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Setting up the PM/RM Controller to run with Phi-Power Motors

Revision 0.7

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1. Introduction

This document describes the setup of Phi-Power motors with the PM and RM Family controllers from Cascadia Motion.

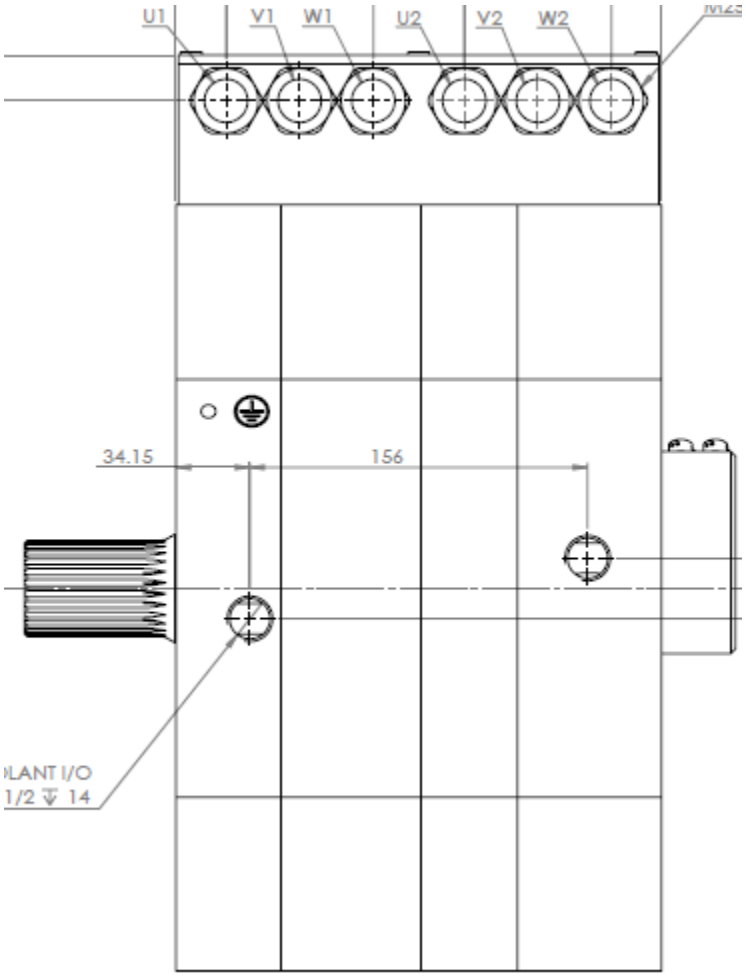
Motor Configuration	Motor Type	Inverter Configuration
PH382.2.6.2.XXX PH381.2.3.1.XXX (2-turn) (using 2x PT100 RTD for temperature)	154	Greater than 400Vdc: PM250DZ PM250DZR Less than 400Vdc: PM250DX
PH382.3.6.2.XXX PH381.3.3.1.XXX (3-turn) (using 2x PT100 RTD for temperature)	155 (3X Resolver) 194 (1X Resolver)	Greater than 400Vdc: PM250DZ PM150DZ Less than 400Vdc: PM150DX
PR.1702.900 Custom	n/a	PM100DXR
PHI301.5.3.1.XXX (5-turn) (1X Resolver)	167	Greater than 400Vdc: PM150DZ PM150DZR Less than 400Vdc: Not a recommended configuration
PHI301.4.3.1.XXX (4-turn) (1X Resolver)	183	Greater than 400Vdc: PM150DZ PM150DZR Less than 400Vdc: PM100DX PM150DX

PH381.4.3.1.XXX PH382.4.6.1.XXX (4-turn) (3X resolver)	184	Greater than 400Vdc: PM150DZ PM250DZ Less than 400Vdc: PM100DX
PH381.4.3.1.XXX PH382.4.6.1.XXX (4-turn) (1X resolver)	185	Greater than 400Vdc: PM150DZ PM250DZ Less than 400Vdc: PM100DX
PHI301.6.3.1.XXX (6-turn) (1X resolver)	219	Greater than 400Vdc: PM150DZ PM150DZR Less than 400Vdc: Not a recommended configuration
PH382.5.3.1 (5-turn) (1X resolver)	224	Greater than 400Vdc: PM150DZ RM300DZ PM250DZ Less than 400Vdc: Not a recommended configuration

There are three sets of connections between the motor and the controller, the resolver, the temperature sensors, and the motor power leads. All must be done properly for the motor to operate correctly.

2. Connections for PH382.X.6 Motor

The PH382.X.6 motors have 6 motor connections. It is intended to be operated by two inverters. The inverters should both be in torque control mode so that the load is balanced between the two inverters. The inverters should have the same torque command.

