Allen-Bradley

PowerFlex®

70 & 700 Adjustable Frequency AC Drive

70 Firmware Versions
Standard Control xxx.x - 2.001
Enhanced Control xxx.x - 2.xxx

700 Firmware Versions
Standard Control xxx.x - 3.001
Vector Control xxx.x - 3.001

Reference Manual

Rockwell Automation

Important User Information

Solid state equipment has operational characteristics differing from those of electromechanical equipment. *Safety Guidelines for the Application, Installation and Maintenance of Solid State Controls* (Publication SGI-1.1 available from your local Rockwell Automation sales office or **www.rockwellautomation.com/literature**) describes some important differences between solid state equipment and hard-wired electromechanical devices. Because of this difference, and also because of the wide variety of uses for solid state equipment, all persons responsible for applying this equipment must satisfy themselves that each intended application of this equipment is acceptable.

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.

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Throughout this manual 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.

Important: Identifies information that is critical for successful application and understanding of the product.

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 the hazard
- recognize the consequences

Shock Hazard labels may be located on or inside the drive to alert people that dangerous voltage may be present.

Burn Hazard labels may be located on or inside the drive to alert people that surfaces may be at dangerous temperatures.

Manual Conventions

Standard = Indicates that the information presented is specific to the Standard Control Option.

Vector = This information only applies to PowerFlex 700 drives with the Vector Control option.

Vector FV = Applies to PowerFlex 700 drives with [Motor Cntl Sel] set to "FVC Vector."

EC = Indicates that the information presented is specific to the PowerFlex 70 Enhanced Control Option.

The information below summarizes the changes to the PowerFlex 70/700 Reference Manual, publication PFLEX-RM001 since the last release.

Change	Page
PowerFlex 700 60 HP, 600V Derate added	1-6
PowerFlex 70 dimensions updated	1-7
PowerFlex 700 Frame 4 dimensions updated	1-14
Analog Input Cable Selection updated	2-18
PowerFlex 700 Analog Output info added for firmware 3.001 & later	2-24
"Bus Regulation" section updated	2-49 - 2-51
Digital Input Cable Selection updated	2-61
PowerFlex 700 Digital Output info added for firmware 3.001 & later	2-82
Fuse & Circuit Breaker tables updated	2-101 - 2-106
Bypass Contactor Attention statement added	2-121
PowerFlex 700 Process PI info added for firmware 3.001 & later	2-150
Scale Blocks sections added	2-157
PowerFlex 700 Torque Reference info added for firmware 3.001 & later	2-209
Dynamic Brake Selection Guide updated	A-1

Notes:

Chapter 1 Specifications & Dimensions

Chapter 2 Detailed Drive Operation

Appendix A Dynamic Brake Selection Guide

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Section 2

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Specifications & Dimensions

PowerFlex 70/700 Specifications

Category	Specification					
Agency Certification	PF70			PF700		
	Type 1, IP 30	*Flange Type*	*Type 4X/ 12, IP 66*	*All*	**Description**	
	✔	✔	✔	✔	c UL us	Listed to UL508C and CAN/CSA-C2.2 No. 14-M91.
		✔				Listed to UL508C for plenums (Rear heatsink only)
	✔	✔	✔	✔	CE	Marked for all applicable European Directives[1] EMC Directive (89/336/EEC) EN 61800-3 Adjustable Speed electrical power drive systems Low Voltage Directive (73/23/EEC) EN 50178 Electronic Equipment for use in Power Installations
	✔	✔	✔	✔	N223	Certified to AS/NZS, 1997 Group 1, Class A.
			✔		NSF	Certified to Criteria C-2, 1983.
	The drive is also designed to meet the following specifications: NFPA 70 - US National Electrical Code NEMA ICS 3.1 - Safety standards for Construction and Guide for Selection, Installation and Operation of Adjustable Speed Drive Systems. IEC 146 - International Electrical Code.					

(1) Applied noise impulses may be counted in addition to the standard pulse train causing erroneously high [Pulse Freq] readings.

Category	Specification						
Protection	**PowerFlex 70 Drive**	**200-208V Drive**	**240V Drive**	**380/400 Drive**	**480V Drive**	**600V Drive**	**690V Drive**
	AC Input Overvoltage Trip:	247VAC	285VAC	475VAC	570VAC	690VAC	
	AC Input Undervoltage Trip:	120VAC	138VAC	233VAC	280VAC	345VAC	
	Bus Overvoltage Trip:	405VDC	405VDC	810VDC	810VDC	1013VDC	
	Bus Undervoltage Output Shutoff:	204VDC	204VDC	407VDC	407VDC	508VDC	
	Bus Undervoltage Fault Level:	160VDC	160VDC	300VDC	300VDC	375VDC	
	Nominal Bus Voltage:	281VDC	324VDC	540VDC	648VDC	810VDC	
	PowerFlex 700						
	AC Input Overvoltage Trip:	See PowerFlex 70 above					
	AC Input Undervoltage Trip:						
	Bus Overvoltage Trip:						
	Bus Undervoltage Shutoff & Fault:	153VDC	153VDC	305VDC	305VDC	381VDC	
	Nominal Bus Voltage:	See PowerFlex 70 above					
	All Drives						
	Heat Sink Thermistor:	Monitored by microprocessor overtemp trip					
	Drive Overcurrent Trip Software Overcurrent Trip: Hardware Overcurrent Trip:	 200% of rated current (typical) 220-300% of rated current (dependent on drive rating)					
	Line transients:	up to 6000 volts peak per IEEE C62.41-1991					
	Control Logic Noise Immunity:	Showering arc transients up to 1500V peak					
	Power Ride-Thru:	15 milliseconds at full load					
	Logic Control Ride-Thru:	0.5 seconds minimum, 2 seconds typical					
	Ground Fault Trip:	Phase-to-ground on drive output					
	Short Circuit Trip:	Phase-to-phase on drive output					

Category	Specification	
Environment	Altitude:	1000 m (3300 ft) max. without derating
	Maximum Surrounding Air Temperature without Derating: **PowerFlex 70** IP20, NEMA Type 1: Flange Mount: IP66, NEMA Type 4X/12: **PowerFlex 700** IP20, NEMA Type 1:	 0 to 50 degrees C (32 to 122 degrees F) 0 to 50 degrees C (32 to 122 degrees F) 0 to 40 degrees C (32 to 104 degrees F) 0 to 50 degrees C (32 to 122 degrees F)
	Storage Temperature (all const.):	–40 to 70 degrees C (–40 to 158 degrees F)
	Atmosphere	**Important:** Drive **must not** be installed in an area where the ambient atmosphere contains volatile or corrosive gas, vapors or dust. If the drive is not going to be installed for a period of time, it must be stored in an area where it will not be exposed to a corrosive atmosphere.
	Relative Humidity:	5 to 95% non-condensing
	Shock:	15G peak for 11ms duration (±1.0 ms)
	Vibration:	0.152 mm (0.006 in.) displacement, 1G peak
Electrical	Voltage Tolerance:	See Voltage Tolerance on page 2-212
	Frequency Tolerance:	47-63 Hz.
	Input Phases:	Three-phase input provides full rating for all drives. Single-phase operation provides 50% of rated current.
	Displacement Power Factor All Drives:	 0.98 across entire speed range.
	Efficiency:	97.5% at rated amps, nominal line volts.
	Maximum Short Circuit Rating:	200,000 Amps symmetrical.
	Actual Short Circuit Rating:	Determined by AIC rating of installed fuse/circuit breaker.
Control	Method:	Sine coded PWM with programmable carrier frequency. Ratings apply to all drives (refer to the *Derating Guidelines* on page 1-3). The drive can be supplied as 6 pulse or 12 pulse in a configured package.
	Carrier Frequency PF70: PF700:	Drive rating based on 4 kHz 2, 4, 8 & 10 kHz Standard; 2, 4, 8 & 12 kHz E C 2, 4, 8 & 10 kHz
	Output Voltage Range:	0 to rated motor voltage
	Output Frequency Range: PF70: PF700:	 0 to 400 Hz Standard, 0 to 500 Hz E C 0 to 400 Hz Standard, 0 to 420 Hz Vector
	Frequency Accuracy Digital Input: Analog Input:	 Within ±0.01% of set output frequency. Within ±0.4% of maximum output frequency.
	Frequency Control	Speed Regulation - w/Slip Compensation (Volts per Hertz Mode) Standard Vector 0.5% of base speed across 40:1 speed range 40:1 operating range 10 rad/sec bandwidth
		Speed Regulation - w/Slip Compensation (Sensorless Vector Mode) Standard Vector 0.5% of base speed across 80:1 speed range 80:1 operating range 20 rad/sec bandwidth
		Speed Regulation - w/Feedback (Sensorless Vector Mode) Vector 0.1% of base speed across 80:1 speed range 80:1 operating range 20 rad/sec bandwidth
	Speed Control	Speed Regulation - w/o Feedback (Vector Control Mode) Vector 0.1% of base speed across 120:1speed range 120:1 operating range 50 rad/sec bandwidth
		Speed Regulation - w/Feedback (Vector Control Mode) Vector 0.001% of base speed across 120:1 speed range 1000:1 operating range 250 rad/sec bandwidth

Category	Specification	
Control *(continued)*	Torque Regulation	Torque Regulation - without feedback **Vector** ±10%, 600 rad/sec bandwidth
		Torque Regulation - with feedback **Vector** ±5%, 2500 rad/sec bandwidth
	Selectable Motor Control:	Sensorless Vector with full tuning. Standard V/Hz with full custom capability. PF700 adds Vector Control.
	Stop Modes:	Multiple programmable stop modes including - Ramp, Coast, DC-Brake, Ramp-to-Hold and S-curve.
	Accel/Decel:	Two independently programmable accel and decel times. Each time may be programmed from 0 - 3600 seconds in 0.1 second increments.
	Intermittent Overload:	110% Overload capability for up to 1 minute 150% Overload capability for up to 3 seconds
	Current Limit Capability:	Proactive Current Limit programmable from 20 to 160% of rated output current. Independently programmable proportional and integral gain.
	Electronic Motor Overload Protection	Class 10 protection with speed sensitive response. Investigated by U.L. to comply with N.E.C. Article 430. U.L. File E59272, volume 12.
Encoder *PowerFlex 700 Only*	Type:	Incremental, dual channel
	Supply:	12V, 500 mA. 12V, 10 mA minimum inputs isolated with differential transmitter, 250 kHz maximum.
	Quadrature:	90°, ±27 degrees at 25 degrees C.
	Duty Cycle:	50%, +10%
	Requirements:	Encoders must be line driver type, quadrature (dual channel) or pulse (single channel), 8-15V DC output, single-ended or differential and capable of supplying a minimum of 10 mA per channel. Maximum input frequency is 250 kHz. The Encoder Interface Board accepts 12V DC square-wave with a minimum high state voltage of 7.0V DC (12 volt encoder). Maximum low state voltage is 0.4V DC.

Input/Output Ratings

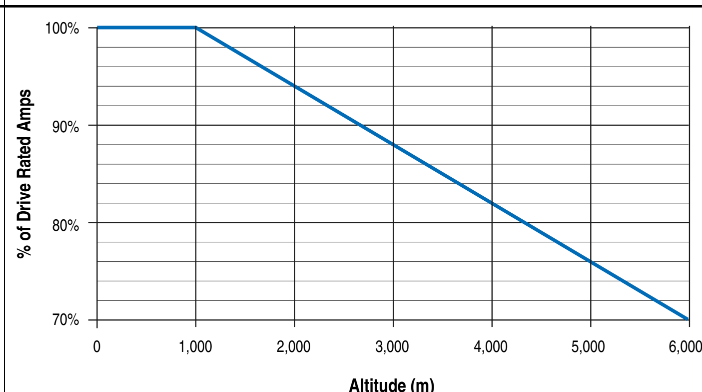
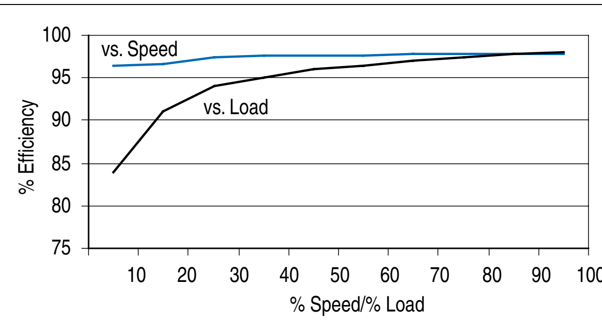
Each PowerFlex Drive has normal and heavy duty torque capabilities. The listings can be found in Tables 2.M through 2.W.

Heat Dissipation

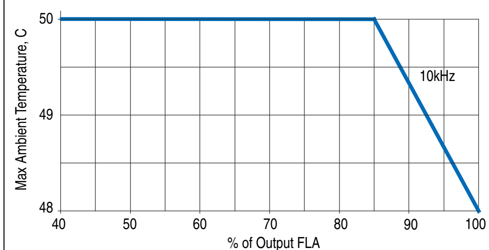
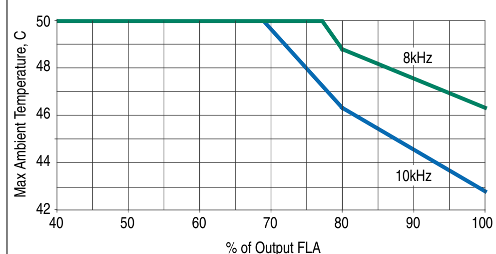
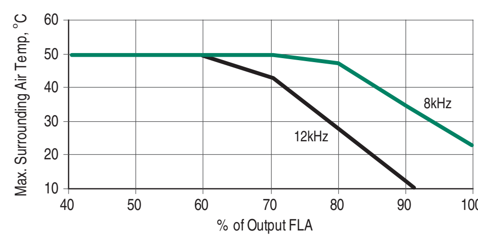
See Watts Loss on page 2-213.

Derating Guidelines

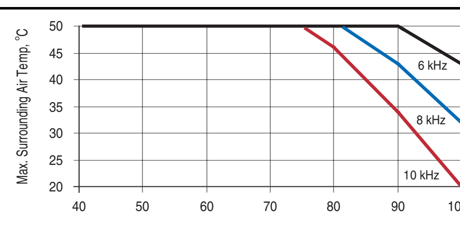
PowerFlex 70 & 700 Altitude and Efficiency

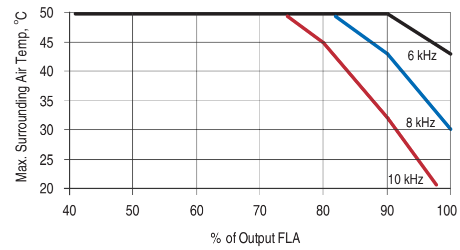
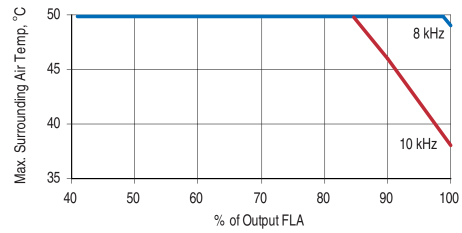
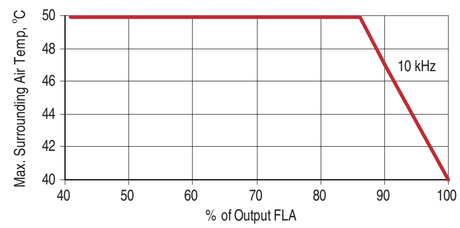
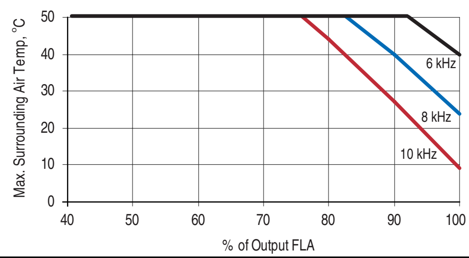
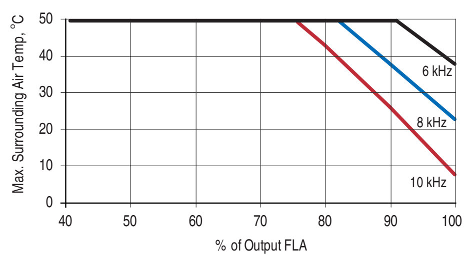
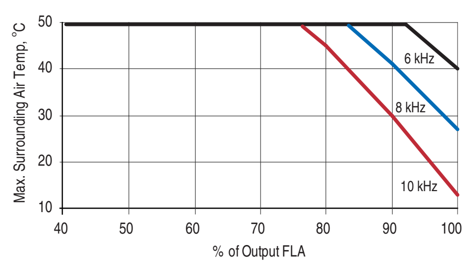
Frame	Type	Derate
All	Altitude	
	Efficiency (typical)	

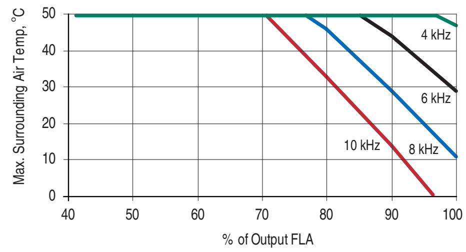
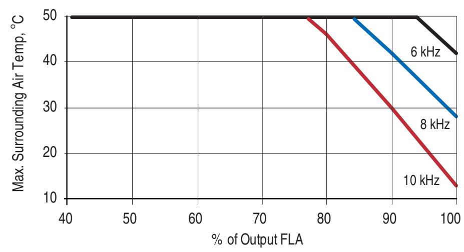
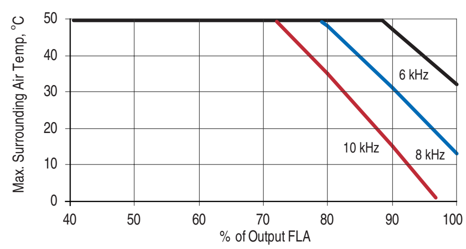
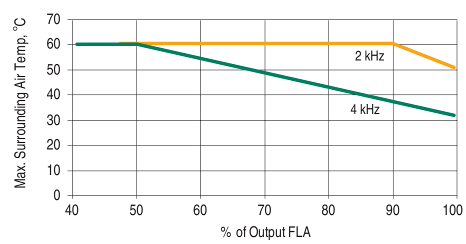
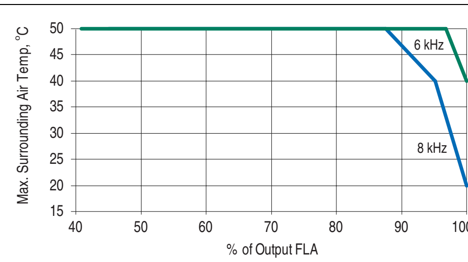
PowerFlex 70 Ambient Temperature/Load

Frame	Class	Enclosure	Frequency	Derate
A	400V	Open, NEMA Type 1, IP20, Flange	2-10 kHz	None
B	400V	Open, NEMA Type 1, IP20, Flange	2-10 kHz	None
C	400V	NEMA Type 1, Flange	2-8 kHz	None
			10 kHz	
D	400V	NEMA Type 1, Flange	2-6 kHz	None
			8-10 kHz	
E	400V	NEMA Type 1, Flange	2-6 kHz	None
			8-10 kHz	

PowerFlex 700 Ambient Temperature/Load

Frame	Voltage	ND Rating	Enclosure	Frequency [1]	Derate
0	400V	5.5 kW	Open, NEMA Type 1, IP20	2-10 kHz	None
	460V	7.5 HP	Open, NEMA Type 1, IP20	2-10 kHz	None
1	400V	11 kW	Open, NEMA Type 1, IP20	2-6 kHz	

Frame	Voltage	ND Rating	Enclosure	Frequency (1)	Derate
1 *cont.*	460V	15 HP	Open, NEMA Type 1, IP20	2-6 kHz	
2	400V	15 kW	Open, NEMA Type 1, IP20	8-10 kHz	
	460V	20 HP	Open, NEMA Type 1, IP20	10 kHz	
		25 HP	Open, NEMA Type 1, IP20	6-10 kHz	
3	400V	18.5 kW	Open, NEMA Type 1, IP20	6-10 kHz	
		22 kW	Open, NEMA Type 1, IP20	2-10 kHz	None
		30 kW	Open, NEMA Type 1, IP20	6-10 kHz	

Frame	Voltage	ND Rating	Enclosure	Frequency[1]	Derate
3 *cont.*	400V	37 kW	Open, NEMA Type 1, IP20	4-10 kHz	
	460V	30 HP	Open, NEMA Type 1, IP20	2-10 kHz	None
		40 HP	Open, NEMA Type 1, IP20	6-10 kHz	
		50 HP	Open, NEMA Type 1, IP20	6-10 kHz	
4	600V	60 HP	Open, NEMA Type 1, IP20	2-4 kHz	
5	400V	55 kW	Open, NEMA Type 1, IP20	2-8 kHz	None
	460V	75 HP	Open, NEMA Type 1, IP20	2-8 kHz	None
		100 HP	Open, NEMA Type 1, IP20	4 kHz	None
				6-8 kHz	

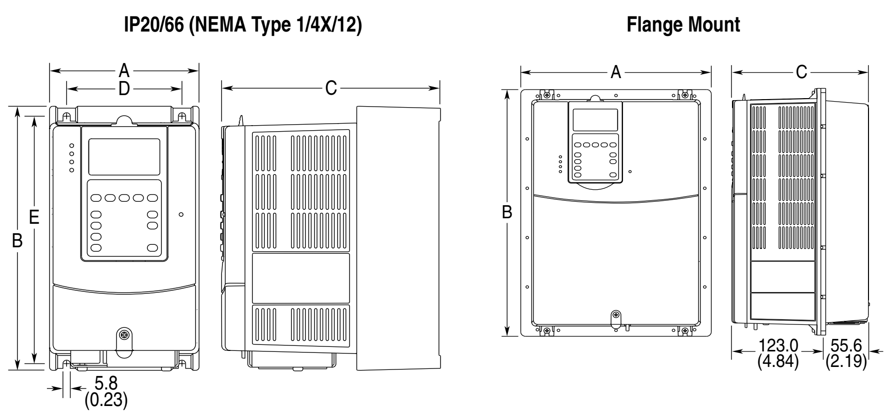
(1) Consult the factory for further derate information at other frequencies.

PowerFlex 70 Dimensions

Table 1.A PowerFlex 70 Frames

Output Power		Frame Size								
		208-240V AC Input			400-480V AC Input			600V AC Input		
kW ND (HD)	HP ND (HD)	Not Filtered	Filtered	IP66 (4X/12)	Not Filtered	Filtered	IP66 (4X/12)	Not Filtered	Filtered	IP66 (4X/12)
0.37 (0.25)	0.5 (0.33)	A	B	B	A	B	B	A	–	B
0.75 (0.55)	1 (0.75)	A	B	B	A	B	B	A	–	B
1.5 (1.1)	2 (1.5)	B	B	B	A	B	B	A	–	B
2.2 (1.5)	3 (2)	B	B	B	B	B	B	B	–	B
4 (3)	5 (3)	–	C	D	B	B	B	B	–	B
5.5 (4)	7.5 (5)	–	D	D	–	C	D	C	–	D
7.5 (5.5)	10 (7.5)	–	D	D	–	C	D	C	–	D
11 (7.5)	15 (10)	–	–	–	–	D	D	D	–	D
15 (11)	20 (15)	–	–	–	–	D	D	D	–	D
18.5 (15)	25 (20)	–	–	–	–	D	D	–	–	–
22 (18.5)	30 (25)	–	–	–	–	D	D	–	–	–

Figure 1.1 PowerFlex 70 Frames A-D

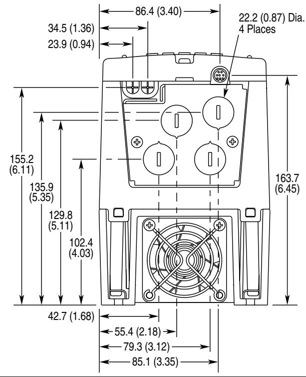


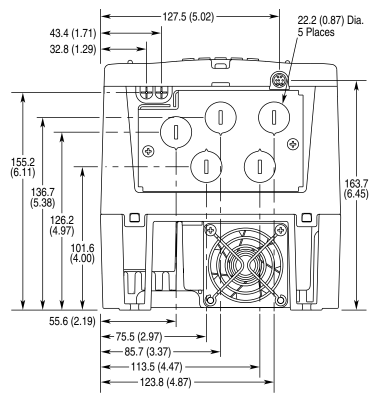
Dimensions are in millimeters and (inches).

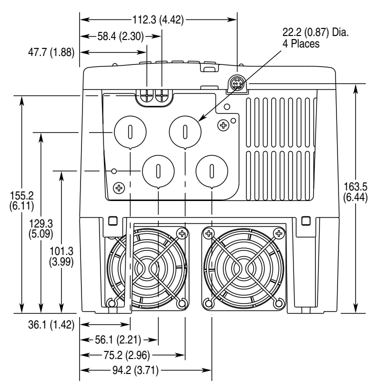
Frame	A	B	C	D	E	Weight [1] *kg (lbs.)*
IP20 / NEMA Type 1						
A	122.4 (4.82)	225.7 (8.89)	179.8 (7.08)	94.2 (3.71)	211.6 (8.33)	2.71 (6.0)
B	171.7 (6.76)	234.6 (9.24)	179.8 (7.08)	122.7 (4.83)	220.2 (8.67)	3.60 (7.9)
C	185.0 (7.28)	300.0 (11.81)	179.8 (7.08)	137.6 (5.42)	285.6 (11.25)	6.89 (15.2)
D	219.9 (8.66)	350.0 (13.78)	179.8 (7.08)	169.0 (6.65)	335.6 (13.21)	9.25 (20.4)
IP66 / NEMA Type 4X/12						
B	171.7 (6.76)	239.8 (9.44)	203.3 (8.00)	122.7 (4.83)	220.2 (8.67)	3.61 (8.0)
D	219.9 (8.66)	350.0 (13.78)	210.7 (8.29)	169.0 (6.65)	335.6 (13.21)	9.13 (20.1)
Flange Mount						
A	156.0 (6.14)	225.8 (8.89)	178.6 (7.03)	–	–	2.71 (6.0)
B	205.2 (8.08)	234.6 (9.24)	178.6 (7.03)	–	–	3.60 (7.9)
C	219.0 (8.62)	300.0 (11.81)	178.6 (7.03)	–	–	6.89 (15.2)
D	248.4 (9.78)	350.0 (13.78)	178.6 (7.03)	–	–	9.25 (20.4)

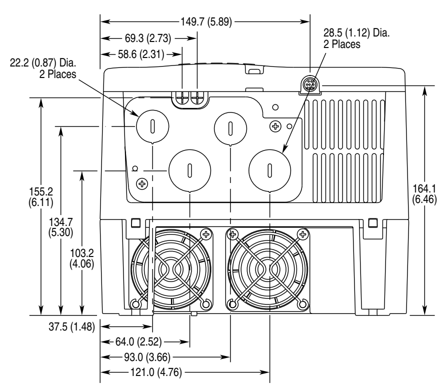
(1) Weights include HIM and Standard I/O.

Figure 1.2 PowerFlex 70 IP20/NEMA Type 1 Bottom View Dimensions

<table>
<tr><th>Frame</th><th>Dimensions in millimeters and (inches)</th></tr>
<tr><td>A</td><td>


</td></tr>
<tr><td>B</td><td>


</td></tr>
<tr><td>C</td><td>


</td></tr>
<tr><td>D</td><td>


</td></tr>
</table>

Figure 1.3 PowerFlex 70 IP66 (NEMA Type 4X/12) Bottom View Dimensions

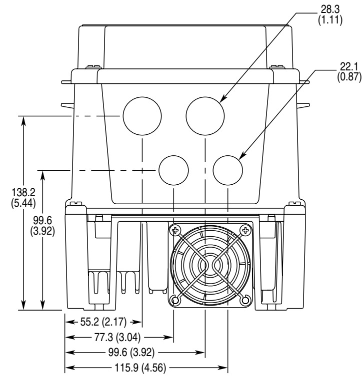
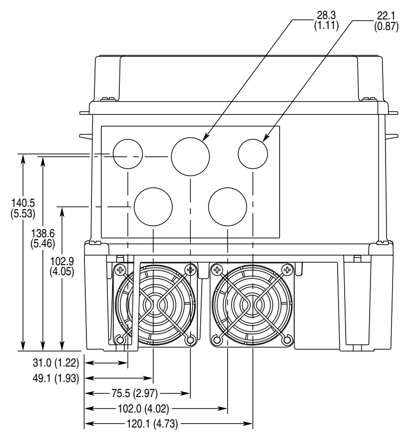
<table>
<tr><th>Frame</th><th>Dimensions in millimeters and (inches)</th></tr>
<tr><td>B</td><td>
</td></tr>
<tr><td>D</td><td>
</td></tr>
</table>

Figure 1.4 PowerFlex 70 Flange Mount Bottom View Dimensions

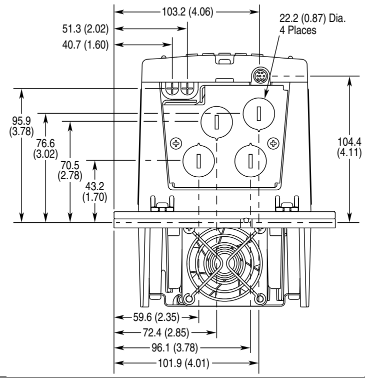
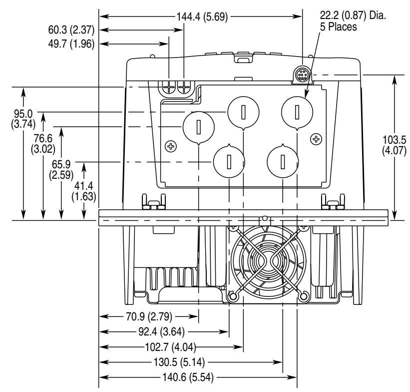
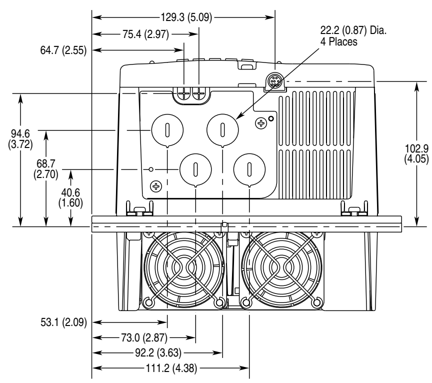
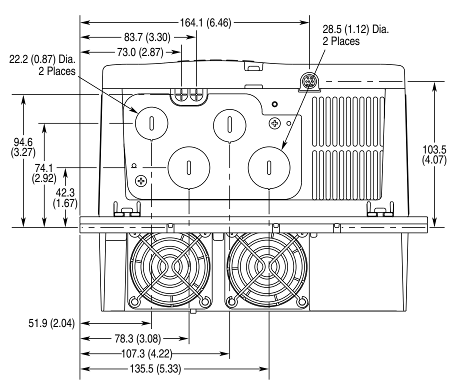
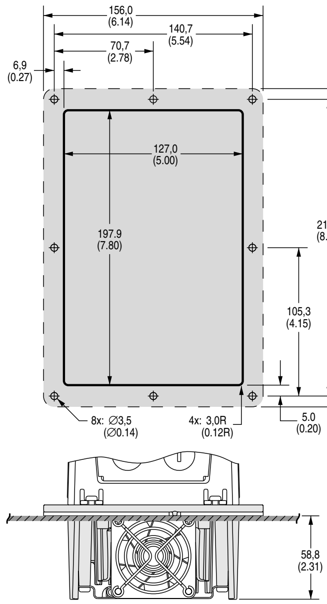
Frame	Dimensions in millimeters and (inches)
A	
B	
C	
D	

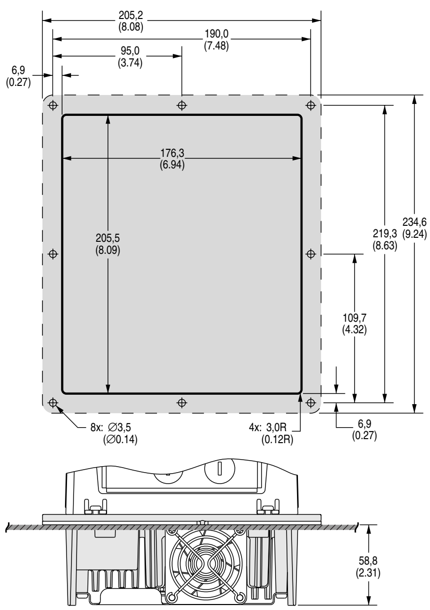
Figure 1.5 PowerFlex 70 Cutout Dimensions

Frame | **Dimensions in millimeters and (inches)**

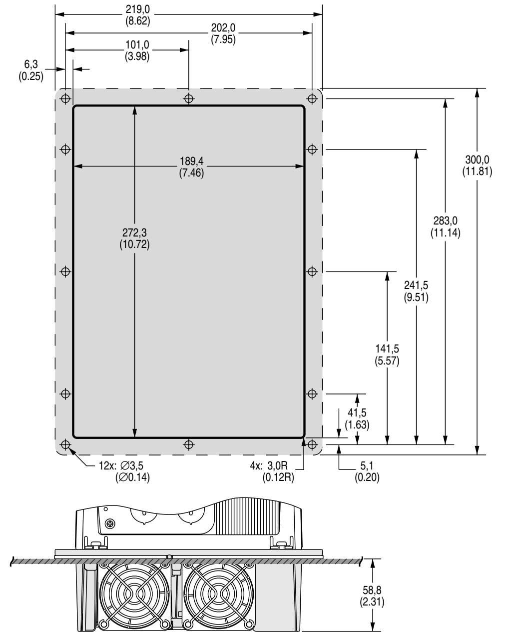
A



B



C



D

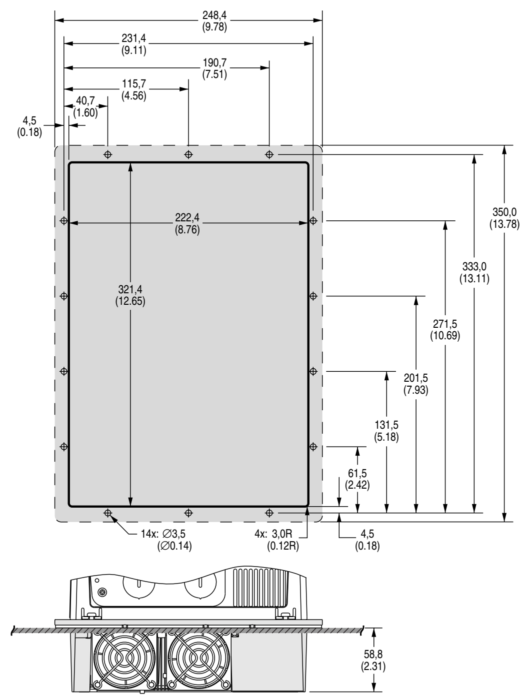
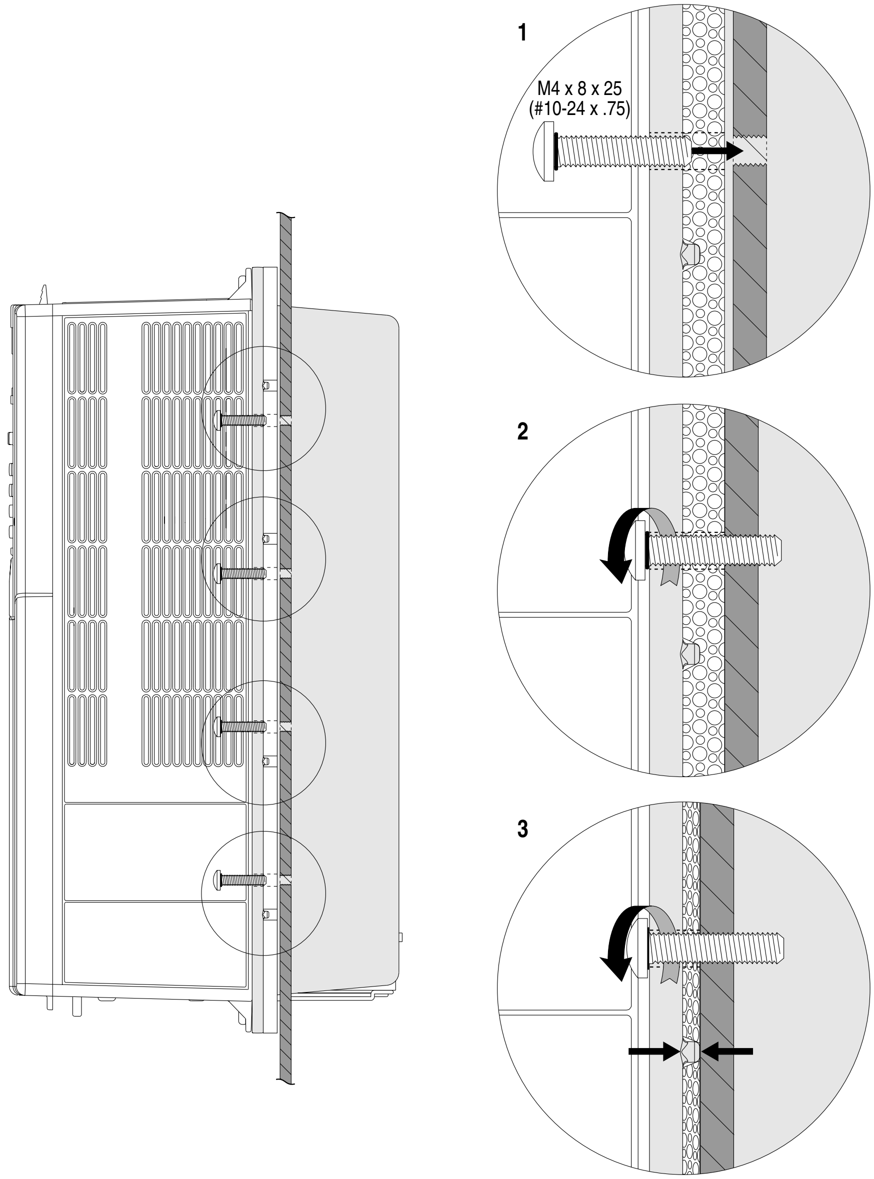


Figure 1.6 Flange Mounting



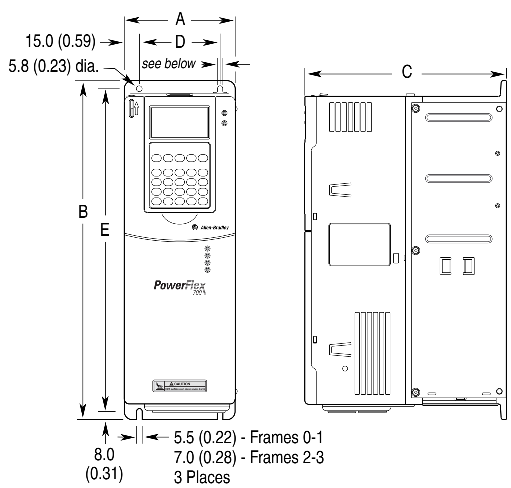
Dimensions are in millimeters and (inches)

PowerFlex 700 Dimensions

Table 1.B PowerFlex 700 Frames

	AC Input								DC Input			
	208/240		400V		480V		600V		540V		650V	
Frame	**ND HP**	**HD HP**	**ND kW**	**HD kW**	**ND HP**	**HD HP**	**ND HP**	**HD HP**	**ND HP**	**HD HP**	**ND HP**	**HD HP**
0	0.5	0.33	0.37	0.25	0.5	0.33	–	–	0.37	0.25	0.5	0.33
	1	0.75	0.75	0.55	1	0.75	–	–	0.75	0.55	1	0.75
	–	–	1.5	0.75	2	1.5	–	–	1.5	0.75	2	1.5
	–	–	2.2	1.5	3	2	–	–	2.2	1.5	3	2
	–	–	4	2.2	5	3	–	–	4	2.2	5	3
	–	–	5.5	4	7.5	5	–	–	5.5	4	7.5	5
1	2	1.5	7.5	5.5	10	7.5	10	7.5	7.5	5.5	10	7.5
	3	2	11	7.5	15	10	15	10	11	7.5	15	10
	5	3	–	–	–	–	–	–	–	–	–	–
	7.5	5	–	–	–	–	–	–	–	–	–	–
2	10	7.5	15	11	20	15	20	15	15	11	20	15
	–	–	18.5	15	25	20	25	20	18.5	15	25	20
3	15	10	22	18.5	30	25	30	25	22	18.5	30	25
	20	15	30	22	40	30	40	30	30	22	40	30
	–	–	37	30	50	40	50	40	37	30	50	40
4	25	20	45	37	60	50	60	50	45	37	60	50
	30	25	–	–	–	–	–	–	–	–	–	–
5	40	30	55	45	75	60	75	60	55	45	75	60
	50	40	–	–	100	75	100	75	–	–	100	75
6	60	50	75	55	125	100	–	–	75	55	125	100
	75	60	90	75	150	125	–	–	90	75	150	125
	–	–	110	90	–	–	–	–	110	90	–	–

Figure 1.7 PowerFlex 700 Frames 0-3 *(0 Frame Shown)*



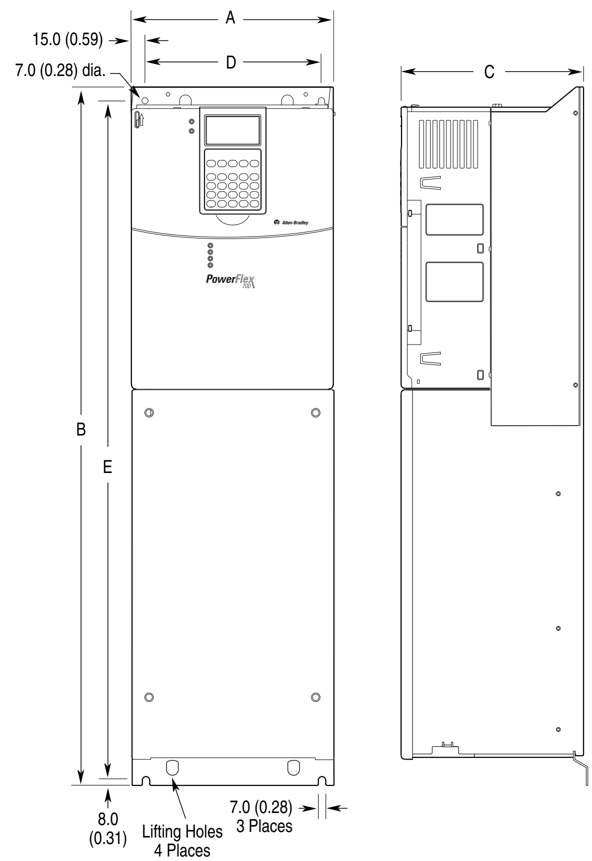
Dimensions are in millimeters and (inches)

Frame[1]	A	B	C	D	E	Weight[2] *kg (lbs.)*	
						Drive	**Drive & Packaging**
0	110.0 (4.33)	336.0 (13.23)	200.0 (7.87)	80.0 (3.15)	320.0 (12.60)	5.22 (11.5)	8.16 (18)
1	135.0 (5.31)	336.0 (13.23)	200.0 (7.87)	105.0 (4.13)	320.0 (12.60)	7.03 (15.5)	9.98 (22)
2	222.0 (8.74)	342.5 (13.48)	200.0 (7.87)	192.0 (7.56)	320.0 (12.60)	12.52 (27.6)	15.20 (33.5)
3	222.0 (8.74)	517.5 (20.37)	200.0 (7.87)	192.0 (7.56)	500.0 (19.69)	18.55 (40.9)	22.68 (50)

(1) Refer to Table 1.B for frame information.

