USER MANUAL UMAX031200

MULTIFUNCTION
11 INPUTS, 9 OUTPUTS
I/O CONTROLLER
WITH CAN, SAE J1939

USER MANUAL

P/N: AX031200

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VERSION HISTORY

Version	Date	Author	Modification
1.0.0.	Dec 4, 2013	Ilona Korpelainen	Initial Draft
---	July 4, 2014	AJW	Updated pin out of connector in dimensional drawing
---	March 27, 2015	AJW	Updated Technical Specifications
---	April 16, 2015	AJW	Added vibration compliance and -01 version.
---	August 21, 2015	AJW	Updated the Axiomatic EA version to V4.10.77.0
--	September 21, 2015	AJW	Updated the Axiomatic EA version to V4.10.78.0
1.0.1.	February 19, 2016	Ilona Korpelainen	Updated to reflect new software version (1.08)
1.0.2.	March 10, 2016	Ilona Korpelainen	Updated to reflect new software version (1.09) Lookup Tables, Logic Blocks and Math function added.
1.0.3	April 3, 2017	Ilona Korpelainen	Missing input type added
--	June 19, 2017	Amanda Wilkins	CE marking added
1.0.4	July 8, 2021	Amanda Wilkins	Updated Relay rating
2	June 9,2022	Dmytro Tsebrii	
2A	October 17, 2022	Dmytro Tsebrii	Changed the ECU function instance and ECU function
2B	August 1, 2023	Kiril Mojsov	Performed Legacy Updates

ACRONYMS

ACK	Positive Acknowledgement (from SAE J1939 standard)
BATT +/-	Battery positive (a.k.a. Vps) or Battery Negative (a.k.a. GND)
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)

Note:

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

TABLE OF CONTENTS

REFERENCES

J1939	Recommended Practice for a Serial Control and Communications Vehicle Network, SAE, April 2011
J1939/21	Data Link Layer, SAE, December 2010
J1939/71	Vehicle Application Layer, SAE, March 2011
J1939/73	Application Layer-Diagnostics, SAE, February 2010
J1939/81	Network Management, SAE, May 2003
TDAX031200	Technical Datasheet, Axiomatic Technologies 2021
UMAX07050x	User Manual, Axiomatic Electronic Assistant and USB-CAN, Axiomatic Technologies, August 2023

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 V4.10.78.0 and higher.

1. OVERVIEW OF CONTROLLER

The 11:9 CAN Controller (ECU) is a device that measures numerous types of input signals as well as drives different outputs. The 11:9 CAN Controller has four Universal inputs, four fully isolated Analog Inputs, two Digital Inputs and a Magnetic Pick-Up. The outputs are one Proportional Output, max 2mA output current, four fully isolated Analog Outputs and four Relay Outputs. 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. Model AX031200 has a 250 kbps baud rate in SAE J1939 and AX031200-01 has a 500 kbps baud rate in SAE J1939.

The Axiomatic Electronic Assistant is used to configure the 11:9 CAN Controller. Programming configurable properties, Axiomatic EA setpoints, are listed in chapter 4. Setpoint configuration can be saved in a file which can then be utilized to program the same configuration to another 11:9 CAN 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 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, lookup table function block, programmable logic function block, math function block, CAN transmit message function block and CAN receive message function block. Input function block includes properties used to select input sensor functionality. Diagnostic function block properties are used to configure fault detection and reaction functionalities. Lookup table function blocks, programmable logic function blocks, math function blocks offer some logical programming to convert signals. The CAN transmit message function block configures properties of the messages sent to the CAN busses. And the CAN receive message function block configures properties of the messages received from the CAN busses. These function blocks are presented in detail in next subchapters.

The 11:9 CAN Controller can be ordered using the following part numbers depending on the application.

AX031200	Controller with the default J1030 baudrate

1.1. Input Function Blocks

The controller has altogether eleven inputs. The four Universal Inputs are the most configurable ones. They can be configured to measure voltage, current, frequency, pulse width (PWM) or digital signal. The four Analog Inputs are fully isolated; each having their own power regulation, ADC and I/O expander. Analog inputs can be configured to measure voltage, current and digital signal.

1.1.1. Universal Input

The Universal Input function block translates physical input signals into the internal function block output signal that can be used by other function blocks of the controller.

There are 4 independent Universal Input function blocks presenting their own universal physical inputs.

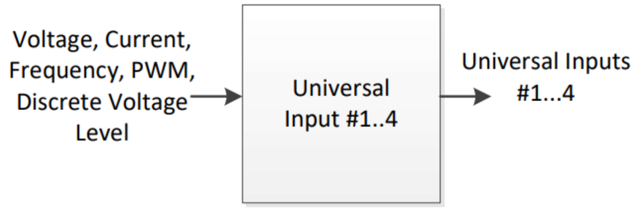


Figure 1. Universal Input Function Block

The internal function block output signal type and units of measurement are presented below.

Table 1. Universal Input Function Block Output Signal

Input Parameter	Type	Units
Voltage	Continuous	V
Current	Continuous	mA
Discrete Voltage Level	Discrete	{0,1}
Resistance Input	Continuous	Ohm
Frequency	Continuous	Hz
PWM Duty Cycle	Continuous	%

Each Universal Input function block has the following configuration parameters.

Table 2. Universal Input Function Block Configuration Parameters

Parameter	Default Value	Range	Units	Description
Input Parameter	1 - Voltage	0 - Input Disabled, 1 - Voltage, 2 - Current, 3 - Discrete Voltage Level, 4 – Resistance Input, 5 - Frequency, 6 - PWM Duty Cycle	–	Defines the input physical parameter that will be measured by the function block.
Input Voltage Range	0 - 0…5V	0 - 0…5 V, 1 - 0…10 V	V	Used in the "Voltage" mode
Input Current Range	0 - 0…20 mA	0 - 0…20mA, 1 - 4…20 mA	mA	Used in the "Current" mode
Input Range Min	0	0…100	-	Depends on the Input Parameter. Used for diagnostic purposes
Input Range Max	5	0…100	-	Depends on the Input Parameter. Used for diagnostic purposes
Voltage LoZ Input	0 - No	0 - No,	–	Activates a 10kOhm pull-down resistor to

Parameter	Default Value	Range	Units	Description
		1 - Yes		avoid ghost voltages in the "Voltage" mode. Warning: Measurement accuracy will be decreased!
Analog Input Filter	0 - Disabled	0 - Disabled, 1 - 50Hz Noise Rejection, 2 - 60Hz Noise Rejection, 3 - Both: 60Hz and 50Hz Noise Rejection	–	Noise Rejection in "Voltage", "Current" and “Resistance” modes
Pull-Up/Pull-Down Resistor	0 - Disabled	0 - Disabled, 1 - 10kOhm Pull-Up, 2 - 10kOhm Pull-Down	–	Used in "Discrete Voltage Level", "Frequency", and "PWM Duty Cycle" modes.
Input Polarity	0 - Active High	0 - Active High, 1 - Active Low	–	Used in "Discrete Voltage Level", "Frequency", and "PWM Duty Cycle" modes.
Discrete Input Debounce Time	50ms	0…1000	ms	Used in "Discrete Voltage Level" mode. If 0 - no debouncing.
Frequency Range	0 - 1Hz…10kHz	0 - 1Hz…10kHz,	Hz	A 16-bit counter is used. Used in "Frequency", and "PWM Duty Cycle" modes.
Frequency/PWM Debounce Filter3	0 - Disabled	0 - Disabled, 1 - 142ns, 2 - 1.14us, 3 - 6.10us	–	Used in "Frequency", and "PWM Duty Cycle" modes.
Frequency/PWM Averaging	0 - No Averaging	0 - No Averaging, 1 - 3 Readings,	–	Defines a moving average filer used in "Frequency", and

Parameter	Default Value	Range	Units	Description
		2 - 5 Readings, 3 - 10 Readings		"PWM Duty Cycle" modes.

1 Input currents below 3mA are output as 0mA when 4…20 mA current range is set.

1.1.2. Voltage Measurements

The Universal Inputs can measure voltages in voltage ranges set by the Voltage Range configuration parameter.

To avoid an influence of ghost voltages, the Voltage LoZ Input configuration parameter can be activated. This will reduce the accuracy of voltage measurements due to the influence of the 10kOhm pull-down shunt resistor and should be used only after careful consideration of the shunt resistor influence on the measured circuit.

The user can set the Analog Input Filter configuration parameter to reduce noise in voltage and other analog signal measurements. The filter is designed to suppress noise from industrial offline voltages. Even when the analog input filter is disabled, the minimum signal filtering is performed by the function block. The parameters of the analog input filter are presented below.

Table 3. Universal Input Analog Input Filter Parameters

Analog Input Filter	Cut-off Frequency (at -3dB)	Settling Time (to 100% of Final Value)	Output Signal Update Rate
Disabled1	70Hz	10ms	1.67ms
50Hz Noise Rejection	12Hz	76.7ms	3.33ms
60Hz Noise Rejection	14Hz	63.3ms	3.33ms
Both: 60Hz and 50Hz Noise Rejection	2.3Hz	396.7ms	16.67ms

1 Minimum filtering is still performed.

1.1.3. Current Measurements

There are two standard current ranges available for current measurements. When the current is below 3mA in the “4…20mA” current range, the output will be forced to zero to facilitate detection of an open circuit condition on the Universal Input.

The Analog Input Filter can be set to reduce the input noise.

1.1.4. Discrete Voltage Level

The Universal Inputs can accept discrete voltage levels. The user should specify the input polarity and define whether the pull-up/pull-down resistor is necessary on the input.

When the "10kOhm Pull-Up" is selected, the pull-up resistor is connected to the internal +14V power supply.

The input states are sampled every 1ms. If debouncing is required, it is set by the Discrete Input Debounce Time configuration parameter. If the Discrete Input Debounce Time is zero, the discrete voltage level input is not debounced.

1.1.5. Resistance Input

The Universal Inputs can measure slowly changing input resistance, for example, a signal coming from a resistive temperature sensor.

The resistance measurements can be done in an auto-range mode.

Resistance Range is set to "Auto Range", a special algorithm is used to dynamically switch between resistance ranges to ensure that the resistance value is measured with the best accuracy and resolution.

If switching between the measurement ranges is not desirable or it is necessary to reduce the measurement time, the Resistance Range can be set to one of the predefined measurement ranges.

The Analog Input Filter configuration parameter can be used to reduce the measurement noise. However, it can also add a delay that can be significant when several universal inputs are used to measure resistance.

There is only one current source shared with all Universal Inputs for resistance measurements. When more then one Universal Input is used to measure resistance, the current source is switched between inputs dramatically increasing the measurement time, see the table below.

Table 4. Universal Input Resistance Measurement Delay

Resistance Measurement	Measurement Delay
No channel or range switching	$0 - No\ delay$
Range switching only	$\begin{cases} T_{sw} + T_s, & during\ range\ switching\ only \\ 0, & all\ other\ time - no\ delay \end{cases}$ $T_{sw} = 30ms\ - switching\ time, T_s - analog\ filter\ settling\ time$
Channel switching (with or without range switching)	$\sum_{n=1}^{N} (T_{sw} + T_{s_n}), \quad N > 1, \quad N - number\ of\ channels$ $n - channel\ number$

For example, if 5 universal inputs are used to measure resistance and Analog Input Filter is set to "Both: 60Hz and 50Hz Noise Rejection" in all universal inputs, the total delay between consequent measurements will be $4 * (30 + 396.7) = 1706.8\ ms$ or less than 2 seconds.

1.1.6. Frequency and PWM

The frequency and PWM duty cycle measurements are performed by counting high-frequency internal clock pulses on every period of the input signal. The universal input channels have different internal organization due to limited hardware resources.

All universal inputs use 16-bit counters with the constant frequency range of 1...10kHz

Table 5. Universal Input Function Block Counters

Function Block	Counter	Frequency Range	Counter Base	Shared Input	Frequency Range and Debounce Filter Setting
Universal Input #1	16-bit	1Hz…10kHz,	Dedicated	N/A	Same input
Universal Input #2			Dedicated	N/A	Same input
Universal Input #3			Dedicated	N/A	Same input
Universal Input #4			Dedicated	N/A	Same input

To measure frequency or PWM duty cycle, the user should first select the Frequency Range parameter and then define how the Pull-Up/Pull-Down Resistor, Frequency/PWM Debounce Filter, and the Frequency/PWM Averaging parameters should be set.

The Input Polarity defines the active edge of the input signal. The Pull-Up/Pull-Down Resistor can be used to pull the input to a no-signal state to avoid an undefined input condition when the signal source is disconnected. The Input Polarity and Pull-Up/Pull-Down Resistor are normally set the following way.

Table 6. Setting Pull-Up/Pull-Down Resistor for Selected Input Polarity. Universal Inputs

Input Polarity	Pull-Up/Pull-Down Resistor
Active High	“Disabled” or “10kOhm Pull-Down”
Active Low	“Disabled” or “10kOhm Pull-Up”

The frequency/PWM debounce filter is used to filter out parasitic spikes that can be present in a noisy input signal. It can be helpful to prevent the input from going into the Recovery state (see 1.1.7 Special Conditions) when, for example, mechanical switches are used to commutate the input signal.

The debounce filter should be used with caution since it can reduce the accuracy and resolution of frequency and PWM measurements if the debouncing time is not significantly less than the period of the input signal.

When a frequency or PWM signal presents a slowly changing parameter, setting an additional moving average filter using the Frequency/PWM Averaging configuration parameter can be helpful in smoothing the results of the input measurements.

1.1.7. Special Conditions

Frequencies below the Minimum Frequency value will be measured as zero and frequencies above the Maximum Frequency value will saturate at the Maximum Frequency value for the Frequency Range, see Table 7 and Table 8.

Table 7. Maximum, Minimum Frequencies and Maximum Recovery Time for Universal Inputs

Frequency Range	Counter	Minimum Frequency	Maximum Frequency	Maximum Recovery Time
1Hz…10kHz	16-Bit	0.9155Hz	12.5kHz	10.9ms

Frequencies above the Maximum Frequency value will switch the input to the Recovery state. The input will stay in the Recovery state until the upcoming counter saturation event when the frequency will be measured again. The input will leave the Recovery state if the measured frequency value is below the Maximum Frequency.

Table 8. Frequency and PWM Measurements for Universal Inputs. Special Conditions

Input Mode	Signal Frequency (F_s)			
	$F_s = 0$ Zero Frequency (DC)	$0 < F_s < F_{min}$ Below Minimum Frequency F_{min}	$F_{min} \leq F_s \leq F_{max}$ Working Frequency	$F_s > F_{max}$ Above Maximum Frequency F_{max}
Measured Frequency F_m	$F_m = 0$	$F_m = 0$	$F_m = F_s$	$F_m = F_{max}$ Recovery state
Measured PWM Duty Cycle D_m	$D_m = \{0, 100\}$	Undefined (not allowed)	$D_m = D_s$, D_s – signal duty cycle	$D_m = 0$ Recovery state

The time between two consequent counter saturation events defines the Maximum Recovery Time, see Table 7. This time is the maximum transient time when the measured frequency will stay equal to the Maximum Frequency value.

When the PWM signal is absent, the duty cycle is measured as 0 or 100% based on the voltage level on the input and the selected Input Polarity. The voltage level is sampled on the counter saturation events until the PWM signal is back on the input.

The transient time between the PWM signal duty cycle and the duty cycle of the DC level when the signal disappears can be up to the Maximum Recovery Time. During the transient time, the measured value will stay equal to the last measured value of the PWM signal duty cycle.

The PWM input signal with a frequency above zero but below the Minimum Frequency value is not allowed. The duty cycle will not be measured, instead, it will be jumping between 0% and 100% depending on the voltage level at the input on the counter saturation events.

When the PWM input signal frequency exceeds the Maximum Frequency value, the input goes into the Recovery state and the PWM duty cycle is measured as 0%. Similar to frequency measurements, the input will stay in the Recovery state for up to the Maximum Recovery Time before the duty cycle is measured again.

1.2. Analog Input

The Analog Input function block is fully isolated. The ECU has 4 Isolated Analog Inputs. The available options for the "**Input Type**" setpoint are listed below.

Table 9. Analog Input Function Block Output Signal

Input Parameter	Type	Units
Voltage	Continuous	V
Current	Continuous	mA
Discrete Voltage Level	Discrete	{0,1}

The Analog Input has the same functionalities as Universal Input for available input types. Please refer to the Section 1.1.1 for the reference.

1.3. Digital Input

The two Digital Inputs measure digital voltage with 3V threshold. The possible input types are listed below.

Table 10. Digital Input Function Block Output Signal

Input Parameter	Type	Units
Input Disabled		
Digital ON/OFF	Discrete	{0,1}

The input logic can be modified by changing the "Input Polarity" setpoint. This setpoint has more setting than the same setpoint in Universal and Analog Input function blocks. Beside Normal Logic and Inversed Logic there is third option: Toggle Logic. If Toggle Logic is chosen, the ECU will toggle its state each time when input is high. The available options are listed in Table 11.

Table 11. Input Polarity Function Block Options

Value	Parameter
0	Normal Logic
1	Inverse Logic
2	Toggle Logic

1.4. Magnetic Pick-Up Input

The Magnetic Input function block can measure frequency in a range 1Hz…10kHz. This function blocks behaves as Universal Input in a Frequency mode. For details, please refer to the Section 1.1.6.

1.5. Relay Output Function Block

The following sub-sections will explain in more detail the functionalities and available setpoints/parameters.

1.5.1. Relay Output Functionality

The relay output has 2 states: Normally Open and Normally Closed. It has 3 pins associated with it: Normally Closed (NC), Normally Open (NO), and Common (C). The **"Relay Output Type"** parameter allows for flexibility in the response of the output. Table 12 shows the options available for this parameter.

Table 12. Relay Output Types

Value	Meaning
0	*Relay Disabled*
1	*Normal Logic*
1	*Inverse Logic*
2	*Latched Logic*
3	*Inverse Latched Logic*
4	*Toggle Logic*

By default, *'Normal Logic'* response is used for the relay outputs. In *'Normal Logic'* response, the Common pin is connected to the Normally Closed pin if the source of the respective relay output is triggered ON, the Common pin is connected to the Normally Open pin.

In the case of *'Inverse Logic'* response, the Common pin is connected to the Normally Open pin when the source of the respective relay output is triggered ON. When the source of the respective relay output is triggered OFF, the Common pin is connected to the Normally Closed pin.

In the case of *'Latched Logic'* response, the Common pin is toggled between Normally Closed and Normally Open pins every time the source of the respective relay output goes from OFF to ON. The *'Inverse Latched Logic'* response will respond the opposite way.

The *'Toggle Logic'* lets the relay output toggle between Normally closed and Normally Open pins for a configured frequency. The time for switching from one state to the other state results the **"Relay Toggle Rate"** which is in milliseconds and by default 500ms.

1.5.2. Relay Output Control / Enable Sources / Override Source

The relay output can be configured to be commanded and/or enabled by the control sources listed in **Error! Reference source not found.**. This table also displays the number associated to the control sources which can be selected. The default control source is highlighted while the default Enable Source and Override Source is configured to *'Control Not Used'.*

The selected control source in the **"Relay Control Source"** parameter is the main commanding source of the relay output based on "**Relay Output Type"** parameter. A delay can be set for both output states when **"Relay Enable Response Delay"** is set to be *'TRUE'.* In case the output state should turn low after a certain amount of time, the parameter **"Relay Delay OFF Time"** can be set.

Whereas the **“Relay Delay ON Time”** can be configured to set a delay before switching from the OFF-state to ON-state. Both delays are configurable in milliseconds.

1.5.3. Relay Output Enable

The **“Relay Enable Source”** will determine whether or not the relay output will be commanded by the **“Relay Control Source”**. There are six different **“Relay Enable Response”** in which the enable signal can be used. These responses are listed in Table 13.

Table 13: Relay Enable Response

Value	Meaning
0	*Enable When ON*
1	*Enable When OFF*
2	*Disable When ON*
3	*Disable When OFF*
4	*Enable When ON Else Keep State*
5	*Enable When OFF Else Keep State*

When the **“Relay Enable Response”** is set to *‘Enable When ON’* or *‘Disable When OFF’*, the relay output will be commanded according to the combined signal of the **“Relay Control Source”** and **“Relay Control Number”** only when the signal of the **“Relay Enable Source”** and **“Relay Enable Number”** is ON. Otherwise, the relay output is commanded to the OFF state.

Similarly, when the **“Relay Enable Response”** is set to *‘Enable When OFF’* or *‘Disable When ON’*, the relay output will be commanded according to the **“Relay Control Source”** and **“Relay Control Number”** only when the signal of the **“Relay Enable Source”** and **“Relay Enable Number”** is OFF. Otherwise, the relay output is commanded to the OFF state.

