Controller Module

CM0212 v1101001

User Guide

Parker Hannifin Corporation

Electronic Motion and Controls Division

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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.

Understanding the CM0212

The Controller Module CM0212 is a general-purpose input / output controller that nominally includes 2 inputs, 12 outputs, 1 regulated voltage output, and 1 CAN communication ports.

Note: The specific input and output configuration is dependent on the hardware configuration for the product. The configuration for the specific variant covered by this manual is outlined in sections 4 through 8.

This module may serve as the base control system for off road vehicles such as tractors, loaders, and backhoes. It is designed to be a cost effective, flexible, robust product as well as offering improved diagnostics.

Figure 1: CM0212 controller module

The principal benefit of the CM0212 is that it can be configured to meet many system requirements through component configuration options, component value modification, and custom software.

The CM0212 is designed to communicate through a J1939-based Controller Area Network (CAN). Custom CAN messaging can be created in software, and the CM0212 can be used in any CAN 2.0B application, including ISO 11783.

The software offered with the CM0212 is a low-level framework that uses the Parker Hannifin Software Development Kit (SDK), which is a tool that enables you to create custom application software for your product.

About the CM0212 User Guide

The CM0212 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. This manual is only intended to describe the CM0212 1101001 hardware configuration.

The configuration described in this manual has 1 x CAN busses, 1 x 5V sensor supply and no status LEDs.

This manual describes the hardware components of the CM0212 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 Hannifin Account Representative.

Section Types

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

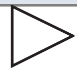
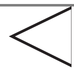
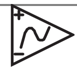
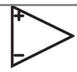
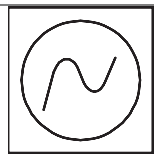
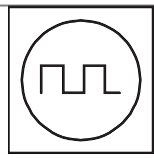
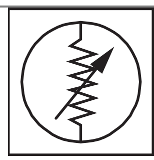
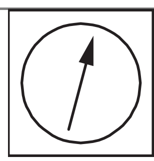
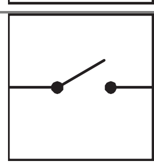
Instruction sections – The only instruction section in this manual is the Quick Start section, which provides procedures for connecting the CM0212 to a development system, powering it up, and downloading application software.

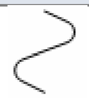
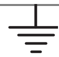
Information sections – Most sections in this manual are informational. They describe the hardware components of the CM0212, and usually have three sub-sections: circuit block diagram, circuit capabilities, and transfer function / use cases information.

Example sections – The only example section in this manual is the Application Examples section, which provides descriptions, diagrams, and explanations for possible CM0212 applications.

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
	Pull-up resistor
	Battery

Symbol	Meaning
	Fuse
	Resistor
	Ground
	Chassis ground

:

Quick Start

This section provides step-by-step instructions on how to connect the CM0212 standalone controller to a development system, install the required software tools, and download the application software.

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 Hannifin.
3. Connect the CM0212 to a development system (desktop) and power it up.
4. Download application software.

Gather Required Materials

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

- CM0212 standalone controller
- Personal computer (PC)
- Controller I/O board
- Controller I/O harness (connects the CM0212 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
- Desktop power supply compatible with the CM0212 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 CM0212 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 CM0212.

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

Install the Required Software Tools

Before you start using the CM0212, you must install the appropriate software tools onto your PC.

The CM0212 requires the following software tools:

- **Data Link Adapter (DLA) drivers:** The DLA acts as the interface between the PC and the CM0212 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 CM0212.

Install the Flash Loader

The Flash Loader doesn't actually need to be installed to work. All you need to do is run **FlashLoader.exe**.

FlashLoader.exe is found within the SDK files. Contact your Parker Hannifin Account Representative if you cannot find the file.

Refer to *Download Application Software using the Flash Loader* on page 17 for details on how to download software to the CM0212 using the Flash Loader.

Connect the CM0212 standalone controller to a Development System

It is a good idea to connect the CM0212 standalone controller 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 CM0212 standalone controller in a development system:

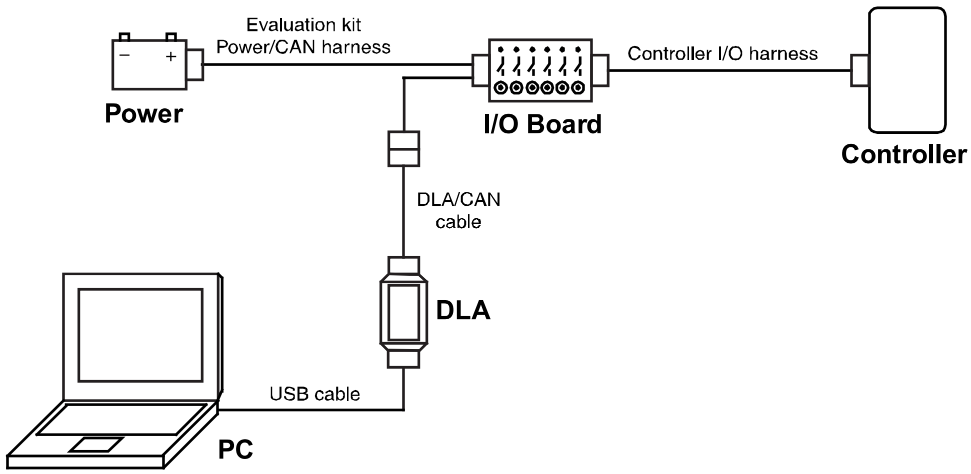


Figure 2: Development system connection

To connect the CM0212 standalone controller 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 16 V DC.

1. Connect the Controller I/O harness to the CM0212 standalone controller.
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 14.

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

Power Up the Development System

Once the CM0212 is connected in a development system, you need to power it up.

To power up the CM0212 standalone controller, do the following:

1. Ensure all controller I/O board digital inputs, jumpers, and dip switches are properly configured for the CM0212. 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 CM0212 (refer to the *Controller I/O Board Reference Manual* for details). The CM0212 will power up.

Note: If the module does not power up and you are unsure if a power control input is set on the CM0212, 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.

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 CM0212.

This section assumes you have a Vansco Software File (VSF) that is ready to be transferred to the CM0212 using the Flash Loader. Parker Hannifin provides a VSF with every CM0212.

Note: For more information about writing software for the CM0212 using the SDK, contact your Parker Hannifin Account Representative.

- **If you are creating a custom application**, the provided VSF is a simple example application that can be transferred to the CM0212 to ensure the product works. Refer to the supplied SDK 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 Hannifin has written for your CM0212.

To transfer the VSF file to the CM0212

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 **CM0212**.
5. From the **Software File Details** list, select your VSF file.
6. Click **Start**.

   Your VSF file downloads to the CM0212.

   Once complete, a confirmation screen opens.

7. Click **OK**.

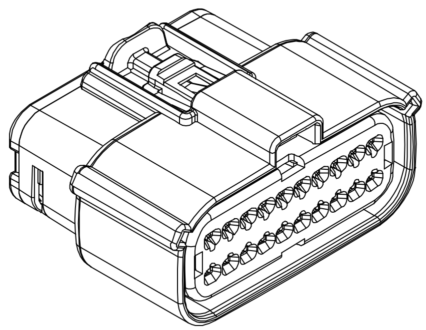
   The CM0212 is now running the application code.

Connectors

The connector on the top of the CM0212 is:

- MX150 – Vehicle Harness Connectors

The Molex MX150 connector is used to interface the CM0212 to the vehicle.



Mating Connector Part Numbers			
Connector	**Shell part no. with locking clip**	**Shell part no. without locking clip**	**Terminals**
J1 connector (gray), 20-pin, key option B	33472-2007	33472-2002	33001-2004

Pinouts

The pins in connector J1 connect to inputs, outputs, power and CAN.

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

J1 Connector Pin-out		
Pin	**I/O name**	**Function**
1	VBATT	12V Battery Supply
2	GROUND	GND
3	CAN_LO	CAN Low
4	CAN_HI	CAN High
5	VSENSOR	5V sensor supply, 75 mA
6	GROUND	GND
7	INPUT2	Analog input (Type 1), Frequency input (Type 1)
8	INPUT1	Analog input (Type 1)
9	OUTPUT1	High-side output Type 1 (2.5 A, PWM)
10	OUTPUT2	High-side output Type 1 (2.5 A, PWM)
11	OUTPUT3	High-side output Type 1 (2.5 A, PWM)
12	OUTPUT4	High-side output Type 1 (2.5 A, PWM)
13	OUTPUT5	High-side output Type 1 (2.5 A, PWM)
14	OUTPUT6	High-side output Type 1 (2.5 A, PWM)
15	OUTPUT7	High-side output Type 1 (2.5 A, PWM)
16	INPUT3* OUTPUT8	Resistive, Type 3 (30Ω – 30kΩ) High-side output Type 1 (2.5 A, PWM)
17	OUTPUT9	Low-side output Type 1 (2.5 A, PWM)
18	OUTPUT10	Low-side output Type 1 (2.5 A, PWM)
19	OUTPUT11	Low-side output Type 2 (2.5 A)
20	OUTPUT12	Low-side output Type 2 (2.5 A)

* Input 3 functionality requires alternate component stuffing

Inputs

The CM0212 has analog, digital and frequency inputs.

