USER MANUAL UMAX184000
UMAX184000-01
UMAX184000-02

12 RTD CHANNELS, 4 UNIVERSAL SIGNAL INPUTS CAN, SAE J1939

USER MANUAL

P/N: AX184000

P/N: AX184000-01 – J1939 500kbits/s Baud Rate

P/N: AX184000-02 – Custom J1939 Baud Rate, 1Mbits/s

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VERSION HISTORY

Version	Date	Author	Modification
1.00	Nov 7, 2016	Ilona Korpelainen	Initial Draft
1.01	Nov 9, 2016	Ilona Korpelainen	Installation Instructions updated
-	Dec. 5, 2016	Amanda Wilkins	Technical Specification updated
1.02	June 9, 2017	Amanda Wilkins	Updated pin out and drawing Added vibration compliance
1.02A	Sep 26, 2017	Ilona Korpelainen	Added note about high speed versions
2.00	June 27, 2019	Ilona Korpelainen	Firmware v.2.00 - Math Blocks added - Lookup Tables added
-	Sep 26, 2019	Ilona Korpelainen	- Control Constant Data added
2.01	August 29, 2023	Kiril Mojsov	Performed Legacy Updates

ACRONYMS

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

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

TABLE OF CONTENTS

REFERENCES

J1939	Recommended Practice for a Serial Control and Communications Vehicle Network, SAE, April 2011
J1939/21	Data Link Layer, SAE, December 2010
J1939/71	Vehicle Application Layer, SAE, March 2011
J1939/73	Application Layer-Diagnostics, SAE, February 2010
J1939/81	Network Management, SAE, May 2003
TDAX184000	Technical Datasheet, 12-Channel RTD Scanner with 4 Universal Inputs and J1939 CAN, Axiomatic Technologies 2016
UMAX07050x	User Manual V5.13.85, Axiomatic Electronic Assistant and USB-CAN, Axiomatic Technologies

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

NOTE: This product is supported by Axiomatic Electronic Assistant V5.13.90 and higher.

1. OVERVIEW OF CONTROLLER

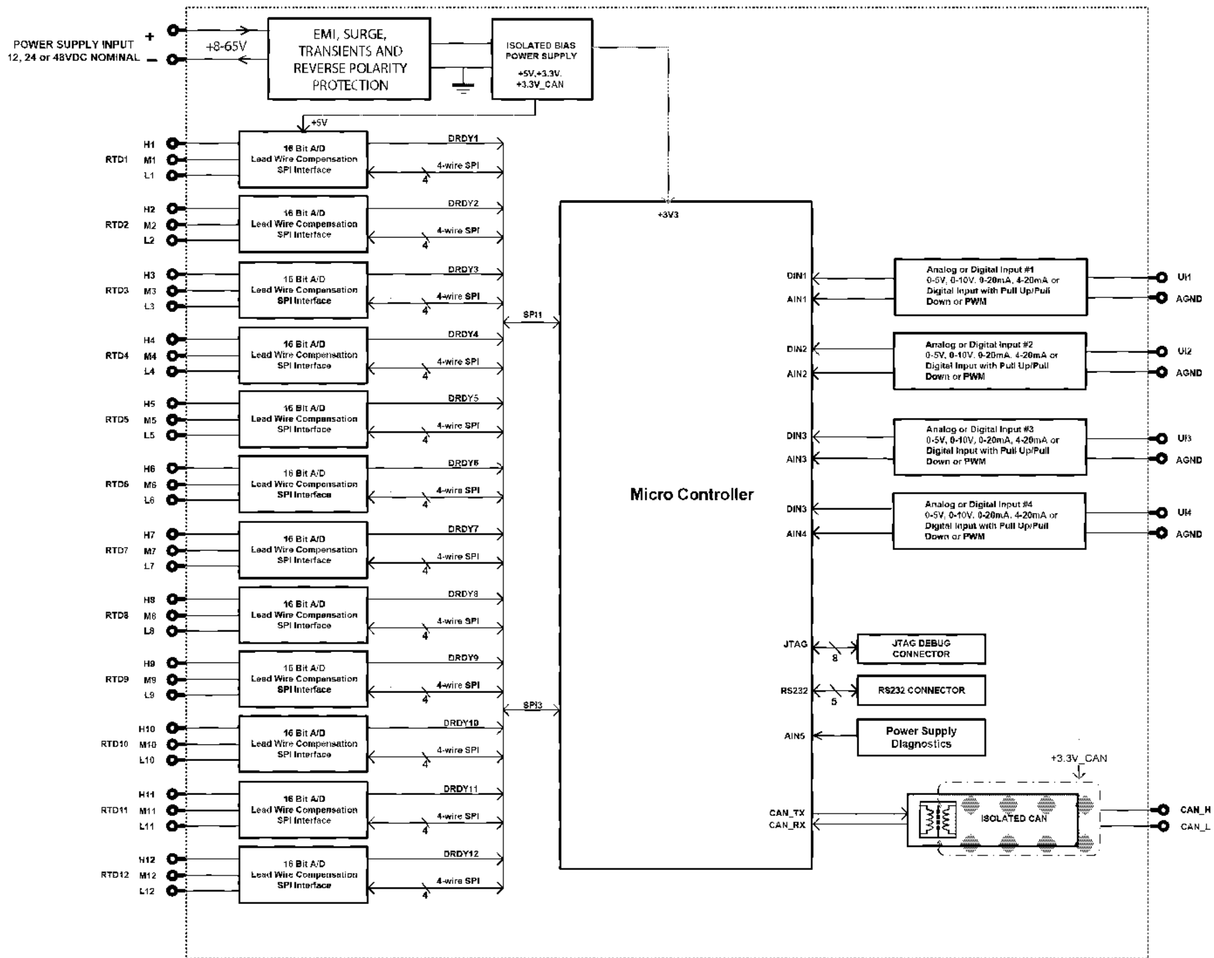


Figure 1 – AX18400 Block Diagram

The 12 RTD Scanner monitors 12 3-wire or 2-wire RTD inputs and provides the temperature information over a SAE J1939 CAN bus. All channels of temperature data are automatically sent over the CAN bus when power is applied with no additional programming or configuration needed. In addition, four configurable universal signal inputs are provided.

The controller has four Universal inputs that can be configured to measure analog voltage or current, frequency/PMW or digital signal. Measured input data can be sent to a SAE J1939 CAN Network.

The *Windows*-based Axiomatic Electronic Assistant (EA) is used to configure the controller via a 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 12 RTD Scanner. Throughout this document, Axiomatic EA setpoint names are referred to with bolded text in double-quotes, and the setpoint option is referred to with italicized text in single-quotes. For example, “**Input Sensor Type**” setpoint set to option ‘*Voltage 0 to 5V*’.

In this document, the configurable properties of the ECU are divided into function blocks, namely RTD Input Function Block, Averaging, Universal Input Function Block, Math Function Block, Lookup Table Function Block, Diagnostic Function Block, CAN Transmit Message Function Block and CAN Receive Message Function Block. These function blocks are presented in detail in next subchapters.

The 12 RTD Scanner can be ordered using the following part numbers depending on the application.

AX184000	Controller with the default J1939 baud rate (250kbits/s).
AX184000-01	Controller with the 500kbits/s J1939 baud rate.
AX184000-02	Controller with a custom 1Mbits/s J1939 baud rate.

1.1. RTD Input Function Blocks

There are twelve RTD channels on the AX184000, each with three pins at the connector for 3-wire and 2-wire connections. Resistance of the RTD is determined with dedicated onboard ADCs. Hardware wire lead resistance compensation is utilized in 3-wire connection.

The resistance measurement is implemented by deriving both reference voltage, for the ADC, and measurement excitation voltage from the same source, thus errors common to both voltages, such as temperature drift and noise, cancel out each other.

In 3-wire connection two closely matched currents flow from RTD_H and RTD_M pins to RTD_L pin. First current flows through wire lead 1, RTD and lead 3. Second current flows through wire lead 2 and wire lead 3. Typically, all three leads of a 3-wire RTD have same length and, thus, the same lead resistance. As both currents have the same value, the circuit implements hardware compensation for the lead wire resistance and the differential voltage between RTD_H and RTD_M pins depends only on the value of the excitation current and RTD resistance.

In 2-wire connection the RTD is connected to RTD_H and RTD_L pins. Excitation current flows from RTD_H pin through wire lead 1, RTD and lead 3. Thus, the lead wire resistance effects on measured voltage. In 2-wire connection any lead wire resistance compensation can be done only by calibration.

Temperature value of the RDT channel is calculated from the measured resistance by using Callendar Van Dusen equation. According to IEC751, the non-linearity of the platinum thermometer can be expressed as:

$R_t = R_0[1 + At + Bt^2 + C(t - 100)t^3]$ in which C is only applicable when t < 0 °C.

The coefficients A, B and C for the standard sensor are stated at IEC751.

The AX18400 has five predefined Callendar Van Dusen Coefficient sets. Predefined coefficient set is selected with “**RTD Coefficient**” setpoint. “**RTD Coefficient**” setpoint options are listen in Table 1 and associated Callendar Van Dusen Constants are listed in Table 2. The ‘User Defined’ option allows Callendar Van Dusen constants to be manually set to whatever is defined for the connected sensor.

0	*IEC 0.00385*
1	*JIS 0.003916*
2	*US 0.003902*
3	*Legacy 0.003920*
4	*SAMA 0.003923*
5	*User Defined*

Table 1 – RTD Coefficient Options

	Constant A (E-03)	**Constant B (E-07)**	**Constant C (E-012)**
0	*3.90830*	*-5.77500*	*-4.18301*
1	*3.974673*	*-5.89730*	*-4.35300*
2	*3.96*	*-5.93*	*-4.30*
3	*3.9848*	*-5.870*	*-4.000*
4	*3.981531*	*-5.853116*	*-4.354530*
5	*User Defined*	*User Defined*	*User Defined*

Table 2 – Predefined Callendar Van Dusen Constants

Temperature SPN for the RTD channel can be selected with “Temperature Suspect Parameter Number” setpoint. The SPN drop list includes all temperature SPNs from the J1939-71 standard published up to January of 2009. List of supported SPNs and associated size, PGN, Transmit rate, index and priority are listed in Table 3.

Each SPN that is supported by the 12 RTD Scanner has a predefined size (1 or 2 bytes) and consequently resolution and offset, associated with it.

One-byte parameters have a resolution of 1ºC/bit and an offset of -40ºC, resulting in a measurable range of -40ºC to 210ºC. Temperatures outside of that range are sent as either the minimum or maximum value allowable.

Two-byte parameters have a resolution of 0.03125ºC/bit and an offset of -273ºC, resulting in a measurable range of -273ºC to 1735ºC. Temperatures outside of that range are sent as either the minimum or maximum value allowable.

When RTD Input block is associated with CAN Transmit (Chapter 1.8) or Diagnostic block (Chapter 1.5), parameters from the SPN list are loaded as default values for the block in question, therefore it is recommended to select SPNs for the RTD channels prior to adjusting Diagnostic and CAN Transmit message setpoints. If an SPN is not supported by the drop list, the user can select a zero SPN, which then allows them to define the SPN and PGN per application requirements.

“RTD Offset” setpoint allows user to define small calibration offset. Offset is defined in Ohms and added to the measured RTD resistance before conversion to Temperature.

In addition to Diagnostic Blocks (Chapter 1.5), which when associated to RTD input allow double over or under temperature detection, there is open circuit detection associated with each RTD channel. Each ADC monitors its reference voltage every 1s. If reference voltage is not present an open circuit fault is flagged. If diagnostic message generation is enabled, by setting **"Open Circuit, Generate Diagnostic Message"** as '*True'*, diagnostic message is sent after delay time defined with **"Open Circuit Delay"** setpoint. In case channel the channel in question is associated with a CAN Transmit error indicator (0xFE, 0xFEFF, 0xFEFFFF) is used instead of measurement data. Open Circuit fault is associated with '*FMI 5 – Current Below Normal or Open Circuit'* and '*Amber Warning Lamp'*.

The 12 RTD Scanner keeps a log of the last 10 scans of raw ADC measurement data. If the raw data has not changed after 10 scans, the scanner will stop broadcasting the 'frozen' data, and start sending the error indicator (0xFE, 0xFEFF, 0xFEFFFF) instead. No DTC is associated with this condition, so the DM11 will not be changed should this happen on one or more channels. This is a redundant safety feature, and should never occur.

ADC sample rate is 50ms.

SPN	Description	Size (Bytes)	PGN	Rate	Index	Priority
0	User Defined	0	0	0	0	0
52	Engine Intercooler Temperature	1	65262	1000	7	6
75	Steering Axle Temperature	1	65273	1000	1	6
79	Road Surface Temperature	2	65269	1000	7	6
90	Power Takeoff Oil Temperature	1	65264	100	1	6
105	Engine Intake Manifold 1 Temperature	1	65270	500	3	6
110	Engine Coolant Temperature	1	65262	1000	1	6
120	Hydraulic Retarted Oil Temperature	1	65275	1000	2	6
169	Cargo Ambient Temperature	2	65276	1000	5	6
170	Cab Interior Temperature	2	65269	1000	2	6
171	Ambient Air Temperature	2	65269	10000	4	6
172	Engine Air Inlet Temperature	1	65269	1000	6	6
173	Engine Exhaust Gas Temperature	2	65270	500	6	6
174	Engine Fuel Temperature 1	1	65262	1000	2	6
175	Engine Oil Temperature 1	2	65262	1000	3	6
176	Engine Turbocharger Oil Temperature	2	65262	1000	5	6
177	Transmission Oil Temperature	2	65272	1000	5	6
242	Tire Temperature	2	65268	10000	3	6
412	Engine Exhaust Gas Recirculation 1 Temperature	2	65188	1000	7	6
441	Auxiliary Temperature 1	1	65164	0	1	7
442	Auxiliary Temperature 2	1	65164	0	2	7
578	Drive Axle Temperature	1	65273	1000	3	6
1122	Engine Alternator Bearing 1 Temperature	1	65191	1000	1	7
1123	Engine Alternator Bearing 2 Temperature	1	65191	1000	2	7
1124	Engine Alternator Winding 1 Temperature	1	65191	1000	3	7
1125	Engine Alternator Winding 2 Temperature	1	65191	1000	4	7
1126	Engine Alternator Winding 3 Temperature	1	65191	1000	5	7
1131	Engine Intake Manifold 2 Temperature	1	65189	500	1	6
1132	Engine Intake Manifold 3 Temperature	1	65189	500	2	6

1133	Engine Intake Manifold 4 Temperature	1	65189	500	3	6
1135	Engine Oil Temperature 2	2	65188	1000	1	6
1136	Engine ECU Temperature	2	65188	1000	3	6
1137	Engine Exhaust Gas Port 1 Temperature	2	65187	1000	1	6
1138	Engine Exhaust Gas Port 2 Temperature	2	65187	1000	3	6
1139	Engine Exhaust Gas Port 3 Temperature	2	65187	1000	5	6
1140	Engine Exhaust Gas Port 4 Temperature	2	65187	1000	7	6
1141	Engine Exhaust Gas Port 5 Temperature	2	65186	1000	1	6
1142	Engine Exhaust Gas Port 6 Temperature	2	65186	1000	3	6
1143	Engine Exhaust Gas Port 7 Temperature	2	65186	1000	5	6
1144	Engine Exhaust Gas Port 8 Temperature	2	65186	1000	7	6
1145	Engine Exhaust Gas Port 9 Temperature	2	65185	1000	1	6
1146	Engine Exhaust Gas Port 10 Temperature	2	65185	1000	3	6
1147	Engine Exhaust Gas Port 11 Temperature	2	65185	1000	5	6
1148	Engine Exhaust Gas Port 12 Temperature	2	65185	1000	7	6
1149	Engine Exhaust Gas Port 13 Temperature	2	65184	1000	1	6
1150	Engine Exhaust Gas Port 14 Temperature	2	65184	1000	3	6
1151	Engine Exhaust Gas Port 15 Temperature	2	65184	1000	5	6
1152	Engine Exhaust Gas Port 16 Temperature	2	65184	1000	7	6
1153	Engine Exhaust Gas Port 17 Temperature	2	65183	1000	1	6
1154	Engine Exhaust Gas Port 18 Temperature	2	65183	1000	3	6
1155	Engine Exhaust Gas Port 19 Temperature	2	65183	1000	5	6
1156	Engine Exhaust Gas Port 20 Temperature	2	65183	1000	7	6
1157	Engine Main Bearing 1 Temperature	2	65182	1000	1	6
1158	Engine Main Bearing 2 Temperature	2	65182	1000	3	6
1159	Engine Main Bearing 3 Temperature	2	65182	1000	5	6
1160	Engine Main Bearing 4 Temperature	2	65182	1000	7	6
1161	Engine Main Bearing 5 Temperature	2	65181	1000	1	6
1162	Engine Main Bearing 6 Temperature	2	65181	1000	3	6
1163	Engine Main Bearing 7 Temperature	2	65181	1000	5	6
1164	Engine Main Bearing 8 Temperature	2	65181	1000	7	6
1165	Engine Main Bearing 9 Temperature	2	65180	1000	1	6
1166	Engine Main Bearing 10 Temperature	2	65180	1000	3	6
1167	Engine Main Bearing 11 Temperature	2	65180	1000	5	6
1172	Engine Turbocharger 1 Compressor Inlet Temperature	2	65178	1000	7	6
1173	Engine Turbocharger 2 Compressor Inlet Temperature	2	65178	1000	1	6
1174	Engine Turbocharger 3 Compressor Inlet Temperature	2	65178	1000	3	6
1175	Engine Turbocharger 4 Compressor Inlet Temperature	2	65178	1000	5	6
1180	Engine Turbocharger 1 Turbine Inlet Temperature	2	65176	1000	1	6
1181	Engine Turbocharger 2 Turbine Inlet Temperature	2	65176	1000	3	6
1182	Engine Turbocharger 3 Turbine Inlet Temperature	2	65176	1000	5	6

