

Preliminary  
TECHNICAL DATASHEET #TDAX100650  
**DC MOTOR CONTROLLER**  
P/N: AX100650

*Variable Speed Control, Onboard Inputs  
6A DC Motor Output, 2.5A Proportional Output, 2 Signal Outputs  
CAN SAE J1939, Rugged Packaging  
High Temperature Operation  
with Electronic Assistant®*

**Features:**

- Unidirectional or bi-directional DC motor control
- Up to 6A nominal continuous output power to the motor
- Flexible control with user selectable modes:
  - Open Loop Speed
  - Closed Loop Speed;
  - Current control;
  - Position control;
  - or PID control.
- One (1) 2.5A Output to drive an hydraulic valve or solenoid configurable as: Proportional Current; Hotshot Digital; PWM Duty Cycle; Proportional Voltage; or On/Off Digital
- Two (2) Signal Outputs (Voltage or Current)
- Two (2) Universal inputs are user configurable as Voltage, Current, Resistive, PWM, or Digital types.
- One (1) magnetic pick up input
- The control input to drive the motor can be mapped to any of the inputs or the controller can respond to messages from a CAN bus.
- User configurable enable function can be mapped to any of the inputs or a CAN message
- Direction control can be mapped to any of the inputs or a CAN message
- Output can be coded as feedback messages sent to the CAN bus
- 1 reference voltage (5V, 50 mA max.) are provided to power an external sensor or potentiometer
- Highly efficient and robust design
- Operational from 9 - 36Vdc (12 or 24Vdc nominal)
- SIL ready microcontroller
- 1 CAN port (SAE J1939) are provided (CANopen on request)
- **Electronic Assistant®** runs on a *Windows* operating system for simple user configuration. An Axiomatic USB-CAN converter links the PC to the CAN bus.
- Compact size for easy mounting
- Suitable for moist, high shock and vibration environments
- Fully sealed with a rugged IP67 enclosure
- Operational up to 125°C temperature



**Applications:** Motor variable speed, position and/or flow control in Lift Equipment, Electric Vehicles for Material Handling, Trucks, Cranes and Hoists, Hydraulic Tail Lifts and Winches, Golf Carts, Military Equipment, Mobile Pumps and Hydraulic Powerpacks

## Ordering Part Numbers:

DC Motor Controller, SAE J1939 250 kbps P/N: **AX100650**  
 DC Motor Controller, SAE J1939 500 kbps P/N: **AX100650-01**  
 DC Motor Controller, SAE J1939 1 Mbps P/N: **AX100650-02**

Configuration Tool: Electronic Assistant® P/N: **AX070502**

Accessories: **Mating Plugs Kit P/N: PL-DTM06-12SA-12SB**

**Description:** The DC Motor Controller has two universal inputs that can be configured to measure voltage, current, frequency, PWM duty cycle, resistance or digital voltage level (on/off). A third input can be a magnetic pick-up sensor. It accepts 12Vdc or 24Vdc nominal input power. The controller is capable of driving DC motors up to 6A nominal. Refer to Figure 1.0.

Measured input data can be sent to a SAE J1939 CAN Network as is or used in the DC controller function blocks for controlling how the DC motor is driven. The configurable properties of the controller are divided into function blocks, namely, the Input Function Block, the Control Logic Block, the Diagnostic Function Block, the CAN Transmit Message Function Block and the CAN Receive Message Function Block.

A *Windows*-based Axiomatic Electronic Assistant® (EA) is used to configure the controller via the USB-CAN device. Refer to Figure 2.0. There are multiple setpoints accessible with the EA that allow the user to configure the controller to drive a variety of different BLDC motors.

A rugged enclosure, IP67 rating and high temperature operation up to 125°C ensure that the controller is suitable for mounting in harsh equipment environments. The controller features a SIL-ready microcontroller.

