Transportation
Products

CBT mVEC User Manual

COOPER Bussmann

Table of Contents

1. mVEC Introduction Section

The multiplexed Vehicle Electrical Center (mVEC), shown in Figure 1, is an enhanced version of the Bussmann Vehicle Electrical Center (VEC) with a Controller Area Network (CAN) interface. The mVEC has VEC-like features (accepts plug-in components common to power distribution such as fuses, relays, circuit breakers, diodes, etc.) and is IP66 compliant. The mVEC incorporates the VEC 'power grid', an electrical component grid for power distribution functions, and the grid is electronically interfaced with a CAN control board that monitors the state of components and controls relays that are plugged into the grid of the mVEC.

Figure 1. Multiplexed Vehicle Electrical Center

The mVEC is a power distribution slave module that distributes power to other devices in a vehicle, and communicates over a CAN bus. Because it is a slave module, the mVEC relies on other CAN modules to control its relays and monitor component status messages.

The mVEC is ideal for various applications including heavy truck, construction, agriculture, transit bus and coach, marine, recreational vehicle, and specialty vehicle applications. The mVEC is a cost effective solution for power distribution systems that require the ability to monitor and control relays and fuses; and a great replacement for complex, fully electronic (solid state) power distribution modules.

The mVEC's grid can be populated with industry standard plug-in components which use "280 series" terminals, including relays, fuses, circuit breakers, diodes, transorbs, resistors, and flasher modules. These components can be configured in many different ways to meet your system requirements.

The mVEC can be connected to 12 V or 24 V systems, or to vehicles with both voltages. The mVEC is based off the Bussmann VEC technology and it is possible to customize the mVEC (create a new variant) so that it is capable of functioning with varying electrical architectures. The mVEC can be enabled (turned-on) by battery voltage through an active-high ignition input or by ground through an active-low ignition input.

The mVEC's CAN control board is protected against over-voltage and reverse-voltage conditions and its relay coil drivers are protected from short-circuits.

The mVEC communicates with other devices on the vehicle's CAN bus using the SAE J1939 protocol, and can be part of a multiplexing system that eliminates the need for individual connections between switches and loads. The mVEC works by receiving messages to turn its relays "on" and "off", and by sending messages indicating the state of its grid components.

Figure 2 shows how an mVEC can be integrated into a vehicle.

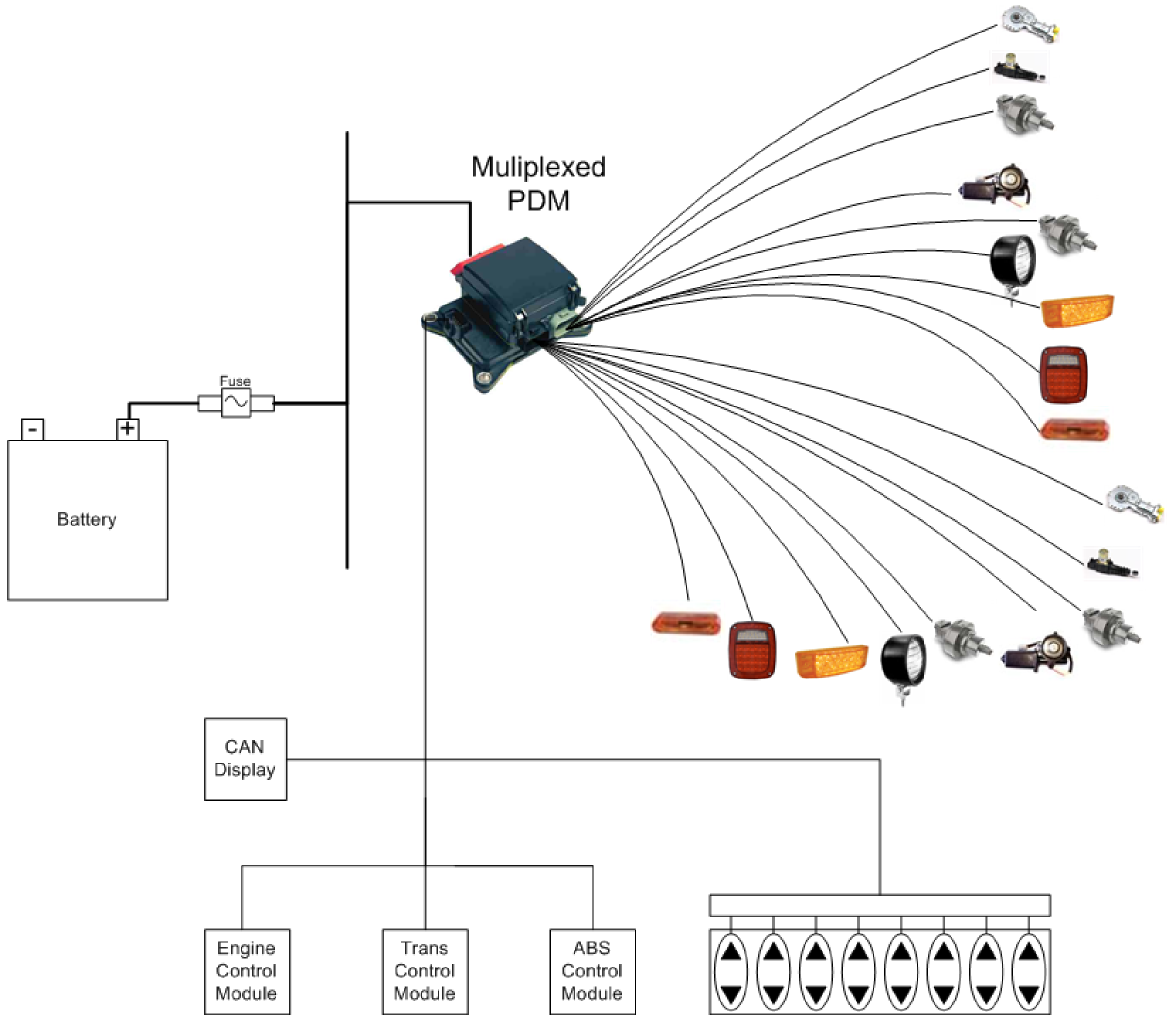

Figure 2. mVEC Integration Diagram

2. Quick Start Section

2.1. Working with the mVEC

The mVEC is a power distribution slave module that distributes power to other modules in a vehicle over a Controller Area Network (CAN) bus. Because it is a slave module, the mVEC relies on other modules to monitor and control its components and software.

2.1.1. mVEC Electrical Grid

The mVEC features the VEC 'power grid' (shown in Figure 3) is the surface of the mVEC - the VEC grid is internal and allows the plug-in components to be inserted into the mVEC) with 64 connection points that can be populated with various components depending on your configuration.

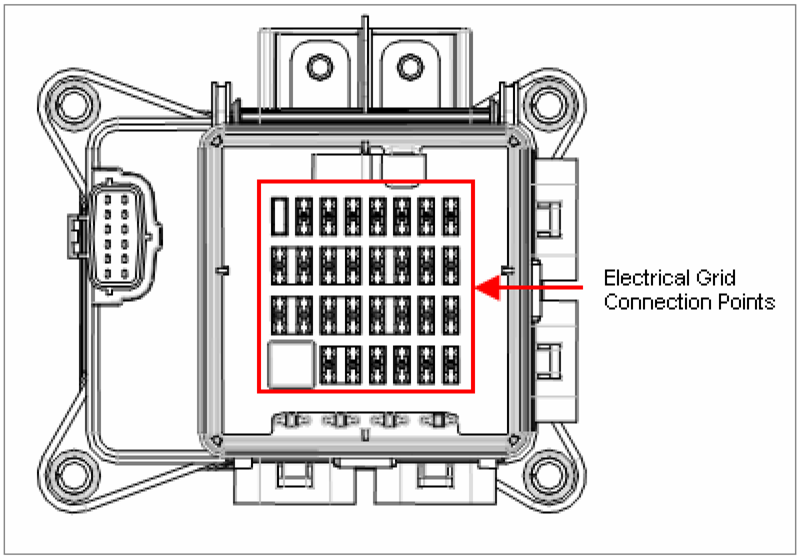

Figure 3: mVEC Grid Area

2.1.2. mVEC Components

The mVEC electrical grid can be populated with components that have 2.8 mm blades on 8.1 mm centerlines (280-series components). mVEC components are used for controlling and/or fusing high-current loads on a vehicle, like relays and fuses. The mVEC components can be configured per the customer's requirements.

2.1.3. Component Descriptions

There are various types of components that can be placed on the mVEC electrical grid, including (but not limited to) relays, fuses, circuit breakers, diodes, transorbs, resistors, and flasher modules. The mVEC can only control and monitor relays, fuses and circuit breakers (type I & III) can only be monitored. Because of this, most of the manual is dedicated to using fuses and relays. Relays that are not controlled via the internal CAN board cannot be monitored as normal since the relay control signals are unknown.

2.1.3.1. Relays

The mVEC can be populated with 4-terminal and 5-terminal relays that can switch power to loads. These relays can be controlled via CAN commands, which signal the internal driver to energize the relay coils by pulling one side of the coil low. (See *Grid Coil Current Limit* in Section 8). The mVEC has the ability to control and monitor relays.

• For information on how the mVEC controls relays, refer to section 7.1.9. *Controlling Relays*
• For information on how the mVEC monitors relays, refer to section 7.2. *Monitoring Fuse, Relay, and System Fault Status*.

2.1.3.2. Circuit Protection – Fuses & Circuit Breakers

Fuses and Circuit Breakers limit the amount of power going to a load. The mVEC determines the state of each fuse / breaker by monitoring the fuse voltage through two internal digital inputs. The mVEC has the ability to monitor fuses / breakers (it cannot control them). Note Type II circuit breakers may not show open status due to the internal resistive component.
• For information on how the mVEC monitors fuses / breakers, refer to section 7.2. *Monitoring Fuse, Relay, and System Fault Status*.

2.1.4. mVEC Software

The mVEC is a slave module, meaning it is controlled by other modules over a Controller Area Network (CAN), using CAN messaging.

OEMs / Integrators / operators are not able to create custom software for the mVEC. However, you can change some of the mVEC's software settings.

• For information on changing software settings, refer to section 7.1. *CAN Software Settings*.
• For information on how the mVEC controls and monitors components, refer to section 9, Programming the mVEC.

3. Configuring the mVEC Options

There are many elements of the mVEC that can be configured. Configuration options for the mVEC fall into two major categories, as follows:

• Hardware configuration options – all hardware configuration options must be selected early in the design process and implemented before production.

• Software configuration options – most software configuration options do not need to be selected until production, and can be modified after production if needed.

Contact your Cooper Bussmann Account Representative for more details about creating a custom configuration for your product.

3.1. Hardware Options

3.1.1. mVEC Electrical Grid Configuration Options

The mVEC's electrical grid has 64 connection points that are used for connecting components to the grid. The components you choose for the grid determine the hardware configuration of your mVEC. Once your configuration is created, you will receive a custom overlay for the grid that has cutouts for each component you selected, see Figure 4.

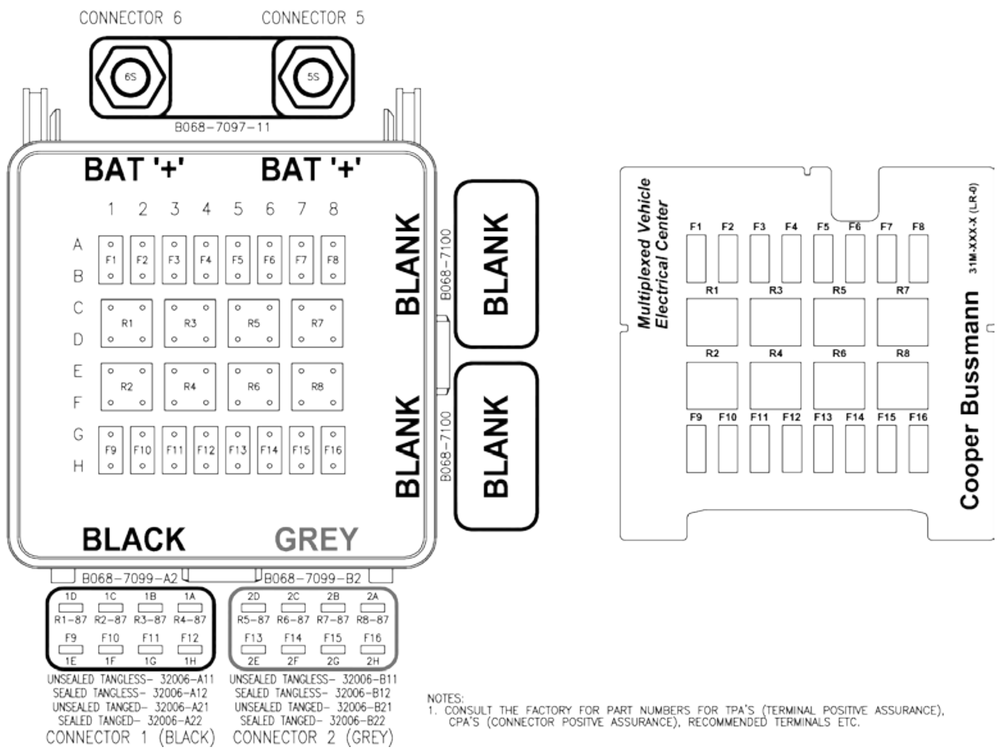

Figure 4. Grid Component and Connector Location Diagram

3.1.2. External High-Side Output Option

An external high-side output can be configured into the mVEC. This output is available on pin #11 on the 12-pin CAN connector, and can be used to drive low-current loads that are external to the mVEC such as relays, LEDs, or other system loads.

3.1.3. Grid Output Connector Options

The configuration options for the output connectors are as follows:

- You can have up to four different output connectors on your mVEC (refer to Figure 5).
- Total current for each connector is 80A.
- Output connectors can be sealed, or unsealed.
- Output connectors can be configured in four different colors, where each color has different keying (useful for ensuring the output connectors are connected to the correct harnesses).

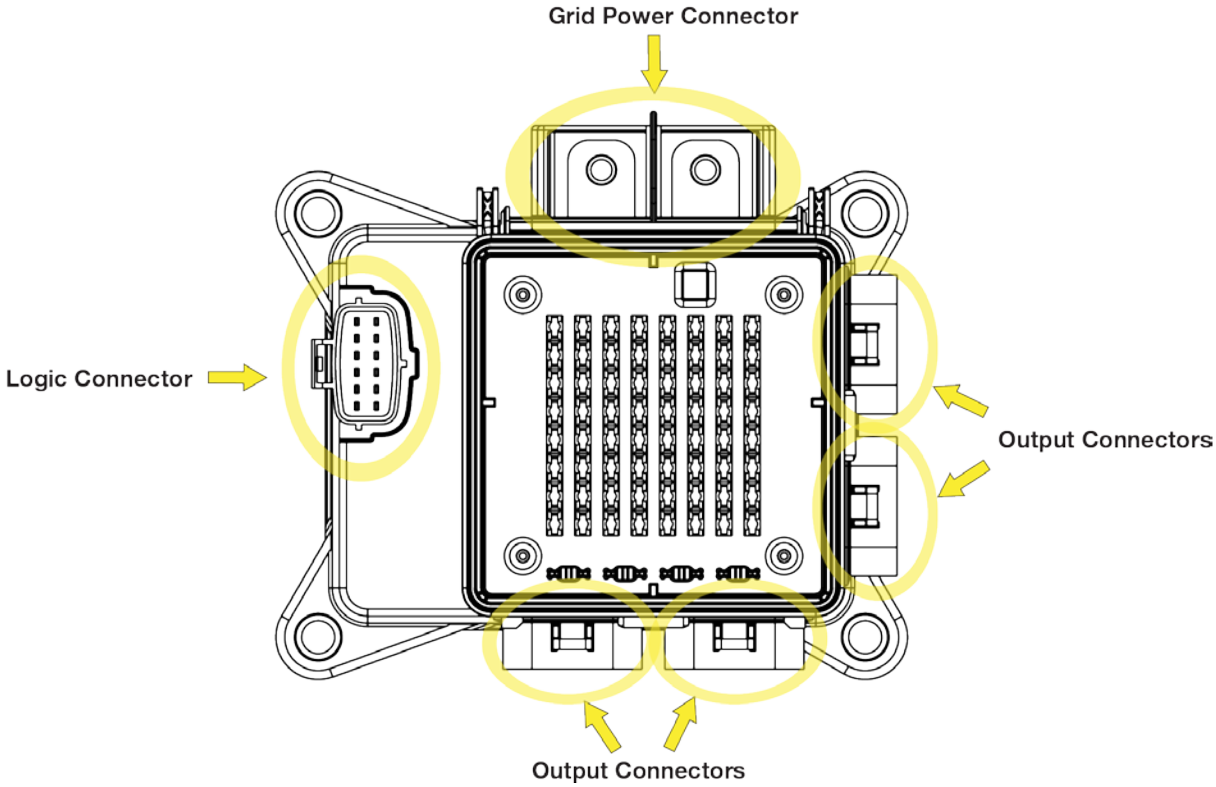

Figure 5. Grid Connector Location Diagram (new diagram text)

3.1.4. Grid Input Power Connection Options

The "Power Grid" of the mVEC has two options for the incoming current: studs or connectors. The maximum input amperage for an mVEC is 200 amps regardless of the input connection type.

