CASCADIA MOTION
7929 SW Burns Way
Suite F
Wilsonville, OR
Phone: 503 344-5085
sales@cascadiamotion.com

PM/RM/CM200
Hardware User Manual

Revision 3.7

0A-0001-01

Everything you need to know to install, set up, and calibrate the PM, RM, and CM family of AC drives on asynchronous and PM synchronous motors in your Electric or Hybrid vehicle

CASCADIA MOTION
7929 SW Burns Way
Suite F
Wilsonville, OR
Phone: 503 344-5085
sales@cascadiamotion.com

Table of Contents

1. Safety First:

 ATTENTION	When you see this sign, PAY ATTENTION! This indicates that something important is about to be said, that concerns your safety and the proper operation of the equipment.
 DANGER	When you see this sign, you are being alerted to an IMMEDIATE DANGER that could cause severe injury or even death. You MUST review these sections carefully an do everything possible to comply with installation and operation requirements, or you risk injury or death to yourself or anyone else who uses the equipment or the vehicle. Failure to comply with safety requirements will void all warranties and could expose you as the installer to liability in the event of an injury. Use the equipment in the manner in which it was intended.
 CAUTION	When you see this sign, you are being advised that the issue under discussion has a serious safety or equipment reliability implication. Use caution and be conservative. Use equipment in the manner described in this User's Manual.

Safety is entirely the responsibility of the installer of this equipment. Cascadia Motion has done everything it can to ensure that the traction controller itself conforms to international standards for safety. This does NOT mean that your installation will be safe, or that it will not interfere with other systems on board your vehicle. It is your responsibility as the installer to review this entire User's Manual, to understand the implications of each and every section, and to know what might be unique about your system application that presents a unique hazard or potential safety issue – and to solve it.

Cascadia Motion is committed to helping you solve these problems, but cannot take responsibility for the application of this traction controller. We can only promise to meet

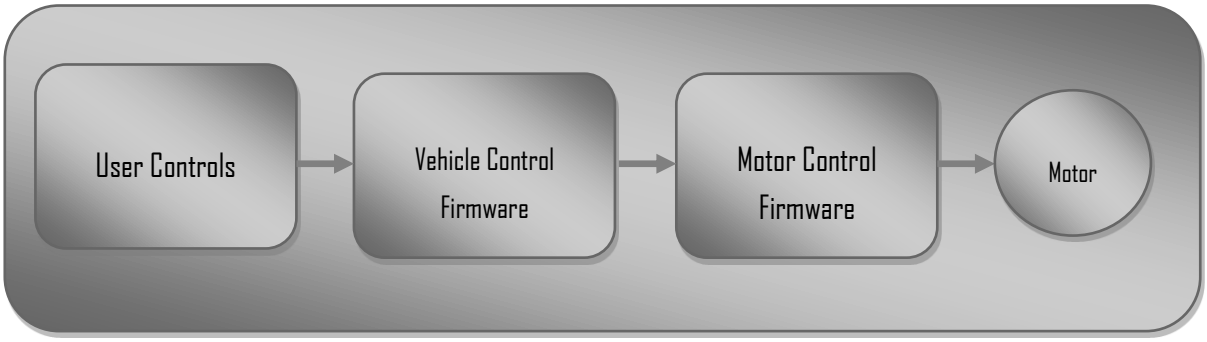
the specifications for this product and that it meets international safety standards when used in accordance with the instructions in this Manual.

2. Functional Overview:

The PM controller family is intended as a traction controller for EV and HEV drive systems, and includes both the motor control function and a rudimentary vehicle controller strategy in the same box. The motor control is a torque commanded, vector control technology has been used on AC Induction and PM Synchronous motors in many applications.

The RM100 controller family is intended for the same type of EV/HEV applications however it has a much more limited set of inputs and outputs. The limited set of I/O prevents it from being properly used in the VSM mode where analog and digital inputs are used to control the operation of the inverter. The RM100 controller is intended for applications where CAN communications is used to control the controller.

The motor control subsystem firmware is mated to a vehicle controller firmware implemented in the DSP controller. This vehicle controller subsystem handles the driver interface (accel and decel / brake pedal inputs, Fwd/Rev controls, etc) and the vehicle interface (power sequencing, built in test, fault handling and safety issues). It is essentially a state machine in front of the motor controller firmware with a defined interface between the two software processes.

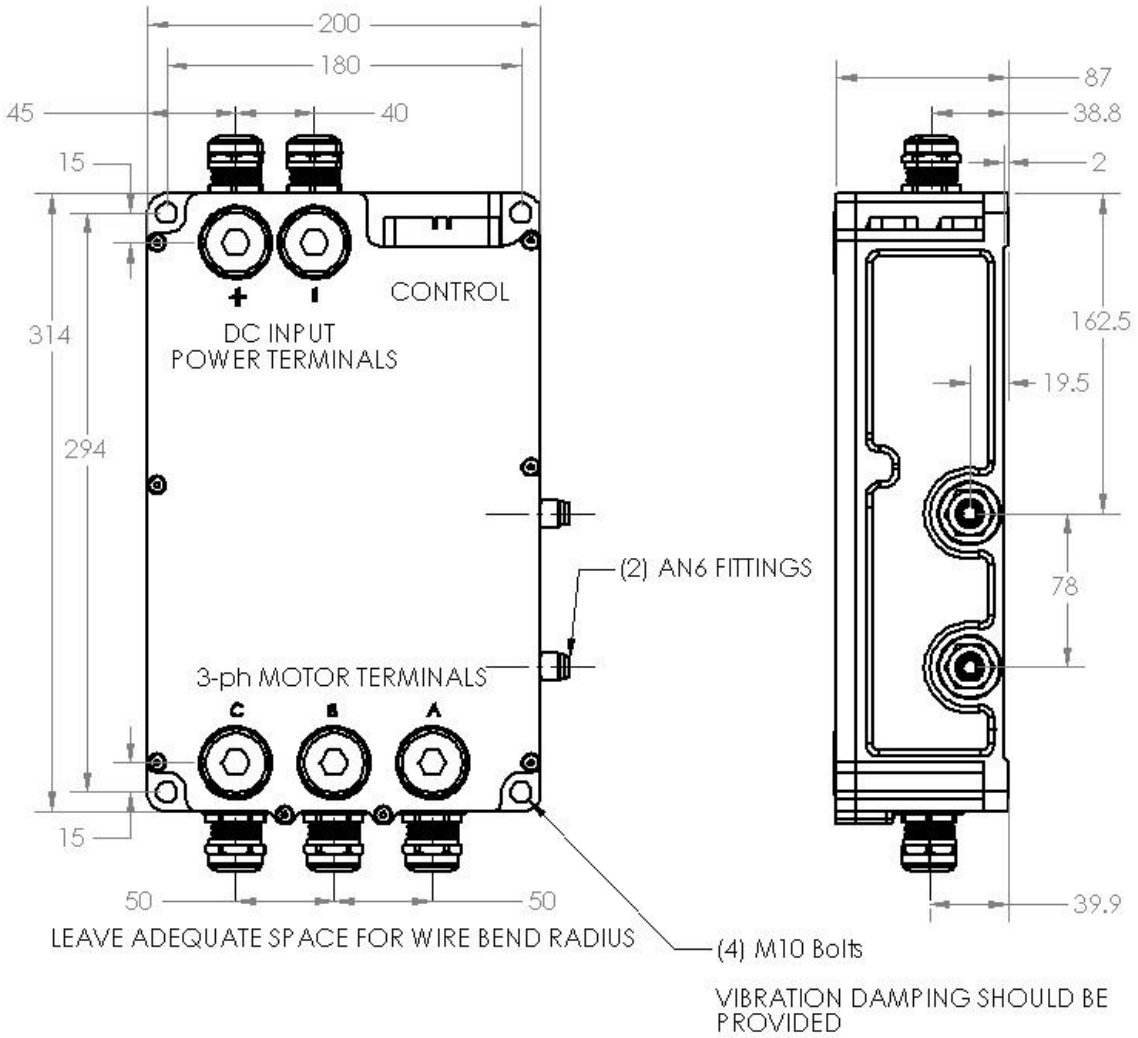


By default, out of the box the parameters are set up in Torque Control Mode, with default motor parameters loaded. The parameters must be changed to match the load motor and operating characteristics before running for the first time. These parameters personalize the drive to the motor and the vehicle.

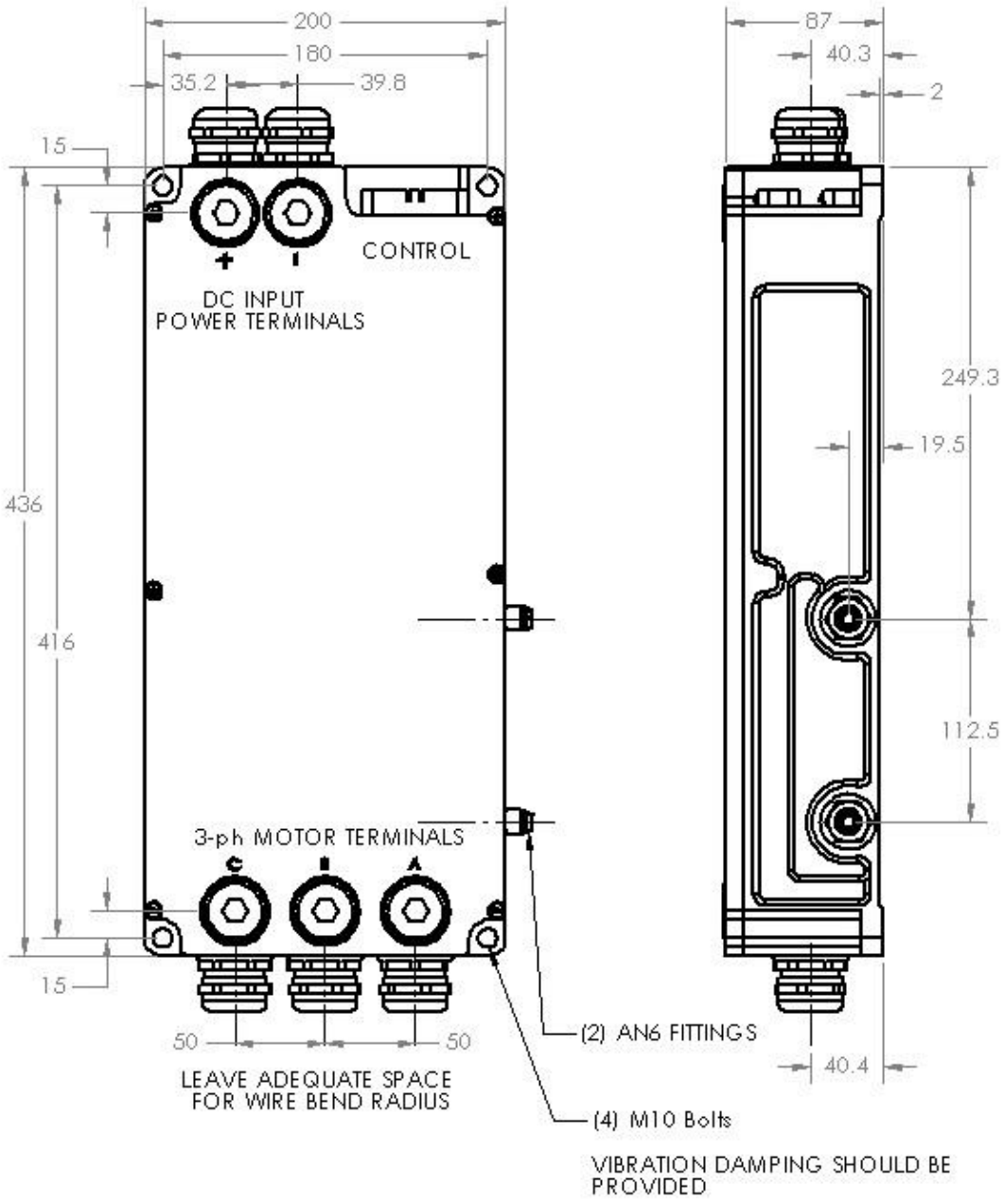
3. Installing the PM Drive:

The PM controller has 4 mounting locations, one at each corner. Mounting orientation is not critical. The controller should be mounted in a location that is not exposed to direct spray from water. Each mounting hole is sized to handle up to a M10 socket head cap screw.

See PM250 Datasheet for more information on mounting the PM250.