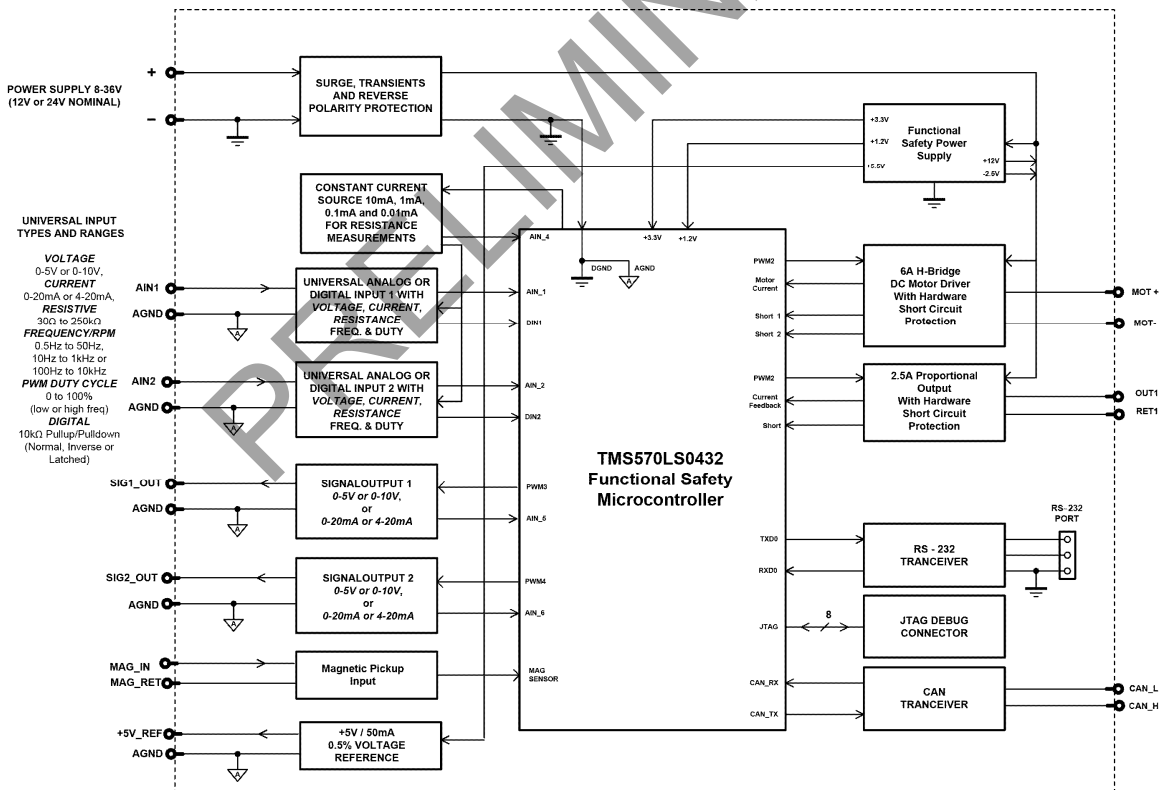
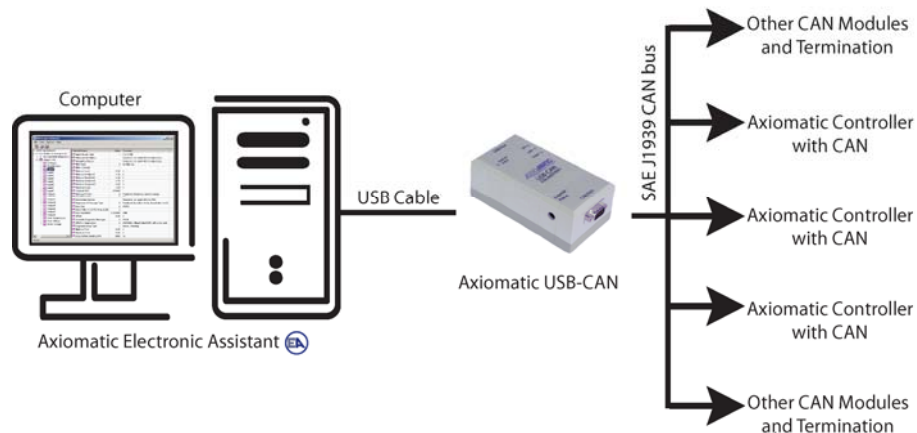


Figure 1 - Block Diagram



**Figure 2 - User Configuration Using Electronic Assistant (EA)**

## Technical Specifications:

All specifications are typical at nominal input voltage and 25 degrees C unless otherwise specified.