3.1.5. Grid Label Options

The mVEC internal surface has a label with cut outs to allow insertion of components in only the positions to be filled per the design. It also may have plug-in descriptions, and identifiers (e.g. fuse numbers, relay identifiers, labels, etc.) For each unique part number, the label is custom marked per the customer's design. .Custom marking may include customer/OEM logos, part numbering, circuit identifiers, etc.

3.1.6. Cover Options

Additional labeling is available on the mVEC cover. Custom marking may be made either on the mVEC interior of the cover (underside) or on the exterior (outside) or both. Standard marking is now done via laser etching.

3.1.7. Fuse Puller and Spare Fuse Options

A fuse puller and up to 4 spare fuses can be included with your mVEC. If included, these items would be stored on the electrical grid as shown in Figure 6.

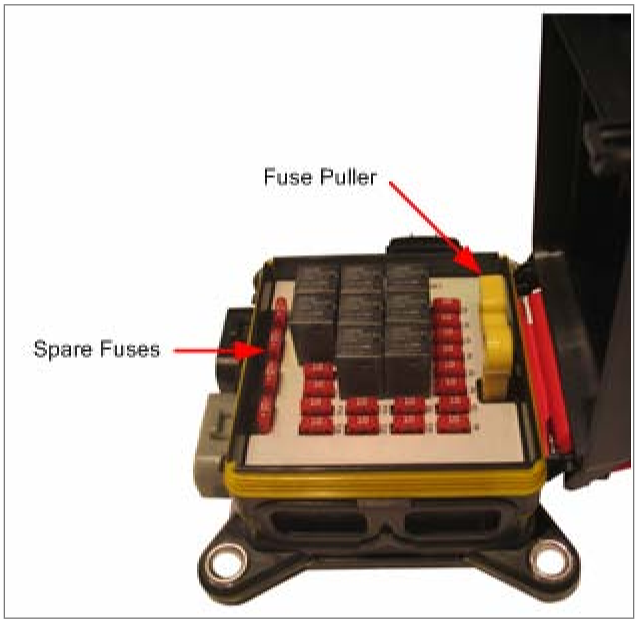

Figure 6. Spare Fuse and Puller Locations

3.2. Software options

The mVEC software configuration options are primarily in the area of base addressing, default states for relays, and population tables for components (whether to detect if they are present and to be monitored or ignored due to an empty plug in position). Some of the options must be configured at the factory before the mVEC is manufactured, and the rest can be configured by the user at anytime.

3.2.1. Fault Detection Options

The mVEC is capable of detecting various faults. However, some faults may need to go unreported, and would need to be disabled in the factory at an early stage of development.
An example would be a fuse that is supplied power through a relay contact. When the relay contact is open the fuse will not have power, causing the mVEC to detect a non-powered fuse fault. It is assumed that fuses always have power; therefore, the non-powered fuse fault should be disabled for this particular fuse. mVEC fault detection capabilities are detailed in various software sections of this manual. See section 9 for more information.

4. External Connections

System connections to the mVEC can be classified into three groups:

- CAN Connector
- Power Output Connectors
- Power Input Connectors

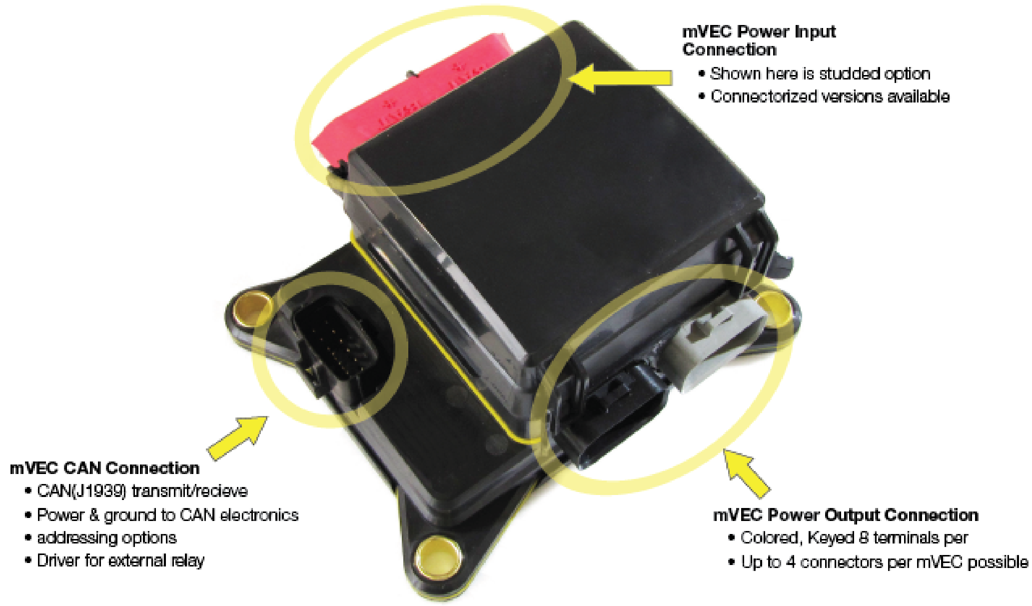

Figure 7. Connector locations

4.1. Control Header Connection

4.1.1. Overview

There is one CAN connector on the mVEC, as shown in the above picture.

The CAN connector is a Tyco AMP connector that provides CAN communication, logic power, and logic ground signals for the mVEC.

- The receptacle contacts on the CAN connector are each rated at 10 A.
- When the CAN connector is mated to the harness, it is sealed to IP66

The following shows the different parts of the logic (mating) connector:

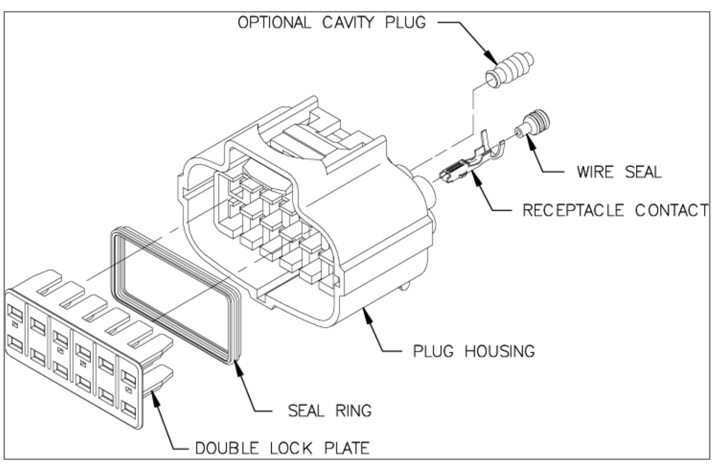

Figure 8: CAN (mating) connector

4.1.2. CAN Connector Part Numbers

The following table shows the mating connector part numbers for the mVEC's CAN connector:

Table 1. CAN connector Part Numbers

Component	Part Number
Plug housing	Tyco (AMP) - 184115-1
Receptacle contact	20-14 AWG, Gold: Tyco (AMP) - 184030-1
Double lock plate	Tyco (AMP) - 184058-1
Wire seal	Tyco (AMP) - 184140-1
Cavity plug	Tyco (AMP) - 172748-1 or 172748-2

4.1.3. CAN Connector Pin Descriptions

The following table shows the pin-out for the CAN connector:

Table 2. 12-Pin Connector Pin-Out

Pin Number	Name	Function
1	VBATT	Power / battery input to power the mVEC control circuitry. 12 or 24V capable.
2	PWR_REF	Voltage reference for the ADDR inputs to offset the mVEC source address.
3	GND_POWER	Ground connection for the mVEC control circuitry and relay coil return path. Wire size must handle all the relay's coil current.
4	ADDR_1	Base address offset bit #1. Internally pull low (logic 0). Connect to PWR_REF to change the offset address to logic 1.
5	CAN_SHIELD	This is the connection point to the CAN shield.
6	CAN_HI	CAN bus high signal connection (CAN_H).
7	IGNITION_LOW	Input enable pin. Pull this input to ground to enable the control circuitry. Typically switched with vehicle ignition, use either this pin or pin 8 for enable control.
8	IGNITION_HIGH	Input enable pin. Pull this input to battery level to enable the control circuitry. Typically switched with vehicle ignition, use either this pin or pin 7 for enable control.
9	ADDR_2	Base address offset bit #2. Internally pull low (logic 0). Connect to PWR_REF to change the offset address to logic 1.
10	ADDR_0	Base address offset bit #0. Internally pull low (logic 0). Connect to PWR_REF to change the offset address to logic 1.
11	HS_OUTPUT	Optional high-side drive output, controlled via CAN command.
12	CAN_LO	CAN bus low signal connection (CAN_L).

4.1.4. Ignition Connections

The mVEC offers two power-enable inputs pins within the CAN connector.

- One is active high, called IGNITION_HIGH
- One is active low, called IGNITION_LOW

The mVEC will remain powered on when either signal is active. Once deactivated, the mVEC will power off, delaying shortly if internal memory requires updating.

Note: Only one of the enable lines should to be used for normal operation. If both are enabled simultaneously, the mVEC will enter a recovery mode application (factory use only).

4.1.4.1. Active-Low Ignition Input Connection

The active-low ignition input (IGNITION_LOW) enables power to the mVEC when the voltage is **lower than ½ battery voltage on Pin 1**.

A shut-down procedure is activated when the voltage on the active-low input is **higher than ½ battery voltage on Pin 1**, or when the input has an open circuit condition.

Caution: The minimum recommended fuse value for the active-low ignition input is **200 mA**. This protection is only needed for the harnessing to the mVEC.

The following shows a typical active-low ignition input connection:

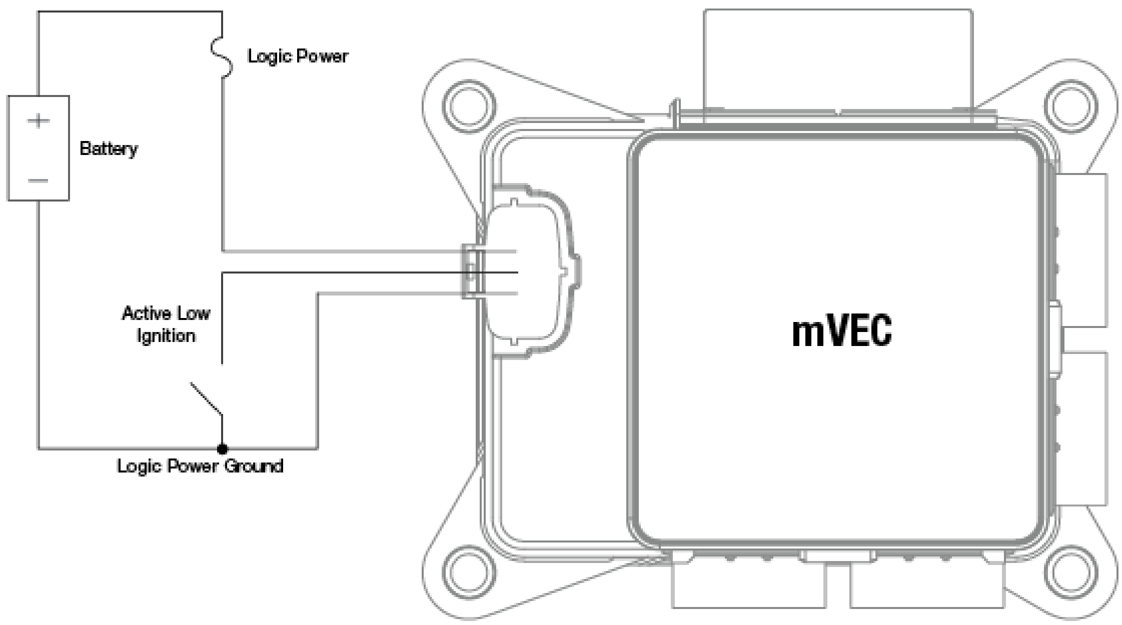

Figure 9: Active-low ignition connections

4.1.4.2. Active-High Ignition Input Connection

The active-high ignition input (IGNITION_HIGH) enables power to the mVEC when the input is **higher than ½ battery voltage on Pin 1.** A shut-down procedure is activated when the voltage on the active-high input is **lower than ½ battery voltage on Pin 1**, or when the input has an open circuit condition.

Caution: The minimum recommended fuse value for the active-high ignition input is **200 mA**. This protection is only needed for the harnessing to the mVEC.

The following shows a typical active-high ignition input connection:

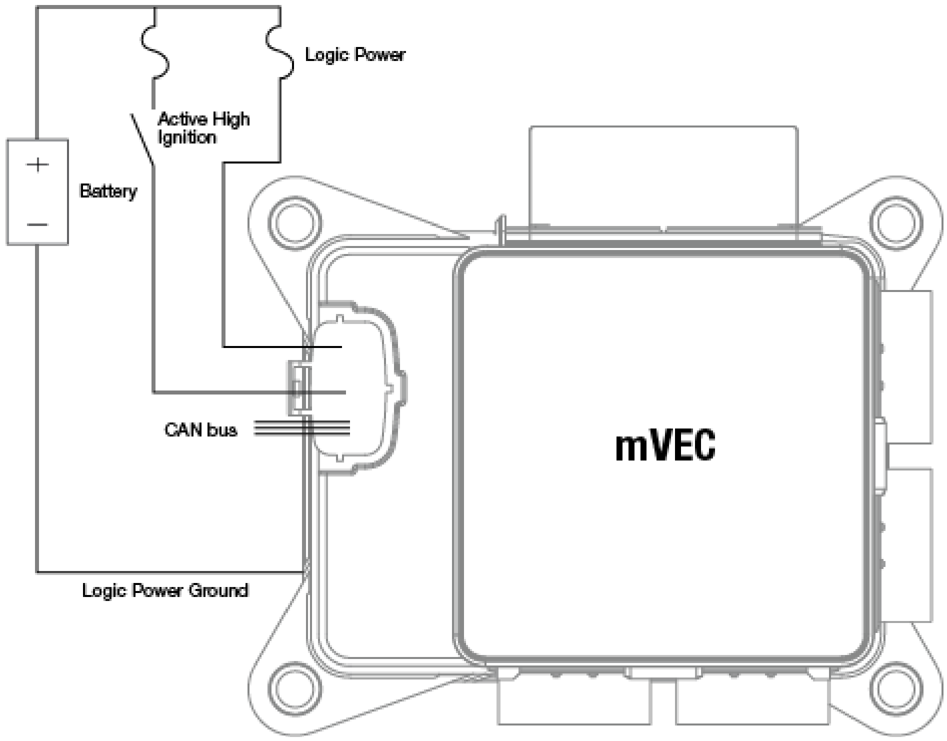

Figure 10: Active-high ignition connections

4.1.4.3. CAN Harness Address Pin Connections

There are three pins dedicated to CAN harness addressing in the CAN connector, called ADDR_0, ADDR_1, and ADDR_2

CAN harness address pins are connected to a power reference (called PWR_REF) that is provided by the mVEC. The power reference should not be used for any other purpose other than for the CAN harness address pins.

The following should be taken into consideration when connecting the CAN harness address pins to power reference:

- The power reference can be spliced into the CAN harness address pins in the CAN connector.
- Pins that need to be pulled high should be connected to the power reference. All other pins can be left open circuit.

Note: Each mVEC on a single network must have a unique source address. The source address may be altered by configuring the source address offset through the mVEC's CAN harness address pins.

The following shows a typical CAN harness address pin connection:

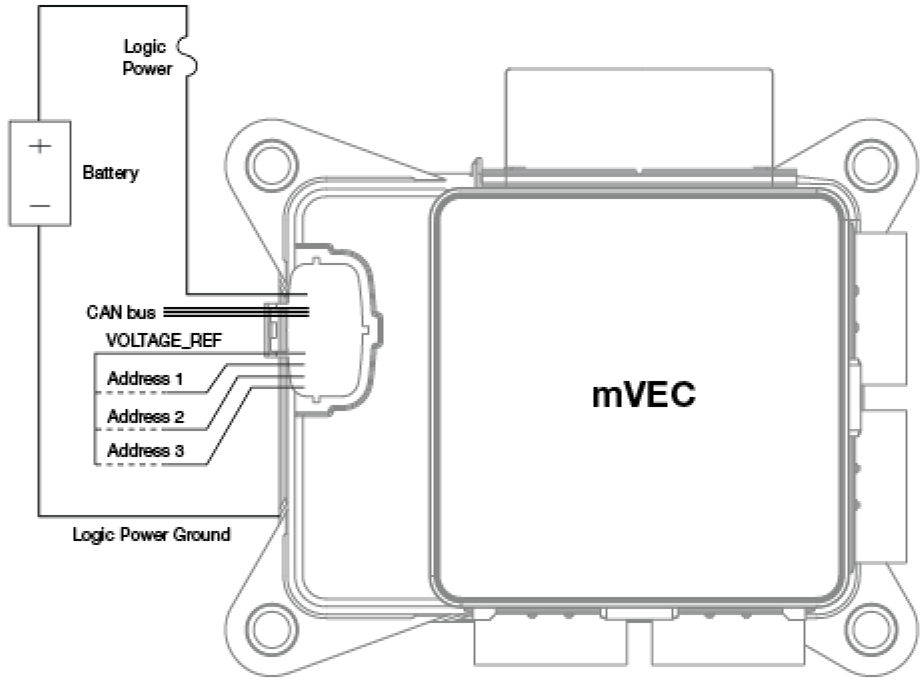

Figure 11. CAN harness address pin connections with power reference to offset

4.2. Bussman 32006 Series Output Connections

Bussman supplies mVEC output connectors , designated 32006-xxx. The –xxx allows choices of color (8 options), type of connector cavity, and sealed or unsealed. There can be up to four output connectors on the mVEC, depending on your configuration. The output connectors are capable of providing 30 A maximum of continuous current per termina (maximum 100A per connector)l**.**

- When a sealed output connector is mated to the harness, it is sealed to IP66.
- All output connector options are readily available through Distribution.

