18 DIGITAL CONTROLLER WITH CAN, SAE J1939

USER MANUAL

P/N: AX030310

P/N: AX030310-01 – J1939 500kbits/s Baud Rate

P/N: AX030310-02 – Custom J1939 Baud Rate, 1Mbits/s

P/N: AX030320

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VERSION HISTORY

Version	Date	Author	Modification
1.0.0.	Aug 21, 2014	Ilona Korpelainen	Initial Draft
--	Nov. 13, 2014	Amanda Wilkins	Block diagram updated
1.0.1.	Nov. 18, 2014	Ilona Korpelainen	ECU ID and Component ID PNGs added
1.0.2.	Mar 2, 2015	Antti Keränen	Added high baud rate P/Ns AX030310-01 and AX030310-02. P/N table added to page 7. Axiomatic EA configuration note added to page 24.
1.0.3.	Sep. 12, 2018	Antti Keränen	Description of AX030320 features added (CAN TX), firmware reflashing section and CAN TX and RX section updated.
1.0.4	July 31, 2023	Kiril Mojsov	Performed Legacy Updates
1.0.4	April 12, 2024	Amanda Wilkins	Marketing review

ACRONYMS

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

Note:

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

TABLE OF CONTENTS

REFERENCES

J1939	Recommended Practice for a Serial Control and Communications Vehicle Network, SAE, April 2011
J1939/21	Data Link Layer, SAE, December 2010
J1939/71	Vehicle Application Layer, SAE, March 2011
J1939/73	Application Layer-Diagnostics, SAE, February 2010
J1939/81	Network Management, SAE, May 2003
TDAX030310	Technical Datasheet, 18 Digital Input Controller with CAN, Axiomatic Technologies 2014
UMAX07050x	User Manual V4.5.53, Axiomatic Electronic Assistant and USB-CAN, Axiomatic Technologies, October 2013

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

NOTE: This product is supported by Axiomatic Electronic Assistant V4.5.53 and higher

1. OVERVIEW OF CONTROLLER

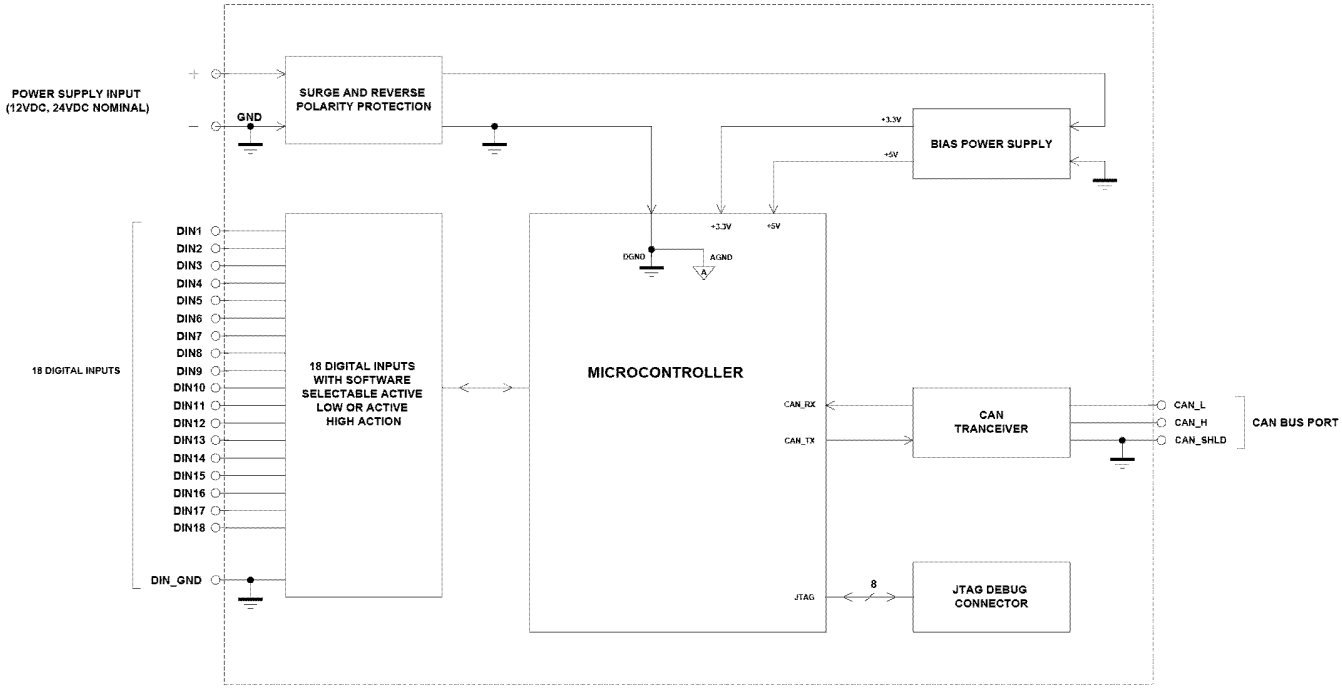


Figure 1 - AX030310 & AX030320 Block Diagram

18 Digital Input Controller is designed to measure digital inputs and send data to an SAE J1939 Network. The ten first inputs can be configured to measure frequency/PWM or digital signals. The last eight digital inputs measure digital signals. A variety of configurable settings is provided to enable custom configurations without the need to reprogram the device.

There are two different firmware versions available for the 18 Digital Input Controller. The difference between the two firmware versions is in the CAN transmit message support and handling. The default firmware version, AX030310 support 20 user configurable CAN transmit messages and the extended CAN transmit version, AX030320, supports 54 user configurable CAN transmit messages.

The *Windows*-based Axiomatic Electronic Assistant (EA) is used to configure the controller via an USB-CAN (AX070501) device. Configurable properties - Axiomatic EA setpoints - are outlined in chapter 4. Setpoint configuration can be saved in a file which can be used to easily program the same configuration into another 18 Digital Input Controller. Throughout this document, Axiomatic EA setpoint names are referred to with bolded text in double-quotes, and the setpoint option is referred to with italicized text in single-quotes. For example, "**Input Sensor Type**" setpoint set to option '*Digital (normal)'*.

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

The 18 Digital Input Controller can be ordered using the following part numbers depending on the application.

AX030310	Controller with the default J1939 baud rate (250kbits/s).
AX030310-01	Controller with the 500kbits/s J1939 baud rate.
AX030310-02	Controller with a custom 1Mbits/s J1939 baud rate.
AX030320	Controller with extended CAN transmit message support (250kbits/s)

1.1. Input Function Blocks

The controller has altogether eighteen inputs. The ten first Inputs can be configured to measure Active High / Active Low, PWM, Pulse (Hz or RPM) or pulse count signal. The eight last inputs measure Active High / Active Low digital signals.

Input setpoint groups have the "**Input Sensor Type**" setpoint, which is used to configure input type. Selecting input type affects other setpoints and how they are interpreted and should thus be selected first on this block. The input sensor types for Inputs 1 to 10 are listed in Table 1. Inputs 11 to 18 support Digital (60-62) sensor types.

0	*Disabled*
40	*Frequency 0.5 to 50 Hz*
41	*Frequency 10 Hz to 1 kHz*
42	*Frequency 100 Hz to 10 kHz*
50	*PWM Low Frequency (<1kHz)*
51	*PWM High Frequency (>100Hz)*
60	*Digital (normal)*
61	*Digital (inverse)*
62	*Digital (latched)*
70	*Counter*

Table 1 – Universal Input Sensor Type Options

0	*None*
1	*111ns*
2	*1.78us*
3	*14.22us*

Table 2 – Debounce Time Options

Frequency/RPM or Pulse Width Modulated (PWM) "**Input Sensor Type**" options connect an input to 16-bit timer pin on the processor. "**Debounce Time**" setpoint is used to select an input capture filter for the timer pin in question. "**Pulse Per Revolution**" setpoint is only associated with the frequency input type. If the setpoint is set to *True*, then the input data will be reported as in rotations-per-minute (RPM). Otherwise, frequency inputs are measured in Hertz.

The 16-bit Counter input sensor type implements the input pulse timing feature. The "**Measuring Window"** setpoint defines number of pulses to be timed. Pulses in the input signal are calculated and the time passed until the number of pulses has been received is timed. Once the count has been reached, the time is transferred as an input signal measurement result and the calculation is started again. Fault diagnostics are not available for this input type.

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

The inputs have user selectable 10kΩ pull-up or pull-down resistors, which is defined by setting the value of the "**Pullup/Pulldown Resistor**" setpoint. Setpoint options are given in Table 3. By default pull-down resistors are enabled for all inputs.

0	*10 kΩ Pulldown*
1	*10 kΩ Pullup*

Table 3 – Pullup/Pulldown Resistor Options

The "**Active High/Active Low**" setpoint is used to configure how signal high and low are interpreted. Setpoint options are given in Table 4. By default, all inputs are selected to be Active High, which means that signal high is interpreted as 1(ON) and signal low as 0(OFF).

0	*Active High*
1	*Active Low*

Table 4 – Active High/Low Options

Table 5 shows the effect of different digital input types on input signal measurement interpretation with recommended "**Pullup/Pulldown Resistor**" and "**Active High/Low**" combinations. Fault diagnostics are not available for digital input types.

Input Sensor Type		**Pulldown Active High**	**Pullup Active Low**	**Input measured (state)**
60	*Digital (normal)*	High	Low or Open	1 (ON)
		Low or Open	High	0 (OFF)
61	*Digital (inverse)*	High or Open	Low	1 (ON)
		Low	High or Open	0 (OFF)
62	*Digital (latched)*	High to Low	Low to High	0 (no change)
		Low to High	High to Low	1 (state change)

Table 5 – Digital Input Sensor Type versus Input State

Above mentioned setpoints are provided for all the inputs. In addition the first ten inputs have setpoints associated with frequency, PMW and counter input types. The setpoints to be presented next are provided only for inputs 1 to 10.

The "**Minimum Range**" and "**Maximum Range**" setpoints are used to define range of the signal input outputs as a control source. For example, if "**Maximum Range**" is set to 100Hz for an input, the control signal is saturated at 100Hz incase input signal rises above 100Hz. The "**Minimum Range**" and "**Maximum Range**" setpoints are interpreted in input types units, thus they should be re-adjusted after editing "**Input Sensor Type**".

Software filters can be applied to the measured input signal. Setpoints "**Software Filter Type**" and "**Software Filter Constant**" are used to configure the software filter. By default no filter is applied to the signal. Software filtering is described in detail in the section below.

The rest of the setpoints in the Input setpoint group are used to configure input related fault diagnostics and are described in section 1.3.

1.2. Input filtering

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

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

Table 6 – Filter Type Options

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

Equation 1 - Moving Average Transfer Function:

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

Equation 2 - Repeating Average Transfer Function:

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

The '*Repeating Average'* option applies the transfer function above to the measured input data, where N is value of the **"Filter Constant"** setpoint. At every reading of the input value, the value is added to the sum. At every N^{th} read, the sum is divided by N, and the result is new CAN message data. The sum is set to zero for the next read and summing is started again.

1.3. Diagnostic Function Blocks

The 18 Digital Input Controller supports diagnostic messaging. DM1 message is a message, containing Active Diagnostic Trouble Codes (DTC) that is sent to the J1939 network in case a fault has been detected. A Diagnostic Trouble Code is defined by the J1939 standard as a four-byte value.

In addition to supporting the DM1 message, the following are supported:

SPN	Suspect Parameter Number	(user defined)
FMI	Failure Mode Identifier	(see Table 9 and Table 10)
CM	Conversion Method	(always set to 0)
OC	Occurrence Count	(number of times the fault has happened)

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

Fault detection and reaction is associated with the ten first Inputs, as diagnostics are available only for non-digital input types. Fault diagnostics are not available for digital input types, and thus diagnostic setpoints are not used with them. In addition to input faults, the 18 Digital Input Controller

can also detect/react to three additional faults namely power supply fault, over temperature fault and communication fault.

The Axiomatic EA provides several setpoints to configure diagnostics. Diagnostics are available only for frequency and PWM input types, thus diagnostic setpoints are provided only for fist 10 Inputs. Input error diagnostic setpoints are among the setpoint group of each input and diagnostic setpoints for additional faults are presented as their own setpoint groups in the Axiomatic EA.

Fault detection thresholds are presented in Table 7. Input errors can be flagged as either a high or low occurrence, thus there are two user selectable threshold value setpoints "**Maximum error**" and "**Minimum error**". Input error thresholds are interpreted in "**Input Sensor Type**" units. Changing input type will change "**Minimum error**" and "**Maximum error**" to corresponding default values, thus Input Sensor Type should be set before adjusting "**Minimum error**" and "**Maximum error**" setpoints. Fault detection can be performed only if the thresholds are within the range of permitted values which are listed in Table 1. For example, 10 Hz to 1 kHz input maximum error has to be less than 1 kHz to enable detection of the fault high occurrence.

Power Supply fault can be also flagged as either a high or low occurrence and has two selectable threshold setpoints. Over Temperature fault reacts only to a single condition and thus, the only one threshold setpoint is supplied. Lost Communication fault occurs if no CAN messages are received within "**Receive Message Timeout**" time (see section 1.8).

Fault	Minimum Threshold	Maximum Threshold
Universal Input	Minimum Error	Maximum Error
Power Supply	Power Undervoltage Threshold	Power Overvoltage Threshold
Over Temperature	N/A	Over Temperature Threshold
Lost Communication	N/A	Received Message Timeout

Table 7 – Fault Detect Thresholds

A hysteresis can be applied to prevent rapid setting and clearing of the error flag when signal value is near the fault detection threshold. Input error and additional error detection hysteresis is configured with "**Hysteresis to clear fault**" setpoint.

"**Generate Diagnostic Messages**" setpoint determines whether an active fault generates diagnostic trouble code (DTC) that is sent to J1939 network as part of diagnostic message (DM). So long as even one Diagnostic function block has "**Generate Diagnostic Messages**" set to '*True'*, the 18 Digital Input Controller will send the DM1 message every one second, regardless of whether there are any active faults, as recommended by standard. While there are no active DTCs, the 18 Digital Input Controller will send "No Active Faults" message. If a previously inactive DTC becomes active, a DM1 will be sent immediately to reflect this. As soon as the last active DTC goes inactive, a DM1 indicating that there are no more active DTCs will be sent.

