Controller Module

CM2723V24 1093001

User Guide

HY33-50 18-IB/US

UG -CM2723 24V –

1093001ECD - 201 701-006

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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 (NOT RELEASED)	

1. 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.

1. 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.

1.1. General safety regulations

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

Warning! 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

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

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

Danger! Risk of death or injury. The CM2723V24 was not developed under nor certified to any functional safety standards. It is the system designer's responsibility to determine the appropriateness of using the CM2723V24 in a system design.

2. 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:

⚠ ***Warning! 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.

3. 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.

4. Safety during installation

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

5. 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.

6. 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.

2. Understanding the CM2723V24

The Controller Module (CM) 2723V24 is a general purpose input / output controller that nominally includes 28 inputs, 22 outputs, 1 regulated voltage output, and 2 CAN communication ports. The module is intended for use on 24V systems.

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: CM2723V24 controller module

The principal benefit of the CM2723V24 is that it can be configured to meet many system requirements through component configuration options, component value modification, and custom software.

The CM2723V24 is designed to communicate through a J1939-based Controller Area Network (CAN). Custom CAN messaging can be created in software, and the CM2723V24 can be used in any CAN 2.0B application, including ISO 11783.

A Parker Hannifin Software Development Kit (SDK) is available for the CM2723V24 which contains the platform software, API documentation and a tool that enables you to create custom application software for your product.

3. About the CM2723V24 User Guide

The CM2723V24 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 1093001 hardware configuration.

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

This manual describes the hardware components of the CM2723V24 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.

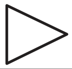
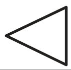
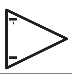
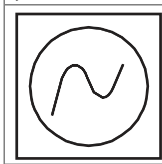
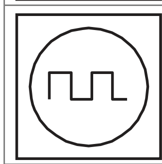
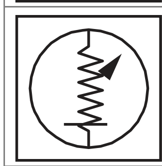
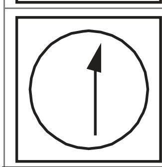
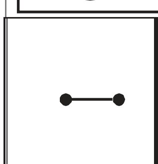
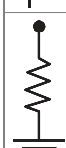
3.1. Section Types

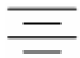
There are three kinds of sections in this manual: instruction, information, and example.

1. *Instruction sections* – The only instruction section in this manual is the Quick Start section, which provides procedures for connecting the CM2723V24 to a development system, powering it up, and downloading application software.
2. *Information sections* – Most sections in this manual are informational. They describe the hardware components of the CM2723V24, and usually have three sub-sections: circuit block diagram, circuit capabilities, and transfer function / use cases information.
3. *Example sections* – The only example section in this manual is the Application Examples section, which provides descriptions, diagrams, and explanations for possible CM2723V24 applications.

3.2. 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

4. Quick Start

This section provides step-by-step instructions on how to connect the CM2723V24 to a development system, install the required software tools, and download the application software.

4.1. Overview

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

1. Gather the required materials.
2. Install the required software tools provided by Parker Hannifin.
3. Connect the CM2723V24 to a development system (desktop) and power it up.
4. Download application software.

4.2. Gather Required Materials

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

- CM2723V24
- Personal computer (PC)
- Controller I/O board
- Controller I/O harness (connects the CM2723V24 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 CM2723V24 and controller I/O board loads (a 24 V DC, 3 A fixed voltage supply is generally suitable, unless driving more significant loads)
- Procurement drawing for the version of CM2723V24 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 CM2723V24.

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.

4.3. Connect the CM2723V24 to a Development System

It is a good idea to connect the CM2723V24 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 CM2723V24 in a development system:

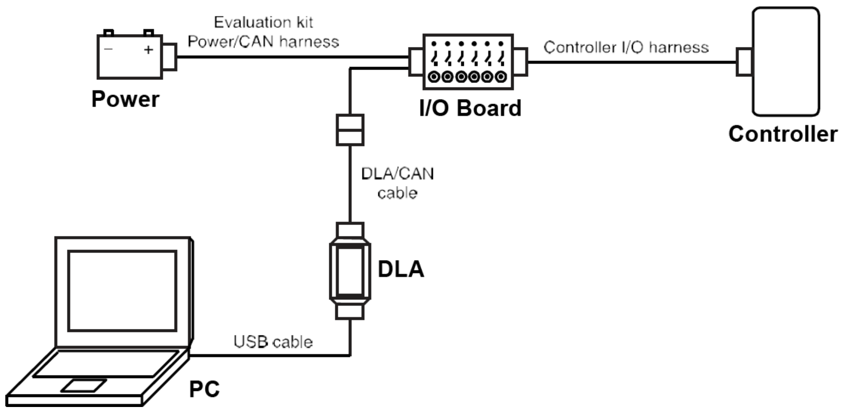


Figure 2: Development system connection

To connect the CM2723V24 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 between 12 V DC and 32 V DC.

1. Connect the Controller I/O harness to the CM2723V24.
2. Connect the Controller I/O harness to the controller I/O board connectors.
3. Do not connect the power wires (RED) from the evaluation kit harness to the power supply (+) terminal at this time.
4. Connect the ground wires (BLACK) from the evaluation kit harness to the power supply (-) terminal.
5. Connect the CAN connector from the evaluation kit power/CAN harness to the corresponding mating connector and harness on the CAN to USB adapter

Note: Do not proceed to the next step until the CAN to USB adapter has been configured. See instructions for the device you are using.

Connect the CAN to USB adapter to a personal computer via the USB port

4.3.1. Power Up the Development System

Once the CM2723V24 is connected in a development system, you need to power it up.

To power up the CM2723V24, do the following:

1. Ensure all controller I/O board digital inputs, jumpers, and dip switches are properly configured for the CM2723V24 variant in use. Refer to the *Controller IO Board Reference Material (HY33-5009-IB/US)* for further details.
2. Connect the power wires (red) from the evaluation kit 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 CM2723V24 (refer to the *Controller I/O Board Reference Manual* for details). The CM2723V24 will power up.

Note: If the module does not power up and you are unsure if a power control input is set on the CM2723V24, 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.

4.4. Download Application Software using Flash Loader

The Flash Loader transfers application software files that were created using the Software Development Kit (SDK), from your PC to the CM2723V24.

Applications need to be written and be downloaded to the product with a VSF file.

Note: Refer to the CM2723V24 Platform Software API document distributed with the SDK for details on how to detect an open load fault. For more information about writing software for the CM2723V24 using the SDK, contact your Parker Hannifin Account Representative.

To transfer a VSF file to the CM2723V24:

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.
4. 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.

5. From the modules list, select CM2723V24.
6. From the Software File Details list, select your VSF file.
7. Click Start - the VSF file downloads to the CM2723V24. Once complete, a confirmation screen opens.
8. Click OK - the CM2723V24 is now running the application code.

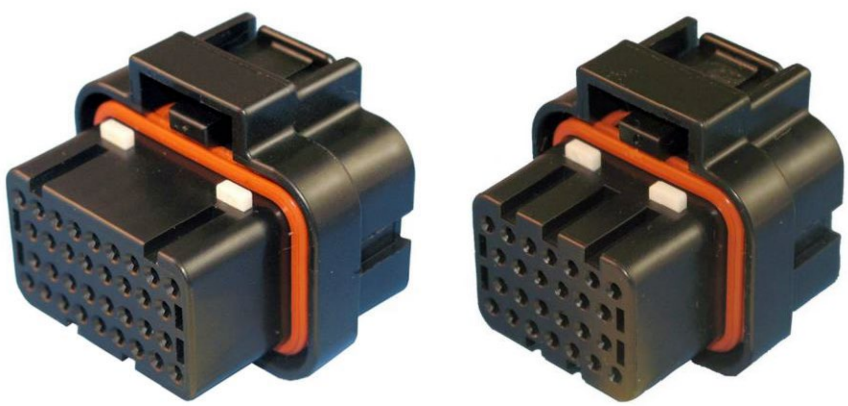
5. Connectors

The CM2723V24 has two Amp Superseal connectors, as follows:

- One 34-pin connector – Black (J1): AMP 4-1437290-1.
- One 26-pin connector – Black (J2): AMP 1473416-1.

Both connectors have pins that connect to inputs, outputs, power, and the Controller Area Network (CAN). The different pin counts prevent you from incorrectly mating the connectors to the vehicle harness. The vehicle harness should be designed to interface with both connectors.

The following are pictures of the required mating connectors:



Mating Connector Part Numbers		
Connector	Shell part no.	Terminals
J1 connector (black), 34-pin, key type 2	4-1437290-1	3-1447221-3 (16-18 AWG)
J2 connector (black), 26-pin, key type 3	1473416-1	3-1447221-3 (16-18 AWG)

5.1. Pinouts

The pins in connectors J1 and J2 connect to inputs, outputs, power, and CAN.

The following tables show the pin-outs for each connector for the 1093001 hardware configuration:

J1 Connector Pin-out		
Pin	**I/O name**	**Function**
1	OUTPUT18	Low-side output Type 1 (2.5 A, PWM)
2	OUTPUT17	Low-side output Type 1 (2.5 A, PWM)
3	OUTPUT10	High-side output Type 2 (1 A, NO PWM)
4	OUTPUT9	High-side output Type 2 (1 A, PWM)
5	OUTPUT11	High-side output Type 2 (1 A, PWM)
6	OUTPUT13	High-side output Type 3 (1 A, NO PWM)
7	OUTPUT12	High-side output Type 3 (1 A, PWM)
8	OUTPUT14	High-side output Type 2 (1 A, PWM)
9	OUTPUT16	High-side output Type 2 (1 A, PWM)
10	OUTPUT19	Low-side output Type 1 (2.5 A, PWM)
11	INPUT25	Analog, Type 1 (0-8V)
12	INPUT26	Analog, Type 1 (0-8V)
13	INPUT11	Frequency, Type 1 (Open Collector)
14	INPUT7	Digital, Type 1 (Active High)
15	INPUT27	Frequency, Type 2 (Active Push/Pull)
16	INPUT13	Digital, Type 2 (Active Low)
17	OUTPUT15	High-side output Type 2 (1 A, PWM)
18	OUTPUT20	Low-side output Type 1 (2.5 A, PWM)
19	INPUT28	Frequency, Type 1 (Open Collector)
20	INPUT24	Analog, Type 1 (0-8V)
21	INPUT5	Digital, Type 1 (Active High)
22	INPUT10	Digital, Type 1 (Active High)
23	INPUT15	Digital, Type 2 (Active Low)
24	INPUT18	Power Control Digital, Type 2 (active-high)
25	INPUT1	Resistive, Type 2 (200Ω – 225kΩ)
26	OUTPUT21	Low-side output Type 2 (2.5 A)
27	OUTPUT22	Low-side output Type 2 (2.5 A)
28	INPUT9	Digital, Type 1 (Active High)
29	INPUT12	Frequency, Type 1 (Open Collector)
30	INPUT6	Digital, Type 1 (Active High)
31	INPUT8	Digital, Type 1 (Active High)
32	INPUT2	Resistive, Type 2 (200Ω – 225kΩ)

J1 Connector Pin-out		
Pin	I/O name	Function
33	INPUT3	Resistive, Type 3 (300Ω – 30kΩ)
34	INPUT14	Digital, Type 2 (Active Low)

J2 Connector Pin-out		
Pin	I/O name	Function
1	INPUT4	Resistive, Type 4 (0Ω – 200Ω)
2	VBATT	12 V battery supply
3	VBATT	12 V battery supply
4	OUTPUT1	High-side output Type 1 (2.5 A, PWM)
5	OUTPUT2	High-side output Type 1 (2.5 A, PWM)
6	OUTPUT3	High-side output Type 1 (2.5 A, PWM)
7	OUTPUT4	High-side output Type 1 (2.5 A, PWM)
8	CAN1 L	CAN Low
9	CAN1 H	CAN High
10	INPUT23	Analog, Type 1 (0-8V)
11	INPUT21	Analog, Type 1 (0-8V)
12	INPUT20	Analog, Type 1 (0-8V)
13	OUTPUT5	High-side output Type 1 (2.5 A, PWM)
14	CAN2 H	CAN High
15	GROUND	GND (Sensor ground)
16	GROUND	GND (Negative battery)
17	GROUND	GND (Negative battery)
18	INPUT19	Resistive, Type 1 (100Ω-10kΩ) (IDtag)
19	OUTPUT6	High-side output Type 1 (3.5 A, PWM)
20	CAN2 L	CAN Low
21	INPUT16	Power Control Digital, Type 1 (active-high)
22	INPUT17	Power Control Digital, Type 1 (active-high)
23	VSENSOR1	5V sensor supply, 75 mA
24	INPUT22	Analog, Type 1 (0-8V)
25	OUTPUT8	High-side output Type 1 (2.5 A, PWM)
26	OUTPUT7	High-side output Type 1 (2.5 A, PWM)

6. Inputs

The CM2723V24 has analog, digital and frequency inputs.

The CM2723V24 is hardware configurable and the specific input configuration will depend on the hardware variant. This manual describes the 1093001 hardware variant.

6.1. Analog Inputs

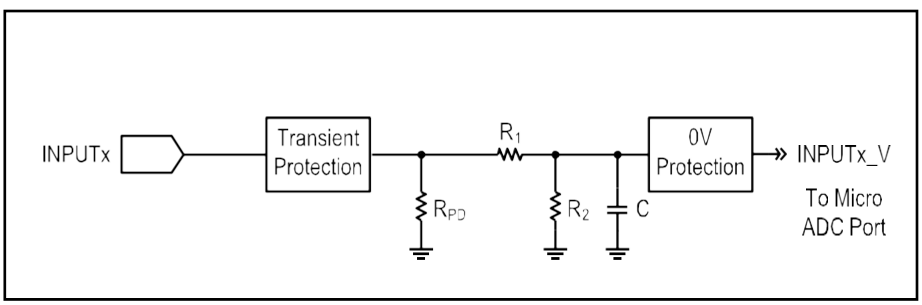
Analog inputs are typically used to read electrical signals that span a voltage range.

6.1.1. Analog input, Type 2 (0-8 V)

This input is intended to support 0-5V and 0-8V sensors. The CM2723V24 has seven Type 2 Analog inputs:

- INPUT20
- INPUT21
- INPUT22
- INPUT23
- INPUT24
- INPUT25
- INPUT26

6.1.1.1. Analog input, Type 2 circuit block diagram



6.1.1.2. Analog input, Type 2 circuit characteristics

The following table provides specifications for the analog input Type 2:

Analog input, Type 1 characteristics				
Item	Min	Nom	Max	Unit
Full scale input voltage	0		8	V
Input voltage range (non-operational)	0		32	V
Input resistance (w.r.t. ground)		34.25		kΩ
Filtering (hardware)		66		Hz
Resolution		2.03		mV/bit
Offset error			13.6	mV

6.1.1.3. Analog input, Type 2 transfer functions

6.1.1.3.1. Use case 1 - 0-5 V or 0-8 V sensors

$$Vs = \frac{3117 \cdot INPUTx\_ADC}{1531904}$$

Where:

- Vs = Voltage measured at product pin
- INPUTx_ADC = the analog to digital count provided by the platform software

6.1.2. 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:

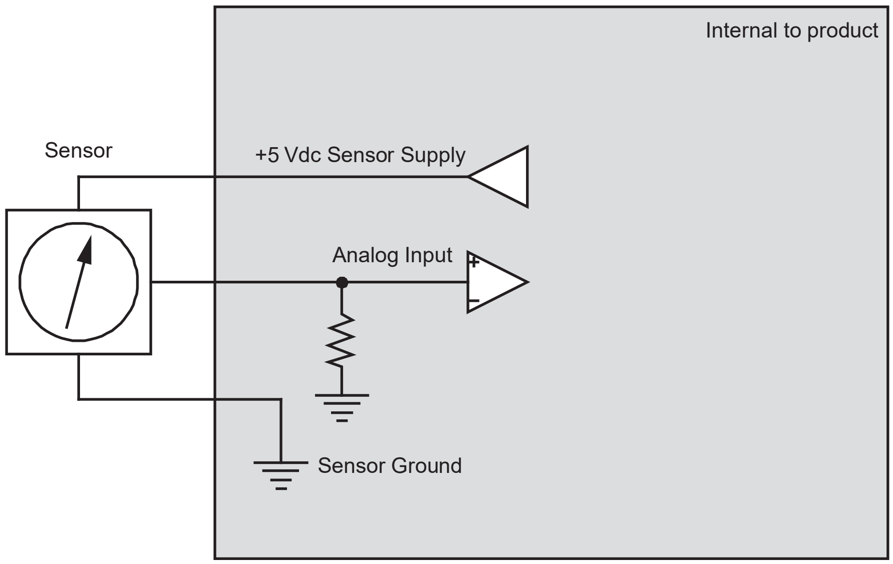


Figure 3: Analog input system noise reduction

Ground level shift

To reduce ground level shift:

- Dedicate one of the 3 system ground inputs (GND) to sensors that have dedicated ground wires, and connect all sensor grounds to this system ground input.
- 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.
- 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.

