USER MANUAL UMAX020530

7 INPUT, 5 OUTPUT VALVE CONTROLLER WITH CAN, SAE J1939

USER MANUAL

P/N: AX020530

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VERSION HISTORY

Version	Date	Author	Modification
1.00	May 19, 2020	Ilona Korpelainen	Initial Draft
1.00A	June 22, 2020	Ilona Korpelainen	
1.00B	Nov 25, 2021	Ilona Korpelainen	Changed AX number
1.00C	Feb 15, 2021	Ilona Korpelainen	Added small note on auto baud rate
-	March 1, 2022	Amanda Wilkins	Updated for Axiomatic EA version 5.15.126 and higher Updated dimensional drawing to generic 24-pin TE Deutsch drawing. Added auto-baud-rate to spec
-	March 4, 2022	Amanda Wilkins (Yatri Shah)	Updated accuracies
2.00	May 11, 2023	Ilona Korpelainen	Updated to match firmware V2.00 -Added SR blocks -updated EA screen captures
2.01	August 1, 2023	M Ejaz	Marketing Review Added the latest technical specifications from the datasheet
2.02	August 8, 2023	Kiril Mojsov	Performed Further Legacy Updates

ACRONYMS

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

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REFERENCES

J1939	Recommended Practice for a Serial Control and Communications Vehicle Network, SAE, April 2011
J1939/21	Data Link Layer, SAE, December 2006
J1939/71	Vehicle Application Layer, SAE, March 2011
J1939/73	Application Layer-Diagnostics, SAE, February 2010
J1939/81	Network Management, SAE, March 2017
TDAX020530	Technical Datasheet, 7 Input 5 Output Valve Controller with CAN, Axiomatic Technologies 2022
UMAX07050x	User Manual V5.15.126, 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 V5.15.126 and higher.

1. OVERVIEW OF CONTROLLER

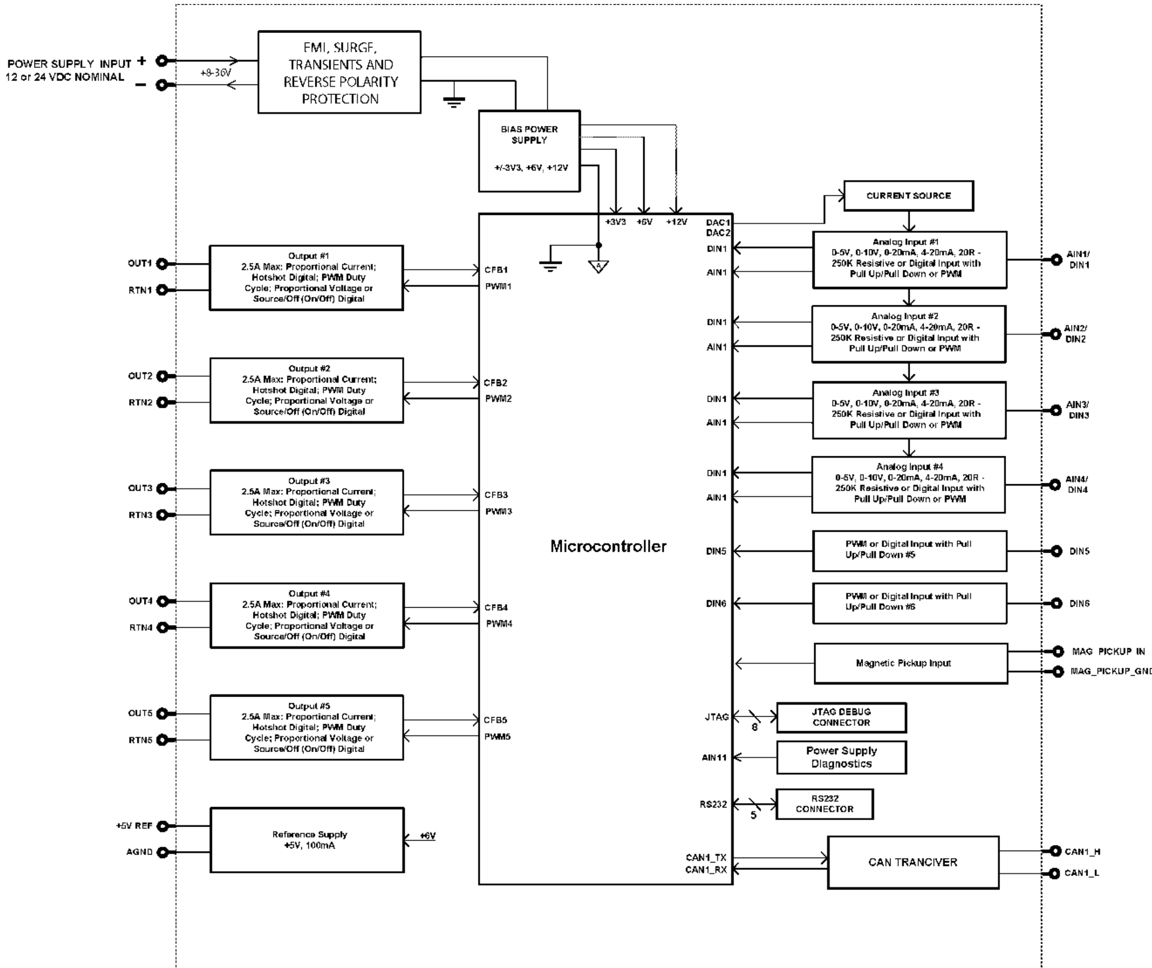


Figure 1 – AX020530 Block Diagram

The 7 Input 5 Output Valve Controller is designed for extremely versatile control of up to five proportional outputs to directly drive solenoids or other loads. 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 custom software.

The controller has four Universal inputs that can be configured to measure analog voltage or current, resistance, frequency/PMW or digital signal and two Digital inputs that can be configured to measure frequency/PWM or digital signals. In addition, there is one Magnetic Input for reading a magnetic pick up sensor. Measured input data can be sent to a SAE J1939 CAN Network or used to drive outputs directly or through the configurable control algorithms.

Half-bridge outputs with high side sourcing up to 2.5A produce the output signals. The outputs can be configured to drive proportional current (up to 2.5A), hotshot digital current, proportional voltage (up to power supply), proportional PWM or straight on/off digital loads. Any of the five proportional outputs can be configured to use any of the on-board inputs as either a control signal or an enable signal as well as SAE J1939 CAN Network data.

A *Windows*-based Axiomatic Electronic Assistant (EA) is used to configure the controller via an USB-CAN (AX070501) device. Configurable properties, Axiomatic EA setpoints, are outlined in chapter 4. Setpoint configuration can be saved in a file which can be used to easily program the same configuration into another 7 Input 5 Output Valve Controller. Throughout this document, Axiomatic EA setpoint names are referred to with bolded text in double-quotes, and the setpoint option is referred to with italicized text in single-quotes. For example, "**Input Sensor Type**" setpoint set to option '*Voltage 0 to 5V*'.

In this document the configurable properties of the ECU are divided into function blocks, namely Input Function Block, Output Function Block, Diagnostic Function Block, PID Control Function Block, Lookup Table Function Block, Programmable Logic Function Block, Math Function Block, DTC React Function Block, CAN Transmit Message Function Block and CAN Receive Message Function Block. These function blocks are presented in detail in next subchapters.

The 7 Input 5 Output Valve Controller part number AX020530 can operate at J1939 standard 250 kbit/s and 500 kbit/s baud rates. In addition, 1000kbit/s baud rate is supported. The baud rate selection is performed upon connection to the CAN network using passive automatic baud rate detection process. Detected baud rate is stored in non-volatile memory and used as starting baud rate for baud rate detection on the next power-up.

1.1. Input Function Blocks

The controller has altogether seven inputs. The four Universal Inputs can be configured to measure voltage, current, resistance, frequency, pulse width (PWM) or digital signal. The two Digital Inputs can be configured to measure frequency, pulse width (PWM) or digital signals. Magnetic input reads magnetic pick up signal with frequency range from 0.5Hz to 20 000Hz.

Universal and Digital Input setpoint groups have the "**Input Sensor Type**" setpoint, which is used to configure input type. Selecting input type effects on other setpoints and how they are interpreted and should thus be selected first on this block. The input sensor types for Universal Inputs are listed in Table 1. Digital inputs do not have analog (10-21) sensor type options in "**Input Sensor Type**" options.

0	*Disabled*
12	*Voltage 0 to 5 V*
13	*Voltage 0 to 10 V*
20	*Current 0 to 20 mA*
21	*Current 4 to 20 mA*
30	*Resistive 20 to 250 000 Ohm*
40	*Frequency 0.5 to 50 Hz*
41	*Frequency 10 Hz to 1 kHz*
42	*Frequency 100 Hz to 20 kHz*
50	*PWM Low Frequency (<1kHz)*
51	*PWM High Frequency (>100Hz)*
60	*Digital (normal)*
61	*Digital (inverse)*
62	*Digital (latched)*
70	*Counter*

71	*Pulse Counter*
72	*Pulse Counter (both edges)*

Table 1 – Universal Input Sensor Type Options

Universal Inputs analog voltage (i.e. 0-5V, 0-10V) or current (0-20mA, 4-20mA) signals go directly to a 12-bit analog-to-digital converter (ADC) on the processor. The voltage input is a high impedance input protected against shorts to GND or Vcc. In current mode, a 124Ω resistor is used to measure the input signal. Analog signals should be connected to the GND reference pins provided on the connector, per Table 25.

Resistive inputs read a resistive value connected between the input pin and GND. Onboard current source is used to provide measuring current (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

An additional software debounce filter can be used with Digital Input types for filtering the inputs using longer time constants than with the default debounce filter. The available software implemented debounce times are listed in Table 3.

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

Table 3 – Software Debounce Filter Times

Frequency/RPM, Pulse Width Modulated (PWM) and Counter "**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 setpoint is set to *True*, then the input data will be reported as in rotations-per-minute (RPM). Otherwise, frequency inputs are measured in Hertz.

"**Measuring Window"** setpoint defines number of pulses to be timed, for *Counter* input type. Pulses in the input signal are calculated and the time passed until the number of pulses have been received is timed. Once the count has been reached, the time is transferred as input signal measurement result and the calculation is started again.

Pulse Counter input types use edge detection to count input signal pulses. Pulse counter calculates rising edges and Pulse counter (both edges) calculates both rising and falling edges.

"**Max pulse count**" setpoint defines maximum number of pulse count, once it is reached count will start again from zero.

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

On Frequency, PWM and digital input modes 22kΩ pull-up or pull-down resistors can be enabled or disabled by setting the value of the "**Pullup/Pulldown Resistor**" setpoint. Setpoint options are given in Table 4. By default, pull-down resistors are enabled for all inputs.

0	*Pullup/down Off*
1	*22 kΩ Pullup*
2	*22 kΩ Pulldown*

Table 4 – 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 5. 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 5 – Active High/Low Options

Table 6 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 6 – 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.

0	*No Filtering*
1	*Moving Average*
2	*Repeating Average*

Table 7 – Filter Type Options

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

<u>Equation 1 - Moving Average Transfer Function:</u>

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

<u>Equation 2 - Repeating Average Transfer Function:</u>

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

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 five Proportional outputs. The Proportional Outputs are half-bridge drive with high side sourcing up to 2,5A. Outputs 1 and Output 3 are connected into mutual timer peripheral, as are Output 2 and Output 4, thus they are operated in common frequency. The fifth output is separate and can have an individual, different frequency.

"**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 8.

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

Table 8 – Output Type Options for Proportional Output

'*Proportional Current'* type has associated with it two setpoints not used by other types, which are the "**Dither Frequency**" and "**Dither Amplitude**" values. The output is controlled by high frequency signal (25kHz), with the low frequency dither superimposed on top. The dither frequency will match what is programmed into the setpoint, but the exact amplitude of the dither will depend on the properties of the load coil. When adjusting the dither amplitude value, select one that is high enough to ensure an immediate response to the coil to small changes in the control inputs, but not so large as to affect the accuracy or stability of the output. Refer to the coil's datasheet for more information.

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

The '*PWM Duty Cycle'* option allows the user to run the output at fixed frequency configure with "**PWM Output Frequency**" setpoint, while the duty cycle changes depending on the control signal. Outputs 1 to 3 run on same output frequency, as do Outputs 2 and 4, thus changing the frequency for one output changes frequency of the other output as well. "**PWM Output Frequency**" is editable only if both outputs 1 and 3, or outputs 2 and 4, are set to '*PWM Duty Cycle' or 'Proportional Voltage'* - type. Configuring output to '*Proportional Current' or 'Hotshot Digital'* type changes frequency automatically to 25kHz. Output 5 is separate and can have an individual frequency.

Instead of proportional output control, there are also two types of digital responses possible as well. With the *'Digital On/Off'* type, should the control require the output to be on, it will be turned on at whatever the system power supply is. The output will source whatever current is required by the load, up to 2,5A.

If a digital **"Output Type"** has been selected the **"Digital Response"** setpoint will be enabled as shown in Table 9.

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

Table 9 – Digital Response Options

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

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

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

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

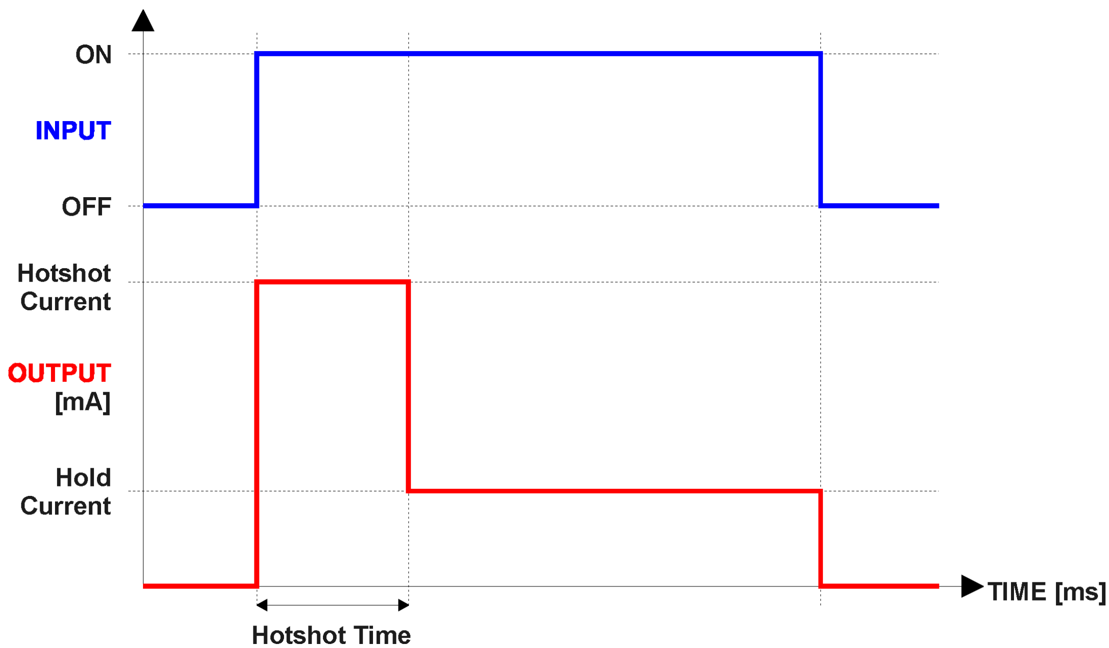


Figure 2 – Hotshot Digital Profile

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

Regardless of what type of control input is selected, the output will always respond in a linear fashion to changes in the input per Equation 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 coil's response. The "**Ramp Up**" and "**Ramp Down**" setpoints are in milliseconds, and the step size of the output change will be determined by taking the absolute value of the output range and dividing it by the ramp time.

The "**Control Source**" setpoint together with "**Control Number**" setpoint determine which signal is used to drive the output. For example, setting "**Control Source**" to '*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.

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

The "**Enable Source**" setpoint together with "**Enable Number**" setpoint determine the enable signal for the output in question. The "**Enable Response**" setpoint is used to select how output will respond to the selected Enable signal. "**Enable Response**" setpoint options are listed in Table 10. If a non-digital signal is selected as Enable signal the signal is interpreted as shown in Figure 4.

0	*Enable When On, Else Shutoff*
1	*Enable When On, Else Rampoff*
2	*Enable When 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 10 – 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 11. 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 11 – 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 12. 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 12 – 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 for current output types. A current feedback signal is measured and compared to desired output current value. Fault detection and associated setpoints are presented in section 1.3.

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

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

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

1.4. Diagnostic Function Blocks

The 7 Input 5 Output Valve 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 14 and Table 15)
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 7 Input 5 Output Valve 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 like the Absolute value error, the only difference is that State error does not allow the user to specify specific threshold values; thresholds ‘1’ and ‘0’ are used instead. This is ideal for monitoring state information, such as received message timeouts.