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

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

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

By default, the fault flag is cleared when error condition that has caused it goes away. The DTC is made Previously Active and is it is no longer included in the DM1 message. To identify a fault having happened, even if the condition that has caused it has gone 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 in DM1**" setpoint determines the lamp type set in this byte of DTC. "**Lamp Set by Event in DM1"** setpoint options are listed in Table 8. By default, the '*Amber, Warning'* lamp is typically the one set be any active fault.

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

Table 8 – Lamp Set by Event in DM1 Options

"**SPN for Event used in DTC**" 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 used in DTC**" in is configured to be different from zero. **It is user's responsibility to select SPN that will not violate J1939 standard.** When the "**SPN for Event used in DTC**" is changed, the OC of the associated error log is automatically reset to zero.

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

Table 9 – FMI for Event Used in DTC Options

Every fault has associated a default FMI with them. The FMI can be configured with the "**FMI for Event Used in DTC**" setpoint, presented in Table 9. When the FMI is selected from Low Fault FMIs in Table 10 for a fault that can be flagged either high or low occurrence, the high occurrence automatically uses the corresponding High Fault FMI by Table 10. If any other FMI is selected than the Low Fault FMI from the Table 10, then both the low and high fault will be assigned the same FMI.

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 10 – Low Fault FMIs and corresponding High Fault FMIs

1.4. Lookup Table Function Block

Lookup Tables are used to give output response up to 10 slopes per input. If more than 10 slopes are required, A Programmable Logic Block can be used to combine up to three tables to get 30 slopes as described in Section 0.

Lookup tables have two differing modes defined by the "**X-Axis Type**" setpoint, given in Table 11. Option '0 – Data Response' is the normal mode where block input signal is selected with the "**X-Axis Source**" and "**X-Axis Number**" setpoints and X values present directly input signal values. With option '1 – Time Response' the input signal is time and X values present time in milliseconds. And selected input signal is used as digital enable.

0	*Data Response*
1	*Time Response*

Table 11 – X-Axis Type Options

The slopes are defined with (x, y) points and associated point response. X value presents input signal value and Y value corresponding Lookup Table output value. "PointN – Response" setpoint defines type of the slope from preceding point to the point in question. Response options are given in Table 12. 'Ramp To' gives a linearized slope between points, whereas 'Jump to' gives a point to point response, where any input value between X_{N-1} and X_N will result Lookup Table output being Y_N. "Point0 – Response" is always 'Jump To' and cannot be edited. Choosing 'Ignored' response causes the associated point and all the following points to be ignored.

0	*Ignore*
1	*Ramp To*
2	*Jump To*

Table 12 – PointN – Response Options

The X values are limited by minimum and maximum range of the selected input source if the source is one of the Input Blocks or a Math Function Block. For the fore mentioned sources X-Axis data will be redefined when ranges are changed, therefore inputs should be adjusted before changing X-Axis values. For other sources Xmin and Xmax are -100000 and 1000000. The X-Axis is constraint to be in rising order, thus value of the next index is greater than or equal to preceding one. Therefore, when adjusting the X-Axis data, it is recommended that X_{10} is changed first, then lower indexes in descending order.

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

The Y-Axis has no constraints on the data it presents, thus inverse, decreasing, increasing or other response can be easily established. The Smallest of the Y-Axis values is used as Lookup Table output min and the largest of the Y-Axis values is used as Lookup Table output max (i.e. used as Xmin and Xmax values in linear calculation). Ignored points are not considered for min and max values.

1.5. Programmable Logic Function Block

The Programmable Logic Function Block is very powerful tool. A Programmable Logic can be linked to up to three Lookup Tables, any of which would be selected only under given conditions. Thus, the output of a Programmable Logic at any given time will be the output of the Lookup Table selected by defined logic. Therefore, up to three different responses to the same input, or three different responses to different inputs, can become the input to another function block.

In order to enable any one of the Programmable Logic blocks, the "**Programmable Logic Enabled**" setpoint must be set to '*True'*. By default, all Logic blocks are disabled.

The three associated tables are selected by setting "**Table X – Lookup Table Block Number**" setpoint to the desired Lookup Table number, for example selecting *1* would set Lookup Table 1 as TableX.

For each TableX there are three conditions that define the logic to select the associated Lookup Table as Logic output. Each condition implements function $Argument1\ Operator\ Argument2$ where Operator is logical operator defined by setpoint "**Table X – Condition Y, Operator**". Setpoint options are listed in Table 13. Condition arguments are selected with "**Table x – Condition Y, Argument Z Source**" and "**Table x – Condition Y, Argument Z Number**" setpoints. If '*0 – Control not Used*' option is selected as "**Table x – Condition Y, Argument Z Source"** the argument is interpreted as 0.

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

Table 13 – Table X – Condition Y, Operator Options

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

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

Table 14 – Table X – Conditions Logical Operator Options

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

1.6. Math Function Block

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

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

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

A mathematical function block includes four selectable functions, which each implements equation $\mathrm{A\ operator\ B}$, where A and B are function inputs and operator is function selected with setpoint "**Math function X Operator**". Setpoint options are presented in Table 15. The functions are connected together, so that result of the preceding function goes into Input A of the next function. Thus Function 1 has both Input A and Input B selectable with setpoints, where Functions 2 to 4 have only Input B selectable. Input is selected by setting "**Function X Input Y Source**" and "**Function X Input Y Number**". If "**Function X Input B Source**" is set to 0 '*Control not used'* signal goes through function unchanged.

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

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

Table 15 – Math function X Operator Options

For logic operations (6, 7, 8) scaled input greater or equal to 1 is treated as TRUE. For logic operations (0 to 8), the result of the function will always be 0 (FALSE) of 1 (TRUE). For the arithmetic

functions (9 to 14), it is recommended to scale the data such that the resulting operation will not exceed full scale (0 to 100%) and saturate the output result.

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

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

1.7. CAN Transmit Message Function Block

The CAN Transmit function block is used to send any output from another function block (i.e. input, CAN receive) to the J1939 network. The AX030310 ECU has twenty and the AX030320 has fifty-four CAN Transmit Messages and each message has four completely user defined signals.

The standard firmware **AX030310 has 20 user configurable CAN transmit messages**. The extended CAN transmit version, **AX030320 has 54 user configurable CAN transmit messages**. The tradeoff is in CAN transmit data update rate, the AX030310 updates its CAN messages at 10ms intervals, the AX030320 uses 20ms update rate.

1.7.1. CAN Transmit Message Setpoints

Each CAN Transmit Message setpoint group includes setpoints that effect the whole message and are thus mutual for all signals of the message. These setpoints are presented in this section. The setpoints that configure an individual signal are presented in next section.

The "**Transmit PGN**" setpoint sets PGN used with the message. **User should be familiar with the SAE J1939 standard and select values for PGN/SPN combinations as appropriate from section J1939/71**.

The "**Repetition Rate**" setpoint defines the interval used to send the message to the J1939 network. If the "**Repetition Rate**" is set to zero, the message is disabled unless it shares its PGN with another message. In case of a shared PGN repetition rate of the LOWEST numbered message are used to send the message 'bundle'.

At power up, transmitted messages will not be broadcast 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.

1.7.2. 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 16. 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.

1.8. CAN Receive Function Block

The CAN Receive function block is designed to take any SPN from the J1939 network and use it as an input to another function block (i.e. Outputs).

The “**Receive Message Enabled**” is the most important setpoint associated with this function block and it should be selected first. Changing it will result in other setpoints being enabled/disabled as appropriate. By default, ALL receive messages are disabled.

Once a message has been enabled, a Lost Communication fault will be flagged if that message is not received off the bud within the “**Receive Message Timeout**” period. This could trigger a Lost Communication event as described in section 1.3. 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 18 Digital Input Controller on Proprietary B PGNs. However, should a PDU1 message be selected, the 18 Digital Input Controller can be setup to receive it from any ECU by setting the “**Specific Address that sends the PGN**” to the Global Address (0xFF). If a specific address is selected instead, then any other ECU data on the PGN will be ignored.

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

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

The 18 Digital Input Controller I/O supports up to four unique CAN Receive Messages. Default setpoint values are listed in section 4.9.

1.9. Available Control Sources

Many of the Function Blocks have selectable input signals, which are determined with "**[Name] Source**" and "**[Name] Number**" setpoints. Together, these setpoints uniquely select how the I/O of the various function blocks are linked together. "**[Name] Source**" setpoint determines the type of the source and "**[Name] Number**" selects the actual source if there is more than one of the same type. Available "**[Name] Source**" options and associated "**[Name] Number**" ranges are listed in Table 16. Sources from 0 to 9 are available for all blocks and sources from 10 to 13 are available sources for CAN Transmit messages. Thought input Sources are freely selectable, not all options would make sense for any particular input, and it is up to the user to program the controller in a logical and functional manner.

Sources	Number Range	Notes
0: Control Not Used	N/A	When this is selected, it disables all other setpoints associated with the signal in question.
1: Received CAN Message	1 to 4	User must enable the function block, as it is disabled by default.
2: Digital Input Measured	1 to 18	
3: Lookup Table	1 to 4	
4: Programmable Logic Block	1 to 4	User must enable the function block, as it is disabled by default.
5: Math Function Block	1 to 6	User must enable the function block, as it is disabled by default.
6: Control Constant Data	1 to 15	1 = FALSE, 2 = TRUE, 3 to 15 = User Selectable
7: Power Supply Measured	N/A	Measured power supply value in Volts, used in Power Supply Diagnostics, can be mapped to a CAN Transmit Message.
8: Processor Temperature Measured	N/A	Measured processor temperature in °C, used in Over Temperature Diagnostics, can be mapped to a CAN Transmit Message.

Table 16 – Available Control Sources and Numbers

If a non-digital signal is selected to drive a digital input, the signal is interpreted to be OFF at or below the minimum of selected source and ON at or above the maximum of the selected source, and it will not change in between those points. Thus, analog to digital interpretation has a built-in hysteresis defined by minimum and maximum of the selected source, as shown in Figure 2. For example, Universal Input signal is interpreted to be ON at or above "Maximum Range" and OFF at or below "Minimum Range".

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

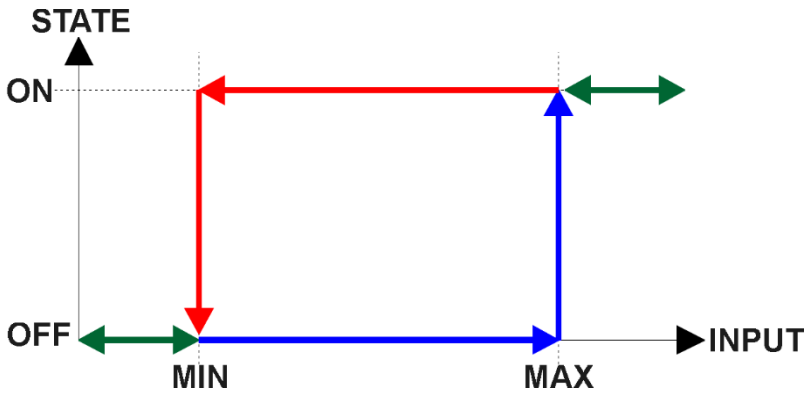


Figure 2 - Analog source to Digital input

2. INSTALLATION INSTRUCTIONS

2.1. Dimensions and Pinout

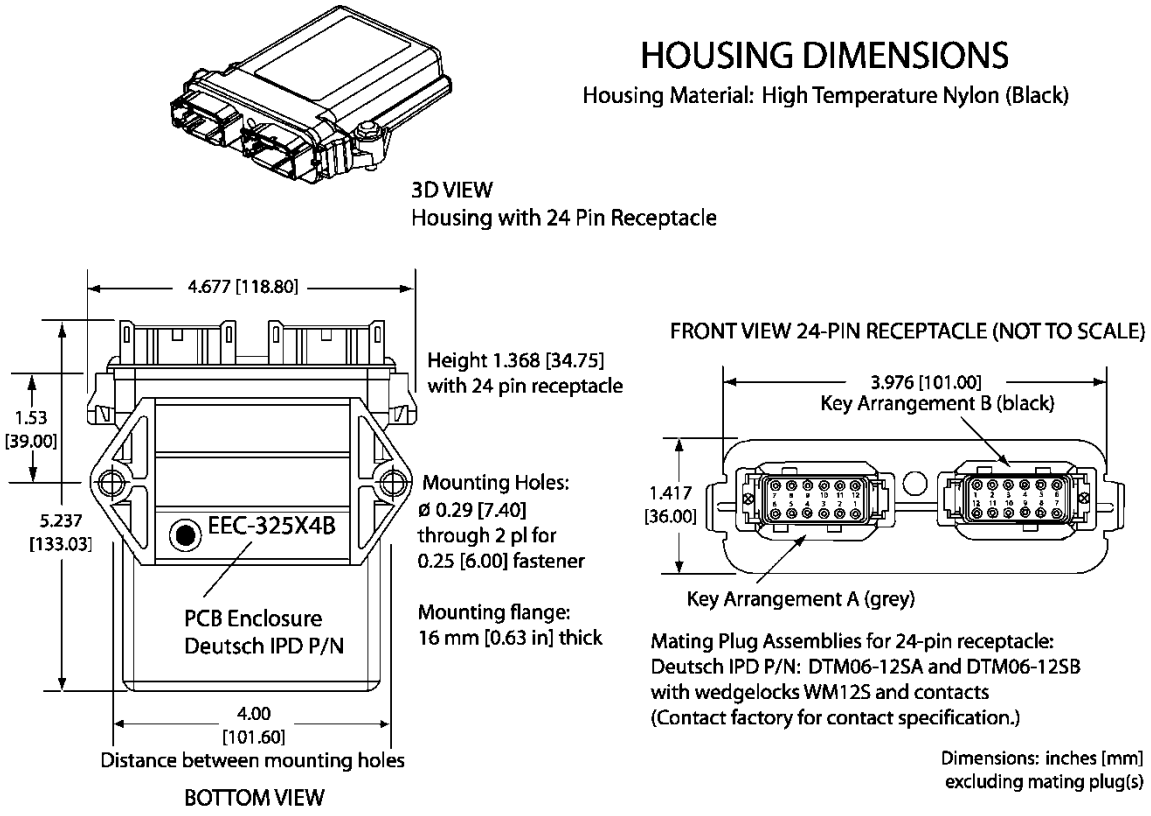


Figure 3 – AX030310 Dimensional Drawing

Grey Connector PIN #	Function	Black Connector PIN #	Function
12	Digital Input 1	12	Digital Input 13
11	Digital Input 2	11	Digital Input 14
10	Digital Input 3	10	Digital Input 15
9	Digital Input 4	9	Digital Input 16
8	Digital Input 5	8	Digital Input 17
7	Digital Input 6	7	Digital Input 18
6	Power +	6	Digital Input 12
5	Power -	5	Digital Input 11
4	Input GND	4	Digital Input 10
3	CAN Shield	3	Digital Input 9
2	CAN Low	2	Digital Input 8
1	CAN High	1	Digital Input 7

Table 17 – AX030310 Connector Pinout

3. OVERVIEW OF J1939 FEATURES

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

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

3.1. Introduction to Supported Messages

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

From J1939-21 – Data Link Layer

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

From J1939-73 – Diagnostics

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

From J1939-81 – Network Management

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

From J1939-71 – Vehicle Application Layer

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

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

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

3.2. NAME, Address and Identification Information

The 18 Digital Input Controller I/O ECU has the following default for the J1939 NAME. The user should refer to the SAE J1939/81 standard for more information on these parameters and their ranges.

