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AEM EV
VCU300 User Guide

Revision A

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Revision History

Revision	Date	Change Description
A	7/6/2020	Initial Release

Cautions and Warnings

Working on tractive systems (which includes but is not limited to motor(s), inverter(s), high voltage battery packs and high voltage cables) requires special experience and training. AEM EV has implemented fault detection and failsafe logic into its vehicle control units ("VCU"), however this does not mean that your VCU installation will be safe or effective, or that your VCU installation will not interfere with other systems on your vehicle and create a hazardous situation. It is the responsibility of the installer to understand the implications of each stage of tractive system installation and testing and to recognize what might be unique about your application that presents potential hazards or safety issues – and it is the responsibility of the installer to solve or address any such hazards or issues.

The following list includes basic recommended practices. This is not a comprehensive list; as noted below, if you are not well-versed in the appropriate installation and testing procedures, you should refer the installation and calibration to a reputable installation facility or contact AEM EV for a referral in your area.

- When access is required near the battery pack, the cell segments must be separated by using an appropriate maintenance disconnect plug.
- When working on the battery pack or tractive system, safety gloves with side shields and appropriate insulated tools must be used.
- Always wear Class 0 gloves rated at 1000V with leather protectors.
- Only use CAT III rated digital multimeters (DMM) and test leads.
- When working on the battery pack or tractive system, work with one hand while keeping the other behind your back.
- During initial system power up and testing, the vehicle must be raised off the ground and supported appropriately. Wheels and tires should be removed.
- During the VCU firmware upgrade process, battery cell segments must be separated using an appropriate maintenance disconnect plug.
- Do not make calibration changes when the inverter pulse width modulation (PWM) is enabled.

USE THIS VCU WITH EXTREME CAUTION. MISUSE AND/OR IMPROPER INSTALLATION CAN CAUSE SIGNIFICANT DAMAGE TO YOUR VEHICLE AND PROPERTY BELONGING TO YOU OR OTHERS, AS WELL AS PERSONAL INJURY OR DEATH. IF YOU ARE NOT WELL VERSED IN THE INSTALLATION OF TRACTIVE SYSTEMS OR CONFIGURING THE CALIBRATIONS IN THE AEM EV VCU THAT ARE NECESSARY TO CONTROL THE VEHICLE, YOU SHOULD REFER THE INSTALLATION AND VCU CALIBRATION TO A REPUTABLE INSTALLATION FACILITY, OR CONTACT AEM EV FOR A REFERRAL IN YOUR AREA. IT IS THE RESPONSIBILITY OF THE INSTALLER TO ULTIMATELY CONFIRM THAT THE INSTALLATION AND CALIBRATIONS ARE SAFE FOR ITS INTENDED USE.

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Electrical Safety Insulation Monitoring

The high voltage system in an electric vehicle is designed to be ungrounded (floating) with respect to the vehicle chassis (frame). Insulation faults can cause electric shock, personal injury and even death. An insulation monitoring device (IMD) must be used to protect against these faults. See Bender https://www.benderinc.com/ for more information.

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Hardware Overview

AEM Part Number	30-8100
Microprocessor	Infineon Tricore TC1793
Clock Speed	200/260 MHz
Environmental	IP6k9k Compliant
Operating Temperature	-40°C to +105°C
Operating Voltage	9 – 16V 16V is the absolute maximum rating. ***The module is not designed for use with 16V battery systems as they typically require ~18V to charge.***
Overvoltage Protection	38.5V
Current Draw: Off-State Current	8.4 mA
Reverse Polarity Supply Voltage	13.5V for 5 min
Wake Switch Power-on threshold	4.13V minimum
Wake Switch Power-off threshold	3.61V maximum
Load dump protection	Load dump on the 12V supply lines must be less than 36V
Main Relay	A VCU controlled main relay is required. Main relay must be source for loads driven by lowside drivers.
Communication Channels	CAN1, 500k, NOT internally terminated, PC Comms
	CAN2, 500k, Internally Terminated, Peripheral Device Comms
	CAN3, 500k, NOT internally terminated, Peripheral Device Comms and Data Transmit
Internal Logging Memory	**None** - External logging possible with AEM Dash units with logging capability and other compatible 3rd party displays and data loggers.

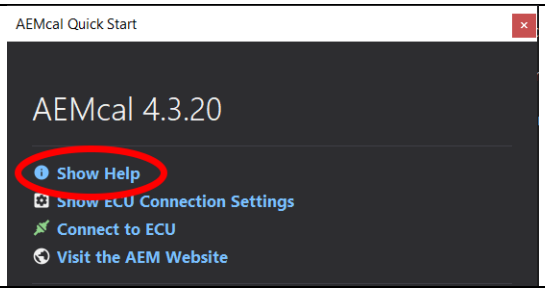
About this document

This document is not a comprehensive step by step guide to every feature available. It is intended to get the VCU powered up properly and running quickly in a bench top environment. Along the way you will become familiar with certain core features. Your primary source for detailed information about VCU functionality is AEMCal. Nearly all features are described using tool tips, compiled help or description pane help. The AEMCal screen capture images in this document are accurate at the time of publication. However, AEMCal and the AEMCal layout files provided by AEM will be updated over time. In the event of a discrepancy, always follow the instructions contained within the layout file.

Software Tools Installation

Go to https://www.aemev.com/documentation/download to download the installers for AEMCal and AEMData. Run both installers to install both tools. During the installation, choose to install the desktop icon. After the installation, restart your PC.

