

Encoder Calibration for SIN/COS Encoder

Revision 0.4

1. Introduction

This document describes the process to calibrate a SIN/COS encoder to work with the PMxxx and CMxxx controllers. The procedure finds the offset voltage of the encoder.

This process applies to PMxxx and CMxxx inverters that have the option –SP (e.g. CM200DZ-SP).

This process is most often used with Yasa motors.

The SIN/COS encoder inputs are single ended analog signals that provide a signal that varies with the motor position. The signals are similar to what a resolver provides but don't have the excitation carrier waveform.

The SIN/COS signal should meet the following requirements:

Offset Voltage	2.5V \pm 0.2V
Signal Voltage	3.8V pk-pk maximum

For PMxxx Gen 3 inverters the SIN/COS input impedance is 1k ohm to 5V. For CMxxx inverters the SIN/COS input impedance is 10K ohm to 1.9V.

For the CMxxx inverters (48 pin Molex CMC I/O connector) the SIN/COS connections to the inverter are:

Encoder Signal	Pin #
SIN (normally ENC_A)	H1
COS (normally ENC_B)	J1
Encoder Power (5V)	J2
Encoder GND	K2
Encoder Shield	G1

For CMxxx inverters the inverter must be an -SP configuration. At a future date CMxxx inverters (starting with the CM350SiC) will be able to automatically reconfigure themselves to be a -SP option.

For PMxxx/RMxxx inverters the connections for SIN/COS are:

Encoder Signal	PM100	PM250	RM100	RM300
SIN	J2-18	J1-D	31	M-2
COS	J2-12	J1-F	30	M-8

Encoder Signal	PM100	PM250	RM100	RM300
XDCR_PWR	J2-1	J1-P	23	M-14
(5V encoder power)	J2-11	J1-C	19	M-3
Connect to all three pins	J2-4	J1-E	18	M-4
GND/AGND	J2-3	J1-J	35	M-13
Shield	J2-19	J1-T	29	M-7

All three pins indicated under XDCR_PWR must be connected together.

2. Encoder Calibration Process

The purpose of this calibration process is to increase the accuracy of sin and cosine inputs to the encoder. There may be an offset associated with each input based on minimum and maximum values.

Important Note: It is not necessary for the high-voltage DC to be connected to the inverter. However, spinning the motor will generate a DC voltage in the inverter, even if the inverter is off. This voltage is dangerous, take proper precautions. If a high-voltage DC is connected to the inverter make sure that it is high enough in value that the voltage generated by the motor will be less than this battery voltage.

The voltage that the inverter is seeing at the SIN/COS inputs can be viewed with the RMS GUI using the following two Memory Window parameters:

Parameter	Description
Sin_corr_(V)_x_100	Value of the SIN input in volts
Cos_corr(V)_x_100	Value of the COS input in volts.

For some versions of code the above two parameters may not show in the Memory window. If they do not show then open the particular defsyms file that the GUI is using in a text editor. Look for these two lines to see if they are preceded by a "#". If they are then remove the "#" and then save and close the file. Restart the RMS GUI and the two lines should appear.

Monitoring of these two signals can help make sure that as the motor rotates the two signals are varying in voltage. They should be 90 degrees offset from each other.

In order to perform the calibration process follow these steps:

1. Start the RMS GUI application.
2. On the EEPROM page of the GUI, make sure that the correct motor type is selected. If not, then select the correct motor type and program EEPROM parameters. The inverter power needs to be recycled after EEPROM parameter programming.
3. Add the following parameters to the Watch Window of the GUI (they are located at the bottom of the list of parameters):

Parameter Name	Address	Default Value
Encoder_Calibration_Command	0x0015	0 (Calibration not in process)
Sin_Minimum_Value_(V)_x_100	0x00E3	0 (0.00 V)
Sin_Maximum_Value_(V)_x_100	0x00E4	500 (5.00 V)
Sin_Offset_(V)_x_100	0x00E5	250 (2.50 V)
Cos_Minimum_Value_(V)_x_100	0x00E6	0 (0.00 V)
Cos_Maximum_Value_(V)_x_100	0x00E7	500 (5.00 V)
Cos_Offset_(V)_x_100	0x00E8	250 (2.50 V)

4. The calibration process can be performed only if all of the following conditions are true:
 - a. Correct Motor Type is selected
 - b. Inverter is disabled
 - c. VSM State is VSM_WAIT (4)
 - d. There are no POST or RUN faults present
5. Enter a '1' (Perform Calibration) command for Encoder_Calibration_Command in the GUI. Make sure the Auto Continuous Refresh is off on the GUI when changing the command) Encoder_Calibration_Command can only have the following values:

 - 0: Calibration not in process
 - 1: Perform Calibration
 - 2: Finish Calibration
6. Turn the Auto Continuous Refresh back on to monitor the values. Rotate the motor slowly by hand. Observe Sin_Minimum_Value_(V)_x_100 and Sin_Maximum_Value_(V)_x_100 changing. Eventually, Sin_Minimum_Value_(V)_x_100 and Sin_Maximum_Value_(V)_x_100 will show the minimum and maximum values, respectively. Same is true for Cos_Minimum_Value_(V)_x_100 and Cos_Maximum_Value_(V)_x_100. Rotate through several revolutions.
7. Turn off the Auto Continuous Refresh. Enter a '2' (Finish Calibration) command to complete the process. Encoder_Calibration_Command will change back to '0' to show that the unit is not in calibration process any more. Also, Sin_Offset_(V)_x_100 and Cos_Offset_(V)_x_100 will be calculated and saved in EEPROM for future use. Turn the 12V power off and on. Verify that the EEPROM values have been updated. The EEPROM values can be viewed with following parameters:

Parameter Name	Address	Default Value
Sin_Offset_EEPROM_(Voltsx100)	0x014C	250
Cos_Offset_EEPROM_(Voltsx100)	0x014D	250

Typically these two parameters should not vary substantially from the default values.

3. Gamma Adjust (PM, CM and RM family)

Finally, it is necessary to perform the gamma adjust on the Sin/Cos encoder. Please reference the [RMS Resolver Calibration process](#) section 2.3. This document can be found on the Support/Documentation section of our website under “Resolver Calibration”. This will step through the process of determining the amount of gamma adjust needed for the motor and inverter pair. Gamma Adjust corrects for the angle offset between the mechanical position of the sensor and the magnet position.

NOTE: The gamma adjust is a required step and cannot be bypassed.

Revision History

Version	Description of Versions / Changes	Responsible Party	Date
0.1	Initial version	Azam Khan	12/29/11
0.2	Updated manual for current software.	Chris Brune	6/22/2018
0.3	Updated manual to include reference to Gamma Adjust in the Resolver Calibration Process document.	Travis Gintz	3/5/2021
0.4	Added detail on the inverter connections.	Chris Brune	2/14/2023