(2) Weights include HIM and Standard I/O.

Figure 1.8 PowerFlex 700 Frame 4



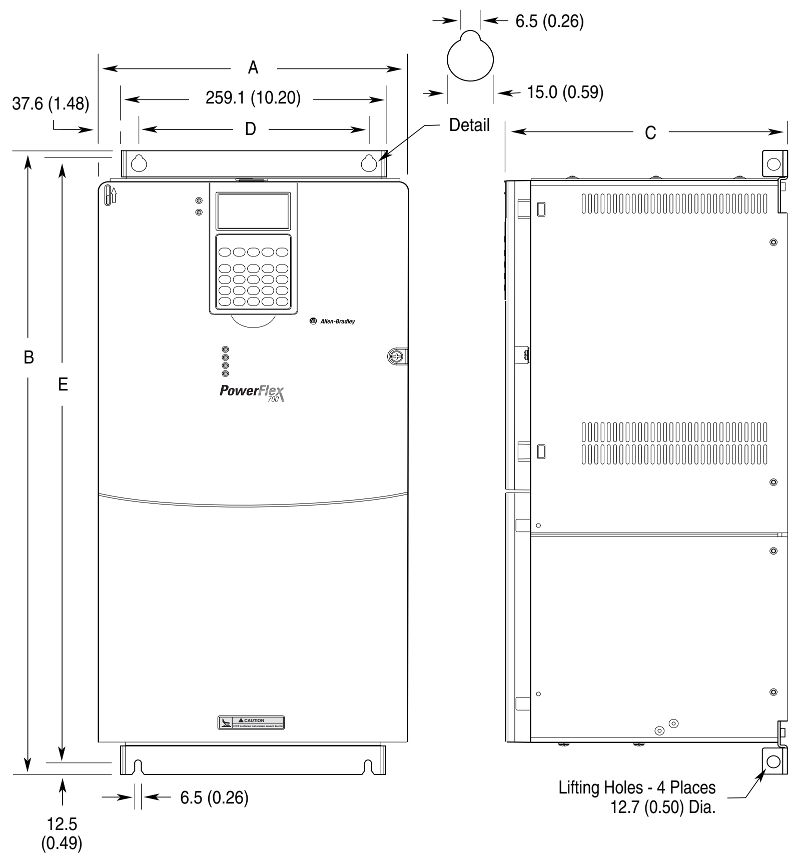
Dimensions are in millimeters and (inches)

Frame(1)	**A** *(Max.)*	**B**	**C** *(Max.)*	**D**	**E**	**Approx. Weight** (2) *kg (lbs.)* Drive	Drive & Packaging
4	220.0 (8.66)	758.8 (29.87)	201.7 (7.94)	192.0 (7.56)	738.2 (29.06)	24.49 (54.0)	29.03 (64.0)

(1) Refer to Table 1.B for frame information.

(2) Weights include HIM and Standard I/O.

Figure 1.9 PowerFlex 700 Frame 5



Dimensions are in millimeters and (inches).

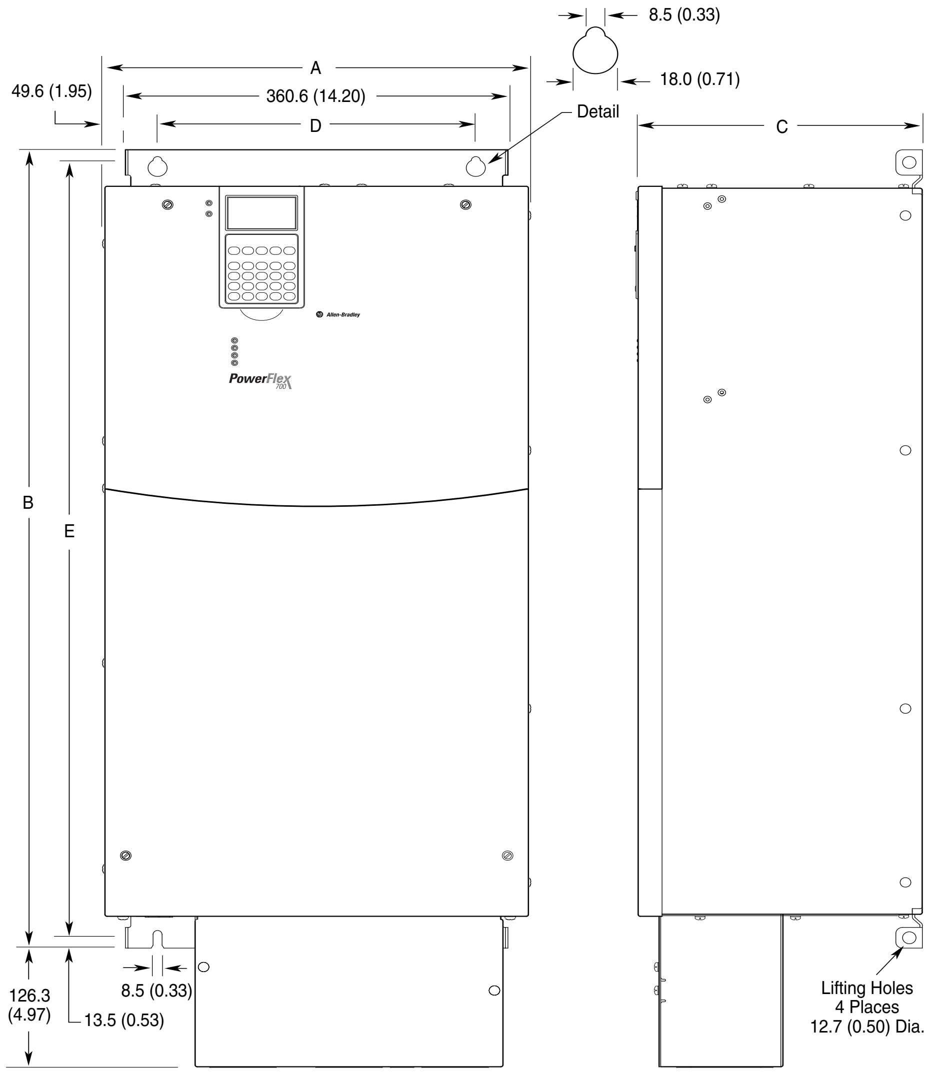
Frame (1)	**A** *(Max.)*	**B**	**C** *(Max.)*	**D**	**E**	**Approx. Weight (3)** *kg (lbs.)*	
						Drive	**Drive & Packaging**
5	308.9 (12.16)	644.5 (25.37) (2)	275.4 (10.84)	225.0 (8.86)	625.0 (24.61)	37.19 (82.0)	42.18 (93.0)

(1) Refer to Table 1.B for frame information.

(2) When using the supplied junction box (100 HP drives Only), add an additional 45.1 mm (1.78 in.) to this dimension.

(3) Weights include HIM and Standard I/O.

Figure 1.10 PowerFlex 700 Frame 6



Dimensions are in millimeters and (inches)

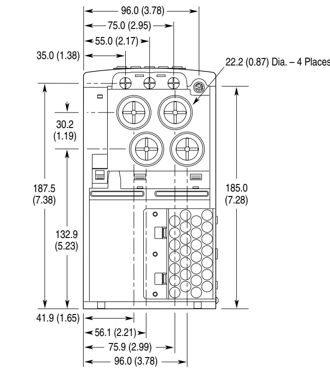
Frame(1)	A *(Max.)*	B	C *(Max.)*	D	E	Approx. Weight (2) *kg (lbs.)* Drive	Drive & Packaging
6	403.9 (15.90)	850.0 (33.46)	275.5 (10.85)	300.0 (11.81)	825.0 (32.48)	71.44 (157.5)	91.85 (202.5)

(1) Refer to Table 1.B for frame information.

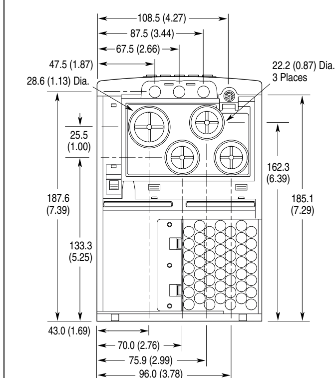
(2) Weights include HIM and Standard I/O.

Figure 1.11 PowerFlex 700 Bottom View Dimensions

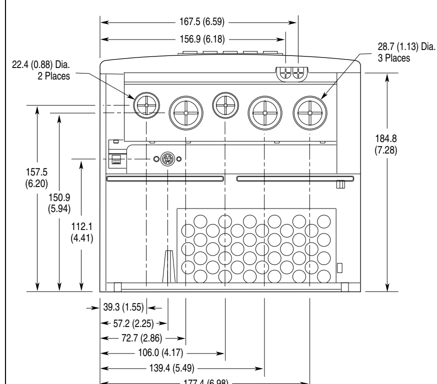
<table>
<tr><th>Frame</th><th>Rating</th><th>Dimensions in millimeters and (inches)</th></tr>
<tr><td>0</td><td>All</td><td>



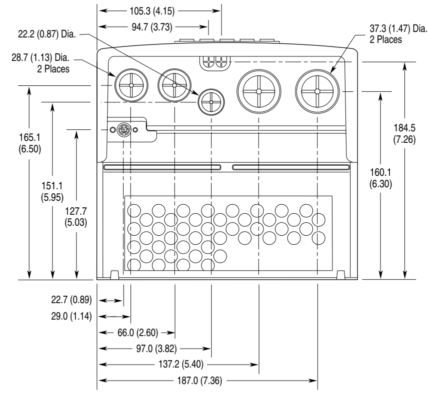
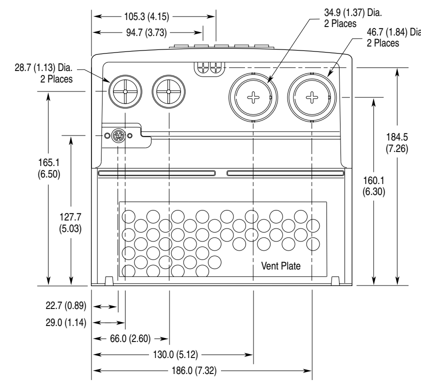
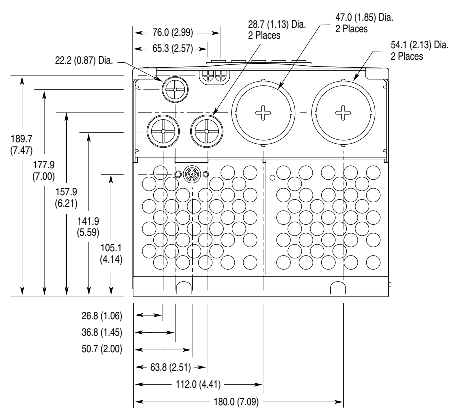
</td></tr>
<tr><td>1</td><td>All</td><td>

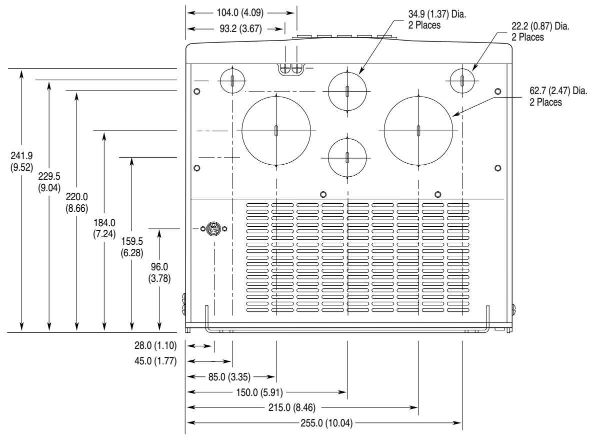
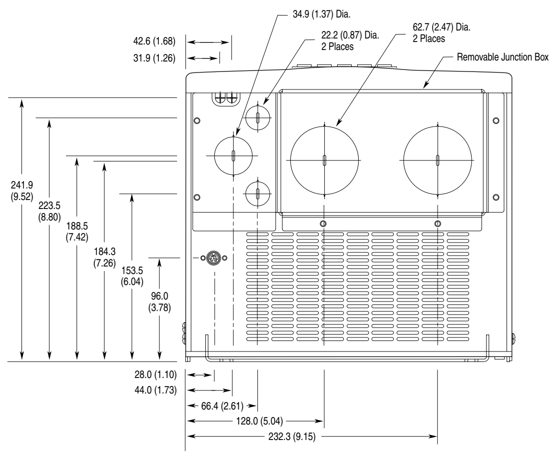
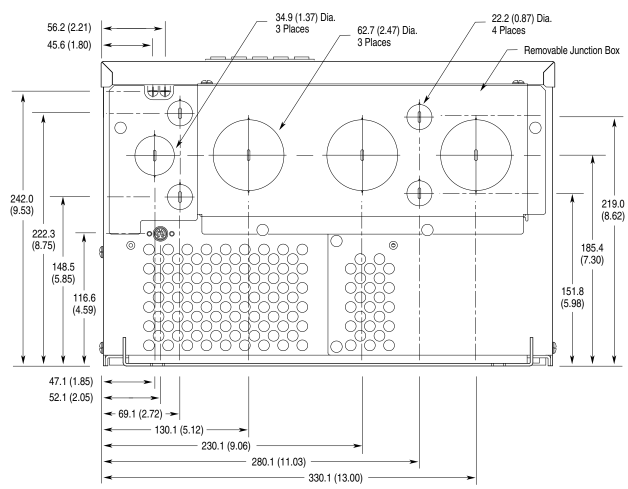


</td></tr>
<tr><td>2</td><td>All</td><td>



</td></tr>
</table>

Frame	Rating	Dimensions in millimeters and (inches)
3	All *except* 50 HP, 480V (37 kW, 400V)	
	50 HP, 480V (37 kW, 400V) Normal Duty Drive	
4	All	

Frame	Rating	Dimensions in millimeters and (inches)
5	75 HP, 480V (55kW, 400V) Normal Duty Drive	
	100 HP, 480V Normal Duty Drive	
6	All	

Notes:

Detailed Drive Operation

This chapter explains PowerFlex drive functions in detail. Explanations are organized alphabetically by topic. Refer to the Table of Contents for a listing of topics.

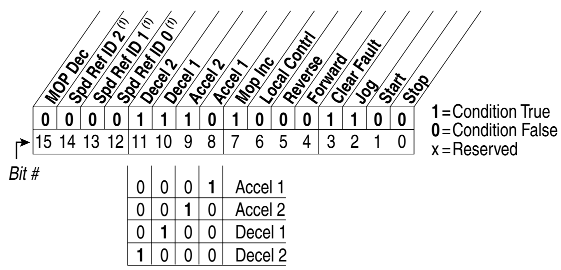
Accel Time

[Accel Time 1, 2]

The Accel Time parameters set the rate at which the drive ramps up its output frequency after a Start command or during an increase in command frequency (speed **change**). The rate established is the result of the programmed Accel Time and the Minimum and Maximum Frequency, as follows:

$$\frac{\text{Maximum Speed}}{\text{Accel Time}} = \text{Accel Rate (Hz./sec.)}$$

Two accel times exist to allow the user to change acceleration rates "on the fly" via PLC command or digital input. The selection is made by programming [Accel Time 1] & [Accel Time 2] and then using one of the digital inputs ([Digital Inx Sel]) programmed as "Accel 2" (see Table 2.I for further information). However, if a PLC is used, manipulate the bits of the command word as shown below.



The effectiveness of these bits or digital inputs can be affected by [Accel Mask]. See Masks on page 2-114 for more information.

Times are adjustable in 0.1 second increments from 0.0 seconds to 3600.0 seconds.

In its factory default condition, when no accel select inputs are closed and no accel time bits are "1," the default acceleration time is Accel Time 1 and the rate is determined as above.

Advanced Tuning

Advanced Tuning Parameters – PF700 Vector Control Only

ATTENTION: To guard against unstable or unpredictable operation, the following parameters must only be changed by qualified service personnel.

The following parameters can only be viewed when "2, Unused" is selected in parameter 196, [Param Access Lvl].

File	Group	No.	Parameter Name & Description	Values	Related
UTILITY	Diag-Motor Cntl	500	**[KI Current Limit]** Current Limit Integral gain. This gain is applied to the current limit error signal to eliminate steady state current limit error. A larger value increases overshoot during a step of motor current/load.	Default: 1500 Min/Max: 0/10000 Units: 1	
		501	**[KD Current Limit]** Current Limit Derivative gain. This gain is applied to the sensed motor current to anticipate a current limit condition. A larger value reduces overshoot of the current relative to the current limit value.	Default: 500 Min/Max: 0/10000 Units: 1	
		502	**[Bus Reg ACR Kp]** This proportional gain, in conjunction with P160, adjusts the output frequency of the drive during a bus limit or inertia ride through condition. The output frequency is adjusted in response to an error in the active, or torque producing, current to maintain the active bus limit, or inertia ride through bus reference. A larger value of gain reduces the dynamic error of the active current.	Default: 450 Min/Max: 0/10000 Units: 1	
		503	**[Jerk]** This parameter allows you to adjust the amount of S-Curve, or "Jerk" applied to the Acc/Dec rate. To enable the Jerk feature, bit 1 of P56 must be set high.	Default: 900 Min/Max: 2/30000 Units: 1	
		504	**[Kp Ln Ls Bus Reg]** This proportional gain adjusts the active current command during an inertia-ride through condition, in response to a bus error. A larger value of gain reduces the dynamic error of the bus voltage as compared to the bus voltage reference.	Default: 500 Min/Max: 0/10000 Units: 1	

File	Group	No.	Parameter Name & Description	Values		Related
UTILITY	Diag-Motor Cntl	505	**[Kd Ln Ls Bus Reg]** Line Loss Bus Reg Kd is a derivative gain, which is applied to the sensed bus voltage to anticipate dynamic changes and minimize them. A larger value reduces overshoot of the bus voltage relative to the inertia-ride through bus voltage reference.	Default: Min/Max: Units:	500 0/10000 1	
		506	**[Angl Stblty Gain]** Angle Stability Gain adjusts the electrical angle to maintain stable motor operation. An increase in the value increases the angle adjustment.	Default: Min/Max: Units:	51 0/32767 1	
		507	**[Volt Stblty Gain]** Adjusts the output voltage to maintain stable motor operation. An increase in the value increases the output voltage adjustment.	Default: Min/Max: Units:	93 0/32767 1	
		508	**[Stability Filter]** The Stability Filter coefficient is used to adjust the bandwidth of a low pass filter. The smaller the value of this coefficient, the lower the bandwidth of the filter.	Default: Min/Max: Units:	3250 0/32767 1	
		509	**[Lo Freq Reg KpId]** This proportional gain adjusts the output voltage at very low frequency in response to the reactive, or d-axis, motor current. A larger value increases the output voltage change.	Default: Min/Max: Units:	64 0/32767 1	
		510	**[Lo Freq Reg KpIq]** The proportional gain adjusts the output voltage at very low frequency in response to the active, or q-axis, motor current. A larger value increases the output voltage change.	Default: Min/Max: Units:	64 0/32767 1	
		511	**[Ki Cur Reg]** This integral gain adjusts the output voltage in response to the q and d axis motor currents. A larger value increases the output voltage change.	Default: Min/Max: Units:	44 0/32767 1	
		512	**[Kp Cur Reg]** This proportional gain adjusts the output voltage in response to the q and d axis motor currents. A larger value increases the output voltage change.	Default: Min/Max: Units:	1600 0/32767 1	
		523	**[Bus Utilization]** This value sets the drive output voltage limit as a percentage of the fundamental output voltage when operating in 6 step mode. Values above 95% increase harmonic content and jeopardize control stability. This output voltage limit is strictly a function of input line and resulting bus voltage.	Default: Min/Max: Units:	95.0% 85.0/100.0% 0.1%	
		524	**[PWM Type Sel]** Allows selection of the active PWM type. A value of 0 is default, and results in a change of PWM method at approximately 2/3 of rated motor frequency. If this is unacceptable for harmonic or audible reasons, a value of 1 disables the change.	Default: Min/Max: Units:	0 0/1 1	
		536	**[Ki Flux Braking]** Proportional gain for the Flux Regulator	Default: Min/Max: Units:	100 0/32767 1	
		537	**[Kp Flux Braking]** Integral gain for the Flux Regulator	Default: Min/Max: Units:	500 0/32767 1	

File	Group	No.	Parameter Name & Description	Values	Related
UTILITY		538	**[Rec Delay Time]** TBD	Default: 1000 Min/Max: 1/30000 Units: 1	
UTILITY	Diag-DACs	513	**[PWM DAC Enable]** Reserved. Do Not Adjust	Default: 0 Min/Max: 0/1 Units: 1	
UTILITY	Diag-DACs	514 515 516 517	**[DAC47-A]** **[DAC47-B]** **[DAC47-C]** **[DAC47-D]** Reserved. Do Not Adjust	Default: 0 Min/Max: 0/7432 Units: 1	
UTILITY	Diag-DACs	518	**[Host DAC Enable]** Reserved. Do Not Adjust	Default: 0 Min/Max: 0/1 Units: 1	
UTILITY	Diag-DACs	519 520 521 522	**[DAC55-A]** **[DAC55-B]** **[DAC55-C]** **[DAC55-D]** Reserved. Do Not Adjust	Default: 0 Min/Max: 0/7432 Units: 1	
UTILITY	Diag-Vector Cnt	525	**[Torq Adapt Speed]** Selects the operating frequency/speed at which the adaptive torque control regulators become active as a percent of motor nameplate frequency.	Default: 10.0% Min/Max: 0.0/100.0% Units: 0.1%	
UTILITY	Diag-Vector Cnt	526	**[Torq Reg Enable]** Enables or disables the torque regulator	Default: 1 Min/Max: 0/1 Units: 1	
UTILITY	Diag-Vector Cnt	527	**[Kp Torq Reg]** Proportional gain for the torque regulator	Default: 32 Min/Max: 0/32767 Units: 1	
UTILITY	Diag-Vector Cnt	528	**[Ki Torq Reg]** Integral gain for the torque regulator	Default: 128 Min/Max: 0/32767 Units: 1	
UTILITY	Diag-Vector Cnt	529	**[Torq Reg Trim]** Torque Regulator trim gain. A larger value increases the developed torque. Typically used to compensate for losses between developed and shaft torque.	Default: 1.0 Min/Max: 0.5/1.5 Units: 0.1	
UTILITY	Diag-Vector Cnt	530	**[Slip Reg Enable]** Enables or disables the slip frequency regulator.	Default: 1 Min/Max: 0/1 Units: 1	
UTILITY	Diag-Vector Cnt	531	**[Kp Slip Reg]** Proportional gain for the slip frequency regulator.	Default: 256 Min/Max: 0/32767 Units: 1	
UTILITY	Diag-Vector Cnt	532	**[Ki Slip Reg]** Integral gain for the slip frequency regulator.	Default: 64 Min/Max: 0/32767 Units: 1	
UTILITY	Diag-Vector Cnt	533	**[Flux Reg Enable]** Enables or disables the flux regulator.	Default: 1 Min/Max: 0/1 Units: 1	
UTILITY	Diag-Vector Cnt	534	**[Kp Flux Reg]** Proportional gain for the flux regulator.	Default: 64 Min/Max: 0/32767 Units: 1	
UTILITY	Diag-Vector Cnt	535	**[Ki Flux Reg]** Integral gain for the flux regulator.	Default: 32 Min/Max: 0/32767 Units: 1	
UTILITY	Diag-Vector Cnt	539	**[Freq Reg Ki]** Integral gain for the Frequency Regulator	Default: 450 Min/Max: 0/32767 Units: 1	

File	Group	No.	Parameter Name & Description	Values		Related
UTILITY	Diag-Vector Cnt	540	**[Freq Reg Kp]** Proportional gain for the Frequency Regulator.	Default: Min/Max: Units:	2000 0/32767 1	
		541	**[Encdlss Ang Comp]** TBD	Default: Min/Max: Units:	0 –1023/1023 1	
		542	**[Encdlss Vlt Comp]** TBD	Default: Min/Max: Units:	6.1 0/115 1	
		544	**[Excitation Kp]** TBD	Default: Min/Max: Units:	1800 0/32767 1	

Alarms

Alarms are indications of situations that are occurring within the drive or application that should be annunciated to the user. These situations may affect the drive operation or application performance. Conditions such as Power Loss or Analog input signal loss can be detected and displayed to the user for drive or operator action.

There are two types of alarms:

- **Type 1 Alarms** are conditions that occur in the drive or application that may require alerting the operator. These conditions, by themselves, do not cause the drive to “trip” or shut down, but they may be an indication that, if the condition persists, it may lead to a drive fault.

- **Type 2 Alarms** are conditions that are caused by improper programming and they prevent the user from Starting the drive until the improper programming is corrected. An example would be programming one digital input for a 2-wire type control (Run Forward) and another digital input for a 3-wire type control (Start). These are mutually exclusive operations, since the drive could not determine how to properly issue a “Run” command. Because the programming conflicts, the drive will issue a type 2 alarm and prevent Starting until the conflict is resolved.

Alarm Status Indication

[Drive Alarm 1]
[Drive Alarm 2]

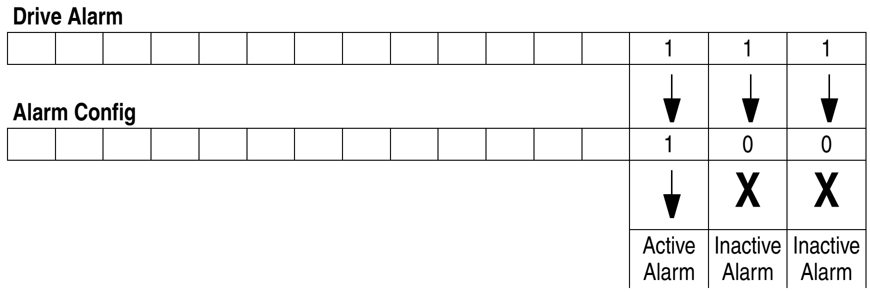
Two 16 bit Drive Alarm parameters are available to indicate the status of any alarm conditions. Both Type 1 and Type 2 alarms are indicated.

A “1” in the bit indicates the presence of the alarm and a “0” indicates no alarm is present

Configuration

In order for a drive alarm to be annunciated to the “outside” world, it must first be “configured” or activated. Configuration parameters contain a configuration bit for each Type 1 alarm. Type 2 alarms are permanently configured to annunciate. The configuration word is a mirror image of the

Drive Alarm word; that is, the same bits in both the Drive Alarm Word and the Alarm Configuration Word represent the same alarm.

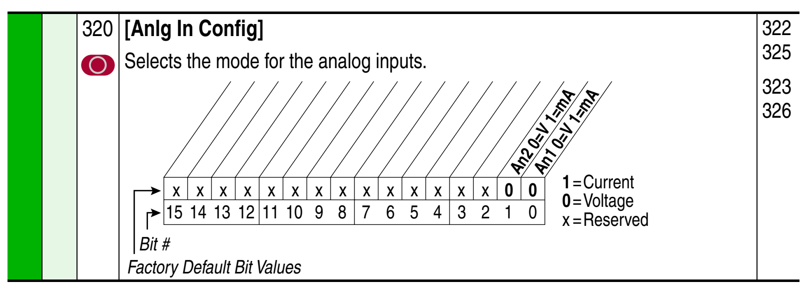


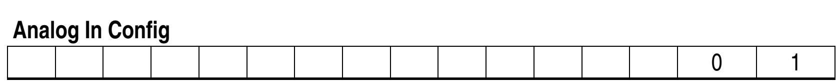
The configuration bits act as a mask to block or pass through the alarm condition to the active condition. An active alarm will be indicated on the LCD HIM and will cause the drive alarm status bit to go high ("1") in the Drive Status word (Bit 6, parameter 209). This bit can then be linked to a digital output for external annunciation. As default, all configuration bits are high ("1"). Note that setting a configuration bit to "0" to "mask" an alarm does not affect the status bit in the Drive Alarm parameter, only its ability to annunciate the condition.

Application

A process is being controlled by a PowerFlex drive. The speed reference to the drive is a 4-20 mA analog signal from a sensor wired to Analog Input 1.

The input is configured for mA by setting the corresponding bit in [Anlg In Config] to "1"





The input is scaled for 4-20 mA by setting [Analog In 1 Lo] to "4" mA and [Analog In 1 Hi] to "20" mA.

The signal is designated as the active speed reference by setting [Speed Ref A Sel] to its factory default value of “1”

Speed References	090	**[Speed Ref A Sel]** Selects the source of the speed reference to the drive unless [Speed Ref B Sel] or [Preset Speed 1-7] is selected. (1) See User Manual for DPI port locations.	Default:	2 “Analog In 2”	002 091 thru 093 101 thru 107 117 thru 120 192 thru 194 213 272 273 320 361 thru 366
			Options:	1 “Analog In 1” 2 “Analog In 2” 3-6 “Reserved” 7 “Pulse In” 8 “Encoder” 9 “MOP Level” 10 “Reserved” 11 “Preset Spd1” 12 “Preset Spd2” 13 “Preset Spd3” 14 “Preset Spd4” 15 “Preset Spd5” 16 “Preset Spd6” 17 “Preset Spd7” 18 “DPI Port 1”(1) 19 “DPI Port 2”(1) 20 “DPI Port 3”(1) 21 “DPI Port 4”(1) 22 “DPI Port 5”(1)	

By setting Speed Ref A Hi to 60 Hz and Speed ref A Lo to 0 Hz, the speed reference is scaled to the application needs. Because of the Input scaling and link to the speed reference, 4 mA represents minimum frequency (0 Hz.) and 20 mA represents Maximum Frequency (60 Hz.)

Scale Block

P322 20mA	P091 60 Hz
P323 4mA	P092 0 HZ

The input is configured to recognize a loss of signal and react accordingly to the programming.

324 327	**[Analog In 1 Loss]** **[Analog In 2 Loss]**	Default:	0 “Disabled” 0 “Disabled”	091 092
	Selects drive action when an analog signal loss is detected. Signal loss is defined as an analog signal less than 1V or 2mA. The signal loss event ends and normal operation resumes when the input signal level is greater than or equal to 1.5V or 3mA.	Options:	0 “Disabled” 1 “Fault” 2 “Hold Input” 3 “Set Input Lo” 4 “Set Input Hi” 5 “Goto Preset1” 6 “Hold OutFreq”	

The loss action is chosen as Hold Input, meaning that the last received signal will be maintained as the speed reference.

Finally, a Digital Output relay is configured to annunciate an alarm by turning on a flashing yellow light mounted on the operator panel of the process control area.

INPUTS & OUTPUTS	Digital Outputs	380	**[Digital Out1 Sel]**	Default:	1	"Fault"	381
		384	**[Digital Out2 Sel]**		4	"Run"	385
		388	Vector **[Digital Out3 Sel]**		4	"Run"	382
			Selects the drive status that will energize a (CRx) output relay.	Options:	1	"Fault"(1)	386
					2	"Alarm"(1)	383
					3	"Ready"	
			(1)Contacts shown in User Manual are in drive powered state with condition present. Refer to "Fault" and "Alarm" information.		4	"Run"	
					5	"Forward Run"	
					6	"Reverse Run"	
					7	"Auto Restart"	
					8	"Powerup Run"	002
			(2)Vector Control Option Only.		9	"At Speed"	001
					10	"At Freq"	003
					11	"At Current"	004
					12	"At Torque"	218
					13	"At Temp"	012
					14	"At Bus Volts"	137
					15	"At PI Error"	157
					16	"DC Braking"	147
					17	"Curr Limit"	053
					18	"Economize"	048
					19	"Motor Overld"	184
					20	"Power Loss"	
					21-26	"Input 1-6 Link"	
					27	"PI Enable"(2)	
					28	"PI Hold"(2)	
					29	"PI Reset"(2)	

While the process is normal and running from the analog input, everything proceeds normally. However, if the wire for the analog input should be severed or the sensor malfunction so that the 4-20mA signal is lost, the following sequence occurs:

1. The drive will sense the signal loss.
2. An active Type 1 Alarm is created and the last signal value is maintained as the speed reference.
3. The alarm activates the digital output relay to light the alarm light for the operator.
4. The operator uses the HIM to switch the drive to Manual Control (see Auto/Manual).
5. The operator manually brings the process to a controlled stop until the signal loss is repaired.

Alarm Queue (PowerFlex 700 Only)

A queue of 8 parameters exists that capture the drive alarms as they occur. A sequential record of the alarm occurrences allows the user to view the history of the eight most recent events.

UTILITY	Alarms	262 263 264 265 266 267 268 269	**[Alarm 1 Code]** **[Alarm 2 Code]** **[Alarm 3 Code]** **[Alarm 4 Code]** **[Alarm 5 Code]** **[Alarm 6 Code]** **[Alarm 7 Code]** **[Alarm 8 Code]** A code that represents a drive alarm. The codes will appear in the order they occur (first 4 alarms in – first 4 out alarm queue). A time stamp is not available with alarms.	Default: Read Only Min/Max: 0/256 Display: 1	261

Analog Inputs

Possible Uses of Analog Inputs

The analog inputs provide data that can be used for the following purposes:

- Provide a value to [Speed Ref A] or [Speed Ref B].
- Provide a trim signal to [Speed Ref A] or [Speed Ref B].
- Provide a reference when the terminal block has assumed manual control of the reference
- Provide the reference and feedback for the PI loop. See Process PI Loop on page 2-137.
- Provide an external and adjustable value for the current limit and DC braking level
- Enter and exit sleep mode.
- Vector FV Provide a value to [Torque Ref A] or [Torque Ref B].

