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RMS PM
Hardware User Manual

Revision 2.0

0A-0001-01

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

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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.

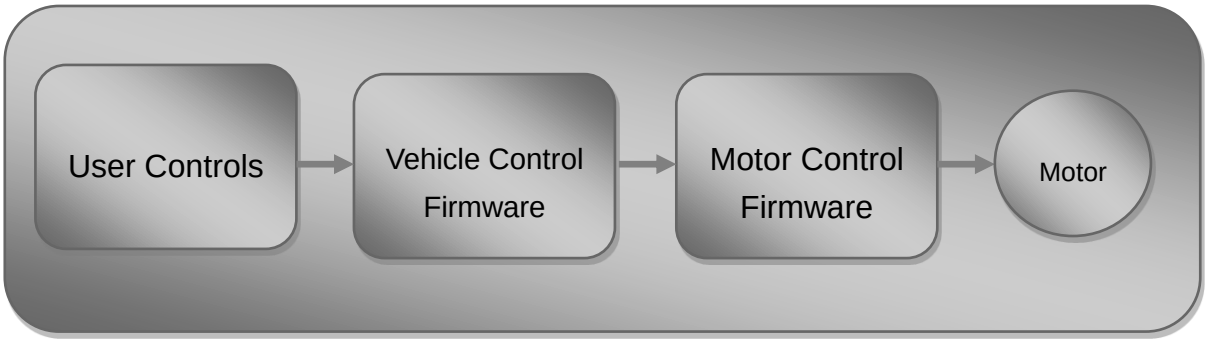
Safety is entirely the responsibility of the installer of this equipment. RMS has done everything it can to ensure that the traction controller itself conforms to international standards for safety, including electrical safety spacings on printed circuit boards and in connectors and wiring harnesses, and for electromagnetic compatibility with other systems on a typical vehicle. 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.

RMS 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 PM100 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, Direct Field Oriented Vector motor control technology that has been used on AC Induction and PM Synchronous motors in many applications. The use of Direct Field Orientation, measuring and regulating the machine flux with the use of an observer, allows the control to track actual torque production in real time, including the effects of transients and disturbances that an Indirect Field Oriented controller cannot handle.

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 standard PM100 is 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.

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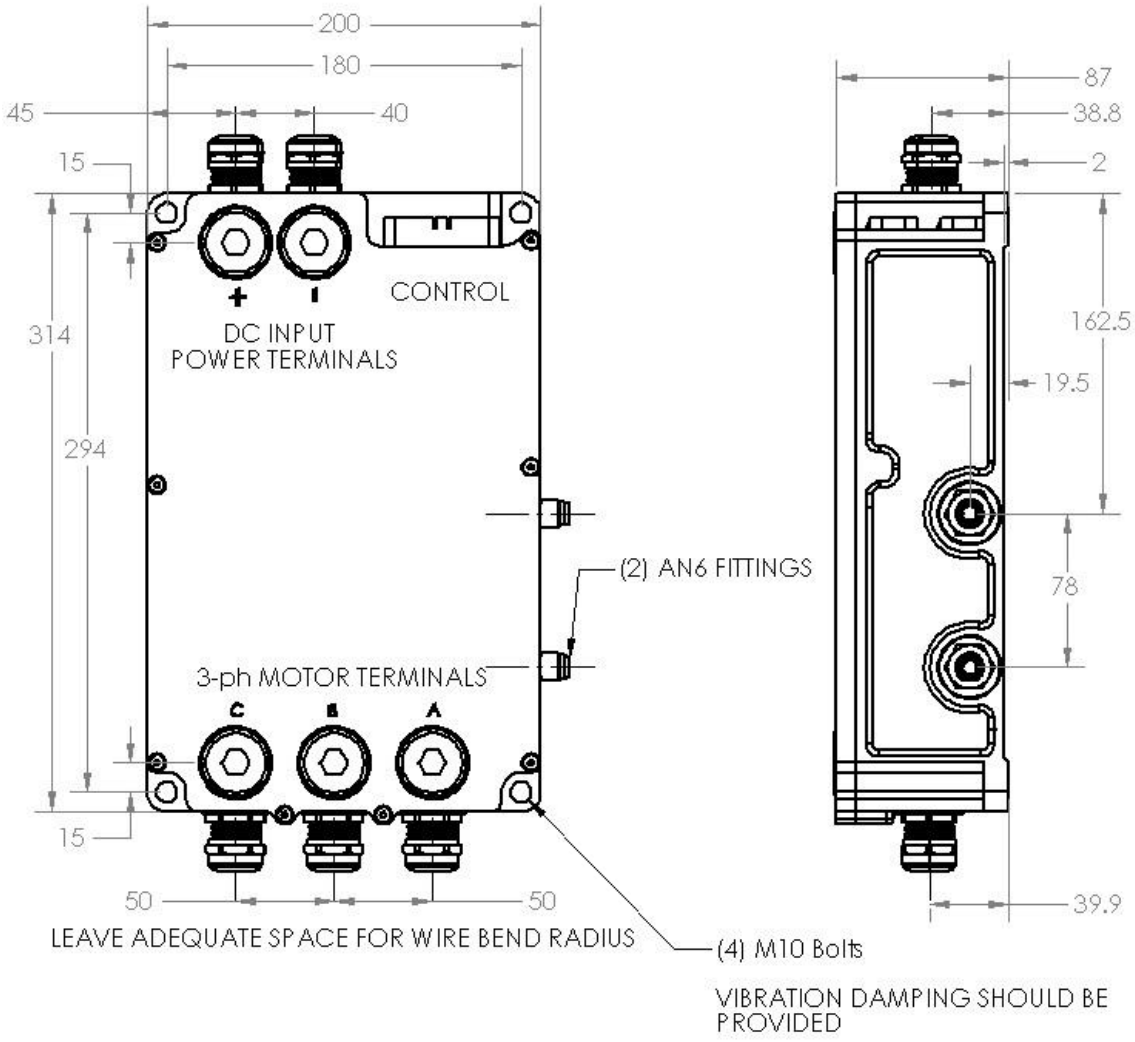
3. Installing the PM Drive:

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.



