DATA LOGGER,

4 Thermocouple, 7 Analog and 3 A/D Inputs with 2 CAN (SAE J1939)

USER MANUAL

P/N: AX181000
P/N: AX181000-01
P/N: AX181000-02

In Europe:
Axiomatic Technologies Oy
Höytämöntie 6
33880 LEMPÄÄLÄ - Finland
Tel. +358 103 375 750
Fax. +358 3 3595 660
www.axiomatic.fi

In North America:
Axiomatic Technologies Corporation
5915 Wallace Street
Mississauga, ON Canada L4Z 1Z8
Tel. 1 905 602 9270
Fax. 1 905 602 9279
www.axiomatic.com

VERSION HISTORY

Version	Date	Author	Modifications
1.0.0.	Aug 20, 2013	Ilona Korpelainen	Initial Draft
1.0.0.	August 23, 2013	Amanda Wilkins	Marketing Review
1.0.0.	Sept. 17, 2013	Ilona Korpelainen	Added information. Pull-up resistors are 5kΩ for Universal Input 8 and 1kΩ for Universal Inputs 9 and 10.
1.0.1	July 22, 2014	Amanda Wilkins	Revised .bmp of dimensional drawing to show correct label orientation. Added quiescent current and response time to specifications.
1.0.2	Oct 30, 2014	Ilona Korpelainen	Added a note about Universal Input frequency mode limitations.
--	September 24, 2015	Amanda Wilkins	Updated EA version to V.4.10.78.0 Added CE mark
--	December 14, 2016	Amanda Wilkins	Added scan rate and part numbers for 500 kbps and 1 Mbps baud rates
-	August 30, 2019	Amanda Wilkins	Added vibration compliance

ACCRONYMS

ACK	Positive Acknowledgement (from SAE J1939 standard)
BATT +/-	Battery positive (a.k.a Vps) or Battery Negative (a.k.a. GND)
DIN	Digital Input used to measure active high or low signals
DM	Diagnostic Message (from SAE J1939 standard)
DOUT	Digital Output, sourcing (high-side) output up to 3A current
DTC	Diagnostic Trouble Code (from SAE J1939 standard)
EA	Electronic Assistant, p/n AX070502 (A Service Tool for AxiomaticECUs)
ECU	Electronic Control Unit (from SAE J1939 standard)
EM	Electro-Magnetic
EMC	Electro-Magnetic Compliance
EMI	Electro-Magnetic Immunity
FIN	Frequency Input used to measure Frequency, RPM or PWM signals
GND	Ground reference (a.k.a. BATT-)
I/O	Inputs and Outputs
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)
UIN	Universal Input used to measure voltage, current, resistive, frequency or digital inputs
UOUT	Universal Output, 0-3A current, digital, voltage or PWM type
Vps	Voltage Power Supply (a.k.a BATT+)
TC	Thermocouple

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REFERENCES

J1939	Recommended Practice for a Serial Control and Communications Vehicle Network, SAE, April 2011
J1939/21	Data Link Layer, SAE, December 2010
J1939/71	Vehicle Application Layer, SAE, March 2011
J1939/73	Application Layer-Diagnostics, SAE, February 2010
J1939/81	Network Management, SAE, May 2003
TDAX181000	Technical Datasheet
UMAX07050x	User Manual V4.10.78, Electronic Assistant and USB-CAN, Axiomatic Technologies

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

NOTE: This product is supported by Electronic Assistant ® V4.10.78.0 and higher.

NOTE: When a description is in "**double-quotes**" and bolded, this refers to the name of a user configurable setpoint (variable). If it is in '*single-quotes*' and italicized, it refers to an option for the associated setpoint.

For example: "**Input Sensor Type**" set to *'Current'*

This product uses the Axiomatic Electronic Assistant to program the setpoints for application specific requirements. After configuration, the setpoints can be saved in a file which could then be flashed into other AX181000 controllers over the CAN network.

One point to note is that if the setpoint **"Auto update when control changes"** is set to TRUE in the file, the controller will automatically update some setpoints to new defaults when key setpoints are changed. This is a useful feature during configuration, but during a setpoint file upload it may be required to reflash the same file a second time if this feature is active. The second upload will ensure all setpoints are correctly updated, since some of them may have been automatically overwritten during the first reflashing process, and therefore don't match the values in the file.

To avoid this potential problem, it is HIGHLY recommended by Axiomatic to always set the **"Auto update when control changes"** setpoint to FALSE before saving a setpoint file, so that it all setpoints will be set as expected on the first upload.

1. OVERVIEW OF CONTROLLER

The Data Logger measures input signals and sends measured data to a SAE J199 CAN network. Data Logger has 4 thermocouple inputs, 7 analog inputs and 3 universal inputs. In addition, the Data Logger measures internally generated sensor excitation voltages (+5V ref), cold junction temperature values utilized in thermocouple voltage to ºC conversion and power supply voltage.

Each measured input signal can be sent to either of the two CAN busses. CAN transmit messages are individually configurable and all inputs, excluding internal inputs, are configurable and are associated with fault detection.

The Data Logger is configured by programming setpoints with the Axiomatic Electronic Assistant®. EA setpoints are divided into setpoint groups by input they are associated with. Most input setpoint groups include configuration setpoints for associated CAN transmit message and fault detection. These setpoints work similarly for all inputs and are thus discussed in their own sections. In this section all the inputs and input type specific setpoints are described, excluding internal inputs which are user configurable only by associated CAN transmit messages.

Data Logger model operates with Simulink® which provides the freedom to configure the control beyond readily available setpoints. Contact your Axiomatic sales representative to learn more about this opportunity.

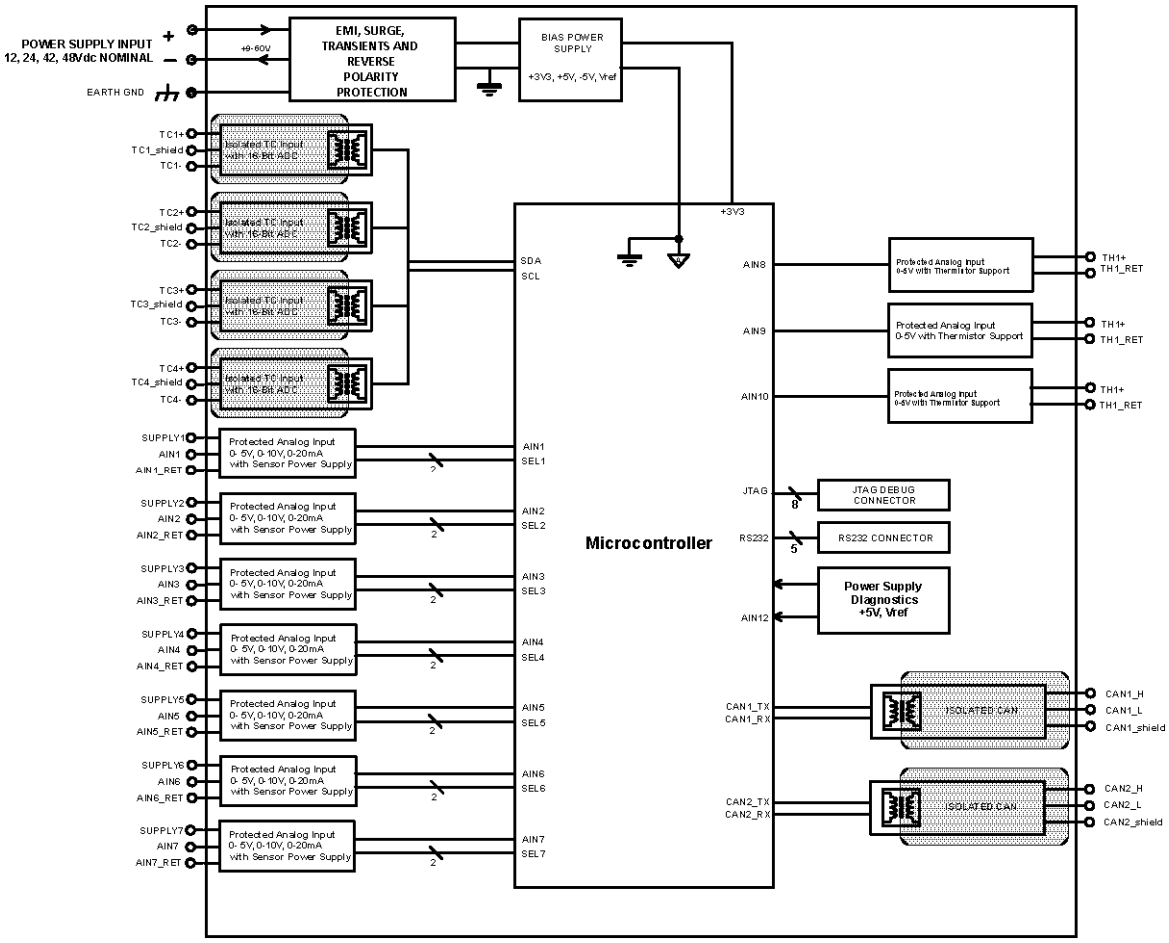


Figure 1 – Hardware Functional Block Diagram

1.1. Thermocouple Inputs

Thermocouple inputs support temperature measurement with J, K and T type thermocouples. Temperature is measured in ºC, with up to a 0.001 ºC resolution. A very precise analog-to-digital converter, with programmable gain, measures the thermocouple input voltage. As the voltage changes, the controller will adjust the gain accordingly to get the best resolution and accuracy of the signal.

The 4 Thermocouple inputs are configured by their individual setpoints as well as by **"TC shared Parameters"** setpoints. **"TC shared Parameters"** parameter group includes setpoints mutual for all thermocouple channels. **"Thermocouple Filter Type"** and **"Thermocouple Filter Constant"** are used to select input data filtering similarly as with other Analog and digital inputs as described in Section 1.3. **"Thermocouple rejection mode"** setpoint defines ADC rejection mode used in measuring thermocouple voltage. Options for the **"Thermocouple rejection mode"** setpoint are listed in ***Table 1***. "**Thermocouple Speed Mode**" is a read only parameter which shows which of the two Speed modes is utilized with thermocouple voltage measurement.

0	Simultaneous 50Hz and 60Hz
1	50Hz
2	60Hz

Table 1 - Thermocouple Rejection Mode Options

Each of the four thermocouple inputs has their own parameter group which defines thermocouples individual setpoints. **"Thermocouple Type"** setpoint selects how thermocouple voltage is converted to ºC. Currently available **"Thermocouple Type"** options are thermocouple J, K and T thermocouple types. Other setpoints in Thermocouple parameter group configure thermocouple associated fault detection and CAN transmit messages, and are described later in chapters 1.4 and 1.5.

1.1. Analog Inputs

The 7 Analog inputs can be configured to measure voltage or current by selecting **"Input Sensor Type"** setpoint. **"Input Sensor Type"** setpoint options are listed in
Table 2*. Selected **"Input Sensor Type"** defines also input range. Signals above or below selected range are rectified to range limits.*

0	*Input Disabled*
12	*Voltage 0 to 5 V(Default)*
13	*Voltage 0 to 10 V*
20	*Current 0 to 20mA*
21	*Current 4 to 20mA*

Table 2 – Analog Input Type Options

Voltage (i.e. 0-5V, 0-10V) or Current (0(4)-20mA) inputs have a hardware filter which then goes directly to a 12-bit analog-to-digital converter (ADC) on the processor. A voltage input is a high impedance input protected against shorts to GND or Vcc. Other setpoints in Analog Input parameter group configure input associated fault detection and CAN transmit messages, and are descripted later in chapters 1.4.and 1.5. Software Filter setpoints are defined in Section 1.3.

