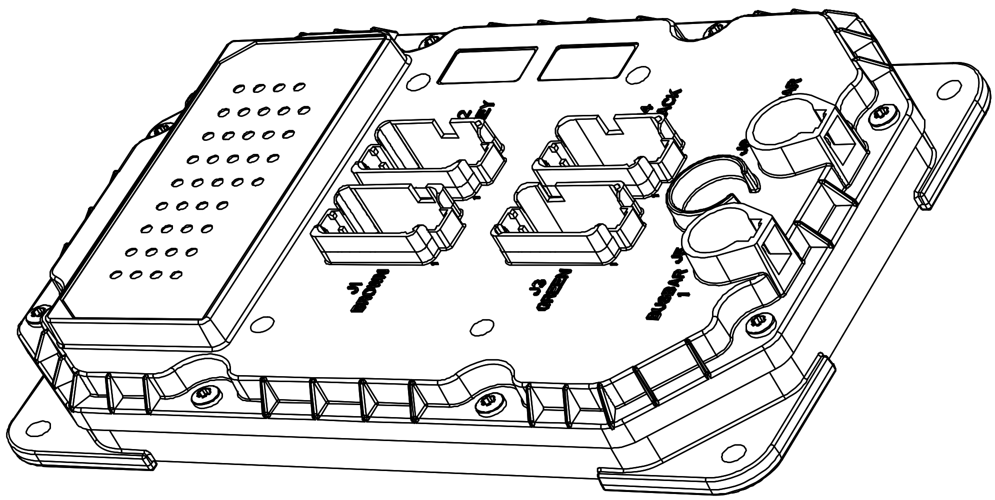
VMM1615

Vansco Multiplexing Module (VMM) 1615

HY33-5008-IB/US
Instruction Book Ed. 05/2011



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ENGINEERING YOUR SUCCESS.

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Contents

1. Introduction

These instructions are meant as a reference tool for the vehicle manufacturer's design, production, and service personnel.

The user of this manual should have basic knowledge in the handling of electronic equipment.

1.1. Safety symbols

Sections regarding safety, marked with a symbol in the left margin, must be read and understood by everyone using the system, carrying out service work or making changes to hardware and software.

The different safety levels used in this manual are defined below.

WARNING

Sections marked with a warning symbol in the left margin, indicate that a hazardous situation exists. If precautions are not taken, this could result in death, serious injury or major property damage.

CAUTION

Sections marked with a caution symbol in the left margin, indicate that a potentially hazardous situation exists. If precautions are not taken, this could result in minor injury or property damage.

NOTICE

Sections marked with a notice symbol in the left margin, indicate there is important information about the product. Ignoring this could result in damage to the product.

Contact the manufacturer if there is anything you are not sure about or if you have any questions regarding the product and its handling or maintenance.

The term "manufacturer" refers to Parker Hannifin Corporation.

2. Precautions

2.1. General safety regulations

Work on the hydraulics control electronics may only be carried out by trained personnel who are well-acquainted with the control system, the machine and its safety regulations.

WARNING

Mounting, modification, repair and maintenance must be carried out in accordance with the manufacturer's regulations. The manufacturer has no responsibility for any accidents caused by incorrectly mounted or incorrectly maintained equipment. The manufacturer does not assume any responsibility for the system being incorrectly applied, or the system being programmed in a manner that jeopardizes safety.

WARNING

Damaged product may not be used. If the control system shows error functions or if electronic modules, cabling or connectors are damaged, the system shall not be used.

WARNING

Electronic control systems in an inappropriate installation and in combination with strong electromagnetic interference fields can, in extreme cases, cause an unintentional change of speed of the output function.

NOTICE

As much as possible of the welding work on the chassis should be done before the installation of the system. If welding has to be done afterwards, the electrical connections on the system must be disconnected from other equipment. The negative cable must always be disconnected from the battery before disconnecting the positive cable. The ground wire of the welder shall be positioned as close as possible to the place of the welding. The cables on the welding unit shall never be placed near the electrical wires of the control system.

2.1.1. Construction regulations

CAUTION

The vehicle must be equipped with an emergency stop which disconnects the supply voltage to the control system's electrical units. The emergency stop must be easily accessible to the operator. The machine must be built if possible, so that the supply voltage to the control system's electrical units is disconnected when the operator leaves the operator's station.

2.1.2. Safety during installation

CAUTION

Incorrectly positioned or mounted cabling can be influenced by radio signals which can interfere with the functions of the system.

2.1.3. Safety during start-up

WARNING

The machine's engine must not be started before the control system is mounted and its electrical functions have been verified.

Ensure that no one is in front, behind or nearby the machine when first starting up the machine.

Follow the instructions for function control in the Start-up section.

2.1.4. Safety during maintenance and fault diagnosis

CAUTION

Ensure that the following requirements are fulfilled before any work is carried out on the hydraulics control electronics.

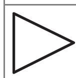
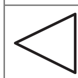
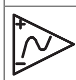
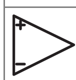
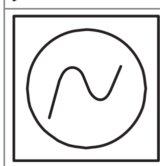
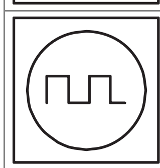
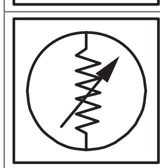
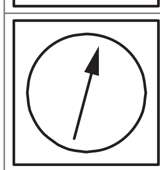
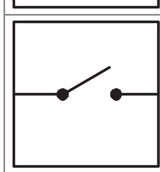
- The machine cannot start moving.
- Functions are positioned safely.
- The machine is turned off.
- The hydraulic system is relieved from any pressure.
- Supply voltage to the control electronics is disconnected.

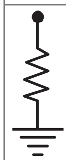
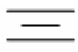
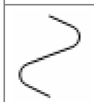
3. How to Use this Manual

This manual describes the hardware components of the VMM1615, but does not explain how to write or configure the software. For more information about software, refer to the appropriate software manual, or contact your Parker Vansco Account Representative.

3.1. Diagram Conventions

There are many connection diagrams found throughout this manual. The following table provides meanings for the different symbols used in those diagrams:

Symbol	Meaning
	General input
	General output
	Frequency input
	Analog input
	Frequency sensor
	Pulse sensor
	Resistive sensor
	General sensor
	Application switch

Symbol	Meaning
	Load
	Pull-down resistor
	Pull-up resistor
	Battery
	Fuse
	Resistor
	Ground
	Chassis ground

4. Quick Start

This section provides step-by-step instructions on how to connect the VMM1615 to a development system, install the required software tools, and download ladder logic application software.

4.1. Overview

The following is a high-level overview of the steps involved with this section:

1. Gather the **required materials**.
2. Install the required **software tools** provided by Parker Vansco.
3. Connect the VMM1615 to a **development system** (desktop) and power it up.
4. Download ladder logic **application software**.

4.2. Gather Required Materials

The following materials are required for the procedures in this section:

- A **VMM1615**
- A **personal computer** (PC)
- A **controller I/O board**
- A **controller I/O harness** (connects the VMM1615 to the controller I/O board)
- An **evaluation kit power harness** (connects the controller I/O board to the power supply)
- A **Data Link Adapter (DLA) kit** (comes with cables needed for connecting the DLA to your PC and to the rest of the system)
- A **desktop power supply** compatible with the VMM1615 and controller I/O board loads (a 12 VDC, 3 A fixed voltage supply is generally suitable, unless driving more significant loads)
- A **procurement drawing** for the version of VMM1615 you are using, that represents the configuration options for your variant of the product.
- **Software tools** and files required for programming and downloading software for the VMM1615.

NOTICE

With the exception of the PC and desktop power supply, all materials and software are available from Parker Vansco. Please consult your Parker Vansco Account Representative for specific details and pricing information.

4.3. Install the Required Software Tools

Before you start using the VMM1615, you must install the software tools onto your PC.

The VMM1615 requires the following software tools:

- **Data Link Adaptor (DLA) drivers**: The DLA acts as the interface between the PC and the VMM1615. Before using the DLA, you must install the DLA drivers.
- **Parker Vansco Software Tools**: Parker Vansco provides the VMMS software tool to create and download software for the VMM1615. Contact your Parker Vansco Account Representative, or visit the Parker website to get further information on how obtain a product key.

4.3.1. Install the Data Link Adaptor (DLA) Driver Software

A Data Link Adaptor (DLA) is needed when connecting the VMM1615 in a development system.

The Parker Vansco DLA requires drivers that you must install on your PC.

NOTICE

Parker Vansco provides the latest DLA software releases through its web site. Please contact your Parker Vansco Account Representative for details on how to download the latest DLA driver software.

To install the Parker Vansco DLA drivers

1. **Download** the driver, run the extracted file and follow the *Install Wizard*.
2. Connect the **USB DLA** to a USB port on your PC.

   The *Found New Hardware* screen opens.
3. Select **Install the software automatically (Recommended)**, and then click **Next**.
4. Click **Finish**.

The USB DLA is now recognized and ready to be used. See the Vansco DLA kit user manual for more detailed instructions.

4.4. Connect the VMM1615 to a Development System

It is a good idea to connect the VMM1615 to a development system (PC, Controller I/O Board, power source, and DLA) to verify your ladder logic application. The development system is an ideal environment for creating and downloading ladder logic software applications.

The following is an overall block diagram of how to connect the VMM1615 in a development system:

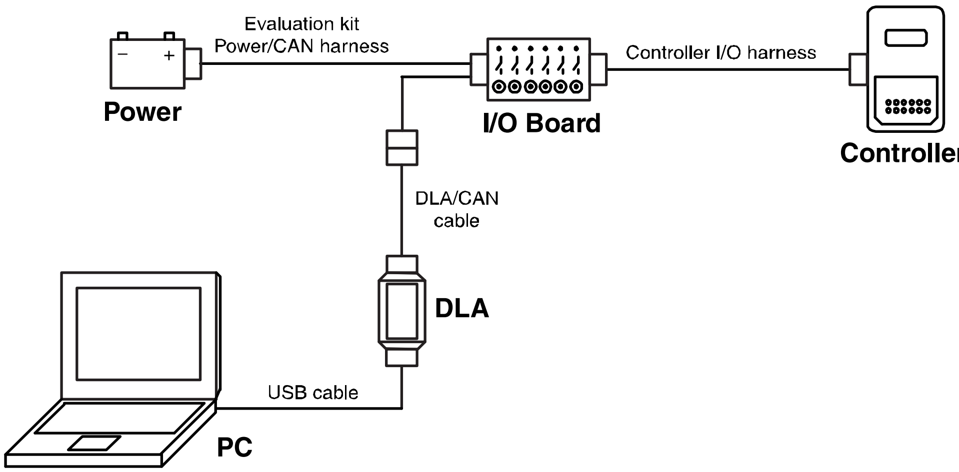


Figure 1: Development system connection

To connect the VMM1615 in a development system, do the following:

NOTICE

Before connecting anything in the development system, ensure the power supply is set to a voltage that is less than 32 VDC.

1. Connect the **Controller I/O harness** to the VMM1615 connectors.
2. Connect the **Controller I/O harness** to the controller I/O board connectors.
3. Connect the **evaluation kit power/CAN harness** to the controller I/O board's JP3 connector.
4. Do *not* connect the **power wire** (RED) from the evaluation kit power/CAN harness to the power supply (+) terminal at this time.
5. Connect the **ground wire** (BLACK) from the evaluation kit power/CAN harness to the power supply (-) terminal.
6. Connect the **CAN connector** from the evaluation kit power/CAN harness to the corresponding mating connector and harness on the DLA.
7. Connect the **DLA** to a personal computer via the USB port.

NOTICE

You must install the DLA drivers before connecting the DLA to the PC.

4.4.1. Power Up the Development System

Once the VMM1615 is set up in a development system, you need to power it up.

To power up the VMM1615, do the following:

1. Ensure all **controller I/O board digital inputs, jumpers, and dip switches** are properly configured for your module type. Refer to the *Controller I/O Board Reference Manual* for further details.
2. Ensure the **power wire** (RED) on the controller I/O board is **not** connected to the power supply (refer to the *Controller I/O Board Reference Manual* for details).
3. Turn the power supply **on**.
4. If using a variable power supply, set the voltage to a value **between 10 - 28 VDC**.
5. Turn the power supply **off**.
6. Connect the **power wire** (RED) on the connector I/O board to the power supply.
7. Turn the power supply **on**.

NOTICE

If `INPUT_1` or `INPUT_2` is configured as a power control input, you must turn on the corresponding digital input switch on the controller I/O board (Digital Input 1 or Digital Input 2). Refer to the *Controller I/O Board Reference Manual* for further details.

4.5. Create and Download Ladder Logic Software Applications

Software applications can be created and downloaded to the VMM1615.

The software applications for the VMM1615 can be created with the Vansco Multiplexing Module Software (VMMS) tool, using ladder logic.

Consult your Parker Vansco Account Representative for information about your software programming options.

5. Inputs

The VMM1615 has three types of inputs, as follows:

- Digital
- Analog
- Frequency

NOTICE

Do not connect inputs directly to unprotected inductive loads such as solenoids or relay coils, because they can produce high voltage spikes that may damage the VMM1615. If an inductive load must be connected to an input, use a protective diode or transorb.

5.1. VMM1615 Digital Input Types

Digital inputs are typically used with electrical signals and switches that are either on or off.

There are 3 types of digital inputs in the VMM1615:

- Programmable Digital Inputs
- Digital Inputs
- Power Control Digital Inputs

5.1.1. Programmable Digital Inputs

The VMM1615 has 5 programmable digital inputs:

- `INPUT3_D` through `INPUT7_D`.

5.1.1.1. Programmable Digital Input Capabilities

The following table provides specifications for the VMM1615's programmable digital inputs:

Table 1: Programmable Digital Input Specifications

Item	MIN	NOM	MAX	UNIT
Input voltage range	0	-	32	V
Over-voltage	-	-	36	V
Inductive load protection	-	Yes	-	-
Pull-up/down resistance	713	750	788	Ω
Capacitance at pin	-	0.005	-	µF
Pull-up/down frequency	-	-	40	Hz

Item	MIN	NOM	MAX	UNIT
Pull-up/down duty cycle	-	-	12	%
Pull-up/down active time	3	-	-	ms
Negative going input threshold	-	-	1.56	V
Positive going input threshold	3.82	-	-	V
Input Frequency @ 50% duty	-	-	20	Hz
Active Low - Activating Resistance @ 6V	263	-	-	Ω
Active Low - Deactivating Resistance @ 6V	-	-	1.32k	Ω
Active Low - Activating Resistance @ 32V	39	-	-	Ω
Active Low - Deactivating Resistance @ 32V	-	-	102	Ω
Active High - Activating Resistance @ 6V	427	-	-	Ω
Active High - Deactivating Resistance @ 6V	-	-	2.1k	Ω
Active High - Activating Resistance @ 32V	5.5k	-	-	Ω
Active High - Deactivating Resistance @ 32V	-	-	14.6k	Ω
Active High - Activating Resistance @ 6V	2.4k	-	-	Ω
Active High - Deactivating Resistance @ 6V	-	-	6.9k	Ω

INFORMATION

In software, the pull-up or pull-down resistors should be switched in the following manner:

- When the input is inactive, switch the pull-up or pull-down on 100% duty.
- When an active state change is detected, switch the pull-up or pull-down off and start to pulse the resistor on and off within the specified frequency and duty cycle shown in the table above.
- The resistor can go back to constant on when the input is inactive.