PM100 Dimensions – top and side views

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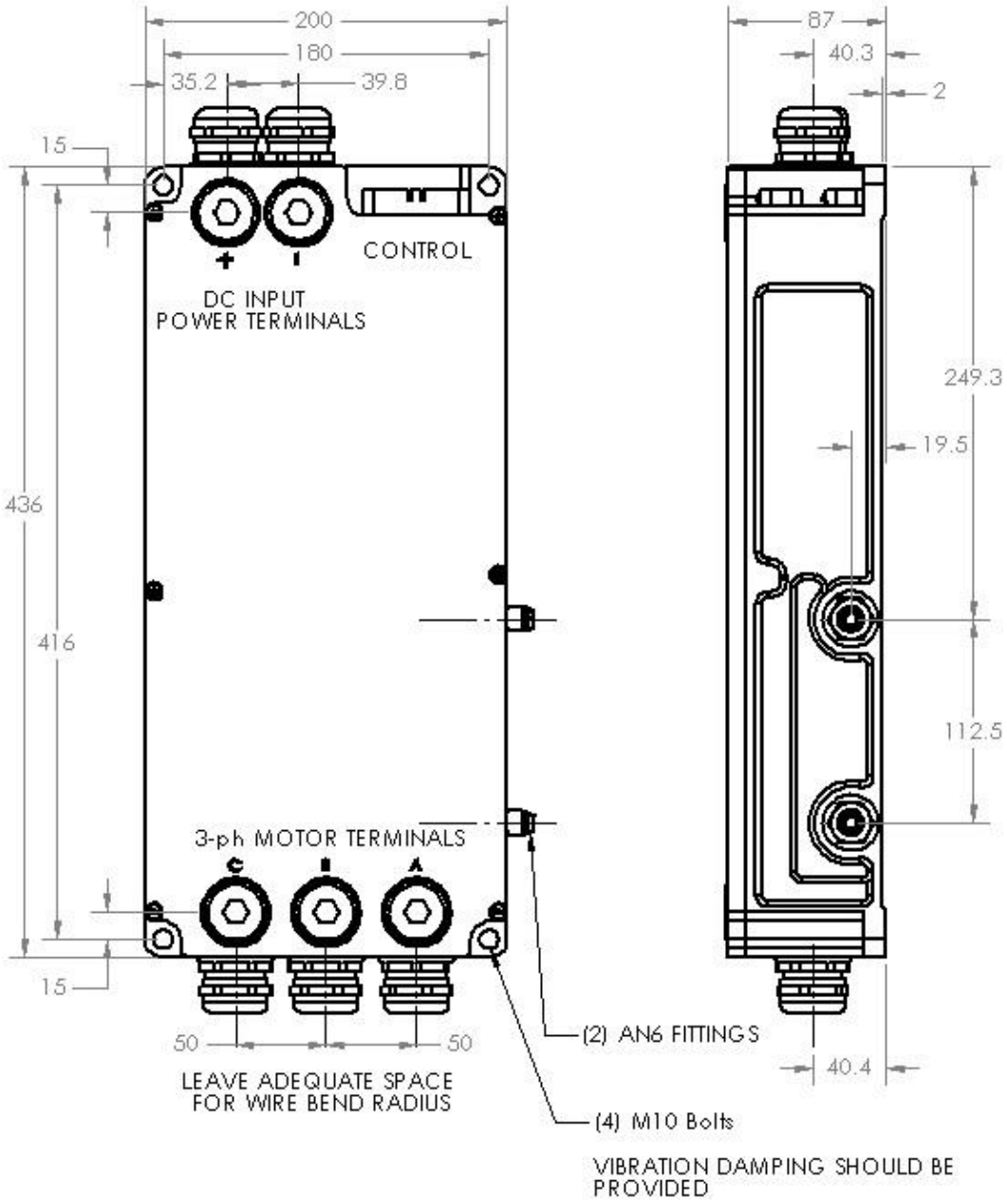

PM150 Dimensions – top and side views

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. Each port is designed to accommodate a 3/8 inch NPT fitting. While it generally isn't critical, 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. 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 Operation -40.. -30; +80.. +100°C with derated output
Coolant Flow Rate	8 – 12 LPM (2 – 3 GPM)
Pressure Drop	PM100, < 0.3 bar (4.4 psi) @ 8 LPM
Port Size	PM100 and PM150, AN-6

3.2 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 GEN2	RTD1	1000 Ohm RTD Input	
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 6 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

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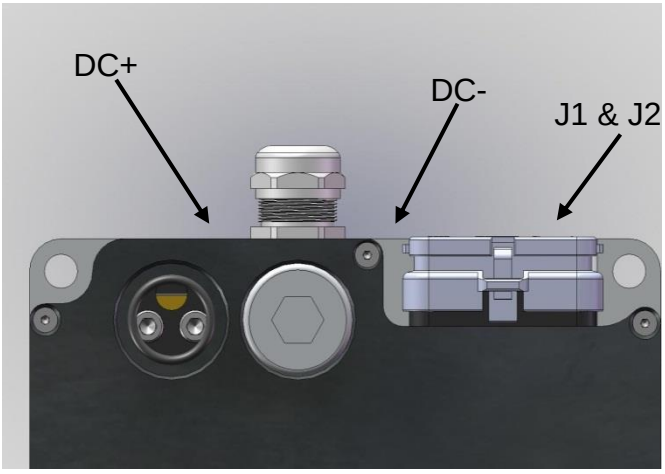
3.3 External Power Connections:

3.3.1 DC+ / DC-:

DC/Battery power is provided to the controller via two wire ports located at the rear of the controller. 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.

