Controller Module

CM2115

User Guide

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Contents

Publication History

The following table provides an overview of the changes made to this document over the course of its publication history.

Release Date	Description of Change
Rev. 001	First release of this document

Safety

Do not perform the procedures in this manual unless you are experienced in the handling of electronic equipment.

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.

Safety symbols

The following symbols are used in this document to indicate potentially hazardous situations:

Danger! Risk of death or injury.

Warning! Risk of damage to equipment or degradation of signal

When you see these symbols, follow the instructions carefully and proceed with caution.

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.

Follow the manufacturer's regulations when mounting, modifying, repairing, and maintaining equipment. The manufacturer assumes no responsibility for any accidents caused by incorrectly mounted or incorrectly maintained equipment. The manufacturer assumes no responsibility for the system being incorrectly applied, or the system being programmed in a manner that jeopardizes safety.

> ⚠ Do not use the product if electronic modules, cabling, or connectors are damaged or if the control system shows error functions.

> ⚠ 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.

Welding after installation

Complete as much as possible of the welding work on the chassis before the installation of the system. If welding has to be done afterwards, proceed as follows:

> ⚠ Do not place the welding unit cables near the electrical wires of the control system.

1. Disconnect the electrical connections between the system and external equipment.
2. Disconnect the negative cable from the battery.
3. Disconnect the positive cable from the battery.
4. Connect the welder's ground wire as close as possible to the place of the welding.

Construction regulations

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. If possible, the machine must be built so that the supply voltage to the control system's electrical units is disconnected when the operator leaves the operator’s station.

Safety during installation

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

Safety during start-up

Danger! Risk of death or injury. Do not start the machine's engine before the control system is mounted and its electrical functions have been verified.

Do not start the machine if anyone is near the machine.

Safety during maintenance and fault diagnosis

Before performing any work on the hydraulics control electronics, ensure that

- 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.

1. Understanding the CM2115

The Controller Module (CM) 2115 is a general purpose input/output controller that monitors digital, analog, and frequency inputs, and controls solid-state switched outputs.

The principal benefit of the CM2115 is that it can be configured to meet many system requirements through component configuration options, component value modification, and custom software.

Figure 1: CM2115 controller

Note: Although the CM2115 is typically used in a vehicle, it can also be used for other applications, such as industrial automation.

The CM2115 is designed to communicate through a J1939-based Controller Area Network (CAN). Custom CAN messaging can be created in software, and the CM2115 can be used in any CAN 2.0B application, including ISO 11783.

The software offered with the CM2115 is a low-level framework that uses the Parker Vansco Software Development Kit (SDK), which is a tool that enables you to create custom application software for your product.

The CM2115 has many features, including the following:

- The CM2115 has seven different types of inputs:

  - Programmable Analog – amplified
  - Programmable Analog – attenuated
  - Digital – Programmable up/down
  - Digital – Programmable pull up
  - 2 x Digital Wakeup – Pull down only
  - Frequency – AC coupled (populated as digital)
  - Frequency – DC coupled
  - The CM2115 analog inputs and frequency input can be configured to function as digital inputs
- The CM2115 has 5 different types of outputs
  - 8 x High Side – 6 x 10A and 2 x 5A
  - 2 x High Side – 5A with accurate current sense
  - 2 x High Side – 2.5A with accurate current sense
  - 1 x Low Side – 2.5A with accurate current sense
  - 2 x solid state relay – 1A
- The CM2115 can provide a signal sensor power supply output rated at up to 300 mA
- The CM2115 has 2 CAN busses, one with wake-on CAN function
- The CM2115 has four 12-pin Deutsch DT connectors that are used to interface with the inputs, outputs, and CAN communication

1.1. Regulatory Compliance

The CM2115 product has declarations of conformity for CE – 2004/1008/EC in accordance with the harmonized standards EN13309:2010 and ISO13766:2006. The product also has type approvals for

- e – EU Automotive directive 75/245/EEC as last amended by 2006/28/EC
- e – EU Agricultural and Forestry Tractors 75/322/EEC as last amended by 2009/64/EC
- E – United Nations mark for approved vehicles and vehicle components sold into the EU and some other countries under UN-ECE Regulation 10.04

Declaration of compliance with the required regulations is provided in separate declaration documents.

2. About the CM2115 User Guide

The CM2115 is designed to be used with configuration (stuffing) options, where specific customer requirements are met by modifying components and component values on a project by project basis. The manual cannot address all of the configurations that are possible - but only focuses on the most commonly used configuration.

The configuration in this manual has 2 CAN busses, 5V sensor supply and no status LEDs.

This manual describes the hardware components of the CM2115, 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.

2.1. Section Types

There are three kinds of sections in this manual: instruction, information, and example.

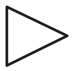
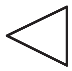
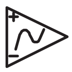
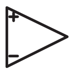
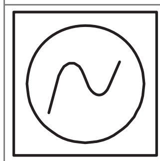
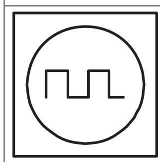
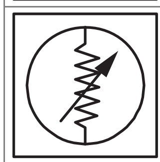
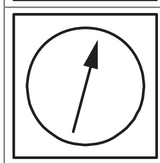
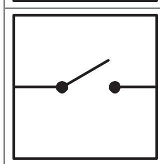
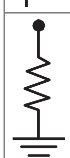
- **Instruction sections** – The only instruction section in this manual is the *Quick Start* section, which provides procedures for connecting the CM2115 to a development system, powering it up, and downloading application software.
- **Information sections** – Most sections in this manual are informational. They describe the hardware components of the CM2115, and usually have three sub-sections: capabilities, configuration options, and installation connections.

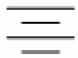
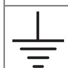
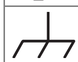
Note: The *configuration options sections* are a reference for what can be configured for each component of the CM2115. All hardware configuration must be selected early in the design process of your product, whereas some of the software configuration options can be implemented at anytime. If you already have a custom configuration for your product, you can ignore these sections.

- **Example sections** – The only example section in this manual is the *Application Examples* section, which provides descriptions, diagrams, and explanations for possible CM2115 applications.

2.2. Diagram conventions

The following symbols are used in the schematic diagrams in this document:

Symbol	Meaning
	General input
	General output
	Frequency input
	Analog input
	Frequency sensor
	Pulse sensor
	Resistive sensor
	General sensor
	Application switch
	Load
	Pull-down resistor

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

3. Quick Start

This section provides step-by-step instructions on how to connect the CM2115 to a development system, install the required software tools, and download the application software.

3.1. 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 CM2115 to a development system (desktop) and power it up.
4. Download application software.

3.2. Gather Required Materials

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

- CM2115
- personal computer (PC)
- controller I/O board
- controller I/O harness (connects the CM2115 to the controller I/O board)
- evaluation kit power harness (connects the controller I/O board to the power supply)
- Data Link Adapter (DLA) kit (comes with cables needed for connecting the DLA to your PC and to the rest of the system)
- desktop power supply compatible with the CM2115 and controller I/O board loads (a 12 V DC, 3 A fixed voltage supply is generally suitable, unless driving more significant loads)
- procurement drawing for the version of CM2115 you are using, indicating the configuration options for your variant of the product.

- software tools and files required for programming and downloading software for the CM2115.

Note: 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.

3.3. Install the Required Software Tools

Before you start using the CM2115, you must install the appropriate software tools onto your PC.

The CM2115 requires the following software tools:

- **Data Link Adapter (DLA) drivers:** The DLA acts as the interface between the PC and the CM2115 CAN bus. Before using the DLA, you must install the DLA drivers.
- **Flash Loader:** Software tool that transfers application software from your PC to the CM2115.

3.3.1. Install the Data Link Adapter Driver Software

A Data Link Adapter (DLA) is needed when connecting the CM2115 in a development system.

Note: 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.

The Parker Vansco DLA requires the installation of drivers on your PC. To install the Parker Vansco DLA drivers:

1. Download the driver, run the extracted file, and follow the Install Wizard. Do not connect the USB DLA until the driver installation is completed.
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**. If the driver is not detected automatically, you can browse to the folder containing the driver (default path C:\Program files\Vansco\USB-DLA).
4. After installation is finished, click **Finish**. The USB DLA is now recognized and ready to be used.

See the Parker Vansco USB DLA kit user manual for more detailed instructions.

3.3.2. Install Flash Loader

The Flash Loader doesn't actually need to be installed to work.

Refer to section *Transfer a Vansco Software File (VSF) to the CM2115* see "*Download Application Software using the Flash Loader*" on page 10 for more details about using the Flash Loader.

3.4. Connect the CM2115 to a Development System

It is a good idea to connect the CM2115 to a development system (PC, Controller I/O Board, power source, and DLA) to verify your application. The development system is an ideal environment for creating and downloading software applications.

The following shows how to connect the CM2115 in a development system:

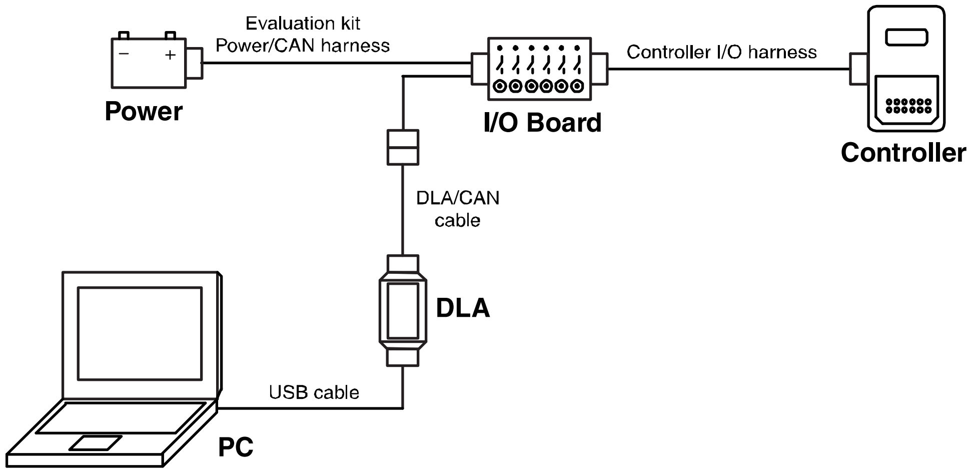


Figure 2: Development system connection

To connect the CM2115 in a development system, do the following:

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

1. Connect the Controller I/O harness to the CM2115 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.

   Note: Do not proceed to the next step before the DLA drivers have been installed. See *Install the Data Link Adapter Driver Software* on page 7.

7. Connect the DLA to a personal computer via the USB port.

3.4.1. Power Up the Development System

Once the CM2115 is connected in a development system, you need to power it up.

To power up the CM2115, do the following:

1. Ensure all controller I/O board digital inputs, jumpers, and dip switches are properly configured for the CM2115. Refer to the *Controller I/O Board Reference Manual* for further details.
2. Connect the power wire (red) from the evaluation kit power/CAN harness to the power supply (+), and turn the power supply on.
3. Turn on the controller I/O board switch that corresponds with the power control input on the CM2115 (refer to the *Controller I/O Board Reference Manual* for details). The power LED on the CM2115 lights up.

Note: If the power LED does not light-up and you are unsure if a power control input is set on the CM2115, try switching all the inputs on the controller I/O board to high, and then to low. If you continue to have problems, consult the Troubleshooting/FAQ section in the *Controller I/O Board Reference Manual* for help.

3.5. Download Application Software using the Flash Loader

The Flash Loader transfers application software files that were created using the Software Development Kit (SDK), from your PC to the CM2115.

This section assumes you have a Vansco Software File (VSF) that is ready to be transferred to the CM2115 using the Flash Loader. Parker Vansco provides a VSF with every CM2115.

Note: For more information about writing software for the CM2115 using the SDK, contact your Parker Vansco Account Representative.

- **If you are creating a custom application**, the provided VSF is a simple example application that can be transferred to the CM2115 to ensure the product works. Refer to the SDK manual for information on how to create a custom application.
- **If you are not creating a custom application**, the provided VSF file is the actual application that Parker Vansco has written for your CM2115.

To transfer the VSF file to the CM2115

1. Set the Controller I/O Board harness **power switch** to the **on** position.
2. Set the Controller I/O Board harness **ignition switch** to the **on** position.
3. Run **FlashLoader.exe**.

   The *Flash Loader* screen opens, showing a box on the left that lists every module on the J1939 network that supports the J1939.

   Note: Additional modules may appear in the modules list, as they also support J1939. Although these “extra” modules support J1939, they won't always support downloading over J1939 with the Flash Loader.

4. From the modules list, select **CM2115**.
5. From the **Software File Details** list, select your VSF file.
6. Click **Start**.

   Your VSF file downloads to the CM2115.

   Once complete, a confirmation screen opens.

7. Click **OK**.

   The CM2115 is now running the application code.

4. Connectors and Pinouts

The CM2115 has four 12-pin Deutsch DT connectors:

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

These connectors are used to connect to the inputs, outputs, and communication channels used by the CM2115. The connectors are keyed to prevent incorrect mating with the vehicle harness.

The vehicle harness should be designed to interface with all connectors. To eliminate mis-mating, it is recommended that the harness-side connectors have enhanced keying.

