Application Technique

Allen-Bradley

PowerFlex 750-Series Configuration with Permanent Magnet Motors

Catalog Numbers 20G, 20J

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Important User Information

Read this document and the documents listed in the additional resources section about installation, configuration, and operation of this equipment before you install, configure, operate, or maintain this product. Users are required to familiarize themselves with installation and wiring instructions in addition to requirements of all applicable codes, laws, and standards.

Activities including installation, adjustments, putting into service, use, assembly, disassembly, and maintenance are required to be carried out by suitably trained personnel in accordance with applicable code of practice.

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

In no event will Rockwell Automation, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

No patent liability is assumed by Rockwell Automation, Inc. with respect to use of information, circuits, equipment, or software described in this manual.

Throughout this manual, when necessary, we use notes to make you aware of safety considerations.

	WARNING: Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.
	ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you identify a hazard, avoid a hazard, and recognize the consequence.
IMPORTANT	Identifies information that is critical for successful application and understanding of the product.

Labels may also be on or inside the equipment to provide specific precautions.

	SHOCK HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that dangerous voltage may be present.
	BURN HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that surfaces may reach dangerous temperatures.
	ARC FLASH HAZARD: Labels may be on or inside the equipment, for example, a motor control center, to alert people to potential Arc Flash. Arc Flash will cause severe injury or death. Wear proper Personal Protective Equipment (PPE). Follow ALL Regulatory requirements for safe work practices and for Personal Protective Equipment (PPE).

Overview

The PowerFlex® 750-Series drives offer control of permanent magnet (PM) motors. The PowerFlex 755 offers both surface-mounted permanent magnet (SPM) and Interior Permanent magnet (IPM) motor control. The PowerFlex 753 only offers IPM motor control. This document contains methodologies for the proper test and setup of PM motors with the PowerFlex 755 drive, using PM flux vector (FV) mode, and the PowerFlex 750-Series drives using IPM FV mode. PM volts per Hertz (VHZ), PM sensorless vector (SV), synchronous reluctance (SyncRel) VHZ, and SyncRel SVC modes are not covered in this document.

This document also contains the proper steps to setup and run the Kinetix VPC continuous duty servo motors with an IPM motor control on a PowerFlex 755 drive. The Kinetix VPC IPM servo motors, have been performance tested and verified for use with this system.

Refer to the Kinetix VPC Continuous Duty Servo Motor Product Profile, publication VPC-PP001 for acceptable configurations.

This document does not cover the newer line start PM synchronous motors from SEW and Baldor, because those motors are controlled using PM VHZ and PM SV modes. This document also does not cover system inertia tune and speed loop tuning.

Intended Audience

This document assumes a functional level of knowledge of the PowerFlex 750-Series drives and associated software.

Required Software

One of the following software packages:

- DriveExecutive™ V 5.06 or higher
- Connected Components Workbench™ software V10.00 or higher

Required Information

Before beginning the startup configuration of a IPM, SPM, or Kinetix VPC IPM motors, gather the information that follows:

Motor Nameplate Data

At minimum, you need the Motor Nameplate data and Motor type.

- Motor Nameplate Voltage (parameter 25 [Motor NP Volts])
- Motor Nameplate Amps (parameter 26 [Motor NP Amps])
- Motor Nameplate Hz (parameter 27 [Motor NP Hertz])
- Motor Nameplate RPM (parameter 28 [Motor NP RPM])
- Motor Nameplate Power (parameter 30 [Motor NP Power])
- Motor Nameplate Poles (parameter 31 [Motor Poles])
- Kinetix VPC IPM servo motor data located in Table 1...Table 6

Motor Feedback Type

- Motor Feedback type: Incremental Encoder (pulses per revolution [PPR] must be an exponent of 2 for PM Control; that is 512, 1024, 2048, and so on), Absolute Encoder within one rotation - Resolver via Advanced Micro Controls, Inc. (AMCI) feedback board - Sine Cosine with EnDat, Hiperface, or SSI communications - Full Digital encoder of EnDat 2.2 or SSI
- Correct encoder feedback card for the type of feedback device used

Feedback type is used to configure parameter 80 [PM Cfg] before running the motor model tuning. Parameter 80 [PM Cfg] is only valid in Flux Vector modes of PM FV and IPM FV.

80	**PM Cfg** Permanent Magnet Motor Configuration	Read/write (RW)	Data Type: 16-bit Integer

Mode	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7
PM with Absolute Feedback (Stegmann, SSI, Heidenhaim)		X						
PM with Incremental Encoder (Pulse, SIN/COS)	X	X						
PM without Feedback		X	X	X				
IPM with Absolute Feedback (Stegmann, SSI, Heidenhaim)						X		
IPM with Incremental Encoder (Pulse, SIN/COS)	X					X		
IPM without Feedback			X			X		

X = 1

This parameter also includes two options for PM FV mode that are selected by P35 [Motor Ctrl Mode].

Options	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	NoMiLimit	NoIntgHld	IdsCmdFFwdEn(1)	VCmdPhShftEn	IPMTqTrmEn	IPM Vqs Disa	PMStabAnglEn	StaticTestEn	Vqs Reg En	AutoOfstTest
Default	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

0 = Disable
1 = Enable

(1) 755 drives only.

Bit 0 "AutoOfstTest" – Enables the PM Offset test to be executed before the drive runs normally after a power cycle or drive reset. Required when the feedback device is not an absolute feedback device. Cannot be enabled if Bit 2 is enabled. Allow for up to 90° of shaft rotation. The value set in P83 [PM Ofst Tst Cur] may need to be increased to complete the test. If shaft rotation is not possible, set Bits 0 and 1 to perform a static test at every start.

Bit 1 "Vqs Reg En" – Enables the Vqs regulator.

Bit 2 "StaticTestEn" – Enables the Static test to be executed before the drive starts. Cannot be enabled if Bit 0 is enabled.

Bit 3 "PMStabAnglEn" – Enables the Permanent Magnet Stability Angle regulator. Used for PM FV Encoderless when P35 [Motor Ctrl Mode] = 6 "PM FV" and P125 [Pri Vel Fdbk Sel] = Open Loop.

Bit 4 "IPM Vqs Disa" – Disables Vqs regulator when P35 [Motor Ctrl Mode] = 10 "IPM FV."

Bit 5 "IPMTqTrmEn" – Enables Torque Trim when P35 [Motor Ctrl Mode] = 10 "IPM FV."

Bit 6 "VCmdPhShftEn" – Enables the enhancement function on the voltage command calculation in all control modes.

Bit 7 "IdsCmdFFwdEn" – Enables the feed forward term calculation for the Vqs regulator in PM with feedback mode.

Bit 8 "NoIntgHld" – This bit defines behavior of the d-q current regulator integrators. When set, the integrators are not held during over modulation; when not set, the integrators are held during over modulation.

Bit 9 "NoMiLimit" – When not set, modulation index is limited based on bus utilization, when set, modulation index is not limited.

Optional Information:

Motor electrical design data sheet and motor type determination.

PM Motor Identification

This section describes the motor types SPM and IPM, and shows examples of where to find motor data.

IPM Motor Types

IPM motor electrical design data is valuable if there are problems tuning the motor. Figure 1 shows a picture of the Marathon SyMax nameplate data. Figure 2 shows an example data sheet that is taken from a Baldor IPM motor data sheet. Both contain Ld and Lq values - indicating that the motors are IPM motors even though they do not state IPM on the label.

