Product	AMD	Type	VFD-C2000	Security Level	☑General ☐High ☐Top
				No.	N/A
Issued by	SC	Author	Andy Lin	Release Date	22nd June, 2012

C2000 Drive PM with FOC Sensorless

Devices and tools:

Inverter: VFD007C23A, Firmware V9.019 (D12234)

PM motor: ECMA-C30602ES

Operation Steps:

1. Set correct parameters 01-00, 01-01 and 01-02 based on PM you are using.
2. Key in the following parameters：

Pr. no	Definition	Setting value
05-33	IM or PM motor choice	1
05-34	PM motor rated current (A)	1.55
05-35	PM motor rated power (kw)	0.20
05-36	PM motor rated speed (rpm)	3000
05-37	PM magnetic roles	10
05-38	PM Inertia (E^{-4} kg-m^2)	0.2

3. Set 05-00=13 for PM motor parameters tuning.

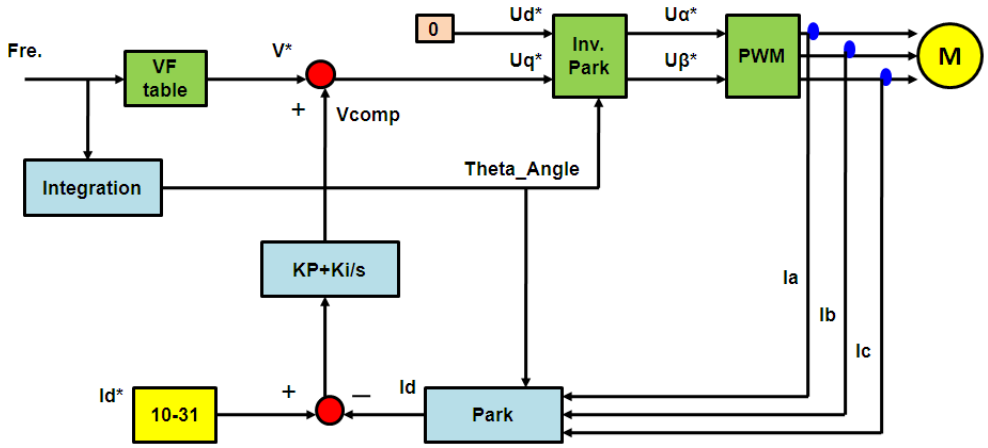
   05-33 to 05-37 must be set before PM motor auto-tuning. However, 05-38 has nothing to do with auto-tuning but for automatical bandwidth in ASR.

4. Check the following parameters after PM motor auto-tuning.

   05-39PM motor stator resistance, 05-40 PM motor Ld, 05-41 PM motor Lq, 05-43 PM Ke.

