



USER MANUAL UMAX100240
USER MANUAL UMAX100240-01
USER MANUAL UMAX100240-02

50W BLDC MOTOR CONTROLLER with CAN, SAE J1939

USER MANUAL

P/N: AX100240

P/N: AX100240-01 – J1939 500kb/s Baud Rate

P/N: AX100240-02 – Custom J1939 Baud Rate, 1Mbits/s

VERSION HISTORY

Version	Date	Author	Modification
1.0.0.	Dec 9, 2021	Antti Keränen	Initial version.
1.0.1	August 31, 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)
BEMF	Back Electromotive Force / Counter-electromotive Force
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
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

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REFERENCES

J1939	Recommended Practice for a Serial Control and Communications Vehicle Network, SAE, April 2011
J1939/21	Data Link Layer, SAE, December 2010
J1939/71	Vehicle Application Layer, SAE, March 2011
J1939/73	Application Layer-Diagnostics, SAE, February 2010
J1939/81	Network Management, SAE, March 2013
TDAX100240	Technical Datasheet, BLDC Motor Controller with CAN, Axiomatic Technologies 2021
UMAX07050x	User Manual V 5.xx.yyy, Axiomatic Electronic Assistant and USB-CAN, Axiomatic Technologies, August 2023

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



NOTE: This product is supported by Axiomatic Electronic Assistant V5.xx.yy.0 and higher.

1. OVERVIEW OF CONTROLLER

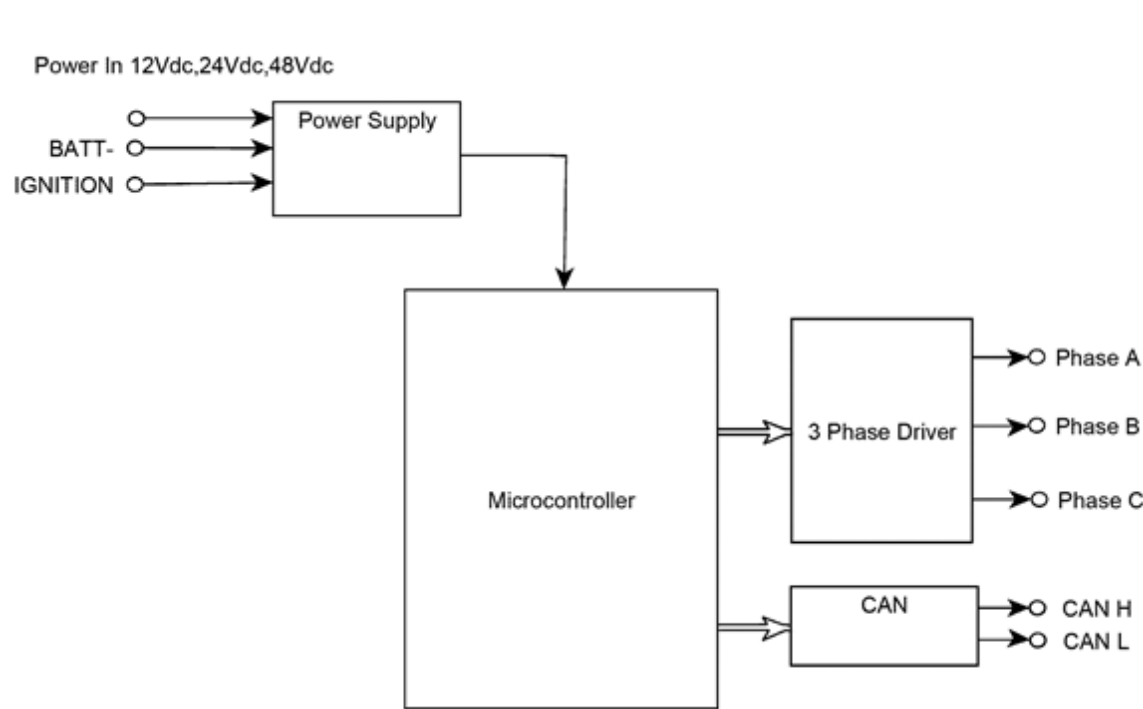


Figure 1 – AX100240 Block Diagram

The AX100240 BLDC / DC motor controller implements the 6 step sensorless BLDC commutation algorithm and also supports driving of a brushed DC motor.

The *Windows*-based Axiomatic Electronic Assistant (EA) is used to configure the controller via a USB-CAN device (P/N: AX070501). Setpoint configuration can be saved in a file which can be used to easily program the same configuration into another BLDC Controller. Throughout this document, Axiomatic EA setpoint names are referred to with bolded text in double-quotes, and the setpoint option is referred to with italicized text in single-quotes. For example, “**Motor Type**” setpoint set to option ‘*BLDC Motor*’.

The BLDC Motor Controller can be ordered using the following part numbers depending on the application.

AX100240	Controller with the default J1939 baud rate (250kbits/s).
AX100240-01	Controller with the 500kbits/s J1939 baud rate.
AX100240-02	Controller with a custom 1Mbits/s J1939 baud rate.

1.1. Motor Control Functionality

The 50W BLDC controller is capable of driving brushless DC motor using Back-EMF rotor position detection. As a configuration option, also brushed DC motor control is supported. There are multiple setpoints accessible with the Axiomatic EA that allow the user to configure the 50W BLDC controller to drive a variety of different BLDC motors.

The Motor Parameters setpoint group (see section 4.3) supports the configuration of the main motor parameters, such as number of pole pairs, rated RPM of the motor and PWM frequency to use in Motor Phase drive.

“**Motor Type**” setpoint selects the motor type to drive. The default is the ‘*BLDC Motor*’. There is also an option to control a brushed DC motor using phase outputs A and B only.

“**Number of pole pairs**” has direct influence on how the 50W BLDC controller picks up the motor RPM, this parameter should be always set to correspond the motor driven by the controller.

The “**Rated RPM**” setpoint is used for normalizing the RPM data in the function blocks. It does not have other influence how the motor is driven by the controller.

The “**PWM Frequency**” sets the frequency to use in the Phase outputs’ PWM signal in kHz.

In case the over current protection gets triggered, the “**Over current event clear time**” specifies the time in milliseconds after which the controller clears the over current status and resumes normal operation. If the event clear time is set to 0ms, the over current status won’t be cleared (a power cycle is required to resume normal operation).



The **IGNITION** pin (**Pin 3**, see Table 4 – AX100240 Connector Pinout) **needs to be connected to VPS** for powering on the AX100240 controller. If this pin is floating / connected to GND, the controller will stay OFF.

In case there is a need to use a combined direction and enable signaling, for example a CAN message containing both information, this is possible to configure by setting the “**Direction Control Source**” to ‘*Control Not Used*’ and “**Motor Enable Control Source**” to ‘*Received CAN Message.*’ With this configuration, the received CAN message values are used as listed in Table 1. The CAN Receive Messages #1 and #2 are configured to implement this type of control by default.

0	<i>Disabled</i>
1	<i>Motor enabled in forward direction</i>
2	<i>Motor enabled in reverse direction</i>
3	<i>Reserved</i>

Table 1 – Combined enable and direction signals

1.1.1. Sensorless Control

The sensorless motor control is based on detecting the back emf voltage on the free phase while the motor is running. While this voltage is available only when the motor is running, the startup procedure is carried out without knowing whether the rotor actually rotates or not. Depending on the

motor in question, the user has to tune the startup parameters in “**Speed Acceleration Control**” setpoint group (see section 4.7).



Figure 2 – Sensorless drive startup steps

The sensorless startup is carried out in two steps, namely:

1. Ramp-Up

During the ramp-up period, the motor is driven in open loop configuration for picking up speed and for making the back emf signals available for the sensorless control. The speed of the ramp up, together with initial and target commutation speed can be configured in “**Speed Acceleration Control**”. The “**Initial startup ramp step length**” defines the commutation interval in the start of the ramp up phase. The “**Final startup ramp step length**” defines the commutation interval in the end of the ramp up phase. The unit value for these setpoints depends on the selected PWM frequency for the motor output. The “**Startup ramp acceleration**” defines the delay for decrementing the ramp by one (i.e. commutation is speeded up).