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

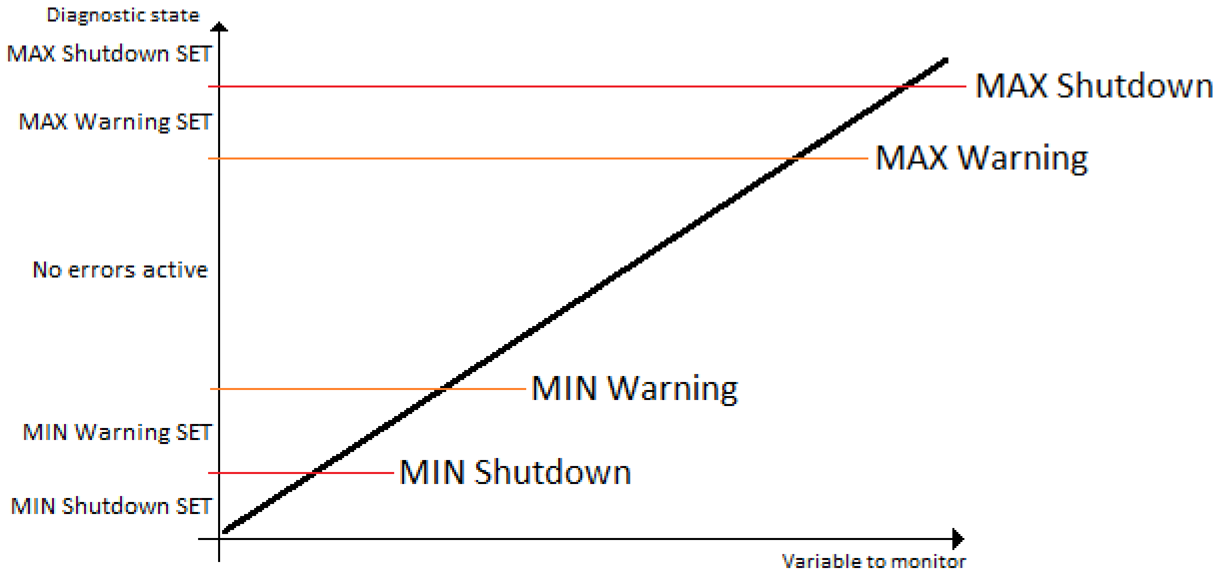


Figure 3 – Double Minimum and Maximum Error Thresholds

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

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

While there are no active DTCs, the 7 Input 5 Output Valve Controller will send “No Active Faults” message. If a previously inactive DTC becomes active, a DM1 will be sent immediately to reflect this. As soon as the last active DTC goes inactive, a DM1 indicating that there are no more active DTCs will be sent.

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

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

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

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

As defined by J1939 Standard the first byte of the DM1 message reflects the Lamp status. "**Lamp Set by Event**" setpoint determines the lamp type set in this byte of DTC. "**Lamp Set by Event"** setpoint options are listed in Table 13. 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 13 – 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 14 – 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 14. When an FMI is selected from Low Fault FMIs in Table 15 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 15. 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 15 – Low Fault FMIs and corresponding High Fault FMIs

1.5. Control Variable Data Blocks

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

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

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

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

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

1.6. PID Control Function Block

The PID Control function block is an independent logic block, but it is normally intended to be associated with proportional output control blocks described 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 7 Input 5 Output Valve 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 16. 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 16 – 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 were 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 $\mathrm{Error_K}$ is less than this value, $\mathrm{Error_K}$ 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.

1.7. 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 1.8.

Lookup tables have three differing modes defined by "**X-Axis Type**" setpoint, given in Table 17. 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. Option '2 – Enabled Data Response' works like the Data Response option with a configurable threshold for the input signal to enable and disable the output. The output value in 'disabled' mode can be defined by the user with "**Output value when disabled**" setpoint.

The Enabled Data Response X-Axis type is targeted for joystick applications, where it is needed to disable the output drive when joystick position exceeds a certain threshold and can be enabled only when the joystick is returned to neutral position.

0	*Data Response*
1	*Time Response*
2	*Enabled Data Response*

Table 17 – 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 18. ‘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 18 – PointN – Response Options

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

The X values are limited by minimum and maximum range of the selected input source if the source is one of the Input Blocks or a Math Function Block. For the fore mentioned sources X-Axis data will be redefined when ranges are changed, therefore inputs should be adjusted before changing X-Axis values. For other sources Xmin and Xmax are 0 and 10,000. 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.

1.8. 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 19. 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 19 – 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 20, 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 20 – 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.

1.9. Math Function Block

There are six 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 $\mathrm{A\ operator\ B}$, where A and B are function inputs and operator is function selected with setpoint "**Math function X Operator**". Setpoint options are presented in Table 21. The functions are connected, so that result of the preceding function goes into Input A of the next function. Thus Function 1 has both Input A and Input B selectable with setpoints, where Functions 2 to 4 have only Input B selectable. Input is selected by setting "**Function X Input Y Source**" and "**Function X Input Y Number**". If "**Function X Input B Source**" is set to 0 '*Control not used'* signal goes through function unchanged.

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

0	*=, True when InA equals InB*
1	*!=, True when InA not equal InB*
2	*>, True when InA greater than InB*
3	*>=, True when InA greater than or equal InB*
4	*<, True when InA less than InB*
5	*<=, True when InA less than or equal InB*
6	*OR, True when InA or InB is True*
7	*AND, True when InA and InB are True*
8	*XOR, True when either InA or InB is True, but not both*
9	*+, Result = InA plus InB*
10	*-, Result = InA minus InB*
11	*x, Result = InA times InB*
12	*/, Result = InA divided by InB*
13	*MIN, Result = Smallest of InA and InB*
14	*MAX, Result = Largest of InA and InB*
15	*MAX-MIN, Result = Absolute value of (InA – InB)*
16	*SIN, Result = InA * SIN(InB)*
17	*COS, Result = InA * COS(InB)*
18	*SQRT, Result = InA * SQRT(InB)*

Table 21 – 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.

1.10. Set / Reset Function Block

Set-Reset Block consists of only 2 control sources: **Reset Source** and **Set Source**. The purpose of these blocks is to simulate a modified latching function in which the 'Reset Signal' has more precedence. The 'latching' function works as per the Table 24 below.

'Set Signal'	'Reset Signal'	'Set-Reset Block Output' **(Initial State: *OFF*)**
OFF	*OFF*	*Latched State*
OFF	*ON*	*OFF*
ON	*OFF*	*ON*
ON	*ON*	*OFF*

Table 22 – Set-Reset Function block operation

The **Reset** and **Set** sources have associated with them a minimum and maximum threshold values which determine the ON and OFF state. For the **Reset Source** are **Reset Minimum Threshold** and **Reset Maximum Threshold**. Similarly, for the **Set Source** are **Set Minimum Threshold** and **Set Maximum Threshold**. These setpoints also allow to have a dead band in between ON/OFF states and they are in terms of percentage of input selected.

As seen in Table 24 above, the 'Reset Signal' has more precedence over the 'Set Signal' - if the state of 'Reset Signal' is *ON*, the state of 'Set-Reset Block Output' will be *OFF*. To create an *ON* state in 'Set-Reset Block Output' the state of 'Reset Signal' must be *OFF* while the state of 'Set Signal' is *ON*. In this case, the state of 'Set-Reset Block Output' will remain *ON* even if 'Set Signal' turns *OFF* as long as 'Reset Signal' remains *OFF.* As soon as the 'Reset Signal' turns *ON* the 'Set-Reset Block Output' will turn *OFF* regardless of the state of 'Set Signal'.

1.11. 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 AX020530 ECU has seven CAN Transmit Messages and each message has four completely user defined signals.

1.11.1. 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.

1.11.2. 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 24. Setting "**Control Source**" to '*Control Not Used'* disables the signal.

"**Transmit Data Type**" setpoint options are listed in Table 23. By default, '*CAN signal continuous*' is selected and signal data is presented continuous form. If '*CAN signal discrete'* the signal data is considered as digital and is interpreted as 0 below "**CAN Transmit Data Maximum**". When '*CAN signal undefined*' signal data is considered undefined and all signal bits are set to 1.

0	*CAN signal undefined*
1	*CAN signal discrete*
2	*CAN signal continuous*

Table 23 – CAN Transmit Data Type Options

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

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

1.12. 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. 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 7 Input 5 Output Valve Controller on Proprietary B PGNs. However, should a PDU1 message be selected, the 7 Input 5 Output Valve 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 Type**”, “**Receive Data Width**”, “**Receive Data Index in Array (LSB)**”, “**Receive Bit Index in Byte (LSB)**”, “**Receive Resolution**” and “**Receive Offset**” can all be used to map any SPN supported by the J1939 standard to the output data of the Received function block.

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 7 Input 5 Output Valve Controller I/O supports up to five unique CAN Receive Messages. Defaults setpoint values are listed in section 0.

1.13. 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.

1.14. 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 24. All sources, except "CAN message reception timeout", are available for all blocks, including output control blocks and CAN Transmit messages. Thought input Sources are freely selectable, not all options would make sense for any input, and it is up to the user to program the controller in a logical and functional manner.

Sources	**Number Range**	**Notes**
0: Control Not Used	N/A	When this is selected, it disables all other setpoints associated with the signal in question.
1: Received CAN Message	1 to 12	User must enable the function block, as it is disabled by default.
2: Universal Input Measured	1 to 4	
3: Digital Input Measured	1 to 2	
4: Magnetic Input Measured	1	
5: PID Function Block	1 to 4	User must enable the function block, as it is disabled by default.
6: Lookup Table	1 to 10	
7: Programmable Logic Block	1 to 4	User must enable the function block, as it is disabled by default.
8: Math Function Block	1 to 6	User must enable the function block, as it is disabled by default.
9: Control Constant Data	1 to 15	1 = FALSE, 2 = TRUE, 3 to 15 = User Selectable
10: Diagnostic Trouble Code	1 to 5	Will only be valid if the corresponding DTC has a non-zero SPN
11: Output Target Value	1 to 5	
12: Output Current Feedback	1 to 5	Measured Feedback current from the proportional output in mA, used in Output Diagnostics.
13: Power Supply Measured	0 to 255	Measured power supply value in Volts. The Parameter sets the threshold in Volts to compare with.
14: Processor Temperature Measured	0 to 255	Measured processor temperature in °C. The Parameter sets the threshold in Celcius to compare with.
15: CAN Reception Timeout	N/A	Only available in Output blocks.
16: Control Variable Data	1 to 6	
17: SR Latch	1 to 4	

Table 24 – Available Control Sources and Numbers

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

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

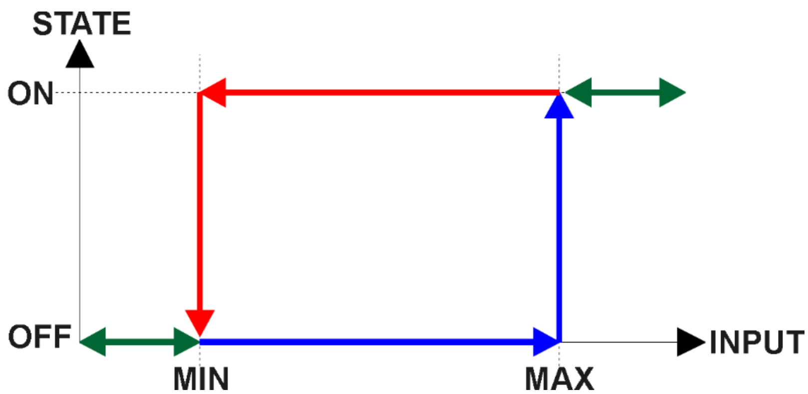


Figure 4 – Analog source to Digital input

2. INSTALLATION INSTRUCTIONS

2.1. Dimensions and Pinout

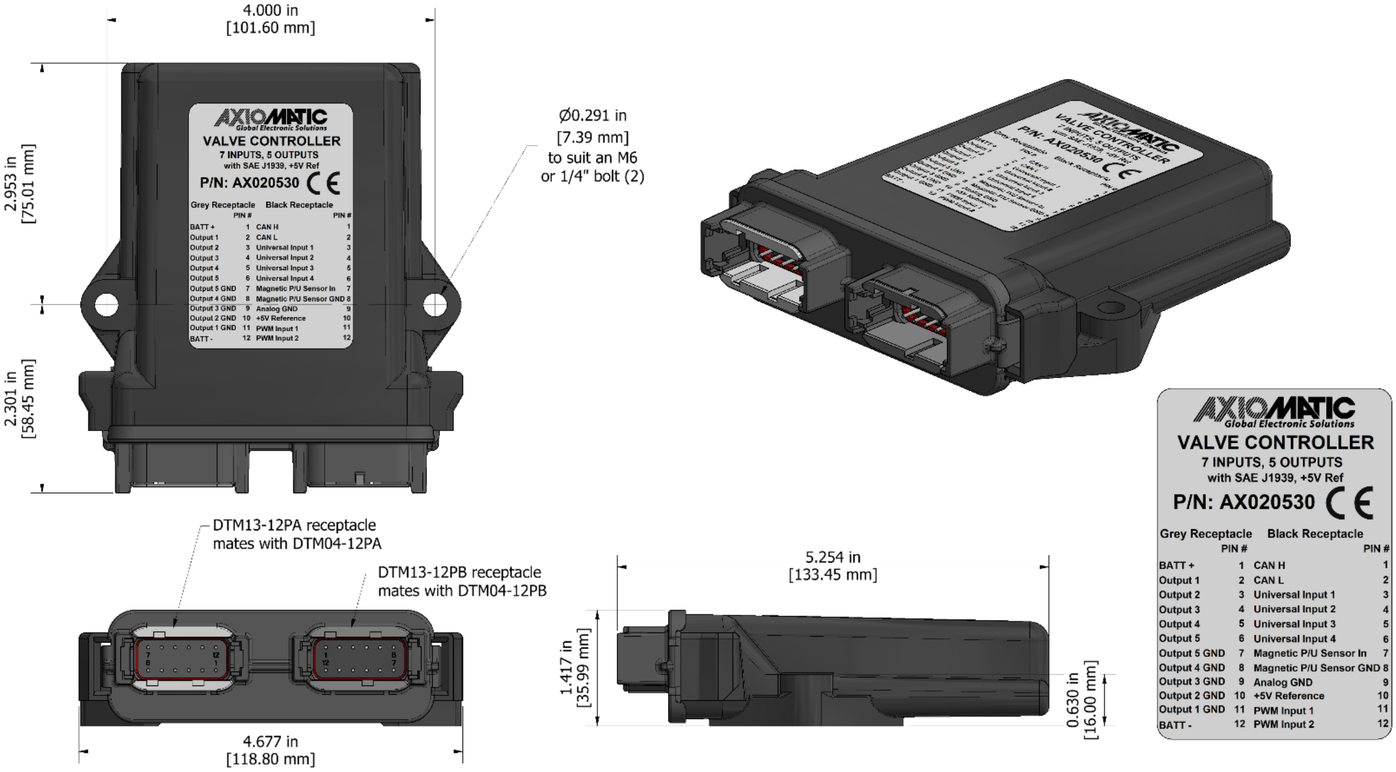
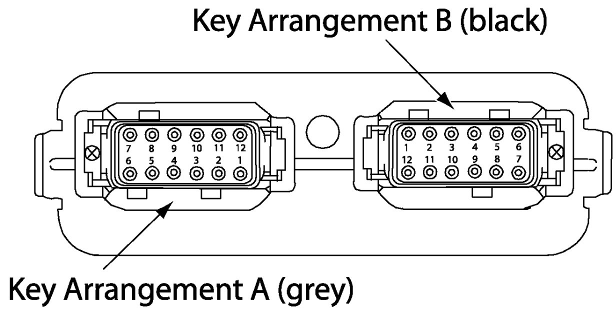


Figure 5 – AX020530 Dimensional Drawing



FRONT VIEW 24 PIN RECEPTACLE

Grey Connector PIN #	Function	Black Connector PIN #	Function
1	BATT +	1	CAN H
2	Output 1	2	CAN L
3	Output 2	3	Universal Input 1
4	Output 3	4	Universal Input 2
5	Output 4	5	Universal Input 3
6	Output 5	6	Universal Input 4
7	Output 5 GND	7	Magnetic Pickup Sensor Input
8	Output 4 GND	8	Magnetic Pickup Sensor GND
9	Output 3 GND	9	Analog GND
10	Output 2 GND	10	+5V Reference
11	Output 1 GND	11	PWM Input 1
12	BATT -	12	PWM Input 2

Table 25 – AX020530 Connector Pinout

3. OVERVIEW OF J1939 FEATURES

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

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

3.1. Introduction to Supported Messages

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

From J1939-21 – Data Link Layer

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

From J1939-73 – Diagnostics

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

From J1939-81 – Network Management

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

From J1939-71 – Vehicle Application Layer

• Software Identification	65242	0x00FEDA

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

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

3.2. NAME, Address and Software ID

The 7 Input 5 Output Valve Controller I/O ECU has the following default for the J1939 NAME. The user should refer to the SAE J1939/81 standard for more information on these parameters and their ranges.

Arbitrary Address Capable	Yes
Industry Group	0, Global
Vehicle System Instance	0
Vehicle System	0, Non-specific system
Function	126, Axiomatic I/O Controller
Function Instance	23, Axiomatic AX020530
ECU Instance	0, First Instance
Manufacture Code	162, Axiomatic Technologies
Identity Number	Variable, uniquely assigned during factory programming for each ECU

The ECU Instance is a configurable setpoint associated with the NAME. Changing this value will allow multiple ECUs of this type to be distinguishable from one another when they are connected on the same network.

The default value of the “ECU Address” setpoint is 128 (0x80), which is the preferred starting address for self-configurable ECUs as set by the SAE in J1939 tables B3 and B7. The Axiomatic EA supports the selection of any address between 0 and 253. ***It is the user’s responsibility to select an address that complies with the standard***. The user must also be aware that since the unit is arbitrary address capable, if another ECU with a higher priority NAME contends for the selected address, The 7 Input 5 Output Valve Controller I/O will continue select the next highest address until it finds one that it can claim. See J1939/81 for more details about address claiming.

