



USER MANUAL UMAX100520

Version 2.0.1

2x Universal Inputs 1x 10A H-Bridge Controller

USER MANUAL

P/N: AX100520

ACRONYMS

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

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

1. OVERVIEW OF CONTROLLER

The ECU is a device that measures numerous types of input signals as well as drives different outputs. The Controller has 2 Universal Inputs. The one output can either be used as Proportional Output with half-bridge drive and high side sourcing up to 10A, or a 10A H-Bridge. Flexible circuit design gives the user a wide range of configurable input and output types. The sophisticated control algorithms allow the user to program the controller for a wide range of applications without the need for custom software.

The ECU has been designed to allow the maximum amount of versatility to optimize the performance of the machine. Numerous configurable variables, called setpoints, have been provided which are accessible using Axiomatic Electronic Assistant. Information about the setpoint defaults and ranges is outlined in Section 0. The EA communicates with the controller over the J1939 CAN bus and uses Memory Access Protocol (MAP) to read/write each setpoint. Once the ECU has been set up as desired, the setpoints can be saved to a file, and flashed into other controllers over the CAN bus using EA.

The ECU is an arbitrary address capable of ECU, which can perform dynamic address allocation at the run time. It also provides all necessary network support required by the J1939 standard.

J1939 Network – Diagnostic Broadcast

Diagnostic messages are triggered by the internal function blocks and then broadcasted on the CAN bus network. However, in some applications this broadcast may not be required and so the user has the option to disable or enable this feature.

1.1. Hardware Block Diagram

The controller contains 2 Universal Inputs, 1 Output, 1 CAN, transient and surge suppression polarity protection and a protected power supply. An embedded 32-bit microcontroller provides the necessary processing power to the controller.

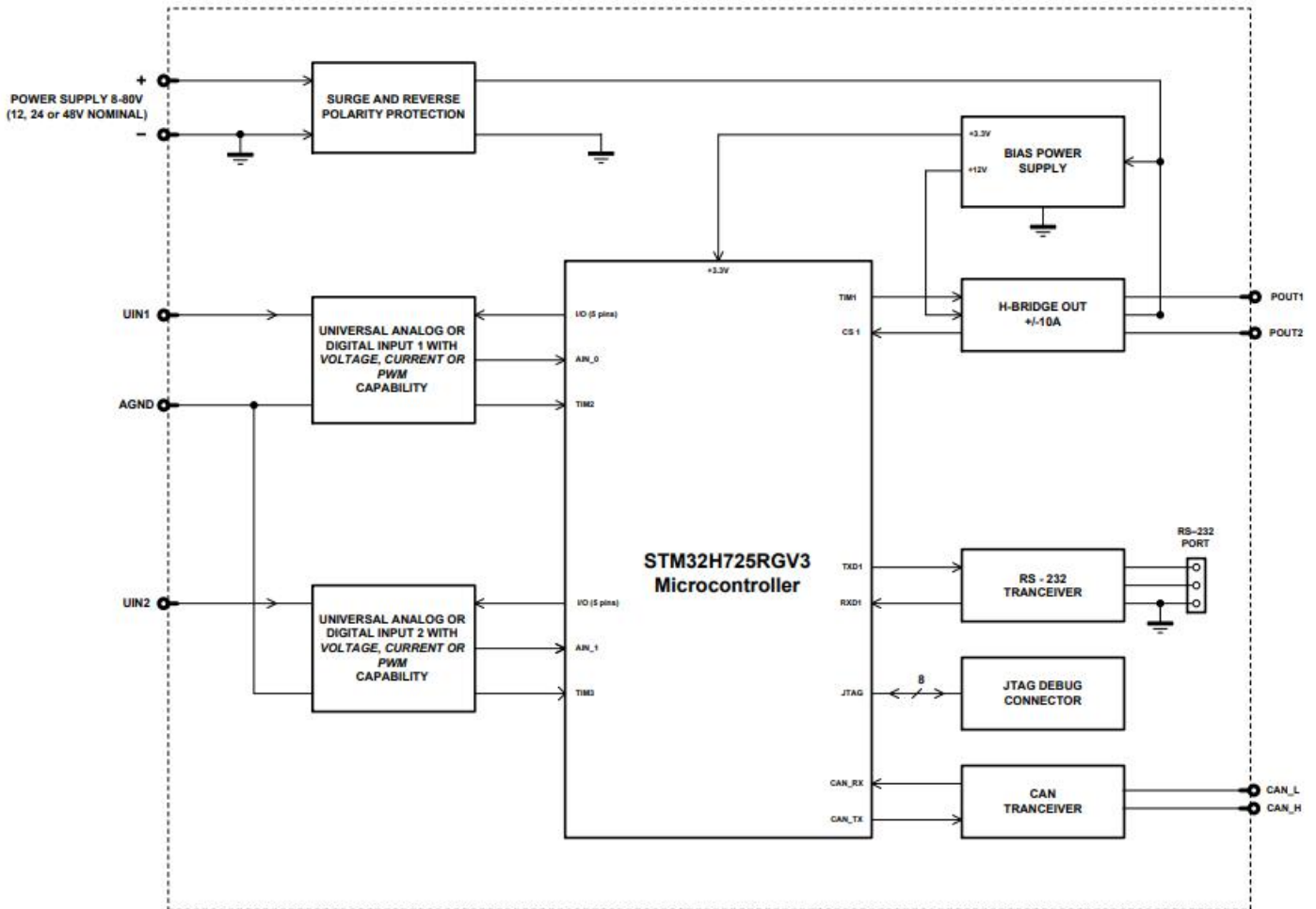


Figure 1. The ECU Flowchart

1.1. Universal Input Function Blocks

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.

The controller has 2 Universal Inputs. They can be configured to measure voltage, current, frequency, pulse width modulation (PWM) or digital signal.

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

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

Table 1. Universal Input Function Block Output Signal

Each Universal Input function block has the following configuration parameters.

Parameter	Default Value	Range	Units	Description
Input Parameter	1 - Voltage	0 - Input Disabled, 1 - Voltage, 2 - Current, 3 - Discrete Voltage Level, 4 - Frequency, 5 - PWM Duty Cycle	-	Defines the input physical parameter that will be measured by the function block.
Voltage Range	0 - 0...5V	0...5 V, 0...10 V	V	Used in the "Voltage" mode
Current Range ¹	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	Pull Down Disabled, Pull Down Enabled	-	Activates a 10kOhm pull-down resistor to avoid ghost voltages in the "Voltage" mode. Warning: Measurement accuracy will be decreased!
Analog Input Filter	0 - Disabled	Disabled, 50Hz Noise Rejection, 60Hz Noise Rejection, Both: 60Hz and 50Hz Noise Rejection	-	Noise Rejection in "Voltage", "Current" and "Resistance" modes
Pull-Up/Pull-Down Resistor	0 - Disabled	Disabled, 10kOhm Pull-Up, 10kOhm Pull-Down	-	Used in "Discrete Voltage Level", "Frequency", and "PWM Duty Cycle" modes.

Parameter	Default Value	Range	Units	Description
Input Polarity	0 - Active High	Active High, 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	1Hz...10kHz	1Hz...10kHz,	Hz	A 16-bit counter is used. Used in "Frequency", and "PWM Duty Cycle" modes.
Frequency/PWM Debounce Filter	0 - Disabled	Disabled, 142ns, 1.14us, 6.10us	–	Used in "Frequency", and "PWM Duty Cycle" modes.
Frequency/PWM Averaging	0 - No Averaging	No Averaging, 3 Readings, 5 Readings, 10 Readings	–	Defines a moving average filter used in "Frequency", and "PWM Duty Cycle" modes.
Software Filter Type	0 – Disabled	0 – Disabled, 1 – Moving Average, 2 – Repeating Average		
Software Filter Constant	10	0...60000		

Table 2. Universal Input Function Block Configuration Parameters

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

1.1.1. Voltage Measurements

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

To avoid the 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.

Analog Input Filter	Cut-off Frequency (at -3dB)	Settling Time (to 100% of Final Value)	Output Signal Update Rate
Disabled ¹	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

Table 3. Universal Input Analog Input Filter Parameters

¹ Minimum filtering is still performed.

1.1.2. 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 up to reduce the input noise.

1.1.3. Discrete Voltage Level

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 +12V voltage rail.

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.

1.1.4. 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.

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

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

Table 4. Universal Input Function Block Counters

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 5. 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.

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.

1.1.5. Software Filtering

There are three options under *Software Filter Type* with two actual types of software filtering: ‘*Moving Average*’ and ‘*Repeating Average*’. Both are used to smoothen the actual sampling and provide more precise data.

If a customer uses the ‘*Moving Average*’ type, setpoint the unit will collect the number of samples equal to the value under the *Software Filter Constant* setpoint and then calculate the average. Each new sample will replace the oldest sample and the average will be recalculated during each new iteration. The algorithm is shown below:

Moving Average:

1. Calculating the first average:

$$N_{avg} = \frac{\sum_{i=0}^C N_i}{C} (1), \text{ where}$$

C – *Software Filter Constant value*;

N_i – *the number of current value*;

N_{avg} – *Average sample*.

2. Replacing the latest item and recalculating the average using formula (1):

$$N_{avg}^{(i)} = \frac{N_{avg}^{(i-1)} - N_l + N_{new}}{c} (2), \text{ where}$$

C – Software Filter Constant value;

$N_{avg}^{(i)}$ – the new average sample;

$N_{avg}^{(i-1)}$ – a previous average sample;

N_l – the oldest sample;

N_{new} – a current sample.

After the first average has been calculated by using formula (1), the second formula is applied during each iteration.

Repeating Average:

The repeating average method is like the moving average except that instead of recalculating the average after each new sample, the unit will gather the required number of samples each time instead.

1.2. Proportional Output Function Block

The controller has 1 Proportional Output. “**Output Type**” setpoint determines what kind of signal the output produces. Changing this setpoint causes other setpoints in the setpoint group to update to match the selected type, thus the “**Output Type**” should be selected before configuring other setpoints within the setpoint group. “**Output Type**” setpoint options are listed in Table 6.

0	<i>Disabled</i>
1	<i>Current</i>
2	<i>Digital Hotshot</i>
3	<i>Voltage (0-Vps)</i>
4	<i>PWM Duty Cycle (0-100%)</i>
5	<i>Digital On/off (0-Vps)</i>

Table 6. Output Type Options for Universal Output

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

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

The ‘*PWM Duty Cycle*’ option allows the user to run the output at fixed frequency configure with “**PWM Output Frequency**” setpoint, while the duty cycle changes depending on the control signal. “**PWM Output Frequency**” is editable only if none of the outputs in the output group is set to ‘*Current*’ or ‘*Hotshot Digital*’ type.

There are also two types of digital responses possible. 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.

If a digital “**Output Type**” has been selected the “**Digital Response**” setpoint will be enabled as shown in Table 7.

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

Table 7. Digital Response Options

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

The “**Digital Out Delay**” setpoint is associated with ‘Normal’ “**Digital Response**”. The “**Digital Out Delay**” defines output state change delay in milliseconds. Setting “**Digital Out Delay**” to 0ms applies no state change delay.

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

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

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

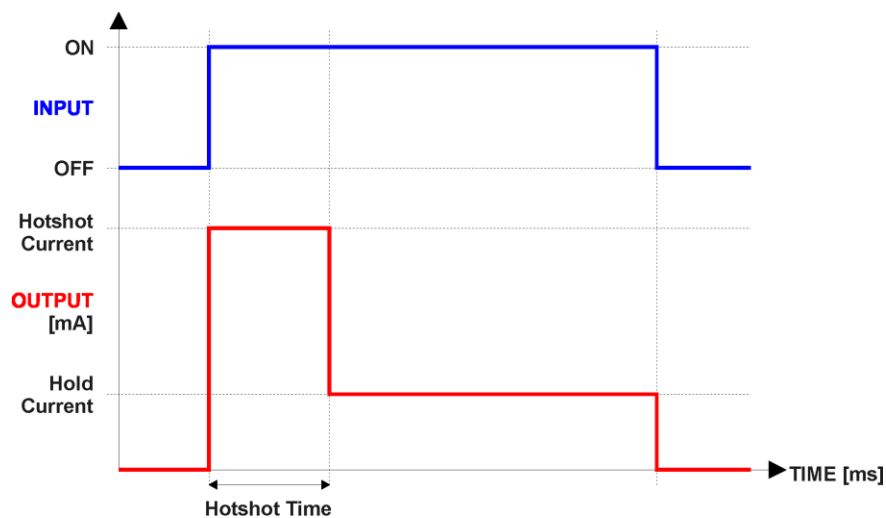


Figure 2. Hotshot Digital Profile

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

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

$$y = mx + a$$

$$m = \frac{Y_{max} - Y_{min}}{X_{max} - X_{min}}$$

$$a = Y_{min} - m * X_{min}$$

Equation 1. Linear Slope Calculations

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

Xmin = Control Input Minimum Ymin = **“Output at Minimum Command”**

Xmax = Control Input Maximum Ymax = **“Output at Maximum Command”**

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

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

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

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

The **“Enable Source”** setpoint together with **“Enable Number”** setpoint determine the enable signal for the output in question. The **“Enable Response”** setpoint is used to select how output will respond to the selected Enable signal. **“Enable Response”** setpoint options are listed Table 8. If a non-digital signal is selected as Enable signal the signal is interpreted as shown below:

0	<i>Enable When On, Else Shutoff</i>
1	<i>Enable When On, Else Rampoff</i>
2	<i>Enable When Off, Else Shutoff</i>
3	<i>Enable When Off, Else Rampoff</i>
4	<i>Enable When On, Else Ramp To Min</i>
5	<i>Enable When On, Else Ramp To Max</i>

Table 8. Enable Response Options

Override input allows the output drive to be configured to go to a default value in the case of the override input being engaged/disengaged, depending on the logic selected in **“Override Response”**, presented in Table 9. When active, the output will be driven to the value in **“Output at Override Command”** regardless of the value of the Control input. The **“Override Source”** and **“Override Number”** together determine the Override input signal.

0	Override When On
1	Override When Off

Table 9. Override Response Options

If a fault is detected in any of the active inputs (Control/Enable/Override) the output will respond per **“Output Fault Response”** setpoint as outlined in Table 10.

0	Shutoff Output
1	Apply Fault Value
2	Hold Last Value

Table 10. Fault Response Options

Regardless of a selected output type, current through the load is available as Output Current Feedback signal and can be selected as input for a Diagnostic Block as described in Section 1.5.

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 Voltage Fault** function block. Also, if the **Over Temperature Fault** function block is enabled, then a microprocessor over-temperature reading disables all the outputs until it has cooled back to the operating range.

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

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

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

1.3. H-Bridge Function Block

The H-Bridge Function Block combines two proportional output terminals into one to provide an H-Bridge output driver. To enable it, the **"H-Bridge Enabled"** setpoint needs to be set to 1, True. In this case, the proportional output will be controlled by this function block.

Please note: if the **"H-Bridge Enabled"** setpoint is set to True, the Proportional Output Blocks will not be available for modification. However, the PID coefficients still can be modified and visible via Axiomatic Electronic Assistant tool.

The control mode, control sources, direction source, ramp up/down time, and responses are available in this function block.

0	Current Control
1	PWM Control

Table 11. Control Mode Options

"Output At Maximum/Minimum Command" setpoints define the current output limits that can be set according to the **"Control Source"** settings. The momentary direction of the h-bridge is defined according to the **"Direction Source"**. The **"Output At Maximum/Minimum Command"** setpoints provide a bipolar range defined by the direction control source. If the range is set to 0...1500mA, it means that the possible output will vary in this range if direction is forward and -1500...0mA if the direction is backward. It is the case for the **"Override Output Value"** setpoint as well.

Please note: if **"Control Source"** or **"Direction Source"** is set to 0, 'No Source', the output will be disabled. Both sources should be set to any non-zero value to allow further configuration.

The control source has also an additional setting: the **"Control Response"** setpoint. It matches the one from Proportional Output Function Block. All possible options for this setpoint are shown below.

0	Single Out Profile
1	OFF When Below Minimum
2	OFF When Above Maximum

Table 12. Control Response Options

To control the speed of output rising or falling the **"Ramp Up/Down Time"** should be used. These setpoints define the time needed to rise the output from **"Output At Minimum Command"** to **"Output At Maximum Command"** value for the ramp up and vice versa for the ramp down. For example, if range is set to 0 to 1000mA, current output is 0mA, and the **"Ramp Up Time"** is set to 5000, the ECU will require 5s to ramp the output up to the maximum. If the current target output value is 500mA, the ECU will spend 2.5s to set it to the maximum. Both ramp up and down setpoints cannot be set to a value lower than 100ms.

Please note: the **"Ramp Up/Down Time"** setpoints are meant to ramp output in one direction per time only. If the direction is changed, the Output will drop to 0 and then will ramp up/down to a needed value. For example, if the current output's value is 500mA and the direction is backward (the actual output is -500mA), at the direction change, the output will drop to 0mA and only after that will ramp up to a 500mA (or to any new commanded value).

The **“Enable Source”**, and **“Override Source”** setpoints match the functionality of the Proportional Output Function Block and are shown in the Section 1.2.

The **“Enable Response”** setpoint has the same configuration options as Proportional Output block. However, options ‘Enable When ON Else Shutoff’ and ‘Enable When OFF Else Shutoff’ are not recommended to be used since they will rapidly reset output to 0mA.

1.4. PID Control Function Block

The PID Control function block is an independent logic block, but it is normally intended to be associated with proportional output control blocks described in the chapters before. When the **Control Source** for an output has been setup as a *PID Function Block*, the command from the selected PID block drives the physical output on the motor controller unit.

To enable the PID Control function the **“PID Enabled”** setpoint should be set to ‘1, True’. The **“Target Source”** and **“Target Number”** setpoints determine control input and the **“Feedback Source”** and **“Feedback Number”** setpoints determine the established feedback signal to the PID Control function block. The **“Control Response”** will use the selected inputs as per the options listed in Table 13. When active, the PID algorithm will be called every **“Cycle Time”** in milliseconds.