### Input Specifications

Power Supply Input - Nominal	12 or 24Vdc nominal (9...36Vdc)
Reverse Polarity Protection	Provided up to -80Vdc
Surge Protection	Provided
Under-voltage Protection	Built-in
Signal Inputs	<p>Two (2) universal inputs are user selectable as: Voltage; Current; Resistive; PWM; or Digital types.</p> <p>12-bit Analog to Digital resolution Protected against short to ground Amplitude: up to +Vsupply</p> <p>Input properties are user configurable. Refer to the block diagram and Table 1.0. Any input on the controller can be coded into a Proprietary B message that can be sent to the CAN network.</p>
Analog/Digital Ground	Three (3) are provided.
Magnetic Pick-up Input	<p>One (1) input for a magnetic pick-up sensor Range: 0.5 Hz to 10 kHz Amplitude: 100 mV to 100 V RMS</p>

<b>Table 1.0 Inputs to AX100650 (Up to 2 user selectable inputs)</b>	
Inputs	Description
Universal Signal Inputs 1-2	<p>Up to 2 universal signal inputs are available.</p> <p>Voltage Input Types: 0...5VDC or 0...10VDC            1mV resolution, accuracy +/- 1% error            The offset is in millivolts and the resolution is mV/bit, when sending a CAN message.            Input measurement setpoints are interpreted in volts.</p> <p>Current Input Types: 4...20mA or 0...20mA            1uA resolution, accuracy +/- 1% error            The offset is in microamps and the resolution is <math>\mu</math>A/bit, when sending a CAN message.            Input measurement setpoints are interpreted in milliamps.            Current sense resistor 124<math>\Omega</math></p> <p>Resistive Type with Auto Ranging and Self Calibration:            20<math>\Omega</math> to 250K<math>\Omega</math>, +/- 1% error</p> <p>PWM Input Type:            PWM Signal Frequency: 0 to 10,000 Hz            PWM Duty Cycle: 0 to 100%            0.01% resolution, accuracy +/- 1% error</p> <p>Digital Input Types: Normal, Inverse and Latched            Active High with 10K Pullup resistor            or Active Low with 10K Pulldown resistor            1 M<math>\Omega</math> Impedance            These inputs can be used as an enable or direction command for the controller.            The input accepted is active high (switch is connected to a +V signal when ON).</p>

### Output Specifications

Output to Motor	<p>Full bridge bi-directional DC motor output            6A @ 24VDC nominal continuous            6A @ 12VDC nominal continuous            100W nominal power rating</p> <p>Current sensing is provided.            Overcurrent protection is provided at 12A.            Short circuit protection is provided.            The maximum rated speed and motor rated current are configurable to suit individual motor specifications.</p>
Output to an Hydraulic Valve or Solenoid	<p>One output selectable as: Proportional Current; Hotshot Digital; PWM Duty Cycle; Proportional Voltage; or On/Off Digital            Half-bridge output, current sensing, grounded load.            High side sourcing up to 2.5A            High frequency drive</p> <p>Overcurrent protection is provided.            Short circuit protection is provided.</p> <p>Current Outputs: 1mA resolution, accuracy +/- 1% error            Voltage Outputs: 0.1V resolution, accuracy +/- 5% error            PWM Outputs: 0.1% resolution, accuracy +/- 0.1% error            Digital On/Off: Sourcing from power supply or output off            Load at supply voltage must not draw more than 2.5A.</p>
Signal Outputs	<p>Two signal outputs are user selectable as: Voltage or Current            12-bit Digital to Analog (voltage, current)            Protected against shorts to GND or +Vcc</p> <p>Voltage Types: 0-5Vdc or 0-10Vdc            1mV resolution, accuracy +/- 1% error</p> <p>Current Types: 0-20mA or 4-20mA            1uA resolution, accuracy +/- 1% error</p>