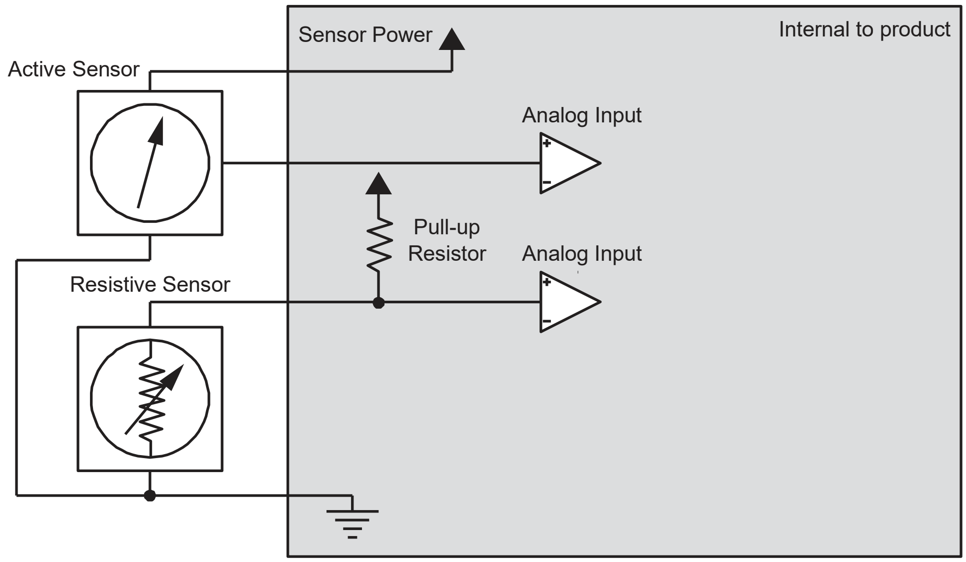


Figure 4: Analog input ground shift connection for sensors that have dedicated ground wires

6.2. Resistive Inputs

Resistive Inputs are typically used to measure the resistance of thermistors, potentiometers or other resistive type sensors.

6.2.1. Resistive input, Type 1

This input is intended to support standard Parker Hannifin IDtag resistors and other resistive type inputs in the range of 200Ω to 10 kΩ.

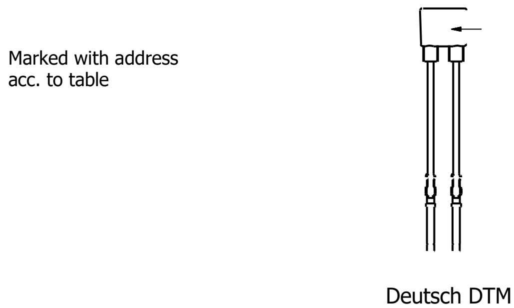
Sensors connected to this input type should use one of the ground wires of the product as a dedicated "sensor ground" through which all system sensors connect for return current. This reduces the errors that could otherwise be seen on analog readings due to ground shift on a system harness.

The CM2723V24 has one Type 1 Resistive input:

- INPUT19

6.2.1.1. Resistive input, Type 1 primary use

This input circuit has been optimized to support standard Parker Hannifin IDtag addressing resistors (0.5% resistors to be used for module addressing).

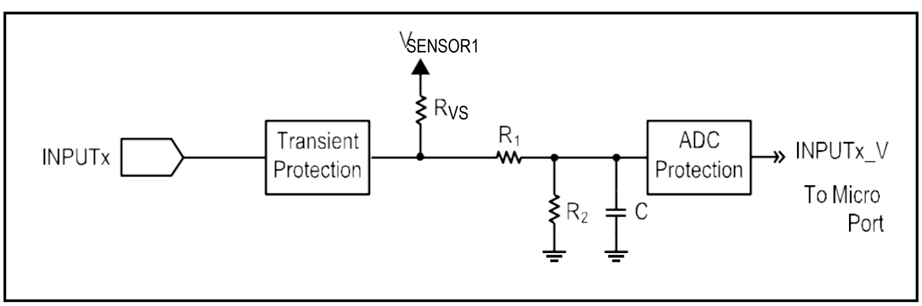


The following table shows the part numbers for the address resistors:

Address	Ordering part number*	Resistance
0	5030160	294
1	5030161	590
2	5030162	976
3	5030163	1.5k
4	5030164	2.23k
5	5030165	3.36k
6	5030166	5.3k
7	5030167	9.53k

* - addressing resistors are sold in bags of 10

6.2.1.2. Resistive input, Type 1 circuit block

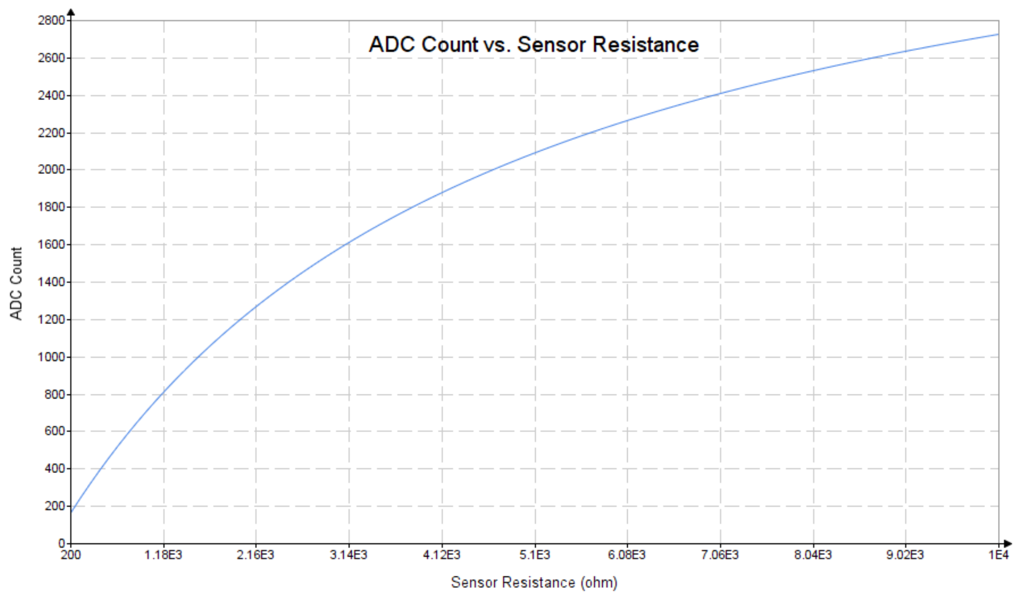


6.2.1.3.Resistive input, Type 1 circuit characteristics

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

Resistive input, Type 1 characteristics				
Item	Min	Nom	Max	Unit
Full scale input resistance [1]	0		10	kΩ
Input voltage range (non-operational)	0		32	V
Pull-up resistance		4750		Ω
Pull-up voltage (VSENSOR)		5		V
Wetting current (when active-low input)			1	mA

Note 1: See plot for full range responses.



6.2.1.4.Resistive input, Type 1 transfer functions

The following section describes common uses for this circuit and the transfer functions for the use cases.

6.2.1.4.1. Use Case 1 – Resistive Sensors

When used for resistive sensors, the following transfer function should be used:

$$Rs = \frac{5869125 \cdot INPUTx\_ADC}{1024000 \cdot VSENSOR - 1284 \cdot INPUTx\_ADC}$$

Where:

- Rs = Resistance measured from product pin to Sensor Ground
- INPUTx_ADC = the analog to digital count provided by the platform software
- VSENSOR = The measured value of VSENSOR in Volts

6.2.1.4.2. Use Case 2 – Active Low Digital Input (Low Wetting Current)

When used for active low digital inputs, the analog feedback for the circuit should be used to determine the digital state:

$$Vs = \frac{999 \cdot INPUTx\_ADC}{819200}$$

Where:

- Vs = Voltage measured at product pin (volts)
- INPUTx_ADC = the analog to digital count provided by the platform software

The analog voltage should be used to determine digital state based on the following table:

Voltage feedback	Condition	Digital state
Vs > 3.0V	Switch Open	FALSE
1.5 ≤ Vs ≤ 3.0V	Hysteresis	Hold last state
Vs < 1.5V	Switch Closed (Connected to Ground)	TRUE

6.2.2. Resistive input, Type 2

This input is intended to support thermistors, RTDs and other resistive type inputs in the range of 200Ω to 225 kΩ.

Sensors connected to this input type should use one of the ground wires of the product as a dedicated "sensor ground" through which all system sensors connect for return current. This reduces the errors that could otherwise be seen on analog readings due to ground shift on a system harness.

The CM2723V24 has two Type 2 Resistive inputs:

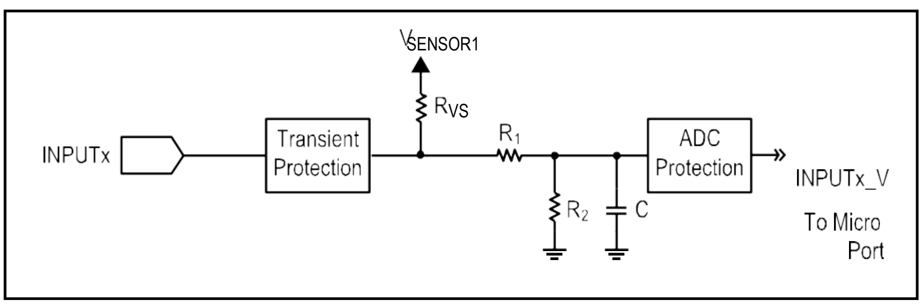
- INPUT1
- INPUT2

6.2.2.1. Resistive input, Type 2 primary use

This input circuit has been optimized for use with a resistive type NTC (negative temperature coefficient) sensor with the following characteristics in the range -40 to +130°C:

T_{OPER} (°C)	R (Ω)	T_{OPER} (°C)	R (Ω)	T_{OPER} (°C)	R (Ω)
-40	225824	25	6800	90	622.5
-35	163132	30	5480	95	534.5
-30	119136	35	4444	100	460.6
-25	87915	40	3624	105	398.3
-20	65524	45	2973	110	345.7
-15	49300	50	2452	115	301.0
-10	37431	55	2032	120	262.9
-5	28667	60	1693	125	230.3
0	22137	65	1417	130	202.4
5	17230	70	1192	135	178.4
10	13513	75	1007	140	157.7
15	10675	80	854.3	145	139.8
20	8492	85	727.8	150	124.2

6.2.2.2. Resistive input, Type 2 circuit block

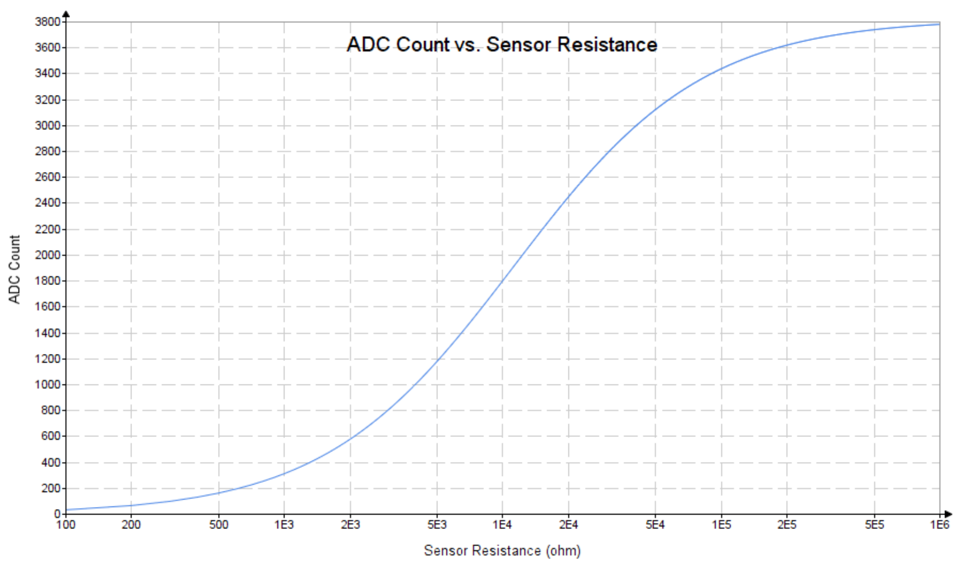


6.2.2.3. Resistive input, Type 2 circuit characteristics

The following table provides specifications for the Resistive Input, Type 2 circuit:

Resistive input, Type 2 characteristics				
Item	Min	Nom	Max	Unit
Full scale input resistance [1]	0		300	kΩ
Full scale input voltage	0		5	V
Input voltage range (non-operational)	0		36	V
Pull-up resistance		12000		Ω
Pull-up voltage (VSESNOR)		5		V
Wetting current			0.4	mA

Note 1: See plot for full range responses.



6.2.2.4. Resistive input, Type 2 transfer functions

The following section describes common uses for this circuit and the transfer functions for the use cases.

6.2.2.4.1. Use Case 1 – Resistive Sensors

When used for resistive sensors, the following transfer function should be used:

$$Rs = \frac{11988000 \cdot INPUTx\_ADC}{819200 \cdot VSENSOR - 1071 \cdot INPUTx\_ADC}$$

Where:

- Rs = Resistance measured from product pin to Sensor Ground
- INPUTx_ADC = the analog to digital count provided by the platform software
- VSENSOR = The measured value of VSENSOR in Volts

6.2.2.4.2. Use Case 2 – Active Low Digital Input (Low Wetting Current)

When used for active low digital inputs, the analog feedback for the circuit should be used to determine the digital state:

$$Vs = \frac{999 \cdot INPUTx\_ADC}{819200}$$

Where:

- Vs = Voltage measured at product pin
- INPUTx_ADC = the analog to digital count provided by the platform software

The analog voltage should be used to determine digital state based on the following table:

Voltage feedback	Condition	Digital state
Vs > 3.0V	Switch Open	FALSE
$1.5 \leq Vs \leq 3.0V$	Hysteresis	Hold last state
Vs < 1.5V	Switch Closed (Connected to Ground)	TRUE

6.2.2.4.3. Use Case 3 – Ratiometric Sensors

This input may be used with Ratiometric Pressure Sensors (such as the Parker Hannifin SCP series). The sensor supply must use the VSENSOR1 pin.

When used for ratiometric pressure sensors, the following transfer function should be used:

$$Vs = \frac{999 \cdot INPUTx\_ADC}{819200}$$

Where:

- Vs = Voltage measured at product pin
- INPUTx_ADC = the analog to digital count provided by the platform software

The voltage ratio is then calculated using:

$$Ratio = \frac{Vs}{VSENSOR}$$

6.2.3. Resistive input, Type 3

This input is intended to support thermistors, RTDs and other resistive type inputs in the range 30Ω to 30kΩ.

Sensors connected to this input type should use one of the ground wires of the product as a dedicated "sensor ground" through which all system sensors connect for return current. This reduces the errors that could otherwise be seen on analog readings due to ground shift on a system harness.