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

Table 13. PID Response Options

When a ‘Single Output’ response is selected, the Target and Feedback inputs do not have to share the same units. In both cases, the signals are converted to a percentage value based on the minimum and maximum values associated with the source function block.

For example, a CAN command could be used to set the target value, in which case it would be converted to a percentage value using **“Data Minimum”** and **“Data Maximum”** setpoints in the appropriate *CAN Receive X* function block. The closed-loop feedback signal, i.e. a Current Feedback from the proportional current output, could be selected as the feedback source. In this case the value of the input would be converted to a percentage based on the **“Output Data Min”** and **“Output Data Max”** setpoints in the output block. The output of the PID function would depend on the difference between the commanded target and the measured feedback as a percentage of each signals range. In this mode, the output of the block would be a value from 0 to 100%.

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

The PID algorithm used is shown below, where G , K_i , T_i , K_d , T_d and $Loop_Update_Rate$ are configurable parameters.

$$PIDOutput_k = P_k + I_k + D_k$$

$$P_k = P_Gain * Error_k$$

$$I_k = I_Gain * ErrorSum_k$$

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

$$Error_k = Target - Feedback$$

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

$$P_Gain = G$$

$$I_Gain = G * K_i * T / T_i \text{ (Note: If } T_i \text{ is zero, } I_Gain = 0)$$

$$D_Gain = G * K_d * T_d / T$$

$$T = Loop_Update_Rate * 0.001$$

Please Note: Each system will have to be tuned for the optimum output response. Response times, overshoots and other variables will have to be decided by the customer using an appropriate PID tuning strategy. Axiomatic is not responsible for tuning the control system.

1.5. Diagnostic Function Block

The 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 16)
CM	Conversion Method	(always set to 0)
OC	Occurrence Count	(number of times the fault has happened)

In addition to supporting the DM1 message, the ECU 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.

By default, the monitoring of operating voltage, CPU temperature and receive message timeouts is configured to diagnostics blocks 1, 2 and 3., In case any of these three diagnostics blocks are needed for some other use, the default settings can be adjusted by the user to suit the application. There are 4 fault types that can be used, *“Minimum and maximum error”*, *“Absolute value error”*, *“State error”* and *“Double minimum and maximum error”*.

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

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

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

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

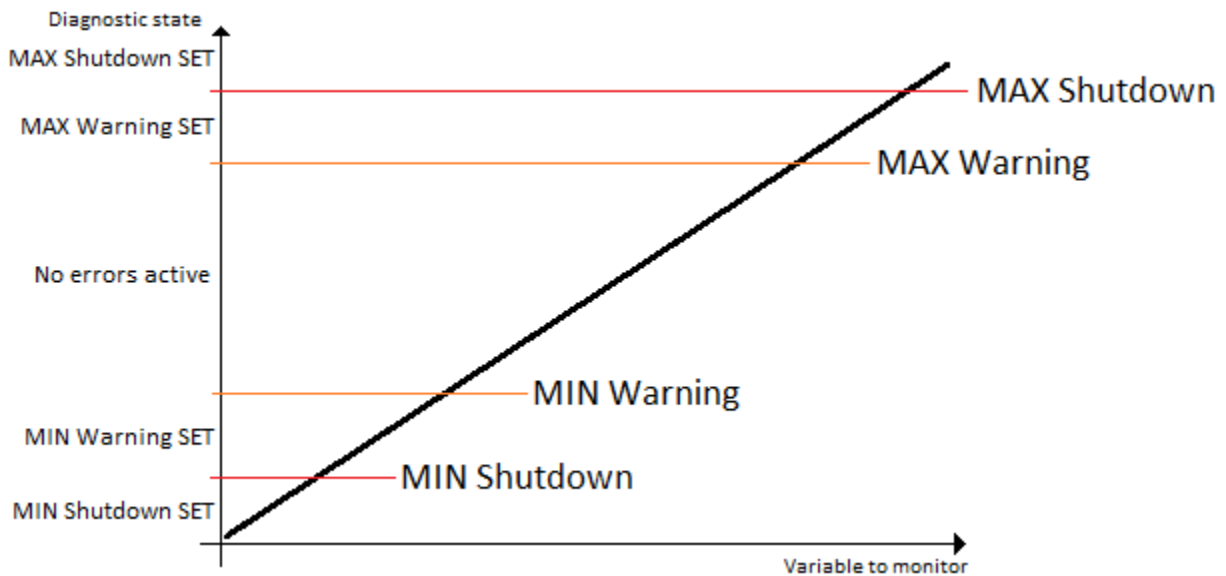


Figure 3. Double Minimum and Maximum Error Thresholds

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

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

While there are no active DTCs, the ECU 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).

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 the error condition that has caused it goes away. The DTC was made Previously Active and it was 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 14. By default, the ‘*Amber, Warning*’ lamp is typically the one set be any active fault.

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

Table 14. Lamp Set by Event in DM1 Options

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

0	<i>Data Valid But Above Normal Operational Range - Most Severe Level</i>
1	<i>Data Valid But Below Normal Operational Range - Most Severe Level</i>
2	<i>Data Intermittent</i>
3	<i>Voltage Above Normal, Or Shorted To High Source</i>
4	<i>Voltage Below Normal, Or Shorted To Low Source</i>
5	<i>Current Below Normal Or Open Circuit</i>
6	<i>Current Above Normal Or Grounded Circuit</i>
7	<i>Mechanical Error</i>
8	<i>Abnormal Frequency Or Pulse Width Or Period</i>
9	<i>Abnormal Update Rate</i>
10	<i>Abnormal Rate Of Change</i>
11	<i>Root Cause Not Known</i>
12	<i>Bad Component</i>
13	<i>Out Of Calibration</i>
14	<i>Special Instructions</i>
15	<i>Data Valid But Above Normal Operating Range – Least Severe Level</i>
16	<i>Data Valid But Above Normal Operating Range – Moderately Severe Level</i>
17	<i>Data Valid But Below Normal Operating Range – Least Severe Level</i>
18	<i>Data Valid But Below Normal Operating Range – Moderately Severe Level</i>
19	<i>Network Error</i>
20	<i>Data Drifted High</i>
21	<i>Data Drifted Low</i>
31	<i>Condition Exists</i>

Table 15. FMI for Event Options

Every fault has associated a default FMI with them. The used FMI can be configured with **“FMI for Event”** setpoint, presented in Table 15. When an FMI is selected from Low Fault FMIs in Table 16 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 16. There is no automatic setting of High and Low FMIs in the firmware, the user can configure these freely.

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

Table 16. Low Fault FMIs and corresponding High Fault FMIs

In this example the Diagnostic Function Block is configured to monitor the power supply voltage level and send the DM1 message if the voltage level drops under 11V.

Here is the DM1 message configuration:

SP MINIMUM SHUTDOWN, Event Generates a DTC in DM1	1	True
SP MINIMUM SHUTDOWN, Lamp Set by Event	1	Amber,Warning
SP MINIMUM SHUTDOWN, SPN for Event	0x007FF00	SPN: 524032
SP MINIMUM SHUTDOWN, FMI for Event	0	Data Valid But Above Normal Operational Range - Most Severe Level
SP MINIMUM SHUTDOWN, Delay Before Event is Flagged	1000	ms

Please note: even though the Diagnostics Function Block is configured as **“Min and Max Error”**, only the low limit will be monitored. Thus a **“Event Generates a DTC in DM1”** setpoint for a maximum shutdown limit is set to 0, False.

To monitor the supply voltage, the **“Function Type to Monitor”** setpoint is set to ‘Power Supply Measured’. The rest of configurations are shown on the Figure 4.

SP Fault Detection Type	0	Min and Max Error
SP Maximum Value for Diagnostic Data	24.00	
SP Minimum Value for Diagnostic Data	0.00	
SP Use Hysteresis When Defining Thresholds	1	True
SP Hysteresis	1.00	
SP Event Cleared Only by DM11	0	False
SP Set Limit for MINIMUM WARNING		Parameter not used with current Fault Detection Type
SP Clear Limit for MINIMUM WARNING		Parameter not used with current Fault Detection Type
SP Set Limit for MAXIMUM WARNING		Parameter not used with current Fault Detection Type
SP Clear Limit for MAXIMUM WARNING		Parameter not used with current Fault Detection Type
SP Set Limit for MINIMUM SHUTDOWN	11.00	
SP Clear Limit for MINIMUM SHUTDOWN		Parameter not used - Hysteresis used when defining thresholds
SP Set Limit for MAXIMUM SHUTDOWN	22.00	

Figure 4. The Diagnostics Configuration

With this configuration, when the power supply voltage measured drops below **“Set Limit for MINIMUM SHUTDOWN”**, the DM1 message with a fault information will be broadcasted after a programmed in **“Delay Before Event is Flagged”** value in milliseconds.

An example of the DM1 message is shown below.

PR	PGN	DA	SA	Len	D0	D1	D2	D3	D4	D5	D6	D7
6	0FECA	-	80	8	04	FF	00	FF	E0	01	FF	FF

Figure 5. The Example of DM1 Message

1.6. 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 Gain” 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 17. The functions are connected, so that result of the preceding function goes into Input A of the next function. Thus, Function 1 has both Input A and Input B selectable with setpoints, where Functions 2 to 4 have only Input B selectable. Input is selected by setting **“Function X Input Y Source”** and **“Function X Input Y Number”**. If **“Function X Input B Source”** is set to 0 ‘Control not used’ signal goes through function unchanged.

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

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

Table 17. Math function X Operator Options

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

This example shows the Math Function Block configured to provide a 4x times the input. There are multiple ways to configure Math Block to do it. One of them is shown below.

SP Math Enabled	1	True	SP Input 3 Source	3	Lookup Table
SP Math Output Minimum Range	0.00		SP Input 3 Number	5	
SP Math Output Maximum Range	100.00		SP Input 3 Minimum	0.00	
SP Input 1 Source	3	Lookup Table	SP Input 3 Maximum	100.00	
SP Input 1 Number	5		SP Input 3 Gain	1.00	
SP Input 1 Minimum	0.00		SP Input 4 Source	3	Lookup Table
SP Input 1 Maximum	100.00		SP Input 4 Number	5	
SP Input 1 Gain	1.00		SP Input 4 Minimum	0.00	
SP Input 2 Source	3	Lookup Table	SP Input 4 Maximum	100.00	
SP Input 2 Number	5		SP Input 4 Gain	1.00	
SP Input 2 Minimum	0.00		SP Math Function 1	9	+, Result = lnA plus lnB
SP Input 2 Maximum	100.00		SP Math Function 2	9	+, Result = lnA plus lnB
SP Input 2 Gain	1.00		SP Math Function 3	9	+, Result = lnA plus lnB

Figure 6. Math Configuration

As an input source the Lookup Table in Time Response mode is used. It ramps the data from 0 to 20 within 5 seconds, thus the Math Output is ranging from 0 to 80. The Math output is on the right with a scale of 10 per 1 square. On the left side there is the LUT output with a scale of 2 per 1 square.

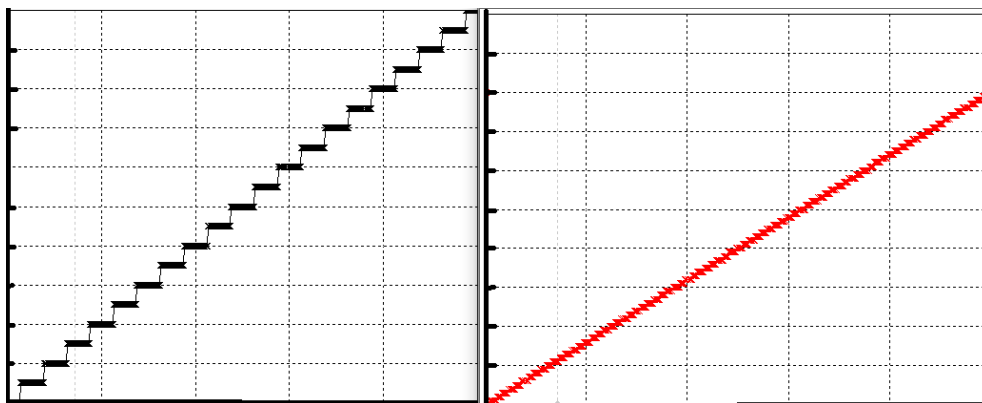


Figure 7. The Math Function Block Output

1.7. 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 8 demonstrates the connections between all parameters.

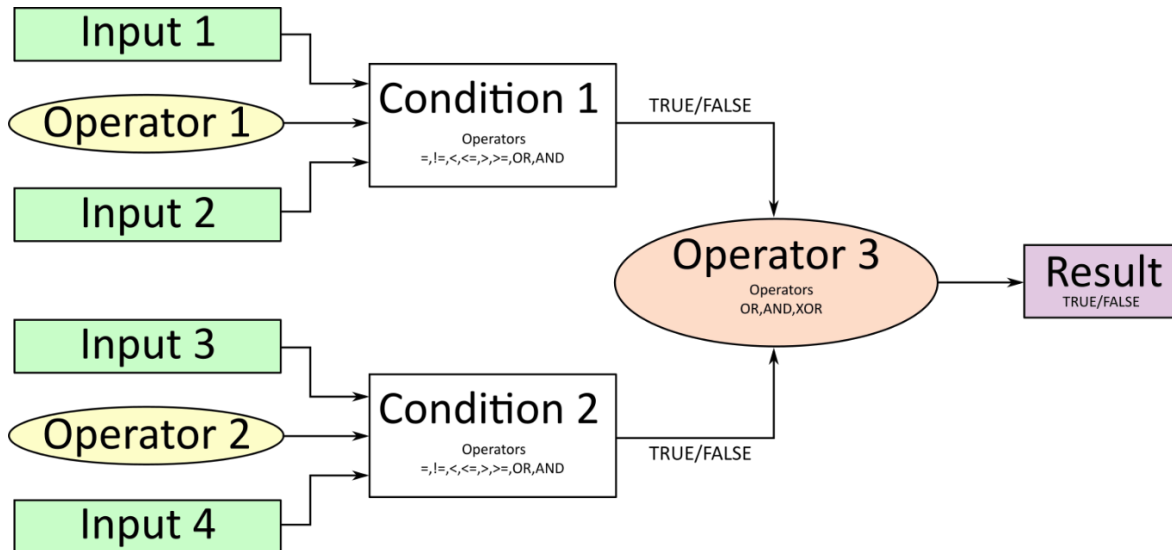


Figure 8. Conditional Block Diagram

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 18. If no source is selected, the output value of an Input will be zero.

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

Table 18. Input Operator Options

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 19.

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

Table 19. Condition Operator Options

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.

This example shows the Conditional Logic Block configured to set the output to 1, True if the input data is more than 50. The configuration is shown below.

SP Conditional Block Enable	1	Enabled
SP Condition 1 Argument 1 Source	3	Lookup Table
SP Condition 1 Argument 1 Number	2	
SP Condition 1 Argument 2 Source	8	Control Constant Data
SP Condition 1 Argument 2 Number	3	
SP Condition 1 Operator (Argument 1/2)	2	>, True When Arg1 Greater Than Arg2
SP Condition 2 Argument 1 Source	0	Control Not Used
SP Condition 2 Argument 1 Number		Parameter not used with current Control Source selected
SP Condition 2 Argument 2 Source	0	Control Not Used
SP Condition 2 Argument 2 Number		Parameter not used with current Control Source selected
SP Condition 2 Operator (Argument 1/2)	0	=, True When Arg1 Equal to Arg2
SP Conditional Result Operator	0	OR

As a control source, the Lookup Table output is used. The LUT is programmed to ramp the output from 0 to 100 and it is shown on the left of the picture below. The Conditional logic output is shown on the right side of the figure.

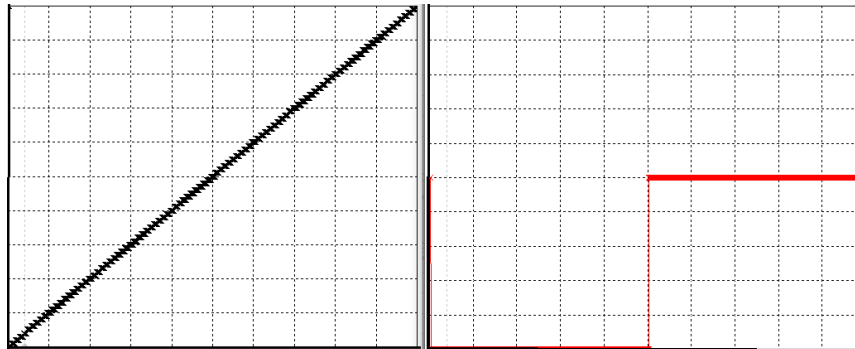


Figure 9. The conditional Logic Block's Output

1.8. 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 20 below.

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

Table 20. Set-Reset Function block operation.

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

As seen in Table 20 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'.

1.9. 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 0.

Lookup tables have two differing modes defined by “**X-Axis Type**” setpoint, given in Table 21. Option ‘0 – *Data Response*’ is the normal mode where block input signal is selected with the “**X-Axis Source**” and “**X-Axis Number**” setpoints and X values present directly input signal values. With option ‘1 – *Time Response*’ the input signal is time and X values present time in milliseconds. And selected input signal is used as digital enable.

0	Data Response
1	Time Response

Table 21. X-Axis Type Options

The “**Auto Repeat**” setpoint determines either lookup table’s output cycle is repeated after reaching the last configured “**Point Y#**”. This setpoint is used only if “**X-Axis Type**” is set to ‘1 – *Time Response*’, and doesn’t affect the output in if it set to ‘0 - *Data Response*’ mode.

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. “**Response #**” setpoint defines type of the slope from preceding point to the point in question. Response options are given in Table 22. ‘*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. “**Response 0**” is always ‘*Jump To*’ and cannot be edited. Choosing ‘*Ignored*’ response causes associated point and all the following points to be ignored.

0	Ignore
1	Ramp To
2	Jump To

Table 22. Response # Options

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.

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

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.