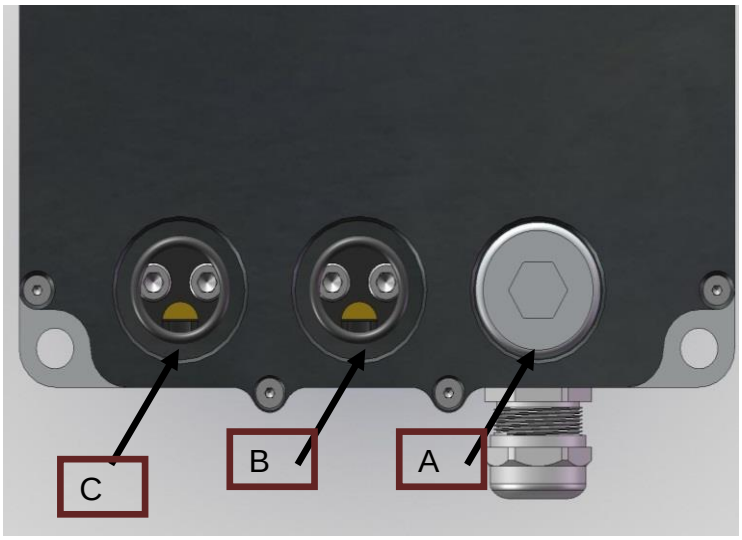


DANGER: Before changing the wiring make sure that the internal DC bus capacitors are discharged. The voltage should be measured at the terminals before disconnecting. If there is any doubt about the safety wait at least 1 hour after power has been removed before touching the terminals.

ATTENTION

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

3.3.2 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. The PM100 family units are shipped with cable glands that are metallic and designed to accommodate shielded wire.

3.3.3 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.

RMS can provide the following parts for up to 360V systems if needed. Reference the following:

- Pre-charge Relay (30A, 12V COIL): RMS p/n 77-0026
- Pre-charge Resistor (600 ohm 50W): RMS p/n 53-0006
- Pre-charge Fuse (5A 500V): RMS p/n 59-0008

Model	Internal Capacitance	Maximum Pre-charge Resistor	RMS Part
PM100DX/PM100DXR	440uF	1200 ohms	53-0006
PM100DZ/PM100DZR	280uF	2000 ohms	Contact RMS
PM150DX/PM150DX	880uF	600 ohms	53-0006
PM150DZ/PM150DZR	560uF	1000 ohms	Contact RMS

For higher voltage systems please contact RMS for more information.

3.3.4 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. RMS has successfully used the following: Tyco/Kilovac p/n EV200AAANA. This contactor is available from RMS, contact us for more information (RMS p/n 77-0025). 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.

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3.3.5 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. Bussmann type FWP-400A is a suitable choice in many applications.

3.3.6 12V Power:

The PM100 requires a source of 12V power to operate. Normally, this power will be on a switched circuit:

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 of J2 (pins 8 and 23). The ground return for 12V power is connected to the GND terminals of J2 (pins 6 and 14). For normal applications only one pin is necessary. If necessary the 2nd set of pins can be used for applications that push higher 12V or GND currents through the controller.

Quiescent currents:

12V Operating Power Input Range	8V – 18V
12V Input Current @ 8V, operating	< >
12V Input Current @ 14V, operating	$2A_{\_typ}$
12V Input Current @ 18V, operating	$1.6A_{\_typ}$
12V Input Current @ 14V, non-operating (PWM off)	< >