Motor Stop	Shut off with or without ramping
Motor Direction	Motor direction command can be mapped to any input or come from the CAN bus.
Motor Control Mode	<p>Flexible control is provided by user configurable parameters for</p> <ul style="list-style-type: none"> <li>➤ Open loop speed</li> <li>➤ Closed loop speed;</li> <li>➤ Current control;</li> <li>➤ Position control; or</li> <li>➤ PID control.</li> </ul> <p>The control input to drive the motor can be mapped to any of the universal inputs or the controller can respond to messages from a CAN bus.</p>
Thermal Protection	Thermal protection is built-in and configurable.
Reference Voltage	1 +5V, +/- 0.5%, 50 mA Three connection points are provided for ease of installation.

## General Specifications

Quiescent Current	Contact Axiomatic.
Weight	Contact Axiomatic.
Operating Conditions	-40°C to +125°C (-40°F to 257°F)
Protection Rating	IP67
Vibration and Shock	Pending
EMC	Pending
Microprocessor	TI TMS320F28069, 32-bit, 256 KB flash program memory, 100 KB RAM SIL 2 ready
Motor Control	<p>Standard embedded software is provided.</p> <p>The configurable properties of the controller are divided into function blocks, namely, the Input Function Block, the Control Logic Block, the Diagnostic Function Block, the CAN Transmit Message Function Block and the CAN Receive Message Function Block.</p> <p>The Motor Parameters setpoint group supports the configuration of the main motor parameters.</p> <p>The following parameters are user configurable.</p> <p><b>Motor Direction:</b> Unidirectional or bi-directional control from an input or the CAN bus. The direction is also configurable.</p> <p><b>Enable:</b> A universal input can be configured to enable the motor when on. A CAN message can also be used as an enable input.</p> <p><b>Control Mode:</b> Open loop speed, closed loop speed, current, position or PID control.</p> <p><b>CAN:</b> CAN bus messages control the motor instead of the signal inputs</p>
Diagnostics	There are 3 Diagnostic blocks that can be configured to monitor various parameters of the Controller. Refer to the User Manual for details.
User Interface	<p>Electronic Assistant® for <i>Windows</i> operating systems It comes with a royalty-free license for use.</p> <p>The Axiomatic Electronic Assistant® requires an USB-CAN converter to link the device's CAN port to a <i>Windows</i>-based PC for initial configuration. Order the EA and Axiomatic USB-CAN as a kit (P/N AX070502), which includes all interconnecting cables. Refer to Figure 2.</p>
Flashing over CAN	The controller software can be reflashed over the CAN connection using the EA.
CAN port	1 CAN port (SAE J1939) (CANopen® on request.)