The ramp-up phase duration is determined by the following formula, in which 10kHz is the default execution speed of the low-level commutation algorithm (“**PWM Frequency**” setpoint in Motor Parameters).

$$t_{ramp-up} = \frac{((Initial\ st.\ up\ ramp\ step\ length - Final\ st.\ up\ ramp\ step\ length) * St.\ up\ ramp\ acceleration)}{10kHz}$$

With default settings, the ramp-up phase duration is 600ms.

2. Normal Operation

After the ramp-up is done, the rotor should be rotating. At this point the controller switches over to normal operation in which the rotor position is picked up by the back emf algorithm and the PWM drive signals are applied accordingly. In this mode the motor driving signals’ PWM duty cycle is determined by the Speed and/or Current controller, as configured.

1.2. CAN Transmit Message Function Block

The CAN Transmit function block is used to send any output from another function block (i.e. measured motor data, CAN receive) to the J1939 network. The AX100240 ECU has two CAN Transmit Messages, and each message has four completely user defined signals.

1.2.1. 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 2 second delay. This is done to prevent any power up or initialization conditions from creating problems on the network.

By default, first message is configured to report Motor RPM, controller temperature, motor current and low level PWM drive value.

1.2.2. 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 2. 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, therefore **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.

1.3. 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. Motor drive).

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.

Once a message has been enabled, the previously received data is reset if that message is not received within the **“Receive Message Timeout”** period. 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 is held until the reception of the next message (or a power cycle).

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

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

The 50W BLDC controller supports up to four unique CAN Receive Messages.

1.4. 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 2. All sources are available for all blocks. Though input Sources are freely selectable, it must be remembered that not all options would make sense in all cases, and it is up to the user to program the controller in a logical and functional manner.

Sources	Number Range	Notes
<i>0: Control Not Used</i>	N/A	When this is selected, it disables all other setpoints associated with the signal in question.
<i>1: Received CAN Message</i>	1 to 4	
<i>2: Control Constant Data</i>	1 to 8	1 = FALSE, 2 = TRUE, 3 to 8 = User Selectable
<i>3: Motor RPM Value</i>	1	Measured RPM reading.
<i>4: Motor Current Feedback</i>	1	Measured motor current in Amps.
<i>5: Power Supply Measured</i>	1	Measured power supply value in Volts.
<i>6: Temperature Measured</i>	1	Measured (processor) temperature in °C.
<i>7: CAN Reception Timeout</i>	1	
<i>8: Additional Control Data</i>	1 to 16	User must enable the function block, as it is disabled by default.

Table 2 – Available Control Sources and Numbers

Additional Data Number	Notes
1	Not used
2	Not used
3	Measured RPM
4	Motor stalled status
5	Target pwm drive (range: 0-32767)
6	Not used
7	Power
8	Not used
9	Not used
10	Not used
11	Not used
12	Internal status flags
13	Not used
14	Not used
15	Not used
16	Not used

Table 3 – Data available in Additional Data Control Source

2. INSTALLATION INSTRUCTIONS

2.1. Dimensions and Pinout

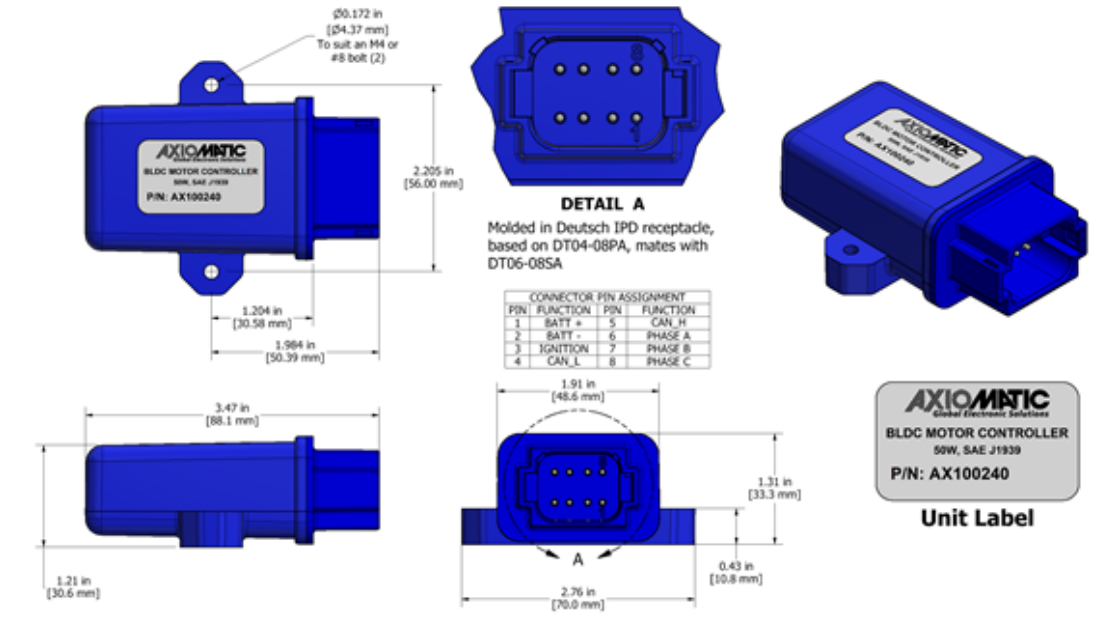


Figure 3 – AX100240 Dimensional Drawing

Connector PIN #	Function
8	Motor PWM (Phase C)
7	Motor PWM (Phase B)
6	Motor PWM (Phase A)
5	CAN H
4	CAN L
3	Ignition
2	Battery -
1	Battery +

Table 4 – AX100240 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

- | | | |
|---------------------------|-------|----------|
| • Software Identification | 65242 | 0x00FEDA |
|---------------------------|-------|----------|

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

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

3.2. NAME, Address and Software ID

The 50W BLDC controller 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	132, Axiomatic Motor Controller
Function Instance	11, Axiomatic AX100240
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 50W BLDC controller will continue select the next highest address until it finds one that it can claim. See J1939/81 for more details about address claiming.

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.

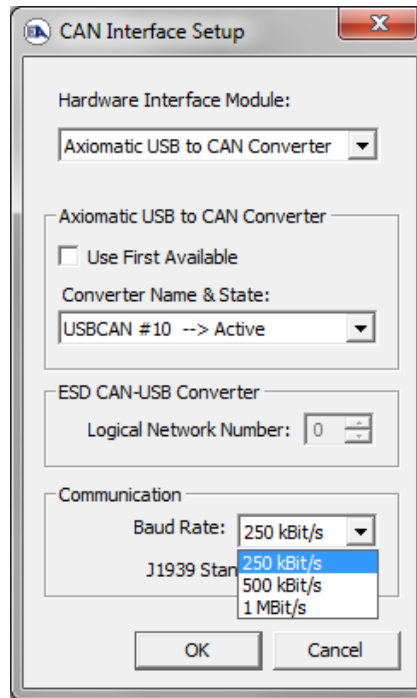
Note: The information provided in the Software ID is available for any J1939 service tool which supports the PGN -SOFT.

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 the BLDC Controller, refer to the relevant section in this user manual.

4.1. Accessing the ECU Using the Axiomatic EA

ECU with P/N AX100240 does not need any specific setup for the Axiomatic EA. In order to access the high speed versions, AX100240-01 and/or AX100240-02, the CAN bus Baud Rate 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.

