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CM0504 User Guide

Controller Module

Parker

ENGINEERING YOUR SUCCESS.

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⚠ Warning!

FAILURE OR IMPROPER SELECTION OR IMPROPER USE OF THE PRODUCTS AND/OR SYSTEMS DESCRIBED HEREIN OR RELATED ITEMS CAN CAUSE DEATH, PERSONAL INJURY AND PROPERTY DAMAGE.

- This document and other information from Parker Hannifin Corporation, its subsidiaries and authorized distributors provide product and/or system options for further investigation by users having technical expertise.
- The user, through its own analysis and testing, is solely responsible for making the final selection of the system and components and assuring that all performance, endurance, maintenance, safety and warning requirements of the application are met. The user must analyze all aspects of the application, follow applicable industry standards, and follow the information concerning the product in the current product catalog and in any other materials provided from Parker or its subsidiaries or authorized distributors.
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- The user will be solely responsible for final disposal of all products.

Contents

Publication History

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

Release Date	Description of Change
Rev. 001	First release of this document
Rev. 002	Pin-outs updated and input characteristics added from HW desc. 1038F11.00A, 6/24/2016
Rev. 003	Input and output section capabilities updated, other minor edits per engineering feedback, 1/31/2017
Rev. 004	Associated input names to correct pins and minor edits throughout per engineering feedback from 7/6/2017
Rev. 005	Edit wire size in connector section. Clarify input types.
Rev. 006	Edits per feedback from HY-JG, 2/12/2018. Software section and Diagnostic (config) Tool screen captures added.
Rev. 007	Edit Environmental specs. Fix table size in software section.
Rev. 008	Add Quick Start chapter. Edits to H-Bridge section.

Safety

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

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

The term “manufacturer” refers to Parker Hannifin Corporation.

Safety symbols

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

Danger! Risk of death or injury.

Warning! Risk of damage to equipment or degradation of signal

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

General safety regulations

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

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

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

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

Welding after installation

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

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

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

Construction regulations

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

Safety during installation

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

Safety during start-up

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

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

Safety during maintenance and fault diagnosis

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

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

1. Understanding the CM0504

The Controller Module (CM) 0504 is a general purpose input / output controller that includes a single CAN interface, 5 inputs and 4 outputs with error checking. The main function of the module is to provide a means of controlling high current loads through messages on the CAN bus. The outputs can be configured as either high-side or low-side drivers. The module outputs can be configured to support up to two full H-bridge motor drives to control directional motors.

The CM0504 is only available as a CAN slave module and does not support standalone operation. However, it does support limited configurability, to specify things like input configurations, and update rates for the messages presented on the CAN bus. The configuration tool is available from our website, www.parker.com/ecd under 'Support'.

Figure 1.1. CM0504 controller module

The CM0504 is designed to communicate through a J1939-based Controller Area Network (CAN) and can be used in any CAN 2.0B application.

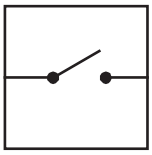
The CM0504 has many features, as follows:

- The CM0504 can monitor up to 5 inputs:
  - 1 active-high with wake up input (can be used as power control).
  - 4 programmable inputs (can be used as analog, digital, resistive, or frequency).
- The CM0504 has 4 outputs:
  - up to 25 A load, module total 100 A (can be configured as high-side or low-side).
  - standard 500 Hz PWM default (capable of up to 2 kHz, engineering review required to verify for each application).
- The CM0504 has 4 connectors (2x Deutsch DTHD 1 position, 1x Deutsch DTP 4 position, 1x Deutsch DTM 12 position) that are used to interface with the inputs, outputs, power and CAN.

This manual describes the hardware components of the CM0504, but does not explain how to configure the software. For more information about software, refer to the appropriate software manual or contact your Parker Vansco Account Representative.

1.1. 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

2. CM0504 Quick start

This section provides step-by-step instructions on how to connect the CM0504, install the required software tools, and configure the CM0504 software. 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.
3. Connect the CM0504 and power it up.
4. Configure CM0504 for its application. (optional)
5. Include the CM0504 slave messaging into your master module(s).

2.1. Gather Required Materials

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

- CM0504
- personal computer (PC)
- harness
- Data Link Adapter (DLA) kit (comes with cables needed for connecting the DLA to your PC and to the rest of the system)
- power supply compatible with the CM0504 and loads
- software tools and files required for programming and downloading software for the CM0504.

2.2. Install the Required Software Tools

Before using the CM0504, install the following software tools onto your PC:

- Data Link Adaptor (DLA) drivers
- The DLA acts as the interface between the PC and the CM0504. Before using the DLA, you must install the DLA drivers.
- CM0504 Diagnostic Tool
- Parker provides the CM0504 Diagnostic Tool to download software for the CM0504 and configure its behavior.

2.2.1. Install the Data Link Adapter Driver Software

A Data Link Adaptor (DLA) is needed when connecting the CM0504 in a development system.

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

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

1. Download the driver, run the extracted file, and follow the Install Wizard. Do not connect the USB DLA until the driver installation is completed.
2. Connect the USB DLA to a USB port on your PC. The Found New Hardware screen opens.
3. Select Install the software automatically (Recommended), and then click Next. If the driver is not

detected automatically, you can browse to the folder containing the driver (default path C:\Program files\Vansco\USB-DLA).

4. After installation is finished, click Finish. The USB DLA is now recognized and ready to be used.

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

2.2.2. Install the CM0504 Diagnostic Tool

The CM0504 Diagnostic Tool is for downloading software for the CM0504 and configuring its behavior.

Note: Please contact your Parker Account Representative for details to obtain and download this software.

To install:

1. Download the software.
2. Save the EXE file in a known location on your PC.
3. Simply double click the EXE to run (i.e there is no installer).

2.3. Connect the CM0504 to a System

The following shows how to connect the CM0504 to a power supply:

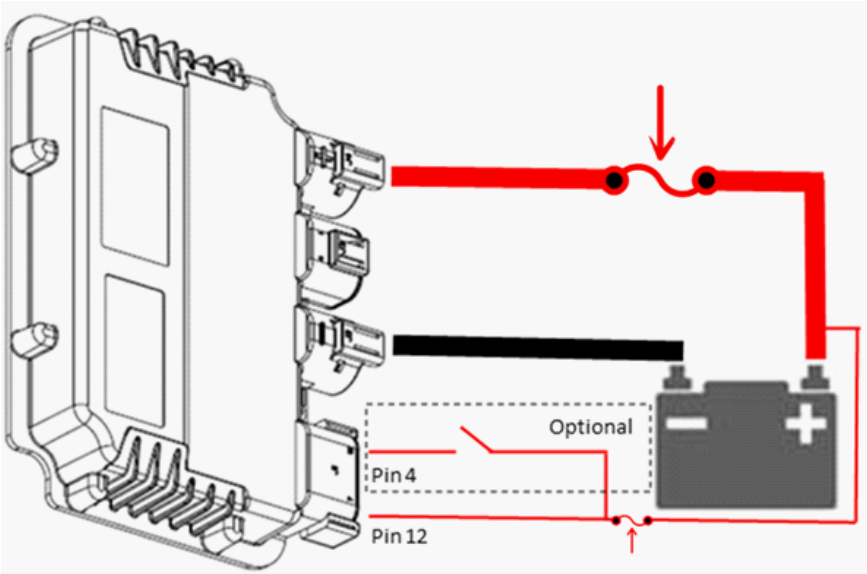


Figure 2.1. CM0504 power connection

⚠ Warning! Size fuses for both the Logic Power and High Current Power appropriately. Improper fusing can result in a fire.

Note: By default the CM0504 will wake-up whenever power is applied to pin J1-12 but it may also be configured to wake on J1-4 or CAN. See sections 3.2.1, 3.2.2, and module settings in 10.1.1 for details.

Important: Both J2 and J4 must always be connected as shown above.

Important: There are 2 ground reference pins in connector J1 – they must not be connected to the power supply return.

To use the CM0504 diagnostic tool, the PC must be connected to the CM0504 through the Parker USB-DLA as shown in the following diagram:

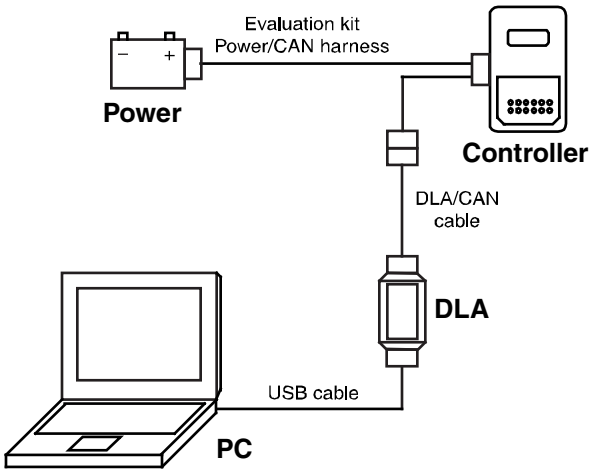


Figure 2.2. Connect Parker USB-DLA

2.4. Configure CM0504 for its application

The CM0504 comes with the J1939 slave application preinstalled and a default configuration that may meet the needs of your application. However, in case the configuration needs to be changed, Parker provides the CM0504 Diagnostic tool. The tool may be used to configure the following features of the CM0504:

- Input type (e.g. digital, analog, frequency)
- Output type (e.g. high side, low side, or H-Bridge)
- Wakeup options (e.g. always on, wake on input, or wake on CAN)
- J1939 slave messages used (e.g. PGN, SA, DA, and broadcast rate)

For details, see sections:

- 10.2 -- default configuration
- 10.1 – detailed instructions for the CM0504 Diagnostic tool

2.5. Include CM0504 slave messaging in your master module

The CM0504 is a slave module which requires a master on the J1939 network to process the value of its inputs and tell it the desired state of its outputs. The J1939 messages used by the CM0504 for this purpose are described in section 10.2. This document assumes the development environment used for the master module provide the facilities to construct these 4 J1939 messages as required.

3. Connectors

The CM0504 has 1 Deutsch DTM 12 position connection:

- J1: DTM04-12PA

This connector is used to connect to the inputs, and communication channels used by the CM0504. The required connector is:

Figure 3.1. DTM06-12SA connector

The CM0504 has 1 Deutsch DTP 4 position connection.

- J3: DTP04-4P

This connector is used to connect to the outputs used by the CM0504. The required connector is:

Figure 3.2. J3 connector

The CM0504 also has 2 Deutsch DTHD 1 position connections for power and ground:

- J2: DTHD04-1-4P
- J4: DTHD04-1-4P

The required connector is:

Figure 3.3. J2 & J4 connector

The maximum wire gage for the J2 and J4 connectors is 6 AWG with GXL insulation.

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

Mating Connector Part Numbers			
Connector	**Shell part no.**	**Wedge part no.**	**Terminal part no.**
Gray (J1) connector	DTM06-12SA	WM12S	16-20 AWG, Gold: 1062-20-0144
Gray (J3) connector	DTP06-4S	WP4S	12-14 AWG, Gold: 1062-12-0144
Black (J2) connector	DTHD06-1-4S	-	6 AWG: 0462-203-04141
Black (J4) connector	DTHD06-1-4S	-	6 AWG: 0462-203-04141

3.1. Pinouts

Pins connect to inputs, outputs, and communication channels. They provide the interface between the vehicle harness and the internal circuitry of the CM0504.

The following tables show the pinouts for each connector:

J1 Connector Pinout		
Pin	**I/O Name**	**Function**
1	GND	Ground (logic / sensor ground)
2	CAN_L	CAN low
3	CAN_SHLD	CAN shield
4	INPUT5	General purpose input Type 2
5	INPUT1	Active high digital wake up input
6	ADDR_L/GND	Address low, IDtag / (sensor ground)
7	ADDR_H/SENSOR	Address high, IDtag / (+5 V supply)
8	INPUT2	General purpose input Type 1
9	INPUT3	General purpose input Type 1
10	INPUT4	General purpose input Type 2
11	CAN_H	CAN high
12	+VBATT	Logic power (positive battery terminal)

J2 Connector Pinout		
Pin	**I/O Name**	**Function**
1	GND	Negative battery terminal (LS output ground)

J3 Connector Pinout		
Pin	**I/O Name**	**Function**
1	OUTPUT2_25A	High-side or low-side output, 25 A
2	OUTPUT4_25A	High-side or low-side output, 25 A
3	OUTPUT3_25A	High-side or low-side output, 25 A
4	OUTPUT1_25A	High-side or low-side output, 25 A

J4 Connector Pinout		
Pin	**I/O Name**	**Function**
1	+VBATT	Positive battery terminal (HS output power)

4. Inputs

The CM0504 has analog, digital, resistive, and frequency inputs.

The following table shows the input numbers and their possible configurations:

Type	Input1	Input2	Input3	Input4	Input5	IDTag (addr)
Wake up	X					
Analog, type 2		X	X	X	X	
Resistive, type 1				X	X	X
Frequency, type 1		X	X	X	X	
Frequency, type 2		X	X			
Digital, type 1 (active low)		X	X			
Digital, type 2 (active high)	X			X	X	

⚠ *Damage to equipment!* Do not connect inputs directly to unprotected inductive loads such as solenoids or relay coils, as these can produce high voltage spikes that may damage the CM0504. If an inductive load must be connected to an input, use a protective diode or transorb.

4.1. Analog input Type 2

There are 4 analog Type 2 inputs (`INPUT2, INPUT3, INPUT4, INPUT5`).

The primary function of the Analog input Type 2 is to interface 0-5V sensors in an application.

4.1.1. Analog input Type 2, circuit characteristics

The following table provides specifications for the analog input:

Analog input Type 2 characteristics				
Item	**Min**	**Nom**	**Max**	**Unit**
Input voltage range (non-operational)	0		32	V
Full scale input voltage	0		5	V
Pull-up resistance		open		
Input resistance w.r.t. ground (pull-up/pull-down inactive)		89		kΩ
Resolution		0.81		mV/bit
Offset error			3.2	mV
Gain error			3.2	mV
Non-linearity error			2.4	mV
Filtering hardware cutoff frequency		39.3		Hz

4.1.2. Analog Inputs 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:

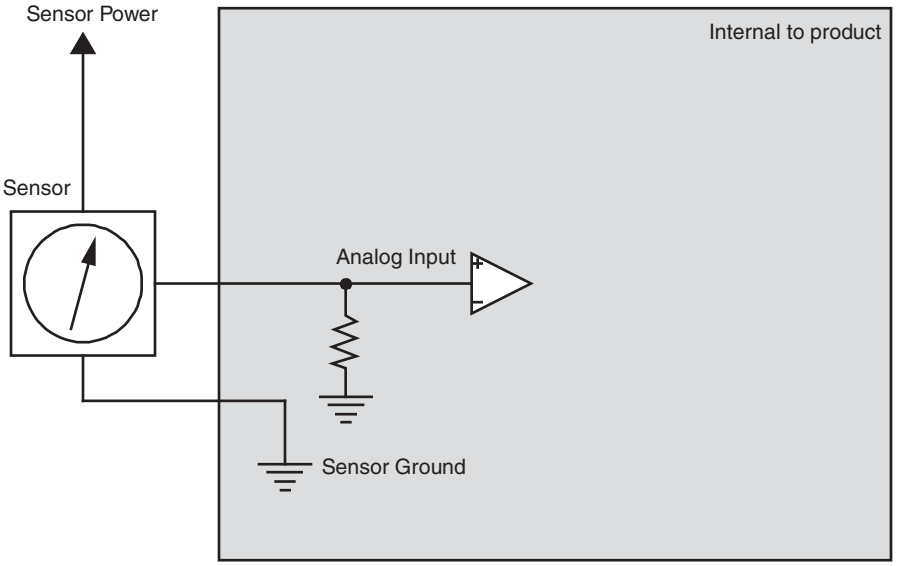


Figure 4.1. Analog input for system noise reduction

Ground level shift

To reduce ground level shift:

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

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

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

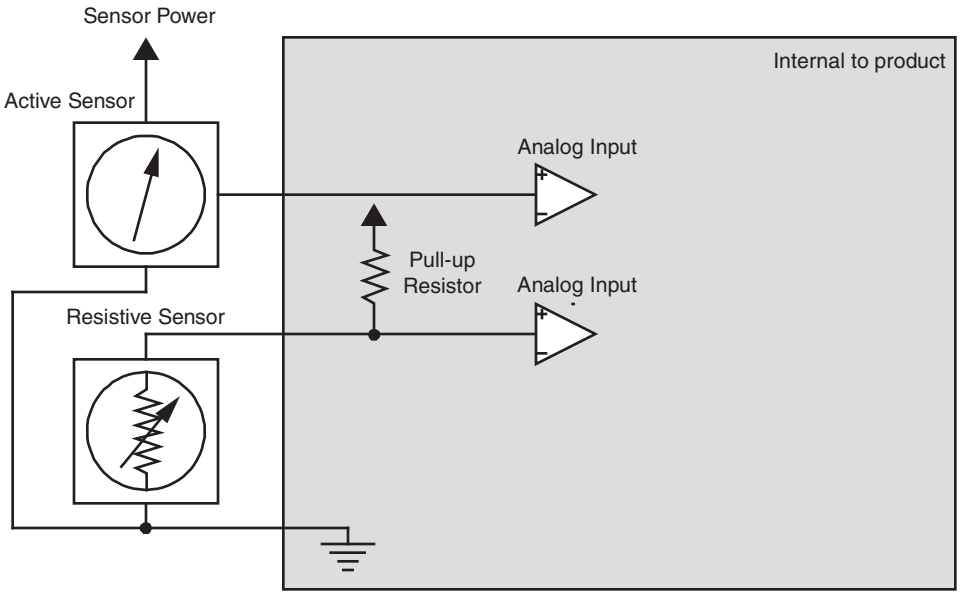


Figure 4.2. Analog input ground shift connection for sensors that have dedicated ground wires

4.2. Power control digital input

The CM0504 has 1 active-high power control digital input that is used for waking up (turning on) the product (`INPUT1`).

