DUAL CHANNEL UNIVERSAL SIGNAL CONVERTER

USER MANUAL

P/N: AX130520

P/N: AX130520-01 – J1939 500kbits/s Baud Rate

P/N: AX130520-02 – Custom J1939 Baud Rate, 1Mbits/s

VERSION HISTORY

Version	Date	Author	Modification
1.0.0.	Jun 10, 2016	Ilona Korpelainen	Initial Draft
1.0.1.	Apr 10, 2017	Ilona Korpelainen	High Speed versions added
--	April 10, 2017	Amanda Wilkins	Added quiescent current and response time
1.0.2.	Dec 7, 2017	Ilona Korpelainen	Firmware v2.01: setpoints "**CAN Bus Fault Disables Outputs**" and "**Send empty DM1 messages**" added (new Axiomatic EA version)
--	Jan 2, 2018	Ilona Korpelainen	Axiomatic EA version number updated
2.01	Jan 30, 2020	Ilona Korpelainen	Updated Dimensional Drawing, added scan rate
2.02	July 27, 2023	Kiril Mojsov	Legacy Updates

ACCRONYMS

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)

Note:

An Axiomatic Electronic Assistant KIT may be ordered as P/N: AX070502 or AX070506K

TABLE OF CONTENTS

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, May 2003
TDAX130520	Technical Datasheet, Axiomatic Technologies 2020
UMAX07050x	User Manual, Axiomatic Electronic Assistant and USB-CAN, Axiomatic Technologies

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: This product is supported by Axiomatic Electronic Assistant V5.13.94.0 and higher

1. OVERVIEW OF CONTROLLER

The Dual Channel Universal Signal Converter (2In2Out) is designed for extremely versatile control of up to two signal level outputs. Its flexible circuit design gives the user a wide range of configurable input and output types. The sophisticated control algorithms allow the user to program the controller for a wide range of applications without the need for customer software.
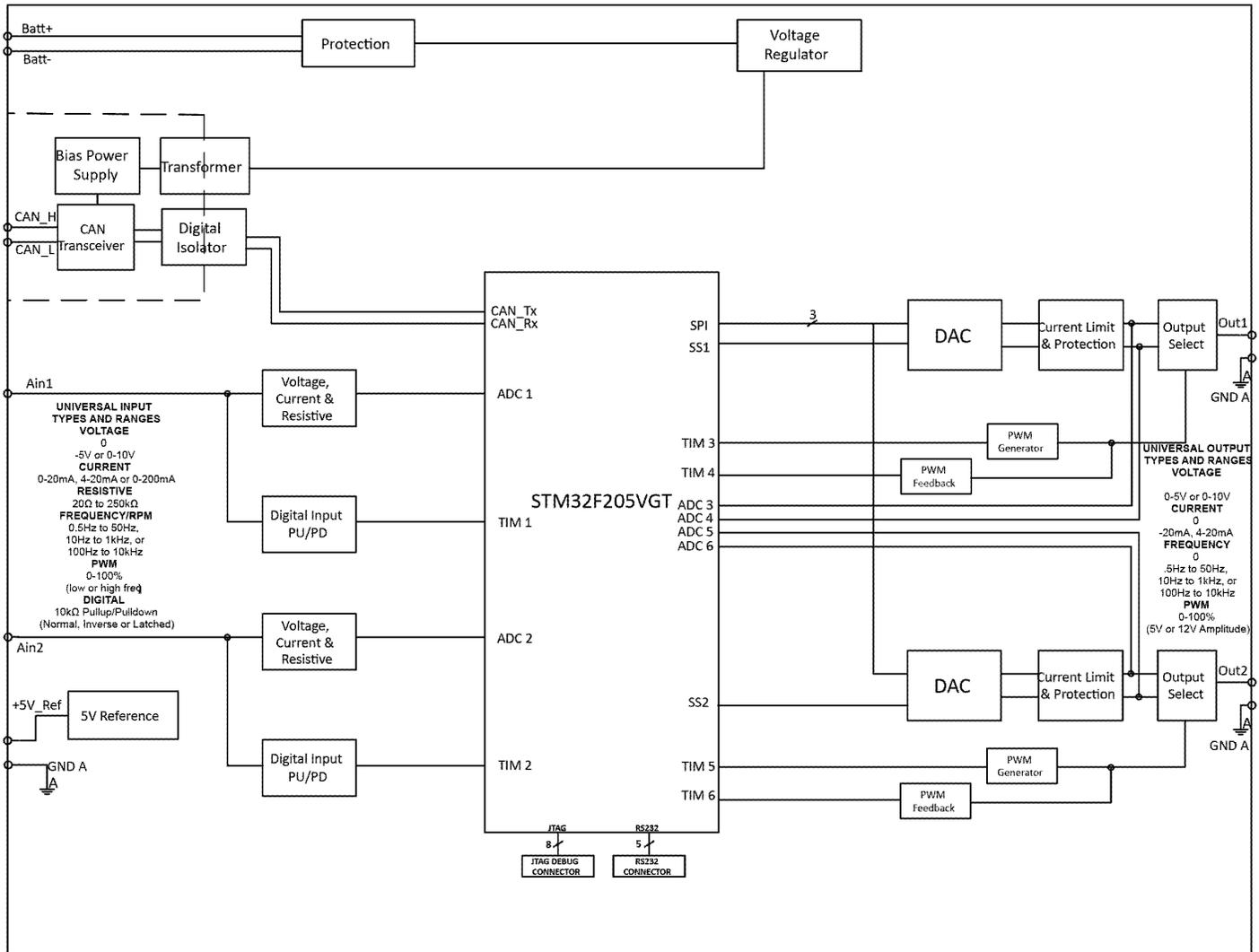
Figure 1 – Hardware Functional Block Diagram

The controller has two fully programmable universal inputs that can be setup to read: voltage, current, resistive, frequency or digital input signals. There are also two universal outputs that can be setup to output: voltage (0-5V, 0-10V), current (0-20mA, 4-20mA, 0-200mA), PWM (fixed frequency), Frequency (fixed duty cycle), variable PWM and Freq, and Digital On/Off.

The Axiomatic Electronic Assistant ⓔⒶ is used to configure the Dual Channel Universal Signal Converter. Configurable properties, Axiomatic EA setpoints, are listed in chapter 3. Setpoint configuration can be saved in a file which can then be utilized to program the same configuration to another Dual Channel Universal Signal Converter. Throughout this document, Axiomatic 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, "**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 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, CAN Receive Message Function Block and Inching Control Block. These function blocks are presented in detail in next subchapters.

The Dual Channel Universal Signal Converter can be ordered using the following part numbers depending on the application.

AX130520	Controller with the default J1939 baud rate (250kbits/s).
AX130520-01	Controller with the 500kbits/s J1939 baud rate.
AX130520-02	Controller with a custom 1Mbits/s J1939 baud rate.

1.1.   Input Function Blocks

The controller has two universal inputs, which can be configured to measure voltage, current, resistance, frequency, pulse width (PWM) or digital signal.

Universal Input setpoint group has 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 are listed in Table 1.

0	*Disabled*
10	*Voltage 0 to 5 V*
11	*Voltage 0 to 10V*
20	*Current 0 to 20 mA*
21	*Current 4 to 20 mA*
22	*Current 0 to 200 mA*
30	*Resistive 20 Ω to 250 kΩ*
40	*Frequency 0.5 to 50 Hz*
41	*Frequency 10 Hz to 1 kHz*
42	*Frequency 100 Hz to 10 kHz*
50	*PWM Low Frequency (<1kHz)*
51	*PWM High Frequency (>100Hz)*
60	*Digital (normal)*
61	*Digital (inverse)*
62	*Digital (latched)*

Table 1 – Universal Input Sensor Type Options

With Universal Inputs voltage (i.e. 0-5V, 0-10Vor current (0-20mA, 4-20mA, 0-200mA) sensor types the input 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 Vps. In current mode, a current sense resistor (249Ω, for 0-20mA and 5Ω for 0-200mA) is used to measure the input signal.

Resistive inputs can accurately read a resistive value connected between the input pin and GND A. The 2In2Out controller multiplexes a configurable current source (10uA, 100uA, 1mA, 10mA) to the input pin set up as resistive input, and measures voltage created across the input. Depending on the value of the resistive load, the input will self-calibrate to the appropriate sourcing current.

0	None
1	111ns
2	1.78us
3	14.22us

Table 2 – Debounce Time Options

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. "**Pulse Per Revolution**" setpoint is only associated with the frequency input type. If the configured to be different from 0, then the input data will be reported as in rotations-per-minute (RPM). Otherwise, frequency inputs are measured in Hertz.

Universal Inputs have 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 2.2V ON threshold and 1V OFF threshold.

On Frequency, PWM and digital input modes 10kΩ 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 3. By default, pull-down resistors are enabled for all inputs.

0	Pullup/down Off
1	10 kΩ Pullup
2	10 kΩ Pulldown

Table 3 – 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 4. 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	Active High
1	Active Low

Table 4 – Active High/Low Options

Table 5 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	*Digital (normal)*	High	Low or Open	1 (ON)
		Low or Open	High	0 (OFF)
61	*Digital (inverse)*	High or Open	Low	1 (ON)
		Low	High or Open	0 (OFF)
62	*Digital (latched)*	High to Low	Low to High	0 (no change)
		Low to High	High to Low	1 (state change)

Table 5 – 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 below.

The rest of the setpoints in the Input setpoint group are used to configure input related fault diagnostics and are described in section 1.4.

1.2. Input filtering

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

"**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 CAN message data, $Value_{N-1}$ is the previous CAN message 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 CAN message data. The sum is set to zero for the next read and summing is started again.

1.3. Output Function Blocks

The controller has two universal outputs. "**Output Type**" setpoint determines what kind of signal the output produces. Changing this setpoint causes other setpoints in the 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 6.

0	*Disabled*
12	*Voltage 0 to 5V*
13	*Voltage 0 to 10V*
20	*Current 0 to 20mA*
21	*Current 4 to 20mA*
40	*Frequency 0 to 50kHz*
50	*PWM*
60	*Digital On/Off*
70	*Mixed PWM and Frequency*

Table 6 – Output Type Options for Universal Output

Voltage and current outputs are generated onboard digital to analog converters (DAC). Frequency, PWM, Digital and Mixed outputs are produced with controllers timer outputs. Signal amplitude can be selected to be either 5V of 12V with "**Frequency/PWM Amplitude**" setpoint.

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

With linear output types (all output types except '*Digital On/Off*'), 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 3.

$$y = mx + a$$

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

$$a = Ymin - m * Xmin$$

Equation 3 - 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 output to follow control signal inversely.

In order 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 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.

"**Fixed Output Frequency/PWM Duty Cycle**" setpoint is used to select output signal duty cycle with '*Frequency 0 to 50kHz*' output type and frequency with '*PWM*' output type. The value of this setpoint defaults when "**Output Type**" setpoint is changed.

With the '*Digital On/Off*' output type, in OFF state output is 0V and in ON state 5V or 12V depending on selected amplitude. The '*Digital On/Off*' output type has several associated setpoints. The "**Digital Response**" setpoint is used to select digital response, setpoint options are listed in Table 7.

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

Table 7 – 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 "**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 8 – Delay Polarity

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

If a '*Blinking*' response is selected, the output will blink at the rate of the "**Digital Blink Rate**" setpoint while the input commands the output ON. When commanded OFF, the output will stay off.

The "**Control Source**" setpoint together with "**Control Number**" setpoint determine which signal is used to drive the output. For example setting "**Control Source**" to '*Universal Input Measured*' and "**Control Number**" to '*1*', connects signal measured from Universal Input1 to the output in question. The input signal is scaled per input type range between 0 and 1 to form control signal. 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.

The '*Mixed PWM and Frequency*' output type has second control input which is selected with "**Frequency Control Source**" and "**Frequency Control Number**" setpoints. Associated "**Mixed Output Frequency Min**" and "**Mixed Output Frequency Max**" setpoints determine minimum and maximum values for the frequency control signal.

In addition to the Control input, 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 for the proportional output are listed in Table 9. If "**Enable Source**" is set to '*Contol not used*', the Enable signal is interpreted to be ON. If a non-digital signal is selected as Enable signal the signal is interpreted as shown in Figure 3.

0	*Enable When On, Else Shutoff*
1	*Enable When On, Else Rampoff*
2	*Enable When Off, Else Shutoff*
3	*Enable When Off, Else Rampoff*
4	*Enable When On, Else Ramp To Min*
5	*Enable When On, Else Ramp To Max*

Table 9 – 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 on Table 10. 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 10 – 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 11. Fault Value is defined by "**Output in Fault Mode**" setpoint value, which is interpreted in selected output units.

0	*Shutoff Output*
1	*Apply Fault Value*
2	*Hold Last Value*

Table 11 – Fault Response Options

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

Fault detection is available all output types. A feedback signal is measured and compared to desired output current value. Fault detection and associated setpoints are presented in section 1.4.

1.4. Diagnostic Function Blocks

The 2In2Out controller supports diagnostic messaging. DM1 message 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 13 and Table 14)	
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 2In2Out controller supports 16 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 default settings can be adjusted by the user 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 similar to 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 2 below.
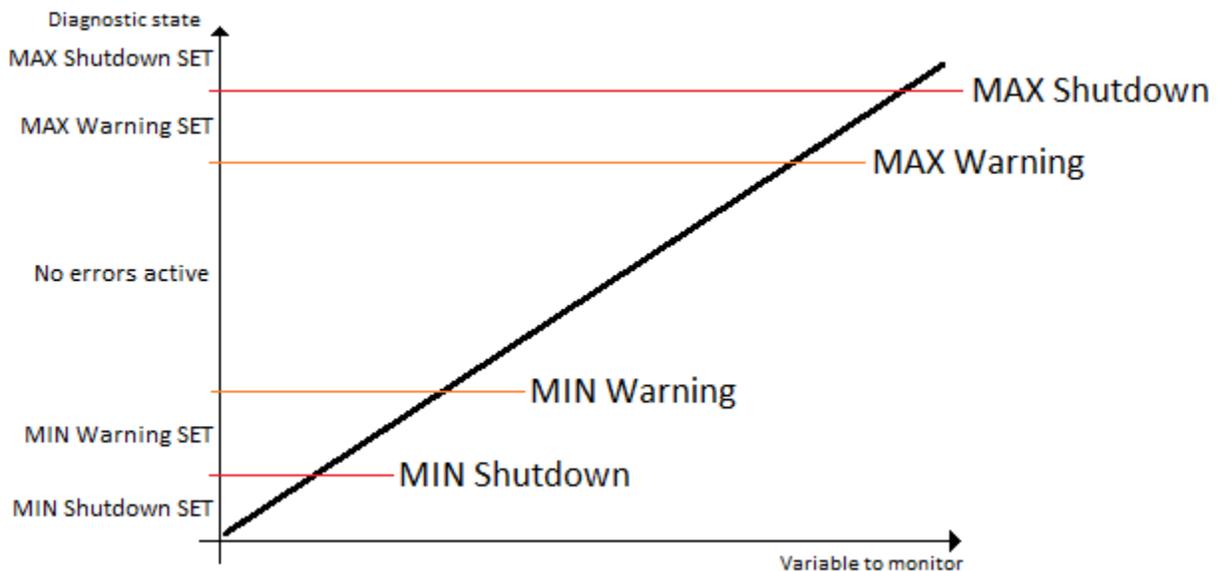
Figure 2 – Double Minimum and Maximum Error Thresholds

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 particular output. This internal flag can be used for driving the particular 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).