Figure 1 - Marathon SyMax IPM Nameplate

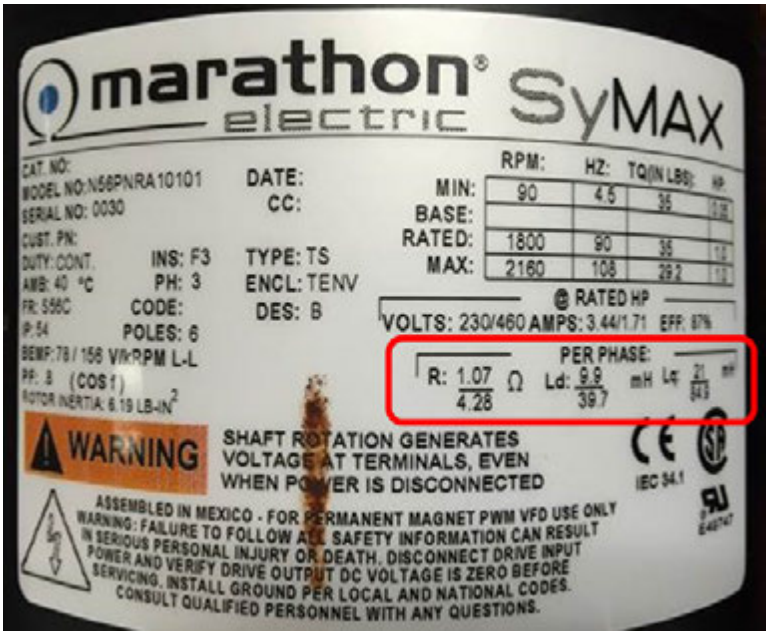


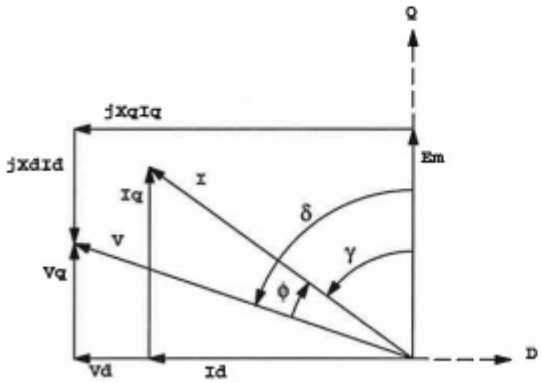
Figure 2 - Baldor IPM Motor Data Sheet

S.O.	0	VOLTS	365	TYPE	IPM	STATOR RES.@ 25 °C	.09628
FRAME	RL2173	AMPS	67	ENCLOSURE	DPFV	OHMS (BETWEEN LINES)	
HP	50	DUTY	CONT	MAX SAFE RPM	5000		
BASE SPEED	1750	S.F.	1.0	WK² (Lb-Ft²)	2.86		
PHASE/HERTZ	3/58.33	AMB °C/INSUL	40/H	MAX INSTANTANEOUS OVERLOAD AMPS	201		

VARIABLE SPEED PERFORMANCE

HP	AMPS (rms)	RPM	GAMMA*	POWER FACT.	EFF.	VOLTS (L-L) (rms)	Em (L-N) (rms)	Lq (mH)	Ld (mH)
OpenCkt**	N/A	1750	5.0	N/A	N/A	N/A	179	N/A	N/A
OpenCkt,hot	N/A	1750	5.0	N/A	N/A	N/A	129	N/A	N/A
10.3	16.8	1750	29.5	96.6	94.4	291	129	22.0	3.40
22.8	33.5	1750	32.0	91.7	94.9	336	129	15.2	3.30
37.0	50.2	1750	41.0	92.5	95.5	355	129	13.1	3.29
50.0	67.0	1750	47.0	92.7	95.4	364	129	11.5	3.20

Remarks: TYPICAL DATA
266% OL BASE: 460V, 175A, 1750RPM, 58.33HZ
266% O/L TOP: 460 V, 151 A, 2400 RPM, 82.33HZ



*Gamma is the current angle relative to counter emf, defined to be positive when current leads counter emf.

Equivalently, Gamma is positive when Id is negative.

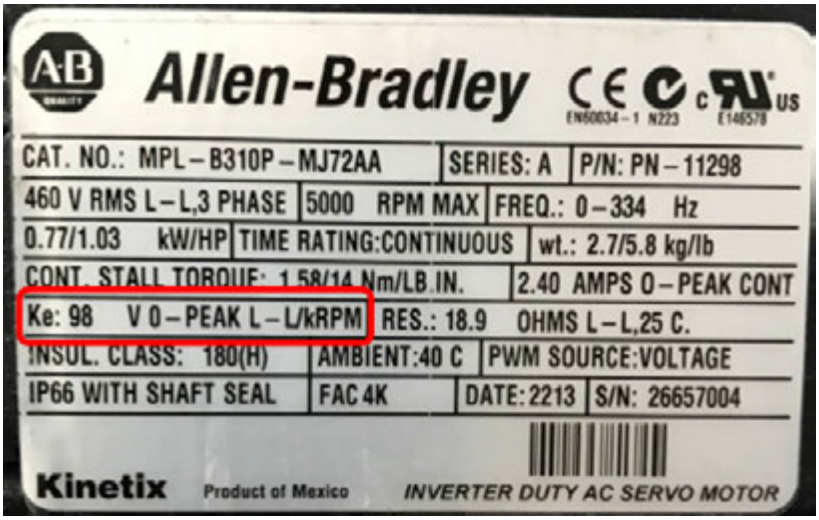
**Data at 25°C - all other data at rated temperature

DR. BY JKA CK. BY RM APP. BY RM DATE 1-28-13	IPM MOTOR PERFORMANCE DATA	PM5751A ISSUE DATE 3-11-13

SPM Motor Types

If the motor is of an SPM type, the nameplate does not include Ld and Lq values, but may contain the resistance and inductance values for the motor along with the Ke (Voltage constant)/1 kRPM. Figure 3 shows the nameplate of an Allen-Bradley® SPM type motor.

Figure 3 - Allen-Bradley SPM Nameplate



Surface-Mounted Permanent Magnet (SPM) Motor Configuration (PowerFlex 755 Only)

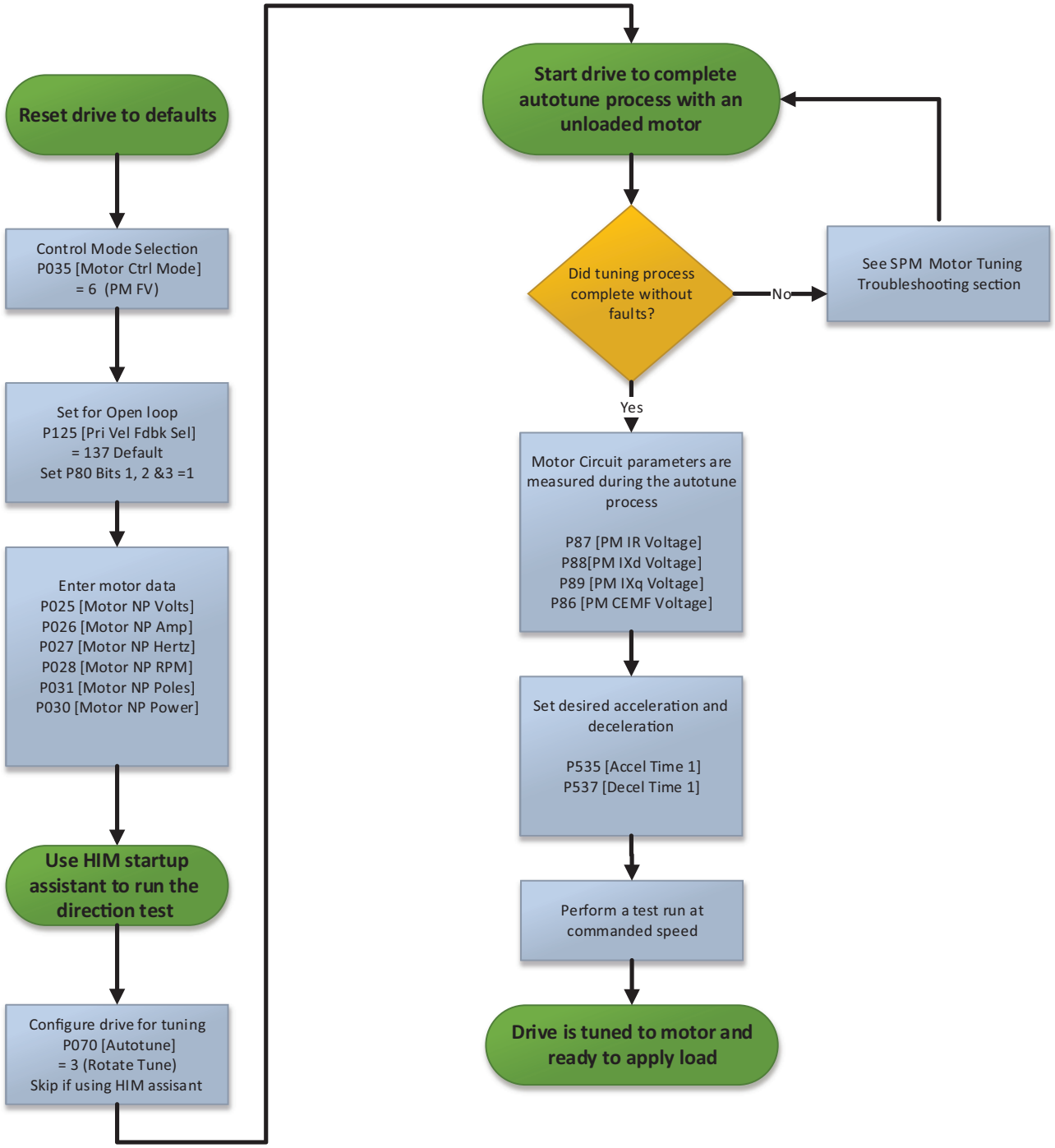
This section describes the open and closed loop startup for SPM motors.