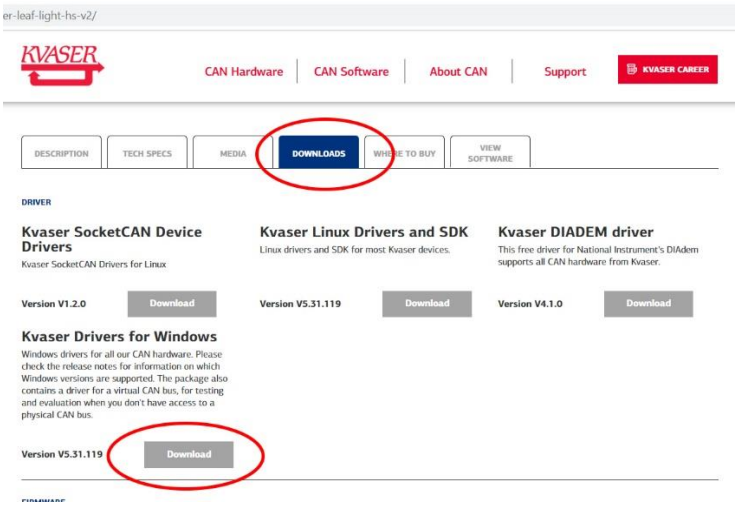
	Launch AEMCal from the desktop icon.

	A Quick Start pane will provide options. Click Show Help to launch the online help for AEMCal. Read and understand all sections before continuing. ***The instructions that follow assume you have read the AEMCal online help content.***

PC Communications with AEMCal

The VCU300 communicates with the PC over the CAN1 network. A CAN to USB converter device is required. For best performance, AEM recommends the Kvaser Leaf Light HS v2 https://www.kvaser.com/product/kvaser-leaf-light-hs-v2/

Once you have the adapter, navigate to the Kvaser DOWNLOADS tab and click the Download button for the Kvaser Drivers for Windows. Note that the Version may not necessarily match the Version in the example image below. Run the executable to install the hardware drivers. **It is always a good idea to restart your PC after installing new hardware drivers. Please do so.**



Harness Connectors

A mating Plug & Pin Kit is available from AEM under PN 30-3710. Following is a list of Bosch recommended tools for working with these connector assemblies. There may be similar and/or compatible tools available in the market. However, AEM will not be responsible for connector housing damage caused by misuse or use of improper tools. If you are not comfortable working with high density connector housings, please seek help from an experienced automotive harness builder. A properly planned and assembled harness is critical for performance and safety.

Tool	Bosch Part Number
Large Terminal Crimp	1 928 498 213
Small Terminal Crimp	1 928 498 212
Terminal Depinning	1 928 498 997

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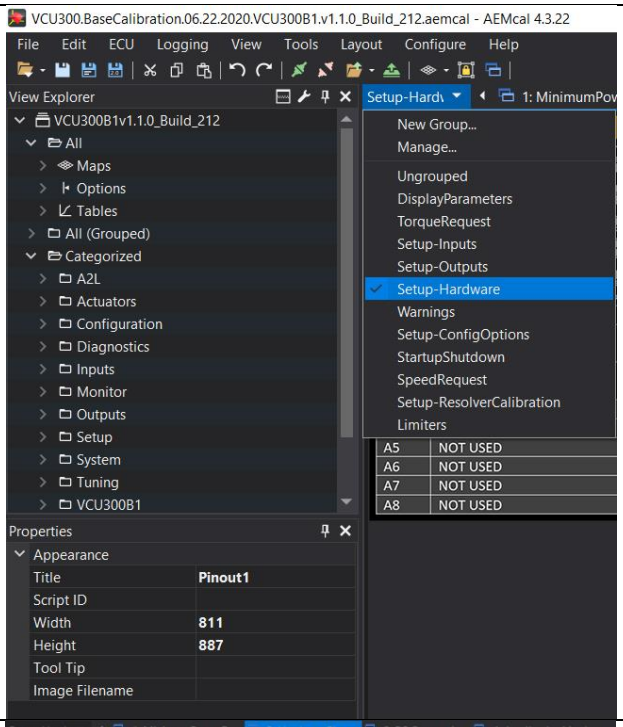
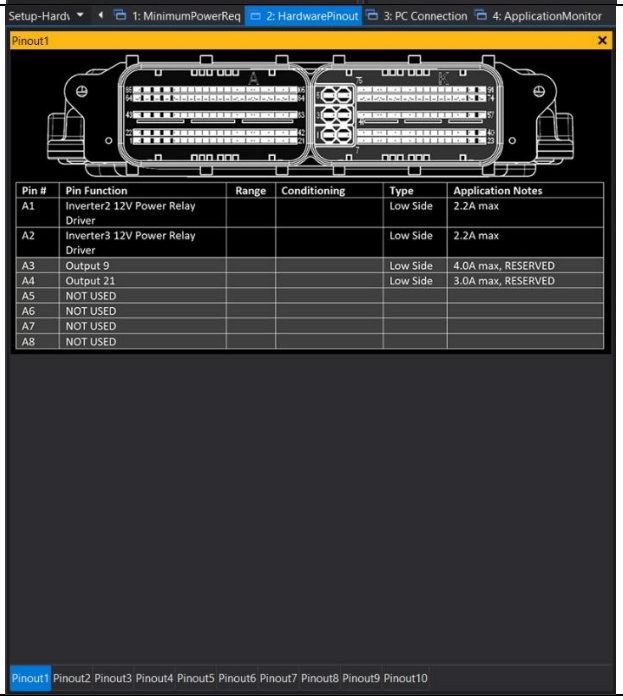
Minimum Power and Programming Requirements

AEM recommends that you familiarize yourself with the VCU200 basic functionality within a bench top environment ***AND NOT ON A VEHICLE*** during the first power up and test.



1. Launch AEMCal. A USB connection to the VCU hardware is not required yet.
2. Open the FactoryBase calibration which should be in the \Documents\AEM\AEMcal\Calibrations\Factory folder.
3. Load the Default300 layout file which should be in the \Documents\AEM\AEMcal\Layouts\Factory folder.
4. Select the Setup-Hardware group



Familiarize yourself with the Hardware Pinout. There are multiple tabs in this pane (Pinout1-10).