The CM0212 module is hardware configurable and the specific input configuration will depend on the hardware variant. This manual describes the CM0212 1101101 hardware variant.

1.1. Analog Inputs

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

1.1.1. Analog input, Type 1 (0-5 V)

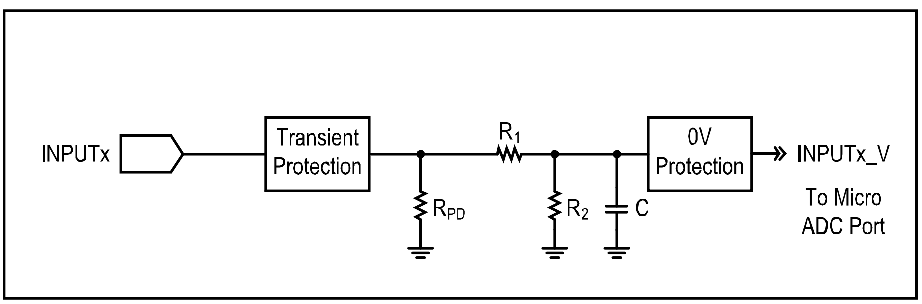
This input is intended to support 0-5V sensors.

The CM0212 has 2 Type 1 Analog inputs:

INPUT1

INPUT2

1.1.1.1. Analog input, Type 1 circuit block diagram



1.1.1.2. Analog input, Type 1 circuit characteristics

The following table provides specifications for the analog input Type 1:

Analog input, Type 1 characteristics				
Item	**Min**	**Nom**	**Max**	**Unit**
Full scale input voltage	0		5	V
Input voltage range (non-operational)	0		26	V
Input resistance (w.r.t. ground)		39		kΩ
Filtering (hardware)		39.8		Hz
Resolution	1.16	1.22	1.28	mV/bit
Offset error			23	mV

1.1.1.3. Analog input, Type 1 transfer functions

1.1.1.3.1. Use case 1 - 0-5 V sensors

$$Vin = \frac{623 \cdot INPUTx\_ADC}{510510} \cdot Volts$$

1.1.2. Analog input connections

Analog inputs are susceptible to system noise, which can affect the accuracy of the signal. Signal accuracy can also be affected by ground level shift, which can cause inputs to activate when they shouldn't.

System noise

To prevent noise pickup on the sensors, use the shortest possible wires when connecting analog inputs to sensors.

The following shows how to connect an analog input to reduce system noise:

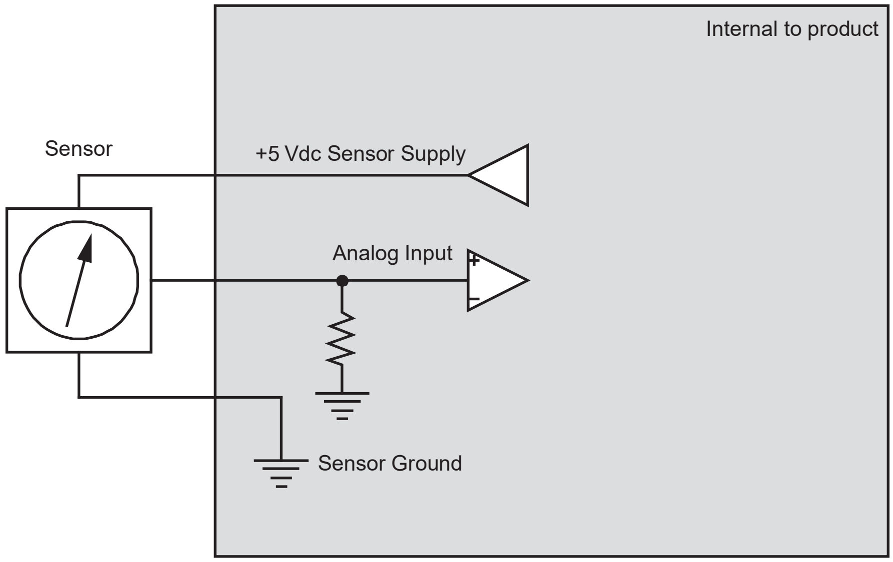


Figure 3: Analog input system noise reduction

Ground level shift

To reduce ground level shift:

1. Dedicate one of the two system ground inputs (GND) to sensors that have dedicated ground wires and connect all sensor grounds to this system ground input.
2. Splice the other system ground inputs together in the vehicle harness (close to the connector) to provide a better ground for the noisier low-side outputs and digital circuits.
3. Position the sensor’s ground connection near the system ground connections to ensure that the signal remains within the digital activation range of the input.

Note 1: The system ground inputs are rated for low-current signals, which ensures the sensor's ground is very close in voltage potential to the system ground.

Note 2: Sensors that don't have a dedicated ground wire are typically grounded to the vehicle chassis through the sensor's body.

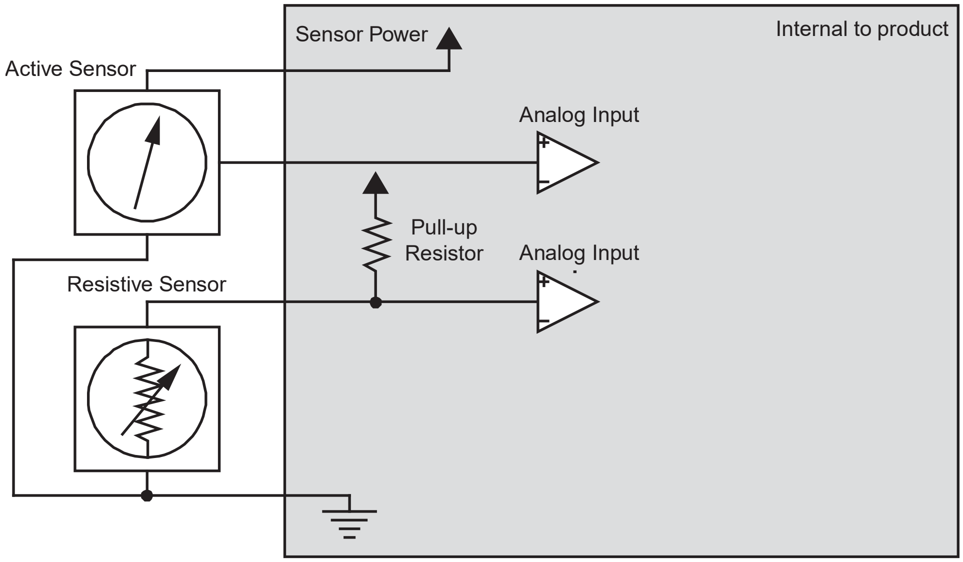


Figure 4: Analog input ground shift connection for sensors that have dedicated ground wires

1.2. Frequency Inputs

Frequency inputs are typically used to read pulse signals.

1.2.1. Frequency input, Type 1

This input is intended to support open collector type frequency inputs.

The CM0212 has one Type 1 Frequency inputs:

INPUT2

1.2.1.1. Frequency input, Type 1 primary use

This input circuit has been optimized to support open collector type frequency sensors that have a resistance range between 1kΩ and 18kΩ resistance to ground (such as the Parker 01879ECD dual output speed sensor).

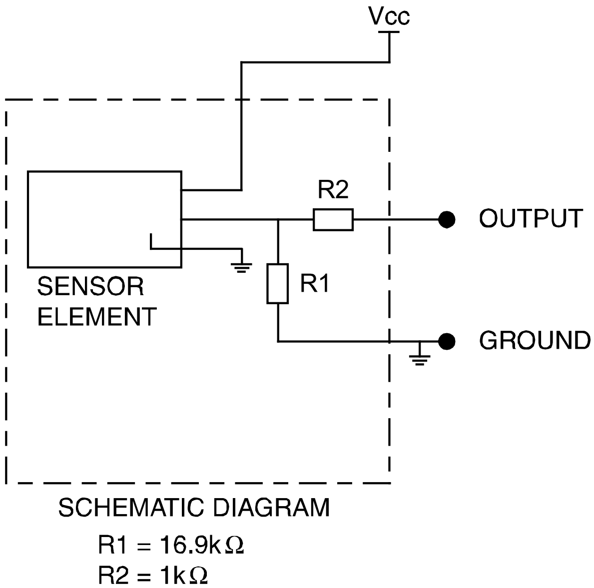
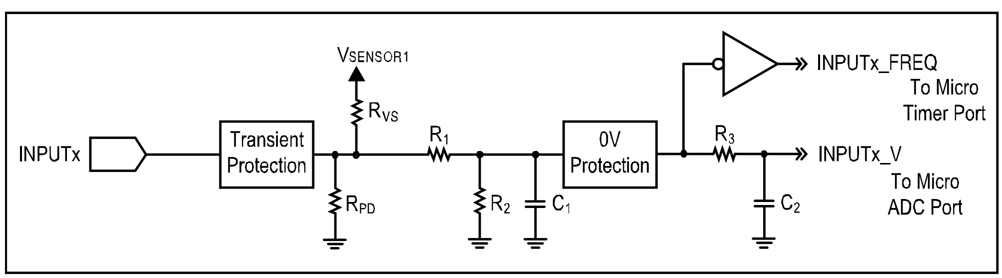


Figure 5: Example speed sensor schematic

For information on how to connect open collector sensors, refer to *Connecting Various Sensors* on page 54.