This example is designed to represent the Lookup Table function block in various modes. First lookup table is configured as Time Response with all responses set to ‘1 – *Ramp To*’. The “**X-Axis Type**” is set to ‘1 – *Time Response*’, and the “**Auto Repeat**” setpoint is set to ‘1 – *True*’. The control source is set to the ‘*Control Constant Data*’ with a value of 1 to be constantly active. The configuration of other setpoints is shown below.

			SP Point X0	0.000	ms	SP Point Y0	0.000
SP Response 1	1	Ramp To	SP Point X1	1000.000	ms	SP Point Y1	10.000
SP Response 2	1	Ramp To	SP Point X2	1000.000	ms	SP Point Y2	20.000
SP Response 3	1	Ramp To	SP Point X3	1000.000	ms	SP Point Y3	30.000
SP Response 4	1	Ramp To	SP Point X4	1000.000	ms	SP Point Y4	40.000
SP Response 5	1	Ramp To	SP Point X5	1000.000	ms	SP Point Y5	50.000
SP Response 6	1	Ramp To	SP Point X6	1000.000	ms	SP Point Y6	60.000
SP Response 7	1	Ramp To	SP Point X7	1000.000	ms	SP Point Y7	70.000
SP Response 8	1	Ramp To	SP Point X8	1000.000	ms	SP Point Y8	80.000
SP Response 9	1	Ramp To	SP Point X9	1000.000	ms	SP Point Y9	90.000
SP Response 10	1	Ramp To	SP Point X10	1000.000	ms	SP Point Y10	100.000

Figure 10. First Lookup Table Response Configuration

The second lookup table is configured to provide output in data response mode and controlled by the first lookup table. The rest of configuration is shown on the Figure 11 below.

			SP Point X0	0.000	SP Point Y0	0.000
SP Response 1	2	Jump To	SP Point X1	10.000	SP Point Y1	10.000
SP Response 2	2	Jump To	SP Point X2	20.000	SP Point Y2	20.000
SP Response 3	2	Jump To	SP Point X3	30.000	SP Point Y3	30.000
SP Response 4	2	Jump To	SP Point X4	40.000	SP Point Y4	40.000
SP Response 5	1	Ramp To	SP Point X5	50.000	SP Point Y5	50.000
SP Response 6	1	Ramp To	SP Point X6	60.000	SP Point Y6	60.000
SP Response 7	1	Ramp To	SP Point X7	70.000	SP Point Y7	70.000
SP Response 8	1	Ramp To	SP Point X8	80.000	SP Point Y8	80.000
SP Response 9	1	Ramp To	SP Point X9	90.000	SP Point Y9	90.000
SP Response 10	1	Ramp To	SP Point X10	100.000	SP Point Y10	100.000

Figure 11. Second Lookup Table Response Configuration

With such a configuration the second lookup table will jump from 0 to 40 and then ramp to 100. The graphical representation of lookup tables output is shown below. On the left graph the time response lookup table, and on the left is a controlled table. The X axis represents the time with a resolution of 1 second per square. The Y axis is the LUT output with a resolution of 10 per square.

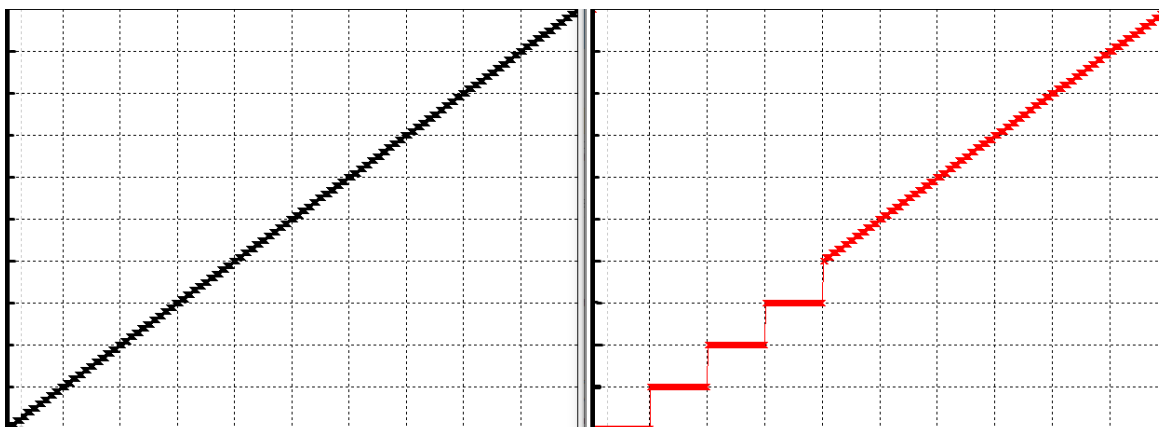


Figure 12. Graphical Representation of the Lookup Table Example

1.10. 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 23. Condition arguments are selected with **“Table X – Condition Y Argument Z Source”** and **“Table X – Condition Y Argument Z Number”** setpoints. If *‘0 – Control not Used’* option is selected as **“Table x – Condition Y Argument Z Source”** the argument is interpreted as 0.

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

Table 23. Table X – Condition Y Operator Options

The three conditions are evaluated and if the result satisfies logical operation defined with **“Logical Operator X”** setpoint, given in Table 24, the associated Lookup Table is selected as output of the Logical block. Option *‘0 – Default Table’* selects associated Lookup Table in all conditions.

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

Table 24. Table X – Conditions Logical Operator Options

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

This example will show how to use 4 Lookup Tables by using the simplest configuration of Programmable Logic Block (PLB). One LUT is configured to jump from 0 to 100 with a step of 10. The second table ramps the output from 0 to 100 and the third one provides a constant output of 50. The last table configured to control previous tables. The PLB uses table 1 if fourth table's output is below 40, table 2 if it is greater than 60, and table 3 otherwise. The configuration of the Programmable Logic Block is shown below.

SP Table Number 1	1	Lookup Table 1	SP Table Number 2	4	Lookup Table 4
SP Logical Operator 1	2	Cnd1 Or Cnd2 Or Cnd3	SP Logical Operator 2	2	Cnd1 Or Cnd2 Or Cnd3
SP Table 1 - Condition 1 Argument 1 Source	3	Lookup Table	SP Table 2 - Condition 1 Argument 1 Source	3	Lookup Table
SP Table 1 - Condition 1 Argument 1 Number	2		SP Table 2 - Condition 1 Argument 1 Number	2	
SP Table 1 - Condition 1 Argument 2 Source	8	Control Constant Data	SP Table 2 - Condition 1 Argument 2 Source	8	Control Constant Data
SP Table 1 - Condition 1 Argument 2 Number	3		SP Table 2 - Condition 1 Argument 2 Number	4	
SP Table 1 - Condition 1 Operator	5	<=, Less Than or Equal	SP Table 2 - Condition 1 Operator	3	>=, Greater Than or Equal
SP Table 1 - Condition 2 Argument 1 Source	0	Control Not Used	SP Table 2 - Condition 2 Argument 1 Source	0	Control Not Used
SP Table 1 - Condition 2 Argument 1 Number		Parameter not used with	SP Table 2 - Condition 2 Argument 1 Number		Parameter not used with current
SP Table 1 - Condition 2 Argument 2 Source	0	Control Not Used	SP Table 2 - Condition 2 Argument 2 Source	0	Control Not Used
SP Table 1 - Condition 2 Argument 2 Number		Parameter not used with	SP Table 2 - Condition 2 Argument 2 Number		Parameter not used with current
SP Table 1 - Condition 2 Operator		Parameter not used with	SP Table 2 - Condition 2 Operator		Parameter not used with current
SP Table 1 - Condition 3 Argument 1 Source	0	Control Not Used	SP Table 2 - Condition 3 Argument 1 Source	0	Control Not Used
SP Table 1 - Condition 3 Argument 1 Number		Parameter not used with	SP Table 2 - Condition 3 Argument 1 Number		Parameter not used with current
SP Table 1 - Condition 3 Argument 2 Source	0	Control Not Used	SP Table 2 - Condition 3 Argument 2 Source	0	Control Not Used
SP Table 1 - Condition 3 Argument 2 Number		Parameter not used with	SP Table 2 - Condition 3 Argument 2 Number		Parameter not used with current
SP Table 1 - Condition 3 Operator		Parameter not used with	SP Table 2 - Condition 3 Operator		Parameter not used with current
SP Table Number 3	3	Lookup Table 3			
SP Logical Operator 3	0	Default Table			

Figure 13. Programmable Logic Block Configuration

With the current configuration the PLB will ramp from 0 to 40, then stay at 50, and after will jump from 60 to 100. The picture below captures the PLB output. On the left, the Lookup Table output and to the left there is a PLB corresponding output.

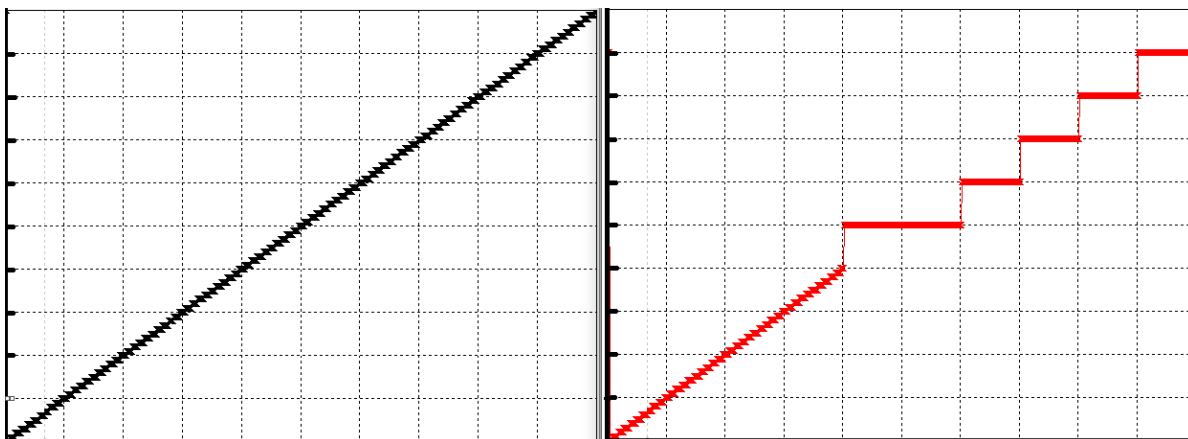


Figure 14. The Programmable Logic Block Output

1.11. 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.

1.12. 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 is 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;
- SPN987 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 match 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.

Also, if the SPN 0x3FFFF is set, the function block will accept any SPN instead.

1.13. 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 AX100520 ECU has five CAN Transmit Messages, and each message has ten completely user defined signals.

1.13.1. CAN Transmit Message Setpoints

Each CAN Transmit Message setpoint group includes setpoints that affect 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 the next section.

The “**Transmit PGN**” setpoint sets PGN used with the message. **Users 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 the case of a shared PGN repetition rate of the LOWEST numbered message are used to send the message ‘bundle’.



At power up, transmitted messages 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.

1.13.2. 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 25. 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.

1.14. 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 bus within the “**Receive Message Timeout**” period. This could trigger a Lost Communication event. 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 AX100520 on Proprietary B PGNs. However, should a PDU1 message be selected, the AX100520 can be setup to receive it from any ECU by setting the “**PGN From Specific Address**” to False (0x00). If a specific address is selected instead, then any other ECU data on the PGN will be ignored.

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

As mentioned earlier, a CAN receive function clock can be selected as the source of the control input for the output function blocks. When this is case, the “**Received Data Min (Off Threshold)**” and “**Received Data Max (On Threshold)**” setpoints determine the minimum and maximum values of the control signal. As the names imply, they are also used as the On/Off thresholds for digital output types. These values are in whatever units the data is AFTER the resolution and offset is applied to CAN receive signal.

The AX100520 supports up to 10 unique CAN Receive Messages. Defaults setpoint values are listed in Section 4.13.

1.15. Available Control Sources

Many of the Function Blocks have selectable input signals, which are determined with “[Name] Source” and “[Name] Number” setpoints. Together, these setpoints uniquely select how the I/O of the various function blocks are linked together. “[Name] Source” setpoint determines the type of the source and “[Name] Number” selects the actual source if there is more than one of the same types. Available “[Name] Source” options and associated “[Name] Number” ranges are listed in Table 25. All sources, except “CAN message reception timeout”, are available for all blocks, including output control blocks and CAN Transmit messages. Though input Sources are freely selectable, not all options would make sense and it is up to the user to program the controller in a logical and functional manner.

Control Source	Range	Notes
0: Control Not Used	N/A	When this is selected, it disables all other setpoints associated with the signal in question.
1: Received CAN Message	1 to 10	
2: Universal Input Measured	1 to 2	
3: Lookup Table	1 to 10	
4: Programmable Logic	1 to 4	
5: Math Logic	1 to 5	
6: Conditional Logic	1 to 10	
7: Set-Reset Latch	1 to 5	
8: Constant Data	1 to 15	[0] - Constant Signal = 0.0 [1] - Constant Signal = 1.0 [2...15] - Data
9: Output Target Value	1	
10: Output Current Feedback	1	Measured Feedback current from the proportional output in mA, used in Output Diagnostics.
11: Power Supply Measured	0 to 255	Measured power supply value in Volts. The Parameter sets the threshold in Volts to compare with.
12: Processor Temperature Measured	0 to 255	Measured processor temperature in °C. The Parameter sets the threshold in Celsius to compare with.
13: CAN Reception Timeout	1 to 10	
14: DTC React	1 to 16	
15: PID	1 to 2	
16: H-Bridge Target Value	1	
17: H-Bridge Current Feedback	1	Measured Feedback current from the H-Bridge in mA, used in Output Diagnostics.

Table 25. Available Control Sources

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 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 15. For example, Universal Input signal is interpreted to be ON at or above “Maximum Range” and OFF at or below “Minimum Range”.

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

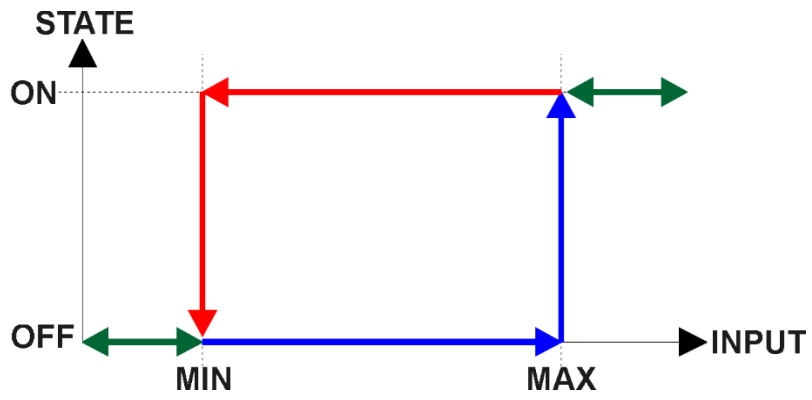


Figure 15. Analog source to Digital input

2. DIMENSIONAL DRAWING

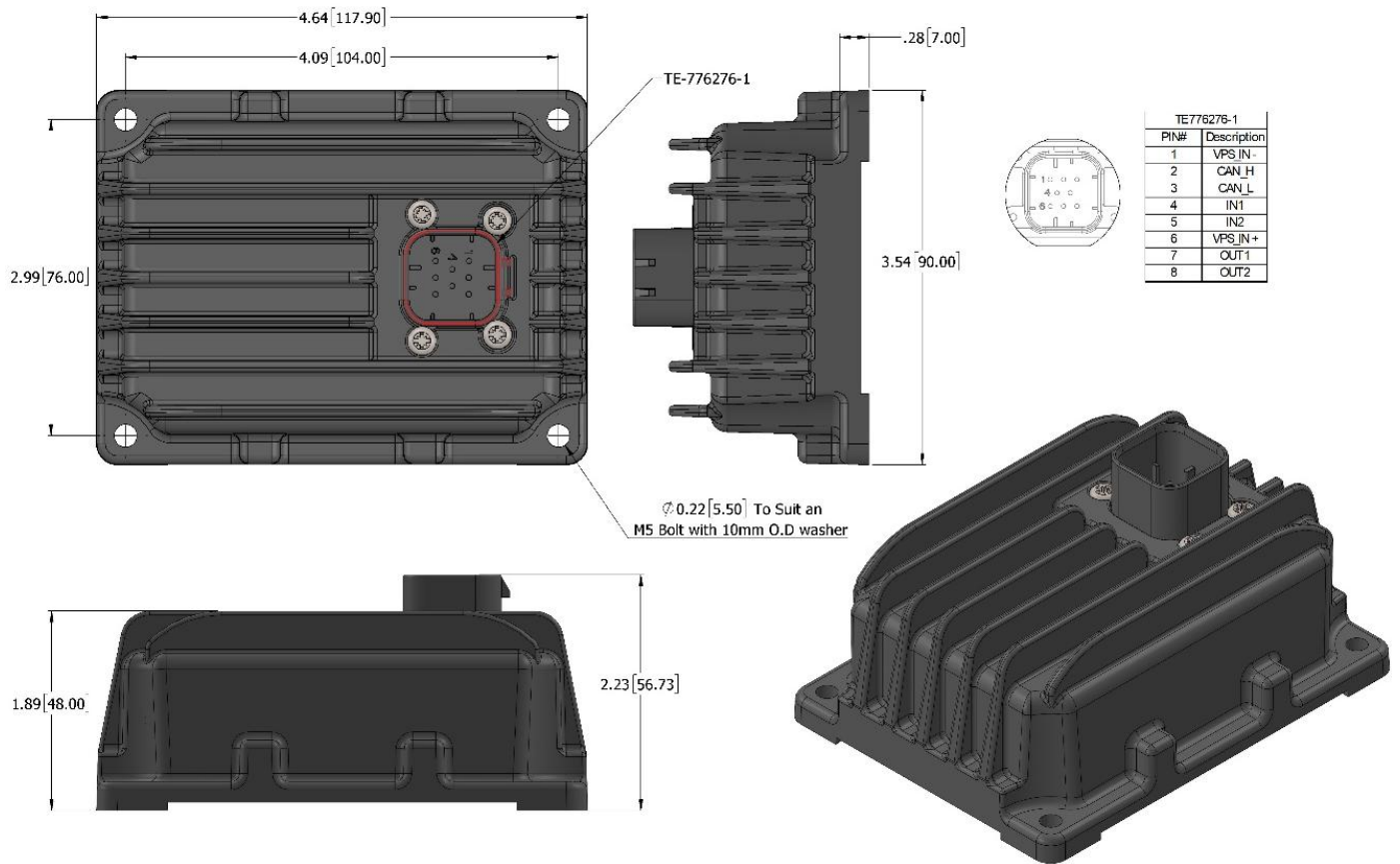


Figure 16. Dimensional Drawing

3. OVERVIEW OF J1939 FEATURES

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

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

3.1. Introduction to Supported Messages

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

From J1939-21 – Data Link Layer

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

From J1939-73 – Diagnostics

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

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 AX100520 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, Axiomatic I/O Controller
Function Instance	25, Axiomatic AX100520
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.