Software Identifier

PGN 65242 Software Identification - SOFT

Transmission Repetition Rate: On request

Data Length:	Variable
Extended Data Page:	0
Data Page:	0
PDU Format:	254
PDU Specific:	218 PGN Supporting Information:
Default Priority:	6
Parameter Group Number:	65242 (0xFEDA)

Start Position	Length	Parameter Name	SPN
1	1 Byte	Number of software identification fields	965
2-n	Variable	Software identification(s), Delimiter (ASCII “*”)	234

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

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

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

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

4. ECU SETPOINTS ACCESSED WITH THE AXIOMATIC ELECTRONIC ASSISTANT

This section describes in detail each setpoint, and their default and ranges. Default values presented in tables are values used when setpoint in question is active. Many of the setpoints are dependent on other setpoints and they may not be active by default. Associated Figures show screen capture of initial operation, however some of the setpoints are not in default condition as they are set differently to activate more setpoints for the image. The setpoints are divided into setpoint groups as they are shown in the Axiomatic EA. For more information on how each setpoint is used by the 7 Input 5 Output Valve controller, refer to the relevant section in this user manual.

4.1. J1939 Network Parameters

"**ECU Instance Number**" and "**ECU Address**" setpoints and their effect are defined in Section 3.2.

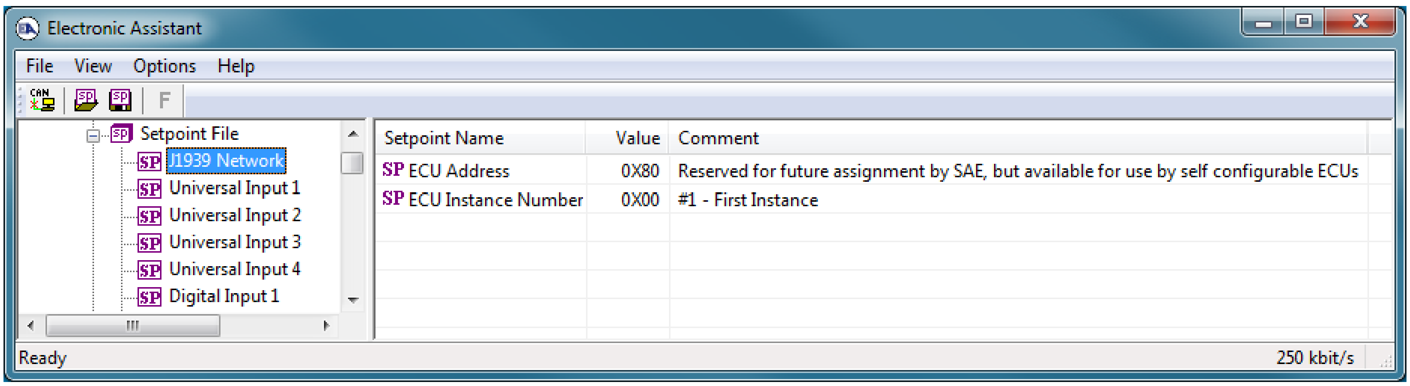


Figure 6 – Screen Capture of J1939 Setpoints

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

Table 26 – 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, such that only the new NAME and address appear in the J1939 CAN Network ECU list.

4.2. Universal Input Setpoints

The Universal Inputs are defined in Section 1.1. Please refer there for detailed information about how these setpoints are used.

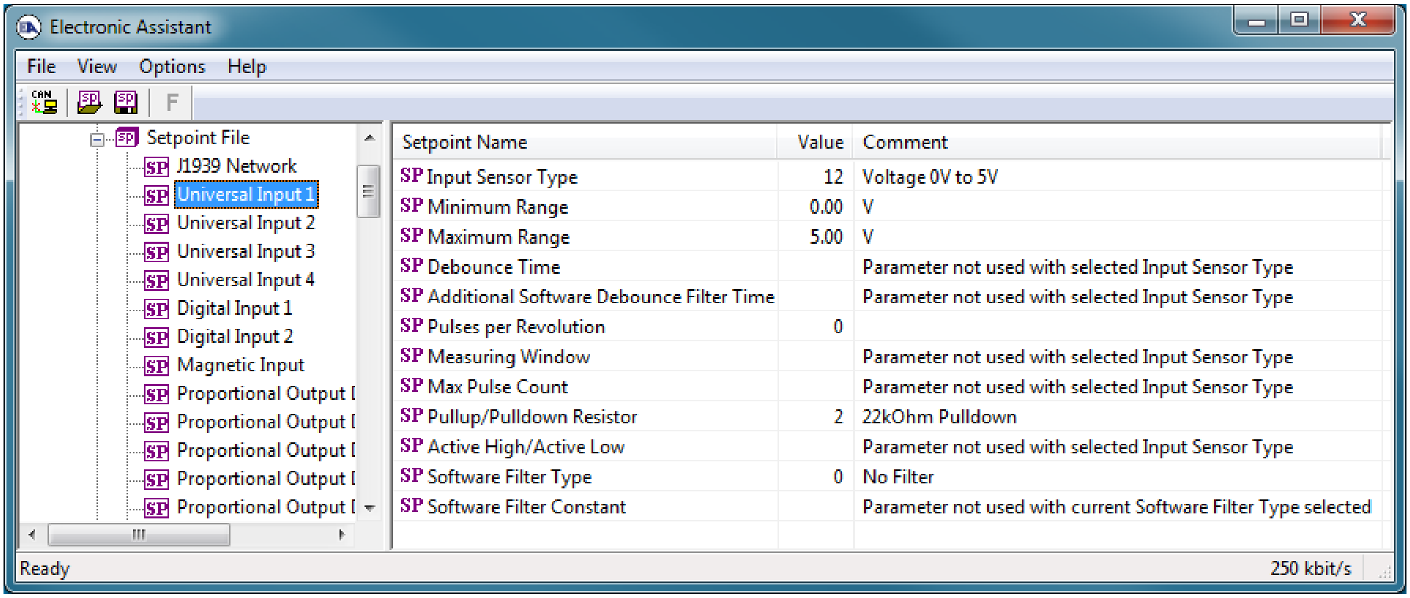


Figure 7 – Screen Capture of Universal Input Setpoints

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
Additional Software Debounce Filter Time	Drop List	0ms	See Table 3
Pulses per Revolution	Drop List	FALSE	See Section 1.1
Measuring Window	1..65535	1000 Pulse(s)	
Maximum Pulse Count	1..65535	10 Pulse(s)	
Pullup/Pulldown Resistor	Drop List	22kΩ Pulldown	See Table 4
Active High/Active Low	Drop List	Active High	See Table 5
Software Filter Type	Drop List	No Filtering	See Table 7
Software Filter Constant	1..1000	1	

Table 27 – Universal Input Setpoints

4.3. Digital Input Setpoints

The Digital Inputs are defined in Section 1.1. Please refer there for detailed information about how these setpoints are used.

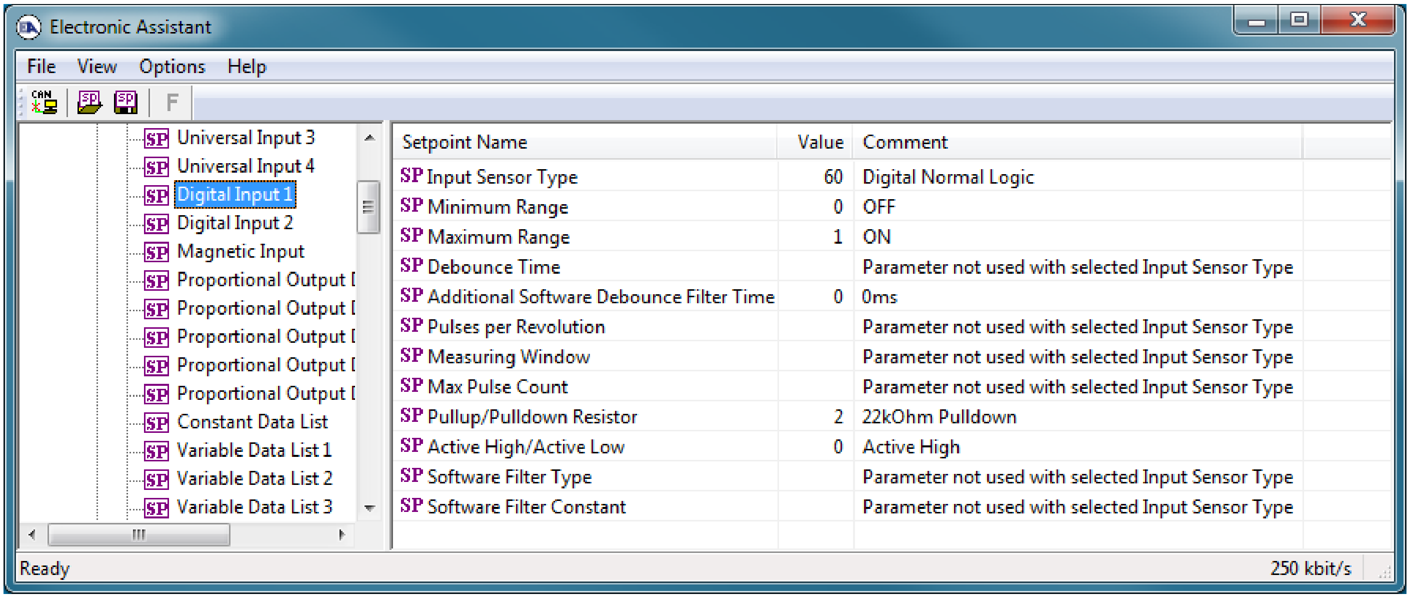


Figure 8 – Screen Capture of Digital Input Setpoints

Name	Range	Default	Notes
Input Sensor Type	Drop List	Digital Normal Logic	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
Additional Software Debounce Filter Time	Drop List	0ms	See Table 3
Pulse per Revolution	Drop List	FALSE	See Section 1.1
Measuring Window	1..65535	1000 Pulse(s)	
Maximum Pulse Count	1..65535	10 Pulse(s)	
Pullup/Pulldown Resistor	Drop List	22kΩ Pulldown	See Table 4
Active High/Active Low	Drop List	Active High	See Table 5
Software Filter Type	Drop List	No Filtering	See Table 7
Software Filter Constant	1..1000	1	

Table 28 – Digital Input Setpoints

4.4. Magnetic Input Setpoints

The Digital Inputs are defined in Section 1.1. Please refer there for detailed information about how these setpoints are used.

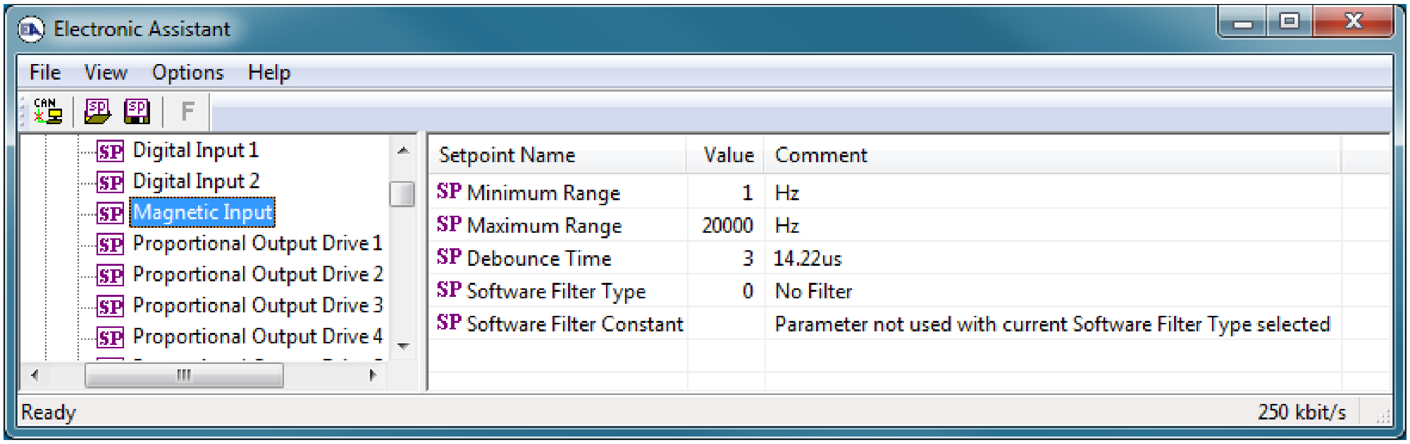


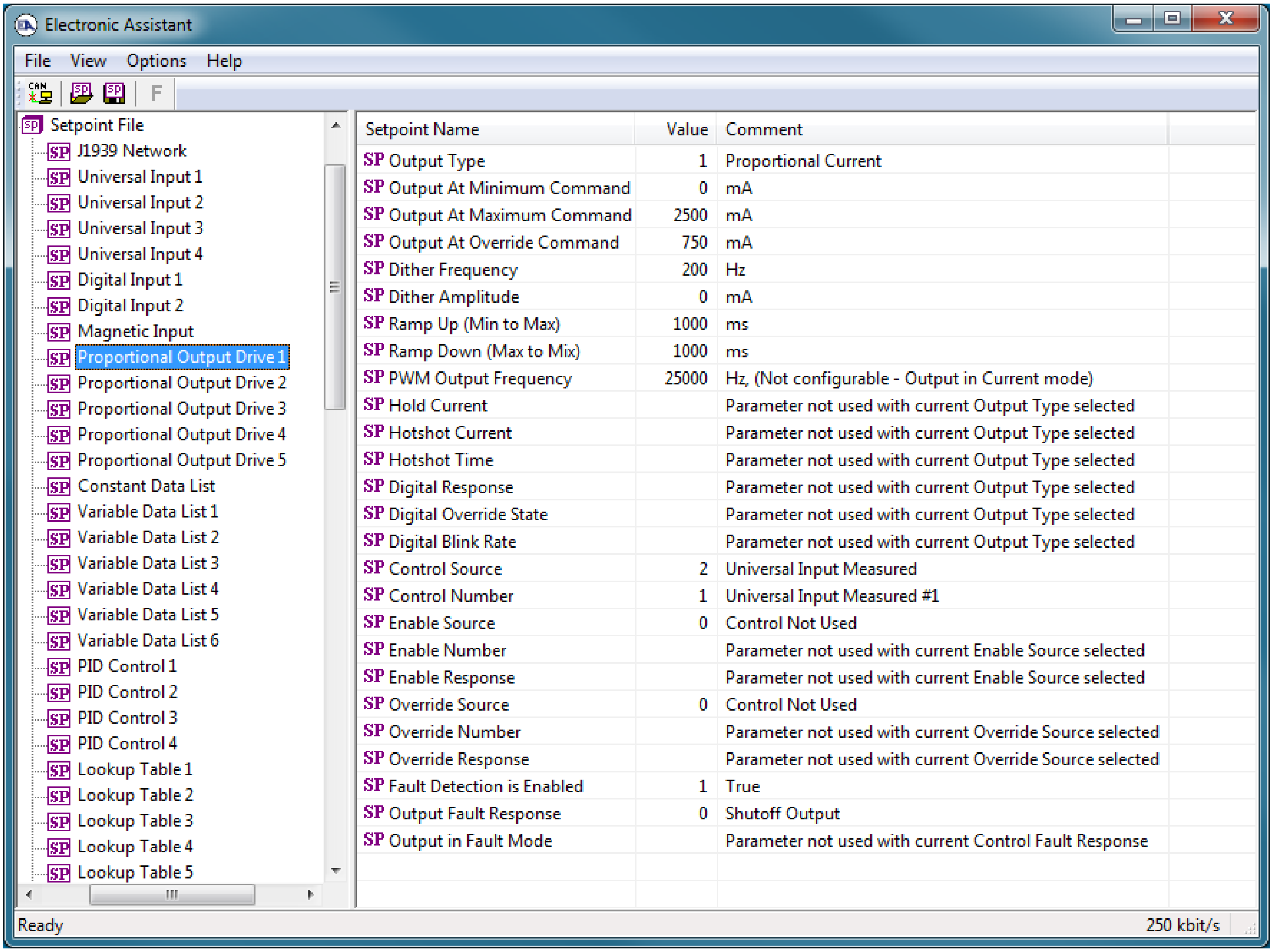
Figure 9 – Screen Capture of Magnetic Input Setpoints

Name	Range	Default	Notes
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
Software Filter Type	Drop List	No Filtering	See Table 7
Software Filter Constant	1..1000	1	

Table 29 – Magnetic Input Setpoints

4.5. Proportional Output Setpoints

The Proportional 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. To enable an output “**Output Type**” and “**Control Source**” must be chosen.