This type of input has a pull-down resistor option only. When the input is active it turns on the power supply pass transistor to power up the unit. The input is sensed directly by the microprocessor.

4.2.1. Power control input, circuit characteristics

The following table provides specifications for the CM0504 power control digital input:

Power control digital input characteristics				
Item	**MIN**	**NOM**	**MAX**	**UNIT**
Input voltage range	0		32	V
Over-voltage			36	V
Pull-down resistance		21.2		kΩ
Capacitance at pin		1000		pF
Input Power Up Threshold	2.5		4.3	V

Note: The power control digital input voltage must be greater than 4.3 V before it is considered an active high input.

The power control digital input wakes up the CM0504 when switched high to a voltage of 4.3 V or greater. The CM0504 will shut off when an open circuit condition occurs on the power control digital input, unless it is configured to 'Wake on CAN'.

4.2.2. Power control digital input connections

If the active high digital input is configured to wake up the module:

- 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 CM0504 to the ignition, place a fuse of 200 mA or higher in the circuit that feeds the CM0504.
- When battery power (VBATT) is connected, and the power control digital input is inactive, the CM0504 will go into sleep mode.
- The CM0504 has 'Wake on CAN' capability. Even when it is not configured for wake on CAN, the bus must be completely silent in order for the CM0504 to stay in low power sleep mode. Until the correct wakeup conditions are sensed, the CM0504 will appear "off" (outputs off and no CAN tx) but there is no way to keep its power supply off if there is CAN activity on the bus.

If your CM0504 must always be powered, the power control digital input does not need to be used. The CM0504 can be configured to always be powered using the CM0504 Configuration Tool software.

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

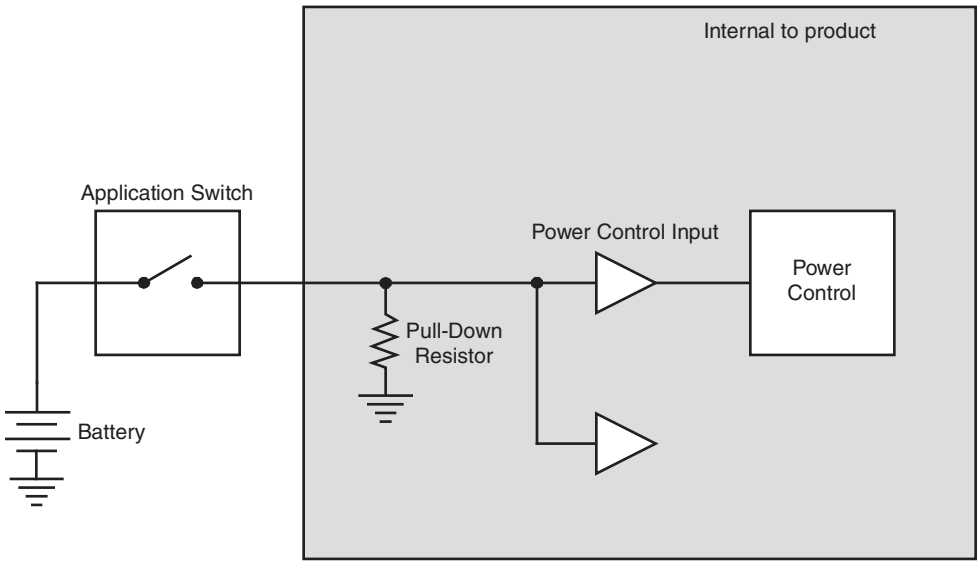


Figure 4.3. Power control digital input installation connections

4.3. INPUT2 and INPUT3, alternate functions

The alternate functions for inputs INPUT2 - INPUT3 is as digital (active-low) inputs and as frequency (type 1 & type 2) inputs.

4.3.1. INPUT2 and INPUT3, Frequency or Digital active-low characteristics

The following table provides specifications for INPUT2 and INPUT3:

Alternate functions input characteristics				
Frequency or Digital active-low configuration				
Item	**Min**	**Nom**	**Max**	**Unit**
Input voltage range	0		32	V
Input frequency range	100		1500	Hz
Pull-up resistance		5.62	open	kΩ
Input resistance w.r.t. ground (pull-up/pull-down inactive)		89		kΩ
Resolution		1		Hz
Positive threshold		5.0		V
Negative threshold		5.72		V
Filtering low pass cutoff frequency		3656		Hz

4.3.2. 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 CM0504 as inactive.
- When the switch is closed, the input is connected to ground, which will be interpreted by the CM0504 as active.

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

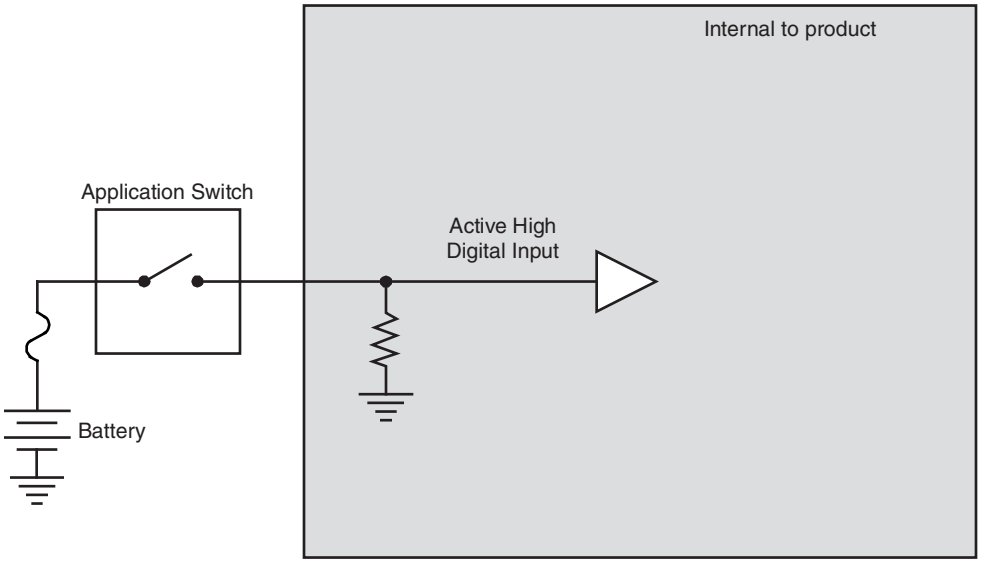


Figure 4.4. Active low digital input connections

4.4. INPUT4 and INPUT5, alternate functions

The alternate functions for inputs INPUT4 - INPUT5 is as digital (active-high) inputs and as frequency (type 2) or resistive (type 1) inputs.

4.4.1. INPUT4 and INPUT5, Resistive characteristics

The following table provides specifications for INPUT4 and INPUT5:

Alternate functions input characteristics				
Resistive configuration				
Item	**Min**	**Nom**	**Max**	**Unit**
Input range	0.1		20	kΩ
Pull-up resistance		2.21		kΩ
Input resistance w.r.t. ground (pull-up/ pull-down inactive)		89		Ω
Filtering hardware cutoff frequency		39.3		Hz
Resolution (analog)		0.81		mV

4.4.2. INPUT4 and INPUT5, Frequency or Digital active-high characteristics

The following table provides specifications for INPUT4 and INPUT5:

Alternate functions input characteristics				
Frequency or Digital active-high configuration				
Item	**Min**	**Nom**	**Max**	**Unit**
Input voltage range	0		32	V
Input frequency range	5		6500	Hz
Pull-up resistance		2.21	open	kΩ
Input resistance w.r.t. ground (pull-up/ pull-down inactive)		77.3		kΩ
Resolution		1		Hz
Positive threshold		5.18		V
Negative threshold		6.24		V
Filtering low pass cutoff frequency		8517		Hz

4.4.3. 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 CM0504 as inactive.
- When the switch is closed, the input is connected to battery voltage, which will be interpreted by the CM0504 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:

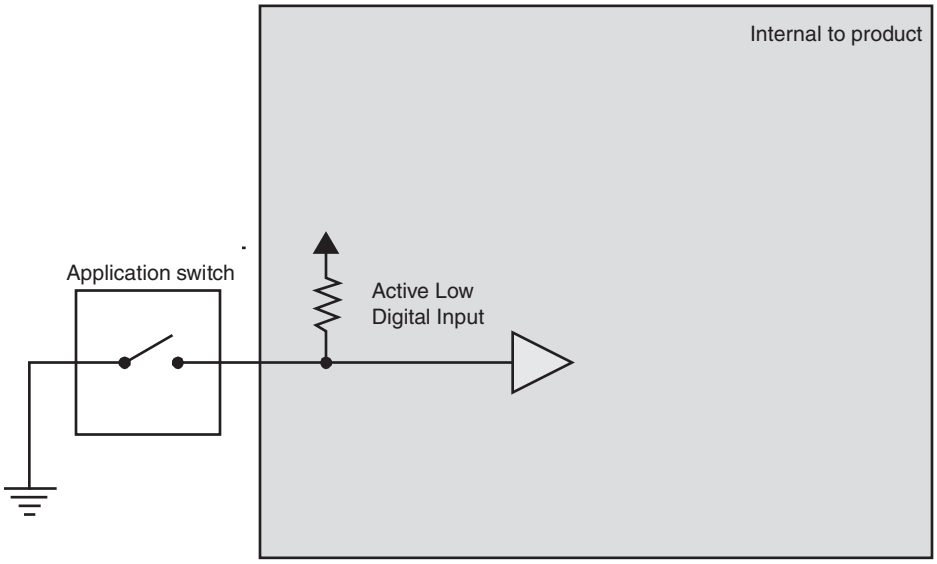


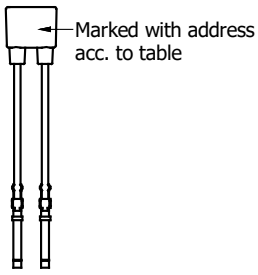
Figure 4.5. Active high digital input

4.5. Addressing

The CM0504 supports addressing of the module using resistor tags.

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

The CM0504 measures the resistance of an IDtag resistor connected between ADDR_H and ADDR_L pins. There can be up to 8 CM0504 modules in a system when address tags are used.



Deutsch DTM

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

Address	Ordering part number*	Resistance (ohms)
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

4.5.1. Addressing installation connections

The IDtag defining the address for the module is inserted into the CM0504 connector positions ADDR_H and ADDR_L.

The following shows a typical module ID connection:

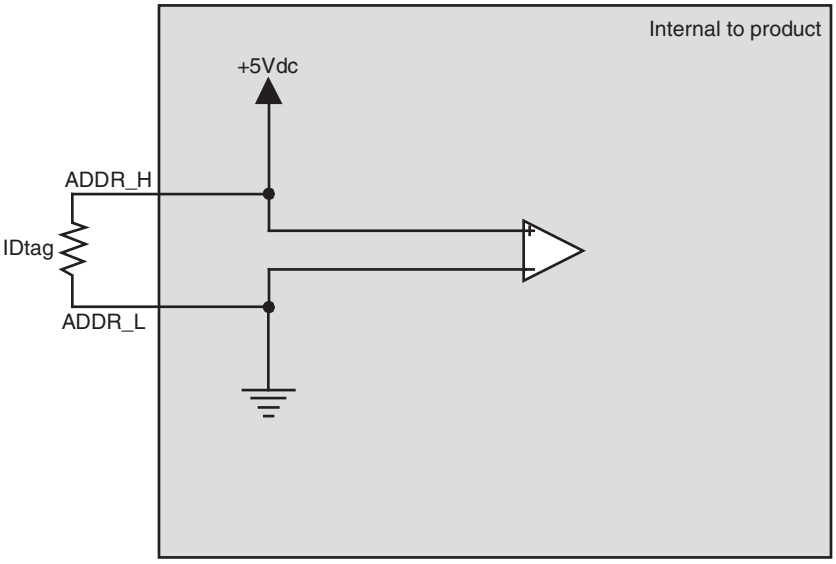


Figure 4.6. Typical IDtag installation

5. Outputs

The CM0504 has 4 solid-state outputs. Output currents are capable of up to 25 A.

The CM0504 has 3 types of outputs depending on configuration. The outputs can be configured as high-side, low-side or two outputs combined (1 high, 1 low) can become an H-Bridge output:

- High-side outputs capable of 25 A
- Low-side outputs capable of 25 A
- H-Bridge configuration (please see H-Brdge Connection section)

5.1. High-side outputs

The CM0504 may be configured to support up to 4 high-side outputs:

- `OUTPUT1_HS` to `OUTPUT4_HS`

The high-side outputs share pins with the low-side outputs and are configured with the software tool.

5.1.1. High-side output capabilities

These outputs provide 25 A maximum continuous current. All 4 outputs can be operated at 25 A output at the same time for a total module current of 100 A maximum.

Note: When outputs are ganged together, the achievable maximum current won't be multiplied.

The following table provides specifications for the high-side outputs:

High-Side Output Specifications				
Item	**MIN**	**NOM**	**MAX**	**UNIT**
Maximum output current			25	A
Output Resistance - w.r.t. ground: Output off		100.9		kΩ
Output Resistance - w.r.t. VBATT: Output on		2.3	2.7	mΩ
Leakage current, strobe off - output off	0.12		0.24	mA
Turn on delay (Off to On state)	4.48			µs
Turn off delay (On to Off state)	8.39			µs
Output pin capacitance		950		pF
PWM frequency (see note 1)			500	Hz
Duty cycle resolution, up to max frequency				%

Note 1: Output PWM frequency can go up to 2000Hz. Parker application engineering would need to review each application request for an output PWM frequency above the default 500 Hz.

5.1.2. High-Side Output Diagnostics and Fault Detection

The CM0504's high-side outputs have the ability to report many different fault conditions, and are protected against short-circuit and over-current, open load, and short-to-battery faults.

5.1.2.1. Short-to-Battery

Short-to-battery faults occur when a high-side output pin is connected to battery voltage.
The high-side output circuit uses voltage on the output pin to determine if a short-to-battery condition exists.

5.1.2.2. Open load (high-side)

Open load faults occur when a high-side output pin is open circuit (not connected to a load). The high-side output circuit uses a small amount of current on the output pin to determine if an open load condition exists.
Note: High-side outputs must be off to detect an open load fault.

5.1.2.3. Over-current (high-side)

Over-current faults occur when the current through a high-side output pin exceeds a threshold defined in the CM0504.

5.2. Low-side outputs

The CM0504 may be software configured to support up to 4 low-side outputs:

- `OUTPUT1_LS` to `OUTPUT4_LS`

The low-side outputs share pins with the high-side outputs and are configured with the software tool.

5.2.1. Low-side output capabilities

The low-side outputs in the module provide a switched GROUND (open drain) digital output from the CM0504 for loads. The outputs do not support PWM.

The following table provides specifications for the CM0504's low-side outputs:

Low-Side Output Characteristics				
Item	**MIN**	**NOM**	**MAX**	**UNIT**
Output voltage range (operational/non-operational)	0		32	V
Output current	0		25	A
Output ON state resistance (w.r.t. GND)		2.0	2.5	mΩ
Output OFF state leakage current	0.3		0.6	mA
Turn ON time to ON state	1.39			µS
Turn OFF time to OFF state	5.78			µS
Output pin capacitance		950		pF

5.2.2. Low-Side Output Diagnostics and Fault Detection

The CM0504's low-side outputs have the ability to report many different fault conditions, and are protected against short-circuit and over-current, open load, and short-to-ground faults.

5.2.2.1. Short-to-Ground

Short-to-ground faults occur when a low-side output pin is connected to ground.