In case the **“Relay Enable Response”** is *‘Enable When ON Else Keep State’*, the relay output will be commanded according to the signal of the **“Relay Control Source”** and **“Relay Control Number”** only when the signal of the **“Relay Enable Source”** and **“Relay Enable Number”** is ON. If the Enable Signal is OFF, the relay output will keep the previous state.

Likewise, when the **“Relay Enable Response”** is configured to *‘Enable When OFF Else Keep State’*, the relay output will be commanded according to the **“Relay Control Source”** and **“Relay Control Number”** only when the combined signal of **“Relay Enable Source”** and **“Relay Enable Number”** is OFF. Otherwise, the relay output holds the previous state.

1.5.4. Relay Output Override

The **“Relay Override Source”** will determine whether or not the relay output will be commanded by the **“Relay Control Source”**. This Source has a higher priority than the Enable Source.

There are two different **“Relay Override Response”** in which the Override signal can be used. These responses are listed in *Table 14*.

Table 14: Relay Override Response Options

Value	Meaning
0	*Override When OFF*
1	*Override When ON*

When the “Relay Override Response” is configured to ‘Override When ON’, the relay output will be commanded according to the signal of the “Relay Control Source” and “Relay Control Number” by the “Relay Override State” only when the override signal is ON. If the “Relay Override Response” is set to ‘Override When OFF’, the relay output will be commanded only according to the signal of the Control Source/Number by the “Relay Override State” only when the override signal is OFF.

In case of *‘Override State OFF’*, the relay output switches to Normally Open. If *‘Override State ON’* is configured, the relay output changes to Normally closed.

Table 15. Relay Override State Options

Value	Meaning
0	*Override State OFF*
1	*Override State ON*

1.5.5. Unlatch Source

This Source can only be configured if the **“Relay Output Type”** is set to *‘Latched Logic* or *‘Inverse Latched Logic*’ and it can be enabled/disabled by the parameter **“Relay Enable Unlatch Source”**. If the signal of the **“Relay Unlatch Source”** is ON, it turns the output OFF when the **“Relay Output Type”** is set to *‘Latched Logic*’. If the Unlatch Source state turns OFF afterwards, the output state stays OFF independent of the output state before. The reverse behavior is applied to the *Inverse Latched Logic*.

1.6. Output Function Blocks

The controller has altogether nine outputs. One Proportional Output, four Analog Outputs. The Proportional Output is half-bridge drive with high side sourcing up to 2A. The current drawn from the output is measured to form a current feedback loop. The Analog Outputs are fully isolated outputs driven by separate digital to analog converters (DAC). The Relay Outputs are digital on/off switches. All outputs have configurable setpoints. Some of the setpoints appear in all output setpoint groups. These setpoints are presented firstly. The Proportional Output has more configurable setpoints than other outputs. The Proportional Output and its setpoints are discussed in detail in section 1.6.1.

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.

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 16. If “**Enable Source**” is set to ‘*Control not used’*, the Enable signal is interpreted to be ON. If a non-digital signal is selected as Enable signal the signal is interpreted as shown in Figure 5.

Table 16 – Enable Response Options

0	*Enable When On, Else Shutoff*
1	*Enable When Off, Else Shutoff*
2	*Enable When On, Else To Min*
3	*Enable When On, Else To Max*
4	*Enable When On, Else Ramp To Min*
5	*Enable When On, Else Ramp To Max*
6	*Enable When On, Else Keep Last Value*
7	*Enable When Off, Else Keep Last Value*

“**Output Type**” setpoint determines what kind of signal the output produces. Changing this setpoint causes other sepoints in the group to update to match selected type, thus the “**Output Type**” should be selected before configuring other setpoints within the setpoint group.

Separate digital to analog (DAC) converters are used to drive Analog Outputs. Analog output “**Output Type**” setpoint options are listed in Table 17. The “**Output type**” setpoint also determines signal minimum and maximum values for an Analog Output.

Table 17 – Output Type Options for Analog Outputs

0	Disabled
1	Voltage Output
2	Current Output

To set the range required, the “**Output Data Min**” and “**Output Data Max**” should be set to needed values. For example, if the Current Output in a range of 4…20mA is required, the “**Output type**” should be set to 2, *Current Output.* “**Output Data Min**” to 4 and “**Output Data Max**” to 20. This method allows to configure the ECU to a suitable range for various applications.

“Output Type” setpoints for the Proportional Output are listed in Table 18. The setpoints options are discussed further in section below.

1.6.1. Proportional Output

The Proportional Output is the most configurable of the 11:9 CAN Controller outputs and have additional setpoints which do not appear with other outputs. The setpoints common to all outputs are explained above. In this section rest of the Proportional Output setpoints are presented.

“**Output Type**” setpoint options for the Proportional Output are listed in Table 18. “**Output Type**” setpoint determines what kind of signal the output produces. Changing this setpoint causes other sepoints in the group to update to match selected type, thus the “**Output Type**” should be selected before configuring other setpoints within the setpoint group.

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 of the 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 1.

$$y = mx + a$$

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

$$a = Ymin - m * Xmin$$

Equation 1 - Linear Slope Calculations

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

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

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

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

Table 18 – Output Type Options for Proportional Output

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

'*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 exactly what is programmed into the setpoint, but the exact amplitude of the dither will depend on the properties of the load coil. When adjusting the dither amplitude value, select one that is high enough to ensure an immediate response to the coil to small changes in the control inputs, but not so large as to effect 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. Since the output is running at a high frequency (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.

Instead of proportional, 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 2A.

If a digital **"Output Type"** has been selected the **"Digital Response"** setpoint will be enabled as shown in Table 19.

Table 19 – Digital Response Options

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

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 a 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.

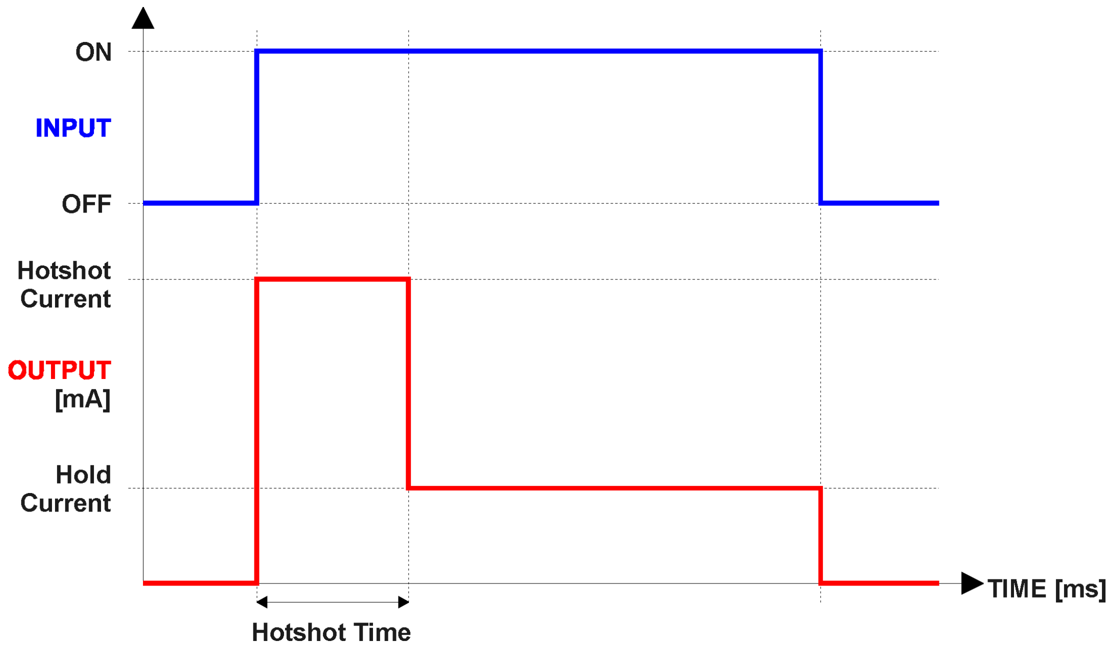


Figure 2 – Hotshot Digital Profile

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 1.7. When fault is detected the output will respond per "**Control Fault Response**" setpoint as outlined in Table 20.

Table 20 – Fault Response Options

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

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

The proportional output in 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 the output. 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

1.7. Diagnostic Function Blocks

The 11:9 CAN Controller ECU 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 which is a combination of:

SPN	Suspect Parameter Number	(user defined)
FMI	Failure Mode Identifier	(see Table 23)
CM	Conversion Method	(always set to 0)
OC	Occurrence Count	(number of times the fault has happened)

In addition to supporting the DM1 message, 11:9 CAN Controller Input also supports:

DM2	Previously Active Diagnostic Trouble Codes	Sent only on request
DM3	Diagnostic Data Clear/Reset of Previously Active DTCs	Done only on request
DM11	Diagnostic Data Clear/Reset for Active DTCs	Done only on request

Fault detection and reaction is a standalone functionality that can be configured to monitor and report diagnostics of various controller parameters. The 11:9 CAN Controller supports 16 Diagnostics Definitions, each freely configurable by the user.

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

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

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

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

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

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

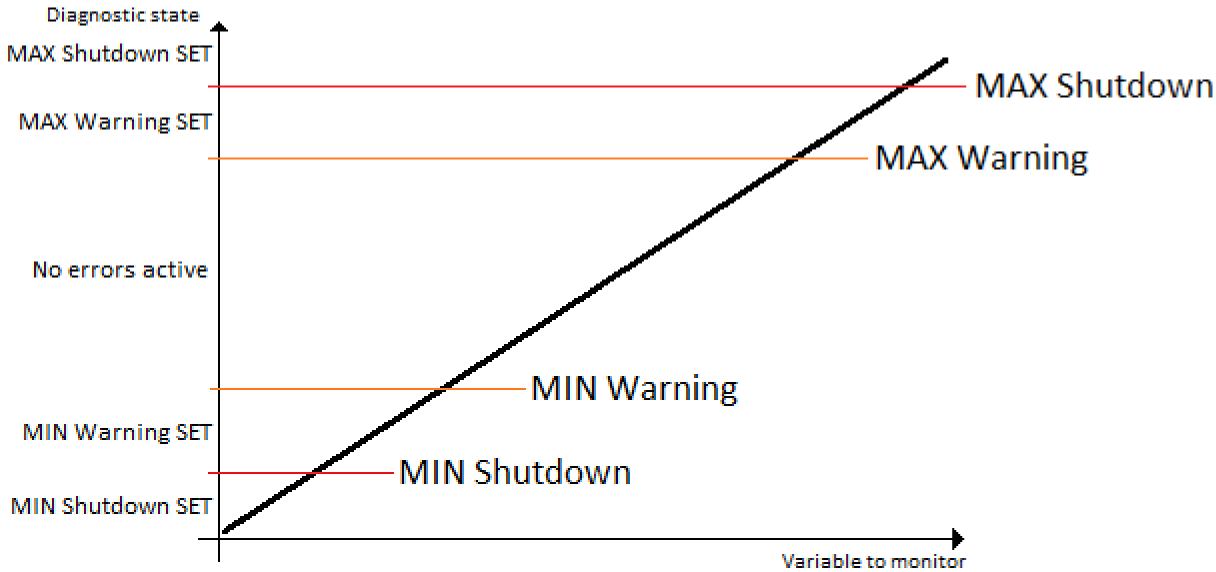


Figure 3 – Double Minimum and Maximum Error Thresholds

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 particular output. This internal flag can be used for driving the particular output to a specified state in case of diagnostic event using Proportional Current Output setpoints “Control Fault Response”, “Output in Fault Mode” and “Fault Detection Enabled”.

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

While there are no active DTCs, the 11:9 CAN 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).

ℹ	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 21. By default, the '*Amber, Warning'* lamp is typically the one set be any active fault.

Table 21 – Lamp Set by Event in DM1 Options

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

"**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.

Table 22 – FMI for Event Options

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*

Every fault has associated a default FMI with them. The used FMI can be configured with "**FMI for Event**" setpoint, presented in Table 22. When an FMI is selected from Low Fault FMIs in Table 23 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 23. There is no automatic setting of High and Low FMIs in the firmware, the user can configure these freely.

Table 23 – Low Fault FMIs and corresponding High Fault FMIs

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*

1.8. Math Function Block

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

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

A mathematical function block includes three selectable functions, in which each implements equation A operator B, where A and B are function inputs and operator is function selected with a setpoint "Math Function X". Setpoint options are presented in Table 24. The functions are connected together, so that result of the preceding function goes into Input A of the next function. Thus Function 1 has both Input A and Input B selectable with setpoints, where Functions 2 to 4 have only Input B selectable. Input is selected by setting "Function X Input Y Source" and "Function X Input Y Number". If "Function X Input B Source" is set to 0 'Control not used' signal goes through function unchanged.

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

Table 24. Math function X Operator Options

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

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

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

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

1.9. Conditional Block

The Conditional Block compares up to four different input sources with different logical or relational operators. The result of each block can therefore only be true (1) or false (0). Figure 4 demonstrates the connections between all parameters.

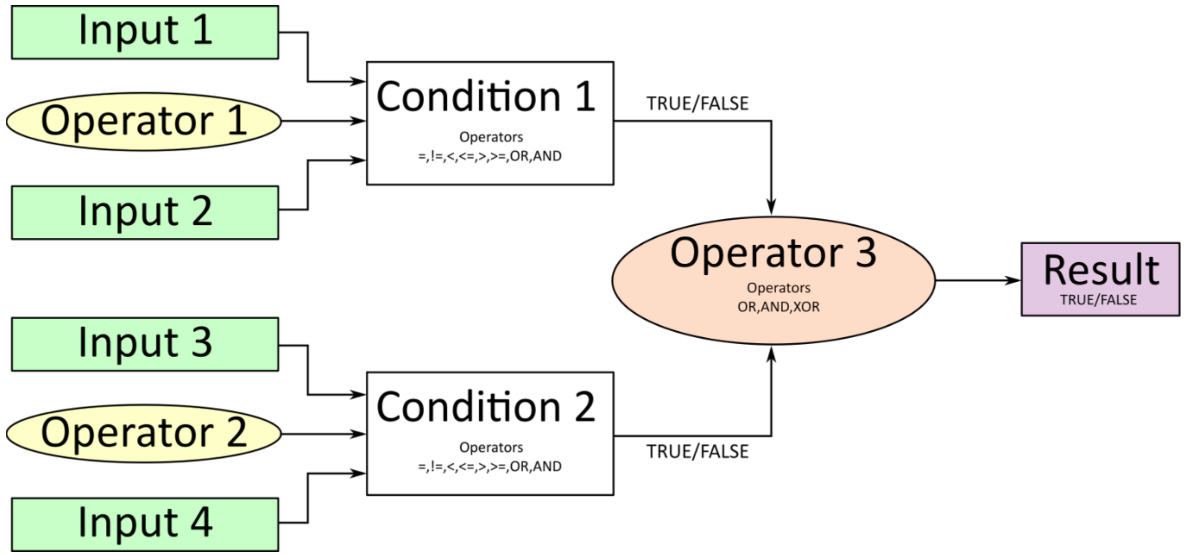


Figure 4: Conditional Block Diagram

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

value of each source will then be compared to each other with an operator of Table 25. If no source is selected, the output value of an Input will be zero.

Table 25. Input Operator Options

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

Operator 1 and Operator 2 are configured to OR by default. The table above cannot be used for comparing the conditions because they can only be compared with logical operators, which are listed in Table 26.

Table 26. Condition Operator Options

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

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

1.10. Set / Reset Latch 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 27 below.

Table 27. Set-Reset Function block operation

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

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 27 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. 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 1.12.

Lookup tables have two differing modes defined by “X-Axis Type” setpoint, given in Table 28. 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.

Table 28. X-Axis Type Options

0	Data Response
1	Time Response

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 29. ‘Ramp To’ gives a linearized slope between points, whereas ‘Jump to’ gives a point to point response, where any input value between XN-1 and XN will result Lookup Table output being YN. “Point0 – Response” is always ‘Jump To’ and cannot be edited. Choosing ‘Ignored’ response causes associated point and all the following points to be ignored.

Table 29. PointN – Response Options

0	Ignore
1	Ramp To
2	Jump To

The X values are limited by minimum and maximum range of the selected input source if the source is a Math Function Block. For the fore mentioned sources X-Axis data will be redefined when ranges are changed, therefore inputs should be adjusted before changing X-Axis values. For other sources Xmin and Xmax are -100000 and 1000000. The X-Axis is constraint to be in rising order, thus value of the next index is greater than or equal to preceding one. Therefore, when adjusting the X-Axis data, it is recommended that X10 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.). Ignored points are not considered for min and max values.

1.12. Programmable Logic Function Block

The Programmable Logic Function Block is a powerful tool. Programmable Logic can be linked to up to three Lookup Tables, any of which would be selected only under given conditions. Thus, the output of a Programmable Logic at any given time will be the output of the Lookup Table selected by the 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 “Logic Enabled” setpoint must be set to ‘True’. By default, all Logic blocks are disabled.

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

For each TableX there are three conditions that define the logic to select the associated Lookup Table as Logic output. Each condition implements function $Argument1\ Operator\ Argument2$ where Operator is logical operator defined by setpoint “Table X – Condition Y Operator”. Setpoint options are listed in Table 30. 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.

Table 30. Table X – Condition Y Operator Options

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

The three conditions are evaluated and if the result satisfies logical operation defined with “Logical Operator X” setpoint, given in Table 31, the associated Lookup Table is selected as output of the Logical block. Option ‘0 – Default Table’ selects associated Lookup Table in all conditions.

Table 31. Table X – Conditions Logical Operator Options

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

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.

1.13. Constant Data

The Constant Data Block contains 2 fixed (False/True) and 13 configurable constant data setpoints which can be used as a control source for other functions. While they are available as a control source to all functions, it is recommended not to use constant data as a control source for the Set-Reset Latch Block.

1.14. DTC React

DTC React is a function block that allows the ECU to receive and process the DM1 messages. There are 16 separated function blocks that can capture up to 16 different DM1 messages. Each DTC React has two mandatory and 2 optional parameters. The mandatory parameters are the SPN and FMI. If only these parameters are used, the output will be set to high if the DM1 message with the combination of selected SPN and FMI. The state will remain high for five seconds and will be set if the DM1 message will be received again.

Among optional parameters there are lamp setting and the source address. To enable them, the "**Lamp Used to Trigger Reaction**" and "**Source Address Used to Trigger Reaction**" should be set to 1, *True*. In this case, beside SPN and FMI the ECU will compare the Lamp Setting and/or Source Address of the received message.

The exceptions are the following SPN:

- SPN 1213 and Lamp Status 0x40;
- SPN623 and Lamp Status 0x10;
- SPN624 and Lamp Status 0x04;
- SPN624 and Lamp Status 0x01;

In case if the SPNs above are chosen, the DTC React function block will set the output to HIGH if SPN and Lamp Status matches even if FMI doesn't match. However, if the "**Source Address Used to Trigger Reaction**" is set to 1, *True* and selected address doesn't match, the DTC React output will be set to FALSE.

1.15. 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 AX031200 ECU has eleven CAN Transmit Messages and each message has four completely user defined signals.

1.15.1. 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.

"**CAN Interface**" setpoint is used to define which of the two CAN Interfaces is used to transmit the message in question.

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.

1.15.2. 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 32. Setting "**Control Source**" to '*Control Not Used'* disables the signal.

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

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

1.16. 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).

"**CAN Interface**" setpoint is used to define from which of the two CAN Interfaces the message in question is received.

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 1.7. In order to avoid timeouts on a heavily saturated network, it is recommended to set the period at least three times longer than the expected update rate. To disable the timeout feature, simply set this value to zero, in which case the received message will never trigger a Lost Communication fault.

By default, all control messages are expected to be sent to the 11:9 CAN Controller on Proprietary B PGNs. However, should a PDU1 message be selected, the 11:9 CAN Controller can be setup to receive it from any ECU by setting the "**Specific Address that sends the PGN**" to the Global Address (0xFF). If a specific address is selected instead, then any other ECU data on the PGN will be ignored.

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

As mentioned earlier, a CAN receive function clock can be selected as the source of the control input for the output function blocks. When this is case, the "**Received Data Min (Off Threshold)**" and "**Received Data Max (On Threshold)**" setpoints determine the minimum and maximum values of the control signal. As the names imply, they are also used as the On/Off thesholds 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 11:9 CAN Controller supports up to nine unique CAN Receive Messages. Defaults setpoint values are listed in section 4.21.