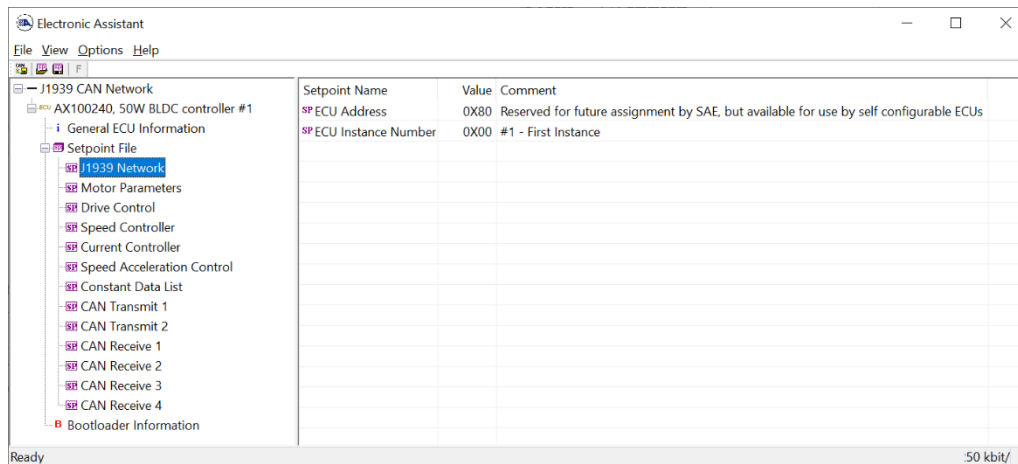


Figure 4 - Screen Capture of J1939 Setpoints

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

Table 5 – 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. Motor Parameter Setpoints

The detailed description of Motor Parameters, please refer to section 0.

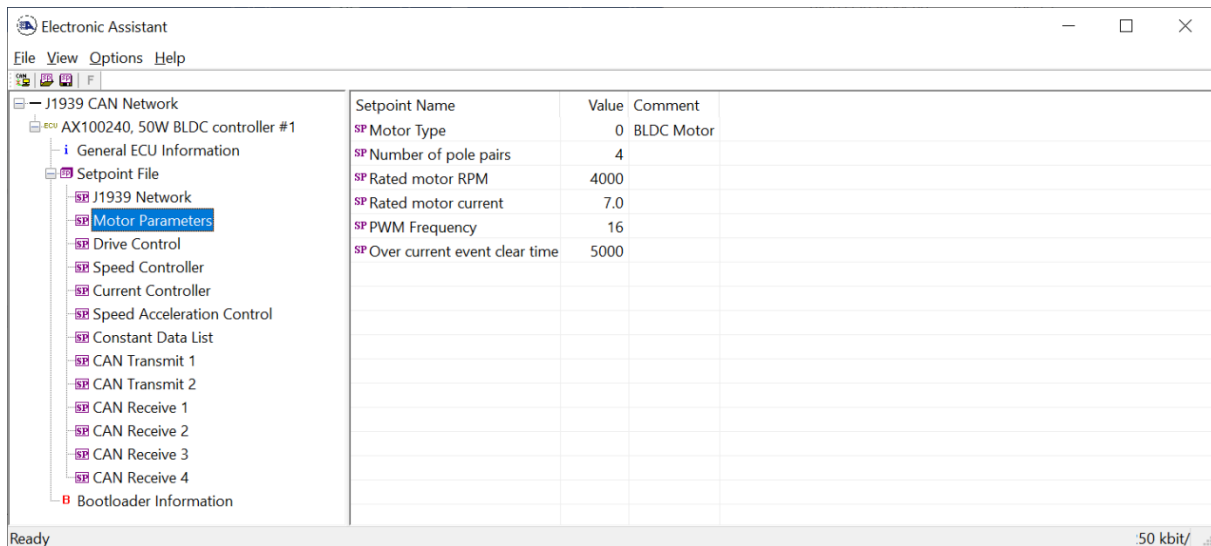


Figure 5 - Screen Capture of Motor Parameter Setpoints

Name	Range	Default	Notes
Motor Type	Drop List	0 – BLDC	0 – BLDC, 1 – DC
Number of pole pairs	0...255	4	
Rated motor RPM	0...20000	4000	RPM
Rated motor current	0...7	7	A
PWM Frequency	5...20	16	kHz
Over current event clear time		5000	ms
RPM filter constant	25		No. of samples in moving average filter
Motor current filter constant	25		No. of samples in moving average filter
Over temperature limit		120	Celsius
Protect action	Drop List	1 – Derate	
Protect action parameter	0 ... 60000	100	Max current derate slope coefficient

Table 6 – Motor Parameter Setpoints

4.4. Drive Control Setpoints

The Drive Control Setpoints let the user to specify which control signals are responsible for the motor driving. In case SPN 7991 style direction+enable signal needs to be used, the 'Direction Control Source' setpoint should be set to 'Control not Used'. This forces the controller to read in the direction control signal together with enable signal. This feature is targeted to be used when direction+enable is received as a CAN message.

In case 'Direction Control Source' should be set as constantly true or false, the Control Constant Data sources #1 (FALSE) and #2 (TRUE) can be used for this purpose.

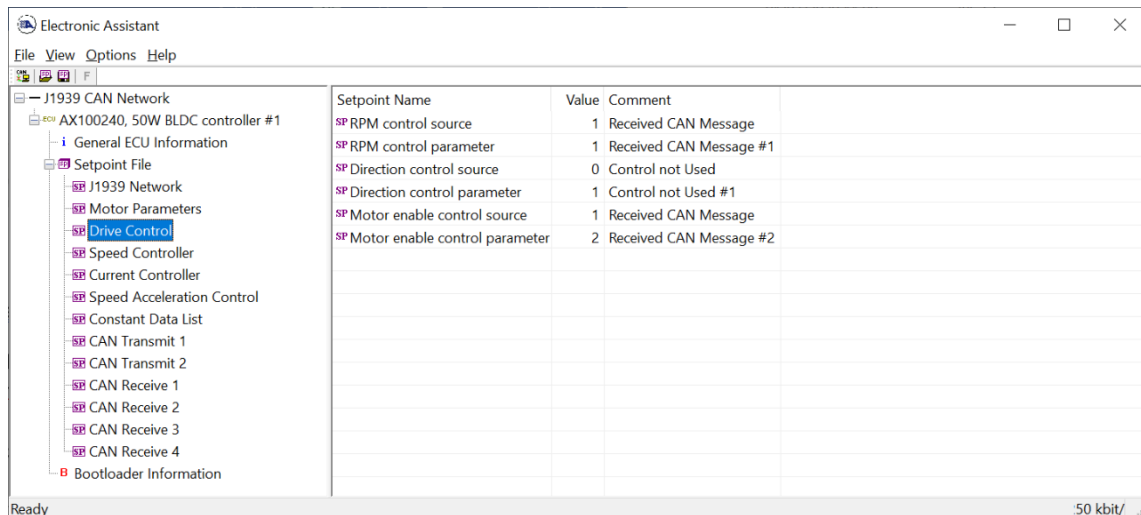


Figure 6 - Screen Capture of Drive Control Setpoints

Name	Range	Default	Notes
RPM control source	Drop List	1	CAN receive message
RPM control source parameter	Depends on source	1	CAN Rx #1
Direction control source	Drop List	0	Set to '0' if direction data should be read in together with enable data in a CAN message (SPN 7991 support)
Direction control source parameter	Depends on source	1	
Enable control source	Drop List	1	CAN receive message
Enable control source parameter	Depends on source	2	CAN Rx #2

Table 7 – Drive Control Setpoints

SPN 7991 data	Function
0	Drive disabled
1	Drive enabled, normal direction
2	Drive enabled, reverse direction
3	Reserved

Table 8 – SPN 7991 style Enable+Direction command

4.5. Speed Controller Setpoints

These setpoints configure the Open and Closed Loop speed control. The closed loop PI controller gains depend on the application in question, and it is on the user's responsibility to find out the correct gains. The closed loop PI controller is executed at 10ms intervals.

