10-OUTPUT
VALVE ETHERNET CONTROLLER
With CAN, SAE J1939

USER MANUAL

P/N: AX029000

VERSION HISTORY

Version	Date	Author	Modification
1.0.0	February 25th, 2020	Peter Sotirakos	Initial Draft; Modified from UMAX021210 V1.0.3
-	April 21, 2020	Amanda Wilkins	Added pinout drawing
2.0.0	November, 2021	Viktor Rogachov	Added Ethernet, Modbus
3.0.0	October 5, 2023	Dmytro Tsebrii	Added Modbus Receive Updated control source list
4.0.0	January 19, 2024	Dmytro Tsebrii	Updated screenshots and EA default configuration tables
4.1.0	February 8, 2024	M Ejaz	Performed legacy changes

ACRONYMS

ACK	Positive Acknowledgement (from SAE J1939 standard)
BATT +/-	Battery positive (a.k.a. Vps) or Battery Negative (a.k.a. GND)
DIN	Digital Input used to measure active high or low signals
DM	Diagnostic Message (from SAE J1939 standard)
DTC	Diagnostic Trouble Code (from SAE J1939 standard)
EA	Axiomatic Electronic Assistant (A Service Tool for Axiomatic ECUs)
ECU	Electronic Control Unit (from SAE J1939 standard)
GND	Ground reference (a.k.a. BATT-)
I/O	Inputs and Outputs
MAP	Memory Access Protocol
NAK	Negative Acknowledgement (from SAE J1939 standard)
PDU1	A format for messages that are to be sent to a destination address, either specific or global (from SAE J1939 standard)
PDU2	A format used to send information that has been labeled using the Group Extension technique and does not contain a destination address.
PGN	Parameter Group Number (from SAE J1939 standard)
PropA	Message that uses the Proprietary A PGN for peer-to-peer communication
PropB	Message that uses a Proprietary B PGN for broadcast communication
PWM	Pulse Width Modulation
RPM	Rotations per Minute
SPN	Suspect Parameter Number (from SAE J1939 standard)
TP	Transport Protocol
UIN	Universal input used to measure voltage, current, frequency or digital inputs
Vps	Voltage Power Supply (a.k.a. BATT+)
%dc	Percent Duty Cycle (Measured from a PWM input)

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REFERENCES

J1939	Recommended Practice for a Serial Control and Communications Vehicle Network, SAE, April 2011
J1939/21	Data Link Layer, SAE, December 2010
J1939/71	Vehicle Application Layer, SAE, March 2011
J1939/73	Application Layer-Diagnostics, SAE, February 2010
J1939/81	Network Management, SAE, March 2017
TDAX029000	Technical Datasheet, 10 Outputs Valve Controller with SAE J1939, Axiomatic Technologies 2023
UMAX07050x	User Manual, Axiomatic Electronic Assistant and USB-CAN, Axiomatic Technologies, 2024

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

NOTE: These products are supported by Axiomatic Electronic Assistant V5.13.88.0 and higher.

1. OVERVIEW OF CONTROLLER
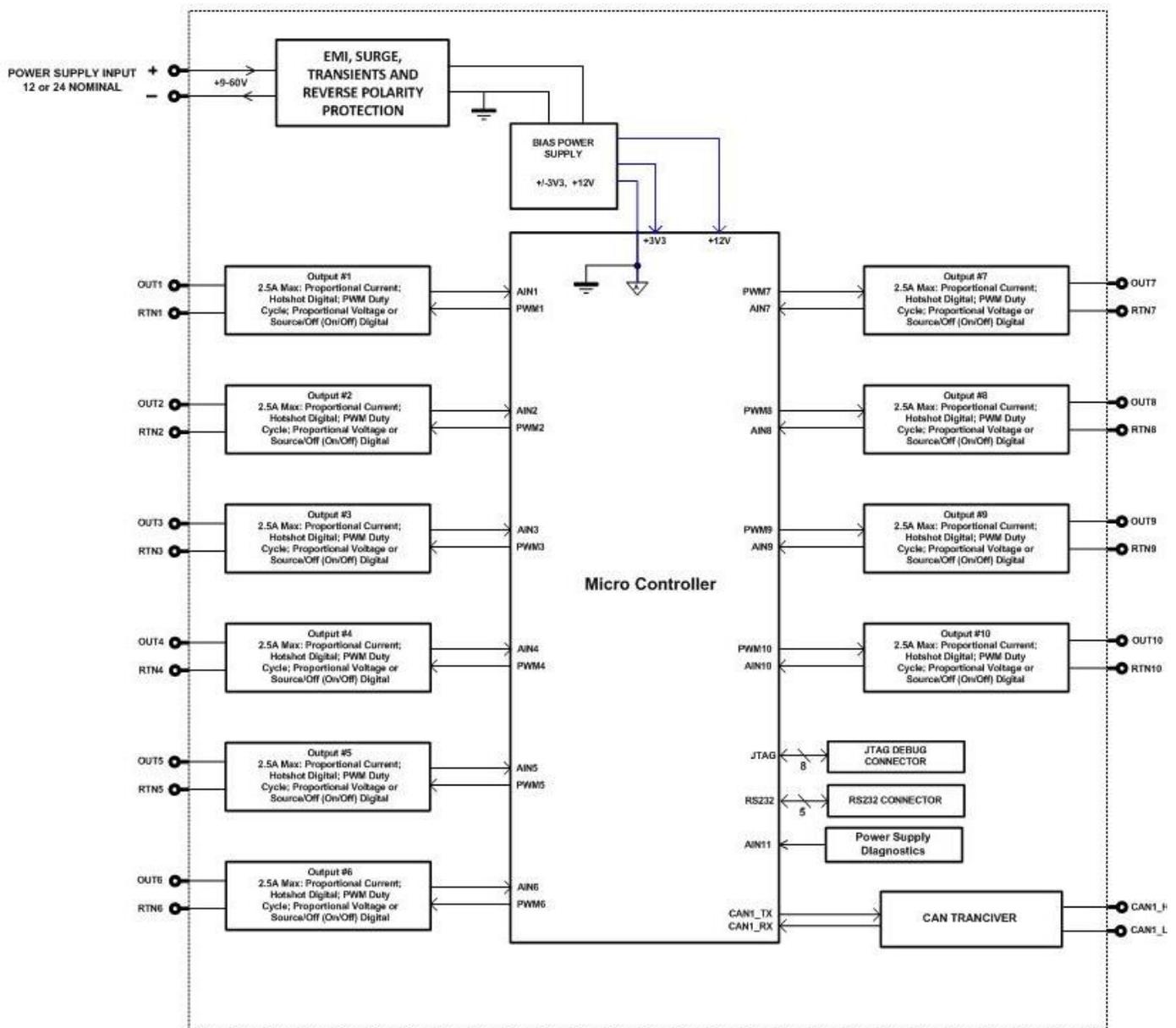
Figure 1 - AX029000 Block Diagram

The 10 Output Valve Controller (CAN-10OUT) is designed for extremely versatile control of up to ten proportional outputs to directly drive coils or other loads. Its flexible circuit design gives the user a wide range of configurable output types. The sophisticated control algorithms allow the user to program the controller for a wide range of applications without the need for custom software.

The ten outputs can be configured to drive proportional current (up to 2.5A each), hotshot digital current, proportional voltage (up to power supply), proportional PWM or straight on/off digital loads. The CAN-10OUT can be operated as either a self-contained control system, driving the outputs directly from the on-board logical function blocks, and/or it can be integrated into a SAE J1939 CAN Network. All outputs and logical function blocks on the unit are inherently independent from one another but can be programmed to interact in many ways.

A *Windows*-based Axiomatic Electronic Assistant (EA) is used to configure the controller via an USB-CAN (AX070501) device. Configurable properties, EA setpoints, are outlined in chapter 4. Setpoint configuration can be saved in a file which can be used to easily program the same configuration into another 10 Output Valve Controller. Throughout this document, EA setpoint names are referred with bolded text in double-quotes and the setpoint option is referred with italicized text in single-quotes. For example, "**Output Type**" setpoint set to option '*Proportional Current (0-2.5A)*'.

In this document the configurable properties of the ECU are divided into function blocks, namely 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 10 Output Valve Controller can be ordered using the following part numbers depending on the application.

AX029000	Controller with J1939 and auto-detected baud rate.
AX029001	Controller with CANopen and auto-detected baud rate.

1.1. Output Function Blocks

The controller has ten Proportional outputs. The Proportional Outputs are half-bridge drives with either high side or low side sourcing up to 2.5A. Five different timer peripherals are used to produce half-bridge drive signals; thus, Outputs are divided into five groups: Output 1, Outputs 2/3/9, Output 4, Outputs 5/7 and Outputs 6/8/10, according to assigned timer peripherals. All outputs within an output group operate on common frequency.

"**Output Type**" setpoint determines what kind of signal the output produces. Changing this setpoint causes other setpoints in the setpoint group to update to match selected type, thus the "**Output Type**" should be selected before configuring other setpoints within the setpoint group. "**Output Type**" setpoint options are listed in Table 1.

0	*Disabled*
1	*Proportional Current (0-2.5A)*
2	*Proportional Voltage (0-Vps)*
3	*PWM Duty Cycle (0-100%)*
4	*Digital On/off (0-Vps)*
5	*Digital Hotshot (0-2.5A)*

Table 1 – Output Type Options for Proportional Output

'*Proportional Current*' type has associated with it two setpoints not used by other types, which are the "**Dither Frequency**" and "**Dither Amplitude**" values. The output is controlled by high frequency signal (25 kHz), with the low frequency dither superimposed on top. Dither frequency is common for all outputs in an output group (Output 1, Outputs 2/3/9, Output 4, Outputs 5/7 and Outputs 6/8/10), thus changing it for one output will affect other outputs in the same output group. The dither frequency will match exactly what is programmed into the setpoint, but the exact amplitude of the dither will depend on the properties of the load coil. When adjusting the dither amplitude value, select one that is high enough to ensure an immediate response to the coil to small changes

in the control inputs, but not so large as to affect the accuracy or stability of the output. Refer to the coil's datasheet for more information.

The '*Proportional Voltage*' uses the measured value of the power supply and adjusts the duty cycle of the output such that the average value will match the target output voltage. If the output is running at a high frequency (for example 25 kHz), the voltage can be easily averaged using a simple low pass filter.

The '*PWM Duty Cycle*' option allows the user to run the output at fixed frequency configure with "**PWM Output Frequency**" setpoint, while the duty cycle changes depending on the control signal. All Outputs in an output group operate on same output frequency, thus changing the frequency for one output changes frequency of the others in the same output group as well. "**PWM Output Frequency**" is editable only if none of the outputs in the output group is set to '*Proportional Current*' or '*Hotshot Digital*' type. Configuring output to '*Proportional Current*' or '*Hotshot Digital*' type changes frequency if the output group automatically to 25 kHz.

Instead of proportional output control, there are also two types of digital responses possible as well. With the '*Digital On/Off*' type, should the control require the output to be on; it will be turned on at whatever the system power supply is. The output will source whatever current is required by the load, up to 2.5A.

If a digital **"Output Type"** has been selected the **"Digital Response"** setpoint will be enabled as shown in Table 2.

0	*Normal On/Off*
1	*Inverse Logic*
2	*Latched Logic*
3	*Blinking Logic*

Table 2 – Digital Response Options

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

The "**High-Side/Low-Side Output Setting**" setpoint defines whether the output will have high or low side sourcing. When 'High' is selected there will be high side sourcing and selecting 'Low' will configure the output to have a low side source.

0	*Low*
1	*High*

Table 3 – High-Side/Low-Side Output Setting

The "**Digital Out Delay**" and "**Delay Polarity**" setpoints are associated with '*Normal*' "**Digital Response**". The "**Digital Out Delay**" defines output state change delay in milliseconds. Setting "**Digital Out Delay**" to 0ms applies no state change delay. The "**Delay Polarity**" setpoint defines which edge the state change delay will be applied. For example, selecting '*Rising Edge*' for "**Delay Polarity**" and setting "**Digital Out Delay**" value >0ms, applies defined delay when driving output signal state changes form OFF to ON.

0	Rising Edge
1	Falling Edge

Table 4 – Delay Polarity

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

If a *'Blinking'* response is selected, then while the input command the output ON, it will blink at the rate in the "**Digital Blink Rate**" setpoint. When commanded OFF, the output will stay off. A blinking response is only available with a *'Digital On/Off'* type of output (not a Hotshot type.)

The *'Hotshot Digital'* type is different from in simple *'Digital On/Off'* in that it still controls the current through the load. This type of output is used to turn on a coil then reduce the current so that the valve will remain open, as shown in Figure 2. Since less energy is used to keep the output engaged, this type of response is very useful to improve overall system efficiency. With this output type there are associated three setpoints: "**Hold Current**", "**Hotshot Current**" and "**Hotshot Time**" which are used to configure form of the output signal as shown in Figure 2.
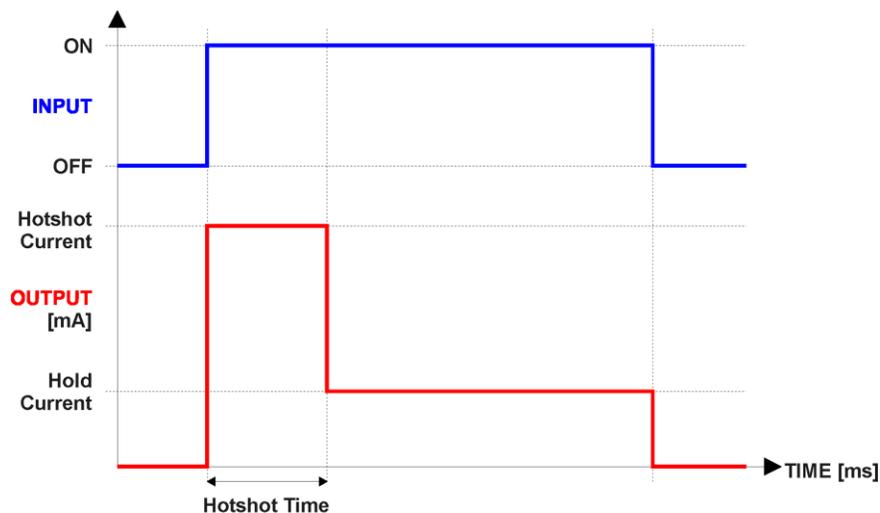
Figure 2 – Hotshot Digital Profile

For Proportional outputs signal minimum and maximum values are configured with "**Output At Minimum Command**" and "**Output At Maximum Command**" setpoints. Value range for both is limited by selected "**Output Type**".