The pull up or pull-down selection signals must never be active at the same time. Doing this will result in a short circuit from battery to ground through the selection transistors.

5.1.1.2. VMM1615 Programmable Digital Input Configuration

Digital inputs are configured as active high or active low by using pull-up or pull-down resistors internal to the module.

- **When the input is configured as active high**, an internal **pull-down** resistor is used, and the input will be active when it is switched to battery voltage.
- **When the input is configured as active low**, an internal **pull-up** resistor is used, and the input will be active when it is switched to ground.

All digital inputs have their wetting current configured according to the following:

INFORMATION

A digital switch (typically connected to a digital input) usually requires wetting current (a small current that burns off contact oxidation when it is activated). The amount of required wetting current required is based on battery voltage and on the value of the pull-down resistor.

- Wetting current is determined by the value of the resistor. The maximum wetting current in the VMM1615 is **10 mA** @7.5 Vdc.

5.1.1.3. Programmable Digital Input Installation Connections

You must be aware of the following when connecting digital inputs:

A digital input is typically connected to a switch that is either open or closed.

- **When the switch is open**, the pull-up or pull-down resistor will ensure no voltage exists on the input signal, which will be interpreted by the VMM1615 as inactive.
- **When the switch is closed**, the input is connected to either battery voltage or ground, which will be interpreted by the VMM1615 as active.

Active high input

- Must be connected to battery power to ensure there is a battery connection when the state of the input changes.

The following shows a typical active high digital input connection:

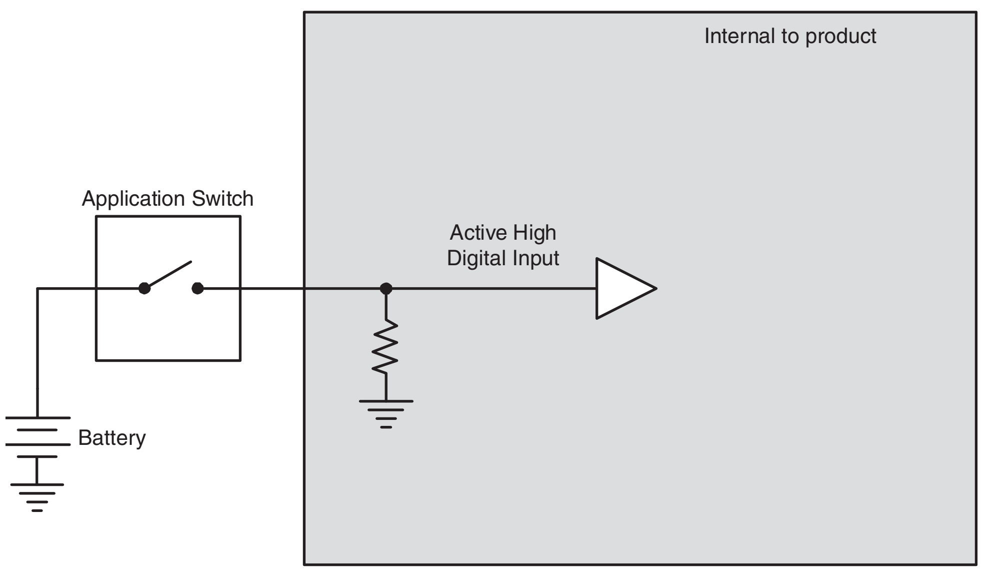


Figure 2: Active high digital input

Active low input

- Must be connected to ground to ensure there is a ground connection when the state of the input changes.

The following shows a typical active low digital input connection:

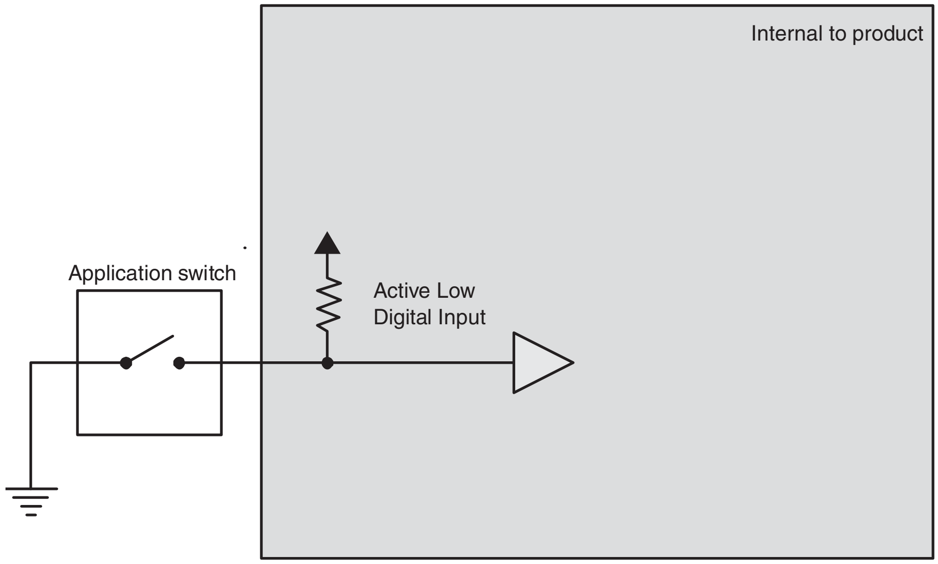


Figure 3: Active low digital input connections

5.1.2. Digital Input

The VMM1615 has 1 digital input:

- `INPUT2_D`

5.1.2.1. VMM1615 Digital Input Capabilities

The VMM1615 has an active high digital input that must be activated (pulled to battery voltage) to enable the unit to function.

The following table provides specifications for the VMM1615's digital input:

Table 2: Digital Input Specifications

Item	MIN	NOM	MAX	UNIT
Input voltage range	0	-	32	V
Over-voltage	-	-	36	V
Inductive load protection	-	Yes	-	-
Pull-down resistance	1.9k	2.0k	2.1k	Ω
Capacitance at pin	-	0.01	-	μF
Negative going input threshold	-	-	1.56	V
Positive going input threshold	3.82	-	-	V
Input Power Up Threshold	1.4	-	3.9	V
Cutoff frequency (hardware)	-	98	-	Hz

INFORMATION

The digital input voltage must be greater than 3.9 V before it is considered an active high input.

5.1.3. Power Control Digital Input

The VMM1615 has one active-high power control digital input that is used for waking up (turning on) the product, as follows:

- `INPUT1_D`

5.1.3.1. VMM1615 Power Control Input Capabilities

The VMM1615 has an active high power control digital input that must be activated to power up the unit.

The following table provides specifications for the VMM1615's power control digital input:

Table 3: Power Control Digital Input Specifications

Item	MIN	NOM	MAX	UNIT
Input voltage range	0	-	32	V
Over-voltage	-	-	36	V
Inductive load protection	-	Yes	-	-
Pull-down resistance	1.9k	2.0k	2.1k	Ω
Capacitance at pin	-	0.01	-	μF
Negative going input threshold	-	-	1.56	V
Positive going input threshold	3.82	-	-	V
Input Power Up Threshold	1.4	-	3.9	V
Cutoff frequency (hardware)	-	98	-	Hz

INFORMATION

The power control digital input voltage must be greater than 3.9 V before it is considered an active high input.

The power control digital input wakes-up the VMM1615 when switched high to a voltage of 3.9 V or greater, and turns the VMM1615 off when switched low to a voltage less than 1.4 V. The VMM1615 will also shut off when an open circuit condition occurs on the power control digital input.

5.1.3.2. VMM1615 Power Control Digital Input Installation Connections

You must be aware of the following when connecting power control inputs:

- The power control digital input is usually connected to the vehicle ignition, but it can be connected to any power source in a system.
- When battery power (`VBATT_LOGIC`) is connected, and the power control digital input is inactive, the VMM1615 will go into sleep mode.

The following diagram shows a typical power control digital input connection:

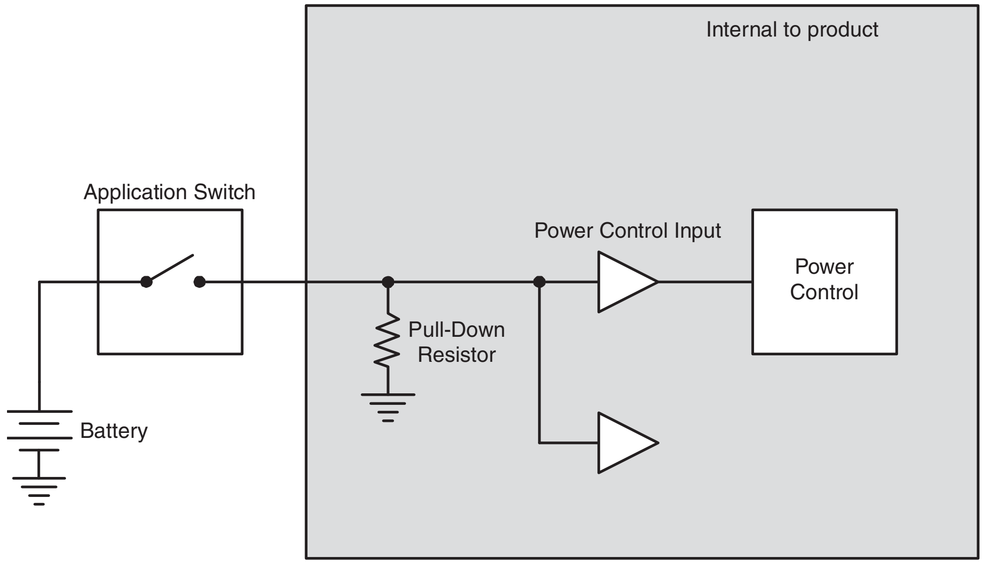


Figure 4: Power control digital input installation connections

5.1.4. Addressing Digital Inputs

Digital inputs `ADDR1`, `ADDR2`, `ADDR3`, `ADDR4` and `ADDR5` are dedicated address inputs . These inputs are used to set the system address on the module such that it is unique among all other modules in the system. The maximum allowable addresses in a VMM system is 31 including all devices on the bus (VMMs, PGM, LIMs, etc.).

These inputs are all low-side inputs with 750 ohm internal pull-up resistors. The inputs are pulsed to ensure that a floating pin is read as inactive by the module.

The addressing arrangement is shown in the following table, which shows the required inputs that need to be active and floating (active shown as 1, floating shown as 0).

Table 4: VMM System Addressing

Address Inputs					VMM address
5	4	3	2	1	
0	0	0	0	0	VMM1
0	0	0	0	1	VMM2
0	0	0	1	0	VMM3
0	0	0	1	1	VMM4
0	0	1	0	0	VMM5
1	1	1	1	0	VMM31

NOTICE

Address 32 is Reserved and therefore may not be used in a system design.

The following shows a typical addressing digital input connection.

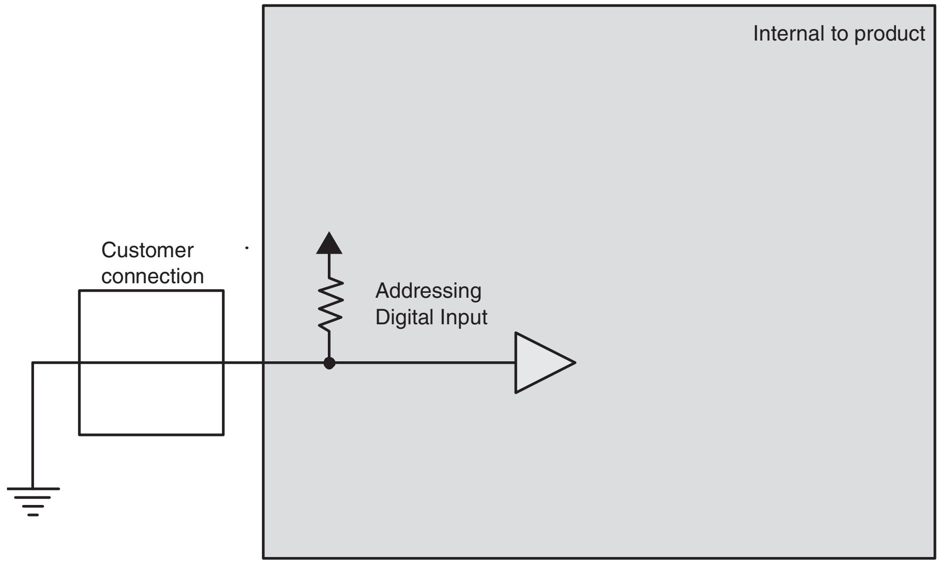


Figure 5: Addressing digital input connections

5.2. VMM1615 Analog Inputs

Analog inputs are typically used to read electrical signals that span a voltage range.

The VMM1615 has 8 analog inputs:

- `INPUT9_AD` through `INPUT16_AD`

Two of the analog inputs (`INPUT9_AD` and `INPUT10_AD`) are type 1, and the remaining analog inputs (`INPUT11_AD` through `INPUT16_AD`) are type 2.

INFORMATION

Analog inputs can be configured to function as programmable digital inputs.

5.2.1. VMM1615 Analog Input Capabilities

Type 1 analog inputs have programmable gain and attenuation to provide a wider array of input range options. These inputs have programmable pull-up or pull-down resistor values, including a resistor that can be used for 4 to 20mA sensor readings.

The following provides specifications for the VMM1615's type 1 analog inputs:

Table 5: Type 1 Analog Input Specifications

Item	MIN	NOM	MAX	UNIT
Input voltage range	0	-	32	V
Over-voltage	-	-	36	V
Inductive load protection	-	No	-	-
Pull-up resistance	3.29k	3.33k	3.36k	Ω

Item	MIN	NOM	MAX	UNIT
Pull-down resistance 1	3.29k	3.33k	3.36k	Ω
Pull-down resistance 2	246	249	252	Ω
Capacitance at pin	-	0.005	-	μF
Input resistance with pull-up/down inactive	74.9k	-	-	Ω
Resolution	-	-	11.25	Bit
Accuracy	-	3		%
Frequency cutoff	-	-	23	Hz
Negative going input threshold	-	-	2.00	V
Positive going input threshold	2.50	-	-	V

Table 6: Type 1 Analog Input Voltage Ranges

Max Volts
0.599
0.749
1.500
3.000
3.119
3.898
4.058
5.072
6.578
7.806
8.220
10.157
15.611
16.462
20.314
32.925

Type 2 analog inputs have programmable attenuation only. These inputs have programmable pull-up or pull-down resistor values, including a resistor that can be used for 4 to 20mA sensor readings.

