

Application Note	AN-MEGA-0016-v104EN
MEGA Servo setup procedure for driving PMS motor	

Inverter type	FRENIC MEGA (-EAQ Type)
Software version	1700
Required options	OPC-G1-PG, OPC-G1-PG2, OPC-G1-PG22, OPC-G1-PMPG or OPC-G1-RES
Related documentation	MEGA Servo IM, SI47-1545-E
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1. Introduction.

MEGA Servo inverter is able to drive a PM Synchronous motor in closed loop control. In this case, the procedure to set up the motor related parameters is a bit different. This document describes a procedure in order to set up the inverter, when driving PMSM with MEGA Servo.

2. Description.

The commissioning procedure for FRENIC MEGA Servo is depicted in figure 1 (extracted from the FRENIC MEGA Servo IM, SI47-1545-E).

For controlling Permanent Magnet Synchronous motor an incremental encoder (open collector or line driver), an absolute encoder (with U, V and W commutation signals) or a resolver must be used as a speed/position feedback. For further details in the installation of the required option card (according to the feedback type used) please refer to the option card instruction manual.

Once the wiring of the motor and the encoder is finished, it is time to set up the inverter in order to drive properly the motor. This document explains the part of the procedure from the “Selection of the motor type” to the “Adjust motor control function code data”.

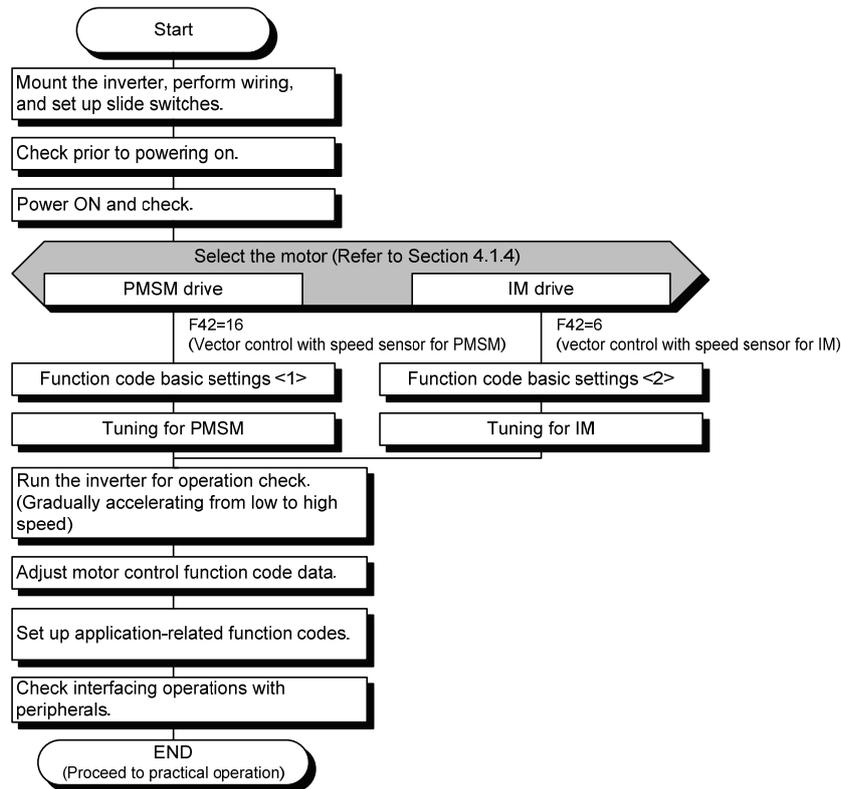


Figure 1. Inverter Commissioning Procedure

2.1 Permanent Magnet Synchronous Motor parameters setting

The first step consists into setting the PM Synchronous motor control in the inverter, and the motor capacity:

- F42 = 16 (Vector control with speed sensor for PMSM)
- P02 = Motor Capacity (from motor's nameplate)

When F42 = 16, the PMS motor parameters will be available (P01 to P03, P30 to P95).

Once the PMSM control is activated, and the motor capacity is set, the next step is to reset the Motor 1 parameters. In this way, the motor parameters (including the PMS motor parameters) will be reset to the default settings for this capacity:

- H03 = 2 (Initialize motor 1 parameters)

Now the inverter is ready for the motor parameters setup. The minimum parameters to set, in order to perform Auto-tuning procedure are shown in table 1.

Table 1. Parameter Setup from SI47-1545 manual

Function code	Name	Function code data	Factory default
F04	Base frequency 1	Motor ratings (print on the nameplate of the motor)	50.0 (Hz)
F05	Rated voltage at base frequency 1		Standard motor rated voltage
P01	Motor 1 (Pole number)		4 pole
P02	(Rated capacity)		Standard motor capacity
P03	(Rated current)		Standard motor rated current
P30	Magnet pole position detection method selection	Motor type	1: IPM
P90	Overcurrent protection level	Current limitation value to prevent demagnetization It is used to protect the demagnetization by the motor overcurrent. Set the value when understanding.	0.00 (A) (disable)
d14	Feedback input (Pulse input format)	Type of the target motor encoder	2: A/B phase with 90 degree phase shift
d15	(Encoder pulse resolution)	Pulse count of the target motor encoder	0400 (hex) (1024 P/R)
F03	Maximum output frequency 1	Specification value Note) When running the motor for a test, set to specification value or more. In the specification value or less, motor might not be able to normally drive.	50.0 (Hz)
F15	Frequency limiter (upper)		70.0 (Hz)
F07	Acceleration time 1		22 kW or less: 6.00 (s) 30 kW or more: 20.00 (s)
F08	Deceleration time 1		22 kW or less: 6.00 (s) 30 kW or more: 20.00 (s)

Note: F03, F15, F07 and F08 will be taken into consideration only if the dynamic autotuning (P04 = 2, described below) is used.