4.2.1. Part Numbers

Because there are so many configuration options for the output connectors, there are a lot of different mating connector possibilities. Here is the part numbering scheme for the 32006 VEC connectors

MALE OUTPUT CONNECTOR (280 SERIES)

32006-X X X

SEALING OPTIONS

1 = Non-sealed 2 = Sealed

CONNECTOR CAVITY CONFIGURATION

1 = For Use With Tangless Wire Terminals
2 = For Use With Tanged Wire Terminals
P = Plugged

PART COLOR

A = Black	**E = Yellow**	**J=Neutral (only available with –JP2 option.)**
B = Gray	**F = Red**	
C = Green	**G = Orange**	
D = Blue	**H = Brown**	

4.2.1.1. Terminal Position Assurance (TPA)

mVEC connectors feature terminal position assurance. Here are the part numbers depending on your sealing configuration.

OUTPUT CONNECTOR – TERMINAL POSITION ASSURANCE (TPA)

32006-TPX

SEALING OPTION

1 = For Use With Non-sealed Terminals

2 = For Use With Sealed Terminals

4.2.1.2. Connector Position Assurance (CPA)

The connector position assurance part number is 32004-CP.

4.2.2. Output Connector Drawing

The output connector pinouts are configuration-specific. Refer to the procurement drawing for your specific mVEC configuration for more details.

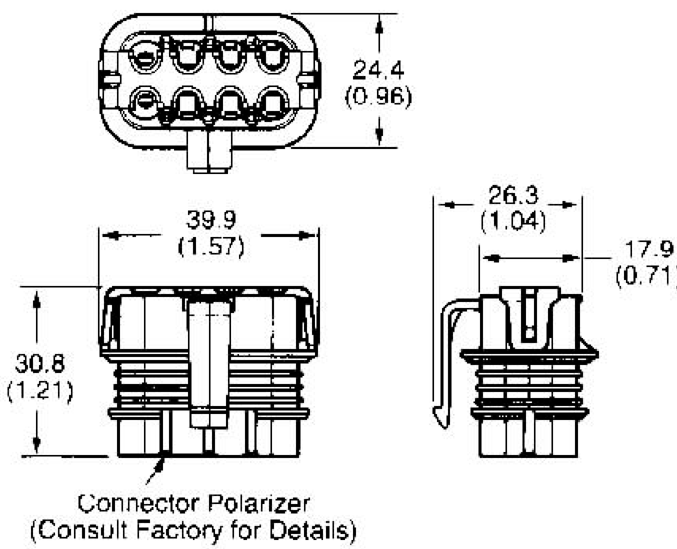

Figure 12. 32006 VEC Connector

Table 3. 32006 Mating Terminal Reference

The chart below is for reference only, and is subject to changes by Delphi Packard. Delphi Packard part numbers are shown.

PART NUMBERS	TERMINALS DESCRIPTION	CABLE RANGE (mm sq)	GAUGE
12110843	280 ser. Metri-Pack Unsealed Female Terminal - Tangless	.35-.50	22-20
12110844	280 ser. Metri-Pack Unsealed Female Terminal - Tangless	.80-1.0	18-16
12129424	280 ser. Metri-Pack Unsealed Female Terminal - Tangless	1.0-2.0	16-14
12110842	280 ser. Metri-Pack Unsealed Female Terminal - Tangless	2.0-3.0	14-12
12129663	280 ser. Metri-Pack Unsealed Female Terminal - Tangless	3.0	12
12129425	280 ser. Metri-Pack Unsealed Female Terminal - Tangless	5.0	10
12110846	280 ser. Metri-Pack Sealed Female Terminal - Tangless	.35-.50	22-20
12110847	280 ser. Metri-Pack Sealed Female Terminal - Tangless	.80-1.0	18-16
12129409	280 ser. Metri-Pack Sealed Female Terminal - Tangless	1.0-2.0	16-14
12110845	280 ser. Metri-Pack Sealed Female Terminal - Tangless	2.0-3.0	14-12
12110853	280 ser. Metri-Pack Sealed Female Terminal - Tangless	3.0-5.0	12-10
12052217	280 ser. Metri-Pack Unsealed Female Terminal - w/Tang	.35-.50	22-20
12034046	280 ser. Metri-Pack Unsealed Female Terminal - w/Tang	.50-.80	20-18

12066214	280 ser. Metri-Pack Unsealed Female Terminal - w/Tang	1.0-2.0	16-14
12129494	280 ser. Metri-Pack Unsealed Female Terminal - w/Tang	2.0-3.0	14-12
12059284	280 ser. Metri-Pack Unsealed Female Terminal - w/Tang	3.0	12
12015858	280 ser. Metri-Pack Unsealed Female Terminal - w/Tang	3.0-5.0	12-10
12084201	280 ser. Metri-Pack Sealed Female Terminal - w/Tang	.35-.50	22-20
12077411	280 ser. Metri-Pack Sealed Female Terminal - w/Tang	.50-.80	20-18
12077412	280 ser. Metri-Pack Sealed Female Terminal - w/Tang	1.0-2.0	16-14
12129493	280 ser. Metri-Pack Sealed Female Terminal - w/Tang	2.0-3.0	14-12
12077413	280 ser. Metri-Pack Sealed Female Terminal - w/Tang	3.0	12
PART NUMBERS	**SEALS DESCRIPTION/COLOR/TYPE**	**CABLE DIA.**	
12015193	280 ser. Metri-Pack cable seal/Blue/Straight	3.45-4.30	
12010293	280 ser. Metri-Pack cable seal/Light Gray/Straight	2.81-3.49	
12015323	280 ser. Metri-Pack cable seal/Green/Ribbed	2.03-2.85	
12041351	280 ser. Metri-Pack cable seal/Tan/Straight	2.03-2.42	
12089679	280 ser. Metri-Pack cable seal/Purple/Ribbed	1.60-2.15	
12015899	280 ser. Metri-Pack cable seal/Dark Red/Ribbed	1.29-1.70	
12129381	800 ser. Metri-Pack cable seal	4.54-4.70	
PART NUMBERS	**CAVITY PLUGS**		
12010300	280 Metri-Pack Cavity plug for 32006-XX Connector		
PART NUMBER	**TERMINAL REMOVAL TOOL**		
12094429	280 & 800 Ser. Metri-Pack Female Terminal Removal Tool		

4.3. mVEC Power Input Connection Options

There are two types of input connectors that can be used with the mVEC (depending on your grid configuration):

- Bladed (using sealed dual-blade connectors)
- Studded (using ring terminals)

4.3.1. Bladed Power

The Bussmann 32004 input connector is one option for mVEC current input. It mates with the dual-bladed connector installed within the mVEC. There can be up to two input connectors on the mVEC, depending on your configuration.

- The input connectors are capable of providing 60 A of continuous current per blade, totaling to 120 amps per connector. For maximum grid amperage, two input connectors must be used.
- When an input connector is mated to the harness, it is sealed to IP66.
- The 32004 is readily available through Distribution.

mVEC input connectors offer somewhat superior protection for the mVEC when in corrosive environments, as compared to the studded inputs. Studded inputs have exposed metal and are susceptible to corrosion from contaminants such as road salt, etc. If the mVEC is to be installed in an external environment, bladed connectors are recommended as inputs.

The two bladed power inputs within a single connector must be the same voltage (one can be unused). The second connector's blades can have a different voltage.

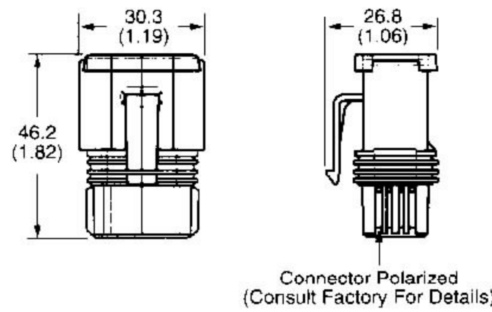

Figure 13. Bussmann 32004 VEC Input connector

4.3.2. Studded Power

The studded input connector uses M8 or M6 studs, and is connected to the harness with ring terminals.

- The **recommended torque** that should be used when attaching the studded power connector is **10-12 ft/lbs**. The maximum torque is 18ft/lbs.
- Bussmann recommends that if the studded input is used and the mounting of the mVEC is in a location where the vehicle could be exposed to corrosive chemicals such as road salts, that 'after treatments' be used to the input area including the following possible actions:
  - Generous application of a dialectric grease to the entire stud assembly (cover the power input stud, the plate of the input area and over the ring terminal
  - Use a epoxy / anti corrosive spray coating over the entire stud assembly (cover the power input stud, the plate of the input area and over the ring terminal

The following shows a studded power (mating) connector:

Figure 14. Studded power (mating) connector

4.3.3. Input Connector Part Numbers

Male input connector (800 Series)

MALE INPUT CONNECTOR (800 SERIES)

32004–X X

SEALING OPTION

1 = Non-sealed 2 = Sealed

PART COLOR

A = Black B = Gray

The following drawing shows a 32004 Input Connector

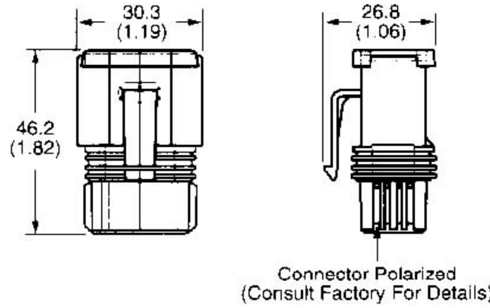

Figure 15. Bussmann 32004 VEC Input connector

4.3.3.1. Terminal Position Assurance (TPA)

mVEC Connectors feature terminal position assurance. Here are the part number depends on your sealing configuration.

Input Connector - TPA

32004-TPX

SEALING OPTION
1 = For Use with Non-Sealed Terminal
2 = For Use with Sealed Terminals

4.3.3.2. Connector Position Assurance (CPA)

Input connector – CPA

32004-CP

5. Vehicle Installation

Vehicle installation will vary depending on the system. Therefore, mechanical, environmental, and electrical guidelines and requirements that you should be aware of before installing the product have been provided.

5.1. Mechanical Information

It is important that the mVEC be installed so that all of the mechanical components are easily accessible.

5.1.1. Dimensions

The following diagrams show the dimensions of the mVEC in millimeters:

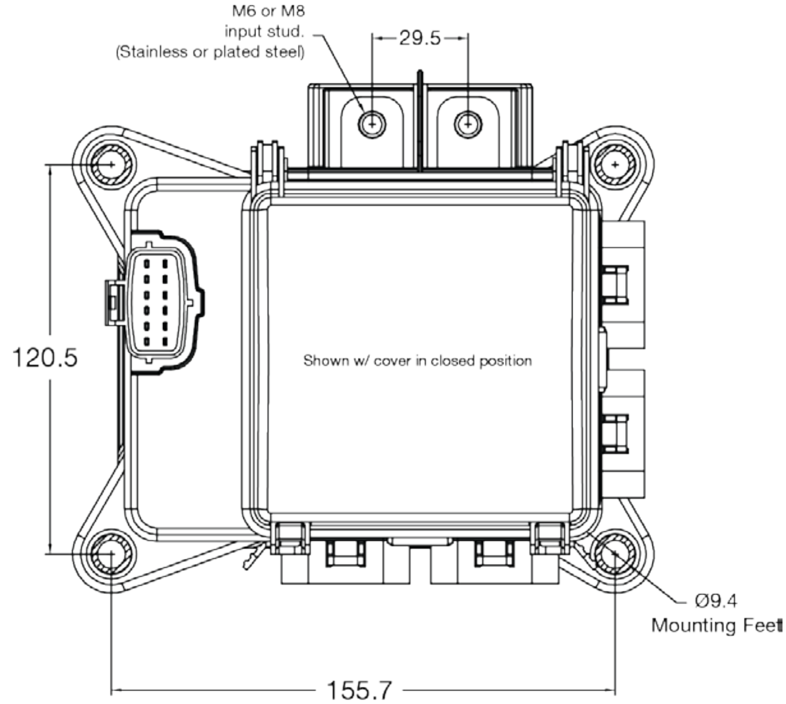

Figure 16. mVEC width and depth

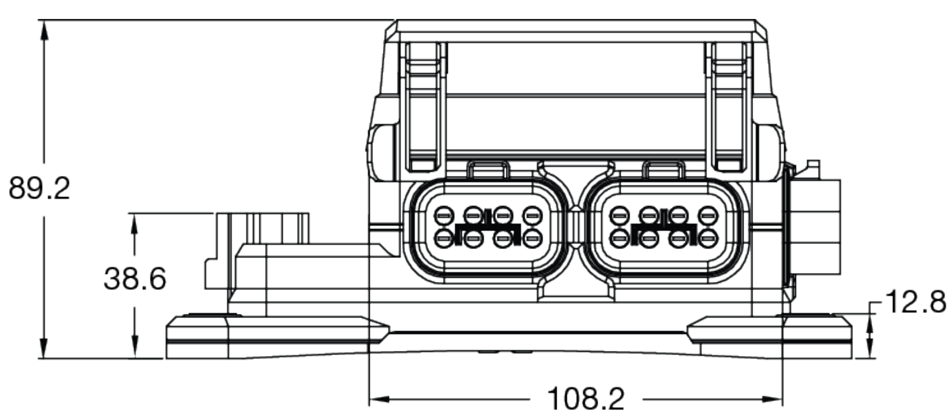

Figure 17. mVEC height with cover closed

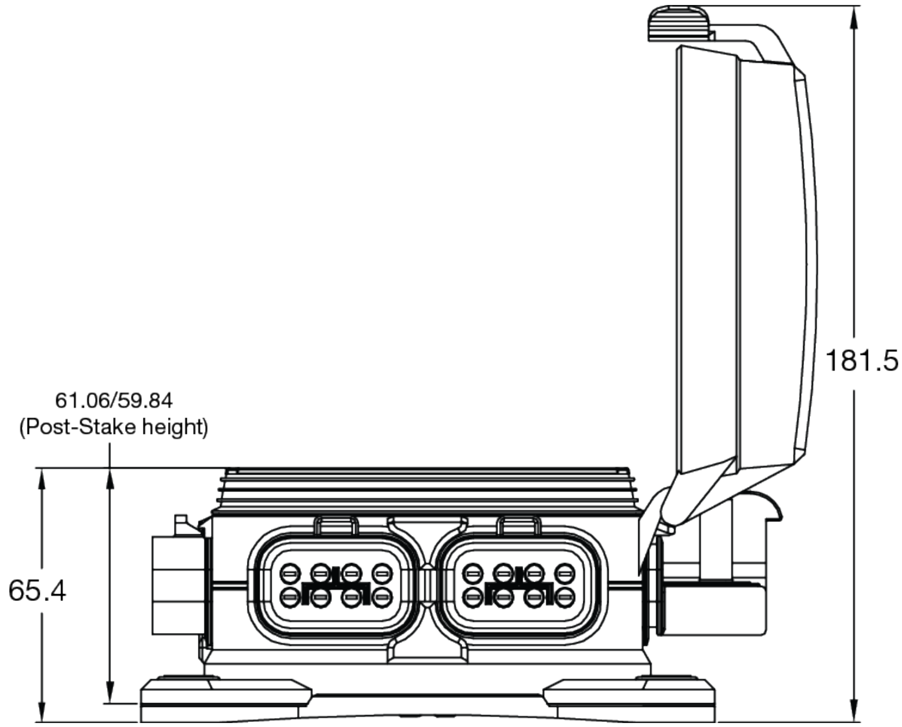

Figure 18. mVEC height with cover open

5.1.2. Mounting Location Selection

Where you mount the mVEC is completely dependent on your system; however, you must take the following environmental and mechanical requirements into consideration before mounting.

If you have any questions, please discuss your mounting options with a Cooper Bussmann representative.

5.1.2.1. Environmental Requirements

The mVEC is designed to operate in harsh environments.

When selecting an mVEC location, ensure the following environmental requirements are respected:

- The mVEC is in an environment within its ambient temperature range.
    - Safe temperature range for the mVEC is –40°C to +85°C.
- The mVEC has been designed and validated to a level of IP66.
    - Realize that this module contains power electronics and has a lid that allows servicing of the plug in components.
    - To maintain high IP rating, the unit must remain with the cover securely attached. Any damage to the housing or removal of the cover degrades the protection of the housing and may lead to eventual failure of the module if exposed to moisture or other contaminants.

Caution: Bussmann does not recommend mounting the mVEC in locations where the module may be subjected to pressure washing. The severity of a pressure wash can exceed the specifications the mVEC has been tested against due to water pressure, water flow, nozzle characteristics, and distance. Under certain conditions, a pressure wash can cut wire insulation.