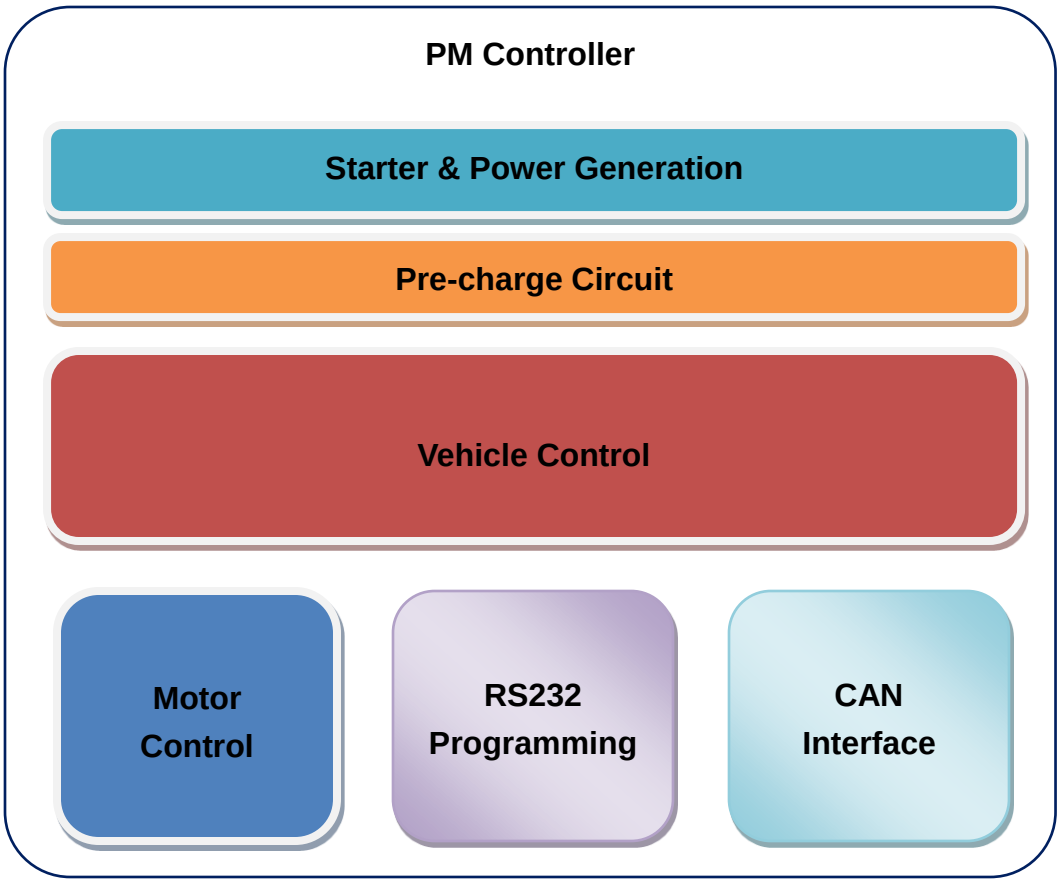
These currents do not include any high-side or low-side drivers:

- 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.

3.4 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



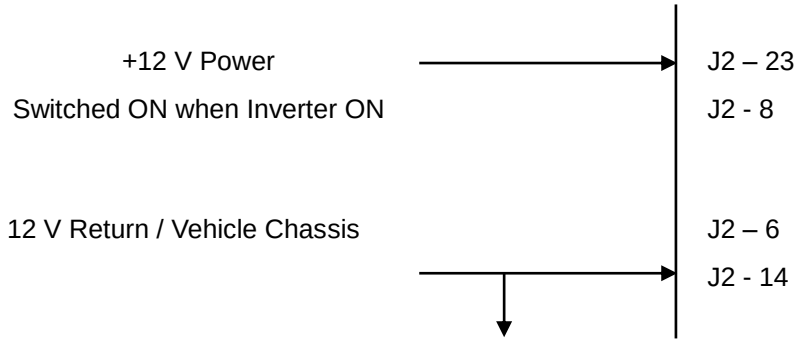
3.4.1 Controller 12V Power Wiring

This circuit can be configured in two different ways:

(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.

Controller 12V Power Wiring - Configuration 0

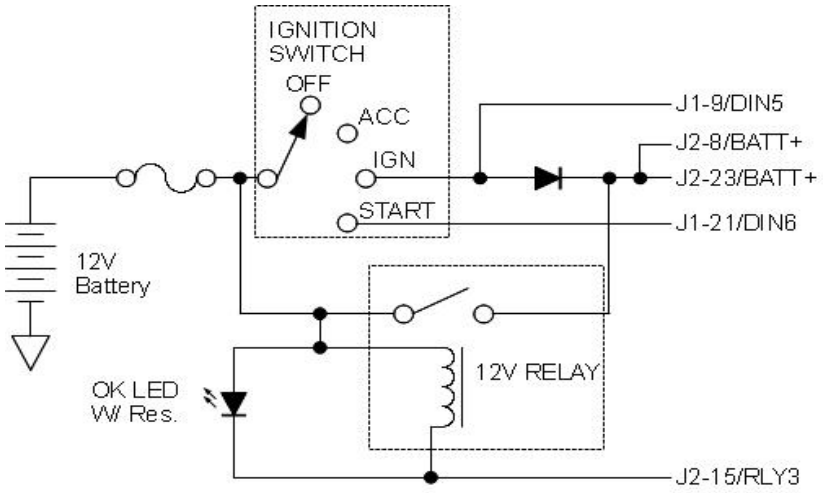


(b) Typical Ignition Configuration

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.