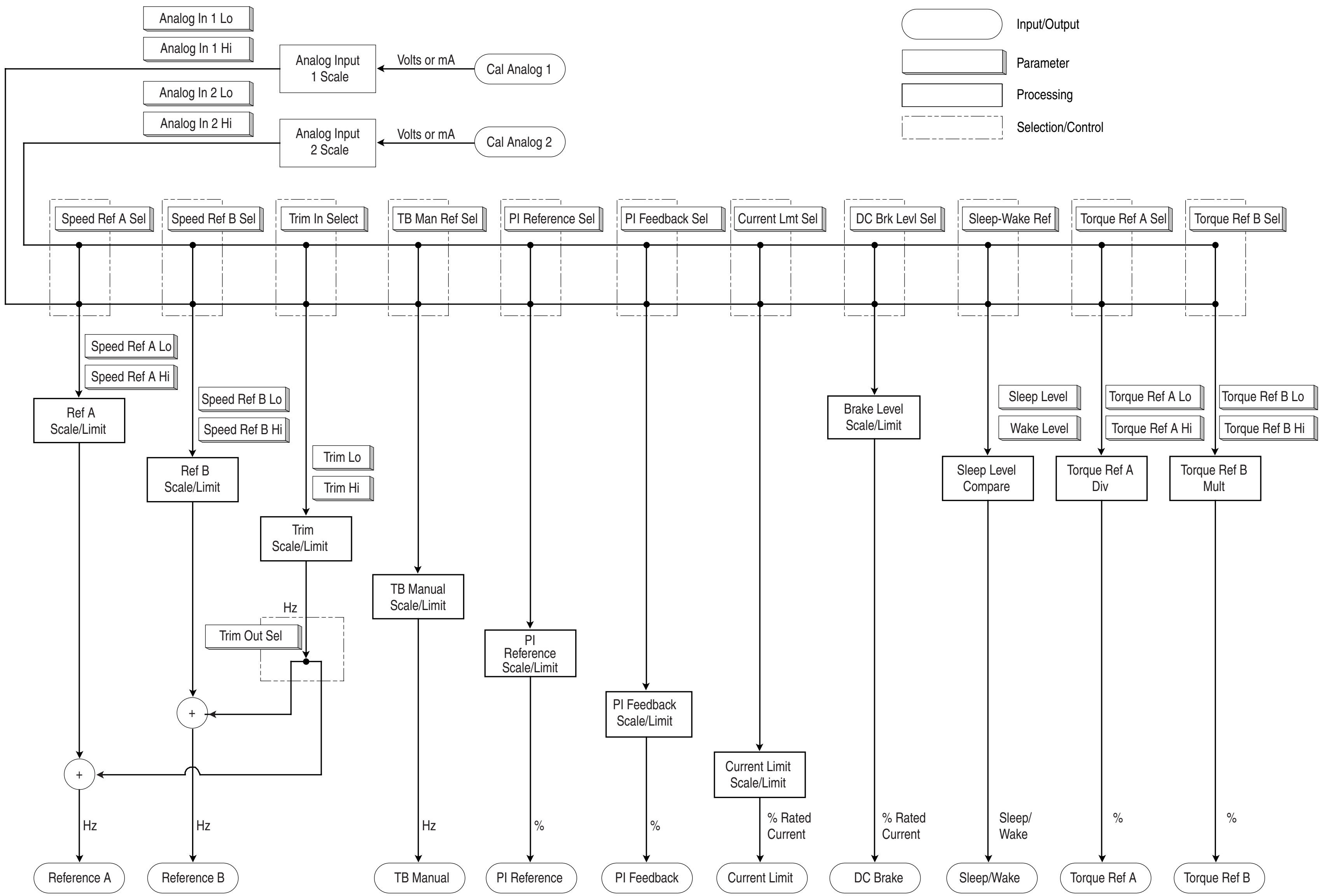
Analog Input Configuration

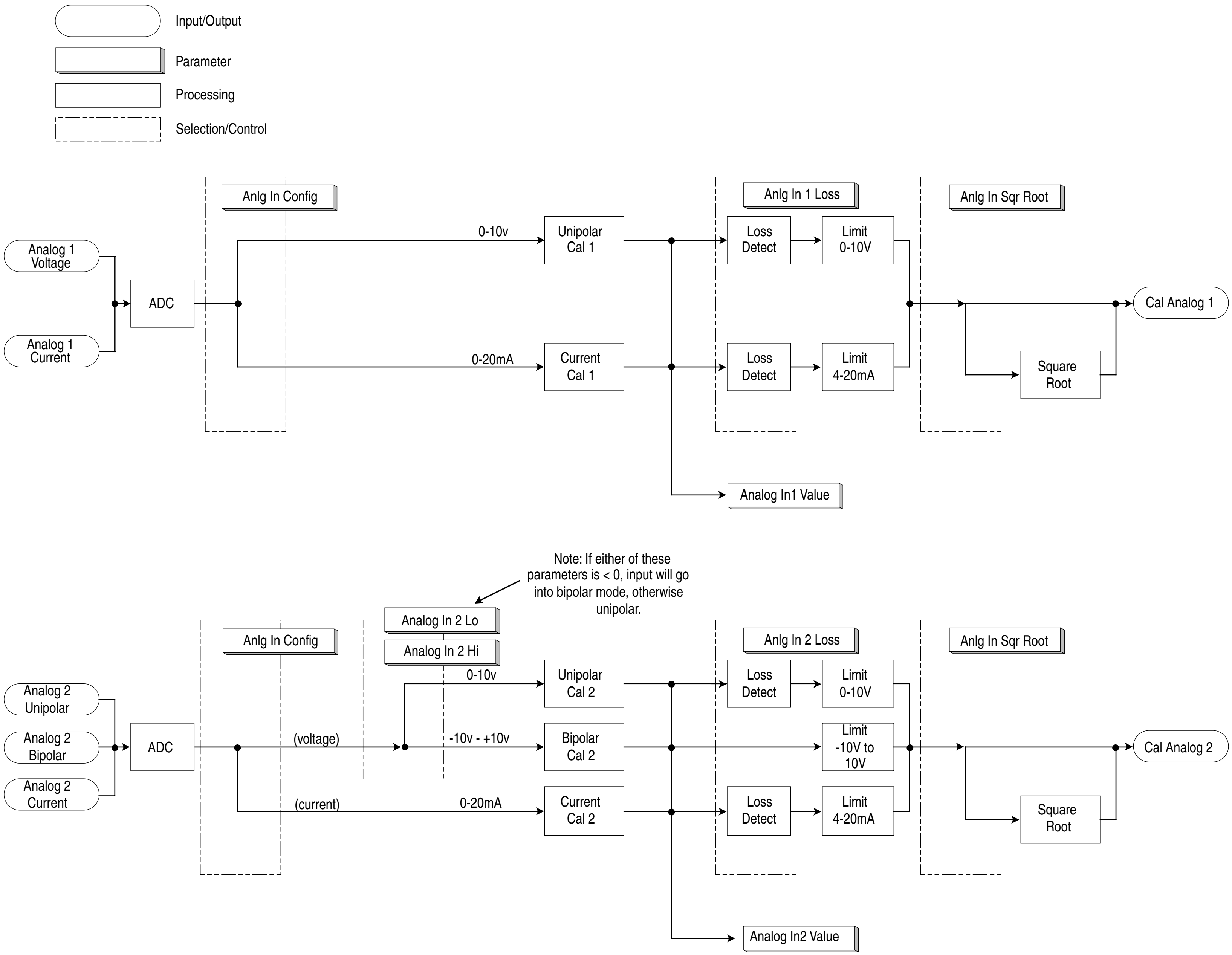
[Anlg In Config]

[Current Lmt Sel] allows an analog input to control the set point while [DC Brk Levl Sel] allows an analog input to define the DC hold level used when Ramp-to-Stop, Ramp-to-Hold, or Brake-to-Stop is active.

To provide local adjustment of a master command signal or to provide improved resolution the input to analog channel 1 or 2 can be defined as a trim input. Setting [Trim In Select] allows the selected channel to modify the commanded frequency by ±10%. The speed command will be reduced by 10% when the input level is at [Anlg In x Lo] with it linearly increasing to 10% above command at [Anlg In xHi].

Feedback can be used to control an operation using the “Process PI” (proportional-integral) feature of the control. In this case one signal, defined using [PI Reference Sel], provides a reference command and a second, defined using [PI Feedback Sel], provides a feedback signal for frequency compensation. Please refer to the Process PI Loop on page 2-137 for details on this mode of operation.


Input/Output
Parameter
Processing
Selection/Control
Analog In 1 Lo
Analog In 1 Hi
Analog Input 1 Scale
Volts or mA
Cal Analog 1
Analog In 2 Lo
Analog In 2 Hi
Analog Input 2 Scale
Volts or mA
Cal Analog 2
Speed Ref A Sel
Speed Ref B Sel
Trim In Select
TB Man Ref Sel
PI Reference Sel
PI Feedback Sel
Current Lmt Sel
DC Brk Levl Sel
Sleep-Wake Ref
Torque Ref A Sel
Torque Ref B Sel
Speed Ref A Lo
Speed Ref A Hi
Ref A Scale/Limit
Speed Ref B Lo
Speed Ref B Hi
Ref B Scale/Limit
Trim Lo
Trim Hi
Trim Scale/Limit
Hz
Trim Out Sel
TB Manual Scale/Limit
PI Reference Scale/Limit
PI Feedback Scale/Limit
Current Limit Scale/Limit
Brake Level Scale/Limit
Sleep Level
Wake Level
Sleep Level Compare
Torque Ref A Lo
Torque Ref A Hi
Torque Ref A Div
Torque Ref B Lo
Torque Ref B Hi
Torque Ref B Mult
+
+
Hz
Hz
Hz
%
%
% Rated Current
% Rated Current
Sleep/ Wake
%
%
Reference A
Reference B
TB Manual
PI Reference
PI Feedback
Current Limit
DC Brake
Sleep/Wake
Torque Ref A
Torque Ref B



Input/Output
Parameter
Processing
Selection/Control
Analog 1 Voltage
Analog 1 Current
ADC
Anlg In Config
0-10v
0-20mA
Unipolar Cal 1
Current Cal 1
Anlg In 1 Loss
Loss Detect
Loss Detect
Limit 0-10V
Limit 4-20mA
Anlg In Sqr Root
Square Root
Cal Analog 1
Analog In1 Value
Note: If either of these parameters is < 0, input will go into bipolar mode, otherwise unipolar.
Analog 2 Unipolar
Analog 2 Bipolar
Analog 2 Current
ADC
Anlg In Config
Analog In 2 Lo
Analog In 2 Hi
(voltage)
(current)
0-10v
-10v - +10v
0-20mA
Unipolar Cal 2
Bipolar Cal 2
Current Cal 2
Anlg In 2 Loss
Loss Detect
Loss Detect
Limit 0-10V
Limit -10V to 10V
Limit 4-20mA
Anlg In Sqr Root
Square Root
Cal Analog 2
Analog In2 Value

Analog Scaling

[Analog In Hi]
[Analog In Lo]

A scaling operation is performed on the value read from an analog input in order to convert it to units usable for some particular purpose. The user controls the scaling by setting parameters that associate a low and high point in the input range (i.e. in volts or mA) with a low and high point in the target range (e.g. reference frequency).

Two sets of numbers may be used to specify the analog input scaling. One set (called the "input scaling points") defines low and high points in terms of the units read by the input hardware, i.e. volts or mA.

The second set of numbers (called the "output scaling points") used in the analog input scaling defines the same low and high points in units appropriate for the desired use of the input. For instance, if the input is to be used as a frequency reference, this second set of numbers would be entered in terms of Hz. For many features the second set of numbers is fixed. The user sets the second set for speed and reference trim.

An analog input or output signal can represent a number of different commands. Typically an analog input is used to control output frequency, but it could control frequency trim, current limit or act as a PI loop input. An analog output typically is a frequency indication, but it could represent output current, voltage, or power. For this reason this document defines an analog signal level as providing a "command" value rather than a "frequency." However when viewing a command value it is presented as a frequency based on the [Minimum Speed] and [Maximum Freq] settings.

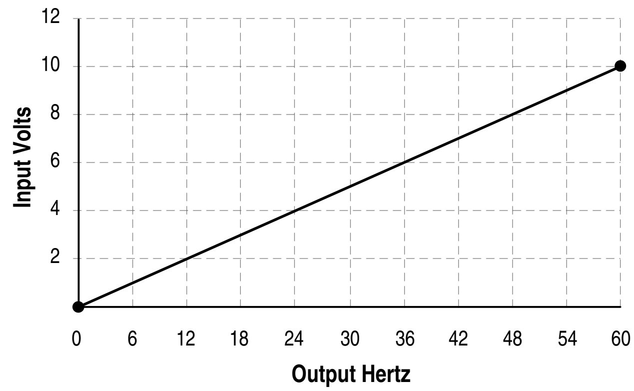
The 0-10 volt input scaling can be adjusted using the following parameters:

- [Analog In x Lo]
- [Analog In x Hi]

<u>Configuration #1:</u>

- [Anlg In Config], bit 0 = "0" (Voltage)
- [Speed Ref A Sel] = "Analog In 1"
- [Speed Ref A Hi] = 60 Hz
- [Speed Ref A Lo] = 0 Hz
- [Analog In 1 Hi] = 10V
- [Analog In 1 Lo] = 0V

This is the default setting, where minimum input (0 volts) represents 0 Hz and maximum input (10 volts) represents 60 Hz (it provides 6 Hz change per input volt).



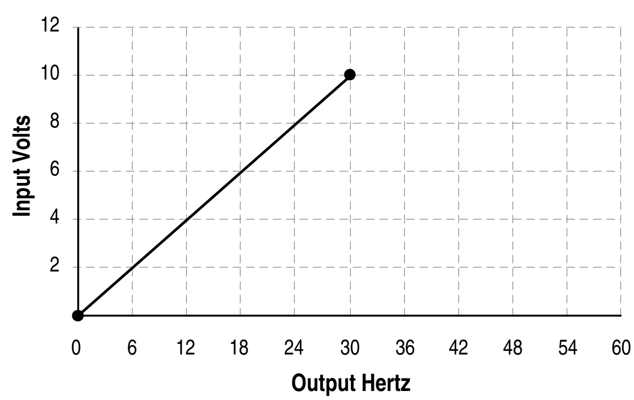
Analog Scaling

[Speed Reference A Sel] = "Analog In 1"	
[Analog In 1 Hi] 10V	[Speed Ref A Hi] 60 Hz
[Analog In 1 Lo] 0V	[Speed Ref A Lo] 0 Hz

Configuration #2:

- [Anlg In Config], bit 0 = "0" (Voltage)
- [Speed Ref A Sel] = "Analog In 1"
- [Speed Ref A Hi] = 30 Hz
- [Speed Ref A Lo] = 0 Hz
- [Analog In 1 Hi] = 10V
- [Analog In 1 Lo] = 0V

This is an application that only requires 30 Hz as a maximum output frequency, but is still configured for full 10 volt input. The result is that the resolution of the input has been doubled, providing only 3 Hz change per input volt (Configuration #1 is 6 Hz/Volt).



Analog Scaling

[Speed Reference A Sel] = "Analog In 1"	
[Analog In 1 Hi] 10V	[Speed Ref A Hi] 30 Hz
[Analog In 1 Lo] 0V	[Speed Ref A Lo] 0 Hz

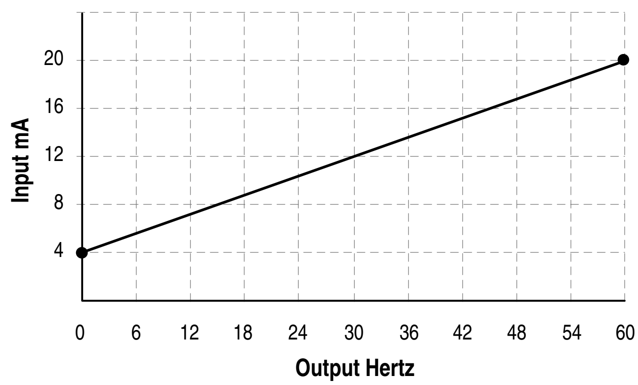
Configuration #3:

- [Anlg In Config], bit 0 = “1” (Current)
- [Speed Ref A Sel] = “Analog In 1”
- [Speed Ref A Hi] = 60 Hz
- [Speed Ref A Lo] = 0 Hz
- [Analog In 1 Hi] = 20 mA
- [Analog In 1 Lo] = 4 mA

This configuration is referred to as offset. In this case, a 4-20 mA input signal provides 0-60 Hz output, providing a 4 mA offset in the speed command.

Analog Scaling

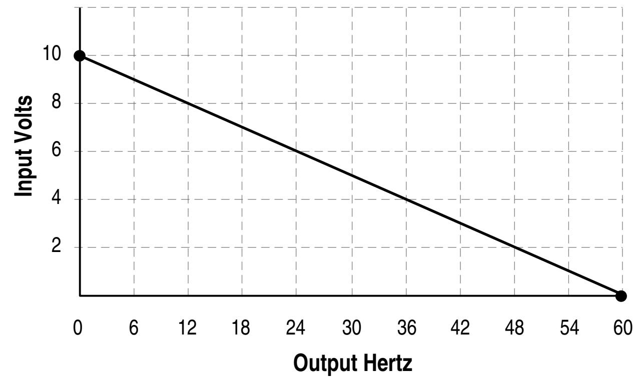
[Speed Reference A Sel] = “Analog In 1”	
[Analog In 1 Hi] 20 mA	[Speed Ref A Hi] 60 Hz
[Analog In 1 Lo] 4 mA	[Speed Ref A Lo] 0 Hz



Configuration #4:

- [Anlg In Config], bit 0 = “0” (Voltage)
- [Speed Ref A Sel] = “Analog In 1”
- [Speed Ref A Hi] = 0 Hz
- [Speed Ref A Lo] = 60 Hz
- [Analog In 1 Hi] = 10V
- [Analog In 1 Lo] = 0V

This configuration is used to invert the operation of the input signal. Here, maximum input (10 Volts) represents 0 Hz and minimum input (0 Volts) represents 60 Hz.



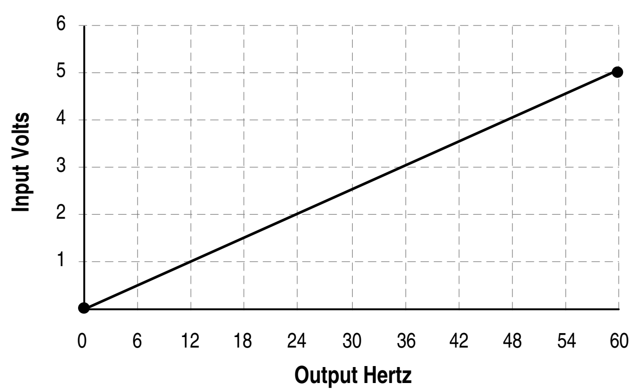
Analog Scaling

[Speed Reference A Sel] = “Analog In 1”	
[Analog In 1 Hi] 10V	[Speed Ref A Hi] 0 Hz
[Analog In 1 Lo] 0V	[Speed Ref A Lo] 60 Hz

<u>Configuration #5:</u>

- [Anlg In Config], bit 0 = “0” (Voltage)
- [Speed Ref A Sel] = “Analog In 1”
- [Speed Ref A Hi] = 60 Hz
- [Speed Ref A Lo] = 0 Hz
- [Analog In 1 Hi] = 5V
- [Analog In 1 Lo] = 0V

This configuration is used when the input signal is 0-5 volts. Here, minimum input (0 Volts) represents 0 Hz and maximum input (5 Volts) represents 60 Hz. This allows full scale operation from a 0-5 volt source.



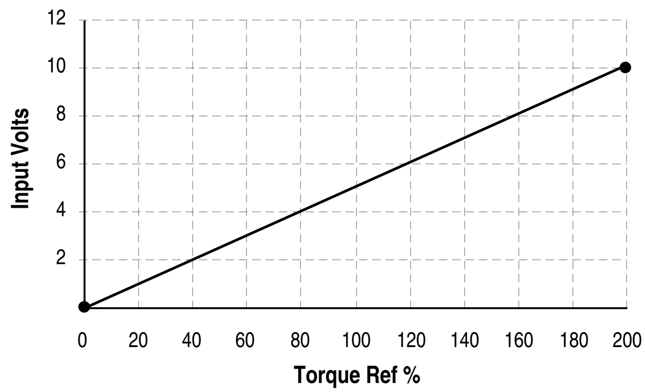
Analog Scaling

[Speed Reference A Sel] = “Analog In 1”	
[Analog In 1 Hi] 5V	[Speed Ref A Hi] 60 Hz
[Analog In 1 Lo] 0V	[Speed Ref A Lo] 0Hz

Vector FV Configuration #6 – Torque Ref:

- [Anlg In Config], bit 0 = "0" (Voltage)
- [Torque Ref A Sel] = "Analog In 1"
- [Torque Ref A Hi] = 200%
- [Torque Ref A Lo] = 0%
- [Torque Ref A Div] = 1

This configuration is used when the input signal is 0-10 volts. The minimum input of 0 volts represents a torque reference of 0% and maximum input of 10 volts represents a torque reference of 200%.



Analog Scaling

[Torque Ref A Sel] = "Analog In 1"	
[Analog In 1 Hi] 10V	[Torque Ref A Hi] 200%
[Analog In 1 Lo] 0V	[Torque Ref A Lo] 0%

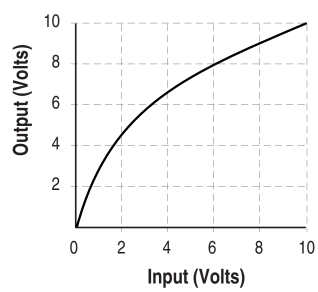
Square Root

[Anlg In Sqr Root]

For both analog inputs, the user can enable a square root function for an analog input through the use of [Analog In Sq Root]. The function should be set to enabled if the input signal varies with the square of the quantity (i.e. drive speed) being monitored.

If the mode of the input is bipolar voltage (–10v to 10v), then the square root function will return 0 for all negative voltages.

The square root function is scaled such that the input range is the same as the output range. For example, if the input is set up as a unipolar voltage input, then the input and output ranges of the square root function will be 0 to 10 volts, as shown in figure below.



Signal Loss

[Analog In 1, 2 Loss]

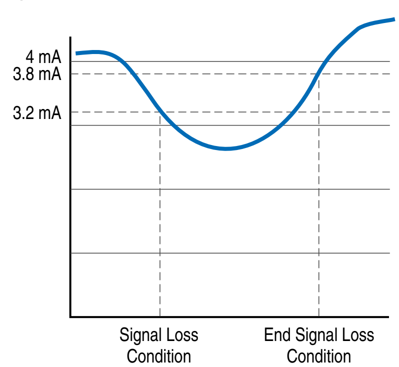
Signal loss detection can be enabled for each analog input. The [Analog In x Loss] parameters control whether signal loss detection is enabled for each input and defines what action the drive will take when loss of any analog input signal occurs.

One of the selections for reaction to signal loss is a drive fault, which will stop the drive. All other choices make it possible for the input signal to return to a usable level while the drive is still running.

- Hold input
- Set input Lo
- Set input Hi
- Goto Preset 1
- Hold Output Frequency

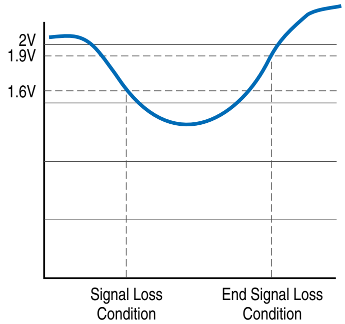
Value	Action on Signal Loss
0	Disabled (default)
1	Fault
2	Hold input (continue to use last frequency command.)
3	Set Input Hi - use [Minimum Speed] as frequency command.
4	Set Input Lo - use [Maximum Speed] as frequency command.
5	use [Preset 1] as frequency command.
6	Hold Out Freq (maintain last output frequency)

If the input is in current mode, 4 mA is the normal minimum usable input value. Any value below 3.2 mA will be interpreted by the drive as a signal loss, and a value of 3.8 mA will be required on the input in order for the signal loss condition to end.



If the input is in unipolar voltage mode, 2V is the normal minimum usable input value. Any value below 1.6 volts will be interpreted by the drive as a signal loss, and a value of 1.9 volts will be required on the input in order for the signal loss condition to end.

No signal loss detection is possible while an input is in bipolar voltage mode. The signal loss condition will never occur even if signal loss detection is enabled.



Trim

An analog input can be used to trim the active speed reference (Speed Reference A/B). If analog is chosen as a trim input, two scale parameters are provide to scale the trim reference. The trim is a +/- value which is summed with the current speed reference. See also Speed Reference on page 2-171.

- [Trim In Select]
- [Trim Out Select]
- [Trim Hi]
- [Trim Lo]

Value Display

Parameters are available in the Monitoring Group to view the actual value of an analog input regardless of its use in the application. Whether it is a current limit adjustment, speed reference or trim function, the incoming value can be read via these parameters.

The value displayed includes the input value plus any factory hardware calibration value, but does not include scaling information programmed by the user (i.e. [Analog In 1 Hi/Lo]). The units displayed are determined by the associated configuration bit (Volts or mA)

Metering	016 017	**[Analog In1 Value]** **[Analog In2 Value]** Value of the signal at the analog inputs.	Default: Min/Max: Display:	Read Only 0.000/20.000 mA –/+10.000V 0.001 mA 0.001 Volt

Cable Selection

Refer to "*Wiring and Grounding Guidelines for Pulse Width Modulated (PWM) AC Drives*," publication DRIVES-IN001 for detailed information on Cable Selection.

Terminal Designations & Wiring Examples

Refer to the appropriate PowerFlex User Manual or "*Wiring and Grounding Guidelines for Pulse Width Modulated (PWM) AC Drives*," publication DRIVES-IN001 for I/O terminal designations and wiring examples.

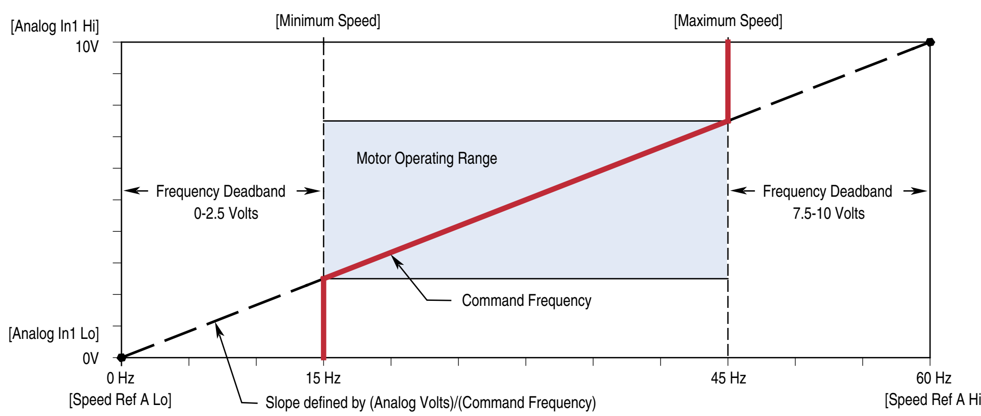
How [Analog Inx Hi/Lo] & [Speed Ref A Hi/Lo] Scales the Frequency Command Slope with [Minimum/Maximum Speed]

Example 1:

Consider the following setup:

- [Anlg In Config], bit 0 = "0" (voltage)
- [Speed Ref A Sel] = "Analog In 1"
- [Analog In1 Hi] = 10V
- [Analog In1 Lo] = 0V
- [Speed Ref A Hi] = 60 Hz
- [Speed Ref A Lo] = 0 Hz
- [Maximum Speed] = 45 Hz
- [Minimum Speed] = 15 Hz

This operation is similar to the 0-10 volts creating a 0-60 Hz signal until the minimum and maximum speeds are added. [Minimum Speed] and [Maximum Speed] limits will create a command frequency deadband.



This deadband, as it relates to the analog input, can be calculated as follows:

1. The ratio of analog input volts to frequency (Volts/Hz) needs to be calculated. The voltage span on the analog input is 10 volts. The frequency span is 60 Hz.

   10 Volts/60 Hz = 0.16667 Volts/Hz

2. Determine the frequency span between the Minimum and Maximum Speed limits and Speed Ref A Hi and Lo.

   [Speed Ref A Hi] – [Maximum Speed] = 60 – 45 = 15 Hz and . . .
   [Minimum Speed] – [Speed Ref A Lo] = 15 – 0 = 15 Hz.

3. Multiply by the Volts/Hertz ratio

   15 Hz x 0.16667 Volts/Hz = 2.5 Volts

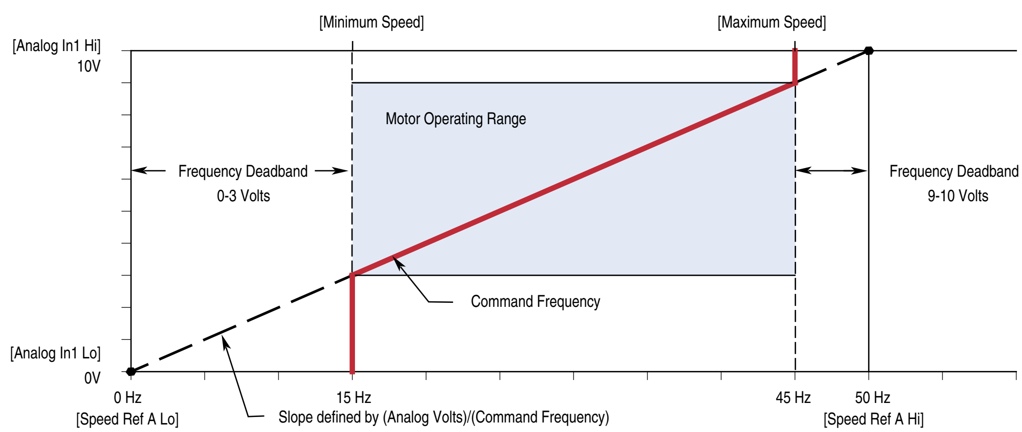
Therefore the command frequency from 0 to 2.5 volts on the analog input will be 15 Hz. After 2.5 volts, the frequency will increase at a rate of 0.16667 volts per hertz to 7.5 volts. After 7.5 volts on the analog input the frequency command will remain at 45 Hertz.

Example 2:

Consider the following setup:

- [Anlg In Config], bit 0 = "0" (voltage)
- [Speed Ref A Sel] = "Analog In 1"
- [Analog In1 Hi] = 10V
- [Analog In1 Lo] = 0V
- [Speed Ref A Hi] = 50hz
- [Speed Ref A Lo] = 0hz
- [Maximum Speed] = 45hz
- [Minimum Speed] = 15hz

The only change from Example 1 is the [Speed Ref A Hi] is changed to 50 Hz.



The deadband, as it relates to the analog input, can be calculated as follows:

1. The ratio of analog input volts to frequency (Volts/Hertz) needs to be calculated. The voltage span on the analog input is 10 volts. The frequency span is 60 Hz.

10 Volts/50 Hz = 0.2 Volts/Hz

2. Determine the frequency span between the minimum and maximum speed limits and the Speed Ref A Hi and Lo.

[Speed Ref A Hi] – [Maximum Speed] = 50 – 45 = 5 Hz and . . .
[Minimum Speed] – [Speed Ref A Lo] = 15 – 0 = 15 Hz

3. Multiply by the volts/hertz ratio

5 Hz x 0.2 Volts/Hz = 1 Volt
15 Hz x 0.2 Volts/Hz = 3 Volts

Here, the deadband is "shifted" due to the 50 Hz limitation. The command frequency from 0 to 3 volts on the analog input will be 15 Hz. After 3 volts, the frequency will increase at a rate of 0.2 volts per hertz up to 9 volts. After 9 volts on the analog input the frequency command will remain at 45 Hz.

Analog Outputs

Explanation

Each drive has one or more analog outputs that can be used to annunciate a wide variety of drive operating conditions and values.

The user selects the analog output source by setting [Analog Out Sel].

INPUTS & OUTPUTS — Analog Outputs

No.	Parameter		
342 345	**[Analog Out1 Sel]** **Vector** **[Analog Out2 Sel]** Selects the source of the value that drives the analog output.	Default: 0 "Output Freq" Options: See Table	001, 002, 003, 004, 005, 007, 006, 012, 135, 136, 137, 138, 220, 219, 377, 378

Options		[Analog Out1 Lo] Value — Param. 341 = Signed	[Analog Out1 Lo] Value — Param. 341 = Absolute	[Analog Out1 Hi] Value
0	"Output Freq"	–[Maximum Speed]	0 Hz	+[Maximum Speed]
1	"Command Freq"	–[Maximum Speed]	0 Hz	+[Maximum Speed]
1*	"Command Spd"	–[Maximum Speed]	0 Hz/RPM	+[Maximum Speed]
2	"Output Amps"	0 Amps	0 Amps	200% Rated
3	"Torque Amps"	–200% Rated	0 Amps	200% Rated
4	"Flux Amps"	0 Amps	0 Amps	200% Rated
5	"Output Power"	0 kW	0 kW	200% Rated
6	"Output Volts"	0 Volts	0 Volts	120% Rated Input Volts
7	"DC Bus Volts"	0 Volts	0 Volts	200% Rated Input Volts
8	"PI Reference" (1)	–100%	0%	100%
9	"PI Feedback"	–100%	0%	100%
10	"PI Error"	–100%	0%	100%
11	"PI Output"	–100%	0%	100%
12	"%Motor OL"	0%	0%	100%
13	"%Drive OL"	0%	0%	100%
14*	"CommandedTrq"	–800% Rated	0%	800% Rated
15*	"MtrTrqCurRef" (1)	–200% Rated	0%	200% Rated
16*	"Speed Ref"	–[Maximum Speed]	0 Hz/RPM	+[Maximum Speed]
17*	"Speed Fdbk"	–[Maximum Speed]	0 Hz/RPM	+[Maximum Speed]
18*	"Pulse In Ref" (1)	–25200.0 RPM	0 Hz/RPM	+[Maximum Speed]
19*	"Torque Est" (1)	–800%	0%	+800%
20-23**	"Scale Block1-4" (1)			
24**	"Param Cntl" (1)			

* Vector Control Option Only **Vector firmware 3.001 & later

(1) Refer to Option Definitions in User Manual..

Configuration

The PowerFlex 70 standard I/O analog output is permanently configured as a 0-10 volt output. The output has 10 bits of resolution yielding 1024 steps. The analog output circuit has a maximum 1.3% gain error and a maximum 7 mV offset error. For a step from minimum to maximum value, the output will be within 0.2% of its final value after 12ms.

The PowerFlex 700 standard I/O analog output is permanently configured as a 0-10 volt output. The output has 10 bits of resolution yielding 1024 steps. The analog output circuit has a maximum 1.3% gain error and a maximum 100 mV offset error. For a step from minimum to maximum value, the output will be within 0.2% of its final value after 12ms.

Absolute (default)

Certain quantities used to drive the analog output are signed, i.e. the quantity can be both positive and negative. The user has the option of having the absolute value (value without sign) of these quantities taken before the scaling occurs. Absolute value is enabled separately for each analog output via the bitmapped parameter [Anlg Out Absolut].

Important: If absolute value is enabled but the quantity selected for output is not a signed quantity, then the absolute value operation will have no effect.

Scaling Blocks

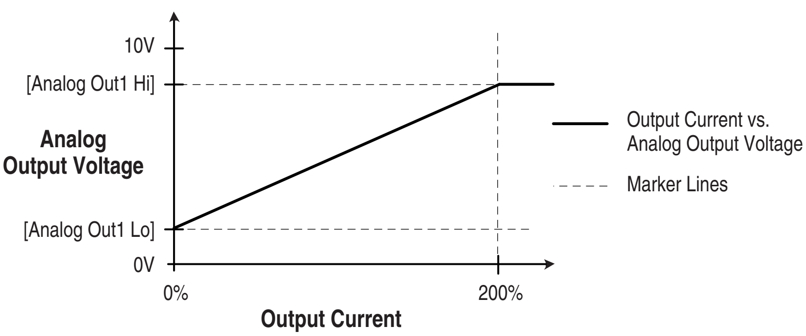
The user defines the scaling for the analog output by entering analog output voltages into two parameters, [Analog Out1 Lo] and [Analog Out1 Hi]. These two output voltages correspond to the bottom and top of the possible range covered by the quantity being output. The output voltage will vary linearly with the quantity being output. The analog output voltage will not go outside the range defined by [Analog Out1 Lo] and [Analog Out1 Hi].

Analog Output Configuration Examples

This section gives a few examples of valid analog output configurations and describes the behavior of the output in each case.

Example 1 -- Unsigned Output Quantity

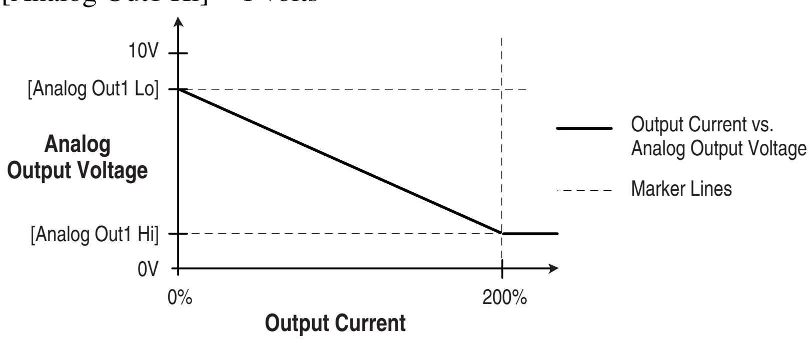
- [Analog Out1 Sel] = "Output Current"
- [Analog Out1 Lo] = 1 volt
- [Analog Out1 Hi] = 9 volts



Note that analog output value never goes outside the range defined by [Analog Out1 Lo] and [Analog Out1 Hi]. This is true in all cases, including all the following examples.