5.2.2.2. Open load (low-side)

Open load faults occur when a low-side output pin is open circuit (not connected to a load).

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

5.2.2.3. Over-current (low-side)

Over-current faults occur when the current through a low-side output pin exceeds a threshold defined in the CM0504.

5.3. High-Side/Low-Side Output Configuration

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

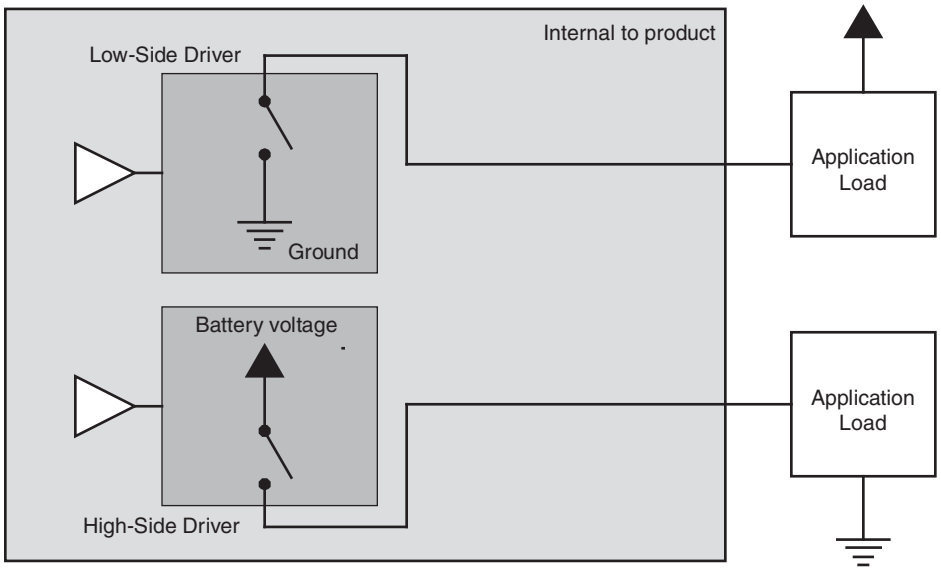


Figure 5.1. High-side/Low-side output configuration

5.3.1. High-Side/Low-Side output connections

5.3.1.1. High-Side Output Connections

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

- High-side outputs are connected to the VBATT pins, which can be connected to a +12 V or +24 V battery. The VBATT powers 4x 25 A outputs. Maximum load on the VBATT is 100 A.
- High-side outputs can provide switched battery power to a variety of load types in a vehicle.

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

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

- High-side outputs should not be connected to loads that will draw currents greater than the maximum peak current, or maximum continuous current.
- The grounds for the loads should be connected physically close to the CM0504 power grounds.

The following shows a typical high-side output connection:

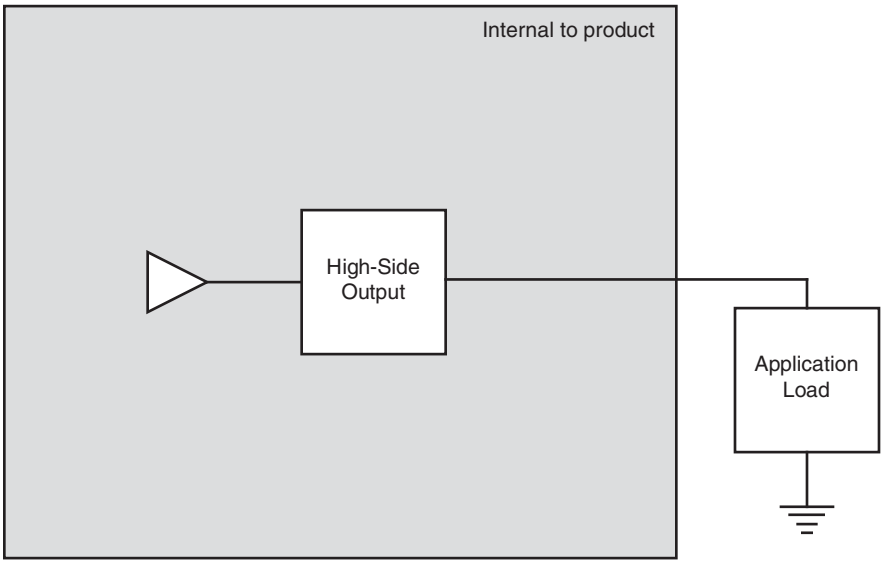


Figure 5.2. High-side output installation connections

5.3.1.2. Low-Side Output Connections

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

- Low-side outputs are connected to the ground pins, which are connected to battery negative terminal. Maximum load on each output is 25 A. Maximum load on the ground is 100 A
- Low-side outputs can provide switched ground path to a variety of load types in a vehicle.

The following shows a typical low-side output connection:

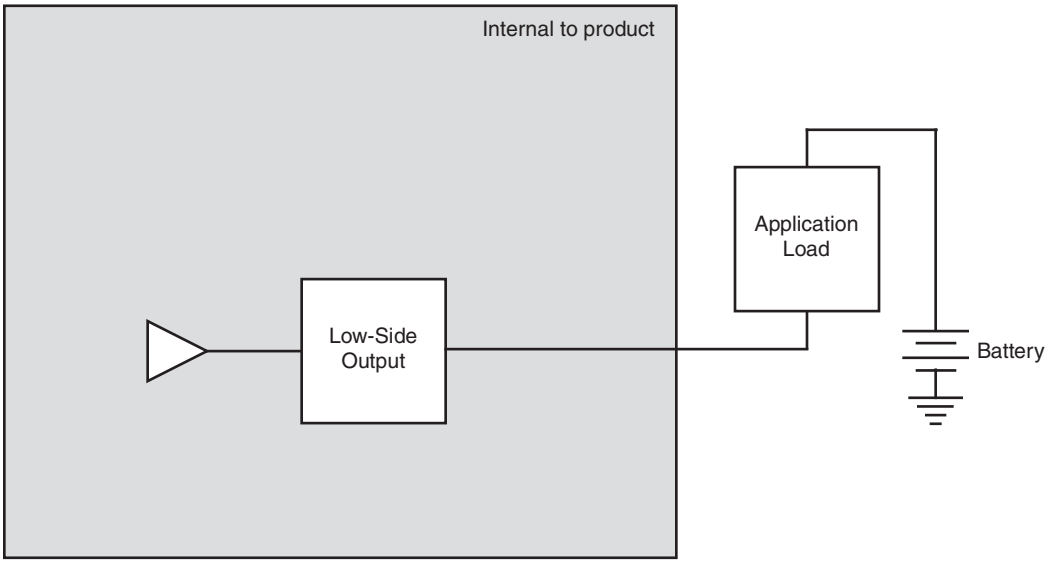


Figure 5.3. Typical low-side output connection

5.3.1.3. H-Bridge Connection

The high-side/low-side outputs can be configured to be an H-Bridge (controlled by activating the one you want to be high side). An H-Bridge allows loads to be controlled by both high side and low side switches at the same time.

H-Bridge connection allows loads to have current reversed through them which allows several load types to reverse direction (motors, solenoids, etc).
There are 2 H-Bridge options that the CM0504 can accommodate. These are configurable in the Software Tool. Configurations are:

- 2 separate H-Bridges that function independent of one another and can handle up to 25 amps each. Please reference the Software Tool for how you must pin the CM0504
- 1 H-Bridge that gangs output pins together. In this configuration that CM0504 can sustain up to 50 amps across this H-Bridge. Please reference the Software Tool for how you must pin the CM0504

⚠ Size your fuses and wires accordingly when altering the output configuration. Improper fusing and wiring can result in a fire.

Note: Fusing of the Bus Bar(s) is not shown in the examples below.

The following figures show a typical setup for an H-Bridge. These show how the H-Bridge is used to reverse current flow direction.

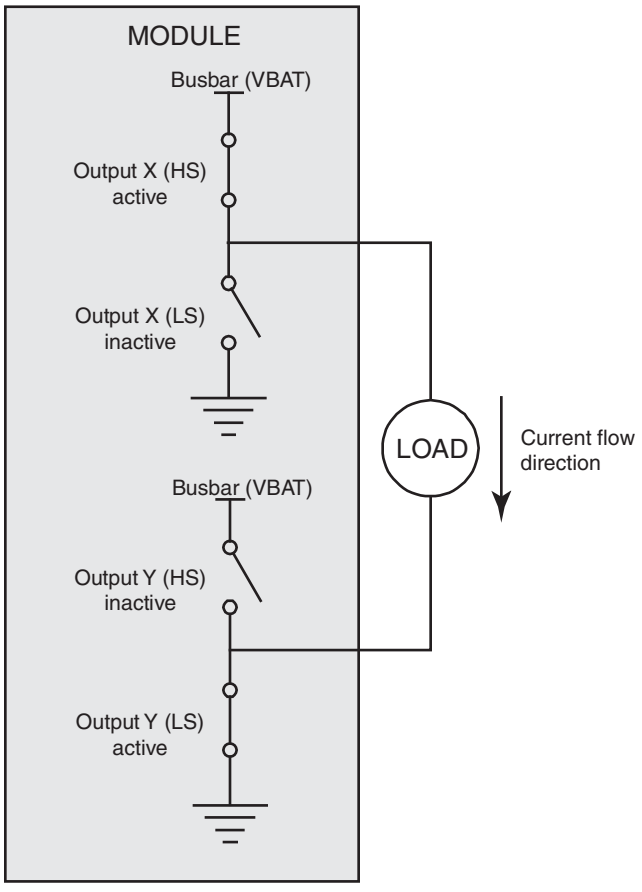


Figure 5.4. H-bridge forward direction

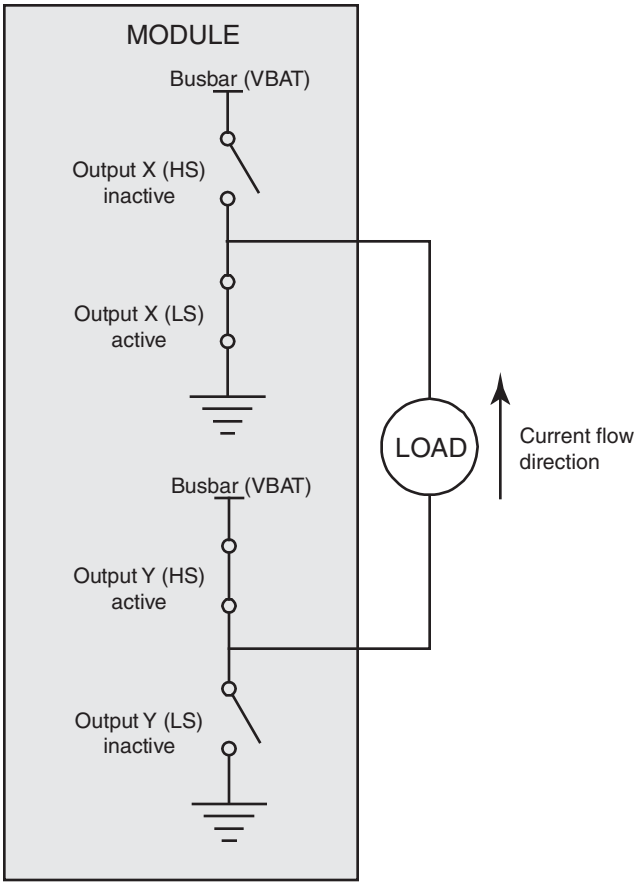


Figure 5.5. H-bridge reverse direction

To activate the H-Bridge as shown above, use the CM0504 Configuration Tool software to set up the out puts for current flow to be controlled in the forward and reverse directions.

6. Power

The CM0504 is powered by the vehicle battery. The CM0504 operates in a 12 V or 24 V system, and can operate from 9 V up to 32 V, with over-voltage protection at 36 V.

When the CM0504 is configured to go into sleep mode, the controller is turned on by applying power to the power control (wake-up) input or a CAN message.

6.1. Logic and output power

The CM0504 has 2 pins, labeled VBATT, dedicated to providing power for logic and outputs, and 2 pins, labeled GND, dedicated to grounding the CM0504.

Note: The power and ground connections are usually paralleled over several pins to minimize voltage drops on higher current applications.

6.1.1. Logic and output power capabilities

The VBATT pins that provide logic and output power are internally connected inside the CM0504.
Logic power refers to the logic circuit, which consists of the microprocessor, RAM, etc. The logic circuit can draw a maximum of 250 mA.
Output power refers to the output circuits connected to the battery positive and ground terminals. Each output circuit can draw a maximum of 25 A.

The following table provides specifications for the CM0504 logic and output power:

Logic and Output Power Specifications				
Item	**Min**	**Nom**	**Max**	**Unit**
Input voltage range	9		32	V
Over voltage			36	V
Current draw in on state (excluding outputs)			250	mA
Current draw in sleep mode (see note 1)	0.6		1.7	mA
Inline fuse required on power circuit pin			130	A
Number of VBATT pins		2		-
Number of ground pins		2		-

Note 1: Current draw in sleep mode depends on the output configuration. Sleep mode current draw will be lesser value when the outputs are configured as HS output.

6.1.2. Logic and output power connections

When connecting the CM0504 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 CM0504 power depends on the amount of current required by the application.
    - It is recommended that you use the largest AWG wire allowed by your connector for the VBATT and GND pins, to meet the amount of expected output current; however, this is not always true and depends on your application.

- The CM0504 is protected against reverse-battery connections by an internal high-current conduction path that goes from ground to power.
    - Select fuse sizes by multiplying the maximum continuous current during normal operation by 1.333 (75% de-rating factor). Do not use slow blow fuses for this application.
- All power connections to the CM0504 should be fused to protect the vehicle harness.

7. Communication

The only type of communication available to the CM0504 is Controller Area Network (CAN) communication.

7.1. Controller area network

The CM0504 has 1 Controller Area Network (CAN) communication port(s) available. The CM0504 hardware provides controller area network (CAN) communication according to the SAE J1939 specification, making the CM0504 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.

7.1.1. J1939 CAN Capabilities

The CAN communicates information at a rate of 250 kbps. CM0504 input and output information is transmitted through the CAN at a broadcast rate of 40 Hz. Lack of regular CAN communication is an indication that there is either a problem with a module in the network, or a problem with the CAN bus.

The following table provides specifications for the CAN:

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

7.1.2. J1939 CAN Installation Connections

The CAN connection for the CM0504 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 CM0504 does not have a CAN termination resistor, which is based on the assumption that the CAN bus is terminated in the harness.

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

- CAN Cable: A shielded twisted-pair cable should be used when connecting multiple modules to the CAN bus. The cable for the J1939 CAN bus has three wires: CAN High, CAN Low, and CAN Shield (which connect to the corresponding CAN_HIGH, CAN_LOW, and CAN_SHIELD pins on the connector). When a module does not have a CAN_SHIELD pin, the CAN Shield should be connected to an available ground terminal attached to the negative battery. The CAN cable must have an impedance of 120 Ω.

- The CAN cable is very susceptible to system noise; therefore, CAN shield must be connected as follows:
    a. Connect CAN Shield to the point of least electrical noise on the CAN bus.
    b. Connect CAN Shield as close to the center of the CAN bus as possible.
    c. Use the lowest impedance connection possible.

Note: Ground loops can damage electronic modules. The CAN Shield can only be grounded to one point on the network. If grounded to multiple points, a ground loop may occur.

- CAN Connectors: Industry-approved CAN connectors are manufactured by ITT Cannon and Deutsch, and come in either T or Y configurations.
- CAN Harness: The CAN harness is the main backbone cable that is used to connect the CAN network. This cable cannot be longer than 40 meters and must have a 120 Ω terminating resistor at each end. The 120 Ω terminating resistors eliminate bus reflections and ensure proper idle-state voltage levels.
- CAN Stubs: The CAN stubs cannot be longer than 1 meter, and each stub should vary in length to eliminate bus reflections and ensure proper idle state voltage levels.
- Max Number of Modules in a System: The CAN bus can handle a maximum of 30 modules in a system at one time.