Setpoint Name	Value	Comment
SP Output Type	1	Proportional Current
SP Output At Minimum Command	0	mA
SP Output At Maximum Command	2500	mA
SP Output At Override Command	750	mA
SP Dither Frequency	200	Hz
SP Dither Amplitude	0	mA
SP Ramp Up (Min to Max)	1000	ms
SP Ramp Down (Max to Mix)	1000	ms
SP PWM Output Frequency	25000	Hz, (Not configurable - Output in Current mode)
SP Hold Current		Parameter not used with current Output Type selected
SP Hotshot Current		Parameter not used with current Output Type selected
SP Hotshot Time		Parameter not used with current Output Type selected
SP Digital Response		Parameter not used with current Output Type selected
SP Digital Override State		Parameter not used with current Output Type selected
SP Digital Blink Rate		Parameter not used with current Output Type selected
SP Control Source	2	Universal Input Measured
SP Control Number	1	Universal Input Measured #1
SP Enable Source	0	Control Not Used
SP Enable Number		Parameter not used with current Enable Source selected
SP Enable Response		Parameter not used with current Enable Source selected
SP Override Source	0	Control Not Used
SP Override Number		Parameter not used with current Override Source selected
SP Override Response		Parameter not used with current Override Source selected
SP Fault Detection is Enabled	1	True
SP Output Fault Response	0	Shutoff Output
SP Output in Fault Mode		Parameter not used with current Control Fault Response

Figure 10 – Screen Capture of Proportional Output Setpoints

Name	Range	Default	Notes
Output Type	Drop List	Disabled	See Table 8
Output At Minimum Command	0 to Limit	0mA	
Output At Maximum Command	0 to Limit	2500mA	
Output At Override Command	0 to Limit	750mA	
Dither Frequency	50 to 400Hz	200Hz	
Dither Amplitude	0 to 500 mA	0	
Ramp Up (Min to Max)	0 to 10 000ms	1000ms	
Ramp Down (Max to Min)	0 to 10 000ms	1000ms	
PWM Output Frequency	1Hz to 25 000Hz	25000Hz	
Hold Current	0 to 1500mA	500mA	
Hotshot Current	0 to 1500mA	1000mA	
Hotshot Time	500 to 10 000 ms	1000ms	
Digital Response	Drop List	Normal On/Off	See Table 9
Digital Override State			
Digital Blink Rate	100 to 5000 ms	1000ms	
Control Source	Drop List	Universal Input Measured	See Table 24
Control Number	Depends on control source	1	See Table 24
Enable Source	Drop List	Control not used	See Table 24
Enable Number	Depends on enable source	1	See Table 24
Enable Response	Drop List	Enable When On, else Shutoff	See Table 10
Override Source	Drop List	Control not used	See Table 24
Override Number	Depends on enable source	1	See Table 24
Override Response	Drop List	Override When On	See Table 11
Fault Detection is Enabled	Drop List	True	
Output Fault Response	Drop List	Shutoff Output	See Table 12
Output in Fault Mode	Depends on Output type	500mA	

Table 30 – Proportional Output Setpoints

4.6. 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 11) are arbitrary and should be configured by the user as appropriate for their application.

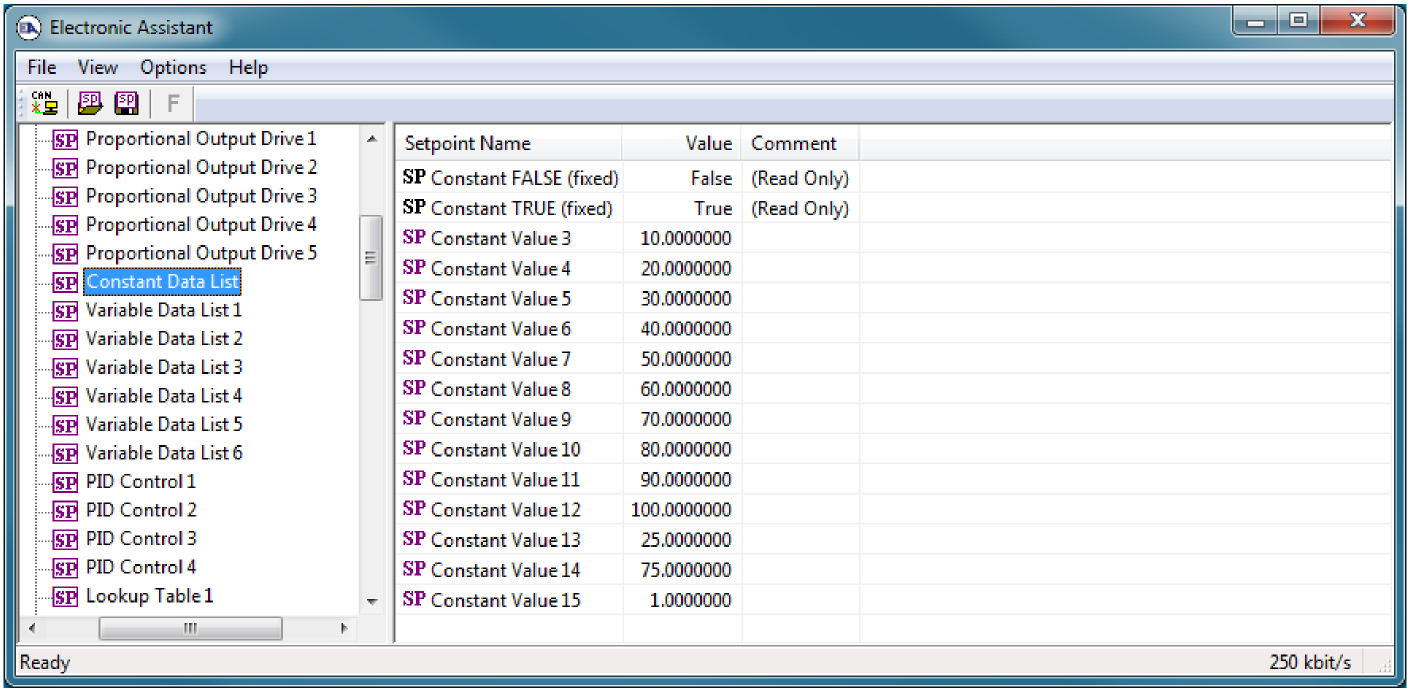


Figure 11 – Screen Capture of Constant Data List Setpoints

4.7. Variable Data List

The Variable Data Lists are defined in Section 1.5. Please refer there for detailed information about how these setpoints are used.

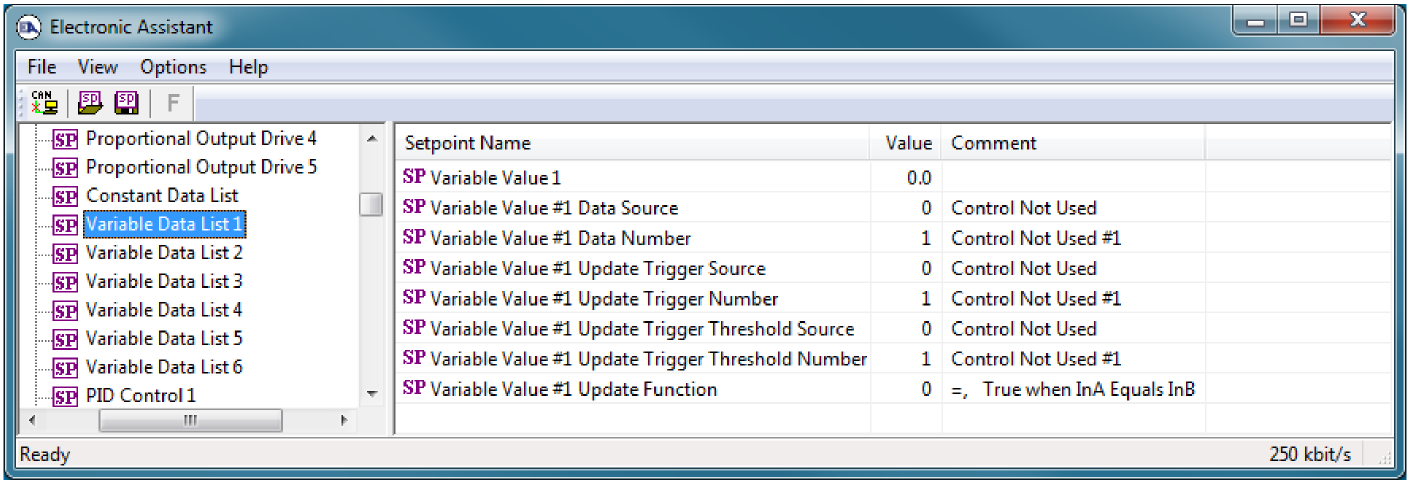


Figure 12 – Screen Capture of Variable Data Setpoints

Name	Range	Default	Notes
Variable Value		0	
Variable Value Data Source	Drop List	Control Not Used	See Table 24
Variable Value Data Number	Depends on control source	1	See Table 24
Variable Value Update Trigger Source	Drop List	Control Not Used	See Table 24
Variable Value Update Trigger Number	Depends on control source	1	See Table 24
Variable Value Update Trigger Threshold Source	Drop List	Control Not Used	See Table 24
Variable Value Update Trigger Threshold Number	Depends on control source	1	See Table 24
Variable Value Update Function	0…17	0	See Table 21

Table 31 – Variable Data Setpoints

4.8. PID Control

The PID Control Function Block is defined in Section 1.6. Please refer there for detailed information about how all these setpoints are used.

Command Source is set to '*Control Not Used'* by default. To enable a PID Control, select appropriate "**PID Target Command Source**" and "**PID Feedback Input Source**".

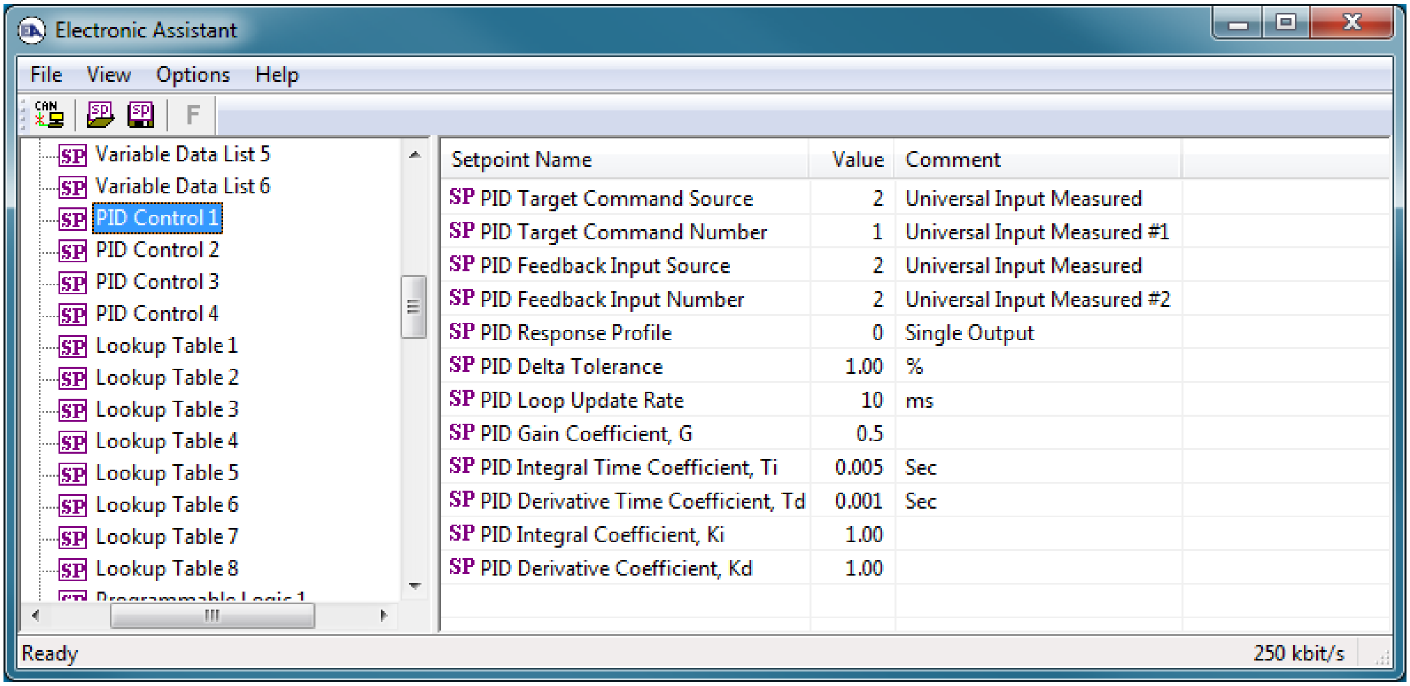


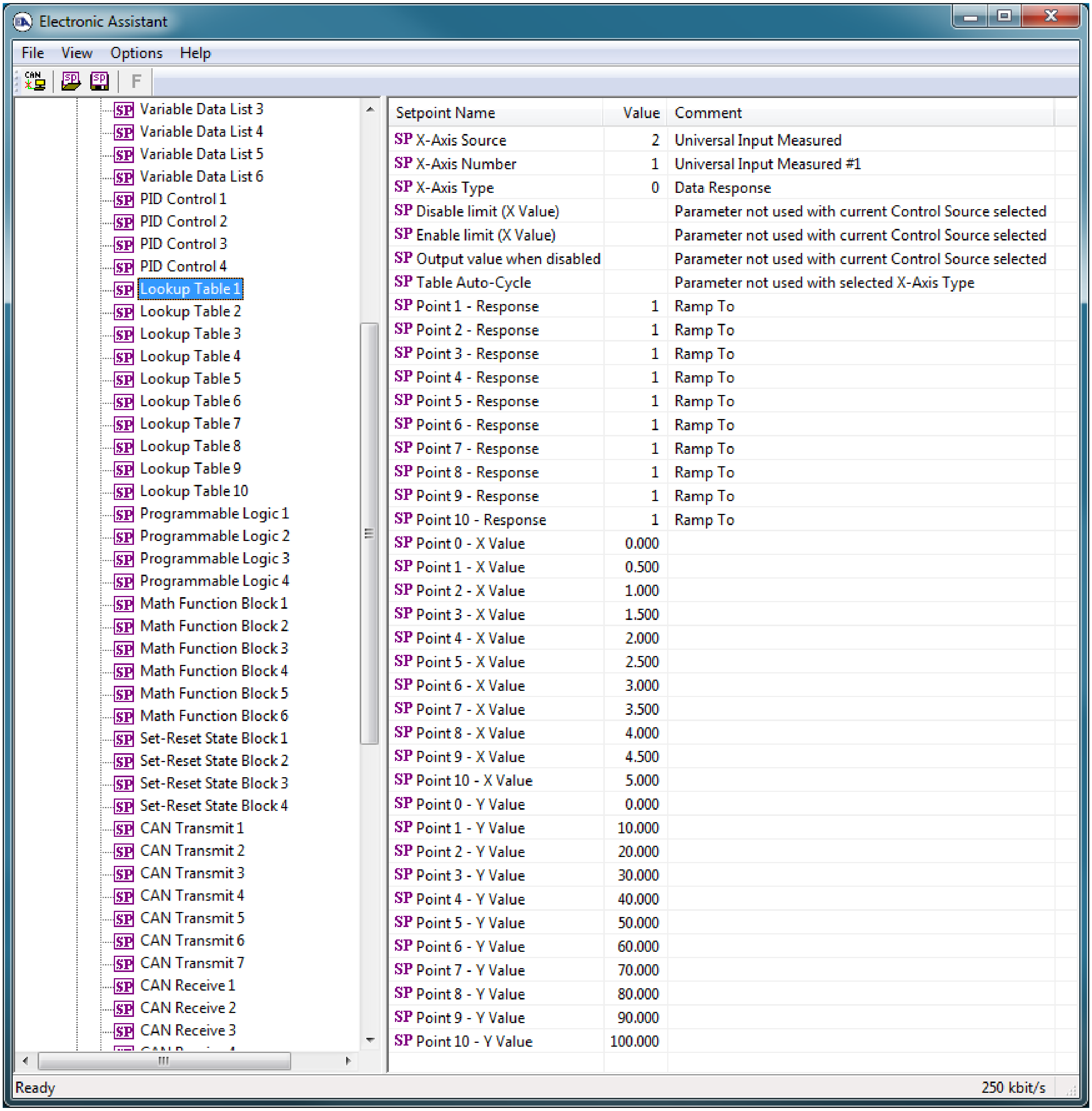
Figure 13 – Screen Capture of PID Control Setpoints

Name	Range	Default	Notes
PID Target Command Source	Drop List	Control Not Used	See Table 24
PID Target Command Number	Depends on control source	1	See Table 24
PID Feedback Input Source	Drop List	Control Not Used	See Table 24
PID Feedback Input Number	Depends on control source	1	See Table 24
PID Response Profile	Drop List	Single Output	See Table 16
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 32 – Programmable Logic Setpoints

4.9. Lookup Table

The Lookup Table Function Block is defined in Section 1.7 Please refer there for detailed information about how all these setpoints are used. “**X-Axis Source**” is set to ‘*Control Not Used*’ by default. To enable a Lookup Table select appropriate “**X-Axis Source**”.