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

Table 32 – Available Control Sources and Numbers

Control Source	**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 9	
2: Universal Input Measured	1 to 4	
3: Digital Input Measured	1 to 2	
4: Analog Input Measured	1 to 4	
5: Magnetic Pick-Up	N/A	
6: Lookup Table	1 to 10	
7: Programmable Logic	1 to 4	
8: Math Logic	1 to 5	
9: Conditional Logic	1 to 10	
10: Set-Reset Latch	1 to 5	
11: Constant Data	1 to 15	
12: Output Target Value	1 to 5	

13: Output Current Feedback	N/A	Measured Feedback current from the proportional output in mA, used in Output Diagnostics.
14: Power Supply Measured	0 to 255	Measured power supply value in Volts. The Parameter sets the threshold in Volts to compare with.
15: Processor Temperature Measured	0 to 255	Measured processor temperature in °C. The Parameter sets the threshold in Celcius to compare with.
16: CAN Reception Timeout	N/A	
17: DTC React	1 to 16	

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 5. For example Universal Input signal is interpreted to be ON at or above "Maximum Range" and OFF at or below "Minimum Range".

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

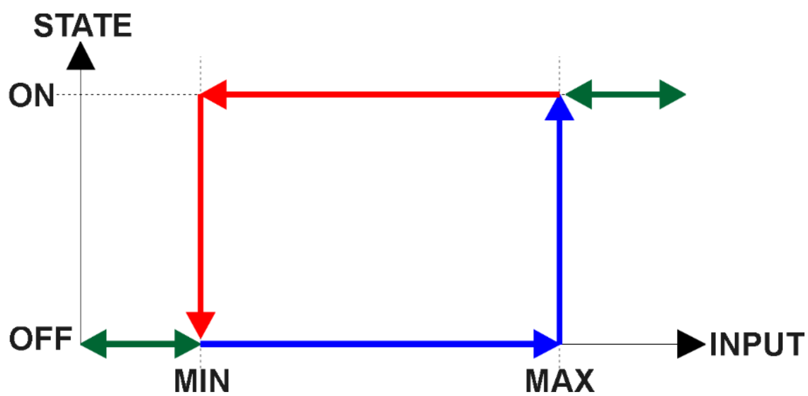


Figure 5 – Analog source to Digital input

2. INSTALLATION INSTRUCTIONS

2.1. Dimensions and Pinout

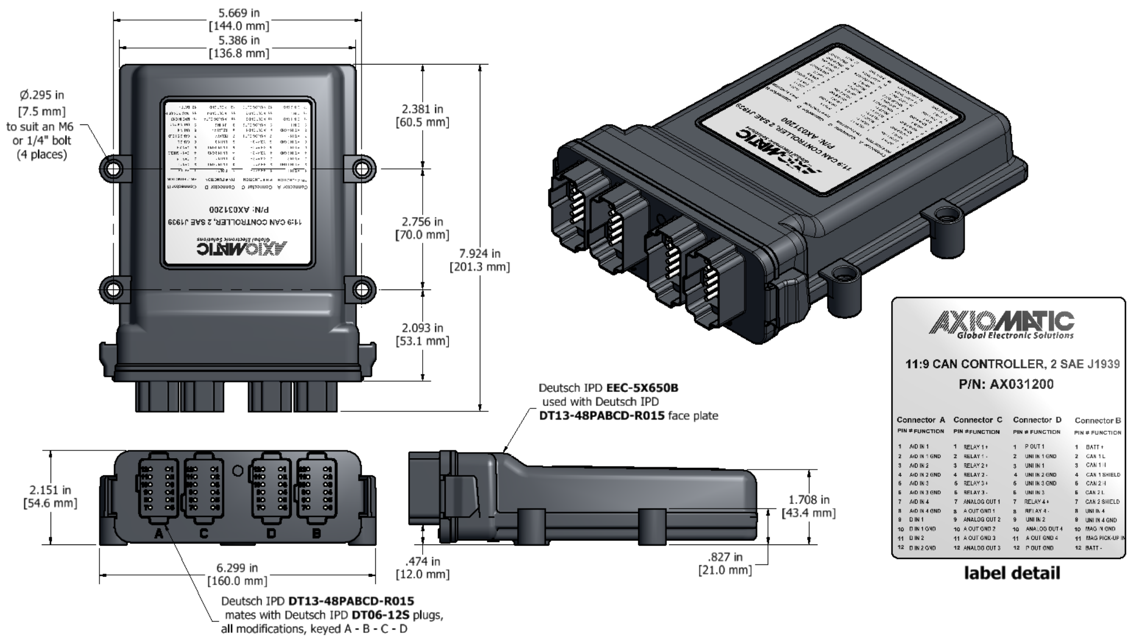


Figure 6 – AX031200 Dimensional Drawing

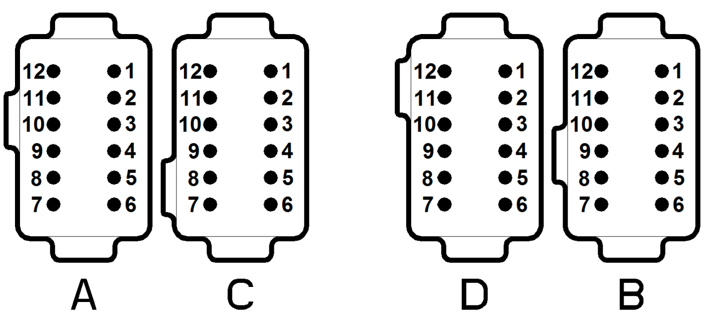


Table 33 – AX031200 Connector Pinout

Connector A			
Pin#	**Function**	**Pin#**	**Function**
12	Digital In GND 2	1	Analog Input 1
11	Digital Input 2	2	Analog In GND 1
10	Digital In GND 1	3	Analog Input 2
9	Digital Input 1	4	Analog In GND 2
8	Analog In GND 4	5	Analog Input 3
7	Analog Input 4	6	Analog In GND 3

Connector C			
Pin#	**Function**	**Pin#**	**Function**
12	Analog Output 3	1	Relay Out 1 +
11	Analog Out GND 3	2	Relay Out 1 -
10	Analog Out GND 2	3	Relay Out 2 +
9	Analog Output 2	4	Relay Out 2 -
8	Analog Out GND 1	5	Relay Out 3 +
7	Analog Output 1	6	Relay Out 3 –

Connector D			
Pin#	**Function**	**Pin#**	**Function**
12	Proportional Output GND	1	Proportional Output
11	Analog Output GND 4	2	Universal Input GND 1
10	Analog Output 4	3	Universal Input 1
9	Universal Input 2	4	Universal Input GND 2
8	Relay Out 4 -	5	Universal Input GND 3
7	Relay Out 4 +	6	Universal Input 3

Connector B			
Pin#	**Function**	**Pin#**	**Function**
12	Batt-	1	Batt+
11	Magnetic Pick-Up	2	CAN1 L
10	Magnetic Pick-Up GND	3	CAN1 H
9	Universal Input GND 4	4	CAN1 Shield
8	Universal Input 4	5	CAN2 H
7	CAN2 Shield	6	CAN2 L

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

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
• Software Identification	65242	0x00FEDA
• Component Identification	65259	0x00FEEB

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

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

3.2. NAME, Address and Software ID

The 11:9 CAN Controller 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	127, I/O Controller
Function Instance	7, Axiomatic AX031200
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 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 11:9 CAN Controller will continue select the next highest address until it finds one that it can claim. See J1939/81 for more details about address claiming.

ECU Identification Information

PGN 64965 ECU Identification Information -ECUID

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

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

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

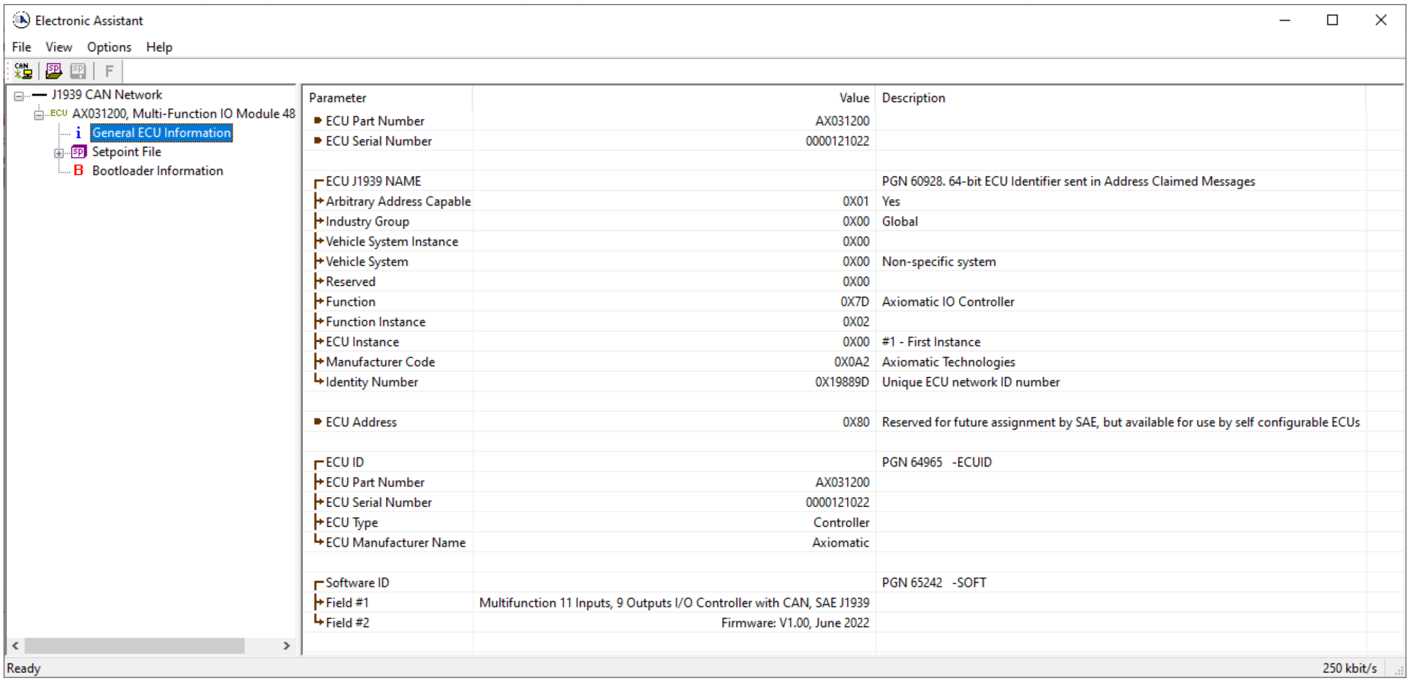


Figure 7 – General ECU Information

Software Identifier

PGN 65242		Software Identification	- SOFT
Transmission Repetition Rate:		On request	
Data Length:		Variable	
Extended Data Page:		0	
Data Page:		0	
PDU Format:		254	
PDU Specific:		218 PGN Supporting Information:	
Default Priority:		6	
Parameter Group Number:		65242 (0xFEDA)	
Start Position	Length	Parameter Name	SPN
1	1 Byte	Number of software identification fields	965
2-n	Variable	Software identification(s), Delimiter (ASCII “*”)	234

For the 11:9 CAN Controller ECU, 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.

Component Identification

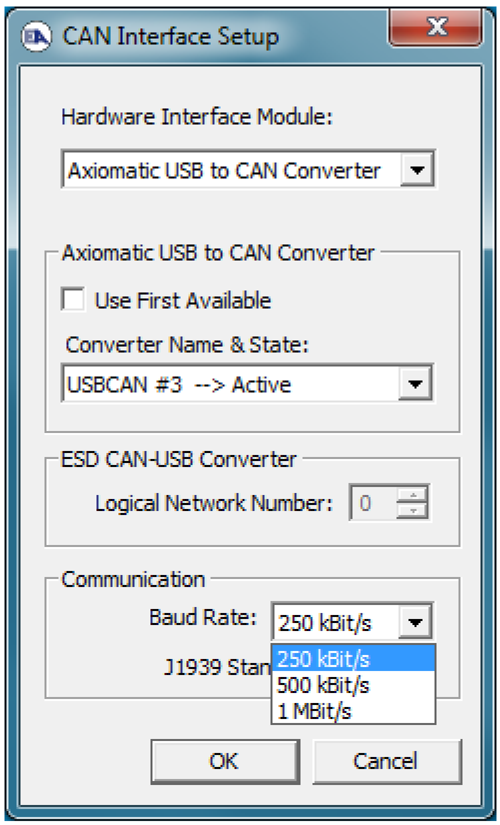
PGN 65259		Component Identification	-CI
Transmission Repetition Rate:		On request	
Data Length:		Variable	
Extended Data Page:		0	
Data Page:		0	
PDU Format:		254	
PDU Specific:		235 PGN Supporting Information:	
Default Priority:		6	
Parameter Group Number:		65259 (0x00FEEB)	
Start Position	Length	Parameter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

4. ECU SETPOINTS ACCESSED WITH THE AXIOMATIC ELECTRONIC ASSISTANT

This section describes in detail each setpoint, and their default and ranges. 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 10 Analog Input, refer to the relevant section in this user manual.

4.1. Accessing the ECU Using the Axiomatic Electronic Assistant

ECU with P/N AX031200 does not need any specific setup for the Axiomatic EA. To access the high-speed versions, AX031200-01 and/or AX031200-02, the CAN bus Baud Rate needs to be set accordingly. The CAN Interface Setup can be found from “Options” menu in the Axiomatic EA. Please refer UMAX07050x **Connecting to the J1939 Bus** section for Axiomatic Electronic Assistant CAN Interface Setup instructions.



4.2. J1939 Network Parameters

“ECU Instance Number” and “ECU Address” setpoints and their effect are defined in section 3.2.

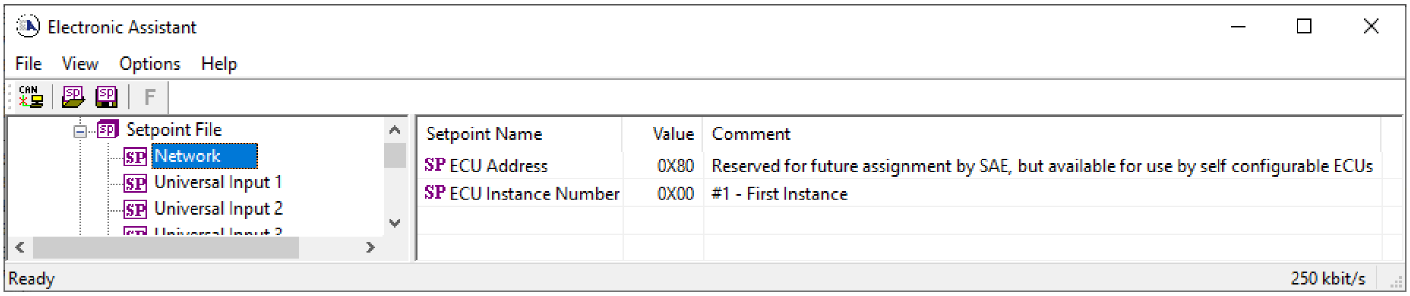


Figure 8 – Screen Capture of J1939 Setpoints

Table 34 – J1939 Network 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

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.

4.3. Universal Input Setpoints

The Universal Inputs are defined in section 1.1.

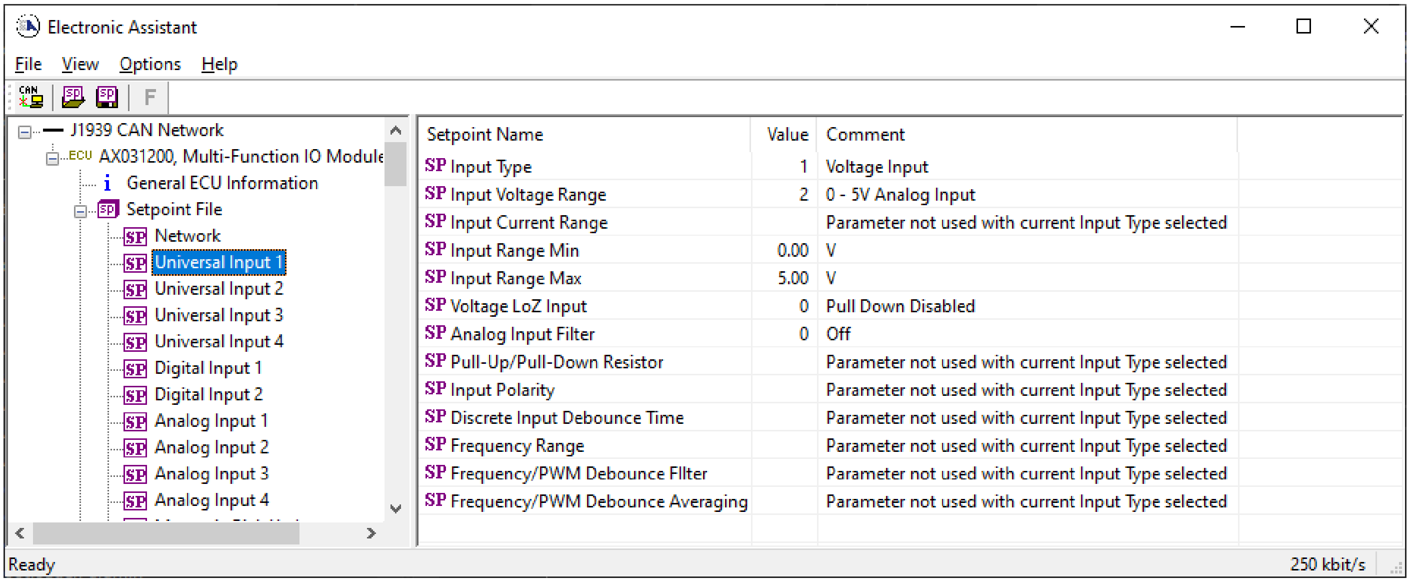


Figure 9 – Screen Capture of Universal Input Setpoints

Table 35 – Universal Input Setpoints

<table>
<tr><th>Name</th><th>Range</th><th>Default</th><th>Notes</th></tr>
<tr><td>Input Type</td><td>Drop List</td><td>Voltage Input</td><td>
4.4. See
4.5. The input logic can be modified by changing the “Input Polarity” setpoint. This setpoint has more setting than the same setpoint in Universal and Analog Input function blocks. Beside Normal Logic and Inversed Logic there is third option: Toggle Logic. If Toggle Logic is chosen, the ECU will toggle its state each time when input is high. The available options are listed in Table 11.
Table 11. Input Polarity Function Block Options
<table>
<tr><th>Value</th><th>Parameter</th></tr>
<tr><td>0</td><td>Normal Logic</td></tr>
<tr><td>1</td><td>Inverse Logic</td></tr>
<tr><td>2</td><td>Toggle Logic</td></tr>
</table>
4.6. Magnetic Pick-Up Input
The Magnetic Input function block can measure frequency in a range 1Hz…10kHz. This function blocks behaves as Universal Input in a
</td></tr>
</table>

			Frequency mode. For details, please refer to the Section 1.1.6. **4.7. Relay Output Function Block** The following sub-sections will explain in more detail the functionalities and available setpoints/parameters. **4.7.1. Relay Output Functionality** The relay output has 2 states: Normally Open and Normally Closed. It has 3 pins associated with it: Normally Closed (NC), Normally Open (NO), and Common (C). The **“Relay Output Type”** parameter allows for flexibility in the response of the output. Table 12 shows the options available for this parameter. Table 12. Relay Output Types <table><tr><th>Value</th><th>Meaning</th></tr><tr><td>0</td><td>*Relay Disabled*</td></tr><tr><td>1</td><td>*Normal Logic*</td></tr><tr><td>1</td><td>*Inverse Logic*</td></tr><tr><td>2</td><td>*Latched Logic*</td></tr><tr><td>3</td><td>*Inverse Latched Logic*</td></tr><tr><td>4</td><td>*Toggle Logic*</td></tr></table> By default, *‘Normal Logic’* response is used for the relay outputs. In *‘Normal Logic’* response, the Common pin is connected to the Normally Closed pin if the source of the respective relay output is triggered ON, the Common pin is connected to the Normally Open pin. In the case of *‘Inverse Logic’* response, the Common pin is connected to the Normally Open pin when the source of the respective relay output is triggered ON. When the source of the respective relay output is triggered OFF, the Common pin is connected to the Normally Closed pin. In the case of *‘Latched Logic’* response, the Common pin is toggled between Normally Closed and Normally Open pins every time the source of the respective relay output

			goes from OFF to ON. The *'Inverse Latched Logic'* response will respond the opposite way. The *'Toggle Logic'* lets the relay output toggle between Normally closed and Normally Open pins for a configured frequency. The time for switching from one state to the other state results the **"Relay Toggle Rate"** which is in milliseconds and by default 500ms. **4.7.2. Relay Output Control / Enable Sources / Override Source** The relay output can be configured to be commanded and/or enabled by the control sources listed in **Error! Reference source not found.**. This table also displays the number associated to the control sources which can be selected. The default control source is highlighted while the default Enable Source and Override Source is configured to *'Control Not Used'.* The selected control source in the **"Relay Control Source"** parameter is the main commanding source of the relay output based on "**Relay Output Type"** parameter. A delay can be set for both output states when **"Relay Enable Response Delay"** is set to be *'TRUE'.* In case the output state should turn low after a certain amount of time, the parameter **"Relay Delay OFF Time"** can be set. Whereas the **"Relay Delay ON Time"** can be configured to set a delay before switching from the OFF-state to ON-state. Both delays are configurable in milliseconds. **4.7.3. Relay Output Enable** The **"Relay Enable Source"** will determine whether or not the relay output will be commanded by the **"Relay Control Source"**. There are six different **"Relay Enable Response"** in which the enable

			signal can be used. These responses are listed in Table 13.