Starter & Power Generation - Configuration 1



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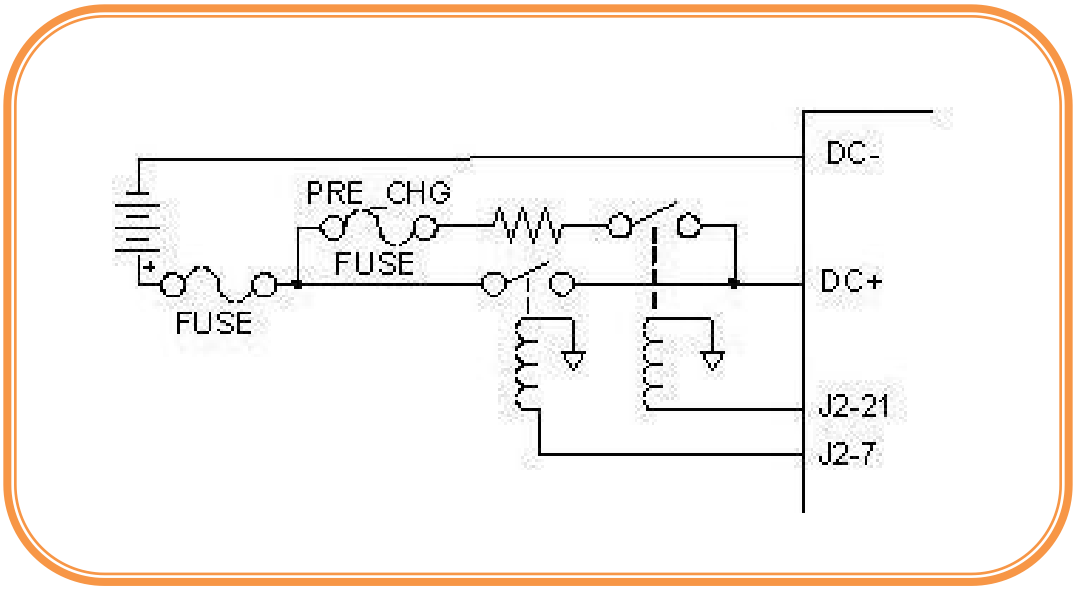
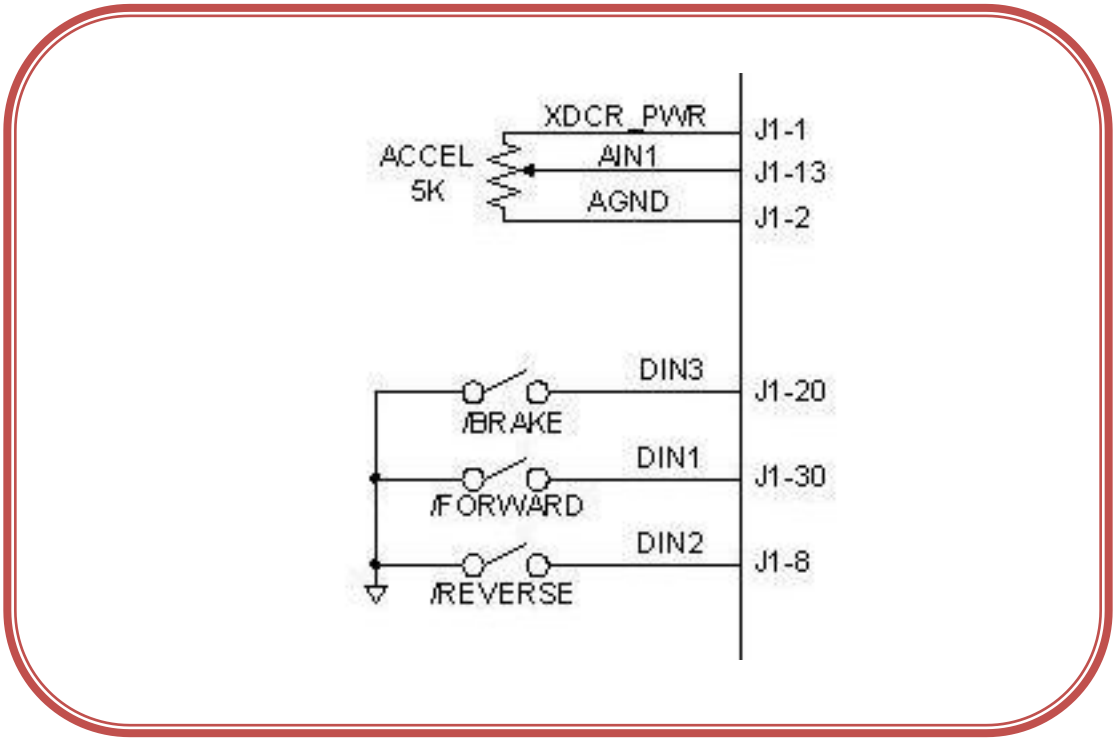
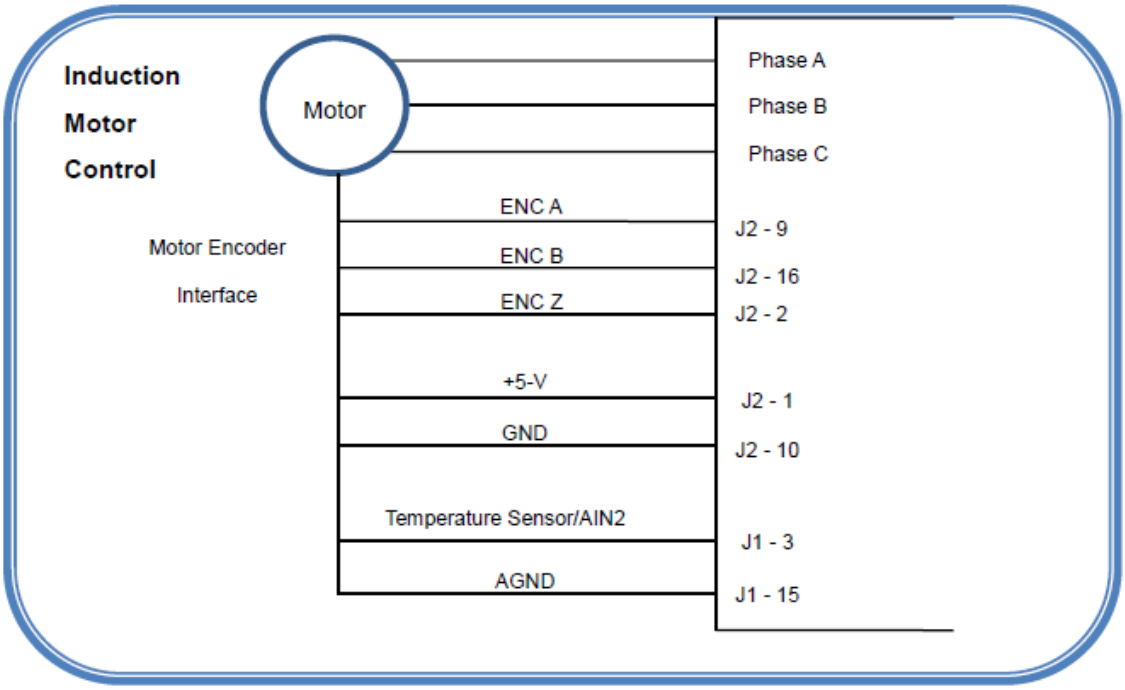
3.4.2 Pre-charge Circuit

