Controller Module

CM0410

User Guide

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Contents

Publication History

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

Release Date	Description of Change
Rev. 002	Minor edits based on AE feedback 10/22/2014
Rev. 001	First release of this document

Safety

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

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

The term "manufacturer" refers to Parker Hannifin Corporation.

Safety symbols

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

Danger! Risk of death or injury.

Warning! Risk of damage to equipment or degradation of signal

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

General safety regulations

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

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

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

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

Welding after installation

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

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

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

Construction regulations

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

Safety during installation

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

Safety during start-up

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

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

Safety during maintenance and fault diagnosis

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

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

1. About the CM0410

The Controller Module (CM) 0410 is a general purpose input / output controller that includes a single CAN interface, 4 inputs, 1 high side current measurement pass-through, and 10 high side outputs with error checking. The main function of the module is to provide a means of controlling mechanical relays or low current loads via messages on the CAN bus. Enhancements have been included to support things like open bulb detection and some limited solenoid PWM control.

The CM0410 is a CAN slave module only and does not supports 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 CM0410 is designed to communicate through a J1939-based Controller Area Network (CAN) and can be used in any CAN 2.0B application.

The CM0410 has many features, as follows:

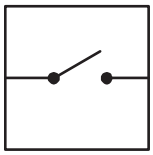
- The CM0410 can monitor up to 4 inputs:
  - 1 general purpose type 1 inputs (can be used as power control, digital, full VBATT range analog, or frequency).
  - 3 general purpose type 2 inputs (can be used as power control, digital, 5V range analog, or frequency).
- The CM0410 can monitor one current input:
  - 1 current measure pass-through (can be used to detect burnt out bulbs).

- The CM0410 has 10 outputs:
  - up to 2 configured as high-drive outputs.
  - the balance are configured as low-drive outputs.
- The CM0410 has one 20-pin Molex MX150 connector that is used to interface with the inputs, outputs, and CAN.

This manual describes the hardware components of the CM0410, 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. General Purpose Inputs

The CM0410 has 4 general purpose inputs.

General purpose inputs can be programmed to be analog, digital, or frequency.

- Analog inputs are typically used for variable voltages.
- Digital inputs are typically used for electrical signals that are either on or off.
- Frequency inputs are typically used for reading pulse signals.

There are 2 types of general purpose inputs, Type 1 and Type 2.

2.1. Type 1 Input Capabilities

There is a single Type 1 input (`INPUT1`). This input provides a fixed attenuation with a software selectable wetting current option.

The primary function of the Type 1 input is to provide a wake on ignition feature as a digital input. A secondary function is to interface with active voltage analog and frequency sensors in an application.

The following table provides specifications for the general purpose input Type 1:

Type 1 Input Specifications - programmable as digital, analog or frequency				
Item	**Min**	**Nom**	**Max**	**Unit**
Input voltage range	0		32	V
Over-voltage			36	V
Input resistance		80		kΩ
Pull-up resistance		open		kΩ
Wetting current (@ 9V)		7		mA
Analog configuration				
Input signal range	0		40	V
Resolution		52		mV/bit
Filtering (hardware) - cutoff frequency		1.7		kHz
Accuracy (analog) - offset error			52	mV
Accuracy (drift)			6	%
Frequency configuration				
Input range	0		10,000	Hz
High threshold		4		V
Low threshold		3.6		V
Filtering (hardware) - cutoff frequency		1.7		kHz

2.2. Type 2 Input Capabilities

There are three Type 2 inputs (`INPUT2-INPUT4`). This input type provides a fixed attenuation with a software selectable pull-up current option.

The function of this type of input is to interface with active voltage analog sensors, resistive sensors, or measure frequency in an application.