The required mating connectors are:

Figure 3: Connector J1

Figure 4: Connector J2

Figure 5: Connector J3

Figure 6: Connector J4

The maximum wire gage for the J1, J2, J3, and J4 connectors is 16 AWG with GXL insulation.

The CM2115 also has two 1-pin Deutsch DTHD connectors for busbar power (power for high-side outputs):

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

The required connector is:

The maximum wire gage for the J5 and J6 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.

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

4.1. CM2115 pinouts

Pins connect to inputs, outputs, and communication channels. They provide the interface between the vehicle harness and the internal circuitry of the CM2115.

The following tables show the pinouts for each connector:

J1 Connector (Brown) Pinout		
Pin	**Name**	**Function**
1	OUTPUT1_10A_HS	10 A High-side output
2	GND	Ground
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

J2 Connector (Gray) Pinout		
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	2.5 A Low-side output
9	OUTPUT15_SSR_B	Solid state relay pin B
10	OUTPUT15_SSR_A	Solid state relay pin A
11	SENSOR_SUPPLY	+5 V or +8 V sensor power
12	OUTPUT2_10A_HS	10 A High-side output

J3 Connector (Green) Pinout		
Pin	**Name**	**Function**
1	OUTPUT7_5A_HS	5 A High-side output with current sense
2	OUTPUT5_10A_HS	10 A High-side output
3	INPUT1_D	Digital input, power control, active high
4	INPUT21_D	Digital input, active low
5	OUTPUT9_5A_HS	5 A High-side output
6	OUTPUT3_10A_HS	10 A 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	2.5 A High-side output with current sense

J4 Connector (Black) Pinout		
Pin	**Name**	**Function**
1	OUTPUT12_2A5_HS	2.5 A High-side output with current sense
2	GND	Ground
3	INPUT17_D	Digital input, active low
4	INPUT18_D	Digital input, active low
5	INPUT19_D	Digital input, active low
6	INPUT20_D	Digital input, active low
7	OUTPUT4_10A_HS	10 A High-side output
8	OUTPUT10_5A_HS	5 A High-side output
9	INPUT16_AD	Analog or Digital input
10	INPUT3_D	Digital input
11	OUTPUT6_10A_HS	10 A High-side output
12	OUTPUT8_5A_HS	5 A High-side output with current sense

5. Inputs

The CM2115 has digital, frequency, and analog inputs.

> ⚠ ***Damage to equipment!*** Do not connect inputs directly to unprotected inductive loads such as solenoids or relay coils, as these can produce high voltage spikes that may damage the CM2115. If an inductive load must be connected to an input, use a protective diode or transorb.

5.1. Programmable Digital Inputs

The CM2115 has 4 programmable digital inputs:

- `INPUT3_D` through `INPUT6_D`.

5.1.1. Programmable Digital Input Capabilities

The following table provides specifications for the CM2115's programmable digital inputs:

Programmable Digital Input Specifications				
Item	**MIN**	**NOM**	**MAX**	**UNIT**
Input voltage range	0	-	32	V
Overvoltage	-	-	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
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	-	-	1.32	kΩ
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	-	-	2.1	kΩ
Active High - Activating Resistance @ 32V	5.5	-	-	kΩ
Active High - Deactivating Resistance @ 32V	-	-	14.6	kΩ
Active High - Activating Resistance @ 6V	2.4	-	-	kΩ
Active High - Deactivating Resistance @ 6V	-	-	6.9	kΩ

5.1.2. 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.

A digital switch (typically connected to a digital input) usually requires wetting current to burn 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 CM2115 is 10 mA at 7.5 V DC.

5.2. Active-Low Digital Inputs

The CM2115 has 5 active-low digital inputs that are used for module addressing when the CM2115 hardware is configured as a VMM module:

- `INPUT17_D` to `INPUT21_D`

5.2.1. Active-Low Digital Input Capabilities

The following table provides specifications for the CM2115 active-low digital inputs:

Active-Low Digital Input Specifications				
Item	**Min**	**Nom**	**Max**	**Unit**
Input voltage range	0	-	32	V
Over-voltage	-	-	36	V
Pull-up resistance	9.8 k	-	10.2	kΩ
Minimum negative going threshold	0.9	-	-	V
Maximum positive going threshold	-	-	2.15	V
Cutoff frequency (hardware)	-	80	-	Hz
De-bounce *time*[1]	-	-	-	ms
Wetting current	316	-	343	uA
Leakage current sleep mode - pin grounded or floating	-	0	-	A

5.2.2. Active-Low Digital Input Installation Connections

An active-low digital input is typically connected to a switch that is either open or closed.

- When the switch is open, the pull-up resistor will ensure no signal exists on the input pin, which will be interpreted by the CM2115 as inactive.
- When the switch is closed, the input is connected to ground, which will be interpreted by the CM2115 as active.

The active-low input must be connected to ground to ensure there is a ground connection when the state of the input changes.

[1] De-bounce time for address inputs is based on hardware cutoff frequency. The software reads the address in succession during power-up until it receives two consecutive results that are the same. The time between readings is in the microsecond range so there is technically no software de-bounce on these inputs.

The following shows a typical active low digital input connection:

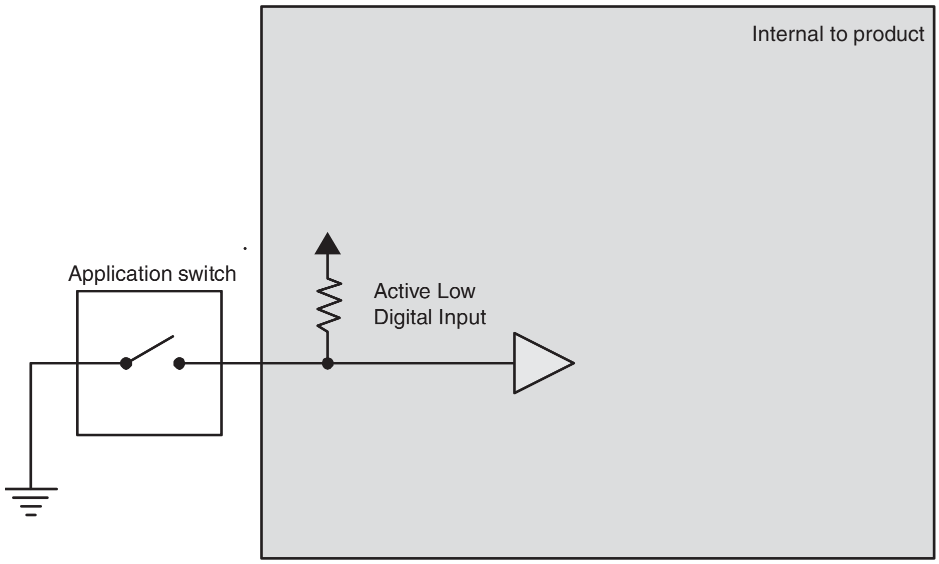


Figure 7: Active low digital input connections

5.3. Power Control Digital Inputs

The CM2115 has 2 active-high power control digital inputs that are used for waking up (turning on) the product, as follows:

- `INPUT1_D` and `INPUT2_D`

5.3.1. Power Control Input Capabilities

The CM2115 has 2 active high digital inputs that can be used for power control. This type of input has a pull down resistor only. The power control input requires an active high signal to be detected by the microprocessor, as well as to power up the module.

The following table provides specifications for the CM2115's power control digital input:

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	1.9	2.0	2.1	kΩ
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

Note: 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 CM2115 when switched high to a voltage of 3.9 V or greater, and turns the CM2115 off when switched low to a voltage less than 1.4 V. The CM2115 also shuts off when an open circuit condition occurs on the power control digital input.

5.3.2. 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 CM2115 will go into sleep mode.

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

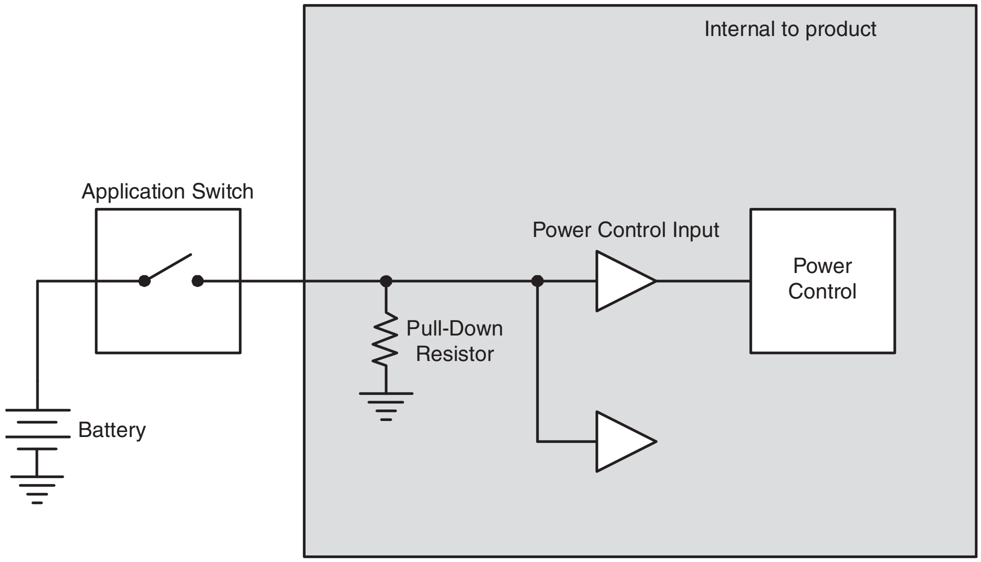


Figure 8: Power control digital input installation connections

5.4. CM2115 Digital Input

The CM2115 has 1 additional digital input:

- INPUT7_D

5.4.1. CM2115 Digital Input Capabilities

This input has programmable pull up/down resistors.

The following table provides specifications for the CM2115's additional digital input.

Digital Input Specifications				
Item	**MIN**	**NOM**	**MAX**	**UNIT**
Input voltage range	0	-	32	V
Over-voltage	-	-	36	V
Pull-up/down resistance	5.31	5.36	5.41	kΩ
Capacitance at pin	-	0.005	-	μF
Inductive load protection	-	Yes	-	-
Negative going input threshold	-	-	1.56	V
Positive going input threshold	3.82	-	-	V

5.5. CM2115 DC-Coupled Frequency Input

There is one type of frequency input in the CM2115:

- DC-coupled frequency input

The input detects frequency signals that are pre-conditioned to fall within the DC threshold ranges of the input. Unlike an AC-coupled input, this input is used with frequency sensors that switch between system ground and sensor/battery power. Typical sensor types are Hall Effect.

The CM2115 has one DC-coupled frequency input:

- INPUT8_DF

5.5.1. CM2115 DC-Coupled Frequency Input Capabilities

A DC-coupled frequency input allows you to read the frequency of external signals that switch between system ground, and sensor or battery power. This input is ideal for use with hall-effect type sensors.

The following table provides specifications for the CM2115's DC-coupled frequency input:

DC-Coupled Frequency Input Specifications				
Item	**MIN**	**NOM**	**MAX**	**UNIT**
Input voltage range	0	-	32	V
Pull-up/pull-down resistance	5.31	5.36	5.41	kΩ
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

5.5.2. CM2115 DC-Coupled Frequency Input Configuration

The DC-coupled frequency input can be configured to use a pull-up resistor, pull-down resistor or neither.