The following provides specifications for the VMM1615's Type 2 analog inputs:

Table 7: Type 2 Analog Input Specifications

Item	MIN	NOM	MAX	UNIT
Input voltage range	0	-	32	V
Over-voltage	-	-	36	V
Inductive load protection	-	No	-	-
Pull-up resistance	3.29k	3.33k	3.36k	Ω
Pull-down resistance 1	3.29k	3.33k	3.36k	Ω

Item	MIN	NOM	MAX	UNIT
Pull-down resistance 2	246	249	252	Ω
Capacitance at pin	-	0.005	-	µF
Input resistance with pull-up/down inactive	74.9k	-	-	Ω
Resolution	-	-	11.25	Bit
Accuracy	-	3		%
Frequency cutoff	-	-	23	Hz
Negative going input threshold	-	-	2.00	V
Positive going input threshold	2.50	-	-	V

Table 8: Type 2 Analog Input Ranges

Max Volts
3.000
15.611
20.314
32.925

5.2.2. VMM1615 Analog Input Configurations

The analog inputs have the ability using VMMS software to have either a pull-up or pull-down resistor enabled, have pull-up and pull-down enabled at same time, have a separate pull-down (of 249 ohms) enabled for 4 to 20 mA current sensor, or no pull-up or pull-down resistors at all.

With Type 1 analog inputs (INPUT9_AD and INPUT10_AD)

- Select the input voltage range, which automatically sets the **attenuation** and **gain**

The following diagram shows the configuration for Type 1 analog inputs:

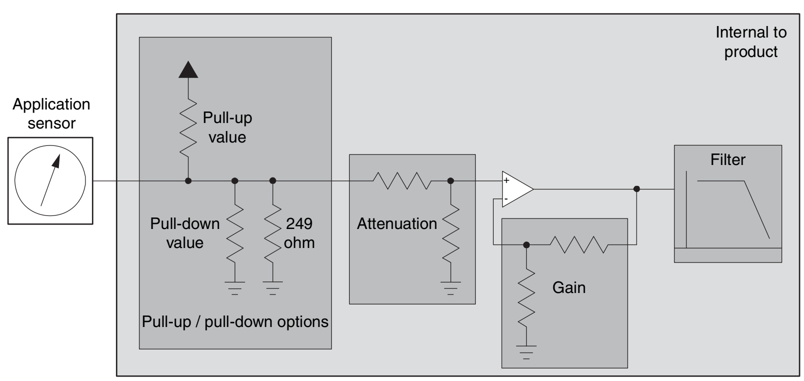


Figure 6: Type 1 analog input configuration options

With Type 2 analog inputs (INPUT11_AD through INPUT16_AD)

- Select the voltage range, which automatically sets the amount of **attenuation**

The following diagram shows the configuration for Type 2 analog inputs:

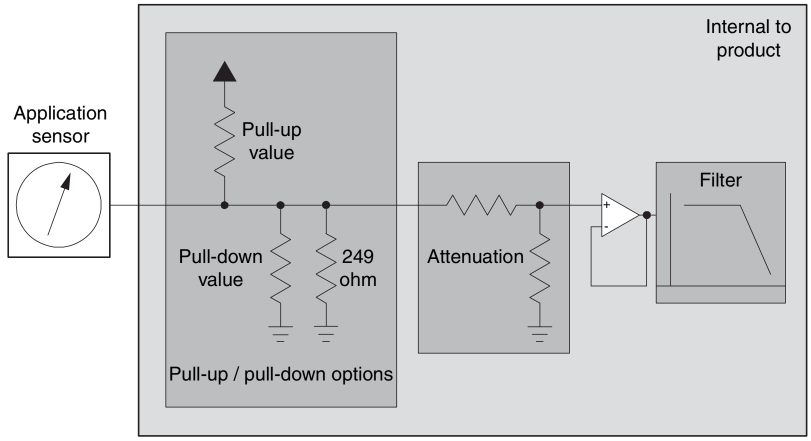


Figure 7: Type 2 analog input configuration options

5.3. VMM1615 DC-Coupled Frequency Inputs

There is one type of frequency input in the VMM1615:

- DC-coupled frequency input

DC-coupled frequency inputs are typically used to read pulse signals.

The VMM1615 has one DC-coupled frequency input:

- `INPUT8_DF`

5.3.1. VMM1615 DC-Coupled Frequency Input Capabilities

DC-coupled frequency inputs allow you to read the frequency of external signals that switch between system ground, and sensor or battery power. These inputs are ideal for use with hall-effect type sensors.

The following table provides specifications for the VMM1615's DC-coupled frequency inputs:

Table 9: DC-Coupled Frequency Input Specifications

Item	MIN	NOM	MAX	UNIT
Input voltage range	0	-	32	V
Pull-up/pull-down resistance	5.31k	5.36k	5.41k	Ω
Capacitance at pin	-	.005		μF
Over-voltage	-	-	36	V
Frequency accuracy	-	-	5	%
Frequency range	1	-	10000	Hz
Negative going threshold	-	-	1.56	V
Positive going threshold	3.82	-	-	V

5.3.2. DC-Coupled Frequency Input Configuration

The DC-coupled frequency inputs

- Use a pull-up or pull-down resistor.

The following diagram shows the configuration for DC-coupled frequency inputs:

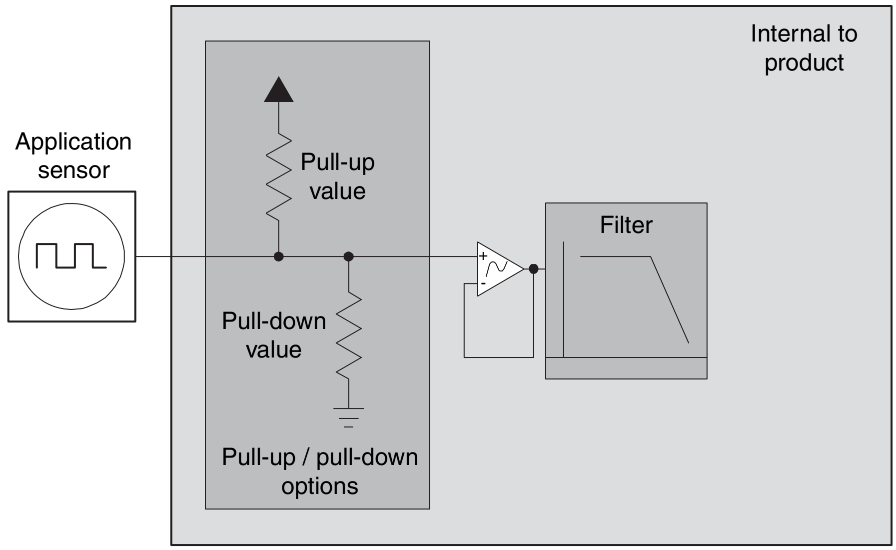


Figure 8: DC-coupled frequency input configuration

6. Outputs

The VMM1615 has 12 solid-state outputs. Output currents can range from 1.0 up to 10.0 Amps.

The VMM1615 has 4 types of outputs:

- High-side outputs
- High-side outputs with current sense
- Low-side outputs
- Solid state relay outputs

INFORMATION

A high-side and a low-side output can be coupled in the external harness to create a half-bridge.

6.1. High-Side Outputs

The controller has a total of 12 high-side outputs.

High-side outputs are used for switching voltage to loads using either a **pulse width modulated (PWM) signal**, or an **on/off signal**. They can also test for various fault conditions, which can be used for software diagnostics (refer to *High-Side Output Diagnostics and Fault Detection see "High-Side Output Diagnostics and Fault Protection" on page 32* for more details).

6 outputs are rated for 10 A:

- `OUTPUT1_10A_HS` to `OUTPUT6_10A_HS`

2 of the outputs are rated for 5 A with current sensing:

- `OUTPUT7_5A_HS` to `OUTPUT8_5A_HS`

2 of the outputs are rated for 5 A:

- `OUTPUT9_5A` to `OUTPUT10_5A`

2 of the outputs are rated for 2.5 A with current sensing:

- `OUTPUT11_2A5_HS` to `OUTPUT12_2A5_HS`

When a high-side output is PWM'd, , the output switches where the percentage of time that the output is “on” vs. “off” is determined by the duty cycle of the signal.

When a high-side output is switched on and off, the output provides battery voltage when in the "on" state and goes high impedance when in the “off” state.

6.1.1. 10A High-Side Output Capabilities

These outputs provide 10A maximum continuous current with a less accurate current sensing function. The current sensing is used to detect over current and provide short circuit protection.

The following table provides specifications for the VMM1615's 10A high-side outputs:

Table 10: 10A High-Side Output Specifications

Item	MIN	NOM	MAX	UNIT
Switchable voltage range	6	-	32	V
Output current	0	-	10	A
Output on state resistance	-	9	-	mΩ
Over-voltage	-	-	36	V
PWM frequency	-	-	500	Hz
PWM resolution	-	-	0.1	%
Integrated flyback diode	-	No	-	-
Inductive pulse protection	-	-	628	V (peak)
Digital feedback negative going threshold	-	-	2.58	V
Digital feedback positive going threshold	2.75	-	-	V
Open load detection resistance	3.29	3.32	3.35	kΩ
Current Sense accuracy @ 10A	-	-	30	%

6.1.1.1. Fixed Output Protection

The outputs have the following fixed protection mechanisms:

- Software fuse – Simulates a mechanical fuse and will trip between 200ms and 1000ms for currents above 10A. Because of this it is important that load inrush events be kept less than 200ms. For loads with inrush duration greater than 200ms, see Appendix A to verify if the load can be reliably driven by the output.
- Short circuit – The output is protected from short circuits.
- Over temperature – The output will turn off in the event of an IC over temperature.

6.1.2. 5A High-Side Output with Current Sense Capabilities

These outputs provide 5A maximum continuous current with accurate current sensing. The current sensing provides accurate readings to detect single load disconnect on parallel driven load applications.

The following table provides specifications for the VMM1615's 5A high-side outputs:

Table 11: 5A High-Side Output with Current Sense Specifications

Item	MIN	NOM	MAX	UNIT
Switchable voltage range	6	-	32	V
Output current	0	-	5	A

Item	MIN	NOM	MAX	UNIT
Output on state resistance	-	20	-	mΩ
Over-voltage	-	-	36	V
PWM frequency	-	-	500	Hz
PWM resolution	-	-	0.1	%
Integrated flyback diode	-	No	-	-
Inductive pulse protection	-	-	628	V (peak)
Digital feedback negative going threshold	-	-	2.69	V
Digital feedback positive going threshold	2.86	-	-	V
Open load detection resistance	9.9k	10k	10.1k	Ω
Current Sense resistance	24.75	25	25.25	mΩ
Current Sense gain	-	275	-	mV/A
Current Sense resolution	-	-	4.4	mA
Current Sense accuracy - Full Scale (5A)	-	3	-	%

6.1.2.1. Fixed Output Protection

The outputs have the following fixed protection mechanisms:

- Hardware overcurrent protection – The output will trip immediately when subjected to currents above 32A +/- 30%.
- Software fuse – Simulates a mechanical fuse and will trip between 200ms and 1000ms for currents above 5A. Because of this it is important that load inrush events be kept less than 200ms. For loads with inrush duration greater than 200ms, see Appendix A to verify if the load can be reliably driven by the output.
- Short circuit – The output is protected from short circuits.
- Over temperature – The output will turn off in the event of an IC over temperature.

6.1.3. 5A High Side Output Capabilities

These outputs provide 5A maximum continuous current with a less accurate current sensing function. The current sensing is used to detect over current and provide short circuit protection.

The following table provides specifications for the VMM1615's 5A high-side outputs:

Table 12: 5A High-Side Output Specifications

Item	MIN	NOM	MAX	UNIT
Switchable voltage range	6	-	32	V
Output current	0	-	5	A
Output on state resistance	-	20	-	mΩ
Over-voltage	-	-	36	V
PWM frequency	-	-	500	Hz
PWM resolution	-	0.1	-	%

Item	MIN	NOM	MAX	UNIT
Integrated flyback diode	-	No	-	-
Inductive pulse protection	-	-	628	V (peak)
Digital feedback negative going threshold	-	-	2.69	V
Digital feedback positive going threshold	2.86	-	-	V
Open load detection resistance	9.9	10	10.1	kΩ
Current Sense gain	-	111	-	mV/A
Current Sense resolution	-	-	11.0	mA
Current Sense accuracy @ 5A	-	-	25	%

6.1.3.1. Fixed Output Protection

The outputs have the following fixed protection mechanisms:

- Hardware overcurrent protection – The output will trip immediately when subjected to currents above 32A +/- 30%.
- Software fuse – Simulates a mechanical fuse and will trip between 200ms and 1000ms for currents above 5A. Because of this it is important that load inrush events be kept less than 200ms. For loads with inrush duration greater than 200ms, see Appendix A to verify if the load can be reliably driven by the output.
- Short circuit – The output is protected from short circuits.
- Over temperature – The output will turn off in the event of an IC over temperature.

6.1.4. 2.5A High-Side Output with Current Sense Capabilities

These outputs provide 2.5A maximum continuous current with accurate current sensing. The current sensing provides accurate readings to detect single load disconnect on parallel driven load applications. The current sensing can also be used for regulating current control of hydraulic coils.

The following table provides specifications for the VMM1615's 2.5A high-side outputs:

Table 13: 2.5A High-Side Output with Current Sense Specifications

Item	MIN	NOM	MAX	UNIT
Switchable voltage range	6	-	32	V
Output current	0	-	2.5	A
Output on state resistance	-	45	-	mΩ
Over-voltage	-	-	36	V
PWM frequency	-	-	500	Hz
PWM resolution	-	-	0.1	%
Integrated flyback diode	-	Yes	-	-
Inductive pulse protection	-	-	628	V (peak)
Digital feedback negative going threshold	-	-	2.63	V

Item	MIN	NOM	MAX	UNIT
Digital feedback positive going threshold	2.80	-	-	V
Open load detection resistance	9.9k	10k	10.1k	Ω
Current Sense resistance	24.75	25	25.25	mΩ
Current Sense gain	-	503	-	mV/A
Current Sense resolution	-	-	2.4	mA
Current Sense accuracy - Full Scale (2.5A)	-	3	-	%

6.1.4.1. Fixed Output Protection

The outputs have the following fixed protection mechanisms:

- Software fuse – Simulates a mechanical fuse and will trip between 200ms and 1000ms for currents above 2.5A. Because of this it is important that load inrush events be kept less than 200ms. For loads with inrush duration greater than 200ms, see Appendix A to verify if the load can be reliably driven by the output.
- Short circuit – The output is protected from short circuits.
- Over temperature – The output will turn off in the event of an IC over temperature.

6.1.5. High-Side Output Configuration

The high-side outputs (to) .

- For software-controlled open load detection, the programmer has the ability to choose when to bias the output through **the open load detection resistor.** This feature may be disabled if the output is connected to sensitive loads, such as LEDs.