The CM2723V24 has one Type 3 Resistive input:

- INPUT3

6.2.3.1. Resistive input, Type 3 primary use

This input circuit has been optimized for use with a resistive type NTC type sensor with the following characteristics in the range of -40 to +125 degrees:

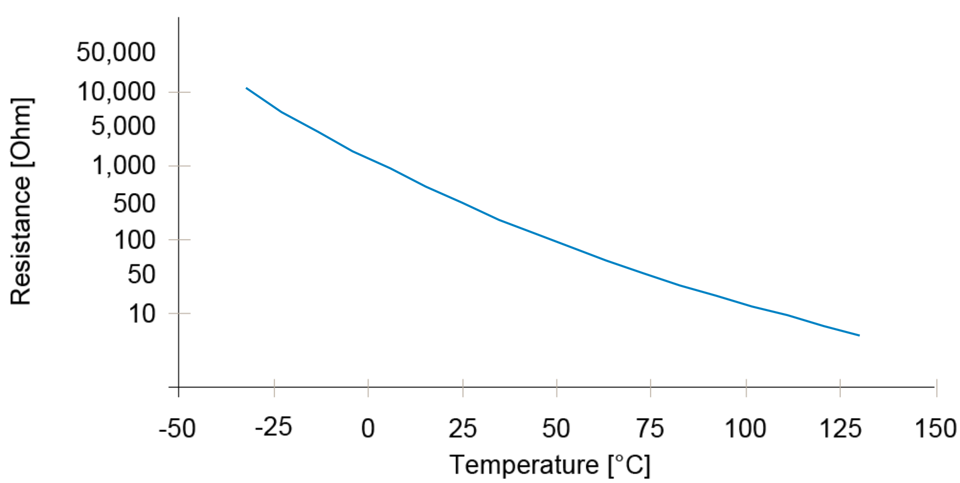
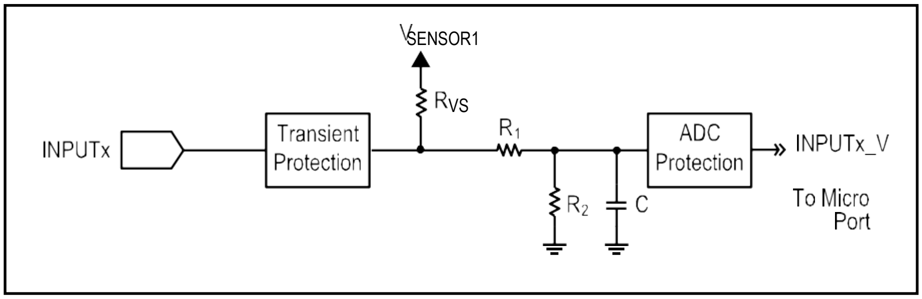


Figure 5: Example of NTC sensor resistance curve

6.2.3.2.Resistive input, Type 3 circuit block

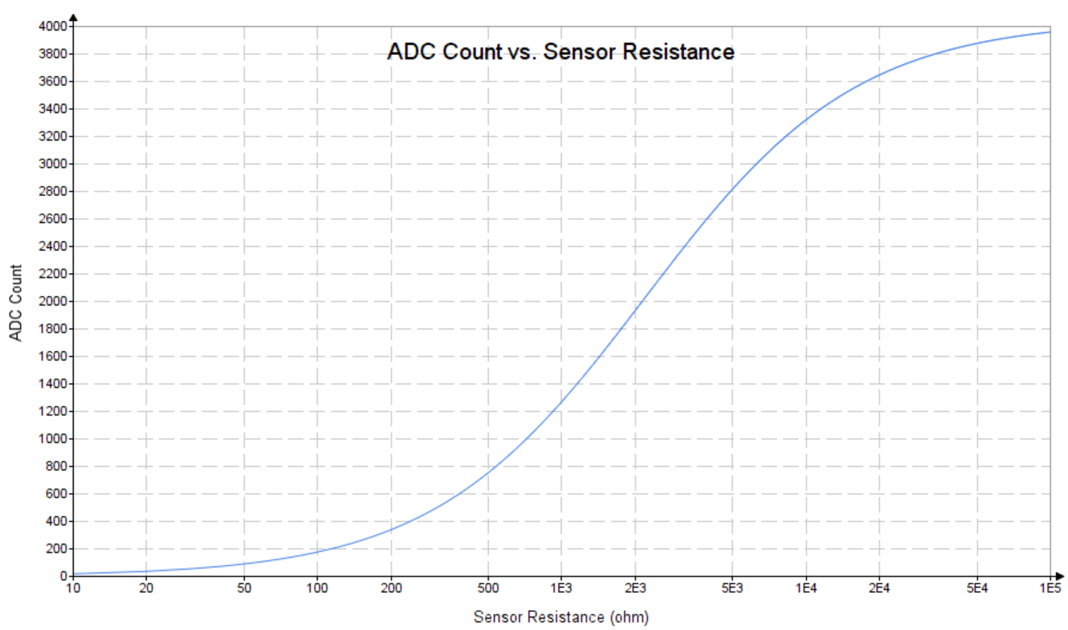


6.2.3.3.Resistive input, Type 3 circuit characteristics

The following table provides specifications for the Resistive Input, Type 3 circuit:

Resistive input, Type 3 characteristics				
Item	Min	Nom	Max	Unit
Full scale input resistance [1]	0		100	kΩ
Input voltage range (non-operational)	0		23	V
Pull-up resistance		2210		Ω
Pull-up voltage (VSENSOR)		5		V
Wetting current			2.2	mA

Note 1: See plot for full range responses.



6.2.3.4. Resistive input, Type 3 transfer functions

The following section describes common uses for this circuit and the transfer functions for the use cases.

6.2.3.4.1. Use Case 1 – Resistive Sensors

When used for resistive sensors, the following transfer function should be used:

$$Rs = \frac{110389500 \cdot INPUTx\_ADC}{40960000 \cdot VSENSOR - 50613 \cdot INPUTx\_ADC}$$

Where:

- Rs = Resistance measured from product pin to Sensor Ground
- INPUTx_ADC = the analog to digital count provided by the platform software
- VSENSOR = The measured value of VSENSOR in Volts

6.2.3.4.2. Use Case 2 – Active Low Digital Input (Low Wetting Current)

When used for active low digital inputs, the analog feedback for the circuit should be used to determine the digital state:

$$Vs = \frac{999 \cdot INPUTx\_ADC}{819200}$$

Where:

- Vs = Voltage measured at product pin
- INPUTx_ADC = the analog to digital count provided by the platform software

The analog voltage should be used to determine digital state based on the following table:

Voltage feedback	Condition	Digital state
Vs > 3.0V	Switch Open	FALSE
1.5 ≤ Vs ≤ 3.0V	Hysteresis	Hold last state
Vs < 1.5V	Switch Closed (Connected to Ground)	TRUE

6.2.4. Resistive input, Type 4

This input is intended to support low resistance sensors such as liquid level sensors in the range 0Ω to 200Ω.

Sensors connected to this input type should use one of the ground wires of the product as a dedicated "sensor ground" through which all system sensors connect for return current. This reduces the errors that could otherwise be seen on analog readings due to ground shift on a system harness.

The CM2723V24 has one Type 4 Resistive input:

- INPUT4

6.2.4.1. Resistive input, Type 4 primary use

This input circuit has been optimized for use with a resistive type level sensor with the following characteristics:

Switch steps	Incremental resistance	Total resistance
9	20	190
8	20	170
7	20	150
6	20	130
5	20	110
4	20	90
3	20	70
2	20	50
1	20	30
0	10	10

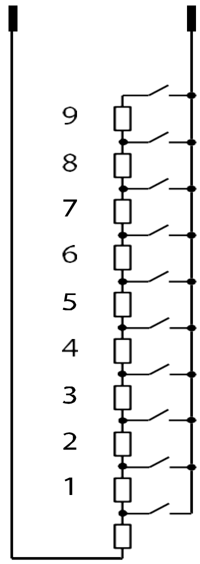
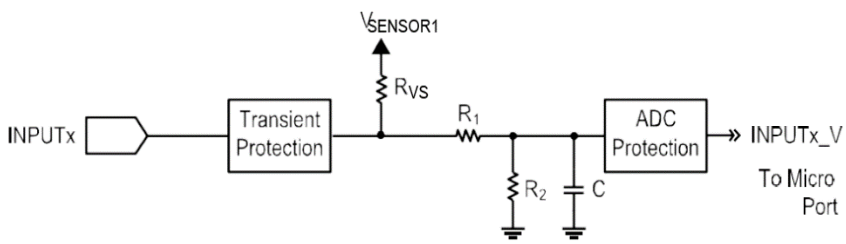


Figure 6: Typical resistive chain liquid level sensor

6.2.4.2. Resistive input, Type 4 circuit block

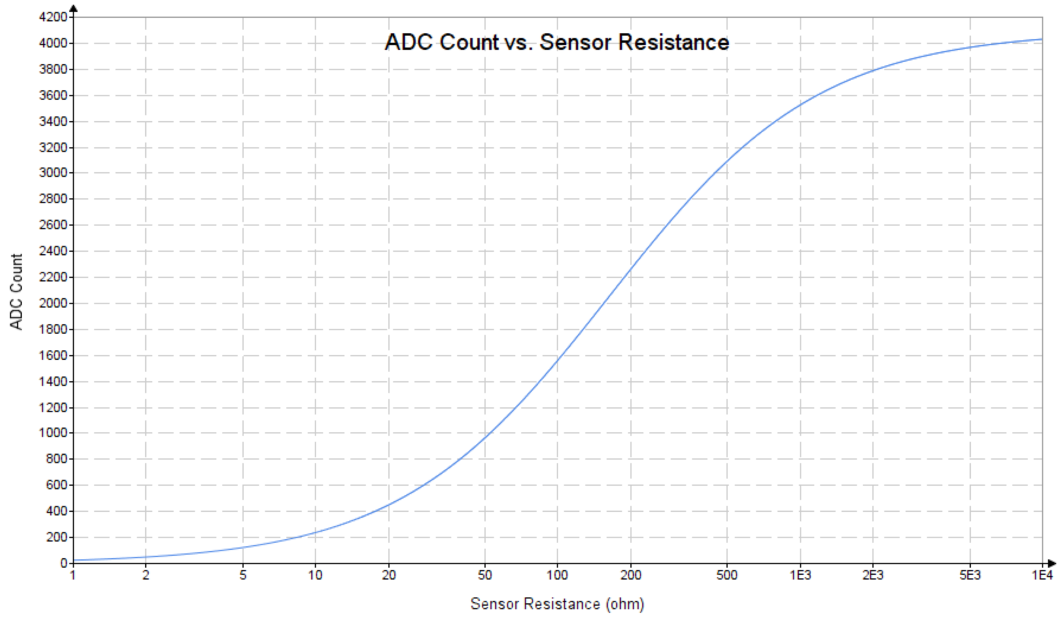


6.2.4.3. Resistive input, Type 4 circuit characteristics

The following table provides specifications for the Resistive Input, Type 4 circuit:

Resistive input, Type 4 characteristics				
Item	Min	Nom	Max	Unit
Full scale input resistance [1]	0		10	kΩ
Input voltage range (non-operational)	0		10	V
Pull-up resistance		162		Ω
Pull-up voltage (VSENSOR)		5		V
Wetting current			30.0	mA

Note 1: See plot for full range responses.



6.2.4.4. Resistive input, Type 4 transfer functions

The following section describes common uses for this circuit and the transfer functions for the use cases.

6.2.4.4.1. Use Case 1 – Resistive Sensors

When used for resistive sensors in the range of 0Ω to 200Ω, the following transfer function should be used:

$$Rs = \frac{40459500 \cdot INPUTx\_ADC}{204800000 \cdot VSENSOR - 249993 \cdot INPUTx\_ADC}$$

Where:

- Rs = Resistance measured from product pin to Sensor Ground
- INPUTx_ADC = the analog to digital count provided by the platform software
- VSENSOR = The measured value of VSENSOR in Volts

6.2.4.4.2. Use Case 2 – Active Low Digital Input (Low Wetting Current)

When used for active low digital inputs, the analog feedback for the circuit should be used to determine the digital state:

$$Vs = \frac{999 \cdot INPUTx\_ADC}{819200}$$

Where:

- Vs = Voltage measured at product pin
- INPUTx_ADC = the analog to digital count provided by the platform software

The analog voltage should be used to determine digital state based on the following table:

Voltage feedback	Condition	Digital state
Vs > 3.0V	Switch Open	FALSE
1.5 ≤ Vs ≤ 3.0V	Hysteresis	Hold last state
Vs < 1.5V	Switch Closed (Connected to Ground)	TRUE

6.3. Frequency Inputs

Frequency inputs are typically used to read pulse signals.

6.3.1. Frequency input, Type 1

This input is intended to support open collector type frequency inputs. The CM2723V24 has three Type 1 Frequency inputs:

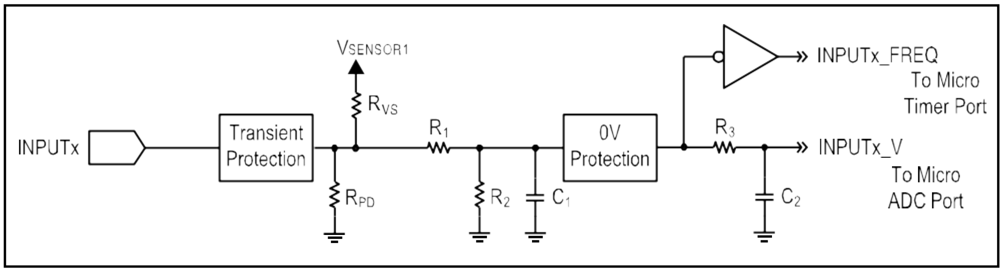
- INPUT11
- INPUT12
- INPUT28

6.3.1.1. Frequency input, Type 1 primary use

This input circuit has been optimized to support open collector type frequency sensors. This type of sensor switches between a low resistance to ground and floating (high resistance to ground) states.

For information on how to connect open collector sensors, refer to Section 11.5 Connecting Various Sensors.

6.3.1.2. Frequency input, Type 1 circuit block



6.3.1.3. 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			6.65	kΩ
Input pull-up voltage		5		V
Logic high threshold			3.25	V
Logic low threshold	0.79			V
Detectable Frequency Range	10		5.6	kHz
Frequency resolution		1		Hz

6.3.1.4. Frequency input, Type 1 transfer functions

6.3.1.4.1. 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 platform software API (no specific transfer function is required).

6.3.1.4.2. 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:

$$Vs = \frac{1031 \cdot INPUTx\_ADC}{1024000}$$

Where:

- Vs = Voltage measured at product pin
- INPUTx_ADC = the analog to digital count provided by the platform software

6.3.1.4.3. Use Case 3 – Resistive Sensor Input

When used as resistive inputs, the following transfer function should be used:

$$Rs = \frac{27424600 \cdot INPUTx\_ADC}{4096000 \cdot VSENSOR - 4257 \cdot INPUTx\_ADC}$$

Where:

- Rs = Resistance measured from product pin to Sensor Ground
- INPUTx_ADC = the analog to digital count provided by the platform software
- VSENSOR = The measured value of VSENSOR in Volts

6.3.2. Frequency input, Type 2

This input is intended to support non-open collector type frequency inputs. The CM2723V24 has one Type 2 Frequency inputs:

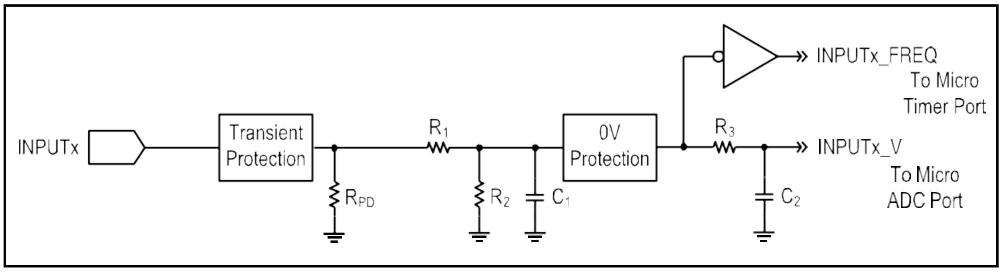
- INPUT27

6.3.2.1. Frequency input, Type 2 primary use

This input circuit is intended to support non-open collector type frequency sensors.

For information on how to connect variable reluctance and other non-open collector sensors, refer to Section 11.5 Connecting Various Sensors.

6.3.2.2.Frequency input, Type 2 circuit block



6.3.2.3.Frequency input, Type 2 circuit characteristics

The following table provides specifications for the Frequency input Type 2:

Frequency input, Type 2 characteristics				
Item	Min	Nom	Max	Unit
Input voltage range	0		5	V
Pull-down resistance		9.5		kΩ
Logic high threshold			3.78	V
Logic low threshold	0.86			V
Frequency range	10		10000	Hz
Frequency resolution		1		Hz

6.3.2.4.Frequency input, Type 2 transfer functions

6.3.2.4.1. Use Case 1 – DC coupled Frequency Input

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

6.3.2.4.2. Use Case 2 – DC coupled Frequency Input (Voltage Feedback)

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

$$Vs = \frac{7 \cdot INPUTx\_ADC}{4096}$$

Where:

- Vs = Voltage measured at product pin
- INPUTx_ADC = the analog to digital count provided by the platform software

6.3.2.4.3. Use Case 3 – Active High Digital Input (Low Wetting Current)

When used for active digital high inputs, the maximum digital (high) voltage should be <= 5.0V

$$Vs = \frac{7 \cdot INPUTx\_ADC}{4096}$$

Where:

- Vs = Voltage measured at product pin
- INPUTx_ADC = the analog to digital count provided by the platform software

Note: This Voltage must then be converted by the application software from an analog voltage to a digital state.

6.4. Digital Inputs

The primary function of this input is to interface with switch type sensors which provide a connection to VBATT or GND when closed within an application.