The following table provides specifications for the general purpose inputs Type 2:

Type 2 Input Specifications - programmable as digital, analog or frequency				
Item	**Min**	**Nom**	**Max**	**Unit**
Input voltage range	0		32	V
Over-voltage			36	V
Input resistance		72		kΩ
Pull-up voltage		12/24		V
Pull-up current (INPUT3)		0.4		mA
Pull-up current (INPUT2, INPUT4)		2.4		mA
Wetting current (@ 9V)		N/A		mA
Analog configuration				
Input signal range	0		5	V
Resolution		6.5		mV/bit
Filtering (hardware) - cutoff frequency		200		Hz
Accuracy (analog) - offset error			15	mV
Accuracy (drift)			6	%
Frequency configuration				
High threshold		2.7		V
Low threshold		2.4		V
Filtering (hardware) - cutoff frequency		200		kHz

3. Current Sense Pass Thru

The CM0410 provides a current sense resistor and the circuitry to measure the high side current passing through on pin 9 (`CS1_IN`) and pin 10 (`CS1_OUT`). As the CM0410 has no driver on these pins, the protection to limit current surges on the sense resistor must be provided externally. The primary function of this circuit is to discriminate the change in current when a bulb is not functional.

3.1. Current Sense Pass Thru Capabilities

The following table provides the specifications of the current sense pass thru input.

Current Sense Pass Thru Specifications				
Item	**Min**	**Nom**	**Max**	**Unit**
Input resistance		0.01		Ω
Input current range	0.2		11	A
Resolution		14.6		mA/bit
Offset error (-40 to +85 °C)	10	40	150	mA
Accuracy	-10		8	%
Accuracy (-40 to +85 °C)	-20		10	%
Accuracy (-40 to +85 °C @ 80 V/m)	-50		30	%

Unless otherwise stated, all specifications are based on an ambient temperature of 25 °C

> ***Damage to equipment!*** The current sense resistor MUST be externally protected to limit the current in the event of a single failure to a maximum of 32A for a maximum of 5 seconds.

More resolution of open bulb detection may be possible by calibrating the unit with the expected system load.

4. Outputs

There are 2 types of outputs on the CM0410. There are ten high-side outputs total.

- 5 high-side outputs capable of PWM, `OUTPUT1`, `OUTPUT3`, `OUTPUT5`, `OUTPUT7`, `OUTPUT9`.
- 5 high-side on-off digital outputs, `OUTPUT2`, `OUTPUT4`, `OUTPUT6`, `OUTPUT8`, `OUTPUT10`.

4.1. Output Capabilities

The nominal system voltage should be either 12V or 24V. Based on the operating voltage, use the table below to determine current limits.

Up to 2 of the outputs may be used in High Drive Mode. The 2 outputs that are chosen for High Drive Mode may *not* be on channels with adjacent numbers. The balance of the channels are restricted to Standard Drive Mode limits.

The maximum current rating with all outputs on must not be exceeded at any time.

The following table provides specifications for the CM0410's output connections.

Output Capabilities				
Item	**Min**	**Nom**	**Max**	**Unit**
Operational voltage range	9		32	V
Output resistance/GND (output off)		73.3		kΩ
Output resistance/VBATT (output on)		140	230	mΩ
Output resistance/VBATT (strobe on)		10		kΩ
Leakage current (output off - strobe off)			5	µA
Turn on delay (off to on)		100	250	µs
Turn off delay (on to off)		100	270	µs
Turn on/off slew rate	0.2			V/µs
PWM frequency			250	Hz
PWM resolution		0.1		%
Output pin capacitance		5		nF
High drive 12V characteristics				
Voltage range	0	12	18	V
Load current range			2	A
Standard drive 12V characteristics				
Voltage range	0	12	18	V
Load current range			0.250	A
High drive 24V characteristics				
Voltage range	0	24	36	V
Load current range			1	A
Standard drive 24V characteristics				
Voltage range	0	24	36	V
Load current range			0.125	A

Unless otherwise stated, all characteristics are based on an ambient temperature of 25°C.