The following diagram shows the configuration for high-side outputs:

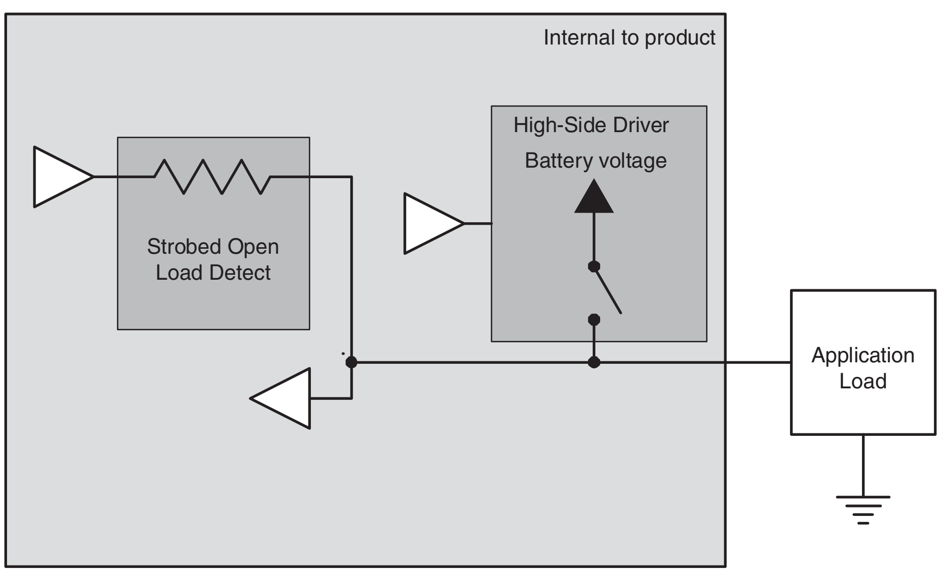


Figure 9: High side output configuration

6.1.6. High Side Output Connections

You must be aware of the following when connecting high-side outputs:

- High-side outputs are connected to one of two internal bus bars, which can be connected to a **+12 V** or **+24 V** battery. Each busbar powers 3x 10A, 2x 5A and 1x 2.5A outputs. Maximum load on each busbar is 40A.
- High-side outputs can provide switched battery power to a variety of load types in a vehicle.
- 2.5 A high-side outputs have internal flyback diodes, which are needed when driving inductive loads (the flyback diodes absorb electrical energy when the load is turned off).

NOTICE

If large inductive loads are used, and the high-side output is providing a continuous PWM signal, then the PWM peak current must not be greater than the specified continuous current for the output (in continuous mode, the average current flow through the diode at 50% duty cycle is approximately equal to ½ the peak current).

When connecting high-side outputs, ensure you follow these best practices:

- High-side outputs should not be connected to loads that will draw currents greater than the maximum peak current, or maximum continuous current.
- The grounds for the loads should be connected physically close to the VMM1615 power grounds.

The following shows a typical high-side 10A or 5A output connection:

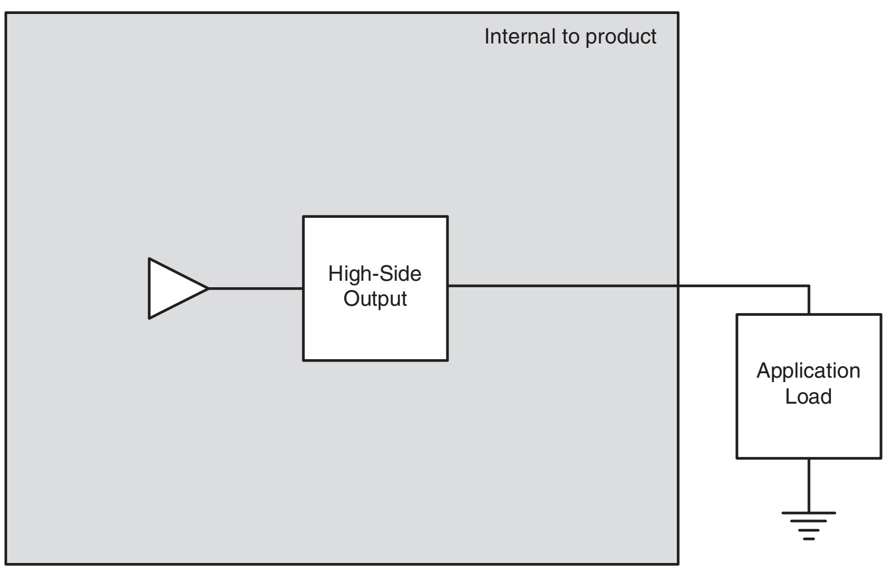


Figure 10: High-side output installation connections

The following shows a typical high-side 2.5A output connection with integrated flyback diode:

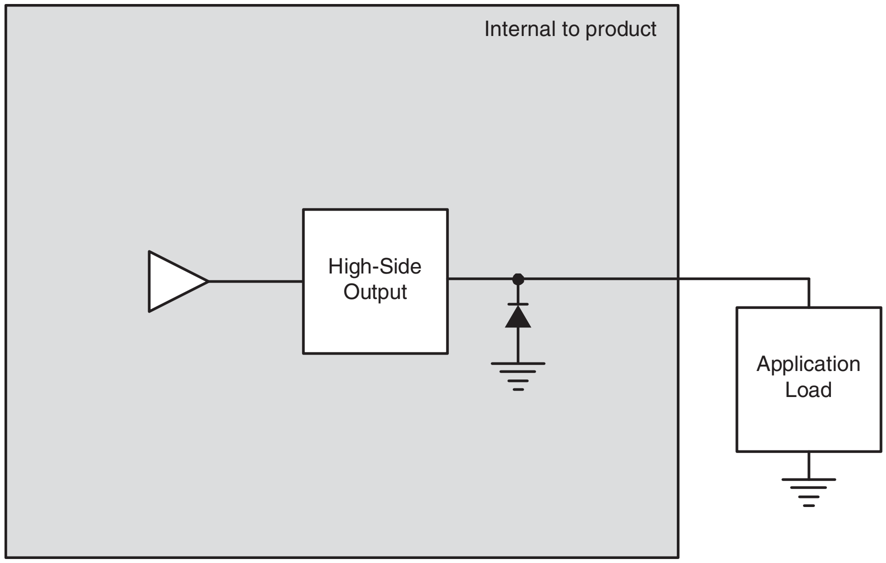


Figure 11: Typical high-side output installation connections

6.1.7. High-Side Output Diagnostics and Fault Protection

Each high-side output has the ability to report many different fault conditions.

The types of faults that are reported are determined by the configuration of your high-side outputs, and this configuration must be considered when writing the application software.

6.1.7.1. Short Circuit

Short-circuit faults occur when a high-side output pin is shorted to ground. The output will turn off and retry as defined by the programmer.

6.1.7.2. Software Overcurrent

Software overcurrent faults occur when the current through a high-side output pin exceeds a threshold defined by the programmer for a period of 1 second.

6.1.7.3. Back Driven Fault

Back driven faults occur when a high-side output pin is connected to battery voltage.

The high-side output circuit uses voltage on the output pin to determine if a short-to-battery condition exists.

INFORMATION

High-side outputs must be "off" to detect a back driven fault.

6.1.7.4. Open Load

Open load faults occur when a high-side output pin is open circuit (not connected to a load). The use of this feature operates is defined by the programmer.

The high-side output circuit uses a small amount of current on the output pin to determine if an open load condition exists.

INFORMATION

High-side outputs with current sense can detect an open load fault when "on" or "off". High-side outputs without current sense must be "off" to detect an open load fault.

6.2. VMM1615 Low-Side Output with Current Sense

The low-side output with current sense is used for switching ground to load, using either a **pulse width modulated (PWM) signal**, or an **on/off signal**. It also has the ability to **sense current** that is provided to the load, through an amplifier circuit.

The VMM1615 has 1 low-side output:

- `OUTPUT13_2A5_LS`

When a low-side output is used as a PWM signal, a pulsed output signal is provided by the VMM1615, where the percentage of time that the output is "on" vs. "off" is determined by the duty cycle of the signal, and the duty cycle is determined by the application software.

INFORMATION

Current flow gets interrupted when using low-side outputs as a PWM signal, because the outputs are not "on" continuously. Therefore, current feedback control systems should use a high-side output for PWM signals, and a low-side output (turned on at 100%) for sensing current.

When low-side outputs are used as an on/off signal, the output provides ground when in the "on" state (the application software is responsible for switching low-side outputs "on" and "off").

When low-side outputs are used to sense current, the application software will monitor the current flowing into the low-side output, and based on the amount of current, will turn the output either "on" or "off".

6.2.1. Low-Side Output with Current Sense Capabilities

This output provides 2.5A maximum continuous current with accurate current sensing. The current sensing provides accurate readings to detect single load disconnect on parallel driven load applications. The current sensing can also be used for current control of hydraulic coils when used with a corresponding high-side driver which performs the PWM function. These outputs can be used to provide a fast PWM signal to functions requiring accurate higher speed PWM signal control.

The following table provides specifications for the VMM1615's low-side output:

Table 14: Low-Side Output Specifications

Item	MIN	NOM	MAX	UNIT
Switchable voltage range	6	-	32	V
Output current	0	-	2.5	A
Output on state resistance	-	82	-	mΩ
Over-voltage	-	-	36	
Short Circuit Protection	-	13	-	A
PWM frequency	-	-	1500	Hz
PWM resolution	-	0.1	-	%
Inductive pulse protection	-	-	628	V (peak)
Current Sense resistance	99	100	101	mΩ
Current Sense gain	-	1	-	V/A
Current Sense resolution/bit	-	-	1.2	mA
Current sense accuracy - Full Scale (2.5A)	-	3	-	%

6.2.1.1. Fixed Output Protection

The outputs have the following fixed protection mechanisms:

- Hardware overcurrent protection – The output will trip immediately when subjected to currents above 13.8A.
- Software fuse – Simulates a mechanical fuse and will trip between 200ms and 1000ms for currents above 2.5A. Because of this it is important that load inrush events be kept less than 200ms. For loads with inrush duration greater than 200ms, see Appendix A to verify if the load can be reliably driven by the output.
- Short circuit – The output is protected from short circuits.

6.2.2. Low-Side Output with Current Sense Configuration

The low-side output with current sense is configured as follows:

- The resistor used for sensing current maximizes the accuracy of the current measurement.

The following diagram shows the configuration options for low-side outputs:

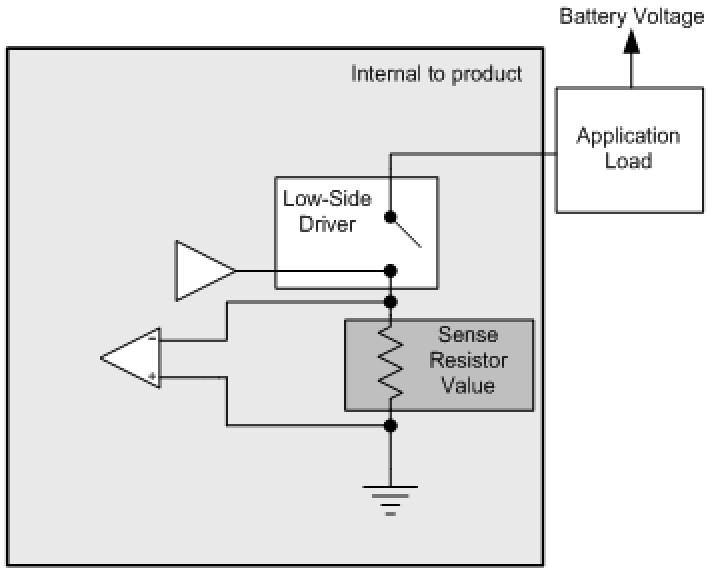


Figure 12: Low-side output with current sense configuration

6.2.3. Low-Side Output with Current Sense Installation Connection

You must be aware of the following when connecting a low-side output:

- Low-side outputs are connected to a common internal ground point that is connected to the battery ground (GROUND). Refer to *Logic and Output Power* for more details about the battery ground.
- Low-side outputs provide switched ground to any load type in a vehicle.
- Low-side outputs can sink up to **2.5 A**.
- When connecting a load to a low-side output, **ensure the load will not** drive currents greater than the maximum specified peak current, or maximum specified continuous current.

The following shows a typical low-side output connection:

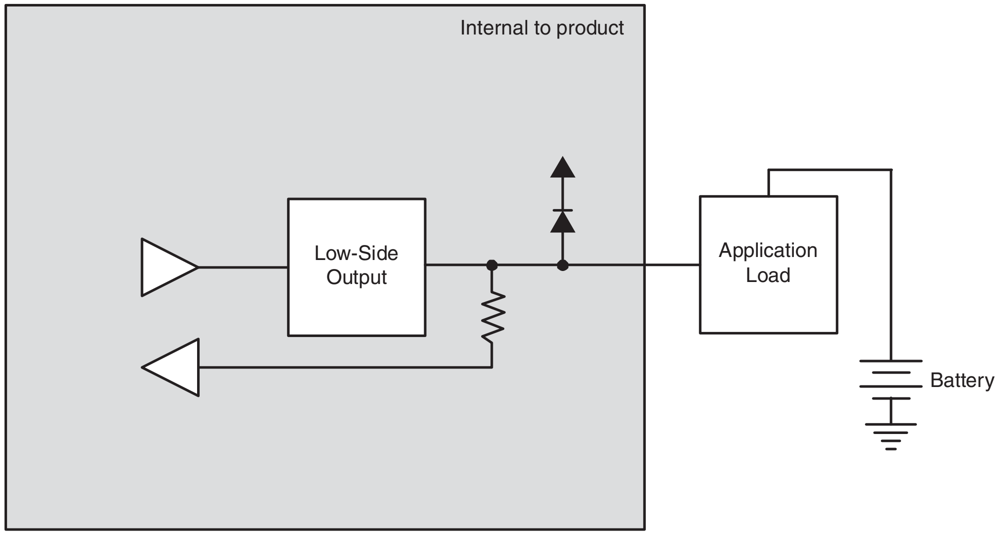


Figure 13: Low-side outputs with current sense installation connections

6.2.4. Low-Side Outputs with Current Sense Diagnostics

The VMM1615's low-side outputs have the ability to report many different fault conditions, and are protected against short-circuit and over-current, open load, and short-to-ground faults.

6.2.4.1. Short-Circuit

Short circuit faults occur when a low-side output pin is shorted to battery. The output will turn off and retry as defined by the programmer.

6.2.4.2. Software Overcurrent

Software overcurrent faults occur when the current through a low-side output pin exceeds a threshold defined by the programmer for a period of 1 second.

6.2.4.3. Open Load

Open load faults occur when a low-side output pin is open circuit (not connected to a load). The use of this feature operates is defined by the programmer.

The low-side output circuit uses a small amount of current on the output pin to determine if an open load condition exists.

INFORMATION

Low-side outputs must be “on” to detect an open-load fault.

6.3. Solid State Relays

The solid state relays are used for switching currents in either direction as an on/off signal. There are two contacts associated with each of this type of output, which act like the two contacts of a normally open mechanical relay.

WARNING

This circuit is not electrically isolated like a mechanical relay. For proper operation the voltage levels being switched must be between ground and the voltage applied to the Logic Power pin.

The VMM1615 has 2 solid state relays:

- `OUTPUT14_SSR_A` and `OUTPUT15_SSR_B`

When solid state relays are used as an on/off signal, the output provides a low impedance path between the “A” and “B” terminals in the “on” state (the application software is responsible for switching solid state relays "on" and "off").