The P30 initial setting should be set depending on the motor permanent magnets arrangement:

- P30 = 1. In case of Inner Permanent Magnets (IPM) motor (setting by default, this will be the setting normally used as the majority of motors behave as IPM type).
- P30 = 2. In case that Surface Permanent Magnets (SPM) synchronous motor is controlled.

During normal operation (except commissioning), the setting of P30 is relevant only when using incremental encoder.

If information about function P90 (“Overcurrent protection level”) is not available, a typical setting could be the double of the rated current. This setting is very important in order to avoid damaging the Permanent magnets of the motor.

2.2 Complete Auto-Tuning and Pole-Tuning Procedure (especially when using incremental encoder).

Now it is time to perform Auto-tuning and Pole-tuning procedures. Please find in table 2 the different Auto-tuning and Pole-tuning procedures available if permanent magnet motor control is active (F42 = 16).

Table 2. Different Auto-tuning and Pole-Tuning procedures from SI47-1545 manual.

P04 data		Motor parameters subjected to tuning	Tuning operation	Select under the following conditions
1	Tune without rotating the motor	Primary resistance (P60) d-axis inductance (P61) q-axis inductance (P62) reserved (P84, P88)	Tuning <u>with the motor stopped</u> .	Impossible to rotate the motor. Because the mechanical load have already been installed. P30=1 or 2 (Note) In case of P30=0 (No operation) or P30=3 (Simple IPM method), tuning without rotating the motor can not be used.
2	Tune with the motor rotating	Primary resistance (P60) d-axis inductance (P61) q-axis inductance (P62) Inductor voltage (P63) Reserved (P84, P88) Magnetic pole position sensor offset (P95)	Tuning the P60 to P62, P84 and P88, <u>with the motor stopped</u> . Tuning the P63 <u>with the motor rotating</u> (50 % of base frequency). (F42=16, and P95=999) Tuning the P95 <u>with the motor rotating</u> (rotation speed = d80).	Possible to rotate the motor, the motor is not coupled to any mechanical load.
4	Pole Tuning with the motor rotating	Magnetic pole position sensor offset (P95)	Tuning the P95 <u>with the motor rotating</u> (rotation speed = d80).	Possible to rotate the motor, the motor is is not coupled to any mechanical load. When using the vector control with speed sensor for PMSM. (F42=16)

The recommended procedure for the Auto-Tuning and Pole-Tuning is as follows:

- 1- Calculate P63 “Inductor Voltage” value. To calculate this value, the Ke constant of the motor is needed (normally supplied by motor manufacturer). Once calculated, save the value in the inverter.

$$P63 = Ke \cdot \frac{N_{rtd}}{1000}$$

Where:

Ke is the back EMF constant, in V/1000rpm

N_{rtd} is the rated speed in rpm

- 2- Perform static Auto-Tuning (P04 = 1). This will calculate the P60, P61, P62, P84 and P88 motor parameters. If OCx or Er7 alarm occurs during this procedure, please check that the back EMF (P63), rated frequency (F04) and rated voltage (F05) parameters are properly adjusted. If it's not possible to perform the Auto-Tuning even the speed loop parameters have been adjusted, please refer to Step 4.
- 3- Perform Pole-Tuning (P04 = 4). The motor will move at d80 speed and function P95 (magnetic pole offset) will be measured. Therefore, the motor must be in no load condition. If Er7 appears during this procedure, please take into account that the speed loop parameters (ASR) affect the pole tuning procedure. A good tip could be to disable the several filters (d01, d02 and d05) or modify the speed loop constants (d03, d04). If it is not possible to solve the problem by adjusting these parameters, please set P30 to the correct value.

If incremental encoder is used, then inverter will perform automatically Pole-Tuning at the very first RUN Command after every inverter power up. Please refer to point 4 explanation, below.

- 4- Once Static Auto-tuning and Pole-Tuning are finished, the value in P86 (North-South discrimination value) must be bigger than 10% to ensure a proper pole offset detection.

In case we cannot achieve $P86 > 10\%$, the first countermeasure to take would be to slightly increase the value of P87 and test again.

If P87 is increased but P86 is still smaller than 10%, then P30 value must be changed. P30 must be changed if Er7 arises, as well. Please refer to table 3 below.