Table 13: Relay Enable Response

Value	Meaning
0	*Enable When ON*
1	*Enable When OFF*
2	*Disable When ON*
3	*Disable When OFF*
4	*Enable When ON Else Keep State*
5	*Enable When OFF Else Keep State*

When the **"Relay Enable Response"** is set to *'Enable When ON'* or *'Disable When OFF'****,*** the relay output will be commanded according to the combined signal of the **"Relay Control Source"** and **"Relay Control Number"** only when the signal of the **"Relay Enable Source"** and **"Relay Enable Number"** is ON. Otherwise, the relay output is commanded to the OFF state.
Similarly, when the **"Relay Enable Response"** is set to *'Enable When OFF'* or *'Disable When ON'*, the relay output will be commanded according to the **"Relay Control Source"** and **"Relay Control Number"** only when the signal of the **"Relay Enable Source"** and **"Relay Enable Number"** is OFF. Otherwise, the relay output is commanded to the OFF state.
In case the **"Relay Enable Response"** is *'Enable When ON Else Keep State'*, the relay output will be commanded according to the signal of the **"Relay Control Source"** and **"Relay Control Number"** only when the signal of the **"Relay Enable Source"** and **"Relay Enable Number"** is ON. If the Enable Signal is OFF, the relay output will keep the previous state.
Likewise, when the **"Relay Enable Response"** is configured to *'Enable When OFF Else Keep State'*, the relay output will be commanded

according to the **“Relay Control Source”** and **“Relay Control Number”** only when the combined signal of **“Relay Enable Source”** and **“Relay Enable Number”** is OFF. Otherwise, the relay output holds the previous state.

4.7.4. Relay Output Override

The **“Relay Override Source”** will determine whether or not the relay output will be commanded by the **“Relay Control Source”**. This Source has a higher priority than the Enable Source.
There are two different **“Relay Override Response”** in which the Override signal can be used. These responses are listed in *Table 14.*

Table 14: Relay Override Response Options

Value	Meaning
0	*Override When OFF*
1	*Override When ON*

When the “Relay Override Response” is configured to ‘Override When ON’, the relay output will be commanded according to the signal of the “Relay Control Source” and “Relay Control Number” by the “Relay Override State” only when the override signal is ON. If the “Relay Override Response” is set to ‘Override When OFF’, the relay output will be commanded only according to the signal of the Control Source/Number by the “Relay Override State” only when the override signal is OFF.
In case of *‘Override State OFF’*, the relay output switches to Normally Open. If *‘Override State ON’* is configured, the relay output changes to Normally closed.

Table 15. Relay Override State Options

Value	Meaning
0	*Override State OFF*
1	*Override State ON*

			4.7.5. Unlatch Source This Source can only be configured if the **"Relay Output Type"** is set to *'Latched Logic* or *'Inverse Latched Logic'* and it can be enabled/disabled by the parameter **"Relay Enable Unlatch Source"**. If the signal of the **"Relay Unlatch Source"** is ON, it turns the output OFF when the **"Relay Output Type"** is set to *'Latched Logic'*. If the Unlatch Source state turns OFF afterwards, the output state stays OFF independent of the output state before. The reverse behavior is applied to the *Inverse Latched Logic*.
Input Voltage Range	Drop List	2, 0-5V Analog Input	
Input Current Range	Drop List	0, 0-20mA Current Input	
Input Range Min	0..100	0	
Input Range Max	0..100	5	
Voltage LoZ Input	Drop List	0, Pull Down Disabled	
Analog Input Filter	Drop List	0, Off	
Pullup/Pulldown Resistor	Drop List	0, No Pull	See Error! Reference source not found.
Input Polarity	Drop List	0, Active High	
Discrete Input Debounce Time	0..60000	50 ms	
Frequency Range	Read only	1Hz to 10kHz	
Frequency/PWM Debounce Filter	Drop List	0, No Filter	
Frequency/PWM Debounce Averaging	Drop List	0, No Averaging	

4.8. Digital Input Setpoints

The Digital Inputs are defined in section 1.3.

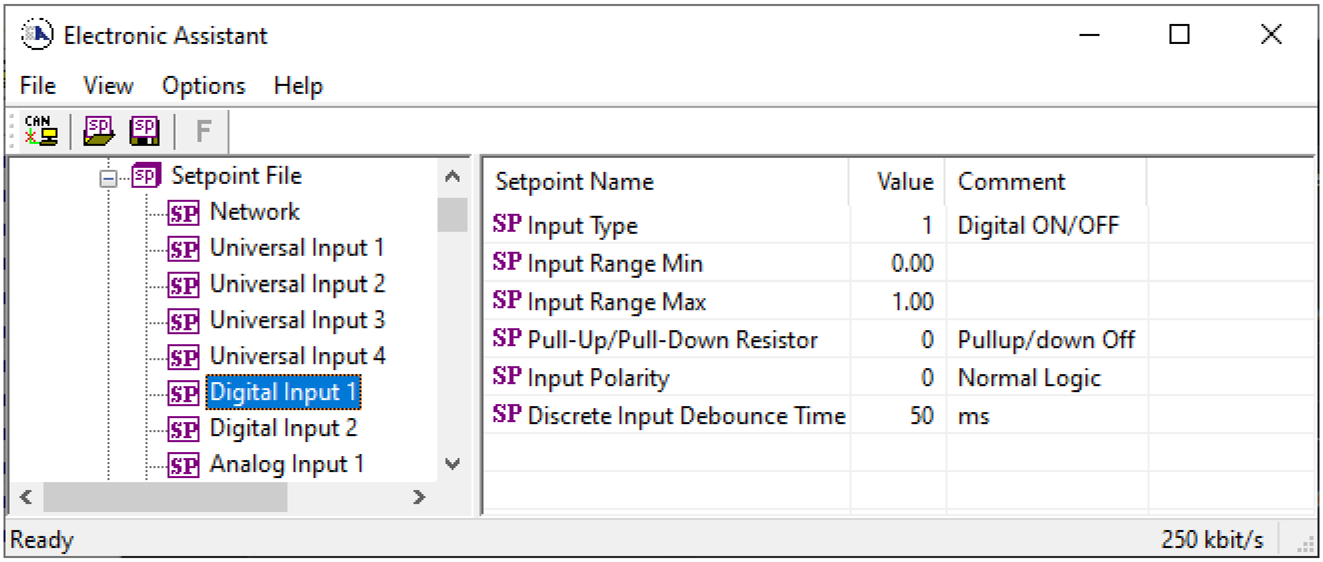


Figure 10 – Screen Capture of Digital Input Setpoints

Table 36 – Digital Input Setpoints

Name	Range	Default	Notes
Input Type	Drop List	1, Digital ON/OFF	See Section 1.3
Input Range Min	0-1	0	
Input Range Max	0-1	1	
Pullup/Pulldown Resistor	Drop List	0, Pullup/down Off	See Section 1.1.4
Input Polarity	Drop List	0, Nirmal Logic	
Discrete Input Debounce Time	0..60000	50 ms	See Section 1.1.4

4.9. Analog Input Setpoints

The Analog Inputs are defined in section 1.2.

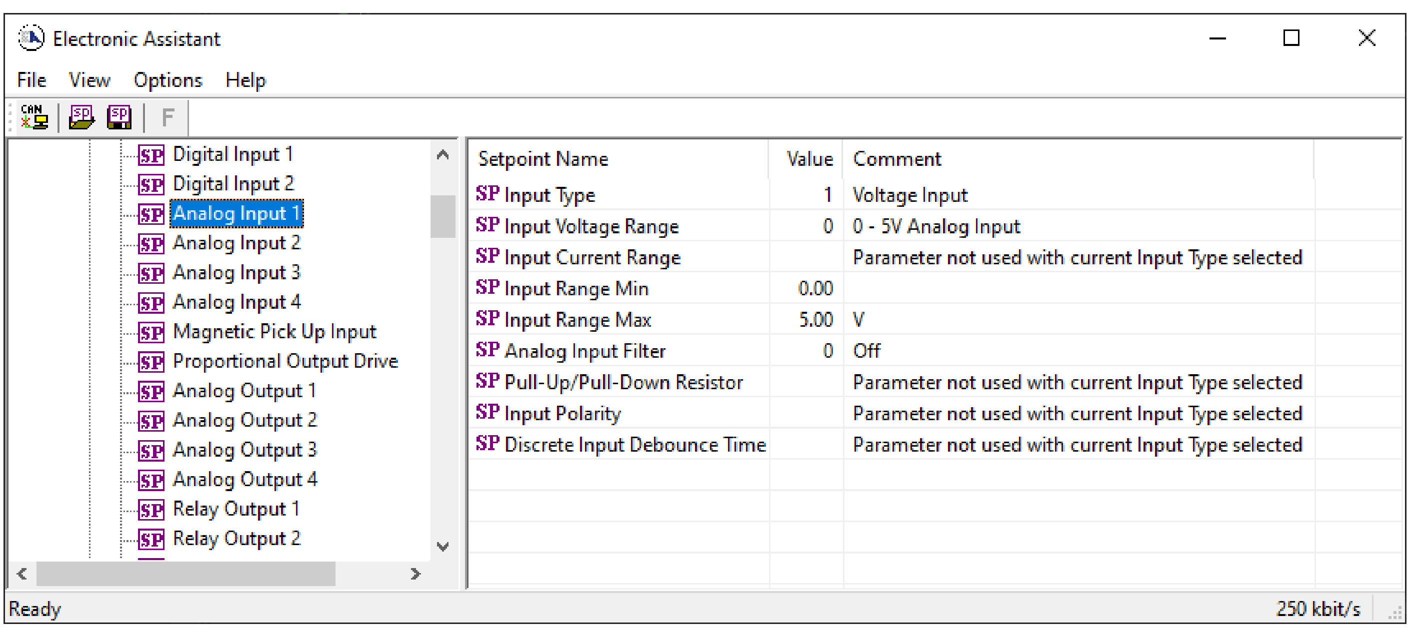


Figure 11 – Screen Capture of Analog Input Setpoints

Table 37 – Analog Input Setpoints

Name	Range	Default	Notes
Input Type	Drop List	Voltage Input	See **Table 9**
Input Voltage Range	Drop List	1, Voltage Input	
Input Current Range	Drop List	0, 0-5V Analog Input	
Input Range Min	0..100	0	
Input Range Max	0..100	5	
Voltage LoZ Input	Drop List	0, Pull Down Disabled	
Analog Input Filter	Drop List	0, Off	
Pullup/Pulldown Resistor	Drop List	0, No Pull	Section 1.1.4
Input Polarity	Drop List	0, Active High	
Discrete Input Debounce Time	0..60000	50 ms	

4.10. Magnetic Pick-Up Input Setpoints

The Magnetic Pick-Up Input defined in section 1.4.

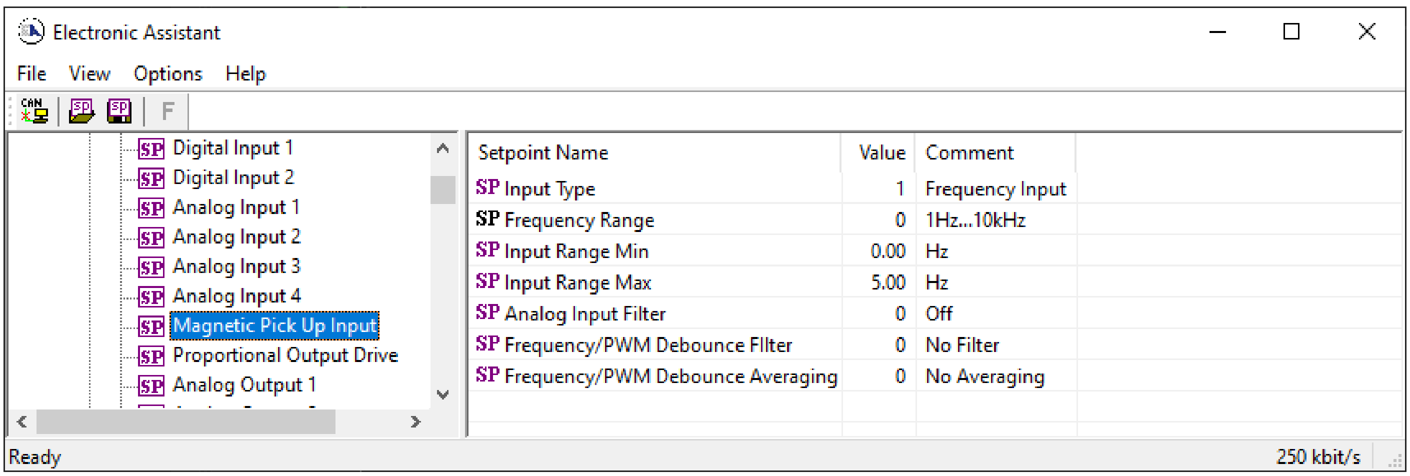


Figure 12 – Screen Capture of Magnetic Pick Up Input Setpoints

Table 38 – Universal Input Setpoints

Name	Range	Default	Notes
Input Type	Drop List	Voltage Input	See 1.4
Frequency Range	Read only	1Hz to 10kHz	
Input Range Min	0..100	0	
Input Range Max	0..100	5	
Analog Input Filter	Drop List	0, Off	
Frequency/PWM Debounce Filter	Drop List	0, No Filter	
Frequency/PWM Debounce Averaging	Drop List	0, No Averaging	

4.11. Proportional Output Setpoints

The Proportional Outputs are defined in sections 1.6 and 1.6.1.

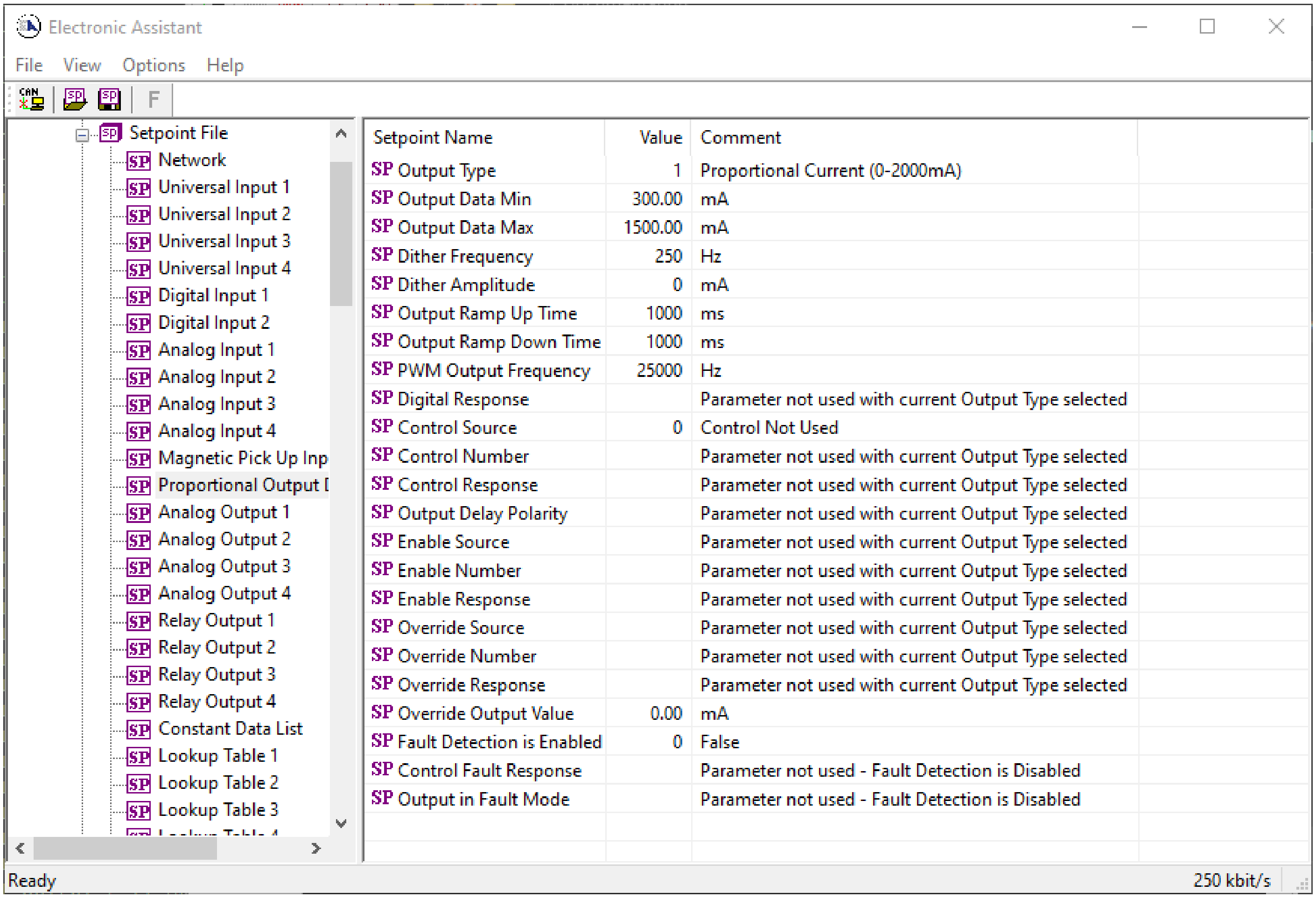


Figure 13 – Screen Capture of Proportional Output Setpoints

Table 39 – Proportional Output Setpoints

Name	**Range**	**Default**	**Notes**
Output Type	Drop List	Proportional current	See Table 18
Output Data Min	0 to Limit	300mA	This setpoint is Hold Current in Digital Hotshot mode
Output Data Max	0 to Limit	1500mA	This setpoint is Hotshot Current in Digital Hotshot mode
Dither Frequency	50 to 400Hz	250Hz	
Dither Amplitude	0 to 500 mA	0	
Ramp Up (Min to Max)	0 to 10 000ms	1000ms	This setpoint is Hotshot Time in Digital Hotshot mode and Digital Delay Time in Digital ON/OFF mode
Ramp Down (Max to Min)	0 to 10 000ms	1000ms	This setpoint is Digital Blink Rate in Digital Hotshot and Digital ON/OFF mode
PWM Output Frequency	1Hz to 25 000Hz	25000Hz	
Digital Response	Drop List	Normal On/Off	See Table 19
Control Source	Drop List	Not Used	See Table 32
Control Number	Depends on control source	1	See Table 32
Enable Source	Drop List	Control not used	See Table 32

Enable Number	Depends on enable source	1	See Table 32
Enable Response	Drop List	Enable When On, Else Shutoff	See Table 16
Override Source	Drop List	Control not used	See Table 32
Override Number	Depends on enable source	1	See Table 32
Override Response	Drop List	Override When On, Else Shutoff	See Table 16
Override Output Value	0-2000	0	
Fault Detection is Enabled	Drop List	0, False	
Control Fault Response	Drop List	1, Apply Fault Value	See Table 20**Table 16**
Override Output Value	0-2000	0	

4.12. Analog Output Setpoints

The Analog Outputs are defined in section 1.6.