5. Power

The CM0410 operates in a 12 V or 24 V system and is powered by a direct battery (VBATT) connection. The controller is turned on by applying power to the wake-up input or a CAN message. The direct battery input is protected against vehicle transients such as load dump and inductive load switching, etc. It is also protected against reverse battery voltage of -42 V through the use of a high-current path that will cause an external fuse to blow.

The following table provides specifications for the CM0410's power connections.

Power (VBATT) Specifications				
Item	**Min**	**Nom**	**Max**	**Units**
Input voltage for normal operation	9	-	32	V
Minimum cranking voltage	6	-	-	V
Over voltage protection (DC)	-	-	42	V
Reverse battery protection (note 1)	-	-	-42	V
Maximum current - 24V (all outputs on)	-	-	3	A
Maximum current - 12V (all outputs on)	-	-	6	A
Off state current	-	-	5	mA
Recommended fast acting external fuse	-	-	15	A

Note 1: The unit is protected against a reverse battery condition by causing an external fuse to blow.

6. Communication

The only type of communication available to the CM0410 is Controller Area Network (CAN) communication.

6.1. J1939 CAN Capabilities

The CAN communicates information at a rate of 250 kbps. CM0410 input and output information is transmitted through the CAN at a broadcast rate of 40 Hz. Lack of regular CAN communication is an indication that there is either a problem with a module in the network, or a problem with the CAN bus.

The following table provides specifications for the CAN:

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

6.2. J1939 CAN Installation Connections

The CAN connection for the CM0410 should conform to the J1939 standard.

For a list of J1939 connection considerations, refer to the SAE J1939 specifications available through the Society for Automotive Engineers. SAE J1939-11 covers the physical aspects of the CAN bus including cable type, connector type, and cable lengths.

Note: The CM0410 does not have a CAN termination resistor, which is based on the assumption that the CAN bus is terminated in the harness.

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

- CAN Cable: A shielded twisted-pair cable should be used when connecting multiple modules to the CAN bus. The cable for the J1939 CAN bus has three wires: CAN High, CAN Low, and CAN Shield (which connect to the

corresponding CAN_HIGH, CAN_LOW, and CAN_SHIELD pins on the connector). The CAN cable must have an impedance of 120 Ω.

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

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

- CAN Connectors: Industry-approved CAN connectors are manufactured by ITT Canon and Deutsch, and come in either T or Y configurations.
- CAN Harness: The CAN harness is the main backbone cable that is used to connect the CAN network. This cable cannot be longer than 40 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:

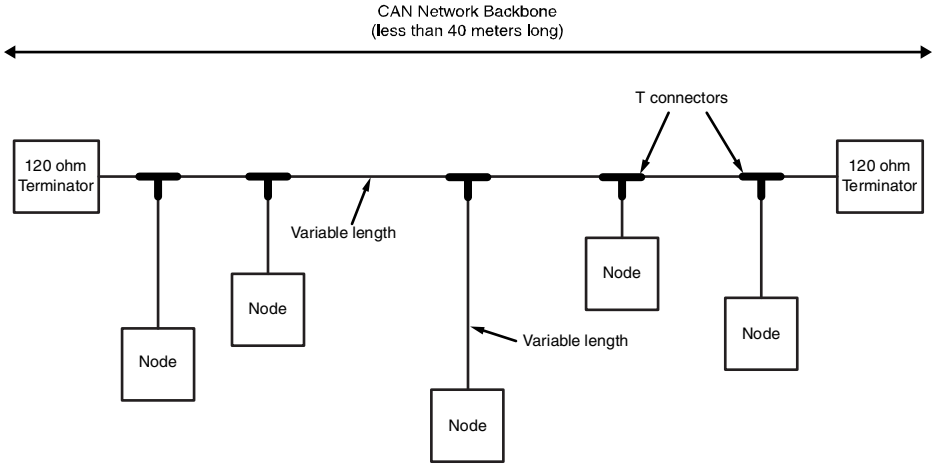


Figure 1: J1939 CAN connection

7. Connector

The connector on the top of the CM0410 is;

- MX150 – Vehicle Harness Connectors

The Molex MX150 connector is used to interface the CM0410 to the vehicle.