1.2. Universal Inputs

The 3 universal inputs have are also configured by selecting **"Input Sensor Type"** setpoint. Universal Input **"Input Sensor Type"** options are listed in ***Table 3***.

0	*Input Disabled*
12	*Voltage 0 to 5V(Default)*
20	*Current 0 to 20mA*
21	*Current 4mA to 20mA*
40	*Frequency 0.5Hz to 50Hz*
41	*Frequency 10Hz to 1kHz*
42	*Frequency 100Hz to 10kHz*
50	*PWM Low Freq (<1kHz)*
51	*PWM High Freq (>100Hz)*
61	*Digital (High)*
70	*Thermistor 5 kΩ pull-up*

Table 3 - Analog/Digital Input Sensor Type Options

Frequency/RPM or Pulse Width Modulated (PWM) inputs are connected to 15-bit timer pins on the processor. Universal Inputs 2 and 3 share a timer in Frequency and PWM mode, thus they should be set on same frequency range to obtain correct results. The **"Input Sensor Type"** *Digital* input pin is connected by pull-up resistor to 5V Vcc, thus indicating active high. This means that when the input signal on the pin goes HIGH (>3V), the normal state response of the input is ON. When nothing or a low (GND) is connected to the pin, the input is OFF.

With the *Thermistor* option, the input accepts 0 to 5V and is connected by pull-up to 5V Vcc. Pull-up resistors are 5kΩ for Universal Input 8 and 1kΩ for Universal Inputs 9 and 10.

Other setpoints in the Universal Input parameter group configure input associated fault detection and CAN transmit messages, and are described later in chapters 1.4. and 1.5. Software Filter setpoints are defined in Section 1.3.

1.3. Input Filtering

Measured input data from analog, universal and thermocouple 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 analog and universal input individually. Thermocouple input filtering in configured simultaneously for all four thermocouple inputs by configuring "**Filter Type**" and "**Filter Constant**" setpoints in Thermocouple Shared Parameters Group. Thus measured input data from all four thermocouples are always filtered similarly.

"**Filter Type**" setpoint defines the type of software filter used. Setpoint option 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.

1.4. Diagnostics

Analog, Universal and Thermocouple inputs are all associated with fault detection. Each of the input setpoint groups includes setpoints to configure fault detection for the input in question. Fault detection works similarly for all inputs, but there are some differing setpoints for thermocouple inputs.

Firstly, input diagnostics are discussed generally so that what is stated applies to all inputs unless otherwise mentioned. Then fault detection for Analog and Universal Inputs is described with more detail. And lastly, Thermocouple fault diagnostics are explained in part that differ from Analog and Universal input fault diagnostics.

1.4.1 Fault Detection in General

Analog, Universal and Thermocouple inputs are associated with fault detection. The "**Fault detection Enabled**" setpoint enables input associated fault detection when set TRUE. When disabled, all diagnostic behavior associated with the input in question is ignored. This feature enables the controller to react to the detected fault and is commonly used for example in shutting down the output in fault conditions. However, as the Data Logger does not have any outputs the feature is not utilized at the moment.

The "**Generate Diagnostic Message"** setpoint configures whether the active diagnostic trouble codes (DTC) of faults in the input in question are included in DM1. So long as even one Diagnostic function block has the **"Generate Diagnostic Message"** set to Enable, the Data Logger will send the DM1 message every one second. This is done regardless of whether or not there are any active faults and as recommended by the standard. While there are no active DTCs, the Data Logger will send the "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, it will send a DM1 indicating that there are no more active DTCs.

A Diagnostic Trouble Code (DTC) is defined by the J1939 standard as a four byte value which is a combination of:

SPN	Suspect Parameter Number	(first 19 bits of the DTC, LSB first)
FMI	Failure Mode Identifier	(next 5 bits of the DTC)
CM	Conversion Method	(1 bit, always set to 0)
OC	Occurrence Count	(7 bits, number of times the fault has happened)

In addition to supporting the DM1 message, the Data Logger 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**

If there is more than one active DTC at any given time, the regular DM1 message will be sent using a multipacket Broadcast Announce Message (BAM). If the controller receives a request for a DM1 while this is true, it will send the multipacket message to the Requester Address using the Transport Protocol (TP).

At power up, the DM1 message will not be broadcasted until after a 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. 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. Thermocouple inputs have slightly different fault detection setup, thus they do not have a "**Delay Before Sending DM1**" setpoint. Actually thermocouple inputs have three timer setpoints instead that act similar to the "**Delay Before Sending DM1**" setpoint.

Previously active DTCs (any with a non-zero OC) are available upon request for a **DM2** message. If there is more than one previously active DTC, the multipacket DM2 will be sent to the Requester Address using the Transport Protocol (TP).

Should a **DM3** be requested, the occurrence count of all previously active DTCs will be reset to zero. The OC of currently active DTCs will not be changed.

By default, every input has associated with it a proprietary SPN. However, this setpoint **"SPN (for Diagnostics)"** is fully configurable by the user should they wish it to reflect a standard SPN defined in J1939-71 instead. If the SPN is changed, the OC of the associate error log is automatically reset to zero.

1.4.2 Analog and Universal Input Diagnostics

In addition to above mentioned setpoints, Analog and Universal inputs have setpoints to further configure fault detection. These setpoints are not available for thermocouple inputs, instead they are readily configured or otherwise different for the thermocouple inputs.

The **"Event Cleared only by DM11"** setpoint configures how error flag for fault in question is cleared. By default, this is always set to False, which means that as soon as the condition that caused an error flag to be set goes away, the DTC is automatically made Previously Active, and is no longer included in the DM1 message. However, when this setpoint is set to True, even if the flag is cleared, the DTC will not be made inactive, so it will continue to be sent on the DM1 message. Only when a DM11 has been requested will the DTC go inactive. This feature may be useful in a system where a critical fault needs to be clearly identified as having happened, even if the conditions that caused it went away.

In addition to all the active DTCs, another part of the DM1 message is the first byte which reflects the Lamp Status. Each input has the setpoint **"Diagnostic Lamp Type"** which determines which lamp will be set in this byte while the DTC is active. The J1939 standard defines the lamps as *'Malfunction', 'Red, Stop', 'Amber, Warning'* or *'Protect'.* By default, the *'Amber, Warning'* lamp is typically the one set by any active fault.

Analog and Universal Input faults can be flagged either a low or high occurrence. **"Minimum Error"** and **"Maximum error"** setpoints for each Analog and Universal input configure the threshold for fault detections. The **"Hysteresis to Clear Fault"** setpoint combined with **"Maximum Error"** and **"Minimum Error"** configures threshold to clear fault. These setpoints are interpreted in percentage of maximum range, which depends on selected **"Input Sensor Type"**. For example **"Maximum Error"** value 96 for 0 to 5V Input Sensor Type gives 4.8V as high occurrence threshold. This combined with **"Hysteresis to Clear Fault"** value 2 configures high occurrence error to be cleared when input decreases below 4.7V. Similarly low occurrence fault is flagged if input degreases below value defined by the **"Minimum Error"**/100 * input range and the fault is cleared as input raises over value defined by (**"Minimum Error"**+**"Hysteresis to Clear Fault"**)/100* input range.

Every input has associated with it a default FMI. The only setpoint for the user to change the FMI is **"FMI for Event used in DTC,"** even though some Diagnostic function blocks can have both high and low errors as shown in Table 5. In those cases, the FMI in the setpoint reflect that of the low end condition, and the FMI used by the high fault will be determined per ***Table 4***. If the FMI is changed, the OC of the associate error log is automatically reset to zero.

FMI for Event used in DTC – Low Fault	Corresponding FMI used in DTC – High Fault
FMI=1, Data Valid But Below Normal Operational 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 Range – 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 4 - Low Fault FMI versus High Fault FMI

If the FMI used is anything other than one of those in Table 5, then both the low and

high faults will be assigned the same FMI. This condition should be avoided, as the log will still used different OC for the two types of faults, even though they will be reported the same in the DTC. It is the user's responsibility to make sure this does not happen.

1.4.3 Thermocouple Input Diagnostics

Thermocouple Input fault detection setpoints differ from Analog and Universal Input fault detection setpoints. For Thermocouple Inputs FMI:s readily are set and are not configurable by user. Instead they are readily set, as are diagnostic lamp types. Supported FMI's and diagnostic lamp types are listed in ***Table 5***. **"High Shutdown Temperature"** and **"Low Shutdown Temperature"** configure high and low occurrence thresholds for Temperature Shutdown fault, likewise **"High Warning Temperature"** and **"Low Warning Temperature"** configure high and low thresholds for Temperature Warning fault. Setpoints are interpreted in 0.1 ºC, thus setpoint value 10 is interpreted as 1 ºC. Hysteresis of 0.1 ºC is applied internally.

Both Temperature Shutdown fault and Temperature Warning fault are associated with timer setpoint similar to the "**Delay Before Sending DM1**" setpoint with Analog and Universal Inputs. Namely **"Shutdown Delay"** and **"Warning Delay"** setpoints, which configure the time fault have to appear remain present before DTC is set active. Third timer setpoint "**Open Circuit Delay**" is associated with Open circuit fault, which reflects thermocouple input measured as an open circuit.

FMI#	FMI Name (J1939)	TC Fault	Lamp Type
0	Data Valid But Above Normal Operational Range – Most Severe	High Temperature Shutdown	Red Stop Lamp
1	Data Valid But Below Normal Operational Range – Most Severe	High Temperature Shutdown	Red Stop Lamp
15	Data Valid But Above Normal Operational Range – Least Severe	High Temperature Warning	Amber Warning Lamp
17	Data Valid But Below Normal Operational Range – Least Severe	Low Temperature Warning	Amber Warning Lamp
5	Current Below Normal or Open Circuit	Thermocouple Open Circuit	Amber Warning Lamp

Table 5 - Supported FMI and associated diagnostic lamp types for Thermocouple Inputs

1.5. CAN Transmits

Each of the input setpoint groups includes setpoints to configure CAN message transmission. In addition there are three extra setpoint groups, namely Excitation Voltage, Cold Junction Temperature and Power Supply Voltage, which consist only of CAN message setpoints.

There are 17 different configurable CAN messages that can be sent from Data Logger. Each is readily associated with an input, thus CAN message data is derived from measured input signal. Data sources cannot be changed by user.

The **"CAN Interface"** setpoint is configured to select the CAN bus where message in question is sent.

The **"Transmit Repetition Rate"** setpoint defines how often the message is sent to the CAN bus. Normally, to disable a transmit message, the **"Transmit Repetition Rate"** is set to zero. However, should message share its Parameter Group Number (PGN) with another message, this is not necessarily true. In the case where multiple messages share the same **"Transmit PGN"**, the repetition rate selected in the message with the LOWEST number will be used for ALL the messages that use that PGN.

By default, all messages are sent on Proprietary B PGNs as broadcast messages. The default settings do 'bundle' multiple messages onto a PGN, as outlined in Section 3. If all of the data is not necessary, disable the entire message by setting the lowest channel using that PGN to zero. If some of the data is not necessary, simply change the PGN of the superfluous channel(s) to an unused value in the Proprietary B range.

At power up, transmitted message will not be broadcasted until after a 5 second delay. This is done to prevent any power up or initialization conditions from creating problems on the network.

Since the defaults are PropB messages, the **"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 select, and it can be set either to the Global Address (0xFF) for broadcasts, or sent to a specific address as setup by the user.