Regardless of what type of control input is selected, the output will always respond in a linear fashion to changes in the input per Equation 1.

$$y = mx + a$$

$$m = \frac{Ymax - Ymin}{Xmax - Xmin}$$

$$a = Ymin - m * Xmin$$

Equation 1 - Linear Slope Calculations

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

Xmin = Control Input Minimum   Ymin = "**Output at Minimum Command**"

Xmax = Control Input Maximum   Ymax = "**Output at Maximum Command**"

In all cases, while X-axis has the constraint that Xmin < Xmax, there is no such limitation on the Y-axis. Thus configuring "**Output At Minimum Command**" to be greater than "**Output At Maximum Command**" allows the output to follow the control signal inversely.

To prevent abrupt changes at the output due to sudden changes in the command input, the user can choose to use the independent up or down ramps to smooth out the coil's response. The "**Ramp Up**" and "**Ramp Down**" setpoints are in milliseconds, and the step size of the output change will be determined by taking the absolute value of the output range and dividing it by the ramp time.

The "**Control Source**" setpoint together with "**Control Number**" setpoint determine which signal is used to drive the output. For example, setting "**Control Source**" to '*Programmable Logic'* and "**Control Number**" to '*1*', connects output signal from Programmable Logic 1 to the output in question. Outputs respond in a linear fashion to changes in control signal. If a non-digital signal is selected to drive digital output the command state will be 0 (OFF) at or below the "**Output At Minimum Command**", 1 (ON) at or above "**Output At Maximum Command**" and will not change in between those points.

In addition to the Control input, Proportional Outputs also support Enable and Override inputs.

The "**Enable Source**" setpoint together with "**Enable Number**" setpoint determine the enable signal for the output in question. The "**Enable Response**" setpoint is used to select how output will respond to the selected Enable signal. "**Enable Response**" setpoint options are listed in Table 5. If a non-digital signal is selected as Enable signal the signal is interpreted as shown in Figure 4.

0	*Enable When ON, Else Shutoff*
1	*Enable When ON, Else Rampoff*
2	*Enable When ON, Else Keep*
3	*Enable When OFF, Else Shutoff*
4	*Enable When OFF, Else Rampoff*
5	*Enable When OFF, Else Keep*

Table 5 – Enable Response Options

Override input allows the output drive to be configured to go to a default value in the case of the override input being engaged/disengaged, depending on the logic selected in "**Override Response**", presented in Table 6. When active, the output will be driven to the value in "**Output at Override Command**" regardless of the value of the Control input. The "**Override Source**" and "**Override Number**" together determine the Override input signal.

0	*Override When On*
1	*Override When Off*

Table 6 – Override Response Options

If a fault is detected in any of the active inputs (Control/Enable/Override) the output will respond per "**Control Fault Response**" setpoint as outlined in Table 7. Fault Value is defined by "**Output in Fault Mode**" setpoint value, which is interpreted in selected output units.

0	*Output Maintain Value*
1	*Output Fault Mode Value*

Table 7 – Fault Response Options

Regardless of a selected output type, current through the load is available as Output Current Feedback signal and can be selected as input for a Diagnostic Block as described in section 1.2.

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

The outputs are inherently protected against a short to GND or +Vps by circuitry. In case of a dead short, the hardware will automatically disable the output drive, regardless of what the processor is commanding for the output. When this happens, the processor detects output hardware shutdown and commands off the output in question. It will continue to drive non-shorted outputs normally and periodically (every 5 seconds) try to re-engage the short load, if still commanded to do so. If the fault has gone away since the last time the output was engaged while shorted, the controller will automatically resume normal operation.

In the case of an open circuit, there will be no interruption of the control for any of the outputs. The processor will continue to attempt to drive the open load.

The measured current through the load is available to be broadcasted on a CAN message if desired. It is also used as the input to the diagnostic function block for each output, and an open or shorted output can be broadcasted in a DM1 message on the CAN network

1.2.   Diagnostic Function Blocks

 The Diagnostic Input function blocks are used to setup the diagnostic messages for the controller.

The 5 types of diagnostics supported by the controller are shown in Table 8.

Function Block	Minimum Threshold	Maximum Threshold
Output Open Circuit Fault	N/A	N/A
Output Short Circuit Fault	N/A	N/A
VPS Undervoltage Fault	VPS Undervoltage	N/A
VPS Overvoltage Fault	N/A	VPS Overvoltage
Over Temperature Fault	N/A	Temperature Shutdown
Lost Communication Fault	N/A	Received Message Timeout (any)

Table 8 – Diagnostic Blocks and Fault Detection Thresholds

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

A Diagnostic Trouble Code (DTC) is defined by the J1939 standard as a 4-byte value which is a combination of:

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

In addition to supporting the DM1 message, the Controller also supports

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**

So long as even one Diagnostic function block has **Event Generates a DTC in DM1** set to true, the Controller will send the DM1 message every one second, regardless of whether there are any active faults, as recommended by the standard. While there are no active DTCs, the Controller will send the "No Active Faults" message. If a previously active DTC becomes inactive, a DM1 will be sent immediately to reflect this. As soon as the last active DTC goes inactive, it will send a DM1 indicating that there are no more active DTCs.

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

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

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

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

By default, every Diagnostic function block has associated with it a proprietary SPN. However, this setpoint **SPN for Event used in DTC** is fully configurable by the user should they wish it to reflect

a standard SPN define in J1939-71 instead. If the SPN is change, the OC of the associate error log is automatically reset to zero.

Every Diagnostic function block also has associated with it a default FMI. The only setpoint for the user to change the FMI is **FMI for Event used in DTC**, even though some Diagnostic function blocks can have both high and low errors. In those cases, the FMI in the setpoint reflects that of the low-end condition, and the FMI used by the high fault will be determined per Table 4. If the FMI is changed, the OC of the associate error log is automatically reset to zero.

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

Table 9 – Low Fault FMI versus High Fault FMI

If the FMI used is anything other than one of those in Table 4, then both the low and the high faults will be assigned the same FMI. This condition should be avoided, as the log will still use different OC for the two types of faults, even though they will be reported the same in the DTC. It is the user's responsibility to make sure this does not happen.

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

1.3.   PID Control Function Block

The PID Control function block is an independent logic block, but it is normally intended to be associated with proportional output control blocks described 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 10 Output Valve Controller.

The "**Target Source**" and "**Target Number**" setpoints determine control input and the "**Feedback Source**" and "**Feedback Number**" setpoints determine the established the feedback signal to the

PID function block. The "**Control Response**" will use the selected inputs as per the options listed in Table 10. When active, the PID algorithm will be called every "**Cycle Time**" in milliseconds.

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

Table 10 – 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 value based on the minimum and maximum values associated with the source function block.

For example, output of a Math Function Block could be used to set the target value, in which case it would be converted to a percentage value using "**Math Output Minimum Range**" and "**Math Output Maximum Range**" setpoints. The closed-loop feedback signal could be connected a '*CAN Receive Message*' and selected as the feedback source. In this case the value of the message data would be converted to a percentage based on the "**Data Minimum**" and "**Data Maximum**" setpoints in the CAN Receive block. The output of the PID function would depend on the difference between the commanded target and the measured feedback as a percentage of each signals range. In this mode, the output of the block would be a value from -100% to 100%.

When a '*Setpoint Control*' response is selected, the "**Target 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%.

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 will be between 0% and 100%.

In Order to allow the output to stabilize, the user can select a non-zero value for "**Output 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 Cycle_Time are configurable parameters.

$$PIDOutput_k = P_k + I_k + D_k$$

$$P_k = P\_Gain * Error_k$$
$$I_k = I\_Gain * ErrorSum_k$$
$$D_k = D\_Gain * (Error_k - Error_{k-1})$$

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

$$P\_Gain = G$$
$$I\_Gain = G * Ki * T/Ti \text{ (Note: If Ti is zero, I\_Gain = 0)}$$
$$D\_Gain = G * Kd * Td/T$$

$$T = Cycle\_Time * 0.001$$

Equation 2 - 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.

1.4. Lookup Table Function Block

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 1.5.

Lookup tables have two differing modes defined by "**X-Axis Type**" setpoint, given in Table 11. 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	Data Response
1	Time Response

Table 11 – 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 12. '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	Ignore
1	Ramp To
2	Jump To

Table 12 – PointN – Response Options

The X values are limited by minimum and maximum range of the selected input source if the source is 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 -100000 and 1000000. 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.

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

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, Section 1.1). Ignored points are not considered for min and max values.

1.5.   Programmable Logic Function Block

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 "**Logic Enabled**" setpoint must be set to '*True*'. By default, all Logic blocks are disabled.

The three associated tables are selected by setting "**Table Number X**" 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 13. 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	*=, Equal*
1	*!=, Not Equal*
2	*>, Greater Than*
3	*>=, Greater Than or Equal*
4	*<, Less Than*
5	*<=, Less Than or Equal*

Table 13 – Table X – Condition Y Operator Options

The three conditions are evaluated and if the result satisfies logical operation defined with "**Logical Operator X**" setpoint, given in Table 14, the associated Lookup Table is selected as output of the Logical block. Option '*0 – Default Table*' selects associated Lookup Table in all conditions.

0	*Default Table (Table1)*
1	*Cnd1 And Cnd2 And Cnd3*
2	*Cnd1 Or Cnd2 Or Cnd3*
3	*(Cnd1 And Cnd2) Or Cnd3*
4	*(Cnd1 Or Cnd2) And Cnd3*

Table 14 – 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.

1.6. 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 six input signals. Each input is then scaled according to the associated limit and scaling setpoints.

Inputs are converted into percentage value based on the "**Input X Minimum**" and "**Input X Maximum**" values selected. For additional control the user can also adjust the "**Input X Decimal Digits**" setpoint to increase the resolution of the input data and the min and max values.

A mathematical function block includes three selectable functions, in which each implements equation $A \; operator \; B$, where A and B are function inputs and operator is function selected with a setpoint "**Math Function X**". Setpoint options are presented in Table 15. The functions are connected, so that result of the preceding function goes into Input A of the next function. Thus Function 1 has both Input A and Input B selectable with setpoints, where Functions 2 to 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.

$$Math \; Block \; Output = \Big(\big((A1 \; op1 \; B1)op2 \; B2\big)op3 \; B3\Big)op4 \; B4$$

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

Table 15 – Math function X Operator Options

For logic operations (6, 7, and 8) scaled input greater than or equal to 1 is treated as TRUE. For logic operations (0 to 8), the result of the function will always be 0 (FALSE) of 1 (TRUE). For the arithmetic functions (9 to 14), it is recommended to scale the data such that the resulting operation will not exceed full scale (0 to 100%) and saturate the output result.

When dividing, a zero divider will always result in a 100% output value for the associated function.

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

1.7. CAN Transmit Message 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 AX029000 ECU has six CAN Transmit Messages, and each message has four completely user defined signals.

1.7.1. 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 "**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**.

"**Transfer Rate**" setpoint defines the interval used to send the message to the J1939 network. If the "**Transfer 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.

By default, all messages are sent on Proprietary B PGNs as broadcast messages. Thus "**Priority**" is always initialized to 6 (low priority) and the "**Destination**" setpoint is not used. This setpoint is only valid when a PDU1 PGN has been selected, and it can be set either to the Global Address (0xFF) for broadcasts or sent to a specific address as setup by the user.

1.7.2. CAN Transmit Signal Setpoints

Each CAN transmit message has four associated signals, which define data inside the Transmit message. "**Signal X Control Source**" setpoint together with "**Signal X Control Number**" setpoint define the signal source of the message. "**Signal X Control Source**" and "**Signal X Control Number**" options are listed in Table 19. Setting "**Signal X Control Source**" to '*Control Not Used*' disables the signal.

"**Signal X Size**" setpoint determines how many bits signal reserves from the message. "**Signal X Pos Byte**" determines in which of 8 bytes of the CAN message LSB of the signal is located. Similarly, "**Signal X Pos Bit**" 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**.

"**Signal X Resolution**" setpoint determines the scaling done on the signal data before it is sent to the bus. "**Signal X 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.

1.7.3. 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 "**Signal Type**" is the most important setpoint associated with this function block and it should be selected first. Setting it to *'Undefined'* will result in other setpoints being disabled. By default, ALL receive messages are set to *'Continuous'*.

By default, all control messages are expected to be sent to the 10 Output Valve Controller on Proprietary B PGNs. However, should a PDU1 message be selected, the 10 Output Valve Controller can be setup to receive it from any ECU by setting the "**Is From Selected Address**" to *'True'* and the "**Selected Address**" to the Global Address (0xFF). If a specific address is selected instead, then any other ECU data on the PGN will be ignored.

The "**Size**", "**Pos Byte**", "**Pos Bit**", "**Resolution**" and "**Offset**" can all be used to map any SPN supported by the J1939 standard to the output data of the Received function block.

As mentioned earlier, 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 "**Data Minimum**" and "**Data Maximum**" 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.

Once a message has been enabled, a Lost Communication fault will be flagged if that message is not received off the bus within the "**Auto-Reset Time**" period. This could trigger a Lost Communication event as described in section 1.2. 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 10 Output Valve Controller I/O supports up to ten unique CAN Receive Messages. Defaults setpoint values are listed in section 444.144.15 .

1.8. Ethernet

The *Ethernet* function block defines the Modbus TCP interface settings. It does not have signal inputs and outputs.

Configuration parameters of the *Ethernet* function block are presented below.

Name	Default Value	Range	Units	Description
MAC Address	Set at the factory	Any valid MAC address	–	Ethernet MAC Address. Set at the factory. Read-only parameter.
IP Address	192.168.0.34	Any IP address	–	The device IP address
Subnet Mask	255.255.255.0	Any IP address	–	The device subnet mask
Gateway	192.168.0.1	Any IP address	–	The device default gateway
Modbus Port	502	Any port value except the Discovery Port (35100)	–	The Modbus listening port
Modbus Timeout	1000	1…10000	ms	The Modbus communication timeout. Not used in the current firmware.