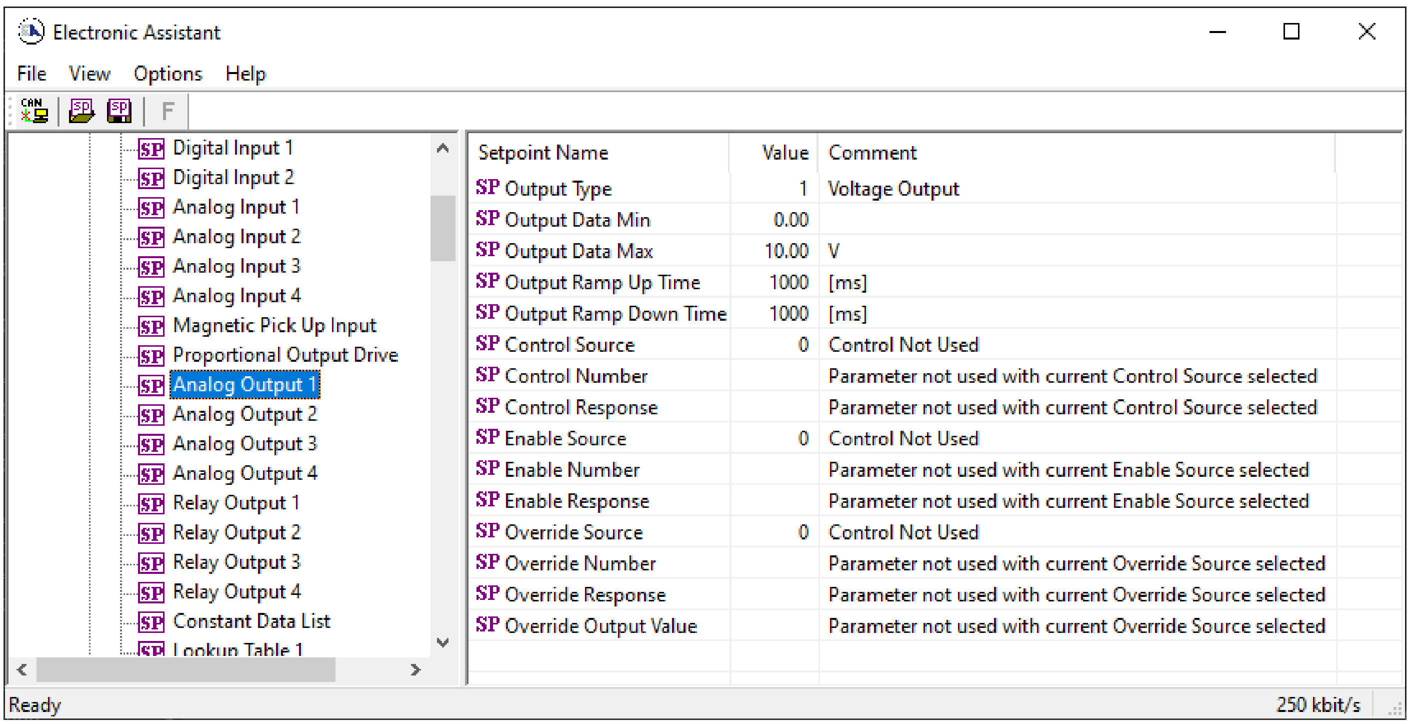


Figure 14 – Screen Capture of Analog Output Setpoints

Table 40 – Analog Output Setpoints

Name	**Range**	**Default**	**Notes**
Output Type	Drop List	Voltage Output	See Table 18
Output Data Min	0 to Limit	0V	
Output Data Max	0 to Limit	10V	
Output Ramp Up (Min to Max)	0 to 10 000ms	1000ms	
Output Ramp Down (Max to Min)	0 to 10 000ms	1000ms	
Control Source	Drop List	Control Not Used	See Table 32
Control Number	Depends on control source	1	See Table 32
Enable Source	Drop List	Control not used	See Table 32
Enable Number	Depends on enable source	1	See Table 32

Enable Response	Drop List	Enable When On, Else Shutoff	See Table 16
Override Source	Drop List	Control not used	See Table 32
Override Number	Depends on enable source	1	See Table 32
Override Response	Drop List	Override When On, Else Shutoff	See Table 16
Override Output Value	0-2000	0	

4.13. Relay Output Setpoints

The Relay Outputs are defined in section 1.5. Please note: *The “**Relay Output Type**” is changed to 1, Normal Logic*

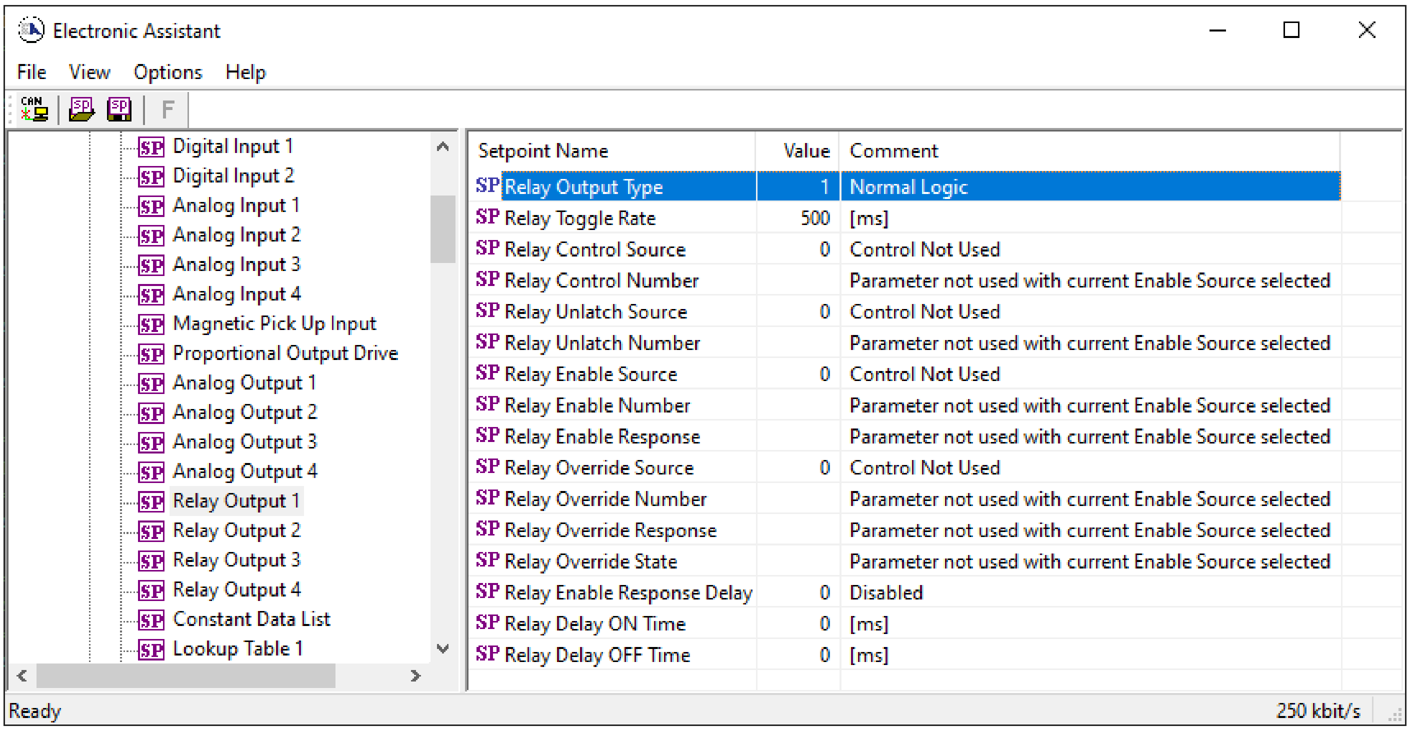


Figure 15 – Screen Capture of Relay Output Setpoints

Table 41 – Relay Output Setpoints

Name	**Range**	**Default**	**Notes**
Relay Output Type	Drop List	Voltage Output	See Table 18
Relay Toggle Rate	0 to 60000	500 ms	
Relay Control Source	Drop List	Control Not Used	See Table 32
Relay Control Number	Depends on control source	1	See Table 32
Relay Enable Source	Drop List	Control not used	See Table 32
Relay Enable Number	Depends on enable source	1	See Table 32
Relay Enable Response	Drop List	Enable When On, Else Shutoff	See Table 16
Relay Override Source	Drop List	Control not used	See Table 32
Relay Override Number	Depends on enable source	1	See Table 32
Relay Override Response	Drop List	Override When On, Else Shutoff	See Table 16
Relay Override State	0-2000	0	

Relay Enable Response Delay	Drop List	0, Disabled	
Relay Delay ON Time	0 to 60000	0 ms	
Relay Delay OFF Time	0 to 60000	0 ms	

4.14. Constant Data List

The Constant Data List Function Block is provide 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 16) are arbitrary and should be configured by the user as appropriate for their application.

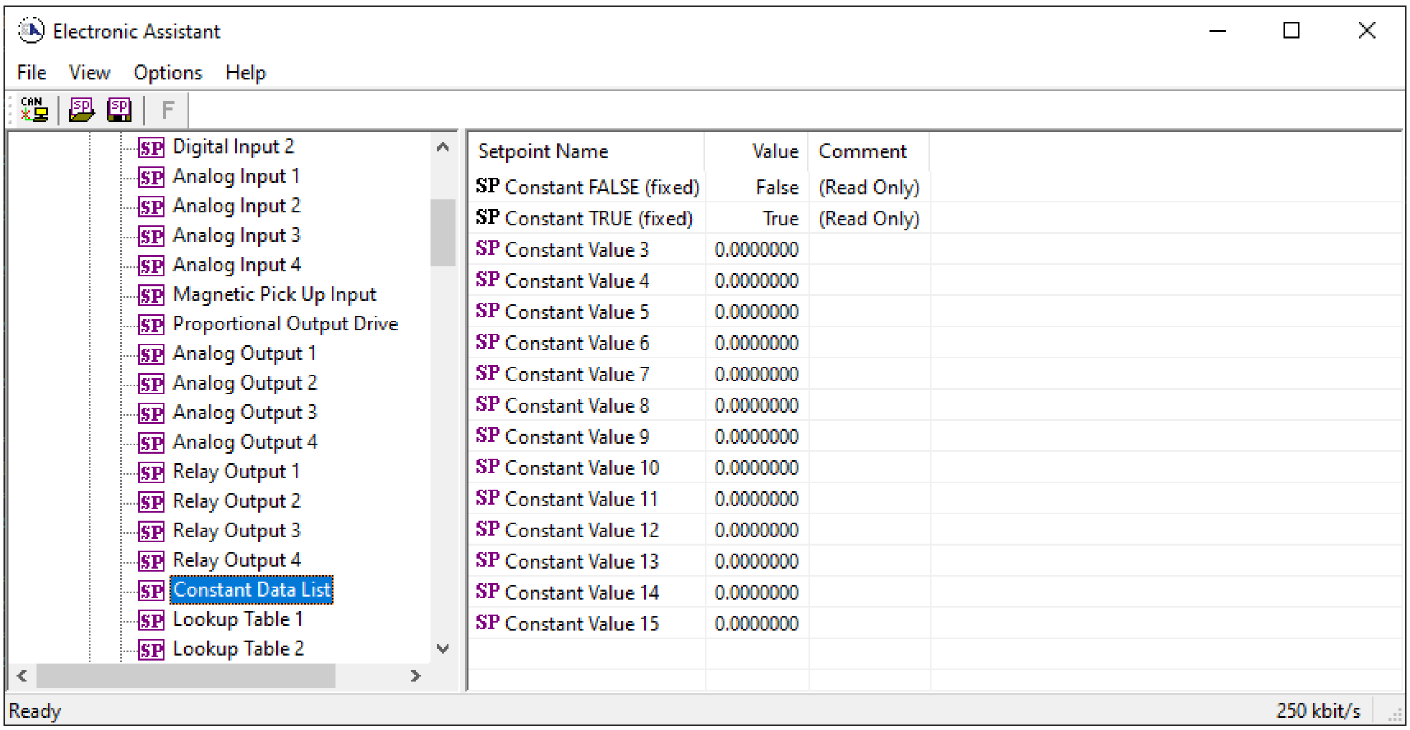


Figure 16 – Screen Capture of Constant Data List Setpoints

4.15. Lookup Table

The Lookup Table Function Block is defined in Section 1.11 Please refer there for detailed information about how all these setpoints are used. "**X-Axis Source**" is set to '*Control Not Used*' by default. To enable a Lookup Table select appropriate "**X-Axis Source**".

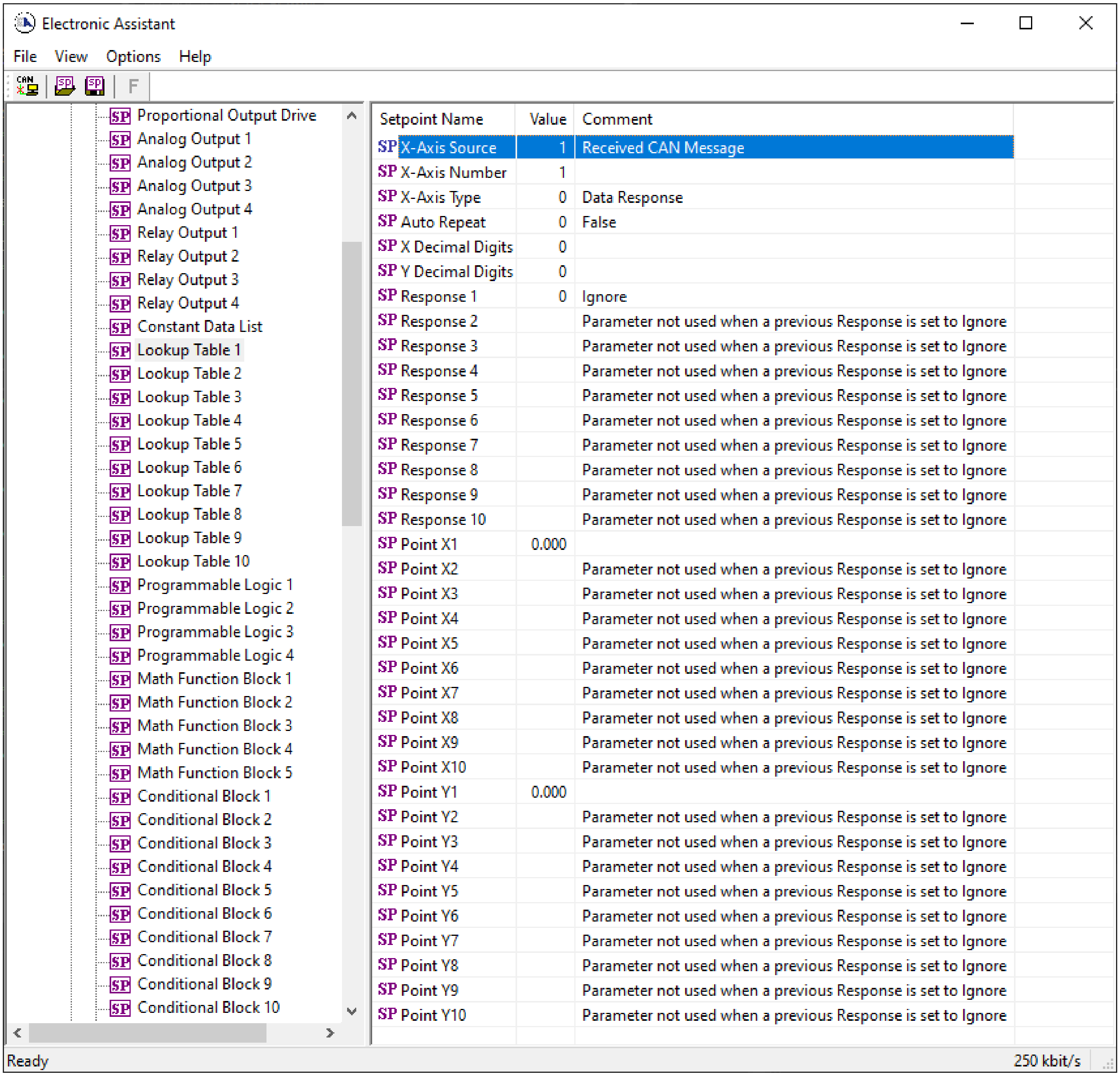


Figure 17 – Screen Capture of Lookup table Setpoints

Table 42 – Lookup Table Setpoints

Name	Range	Default	Notes
X-Axis Source	Drop List	Control Not Used	See Table 32
X-Axis Number	Depends on control source	1	See Table 32
X-Axis Type	Drop List	Data Response	See Table 28
Table Auto-Cycle	Drop List	0	
Point 1 - Response	Drop List	Ramp To	See Table 29
Point 2 - Response	Drop List	Ramp To	See Table 29
Point 3 - Response	Drop List	Ramp To	See Table 29
Point 4 - Response	Drop List	Ramp To	See Table 29
Point 5 - Response	Drop List	Ramp To	See Table 29
Point 6 - Response	Drop List	Ramp To	See Table 29

Point 7 - Response	Drop List	Ramp To	See Table 29
Point 8 - Response	Drop List	Ramp To	See Table 29
Point 9 - Response	Drop List	Ramp To	See Table 29
Point 10 - Response	Drop List	Ramp To	See Table 29
Point 1 - X Value	From X-Axis source minimum to Point 1 - X Value	X-Axis source minimum 0.000	See Section 1.11
Point 2 - X Value	From Point 0 - X Value to Point 2 - X Value	0.500	See Section 1.11
Point 3 - X Value	From Point 1 - X Value to Point 3 - X Value	1.000	See Section 1.11
Point 4 - X Value	From Point 2 - X Value to Point 4 - X Value	1.500	See Section 1.11
Point 5 - X Value	From Point 3 - X Value to Point 5 - X Value source	2.000	See Section 1.11
Point 6 - X Value	From Point 4 - X Value to Point 6 - X Value	2.500	See Section 1.11
Point 7 - X Value	From Point 5 - X Value to Point 7 - X Value	3.000	See Section 1.11
Point 8 - X Value	From Point 6 - X Value to Point 8 - X Value	3.500	See Section 1.11
Point 9 - X Value	From Point 7 - X Value to Point 9 - X Value	4.000	See Section 1.11
Point 10 - X Value	From Point 8 - X Value to Point 10 - X Value	4.500	See Section 1.11
Point 1 - Y Value	-10^6 to 10^6	0.000	
Point 2 - Y Value	-10^6 to 10^6	10.000	
Point 3 - Y Value	-10^6 to 10^6	20.000	
Point 4 - Y Value	-10^6 to 10^6	30.000	
Point 5 - Y Value	-10^6 to 10^6	40.000	
Point 6 - Y Value	-10^6 to 10^6	50.000	
Point 7 - Y Value	-10^6 to 10^6	60.000	
Point 8 - Y Value	-10^6 to 10^6	70.000	
Point 9 - Y Value	-10^6 to 10^6	80.000	
Point 10 - Y Value	-10^6 to 10^6	90.000	

4.16. Programmable Logic

The Programmable Logic function block is defined in Section 1.12. 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**”.

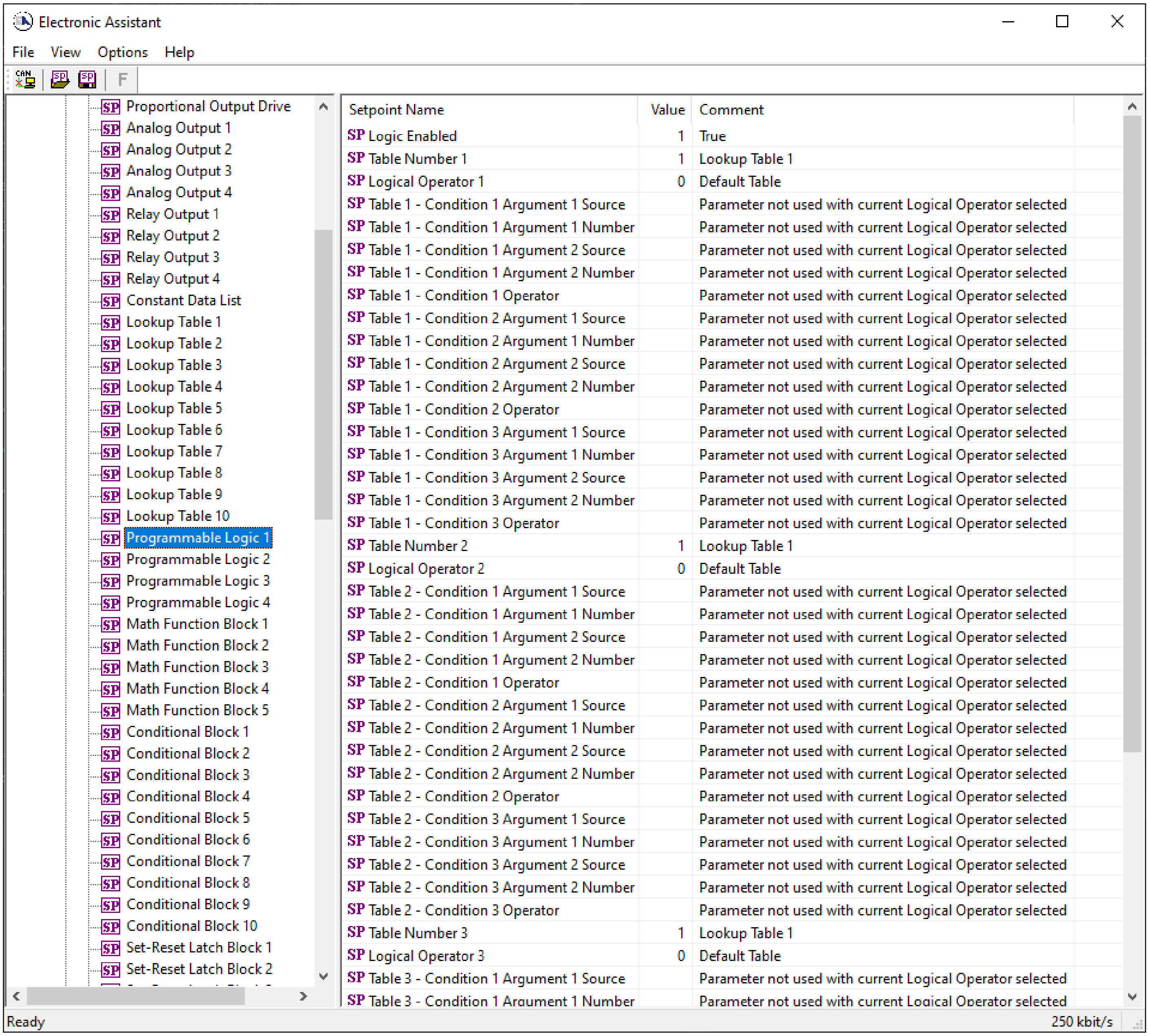


Figure 18 – Screen Capture of Programmable Logic Setpoints

Setpoint ranges and default values for Programmable Logic Blocs are listed in Table 43. 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**".