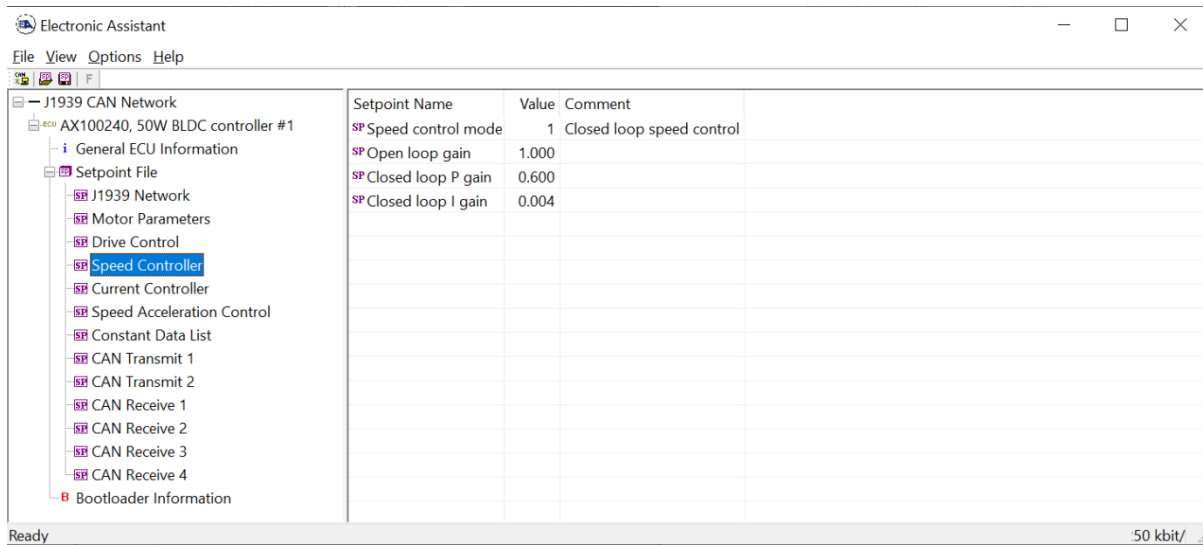


Figure 7 - Screen Capture of Speed Controller Setpoints

Name	Range	Default	Notes
Speed control mode	Drop List	1	Closed loop control
Open loop gain	0 ... 100.0	1.0	
Closed loop P gain	0.0 ... 100.0	0.600	
Closed loop I gain	0.0 ... 100.0	0.004	

Table 9 – Speed Controller Setpoints

4.6. Current Controller Setpoints

These setpoints configure the Open and Closed Loop current control. The closed loop PI controller gains depend on the application in question, and it is on the user's responsibility to find out the correct gains. The closed loop PI controller is executed at 10ms intervals.

The closed loop current control is applied only when the measured motor current exceeds the "Closed loop current threshold" value. If the measured current stays below that limit, the current control is not applied.

When the current control is not applied, the PWM duty cycle for motor driving depends only on the speed controller block.

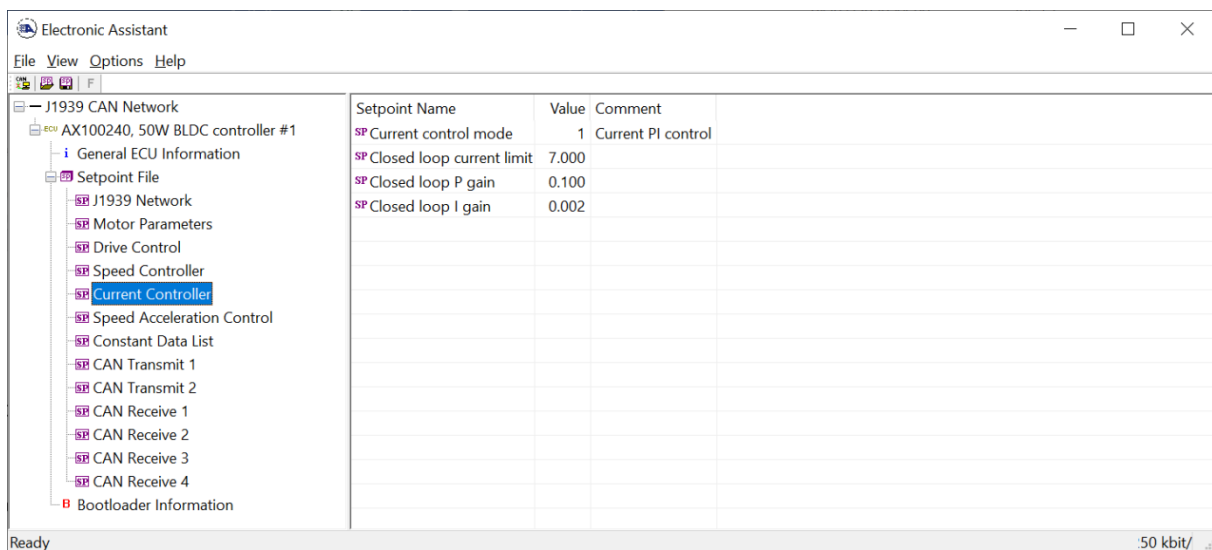


Figure 8 - Screen Capture of Current Controller Setpoints

Name	Range	Default	Notes
Current control mode	Drop List	0	No current control
Closed loop current threshold	0.0 ... 7.0	7.0	[A]
Closed loop P gain	0.0 ... 100.0	1.0	
Closed loop I gain	0.0 ... 100.0	0.0	

Table 10 – Current Controller Setpoints

4.7. Speed Acceleration Control Setpoints

For detailed description of Speed Acceleration Control, please refer to section 1.1.1

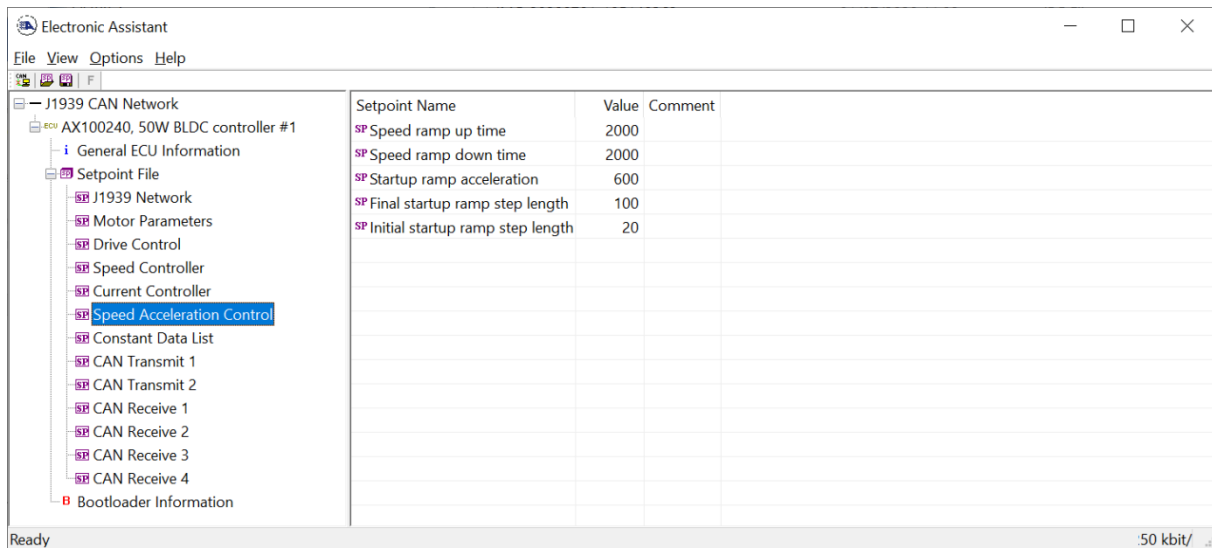


Figure 9 - Screen Capture of Speed Acceleration Control Setpoints

Name	Range	Default	Notes
Speed ramp up time	0...60000	1000	milliseconds
Speed ramp down time	0...60000	1000	milliseconds
Startup ramp acceleration	0...32767	20	ISR ticks
Initial startup ramp step length	0...32767	500	ISR ticks
Final startup ramp step length	0...32767	200	ISR ticks

Table 11 – Speed Acceleration Control Setpoints

4.9. CAN Transmit Setpoints

Please refer to section 0 for detailed information how these setpoints are used.