1183	Engine Turbocharger 4 Turbine Inlet Temperature	2	65176	1000	7	6
1184	Engine Turbocharger 1 Turbine Outlet Temperature	2	65175	1000	1	6
1185	Engine Turbocharger 2 Turbine Outlet Temperature	2	65175	1000	3	6
1186	Engine Turbocharger 3 Turbine Outlet Temperature	2	65175	1000	5	6
1187	Engine Turbocharger 4 Turbine Outlet Temperature	2	65175	1000	7	6
1212	Engine Auxiliary Coolant Temperature	1	65172	500	2	6
1636	Engine Intake Manifold 1 Air Temperature (High Resolution)	2	65129	1000	1	6
1637	Engine Coolant Temperature (High Resolution)	2	65129	1000	3	6
1638	Hydraulic Temperature	1	65128	1000	1	6
1687	Auxilary Heater Outlet Coolant Temperature	1	65133	1000	1	6
1688	Auxilary Heater Input Air Temperature	1	65133	1000	2	6
1800	Battery 1 Temperature	1	65104	1000	1	6
1801	Battery 1 Temperature	1	65104	1000	2	6
1802	Engine Intake Manifold 5 Temperature	1	65189	1000	4	6
1803	Engine Intake Manifold 6 Temperature	1	65189	500	5	6
2433	Engine Exhaust Gas Temperature - Right Manifold	2	65031	500	1	6
2434	Engine Exhaust Gas Temperature - Left Manifold	2	65031	500	3	6
2629	Engine Turbocharger 1 Compressor Outlet Temperature	2	64979	500	1	6
2630	Engine Charge Air Cooler 1 Outlet Temperature	2	65129	1000	7	6
2799	Engine Turbocharger 2 Compressor Outlet Temperature	2	64979	1000	3	6
2800	Engine Turbocharger 3 Compressor Outlet Temperature	2	64979	1000	5	6
2801	Engine Turbocharger 4 Compressor Outlet Temperature	2	64979	1000	7	6
2986	Engine Intake Valve Actuation System Oil Temperature	2	65129	1000	5	6
3031	Aftertreatment 1 SCR Catalyst Tank Temparature	1	65110	1000	2	6
3241	Aftertreatment 1 Exhaust Gas Temperature 1	2	64948	500	1	6
3242	Aftertreatment 1 Diesel Particulate Filter Intake Gas Temparature		64948	500	3	6
3245	Aftertreatment 1 Exhaust Gas Temparature 3	2	64947	500	1	6
3246	Aftertreatment 1 Diesel Particulate Filter Outlet Gas Temparature	2	64947	500	3	6
3249	Aftertreatment 1 Exhaust Gas Temperature 2	2	64946	500	1	6
3250	Aftertreatment 1 Diesel Particulate Filter Intermediate Gas Temparature	2	64946	500	3	6

3275	Aftertreatment 2 Exhaust Gas Temperature 1	2	64945	500	1	6
3276	Aftertreatment 2 Diesel Particulate Filter Intake Gas Temperature	2	64945	500	3	6
3279	Aftertreatment 2 Exhaust Gas Temperature 3	2	64944	500	1	6
3280	Aftertreatment 2 Diesel Particulate Filter Outlet Gas Temperature	2	64944	500	3	6
3283	Aftertreatment 2 Exhaust Gas Temperature 2	2	64943	500	1	6
3284	Aftertreatment 2 Diesel Particulate Filter Intermediate Gas Temperature	2	64943	500	3	6
3468	Engine Fuel Temperature 2	1	64930	500	5	4
3515	Aftertreatment 1 SCR Catalyst Reagent Temparature 2	1	64923	1000	1	6
3823	Transmission Torque Converter Oil Outlet Temparature	2	64917	1000	2	6
3831	Aftertreatment 1 Secondary Air Temparature	2	64877	500	3	6
3834	Aftertreatment 2 Secondary Air Temparature	2	64876	500	3	6
4076	Engine Coolant Temparature 2	1	64870	1000	1	6
4151	Engine Exhaust Gas Temperature Average	2	64851	500	1	5
4152	Engine Exhaust Gas Temperature Average - Bank 2	2	64851	500	3	5
4153	Engine Exhaust Gas Temperature Average - Bank 1	2	64851	500	5	5
4193	Engine Coolant Pump Outlet Temperature	1	64870	1000	2	6
4288	Engine Exhaust Valve Actuation System Oil Temparature	2	64870	1000	4	6
4289	Aftertreatment 1 Three Way Catalytic Converter Intake Gas Temparature	2	64838	500	1	6
4290	Aftertreatment 1 Three Way Catalytic Converter Outlet Gas Temparature	2	64838	500	3	6
4295	Aftertreatment 2 Three Way Catalytic Converter Intake Gas Temparature	2	64837	500	1	6
4296	Aftertreatment 2 Three Way Catalytic Converter Outlet Gas Temparature	2	64837	500	3	6
4337	Aftertreatment 1 SCR Dosing Reagent Temparature	1	64833	500	3	6
4360	Aftertreatment 1 SCR Catalyst Intake Gas Temparature	2	64830	500	1	6
4363	Aftertreatment 1 SCR Catalyst Outlet Gas Temparature	2	64830	500	4	6
4368	Aftertreatment 1 SCR Catalyst Reagent Tank 2 Temparature	1	64829	1000	2	6
4390	Aftertreatment 2 SCR Dosing Reagent Temparature	1	64827	500	3	6
4413	Aftertreatment 2 SCR Catalyst Intake Gas Temparature	2	64824	500	1	6
4415	Aftertreatment 2 SCR Catalyst Outlet Gas Temparature	2	64824	500	4	6
4420	Aftertreatment 2 SCR Catalyst Reagent Temparature 2	1	64822	1000	1	6

4427	Aftertreatment 2 SCR Catalyst Tank Temparature	1	64821	1000	2	6
4434	Aftertreatment 2 SCR Catalyst Reagent Tank 2 Temparature	1	64820	1000	2	6
4750	Engine Exhaust Gas Recirculation 1 (EGR1) Cooler Intake Temparature	2	64879	0	3	6
4753	Aftertreatment 1 Gas Oxidation Catalyst Intake Gas Temparature	2	64802	500	1	6
4754	Aftertreatment 1 Gas Oxidation Catalyst Outlet Gas Temparature	2	64802	500	3	6
4759	Aftertreatment 2 Gas Oxidation Catalyst Intake Gas Temparature	2	64801	500	1	6
4760	Aftertreatment 2 Gas Oxidation Catalyst Outlet Gas Temparature	2	64801	500	3	6
4765	Aftertreatment 1 Diesel Oxidation Catalyst Intake Gas Temparature	2	64800	500	1	6
4766	Aftertreatment 1 Diesel Oxidation Catalyst Outlet Gas Temparature	2	64800	500	3	6
4771	Aftertreatment 2 Diesel Oxidation Catalyst Intake Gas Temparature	2	64799	500	1	6
4772	Aftertreatment 2 Diesel Oxidation Catalyst Outlet Gas Temparature	2	64799	500	3	6
4809	Aftertreatment 1 Warm Up Diesel Oxidation Catalyst Intake Temparature	2	64794	500	1	6
4810	Aftertreatment 1 Warm Up Diesel Oxidation Catalyst Outlet Temparature	2	64794	500	3	6
5020	Engine Exhaust Gas Recirculation 1 (EGR1) Mixer Intake Temparature	2	64870	1000	6	6
5148	Low Voltage Disconnect Temparature	1	64769	1000	4	6
5255	Engine Exhaust Gas Recirculation 2 (EGR2) Temparature	2	64767	1000	1	6
5256	Engine Exhaust Gas Recirculation 2 (EGR2) Mixer Intake Temparature	2	64767	0	3	6
5258	Engine Exhaust Gas Recirculation 2 (EGR2) Cooler Intake Temparature	2	64766	1000	1	6
5280	Engine Charge Air Cooler 1 Precooler Intake Temperature	2	64759	1000	1	6
5281	Engine Charge Air Cooler 1 Precooler Outlet Temperature	2	64759	1000	3	6
5283	Engine Charge Air Cooler 1 Intake Temperature	2	64758	1000	1	6
5284	Engine Charge Air Cooler 1 Ambient Air Temperature	2	64758	1000	3	6
5286	Engine Charge Air Cooler 2 Precooler Intake Temperature	2	64757	1000	1	6
5287	Engine Charge Air Cooler 2 Precooler Outlet Temperature	2	64757	1000	3	6
5289	Engine Charge Air Cooler 2 Intake Temperature	2	64756	1000	1	6

5290	Engine Charge Air Cooler 2 Outlet Temperature	2	64756	1000	3	6
5291	Engine Charge Air Cooler 2 Ambient Air Temperature	2	64756	1000	5	6
5315	Aftertreatment 2 Warm Up Diesel Oxidation Catalyst Intake Temparature	2	64749	500	1	6
5316	Aftertreatment 2 Warm Up Diesel Oxidation Catalyst Outlet Temparature	2	64749	500	3	6
5456	Aftertreatment 1 Hydrocarbon Doser Intake Fuel Temparature	1	64869	500	6	6

Table 3 – Supported Suspect Parameter Numbers

1.2. Averaging

Averaging block calculates average temperature of the selected RTD channels and can be used for example to produce data for Engine Average Information message. There are three Averaging blocks with twelve selectable **"Averaging Value"** 's, which can be selected to be any of the twelve RTD channels. When, **"Averaging Value"** is set to 'Disabled', the value is omitted from average calculation. New average value is calculated every 100ms. By default, Averaging 1 is set to produce average temperature of all twelve RTD channels, Averaging 2 is set to produce average temperature of RTD channels 1 to 6 and Averaging 2 is set to produce average temperature of RTD channels 7 to 12. Outputs of the Averaging blocks are associated with CAN Transmit 13 to produce PGN 64851 Engine Average Information per J1939-71, Janyary 2009.

1.3. Universal Input Function Blocks

The four Universal Inputs can be configured to measure voltage, current, frequency, pulse width (PWM) or digital signal. Universal Input setpoint group has the "**Input Sensor Type**" setpoint, which is used to configure input type. Selecting input type effects on other setpoints and how they are interpreted and should thus be selected first on this block. The input sensor types for Universal Inputs are listed in Table 4.

0	*Disabled*
12	*Voltage 0 to 5 V*
13	*Voltage 0 to 10 V*
20	*Current 0 to 20 mA*
21	*Current 4 to 20 mA*
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 4 – Universal Input Sensor Type Options

On Universal Input analog voltage (i.e. 0-5V, 0-10V) or current (0-20mA, 4-20mA) signals go directly to a 12-bit analog-to-digital converter (ADC) on the processor. The voltage input is a high impedance input protected against shorts to GND or Vcc. In current mode, a 249Ω resistor is used to measure the input signal. Analog signals should be connected to the GND reference pins provided on the connector.

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

Table 5 – Debounce Time Options

An additional software debounce filter can be used with Digital Input types for filtering the inputs using longer time constants than with the default debounce filter. The available software implemented debounce times are listed in Table 6.

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

Table 6 - Software Debounce Filter Times

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.

Universal Inputs have all available three Digital "**Input Sensor Type**" options: Normal, Inverse and Latched. With digital input sensor types, the input measurement is given, either 1 (ON) or 0 (OFF). The Universal inputs measure digital voltage with 2V threshold.

On Frequency, PWM and digital input modes 10kΩ pull-up or pull-down resistors can be enabled or disabled by setting the value of the "**Pullup/Pulldown Resistor**" setpoint. Setpoint options are given in Table 7. By default, pull-down resistors are enabled for all inputs.

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

Table 7 – Pullup/Pulldown Resistor Options

“**Active High/Active Low**” setpoint is used to configure how signal high and low are interpreted. Setpoint options are given in Table 8. 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 8 – Active High/Low Options

Table 9 shows the effect of different digital input types on input signal measurement interpretation with recommended “**Pullup/Pulldown Resistor**” and “**Active High/Low**” combinations. Fault diagnostics are not available for digital input types.

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

Table 9 – Digital Input Sensor Type versus Input State

The “**Minimum Range**” and “**Maximum Range**” setpoints are used to define range of the signal input outputs as a control source. For example, if “**Maximum Range**” is set to 4V for an input, the control signal is saturated at 4V if input signal rises above 4V. The “**Minimum Range**” and “**Maximum Range**” setpoints are interpreted in input types units, thus they should be re-adjusted after editing “**Input Sensor Type**”.

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

Input sample rate is 10ms for voltage, current and digital input types. Frequency, PWM and Counter sample rate depend on input signal frequency.

1.4. 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 10 – Filter Type Options

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

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

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

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

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

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

1.5. Math Function Blocks

There are four mathematical function blocks that allow the user to define basic algorithms.

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 $A \text{ operator } B$, where A and B are function inputs and operator is function selected with setpoint "**Math function X Operator**". Setpoint options are presented in Table 11. 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*
15	*MAX-MIN, Result = Absolute value of (InA – InB)*
16	*SIN, Result = InA * SIN(InB)*
17	*COS, Result = InA * COS(InB)*
18	*SQRT, Result = InA * SQRT(InB)*

Table 11 – 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.

1.6. Lookup Table Function Block

Lookup Tables are used to give output response up to 10 slopes per input.

Lookup tables have three differing modes defined by "**X-Axis Type**" setpoint, given in Table 12. Option '0 – Data Response' is the normal mode where block input signal is selected with the "**X-Axis Source**" and "**X-Axis Number**" setpoints and X values present directly input signal values. With option '1 – Time Response' the input signal is time and X values present time in milliseconds. And selected input signal is used as digital enable. Option '2 – Enabled Data Response' works like the Data Response option with a configurable threshold for the input signal to enable and disable the output. The output value in 'disabled' mode can be defined by the user with "**Output value when disabled**" setpoint.

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

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

Table 12 – 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 13. 'Ramp To' gives a linearized slope between points, whereas 'Jump to' gives a point to point response, where any input value between X_{N-1} and X_N will result Lookup Table output being Y_N. "Point0 – Response" is always 'Jump To' and cannot be edited. Choosing 'Ignored' response causes associated point and all the following points to be ignored.

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

Table 13 – PointN – Response Options

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

The X values are limited by minimum and maximum range of the selected input source if the source is one of the Input Blocks or a Math Function Block. For the fore mentioned sources X-Axis data will be redefined when ranges are changed, therefore inputs should be adjusted before changing X-Axis values. For other sources Xmin and Xmax are 0 and 10,000. The X-Axis is constraint to be in rising order, thus value of the next index is greater than or equal to preceding one. Therefore, when adjusting the X-Axis data, it is recommended that X_{10} is changed first, then lower indexes in descending order.