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

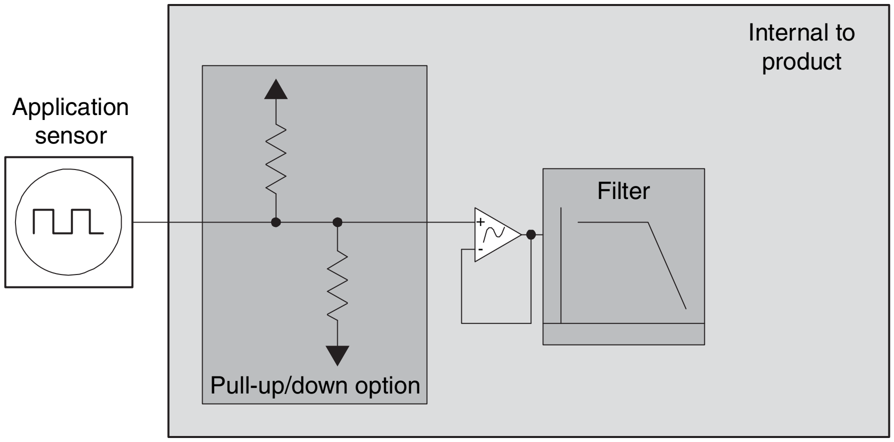


Figure 9: DC-coupled frequency input configuration

5.6. Analog Inputs

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

The CM2115 has 8 analog inputs:

- INPUT9_AD through INPUT16_AD

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

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

5.6.1. Analog Input Capabilities

Type 1 analog inputs have programmable gain and are driven through an amplifier 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 CM2115's type 1 analog inputs:

Type 1 Analog Input Specifications				
Item	**MIN**	**NOM**	**MAX**	**UNIT**
Input voltage range	0	-	32	V
Overvoltage	-	-	36	V
Inductive load protection	-	No	-	-
Pull-up voltage		V_{LOGIC} - 0.7		V
Pull-up resistance	3.29k	3.33k	3.36k	Ω
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	74.9	-	-	KΩ
Resolution	-	-	11.25	Bit
Frequency cutoff	-	23	-	Hz

Type 1 Analog Input Voltage Ranges					
GAIN	Max Volts	ATN1	ATN2	GAIN1	GAIN2
5.005	0.599	OFF	OFF	ON	ON
4.005	0.749	OFF	OFF	OFF	ON
2.000	1.500	OFF	OFF	ON	OFF
1.000	3.000	OFF	OFF	OFF	OFF
0.962	3.119	ON	OFF	ON	ON
0.770	3.898	ON	OFF	OFF	ON
0.739	4.058	OFF	ON	ON	ON
0.592	5.072	OFF	ON	OFF	ON
0.456	6.578	ON	ON	ON	ON
0.384	7.806	ON	OFF	ON	OFF
0.365	8.220	ON	ON	OFF	ON
0.295	10.157	OFF	ON	ON	OFF
0.192	15.611	ON	OFF	OFF	OFF
0.182	16.462	ON	ON	ON	OFF
0.148	20.314	OFF	ON	OFF	OFF
0.091	32.925	ON	ON	OFF	OFF

Type 2 analog inputs have programmable attenuation and are driven directly into the module analog to digital converter (ADC). 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 CM2115's Type 2 analog inputs:

Type 2 Analog Input Specifications				
Item	MIN	NOM	MAX	UNIT
Input voltage range	0	-	32	V
Overvoltage	-	-	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
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

Type 2 Analog Input Ranges - INPUT 15			
GAIN	**Max Volts**	**ATN1**	**ATN2**
1.000	3.000	OFF	OFF
0.192	15.611	ON	OFF
0.148	20.314	OFF	ON
0.091	32.925	ON	ON

Type 2 Analog Input Ranges - INPUT 11-14, 16			
GAIN	**Max Volts**	**ATN1**	**ATN2**
1.000	3.000	OFF	OFF
0.542	5.535	ON	OFF
0.223	13.423	OFF	ON
0.188	15.958	ON	ON

5.6.2. Analog Input Configurations

The analog inputs have the ability using 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 in your application and the corresponding attenuation and gain

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

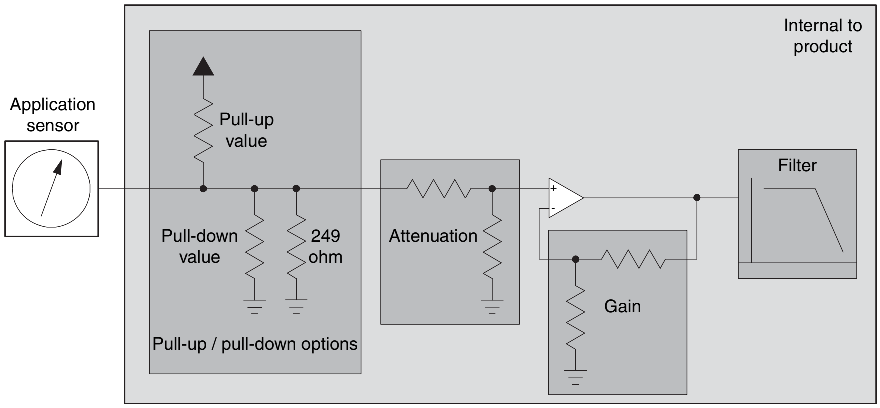


Figure 10: Type 1 analog input configuration options

With Type 2 analog inputs (INPUT11_AD through INPUT16_AD)

- Select the input voltage range in your application and the corresponding attenuation.

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

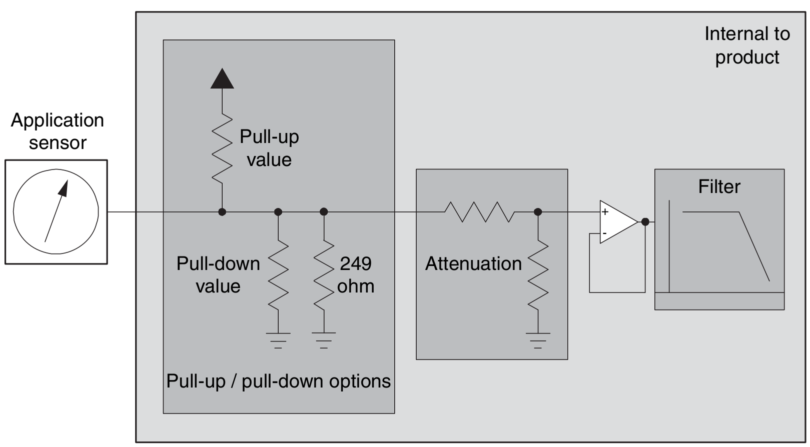


Figure 11: Type 2 analog input configuration options

6. Outputs

The CM2115 has 15 solid-state outputs. Output currents can range from 1.0 to 10.0 Amps.

The CM2115 has 4 types of outputs:

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

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* 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

6.1.1. 10 A High-Side Output Capabilities

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

The following table provides specifications for the CM2115's 10 A high-side outputs:

10 A 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
Overvoltage	-	-	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 gain	-	77	-	mV/A
Current sense resolution/bit	-	15.9	-	mA
Current sense accuracy @ 10 A	-	-	30	%
Leakage current when off	-	-	51	uA

Fixed Output Protection

The outputs have the following fixed protection mechanisms:

- Software fuse – The software samples the measured current at a predefined rate and compares this value to a set of current ranges. In these ranges multipliers are specified which either increment or decrement the fuse value by a multiplier. If the fuse value reaches the trip point, the output is shut off. The fuse value cannot be decremented below the minimum fuse value. This mechanism is disabled in the event of a hard short circuit
- Software short circuit – The output has software short circuit detection. If the output is PWM'd, the digital feedback is sampled at each falling edge. If the output is simply turned on, the digital feedback is sampled at the set frequency.

10 A High-Side Output Software Short Circuit Specifications				
Item	**MIN**	**NOM**	**MAX**	**UNIT**
Digital feedback negative going threshold	-	-	2.58	V
Digital feedback positive going threshold	2.75	-	-	V
Sample rate	1	-	5000	Hz

- Over temperature – If the temperature of the driver IC reaches the thermal trip point, the output is disabled. The output will be re-enabled when the driver cools down to an acceptable level.

6.1.2. 5 A High-Side Output Capabilities

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

The following table provides specifications for the CM2115's 5 A high-side outputs:

5 A 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
Overvoltage	-	-	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	9.9	10	10.1	kΩ
Current Sense gain	-	111	-	mV/A
Current Sense resolution	-	-	11.0	mA
Current Sense accuracy @ 5A	-	-	25	%
Leakage current when off	-	-	15	uA

Fixed Output Protection

The outputs have the following fixed protection mechanisms:

- Software fuse – The software samples the measured current at a predefined rate and compares this value to a set of current ranges. In these ranges multipliers are specified which either increment or decrement the fuse value by a multiplier. If the fuse value reaches the trip point, the output is shut off. The fuse value cannot be decremented below the minimum fuse value. This mechanism is disabled in the event of a hard short circuit
- Software short circuit – The output has software short circuit detection. If the output is PWM'd, the digital feedback is sampled at each falling edge. If the output is simply turned on, the digital feedback is sampled at the set frequency.

5 A High-Side Output Software Short Circuit Specifications				
Item	**MIN**	**NOM**	**MAX**	**UNIT**
Digital feedback negative going threshold	-	-	2.69	V
Digital feedback positive going threshold	2.86	-	-	V
Sample rate	1	-	5000	Hz

- Over temperature – If the temperature of the driver IC reaches the thermal trip point, the output is disabled. The output will be re-enabled when the driver cools down to an acceptable level.
- Hardware overcurrent protection – The output has hardware overcurrent protection which will disable the output when a potentially damaging overcurrent situation is detected. The tripping threshold of the circuit is a function of both current and time. The figure shows the envelope of inrush current that the circuit is designed to permit. An inrush profile with currents outside of this envelope is not guaranteed to pass through without tripping the hardware overcurrent circuit.

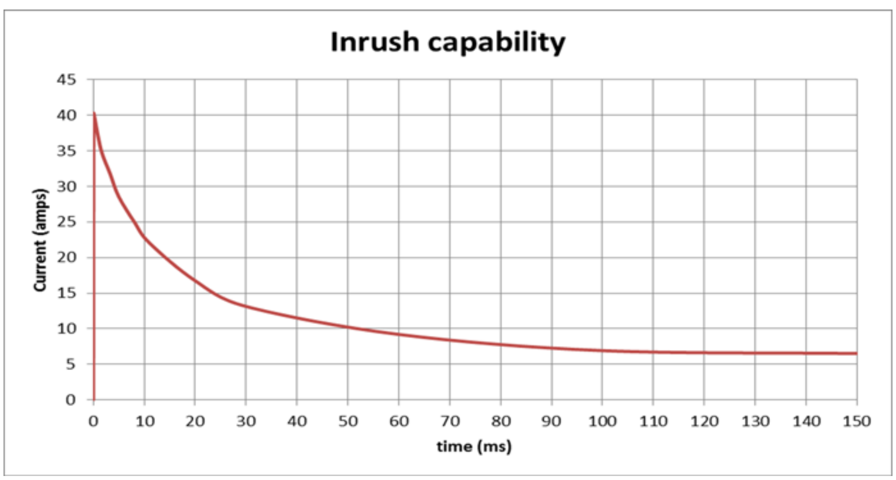


Figure 12: High Side Output - 5A Inrush envelope

6.1.3. 5 A High-Side Output with Current Sense Capabilities

These outputs provide 5 A maximum continuous current with accurate current sensing. The current sensing provides accurate readings to detect single load disconnect on parallel driven load applications (i.e. when multiple loads are driven by a single output).

The following table provides specifications for the CM2115's 5 A high-side outputs:

5 A High-Side Output with Current Sense Specifications				
Item	**MIN**	**NOM**	**MAX**	**UNIT**
Switchable voltage range	6	-	32	V
Output current	0	-	5	A
Output on state resistance	-	20	-	mΩ
Overvoltage	-	-	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 (5 A)	-	3	-	%
Leakage current when off	-	-	15	uA

Fixed Output Protection

The outputs have the following fixed protection mechanisms:

- Software fuse – The software samples the measured current at a predefined rate and compares this value to a set of current ranges. In these ranges multipliers are specified which either increment or decrement the fuse value by a multiplier. If the fuse value reaches the trip point, the output is shut off. The fuse value cannot be decremented below the minimum fuse value. This mechanism is disabled in the event of a hard short circuit
- Software short circuit – The output has software short circuit detection. If the output is PWM'd, the digital feedback is sampled at each falling edge. If the output is simply turned on, the digital feedback is sampled at the set frequency.

5 A High-Side Output w/CS Software Short Circuit Specifications				
Item	**MIN**	**NOM**	**MAX**	**UNIT**
Digital feedback negative going threshold	-	-	2.69	V
Digital feedback positive going threshold	2.86	-	-	V
Sample rate	1	-	5000	Hz

- Over temperature – If the temperature of the driver IC reaches the thermal trip point, the output is disabled. The output will be re-enabled when the driver cools down to an acceptable level.
- Hardware overcurrent protection – The output has hardware overcurrent protection which will disable the output when a potentially damaging overcurrent situation is detected. The tripping threshold of the circuit is a function of both current and time. The figure shows the envelope of inrush current that the circuit is designed to permit. An inrush profile with currents outside of this envelope is not guaranteed to pass through without tripping the hardware overcurrent circuit.

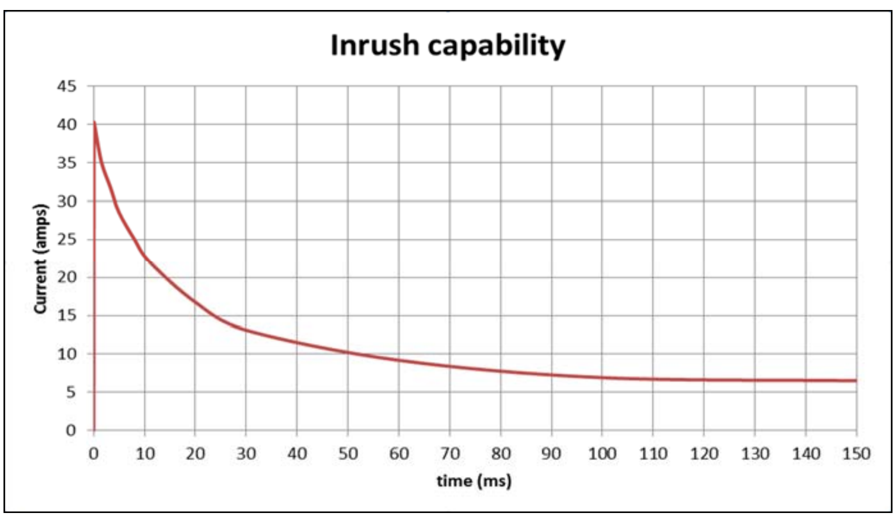


Figure 13: High side output - 5A current sense inrush envelope

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

These outputs provide 2.5 A maximum continuous current with accurate current sensing. The current sensing provides accurate readings to detect single load disconnect on parallel driven load applications (i.e. when multiple loads are driven by a single output). The current sensing can also be used for regulating current control of hydraulic coils.