Arbitrary Address Capable	Yes
Industry Group	0, Global
Vehicle System Instance	0
Vehicle System	0, Non-specific system
Function	125, Axiomatic I/O Controller
Function Instance	6, Axiomatic AX030310
ECU Instance	0, First Instance
Manufacture Code	162, Axiomatic Technologies
Identity Number	Variable uniquely assigned during factory programming for each ECU

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

The default value of the “ECU Address” setpoint is 128 (0x80), which is the preferred starting address for self-configurable ECUs as set by the SAE in J1939 tables B3 and B7. The Axiomatic EA will allow the selection of any address between 0 and 253. ***It is user’s responsibility to select an address that complies with the standard***. The user must also be aware that since the unit is arbitrary address capable, if another ECU with a higher priority NAME contends for the selected address, the 18 Digital Input Controller I/O will continue select the next highest address until it finds one that it can claim. See J1939/81 for more details about address claiming.

ECU Identification Information

PGN 64965		ECU Identification Information	ECUID
Transmission Repetition Rate:		On request	
Data Length:		Variable	
Extended Data Page:		0	
Data Page:		0	
PDU Format:		253	
PDU Specific:		197 PGN Supporting Information:	
Default Priority:		6	
Parameter Group Number:		64965 (0x00FDC5)	
Start Position	Length	Parameter Name	SPN
a	Variable	ECU Part Number, Delimiter (ASCII “*”)	2901
b	Variable	ECU Serial Number, Delimiter (ASCII “*”)	2902
c	Variable	ECU Location, Delimiter (ASCII “*”)	2903
d	Variable	ECU Type, Delimiter (ASCII “*”)	2904
e	Variable	ECU Manufacturer Name, Delimiter (ASCII “*”)	4304

Software Identifier

PGN 65242		Software Identification	-SOFT
Transmission Repetition Rate:		On request	
Data Length:		Variable	
Extended Data Page:		0	
Data Page:		0	
PDU Format:		254	
PDU Specific:		218 PGN Supporting Information:	
Default Priority:		6	
Parameter Group Number:		65242 (0x00FEDA)	
Start Position	Length	Parameter Name	SPN
1	1 Byte	Number of software identification fields	965
2-n	Variable	Software identification(s), Delimiter (ASCII “*”)	234

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

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

The Axiomatic EA shows all this information in “General ECU Information”, as shown in Figure 4.

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

Component Identification

PGN 65259	Component Identification	CI
Transmission Repetition Rate:	On request	
Data Length:	Variable	
Extended Data Page:	0	
Data Page:	0	
PDU Format:	254	
PDU Specific:	235 PGN Supporting Information:	
Default Priority:	6	
Parameter Group Number:	65259 (0x00FEEB)	

Start Position	Length	Parameter Name	SPN
a	Variable	Make, Delimiter (ASCII “*”)	586
b	Variable	Model, Delimiter (ASCII “*”)	587
c	Variable	Serial Number, Delimiter (ASCII “*”)	588
d	Variable	Unit Number (Power Unit), Delimiter (ASCII “*”)	233

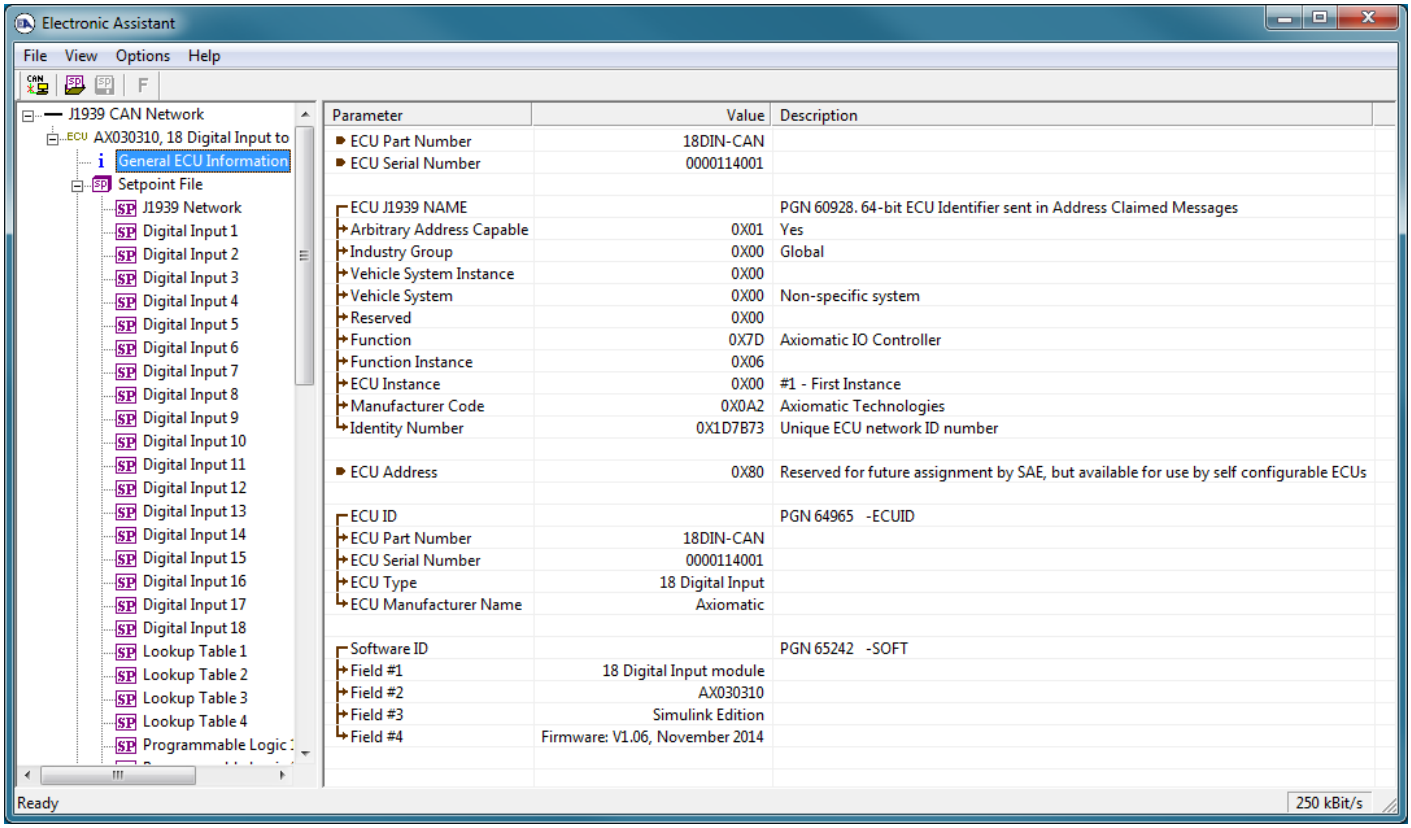


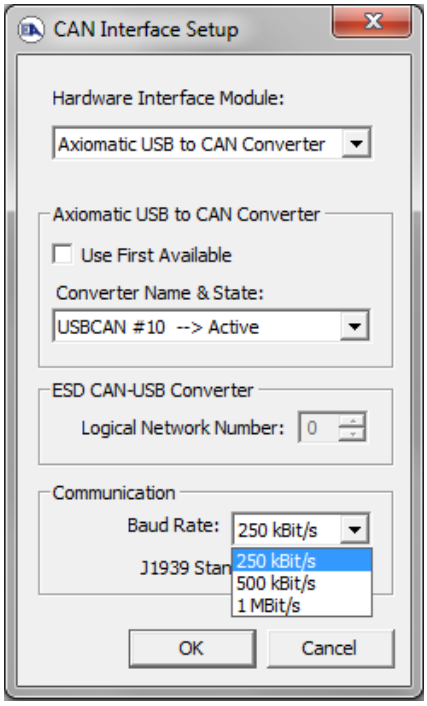
Figure 4 - General ECU Information

4. ECU SETPOINTS ACCESSED WITH THE AXIOMATIC ELECTRONIC ASSISTANT

This section describes in detail each setpoint, and their default and ranges. Default values presented in tables are values used when the setpoint in question is active. Many of the setpoints are dependent on other setpoints and they may not be active by default. Associated Figures show screen capture of initial operation, however some of the setpoints are not in default condition as they are set differently to activate more setpoints for the image. The setpoints are divided into setpoint groups as they are shown in the Axiomatic EA. For more information on how each setpoint is used by the 18 Digital Input controller, refer to the relevant section in this user manual.

4.1. Accessing the ECU Using the Axiomatic EA

ECUs with P/N AX030310 or P/N AX030320 do not need any specific setup for the Axiomatic EA. To access the high-speed versions, AX030310-01 and/or AX030310-02, the CAN bus Baud Rata needs to be set accordingly. The CAN Interface Setup can be found from “Options” menu in the Axiomatic EA.



4.2. J1939 Network Parameters

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

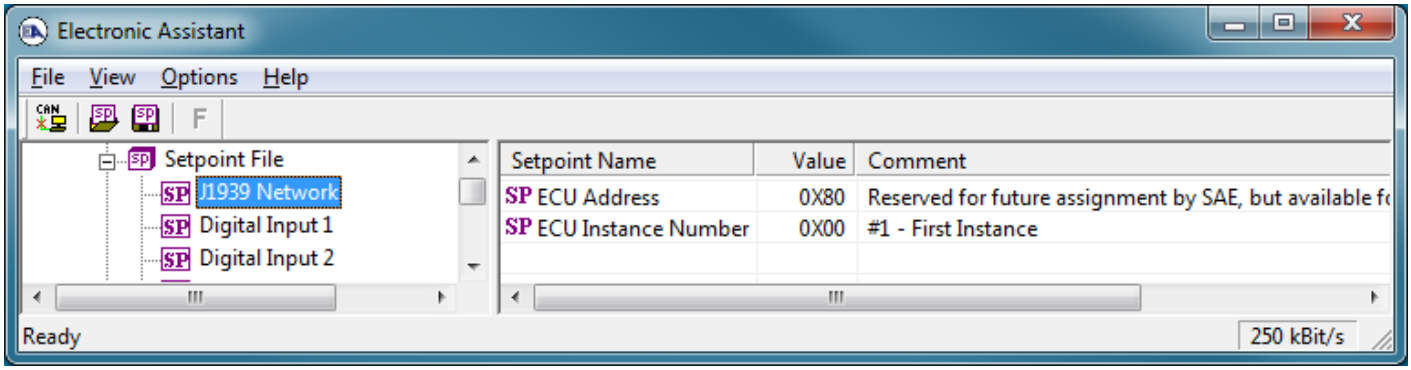


Figure 5 - Screen Capture of J1939 Setpoints

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

Table 18 - J1939 Network Setpoints

If non-default values for the **"ECU Instance Number"** or **"ECU Address"** are used, they will be mirrored during a setpoint file flashing, and will only take effect once the entire file has been downloaded to the unit. After the setpoint flashing is complete, the unit will claim the new address and/or re-claim the address with the new NAME. If these setpoints are changing, it is recommended to close and re-open the CAN connection on the Axiomatic EA after the file is loaded so that only the new NAME and address are showing in the J1939 CAN Network ECU list.

4.3. Digital Input Setpoints

The Digital Inputs are defined in Section 0. The setpoint group includes diagnostic related setpoints, which are presented in Section 1.3 in detail.