1.2.1.2. Frequency input, Type 1 circuit block



1.2.1.3. Frequency input, Type 1 circuit characteristics

The following table provides specifications for the Frequency input Type 1:

Frequency input, Type 1 characteristics				
Item	**Min**	**Nom**	**Max**	**Unit**
Input voltage range	0		5	V
Pull-up resistance			6.34	kΩ
Input pull-up voltage		5		V
Logic high threshold		3.23	3.25	V
Logic low threshold	0.79	0.80		V
Band-pass upper cut-off		4.44		kHz
Frequency range	10		4400	Hz
Frequency resolution		1		Hz

1.2.1.4. Frequency input, Type 1 transfer functions

1.2.1.4.1. Use Case 1 – Open Collector Frequency Input

When used for open collector Frequency Inputs, the frequency, duty cycle, period and pulse count for the input are available directly via the software API (no specific transfer function is required).

1.2.1.4.2. Use Case 2 – Open Collector Frequency Input (Voltage Feedback)

When used for analog feedback on the frequency input (for diagnostic purposes), the following transfer function should be used:

$$Vin = \frac{623 \cdot INPUTx\_ADC}{510510} \cdot Volts$$

Outputs

The CM0212 has High-Side and Low-Side outputs.

The CM0212 module is hardware configurable, and the specific output configuration will depend on the hardware variant. This manual describes the 1101001 hardware variant.

High-Side Outputs

High-Side outputs are outputs which connect the output pin to VBATT through the controller.

High-side output, Type 1 (2.5 A)

This output type provides a PWM capable 2.5A high-side output.

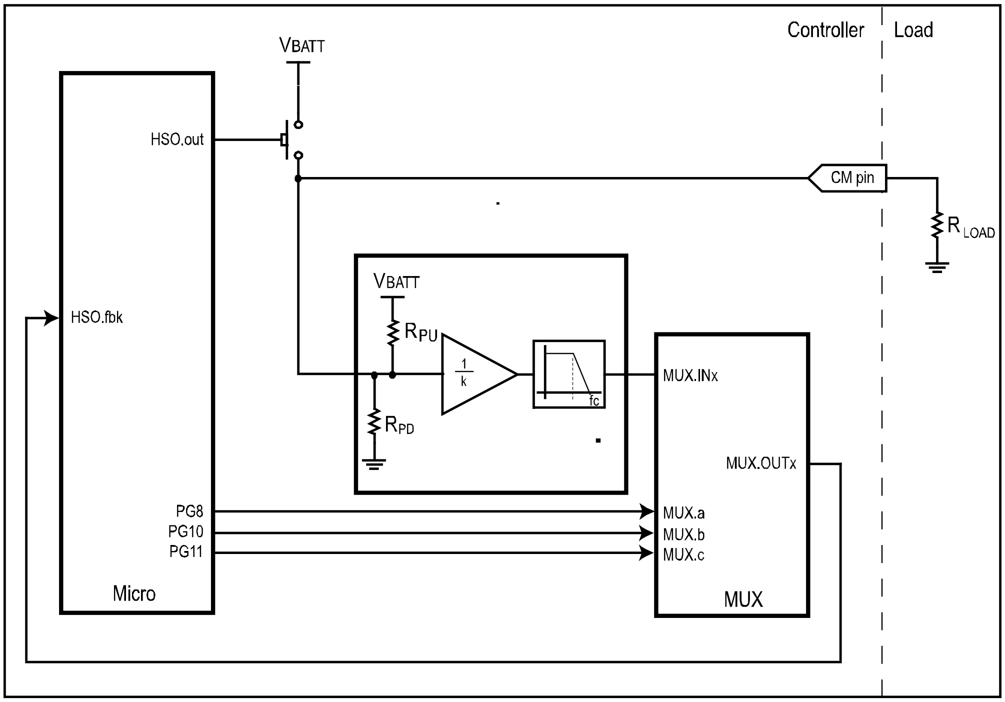
High-Side Output, Type 1 outputs are used for switching voltage to loads (e.g. valve solenoids, lights) using either a pulse width modulated (PWM) signal, or an on/off signal. They can also test for various fault conditions, which can be used for software diagnostics (refer to High-Side Output Diagnostics and Fault Detection for more details).

All High-Side Output, Type 1 outputs come with internal flyback diodes that provide protection when driving inductive loads.

The CM0212 has 8 high-side outputs Type 1:

- OUTPUT1
- OUTPUT2
- OUTPUT3
- OUTPUT4
- OUTPUT5
- OUTPUT6
- OUTPUT7
- OUTPUT8

High-side output, Type 1 circuit block



High-side output, Type 1 circuit characteristics

The following table provides specifications for the CM0212 High-side, Type 1 outputs:

High-Side Output, Type 1 Characteristics				
Item	**MIN**	**NOM**	**MAX**	**UNIT**
Output current	0		2.5	A
Output ON state resistance		20		mΩ
Output OFF state leakage current (VBATT=12V)		0.63		mA
PWM frequency	50		250	Hz
Turn on time to ON state	30	90	230	µS
Turn off time to OFF state	30	90	230	µS
Turn ON/OFF slew rate	0.1	0.25	0.5	µS
Output pin capacitance		500		nF

High-side output, Type 1 fault detection

High-Side Output, Type 1 outputs can detect the following faults:

- Open Circuit when OFF
- Short to Battery when OFF
- Short to Ground when ON

Note: Higher than 300 ohms load won't guarantee open circuit fault detection.

The following table shows the Output Current Threshold for fault detection:

Outputs	Current Threshold	
	Over current	Short circuit
1-8	4.0 A	5.0 A

High-Side Output Diagnostics and Fault Detection

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

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

Open Load

Open load faults occur when a high-side output pin is open circuit (not connected to a load). The high-side output circuit uses a small amount of current on the output pin to determine if an open load condition exists.

Refer to the CM0212 Platform Framework API document distributed with the SDK for details on how to detect an open load fault.

Short Circuit

Short-circuit faults occur when a high-side output pin is shorted to ground. Refer to the CM0212 Platform Framework API document distributed with the SDK for details on how to recover from a short circuit.

Short-to-Battery

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

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

Note: To detect a short-to-battery fault, high-side outputs must be off.

Software Overcurrent

Software overcurrent faults occur when the current through a high-side output pin exceeds a threshold defined in the CM0212 Platform Framework API document distributed with the SDK.

High-Side Output Installation Connections

When connecting high-side outputs, note that:

- High-side outputs are connected to an internal bus bar, which is connected to the battery. The bus bar is also connected to logic power (VBATT), and both share the same connector pins.
- High-side outputs can provide switched battery power to any load type in a vehicle.
- High-side outputs can source up to 2.5 A max.
- 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).

Inductive loads will create an average current flow that moves out of the high-side output. When the output is on, the current flows through the output driver, and when the output is off, the current flows through the flyback diode. A duty cycle of 50% will produce the worst case average current flow through these two devices.

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 ½ the peak current).

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

- High-side outputs should not be connected to loads that will draw currents greater than the maximum peak current, or maximum continuous current.
- The grounds for the loads should be connected physically close to the CM0212 power grounds.

The following shows a typical high-side output connection:

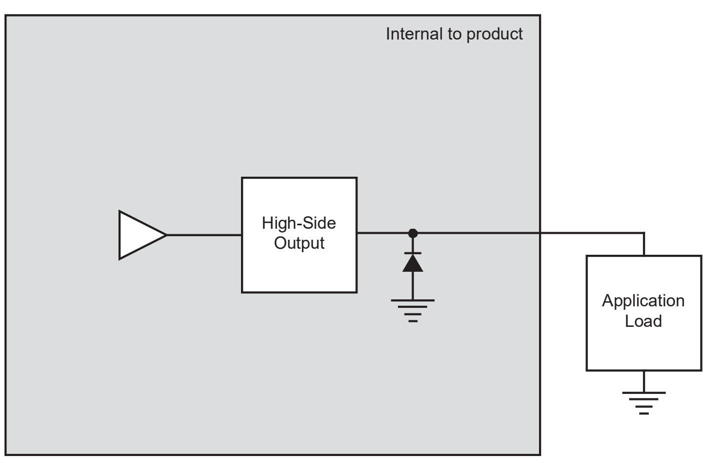


Figure 6: Typical high-side output installation connections

Low-Side Outputs

Low-side outputs are outputs which connect the output pin to GND through the controller.