Open Loop SPM Motor Startup Flowchart

The flowchart in Figure 4 steps through the configuration and rotate tune of SPM motors in open loop mode. We recommend that you use the Human Interface Module (HIM) to run the initial startup of the motor so that the direction test is run properly. Make sure to set parameter 80 [PM Cfg] **before** using the HIM startup assistant to start up the motor. The following flowcharts are for starting up with HIM-assisted startup.

TIP PowerFlex 755 Frame 8…10 do not support permanent magnet open loop mode.

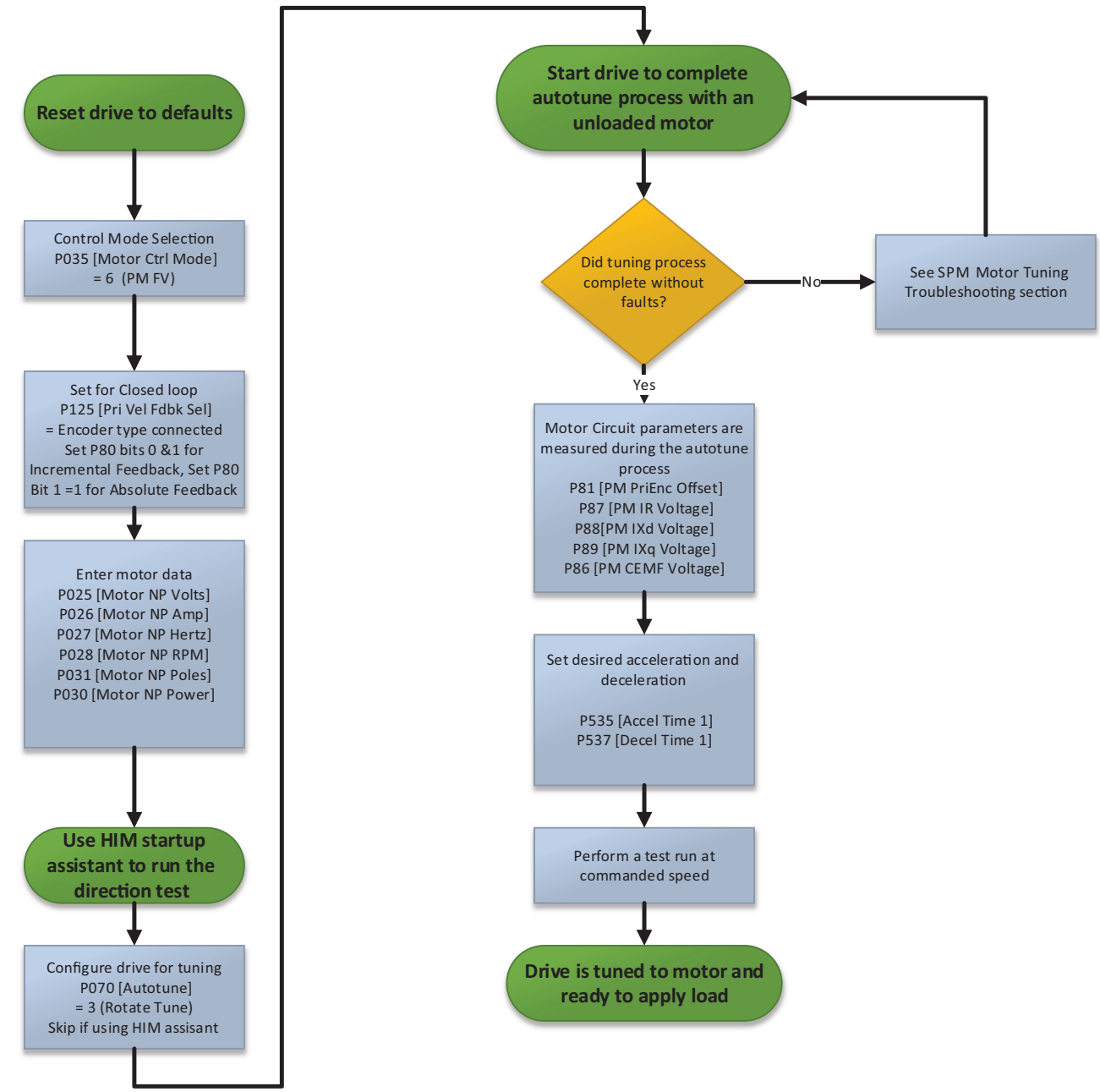
Figure 4 - Open Loop SPM Motor Startup Procedure



Closed Loop SPM Motor Startup Flowchart

The flowchart in Figure 5 steps through the configuration and rotate tune of SPM motors in closed loop mode. We recommend that you use the HIM to run the initial startup of the motor so that the direction test is run properly. Make sure to set parameter 80 [PM Cfg] **before** using the HIM startup assistant to start up the motor.

Figure 5 - Closed Loop SPM Motor Startup Procedure



SPM Motor Startup Troubleshooting

This section provides tips to follow if a problem or fault occurs during the startup routine.

Direction test does not rotate - When attempting to run the motor direction test, the motor just oscillates or does not rotate indicates that parameter 93 [PM Dir Test Cur] is too low. The default for this parameter is 10% of the motor rating and is too low for anything but a bare motor shaft. We suggest setting the parameter to 50% of the motor rated current and increase to 100% if needed to complete the test.

Fault 197 PM Offset Failed - This fault occurs if the motor does not move the specified minimum distance during the commutation offset test. This problem could be caused if the motor has a brake and the brake is not released during the test. The problem could also occur if the load on the motor is greater than the motor capability because of the PM Offset Test current setting. Verify that the motor or load does not have a brake. Verify the motor poles, an incorrect pole setting causes distance to travel to be incorrect. Increase parameter 83 [PM OfstTst Cur] to something greater than the default 40%, suggest starting at 50% and increase if needed because of the load on the motor. If the motor oscillates during the test, then fails, try increasing the values of parameter 84 [PM OfsTst CRamp] and parameter 85 [PM OfsTst FRamp] by 25% then attempt the test again. Retry until motor pulls to each position without faulting on a PM Offset Failed. If you are using an incremental encoder, the motor must be able to rotate freely on the first start after a power cycle so the commutation offset test can be run. A best practice for incremental encoders is the ability of the motor to move between poles on a start at all times so the offset test does not fail when it is required to run.

Calculating motor data or Cannot run a rotate tune - If you cannot run a motor rotate tune, and you have a motor electrical equivalent circuit, you can calculate the drive parameters. Resistance and Inductance are in phase-to-phase, Voltage Constant (Ke) is in Volts RMS per 1000 RPM Phase to Phase. If it is in Volts per 1000 RPM 0-Pk, then divide by the Sqrt(2) to get RMS voltage.

Motor Hertz = (RPM * Poles)/120

P86 PM CEMF Voltage = (Ke * RPM)/1000

P87 PM IR Voltage = (Ohms * amps * Sqrt(3))/2

P88 PM Ixq Voltage = (Henries * amps * Hertz * Sqrt(3) * (2 * π))/2

Commutation angle test must be run by the drive. If the encoder is an absolute within one revolution you can set P80 bit 0 = 1, then command a start with a zero speed reference. The commutation test runs and P81 is populated then set P80 bit 0 = 0.