The **"Transmit Data Size"** setpoint determines how the data sent to the selected CAN bus. The **"Transmit Data Index"** setpoint defines in which byte at 8-byte data frame the LSB is situated. The **"Transmit Bit Index"** setpoint defines location of the LSB inside defined byte. Both of indexes are counted from 0 to 7, 0 denoting the MSB. Setpoint **"Transmit Resolution"** determines the scaling of the data in the message. Resolution is interpreted in units of selected input sensor type per bit. The **"Transmit Offset"** setpoint determines the value that is subtracted from the data before scaling. Offset is interpreted in units of selected input. These setpoints can all be used to map the data to any SPN supported by the J1939 standard. The defaults used by the Data Logger are all for proprietary SPNs, and are defined in detail in Section 3.3.

Note: CAN Data = (Input Data – Offset)/Resolution

2. INSTALLATION INSTRUCTIONS

2.1. Dimensions and Pinout

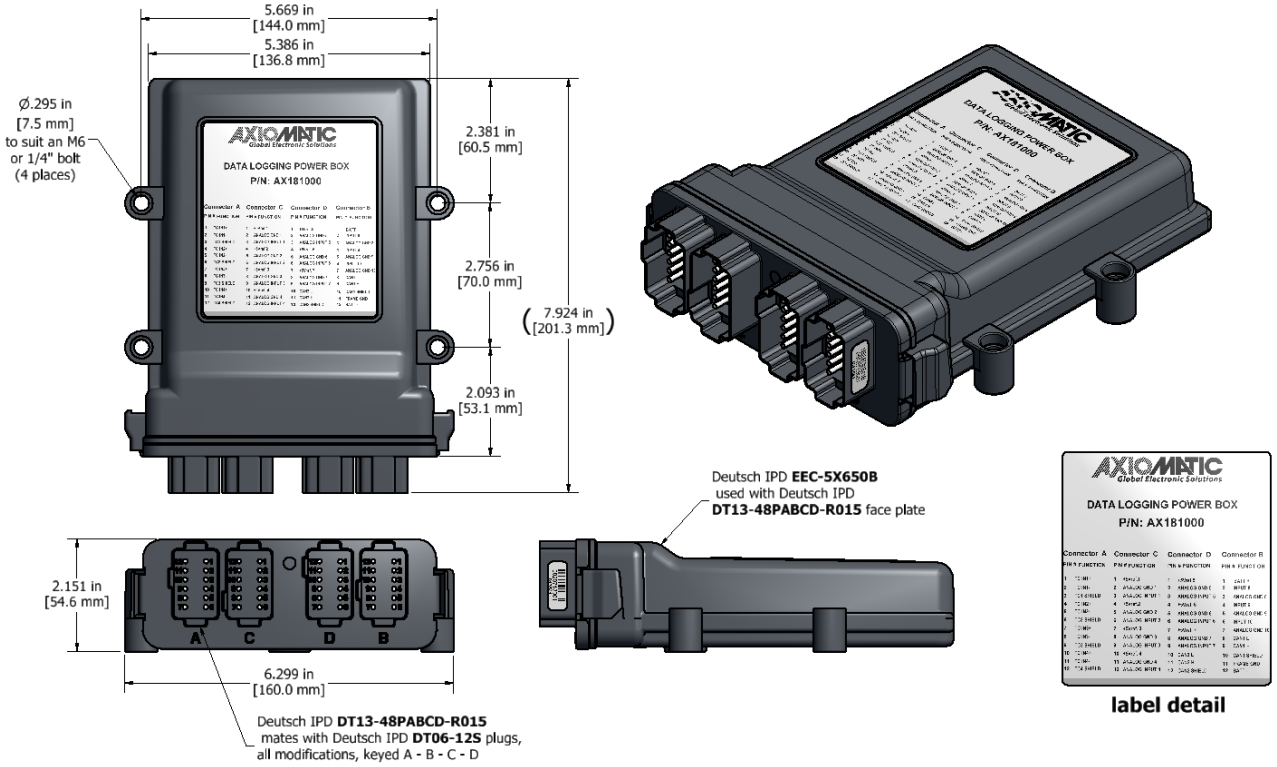


Figure 2 - AX181000 Dimensional Drawing

Connector A		Connector C		Connector D		Connector B	
Pin#	**Function**	**Pin#**	**Function**	**Pin#**	**Function**	**Pin#**	**Function**
1	TC IN1+	1	+5Vref. 1	1	+5Vref. 5	1	Batt+
2	TC IN1-	2	Analog GND 1	2	Analog GND 5	2	Input 8
3	TC1 Shield	3	Analog Input 1	3	Analog Input 5	3	Analog GND 8
4	TC IN2+	4	+5Vref. 2	4	+5Vref. 6	4	Input 9
5	TC IN2-	5	Analog GND 2	5	Analog GND 6	5	Analog GND 9
6	TC2 Shield	6	Analog Input 2	6	Analog Input 6	6	Input 10
7	TC IN3+	7	+5Vref. 3	7	+5Vref. 7	7	Analog GND 10
8	TC IN3-	8	Analog GND 3	8	Analog GND 7	8	CAN1 L
9	TC3 Shield	9	Analog Input 3	9	Analog Input 8	9	CAN1 H
10	TC IN4+	10	+5Vref. 4	10	CAN2 L	10	CAN1 Shield
11	TC IN4-	11	Analog GND 4	11	CAN2 H	11	Frame GND
12	TC4 Shield	12	Analog Input 4	12	CAN2 Shield	12	Batt-

Table 6 - AX181000 Connector Pinout

NB. Input 8, Input 9 and Input 10 are Universal inputs and are denoted as Universal Input 1 Universal Input 2 and Universal Input 3. The two CAN buses CAN1 and CAN2 are denoted as CAN0 and CAN1 from time to time.

3. OVERVIEW OF J1939 FEATURES

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

- Configurable ECU Instance in the NAME (to allow multiple ECUs on the same network)
- Configurable Transmit PGN and SPN Parameters
- Configurable Receive PGN and SPN Parameters
- Sending DM1 Diagnostic Message Parameters
- Reading and reacting to DM1 messages sent by other ECUs
- Diagnostic Log, maintained in non-volatile memory, for sending DM2 messages

3.1. Introduction To Supported Message

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

From J1939-21 - Data Link Layer

- Request 59904 ($00EA00)
- Acknowledgment 59392 ($00E800)
- Transport Protocol – Connection Management 60416 ($00EC00)
- Transport Protocol – Data Transfer Message 60160 ($00EB00)
- PropB Transmit, Default Measured Inputs Feedback Message 65280 ($00FF00)

Note: Any Proprietary B PGN in the range 65280 to 65535 ($00FF00 to $00FFFF) can be selected
Note: The Proprietary A PGN 61184 ($00EF00) can also be selected for any of the messages

From J1939-73 - Diagnostics

- DM1 – Active Diagnostic Trouble Codes 65226 ($00FECA)
- DM2 – Previously Active Diagnostic Trouble Codes 65227 ($00FECB)
- DM3 – Diagnostic Data Clear/Reset for Previously Active DTCs 65228 ($00FECC)
- DM11 - Diagnostic Data Clear/Reset for Active DTCs 65235 ($00FED3)
- DM14 – Memory Access Request 55552 ($00D900)
- DM15 – Memory Access Response 55296 ($00D800)
- DM16 – Binary Data Transfer 55040 ($00D700)

From J1939-81 - Network Management

- Address Claimed/Cannot Claim 60928 ($00EE00)
- Commanded Address 65240 ($00FED8)

6B**From J1939-71 – Vehicle Application Layer**

- Software Identification 65242($00FEDA)

None of the application layer PGNs are supported as part of the default configurations, but they can be selected as desired for either transmit or received function blocks.
Setpoints are accessed using standard Memory Access Protocol (MAP) with proprietary addresses. The Electronic Assistant® (EA) allows for quick and easy configuration of the unit over the CAN network.

3.2. NAME, Address and Software ID

The Data Logger ECU has the following defaults 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	130, On-board data logger
Function Instance	0, Axiomatic AX181000
ECU Instance	**0, First Instance**
Manufacture Code	162, Axiomatic Technologies Corporation
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 by other ECUs (including the Electronic Assistant®) when they are all connected on the same network.

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 and 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 Data Logger will continue select the next highest address until it find one that it can claim. See J1939/81 for more details about address claiming.

Software Identifier

PGN 65242 Software Identification - SOFT

Transmission Repetition Rate: On request

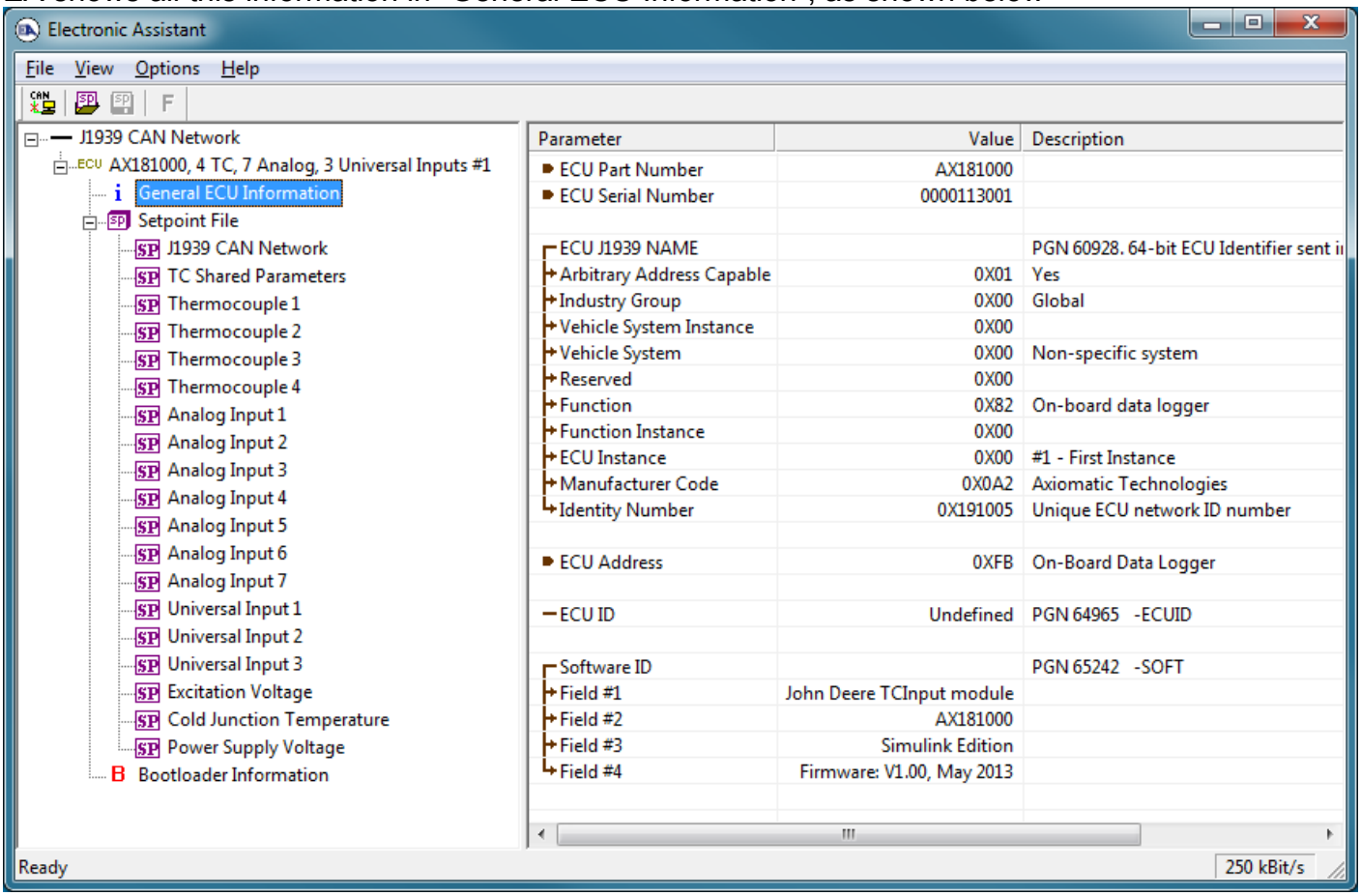
Data Length: Variable
Extended Data Page: 0
Data Page: 0
PDU Format: 254
PDU Specific: 218 PGN Supporting Information:
Default Priority: 6
Parameter Group Number: 65242 (0xFEDA)

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

For the Data Logger ECU, Byte 1 is set to 5, and the identification fields are as follows

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

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



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

3.3. CAN Transmit Message Defaults

This section outlines the **default** settings of the Data Logger CAN transmissions. Recall, however, that this is a fully programmable unit, such that all these SPNs can be sent on different PGNs if so desired. **Table *7*** lists CAN message defaults for each of the 17 CAN messages. In the "Input" column are listed inputs associated with each can message as shown in the EA. The "PGN" column shows default PGNs for these messages, and the "SPN" column list default SPNs for input associated fault detection. In "Input name" column are listed the corresponding input labels marked on the current product housing. The internal inputs (Excitation Voltage, Cold Junction Voltage and Power Supply Voltage) do not have available Input name and are not associated with any fault detection.