The following table provides specifications for the CM2115's 2.5 A high-side outputs:

2.5 A 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
Overvoltage	-	-	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
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 (2.5 A)	-	3	-	%
Leakage current	-	-	16	uA

Fixed Output Protection

The outputs have the following fixed protection mechanisms:

- Software fuse – The software samples the measured current at a predefined rate and compares this value to a set of current ranges. In these ranges multipliers are specified which either increment or decrement the fuse value by a multiplier. If the fuse value reaches the trip point, the output is shut off. The fuse value cannot be decremented below the minimum fuse value. This mechanism is disabled in the event of a hard short circuit
- Software short circuit – The output has software short circuit detection. If the output is PWM'd, the digital feedback is sampled at each falling edge. If the output is simply turned on, the digital feedback is sampled at the set frequency.

2.5 A High-Side Output w/CS Software Short Circuit Specifications				
Item	**MIN**	**NOM**	**MAX**	**UNIT**
Digital feedback negative going threshold	-	-	2.63	V
Digital feedback positive going threshold	2.80	-	-	V
Sample rate	1	-	5000	Hz

- Over temperature – If the temperature of the driver IC reaches the thermal trip point, the output is disabled. The output will be re-enabled when the driver cools down to an acceptable level.

6.1.5. High-Side Output Configuration

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 by the programmer using software if the output is connected to sensitive loads, such as LEDs.

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

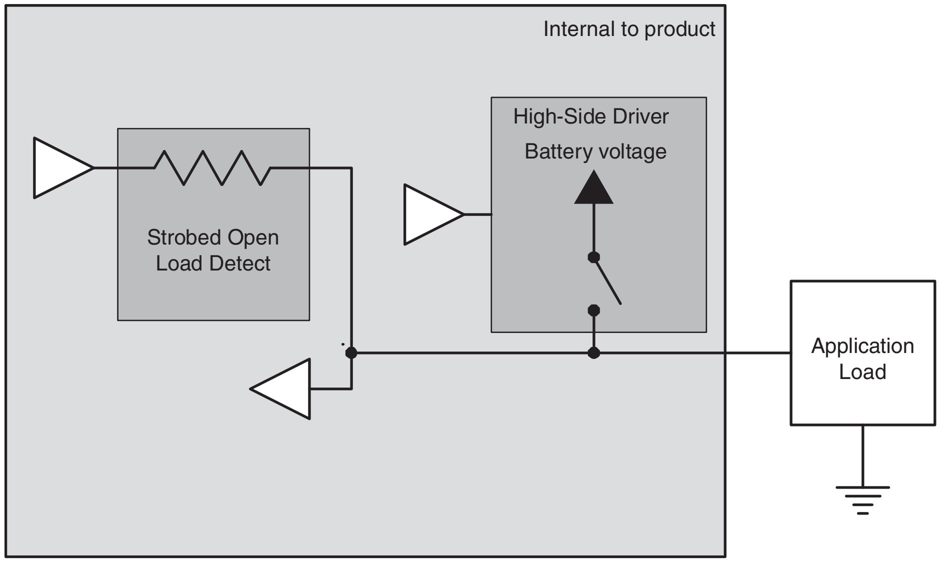


Figure 14: High side output configuration

6.1.6. High-Side Output Connections

When connecting high-side outputs, note that:

- 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 10 A, 2x 5 A, and 1x 2.5 A outputs. Maximum load on each busbar is 40 A.
- 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).

Note: If large inductive loads are used, and the high-side output is providing a continuous PWM signal, 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 one half of the peak current).

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

- Do not connect high-side outputs to loads that will draw currents greater than the maximum peak current or maximum continuous current.
- Connect the load grounds in close physical proximity to the power grounds.

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

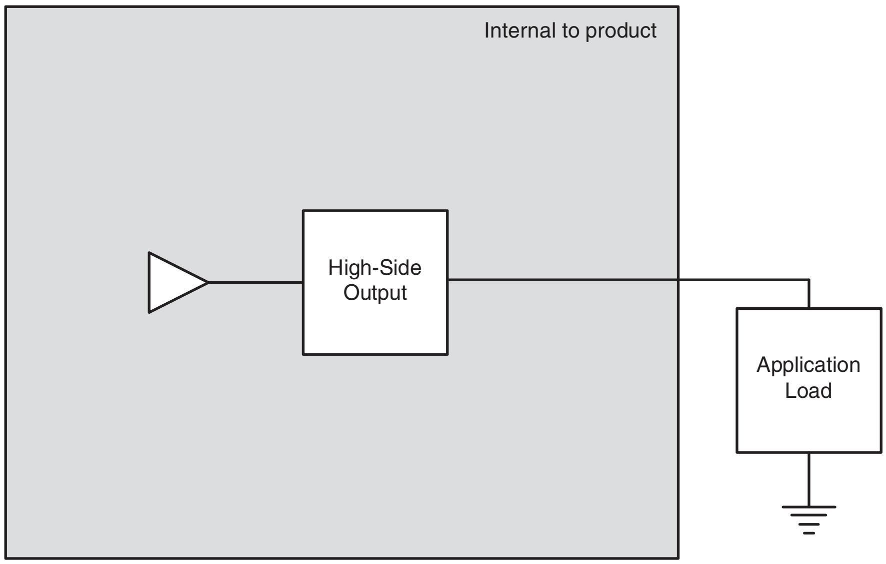


Figure 15: High-side output installation connections

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

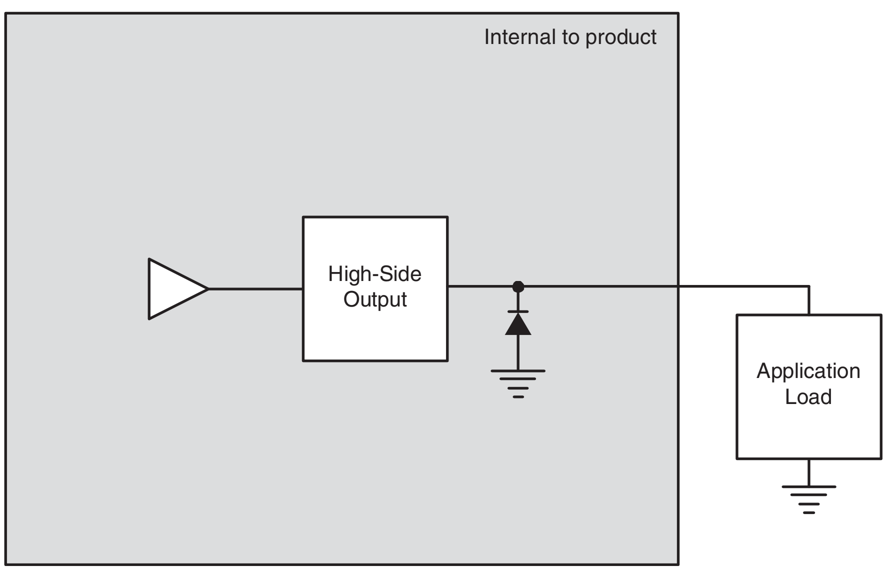


Figure 16: Typical high-side output installation connections

6.2. 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 CM2115 has 1 low-side output:

- OUTPUT13_2A5_LS

The length of the duty cycle is defined in the application software.

Note: Current flow is 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 2.5 A 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 CM2115's low-side output:

2.5A Low-Side Output Specifications				
Item	**MIN**	**NOM**	**MAX**	**UNIT**
Switchable voltage range	6	-	V_{LOGIC}	V
Output current	0	-	2.5	A
Output on state resistance	-	82	-	mΩ
Overvoltage	-	-	36	
Short Circuit Protection	-	13	-	A
Short Circuit Trip Time	-	-	1	ms
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 (2.5 A)	-	3	-	%
Leakage current when off	-	-	10	uA

Fixed Output Protection

The outputs have the following fixed protection mechanisms:

- Software fuse – The software samples the measured current at a predefined rate and compares this value to a set of current ranges. In these ranges multipliers are specified which either increment or decrement the fuse value by a multiplier. If the fuse value reaches the trip point, the output is shut off. The fuse value cannot be decremented below the minimum fuse value. This mechanism is disabled in the event of a hard short circuit
- Hardware overcurrent protection – The output has hardware overcurrent protection which will disable the output when a potentially damaging overcurrent situation is detected. The tripping threshold of the circuit is a function of both current and time. The figure shows the envelope of inrush current that the circuit is designed to permit. An inrush profile with currents outside of this envelope is not guaranteed to pass through without tripping the hardware overcurrent circuit.

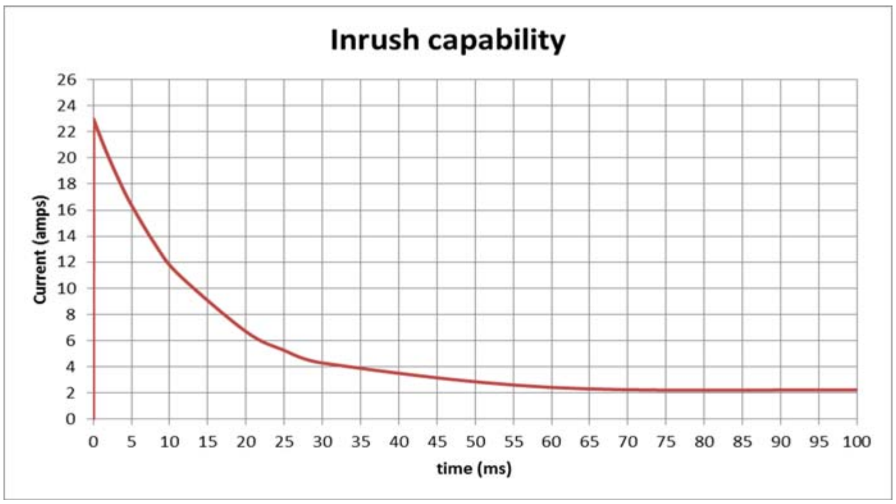


Figure 17: Low Side output - 2.5A Inrush envelope

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:

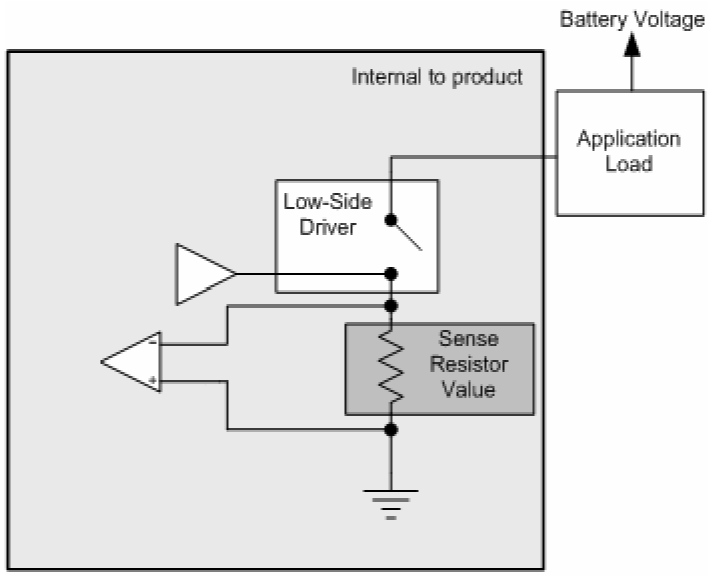


Figure 18: Low-side output with current sense configuration

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 same voltage that is applied to the VBATT_LOGIC power pin.

The CM2115 has 2 solid state relays:

- OUTPUT14_SSR_A/OUTPUT14_SSR_B and OUTPUT15_SSR_A/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 1.0 A maximum continuous current between their terminals.

The following table provides specifications for the CM2115's solid state relay:

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
Overvoltage	-	-	V_{LOGIC}	V
PWM frequency	-	-	0	Hz
Inductive pulse protection	-	-	628	V (peak)
Short Circuit Protection	-	4	-	A
Short Circuit Trip time	-	-	1	ms
Leakage current when off	-	-	±160	uA

6.3.1.1. Fixed Output Protection

The outputs have the following fixed protection mechanisms:

- Hardware overcurrent protection – The output will be disabled when a potentially damaging overcurrent situation is detected. The tripping threshold of the circuit is a function of both current and time. The figure shows the envelope of inrush current that the circuit is designed to permit. An inrush profile with currents outside of this envelope is not guaranteed to pass through without tripping the hardware overcurrent circuit.