5.1.2.2. Mechanical Requirements

When selecting an mVEC mounting location, ensure the following mechanical requirements are respected:

- It is highly recommended that it be mounted in locations that are not routinely exposed to direct and routine water sprays. Wherever possible, the mVEC should be placed in covered, shielded, interior locations on a vehicle.
- The mVEC and its connectors are shielded from harsh impact, debris, etc, and is not designed for other mechanical purposes other than that of a power distribution module. It should not be placed where someone could step on it.
- Mount the mVEC harnesses with sufficient strain relief and adequate bend radius.
- The mVEC cover can be fully opened.
- The mVEC mounting location / orientation should facilitate easy servicing of the plug-in power distribution components (fuses, relays, etc.)
- Consider operator's view of the mVEC labels when mounting unit.
- The mVEC should not be mounted upside-down. Best position is horizontal, but the mVEC is capable of being mounted up to a 90 degree angle from the horizontal.

5.1.3. Electrical Connections to the Vehicle

Depending on the design of the mVEC you plan to use, to connect an mVEC to a vehicle, a number of connections should be made, which may including the following:

- Power connections
- Ignition connections
- CAN harness address pin connections
- Relay output connections
- CAN connections
- Fuse and breaker connections
- External high-side output connections (optional)

The following shows an overview of how to connect the mVEC to a vehicle:

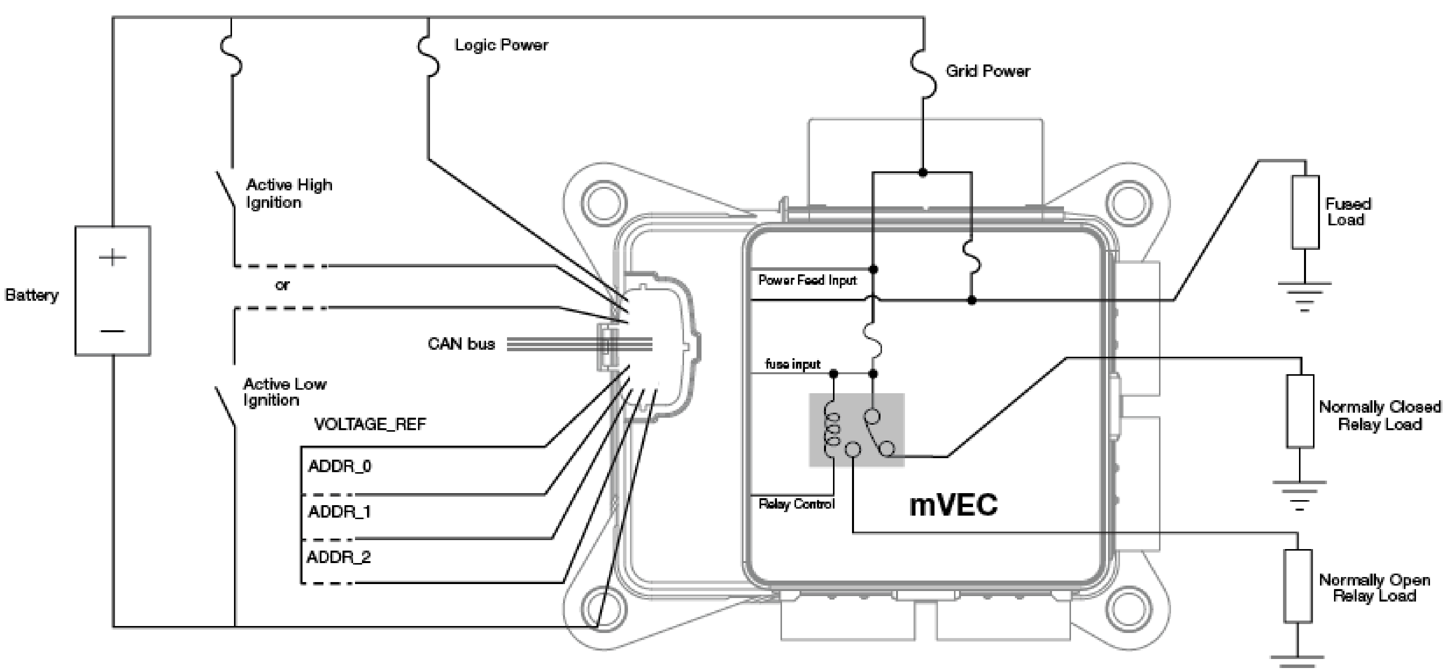

Figure 19. Overview of electrical

5.1.4. Power Connections to the mVEC: Connector Details

The mVEC is available for 12 V or 24 V operation (relay dependent) without internal circuitry changes. Its operating voltage range is 9V - 32V, and it can withstand double battery conditions up to 48 V for 5 minutes.

The mVEC has two types of power feeds: grid power and logic power.

- **Input power:** provides power to the VEC power grid (typically via input connectors / studs) with the amperage exiting via output pins on the mVEC electrical grid,
- **CAN layered, Logic power:** provides power to the mVEC's microprocessor and logic peripherals, and is delivered through the CAN connector

5.1.4.1. Grid and Logic Power Connection Requirements

It is important to take the following into consideration when connecting power:

- The mVEC harnesses and components should be fused.
  - Logic power should be fused to protect the harnessing between the battery and the mVEC.
  - Power signals should be fused based on the loads driven by the mVEC.
  - Connect logic power and logic ground directly to the battery.
- Separate the grid power and ground connections from the logic power and ground connections to ensure the power provided to the microprocessor is free of transients, and to ensure the vehicle loads do not affect the logic ground connections.
- Connect the ground for grid power directly to the chassis. Do not splice the grid grounds into the harness grounds or battery ground.
- **Ensure that the power and the ignition input to the mVEC remain valid while setting any User Configured Software Options. Failure to maintain valid power and ignition during these operations may result in a non-functional unit.**

5.1.4.2. Grid Component Connection to Loads

The grid components (relays, fuses, circuit breaker, etc.) connect to load via the output terminals as per the wiring schematic. It is recommended to distribute high current loads around the mVEC's output connectors.

5.1.5. High-Side Drive (Optional)

The mVEC provides a CAN controlled output that is capable of driving high-side outputs up to 500 mA. This output is protected against short circuits. The high-side output is used for driving external loads like LEDs or relays.

The following diagram shows a typical high-side output connection to an LED:

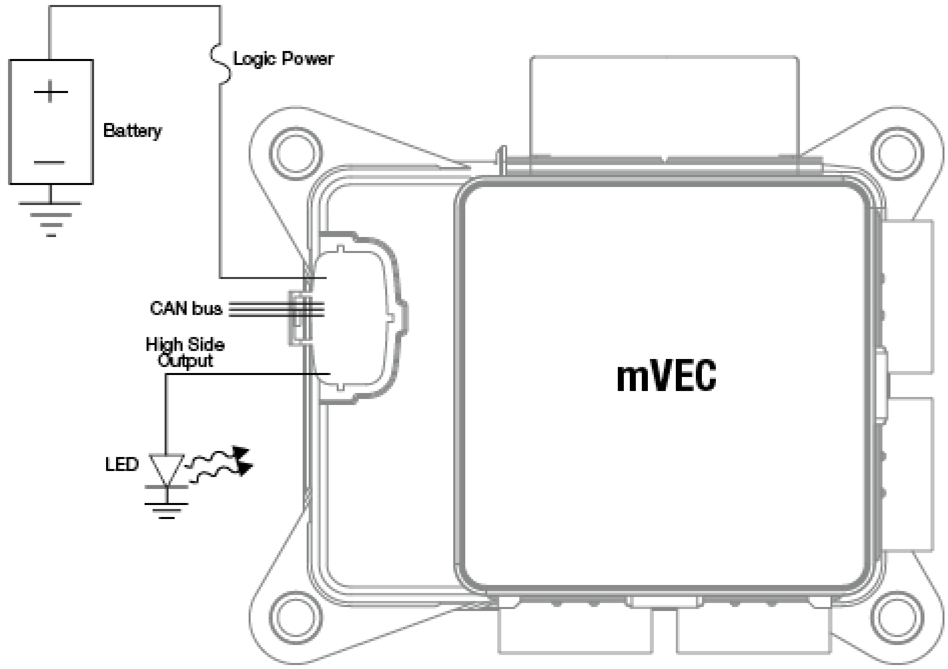

Figure 20. High-side output driving an LED

5.1.6. CAN Connection

The mVEC is designed to interface to a vehicle Control Area Network (CAN) that conforms to the SAE J1939 standard.

For a list of J1939 connection considerations, refer to the SAE J1939 specifications available through the Society for Automotive Engineers. SAE J1939-11 covers the physical aspects of the CAN bus including cable type, connector type, and cable lengths.

This section describes the components and connections necessary to create a 1939-11 industry standard CAN connection.

Note: The mVEC does not have a CAN termination resistor, which is based on the assumption the CAN bus is terminated in the vehicle harness.

The following lists the elements that are required for a J1939 CAN connection:

- **CAN Cable**: A shielded-twisted-pair-cable should be used for connecting multiple modules to the CAN bus. The cable for the J1939 bus has three wires: CAN High, CAN Low, and CAN Shield (which connect to the corresponding CAN_HI, CAN_LO, and CAN_SHIELD pins on the CAN connector). This cable must have an impedance of 60 Ω.
    - **The CAN cable is very susceptible to system noise**, and therefore, the CAN Shield wire must be connected according to the following:
        a) Connect CAN Shield to the point of least electrical noise on the CAN bus. It is recommended to connect CAN Shield to the vehicle chassis.
        b) Use the lowest impedance connection possible.
        c) Connect CAN Shield as close to the center of the CAN bus as possible

    Note: CAN Shield can only be grounded to one point on the network. If grounded to multiple points, a ground-loop may occur.

- **CAN Connectors**: Industry approved CAN connectors are manufactured by ITT, Canon, and Deutsch, and come in either “T” or “Y” configuration.
- **CAN Harness**: The CAN harness is the “main backbone” cable that is used to connect the CAN network. This cable cannot be longer than 40 meters, and must have a 120 Ω terminator resistor

at each end. The 120 Ω terminator resistors eliminate CAN bus reflections and ensure proper idle-state voltage levels.

- **CAN Stubs**: The CAN stubs cannot be longer than 1 meter, and each stub should vary in length to eliminate CAN bus reflections and ensure proper idle-state voltage levels.
- **Maximum Number of Modules in a System**: The CAN bus can handle a maximum of 30 modules in a system at one time.

The following diagram shows a typical CAN connection using the J1939 standard:

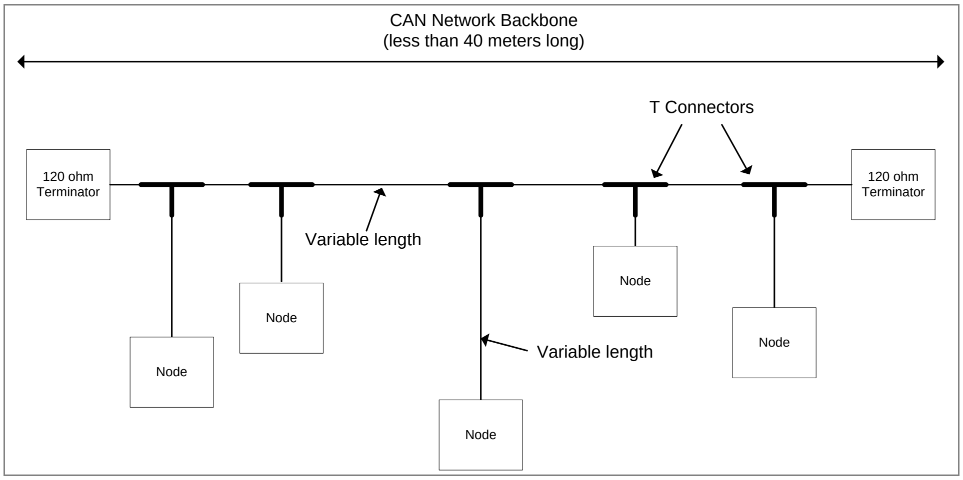

Figure 21. CAN connection

6. Application Examples

The purpose of this section is to provide various examples of how the mVEC can be used for different applications.

Note – these sections describe how the mVEC can support / provide CAN visibility to basic power distribution functions. Many of these features / examples are covered in existing (reused) mVEC designs, or may be utilized in new custom mVEC variants.

Note: It is the system designer's responsibility to ensure safe and correct vehicle operation under all conditions. These examples are for illustrative purposes only.

6.1. Switched Fuse Load

A switched fused load can be used in the mVEC to provide power to vehicle systems (lamps, solenoids, etc.).

An external controller provides the logic for switching the mVEC relay "on" or "off".

The following shows the typical connections for a switched fused load:

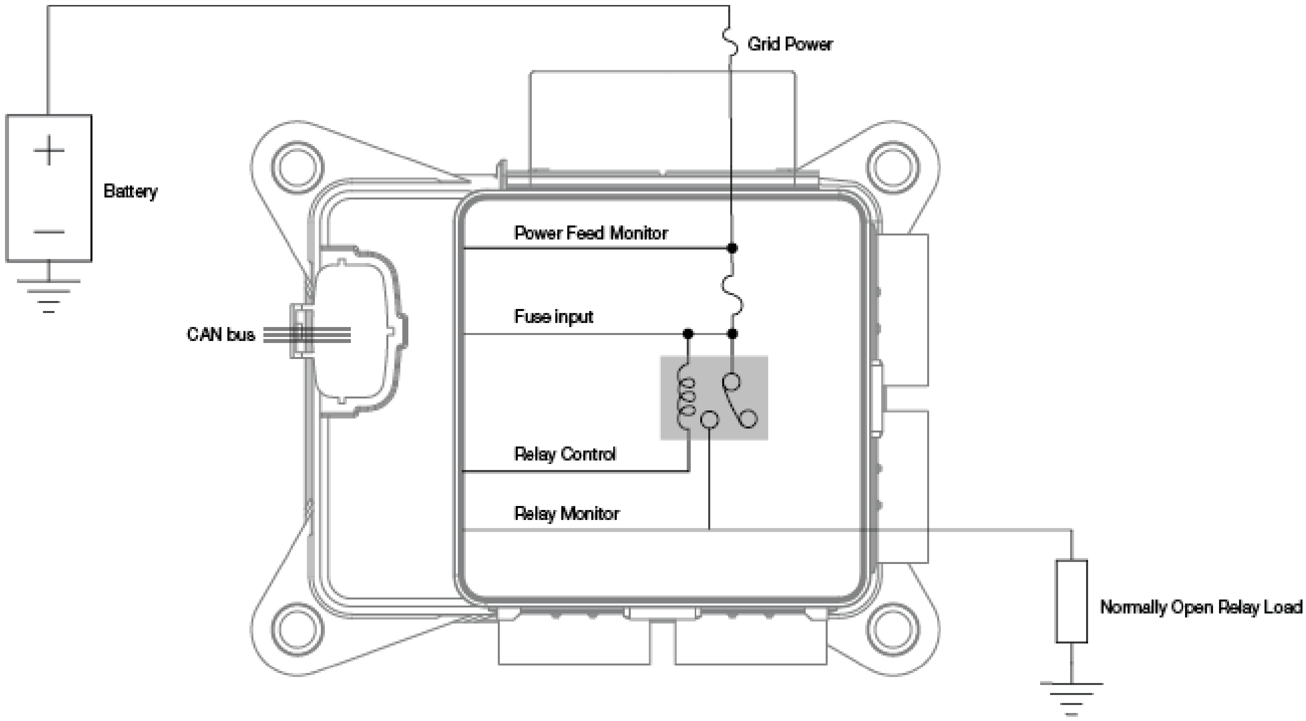

Figure 22. Switched fused load

6.2. Inductive Load Protection

When an inductive load does not include a suppression device, protective components such as diodes can be placed on the mVEC grid to provide protection from voltages induced when the inductive load is turned “on” or “off”.