6.3.1. Solid State Relay Capabilities

These outputs support 1.0A maximum continuous current between their terminals.

The following table provides specifications for the VMM1615's solid state relay:

Table 15: Solid State Relay Specifications

Item	MIN	NOM	MAX	UNIT
Switchable voltage range	0	-	V_{LOGIC}	V
Output current	0	-	1	A
Output on state resistance	-	164	-	mΩ
Over-voltage	-	-	V_{LOGIC}	V
PWM frequency	-	-	0	Hz
Inductive pulse protection	-	-	628	V (peak)
Short Circuit Protection	-	4	-	A
Short Circuit Trip time	-	-	1	ms

6.3.1.1. Fixed Output Protection

The outputs have the following fixed protection mechanisms:

- Hardware overcurrent protection – The output will trip immediately when subjected to currents above 13.8A.

6.3.2. Solid State Relay Installation Connections

You must be aware of the following when connecting solid state relays:

- The solid state relay provides a low impedance path between the “A” and “B” terminal.

- This circuit is not electrically isolated like a mechanical relay. For proper operation the voltage levels being switched must be between ground and the voltage applied to the Logic Power pin.
- Solid state relays can support up to 1.0 A.
- When connecting a load to a solid state relay, ensure the load will not drive currents greater than the maximum specified peak current, or maximum specified continuous current.

The following shows typical solid state relay connections:

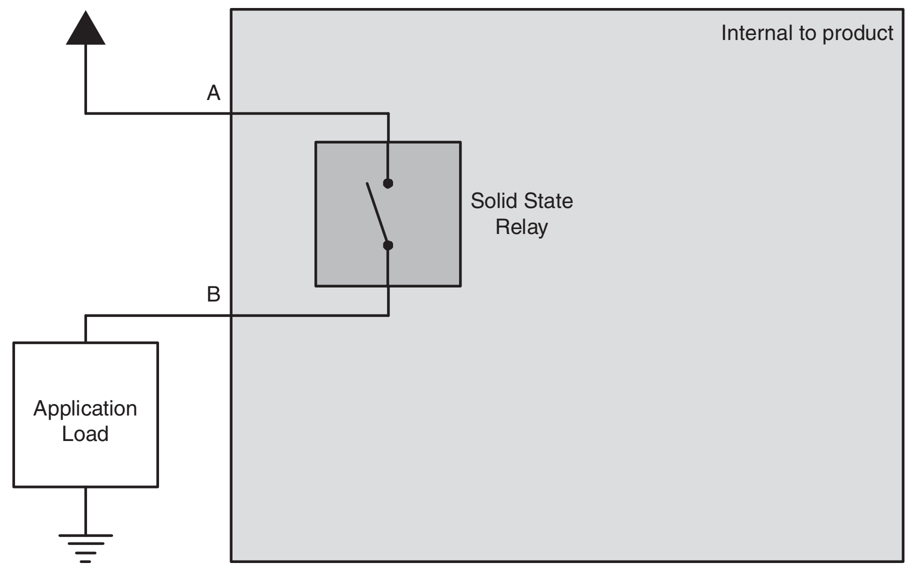


Figure 14: Solid State Relay switching high

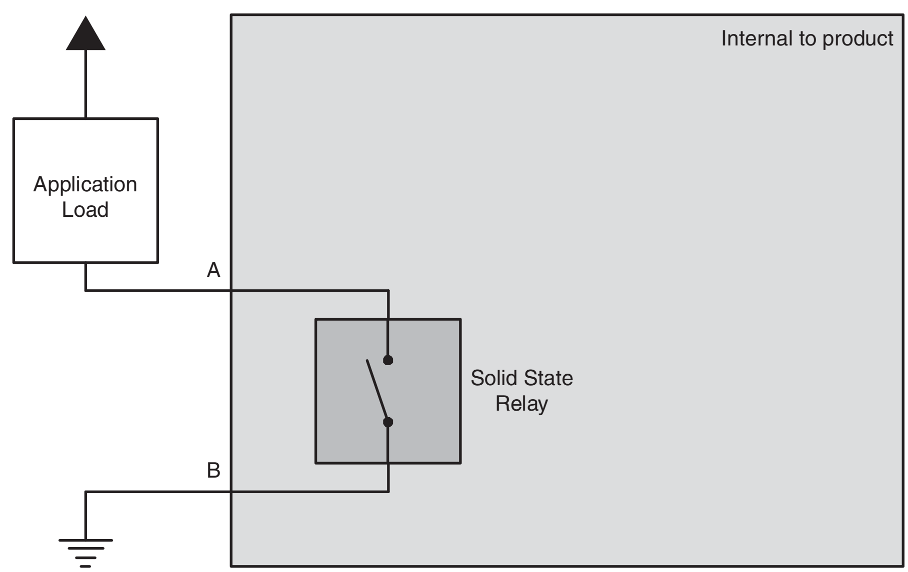


Figure 15: Solid State Relay switching low

6.3.3. Solid State Relay Diagnostics

Each solid state relay has the ability to report one type of fault condition.

6.3.3.1. Short Circuit

Short circuit faults occur when a solid state relay senses a short from battery to ground across its terminals. The output will turn off and retry as defined by the programmer.

7. Power

The VMM1615 is powered by the vehicle battery. The VMM1615 operates in a 12 V or 24 V system, and can operate from 6 V up to 32 V, with overvoltage protection at 36 V protection.

The VMM1615 has various pins on the connectors that are used for different types of power, as detailed in the following sections.

7.1. Logic Power

The VMM1615 has **1 pin** dedicated to providing power for logic circuitry, called `VBATT_LOGIC`. and **2 pins** dedicated to grounding the VMM1615, called `GROUND`.

7.1.1. Logic Power Capabilities

Logic power provides power to the logic circuit, which consists of the microprocessor, RAM, etc. The logic circuit can draw a maximum of 350 mA.

The following table provides specifications for the VMM1615 logic power:

Table 16: Logic Power Specifications

Item	MIN	NOM	MAX	UNIT
Input voltage range	6	-	32	V
Over-voltage	-	-	36	
Current draw in on state	70 @ 32VDC	180 @ 14VDC	350 @ 6VDC	mA
Current draw in off state	-	0.3	1	mA
Inline fuse required on logic power pin		2		A
Number of logic power pins		1		
Number of ground pins		2		

7.1.2. Logic Power Installation Connections

When connecting the VMM1615 logic power, you should be aware of the following:

- Logic power connections are made using the `VBATT_LOGIC` and `GROUND` pins.
- The VMM1615 is protected against reverse battery connections by an internal high-current conduction path that goes from ground to power. To protect the VMM1615 from damage in a reverse battery condition, place a fuse of **2 A or less** in series with the power wires in the application harness.

Reverse battery protection is only guaranteed when using standard automotive fuses.

- All power connections to the VMM1615 should be fused to protect the vehicle harness.

INFORMATION

The system designer is responsible for selecting the appropriate fuses. Select fuse sizes by multiplying the maximum continuous current during normal operation by 1.333 (75% de-rating factor). Do not use slow blow fuses for this application.

7.2. Busbar Power

There are two main power connections for the high current bus bar battery power inputs (`VBATT_BUSBAR1` and `VBATT_BUSBAR2`). The busbar inputs are separated into two connectors (`J5` and `J6`).

7.2.1. Output Power Capabilities

Busbar power provides power to the output circuits through a battery or ground connection. Each busbar circuit can draw a maximum of 40 A.

The following table provides specifications for the VMM1615 busbar power:

Table 17: Busbar Power Specifications

Item	MIN	NOM	MAX	UNIT
Number of busbars	-	2	-	
Busbar voltage range	6	-	32	V
Over voltage	-	-	36	V
Busbar current	-	-	40	A (per busbar)
Inline fuse required on power pins		50		A

7.3. Sensor Power

The VMM1615 has one pin dedicated to providing power to external sensors called `SENSOR_SUPPLY`.

WARNING

Do not drive more than **mA** of current through the SENSOR_SUPPLY pin. If you do, the pin will protect itself by dropping the voltage, which will result in a lack of power to your sensors, potentially causing unknown vehicle responses.

7.3.1. Sensor Power Capabilities

`SENSOR_SUPPLY` is a 5 V or 8 V linear power supply that is capable of continuously providing 300 mA to external sensors.

INFORMATION

The voltage provided to the VMM1615 must be 7 V or greater to ensure the SENSOR_SUPPLY can provide 5 V. The voltage provided to the product must be 10.5 V or greater to ensure the sensor supply can provide 8 V.

The following table provides specifications for the VMM1615's sensor power output:

Table 18: Sensor Power Specifications

Item	MIN	NOM	MAX	UNIT
Input voltage range (5 V output)	7	-	32	
Input voltage range (8 V output)	10.5	-	32	V
Over-voltage	-	-	36	V
Output voltage range (5 V)	4.74	5.02	5.30	V
Output voltage range (8 V)	7.63	8.09	8.56	V
Output voltage accuracy	-	-	6	%
Output current	0	-	300	mA

7.3.1.1. Sensor Power Fault Responses

SENSOR_SUPPLY is designed to survive short-to-battery, short-to-ground, and over-current events. If these events occur, the circuit will recover as described in the following table:

Table 19: Sensor Power Fault Recovery

Event	Recovery
Short-to-battery (sensor voltage = battery voltage)	Sensor voltage recovers when the short is removed.
Short-to-ground (sensor voltage = ground)	Sensor voltage recovers when the short is removed.
Over-current (sensor voltage = ground)	Sensor voltage recovers when the over-current condition is removed.

7.3.2. Sensor Power Installation Connections

For information on how to connect sensors, refer to Application Examples.

8. Communication

The VMM1615 uses the Controller Area Network (CAN) communication when communicating with other modules on the vehicle, or with a personal computer:

8.1. Controller Area Network (CAN)

The VMM1615 hardware provides CAN communication according to the **SAE J1939 specification**, making the VMM1615 compatible with any CAN-based protocol through software.

CAN communication is used to communicate the status of multiple modules that are connected together in the same network.

8.1.1. VMM1615 CAN Capabilities

The CAN communicates information at a rate of **250 kbps**. Input and output information is communicated through the CAN at a sample rate of **40 Hz**. Lack of regular CAN communication is an indication that there is either a problem with a module in the network, or a problem with the CAN bus.

These CAN ports offer CAN 2.0B compatible hardware with a Wake on CAN function on CAN1, which is a way to provide power control to the VMM1615.

Wake on CAN allows the VMM1615 to come out of 'sleep mode' when any CAN activity is received by the module. If the CAN activity is not continuous, the VMM1615 will return to 'sleep mode'.

INFORMATION

It is not possible to filter messages that are used to turn on the VMM1615 using Wake on CAN, and therefore, any message will turn on the VMM1615. The application software must be written to determine how the VMM1615 will behave when it is turned on.

The following table provides specifications for the CAN:

Table 20: CAN Specifications

Item	MIN	NOM	MAX	UNIT
Baud rate	-	250	-	kbps
J1939 compliant	-	Yes	-	
Wake on CAN option	-	Yes	-	CAN1
Termination resistor	-	No	-	

8.1.2. J1939 CAN Configuration

There are two features associated to CAN communication that are configured:

- **Wake on CAN** - the VMM1615 will turn on when a CAN message is received.
- **Internal CAN Termination Resistor** - the VMM1615 does not have a **120 Ω** CAN termination resistor embedded inside the module, which is required to use CAN communication. You are required to design it into the vehicle harness.

INFORMATION

Putting CAN termination resistors in the module would violate the J1939 specification, which states that the resistor should be designed into the harness.

8.1.3. J1939 CAN Installation Connections

The CAN connection for the VMM1615 should conform to the 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.

INFORMATION

The VMM1615 does not have a CAN termination resistor, which is based on the assumption that the CAN bus is terminated in the harness.

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

- **CAN Cable**: A shielded twisted-pair cable should be used when connecting multiple modules to the CAN bus. The cable for the J1939 CAN bus has three wires: CAN High, CAN Low, and CAN Shield (which connect to the corresponding `CAN_HIGH`, `CAN_LOW`, and `CAN_SHIELD` pins on the connector). The CAN cable must have an impedance of 120 Ω.
  - **The CAN cable is very susceptible to system noise**; therefore, CAN Shield must be connected according to the following:
    a. Connect CAN Shield to the point of least electrical noise on the CAN bus.
    b. Connect CAN Shield as close to the centre of the CAN bus as possible.
    c. Use the lowest impedance connection possible.

NOTICE

Ground loops can damage electronic modules. The 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" configurations.

- **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 metres, and must have a 120 Ω terminator resistor at each end. The 120 Ω terminator resistors eliminate bus reflections and ensure proper idle state voltage levels.
- **CAN Stubs**: The CAN stubs cannot be longer than 1 m, and each stub should vary in length to eliminate bus reflections and ensure proper idle state voltage levels.
- **Max Number of Modules in a System**: The CAN bus can handle a maximum of 30 modules in a system at one time.

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

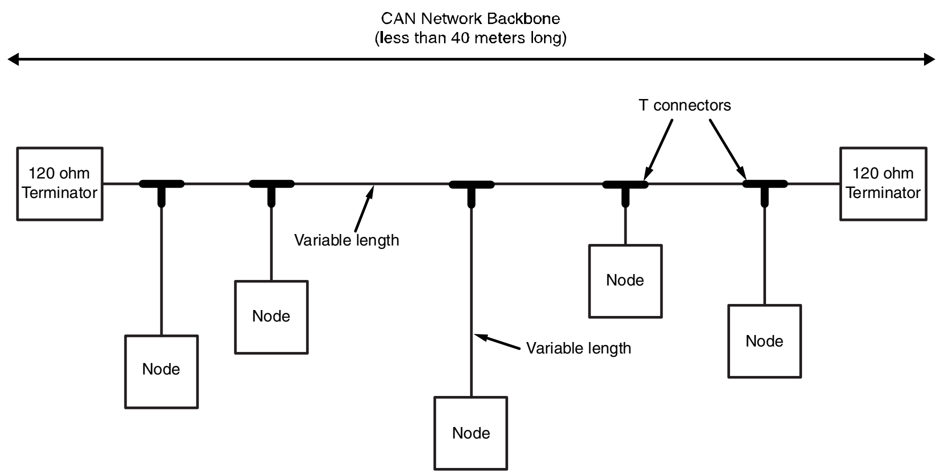


Figure 16: J1939 CAN connection

9. VMM1615 Diagnostic LED's

There are 40 available diagnostic LEDs on this module. The LEDs are used to provide diagnostic information for input states, output states, CAN bus activity and module power.

9.1. Power LED

The power LED has 3 states, “on”, “off” and “flashing”.

- Off = Sleep Mode
- On Solid = Module Operating Normally
- Flashing = Programming Mode (1Hz)
    - o = System Fault (not 1Hz)

9.2. Standby LED

The standby LED has 2 states, “on” or “off”. There are 2 conditions that will turn “on” the standby LED.