CAN Interfaces	<p>The motor controller is compliant with Bosch CAN protocol specification, Rev.2.0, Part B, and the following J1939 standards.</p> <table border="1" data-bbox="613 243 1385 1115"> <thead> <tr> <th colspan="2" data-bbox="613 243 1385 279">Table 2: J1939 Compliance</th> </tr> <tr> <th data-bbox="613 279 841 331">OSI Network Model Layer</th> <th data-bbox="841 279 1385 331">J1939 Standard</th> </tr> </thead> <tbody> <tr> <td data-bbox="613 331 841 411">Physical</td> <td data-bbox="841 331 1385 411">J1939/11 – Physical Layer, 250K bit/s, Twisted Shielded Pair. J1939/15 - Reduced Physical Layer, 250K bits/sec, Un-Shielded Twisted Pair (UTP).</td> </tr> <tr> <td data-bbox="613 411 841 632" rowspan="2">Data Link</td> <td data-bbox="841 411 1385 447">J1939/21 – Data Link Layer</td> </tr> <tr> <td data-bbox="841 447 1385 632">Request (PGN 59904) Acknowledgement (PGN 59392) Transport Protocol – Connection Management (PGN 60416) Transport Protocol – Data Transfer Message (PGN 60160) Proprietary A (PGN 61184) Proprietary B (PGN's 65280 to 65535) NB. The user can also configure an input channel to send messages to another node using the Proprietary A PGN 61184.</td> </tr> <tr> <td data-bbox="613 632 841 789" rowspan="2">Network Layer</td> <td data-bbox="841 632 1385 695">J1939/81 – Network Management J1939, Appendix B – Address and Identity Assignments</td> </tr> <tr> <td data-bbox="841 695 1385 789">Arbitrary Address Capable ECU - It can dynamically change its network address in real time. The controller supports: Address Claimed Messages (PGN 60928) and Commanded Address Messages (PGN 65240).</td> </tr> <tr> <td data-bbox="613 789 841 1115" rowspan="3">Application Layer</td> <td data-bbox="841 789 1385 825">J1939/71 – Vehicle Application Layer</td> </tr> <tr> <td data-bbox="841 825 1385 1024">None of the application layer PGN's are supported as part of the default configurations. However, the controller could be configured such that any of the input messages to be sent will use a PGN from this section, or for the outputs to respond to the data in a message with a PGN from this section. The data size, index, resolution and offset can all be configured for the appropriate SPN associated with the PGN. <i>It is the user's responsibility to configure the controller such that it will not violate the J1939 standard.</i></td> </tr> <tr> <td data-bbox="841 1024 1385 1060">J1939/73 – Application Layer – Diagnostics</td> </tr> <tr> <td data-bbox="613 1060 1385 1115"></td> <td data-bbox="841 1060 1385 1115">DM – Diagnostic messaging (on request)</td> </tr> </tbody> </table>	Table 2: J1939 Compliance		OSI Network Model Layer	J1939 Standard	Physical	J1939/11 – Physical Layer, 250K bit/s, Twisted Shielded Pair. J1939/15 - Reduced Physical Layer, 250K bits/sec, Un-Shielded Twisted Pair (UTP).	Data Link	J1939/21 – Data Link Layer	Request (PGN 59904) Acknowledgement (PGN 59392) Transport Protocol – Connection Management (PGN 60416) Transport Protocol – Data Transfer Message (PGN 60160) Proprietary A (PGN 61184) Proprietary B (PGN's 65280 to 65535) NB. The user can also configure an input channel to send messages to another node using the Proprietary A PGN 61184.	Network Layer	J1939/81 – Network Management J1939, Appendix B – Address and Identity Assignments	Arbitrary Address Capable ECU - It can dynamically change its network address in real time. The controller supports: Address Claimed Messages (PGN 60928) and Commanded Address Messages (PGN 65240).	Application Layer	J1939/71 – Vehicle Application Layer	None of the application layer PGN's are supported as part of the default configurations. However, the controller could be configured such that any of the input messages to be sent will use a PGN from this section, or for the outputs to respond to the data in a message with a PGN from this section. The data size, index, resolution and offset can all be configured for the appropriate SPN associated with the PGN. <i>It is the user's responsibility to configure the controller such that it will not violate the J1939 standard.</i>	J1939/73 – Application Layer – Diagnostics		DM – Diagnostic messaging (on request)
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Enclosure and Dimensions	<p>High Temperature Nylon housing - Deutsch IPD PCB Enclosure (EEC-325X4B) 4.62 x 5.24 x 1.43 inches 117.42 x 133.09 x 36.36 mm (W x L x H excluding mating plugs) <i>Refer to Figure 3.0.</i></p>																		
Electrical Connections	<p>Deutsch DTM series 24 pin receptacle (DTM13-12PA-12PB-R008) <i>Refer to Table 4.</i> Wires should be of the appropriate gauge to meet requirements of applicable electric codes and suit the specifications of the connector(s).</p>																		
Mating Plug Kit	<p>A mating plug kit comprised of all mating connectors is available as P/N: PL-DTM06-12SA-12SB. It includes: Deutsch DTM06-12SA; DTM06-12SB: 2 wedgelocks WM12S; and 24 contacts 0462-201-20141. 20 AWG wire is recommended for use with contacts 0462-201-20141.</p>																		
Mounting	<p>The motor controller should be mounted as close to the battery and/or the motor as possible. Install the unit with appropriate space available for servicing and for adequate wire harness access and strain relief.</p> <p>Mounting holes sized for ¼ inch or M6 bolts. The bolt length will be determined by the end-user's mounting plate thickness. The mounting flange of the controller is 0.63 inches (16 mm) thick. If the module is mounted without an enclosure, it should be mounted vertically with connectors facing left and right to reduce likelihood of moisture entry. The CAN wiring is considered intrinsically safe. The power wires are not considered intrinsically safe and so in hazardous locations, they need to be located in conduit or conduit trays at all times. The module must be mounted in an enclosure in hazardous locations for this purpose.</p> <p>All field wiring should be suitable for the operating temperature range.</p>																		