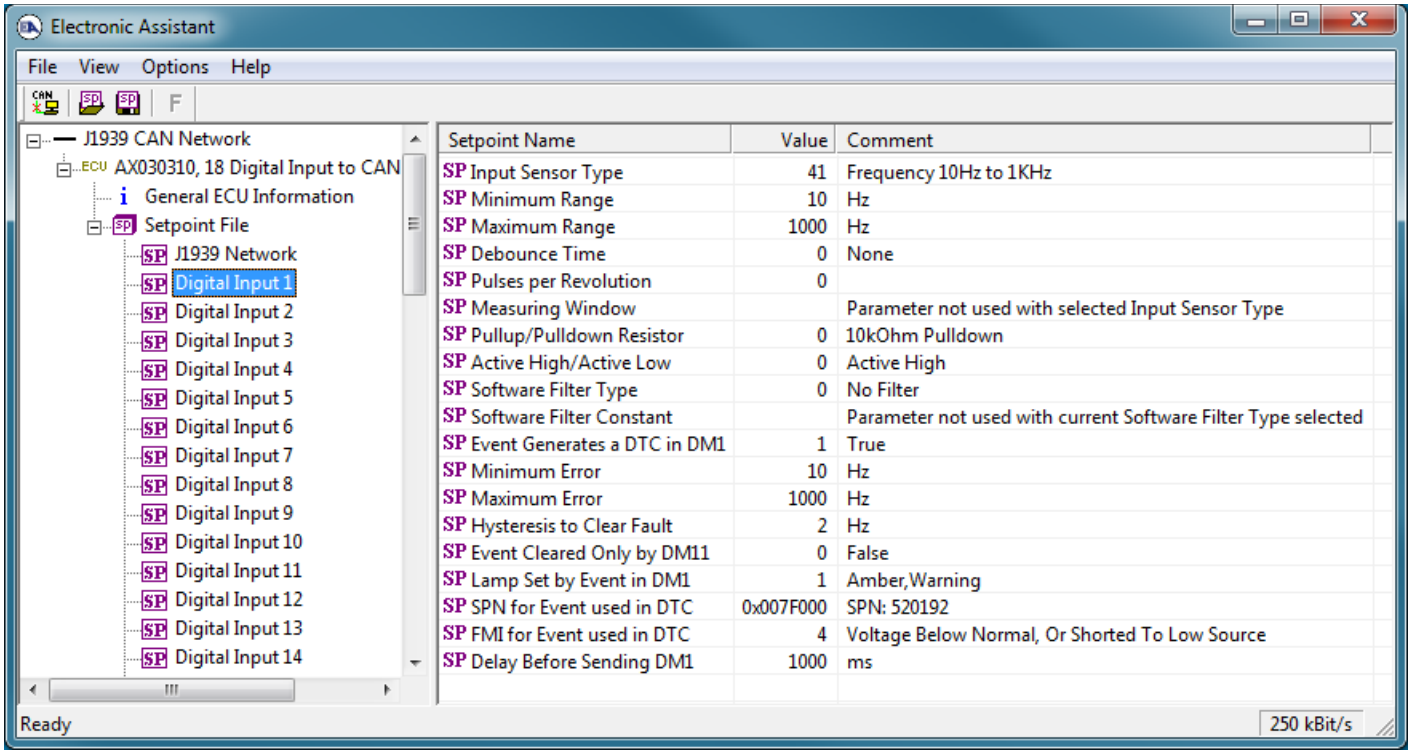


Figure 6 - Screen Capture of Digital Input Setpoints

Name	Range	Default	Notes
Input Sensor Type	Drop List	Digital Normal Logic	See Table 1
Minimum Range	From Minimum Error to Maximum Range	Depends on Input Sensor Type	
Maximum Range	From Minimum Range to Maximum Error	Depends on Input Sensor Type	
Debounce Time	Drop List	None	See Table 2
Pulse per Revolution	Drop List	FALSE	See Section 0
Pullup/Pulldown Resistor	Drop List	10kΩ Pulldown	See Table 3
Active High/Active Low	Drop List	Active High	See Table 4
Software Filter Type	Drop List	No Filtering	See Table 6
Software Filter Constant	1..1000	1	
Event Generates a DTC by DM1	Drop List	False	
Minimum Error	0.00 to Minimum Range	Depends on Input Sensor Type	See Section 1.3
Maximum Error	Maximum Range to Limit	Depends on Input Sensor Type	See Section 1.3
Hysteresis to Clear Fault	From range min to range max/2	Depends on Input Sensor Type	See Section 1.3
Event Cleared only by DM11	Drop List	False	
Lamp Set by Event in DM1	Drop List	Amber Warning	See Table 8
SPN for Event used in DTC	0...65535	Different for each	
FMI for Event used in DTC	Drop List	4	See Table 9
Delay Before Sending DM1	0...60000 ms	1000	

Table 19 - Digital Input Setpoints

4.4. 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**".

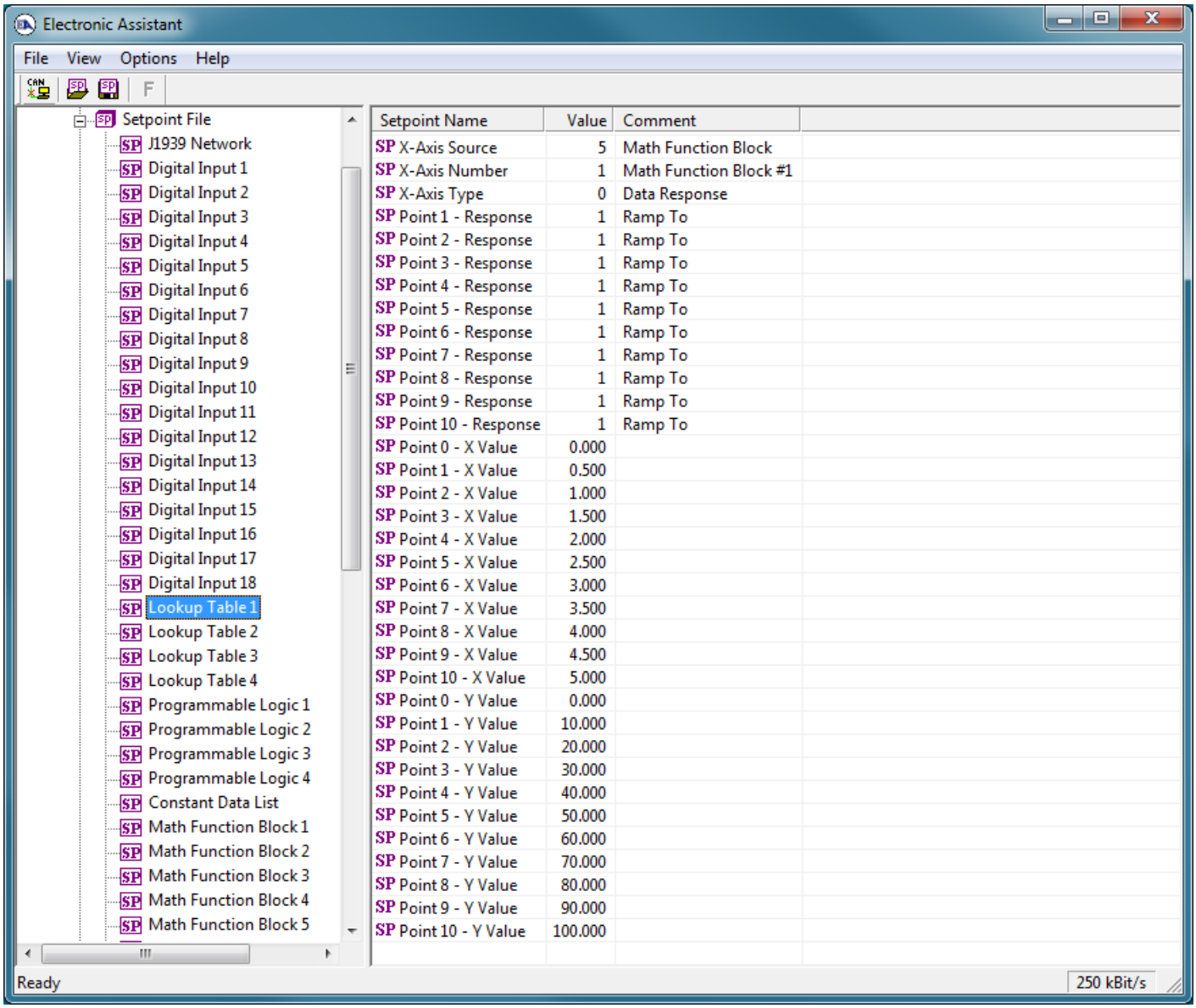


Figure 7 - Screen Capture of Lookup Table Setpoints

Name	Range	Default	Notes
X-Axis Source	Drop List	Control Not Used	See Table 16
X-Axis Number	Depends on control source	1	See Table 16
X-Axis Type	Drop List	Data Response	See Table 11
Point 1 - Response	Drop List	Ramp To	See Table 12
Point 2 - Response	Drop List	Ramp To	See Table 12
Point 3 - Response	Drop List	Ramp To	See Table 12
Point 4 - Response	Drop List	Ramp To	See Table 12
Point 5 - Response	Drop List	Ramp To	See Table 12
Point 6 - Response	Drop List	Ramp To	See Table 12
Point 7 - Response	Drop List	Ramp To	See Table 12
Point 8 - Response	Drop List	Ramp To	See Table 12
Point 9 - Response	Drop List	Ramp To	See Table 12
Point 10 - Response	Drop List	Ramp To	See Table 12
Point 0 - X Value	From X-Axis source minimum to Point 1 - X Value	X-Axis source minimum 0.000	See Section 0
Point 1 - X Value	From Point 0 - X Value to Point 2 - X Value	0.500	See Section 0
Point 2 - X Value	From Point 1 - X Value to Point 3 - X Value	1.000	See Section 0
Point 3 - X Value	From Point 2 - X Value to Point 4 - X Value	1.500	See Section 0
Point 4 - X Value	From Point 3 - X Value to Point 5 - X Value source	2.000	See Section 0
Point 5 - X Value	From Point 4 - X Value to Point 6 - X Value	2.500	See Section 0
Point 6 - X Value	From Point 5 - X Value to Point 7 - X Value	3.000	See Section 0
Point 7 - X Value	From Point 6 - X Value to Point 8 - X Value	3.500	See Section 0
Point 8 - X Value	From Point 7 - X Value to Point 9 - X Value	4.000	See Section 0
Point 9 - X Value	From Point 8 - X Value to Point 10 - X Value	4.500	See Section 0
Point 10 - X Value	From Point 9 - X Value to X-Axis source maximum	X-Axis source maximum 5.000	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 - Value	-10^6 to 10^6	100.000	

Table 20 – Lookup Table Setpoints

4.5. 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**".

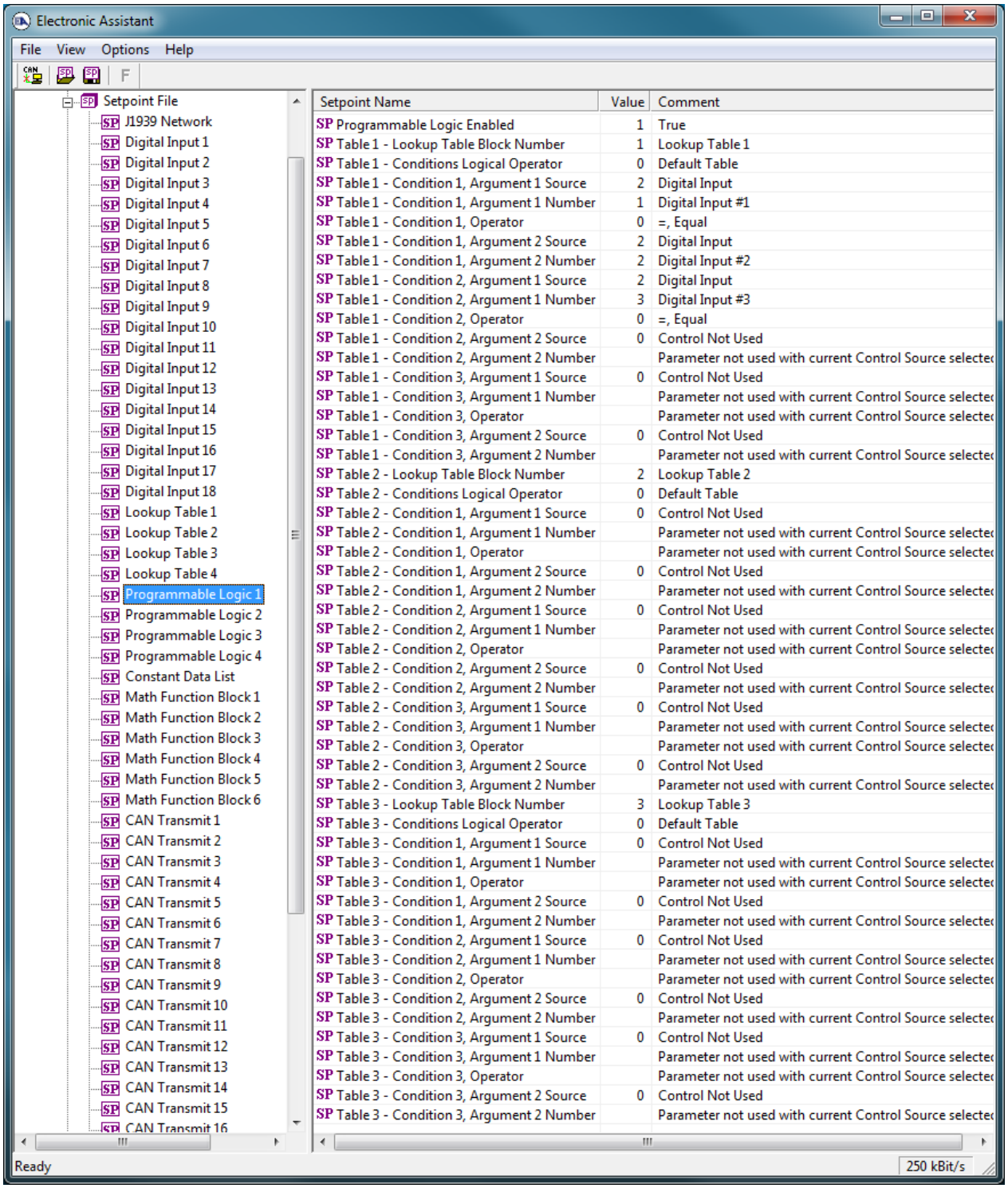


Figure 8 - Screen Capture of Programmable Logic Setpoints

Setpoint ranges and default values for Programmable Logic Blocs are listed in Table 21. Only "**Table1**" setpoints 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 14
Table1 - Condition1, Argument 1 Source	Drop List	Control Not Used	See Table 16
Table1 - Condition1, Argument 1 Number	Depends on control source	1	See Table 16
Table1 - Condition1, Operator	Drop List	=, Equal	See Table 13
Table1 - Condition1, Argument 2 Source	Drop List	Control Not Used	See Table 16
Table1 - Condition1, Argument 2 Number	Depends on control source	1	See Table 16
Table1 - Condition2, Argument 1 Source	Drop List	Control Not Used	See Table 16
Table1 - Condition2, Argument 1 Number	Depends on control source	1	See Table 16
Table1 - Condition2, Operator	Drop List	=, Equal	See Table 13
Table1 - Condition2, Argument 2 Source	Drop List	Control Not Used	See Table 16
Table1 - Condition2, Argument 2 Number	Depends on control source	1	See Table 16
Table1 - Condition3, Argument 1 Source	Drop List	Control Not Used	See Table 16
Table1 - Condition3, Argument 1 Number	Depends on control source	1	See Table 16
Table1 - Condition3, Operator	Drop List	=, Equal	See Table 13
Table1 - Condition3, Argument 2 Source	Drop List	Control Not Used	See Table 16
Table1 - Condition3, Argument 2 Number	Depends on control source	1	See Table 16

Table 21 – Programmable Logic Setpoints

4.6. Constant Data List

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

The first two constants are fixed values of 0 (False) and 1 (True) for use in binary logic. The remaining 13 constants are fully user programmable to any value between +/. 1 000 000. The default values (shown in Figure 9) are arbitrary and should be configured by the user as appropriate for their application.