In addition, the CAN bus condition is monitored, and the outputs are shutdown, if CAN bus disconnection is detected. Setting "**CAN Bus Fault Disables Outputs**" setpoint to FALSE enables outputs regardless of the CAN bus condition.

While there are no active DTCs, The Dual Channel Universal Signal Converter will send "No Active Faults" message. If desired, "No Active Faults" messages can be stopped by setting "**Send empty DM1 messages**" to FALSE. 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 12. By default, the '*Amber, Warning*' lamp is typically the one set be any active fault.

0	*Protect*
1	*Amber Warning*
2	*Red Stop*
3	*Malfunction*

Table 12 – 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	*Data Valid But Above Normal Operational Range - Most Severe Level*
1	*Data Valid But Below Normal Operational Range - Most Severe Level*
2	*Data Intermittent*
3	*Voltage Above Normal, Or Shorted To High Source*
4	*Voltage Below Normal, Or Shorted To Low Source*
5	*Current Below Normal Or Open Circuit*
6	*Current Above Normal Or Grounded Circuit*
7	*Mechanical Error*
8	*Abnormal Frequency Or Pulse Width Or Period*
9	*Abnormal Update Rate*
10	*Abnormal Rate Of Change*
11	*Root Cause Not Known*
12	*Bad Component*
13	*Out Of Calibration*
14	*Special Instructions*
15	*Data Valid But Above Normal Operating Range – Least Severe Level*

16	*Data Valid But Above Normal Operating Range – Moderately Severe Level*
17	*Data Valid But Below Normal Operating Range – Least Severe Level*
18	*Data Valid But Below Normal Operating Range – Moderately Severe Level*
19	*Network Error*
20	*Data Drifted High*
21	*Data Drifted Low*
31	*Condition Exists*

Table 13 – 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 13. When an FMI is selected from Low Fault FMIs in Table 14 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 14. 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
FMI=1, Data Valid But Below Normal Operation 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 Level – 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 14 – Low Fault FMIs and corresponding High Fault FMIs

1.5. 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 2In2Out 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 15. When active, the PID algorithm will be called every "**PID Loop Update Rate**" in milliseconds.

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

Table 15 – 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 -100% to 100%.

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 in order to get the expected output response. In this mode, the output would be between 0% to 100%.

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

The PID algorithm used is shown below, where G, Ki, Ti, Kd, Td and Loop_Update_Rate are configurable parameters.

$$PIDOutput_k = P_k + I_k + D_k$$

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

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

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

$$D\_Gain = G * Kd * Td/T$$

$$T = Loop\_Update\_Rate * 0.001$$

Equation 4 - 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.

1.6. 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 1.7.

Lookup tables have two differing modes defined by "**X-Axis Type**" setpoint, given in Table 16. 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 16 – 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 17. '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 17 – PointN – Response Options

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 -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 1.3). Ignored points are not considered for min and max values.

1.7. 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.

In order 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 18. 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 18 – 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 19, 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 19 – 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.

1.8. 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.

Inputs are converted into percentage value based on the "**Function X Input Y Minimum**" and "**Function X Input Y Maximum**" values selected. For additional control the user can also adjust the "**Function X Input Y Scaler**". By default, each input has a scaling 'weight' of 1.0 However, each input can be scaled from -1.0 to 1.0 as necessary before it is applied in the function.

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

A mathematical function block includes four selectable functions, which each implements equation $A \ operator \ B$, where A and B are function inputs and operator is function selected with setpoint "**Math function X Operator**". Setpoint options are presented in Table 20. 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.

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

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 20 – 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) 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 I selected as the input source for another function block.

1.9.   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 input for any function block as appropriate.

1.10.   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 2In2Out has eight CAN Transmit Messages and each message has four completely user defined signals.

1.10.1.   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.

By default, all messages are sent on Proprietary B PGNs as broadcast messages. Thus "**Transmit Message Priority**" is always initialized to 6 (low priority) and the "**Destination Address**" 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.

1.10.2. 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 21. Setting "**Control Source**" to '*Control Not Used*' disables the signal.

"**Transmit Data Size**" 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.

1.11. 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 1.4. In order 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.

By default, all control messages are expected to be sent to the Dual Channel Universal Signal Converter on Proprietary B PGNs. However, should a PDU1 message be selected, the Dual Channel Universal Signal Converter Output Controller can be setup to receive it from any ECU by setting the "**Specific Address that sends the PGN**" to the Global Address (0xFF). If a specific address is selected instead, then any other ECU data on the PGN will be ignored.

The "**Receive Data Size**", "**Receive Data Index in Array (LSB)**", "**Receive Bit Index in Byte (LSB)**", "**Receive Resolution**" and "**Receive Offset**" can all be 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 "**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 Dual Channel Universal Signal Converter I/O supports up to eight unique CAN Receive Messages. Defaults setpoint values are listed in section 3.10.

1.12. 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 21. 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 particular 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 2	
3: PID Function Block	1 to 2	User must enable the function block, as it is disabled by default.
4: Lookup Table	1 to 8	
5: Programmable Logic Block	1 to 4	User must enable the function block, as it is disabled by default.
6: Math Function Block	1 to 4	User must enable the function block, as it is disabled by default.
7: Control Constant Data	1 to 15	1 = FALSE, 2 = TRUE, 3 to 15 = User Selectable
8: Diagnostic Trouble Code	1 to 5	Will only be valid if the corresponding DTC has a non-zero SPN
9: Inching Control	N/A	User must enable the function block, as it is disabled by default.
10: Output Target Value	1 to 2	Can be mapped to a CAN Transmit Message.
11: Output Feedback	1 to 2	Measured output feedback, used in Output Diagnostics, can be mapped to a CAN Transmit Message.
12: Power Supply Measured	N/A	Measured power supply value in Volts, used in Power Supply Diagnostics, can be mapped to a CAN Transmit Message.

13: Processor Temperature Measured	N/A	Measured processor temperature in °C, used in Over Temperature Diagnostics, can be mapped to a CAN Transmit Message.
14: CAN Reception Timeout	N/A	Only available in Diagnostic Blocks.

Table 21 – 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 3. For example, 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 has to assign appropriate constant values according to intended use.
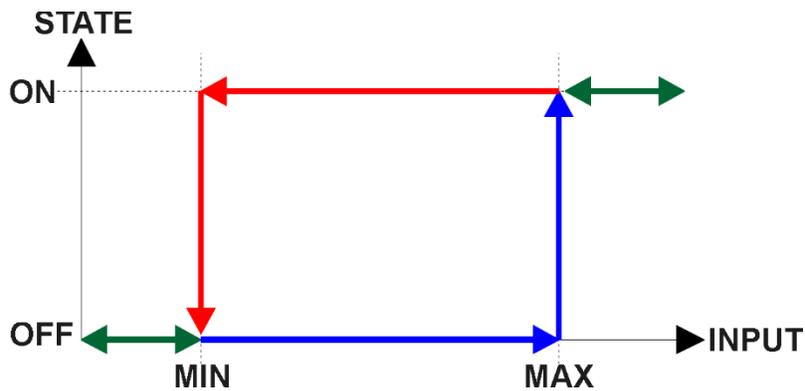

Figure 3 - Analog source to Digital input

1.13. Inching Control Block

The Inching Control Block provides fast and easy setup to control output with dual input. The Inching Control Block has two selectable inputs: Increasing Input, selected with "**IncInput Source**" and "**IncInput Number**" setpoints, and Decreasing Input, selected with "**DecInput Source**" and "**DecInput Number**" setpoints. Both inputs of the block are digital, thus when a non-digital signal is selected as an input it is interpreted in a manner described in section 1.12.

The Control implements a xor logic, where output value increases when incrementing input is ON, decreases when decreasing input is ON and is held in current value while both inputs are ON or OFF, as shown in Table 22. Output of the control block is a value between 0 and 100 (%).

Increasing Input	Decreasing Input	Output
OFF	OFF	HOLD

ON	OFF	INCREASE
OFF	ON	DECREASE
ON	ON	HOLD

Table 22 – Inching Control Logic

Each input has a selectable mode that defines how the control block output responses when an input is ON. In 'Ramp' mode the output continuously ramps increasing towards maximum (100) or ramps decreasing towards minimum (0), while an input signal is ON. In 'Notch' mode the output increases by a set notch value, or decreases by a set notch value, when an input signal state changes from OFF to ON. The modes are selected with "**Inc Response**" and "**Dec Response**" setpoints. Ramp times are defined with setpoints "**Inc Ramp**" and "**Dec Ramp**". And notch values are set with "**Inc Notch**" and "**Dec Notch**" setpoints.

0	Ramp
1	Notch

Table 23 – Inc Response and Dec Response Options

After a power cycle, enabled Inching Control Block output holds the value set with "**Start Value**" setpoint until input turns ON.

2.   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

2.1.   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
	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

• ECU Identification Information	64965	0x00FDC5
• Software Identification	65242	0x00FEDA
• Component Identification	65259	0x00FEEB

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 (Axiomatic EA) allows for quick and easy configuration of the unit over CAN network.

2.2. NAME, Address and Identification Information

The 2In2Out Controller 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	125, Axiomatic I/O Controller
Function Instance	21, Axiomatic AX130520
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 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 2In2Out 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.
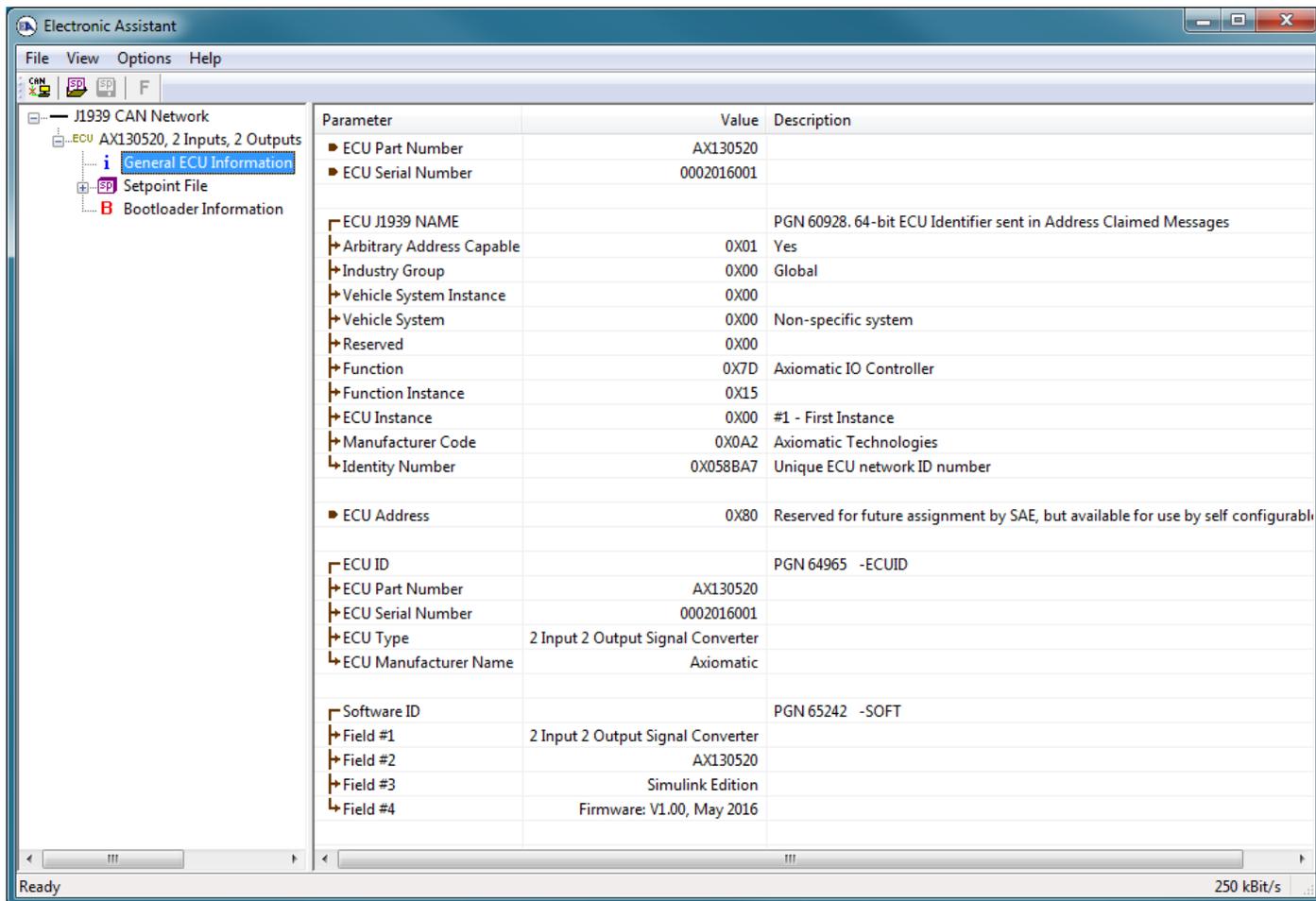
Figure 4 - General ECU Information

ECU Identification Information

PGN 64965	ECU Identification Information	-ECUID

Transmission Repetition Rate: On request

Data Length: Variable
Extended Data Page: 0
Data Page: 0
PDU Format: 253
PDU Specific: 197 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 64965 (0x00FDC5)

Start Position	Length	Parameter Name	SPN
a	Variable	ECU Part Number, Delimiter (ASCII "*")	2901
b	Variable	ECU Serial Number, Delimiter (ASCII "*")	2902
c	Variable	ECU Location, Delimiter (ASCII "*")	2903
d	Variable	ECU Type, Delimiter (ASCII "*")	2904
e	Variable	ECU Manufacturer Name, Delimiter (ASCII "*")	4304

(a)*(b)*(c)*(d)*(e)*

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 (0x00FEDA)	
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 in Figure 4.