Example 2 -- Unsigned Output Quantity, Negative Slope

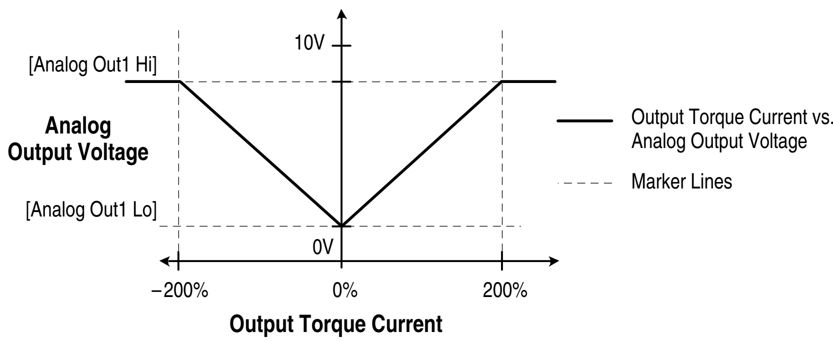
- [Analog Out1 Sel] = "Output Current"
- [Analog Out1 Lo] = 9 volts
- [Analog Out1 Hi] = 1 volts



This example shows that you can have [Analog Out1 Lo] greater than [Analog Out1 Hi]. The result is a negative slope on the scaling from original quantity to analog output voltage. Negative slope could also be applied to any of the other examples in this section.

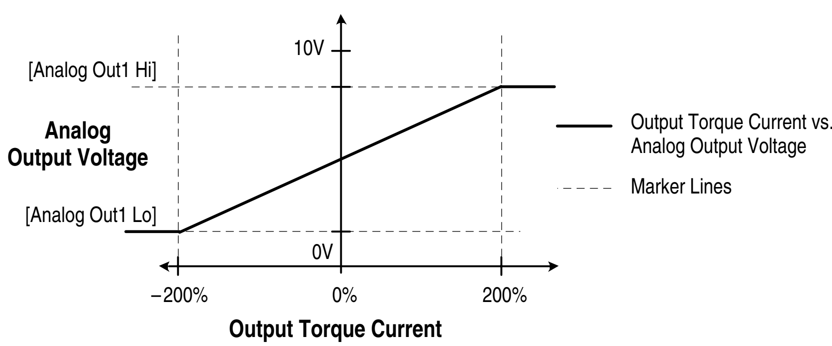
Example 3 – Signed Output Quantity, Absolute Value Enabled

- [Analog Out1 Sel] = "Output Torque Current"
- [Analog Out1 Lo] = 1 volt
- [Analog Out1 Hi] = 9 volts
- [Anlg Out Absolut] set so that absolute value is enabled for output 1.



Example 4 – Signed Output Quantity, Absolute Value Disabled

- [Analog Out1 Sel] = "Output Torque Current"
- [Analog Out1 Lo] = 1 volt
- [Analog Out1 Hi] set to 9 volts
- [Anlg Out Absolut] set so that absolute value is disabled for output 1.



Filtering

Software filtering will be performed on the analog outputs for certain signal sources, as specified in Table 2.A. "Filter A" is one possible such filter, and it is described later in this section. Any software filtering is in addition to any hardware filtering and sampling delays.

Table 2.A Software Filters

Quantity	Filter
Output Frequency	No extra filtering
Commanded Frequency	No extra filtering
Output Current	Filter A
Output Torque Current	Filter A
Output Flux Current	Filter A
Output Power	Filter A
Output Voltage	No extra filtering
DC Bus Voltage	Filter A
PI Reference	No extra filtering
PI Feedback	No extra filtering
PI Error	No extra filtering
PI Output	No extra filtering

Analog output software filters are specified in terms of the time it will take the output of the filter to move from 0% to various higher levels, given an instantaneous step in the filter input from 0% to 100%. The numbers describing filters in this document should be considered approximate; the actual values will depend on implementation.

Filter A is a single pole digital filter with a 162ms time constant. Given a 0% to 100% step input from a steady state, the output of Filter A will take 500ms to get to 95% of maximum, 810 ms to get to 99%, and 910 ms to get to 100%.

PowerFlex 700 Firmware 3.001 (& later) Enhancements

Certain analog output enhancements have been included in firmware version 3.001 (and later) for the PowerFlex 700 Vector Control drive. These include:

- Ability to scale the analog outputs
- Connect scale blocks to the analog outputs
- Analog Output controlled via Datalink

Output Scaling

A new scaling feature has been added to allow scaling. Prior to this feature, [Analog Outx Lo] and [Analog Outx Hi] limited only the voltage. This voltage range was scaled to the selected option range listed in [Analog Outx Sel]. With the new feature, [Analog Outx Lo] and [Analog Outx Hi] still set the voltage range, but the scaling parameter now scales the range of the [Analog Outx Sel] selection. See the following example.

INPUTS & OUTPUTS	Analog Outputs	354 355	**Vector v3** **[Anlg Out1 Scale]** **Vector v3** **[Anlg Out2 Scale]** Sets the high value for the range of analog out scale. Entering 0.0 will disable this scale and max scale will be used. Example: If [Analog Out Sel] = "Commanded Trq," a value of 150 = 150% scale in place of the default 800%.	Default: 0.0 Min/Max: [Analog Out1 Sel] Units: 0.01	

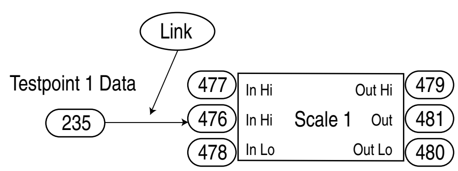
Example
Analog Output 1 set for 0-10V DC at 0-100% Commanded Torque.

Setup
- [Analog Out1 Sel], parameter 342 = 14 "Commanded Torque"
- [Analog Out1 Hi], parameter 343 = 10.000 Volts
- [Analog Out1 Lo], parameter 344 = 0.000 Volts
- [Anlg Out1 Scale], parameter 354 = 100.0

If [Analog Out1 Lo] = –10.000 Volts the output will be –10.0 to +10.0V DC for –100% to +100% Commanded Torque.

If [Anlg Out1 Scale] = 0.0, the default scaling listed in [Analog Out1 Sel] will be used. This would be 0-1.25V DC for 0-100% Torque or 0-800% for 0-10V DC.

Scale Block Analog Output
Selects scaled analog output relative to the Scale Block value. Values not in the [Analog OutX Sel] parameter list can be used to drive the analog outputs. When using the Scale Block select, the Scale block Out Hi and Out Lo parameters are not used.



Example
Analog Output 2 set for 0-10V DC for Heat Sink Temp 0-100 Degrees C. using Scale Block 1.

Setup
- Link [Scale1 In Value], parameter 476 to [Testpoint 1 Data], param. 235
- [Testpoint 1 Sel], parameter 234 = 2 "Heat Sink Temp"
- [Analog Out2 Sel], parameter 345 = 20 "Scale Block 1"
- [Analog Out2 Hi], parameter 346 = 10.000 Volts
- [Analog Out2 Lo], parameter 347 = 0.000 Volts
- [Scale1 In Hi], parameter 477 = 100
- [Scale1 In Lo], parameter 478 = 0

Parameter Controlled Analog Output

Enables the analog outputs to be controlled by Datalinks to the drive.

		377 378	**Vector v3** **[Anlg1 Out Setpt]** **Vector v3** **[Anlg2 Out Setpt]** Sets the analog output value from a communication device. Example: Set [Data In Ax] to “377” (value from communication device). Then set [Analog Outx Sel] to “Param Cntl.”	Default: Min/Max: Units:	20.000 mA, 10.000 Volts 0.000/20.000mA –/+10.000V 0.001 mA 0.001 Volt

Example

Analog Output 1 controlled by DataLink C1. Output 0-10V DC with DataLink values of 0-10000.

Setup

- [Data In C1], parameter = 304 “Analog Output 1 Setpoint”
- [Analog Out1 Sel], parameter 342 = 24 “Parameter Control”
- [Analog Out1 Hi], parameter 343 = 10.000 Volts
- [Analog Out1 Lo], parameter 344= 0.000 Volts

The device that writes to DataLink C1 now controls the voltage output of Analog Out1. For example: 2500 = 2.5V DC, 5000 = 5.0V DC, 7500 = 7.5V DC.

Auto/Manual

The intent of Auto/Manual is to allow the user to override the selected reference (referred to as the “auto” reference) by either toggling a button on the programming terminal (HIM), or continuously asserting a digital input that is configured for Auto/Manual.

- “Alt” Function on the HIM

  By toggling the “Alt” and “Auto/Man” function on the HIM, the user can switch the speed reference back and forth between the active “Auto” source (per drive programming and inputs) and the HIM requesting the manual control. “Manual” switches the Reference Source to the HIM, “Auto” switches it back to drive programming.

  The HIM manual reference can be **preloaded** from the auto source by enabling the [Man Ref Preload] parameter. With the preload function enabled, when the HIM requests Manual control, the current value of the auto source is loaded into the HIM reference before manual control is granted. This allows the manual control to begin at the same speed as the auto source, creating a smooth transition. If the preload function is disabled, the speed will ramp to whatever manual reference was present in the HIM at the time manual control was granted.

- Digital Input

  By toggling the digital input programmed as Auto/Manual, the user can switch the speed reference back and forth between the active “Auto” source (per drive programming and inputs) and the designated Terminal Block manual reference. When this digital input is asserted, the TB will attempt to gain exclusive control (Manual) of the reference. If granted control of the reference, the specific source for the reference is determined by the parameter TB manual reference select.

  The TB manual reference is selected in [TB Man Ref Sel]. The choices for this parameter are:

  – Analog Input 1
  – Analog Input 2
  – MOP Level
  – Analog Input 3 (PF700 Only)
  – Pulse Input (PF700 Only)
  – Encoder input (PF700 Only)
  – Releasing this input sends the control back to the Auto source.

General Rules

The following rules apply to the granting and releasing of Manual control:

1. Manual control is requested through a one-time request (Auto/Man toggle, not continuously asserted). Once granted, the terminal holds Manual control until the Auto/Man button is pressed again, which releases Manual control (i.e. back to Auto mode).

2. Manual control can only be granted to the TB or to a programming terminal (e.g. HIM) if Manual control is not already being exercised by the TB or another programming terminal at the time.

3. Manual control can only be granted to a terminal if no other device has Local control already asserted (i.e. no other device has ownership of the Local control function).

4. A HIM (or TB) with Manual control active can have it taken away if another DPI port requests, and is granted Local control. In this case when Local control is released the drive will not go back to Manual control, Manual control must be again requested (edge based request, see 1. above). This is true for both the HIM and the TB (i.e. if the TB switch was in the Manual position it must be switched to Auto and back to Manual to get Manual control again).

5. The status indicator (point LED on LED HIM & Text on LCD HIM) will indicate when that particular terminal has been granted Manual control, not the fact any terminal connected has Manual control and not the fact that the particular terminal has simply asked for Manual control.

6. When Manual control is granted, the drive will latch and save the current reference value prior to entering Manual. When Manual control is then released the drive will use that latched reference for the drive until another DPI device arbitrates ownership and changes the reference to a different value.

7. If a terminal has Manual control and clears its DPI reference mask (disallows reference ownership), then Manual control will be released. By extension, if the drive is configured such that the HIM can not select the reference (via reference mask setting), then the drive will not allow the terminal to acquire Manual control.

8. If a terminal has Manual control and clears its DPI logic mask (allowing disconnect of the terminal), then Manual control will be released. By extension if the drive is configured such that the HIM can be unplugged (via logic mask setting), then the drive will not allow the terminal to acquire Manual control. The disconnect also applies to a DPI HIM that executes a soft "Logout."

9. If a com loss fault occurs on a DPI that has Manual control, then Manual control will be released as a consequence of the fault (on that port which had Manual control).

10. There will be no way to request and hence no support of the Auto/ Manual feature on old SCANport based HIMs.

11. You can not acquire Manual control if you are already an assigned source for the DPI port requesting Manual.

12. When a restore factory defaults is performed Manual control is aborted.

Auto Restart (Reset/Run)

The Auto Restart feature provides the ability for the drive to automatically perform a fault reset followed by a start attempt without user or application intervention. This allows remote or “unattended” operation. Only certain faults are allowed to be reset. Certain faults (Type 2) that indicate possible drive component malfunction are not resettable.

Caution should be used when enabling this feature, since the drive will attempt to issue its own start command based on user selected programming.

Configuration

This feature is configured through two user parameters

No.	Parameter	Values	Related
174	**[Auto Rstrt Tries]** Sets the maximum number of times the drive attempts to reset a fault and restart.	Default: 0 Min/Max: 0/9 Display: 1	175
	ATTENTION: Equipment damage and/or personal injury may result if this parameter is used in an inappropriate application. Do Not use this function without considering applicable local, national and international codes, standards, regulations or industry guidelines.		
175	**[Auto Rstrt Delay]** Sets the time between restart attempts when [Auto Rstrt Tries] is set to a value other than zero.	Default: 1.0 Secs Min/Max: 0.5/30.0 Secs Display: 0.1 Secs	174

Setting [Auto Rstrt Tries] to a value greater than zero will enable the Auto Restart feature. Setting the number of tries equal to zero will disable the feature.

The [Auto Rstrt Delay] parameter sets the time, in seconds, between each reset/run attempt.

The auto-reset/run feature provides 2 status bits in [Drive Status 2] – an active status, and a countdown status.

UTILITY — Diagnostics

No.	Parameter		Related
210	**[Drive Status 2]** Present operating condition of the drive.	Read Only	209

Bit #	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Name			DPI at 500 k	Motor Overld	Bus Freq Reg	Curr Limit	AutoRst Act	AutoRst Ctdn	DB Active *	AutoTuning	DC Braking	Stopping	Jogging	Running	Active	Ready
Default	x	x	0	0	0	0	0	0	0	0	0	0	0	0	0	0

1=Condition True
0=Condition False
x=Reserved

** Vector firmware 3.001 & later*

The typical steps performed in an Auto-Reset/Run cycle are as follows:

1. The drive is running and an auto-resettable fault occurs, tripping the drive.
2. After the number of seconds in [Auto Rstrt Delay], the drive will automatically perform an internal Fault Reset, resetting the faulted condition.

3. The drive will then issue an internal Start command to start the drive.
4. If another auto-resettable fault occurs the cycle will repeat itself up to the number of attempts set in [Auto Rstrt Tries].
5. If the drive faults repeatedly for more than the number of attempts set in [Auto Rstrt Tries] with less than five minutes between each fault, the auto-reset/run is considered unsuccessful and the drive remains in the faulted state.
6. Aborting an Auto-Reset/Run Cycle (see Aborting an Auto-Reset/Run Cycle for details).
7. If the drive remains running for five minutes or more since the last reset/run without a fault, or is otherwise stopped or reset, the auto-reset/run is considered successful. The entire process is reset to the beginning and will repeat on the next fault.

Beginning an Auto-Reset/Run Cycle

The following conditions must be met when a fault occurs for the drive to begin an auto-reset/run cycle.

- The fault must be defined as an auto-resettable fault
- [Auto Rstrt Tries] setting must be greater than zero.
- The drive must have been running, not jogging, not autotuning, and not stopping, when the fault occurred. (Note that a DC Hold state is part of a stop sequence and therefore is considered stopping.)

Aborting an Auto-Reset/Run Cycle

During an auto-reset/run cycle the following actions/conditions will abort the reset/run attempt process.

- Issuing a stop command from any source. (Note: Removal of a 2-wire run-fwd or run-rev command is considered a stop assertion).
- Issuing a fault reset command from any source.
- Removal of the *enable* input signal.
- Setting [Auto Rstrt Tries] to zero.
- The occurrence of a fault which is not auto-resettable.
- Removing power from the drive.
- Exhausting an Auto-Reset/Run Cycle

After all [Auto Rstrt Tries] have been made and the drive has not successfully restarted and remained running for five minutes or more, the auto-reset/run cycle will be considered exhausted and therefore unsuccessful. In this case the auto-reset/run cycle will terminate and an additional fault, "Auto Rstrt Tries" (Auto Restart Tries) will be issued if bit 5 of [Fault Config 1] = "1."

Autotune

Description of parameters determined by the autotune tests.

Flux Current Test

[Flux Current Ref] is set by the flux current test. Flux current is the reactive portion of the motor current (portion of the current that is out of phase with the motor voltage) and is used to magnetize the motor. The flux current test is used to identify the value of motor flux current required to produce rated motor torque at rated current. When the flux test is performed, the motor will rotate. The drive accelerates the motor to approximately two-thirds of base speed and then coasts for several seconds.

IR Voltage Drop Test

[IR Voltage Drop] is set by the IR voltage drop test. [IR Voltage Drop] is used by the IR Compensation procedure to provide additional voltage at all frequencies to offset the voltage drop developed across the stator resistance. An accurate calculation of the [IR Voltage Drop] will ensure higher starting torque and better performance at low speed operation. The motor should not rotate during this test.

Vector FV Leakage Inductance Test

[Ixo Voltage Drop] is set by the leakage inductance test. This test measures the inductance characteristics of the motor. A measurement of the motor inductance is required to determine references for the regulators that control torque. The motor should not rotate during this test.

Vector FV Inertia Test

[Total Inertia] is set by the inertia test. [Total Inertia] represents the time in seconds, for the motor coupled to a load to accelerate from zero to base speed at rated motor torque. During this test, the motor is accelerated to about 2/3 of base motor speed. This test is performed during the Start-up mode, but can be manually performed by setting [Inertia Autotune] to "Inertia Tune". The [Total Inertia] and [Speed Desired BW] automatically determine the [Ki Speed Loop] and [Kp Speed Loop] gains for the speed regulator.

Autotune Procedure for Sensorless Vector and Economizer

The purpose of Autotune is to identify the motor flux current and stator resistance for use in Sensorless Vector Control and Economizer modes.

The user must enter motor nameplate data into the following parameters for the Autotune procedure to obtain accurate results:

- [Motor NP Volts]
- [Motor NP Hertz]
- [Motor NP Power]

Next, the Dynamic or Static Autotune should be performed:

- Dynamic - the motor shaft will rotate during this test. The dynamic autotune procedure determines both the stator resistance and motor flux current. The test to identify the motor flux current requires the load to be uncoupled from the motor to find an accurate value. If this is not possible then the static test can be performed.
- Static - the motor shaft will not rotate during this test. The static test determines only [IR Voltage Drop]. This test does not require the load to be uncoupled from the motor.

The static and dynamic tests can be performed during the Start-up routine on the LCD HIM. The tests can also be run manually by setting the value of the [Autotune] parameter to 1 “Static Tune” or 2 “Rotate Tune”.

Alternate Methods to Determine [IR Voltage Drop] & [Flux Current Ref]

If it is not possible or desirable to run the Autotune tests, there are three other methods for the drive to determine the [IR Voltage Drop] and [Flux Current] parameters:

- The first method is used when the motor nameplate parameters are left at default. When the drive is initially powered up, the [Autotune] parameter is defaulted to a value of 3 “Calculate”. The values for [IR Voltage Drop] and [Flux Current] are calculated based on the default motor nameplate data. This is the least preferred method.
- The second method calculates them from the user-entered motor nameplate data parameters. When [Autotune] is set to 3 “Calculate”, any changes made by the user to motor nameplate HP, Voltage, or Frequency activates a new calculation. This calculation is based on a typical motor with those nameplate values.
- Finally, if the stator resistance and flux current of the motor are known, the user can calculate the voltage drop across the stator resistance. Then set [Autotune] to 0 “Ready” and directly enter these values into the [Flux Current] and [IR Voltage Drop] parameters.

Autotune Procedure for Flux Vector

Vector FV For FVC vector control an accurate model of the motor must be used. For this reason, the motor data must be entered and the autotune tests should be performed with the connected motor.

Motor nameplate data must be entered into the following parameters for the Autotune procedure to obtain accurate results:

- [Motor NP Volts]
- [Motor NP FLA]
- [Motor NP Hertz]
- [Motor NP RPM]
- [Motor NP Power]
- [Motor Poles]

Next the Dynamic or Static Autotune should be performed:

- Dynamic - the motor shaft will rotate during this test. The dynamic autotune procedure determines the stator resistance, motor flux current, and leakage inductance. The test to identify the motor flux current requires the load to be uncoupled from the motor to find an accurate value. If this is not possible then the static test can be performed.
- Static - the motor shaft will not rotate during this test. The static test determines only [IR Voltage Drop] and [Ixo Voltage Drop]. This test does not require the load to be uncoupled from the motor.

The static and dynamic tests can be performed during the Start-up routine on the LCD HIM. The tests can also be run manually by setting the value of [Autotune] to "1," (Static Tune) or "2" (Rotate Tune), respectively, and then starting the drive.

After the Static or Dynamic Autotune the Inertia test should be performed. The motor shaft will rotate during the inertia test. During the inertia test the motor should be coupled to the load to find an accurate value. The inertia test can be performed during the Start-up routine on the LCD HIM. The inertia test can also be run manually by setting [Inertia Autotune] to 1 "Inertia Tune", and then starting the drive.

Troubleshooting the Autotune Procedure

If any errors are encountered during the Autotune process drive parameters are not changed, the appropriate fault code will be displayed in the fault queue, and the [Autotune] parameter is reset to 0. If the Autotune procedure is aborted by the user, the drive parameters are not changed and the [Autotune] parameter is reset to 0.

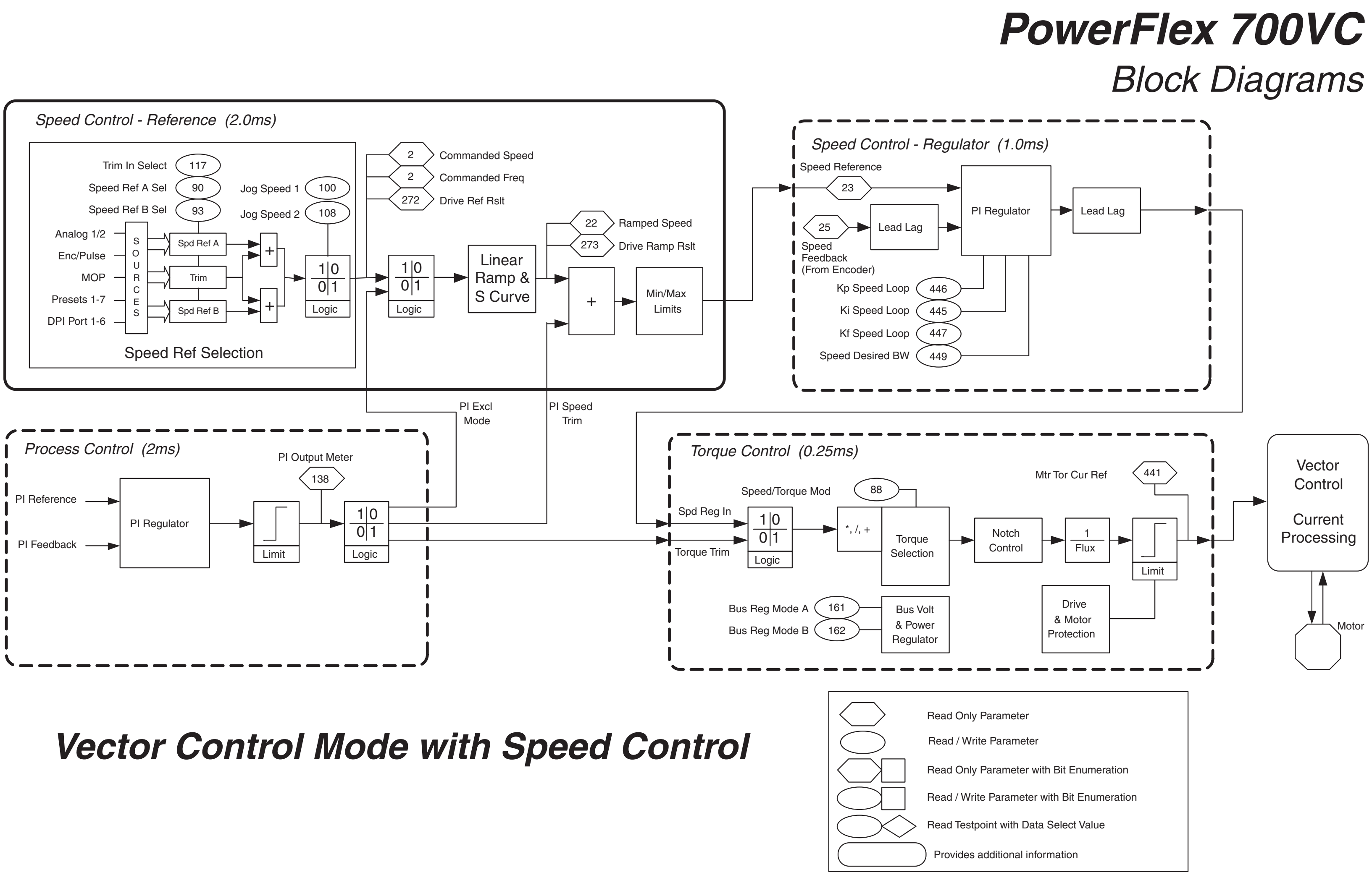
The following conditions will generate a fault during an Autotune procedure:

- Incorrect stator resistance measurement
- Incorrect motor flux current measurement
- Load too large
- Autotune aborted by user
- Vector FV Incorrect leakage inductance measurement

Block Diagrams

The following pages contain the block diagrams for the PowerFlex 700 Vector Control drive.

Figure 2.1 PowerFlex 700VC Block Diagams (1)



PowerFlex 700VC

Block Diagrams

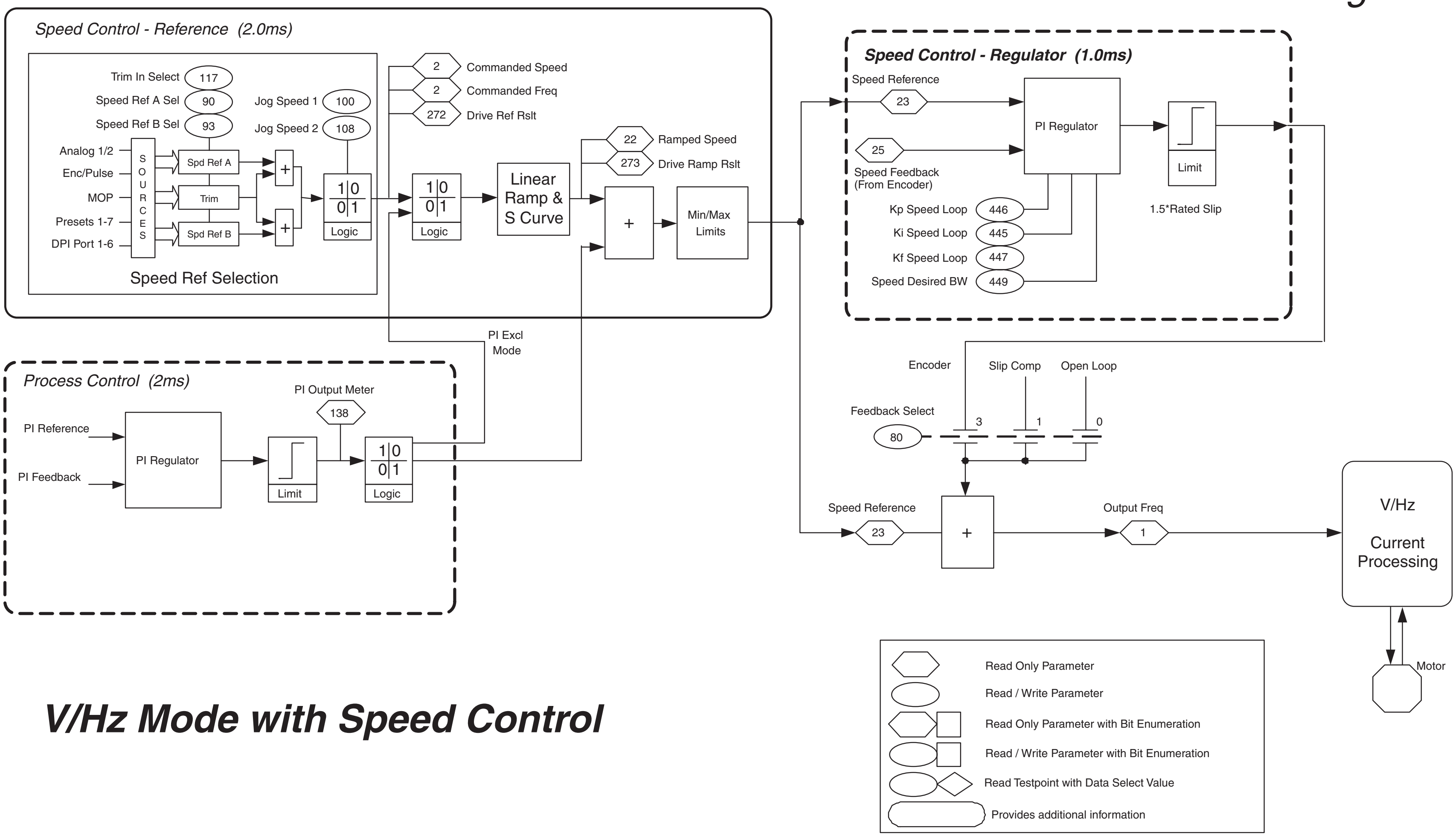


Figure 2.2 PowerFlex 700VC Block Diagrams (2)

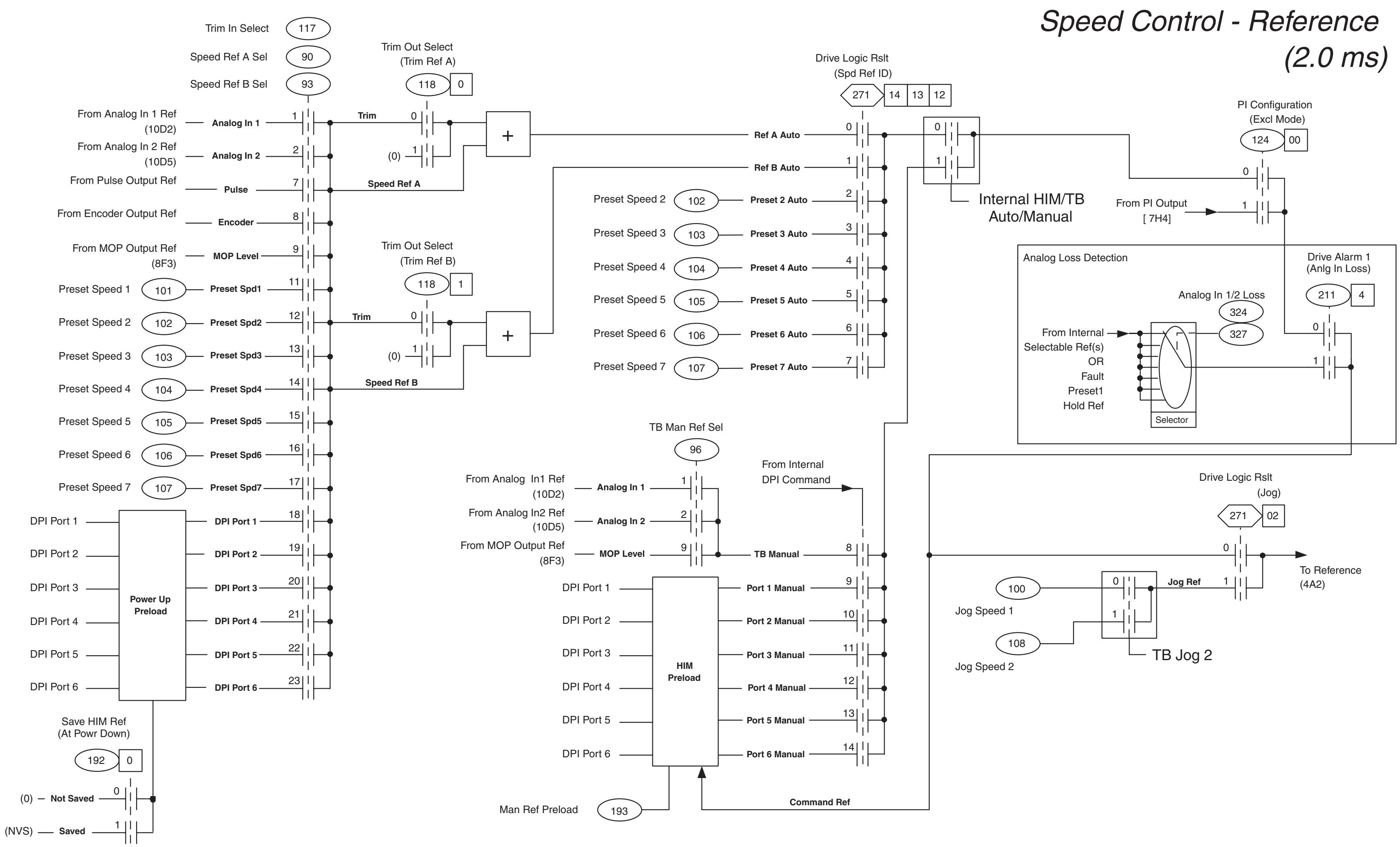
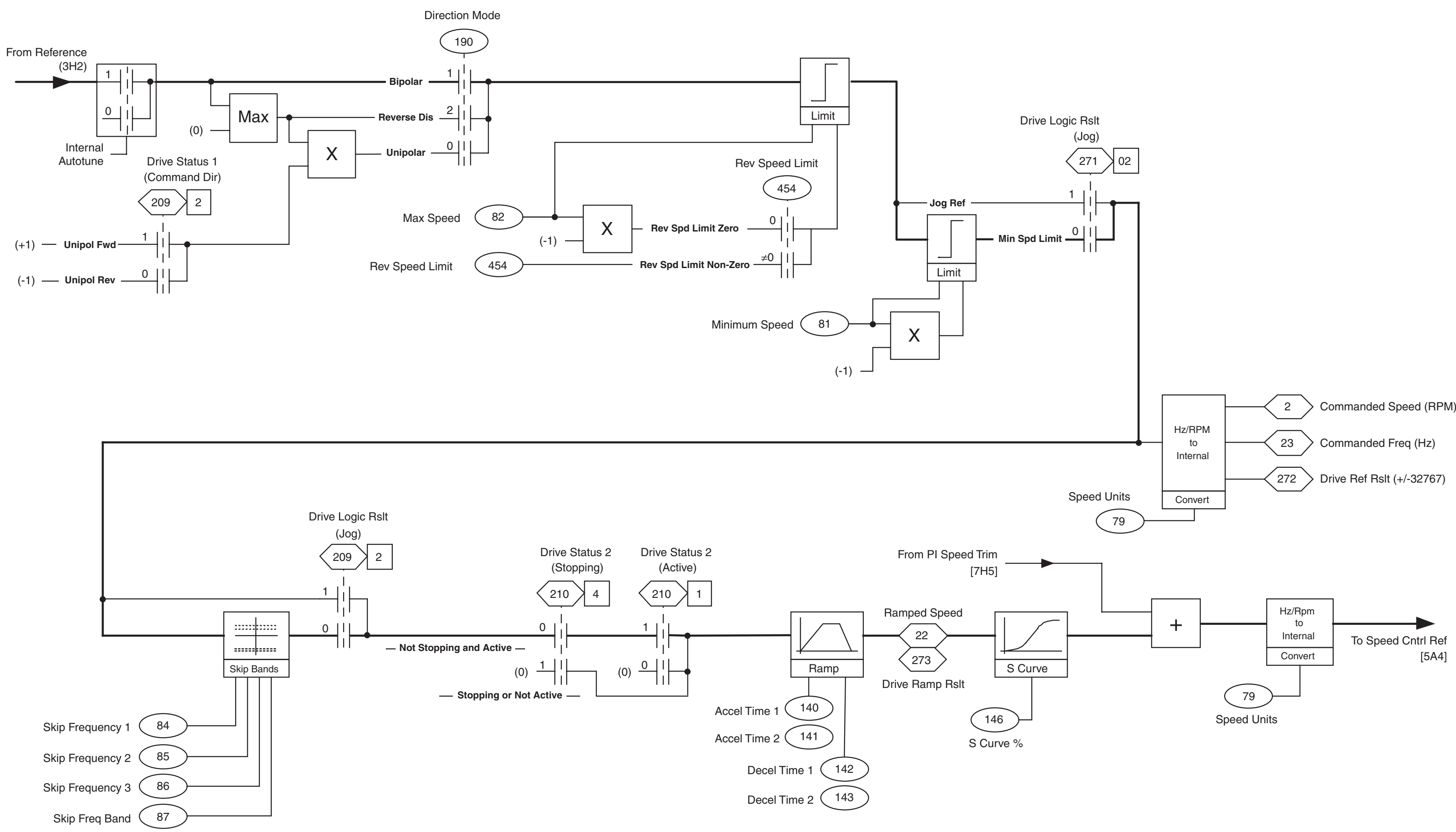


Figure 2.3 PowerFlex 700VC Block Diagrams (3)

Figure 2.4 PowerFlex 700VC Block Diagrams (4)

Speed Control - Reference (2.0 ms)



Speed Control - Regulator (1.0 ms)