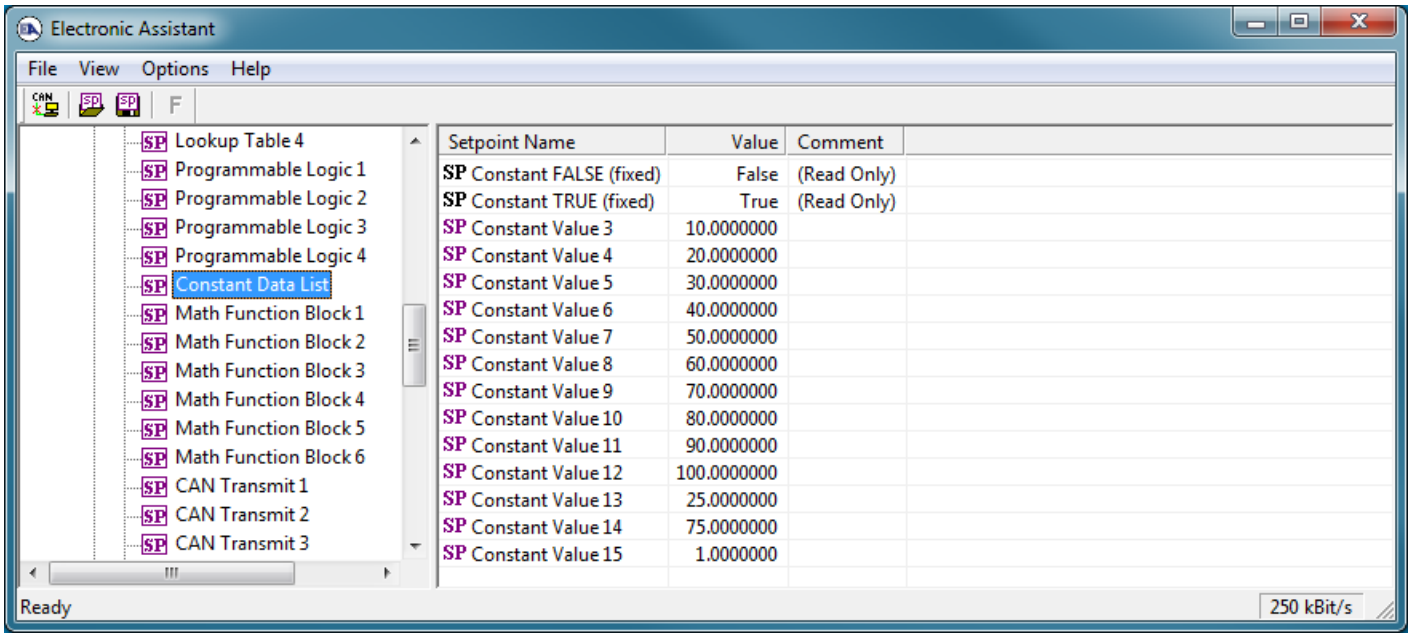


Figure 9 - Screen Capture of Constant Data List Setpoints

4.7. Math Function Block

The Math Function Block is defined in Section 0. Please refer there for detailed information about how all these setpoints are used. "**Math Function Enabled**" is 'False' by default. To enable a Math function Block, set "**Math Function Enabled**" to 'True' and select appropriate "**Input Source**".

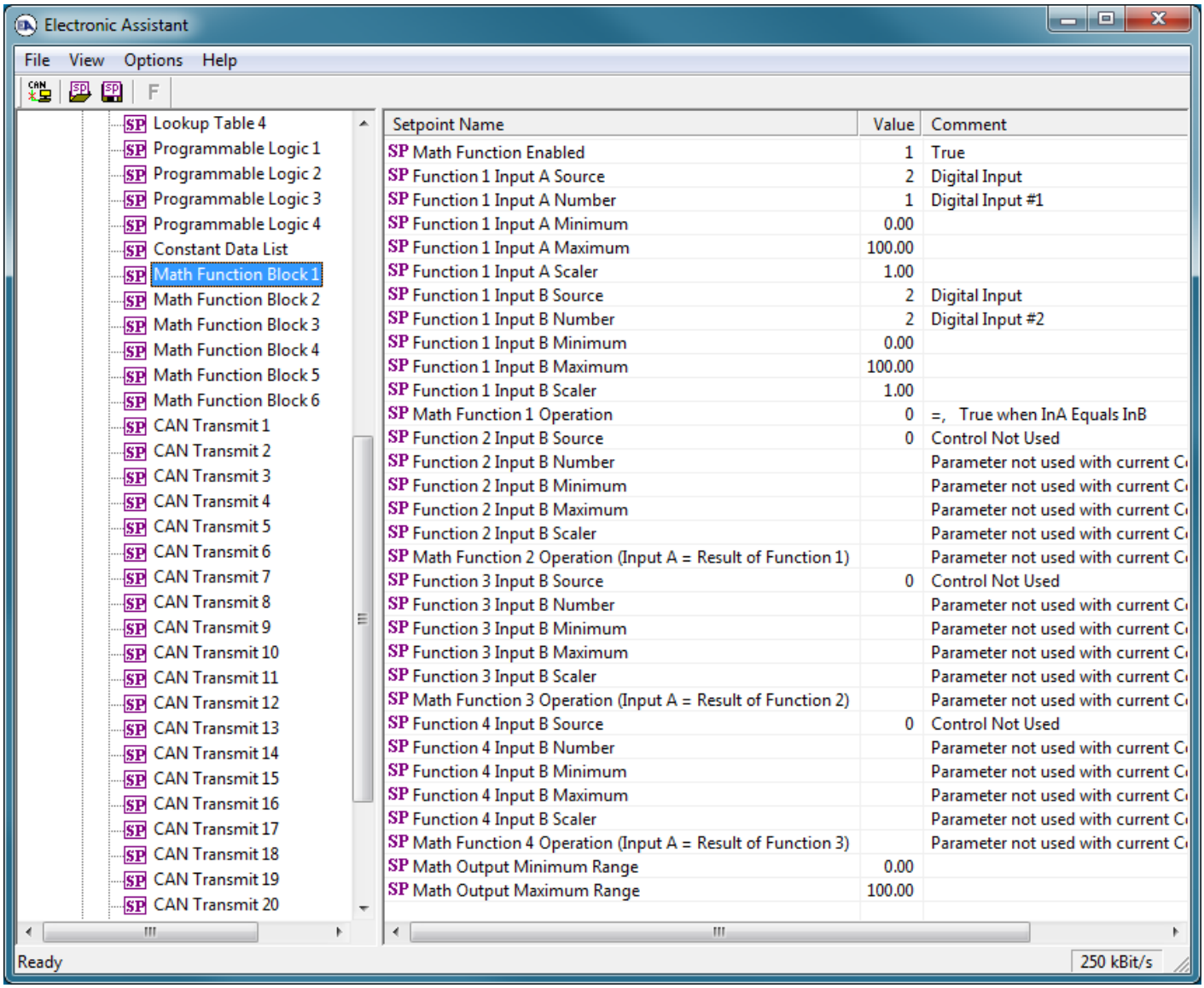


Figure 10 - Screen Capture of Math Function Block Setpoints

Name	Range	Default	Notes
Math Function Enabled	Drop List	False	
Function 1 Input A Source	Drop List	Control not used	See Table 16
Function 1 Input A Number	Depends on control source	1	See Table 16
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 16
Function 1 Input B Number	Depends on control source	1	See Table 16
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 15
Function 2 Input B Source	Drop List	Control not used	See Table 16
Function 2 Input B Number	Depends on control source	1	See Table 16
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 15
Function 3 Input B Source	Drop List	Control not used	See Table 16
Function 3 Input B Number	Depends on control source	1	See Table 16
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 15
Function 4 Input B Source	Drop List	Control not used	See Table 16
Function 4 Input B Number	Depends on control source	1	See Table 16
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 15
Math Output Minimum Range	-10^6 to 10^6	0.0	
Math Output Maximum Range	-10^6 to 10^6	100.0	

Table 22 – Math Function Setpoints

4.8. CAN Transmit Setpoints

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

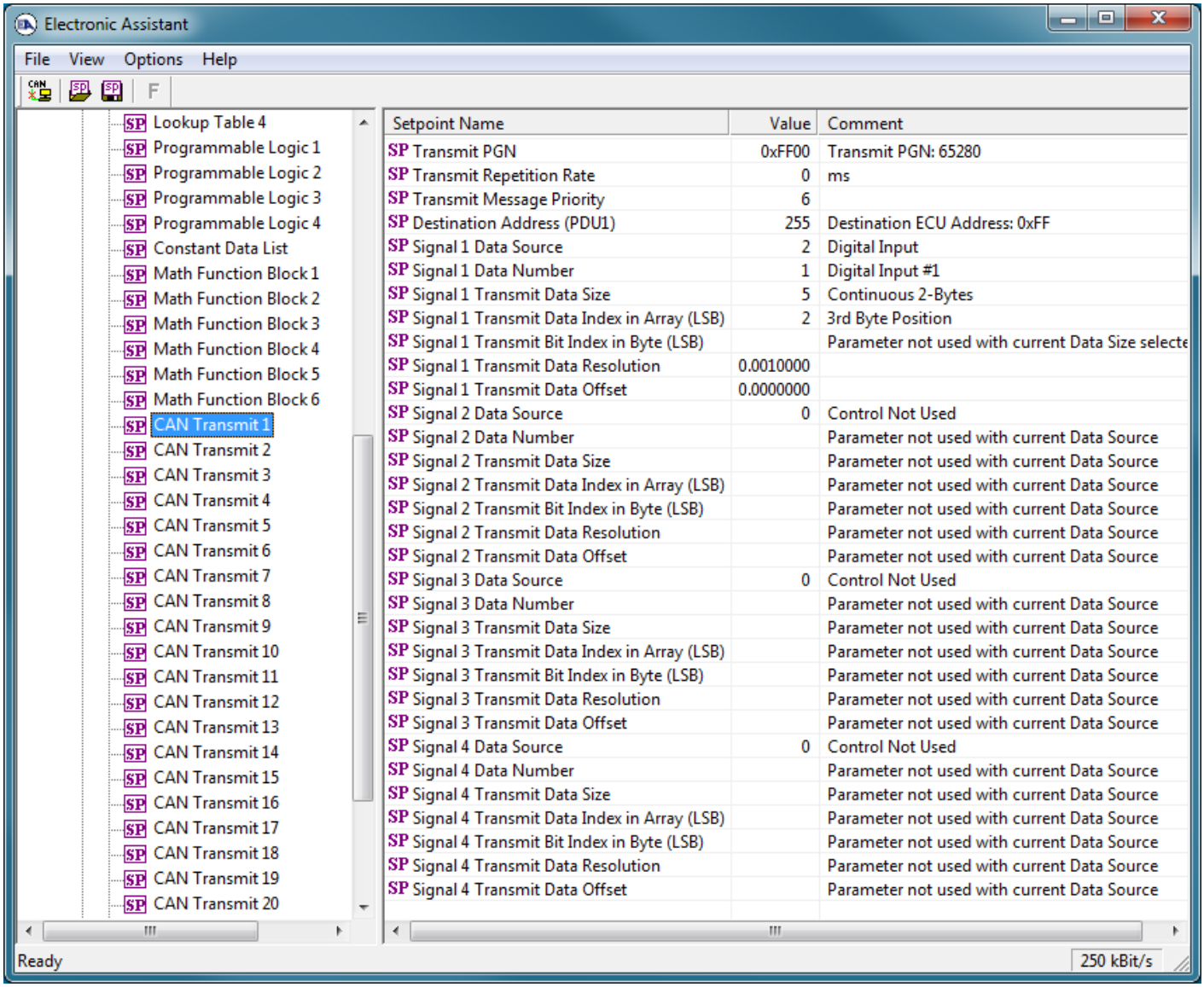


Figure 11 - Screen Capture of CAN Transmit Message Setpoints

Name	Range	Default	Notes
Transmit PGN	0xff00 … 0xffff	Different for each	See Section 1.7.1
Transmit Repetition Rate	0 … 65000 ms	0ms	0ms disables transmit
Transmit Message Priority	0...7	6	Proprietary B Priority
Destination Address	0...255	255	Not used by default
Signal 1 Control Source	Drop List	Different for each	See Table 16
Signal 1 Control Number	Drop List	Different for each	See 1.7.2
Signal 1 Transmit Data Size	Drop List	2 bytes	
Signal 1 Transmit Data Index in Array	0-7	2	
Signal 1 Transmit Bit Index In Byte	0-7	0	
Signal 1 Transmit Data Resolution	-100000.0 to 100000	0.001	
Signal 1 Transmit Data Offset	-10000 to 10000	0.0	
Signal 2 Control Source	Drop List	Signal undefined	See Table 16
Signal 2 Control Number	Drop List	Signal undefined	See 1.7.2
Signal 2 Transmit Data Size	Drop List	2 bytes	
Signal 2 Transmit Data Index in Array	0-7	0	
Signal 2 Transmit Bit Index In Byte	0-7	0	
Signal 2 Transmit Data Resolution	-100000.0 to 100000	0.001	
Signal 2 Transmit Data Offset	-10000 to 10000	0.0	
Signal 3 Control Source	Drop List	Signal undefined	See Table 16
Signal 3 Control Number	Drop List	Signal undefined	See 1.7.2
Signal 3 Transmit Data Size	Drop List	2 bytes	
Signal 3 Transmit Data Index in Array	0-7	0	
Signal 3 Transmit Bit Index In Byte	0-7	0	
Signal 3 Transmit Data Resolution	-100000.0 to 100000	0.001	
Signal 3 Transmit Data Offset	-10000 to 10000	0.0	
Signal 4 Control Source	Drop List	Signal undefined	See Table 16
Signal 4 Control Number	Drop List	Signal undefined	See 1.7.2
Signal 4 Transmit Data Size	Drop List	2 bytes	
Signal 4 Transmit Data Index in Array	0-7	0	
Signal 4 Transmit Bit Index In Byte	0-7	0	
Signal 4 Transmit Data Resolution	-100000.0 to 100000	0.001	
Signal 4 Transmit Data Offset	-10000 to 10000	0.0	

Table 23 - CAN Transmit Message Setpoints

4.9. CAN Receive Setpoints

The Math Function Block is defined in Section 1.8. 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.