Low-side output, Type 1 (2.5 A, PWM)

Type 1 Low-Side outputs are used for switching grounds to loads using either a pulse width modulated (PWM) signal, or an on/off signal. These outputs can be used to drive a variety of loads such as LEDs, relays and solenoids, up to 2.5 A. They also have the ability to sense current that is provided to loads, through an amplifier circuit.

All Type 1 Low-Side outputs are provided with flyback (free-wheeling) diodes that provide protection when driving inductive loads.

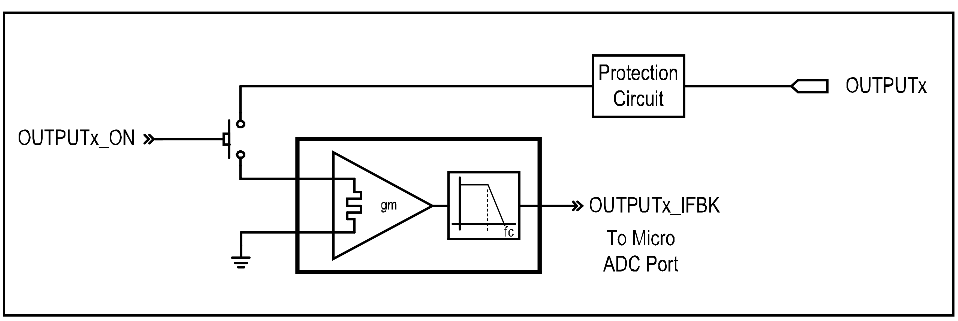
When Type 1 Low-Side outputs are used to sense current, the application software will monitor the current flowing into the Low-Side output.

Note: Current flow to sense circuit gets interrupted when using Low-Side outputs as a PWM signal as the outputs are not "on" continuously. As a result, the Low-Side output current sense will not be accurate if it is used in a PWM mode. When current sensing, the system should use a High-Side output for PWM signals, and a Low-Side output (turned on at 100%) for sensing current.

The CM0212 has 2 Type 1 low-side outputs:

- OUTPUT9
- OUTPUT10

Low-side output, Type 1 circuit block



Low-side output, Type 1 circuit characteristics

The following table provides specifications for the CM0212's Low-side Type 1 outputs:

Low-Side Output Type 1 Characteristics				
Item	**MIN**	**NOM**	**MAX**	**UNIT**
Input voltage range (operational/non-operational)	0		16	V
Output current	0		2.5	A
Total output ON state resistance w.r.t. GND		85	140.7	mΩ
Output ON state resistance		35	90	mΩ
Current sense resistance	49.3	50.0	50.7	mΩ
Output OFF state leakage current		1.5	15	µA
PWM frequency	50		250	Hz
Turn on time to ON state		60	100	µS
Turn off time to OFF state		60	100	µS
Turn ON/OFF slew rate		0.3	1.5	V/µS
Output pin capacitance		5		nF

Low-side output, Type 1 transfer functions

The current for the product can be determined using the following transfer function:

$$I= \frac{88 \bullet INPUTx\_ADC}{63} \quad mA$$

Where:

- I = Current
- INPUTx_ADC = the analog to digital count provided by the platform software

Note: To prevent aliasing, you should filter at half the rate of your sampling rate, according to the Nyquist criterion.

Low-side output, Type 1 fault detection

Low-Side Output, Type 1 outputs can detect the following faults:

- Open Circuit when ON
- Short to Battery when ON

Low-side output, Type 2 (2.5 A, digital)

Type 2 Low-Side outputs are used for switching grounds to loads using an on/off signal. These outputs can be used to drive a variety of loads such as LEDs, relays and solenoids, up to 2.5 A. They also have the ability to sense current that is provided to loads, through an amplifier circuit.

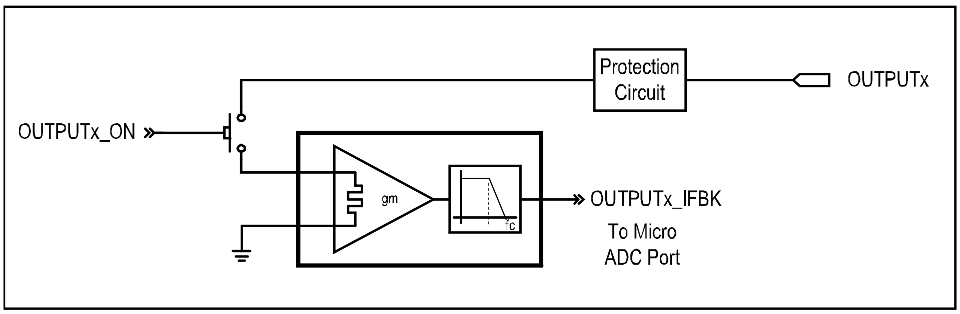
All Type 2 Low-Side outputs are provided with flyback (free-wheeling) diodes that provide protection when driving inductive loads.

When Type 2 Low-Side outputs are used to sense current, the application software will monitor the current flowing into the Low-Side output.

The CM0212 has 2 Type 2 low-side outputs:

- OUTPUT11
- OUTPUT12

Low-side output, Type 2 circuit block



Low-side output, Type 2 circuit characteristics

The following table provides specifications for the CM0212's Low-side Type 2 outputs:

Low-Side Output Type 2 Characteristics				
Item	**MIN**	**NOM**	**MAX**	**UNIT**
Input voltage range (operational/non-operational)	0		16	V
Output current	0		2.5	A
Total output ON state resistance w.r.t. GND		85	140.7	mΩ
Output ON state resistance		35	90	mΩ
Current sense resistance	49.3	50.0	50.7	mΩ
Output OFF state leakage current		1.5	15	µA
PWM frequency	n/a			
Turn on time to ON state		60	100	µS
Turn off time to OFF state		60	100	µS
Turn ON/OFF slew rate		0.3	1.5	V/µS
Output pin capacitance		5		nF

Low-side output, Type 2 transfer functions

The current for the product can be determined using the following transfer function:

$$I = \frac{136 \bullet INPUTx\_ADC}{195} \; mA$$

Where:

- I = Current
- INPUTx_ADC = the analog to digital count provided by the platform software

Note: To prevent aliasing, you should filter at half the rate of your sampling rate, according to the Nyquist criterion.

Low-side output, Type 2 fault detection

Low-Side Output, Type 2 outputs can detect the following faults:

- Open Circuit when ON
- Short to Battery when ON

Low-Side Output Diagnostics and Fault Detection

The CM0212's low-side outputs have the ability to report many different fault conditions, and are protected against short-circuit and over-current, open load, and short-to-ground faults.

Open Load

Open load faults occur when a low-side output pin is open circuit (not connected to a load). The use of this feature operates is defined in the CM0212 Platform Framework API document distributed with the SDK.

Note: Low-side outputs must be on to detect an open-load fault.

Short-Circuit

Short circuit faults occur when a low-side output pin is shorted to battery. For details on how to recover from a short circuit refer to the CM0212 Platform Framework API document distributed with the SDK.

Software Overcurrent

Software overcurrent faults occur when the current through a low-side output pin exceeds a threshold defined in the CM0212 Platform Framework API document distributed with the SDK.

Low-side output installation connections

When connecting low-side outputs, note that

- Low-side outputs are connected to a common internal ground point that is connected to the battery ground (GND).
- Low-side outputs provide switched ground to any load type in a vehicle.
- When connecting a load to a low-side output, ensure the load will not drive currents greater than the maximum specified peak current, or maximum specified continuous current.

The following shows a typical low-side output connection:

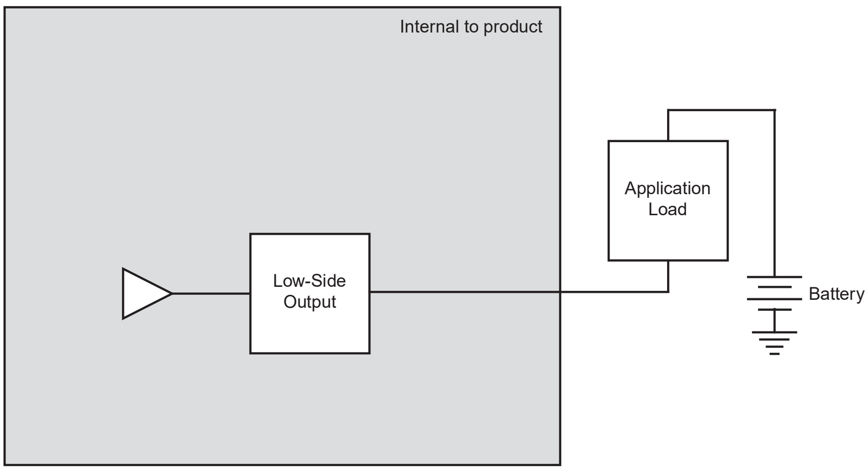


Figure 7: Typical low-side output connection

Sensor Power Outputs

The CM0212 has 1 pin, labeled `VSENSOR`, dedicated to providing power to external sensors.