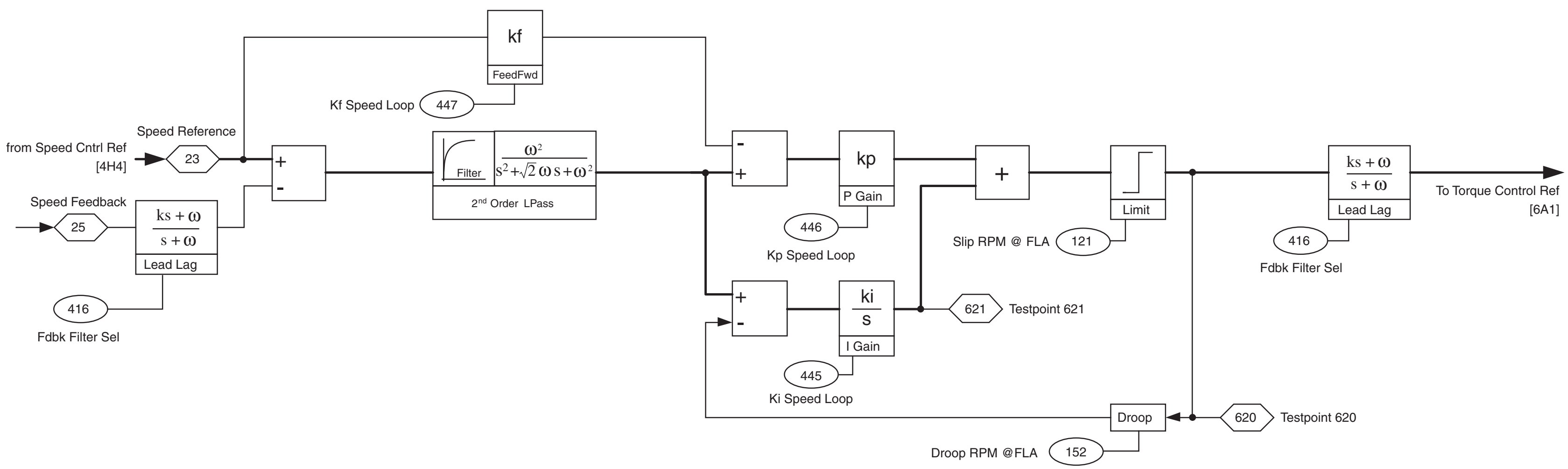


Figure 2.5 PowerFlex 700VC Block Diagams (5)

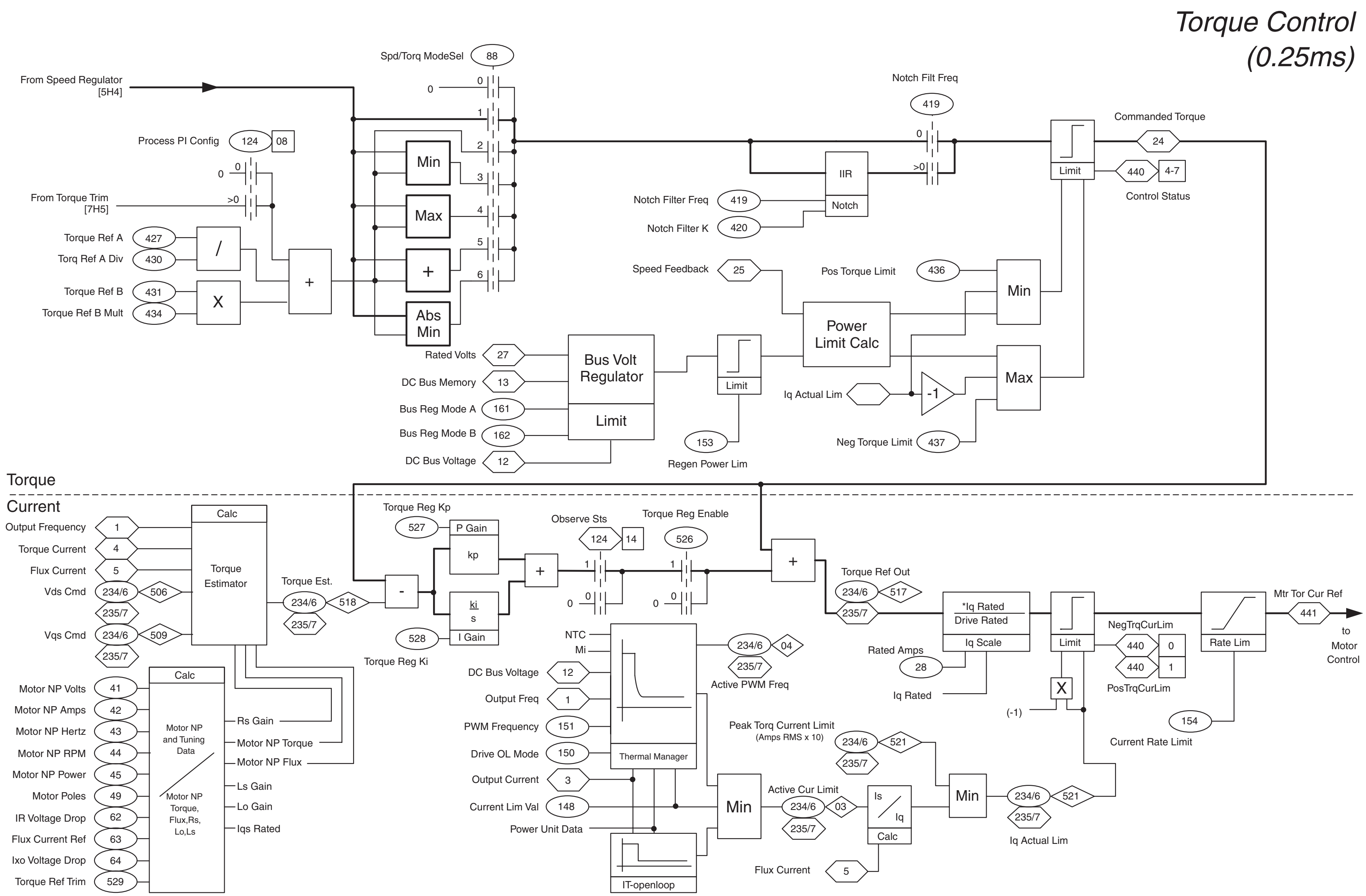


Figure 2.6 PowerFlex 700VC Block Diagrams (6)

Process Trim
(2.0 ms)

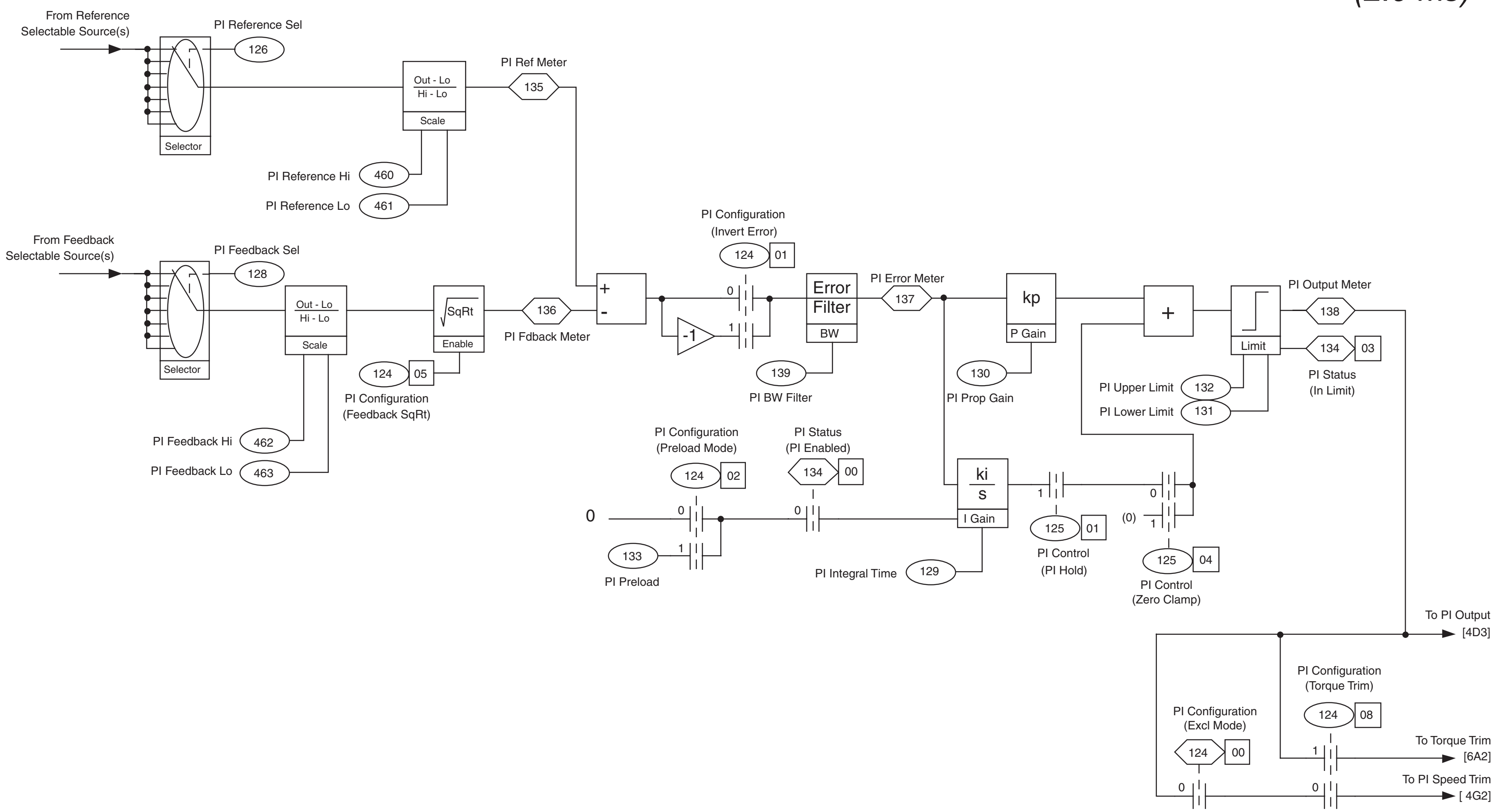
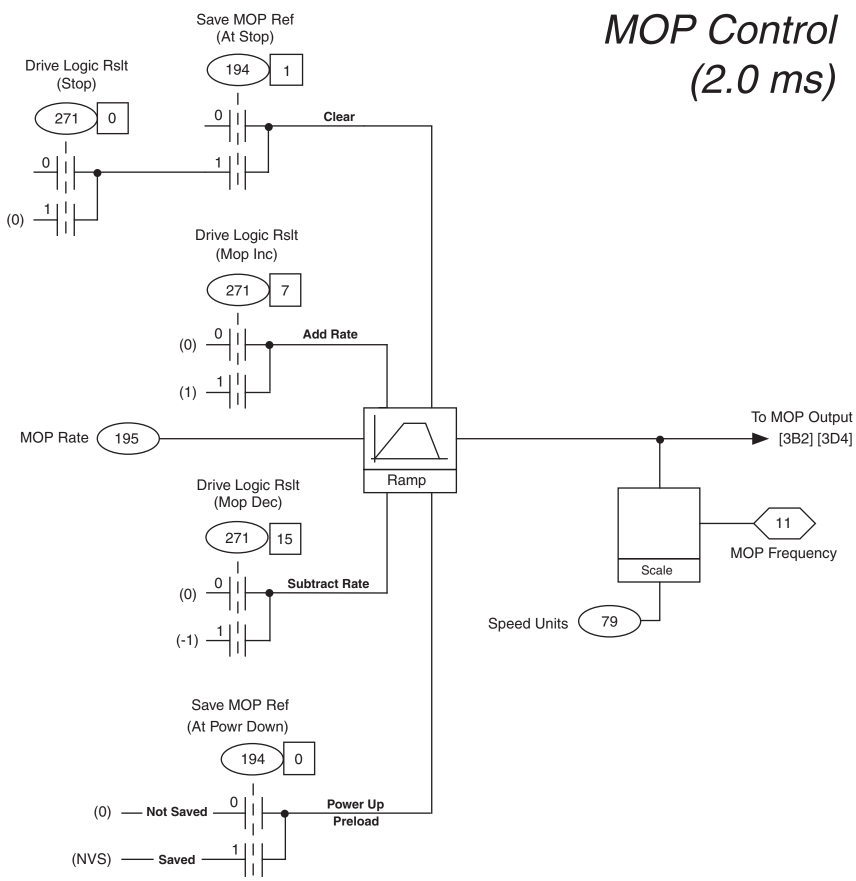


Figure 2.7 PowerFlex 700VC Block Diagrams (7)

Figure 2.8 PowerFlex 700VC Block Diagams (8)



Inputs & Outputs - Digital (0.5ms)

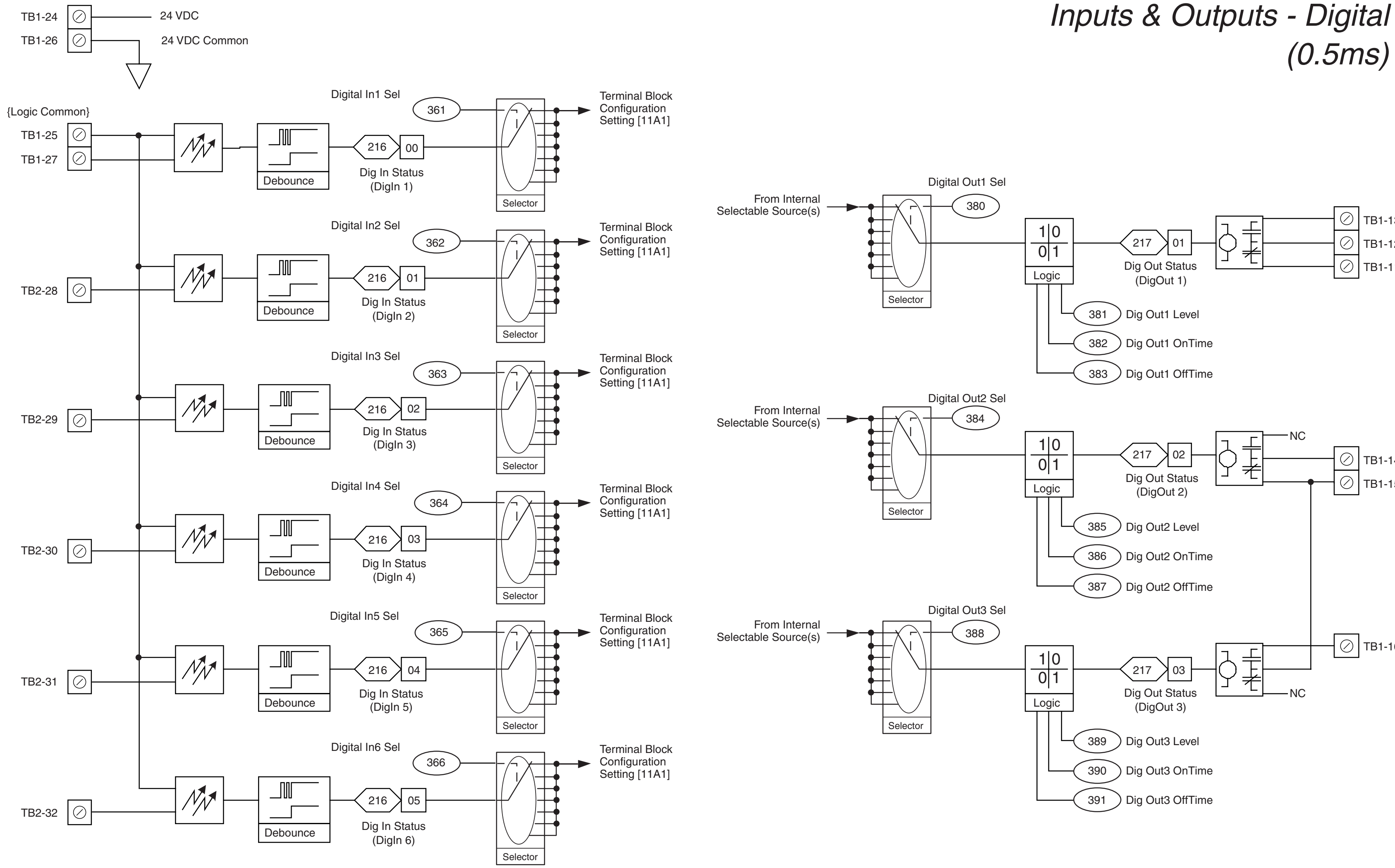
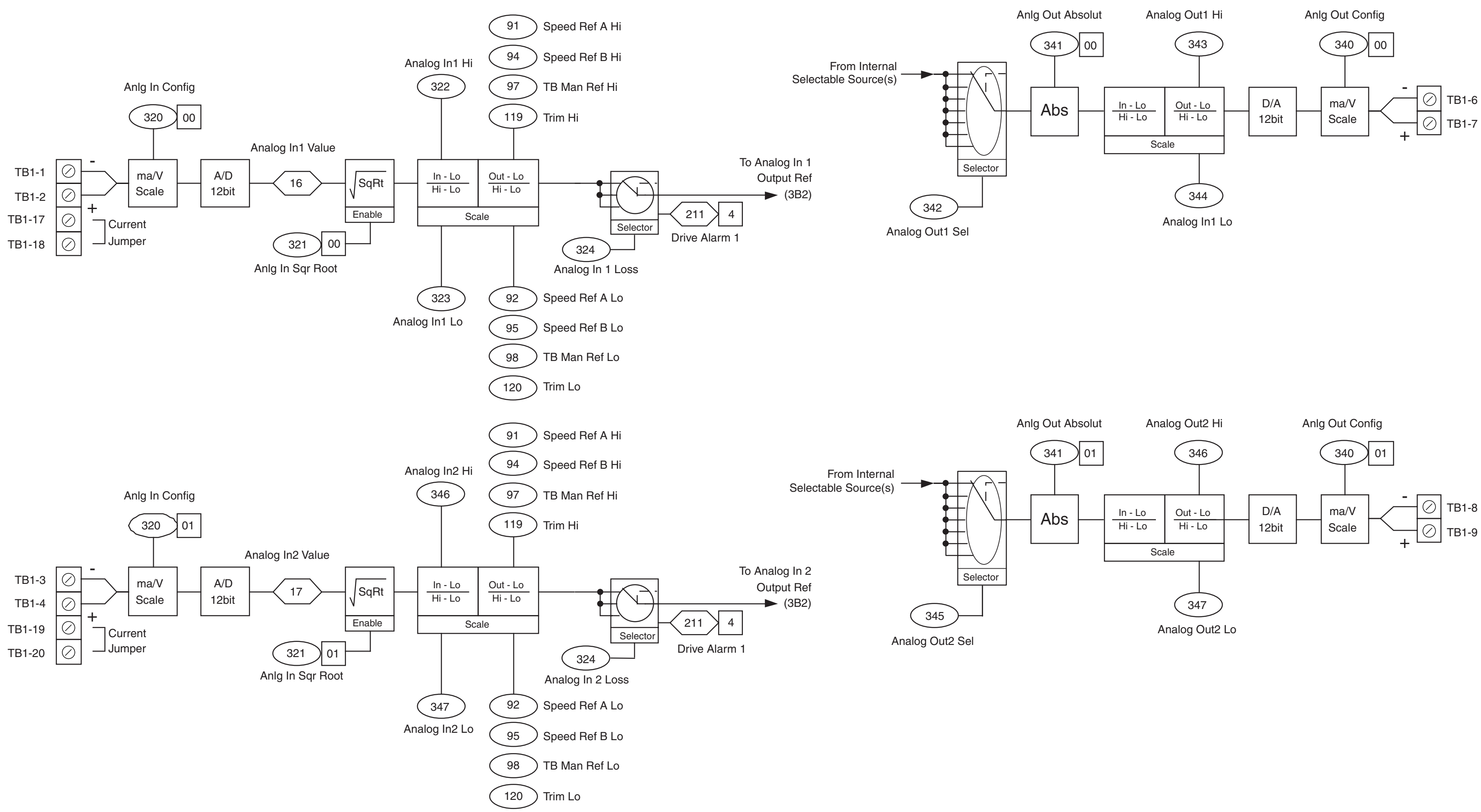


Figure 2.9 PowerFlex 700VC Block Diagrams (9)

Figure 2.10 PowerFlex 700VC Block Diagrams (10)

Inputs & Outputs - Analog (2.0ms)



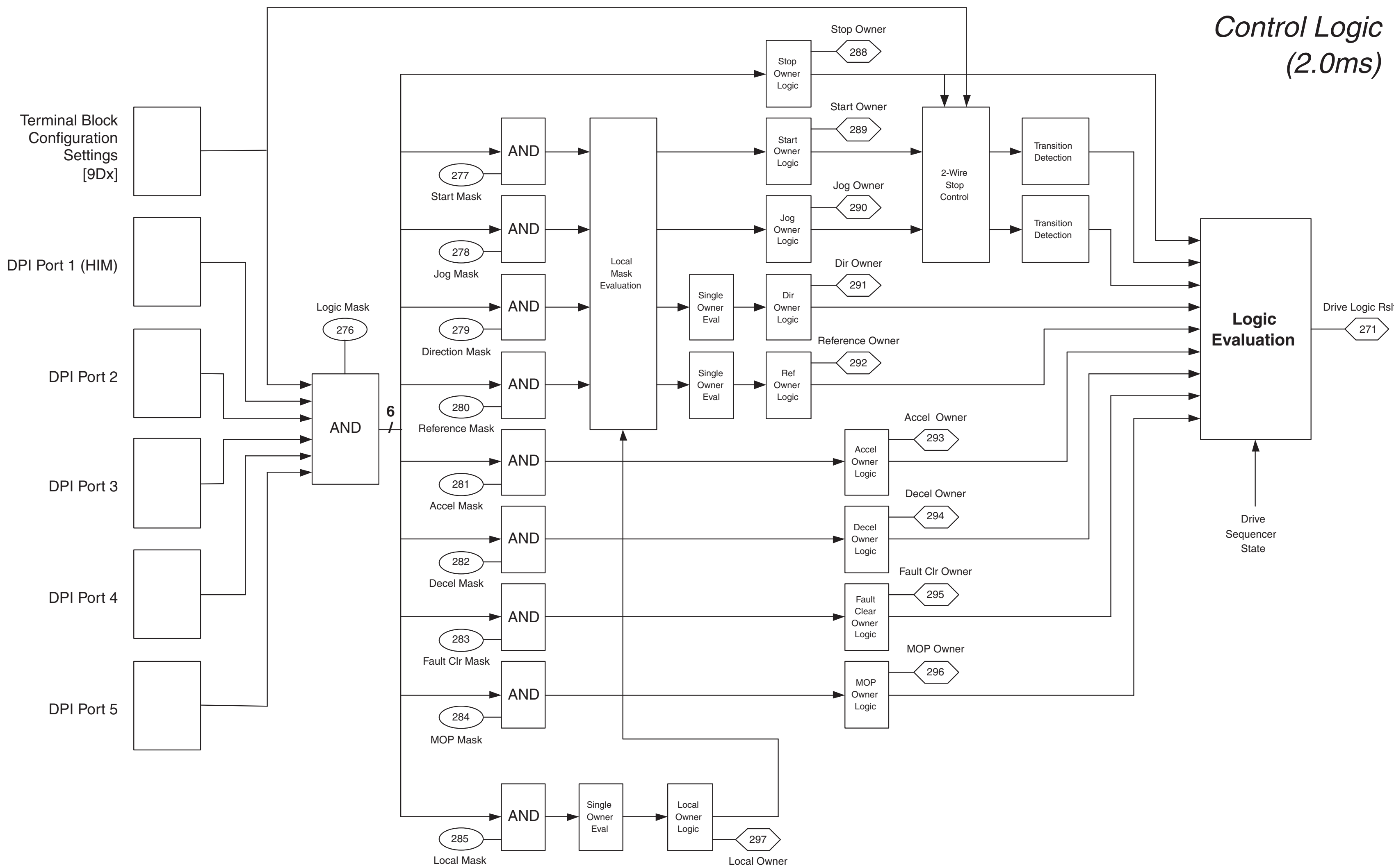


Figure 2.11 PowerFlex 700VC Block Diagrams (11)

Inverter Overload IT

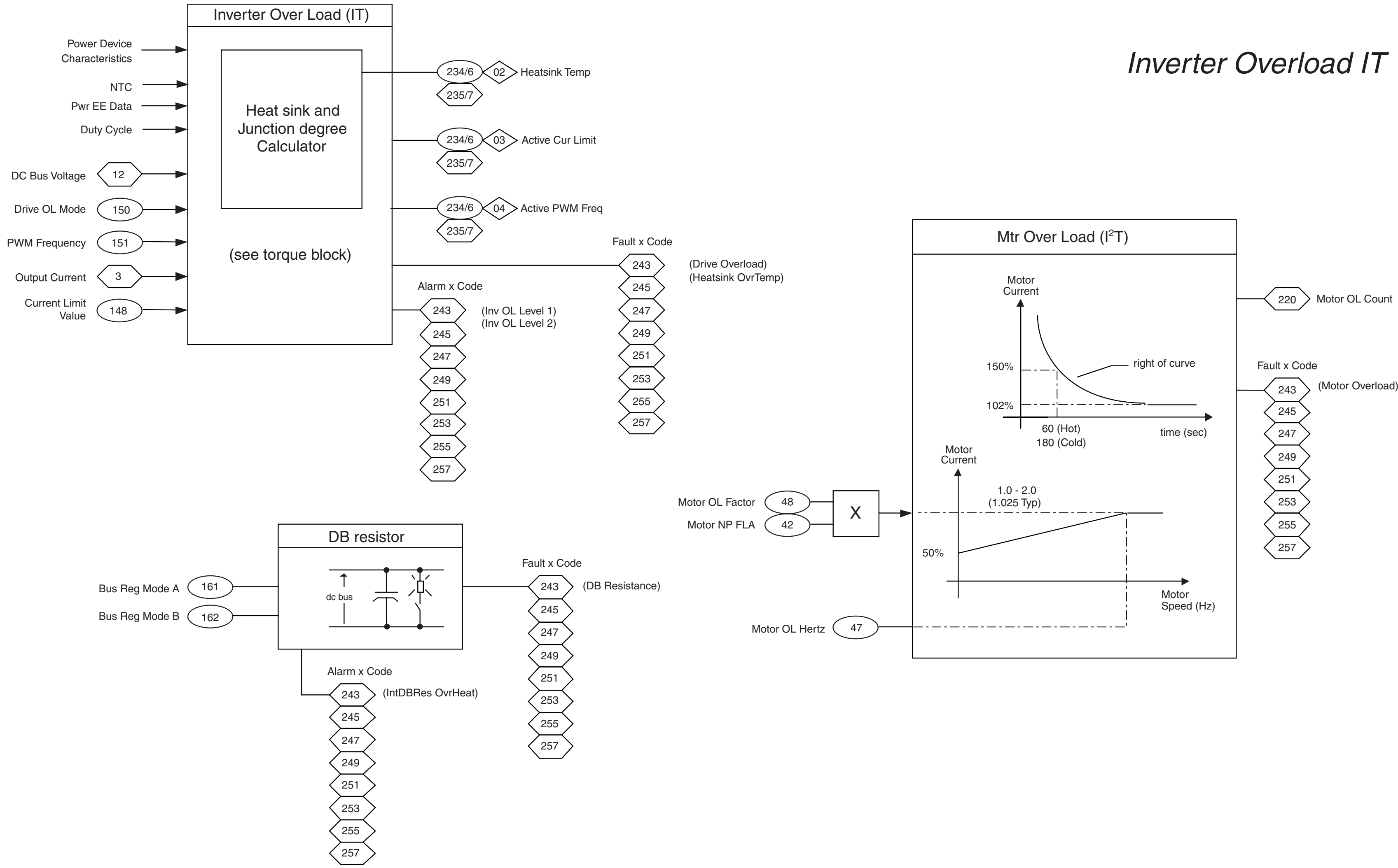


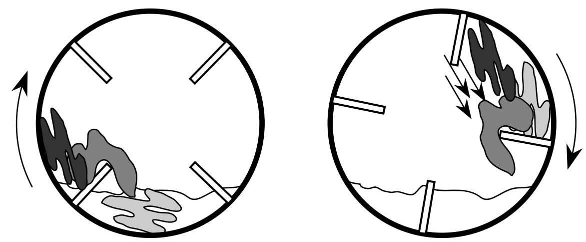
Figure 2.12 PowerFlex 700VC Block Diagrams (12)

Bus Regulation

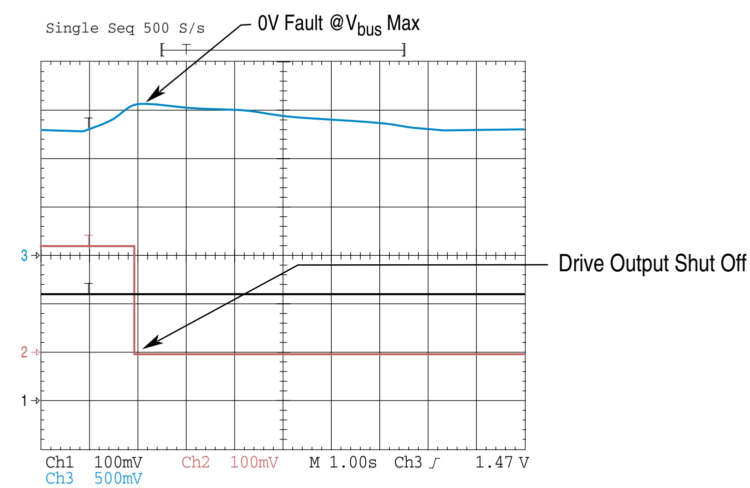
[Bus Reg Gain]
[Bus Reg Mode A, B]

Some applications, such as the hide tanning shown here, create an intermittent regeneration condition. When the hides are being lifted (on the left), motoring current exists. However, when the hides reach the top and fall onto a paddle, the motor regenerates power back to the drive, creating the potential for a nuisance overvoltage trip.

When an AC motor regenerates energy from the load, the drive DC bus voltage increases unless there is another means (dynamic braking chopper/ resistor, etc.) of dissipating the energy.



Without bus regulation, if the bus voltage exceeds the operating limit established by the power components of the drive, the drive will fault, shutting off the output devices to protect itself from excess voltage.

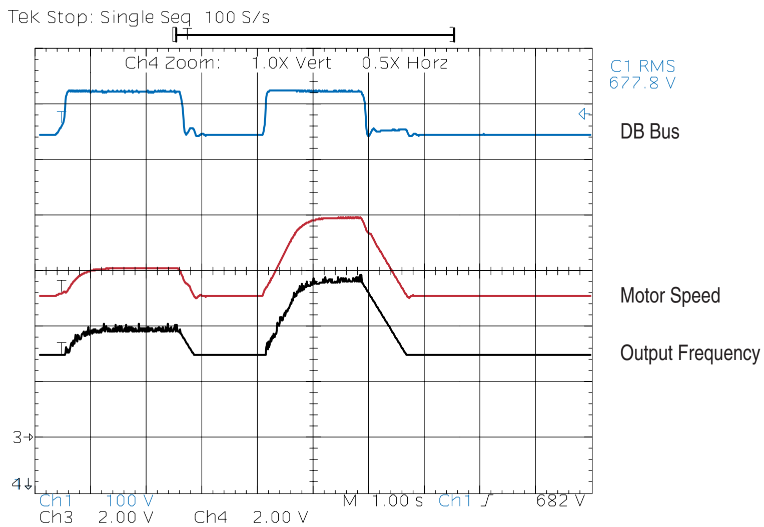


With bus regulation enabled, the drive can respond to the increasing voltage by advancing the output frequency until the regeneration is counteracted. This keeps the bus voltage at a regulated level below the trip point.

Since the same integrator is used for bus regulation as for normal frequency ramp operation, a smooth transition between normal frequency ramp operation and bus regulation is accomplished.

The regulator senses a rapid rise in the bus voltage and activates prior to actually reaching the internal bus voltage regulation set point Vreg. This is important since it minimizes overshoot in the bus voltage when bus regulation begins thereby attempting to avoid an over-voltage fault.

The bus voltage regulation set point (Vreg) in the drive is fixed for each voltage class of drive. The bus voltage regulation set points are identical to the internal dynamic brake regulation set points VDB's.



To avoid over-voltage faults, a bus voltage regulator is incorporated as part of the acceleration/deceleration control. As the bus voltage begins to approach the bus voltage regulation point (Vreg), the bus voltage regulator increases the magnitude of the output frequency and voltage to reduce the bus voltage. The bus voltage regulator function takes precedence over the other two functions. See Figure 2.13.

The bus voltage regulator is shown in the lower one-third of Figure 2.13. The inputs to the bus voltage regulator are the bus voltage, the bus voltage regulation set point Vreg, proportional gain, integral gain, and derivative gain. The gains are intended to be internal values and not parameters. These will be test points that are not visible to the user. Bus voltage regulation is selected by the user in the Bus Reg Mode parameter.

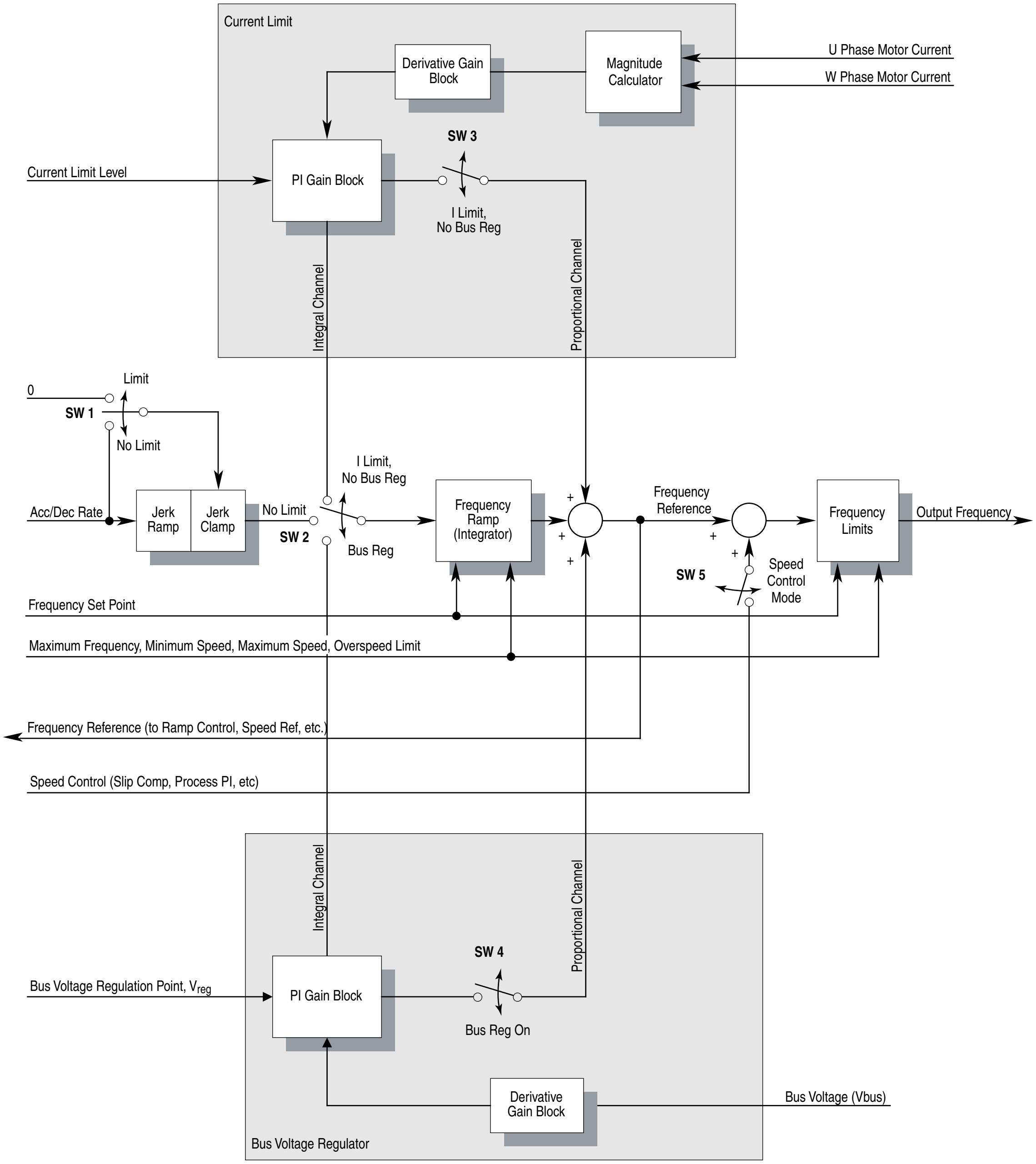
Operation

Bus voltage regulation begins when the bus voltage exceeds the bus voltage regulation set point Vreg and the switches shown in Figure 2.13 move to the positions shown in Table 2.B.

Table 2.B Switch Positions for Bus Regulator Active

	SW 1	SW 2	SW 3	SW 4	SW 5
Bus Regulation	Limit	Bus Reg	Open	Closed	Don't Care

Figure 2.13 Bus Voltage Regulator, Current Limit and Frequency Ramp.



The derivative term senses a rapid rise in the bus voltage and activates the bus regulator prior to actually reaching the bus voltage regulation set point Vreg. The derivative term is important since it minimizes overshoot in the bus voltage when bus regulation begins thereby attempting to avoid an over-voltage fault. The integral channel acts as the acceleration or deceleration rate and is fed to the frequency ramp integrator. The proportional term is added directly to the output of the frequency ramp integrator to form the output frequency. The output frequency is then limited to a maximum output frequency.

Bus voltage regulation is the highest priority of the three components of this controller because minimal drive current will result when limiting the bus voltage and therefore, current limit will not occur.

ATTENTION: The "adjust freq" portion of the bus regulator function is extremely useful for preventing nuisance overvoltage faults resulting from aggressive decelerations, overhauling loads, and eccentric loads. It forces the output frequency to be greater than commanded frequency while the drive's bus voltage is increasing towards levels that would otherwise cause a fault; however, it can also cause either of the following two conditions to occur.
1. Fast positive changes in input voltage (more than a 10% increase within 6 minutes) can cause uncommanded positive speed changes; however an "OverSpeed Limit" fault will occur if the speed reaches [Max Speed] + [Overspeed Limit]. If this condition is unacceptable, action should be taken to 1) limit supply voltages within the specification of the drive and, 2) limit fast positive input voltage changes to less than 10%. Without taking such actions, if this operation is unacceptable, the "adjust freq" portion of the bus regulator function must be disabled (see parameters 161 and 162).
2. Actual deceleration times can be longer than commanded deceleration times; however, a "Decel Inhibit" fault is generated if the drive stops decelerating altogether. If this condition is unacceptable, the "adjust freq" portion of the bus regulator must be disabled (see parameters 161 and 162). In addition, installing a properly sized dynamic brake resistor will provide equal or better performance in most cases.
Note: These faults are not instantaneous and have shown test results that take between 2 and 12 seconds to occur.