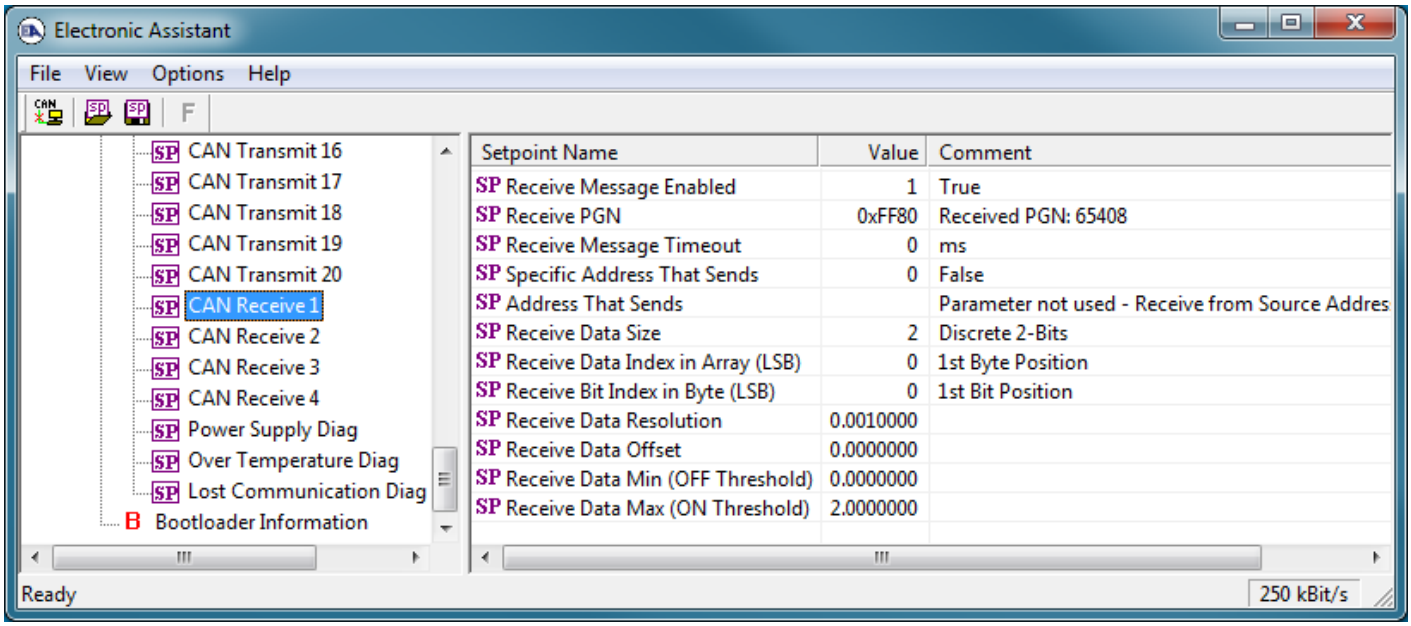


Figure 12 - Screen Capture of CAN Receive Message Setpoints

Name	Range	Default	Notes
Received Message Enabled	Drop List	False	
Received PGN	0 to 65536	Different for each	
Received Message Timeout	0 to 60 000 ms	0ms	
Specific Address that sends PGN	Drop List	False	
Address That Sends	0 to 255	254 (0xFE, Null Addr)	
Receive Transmit Data Size	Drop List	2 bytes	
Receive Transmit Data Index in Array	0-7	0	
Receive Transmit Bit Index In Byte	0-7	0	
Receive Transmit Data Resolution	-100000.0 to 100000	0.001	
Receive Transmit Data Offset	-10000 to 10000	0.0	
Receive Data Min (Off Threshold)	-1000000 to Max	0.0	
Receive Data Max (On Threshold)	-100000 to 100000	2.0	

Table 24 - CAN Receive Setpoints

4.10. [Additional] Diagnostic Setpoints

There are three additional fault diagnostic setpoint groups namely Over Temperature, Over Voltage and Under Voltage. Setpoints of these groups are presented in tables below. The Diagnostic Function Block is defined in Section 1.3. Please refer there for detailed information how these setpoints are used.

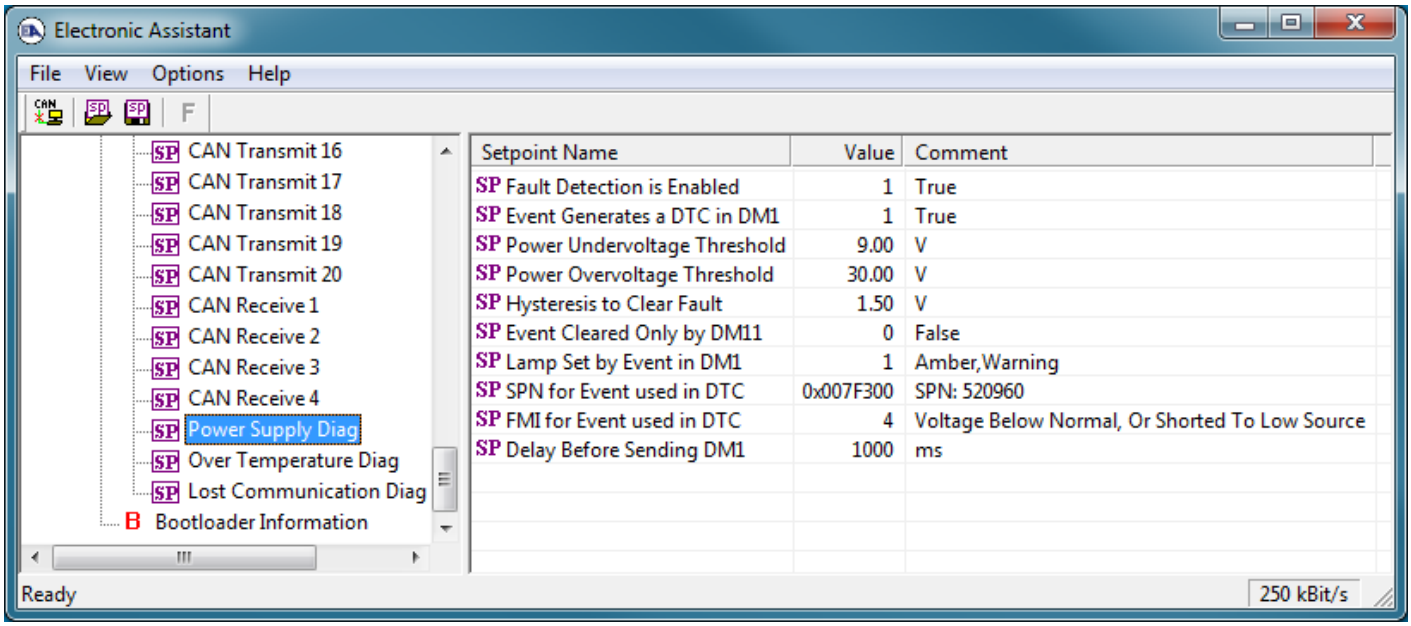


Figure 13 - Screen Capture of Power Supply Diagnostic Setpoints

Name	Range	Default	Notes
Fault Detection is Enabled	Drop List	True	
Power Fault Disables Outputs	Drop List	False	
Event Generates a DTC by DM1	Drop List	False	
Power Undervoltage Threshold	From 5V to overvoltage threshold	9V	
Power Overvoltage Threshold	From undervoltage threshold to 100V	30V	
Hysteresis to Clear Fault	From range min to range max/2	1.5V	
Event Cleared only by DM11	Drop List	False	
Lamp Set by Event in DM1	Drop List	Amber Warning	See Table 8
SPN for Event used in DTC	0...65535	520704 ($7F200)	It is the user's responsibility to select an SPN that will not violate the J1939 standard.
FMI for Event used in DTC	Drop List	4, Voltage Below Normal	See Table 9
Delay Before Sending DM1	0...60000 ms	1000	

Table 25 – Power Supply Diagnostic Setpoints

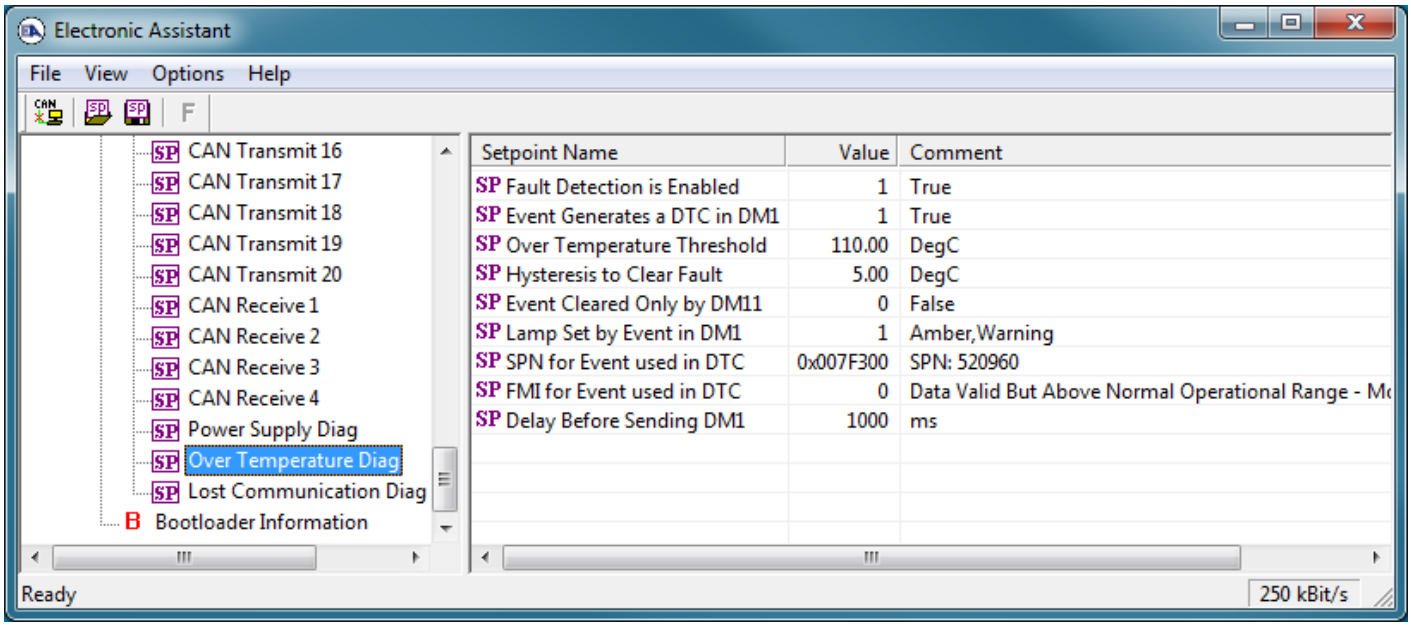


Figure 14 - Screen Capture of Over Temperature Diagnostic Setpoints

Name	Range	Default	Notes
Fault Detection is Enabled	Drop List	True	
Over Temperature Shutdown	Drop List	False	
Event Generates a DTC by DM1	Drop List	False	
Power Over Temperature Threshold	From 50°C to 150°C	110°C	
Hysteresis to Clear Fault	From 0°C to 50°C	5°C	
Event Cleared only by DM11	Drop List	False	
Lamp Set by Event in DM1	Drop List	Amber Warning	See Table 8
SPN for Event used in DTC	0...65535	520960 ($7F300)	It is the user's responsibility to select an SPN that will not violate the J1939 standard.
FMI for Event used in DTC	Drop List	0, Data Above Normal – Most Sever	See Table 9
Delay Before Sending DM1	0...60000 ms	1000	

Table 26 - Over Temperature Diagnostic Setpoints

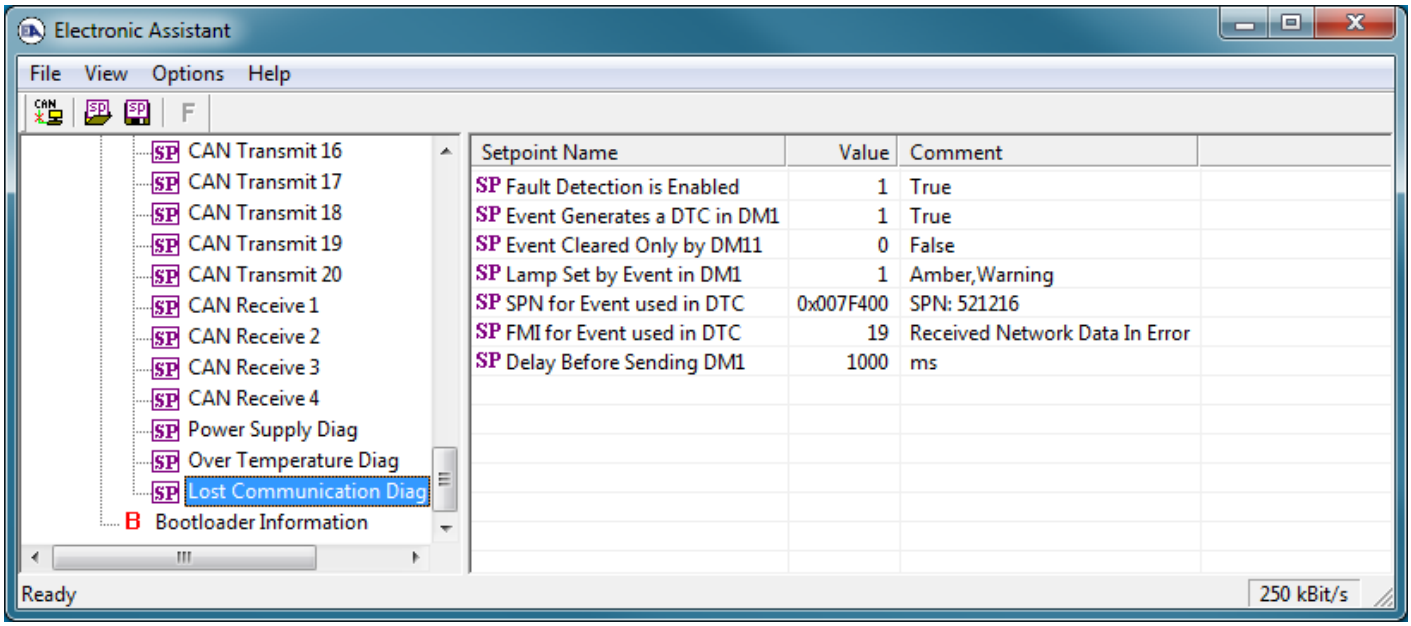


Figure 15 - Screen Capture of Lost Communication Diagnostic Setpoints

Name	Range	Default	Notes
Fault Detection is Enabled	Drop List	True	
Event Generates a DTC by DM1	Drop List	False	
Event Cleared only by DM11	Drop List	False	
Lamp Set by Event in DM1	Drop List	Amber Warning	See Table 8
SPN for Event used in DTC	0...65535	521216 ($7F400)	It is the user's responsibility to select an SPN that will not violate the J1939 standard.
FMI for Event used in DTC	Drop List	19, Received Data Error	See Table 9
Delay Before Sending DM1	0...60000 ms	1000	