Interior Permanent Magnet (IPM) Motor Configuration

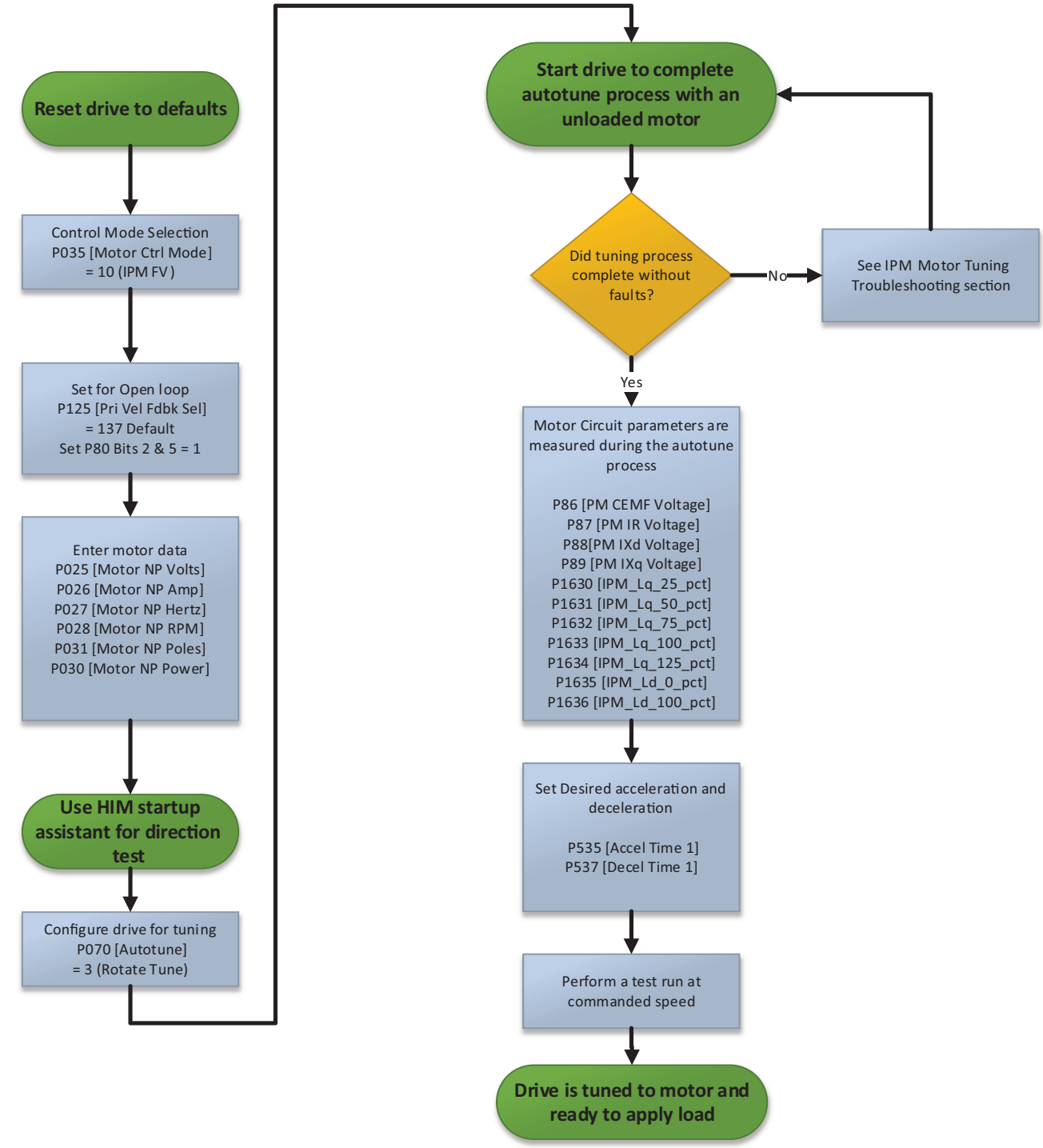
This section describes the open and closed loop startup for IPM motors.

Open Loop IPM Motor Startup Flowchart

The flowchart in Figure 6 steps through the configuration and rotate tune of IPM motors in an open loop mode. We recommend that you use the HIM to run the initial startup of the motor so that the direction test is run properly. The HIM cannot be used to test more than the direction in IPM FV mode with the assisted startup mode and must be finished via drive parameters. Set parameter 80 [PM Cfg] **before** using the HIM startup assistant to start up the motor.

TIP PowerFlex 755 Frame 8…10 do not support permanent magnet open loop mode.

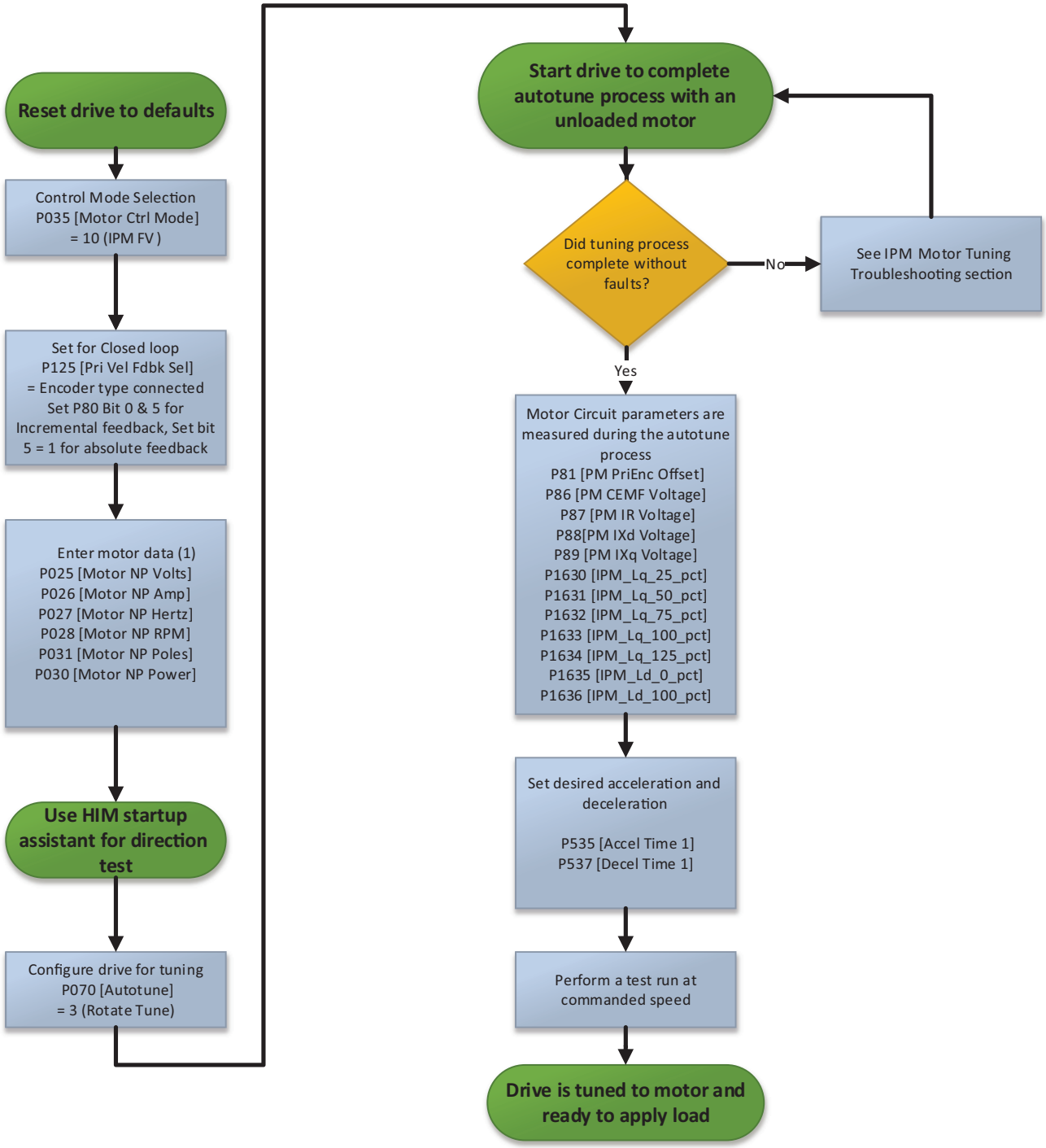
Figure 6 - Open Loop IPM Startup Procedure



Closed Loop IPM Motor Startup Flowchart

The flowchart in Figure 7 steps through the configuration and rotate tune of IPM motors in a closed loop mode. We recommend that you use the HIM to run the initial startup of the motor so that the direction test is run properly. The HIM cannot be used to test more than the direction in IPM FV mode with the assisted startup mode and must be finished via drive parameters. Set parameter 80 [PM Cfg] **before** using the HIM motor assistant to start up the motor.