First, when there is any activity on CAN 1 Network but no power control flags are active. Second, when all power control inputs and power control flags have been removed.

If any power control inputs or power control flags are active for the corresponding unit, then the standby LED will be “off”

9.3. NET1 and NET2 LEDs

If the NET1 or NET2 LED is “flickering”, “flashing” or “on solid”, then there is activity on that CAN Bus.

If the NET1 or NET2 LED is “off”, then there is no activity on that CAN Bus.

9.4. Address LEDs

An address LED has 2 states, “on” or “off”. If the address pin is active then the corresponding LED for that input will be “on”. If the address pin is inactive then that LED will be “off”.

INFORMATION

Address LEDs do not provide any error/fault detection.

9.5. Inputs LEDs

An input LED has 2 states, “on” or “off”. If the input pin is active then the corresponding LED for that input will be “on”. If the input pin is inactive then that LED will be “off”.

INFORMATION

Input LEDs do not provide any error/fault detection.

9.6. Output LEDs

An output LED has 3 states, “on”, “off” or “flashing”. Through software if the output condition is true, then the corresponding LED will be “on”. If the condition through software is false then that LED will be “off”. The output LEDs also provide error/fault status. If an output LED is “flashing” that means there is an fault on that output.

10. VMM1615 Connectors

The VMM1615 has four 12-pin Deutsch DT connectors, as follows:

- Brown (J1): DT15-12PD
- Grey (J2): DT15-12PA
- Green (J3): DT15-12PC
- Black (J4): DT15-12PB

The connectors have pins that connect to inputs, outputs, and communication channels used by the VMM1615. They also have keying that prevents you from incorrectly mating the connectors to the vehicle harness.

The vehicle harness should be designed to interface with all connectors.

NOTICE

To prevent miss keying, it is recommend to use the enhanced keying version of mating connectors (harness side).

The following are pictures of the required mating connectors:

Figure 17: Connector J1

Figure 18: Connector J2

Figure 19: Connector J3

Figure 20: Connector J4

INFORMATION

The maximum wire gauge usable in the VMM1615 DT06 connectors is 16 AWG with GXL insulation.

The VMM1615 also has two 1-pin Deutsch DTHD connectors for busbar power (power for High-side outputs), as follows:

- Black (J5): DTHD04-1-8P
- Black (J6): DTHD04-1-8P

The following is a picture of the required connectors:

Figure 21: Connector J5 and J6

INFORMATION

The maximum wire gauge usable in the VMM1615 DTHD connectors is 8 AWG with GXL insulation.

The following table shows the part numbers for the mating connectors and terminals that are used in the vehicle harness:

Table 21: Mating Connector Part Numbers

Connector	Shell part no.	Wedge part no.	Terminal part no.
Brown (J1) connector	DT06-12SD-P012	W12S or W12S-P012	16-20AWG, Gold: 1062-16-144
Grey (J2) connector	DT06-12SA-P012	W12S or W12S-P012	16-20AWG, Gold: 1062-16-144
Green (J3) connector	DT06-12SC-P012	W12S or W12S-P012	16-20AWG, Gold: 1062-16-144
Black (J4) connector	DT06-12SB-P012	W12S or W12S-P012	16-20AWG, Gold: 1062-16-144
Black (J5) connector	DTHD06-1-8S	-	8-10AWG: 0462-203-08141
Black (J6) connector	DTHD06-1-8S	-	8-10AWG: 0462-203-08141

10.1. VMM1615 Connector Pin-outs

Connector pins connect to inputs, outputs, and communication channels. They provide the interface between the vehicle harness and the internal circuitry of the VMM1615.

The following tables show the pin-outs for each connector:

Table 22: Brown (J1) Connector Pin-out

Connector pin	Name	Function
1	`OUTPUT1_10A_HS`	10A High-side output
2	`GND`	System ground input
3	`VBATT_LOGIC`	Logic power
4	`INPUT15_AD`	Analog or Digital input
5	`INPUT7_D`	Digital input
6	`INPUT8_DF`	Digital or Frequency input
7	`OUTPUT14_SSR_A`	Solid state relay pin A
8	`CAN2_HI`	CAN 2 High
9	`CAN2_LO`	CAN 2 Low
10	`CAN1_HI`	CAN 1 High
11	`CAN1_LO`	CAN 1 Low
12	`CAN1_SHLD`	CAN 1 shield

Table 23: Grey (J2) Connector Pin-out

Connector pin	Name	Function
1	INPUT4_D	Digital input
2	INPUT9_AD	Analog or Digital input
3	INPUT10_AD	Analog or Digital input
4	INPUT11_AD	Analog or Digital input
5	INPUT12_AD	Analog or Digital input
6	GND	Ground
7	OUTPUT14_SSR_B	Solid state relay pin B
8	OUTPUT13_2A5_LS	2.5A Low-side output
9	OUTPUT15_SSR_B	Solid state relay pin B
10	OUTPUT15_SSR_A	Solid state relay pin A
11	SENSOR_SUPPLY	+5V or +8V sensor power
12	OUTPUT2_10A_HS	10A High-side output

Table 24: Green (J3) Connector Pin-out

Connector pin	Name	Function
1	OUTPUT7_5A_HS	5A High-side output with current sense
2	OUTPUT5_10A_HS	10A High-side output
3	INPUT1_D	Digital input, power control, active high
4	ADDR_5	Address input
5	OUTPUT9_5A_HS	5A High-side output
6	OUTPUT3_10A_HS	10A High-side output
7	INPUT2_D	Digital input
8	INPUT13_AD	Analog or Digital input
9	INPUT14_AD	Analog or Digital input
10	INPUT5_D	Digital input
11	INPUT6_D	Digital input
12	OUTPUT11_2A5_HS	2.5A High-side output with current sense

Table 25: Black (J4) Connector Pin-out

Connector pin	Name	Function
1	OUTPUT12_2A5_HS	2.5A High-side output with current sense
2	GND	System ground input
3	ADDR1	Address input
4	ADDR2	Address input
5	ADDR3	Address input
6	ADDR4	Address input
7	OUTPUT4_10A_HS	10A High-side output
8	OUTPUT10_5A_HS	5A High-side output
9	INPUT16_AD	Analog or Digital input
10	INPUT3_D	Digital input
11	OUTPUT6_10A_HS	10A High-side output
12	OUTPUT8_5A_HS	5A High-side output with current sense

11. Installing a VMM1615 into a Vehicle

Because every system is different, it is difficult for us to provide specific instructions on how to install a VMM1615 into a vehicle. Instead, we have provided **mechanical, environmental, and electrical guidelines and requirements** that you should be aware of before installing the product.

INFORMATION

The vehicle manufacturer is responsible for creating procedures for mounting the VMM1615 in a vehicle during production assembly.

11.1. Mechanical Guidelines

Ensure you review the following mechanical guideline sections before installing the VMM1615 into a vehicle.

11.1.1. VMM1615 Dimensions

The following diagram shows the dimensions of the VMM1615:

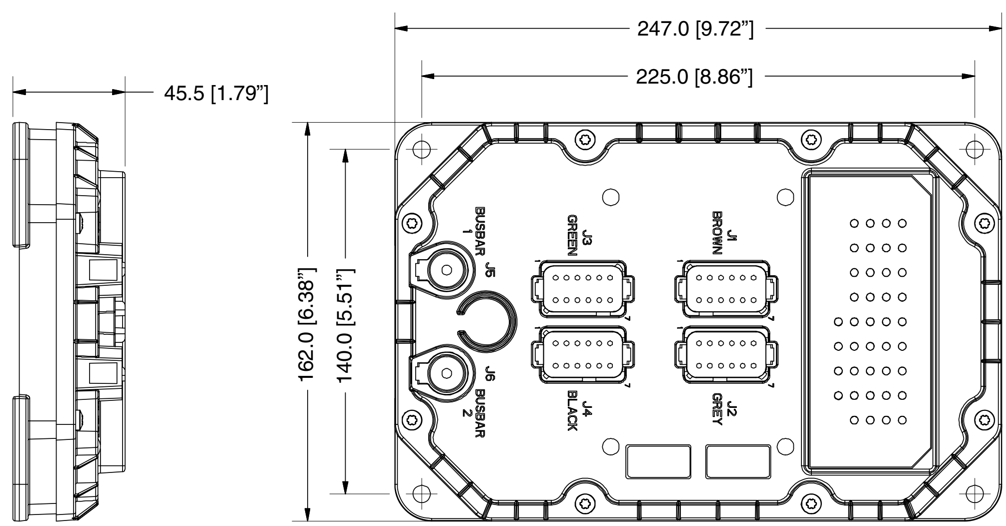


Figure 22: VMM1615 dimensions

11.1.2. Selecting a Mounting Location

The VMM1615 can be installed in the vehicle's cab, or on the chassis. If used for a marine application, ensure it is protected from excessive salt spray.

Before mounting the VMM1615, ensure you review the following environmental and mechanical requirements.

NOTICE

Do not install the VMM1615 close to any significant heat sources, such as a turbo, exhaust manifold, etc. Also avoid installing the VMM1615 near any drive-train component, such as a transmission or engine block.

11.1.2.1. Environmental Requirements

NOTICE

The VMM1615 warranty does not cover damage to the product when exposed to environmental conditions that exceed the design limitations of the product.

Review the following environmental specifications before selecting a mounting location for the VMM1615:

- The VMM1615 must be in an environment that is within its ambient temperature range.
  - Safe operating temperature range for a VMM is **–40°C to +85°C**.
- The VMM1615 must be in an environment that does not exceed its particle ingress rating.
  - The sealing standard for the VMM1615 is **EP455 level 1 (IPX6)**.

NOTICE

The VMM1615 has not been tested for water ingress according to the EP455 level 1 standard.

- The VMM is protected from **aggressive pressure wash up to 1000 psi @ 1 m (3.28 ft.)**

NOTICE

Exercise caution when pressure washing the VMM1615. The severity of a pressure wash can exceed the VMM1615 pressure wash specifications related to water pressure, water flow, nozzle characteristics, and distance. Under certain conditions a pressure wash jet can cut wires.

11.1.2.2. Mechanical Requirements

Review the following mechanical requirements before selecting a mounting location for the VMM1615:

- The VMM1615 should be mounted vertically so **moisture will drain away from it**.
- The wire harness should have drip loops incorporated into the design to divert water away from the VMM1615.
- The harness should be **shielded from harsh impact**.

- The harness should **connect easily** to the connector and have **adequate bend radius**.
- The **labels and LEDs** should be easy to read.
- The VMM1615 should be in a location that is **easily accessible for service**.

11.1.3. Mounting the VMM1615 to a Vehicle

It is up to the original equipment manufacturer (OEM) to ensure the product is securely mounted to the vehicle.

The following guidelines are related to physically attaching the VMM1615 to a vehicle:

- The VMM1615 should be secured with **bolts in all four bolt holes** using 1/4"-20 **Hex Head** or equivalent metric size () bolts.
- The bolts should be tightened according to the fastener manufacturer's tightening torque specifications..

11.1.3.1. Recommended Mounting Orientation

The VMM1615 should be mounted vertically so moisture drains away from it, as shown in the following:

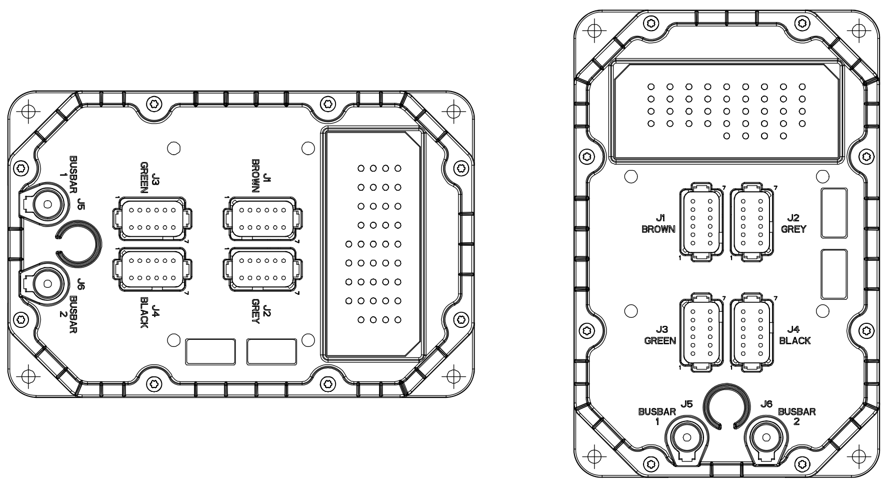


Figure 23: Recommended orientations

11.2. Electrical Guidelines

The following sections provide electrical guidelines to install the VMM1615 in a vehicle.

11.2.1. Designing the Vehicle Harness

The vehicle manufacturer is responsible for designing a vehicle harness that mates with the VMM1615 connector(s).

The vehicle harness design depends on the following:

- How the VMM1615's inputs, outputs, communication, and power pins are configured.
- Other components on the vehicle and their physical locations.
- The routing of the harness.

For guidelines and recommendations on how to connect the different elements of the VMM1615, refer to the *Installation Connections* sections found within each input, output, communication, and power section in this manual.

11.2.2. Connecting the Vehicle Harness to the VMM1615

Once the vehicle harness is designed, it can be connected to the VMM1615 simply by clicking the mating connector into the connector port on the VMM1615.

12. Application Examples

The purpose of this section is to provide examples of how the VMM1615 can be used for different purposes.

The following examples are covered in this section:

- Implementing safety interlocks
- Controlling indicator lights
- Controlling a proportional valve
- Controlling motor speed
- Using one analog input as two digital inputs
- Connecting sensors

INFORMATION

These examples are for illustrative purposes only.

12.1. Implementing Safety Interlocks

Safety is paramount when creating controls for a vehicle.

One safety feature that can be implemented with the VMM1615 is to ensure the vehicle doesn't move when it is not being used, and no one is sitting in the operator's seat.

To prevent the vehicle from moving when no one is sitting in the operator seat:

1. Place a **seat switch interlock** on the operator seat and connect the switch to a digital input.
2. Write ladder logic application code for the digital input so that it shuts down critical vehicle functions when the switch is open (when no one is sitting in the seat).

INFORMATION

The example above may cause unwanted shutdowns if the operator moves around while controlling the vehicle. To prevent this, use software filtering that will prevent the vehicle from shutting down unless the switch is open for more than a defined period of time.