Setpoint Name	Value	Comment
SP X-Axis Source	2	Universal Input Measured
SP X-Axis Number	1	Universal Input Measured #1
SP X-Axis Type	0	Data Response
SP Disable limit (X Value)		Parameter not used with current Control Source selected
SP Enable limit (X Value)		Parameter not used with current Control Source selected
SP Output value when disabled		Parameter not used with current Control Source selected
SP Table Auto-Cycle		Parameter not used with selected X-Axis Type
SP Point 1 - Response	1	Ramp To
SP Point 2 - Response	1	Ramp To
SP Point 3 - Response	1	Ramp To
SP Point 4 - Response	1	Ramp To
SP Point 5 - Response	1	Ramp To
SP Point 6 - Response	1	Ramp To
SP Point 7 - Response	1	Ramp To
SP Point 8 - Response	1	Ramp To
SP Point 9 - Response	1	Ramp To
SP Point 10 - Response	1	Ramp To
SP Point 0 - X Value	0.000	
SP Point 1 - X Value	0.500	
SP Point 2 - X Value	1.000	
SP Point 3 - X Value	1.500	
SP Point 4 - X Value	2.000	
SP Point 5 - X Value	2.500	
SP Point 6 - X Value	3.000	
SP Point 7 - X Value	3.500	
SP Point 8 - X Value	4.000	
SP Point 9 - X Value	4.500	
SP Point 10 - X Value	5.000	
SP Point 0 - Y Value	0.000	
SP Point 1 - Y Value	10.000	
SP Point 2 - Y Value	20.000	
SP Point 3 - Y Value	30.000	
SP Point 4 - Y Value	40.000	
SP Point 5 - Y Value	50.000	
SP Point 6 - Y Value	60.000	
SP Point 7 - Y Value	70.000	
SP Point 8 - Y Value	80.000	
SP Point 9 - Y Value	90.000	
SP Point 10 - Y Value	100.000	

Figure 14 – Screen Capture of Lookup table Setpoints

Name	Range	Default	Notes
X-Axis Source	Drop List	Control Not Used	See Table 24
X-Axis Number	Depends on control source	1	See Table 24
X-Axis Type	Drop List	Data Response	See Table 17
Disable limit (X Value)	From X-Axis source minimum to X-Axis source maximum	X-Axis source maximum 5.000	See Section 1.7
Enable limit (X Value)	From X-Axis source minimum to X-Axis source maximum	2.500	See Section 1.7
Output value when disabled	-10^6 to 10^6	0.000	See Section 1.7
Table Auto-Cycle	Drop List	0	
Point 1 - Response	Drop List	Ramp To	See Table 18
Point 2 - Response	Drop List	Ramp To	See Table 18
Point 3 - Response	Drop List	Ramp To	See Table 18
Point 4 - Response	Drop List	Ramp To	See Table 18
Point 5 - Response	Drop List	Ramp To	See Table 18
Point 6 - Response	Drop List	Ramp To	See Table 18
Point 7 - Response	Drop List	Ramp To	See Table 18
Point 8 - Response	Drop List	Ramp To	See Table 18
Point 9 - Response	Drop List	Ramp To	See Table 18
Point 10 - Response	Drop List	Ramp To	See Table 18
Point 0 - X Value	From X-Axis source minimum to Point 1 - X Value	X-Axis source minimum 0.000	See Section 1.7
Point 1 - X Value	From Point 0 - X Value to Point 2 - X Value	0.500	See Section 1.7
Point 2 - X Value	From Point 1 - X Value to Point 3 - X Value	1.000	See Section 1.7
Point 3 - X Value	From Point 2 - X Value to Point 4 - X Value	1.500	See Section 1.7
Point 4 - X Value	From Point 3 - X Value to Point 5 - X Value source	2.000	See Section 1.7
Point 5 - X Value	From Point 4 - X Value to Point 6 - X Value	2.500	See Section 1.7
Point 6 - X Value	From Point 5 - X Value to Point 7 - X Value	3.000	See Section 1.7
Point 7 - X Value	From Point 6 - X Value to Point 8 - X Value	3.500	See Section 1.7
Point 8 - X Value	From Point 7 - X Value to Point 9 - X Value	4.000	See Section 1.7
Point 9 - X Value	From Point 8 - X Value to Point 10 - X Value	4.500	See Section 1.7
Point 10 - X Value	From Point 9 - X Value to X-Axis source maximum	X-Axis source maximum 5.000	See Section 1.7
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 33 – Lookup Table Setpoints

4.10. Programmable Logic

The Programmable Logic function block is defined in Section 1.8. 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**".

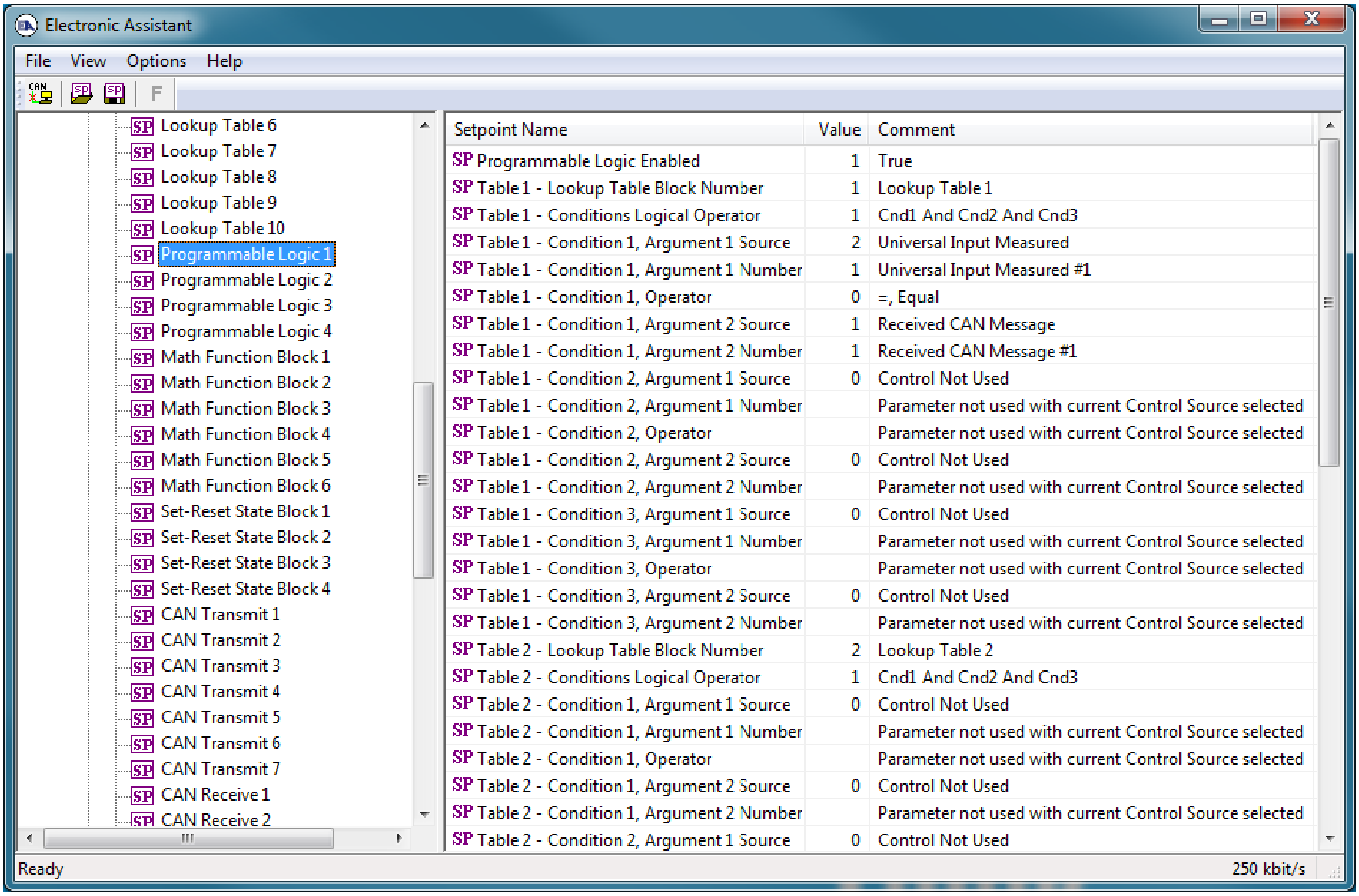


Figure 15 – Screen Capture of Programmable Logic Setpoints

Setpoint ranges and default values for Programmable Logic Blocs are listed in Table 34. 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**".

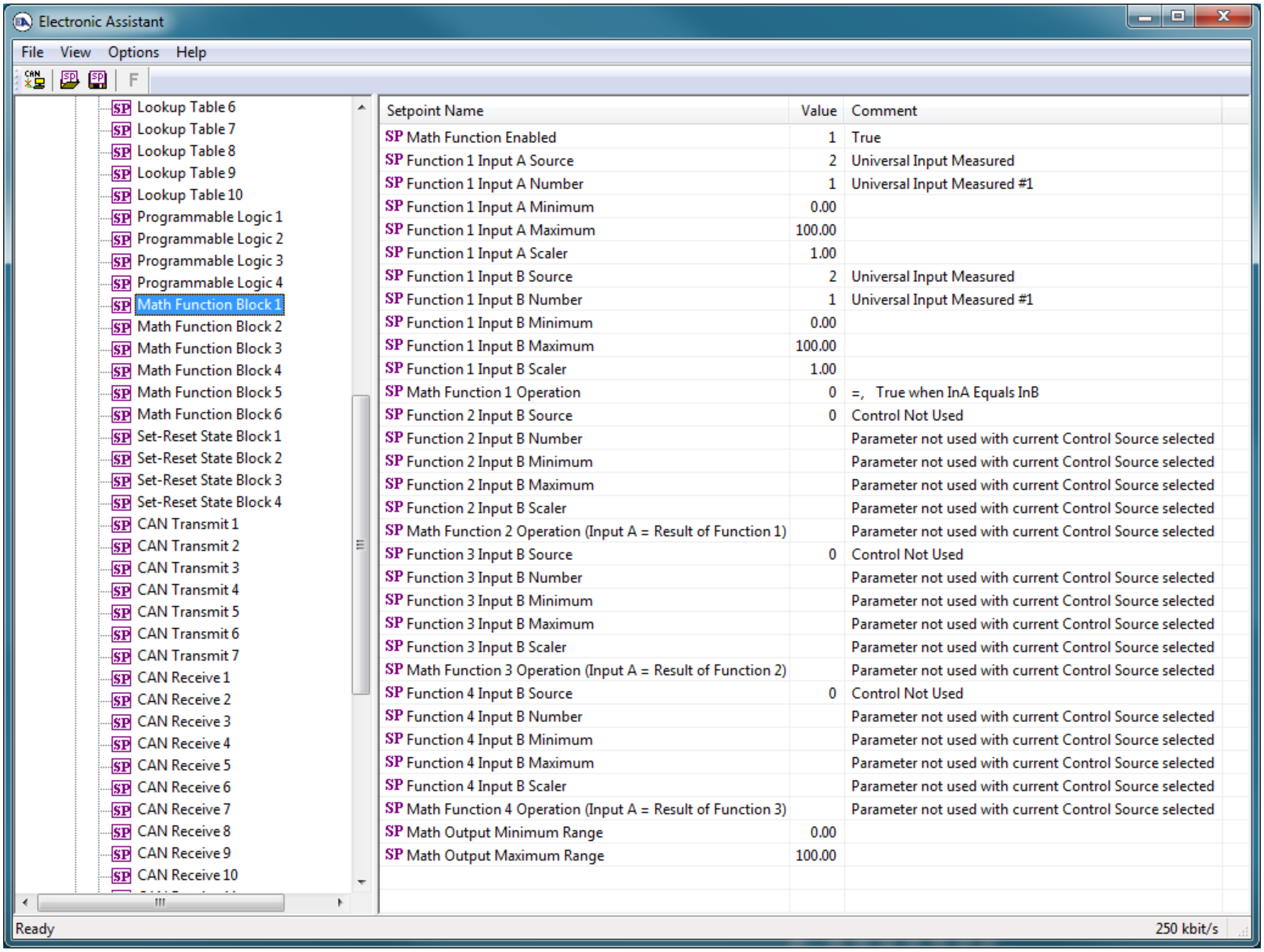
Name	Range	Default	Notes
Programmable Logic Enabled	Drop List	False	
Table1 - Lookup Table Block Number	1 to 8	Look up Table 1	
Table1 - Conditions Logical Operation	Drop List	Default Table	See Table 20
Table1 - Condition1, Argument 1 Source	Drop List	Control Not Used	See Table 24
Table1 - Condition1, Argument 1 Number	Depends on control source	1	See Table 24
Table1 - Condition1, Operator	Drop List	=, Equal	See Table 19
Table1 - Condition1, Argument 2 Source	Drop List	Control Not Used	See Table 24
Table1 - Condition1, Argument 2 Number	Depends on control source	1	See Table 24
Table1 - Condition2, Argument 1 Source	Drop List	Control Not Used	See Table 24
Table1 - Condition2, Argument 1 Number	Depends on control source	1	See Table 24
Table1 - Condition2, Operator	Drop List	=, Equal	See Table 19

Table1 - Condition2, Argument 2 Source	Drop List	Control Not Used	See Table 24
Table1 - Condition2, Argument 2 Number	Depends on control source	1	See Table 24
Table1 - Condition3, Argument 1 Source	Drop List	Control Not Used	See Table 24
Table1 - Condition3, Argument 1 Number	Depends on control source	1	See Table 24
Table1 - Condition3, Operator	Drop List	=, Equal	See Table 19
Table1 - Condition3, Argument 2 Source	Drop List	Control Not Used	See Table 24
Table1 - Condition3, Argument 2 Number	Depends on control source	1	See Table 24

Table 34 – Programmable Logic Setpoints

4.11. Math Function Block

The Math Function Block is defined in Section 1.9. Please refer there for detailed information about how all these setpoints are used. “**Math Function Enabled**” is ‘False’ by default. To enable a Math function Block, set “**Math Function Enabled**” to ‘True’ and select appropriate “**Input Source**”.



Setpoint Name	Value	Comment
SP Math Function Enabled	1	True
SP Function 1 Input A Source	2	Universal Input Measured
SP Function 1 Input A Number	1	Universal Input Measured #1
SP Function 1 Input A Minimum	0.00	
SP Function 1 Input A Maximum	100.00	
SP Function 1 Input A Scaler	1.00	
SP Function 1 Input B Source	2	Universal Input Measured
SP Function 1 Input B Number	1	Universal Input Measured #1
SP Function 1 Input B Minimum	0.00	
SP Function 1 Input B Maximum	100.00	
SP Function 1 Input B Scaler	1.00	
SP Math Function 1 Operation	0	=, True when InA Equals InB
SP Function 2 Input B Source	0	Control Not Used
SP Function 2 Input B Number		Parameter not used with current Control Source selected
SP Function 2 Input B Minimum		Parameter not used with current Control Source selected
SP Function 2 Input B Maximum		Parameter not used with current Control Source selected
SP Function 2 Input B Scaler		Parameter not used with current Control Source selected
SP Math Function 2 Operation (Input A = Result of Function 1)		Parameter not used with current Control Source selected
SP Function 3 Input B Source	0	Control Not Used
SP Function 3 Input B Number		Parameter not used with current Control Source selected
SP Function 3 Input B Minimum		Parameter not used with current Control Source selected
SP Function 3 Input B Maximum		Parameter not used with current Control Source selected
SP Function 3 Input B Scaler		Parameter not used with current Control Source selected
SP Math Function 3 Operation (Input A = Result of Function 2)		Parameter not used with current Control Source selected
SP Function 4 Input B Source	0	Control Not Used
SP Function 4 Input B Number		Parameter not used with current Control Source selected
SP Function 4 Input B Minimum		Parameter not used with current Control Source selected
SP Function 4 Input B Maximum		Parameter not used with current Control Source selected
SP Function 4 Input B Scaler		Parameter not used with current Control Source selected
SP Math Function 4 Operation (Input A = Result of Function 3)		Parameter not used with current Control Source selected
SP Math Output Minimum Range	0.00	
SP Math Output Maximum Range	100.00	

Figure 16 – Screen Capture of Math Function Block Setpoints

Name	Range	Default	Notes
Math Function Enabled	Drop List	False	
Function 1 Input A Source	Drop List	Control not used	See Table 24
Function 1 Input A Number	Depends on control source	1	See Table 24
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 24
Function 1 Input B Number	Depends on control source	1	See Table 24
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 21
Function 2 Input B Source	Drop List	Control not used	See Table 24
Function 2 Input B Number	Depends on control source	1	See Table 24
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 21
Function 3 Input B Source	Drop List	Control not used	See Table 24
Function 3 Input B Number	Depends on control source	1	See Table 24
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 21
Function 4 Input B Source	Drop List	Control not used	See Table 24
Function 4 Input B Number	Depends on control source	1	See Table 24
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 21
Math Output Minimum Range	-10^6 to 10^6	0.0	
Math Outptu Maximum Range	-10^6 to 10^6	100.0	

Table 35 – Math Function Setpoints

4.12. Set-Reset state Setpoints

The Set-Reset State Block is defined in Section 1.10. Please refer there for detailed information about how all these setpoints are used. "**Block Enabled**" is 'False' by default. To enable a Set-Reset State Block, set "**Block Enabled**" to 'True' and select appropriate "**Reset Source**" and "**Set Source**".

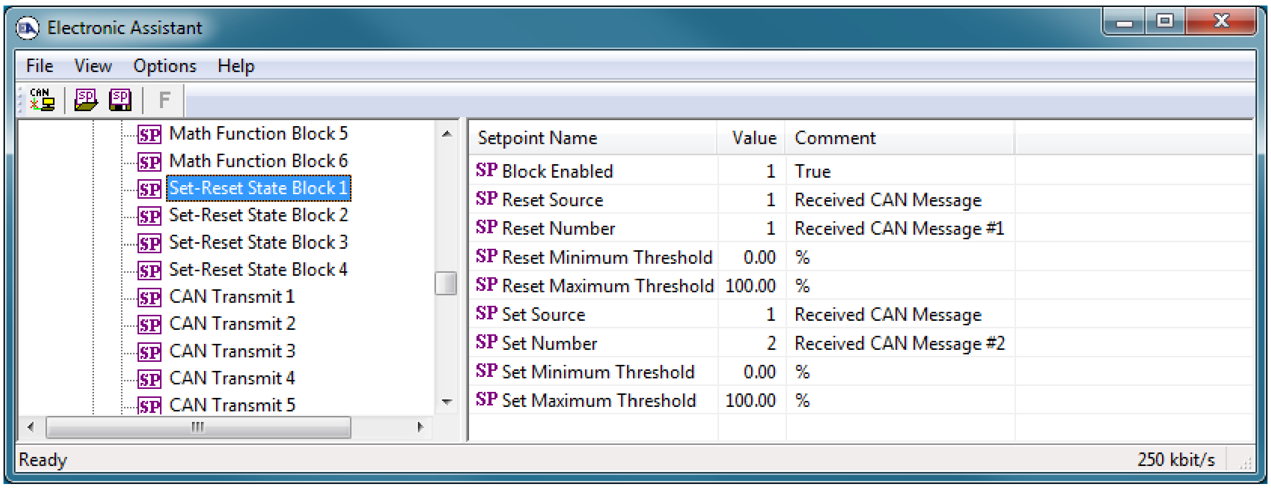


Figure 17 – Screen Capture of Set-Reset State Block Setpoints

Name	Range	Default	Notes
Block Enabled	Drop List	False	
Reset Source	Drop List	Control not used	
Reset Number	Drop List	Control not used #1	See Table 24
Reset Minimum Threshold	0..100	0%	
Reset Maximum Threshold	0..100	100%	
Set Source	Drop List	Control not used	
Set Number	Drop List	Control not used #1	See Table 24
Set Minimum Threshold	0..100	0%	
Set Maximum Threshold	0..100	100%	

Table 36 – Set-Reset State Block Setpoints

4.13. CAN Transmit Setpoints

CAN Transmit Message Function Block is presented in Section 1.11. Please refer there for detailed information how these setpoints are used. "**Transmit Repetition Rate**" is 0ms by default, thus no message will be sent.