Table 4.0. Electrical Pin Out			
Grey Connector		Black Connector	
Pin #	Function	Pin #	Function
1	CAN_L	1	Universal Input 1
2	Signal 2 Return	2	+5V Reference
3	Signal 1 Return	3	Analog GND
4	GND	4	Universal Input 2
5	Output 1	5	+5V Reference
6	Batt -	6	Analog GND
7	Batt +	7	Magnetic Pick-up Input
8	MOTOR +	8	Magnetic Pick-up Input GND
9	MOTOR -	9	Not Used
10	Signal 1 Output	10	Not Used
11	Signal 2 Output	11	+5V Reference
12	CAN_H	12	Analog GND

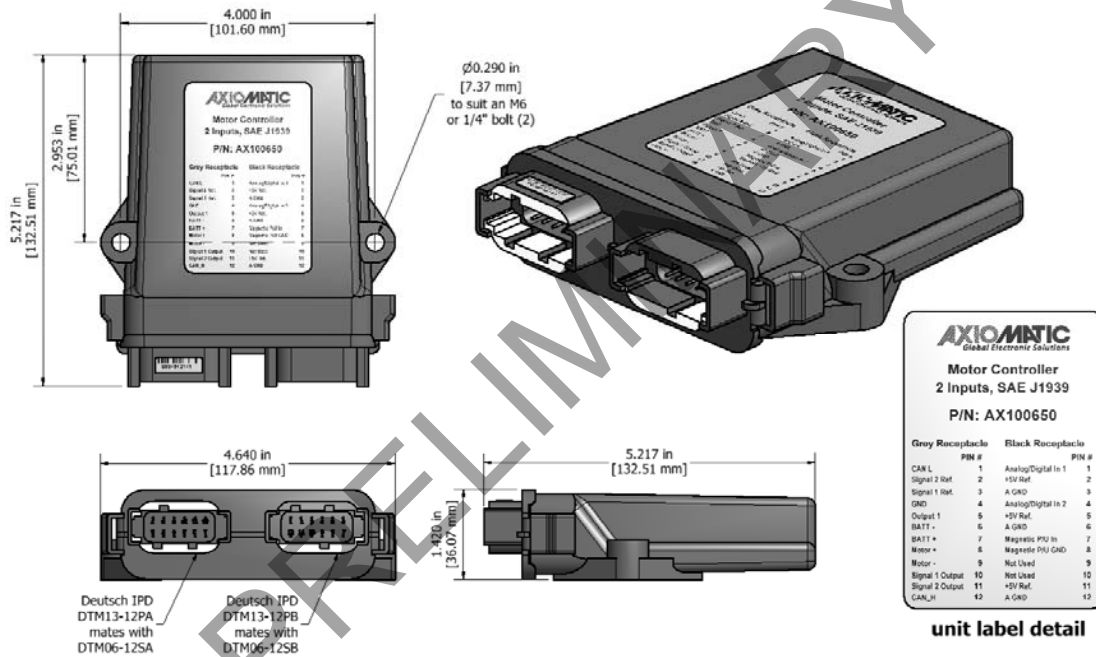


Figure 3 - Dimensional Drawing

Notes:

CANopen® is a registered community trade mark of CAN in Automation e.V.  
Electronic Assistant® is a registered U.S. trade mark of Axiomatic Technologies Corporation.

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 [www.axiomatic.com/service.html](http://www.axiomatic.com/service.html).

Form: TDAX100650-10/31/17