PM100 Dimensions – top and side views



PM150 Dimensions – top and side views

3.1 Liquid Cooling Connections:

The controller must be cooled by passing liquid through it. The controller includes two ports to be used for liquid cooling. The PM100 and PM150 have a symmetrical design and is less sensitive to fluid direction. However, it is preferred that the rearmost plenum (the ports furthest from the 3 AC output terminals) be the fluid inlet, as this keeps the coolest fluid near the DC Link capacitor assembly. The PM250, RM100, RM300 have markings on the housing that indicate the required direction of the coolant through the inverter. The RM100 and RM300 also have coolant direction marked in the housing. The coolant direction must be minded. See table below for coolant specifications:

Coolant Type	50/50 mix ethylene glycol (antifreeze) / water or propylene glycol / water; with Aluminum corrosion inhibitor additive
Coolant Temperature	-30°C to +80°C full power, for PM inverters -30°C to +45°C full power, 45°C to +80°C de-rated output on CM inverters Operation -40.. -30; +80.. +100°C with de-rated output on all inverters
Coolant Flow Rate	8 – 12 LPM (2 – 3 GPM), PM100/PM150/RM100
	12 LPM minimum, CM200
	24 LPM minimum, CM350
	20 – 30 LPM (5 – 6 GPM), PM250, RM300
Pressure Drop	PM100, 0.3 bar (4.4 psi) @ 8 LPM @ 25°C
	PM150, 0.4 bar (5.8 psi) @ 8 LPM @ 25°C
	PM250, 0.9 bar (13 psi) @ 20 LPM @ 25°C
	RM100, 0.06 bar (0.8 psi) @ 8 LPM @ 25°C
	CM200, 0.3 bar (4.3 psi) @ 12 LPM @ 25°C
	CM350, 0.3 bar (4.3 psi) @ 24 LPM @ 25°C
	RM300, TBD
Port Size	PM100 and PM150, AN-6
	PM250, SAE ORB -10

	RM100, Custom O-ring port, the following options are provided to be installed in the unit, each kit includes materials for both ports. - ARaymond NT100 / 16mm Straight, CM p/n G1-0023-01 - ARaymond NT100 / 16mm 45deg, CM p/n G1-0024-01 - ARaymond NT100 / 16mm 90deg, CM p/n G1-0025-01 - 16mm / 5/8” Hose Barb, CM p/n G1-0026-01
	RM300, Custom O-ring port. The RM300 comes standard with an adapter that has a 25.4mm / 1 inch hose barb. The cooling port adapters are included in kit p/n G1-0031-01.
	PM500, SAE ORB -12
	CM200, SAE ORB -06, comes with 5/8” hose barb and -8 AN fitting
	CM350, SAE ORB -10, comes with 5/8” hose barb and -10 AN fitting

RM100 Coolant Port Options (Does not apply to PM100/PM150/PM250/RM300/CM200)

ARaymond NT100 / J20 Straight, CM Kit G1-0023-01

ARaymond NT100 / J29 90 degree, CM kit G1-0025-01

ARaymond NT100 / J30 45 degree, CM kit G1-0024-01

For proper operation of the inverter the coolant must flow at a rate equal to or above the minimum specified flow rate at all times that the motor is enabled. The flow rate should not be reduced when the inverter is “not being run hard”. The design of the heat exchanger does not allow for reduced or no coolant flow. It is possible to adjust the fan speed on the coolant radiator as needed depending on the operating conditions of the inverter.

Since the maximum coolant temperature is less than the boiling point of water the cooling system does not need to be operated under pressure. Other devices (e.g. motor, charger, DC/DC converter) that are added in series with the inverter increase the total pressure drop of the system. Even simple fittings and hose length will contribute to the total system pressure drop. The total system pressure may add up to a level that is beyond the capability of the chosen pump. The best practice is to measure the actual coolant flow after the system has been assembled.

Certain pump types are not capable of driving any significant pressure. A pump may have a high flow rate, but it may not be able to drive any substantial pressure. The PM250 unit has an especially high pressure drop. An example pump suitable for the PM250 is the EMP WP 29. Pump suitable for the PM100/PM150/RM100/CM200 is the Bosch PCE-XL (see Cascadia Motion website).

As noted above proper coolant flow is essential to the operation of the inverter. If the flow rate is not sufficient the power module internal to the inverter can be damaged even though the indicated power module temperatures are below an over-temperature threshold. The power module temperature sensors are located in such a way that they are much closer to the temperature of the coolant than they are to the temperature of the transistors and diodes used inside the power module.

Loss of coolant for even a few seconds can result in failure of the power module.

Cascadia Motion recommends that the user install a device to ensure that the coolant pump is operating properly at all times when the inverter is enabled. The inverter should be immediately stopped if the coolant is not flowing.

There are many ways that coolant flow could be measured. A flow sensor could be added to the cooling loop. Often these types of sensors produce a pulse output. To read the pulse output would require the use of a device to interpret this signal (Cascadia Motion does not supply this).

Another option is to monitor the pressure in the cooling system. Typically the inverter would be placed near the end of the cooling loop, just before the radiator. So a typical cooling loop might look like pump outlet, inverter, radiator/reservoir, pump inlet. Typically the reservoir is at ambient error pressure. So the inverter should be at a pressure that is higher than ambient. If a pressure switch is placed at the input coolant port of the inverter it should be able to detect that coolant is flowing.

Various types of coolant pressure switches exist. If a type is used that closes the switch when the pressure is above a certain level is used then this could be inserted in series with the ground connection of the forward/reverse switches (for VSM mode applications) or just connected directly to one of the inputs for monitoring via CAN.

A pressure switch that closes when the pressure is above about 6 psi (~0.4 bar) should be suitable for the PM100 and PM150. For the PM250 the required pressure is higher and should be about 10 psi (~ 0.7 bar).

3.2 PM100/PM150 External Signal Connectors:

Two sealed automotive connectors are provided to connect to the internal I/O resources. J1 and J2 are standard AMPSEAL connectors by AMP/Tyco:

3.2.1 J1 – 35p AMPSEAL Plug 776164-1 with crimp contact 770854-1

GEN2 refers to PM100 Units w/ serial number less than 344

GEN3 refers to PM100 Units w/ serial number of 344 or greater and all PM150 units

Pin #	Pin Name	Description	Notes
1	XDCR_PWR	+5V @ 80mA max	Accel Pedal Power
13	AIN1	Analog Input 1 0-$5V_{FS}$	Accel Pedal wiper
24	AIN2	Analog Input 2 0-$5V_{FS}$	Motor Temperature Sensor
2	AGND	Analog Ground	Accel Pedal GND
14	XDCR_PWR	+5V @ 80mA max	Spare 5V transducer power
25	AIN3	Analog Input 3 0-$5V_{FS}$	Brake Pedal
3	AIN4	Analog Input 4 0-$5V_{FS}$	
15	AGND	Analog Ground	
26	XDCR_PWR	+5V @ 80mA max	Spare 5V transducer power
4	RTD1	1000 Ohm RTD Input	

GEN2			
4 GEN3	AOUT	Analog Output 0 – 5V	
16 GEN2	RTD2	1000 Ohm RTD Input	
16 GEN3	AIN6	Analog Input 6 0-5V_{FS}	Available for user-defined functionality
27 GEN2	RTD3	1000 Ohm RTD Input	
27 GEN3	RLY6	Hi-Side Relay Driver	Available for user-defined functionality, CAN control.
5 GEN2	RTD4	100 Ohm RTD Input	
5 GEN3	RTD1	RTD Input (PT100 or PT1000)	Software selectable input type.
17	AGND	Analog Ground	
28	XDCR_PWR	+5V @ 80mA max	Spare 5V transducer power
6 GEN2	RTD5	100 Ohm RTD Input	
6 GEN3	RTD2	RTD Input (PT100 or PT1000)	Software selectable input type.
18 GEN2	<reserved>	DO NOT CONNECT	
18 GEN3	AIN5	Analog Input 5 0-5V_{FS}	Available for user-defined functionality
29 GEN2	<reserved>	DO NOT CONNECT	
29 GEN3	RLY5	Hi-Side Relay Driver	Available for user-defined functionality, CAN control.
7	/PROG_ENA	Serial Boot Loader enable	
19	AGND	Analog Ground	
30	DIN1	Digital Input 1 – STG(1)	Forward Enable Switch
8	DIN2	Digital Input 2 - STG	Reverse Enable Switch

20	DIN3	Digital Input 3 - STG	Brake Switch
31	DIN4	Digital Input 4 - STG	REGEN Disable Input (if used)
9	DIN5	Digital Input 5 – STB(2)	Ignition Input (if used)
21	DIN6	Digital Input 6 - STB	Start Input (if used)
32 GEN2	<reserved>	DO NOT CONNECT	
32 GEN3	DIN7	Digital Input 7 - STB	Available for user-defined function.
10 GEN2	<reserved>	DO NOT CONNECT	
10 GEN3	DIN8	Digital Input 8 - STB	Available for user-defined function.
22	GND	Ground	
33	CANA_H	CAN Channel A Hi	
11	CANA_L	CAN Channel A Low	
23	CANB_H	CAN Channel B Hi	
34	CANB_L	CAN Channel B Low	
12	TXD	RS-232 Transmit	
35	RXD	RS-232 Receive	

(1)– Switch to GND; (2) – Switch to Battery

3.2.2 J2 – 23p AMPSEAL Plug 770680-1 with crimp contact 770854-1

Pin#	Pin Name	Description	Notes
1	XDCR_PWR	+5V @ 80mA max	Encoder Power
9	ENCA	Encoder Channel A input	Used with Induction Motors
16	ENCB	Encoder Channel B input	
2	ENCZ	Encoder Channel Z input (Index)	
10	GND	GND	Encoder GND
17	EXC	Resolver excitation output	Used with PM Motors
3	GND	Resolver excitation return	

11	SIN	Resolver Sine winding +	
18	/SIN	Resolver Sine winding -	
4	COS	Resolver Cosine winding +	
12	/COS	Resolver Cosine winding -	
19	GND		Resolver Shield GND
5	<reserved>	DO NOT CONNECT	
13	<reserved>	DO NOT CONNECT	
20	<reserved>	DO NOT CONNECT	
6	GND	Main 12V return	Chassis GND
14	GND	Main 12V return	Chassis GND
21	RLY1	Hi-Side Relay Driver	Pre-Charge Contactor Drive
7	RLY2	Hi-Side Relay Driver	Main Relay Drive
15	RLY3	Lo-Side Relay Driver	OK Indicator Drive / 12V Power Relay Drive
22	RLY4	Lo-Side Relay Driver	Fault Indicator Drive
8	BATT+	Main 12V power source	12V Ignition Power Input
23	BATT+	Main 12V power source	12V Ignition Power Input

3.3 PM250 External Connections:

The PM250 has two external connectors. J2 is a 41 pin circular connector, J1 is a 26 pin circular connector. J2 contains mostly signals that would go to the vehicle harness. J1 contains mostly signals that would go to the motor. A connector kit that contains both J1 and J2 can be purchased from Cascadia Motion as G1-0016-01. We recommend using one of the following crimpers (not provided by Cascadia Motion): Plier M22520/1-01 with Turret M22520/1-04 or Plier M22520/2-01 with Turret M22520/2-10.

J1 Connections

Pin#	Pin Name	Description	Notes
A	EXC	Resolver excitation output	Used with PM Motors
B	GND	Resolver excitation return	
C	SIN	Resolver Sine winding +	
D	/SIN	Resolver Sine winding -	
E	COS	Resolver Cosine winding +	

F	/COS	Resolver Cosine winding -	
G	RTD1P	RTD1 Positive	Can be either PT100 or PT1000
H	RTD1N	RTD1 Negative	
J	GND	GND	Encoder GND
K	HALL C	Hall Input C	
L	HALL A	Hall Input A	For use with certain motors that support Hall encoders.
M	ENCZ	Encoder Channel Z input (Index)	
N	ENC A	Encoder Channel A input	Quadrature encoder used with Induction Motors
P	XDCR_PWR	+5V @ 80mA max	Encoder Power
R	RTD2P	RTD2 Positive	Can be either PT100 or PT1000
S	RTD2N	RTD2 Negative	
T	GND		Resolver Shield GND
U	AIN2	Analog Input 2	Used with certain motors for temperature sensing.
V	AIN4	Analog Input 4	Used with certain motors for temperature sensing.
W	AGND	Analog Ground	Ground reference for use with AIN2 and AIN4
X	XDCR_PWR	+5V @ 80mA max	For use with pull-up resistor.
Y	HALL B	Hall Input B	
Z	GND		
AA or a	ENCB	Encoder Channel B input	
AB or b	AIN2PU	Pull-up resistor on AIN2	If connected to XDCR_PWR will enable a 1K ohm pull-up resistor to be connected to AIN2.
AC or c	AIN4PU	Pull-up resistor on AIN4	If connected to XDCR_PWR will enable a 1K ohm pull-up resistor to be connected to AIN4.