6.4.1. Digital input, Type 1

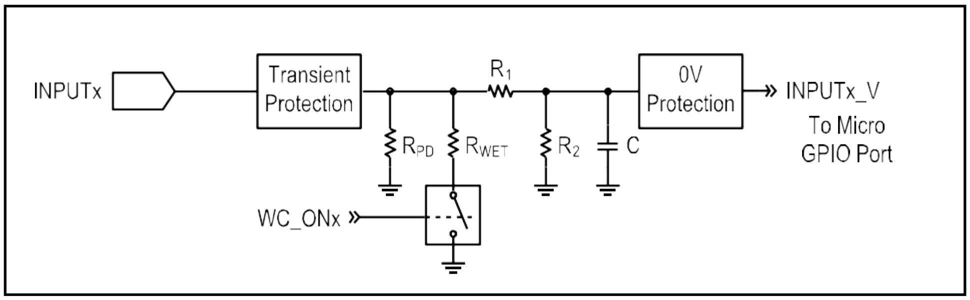
The primary function of this input is to interface with active high switch type sensors.

The CM2723V24 has nine Type 1 Digital inputs:

- INPUT5
- INPUT6
- INPUT7
- INPUT8

- INPUT9
- INPUT10
- INPUT16 (Wake Up) (Refer to Power Control Section 6.5)
- INPUT17 (Wake Up) (Refer to Power Control Section 6.5)
- INPUT18 (Wake Up) (Refer to Power Control Section 6.5)

6.4.1.1. Digital input, Type 1 circuit block



6.4.1.2. Digital input, Type 1 circuit characteristics

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

Digital input, Type 1 characteristics				
Item	Min	Nom	Max	Unit
Input voltage range (non-operational)	0		36	V
Input voltage range (operational)	12	24	32	V
Inductive load protection		Yes		
Pull-down resistance (wetting resistance disabled)		22.1		kΩ
Pull-down resistance (wetting resistance enabled)		2.21		kΩ
DC wetting current (24V)		1.1		mA
Pulsed wetting current (24V)		11		mA
Pulsed wetting current duty cycle (@ 100Hz)			10	%
Negative going input threshold	1.32			V
Positive going input threshold			3.21	V

6.4.2. Active-High Digital Input Connections

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

- When an active-high switch is open, the pull-down resistor ensures that no voltage exists on the input signal, which will be interpreted by the CM2723V24 as inactive.

- When the switch is closed, the input is connected to battery voltage, which will be interpreted by the CM2723V24 as active.

For an input that is active-high:

- It must be connected to battery power so that there is a battery connection when the state of the input changes.
- The power provided to the digital switch connected to the input must be provided through a fuse in the wire harness.

A typical active-high digital input connection is shown below:

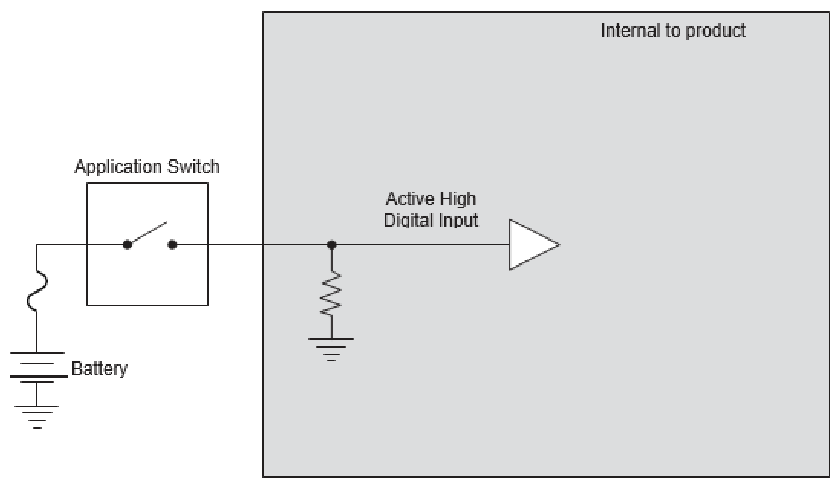


Figure 8: Active high digital input

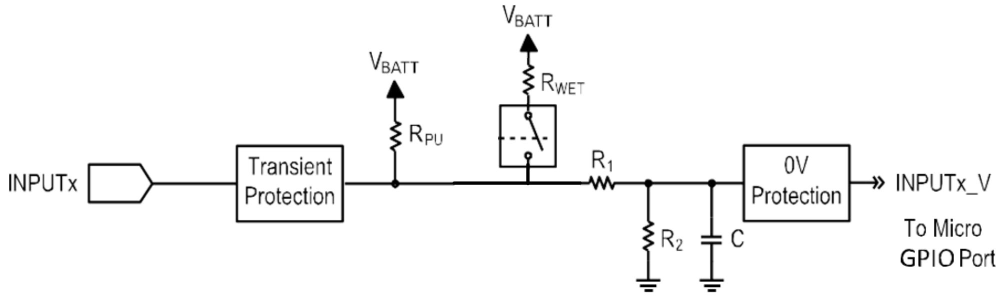
6.4.3. Digital input, Type 2

The primary function of this input is to interface with active-low switch type sensors.

The CM2723V24 has three Type 2 Digital input:

- INPUT13
- INPUT14
- INPUT15

6.4.3.1. Digital input, Type 2 circuit block



6.4.3.2. Digital input, Type 2 circuit characteristics

The following table provides specifications for the Digital input Type 2:

Digital input, Type 2 characteristics				
Item	Min	Nom	Max	Unit
Input voltage range (non-operational)	0		36	V
Input voltage range (operational)	12	24	32	V
Inductive load protection		Yes		
Pull-up resistance (wetting resistance disabled)		22.1		kΩ
Pull-up resistance (wetting resistance enabled)		2.21		kΩ
DC wetting current (24V)		1.1		mA
Pulsed wetting current (24V)		11		mA
Pulsed wetting current duty cycle (@ 100Hz)			10	%
Negative going input threshold	2.7			V
Positive going input threshold			6.9	V

6.4.4. Active-Low Digital Input 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 CM2723V24 as inactive.
- When the switch is closed, the input is connected to ground, which will be interpreted by the CM2723V24 as active.

The following shows a typical active low digital input connection:

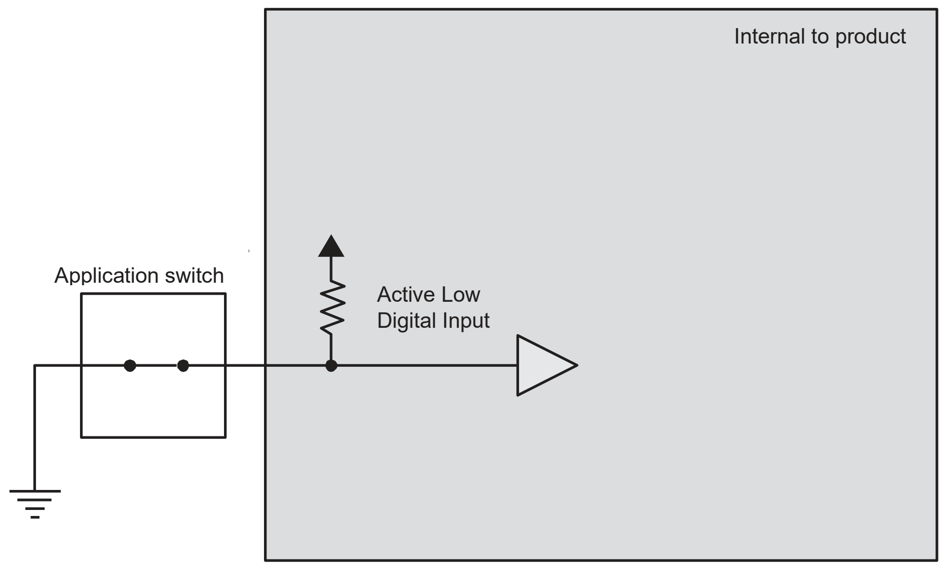


Figure 9: Active low digital input connections

6.5. Power Control Inputs

Power control digital inputs are used to wake up the product.

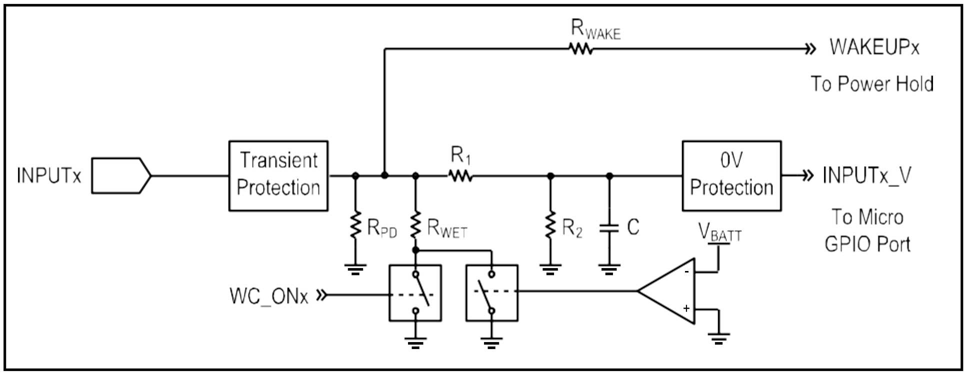
6.5.1. Power control wake up, Type 1

This input is intended to support active high digital inputs which are intended to wake up the controller. It provides a high wetting current while the controller is in standby.

The CM2723V24 has two Type 1 power control digital inputs that can be used for waking up (turning on) the product, as follows:

- INPUT16
- INPUT17

6.5.1.1. Power control wake up, Type 1 circuit block



6.5.1.2. Power control wake up, Type 1 circuit characteristics

The following table provides specifications for the Power control wake up, Type 1 inputs:

Power control wake up, Type 1 characteristics				
Item	MIN	NOM	MAX	UNIT
Input voltage range (non-operational)	0	-	36	V
Input voltage range (operational)	12	24	32	V
Inductive load protection		Yes		
Pull-down resistance (wetting resistance disabled)		22.1		kΩ
Pull-down resistance (wetting resistance enabled)		2.21		kΩ
DC wetting current (24V)		1.1		mA
Pulsed wetting current (24V)		11		mA
Pulsed wetting current duty cycle (@ 100Hz)			10	%
DC wetting current – Standby Mode (24V)		11		mA
Negative going input threshold	1.32			V
Positive going input threshold			3.21	V

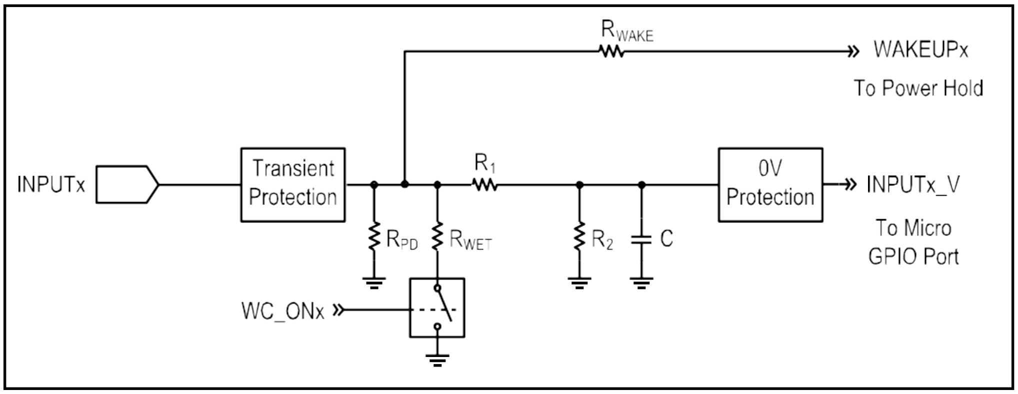
6.5.2. Power control wake up, Type 2

This input is intended to support active high digital inputs which are intended to wake up the controller. It does NOT provide a high wetting current while the controller is in standby.

The CM2723V24 has one Type 2 power control digital input that can be used for waking up (turning on) the product, as follows:

- INPUT18

6.5.2.1. Power control wake up, Type 2 circuit block



6.5.2.2. Power control wake up, Type 2 circuit characteristics

The following table provides specifications for the Power control wake up, Type 2 input:

Power control wake up, Type 2 characteristics				
Item	MIN	NOM	MAX	UNIT
Input voltage range (non-operational)	0	-	36	V
Input voltage range (operational)	12	24	32	V
Inductive load protection		Yes		
Pull-down resistance (wetting resistance disabled)		22.1		kΩ
Pull-down resistance (wetting resistance enabled)		2.21		kΩ
DC wetting current (24V)		1.1		mA
Pulsed wetting current (24V)		11		mA
Pulsed wetting current duty cycle (@ 100Hz)			10	%
Negative going input threshold	1.32			V
Positive going input threshold			3.21	V

6.5.3. Power Control Digital Input Installation Connections

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

- The power control digital input is usually connected to the vehicle ignition, but it can be connected to any power source in a system.
- To protect the harness that connects the CM2723V24 to the

ignition, place a fuse in the circuit that feeds the CM2723V24.

- If your CM2723V24 must always be powered, the power control digital input can be directly connected to a fused battery power input (called VBATT), which will provide constant power.
- When battery power (VBATT) is connected, and the power control digital input is inactive, the CM2723V24 will go into sleep mode.

The following shows a typical power control digital input connection:

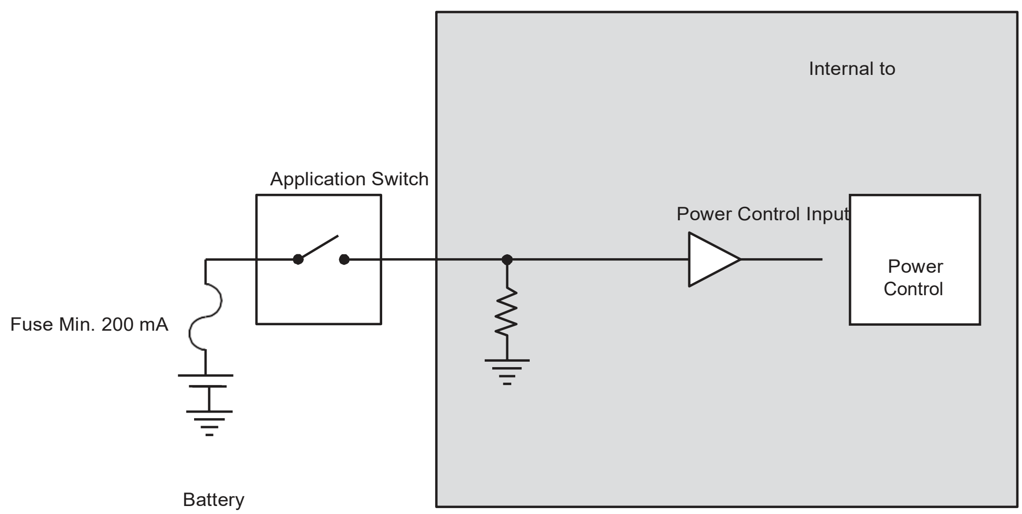


Figure 10: Power control digital input installation connections

7. Outputs

The CM2723V24 has high side and low side Outputs.

The CM2723V24 is hardware configurable and the specific output configuration will depend on the hardware variant. This manual describes the 1093001 hardware variant.

7.1. High-Side Outputs

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

7.1.1. High-side output, Type 1 (2.5 A)

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

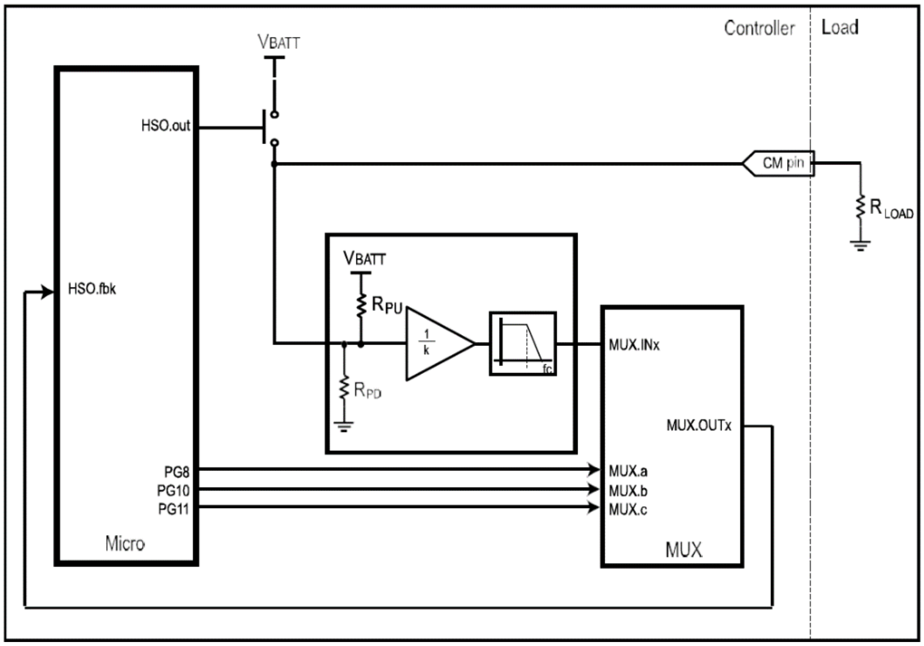
HS Output, Type 1 are used for switching voltage to loads (e.g. valve solenoids, lights) using either a pulse width modulated (PWM) signal, or an on/off signal. They can also test for various fault conditions, which can be used for software diagnostics.

