CASCADIA MOTION
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Setting up the Controller to run with Emrax Motor

Revision 1.2

1. Setup

This document describes setting up the Emrax motor manufactured by Emrax d.o.o. (www.emrax.com) to work with inverters made by Cascadia Motion. Emrax makes several different sizes motors in both liquid cooled and air cooled variations.

The motor purchased from Emrax must be configured to come with a resolver. As of this writing the motor is offered with either a 1X (2 pole) resolver or a 5X (10 pole) resolver. Cascadia Motion **highly recommends** the use of the 5X resolver. The 1X resolver is known to have problems with noise. It is highly recommended to use the 5X resolver.

The software is not configured to use the RM44AC sin/cos encoder (or any other RLS product). Cascadia Motion does not support the use of the RM44AC because of an unspecified phase shift inherent to the design of the encoder.

Each Emrax motor size comes in 3 different motor winding configurations depending on the intended operating voltage. Cascadia does not currently support the Low Voltage configuration of Emrax motors.

Emrax Motor Type	Motor Type # (resolver type)	Max. Motor Current	Recommended CM Controllers
Emrax 188 Medium Voltage	151 (5X)	300Arms	PM100DX (1X resolver not supported)
Emrax 188 High Voltage	198 (5X)	200Arms	PM100DX, PM100DZ
Emrax 208 Medium Voltage	91 (1X) 117 (5X)	320Arms	PM100DX
Emrax 208 High Voltage	129 (1X) 130 (5X)	200Arms	PM100DX,PM100DZ
Emrax 228 Medium Voltage	82 (1X) 128 (5X)	320Arms	PM100DX
Emrax 228 High Voltage	40 (1X) 42 (5X)	240Arms	PM100DX, PM100DZ, PM150DZ
Emrax 268 Medium Voltage	84 (1X) 131 (5X)	350Arms	PM100DX, PM150DZ
Emrax 268 High Voltage	87 (1X) 132 (5X)	240Arms	PM100DX, PM100DZ, PM150DZ

Emrax 348 Medium Voltage	157 (1X) 158 (5X)	450Arms	PM150DX, PM150DZ, PM250DZ

To set the controller to run the Emrax motor set the EEPROM parameter Motor Type per the above table. Review the table in Section 2.1 for additional parameters that should be verified.

There are three phase terminals on the Emrax motor. They are not labeled, but do have different color heat shrink on them. These need to be connected to the motor controller as follows. Do not change this order as it will cause the motor to not spin.

Color	PM100/PM150 Terminals
Red	A
Black	B
Blue	C

The LTN RE-15 resolver type connections are as follows:

Color	10p Delphi	PM100/PM150	Pairing
Red/White	B	J2-17	Twisted Pair
Black/White	A	J2-3	
Red	C	J2-11	Twisted Pair
Black	E	J2-18	
Yellow	D	J2-4	Twisted Pair
Blue	F	J2-12	

The preferred resolver is the Tamagawa 5X resolver, TS2620N1095E161
The 1X resolver TS2620N21E11 has the same wire color choice as shown below:

Color	10p Delphi	PM100/PM150	Pairing
Red/White	B	J2-17	Twisted Pair
Yellow/White	A	J2-3	
Red	C	J2-11	Twisted Pair
Black	E	J2-18	
Yellow	D	J2-4	Twisted Pair
Blue	F	J2-12	

The 10 pin Delphi connector pins are given only as a reference as this is what was used on the CM dyno for testing.

The above wiring should result in a motor that spins counter-clockwise when facing the shaft side of the motor. The direction of rotation can be effected by swapping of SIN/COS resolver signals or the motor phases. In some cases it may be necessary to swap either the resolver signals or the motor phases to get the rotation of direction correct for both the motor and the resolver. The resolver calibration process should indicate if there is a problem with them not being matched (the resolver can't be calibrated and the motor won't spin).

CM recommends the use of twisted shielded pair wiring for the resolver. Resolver feedback cable should be kept away from the high voltage leads to minimize the electrical noise introduced into the system.

The temperature sensor should be connected to the AIN2 input. A pull-up resistor (3.01K 1%) must be added between AIN2 and XDCR_PWR.

Signal	Connects to
AIN2	One end of sensor and one end of pull-up resistor
AGND	Other end of sensor
XDCR_PWR	Other end of pull-up resistor.