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

The Y-Axis has no constraints on the data it presents, thus inverse, decreasing, increasing or other response can be easily established. The Smallest of the Y-Axis values is used as Lookup Table output min and the largest of the Y-Axis values is used as Lookup Table output max (i.e. used as

Xmin and Xmax values in linear calculation). Ignored points are not considered for min and max values.

1.7. Diagnostc Function Blocks

The 12 RTD Scanner 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 15 and Table 16)
CM	Conversion Method	(always set to 0)
OC	Occurrence Count	(number of times the fault has happened)
DM2	Previously Active Diagnostic Trouble Codes	Sent only on request
DM3	Diagnostic Data Clear/Reset of Previously Active DTCs	Done only on request
DM11	Diagnostic Data Clear/Reset for Active DTCs	Done only on request

Fault detection and reaction is a standalone functionality that can be configured to monitor and report diagnostics of various controller parameters. The 12 RTD Scanner supports 19 Diagnostics Definitions, each freely configurable by the user.

By default, the monitoring of operating voltage, CPU temperature and receive message timeouts is configured to diagnostics blocks 1, 2 and 3. Diagnostic blocks 4 to 15 are set to monitor RTD inputs 1 to 12 temperature, by default. In case any of these diagnostics blocks are needed for some other use, the default settings can be adjusted by the user to suit the application.

When, an RTD channel is associated with a Diagnostic Block with “Function Type to Monitor” and “Function Parameter to Monitor” setpoints, all the SPNs of the Diagnostic Block in question are initialized with the SPN of the selected SPN channel. Thus “Function Type to Monitor” and “Function Parameter to Monitor” setpoints should be set before adjusting SPNs.

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

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

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

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

Double minimum and maximum error lets user to specify four thresholds, each with independent diagnostic parameters. The diagnostic status and threshold values is determined and expected as show in Figure 2 below.

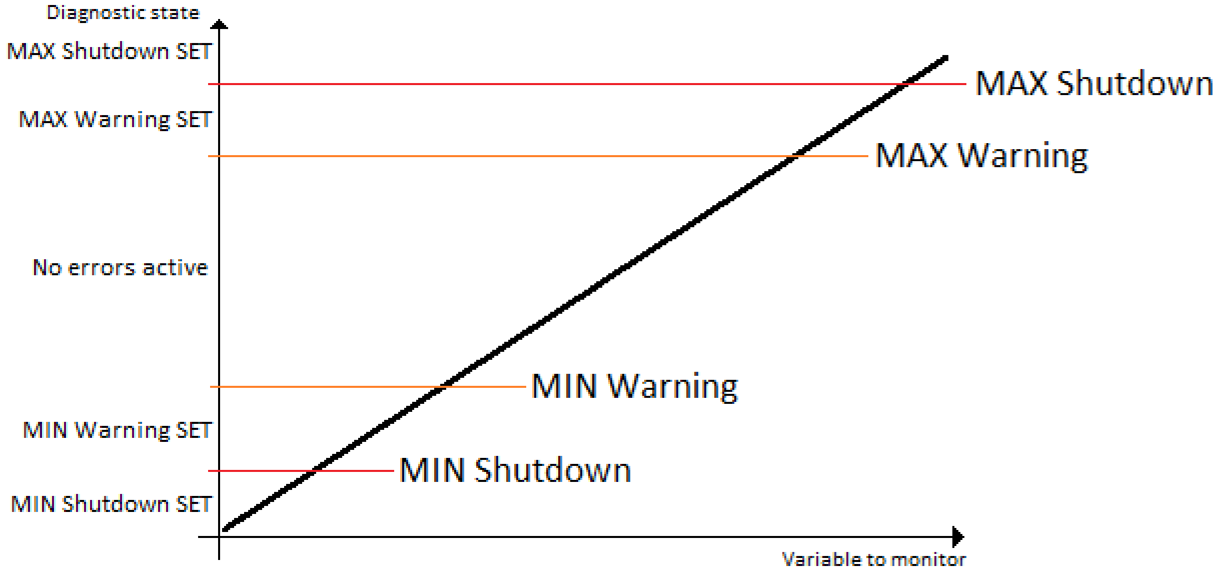
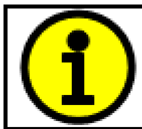


Figure 2 – Double Minimum and Maximum Error Thresholds

While there are no active DTCs, the 12 RTD Scanner will send "No Active Faults" message. If a previously inactive DTC becomes active, a DM1 will be sent immediately to reflect this. As soon as the last active DTC goes inactive, a DM1 indicating that there are no more active DTCs will be sent.

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

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

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

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

As defined by J1939 Standard the first byte of the DM1 message reflects the Lamp status. "**Lamp Set by Event**" setpoint determines the lamp type set in this byte of DTC. "**Lamp Set by Event"** setpoint options are listed in Table 14. 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 14 – Lamp Set by Event in DM1 Options

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

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

Table 15 – FMI for Event Options

Every fault has associated a default FMI with them. The used FMI can be configured with "**FMI for Event**" setpoint, presented in Table 15. When an FMI is selected from Low Fault FMIs in Table 16 for a fault that can be flagged either high or low occurrence, it is recommended that the user would select the high occurrence FMI from the right column of Table 16. There is no automatic setting of High and Low FMIs in the firmware, the user can configure these freely.

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

Table 16 – Low Fault FMIs and corresponding High Fault FMIs

1.8. CAN Transmit Message Function Block

The CAN Transmit function block is used to send any output from another function block (i.e. RTD input, Universal input, Averaging, CAN receive) to the J1939 network. The AX184000 ECU has sixteen CAN Transmit Messages and each message has four completely user defined signals. By default, CAN Transmit Messages 1 to 12 are associated with RTD inputs 1 to 12. And CAN Transmit Message 13 is set to produce PGN 64851 Engine Average message. Remaining three transmit messages follow defaults indicated in next subchapters.

When, an RTD channel is associated with a CAN transmit message as Signal 1 Source with "**Control Source**" and "**Control Number**" setpoints, if SPN of the RTD channel is selected from the list of supported suspect parameter numbers Table 3, Signals 2 to 4 Source is set to 0 and CAN Transmit Message setpoints are initialized with associated parameters. Thus "**Control Source**" and "**Control Number**" setpoints should be set, before adjusting other CAN Transmit message setpoints.

Transmit Message "**Transmit PGN**", "**Repetition Rate**", "**Transmit Message Priority**", "**Transmit Data Size**" and "**Transmit Message Priority**" are loaded from Table 3. Signal "**Transmit Data Resolution**", "**Transmit Data Offset**", "**Transmit Data Minimum**" and "**Transmit Data Maximum**" are set per "**Transmit Data Size**": One-byte parameters have a resolution of 1ºC/bit and an offset of -40ºC, resulting in a measurable range of -40ºC to 210ºC and two-byte parameters have a resolution of 0.03125ºC/bit and an offset of -273ºC, resulting in a measurable range of -273ºC to 1735ºC.

If a fault is flagged for a CAN Transmit message source error indicator (0xFE, 0xFEFF, 0xFEFFFF) is send instead of the source data.

1.8.1. CAN Transmit Message Setpoints

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

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

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

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

By default, all messages are sent on Proprietary B PGNs as broadcast messages. Thus "**Transmit Message Priority**" is always initialized to 6 (low priority) and the "**Destination Address**" setpoint is not used. This setpoint is only valid when a PDU1 PGN has been selected, and it can be set either to the Global Address (0xFF) for broadcasts, or sent to a specific address as setup by the user.

1.8.2. 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 17. 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.

1.9. 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 1.5. In order to avoid timeouts on a heavily saturated network, it is recommended to set the period at least three times longer than the expected update rate. To disable the timeout feature, simply set this value to zero, in which case the received message will never trigger a Lost Communication fault.

By default, all control messages are expected to be sent to the 12 RTD Scanner on Proprietary B PGNs. However, should a PDU1 message be selected, the 12 RTD Scanner 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.

12 RTD Scanner supports up to four unique CAN Receive Messages. Defaults setpoint values are listed in section 4.

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

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 5	User must enable the function block, as it is disabled by default.
2: RTD Input	1 to 24	1-12 measured value in °C 13-24 measured value in °F
3: Universal Input Measured	1 to 4	
4: Averaging	1 to 3	
5: Math Function Block	1 to 4	
6: Lookup Table	1 to 4	
7: Control Constant Data	1 to 15	
8: Power Supply Measured	0 to 255	Measured power supply value in Volts. The Parameter sets the threshold in Volts to compare with.
9: Processor Temperature Measured	0 to 255	Measured processor temperature in °C. The Parameter sets the threshold in Celcius to compare with.
10: CAN Reception Timeout	N/A	Only available in Diagnostic blocks.

Table 17 – Available Control Sources and Numbers

2. INSTALLATION INSTRUCTIONS

2.1. Dimensions and Pinout

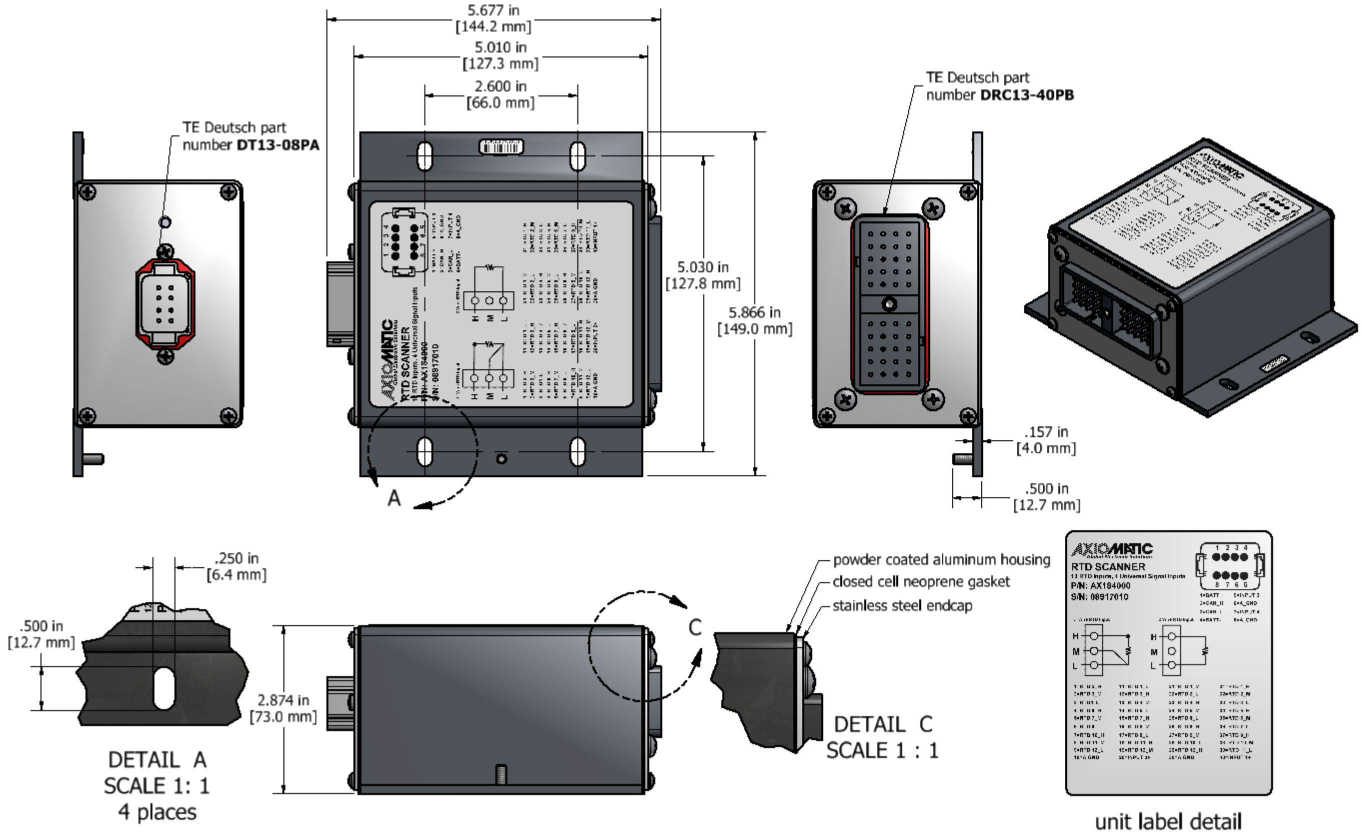


Figure 3 – AX184000 Dimensional Drawing

PIN#	Description
1	BATT +
2	CAN_H
3	CAN_L
4	BATT -
5	Universal Input 3 +
6	Analog GND
7	Universal Input 4+
8	Analog GND

Table 18 – AX184000 DT13-08PA Connector Pinout

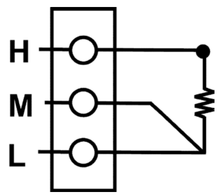


Figure 4 – AX184000 3-wire RTD Input Wiring

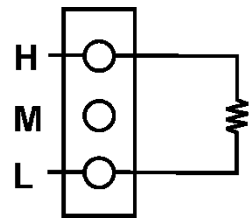


Figure 5 – AX184000 2-wire RTD Input Wiring

PIN#	Description	PIN#	Description	PIN#	Description	PIN#	Description	PIN#	Description
1	RTD 2 _High	5	RTD 7 _Medium	9	RTD 12 _Low	13	RTD 4 _Medium	17	RTD 9 _Low
2	RTD 3 _Medium	6	RTD 8 _Low	10	Analog GND	14	RTD 5 _Low	18	RTD 11 _High
3	RTD 4 _Low	7	RTD 10 _High	11	RTD 1 _Low	15	RTD 7 _High	19	RTD 12 _Medium
4	RTD 6 _High	8	RTD 11 _Medium	12	RTD 3 _High	16	RTD 8 _Medium	20	Universal Input 2
PIN#	Description	PIN#	Description	PIN#	Description	PIN#	Description	PIN#	Description
21	RTD 1 _Medium	25	RTD 6 _Low	29	RTD 12 _High	33	RTD 3 _Low	37	RTD 9 _High
22	RTD 2 _Low	26	RTD 8 _High	30	Analog GND	34	RTD 5 _High	38	RTD 10 _Medium
23	RTD 4 _High	27	RTD 9 _Medium	31	RTD 1 _High	35	RTD 6 _Medium	39	RTD 11 _Low
24	RTD 5 _Medium	28	RTD 10 _Low	32	RTD 2 _Medium	36	RTD 7 _Low	40	Universal Input 1

Table 19 – AX184000 DRC13-40PB 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
• All of the temperature SPNs from this section, and their corresponding PGNs		

ECU Identification Information, Software Identification and Component Identification PGNs are not supported as part of the default configurations, but they can be selected as desired for transmit function blocks.

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

3.2. NAME, Address and Software ID

The 6 Input 5 Output Valve Controller I/O ECU has the following default for the J1939 NAME. The user should refer to the SAE J1939/81 standard for more information on these parameters and their ranges.

Arbitrary Address Capable	Yes
Industry Group	0, Global
Vehicle System Instance	0
Vehicle System	0, Non-specific system
Function	125, Axiomatic I/O Controller
Function Instance	3, Axiomatic AX020510
ECU Instance	0, First Instance
Manufacture Code	162, Axiomatic Technologies
Identity Number	Variable, uniquely assigned during factory programming for each ECU

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

The default value of the “ECU Address” setpoint is 128 (0x80), which is the preferred starting address for self-configurable ECUs as set by the SAE in J1939 tables B3 and B7. The Axiomatic EA supports the selection of any address between 0 and 253. ***It is user’s responsibility to select an address that complies with the standard***. The user must also be aware that since the unit is arbitrary address capable, if another ECU with a higher priority NAME contends for the selected address, the 6 Input 5 Output Valve Controller I/O will continue select the next highest address until it finds one that it can claim. See J1939/81 for more details about address claiming.