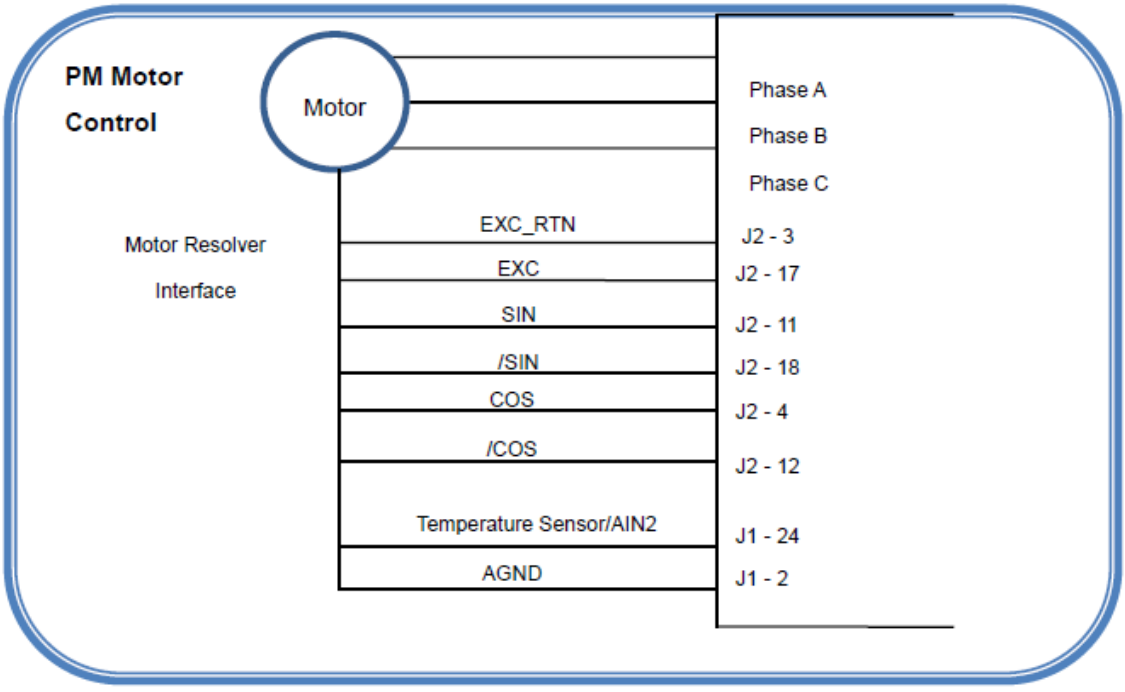


3.4.3 Vehicle Control (Does not apply if using CAN for control)



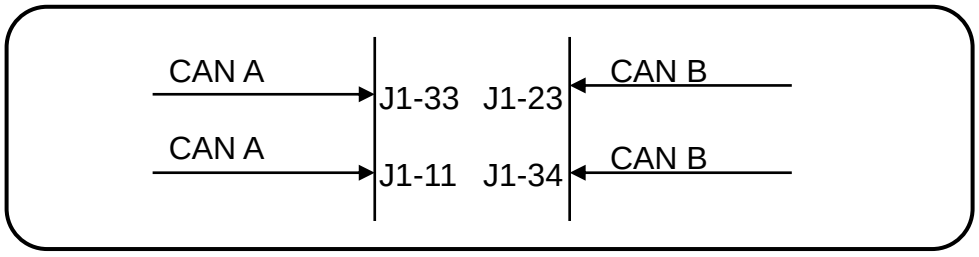
3.4.4 Motor Control (Typical Wiring)





3.4.5 CAN Interface

PM100 controller has 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. The CAN protocol conforms to CAN 2.0 A using 11-bit identifiers. The default bus speed is 250kbps and every message has a data length code (DLC) of 8 bytes.



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 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.
- CAN Identifier Offset: The default identifier is 0x0A0. However, user can choose any address between 0 and 0x7C0.
- CAN Active Messages Word: This parameter is defined to enable/disable CAN Broadcast Messages. Each bit in this parameter represents a CAN Message broadcast status. Setting the bit to 0 disables the corresponding message. Setting the bit to 1 enables the broadcast.