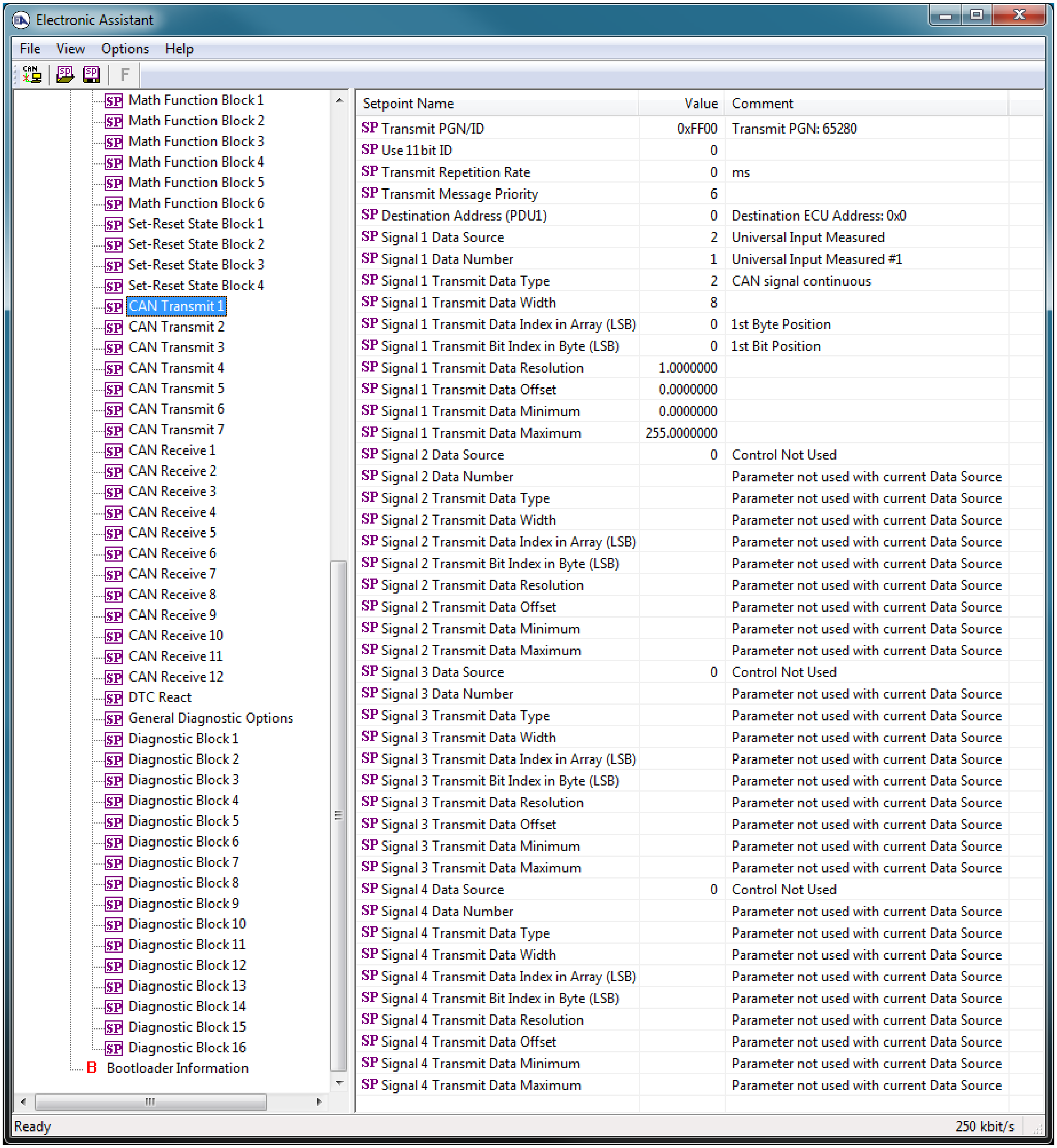


Figure 18 – Screen Capture of CAN Transmit Message Setpoints

Name	Range	Default	Notes
Transmit PGN/ID	0xff00 … 0xffff	Different for each	See Section 1.11.1
Use 11bit ID	Drop List	False	
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	Signal undefined	See Table 24
Signal 1 Control Number	Drop List	Signal undefined	See 1.11.2
Signal 1 Transmit Data Type	Drop List	CAN signal continuous	
Signal 1 Transmit Data Width	1-32	8	
Signal 1 Transmit Data Index in Array	0-7	0	
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 1 Transmit Data Minimum	-1000000 to Max	0.0	
Signal 1 Transmit Data Maximum	Min to 100000	2.5	
Signal 2 Control Source	Drop List	Signal undefined	See Table 24
Signal 2 Control Number	Drop List	Signal undefined	See 1.11.2
Signal 2 Transmit Data Type	Drop List	CAN signal continuous	
Signal 2 Transmit Data Width	1-32	8	
Signal 2 Transmit Data Index in Array	0-7	1	
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 2 Transmit Data Minimum	-1000000 to Max	0.0	
Signal 2 Transmit Data Maximum	Min to 100000	2.5	
Signal 3 Control Source	Drop List	Signal undefined	See Table 24
Signal 3 Control Number	Drop List	Signal undefined	See 1.11.2
Signal 3 Transmit Data Type	Drop List	CAN signal continuous	
Signal 3 Transmit Data Width	1-32	8	
Signal 3 Transmit Data Index in Array	0-7	2	
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 3Transmit Data Minimum	-1000000 to Max	0.0	
Signal 3 Transmit Data Maximum	Min to 100000	2.5	
Signal 4 Control Source	Drop List	Signal undefined	See Table 24
Signal 4 Control Number	Drop List	Signal undefined	See 1.11.2
Signal 4 Transmit Data Type	Drop List	CAN signal continuous	
Signal 4 Transmit Data Width	1-32	8	
Signal 4 Transmit Data Index in Array	0-7	3	
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	
Signal 4 Transmit Data Minimum	-1000000 to Max	0.0	
Signal 4 Transmit Data Maximum	Min to 100000	2.5	

Table 37 – CAN Transmit Message Setpoints

4.14. CAN Receive Setpoints

The Math Function Block is defined in Section 1.12. 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.

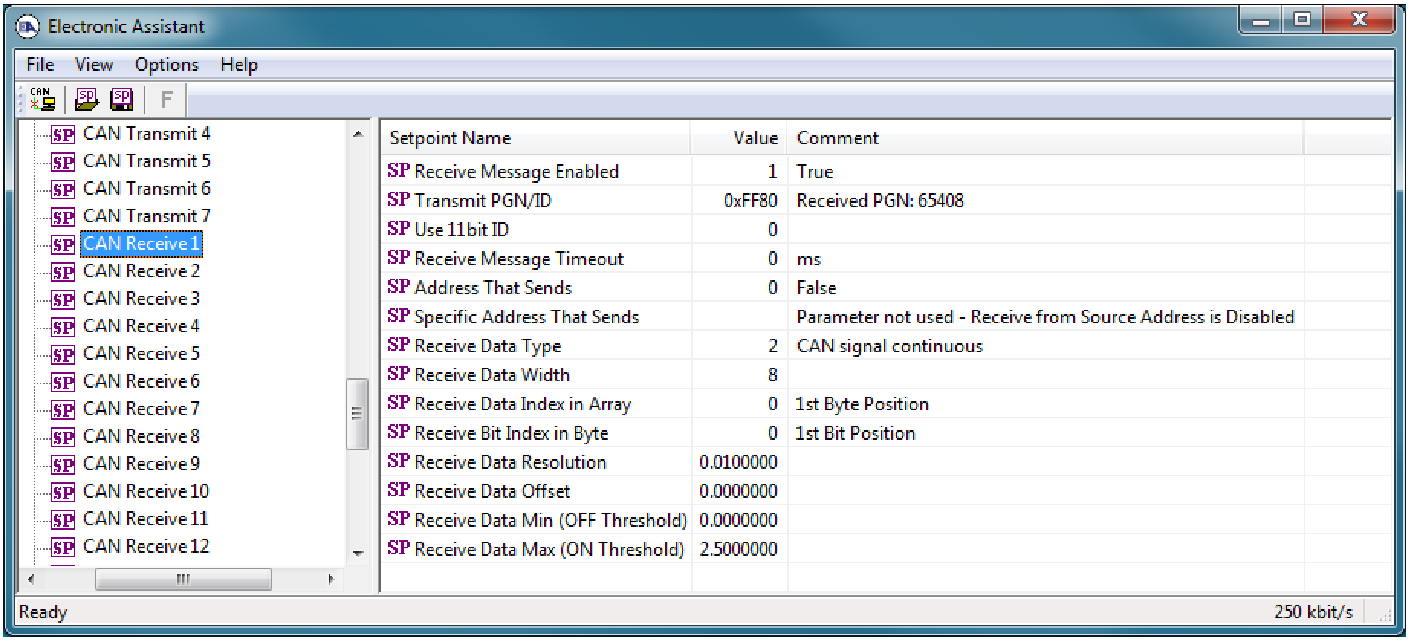


Figure 19 – Screen Capture of CAN Receive Message Setpoints

Name	Range	Default	Notes
Received Message Enabled	Drop List	False	
Received PGN/ID	0 to 65536	Different for each	
Use 11bit ID	Drop List	False	
Received Message Timeout	0 to 60 000 ms	0ms	
Address That Sends	Drop List	False	
Specific Address That Sends	0 to 255	0x00	
Receive Data Type	Drop List	CAN signal continuous	
Receive Data Width	1-32	8	
Receive Data Index in Array	0-7	0	
Receive Bit Index In Byte	0-7	0	
Receive Data Resolution	-100000.0 to 100000	0.01	
Receive 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	2.5	

Table 38 – CAN Receive Setpoints

4.15. DTC React

The DTC React Function Block is defined in Section 1.13. Please refer there for detailed information about how these setpoints are used.

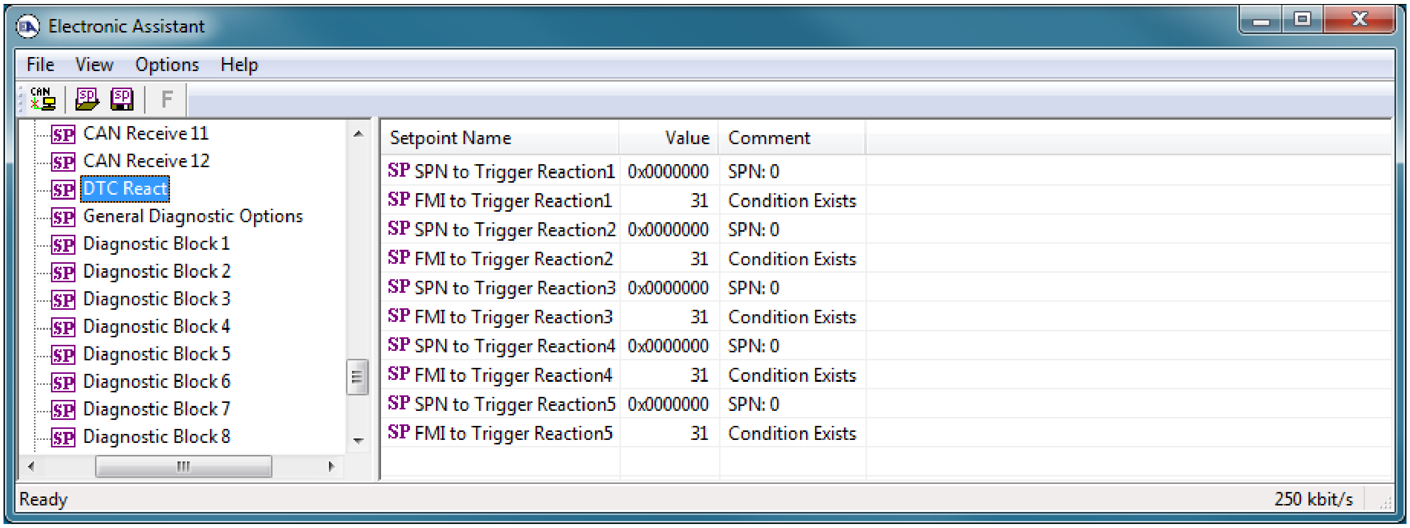


Figure 20 – Screen Capture of DTC React Setpoints

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 39 – DTC React Setpoints

4.16. General Diagnostics Options

These setpoints control the shutdown of the ECU in case of a power supply or CPU temperature related errors. Refer to section 1.4 for more info.

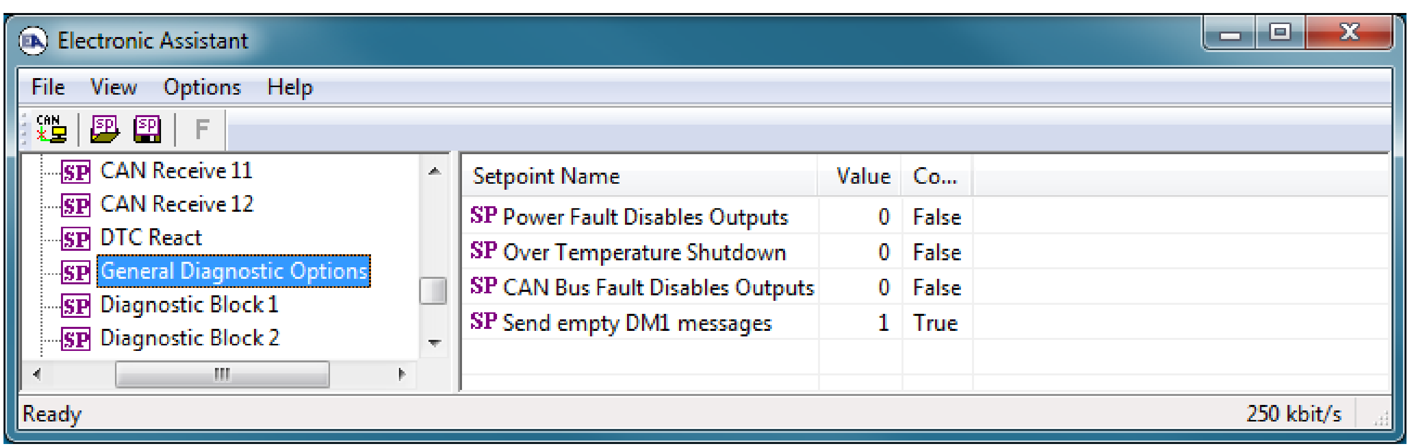


Figure 21 – Screen Capture of General Diagnostics Options Setpoints

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

Table 40 – General Diagnostics Options Setpoints

4.17. Diagnostics 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.

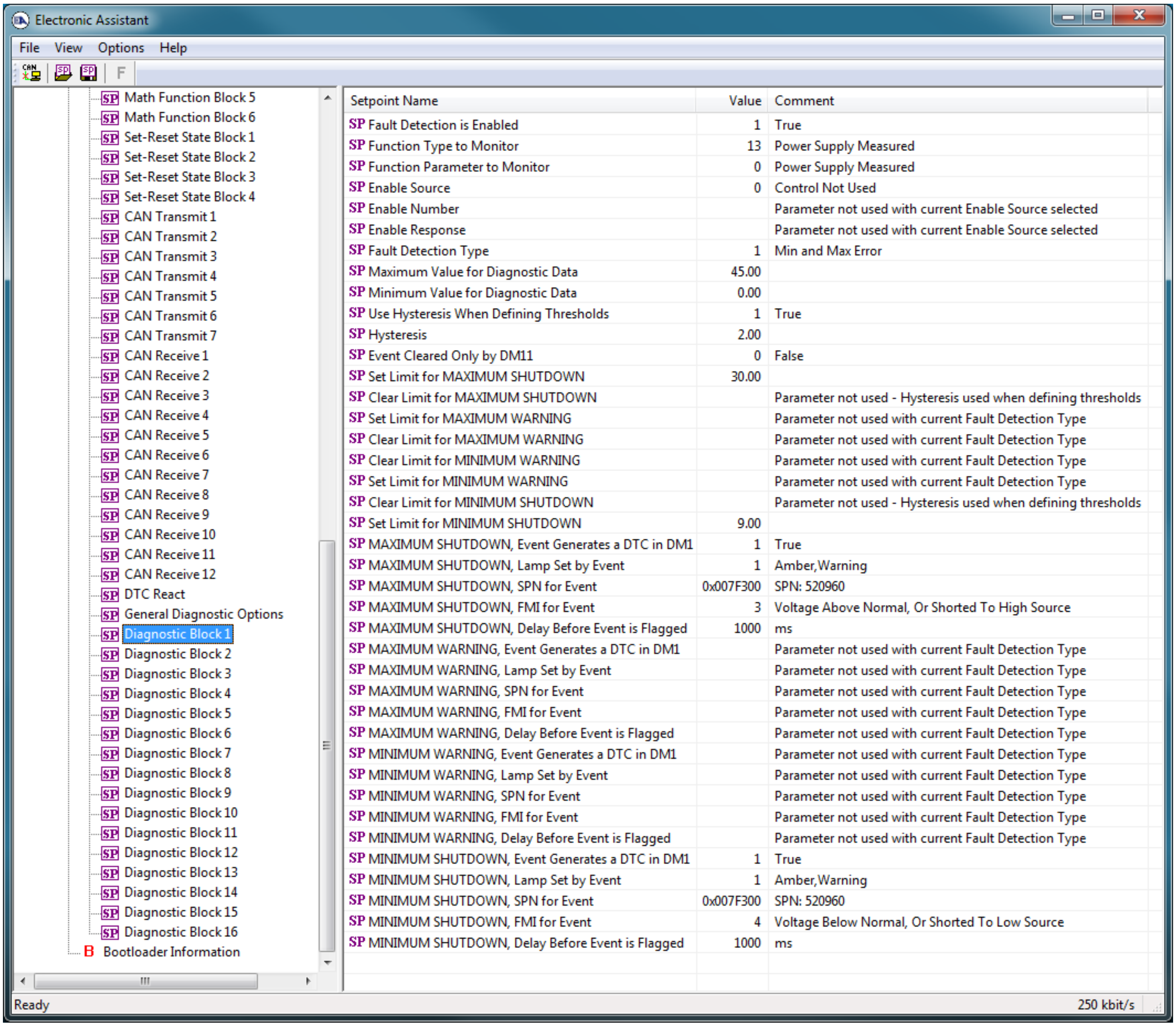


Figure 22 – Screen Capture of Diagnostic Block Setpoint

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 13
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 14