The screenshot shows the Electronic Assistant software interface. On the left, a tree view displays the project structure for 'J1939 CAN Network' and 'AX100240, 50W BLDC controller #1'. The 'CAN Transmit 1' setpoint is selected. The main area displays a table of setpoints with columns for Setpoint Name, Value, and Comment.

Setpoint Name	Value	Comment
SP Transmit PGN	0xFF80	Transmit PGN: 65408
SP Transmit Repetition Rate	200 ms	
SP Transmit Message Priority	6	
SP Destination Address (PDU1)	255	Destination ECU Address: 0xFF
SP Signal 1 Data Source	3	Motor RPM Value
SP Signal 1 Data Number	1	Motor RPM Value #1
SP Signal 1 Type	2	CAN signal continuous
SP Signal 1 Byte Position	0	1st Byte Position
SP Signal 1 Bit Position	0	1st Bit Position
SP Signal 1 Data Size	16	
SP Signal 1 Transmit Data Resolution	1.0000000	
SP Signal 1 Transmit Data Offset	0.0000000	
SP Signal 1 Transmit Data Minimum	0.0000000	
SP Signal 1 Transmit Data Maximum	7000.0000000	
SP Signal 2 Data Source	6	Temperature Measured
SP Signal 2 Data Number	1	Temperature Measured
SP Signal 2 Type	2	CAN signal continuous
SP Signal 2 Byte Position	3	4th Byte Position
SP Signal 2 Bit Position	0	1st Bit Position
SP Signal 2 Data Size	8	
SP Signal 2 Transmit Data Resolution	1.0000000	
SP Signal 2 Transmit Data Offset	-40.0000000	
SP Signal 2 Transmit Data Minimum	-40.0000000	
SP Signal 2 Transmit Data Maximum	150.0000000	
SP Signal 3 Data Source	4	Motor Current Feedback
SP Signal 3 Data Number	1	Motor Current Feedback #1
SP Signal 3 Type	2	CAN signal continuous
SP Signal 3 Byte Position	4	5th Byte Position
SP Signal 3 Bit Position	0	1st Bit Position
SP Signal 3 Data Size	8	
SP Signal 3 Transmit Data Resolution	0.1250000	
SP Signal 3 Transmit Data Offset	0.0000000	
SP Signal 3 Transmit Data Minimum	0.0000000	
SP Signal 3 Transmit Data Maximum	10.0000000	

Figure 11 - Screen Capture of CAN Transmit Message Setpoints

Name	Range	Default	Notes
Transmit PGN	0xff00 ... 0xffff	Different for each	
Transmit Repetition Rate	0 ... 65000 ms	0ms	0ms disables transmit
Transmit Message Priority	0...7	6	
Destination Address	0...255	255	Not used by default
Signal 1 Data Source	Drop List	Different for each	See Table 2
Signal 1 Data Number	Drop List	Different for each	
Signal 1 Type	Drop List	2	Continuous data
Signal 1 Byte Position	0-7	0	
Signal 1 Bit Position	0-7	0	
Signal 1 Data Size	Drop List	16 bits	
Signal 1 Transmit Data Resolution	-100000.0 to 100000	Different for each	
Signal 1 Transmit Data Offset	-10000 to 10000	0.0	
Signal 1 Transmit Data Minimum	-100000.0 to 100000	0.0	
Signal 1 Transmit Data Maximum	-100000.0 to 100000	Different for each	
Signal 2 Data Source	Drop List	Different for each	See Table 2
Signal 2 Data Number	Drop List	Different for each	
Signal 2 Type	Drop List	2	Continuous data
Signal 2 Byte Position	0-7	0	
Signal 2 Bit Position	0-7	0	
Signal 2 Data Size	Drop List	16 bits	
Signal 2 Transmit Data Resolution	-100000.0 to 100000	Different for each	
Signal 2 Transmit Data Offset	-10000 to 10000	0.0	
Signal 2 Transmit Data Minimum	-100000.0 to 100000	0.0	
Signal 2 Transmit Data Maximum	-100000.0 to 100000	Different for each	
Signal 3 Data Source	Drop List	Different for each	See Table 2
Signal 3 Data Number	Drop List	Different for each	
Signal 3 Type	Drop List	2	Continuous data
Signal 3 Byte Position	0-7	0	
Signal 3 Bit Position	0-7	0	
Signal 3 Data Size	Drop List	16 bits	
Signal 3 Transmit Data Resolution	-100000.0 to 100000	Different for each	
Signal 3 Transmit Data Offset	-10000 to 10000	0.0	
Signal 3 Transmit Data Minimum	-100000.0 to 100000	0.0	
Signal 3 Transmit Data Maximum	-100000.0 to 100000	Different for each	
Signal 4 Data Source	Drop List	Different for each	See Table 2
Signal 4 Data Number	Drop List	Different for each	
Signal 4 Type	Drop List	2	Continuous data
Signal 4 Byte Position	0-7	0	
Signal 4 Bit Position	0-7	0	
Signal 4 Data Size	Drop List	16 bits	
Signal 4 Transmit Data Resolution	-100000.0 to 100000	Different for each	
Signal 4 Transmit Data Offset	-10000 to 10000	0.0	
Signal 4 Transmit Data Minimum	-100000.0 to 100000	0.0	
Signal 4 Transmit Data Maximum	-100000.0 to 100000	Different for each	

Table 12 – CAN Transmit Message Setpoints

4.10. CAN Receive Setpoints

Please refer to section 1.3 for detailed information about how these setpoints are used.

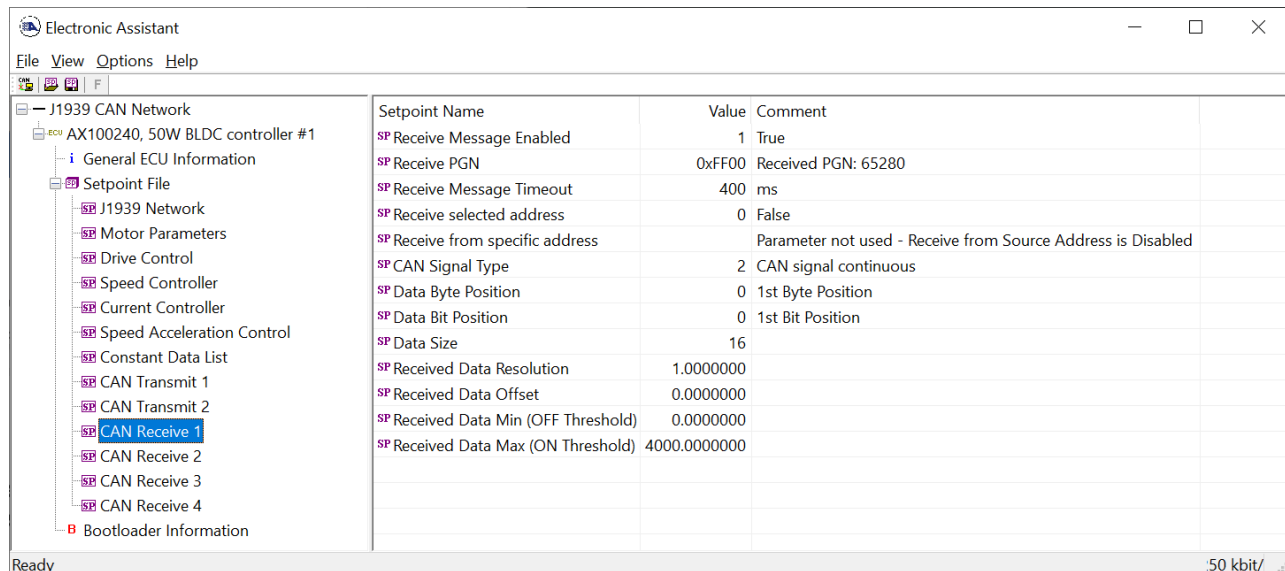


Figure 12 - Screen Capture of CAN Receive Message Setpoints

Name	Range	Default	Notes
Received Message Enabled	Drop List	False	
Received PGN	0 to 65536	Different for each	
Received Message Timeout	0 to 60 000 ms	0ms	
Receive selected address	Drop List	False	
Receive from specific address	0 to 255	254 (0xFE, Null Addr)	
CAN Signal Type	Drop List	2 – Continuous data	
Data Byte Position	0-7	0	
Data Bit Position	0-7	0	
Data Size	0-32	8 bits	
Received Data Resolution	-100000.0 to 100000	0.01	
Received Data Offset	-10000 to 10000	0.0	
Received Data Min (OFF Threshold)	-1000000 to Max	0.0	
Received Data Max (ON Threshold)	-100000 to 100000	2.5	