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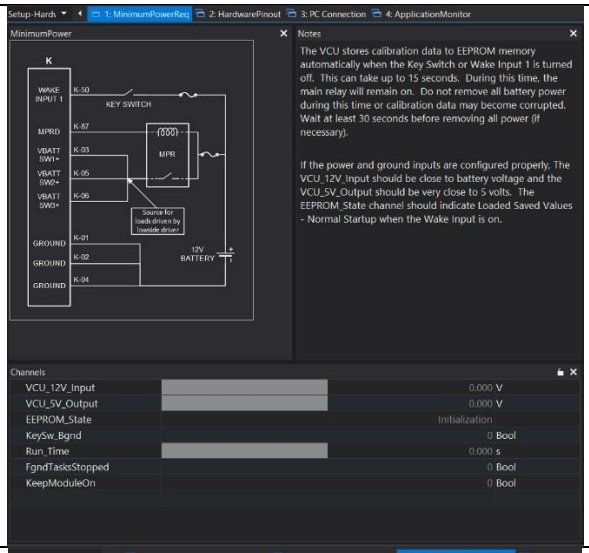
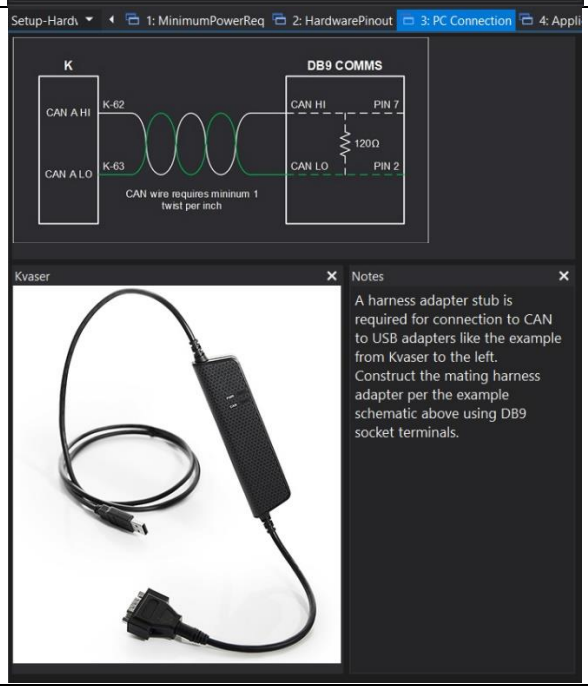
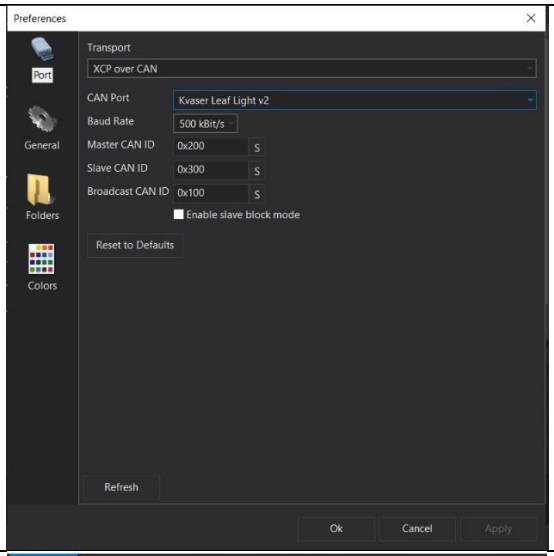
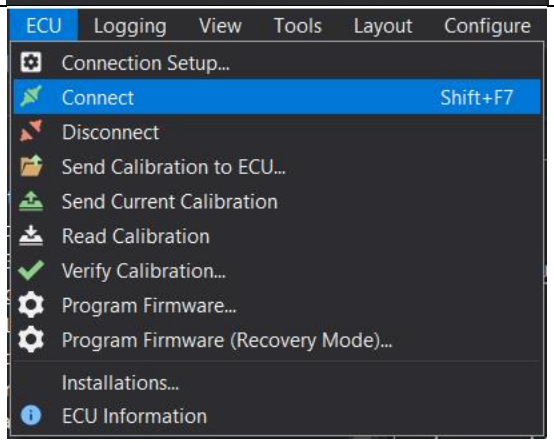
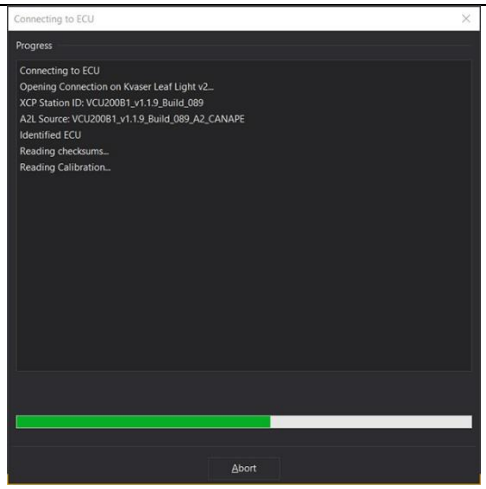
	Select the MinimumPowerReq tab which includes an example wiring schematic and general information about power distribution. Use the Hardware Pinout and the Minimum Power schematic shown to build a test bench harness that can be powered from a 12V bench top power supply.
	Select the PC Connection tab. Assemble and add a PC communications stub to your harness. Use the example schematic for reference. The VCU300 communicates with your PC via a CAN to USB adapter. If you do not have experience assembling harnesses for use in vehicle networks, please seek help from an experienced automotive harness builder. The VCU300 functions as a CAN network data hub. Proper network wiring is critical for performance and safety.



1. Connect your CAN to USB adapter to an available USB port on your PC.
2. Within AEMCal, go to ECU | Connection Setup…
3. In the Port pane, ensure your settings match the example at left.
4. Select your CAN to USB adapter from the CAN Port dropdown selection list. If your device drivers were installed correctly, your adapter should appear in this list. The example shows the Kvaser Leaf Light v2. If it does not appear, try restarting AEMCal. If you still have problems, there may be an issue with your adapter device driver installation. Stop and contact the adapter manufacturer for troubleshooting support.



1. Connect the power leads of your test harness to your 12V bench top power supply.
2. Set the power supply current limit to approximately 1.0 amp.
3. Turn the power supply switch on.
4. Using your harness, turn the VCU ‘Key Switch’ on.
5. At power up, the VCU should draw between 100 and 500 mA depending on other loads present in the harness. A lighted switch may create more current draw. If the current is not within this range, double check your power distribution wiring.
6. Connect the CAN to USB adapter to your harness DB9 communications interface.
7. Go to ECU | Connect or the Shift+F7 hotkey combo. AEMCal will attempt to connect to your VCU.