Input	PGN	SPN	Input name
Thermocouple1	0xFF0A	0x7F000	TC IN1
Thermocouple2	0xFF0B	0x7F001	TC IN2
Thermocouple3	0xFF0C	0x7F002	TC IN3
Thermocouple4	0xFF0D	0x7F003	TC IN4
Analog Input 1	0xFF00	0	Analog Input 1
Analog Input 2	0xFF01	0	Analog Input 2
Analog Input 3	0xFF02	0	Analog Input 3
Analog Input 4	0xFF03	0	Analog Input 4
Analog Input 5	0xFF04	0	Analog Input 5
Analog Input 6	0xFF07	0	Analog Input 6
Analog Input 7	0xFF0E	0	Analog Input 7
Universal Input 1	0xFF05	0	Input 8
Universal Input 2	0xFF06	0	Input 9
Universal Input 3	0xFF08	0	Input 10
Excitation Voltage	0xFF09	N/A	N/A
Cold Junction Voltage	0xFF0F	N/A	N/A
Power Supply Voltage	0xFF10	N/A	N/A

Table 7 - CAN Message Default settings

4. ECU SETPOINTS ACCESSED WITH ELECTRONIC ASSISTANT

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

4.1. J1939 CAN Network Setpoints

The J1939 CAN Network setpoints deal with the 2 CAN Network.

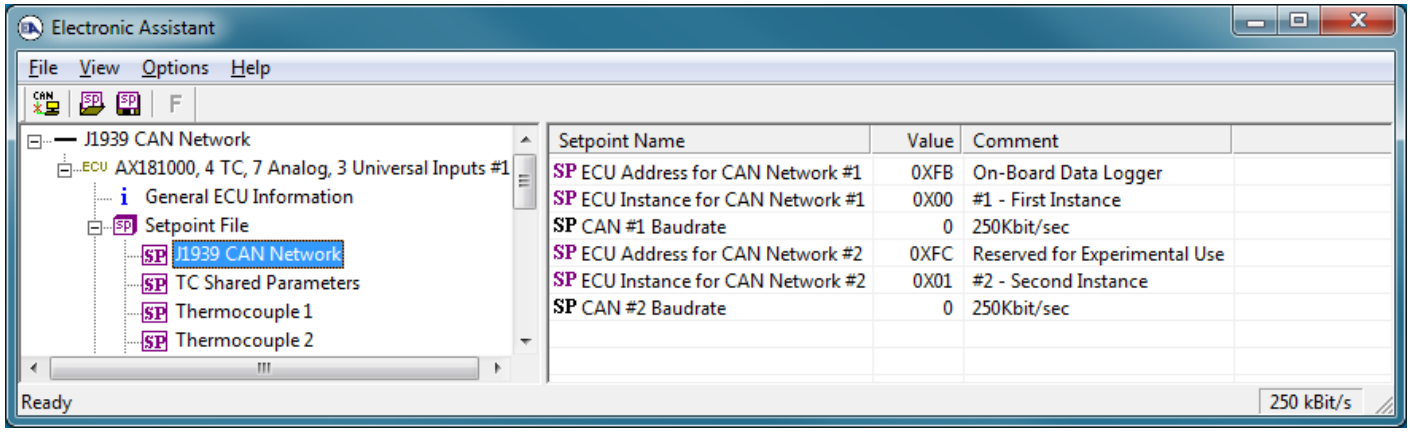


Figure 3 - Screen Capture of Default J1939 CAN Network Setpoints

Name	Range	Default	Notes
ECU Address for CAN Network #1	0 to 253	128	Preferred address for a self-configurable ECU
ECU Instance Number for CAN Network #1	Drop List	0, #1 – First Instance	Per J1939-81
CAN #1 Baudrate	Read only	250Kbit/sec	
ECU Address for CAN Network #2	0 to 253	129	Preferred address for a self-configurable ECU
ECU Instance Number for CAN Network #2	Drop List	1, #2 – First Instance	Per J1939-81
CAN #2 Baudrate	Read only	250Kbit/sec	

Table 8 - J1939 CAN 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 EA after the file is loaded so that only the new NAME and address are showing in the J1939 CAN Network ECU list.

4.2. TC Shared Parameters Setpoints

The Thermocouple Inputs are defined in section 1.1. The TC Shared Parameters setpoints apply to all four Thermocouple inputs, thus features configured with these setpoints are same for all thermocouple inputs.

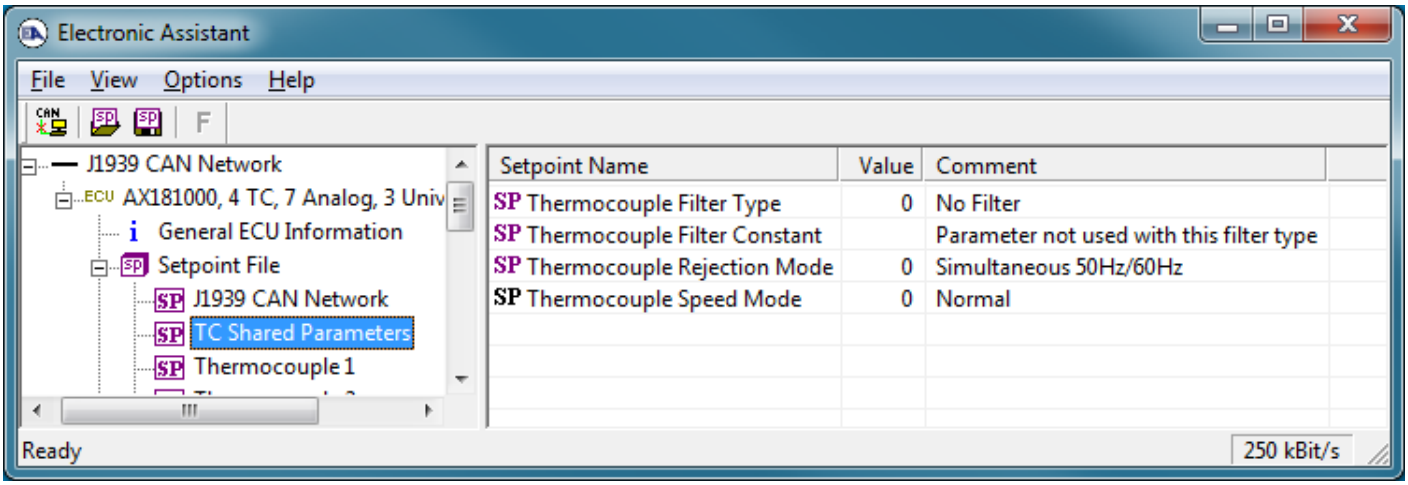


Figure 4 - Screen Capture of Default TC Shared Parameters Setpoints

By default, Thermocouple inputs do not use software filtering. The ADC's measuring Thermocouple voltage is configured to Simultaneous 50Hz/60Hz rejection mode and normal speed mode.

Name	Range	Default	Notes
Thermocouple FilterType	Drop List	No Filter	
Thermocouple Filter Constant	1 to 1 000	1	Not used by default
Thermocouple Rejection Mode	Drop List	Simultaneous 50Hz/60Hz	
Thermocouple Speed Mode	Read only	Normal	

Table 9 - TC Shared Parameters Setpoints

4.3. Thermocouple Input Setpoints

The Thermocouple Inputs are defined in section 1.1. All four Thermocouple Inputs have similar setpoints. Default values for all Thermocouple inputs are same except "Transmit PGN" and SPN for Diagnostics. Thermocouple Input setpoints include CAN message and fault detection related setpoints. Detailed information for these setpoints can be found in sections 1.5 and 1.4.