J2 Connections

Pin #	Pin Name	Description	Notes
A	CANB_H	CAN Channel B Hi	
B	CANB_L	CAN Channel B Low	
C	RLY2	Hi-Side Relay Driver	Main Relay Drive
D	RLY3	Lo-Side Relay Driver	OK Indicator Drive / 12V Power Relay Drive
E	RLY5	Hi-Side Relay Driver	Available for user-defined functionality, CAN control.
F	DIN1	Digital Input 1 – STG(1)	Forward Enable Switch
G	DIN2	Digital Input 2 - STG	Reverse Enable Switch
H	DIN5	Digital Input 5 – STB(2)	Ignition Input (if used)
J	DIN7	Digital Input 7 - STB	Available for user-defined function.
K	GND	Main 12V return	
L	GND	Main 12V return	
M	BATT+	Main 12V power source	12V Ignition Power Input
N	BATT+	Main 12V power source	12V Ignition Power Input
P	AIN1	Analog Input 1 0-5V_{FS}	Accel Pedal wiper
R	AGND	Analog Ground	Accel Pedal GND
S	AIN3	Analog Input 3 0-5V_{FS}	Brake Pedal
T	AIN5	Analog Input 5 0-5V_{FS}	Available for user-defined functionality
U	AIN6	Analog Input 6 0-5V_{FS}	Available for user-defined functionality
V	AGND	Analog Ground	
W	CANA_H	CAN Channel A Hi	
X	GND	Ground	CAN B Shield
Y	RLY1	Hi-Side Relay Driver	Pre-Charge Contactor Drive
Z	RLY4	Lo-Side Relay Driver	Fault Indicator Drive
AA or a	RLY6	Hi-Side Relay Driver	Available for user-defined functionality, CAN control.
AB or b	DIN3	Digital Input 3 - STG	Brake Switch
AC or c	DIN6	Digital Input 6 - STB	Start Input (if used)

AD or d	GND	Main 12V return	
AE or e	BATT+	Main 12V power source	12V Ignition Power Input
AF or f	XDCR_PWR	+5V @ 80mA max	Accel Pedal Power
AG or g	AGND	Analog Ground	
AH or h	XDCR_PWR	+5V @ 80mA max	Spare 5V transducer power
AI or i	XDCR_PWR	+5V @ 80mA max	Spare 5V transducer power
AJ or j	CANA_L	CAN Channel A Low	
AK or k	GND	Ground	CAN A Shield
AM or m	RXD	RS-232 Receive	
AN or n	DIN4	Digital Input 4 - STG	REGEN Disable Input (if used)
AP or p	DIN8	Digital Input 8 - STB	Available for user-defined function.
AQ or q	/PROG_ENA	Serial Boot Loader enable	
AR or r	TXD	RS-232 Transmit	
AS or s	AOUT	Analog Output 0 – 5V	
AT or t	GND	Ground	Serial I/O GND

3.4 RM100 Signal Connections

The RM100 uses a single 35 pin Ampseal connector for the I/O Signals. Mating connector is Tyco part number 776164-1, mating contact is 770854-3 for 16-20 AWG wire. Must use Tyco crimper 58529-1 (AMP Pro-Crimper II). A kit of the connector and contacts is available from Cascadia Motion as part number G1-0021-01.

Pin #	Pin Name	Description	Notes
1	RLY1 (Pre-charge)	High Side Driver	If pre-charge function is used this output serves as the pre-charge contactor output.
2	AIN1	Analog Input 1 0-$5V_{FS}$	Accel Pedal wiper
3	AIN2	Analog Input 2 0-$5V_{FS}$	Motor Temperature Sensor
4	/PROG_ENA	Serial Boot Loader enable	This pin is grounded when power is applied to enable reprogramming of the firmware.
5	CANA_H	CAN Channel A Hi	CAN Communications channel

6	CANA_L	CAN Channel A Low	
7	CANB_H	CAN Channel B Hi	Secondary CAN Communications channel, currently not used.
8	CANB_L	CAN Channel B Low	
9	CAN Shield		Connection of CAN cable shield.
10	TXD	RS-232 Transmit	Used for RMS GUI and C2prog
11	RXD	RS-232 Receive	Used for RMS GUI and C2prog
12	GND	RS-232 Ground	
13	RLY2 (Main)	High Side Driver	If the pre-charge function is used this output serves as the main contactor output.
14	AIN3	Analog Input 3 0-5V_{FS}	Brake Pedal
15	DIN1	Digital Input 1 – STG	Forward Enable Switch
16	DIN2	Digital Input 2 - STG	Reverse Enable Switch
17	/EXC	Resolver excitation return	
18	COS	Resolver COS winding	
19	SIN	Resolver SIN winding	
20	RTD1-	Return side of RTD1	
21	RTD2+	Positive side of RTD2	Temperature Sensor software configurable for PT100 or PT1000.
22	RTD2-	Return side of RTD2	
23	XDCR_PWR	+5V	Transducer power output
24	BATT+	12V/24V Input	Input power for inverter. Must be on a switched connection as this input will always draw current.
25	BATT+	12V/24V Input	Redundant connection can be used if desired of needed for additional current capability.
26	BATT_RTN	12/24V Return	Normally tied to vehicle power system chassis.
27	BATT_RTN	12/24V Return	Redundant connection can be used if desired of needed for

			additional current capability.
28	EXC	Resolver excitation	
29	SHIELD	Resolver Cable Shield connection	Resolver cable shield should connected to this pin. Do not connect the shield to the case of the motor.
30	/COS	Resolver COS winding return	
31	/SIN	Resolver SIN winding return	
32	RTD1+	Positive side of RTD1	Temperature Sensor software configurable for PT100 or PT1000.
33	HVIL IN	High Voltage Interlock Input	HVIL IN to HVIL OOUT is a circuit loop that will read shorted when all HV connectors are plugged in.
34	HVIL OUT	High Voltage Interlock Output	
35	AGND	Analog Ground	Ground reference from analog inputs.

3.5 RM300 Signal Connections

The RM300 uses two connectors for the low voltage I/O signals. The 35 pin connector (marked I/O on the housing) is for the signals related to the communications/control of the inverter. The 14 pin connector (marked M on the housing) is for the motor related signals. The 35 pin mating connector is Tyco part number 776164-1, the 14 pin mating connector is 776273-1, mating contact is 770854-3 for 16-20 AWG wire. Must use Tyco crimper 58529-1 (AMP Pro-Crimper II). A kit of the connector and contacts is available from Cascadia Motion as part number G1-0030-01.

“I/O” Connector – Input / Output Connector

Pin #	Pin Name	Description	Notes

1	BATT+	12V/24V Input	Input power for inverter. Must be on a switched connection as this input will always draw current.
2	BATT+	12V/24V Input	Redundant connection can be used if desired of needed for additional current capability.
3	BATT_RTN	12/24V Return	Normally tied to vehicle power system chassis.
4	BATT_RTN	12/24V Return	Redundant connection can be used if desired of needed for additional current capability.
5	AIN4	Analog Input 4 0-5V_{FS}	
6	GND	Digital Ground	Digital Ground, can be used for digital inputs (STG types)
7	CANA_H	CAN Channel A Hi	CAN Communications channel
8	CANA_L	CAN Channel A Low	
9	CANB_H	CAN Channel B Hi	Secondary CAN Communications channel, currently not used.
10	CANB_L	CAN Channel B Low	
11	CAN Shield		Connection of CAN cable shield.
12	DIN2	Digital Input 2 - STG	Reverse Enable Switch
13	RLY2 (Main)	High Side Driver	If the pre-charge function is used this output serves as the main contactor output.
14	/PROG_ENA	Serial Boot Loader enable	This pin is grounded when power is applied to enable reprogramming of the firmware.
15	XDCR_PWR	+5V	Transducer power output
16	AIN1	Analog Input 1 0-5V_{FS}	Accel Pedal wiper
17	AIN3	Analog Input 3 0-5V_{FS}	Brake Pedal
18	AIN6	Analog Input 6 0-5V_{FS}	

19	AGND	Analog Ground	Ground reference from analog inputs. Do not connect to GND, BATT_RTN, or chassis
20	GND	RS-232 Ground	
21	RXD	RS-232 Receive	Used for RMS GUI and C2prog
22	TXD	RS-232 Transmit	Used for RMS GUI and C2prog
23	DIN1	Digital Input 1 – STG	Forward Enable Switch
24	RLY1 (Pre-charge)	High Side Driver	If pre-charge function is used this output serves as the pre-charge contactor output.
25	HVIL IN	High Voltage Interlock Input	HVIL IN to HVIL OOUT is a circuit loop that will read shorted when all HV connectors are plugged in.
26	HVIL OUT	High Voltage Interlock Output	
27	DIN3	Digital Input 3 – STG	Brake Switch
28	DIN4	Digital Input 4 – STG	
29	DIN5	Digital Input 5 – STG	Can be used as Ignition Input, but note the RM300 is a Switch To Ground input which is different than the PM family.
30	DIN6	Digital Input 6 – STG	Can be used as Start Input, but note the RM300 is a Switch To Ground input which is different than the PM family.
31	DIN7	Digital Input 7 – STB	Switch To Battery input.
32	DIN8	Digital Input 8 – STB	Switch To Battery input.
33	XDCR_PWR	+5V	Transducer power output
34	GND	Digital Ground	Digital Ground, can be used for digital inputs (STG types)
35	AGND	Analog Ground	Ground reference from analog inputs. Do not connect to GND, BATT_RTN, or chassis

"M" Connector – Motor connections connector

Pin #	Pin Name	Description	Notes
1	/EXC	Resolver excitation return	
2	/SIN	Resolver SIN winding return	
3	SIN	Resolver SIN winding	
4	COS	Resolver COS winding	
5	RTD1+	Positive side of RTD1	Temperature Sensor software configurable for PT100 or PT1000.
6	EXC	Resolver excitation	
7	SHIELD	Resolver Cable Shield connection	Resolver cable shield should connected to this pin. Do not connect the shield to the case of the motor.
8	/COS	Resolver COS winding return	
9	RTD1-	Return side of RTD1	
10	RTD2+	Positive side of RTD2	Temperature Sensor software configurable for PT100 or PT1000.
11	RTD2-	Return side of RTD2	
12	AIN2	Analog Input 2 0-5V_{FS}	Motor Temperature Sensor
13	AGND	Analog Ground	Ground reference from analog inputs. Do not connect to GND, BATT_RTN, or chassis
14	XDCR_PWR	+5V	Transducer power output

3.6 PM500 Signal Connections

The PM500 uses three connectors for the low voltage I/O signals. The J1 connector contains I/O signals that are common to both inverters inside the PM500 housing. Signals are for Inverter 1/Motor 1 are prefixed by M1, signals for Inverter 2/Motor 2 are prefixed by

M2. Some signals are common to both Inverter 1 and Inverter 2. Motor 1 connector contains resolver signals for Inverter 1 and Motor 2 contains resolver signals for Inverter 2.