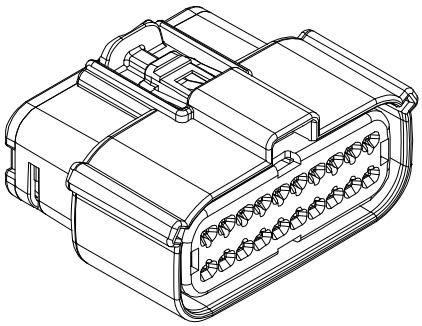


Figure 2: MX150 20-pin connector

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

7.1. Pinout

The pins in connector position J1 connects to inputs, outputs, power and CAN communication channels.

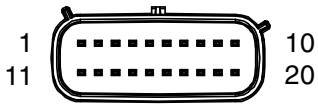


Figure 3: MX150 Key B 20 position connector

The following table shows the pin-out for the connector:

J1 Connector Pin-out		
Pin	**Name**	**Function**
1	VBATT	Positive battery
2	GND_POWER	Negative battery
3	CAN1_LO	CAN 1 low
4	CAN1_HI	CAN 1 high
5	INPUT4	Input 4 (type 2)
6	INPUT3	Input 3 (type 2)
7	INPUT2	Input 2 (type 2)
8	INPUT1	Input 1 (type 1)
9	CS1_IN	Current sense input
10	CS1_OUT	Current sense output
11	OUTPUT9	High-side output 9
12	OUTPUT10	High-side output 10
13	OUTPUT7	High-side output 7
14	OUTPUT8	High-side output 8
15	OUTPUT5	High-side output 5
16	OUTPUT6	High-side output 6
17	OUTPUT3	High-side output 3
18	OUTPUT4	High-side output 4
19	OUTPUT1	High-side output 1
20	OUTPUT2	High-side output 2

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 CM0410.

The vehicle manufacturer is responsible for creating procedures for mounting the CM0410 in a vehicle during production assembly.

8.1. Mounting the CM0410 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 CM0410 to a vehicle:

- Secure the CM0410 with bolts in all bolt holes using Hex Head or equivalent metric size (M6) bolts.
- The bolts should be tightened according to the fastener manufacturer's tightening torque specifications.

8.2. Mechanical Requirements

Review the following mechanical requirements before selecting a mounting location for the CM0410:

- The CM0410 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 CM0410.
- The harness should be shielded from harsh impact.
- The harness should connect easily to the connector and have adequate bend radius.
- The product label should be easy to read.
- The CM0410 should be in a location that is easily accessible for service.

8.3. Dimensions

The following shows the dimensions of the CM0410 in millimeters:

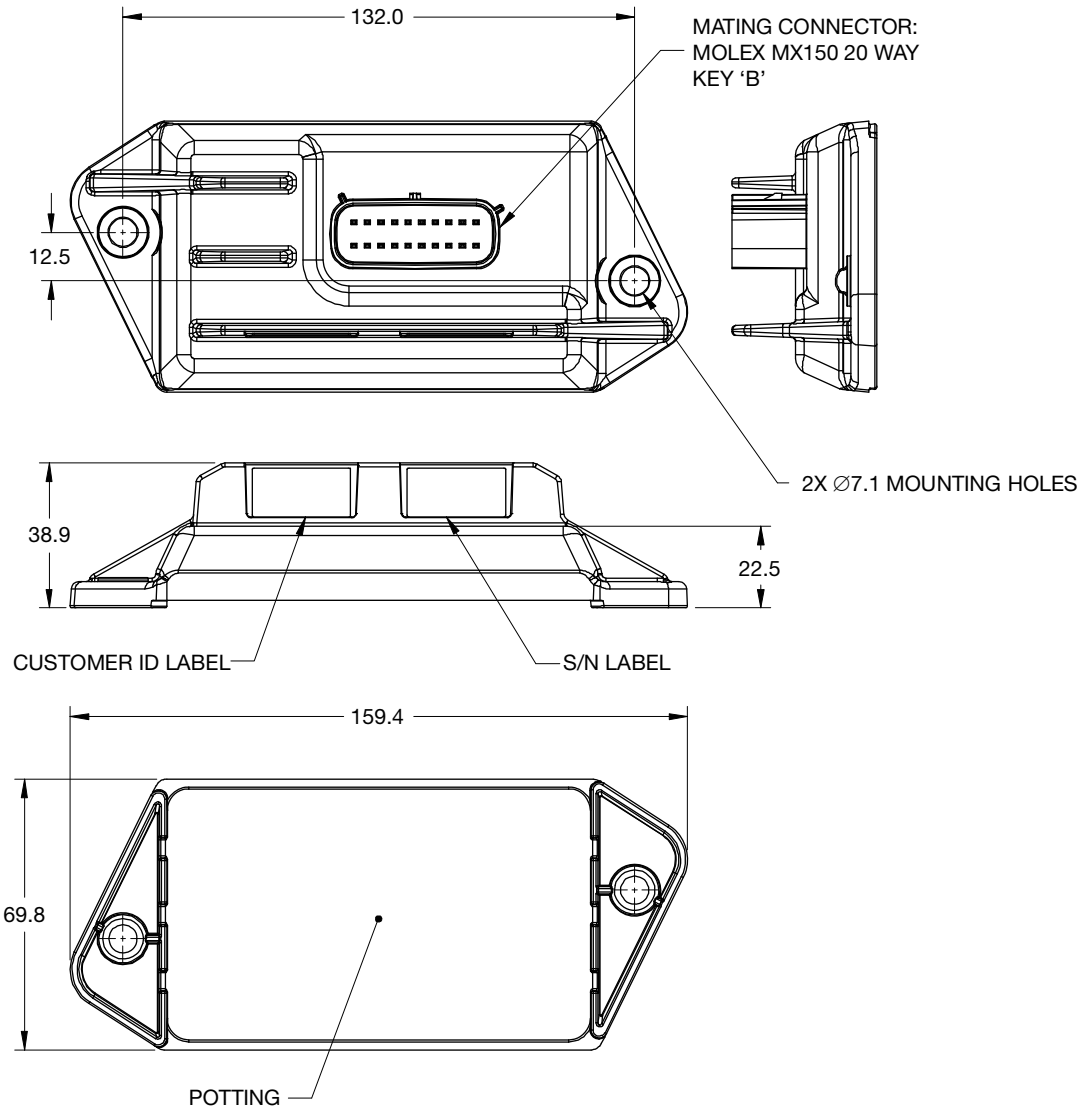


Figure 4: CM0410 dimensions

9. Glossary

AC-coupled

A circuit that eliminates the DC offset voltage of the signal. This circuit is typically used with frequency inputs that have a DC offset. Note that the DC offset value varies by product.

active high

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

active low

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

ADC

Analog to digital conversion.

aliasing

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

amplified

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

analog input

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

anti-alias filtering

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

attenuation

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

bi-directional pin

A pin that can be used as either an input or output.

black box

A custom-compiled algorithm written in C programming language that allows a system designer to implement algorithms that are not possible in ladder logic.

bus

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

bus bar

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

CAN bus

See *controller area network (CAN) bus*.

CAN high

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

CAN low

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

CAN shield

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

clamped

Voltage that is prevented from going above a specific value.