Table 43 – Programmable Logic Setpoints

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 31
Table1 - Condition1, Argument 1 Source	Drop List	Control Not Used	See Table 32
Table1 - Condition1, Argument 1 Number	Depends on control source	1	See Table 32
Table1 - Condition1, Operator	Drop List	=, Equal	See Table 30
Table1 - Condition1, Argument 2 Source	Drop List	Control Not Used	See Table 32
Table1 - Condition1, Argument 2 Number	Depends on control source	1	See Table 32
Table1 - Condition2, Argument 1 Source	Drop List	Control Not Used	See Table 32
Table1 - Condition2, Argument 1 Number	Depends on control source	1	See Table 32
Table1 - Condition2, Operator	Drop List	=, Equal	See Table 30
Table1 - Condition2, Argument 2 Source	Drop List	Control Not Used	See Table 32
Table1 - Condition2, Argument 2 Number	Depends on control source	1	See Table 32
Table1 - Condition3, Argument 1 Source	Drop List	Control Not Used	See Table 32
Table1 - Condition3, Argument 1 Number	Depends on control source	1	See Table 32
Table1 - Condition3, Operator	Drop List	=, Equal	See Table 30
Table1 - Condition3, Argument 2 Source	Drop List	Control Not Used	See Table 32
Table1 - Condition3, Argument 2 Number	Depends on control source	1	See Table 32

4.17. Math Function Block

The Math Function Block is defined in Section 1.8. Please refer there for detailed information about how all these setpoints are used. "**Math Function Enabled**" is 'False' by default. To enable a Math function Block, set "**Math Function Enabled**" to 'True' and select appropriate "**Input Source**".

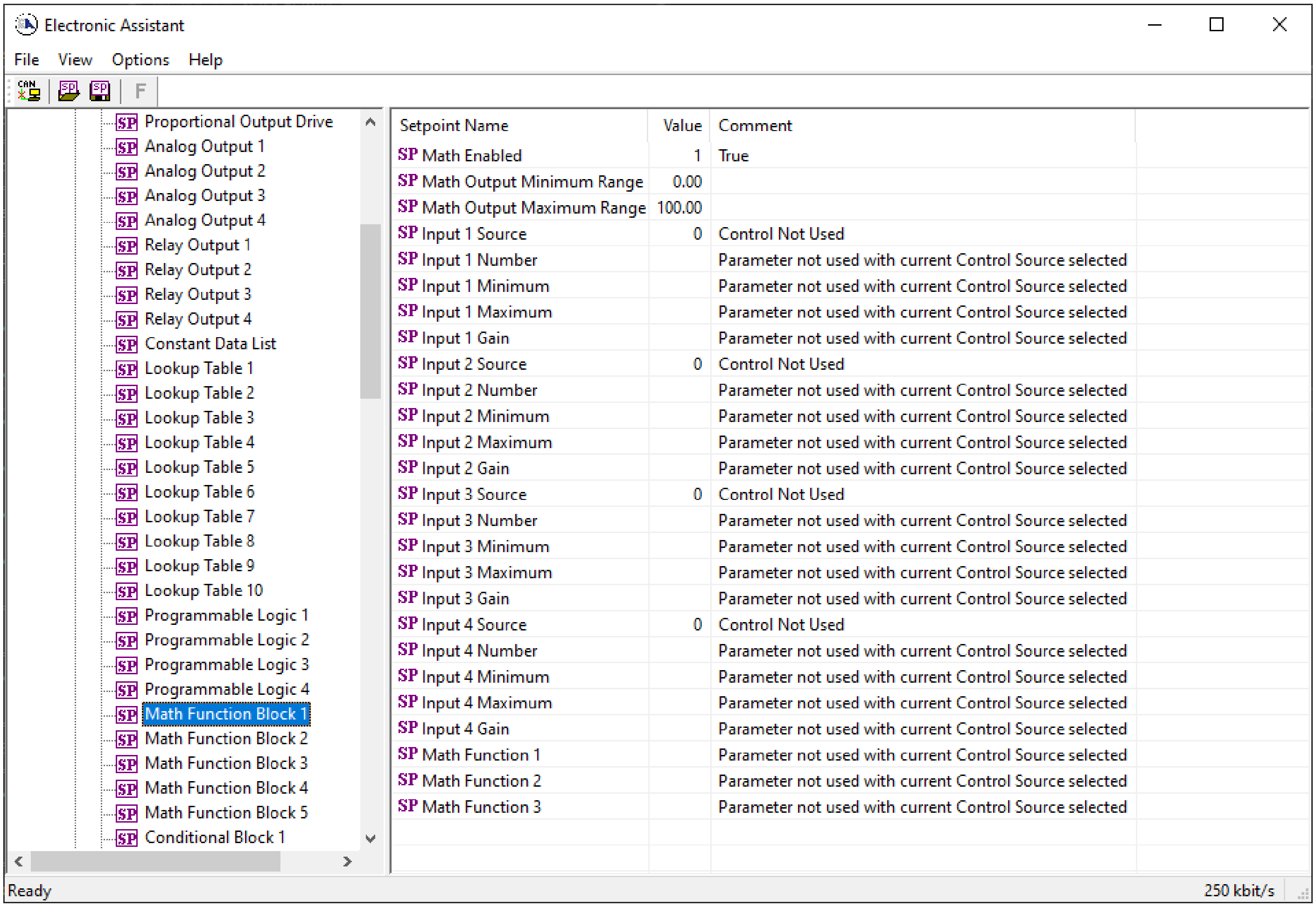


Figure 19 – Screen Capture of Math Function Block Setpoints

Table 44 – Math Function Setpoints

Name	Range	Default	Notes
Math Function Enabled	Drop List	False	
Function 1 Input A Source	Drop List	Control not used	See Table 32
Function 1 Input A Number	Depends on control source	1	See Table 32
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 32
Function 1 Input B Number	Depends on control source	1	See Table 32
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 24
Function 2 Input B Source	Drop List	Control not used	See Table 32
Function 2 Input B Number	Depends on control source	1	See Table 32
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 24
Function 3 Input B Source	Drop List	Control not used	See Table 32

Function 3 Input B Number	Depends on control source	1	See Table 32
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 24
Function 4 Input B Source	Drop List	Control not used	See Table 32
Function 4 Input B Number	Depends on control source	1	See Table 32
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 24
Math Output Minimum Range	-10^6 to 10^6	0.0	
Math Outptu Maximum Range	-10^6 to 10^6	100.0	

4.18. Conditional Logic Block Setpoints

The Conditional Block setpoints are defined in Section 1.9. Refer to that section for detailed information on how these setpoints are used. The screen capture in Figure 20 displays the available setpoints for each of the Conditional Blocks. The table below the screen capture highlights the allowable ranges for each setpoint.

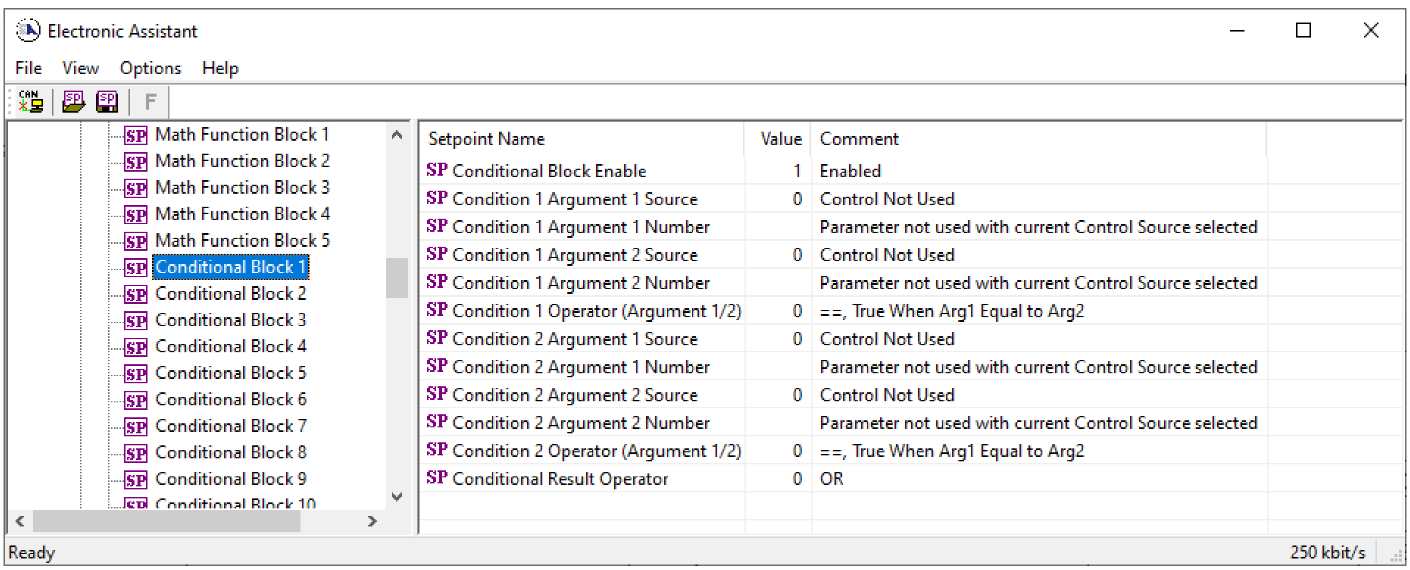


Figure 20: Screen Capture of Conditional Block Setpoints

Table 45. Default Conditional Block Setpoints

Name	Range	Default	Notes
Conditional Function Enabled	Drop List	Disabled	
Condition 1 Argument 1 Source	Drop List	Digital Input	Refer to Table 32
Condition 1 Argument 1 Number	Depends on Source Selected	0	Refer to Table 32
Condition 1 Argument 2 Source	Drop List	Digital Input	Refer to Table 32
Condition 1 Argument 2 Number	Depends on Source Selected	0	Refer to Table 32

Condition 1 Operator (Argument 1/2)	Drop List	0	Refer to Table 25
Condition 2 Argument 1 Source	Drop List	Digital Input	Refer to Table 32
Condition 2 Argument 1 Number	Depends on Source Selected	0	Refer to Table 32
Condition 2 Argument 2 Source	Drop List	Digital Input	Refer to Table 32
Condition 2 Argument 2 Number	Depends on Source Selected	0	Refer to Table 32
Condition 2 Operator (Argument 1/2)	Drop List	0	Refer to Table 25
Conditional Result Operator	Drop List	OR	Refer to Table 26

4.19. Set-Reset Latch Block

The Set-Reset Latch Block setpoints are defined in Section 1.10. Refer to that section for detailed information on how these setpoints are used. The screen capture in Figure 21 displays the available setpoints for each of the Set-Reset Latch Blocks. The table below the screen capture highlights the allowable ranges for each setpoint.

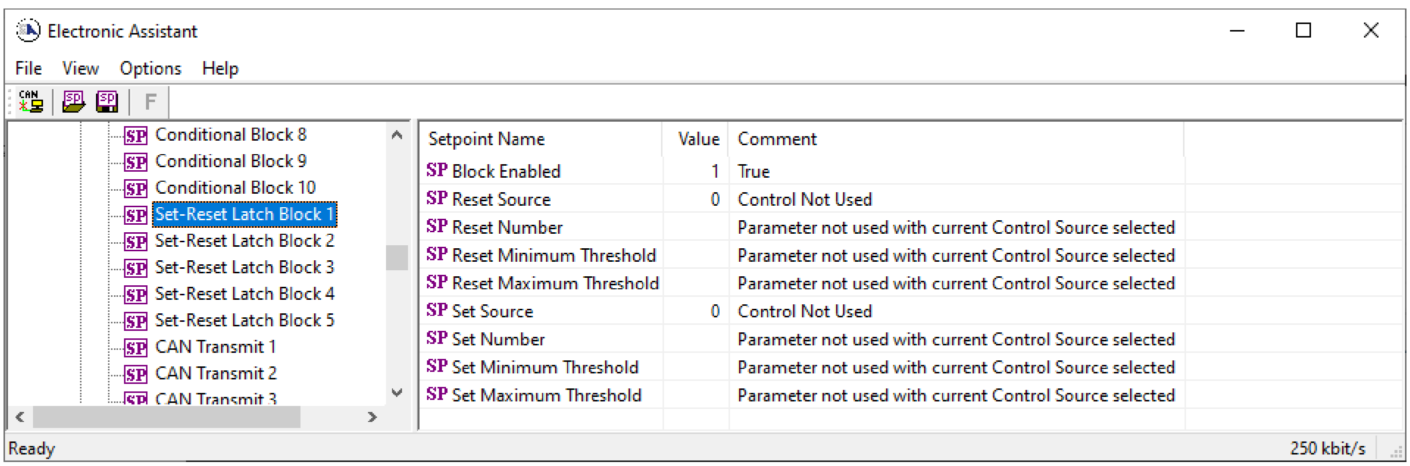


Figure 21: Screen Capture of Set-Reset Latch Block Setpoints

Table 46. Default Set-Reset Latch Block Setpoints

Name	**Range**	**Default**	**Notes**
Block Enabled	Drop List	False	
Reset Source	Drop List	Control Not Used	Refer to Table 32
Reset Number	Depends on Source Selected	1	Refer to Table 32
Reset Minimum Threshold	Drop List	0%	Refer to Section 1.10
Reset Maximum Threshold	Depends on Source Selected	100%	Refer to Section 1.10

Set Source	Drop List	Control Not Used	Refer to Table 32
Set Number	Drop List	1	Refer to Table 32
Set Minimum Threshold	Depends on Source Selected	0%	Refer to Section 1.10
Set Maximum Threshold	Drop List	100%	Refer to Section 1.10

4.20. CAN Transmit Setpoints

CAN Transmit Message Function Block is presented in section 1.15. Please refer there for detailed information how these setpoints are used. "**Transmit Repetition Rate**" is 0ms by default, thus no message will be sent.

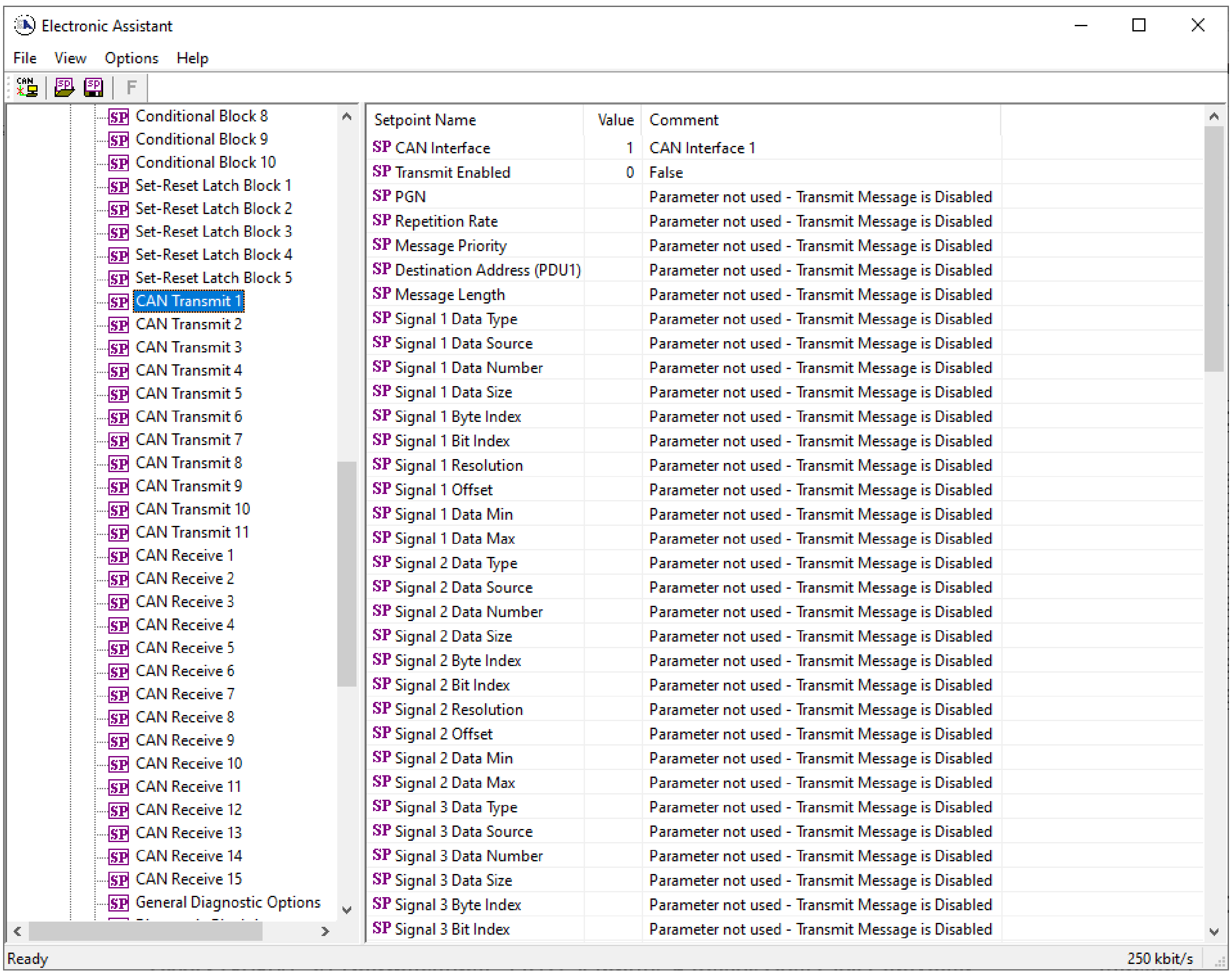


Figure 22 – Screen Capture of CAN Transmit Message Setpoints

Table 47 – CAN Transmit Message Setpoints

Name	Range	Default	Notes
CAN Interface	Drop List	CAN Interface #1	
Transmit Enabled	Drop List	0, False	
Transmit PGN	0xff00 … 0xffff	Different for each	See section 1.15.1
Transmit Repetition Rate	0 … 65000 ms	0ms	0ms disables transmit
Transmit Message Priority	0...7	6	Proprietary B Priority
Destination Address	0...255	255	Not used by default
Signal X Control Source	Drop List	Different for each	See Table 32
Signal X Control Number	Drop List	Different for each	See 1.15.2
Signal X Transmit Data Size	Drop List	2 bytes	
Signal X Transmit Data Index in Array	0-7	0	
Signal X Transmit Bit Index In Byte	0-7	0	
Signal X Transmit Data Resolution	-100000.0 to 100000	1/bits	
Signal X Transmit Data Offset	-10000 to 10000	0.0	
Signal X Transmit Data Minimum	-100000.0 to 100000	0.0	
Signal X Transmit Data Maximum	-100000.0 to 100000	65535.0	

4.21. CAN Receive Setpoints

The CAN Receive Block is defined in section 1.16. 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.