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

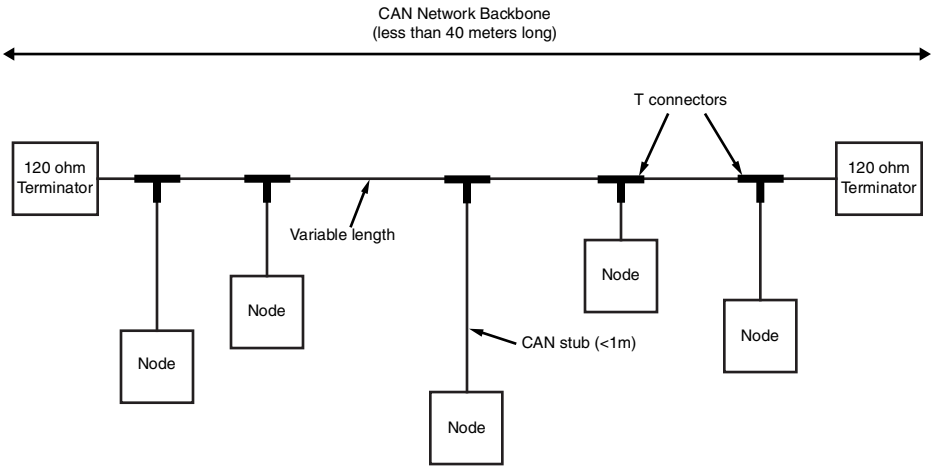


Figure 7.1. J1939 CAN connection

8. 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 CM0504.

> The vehicle manufacturer is responsible for creating procedures for mounting the CM0504 in a vehicle during production assembly.

8.1. Mechanical Requirements

Review the following mechanical requirements before selecting a mounting location for the CM0504:

- The CM0504 should be mounted vertically so moisture will drain away from it.
- The wire harness should have drip loops incorporated into the design to divert water away from the CM0504.
- 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 CM0504 should be in a location that is easily accessible for service.

8.2. Dimensions

The following shows the dimensions of the CM0504 in millimeters:

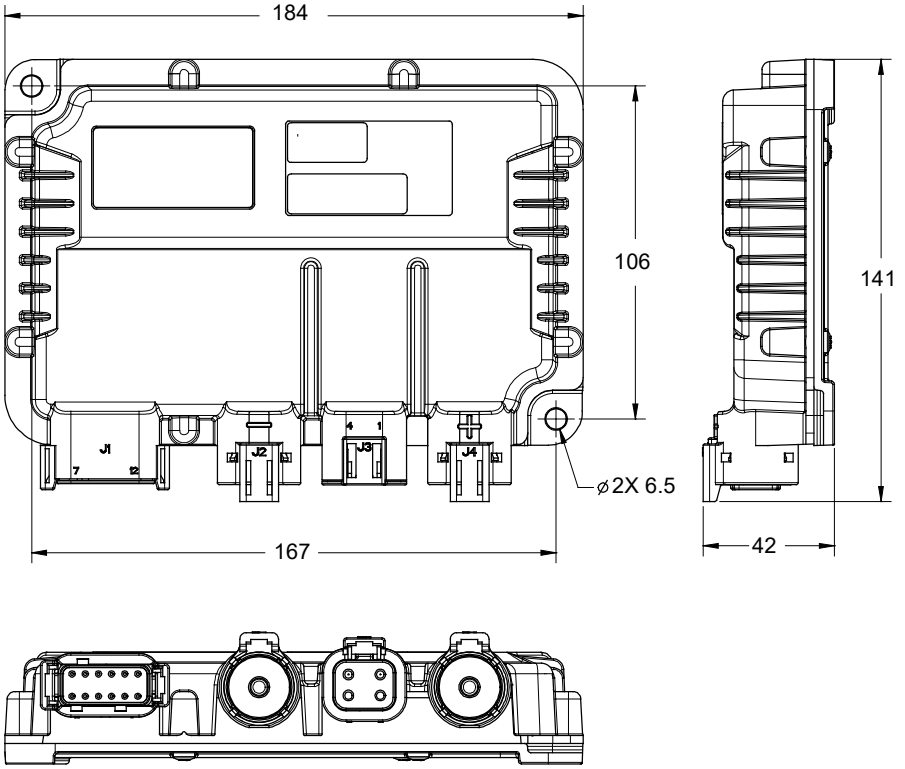


Figure 8.1. CM0504 dimensions

8.3. Selecting a Mounting Location

The CM0504 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 CM0504, ensure you review the following environmental and mechanical requirements.

Do not install the CM0504 close to any significant heat sources, such as a turbo, exhaust manifold, etc. Also avoid installing the CM0504 near any drive-train component, such as a transmission or engine block.

The CM0504 should be mounted with the connectors facing down, so that moisture drains away from it, as shown in the following:

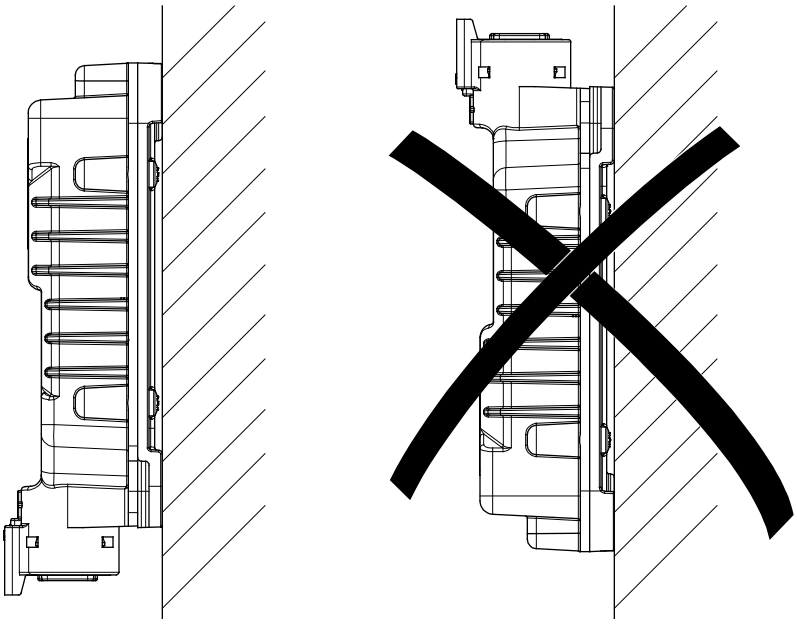


Figure 8.2. CM0504 mounting orientation

8.4. Mounting the CM0504 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 CM0504 to a vehicle:

- Secure the CM0504 with bolts in all bolt holes using Hex Head 1/4"-20 or equivalent metric size (6 mm) bolts.
- The bolts should be tightened according to the fastener manufacturer's tightening torque specifications

8.5. Designing and Connecting the Vehicle Harness

The vehicle manufacturer is responsible for designing a vehicle harness that mates with the CM0504 connector(s).
The vehicle harness design depends on the following:

- How the CM0504's inputs, outputs, communication, and power pins are configured.
- Other components on the vehicle and their physical locations.
- The routing of the harness.

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

Once the vehicle harness is designed, it can be connected to the CM0504 simply by clicking the mating connectors into the connector ports on the CM0504.

9. Environmental Protection

The CM0504 is manufactured and tested to meet stringent industry standards as shown below.

If any additional information is required, please contact your Parker Vansco representative for more details.

9.1. General

Operating Temperature –40°C to +85°C
Storage Temperature –40°C to +85°C

9.2. Environment

Humidity (soak)	ANSI/ASAE EP455 DEC 1990 (R2008) section 5.13.2
Humidity (cyclic)	ANSI/ASAE EP455 DEC 1990 (R2008) section 5.13.1
Dust/Water Ingress Protection	IP67 and IP69K
Salt Spray	MIL-STD-202G Method 101E condition B
Shock	ANSI/ASAE EP455 Dec 1990 (R2008) Section 5.14.1
Random Vibration	BS EN7691:1994 section 6.6.1 severity level 3
ESD	ISO 10605:2008(E) section 8.3 and 9.3
EMC Susceptibility	ISO 13766 2006 section 5.8.2
EMC Emissions	ANSI/ASAE EP455 DEC1990 (R2008) section 5.16.3.1

9.3. Markings/Approvals

CE 2014/30/EU, EMC directive

E-mark ECE Regulation 10: 2014 Addendum 9, Rev. 5,
Approval number E8 10R-05 9628

10. Application Examples

The purpose of this section is to provide examples of how the CM0504 can be used for different purposes.

The following examples (used for illustrative purposes only) are covered in this section:

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

10.1. Implementing Safety Interlocks

Safety is paramount when creating controls for a vehicle.

One safety feature that can be implemented with the CM0504 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:

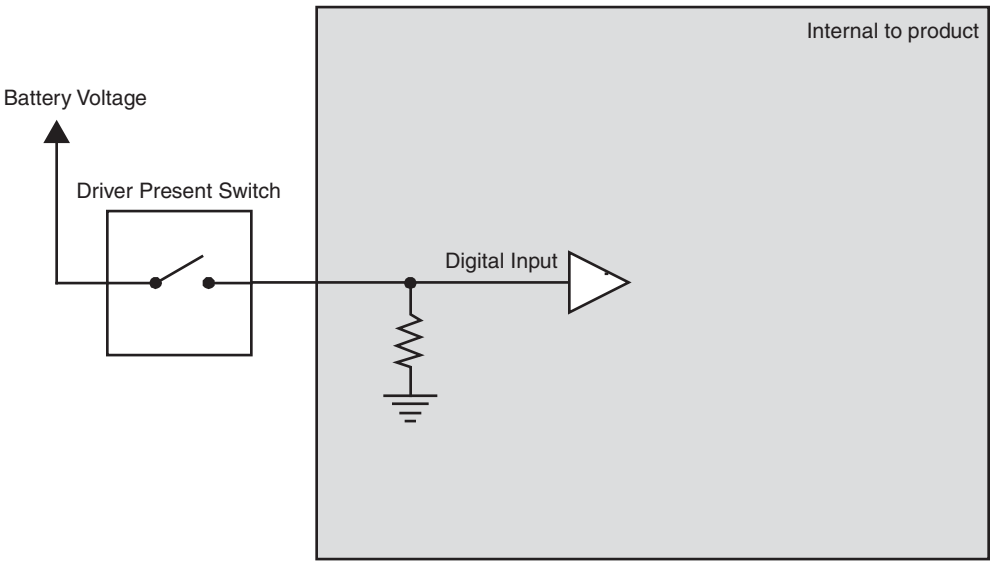


Figure 10.1. Seat switch interlock connection

10.2. Controlling Indicator Lights

Multiple CM0504 can be used together in a system to control a vehicle's indicator lights. For example, you could connect three CM0504s, communicating over the CAN bus, as follows.:

- Connect one CM0504 to the rear indicator lights.
- Connect one CM0504 to the front indicator lights.
- Connect one CM0504 to the turn signal and hazard switches.

The following shows how to connect three CM0504s together in a system to control indicator lights:

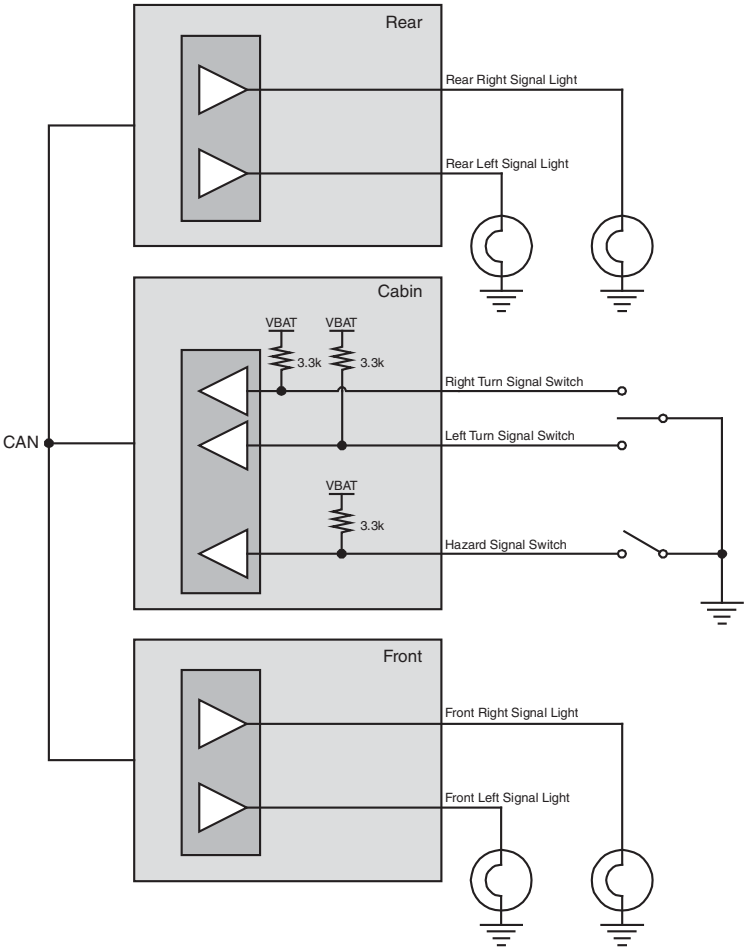


Figure 10.2. Indicator light connections

10.3. Controlling a Proportional Valve

The CM0504 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 CM0504 has Proportional-Integral-Differential (PID) capabilities that make it possible to control devices like proportional valves through software. Refer to the appropriate software manual, or contact your Parker Vansco Account Representative for more details about software. This section only provides hardware connection information.

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

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

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

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

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

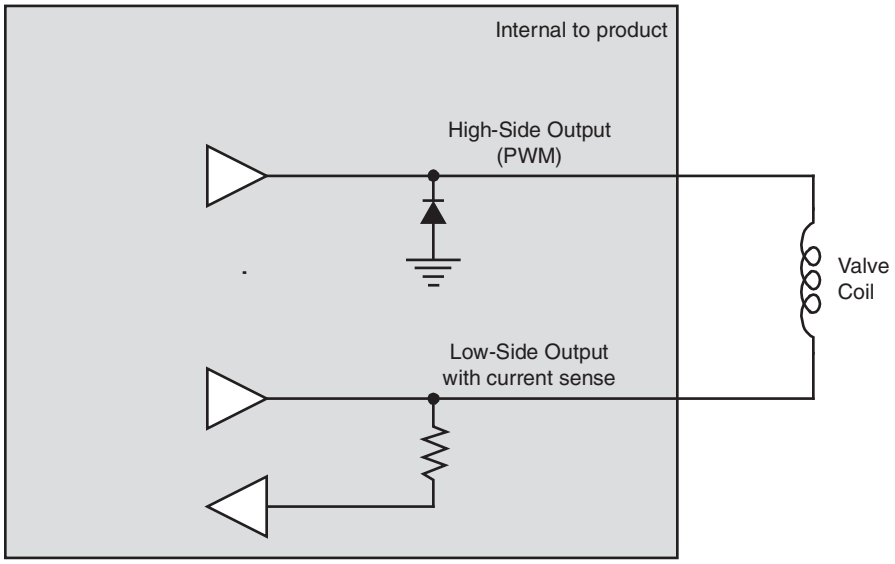


Figure 10.3. Connection for controlling a proportional valve

10.4. Controlling Motor Speed

The CM0504 can be used to control the DC motor speed of motors that provide a tachometer output.

Note: The CM0504 has Proportional Integral Differential (PID) capabilities that make it possible to control devices like proportional valves through software. Refer to the appropriate software manual, or contact your Parker Vansco Account Representative for more details about software. This section only provides hardware connection information.

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

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

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

The following shows how to connect the CM0504 to control the speed of a motor:

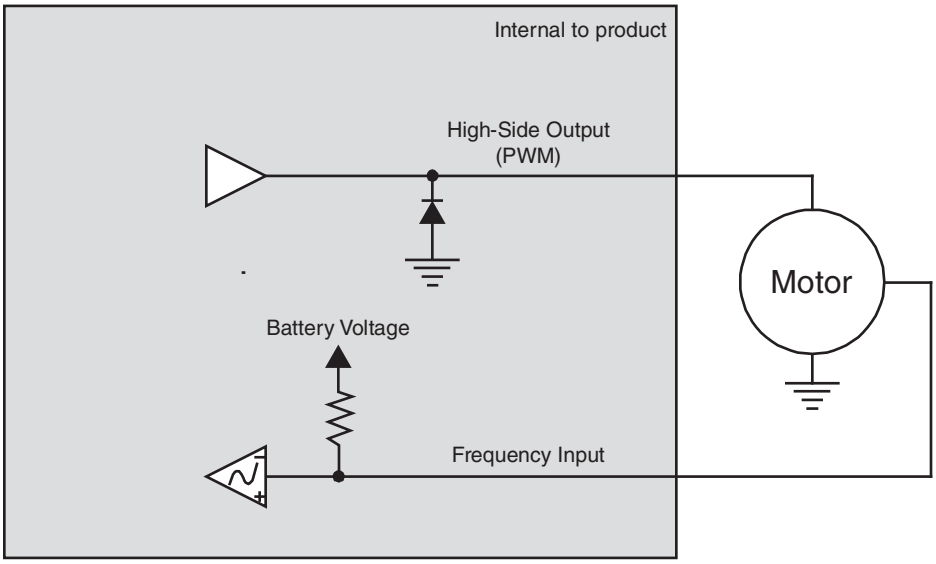


Figure 10.4. Connection for controlling motor speed

10.5. Connecting Various Sensors

There are many types of sensors that can be connected to the CM0504, 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 CM0504, use the sensor's specification to ensure that the CM0504 is configured correctly for the sensor.