Figure 7 - Closed Loop IPM Startup Procedure

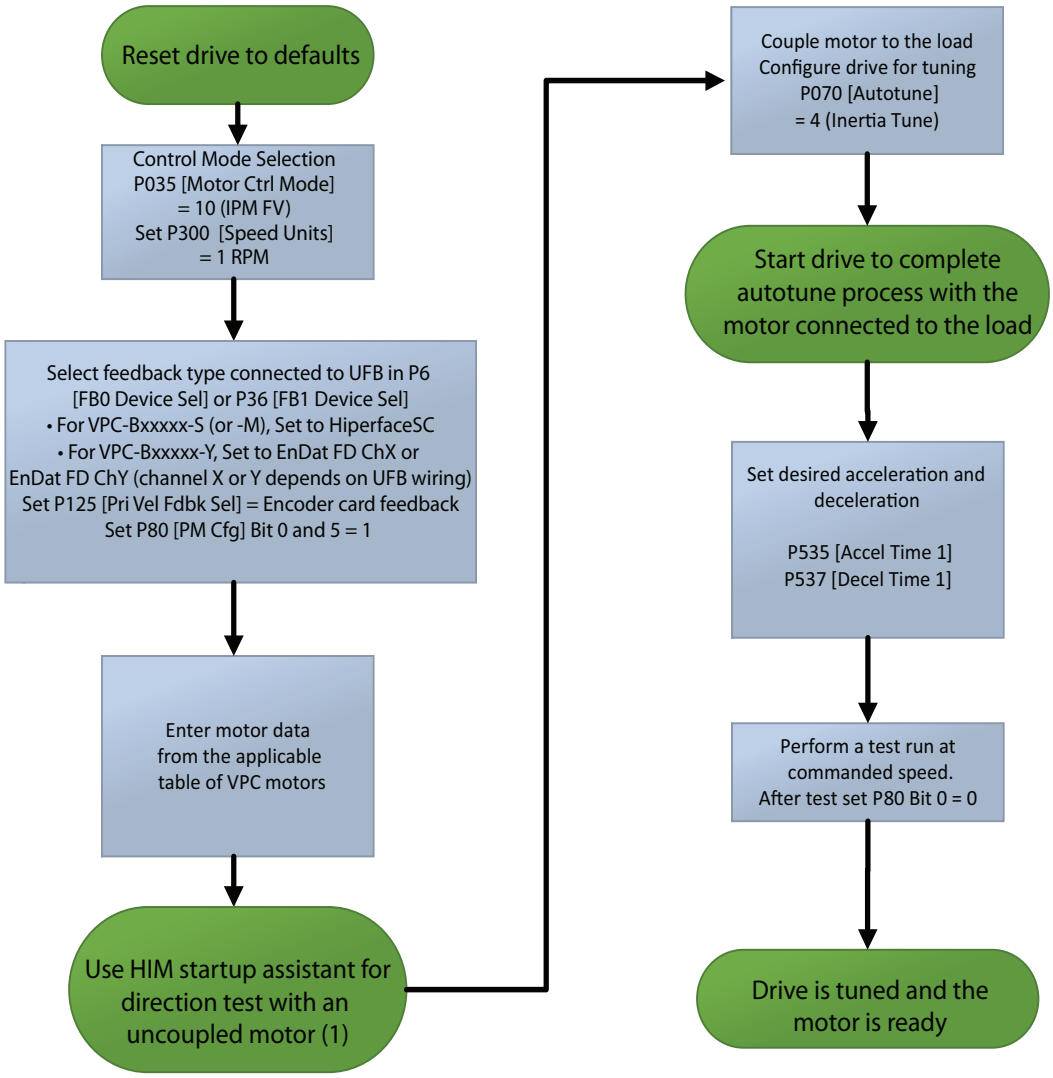


(1) In I/O mode, add the Kinetix VPC motor data instead of preforming autotune.

Configuring a Kinetix VPC IPM Motor with a PowerFlex 755 Drive

The flowchart in Figure 8 steps through the configuration and rotate tune of a Kinetix VPC motors in a closed loop mode. We recommend that you use the HIM to run the initial startup of the motor so that the direction test runs properly. Refer to the relevant motor parameters provided in Table 1...Table 6 to configure a specific motor. Set parameter 80 [PM Cfg] **before** using the HIM motor assistant to start up the motor.

Figure 8 - Closed Loop Kinetix VPC Motor Startup Procedure



(1) Kinetix VPC motor catalog numbers: VCP-Bxxxxx-xxx4, have optional parking brakes. Verify that brake is disengaged before performing rotational tests.

Enter the applicable motor data into the parameter listed:

Table 1 - Kinetix VPC FANLESS MOTOR DATA VPC-B165*xxx*

Parameter No.	Name	Units	VPC-B1652A-xxxxAS	VPC-B1653A-xxxxAS
25	Motor NP Volts	VAC	480	480
26	Motor NP Amps	Amps	7.14	9.26
27	Motor NP Hertz	Hz	125	125
28	Motor NP RPM	RPM	1500	1500
29	Mtr NP Pwr Units		kW	kW
30	Motor NP Power	kW	3.4	4.4
31	Motor Poles	Pole	10	10
35	Motor Ctrl Mode		IPM FV	IPM FV
36	Maximum Voltage	VAC	480	480
37	Maximum Freq	Hz	166.7	166.7
38(1)	PMW Frequency	kHz	4	4
76(2)	Total Inertia	Secs	0.021	0.023
86	PM CEMF Voltage	VAC	329.9	335.2
87	PM IR Voltage	VAC	13.80	11.49
300	Speed Units	RPM	1	1
413	Mtr OL Factor		1.1	1.1
520	Max Fwd Speed	RPM	2000	2000
521	Max Rev Speed	RPM	-2000	-2000
1629	IPM Bus Prot	RPM	2347	2310
1630	IPM_Lq_25_pct	mH	34.05	21.72
1631	IPM_Lq_50_pct	mH	33.61	21.29
1632	IPM_Lq_75_pct	mH	32.55	20.70
1633	IPM_Lq_100_pct	mH	31.12	19.87
1634	IPM_Lq_125_pct	mH	29.42	18.96
1635	IPM_Ld_0_pct	mH	27.33	18.38
1636	IPM_Ld_100_pct	mH	24.87	16.91
1641	IPM Max Spd	RPM	2000	2000

(1) Minimum allowable PMW switching frequency for Kinetix VPC motors is 4 kHz.

(2) This table specifies motor inertia only (not including the inertia of a connected/driven load). Total inertia can be determined during Inertia Tune. If Inertia Tune cannot be performed, then use the value specified in this table (or default value for this parameter) as a starting value.

Table 2 - Kinetix VPC FANLESS MOTOR DATA VPC-B215xxx

Parameter No.	Name	Units	VPC-B21539-xxxxAS	VPC-B21549-xxxxAS	VPC-B2153A-xxxxAS	VPC-B2154A-xxxxAS	VPC-B2154B-xxxxAS	VPC-B2155B-xxxxAS	VPC-B2156A-xxxxAS
25	Motor NP Volts	VAC	480	480	480	480	480	480	480
26	Motor NP Amps	Amps	10.96	13.72	14.42	19.29	26.80	34.50	32.38
27	Motor NP Hertz	Hz	83.33	83.33	125	125	166.67	166.67	125
28	Motor NP RPM	RPM	1000	1000	1500	1500	2000	2000	1500
29	Mtr NP Pwr Units		kW	kW	kW	kW	kW	kW	kW
30	Motor NP Power	kW	5.3	6.7	7.3	9.2	9.4	10.8	8.8

Table 2 - Kinetix VPC FANLESS MOTOR DATA VPC-B215xxx (Continued)

Parameter No.	Name	Units	VPC-B21539-xxxxAS	VPC-B21549-xxxxAS	VPC-B2153A-xxxxAS	VPC-B2154A-xxxxAS	VPC-B2154B-xxxxAS	VPC-B2155B-xxxxAS	VPC-B2156A-xxxxAS
31	Motor Poles	Pole	10	10	10	10	10	10	10
35	Motor Ctrl Mode		IPM FV	IPM FV	IPM FV	IPM FV	IPM FV	IPM FV	IPM FV
36	Maximum Voltage	VAC	480	480	480	480	480	480	480
37	Maximum Freq	Hz	166.7	166.7	166.7	166.7	166.7	166.7	166.7
38(1)	PMW Frequency	kHz	4	4	4	4	4	4	4
76(2)	Inertia	Secs	0.022	0.023	0.036	0.037	0.064	0.069	0.057
86	PM CEMF Voltage	VAC	328.1	328.1	333.0	332.0	240.4	247.5	188.8
87	PM IR Voltage	VAC	11.73	9.80	6.69	6.85	2.88	2.90	2.44
300	Speed Units	RPM	1	1	1	1	1	1	1
413	Mtr OL Factor		1.1	1.1	1.1	1.1	1.1	1.1	1.1
520	Max Fwd Speed	RPM	2000	2000	2000	2000	2000	2000	2000
521	Max Rev Speed	RPM	-2000	-2000	-2000	-2000	-2000	-2000	-2000
1629	IPM Bus Prot	RPM	1573	1573	2325	2333	4294	4172	4101
1630	IPM_Lq_25_pct	mH	27.78	18.95	12.11	9.45	2.82	2.67	2.21
1631	IPM_Lq_50_pct	mH	27.50	18.95	12.11	9.31	2.70	2.64	2.21
1632	IPM_Lq_75_pct	mH	26.78	18.67	12.06	9.05	2.61	2.54	2.20
1633	IPM_Lq_100_pct	mH	25.78	18.04	11.81	8.73	2.52	2.42	2.19
1634	IPM_Lq_125_pct	mH	24.61	17.47	11.32	8.34	2.40	2.31	2.17
1635	IPM_Ld_0_pct	mH	22.93	16.04	10.35	7.60	2.33	1.90	1.63
1636	IPM_Ld_100_pct	mH	21.28	15.27	10.14	7.01	2.07	1.71	1.62
1641	IPM Max Spd	RPM	2000	2000	2000	2000	2000	2000	2000

(1) Minimum allowable PMW switching frequency for Kinetix VPC motors is 4 kHz.