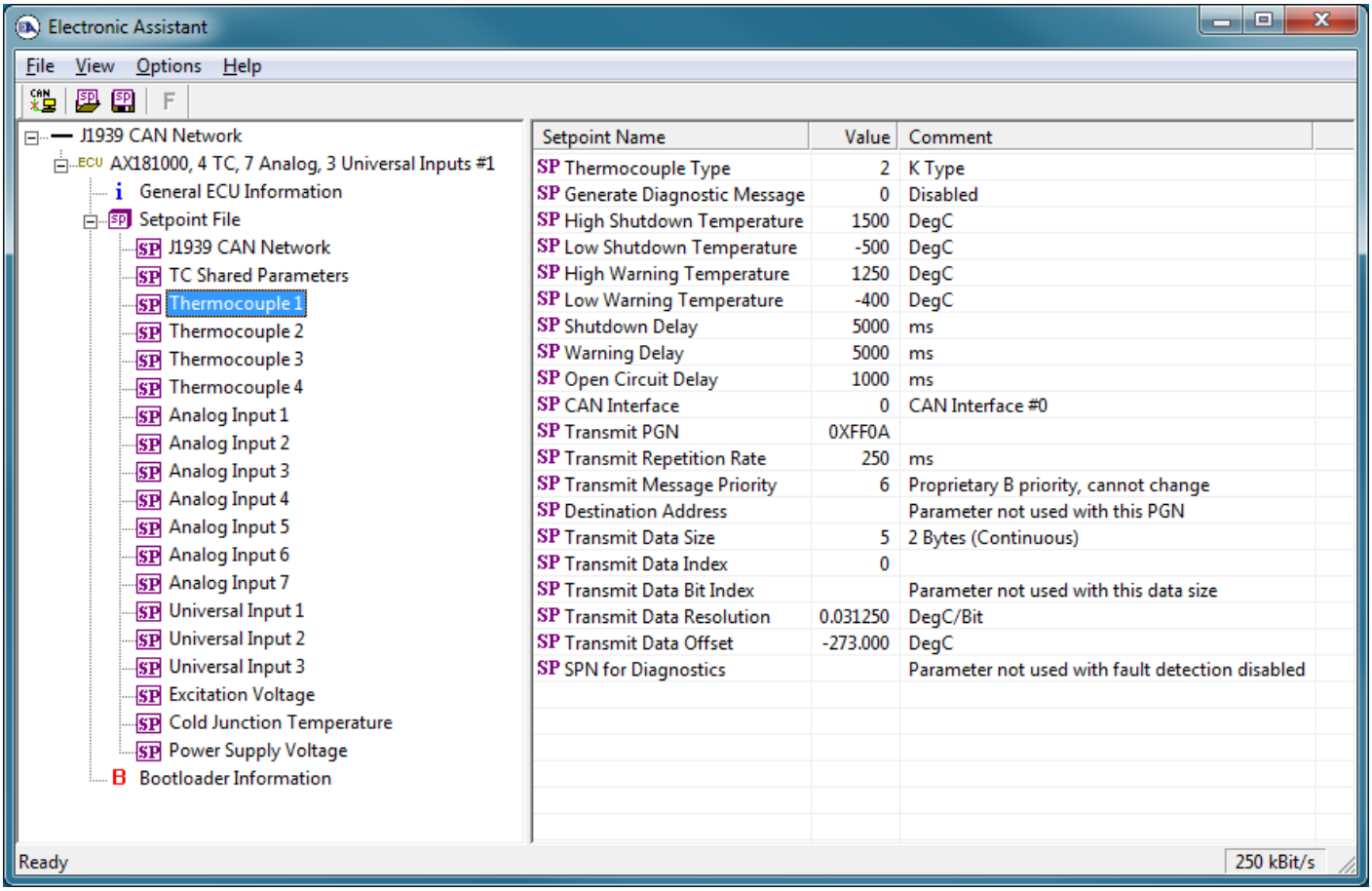


Figure 5 - Screen Capture of Default Thermocouple1 Setpoints

Name	Range	Default	Notes
Thermocouple Type	Drop List	K Type	Other types can be made available on request. Contact your Axiomatic sales rep.
Generate Diagnostic Message	Disabled, Enabled	Disabled	
High Shutdown Temperature	Low Warning Temperature to 1735ºC	1500	
Low Shutdown Temperature	-200ºC to High Warning Temperature	-500	
High Warning Temperature	Low Warning Temperature to 1735ºC	1250	
Low Warning Temperature	-200ºC to High Warning Temperature	-400	
Shutdown Delay	0 to 60 000ms	5000ms	
Warning Delay	0 to 60 000ms	5000ms	
Open Circuit Delay	0 to 60 000ms	1000ms	
CAN Interface	Drop List	CAN Interface #0	
Transmit PGN	0 to 65535	Different for each	See Section 3.3
Transmit Repetition Rate	0 to 60 000ms	250ms	
Transmit Message Priority	Cannot change	6	Proprietary B Priority
Destination Address	0 to 255	254 (0xFE, Null Address)	Not used by default
Transmit Data Size	Drop List	2 bytes	
Transmit Data Index	1 to 9-DataSize	0	
Transmit Data bit index	1 to 9-BitSize	0	Not used by default
Transmit Data Resolution	-10^6 to 10^6	0.031250 °C/Bit	
Transmit Data Offset	-10^4 to 10^4	-273.000 °C	
SPN for Diagnostics	1 to 524287		Not used by default

Table 10 - Thermocouple Input Setpoints

4.4. Analog Input Setpoints

The Analog inputs are defined in Section 1.1. Analog input setpoints include CAN message and fault detection related setpoints. Detailed information can be found in sections 1.5 and 1.4.

By default, Analog inputs are configured to accept a voltage input in the range of 0 to 5V. Analog inputs do not apply any software filtering. Fault detection and DTC generation are both disabled. Default "Transmit PGN" and "FMI for Event used in DTC" are defined in ***Table 12***.

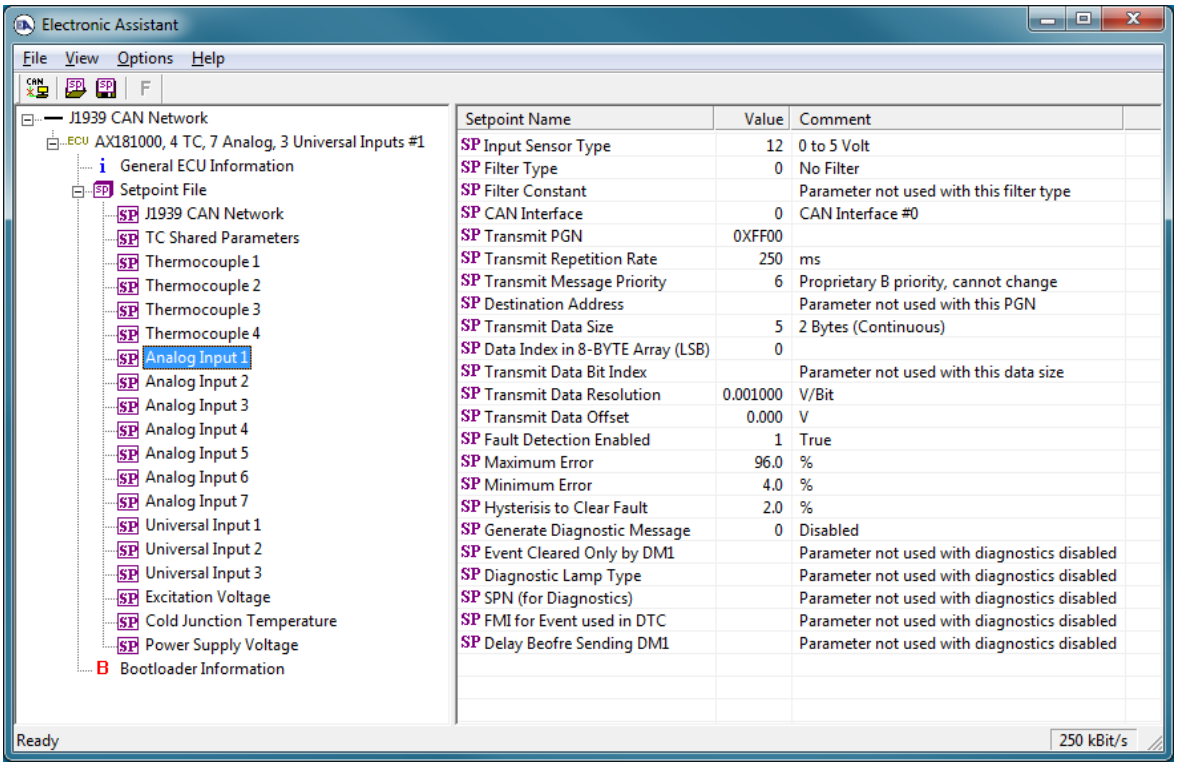


Figure 6 - Screen Capture of Default Analog Input 1 Setpoints

Name	Range	Default	Notes
Input Sensor Type	Drop List	0 to 5 Volt	
Filter Type	Drop List	No Filter	
Filter Constant	1 to 1 000	1	Not used by default
CAN Interface	Drop List	CAN Interface #0	
Transmit PGN	0 to 65535	Different for each	See Section 3.3
Transmit Repetition Rate	0 to 60 000ms	250ms	
Transmit Message Priority	Cannot change	6	Propietary B Priority
Destination Address	0 to 255	254 (0xFE, Null Address)	Not used by default
Transmit Data Size	Drop List	2 bytes	
Transmit Data Index	1 to 9-DataSize	0	
Transmit Data bit index	1 to 9-BitSize	Not used	Not used by default
Transmit Data Resolution	-10^6 to 10^6	0.0010000 unit/Bit	
Transmit Data Offset	-10^4 to 10^4	0	
Fault Detection Enabled	False, True	True	
Maximum Error	0 to 100	96.0	
Minimum Error	0 to 100	4.0	
Hysteresis to Clear Fault	0 to 100	2.0	
Generate Diagnostic Message	Disabled, Enabled	Disabled	
Event Cleared Only by DM1	False, True	False	
Diagnostic Lamp Type	Drop List	Amber Warning	Not used by default
SPN (for Diagnostics)	1 to 524287	Different for each	See Section 3.3
FMI for Event used in DTC	Drop List	4	
Delay Before Sending DM1	0 to 60,000ms	1000ms	

Table 11 - Analog Input Setpoints

4.5. Universal Input Setpoints

Universal inputs have very similar setpoint and defaults as analog inputs. Refer to Section 1.2. Analog input setpoints include CAN message and fault detection related setpoints. For detailed information on these setpoints refer to sections 1.5 and 1.4. Default “Transmit PGN” and “FMI for Event used in DTC” are defined in ***Table 13***.

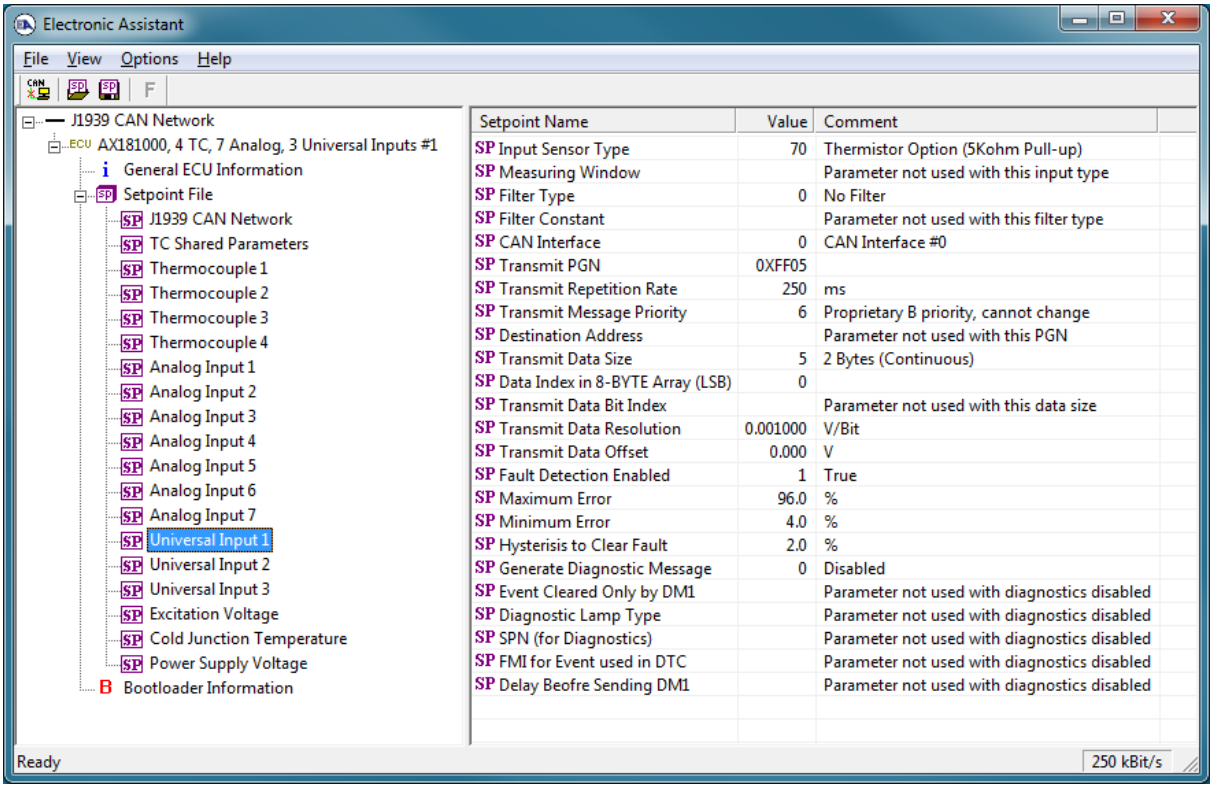


Figure 7 - Screen Capture of Default Universal Input 1 Setpoints

Name	Range	Default	Notes
Input Sensor Type	Drop List	0 to 5 Volt	
Measuring Window	100 to 1 000		Not used by default
Filter Type	Drop List	No Filter	
Filter Constant	1 to 1 000	1	Not used by default
CAN Interface	Drop List	CAN Interface #0	
Transmit PGN	0 to 65535	Different for each	See Section 3.3
Transmit Repetition Rate	0 to 60 000ms	250ms	
Transmit Message Priority	Cannot change	6	Proprietary B Priority
Destination Address	0 to 255	254 (0xFE, Null Address)	Not used by default
Transmit Data Size	Drop List	2 bytes	
Transmit Data Index	1 to 9-DataSize	0	
Transmit Data bit index	1 to 9-BitSize	Not used	Not used by default
Transmit Data Resolution	-10^6 to 10^6	0.0010000 unit/Bit	
Transmit Data Offset	-10^4 to 10^4	0	
Fault Detection Enabled	False, True	True	
Maximum Error	0 to 100	96.0	
Minimum Error	0 to 100	4.0	
Hysteresis to Clear Fault	0 to 100	2.0	
Generate Diagnostic Message	Disabled, Enabled	Disabled	
Event Cleared Only by DM1	False, True	False	
Diagnostic Lamp Type	Drop List	Amber Warning	Not used by default
SPN (for Diagnostics)	1 to 524287	Different for each	See Section 3.3
FMI for Event used in DTC	Drop List	4	
Delay Before Sending DM1	0 to 60,000ms	1000ms	