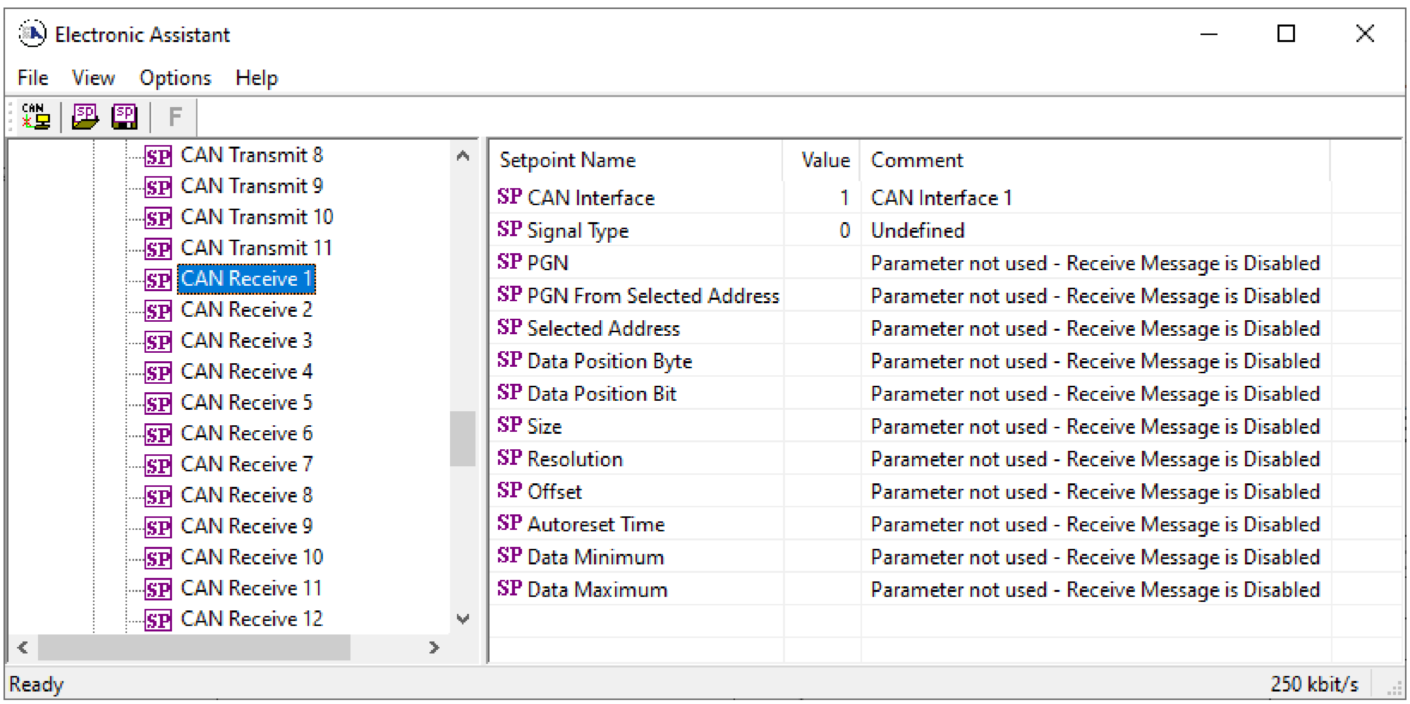


Figure 23 – Screen Capture of CAN Receive Message Setpoints

Table 48 – CAN Receive Setpoints

Name	Range	Default	Notes
CAN Interface	Drop List	CAN Interface #1	
Received Message Enabled	Drop List	False	
Received PGN	0 to 65536	Different for each	
Received Message Timeout	0 to 60 000 ms	0ms	
Specific Address that sends PGN	0 to 255	254 (0xFE, Null Addr)	
Receive Transmit Data Size	Drop List	2 bytes	

Receive Transmit Data Index in Array	0-7	4	
Receive Transmit Bit Index In Byte	0-7	0	
Receive Transmit Data Resolution	-100000.0 to 100000	0.001	
Receive Transmit Data Offset	-10000 to 10000	0.0	
Receive Data Min (Off Threshold)	-1000000 to Max	0.0	
Receive Data Max (On Threshold)	-100000 to 100000	2.0	

4.22. 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 1.7 for more info.

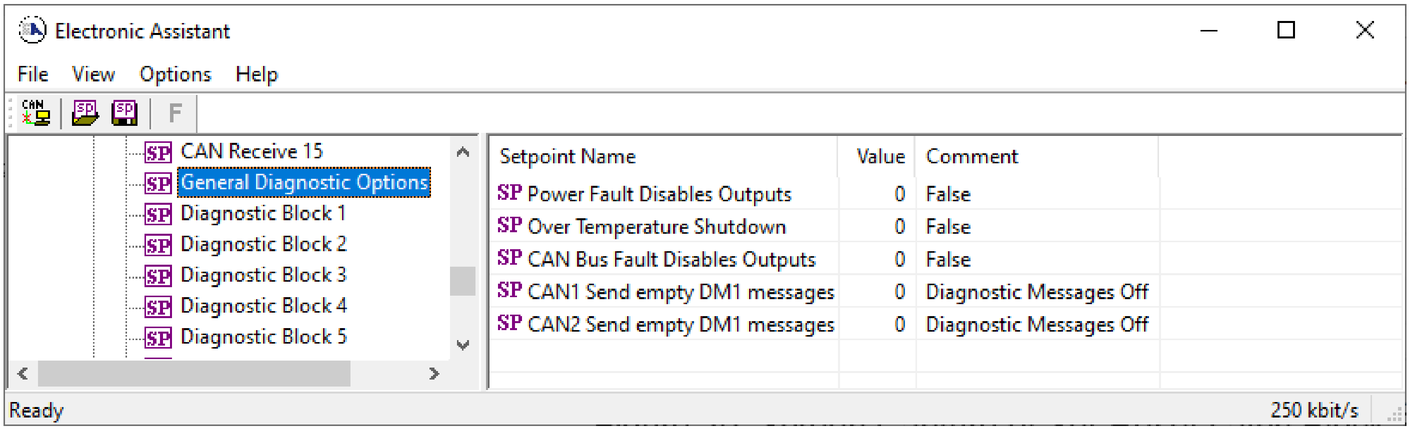


Figure 24 – Screen Capture of General Diagnostics Options Setpoints

Table 49 – General Diagnostics Options Setpoints

Name	**Range**	**Default**	**Notes**
Power Fault Disables Outputs	Drop List	0	
Over Temperature Shutdown	Drop List	0	

4.23. 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 1.7. Please refer there for detailed information how these setpoints are used.

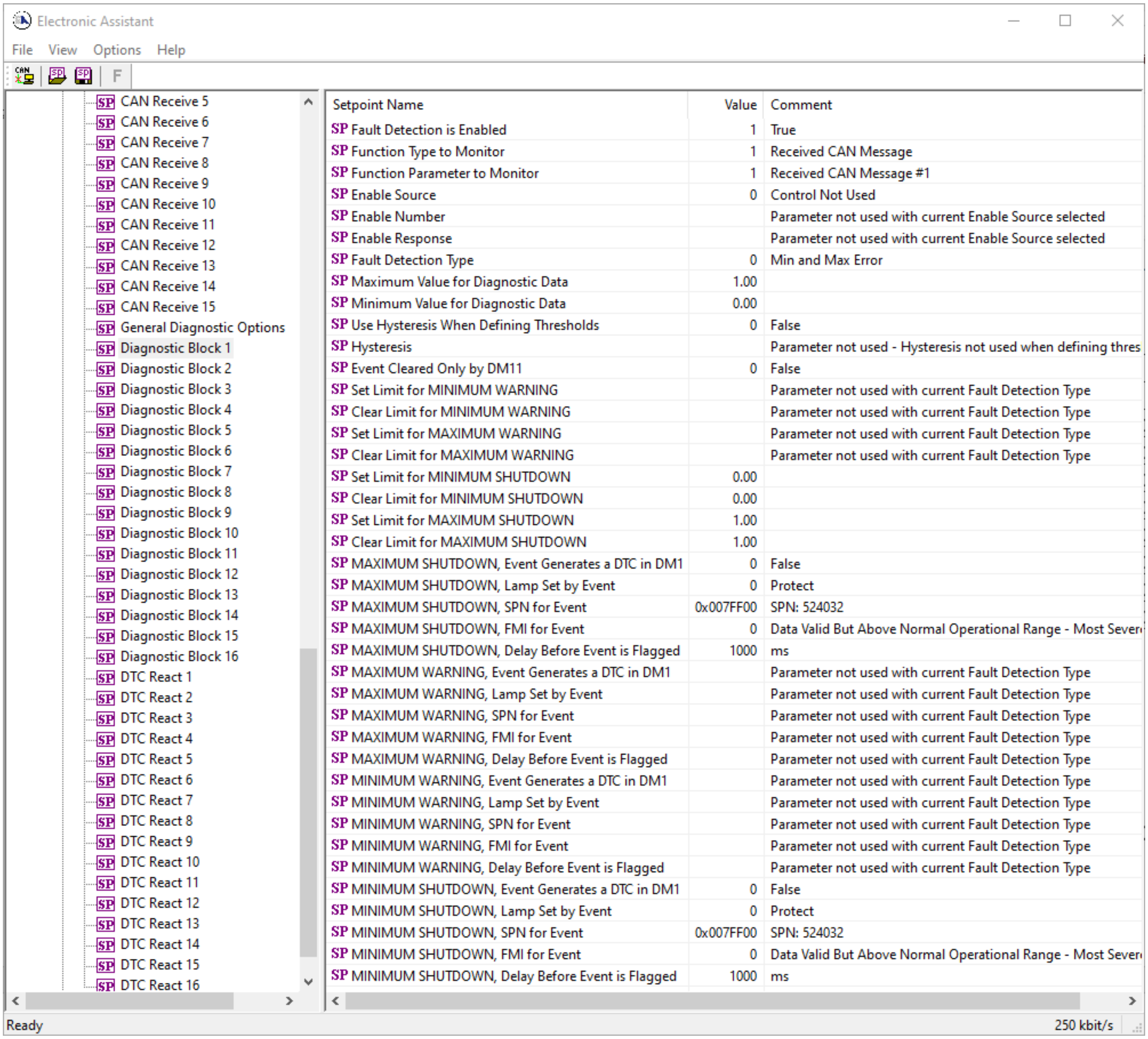


Figure 25 – Screen Capture of Diagnostic Block Setpoints

Table 50 – Diagnostic Block Setpoints

Name	Range	Default	Notes
Fault Detection is Enabled	Drop List	False	
Function Type to Monitor	Drop List	0 – Control not used	
Function parameter to Monitor	Drop List	0 – No selection	
Fault Detection Type	Drop List	0 – Min and Max Error	See section 1.7
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 21
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 22
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 21
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 22
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 21
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 22
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 21
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 22
MINIMUM SHUTDOWN, Delay Before Event is Flagged	0…60000 ms	1000	

4.24. DTC React Function Block

The DTC React function block is described in Section 1.14. The Figure below shows the DTC React function block setpoints. The Table below show the default values. Please note: *The setpoint "DTC React is Enabled" was changed to 1, True.*

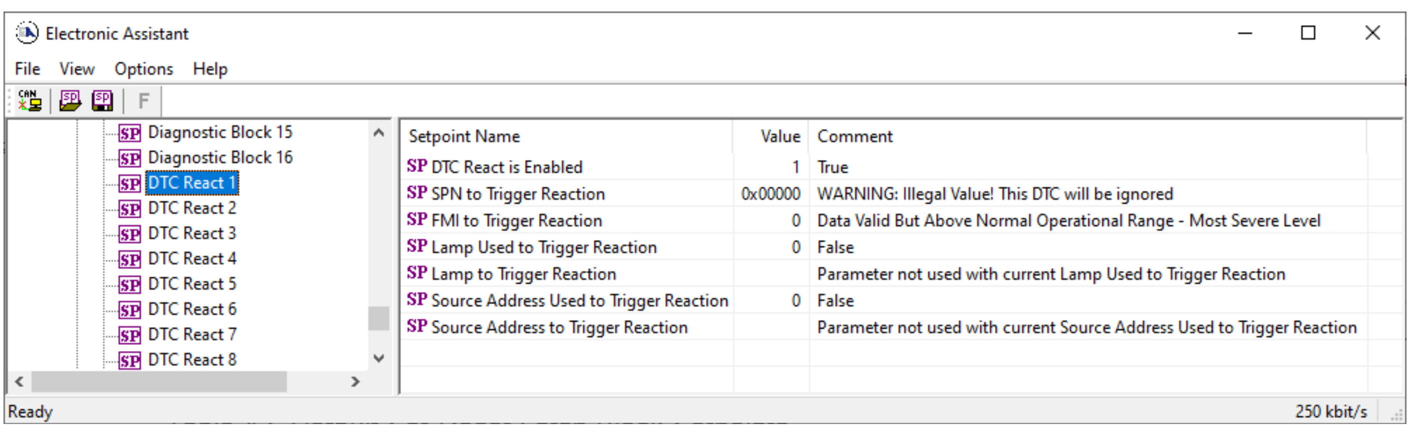


Figure 26 DTC React Setpoints

Table 51 – DTC React Setpoints

Name	**Range**	**Default**	**Notes**
DTC React is Enabled	Drop List	0, False	

SPN to Trigger Reaction	0x00 to 0x3FFFF	0	
FMI to Trigger Reaction	Drop List	0	
Lamp Used to Trigger Reaction	Drop list	0, False	
Lamp to Trigger Reaction	Drop List	0, Protect	
Source Address Used to Trigger Reaction	Drop list	0, False	
Source Address to Trigger Reaction	0x00 to 0xFF	0	

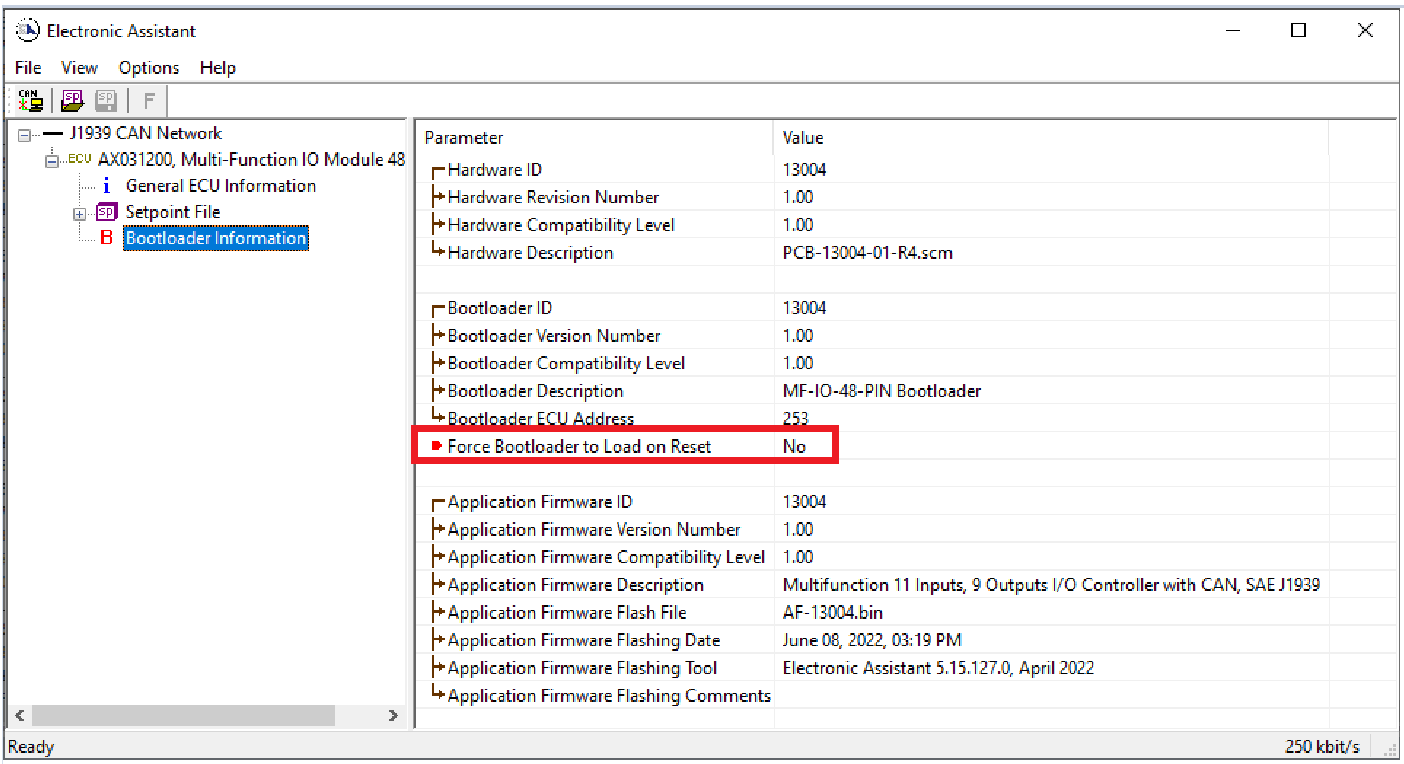
5. REFLASHING OVER CAN WITH THE AXIOMATIC EA BOOTLOADER

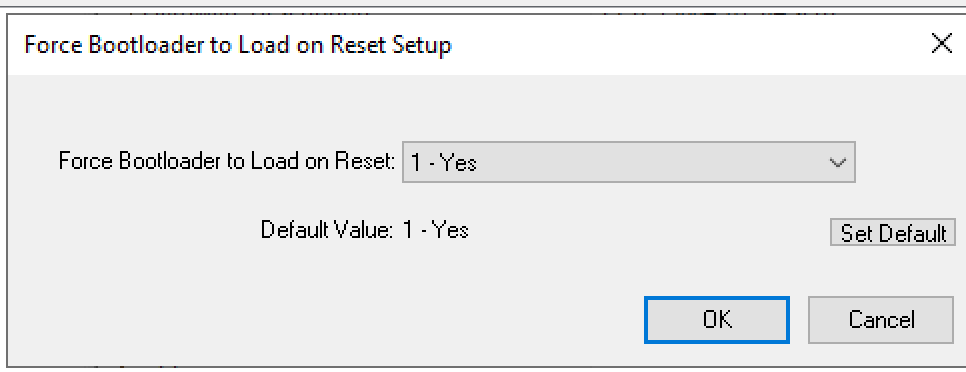
The AX031200 can be upgraded with new application firmware using the **Bootloader Information** section. This section details the simple step-by-step instructions to upload new firmware provided by Axiomatic onto the unit via CAN, without requiring it to be disconnected from the J1939 network.

Note: To upgrade the firmware use Axiomatic Electronic Assistant V4.5.53.0 or higher.

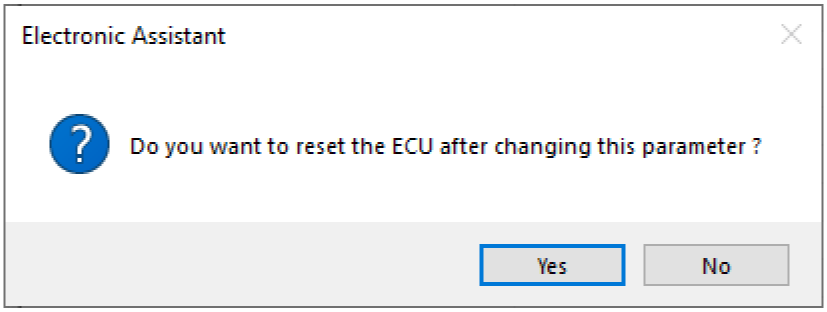
1. When the Axiomatic EA first connects to the ECU, the **Bootloader Information** section will display the following information.