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

The CM2723V24 has eight Type 1 high-side outputs:

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

7.1.1.1.High-side output, Type 1 circuit block



Note: On some hardware variants Rpu may not be stuffed, affecting the open load detection and using the output as a digital input, see further notes below.

7.1.1.2.High-side output, Type 1 circuit characteristics

The following table provides specifications for the CM2723V24 - 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		32		mΩ
Output OFF state leakage current (VBATT=24V)		1.2		mA
PWM frequency	50		250	Hz
Turn on time to ON state	20		150	μS
Turn off time to OFF state	20		150	μS
Turn ON/OFF slew rate			70	μS
Output pin capacitance		5		nF

7.1.1.3.High-side output, Type 1 fault detection

High Side Output, Type 1 has a voltage feedback circuit which is used for determining fault status of the output.

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

- Open Circuit when OFF
- Short to Battery (Back Driven) when OFF
- Short to Ground when ON
- Overcurrent when ON

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

Outputs	Current Threshold	
	Over current	Short circuit
1-8	>= 2.80 A	>= 4.00 A

Note: The values in the above table are trigger points in the PFW for faults. The output drivers self-protect and will start heating up above the over current threshold, eventually disabling the output. The driver will clamp the current feedback to the max reading.

Note: A load of 300 ohms or less guarantees no open circuit fault detection.

7.1.1.3.1. Open Circuit Fault:

Note: On some hardware variants Rpu may not be stuffed (see High-side output, Type 1 circuit block above), resulting in no open load detection for the output unless an external pull is added to the harness.

- Open circuit fault is detected when the output is open.
- The output must be OFF for the fault to be detected.
- The platform software trip time for this fault is 100ms.
- When the fault is detected, the output is NOT inhibited, but if detected during PWMing the output will be inhibited.
- The platform software output status value for this fault = 4.

7.1.1.3.2. Short to Battery (Back driven) Fault:

- Short to Battery fault is detected when the output is connected (shorted) to battery.
- The output must be OFF for the fault to be detected.
- The platform software trip time for this fault is 100ms.

- When the fault is detected, the output is NOT inhibited.
- The platform software output status value for this fault = 5.

7.1.1.3.3. Short to Ground Fault:

- Short to Ground fault is detected when the output is connected / shorted to ground or current > than the short circuit threshold (in the above table).
- The output must be ON for the fault to be detected.
- The platform software trip time for this fault is 75ms.
- When the fault is detected, the output is inhibited.
- An inhibited output can be recovered by the application code.
- If the platform software encounters five short circuits during a power session, the output will be latched off until the system is reset.
- The platform software output status value for this fault = 2.

7.1.1.3.4. Overcurrent Fault:

- Overcurrent fault is detected when the output is ON and the current > the overcurrent threshold (in the above table).
- The output must be ON for the fault to be detected.
- The output must be on for at least 1 sec. before this is checked.
- When the fault is detected, the output is NOT inhibited.
- The platform software output status value for this fault = 3.

Note: More information about the fault detection and output status values can be found in the documentation provided with the SDK, see: hw_dictionary.h (enum output_channel_enum) and hw_outputs.h (enum _output_state_t).

7.1.1.4. High-side output, Type 1 used as analog input

High Side Output, Type 1 has a voltage feedback circuit which allows the output to be used as a resistive input (for diagnostic purposes).

Note: Using this input as an analog input, should be limited due to a slower sample rate and less accuracy from current leakage paths.

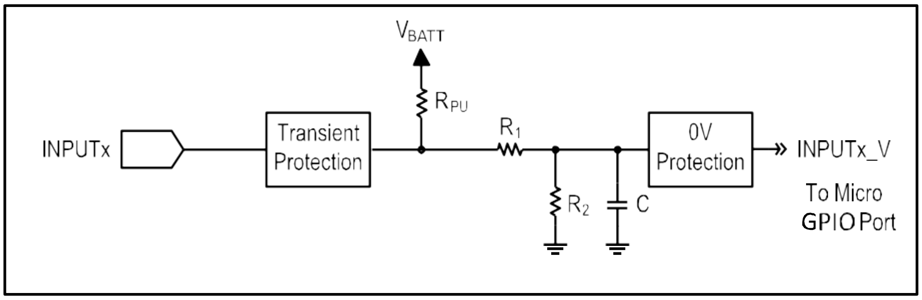
When used as an analog input, the following transfer function should be used:

$$Vs = \frac{109 \cdot ADC}{12288}$$

Where:

- Vs = Voltage measured at product pin
- INPUTx_ADC = the analog to digital count provided by the platform software

Note: On some hardware variants Rpu may not be stuffed – the output can then be used as an active high digital input.



The following table provides specifications for the analog feedback circuit:

Input Circuit Characteristics				
Item	Min	Nom	Max	Unit
Input voltage range[1]			8.8	V
Pull-up resistance		20000		Ω
Pull-up voltage (SW_VBATT)		24		V

Note 1: Assumes a 2% error for tolerance stack up and temperature error – the ADC will clip beyond the max value.

7.1.2. High-side output, Type 2 (1 A, PWM)

This output type provides a PWM capable 1A high-side output.

HS Output, Type 2 outputs are used for switching voltage to low power loads (e.g. LEDs, relays) using either a pulse width modulated (PWM) signal, or an on/off signal.

Note: If using these outputs to drive LEDs they will glow when off if there not enough load due to the open circuit detection circuit. This can be overcome by adding parallel resistance to ground to increase the load.

They can also test for various fault conditions, which can be used for software diagnostics.

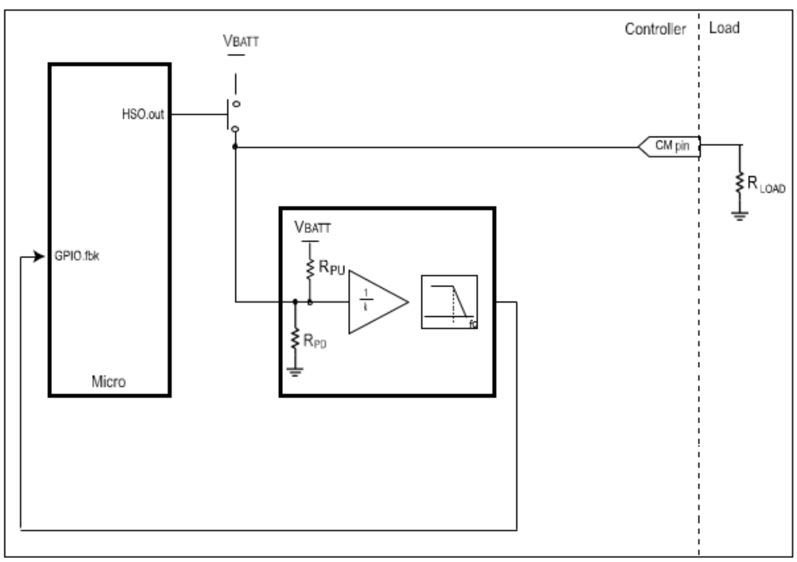
Note: These outputs do NOT have Short to Battery fault detection since they only have digital feedback.

> ⚠ ***Warning! HS Output, Type 2 outputs do not come with internal flyback diodes that provide protection when driving inductive loads.***

The CM2723V24 has six Type 2 high-side outputs:

- OUTPUT9
- OUTPUT11
- OUTPUT12
- OUTPUT14
- OUTPUT15
- OUTPUT16

7.1.2.1.High-side output, Type 2 circuit block



Note: On some hardware variants Rpu may not be stuffed affecting the open load detection and using the output as a digital input, see further notes below.

7.1.2.2.High-side output, Type 2 circuit characteristics

The following table provides specifications for the CM2723V24 - High-side Type 2 outputs:

High-Side Output Type 2 Characteristics				
Item	MIN	NOM	MAX	UNIT
Output current	0		1	A
Output ON state resistance		100		mΩ
Output OFF state leakage current (VBATT=24V)		1.2		mA
PWM frequency	50		250	Hz
Turn on time to ON state	20		150	μS
Turn off time to OFF state	20		150	μS
Turn ON/OFF slew rate			70	μS
Output pin capacitance		5		nF

7.1.2.3.High-side output, Type 2 fault detection

High Side Output, Type 2 has a digital feedback circuit which is used for determining fault status of the output.

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

- Open Circuit / Short to Battery when OFF (same fault)
- Short to Ground when ON
- Overcurrent when ON

Note: A load of 300 ohms or less guarantees no open circuit fault detection.

High Side Output, Type 2 also has a current feedback circuit which is used for determining some types of faults.

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

Outputs	**Current Threshold**	
	Over current	**Short circuit**
9-16	>= 1.11 A	>= 1.25 A

Note: The values in the above table are trigger points in the PFW for faults. The output drivers self-protect and will start heating up above the over current threshold, eventually disabling the output. The driver will clamp the current feedback to the max reading.

7.1.2.3.1. Open Circuit Fault:

Note: On some hardware variants Rpu may not be stuffed (see High-side output, Type 2 circuit block above), resulting in no open load detection for the output unless an external pull is added to the harness.

- This fault could also be a Short to Battery – as the output uses digital feedback (not analog), there no way to distinguish between the 2 fault types.
- Open circuit fault is detected when the output is open
- The output must be OFF for the fault to be detected.
- The platform software trip time for this fault is 100ms.
- When the fault is detected, the output is NOT inhibited, but if detected during PWMing the output will be inhibited.
- The platform software output status value for this fault = 4.

7.1.2.3.2. Short to Ground Fault:

- Short to Ground fault is detected when the output is connected (shorted) to ground or current > than the short circuit threshold (in the above table).
- The output must be ON for the fault to be detected.
- The platform software trip time for this fault is 50ms.
- When the fault is detected, the output is inhibited.
- An inhibited output can be recovered by the application code.
- If the platform software encounters five short circuits during a power session, the output will be latched off until the system is reset.
- The platform software output status value for this fault = 2.

7.1.2.3.3. Overcurrent Fault:

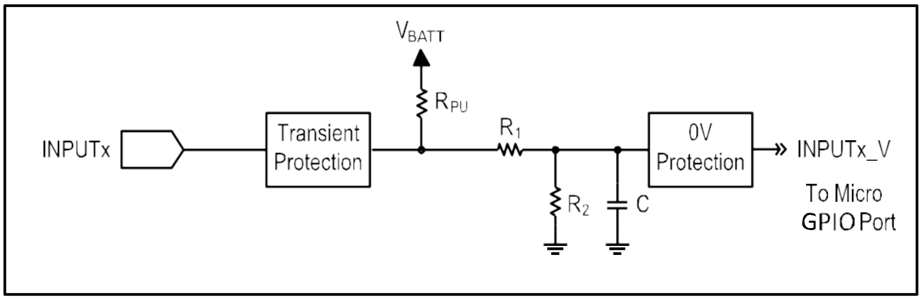
- Overcurrent fault is detected when the output is ON and the current > the overcurrent threshold (in the above table).
- The output must be ON for the fault to be detected.
- The output must be on for at least 1 sec. before this is checked.
- When the fault is detected, the output is NOT inhibited.
- The platform software output status value for this fault = 3.

Note: More information about the fault detection and output status values can be found in the documentation provided with the SDK, see: hw_dictionary.h (enum output_channel_enum) and hw_outputs.h (enum _output_state_t).

7.1.2.4. High-side output, Type 2 used as a digital input

High Side Output, Type 2 has an open load detect circuit with digital feedback which allows the output to be used as a low wetting current active low digital input.

Note: On some hardware variants Rpu may not be stuffed – the output can then be used as an active high digital input.



The following table provides specifications for the digital feedback circuit:

Digital Feedback Circuit Characteristics				
Item	MIN	NOM	MAX	UNIT
Voltage range (non-operational)	0		36	V
Voltage range (operational)	0		32	V
Inductive load protection		NO		
Pull-up resistance		20		kΩ
DC wetting current (24V)		1.2		mA
Negative going input threshold	2.7			V
Positive going input threshold			6.2	V

7.1.3. High-side output, Type 3 (1 A, digital)

This output type provides a digital capable 1 A high-side output.

HS Output, Type 2 outputs are used for switching voltage to low power loads (e.g. LEDs, relays) using an on/off signal.

Note: If using these outputs to drive LEDs they will glow when off if there not enough load due to the open circuit detection circuit. This can be overcome by adding parallel resistance to ground to increase the load.

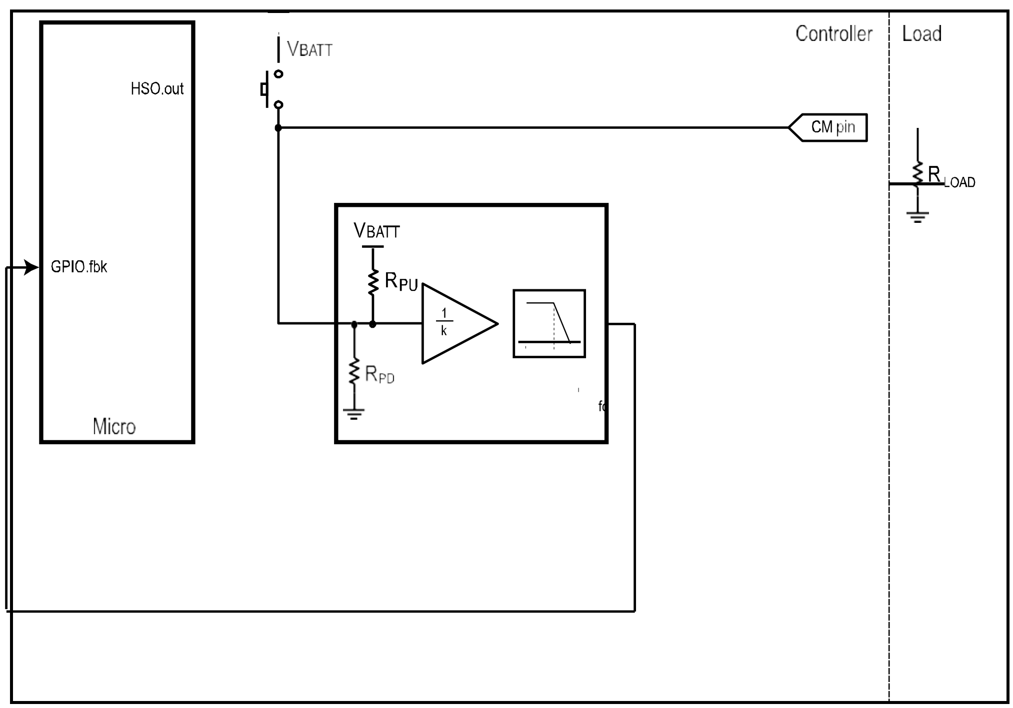
They can also test for various fault conditions, which can be used for software diagnostics.

⚠ ***Warning! HS Output, Type 3 outputs do not come with internal flyback diodes that provide protection when driving inductive loads.***

The CM2723V24 has two Type 3 high-side outputs:

- OUTPUT10
- OUTPUT13

7.1.3.1.High-side output, Type 3 circuit block



Note: On some hardware variants Rpu may not be stuffed affecting the open load detection and using the output as a digital input, see further notes below.

7.1.3.2. High-side output, Type 3 circuit characteristics

The following table provides specifications for the CM2723V24 - High-side Type 3 outputs:

High-Side Output Type 3 Characteristics				
Item	MIN	NOM	MAX	UNIT
Output current	0		1	A
Output ON state resistance		100		mΩ
Output OFF state leakage current (VBATT=12V)		1.2		mA
Turn on time to ON state	20		150	µS
Turn off time to OFF state	20		150	µS
Turn ON/OFF slew rate			70	µS
Output pin capacitance		5		nF

7.1.3.3. High-side output, Type 3 fault detection

High Side Output, Type 3 has a digital feedback circuit which is used for determining fault status of the output.

High Side Output, Type 3 outputs can detect the following faults:

- Open Circuit / Short to Battery when OFF (same fault)
- Short to Ground when ON
- Overcurrent when ON

Note: A load of 300 ohms or less guarantees no open circuit fault detection.