Table 12 - Universal Input Setpoints

4.6. Internal Input (Extra CAN Message) Setpoints

The three internal inputs Excitation Voltage, Cold Junction Temperature and Power Supply Voltage are associated with their own CAN messages. Setpoints of these inputs are all related in associated CAN message configuration. CAN message related setpoints are described in more detailed in section 1.5. Default “Transmit PGN” is defined in ***Table 14***.

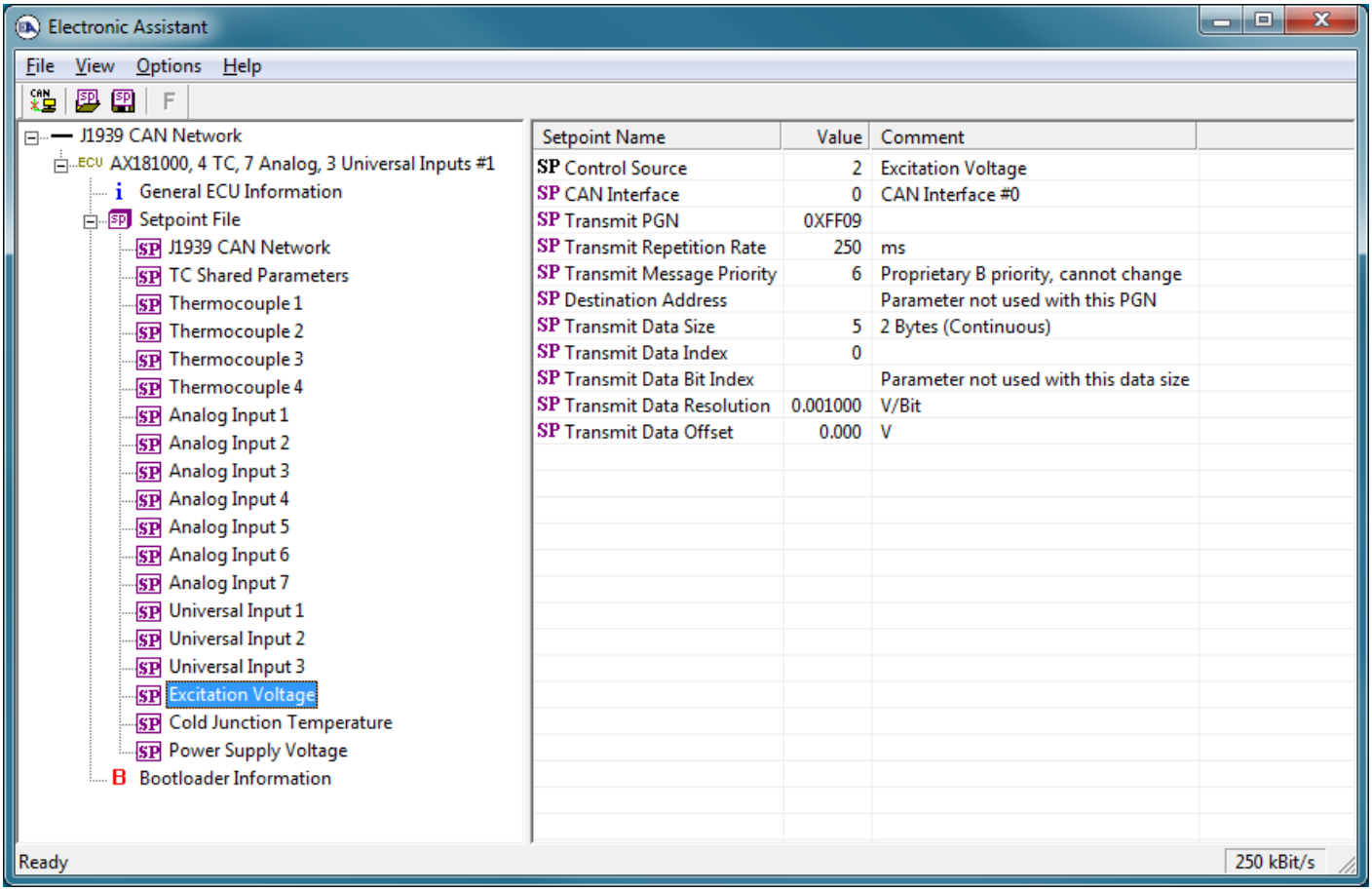


Figure 8 - Screen Capture of Default Excitation Voltage Setpoints

Name	Range	Default	Notes
Control Source	Read Only	Excitation Voltage, Cold Junction Temperature, Power Supply Voltage	
CAN Interface	Drop List	CAN Interface #0	
Transmit PGN	0 to 65535	0xFF09, 0xFF0F, 0xFF010	See Section 3.3
Transmit Repetition Rate	0 to 60 000ms	250ms	
Transmit Meassage Priority	Cannot change	6	Propietary B Priority
Destination Address	0 to 255	254 (0xFE, Null Address)	Not used by default
Transmit Data Size	Drop List	2 bytes	
Transmit Data Index	0 to 7-DataSize	0	
Transmit Data bit index	0 to 7-BitSize	Not used	Not used by default
Transmit Data Resolution	-10^6 to 10^6	0.0010000 unit/Bit	
Transmit Data Offset	-10^4 to 10^4	0	

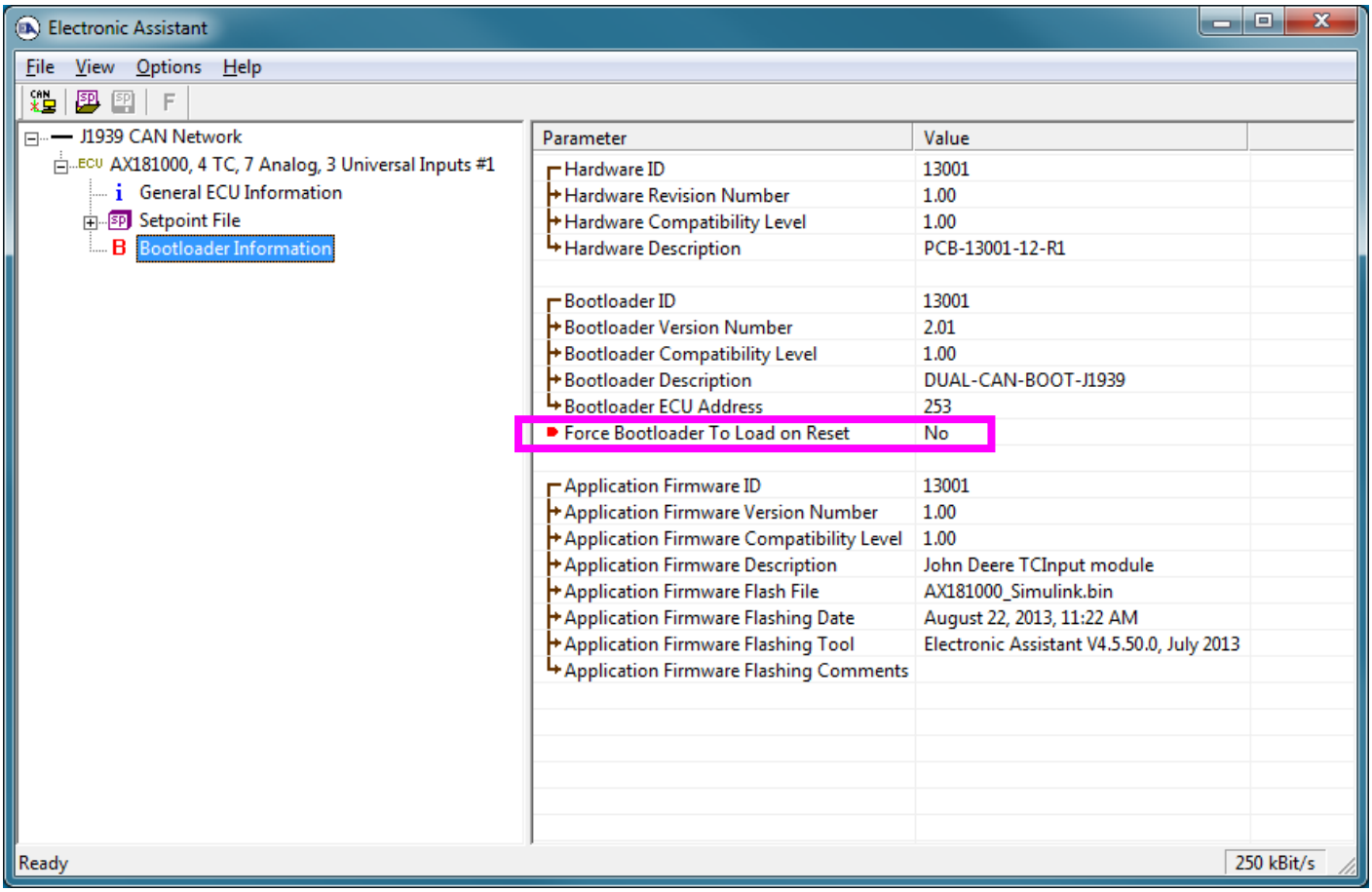
Table 13 - Internal Input (Extra CAN Message) Setpoints

5. REFLASHING OVER CAN WITH EA® BOOTLOADER

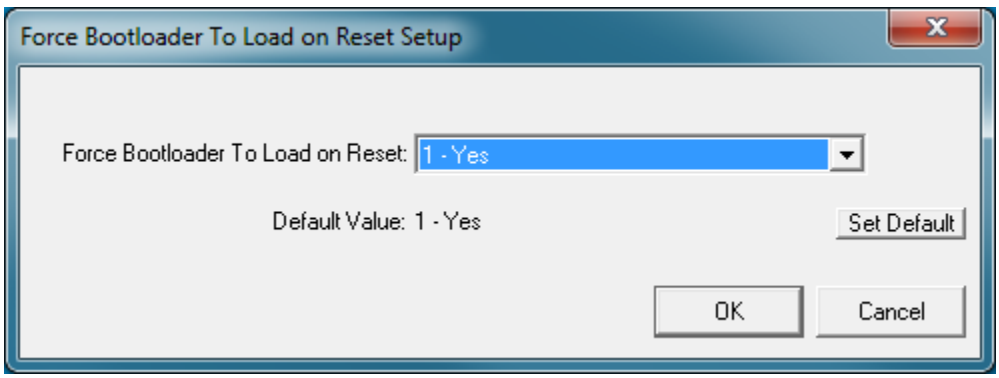
The AX181000 can be upgraded with new application firmware using the **Bootloader Information** section. This section details the simple step-by-step instructions to upload new firmware provided by Axiomatic onto the unit via CAN, without requiring it to be disconnected from the J1939 network.