Table 16. Ethernet Function Block Configuration Parameters

Any updates to the function block configuration parameters will require a manual reset of the controller to apply the new Ethernet settings.

1.8.1. Modbus TCP Interface

The Modbus TCP/IP interface[1] runs over a standard 10/100 Mbit/s Ethernet link. The controller is presented as a slave device (a server) on the Modbus network. It supports with up to 8 simultaneous client connections from master devices.

[1]The interface is compliant with:

MODBUS Messaging on TCP/IP Implementation Guide V1.0b. Modbus Organization. October 24, 2006, 46p.

MODBUS Application Protocol Specification V1.1b3. Modbus Organization. April 26, 2012, 50p.

The following Modbus functions are supported by the controller.

Name	Function Code/Subcode	Description
Read Discrete Inputs	2	Reads values of the universal inputs when they are in the discrete voltage level mode
Read Input Registers	4	Reads values of the universal inputs
Read Holding Registers	3	Reads one or several configuration parameters
Write Single Register	6	Writes a configuration parameter
Write Multiple Registers	16	Writes one or several configuration parameters
Read/Write Multiple Registers	23	Writes and then reads configuration parameters
Encapsulated Interface Transport	43/14	Reads Device Identification

Table 17. Modbus Functions Supported by the Controller

The Modbus addresses are presented in the MODBUS ADDRESS MAP AX29000 document.

The Unit Identifier in the Modbus TCP header is ignored.

Floating-point variables are presented in a standard IEEE 754 single-precision 32-bit format, most significant word first. Double-word 32-bit integers are also presented with the most significant word first.

Reading and writing operations on variables occupying more than one word (a 16-bit Modbus register) are buffered. The buffering is made transparent to the user. However, it should be taken into consideration that writing to a non-volatile memory is not performed until all registers assigned to the variable are written. The writing operation should be performed without overlapping (writing to the same register twice) and without breaking the writing operation sequence with a reading operation or a writing operation to a different variable.

The Modbus functions "Write Multiple Registers" and "Read/Write Multiple Registers", when they include all registers assigned to a variable in one function call, meet the abovementioned writing requirements.

The Modbus writing operations are subject to a validity check. If a configuration parameter value is not in a valid range, the Modbus operation will succeed, but the configuration parameter will not be written.

The following device identification information can be read using the Encapsulated Interface Transport 43/14 function.

Object ID	Object Name	Description
0x00	VendorName	"Axiomatic"
0x01	ProductCode	Controller P/N. "AX029000"
0x02	MajorMinorRevision	Current firmware version. For example, "V2.00"
0x03	VendorUrl	"www.axiomatic.com"
0x04	ProductName	"IO Controller"
0x05	ModelName	Same as ProductCode. Controller P/N. "AX029000"
0x06	UserApplicationName	Firmware description. Depends on the firmware version. For V1.xx: "10-Output Valve Ethernet Driver"
0x80	SerialNumber	Private Object. Controller S/N. For example, "0012020016"

Table 18. Modbus Device Identification

All device identification objects are presented in ASCII strings.

1.8.2. Discovery Protocol

The controller supports an Axiomatic proprietary protocol that allows the discovery of Axiomatic controllers on a LAN by sending a global UDP request on port 35100[1].

[1] O. Bogush, "Ethernet to CAN Converter Discovery Protocol. CAN-ENET, AX140900, Project 15129. Document version: 1," Axiomatic Technologies Corporation, October 26, 2016.

Axiomatic provides a Windows console application `AxioDisc.exe` that can be used to discover the controller. The application shows the controller MAC address, IP address, web server port (not used), device port (Modbus port), device port type (TCP), the controller part number and serial number, see Figure 3.

The `AxioDisc.exe.` application is available upon request.

Figure 3. Discovery of the Controller on LAN Using AxioDisc.exe Application

1.9. Modbus Receive Function Block

The Modbus Receive function block allows ECU to receive up to 16 bit of Modbus incoming data from a chosen register.

To enable the block, **"Signal Enabled"** setpoint should be set to *1, True*. The register address can be chosen from a predefined range of addresses and is configured by setting the **"Register Address"** setpoint. The range is shown in a Modbus Address Map. The **"Data Size in Bits"** and **"Data Position Bit"** setpoints help to process the register data, so the unused bits will be stripped.

Please note: the incoming data cannot exceed 16 bits and is limited to one register. Thus, if **"Data Size in Bits"** and **"Data Position Bit"** configuration exceeds the register limits, everything extra will be stripped.

Also, the Modbus Receive function block has a resolution and offset that are applied at last. Overall, the output data will be processed in the following way:

$$Out_{PV} = ((In_{FV} \& Mask) \gg Position) * Resolution + Offset$$

where InPV – Input register data,
Mask – a bit mask that is calculated based on the data size and the position set,
Position – a value set in "Data Position Bit",
Resolution and Offset – "Resolution" and "Offset" setpoint values

If the data is planned to be received within a certain timeframe, the Modbus Receive function block has an auto resetting feature. The controller can be configured to set the output data to 'Not Available' if the last data wasn't received within the **"Autoreset Time"** in ms. If the **"Autoreset Time"** setpoint is set to 0 ms, this feature will be disabled.

1.10. 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 types. Available "**[Name] Source**" options and associated "**[Name] Number**" ranges are listed in

Table 19. Though 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 10	User must enable the function block, as it is disabled by default.
2: Constant Discrete Data	N/A	
3: Constant Continuous Data	N/A	
4: PID Block	1 to 4	User must enable the function block, as it is disabled by default.
5: Lookup Table	1 to 12	User must enable the function block, as it is disabled by default.
6: Math Function Block	1 to 6	User must enable the function block, as it is disabled by default.
7: Programmable Logic Block	1 to 4	User must enable the function block, as it is disabled by default.
8: Diagnostic Trouble Code	1 to 5	Will only be valid if the corresponding DTC has a non-zero SPN
9: Output Target Value	1 to 10	Can be mapped to a CAN Transmit Message.
10: Output Current Feedback	1 to 10	Measured Feedback current from the proportional output in mA and used in Output Diagnostics, can be mapped to a CAN Transmit Message.
11: Power Supply Measured	N/A	Measured power supply value in Volts and used in Power Supply Diagnostics, can be mapped to a CAN Transmit Message.
12: Processor Temperature Measured	N/A	Measured processor temperature in °C and used in Over Temperature Diagnostics, can be mapped to a CAN Transmit Message.
13: Modbus Receive Block	1 to 10	User must enable the function block, as it is disabled by default.

Table 19 – Available Control Sources and Numbers

If a non-digital signal is selected to drive a digital input, 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. For example, CAN Receive message 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 has to assign appropriate constant values according to intended use.
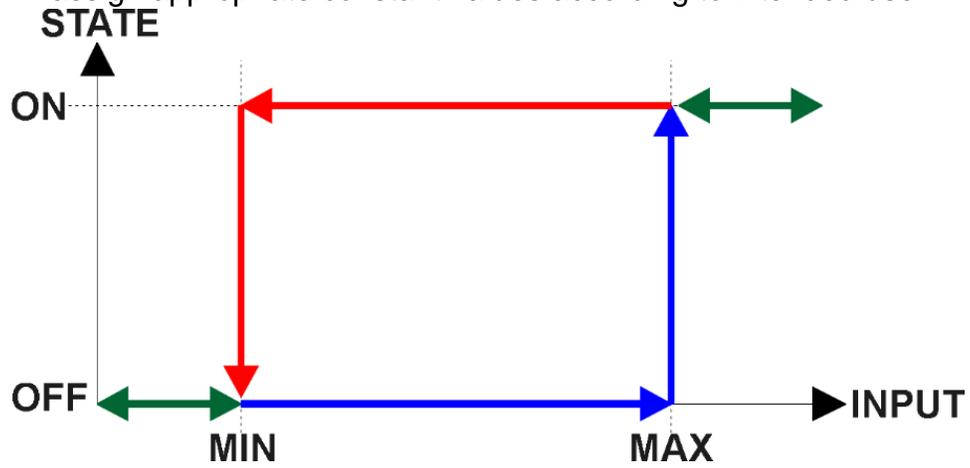
Figure 4 - Analog source to Digital input

2. INSTALLATION INSTRUCTIONS

2.1. Dimensions and Pinout

OUT 1 - 5	
pin	signal
1	OUT1
2	OUT1_RET
3	OUT2
4	OUT2_RET
5	OUT3
6	OUT3_RET
7	OUT4
8	OUT4_RET
9	OUT5
10	OUT5_RET

OUT 6 - 10	
pin	signal
1	OUT6
2	OUT6_RET
3	OUT7
4	OUT7_RET
5	OUT8
6	OUT8_RET
7	OUT9
8	OUT9_RET
9	OUT10
10	OUT10_RET

POWER	
pin	signal
1	BATT +
2	BATT -

CAN	
pin	signal
1	CAN_H
2	CAN_L

Figure 5 – AX029000 Dimensional Drawing

3. OVERVIEW OF 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

3.1. 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

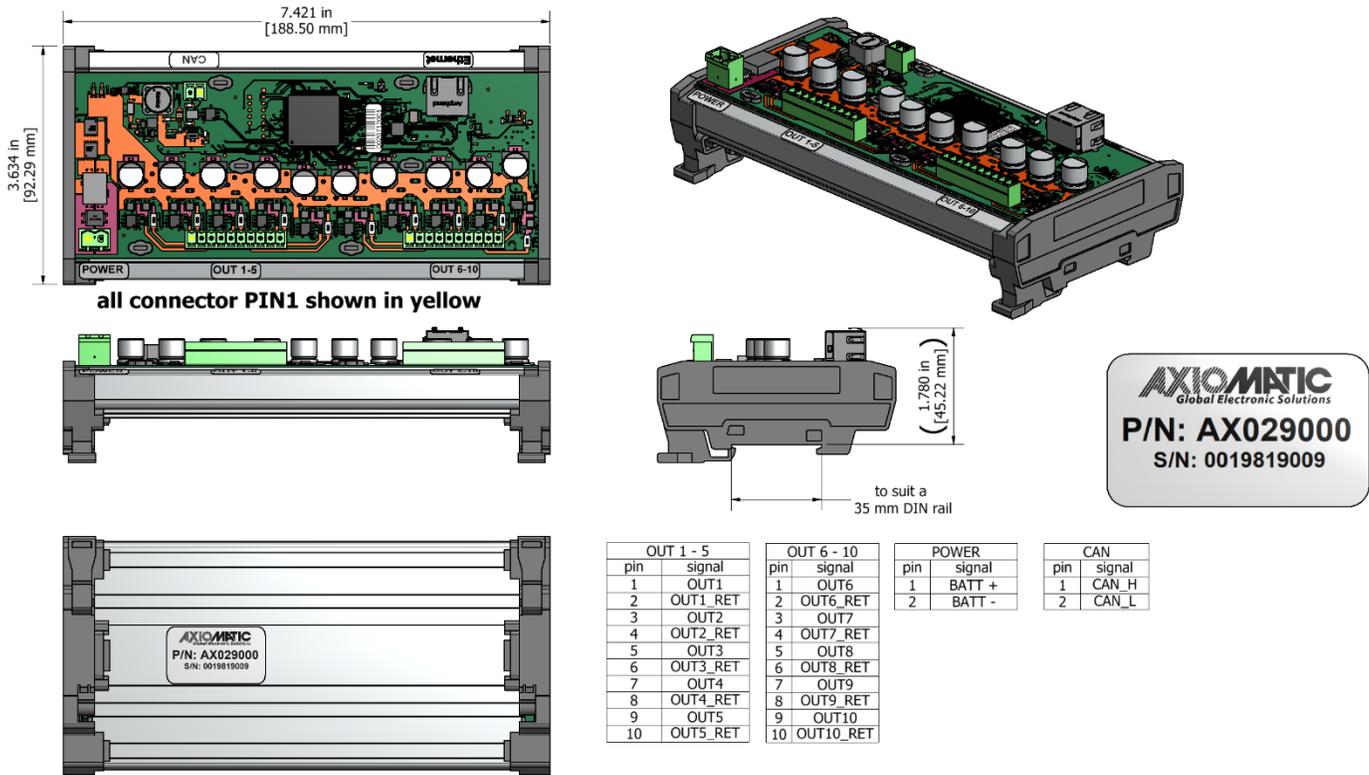|			
•	DM1 – Active Diagnostic Trouble Codes	65226	0x00FECA
•	DM2 – Previously Active Diagnostic Trouble Codes	65227	0x00FECB
•	DM3 – Diagnostic Data Clear/Reset for Previously Active DTCs	65228	0x00FECC
•	DM11 – Diagnostic Data Clear/Reset for Active DTCs	65235	0x00FED3
•	DM14 – Memory Access Request	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.

3.2. NAME, Address and Software ID

The 10 Output Valve 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 Address Capable	Yes
Industry Group	0, Global
Vehicle System Instance	0
Vehicle System	0, Non-specific system
Function	126, Axiomatic I/O Controller
Function Instance	17, Axiomatic AX029000
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 EA will allow the selection of any address between 0 and 253. ***It is 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 10 Output Valve Controller I/O 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 EA shows all this information in "General ECU Information", as shown below.

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

4. CONTROLLER CONFIGURATION

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 EA. For more information on how each setpoint is used by 10-Output Valve controller, refer to the relevant section in this user manual.

The controller can be configured in two independent ways: through the Modbus or CAN interface.

4.1. Modbus Configuration

The controller can be configured through the Modbus TCP interface using any third-party software tools.

The configuration parameters are grouped by the function blocks, see MODBUS ADDRESS MAP AX29000 document.

The controller checks configuration parameters for validity before accepting them and writing in a non-volatile memory. If a configuration parameter is invalid, the Modbus writing function will succeed, but the configuration parameter will not be written.

The controller will reset all relevant function blocks after each change of the configuration parameters. The exception is the *Ethernet* function block that maintains the Ethernet connection. The user will need to perform a manual reset by cycling the controller power to start using the new Ethernet settings.

Any changes in CAN function blocks through Modbus will restart CAN communication of the controller.