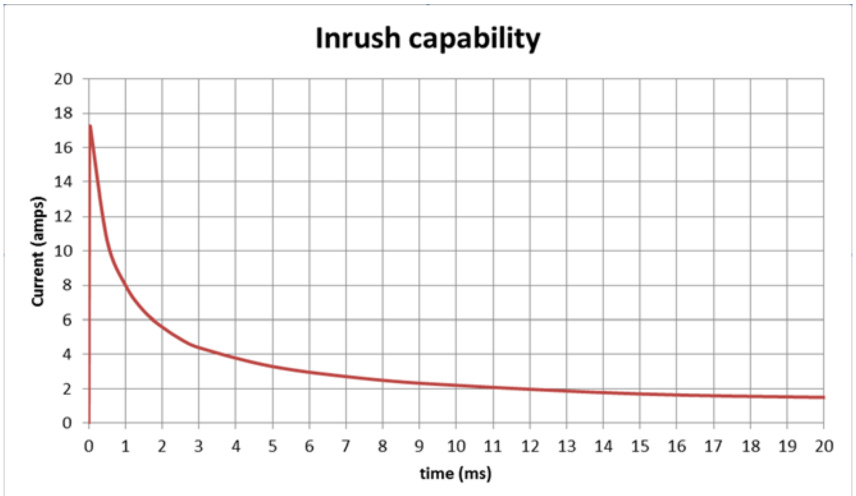


Figure 19: Solid State Relay Output Inrush Capability

6.3.2. Solid State Relay Diagnostics

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

6.3.2.1. 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.

6.3.3. Solid State Relay Installation Connections

When connecting solid state relays, note that

- 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:

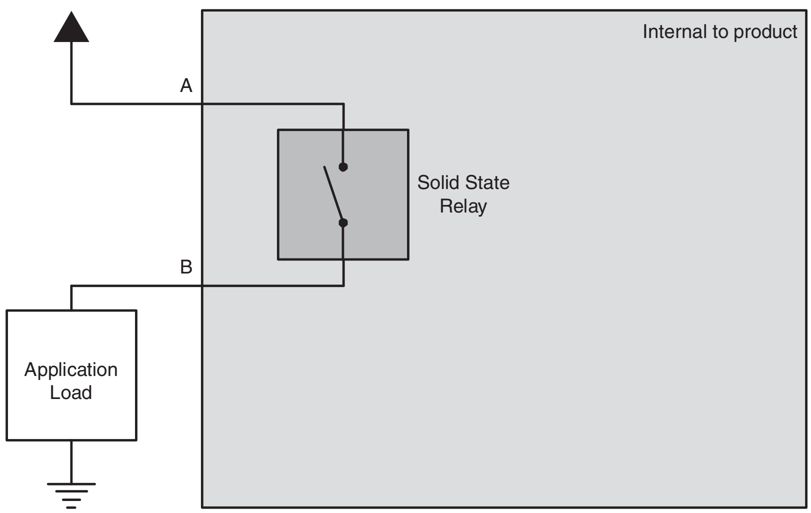


Figure 20: Solid State Relay switching high

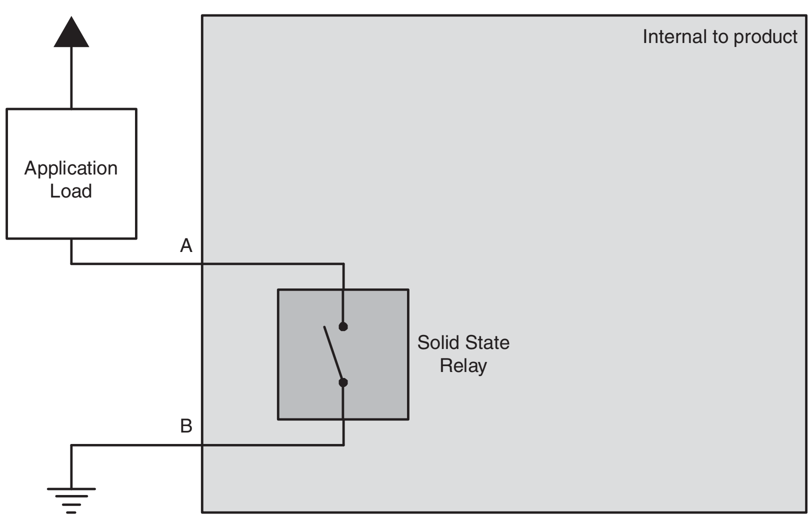


Figure 21: Solid State Relay switching low

7. Power

The CM2115 is powered by the vehicle battery. The CM2115 operates in a 12 V or 24 V system, and can operate from 6.5 V up to 32 V, with over-voltage protection at 36 V.

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

7.1. Logic Power

The CM2115 has one pin, labeled VBATT_LOGIC, dedicated to providing power for logic circuitry, and three pins, labeled GND, dedicated to grounding the CM2115.

7.1.1. Logic Power Capabilities

Logic power provides power to the logic circuit, which consists of the microprocessor, RAM, etc.

While this input can be connected to any voltage within the specified voltage range, it is required that the voltage be greater than or equal to the maximum voltage present on either of the busbar inputs, and the bias for any low side or solid state relay outputs. Failure to do so may damage the module.

The following table provides specifications for the CM2115 logic power:

Logic Power Specifications				
Item	**MIN**	**NOM**	**MAX**	**UNIT**
Input voltage range	6	-	32	V
Overvoltage	-	-	36	V
Current, operating mode @ 6V	-	-	700	mA
Current, operating mode @ 32V	-	-	180	mA
Current, sleep mode @ 32V	-	0.3	1	mA
Recommended inline fuse	-	-	10	A
Recommended inline circuit breaker	-	-	6	A

7.2. Busbar Power

There are two main power connections for the high current bus bar battery power inputs (BUSBAR1 and BUSBAR2). The busbar inputs are separated into two connectors (J1 and J2).

7.2.1. Busbar 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 CM2115 busbar power:

Busbar Power Specifications				
Item	**MIN**	**NOM**	**MAX**	**UNIT**
Number of busbars	-	2	-	
Busbar voltage range	6	-	32	V
Overvoltage (5 minutes)	-	-	36	V
Busbar current (per connector)	-	-	40	A
Inline fuse required on busbar pins	-	-	50	A

7.3. Logic and Output Power Connections

When connecting the CM2115 logic power, note that

- Logic power connections are made using the VBATT_LOGIC and GND pins.
- The CM2115 is protected against reverse-battery connections by an internal high-current conduction path that goes from ground to power. To protect the CM2115 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.

Note: Reverse-battery protection is only guaranteed when using standard automotive 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.

- All power connections to the CM2115 should be fused to protect the vehicle harness.

8. Sensor supply

The CM2115 has one pin, labeled `SENSOR_SUPPLY`, dedicated to providing power to external sensor.

> ⚠ ***Warning!*** Do not drive more than 100 mA of current through the `SENSOR_SUPPLY` pin. Doing so will cause the pin to protect itself by dropping the voltage, which will result in a lack of power to the sensors, causing unknown vehicle responses.

8.1. Sensor Power Capabilities

`SENSOR_SUPPLY` is a 5V linear power supply that is capable of continuously providing up to 100mA to external sensors.

Note: The voltage provided to the CM2115 must be 6.5 V or greater to ensure the sensor supply can provide 5 V.

Depending on system voltage, `SENSOR_SUPPLY` is capable of delivering different amounts of current to the sensors, as detailed in the following table:

Maximum Sensor Current at Various Voltages	
Input Voltage	**Maximum Sensor Current**
6.5–14 VDC	100 mA
14–24 VDC	50 mA
24–32 VDC	30 mA

The following table provides specifications for the CM2115 sensor power:

Sensor Power Specifications				
Item	**Min**	**Nom**	**Max**	**Unit**
Input voltage range	6.5	-	32	V
Overvoltage	-	-	36	V
Output voltage range	4.8	5	5.2	V
Output voltage accuracy	-	4	-	%
Output current (linear) @ 6.5 to 14 V battery	0	-	100	mA
Output current (linear) @ 14 to 24 V battery	0	-	50	mA
Output current (linear) @ 24 to 32 V battery	0	-	30	mA
Number of sensor power connector pins	-	1	-	-

8.1.1. 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:

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.

8.2. Sensor Power Connections

For information on how to connect sensors, refer to *Application Examples* on page 57.

9. Communication

The only type of communication available to the CM2115 is Controller Area Network (CAN) communication.

9.1. Controller area network

The CM2115 has 2 Controller Area Network (CAN) communication port(s) available. The CM2115 hardware provides controller area network (CAN) communication according to the SAE J1939 specification, making the CM2115 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.

9.1.1. J1939 CAN Capabilities

The CAN communicates information at a rate of 250 kbps. CM2115 input and output information is transmitted through the CAN at a broadcast 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.

The following table provides specifications for the CAN:

Item	Min	Nom	Max	Unit
Max voltage	-	-	32	V
Onboard terminator option	-	No	-	
Wake on CAN option	-	No	-	
Baud rate	-	250	-	kbps
J1939 compliant	-	Yes	-	

9.1.2. J1939 CAN Installation Connections

The CAN connection for the CM2115 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.

Note: The CM2115 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 as follows:
  a. Connect CAN Shield to the point of least electrical noise on the CAN bus.
  b. Connect CAN Shield as close to the center of the CAN bus as possible.
  c. Use the lowest impedance connection possible.

Note: 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 Cannon 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 meters and must have a 120 Ω terminating resistor at each end. The 120 Ω terminating resistors eliminate 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 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:

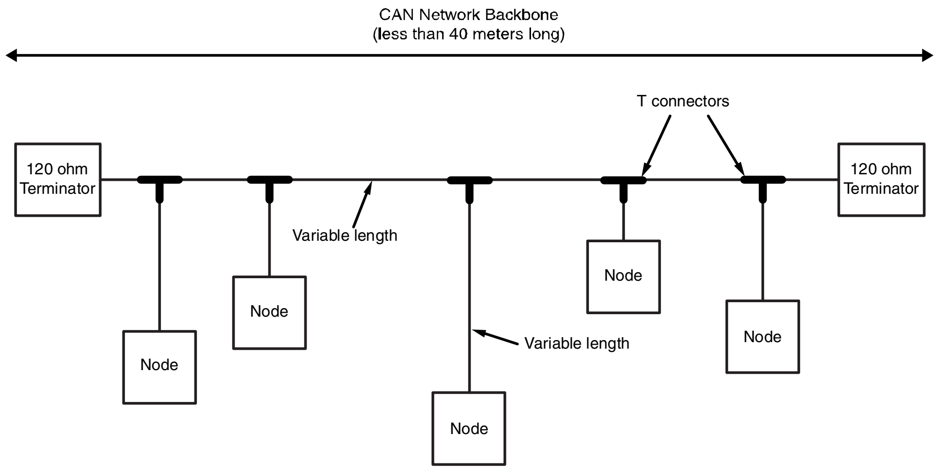


Figure 22: J1939 CAN connection

10. Installation

Because every system is different, it is not feasible to provide detailed installation instructions that will be suitable for every assembly. This chapter therefore provides only high-level guidelines on installing the CM2115.

The vehicle manufacturer is responsible for creating procedures for mounting the CM2115 in a vehicle during production assembly.

10.1. Mechanical Installation Guidelines

Use the following guidelines when installing the CM2115 in a vehicle.

10.1.1. CM2115 Dimensions

The following diagram shows the dimensions of the CM2115:

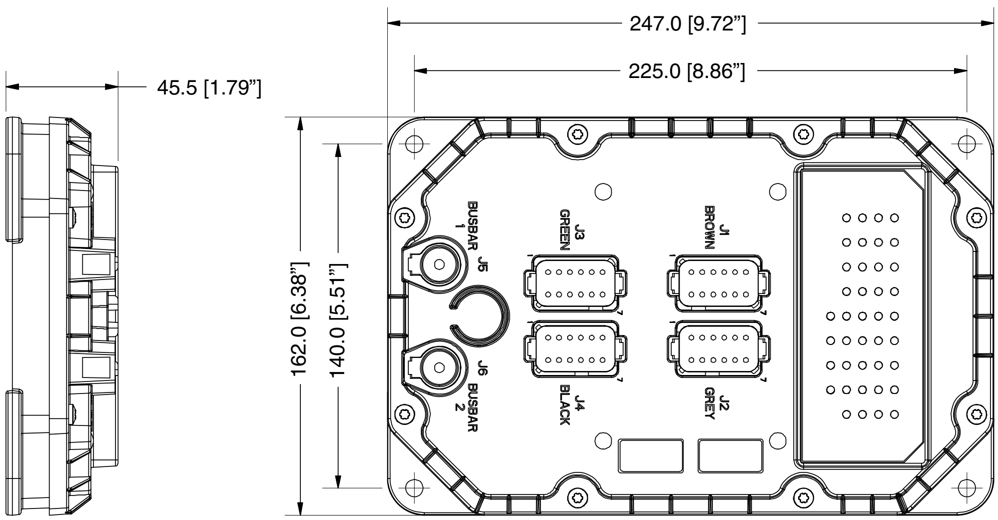


Figure 23: CM2115 dimensions

10.1.2. Selecting a Mounting Location

The CM2115 can be installed in the vehicle's cab, engine compartment, or on the chassis. If used for a marine application, ensure it is protected from excessive salt spray.

Before mounting the CM2115, ensure you review the following environmental and mechanical requirements.

Caution: Do not install the CM2115 close to any significant heat sources, such as a turbo, exhaust manifold, etc. Also avoid installing the CM2115 near any drive-train component, such as a transmission or engine block.