3.2.1. ECU Address

The default value of this setpoint is 128 (0x80), which is the preferred starting address for self-configurable ECUs as set by the SAE in J1939 tables B3 to B7. The EA will allow the selection of any address between 0 to 253, and ***it is the user's responsibility to select an address that complies with the standard.*** The user must also be aware that since the unit is arbitrary address capable, if another ECU with a higher priority NAME contends for the selected address, the 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.

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	

3.2.2. Software Identifier

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

(Version)*

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

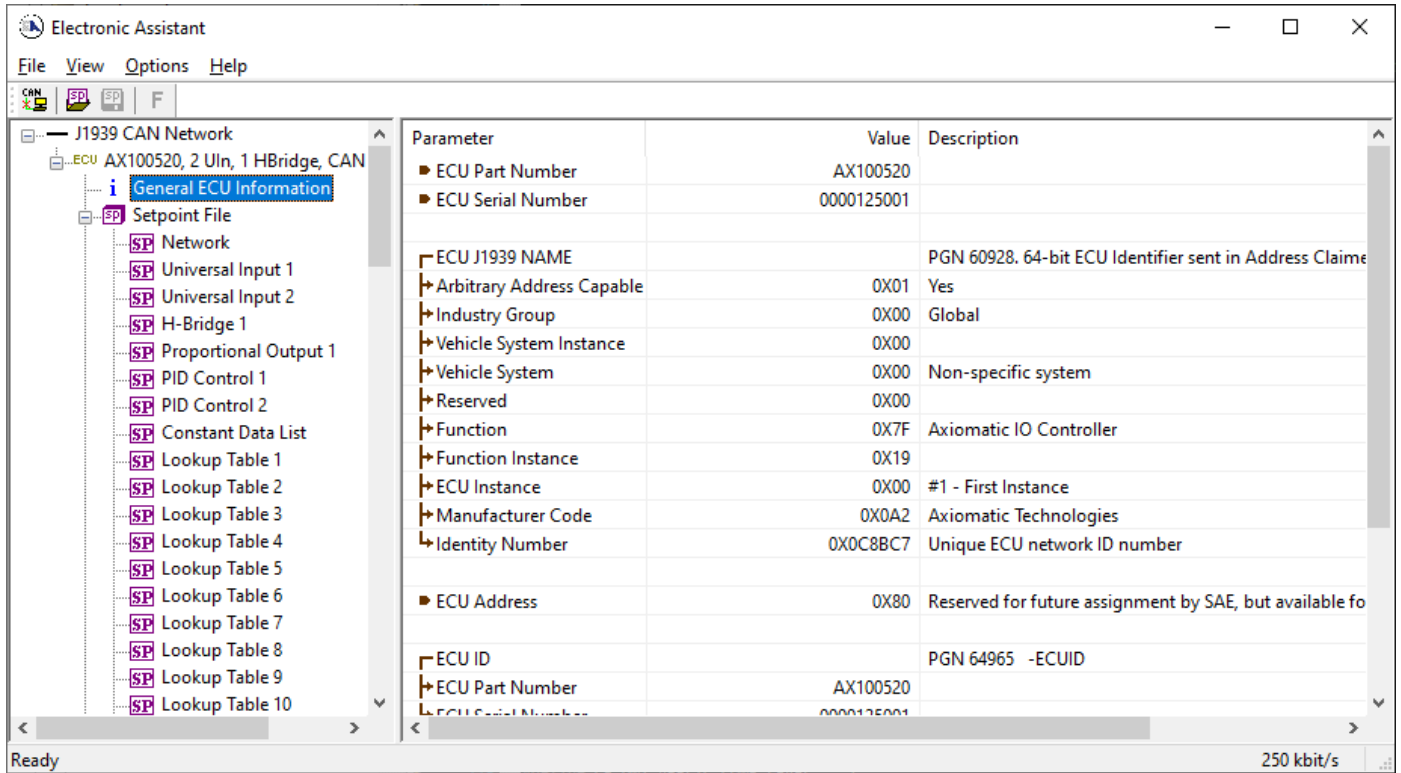


Figure 17. General ECU Information

4. ECU SETPOINTS ACCESSED WITH AXIOMATIC ELECTRONIC ASSISTANT

Many setpoints have been referenced throughout this manual. This section describes in detail each setpoint, their defaults and ranges. For more information on how each setpoint is used by the ECU, refer to the relevant section of the User Manual.

4.1. J1939 Network Setpoints

The J1939 Network setpoints deal with setpoints such as *ECU Instance Number* and *ECU Address*. Figure 18 and Table 26. Default J1939 Network Setpoints Function blocks in EA below will explain these setpoints and their ranges.

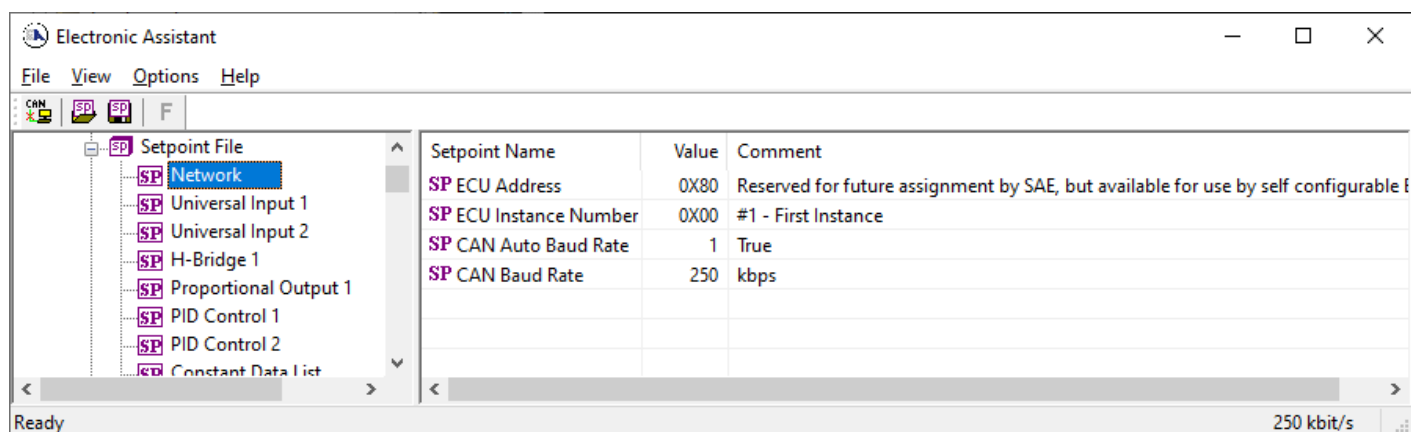


Figure 18. Screen Capture of Default J1939 Network Setpoints

Name	Range	Default	Notes
ECU Address	0x80	0..253	Preferred address for a self-configurable ECU
ECU Instance	0..7	0x00	Per J1939-81
Baud Rate	{125, 250, 500, 1000}	250	Current baud rate on the CAN network.
Automatic Baud Rate Detection	0 - No, 1 - Yes	1 - Yes	Set to "No" once ECU is permanently installed on the CAN network.

Table 26. Default J1939 Network Setpoints Function blocks in EA

4.2. Universal Input Setpoints

The Universal Inputs are defined in section 1.1.

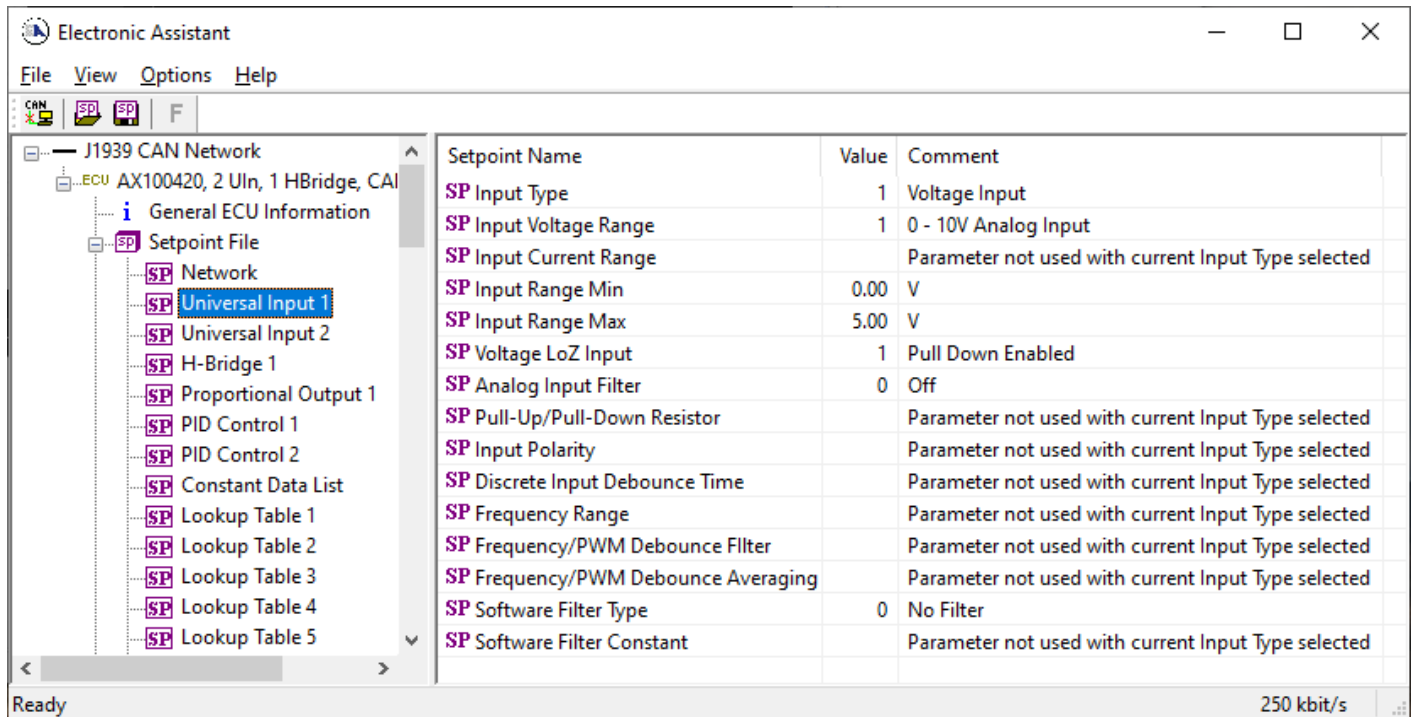


Figure 19. Screen Capture of Universal Input Setpoints

Name	Range	Default	Notes
Input Type	Drop List	Voltage Input	See Section 1.1
Input Voltage Range	Drop List	2, 0-5V Analog Input	See Section 1.1
Input Range Min	0..100	0	See Section 1.1
Input Range Max	0..100	5	See Section 1.1
Voltage LoZ Input	Drop List	0, Pull Down Disabled	See Section 1.1
Analog Input Filter	Drop List	0, Off	See Section 1.1
Pullup/Pulldown Resistor	Drop List	0, No Pull	See Section 1.1
Input Polarity	Drop List	0, Active High	See Section 1.1
Discrete Input Debounce Time	0..60000	50 ms	See Section 1.1
Frequency Range	Read only	1Hz to 10kHz	See Section 1.1
Frequency/PWM Debounce Filter	Drop List	0, No Filter	See Section 1.1
Frequency/PWM Debounce Averaging	Drop List	0, No Averaging	See Section 1.1
Software Filter Type	Drop List	0, Disabled	See Section 1.1
Software Filter Constant	0..60000	10	See Section 1.1

Table 27. Universal Input Setpoints

4.3. H-Bridge Function Block

The H-Bridge is defined in Section 0.

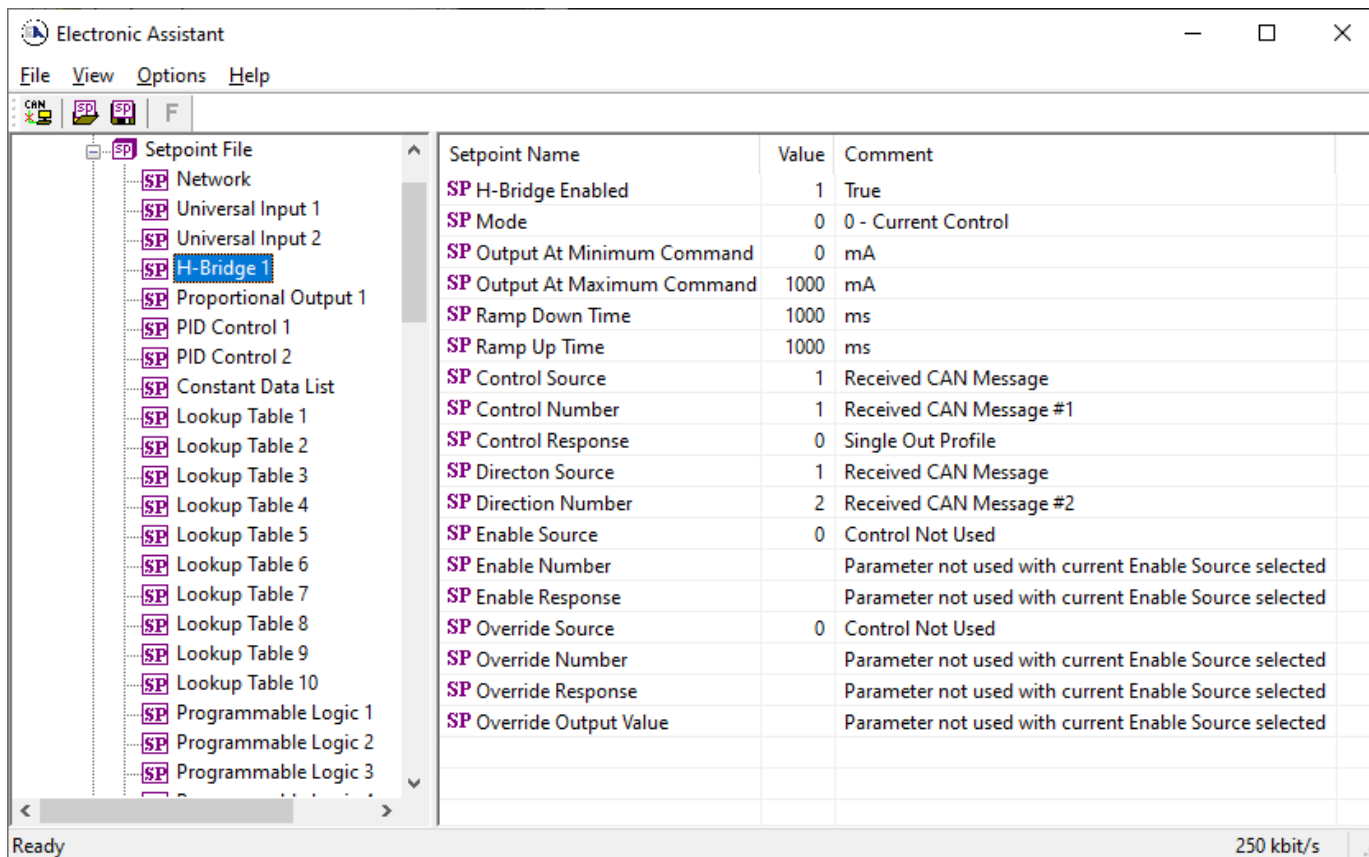


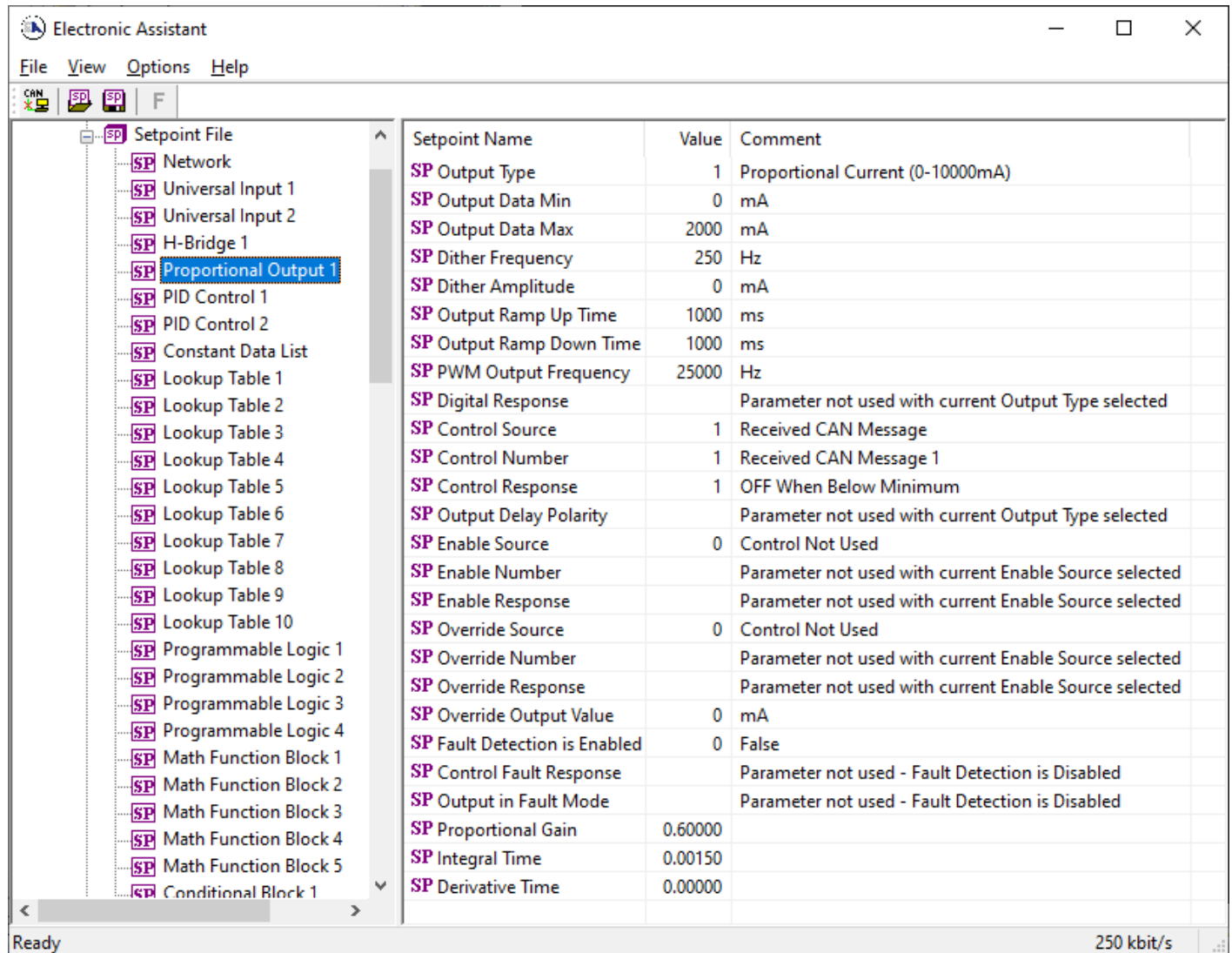
Figure 20. Screen Capture of H-Bridge Setpoints