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

Outputs	Current Threshold	
	Over current	Short circuit
10, 13	>= 1.11 A	>= 1.25 A

Note: The values in the above table are trigger points in the PFW for faults. The output drivers self-protect and will start heating up above the over current threshold, eventually disabling the output. The driver will clamp the current feedback to the max reading.

7.1.3.3.1. Open Circuit Fault:

Note: On some hardware variants Rpu may not be stuffed (see High-side output, Type 3 circuit block above), resulting in no open load detection for the output unless an external pull is added to the harness.

- This fault could also be a Short to Battery – as the output uses digital feedback (not analog), there no way to distinguish between the 2 fault types.
- Open circuit fault is detected when the output is open – no load (or > 300 ohms) is connected to the output pin.
- The output must be OFF for the fault to be detected.
- The platform software trip time for this fault is 100ms.
- When the fault is detected, the output is NOT inhibited, but if detected during PWMing the output will be inhibited.
- The platform software output status value for this fault = 4.

7.1.3.3.2. Short to Ground Fault:

- Short to Ground fault is detected when the output is connected (shorted) to ground or current > than the short circuit threshold (in the above table).
- The output must be ON for the fault to be detected.
- The platform software trip time for this fault is 50ms.
- When the fault is detected, the output is inhibited.
- An inhibited output can be recovered by the application code.
- If the platform software encounters five short circuits during a power session, the output will be latched off until the system is reset.
- The platform software output status value for this fault = 2.

7.1.3.3.3. Overcurrent Fault:

- Overcurrent fault is detected when the output is ON and the current > the overcurrent threshold (in the above table).
- The output must be ON for the fault to be detected.
- The output must be on for at least 1 sec. before this is checked.
- When the fault is detected, the output is NOT inhibited.

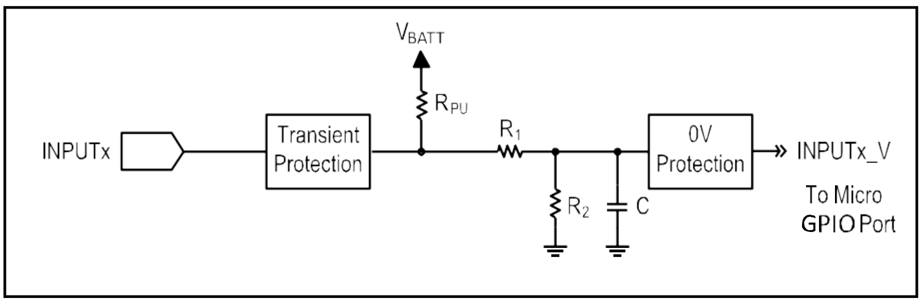
- The platform software output status value for this fault = 3.

Note: More information about the fault detection and output status values can be found in the documentation provided with the SDK, see: hw_dictionary.h (enum output_channel_enum) and hw_outputs.h (enum _output_state_t).

7.1.3.4. High-side output, Type 3 used as a digital input

High Side Output, Type 3 has an open load detect circuit with digital feedback which allows the output to be used as a low wetting current active low digital input.

Note: On some other hardware variants Rpu may not be stuffed – the output can then be used as an active high digital input.



The following table provides specifications for the digital feedback circuit:

Digital Feedback Characteristics				
Item	MIN	NOM	MAX	UNIT
Voltage range (non-operational)	0		36	V
Voltage range (operational)	0		32	V
Inductive load protection		NO		
Pull-up resistance		20		kΩ
DC wetting current (24V)		1.2		mA
Negative going input threshold	2.7			V
Positive going input threshold			6.2	V

7.1.4. 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.
- Individual High-side outputs can source up to 2.5 A max (HS Output Type 1), 1 A max (HS Output Type 2) and 1 A max (HS Output Type 3), however total High-side output current for all outputs at a given time shall not exceed 15A.
- High-side outputs 1 to 8 have internal flyback diodes, which are needed when driving inductive loads (the flyback diodes absorb electrical energy when the load is turned off).
- High-side outputs 9 to 16 have internal TVS diodes and are not intended to drive un-suppressed inductive loads while PWMing.

⚠ ***Warning! When PWMing outputs 9 to 16 into inductive loads, suppression diodes are required to be added across the inductive load.***

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.

⚠ ***Warning! When driving inductive loads, and the high-side output is providing a continuous PWM signal, the load current must not be greater than the specified continuous current for the output when PWM duty cycle is set to 100%. In other words, the outputs should never drive a load that would result in greater than the specified current when operated in a DC mode, regardless of what average current flows in the load while PWMing.***

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 CM2723V24 power grounds.

The following shows a typical high-side output connection:

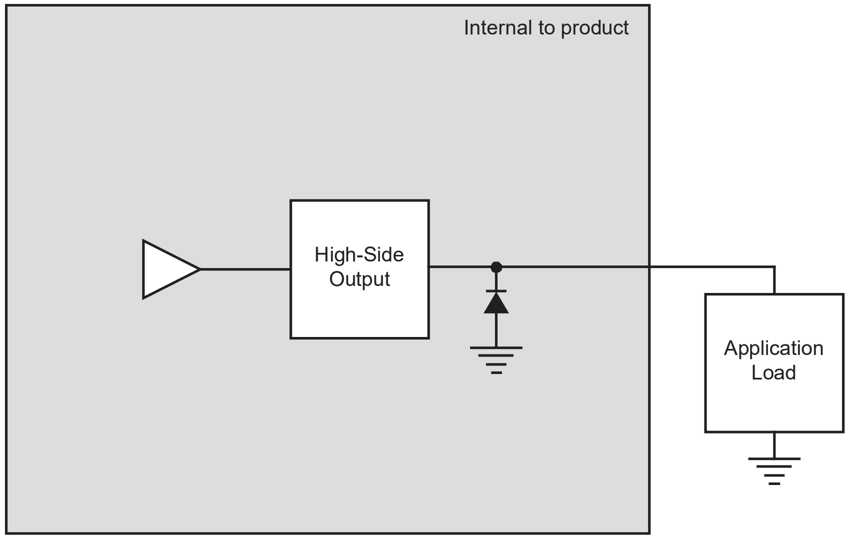


Figure 11: Typical high-side output installation connections

7.2. Low-Side Outputs

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

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

LS Outputs, Type 1 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.

Warning! LS Output, Type 1 outputs do not come with internal flyback diodes that provide protection when driving inductive loads.

Note: If a LS Output, Type 1 is paired with a HS Output that does have a flyback diode, then an external diode is not required. Otherwise, an external diode is required when driving inductive loads.

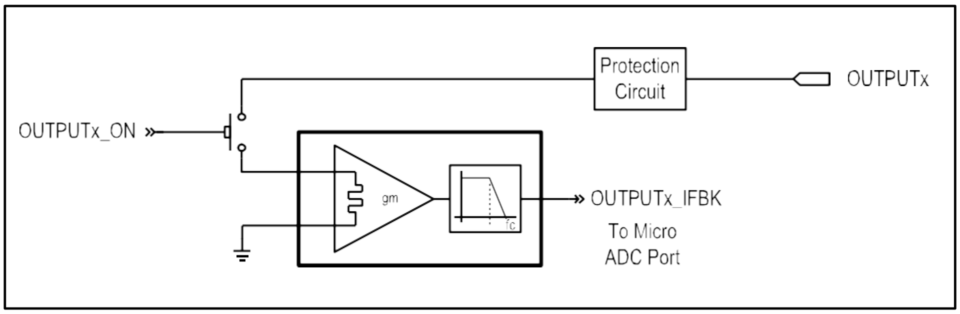
When LS Outputs, Type 1 outputs are used to sense current, the application software will monitor the current flowing into the low side output.

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 LS 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 CM2723V24 has 2 Type 1 low-side outputs:

- OUTPUT17
- OUTPUT18

7.2.1.1. Low-side output, Type 1 circuit block



7.2.1.2. Low-side output, Type 1 circuit characteristics

The following table provides specifications for the CM2723V24 - Low-side Type 1 outputs:

Low-Side Output Type 1 Characteristics				
Item	MIN	NOM	MAX	UNIT
Input voltage range (operational/non-operational)	0		36	V
Output current	0		2.5	A
Total output ON state resistance w.r.t. GND		70		mΩ
Output ON state resistance		20		mΩ
Current sense resistance		50		mΩ
Output OFF state leakage current			30	µA
PWM frequency			250	Hz
Turn on time to ON state		12	22	µS
Turn off time to OFF state		12	22	µS
Turn ON/OFF slew rate		7.7		V/µS
Output pin capacitance		5		nF

7.2.1.3. 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, one should filter at half the rate of your sampling rate, according to the Nyquist criterion.

7.2.1.4. Low-side output, Type 1 fault detection

Low Side Output, Type 1 has a current feedback circuit which is used for determining fault status of the output.

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

- Open Circuit when ON
- Short to Battery when ON
- Overcurrent when ON

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

Outputs	Current Threshold	
	Over current	Short circuit
17 & 18	>= 2.58 A	>= 2.70 A

Note: The platform software does NOT detect Short to Ground faults. Short to Ground faults may be detectable at the application code level but requires knowledge of the load current.

7.2.1.4.1. Open Circuit Fault:

- Open circuit fault is detected when the output is open – no load (<= 200mA) is connected to the output pin.
- The output must be ON for the fault to be detected.
- The platform software trip time for this fault is 50ms.

- When the fault is detected, the output is NOT inhibited.
- The platform software output status value for this fault = 4.

7.2.1.4.2. Short to Battery Fault:

- Short to Battery fault is detected when the output is connected (shorted) to battery or current > the short circuit threshold.
- The output must be ON for the fault to be detected.
- The platform software trip time for this fault is 10ms.
- When the fault is detected, the output is inhibited.
- The platform software output status value for this fault = 2.

7.2.1.4.3. Overcurrent Fault:

- Overcurrent fault is detected when the output is ON and the current > the overcurrent threshold.
- The output must be ON for the fault to be detected.
- The platform software trip time for this fault is 0ms (immediately).
- If the overcurrent is sustained for the short circuit trip time (50ms) then the fault will become a short to battery fault.
- When the fault is detected, the output is NOT inhibited.
- The platform software output status value for this fault = 3.

Note: More information about the fault detection and output status values can be found in the documentation provided with the SDK, see: hw_dictionary.h (enum output_channel_enum) and hw_outputs.h (enum _output_state_t).

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

Type 2 LS 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.

⚠ ***Warning! LS Output, Type 2 outputs do not come with internal flyback diodes that provide protection when driving inductive loads.***

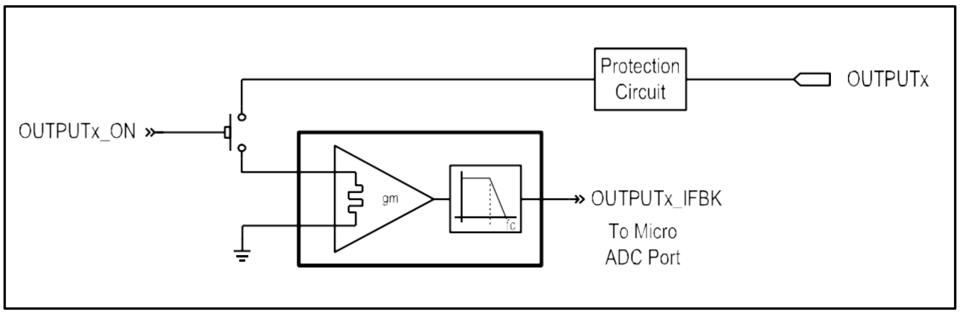
Note: If a LS Output, Type 2 is paired with a HS Output that does have a flyback diode, then an external diode is not required. Otherwise, an external diode is required when driving inductive loads.

When Type 2 LS outputs are used to sense current, the application software will monitor the current flowing into the low side output.

The CM2723V24 has 4 Type 2 low-side outputs:

- OUTPUT19
- OUTPUT20
- OUTPUT21
- OUTPUT22

7.2.2.1. Low-side output, Type 2 circuit block



7.2.2.2. Low-side output, Type 2 circuit characteristics

The following table provides specifications for the CM2723V24 - Low-side Type 2 outputs:

Low-Side Output Type 2 Characteristics				
Item	MIN	NOM	MAX	UNIT
Input voltage range (operational/non-operational)	0		36	V
Output current	0		2.5	A
Total output ON state resistance w.r.t. GND		70		mΩ
Output ON state resistance		20		mΩ
Current sense resistance		50		mΩ
Output OFF state leakage current			30	µA
PWM frequency			250	Hz
Turn on time to ON state		12	22	µS
Turn off time to OFF state		12	22	µS
Turn ON/OFF slew rate		7.7		V/µS
Output pin capacitance		5		nF

7.2.2.3. Low-side output, Type 2 transfer functions

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

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

Where:

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

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

7.2.2.4. Low-side output, Type 2 fault detection

Low Side Output, Type 1 has a current feedback circuit which is used for determining fault status of the output.

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

- Open Circuit when ON
- Short to Battery when ON
- Overcurrent when ON

Outputs	Current Threshold	
	Over current	Short circuit
19 - 22	>= 2.58 A	>= 2.70 A

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

Note: The platform software does NOT detect Short to Ground faults. Short to Ground faults may be detectable at the application code level but requires knowledge of the load current.

7.2.2.4.1. Open Circuit Fault:

- Open circuit fault is detected when the output is open – no load (<= 100mA) is connected to the output pin.
- The output must be ON for the fault to be detected.
- The platform software trip time for this fault is 50ms.
- When the fault is detected, the output is NOT inhibited.

- The platform software output status value for this fault = 4.

7.2.2.4.2. Short to Battery Fault:

- Short to Battery fault is detected when the output is connected (shorted) to battery or current > the short circuit threshold.
- The output must be ON for the fault to be detected.
- The platform software trip time for this fault is 10ms.
- When the fault is detected, the output is inhibited.
- The platform software output status value for this fault = 2.

7.2.2.4.3. Overcurrent Fault:

- Overcurrent fault is detected when the output is ON and the current > the overcurrent threshold.
- The output must be ON for the fault to be detected.
- The platform software trip time for this fault is 0ms (immediately).
- If the overcurrent is sustained for the short circuit trip time (50ms) then the fault will become a short to battery fault.
- When the fault is detected, the output is NOT inhibited.
- The platform software output status value for this fault = 3.

Note: More information about the fault detection and output status values can be found in the documentation provided with the SDK, see: hw_dictionary.h (enum output_channel_enum) and hw_outputs.h (enum _output_state_t).

7.2.2.5. 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:

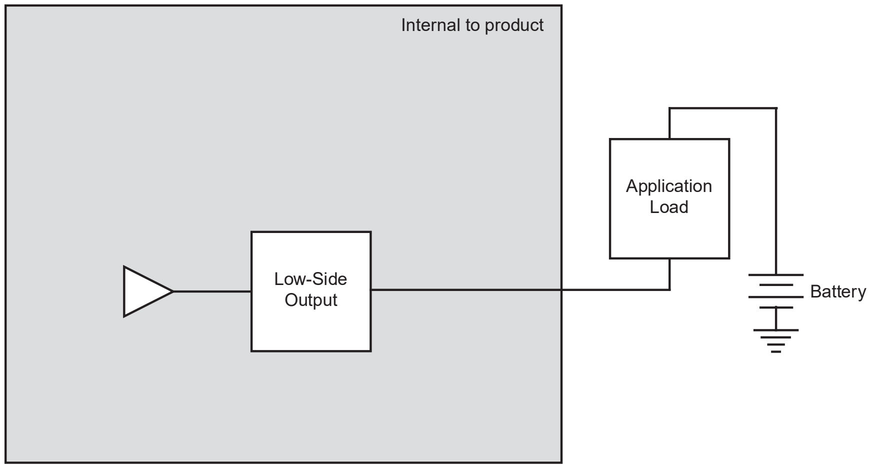


Figure 12: Typical low-side output connection

7.3. Sensor Power Outputs

The CM2723V24 has 1 pin, labeled `VSENSOR`, dedicated to providing power to external sensors.

Warning! Do not drive more than 75 mA of current through 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.

7.3.1. Sensor supply, Type 1

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

The Type 1 sensor power output is intended to power external sensors in a system. It is not to be used to power inductive, motor, or bulb loads.

The CM2723V24 has one Type 1 Sensor Supply output:

- VSENSOR

7.3.1.1. 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			150	mA
Output short circuit current		0.2		A
Output capacitance		67		μF

Note 1: This value is dependent on operating ambient temperature of the CM2723V24. Colder temperatures result in higher current required to trip short circuit protection.