> ⚠ *Warning!* Do not drive more than 75 mA of current through each `VSENSOR` 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.

Sensor supply, Type 1

Sensor supply Type 1 is intended to supply 5V to sensors and other devices.

The Type 1 sensor power outputs are intended to power external sensors in a system. They are not to be used to power inductive, motor, or bulb loads.

The CM0212 has 1 Type 1 Sensor Supply outputs:

- VSENSOR

Sensor supply, Type 1 circuit characteristics

The following table provides specifications for the Type 1 sensor supply:

Sensor Supply Type 1 Characteristics				
Item	**Min**	**Nom**	**Max**	**Unit**
Output voltage range	4.75	5.0	5.25	V
Output current			75	mA
Output short circuit current		0.2		A
Output capacitance		100		µF

Sensor supply, Type 1 transfer functions

The sensor supply has voltage feedback. The following transfer function should be used for the voltage feedback:

$$V_{SENSOR} = \frac{2 \bullet INPUTx\_ADC}{1365} \text{ Volts}$$

Where:

- Vsensor = Sensor Voltage
- INPUTx_ADC = the analog to digital count provided by the platform software

Sensor Power Connections

For information on how to connect sensors, refer to chapter 8 *Application Examples*.

Sensor Power Fault Responses

VSENSOR 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.

Power

The CM0212 is powered by the vehicle battery. The CM0212 operates in a 12 V system, and can operate from 9 V up to 16 V.

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

Power Capabilities

The VBATT and GND pins provide power to the logic circuit and to the output circuit.

The logic circuit, which consists of the microprocessor, RAM, etc. can draw a maximum of 200 mA.

The output circuit which consists of the high-side outputs can draw a maximum of 10 A. When creating applications care should be taken so that the combination of simultaneously energized outputs does not exceed 10 A.

The following table provides specifications for the CM0212 logic and output power:

Logic and Output Power Specifications				
Item	**Min**	**Nom**	**Max**	**Unit**
Input voltage range	9	12	16	V
Overvoltage	-	-	26	V
Cold Cranking (Under Voltage)	6	-	-	V
Current draw in on state (excluding outputs)	-	-	200	mA
Current draw in on state (including outputs)	-	-	11	A
Current draw in sleep *mode*[1]	-	-	5	mA
Inline fuse required on power pins (ATO *style)*[2]	-	20	-	A
Number of power pins	-	2	-	-
Number of ground pins	-	3	-	-

Power transfer functions

The power supply has voltage feedback. The following transfer function should be used for the voltage feedback:

$$V_{VBATT} = \frac{3001 \bullet INPUTx\_ADC}{410865} \text{ Volts}$$

Where:

- VVBATT = Battery Voltage
- INPUTx_ADC = the analog to digital count provided by the platform software

Logic and output power connections

When connecting the CM0212 logic and output power, note that:

- Logic and output power connections are made using the VBATT and GND pins.
- When there are multiple output power pins, the number of wires needed to connect the CM0212 power depends on the amount of current required by the application.
- It is recommended that you use the largest AWG wire allowed by your connector for the VBATT and GND pins, to meet the amount of expected output current; however, this is not always true and depends on your application.
- The CM0212 is protected against reverse-battery connections by an internal high-current conduction path that goes from ground to power. To protect the CM0212 from damage in a reverse-battery condition, place a fuse of 15 A or less in series with the power wires in the application harness.

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 CM0212 should be fused to protect the vehicle harness.

Communication

The only type of communication available to the CM0212 is Controller Area Network (CAN) communication.

Controller area network

The CM0212 has 1 Controller Area Network (CAN) communication port(s) available. The CM0212 hardware provides controller area network (CAN) communication according to the SAE J1939 specification, making the CM0212 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.

J1939 CAN Capabilities

The CAN typically communicates information at a rate of 250 kbps. 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:

CAN Specifications				
Item	**MIN**	**NOM**	**MAX**	**UNIT**
Baud rate limitations (hardware)	-	-	1000	kbps
Baud rate limitations (software)	-	250	-	kbps
Wake on CAN option	-	no	-	
Termination resistor (internal)	120	-	-	Ω

J1939 CAN Configuration

There is one feature associated to CAN communication in the CM0212 that can be configured**:**

- **Internal CAN Termination Resistor** – The 1101001 variant is populated with a software selectable **120 Ω** CAN termination resistor embedded inside the module. Embedding the resistor in the module allows you to avoid designing it into the vehicle harness.

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

J1939 CAN Installation Connections

The CAN connection for the CM0212 should conform to the J1939 standard. The J1939 standard is a robust automotive specification that is a good CAN installation guideline even when the J1939 CAN protocol is not being used.

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 standard variant of the CM0212 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). When a module does not have a CAN_SHIELD pin, the CAN Shield should be connected to an available ground terminal attached to the negative battery. 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:

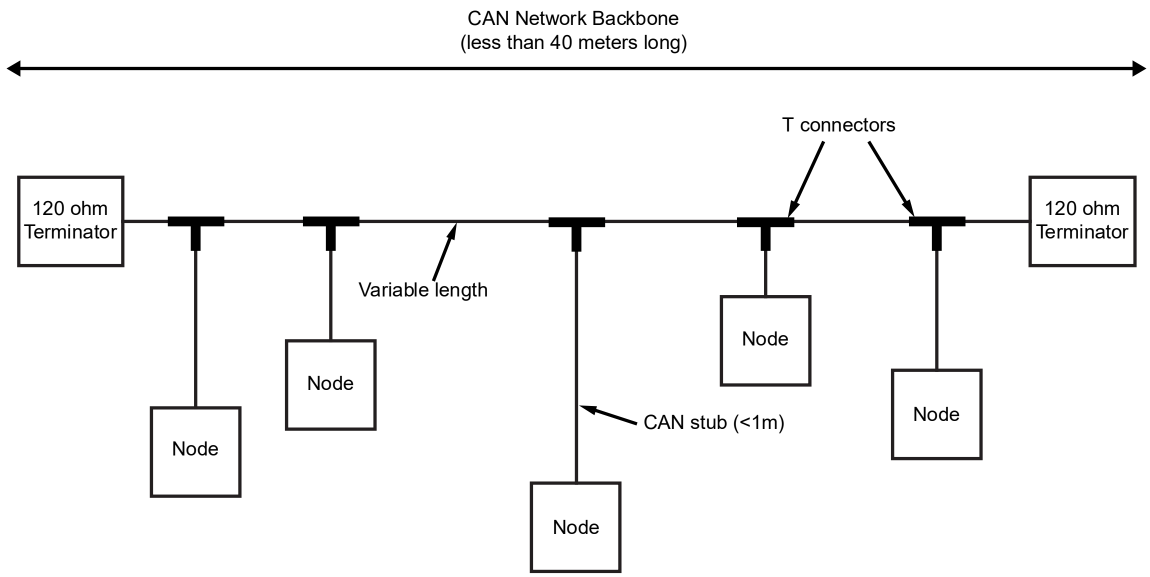


Figure 8: J1939 CAN connection

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 CM0212.

The vehicle manufacturer is responsible for creating procedures for mounting the CM0212 in a vehicle during production assembly.

Mechanical Requirements

Review the following mechanical requirements before selecting a mounting location for the CM0212:

- The CM0212 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 CM0212.
- 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 CM0212 should be in a location that is easily accessible for service.

Dimensions

The following shows the dimensions of the CM0212 in millimeters:

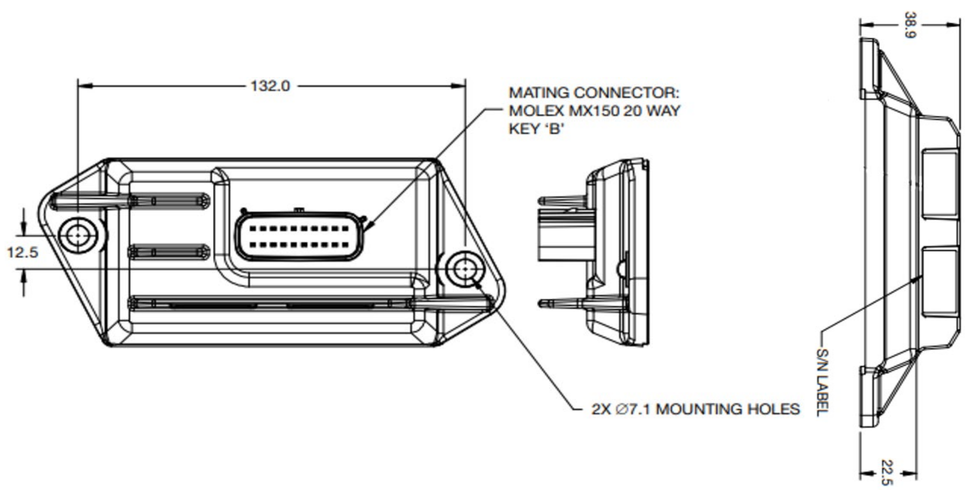


Figure 9: CM0212 dimensions

Selecting a Mounting Location

The CM0212 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 CM0212, ensure you review the following environmental and mechanical requirements.