ECU Identification Information

PGN 64965	ECU Identification Information	-ECUID
Transmission Repetition Rate:	On request	
Data Length:	Variable	
Extended Data Page:	0	
Data Page:	0	
PDU Format:	253	
PDU Specific:	197 PGN Supporting Information:	
Default Priority:	6	

Parameter Group Number: 64965 (0x00FDC5)

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

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

Software Identifier

PGN 65242 Software Identification - SOFT

Transmission Repetition Rate: On request

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

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

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

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

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

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

Component Identification

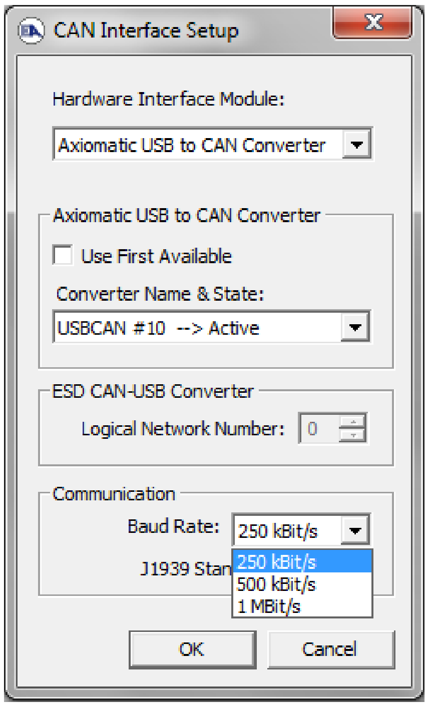
PGN 65259		Component Identification		-CI
Transmission Repetition Rate:		On request		
Data Length:		Variable		
Extended Data Page:		0		
Data Page:		0		
PDU Format:		254		
PDU Specific:		235 PGN Supporting Information:		
Default Priority:		6		
Parameter Group Number:		65259 (0x00FEEB)		
Start Position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

4. ECU SETPOINTS ACCESSED WITH THE AXIOMATIC ELECTRONIC ASSISTANT

This section describes in detail each setpoint, and their default and ranges. Default values presented in tables are values used when setpoint in question is active. Many of the setpoints are dependent on other setpoints and they may not be active by default. Associated Figures show screen capture of initial operation, however some of the setpoints are not in default condition as they are set differently to activate more setpoints for the image. The setpoints are divided into setpoint groups as they are shown in the Axiomatic EA. For more information on how each setpoint is used by 12 RTD Scanner, refer to the relevant section in this user manual.

4.1. Accessing the ECU Using the Axiomatic EA

ECU with P/N AX184000 does not need any specific setup for the Axiomatic EA. In order to access the high speed versions, AX184000-01 and/or AX184000-02, the CAN bus Baud Rata needs to be set accordingly. The CAN Interface Setup can be found from "Options" menu in the EA.



4.2. J1939 Network Parameters

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

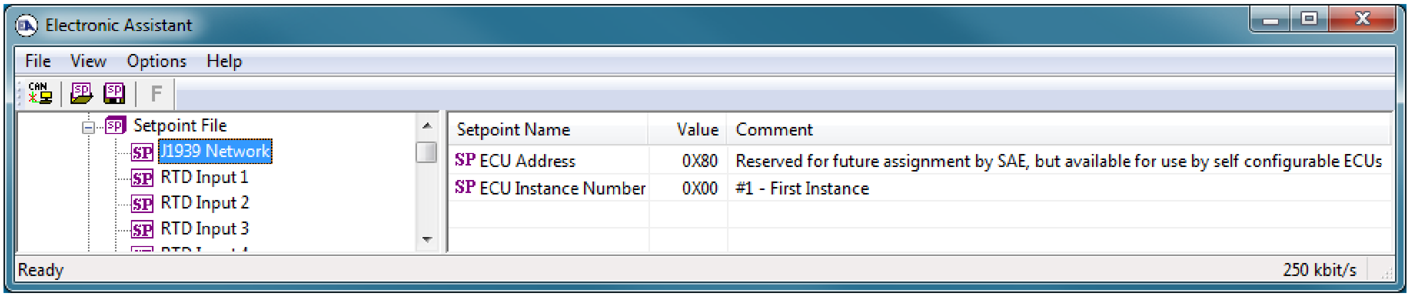


Figure 6 - Screen Capture of J1939 Setpoints

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

Table 20 – 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 appear in the J1939 CAN Network ECU list.

4.3. RTD Input Setpoints

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

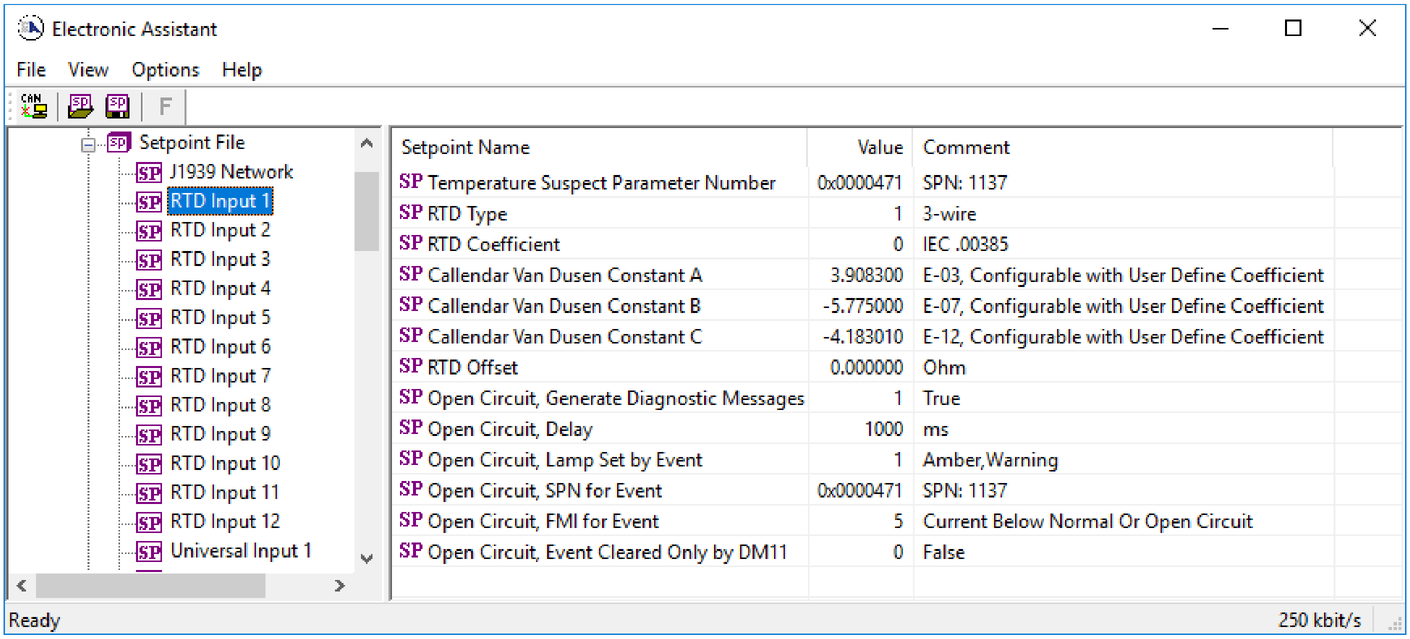


Figure 7 - Screen Capture of RTD Input Setpoints

Name	Range	Default	Notes
Temperature Suspect Parameter Number	Drop List	Different for each	See Table 3
RTD Type	Drop List	3-wire	0 – Disabled 1 – 3-wire 2 – 2-wire
RTD Coefficient	Drop List	IEC 0.00385	See Table 1
Callendar Van Dusen Constant A	-10.000000 to 10.000000 E-03	3.908300 E-03	See Table 2
Callendar Van Dusen Constant B	-10.000000 to 10.000000 E-07	-5.77500 E-07	See Table 2
Callendar Van Dusen Constant C	-10.000000 to 10.000000 E-012	-4.183010 E-012	See Table 2
RTD Offset	-10.000000 to 10.000000	0.000000 Ohm	See Section 1.1
Open Circuit, Generate Diagnostic messages	False, True	True	See Section 1.1
Open Circuit Delay	0...60000 ms	1000ms	See Section 1.1
Open Circuit, Lamp Set by Event	Drop List	Amber Warning	See Table 14
Open Circuit, SPN for Event	0...524287	Different for each	It is the user's responsibility to select an SPN that will not violate the J1939 standard.
Open Circuit, FMI for Event	Drop List	4, Current Below Normal Or Open Circuit	See Table 15
Open Circuit, Event Cleared Only by DM11	False, True	False	

Table 21 – RTD Input Setpoints

4.4. Universal Input Setpoints

The Universal Inputs are defined in Section 1.3. Please refer there for detailed information how these setpoints are used.

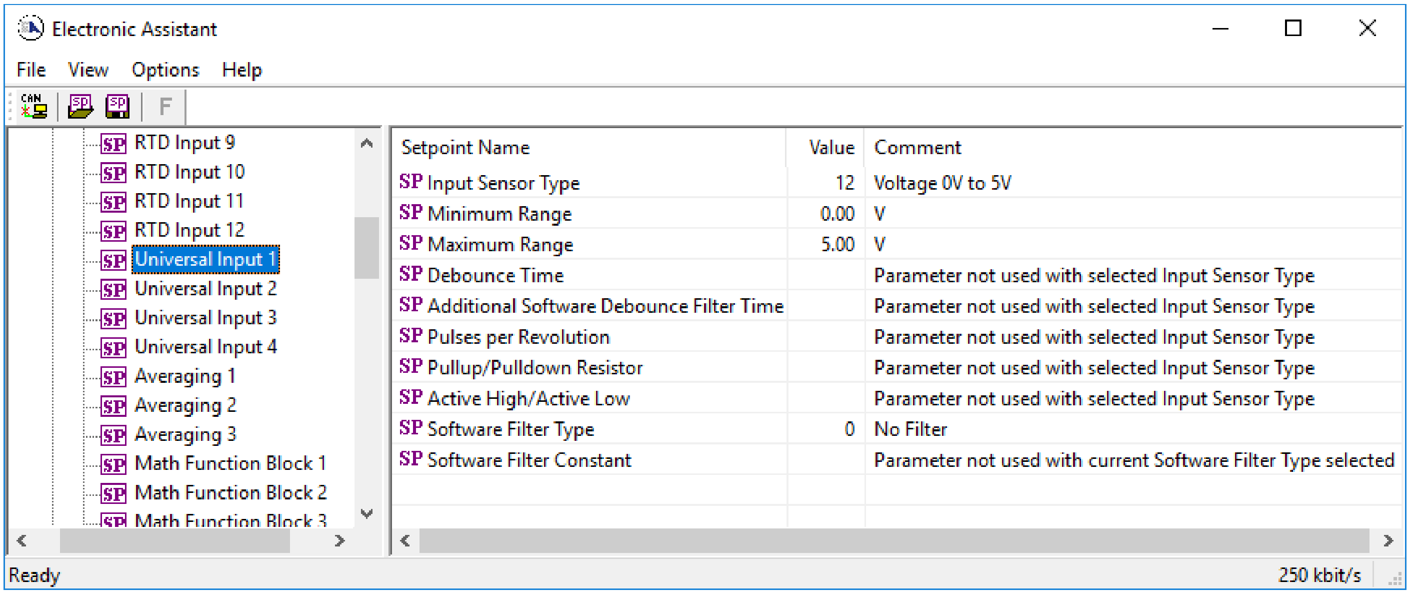


Figure 8 - Screen Capture of Universal Input Setpoints

Name	Range	Default	Notes
Input Sensor Type	Drop List	VOLTAGE_0_TO_5V	See Table 4
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 5
Additional Software Debounce Filter Time	Drop List	0ms	See Table 6
Pulses per Revolution	Drop List	FALSE	See Section 1.1
Pullup/Pulldown Resistor	Drop List	10kΩ Pulldown	See Table 7
Active High/Active Low	Drop List	Active High	See Table 8
Software Filter Type	Drop List	No Filtering	See Table 10
Software Filter Constant	1..1000	1	

Table 22 – Universal Input Setpoints

4.5. Averaging Setpoints

The Averaging function blocks are defined in Section 1.2. Please refer there for detailed information how these setpoints are used.

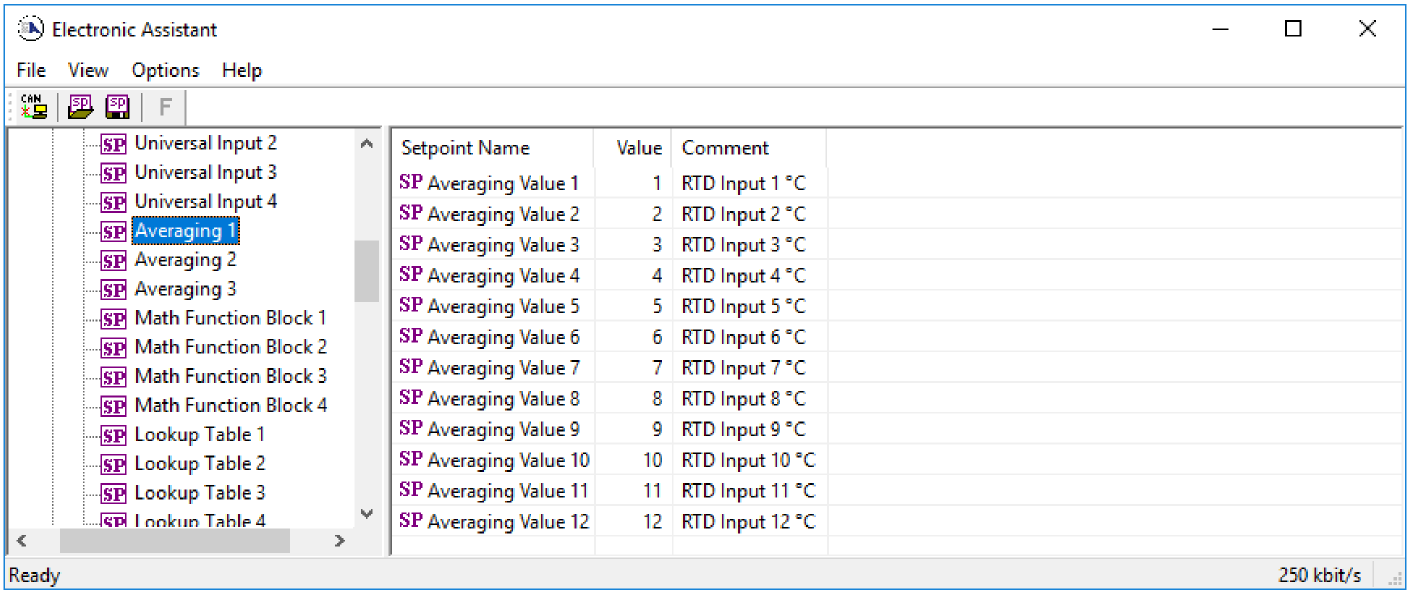


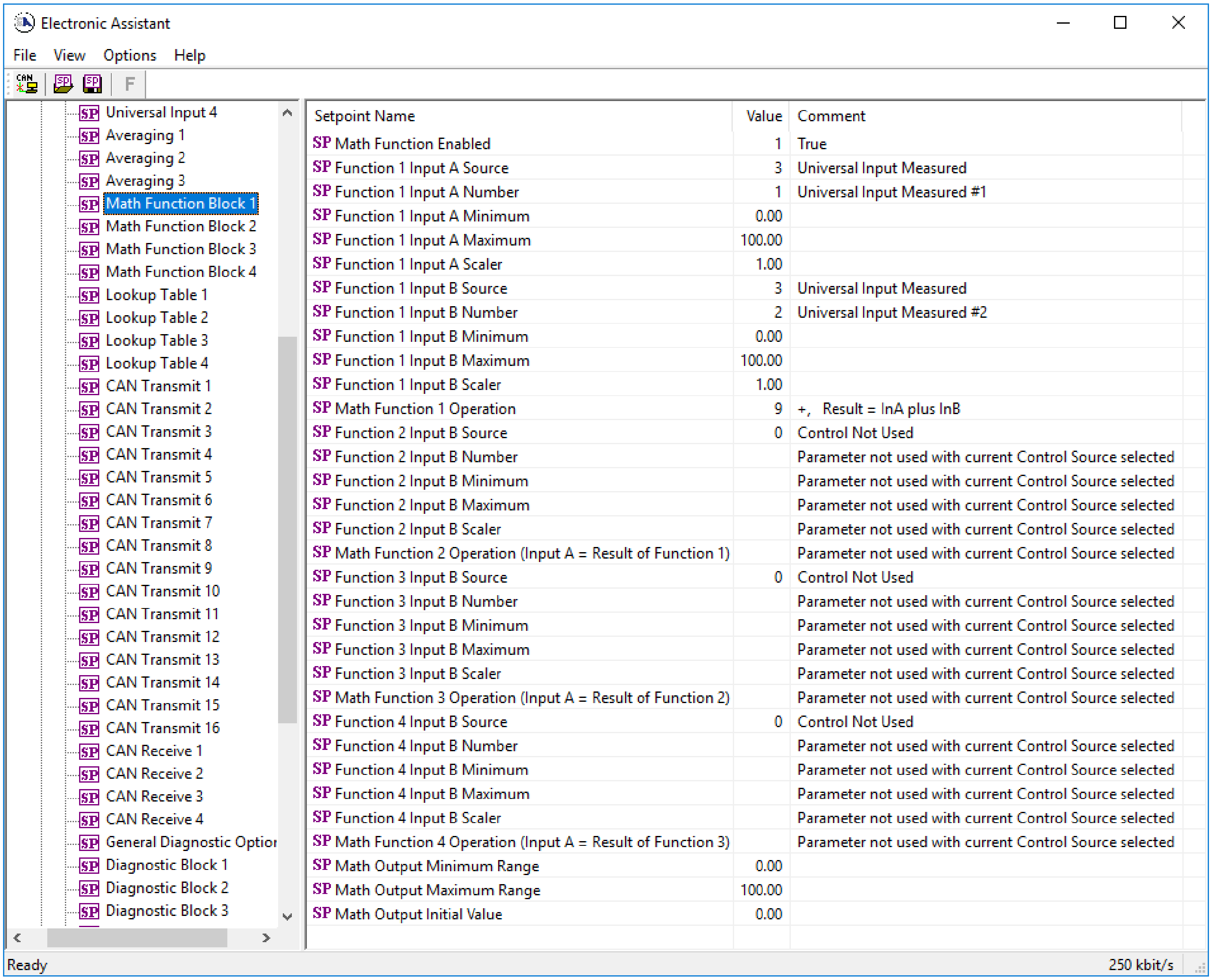
Figure 9 - Screen Capture of Averaging Setpoints