J1 I/O Connector – 41 pin

Pin #	Pin Name	Description	Notes
A	M1_CANA_L	CAN Channel A Low	
B	M1_CANA_H	CAN Channel A High	
C	M2_RLY6	Hi-Side Relay Driver	
D	M1_RLY1	Hi-Side Relay Driver	Pre-Charge Contactor Drive
E	AGND	Analog Ground	For both M1 and M2
F	AIN3	Analog Input 3 0-5V_{FS}	Brake Pedal
G	DIN2	Digital Input 2 - STG	Reverse Enable Switch (if used)
H	DIN1	Digital Input 1 – STG	Forward Enable Switch (if used)
J	M1_RLY5	High Side Relay Driver	
K	BATT+	Main 12V power source	For both M1 and M2
L	BATT+	Main 12V power source	For both M1 and M2
M	BATT_GND	Main 12V return	For both M1 and M2
N	BATT_GND	Main 12V return	For both M1 and M2
P	RLY3	Low Side Relay Driver	Combined M1 OR M2
R	DIN6	Digital Input 6 - STB	Start Input (if used)
S	DIN3	Digital Input 3 - STG	Brake Switch (if used)
T	DIN7	Digital Input 7 - STB	Available for user-defined function.
U	DIN5	Digital Input 5 – STB	Ignition Input (if used)
V	GND	Ground	CAN M1 Shield
W	M2_CANA_H	CAN Channel A High	
X	GND	Ground	CAN M2 Shield
Y	HVIL_B		HVIL Loop
Z	AIN1	Analog Input 1 0-5V_{FS}	Accel Pedal wiper
AA or a	M1_RLY2	Hi-Side Relay Driver	Main Relay Drive
AB or b	M1_XDCR_PWR	+5V @ 80mA max	
AC or c	HVIL_A		HVIL Loop
AD or d	BATT+	Main 12V power source	For both M1 and M2

AE or e	BATT_GND	Main 12V return	For both M1 and M2
AF or f	M2_RLY4	Lo-Side Relay Driver	Fault Indicator Drive
AG or g	M1_RLY4	Lo-Side Relay Driver	Fault Indicator Drive
AH or h	M2_/PROG_ENA	Serial Boot Loader enable	Connect to M2_GND for boot mode
AI or i	M2_TXD	RS-232 Transmit	
AJ or j	M2_CANA_LO	CAN Channel A Low	
AK or k	M1_TXD	RS-232 Transmit	
AM or m	M1_RXD	RS-232 Receive	
AN or n	M2_XDCR_PWR	+5V @ 80mA max	
AP or p	M1_/PROG_ENA	Serial Boot Loader enable	Connect to M1_GND for boot mode
AQ or q	BENDER_MHS		
AR or r	M2_RXD	RS-232 Receive	
AS or s	M2_GND	RS-232 Ground	
AT or t	M1_GND	RS-232 Ground	

MOTOR 1 and Motor 2 Connector – 26 pin

Pin#	Pin Name	Description	Notes
A	/EXC	Resolver excitation return	
B	EXC	Resolver excitation output	Used with PM Motors
C	/SIN	Resolver Sine winding -	
D	SIN	Resolver Sine winding +	
E	/COS	Resolver Cosine winding -	
F	COS	Resolver Cosine winding +	
G	RTD1P	RTD1 Positive	Can be either PT100 or PT1000
H	RTD1N	RTD1 Negative	
J	GND	GND	Encoder GND
K	ENCB	Encoder Channel B input	
L	ENCZ	Encoder Channel Z input (Index)	
M	AIN6	Analog Input 6	

N	GND	Encoder Ground	
P	XDCR_PWR	+5V @ 80mA max	Encoder Power
R	RTD2P	RTD2 Positive	Can be either PT100 or PT1000
S	RTD2N	RTD2 Negative	
T	GND		Resolver Shield GND
U	AIN2	Analog Input 2	Used with certain motors for temperature sensing.
V	AIN4	Analog Input 4	Used with certain motors for temperature sensing.
W	AGND	Analog Ground	Ground reference for use with AIN2 and AIN4
X	XDCR_PWR	+5V @ 80mA max	For use with pull-up resistor.
Y	ENC A	Encoder Channel A input	Quadrature encoder used with Induction Motors
Z	AGND	Analog Ground	Ground reference for use with AIN2 and AIN4
AA or a	DIN8	Digital Input 8	
AB or b	AIN2PU	Pull-up resistor on AIN2	If connected to XDCR_PWR will enable a 1K ohm pull-up resistor to be connected to AIN2.
AC or c	AIN4PU	Pull-up resistor on AIN4	If connected to XDCR_PWR will enable a 1K ohm pull-up resistor to be connected to AIN4.

3.7 CM200 and CM350 Signal Connector

The CM200 and CM350 use the same Low Voltage I/O connector and have the same connecctions. A Molex CMC 48 way connector is used for all low voltage signals. Note, the iM-225/iM-375/iM-425 motor assemblies use variants of the CM200/CM350 that have identical low voltage inverter connections.

Mating Housing: Molex 64320-3311

Strain Relief: Molex 64320-1301

Contact, CP 0.6, 0.5mm^2/20AWG, Wire OD 1.4-1.7mm: Molex 64322-1239

Contact, CP 0.6, 0.75mm^2/18AWG, Wire OD 1.4-1.7mm: Molex 64322-1219

Contact, CP 1.5, 0.5-1mm^2/18AWG, Wire OD 1.4-2.15mm: Molex 64323-1319
Blind plug, CP 0.6: Molex 643251010
Blind plug, CP 1.5: Molex 643251023

Please refer to the Molex web site for details on the connector. Cascadia Motion highly recommends the use of the factory crimper for the contacts. Note that this connector has two different contacts sizes, A1 thru K4 are the CP 0.6 size, L1 thru M4 are the CP 1.5 size.

I/O Connector – 48 pin

Pin #	Pin Name	Description	Notes
A1	/SIN	Resolver Sine winding -	
A2	CANA_H	CAN Channel A High	CAN high Port A
A3	RTD1P	RTD1 Positive	Allows connection of PT100 or PT1000 RTD for temperature monitoring.
A4	AGND	Analog Ground	For use with analog inputs.
B1	SIN	Resolver Sine winding +	
B2	CANA_L	CAN Channel A Low	CAN low Port A
B3	RTD1N	RTD1 Negative	See RTD1P
B4	AIN1	Analog Input 1	
C1	/COS	Resolver Cosine winding -	
C2	CANA_T	CAN A Terminator Loop	Short to CANA_L to include a 120 ohm terminator from CANA_H to CANA_L.
C3	RTD2P	RTD2 Positive	Allows connection of PT100 or PT1000 RTD for temperature monitoring.
C4	AIN2	Analog Input 2	
D1	COS	Resolver Cosine winding +	
D2	CAN_GND	CAN ground	CAN is isolated from GND/KL31. CAN shield should be connected here.
D3	RTD2N	RTD2 Negative	See RTD2P
D4	AIN3	Analog Input 3	

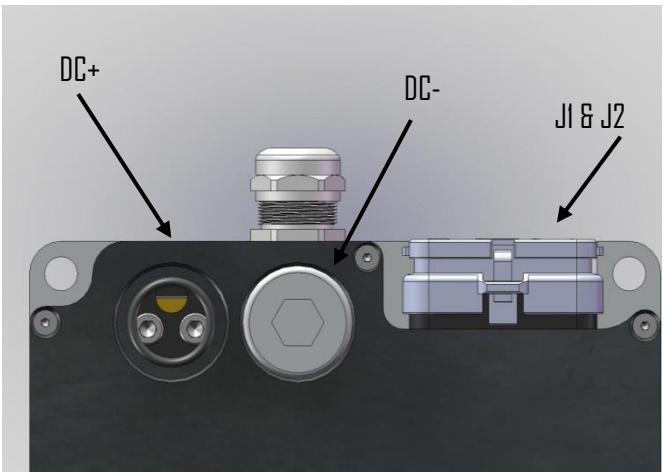
Pin #	Pin Name	Description	Notes
E1	EXC	Resolver excitation output	
E2	CANB_T	CAN B Terminator Loop	Short to CANB_L to include a 120 ohm terminator from CANB_H to CANB_L.
E3	DIN1	Digital Input 1 – STG	Forward Enable Switch (if used)
E4	AIN4	Analog Input 4	
F1	/EXC	Resolver excitation return	
F2	CANB_H	CAN Channel B High	
F3	DIN2	Digital Input 2 - STG	Reverse Enable Switch (if used)
F4	RS232_GND	RS232 Ground	Normally connected to pin 5 of DB9 connector.
G1	GND	Resolver Shield Ground	
G2	CANB_L	CAN Channel B Low	
G3	DIN3	Digital Input 3 - STG	Brake Switch (if used)
G4	RS232_RXD	RS232 Inverter Receive	Normally connected to pin 3 of DB9 connector.
H1	ENC_A	Encoder Channel A input	
H2	/PROG	Program Enable	If grounded at power up inverter will go into bootloader mode for use with C2prog software.
H3	DIN4	DIN4	Digital Input 4 – STG
H4	RS232_TXD	RS232 Inverter Transmit	Normally connected to pin 2 of DB9.
J1	ENC_B	Encoder Channel B input	
J2	ENC_PWR	5V power for encoder	
J3	HVIL_IN	High Voltage Interlock Input	When all high voltage plugs are installed HVIL_IN will be connected to HVIL_OUT
J4	HVIL_OUT	High Voltage Interlock Output	See HVIL_IN
K1	ENC_Z	Encoder Channel Z input (Index)	

Pin #	Pin Name	Description	Notes
K2	DGND	Digital Ground	Ground return for encoder signals.
K3	XDCR_PWR	5V power for transducers	Used with sensors connected to analog inputs.
K4	AGND	Analog Ground	For use with analog inputs.
L1	RLY1	High Side Driver	If pre-charge function is used this output serves as the pre-charge contactor output.
L2	RLY2 (Main)	High Side Driver	If the pre-charge function is used this output serves as the main contactor output.
L3	RLY3	Lo-Side Relay Driver	OK Indicator Drive / 12V Power Relay Drive
L4	RLY4	Lo-Side Relay Driver	Fault Indicator Drive
M1	KL30_BATT	12V/24V Constant Voltage	Constant 12V power, when in the off state input current is less than 1mA
M2	KL15	Switched 12V/24V	Turns on internal power supplies to power up the inverter and start communications.
M3	KL15_EN	Safety Switched 12V/24V	If voltage is removed then inverter will declare a hardware gate fault, a completely hardware based disable of the PWM from the inverter.
M4	KL31_GND	12V/24V System Ground	12V/24V system return.

3.8 External Power Connections:

3.6.1 DC+ / DC-:

DC/Battery power is provided to the controller via two wire ports located at the rear of the controller (PM100 and PM150 shown) or front (PM250/RM100/RM300). The DC power ports are marked clearly on the front face of the PM250/RM100/RM300 controllers. The DC power must be run through an external pre-charge circuit to safely charge the capacitors inside the controller before the main contactor engages (refer to application schematic). The main contactor provides a safety disconnect of the DC power in case of a fault condition. Make sure that the wire to the drive is sized properly to handle the current.



DANGER: Before changing the wiring make sure that the internal DC bus capacitors are discharged. The voltage should be measured at the terminals before disconnecting. If there is any doubt about the safety wait at least 1 hour after power has been removed before touching the terminals.

ATTENTION

Refer to the PM100 HV Connection Manual for more information on how to install the wires into the inverter.

On the PM250 unit the DC connections are marked “+” for the DC+ and “-“ for the DC-.

The RM100 Unit uses the Amphenol PowerLok™ 300 for the high voltage connections. These connectors utilize the Amphenol RADSOK™ technology. Each connection is a specific color and keying so that the cables cannot be interchanged.

Inverter Connection	PowerLok™ Color	PowerLok™ Key
DC+	Red	W
DC-	Black	Y
Phase U	Green	V
Phase V	Orange	X
Phase W	Yellow	U

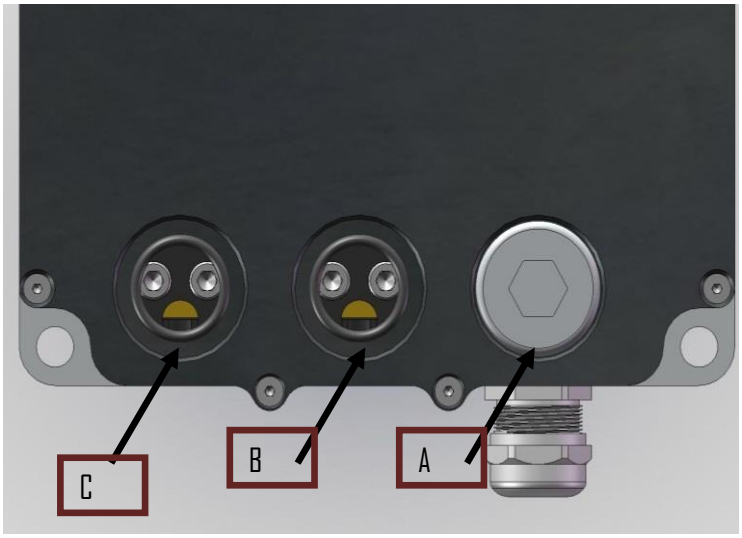
The housing of the RM100 is marked with the HV Connection designations. The PM Family of inverters uses the Phase A, B, C designation instead of the RM Family U, V, W. References in documentation to Phase A refer to Phase U, Phase B to Phase V, and Phase C to Phase W.

The PowerLok™ 300 is available for many different sizes of wires. Contact Cascadia Motion for more information about ordering connectors/cables. Please refer to the RM100 HV Connection Manual for more details on how to connect to the RM100.

The RM300 uses the PowerLok™ 500 connector family. Please see the separate RM300 HV connection manual for more information.