Note: To upgrade the firmware use Electronic Assistant ® V4.10.78.0 or higher.

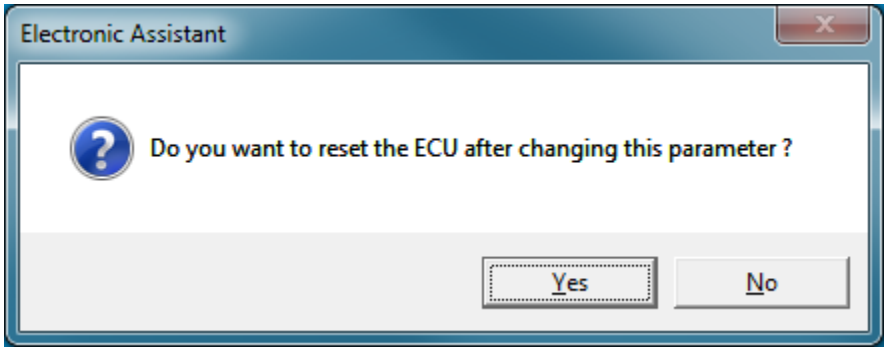
1. When EA first connects to the ECU, the **Bootloader Information** section will display the following information.



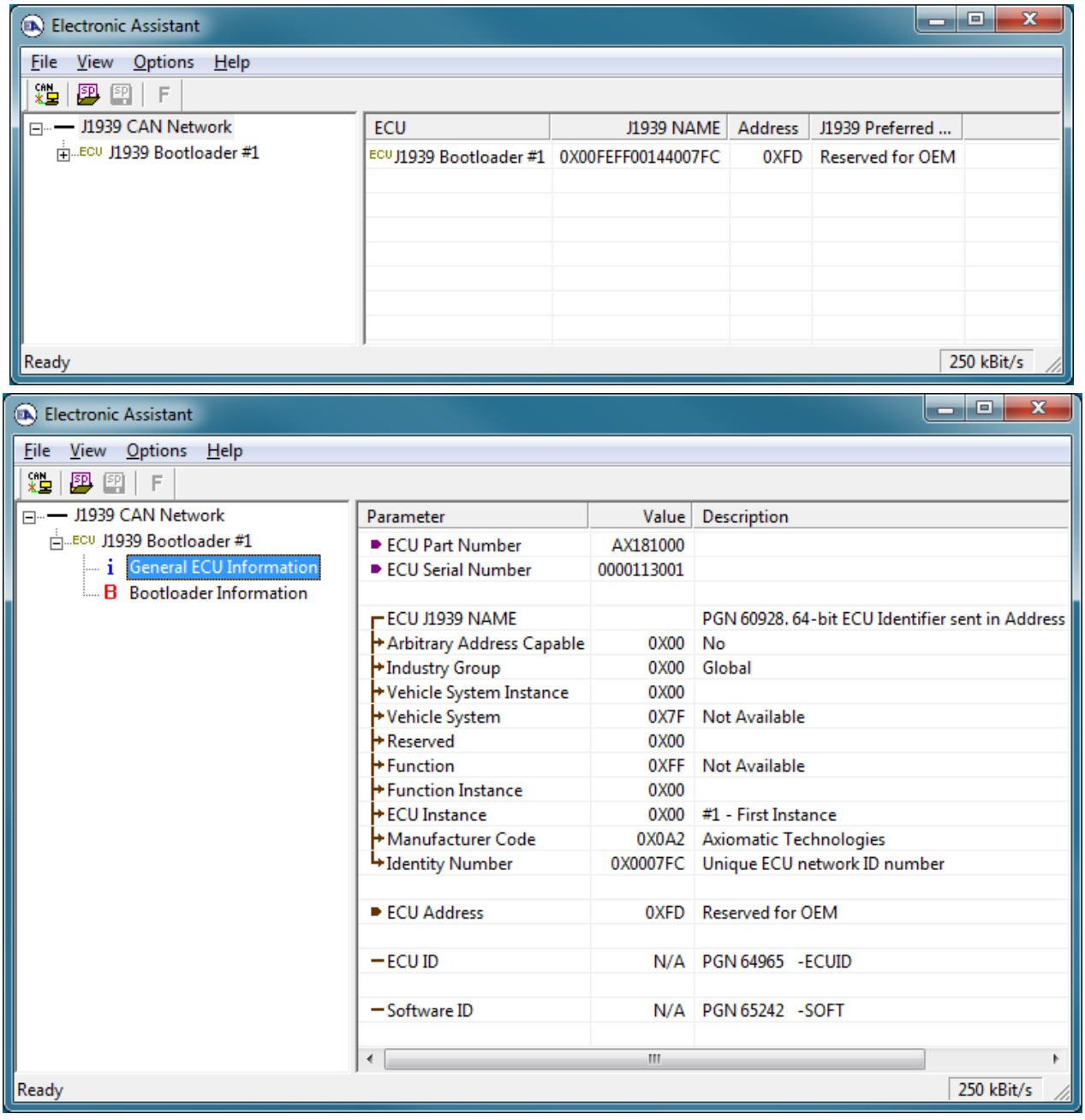
2. To use the bootloader to upgrade the firmware running on the ECU, change the variable **"Force Bootloader To Load on Reset**" to *Yes.*



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

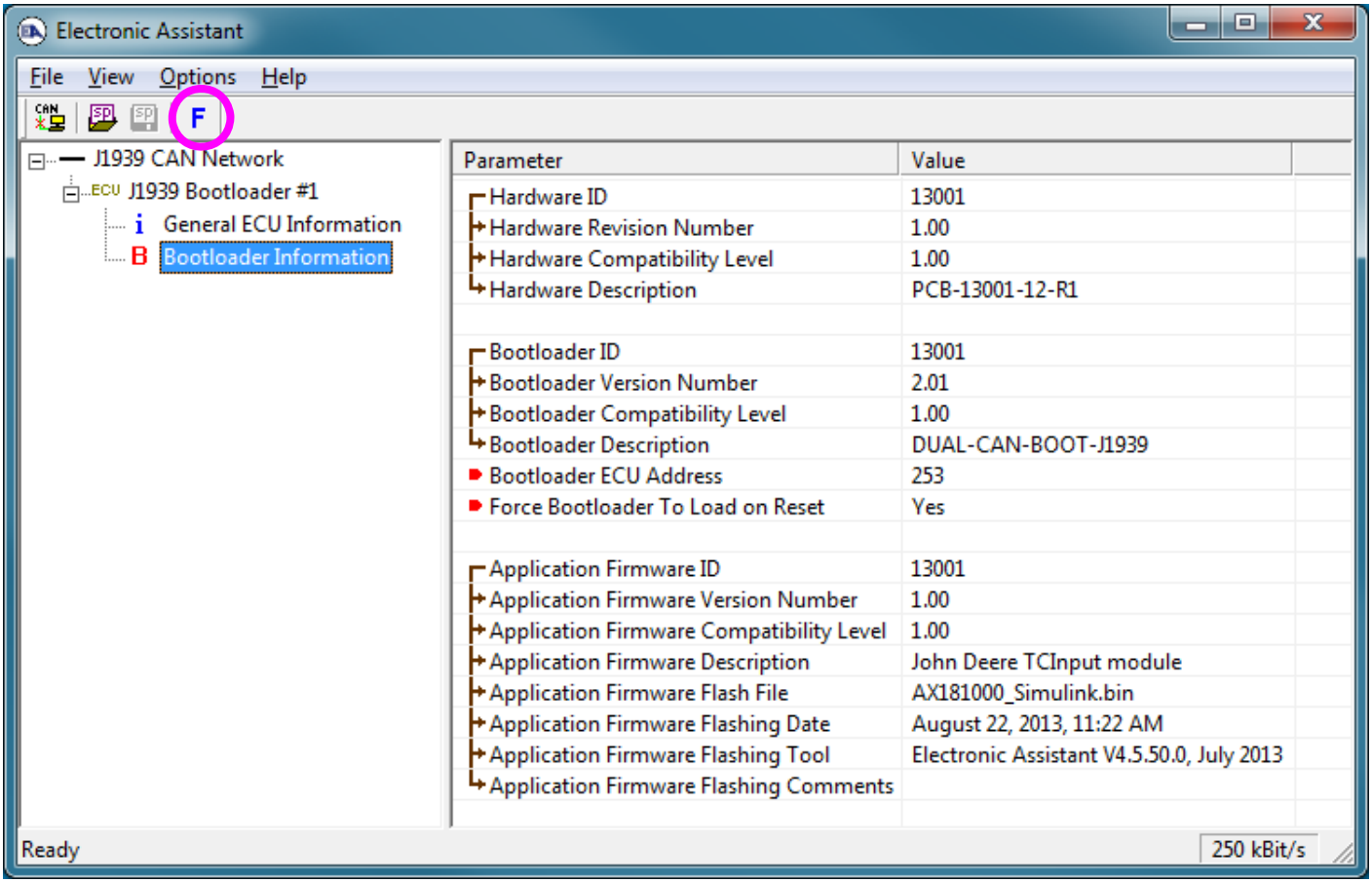


4. Upon reset, the ECU will no longer show up on the J1939 network as an AX181000 but rather as **J1939 Bootloader #1**.



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.

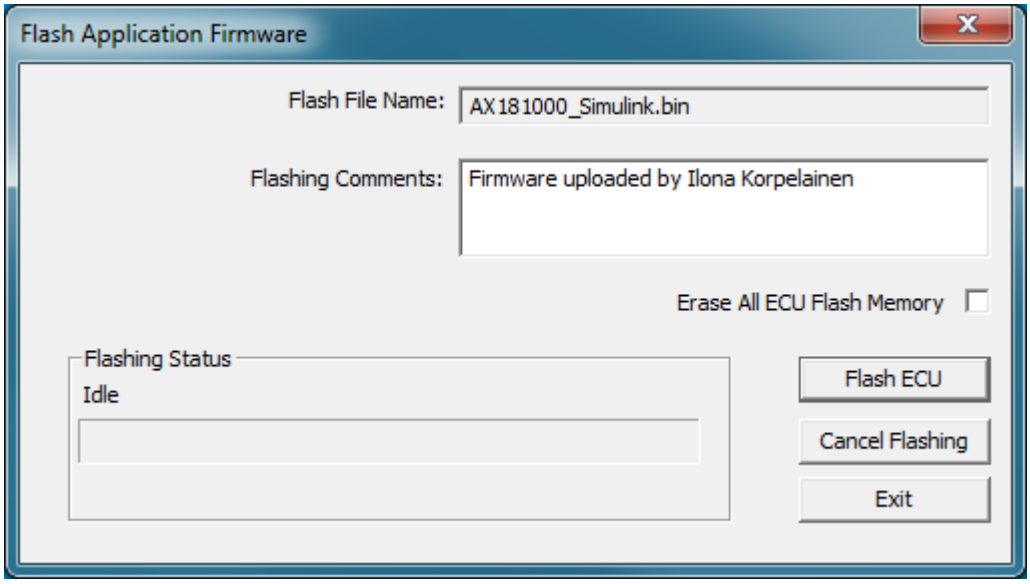
5. When the **Bootloader Information** section is selected, the same information is shown as when it was running the AX181000 firmware, but in this case the **F**lashing feature has been enabled.