The following diagram shows a typical seat switch interlock connection:

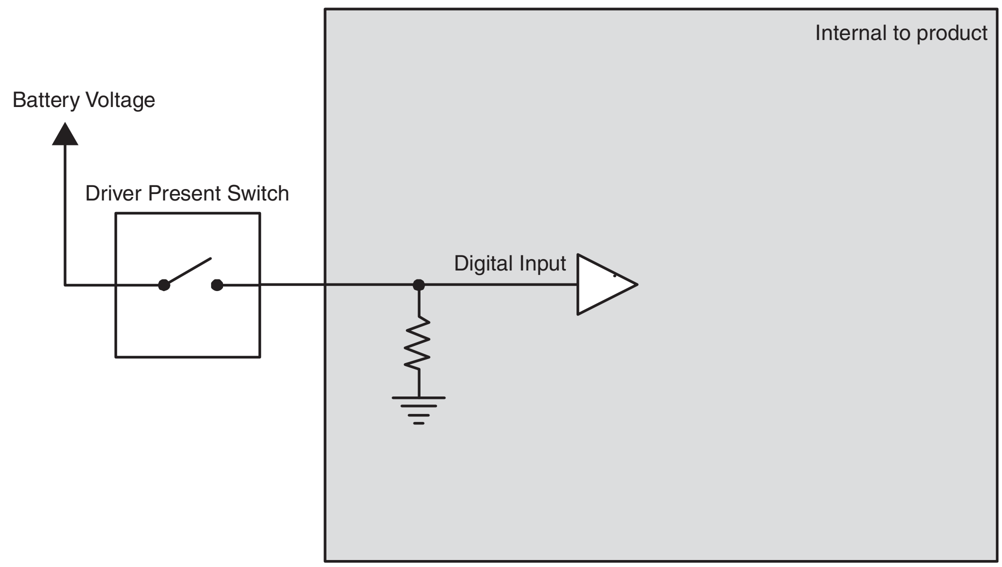


Figure 24: Seat switch interlock connection

12.2. Controlling Indicator Lights

Multiple VMM1615 can be used together in a system to control a vehicle's indicator lights.

The VMM1615s would communicate over CAN, and be connected according to the following:

- One VMM1615 could be wired to the rear indicator lights
- One VMM1615 could be wired to the front indicator lights
- One VMM1615 could be wired to the turn signal and hazard switches

The following shows how to connect three VMM1615s together in a system to control indicator lights:

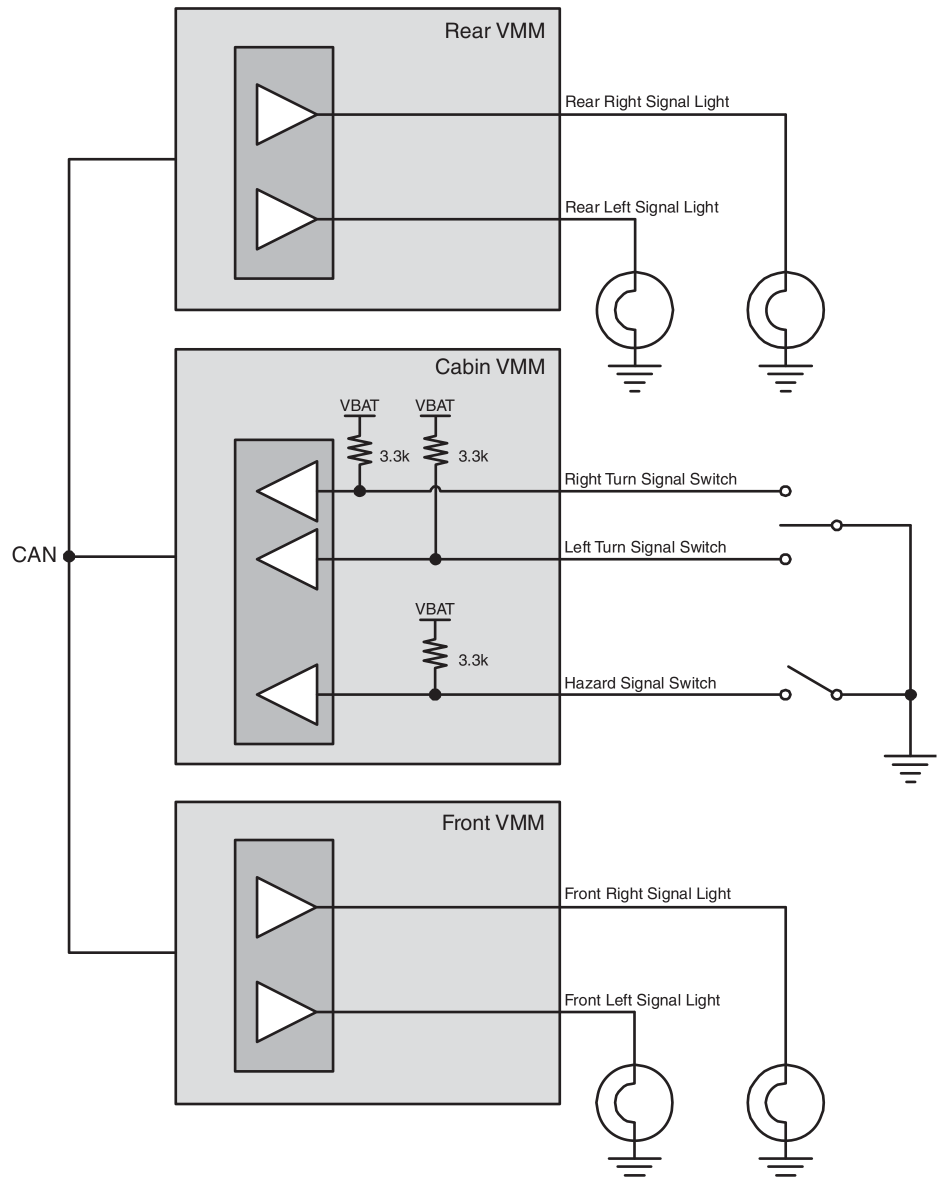


Figure 25: Indicator light connections

12.3. Controlling a Proportional Valve

INFORMATION

The VMM1615 has Proportional Integral Differential (PID) capabilities that make it possible to control devices like proportional valves through software. Refer to the appropriate software manual, or contact your Parker Vansco Account Representative for more details about software. This section only provides hardware connection information.

The VMM1615 can be used to control a proportional hydraulic valve through a **high-side output with PWM capability**, and a **low-side output with current sense**.

When making the connection, it is highly recommended to use the high-side and low-side outputs in pairs to avoid potential problems.

- The high-side output would drive power to the valve coil and adjust the duty cycle of a PWM signal.
- The low-side output would be used as a return path to ground for the valve coil, and provides feedback on the amount of current flowing through the valve coil.

The application code should be written so that the PWM duty cycle for the output is adjusted to achieve a target current through the valve coil.

- If current feedback is lower than target, the PWM duty cycle should increase to boost average current through the valve coil.
- If the current feedback is higher than target, the PWM duty cycle should decrease to reduce average current through the valve coil.

The following shows how to connect a high-side and low-side output to control a proportional hydraulic valve:

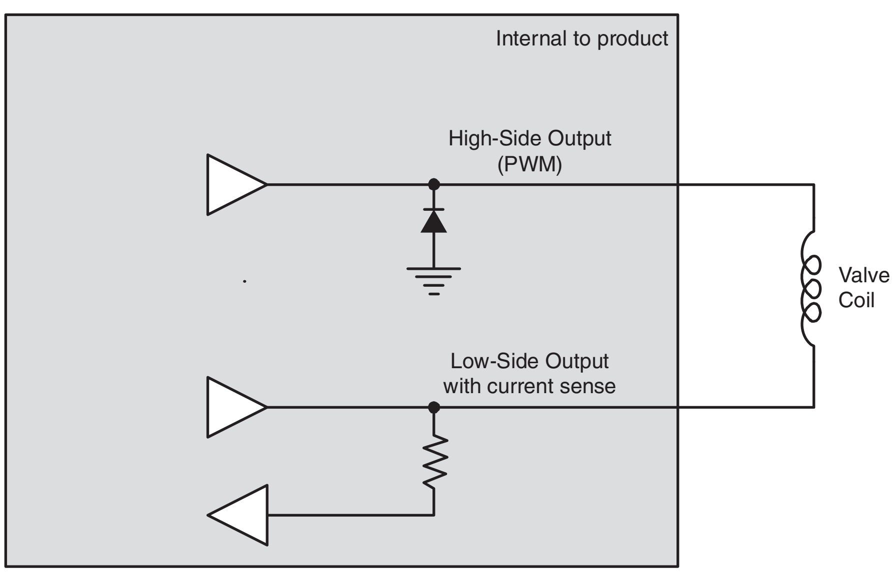


Figure 26: Connection for controlling a proportional valve

12.4. Controlling Motor Speed

INFORMATION

The VMM1615 has Proportional Integral Differential (PID) capabilities that make it possible to control devices like proportional valves through software. Refer to the appropriate software manual, or contact your Parker Vansco Account Representative for more details about software. This section only provides hardware connection information.

The VMM1615 can be used to control the DC motor speed of motors that provide a tachometer output.

To do this, you would use a **high-side output with PWM capabilities** to control the speed of the motor, and a **DC-coupled frequency input** to monitor the output from the motor.

The application code should be written so that the PWM duty cycle for the high-side output is adjusted to achieve a target speed (frequency) for the motor.

- If the frequency feedback is lower than target, the PWM duty cycle should increase to boost the average current through the motor to speed it up.
- If the frequency feedback is higher than target, the PWM duty cycle should decrease to reduce average current through the motor to slow it down.

The following shows how to connect the VMM1615 to control the speed of a motor:

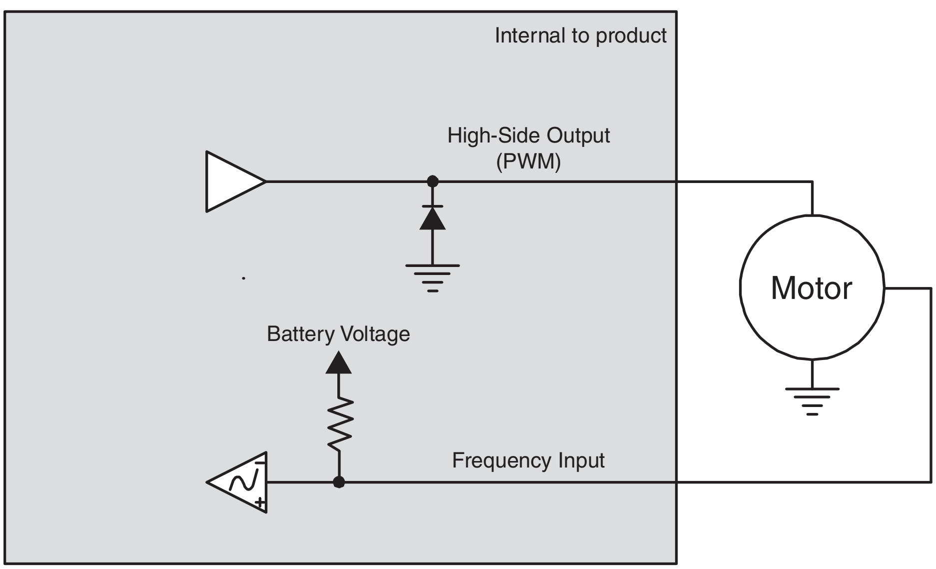


Figure 27: Connection for controlling motor speed

12.5. VMM1615 Using one Analog Input as two Digital Inputs

The VMM1615 allows you to use one analog input as two digital inputs, which is useful in reducing harness lead or if you are running out of digital inputs in your system.

To do this, you would connect the analog input to a single pole, double throw (SPDT) switch.

INFORMATION

You will need to write software that controls the switch according to the voltage value readings provided by the analog input. Refer to the appropriate software manual, or contact your Parker Vansco Account Representative for more information on writing software.

When making the connection, ensure there is a voltage difference between the two pins on the SPDT switch. This can be done by:

- enabling the internal pull-up resistor and pull-down resistor on the analog input (done through software);
- The SPDT switch is then connected one side to Vbatt and the other to Gnd, with the signal pin going to the analog input.

The following shows how to connect an analog input to a SPDT switch:

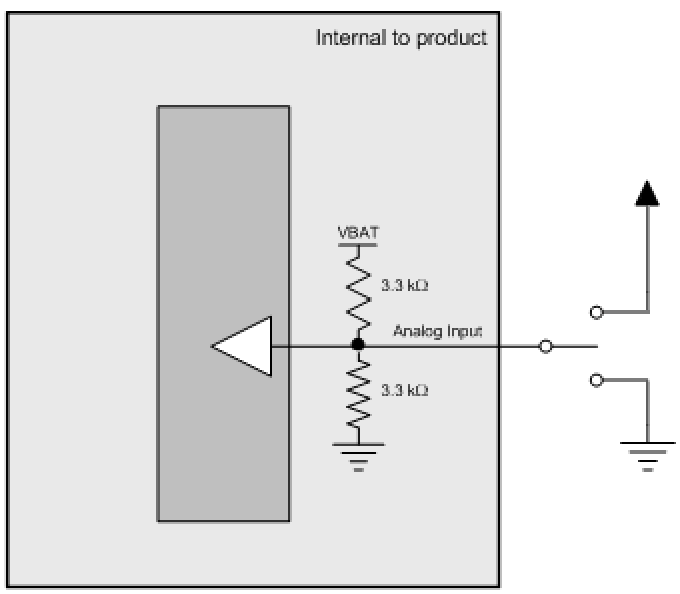


Figure 28: Using 1 analog input as 2 digital inputs

12.6. Connecting Common Sensors

There are many types of sensors that can be connected to the VMM1615, the most common are as follows:

- Open collector sensors
- Switch sensors
- Voltage sensors
- Potentiometer (ratiometric) sensors

INFORMATION

To optimize the reading accuracy for sensors, dedicate one of the main ground pins (called `GROUND`) as a low-current ground return for all sensors on the vehicle.

INFORMATION

When connecting sensors to the VMM1615, refer to the sensor manufacturer's specifications to ensure the VMM1615 is configured correctly for the sensor.

12.6.1. Open Collector

Open collector sensors are compatible with each type of input on the VMM1615.

Open collector sensors are typically used in applications that require digital or frequency measurements. They work by pulling voltage down to ground or up to power when activated, and are basically a switch that turns "on" and "off".

INFORMATION

Open collector sensors need a pull-up or pull-down resistor to bias the state of the sensor when the sensor is not activated. Pull-up and pull-down resistors are internal to the VMM1615.

The following shows a typical open collector sensor connection:

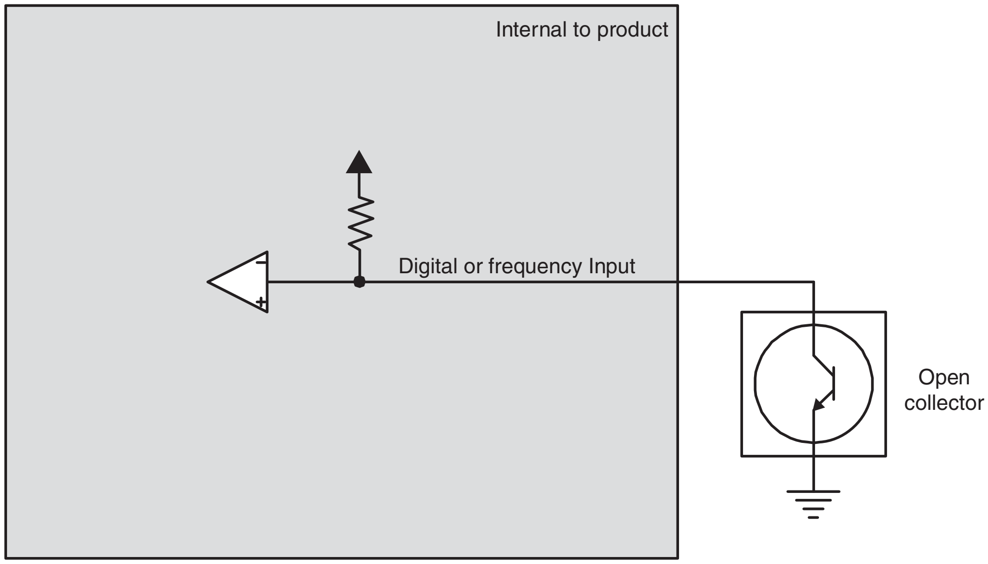


Figure 29: Open collector sensor connection

12.6.2. Connecting a switch to VMM1615

A switch is a type of sensor that uses mechanical contacts in one of two states: open or closed. Sensor switches are used to turn sensors on and off, and can be wired directly to digital inputs.