The CM200 uses Rosenberger HPK family connectors for making connection to the DC bus input of the inverter. The HPK family is available in various wires sizes between 16mm^2 and 50mm^2.

3.6.2 Phase A / Phase B / Phase C:



Phase A, Phase B, and Phase C are wired to the motor. It is important the 3 wires be wired to the motor such that they give the proper direction of rotation. The motor wires are the most likely to generate EMI and they also carry a higher average current than the DC power wires. When installed in the vehicle these wires should be kept as short as possible. It is also recommended that shielded wire be used for the motor wires. This can be done by adding a copper braid over the wires, or using wire that includes a shield. All of the PM100/150/250 family units are shipped with cable glands that are metallic and designed to accommodate shielded wire.
The PM250 and RM300 AC motor connections are marked on the unit with the letters “A”, “B”, and “C”. On the RM100 the phases are marked with “U”, “V”, and “W”.

The CM200 uses Rosenberger HPK connectors for the AC connections. The cables must use shielded wire. The shield is connected to the chassis of the inverter and the chassis of the motor.

3.6.3 Pre-Charge Circuit:

An external pre-charge circuit must be used with the controller. The circuit limits peak inrush current into the controller when the main contactor is engaged. The pre-charge circuit adds a resistor, relay, and fuse in parallel with the main contactor. When the controller is powered on the controller will first engage the pre-charge relay to charge the capacitors internal to the controller. If the capacitors charge properly then the main contactor will engage.
The pre-charge resistor should be sized to rapidly charge the capacitor, but not dissipate too much power in a fault condition. The pre-charge resistor should be sized so that if the controller had a short on its input the pre-charge resistor would not fail. The pre-charge relay

will only remain closed for about 3 seconds. The pre-charge sequence must complete before this time or the inverter will declare a fault condition and open the pre-charge relay. The pre-charge circuit should be fused with a small fuse appropriate to the wire used. Since the pre-charge current is generally very low, approximately 0.5 amps in the example below, small wire can be used (recommend 18 AWG). A 5 amp fuse would be appropriate for this wire.

Sizing Example:

A typical application could have a maximum DC bus voltage of 320 volts. If a 600 ohm resistor were chosen this would result in a power dissipation of 171 watts. This is within the short term rating of a 50 watt wire-wound resistor. The internal capacitance of the controller is approximately 500uF. It takes approximately 3 time constants before the controller will close the main contactor, thus in this example it will take 0.9 seconds for the pre-charge to complete.

Cascadia Motion can provide the following parts if needed. Reference the following:

- Pre-charge Relay (30A, 12V COIL): p/n 77-0026 for DX inverters
- Pre-charge Relay (50A/1000V, 12V COIL): p/n 77-0034 for DZ inverters
- Pre-charge Resistor (600 ohm 50W): p/n 53-0006 for DX inverters
- Pre-charge Resistor (1K ohm 100W): p/n 53-0008 for DZ inverters
- Pre-charge Fuse (5A 500V): p/n G1-0013-01 for DX inverters
- Pre-charge Fuse (5A 1000V): p/n G1-0015-01 for DZ inverters

Model	Internal Capacitance	Maximum Pre-charge Resistor	Cascadia Motion Part Number
PM100DX/PM100DXR	440uF	1200 ohms	53-0006
PM100DZ/PM100DZR	280uF	2000 ohms	53-0008
PM150DX/PM150DX	880uF	600 ohms	53-0006
PM150DZ/PM150DZR	560uF	1000 ohms	53-0008
PM250DZ	645uF	1000 ohms	53-0008
PM250DX	1500uF	400 ohms	n/a
RM100DX	570uF	1000 ohms	53-0006
RM100DZ	250uF	2000 ohms	53-0008
RM300DX	1710uF	400 ohms	n/a
RM300DZ	750uF	1000 ohms	53-0006

CM200DX	650uF	600 ohms	53-0006
CM200DZ	255uF	2000 ohms	53-0008
CM350DZ	510uF	1000 ohms	53-0008
PM500DZ	1500uF	400 ohms	n/a

3.6.4 Main Contactor:

The main contactor is the switching element between the DC high-voltage power source (typically a battery) and the controller. The main contactor must be sized to handle the operating currents of the controller. In addition the main contactor must be able to open under a fault condition. Generally only one contactor is needed, the application schematic shows the main contactor in series with the positive path from the battery to the controller. Cascadia Motion has successfully used the following: Gigavac GX14BA, Cascadia Motion p/n 77-0035. The contactor must be rated to handle DC voltage, AC only rated contactors and relays must not be used. DC rated contactors are usually polarity sensitive. That is the normal operating current should flow in a particular direction. Refer to the contactor data sheet for more information.

3.6.5 Main Fuse:

The DC Power input to the controller must be fused. The fuse must be rated for the voltage of the battery as well as rated to open under the short circuit current that the battery can produce. Generally, this fuse (or equivalent fusible link) may be a part of the battery pack, but if the pack protection is not present or adequate, this fuse is required to prevent a potential battery pack fire. The fuse should be rated to handle the maximum DC input current of the controller. A semiconductor type fuse is recommended.

3.6.6 Passive Discharge of the High Voltage DC Bus:

As noted above the inverter contains a large amount of DC bus capacitance. This capacitance will store energy long after the high voltage has been removed from the unit. If other provisions have not been made for discharging these capacitors then the unit wiring should not be touched for at least 5 minutes after the high voltage has been removed from it.

The voltage will slowly decay due to internal resistors inside the unit. The resistor values are shown in the table below:

Model	Passive Discharge Resistance	DC Link Capacitance	3 Time Constants	Y-Capacitance
PM100DX/PM100DXR	120K ohms	440uF	158 s	300nF
PM100DZ/PM100DZR	120K ohms	280uF	101 s	300nF
PM150DX/PM150DX	120K ohms	880uF	317 s	300nF
PM150DZ/PM150DZR	120K ohms	560uF	202 s	300nF
PM250DZ	188K ohms	645uF	364 s	388nF
PM250DX	188K ohms	1500uF	846 s	388nF
RM100DX	40K ohms	570uF	68 s	136nF
RM100DZ	40K ohms	250uF	30 s	136nF
RM300DX	25K ohms	1710uF	128 s	136nF
RM300DZ	25K ohms	750uF	19 s	136nF
CM200DX	70K ohms	650uF	137 s	136nF
CM200DZ	70K ohms	255uF	54 s	136nF
CM350DZ	60K ohms	510uF	92 s	188nF
PM500DZ	25K ohms	1500uF	77 s	136nF

For reference the value of 3 time constants is shown. This time would dissipate the voltage to less than 5% of the original value. Three time constants would allow the voltage to decay to a value that is normally safe to touch. However, the capacitors will still have some energy stored in them.

The passive resistance value shown in the table in connected to the high voltage DC bus at all times. The inverter will draw a corresponding amount of current from the high voltage at all times. For example if a PM100DX is being used at 320V it would draw 320/120K = 2.7mA even when the inverter is disabled.

If it is desired to have the DC bus voltage discharge faster the user must either provide an external method of discharge or consider the use of the Active Discharge feature of the inverter. Consultant the manual **Inverter Discharge Process**.

The above table also shows the Y-Capacitance value for the inverter. The Y-Capacitance is the total amount of capacitance connected between the DC bus and the chassis of the inverter. Half of the shown amount is connected to each side of the DC bus (DC Bus Positive / DC Bus negative).

3.6.7 12V Power:

The inverter requires a source of 12V power to operate. Normally, this power will be on a switched circuit. The inverter will turn on and communicate without high voltage present. This allows setup of parameters without high voltage.

When the vehicle is turned OFF - the 12V power is removed from the controller by a switch. This switched 12V power is connected to the BATT+ terminals (refer to pin list for pin designation). The ground return for 12V power is connected to the GND terminals (refer to pin list for pin designation). For normal applications only one pin is necessary. If necessary more than one pin can be used for applications that push higher 12V or GND currents through the controller.

Input currents:

12V Operating Power Input Range	Input Current
12V Input Current @ 9V, operating	2.1$A_{_typ}$ PM100 2.5 $A_{\_typ}$ PM150 2.1 $A_{\_typ}$ PM250DZ
12V Input Current @ 14V, operating	1.5$A_{_typ}$ PM100 1.8 $A_{\_typ}$ PM150 1.6 $A_{\_typ}$ PM250DZ
12V Input Current @ 14V, non-operating (PWM off)	0.5 $A_{\_typ}$ PM100 0.6 $A_{\_typ}$ PM150 0.8 $A_{\_typ}$ PM250DZ

The CM200DX, CM200DZ, RM100 and RM300 allow for operation from both 12V and 24V systems (the PM family does not have this capability). Valid range of operation for the RM100 and RM300 is 9 to 32V.

RM100 typical operating currents are shown below.

RM100DX @ 12V, non-operating	0.9 A
RM100DX @ 12V, operating	1.7 A
RM100DX @ 24V, non-operating	0.44 A
RM100DX @ 24V, operating	0.80 A
RM100DZ @ 12V, non-operating	0.9 A
RM100DZ @ 12V, operating	1.3 A
RM100DZ @ 24V, non-operating	0.5 A
RM100DZ @ 24V, operating	0.6 A

RM300DZ typical operating currents are shown below.

RM300DZ @ 12V, non-operating	1.06 A
RM300DZ @ 12V, operating	2.0 A
RM300DZ @ 24V, non-operating	0.51 A
RM300DZ @ 24V, operating	1 A

CM200DX typical operating currents are shown below.

CM200DX @ 12V, non-operating	0.6 A
CM200DX @ 12V, operating	1.0 A
CM200DX @ 24V, non-operating	0.3 A
CM200DX @ 24V, operating	0.5 A
KL30 input current with KL15 off	< 1mA

These currents do not include any high-side or low-side drivers:

- Any hi-side driver output currents, including the main and pre-charge contactor relay drive currents, will come through the BATT+ pins and will add to the above currents.
- Any low-side driver output currents, including indicator lamp current, will come through the GND pins, and should be considered in sizing this connection.

3.6.8 Grounding

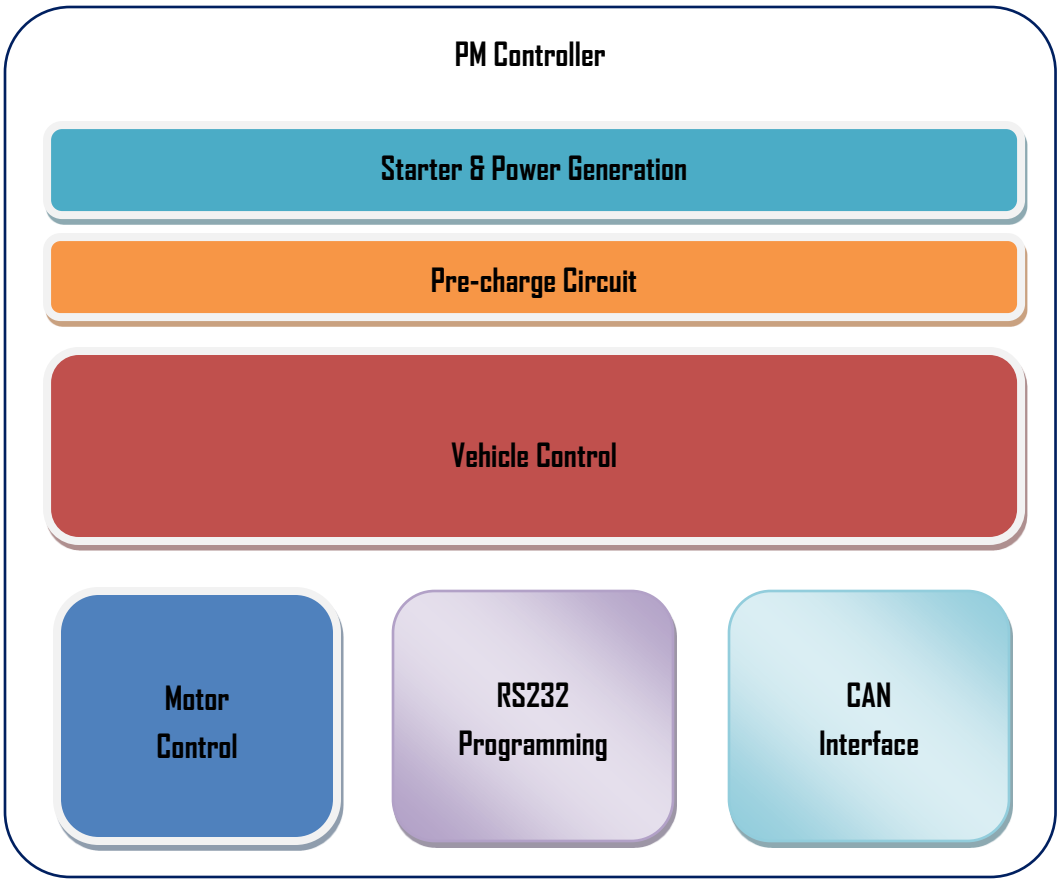
The inverter housing has a location for connecting the case to ground. The inverter housing must be connected to the motor case. It must also be connected to the vehicle

chassis and this assumes that the vehicle chassis is at the same potential as the 12V GND. The inverter housing should not be allowed to be more than a few volts above the 12V GND. If the inverter housing was disconnected hazardous voltages could develop on the housing.