4.2. CAN Configuration

The controller supports the J1939 memory access protocol for configuring the unit through the CAN interface. The Axiomatic PC-based Electronic Assistant (EA) software can be used for viewing and changing the controller configuration parameters.

Axiomatic provides PC-based Electronic Assistant (EA) software to communicate with a wide range of Axiomatic products. The software can be downloaded from the Axiomatic website www.axiomatic.com.

The EA uses the Axiomatic USB-CAN converter P/N AX070501 to connect to the CAN network. The converter with cables can be ordered as an EA kit P/N AX070502 or AX070506K.

Please, refer to the user manual UMAX07050X for the description of the EA and associated products, and for the CAN network connection troubleshooting.

The user should use EA software version 5.15.113.0 or higher, which supports this controller firmware. The most recent EA software version can be downloaded from the Axiomatic website.

4.3.   Accessing the ECU Using EA

ECU with P/N AX029000 does not need any specific setup for EA. The 10-Output Valve Controller is operable at 250k, 500k or 1M Bit/s baud rates and will detect which one is set through EA. The CAN Interface Setup can be found from "Options" menu in EA.
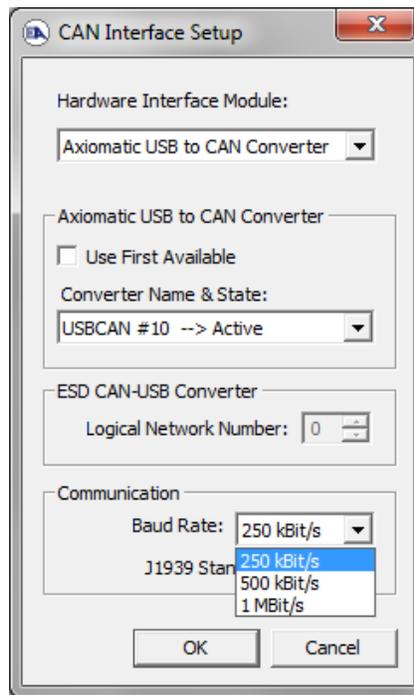
4.4. J1939 Network Parameters

"**ECU Instance Number**" and "**ECU Address**" setpoints and their effect are defined in Section 3.2.
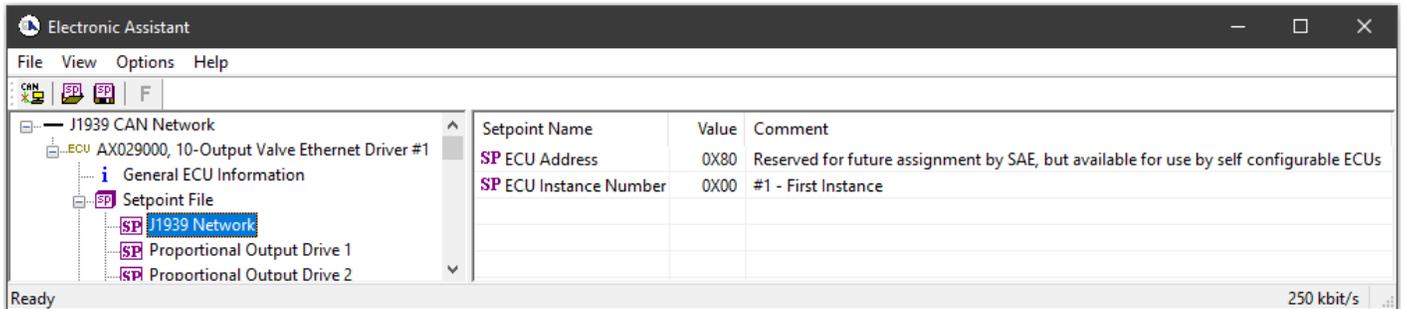
Figure 6 - Screen Capture of J1939 Setpoints

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 20 – 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 EA after the file is loaded so that only the new NAME and address are showing in the J1939 CAN Network ECU list.

4.5. Ethernet Parameter Setpoints

The Ethernet parameters can be configured using EA. A power cycle is needed for taking the new settings into use.
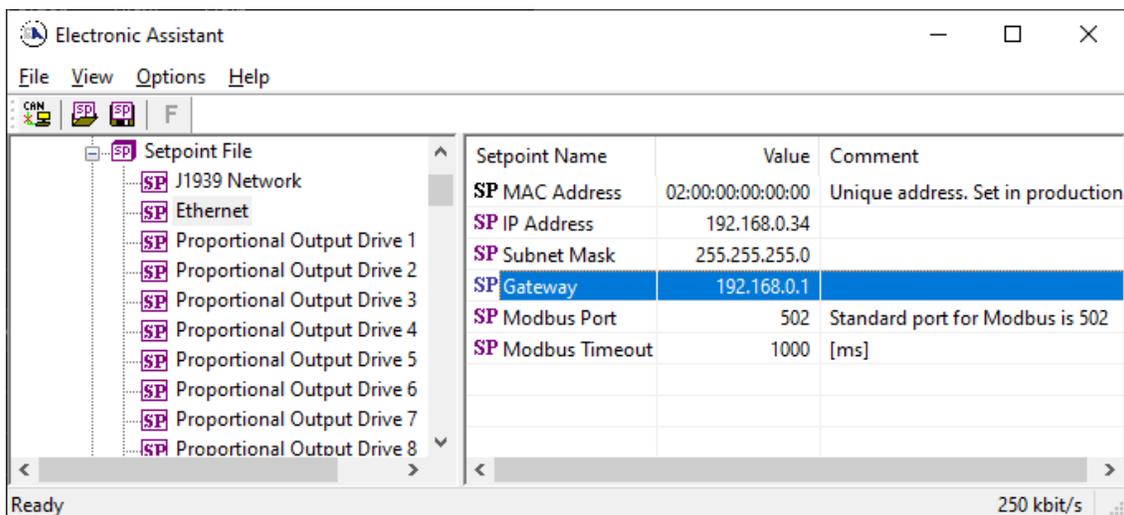
Figure 7 – Screen Capture of Ethernet Parameter Setpoints

Name	Range	Default	Notes
IP Address		192.168.0.34	
Subnet Mask		255.255.255.0	
Gateway		0	
Modbus Port	0…65535	502	
Modbus Timeout	0…10000	1000	

Table 21 – Ethernet Parameter Setpoints

4.6. Proportional Output Setpoints

The Proportional Output Function Block is defined in Section 1.1. Please refer there for detailed information about how these setpoints are used. Outputs are in Current mode by default. In order to enable an output "**Output Type**" and "**Control Source**" must be chosen.

Figure 8 - Screen Capture of Proportional Output Setpoints

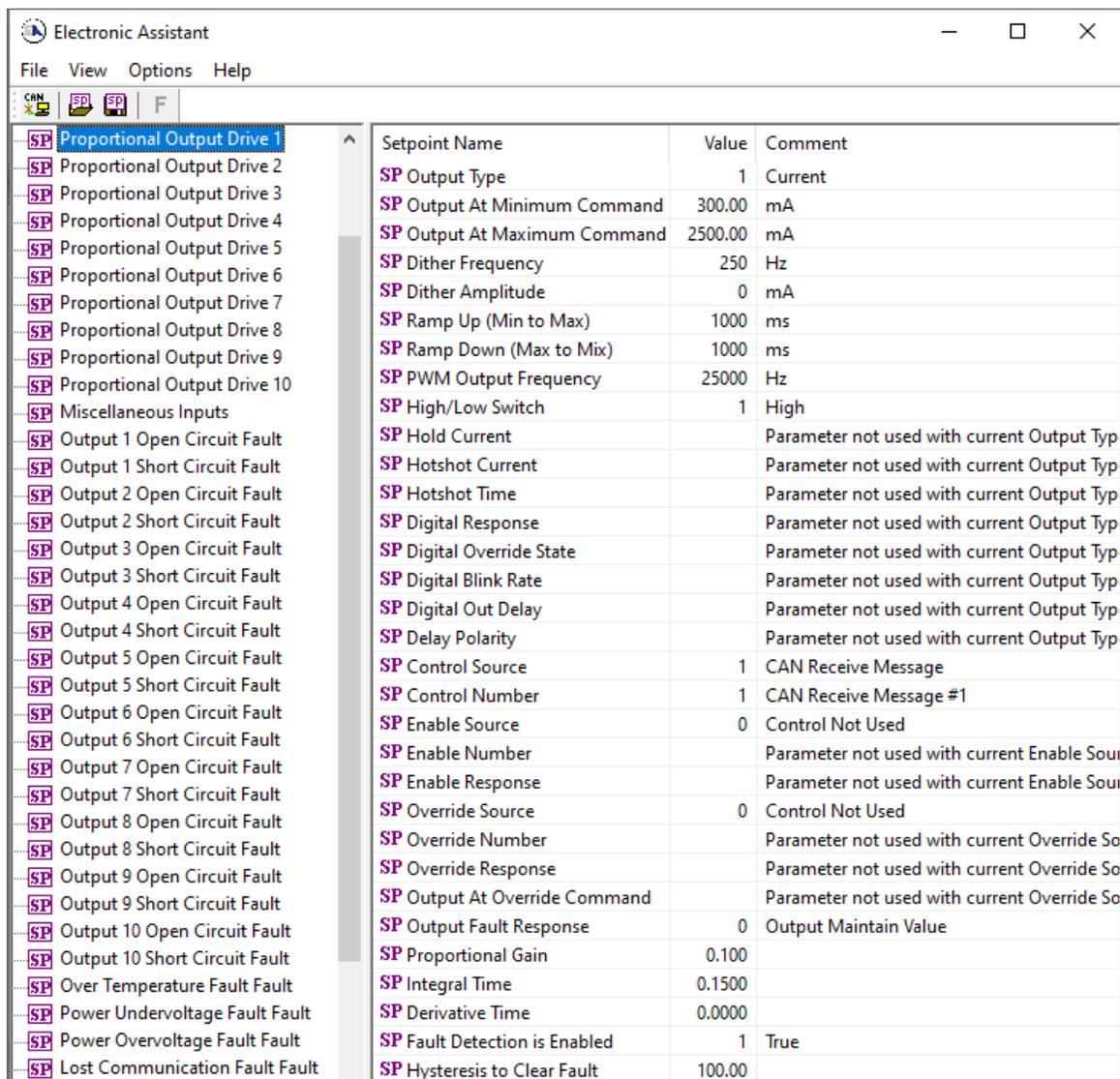| Name	Range	Default	Notes
Output Type	Drop List	Disabled	See Table 1
Output At Minimum Command	0…Limit	300mA	
Output At Maximum Command	0…Limit	2500mA	
Output At Override Command	0…Limit	750mA	
Dither Frequency	50…400Hz	200Hz	
Dither Amplitude	0…500 mA	0	
Ramp Up (Min to Max)	0…10 000ms	1000ms	
Ramp Down (Max to Min)	0…10 000ms	1000ms	
PWM Output Frequency	1…25 000Hz	500Hz	
High/Low Switch	Drop List	1, High	
Hold Current	0… 1500mA	500mA	
Hotshot Current	0…1500mA	1000mA	
Hotshot Time	500…10 000 ms	1000ms	
Digital Response	Drop List	Normal On/Off	See Table 2
Digital Override State	Drop List	ON	ON / OFF
Digital Blink Rate	100…5000 ms	1000ms	
Digital Out Delay	0 t0 60000ms	0ms	0ms →No delay
Delay Polarity	Drop List	Rising Edge	See Table 4
Control Source	Drop List	CAN Transmit Message	See Table 19
Control Number	Depends on control source	1	See Table 19
Enable Source	Drop List	Control not used	See Table 19
Enable Number	Depends on enable source	1	See Table 19
Enable Response	Drop List	Enable When On, else Shutoff	See Table 5
Override Source	Drop List	Control not used	See Table 19
Override Number	Depends on enable source	1	See Table 19
Override Response	Drop List	Override When On	See Table 6
Fault Detection is Enabled	Drop List	True	
Output Fault Response	Drop List	Shutoff Output	See Table 7
Output in Fault Mode	Depends on Output type	500mA	
Hysteresis to Clear Fault	0.01…250.00 mA	100.00mA	

Table 22 – Proportional Output Setpoints

4.7. Miscellaneous Inputs Setpoints

The Miscellaneous Inputs Function Block contains setpoints affecting the controller's diagnostic behavior. The voltage thresholds and shutdown temperature serve as the limits for when their corresponding fault will be triggered.
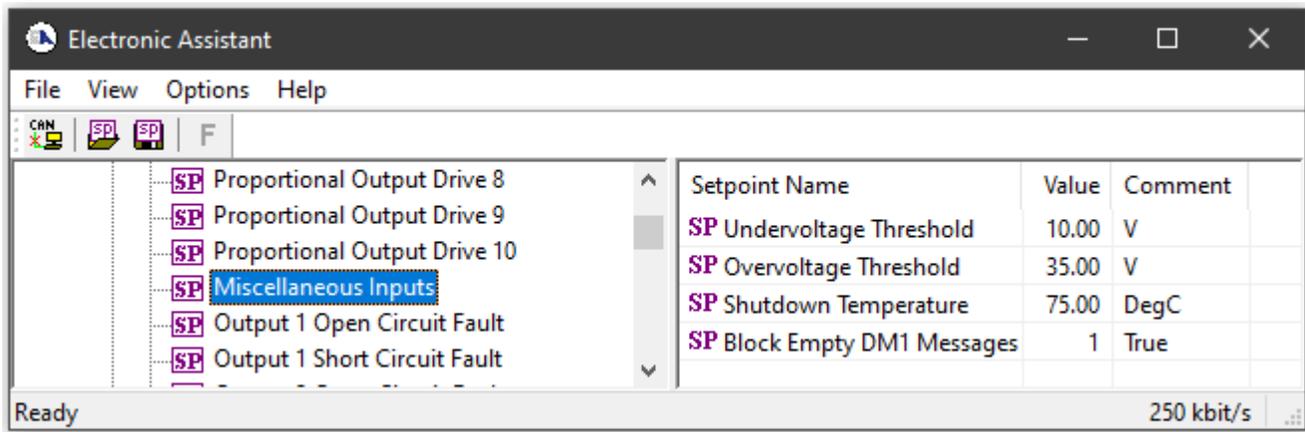
Figure 9 - Screen Capture of Miscellaneous Inputs Setpoints