(2) This table specifies motor inertia only (not including the inertia of a connected/driven load). Total inertia can be determined during Inertia Tune. If Inertia Tune cannot be performed, then use the value specified in this table (or default value for this parameter) as a starting value.

Table 3 - Kinetix VPC FANLESS MOTOR DATA VPC-B300xxx

Parameter No.	Name	Units	VPC-B30029-xxxxAS	VPC-B30039-xxxxAS	VPC-B30049-xxxxAS	VPC-B3002A-xxxxAS	VPC-B3003A-xxxxAS	VPC-B3004A-xxxxAS
25	Motor NP Volts	VAC	480	480	480	480	480	480
26	Motor NP Amps	Amps	20.62	26.86	32.91	28.00	33.72	47.58
27	Motor NP Hertz	Hz	83.33	83.33	83.33	125	125	125
28	Motor NP RPM	RPM	1000	1000	1000	1500	1500	1500
29	Mtr NP Pwr Units		kW	kW	kW	kW	kW	kW
30	Motor NP Power	kW	10.5	14.2	17.6	14.2	17.5	24.4
31	Motor Poles	Pole	10	10	10	10	10	10
35	Motor Ctrl Mode		IPM FV	IPM FV	IPM FV	IPM FV	IPM FV	IPM FV
36	Maximum Voltage	VAC	480	480	480	480	480	480
37	Maximum Freq	Hz	166.7	166.7	166.7	166.7	166.7	166.7
38(1)	PMW Frequency	kHz	4	4	4	4	4	4
76(2)	Inertia Tune	Secs	0.030	0.031	0.032	0.050	0.056	0.053

Table 3 - Kinetix VPC FANLESS MOTOR DATA VPC-B300xxx (Continued)

Parameter No.	Name	Units	VPC-B30029-xxxxAS	VPC-B30039-xxxxAS	VPC-B30049-xxxxAS	VPC-B3002A-xxxxAS	VPC-B3003A-xxxxAS	VPC-B3004A-xxxxAS
86	PM CEMF Voltage	VAC	345.8	350.7	361.3	350.0	357.4	363.8
87	PM IR Voltage	VAC	8.09	6.26	5.70	4.87	3.80	4.04
300	Speed Units	RPM	1	1	1	1	1	1
413	Mtr OL Factor		1.1	1.1	1.1	1.1	1.1	1.1
520	Max Fwd Speed	RPM	2000	2000	2000	2000	2000	2000
521	Max Rev Speed	RPM	-2000	-2000	-2000	-2000	-2000	-2000
1629	IPM Bus Prot	RPM	1493	1472	1429	2212	2166	2128
1630	IPM_Lq_25_pct	mH	14.90	9.89	7.42	7.02	4.65	3.40
1631	IPM_Lq_50_pct	mH	14.86	9.89	7.42	7.02	4.65	3.40
1632	IPM_Lq_75_pct	mH	14.39	9.71	7.32	6.88	4.62	3.38
1633	IPM_Lq_100_pct	mH	13.69	9.36	7.13	6.64	4.52	3.30
1634	IPM_Lq_125_pct	mH	12.92	8.93	6.88	6.33	4.38	3.19
1635	IPM_Ld_0_pct	mH	12.97	8.45	6.20	5.95	3.99	2.82
1636	IPM_Ld_100_pct	mH	11.92	8.03	5.96	5.63	3.87	2.74
1641	IPM Max Spd	RPM	2000	2000	2000	2000	2000	2000

(1) Minimum allowable PMW switching frequency for Kinetix VPC motors is 4 kHz.

(2) This table specifies motor inertia only (not including the inertia of a connected/driven load). Total inertia can be determined during Inertia Tune. If Inertia Tune cannot be performed, then use the value specified in this table (or default value for this parameter) as a starting value.

Table 4 - Kinetix VPC Fan Motor Data VPC-B165*xxx*

Parameter No.	Name	Units	VPC-B1652A-xxxxFS	VPC-B1653A-xxxxFS
25	Motor NP Volts	VAC	480	480
26	Motor NP Amps	Amps	7.91	11.13
27	Motor NP Hertz	Hz	125	125
28	Motor NP RPM	RPM	1500	1500
29	Mtr NP Pwr Units		kW	kW
30	Motor NP Power	kW	4.0	5.5
31	Motor Poles	Pole	10	10
35	Motor Ctrl Mode		IPM FV	IPM FV
36	Maximum Voltage	VAC	480	480
37	Maximum Freq	Hz	166.7	166.7
38(1)	PMW Frequency	kHz	4	4
76(2)	Inertia	Secs	0.018	0.018
86	PM CEMF Voltage	VAC	329.9	335.2
87	PM IR Voltage	VAC	15.29	13.80
300	Speed Units	RPM	1	1
413	Mtr OL Factor		1.1	1.1
520	Max Fwd Speed	RPM	2000	2000
521	Max Rev Speed	RPM	-2000	-2000
1629	IPM Bus Prot	RPM	2347	2310

Table 4 - Kinetix VPC Fan Motor Data VPC-B165*xxx*

Parameter No.	Name	Units	VPC-B1652A-xxxxFS	VPC-B1653A-xxxxFS
1630	IPM_Lq_25_pct	mH	34.05	21.72
1631	IPM_Lq_50_pct	mH	33.61	21.29
1632	IPM_Lq_75_pct	mH	32.55	20.70
1633	IPM_Lq_100_pct	mH	31.12	19.87
1634	IPM_Lq_125_pct	mH	29.42	18.96
1635	IPM_Ld_0_pct	mH	27.33	18.38
1636	IPM_Ld_100_pct	mH	24.87	16.91
1641	IPM Max Spd	RPM	2000	2000

(1) Minimum allowable PMW switching frequency for Kinetix VPC motors is 4 kHz.

(2) This table specifies motor inertia only (not including the inertia of a connected/driven load). Total inertia can be determined during Inertia Tune. If Inertia Tune cannot be performed, then use the value specified in this table (or default value for this parameter) as a starting value.

Table 5 - Kinetix VPC Fan Motor Data VPC-B215*xxx*

Parameter No.	Name	Units	VPC-B21539-xxxxFS	VPC-B21549-xxxxFS	VPC-B2153A-xxxxFS	VPC-B2154A-xxxxFS
25	Motor NP Volts	VAC	480	480	480	480
26	Motor NP Amps	Amps	11.04	15.34	15.00	21.78
27	Motor NP Hertz	Hz	83.33	83.33	125	125
28	Motor NP RPM	RPM	1000	1000	1500	1500
29	Mtr NP Pwr Units		kW	kW	kW	kW
30	Motor NP Power	kW	5.5	7.5	7.5	11.0
31	Motor Poles	Pole	10	10	10	10
35	Motor Ctrl Mode		IPM FV	IPM FV	IPM FV	IPM FV
36	Maximum Voltage	VAC	480	480	480	480
37	Maximum Freq	Hz	166.7	166.7	166.7	166.7
38(1)	PMW Frequency	kHz	4	4	4	4
76(2)	Inertia	Secs	0.021	0.020	0.035	0.031
86	PM CEMF Voltage	VAC	328.1	328.1	333.0	332.0
87	PM IR Voltage	VAC	11.28	10.96	6.96	7.73
300	Speed Units	RPM	1	1	1	1
413	Mtr OL Factor		1.1	1.1	1.1	1.1
520	Max Fwd Speed	RPM	2000	2000	2000	2000
521	Max Rev Speed	RPM	-2000	-2000	-2000	-2000
1629	IPM Bus Prot	RPM	1573	1573	2325	2333
1630	IPM_Lq_25_pct	mH	27.78	18.95	12.11	9.45
1631	IPM_Lq_50_pct	mH	27.50	18.95	12.11	9.31
1632	IPM_Lq_75_pct	mH	26.78	18.67	12.06	9.05

Table 5 - Kinetix VPC Fan Motor Data VPC-B215*xxx (Continued)*

Parameter No.	Name	Units	VPC-B21539-xxxxFS	VPC-B21549-xxxxFS	VPC-B2153A-xxxxFS	VPC-B2154A-xxxxFS
1633	IPM_Lq_100_pct	mH	25.78	18.04	11.81	8.73
1634	IPM_Lq_125_pct	mH	24.61	17.47	11.32	8.34
1635	IPM_Ld_0_pct	mH	22.93	16.04	10.35	7.60
1636	IPM_Ld_100_pct	mH	21.28	15.27	10.14	7.01
1641	IPM Max Spd	RPM	2000	2000	2000	2000

(1) Minimum allowable PMW switching frequency for Kinetix VPC motors is 4 kHz.