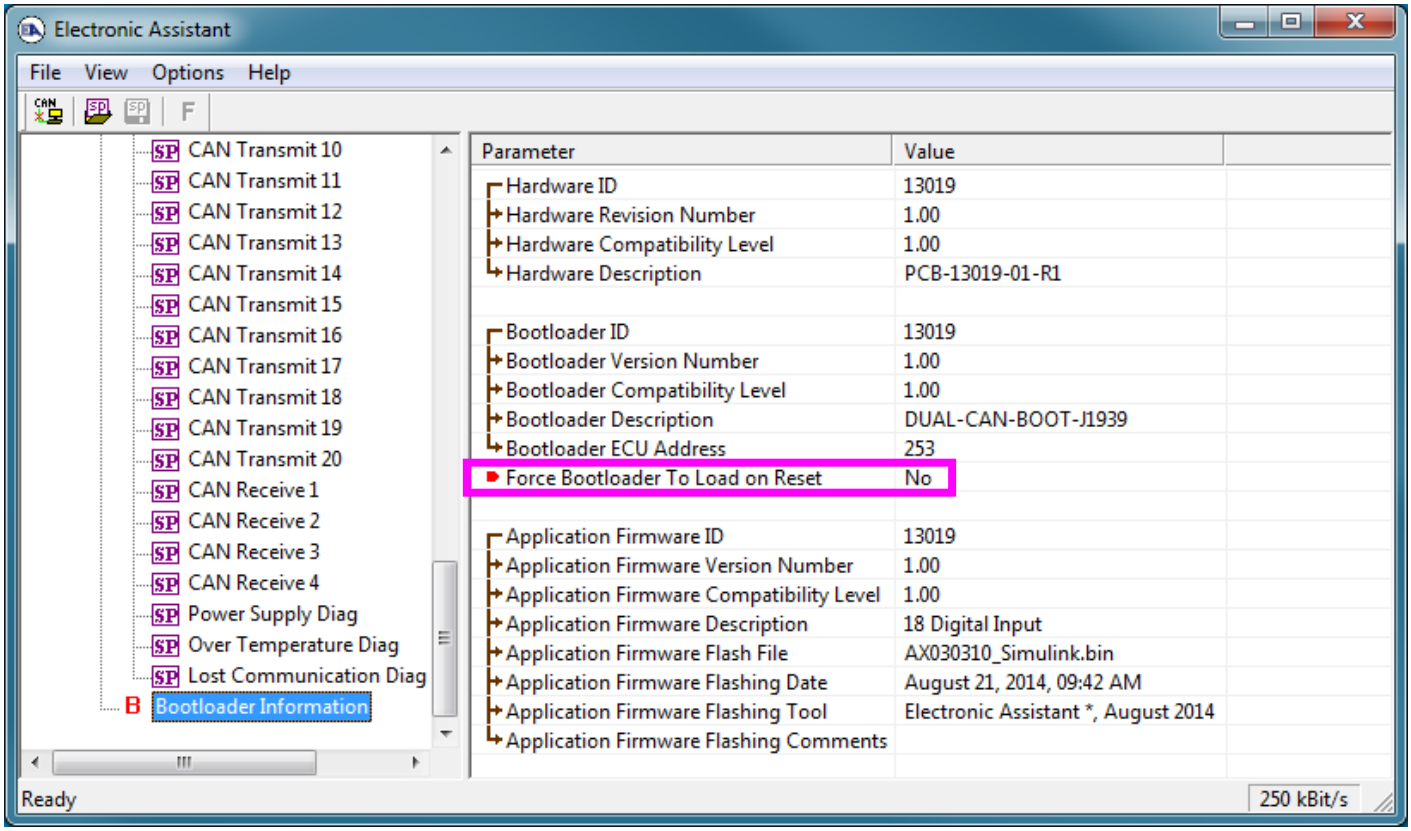
Table 27 - Lost Communication Diagnostic Setpoints

5. REFLASHING OVER CAN WITH THE AXIOMATIC EA BOOTLOADER

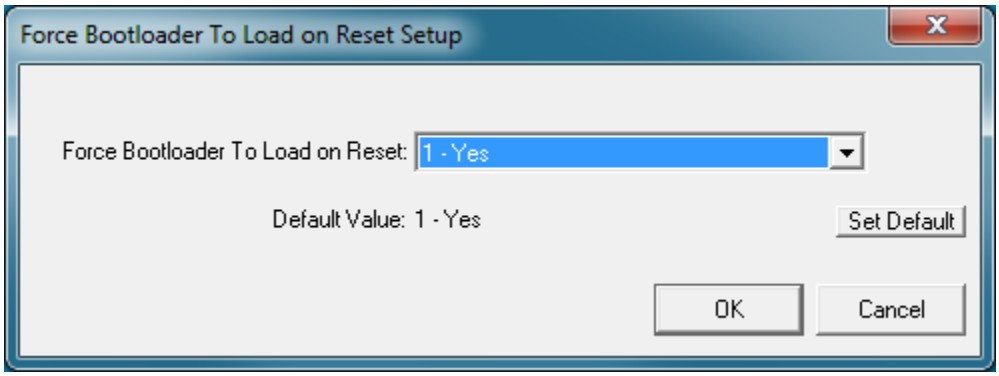
The AX030310 can be upgraded with new application firmware using the **Bootloader Information** section. This section details the simple step-by-step instructions to upload new firmware provided by Axiomatic onto the unit via CAN, without requiring it to be disconnected from the J1939 network.

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

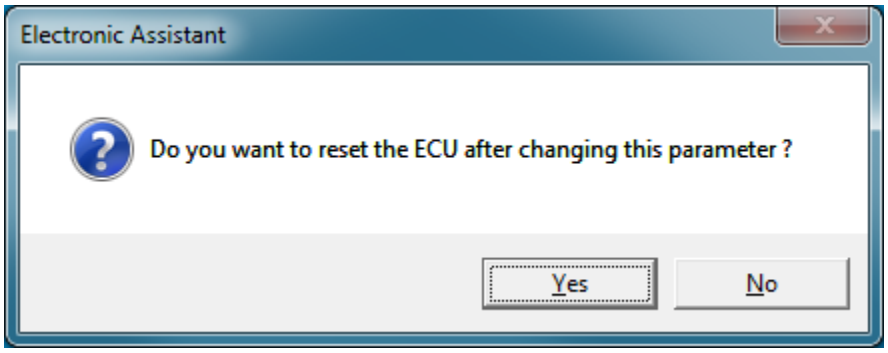
1. When the Axiomatic EA first connects to the ECU, the **Bootloader Information** section will display the following information:



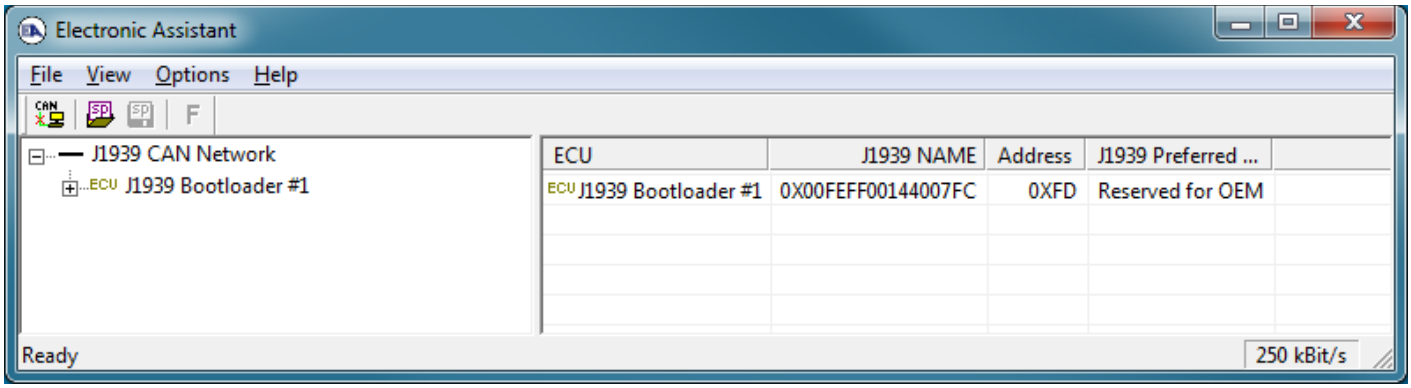
2. To use the bootloader to upgrade the firmware running on the ECU, change the variable **"Force Bootloader To Load on Reset**" to *Yes.*