CMOS

See *Complementary Metal-Oxide Semi-Conductor*.

complementary metal-oxide semi-conductor

A technology for constructing integrated circuits that yield high speed combined with low power consumption. CMOS technology is used in computer chips.

controller area network (CAN) bus

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

controller I/O board

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

controller module

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

current feedback

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

current feedback control

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

current sensor

A device that detects electrical current in a wire and generates a signal proportional to it.

data link adaptor (DLA)

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

DC-coupled

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

dead-fronted

A situation in which the telltales are inactive and the display appears black.

de-rating

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

digital input

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

dimension

To select values so that they generate optimal results.

driver (hardware)

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

driver (software)

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

duty cycle

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

electromagnetic compatibility (EMC)

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

electromagnetic susceptibility

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

EMC

See *electromagnetic compatibility*.

FET

See *field effect transistor*.

field-effect transistor (FET)

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

floating input

An input, isolated from a ground connection, that does not resist being pulled high or low when inactive.

flyback

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

frequency input

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

gain

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

general purpose input

An input that can be used as an analog, digital, or frequency input.

ground level shift

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

half-bridge

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

harness address pins

The pins a product uses to identify itself within a system.

H-bridge

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

high-side output

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

hysteresis

The tendency, either by nature or design, for a device or system to remain temporarily (lag) in one state before switching to another. Hysteresis might be intentionally added to electronic circuits prevent unwanted rapid switching. A furnace, for example, is designed to remain on or off for some time after the room temperature reaches the thermostat's set point.

inductive load

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

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

inrush current

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

keyed

Notches, slots, or other mechanical devices added to connectors so that they are connected to their mates with the proper orientation.

leakage current

Current that flows when the ideal current is zero.

load

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

load dump

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

logic ground

Ground pins for the microprocessor and logic peripherals.

logic power

Power pins for the microprocessor and logic peripherals.

low-side output

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

module address

The binary address of the CM0410, as determined by the harnessing.

network fault flag

A special flag available in ladder logic that indicates a network problem exists (when master power is inactive and ladder logic references VMM(s) that are not available, or VMM(s) do not contain the same version of ladder logic).

Nyquist criterion

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

open load

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

overcurrent

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

overvoltage

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

panel-mounted

A device mounted into a flat panel that has a cutout in the shape of the device.

PID controller

See *proportional-integral-differential (PID) controller*.

power control input

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

procurement drawing

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

proportional-integral-differential (PID) controller

A system or device controller that, through constant feedback about differences between the desired state and the current state, adjusts inputs accordingly. An example of such a controller is one that prevents a vehicle from traveling faster than a specified speed, regardless of the amount of pressure on the gas pedal.

pull-down resistor

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

pull-up resistor

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

pulse counter

A device that detects and counts pulses occurring on a frequency input for a given period of time.

pulse-width modulation (PWM)

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

PWM

See *pulse-width modulation*.

quadrature

A shaft rotation monitoring technique that provides the speed, position, and direction of the shaft.

RMS

Root Mean Square. This is a statistical measure of the magnitude of a varying quantity.

sample rate

The rate at which the microprocessor reads analog voltage levels.

sensor power

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

shielded twisted-pair cable

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

short-to-battery

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

short-to-ground

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

sleep mode

A low-power mode that is assumed by the CM0410 when the voltage on the power control inputs drop below a certain value.

slew rate

1. The maximum rate at which an output voltage can swing across its full dynamic range.
2. The maximum rate at which a control system can react to an adjustment or change.

steady state

In a circuit or network, a state of equilibrium undisturbed by transients. Compare *transient*.

switch outputs

An output that is digital in nature. It switches to battery and/or ground levels.

switching threshold current

The minimum amount of current required in an input before its associated telltale illuminates.

system noise

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

temperature sensor

The temperature sensor is specified to be accurate to ±4 °C over the whole -40 °C to 125 °C temperature range.

terminating resistor

A resistor placed at the end of a wire to absorb signals and prevent them from reflecting back into the line and causing interference.

transient

A short-lived burst of energy caused by a sudden change of state. Compare *steady state*.

transient voltage suppressor

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

transorb

See transient voltage suppressor.

trip time

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

wake on CAN

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

wetting current

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

Zener diode

A diode that allows current to flow in the reverse direction when voltage is above a certain value.

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