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 13
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 14
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 13
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 14
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 13
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 14
MINIMUM SHUTDOWN, Delay Before Event is Flagged	0...60000 ms	1000	

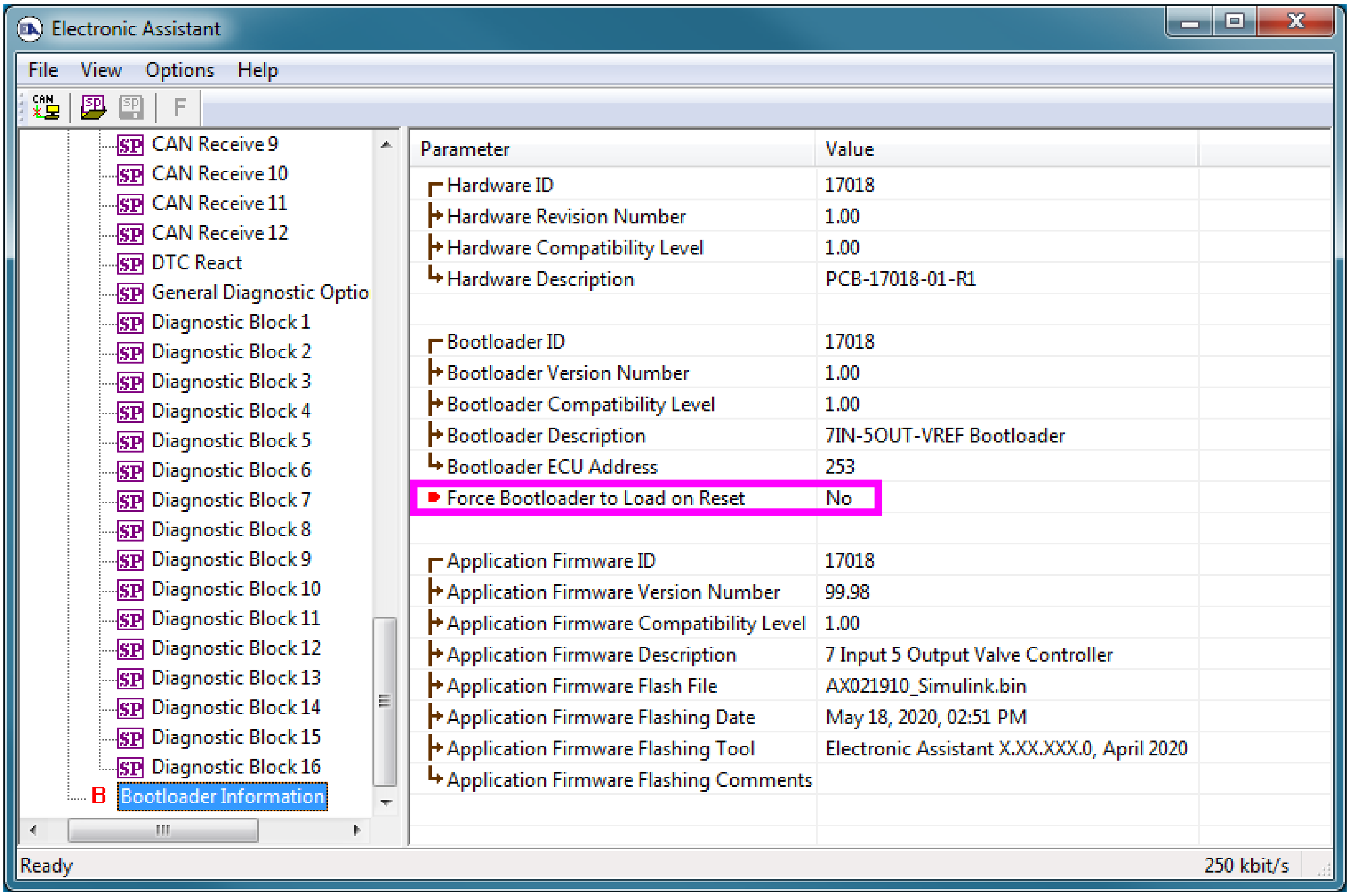
Table 41 – Diagnostic Block Setpoints

5. REFLASHING OVER CAN WITH THE AXIOMATIC EA BOOTLOADER

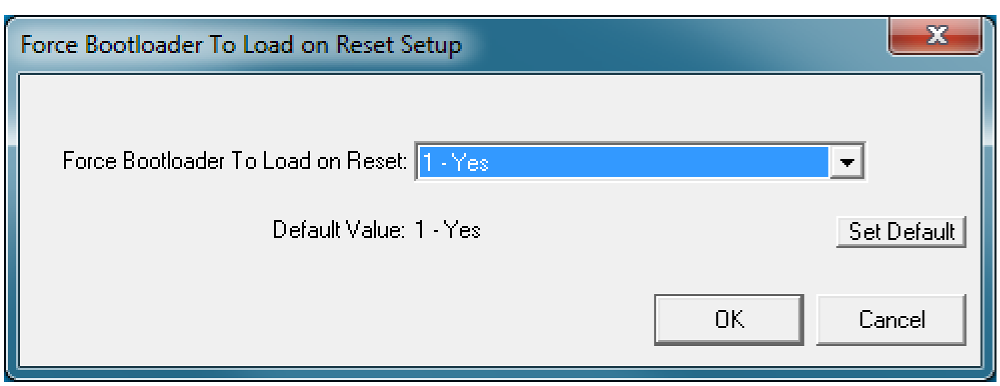
The AX020530 can be upgraded with new application firmware using the **Bootloader Information** section. This section details the simple step-by-step instructions to upload new firmware provided by Axiomatic onto the unit via CAN, without requiring it to be disconnected from the J1939 network.

Note: To upgrade the firmware use Axiomatic Electronic Assistant V 5.15.126 *or higher.*

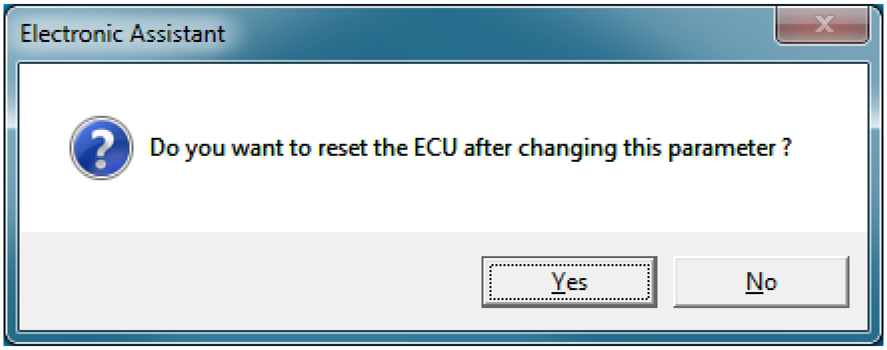
1. When the Axiomatic EA first connects to the ECU, the **Bootloader Information** section will display the following information.



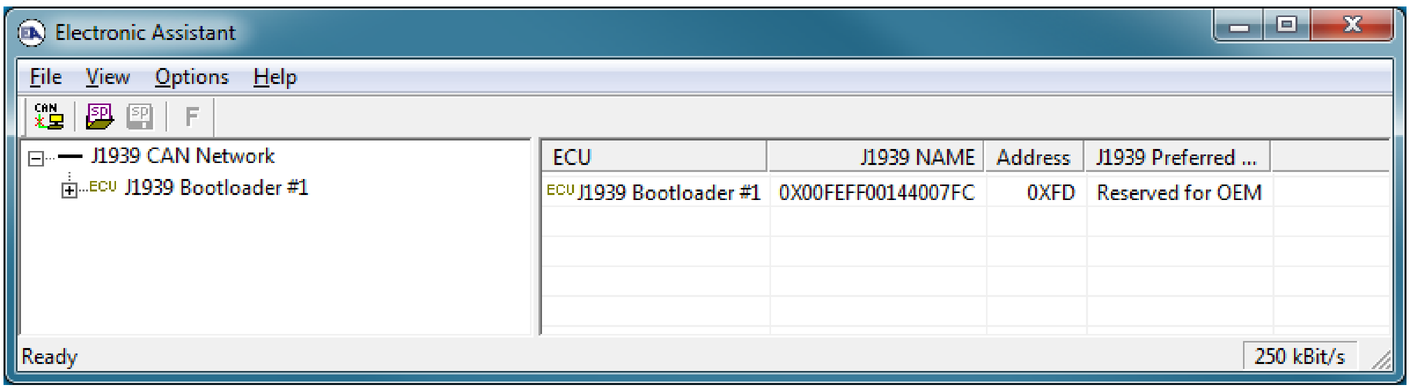
2. To use the bootloader to upgrade the firmware running on the ECU, change the variable **"Force Bootloader To Load on Reset**" to *Yes.*

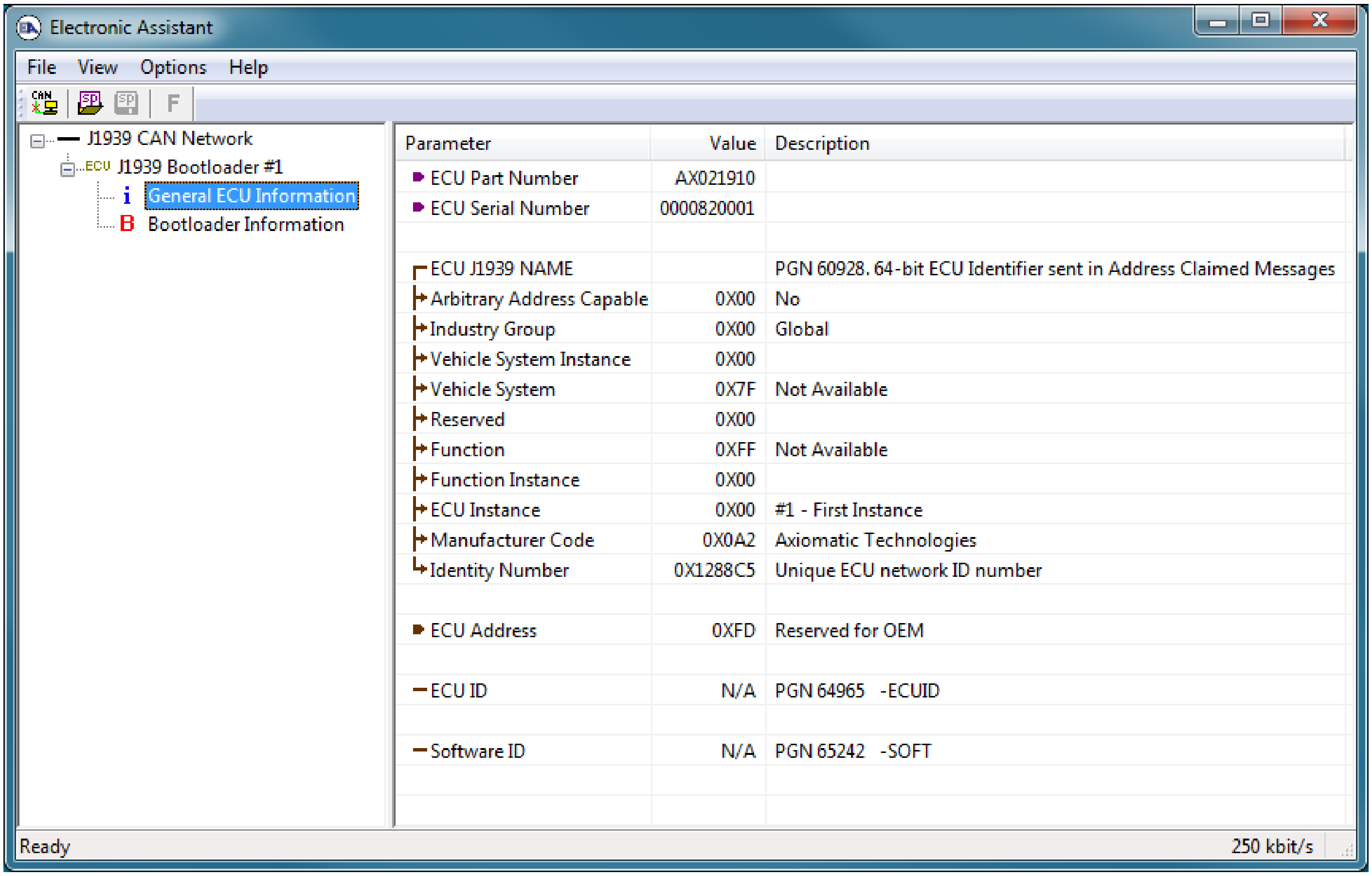


3. When the prompt box asks if you want to reset the ECU, select *Yes*.



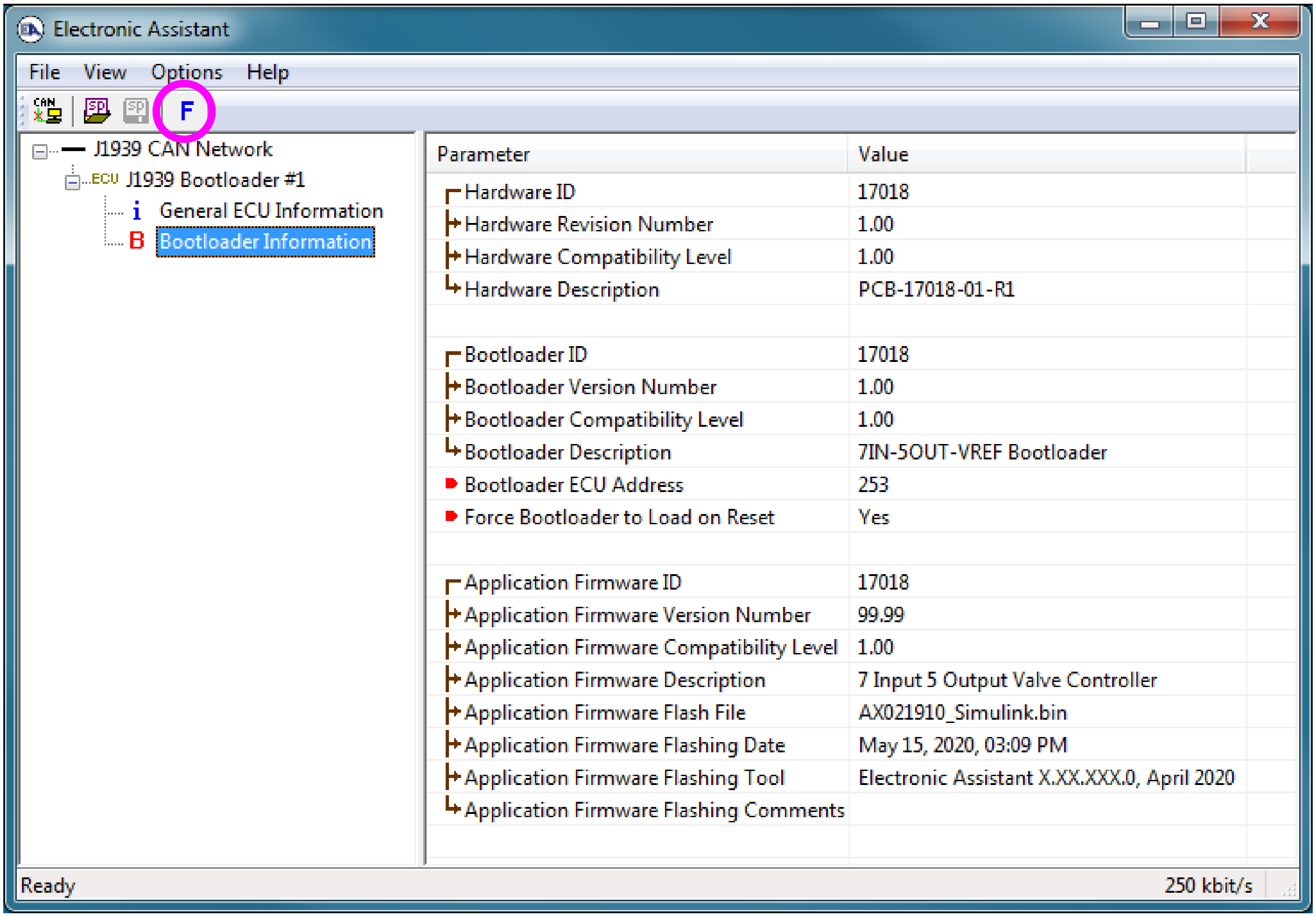
4. Upon reset, the ECU will no longer show up on the J1939 network as an AX020530 but rather as **J1939 Bootloader #1**.