The following shows an example of inductive load protection:

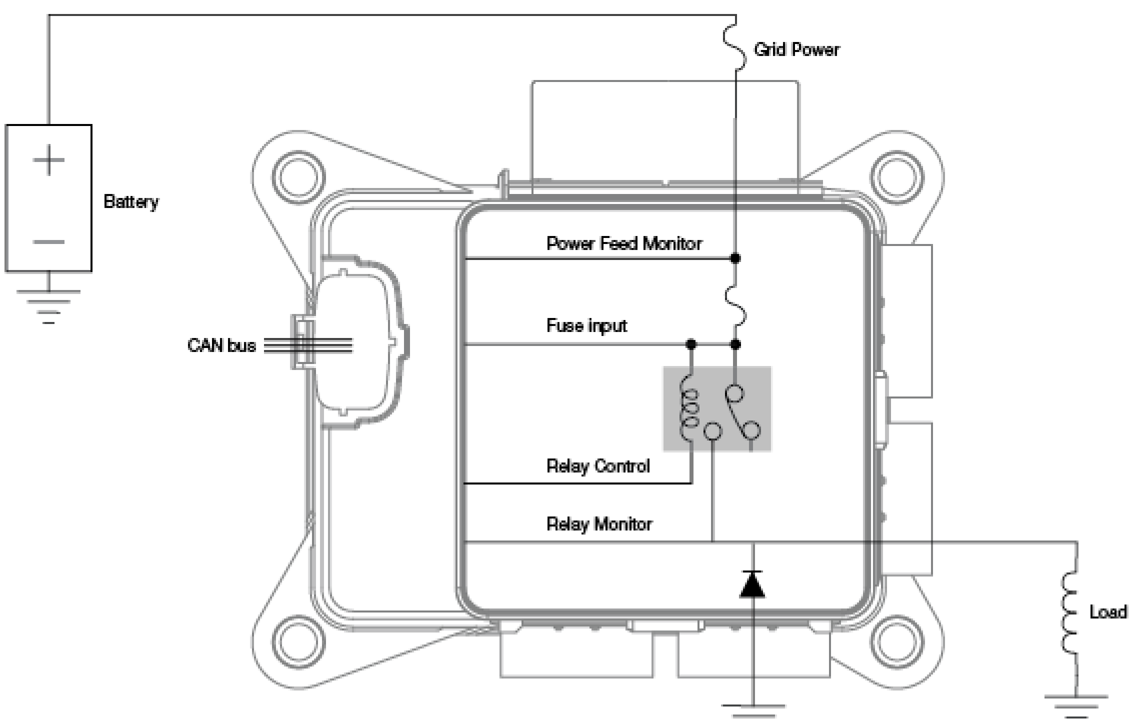

Figure 23. Inductive load protection.

6.3. Controlling a Motor using an H-Bridge

The mVEC can provide simple H-bridge circuit functionality, and can eliminate the need for solid state modules, or relay logic.

An H-bridge is typically used to drive a DC motor.

In H-bridge circuits, the polarity of the output across a load must be reversed. The customer can use a pair of relays on the mVEC to do this.

Logic in an external module controlling the mVEC can switch the pair of relays to control the direction and operation of a motor. H-bridge capability can be requested over the CAN bus on a relay-by-relay basis.

The relays can be driven in four unique ways (off-off, on-off, off-on, on-on), and three separate modes of operation (brake, forward, and reverse) are possible, as illustrated in **Table 4.**

Table 4. H-Bridge States for Motor Control

Relay 1	Relay 2	Motor 1	Motor 2	Motor State
OFF	OFF	GROUND	GROUND	BRAKE
ON	OFF	VBATT	GROUND	FORWARD
OFF	ON	GROUND	VBATT	REVERSE
ON	ON	VBATT	VBATT	BRAKE

The following shows an example of how to connect an H-bridge to control a motor:

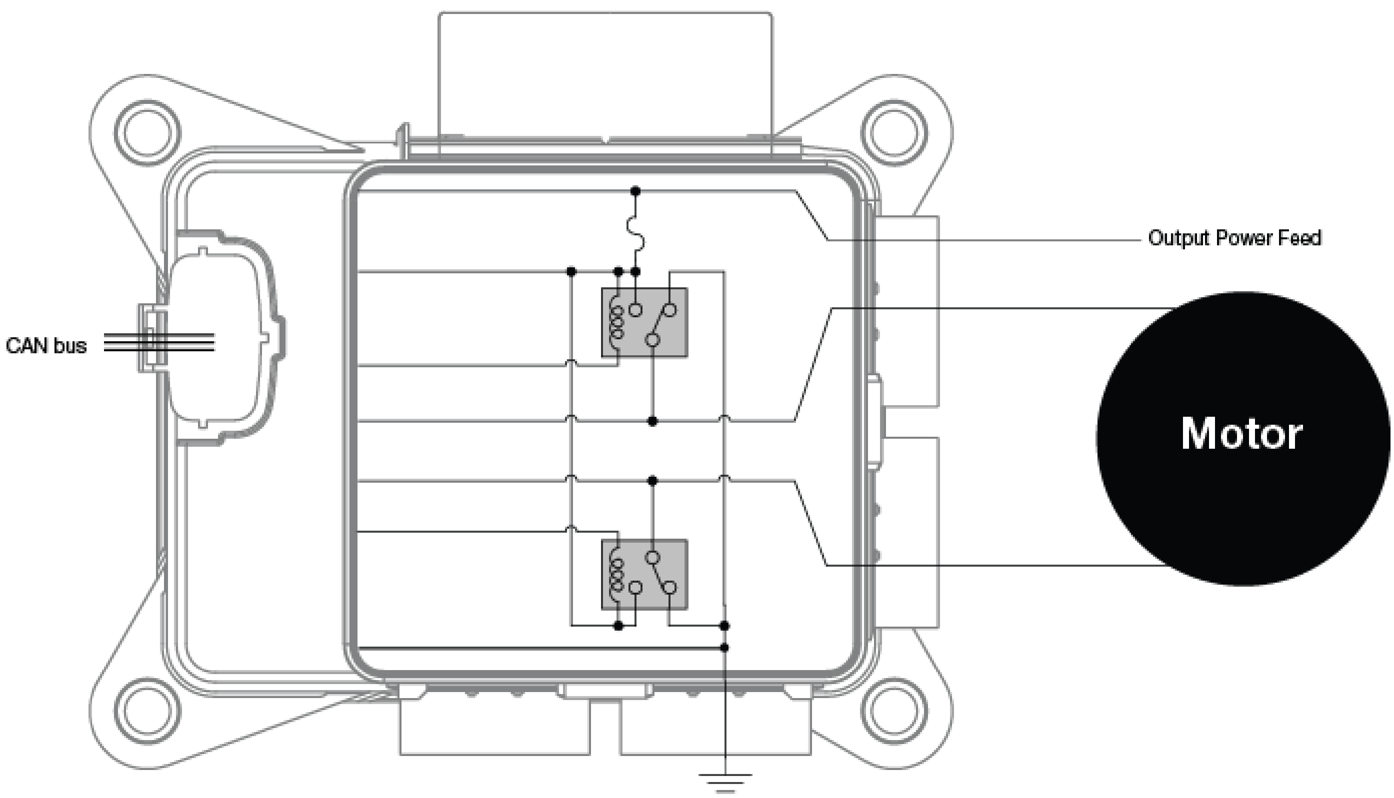

Figure 24. H-bridge

6.4. Controlling Flashers using Relays

Relays in the mVEC grid can be wired to the turn signal lights, controlled by an external controller through CAN messages telling the relay to turn “on” and “off”.

The following shows an example of how the mVEC could be used to power turn signals:

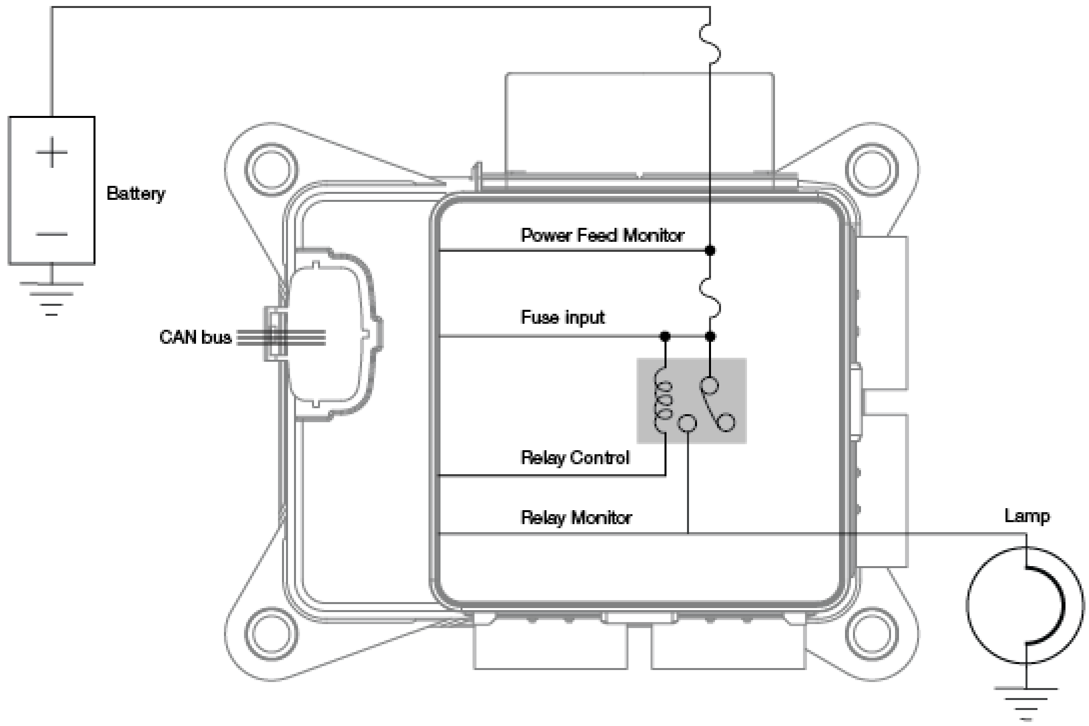

Figure 25. Flasher function using a relay

6.5. High-Side Output Power Master

The high-side output can be connected to a master power relay on the vehicle and feed power to other vehicle systems, including the grid power connections. This allows the mVEC to control power going to other vehicle systems, and minimize the current drawn by the system when ignition is switched “off”.

Caution: If the master power relay feeds the circuit controlling the starter motor system, voltage drops can occur during ignition cranking. If the voltage drops below the operating voltage of the mVEC, the master power relay will turn “off”.

When the default state of the mVEC’s high-side output is “on”, the output will turn “on” when the mVEC is powered, without requiring another controller to send a command to the mVEC to turn it “on”.

The following shows an example of using the high-side output for master power:

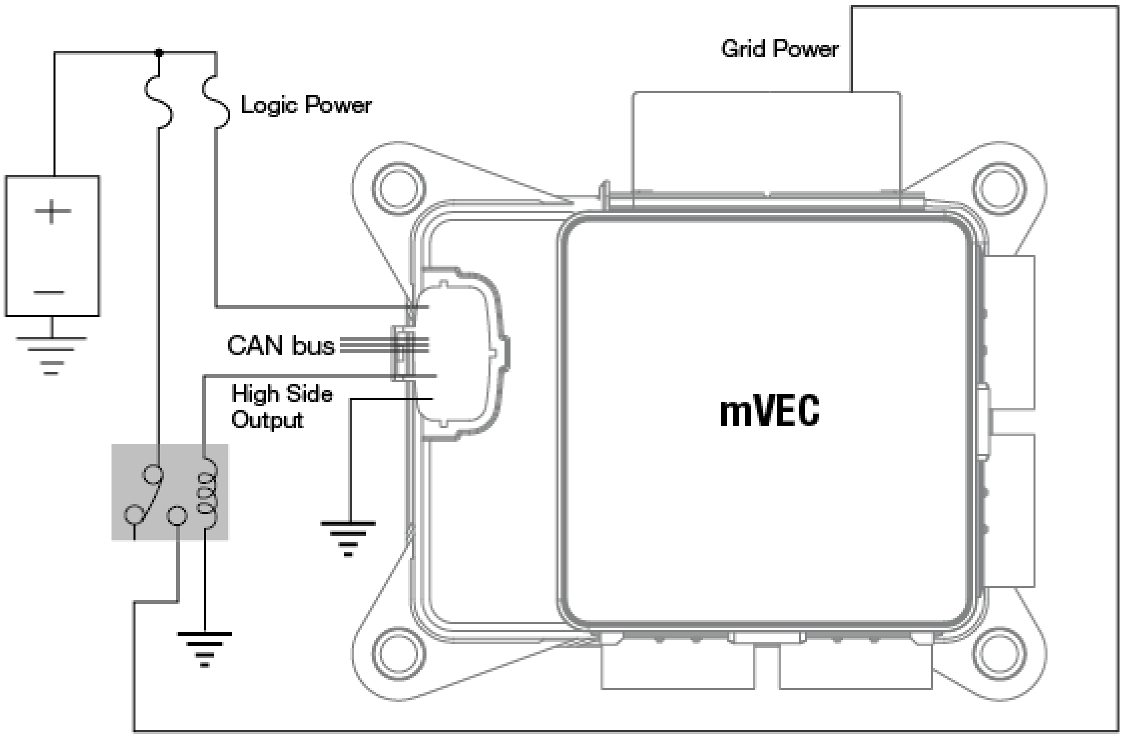

Figure 26. High-side output master power

7. *PROGRAMMING the mVEC (Using J1939 Messages to Set, Control, and Monitor the mVEC)*

7.1. CAN Software Settings

A number of mVEC software settings can be viewed and changed using J1939 Proprietary A messages (refer to section 7.1.1. *Proprietary A Messages*).

The software settings that can be changed include the following:

- CAN Source Address
- Parameter Group Number (PGN) for Proprietary B messages
- Population Table
- Default Relay states
- Startup delay
- CAN message count threshold and source address

Note: It is recommended that the mVEC be set-up in a stand-alone environment when working with software settings.

7.1.1. Proprietary A Messages

Proprietary A messages (PGN EF00) are used for viewing and changing various mVEC software settings. These messages allow you to define which module in a system is going to receive the message.

- Proprietary A messages sent to the mVEC from external devices are called **command messages**.
- Proprietary A messages sent from the mVEC in response to command messages are called **reply messages**.

When the mVEC receives a Proprietary A command message, it responds with a Proprietary A reply message. The reply is sent to the CAN node that sent the command message.

The first data byte of a Proprietary A message is the *message ID*. For messages that have less than 8 bytes, the unused bytes can be filled in with 0x00 or 0xFF without interfering with mVEC performance.

The second data byte of a Proprietary A message may be used as a grid address if the message is grid specific. The parameter called *grid address* identifies a particular grid within the mVEC (for mVECs with more than one grid). An mVEC with one 8x8 grid would use 0x00 as its grid address.

For a summary of all Proprietary A messages, refer to section 7.3.1. *Proprietary A Messages*.

7.1.2. CAN Source Address

If multiple mVECs are being used in a vehicle, each must have a unique **CAN source address** so that other modules can identify which mVEC is sending and receiving messages.

The source address on an mVEC is determined with the following equation:

CAN Source Address = Source Address Base + Source Address Offset

Note: The default value for the source address base is 0xB0 (176 DEC).

If your system uses 8 mVECs or less, you can assign CAN source addresses using one of the following methods:

- **Method 1** - Give each mVEC in your vehicle a **unique source address base** by changing the source address base value in software, and leave the source address offset (harness address pins) the same for each. Refer to section 7.1.2.2. *Changing the Source Address Base* for more information.

- **Method 2** - Give each mVEC in your vehicle a **unique source address offset** by configuring the CAN harness address pins in the CAN connector**,** and leave the source address base the same for each. Refer to section 7.1.2.3. *Changing the Source Address Offset* for more information.

If your system uses more than 8 mVECs, you can combine different source address bases with different source address offsets to create more than 8 unique CAN source addresses.

7.1.2.1. Viewing the Source Address Base and Source Address Offset

To view an mVEC's source address base and source address offset

- Send **message ID 0x97** to the mVEC. See *Message ID 0x97 (Command)* for more details about the message.

  The mVEC responds with **message ID 0x97**, which displays the current values for the mVECs *source address offset* in **byte 2.0** and *source address base* in **byte 3.0.** See *Message ID 0x97 (Reply)*.

7.1.2.2. Changing the Source Address Base

- To set the source address base, set the desired source address base value in **byte 1.0** of **message ID 0x90**, and send the message to the mVEC. See *Message ID 0x90 (Command)*.

  The mVEC responds with **message ID 0x01**, which indicates if the change was a success or failure in **byte 2.0.** See *Message ID 0x01 (Reply)*.

  Changes made to the source address base will not take effect until the ignition power to the mVEC is cycled.

Note: Byte 2.0 in message ID 0x90 is the PGN base value. If you wish to leave the PGN base value as is, then use 0xFF.

7.1.2.3. Changing the Source Address Offset

The mVEC's source address offset is assigned by configuring the CAN harness address pins (called ADDR_0, ADDR_1 and ADDR_2) in the mVEC's CAN connector. Refer to section 5.1.6. *CAN Connection* for more information about connecting and configuring the CAN harness address pins.

Up to 8 different source address offsets can be created using different combinations of CAN harness address pin states. There are two CAN harness address pin states: open and GND_REF.

- GND_REF indicates the CAN harness address pin is connected to the GND_REF pin on the CAN connector.
- Open indicates the CAN harness address pin is open circuit (not connected).

Changes made to the source address offset when the mVEC is powered will not take effect until the ignition power to the mVEC is cycled.

The following table shows all the possible address pin states and the resulting offsets they produce:

Table 5. CAN Harness Address Pin States and Offsets

ADDR_2	ADDR_1	ADDR_0	Offset

ADDR_2	ADDR_1	ADDR_0	Offset
Open	Open	Open	0
Open	Open	GND_REF	1
Open	GND_REF	Open	2
Open	GND_REF	GND_REF	3
GND_REF	Open	Open	4
GND_REF	Open	GND_REF	5
GND_REF	GND_REF	Open	6
GND_REF	GND_REF	GND_REF	7

7.1.3. Parameter Group Number (PGN) Base for Proprietary B Messages

The PGN Base identifies which type of Proprietary B message is being sent by the mVEC. The mVEC uses Proprietary B messages to send three types of information: fuse status, relay status, and error status.

It may be necessary to change the PGN Base for Proprietary B messages to avoid conflicts with Proprietary B messages from other modules. The Proprietary B PGN has an upper byte and a lower byte.