Name	Range	Default	Notes
Undervoltage Threshold	8…Overvoltage Threshold	10V	
Overvoltage Threshold	Undervoltage Threshold…36	30V	
Shutdown Temperature	-40…85°C	75°C	
Block Empty DM1 Messages	Drop List	False	

Table 23 – Miscellaneous Inputs Setpoints

4.8.   Diagnostic Input Setpoints

The Diagnostic Input function block is defined in Section 1.2. Please refer to that section for detailed information about how all these setpoints are used.
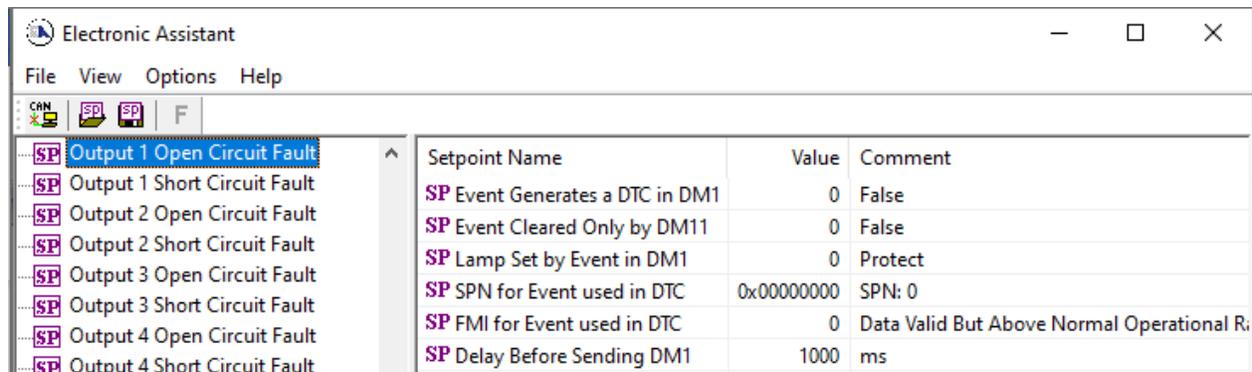
Figure 10 - Screen Capture of Diagnostic Input Setpoints

Name	Range	Default	Notes
Event Generates a DTC in DM1	Drop List	True	Refer to Section 1.2
Event Only Cleared by DM11	Drop List	False	Refer to Section 1.2
Lamp Set by Event in DM1	Drop List	0	Refer to Section 1.2
SPN for Event used in DTC	0…524287	n	Refer to Section 1.2
FMI for Event used in DTC	Drop List	0	Refer to Section 1.2
Delay Before Sending DM1	0…60000 ms	1000 ms	Refer to Section 1.2

Table 24 – Diagnostic Input Setpoints

4.9. Constant Data Setpoints

The Constant Data Function Block is provided to allow the user to select values as desired for various logic block functions.
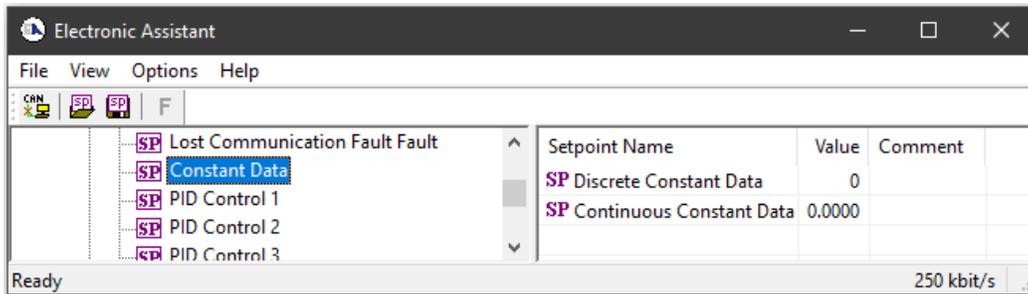
Figure 11 - Screen Capture of Diagnostic Input Setpoints

Name	Range	Default	Notes
Discrete Constant Data	0…4294967295	0	
Continuous Constant Data	-3.4e38…3.4e38	0	

Table 25 – Diagnostic Input Setpoints

4.10. PID Control Setpoints

The PID Control Function Block is defined in Section 1.3. 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 "**Target Source**" and "**Feedback Source**".
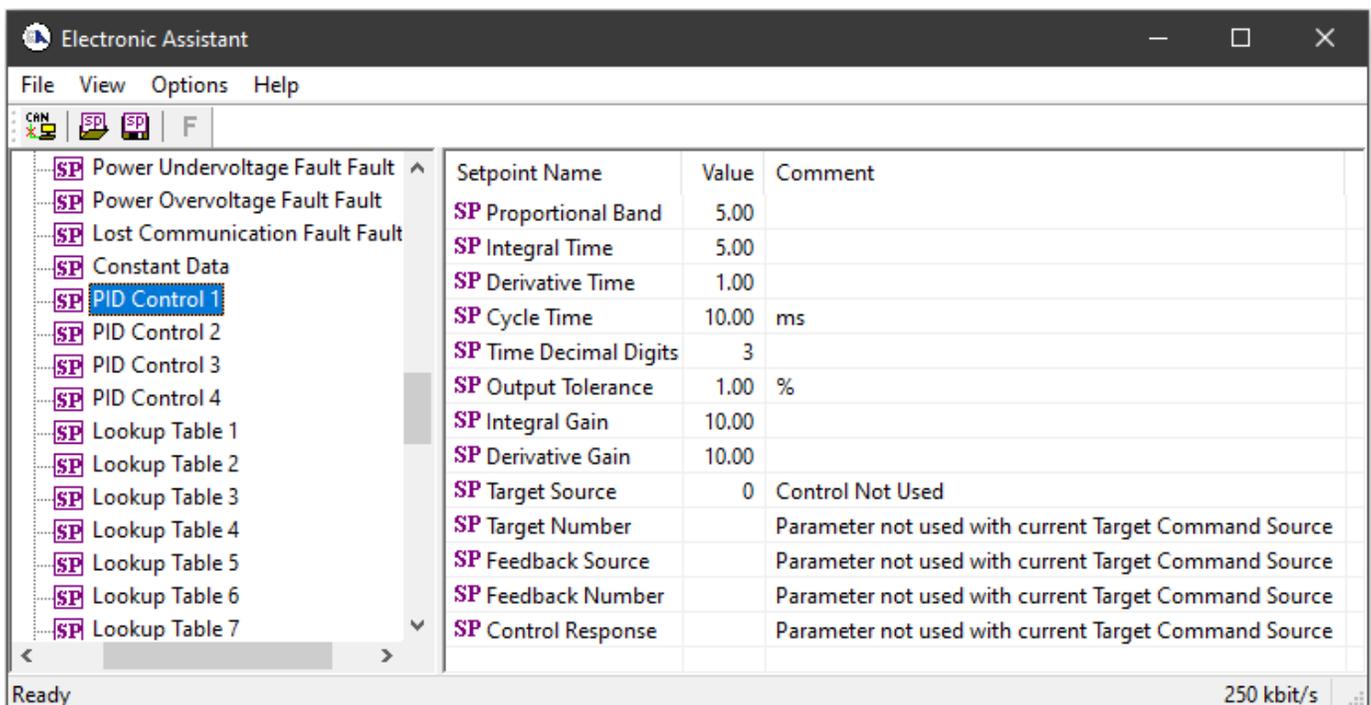
Figure 12 - Screen Capture of PID Control Setpoints

Name	Range	Default	Notes
Proportional Band, G	0…10	5.00	See Equation 2
Integral Time, Ti	0.001…1000.0	5.00	
Derivative Time, Td	0.001…1000.0	1.00	
Cycle Time	1…1000 ms	10ms	
Time Decimal Digits	0…3	3	Resolution is 10^x, affects Ti and Td
Output Tolerance	0…100 %	1.00 %	
Integral Gain, Ki	0.0…10.0	10.00	0 disables integral, PD ctrl
Derivative Gain, Kd	0.0…10.0	10.00	0 disables derivative, PI ctrl
Target Source	Drop List	Control Not Used	See Table 19
Target Number	Depends on control source	1	See Table 19
Feedback Source	Drop List	Control Not Used	See Table 19
Feedback Number	Depends on control source	1	See Table 19
Control Response	Drop List	Single Output	See Table 10

Table 26 – Programmable Logic Setpoints

4.11. Lookup Table Setpoints

The Lookup Table Function Block is defined in Section 1.4 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**".
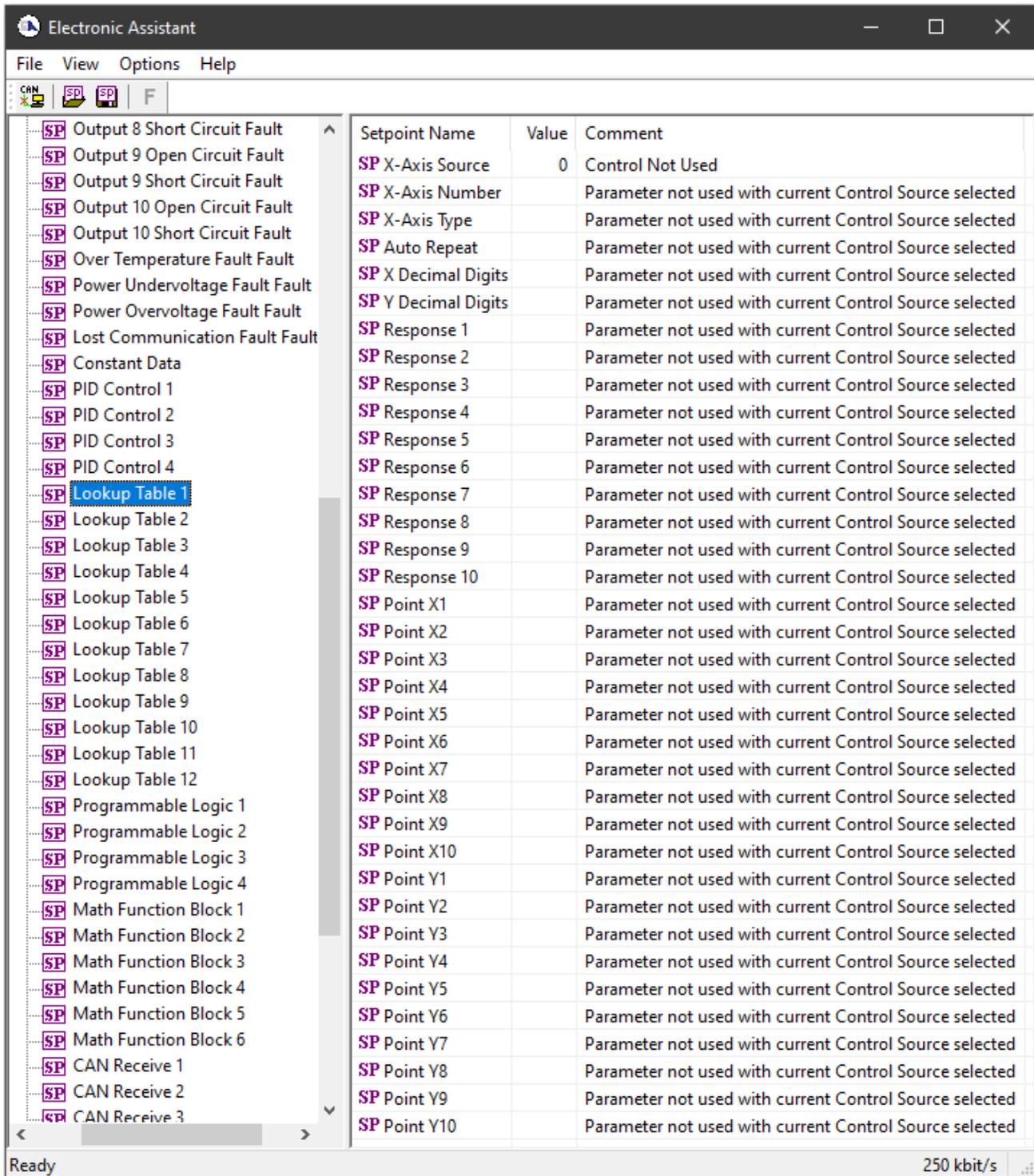
Figure 13 - Screen Capture of Lookup table Setpoints

Name	Range	Default	Notes
X-Axis Source	Drop List	Control Not Used	See Table 19
X-Axis Number	Depends on control source	1	See Table 19
X-Axis Type	Drop List	Data Response	See Table 11
Auto Repeat	Drop List	False	
X Decimal Digits	0…3	0	Resolution is 10^x, affects X points
Y Decimal Digits	0…3	0	Resolution is 10^x, affects Y points
Response 1	Drop List	Ramp To	See Table 12
Response 2	Drop List	Ramp To	See Table 12
Response 3	Drop List	Ramp To	See Table 12
Response 4	Drop List	Ramp To	See Table 12
Response 5	Drop List	Ramp To	See Table 12
Response 6	Drop List	Ramp To	See Table 12
Response 7	Drop List	Ramp To	See Table 12
Response 8	Drop List	Ramp To	See Table 12
Response 9	Drop List	Ramp To	See Table 12
Response 10	Drop List	Ramp To	See Table 12
Point X1	From X-Axis source minimum to Point 1 - X Value	X-Axis source minimum Depends on the Table number	See Section 1.4
Point X2	From Point 0 - X Value to Point 2 - X Value	Depends on the Table number	See Section 1.4
Point X3	From Point 1 - X Value to Point 3 - X Value	Depends on the Table number	See Section 1.4
Point X4	From Point 2 - X Value to Point 4 - X Value	Depends on the Table number	See Section 1.4
Point X5	From Point 3 - X Value to Point 5 - X Value source	Depends on the Table number	See Section 1.4
Point X6	From Point 4 - X Value to Point 6 - X Value	Depends on the Table number	See Section 1.4
Point X7	From Point 5 - X Value to Point 7 - X Value	Depends on the Table number	See Section 1.4
Point X8	From Point 6 - X Value to Point 8 - X Value	Depends on the Table number	See Section 1.4
Point X9	From Point 7 - X Value to Point 9 - X Value	Depends on the Table number	See Section 1.4
Point X10	From Point 8 - X Value to Point 10 - X Value	Depends on the Table number	See Section 1.4
Point Y1	-10^6 to 10^6	Depends on the Table number	
Point Y2	-10^6 to 10^6	Depends on the Table number	
Point Y3	-10^6 to 10^6	Depends on the Table number	
Point Y4	-10^6 to 10^6	Depends on the Table number	
Point Y5	-10^6 to 10^6	Depends on the Table number	
Point Y6	-10^6 to 10^6	Depends on the Table number	
Point Y7	-10^6 to 10^6	Depends on the Table number	
Point Y8	-10^6 to 10^6	Depends on the Table number	
Point Y9	-10^6 to 10^6	Depends on the Table number	
Point Y10	-10^6 to 10^6	Depends on the Table number	