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

Component Identification

PGN 65259		Component Identification	-CI
Transmission Repetition Rate:		On request	
Data Length:		Variable	
Extended Data Page:		0	
Data Page:		0	
PDU Format:		254	
PDU Specific:		235 PGN Supporting Information:	
Default Priority:		6	
Parameter Group Number:		65259 (0x00FEEB)	
Start Position	Length	Parameter Name	SPN
a	1-5 Byte	Make, Delimiter (ASCII "*")	586
b	Variable	Model, Delimiter (ASCII "*")	587
c	Variable	Serial Number, Delimiter (ASCII "*")	588
d	Variable	Unit Number (Power Unit), Delimiter (ASCII "*")	233

(a)*(b)*(c)*(d)*(e)*

3. ECU SETPOINTS ACCESSED WITH 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 2In2Out, refer to the relevant section in this user manual.

3.1. J1939 Network Parameters

"**ECU Instance Number**" and "**ECU Address**" setpoints and their effect are defined in Section 2.2.
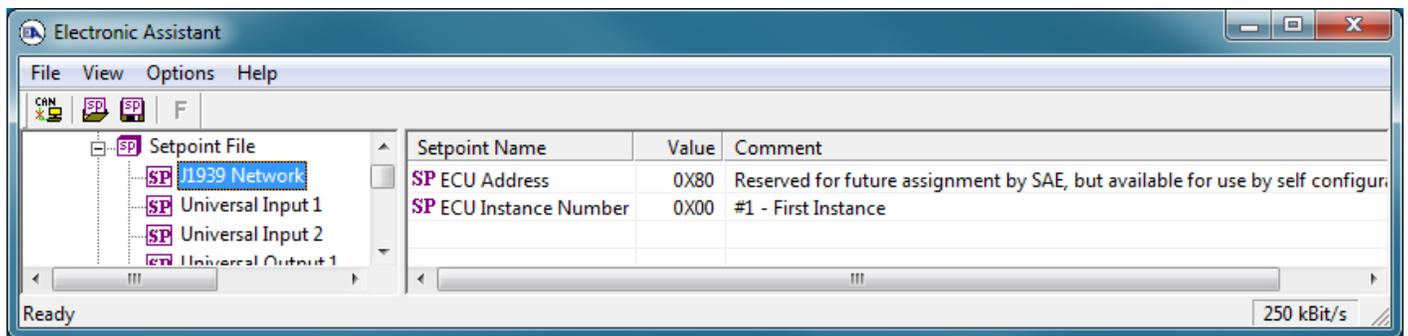
Figure 5 - Screen Capture of J1939 Setpoints

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 24 – 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 appear in the J1939 CAN Network ECU list.

3.2. Universal Input Setpoints

The Universal Inputs are defined in Section 1.1. The setpoint group includes diagnostic related setpoints, which are presented in Section 1.3 in detail.
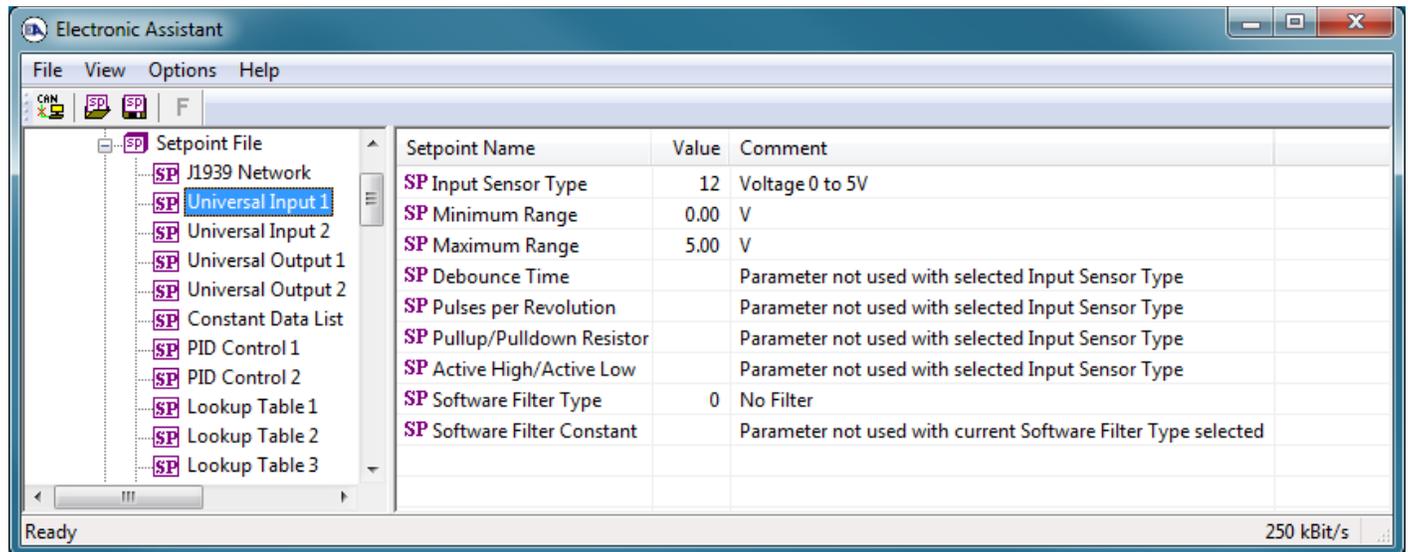

Figure 6 - Screen Capture of Universal Input Setpoints

Name	Range	Default	Notes
Input Sensor Type	Drop List	Voltage 0 to 5V	See Table 1
Minimum Range	From Minimum Error to Maximum Range	Depends on Input Sensor Type	
Maximum Range	From Minimum Range to Maximum Error	Depends on Input Sensor Type	
Debounce Time	Drop List	None	See Table 2
Pulse per Revolution	0 to 1.00	1	See Section 1.1
Pullup/Pulldown Resistor	Drop List	10kΩ Pulldown	See Table 3
Active High/Active Low	Drop List	Active High	See Table 4
Software Filter Type	Drop List	No Filtering	See Section 1.2
Software Filter Constant	1..1000	1	

Table 25 – Universal Input Setpoints

3.3. Universal Output Setpoints

The Universal Output Function Block is defined in Section 1.3. Please refer there for detailed information about how these setpoints are used. Outputs are disabled by default. In order to enable an output "**Output Type**" and "**Control Source**" have to be chosen.
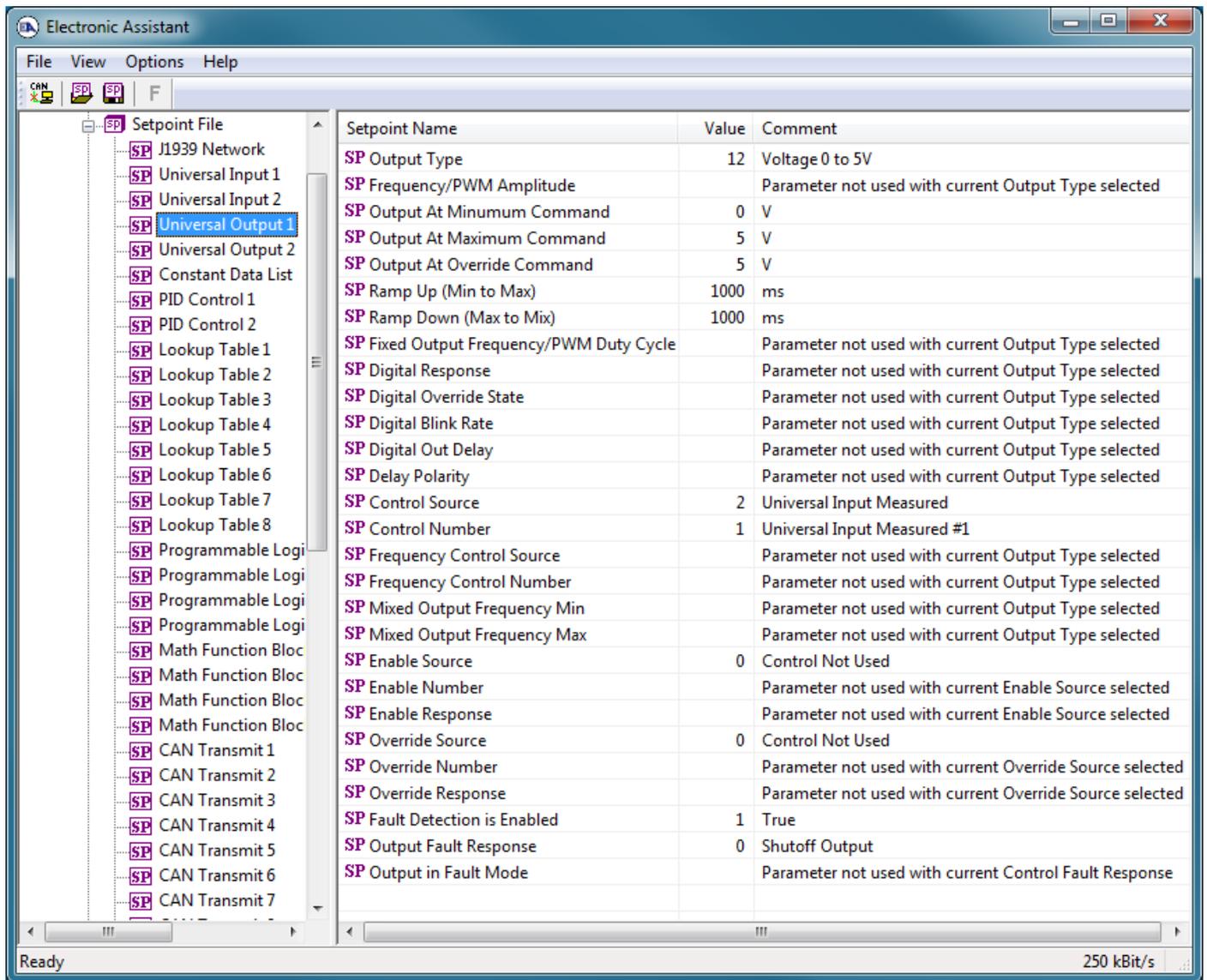
Figure 7 - Screen Capture of Universal Output Setpoints

Name	Range	Default	Notes
Output Type	Drop List	Disabled	See Table 6
Frequency/PWM Amplitude	Drop List	0 to 5 V	
Output At Minimum Command	Limit to Limit	Depends on Output Type	
Output At Maximum Command	Limit to Limit	Depends on Output Type	
Output At Override Command	Limit to Limit	Depends on Output Type	
Ramp Up (Min to Max)	0 to 10 000ms	0ms	
Ramp Down (Max to Min)	0 to 10 000ms	0ms	
Fixed Output Frequency/PWM Duty Cycle	0.1 to 100 % 0.1 Hz to 50 000 Hz	50 % 250 Hz	
Digital Response	Drop List	Normal On/Off	See Table 7
Digital Override State	Drop List	ON	
Digital Blink Rate	100 to 5000 ms	1000ms	
Control Source	Drop List	Universal Input Measured	See Table 21
Control Number	Depends on control source	1	See Table 21
Frequency Control Source	Drop List	Control not used	See Table 21
Frequency Control Number	Depends on control source	1	See Table 21
Mixed Output Frequency Min	0.1 Hz to 50 000 Hz	50.0 Hz	
Mixed Output Frequency Min	0.1 Hz to 50 000 Hz	250.0 Hz	
Enable Source	Drop List	Control not used	See Table 21
Enable Number	Depends on enable source	1	See Table 21
Enable Response	Drop List	Enable When On, else Shutoff	See Table 9
Override Source	Drop List	Control not used	See Table 21
Override Number	Depends on override source	1	See Table 21
Override Response	Drop List	Override When On	See Table 10
Fault Detection is Enabled	Drop List	True	
Output Fault Response	Drop List	Shutoff Output	See Table 11
Output in Fault Mode	Limit to Limit	Depends on Output Type	

Table 26 – Universal Output Setpoints

3.4. Constant Data List

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 (shown in Figure 8) are arbitrary and should be configured by the user as appropriate for their application.
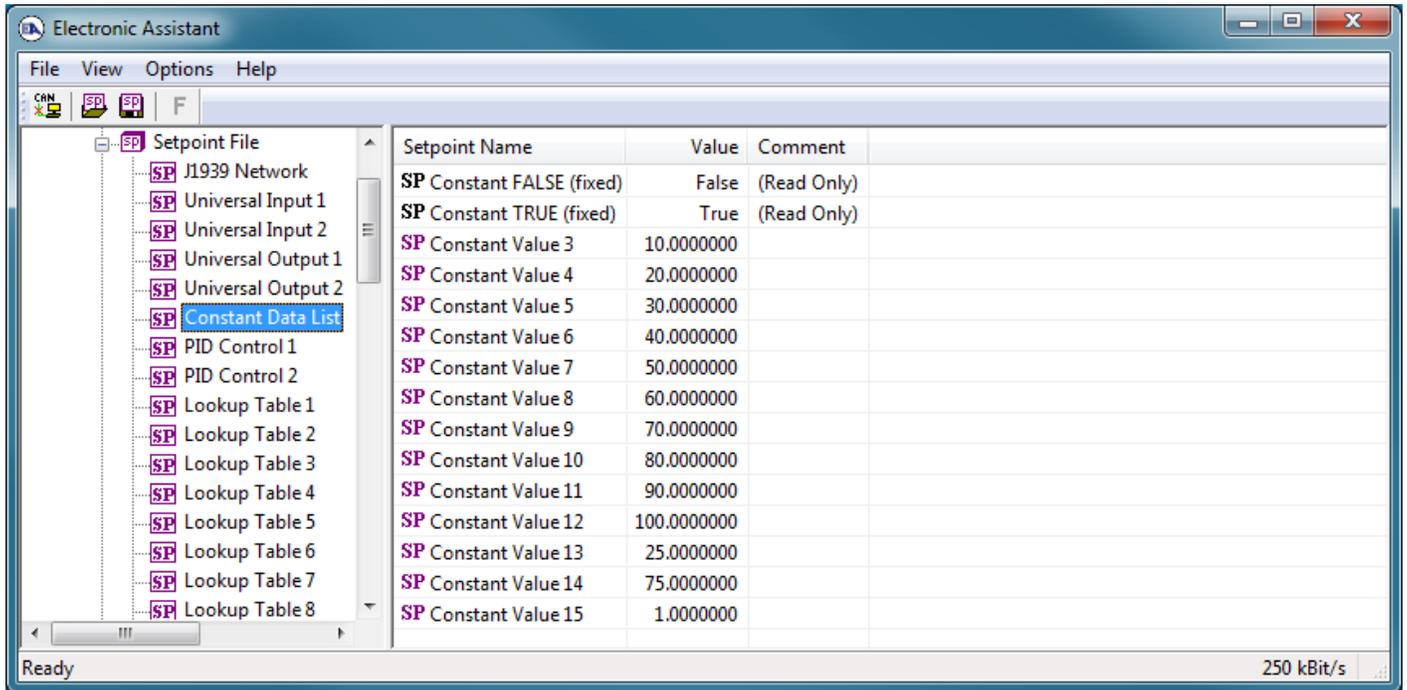
Figure 8 - Screen Capture of Constant Data List Setpoints