Caution: Do not install the CM0212 close to any significant heat sources, such as a turbo, exhaust manifold, etc. Also avoid installing the CM0212 near any drive-train component, such as a transmission or engine block.

The CM0212 should be mounted with the connectors facing down, so that moisture drains away from it, as shown in the following:

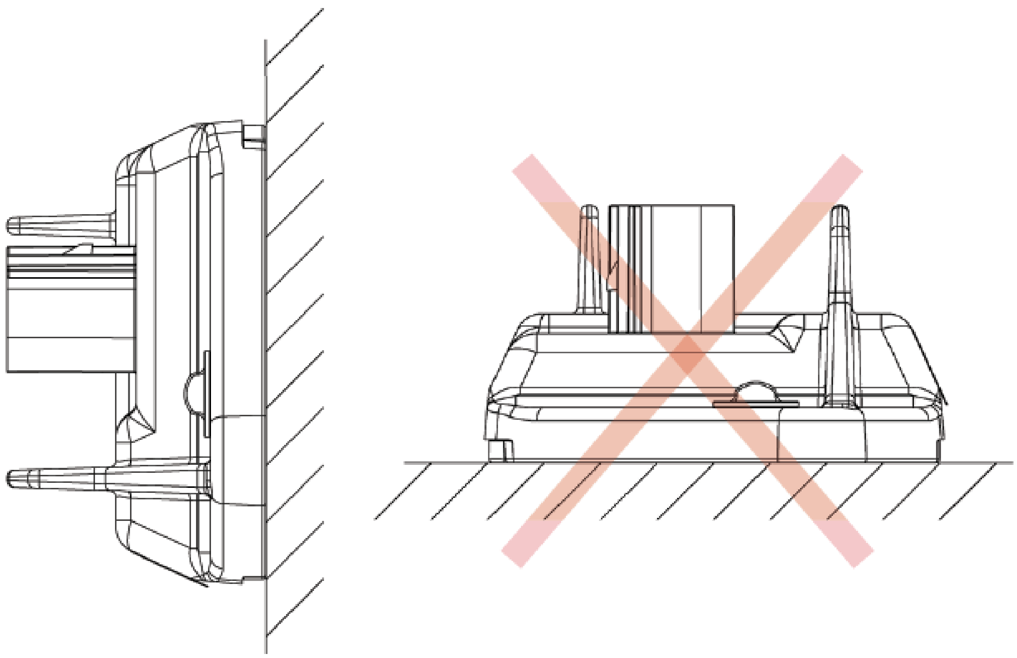


Figure 10: Recommended mounting orientation

Mounting the CM0212 to a Vehicle

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

The following guidelines are related to physically attaching the CM0212 to a vehicle:

- Secure the CM0212 with bolts in all bolt holes using Hex Head or equivalent metric size (M6) bolts.
- The bolts should be tightened according to the fastener manufacturer's tightening torque specifications.

Mechanical Requirements

Review the following mechanical requirements before selecting a mounting location for the CM0212:

- The CM0212 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 CM0212
- The harness should be shielded from harsh impact
- The harness should connect easily to the connector and have adequate bend radius
- The product label should be easy to read
- The CM0212 should be in a location that is easily accessible for service

7.6 Designing and Connecting the Vehicle Harness

The vehicle manufacturer is responsible for designing a vehicle harness that mates with the CM0212 connector(s).

The vehicle harness design depends on the following:

- How the CM0212's inputs, outputs, communication, and power pins are configured.
- Other components on the vehicle and their physical locations.
- The routing of the harness.

Details on recommended wire diameters for use with the product connector are covered in the connector manufacturer's datasheet. Wire diameters used should be sufficient for the expect module current.

Once the vehicle harness is designed, it can be connected to the CM0212 simply by clicking the mating connectors into the connector ports on the CM0212.

Application Examples

The purpose of this section is to provide examples of how the CM0212 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

Implementing Safety Interlocks

Safety is paramount when creating controls for a vehicle.

One safety feature that can be implemented with the CM0212 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:

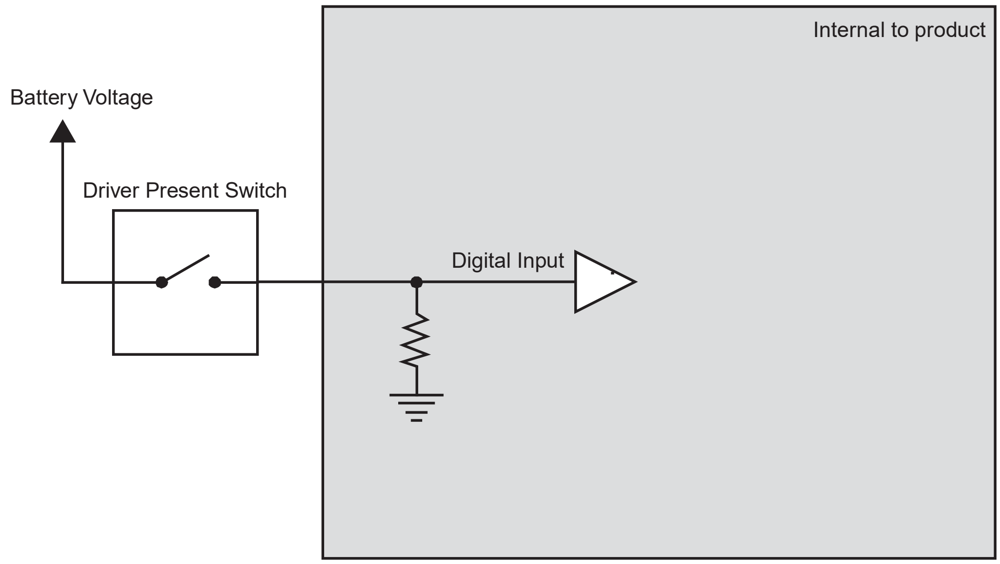


Figure 11: Seat switch interlock connection

Controlling Indicator Lights

Multiple CM0212 can be used together in a system to control a vehicle's indicator lights. For example, you could connect three CM0212s, communicating over the CAN bus, as follows.:

- Connect one CM0212 to the rear indicator lights.
- Connect one CM0212 to the front indicator lights.
- Connect one CM0212 to the turn signal and hazard switches.

The following shows how to connect three CM0212s together in a system to control indicator lights:

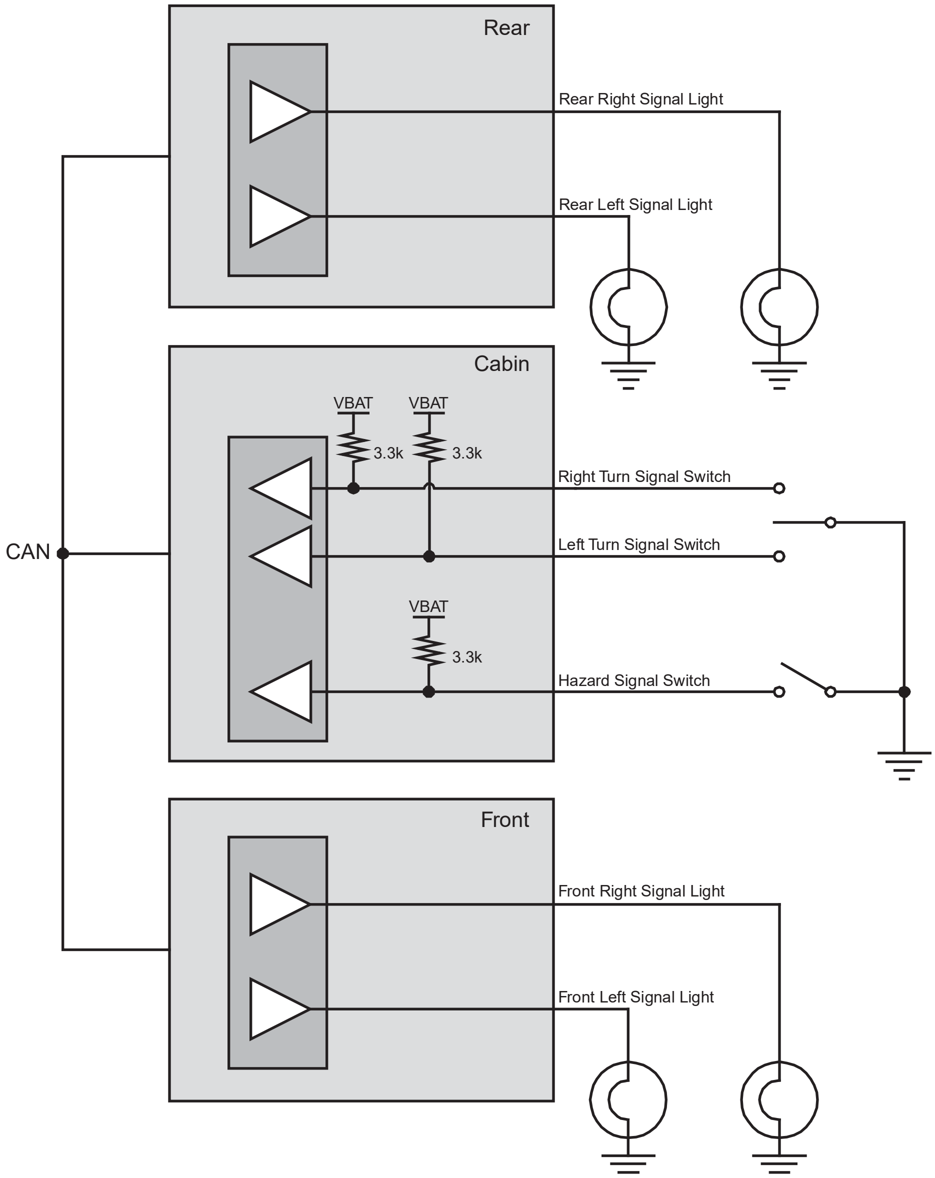


Figure 12: Indicator light connections

Controlling a Proportional Valve

The CM0212 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 CM0212 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