(2) This table specifies motor inertia only (not including the inertia of a connected/driven load). Total inertia can be determined during Inertia Tune. If Inertia Tune cannot be performed, then use the value specified in this table (or default value for this parameter) as a starting value.

Table 6 - Kinetix VPC Fan Motor Data VPC-B215*xxx*

Parameter No.	Name	Units	VPC-B30029-xxxxFS	VPC-B30039-xxxxFS	VPC-B30049-xxxxFS	VPC-B3002A-xxxxFS	VPC-B3003A-xxxxFS	VPC-B3004A-xxxxFS
25	Motor NP Volts	VAC	480	480	480	480	480	480
26	Motor NP Amps	Amps	20.62	26.86	32.91	28.00	39.80	54.84
27	Motor NP Hertz	Hz	83.33	83.33	83.33	125	125	125
28	Motor NP RPM	RPM	1000	1000	1000	1500	1500	1500
29	Mtr NP Pwr Units		kW	kW	kW	kW	kW	kW
30	Motor NP Power	kW	11.0	15.0	18.5	15.0	22.0	30.0
31	Motor Poles	Pole	10	10	10	10	10	10
35	Motor Ctrl Mode		IPM FV	IPM FV	IPM FV	IPM FV	IPM FV	IPM FV
36	Maximum Voltage	VAC	480	480	480	480	480	480
37	Maximum Freq	Hz	166.7	166.7	166.7	166.7	166.7	166.7
38(1)	PMW Frequency	kHz	4	4	4	4	4	4
76(2)	Inertia	Secs	0.028	0.029	0.031	0.047	0.045	0.043
86	PM CEMF Voltage	VAC	345.8	350.7	361.3	350.0	357.4	363.8
87	PM IR Voltage	VAC	8.09	6.26	5.70	4.87	4.48	4.65
300	Speed Units	RPM	1	1	1	1	1	1
413	Mtr OL Factor		1.1	1.1	1.1	1.1	1.1	1.1
520	Max Fwd Speed	RPM	2000	2000	2000	2000	2000	2000
521	Max Rev Speed	RPM	-2000	-2000	-2000	-2000	-2000	-2000
1629	IPM Bus Prot	RPM	1493	1472	1429	2212	2166	2128
1630	IPM_Lq_25_pct	mH	14.90	9.89	7.42	7.02	4.65	3.40
1631	IPM_Lq_50_pct	mH	14.86	9.89	7.42	7.02	4.65	3.40
1632	IPM_Lq_75_pct	mH	14.39	9.71	7.32	6.88	4.62	3.38
1633	IPM_Lq_100_pct	mH	13.69	9.36	7.13	6.64	4.52	3.30
1634	IPM_Lq_125_pct	mH	12.92	8.93	6.88	6.33	4.38	3.19
1635	IPM_Ld_0_pct	mH	12.97	8.45	6.20	5.95	3.99	2.82
1636	IPM_Ld_100_pct	mH	11.92	8.03	5.96	5.63	3.87	2.74
1641	IPM Max Spd	RPM	2000	2000	2000	2000	2000	2000

(1) Minimum allowable PMW switching frequency for Kinetix VPC motors is 4 kHz.

(2) This table specifies motor inertia only (not including the inertia of a connected/driven load). Total inertia can be determined during Inertia Tune. If Inertia Tune cannot be performed, then use the value specified in this table (or default value for this parameter) as a starting value.

IPM Motor Startup Troubleshooting

If there is a problem or fault during the tuning process of an IPM motor, the following steps may need to be taken.

Direction test does not rotate - When attempting to run the motor direction test the motor just oscillates or does not rotate indicates that parameter 93 [PM Dir Test Cur] is too low. The default for this parameter is 10% of the motor rating and is too low for anything but a bare motor shaft. We suggest setting to 50% of the motor rated current, and increase to 100% if needed to complete the test.

Fault 197 PM Offset Failed

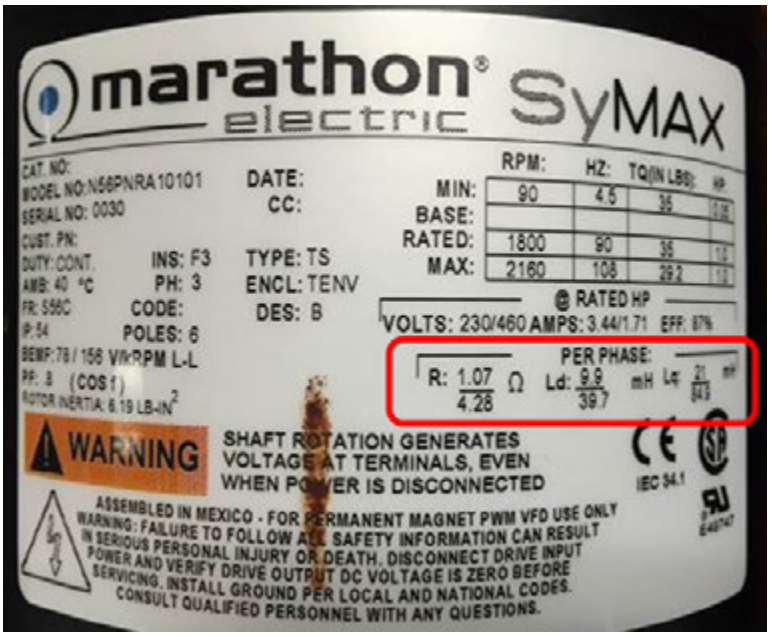
This fault occurs if the motor does not move the specified minimum distance during the commutation offset test. This could be caused if the motor has a brake and the brake is not released during the test, the load on the motor is greater than the motor capability because of the PM Offset Test current setting. Verify that the motor or load does not have a brake. Verify the motor poles, incorrect pole settings cause incorrect distance to travel. Increase parameter 83 [PM OfstTst Cur] to something greater than the default 40%, suggest starting at 50% and increase if needed because of the load on the motor. If the motor oscillates during the test, then fails, try increasing the values of parameter 84 [PM OfsTst CRamp] and parameter 85 [PM OfsTst FRamp] by 25% and attempt the test again. Retry until motor pulls to each position without faulting on a PM Offset Failed.

Fault 35 IPM OverCurrent - the following steps may help:

1. Increase parameter 1640 [IPM Max Cur] from 200% to 250% or more. This increases the level at which the IPM OverCurrent is reported.
2. Decrease parameter 1660 [IPM Stc OfsTst K] from 1.0 to 0.4 in increments of 0.1 until the test passes. This helps reduce/lower the current pulses during the **Static Offset** test.
3. Change parameter 95 [VCL Cur Reg BW] to 500.

If none of the above allow the autotune to pass, you need the motor Lq and Ld values from the motor data sheet. Figure 9 is a Marathon SyMax motor nameplate. The Lq and Ld values are on the nameplate. Enter the same Lq value in parameters 1630...1634 and enter the same Ld values in parameters 1635...1636. Then run the autotune test again, this configures the current regulator to the motor. If you have the motor data sheet from the beginning of the document you can enter the Lq and Ld values from that for the equivalent P1630...1636 data.

Figure 9 - Marathon SyMax IPM Nameplate



Examples:

- The Baldor motor data sheet has the Lq and Ld values for 25, 50, 75, and 100% that can be used to populate parameters 1630...1636. Use the 100% value for the 125% in parameter 1634 as a starting point.
- The Marathon SyMax motor only has the Lq and Ld values from 100% load. You can use these to populate the entire 25...125% ranges in parameters 1630...1636.