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

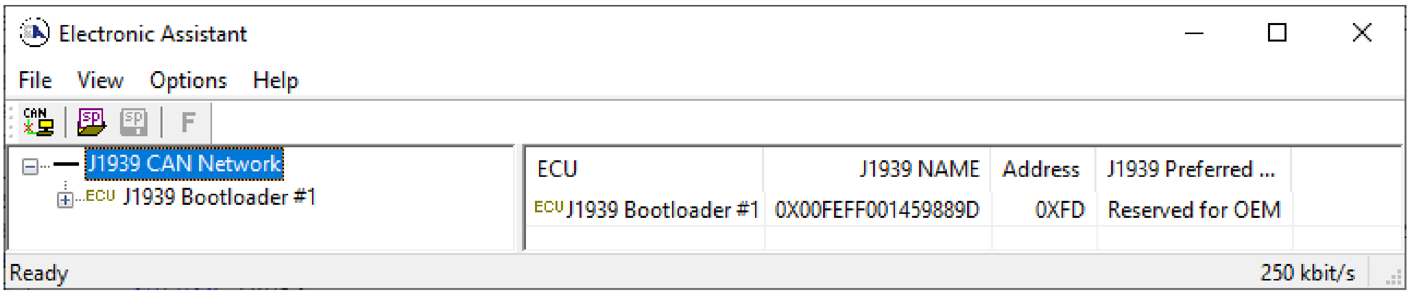


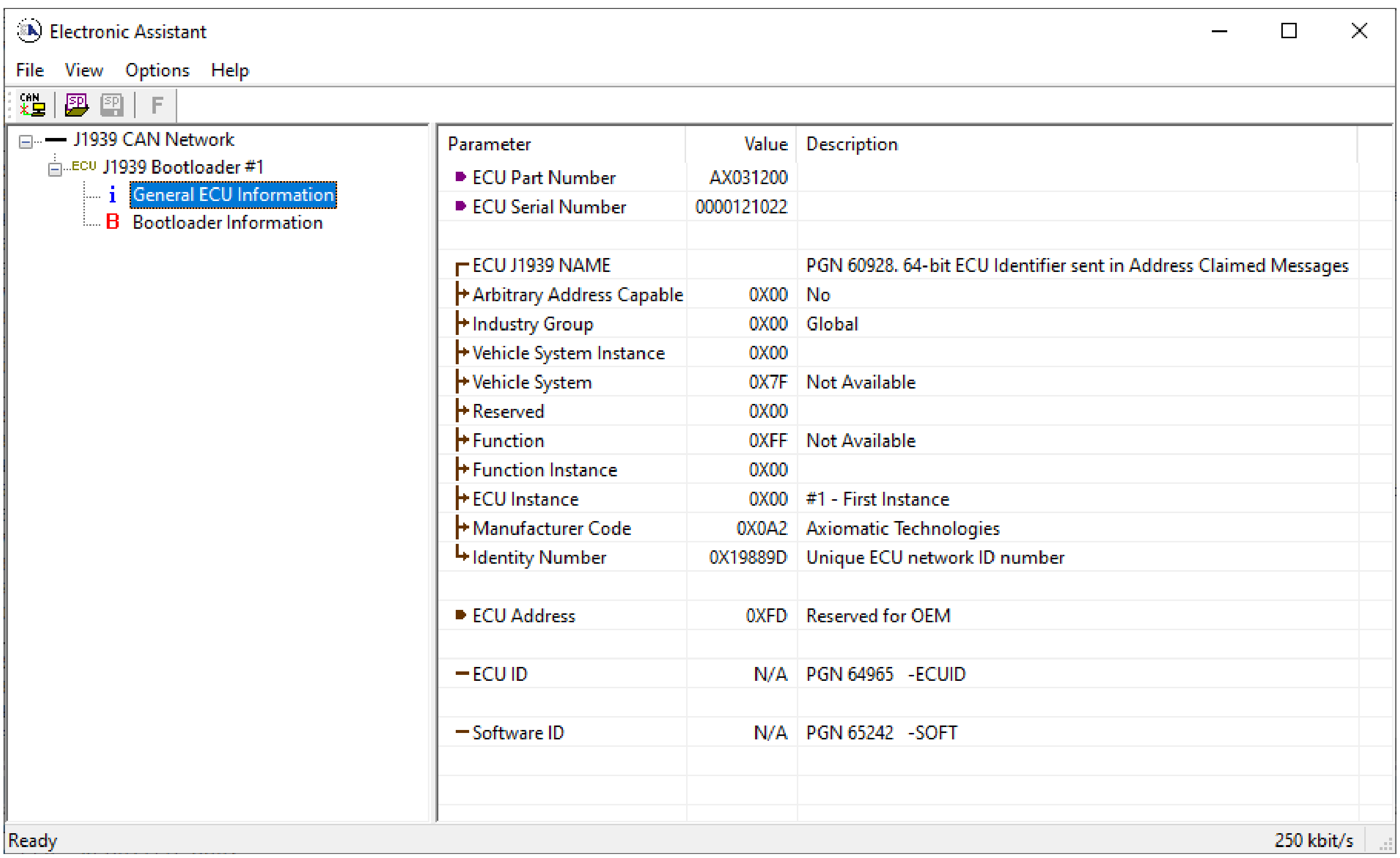


3. When the prompt box asks if you want to reset the ECU, select *Yes*.



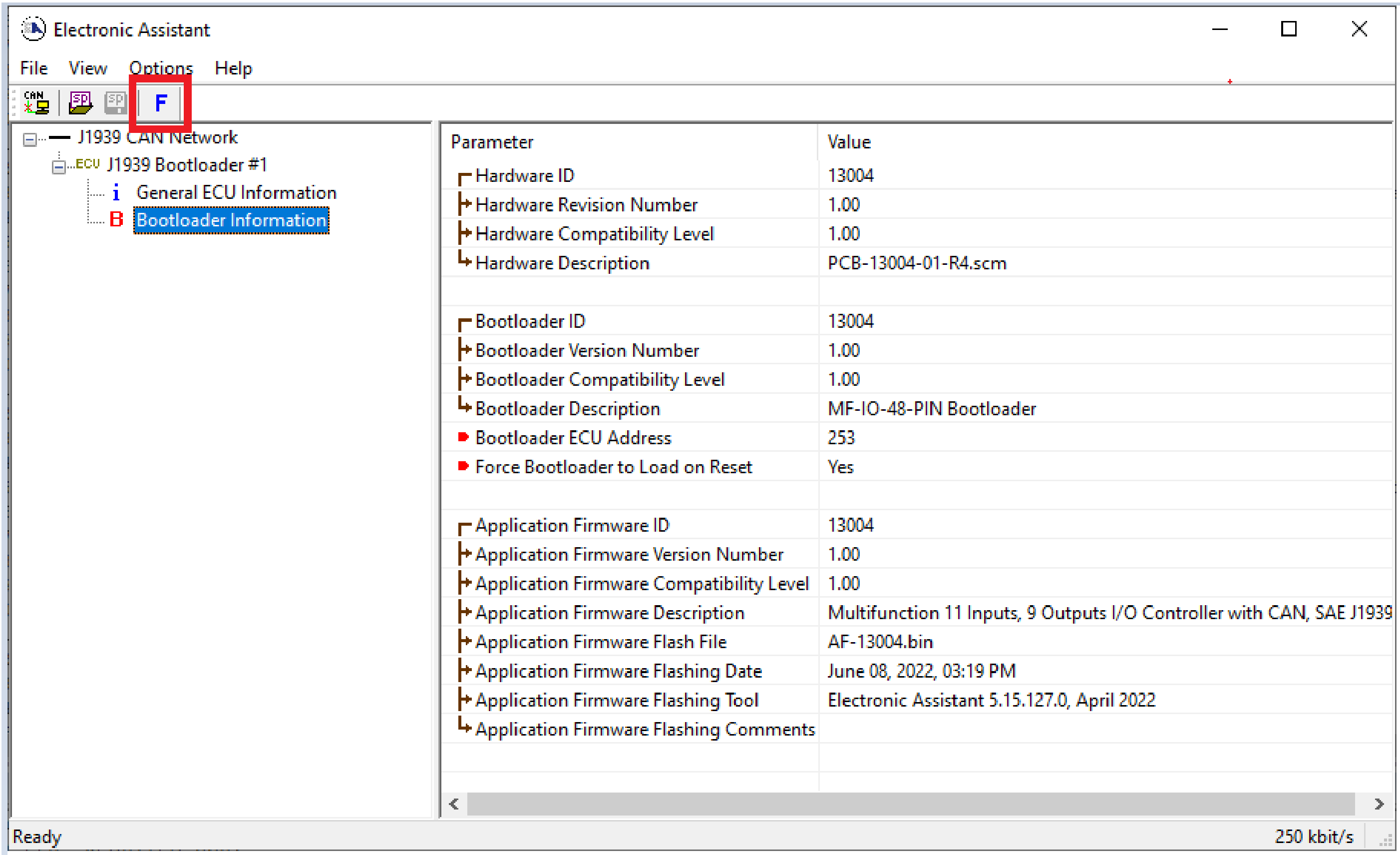
4. Upon reset, the ECU will no longer show up on the J1939 network as an AX031200 but rather as **J1939 Bootloader #1**.





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.

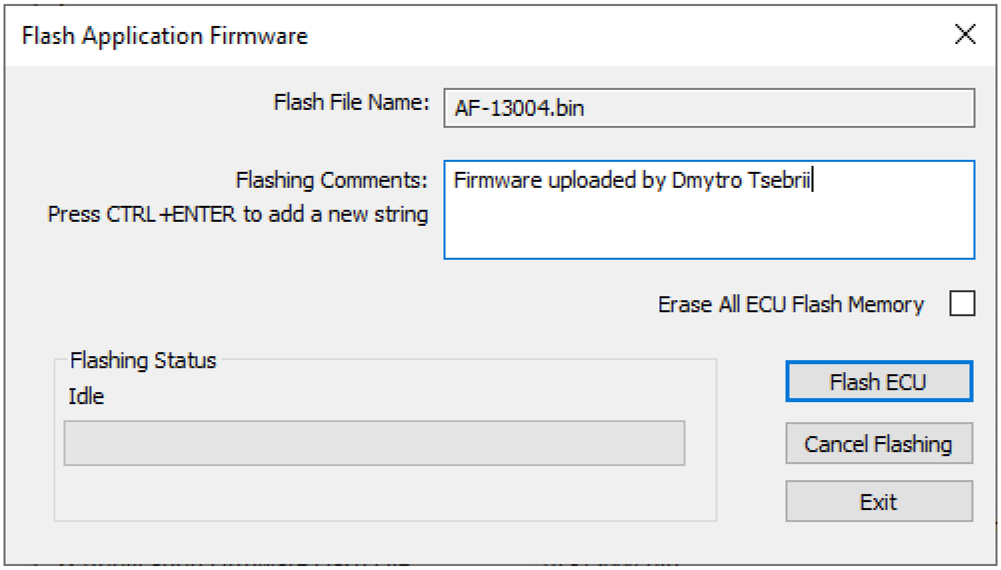
5. When the **Bootloader Information** section is selected, the same information is shown as when it was running the AX031200 firmware, but in this case the Flashing feature has been enabled.



6. Select the Flashing button and navigate to where you had saved the **AF-13004-VX.XX.bin** file sent from Axiomatic. (Note: only binary (.bin) files can be flashed using the Axiomatic EA tool.)

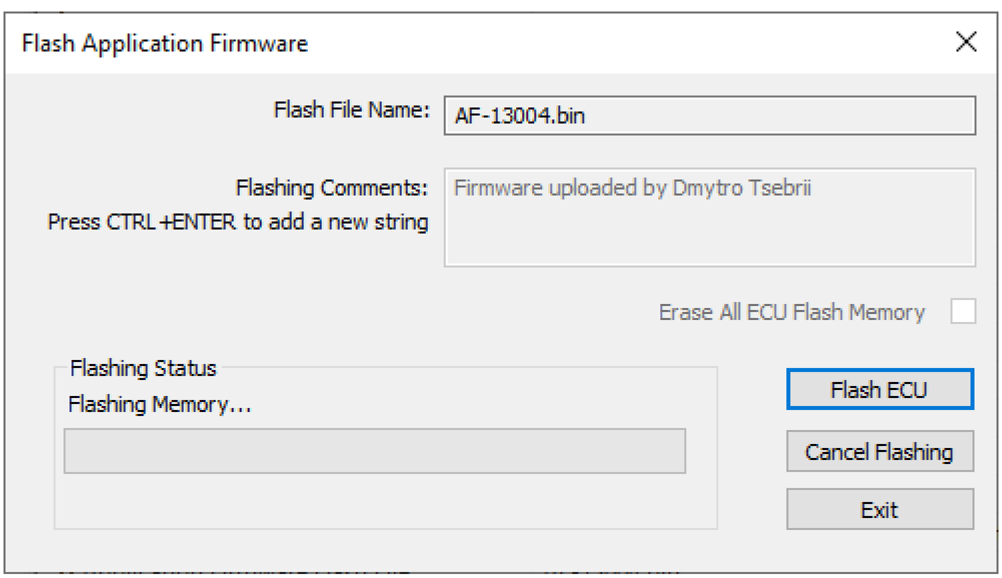
7. Once the Flash Application Firmware window opens, you can enter comments such as “Firmware upgraded by [Name]” if you so desire. This is not required, and you can leave the field blank if you do not want to use it.

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

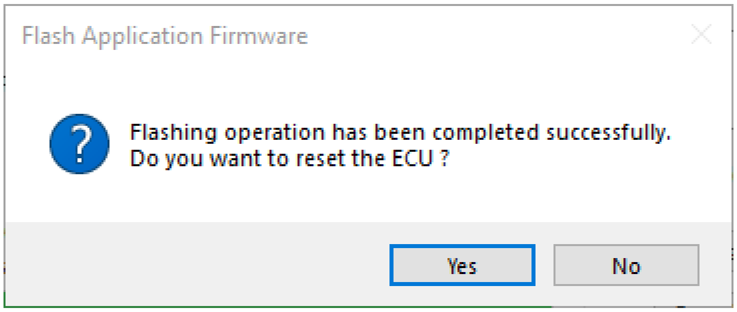


WARNING: Do not check the "Erase All ECU Flash Memory" box unless instructed to do so by your Axiomatic contact. Selecting this will erased ALL data stored in non-volatile flash, including the calibration done by Axiomatic during factory testing. It will also erase any configuration of the setpoints that might have been done to the ECU and reset all setpoints to their factory defaults. By leaving this box unchecked, none of the setpoints will be changed when the new firmware is uploaded.

A progress bar will show how much of the firmware has been sent as the upload progresses. The more traffic there is on the J1939 network, the longer the upload process will take.



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 AX031200 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 AX031200 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

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/.

Inputs

Power Supply Input	12 Vdc or 24 Vdc nominal (9…60 Vdc power supply range) Shutdown voltage is 7.5 Vdc.
Protection	Surge and transient protection Reverse polarity protection Overvoltage protection is up to 80 V.
Inputs	11 Inputs, user selectable: 4 Isolated Analog Inputs 2 Isolated Digital Inputs 1 Magnetic Pick Up Input 4 Universal Inputs Refer to Table 1.0. Inputs and Power are isolated from the outputs and CAN.
Input Grounds	Provided

Table 1.0 – Inputs – User Programmable Options	
Analog Inputs	Four fully isolated inputs selectable as : Voltage, Current or Digital types 12-bit Analog to Digital (voltage, current) Inputs are sampled every 1 msec. Protected against shorts to GND or +Vcc
Voltage Type	0-5 V (Impedance 200 KOhm) 0-10 V (Impedance 150 KOhm) 1mV resolution, accuracy +/- 1% error
Current Type	0-20 mA (Impedance 125 Ohm) 4-20 mA (Impedance 125 Ohm) 6 uA resolution, accuracy +/- 1% error Current sense resistor 124Ω
Digital Type	Active High or Active Low
Digital Input	Two fully isolated Active High or Active Low Inputs Configurable 10kΩ pullup or pulldown resistor Pullup at 5VDC, pulldown to reference.
Magnetic Pick Up Input	One input Range: 0.5 Hz to 10 kHz 100mV to 100V RMS
Universal Inputs	Four fully independent inputs selectable as : Voltage; Current; Resistive; Frequency; RPM; PWM; or Digital types 12-bit Analog to Digital (voltage, current, resistive) 15-bit Timer (frequency, RPM, PWM) Protected against shorts to GND or +Vcc
Voltage Type	0-1V, 0-2.5V, 0--5V or 0-10V 1mV resolution, accuracy +/- 1% error
Current Type	0-20mA or 4-20mA 1uA resolution, accuracy +/- 2% error Current sense resistor 124Ω
Resistive Type	Self-calibrating for range of 30 Ω to 250 kΩ 1Ω resolution, accuracy +/- 1% error
PWM Input	1MΩ Impedance 0 to 100% 100 Hz to 10 kHz 0.01% resolution, accuracy +/- 1% error
Frequency/RPM Input	0.5 Hz to 50 Hz; 0.01 Hz resolution 10 Hz to 1 kHz; 0.1Hz resolution 100 Hz to 10 kHz; 1 Hz resolution Accuracy +/- 1% error
Digital Input	Active High or Active Low with 22 kOhm pull-up or pull-down

Outputs

<table>
<tr><td>Outputs</td><td>4 Isolated Analog Outputs
4 Relay Outputs
1 Valve Driver Output

The outputs are user selectable as follows. Refer to Table 2.0.
<table>
<tr><td colspan="2">Table 2.0: Outputs</td></tr>
<tr><td>Analog Outputs:</td><td>Four fully isolated analog outputs as : Voltage or Current
12-bit Digital to Analog (voltage, current)
Protected against shorts to GND or +Vcc

<u>Voltage Output:</u>
0-5 Vdc or 0-10 Vdc
1mV resolution, accuracy +/- 1% error
<table>
<tr><td>Output Range</td><td>Maximum load</td></tr>
<tr><td>0-5V</td><td>1kΩ</td></tr>
<tr><td>0-10V</td><td>10kΩ</td></tr>
</table>
<u>Current Output:</u>
0-20 mA or 4-20 mA
Max. load resistance is < 350 Ohms
Compliance Voltage is 7 V.
6.1 uA resolution, accuracy +/- 1% error</td></tr>
<tr><td>Relay Outputs</td><td>Four Relay Outputs
Max. 5A, 250VAC or 220VDC, NO</td></tr>
<tr><td>Valve Driver Output</td><td>One fully independent software controlled output selectable as:
• Proportional Current;
• Hotshot Digital;
• PWM Duty Cycle;
• Proportional Voltage;
• or On/Off Digital
Half-bridge output, current sensing, grounded load.
High side sourcing up to 2A

Current Outputs: 1mA resolution, accuracy +/- 2% error

Voltage Outputs: 0.1V resolution, accuracy +/- 5% error
Average output based on unit power supply
High frequency drive at 25kHz

PWM Outputs: 0.1% resolution, accuracy +/- 0.1% error

Digital On/Off:
Load at supply voltage must not draw more than 2A.</td></tr>
</table></td></tr>
<tr><td>Isolation</td><td>300 Vrms
The outputs are isolated from the inputs.
The CAN bus port is isolated from both inputs and outputs.</td></tr>
<tr><td>Protection for Output Terminals</td><td>Fully protected against short circuit to output ground and +Vcc.
Unit will fail safe in the case of a short circuit condition, self-recovering when the short is removed.</td></tr>
</table>

General Specifications

Microprocessor	STM32 32-bit, 512 kByte flash memory
Typical Quiescent Current	97 mA @ 24Vdc
Control Logic	Standard embedded software is provided.
Communications	2 Isolated CAN ports (SAE J1939) (A CANopen® model is available as P/N: AX031201.) AX031200 – 250 kbps baud rate AX031200-01 – 600 kbps baud rate
Network Termination	It is necessary to terminate the network with external termination resistors. The resistors are 120 Ohm, 0.25W minimum, metal film or similar type. They should be placed between CAN_H and CAN_L terminals at both ends of the network.

User Interface	The Axiomatic Electronic Assistant KIT, P/Ns: **AX070502** or **AX070506K**
EMC Compliance	CE marking
Vibration	Random Vibration: 7.68 Grms peak Sinusoidal Component: 10 g peak Based on MIL-STD-202G, Methods 204G, 214A and 213B
Operating Conditions	-40 to 85 °C (-40 to 185 °F)
Storage Temperature	-55 to 125 °C (-67 to 257°F)
Protection	IP67
Weight	1.35 lbs. (0.612 kg)
Enclosure	High Temperature Nylon Enclosure – (equivalent TE Deutsch P/N: EEC-5X650B) 4.03 x 4.25 x 1.68 inches 102.44 x 107.96 x 42.67 mm L x W x H including integral connector Refer to the dimensional drawing.
Installation	For mounting information, refer to the dimensional drawing. Mounting holes sized for ¼ inch or M6 bolts. The bolt length will be determined by the end-user's mounting plate thickness. The mounting flange of the controller is 0.25 inches (6.35 mm) thick. If the module is mounted without an enclosure, it should be mounted to reduce the likelihood of moisture entry. Install the unit with appropriate space available for servicing and for adequate wire harness access (6 inches or 15 cm) and strain relief (12 inches or 30 cm). Wires should be of the appropriate gauge to meet requirements of applicable electrical codes and suit the specifications of the connector. The module must be mounted in an enclosure in hazardous locations. All field wiring should be suitable for the operating temperature range of the module. All chassis grounding should go to a single ground point designated for the machine and all related equipment.
Mating Plugs	Mates with the following TE Deutsch P/Ns: DT06-12SA Plug, DT 12 Way A Key DT06-12SB Plug, DT 12 Way B Key DT06-12SC Plug, DT 12 Way C Key DT06-12SD Plug, DT 12 Way D Key A set equivalent to these mating plugs is available as ordering P/N: AX070123.

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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.

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