- The upper byte of the PGN is always 0xFF
- The lower byte of the PGN is determined by adding the **PGN base value** and **PGN offset value.**

The PGN base value defaults to **0xA0 (160 DEC)**. To change the PGN you must change the PGN base value. The PGN base can be set to any value between 0x00 and 0xF1.

The PGN offset values are not configurable, and are set as follows:

- Fuse status offset – 0x00
- Relay status offset – 0x01
- Error status offset – 0x02

For example, if you are using the default PGN base value of 0xA0, the PGN values would be 0xFFA0 (fuse status), 0xFFA1 (relay status), and 0xFFA2 (error status).

7.1.3.1. Viewing the PGN Base Value

To view an mVEC's PGN base value

- Send **message ID 0x97** to the mVEC. See M*essage ID 0x97 (Command)* for more details about the message.

  The mVEC responds with **message ID 0x97**, which displays the current value for the PGN base in **byte 7.0.** See *Message ID 0x97 (Reply).*

7.1.3.2. Changing the PGN Base Value

To change the status PGN base value

- Set the desired PGN base value in **byte 2.0** of **message ID 0x90,** and send the message to the mVEC. See *Message ID 0x90 (Command)* for more details about the message.
-

The mVEC responds with **message ID 0x01**, which indicates if the change was a success or failure in **byte 2.0**. See *Message ID 0x01 (Reply).*

Note: Byte 1.0 in message ID 0x90 is the source address base value. If you wish to leave the source address base value as is, then use 0xFF.

7.1.4. Population Table

The hardware configuration of your mVEC defines which components belong on the mVEC's electrical grid, and where each component must be connected. For the mVEC to work properly, all components configured to be connected to the electrical grid must actually be connected.

Note: The term "connected" in this section refers to physically plugging a component into the top of the mVEC's electrical grid.

A population table (stored in Flash memory) indicates whether or not the components are actually connected to the electrical grid. If a component is not connected (but should be according to the population table), the mVEC will generate an error in the corresponding status message, indicating the component is missing (refer to section 7.2. *Monitoring Fuse, Relay, and System Fault Status* for more details about status messages).

To avoid errors from a missing component, you must send the mVEC a message telling it to stop controlling or monitoring the component, which is done through the population table using message ID 0x94.

7.1.4.1. Viewing the Population Table

To view the population table

- Send **message ID 0x92** to the mVEC. See *Message ID 0x92 (Command)* for more details about the message.

  The mVEC responds with **message ID 0x94,** which diplays the current population values for each component:

  - 0 indicates the component is not controlled and monitored.
  - 1 indicates the component is controlled and monitored.

  See *Message ID 0x94 (Reply).*

Note: If the grid address you are trying to view is invalid, the mVEC responds with **message ID 0x01**, and displays a value of 0 (failure) in **byte 2.0**.

7.1.4.2. Changing the Population Table

To change the population table setting for a component

- Set the desired population value(s) in the appropriate byte(s) of **message ID 0x94**, and send the message to the mVEC. See *Message ID 0x94 (Command)* for more details about the message.
- The following population values can be used:
  - 0 indicates the component is not populated and does not need to be controlled and monitored
  - 1 indicates the component is populated and must be controlled and monitored.

The mVEC responds with **message ID 0x01**, which indicates if the operation was a success or failure in **byte 2.0.** See *Message ID 0x01 (Reply).*

Note: You cannot 'populate' a device that was not in the original factory configuration. You may only alter the population settings of factory-installed devices.

7.1.5. Default Relay States

The default relay states are the "safe" relay states the mVEC assumes when it powers-up, and when the CAN message count threshold is breached. When the mVEC is shipped, all of the default relay states are set to "off" (0). The following sections show how to view and change the default relay states.

7.1.5.1. Viewing the Default Relay States

To view the default relay states of the mVEC

- Send the **message ID 0x96** to the mVEC. See *Message ID 0x96 (Command)* for more details about the message.

  If the grid address is valid, the mVEC responds with **message ID 0x96,** which shows the default relay states in **byte 4.0 to byte 5.4**. See *Message ID 0x96 (Reply)*.

  If the grid address is invalid, the mVEC responds with **message ID 0x01**, and displays a value of 0 (failure) in **byte 2.0**. See *Message ID 0x01 (Reply).*

7.1.5.2. Changing the Default Relay States

To change the default relay states

- Set the desired default relay states in the appropriate bytes of **message ID 0x95,** and send the message to the mVEC. See *Message ID 0x95 (Command)* for more details about the message.
- The following default relay state values can be used:
  - 0 sets the default state to "off"
  - 1 sets the default state to "on"

  The mVEC responds with the message **message ID 0x01**, which indicates if the operation was a success or failure in **byte 2.0**. See *Message ID 0x01 (Reply).*

7.1.6. Start-up Delay Time

The start-up delay is the number of milliseconds the mVEC waits after start-up before receiving commands, or sending messages.

The start-up delay range is 0 milliseconds to 65,534 milliseconds (65.5 seconds), which is 0x0000 to 0xFFFE.

Note: The default start-up delay time is 1,000 ms (1 second).

7.1.6.1. Viewing the Start-up Delay Time

To view the current start-up delay time

- Send **message ID 0x96** to the mVEC, see *Message ID 0x96 (Command)* for more details about the message.

  If the grid address is valid, the mVEC responds with **message ID 0x96**, which shows the values for the start-up delay in **bytes 6.0 and 7.0**. See *Message ID 0x96 (Reply).*

  If the grid address is invalid, the mVEC responds with **message ID 0x01**, and displays a value of 0 (failure) in **byte 2.0**. See *Message ID 0x01 (Reply).*

7.1.6.2. Changing the Start-up Delay Time

To set the delay time

- Set the desired start-up delay time values in **byte 1.0 and 2.0** of **message ID 0x99**, and send the message to the mVEC. See *Message ID 0x99 (Command)* for more details about the message.

  The mVEC responds with **message ID 0x01**, which indicates success or failure in **byte 2.0**. See *Message ID 0x01 (Reply).*

7.1.7. CAN Message Count Threshold

The CAN message count threshold refers to the minimum number of messages that must be received by the mVEC every two seconds. If the mVEC does not receive enough messages over two seconds, it switches all relays to their default state. The relays will remain in the default state until the mVEC receives a **message ID 0x80 or message ID 0x88** with different relay state information, or until ignition power is cycled (for more details on default relay states, see 7.4.2. Relay Status).

There are two ways you can use the CAN message count threshold:

- The same CAN message count threshold can be applied to all modules communicating with the mVEC by not setting a specific CAN timeout source address.
- A specific CAN message count threshold can be applied to one module communicating with the mVEC by using a specific CAN timeout source address. If this is used, the mVEC will only count messages from the indicated module.

7.1.7.1. Viewing the CAN Message Count Threshold

To view the CAN message count threshold

- Send **message ID 0x97** to the mVEC. See *Message ID 0x97 (Command)* for more details about the message.

  The mVEC responds with **message ID 0x97**, which displays the values for the *CAN message count threshold* in **byte 4.0** (LSB) and **byte 5.0** (MSB), and the *CAN timeout source address* in **byte 6.0**. See *Message ID 0x97 (Reply).*

7.1.7.2. Changing the CAN Message Count Threshold

To change the CAN message count threshold

- Set the desired *CAN message count threshold* in **byte 1.0** (LSB) and **byte 2.0** (MSB), and *CAN timeout source address* in **byte 3.0** of **message ID 0x98**, and send the message to the mVEC, see *Message ID 0x98 (Command)* for more details about the message.

  The following are things to consider when setting the CAN message count threshold:

  - Setting the CAN message count threshold to a value of “0” will disable the CAN timeout feature. Any value other than “0” will be the actual CAN message count threshold.
  - Setting the CAN timeout source address to 0xFF will apply the same CAN message count threshold to all modules communicating with the mVEC. If you only want the mVEC to count messages received from one module, you must provide the CAN timeout source address for that specific module.

The mVEC responds with **message ID 0x01**, which indicates success or failure in byte 2.0. See *Message ID 0x01 (Reply).*

7.1.8. Software Version Number

It may be necessary to indicate the software version number for your mVEC when corresponding with Cooper Bussmann.

7.1.8.1. Viewing the Software Version Number

To determine the mVEC's software version number

- Send the message **message ID 0x12** to the mVEC. See *Message ID 0x12 (Command)* for more details about the message.

  The mVEC responds with the message **message ID 0x13**. See *Message ID 0x13 (Reply).*

  The values that are returned depend on the operating mode of the mVEC. The operating mode is indicated in **byte 1.0** of **message ID 0x13**.

  - **If the operating mode is 0 (Run)**, the software version number will be shown in byte 2.0 and 3.0, and the bootloader version number will be shown in byte 4.0 and 5.0.
  - **Operating mode is 1** is reserved.
  - **If the operating mode is 2 (Test Mode)**, the software version number will be the same as that in mode 0 (Run).

7.1.9. Controlling Relays

The mVEC's relays are controlled by CAN messages received from external devices that tell the mVEC to turn the relays "on" or "off". The following sections describe how to view and change the state of a relay.

7.1.9.1. Viewing Relay States

To determine the state of the mVEC's relays

- Send **message ID 0x96** to the mVEC. See *Message ID 0x96 (Command)* for more details about the message.

  If the grid address is valid, the mVEC responds with **message ID 0x96**, which shows the state of the mVECs relays (and high-side drive, if installed) in **bytes 2.0 to 3.4**. See *Message ID 0x96 (Reply).*

  If the grid address is invalid, the mVEC responds with **message ID 0x01**, and displays a value of 0 (failure) in **byte 2.0**. See *Message ID 0x01 (Reply).*

7.1.9.2. Changing Relay States

There are two messages that can be used when changing the state of a relay, as follows:

- **Message ID 0x80** - does not provide a diagnostic reply message from the mVEC indicating if the message was a success or failure.
- **Message ID 0x88** – does provide a diagnostic reply message from the mVEC indicating if the message was a success or failure.

7.1.9.3. Changing Relay States Using Message ID 0x80

To change the state of a relay and not receive a diagnostic reply, set the desired relay states in the appropriate bytes of **message ID 0x80,** and send the message to the mVEC, see *Message ID 0x80 (Command)* for more details about the message.

Each relay state value will have one of the bit settings described in **Table 7** listed for message ID 0x80. See *Message ID 0x80 (Command)* for more details about the message.

If the message fails because it is too short, contains an invalid grid address, or is trying to control a relay that is not in a controlled and monitored component location, message ID 0x80 will be ignored.

7.1.9.4. Changing Relay States Using Message ID 0x88

To change the state of a relay and receive a diagnostic reply set the desired relay states in the appropriate bytes of **message ID 0x88,** and send the message to the mVEC, see *Message ID 0x88 (Command)* for more details about the messageEach relay state value will have one of the bit settings described in **Table 7** listed for message ID 0x80, see *Message ID 0x80 (Command)* for more details about the message.

The mVEC responds with **message ID 0x01**, which indicates success or failure in **byte 2.0**, see *Message ID 0x01 (Reply)*.

If the message fails because it is short, contains an invalid grid address, or is trying to control a relay that is not in a controlled and monitored location on the grid, message ID 0x01 will have additional bytes explaining the failure, as detailed in the description for **Message ID 0x01 (Reply)**.

7.2. Monitoring Fuse, Relay, and System Fault States

Fuses, relays and errors are monitored by the mVEC, and the state of each is communicated periodically to other modules on the CAN bus using Proprietary B status messages.

7.2.1. Proprietary B Messages

All Proprietary B messages start at PGN FF00. These messages do not allow you to define which module receives the message; they are broadcast to all modules on the CAN bus at the same time.

The mVEC uses Proprietary B messages to communicate three types of information: **fuse status**, **relay status**, and **error status**. These messages are sent by the mVEC **once every 1000 ms**, or every time the status of a relay or fuse is changed (up to once every 25 ms).

Note: Error messages are only sent when the mVEC experiences an error, or when there is a specific J1939 request from another module to obtain error information (they are not sent once every 1000 ms). Once an error is detected, the error message is sent once every 1000 ms until it is corrected.

Each type of Proprietary B message is identified by a **Parameter Group Number (PGN)** that may need to be changed to avoid message conflicts with other modules. Refer to section *7.3.2. Proprietary B Messages* for more information on changing the PGN Base for Proprietary B messages.

7.2.2. Fuse Status Messages

The mVEC automatically sends Proprietary B message **0xFF00 + PGN base (defaults to 0xFFAO)** indicating the fault state of its fuses once every 1000 ms, or every time the state of a fuse is changed (up to once every 25 ms). Refer to section 7.3.2.1*. Fuse Status* for more details about this message.

- The state of each fuse on the mVEC is represented by a two-bit value. See Table 25.

Note: You have the option of disabling the "Not Powered" fuse fault. Doing so will prevent fuses downstream from a relay from generating error messages when the relay is "off" (because they are not receiving power). Disabling the "Not Powered" fuse fault must be done during production at the factory, and cannot be implemented once the product is shipped.

7.2.3. Relay Status Messages

The mVEC automatically sends Proprietary B message **0xFF01 + PGN base (defaults to 0xFFA1)** indicating the fault state of its relays once every 1000 ms, or every time the state of a relay is changed (no more than once every 25 ms). Refer to section 7.3.2.2. *Relay Status* for more information about this message.

- The state of each relay on the mVEC is represented by a four-bit value. See Table 27.
- Some of the faults shown in the table can be disabled at the factory during production. These cannot be disabled after your mVEC is shipped.

Note: If multiple faults occur on the same relay at the same time, only the first fault that is detected will be reported by the mVEC.

Note: If a shorted relay coil is detected when a relay is switched "on", the mVEC turns that relay coil driver "off" to protect the circuit and reports the "coil shorted" error. The relay will remain "off" until the mVEC receives a command to turn it "off" and then back "on".

7.2.4. System Error Status Messages

System error messages are Proprietary B messages; however, they are not sent by the mVEC on a regular basis like other Proprietary B messages. Instead, they are sent every time a system error occurs, or when there is a specific J1939 Request message from an external module to obtain System Error Status information.

When a system error occurs, the message **0xFF02 + PGN base (defaults to 0xFFA2)** is transmitted once every 1000 ms until either the power is cycled, or CAN communication is restored, see 7.3.2.3. *System Error Status* for more details about the message.

Note: The mVEC will send an error message at least once after CAN communication is restored.

7.3. CAN Message Definitions

The mVEC uses two kinds of messages when communicating with other modules:

- Proprietary A
- Proprietary B

The sections that follow show the settings and values for the various Proprietary A and Proprietary B messages.

- Settings enclosed by round brackets (xxx) are actual values.
- Settings enclosed by square brackets [xxx] are default values.

7.3.1. Proprietary A Messages

When the mVEC receives a Proprietary A message from an external device, it sends a reply message back to that device using a Proprietary A message.

- Messages sent from the external device to the mVEC are called **command** messages.
- Messages sent from the mVEC back to the external device are called **reply** messages.

7.3.1.1. Command Messages

Command messages are sent to the mVEC by external modules. The mVEC replies to every command message except message ID 0x80. All command messages have the following message format:

pgn61184 – Proprietary A

Transmission Repetition Rate:	N/A, received message only
Data Length:	As defined below, no more than 8 bytes
Data Page:	0
PDU Format:	239
PDU Specific:	Destination Address (mVEC CAN Source Address)
Default Priority:	6
Parameter Group Number:	61184 (00EF00 16)

The data bytes of each command message are formatted as described in the following sections.

7.3.1.1.1. Message ID 0x12 (Command)

Message ID 0x12 is used for viewing the mVEC's software version number. The mVEC responds to this message with reply message ID 0x13.

The following table shows the format of the data bytes of message ID 0x12:

Table 6. Message ID 0x12 (Command)

Byte	Description	Value
0	Message ID	Message ID (0x12)
1-7	Reserved	

7.3.1.1.2. Message ID 0x80 (Command)

Message ID 0x80 is used to change the state of relays or the high-side drive (if installed). The mVEC **does not** respond to this message. Refer to section 7.3.2.2. *Relay Status* for the different relay state values.

The following table shows the format of the data bytes of message ID 0x80:

Table 7. Message ID 0x80 (Command)

Byte	Size (Bits)	Meaning
0.0	8	Message ID (0x80)
1.0	8	Grid address (0x00)
2.0	2	Relay 1 state
2.2	2	Relay 2 state
2.4	2	Relay 3 state
2.6	2	Relay 4 state
3.0	2	Relay 5 state
3.2	2	Relay 6 state
3.4	2	Relay 7 state
3.6	2	Relay 8 state
4.0	2	Relay 9 state
4.2	2	Relay 10 state
4.4	2	Relay 11 state
4.6	2	Relay 12 state
5.0	2	High-side output state

Byte	Size (Bits)	Meaning
5.2	6	Reserved
	Total: 6 bytes	

Each relay state value will have one of the following bit settings:

Table 8. Relay State Values

Bit Value	Hex Value	Action
00	0	Turn relay off
01	1	Turn relay on
10	2	Do not change relay state
11	3	Do not change relay state

The “Do not change” values shown above are used when multiple modules are controlling the same mVEC to enable you to leave the state of some relays unchanged while changing the state of others with the same message.