3.5. PID Control

The PID Control Function Block is defined in Section 1.5. 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**".
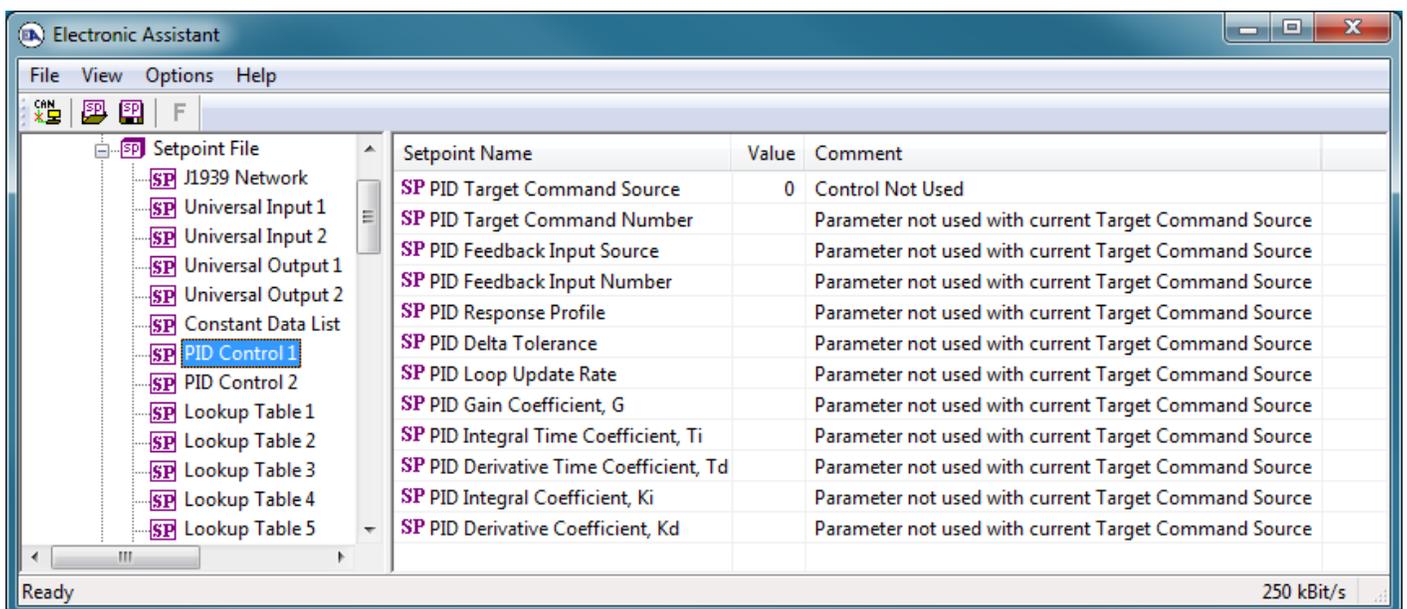

Figure 9 - Screen Capture of PID Control Setpoints

Name	Range	Default	Notes
PID Target Command Source	Drop List	Control Not Used	See Table 21
PID Target Command Number	Depends on control source	1	See Table 21
PID Feedback Input Source	Drop List	Control Not Used	See Table 21
PID Feedback Input Number	Depends on control source	1	See Table 21
PID Response Profile	Drop List	Single Output	See Table 15
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 10	0.5	See Equation 4
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	1.00	0 disables integral, PD ctrl
PID Derivative Coeffecient, Kd	0 to 10	1.00	0 disables derivative, PI ctrl

Table 27 – Programmable Logic Setpoints

3.6. Lookup Table

The Lookup Table Function Block is defined in Section 1.6 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**".
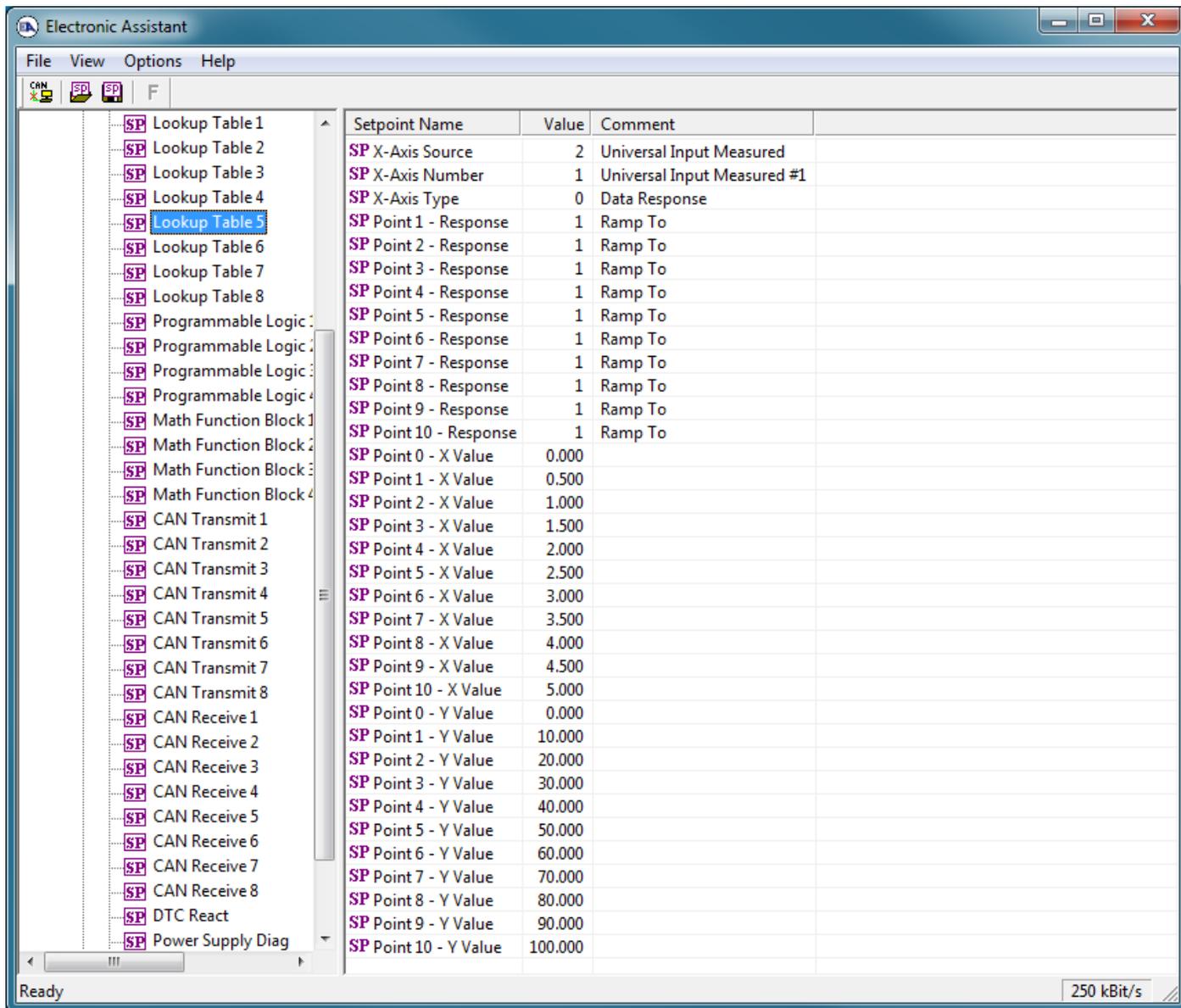
Figure 10 - Screen Capture of Lookup table Setpoints

Name	Range	Default	Notes
X-Axis Source	Drop List	Control Not Used	See Table 21
X-Axis Number	Depends on control source	1	See Table 21
X-Axis Type	Drop List	Data Response	See Table 16
Point 1 - Response	Drop List	Ramp To	See Table 17
Point 2 - Response	Drop List	Ramp To	See Table 17
Point 3 - Response	Drop List	Ramp To	See Table 17
Point 4 - Response	Drop List	Ramp To	See Table 17
Point 5 - Response	Drop List	Ramp To	See Table 17
Point 6 - Response	Drop List	Ramp To	See Table 17
Point 7 - Response	Drop List	Ramp To	See Table 17
Point 8 - Response	Drop List	Ramp To	See Table 17
Point 9 - Response	Drop List	Ramp To	See Table 17
Point 10 - Response	Drop List	Ramp To	See Table 17
Point 0 - X Value	From X-Axis source minimum to Point 1 - X Value	X-Axis source minimum 0.000	See Section 1.6

Point 1 - X Value	From Point 0 - X Value to Point 2 - X Value	0.500	See Section 1.6
Point 2 - X Value	From Point 1 - X Value to Point 3 - X Value	1.000	See Section 1.6
Point 3 - X Value	From Point 2 - X Value to Point 4 - X Value	1.500	See Section 1.6
Point 4 - X Value	From Point 3 - X Value to Point 5 - X Value source	2.000	See Section 1.6
Point 5 - X Value	From Point 4 - X Value to Point 6 - X Value	2.500	See Section 1.6
Point 6 - X Value	From Point 5 - X Value to Point 7 - X Value	3.000	See Section 1.6
Point 7 - X Value	From Point 6 - X Value to Point 8 - X Value	3.500	See Section 1.6
Point 8 - X Value	From Point 7 - X Value to Point 9 - X Value	4.000	See Section 1.6
Point 9 - X Value	From Point 8 - X Value to Point 10 - X Value	4.500	See Section 1.6
Point 10 - X Value	From Point 9 - X Value to X-Axis source maximum	X-Axis source maximum 5.000	See Section 1.6
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 28 – Lookup Table Setpoints

3.7. Programmable Logic

The Programmable Logic function block is defined in Section 1.7. 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**".
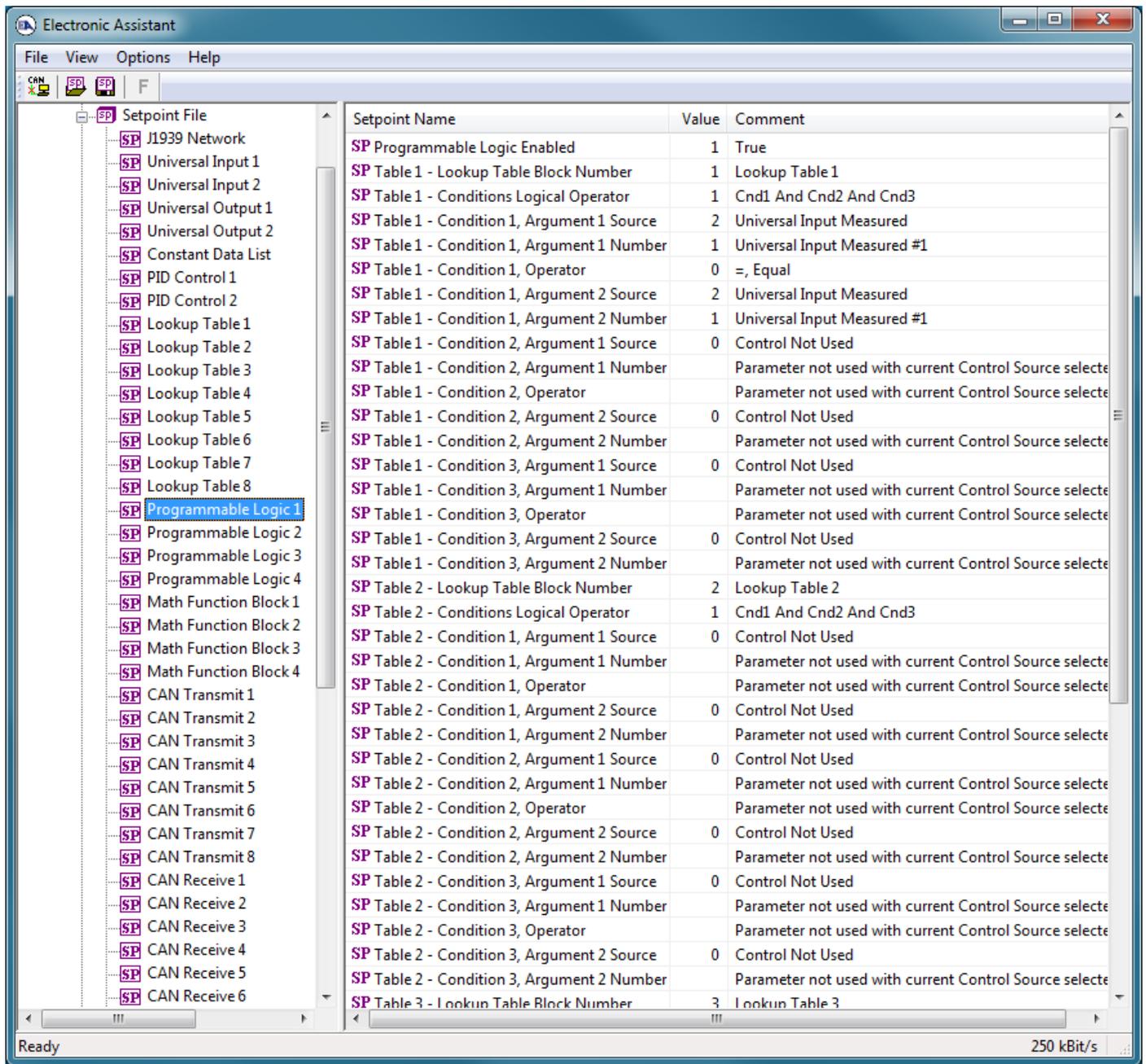
Figure 11 - Screen Capture of Programmable Logic Setpoints