PowerFlex 70/700

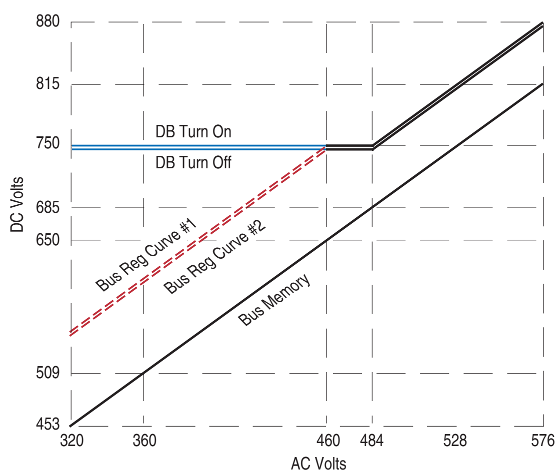
The user selects the bus voltage regulator using the Bus Reg Mode parameters. The available modes include:

- off
- frequency regulation
- dynamic braking
- frequency regulation as the primary regulation means with dynamic braking as a secondary means
- dynamic braking as the primary regulation means with frequency regulation as a secondary means

The bus voltage regulation setpoint is determined off of bus memory (a means to average DC bus over a period of time). The following graph and tables describe the operation.

Table 2.C

Voltage Class	DC Bus Memory	DB On Setpoint	DB Off Setpoint
240	< 342V DC	375V DC	On – 4V DC
	> 342V DC	Memory + 33V DC	
480	< 685V DC	750V DC	On – 8V DC
	> 685V DC	Memory + 65V DC	
600	< 856V DC	937V DC	On – 10V DC
	> 856V DC	Memory + 81V DC	
600/690V PowerFlex 700 Frames 5 & 6 Only	< 983V DC	1076V DC	On – 11V DC
	> 983V DC	Memory + 93V DC	



If [Bus Reg Mode A], parameter 161 is set to "Dynamic Brak"

The Dynamic Brake Regulator is enabled. In "Dynamic Brak" mode the Bus Voltage Regulator is turned off. The "DB Turn On" and turn off curves apply (Table 2.C). For example, with a DC Bus Memory at 684V DC, the Dynamic Brake Regulator will turn on at 750V DC and turn back off at 742V DC.

If [Bus Reg Mode A], parameter 161 is set to "Both-Frq 1st"

Both regulators are enabled, and the operating point of the Bus Voltage Regulator is lower than that of the Dynamic Brake Regulator. The Bus Voltage Regulator setpoint follows the "Bus Reg Curve 2" below a DC Bus Memory of 650V DC and follows the "DB Turn Off" curve above a DC Bus Memory of 650V DC (Table 2.D). The Dynamic Brake Regulator follows the "DB Turn On" and turn off curves (Table 2.C). For example, with a DC Bus Memory at 684V DC, the Bus Voltage Regulator setpoint is 742V DC and the Dynamic Brake Regulator will turn on at 750V DC and back off at 742V DC.

If [Bus Reg Mode A], parameter 161 is set to "Adjust Freq"

The Bus Voltage Regulator is enabled. The Bus Voltage Regulator setpoint follows "Bus Reg Curve 1" below a DC Bus Memory of 650V DC and follows the "DB Turn On" above a DC Bus Memory of 650V DC (Table 2.D). For example, with a DC Bus Memory at 684V DC, the adjust frequency setpoint is 750V DC.

If [Bus Reg Mode A], parameter 161 is set to "Both-DB 1st"

Both regulators are enabled, and the operating point of the Dynamic Brake Regulator is lower than that of the Bus Voltage Regulator. The Bus Voltage Regulator setpoint follows the "DB Turn On" curve (Table 2.C). The Dynamic Brake Regulator follows the "DB Turn On" and turn off curves (Table 2.C). For example, with a DC Bus Memory at 684V DC, the Bus Voltage Regulator setpoint is 750V DC and the Dynamic Brake Regulator will turn on at 750V DC and back off at 742V DC.

Table 2.D

Voltage Class	DC Bus Memory	Bus Reg Curve #1	Bus Reg Curve #2
240	< 325V DC	Memory + 50V DC	Curve 1 – 4V DC
	325V DC ≤ DC Bus Memory ≤ 342V DC	375V DC	
	> 342V DC	Memory + 33V DC	
480	< 650V DC	Memory + 100V DC	Curve 1 – 8V DC
	650V DC ≤ DC Bus Memory ≤ 685V DC	750V DC	
	> 685V DC	Memory + 65V DC	
600	< 813V DC	Memory + 125V DC	Curve 1 – 10V DC
	813V DC ≤ DC Bus Memory ≤ 856V DC	937V DC	
	> 856V DC	Memory + 81V DC	
600/690V PowerFlex 700 Frames 5 & 6 Only	< 933V DC	Memory + 143V DC	Curve 1 – 11V DC
	933V DC ≤ DC Bus Memory ≤ 983V DC	1076V DC	
	> 983V DC	Memory + 93V DC	

Cable, Control

Refer to "*Wiring and Grounding Guidelines for Pulse Width Modulated (PWM) AC Drives*," publication DRIVES-IN001 for detailed information on Cable, Control.

Cable, Motor Lengths

Refer to "*Wiring and Grounding Guidelines for Pulse Width Modulated (PWM) AC Drives*," publication DRIVES-IN001 for detailed information on Cable, Motor Lengths.

Cable, Power

Refer to "*Wiring and Grounding Guidelines for Pulse Width Modulated (PWM) AC Drives*," publication DRIVES-IN001 for detailed information on Cable, Power.

Cable Trays and Conduit

Refer to "*Wiring and Grounding Guidelines for Pulse Width Modulated (PWM) AC Drives*," publication DRIVES-IN001 for detailed information on Cable Trays and Conduit.

Carrier (PWM) Frequency

See page 1-3 for derating guidelines as they relate to carrier frequency.

In general, the lowest possible switching frequency that is acceptable for any particular application is the one that should be used. There are several benefits to increasing the switching frequency. Refer to Figure 2.14 and Figure 2.15. Note the output current at 2 kHz and 4 kHz. The "smoothing" of the current waveform continues all the way to 10 kHz.

Figure 2.14 Current at 2 kHz PWM Frequency

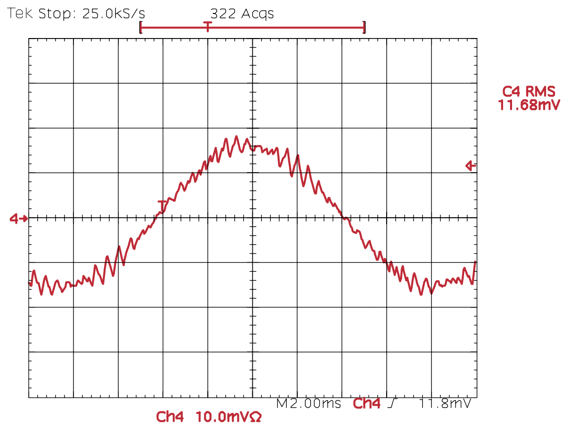
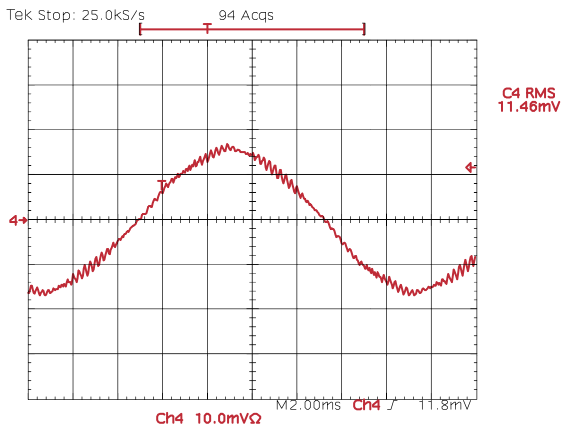


Figure 2.15 Current at 4 kHz PWM Frequency



The benefits of increased carrier frequency include less motor heating and lower audible noise. An increase in motor heating is considered negligible and motor failure at lower switching frequencies is very remote. The higher switching frequency creates less vibration in the motor windings and laminations thus, lower audible noise. This may be desirable in some applications.

Some undesirable effects of higher switching frequencies include derating ambient temperature vs. load characteristics of the drive, higher cable charging currents and higher potential for common mode noise.

A very large majority of all drive applications will perform adequately at 2-4 kHz.

CE Conformity

EMC Instructions

CE Conformity

Conformity with the Low Voltage (LV) Directive and Electromagnetic Compatibility (EMC) Directive has been demonstrated using harmonized European Norm (EN) standards published in the Official Journal of the European Communities. PowerFlex Drives comply with the EN standards listed below when installed according to the User and Reference Manuals.

CE Declarations of Conformity are available online at:
http://www.ab.com/certification/ce/docs.

Low Voltage Directive (73/23/EEC)

- EN50178 Electronic equipment for use in power installations.

EMC Directive (89/336/EEC)

- EN61800-3 Adjustable speed electrical power drive systems Part 3: EMC product standard including specific test methods.

General Notes

- If the adhesive label is removed from the top of the drive, the drive must be installed in an enclosure with side openings less than 12.5 mm (0.5 in.) and top openings less than 1.0 mm (0.04 in.) to maintain compliance with the LV Directive.
- The motor cable should be kept as short as possible in order to avoid electromagnetic emission as well as capacitive currents.
- Use of line filters in ungrounded systems is not recommended.
- PowerFlex drives may cause radio frequency interference if used in a residential or domestic environment. The user is required to take measures to prevent interference, in addition to the essential requirements for CE compliance listed below, if necessary.
- Conformity of the drive with CE EMC requirements does not guarantee an entire machine or installation complies with CE EMC requirements. Many factors can influence total machine/installation compliance.
- PowerFlex drives can generate conducted low frequency disturbances (harmonic emissions) on the AC supply system.

Essential Requirements for CE Compliance

Conditions 1-6 listed below **must be** satisfied for PowerFlex drives to meet the requirements of **EN61800-3**.

1. Standard PowerFlex CE compatible Drive.
2. Review important precautions/attention statements throughout the User Manual before installing the drive.
3. Grounding as described on page 2-107.
4. Output power, control (I/O) and signal wiring must be braided, shielded cable with a coverage of 75% or better, metal conduit or equivalent attenuation.
5. All shielded cables should terminate with the proper shielded connector.
6. Conditions in the appropriate table (2.E, 2.F or 2.G).

Table 2.E PowerFlex 70 – EN61800-3 EMC Compatibility

Frame	Drive Description	Second Environment			
		Restrict Motor Cable to 40 m (131 ft.)	*Internal Filter Option*	*External Filter (1)*	*Input Ferrite (2)*
A	Drive Only	✔	–	✔	–
	Drive with any Comm Option	✔	–	✔	–
	Drive with ControlNet	✔	–	✔	✔
B	Drive Only	✔	✔	–	–
	Drive with any Comm Option	✔	✔	–	–
	Drive with ControlNet	✔	✔	–	✔
C	Drive Only	✔	–	–	–
	Drive with any Comm Option	✔	–	–	–
	Drive with ControlNet	✔	–	–	✔
D	Drive Only	✔	–	–	–
	Drive with any Comm Option	✔	–	–	–
	Drive with ControlNet	✔	–	–	✔
E	Drive Only	✔	–	–	–
	Drive with any Comm Option	✔	–	–	–
	Drive with ControlNet	✔	–	–	✔

Table 2.F PowerFlex 70 – EN61800-3 First Environment Restricted Distribution)

Frame	Drive Description	First Environment Restricted Distribution				
		Restrict Motor Cable to:	*Internal Filter Option*	*External Filter (1)*	*Comm Cable Ferrite (2)*	*Common Mode Core (3)*
A	Drive Only	40 m (131 ft.)	–	✔	–	–
	Drive with any Comm Option	40 m (131 ft.)	–	✔	–	–
	Drive with ControlNet	40 m (131 ft.)	–	✔	✔	–
B	Drive Only	12 m (40 ft.)	✔	–	–	–
	Drive with any Comm Option	12 m (40 ft.)	✔	–	–	–
	Drive with ControlNet	12 m (40 ft.)	✔	–	✔	–
C	Drive Only	12 m (40 ft.)	–	–	–	✔
	Drive with any Comm Option	12 m (40 ft.)	–	–	–	✔
	Drive with ControlNet	12 m (40 ft.)	–	–	✔	✔
D	Drive Only	12 m (40 ft.)	–	–	–	–
	Drive with any Comm Option	12 m (40 ft.)	–	–	–	–
	Drive with ControlNet	12 m (40 ft.)	–	–	✔	–
E	Drive Only	30 m (98 ft.)	–	✔	–	–
	Drive with any Comm Option	30 m (98 ft.)	–	✔	–	–
	Drive with ControlNet	30 m (98 ft.)	–	✔	✔	–

Table 2.G PowerFlex 700 EN61800-3 EMC Compatibility (1)

Frame	Second Environment *Restrict Motor Cable to 30 m (98 ft.)*	First Environment Restricted Distribution *Restrict Motor Cable to 150 m (492 ft.)*	
	Any Drive and Option	*Any Drive and Option*	*External Filter Required*
0-6	✔	✔	✔

(1) External filters for First Environment installations and increasing motor cable lengths in Second Environment installations are available. Roxburgh models KMFA (RF3 for UL installations) and MIF or Schaffner FN3258 and FN258 models are recommended. Refer to Table 2.H and **http://www.deltron-emcon.com** and **http://www.mtecorp.com** (USA) or **http://www.schaffner.com**, respectively.

(2) Two turns of the blue comm option cable through a Ferrite Core (Frames A, B, C Fair-Rite #2643102002, Frame D Fair-Rite #2643251002 or equivalent).

(3) Refer to the 1321 Reactor and Isolation Transformer Technical Data publication, 1321-TD001x for 1321-Mxxx selection information.

Table 2.H Recommended Filters [1]

Manufacturer	Drive Type	Frame	Manufacturer Part Number	Class A (Meters)	Class B (Meters)	Manufacturer Part Number	Class A (Meters)	Class B (Meters)
Deltron	PowerFlex 70	A	KMF306A	25	25	–	–	–
		B w/o Filter	KMF310A	50	25	–	–	–
		B w/Filter	KMF306A	100	50	MIF306	–	100
		C	KMF318A	–	150	–	–	–
		D	KMF336A	150	5	MIF330	–	150
		D w/o DC CM Capacitor	KMF336A	–	50	–	–	–
		E	–	–	–	MIF3100	–	30
	PowerFlex 700	0	KMF318A	–	100	MIF316	–	150
		1	KMF325A	–	150	–	–	–
		2	KMF350A	200	150	–	–	–
		2 w/o DC CM Capacitor	KMF350A	176	150	–	–	–
		3	KMF370A	150	100	–	–	–
		3 w/o DC CM Capacitor	KMF370A	150	100	–	–	–
Schaffner	PowerFlex 70	A	FN3258-7-45	–	50	–	–	–
		B w/o Filter	FN3258-7-45	100	50	–	–	–
		B w/Filter	FN3258-7-45	–	100	–	–	–
		C	FN3258-16-45	–	150	–	–	–
		D	FN3258-30-47	0	0	FN258-30-07	–	150
		D w/o DC CM Capacitor	FN3258-30-47	–	150	–	–	–
	PowerFlex 700	0	FN3258-16-45	–	150	–	–	–
		1	FN3258-30-47	–	150	–	–	–
		2	FN3258-42-47	50	50	–	–	–
		2 w/o DC CM Capacitor	FN3258-42-47	150	150	–	–	–
		3	FN3258-75-52	100	100	–	–	–
		3 w/o DC CM Capacitor	FN3258-75-52	150	150	–	–	–

(1) Use of these filters assumes that the drive is mounted in an EMC enclosure.

Copy Cat

Some PowerFlex drives have a feature called Copy Cat, which allows the user to upload a complete set of parameters to the LCD HIM. This information can then be used as backup or can be transferred to another drive by downloading the memory.

Generally, the transfer process manages all conflicts. If a parameter from HIM memory does not exist in the target drive, if the value stored is out of range for the drive or the parameter cannot be downloaded because the drive is running, the download will stop and a text message will be issued. The user than has the option of completely stopping the download or continuing after noting the discrepancy for the parameter that could not be downloaded. These parameters can then be adjusted manually.

The LCD HIM will store a number of parameter sets (memory dependant) and each individual set can be named for clarity.

Current Limit

[Current Lmt Sel]
[Current Lmt Val]
[Current Lmt Gain]

There are 6 ways that the drive can protect itself from overcurrent or overload situations:

- Instantaneous Overcurrent trip
- Software Instantaneous Trip
- Software Current Limit
- Overload Protection IT
- Heatsink temperature protection
- Thermal Manager

1. Instantaneous Overcurrent - This is a feature that instantaneously trips or faults the drive if the output current exceeds this value. The value is fixed by hardware and is typically 250% of drive rated amps. The Fault code for this feature is F12 "HW Overcurrent." This feature cannot be defeated or mitigated.

2. Software Instantaneous Trip - There could be situations where peak currents do not reach the F12 "HW Overcurrent" value and are sustained long enough and high enough to damage certain drive components. If this situation occurs, the drives protection scheme will cause an F36 "SW Overcurrent" fault. The point at which this fault occurs is fixed and stored in drive memory.

3. Software Current Limit - This is a software feature that selectively faults the drive or attempts to reduce current by folding back output voltage and frequency if the output current exceeds this value. The [Current Lmt Val] parameter is programmable between approximately 25% and 150% of drive rating. The reaction to exceeding this value is programmable with [Shear Pin Fault]. Enabling this parameter creates an F63 "Shear Pin Fault." Disabling this parameter causes the drive to use Volts/Hz fold back to try and reduce load.

   The frequency adjust or fold back operation consists of two modes. In the primary mode of current limit operation, motor phase current is sampled and compared to the Current Limit setting in the [Current Lmt Val]. If a current "error" exists, error is scaled by an integral gain and fed to the integrator. The output of this integrator is summed with the proportional term and the active speed mode component to adjust the output frequency and the commanded voltage. The second mode of current limit operation is invoked when a frequency limit has been reached and current limit continues to be active. At this point, a current regulator is activated to adjust the output voltage to limit the current. When the current limit condition ceases or the output voltage of the current regulator attempts to exceed the open loop voltage commands, control is transferred to the primary current limit mode or normal ramp operation.

4. Overload Protection I^2T - This is a software feature that monitors the output current over time and integrates per IT. The base protection is 110% for 1 minute or the equivalent I^2T value (i.e. 150% for 3 seconds, etc.). If the IT integrates to maximum, an F64 "Drive Overload" fault will occur. The approximate integrated value can be monitored via the [Drive OL Count] parameter.

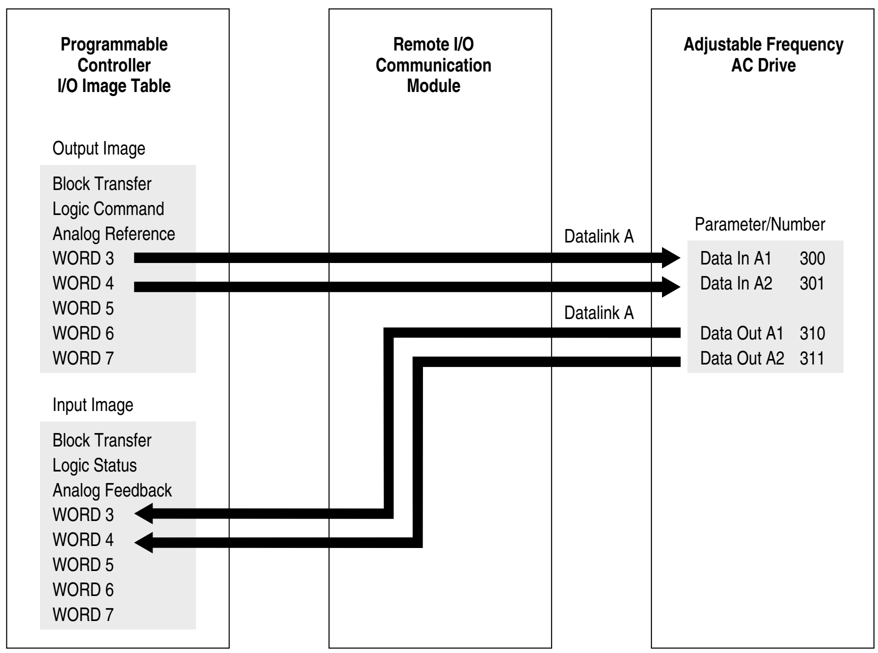
5. Heatsink Temperature Protection - The drive constantly monitors the heatsink temperature. If the temperature exceeds the drive maximum, a "Heatsink OvrTemp" fault will occur. The value is fixed by hardware at a nominal value of 100 degrees C. This fault is generally not used for overcurrent protection due to the thermal time constant of the heatsink. It is an overload protection.

6. Thermal manager (see Drive Overload on page 2-86).

Datalinks

A Datalink is one of the mechanisms used by PowerFlex drives to transfer data to and from a programmable controller. Datalinks allow a parameter value to be changed without using an Explicit Message or Block Transfer. Datalinks consist of a pair of parameters that can be used independently for 16 bit transfers or in conjunction for 32 bit transfers. Because each Datalink consists of a pair of parameters, when enabled, each Datalink occupies two 16 or 32-bit words in both the input and output image tables, depending on configuration. A user enters a parameter number into the Datalink parameter. The value that is in the corresponding output data table word in the controller is then transferred to the parameter whose number has been placed in the Datalink parameter. The following example demonstrates this concept. The object of the example is to change Accel and Decel times "on the fly" under PLC control.

The user makes the following PowerFlex drive parameter settings:
Parameter 300 [Data In A1] = 140 (the parameter number of [Accel Time 1]
Parameter 301 [Data In A2] = 142 (the parameter number of [Decel Time 1]



In the PLC data Table, the user enters Word 3 as a value of 100 (10.0 Secs) and word 4 as a value of 133 (13.3 seconds). On each I/O scan, the parameters in the PowerFlex drive are updated with the value from the data table:
Accel Time P140 = 10.0 seconds (value from output image table Word 3)
Decel Time P142 = 13.3 seconds (value from output image table Word 4).

Any time these values need to be changed, the new values are entered into the data table, and the parameters are updated on the next PLC I/O scan.

Rules for Using Datalinks

1. 1. A Datalink consists of 4 words, 2 for Datalink x IN and 2 for Datalink x Out. They cannot be separated or turned on individually.
2. Only one communications adapter can use each set of Datalink parameters in a PowerFlex drive. If more than one communications adapter is connected to a single drive, multiple adapters must not try to use the same Datalink.
3. Parameter settings in the drive determine the data passed through the Datalink mechanism
4. When you use a Datalink to change a value, the value is not written to the Non-Volatile Storage (EEprom memory). The value is stored in volatile memory (RAM) and lost when the drive loses power.

32-Bit Parameters using 16-Bit Datalinks

To read (and/or write) a 32-bit parameter using 16-bit Datalinks, typically both Datalinks (A,B,C,D) are set to the 32-bit parameter. For example, to read Parameter 09 - [Elapsed MWh], both Datalink A1 and A2 are set to "9." Datalink A1 will contain the least significant word (LSW) and Datalink A2 the most significant word (MSW). In this example, the parameter 9 value of 5.8MWh is read as a "58" in Datalink A1

Datalink	Most/Least Significant Word	Parameter	Data (decimal)
A1	LSW	9	58
A2	MSW	9	0

Regardless of the Datalink combination, x1 will always contain the LSW and x2 will always contain the MSW.

In the following examples Parameter 242 - [Power Up Marker] contains a value of 88.4541 hours.

Datalink	Most/Least Significant Word	Parameter	Data (decimal)
A1	LSW	242	32573
A2	-Not Used-	0	0

Datalink	Most/Least Significant Word	Parameter	Data (decimal)
A1	-Not Used-	0	0
A2	MSW	242	13

Even if non-consecutive Datalinks are used (in the next example, Datalinks A1 and B2 would not be used), data is still returned in the same way.

Datalink	Most/Least Significant Word	Parameter	Data (decimal)
A2	MSW	242	13
B1	LSW	242	32573

32-bit data is stored in binary as follows:

MSW	2^{31} through 2^{16}
LSW	2^{15} through 2^{0}

Example

Parameter 242 - [Power Up Marker] = 88.4541 hours
MSW = $13_{decimal} = 1101_{binary} = 2^{16} + 2^{18} + 2^{19} = 851968$
LSW = 32573
851968 + 32573 = 884541

DC Bus Voltage / Memory

[DC Bus Voltage] is a measurement of the instantaneous value. [DC Bus Memory] is a heavily filtered value or "nominal" bus voltage. Just after the pre-charge relay is closed during initial power-up bus pre-charge, bus memory is set equal to bus voltage. Thereafter it is updated by ramping at a very slow rate toward Vbus. The filtered value ramps at approximately 2.4V DC per minute (for a 480V AC drive).

Bus memory is used as the base line to sense a power loss condition. If the drive enters a power loss state, the bus memory will also be used for recovery (i.e. pre-charge control or inertia ride through upon return of the power source) upon return of the power source. Update of the bus memory is blocked during deceleration to prevent a false high value caused by a regenerative condition.

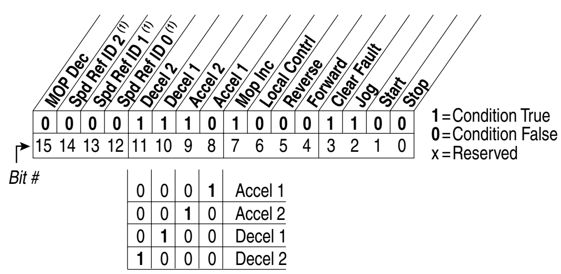
Decel Time

[Decel Time 1, 2]

Sets the rate at which the drive ramps down its output frequency after a Stop command or during a decrease in command frequency (speed **change**). The rate established is the result of the programmed Decel Time and the Minimum and Maximum Frequency, as follows:

$$\frac{\text{Maximum Speed}}{\text{Decel Time}} = \text{Decel Rate (Hz/sec)}$$

Two decel times exist to allow the user to change rates "on the fly" via PLC command or digital input. The selection is made by programming [Decel Time 1] & [Decel Time 2] and then using one of the digital inputs ([Digital Inx Sel]) programmed as "Decel 2" (see Table 2.I for further information). However, if a PLC is used, manipulate the bits of the command word as shown below.



The effectiveness of these bits or digital inputs can be affected by [Decel Mask]. See Masks on page 2-114 for more information.

Times are adjustable in 0.1 second increments from 0.0 seconds to 3600.0 seconds.

In its factory default condition, when no decel select inputs are closed and no time bits are "1," the default deceleration time is [Decel Time 1] and the rate is determined as above.

Digital Inputs

Cable Selection

Refer to "*Wiring and Grounding Guidelines for Pulse Width Modulated (PWM) AC Drives*," publication DRIVES-IN001 for detailed information on Cable Selection for Digital Inputs.

Wiring Examples

Refer to the appropriate PowerFlex user manual for wiring diagrams.

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Each digital input has a maximum response/pass through/function execution time of 25ms. For example, no more than 25ms should elapse from the time the level changes at the Start input to the time voltage is applied to the motor.

There is both hardware and software filtering on these inputs. The hardware provides an average delay of 12ms from the time the level changes at the input to the earliest time that the software can detect the change. The actual time can vary between boards from 7 to 17ms, but any particular board should be consistent to within 1% of its average value. The amount of software filtering is not alterable by the user.

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Each digital input has a maximum response/pass through/function execution time of 25ms. This means that, for example, no more than 25ms should elapse from the time the level changes at the Start input to the time voltage is applied to the motor.

Digital Input Configuration

Inputs are configured for the required function by setting a [Digital Inx Sel] parameter (one for each input). These parameters cannot be changed while the drive is running.

PowerFlex 700 Digital Input Selection

INPUTS & OUTPUTS

Digital Inputs

No.	Parameter	Default		
361	**[Digital In1 Sel]**	Default:	4	"Stop – CF"
362	**[Digital In2 Sel]**	Default:	5	"Start"
363	**[Digital In3 Sel]**	Default:	18	"Auto/ Manual"
364	**[Digital In4 Sel]**	Default:	15	"Speed Sel 1"
365	**[Digital In5 Sel]**	Default:	16	"Speed Sel 2"
366	**[Digital In6 Sel]**(11)	Default:	17	"Speed Sel 3"

Selects the function for the digital inputs.

(1) Speed Select Inputs.

3	2	1	Auto Reference Source
0	0	0	Reference A
0	0	1	Reference B
0	1	0	Preset Speed 2
0	1	1	Preset Speed 3
1	0	0	Preset Speed 4
1	0	1	Preset Speed 5
1	1	0	Preset Speed 6
1	1	1	Preset Speed 7

To access Preset Speed 1, set [Speed Ref x Sel] to "Preset Speed 1".

Type 2 Alarms - Some digital input programming may cause conflicts that will result in a Type 2 alarm. Example: [Digital In1 Sel] set to "5, Start" in 3-wire control and [Digital In2 Sel] set to 7 "Run" in 2-wire.

Refer to User Manual for information on resolving this type of conflict.

(2) Vector Control Option Only.

(3)

3	2	1	Spd/Trq Mode
0	0	0	Zero Torque
0	0	1	Spd Reg
0	1	0	Torque Reg
0	1	1	Min Spd/Trq
1	0	0	Max Spd/Trq
1	0	1	Sum Spd/Trq
1	1	0	Absolute
1	1	1	Zero Trq

Options:	Value	Option	Related
	0	"Not Used"	
	1	"Enable"(8)(10)	
	2	"Clear Faults"(CF)(4)	
	3	"Aux Fault"	
	4	"Stop – CF"(10)	
	5	"Start"(5)(9)	
	6	"Fwd/ Reverse"(5)	
	7	"Run"(6)(10)	
	8	"Run Forward"(6)	
	9	"Run Reverse"(6)	
	10	"Jog"(5) "Jog1"(2)(5)	
	11	"Jog Forward"(6)	100
	12	"Jog Reverse"(6)	
	13	"Stop Mode B"	
	14	"Bus Reg Md B"	156
	15-17	"Speed Sel 1-3"(1)	162
	18	"Auto/ Manual"(7)	
	19	"Local"	
	20	"Acc2 & Dec2"	
	21	"Accel 2"	096
	22	"Decel 2"	
	23	"MOP Inc"	140
	24	"MOP Dec"	
	25	"Excl Link"	
	26	"PI Enable"	194
	27	"PI Hold"	
	28	"PI Reset"	380
	29	"Pwr Loss Lvl"	384
	30	"Precharge En"	388
	31-33	"Spd/Trq Sel1-3"(2,3)	124
	34	"Jog 2"(2)	

(4) When [Digital Inx Sel] is set to option 2 "Clear Faults" the Stop button cannot be used to clear a fault condition.

(5) Typical 3-Wire Inputs - Requires that only 3-wire functions are chosen. Including 2-wire selections will cause a type 2 alarm.

(6) Typical 2-Wire Inputs - Requires that only 2-wire functions are chosen. Including 3-wire selections will cause a type 2 alarm. See User Manual for conflicts.

(7) Auto/Manual - Refer to User Manual for details.

(8) Opening an "Enable" input will cause the motor to coast-to-stop, ignoring any programmed Stop modes.

(9) A "Dig In ConflictB" alarm will occur if a "Start" input is programmed without a "Stop" input.

(10) Refer to the Sleep-Wake Mode Attention statement on User Manual .

(11) A dedicated hardware enable input is available via a jumper selection. Refer to User Manual for further information.

PowerFlex 70 Digital Input Selection

INPUTS & OUTPUTS (File J) — Digital Inputs

No.	Parameter			
361	**[Digital In1 Sel]**	Default: 4	"Stop – CF" (CF = Clear Fault)	
362	**[Digital In2 Sel]**	Default: 5	"Start"	
363	**[Digital In3 Sel]**	Default: 18	"Auto/ Manual"	
364	**[Digital In4 Sel]**	Default: 15	"Speed Sel 1"	
365	**[Digital In5 Sel]**	Default: 16	"Speed Sel 2"	
366	**[Digital In6 Sel]**	Default: 17	"Speed Sel 3"	

Selects the function for the digital inputs.

(1) When [Digital Inx Sel] is set to option 2 "Clear Faults" the Stop button cannot be used to clear a fault condition.

(2) Typical 3-Wire Inputs.
Requires that only 3-wire functions are chosen. Including 2-wire selections will cause a type 2 alarm.

(3) Typical 2-Wire Inputs.
Requires that only 2-wire functions are chosen. Including 3-wire selections will cause a type 2 alarm.

(4) Speed Select Inputs.

3	2	1	Auto Reference Source
0	0	0	Reference A
0	0	1	Reference B
0	1	0	Preset Speed 2
0	1	1	Preset Speed 3
1	0	0	Preset Speed 4
1	0	1	Preset Speed 5
1	1	0	Preset Speed 6
1	1	1	Preset Speed 7

To access Preset Speed 1, set [Speed Ref A Sel] or [Speed Ref B Sel] to "Preset Speed 1".

Type 2 Alarms
Some digital input programming may cause conflicts that will result in a Type 2 alarm. Example: [Digital In1 Sel] set to 5 "Start" in 3-wire control and [Digital In2 Sel] set to 7 "Run" in 2-wire.

Refer to Alarm Descriptions in the User Manual for information on resolving this type of conflict.

(5) Auto/Manual - Refer to User Manual for details.

(6) Opening an "Enable" input will cause the motor to coast-to-stop, ignoring any programmed Stop modes.

(7) A "Dig In ConflictB" alarm will occur if a "Start" input is programmed without a "Stop" input.

Options:

Value	Option	Related
0	"Not Used"	
1	"Enable"(6)	
2	"Clear Faults"(1)	
3	"Aux Fault"	
4	"Stop – CF"(2)	
5	"Start"(2)(7)	
6	"Fwd/ Reverse"(2)	
7	"Run"(3)	
8	"Run Forward"(3)	
9	"Run Reverse"(3)	
10	"Jog"(2)	100
11	"Jog Forward"	
12	"Jog Reverse"	
13	"Stop Mode B"	156
14	"Bus Reg Md B"	162
15	"Speed Sel 1"(4)	
16	"Speed Sel 2"(4)	
17	"Speed Sel 3"(4)	
18	"Auto/ Manual"(5)	096
19	"Local"	
20	"Acc2 & Dec2"	140
21	"Accel 2"	
22	"Decel 2"	
23	"MOP Inc"	194
24	"MOP Dec"	
25	"Excl Link"	380
26	"PI Enable"	384
27	"PI Hold"	388
28	"PI Reset"	124

The available functions are defined in Table 2.I.

Table 2.I Digital Input Function List

Input Function Name	Purpose
Stop - CF	Stop drive Clear Faults (open to closed transition)
Run Forward	Run in forward direction (2-wire start mode)
Run Reverse	Run in reverse direction (2-wire start mode)
Run	Run in current direction (2-wire start mode)
Start	Start drive (3-wire start mode)
Forward/Reverse	Set drive direction (3-wire mode only)
Jog	Jog drive
Jog Forward	Jog in forward direction
Jog Reverse	Jog in reverse direction
Speed Select 3 Speed Select 2 Speed Select 1	Select which Speed reference the drive uses.
Auto/Manual	Allows terminal block to assume complete control of Speed Reference.
Accel 2	Select acceleration rate 1 or 2.
Decel 2	Select deceleration rate 1 or 2.
Accel 2 & Decel 2	Select acceleration rate 1 and deceleration rate 1 or acceleration rate 2 and deceleration rate 2.
MOP Increment	Increment MOP (Motor Operated Pot Function Speed ref)
MOP Decrement	Decrement MOP (Motor Operated Pot Function Speed ref)
Stop Mode B	Select Stop Mode A (open) or B (closed)
Bus Regulation Mode B	Select which bus regulation mode to use
PI Enable	Enable Process PI loop.
PI Hold	Hold integrator for Process PI loop at current value.
PI Reset	Clamp integrator for Process PI loop to 0.
Auxiliary Fault	Open to cause "auxiliary fault" (external string).
Local Control	Allows terminal block to assume complete control of drive logic.
Clear Faults	Clear faults and return drive to ready status.
Enable	Open input causes drive to coast to stop, disallows start.
Exclusive Link	Exclusive Link – digital input is routed through to digital output, no other use.
Power Loss Level (PowerFlex 700 only)	Selects between using fixed value for power loss level and getting the level from a parameter
Precharge Enable (PowerFlex 700 only)	If common bus configuration, denotes whether drive is disconnected from DC bus or not. Controls precharge sequence on reconnection to bus.

Input Function Detailed Descriptions

- **Stop - Clear Faults**

  An open input will cause the drive to stop and become "not ready". A closed input will allow the drive to run.

  If "Start" is configured, then "Stop - Clear Faults" must also be configured. Otherwise, a digital input configuration alarm will occur. "Stop - Clear Faults" is optional in all other circumstances.

  An open to closed transition is interpreted as a Clear Faults request. The drive will clear any existing faults. The terminal block bit must be set in the [Fault Mask] and [Logic Mask] parameters in order for the terminal block to clear faults using this input function.

If the “Clear Faults” input function is configured at the same time as “Stop - Clear Faults”, then it will not be possible to reset faults with the “Stop - Clear Faults” input.

- **Run Forward, Run Reverse**

  An open to closed transition on one input or both inputs while drive is stopped will cause the drive to run unless the “Stop - Clear Faults” input function is configured and open.

  The table below describes the basic action taken by the drive in response to particular states of these input functions.

Run Forward	Run Reverse	Action
Open	Open	Drive stops, terminal block relinquishes direction ownership.
Open	Closed	Drive runs in reverse direction, terminal block takes direction ownership.
Closed	Open	Drive runs in forward direction, terminal block takes direction ownership.
Closed	Closed	Drive continues to run in current direction, but terminal block maintains direction ownership.

  If one of these input functions is configured and the other one isn’t, the above description still applies, but the unconfigured input function should be considered permanently open.

  The terminal block bit must be set in the [Start Mask], [Direction Mask], and [Logic Mask] parameters in order for the terminal block to start or change the direction of the drive using these inputs.

  Important: Direction control is an “Exclusive Ownership” function (see Owners). This means that only one control device (terminal block, DPI device, HIM, etc.) at a time is allowed to control direction at a time. The terminal block must become direction “owner” before it can be used to control direction. If another device is currently the direction owner (as indicated by [Direction Owner]), **it will not be possible to start the drive or change direction by using the terminal block digital inputs programmed for both Run and Direction control (i.e. Run/Fwd).**

  If one or both of these input functions is configured, it will not be possible to start or jog the drive from any other control device. This is true irrespective of the state of the [Start Mask], [Direction Mask], and [Logic Mask] parameters.