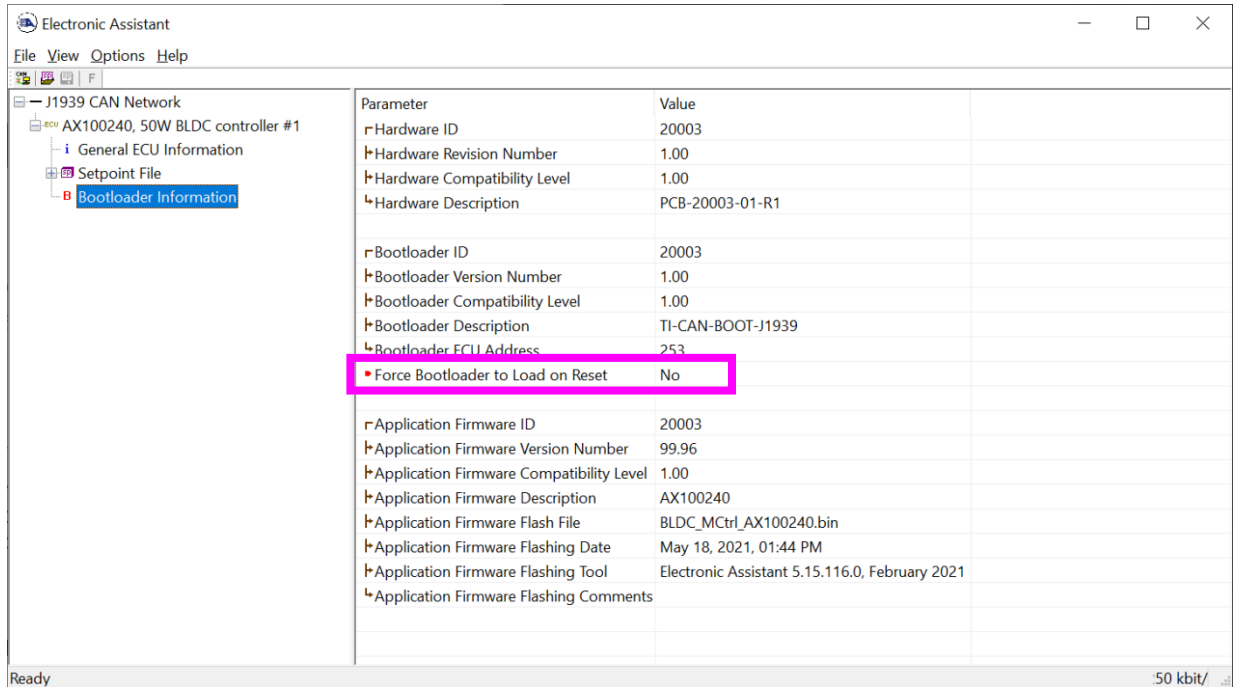
Table 13 – CAN Receive Setpoints

5. REFLASHING OVER CAN WITH THE AXIOMATIC EA BOOTLOADER

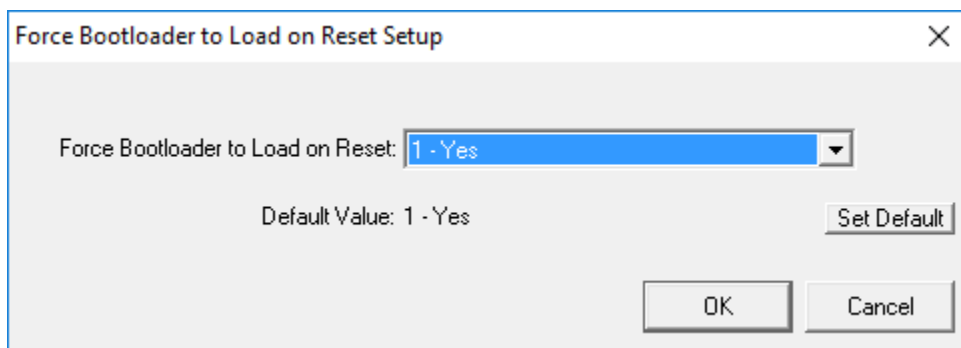
The AX100240 can be upgraded with new application firmware using the **Bootloader Information** section. This section details the simple step-by-step instructions to upload new firmware provided by Axiomatic onto the unit via CAN, without requiring it to be disconnected from the J1939 network.

Note: To upgrade the firmware use Axiomatic Electronic Assistant V5.xx.yy.0 or higher.

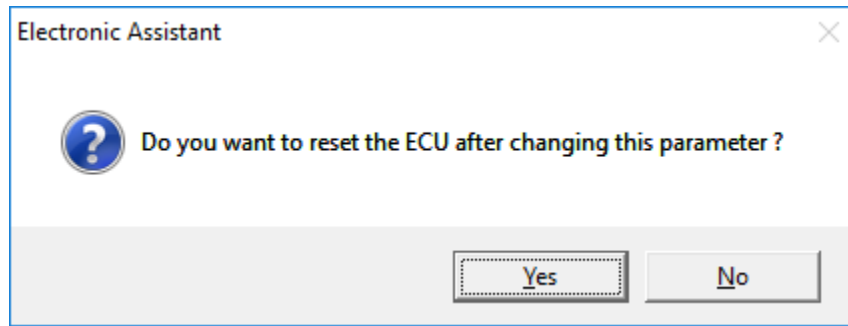
1. When the Axiomatic EA first connects to the ECU, the **Bootloader Information** section will display the following information.