Name	Range	Default	Notes
Averaging Value 1	Drop List	RTD Input 1	
Averaging Value 2	Drop List	RTD Input 2	
Averaging Value 3	Drop List	RTD Input 3	
Averaging Value 4	Drop List	RTD Input 4	
Averaging Value 5	Drop List	RTD Input 5	
Averaging Value 6	Drop List	RTD Input 6	
Averaging Value 7	Drop List	RTD Input 7	
Averaging Value 8	Drop List	RTD Input 8	
Averaging Value 9	Drop List	RTD Input 9	
Averaging Value 10	Drop List	RTD Input 10	
Averaging Value 11	Drop List	RTD Input 11	
Averaging Value 12	Drop List	RTD Input 12	

Table 23 – Averaging Setpoints

4.6. Math Function Block Setpoints

The Math Function Block is defined in Section 1.5. Please refer there for detailed information about how all these setpoints are used. "**Math Function Enabled**" is 'False' by default. To enable a Math Function Block, set "**Math Function Enabled**" to 'True' and select appropriate "**Input Source**".



Setpoint Name	Value	Comment
SP Math Function Enabled	1	True
SP Function 1 Input A Source	3	Universal Input Measured
SP Function 1 Input A Number	1	Universal Input Measured #1
SP Function 1 Input A Minimum	0.00	
SP Function 1 Input A Maximum	100.00	
SP Function 1 Input A Scaler	1.00	
SP Function 1 Input B Source	3	Universal Input Measured
SP Function 1 Input B Number	2	Universal Input Measured #2
SP Function 1 Input B Minimum	0.00	
SP Function 1 Input B Maximum	100.00	
SP Function 1 Input B Scaler	1.00	
SP Math Function 1 Operation	9	+, Result = InA plus InB
SP Function 2 Input B Source	0	Control Not Used
SP Function 2 Input B Number		Parameter not used with current Control Source selected
SP Function 2 Input B Minimum		Parameter not used with current Control Source selected
SP Function 2 Input B Maximum		Parameter not used with current Control Source selected
SP Function 2 Input B Scaler		Parameter not used with current Control Source selected
SP Math Function 2 Operation (Input A = Result of Function 1)		Parameter not used with current Control Source selected
SP Function 3 Input B Source	0	Control Not Used
SP Function 3 Input B Number		Parameter not used with current Control Source selected
SP Function 3 Input B Minimum		Parameter not used with current Control Source selected
SP Function 3 Input B Maximum		Parameter not used with current Control Source selected
SP Function 3 Input B Scaler		Parameter not used with current Control Source selected
SP Math Function 3 Operation (Input A = Result of Function 2)		Parameter not used with current Control Source selected
SP Function 4 Input B Source	0	Control Not Used
SP Function 4 Input B Number		Parameter not used with current Control Source selected
SP Function 4 Input B Minimum		Parameter not used with current Control Source selected
SP Function 4 Input B Maximum		Parameter not used with current Control Source selected
SP Function 4 Input B Scaler		Parameter not used with current Control Source selected
SP Math Function 4 Operation (Input A = Result of Function 3)		Parameter not used with current Control Source selected
SP Math Output Minimum Range	0.00	
SP Math Output Maximum Range	100.00	
SP Math Output Initial Value	0.00	

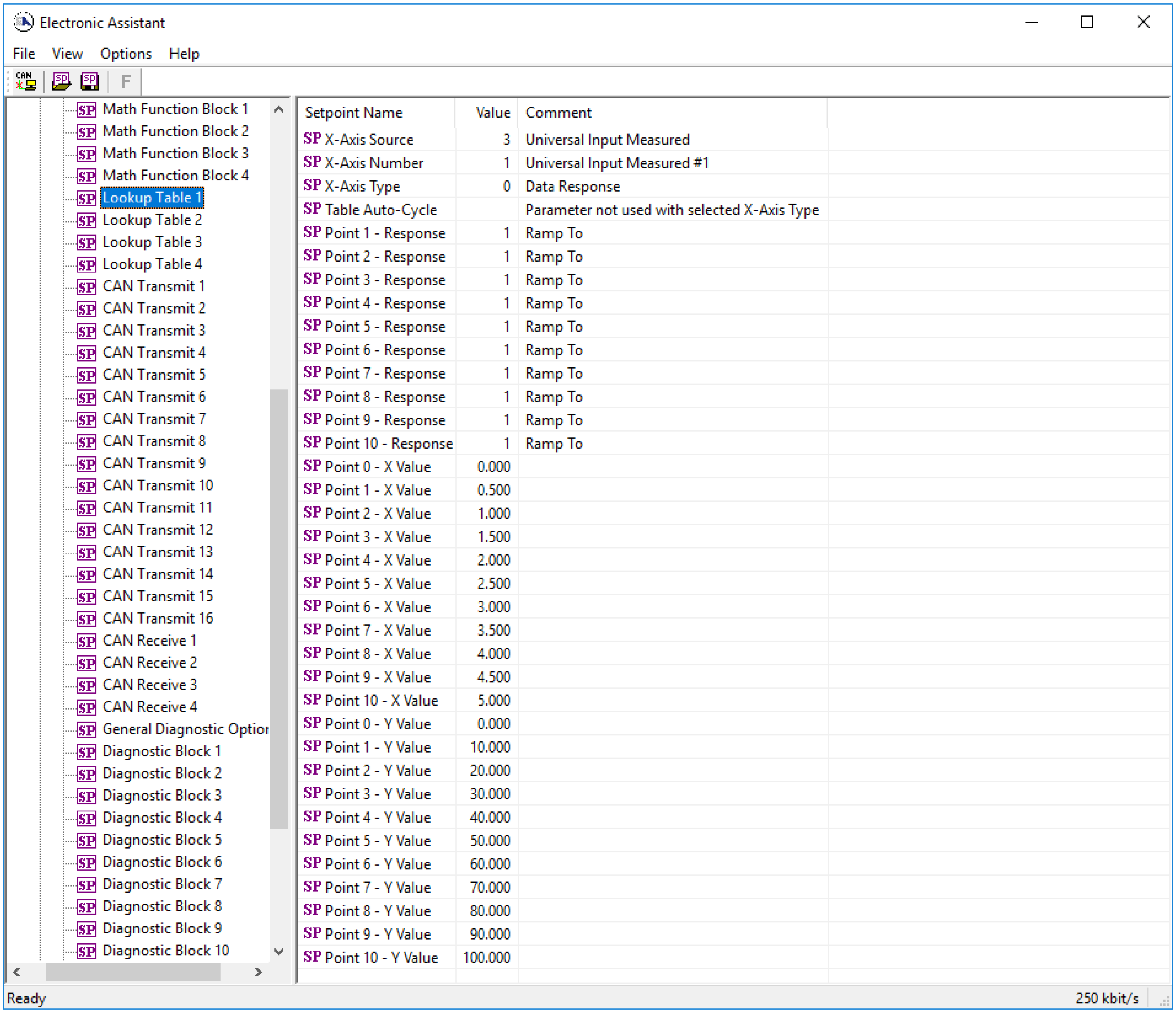
Figure 10 – Screen Capture of Math Function Block Setpoints

Name	Range	Default	Notes
Math Function Enabled	Drop List	False	
Function 1 Input A Source	Drop List	Control not used	See Table 17
Function 1 Input A Number	Depends on control source	1	See Table 17
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 17
Function 1 Input B Number	Depends on control source	1	See Table 17
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 11
Function 2 Input B Source	Drop List	Control not used	See Table 17
Function 2 Input B Number	Depends on control source	1	See Table 17
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 11
Function 3 Input B Source	Drop List	Control not used	See Table 17
Function 3 Input B Number	Depends on control source	1	See Table 17
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 11
Function 4 Input B Source	Drop List	Control not used	See Table 17
Function 4 Input B Number	Depends on control source	1	See Table 17
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 11
Math Output Minimum Range	-10^6 to 10^6	0.0	
Math Output Maximum Range	-10^6 to 10^6	100.0	
Math Output Initial Value	-10^6 to 10^6	0.0	

Table 24 – Math Function Setpoints

4.7. Lookup Table Setpoints

The Lookup Table Function Block is defined in Section 1.6. Please refer there for detailed information about how all these setpoints are used. “**X-Axis Source**” is set to ‘*Control Not Used*’ by default. To enable a Lookup Table select appropriate “**X-Axis Source**”.



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

Figure 11 – Screen Capture of Lookup table Setpoints

Name	Range	Default	Notes
X-Axis Source	Drop List	Control Not Used	See Table 17
X-Axis Number	Depends on control source	1	See Table 17
X-Axis Type	Drop List	Data Response	See Table 12
Disable limit (X Value)	From X-Axis source minimum to X-Axis source maximum	X-Axis source maximum 5.000	See Section 1.6.
Enable limit (X Value)	From X-Axis source minimum to X-Axis source maximum	2.500	See Section 1.6.
Output value when disabled	-10^6 to 10^6	0.000	See Section 1.6.
Table Auto-Cycle	Drop List	0	
Point 1 - Response	Drop List	Ramp To	See Table 13
Point 2 - Response	Drop List	Ramp To	See Table 13
Point 3 - Response	Drop List	Ramp To	See Table 13
Point 4 - Response	Drop List	Ramp To	See Table 13
Point 5 - Response	Drop List	Ramp To	See Table 13
Point 6 - Response	Drop List	Ramp To	See Table 13
Point 7 - Response	Drop List	Ramp To	See Table 13
Point 8 - Response	Drop List	Ramp To	See Table 13
Point 9 - Response	Drop List	Ramp To	See Table 13
Point 10 - Response	Drop List	Ramp To	See Table 13
Point 0 - X Value	From X-Axis source minimum to Point 1 - X Value	X-Axis source minimum 0.000	See Section 1.6.
Point 1 - X Value	From Point 0 - X Value to Point 2 - X Value	0.500	See Section 1.6.
Point 2 - X Value	From Point 1 - X Value to Point 3 - X Value	1.000	See Section 1.6.
Point 3 - X Value	From Point 2 - X Value to Point 4 - X Value	1.500	See Section 1.6.
Point 4 - X Value	From Point 3 - X Value to Point 5 - X Value source	2.000	See Section 1.6.
Point 5 - X Value	From Point 4 - X Value to Point 6 - X Value	2.500	See Section 1.6.
Point 6 - X Value	From Point 5 - X Value to Point 7 - X Value	3.000	See Section 1.6.
Point 7 - X Value	From Point 6 - X Value to Point 8 - X Value	3.500	See Section 1.6.
Point 8 - X Value	From Point 7 - X Value to Point 9 - X Value	4.000	See Section 1.6.
Point 9 - X Value	From Point 8 - X Value to Point 10 - X Value	4.500	See Section 1.6.
Point 10 - X Value	From Point 9 - X Value to X-Axis source maximum	X-Axis source maximum 5.000	See Section 1.6.
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 25 – Lookup Table Setpoints

4.8. Constant Data List Setpoints

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

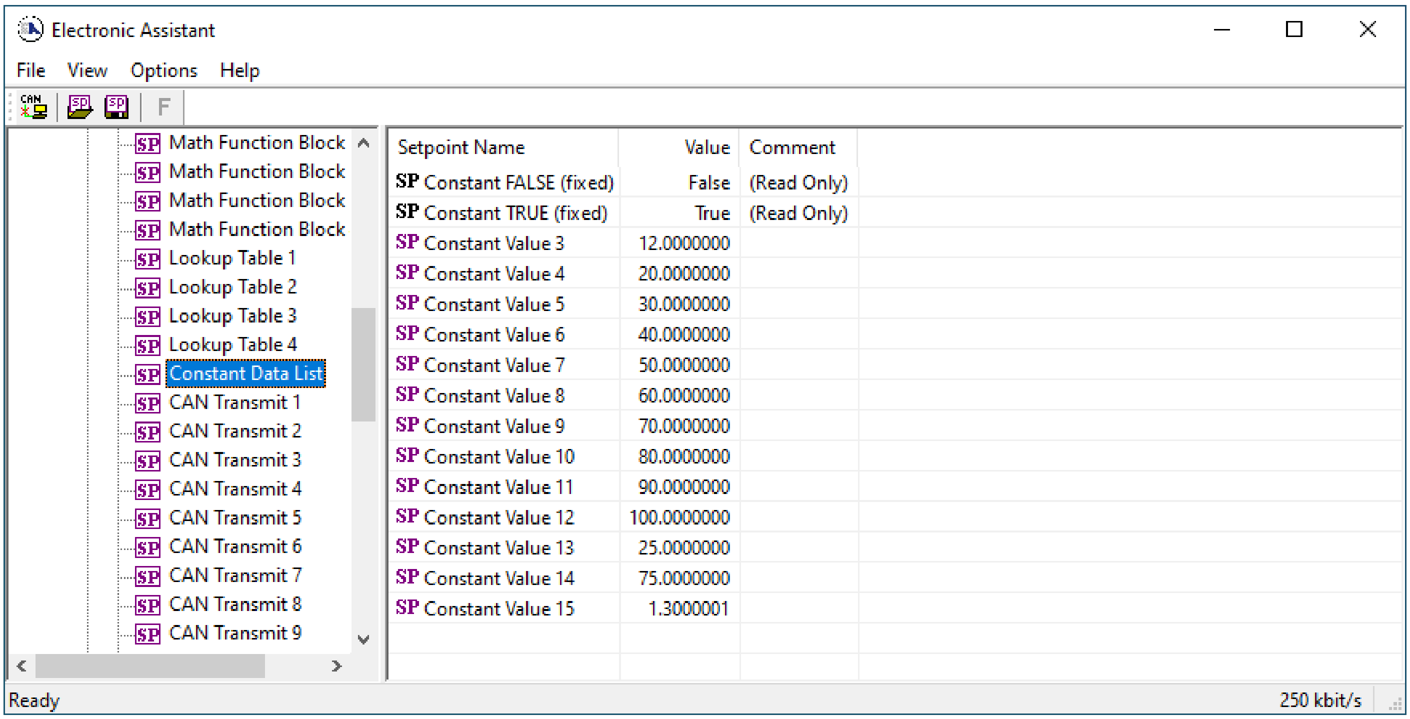


Figure 12 – Screen Capture of Constant Data List Setpoints

4.9. CAN Transmit Setpoints

CAN Transmit Message Function Block is presented in Section 1.8. Please refer there for detailed information how these setpoints are used. By default, CAN Transmit Messages 1 to 12 are associated with RTD inputs 1 to 12. And CAN Transmit Message 13 is set to produce PGN 64851 Engine Average message. Remaining three transmit messages utilize following defaults.