Setpoint ranges and default values for Programmable Logic Blocs are listed in Table 29. 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 8	Look up Table 1	
Table1 - Conditions Logical Operation	Drop List	Default Table	See Table 19
Table1 - Condition1, Argument 1 Source	Drop List	Control Not Used	See Table 21
Table1 - Condition1, Argument 1 Number	Depends on control source	1	See Table 21
Table1 - Condition1, Operator	Drop List	=, Equal	See Table 18
Table1 - Condition1, Argument 2 Source	Drop List	Control Not Used	See Table 21
Table1 - Condition1, Argument 2 Number	Depends on control source	1	See Table 21
Table1 - Condition2, Argument 1 Source	Drop List	Control Not Used	See Table 21
Table1 - Condition2, Argument 1 Number	Depends on control source	1	See Table 21
Table1 - Condition2, Operator	Drop List	=, Equal	See Table 18
Table1 - Condition2, Argument 2 Source	Drop List	Control Not Used	See Table 21
Table1 - Condition2, Argument 2 Number	Depends on control source	1	See Table 21
Table1 - Condition3, Argument 1 Source	Drop List	Control Not Used	See Table 21
Table1 - Condition3, Argument 1 Number	Depends on control source	1	See Table 21
Table1 - Condition3, Operator	Drop List	=, Equal	See Table 18
Table1 - Condition3, Argument 2 Source	Drop List	Control Not Used	See Table 21
Table1 - Condition3, Argument 2 Number	Depends on control source	1	See Table 21

Table 29 – Programmable Logic Setpoints

3.8. Math Function Block

The Math Function Block is defined in Section 1.8. 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**".
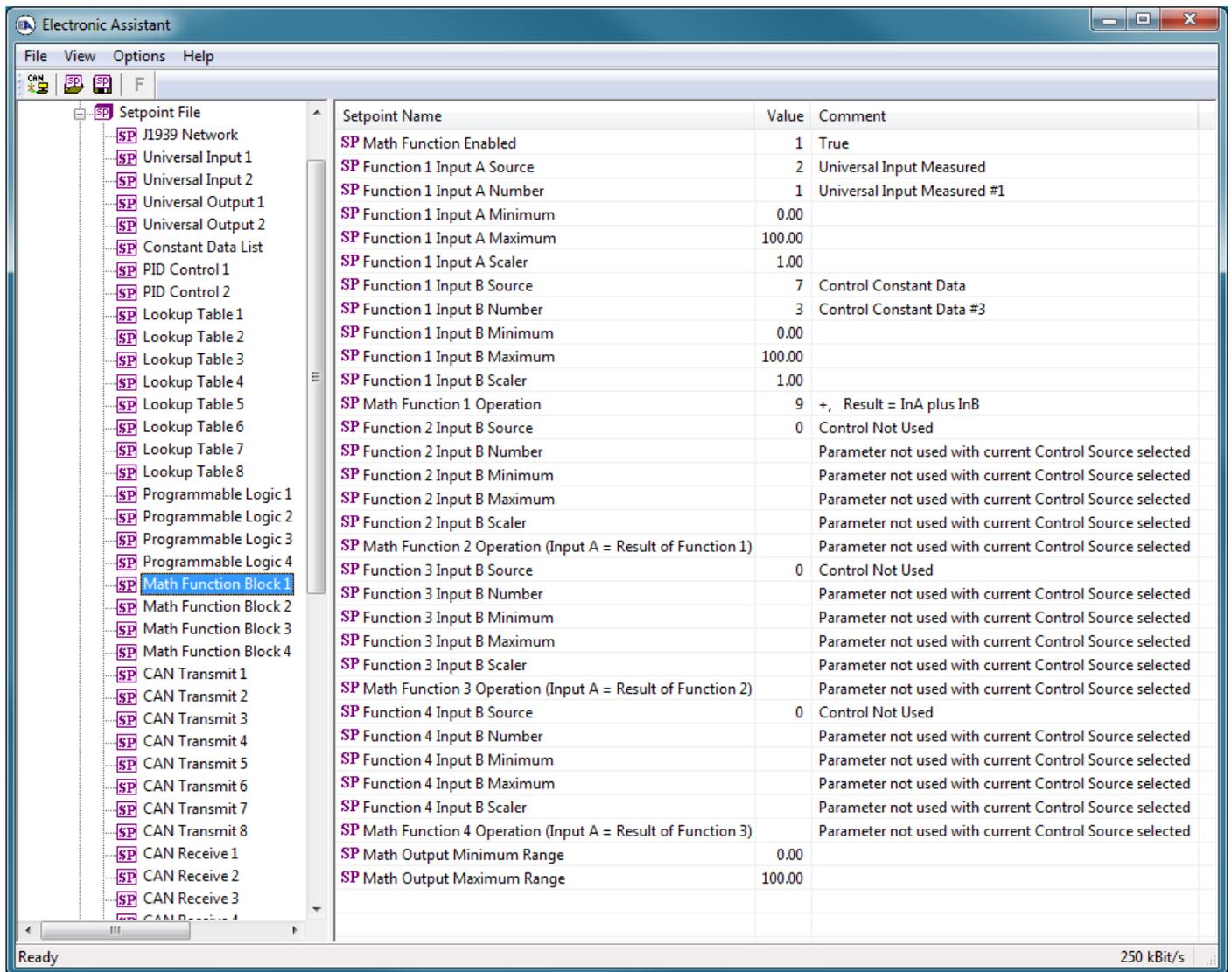
Figure 12 - Screen Capture of Math Function Block Setpoints

Name	Range	Default	Notes
Math Function Enabled	Drop List	False	
Function 1 Input A Source	Drop List	Control not used	See Table 21
Function 1 Input A Number	Depends on control source	1	See Table 21
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 21
Function 1 Input B Number	Depends on control source	1	See Table 21
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 20
Function 2 Input B Source	Drop List	Control not used	See Table 21
Function 2 Input B Number	Depends on control source	1	See Table 21
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 20
Function 3 Input B Source	Drop List	Control not used	See Table 21
Function 3 Input B Number	Depends on control source	1	See Table 21
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 20
Function 4 Input B Source	Drop List	Control not used	See Table 21
Function 4 Input B Number	Depends on control source	1	See Table 21
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 20
Math Output Minimum Range	-10^6 to 10^6	0.0	
Math Outptu Maximum Range	-10^6 to 10^6	100.0	

Table 30 – Math Function Setpoints

3.9.   CAN Transmit Setpoints

CAN Transmit Message Function Block is presented in Section 1.10. Please refer there for detailed information how these setpoints are used. "**Transmit Repetition Rate**" is 0ms by default, thus no message will be sent.
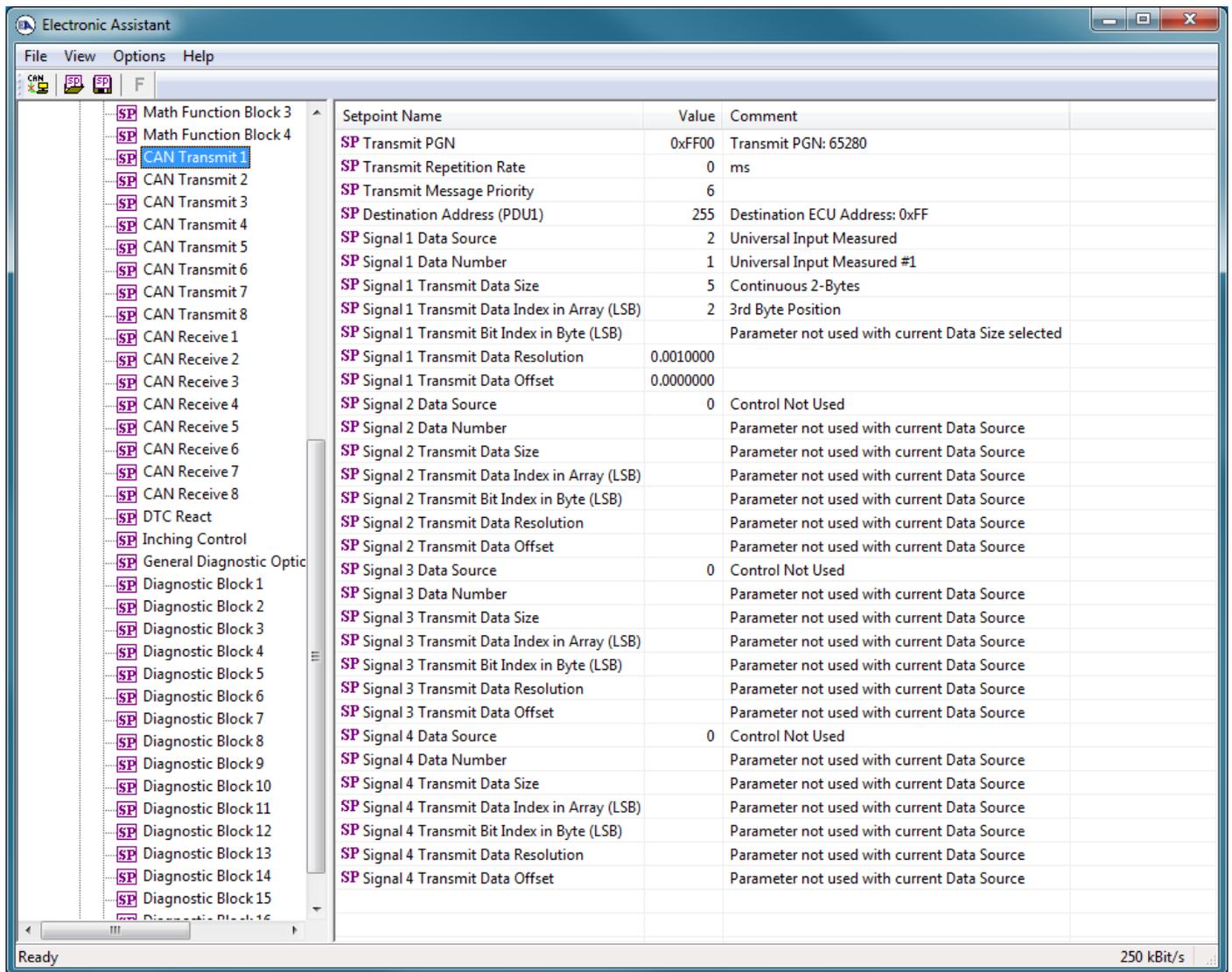
Figure 13 - Screen Capture of CAN Transmit Message Setpoints

Name	Range	Default	Notes
Transmit PGN	0xff00 … 0xffff	Different for each	See Section 1.10.1
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 21
Signal 1 Control Number	Drop List	Different for each	See 1.10.2
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	0.001	
Signal 1 Transmit Data Offset	-10000 to 10000	0.0	
Signal 2 Control Source	Drop List	Signal undefined	See Table 21
Signal 2 Control Number	Drop List	Signal undefined	See 1.10.2
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	0.001	
Signal 2 Transmit Data Offset	-10000 to 10000	0.0	
Signal 3 Control Source	Drop List	Signal undefined	See Table 21
Signal 3 Control Number	Drop List	Signal undefined	See 1.10.2
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 21
Signal 4 Control Number	Drop List	Signal undefined	See 1.10.2
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	0.001	
Signal 4 Transmit Data Offset	-10000 to 10000	0.0	

Table 31 – CAN Transmit Message Setpoints

3.10. CAN Receive Setpoints

The Math Function Block is defined in Section 1.11. 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.
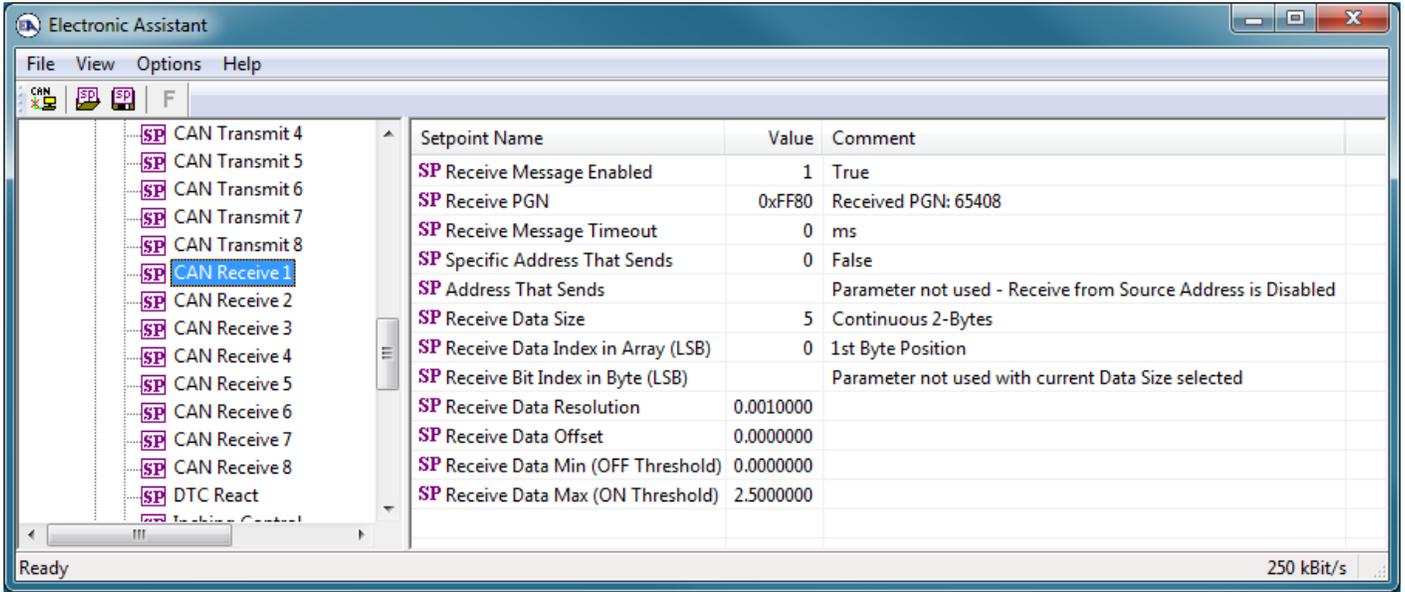
Figure 14 - Screen Capture of CAN Receive Message Setpoints