Hannifin 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:

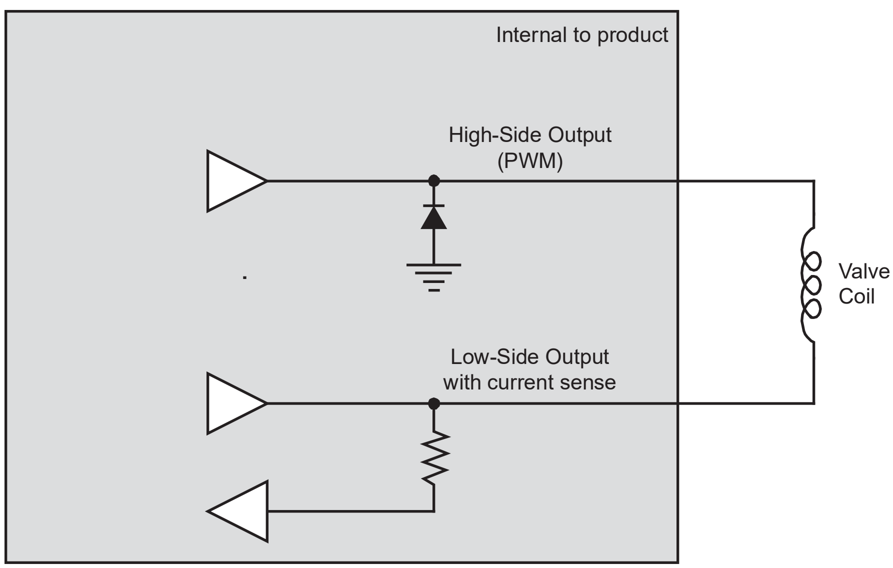


Figure 13: Connection for controlling a proportional valve

Controlling Motor Speed

The CM0212 can be used to control the DC motor speed of motors that provide a tachometer output.

Note: The CM0212 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

Hannifin 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 CM0212 to control the speed of a motor:

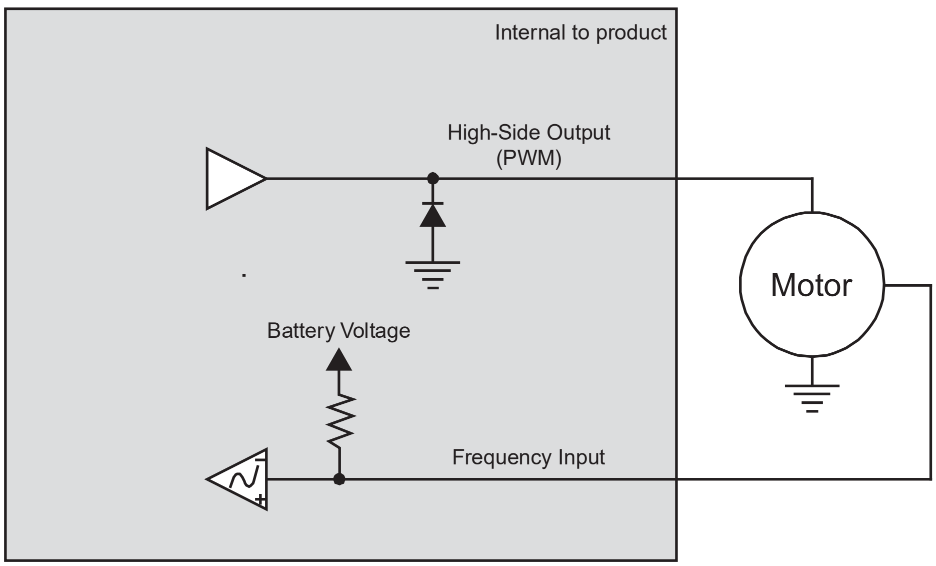


Figure 14: Connection for controlling motor speed

Connecting Various Sensors

There are many types of sensors that can be connected to the CM0212, 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 CM0212, use the sensor's specification to ensure that the CM0212 is configured correctly for the sensor.

Open Emitter

Open emitter sensors are compatible with Input 2 of the CM0212.

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

Note: Open emitter sensors need a pull-down resistor to bias the state of the sensor when the sensor is not activated. Pull-down resistors are internal to the CM0212.

The following shows a typical PNP open emitter sensor connection:

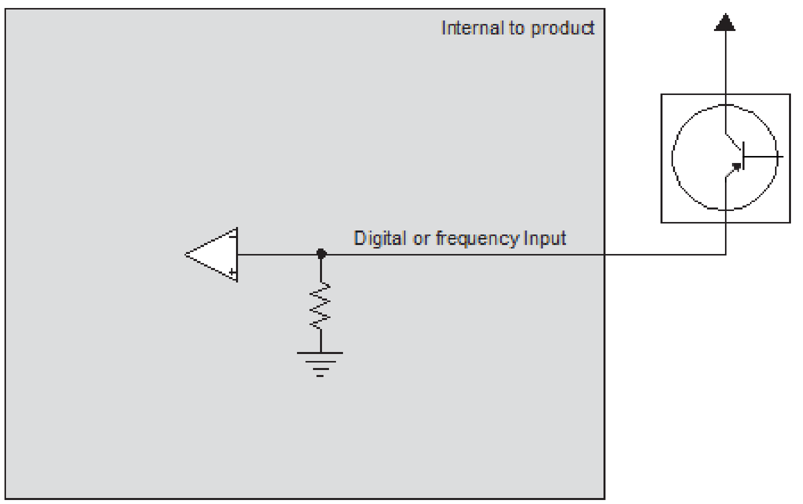


Figure 15: Open emitter active high connection

Variable Resistance

Variable resistance sensors change impedance to represent its 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 CM0212 cannot measure resistance directly.

To make the CM0212 measure resistance accurately, do the following:

- Include a precision pull-up resistor between the sensor and the sensor power output (called `VSENSOR`).
- 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:

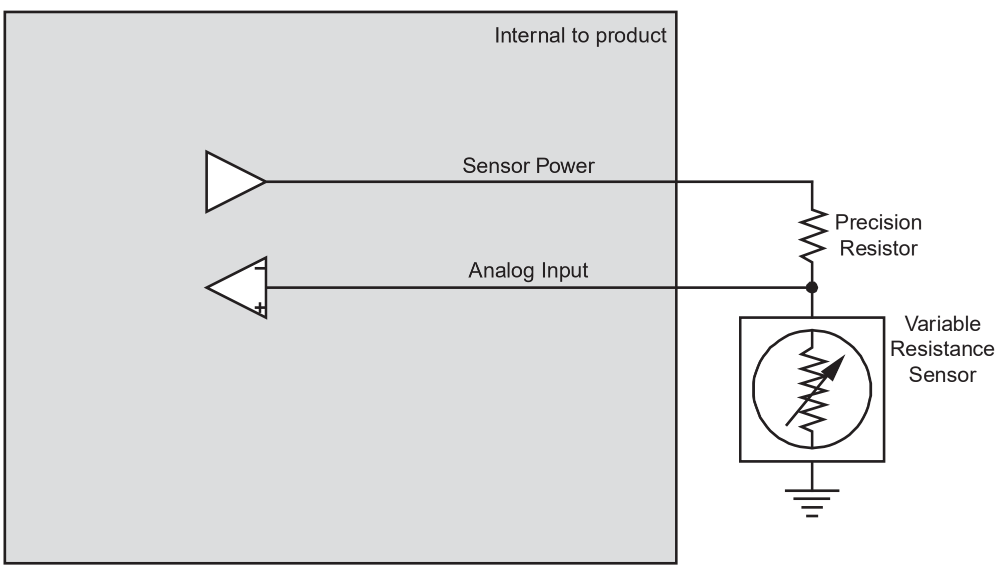


Figure 16: Variable resistance sensor connection

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:

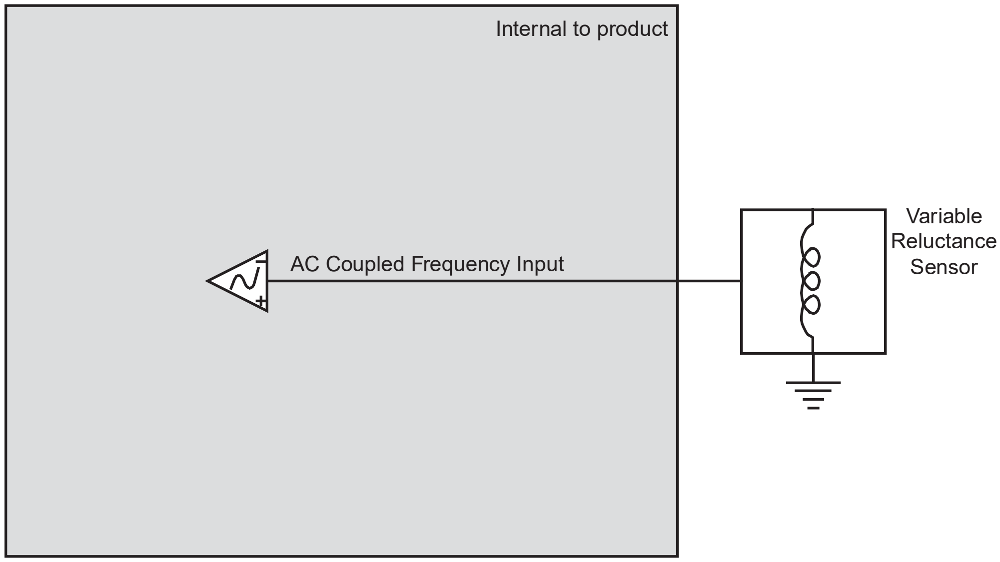


Figure 17: Variable reluctance sensor connection

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-high sensor switches are a common type which are generally safer to use.

The following shows a typical sensor switch connection:

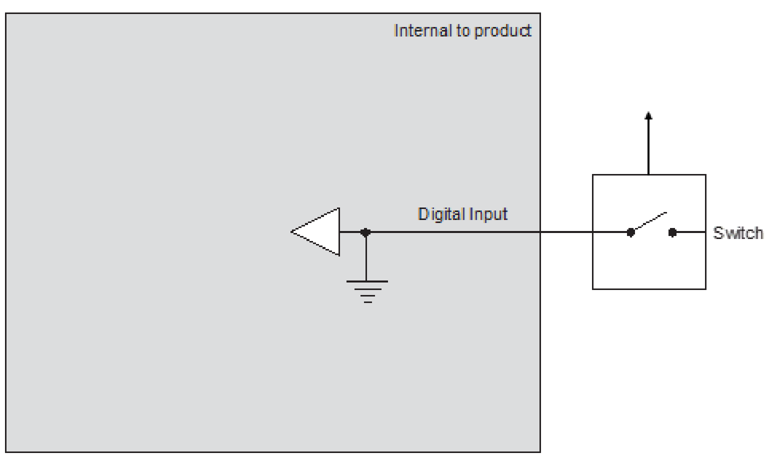


Figure 18: Switch sensor connection

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.

The following shows a typical voltage sensor connection:

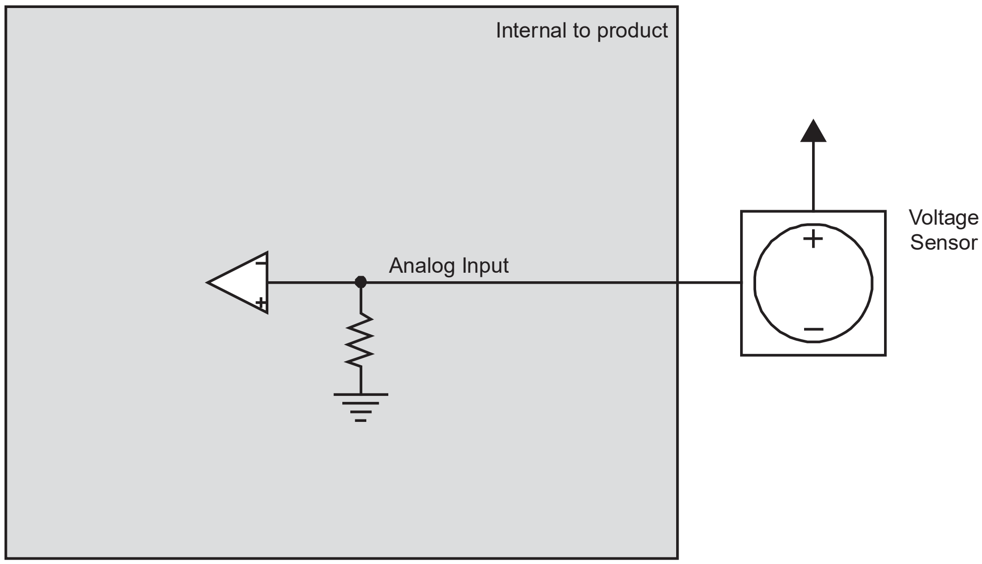


Figure 19: Voltage sensor connection

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:

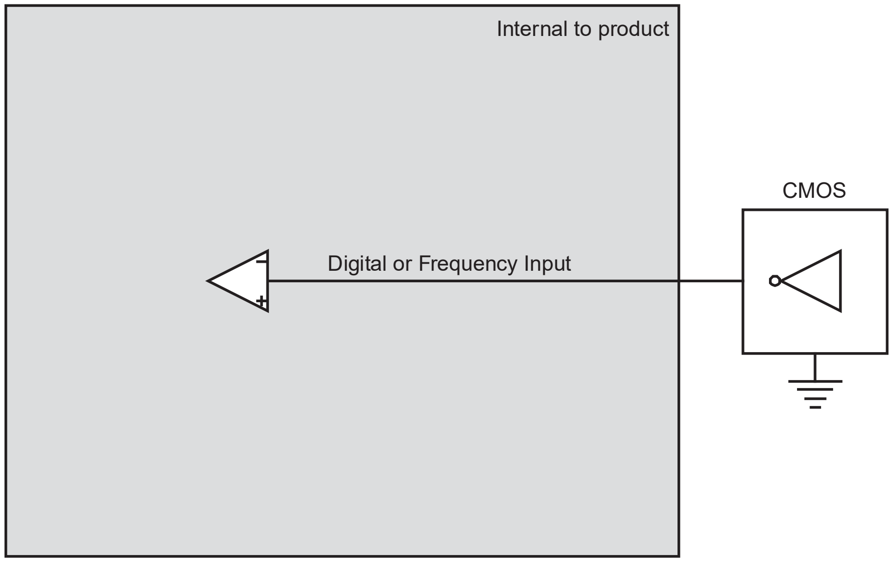


Figure 20: CMOS sensor connection

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 `VSENSOR` pin, and the other end to a `GND` pin on the CM0212.
- Connect the sensor signal to an analog input.

The following shows a typical potentiometer sensor connection:

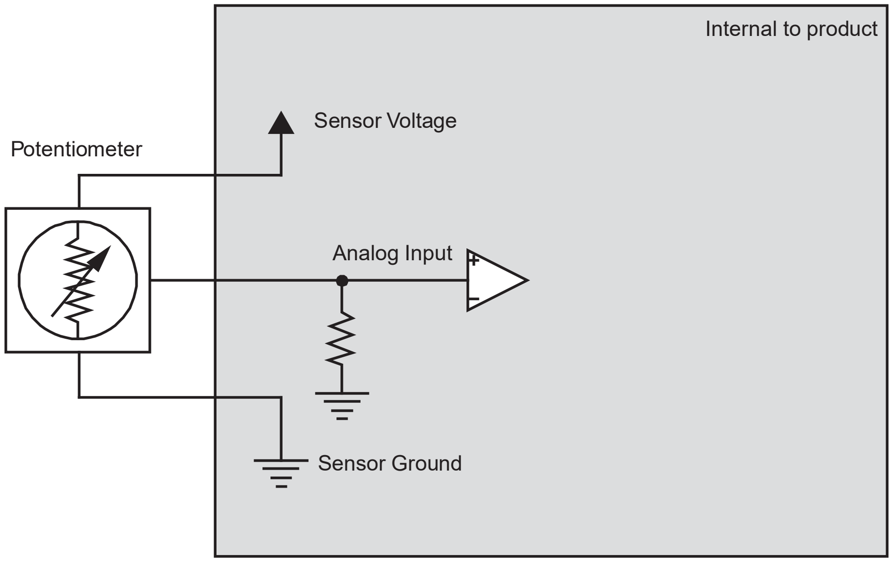


Figure 21: Potentiometer (ratiometric) sensor connection

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