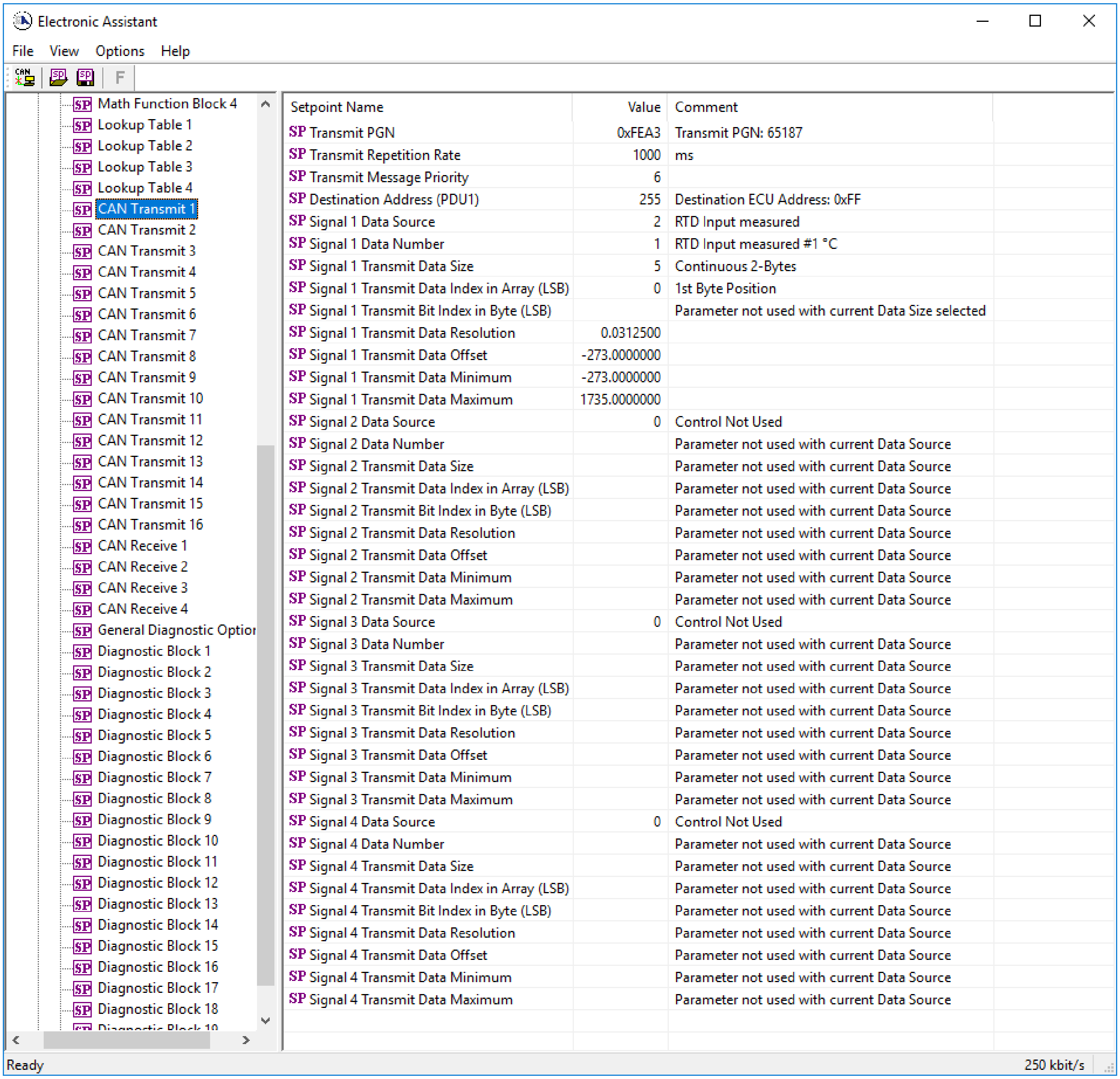


Figure 13 - Screen Capture of CAN Transmit Message Setpoints

Name	Range	Default	Notes
Transmit PGN	0xff00 … 0xffff	Different for each	See Section 1.8.1
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 17
Signal 1 Control Number	Drop List	Different for each	See 1.8.2
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 1 Transmit Data Minimum	-1000000 to Max		
Signal 1 Transmit Data Maximum	-100000 to 100000		
Signal 2 Control Source	Drop List	Signal undefined	See Table 17
Signal 2 Control Number	Drop List	Signal undefined	See 1.8.2
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 2 Transmit Data Minimum	-1000000 to Max		
Signal 2 Transmit Data Maximum	-100000 to 100000		
Signal 3 Control Source	Drop List	Signal undefined	See Table 17
Signal 3 Control Number	Drop List	Signal undefined	See 1.8.2
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 3 Transmit Data Minimum	-1000000 to Max		
Signal 3 Transmit Data Maximum	-100000 to 100000		
Signal 4 Control Source	Drop List	Signal undefined	See Table 17
Signal 4 Control Number	Drop List	Signal undefined	See 1.8.2
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	
Signal 4 Transmit Data Minimum	-1000000 to Max		
Signal 4 Transmit Data Maximum	-100000 to 100000		

Table 26 – CAN Transmit Message Setpoints

4.10. CAN Receive Setpoints

The Math Function Block is defined in Section 1.9. 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.

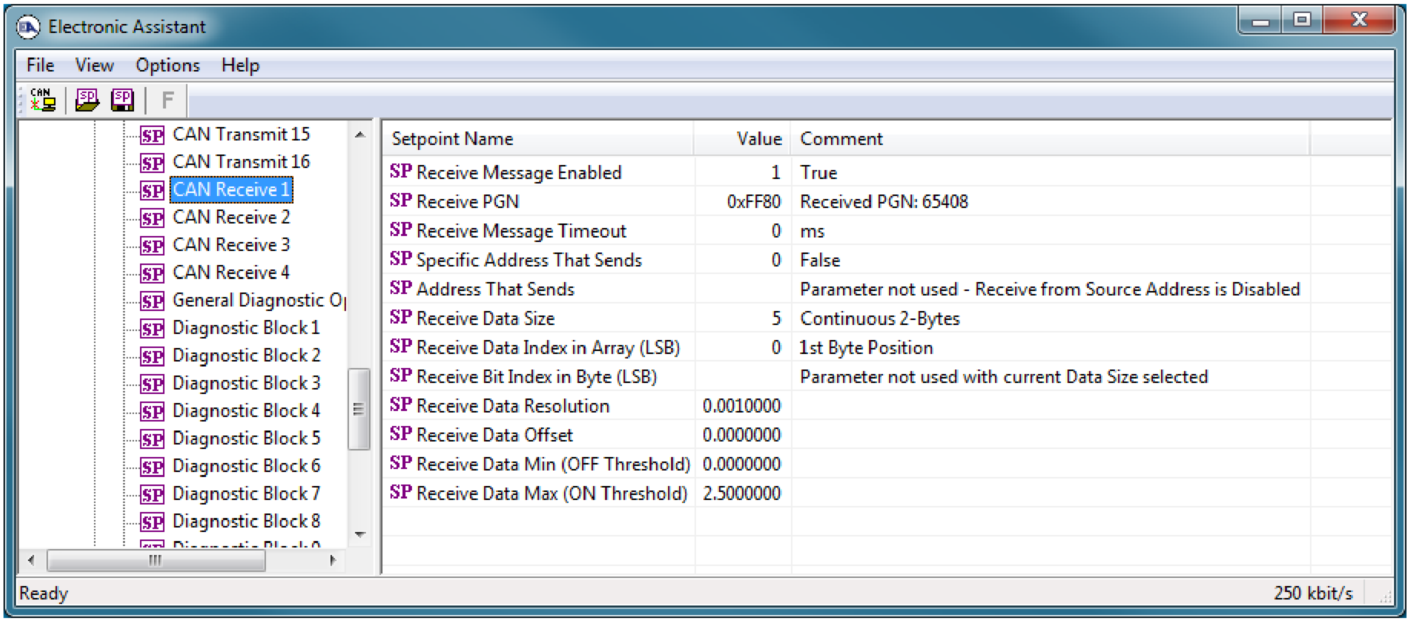


Figure 14 - Screen Capture of CAN Receive Message Setpoints

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 27 – CAN Receive Setpoints

4.11. General Diagnostics Options

These setpoints control the shutdown of the ECU in case of a power supply or CPU temperature related errors. Refer to section 1.5 for more info.

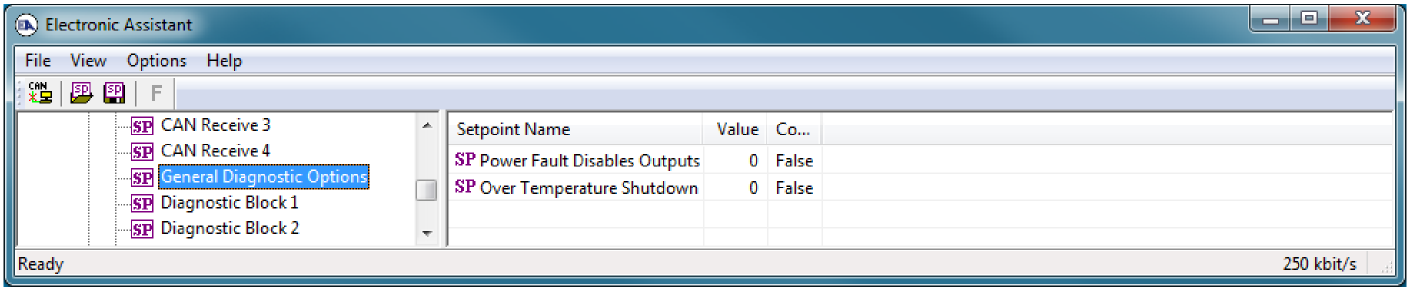


Figure 15 - Screen Capture of General Diagnostics Options Setpoints

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

Table 28 – General Diagnostics Options Setpoints

4.12. Diagnostics Blocks

There are 19 Diagnostics blocks that can be configured to monitor various parameters of the Controller. By default, the monitoring of operating voltage, CPU temperature and receive message timeouts is configured to diagnostics blocks 1, 2 and 3. Diagnostic blocks 4 to 15 are configured to monitor RTD inputs 1 to 12. The Diagnostic Function Block is defined in section 1.5. Please refer there for detailed information how these setpoints are used.

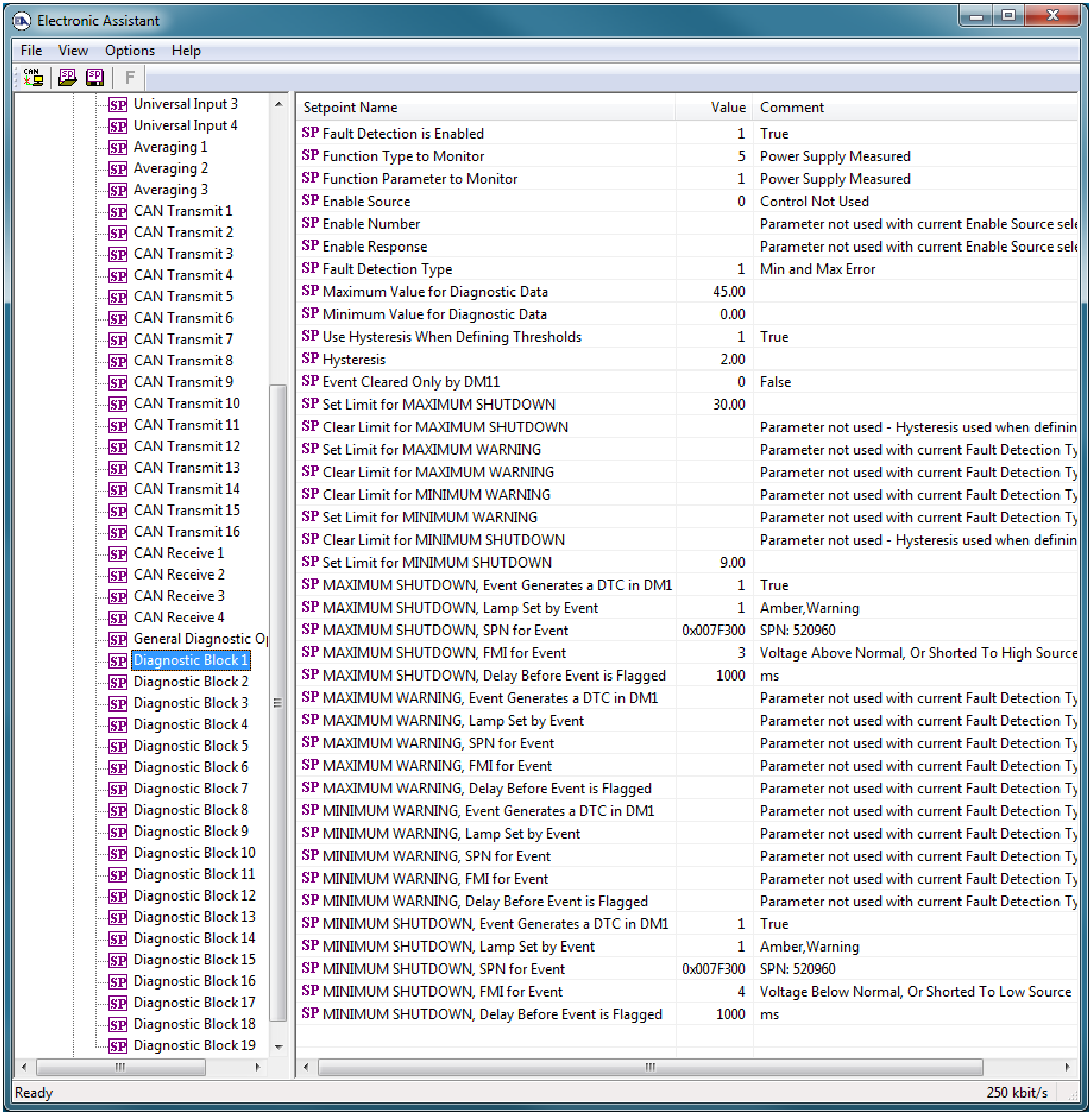


Figure 16 - Screen Capture of Diagnostic Block Setpoints

Name	Range	Default	Notes
Fault Detection is Enabled	Drop List	False	
Function Type to Monitor	Drop List	0 – Control not used	
Function parameter to Monitor	Drop List	0 – No selection	
Fault Detection Type	Drop List	1 – Min and Max Error	See section 1.5
Maximum Value for Diagnostic Data	Minimum Value for Diagnostic Data … $4.28e^9$	5.0	
Minimum Value for Diagnostic Data	0.0 … Maximum Value for Diagnostic Data	0.0	
Use Hysteresis When Defining Thresholds	Drop List	False	
Hysteresis	0.0 … Maximum Value for Diagnostic Data	0.0	
Event Cleared only by DM11	Drop List	False	
Set Limit for MAXIMUM SHUTDOWN	Minimum Value for Diagnostic Data … Maximum Value for Diagnostics Data	4.8	
Clear Limit for MAXIMUM SHUTDOWN	Minimum Value for Diagnostic Data … Maximum Value for Diagnostics Data	4.6	
Set Limit for MAXIMUM WARNING	Minimum Value for Diagnostic Data … Maximum Value for Diagnostics Data	0.0	
Clear Limit for MAXIMUM WARNING	Minimum Value for Diagnostic Data … Maximum Value for Diagnostics Data	0.0	
Clear Limit for MINIMUM WARNING	Minimum Value for Diagnostic Data … Maximum Value for Diagnostics Data	0.0	
Set Limit for MINIMUM WARNING	Minimum Value for Diagnostic Data … Maximum Value for Diagnostics Data	0.0	
Clear Limit for MINIMUM SHUTDOWN	Minimum Value for Diagnostic Data … Maximum Value for Diagnostics Data	0.4	
Set Limit for MINIMUM SHUTDOWN	Minimum Value for Diagnostic Data … Maximum Value for Diagnostics Data	0.2	
MAXIMUM SHUTDOWN, Event Generates a DTC in DM1	Drop List	True	
MAXIMUM SHUTDOWN, Lamp Set by Event	Drop List	0 – Protect	See Table 14
MAXIMUM SHUTDOWN, SPN for Event	0...524287	520448 ($7F100)	It is the user’s responsibility to select an SPN that will not violate the J1939 standard.

