]</td> </tr> <tr> <td>Current</td> <td>+/- 1%</td> <td>1 [uA]</td> </tr> <tr> <td>PWM</td> <td>+/- 1%</td> <td>0.1 [%]</td> </tr> <tr> <td>Frequency</td> <td>+/- 1%</td> <td>0.01 [Hz]</td> </tr> </tbody> </table>	Table 2.0. Input Accuracy			Input Type	Accuracy	Resolution	Voltage	+/- 1%	1 [mV]	Current	+/- 1%	1 [uA]	PWM	+/- 1%	0.1 [%]	Frequency	+/- 1%	0.01 [Hz]																										
Table 2.0. Input Accuracy																																													
Input Type	Accuracy	Resolution																																											
Voltage	+/- 1%	1 [mV]																																											
Current	+/- 1%	1 [uA]																																											
PWM	+/- 1%	0.1 [%]																																											
Frequency	+/- 1%	0.01 [Hz]																																											
Analog Ground	One sensor ground connection is provided.																																												
Reference Voltages	2 +5V, 200 mA maximum Regulation at +/-0.5% accuracy is provided.																																												

Output Specifications

Outputs	<p>Two outputs for a bidirectional Brushed DC Motor, up to 6A Two bidirectional full bridge outputs</p> <p>Or One output for a BLDC Motor, up to 6A One 3-phase half-bridge output, current sensing per each phase HALL Effect Sensor operation</p> <p>6A nominal current output (100W)</p> <p>NB. The maximum total current draw permitted on the power supply input pins is 7.5 Amps @ 24Vdc, at one time.</p>
V Bridge Connection	Separate +Vsupply connection for motor outputs
PWM Outputs	<p>Up to 3 independent PWM outputs (available if encoder input option is not selected)</p> <p>PWM Frequency: 0-250 kHz</p> <p>Duty Cycle: 0 to 100%</p>
Output Accuracy	PWM outputs +/-0.1%
Protection	Overcurrent protection is provided on all outputs. It is programmable.

General Specifications

Operating Conditions	-40 to 85°C (-40 to 185°F)
Weight	0.60 lb. (0.272 kg)
Protection	IP65; Unit is conformal coated within the housing.
Microprocessor	STM32F407VGT7
Quiescent Current Draw	45 mA @ 24Vdc Typical; 73 mA @ 12Vdc Typical
CAN Interface	<p>2 CAN ports (SAE J1939)</p> <p>250 kbps baud rate</p>
Network Termination	It is necessary to terminate the network with external termination resistors. The resistors are 120 Ohm, 0.25W minimum, metal film or similar type. They should be placed between CAN_H and CAN_L terminals at both ends of the network.
Control Logic	Standard embedded software is provided and is configurable using the Electronic Assistant (EA).
User Interface	User configuration and diagnostics are provided with the Axiomatic Electronic Assistant, P/Ns: AX070502 or AX070506K
Electrical Connections	<p>Refer to Table 3.0.</p> <p>24-pin receptacle (equivalent TE Deutsch P/N: DTM13-12PA-12PB-R008)</p> <p>Mating plugs kits are available on request and are equivalent to TE Deutsch P/Ns: DTM06-12SA and DTM06-12SB with 2 wedgelocks (WM12S) and 24 contacts (0462-201-20141).</p> <p>20 AWG wire is recommended for use with contacts 0462-201-20141.</p> <p style="text-align: center;">Key Arrangement B (black)</p>  <p style="text-align: center;">Key Arrangement A (grey)</p> <p style="text-align: center;">FRONT VIEW 24 PIN RECEPTACLE</p>
Enclosure and Dimensions	<p>High Temperature Nylon PCB Enclosure – (equivalent TE Deutsch P/N: EEC-325X4B)</p> <p>4.62 x 5.24 x 1.43 inches</p> <p>117.42 x 133.09 x 36.36 mm (W x L x H excluding mating plug)</p> <p>Refer to Figure 2.0.</p>



Dimensional Drawing

Pin out: AX100270

Grey Connector PIN #	Function	Black Connector PIN #	Function
1	Sensor GND	1	+5V Reference 2
2	Hall B	2	A/D Input 1
3	Battery +	3	A/D Input 2
4	Motor D	4	Encoder A/PWM Out 1
5	Motor C	5	Encoder B/PWM Out 2
6	Battery - (GND)	6	PWM In/Out
7	V Bridge	7	CAN 2_H
8	Motor B	8	CAN 2_L
9	Motor A	9	CAN 1_H
10	Hall A	10	CAN 1_L
11	Hall C	11	A/D Input 4
12	+5V Reference 1	12	A/D Input 3

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DC/DC Power Converters
Engine Temperature Scanners
Ethernet/CAN Converters,
Gateways, Switches
Fan Drive Controllers
Gateways, CAN/Modbus, RS-232
Gyroscopes, Inclinometers
Hydraulic Valve Controllers
Inclinometers, Triaxial
I/O Controls
LVDT Signal Converters
Machine Controls
Modbus, RS-422, RS-485 Controls
Motor Controls, Inverters
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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

We have an ISO9001:2015 registered design/manufacturing facility in Canada.

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 at <https://www.axiomatic.com/service/>.

COMPLIANCE

Product compliance details can be found in the product literature and/or on axiomatic.com. Any inquiries should be sent to sales@axiomatic.com.

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.

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
- Runtime hours, description of problem
- Wiring set up diagram, application and other comments as needed

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.

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