Name	Range	Default	Notes
H-bridge Enabled	Drop List	False	
Mode	Drop List	Current Control	
H-bridge Enabled	Drop List	False	
Output At Minimum Command	0 to Limit	0	
Output At Minimum Command	0 to Limit	1000mA	
Ramp Down Time	0 to 10000	1000ms	
Ramp Up Time	0 to 10000	1000ms	
Control Source	Drop List	Source Not Used	See Table 25
Control Number	Depends on source	1	See Table 25
Control Response	Drop List	Single Out Profile	
Direction Source	Drop List	Source Not Used	See Table 25
Direction Number	Depends on source	1	See Table 25
Enable Source	Drop List	Source Not Used	See Table 25
Enable Number	Depends on source	1	See Table 25
Enable Response	Drop List	Enable When On Else Shutoff	
Override Source	Drop List	Source Not Used	See Table 25
Override Number	Depends on source	1	See Table 25
Override Response	Drop List	Override When On	
Override Output Value	0- Limit	500mA	

Table 28. H-Bridge Setpoints

4.4. Proportional Output Setpoints

The Proportional Output is defined in Section 1.2.



The screenshot shows the 'Electronic Assistant' software window. The left-hand pane displays a tree view of configuration options under 'Setpoint File'. 'Proportional Output 1' is selected and highlighted. The right-hand pane shows a table of parameters for this setpoint.

Setpoint Name	Value	Comment
SP Output Type	1	Proportional Current (0-10000mA)
SP Output Data Min	0	mA
SP Output Data Max	2000	mA
SP Dither Frequency	250	Hz
SP Dither Amplitude	0	mA
SP Output Ramp Up Time	1000	ms
SP Output Ramp Down Time	1000	ms
SP PWM Output Frequency	25000	Hz
SP Digital Response		Parameter not used with current Output Type selected
SP Control Source	1	Received CAN Message
SP Control Number	1	Received CAN Message 1
SP Control Response	1	OFF When Below Minimum
SP Output Delay Polarity		Parameter not used with current Output Type selected
SP Enable Source	0	Control Not Used
SP Enable Number		Parameter not used with current Enable Source selected
SP Enable Response		Parameter not used with current Enable Source selected
SP Override Source	0	Control Not Used
SP Override Number		Parameter not used with current Enable Source selected
SP Override Response		Parameter not used with current Enable Source selected
SP Override Output Value	0	mA
SP Fault Detection is Enabled	0	False
SP Control Fault Response		Parameter not used - Fault Detection is Disabled
SP Output in Fault Mode		Parameter not used - Fault Detection is Disabled
SP Proportional Gain	0.60000	
SP Integral Time	0.00150	
SP Derivative Time	0.00000	

The status bar at the bottom of the window shows 'Ready' on the left and '250 kbit/s' on the right.

Figure 21. Screen Capture of Proportional Output Setpoints

Name	Range	Default	Notes
Output Type	Drop List	Proportional voltage	See Table 6
Output Data Min	0 to Limit	0mA	This setpoint is Hold Current in Digital Hotshot mode
Output Data Max	0 to Limit	2000mA	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 7
Control Source	Drop List	Not Used	See Table 25
Control Number	Depends on control source	1	See Table 25
Enable Source	Drop List	Control not used	See Table 25
Enable Number	Depends on enable source	1	See Table 25
Enable Response	Drop List	Enable When On, Else Shutoff	See Table 8
Override Source	Drop List	Control not used	See Table 25
Override Number	Depends on enable source	1	See Table 25
Override Response	Drop List	Override When On, Else Shutoff	See Table 8
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 10
Output in Fault Mode	0 to Limit	0	

Table 29. Proportional Output Setpoints

4.5. PID Control Function Block

The PID Control Function Block is defined in Section 0. Please refer there for detailed information about how all these setpoints are used.

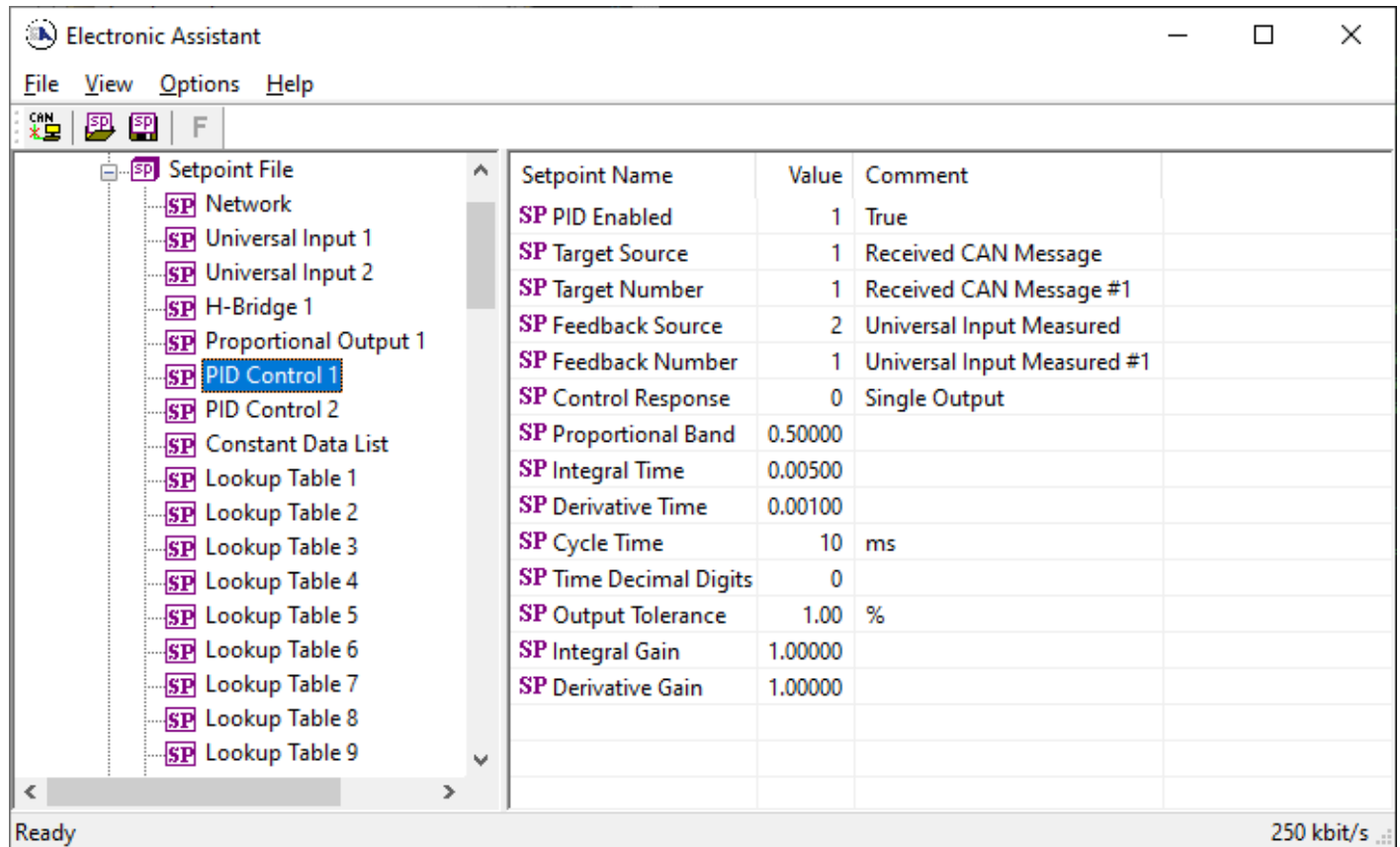


Figure 22. Screen Capture of PID Blok setpoints.

Name	Range	Default	Notes
PID Enabled	Drop List	False	
Target Source	Drop List	No Source	See Table 25
Target Number	Depends on Control Source	1	See Table 25
Feedback Source	Drop List	No Source	See Table 25
Feedback Number	Depends on Control Source	1	See Table 25
Control Response	Drop list	0, Single Output	
Proportional Band	0 – 10000	0.5	
Integral Gain	0 – 10000	0.005	
Derivative Time	0 - 10000	0.001	
Cycle Time	0 – 1000	3 ms	
Time Decimal Digits	0 – 3	0	
Output Tolerance	0 – 100	1%	
Integral Gain	0 – 10	1	
Derivative Gain	0 – 10	1	

Table 30. PID Function Block Setpoints

4.6. Constant Data List

The Constant Data List Function Block is provided to allow the user to select values as desired for various logic block functions.

The first two constants are fixed values of 0 (False) and 1 (True) for use in binary logic. The remaining 13 constants are fully user programmable to any value between +/- 100. The default values (shown in Figure 23) are arbitrary and should be configured by the user as appropriate for their application.

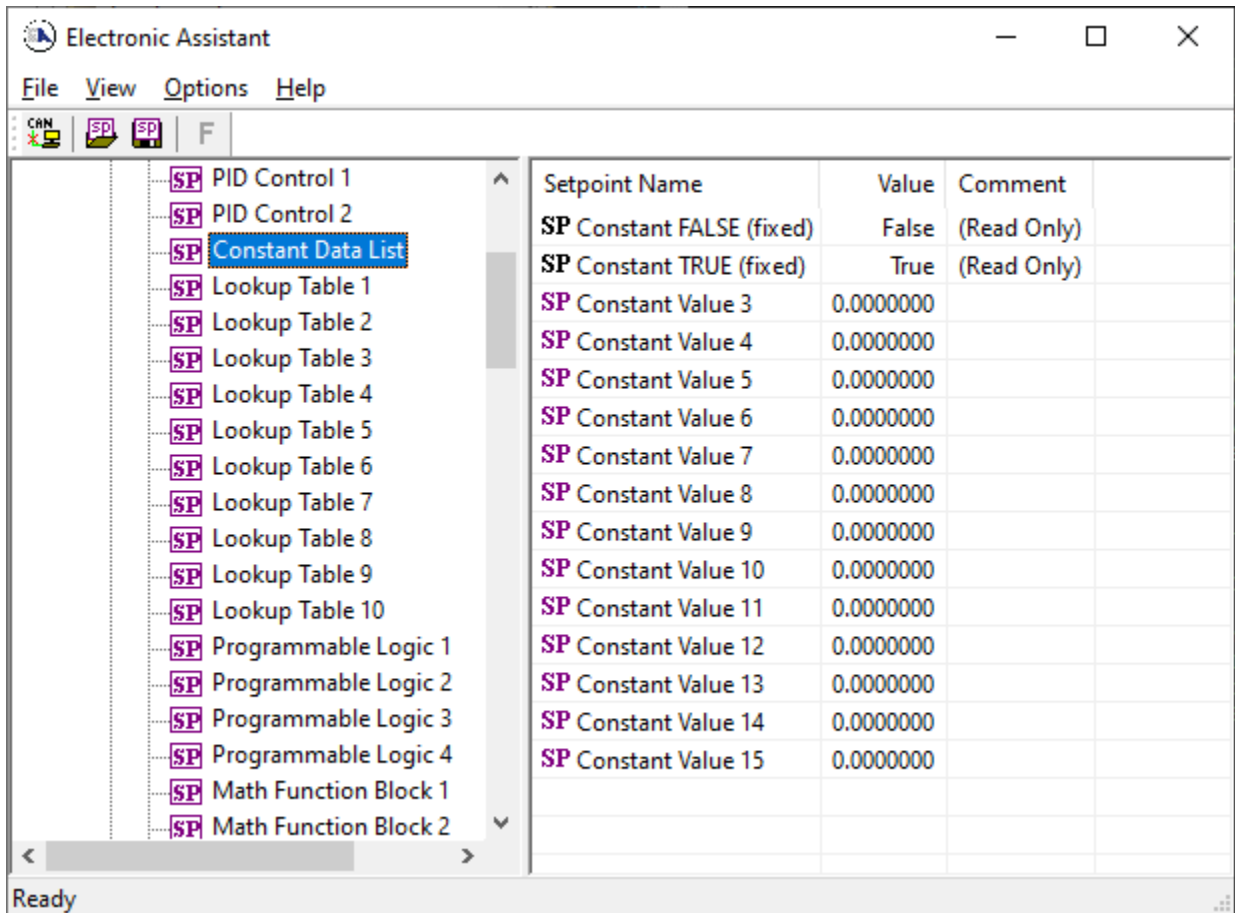


Figure 23. Screen Capture of Constant Data List Setpoints

4.7. Lookup Table

The Lookup Table Function Block is defined in Section 0 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**”.

The screenshot shows the 'Electronic Assistant' software window. The left-hand pane displays a tree view of function blocks, with 'Lookup Table 1' highlighted. The right-hand pane shows the configuration table for the selected block. The table has three columns: 'Setpoint Name', 'Value', and 'Comment'.

Setpoint Name	Value	Comment
SP X-Axis Source	1	Received CAN Message
SP X-Axis Number	1	
SP X-Axis Type	0	Data Response
SP Auto Repeat	0	False
SP Response 1	1	Ramp To
SP Response 2	1	Ramp To
SP Response 3	1	Ramp To
SP Response 4	1	Ramp To
SP Response 5	1	Ramp To
SP Response 6	1	Ramp To
SP Response 7	1	Ramp To
SP Response 8	1	Ramp To
SP Response 9	1	Ramp To
SP Response 10	1	Ramp To
SP Point X0	0.000	
SP Point X1	5.000	
SP Point X2	10.000	
SP Point X3	15.000	
SP Point X4	20.000	
SP Point X5	25.000	
SP Point X6	30.000	
SP Point X7	35.000	
SP Point X8	40.000	
SP Point X9	45.000	
SP Point X10	50.000	
SP Point X11	55.000	

Figure 24. Screen Capture of Lookup table Setpoints.

Name	Range	Default	Notes
X-Axis Source	Drop List	Control Not Used	See Table 25
X-Axis Number	Depends on control source	1	See Table 25
X-Axis Type	Drop List	Data Response	See Table 21
Table Auto-Cycle	Drop List	0	
Point 1 - Response	Drop List	Ramp To	See Table 22
Point 2 - Response	Drop List	Ramp To	See Table 22
Point 3 - Response	Drop List	Ramp To	See Table 22
Point 4 - Response	Drop List	Ramp To	See Table 22
Point 5 - Response	Drop List	Ramp To	See Table 22
Point 6 - Response	Drop List	Ramp To	See Table 22
Point 7 - Response	Drop List	Ramp To	See Table 22
Point 8 - Response	Drop List	Ramp To	See Table 22
Point 9 - Response	Drop List	Ramp To	See Table 22
Point 10 - Response	Drop List	Ramp To	See Table 22
Point 0 - X Value	From X-Axis source minimum	X-Axis source minimum 0.000	See Section 0
Point 1 - X Value	From X-Axis source minimum to Point 1 - X Value	5.000	See Section 0
Point 2 - X Value	From Point 0 - X Value to Point 2 - X Value	10.000	See Section 0
Point 3 - X Value	From Point 1 - X Value to Point 3 - X Value	15.000	See Section 0
Point 4 - X Value	From Point 2 - X Value to Point 4 - X Value	20.000	See Section 0
Point 5 - X Value	From Point 3 - X Value to Point 5 - X Value source	25.000	See Section 0
Point 6 - X Value	From Point 4 - X Value to Point 6 - X Value	30.000	See Section 0
Point 7 - X Value	From Point 5 - X Value to Point 7 - X Value	35.000	See Section 0
Point 8 - X Value	From Point 6 - X Value to Point 8 - X Value	40.000	See Section 0
Point 9 - X Value	From Point 7 - X Value to Point 9 - X Value	45.000	See Section 0
Point 10 - X Value	From Point 8 - X Value to Point 10 - X Value	50.000	See Section 0
Point 0 - Y Value	-10 ⁶ to 10 ⁶	0.000	
Point 1 - Y Value	-10 ⁶ to 10 ⁶	10.000	
Point 2 - Y Value	-10 ⁶ to 10 ⁶	20.000	
Point 3 - Y Value	-10 ⁶ to 10 ⁶	30.000	
Point 4 - Y Value	-10 ⁶ to 10 ⁶	40.000	
Point 5 - Y Value	-10 ⁶ to 10 ⁶	50.000	
Point 6 - Y Value	-10 ⁶ to 10 ⁶	60.000	
Point 7 - Y Value	-10 ⁶ to 10 ⁶	70.000	
Point 8 - Y Value	-10 ⁶ to 10 ⁶	80.000	
Point 9 - Y Value	-10 ⁶ to 10 ⁶	90.000	
Point 10 - Y Value	-10 ⁶ to 10 ⁶	100.000	

Table 31. Lookup Table Setpoints

4.8. Programmable Logic

The Programmable Logic function block is defined in Section 0. Please refer there for detailed information about how all these setpoints are used. “**Programmable Logic Enabled**” is ‘*False*’ by default. To enable Logic set “**Programmable Logic Enabled**” to ‘*True*’ and select appropriate “**Argument Source**”.