10.5.1. Open Collector

Open collector sensors are compatible with each type of input on the CM0504.

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 CM0504.

The following shows a typical NPN open collector sensor connection:

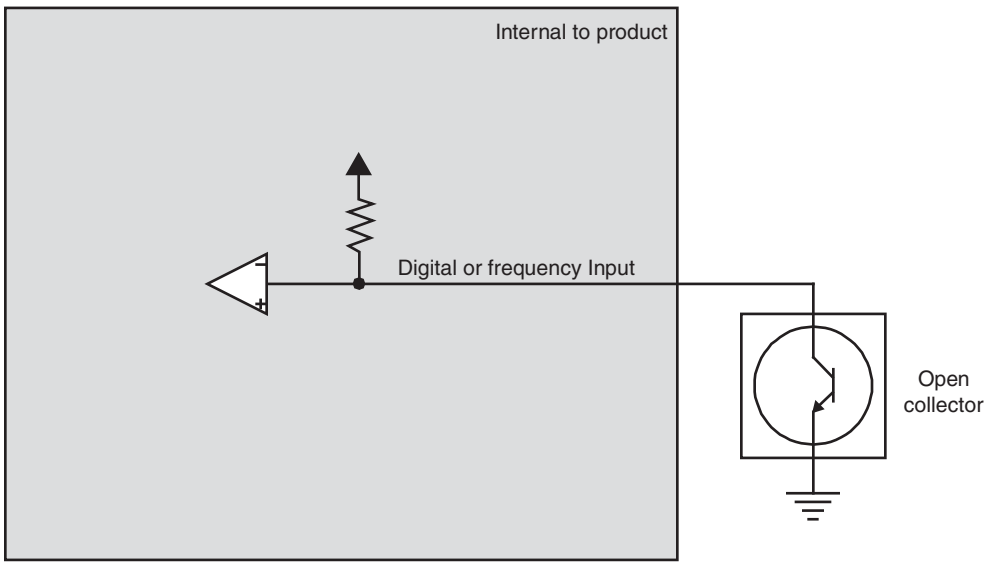


Figure 10.5. Open collector sensor connection

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

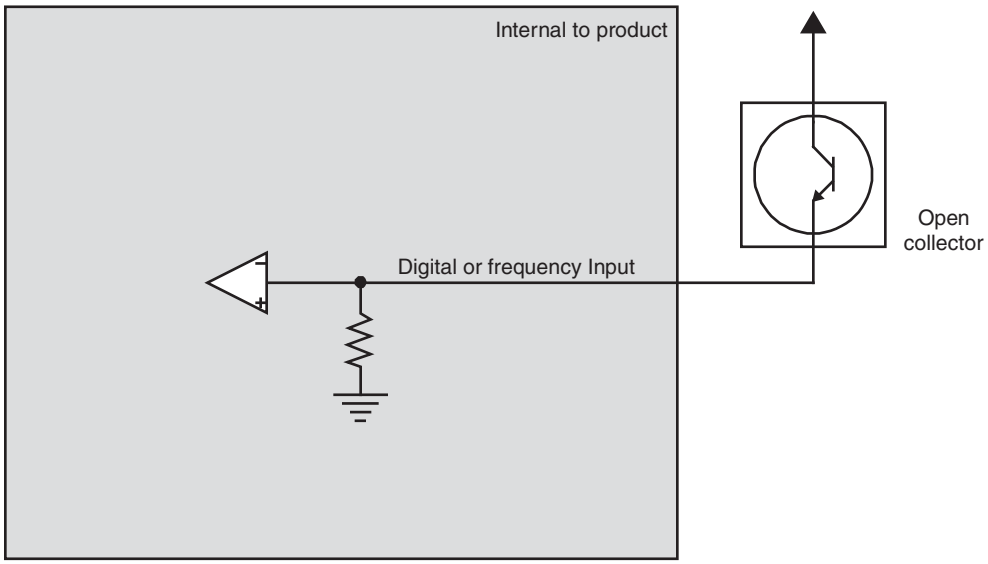


Figure 10.6. Open collector active high connection

10.5.2. 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 CM0504 cannot measure resistance directly.

To make the CM0504 measure resistance accurately, do the following:

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

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

The following shows a typical variable resistance sensor connection:

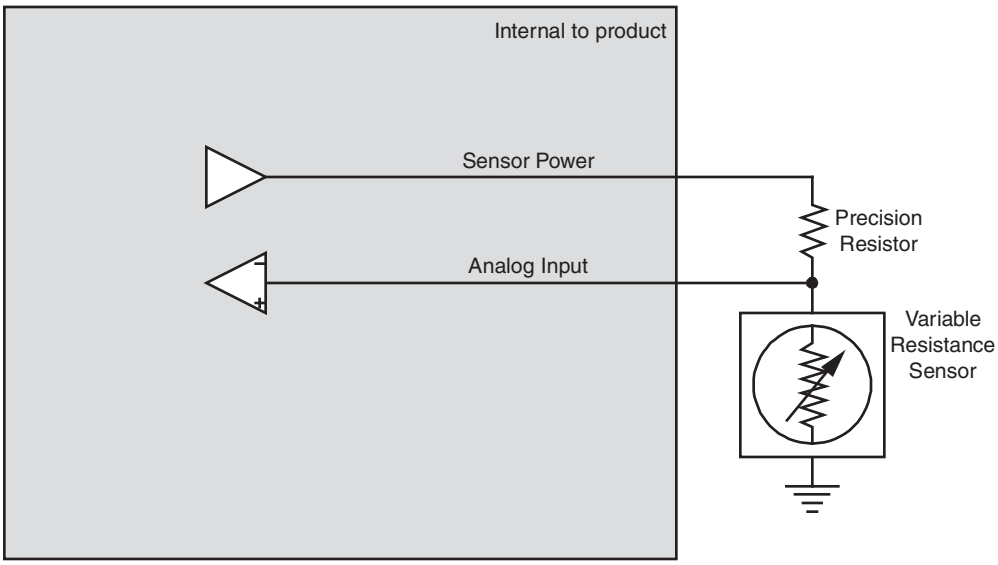


Figure 10.7. Variable resistance sensor connection

10.5.3. 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 out-putting a sine wave type signal. They work by using an increase or decrease in a magnetic field to detect the proximity of a part or device.

The following shows a typical variable reluctance connection:

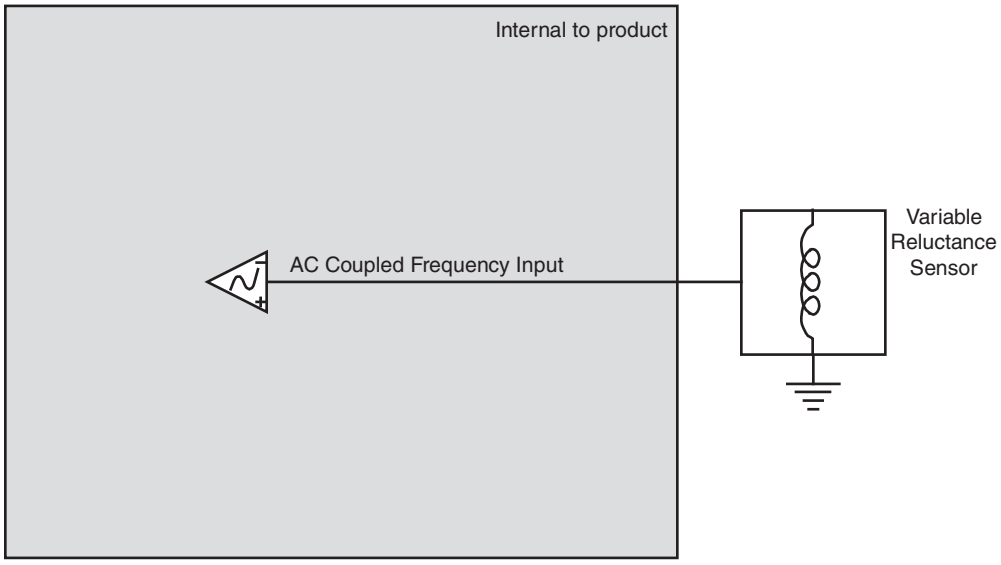


Figure 10.8. Variable reluctance sensor connection

10.5.4. 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.

⚠ 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:

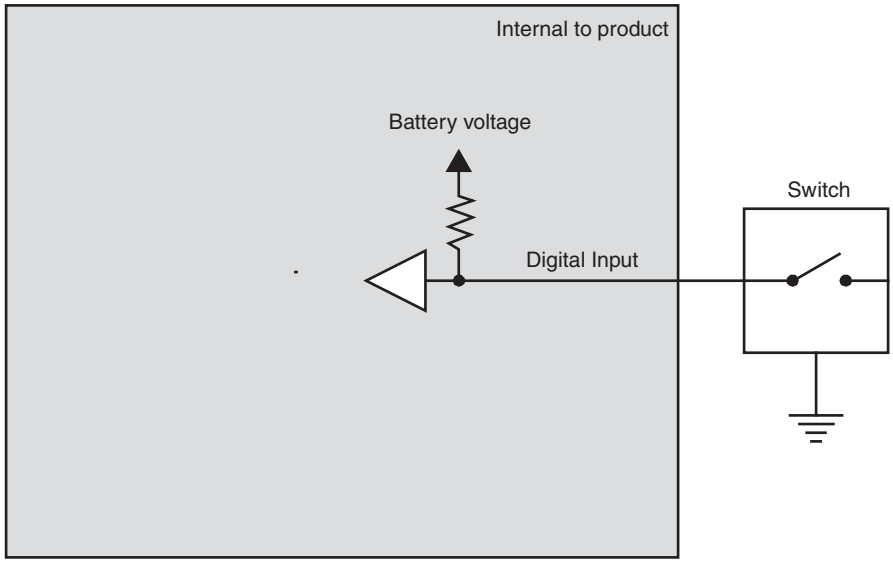


Figure 10.9. Switch sensor connection

10.5.5. 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:

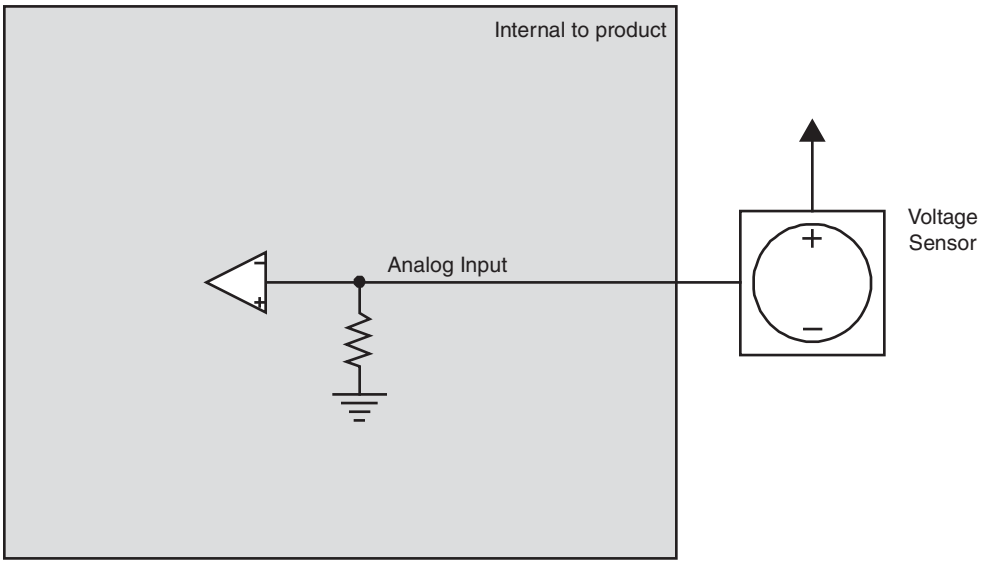


Figure 10.10. Figure 27: Voltage sensor connection

10.5.6. 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:

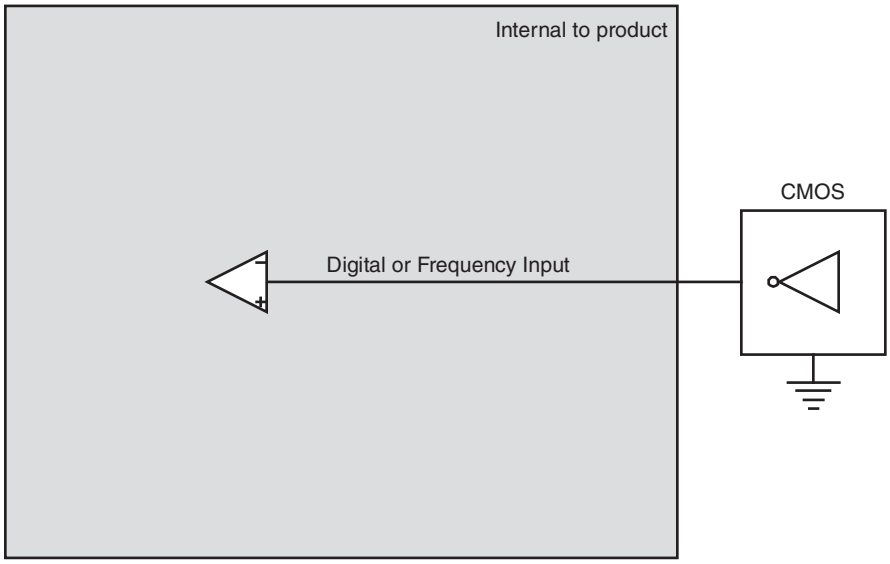


Figure 10.11. CMOS sensor connection

10.5.7. 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 `SENSOR_SUPPLY` pin, and the other end to a `GND` pin on the CM0504.
- Connect the sensor signal to an analog input.

The following shows a typical potentiometer sensor connection:

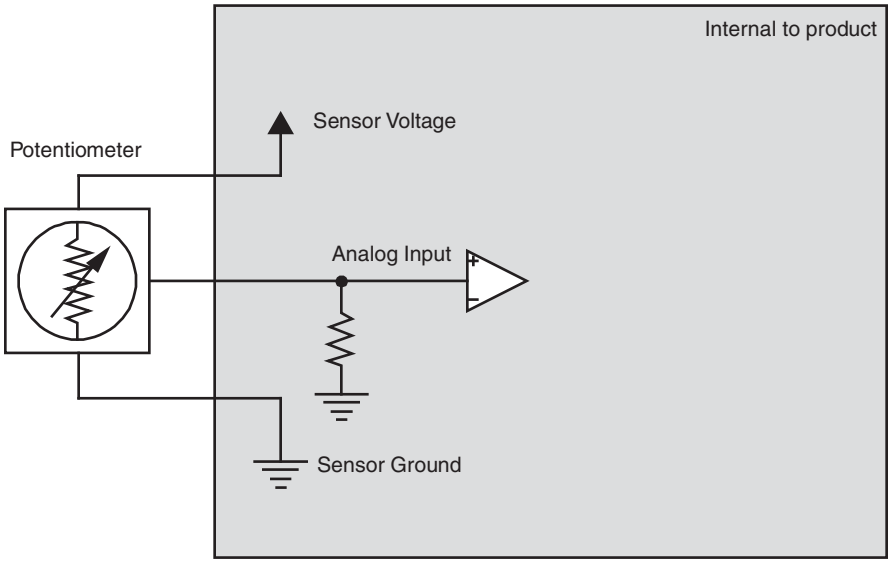


Figure 10.12. Potentiometer (ratiometric) sensor connection

10.6. Using one Analog Input as Two Digital Inputs

The CM0504 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 Vansco 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:

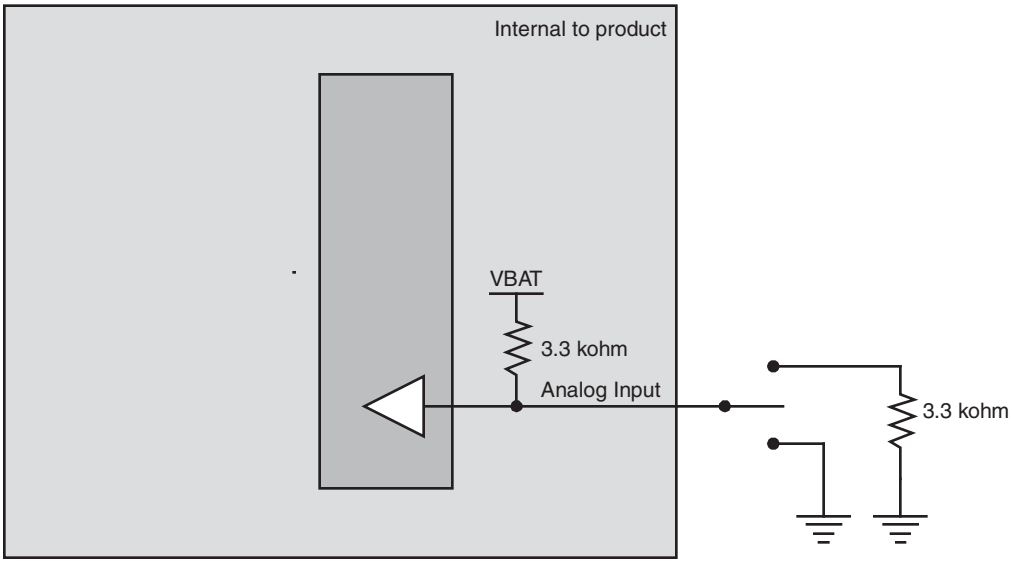


Figure 10.13. Connecting an analog input to an SPDT switch

11. Software

The CM0504 software is responsible for providing general mechanisms to control the outputs (including detecting fault conditions), monitor the inputs, and transmit/receive J1939/CAN messages. The software on another level uses these mechanisms to implement some sort of application program. The default application for this product is to perform as a *slave controller*, which receives CAN messages from a master controller telling it how to drive the outputs, and transmits CAN messages reporting the state of inputs and fault status of outputs.