Table 3. P30 setup process

Permanent Magnet	Initial P30	Tuning	New P30
IPM	1	$P86 < 10\%$ or Er7	3
SPM	2	$P86 < 10\%$ or Er7	0

If P30 is set to 3 or 2 and Er7 still occurs then please set P30 to 0 and try to perform Dynamic Auto-tuning.

When using incremental encoder, the automatic Pole-Tuning procedure will change depending on the P30 value. Please refer to Table 4.

Table 4. Pole-Tuning behaviour in case of using incremental encoder

F42 data	Encoder	P95 data	P30 data	Starting operation
16: Vector control with sensor for PM	Incremental: A/B phase with 90 degree phase shift and Z phase	999 (No adjustment of offset)	0: Alignment method by current 3: Alignment method by current for IPMSM	< Start impossible > Er7 alarm is occurred, and it does not start. Adjust P95.
			1: Method for IPMSM 2: Method for SPMSM	< Magnetic pole position detection start > After detecting the magnetic pole position, it starts from 0 Hz.
		0.0 to 359.9° (Offset has been adjusted)	0, 3	< Magnetic pole position alignment start > Only at the first operation after the power supply of the inverter has been turned on, the magnetic pole position alignment operates by the frequency of d80. After the magnetic pole position alignment is completed, inverter accelerates the motor to the reference speed. From second operation, it starts from 0 Hz (Normal start). The magnetic pole position alignment operation takes the time for one rotation of the mechanical angle in maximum case. (Function code d80)
			1, 2	< Magnet pole position detection start > After magnetic pole position detected, it starts from 0 Hz.

Only in case of $P30 = 1$ or 2 , the automatic Pole-Tuning at every power up will be completely static, so no other consideration must be taken into account. On the other hand, if P30 is equal to 0 or 3, this automatic Pole-Tuning after the power up will not be static, and the inverter will turn the motor at d80 speed. This behaviour may not be acceptable in certain applications (e.g. vertical loads).

If it is not possible to calculate the back EMF constant value (P63) or if the value of P30 is different than 1 or 2, the dynamic auto-tuning procedure (P04 = 2) is available for the user. During the Dynamic Auto-Tuning, no load must be attached to the motor shaft.

When P30 = 0, it is recommended to set F23 = 1.0 Hz and F24 = 1.0 s momentarily, just for the Dynamic Auto-Tuning procedure.

The Dynamic Auto-Tuning consists on the following stages:

- a. Static Auto-tuning, like the point 3 in the procedure above.
- b. Dynamic Pole-Tuning, like the point 2 in the procedure above.
- c. Calculation of the P63 value, with the motor driving at the half of the rated speed (F03). For this stage, acceleration/deceleration times and maximum speed level have to be properly set.

2.3 Simplified Auto-Tuning and Pole-Tuning Procedure (for resolver or absolute encoder)

Alternatively, a simplified procedure for the Pole-Tuning + Auto-Tuning can be performed in case resolver or absolute encoder (Incremental + U, V, W signals, d14 = 4) feedbacks are used. After setting the function codes described in Table 1, please set P30 = 0 and execute the Dynamic auto-tuning (P04 = 2), as described in previous subchapter 2.2 (instead of following steps 1 to 4 from the procedure described in subchapter 2.2).

2.4 Current Loop gain setting

After the Auto-Tuning procedure, it's time to adjust the Current Loop gain (d91). Normally, it is not needed to change the default setting (999), because in this case the inverter will use a value based on the motor parameters.

Modify the d91 value only if:

- Current flowing in the motor is not enough to achieve the desired dynamic performance (even the Torque Command value is saturated): increase slightly d91 value, and test again.
- If OCx errors arise when trying to move the motor, or if noise from the motor can be observed when current is flowing through it, or when the inverter output current wave shape is not a sinusoidal shape: decrease slightly d91 value, and test again.

The base value for testing a new setting in d91 (the default setting is "999: Automatic") can be obtained by means of the following formula:

$$d91 = \frac{L_d \cdot I_n \cdot K}{V_n}$$

where,

L_d , is the motor d-axis inductance in mH, from P61

I_n is the motor rated current in A (value set in P03)

K is a constant value, 2.165

V_n is the motor rated voltage in V (value set in F05)

Note: d91 value depends only on the motor parameters, not in the load or the mechanical configuration (inertia, gear ratio, etc.) of the installation.

3. Conclusion.

Using FRENIC MEGA Servo software version, the inverter will be able to drive PM synchronous motors in closed loop. The commissioning procedure of a PM synchronous motor is slightly different to an Induction Motor. Following this procedure, the inverter will be adjusted for driving properly a Permanent Magnet synchronous motor in closed loop.

4. Document history.

Version	Changes applied	Date	Written	Checked	Approved
1.0.0	First version	05/08/2011	JM Ibañez		
1.0.1	Small text corrections	29/08/2011	JM Ibañez		
1.0.2	Added several explanations	09/09/2011	JM Ibañez	D.Bedford	
1.0.3	Small text corrections Added simplified procedure	14/09/2011	JM Ibañez	D.Bedford	D.Bedford
1.0.4	Added calculation formula of d91. Some text corrections	21/10/2011	JM Ibañez	D.Bedford	D.Bedford