Active-high sensor switches may be used by the VMM1615. To use active-high switches, the VMM1615 has an internal pull-down resistor for the digital input.

The following shows a typical sensor switch connection:

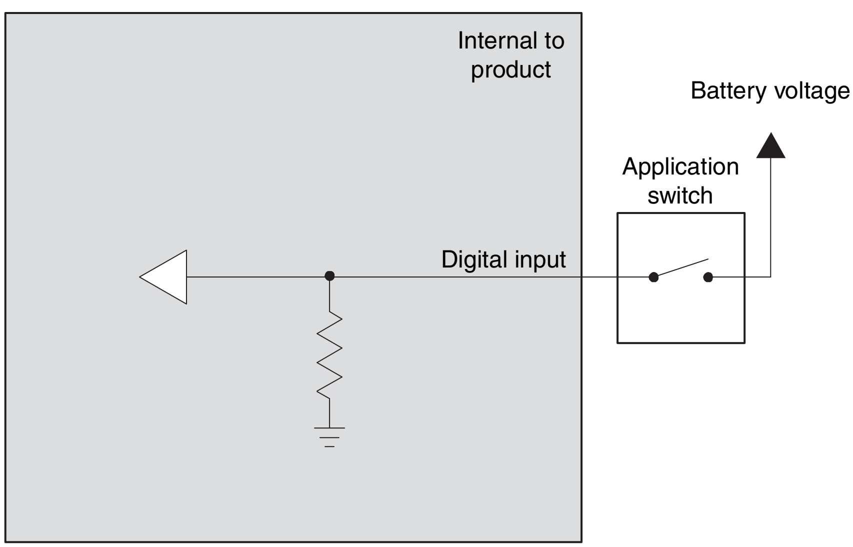


Figure 30: Switch sensor active high connection

12.6.3. Voltage

Voltage type sensors work by driving an analog voltage signal to report the sensor's measured value.

Voltage sensors are compatible with analog inputs, and are typically used in applications that require variable voltage measurements.

INFORMATION

Ensure you configure the analog input voltage (gain and attenuation factors) so the input's voltage is close to, but higher than, the maximum output voltage of the sensor.

The following shows a typical voltage sensor connection:

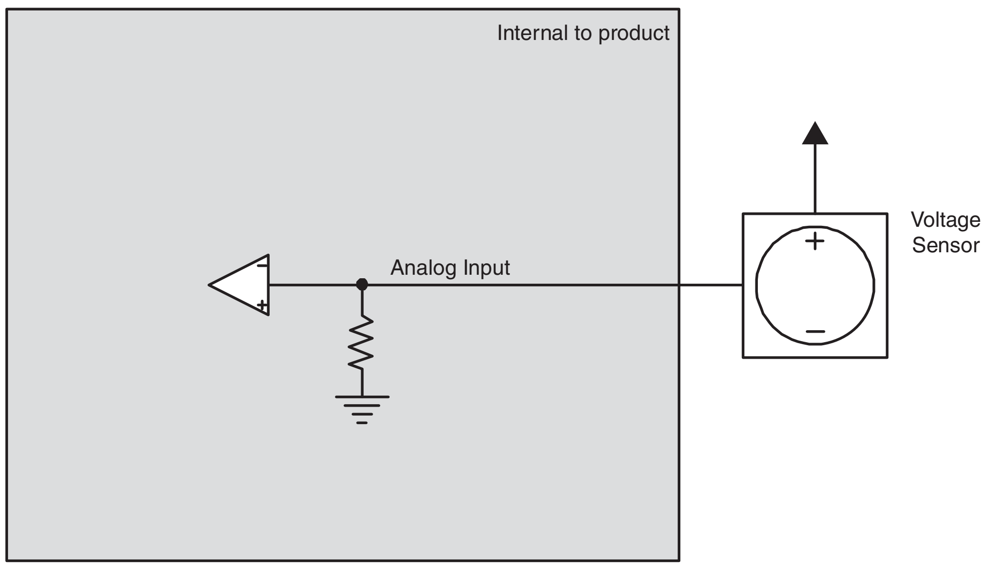


Figure 31: Voltage sensor connection

12.6.4. Potentiometer (Ratiometric)

Potentiometers and other ratiometric type sensors can be wired directly to analog inputs.

Potentiometers are resistive devices that use a wiper arm to create a voltage divider. Changes to resistive measurements happen as the wiper arm moves along a resistive element.

When connecting potentiometer sensors, it is important to do the following:

- Connect one end of the sensor to the `SENSOR_SUPPLY` pin, and the other end to a `GROUND` pin on the VMM1615.
- Connect the sensor signal to an analog input.

The following shows a typical potentiometer sensor connection:

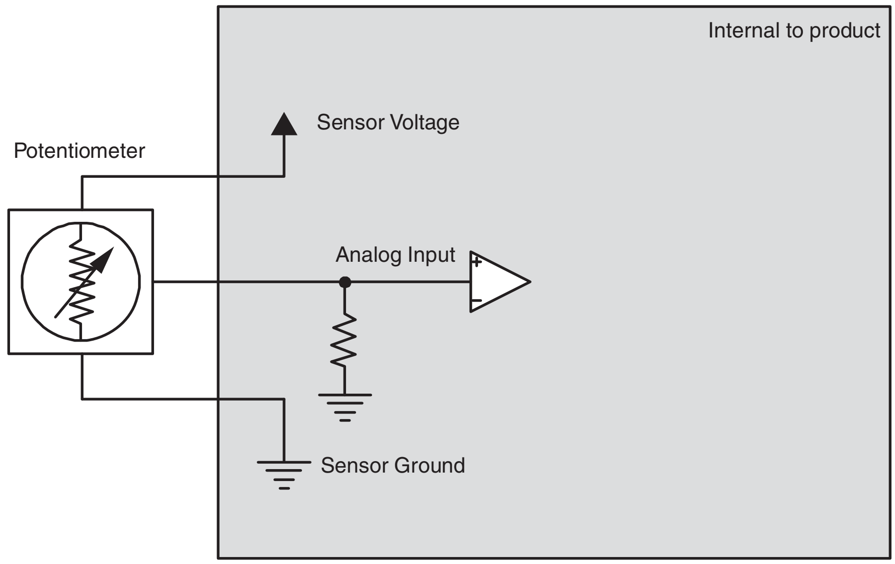


Figure 32: Potentiometer (ratiometric) sensor connection

13. Startup

13.1. Start-up procedures

This chapter contains instructions for action to be taken in connection with the initial start.

WARNING

Risk of injury!
If the control system is not fitted properly, the machine could move uncontrollably.
The machine's engine shall not be started before the control system is completely fitted and its signals are verified.

13.1.1. Starting the control system

Start the control system as follows:

- Prior to start, all modules and cables are to be fitted correctly.
- Check fuses, i.e. make sure that the supply voltage to the modules is equipped with the correct fuse.
- Make sure that connections for supply voltage and return lines are correct in the cable's conductor joint.
- Make sure the emergency stop works.
    - o The emergency stop should disconnect the supply voltage to all modules.

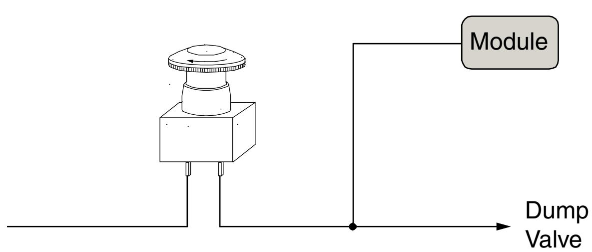


Figure 33: Emergency stop

Alternatively, the emergency stop may also shut off the diesel engine or a dump valve, and with that depressurize the hydraulic system.

13.1.2. Prepare for system start

WARNING

Make sure no one is in dangerous proximity to the vehicle to avoid injuries when it starts.

Prepare for the initial system start as follows:

- The engine for the hydraulic system's pump shall be in off position.
- Make sure that all connectors are properly connected.
- Turn on the control system.
- Make sure that voltage is being supplied to all modules.
- Make sure the emergency stop is functioning properly.

13.1.3. Start the system

Start the system as follows:

- Start the engine for the hydraulic system's pump, assuming that the above mentioned inspections have been carried out and shown correct values.
- Calibrate and adjust input and output signals, and check every output function carefully.
- In addition to these measures, the machine shall also meet the machine directives for the country in question.

14. Glossary of Terms

active-high

Input type that is considered "on" when it reads a battery voltage level and "off" when it is floating or grounded.

active-low

Input type that is considered "on" when it reads a ground voltage level and "off" when it is floating or connected to battery voltage.

aliasing

A situation can arise in digital systems where a sampled analog value produces a measured signal with a frequency that is less than the actual analog signal. Aliasing occurs when the analog signal being sampled has a frequency greater than half the sample rate.

amplified

A circuit that applies a gain with a value greater than one (1) to a measured signal, which is typically used with analog inputs.

analog input

An input that allows a voltage level to be read and converted to discrete digital values within a microprocessor.

anti-alias filtering

Filters incorporated in hardware that ensure the analog value being read by the module does not have a frequency component greater than half the sample rate.

application software

A level of software that makes a product (hardware) perform desired functions for the end user.

attenuation

Decreasing the voltage level of an input signal to maximize the resolution of an input.

CAN

Controller Area Network

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 Shield

A shielding that wraps around the CAN High and CAN Low wires (twisted-pair), completing the shielded twisted-pair cable.

CMOS

CMOS stands for Complimentary Metal-Oxide Semi-Conductor

Controller Area Network

A computer network protocol designed for the heavy equipment and automotive environment that allows microcontrollers and other devices to communicate with each other without using a host computer; also known as CAN.

controller I/O board

A development product that allows users to test products on a bench in a development environment before installing the product on a vehicle.

controller module

Any module that has embedded software used for controlling input and output functions.

current feedback

A circuit that allows software to measure the amount of current provided by the outputs. This circuit is typically connected to an analog input that is connected to the microprocessor. Note that current feedback is also known as current sense or current sensing.

current feedback control

Varying the duty cycle of an output so the output provides a desired amount of current to the load.

current sensing

When an analog input reads the amount of current flowing through an output driver circuit.

Data Link Adaptor (DLA)

A development tool that connects the CAN bus to a personal computer (through a USB or RS232 port), so that programming and diagnostics can be performed on the product before installing it in a vehicle.

DC-coupled

A circuit used with signals that have minimal DC offset. The signal being read by this circuit must fall within the detection threshold range specified for the input.

de-rating

To reduce the rated output current level to a value less than the specified rating. De-rating is typically done so a product does not over-heat.

digital input

An input that is typically controlled by an external switch that makes the input either active (on), or inactive (off).

driver (hardware)

An electronic device that switches power or ground to an external load. The driver is a key component used in all output circuits.

driver (software)

A block of software that provides access to different hardware components.

FET

Field Effect Technology

Field Effect Transistor (FET)

An electronic device used either as a power switch, or amplifier in electronic circuitry. FETs are typically used as drivers.

frequency input

An input that allows a frequency value to be read from an oscillating input signal.

gain

Increasing the voltage level of an input signal to maximize the resolution of an input.

ground shift

The difference in ground potential from one harness location to another, which is typical in systems with large wire harnesses and high current loads.

half-bridge

When a high-side and low-side switch are used together to provide a load with both a battery voltage and a ground.

H-bridge

A combination of two half-bridge circuits used together to form one circuit. H-bridges provide current flow in both directions on a load, allowing the direction of a load to be reversed.

high-side output

An output that provides switched battery voltage to an external load.

hysteresis

Causes the activation and deactivation voltage levels on an input to overlap, which ensures the input only changes state when there is a significant shift in voltage.

inductive load

A load that produces a magnetic field when energized. Inductors are electrical components that store energy and are characterized by the following equation:

$$E_{\text{stored}} = \frac{1}{2}LI^2$$

load

Any component that draws current from the module, and is typically switched “on” and “off” with outputs. Examples include bulbs, solenoids, motors, etc.

logic power

Power pins for the microprocessor and logic peripherals.

low-side output

An output that provides a switched ground voltage to an external load.

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 a broken/worn connector pin.

over-current

A fault state that occurs when a load draws more current than specified for an output, which results in the output shutting down to protect the circuitry of the product.

over-voltage

When the voltage exceeds the normal operating voltage of the product, which results in the VMM1615 shutting down to protect its circuitry.

power control input

A digital input that is used to turn on the product. When the input is active, the product "turns on” and operates in normal mode, and when the input is inactive, the product “powers down” and will not operate.

procurement drawing

A mechanical drawing showing the dimensions, pin-outs, and implemented configuration options for a Parker Vansco product.

Proportional Integral Differential (PID)

This refers to the proportional-integral-differential closed-loop control algorithm.

pull-down

A resistor that connects an input to a ground reference so that an open circuit can be recognized by the microprocessor, which is typically used on active-high digital inputs or analog inputs.

pull-up

A resistor that connects an input to a voltage reference so that an open circuit can be recognized by the microprocessor, which is typically used on active-low digital inputs or analog inputs.

Pulse Width Modulation (PWM)

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.

sensor power

A regulated voltage output that provides a set voltage level for analog sensors attached to the product.

shielded twisted-pair cable

A type of cable used for CAN communication that consists of two wires (CAN High and CAN Low) twisted together. These wires are covered by a shield material (CAN Shield) that improves the cable's immunity against electrical noise.

short-to-battery

A fault state that occurs when an input or output pin on the product is connected to battery power, potentially resulting in high current flow.

short-to-ground

A fault state that occurs when an input or output pin on the product is connected to system ground, potentially resulting in high current flow.

system noise

Electrical interference generated from external devices that affect the behaviour of inputs, outputs and sensors. System noise can be generated from things like the vehicle alternator, engine, transmission, etc.

trip time

The amount of time it takes a circuit to protect itself after a fault occurs.

Wake on CAN

A method of power control that makes the product turn on when a CAN message is received from another module in the system, and turn off as determined by the application software.

wetting current

The amount of current that flows into, or out of, a digital input. The current helps eliminate oxidation on the contacts of digital switches and relays. Switches with gold or silver contacts typically require much less wetting current than standard tinned contacts.

15. Index