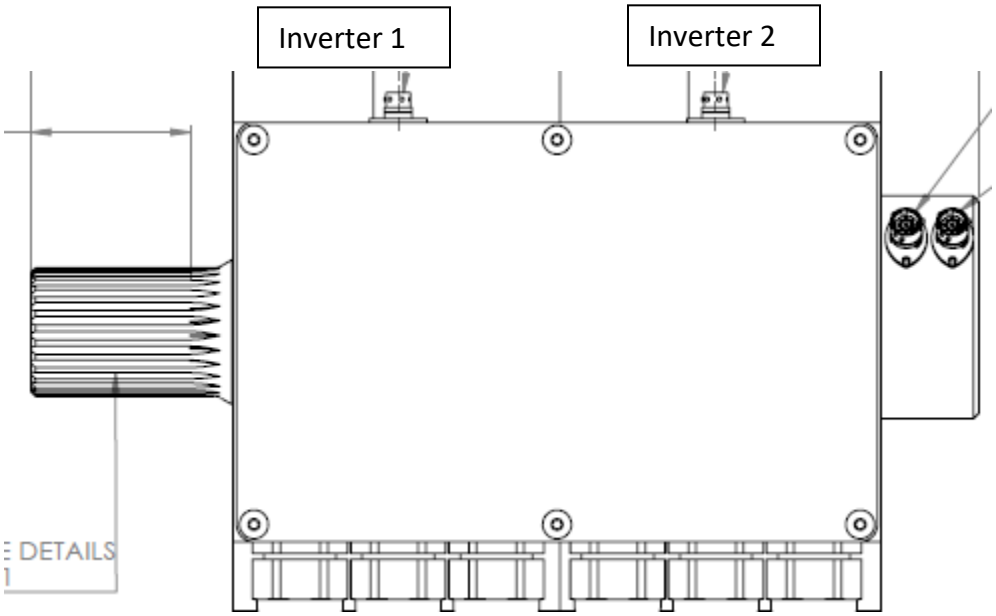


Motor High Voltage Connection Order

The PH382.X.6 requires two inverters to operate. Connections to the two inverters are as shown below.

Motor	Inverter
U1	Inverter 1 Phase A
V1	Inverter 1 Phase B
W1	Inverter 1 Phase C
U2	Inverter 2 Phase A
V2	Inverter 2 Phase B
W2	Inverter 2 Phase C

If the connections are made as noted above the motor shaft will turn in a clockwise fashion (when facing the shaft) for positive speed feedback.



The motor has two resolver connections. One resolver connection goes to each inverter. The resolver connections are at the back of the motor using a 9 pin Deutsch ASDD connector. The connector closest to the motor body should be connected to Inverter #1.

ASDD Pin #	Signal	Color	PM100 /PM150	PM250
1	R1 / EXC+	Black	J2-17	J1-A
2	R2 / EXC-	Brown	J2-3	J1-B
3	S1 / COS+	Red	J2-4	J1-E
4	S3 / COS-	Orange	J2-12	J1-F
5	S2 / SIN+	Yellow	J2-11	J1-C
6	S4 / SIN-	Green	J2-18	J1-D
7	Interlock	Blue	n/a	n/a
8	Interlock	Purple	n/a	n/a
9	Not used	Grey	n/a	n/a

The motor also has two connectors for motor temperature. One for Inverter 1 and one for Inverter 2. Each connector has signals for two PT100 RTDs. Each connector is a 6 way Deutsch ASX connector.

ASX Pin #	Signal	Color	PM100 /PM150	PM250
1	Stator RTD+	Black	J1-5	J1-G
2	Stator RTD-	Brown	J1-15	J1-H

3	Mid Stator RTD+	Red	J1-6	J1-R
4	Mid Stator RTD-	Orange	J1-17	J1-S
5	Interlock	Yellow	n/a	n/a
6	Interlock	Green	n/a	n/a

If desired the Interlock connections can be used by the system vehicle controller to detect when the resolver connector has been unplugged.

The preferred option of the resolver wiring is to use shielded twisted pair wire. **The shield should be left disconnected on the motor side, it should only be connected on the inverter side to J1-T (for PM250) and J2-19 (PM100/PM150).**

3. Setting the 'Motor Type'

The PM controller firmware has the ability to drive several different motor types. The user must tell the controller what type of motor it is to be used with. This is done via the Motor_Type_EEPROM parameter. Refer to the Programming EEPROM Parameters using GUI manual for more information on programming EEPROM parameters. For Phi-Power motors the following motor types are used:

Model	Motor Type	Temperature Sensor Type	Firmware Version
PH381-2	154	PT100 RTDs	19B4 20180511
PH381-3	155	PT100 RTDs	19B4 20180511
PH381-3	194	PT100 RTDs	2024 20200115
PHI301-5	167	PT100 RTDs	2016 20181105
PHI301-4	183	PT100 RTDs	2019 20190823
PH381-4 (3X resolver)	184	PT100 RTDs	2019 20190823
PH381-4 (1X resolver)	185	PT100 RTDs	2020 20190904
PHI301-5	219	PT100 RTDs	2020 20201014
PH382-5	224	PT100 RTDs	2042 20201123

***** Please note that motor type numbers above 60 must use the Group 2 firmware.**

The controller has the ability to use PT100 or PT1000 RTDs. Since this motor has PT100 RTD the controller must be told to configure the RTD inputs for PT100. This is done by setting the RTD_Selection_EEPROM_(BITS_1_0) parameter to a value of 3.