- **Run**

  An open to closed transition on this input while drive is stopped will cause the drive to run in the currently selected direction unless the “Stop - Clear Faults” input function is configured and open.

  If this input is open, then the drive will stop.

  The purpose of this input function is to allow a 2-wire start while the direction is being controlled by some other means.

The terminal block bit must be set in the [Start Mask] and [Logic Mask] parameters in order for the terminal block to start the drive using this input.

If the “Run” input function is configured, it will not be possible to start or jog the drive from any other control device. This is true irrespective of the state of the [Start Mask], [Direction Mask], and [Logic Mask] parameters.

The Effects of 2-Wire Start Modes on Other DPI Devices

The “Run/Stop” and “Run Fwd/Rev” start modes are also called “2-wire” start modes, because they allow the drive to be started and stopped with only a single input and two wires. When a “2-wire” terminal block start mode is put into effect by the user, the drive can no longer be started or jogged from any other control device (i.e. HIM, network card, etc.). This restriction persists as long as one or more of “Run”, “Run Forward”, and “Run Reverse” are configured. This is true even if the configuration is otherwise illegal and causes a configuration alarm. See page 2-109 for typical 2 and 3-wire configurations.

- **Start**
  An open to closed transition while the drive is stopped will cause the drive to run in the current direction, unless the “Stop – Clear Faults” input function is open.

  The terminal block bit must be set in the [Start Mask] and [Logic Mask] parameters in order for the terminal block to start or change the direction of the drive using these inputs.

  If “Start” is configured, then “Stop - Clear Faults” must also be configured.

- **Forward/Reverse**
  This function is one of the ways to provide direction control when the Start / Stop / Run functions of the drive are configured as 3 – wire control.

  An open input sets direction to forward. A closed input sets direction to reverse. If state of input changes and drive is running or jogging, drive will change direction.

  The terminal block bit must be set in the [Direction Mask] and [Logic Mask] parameters in order for the terminal block to select the direction of the drive using this input function.

Important: Direction control is an “Exclusive Ownership” function (see Owners). This means that only one control device (terminal block, DPI device, HIM, etc.) at a time is allowed to control direction at a time. The terminal block must become direction “owner” before it can be used to control direction. If another device is currently the direction owner (as indicated by [Direction Owner]), **it will not be possible to**

start the drive or change direction by using the terminal block digital inputs programmed for both Run and Direction control (i.e. Run/Fwd).

Important: Because an open condition (or unwired condition) commands Forward, the terminal block seeks direction ownership as soon as this input function is configured, which may happen at power-up. In order for the terminal block to actually gain ownership, the masks must be set up correctly (see above) and no other device can currently have direction ownership. Once the terminal block gains direction ownership, it will retain it until shutdown, until the [Direction Mask] or [Logic Mask] bits for the terminal block are cleared, or until this input function is no longer configured

- **Jog**

  Jog is essentially a non-latched "run/start" command. An open to closed transition while drive is stopped causes drive to start (jog) in the current direction. When the input opens while drive is running (jogging), the drive will stop.

  The drive will not jog while running or while the "Stop - Clear Faults" input is open. **Start has precedence.**

ATTENTION: If a normal drive start command is received while the drive is jogging, the drive will switch from jog mode to run mode. The drive will not stop, but may change speed and/or change direction.

The terminal block bit must be set in the [Jog Mask] and [Logic Mask] parameters in order for the terminal block to cause the drive to jog using this input function.

- **Jog Forward, Jog Reverse**

  An open to closed transition on one input or both inputs while drive is stopped will cause the drive to jog unless the "Stop - Clear Faults" input function is configured and open. The table below describes the actions taken by the drive in response to various states of these input functions.

Jog Forward	Jog Reverse	Action
Open	Open	Drive will stop if already jogging, but can be started by other means. Terminal block relinquishes direction ownership.
Open	Closed	Drive jogs in reverse direction. Terminal block takes direction ownership.
Closed	Open	Drive jogs in forward direction. Terminal block takes direction ownership.
Closed	Closed	Drive continues to jog in current direction, but terminal block maintains direction ownership.

If one of these input functions is configured and the other one isn't, the above description still applies, but the unconfigured input function should be considered permanently open.

The drive will not jog while drive is running or while "Stop - Clear Faults" input is open. **Start has precedence**.

ATTENTION: If a normal drive start command is received while the drive is jogging, the drive will switch from jog mode to run mode. The drive will not stop, but may change speed and/or change direction.

The terminal block bit must be set in the [Jog Mask], [Direction Mask], and [Logic Mask] parameters in order for the terminal block to cause the drive to jog using these input functions.

Important: Direction control is an "Exclusive Ownership" function (see Owners). This means that only one control device (terminal block, DPI device, HIM, etc.) at a time is allowed to control direction at a time. The terminal block must become direction "owner" before it can be used to control direction. If another device is currently the direction owner (as indicated by [Direction Owner]), **it will not be possible to jog the drive or change direction by using the terminal block digital inputs programmed for both Run and Direction control (i.e. Run/Fwd).**

If another device is not currently the direction owner (as indicated by [Direction Owner]) and the terminal block bit is set in the [Direction Mask] and [Logic Mask] parameters, the terminal block becomes direction owner as soon as one (or both) of the "Jog Forward" or "Jog Reverse" input functions is closed.

- **Speed select 1, 2, and 3**

  One, two, or three digital input functions can be used to select the speed reference used by the drive, and they are called the Speed Select input functions. The current open/closed state of all Speed Select input functions combine to select which source is the current speed reference. There are 8 possible combinations of open/closed states for the three input functions, and thus 8 possible parameters can be selected. The 8 parameters are: [Speed Ref A Sel], [Speed Ref B Sel], and [Preset Speed 2] through [Preset Speed 7].

  If the Speed Select input functions select [Speed Ref A Sel] or [Speed Ref B Sel], then the value of that parameter further selects a reference source. There are a large number of possible selections, including all 7 presets.

  If the input functions directly select one of the preset speed parameters, then the parameter contains a frequency that is to be used as the reference.

The terminal block bit must be set in the [Reference Mask] and [Logic Mask] parameters in order for the reference selection to be controlled from the terminal block using the Speed Select inputs functions.

Important: Reference Control is an "Exclusive Ownership" function (see Owners on page 2-127). This means that only one control device (terminal block, DPI device, HIM, etc.) at a time is allowed to select the reference source. The terminal block must become direction "owner" before it can be used to control direction. If another device is currently the reference owner (as indicated by [Reference Owner]), it will not be possible to select the reference by using the terminal block digital inputs, and the Speed Select Inputs will have no effect on which reference the drive is currently using.

Because any combination of open/closed conditions (or unwired condition) commands a reference source, terminal block seeks ownership of reference selection as soon as any of these input functions are configured, which may happen at power-up. In order for the terminal block to actually gain ownership, the masks must be set up correctly (see above) and no other device can currently have reference ownership. Once the terminal block gains reference ownership, it will retain it until shutdown, until the [Reference Mask] or [Logic Mask] bits for the terminal block are cleared, or until none of the digital inputs are configured as Speed Select input functions.

The Speed Select input function configuration process involves assigning the functionality of the three possible Speed Select input functions to physical digital inputs. The three Speed Select inputs functions are called "Speed Select 1", "Speed Select 2", and "Speed Select 3", and they are assigned to physical inputs using the [Digital In*x* Sel] parameters.

The table below describes the various reference sources that can be selected using all three of the Speed Select input functions.

Speed Select 3	Speed Select 2	Speed Select 1	Parameter that determines Reference
Open	Open	Open	[Speed Ref A Sel]
Open	Open	Closed	[Speed Ref B Sel]
Open	Closed	Open	[Preset Speed 2]
Open	Closed	Closed	[Preset Speed 3]
Closed	Open	Open	[Preset Speed 4]
Closed	Open	Closed	[Preset Speed 5]
Closed	Closed	Open	[Preset Speed 6]
Closed	Closed	Closed	[Preset Speed 7]

If any of the three Reference Select input functions are not configured, then the software will still follow the table, but will treat the unconfigured inputs as if they are permanently open.

As an example, the table below describes what reference selections can be made if "Speed Select 1" is the only configured input function. This configuration allows a single input to choose between [Speed Ref A Sel] and [Speed Ref B Sel].

Speed Select 1	Selected Parameter that determines Reference
Open	[Speed Ref A Sel]
Closed	[Speed Ref B Sel]

As another example, describes what reference selections can be made if the “Speed Select 3” and “Speed Select 2” input functions are configured, but “Speed Select 1” is not.

Speed Select 3	Speed Select 2	Selected Parameter that determines reference
Open	Open	[Speed Ref A Sel]
Open	Closed	[Preset Speed 2]
Closed	Open	[Preset Speed 4]
Closed	Closed	[Preset Speed 6]

- **Auto/Manual**

  The Auto/Manual facility is essentially a higher priority reference select. It allows a single control device to assume exclusive control of reference select, irrespective of the reference select digital inputs, reference select DPI commands, the reference mask, and the reference owner.

  If the “Auto/Manual” input function is closed, then the drive will use one of the analog inputs (defined by [TB Man Ref Sel]) as the reference, ignoring the normal reference selection mechanisms. This mode of reference selection is called “Terminal Block Manual Reference Selection Mode”.

  If this input function is open, then the terminal block does not request manual control of the reference. If no control device (including the terminal block) is currently requesting manual control of the reference, then the drive will use the normal reference selection mechanisms. This is called “Automatic Reference Selection” mode.

  The drive arbitrates among manual reference requests from different control devices, including the terminal block.

- **Accel 2 / Decel 2**

  The Acceleration/Deceleration Rate Control input functions (Acc/Dec input functions for short) allow the rate of acceleration and deceleration for the drive to be selected from the terminal block. The rates themselves are contained in [Accel Time 1], [Decel Time 1], [Accel Time 2], and [Decel Time 2]. The Acc/Dec input functions are used to determine which of these acceleration and deceleration rates are in effect at a particular time.

  The terminal block bit must be set in the [Accel Mask] and [Logic Mask] parameters in order for the acceleration rate selection to be controlled from the terminal block. The terminal block bit must be set in the [Decel Mask] and [Logic Mask] parameters in order for the deceleration rate selection to be controlled from the terminal block.

  There are two different schemes for using the Acc/Dec input functions. Each one will be described in its own section.

- **Accel 2, Decel 2**

  In the first scheme, one input function (called “Accel 2”) selects between [Accel Time 1] and [Accel Time 2], and another input function (called “Decel 2”) selects between [Decel Time 1] and [Decel Time 2]. The open state of the function selects [Accel Time 1] or [Decel Time 1], and the closed state selects [Accel Time 2] or [Decel Time 2].

  Important: Acc/Dec Control is an “Exclusive Ownership” function (see Owners). This means that only one control device (terminal block, DPI device, HIM, etc.) at a time is allowed to select the Acc/Dec rates. The terminal block must become Acc/Dec “owner” before it can be used to control ramp rates. If another device is currently the reference owner (as indicated by [Reference Owner]), it will not be possible to select the reference by using the terminal block digital inputs, and the Speed Select Inputs will have no effect on which reference the drive is currently using.

  Because any combination of open / closed conditions (or unwired condition) commands a reference source, the terminal block seeks accel ownership as soon as the “Accel 2” input function is configured, which may happen at power-up. In order for the terminal block to actually gain ownership, the masks must be set up correctly (see above) and no other device can currently have accel ownership. Once the terminal block gains accel ownership, it will retain it until shutdown, until the [Accel Mask] or [Logic Mask] bits for the terminal block are cleared, or until “Accel 2” is unconfigured.

  For the “Decel 2” input function, deceleration rate selection ownership is handled in a similar fashion to acceleration rate selection ownership.

- **Acc2 & Dec2**

  In the second scheme, the “1” rates are combined (Acc and Dec) and the “2” rates are combined. A single input function is used to select between [Accel Time 1]/[Decel Time 1] and [Accel Time 2]/[Decel Time 2]. This input function is called “Acc 2 & Dec 2”.

  If function is open, then drive will use [Accel Time 1] as the acceleration rate and [Decel Time 1] as the deceleration rate. If function is closed, then drive will use [Accel Time 2] as the acceleration rate and [Decel Time 2] as the deceleration rate.

  The same ownership rules as above apply.

- **MOP Increment, MOP Decrement**

  These inputs are used to increment and decrement the Motor Operated Potentiometer (MOP) value inside the drive. The MOP is a reference setpoint (called the “MOP Value”) that can be incremented and decremented by external devices. The MOP value will be retained through a power cycle.

  While the “MOP Increment” input is closed, MOP value will increase at rate contained in [MOP Rate]. Units for rate are Hz per second.

While the “MOP Decrement” input is closed, MOP value will decrease at rate contained in [MOP Rate]. Units for rate are Hz per second.

If both the “MOP Increment” and “MOP Decrement” inputs are closed, MOP value will stay the same.

The terminal block bit must be set in the [MOP Mask] and [Logic Mask] parameters in order for the MOP to be controlled from the terminal block.

In order for the drive to use the MOP value as the current speed reference, either [Speed Ref A Sel] or [Speed Ref B Sel] must be set to “MOP.”

- **Stop Mode B**
  This digital input function selects between two different drive stop modes. See also Stop Modes on page 2-201.

  If the input is open, then [Stop Mode A] selects which stop mode to use. If the input is closed, then [Stop Mode B] selects which stop mode to use. If this input function is not configured, then [Stop Mode A] always selects which stop mode to use.

- **Bus Regulation Mode B**
  This digital input function selects how the drive will regulate excess voltage on the DC bus. See also Bus Regulation.

  If the input is open, then [Bus Reg Mode A] selects which bus regulation mode to use. If the input is closed, then [Bus Reg Mode B] selects which bus regulation mode to use. If this input function is not configured, then [Bus Reg Mode A] always selects which bus regulation mode to use.

- **PI Enable**
  If this input function is closed, the operation of the Process PI loop will be enabled.

  If this input function is open, the operation of the Process PI loop will be disabled. See Process PI Loop on page 2-137.

- **PI Hold**
  If this input function is closed, the integrator for the Process PI loop will be held at the current value, which is to say that it will not increase.

  If this input function is open, the integrator for the Process PI loop will be allowed to increase. See Process PI Loop on page 2-137.

- **PI Reset**
  If this input function is closed, the integrator for the Process PI loop will be reset to 0.

  If this input function is open, the integrator for the Process PI loop will integrate normally. See Process PI Loop on page 2-137.

- **Auxiliary Fault**

  The "Aux Fault" input function allows external equipment to fault the drive. Typically, one or more machine inputs (limit switches, pushbuttons, etc.) will be connected in series and then connected to this input. If the input function is open, the software detects the change of state then the drive will fault with the "Auxiliary Input" (F2) fault code.

  If the "Aux Fault" input function is assigned to a physical digital input, that input will be active regardless of any drive control masks. Also, the input will be active even if a device other than the terminal block gains complete local control of drive logic. See Local Control.

  If this input function is not configured, then the fault will not occur.

- **Local Control**

  The "Local Control" input function allows exclusive control of all drive logic functions from the terminal block. If this input function is closed, the terminal block has exclusive control (disabling all the DPI devices) of drive logic, including start, reference selection, acceleration rate selection, etc. The exception is the stop condition, which can always be asserted from any connected control device.

  The drive must be stopped in order for the terminal block to gain complete local control.

  Important: Local Control is an "Exclusive Ownership" function (see Owners). This means that only one control device (terminal block, DPI device, HIM, etc.) at a time is allowed take local control. If another device is not currently the local owner (as indicated by [Local Owner]) and the terminal block bit is set in the [Local Mask] and [Logic Mask] parameters, the terminal block becomes local owner as soon as the "Local Control" input function is closed.

- **Clear Faults**

  The "Clear Faults" digital input function allows an external device to reset drive faults through the terminal block. An open to closed transition on this input will cause the current fault (if any) to be reset.

  If this input is configured at the same time as "Stop - Clear Faults", then only the "Clear Faults" input can actually cause faults to be reset.

  The terminal block bit must be set in the [Fault Mask] and [Logic Mask] parameters in order for faults to be reset from the terminal block.

- **Enable**

  If this input is closed, then the drive can run (start permissive). If open, the drive will not start.

  If the drive is already running when this input is opened, the drive will coast and indicate "not enabled" on the HIM (if present). This is not considered a fault condition, and no fault will be generated.

This input is not used for a fast output power removal. The drive will not stop running until the software detects the open state of this input function.

If multiple "Enable" inputs are configured, then the drive will not run if any of the inputs are open.

- **Exclusive Link**

  This input function is used to activate the state of the input to control one of the drive's digital outputs. See Digital Outputs.

  If an Input is so configured, no function exists for the input until complementary Digital Output programming is done. If no outputs are programmed (linked), the input has no function.

  This choice is made when the user wishes to link the input to the output, but desires that no other functionality be assigned to the input.

  The state of any digital input can be "passed through" to a digital output by setting the value of a digital output configuration parameter ([Digital Out*x* Sel]) to "Input *n* Link". The output will then be controlled by the state of the input, even if the input is being used for a second function. If the input is configured as "Not used" input function, the link to the input is considered non-functional.

- **Power Loss Level (PowerFlex 700 only)**

  When the DC bus level in the drive falls below a certain level, a "power loss" condition is created in the drive logic. This input allows the user to select between two different "power loss" detection levels dynamically.

  If the physical input is closed, then the drive will take its power loss level from [Power Loss Level]. If the physical input is open (de-energized), then the drive will use a power loss level designated by internal drive memory, typically 82% of nominal.

  If the input function is not configured, then the drive always uses the internal power loss level. This input function is used in PowerFlex 700 drives only. In PowerFlex 70 drives, the power loss level is always internal and not selectable.

- **Precharge Enable (PowerFlex 700 only)**

  This input function is used to manage disconnection from a common DC bus.

  If the physical input is closed, this indicates that the drive is connected to common DC bus and normal precharge handling can occur, and that the drive can run (start permissive). If the physical input is open, this indicates that the drive is disconnected from the common DC bus, and thus the drive should enter the precharge state (precharge relay open) and initiate a coast stop immediately in order to prepare for reconnection to the bus.

  If this input function is not configured, then the drive assumes that it is always connected to the DC bus, and no special precharge handling will be done. This input function is used in PowerFlex 700 drive only. In

PowerFlex 70 drives, the drive assumes it is always connected to the DC bus.

Digital Input Conflict Alarms

If the user configures the digital inputs so that one or more selections conflict with each other, one of the digital input configuration alarms will be asserted**. As long as the Digital Input Conflict exists, the drive will not start.** These alarms will be automatically cleared by the drive as soon as the user changes the parameters so that there is an internally consistent digital input configuration.

Examples of configurations that cause an alarm are:

- User tries to configure both the “Start” input function and the “Run Forward” input function at the same time. “Start” is only used in “3-wire” start mode, and “Run Forward” is only used in “2-wire” run mode, so they should never be configured at the same time
- User tries to assign a toggle input function (for instance “Forward/ Reverse”) to more than one physical digital input simultaneously.
- These alarms, called Type 2 Alarms, are different from other alarms in that it will not be possible to start the drive while the alarm is active. It should not be possible for any of these alarms to occur while drive is running, because all configuration parameters are only changeable while drive is stopped. Whenever one or more of these alarms is asserted, the drive ready status will become “not ready” and the HIM will reflect a message signaling the conflict. In addition, the drive status light will be flashing yellow.

There are three different digital input configuration alarms. They appear to the user (in [Drive Alarm 2]) as “DigIn CflctA”, “DigIn CflctB”, and “DigIn CflctC”.

“DigIn CflctA” indicates a conflict between different input functions that are not specifically associated with particular start modes.

The table below defines which pairs of input functions are in conflict. Combinations marked with a “✱” will cause an alarm.

Important: There are combinations of input functions in Table 2.J that will produce **other** digital input configuration alarms. “DigIn CflctA” alarm will **also** be produced if “Start” is configured and “Stop – Clear Faults” is not.

Table 2.J Input function combinations that produce “DigIn CflctA” alarm

	Acc2/Dec2	Accel 2	Decel 2	Jog	Jog Fwd	Jog Rev	Fwd/Rev
Acc2 / Dec2		✱	✱				
Accel 2	✱						
Decel 2	✱						
Jog					✱	✱	
Jog Fwd				✱			✱
Jog Rev				✱			✱
Fwd / Rev					✱	✱	

“DigIn CflctB” indicates a digital Start input has been configured without a Stop input or other functions are in conflict. Combinations that conflict are marked with a “🔔” and will cause an alarm.

Table 2.K Input function combinations that produce “DigIn CflctB” alarm

	Start	Stop–CF	Run	Run Fwd	Run Rev	Jog	Jog Fwd	Jog Rev	Fwd/ Rev
Start			🔔	🔔	🔔		🔔	🔔	
Stop–CF									
Run	🔔			🔔	🔔		🔔	🔔	
Run Fwd	🔔		🔔			🔔			🔔
Run Rev	🔔		🔔			🔔			🔔
Jog				🔔	🔔				
Jog Fwd	🔔		🔔						
Jog Rev	🔔		🔔						
Fwd / Rev				🔔	🔔				

“Digin CflctC” indicates that more than one physical input has been configured to the same input function, and this kind of multiple configuration isn’t allowed for that function. Multiple configuration is allowed for some input functions and not allowed for others.

The input functions for which multiple configuration is not allowed are:

Forward/Reverse	Run Forward	Stop Mode B
Speed Select 1	Run Reverse	Bus Regulation Mode B
Speed Select 2	Jog Forward	Accel2 & Decel2
Speed Select 3	Jog Reverse	Accel 2
	Run	Decel 2

There is one additional alarm that is related to digital inputs: the “Bipolar Cflct” alarm occurs when there is a conflict between determining motor direction using digital inputs on the terminal block and determining it by the polarity of an analog speed reference signal.

Note that the drive will assert an alarm when the user sets up a illegal configuration rather than refusing the first parameter value that results in such a configuration. This is necessary because the user may have to change several parameters one at a time in order to get to a new desired configuration, and some of the intermediate configurations may actually be illegal. Using this scheme, the user or a network device can send parameter updates in any order when setting up the digital input configuration.

The “Bipolar Cflct” alarm occurs when there is a conflict between determining motor direction using digital inputs on the terminal block and determining it by some other means.

When [Direction Mode] is “Bipolar”, the drive uses the sign of the reference to determine drive direction; when [Direction Mode] is “Reverse Dis”, then the drive never permits the motor to run in the reverse direction. In both of these cases, the terminal block inputs cannot be used to set direction, so this alarm is asserted if any digital input function that can set motor direction is configured.

The “Bipolar Cflct” alarm will be asserted if **both** of the following are true:

- One or more of the following digital input functions are configured: “Forward/Reverse”, “Run Forward”, “Run Reverse”, “Jog Forward”, “Jog Reverse”.
- [Direction Mode] is set to “Bipolar” or “Reverse Dis”.

Digital In Status

This parameter represents the current state of the digital inputs. It contains one bit for each input. The bits are “1” when the input is closed and “0” when the input is open.

Digital In Examples

PowerFlex 70

Figure 2.16 shows a typical digital input configuration that includes “3-wire” start. The digital input configuration parameters should be set as shown.

Figure 2.16 Typical digital input configuration with “3-wire” start

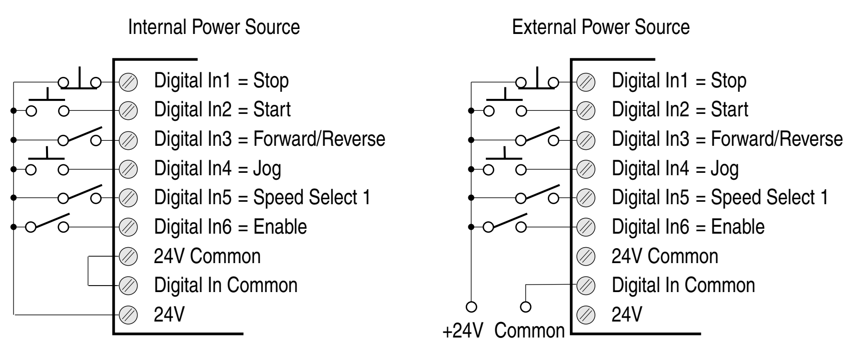
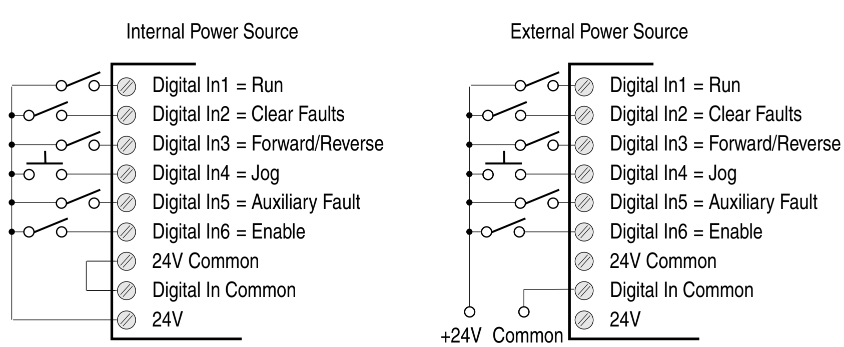


Figure 2.17 represents a typical digital input configuration that includes “2-wire” start. The digital input configuration parameters should be set up as shown

Figure 2.17 Typical digital input configuration with “Run Fwd/Rev” start



Digital Outputs

Each drive provides digital (relay) outputs for external annunciation of a variety of drive conditions. Each relay is a Form C (1 N.O. – 1 N.C. with shared common) device whose contacts and associated terminals are rated for a maximum of 250V AC or 220V DC. The table below shows specifications and limits for each relay/contact.

	PowerFlex 70		PowerFlex 700	
	Resistive Load	Inductive Load	Resistive Load	Inductive Load
Rated Voltage	250V AC	250V AC	240V AC	240V AC
	220V DC	220V DC	30V DC	30V DC
Maximum Current	3 A	1.5 A	5 A	3.5 A
Maximum Power	AC - 50 VA	AC - 25 VA	1200 VA	840 VA
	DC - 60 W	DC - 30 W	150W	105W
Minimum DC Current	10 µA		10 mA	
Switching Time	8 ms		10 ms	
Initial State	De-energized		De-energized	
Number of relays (Standard I/O)	2		2 - Standard Control 3 - Vector Control	

Configuration

The outputs may be independently configured via the following parameters to switch for various states of the drive.

PowerFlex 700 Digital Output Selection

No.	Parameter	Values	Related
380 384 388	**[Digital Out1 Sel]**(5) **[Digital Out2 Sel]** Vector **[Digital Out3 Sel]** Selects the drive status that will energize a (CRx) output relay. (1) Any relay programmed as Fault or Alarm will energize (pick up) when power is applied to drive and deenergize (drop out) when a fault or alarm exists. Relays selected for other functions will energize only when that condition exists and will deenergize when condition is removed. (2) Vector Control Option Only. (3) Activation level is defined in [Dig Outx Level] below. (4) Vector firmware 3.001 and later. (5) When [TorqProve Cnfg] is set to "Enable," [Digital Out1 Sel] becomes the brake control and any other selection will be ignored. (6) Refer to Option Definitions in User Manual.	Default: 1 "Fault" 4 "Run" 4 "Run" Options: 1 "Fault"(1) 2 "Alarm"(1) 3 "Ready" 4 "Run" 5 "Forward Run" 6 "Reverse Run" 7 "Auto Restart" 8 "Powerup Run" 9 "At Speed"(6) 10 "At Freq"(3) 11 "At Current"(3) 12 "At Torque"(3) 13 "At Temp"(3) 14 "At Bus Volts"(3) 15 "At PI Error"(3) 16 "DC Braking" 17 "Curr Limit" 18 "Economize" 19 "Motor Overld" 20 "Power Loss" 21-26 "Input 1-6 Link"(6) 27 "PI Enable"(2) 28 "PI Hold"(2) 29 "Drive Overload"(2) 30 "Param Cntl"(4, 6)	381 385 389 382 386 390 383 002 001 003 004 218 012 137 157 147 053 048 184 379

PowerFlex 70 Digital Output Selection

INPUTS & OUTPUTS (File J)	Digital Outputs	380 384	**[Digital Out1 Sel]** **[Digital Out2 Sel]** Selects the drive status that will energize a (CRx) output relay. (1) Contacts shown on page 1-14 of the User Manual are in drive powered state with condition not present. For functions such as “Fault” and “Alarm” the normal relay state is energized and N.O. / N.C. contact wiring may have to be reversed.	Default: 1 “Fault” 4 “Run” Options: 1 “Fault”(1) 2 “Alarm”(1) 3 “Ready” 4 “Run” 5 “Forward Run” 6 “Reverse Run” 7 “Auto Restart” 8 “Powerup Run” 9 “At Speed” 10 “At Freq” 11 “At Current” 12 “At Torque” 13 “At Temp” 14 “At Bus Volts” 15 “At PI Error” 16 “DC Braking” 17 “Curr Limit” 18 “Economize” 19 “Motor Overld” 20 “Power Loss” 21 “Input 1 Link” 22 “Input 2 Link” 23 “Input 3 Link” 24 “Input 4 Link” 25 “Input 5 Link” 26 “Input 6 Link”	381 385 389 382 386 390 383 002 001 003 004 218 012 137 157 147 053 048 184

The selections can be divided into three types of annunciation.

1. The relay changes state due to a particular status condition in the drive.

The following drive conditions or status can be selected to cause the relay activation:

Condition	Description
Fault	A drive Fault has occurred and stopped the drive
Alarm	A Drive Type 1 or Type 2 Alarm condition exists
Ready	The drive is powered, Enabled and no Start Inhibits exist. It is “ready” to run
Run	The drive is outputting Voltage and frequency to the motor (indicates 3–wire control, either direction)
Forward Run	The drive is outputting Voltage and frequency to the motor (indicates 2–wire control in Forward)
Reverse Run	The drive is outputting Voltage and frequency to the motor (indicates 2–wire control in Reverse)
Reset/Run	The drive is currently attempting the routine to clear a fault and restart the drive
Powerup Run	The drive is currently executing the Auto Restart or “Run at Power Up” function
DC Braking	The drive is currently executing either a “DC Brake” or a “Ramp to Hold” Stop command and the DC braking voltage is still being applied to the motor.
Current Limit	The drive is currently limiting output current
Economize	The drive is currently reducing the output voltage to the motor to attempt to reduce energy costs during a lightly loaded situation.
Mtr Overload	The drive output current has exceeded the programmed [Motor NP FLA] and the electronic motor overload function is accumulating towards an eventual trip.
Power Loss	The drive has monitored DC bus voltage and sensed a loss of input AC power that caused the DC bus voltage to fall below the fixed monitoring value (82% of [DC bus Memory]

2. The relay changes state because a particular value in the drive has exceeded a preset limit.

   The following drive values can be selected to cause the relay activation:

Condition	Description
At Speed	The drive Output Frequency has equalled the commanded frequency

   The balance of these functions require that the user set a limit for the specified value. The limit is set into one of two parameters: [Dig Out1 Level] and [Dig Out2 Level] depending on the output being used. If the value for the specified function (frequency, current, etc.) exceeds the user programmed limit, the relay will activate. If the value falls back below the limit, the relay will deactivate.

		381 385 389	**[Dig Out1 Level]** **[Dig Out2 Level]** Vector **[Dig Out3 Level]** Sets the relay activation level for options 10 – 15 in [Digital Outx Sel]. Units are assumed to match the above selection (i.e. "At Freq" = Hz, "At Torque" = Amps).	Default: 0.0 0.0 Min/Max: 0.0/819.2 Units: 0.1	380 384 388

   Notice that the [Dig Outx Level] parameters do not have units. The drive assumes the units from the selection for the annunciated value. For example, if the chosen "driver" is current, the drive assumes that the entered value for the limit [Dig Outx Level] is% rated Amps. If the chosen "driver" is Temperature, the drive assumes that the entered value for the limit [Dig Outx Level] is degrees C. No units will be reported to LCD HIM users, offline tools, devices communicating over a network, PLC's, etc.

   The online and offline limits for the digital output threshold parameters will be the minimum and maximum threshold value required for any output condition.

   If the user changes the currently selected output condition for a digital output, then the implied units of the corresponding threshold parameter will change with it, although the value of the parameter itself will not. **For example,** if the output is set for "At Current" and the threshold for 100, drive current over 100% will activate the relay. If the user changes the output to "At Temp", the relay will deactivate (even if current > 100%) because the drive is cooler than 100 degrees C.

   The following values can be annunciated

Value	Description
At Freq	The drive output frequency equals or exceeds the programmed Limit
At Current	The drive total output current exceeds the programmed Limit
At Torque	The drive output torque current component exceeds the programmed Limit
At Temp	The drive operating temperature exceeds the programmed Limit
At Bus Volts	The drive bus voltage exceeds the programmed Limit
At PI Error	The drive Process PI Loop error exceeds the programmed Limit

3. The relay changes state because a Digital Input link has been established and the Input is closed.

An Output can be "linked" directly to an Digital Input so that the output "tracks" the input. When the input is closed, the Output will be energized, and when the input is open, the output will be de-energized. This "tracking will occur if two conditions exist:

- The Input is configured for any choice other than "Unused"
- The Output is configured for the appropriate "Input x Link"

Note that the output will continue to track or be controlled by the state of the input, even if the input has been assigned a function (i.e. Start, Jog)

Output Time Delay

Each digital output has two user-controlled timers associated with it.

One timer (the ON timer) defines the delay time between a FALSE to TRUE transition (condition appears) on the output condition and the corresponding change in state of the digital output.

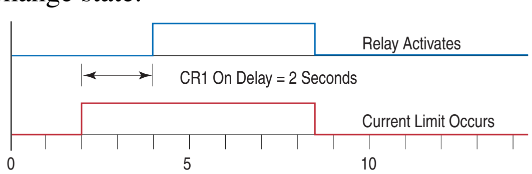
The second timer (the OFF timer) defines the delay time between a TRUE to FALSE transition (condition disappears) on the output condition and the corresponding change in the state of the digital output.

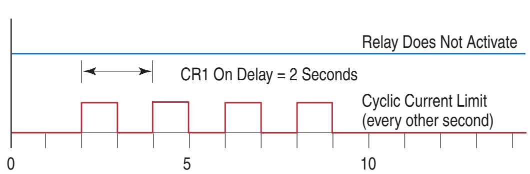
		382 386 390	**[Dig Out1 OnTime]** **[Dig Out2 OnTime]** Vector **[Dig Out3 OnTime]** Sets the "ON Delay" time for the digital outputs. This is the time between the occurrence of a condition and activation of the relay.	Default: 0.00 Secs 0.00 Secs Min/Max: 0.00/600.00 Secs Units: 0.01 Secs	380 384 388
		383 387 391	**[Dig Out1 OffTime]** **[Dig Out2 OffTime]** Vector **[Dig Out3 OffTime]** Sets the "OFF Delay" time for the digital outputs. This is the time between the disappearance of a condition and de-activation of the relay.	Default: 0.00 Secs 0.00 Secs Min/Max: 0.00/600.00 Secs Units: 0.01 Secs	380 384 388

Either timer can be disabled by setting the corresponding delay time to "0."

Important: Whether a particular type of transition (False-True or True-False) on an output condition results in an energized or de-energized output depends on the output condition.

If a transition on an output condition occurs and starts a timer, and the output condition goes back to its original state before the timer runs out, then the timer will be aborted and the corresponding digital output will not change state.





PowerFlex 700 Firmware 3.001 (& later) Enhancements

Certain digital output enhancements have been included in firmware version 3.001 (and later) for the PowerFlex 700 Vector Control drive. These include:

- Digital output control via Datalink

Parameter Controlled Digital Outputs

Enables control of the digital outputs through the Data In parameters.

INPUTS & OUTPUTS | Digital Outputs

379 **Vector v3** **[Dig Out Setpt]** 380

Sets the digital output value from a communication device.

Example

Set [Data In B1] to "379." The first three bits of this value will determine the setting of [Digital Outx Sel] which should be set to "24, Param Cntl."

													Net DigOut3	Net DigOut2	Net DigOut1
x	x	x	x	x	x	x	x	x	x	x	x	x	0	0	0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bit #

1 = Output Energized
0 = Output De-energized
x = Reserved

Example

Digital Output 2 controlled by Data In B1

Setup

- [Data In B1], parameter 302 = 379 ([Dig Out Setpt] as the Data In target)
- [Digital Out2 Sel], parameter 384 = 30 "Param Cntl"

When Bit 1 of Data In B1 =1 Digital Out 2 will be energized.

Direction Control

Direction control of the drive is an exclusive ownership function. Thus only one device can be commanding/controlling direction at a time and that device can only command one direction or the other, not both. Direction is defined as the forward (+) or reverse (–) control of the drive output frequency, not motor rotation. Motor wiring and phasing determines its CW or CCW rotation. Direction of the drive is controlled in one of four ways:

1. 2-Wire digital input selection such as Run Forward or Run Reverse (Figure 2.17 on page 2-77).
2. 3-Wire digital input selection such as Forward/Reverse, Forward or Reverse (Figure 2.16 on page 2-77).
3. Control Word bit manipulation from a DPI device such as a communications interface. Bits 4 & 5 control direction. Refer to the *Logic Command Word* information in Appendix A of the PowerFlex 70 or 700 User Manual.
4. The sign (+/-) of a bipolar analog input.

Direction commands by various devices can be controlled using the [Direction Mask]. See page 2-114 for details on masks.

Refer to Digital Inputs on page 2-61 and Analog Inputs on page 2-9 for more detail on the configuration and operating rules for direction control.

DPI

Drive Peripheral Interface (DPI) is an enhancement to SCANport that provides more functions and better performance. SCANport was a CAN based, Master-Slave protocol, created to provide a standard way of connecting motor control products and optional peripheral devices together. It allows multiple (up to 6) devices to communicate with a motor control product without requiring configuration of the peripheral. SCANport and DPI both provide two basic message types called Client/Server (C/S) and Producer/Consumer (P/C). Client/Server messages are used to transfer parameter and configuration information in the background (relative to other message types). Producer/Consumer messages are used for control and status information. DPI adds a higher baud rate, brand specific enabling, Peer-to-Peer (P/P) communication, and Flash Memory programming support. PowerFlex 70 & 700 support the existing SCANport and DPI communication protocols. Multiple devices of each type (SCANport or DPI) can be attached to and communicate with PowerFlex 70 & 700 drives at the same time. This communication interface is the primary way to interact with, and control the drive.

