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Setting up the PM/RM Controller to run with BorgWarner Motors

Revision 2.8

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1. Introduction

This document describes how to interface the BorgWarner (formerly Remy) motors to the Cascadia Motion inverters.

The following BorgWarner motor and controller configurations are currently supported:

Motor	Controller Configuration
HVH250-090S	PM100DX & 320V Battery
HVH250-090S	PM100DZ, PM150DZ & 650V Battery
HVH250-090P	PM100DX, PM100DXR, PM150DX & 320V Battery
HVH250-090P	PM150DZ, PM150DZR, PM250DZ & 650V Battery
HVH250-115S	PM100DX & 320V Battery
HVH250-115S	PM100DZ, PM150DZ & 650V Battery
HVH250-115P	PM100DX, PM100DXR, PM150DX, PM250DX & 320V Battery
HVH250-115P	PM150DZ, PM150DZR, PM250DZ & 650V Battery
HVH410-075DOM	PM150DZ, PM250DZ & 650V Battery
HVH410-150P*	PM100DX, PM100DXR, PM150DX & 320V Battery
HVH410-150S*	PM100DX & 320V Battery
HVH410-150DOM	PM150DZ, PM250DZ & 650V Battery
HVH146	PM100DX, CM200DX & 320V Battery

* as of 8/3/12 this motor is unverified as to its performance.

Note: 320V/650V Battery represents the nominal configuration point. The controller will automatically scale operation for battery voltages that are higher or lower than the nominal point. However, the motor performance will be diminished as the battery voltage is less than nominal. Additionally, a PM150DX or PM100DXR can be used in a configuration where the PM100DX is recommended. The PM150DX and PM100DXR will have excess capability that can not be used.

Although not specifically called out RM100 inverters can be configured for the same motors as PM100 inverters. RM300 inverters can be configured for the same motors as PM250 inverters.

There are two sets of connections between the motor and the controller, the resolver/temperature sensor and the motor power leads. Both must be done properly for the motor to operate correctly.

The motors can come in several different form factors. The motor can come in its “cartridge” form that includes a steel housing that goes around the stator and does not include a motor shaft (see Figure 2). The motor normally comes in an aluminum case that includes a motor shaft (see Figure 3).

The resolver connector that comes standard with the cartridge version is a 10 pin Delphi connector. The connector can come in various keying options. The color of connector can also be different (cream, blue, and black). Regardless of the color of connector body the connection pin-out between this Delphi connector and the controller are the same.

Refer to Figure 1 below for the connections between the BorgWarner Motor and the controller when the Delphi (Aptiv) 10 pin connector is used. A resistor (Rpu) must be added for the motor temperature sensor to work properly. This resistor must be 1.00K ohm, 1% tolerance. The power rating of the resistor is not critical. Refer to the PM/RM Hardware User’s Manual for more information on the controller connectors.

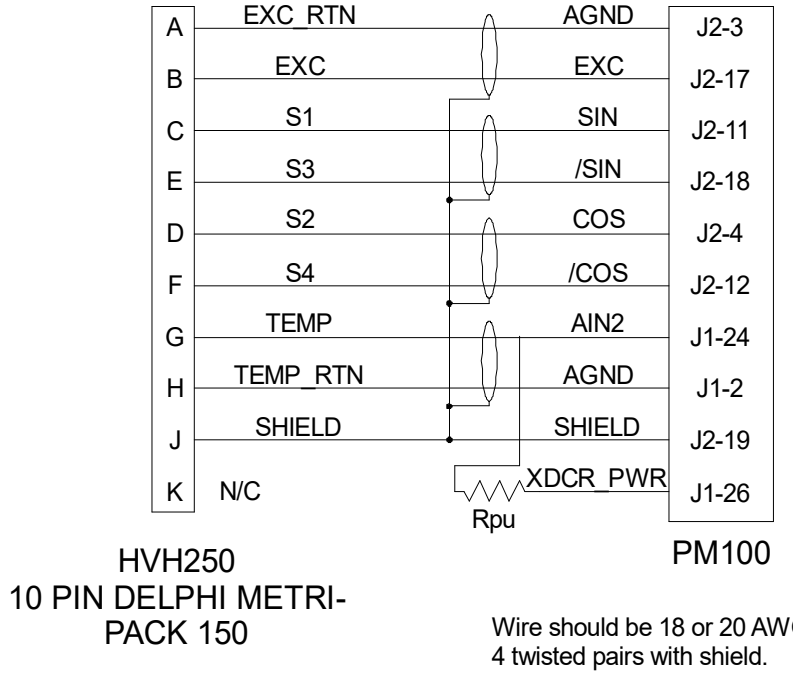

Figure 1: Resolver Connections

The motor cables must be connected in a specific order between the BorgWarner motor and the inverter. Figure 2 shows the connection designations on the BorgWarner motor for the EP8 cartridge. This picture shows the rear of the motor (opposite the shaft side of the motor).