AEMCal will present a similar window to the one shown at left. A scroll bar will indicate connection progress as AEMCal retrieves calibration data from your VCU. If you do not see this progress bar at first, click Abort and:

1. Make sure there are no other devices connected or applications running that may be using your PC USB ports.
2. Double check the pinout of the harness DB9 interface connector.
3. Disconnect the CAN to USB adapter from your PC then plug it back in.
4. Try restarting AEMCal and repeating the process.

If you got this far, congratulations! Your VCU is powered up and communicating with AEMCal.

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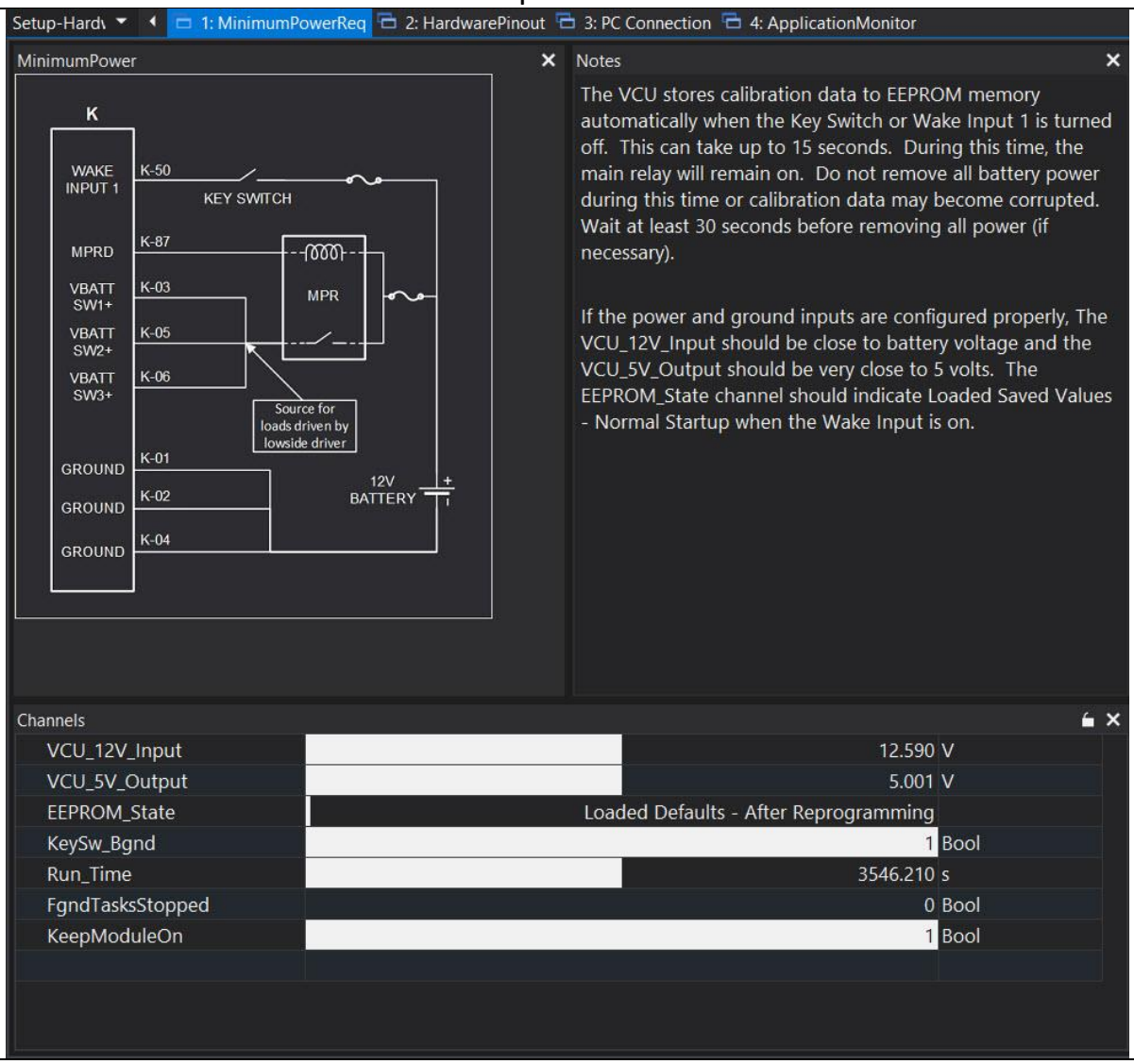
Basic VCU Function Check & AEMCal Work Space Tour



1. Within AEMCal, navigate to the Setup-Hardware group and select the MinimumPowerReq tab.
2. Live data from the VCU will be presented in the Channels list. Note the green Online indication in the lower right. Note the Description Pane. If you do not see the Description Pane, go to View | Descriptions or hit Cntrl+D.
3. Ensure that:
    a. The VCU_12V_Input internal measurement matches (approximately) the output from your power supply.
    b. The VCU_5V_Output internal measurement is close to 5 volts.
    c. The Run_Time_Counter is incrementing.
    d. The EEPROM_State indicates Loaded Saved Values – Normal Startup.

Congratulations! Another milestone passed.