6. Select the **F**lashing button and navigate to where you had saved the **AX181000_Simulink.bin** file sent from Axiomatic. (Note: only binary (.bin) files can be flashed using the EA tool.)

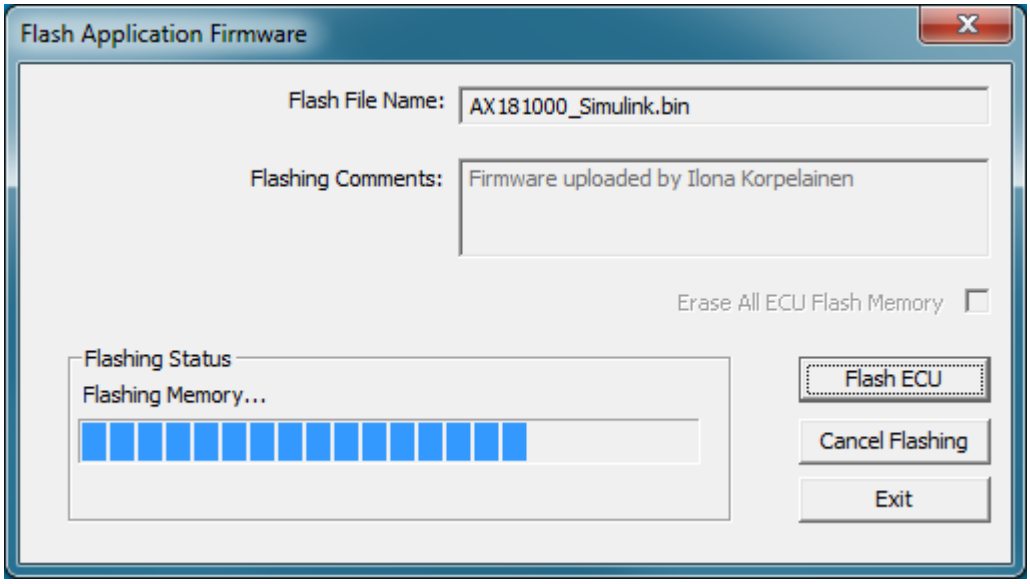
7. Once the Flash Application Firmware window opens, you can enter comments such as “Firmware upgraded by [Name]” if you so desire. This is not required, and you can leave the field blank if you do not want to use it.

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

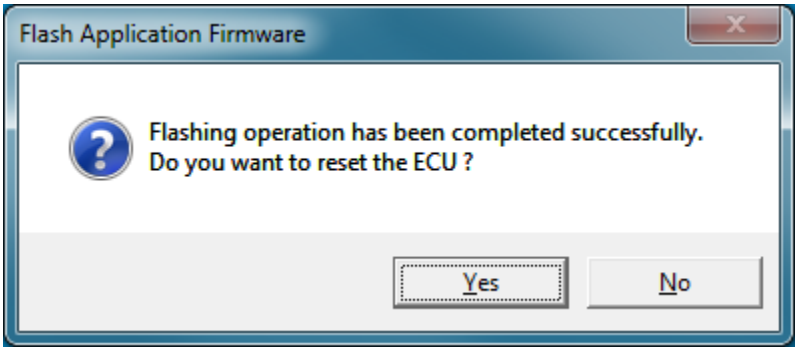


WARNING: Do not check the “Erase All ECU Flash Memory” box unless instructed to do so by your Axiomatic contact. Selecting this will erased ALL data stored in non-volatile flash, including the calibration done by Axiomatic during factory testing. It will also erase any configuration of the setpoints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

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



Once the firmware has finished uploading, a message will pop up indicating the successful operation. If you select to reset the ECU, the new version of the AX181000 application will start running, and the ECU will be identified as such by EA. Otherwise, The next time the ECU is power-cycled, the AX181000 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 B – Technical Specifications

Inputs

Power Supply Input	12 Vdc, 24 Vdc or 48 Vdc nominal (9…60 Vdc power supply range)
Protection	Reverse polarity protection Overvoltage protection is up to 120 V.
Inputs	4 Thermocouple Inputs 7 Analog Signal Inputs 3 Analog or Digital Signal Inputs User programmable (Refer to Table 1.0.) Inputs and Power are isolated from CAN.
Analog Grounds	10 are provided and they are common to each other.

User Programmable Options	
Thermocouple Inputs	Reads up to 4 Type J, K or T thermocouple inputs • Full channel to channel isolation and isolation from CAN line, other inputs and power supply • Cold junction compensation is provided. • Thermocouple input resolution is 0.1 °C. • Accuracy is +/-1 °C throughout the entire range of the thermocouple input. • 4 shield connections are provided. • The sample rate for the 4 channels is 300 ms.
Analog Input Functions	Voltage Input or Current Input
Voltage Input	0-5 V (Impedance 200 KOhm) 0-10V (Impedance 150 KOhm)
Current Input	0-20 mA (Impedance 125 Ohm) 4-20 mA (Impedance 125 Ohm)
Digital Input Functions	Discrete Input, PWM Input, Frequency Input
Digital Input Level	12V or 24V Threshold: Low <1.5 V High >3.5V
PWM Input	0 to 100% 100 Hz to 10 kHz Note: Universal Inputs 2 and 3 share a timer in Frequency and PWM mode, thus they should be set on same frequency range.
Frequency/RPM Input	0.5 Hz to 50 Hz; 10 Hz to 1 kHz; or 100 Hz to 10 kHz
Digital Input	Active High with pull-up (input 8 - 5kΩ, input 9 and input 10 – 1kΩ)
Input Accuracy	
Input Resolution	12-bit

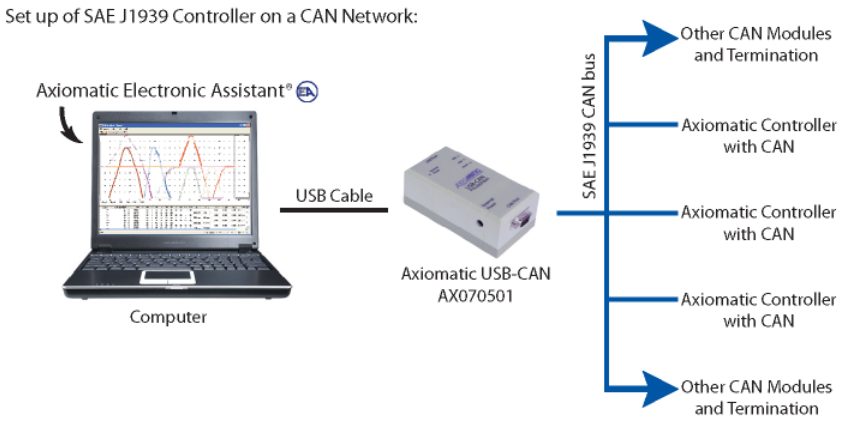
Input Type	Input Range	Accuracy
Voltage	0-5V	0.1%
	0-10V	0.1%
Current	0(4)-20mA	0.1%
Frequency	0.5Hz-50Hz	0.2%
	10Hz-1kHz	0.17%
	100Hz-10kHz	0.17%
PWM	Low Frequency	0.08%
	High Frequency	0.41%

Outputs

CAN bus	SAE J1939
Reference Voltages	7 provided +5V (30 mA)

General Specifications

Microprocessor	STM32F205 32-bit, 512 Kbyte flash memory
Typical Quiescent Current	84 mA@12Vdc; 52 mA@24Vdc
Response Time	3 mSec.
Control Logic	Standard embedded software is provided.
Communications	2 Isolated CAN ports (SAE J1939) 300 Vrms
Baud Rates	AX181000: 250 kbps AX181000-03: 500 kbps AX181000-04: 1 Mbps
Network Termination	It is necessary to terminate the network with external termination resistors. The resistors are 120 Ohm, 0.25W minimum, metal film or similar type. They should be placed between CAN_H and CAN_L terminals at both ends of the network.
User Interface	The Electronic Assistant®, P/N: **AX070502**, for *Windows* operating systems comes with a royalty-free license for use on multiple computers. It includes an Axiomatic USB-CAN converter to link the device's CAN port to a *Windows*-based PC.
Operating Conditions	-40 to 85 °C (-40 to 185 °F)
Storage Temperature	-55 to 125 °C (-67 to 257°F)
Protection	IP67
Compliance	CE mark for EMC Directive and RoHS Directive
Vibration	Random Vibration: 7.68 Grms peak Sinusoidal Component: 10 g peak Based on MIL-STD-202G, Methods 204G, 214A and 213B
Weight	1.30 lb. (0.59 kg)
Packaging	High Temperature Nylon housing, TE Deutsch P/N: EEC-5X650B 4.03 x 4.25 x 1.68 inches 102.44 x 107.96 x 42.67 mm L x W x H including integral connector Refer to the dimensional drawing.
Electrical Connections	48 pin Deutsch IPD connector P/N: DT13-48PABCD-R015 Mates with: TE Deutsch P/N's DT06-12SA Plug, DT 12 Way A Key DT06-12SB Plug, DT 12 Way B Key DT06-12SC Plug, DT 12 Way C Key DT06-12SD Plug, DT 12 Way D Key



OUR PRODUCTS

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CAN bus Controls, Gateways

CAN/Wifi, CAN/Bluetooth

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Engine Temperature Scanners

Ethernet/CAN Converters

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Machine Controls

Motor Controls

PID Controls

Position Sensors, Angle Measurement Inclinometers, Gyroscopes

Power Supplies

PWM Signal Converters/Isolators

Resolver Signal Conditioners

Service Tools

Signal Conditioners

Strain Gauge CAN Controls

Surge Suppressors

OUR COMPANY

Axiomatic provides electronic machine controls, components, and systems to the off-highway, commercial vehicle, electric vehicle, power generator set, material handling, renewable energy and industrial OEM markets.

We provide efficient, innovative solutions that focus on adding value for our customers.

We emphasize service and partnership with our customers, suppliers, and employees to build long term relationships and mutual trust.

QUALITY DESIGN AND MANUFACTURING

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SERVICE

All products to be returned to Axiomatic require a Return Materials Authorization Number (RMA#).

Please provide the following information when requesting an RMA number:

- Serial number, part number
- Axiomatic invoice number and date
- Hours of operation, description of problem
- Wiring set up diagram, application
- Other comments as needed

When preparing the return shipping paperwork, please note the following. The commercial invoice for customs (and packing slip) should state the harmonized international HS (tariff code), valuation and return goods terminology, as shown in italics below. The value of the units on the commercial invoice should be identical to their purchase price.

Goods Made In Canada (or Finland)
Returned Goods for Warranty Evaluation, HS: 9813.00
Valuation Identical Goods
Axiomatic RMA#

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CONTACTS

Axiomatic Technologies Corporation
5915 Wallace Street
Mississauga, ON
CANADA L4Z 1Z8
TEL: +1 905 602 9270
FAX: +1 905 602 9279
www.axiomatic.com

Axiomatic Technologies Oy
Höytämöntie 6
33880 Lempäälä
FINLAND
TEL: +358 103 375 750
FAX: +358 3 3595 660
www.axiomatic.fi