Setpoint Name	Value	Comment
SP Logic Enabled	1	True
SP Table Number 1	1	Lookup Table 1
SP Logical Operator 1	1	Cnd1 And Cnd2 And Cnd3
SP Table 1 - Condition 1 Argument 1 Source	8	Control Constant Data
SP Table 1 - Condition 1 Argument 1 Number	1	
SP Table 1 - Condition 1 Argument 2 Source	8	Control Constant Data
SP Table 1 - Condition 1 Argument 2 Number	2	
SP Table 1 - Condition 1 Operator	0	=, Equal
SP Table 1 - Condition 2 Argument 1 Source	0	Control Not Used
SP Table 1 - Condition 2 Argument 1 Number		Parameter not used with current Control Source
SP Table 1 - Condition 2 Argument 2 Source	0	Control Not Used
SP Table 1 - Condition 2 Argument 2 Number		Parameter not used with current Control Source
SP Table 1 - Condition 2 Operator		Parameter not used with current Control Source
SP Table 1 - Condition 3 Argument 1 Source	0	Control Not Used
SP Table 1 - Condition 3 Argument 1 Number		Parameter not used with current Control Source
SP Table 1 - Condition 3 Argument 2 Source	0	Control Not Used
SP Table 1 - Condition 3 Argument 2 Number		Parameter not used with current Control Source
SP Table 1 - Condition 3 Operator		Parameter not used with current Control Source
SP Table Number 2	2	Lookup Table 2
SP Logical Operator 2	1	Cnd1 And Cnd2 And Cnd3
SP Table 2 - Condition 1 Argument 1 Source	1	Received CAN Message
SP Table 2 - Condition 1 Argument 1 Number	1	
SP Table 2 - Condition 1 Argument 2 Source	1	Received CAN Message
SP Table 2 - Condition 1 Argument 2 Number	2	
SP Table 2 - Condition 1 Operator	0	=, Equal
SP Table 2 - Condition 2 Argument 1 Source	0	Control Not Used
SP Table 2 - Condition 2 Argument 1 Number		Parameter not used with current Control Source
SP Table 2 - Condition 2 Argument 2 Source	0	Control Not Used
SP Table 2 - Condition 2 Argument 2 Number		Parameter not used with current Control Source

Figure 25. Screen Capture of Programmable Logic Setpoints

Setpoint ranges and default values for Programmable Logic Blocs are listed in Table 32. Only “**Table1**” setpoint are listed, because other “**TableX**” setpoints are similar, except for the default value of the “**Lookup Table Block Number**” setpoint, which is X for “**TableX**”.

Name	Range	Default	Notes
Programmable Logic Enabled	Drop List	False	
Table1 - Lookup Table Block Number	1 to 8	Look up Table 1	
Table1 - Conditions Logical Operation	Drop List	Default Table	See Table 24
Table1 - Condition1, Argument 1 Source	Drop List	Control Not Used	See Table 25
Table1 - Condition1, Argument 1 Number	Depends on control source	1	See Table 25
Table1 - Condition1, Operator	Drop List	=, Equal	See Table 23
Table1 - Condition1, Argument 2 Source	Drop List	Control Not Used	See Table 25
Table1 - Condition1, Argument 2 Number	Depends on control source	1	See Table 25
Table1 - Condition2, Argument 1 Source	Drop List	Control Not Used	See Table 25
Table1 - Condition2, Argument 1 Number	Depends on control source	1	See Table 25
Table1 - Condition2, Operator	Drop List	=, Equal	See Table 23
Table1 - Condition2, Argument 2 Source	Drop List	Control Not Used	See Table 25
Table1 - Condition2, Argument 2 Number	Depends on control source	1	See Table 25
Table1 - Condition3, Argument 1 Source	Drop List	Control Not Used	See Table 25
Table1 - Condition3, Argument 1 Number	Depends on control source	1	See Table 25
Table1 - Condition3, Operator	Drop List	=, Equal	See Table 23
Table1 - Condition3, Argument 2 Source	Drop List	Control Not Used	See Table 25
Table1 - Condition3, Argument 2 Number	Depends on control source	1	See Table 25

Table 32. Programmable Logic Setpoints

4.9. Math Function Block

The Math Function Block is defined in Section 1.6. Please refer there for detailed information about how all these setpoints are used. “**Math Function Enabled**” is ‘False’ by default. To enable a Math function Block, set “**Math Function Enabled**” to ‘True’ and select appropriate “**Input Source**”.

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Setpoint Name	Value	Comment
SP Math Enabled	1	True
SP Math Output Minimum Range	0.00	
SP Math Output Maximum Range	100.00	
SP Input 1 Source	2	Universal Input Measured
SP Input 1 Number	1	
SP Input 1 Minimum	0.00	
SP Input 1 Maximum	100.00	
SP Input 1 Gain	1.00	
SP Input 2 Source	0	Control Not Used
SP Input 2 Number		Parameter not used with current Control Source selected
SP Input 2 Minimum		Parameter not used with current Control Source selected
SP Input 2 Maximum		Parameter not used with current Control Source selected
SP Input 2 Gain		Parameter not used with current Control Source selected
SP Input 3 Source	0	Control Not Used
SP Input 3 Number		Parameter not used with current Control Source selected
SP Input 3 Minimum		Parameter not used with current Control Source selected
SP Input 3 Maximum		Parameter not used with current Control Source selected
SP Input 3 Gain		Parameter not used with current Control Source selected
SP Input 4 Source	0	Control Not Used
SP Input 4 Number		Parameter not used with current Control Source selected
SP Input 4 Minimum		Parameter not used with current Control Source selected
SP Input 4 Maximum		Parameter not used with current Control Source selected
SP Input 4 Gain		Parameter not used with current Control Source selected
SP Math Function 1		Parameter not used with current Control Source selected
SP Math Function 2		Parameter not used with current Control Source selected
SP Math Function 3		Parameter not used with current Control Source selected

Ready 250 kbit/s

Figure 26. Screen Capture of Math Function Block Setpoints

Name	Range	Default	Notes
Math Function Enabled	Drop List	False	
Function 1 Input A Source	Drop List	Control not used	See Table 25
Function 1 Input A Number	Depends on control source	1	See Table 25
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 25
Function 1 Input B Number	Depends on control source	1	See Table 25
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 17
Function 2 Input B Source	Drop List	Control not used	See Table 25
Function 2 Input B Number	Depends on control source	1	See Table 25
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 17
Function 3 Input B Source	Drop List	Control not used	See Table 25
Function 3 Input B Number	Depends on control source	1	See Table 25
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 17
Function 4 Input B Source	Drop List	Control not used	See Table 25
Function 4 Input B Number	Depends on control source	1	See Table 25
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 17
Math Output Minimum Range	-10^6 to 10^6	0.0	
Math Output Maximum Range	-10^6 to 10^6	100.0	

Table 33. Math Function Setpoints

4.10. Conditional Logic Block Setpoints

The Conditional Block setpoints are defined in Section 1.7. Refer to that section for detailed information on how these setpoints are used. The screen capture in Figure 27 displays the available setpoints for each of the Conditional Blocks. The table below the screen capture highlights the allowable ranges for each setpoint.

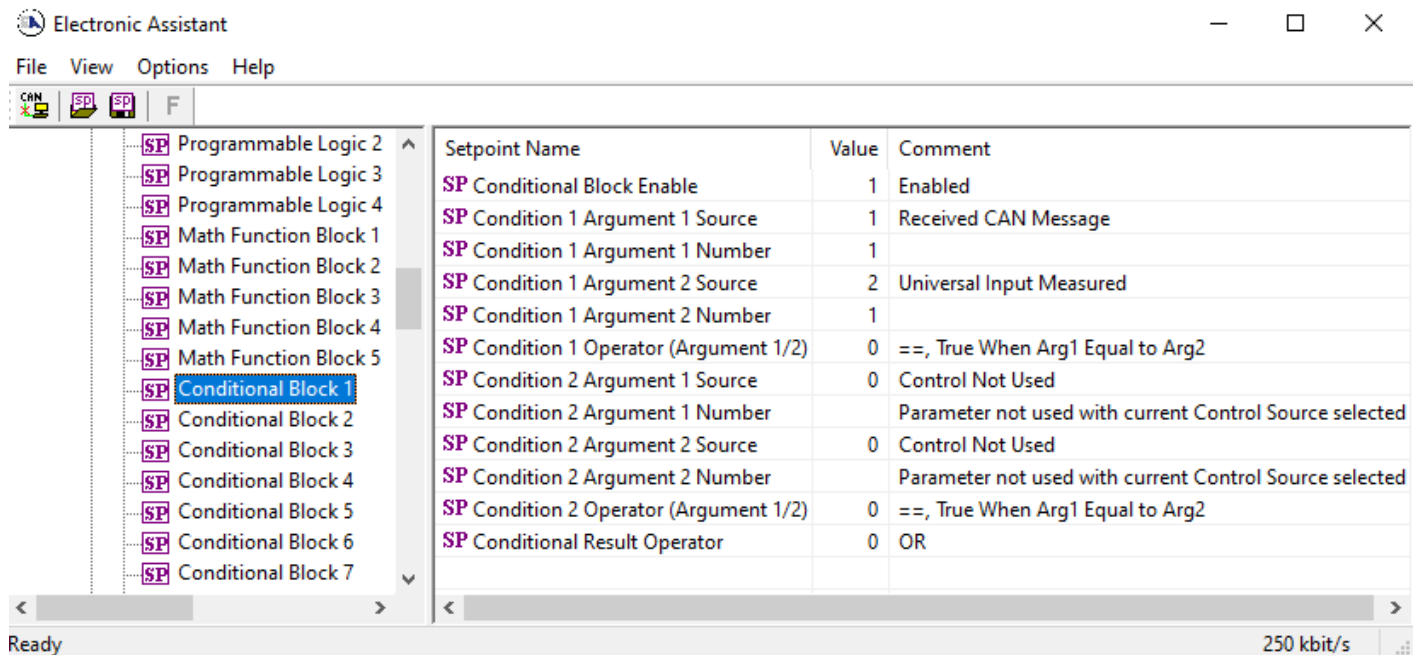


Figure 27. Screen Capture of Conditional Block Setpoints

Name	Range	Default	Notes
Conditional Function Enabled	Drop List	Disabled	
Condition 1 Argument 1 Source	Drop List	Digital Input	See Table 25
Condition 1 Argument 1 Number	Depends on Source Selected	0	See Table 25
Condition 1 Argument 2 Source	Drop List	Digital Input	See Table 25
Condition 1 Argument 2 Number	Depends on Source Selected	0	See Table 25
Condition 1 Operator (Argument 1/2)	Drop List	0	See Table 18
Condition 2 Argument 1 Source	Drop List	Digital Input	See Table 25
Condition 2 Argument 1 Number	Depends on Source Selected	0	See Table 25
Condition 2 Argument 2 Source	Drop List	Digital Input	See Table 25
Condition 2 Argument 2 Number	Depends on Source Selected	0	See Table 25
Condition 2 Operator (Argument 1/2)	Drop List	0	See Table 18
Conditional Result Operator	Drop List	OR	See Table 19

Table 34. Default Conditional Block Setpoints

4.11. Set-Reset Latch Block

The Set-Reset Latch Block setpoints are defined in Section 1.8. Refer to that section for detailed information on how these setpoints are used. The screen capture in Figure 28 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.

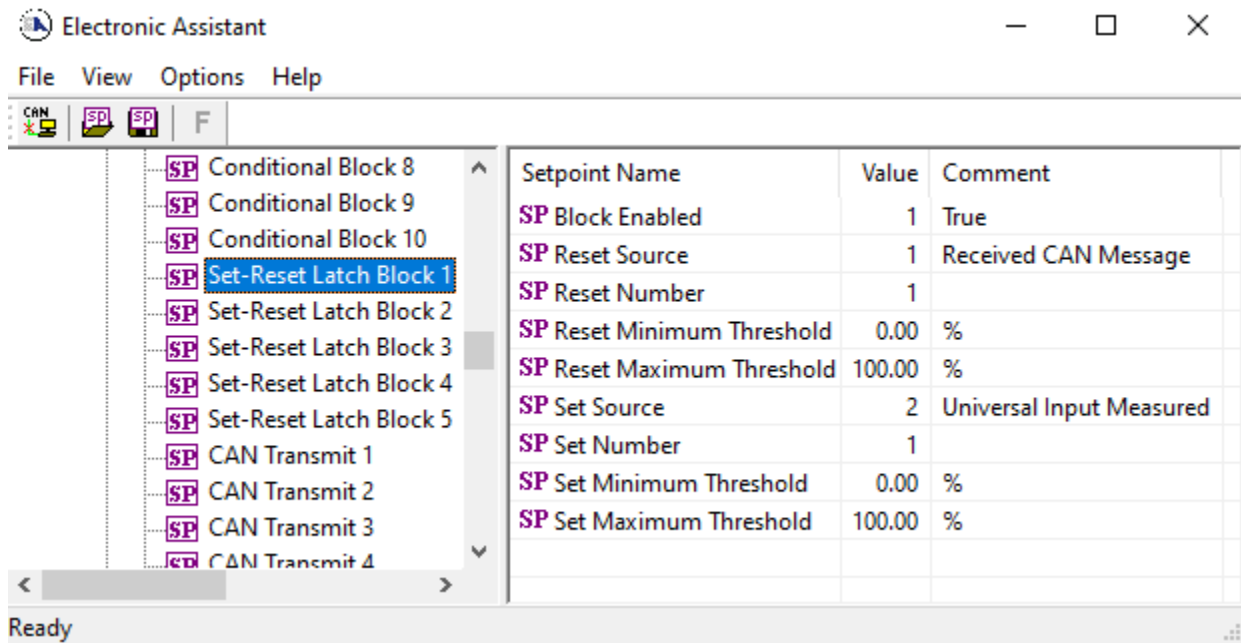


Figure 28. Screen Capture of Set-Reset Latch Block Setpoints

Name	Range	Default	Notes
Block Enabled	Drop List	False	
Reset Source	Drop List	Control Not Used	See Table 25
Reset Number	Depends on Source Selected	1	See Table 25
Reset Minimum Threshold		0%	Refer to Section 1.8
Reset Maximum Threshold		100%	Refer to Section 1.8
Set Source	Drop List	Control Not Used	See Table 25
Set Number	Depends on Source Selected	1	See Table 25
Set Minimum Threshold		0%	Refer to Section 1.8
Set Maximum Threshold		100%	Refer to Section 1.8

Table 35. Default Set-Reset Latch Block Setpoints

4.12. CAN Transmit Setpoints

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

Setpoint Name	Value	Comment
SP Transmit Enabled	1	True
SP PGN	0xFF00	Transmit PGN: 65280
SP Repetition Rate	0	ms
SP Message Priority	6	
SP Destination Address (PDU1)	255	Destination ECU Address: 0xFF
SP Message Length	8	Byte(s)
SP Signal 1 Data Type	2	Continuous
SP Signal 1 Data Source	2	Universal Input Measured
SP Signal 1 Data Number	1	
SP Signal 1 Data Size	8	bits
SP Signal 1 Byte Index	1	1st Byte Position
SP Signal 1 Bit Index	1	1st Bit Position
SP Signal 1 Resolution	1.0000	
SP Signal 1 Offset	0.0000	
SP Signal 2 Data Type	0	Undefined
SP Signal 2 Data Source	0	Control Not Used
SP Signal 2 Data Number		Parameter not used with current Data Source
SP Signal 2 Data Size		Parameter not used with current Data Source
SP Signal 2 Byte Index		Parameter not used with current Data Source
SP Signal 2 Bit Index		Parameter not used with current Data Source
SP Signal 2 Resolution		Parameter not used with current Data Source
SP Signal 2 Offset		Parameter not used with current Data Source
SP Signal 3 Data Type	0	Undefined

Figure 29. Screen Capture of CAN Transmit Message Setpoints

Name	Range	Default	Notes
Transmit Enabled	Drop List	0, False	
Transmit PGN	0xff00 ... 0xffff	Different for each	See section 1.13.1
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 25
Signal X Control Number	Drop List	Different for each	See Table 25
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	

Table 36. CAN Transmit Message Setpoints

4.13. CAN Receive Setpoints

The CAN Receive Block is defined in Section 0. 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.