10.1.2.1. Mechanical Requirements

Review the following mechanical requirements before selecting a mounting location for the CM2115:

- The CM2115 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 CM2115.
- The harness should be shielded from harsh impact.
- The harness should connect easily to the connector and have adequate bend radius.
- The labels should be easy to read.
- The CM2115 should be in a location that is easily accessible for service.

10.1.2.2. Environmental Requirements

The CM2115 warranty does not cover damage caused by exposure of the product to environmental conditions that exceed its design limitations.

1. Mount the CM2115 in an environment that is within its ambient temperature range of –40 °C to +85 °C.
2. Mount the CM2115 in an environment that is within its particle ingress rating. The sealing standard for the CM2115 is EP455 level 1.

Note: The CM2115 has not been tested for water ingress according to the EP455 level 1 standard.

The CM2115 is protected from aggressive pressure wash up to 1000 psi at 1 m (3.28 ft.).

> ⚠ ***Warning! Damage to equipment.*** Exercise caution when pressure-washing the CM2115. The severity of a pressure wash can exceed the CM2115 pressure wash specifications related to water pressure, water flow, nozzle characteristics, and distance. Under certain conditions a pressure wash jet can cut wires.

10.1.3. Mounting the CM2115

Secure the CM2115 to the vehicle using four 1/4"-20 or M6 fasteners.

10.1.3.1. Recommended Mounting Orientation

The CM2115 should be mounted so that moisture drains away from it.

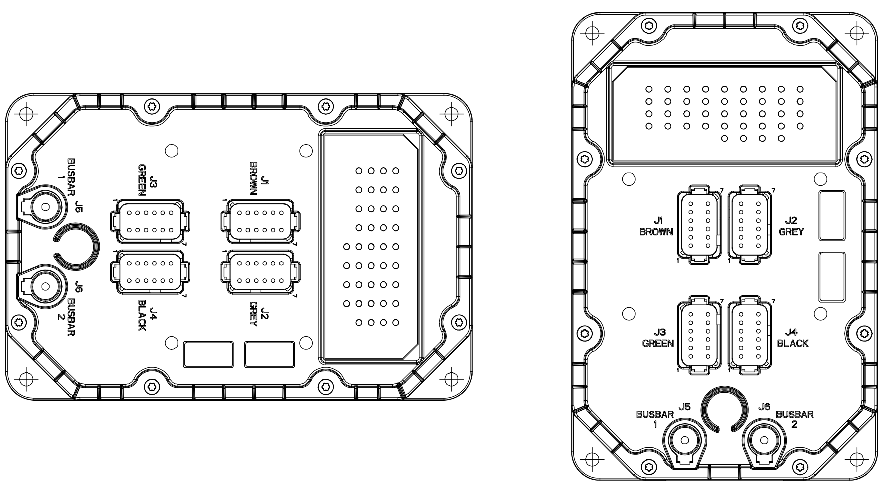


Figure 24: Recommended orientations

10.2. Electrical Installation Guidelines

Use the following guidelines when installing the CM2115 in a vehicle.

10.2.1. Designing and Connecting the Vehicle Harness

The vehicle manufacturer is responsible for designing a vehicle harness that mates with the CM2115 connector(s).

The vehicle harness design depends on the following:

- How the CM2115's inputs, outputs, communication, and power pins are configured.
- Other components on the vehicle and their physical locations.
- The routing of the harness.

Suggested wire sizing for the various connections are as follows:

- Inputs, 18 AWG
- Outputs, 16 AWG
- Logic power and ground, 18 AWG
- Other powers and grounds, 16 AWG
- Busbar power, if applicable, 14 AWG per 20 A of current (or 8 AWG per 40 A of current for single pin busbar connectors)

Once the vehicle harness is designed, it can be connected to the CM2115 simply by clicking the mating connector into the connector port on the CM2115.

11. Application Examples

The purpose of this section is to provide examples of how the CM2115 can be used for different purposes.

The following examples (used for illustrative purposes only) 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

11.1. Implementing Safety Interlocks

Safety is paramount when creating controls for a vehicle.

One safety feature that can be implemented with the CM2115 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 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).

Note: 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:

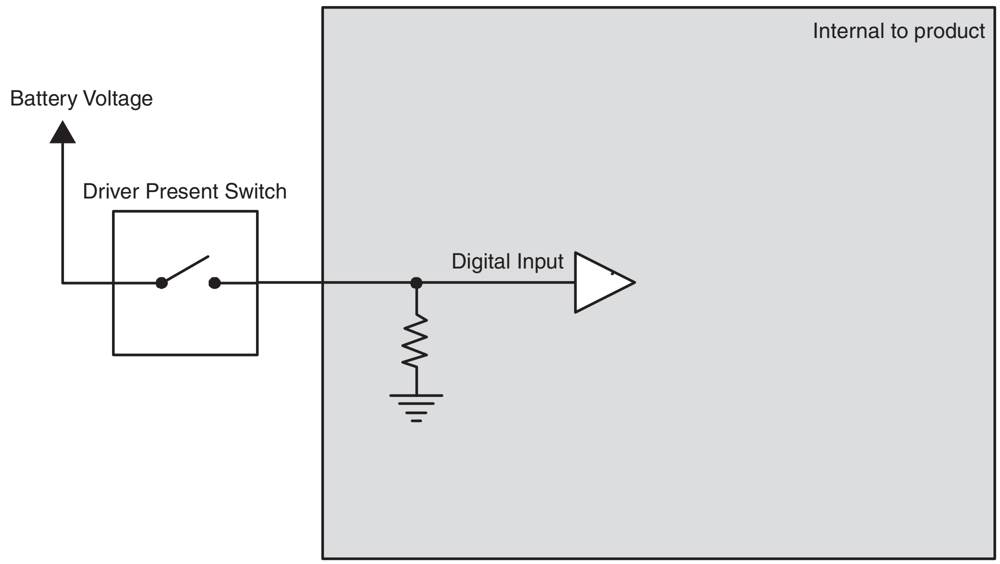


Figure 25: Seat switch interlock connection

11.2. Controlling Indicator Lights

Multiple CM2115 can be used together in a system to control a vehicle's indicator lights. For example, you could connect three CM2115s, communicating over the CAN bus, as follows.:

- Connect one CM2115 to the rear indicator lights.
- Connect one CM2115 to the front indicator lights.
- Connect one CM2115 to the turn signal and hazard switches.

The following shows how to connect three CM2115s together in a system to control indicator lights:

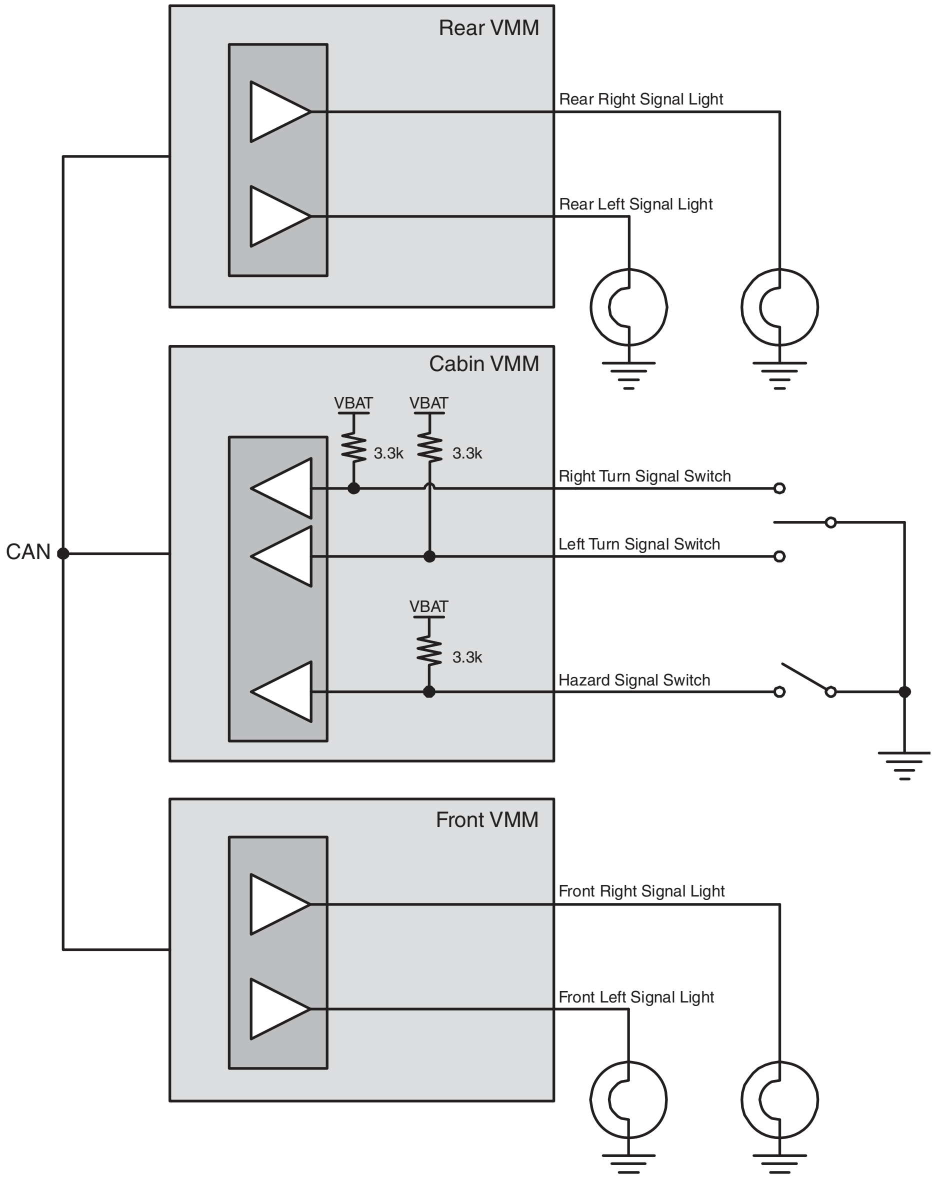


Figure 26: Indicator light connections

11.3. Controlling a Proportional Valve

The CM2115 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.

Note: The CM2115 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.

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:

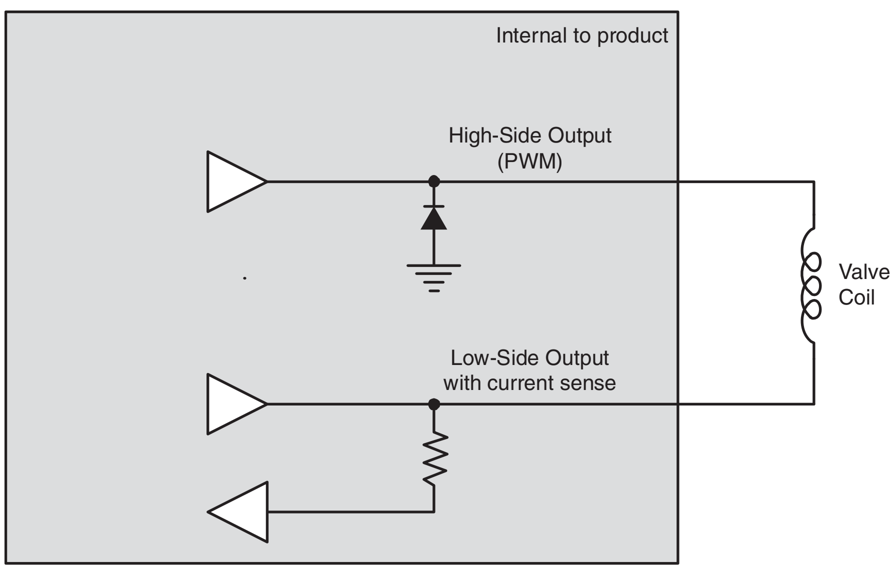


Figure 27: Connection for controlling a proportional valve

11.4. Controlling Motor Speed

The CM2115 can be used to control the DC motor speed of motors that provide a tachometer output.

Note: The CM2115 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.

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 CM2115 to control the speed of a motor:

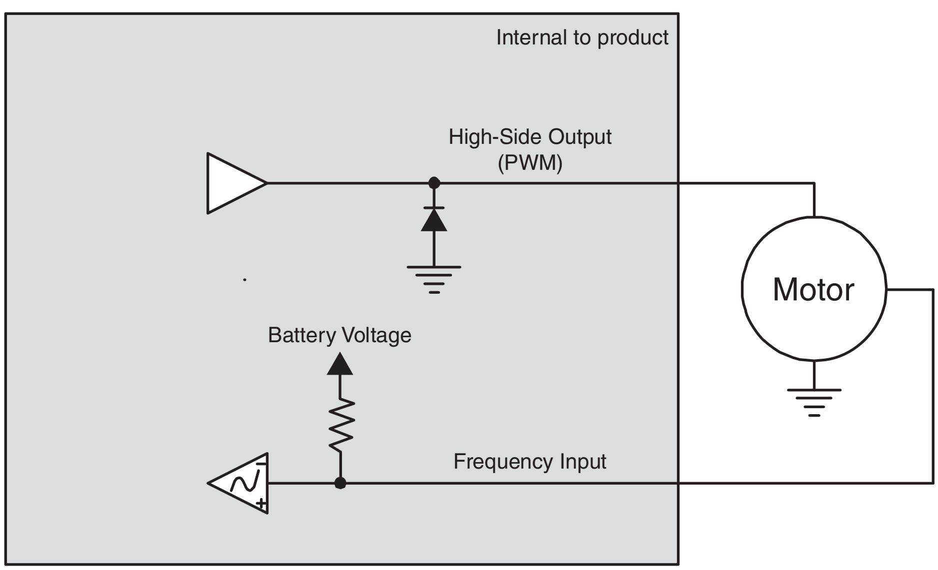


Figure 28: Connection for controlling motor speed

11.5. Using one Analog Input as Two Digital Inputs

The CM2115 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.