3.9 Typical Application Wiring Diagram:

The wiring diagrams covers following areas:

- Starter & Power Generation
- Precharge Circuit
- Motor & Encoder
- Transmission Control
- RS232 Programming
- CAN Interface
- Motor Temperature Sensor



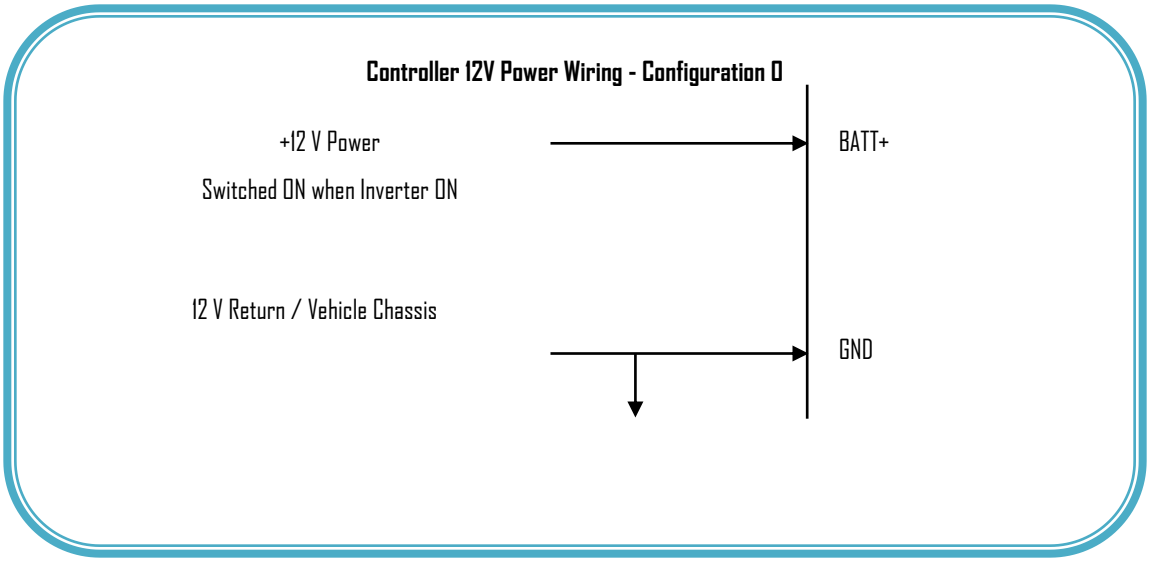
3.7.1 Controller 12V Power Wiring

This circuit can be configured in two different ways:

NOTE: RM100 can only use the Simple ON/OFF Configuration.

(a) Simple ON/OFF Configuration

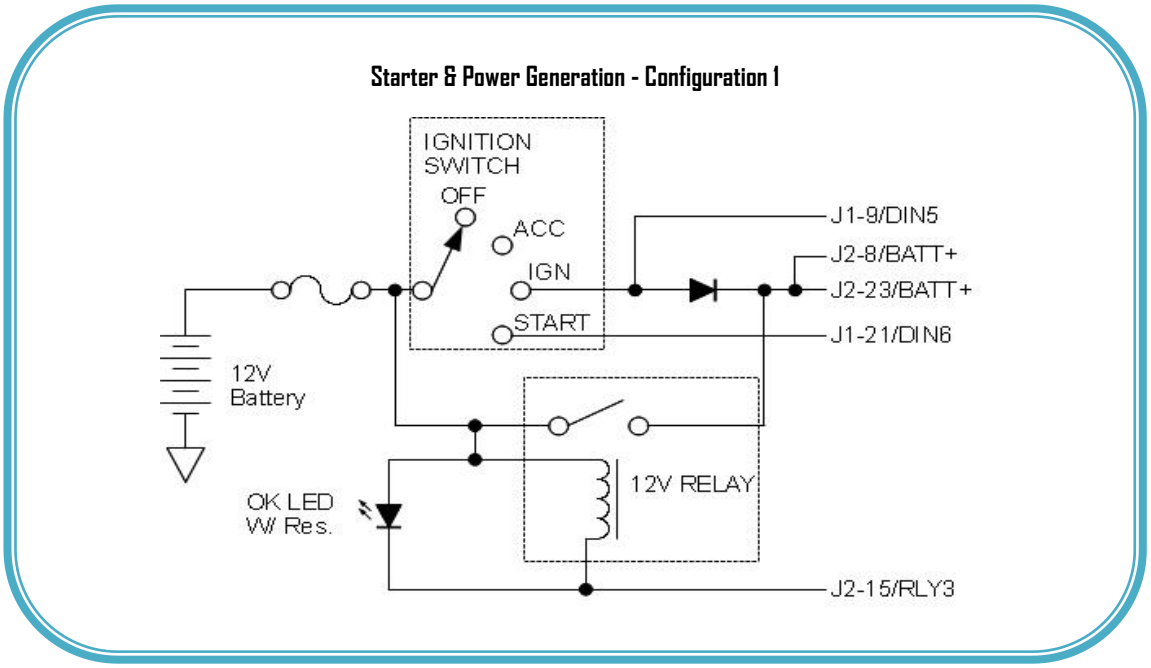
In this configuration an external switch or controller is responsible for control of the 12V power. Thus the inverter will have a less controlled shutdown process as power could be removed while it is actively controlling the motor. When using this configuration set the EEPROM parameter Key_Switch_Mode_EEPROM to 0.



(b) Typical Ignition Configuration (PM Products Only)

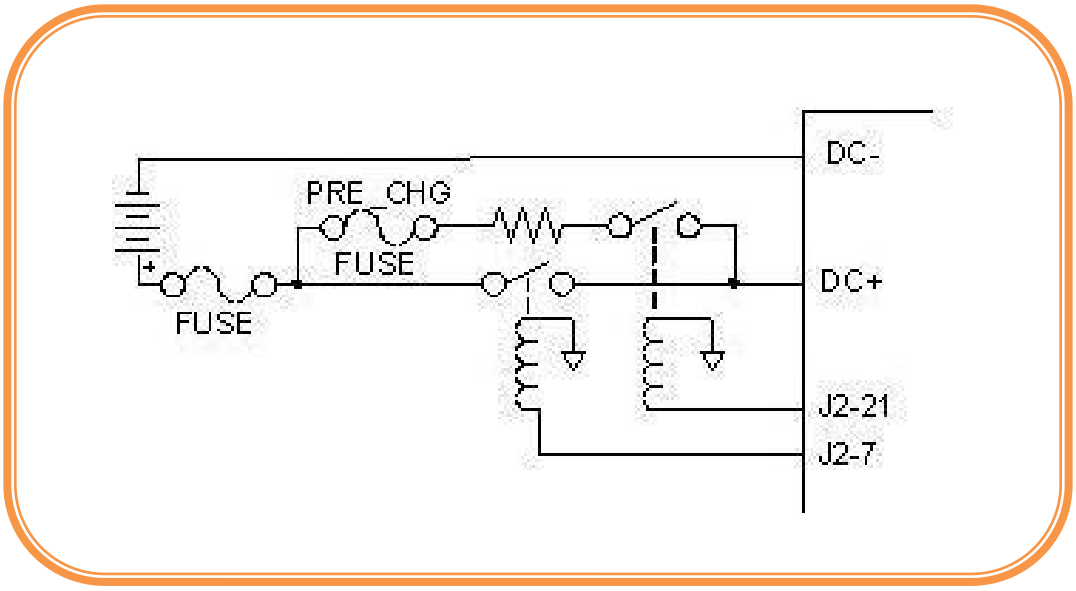
In this configuration an external, user supplied relay, diode, and switch are used to control power. When the Ignition Switch is put into the IGN position power is supplied through the diode. Once the controller completes an initial power up sequence it then turns on the RLY3 output to turn on the external 12V relay. The controller monitors DIN5 to control the relay. When it is detected that Ignition has been removed (via DIN5) an orderly shutdown process is initiated. When the process is completed the RLY3 output is turned off and power is removed from the controller. In this mode the START position of the switch is used to actively turn on PWM to the motor (VSM mode).

The diode should have a current rating of at least 3 amps.



Note: Only PM100/PM150 Connections shown, refer to PM250 connector for equivalent pins.

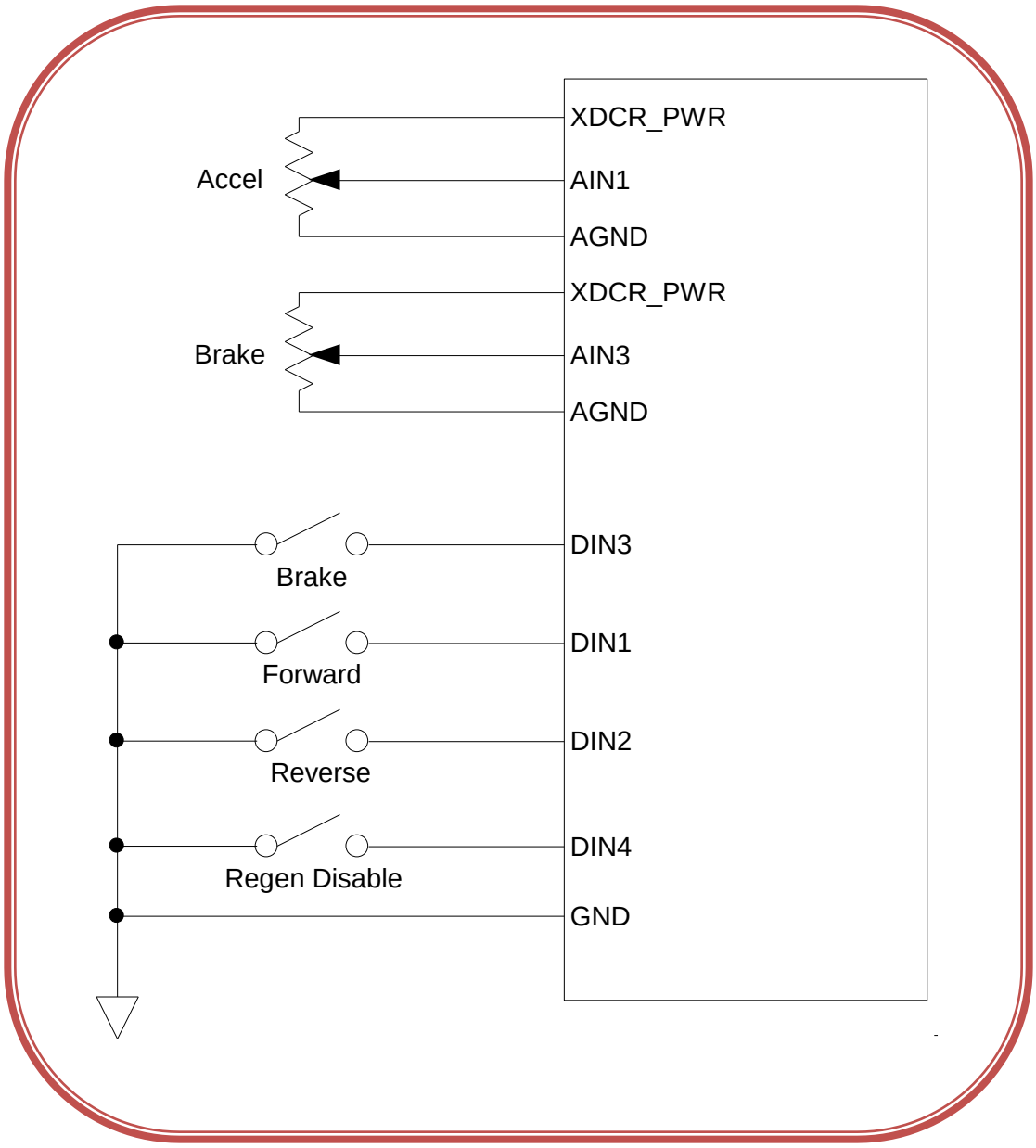
3.7.2 Pre-charge Circuit



Note: Only PM100/PM150 Connections shown, refer to PM250/RM100 connector for equivalent pins.