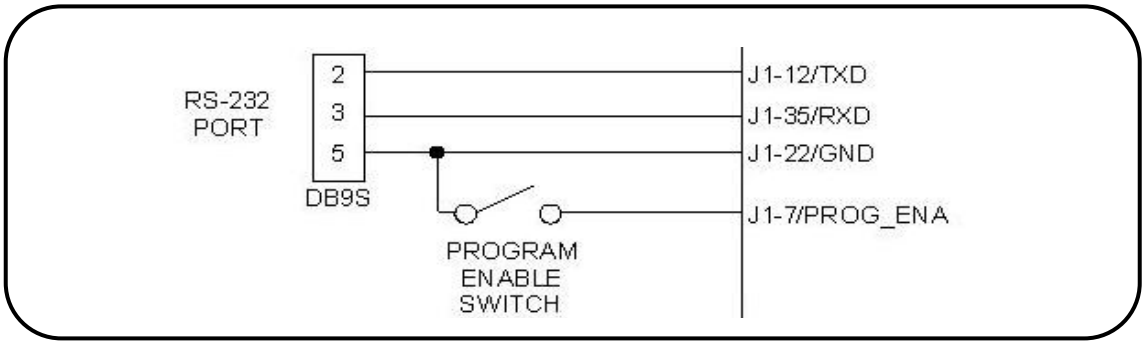
For more information on CAN interface and messages, please refer to the “RMS CAN Protocol” document.

3.4.6 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. RMS provides a simple Windows PC based software package for monitoring and changing parameters (RMS GUI).

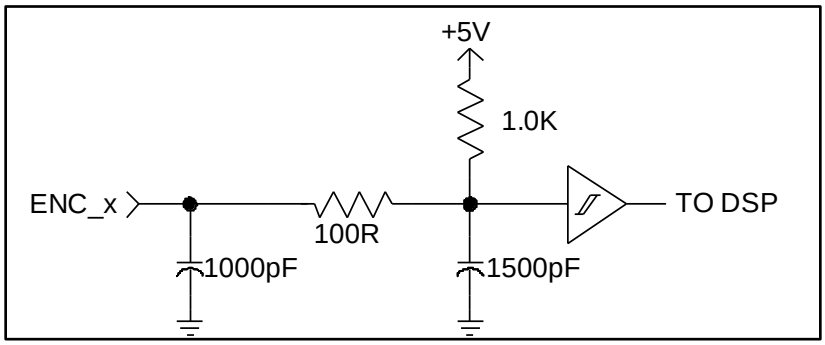
The drive can also be placed in a data-logging mode, and used with a PC, Palm, or other serial device the unit broadcasts datasets at 3Hz of a number of parameters that allow performance and energy consumption data to be gathered in real time.

For more information on RS232 data logging refer to the “RMS SCI Data Acquisition” document.



3.4.7 Encoder Interface:

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

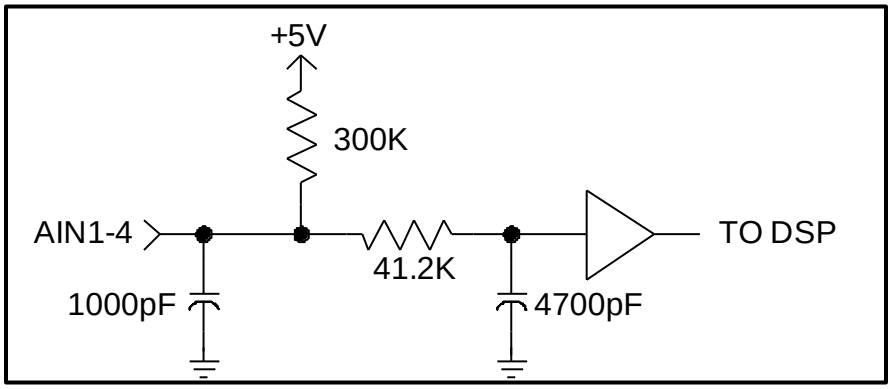
3.4.8 Resolver Interface:

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. Currently all PM type motors used with the RMS controller require a resolver for position feedback.

4. Vehicle Interface Setup

4.1 Analog Inputs:

There are 4 analog inputs, 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).



Schematic of Analog Inputs AIN1 – 4

The vehicle control system assigns the analog inputs as follows:

Input Name	Pin #	Function
AIN1	J1-13	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	J1-24	Motor thermistor The motor thermistor can be connected between this input and analog ground. An external pull-up resistor will be required.
AIN3	J1-25	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	J1-3	Not assigned.

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.

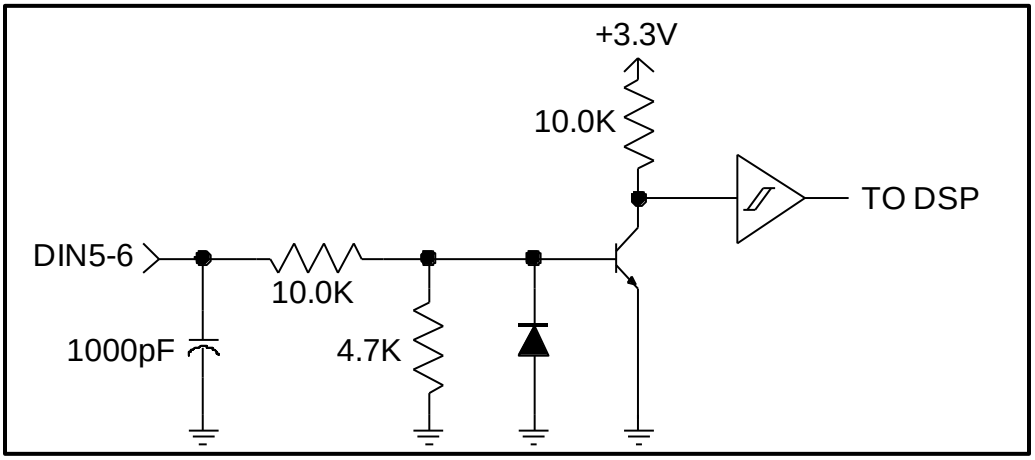
The analog signals should be referenced to one of the analog ground (AGND) pins available on J1. This will reduce noise. Analog ground should NOT be connected to GND or the vehicle chassis.