Fault 195 IPMSpdEstErr - the following parameters may help:

- Increase parameter 1640 [IPM Max Cur] from 200% to 250% or more. This increases the level at which the IPM overcurrent is reported.
- Set parameter 1629 [IPM Bus Prot] to at least half the motor nameplate base frequency plus 10. Increase to allow autotune to reach higher rotate speed.
- Set parameter 1641 [IPM Max Spd] to at least half the motor nameplate base frequency plus 10. Increase to allow autotune to reach higher rotate speed.
- Parameter 1651 [IPM SpdEst Ki] default value is 2500. Decrease to 1000. This allows increased filtering during rotate autotune. You may have to increase the value in some instances.
- Set parameter 37 [Max Freq] to 10 Hz greater than the motor nameplate
- Set parameter 71 [Autotune Torque] to 25%, some motors have had to be set as low as 7% to pass the test and pass the Inertia Tune
- Set parameter 86 [PM CEMF] to the data sheet value or nameplate value for the rated RPM of the motor. Typical CEMF numbers are listed in volts per 1000 RPM, a 1750 RPM motor with a CEMF of 156 V/kRPM would be 273 in parameter 86.

The IPMSpd is estimated from estimated Theta_E with a PLL loop. If the Theta error within the PLL exceeds a hard coded angle value, then IPMSpdEstErr is issued.

The PI gains of the PLL loop are;

parameter 1650 [IPMSpdEst Kp] default = 30

parameter 1651 [IPMSpdEstKi] default = 2500

It is possible that P1650 [IPMSpdEst Kp] needs higher gain.

We do not have a clear idea about what values are best for each motor, but below are some examples.

- For experience with a smaller motor,
  - P1650 [IPMSpdEst Kp] = 1000,
  - P1651 [IPMSpdEstKi] = 1500

Fault 77 IR Volts Range - If this fault occurs changing the carrier frequency to 2 kHz may help. It may also require resetting the drive to defaults and start over.

Issues with Low Speed motors, for example, 15 Hz max frequency 4 poles

The default settings of the control mode transitions are below. You may need to lower the transition points for these low speed 4 pole motors to operate properly.

Default Settings of Control Mode Transitions

Parameter	Default Setting	Operating point	RPM range with a 4-pole motor
P1653 [IPM Tran PWM]	8 Hz	—	240
P1654 [IPMTran PWM Hyst]	2 Hz	8+2 = 10 Hz	300
P1655 [IPM Tran Mode]	4 Hz	—	120
P1656 [IPM TranMod Hyst]	3 Hz	4+3 = 7 Hz	210

When you start the motor from 0 RPM:

1. The drive tries to identify the north/south of the rotor magnet.
2. The drive tries to identify the rotor magnet position using a pulse width modified (PWM) scheme for low speed.
3. When the rotor speed reaches 180 RPM, the control mode makes a transition to a rotor magnet identification scheme for higher speed.
4. When the rotor speed reaches 300 RPM, the PWM scheme makes a transition to a normal PWM scheme.

When the motor is stopping from above 300 RPM:

1. The control is running with normal PWM scheme.
2. The control is running with a rotor magnet identification scheme for higher speed range.
3. When the rotor speed is down to 240 RPM, the drive switches to a PWM scheme for low speed.
4. When the rotor speed is down to 120 RPM, the control mode makes a transition to a rotor magnet identification scheme for low speed.

Commutation Offset for SMP and IPM Motors

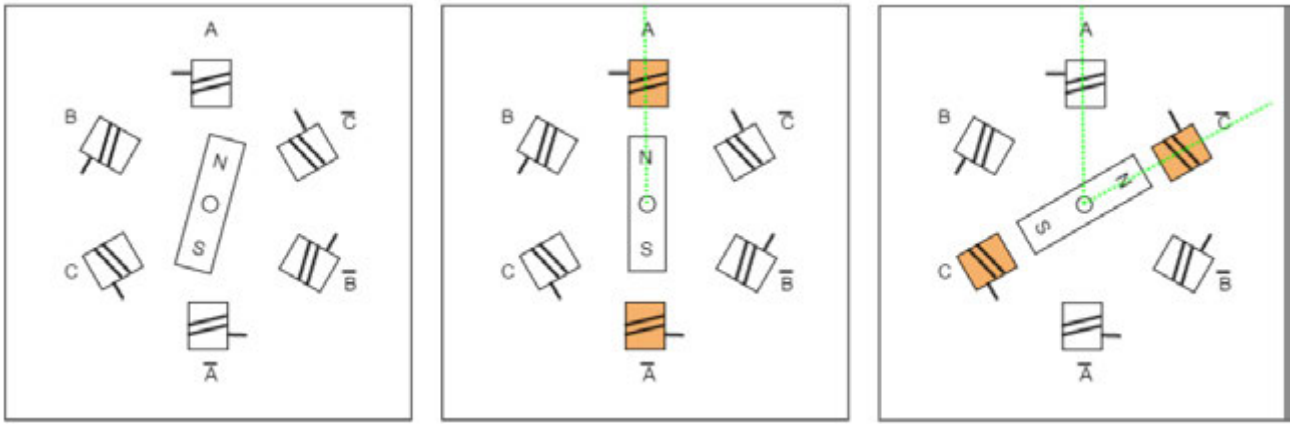
To properly control any SPM or IPM motors, you must know the commutation angle. If the commutation angle is not correct, the motor draws much higher current and produces lower torque. This is the reason that you cannot run a PM motor in V/Hz or sensorless vector modes. If you start a drive in V/Hz mode, and the voltage angle is not correct, one of two things may occur. Either the motor jumps forward or reverses to align with the output voltage, or the motor does not move at all because the voltage angle is so far from the correct commutation angle.

Commutation Offset Angle Measurement

Commutation offset in the PowerFlex 755 is measured to calculate the proper magnet position in relation to the stator. With an absolute encoder, it is measured once on the initial startup and stored in parameter 81 [PM Offset]. The number is 0...1023 in standalone mode and is in degrees of electrical angle in an Integrated Motion Axis. To convert from standalone mode to degrees, take P81 value / 1024 *360. If the encoder is ever replaced or uncoupled, the commutation test must be run again to align the feedback with the motor.

The commutation test is accomplished as shown in Figure 10.

Figure 10 - Commutation Offset Angle Measurement



Initial position of the rotor.

One set of windings is energized and the rotor is pulled into alignment and the encoder position is stored.

The second set of windings is energized and the rotor is pulled to the next pole and the encoder position is stored. P81 is calculated and stored.

With an incremental encoder, the commutation angle in the PowerFlex 755 is measured once on the first start after power up. The system must allow the movement of the motor to align the poles and the commutation test current must be set high enough to accomplish the task.

Without motor feedback, the PowerFlex 755 uses a static test is run by pulsing each IGBT independently. The current waveform from all six IGBT firings is analyzed and the commutation angle is estimated. This test is run on every start of a PM motor without feedback.

Notes:

Rockwell Automation Support

Use the following resources to access support information.

Technical Support Center	Knowledgebase Articles, How-to Videos, FAQs, Chat, User Forums, and Product Notification Updates.	www.rockwellautomation.com/knowledgebase
Local Technical Support Phone Numbers	Locate the phone number for your country.	www.rockwellautomation.com/global/support/get-support-now.page
Direct Dial Codes	Find the Direct Dial Code for your product. Use the code to route your call directly to a technical support engineer.	www.rockwellautomation.com/global/support/direct-dial.page
Literature Library	Installation Instructions, Manuals, Brochures, and Technical Data.	www.rockwellautomation.com/literature
Product Compatibility and Download Center (PCDC)	Get help determining how products interact, check features and capabilities, and find associated firmware.	www.rockwellautomation.com/global/support/pcdc.page

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Rockwell Otomasyon Ticaret A.Ş., Kar Plaza İş Merkezi E Blok Kat:6 34752 İçerenköy, İstanbul, Tel: +90 (216) 5698400

www.rockwellautomation.com

Power, Control and Information Solutions Headquarters

Americas: Rockwell Automation, 1201 South Second Street, Milwaukee, WI 53204-2496 USA, Tel: (1) 414.382.2000, Fax: (1) 414.382.4444
Europe/Middle East/Africa: Rockwell Automation NV, Pegasus Park, De Kleetlaan 12a, 1831 Diegem, Belgium, Tel: (32) 2 663 0600, Fax: (32) 2 663 0640
Asia Pacific: Rockwell Automation, Level 14, Core F, Cyberport 3, 100 Cyberport Road, Hong Kong, Tel: (852) 2887 4788, Fax: (852) 2508 1846

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