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

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 on the analog input (done through software)
- adding a resistor to one of the pins on the SPDT switch.

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

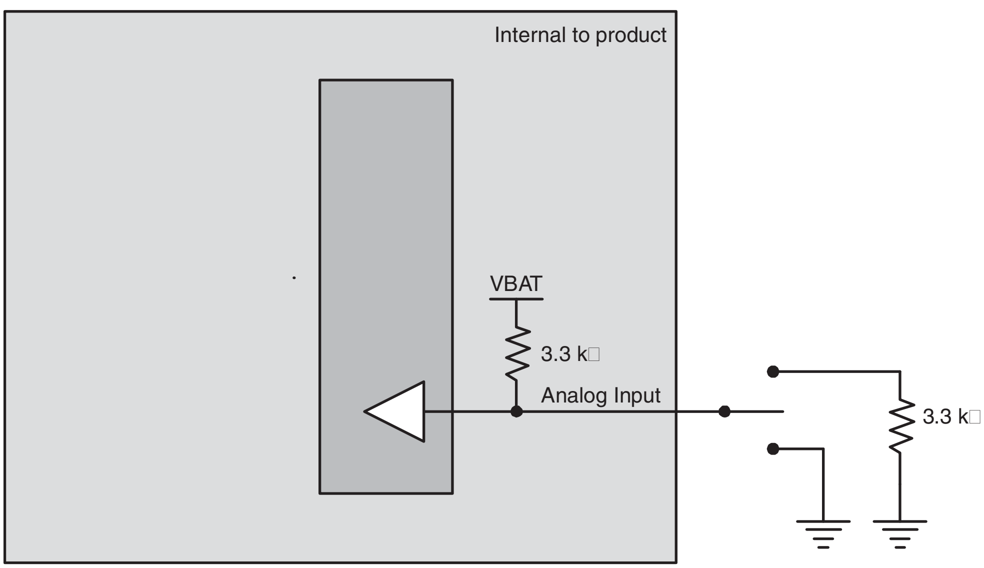


Figure 29: Connecting an analog input to an SPDT switch

11.6. Connecting Various Sensors

There are many types of sensors that can be connected to the CM2115, as follows:

- Open collector sensors
- Variable resistance sensors
- Variable reluctance sensors
- Switch sensors

- Voltage sensors
- CMOS sensors
- Potentiometer (ratiometric) sensors

Note 1: To optimize the reading accuracy for sensors, dedicate one of the main ground pins (called GND) as a low-current ground return for all sensors on the vehicle.

Note 2: When connecting sensors to the CM2115, use the sensor's specification to ensure that the CM2115 is configured correctly for the sensor.

11.6.1. Open Collector

Open collector sensors are compatible with each type of input on the CM2115.

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.

Note: 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 CM2115.

The following shows a typical open collector sensor connection:

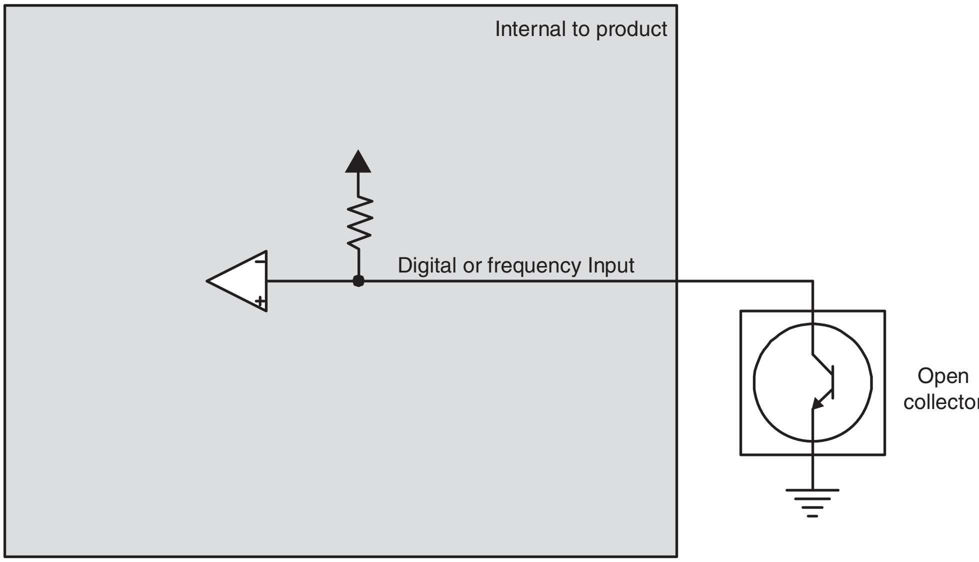


Figure 30: Open collector sensor connection

11.6.2. Variable Resistance

Variable resistance sensors change impedance to represent it's measured value, and are compatible with analog inputs.

Variable resistance sensors are typically used in thermal and pressure applications. They work by changing the voltage reading on the sensor according to changes in pressure or temperature in the application.

The CM2115 cannot measure resistance directly.

To make the CM2115 measure resistance accurately, do the following:

- Include a precision pull-up resistor between the sensor and the sensor power output (called `SENSOR_SUPPLY`).
- Ensure the value of the precision resistor allows the maximum possible resolution for the sensor's input.
- Dimension the precision resistor to get the maximum voltage range from the sensor.

Note: Variable resistance sensor accuracy may suffer at the extremes of the sensor's range. A tolerance analysis should be performed to ensure measurement accuracy is acceptable for your application.

The following shows a typical variable resistance sensor connection:

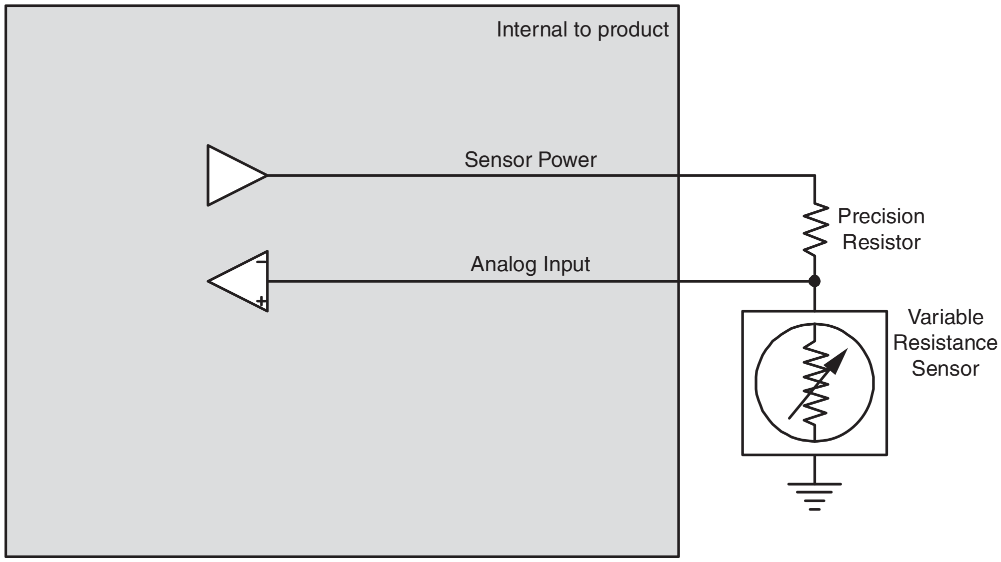


Figure 31: Variable resistance sensor connection

11.6.3. Variable Reluctance

Variable reluctance sensors are typically used in frequency measurement applications, and are compatible with AC-coupled frequency inputs.

Variable reluctance sensors do not require power (the power is induced), and they create frequency by out-putting a sine wave type signal. They work by using an increase or decrease in a magnetic field to detect the proximity of a part or device.

The following shows a typical variable reluctance connection:

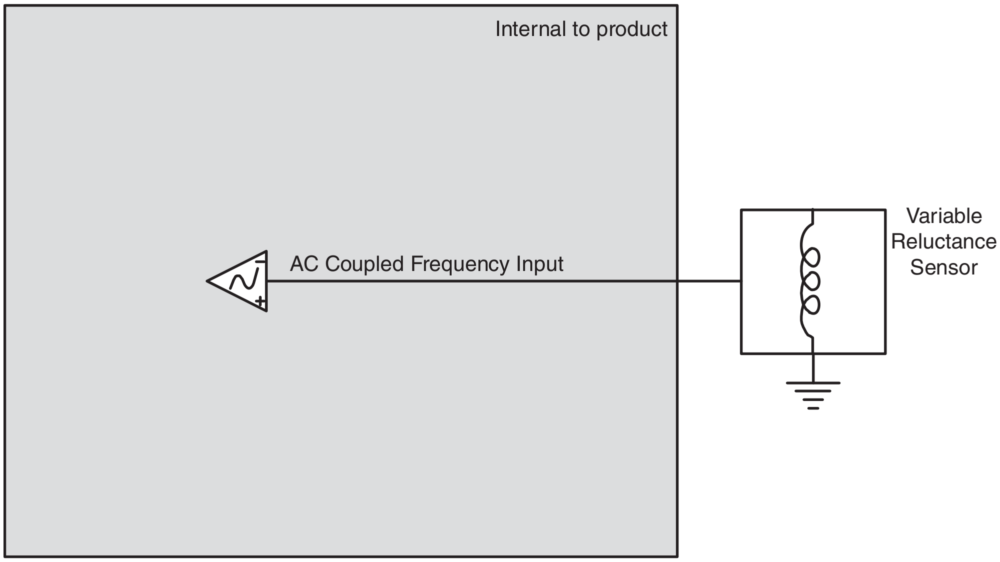


Figure 32: Variable reluctance sensor connection

11.6.4. Switch

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-low sensor switches are common. To use active-low switches, the internal pull-up resistor on the input that the sensor is wired to must be enabled.

> ⚠ Use of active-low switches is not recommended. A broken wire on this type of switch, if it makes contact with the chassis, will activate the function.

Active-high sensor switches are another common type which are generally safer. To use active-high switches, the internal pull-down resistor for the input that the sensor is wired to must be enabled.

The following shows a typical sensor switch connection:

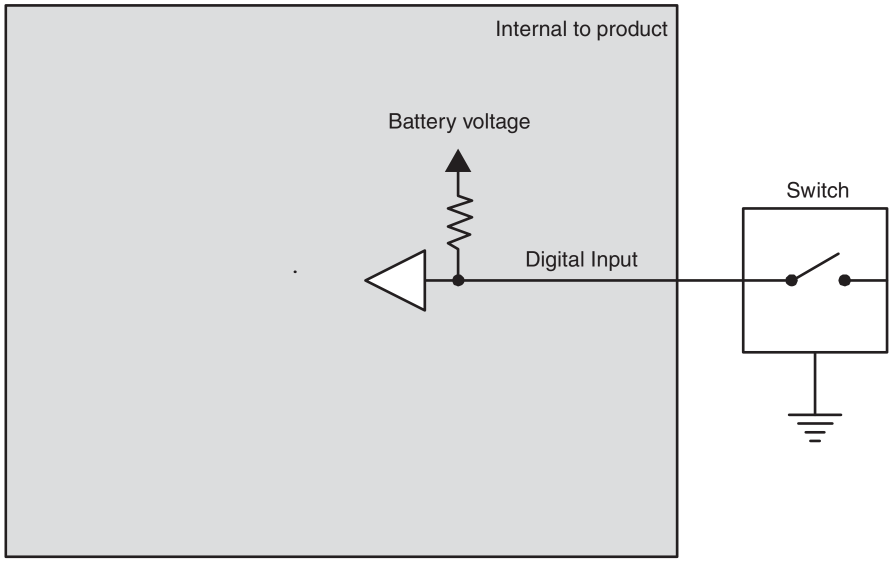


Figure 33: Switch sensor connection

11.6.5. 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.