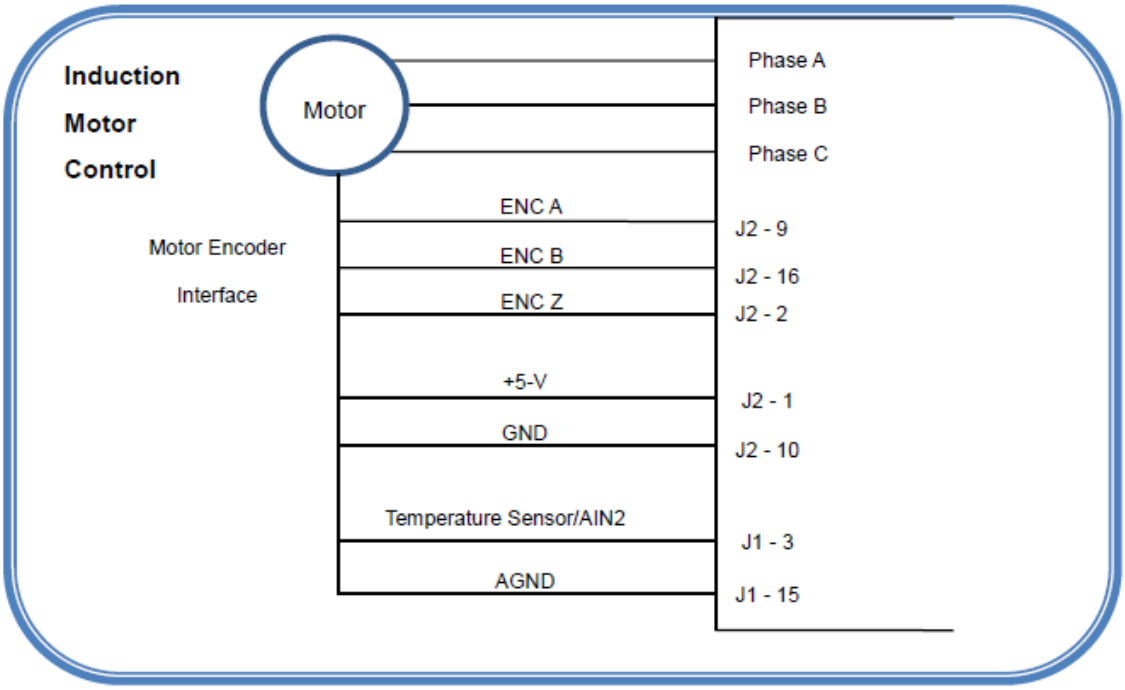
3.7.3 Analog/Digital Vehicle Control

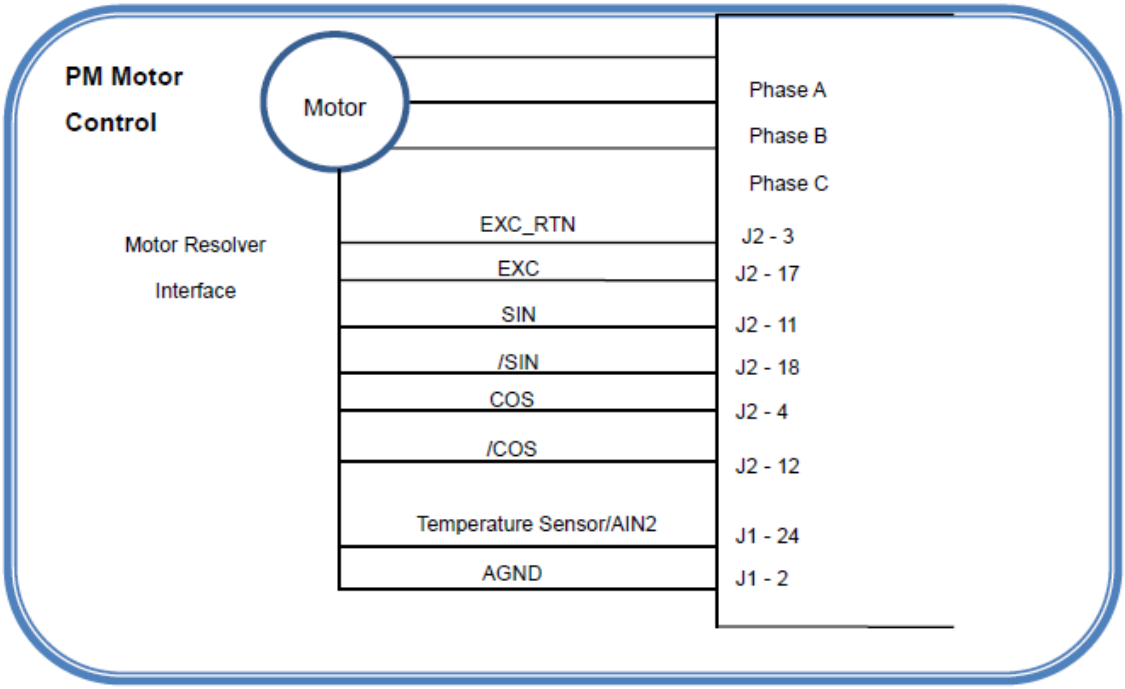
If using VSM Mode then analog / digital signals can be used to control the operation of the inverter. The limited I/O of the RM100 prevents this functionality.



3.7.4 Motor Control (Typical Wiring)

Only PM100/PM150 Pins are shown. Refer to motor specific manuals for details.





3.7.5 CAN Interface

The controllers have one active CAN interface CAN A. The controller contains hardware to support a second CAN interface (CAN B), but currently only CAN A is active. CAN B is reserved for future use. Refer to the CAN Protocol document for the various ways that the CAN bus can be configured.

The CAN interface has multiple purposes:

- Provides direct control of the motor
- Provides diagnostic and monitoring capabilities
- Provides user-adjustable configuration

The user can change the following hardware related configuration parameters:

- Inverter Command Mode: Setting this parameter to 1 allows the CAN mode to become active.
- CAN Bus Speed: Allowed speeds are 125 Kbps, 250 Kbps, 500 Kbps, or 1 Mbps. Enter 125, 250, 500, or 1000 to program the configuration parameter.
- CAN Terminator Resistor: The resistor can be applied or opened (PM Family only).

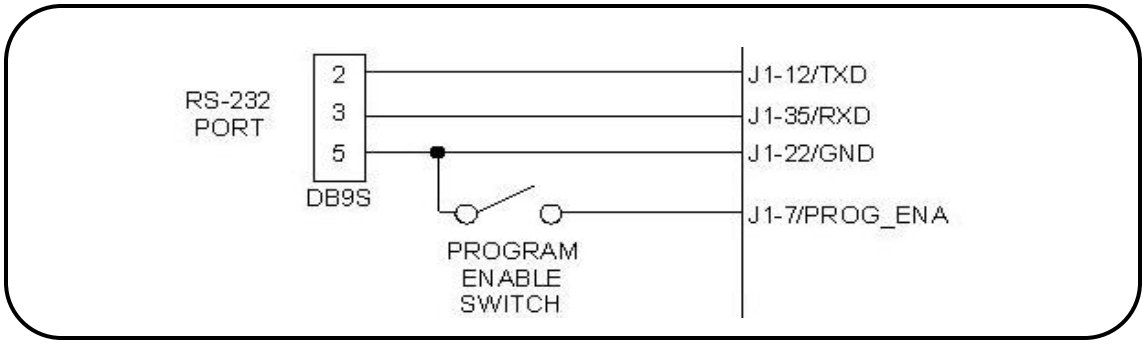
For more information on CAN interface and messages, please refer to the CAN Protocol manual.

3.7.6 RS-232 Interface

There is one RS-232 serial interface. This port can be used to set up and tune the controller, and to download controller software updates from a PC. A simple Windows PC based software package for monitoring and changing parameters (RMS GUI).

The drive can also be placed in a data-logging mode, and used with a PC or other serial device the unit broadcasts datasets at 3Hz of a number of parameters that allow performance and energy consumption data to be gathered in real time.

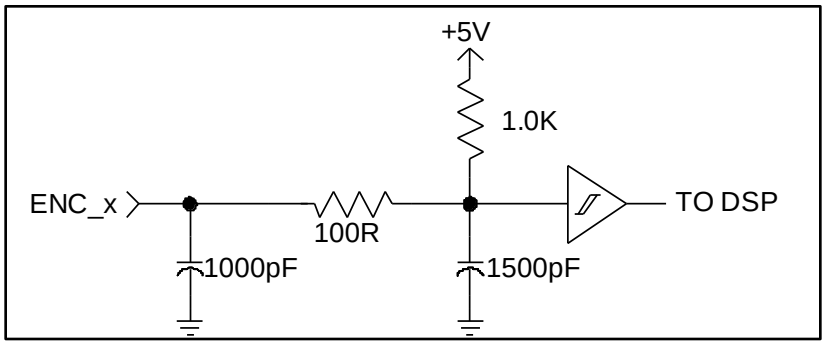
For more information on RS232 data logging refer to the SCI Data Acquisition manual.



Note: Only PM100/PM150 Connections shown, refer to PM250/RM100/RM300 connector descriptions for equivalent pins.

3.7.7 Encoder Interface (Not included on RM100/RM300):

The induction motor control software currently mandates the use of a position encoder on the motor. The encoder provides information about motor speed that is used by the induction motor control software. The controller provides a 5V interface to power the external encoder and to receive, level translate, and filter the signals from A, B and INDEX channels. For induction motor applications the INDEX channel is not used, but it may be wired. The encoder is connected internally to the TI DSP QEP Module (Quadrature Encoder Peripheral), which has special hardware for wide dynamic range speed and angle calculation from the encoder data. The drive has internal pull-up resistors on these inputs, and works with encoders that have either bi-polar or open-collector outputs.



Schematic of Encoder Inputs

3.7.8 Resolver Interface:

A resolver is a position sensor that is often used with Permanent Magnet type motors. There are various types of resolvers. The resolver requires an excitation voltage and provides a SIN and COS feedback.

The PM Controllers (Gen3) have a resolver excitation frequency that matches the PWM frequency (12kHz). The excitation voltage from the controller can be adjusted as needed.

The excitation voltage is adjusted so that the SIN/COS feedback voltage is no more than 1.2Vpk.

The RM, PM (Gen5), and CM200 inverters have an excitation frequency of 10kHz that is not synchronized with the PWM frequency. These controllers use a dedicated Resolver to Digital Converter (RDC).

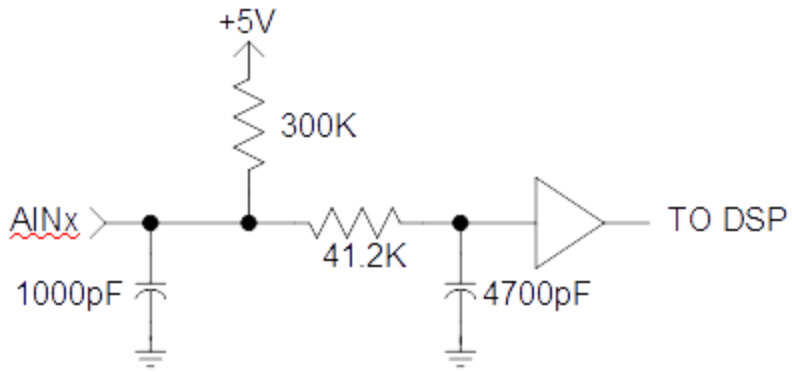
For RM and Gen 5 the target SIN/COS voltage is 3.15Vpk-pk ± 27%.

For CM200 the target SIN/COS voltage is dependent on how the RDC is configured. Contact Cascadia Motion for more information.

4. Vehicle Interface Setup

4.1 Analog Inputs:

There are 4 analog inputs on GEN 2 units (AIN1-4), 6 analog inputs on GEN 3 units (PM100/PM150/PM250) as AIN1-6, and 3 analog inputs on the RM100 (AIN1-3) and 5 analog inputs on the RM300 (AIN 1-4 and AIN6). The CM200 has 4 analog inputs. The inputs are intended for general analog signal sensing (0 – 5V). There are 5 dedicated RTD sensor inputs (three 1,000 Ohm and two 100 Ohm calibrated RTD channels) on GEN 2 units. There are 2 RTD inputs on GEN 3 units and RM100/RM300, selectable as PT 100 or PT1000 by software.