When you set the motor type via the GUI it will automatically adjust some default parameters. However, there are several additional parameters that should be reviewed and adjusted if desired.

EEPROM Parameter	Description
Veh_Flux_EEPROM_(Wb)_x_1000	This is the back EMF (flux) constant for the motor. It will automatically default to the correct value when the motor type is changed. There is no need to change this.
IQ_Limit_EEPROM_(Amps)_x_10	This parameter sets the maximum value of the torque producing current that can be commanded. The amount of allowable current is dependent on the motor type and the controller type. The current is set in peak Amps times 10. For example, 300 A_{rms} = 4250.
ID_Limit_EEPROM_(Amps)_x_10	This parameter sets the maximum amount of field weakening current.
Mtr_OverTemp_Limit_EEPROM_(C)_x_10	This parameter sets the motor over-temperature fault limit. It is set in degrees C times 10. Thus for 150°C it would be set to 1500. It would be wise to set this parameter so that if a cooling system failure occurs it would fault immediately.
Motor_Overspeed_EEPROM_(RPM)	This parameter sets the speed at which an over-speed fault will be generated. It should be set based on the needs of the vehicle system for over-speed protection.
Max_Speed_EEPROM_(RPM)	This parameter sets the maximum speed that the controller will command.
Break_Speed_EEPROM_(RPM)	The Break Speed is the speed at which the torque capability of the motor starts to decrease due to lack of voltage from the motor controller. This value should be set based on information from either Cascadia Motion or the motor manufacturer on the performance of the motor with the particular battery voltage being used.
Motor_Torque_Limit_EEPROM_(Nm)_x_10	This sets the maximum torque command when operating in VSM mode.
Regen_Torque_Limit_EEPROM_(Nm)_x_10	This sets the maximum regen torque command when operating in VSM mode.

3.1 Recommended Settings for Parameters

The table below shows the Cascadia Motion recommended settings for the parameters that are motor specific. There are many factors that may influence a decision to deviate from these settings. If there are questions about the settings, please contact either Cascadia Motion or Phi-Power for more information.

Motor	Inverter	Battery	Vehicle Flux*	IQ Limit	ID Limit	Motor Over-speed**	Break Speed	Torque Limit*** (Motor/Regen)
		Volts	*Weber*	*A (pk)*	*A (pk)*	*RPM*	*RPM*	*N.m.*
PH381.2 Type 154	PM250DZ	650	*	848	300	6200	6000	573
	PM250DZR			989				668
	PM250DX	320		989		6200	3000	668
PH381.3 Type 155 Type 194	PM150DZ	650	*	424	300	6200	4500	428
	PM250DZ			728				734
	PM150DX	320		636			2250	641
PHI301.5 Type 167	PM150DZ	650	*	424	170	9000	5500	363
	PM150DZR			498				426
PHI301.4 Type 183	PM100DX	320	*	495	230	9000	TBD	364
	PM150DX			636			TBD	467
	PM150DZ	650		425			TBD	312
	PM150DZR			566			TBD	416
PH381.4 Type 184 Type 185	PM100DX	320	*	495	230	6200	TBD	664
	PM150DZ	650		425		6200	TBD	570
	PM250DZ			596			TBD	800
PHI301.6 Type 219	PM100DZ	650	*	283	188	9000	5500	312
	PM150DZ			415				457
PM382.5 Type 224	PM150DZ	650	*	424	453	6200	TBD	711
	PM250DZ			748				1252
	RM300DZ			748				1252

* Do not change the Veh_Flux level from the default that is set when the motor type is changed.

** The motor over-speed parameters are given based on the capability of the given motor for the particular battery voltage and inverter.

*** Note that the maximum torque command shown does not indicate that the motor will actually achieve that torque. The torque number shown does not include saturation effects that will reduce the actual torque to be less than the number shown. The torque command shown is given to indicate the torque command that is needed to achieve the maximum current of either the motor or the inverter.

Revision History

Version	Description of Versions / Changes	Responsible Party	Date
0.1	Initial version	Chris Brune	5/11/2018
0.2	Add information about PHI301.5 Add clarification on the RTD settings.	Chris Brune	3/10/2019
0.3	Add information about PH301.4 Add information about PH381.4 Updated RMS to Cascadia Motion.	Chris Brune	8/23/2019
0.4	Add information about PH381.4 with 1X resolver	Chris Brune	9/4/2019
0.5	Add information about PH381.3 with 1X resolver	Chris Brune	1/15/2020
0.6	Add information about PH301.6 with 1X resolver	Chris Brune	10/14/2020
0.7	Add information about PH382.5.3.1 with 1X resolver	Chris Brune	11/23/2020