Note: 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:

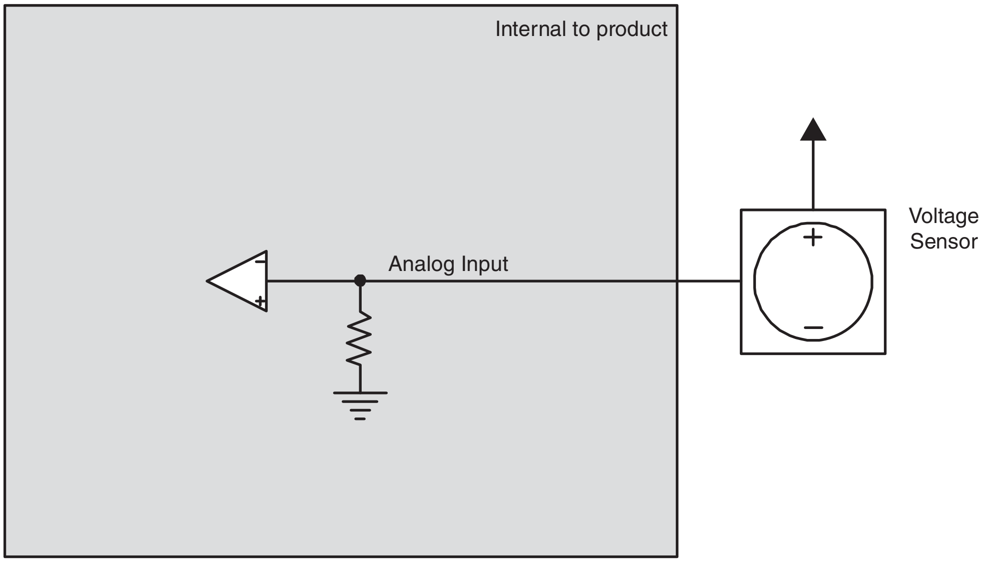


Figure 34: Voltage sensor connection

11.6.6. CMOS

A sensor with a CMOS-type output drives a high and low signal, and is typically used in digital and frequency applications, and therefore, CMOS sensors can be wired directly to digital and frequency inputs.

The following shows a typical CMOS sensor connection:

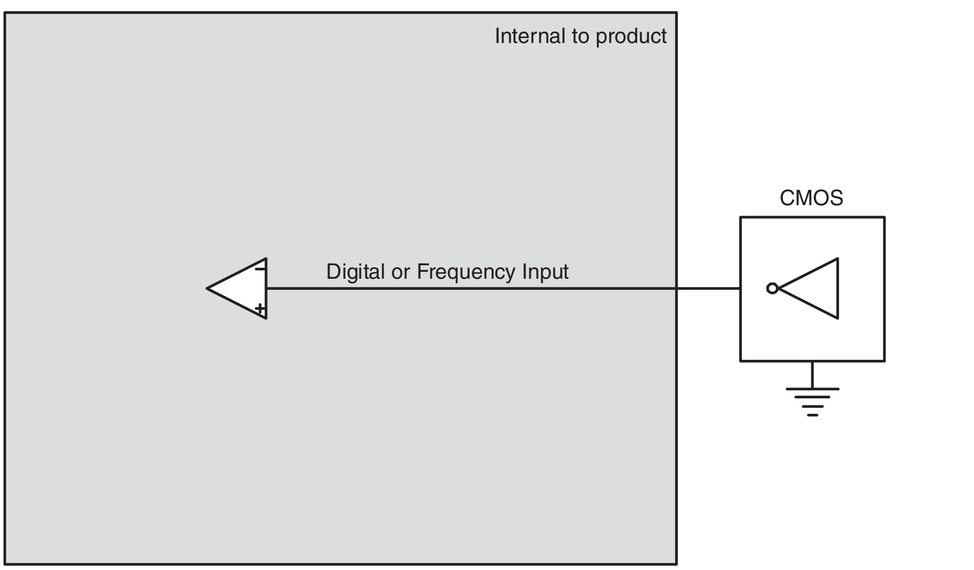


Figure 35: CMOS sensor connection

11.6.7. 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 `GND` pin on the CM2115.
- Connect the sensor signal to an analog input.

The following shows a typical potentiometer sensor connection:

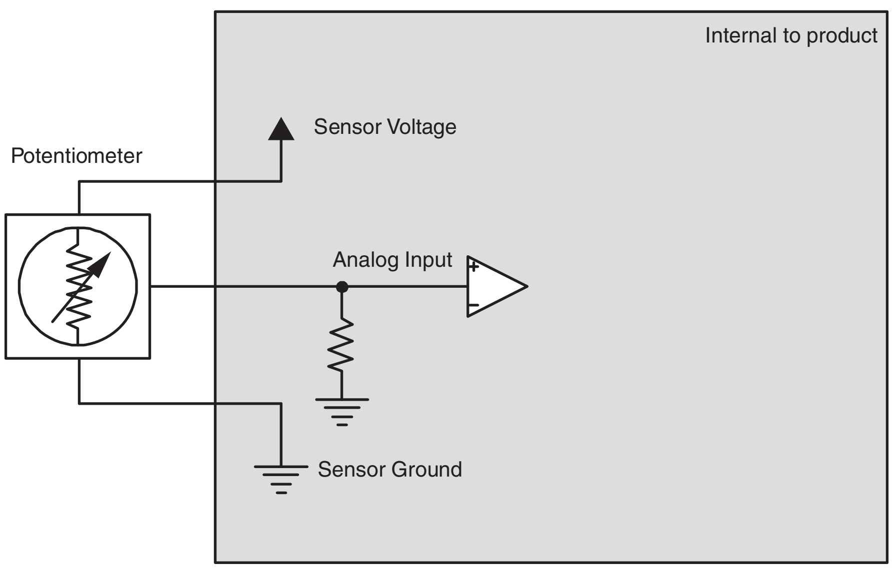


Figure 36: Potentiometer (ratiometric) sensor connection

12. Summary of Test Results

Product testing is performed as per the Parker Vansco DVT Specification. Test results for the CM2115 are grandfathered from the VMM1615 product for which the CM2115 shares a common PCBA and enclosure.

The following table shows the specifications that the product meets:

Test Description	Test Standard
Storage Temperature	ASAE EP455_Feb_2008_section 5.1.2 Level 1
Thermal Shock	SAE J1455_Jun/2006_ section 4.1.3.2 Level 2
Operating Temperature	ASAE EP455_Feb_2008_section 5.1.1 Level 2
High Temperature Soak	IEC 68-2-2_1974_ Section two - Test Bb: Dry Heat for non heat-dissipating specimen with gradual change of temperature 18.3
Low Temperature Soak	IEC 68-2-1_April_1990_Section two - Test Ab: Cold for non heat-dissipating specimen with gradual change of temperature 18.3
Salt Spray	MIL-STD-202G_Feb_2002_ Method 101E
Chemical Exposure - Brush	ASAE EP455_Feb_2008_ section 5.8.2
Solar Radiation - UV Effects	IEC 68-2-5 1975_Procedure C
Vibration – Swept Sine	SAE J1455_Jun_2006_section 4.10.4.1_Appendix A
Vibration -Random	SAE J1455_Jun_2006_ section 4.10.4.2 Figure 10
Vibration – Operational Shock	ASAE EP455_Feb_2008_section 5.14.1
Pressure Wash IPX6	60529 IEC Edition 2.1 2001-02 section 14.2.6
Altitude – Storage	ASAE EP455_Feb_2008_section 5.2.2
Dust Ingress –IP6X	60529 IEC Edition 2.1 2001-02 section 13.6.1
24 Hour Humidity Cycle	ASAE EP455_Feb_2008_section 5.13.1
Humidity Soak	ASAE EP455_Feb_2008_section 5.13.1
Installation Harness Shock	ANSI/ASAE EP455 _FEB/08 section 5.14.2.1
Handling Drop	ASAE J1455_JUN2006 Section 4.11.3.1
Particle impact - surface	Similar to SAE J400
Operating Voltage – 12V/24V	SAE J1455 _JUN_2006_section 4.13.1.1 SAE J1455 _JUN_2006_section 4.13.1.2 ANSI/ASAE EP455_Feb_2008 section 5.10.1
Operational Power Up – 12V/24V	ANSI/ASAE EP455_Feb_2008_section 5.10.7
Over Voltage – 24V	ANSI/ASAE EP455_Feb_2008_Section 5.10.2 Level 1 SAE J1455 _JUN_2006_section 4.13.1.2

Reverse Polarity - 12V/24V	ANSI/ASAE EP455_Feb_2008_Section 5.10.2 SAE J1455 _JUN_2006_section 4.13.1.1 SAE J1455 _JUN_2006_section 4.13.1.2 External Fuse
Short Circuit Protection - 12V/24V	ANSI/ASAE EP455_Feb_2008_Section 5.10.4 Deviated: used 12V battery and 24V battery
Alternator Field Decay – Power Leads – 12V	ANSI/ASAE EP455_Feb_2008 section 5.11.2 Deviated Rs=10 Ω instead of 15 Ω
Positive Inductive Transient Power Lines – 24V	ISO 7637-2_Jun/04 section 5.6.2_Pulse 2a at 100V
Inductive Load Switching Power Lines – 24V	ISO 7637-2_Jun/04 section 5.6.1 Pulse 1 at -500V; Deviated Rs=10 Ω instead of 50 Ω
Mutual Coupling –12V / 24V Coupling Clamp	ISO7637-3_Jan_2007 section 3.4.2 ± 300V
Transient Load Dump	SAE J1455_Jun2006 section 4.13.2.2.1
Accessory Noise – 24V	ANSI/ASAE EP455_Feb_2008_Section 5.11.1 at 27V
Batteryless Operation – 12V	ANSI/ASAE EP455_Feb_2008_Section 5.11.3
Cranking Waveform – 12V	ISO 7637-2_Jun/04 section 5.6.4
EMC – Emissions	ISO 14982/SAE J1113-41 Deviations: Used ANSI/ASAE EP455 Limit lines
EMC – Susceptibility	100 V/m at most frequencies (test equipment limitation) ANSI/ASAE EP455_Feb_2008_Section 5.16.3 ISO 14982 SAE J1113-41
Electrostatic Discharge, Handling & Operational	ANSI/ASAE EP455_Feb_2008_Section 5.12.2 Deviated: uncontrolled approach rate

13. Glossary

active high

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

active low

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

aliasing

In analog-to-digital conversion, distortion that occurs when the analog signal being sampled has a frequency greater than half the sample rate. An example of aliasing is the wagon-wheel effect often seen in films, in which a spoked wheel appears to rotate differently from its true rotation.

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

A gradual decrease in a current's intensity. Such a decrease may occur naturally, or intentionally through the use of an attenuator.

bus

A subsystem that transfers data between components within a computer or between computers.

bus bar

A strip or bar of copper, brass, or aluminum that conducts electricity.

CAN bus

See *controller area network (CAN) bus*.

CAN high

The positive wire in a shielded twisted-pair cable, which, when connected with a CAN low, provides a complete CAN differential signal.

CAN low

The negative wire in a shielded twisted-pair cable, which, when connected with a CAN high, provides a complete CAN differential signal.

CAN shield

The shielding that wraps around the CAN high and CAN low wires in a shielded twisted-pair cable.

controller area network (CAN) bus

A communications network bus that permits data from sensors and other equipment within a motor vehicle to communicate with each other and, through telltales and other diagnostic tools, with the operator.

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. Also known as current sense or current sensing.

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

DC coupling passes the full spectrum of frequencies including direct current. The signal being read by this circuit must fall within the detection threshold range specified for the input.

de-rating

The reduction of the rated output current level to a value less than the specified rating. De-rating is typically done so that a product does not overheat.

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.

duty cycle

The time that a device spends in an active or operative state, expressed as a fraction or percentage of the total cycle time (start, operate, stop).

electromagnetic compatibility (EMC)

The ability of a component within a system to function correctly despite electromagnetic interference propagated by other components in the system.

electromagnetic susceptibility

The ease with which a device, component, circuit, etc., suffers a degradation of performance when subjected to electromagnetic energy.

field-effect transistor (FET)

A transistor whose flow of charge carriers is controlled by an external electric field.

flyback

A voltage spike seen across an inductive load when its supply voltage is suddenly reduced or removed.

frequency input

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

gain

To increase the voltage level of an input signal to maximize the resolution of an input.

ground level shift

An undesirable condition in which the ground level elevates. This condition can cause inputs to activate when they shouldn't.

half-bridge

The simultaneous use of a high-side switch and a low-side switch in order to provide a load having 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.

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:

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

inrush current

The peak instantaneous input current drawn by an electrical device when first turned on.

leakage current

Current that flows when the ideal current is zero.

load dump

A surge in the power line caused by the disconnection of a vehicle battery from the alternator while the battery is being charged. The peak voltage of this surge may be as high as 120 V and may, unless precautions are taken, affect other loads connected to the alternator.

logic ground

Ground pins for the microprocessor and logic peripherals.

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.

Nyquist criterion

A theorem stating that a reconstructed signal will match the original signal provided that the original signal contains no frequencies at or higher than one-half the sampling frequency

open load

The disconnection of a load from an output, often because of a broken or worn wire or connector pin.

overcurrent

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.

overvoltage

A situation in which the voltage in a circuit rises above its upper design limit.

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; when the input is inactive, the product powers down and will not operate.

pull-down resistor

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 resistor

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 digital logic circuit programmed to produce a pulse having any desired period or duty cycle. It is a means of controlling variable speed motors. See also duty cycle.

sensor power

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

short-to-battery

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

transient voltage suppressor

A Zener diode engineered for high-power current switching. See also *Zener diode*.

transorb

See transient voltage suppressor.

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 minimum current needed to flow through a mechanical switch to break through any film of oxidation that may be on the switch contacts.

14. Index

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