2. Setting the 'Motor Type'

The 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. As different motors become available, they are added to the firmware of the inverter. The table below indicates the firmware version at which the motor was added.

Motor Model	Motor Type (Resolver)	Release Version
Emrax 188 Medium Voltage	151 (5X)	20200326 2026
Emrax 188 High Voltage	198 (5X)	19B0
Emrax 208 Medium Voltage	91 (1X) 117 (5X)	19B3
Emrax 208 High Voltage	129 (1X) 130 (5X)	1993
Emrax 228 Medium Voltage	82 (1X) 128 (5X)	19B2
Emrax 228 High Voltage	40 (1X) 42 (5X)	19B2

Emrax 268 Medium Voltage	84 (1X) 131 (5X)	1937
Emrax 268 High Voltage	87 (1X) 132 (5X)	1946
Emrax 348 Medium Voltage	157 (1X) 158 (5X)	19B5

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 CM or Emrax 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.

After setting all of the parameters it is necessary for the Resolver to be calibrated. The calibration must be performed on each motor, it will vary from motor to motor. Please refer to the Resolver Calibration manual for more information on how to perform the resolver calibration.

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 Cascadia Motion for more information

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.*
188 Medium Voltage Type 151	PM100DX	270	*	424	200**	7,000	6,000	121
188 High Voltage Type 198	PM100DX	360	*	283	150	7,000	3,300	132
	PM100DZ	650					6,500	
208 Medium Voltage Type 91 Type 117	PM100DX PM150DX	320	*	425	425**	6,500	4,000	166
208 High Voltage Type 129 Type 130	PM100DZ	450	*	283	150**	6,500	4,000	166
	PM100DX	360		283	150**			
228 Medium Voltage Type 82 Type 128	PM100DX	360	*	453	221**	4,500	4,000	231
228 High Voltage Type 40 Type 42	PM100DZ PM150DZ	400	*	339	150**	4,500	4,000	260
	PM100DX	360		339	150**			
268 Medium	PM100DX	320	*	495	200**	4,500	2,000	490

Voltage Type 84 Type 131	PM150DZ	600		425	200**		3,000	421
268 High Voltage Type 87 Type 132	PM100DZ PM150DZ	600	*	339	143**	4,500	3,000	493
	PM100DX	360						
348 Medium Voltage Type 157 Type 158	PM150DX	360	*	636	335**	4,500	1,250	1040
	PM150DZ	600		425	335**	4,500	2,100	695
	PM250DZ			636	335**	4,500	2,100	1040

* Do not change the Veh_Flux level from the default that is set when the motor type is changed.
** CM recommends that the ID Limit initially be set to 0. This can prevent the motor speed from increasing significantly in light load conditions. Once the system is operating under load the ID Limit can be increased as needed.

*** The indicated torque is not meant to represent the torque that the motor will actually achieve, but the required torque command to get the maximum motor current per Emrax specification. The actual motor torque will be reduced by the saturation effects in the motor.

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Revision History

Version	Description of Versions / Changes	Responsible Party	Date
0.1	Initial version	Chris Brune	1/18/2012
0.2	Added new Emrax model, 228 medium voltage. Clarified existing data	Chris Brune	11/25/2014
0.3	Added Emrax 268 Medium Voltage.	Chris Brune	1/19/2015
0.4	Changed color call out for the resolver from yellow/white to black/white. Added notes about twisted pair wiring.	Chris Brune	4/27/2015
0.5	Added Emrax 268 High Voltage	Chris Brune	6/18/2015
0.6	Added Emrax 207 Medium Voltage	Chris Brune	8/28/2015
0.7	Added Emrax 208 High Voltage. Added 5X resolver versions for all motor types. Changed formatting of document.	Chris Brune	11/21/2016
0.8	Added Emrax 188 Medium Voltage. Adjusted torque limits to reflect torque needed to achieve maximum current	Chris Brune	3/19/2018
0.9	Added settings for Emrax 268 MV and PM150DZ	Chris Brune	4/10/2018
1.0	Added settings for Emrax 348 MV.	Chris Brune	6/05/2018
1.1	Added 1X resolver note about the wire colors.	Chris Brune	7/25/2018
1.2	Updated to Cascadia Motion. Added Emrax 188 HV, motor type 198. Added notes on firmware version when motor was incorporated.	Chris Brune	3/26/2020