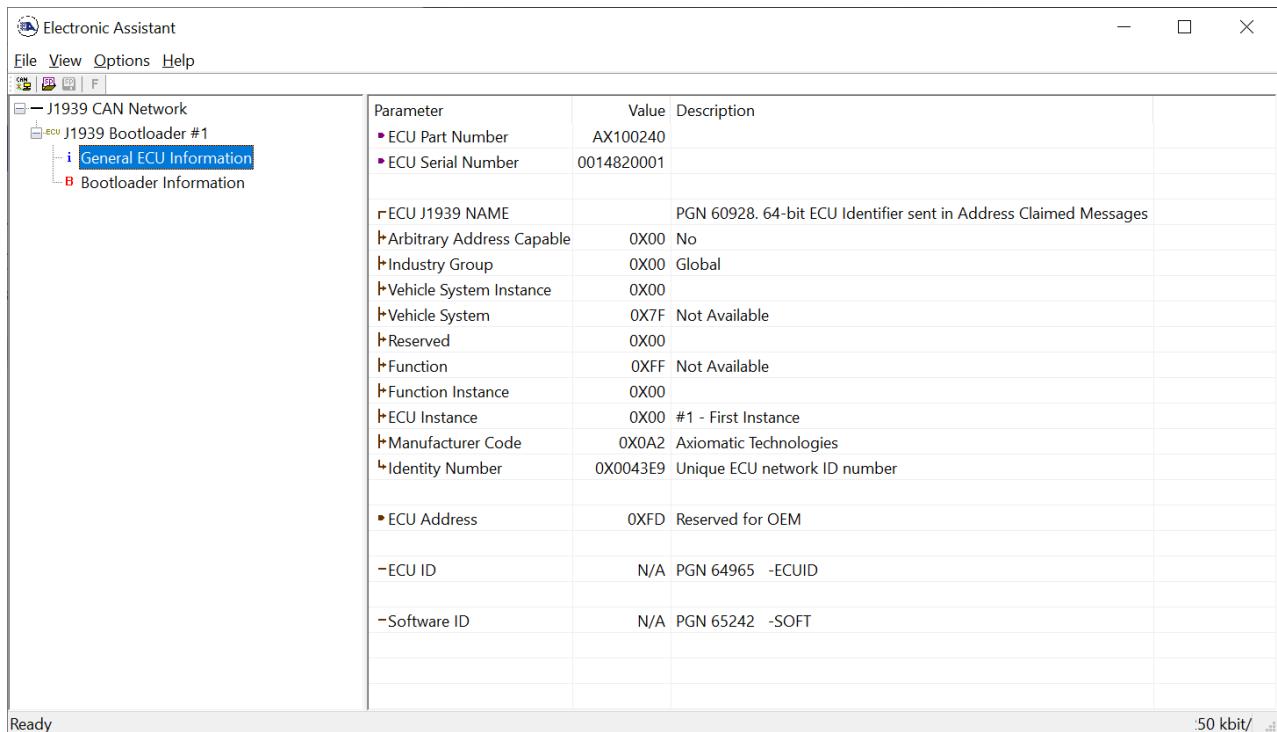
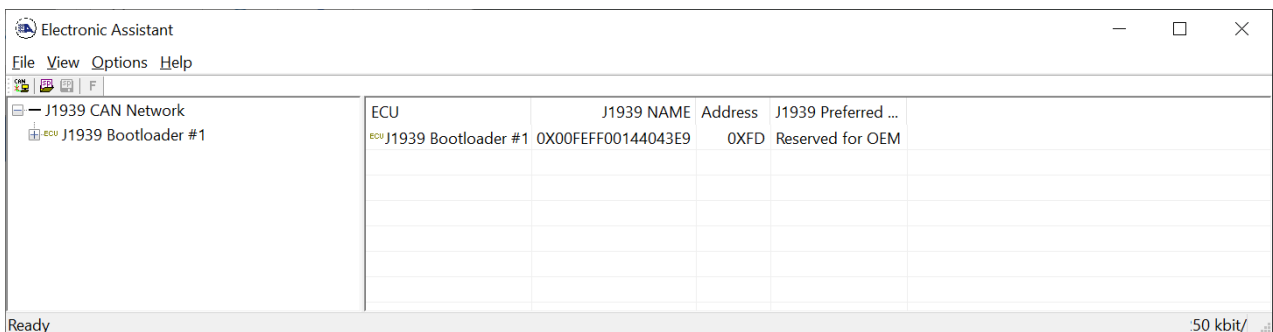
2. To use the bootloader to upgrade the firmware running on the ECU, change the variable “**Force Bootloader To Load on Reset**” to Yes.



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



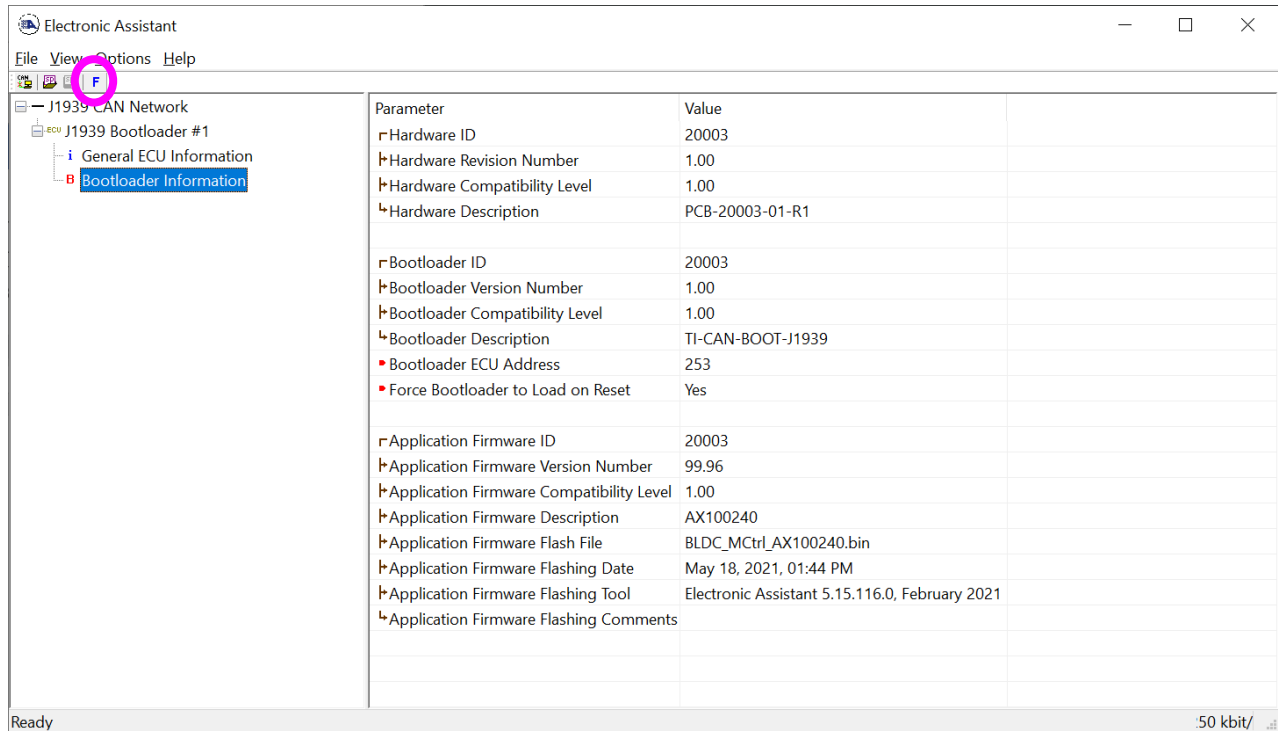
4. Upon reset, the ECU will no longer show up on the J1939 network as an AX100240 but rather as **J1939 Bootloader #1**.



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.

- When the **Bootloader Information** section is selected, the same information is shown as when it was running the AX100240 firmware, but in this case the **F**lashing feature has been enabled.



- Select the **F**lashing button and navigate to where you had saved the **AF-20003-x.xx.bin** file sent from Axiomatic. (Note: only binary (.bin) files can be flashed using the Axiomatic EA tool.)
- 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/timestamp the file, as this is done automatically by the Axiomatic EA tool when you upload the new firmware.