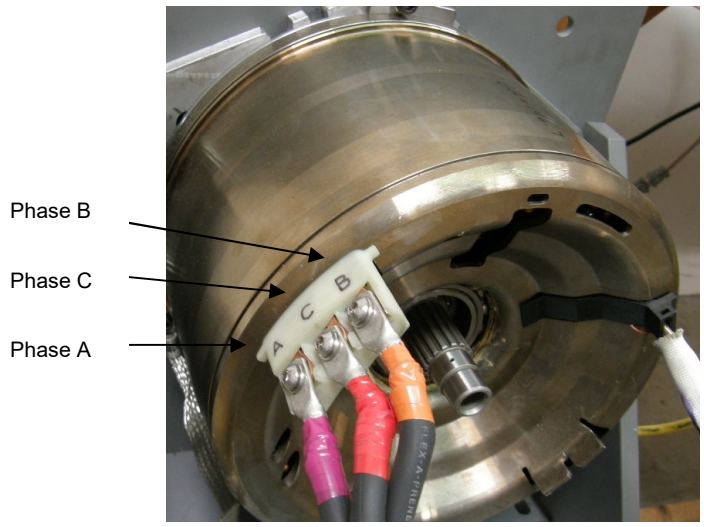

Figure 2:
BorgWarner Cartridge
Connections
(old EP8)

There is a newer revision to the BorgWarner cartridge than what is shown in Figure 2. The newer revision has a new plastic terminal block. The motor phase designations are imprinted into the plastic of the terminal block. Please use these designations when connecting the power leads from the motor to the controller. Refer to the PM/RM Hardware User's Manual for the corresponding phase designations on the PM/RM controllers.

The motor usually comes with its own housing as shown in Figure 3 (note that there are newer versions of the housing than what is shown).

The new Generation 1.6 housing has markings on the housing for A B C motor phases. Please connect these as shown on the housing to the inverter A B C, where A=U, B=V, C=W.

The rotation direction for the motor is shown in the picture below. This sets the counter-clockwise direction as forward and clockwise as reverse while facing the shaft of the motor.

Figure 3: Motor Housing with shaft

The housing uses a different connector than the cartridge. The connector is Amphenol D38999/20FD15PN. The mating connector is Amphenol D38999/26FD15SN. The mating connector is available from Cascadia Motion (p/n 86-0100).

Motor Pin	PM100/PM150 Pin	PM250 Pin	Function
A	J2-3	J1-B	Excitation negative
B	J2-17	J1-A	Excitation positive
C	J2-11	J1-C	SIN positive
D	J2-4	J1-E	COS positive
E	J2-18	J1-D	SIN negative
F	J2-12	J1-F	COS negative
G	J1-24	J1-U	Temperature sensor, AIN2 For PM100/PM150 1K pull-up must be installed to XDCR_PWR
H	J1-2	J1-W	Temperature sensor, AGND
J	J1-19	J1-T	Shield
K	n/a	n/a	Safety cover switch, not connected to inverter.
L	n/a	n/a	Safety cover switch, not connected to inverter.
M-R	n/a	n/a	Spare

		J1-b to J1-X	Making this connection will connect 1K pull-up internal to inverter. External-pullup not required.

For the PM100 and PM150 note that for the controller to properly measure the motor temperature a 1.00K ohm pull-up resistor must be provided between Pin G/J1-24 and XDCR_PWR (J1-26, also available on other pins). Please see the information above for more description of the resistor. For the PM250 the jumper described in the table will provide this resistor.

The BorgWarner motors (Generation 1.6) are now offered with a third connector option. This connector is an 18 pin Tyco Connector.

Motor Pin	PM100/PM150 Pin	PM250 Pin	Function
1	J2-3	J1-B	Excitation negative
10	J2-17	J1-A	Excitation positive
12	J2-11	J1-C	SIN positive
11	J2-4	J1-E	COS positive
3	J2-18	J1-D	SIN negative
2	J2-12	J1-F	COS negative
9	J1-24	J1-U	Temperature sensor, AIN2
18	J1-2 or other AGND	J1-W	Temperature sensor, AGND
5	J2-19	J1-T	Shield
n/a	J1-26 or other XDCR_PWR		Connect 1.00K ohm pull-up resistor between XDCR_PWR and AIN2 (J1-24)
n/a	n/a	J1-X to J1-b	Jumper to install 1K pull-up resistor that is internal to the inverter.