Table 27 – Lookup Table Setpoints

4.12. Programmable Logic Setpoints

The Programmable Logic function block is defined in Section 1.5. Please refer there for detailed information about how all these setpoints are used. "**Logic Enabled**" is '*False*' by default. To enable Logic set "**Logic Enabled**" to '*True*' and select appropriate "**Argument Source**".
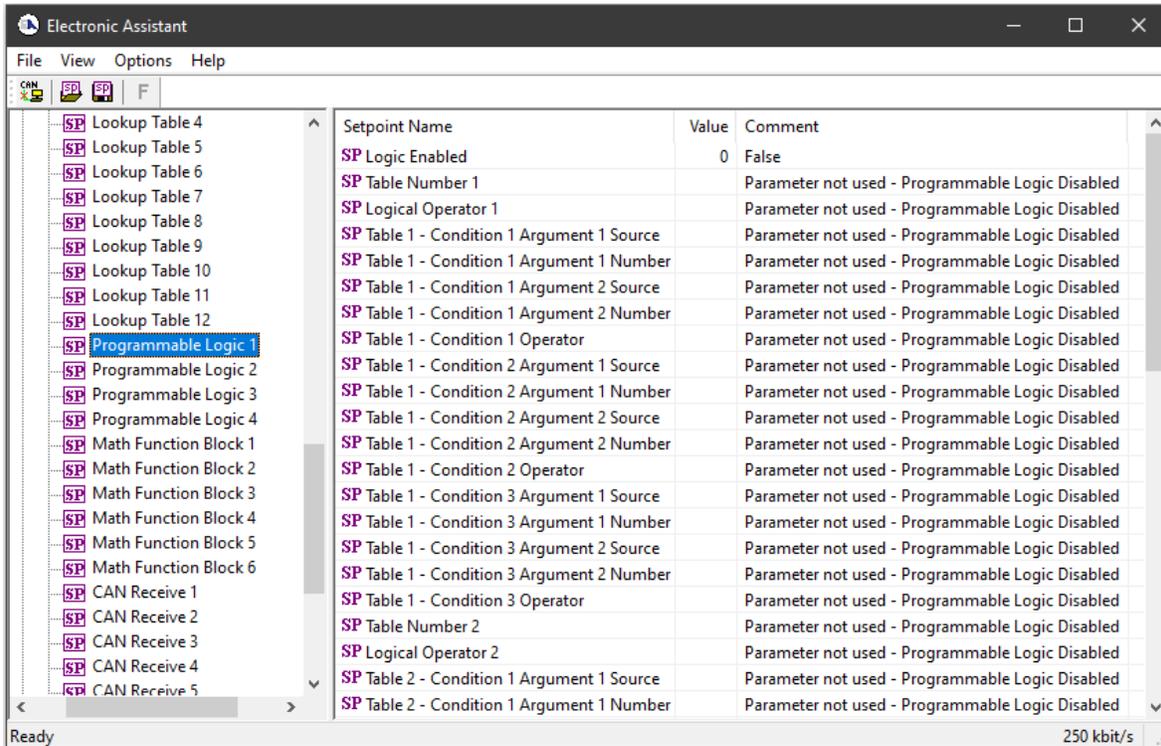

Figure 14 - Screen Capture of Programmable Logic Setpoints

Setpoint ranges and default values for Programmable Logic Blocks are listed in Table 28. Only "**Table 1**" setpoint are listed, because other "**Table X**" setpoints are similar, except for the default value of the "**Table Number**" setpoint, which is X for "**Table X**".

Name	Range	Default	Notes
Logic Enabled	Drop List	False	
Table Number 1	1 to 12	Lookup Table 1	
Logical Operator 1	Drop List	Default Table	See Table 14
Table 1 - Condition 1 Argument 1 Source	Drop List	Control Not Used	See Table 19
Table 1 - Condition 1 Argument 1 Number	Depends on control source	1	See Table 19
Table 1 - Condition 1 Argument 2 Source	Drop List	Control Not Used	See Table 19
Table 1 - Condition 1 Argument 2 Number	Depends on control source	1	See Table 19
Table 1 - Condition 1 Operator	Drop List	=, Equal	See Table 13
Table 1 - Condition 2 Argument 1 Source	Drop List	Control Not Used	See Table 19
Table 1 - Condition 2 Argument 1 Number	Depends on control source	1	See Table 19
Table 1 - Condition 2 Argument 2 Source	Drop List	Control Not Used	See Table 19
Table 1 - Condition 2 Argument 2 Number	Depends on control source	1	See Table 19
Table 1 - Condition 2 Operator	Drop List	=, Equal	See Table 13
Table 1 - Condition 3 Argument 1 Source	Drop List	Control Not Used	See Table 19
Table 1 - Condition 3 Argument 1 Number	Depends on control source	1	See Table 19
Table 1 - Condition 3 Argument 2 Source	Drop List	Control Not Used	See Table 19
Table 1 - Condition 3 Argument 2 Number	Depends on control source	1	See Table 19
Table 1 - Condition 3 Operator	Drop List	=, Equal	See Table 13

Table 28 – Programmable Logic Setpoints

4.13. Math Function Block

The Math Function Block is defined in Section 1.6. 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**".
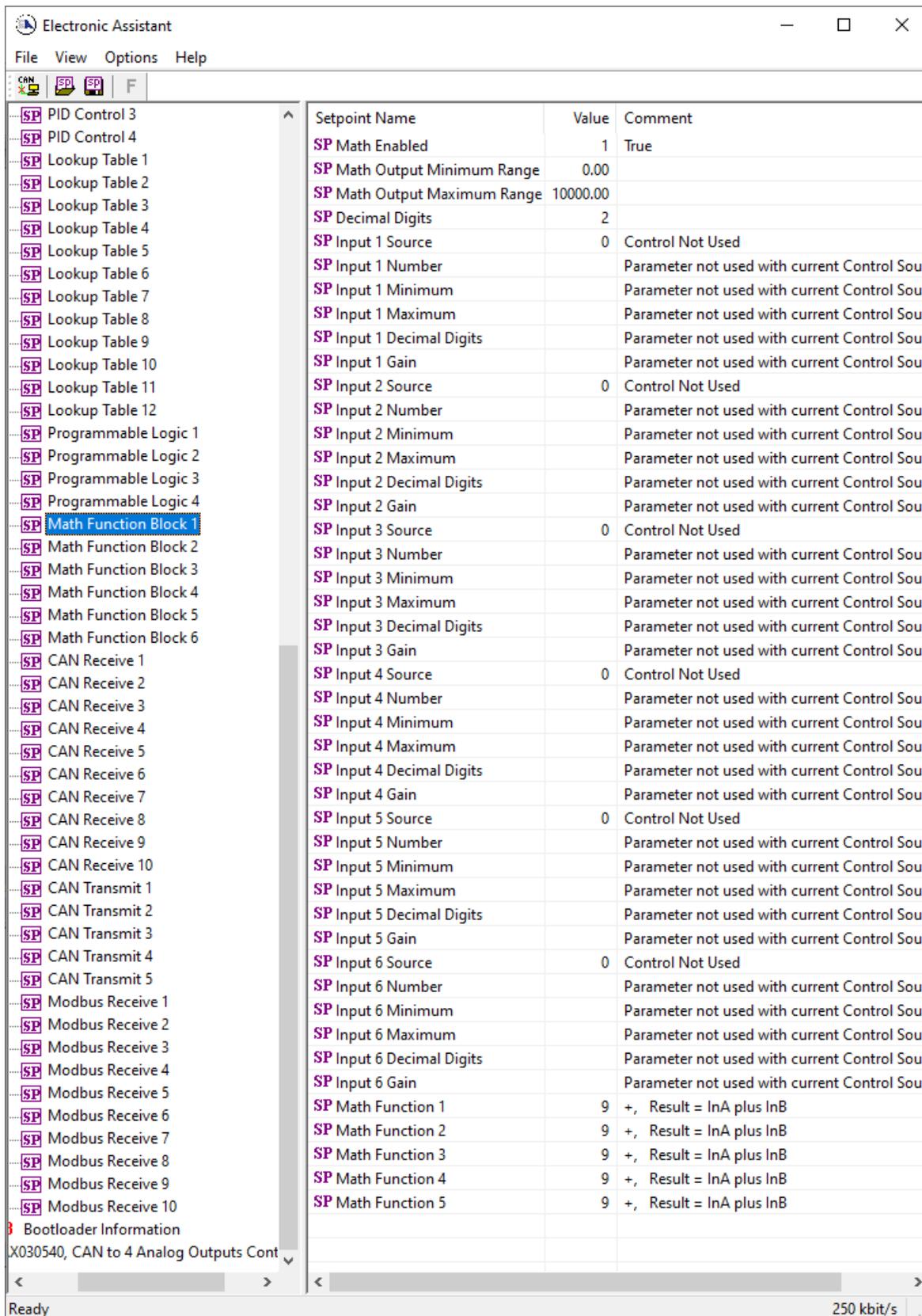
Figure 15 - Screen Capture of Math Function Block Setpoints

Setpoint ranges and default values for Math Blocks are listed in Table 29Table 28. Only "**Input 1**"
setpoint are listed, because other "**Input X**" setpoints are similar.

Name	Range	Default	Notes
Math Enabled	Drop List	False	
Math Output Minimum Range	-32768…32767	0	
Math Output Maximum Range	-32768…32767	10000.0	
Decimal Digits	0…3	2	Resolution is 10^x, affects Output Min/Max Ranges
Input 1 Source	Drop List	Control not used	See Table 19
Input 1 Number	Depends on control source	1	See Table 19
Input 1 Function Number	1…3	1	
Input 1 Minimum	$-10^6…10^6$	0.00	
Input 1 Maximum	$-10^6…10^6$	10000.00	
Input 1 Decimal Digits	0..3	2	Resolution is 10^x, affects Input 1 Min/Max Ranges
Input 1 Gain	-100…100	100	
Math Function 1	Drop List	+, Result = InA plus InB	See Table 15
Math Function 2	Drop List	+, Result = InA plus InB	See Table 15
Math Function 3	Drop List	+, Result = InA plus InB	See Table 15

Table 29 – Math Function Setpoints

4.14. CAN Receive Setpoints

The Math Function Block is defined in Section 1.7.3. Please refer there for detailed information about how these setpoints are used. "**Receive Message Timeout**" is set to 0ms by default.
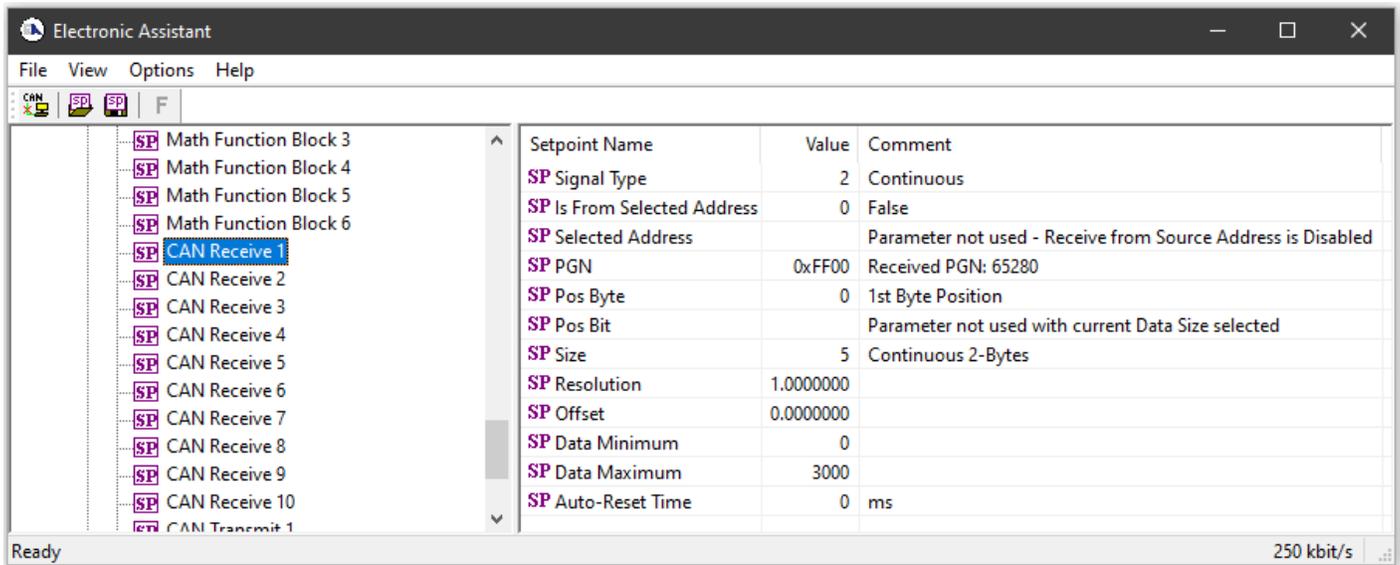
Figure 16 - Screen Capture of CAN Receive Message Setpoints

Name	Range	Default	Notes
Signal Type	Drop List	2, Continuous	
Is From Selected Address	Drop List	False	
Specific Address	Drop List	False	
Selected PGN	0 to 65536	Different for each	
Address That Sends	0 to 255	254 (0xFE, Null Addr)	
Receive Transmit Data Index in Array	0-7	0	
Receive Transmit Bit Index In Byte	0-7	0	
Size	Drop List	Continuous 2-Bytes	