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 PGN	Drop List	False	
Address That Sends	0 to 255	254 (0xFE, Null Addr)	
Receive Transmit Data Size	Drop List	2 bytes	
Receive Transmit 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 32 – CAN Receive Setpoints

3.11. DTC React

The DTC React Function Block is defined in Section 1.9. Please refer there for detailed information about how these setpoints are used.
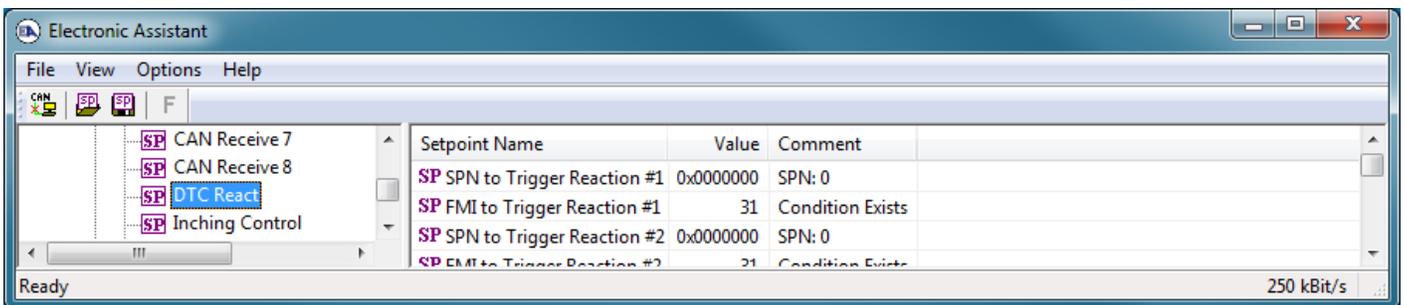
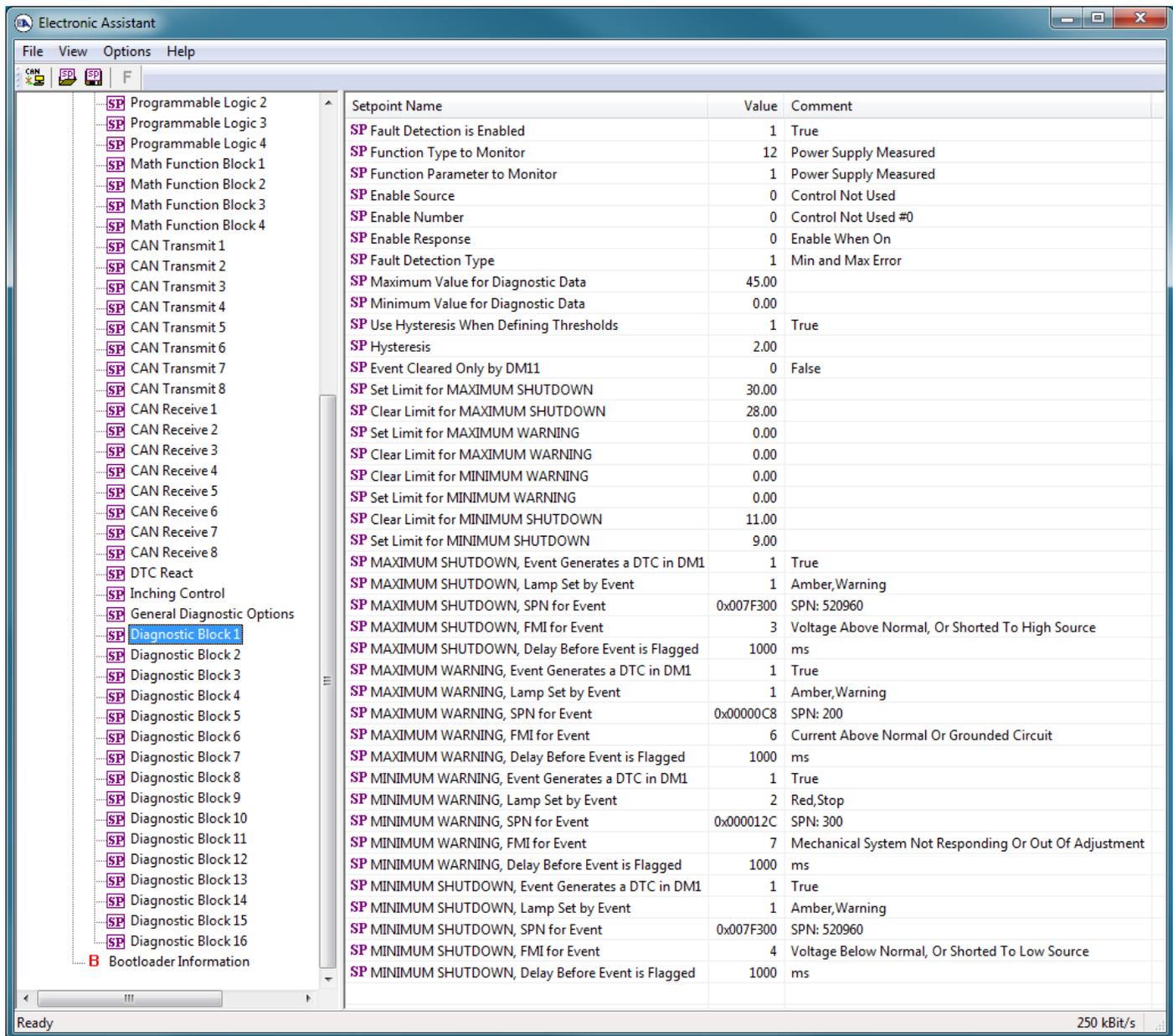**Figure 15 - Screen Capture of DTC React Setpoints**

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 33 – DTC React Setpoints

3.12. Inching Control

The Inching Control Block is defined in Section 1.13 Please refer there for detailed information about how these setpoints are used.
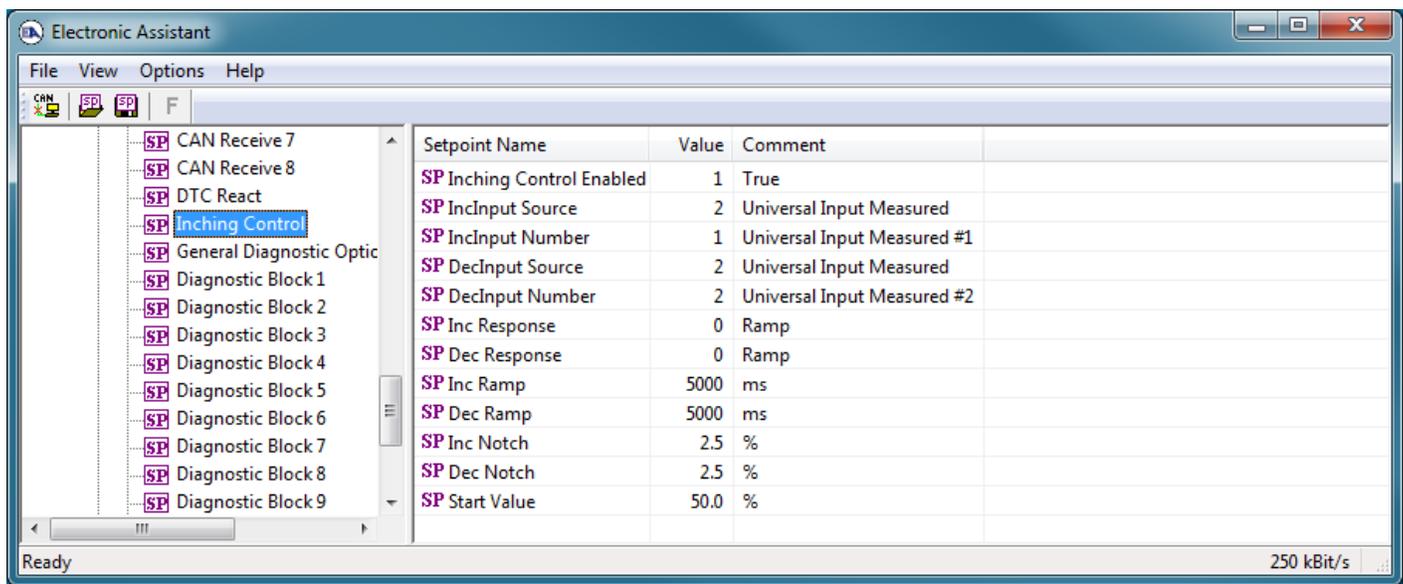
Figure 16 - Screen Capture of Inching Control Setpoints

Name	Range	Default	Notes
Inching Control Enabled	Drop List	False	
IncInput Source	Drop List	Universal Input Measured	See Table 21
IncInput Number	Depends on IncInput source	1	See Table 21
DecInput Source	Drop List	Universal Input Measured	See Table 21
DecInput Number	Depends on DecInput source	2	See Table 21
Inc Response	Drop List	Ramp	See Table 23
Dec Response	Drop List	Ramp	See Table 23
Inc Ramp	0 to 20 000 ms	5000 ms	
Dec Ramp	0 to 20 000 ms	5000 ms	
Inc Notch	0 to 100 %	2.5 %	
Dec Notch	0 to 100 %	2.5 %	
Start Value	0 to 100 %	50.0 %	

Table 34 – Inching Control Setpoints

3.13. General Diagnostic Options

These setpoints control the shutdown of the ECU in case of a power supply or CPU temperature related errors. Refer to section 1.4 for more info.
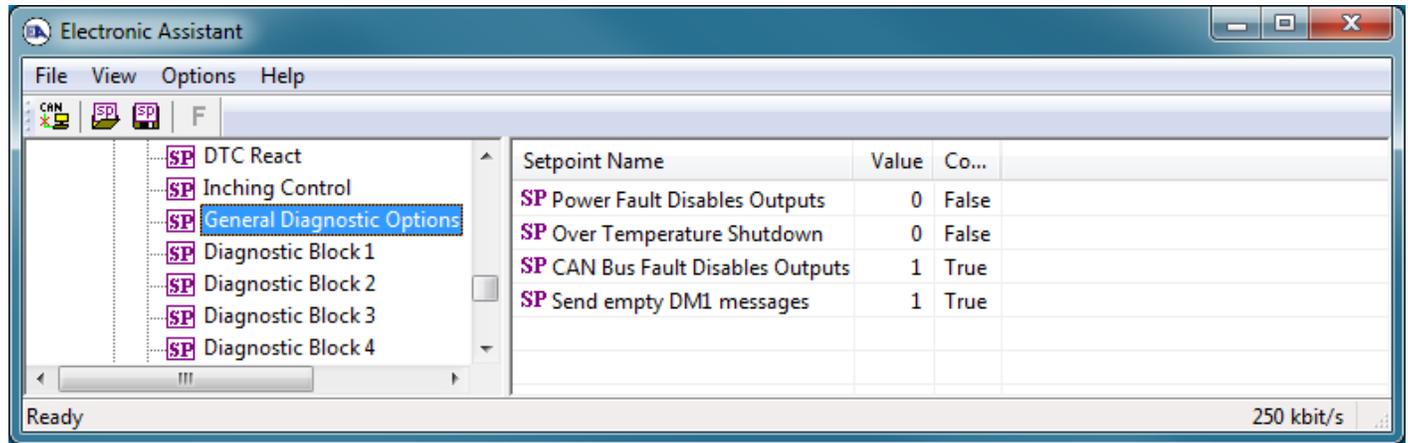
Figure 17 - Screen Capture of General Diagnostics Options Setpoints

Name	Range	Default	Notes
Power Fault Disables Outputs	Drop List	0	
Over Temperature Shutdown	Drop List	0	
CAN Bus Fault Disables Outputs	Drop List	1	
Send empty DM1 messages	Drop List	1	

Table 35 – General Diagnostics Options Setpoints

3.14. Diagnostic Blocks

There are 16 Diagnostics blocks that can be configured to monitor various parameters of the Controller. The Diagnostic Function Block is defined in section 1.4. Please refer there for detailed information how these setpoints are used.