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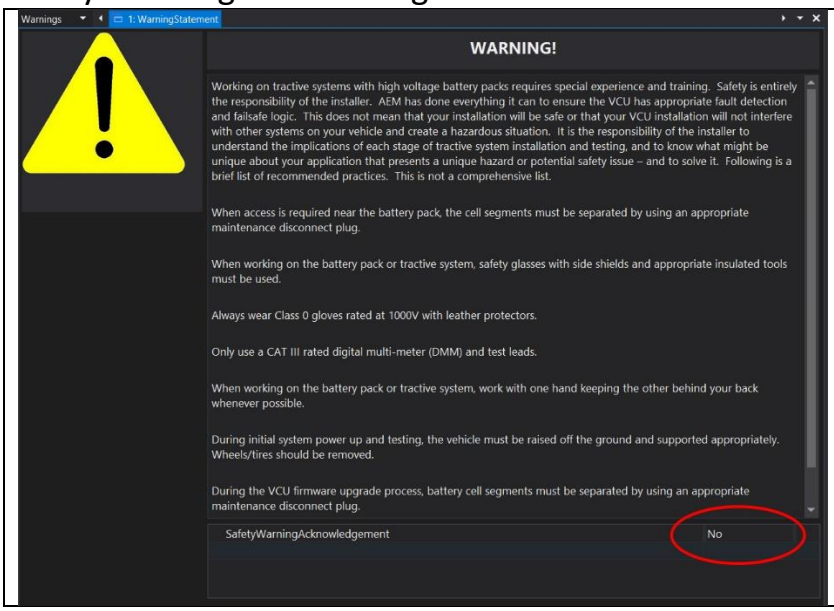
Safety Warning Acknowledgement



1. Within the Warnings group, view the WarningStatement tab.
2. Read the warning statement.
3. After reading and acknowledging the statement, Select Yes for the SafetyWarningAknowledgment setting.

The VCU must be powered up and connected to AEMCal before making this change. If you do not acknowledge this statement, the VCU will only allow a 0.0 N.m torque command regardless of any other calibration settings.

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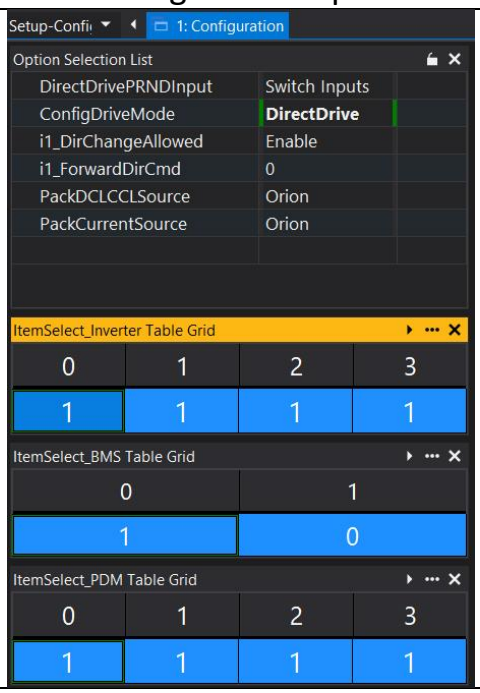
Fundamental Configuration Options



There are several fundamental configuration settings required.

1. Go to the Setup-ConfigOptions group and select the Configuration tab.
2. Select each setting and read the Description field for definitions and instructions.
3. Make your selections to configure the VCU for your application.

Minimum Required Inputs Setup

The following sections describe setup of the minimum required inputs. These steps assume the inputs are connected to the VCU and the VCU is powered up and running. Before proceeding, use the VCU pinout table in the Setup-Hardware group, HardwarePinout tab as a reference for adding the inputs to your harness. These include:

1. Ignition Switch
2. Accelerator Pedal
3. Brake Switch
4. Drive Mode PRND inputs
5. Main HVIL Loop
6. IMD

AEM recommends adding these inputs to your bench test harness. It is much easier to debug harness assembly problems within a bench test environment.

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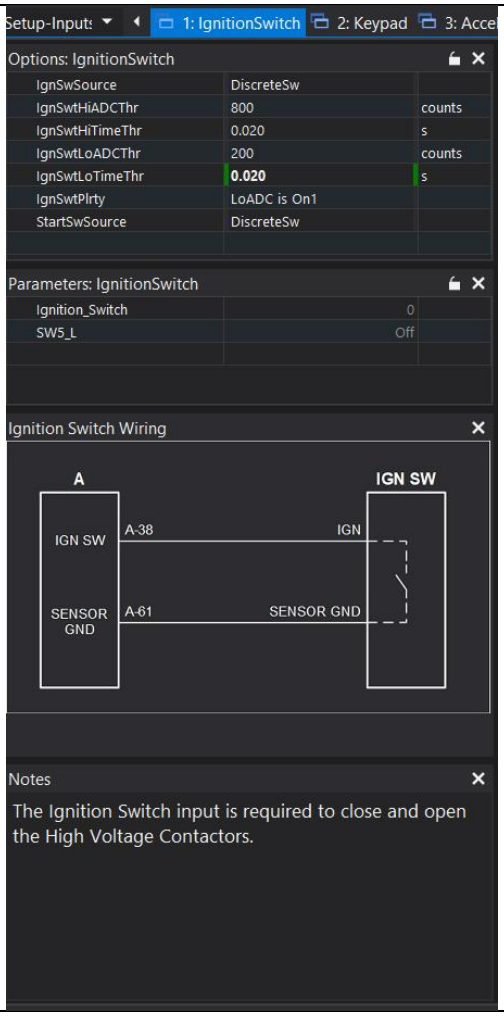
Ignition Switch



1. Go to the Setup-Inputs group and select the IgnitionSwitch tab.
2. Read the notes, Descriptions and wiring diagram.
3. Configure the settings for your application.

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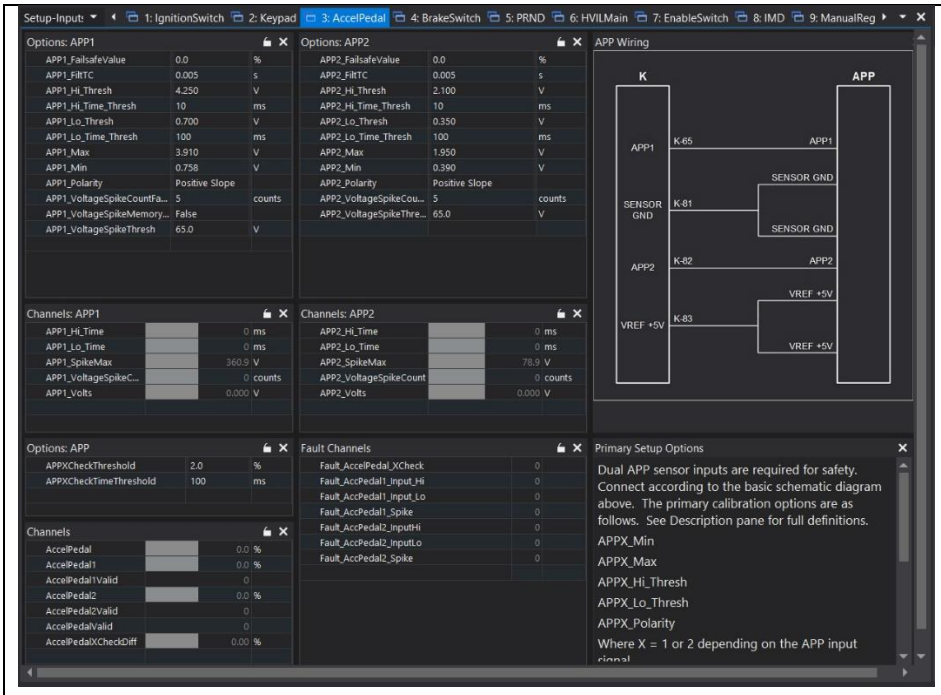
Accelerator Pedal