7.3.1.2. 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

7.3.2. Sensor Power Connections

For information on how to connect sensors, refer to Section 11 Application Examples.

7.3.3. 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.

8. Power

The CM2723V24 is powered by the vehicle battery. The CM2723V24 operates in a 24V system, and can operate from 12V up to 32V, with over-voltage protection at 36V.

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

8.1. Power Capabilities

The VBATT and GND pins provide power to the logic circuit and to the output circuit. All power pins on the product must connected in a system to achieve the specifications defined in this document.

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 15 A. When creating applications care should be taken so that the combination of simultaneously energized outputs does not exceed 15 A.

The following table provides specifications for the CM2723V24 logic and output power:

Logic and Output Power Specifications				
Item	Min	Nom	Max	Unit
Input voltage range	12	24	32	V
Overvoltage	-	-	36	V
Current draw in on state (excluding outputs)	-	-	200	mA
Current draw in on state (including outputs)	-	-	15	A
Current draw in sleep *mode*	-	-	5	mA
Inline fuse required on power pins (ATO *style)*	-	20	-	A
Number of power pins	-	2	-	-
Number of ground pins	-	3	-	-

Note 1: When both VBATT connector pins are used. If only one VBATT connector pin is used, this value is half. This maximum current is true of the ground pins as well.

Note 2: Assumes there is no current flow through input or output connections in harness. Either active high inputs are not connected to battery during sleep mode, or active-low inputs are not connected to ground during sleep mode.

Note 3: This is required to ensure proper reverse battery protection on the module. Failure to include this fuse in the end application harness could result in damage to the module and/or the application harness.

Note 4: One ground pin can be used as a low current Sensor Ground return path for sensors connected to the CM2723V24 inputs. This minimizes error due to ground shift.

8.2. Power transfer functions

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

$$VBATT = \frac{8763 \cdot INPUTx\_ADC}{905216}$$

Where:

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

8.3. Logic and output power connections

When connecting the CM2723V24 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 CM2723V24 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.
- The CM2723V24 is protected against reverse-battery connections by an internal high-current conduction path that goes from ground to power. To protect the CM2723V24 from damage in a reverse-battery condition, place a fuse of 20 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).
- All power connections to the CM2723V24 should be fused to protect the vehicle harness.

Warning! Do not use slow-blow fuses for this application.

9. Communication

The only type of communication available to the CM2723V24 is Controller Area Network (CAN) communication.

9.1. Controller area network

The CM2723V24 has 2 Controller Area Network (CAN) communication port(s) available. The CM2723V24 hardware provides controller area network (CAN) communication according to the SAE J1939 specification, making the CM2723V24 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 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)		no		

9.1.2. J1939 CAN Configuration

There is no CAN user configuration available for this variant.

There is no internal CAN termination resistor.

9.1.3. J1939 CAN Installation Connections

The CAN connection for the CM2723V24 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 CM2723V24 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:
  - Connect CAN Shield to the point of least electrical noise on the CAN bus.
  - Connect CAN Shield as close to the center of the CAN bus as possible.
  - Use the lowest impedance connection possible.

⚠ Warning! 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:

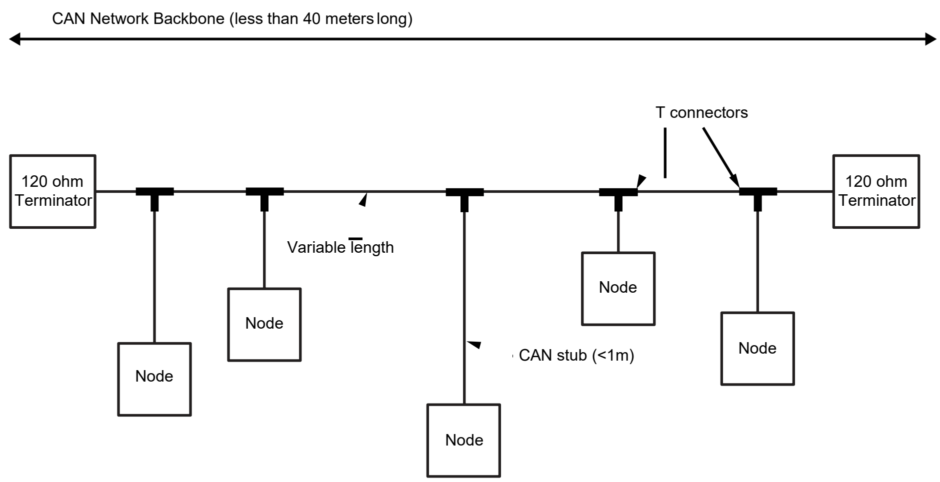


Figure 13: J1939 CAN connection

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 CM2723V24.

The vehicle manufacturer is responsible for creating procedures for mounting the CM2723V24 in a vehicle during production assembly.

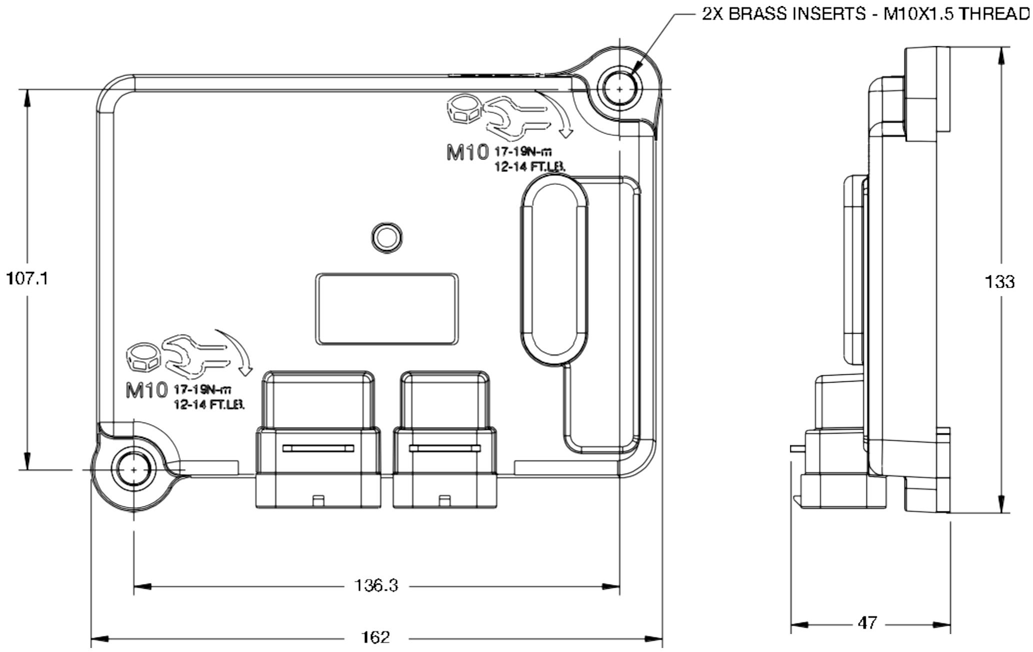
10.1. Mechanical Requirements

Review the following mechanical requirements before selecting a mounting location for the CM2723V24:

- The CM2723V24 should be mounted with the connectors facing down, so that moisture drains away from it.
- The wire harness should have drip loops incorporated into the design to divert water away from the CM2723V24.
- 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 CM2723V24 should be in a location that is easily accessible for service.

10.2. Dimensions

The following shows the dimensions of the CM2723V24 in millimeters:



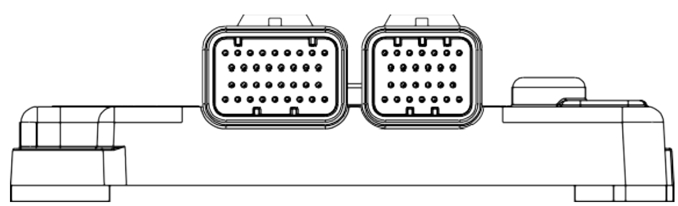


Figure 14: CM2723V24 dimensions

10.3. Selecting a Mounting Location

The CM2723V24 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 CM2723V24, ensure you review the following environmental and mechanical requirements.

⚠ ***Warning! Risk of damage to equipment or degradation of signal Do not install the CM2723V24 close to any significant heat sources, such as a turbo, exhaust manifold, etc. Also avoid installing the CM2723V24 near any drive-train component, such as a transmission or engine block.***

The CM2723V24 should be mounted with the connectors facing down, so that moisture drains away from it, as shown in the following:

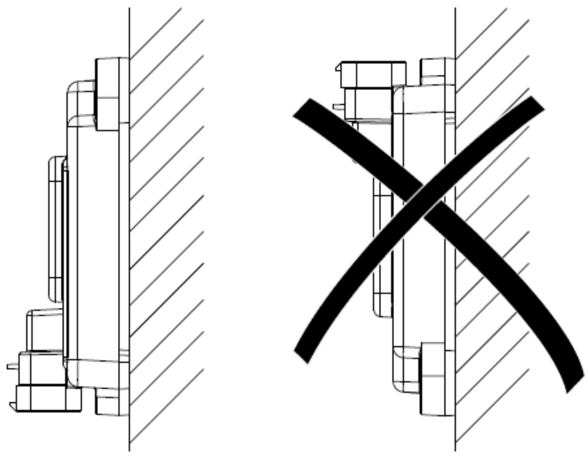


Figure 15: Recommended mounting orientation

10.4. Mounting the CM2723V24 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 CM2723V24 to a vehicle:

- Secure the CM2723V24 with M10-1.5 bolts in both threaded brass insert locations, coming through the panel/mounting surface from behind.
- The bolts should be tightened to 19 Nm (14 ft-lb) max.

10.5. Designing and Connecting the Vehicle Harness

The vehicle manufacturer is responsible for designing a vehicle harness that mates with the CM2723V24 connector(s).

The vehicle harness design depends on the following:

- How the CM2723V24; 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 CM2723V24 simply by clicking the mating connectors into the connector ports on the CM2723V24.

11. Application Examples

The purpose of this section is to provide examples of how the CM2723V24 can be used for different purposes.

⚠ ***Warning! Risk of damage to equipment or degradation of signal. The information contained in the following sections is for information only and does not imply that the CM2723V24 is usable within a functional safety system design nor that it is compliant to any functional safety standard. It is the system designer's responsibility to determine the appropriateness of using the CM2723V24 in a system design.***

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 CM2723V24 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:

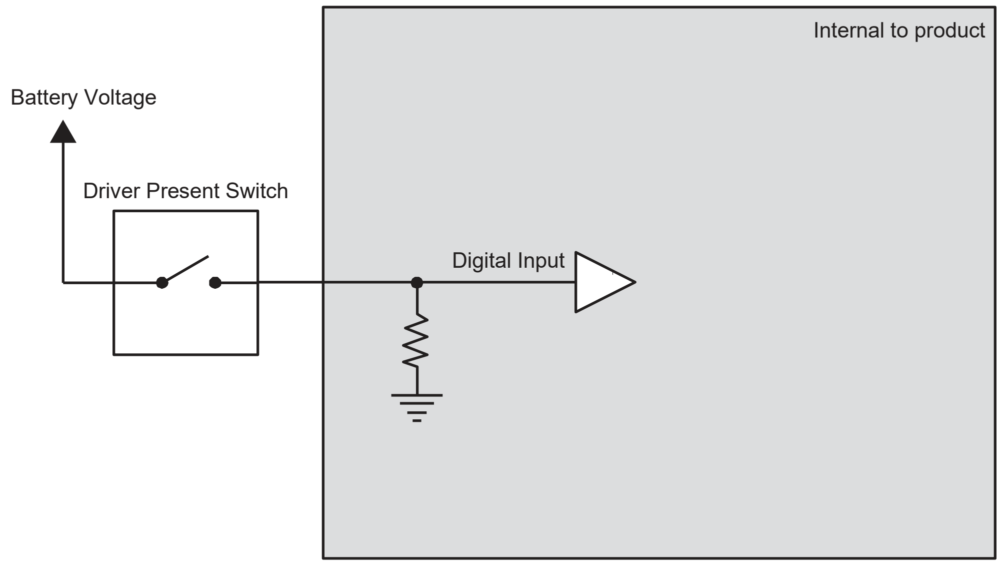


Figure 16: Seat switch interlock connection

11.2. Controlling Indicator Lights

Multiple CM2723V24 can be used together in a system to control a vehicle's indicator lights. For example, you could connect three CM2723V24s, communicating over the CAN bus, as follows:

- Connect one CM2723V24 to the rear indicator lights.
- Connect one CM2723V24 to the front indicator lights.
- Connect one CM2723V24 to the turn signal and hazard switches.

The following shows how to connect three CM2723V24s together in a system to control indicator lights:

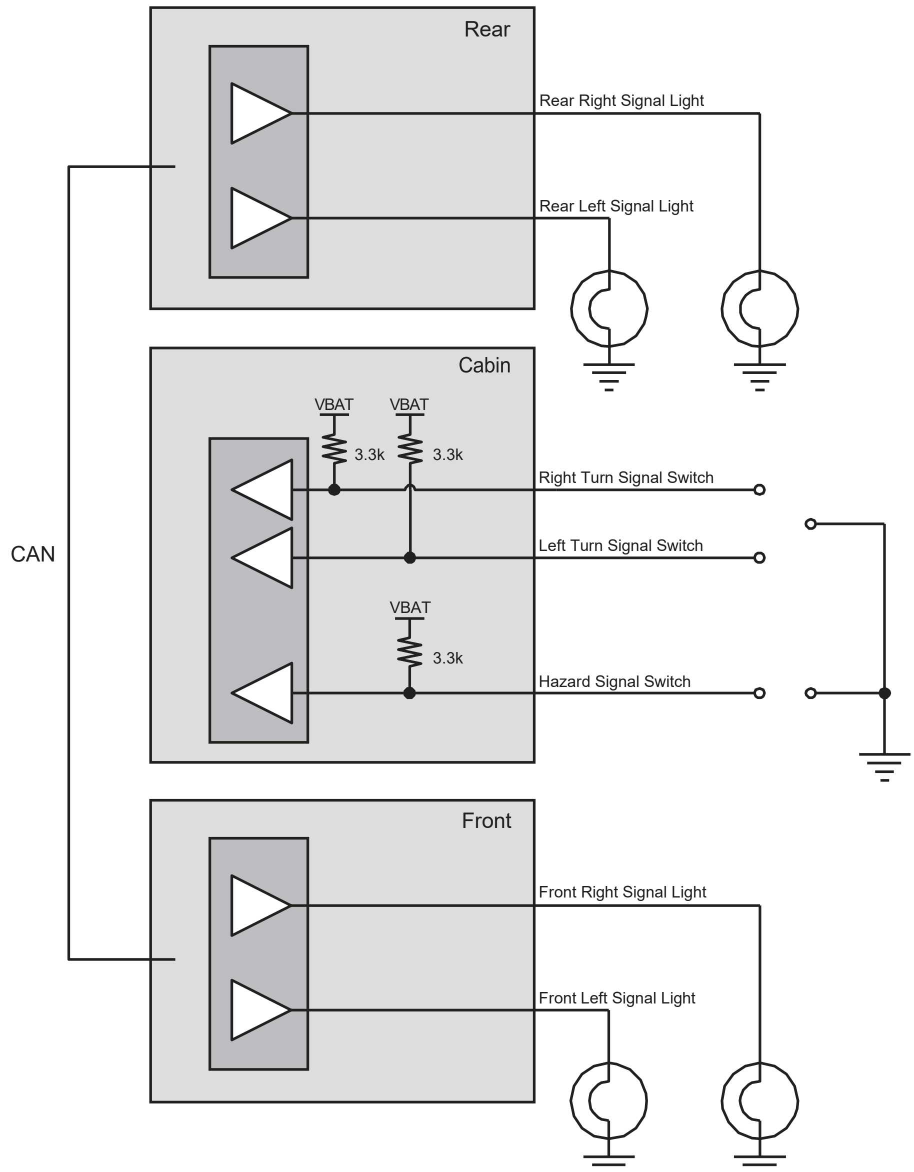


Figure 17: Indicator light connections

11.3. Controlling a Proportional Valve

The CM2723V24 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 CM2723V24 has Proportional-Integral-Differential (PID) capabilities that make it possible to control devices like proportional valves through software. Contact you Parker Hannifin Account Representative for information on software methods to implement PIDs and closed loop control.