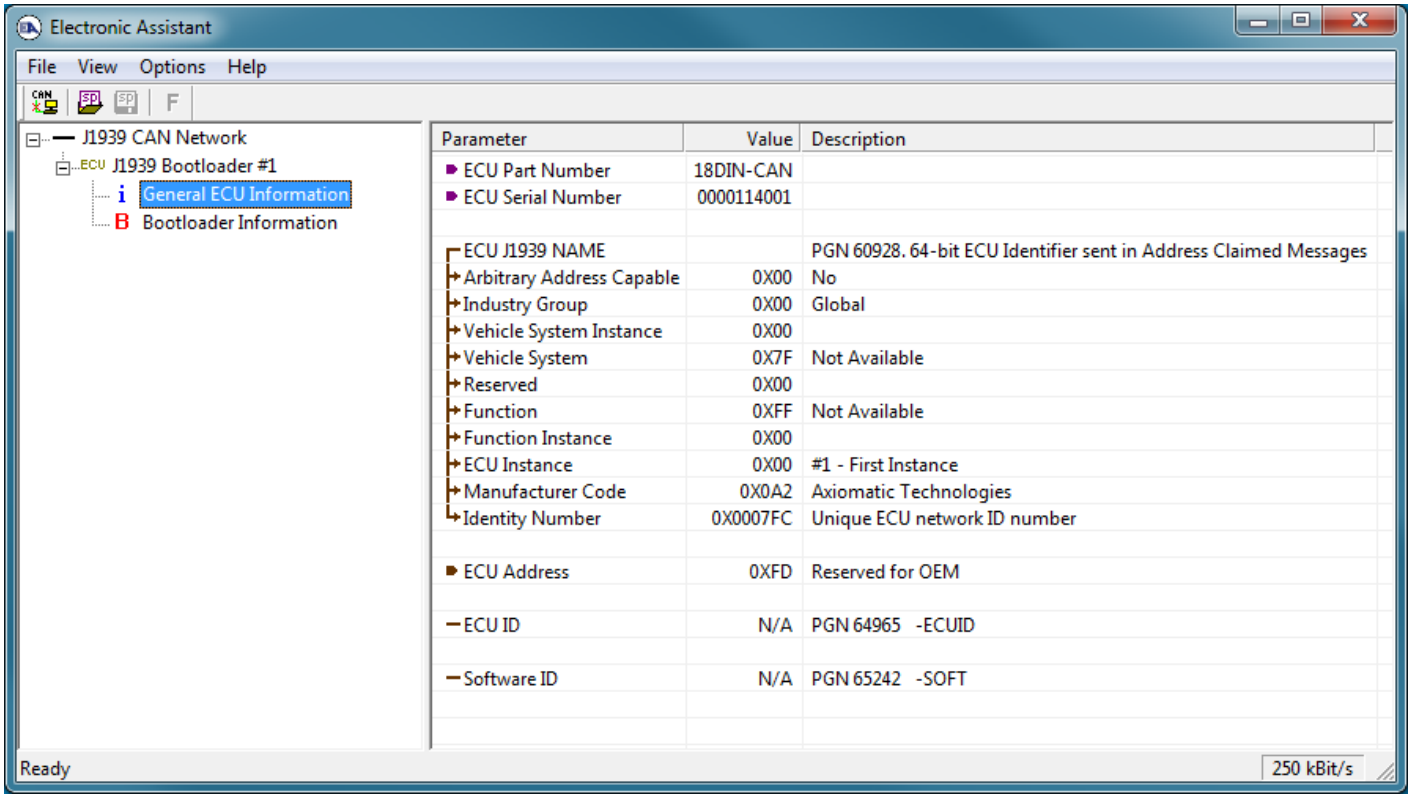


3. When the prompt box asks if you want to reset the ECU, select *Yes*.



4. Upon reset, the ECU will no longer show up on the J1939 network as an AX030310 but rather as **J1939 Bootloader #1**.

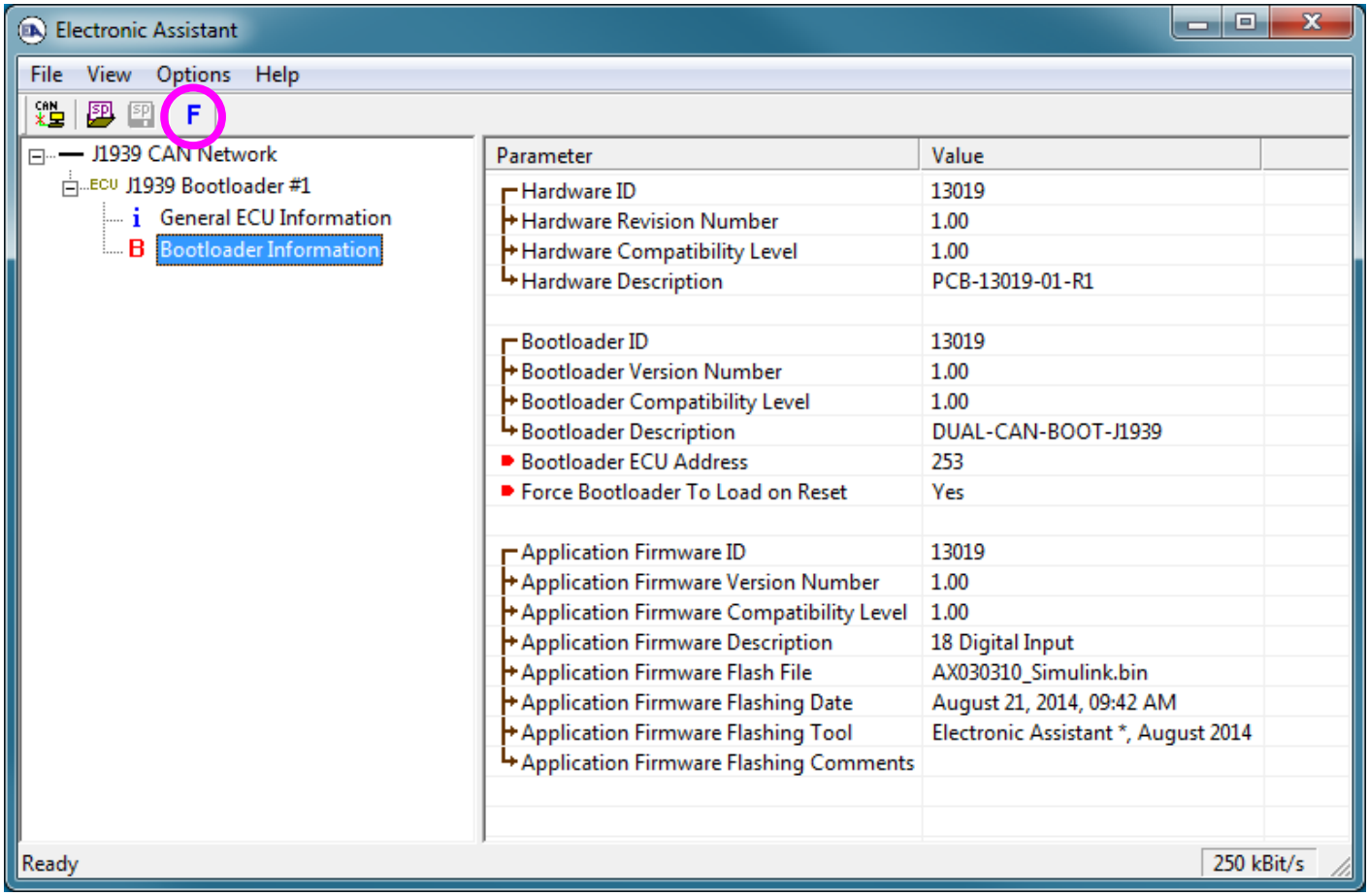




Note that the bootloader is NOT Arbitrary Address Capable. This means that if you want to have multiple bootloaders running simultaneously (not recommended) you would have to manually change the address for each one before activating the next, or there will be address conflicts. And

only one ECU would show up as the bootloader. Once the 'active' bootloader returns to regular functionality, the other ECU(s) would have to be power cycled to re-activate the bootloader feature.

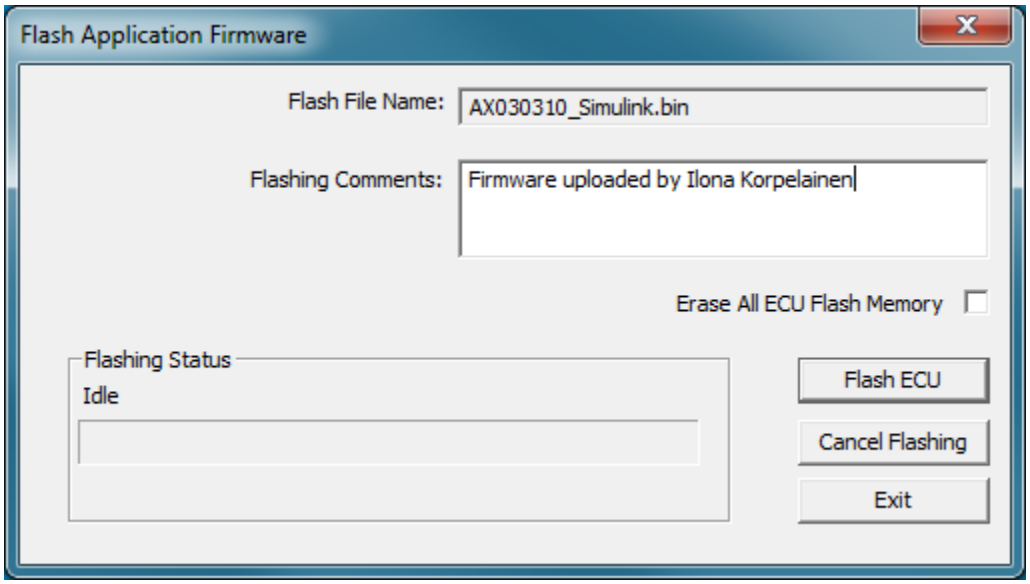
5. When the **Bootloader Information** section is selected, the same information is shown as when it was running the AX030310 firmware, but in this case the **F**lashing feature has been enabled.



6. Select the **F**lashing button and navigate to where you had saved the **AX030310_Simulink.bin** file sent from Axiomatic. (Note: only binary (.bin) files can be flashed using the Axiomatic EA tool.)

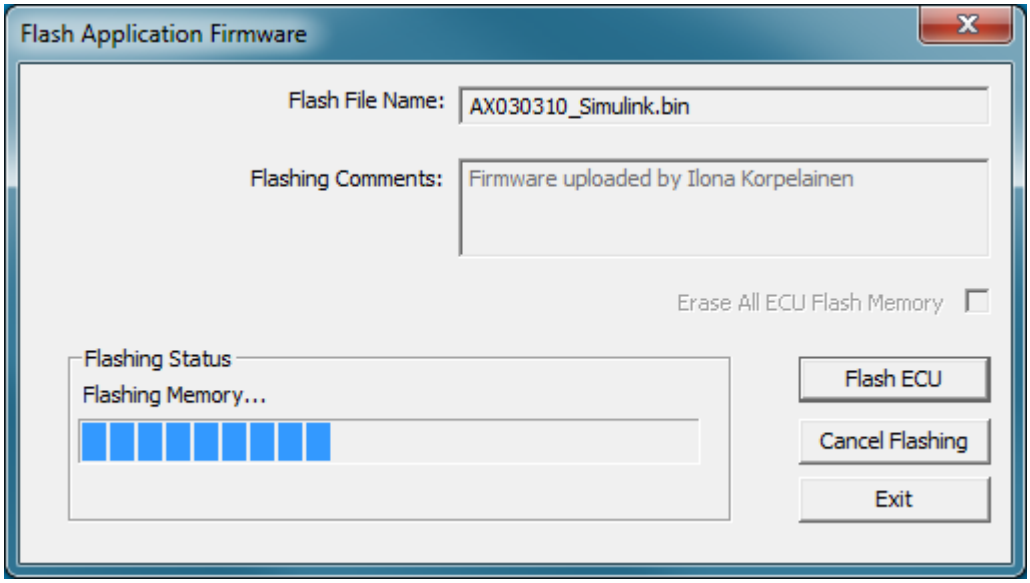
7. Once the Flash Application Firmware window opens, you can enter comments such as "Firmware upgraded by [Name]" if you so desire. This is not required, and you can leave the field blank if you do not want to use it.

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



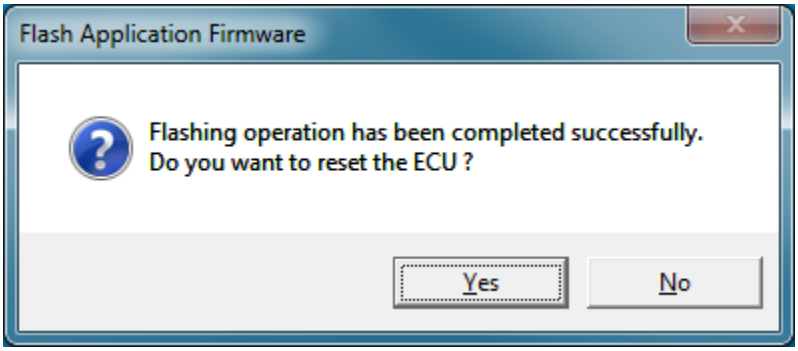
NOTE: It is good practice to tick the “Erase All ECU Flash Memory” box. Please note, that selecting this option will **erase ALL data stored in non-volatile flash**. It will also erase any configuration of the setpoints that might have been done to the ECU and reset all setpoints to their factory defaults. In case the controller contains custom settings, those settings need to be saved to PC before reflashing.

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



Once the firmware has finished uploading, a message will pop up indicating the successful operation. If you select to reset the ECU, the new version of the AX030310 application will start

running, and the ECU will be identified as such by the Axiomatic EA. Otherwise, the next time the ECU is power-cycled, the AX030310 application will run rather than the bootloader function.



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

APPENDIX A - TECHNICAL SPECIFICATION

Technical Specifications:

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

Input Specifications (Refer to the block diagram.)

Power Supply Input - Nominal	12V, 24VDC nominal (8…36VDC power supply range)
Protection	Surge and reverse polarity protection are provided.
All Inputs	Up to 18 digital inputs are selectable by the user. Refer to Table 1.0.
Input Protection	Full protection to all other physical pins (any other input or power terminal).
CAN Commands	SAE J1939 {CANopen® model P/N: AX030311}
Ground Connection	1 Digital GND connection is provided.

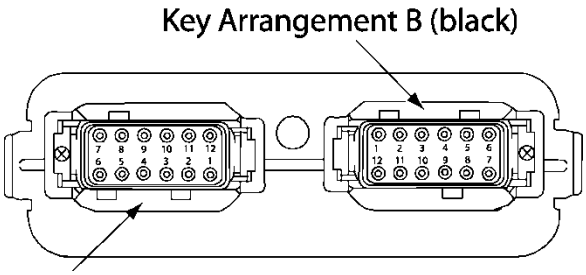
Table 1.0 - Inputs

Digital Inputs	Up to 18 digital inputs are available. The first 10 digital inputs can be configured for any one of the following options. Disable Input Digital Input PWM signal input (1-10,000 Hz, 0-100% D.C.) Frequency Input (Hz or RPM) (50 to 10,000 Hz, 50 mV-3V RMS)* 16-bit Counter Input The last 8 digital inputs can be configured for any one of the following options. Disable Input Digital Input Threshold 3.5V Hysteresis 0.4V Pull up/ Pull down 10 KOhm Input voltage maximum is 30Vdc.
Input Accuracy	PWM, single channel: +/- 0.05% to +/- 1.25% (over the 500 Hz to 10 kHz range) Frequency/RPM, single channel: +/- 1% 16-bit counter, single channel: +/- 3 mSec (@50 Hz)
Input Resolution	PWM, single channel: +/- 0.05% to +/- 1.25%, 0 decimal place resolution Frequency/RPM (single channel) 0.5 Hz to 50 Hz: +/- 0.01Hz, 0 decimal place resolution 50 Hz to 10kHz: +/- 1Hz, 0 decimal place resolution 16-bit counter, single channel: 1 pulse resolution

Output Specifications

CAN Messages	SAE J1939

General Specifications

Microprocessor	STM32F205RET6
Control Logic	Standard embedded software (*Application-specific logic is available on request.)*
User Interface (PC-based)	The Axiomatic Electronic Assistant for *Windows* operating systems It comes with a royalty-free license for use. The Axiomatic Electronic Assistant requires an Axiomatic USB-CAN converter to link the device's CAN port to a *Windows*-based PC. This is included in the Configuration KIT, P/Ns: **AX070502** or **AX070506K**.
CAN Communications	1 CAN port (SAE J1939)
Quiescent Current Draw	13.71 mA @ 24V 24.15 mA @ 12V 31.68 mA @ 9V
Compliance	CE mark: EMC Directive RoHS Directive Exempt from Low Voltage Directive
Network Termination	It is necessary to terminate the network with external termination resistors. The resistors are 120 Ohm, 0.25W minimum, metal film or similar type. They should be placed between CAN_H and CAN_L terminals at both ends of the network.
Operating Conditions	-40 to 85 °C (-40 to 185 °F)
Protection	IP67, PCB is conformal coated and protected by the housing.
Weight	0.50 lbs. (0.23 kg)
Enclosure and Dimensions	High Temperature Nylon PCB Enclosure - (equivalent TE Deutsch P/N: EEC-325X4B) 4.62 x 5.24 x 1.43 inches 117.42 x 133.09 x 36.36 mm (W x L x H excluding mating plugs) Refer to Section 2.1 dimensional drawing.
Electrical Connections	Refer to the Installation section, Section 2.1. 24-pin receptacle (equivalent TE Deutsch P/N: DTM13-12PA-12PB-R008) Mating plugs kits are available and include TE Deutsch P/N: DTM06-12SA and DTM06-12SB with 2 wedgelocks (WM12S) and 24 contacts (0462-201-20141). 20 AWG wire is recommended for use with contacts 0462-201-20141.  FRONT VIEW 24 PIN RECEPTACLE

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PWM Signal Converters/Isolators

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Signal Conditioners, Converters

Strain Gauge CAN Controls

Surge Suppressors

OUR COMPANY

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

QUALITY DESIGN AND MANUFACTURING

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

WARRANTY, APPLICATION APPROVALS/LIMITATIONS

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

COMPLIANCE

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

SAFE USE

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

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

SERVICE

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

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

DISPOSAL

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

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