Schematic of Analog Inputs

The vehicle control system assigns the analog inputs as follows:

Input Name	Function
AIN1	ACCEL The input should be tied to the vehicle accelerator. The input can be used with either a 0-5V signal or a potentiometer.
AIN2	Motor thermistor The motor thermistor can be connected between this input and analog ground. An external pull-up resistor will be required.
AIN3	BRAKE The input should be tied to the brake pedal. The input can be used with either a 0-5V signal or a potentiometer.

AIN4	Not assigned. For some motor types may be assigned to a secondary motor temperature.
AIN5	Not assigned.
AIN6	Not assigned.

The CM200 provides programmable pull-up resistors (1K) on AIN1, AIN2, and AIN3. These pull-ups can be turned on and off via software. The CM200 also provides a 10K pull-down resistor on AIN4 that can not be turned off.

A 5V power supply (XDCR_PWR) is provided for powering sensors or potentiometers. This supply is available on several pins of J1 and J2 to ease connection. However, the total supply current available from this supply is limited to 80mA.

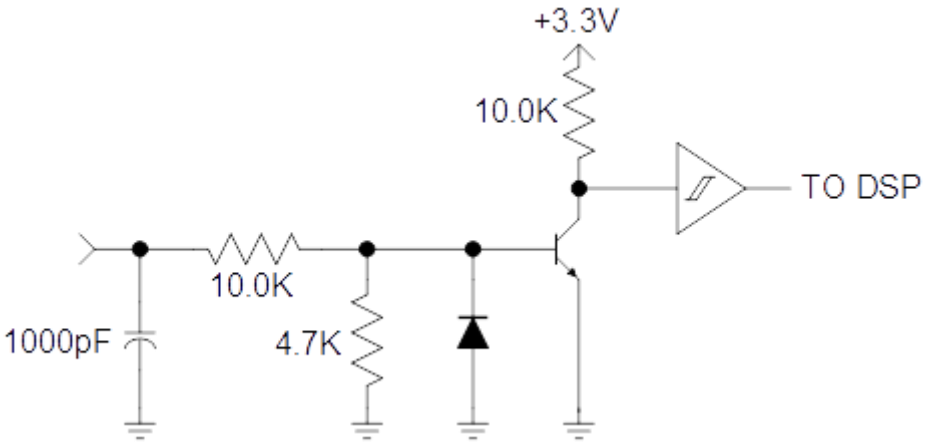
The analog signals should be referenced to one of the analog ground (AGND) pins available on J1. This will reduce noise. Analog ground should NOT be connected to GND or the vehicle chassis.

Description	Parameter	Value
Analog Inputs		
Input Range	V_{range}	0 - 5.00V
Offset Voltage	V_{ofs}	+50mV
Gain Accuracy	G	+5%
ADC Resolution		12b
Pull-up Resistance	R_{pu}	300 k Ω
RTD Inputs – PT 1000 type		1000 Ω / 0ºC
Offset – 25ºC ambient		±3ºC
Temperature error – additional error over temperature		±3ºC
RTD Inputs – PT 100 type		100 Ω / 0ºC
Offset – 25ºC ambient		±3ºC
Temperature error – additional error over temperature		±3°C

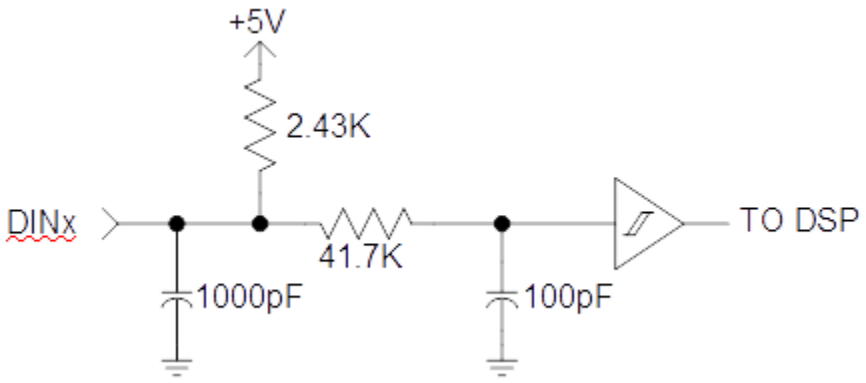
The controller uses two-wire type RTDs. One side of the RTD should be connected to the RTD input. The other side should be connected to Analog Ground or the dedicated RTD ground pin (RTDxN).

4.2 Digital Inputs:

There are up to 8 digital inputs for general interface to the vehicle and for feedback from external contactors and switchgear as required in the application. Some inputs are “Switch To Battery” (STB) inputs. These inputs are designed to be used in an application that switches the input to a positive battery potential. Some of the inputs are “Switch To Ground” (STG) inputs. These STG inputs are designed to be used in an application that switches the input to ground.



Switch to Battery (STB) Input Schematic



Switch To Ground (STG) Input Schematic

The vehicle control system software currently assigns these inputs as follows:

Input	Type	Signal Name	Function
DIN1	STG	FWD_ENA	This input should be connected to a switch that grounds this input when the user is commanding forward direction.
DIN2	STG	REV_ENA	This input should be connected to a switch that grounds this input when the user is commanding reverse direction.
DIN3	STG	BRAKE	This input should be connected to a switch that grounds the input when the brake is pressed.
DIN4	STG	REGEN Disable	This input should be connected to a switch that grounds the input to enable this feature (that is, disable REGEN).
DIN5	STB	IGNITION	If used, this input is assigned to the IGNITION feature.
DIN6	STB	START	If used, this input is assigned to the START feature.
DIN7	STB	Not assigned	Input available for user.
DIN8	STB	Not assigned	Input available for user.

Not all inputs are available on each unit. Below is a table showing which inputs are available (n/a indicates not available).

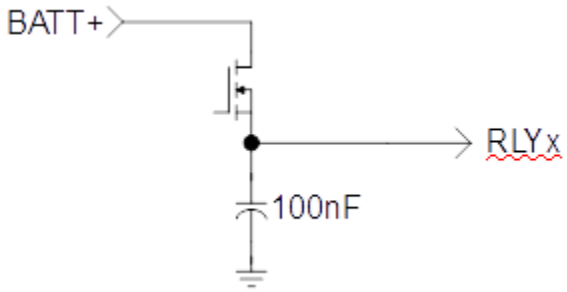
Input	Type	PM100 (Gen2)	Gen3 & Gen5 PM100/PM150/PM250	RM100	RM300	CM200
DIN1	STG	Yes	Yes	Yes	Yes	Yes
DIN2	STG	Yes	Yes	Yes	Yes	Yes
DIN3	STG	Yes	Yes	n/a	Yes	Yes
DIN4	STG	Yes	Yes	n/a	Yes	Yes
DIN5	STB	Yes	Yes	n/a	Yes, STG	n/a
DIN6	STB	Yes	Yes	n/a	Yes, STG	n/a
DIN7	STB	n/a	Yes	n/a	Yes	n/a
DIN8	STB	n/a	Yes	n/a	Yes	n/a

The electrical parameters of the digital inputs are shown in the table below.

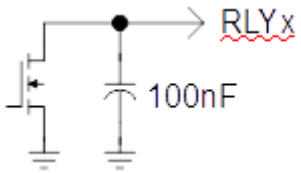
Description	Parameter	Value
Switch to Ground Inputs (DIN1-4)		
Voltage level for “ON”	V_{STG-ON}	<0.9 V
Voltage level for “OFF”	$V_{STG-OFF}$	>4.2 V
Pull-up resistor to 5V	V_{STG-PU}	2.4 kΩ
Maximum Voltage on Input	$V_{STG-MAX}$	18 V
Switch to Battery Inputs (DIN5-8)		
Voltage level for “ON”	V_{STB-ON}	>2.5 V
Voltage level for “OFF”	$V_{STB-OFF}$	<1.3 V
Pull-down resistor	R_{STB-PD}	10 kΩ
Maximum Voltage on Input	$V_{STB-MAX}$	18 V

4.3 Digital Outputs

There are up to 6 digital outputs available. See the table below for more specifics on availability across each model. There are two types of outputs available depending on the particular model.



Schematic of High-Side Driver



Schematic of Low-Side Driver

The vehicle control system assigns the outputs as follows:

Output Name	Type	Function Name	Function
RLY1	HSD	PRECHARGE DRIVE	This output provides power to the pre-charge relay.
RLY2	HSD	MAIN DRIVE	This output provides power to the main contactor.
RLY3	LSD	OK INDICATOR	This output provides a grounded signal to the OK indicator. The indicator turns on when power is applied to the drive and the drive has completed the pre-charge sequence. If used, this output is also used to power the external 12V power relay.
RLY4	LSD	FAULT INDICATOR	This output provides a grounded signal to a fault indicator. The indicator will blink a fault code if the drive has detected a fault.
RLY5	HSD	n/a	Not assigned. Available for use through CAN.
RLY6	HSD	n/a	Not assigned. Available for use through CAN.

The table below documents the availability of each output type across the different inverter models.

Input	Type	PM100 (Gen2)	Gen3 & Gen5 PM100/PM150/PM250	RM100	RM300	CM200
RLY1	HSD	Yes	Yes	Yes	Yes	Yes
RLY2	HSD	Yes	Yes	Yes	Yes	Yes
RLY3	LSD	Yes	Yes	n/a	n/a	Yes
RLY4	LSD	Yes	Yes	n/a	n/a	Yes
RLY5	HSD	n/a	Yes	n/a	n/a	n/a
RLY6	HSD	n/a	Yes	n/a	n/a	n/a

Description	Parameter	Value
Hi-Side Drivers (RLY1-2 and RLY 5-6)		
Output Current - Continuous	Io_cont	1.5A
Output Current – Surge	Io_pk	7A
Low-Side Drivers (RLY3-4)		
Output Current - Continuous	Io_cont	1.5A
Output Current - Surge	Io_pk	3A

Revision History

Version	Description of Versions/ Changes	Updated by	Date
1.8	Added that RTDs should be connected to analog ground.	Azam Khan	9/18/12
1.9	• Updated diagrams that show the dimensions of PM100 and PM150 drives. • Rearranged subsections in section 3.4, PM Motor Controller	Azam Khan	1/15/14
2.0	Distinguished Gen2 connections on J1 – 35p AmpSeal connector from that of Gen 3.	Chris Brune	2/20/14
2.1	Added connector information for the PM250. Updated signal information to reflect the Gen 3 control board used in the PM100, PM150, and PM250.	Chris Brune	3/24/15
2.2	Added additional comments about the cooling system and pressure switches. Added notes about the passive resistor on the DC bus.	Chris Brune	5/11/16
2.3	Added lower case pin designations to the PM250 connectors. Clarified the schematic images only show the PM100/150 pinouts.	Chris Brune	11/29/2016
2.4	Added note about housing grounding. Removed references that are PM100 specific. Improved clarity across different PM Family members.	Chris Brune	12/6/2016
2.5	Corrected wording about pressure switch.	Chris Brune	12/19/2016
2.6	Removed reference to 3/8” NPT. Clarified information about cooling.	Chris Brune	4/5/2017
2.7	Added information about RM100	Chris Brune	6/8/2017
2.8	Corrected the color/key information about the RM100.	Chris Brune	8/29/2017
2.9	Added information about RM100 cooling. Clarified that VSM mode is not available for RM100. Additional clarifications of I/O capability of RM100.	Chris Brune	9/13/2017

3.0	Formatting on RM100 coolant ports. Added RM100 input current info. Updated the Digital Input section to clearly show which inputs are available. Updated Digital outputs section to show which are available. Clarified analog inputs availability.	Chris Brune	1/17/2018
3.1	Updates to include the RM300	Chris Brune	4/2/2019
3.2	Update formatting for Cascadia Motion. Add PM500 information. Add L100 information.	Chris Brune	11/13/2020
3.3	Name change from L100 to CM200	Travis Gintz	1/14/2021
3.4	Correct swapped CAN lines on M1 for PM500.	Chris Brune	2/1/2021
3.5	Added PM500 recommended pre-charge resistor.	Chris Brune	5/12/2021
3.6	Added PM250 crimper. Corrected CM200 connector pin part number, added RM300DZ 12/24V current draw.	Travis Gintz	6/17/2021
3.7	Added Y-capacitance. Added CM200DZ/CM350DZ capacitance values. Added precharge info for CM200DZ/CM350DZ. Updated coolant information for CM200/CM350.	Chris Brune	10/25/2021