The mating connector details are as follows:

Tyco p/n 1-1563759-1, Mating Connector Housing
Tyco p/n 963531-1, Sealing Plug / White, for unused pins
Tyco p/n 1241381-3, Mating Contact, 17-20AWG, silver plated
Tyco p/n 963530-1, Wire Seal for 1.4-1.9mm insulation diameter

A kit of these 4 parts is available from Cascadia Motion, refer to p/n G1-0010-01.

** Please note that BorgWarner documents may refer to the SIN/COS signals differently than the Cascadia Motion documents. Please use the Cascadia Motion documents when connecting the inverter and the motor.

The HVH410 Motors also use the Amphenol D38999/20FD15PN. The mating connector is Amphenol D38999/26FD15SN. The mating connector is available from Cascadia Motion (p/n 86-0100). The HVH410 motors use a different temperature sensor than the HVH250 motors. The HVH410 motors use two PT100 RTDs. Thus, the connections at the motor and the inverter are different for the HVH410 as compared to the HVH250.

Motor Pin	PM100/PM150 Pin	PM250 Pin	Function
A	J2-3	J1-B	Excitation negative
B	J2-17	J1-A	Excitation positive
C	J2-11	J1-C	SIN positive
D	J2-4	J1-E	COS positive
E	J2-18	J1-D	SIN negative
F	J2-12	J1-F	COS negative
G	J1-5	J1-G	Temperature sensor #1
H	J1-15 (AGND)	J1-H	Temperature sensor #1
J	J1-19	J1-T	Shield
K	J1-6	J1-R	Temperature sensor #2
L	J1-15 (AGND)	J1-S	Temperature sensor #2
M	n/a	n/a	High Voltage Interlock – not used by inverter
N	n/a	n/a	High Voltage Interlock – not used by inverter
P	Not used	n/a	Spare
R	Not used	n/a	Spare

The pin names designated in the above table may differ from the BorgWarner definitions, but these are the designations that have been used in the software used with the inverters.

The Motor Temperature of the HVH410 is determined to be the greater of either Temperature Sensor #1 or Temperature Sensor #2. Both sensors must be used.

The BorgWarner HVH146 motor uses a 12 pin TE connector for the resolver, the mating connector part number is TE p/n 1-1703639-1.

Motor Pin	PM100 Pin	CM200 Pin	Function
11	J2-3	F1	Excitation negative
5	J2-17	E1	Excitation positive
4	J2-11	B1	SIN positive
3	J2-4	D1	COS positive
10	J2-18	A1	SIN negative
9	J2-12	C1	COS negative
7	J1-24		Temperature sensor, AIN2
8	J1-2 or other AGND		Temperature sensor, AGND
n/a	J2-19		Shield
n/a	J1-26 or other XDCR_PWR	n/a	Connect 1.00K ohm pull-up resistor between XDCR_PWR and AIN2 (J1-24) on PM100 only
6	n/a	n/a	HVIL loop
12	n/a	n/a	HVIL loop

2. Setting the 'Motor Type'

The 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 the BorgWarner Motors the following motor types are used:

Model	Motor Type
HVH250-090S @ 320V	1
HVH250-090S @ 650V	75
HVH250-090D @ 320V	11
HVH250-090D @ 650V	67
HVH250-115S @ 320V	31
HVH250-115S @ 650V	56
HVH250-115D @ 320V	36
HVH250-115D @650V	58
HVH410-075DOM @ 650V	107
HVH410-075SOM @ 650V	209
~~HVH410-150DOM @ 320V*~~	~~39~~
HVH410-150DOM @ 650V**	73
HVH410-150SOM @ 320V**	46
HVH146 @ 320V	195

- BorgWarner historically used the suffix "P" for motors that now use the D or DOM suffix.
- * not currently supported
- ** limited accuracy on torque feedback, limited verification

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 BorgWarner 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.

2.1 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 setting please contact either Cascadia Motion or BorgWarner for more information. These settings are derived from data provided by BorgWarner to Cascadia Motion.