Resolution	-100000.0 to 100000	1.0	
Offset	-10000 to 10000	0.0	
Data Minimum	-1000000 to Max	0.0	
Data Maximum	-100000 to 100000	100.0	
Auto-Reset Time	0 to 60 000 ms	0 ms	0ms disables the Lost Comm Fault

Table 30 – CAN Receive Setpoints

4.15. CAN Transmit Setpoints

CAN Transmit Message Function Block is presented in Section 1.7. Please refer there for detailed information how these setpoints are used. "**Transmit Repetition Rate**" is 0ms by default, thus no message will be sent.
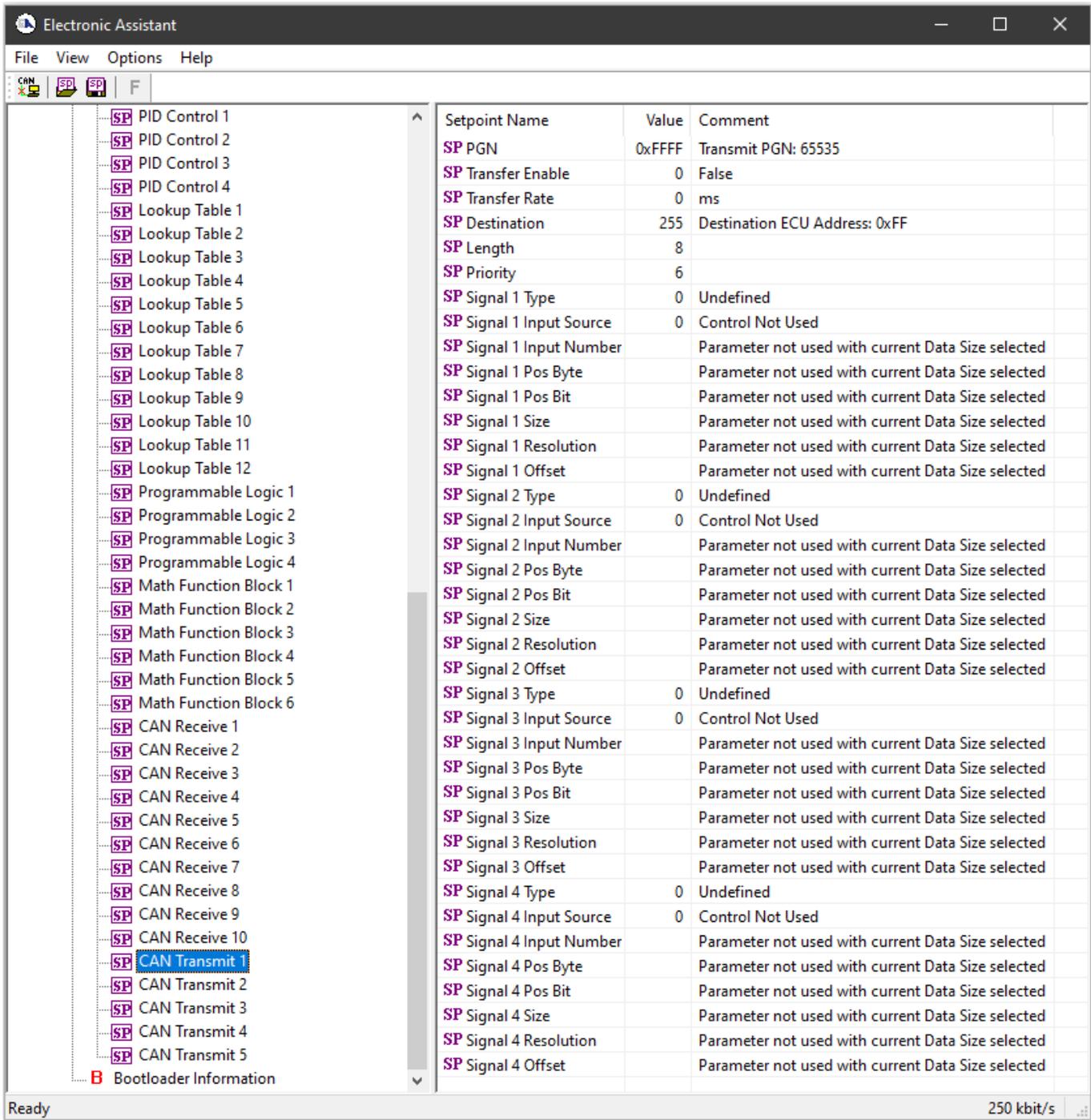
Figure 17 - Screen Capture of CAN Transmit Message Setpoints

Name	Range	Default	Notes
Transmit PGN	0xff00 … 0x3ffff	Different for each	See Section 1.7.1
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 19
Signal 1 Control Number	Drop List	Different for each	See 1.7.2
Signal 1 Transmit Data Size	Drop List	2 bytes	
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	1.0	
Signal 1 Transmit Data Offset	-10000 to 10000	0.0	
Signal 2 Control Source	Drop List	Signal undefined	See Table 19
Signal 2 Control Number	Drop List	Signal undefined	See 1.7.2
Signal 2 Transmit Data Size	Drop List	2 bytes	
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	1.0	
Signal 2 Transmit Data Offset	-10000 to 10000	0.0	
Signal 3 Control Source	Drop List	Signal undefined	See Table 19
Signal 3 Control Number	Drop List	Signal undefined	See 1.7.2
Signal 3 Transmit Data Size	Drop List	2 bytes	
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 19
Signal 4 Control Number	Drop List	Signal undefined	See 1.7.2
Signal 4 Transmit Data Size	Drop List	2 bytes	
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	1.0	
Signal 4 Transmit Data Offset	-10000 to 10000	0.0	

Table 31 – CAN Transmit Message Setpoints

4.16. Modbus Receive Function Block

The Modbus Receive Function Block is defined in section 1.9.Please refer there for detailed information about how these setpoints are used.

Please note: some setpoints were changed from their original values for demonstration purposes.
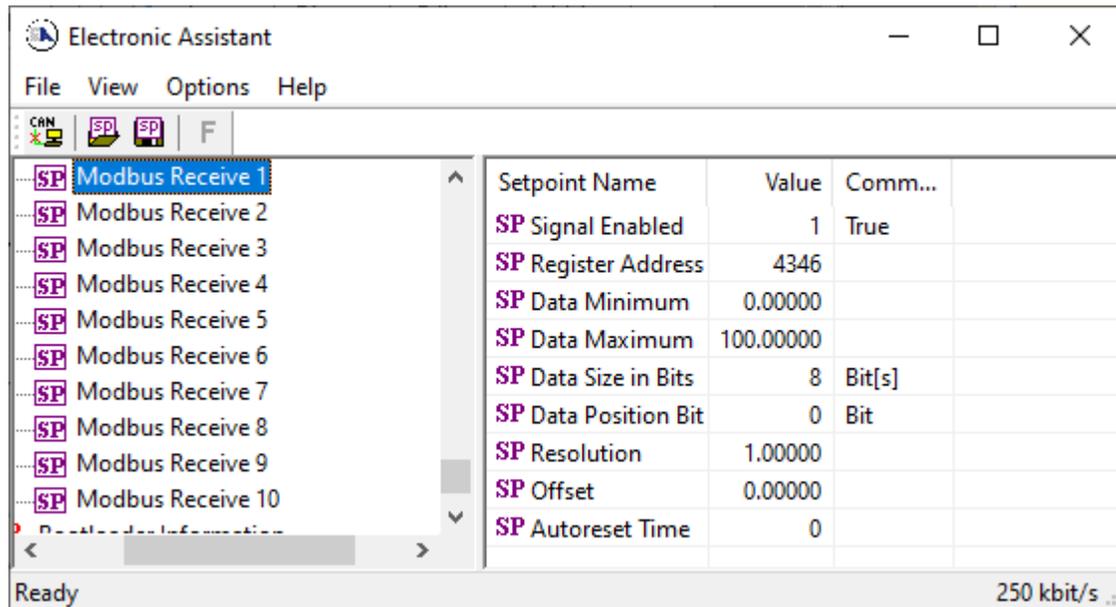
Figure 18 – The Screen Capture of Modbus Receive Function Block

Name	Range	Default	Notes
Signal Enabled	Drop List	False	
Register Address	-		Check Modbus Address Map
Data Minimum	-65535 – 65535	0	
Data Maximum	-65535 – 65535	100	
Data Size in Bits	0 - 16	8	
Data Position Bit	0-15	0	
Resolution	0.001 – 0xFFFFFFFF	1	
Offset	-65535 – 65535	0	
Autoreset Time	0 – 60000	0	

Table 32 Modbus Function Block Setpoints

5. REFLASHING OVER CAN WITH EA BOOTLOADER

The AX029000 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 V5.13.88.0 or higher.

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

2. To use the bootloader for upgrading the firmware running on the ECU, change the variable **"Force Bootloader To Load on Reset"** to *Yes*.

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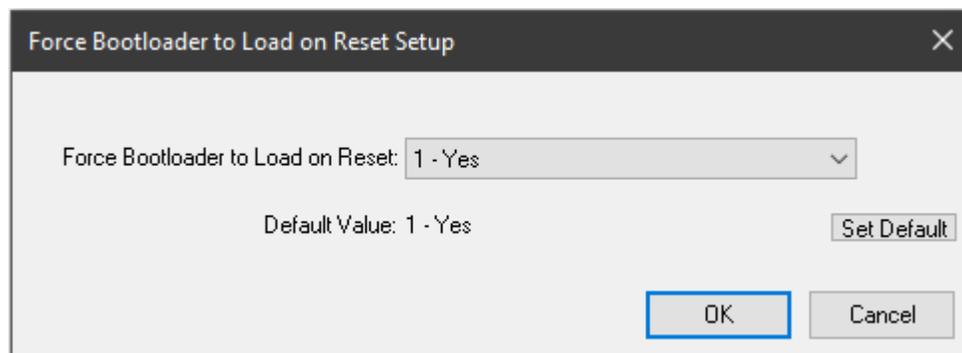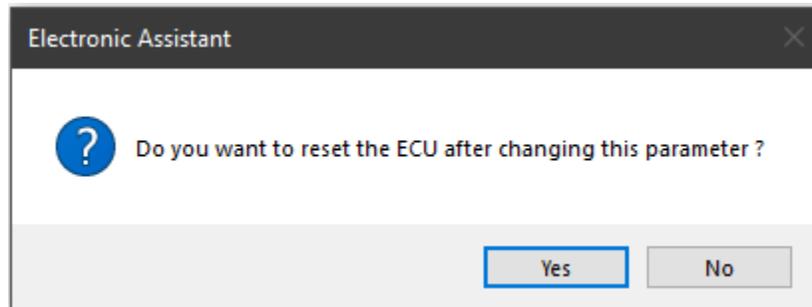
Electronic Assistant ✕

? Do you want to reset the ECU after changing this parameter ?

[Yes] [No]

4. Upon reset, the ECU will no longer show up on the J1939 network as an AX029000 but rather as **J1939 Bootloader #1**.

Electronic Assistant — ☐ ✕

File   View   Options   Help

ECU	J1939 NAME	Address	J1939 Preferred Address Assignment
ECU J1939 Bootloader #1	0X00FEFF0014418640	0XFD	Reserved for OEM

J1939 CAN Network
⊞ ECU J1939 Bootloader #1

Ready   250 kbit/s

Electronic Assistant — ☐ ✕

File   View   Options   Help

J1939 CAN Network
  ECU J1939 Bootloader #1
    i General ECU Information
    B Bootloader Information

Parameter	Value	Description
► ECU Part Number	AX029000	
► ECU Serial Number	0000119001	
⌐ ECU J1939 NAME		PGN 60928. 64-bit ECU Identifier sent in Address Claimed Messages
Arbitrary Address Capable	0X00	No
Industry Group	0X00	Global
Vehicle System Instance	0X00	
Vehicle System	0X7F	Not Available
Reserved	0X00	
Function	0XFF	Not Available
Function Instance	0X00	
ECU Instance	0X00	#1 - First Instance
Manufacturer Code	0X0A2	Axiomatic Technologies
Identity Number	0X018640	Unique ECU network ID number
► ECU Address	0XFD	Reserved for OEM
─ ECU ID	N/A	PGN 64965 -ECUID
─ Software ID	N/A	PGN 65242 -SOFT

Ready   250 kbit/s

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.

5. When the **Bootloader Information** section is selected, the same information is shown as when it was running the AX029000 firmware, but in this case the **F**lashing feature has been enabled.