This document is not intended to explain the CM0504 internal code in detail, but rather to document how to configure and use the CM0504 with its PC configuration tool.

11.1. CM0504 diagnostic tool

There are a few general things to point out about the tool:

- the GUI is basic — the main menu pops up when you right-click on the tool window
- the tool follows the convention that **blue labels/widgets** (in this document and in the GUI) denote configurable properties — "undefined" is a valid configuration value for some configurable properties. Undefined values are shown as blank/empty boxes. You can right-click on associated widgets to pop up a menu allowing you to change a property's value to undefined. By definition, operational values cannot be undefined.
- **green labels/widgets** (in this document) denote one-time configurable properties that generally were configured at the factory
- **gray labels/widgets** denote properties that cannot be changed by the user
- GUI appearance/behaviour may change depending on user selections, and in some cases depending on the values of some properties. For example, some widgets are hidden or disabled when operational values are not selected. For channels that are ganged (or part of an H-bridge), only widgets associated with the gang "leader" (or master "leg" of the H-bridge) are enabled.
- the diagnostic protocol used between the tool and the CM0504 is robust, however, it is possible to confuse the tool so that it won't talk to the CM0504. This is especially true if you reconfigure the CM0504's J1939 identity, or if you unplug one CM0504 and plug in another
- there may be multiple modules on the CAN bus, some which are not CM0504's — generally, the tool interacts with only one CM0504 at a time (typically the first one it happens to see, but the user can choose another)
- for various reasons, a CM0504 may be plugged in to the bus but holding itself silent, so the tool is unaware of its presence. Similarly, the module may be talking on the bus but the tool does not recognize it as a CM0504 (because it has been incorrectly configured). The user may need to take some action to "wakeup" or "unlock" the CM0504, or force the tool to recognize it as a CM0504.
- the tool attempts to be backwards compatible with older versions of CM0504, but there may be scenarios where an older CM0504 didn't support a feature, which is not handled well by the tool
- the CM0504 supports selectable CAN bit rates (100K, 250K, 500K & 1M), but PC tool currently only supports 250K

Note: As of the date of this publication, hardware input numbers and software input numbers are different. Keep this in mind as you use the software tool.

Hardware INPUT1 = software INPUT5, hardware INPUT2-INPUT5 = software INPUT1-INPUT4.

11.1.1. Using the tool

In user mode, the tool is a single/main window containing the following elements:

- a drop-down list box (in the upper left corner of the window) showing the SA (Source Address) of the currently connected CM0504 — if you drop down the list, you can see what other CM0504's are (or were) on the bus, and select another one to talk with.

Figure 11.1. Source address claim

- radio buttons to select between Operational Values and Config Settings, i.e. regarding what kind of values are displayed on the main window, or which are shown in the input/output properties dialog boxes. When the config settings option is selected, properties that are not configurable are shown as blank values.

Figure 11.2. Op values and config settings

- the *Install S/W* button — the user will be prompted to select a .pkg file that contains the S/W he wishes to install. If there are multiple CM0504's on the bus, the user can select which ones to get the install. (Currently, the tool installs all components from the pkg — the planned behaviour was to not reinstall the same version of a component, and to ask the user whether an older version of a component should be installed over the existing newer version.). A dialog box pops up showing the progress as each component is installed.

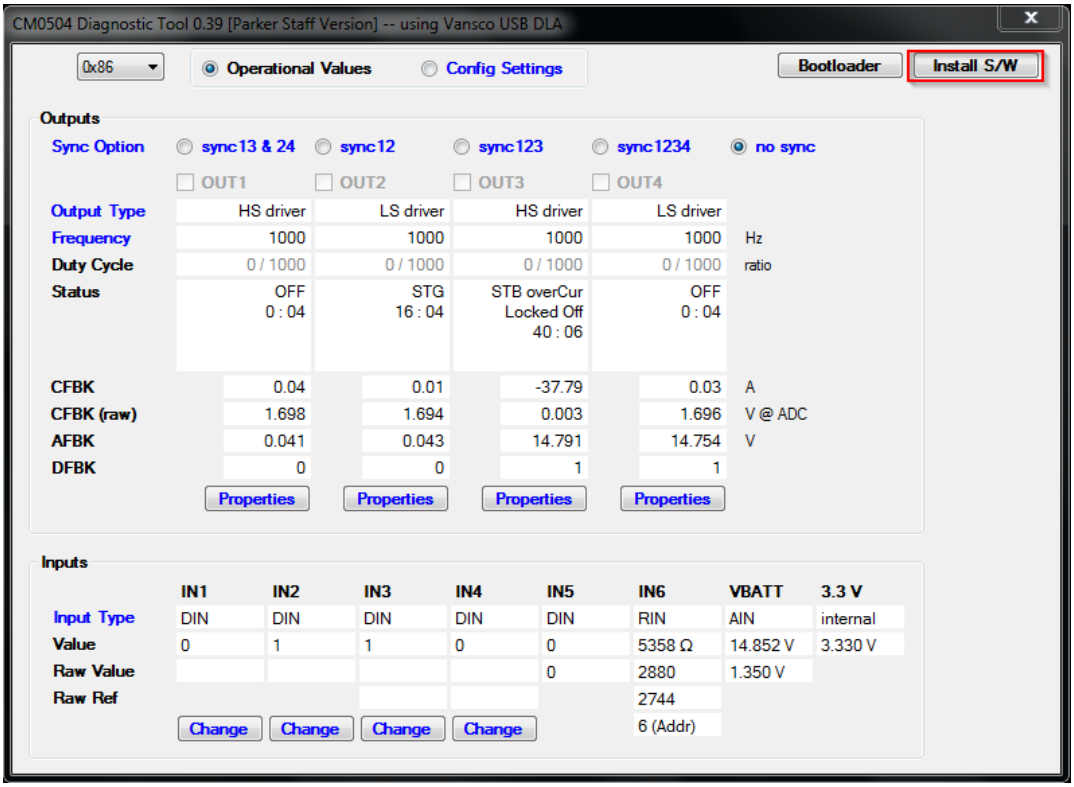


Figure 11.3. Install S/W button

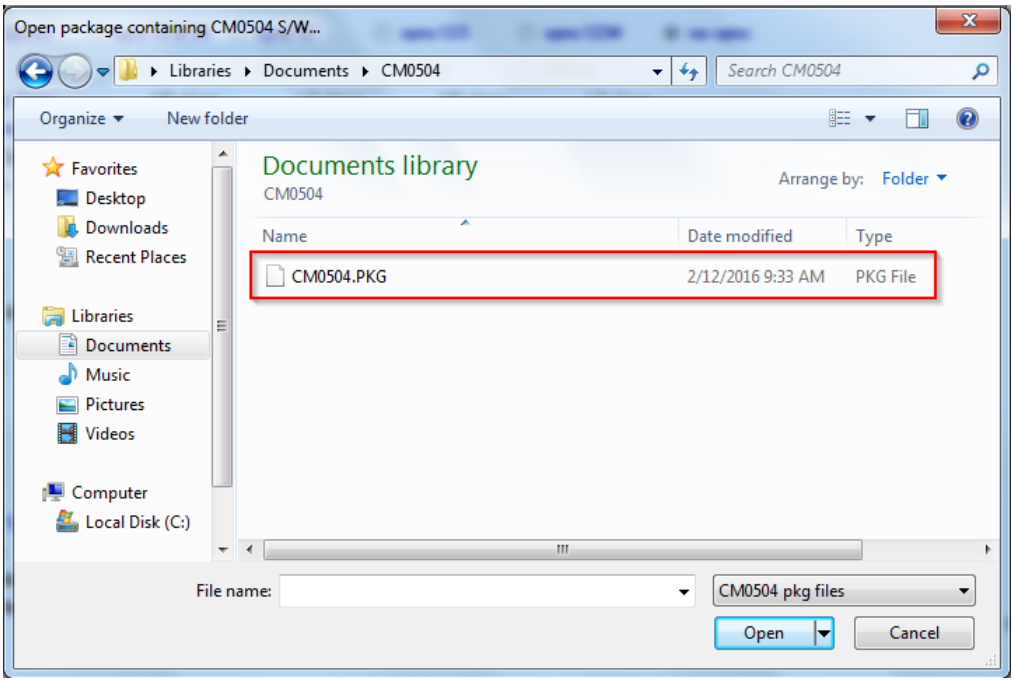


Figure 11.4. Software file dialog box

- the Outputs group shows the current/configured value of output properties (for each of the 4 channels):

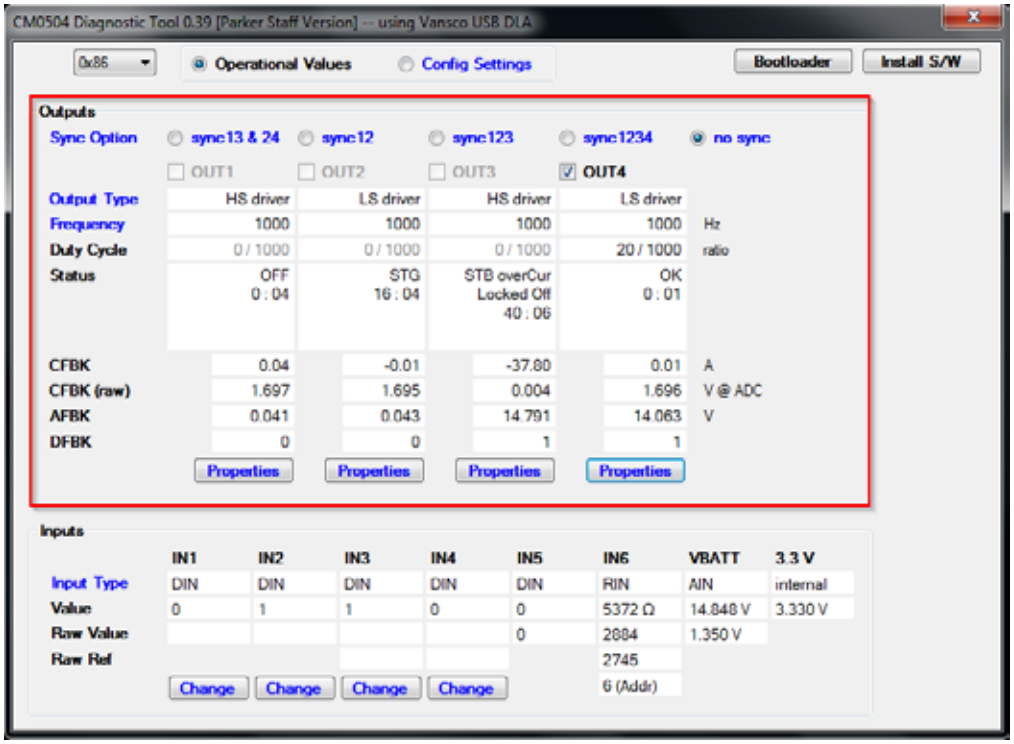


Figure 11.5. Outputs group

- **Sync Option** radio buttons show/control the syncOption property, i.e. which output channels are ganged together — if undefined, no button is selected. Note - this property can only be changed from the main window (all other properties, except ***PWMduty***, can only be changed via a dialog box).
- OUT1..OUT4 checkboxes are simply a convenience to allow the user to easily turn outputs on/off, i.e. toggle ***PWMduty*** between 0 and the last user-entered value — they are visible only for operational values.
- **Output Type** shows the ***driveConfiguration*** property
- **Frequency** shows the ***PWMfreq*** property
- Duty Cycle shows the ***PWMduty*** and corresponding ***PWMrange*** properties — when the output is off, the corresponding **OUTi** checkbox is unchecked, and the duty cycle shown is the last one entered by the user
- Status shows various conditions derived from the ***OUTstatus*** and ***OUTfaultSet*** properties — additional description t.b.d.
- CFBK shows the ***CFBK*** property — note that all feedback values (***AFBK*** and ***DFBK***, too) correspond to samples taken at the midpoint of a PWM pulse ⇨ average current is NOT reported
- CFBK (raw) shows the ***CFBKinternal*** property (i.e. voltage level at ADC chip)
- AFBK shows the ***AFBK*** property
- DFBK shows the ***DFBK*** property

- **Properties** buttons — when pressed, call up the **Config OUT*i*** dialog box allowing you to enter values for changeable output properties for one channel (see below)

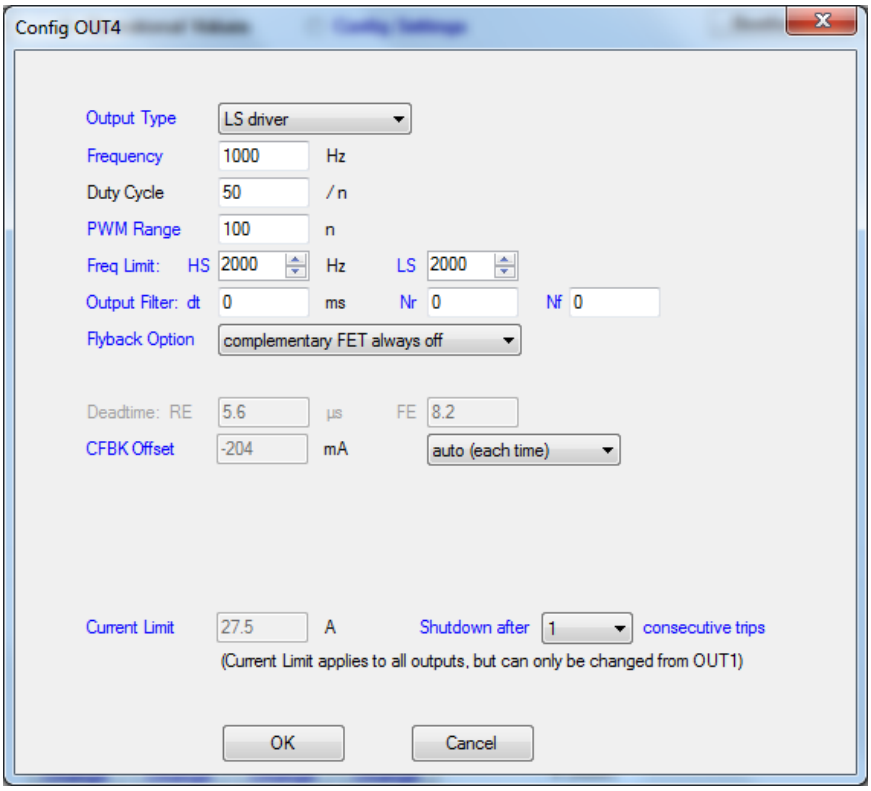


Figure 11.6. Output properties dialog box

- the Inputs group shows the current/configured value of input properties (for each channel) — what is shown for values varies depending on Input Type:

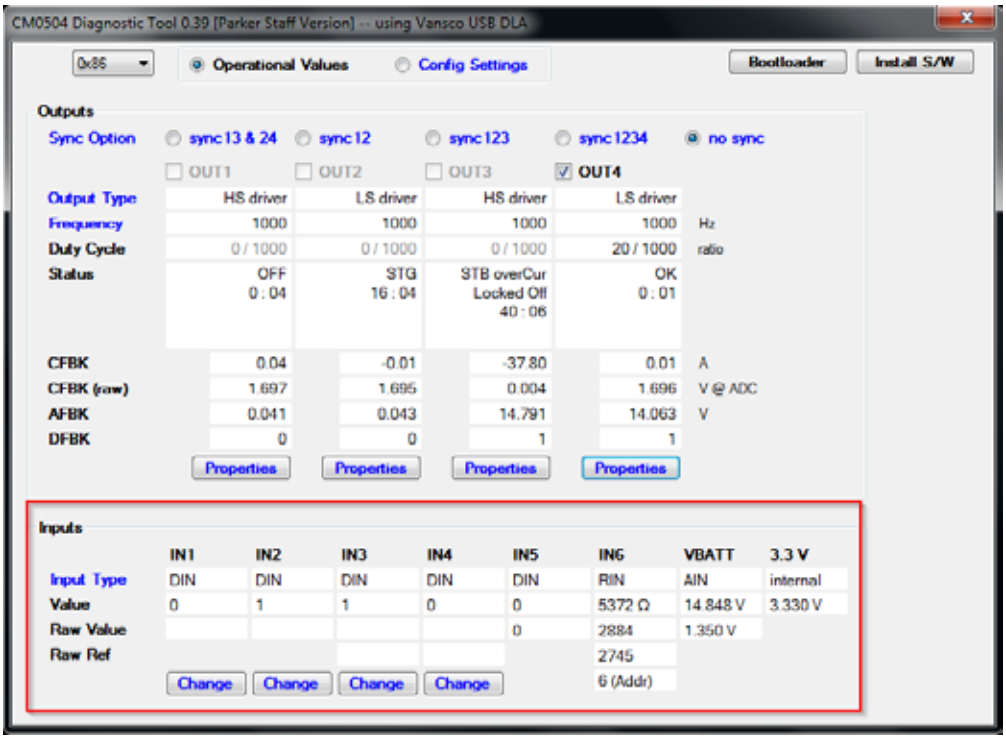
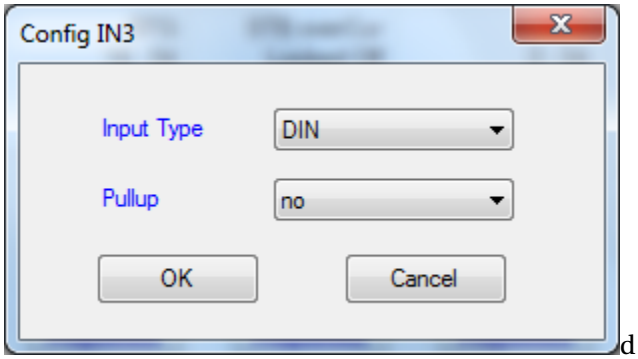


Figure 11.7. Inputs group

- **Input Type** shows the ***inputType*** property of the CM0504's four general purpose inputs (type of input is fixed for the other input channels), and determines what form of input value(s) are shown below. Note that columns labeled **IN1** to **IN4** correspond to the CM0504's four general purpose inputs, **IN5** corresponds to what is considered its 5th input which is also a H/W wakeup signal, **IN6** corresponds to the input used with a keyed resistor as the module's harness address, and the last 2 columns correspond to external and internal power supply voltages. Only the four general purpose inputs are configurable, with input type RIN supported in H/W for channels **IN3** & **IN4** only.
- depending on input type, Value shows properties ***DIN***, ***AIN***, ***FINfreq***, ***FINduty***, ***FINcount***, or ***RIN***
- what Raw Value shows depends on input type — for AIN, it shows ***AINinternal***; for RIN it shows ***AINraw***; for all else it shows nothing, except for **IN5** (fixed as DIN) it shows ***FINcount***
- Raw Ref shows the RINref property
- column **IN6** has an additional unlabeled value — it shows the ***ADDR*** property
- **Change** buttons — when pressed, call up the **Config IN*i*** dialog box allowing you to enter values for changeable input properties for one channel (see below)



d

Figure 11.8. Input properties dialog box

- when you right-click on the main window (other than on the **Sync Option** radio buttons), a menu pops up which contains the following items:

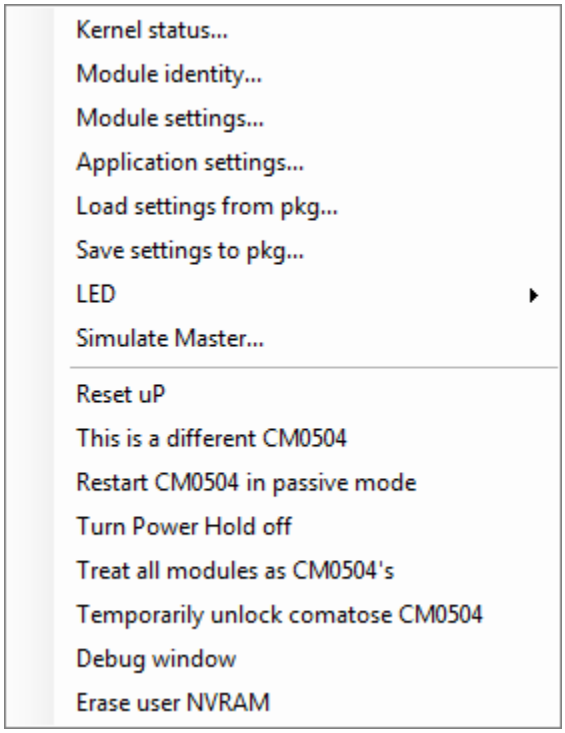
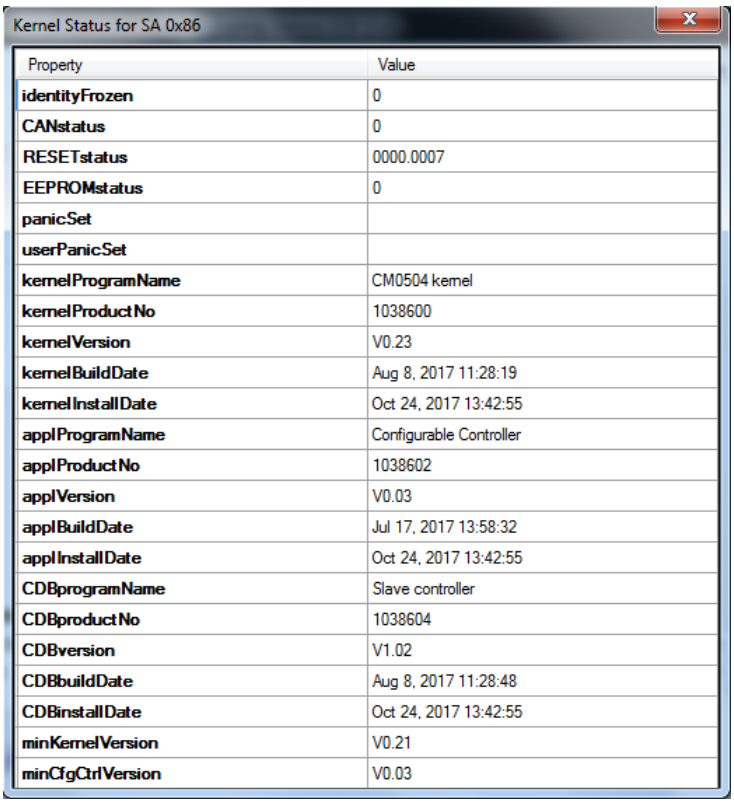


Figure 11.9. Right click selection window

- *Kernel status...* — calls up a dialog box that shows identification, version and build/install date properties of all S/W components installed (i.e. kernel must be installed, but user application and CDB may be missing). It also shows the values of properties: ***identityFrozen***, ***CANstatus***, ***RESETstatus***, ***EEPROMstatus***, ***panicSet*** and ***userPanicSet***.



Property	Value
identityFrozen	0
CANstatus	0
RESETstatus	0000.0007
EEPROMstatus	0
panicSet	
userPanicSet	
kernelProgramName	CM0504 kernel
kernelProductNo	1038600
kernelVersion	V0.23
kernelBuildDate	Aug 8, 2017 11:28:19
kernelInstallDate	Oct 24, 2017 13:42:55
applProgramName	Configurable Controller
applProductNo	1038602
applVersion	V0.03
applBuildDate	Jul 17, 2017 13:58:32
applInstallDate	Oct 24, 2017 13:42:55
CDBprogramName	Slave controller
CDBproductNo	1038604
CDBversion	V1.02
CDBbuildDate	Aug 8, 2017 11:28:48
CDBinstallDate	Oct 24, 2017 13:42:55
minKernelVersion	V0.21
minCfgCtrlVersion	V0.03

Figure 11.10. Kernel status

- *Module identity...* — calls up the Module Identity dialog box (see below) that shows all read-only (one-time settable) properties that collectively define the CM0504's physical identity. It also allows you to configure the CM0504's J1939 NAME and SA (base and OEM).

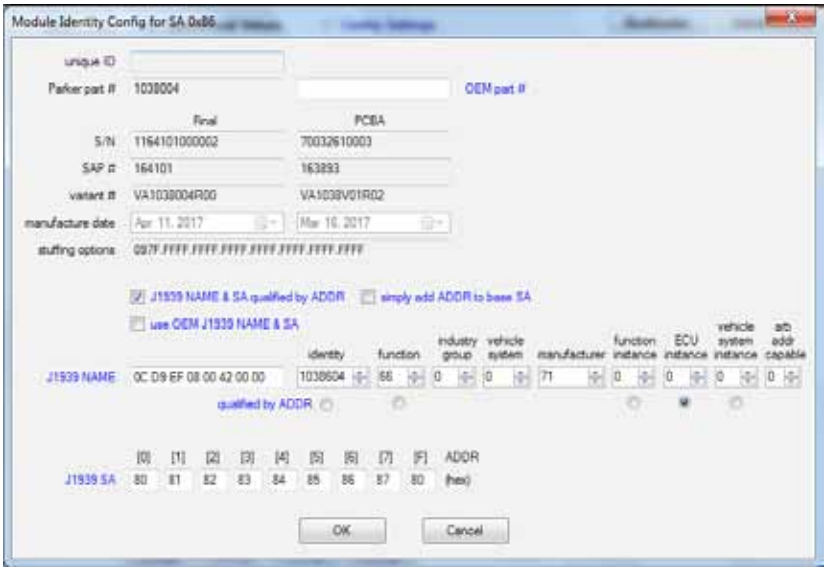


Figure 11.11. Module identity

- *Module settings...* — calls up the Module Settings dialog box (see below) that allows you to view/change kernel properties.

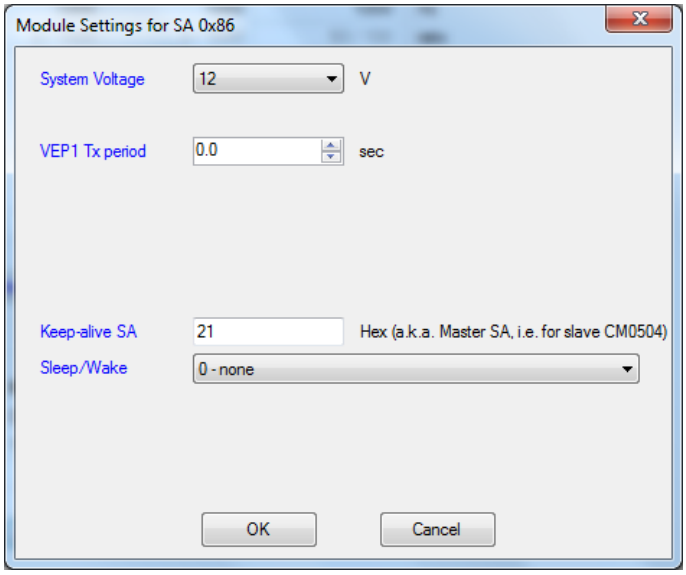


Figure 11.12. Module settings

- *Application settings...* — calls up a dialog box that allows you to view/change user application parameters (or UDP's), if any.

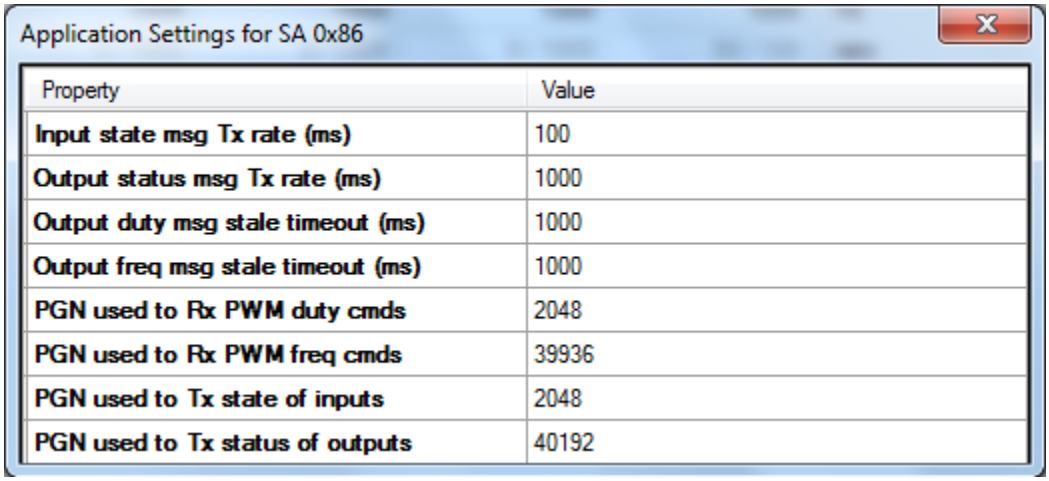


Figure 11.13. Application settings

- *Load settings from pkg...* — normally pkg files contain a component that consists of a table of factory default values for some or all configurable properties, including UDP's. When this menu command is invoked, the PC tool prompts for a pkg file, and applies the settings it finds in this table.
- *Save settings to pkg...* — creates a pkg with a single component that contains a table of setting values for some or all configurable properties, including UDP's. Has options for operational vs config, for omitting properties with undefined values, and for selecting categories of properties to include (i.e. kernel, module, application, input & output).

- LED — has a sub-menu of colors: Off, Blue, Green, Cyan, Red, Magenta, Yellow, and White. When you select one of these, the PC tool sets the LED output property to that value.

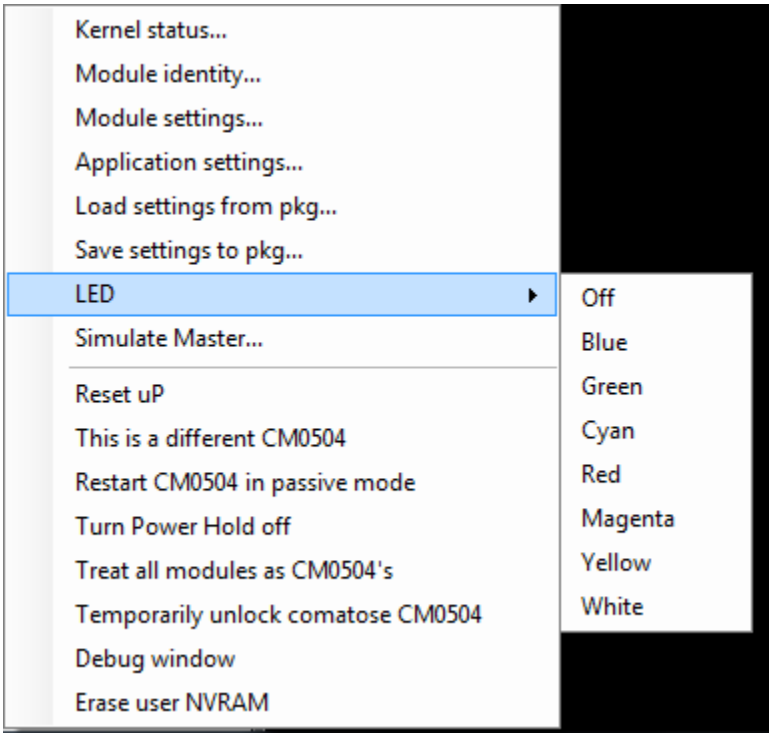


Figure 11.14. LED sub-menu

- *Simulate Master...* — puts the PC tool into a special mode where is plays the role of a very primitive "master" controller to a CM0504 that is running the slave controller application. While in this mode, the PC tool displays a dialog box that shows the PWM frequency and duty cycle the master is requesting for each channel (the user can change these) and the input state and output fault status being reported by the slave. It also shows the CAN messages being sent and received.