Figure 18 - 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 1.4
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 12
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 13
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 12
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 13

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 12
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 13
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 12
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 13
MINIMUM SHUTDOWN, Delay Before Event is Flagged	0...60000 ms	1000	

Table 36 – Diagnostic Block Setpoints

4. REFLASHING OVER CAN WITH THE AXIOMATIC EA BOOTLOADER

The AX130520 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 🄴🄰 *V4.5.53.0 or higher.*

1. When the Axiomatic EA first connects to the ECU, the **Bootloader Information** section will display the following information.
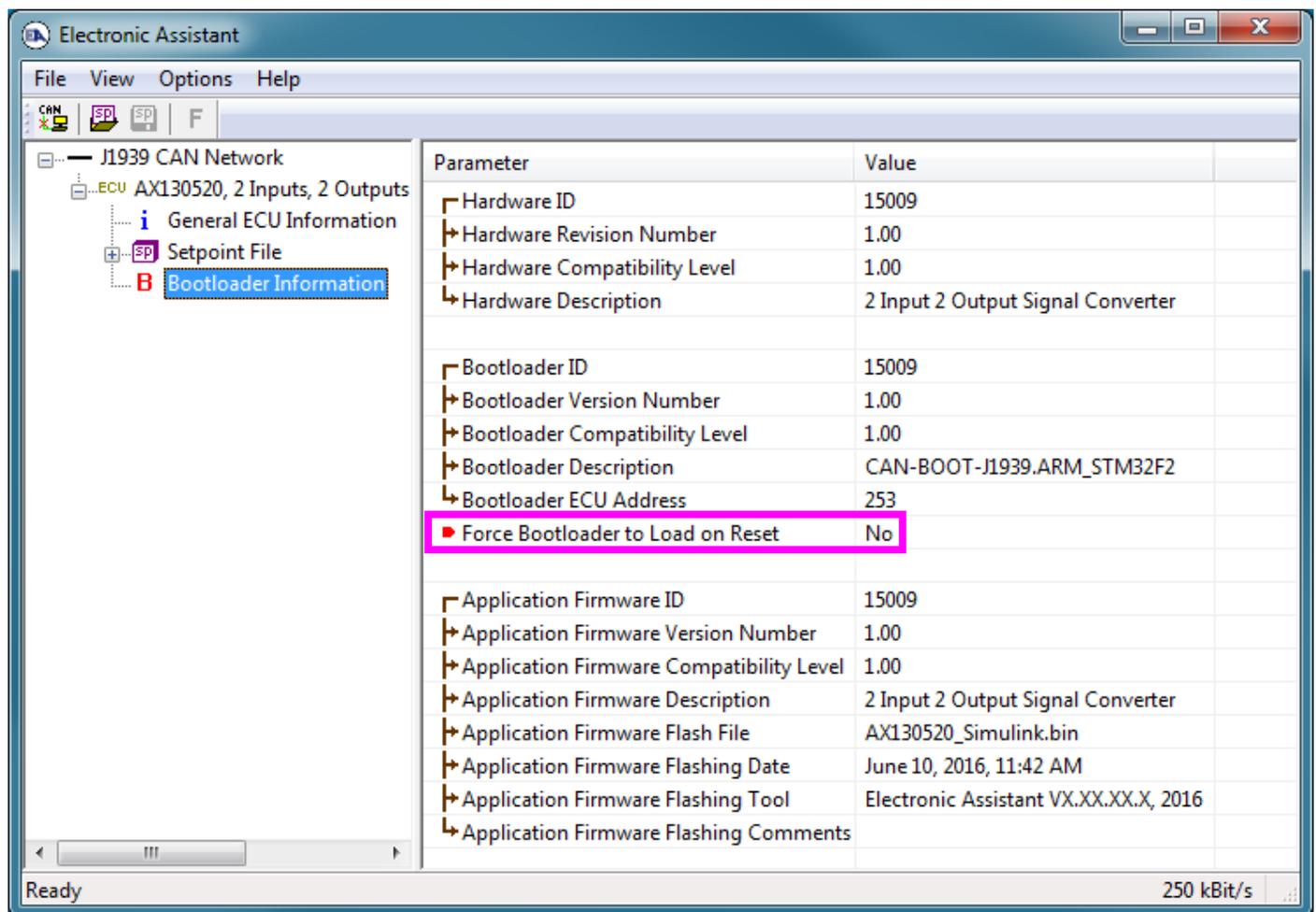
2. To use the bootloader to upgrade the firmware running on the ECU, change the variable **"Force Bootloader To Load on Reset"** to *Yes.*
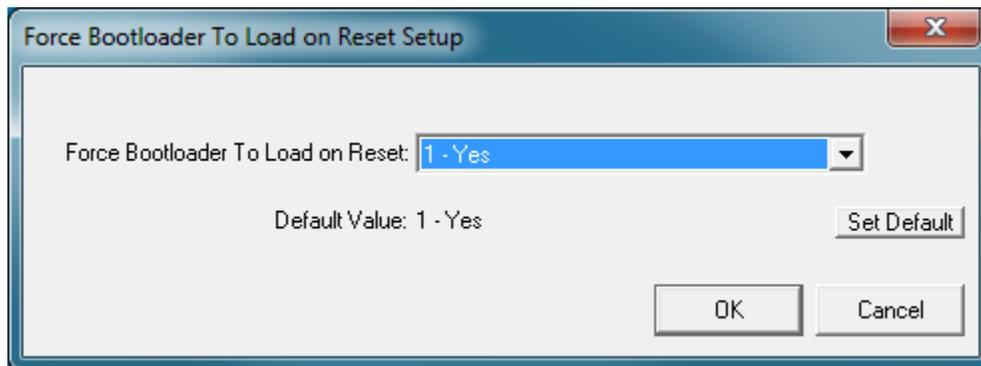
3. When the prompt box asks if you want to reset the ECU, select *Yes*.
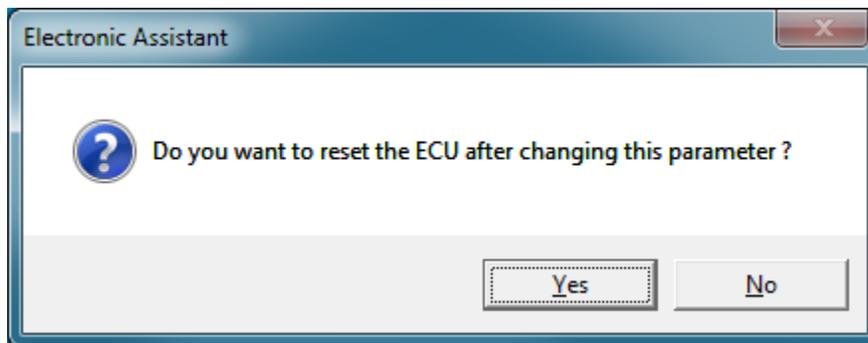
4. Upon reset, the ECU will no longer show up on the J1939 network as an AX130520 but rather as **J1939 Bootloader #1**.
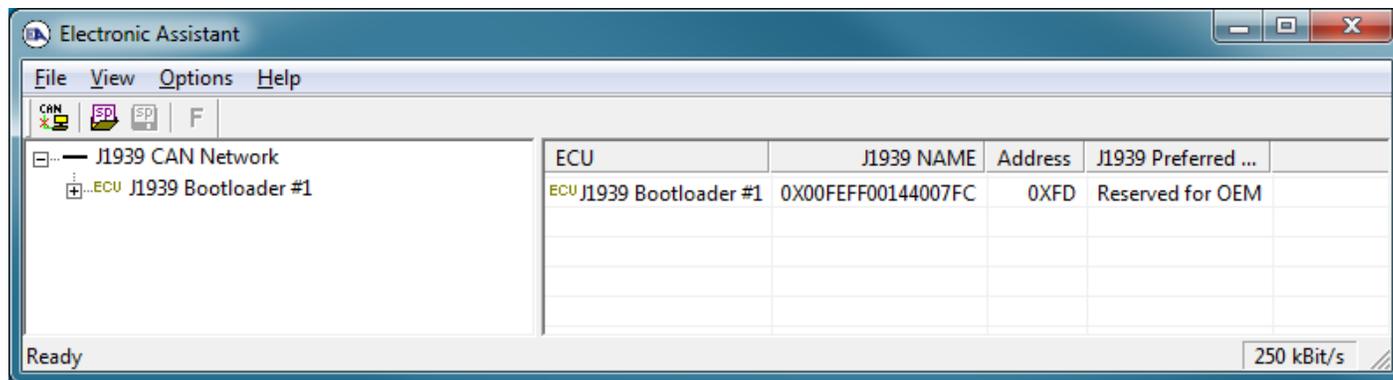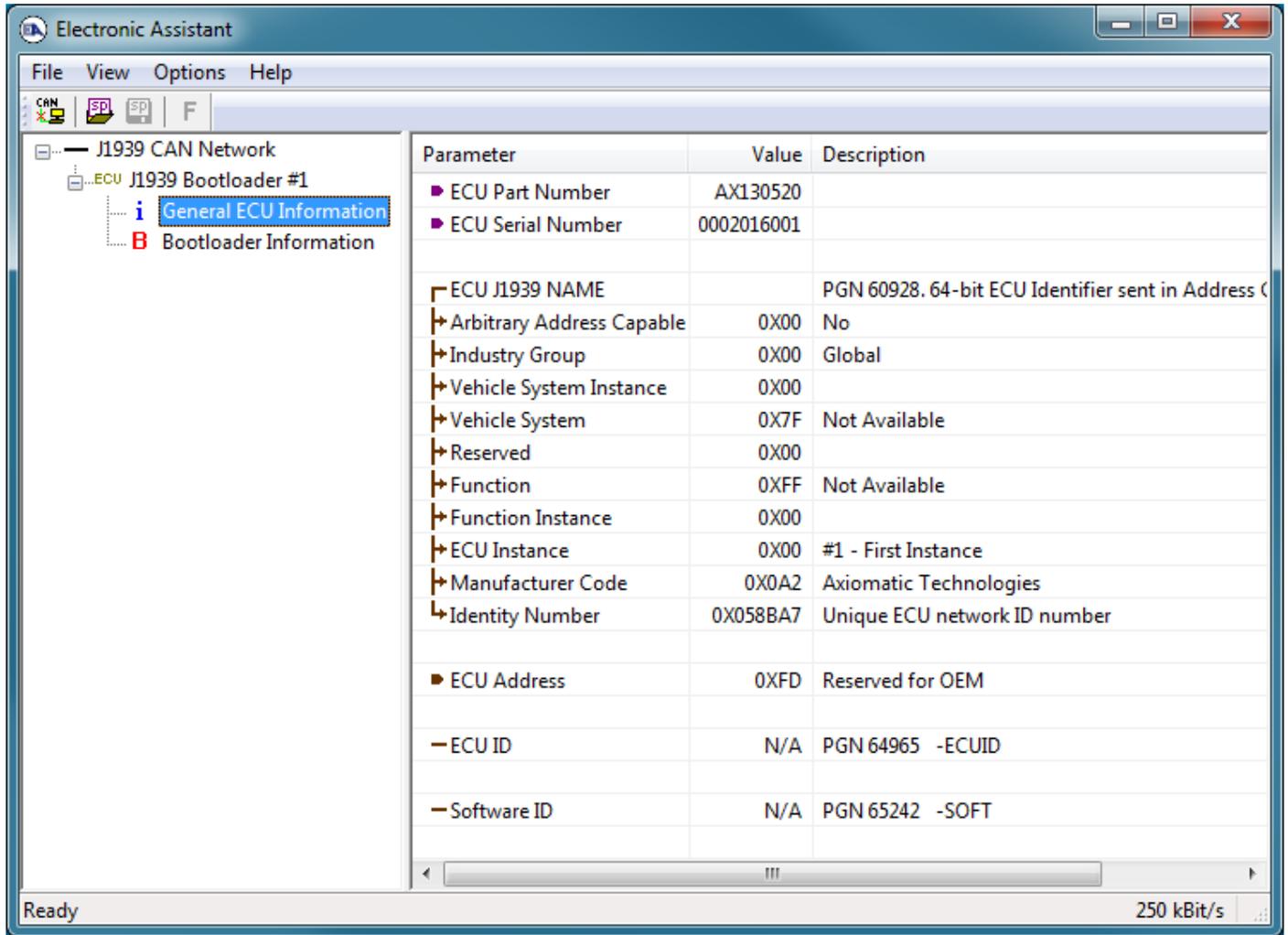
Note that the bootloader is NOT Arbitrary Address Capable. This means that if you want to have multiple bootloaders running simultaneously (not recommended) you would have to manually change the address for each one before activating the next, or there will be address conflicts. And only one ECU would 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.

5. When the **Bootloader Information** section is selected, the same information is shown as when it was running the AX130520 firmware, but in this case the Flashing feature has been enabled.

Parameter	Value
Hardware ID	15009
Hardware Revision Number	1.00
Hardware Compatibility Level	1.00
Hardware Description	2 Input 2 Output Signal Converter
Bootloader ID	15009
Bootloader Version Number	1.00
Bootloader Compatibility Level	1.00
Bootloader Description	CAN-BOOT-J1939.ARM_STM32F2
Bootloader ECU Address	253
Force Bootloader to Load on Reset	Yes
Application Firmware ID	15009
Application Firmware Version Number	1.00
Application Firmware Compatibility Level	1.00
Application Firmware Description	2 Input 2 Output Signal Converter
Application Firmware Flash File	AX130520_Simulink.bin
Application Firmware Flashing Date	June 10, 2016, 11:42 AM
Application Firmware Flashing Tool	Electronic Assistant VX.XX.XX.X, 2016
Application Firmware Flashing Comments	