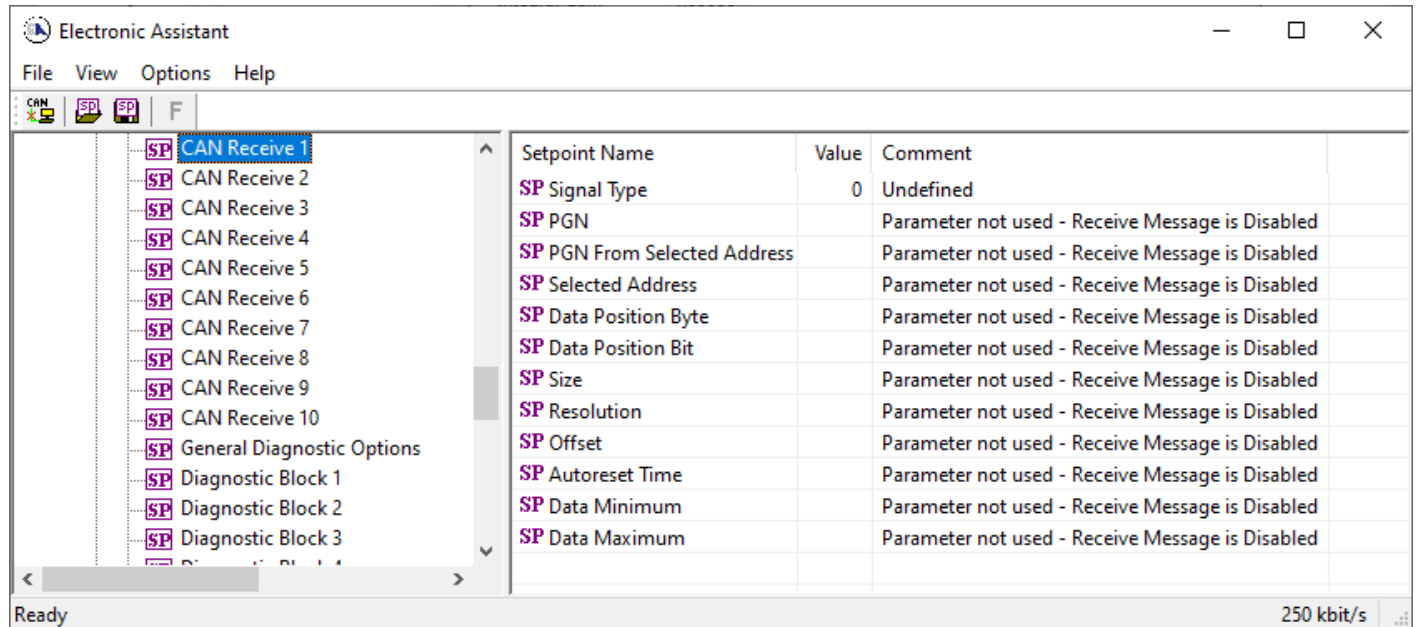


Figure 30. Screen Capture of CAN Receive Message Setpoints

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	

Table 37. CAN Receive Setpoints

4.14. General Diagnostics Options

These setpoints control the shutdown of the ECU in case of a power supply or CPU temperature related errors.

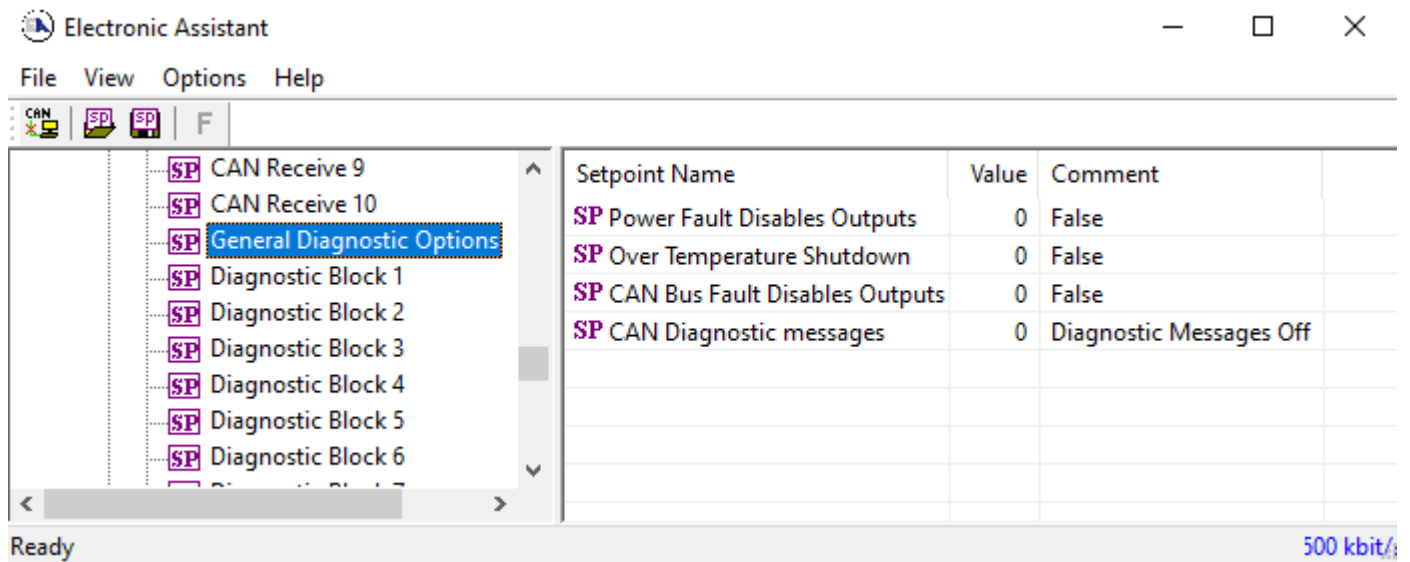


Figure 31. Screen Capture of General Diagnostics Options Setpoints

Name	Range	Default	Notes
Power Fault Disables Outputs	Drop List	0	
Over Temperature Shutdown	Drop List	0	
CAN Bus Fault Disables Outputs	Drop List	0	
CAN Diagnostic messages	Drop List	0	

Table 38. General Diagnostics Options Setpoints

4.15. 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 1.5. Please refer there for detailed information on how these setpoints are used.

Setpoint Name	Value	Comment
SP Fault Detection is Enabled	1	True
SP Function Type to Monitor	1	Received CAN Message
SP Function Parameter to Monitor	1	Received CAN Message #1
SP Enable Source	0	Control Not Used
SP Enable Number		Parameter not used with current Enable Source selected
SP Enable Response		Parameter not used with current Enable Source selected
SP Fault Detection Type	0	Min and Max Error
SP Maximum Value for Diagnostic Data	1.00	
SP Minimum Value for Diagnostic Data	0.00	
SP Use Hysteresis When Defining Thresholds	0	False
SP Hysteresis		Parameter not used - Hysteresis not used when defining thresholds
SP Event Cleared Only by DM11	0	False
SP Set Limit for MINIMUM WARNING		Parameter not used with current Fault Detection Type
SP Clear Limit for MINIMUM WARNING		Parameter not used with current Fault Detection Type
SP Set Limit for MAXIMUM WARNING		Parameter not used with current Fault Detection Type
SP Clear Limit for MAXIMUM WARNING		Parameter not used with current Fault Detection Type
SP Set Limit for MINIMUM SHUTDOWN	0.00	
SP Clear Limit for MINIMUM SHUTDOWN	0.00	
SP Set Limit for MAXIMUM SHUTDOWN	1.00	
SP Clear Limit for MAXIMUM SHUTDOWN	1.00	
SP MAXIMUM SHUTDOWN, Event Generates a DTC in DM1	0	False
SP MAXIMUM SHUTDOWN, Lamp Set by Event	0	Protect
SP MAXIMUM SHUTDOWN, SPN for Event	0x007FF00	SPN: 524032
SP MAXIMUM SHUTDOWN, FMI for Event	0	Data Valid But Above Normal Operational Range - Most Severe Level
SP MAXIMUM SHUTDOWN, Delay Before Event is Flagged	1000	ms
SP MAXIMUM WARNING, Event Generates a DTC in DM1		Parameter not used with current Fault Detection Type
SP MAXIMUM WARNING, Lamp Set by Event		Parameter not used with current Fault Detection Type
SP MAXIMUM WARNING, SPN for Event		Parameter not used with current Fault Detection Type
SP MAXIMUM WARNING, FMI for Event		Parameter not used with current Fault Detection Type
SP MAXIMUM WARNING, Delay Before Event is Flagged		Parameter not used with current Fault Detection Type
SP MINIMUM WARNING, Event Generates a DTC in DM1		Parameter not used with current Fault Detection Type
SP MINIMUM WARNING, Lamp Set by Event		Parameter not used with current Fault Detection Type
SP MINIMUM WARNING, SPN for Event		Parameter not used with current Fault Detection Type
SP MINIMUM WARNING, FMI for Event		Parameter not used with current Fault Detection Type
SP MINIMUM WARNING, Delay Before Event is Flagged		Parameter not used with current Fault Detection Type
SP MINIMUM SHUTDOWN, Event Generates a DTC in DM1	0	False
SP MINIMUM SHUTDOWN, Lamp Set by Event	0	Protect
SP MINIMUM SHUTDOWN, SPN for Event	0x007FF00	SPN: 524032
SP MINIMUM SHUTDOWN, FMI for Event	0	Data Valid But Above Normal Operational Range - Most Severe Level
SP MINIMUM SHUTDOWN, Delay Before Event is Flagged	1000	ms

Figure 32. Screen Capture of Diagnostic Block Setpoints

Name	Range	Default	Notes
Fault Detection is Enabled	Drop List	False	
Function Type to Monitor	Drop List	0 – Control not used	
Function parameter to Monitor	Drop List	0 – No selection	
Fault Detection Type	Drop List	0 – Min and Max Error	See section 1.5
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 14

Name	Range	Default	Notes
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 15
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 14
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 15
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 14
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 15
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 14
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 15
MINIMUM SHUTDOWN, Delay Before Event is Flagged	0...60000 ms	1000	

Table 39. Diagnostic Block Setpoints

4.16. DTC React Function Block

The DTC React function block is described in Section 0. 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.*

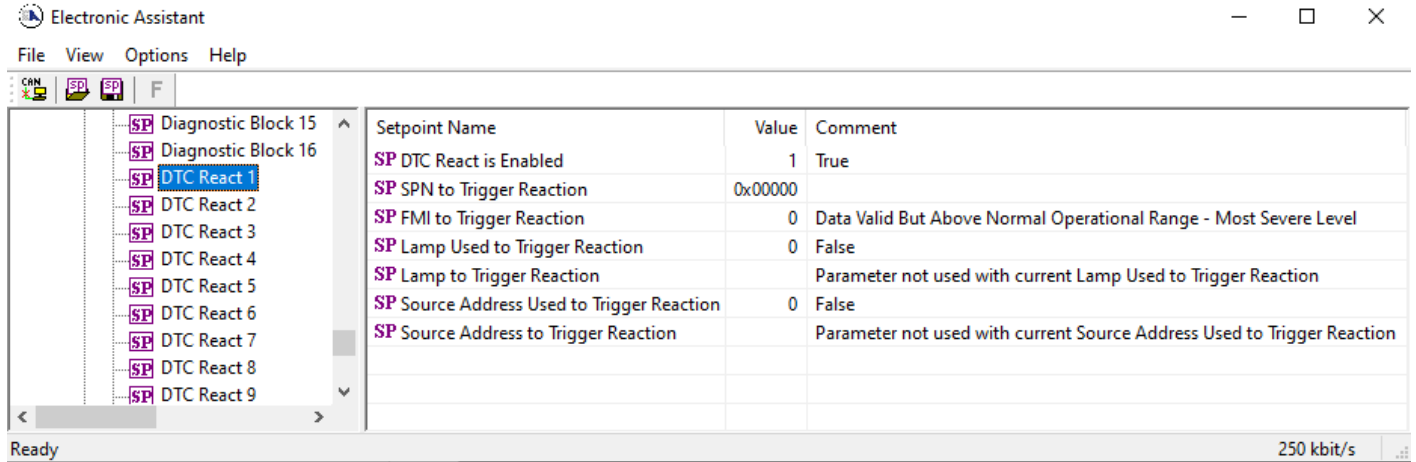


Figure 33. DTC React Setpoints

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	

Table 40. DTC React Setpoints

5. REFLASHING OVER CAN WITH EA BOOTLOADER

The controller 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.

To flash the new firmware, the user should activate the embedded bootloader. To do so, start the EA and, in the *Bootloader Information* group screen, click on the *Force Bootloader to Load on Reset* parameter. The following dialog will appear, see *Figure 34*.

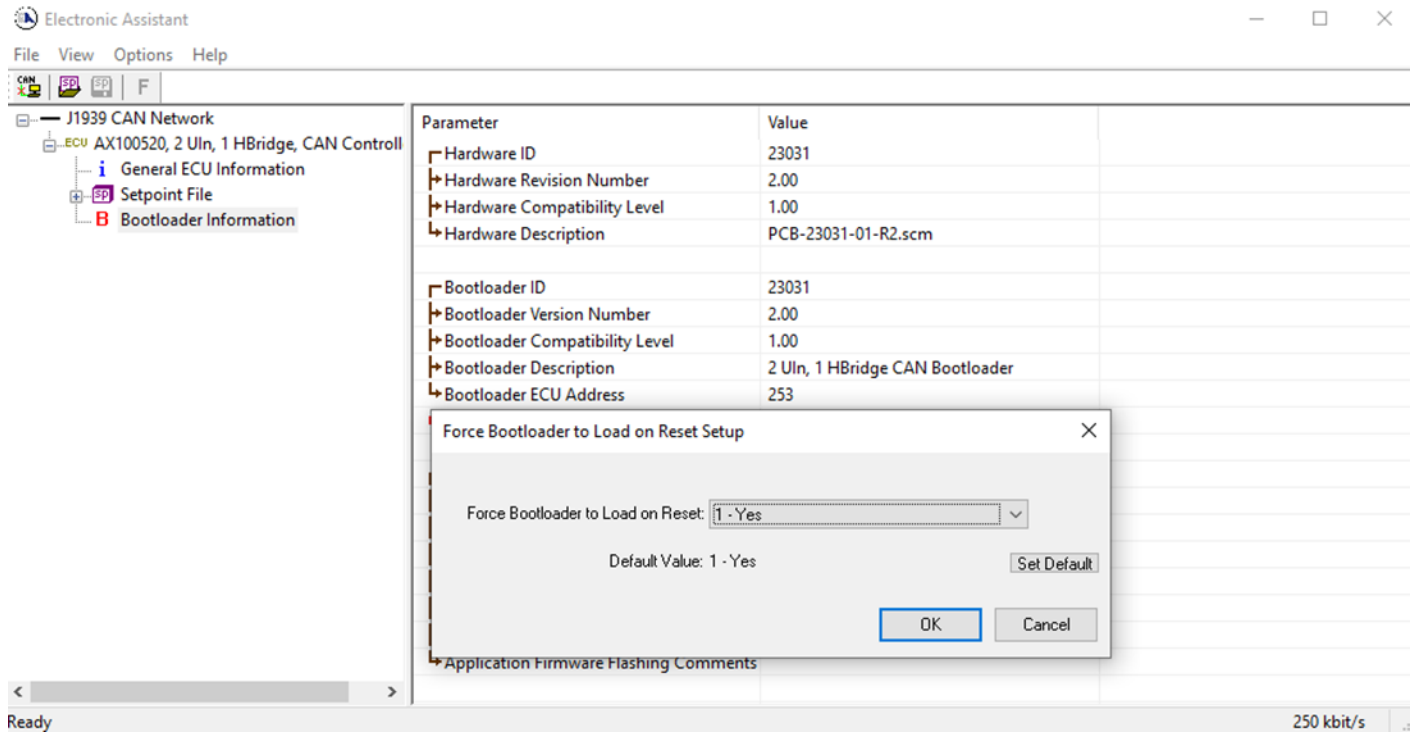


Figure 34. Bootloader Activation. First Step

The EA will prompt the user to change the *Force Bootloader to Load on Reset* parameter flag to “Yes”. This will automatically activate the bootloader on the next ECU reset. After accepting the change, the next screen will ask the user if the reset is required. Select “Yes”.

After automatic reset, instead of the firmware info, the user will see *J1939 Bootloader* ECU in the *J1939 CAN Network* top-level group in the EA. This means that the bootloader is activated and ready to accept the new firmware.

All the bootloader specific information: controller hardware, bootloader details, and the currently installed application firmware remains the same in the bootloader mode and the user can read it in the *Bootloader Information* group screen, see *Figure 35*. The information can be slightly different for different versions of the bootloader.

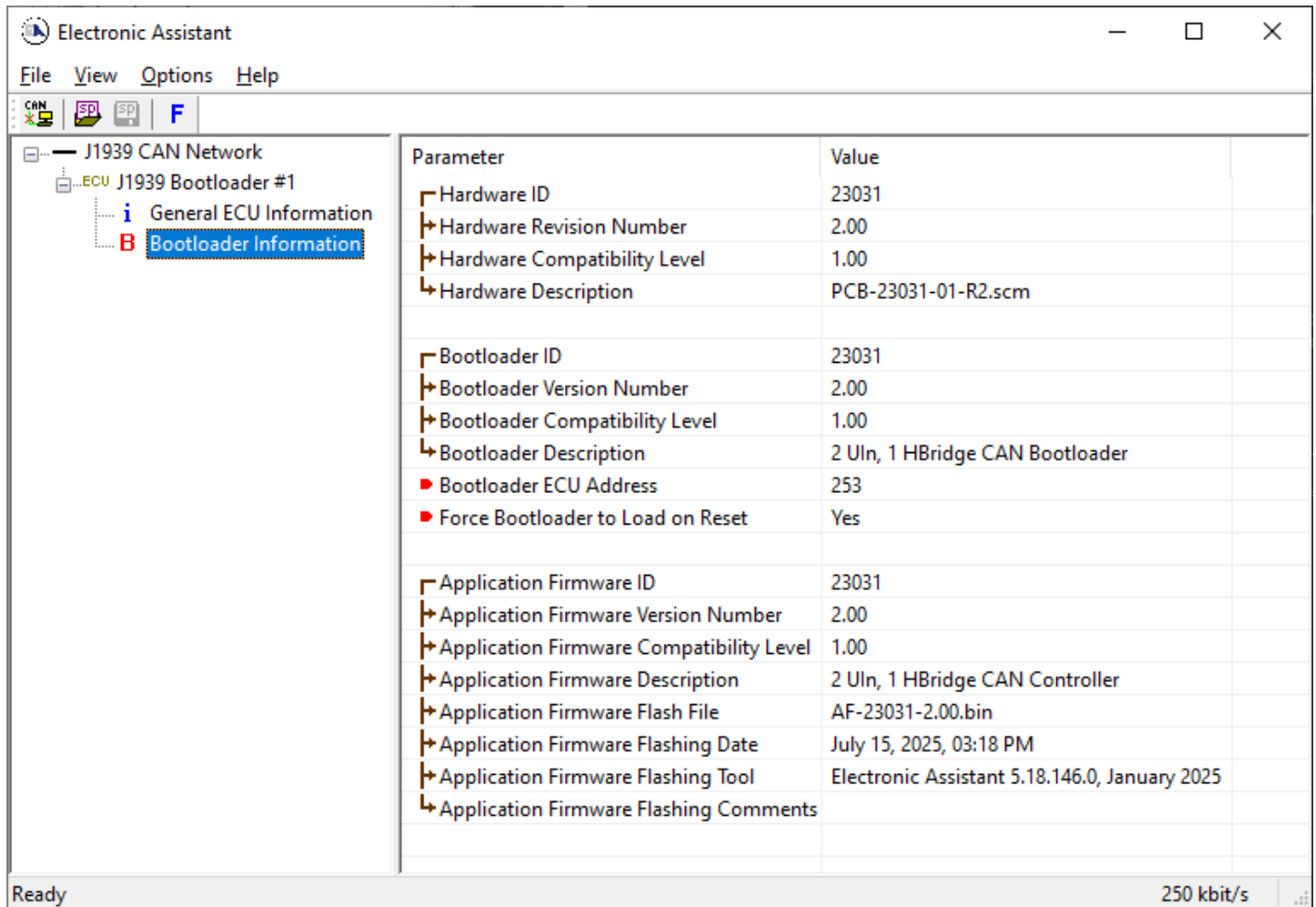


Figure 35. Bootloader Information Screen

At this point, the user can return to the installed controller firmware by changing the *Force Bootloader to Load on Reset* flag back to *No* and resetting the ECU.