Select the AccelPedal tab. This tab is large but for most applications, there are only a handful of settings changes required. The basic pedal calibration process is as follows. See notes and Descriptions in the tab for more details.

1. With the pedal closed, monitor the channel APPX_Volts vs the option APPX_Min. Set APPX_Min = APPX_Volts.
2. With the pedal fully open, monitor the channel APPX_Volts vs the option APPX_Max. Set APPX_Max = APPX_Volts.
3. Set the APPX_Hi_Thresh and APPX_Lo_Thresh slightly outside these calibration limits. These will be your fault detection thresholds.

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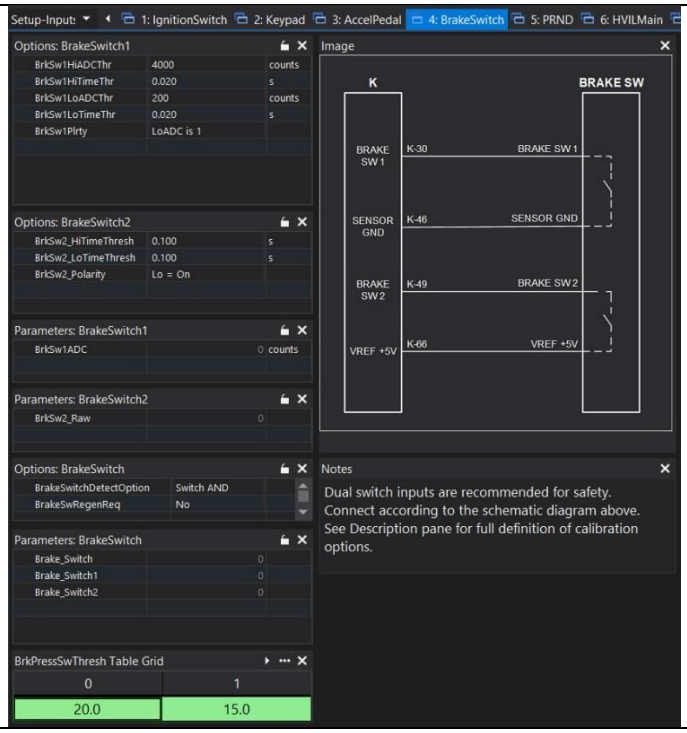
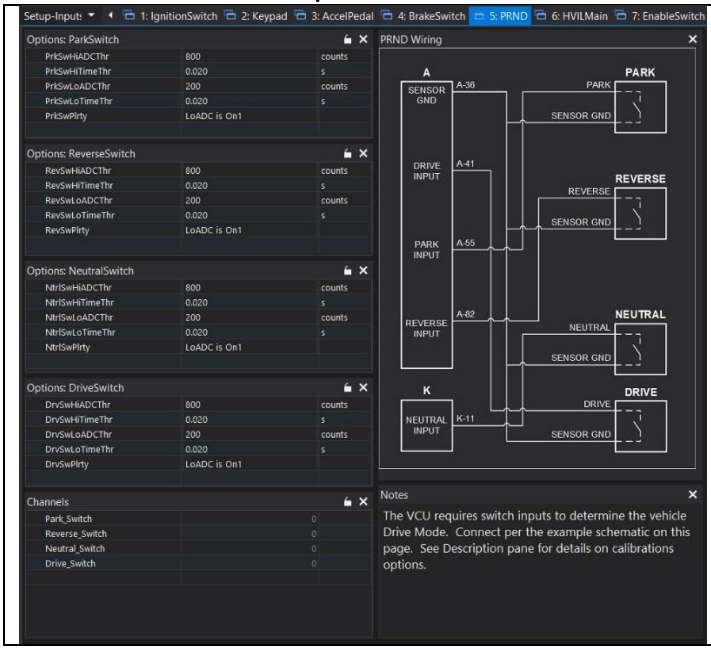
Brake Switch



A properly setup and configured Brake Switch input is critical for safety and functionality.

1. Go to the Setup-Inputs group and select the BrakeSwitch tab.
2. Use the example wiring diagram to add the Brake Switch input to your VCU.
3. Read the notes and Descriptions and configure for your application.

Drive Mode PRND Inputs



Discrete PRND switch inputs are required for indirect drive applications. There is a choice between discrete switch inputs or the AEM 8-Button CAN Keypad for direct drive applications.

1. Go to the Setup-Inputs group and select the PRND tab.
2. Use the example wiring diagram to add the switch inputs to your VCU.
3. Read the notes and Descriptions and configure for your application.