5. Understanding the PM Sensorless Idea in C2000.

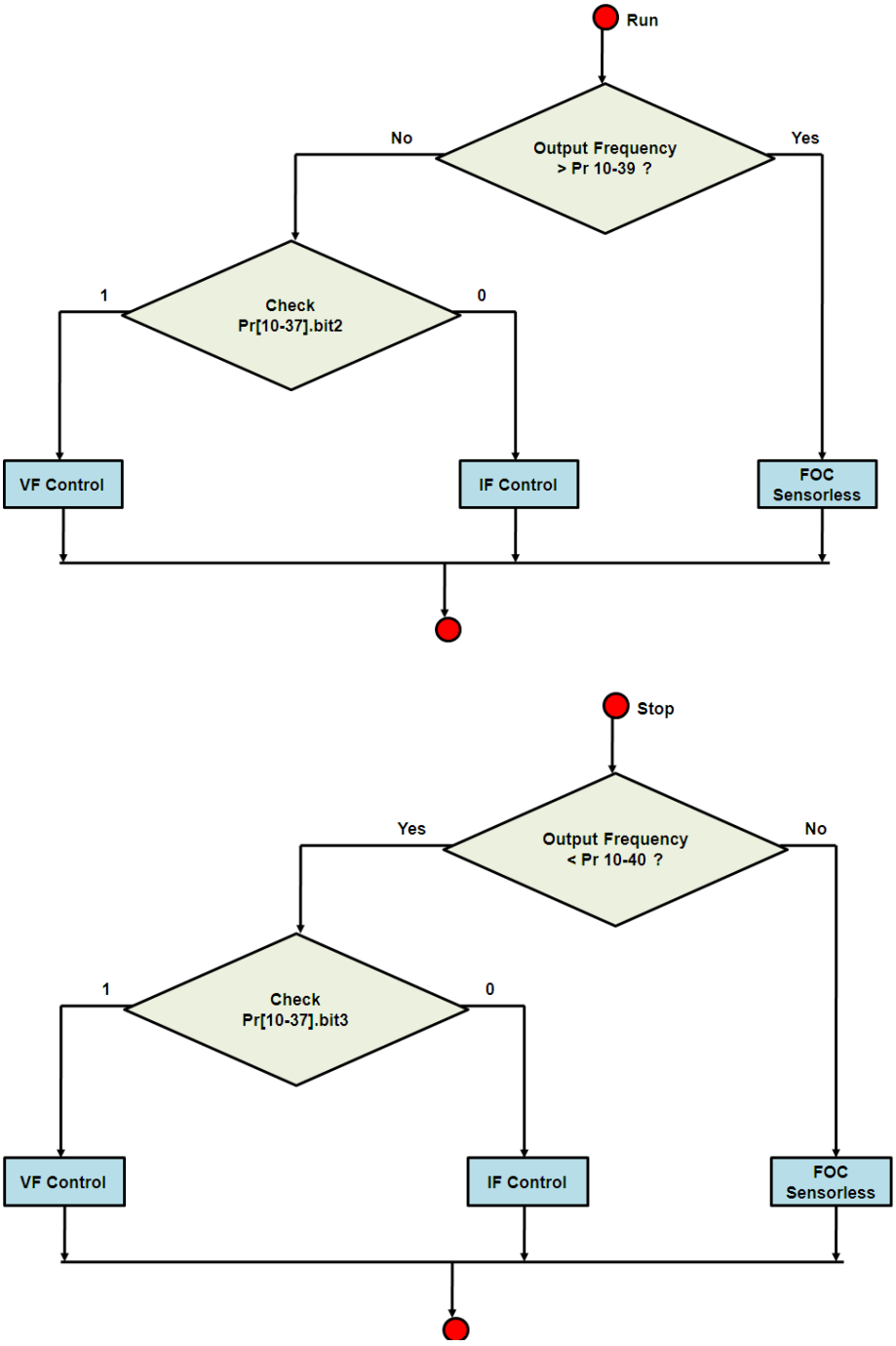
- C2000 PM sensorless idea before V9.019 D12234 firmware (Including V9.019 D12234) is one hybrid method between Vector control with VF/IF mode.
- IF mode is the special VF mode and it adds the Id feedback calculator into. Please kindly refer to the diagram as below. There is one new parameter **Pr10-31**namly Id command which can control the output current. This parameter can strengthen output torque by adding the Vcomp from Id feedback calculation.



- C2000 PM sensorless logical start operation can be referred as follows. And we can see **Pr10-39** is the judgement principle. When output frequency is higher than Pr10-39, the control will go to the real FOC sensorless based on Vector Control. Contrarily, control will go to VF or IF mode. Besides, **Pr10-37** is the judgement principle for VF/IF choice. When 10-37 bit 2 is 1, the control will be VF, contrarily, the control will be IF. Of course, 10-37 must be under 10-39, and 10-37 will be no any use if output frequency is higher than 10-39.

- C2000 PM sensorless logical stop operation is very similar as the start operation. Only one difference is the judgement principle is from Pr10-39 to **Pr10-40**. When we stop and output frequency is lower than 10-40, the control will be IF/VF mode, and if output frequency is still higher than 10-40, control will still be FOC sensorlss. IF/VF choice judgement still is based on Pr10-37 bit2.

  Pr 10-40 should be lower than or equal to Pr 10-39 for a right logical setting.



6. Set the following parameters for PM motor no-load commissioning.

Pr. no	Definition	Setting value
00-11	Control of speed mode	6
10-31	I/F mode, current command	20%
10-32	PM high speed observer bandwidth	20
10-37	PM Sensorless mode control bit	0
10-39	Frequency switch point from I/F to FOC	25Hz
10-40	Frequency switch point from FOC to I/F	25Hz

11-00	System control(Auto tuning for ASR)	0001H
11-01	Per unit of system inertia(256=1PU)	200
11-02	ASR1/ASR2 switch frequency	35Hz
11-03	ASR1 Low Frequency Bandwidth	10HZ
11-04	ASR2 High Frequency Bandwidth	10HZ
11-05	Zero Frequency Bandwidth	10HZ

10-37 is one special for PM Sensorless Mode Control bit, the bit definitions as follows.