6. Select the **F**lashing button and navigate to where you had saved the **AX130520_Simulink.bin** file sent from Axiomatic. (Note: only binary (.bin) files can be flashed using the Axiomatic 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 Axiomatic EA tool when you upload the new firmware.
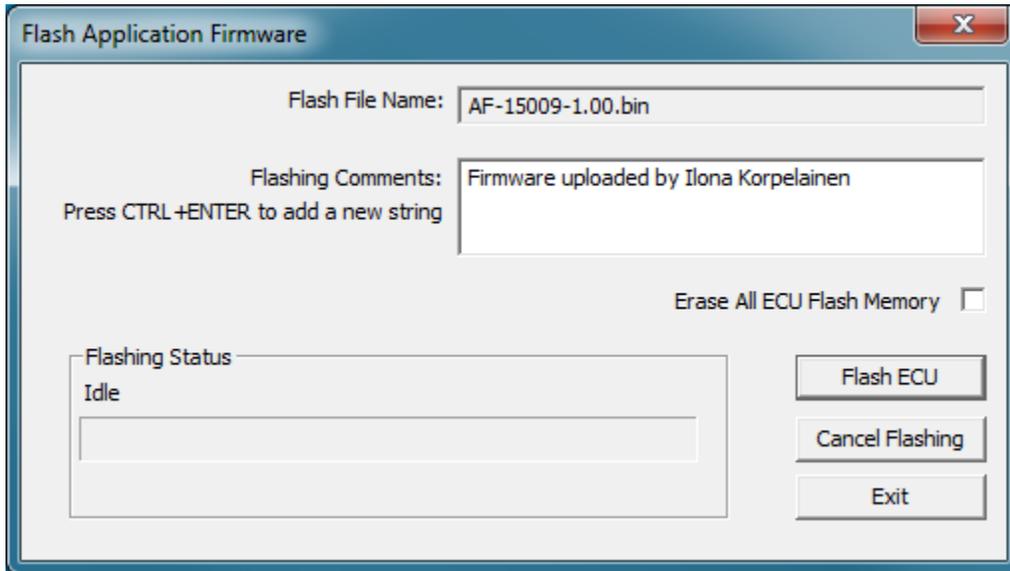
⚠️ WARNING: Do not check the "Erase All ECU Flash Memory" box unless instructed to do so by your Axiomatic contact. Selecting this will erase ALL data stored in non-volatile flash including the calibration from Axiomatic factory testing. It will also erase any configuration of the setpoints that might 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.
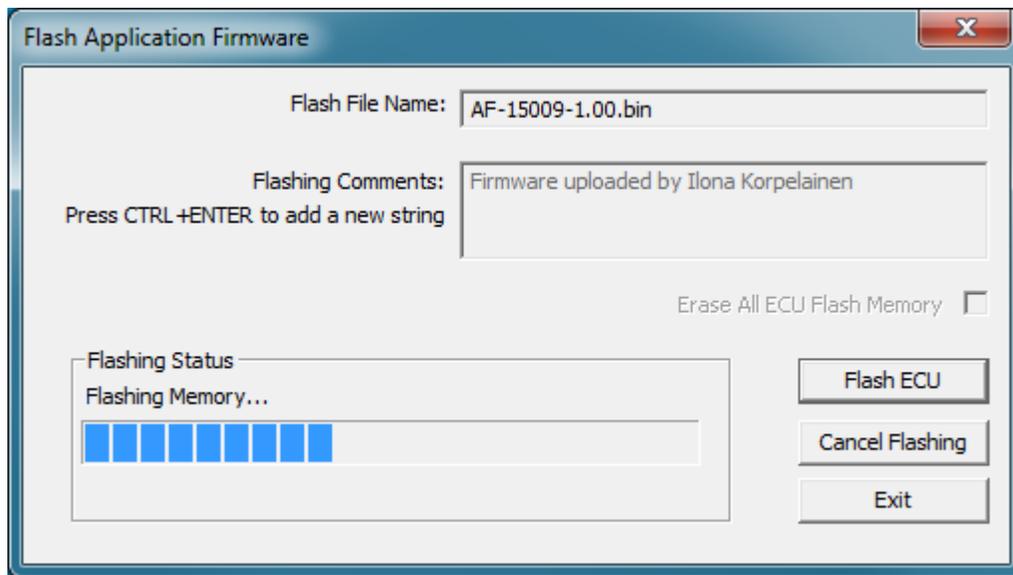
Once the firmware has finished uploading, a message will pop up indicating the successful operation. If you select to reset the ECU, the new version of the AX130520 application will start

running, and the ECU will be identified as such by the Axiomatic EA. Otherwise, the next time the ECU is power-cycled, the AX130520 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:

A-1

Power Supply

Power Supply Input	12 Vdc or 24 Vdc nominal 9…36 Vdc power supply range Shutdown voltage is 8.0 Vdc.
Protection	Reverse polarity protection Overvoltage protection is up to 45 V.

Inputs

Inputs	2 Universal Signal Inputs User programmable as Voltage, Current, Resistive, Frequency, RPM, PWM or Digital signal inputs types. Refer to Table 1.0.

Table 1.0 –User Programmable Universal Inputs

Analog & Digital Input Functions	Voltage Input, Current Input, Resistive Input or Digital Input 12 bit Analog to Digital
Voltage Input	0-5 V (Impedance 110 KΩ) 0-10 V (Impedance 130 KΩ)
Current Input	0-200 mA (Impedance 5 Ω); 1V max. 0-20 mA (Impedance 249 Ω) 4-20 mA (Impedance 249 Ω)
Resistive	20 Ohms to 250 kOhms Self-calibrating
Digital Input Level	Accepts 5 V TTL Accepts up to Vps Threshold: Low <1V High >2.2V Normal, Inverse or Latched 10kOhm Pull up/Pull down
Digital Input	Active High or Active Low with 10 kOhm pull-up or pull-down
Timer Input Functions	PWM Input, Frequency Input, RPM Input 15-bit Timer
PWM Input	100 Hz to 10 kHz 0 to 100% D.C. (Impedance 1MOhm)
Frequency/RPM Input	0.5 Hz to 50 Hz; 10 Hz to 1 kHz; or 100 Hz to 10 kHz 1%DC to 99%DC

Maximum and Minimum Ratings				
	Characteristic	**Min**	**Max**	**Units**
	Power Supply	9	36	V dc
	Voltage Input	0	36	V dc
	Current Input 0(4)-20 mA	0	12	Vdc
	Current Input 0-200 mA	0	1V	Vdc
	Resistive Input	20	250 000	Ω
	Digital Input	0	36	Vdc
	PWM Duty Cycle	0	100	%
	PWM Frequency	100	10 000	Hz
	PWM Voltage pk - pk	0	36	V dc
	RPM Frequency	0.5	10 000	Hz

Input Grounds	1 provided			
Protection	All inputs are protected against short to GND. All inputs, except current inputs, are protected against shorts to Nominal Vps (36Vdc).			

Input Accuracy and Resolution				
	Input Type	Input Range	Accuracy	Resolution
	Voltage	0-5V	+/- 1%	1 mV
		0-10V	+/- 1%	1 mV
	Current	0(4)-20mA	+/-2%	1 µA
		0-200mA	+/-2%	1 µA
	Resistive	20-250kΩ	+/-1%	1 Ω for lower ranges 1 kΩ for higher ranges
	Frequency	0.5Hz-50Hz	+/-1%	0.01 Hz
		10Hz-1kHz	+/-1%	0.1 Hz
		100Hz-10kHz	+/-1%	1 Hz
	PWM	Low Frequency	+/-1%	0.01%
		High Frequency	+/-1%	0.01%

Scan Rate	The input blocks are triggered with a 10 mSec timer so the scan rate is 100 samples per second.

Outputs

Outputs	2 Isolated Signal Outputs Voltage, Current or Digital The outputs are user selectable as follows. Refer to Table 2.0.

Table 2.0: Programmable Outputs

Analog Voltage or Current Outputs:	Voltage Output: 0-5 Vdc, 0-10 Vdc Maximum load is 50 mA. Current Output: 0-20 mA or 4-20 mA Maximum load resistance is < 500 Ohms. Compliance Voltage is 10V.
PWM, Frequency or Mixed PWM/Frequency Output:	0.1 Hz to 50 kHz 0-100% D.C. 5 V or 12 V Amplitude Push pull output Maximum load is 50 mA. Over-current protection (50 mA)
Digital Output:	Digital Level Digital ON/OFF 5 V or 12 V Amplitude Maximum load is 50 mA.

Output Accuracy and Resolution				
	Output Type	Output Range	Output Accuracy	Output Resolution
	Voltage	0-5V	+/- 1%	1 mV
		0-10V	+/- 1%	1 mV
	Current	0(4)-20mA	+/- 1%	0.5 µA
	Digital	On/Off	+/- 1%	N/A
	Frequency	0.1Hz-50kHz	+/- 1%	TBD
	PWM	Low Frequency	+/- 1%	TBD
		High Frequency	+/- 1%	TBD

Voltage Reference	+5V, 50 mA Ground is shared with Input Grounds.
Protection for Output Terminals	Fully protected against short circuit to output ground. Unit will fail safe in the case of a short circuit condition, self-recovering when the short is removed.

General Specifications

Microprocessor	STM32F205VGT
Isolation	300 Vrms Power and CAN are isolated from each other
Typical Quiescent Current	60 mA @ 12Vdc typical; 34 mA @ 24Vdc typical
Response Time	28.4 milliseconds
Control Logic	Standard embedded software is provided. *(Application-specific control logic or a set point file is available on request.)*
Simulink®	Model **AX130520** was developed using Simulink®. **Simulink®** is a model-based design tool from Mathworks®. Using Simulink®, the OEM machine designer may simulate their control system with the Axiomatic module included. This permits fine tuning of the design parameters and testing of functionality prior to machine prototype installation. The Hardware Interface Library for Simulink® is available from Axiomatic on request.
Communications	1 Isolated CAN port (SAE J1939) (CANopen® on request) Models: AX130520 – 250 kbps baud rate AX130520-01 – 500 kbps baud rate AX130520-02 – 1 Mbps baud rate
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.
User Interface	The AX130520 setpoints can be viewed and programmed using the standard J1939 memory access protocol through the CAN port and the PC-based Axiomatic Electronic Assistant. The Axiomatic EA can store all setpoints in one setpoint file and then flash them into the unit in one operation. The setpoint file is created and stored on disk using a command *Save Setpoint File* from the Axiomatic EA menu or toolbar. The user then can open the setpoint file, view or print it and flash the setpoint file into the AX130520. The Axiomatic Electronic Assistant, P/Ns: **AX070502** or **AX070506K**, for *Windows* operating systems comes with a royalty-free license for use on multiple computers. It includes an Axiomatic USB-CAN converter to link the device's CAN port to a *Windows*-based PC.
Operating Conditions	-40 to 85 °C (-40 to 185 °F)
Storage Temperature	-55 to 125 °C (-67 to 257°F)
Protection	IP67
Vibration	MIL-STD-202G, Test 204D and 214A (Sine and Random) 10 g peak (Sine) 7.86 Grms peak (Random)
Shock	MIL-STD-202G, Test 213B 50g
Weight	0.55 lb. (0.249 kg)
Enclosure	High Temperature Nylon PCB Enclosure - (equivalent TE Deutsch P/N: EEC-325X4B) Refer to the dimensional drawing.
Installation	For mounting information, refer to the dimensional drawing. Mounting holes sized for ¼ inch or M6 bolts. The bolt length will be determined by the end-user's mounting plate thickness. The mounting flange of the controller is 0.63 inches (16 mm) thick. If the module is mounted without an enclosure, it should be mounted vertically with connectors facing left and right to reduce likelihood of moisture entry. The CAN wiring is considered intrinsically safe. The power wires are not considered intrinsically safe and so in hazardous locations, they need to be located in conduit or conduit trays at all times. The module must be mounted in an enclosure in hazardous locations for this purpose. No wire or cable harness should exceed 30 meters in length. The power input wiring should be limited to 10 meters. All field wiring should be suitable for the operating temperature range. Install the unit with appropriate space available for servicing and for adequate wire harness access (6 inches or 15 cm) and strain relief (12 inches or 30 cm).

Dimensional Drawing
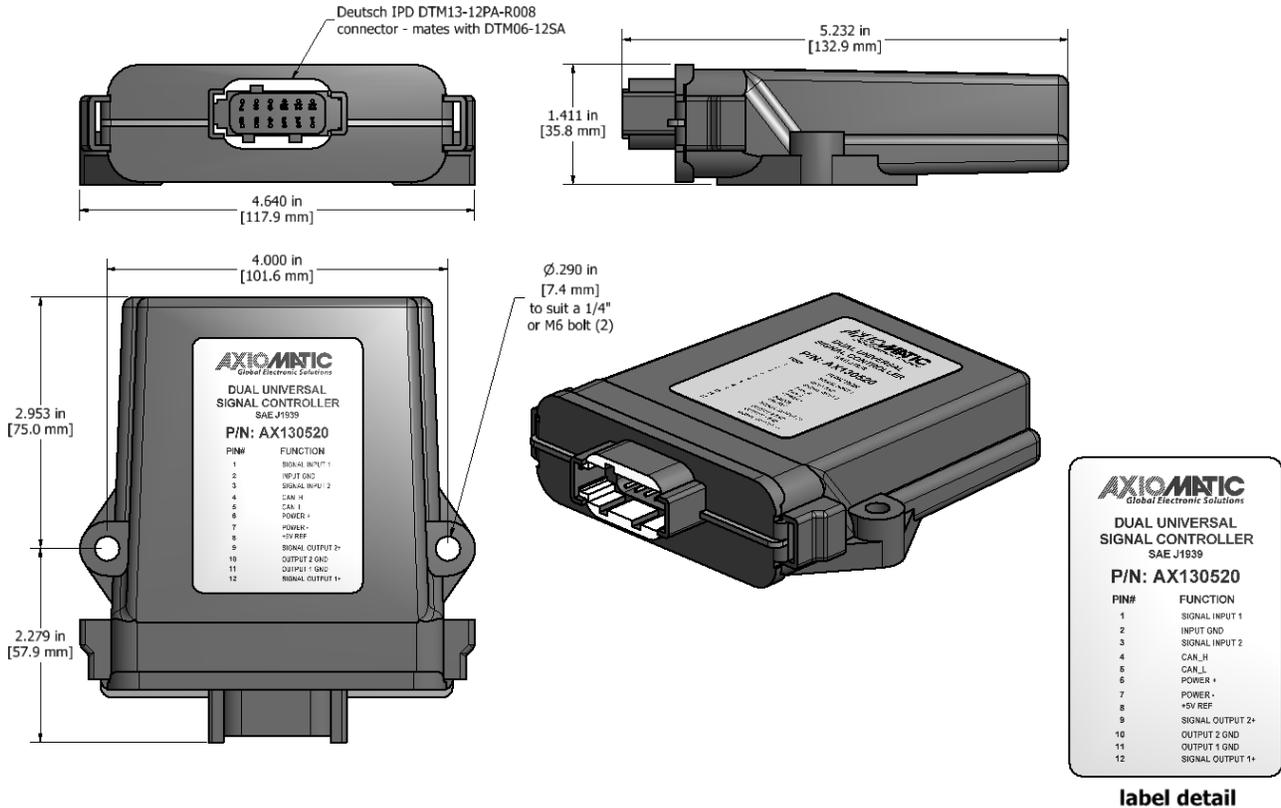
Electrical Connections	12 pin receptacle (Equivalent TE Deutsch P/N: DTM13-12PA-R008)
	20 AWG wire is recommended for use with contacts 0462-201-20141.
	Mating plug KIT: Available from Axiomatic as P/N: **PL-DTM06-12SA**. It is comprised of the following TE Deutsch P/N equivalents: plug (DTM06-12SA); wedgelock (WM12S); and 12 contacts (0462-201-20141) as well as 6 sealing plugs (0413-204-2005).

Pin #	Description
1	Analog/Digital Input 1
2	Input GND
3	Analog/Digital Input 2
4	CAN_H
5	CAN_L
6	Power +
7	Power -
8	+5V Reference
9	Analog/Digital Output 2+
10	Output GND 2
11	Output GND 1
12	Analog/Digital Output 1+

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CAN Controls, Routers, Repeaters

CAN/WiFi, CAN/Bluetooth, Routers

Current/Voltage/PWM Converters

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

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.*

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

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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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