MAXIMUM SHUTDOWN, FMI for Event	Drop List	3, Voltage Above Normal	See Table 15
MAXIMUM SHUTDOWN, Delay Before Event is Flagged	0...60000 ms	1000	
MAXIMUM WARNING, Event Generates a DTC in DM1	Drop List	True	
MAXIMUM WARNING, Lamp Set by Event	Drop List	0 – Protect	See Table 14
MAXIMUM WARNING, SPN for Event	0...524287	520704 ($7F200)	It is the user's responsibility to select an SPN that will not violate the J1939 standard.
MAXIMUM WARNING, FMI for Event	Drop List	3, Voltage Above Normal	See Table 15
MAXIMUM WARNING, Delay Before Event is Flagged	0...60000 ms	1000	
MINIMUM WARNING, Event Generates a DTC in DM1	Drop List	True	
MINIMUM WARNING, Lamp Set by Event	Drop List	0 – Protect	See Table 14
MAXIMUM WARNING, SPN for Event	0...524287	520960 ($7F300)	It is the user's responsibility to select an SPN that will not violate the J1939 standard.
MINIMUM WARNING, FMI for Event	Drop List	4, Voltage Below Normal	See Table 15
MINIMUM WARNING, Delay Before Event is Flagged	0...60000 ms	1000	
MINIMUM SHUTDOWN, Event Generates a DTC in DM1	Drop List	True	
MINIMUM SHUTDOWN, Lamp Set by Event	Drop List	Amber Warning	See Table 14
MINIMUM SHUTDOWN, SPN for Event	0...524287	521216 ($7F400)	It is the user's responsibility to select an SPN that will not violate the J1939 standard.
MINIMUM SHUTDOWN, FMI for Event	Drop List	4, Voltage Below Normal	See Table 15
MINIMUM SHUTDOWN, Delay Before Event is Flagged	0...60000 ms	1000	

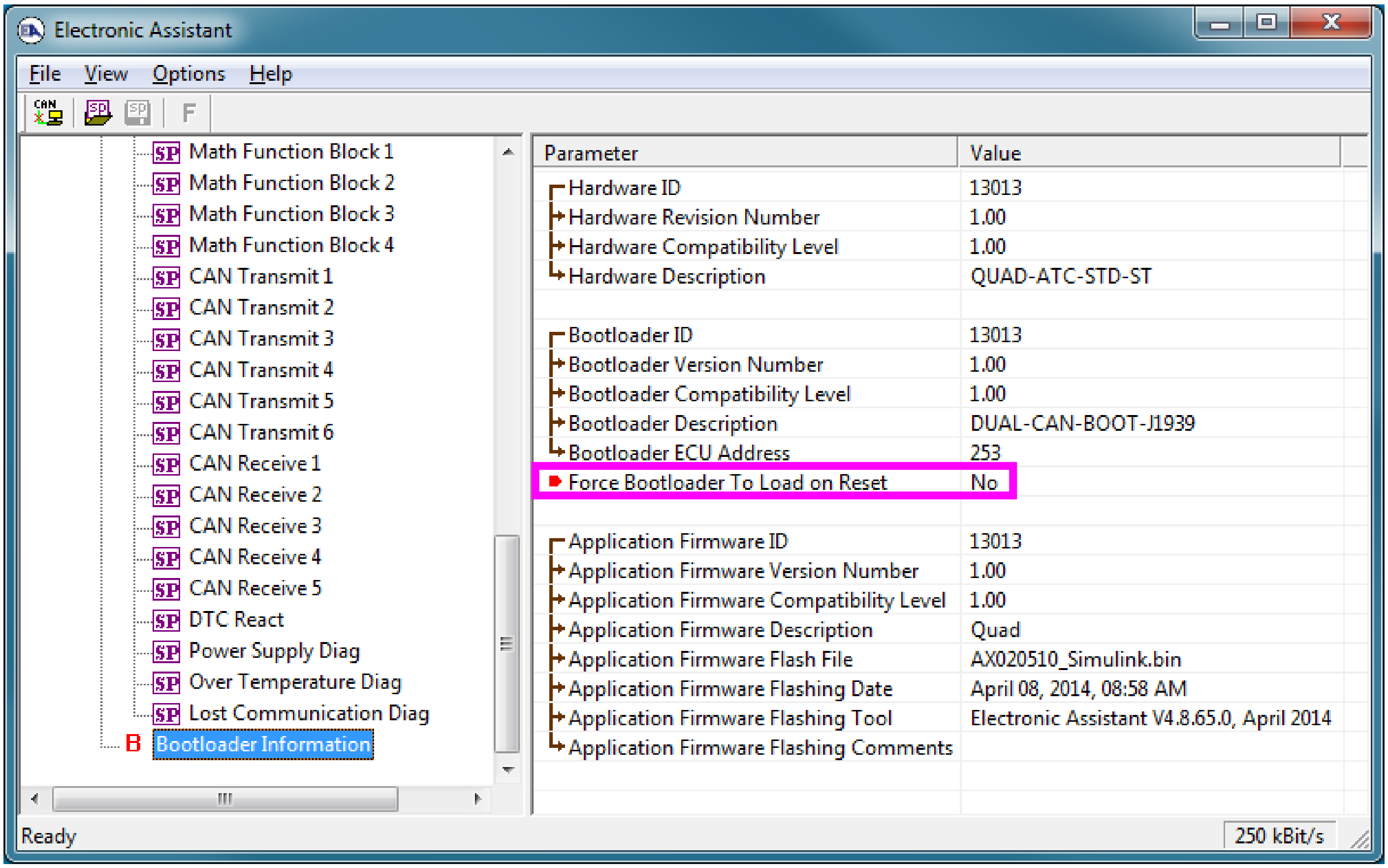
Table 29 – Diagnostic Block Setpoints

5. REFLASHING OVER CAN WITH THE AXIOMATIC EA BOOTLOADER

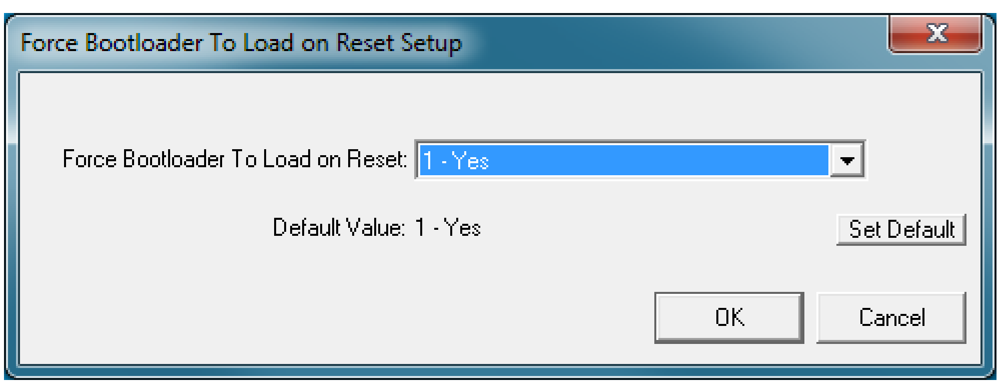
The AX184000 can be upgraded with new application firmware using the **Bootloader Information** section. This section details the simple step-by-step instructions to upload new firmware provided by Axiomatic onto the unit via CAN, without requiring it to be disconnected from the J1939 network.

Note: To upgrade the firmware use Axiomatic Electronic Assistant VX.X.XX.X or higher.

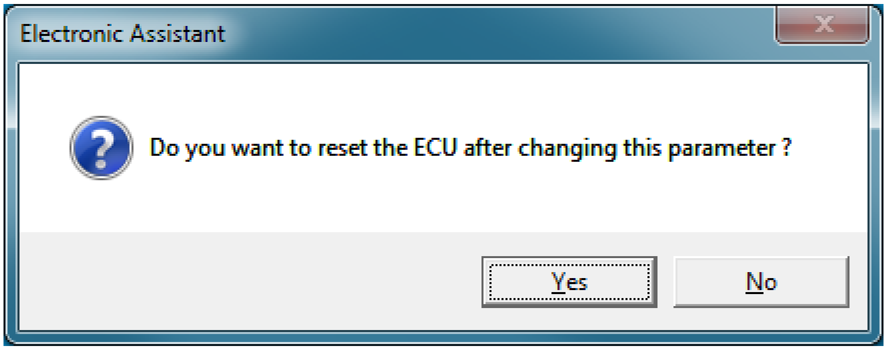
1. When the Axiomatic EA first connects to the ECU, the **Bootloader Information** section will display the following information.



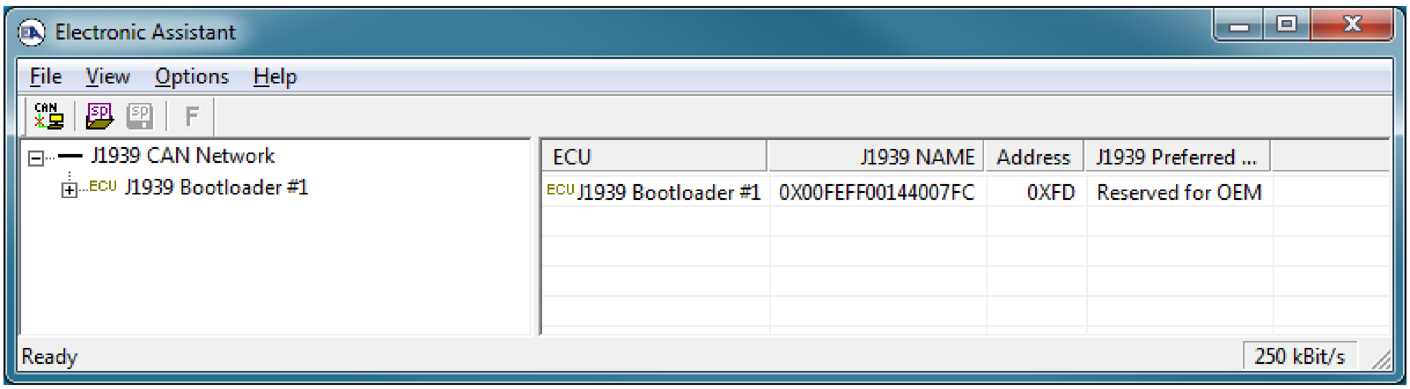
2. To use the bootloader to upgrade the firmware running on the ECU, change the variable **"Force Bootloader To Load on Reset**" to *Yes.*