Bit. no	Definition	Explanation
2	Choose a control mode to start	0: Start by IF mode; (suggest use I/F mode) 1: Start by VF mode.
3	Choose a control mode to stop	0: Stop by IF mode; (Suggest use IF mode) 1: Stop by VF mode.
5	Choose stop mode	0: When lower than Pr10-40, free run to stop; 1: When lower than Pr10-40, decelerate to stop.

7. Start the C2000 for running.

Attentions:

A. Why are there two methods in PM sensorless control mode?

PM Sensorless Control Mode is based on Observer for replacing the PG card. And Observer must require not too low frequency for ensuring the estimation correctly. Hence when we start the C2000, frequency is not high since there is one acceleration process, IF/VF mode can work during this time, and PM vector control will be switched after frequency is OK. Now we regard Pr10-39 as the IF/VF and FOC sensorless vector control switch judgement. The whole process FOC Sensorless Control Mode is researching now. Hence the hybrid based on VF/IF and FOC Sensorless Vector Control is not the final one for Delta Inverter.

B. Why is there no Magnetic Angle auto-tuning in PM sensorless control mode?

As we know, for PM control, the magnetic angle is very important to ensure the control operation. However, in PM sensorless, there is no magnetic angle auto-tuning there. This is because PM sensorless Vector control is based on Observer Calculator, and the magnetic angle can be calculated by Obserser Calculator, so we don't need to take the magnetic angle auto-tuning for PM sensorless.

C. Is there a principle for setting Pr10-39?

Pr10-39 usually is set to 1/10 of PM rated speed. In this case, PM rated speed is 250HZ, so we set 10-39=25HZ.

If Pr10-39 is too low, FOC Sensorless Observer can't ensure the calculation precision and the vibration will be there.

D. Why do we suggest to choose IF mode better than VF mode?

When the output frequency is lower than Pr10-39, the control mode will be IF or VF based on Pr10-37 bit 2.

VF mode is the common mode and it is easy to understand but can't ensure the output current invariable. IF mode is based on VF mode and adds the Id calculation loop, so IF mode can ensure the output current invariable, which is good for reducing the vibration. Hence, we suggest you choose IF mode as the mode when your output frequency is lower than Pr10-39.

E. How to set Pr10-31?

Pr10-31 is the Id command for IF mode. If Pr10-31 is too high, it is good for reducing the vibration but when the output frequency is higher than Pr10-39, the control will switch from IF to FOC Sensorless Vector Control and it is easy to cause OL or OC.

The default value of 10-31 is 40% namely the empty load current. Besides, during IF mode, 10-31 value is the output current, and we can see the value in the keypad output current.

F. Is inertia auto-tuning there in FOC sensorless control mode?

FOC sensorless control mode must be based on Pr11-00=1 namely enable automatic bandwidth function. So Pr11-01 inertia must be set properly. However, there is no inertia auto-tuning operation in FOC sensorless control mode, and we just set 11-01 by hand and experience.

Generally, we can set Pr11-01 one value first, and if we find the vibration there, we can reduce the 11-01 for suppressing the vibration.

G. Does motor Auto-tuning in PM Sensorless support IPM?

PM sensorless auto-tuning can get different value of Ld Lq, and Lq usually is 2 times than Ld. Hence this is standard method for IPM. C2000 PM+PG auto-tuning just get the same Ld Lq, and it is for SPM. Of course, if you are testing C2000 to IPM, that is also OK but the effect is a little gap with the one which is dedicated to drive IPM.

H. How to set Pr11-02?

We suggest Pr11-02 should be set the value which is 10HZ more than Pr10-39. In this case, Pr10-39 is 25HZ, so Pr11-02 is 35HZ.

Pr11-02 will decide the ASR1 ASR2 switch judgement, if it is too close to Pr10-39, the control mode switch time is so close to ASR switch time and the vibration will be there.

I. How can we get Pr05-43 based on PM Rated Power, PM Rated Current and PM Rated Speed.

$$Ke = \frac{2}{3}\left(\frac{\text{Power}}{\sqrt{2}*\text{Irate}}\right)*\frac{1}{\sqrt{2}}*\frac{1000}{\text{Speed}} = \frac{\text{Power}*1000}{3*\text{Irate}*\text{Speed}}$$

Power is Pr05-35 namely Rated Power of PM, Irate is Pr05-34 namely Rated Current of PM Speed is Pr05-36 namely Rated Speed of PM.

The unit of Power is W, the unit of current is A, the unit of speed is rpm, and the unit of Ke is V/1000rpm.

J. Does P05-00=13 need empty load?

P05-00=13 is one static auto-tuning, so it doesn't need empty load, we just take it with any loading situation.