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.

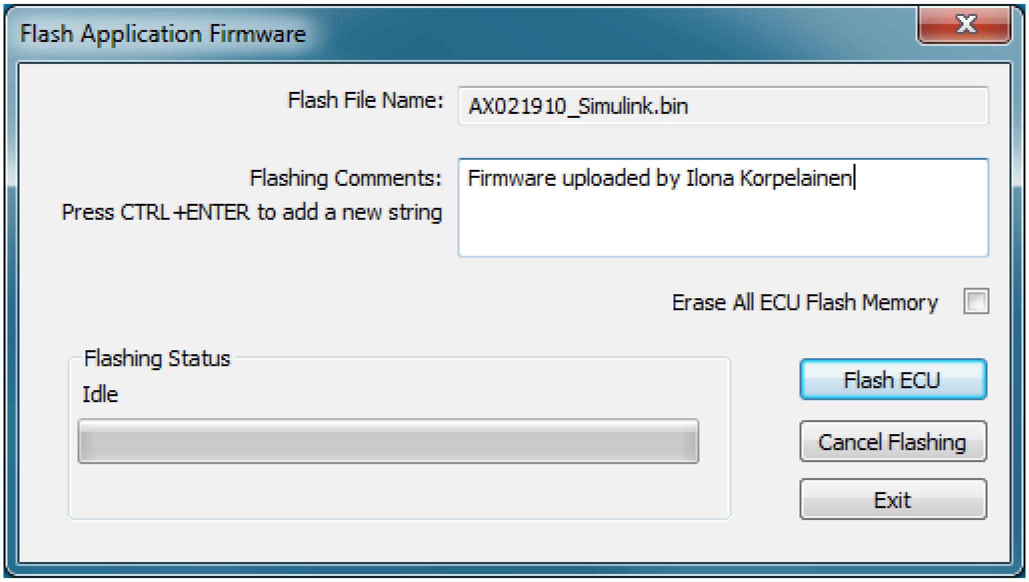
5. When the **Bootloader Information** section is selected, the same information is shown as when it was running the AX020530 firmware, but in this case the **F**lashing feature has been enabled.



6. Select the **F**lashing button and navigate to where you had saved the **AX020530_Simulink.bin** file sent from Axiomatic. (Note: only binary (.bin) files can be flashed using the Axiomatic EA tool.)

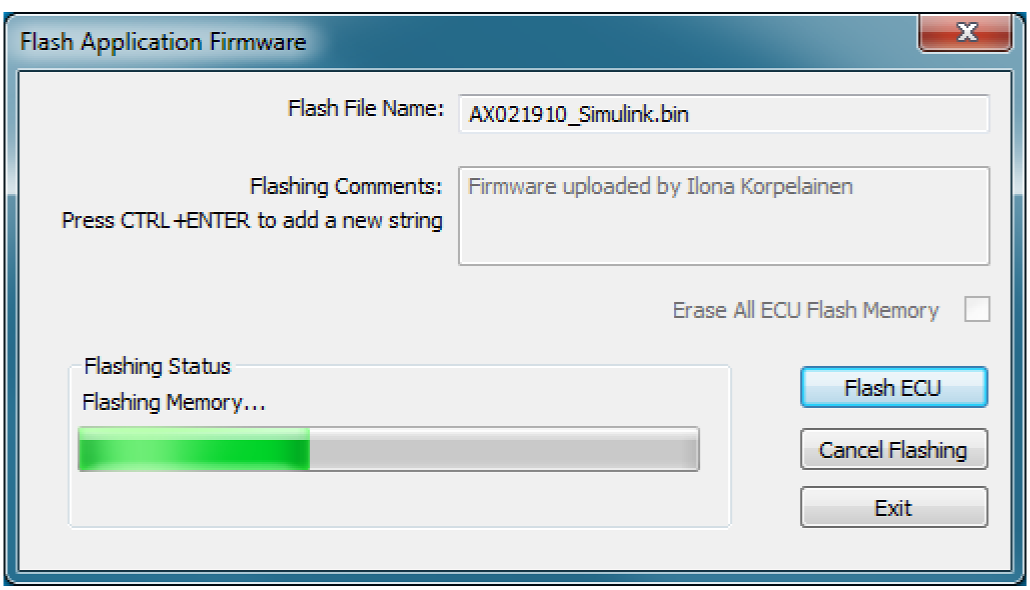
7. Once the Flash Application Firmware window opens, you can enter comments such as “Firmware upgraded by [Name]” if you so desire. This is not required, and you can leave the field blank if you do not want to use it.

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

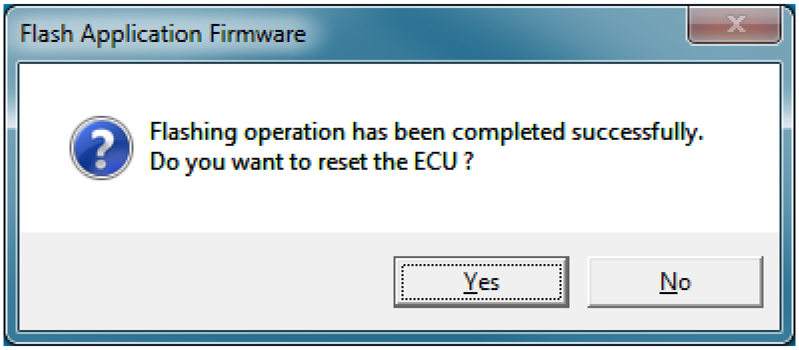


WARNING: Do not check the “Erase All ECU Flash Memory” box unless instructed to do so by your Axiomatic contact. Selecting this will erase ALL data stored in non-volatile flash including the calibration from Axiomatic factory testing. It will also erase any configuration of the setpoints that might have 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 AX020530 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 AX020530 application will run rather than the bootloader function.



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

APPENDIX A - TECHNICAL SPECIFICATION

Technical Specifications:

Specifications are indicative and subject to change. Actual performance will vary depending on the application and operating conditions. Users should satisfy themselves that the product is suitable for use in the intended application. All our products carry a limited warranty against defects in material and workmanship. Please refer to our Warranty, Application Approvals/ Limitations and Return Materials Process as described on https://www.axiomatic.com/service/.

Input

<table>
<tr><td>Power Supply Input</td><td>12 or 24VDC nominal (8 to 36 VDC range)
Note: The maximum total current draw permitted on the power supply input pins is
7.5 A @ 24 VDC, at one time.</td></tr>
<tr><td>Quiescent Current Draw</td><td>97 mA @ 12 VDC; 59 mA @ 24 VDC Typical</td></tr>
<tr><td>Reverse Polarity Protection</td><td>Provided up to 80 VDC</td></tr>
<tr><td>Surge and Transient Protection</td><td>Provided</td></tr>
<tr><td>Under-Voltage Protection</td><td>Provided (hardware shutdown @ 6 V)</td></tr>
<tr><td>Over-Voltage Protection</td><td>Provided (hardware shutdown @ 41 V)</td></tr>
<tr><td>All Inputs</td><td>Up to 7 inputs are selectable by the user from the following.
4 voltage, current, resistive, frequency, PWM, or digital
1 Magnetic Pick-Up sensor
2 PWM signal
All inputs, except for frequency and counter, are sampled every 10 ms.</td></tr>
<tr><td>Magnetic Pick-Up Sensor Input</td><td>1 input is configurable as the following.
Frequency range: 0.5 Hz to 20000 Hz
Amplitude: 100 mVAC to 100 VAC (RMS)</td></tr>
<tr><td>Minimum and Maximum Ratings</td><td>
<table>
<tr><th colspan="4">Table 1.0. Absolute Maximum and Minimum Ratings</th></tr>
<tr><th>Characteristic</th><th>Min</th><th>Max</th><th>Units</th></tr>
<tr><td>Power Supply</td><td>8</td><td>36</td><td>VDC</td></tr>
<tr><td>Voltage Input</td><td>0</td><td>36</td><td>VDC</td></tr>
<tr><td>Current Input</td><td>0</td><td>21</td><td>mA</td></tr>
<tr><td>Current Input – Voltage Level</td><td>0</td><td>12</td><td>VDC</td></tr>
<tr><td>Digital Type Input – Voltage Level</td><td>0</td><td>36</td><td>VDC</td></tr>
<tr><td>PWM Duty Cycle</td><td>0</td><td>100</td><td>%</td></tr>
<tr><td>PWM Frequency</td><td>1</td><td>20 000</td><td>Hz</td></tr>
<tr><td>PWM Voltage pk-pk</td><td>0</td><td>36</td><td>VDC</td></tr>
<tr><td>RPM Frequency</td><td>1</td><td>20 000</td><td>Hz</td></tr>
</table>
</td></tr>
<tr><td>Input Impedance</td><td>Voltage: 0-5 V range: 204 kΩ
0-10 V range: 136 kΩ

Current: 124 Ω

Resistive: 2 GΩ

PWM/Frequency/RPM: 1 MΩ</td></tr>
<tr><td>Input Accuracy and Resolution</td><td>
<table>
<tr><th colspan="3">Table 2.0. Input Accuracy</th></tr>
<tr><th>Input Type</th><th>Accuracy</th><th>Resolution</th></tr>
<tr><td>Voltage</td><td>±1%</td><td>1 mV</td></tr>
<tr><td>Current</td><td>±4%</td><td>1 µA</td></tr>
<tr><td>Resistive</td><td>±12%</td><td>0.1%</td></tr>
<tr><td>PWM</td><td>±0.16% (<5kHz)
±1% (>5kHz)</td><td>0.01%</td></tr>
<tr><td>Frequency/RPM</td><td>±1.5%</td><td>0.01%</td></tr>
</table>
</td></tr>
<tr><td>Analog Ground</td><td>1 analog ground connection is provided.</td></tr>
<tr><td>Reference Voltages</td><td>1 +5 V, 100 mA maximum
Regulation at ±0.5% accuracy is provided.</td></tr>
</table>

Output

<table>
<tr><td>All Outputs</td><td>High side (sourcing) up to 2.5 A
Half-bridge output, current sensing, grounded load
High frequency PWM

5 independent outputs (0 to 2.5 A) are user selectable as:
Disabled output
Proportional current (See Table 3.0)
Hotshot digital
PWM duty cycle (Outputs 1 to 4 run on the same output frequency. Output 5 can have a different frequency setting.)
Proportional voltage
On/off digital (Normal, inverse, latched, blinking logic are selectable.)
Outputs 1 & 3 share a timer, so they run on the same frequency.
Outputs 2 & 4 share a timer and run on the same frequency.

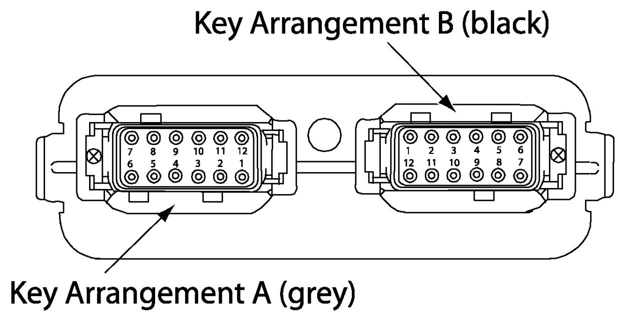
Current outputs: 1 mA resolution
Voltage outputs: 0.1 V resolution
PWM outputs: 0.1% resolution
Digital on/off: Sourcing from power supply or output off
(Note: Load at supply voltage must not draw more than 2.5 A)

Note: The maximum total current draw permitted on the power supply input pins is
7.5 A @ 24 VDC, at one time.
<table>
<tr><th colspan="2">Table 3.0: Proportional Output Adjustments</th></tr>
<tr><th>Adjustable Parameter</th><th>Description</th></tr>
<tr><td>Output Current Adjustments</td><td>0 to Imax (2.5 A)
Both minimum and maximum current settings are user configurable.</td></tr>
<tr><td>Superimposed Dither</td><td>Dither adjustments are configurable for each channel.
<u>Dither Amplitude</u>:
0 mA (factory default)
Adjustable from 0-500 mA
<u>Dither Frequency</u>:
200 Hz (factory default)
Adjustable from 50-400 Hz
Note: Outputs 1 to 4 run on the same dither frequency.</td></tr>
<tr><td>Ramp Rates</td><td>Ramp adjustments are configurable for each channel.
1,000 ms (default)
Adjustable from 0 to 10,000 ms</td></tr>
</table></td></tr>
<tr><td>Output Accuracy</td><td>Current outputs ±0.01%
Voltage outputs ±0.01%
PWM outputs ±0.02%</td></tr>
<tr><td>Protection</td><td>Overcurrent protection is provided on all outputs.
Short circuit protection is provided all outputs.</td></tr>
<tr><td>Error Conditions</td><td>If an error on the input is detected, the output of the controller shuts off.</td></tr>
</table>

General Specifications

Microcontroller	STM32F427VIT7
Communication	1 CAN port (SAE J1939) 250 kbit/s, 500 kbit/s, 667 kbit/s, 1 Mbit/s auto-baud-rate detection
Control Logic	Standard embedded software is provided and is configurable using the Axiomatic Electronic Assistant (EA). Setpoint configuration files can be saved and used to program additional controllers. (Application-specific control logic is available on request.) Refer to the User Manual UMAX020530.
Diagnostics	Refer to the User Manual.
User Interface	User configuration and diagnostics are provided with the Axiomatic Electronic Assistant KIT, P/Ns: **AX070502** or **AX070506K**.
Network Termination	It is necessary to terminate the network with external termination resistors. The resistors are 120 Ω, 0.25 W minimum, metal film or similar type. They should be placed between CAN_H and CAN_L terminals at both ends of the network.
Compliance	CE/ UKCA marking
Vibration	MIL-STD-202G, Test 204G and 214A (Sine and Random) 12.5 g peak (Sine) 9.4 Grms peak (Random)
Operating Conditions	-40°C to 85°C (-40°F to 185°F)
Storage Temperature	-50°C to 125°C (-58°F to 257°F)
Weight	0.55 lb. (0.25 kg)

<table>
<tr><td>Protection</td><td>IP67; Unit is conformal coated within the housing.</td></tr>
<tr><td>Enclosure and Dimensions</td><td>High Temperature Nylon Enclosure – (equivalent TE Deutsch P/N: EEC-325X4B)
Flammability rating: UL 94 HB
4.677 in x 5.254 in x 1.417 in
118.80 mm x 133.45 mm x 35.99 mm
(W x L x H excluding mating plug)
Refer to Dimensional Drawing.</td></tr>
<tr><td>Electrical Connections</td><td>24-pin receptacle - (equivalent TE Deutsch P/N: DTM13-12PA-12PB-R008)
Refer to Table 4.0.



FRONT VIEW 24 PIN RECEPTACLE

<table>
<tr><th colspan="4">Table 4.0 – Pin-Out</th></tr>
<tr><th colspan="2">Grey Connector</th><th colspan="2">Black Connector</th></tr>
<tr><th>Pin #</th><th>Function</th><th>Pin #</th><th>Function</th></tr>
<tr><td>1</td><td>BATT +</td><td>1</td><td>CAN H</td></tr>
<tr><td>2</td><td>Output 1</td><td>2</td><td>CAN L</td></tr>
<tr><td>3</td><td>Output 2</td><td>3</td><td>Universal Input 1</td></tr>
<tr><td>4</td><td>Output 3</td><td>4</td><td>Universal Input 2</td></tr>
<tr><td>5</td><td>Output 4</td><td>5</td><td>Universal Input 3</td></tr>
<tr><td>6</td><td>Output 5</td><td>6</td><td>Universal Input 4</td></tr>
<tr><td>7</td><td>Output 5 GND</td><td>7</td><td>Magnetic Pickup Sensor Input</td></tr>
<tr><td>8</td><td>Output 4 GND</td><td>8</td><td>Magnetic Pickup Sensor GND</td></tr>
<tr><td>9</td><td>Output 3 GND</td><td>9</td><td>Analog GND</td></tr>
<tr><td>10</td><td>Output 2 GND</td><td>10</td><td>+5 V Reference</td></tr>
<tr><td>11</td><td>Output 1 GND</td><td>11</td><td>PWM Input 1</td></tr>
<tr><td>12</td><td>BATT -</td><td>12</td><td>PWM Input 2</td></tr>
</table></td></tr>
<tr><td>Mating Connectors</td><td>Mating plugs kits are available on request and are equivalent to TE Deutsch plug P/Ns: DTM06-12SA and DTM06-12SB with 2 wedgelocks (WM12S), 18 sealing plugs (0413-204-2005) and 24 contacts (0462-201-20141).
20 AWG wire is recommended for use with contacts 0462-201-20141.</td></tr>
</table>

OUR PRODUCTS

AC/DC Power Supplies

Actuator Controls/Interfaces

Automotive Ethernet Interfaces

Battery Chargers

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.***

QUALITY DESIGN AND MANUFACTURING

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

WARRANTY, APPLICATION APPROVALS/LIMITATIONS

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

COMPLIANCE

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

SAFE USE

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

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

SERVICE

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

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

DISPOSAL

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

CONTACTS

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