To flash the new firmware, the user should click on **F** toolbar icon or from the *File* menu select the *Open Flash File* command. The *Open Application Firmware Flash File* dialog will appear. Pick up the flash file with the new converter firmware and confirm the selection by pressing the *Open* button. The *Flash Application Firmware* dialog window will appear¹, see Figure 36.

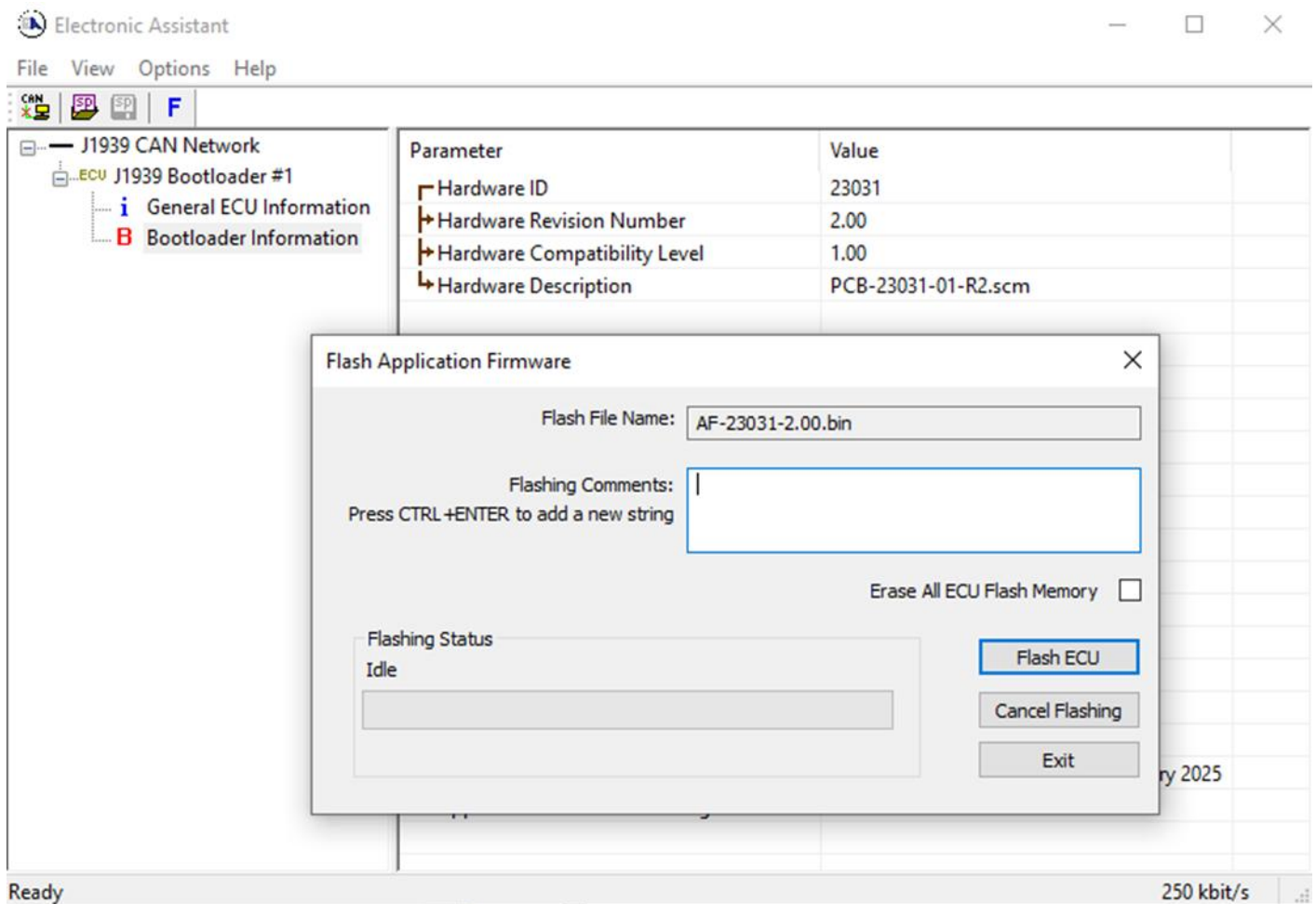


Figure 36. Flashing New Firmware. Preparation

¹ In this example, instead of the new firmware, the old firmware V2.00 is being simply re-flashed.

Now the user can add any comments to the flashing operation in the *Flashing Comments* field. They will be stored in the *Bootloader Information* group after flashing.

The user can also check the *Erase All ECU Flash Memory* flag to erase all flash memory. This operation, used in other products to reset configuration parameters kept in the flash memory to their default values, has no effect on this product. This is because the configuration parameters of the inclinometer are stored in a separate EEPROM memory.

Select the *Flash ECU* button to start flashing. A reminder that the old application firmware will be destroyed by the flashing operation will appear. Press *Ok* to continue and watch the dynamics of the flashing operation in the *Flashing Status* field. When flashing is done, the following screen will appear prompting the user to reset the ECU, see Figure 37.

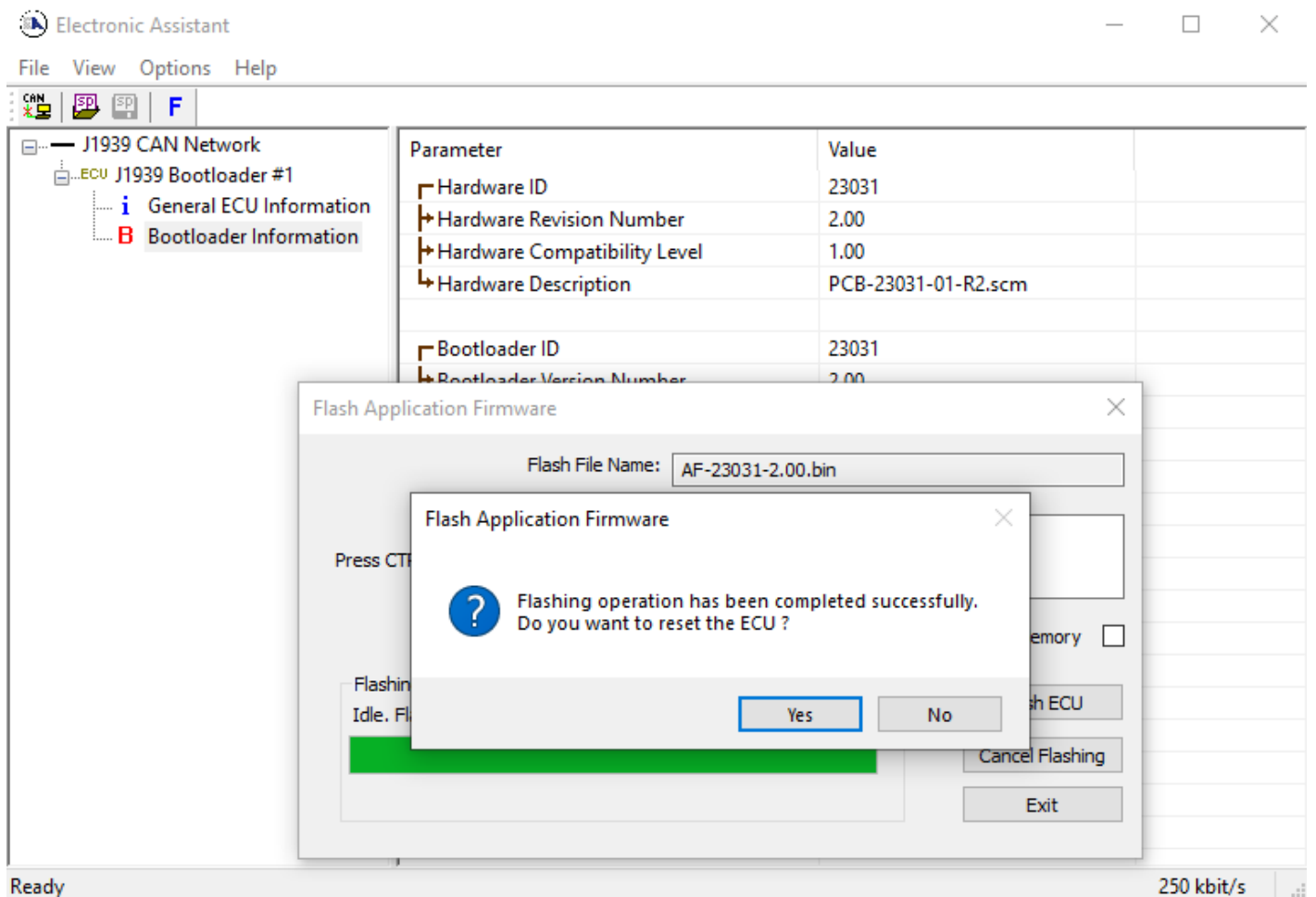


Figure 37. Flashing New Firmware. Final Reset.

Select Yes and see the ECU running the new firmware, see Figure 38. This will indicate that the flashing operation has been performed successfully.

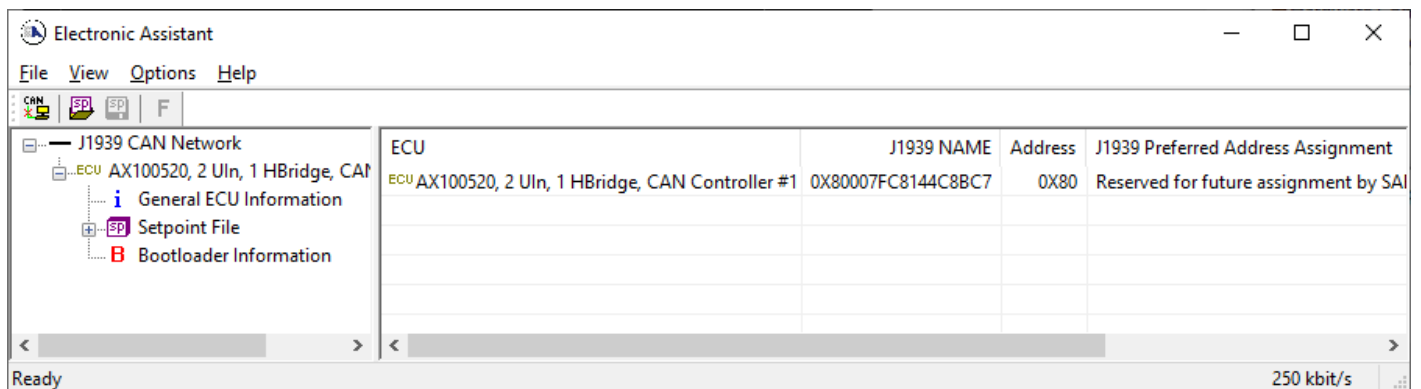


Figure 38. Firmware has been Updated. New Firmware Screen

For more information, see the *J1939 Bootloader* section of the EA user manual.

6. 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 Limitations & Return Materials Process as described on <https://www.axiomatic.com/service/>.

Power Input

Power Input	12, 24, or 48 VDC nominal 8 to 80 VDC range
Quiescent Current	52.6 mA @ 12 VDC; 42 mA @ 24 VDC; 30 mA @ 48 VDC typical
Protections	Surge protection is provided. Reverse polarity protection is provided. Under-voltage protection is provided. (Hardware shutdown at 6 V) Over-voltage protection is provided. (Hardware shutdown at 86 V)

Inputs

Inputs	2x universal inputs selectable as voltage, current, frequency, PWM, or digital types	
	Voltage	Range: 0 to 5 V, 0 to 10 V Resolution: 1 mV Accuracy: ± 1 % error
	Current	Range: 0 to 20 mA, 4 to 20 mA Resolution: 1 μ A Accuracy: ± 1 % error
	Frequency	Frequency: 0 to 10,000 Hz Resolution: 0.01 % Accuracy: ± 1 % error
	PWM	Frequency: 0 to 10,000 Hz Duty Cycle: 0 to 100 % Resolution: 0.01 % Accuracy: ± 1 % error
	Digital	1 M Ω impedance; or Active High with 10 k Ω pull-up; or Active Low with 10 k Ω pull-down resistor to Ground Amplitude: Up to 36 V
	12-bit analog to digital resolution	
Protection	Protected against short circuit to Ground	

Output

Output	1x output (up to 10 A sourcing or up to -10 A sinking) programmable either as: <ul style="list-style-type: none"> • 1x full H-bridge output • 1x proportional output <p>The proportional output is further configurable as follows.</p>		
	Proportional Voltage	Range: 0 to Vps (up to 48 V) Resolution: 10 mV Accuracy: ± 5 % error	
	Proportional Current	Ranges: 0 to 10 A Resolution: 10 mA Accuracy: ± 1 % error	
	Hotshot Digital	See Figure 39. Hotshot Digital Profile.	
	PWM	Range: 1 Hz to 10 kHz Duty Cycle: 0 to 100 % Resolution: 0.01% Accuracy: ± 1 % error	
	Digital	On/Off	
	Disabled	-	
		Current sensing is provided. The total load at power supply voltage must not exceed more than 32 A.	
		Note: The load is connected between two output pins "Output 1" and "Output 2".	
	Protection	Overcurrent protection against shorts to Ground or +Vsupply at 23 A per output	

General Specifications

Microcontroller	STM32H725RGV3 32-bit, 1 MB flash memory																		
Communications	1x CAN port (SAE J1939) Supported baud-rates: 125 kbit/s, 250 kbit/s, 500 kbit/s, or 1 Mbit/s with auto-baud-rate detection																		
Network Termination	It is necessary to terminate the network with external termination resistors. The resistors are 120 Ω , 0.25 W minimum, metal film or similar type. They should be placed between CAN High and CAN Low terminals at both ends of the network.																		
User Interface	Axiomatic Electronic Assistant KIT - P/Ns: AX070502 or AX070506K																		
Compliance	RoHS																		
Protection Rating	IP67 (IEC 60529 compliant when mating connectors compliant with IEC 61076-2-101:2012 are installed.)																		
Operating Conditions	-40 to 85 °C (-40 to 185 °F)																		
Storage Temperature	-50 to 125 °C (-58 to 257 °F)																		
Weight	1.144 lb. (0.519 kg)																		
Enclosure	Cast Aluminum enclosure, anodized 4.64 in. x 3.54 in. x 2.23 in. (117.90 mm x 90.00 mm x 56.73 mm) L x W x H includes the integral connector Refer to Dimensional Drawing.																		
Electrical Connections	8-pin TE AMPSEAL connector - P/N: 776276-1 <table border="1" data-bbox="370 682 789 919"> <thead> <tr> <th>Pin</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Power Input -</td> </tr> <tr> <td>2</td> <td>CAN High</td> </tr> <tr> <td>3</td> <td>CAN Low</td> </tr> <tr> <td>4</td> <td>Input 1</td> </tr> <tr> <td>5</td> <td>Input 2</td> </tr> <tr> <td>6</td> <td>Power Input +</td> </tr> <tr> <td>7</td> <td>Output 1</td> </tr> <tr> <td>8</td> <td>Output 2</td> </tr> </tbody> </table>	Pin	Description	1	Power Input -	2	CAN High	3	CAN Low	4	Input 1	5	Input 2	6	Power Input +	7	Output 1	8	Output 2
Pin	Description																		
1	Power Input -																		
2	CAN High																		
3	CAN Low																		
4	Input 1																		
5	Input 2																		
6	Power Input +																		
7	Output 1																		
8	Output 2																		
Mounting	Mounting holes are sized for #10 or M5 bolts. Use 10 mm (O.D.) washers with the bolts. The bolt length will be determined by the end-user's mounting plate thickness. The mounting flange of the controller is 0.28 in. (7 mm) thick. It should be mounted with connectors facing left or right to reduce the likelihood of moisture entry. All field wiring should be suitable for the operating temperature range. Install the unit with appropriate space available for servicing and for adequate wire harness access (6 in. or 15 cm) and strain relief (12 in. or 30 cm).																		

7. VERSION HISTORY

User Manual Version	Firmware Version	Date	Author	Modifications
1.0.0	1.xx	December 2024	VR	<ul style="list-style-type: none">• Initial release
2.0.0	2.xx	July 2025	VR	<ul style="list-style-type: none">• Changed part number• Added PWM Control for H-Bridge
2.0.1	2.xx	November 2025	M Ejaz	<ul style="list-style-type: none">• Reformatted• Updated the title• Updated technical specifications• Added dimensional drawing