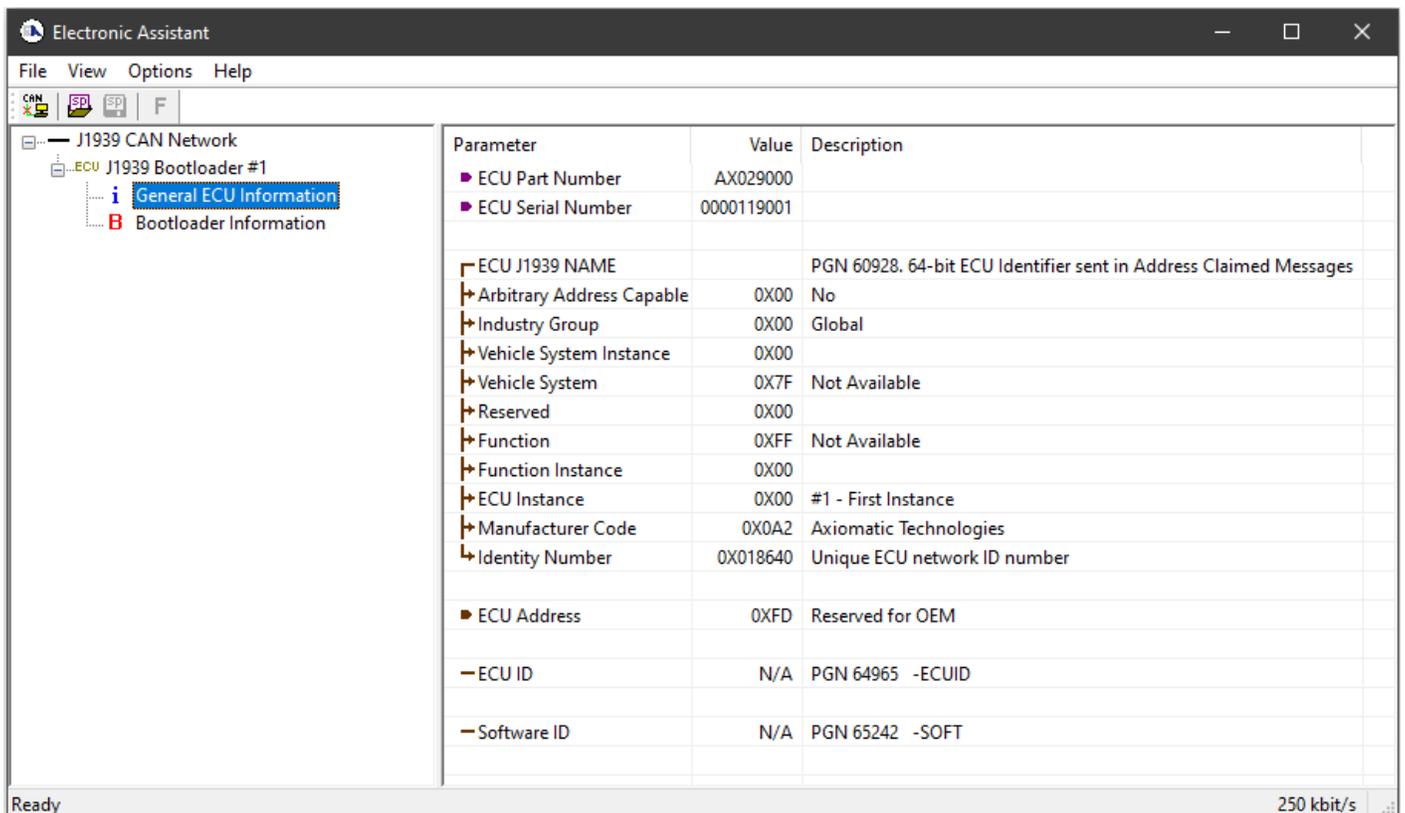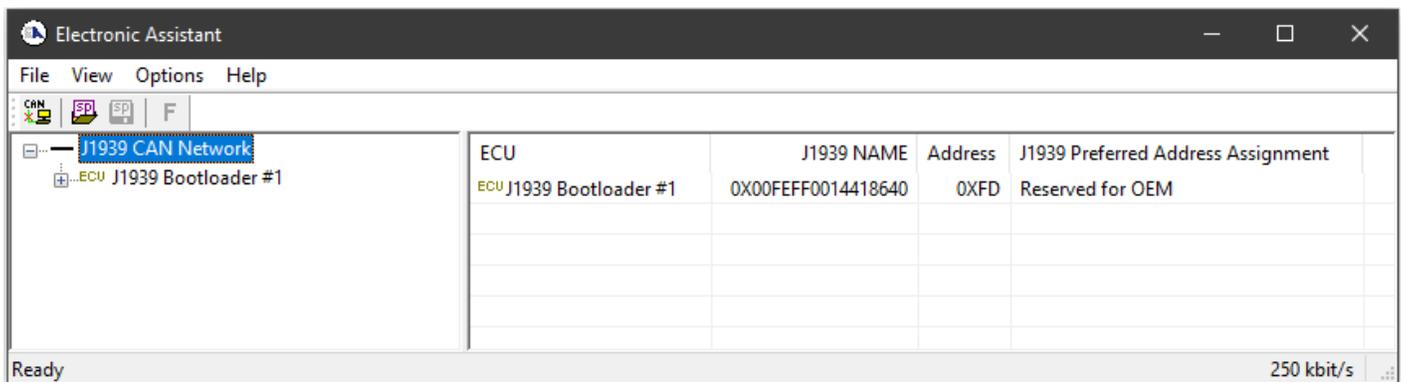| Parameter	Value	
Electronic Assistant		
File View Options Help		
J1939 CAN Network		
ECU J1939 Bootloader #1		
i General ECU Information		
B Bootloader Information		
Hardware ID	19002	
Hardware Revision Number	1.00	
Hardware Compatibility Level	1.00	
Hardware Description	PCB-19002-01-R1	
Bootloader ID	19002	
Bootloader Version Number	1.00	
Bootloader Compatibility Level	1.00	
Bootloader Description	10OUT-HLS-ENET-CAN-DR Bootloader	
Bootloader ECU Address	253	
Force Bootloader to Load on Reset	Yes	
Application Firmware ID	19002	
Application Firmware Version Number	1.03	
Application Firmware Compatibility Level	1.00	
Application Firmware Description	10-Output Valve Ethernet Driver	
Application Firmware Flash File	Control.bin	
Application Firmware Flashing Date	January 16, 2020, 06:09 PM	
Application Firmware Flashing Tool	Electronic Assistant 5.15.108.0, December 2019	
Application Firmware Flashing Comments		
Ready		250 kbit/s

6. Select the **F**lashing button and navigate to where you had saved the **AF-19002-X.XX.bin** file sent from Axiomatic. (Note: only binary (.bin) files can be flashed using the EA tool.)

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

   Note: You do not have to date/time-stamp the file, as this is done automatically by the EA tool when you upload the new firmware.
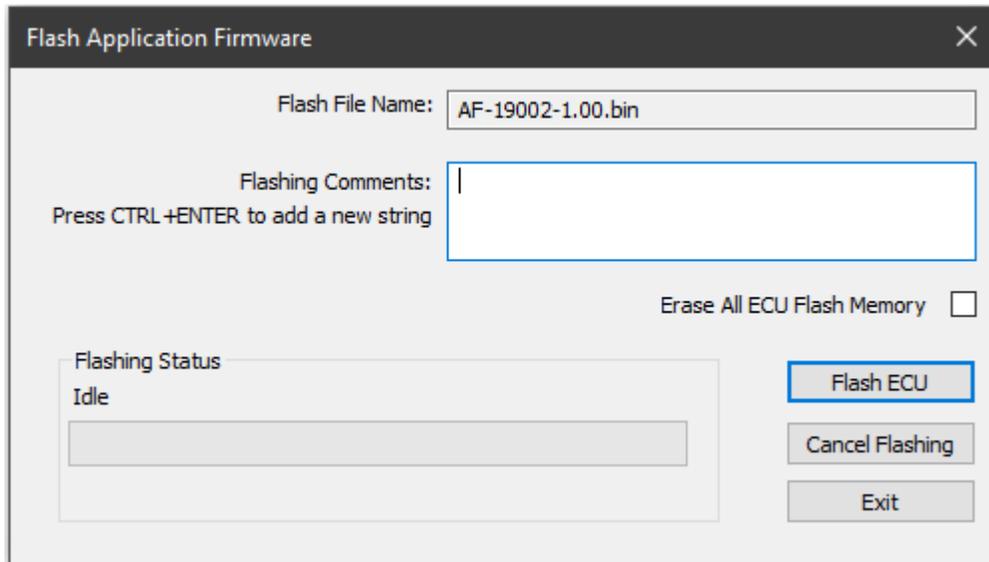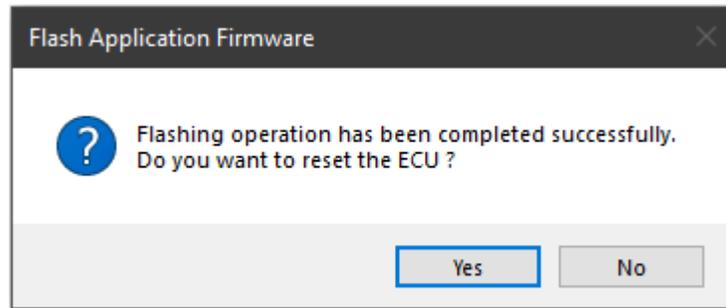
> **WARNING:** Do not check the "Erase All ECU Flash Memory" box unless instructed to do so by your Axiomatic contact. Selecting this will erase ALL data stored in non-volatile flash including the calibration from Axiomatic factory testing. It will also erase any configuration of the setpoints that might have been done to the ECU and reset all setpoints to their factory defaults. By leaving this box unchecked, none of the setpoints will be changed when the new firmware is uploaded.

A progress bar will show how much of the firmware has been sent as the upload progresses. The more traffic there is on the J1939 network, the longer the upload process will take.
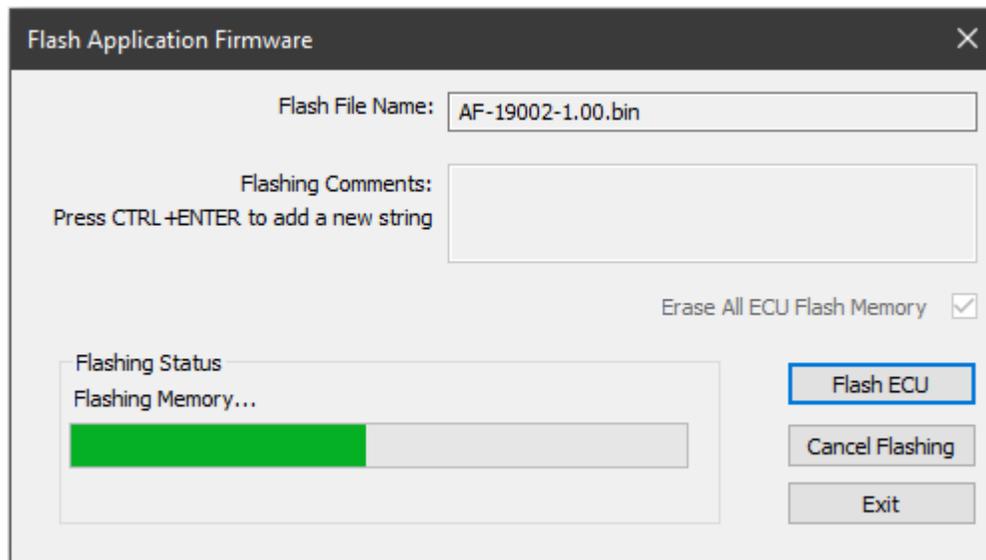
Once the firmware has finished uploading, a message will pop up indicating the successful operation. If you select to reset the ECU, the new version of the AX029000 application will start running, and the ECU will be identified as such by EA. Otherwise, the next time the ECU is power-cycled, the AX029000 application will run rather than the bootloader function.

Flash Application Firmware ✕

? Flashing operation has been completed successfully.
Do you want to reset the ECU ?

[Yes] [No]

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

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/.

Power Supply

Power Supply Input	12 Vdc or 24 Vdc nominal 8…36 Vdc power supply range Maximum supply current is 15A @ 24Vdc at any time.
Protection	Reverse polarity protection is provided up to -80Vdc. Surge and transient protection are provided. Overvoltage shutdown of the output load is provided. Undervoltage protection (hardware and software shutdown) is provided.

Outputs

Outputs	10 independent universal outputs selectable as: proportional current, proportional voltage, hotshot or ON/OFF digital or PWM type. High side sourcing or low side sinking Half-bridge output, current sensing Up to 2.5A each Overcurrent protection Short circuit protection All output types have configurable minimum and maximum output levels within the range for the type selected. Current Outputs: 1mA resolution, accuracy +/- 1% error Voltage Outputs: 0.1V resolution, accuracy +/- 5% error High frequency drive PWM Outputs: 0.1% resolution, accuracy +/- 0.1% error Digital On/Off: Sourcing from power supply, sinking from output to ground or off. Load at supply voltage must not draw more than 2.5A.
LED Voltage Supply	Twelve +5Vdc LED voltage outputs via 332Ω resistor

General Specifications

Microcontroller	STM32F407ZG, 32-bit, 1MByte flash memory
Quiescent Current	122.3mA @ 12Vdc ; 80.7mA @ 24Vdc typical
CAN Communications	Model: **AX029000** 250 kbps SAE J1939 Model: **AX029001** CANopen®
Control Logic	User programmable functionality using the Axiomatic Electronic Assistant service tool.
CAN Communications	Compliant to SAE CAN J1939 Standard 1 CAN port (SAE J1939)
Ethernet Communications	One 10/100 Mbit Ethernet compliant port Modbus is available on request.
User Interface	Axiomatic Electronic Assistant KIT, P/Ns: **AX070502** or **AX070506K**
Protection	IP20
Weight	0.45 lb. (0.204 kg)
Operating Temperature	-40 to 85°C (-40 to 185°F)
Enclosure, Dimensions	PHOENIX 2 MCV1.5/10-G-3.81 HEADER VERTICAL 10 PIN 3.81mm 8A 160V T/H 1 MCV1.5/2-G-3.81HEADER VERTICAL 2 PIN 3.81mm 8A 160V T/H 1 MSTBVA2.5HC/2-G-5.08 - HEADER VERTICAL 2 PIN 5.08 16A 250V T/H 1 UM-PRO_72X168.5 UM-PRO PROFILE 72 X 168.5mm -40-100C 1 UM-PRO72_COVER-L - END CAP LEFT 72mm BLK 1 UM-PRO72_COVER-R - END CAP RIGHT 72mm BLK 4 UM-PRO_PCB_S-LOCK - S-LOCK CLIP BLK FOR TOP RAIL 2 UM-PRO_PCB_C-LOCK_L1- C-LOCK CLIP BLK FOR TOP RAIL 1 UM-PRO72_FOOT FOOT DIN RAIL (OPTIONAL) Polyamide, UL94V0, cULus recognized, China RoHS DIN rail TH 35-7.5 *Refer to dimensional drawing.*

Electrical Connections	Screw terminals are included in part number AX070151. PHOENIX **2 MC1,5/10-ST-3,81** – ten position screw terminal plug **1 MC1,5/ 2-ST-3,81** - two position PCB screw terminal plug 1 **MVSTBR2,5HC/2-ST-5,08** screw terminal plug *Refer to Figure 3.0.*
Installation	DIN rail mount, TH 35-7.5
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.

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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

Power Supplies, DC/DC, AC/DC

PWM Signal Converters/Isolators

Resolver Signal Conditioners

Service Tools

Signal Conditioners, Converters

Strain Gauge CAN Controls

Surge Suppressors

OUR COMPANY

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

QUALITY DESIGN AND MANUFACTURING

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

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COMPLIANCE

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

SERVICE

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

CONTACTS

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