7.3.1.1.3. Message ID 0x88 (Command)

Message ID 0x88 is used to change the active state of relays or the high-side drive (if installed). The mVEC responds to this message with reply message ID 0x01. Refer to section 7.3.2.2. *Relay Status* for the different relay state values.

The following table shows the format of the data bytes of message ID 0x88:

Table 9. Message ID 0x88 (Command)

Byte	Size (Bits)	Meaning
0.0	8	Message ID (0x88)
1.0	8	Grid address (0x00)
2.0	2	Relay 1 state
2.2	2	Relay 2 state
2.4	2	Relay 3 state
2.6	2	Relay 4 state
3.0	2	Relay 5 state
3.2	2	Relay 6 state
3.4	2	Relay 7 state
3.6	2	Relay 8 state
4.0	2	Relay 9 state
4.2	2	Relay 10 state
4.4	2	Relay 11 state
4.6	2	Relay 12 state
5.0	2	High-side output state
5.2	6	Reserved
	Total: 6 bytes	

Each relay state value will have one of the bit settings described in Table 8. *Relay State Values* listed for message ID 0x80.

7.3.1.1.4. Message ID 0x90 (Command)

Message ID 0x90 is used to set:

- the CAN source address base value
- the PGN base value

The mVEC responds to this message with reply message ID 0x01. The new setting for the CAN source address takes effect on the next power cycle. The new setting for the PGN base value takes effect immediately.

The following table shows the format of the data bytes of message ID 0x90:

Table 10. Message ID 0x90 (Command)

Byte	Size (Bits)	Value
0.0	8	Message ID (0x90)
1.0	8	Source address base. Use 0xFF to indicate no change.
2.0	8	Status PGN base. Use 0xFF to indicate no change.
	Total: 3 bytes	

7.3.1.1.5. Message ID 0x92 (Command)

Message ID 0x92 is used to view the population table. The mVEC responds to this message with reply message ID 0x94 (or reply message ID 0x01 if the grid address is invalid).

The following table shows the format of the data bytes of message ID 0x92:

Table 11. Message ID 0x92 (Command)

Byte	Size (Bits)	Meaning
0	1	Message ID (0x92)
1	1	Grid address (0x00)
	Total: 2 bytes	

7.3.1.1.6. Message ID 0x94 (Command)

Message ID 0x94 is used to change the population table settings.

The mVEC responds to this message with reply message ID 0x01.

The following table shows the format of the data bytes of message ID 0x94:

Note: A value of 1 = populated and 0 = unpopulated.

Table 12. Message ID 0x94 (Command)

		Meaning
0.0	8	Message ID (0x94)
1.0	8	Grid Address (0x00)
2.0	1	Fuse 1 populated
2.1	1	Fuse 2 populated
2.2	1	Fuse 3 populated
2.3	1	Fuse 4 populated
2.4	1	Fuse 5 populated
2.5	1	Fuse 6 populated
2.6	1	Fuse 7 populated
2.7	1	Fuse 8 populated
3.0	1	Fuse 9 populated
3.1	1	Fuse 10 populated
3.2	1	Fuse 11 populated
3.3	1	Fuse 12 populated
3.4	1	Fuse 13 populated
3.5	1	Fuse 14 populated
3.6	1	Fuse 15 populated
3.7	1	Fuse 16 populated
4.0	1	Fuse 17 populated
4.1	1	Fuse 18 populated
4.2	1	Fuse 19 populated
4.3	1	Fuse 20 populated
4.4	1	Fuse 21 populated
4.5	1	Fuse 22 populated
4.6	1	Fuse 23 populated
4.7	1	Fuse 24 populated
5.0	8	Reserved
6.0	1	Relay 1 populated
6.1	1	Relay 2 populated
6.2	1	Relay 3 populated
6.3	1	Relay 4 populated
6.4	1	Relay 5 populated
6.5	1	Relay 6 populated
6.6	1	Relay 7 populated
6.7	1	Relay 8 populated

		Meaning
7.0	1	Relay 9 populated
7.1	1	Relay 10 populated
7.2	1	Relay 11 populated
7.3	1	Relay 12 populated
7.4	1	High-side output
7.5	3	Reserved
	Total: 8 bytes	

7.3.1.1.7. Message ID 0x95 (Command)

Message ID 0x95 is used to change the default relay states. The mVEC responds to this message with reply message ID 0x01.

The following table shows the format of the data bytes of message ID 0x95:

Note: A default state value of 1 = on and 0 = off.

Table 13. Message ID 0x95 (Command)

Byte	Size (Bits)	Meaning
0.0	8	Message ID (0x95)
1.0	8	Grid Address (0x00)
2.0	1	Relay 1 default state
2.1	1	Relay 2 default state
2.2	1	Relay 3 default state
2.3	1	Relay 4 default state
2.4	1	Relay 5 default state
2.5	1	Relay 6 default state
2.6	1	Relay 7 default state
2.7	1	Relay 8 default state
3.0	1	Relay 9 default state
3.1	1	Relay 10 default state
3.2	1	Relay 11 default state
3.3	1	Relay 12 default state
3.4	1	High-side output default state
3.5	3	Reserved
	Total: 4 bytes	

7.3.1.1.8. Message ID 0x96 (Command)

Message ID 0x96 is used to view:

- The start-up delay time
- The default relay states
- The current relay states

The mVEC responds to this message with reply message ID 0x96 (or reply message ID 0x01 if the grid address is invalid).

The following table shows the format of the data bytes of message ID 0x96 (command):

Table 14. Message ID 0x96 (Command)

Byte	Size (Bits)	Meaning
0	1	Message ID (0x96)
1	1	Grid address (0x00)
	Total: 2 bytes	

7.3.1.1.9. Message ID 0x97 (Command)

Message ID 0x97 is used to view:

- The mapping board configuration
- The CAN source address offset
- The CAN source address base
- The PGN base value
- The CAN message count threshold
- The CAN timeout source address

The mVEC responds to this message with reply message ID 0x97.

The following table shows the format of the data bytes of message ID 0x97 (command):

Table 15. Message ID 0x97 (Command)

Byte	Size (Bits)	Meaning
0	1	Message ID (0x97)
	Total: 1 byte	

7.3.1.1.10. Message ID 0x98 (Command)

Message ID 0x98 is used to change:

- The CAN message count threshold (set both bytes to zero to disable)
- The CAN timeout source address

The mVEC responds to this message with reply message ID 0x01.

The following table shows the format of the data bytes of message ID 0x98 (command):

Table 16. Message ID 0x98 (Command)

Byte	Size (Bits)	Value
0.0	8	Message ID (0x98)
1.0	8	CAN message count threshold (LSB)
2.0	8	CAN message count threshold (MSB)

Byte	Size (Bits)	Value
3.0	8	CAN timeout source address [0xFF = count all messages from all addresses]
	Total: 4 bytes	

7.3.1.1.11. Message ID 0x99 (Command)

Message ID 0x99 is used for setting the start-up delay time. The mVEC responds to this message with reply message ID 0x01.

The following shows the format of the data bytes of message ID 0x99:

Table 17. Message ID 0x99 (Command)

Byte	Size (Bits)	Value
0.0	8	Message ID (0x99)
1.0	8	Start-up delay (LSB)
2.0	8	Start-up delay (MSB)
	Total: 3 bytes	

7.3.1.2. Reply Messages

Reply messages are sent by the mVEC after it receives command messages from external modules. All reply messages have the following message format:

pgn61184 – Proprietary A

Transmission Repetition Rate:	As required, in response to command messages
Data Length:	8 bytes
Data Page:	0
PDU Format:	239
PDU Specific:	Destination Address (address of node that sent command)
Default Priority:	6
Parameter Group Number:	61184 (00EF00 16)

The data bytes of the reply messages are formatted as described in the following sections.

7.3.1.2.1. Message ID 0x01 (Reply)

Message ID 0x01 is a diagnostic message that indicates success or failure.

The following table shows the format of the data bytes of message ID 0x01:

Table 18. Message ID 0x01 (Reply)

Byte	Size (Bits)	Value
0.0	8	Message ID (0x01)
1.0	8	Message ID being responded to
2.0	8	0 = failure 1 = success
3.0-7.0	8	Reserved

If the diagnostic reply message is in response to a **Message ID 0x88**, and that message failed because it was short, contained an invalid grid address, or was trying to control a relay that is not in a controlled and monitored location on the grid, **message ID 0x01** will have additional bytes explaining the failure, as detailed in the following table:

Table 19. Relay State Change Failure Message

Byte	Size (Bits)	Value
3.0	8	Default: Grid Address requested Or 0xE0 = Message is too short 0xE1 = Invalid offset
4.0	1	Relay 1 unable to change state as requested
4.1	1	Relay 2 unable to change state as requested
4.2	1	Relay 3 unable to change state as requested
4.3	1	Relay 4 unable to change state as requested
4.4	1	Relay 5 unable to change state as requested
4.5	1	Relay 6 unable to change state as requested
4.6	1	Relay 7 unable to change state as requested
4.7	1	Relay 8 unable to change state as requested
5.0	1	Relay 9 unable to change state as requested
5.1	1	Relay 10 unable to change state as requested
5.2	1	Relay 11 unable to change state as requested
5.3	1	Relay 12 unable to change state as requested
5.4	1	High-Side Output unable to change state as requested
5.5	3	Reserved
6.0-7.0	8	Reserved
	Total: 8 bytes	

7.3.1.2.2. Message ID 0x13 (Reply)

Message ID 0x13 is sent by the mVEC after receiving the command message ID 0x12.

The following table shows the format of the data bytes of message ID 0x13:

Table 20. Message ID 0x13 (Reply)

Byte	Description	Value
0	Response	Message ID (0x13)
1	Operating Mode	0 = Run (application) 1 = Reserved 2 = Test Mode (bootloader)
2-3	Software Version	Software version
4-5	Alternate Version	Bootloader version.
6-7	Reserved	

7.3.1.2.3. Message ID 0x94 (Reply)

Message ID 0x94 is sent by the mVEC after receiving command message ID 0x92.

The following table shows the format of the data bytes of message ID 0x94:

Table 21. Message ID 0x94 (Reply)

Byte	Size (Bits)	Meaning

Byte	Size (Bits)	Meaning
0.0	8	Message ID (0x94)
1.0	8	Grid address (0x00)
2.0	1	Fuse 1 populated
2.1	1	Fuse 2 populated
2.2	1	Fuse 3 populated
2.3	1	Fuse 4 populated
2.4	1	Fuse 5 populated
2.5	1	Fuse 6 populated
2.6	1	Fuse 7 populated
2.7	1	Fuse 8 populated
3.0	1	Fuse 9 populated
3.1	1	Fuse 10 populated
3.2	1	Fuse 11 populated
3.3	1	Fuse 12 populated
3.4	1	Fuse 13 populated
3.5	1	Fuse 14 populated
3.6	1	Fuse 15 populated
3.7	1	Fuse 16 populated
4.0	1	Fuse 17 populated
4.1	1	Fuse 18 populated
4.2	1	Fuse 19 populated
4.3	1	Fuse 20 populated
4.4	1	Fuse 21 populated
4.5	1	Fuse 22 populated
4.6	1	Fuse 23 populated
4.7	1	Fuse 24 populated
5.0	8	Reserved
6.0	1	Relay 1 populated
6.1	1	Relay 2 populated
6.2	1	Relay 3 populated
6.3	1	Relay 4 populated
6.4	1	Relay 5 populated
6.5	1	Relay 6 populated
6.6	1	Relay 7 populated
6.7	1	Relay 8 populated
7.0	1	Relay 9 populated
7.1	1	Relay 10 populated
7.2	1	Relay 11 populated
7.3	1	Relay 12 populated
7.4	1	High-side output
7.5	3	Reserved
	Total: 8 bytes	

7.3.1.2.4. Message ID 0x96 (Reply)

Message ID 0x96 is sent by the mVEC after receiving command message ID 0x96.

The following table shows the format of the data bytes of message ID 0x96:

Table 22. Message ID 0x96 (Reply)

Byte	Size (Bits)	Value
0.0	8	Message ID (0x96)
1.0	8	Grid address (0x00)
2.0	1	Relay 1 state (on / off)
2.1	1	Relay 2 state (on / off)
2.2	1	Relay 3 state (on / off)
2.3	1	Relay 4 state (on / off)
2.4	1	Relay 5 state (on / off)
2.5	1	Relay 6 state (on / off)
2.6	1	Relay 7 state (on / off)
2.7	1	Relay 8 state (on / off)
3.0	1	Relay 9 state (on / off)
3.1	1	Relay 10 state (on / off)
3.2	1	Relay 11 state (on / off)
3.3	1	Relay 12 state (on / off)
3.4	1	High-side output on / off
3.5	3	Reserved
4.0	1	Relay 1 default state
4.1	1	Relay 2 default state
4.2	1	Relay 3 default state
4.3	1	Relay 4 default state
4.4	1	Relay 5 default state
4.5	1	Relay 6 default state
4.6	1	Relay 7 default state
4.7	1	Relay 8 default state
5.0	1	Relay 9 default state
5.1	1	Relay 10 default state
5.2	1	Relay 11 default state
5.3	1	Relay 12 default state
5.4	1	High-side output default state
5.5	3	Reserved
6.0	8	Start-up delay (LSB)
7.0	8	Start-up delay (MSB)
	Total: 8 bytes	

7.3.1.2.5. Message ID 0x97 (Reply)

Message ID 0x97 is sent by the mVEC after receiving command message ID 0x97.

The following table shows the format of the data bytes of message ID 0x97:

Table 23. Message ID 0x97 (Reply)

Byte	Size (Bits)	Value
0.0	8	Message ID (0x97)
1.0	8	Detected circuit board configuration (Read from mapping board)
2.0	8	CAN source address offset (cable select)
3.0	8	CAN source address base
4.0	8	CAN message count threshold (LSB)
5.0	8	CAN message count threshold (MSB)
6.0	8	CAN timeout source address
7.0	8	Status PGN base
Total: 8 bytes		

7.3.2. Proprietary B Messages

Proprietary B messages are sent by the mVEC (to every module in the system) once every 1000 ms, or every time the state of a relay, fuse, or error is changed (up to once every 25 ms).

7.3.2.1. Fuse Status

The status of the mVEC's fuses is transmitted in message **0xFF00 + PGN base (defaults to 0xFFAO)**.

pgn65283 – Proprietary B – Fuse Status –
Transmission Repetition Rate: 1000ms
Data Length: 8 bytes
Data Page: 0
PDU Format: 255
PDU Specific: 0
Default Priority: 6
Parameter Group Number: 65280 (00FF00 16) (depends on PGN Base setting)

The following table shows the format of the data bytes of Fuse Status message:

Table 24. Fuse Status Message

Byte	Size (Bits)	Value
0.0	8	Grid address (0x00)
1.0	2	Fuse 1 status
1.2	2	Fuse 2 status
1.4	2	Fuse 3 status
1.6	2	Fuse 4 status
2.0	2	Fuse 5 status
2.2	2	Fuse 6 status
2.4	2	Fuse 7 status
2.6	2	Fuse 8 status
3.0	2	Fuse 9 status
3.2	2	Fuse 10 status
3.4	2	Fuse 11 status
3.6	2	Fuse 12 status

Byte	Size (Bits)	Value
4.0	2	Fuse 13 status
4.2	2	Fuse 14 status
4.4	2	Fuse 15 status
4.6	2	Fuse 16 status
5.0	2	Fuse 17 status
5.2	2	Fuse 18 status
5.4	2	Fuse 19 status
5.6	2	Fuse 20 status
6.0	2	Fuse 21 status
6.2	2	Fuse 22 status
6.4	2	Fuse 23 status
6.6	2	Fuse 24 status
7.0	8	Reserved
	Total: 8 bytes	

Each fuse status value will have one of the following bit settings:

Table 25. Fuse Status Values

Bit Value	Hex Value	Meaning	Option to Disable?
00	0	No Fault	No
01	1	Blown	No
10	2	Not Powered	Yes
11	3	Not Used	No

7.3.2.2. Relay Status

The status of the mVEC's relays is transmitted in message **0xFF01 + PGN base (defaults to 0xFFA1)**.

pgn65283 – Proprietary B – Relay Status –
Transmission Repetition Rate: 1000ms
Data Length: 8 bytes
Data Page: 0
PDU Format: 255
PDU Specific: 1
Default Priority: 6
Parameter Group Number: 65281 (00FF01 16) (depends on PGN Base setting)

The following table shows the format of the data bytes of Relay Status message:

Table 26. Relay Status Message

Byte	Size (Bits)	Value
0.0	8	Grid address (0x00)
1.0	4	Relay 1 status
1.4	4	Relay 2 status
2.0	4	Relay 3 status
2.4	4	Relay 4 status

Byte	Size (Bits)	Value
3.0	4	Relay 5 status
3.4	4	Relay 6 status
4.0	4	Relay 7 status
4.4	4	Relay 8 status
5.0	4	Relay 9 status
5.4	4	Relay 10 status
6.0	4	Relay 11 status
6.4	4	Relay 12 status
7.0	4	High-side output status
7.4	4	Reserved
	Total: 8 bytes	

Each relay status value will have one of the following bit settings:

Table 27. Relay Status Values

Bit Value	Hex Value	Meaning	Option to Disable
0000	0	Okay	No
0001	1	Relay coil open or relay not present	No
0010	2	Coil shorted or failed relay driver	No
0011	3	Normally Open (N.O) contact is open (when a N.O contact is not connected to the Common (C) terminal, but should be).	No
0100	4	Normally Closed (N.C) contact is open (when a N.C contact is not connected to the Common (C) terminal, but should be).	No
0101	5	The coil is not receiving power	Yes
0110	6	Normally Open (N.O) contact is shorted (when a N.O contact is connected to the Common (C) terminal, but should not be).	Yes
0111	7	Normally Closed (N.C) contact is shorted (when a N.C contact is connected to the Common (C) terminal, but should not be)	Yes
1000	8	Reserved	No
1001	9	Reserved	No
1010	A	Reserved	No
1011	B	High-side driver is reporting a fault condition.	No
1100	C	High-side driver has an open-load	Yes
1101	D	High-side driver is over voltage	No
1110	E	Reserved	
1111	F	Relay location not used	No

7.3.2.3. System Error Status

System error status messages are sent in message **0xFF02 + PGN base (defaults to 0xFFA2)**.

pgn65283 – Proprietary B – System Error Status –

Transmission Repetition Rate: 1000ms
Data Length: 8 bytes
Data Page: 0
PDU Format: 255
PDU Specific: 2
Default Priority: 6
Parameter Group Number: 65282 (00FF02 16) (depends on PGN Base setting)

The following table shows the format of the data bytes of System Error Status message:

Table 28. Error Messages

Byte	Size (Bits)	Meaning	Corrective Action
0.0	8	Grid address (0x00)	
1.0	1	mVEC contains invalid configuration information.	mVEC must be re-configured by Cooper Bussmann.
1.1	1	Internal electrical grid identifier values have changed since power-up. **Note:** Initial error may have no effect, but functionality may change on next power-up.	mVEC must be serviced by Cooper Bussmann.
1.2	1	CAN Harness address input pin values have changed during operation.	Check harness connections. If no result, contact Cooper Bussmann.
1.3	1	CAN Rx communication error. This happens when the mVEC receives an insufficient number of messages.	Adjust CAN message count threshold. Check module harnesses in the system that are sending the mVEC messages.
1.4	1	CAN Tx communication error. This happens when a message sent by the mVEC is not received by an external module.	Cycle vehicle power. Check terminators in the harness. If no result, contact Cooper Bussmann.
1.5	1	Unexpected reset, or watchdog timer reset.	Check power and ground connections on the CAN connector. Refer to Section 11. *Troubleshooting* for more details.
1.6	1	Over voltage	Batt+ is greater than about 43v. Reduce input voltage.
1.7	1	SPI error	Internal error.
2.0	1	Short message received	Erase Region command incomplete. Check host application.
2.1	1	Bad FLASH address	Invalid address specified for Erase Region or Write Memory command.
2.2	1	Invalid length	Invalid data length specified for Write Memory command.
2.3	1	Checksum failure	Invalid checksum for received data for Write Memory command.

Byte	Size (Bits)	Meaning	Corrective Action
2.4	1	FLASH miscompare	FLASH data doesn't match received data after Write Memory command.
2.5	1	Reserved	
2.6	1	Reserved	
2.7	1	Reserved	
3.0-7.0	8	Reserved	

8. Hardware Specifications

Environmental Specification

Characteristic	Parameter	Unit	Notes:
Operating Temperature	-40 to +85	°C	EP455 (R2008), Section 5.1.1
Storage Temperature	-40 to +125	°C	EP455 (R2008), Section 5.1.2
Thermal Shock	-40 to +85	°C	SAE J1455 (RJUN2006), Sec. 4.1.3.2
Temperature Life	+85	°C	100 hour at temperature, CEI IEC 68-2-2
Vibration			SAE J1455 (R2006), Section 4.10.4.2
Mechanical Shock			SAE J2030 (RDEC2002), Section 6.16
Temperature/Humidity	-40 to +85	°C	SAE J1455 (RJUN2006), Sec. 4.2.3
Salt Fog			Subject the mVEC to a ninety-six (96) hour period of salt fog per ASTM B117-94, Salt Fog Test
Chemical Resistance			Brake Fluid, AT Fluid, Antifreeze, Windshield Wash Fluid, PS Fluid, Oil
Ingress Protection	IP66		Low and HighPressure Spray, Splash
Bombardment Test			24 Hour of Dust, Sand, and Gravel
Label Test			24 Hour Temperature/Humidity

Electrical Specifications

Maximum Ratings
Maximum ratings establish the maximum electrical rating to which the unit may be subjected.

Characteristic	MIN	TYP	MAX	Unit	Notes:
Standoff Voltage			48	V	Voltage applied to battery terminal.
Time at Standoff			15	Sec	
External High-Side Drive Current			500	mA	Maximum continuous load on this drive output.
Grid Coil Current Limit			350	mA	

General
Unless otherwise stated, conditions apply to full temperature range and full input voltage range.

Characteristic	MIN	MAX	Unit	Notes:
Battery Voltage	9	32	V	The mVEC control will operate normally within this range of battery voltage.
Battery Quiescent Current		2.5	mA	For the control board only when both ignition inputs are inactive. Less for 12V systems.
Power Enable High Voltage	> ½ BAT_PWR		V	Enable voltage must be above this level for normal operaton.
Power Enable Low Voltage		< ½ BAT_PWR	V	Enable voltage must be below this level for normal operaton.

Grid
Ratings apply to all grid configurations.

Characteristic	MIN	MAX	Unit	Notes:
Dielectric Voltage Withstand		80	V	No evidence of insulation breakdown or arc over applied voltage between input and output terminals on the grid that are intended to be electrically isolated from each other.
Low Voltage Resistance		190	mV	The maximum allowable voltage drop between input wire to output wire just beyond the crimp connection at 10A loading.
Electrical Ratings		200	A	Studded input terminal (limited by grid)
		60	A	800 series input terminal
		30	A	Top grid component terminals and 280 series output terminals
		135	%	Overload of any Mini Buss fuse or Buss compatible circuit breaker device without evidence of damage or distortion
		60	°C	Temperature rise due to electrical loading at any input, output, or grid component terminal when individually subjected to the above ratings. Temperature rise is dependent upon each circuit application.
Insulation Resistance	10M		Ω	With 80VDC bewteen input and output grid terminaals

Abnormal Conditions
Ratings apply to the external 12-pin connector. Grid connections subject to application conditions.

Characteristic	Parameter	Unit	Notes:
Reverse Battery	- 24	V	SAE J1455 (RJUN2006), duration of 5 min.
Short Circuit Protection	Short to ground, 5 min. Short to 16VDC, 5 min.		EP455 (R2008) Section 5.10.4
Power Up Operational	Ramp battery voltage from 0 to minimum operating voltage at 1V/ms.		EP455 (R2008) Section 5.10.7

Transient Tests
Ratings apply to the control board and its external 12-pin connector. Grid connections subject to application conditions.

Characteristic	Parameter	Unit	Notes:
Accesory Noise	$14 + 1.5 \sin(2\pi f \cdot t)$	V	EP455 (R2008), Section 5.11.1
Alternator Field Decay	$14 - 90\ e^{-t/0.038}$ V	V	EP455 (R2008), Section 5.11.2

Batteryless Operation	6+|12.6sin(2πf·t)|	V	EP455 (R2008), Section 5.11.3
Inductive Load Switching	14±600e(-t/0.001)	V	J1455 (2003), Section 4.11.2.2.2
Load Dump	28+122e(–t/0.4s)	V	J1455 (2003)
Mutual Coupling Power Line	$14 + 200e^{-t/(14x10-6)}$	V	EP455 (R2008), Section 5.11.6.1
Mutual Coupling Signal Line	$\pm 200e^{-t/(14x10-6)}$	V	EP455 (R2008), Section 5.11.6.2
ESD Package and Handling	±15kV	V	SAE J1113-13 (RNOV2004), Sec. 5.0
ESD Powered Mode	±15kV	V	SAE J1113-13 (RNOV2004), Sec. 4.0

Electro-Magnetism Compliance
Ratings apply to the control board.

Characteristic	Level	Notes:
Radiated Emissions	0.01MHz to 1GHz, Narrow band 1MHz normalized	EP455 (R2008), Section 5.16.3.1 and SO 14982
Susceptibility	Level 1 CW 14kHz to 1GHz, VPol CW 30MHz to 1GHz, HPol 100V/m	EP455 (R2008), Section 5.16.1

9. Troubleshooting

Problem	Possible Causes	Possible Solutions
Everything is connected but there is no communication	The mVEC is not powered	• Is IGNITION_HIGH connected to power or IGNITION_LOW connected to ground?
	The voltage on the address lines is not what it should be.	• Verify the address lines are configured correctly.
	The CAN bus is marginal or not functional.	• Use a PC-based CAN tool to verify that messages can be sent and received on the CAN bus. • Are CAN_HI & CAN_LO reversed? • Are CAN_HI or CAN_LO shorted to ground or to CAN_SHIELD? • Are CAN_HI or CAN_LO open? • Is the CAN bus terminated properly?
	The mVEC software is configured differently than it should be.	• Is there “mVEC-like” communication from an unexpected source address and/or PGN? These are configurable, and if they are not what you expect, the mVEC will be broadcasting on different source addresses and PGNs.
The mVEC is communicating, but the relays will not turn “on”.	The relays do not have power.	• Make sure the relay message is the version that requests a diagnostic response (message 0x88). • Check the codes returned by the mVEC against the responses listed in section 7.3.2.2. • Check for lack of grid power connection, blown fuse, improperly seated relay, and improperly seated fuse.
	The relay message is being rejected.	• Make sure the relay message is the version that requests a diagnostic response (message 0x88). • Check the codes returned by the mVEC against the responses listed in section *7.3.2.2*. • Check message length, offset value, and whether the component location is populated with a relay.
	The destination address is incorrect.	• Confirm the destination address of the relay message matches the source address that is sending fuse and relay status messages.
	You are trying to drive 24V relays from a 12V supply.	• Make sure the power supply matches the relays. A 24V mVEC will communicate when powered by 12V, but the 24V relays will not engage.
The mVEC resets when the loads are turned “on”.	Insufficient transient response from the desktop power supply.	• Desktop power supplies, even if they are rated for the current requested, can sag substantially when large loads are switched “on”, a phenomenon that can be confirmed with an oscilloscope.

Problem	Possible Causes	Possible Solutions
	Power drop or ground lift at a high-current connection point.	• Make sure the CAN connector power and ground are not tied to the high-current power and ground studs. When large loads are enabled, the voltage drop (or lift at the ground) could be significant.

10. FAQ

What does mVEC stand for?

Multiplexed Vehicle Electrical Center.

Will the mVEC still function if I remove components from its electrical grid?

You must change the population table setting for components that are removed from the grid; otherwise, the mVEC will report errors for the missing component. Refer to section *7.1.4. Population Table* for more details.

How does a system of modules identify which message is being sent by which mVEC?

Using a unique PGN base in combination with a unique CAN source address enables a system to identify which messages are being sent by which mVEC.

How is the source address of the mVEC changed?

Refer to section *7.1.2. CAN Source Address*.

What is a grid address?

The grid address identifies the component grid. At present, there are no multiple-grid mVECs, so this is a reserved byte for future expansion. For mVECs with 1 grid, the grid address value should be set to 0.

Do I need to fuse power going to the mVEC power studs?

Fuse wires going to the mVEC power studs close to the battery. Though extra fusing is not required to protect the mVEC, heavy gauge wire that is not fused running through a vehicle is not a safe design practice.

Does the power going to the CAN connector have to be fused?

Yes. A 5 A fuse should be used.

What are the recommended mounting practices for the mVEC?

For recommended mounting practices see section *5.1.2 Mounting Location Selection*.

Can the mVEC be pressure washed or immersed in water?

An unsealed mVEC should not be pressure washed or immersed in water.

A sealed mVEC can handle pressure washing, but cannot be immersed in water.

What is the maximum torque that can be applied to the studded power connector?

The maximum torque that can be applied to the power lugs is 18 ft./lbs.

Can the mVEC drive relays that aren't actually on the mVEC's electrical grid?

The mVEC can be configured with an external high-side output, so it is possible to drive a single external relay from an mVEC. The mVEC relays could be used to drive other higher-current relays or solenoids.

What is the current capacity of the mVEC?

The approximate current capacity of the mVEC is 200 A, but that is dependent on the application, type of load, etc.

Can the relay outputs be pulse-width modulated (PWM'd)?

Relays are mechanical devices and cannot be PWM'd at the high frequencies possible with solid state outputs; however, low frequency applications such as turn signals can be run by the mVEC.

Can the external high-side output be used to control something other than a relay?

Yes, as long as the load does not exceed 500 mA.

What are the low-side outputs protected against?

Low-side outputs are protected against short-circuits and designed to withstand electrical transient pulse levels likely to be encountered on vehicles.

Can the grid connection inputs for fuses be used to monitor things other than fuses?

Yes, these inputs can be wired directly to output pins through the grid and can monitor active-high digital states (all inputs are tied to weak pull-down resistors). This is not the intended use of the mVEC, so care should be taken to ensure faults reported by the software will be interpreted correctly.

Does the mVEC need a master module on the CAN bus to control it, or can it control itself?

The mVEC is designed as a slave module, meaning it is controlled by other modules; however, Cooper Bussmann can develop and embed custom application code in the mVEC to allow it to operate as a stand-alone device.

There may be a development charge associated with this and minimum order quantities may apply. Consult your Cooper Bussmann account manager.

Can the mVEC be used as an H-bridge?

The mVEC can be used in an H-bridge configuration if two 5-pin relays are used.

Will the mVEC work on a 42 V electrical system?

No. The mVEC is designed for 12 V and 24 V systems. It is not intended for use on 42 V electrical systems.

How far can the mVEC be from the controller sending it commands?

The mVEC is designed to communicate on a J1939 compliant CAN bus. Refer to section 5.1.6. *CAN Connection* for more details about connection limitations.

How many mVECs can be in a vehicle?

30 mVEC modules can be in the same system on the same vehicle.

Is black the only mVEC color?

Yes.

Should the mVEC be disconnected when welding it to a vehicle (if welding is necessary)?

Cooper Bussmann recommends that all electrical devices be disconnected during welding to avoid potential damage to them.

The mVEC should not be subjected to environmental conditions that exceed the mVEC's design limitations.

11. Glossary of Terms

CAN

Controller Area Network. A communication network designed for heavy equipment and automotives environments.

CAN High

One of the wires used in the shielded twisted-pair cable, which provides the positive signal that, when connected with CAN Low, provides a complete CAN differential signal.

CAN Low

One of the wires used in the shielded twisted-pair cable, which provides the negative signal that, when connected with CAN High, provides a complete CAN differential signal.

CAN message count threshold

The minimum number of messages that must be received by the mVEC every two seconds.

CAN Shield

A shielding that wraps around the CAN High and CAN Low "twisted pair," which completes the shielded twisted-pair cable.

CAN source address

An address that identifies which mVEC on the CAN bus has sent a message.

command message

Messages sent to the mVEC from other modules.

component

A device that can be plugged into the mVEC electrical grid. Components include fuses, relays, breakers, diodes, etc.

Connector Position Assurance

A device that prevents you from accidentally pulling-out a connector from the mVEC.

electrical grid

A grid with 64 connection points that is used as the interface for plugging components into the mVEC.

H-bridge

A combination of two half-bridge circuits. H-bridges are used to provide current flow in both directions on a load, which allows the direction of a load to be reversed.

load

A load is any item that draws current from the module, and is typically switched "on" and "off" with outputs. Examples include but are not limited to bulbs, solenoids, motors, etc.

multiplexing

Simultaneously transmitting multiple messages over one communication channel in a local area network, which dramatically reduces the number of wires needed for switch and load connections.

mVEC

Multiplexed Vehicle Electrical Center.

open load

A fault state that occurs when a load that should be connected to an output becomes disconnected, which typically occurs because of a broken/worn wire in the wire harness or connector pin.

PGN

Parameter Group Number. In the mVEC, the PGN is used to identify which type of Proprietary B message is being sent by the mVEC.

population table

Indicates which components are connected to the electrical grid.

Proprietary A message

A J1939 CAN message that allows you to define which module in a system is going to receive the message.

Proprietary B message

A range of J1939 CAN messages that are broadcast to all modules on the CAN bus at the same time.

PWM

Pulse Width Modulation. A type of square wave frequency signal where the ratio of “on” time vs. “off” time is determined by the duty cycle of the signal. The duty cycle refers to the percent of time the square wave is “on” vs. “off”. PWM signals are typically used to drive varying amounts of current to loads, or to transmit data.

reply message

Messages sent by the mVEC to other modules.

shielded twisted-pair cable

A type of cable that consists of two wires twisted together, and covered with a shield material to improve immunity against electrical noise. This cable is used when connecting the CAN bus.

slave module

A module that relies on other devices to monitor and control it. The mVEC is a slave module.

start-up delay

The number of milliseconds the mVEC waits after start-up before receiving commands, or sending messages.

status messages

Messages sent by the mVEC to other modules once every 1000 ms indicating the status of its relays, fuses and (if active) errors.

Terminal Position Assurance

A device that prevents you from accidentally pulling-out wire terminals from the male input and/or output connectors.

Power Management

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