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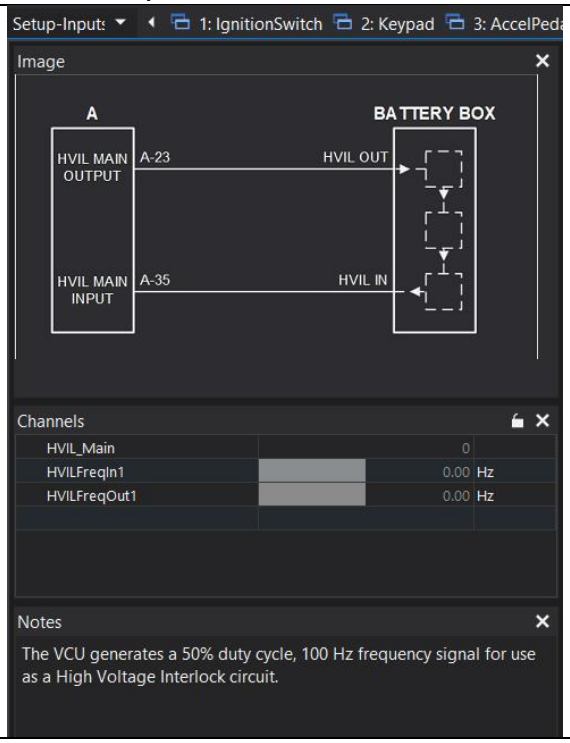
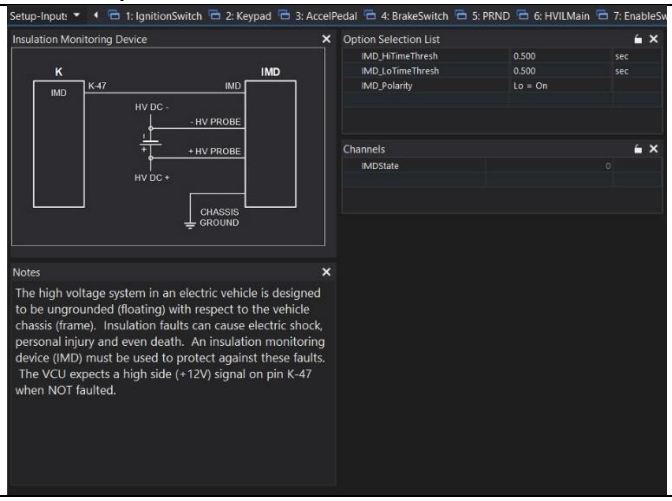
Main HVIL Loop



A completed Main HVIL loop is required for high voltage contactor function.

1. Go to the Setup-Inputs group and select the HVILMain tab.
2. Use the example wiring diagram to add the loop to your VCU.

IMD Setup



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1. Go to the Setup-Inputs group and select the IMD tab.
2. Read all notes and Description text and configure for your application.

VCU Outputs Setup

In most cases, there are options for output control. In cases where an AEM PDU-8 control output is available, we recommend using the PDU-8 over other methods. The current limiting and fault detection features increase safety and reliability. This is especially important for high voltage contactor control.

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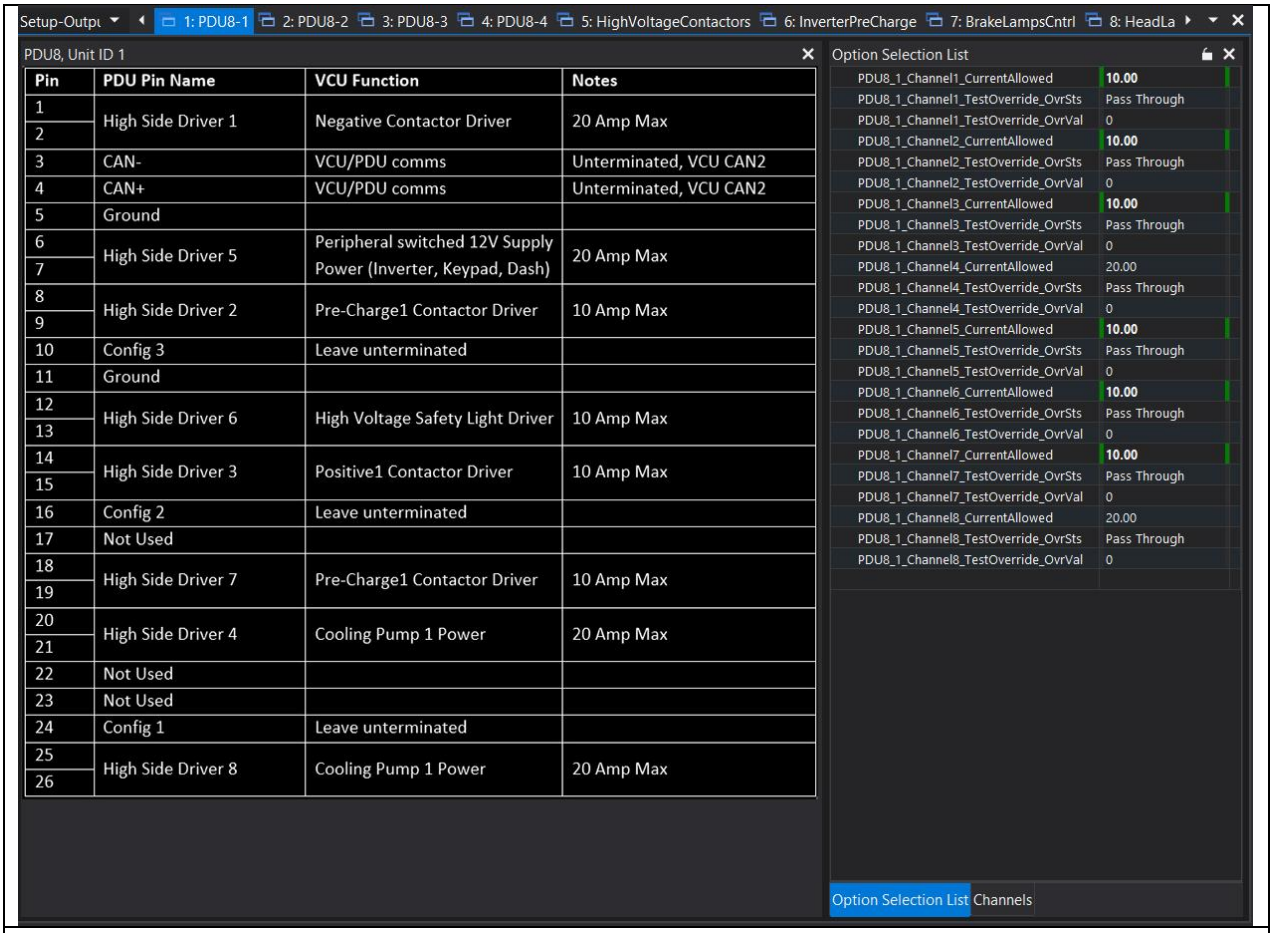