Motor Type	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.*
HVH250 090S Type 1	PM100DX PM100DXR PM150DX	320	*	425	425	10,000	2,250	330
HVH250 090S Type 75	PM100DZ	650	*	283	283	10,000	5,000	220
	PM150DZ			425	425			320
HVH250 090D Type 11	PM100DX	320	*	495	495	10,000	4,500	190
	PM100DXR PM150DX			636	636	10,000	4,500	250
	PM250DX			849	849	10,000	4,500	320
HVH250 090D Type 67	PM100DZ	650	*	283	283	10,000	9,000	110
	PM150DZ			425	425			170
	PM150DZR			566	566			220
	PM250DZ			849	849			330
HVH250 115S Type 31	PM100DX PM100DXR PM150DX	320	*	425	425	10,000	1,700	410
HVH250 115S Type 56	PM150DZ	650	*	425	425	10,000	3,400	410
HVH250 115D Type 36	PM100DX	320	*	495	495	10,000	4,100	250
	PM100DXR PM150DX			636	636	10,000	3,600	320
	PM250DX			990	990	10,000	3,400	480
HVH250 115D Type 58	PM150DZ	650	*	425	425	10,000	8,500	210
	PM150DZR			566	566			285
	PM250DZ			849	849			430
HVH410 075SOM Type 209	PM150DZ	650	*	495	495	5,000	1,300	1040
	PM150DZR							1160
	PM250DZ							
HVH410 075DOM Type 107	PM150DZ	650	*	425	425	6,000	2,700	540
	PM150DZR			566	566			720
	PM250DZ			636	636			790

Motor Type	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.*
HVH410 150DOM Type 39	PM100DX PM100DXR PM150DX	320	*	425	425	6,000	300	2000
HVH410 150SOM Type 46	PM100DX PM100DXR PM150DX	320	*	425	425	2,000	300	2000
HVH410 150DOM Type 73	PM150DZ	650	*	425	425	6,000	1,600	1050
	PM150DZR			566	566			1400
	PM250DZ			849	849			2025
HVH146 Type 195	PM100DX CM200DX	320V	*	495	495	16,000	6,500	164
				532	532			

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

Revision History

Version	Description of Versions / Changes	Responsible Party	Date
0.1	Initial version	Chris Brune	5/24/2011
0.2	-	-	-
0.3	-	-	-
0.4	Separated the calibration process as a new document, “RMS Resolver Calibration Process”.	Azam Khan	6/14/2011
0.5	Added HVH250-115S, motor type 31.	Azam Khan	7/18/2011
0.6	Added detail on parameter setup	Chris Brune	7/26/2011
0.7	Added picture to show the direction of rotation of a Remy motor. Added HVH250-115P, motor type 36.	Azam Khan	10/26/2011
0.8	Added HVH410-150S, motor type 46. Added HVH410-150P motor type 39	Chris Brune	08/03/2012
0.9	Added information on Remy Resolver connector	Chris Brune	10/12/2012
1.0	Added information on Remy Tyco rectangular connector	Chris Brune	11/1/2012
1.1	Added HVH250-115S @650V	Azam Khan	4/30/2013
1.2	Added HVH250-115P @650V	Azam Khan	6/5/2013
1.3	Minor edit	Chris Brune	6/24/13
1.4	Corrected values in the table in Section 2.1. Added clarification to values in Section 2.1	Chris Brune	10/29/13
1.5	Add Motor type 67. HVH250-90P @ 650V	Chris Brune	12/13/13

1.6	Corrected entry in connector table from J1-19 to J2-19. Added clarification to connector table.	Chris Brune	4/2/2014
1.7	Added motor type for HVH250-090S @ 650V. Clarification of Gen 1.6 housing info.	Chris Brune	5/19/2014
1.8	Added line for PM150DZR, Motor type 58. Rearranged table on page 3 for clarity.	Chris Brune	5/27/2014
1.9	Starting with code version 1941 have added expanded coverage of the 115P and 90P motors up to 600Arms with the PM250DZ.	Chris Brune	3/13/2015
2.0	Added motor type 73, HVH410-150DOM @ 650V and motor type 107 HVH410-075DOM @ 650V.	Chris Brune	9/12/2016
2.1	Add PM250DX information	Chris Brune	9/27/2017
2.2	Removed support for HVH250-060S. Added support for higher torque in HV250-115DOM in firmware version 19AA.	Chris Brune	11/2/2017
2.3	Added detail on the HVH410 resolver and motor temperature connections.	Chris Brune	2/8/2019
2.4	Updated to Cascadia Motion name. Added PM250 resolver connection information. Updated P suffix to D suffix. Update Remy to BorgWarner.	Chris Brune	6/12/2020
2.5	Added HVH410-075SOM. Corrected information on HVH410-150DOM	Chris Brune	7/8/2020
2.7	Added HVH146. Added to Gen 3 code in version 2045.	Chris Brune	5/18/2021
2.8	Updated HVH410-150-DOM/PM250DZ Id/Iq and Torque Limits in table.	Travis Gintz	12/15/2022