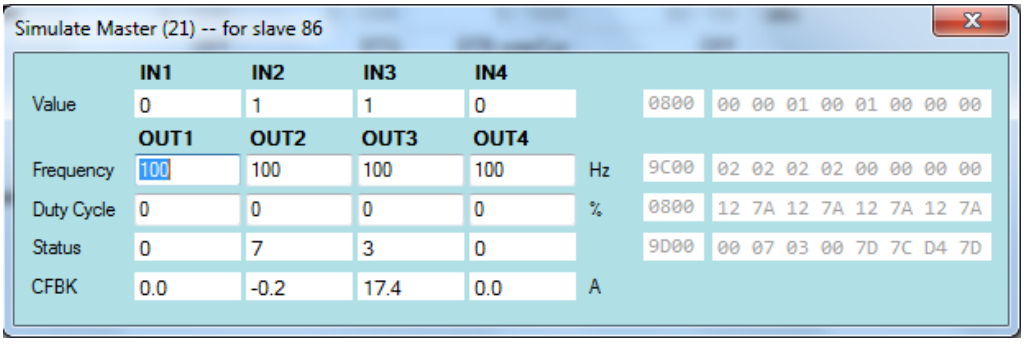


Figure 11.15. Simulate master mode

Reset μP — this causes the PC tool to send a special diagnostic protocol command telling the CM0504 to reset itself.

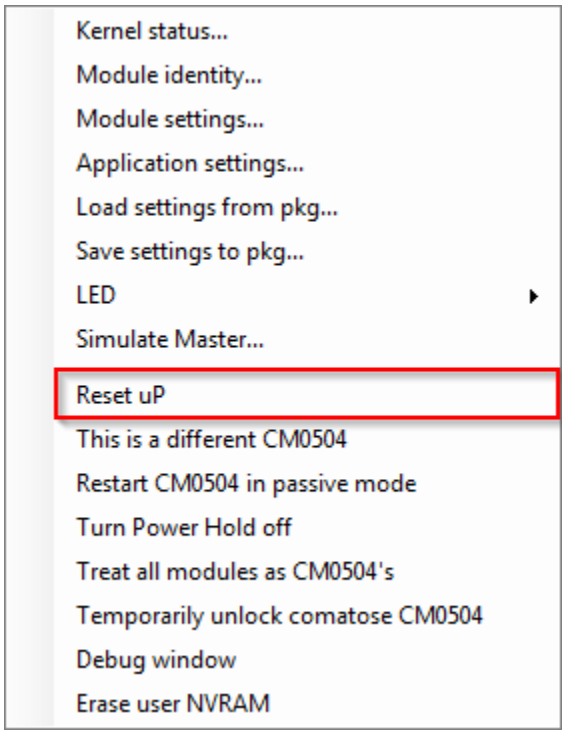


Figure 11.16. Reset uP

- *This is a different CM0504* — sometimes the PC tool gets confused and seems to stop talking to the CM0504, especially after its J1939 SA is changed. This tells the PC tool to start over and try to make "first contact" with a CM0504.

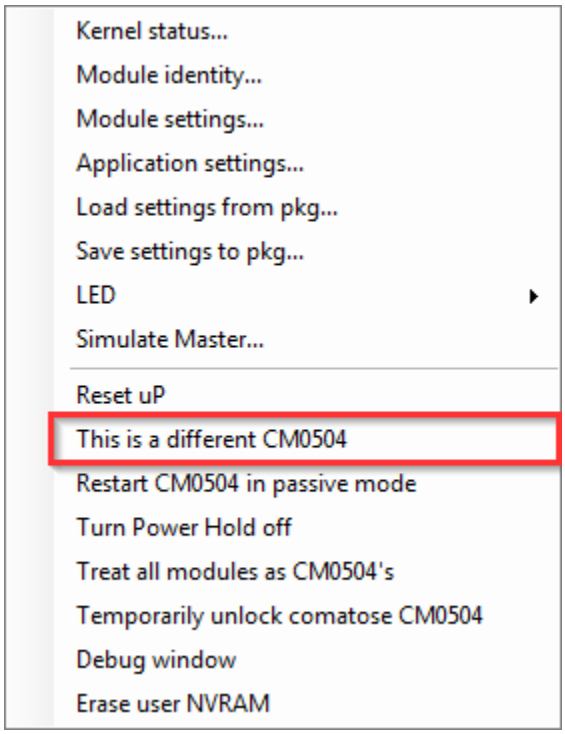


Figure 11.17. Tell PC tool to make first contact with a CM0504

- *Restart CM0504 in passive mode* — this causes the PC tool to send a special diagnostic protocol command telling the CM0504 user application to go into passive mode. In passive mode, the user application essentially stops running, other than allowing you to get/set its UDP's. You might want to do this if you are trying to use the PC tool to manually control I/O's, and the user application is fighting you, or if the user application is hammering the bus with a high CAN message rate (i.e. due to an incorrect configuration), and you are having trouble trying to reconfigure it.

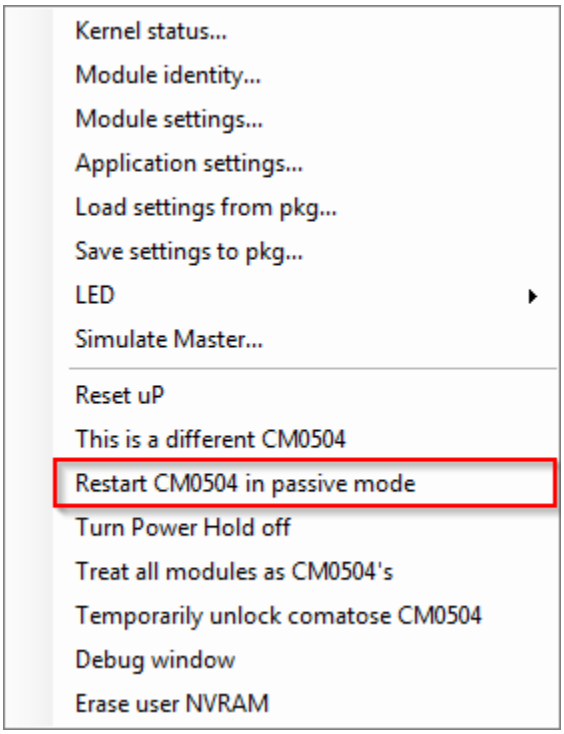


Figure 11.18. Put CM0504 in passive mode

- *Temporarily unlock comatose CM0504* — there are various situations where the CM0504 deliberately holds itself off the CAN bus. One of the ways this can occur is if the CM0504 is a "asleep" waiting to Rx a certain PGN to "wake up", and you don't know what the value of its keepAlivePGN property is. This menu item causes the PC tool to send a special CAN message that tells the CM0504 to stop holding off and announce itself.

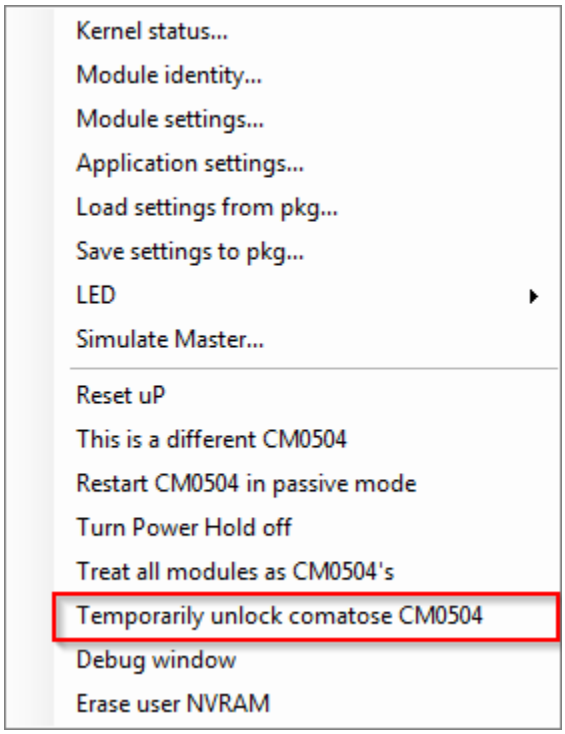


Figure 11.19. Unlock CM0504 that is not communicating

The following tables give more details about the Output, Input, and Module dialog boxes referenced above.

The **Config OUT*i*** dialog box contains the following widgets associated with underlying output properties:

Widget	Property	Notes
Output Type	***driveConfiguration***	options permitted are channel-specific & and may depend on how other channels are configured (i.e. as H-bridge) or ganged via **syncOption**
Frequency	***PWMfreq***	subject to **freqLimitHS/LS**
Duty Cycle	***PWMduty***	this is NOT expressed as a percent, rather it is 0 to PWMrange for H-bridge, a separate unlabeled widget is shown, which allows you to enter a signed duty –PWMrange to PWMrange
PWM Range	***PWMrange***	limit 1000
Freq Limit **HS** **LS**	 ***freqLimitHS*** ***freqLimitLS***	disabled
Output Filter	***outputFilter***	3 widgets correspond to this property's 3 subfields: **dt, Nr & Nf**
Flyback Option	***flybackOption*** ***flybackExt***	this is a list box, with 2 additional widgets, min & max, shown when option "flyback off after delay" is selected, plus widgets: **off level(s) & complementary FET used during PWM**
Deadtime	***deadTime***	2 widgets correspond to this property's 2 subfields: **RE & FE**
CFBK Offset	***CFBKoption***	there are 2 widgets for this item. The list box allows you to choose whether CFBK calibration is automatic or manual. When manual is selected, the number box is enabled allowing you to enter an offset value in mA.
H-bridge change dir options	***HbridgeChangeDir***	this is shown only if the channel is configured as an H-bridge and it is the master leg for the H-bridge. There are 3 widgets corresponding to this property's 3 subfields: ms delay, skip delay if already stopped, and levels during delay
Current Limit	***currentLimit***	this property pertains to all output channels, but it can only be changed via OUT1
Shutdown after . . . consecutive trips	***ocFilterLimit***	

The **Config IN*i*** dialog box contains the following widgets associated with underlying output properties:

Widget	Property	Notes
Input Type	***inputType***	options permitted are channel-specific
Pullup	***pullup***	

The **Module Identity** dialog box contains the following widgets associated with underlying output properties:

Widget	Property	Notes
Unique ID	***uniqueID***	
Parker part #	***ParkerPartNo***	
OEM part #	***OEMpartNo***	
S/N - Final **S/N - PCBA**	***serialNo*** ***PCBserialNo***	
SAP # - Final **SAP # - PCBA**	***SAP_No*** ***PCB_SAP_No***	
variant # - Final **variant # - PCBA**	***variantNo*** ***PCBvariantNo***	
manufacture date - Final **manufacture date - PCBA**	***mfgDate*** ***PCBmfgDate***	
stuffing options	***boardOptions***	shown in hex. Currently not used.
(see notes for this row)	***J1939option***	there are 4 widgets for this item: **J1939 NAME & SA qualified by ADDR** **simply add ADDR to base SA** **use OEM J1939 NAME & SA qualified by ADDR** allowing you to select whether or not NAME & SA are qualified by ***ADDR*** (and if so, which field of NAME that ***ADDR*** is added to), to select whether to use OEM NAME & SA instead, and whether you wish to enter specific SA's for each possible ***ADDR*** value, or to simply add ***ADDR*** to the base SA
J1939 NAME	***baseNAME***	additional widgets show the J1939 NAME broken out into individual fields — you can only set the NAME through these widgets, but the final NAME is also shown as 8 hex bytes
OEM NAME	***OEM_NAME***	similar to above
J1939 SA	***baseSA*** ***baseSA1_8***	used when not qualified by **ADDR**, or when **ADDR** = 0 corresponding to **ADDR 1..7** and F
OEM SA	***OEM_SA***	when **OEM J1939 NAME & SA** is selected, use this instead of ***baseSA***, but continue to use ***baseSA1_8*** when qualified by ***ADDR***

The Module Settings dialog box contains the following elements:

Widget	Property	Notes
System Voltage	nominalVss	
CAN speed	CANspeed	currently PC tool only supports 250K bps
Report faults by DM1	txDM1option	sub-items shown only when DM1 reporting is enabled
Vbat fault ranges	VsysBounds	ranges specified relative to nominalVsys by nibbles of a hex value
User Panic SPN	userPanicSPNoffset	numeric value is added to 0x7E000 to produce proprietary SPN #
Kernel Panic SPN	kernelPanicSPNoffset	
VEP1 Tx period	VEP1txPeriod	
Keep-alive SA	keepAliveSA	shown in hex. Currently not used.
the following appear only if CM0504 H/W supports sleep mode		
Sleep/Wake	***sleepOption***	sub-items shown depend on option selected
Bus idle timeout	***busIdleTimeout***	similar to above
Keep-alive PGN	***keepAlivePGN***	
Keep-alive timeout	***keepAliveTimeout***	

11.2. Default J1939 messages

Once configured, the CM0504 behaves as a slave I/O device that simply turns on/off outputs and reports input and output status via J1939 messages. The following sections describe the messages used by the default CM0504 configuration.

11.2.1. Configuration summary

The default configuration of the CM0504 has all inputs configured as analog inputs and all outputs configured as independent high side outputs.

11.2.2. J1939 address and identity

The J1939 address and part of the J1939 NAME that the CM0504 uses varies depending on the module address (determined by the IdTag connected between `ADDR_H` and `ADDR_L`).

IDtag		J1939	
Resistance	**Part number**	**Address**	**NAME field ECU instance**
294 or no IDtag	5030160 or none	0x080	0
590	5030161	0x081	1
976	5030162	0x082	2
1500	5030163	0x083	3
2230	5030164	0x084	4
3360	5030165	0x085	5
5300	5030166	0x086	6
9530	5030167	0x087	7

The fixed parts of the J1939 NAME are as follows:

J1939 NAME field	Value
Identity	1038604
Manufacturer Code	71
Function Instance	0
Function	66
Vehicle System	0
Vehicle System Instance	0
Industry Group	0
Arbitrary Address Capable	0

11.2.3. Master module J1939 address

The CM0504 uses destination specific (PDU1 format) J1939 messages. This means that for messages received by the CM0504 both the destination address must match it's own address and the source address must be the master module's address. Also, messages that are transmitted by the CM0504 are sent to the master module's address. This master module address is 33 (0x21).

11.2.4. Input status message

Direction:	Transmitted by the CM0504
Transmission repetition rate:	100 ms
Data length:	8 bytes
Data page:	0
Priority:	6
Parameter Group Number (PGN)	2048 (0x800)
Bytes 1 to 2:	Input 1 analog value [LSB first, 1 mV/bit, offset = 0]
Bytes 3 to 4:	Input 2 analog value [LSB first, 1 mV/bit, offset = 0]
Bytes 5 to 6:	Input 3 analog value [LSB first, 1 mV/bit, offset = 0]
Bytes 7 to 8:	Input 4 analog value [LSB first, 1 mV/bit, offset = 0]

11.2.5. Output duty cycle control message

Direction:	Received by the CM0504
Transmission repetition rate:	1000 ms
Data length:	8 bytes
Data page:	0
Priority:	6
Parameter Group Number (PGN)	2048 (0x800)
Bytes 1 to 2:	Output 1 duty cycle command [LSB first, 0.004%/bit, offset = -125%]
Bytes 3 to 4:	Output 2 duty cycle command [LSB first, 0.004%/bit, offset = -125%]
Bytes 5 to 6:	Output 3 duty cycle command [LSB first, 0.004%/bit, offset = -125%]
Bytes 7 to 8:	Output 4 duty cycle command [LSB first, 0.004%/bit, offset = -125%]

11.2.6. Output frequency control message

Direction:	Received by the CM0504
Transmission repetition rate:	1000 ms
Data length:	8 bytes
Data page:	0
Priority:	6
Parameter Group Number (PGN)	39936 (0x9C00)
Byte 1:	Output 1 frequency command [50 Hz/bit, offset =0]
Byte 2:	Output 2 frequency command [50 Hz/bit, offset =0]
Byte 3:	Output 3 frequency command [50 Hz/bit, offset =0]
Byte 4:	Output 4 frequency command [50 Hz/bit, offset =0]
Bytes 5 to 8:	not used

11.2.7. Output status message

Direction:	Transmitted by the CM0504
Transmission repetition rate:	1000 ms
Data length:	8 bytes
Data page:	0
Priority:	6
Parameter Group Number (PGN)	40192 (0x9D00)
Byte 1:	Output 1 state (see table)
Byte 2:	Output 2 state (see table)
Byte 3:	Output 3 state (see table)
Byte 4:	Output 4 state (see table)
Byte 5:	Output 1 current [0.2 A/bit, offset = -25 A]
Byte 6:	Output 2 current [0.2 A/bit, offset = -25 A]
Byte 7:	Output 3 current [0.2 A/bit, offset = -25 A]
Byte 8:	Output 4 current [0.2 A/bit, offset = -25 A]

Output state encoding table:

Value	Meaning
0	OFF (no faults detected)
1	ON (no faults detected)
2	shorted to opposite polarity (e.g. high side output shorted to ground)
3	Current is greater than configured limit (27.5 A)
4	Open load detected
5	Shorted to driven polarity (e.g. high side output shorted to battery)
6	No output supply voltage
7	Maybe short (short circuit condition has been detected but the output on time is too short to tell for sure)
8	Output supply voltage is higher than configured limit
9	Output supply voltage is lower than configured limit

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