Description	Parameter	Value
AIN 1 – AIN 4		
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
RTD1 – RTD3		1000 Ω / 0ºC
Offset – 25ºC ambient		±3ºC
Temperature error – additional error over temperature		±3ºC
RTD4 – RTD5		100 Ω / 0ºC
Offset – 25ºC ambient		±3ºC
Temperature error – additional error over temperature		±3°C

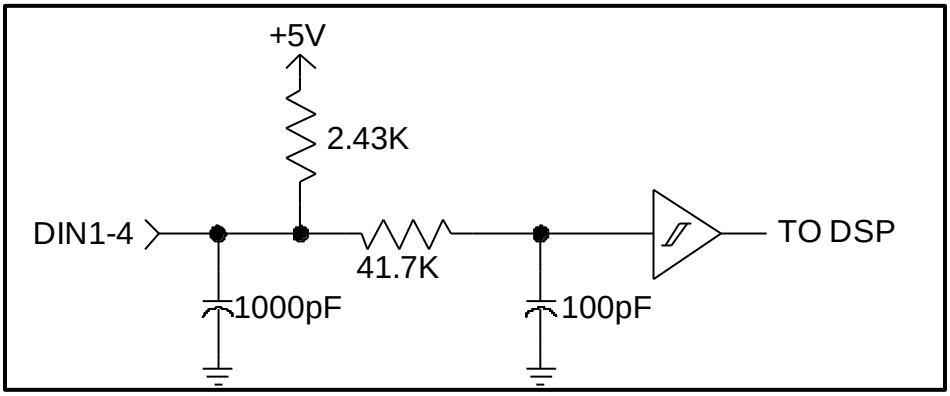
RTD inputs should be connected to analog GND.

4.2 Digital Inputs:

There are 6 digital inputs for general interface to the vehicle and for feedback from external contactors and switchgear as required in the application. Two 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. There are four inputs that 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

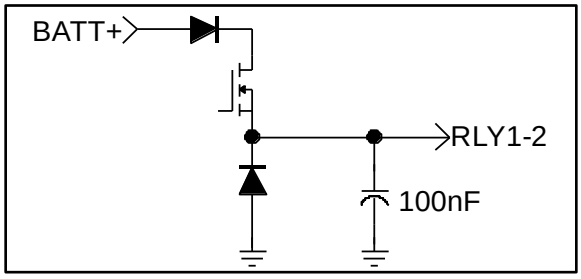
The vehicle control system software currently assigns these inputs as follows:

Input	Type	Pin #	Signal Name	Function
DIN1	STG	J1-30	FWD_ENA	This input should be connected to a switch that grounds this input when the user is commanding forward direction.
DIN2	STG	J1-8	REV_ENA	This input should be connected to a switch that grounds this input when the user is commanding reverse direction.
DIN3	STG	J1-20	BRAKE	This input should be connected to a switch that grounds the input when the brake is pressed.
DIN4	STG	J1-31	REGEN Disable	This input should be connected to a switch that grounds the input to enable this feature (that is, disable REGEN).
DIN5	STB	J1-9	IGNITION	If used, this input is assigned to the IGNITION feature.
DIN6	STB	J1-21	START	If used, this input is assigned to the START feature.

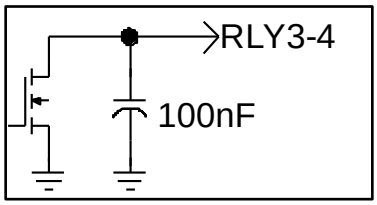
Description	Parameter	Value
Switch to Ground Inputs (DIN1 - DIN4)		
Voltage level for “ON”	V_{STG-ON}	<0.9 V
Voltage level for “OFF”	$V_{STG-OFF}$	>4.2 V
Pull-up resistor to 5V	V_{STG-PU}	2.4 kΩ
Maximum Voltage on Input	$V_{STG-MAX}$	18 V
Switch to Battery Inputs (DIN5 - DIN6)		
Voltage level for “ON”	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 4 digital outputs for general interface to the vehicle. Two of the outputs provide a high-side driver (output switches to battery potential). Two of the outputs are low-side drive (output switches to ground).



Schematic of High-Side Driver (RLY1-2)



Schematic of Low-Side Driver (RLY3-4)

The vehicle control system assigns the outputs as follows:

Output Name	Pin #	Signal Name	Function
RLY1 / HSD	J2-21	PRECHARGE DRIVE	This output provides power to the pre-charge relay.
RLY2 / HSD	J2-7	MAIN DRIVE	This output provides power to the main contactor.
RLY3 / LSD	J2-15	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	J2-22	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.

Description	Parameter	Value
Hi-Side Drivers (RLY1-2)		
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

Each of the digital outputs is rated for 1.5 Amp. However, the two high-side drivers (RLY1 and RLY2) share a common reverse polarity diode thus the total current consumption of these two outputs cannot exceed 1 amp continuous.

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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 3J1 – 35p AmpSeal connector from that of Gen 3.	Chris Brune	2/20/14