Flash Application Firmware

Flash File Name: AF-20003-1.02.bin

Flashing Comments:
Press CTRL+ENTER to add a new string

Erase All ECU Flash Memory

Flashing Status
Idle

Flash ECU

Cancel Flashing

Exit



NOTE: Please make sure that the “Erase All ECU Flash Memory” box is checked. Selecting this will erase ALL data stored in non-volatile flash. It will also erase any configuration of the setpoints that might have been done to the ECU and reset all setpoints to their factory defaults. **If this box is left unchecked, the firmware upload will FAIL.**

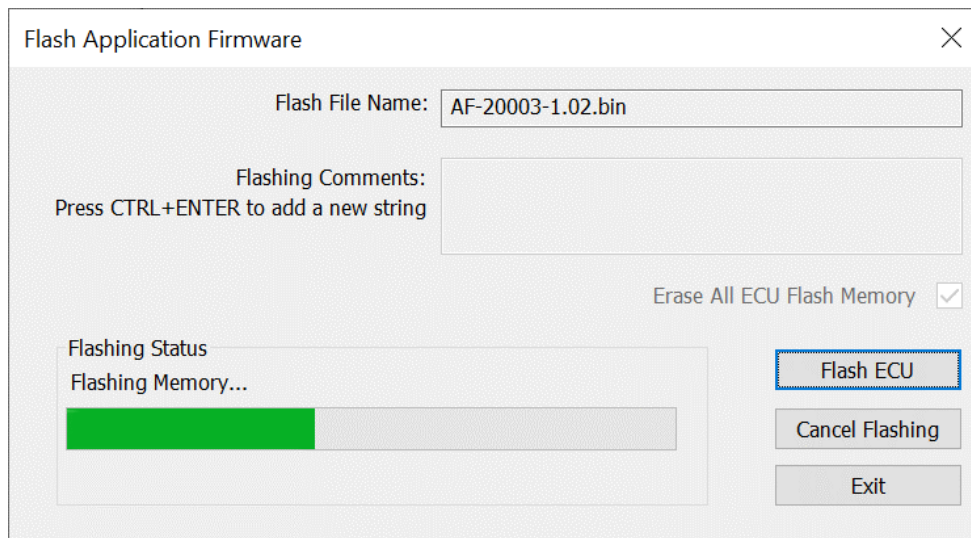
When proceeding to flashing with the “Erase All ECU Flash Memory” option checked, the Axiomatic EA will warn the user about erasing all setpoint data.

Flash Application Firmware

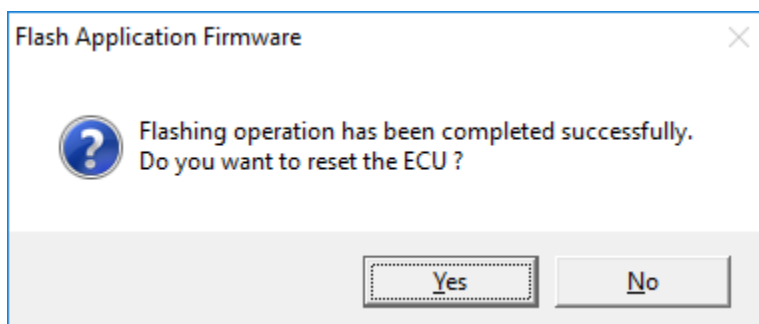
Please note, that by continuing this operation you will erase the existing application firmware from the ECU. Make sure you have selected a correct flash file! To continue, press “Ok” or cancel the operation.

OK Cancel

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 AX100240 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 AX100240 application will run rather than the bootloader function.



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

APPENDIX A - TECHNICAL SPECIFICATION

Technical Specifications:

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

Input Specifications

Power Supply Input - Nominal	12, 24 or 48Vdc nominal (8...90Vdc)
Reverse Polarity Protection	Provided up to -150Vdc
Surge Protection	Provided
Under-voltage Protection	Built-in
Ignition Switch Input	The ignition key input turns the unit power ON. Minimum 2.5V, maximum +Vps

Output Specifications

Output to Motor	3 phase, H-bridge output 2.5A per each phase <i>Ratings are preliminary and subject to validation.</i> 2.5A @ 48Vdc nominal continuous 2.5A @ 24Vdc nominal continuous 2.5A @ 12Vdc nominal continuous 50W nominal power rating Sensorless operation Overcurrent protection is provided at 5A. Short circuit protection is provided. The maximum rated speed and the motor rated current are configurable to suit individual motor specifications.
Motor Stop	Shut off with or without ramping
Motor Direction	Motor direction command can come from the CAN bus.
Motor Control Mode	Flexible control is provided by user configurable parameters for Speed control (BLDC motors only) Current control; The control input to drive the motor responds to messages from the CAN bus. It features continuous operation if the CAN signal is lost.
Thermal Protection	Thermal protection is built-in and configurable.

General Specifications

Microprocessor	TI TMS320F280048, 32-bit, 256 KB flash program memory, 100 KB RAM
Motor Control	Custom embedded software is provided. Refer to the user manual.
Quiescent Current	Contact Axiomatic.
User Interface	Via the Axiomatic Electronic Assistant, P/Ns: AX070502 or AX070506K
Flashing over CAN	The controller software can be reflashed over the CAN connection using the Axiomatic EA.
CAN port	1 CAN port (SAE J1939) 250 kbps baud rate
Weight	0.15 lb. (0.068 kg) Preliminary
Operating Conditions	-40°C to +125°C (-40°F to 257°F)
Protection Rating	IP67
Vibration	MIL-STD-202G, Method 204D test condition C (Sine) and Method 214A, test condition B (Random) 10 g peak (Sine) 7.68 Grms peak (Random)
Shock	MIL-STD-202G, Method 213B, test condition A 50g (half sine pulse, 9ms long, 8 per axis)
Enclosure and Dimensions	Molded Enclosure, integral connector Nylon 6/6, 30% glass, ultrasonically welded 3.47 x 2.75 x 1.31 inches (88.2 x 70.0 x 33.3 mm) L x W x H including integral connector Refer to the dimensional drawing.
Electrical Connections	Integral 8-pin receptacle (equivalent TE Deutsch P/N: DT04-08PA) 18 AWG wire is recommended for use with contacts 0462-201-16141.

	<p>A mating plug kit is available. Ordering P/N: AX070112 is comprised of 1 DT06-08SA, 1 W8S, 8 0462-201-16141, and 3 114017.</p> <table border="1" data-bbox="488 205 940 474"> <thead> <tr> <th data-bbox="488 205 631 233">PIN #</th> <th data-bbox="631 205 940 233">FUNCTION</th> </tr> </thead> <tbody> <tr> <td data-bbox="488 233 631 260">1</td> <td data-bbox="631 233 940 260">BATT+</td> </tr> <tr> <td data-bbox="488 260 631 287">2</td> <td data-bbox="631 260 940 287">BATT-</td> </tr> <tr> <td data-bbox="488 287 631 315">3</td> <td data-bbox="631 287 940 315">IGNITION</td> </tr> <tr> <td data-bbox="488 315 631 342">4</td> <td data-bbox="631 315 940 342">CAN_L</td> </tr> <tr> <td data-bbox="488 342 631 369">5</td> <td data-bbox="631 342 940 369">CAN_H</td> </tr> <tr> <td data-bbox="488 369 631 396">6</td> <td data-bbox="631 369 940 396">MOTOR_A</td> </tr> <tr> <td data-bbox="488 396 631 424">7</td> <td data-bbox="631 396 940 424">MOTOR_B</td> </tr> <tr> <td data-bbox="488 424 631 451">8</td> <td data-bbox="631 424 940 451">MOTOR_C</td> </tr> </tbody> </table>	PIN #	FUNCTION	1	BATT+	2	BATT-	3	IGNITION	4	CAN_L	5	CAN_H	6	MOTOR_A	7	MOTOR_B	8	MOTOR_C
PIN #	FUNCTION																		
1	BATT+																		
2	BATT-																		
3	IGNITION																		
4	CAN_L																		
5	CAN_H																		
6	MOTOR_A																		
7	MOTOR_B																		
8	MOTOR_C																		
Mounting	<p>Mounting holes are sized for #8 or M4 bolts. The bolt length will be determined by the end-user's mounting plate thickness. The mounting flange of the controller is 0.425 inches (10.8 mm) thick. It should be mounted with connectors facing left or right to reduce likelihood of moisture entry. All field wiring should be suitable for the operating temperature range. Install the unit with appropriate space available for servicing and for adequate wire harness access (6 inches or 15 cm) and strain relief (12 inches or 30 cm).</p>																		

OUR PRODUCTS

AC/DC Power Supplies
Actuator Controls/Interfaces
Automotive Ethernet Interfaces
Battery Chargers
CAN Controls, Routers, Repeaters
CAN/WiFi, CAN/Bluetooth, Routers
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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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