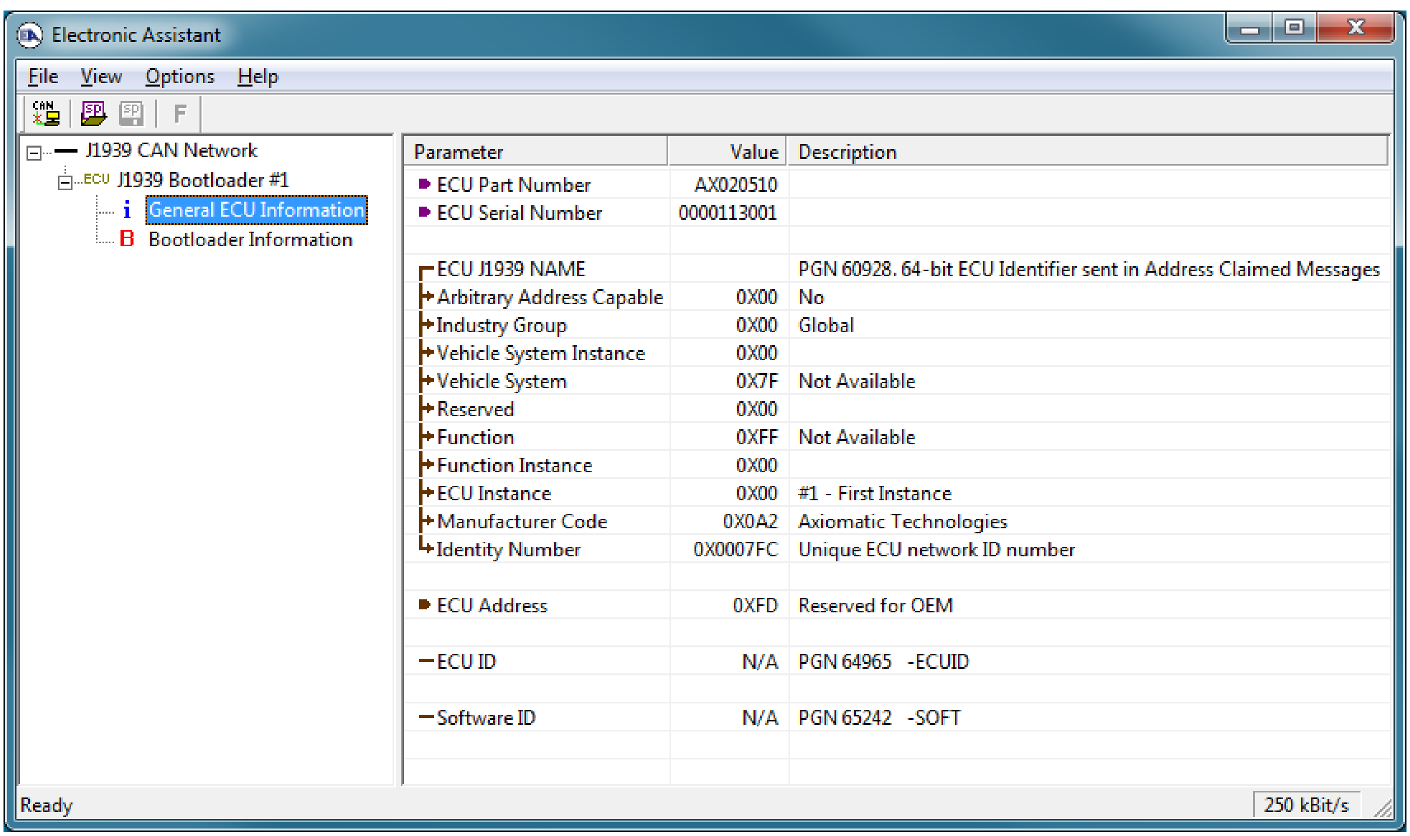


3. When the prompt box asks if you want to reset the ECU, select *Yes.*



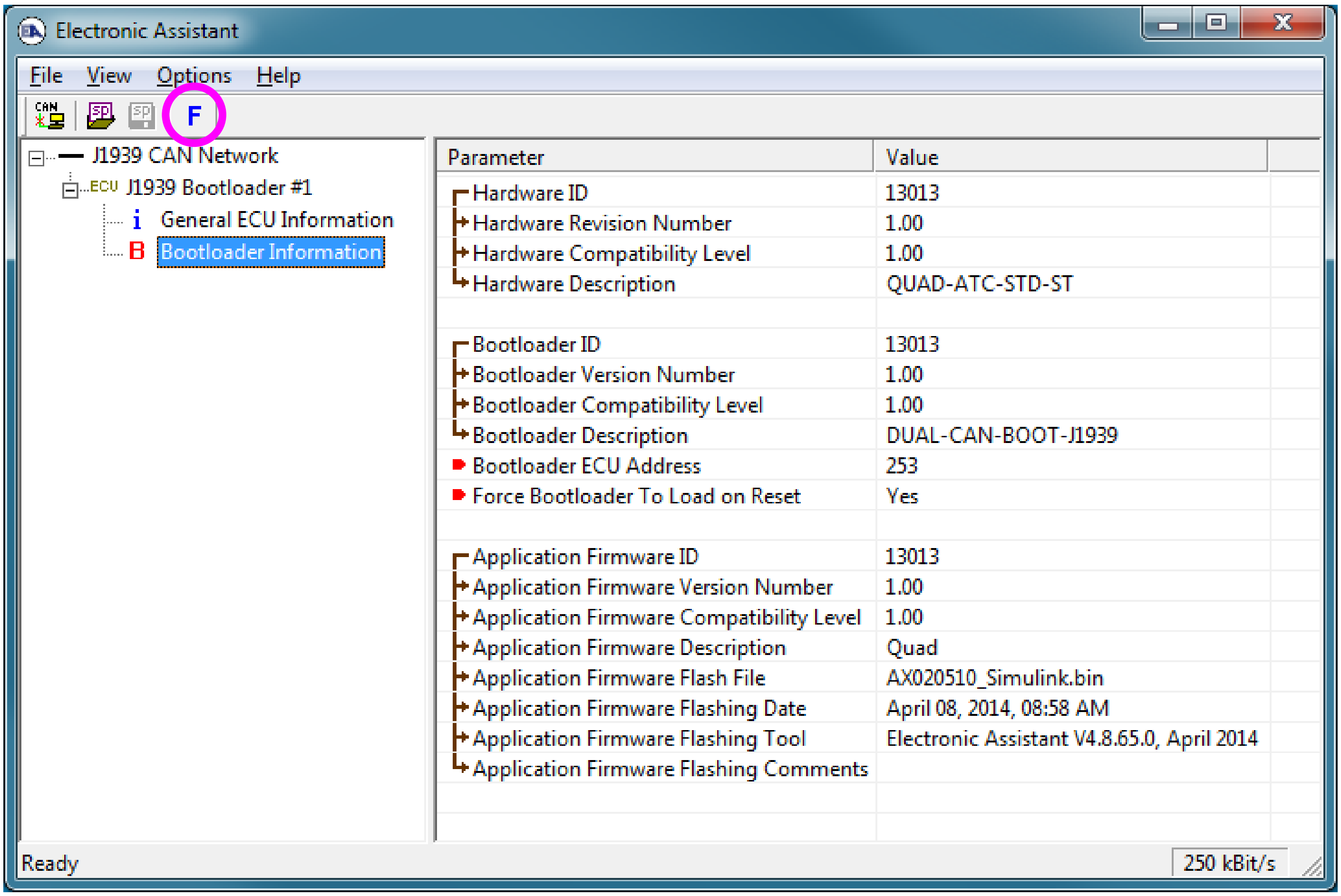
4. Upon reset, the ECU will no longer show up on the J1939 network as an AX184000 but rather as **J1939 Bootloader #1**.





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.

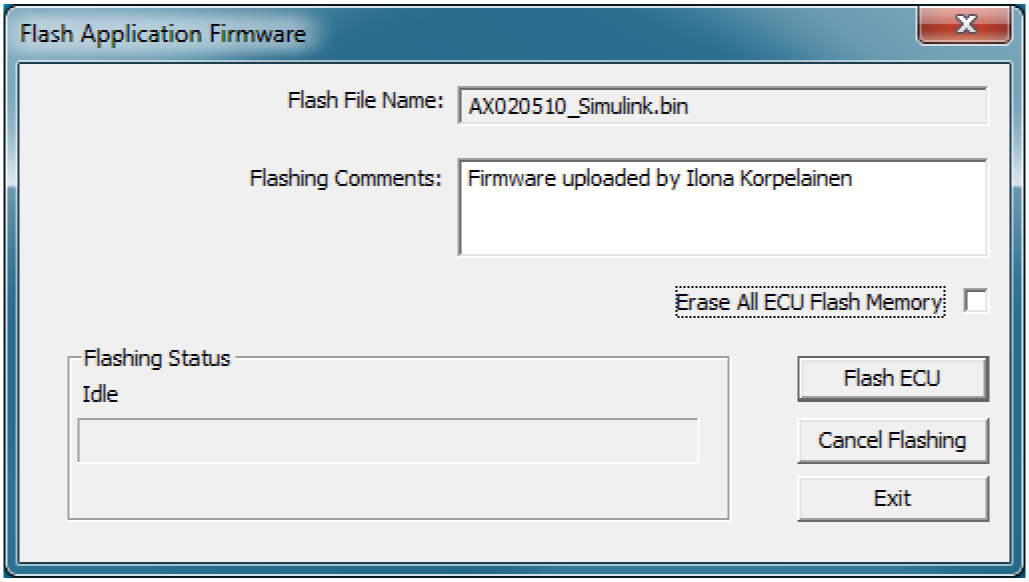
5. When the **Bootloader Information** section is selected, the same information is shown as when it was running the AX184000 firmware, but in this case the F̲lashing feature has been enabled.



6. Select the F̲lashing button and navigate to where you had saved the **AX184000_Simulink.bin** file sent from Axiomatic. (Note: only binary (.bin) files can be flashed using the Axiomatic EA tool.)

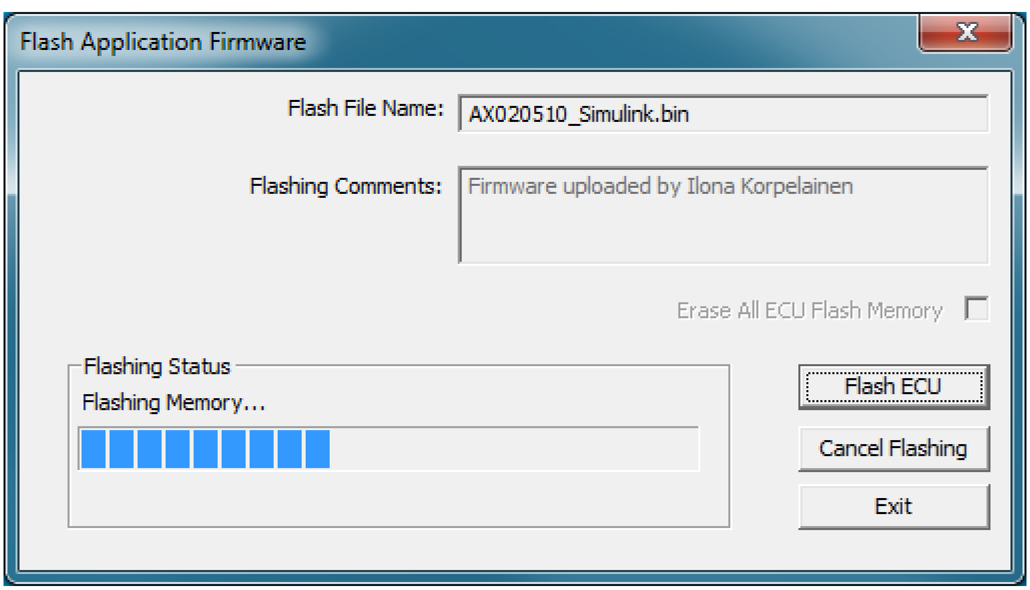
7. Once the Flash Application Firmware window opens, you can enter comments such as "Firmware upgraded by [Name]" if you so desire. This is not required, and you can leave the field blank if you do not want to use it.

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

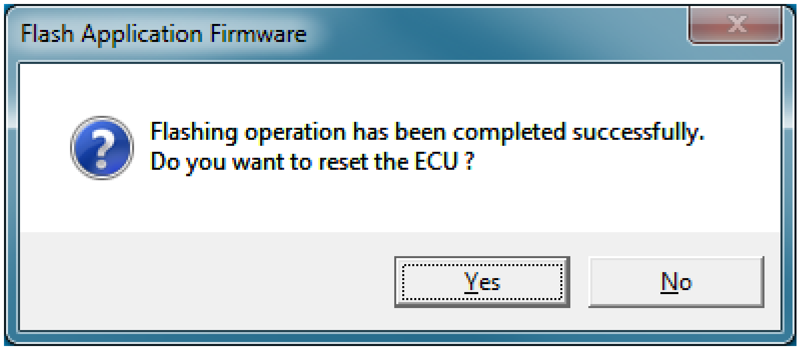


WARNING: Do not check the "Erase All ECU Flash Memory" box unless instructed to do so by your Axiomatic contact. Selecting this will erase ALL data stored in non-volatile flash including the calibration from Axiomatic factory testing. It will also erase any configuration of the setpoints that might have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

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



Once the firmware has finished uploading, a message will pop up indicating the successful operation. If you select to reset the ECU, the new version of the AX184000 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 AX184000 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/.

Power and Protections

Power Supply Input	12V or 24VDC nominal (8…65 VDC power supply range) 50 or 60 Hz is user selectable.
Supply Current	90 mA at 12 Vdc Typical 45 mA at 24 Vdc Typical Inrush does not exceed 500 mA.
Protection	Reverse polarity protection is provided. Power supply input section protects against transients, surges (up to 175V) and short circuits and is isolated from RTD inputs

RTD Inputs

RTD Types	Up to 12 channels, independently configurable for 2 or 3 wire RTDs. Each channel operates independently.
RTD Inputs	Each channel independently supports specific sensors IEC 0.00385, JIS 0.003916, US 0.003902, Legacy 0.003920, SAMA 0.003923. A user defined coefficient would enable custom Callendar-Van Dusen constants to be set for sensors not listed above. The device accepts inputs within the following range of 20 - 400 Ohms. RTD lead resistance range is 0 – 10 Ohms. Accuracy: +/- 1°C with offset calibration performed at R = 100 Ohms, typical at ambient temperature Resolution: 0.001°C Isolation voltage is 400V.
Shield	To connect a Shield, use the grounding stud provided on the base plate.
Scan Rate	50ms per channel, total sweep time maximum 50 ms 20 samples per second for all 12 channels
Common Mode Readings	Input range +/- 2V maximum Rejection is 115db at 5Vp-p (50-60Hz)
Thermal Drift	40 ppm/°C of span (maximum)
Isolation	Digital isolation is 500VDC from input to ground. Three-way isolation is provided for the CAN line, inputs and power supply

SPNs and PGNs	The SPN drop list includes all temperature SPNs from the J1939-71 standard published up to January of 2009. If an SPN is not supported by the drop list, the user can select a zero SPN, which then allows them to define the SPN and PGN per the application requirements. One byte parameters have a resolution of 1 °C / bit and a range of -40 °C to 210 °C. Two byte parameters have resolution of 0.03125 °C / bit and a range of -273 °C to 1735 °C (per SAE J1939). The Parameter Group Number (PGN) that will be used to send a temperature to the J1939 network will be entirely dependent on the Suspect Parameter Number (SPN) that was selected for that channel. In all cases, the PGN is a PDU2 type. Each PGN has a predefined priority and repetition rate associate with it.
Averaging	The average temperature of all the active channels can be broadcasted to the network using the default "Engine Average Information" PGN, or on a Proprietary B message.
Protection	Open circuit detection Frozen data detection Over or under temperature detection High temperature shutdown detection

Signal Inputs

Universal Inputs (4)	Four universal inputs are user selectable as: voltage; current; PWM; or digital types. 12-bit Analog to Digital resolution. Protected against shorts to GND. Voltage Types: 0-5Vdc or 0-10Vdc 1mV resolution, accuracy +/- 1% error Current Types: 0-20 mA or 4-20 mA Current sense resistor 249Ω 1uA resolution, accuracy +/- 1% error Frequency: 0.5 to 50Hz or 10 Hz to 1 kHz or 100 Hz to 10 kHz Frequency Input: 0.01% resolution, accuracy +/- 1% error PWM Signal Frequency: 0 – 10,000 Hz PWM Duty Cycle: 0 to 100% PWM Input: 0.01% resolution, accuracy +/- 1% error Counter Counter Input: 0.01% resolution, accuracy +/- 1% error Digital Input: 1MΩ Impedance or Active High with 10K Pullup or Active Low with 10K Pulldown resistor to GND Amplitude: up to +Vsupply
Analog Grounds	Four (4) analog ground connections are provided.

Communications

CAN	1 CAN 2.0B port, protocol SAE J1939 250 kbps Baud Rate Digital isolation is provided for the CAN line.
Network Termination	According to the CAN standard, 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.

General Specifications

Microprocessor	STM32F205V 12-bit, 1 Mbyte Flash Memory

Control Logic	User programmable functionality with the Axiomatic Electronic Assistant: Node address is auto configurable as per J1939-81 and/or via customer configuration. Monitored parameters and diagnostics are user selectable from a drop-down list in the Axiomatic EA. Monitored parameters and diagnostics are read-only over the network. All parameter locations have default values that do not conflict. Units are pre-configured with default values at the factory. Refer to the user manual. Parameter values and diagnostic error codes are retained when the modules are de-energized. Easily selectable SPNs from a drop-down list of the temperature SPNs supported by SAE J1939. User defined SPN and PGN's are configurable with the Axiomatic Electronic Assistant, to suit the desired application. Configurable ECU Instance in the NAME to allow for multiple ECU's on the same network The bit-rate is 250 kbit/s. Other bit-rates (125 kbit/s, 500 kbit/s or 1 Mbit/s) can be factory programmed on request. Contact Axiomatic for an ordering P/N. Module is fully functional during configuration and communications.
SAE J1939 Profile	For J1939 compliance (SAE, Recommended Practice for a Serial Control and Communications Vehicle Network, October 2007) all modules comply with the applicable portions of the following: SAE J1939-21, December 2006, Data Link Layer SAE J1939-71, January 2009, Vehicle Application Layer SAE J1939-73, September 2006, Application Layer – Diagnostics SAE J1939-81, May 2003, Network Management *Customer specific proprietary extensions can also be included in the SAE J1939 profile on request.*
Diagnostics	Configurable Diagnostic Messaging parameters Diagnostic Log is maintained in non-volatile memory. Each RTD channel can be configured to send diagnostic messages to the network if the temperature goes out of range.
User Interface	Via The Axiomatic Electronic Assistant, P/Ns: AX070502 or AX070506K Updates for the Axiomatic EA are found on www.axiomatic.com under the log-in tab.
UL and cUL Compliance	Pending
CE Compliance	2004/108/EC (EMC Directive) pending 2011/65/EU (RoHS Directive)
Vibration	MIL-STD-202G, Test 204D and 214A (Sine and Random) 10 g peak (Sine); 7.86 Grms peak (Random)
Shock	MIL-STD-202G, Test 213B, 50 g

Operating Temperature Range	-40 to 85 ºC (-40 to 185 ºF)
Storage Temperature Range	-50 to 120 ºC (-58 to 248 ºF)
Humidity	Protected against 95% humidity non-condensing, 30 ºC to 60 ºC
Protection	IP67
Weight	2.1 lb. (0.96 kg)
Enclosure	Rugged aluminum housing, stainless steel end plates, neoprene gaskets 145.30 x 149.00 x 73.00 mm (5.72 x 5.86 x 2.87”) L x W x H Connectors: Equivalent to TE Deutsch P/Ns: 1 8-pin DT13-08PA, 1 40-pin DRC13-40PX Can be mounted directly on the power generator set or remotely Suitable for moist, high shock, vibrating and non-hazardous environments *Refer to the installation instructions section for pin out.*

AXIOMATIC
Global Electronic Solutions

OUR PRODUCTS

AC/DC Power Supplies

Actuator Controls/Interfaces

Automotive Ethernet Interfaces

Battery Chargers

CAN Controls, Routers, Repeaters

CAN/WiFi, CAN/Bluetooth, Routers

Current/Voltage/PWM Converters

DC/DC Power Converters

Engine Temperature Scanners

Ethernet/CAN Converters, Gateways, Switches

Fan Drive Controllers

Gateways, CAN/Modbus, RS-232

Gyroscopes, Inclinometers

Hydraulic Valve Controllers

Inclinometers, Triaxial

I/O Controls

LVDT Signal Converters

Machine Controls

Modbus, RS-422, RS-485 Controls

Motor Controls, Inverters

Power Supplies, DC/DC, AC/DC

PWM Signal Converters/Isolators

Resolver Signal Conditioners

Service Tools

Signal Conditioners, Converters

Strain Gauge CAN Controls

Surge Suppressors

OUR COMPANY

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

QUALITY DESIGN AND MANUFACTURING

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

WARRANTY, APPLICATION APPROVALS/LIMITATIONS

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

COMPLIANCE

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

SAFE USE

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

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

SERVICE

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

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

DISPOSAL

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

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