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:

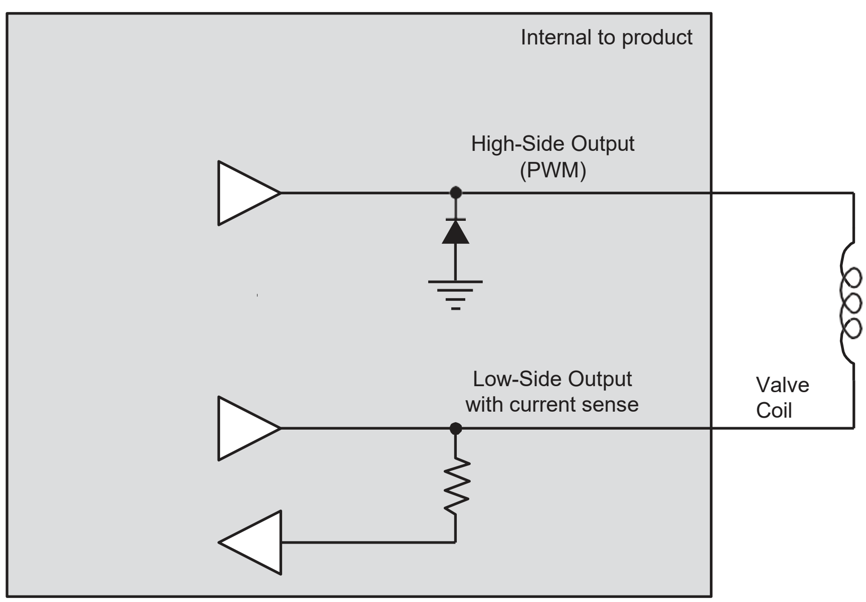


Figure 18: Connection for controlling a proportional valve

11.4. Controlling Motor Speed

The CM2723V24 can be used to control the DC motor speed of motors that provide a tachometer output.

Note: The CM2723V24 has Proportional Integral Differential (PID) capabilities that make it possible to control devices like proportional valves through software. Contact you Parker Hannifin Account Representative for information on software methods to implement PIDs and closed loop control.

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 CM2723V24 to control the speed of a motor:

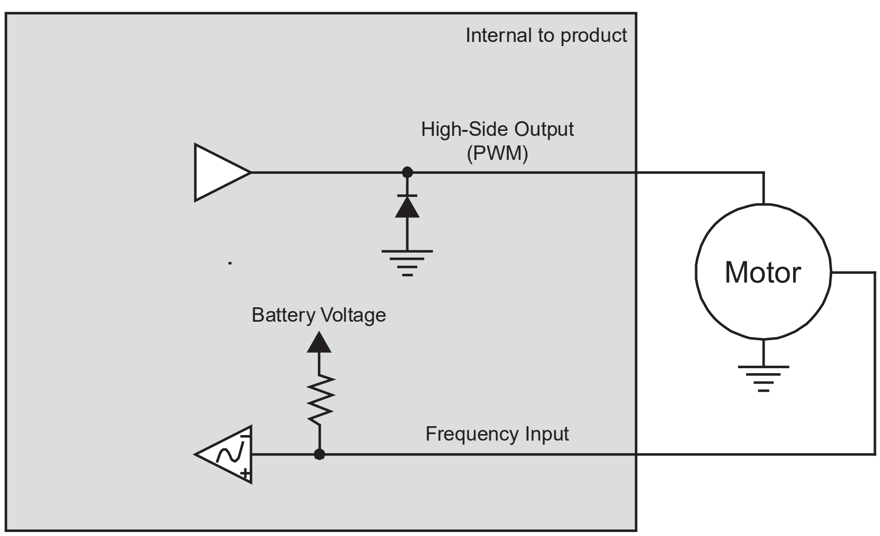


Figure 19: Connection for controlling motor speed

11.5. Connecting Various Sensors

There are many types of sensors that can be connected to the CM2723V24, 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 CM2723V24, use the sensor's specification to ensure that the CM2723V24 is configured correctly for the sensor.

11.5.1. Open Collector

Open collector sensors are compatible with each type of input on the CM2723V24.

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 CM2723V24.

The following shows a typical NPN open collector sensor connection:

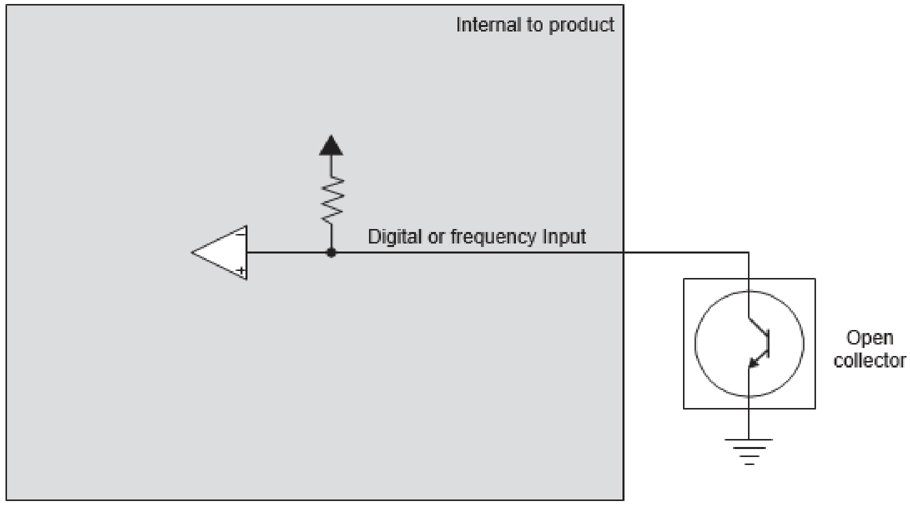


Figure 20: Open collector sensor connection

The following shows a typical PNP open collector (also called open emitter) sensor connection:

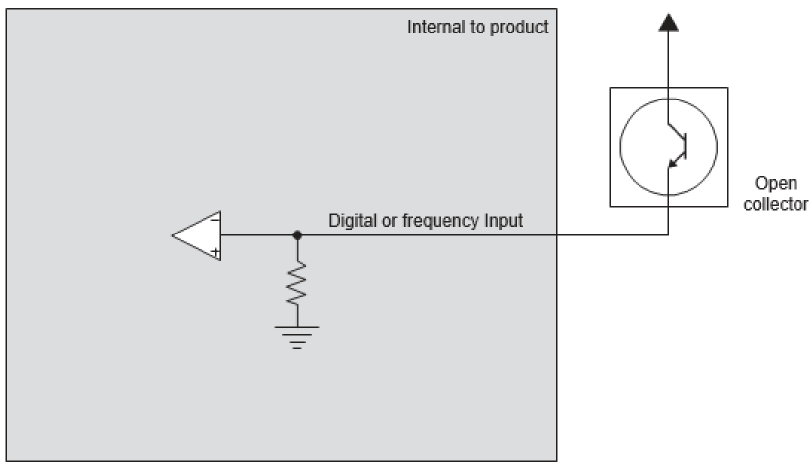


Figure 21: Open collector active high connection

11.5.2. 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 CM2723V24 cannot measure resistance directly.

To make the CM2723V24 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:

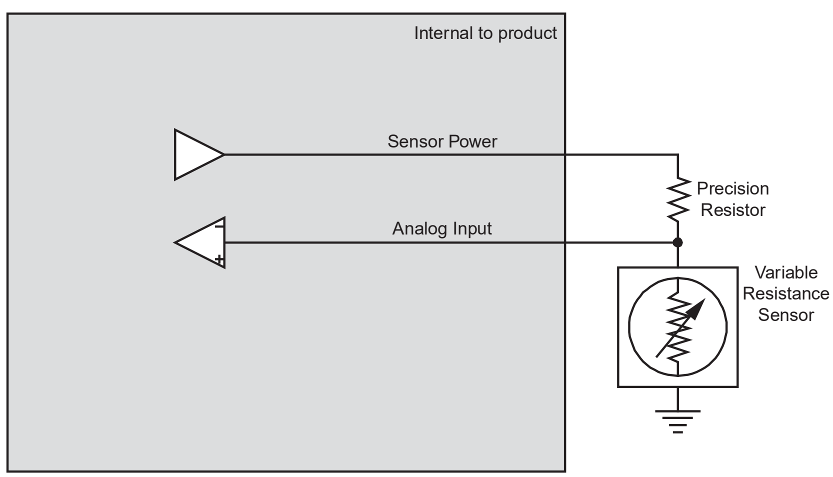


Figure 22: Variable resistance sensor connection

11.5.3. 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 outputting 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:

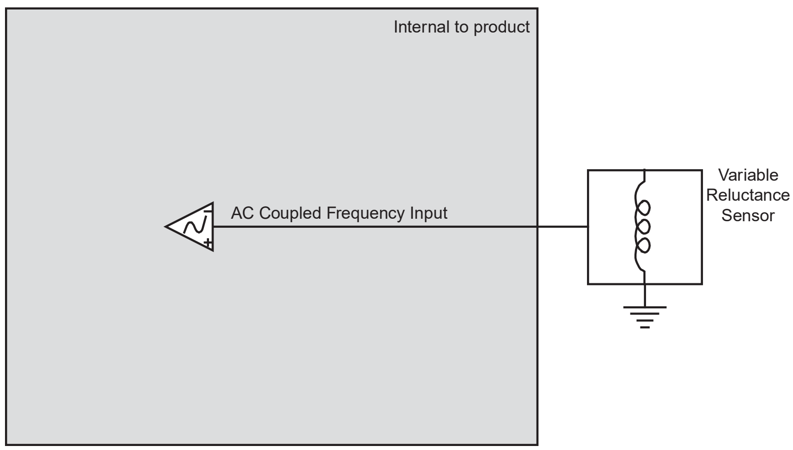


Figure 23: Variable reluctance sensor connection

11.5.4. 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.

⚠ ***Warning! 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:

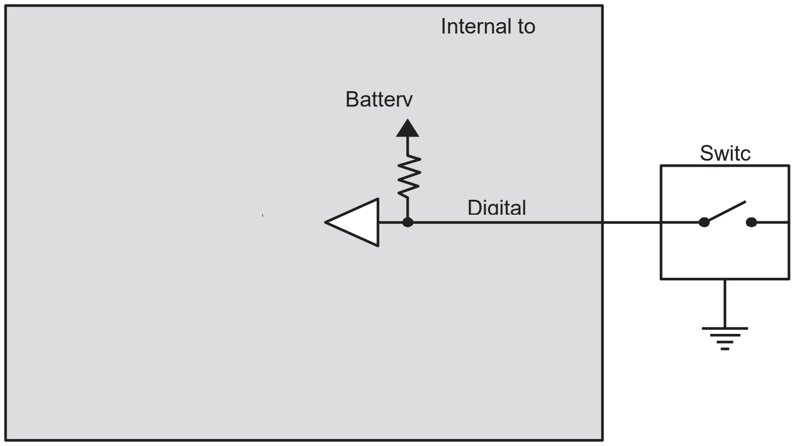


Figure 24: Switch sensor connection

11.5.5. 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:

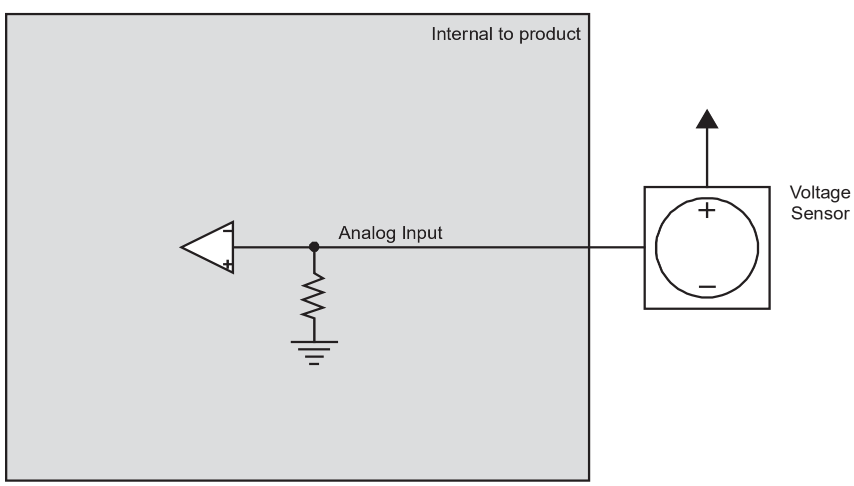


Figure 25: Voltage sensor connection

11.5.6. 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:

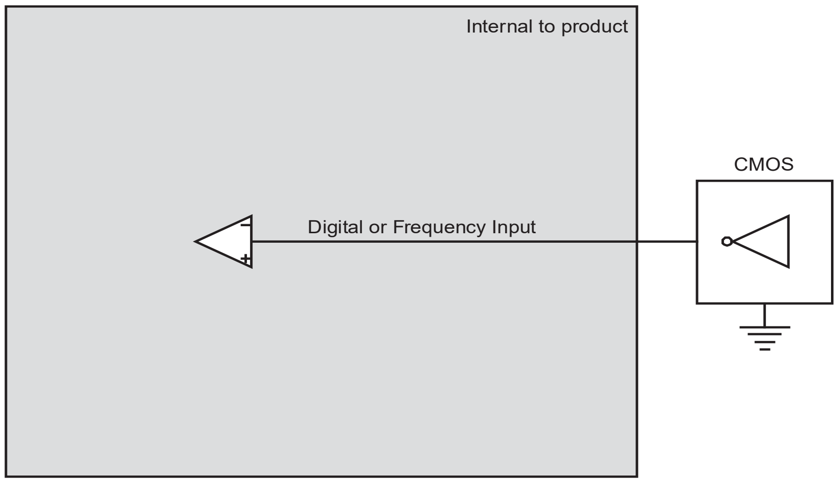


Figure 26: CMOS sensor connection

11.5.7. 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 `VSENSOR` pin, and the other end to a GND

pin on the CM2723V24.

- Connect the sensor signal to an analog input.

The following shows a typical potentiometer sensor connection:

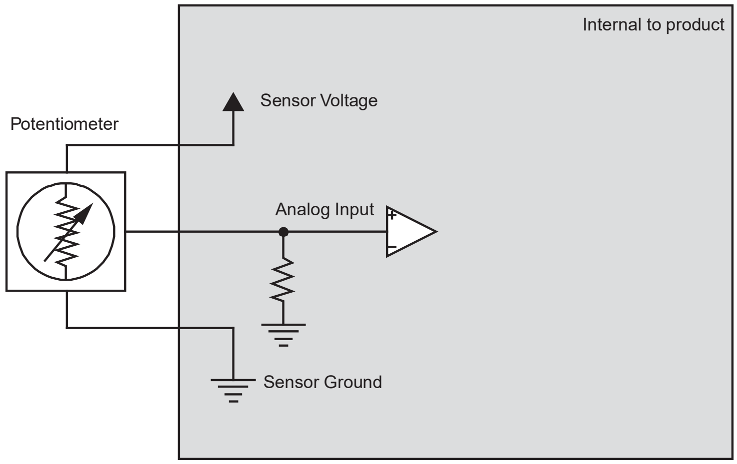


Figure 27: Potentiometer (ratiometric) sensor connection

11.6. Using one Analog Input as Two Digital Inputs

The CM2723V24 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 your application logic to act according to the voltage value readings provided by the analog input. Refer to the appropriate help file, or contact your Parker Hannifin Account Representative for more information.

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:

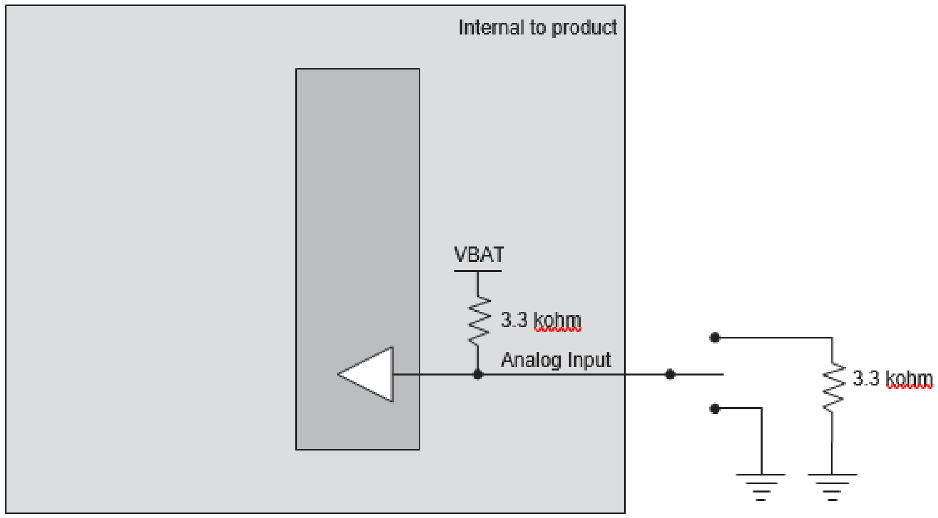


Figure 28: Connecting an analog input to an SPDT switch

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