Pin	PDU Pin Name	VCU Function	Notes
1	High Side Driver 1	Negative Contactor Driver	20 Amp Max
2			
3	CAN-	VCU/PDU comms	Unterminated, VCU CAN2
4	CAN+	VCU/PDU comms	Unterminated, VCU CAN2
5	Ground		
6	High Side Driver 5	Peripheral switched 12V Supply Power (Inverter, Keypad, Dash)	20 Amp Max
7			
8	High Side Driver 2	Pre-Charge1 Contactor Driver	10 Amp Max
9			
10	Config 3	Leave unterminated	
11	Ground		
12	High Side Driver 6	High Voltage Safety Light Driver	10 Amp Max
13			
14	High Side Driver 3	Positive1 Contactor Driver	10 Amp Max
15			
16	Config 2	Leave unterminated	
17	Not Used		
18	High Side Driver 7	Pre-Charge1 Contactor Driver	10 Amp Max
19			
20	High Side Driver 4	Cooling Pump 1 Power	20 Amp Max
21			
22	Not Used		
23	Not Used		
24	Config 1	Leave unterminated	
25	High Side Driver 8	Cooling Pump 1 Power	20 Amp Max
26			

1. Go to the Setup-Outputs group and select the PDU8-1 through PDU8-4 tabs.
2. Review the pinout table for VCU functions for each output channels. These output functions are not re-assignable.
3. Manual override settings are available for testing each output. Set the _OvrVal to 1 then set the _OvrSts to *override* to override the the output logic.
4. Refer to the user instructions provided with the AEM PDU8 for more information on hardware capabilities and wiring.

CAUTION!
Do not manually override high voltage contactor drivers when they are connected to the battery pack.

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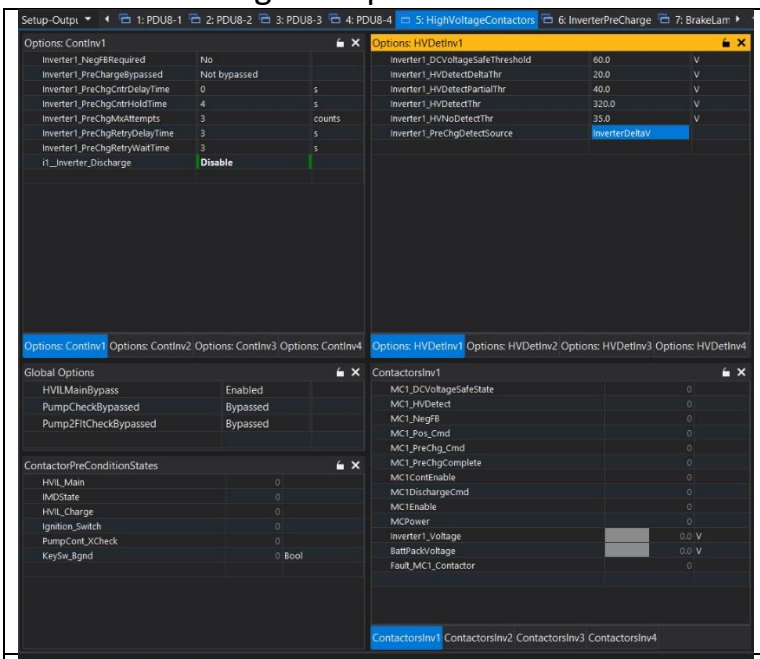
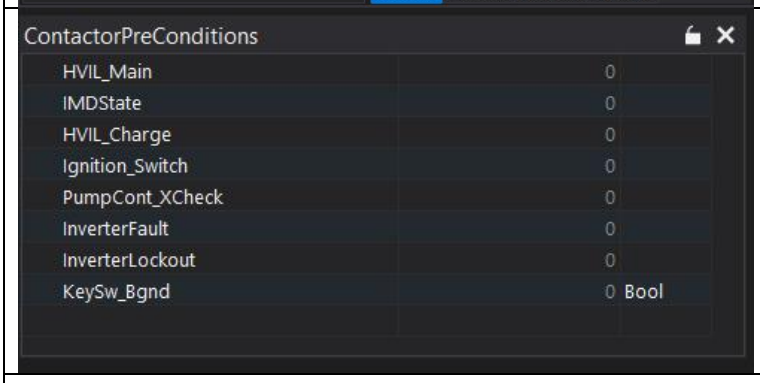
Inverter PreCharge Setup



1. Go to the Setup-Outputs group and select the HighVoltageContactors tab.
2. These settings must be configured properly for your high voltage battery pack range. Familiarize yourself with the Description for each option and channel.
3. Configure the settings for your application.



The ContactorPreConditions channel list is helpful information for first time setups. Read the Description for each channel and monitor during Inverter PreCharge.

CAUTION!
Do not manually override high voltage contactor drivers when they are connected to the battery pack.

Additional Features and Functions

This document is just an introduction to the many features and functions of the VCU300. See the AEM factory layout along with the help content within AEMCal for more detailed information.

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AEM Performance Electronics warrants to the consumer that all AEM Electronics products will be free from defects in material and workmanship for a period of twelve months from the date of the original purchase. Products that fail within this 12-month warranty period will be repaired or replaced when determined by us that the product failed due to defects in material or workmanship. This warranty is limited to the repair or replacement of the AEM Electronics part. This warranty applies only to the original purchaser of the product and is non-transferable. All implied warranties shall be limited in duration to the said 12-month warranty period. Improper use or installation, accident, abuse, unauthorized repairs or alterations performed by the user on any AEM Electronics products voids this warranty.

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You can reach our Tech Support Team for support on all AEM Electronics performance products by phone at 1-800-423-0046. To contact us by email for engine management systems, email us at emstech@aemelectronics.com. For all other products, email us at gen.tech@aemelectronics.com.

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