

Subject : Permanent Magnet Synchronous Motor control using incremental encoder with MD810 drive

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Revision History

Revision	Date	Revising Author	Description
1.0	04/11/2019	David Bedford	First issue
1.1	23/05/2020	David Bedford	Basic parameters added
1.2	16/01/2022	David Bedford	Header updated. Tables 4, 5 and 6 updated.

Summary of contents




This document describes the set up and commissioning of MD810 drive when controlling permanent magnet synchronous motor with quadrature incremental encoder.

1. Encoder specifications.

In order to control a permanent magnet synchronous motor in closed loop, the encoder should have, additionally to A and B phase signals, the Z (marker) signal. This Z (marker) signal allows to have a reference position within a motor revolution. And therefore, it allows to determine the relative position of the motor magnetic poles in relation to this Z (marker) signal, which is called *encoder installation angle*. This *encoder installation angle* is measured by a dedicated auto-tuning procedure, as we explain in clause 2 of this document.

In case of MD810 drive, it is possible to connect either an open collector (+15V power supply), push pull (+15V power supply) or line driver (differential signals, +5V power supply) type encoders. In case of open collector and push pull encoder types, only 3 signals need to be connected: A, B and Z. In case of line driver (differential) encoder type, 6 signals have to be connected: A, B and Z and their complementary signals A/, B/ and Z/. The terminals for the encoder connection are described in table 1 below.

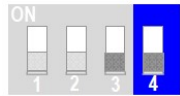
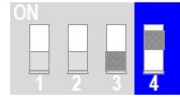
Table 1. Encoder connection terminals.

Drive type	Single drive unit	Dual drive unit (drive 1)	Dual drive unit (drive 2)
Connector	CN3	CN2	CN4
Terminal Layout	 <div style="display: flex; flex-direction: column; align-items: center;"> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">A+ A- B+ B- Z+ Z- 5V PGND 15V</div> <div style="border: 1px solid black; padding: 2px;">23</div> </div>	 <div style="display: flex; flex-direction: column; align-items: center;"> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">A+ A- B+ B- Z+ Z- 5V PGND 15V</div> <div style="border: 1px solid black; padding: 2px;">23</div> </div>	 <div style="display: flex; flex-direction: column; align-items: center;"> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">A+ A- B+ B- Z+ Z- 5V PGND 15V</div> <div style="border: 1px solid black; padding: 2px;">23</div> </div>

It is very important to know the encoder supply voltage before making the connection, otherwise the encoder could be damaged. In MD810 single drive units it is possible to select the encoder supply voltage between +15V and +5V, by using DIP

switch 4 of S2, as shown in table 2 below.

Table 2. Setting of DIP switch 4 of S2 in single drive units.

DIP switch 4 of S2	OFF: +15V Power supply	
	ON: +5V Power supply	

In MD810 dual drive units, there is no DIP switch for the selection of the encoder supply voltage. To do so, use function code F1-25 to select between +15V and +5V, as shown in Table 3 below.

Table 3. Setting of parameter F1-25 in dual drive units.

F1-25 setting	Encoder supply voltage
F1-25=0	+15 V
F1-25=1 (default)	+5V

Additionally to the supply voltage settings, the parameters described in table 4 below related to the encoder have to be set.

Table 4. Encoder related parameters.

Parameter	Setting	Description
F1-27	Set according to the number of pulses per revolution of the encoder	Encoder pulses per revolution
F1-28	Set to 0 for A, B, Z incremental encoder	This parameter is used to select the encoder type
F1-30	Set depending on the installation location and wiring of the encoder	Encoder wiring flag. Used to reverse the A, B phases of the encoder. This parameter is set automatically by dynamic auto-tuning (F1-37=12).

2. Motor parameter setting.

Additional to the encoder settings, in order to control permanent magnet synchronous motor, the parameters described in table 5 below should be set.

Table 5. Basic parameter for PMS motor control.

Parameter	Setting	Description
F0-01	Set to 1 for closed loop control (FVC)	1 st motor control mode
F0-10	Set the desired maximum frequency (Hz)	This parameter sets the maximum output frequency. Some parameters are scaled to the value of this parameter, like the acceleration/deceleration times. Also the frequency setpoint by analog input is scaled to the value of this parameter.
F0-12	Set the desired upper limit of the frequency setpoint	This parameters limit the frequency setpoint
F1-00	Set to 2 for PMS motor control	Selection of PMS motor control
F1-01	Set the motor rated power (kW)	Rated power of the motor in kW
F1-02	Set the motor rated voltage (V)	Rated voltage of the motor.
F1-03	Set the motor rated current (A)	Rated current of the motor in A.
F1-04	Set the motor rated frequency (Hz)	Rated frequency of the motor in Hz.
F1-05	Set the motor rated speed (RPM)	Rated speed of the motor in RPM.

3. Auto-tuning procedure.

In order to control a permanent magnet synchronous motor in closed loop, it is compulsory to perform a dynamic (rotating) auto-tuning procedure, which measures the motor parameters. As described in the table 6 below, the selection of the auto-tuning method by parameter F1-37 (Auto-tuning selection), determines which parameters are measured.

In both methods described in table 6, the *encoder installation angle* (parameter F1-31) is measured. In any case, it is highly recommended to execute “synchronous motor dynamic no-load auto-tuning” (F1-37=12), which also measures the back EMF of the motor.

Table 6. Dynamic (rotating) auto-tuning methods, depending on F1-37 setting.

F1-37 (Auto-tuning selection)	Parameters identified by tuning	Necessary conditions	Rotor rotates?
11: Synchronous motor no-load partial auto-tuning	<ul style="list-style-type: none"> - stator resistance value (F1-06) - d/q shaft inductance (d: F1-17, q: F1-18) - encoder installation angle (F1-31) 	<ul style="list-style-type: none"> 1. Z signal is mandatory for ABZ quadrature incremental encoder 2. Back EMF value (F1-19) should be set manually 	ABZ type encoder: Yes Resolver: No
12: Synchronous motor dynamic no-load auto-tuning	<ul style="list-style-type: none"> - stator resistance value (F1-06) - d/q shaft inductance (d: F1-17, q: F1-18) - encoder wiring flag (F1-30) - encoder installation angle (F1-31) - back EMF (F1-19) 	<ul style="list-style-type: none"> 1. Z signal is mandatory for ABZ quadrature incremental encoder 2. No load condition 	Yes

4. Operation.

After executing the auto-tuning procedure, the drive will be able to control the motor properly. At the first start after power up, the drive will execute a pole position detection to be able to control the motor. After rotating one turn (at most), the Z (marker) signal is detected, which allows to reposition accurately the motor poles based on the detected position of the Z (marker) signal and the *encoder installation angle* (parameter F1-31).

5. Conclusion.

With MD810 drive it is possible to control permanent magnet synchronous motor in closed loop (FVC) by using an inexpensive quadrature incremental encoder.

The following points need to be considered:

- A, B and Z signals (and their complementary ones in case of Line Driver) should be connected to the drive encoder interface.
- A dynamic (rotating) auto-tuning procedure should be executed to measure the relative position between the encoder and the motor poles (*encoder installation angle*, parameter F1-31).