Important: The PowerFlex 700 Vector Control option only supports the DPI communication protocol. It will not communicate with SCANport peripheral devices.

Client/Server

Client/Server messages operate in the background (relative to other message types) and are used for non-control purposes. The Client/Server messages are based on a 10ms "ping" event that allows peripherals to perform a single transaction (i.e. one C/S transaction per peripheral per time period). Message fragmentation (because the message transaction is larger than the standard CAN message of eight data bytes) is automatically handled by Client/Server operation. The following types of messaging are covered:

- Logging in peripheral devices
- Read/Write of parameter values
- Access to all parameter information (limits, scaling, default, etc.)
- User set access
- Fault/Alarm queue access
- Event notification (fault, alarm, etc.)
- Access to all drive classes/objects (e.g. Device, Peripheral, Parameter, etc.)

Producer/Consumer operation overview

Producer/Consumer messages operate at a higher priority than Client/Server messages and are used to control/report the operation of the drive (e.g. start, stop, etc.). A P/C status message is transmitted every 5ms (by the drive) and a command message is received from every change of state in any attached DPI peripheral. Change of state is a button being pressed or error detected by a DPI peripheral. SCANport devices are slightly different in that those peripherals transmit command messages upon reception of a drive status message rather than on detection of a change of state. Producer/Consumer messages are of fixed size, so support of message fragmentation is not required. The following types of messaging are covered:

- Drive status (running, faulted, etc.)
- Drive commands (start, stop, etc.)
- Control logic parsing operations (e.g., mask and owner parameters)
- Entering Flash programming mode
- “Soft” login and logout of peripheral devices (enabling/disabling of peripheral control)

Peer-to-Peer operation

Peer-to-Peer messaging allows two devices to communicate directly rather than through the master or host (i.e. drive). They are the same priority as C/S messages and will occur in the background. In the PowerFlex 70 drive, the only Peer-to-Peer functionality supports proxy operations for the LED HIM. Since the PowerFlex 700 drive does not support an LED HIM, it will not support Peer-to-Peer proxy operations. The Peer-to-Peer proxy operation is only used so that the LED HIM can access parameters that are not directly part of the regulator board (e.g. DeviceNet baud rate, etc.). The LED HIM is not attached to a drive through a CAN connection (as normal DPI or SCANport devices are), so a proxy function is needed to create a DPI message to access information in an off-board peripheral. If an LCD HIM is attached to the PowerFlex 70 or 700 drive, it will be able to directly request off-board parameters using Peer-to-Peer messages (i.e. no proxy support needed in the drive). Because the PowerFlex 70 supports the LED HIM, only 4 communication ports can be used. PowerFlex 700 drives can use all 6 communication ports because Peer-to-Peer proxy operations are not needed. All Peer-to-Peer operations occur without any intervention from the user (regardless whether proxy or normal P/P operation), no setup is required. No Peer-to-Peer proxy operations are required while the drive is in Flash mode.

All the timing requirements specified in the DPI and SCANport System, Control, and Messaging specifications are supported. Peripheral devices will be scanned (“pinged”) at a 10ms rate. Drive status messages will be produced at a 5ms rate, while peripheral command messages will be accepted (by the drive) as they occur (i.e. change of state). Based on these timings, the following worst case conditions can occur (independent of the baud rate and protocol):

- Change of peripheral state (e.g. Start, Stop, etc.) to change in the drive – 10ms
- Change in reference value to change in drive operation – 10ms
- Change in Datalink data value to change in the drive – 10ms
- Change of parameter value into drive – 20ms times the number of attached peripherals

The maximum time to detect the loss of communication from a peripheral device is 500ms.

Table 2.L Timing specifications contained in DPI and SCANport

DPI	Host status messages only go out to peripherals once they log in and at least every 125ms (to all attached peripherals). Peripherals time out if >250ms. Actual time dependent on number of peripherals attached. Minimum time goal of 5ms (may have to be dependent on Port Baud Rate). DPI allows minimum 5ms status at 125k and 1ms status at 500k.
SCANport	Host status messages only go out to peripherals once they log in. Peripherals time out if >500ms. If Peripheral receives incorrect status message type, Peripheral generates an error. Actual time dependent on number of peripherals attached. SCANport allows minimum rate of 5ms.
DPI	Host determines MUT based on number of attached peripherals. Range of values from 2 to 125ms. Minimum goal time of 5ms. DPI allows 2ms min at 500k and 5ms min at 125k.
SCANport	No MUT.
DPI	Peripheral command messages (including Datalinks) generated on change-of-state, but not faster than Host MUT and at least every 250ms. Host will time out if >500ms.
SCANport	Command messages produced as a result of Host status message. If no command response to Host status within 3 status scan times, Host will time out on that peripheral.
DPI	Peer messages requests cannot be sent any faster than 2x of MUT.
SCANport	No Peer message support
DPI	Host must ping every port at least every 2 sec. Peripherals time out if >3 sec. Host will wait maximum of 10ms (125k) or 5ms (500k) for peripheral response to ping. Peripherals typical response time is 1ms. Peripherals only allow one pending explicit message (i.e. ping response or peer request) at a time.
SCANport	Host waits at least 10ms for response to ping. Host cannot send more than 2 event messages (including ping) to a peripheral within 5ms. Peripherals typical response time is 1ms.
DPI	Response to an explicit request or fragment must occur within 1 sec or device will time out (applies to Host or Peripheral). Time-out implies retry from beginning. Maximum number of fragments per transaction is 16. Flash memory is exception with 22 fragments allowed.
SCANport	Assume same 1 sec time-out. Maximum number of fragments is 16
DPI	During Flash mode, host stops ping, but still supports status/command messages at a 1 – 5 sec rate. Drive will use 1 sec rate. Data transfer occurs via explicit message as fast as possible (i.e. peripheral request, host response, peripheral request, etc.) but only between two devices.
SCANport	No Flash mode support

The Minimum Update Time (MUT), is based on the message type only. A standard command and Datalink command could be transmitted from the same peripheral faster than the MUT and still be O.K. Two successive Datalink commands or standard commands will still have to be separated by the MUT, however.

Drive Overload

The drive thermal overload has two primary functions. The first requirement is to make sure the drive is not damaged by abuse. The second is to perform the first in a manor that does not degrade the performance, as long the drive temperature and current ratings are not exceeded.

The purpose of is to protect the power structure from abuse. Any protection for the motor and associated wiring is provided by a Motor Thermal Overload feature.

The drive will monitor the temperature of the power module based on a measured temperature and a thermal model of the IGBT. As the temperature rises the drive may lower the PWM frequency to decrease the switching losses in the IGBT. If the temperature continues to rise, the drive may reduce current limit to try to decrease the load on the drive. If the drive temperature becomes critical the drive will generate a fault.

If the drive is operated in a low ambient condition the drive may exceed rated levels of current before the monitored temperature becomes critical. To guard against this situation the drive thermal overload also includes an inverse time algorithm. When this scheme detects operation beyond rated levels, current limit may be reduced or a fault may be generated.

Operation

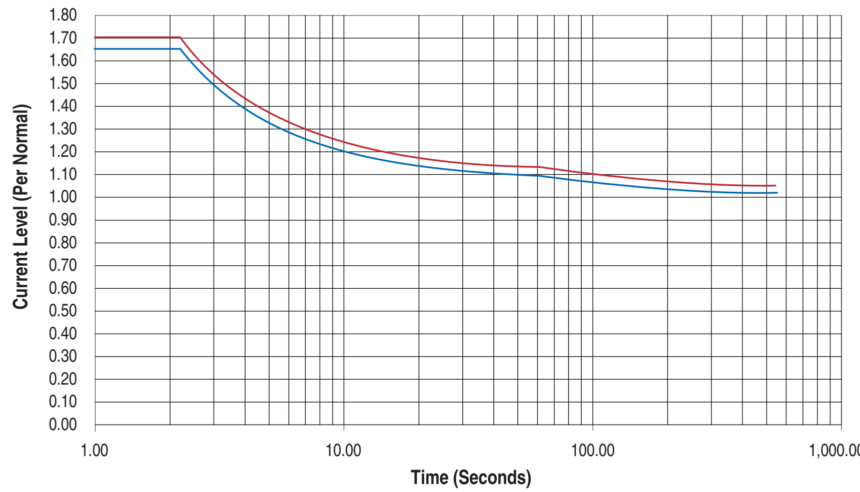
The drive thermal overload has two separate protection schemes, an overall RMS protection based on current over time, and an IGBT junction thermal manager based on measured power module temperature and operating conditions. The drive may fold back current limit when either of these methods detects a problem.

Overall RMS Protection

The overall RMS protection makes sure the current ratings of the drive are not exceeded. The lower curve in Figure 2.18 shows the boundary of normal-duty operation. In normal duty, the drive is rated to produce 110% of rated current for 60 seconds, 150% of rated current for three seconds, and 165% of rated current for 100 milliseconds. The maximum value for current limit is 150% so the limit of 165% for 100 milliseconds should never be crossed. If the load on the drive exceeds the level of current as shown on the upper curve, current limit may fold back to 100% of the drive rating until the 10/90 or 5/95 duty cycle has been achieved. For example, 60 seconds at 110% will be followed by 9 minutes at 100%, and 3 seconds at 150% will be followed by 57 seconds at 100%. With the threshold for where to take action slightly above the rated level the drive will only fold back when drive ratings are exceeded.

If fold back of current limit is not enabled in [Drive OL Mode], the drive will generate a fault when operation exceeds the rated levels. This fault can not be disabled. If current limit fold back is enabled then a fault is generated when current limit is reduced.

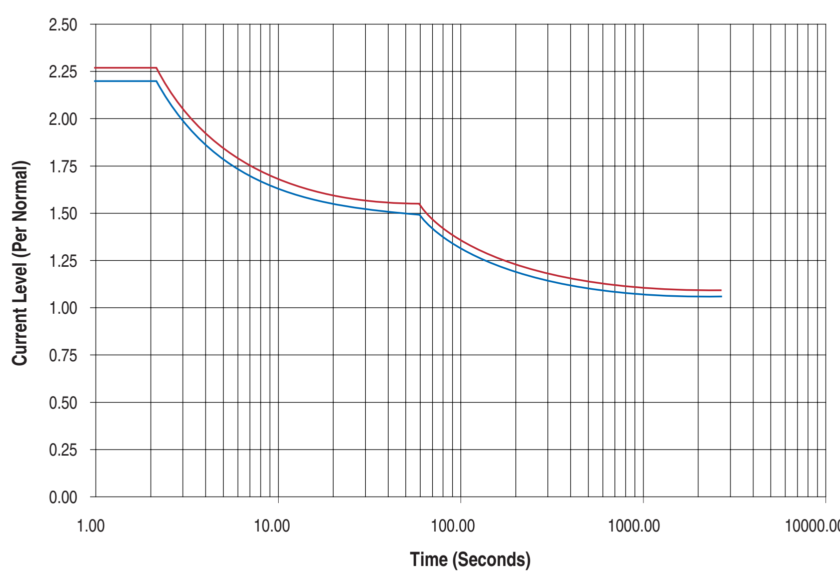
Figure 2.18 Normal Duty Boundary of Operation



The lower curve in Figure 2.19 shows the boundary of heavy duty operation. In heavy duty, the drive is rated to produce 150% of rated current for 60 seconds, 200% for three seconds, and 220% for 100 milliseconds. The maximum value for current limit is 200% so the limit of 220% for 100 milliseconds should never be crossed. If the load on the drive exceeds the level of current as shown on the upper curve, current limit may fold back to 100% of the drive rating until the 10/90 or 5/95 duty cycle has been achieved. For example, 60 seconds at 150% will be followed by 9 minutes at 100%, and 3 seconds at 200% will be followed by 57 seconds at 100%. With the threshold for where to take action slightly above the rated level the drive will only fold back when drive ratings are exceeded.

Again, if fold back of current limit is not enabled in the [Drive OL Mode], the drive will generate a fault when operation exceeds the rated levels. This fault can not be disabled. If current limit fold back is enabled then a fault is generated when current limit is reduced.

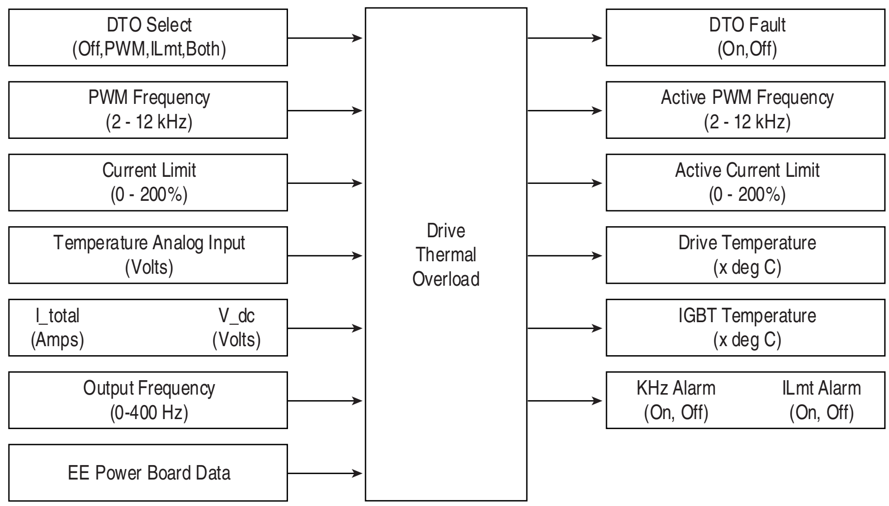
Figure 2.19 Heavy Duty Boundary of Operation



Thermal Manager Protection

The thermal manager protection assures that the thermal ratings of the power module are not exceeded. The operation of the thermal manager can be thought of as a function block with the inputs and outputs as shown below.

Figure 2.20 Thermal Manager Inputs/Outputs



The following is a generalization of the calculations done by the thermal manager. The IGBT junction temperature T_J is calculated based on the measured drive temperature T_{Drive}, and a temperature rise that is a function of operating conditions. When the calculated junction temperature reaches a maximum limit the drive will generate a fault. This fault can not be disabled. This maximum junction temperature is stored in EE on the power board along with other information to define the operation of the drive thermal overload function. These values are not user adjustable. In addition to the maximum junction temperature there are thresholds that select the point at which the PWM frequency begins to fold back, and the point at which current limit begins to fold back. As T_J increases the thermal manager may reduce the PWM frequency. If T_J continues to rise current limit may be reduced, and if T_J continues to rise the drive generates a fault. The calculation of the reduced PWM frequency and current limit is implemented with an integral control.

PWM Frequency

PWM Frequency as selected by the user can be reduced by the thermal manager. The resulting Active PWM Frequency may be displayed in a test point parameter.

The active PWM frequency will change in steps of 2 kHz. It will always be less than or equal to the value selected by the user, and will not be less than the drives minimum PWM frequency. When drive temperature reaches the level where PWM frequency would be limited, the *Drv OL Lvl 1* Alarm is turned on. This alarm will be annunciated even if the reduced PWM frequency is not enabled.

Current Limit

Current Limit as selected by the user can be reduced by the thermal manager. The resulting active current limit may be displayed as a test point parameter.

The active current limit will always be less than or equal to the value selected by the user, and will not be less than flux current. When drive temperature reaches the level where current limit would be clamped, the *Drv OL Lvl 2* Alarm is turned on. This alarm will be annunciated even if reduced current limit is not enabled.

The active current limit is used during normal operation and during DC injection braking. Any level of current requested for DC injection braking is limited by the Active Current Limit.

Configuration

The [Drive OL Mode] allows the user to select the action(s) to perform with increased current or drive temperature. When this parameter is "Disabled," the drive will not modify the PWM frequency or current limit. When set to "Reduce PWM" the drive will only modify the PWM frequency. "Reduce CLim" will only modify the current limit. Setting this parameter to "Both-PWM 1st" the drive will modify the PWM frequency and the current limit.

DTO Fault

For all possible settings of [Drive OL Mode], the drive will always monitor the T_j and T_{Drive} and generate a fault when either temperature becomes critical. If T_{Drive} is less than –20° C, a fault is generated. With these provisions, a DTO fault is generated if the NTC ever malfunctions.

Temperature Display

The Drive's temperature is measured (NTC in the IGBT module) and displayed as a percentage of drive thermal capacity in [Drive Temp]. This parameter is normalized to the thermal capacity of the drive (frame dependent) and displays thermal usage in % of maximum (100% = drive Trip). A test point, "Heatsink temperature" is available to read temperature directly in degrees C, but cannot be related to the trip point since "maximums" are only given in %. The IGBT temperature shown in Figure 2.20 is used only for internal development and is not provided to the user.

Low Speed Operation

When operation is below 4 Hz, the duty cycle is such that a given IGBT will carry more of the load for a while and more heat will build up in that device. The thermal manager will increase the calculated IGBT temperature at low output frequencies and will cause corrective action to take place sooner.

When the drive is in current limit the output frequency is reduced to try to reduce the load. This works fine for a variable torque load, but for a constant torque load reducing the output frequency does not lower the current (load). Lowering current limit on a CT load will push the drive down to a region where the thermal issue becomes worse. In this situation the thermal manager will increase the calculated losses in the power module to track the worst case IGBT. For example, if the thermal manager normally provides 150% for 3 seconds at high speeds, it may only provide 150% for one second before generating a fault at low speeds.

If operating at 60Hz 120%, lowering the current limit may cause a fault sooner than allowing the drive to continue to operate. In this case the user may want to disable current limit fold back.

Drive Ratings (kW, Amps, Volts)

Refer to Fuses and Circuit Breakers on page 2-100.

Droop

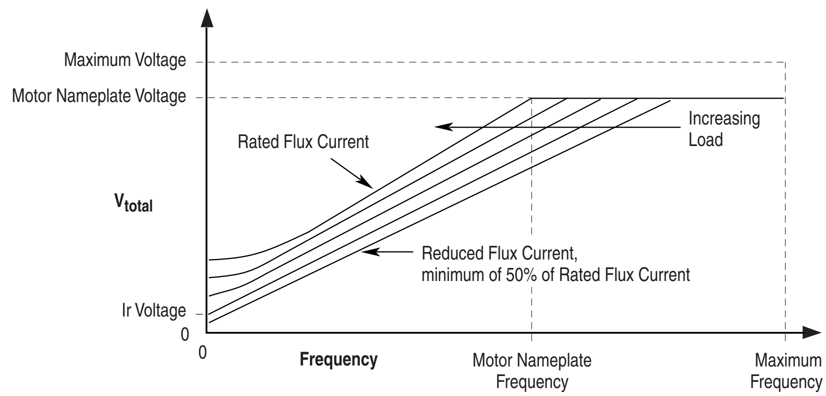
Vector Droop is used to “shed” load and is usually used when a soft coupling of two motors is present in an application. The master drive speed regulates and the follower uses droop so it does not “fight” the master. The input to the droop block is the commanded motor torque. The output of the droop block reduces the speed reference. [Droop RPM @ FLA] sets the amount of speed, in RPM, that the speed reference is reduced when at full load torque. For example, when [Droop RPM @ FLA] is set to 50 RPM and the drive is running at 100% rated motor torque, the droop block would subtract 50 RPM from the speed reference.

Economizer (Auto-Economizer)

Refer to Torque Performance Modes on page 2-205.

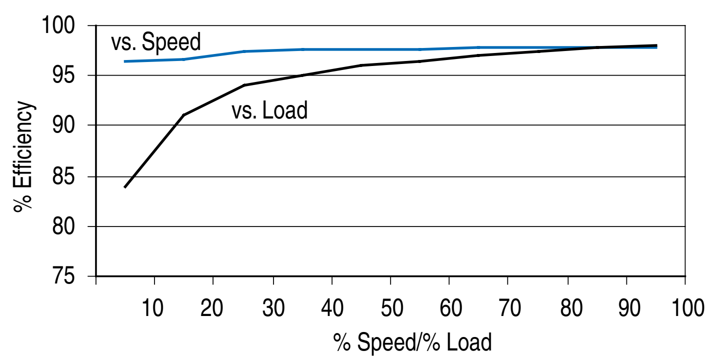
Economizer mode consists of the sensorless vector control with an additional energy savings function.

When steady state speed is achieved, the economizer becomes active and automatically adjusts the drive output voltage based on applied load. By matching output voltage to applied load, the motor efficiency is optimized. Reduced load commands a reduction in motor flux current. The flux current is reduced as long as the total drive output current does not exceed 75% of motor rated current as programmed in [Motor NP FLA], parameter 42. The flux current is not allowed to be less than 50% of the motor flux current as programmed in [Flux Current Ref], parameter 63. During acceleration and deceleration, the economizer is inactive and sensorless vector motor control performs normally.



Efficiency

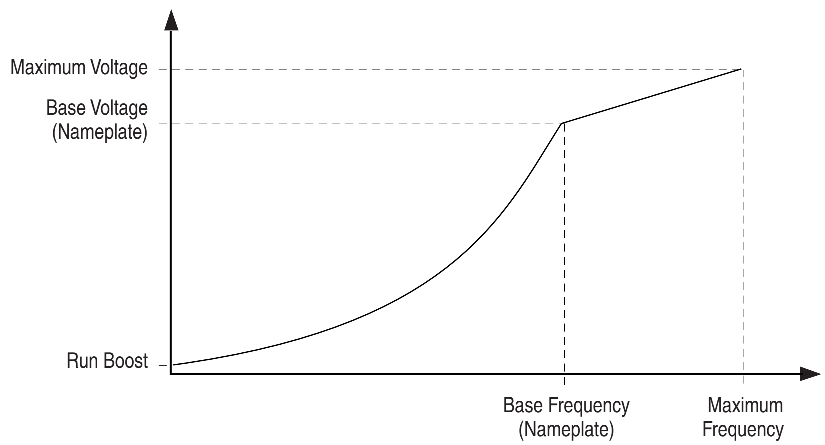
The following chart shows typical efficiency for PWM variable frequency drives, regardless of size. Drives are most efficient at full load and full speed.



Fan Curve

When torque performance (see page 2-205) is set to Fan/Pump, the relationship between frequency and voltage is shown in the following figure. The fan/pump curve generates voltage that is a function of the stator frequency squared up to the motor nameplate frequency. Above base frequency voltage is a linear function of frequency. At low speed the fan curve can be offset by the run boost parameter to provide extra starting torque if needed. No extra parameters are needed for fan/pump curve.

The pattern matches the speed vs. load characteristics of a centrifugal fan or pump and optimizes the drive output to those characteristics.



Fan

See Fan Curve above.

Faults

Faults are events or conditions occurring within and/or outside of the drive. Theses events or conditions are (by default) considered to be of such significant magnitude that drive operation should or must be discontinued. Faults are annunciated to the user via the HIM, communications and/or contact outputs. The condition that caused the fault determines the user response.

Once a fault occurs, the fault condition is latched, requiring the user or application to perform a fault reset action to clear the latched condition. If the condition that caused fault still exists when the fault is reset, the drive will fault again and the fault will be latched again.

When a Fault Occurs

1. The drive is set as faulted, causing the drive output to be immediately disabled and a "coast to stop" sequence to occur
2. The fault code is entered into the first buffer of the fault queue (see "Fault Queue" below for rules).
3. Additional data on the status of the drive at the time that the fault occurred is recorded. Note that there is only a single copy of this information which is always related to the most recent fault queue entry [Fault 1 Code], parameter 243. When another fault occurs, this data is overwritten with the new fault data. The following data/conditions are captured and latched into non-volatile drive memory:
   – [Status 1 @ Fault] - drive condition at the time of the fault.
   – [Status 2 @ Fault] - drive condition at the time of the fault.
   – [Alarm 1 @ Fault], - alarm condition at the time of the fault.
   – [Alarm 2 @ Fault] - alarm conditions at the time of the fault.
   – Fault Motor Amps - motor amps at time of fault.
   – [Fault Bus Volts] - unfiltered DC Bus volts at time of fault..
   – [Fault Frequency] (Standard Control).
   – [Fault Speed] (Vector Control) - drive output frequency (or speed) at time of fault.

Fault Queue

Faults are also logged into a fault queue such that a history of the most recent fault events is retained. Each recorded event includes a fault code (with associated text) and a fault "time of occurrence." The PowerFlex 70 drive has a four event queue and the PowerFlex 700 has an eight event queue.

A fault queue will record the occurrence of each fault event that occurs while no other fault is latched. Each fault queue entry will include a fault code and a time stamp value. A new fault event will not be logged to the fault queue if a previous fault has already occurred, but has not yet been reset. Only faults that actually trip the drive will be logged. No fault that occurs while the drive is already faulted will be logged.

The fault queue will be a first-in, first-out (FIFO) queue. Fault queue entry #1 will always be the most-recent entry (newest). Entry 4 (8) will always be the oldest. As a new fault is logged, each existing entry will be shifted up by one (i.e. previous entry #1 will move to entry #2, previous entry #2 will move to entry #3, etc.). If the queue is full when a fault occurs, the oldest entry will be discarded.

The fault queue will be saved in nonvolatile storage at power loss, thus retaining its contents through a power off - on cycle.

Fault Code/Text [Fault Code 1-x]

The fault code for each entry can be read in its respective read-only parameter. When viewed with a HIM, only the fault code is displayed. If viewed via a DPI peripheral (communications network), the queue is not accessed through parameters, and a text string of up to 16 characters is also available.

Fault Time [Fault 1-8 Time]

PowerFlex drives have an internal drive-under-power-timer. The user has no control over the value of this timer, which will increment in value over the life of the drive and saved in nonvolatile storage. Each time the drive is powered down and then repowered, the value of this timer is written to [Power Up Marker], parameter 242.

The time is presented in xxx.yyyy hours (4 decimal places). Each increment of 1 represents approximately 0.36 seconds. Internally it will be accumulated in a 32-bit unsigned integer with a resolution of 0.35 seconds, resulting in a rollover to zero every 47.66 years.

The time stamp value recorded in the fault queue at the time of a fault is the value of internal drive under power timer. By comparing this value to the [PowerUp Marker], it is possible to determine when the fault occurred relative to the last drive power-up.

The time stamp for each fault queue entry can be read via the corresponding parameter. Time comparisons of one fault to the next and/or with [PowerUp Marker] are only meaningful if they occur less than or equal to the rollover range.

Resetting or Clearing a Fault

A latched fault condition can be cleared by the following:

1. An off to on transition on a digital input configured for fault reset or stop/reset.
2. Setting [Fault Clear] to "1."
3. A DPI peripheral (several ways).
4. Performing a reset to factory defaults via parameter write.
5. Cycling power to the drive such that the control board goes through a power-up sequence.

Resetting faults will clear the faulted status indication. If any fault condition still exists, the fault will relatch and another entry made in the fault queue.

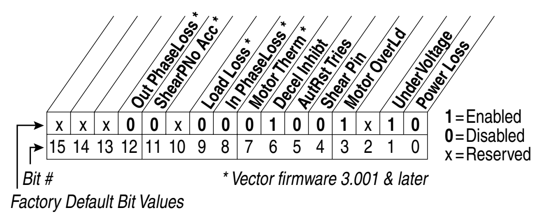
Clearing the Fault Queue

Performing a fault reset does not clear the fault queue. Clearing the fault queue is a separate action.

Fault Configuration

The drive can be configured such that some fault conditions do not trip the drive. Configurable faults include those that are user inputs.

[Fault Config 1] is a bit-mapped 16 bit word enabling or disabling certain fault conditions (see below). Disabling a fault removes the effect of the fault condition and makes the event unknown to the user. If the bit is on, the fault is enabled. If the bit is off, the fault is not enabled.



Power Up Marker

Copy of factory "drive under power" timer at the last power-up of the drive. Used to provide relevance of Fault 'n' Time values with respect to the last power-up of the drive.

This value will rollover to 0 after the drive has been powered on for more than the hours shown in the Range field (approximately 47.667 years).

Flux Braking

Vector You can use flux braking to stop the drive or to shorten the deceleration time to a lower speed. Other methods of deceleration or stopping may perform better depending on the motor and the load.

To enable flux braking:

1. [Bus Reg Mode A, B] must be set to “1” Adjust Freq to enable the bus regulator.
2. [Flux Braking] must be set to 1 “Enabled”.

When enabled, flux braking automatically increases the motor flux resulting in an increase of motor losses. The flux current is only increased when the bus voltage regulator is active. When the bus voltage regulator is not active, the flux current is returned to normal. The maximum flux current is equal to rated motor current but may be further reduced depending on the load level, IT protection, or current limits. In general, the flux current is not increased when the motor is at or above rated speed. At higher speeds, field weakening is active and the motor flux current cannot be increased. As the speed decreases below base speed, the flux current increases until there is enough voltage margin to run rated motor current.

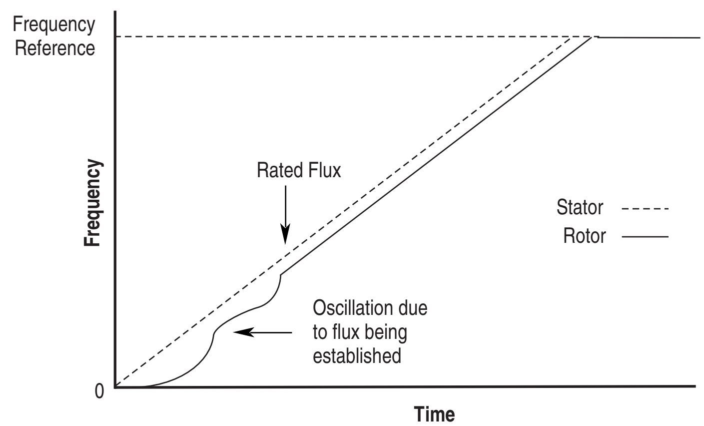
Because flux braking increases motor losses, the duty cycle used with this method must be limited. Check with the motor vendor for flux braking or DC braking application guidelines. You may also want to consider using external motor thermal protection.

Flux Up

[Flux Up Mode]
AC induction motors require flux to be established before controlled torque can be developed. To build flux in these motors, voltage is applied to them. PowerFlex drives have two methods to flux the motor.

The first method is a normal start. During a normal start, flux is established as the output voltage and frequency are applied to the motor. While the flux is being built, the unpredictable nature of the developed torque may cause the rotor to oscillate even though acceleration of the load may occur. In the motor, the acceleration profile may not follow the commanded acceleration profile due to the lack of developed torque.

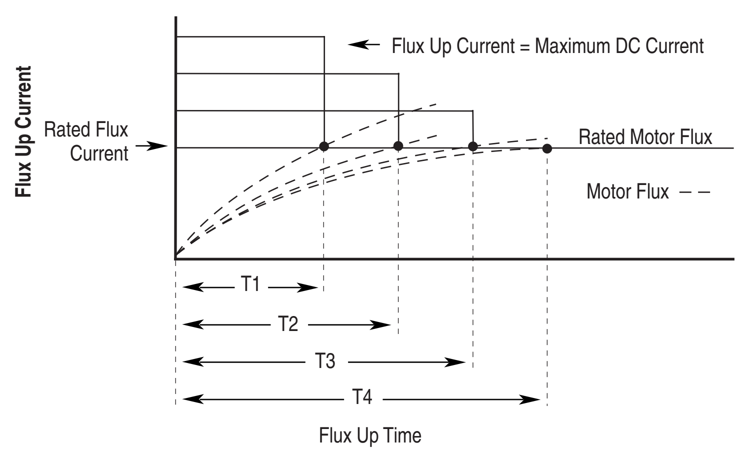
Figure 2.21 Accel Profile during Normal Start - No Flux Up



The second method is Flux Up Mode. In this mode, DC current is applied to the motor at a level equal to the lesser of the current limit setting, drive rated current, and drive DC current rating. The flux up time period is based on the level of flux up current and the rotor time constant of the motor.

The flux up current is not user adjustable.

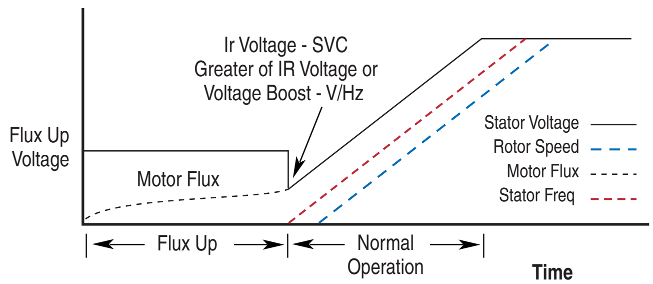
Figure 2.22 Flux Up Current versus Flux Up Time



[Flux Up Time]

Once rated flux is reached in the motor, normal operation begins and the desired acceleration profile is achieved.

Rated Flux Reached



Flying Start

The Flying Start feature is used to start into a rotating motor, as quick as possible, and resume normal operation with a minimal impact on load or speed.

When a drive is started in its normal mode it initially applies a frequency of 0 Hz and ramps to the desired frequency. If the drive is started in this mode with the motor already spinning, large currents will be generated. An overcurrent trip may result if the current limiter cannot react quickly enough. The likelihood of an overcurrent trip is further increased if there is a residual flux (back emf) on the spinning motor when the drive starts. Even if the current limiter is fast enough to prevent an overcurrent trip, it will take an unacceptable amount of time for synchronization to occur and for the motor to reach its desired frequency. In addition, larger mechanical stress is placed on the application, increasing downtime and repair costs while decreasing productivity.

In Flying Start mode, the drive's response to a start command will be to identify the motor's speed and apply a voltage that is synchronized in frequency, amplitude and phase to the back emf of the spinning motor. The motor will then accelerate to the desired frequency. This process will prevent an overcurrent trip and significantly reduce the time for the motor to reach its desired frequency. Since the motor is "picked up "smoothly at its rotating speed and ramped to the proper speed, little or no mechanical stress is present.

Configuration

Flying Start is activated by setting the [Flying Start En] parameter to "Enable"

		169	**[Flying Start En]** Enables/disables the function which reconnects to a spinning motor at actual RPM when a start command is issued.	Default: 0 "Disabled" Options: 0 "Disabled" 1 "Enabled"	170

The gain can be adjusted to increase responsiveness. Increasing the value in [Flying StartGain] increases the responsiveness of the Flaying Start Feature

	Restart Modes	170	**[Flying StartGain]** Sets the response of the flying start function.	Default: 4000 Min/Max: 20/32767 Display: 1	169

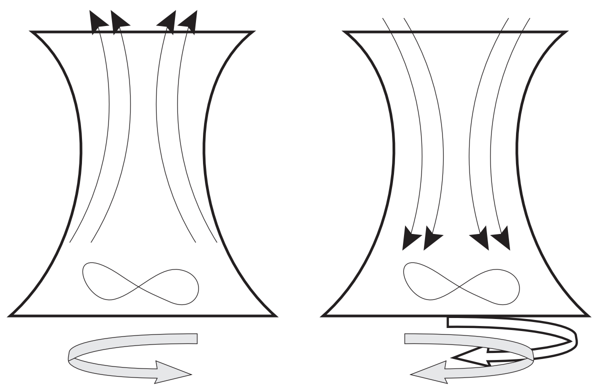
Application Example

In some applications, such as large fans, wind or drafts may rotate the fan in the reverse direction when the drive is stopped. If the drive were started in the normal manner, its output would begin at zero Hz, acting as a brake to bring the reverse rotating fan to a stop and then accelerating it in the correct direction.

This operation can be very hard on the mechanics of the system including fans, belts and other coupling devices.

Cooling Tower Fans

Draft/wind blows idle fans in reverse direction. Restart at zero damages fans, breaks belts. Flying start alleviates the problem



Fuses and Circuit Breakers

Tables 2.M through 2.W provide drive ratings (including continuous, 1 minute and 3 second) and recommended AC line input fuse and circuit breaker information. Both types of short circuit protection are acceptable for UL and IEC requirements. Sizes listed are the recommended sizes based on 40 degree C and the U.S. N.E.C. Other country, state or local codes may require different ratings.

Fusing

If fuses are chosen as the desired protection method, refer to the recommended types listed below. If available amp ratings do not match the tables provided, the closest fuse rating that exceeds the drive rating should be chosen.

- IEC – BS88 (British Standard) Parts 1 & 2[1], EN60269-1, Parts 1 & 2, type gG or equivalent should be used.
- UL – UL Class CC, T, RK1 or J must be used.

Circuit Breakers

The "non-fuse" listings in the following tables include both circuit breakers (inverse time or instantaneous trip) and 140M Self-Protecting Motor Starters. **If one of these is chosen as the desired protection method**, the following requirements apply.

- IEC and UL – Both types of devices are acceptable for IEC and UL installations.

(1) Typical designations include, but may not be limited to the following; Parts 1 & 2: AC, AD, BC, BD, CD, DD, ED, EFS, EF, FF, FG, GF, GG, GH.

Table 2.M PF70 208/240 Volt AC Input Recommended Protection Devices

Drive Catalog Number	Frame(1)	HP Rating		Input Ratings		Output Amps			Dual Element Time Delay Fuse		Non-Time Delay Fuse		Circuit Breaker(4)	Motor Circuit Protector(6)	140M Motor Starter with Adjustable Current Range(7)(8)			
		ND	*HD*	*Amps*	*kVA*	*Cont.*	*1 Min.*	*3 Sec.*	*Min.*(2)	*Max.*(3)	*Min.*(2)	*Max.*(3)	*Max.*(5)	*Max.*(5)	*Available Catalog Numbers*(9)			
208 Volt AC Input																		
20AB2P2	A	0.5	0.33	2.9	1.1	2.5	2.7	3.7	6	6	6	10	15	7	140M-C2E-B40	140M-D8E-B40	–	–
20AB4P2	A	1	0.75	5.6	2	4.8	5.5	7.4	10	10	10	17.5	15	7	140M-C2E-B63	140M-D8E-B63	–	–
20AB6P8	B	2	1.5	10	3.6	7.8	10.3	13.8	15	15	15	30	30	15	140M-C2E-C10	140M-D8E-C10	140M-F8E-C10	–
20AB9P6	B	3	2	14	5.1	11	12.1	16.5	20	25	20	40	40	30	140M-C2E-C16	140M-D8E-C16	140M-F8E-C16	–
20AB015	C	5	3	16	5.8	17.5	19.2	26.6	20	35	20	70	70	30	140M-C2E-C20	140M-D8E-C20	140M-F8E-C20	–
20AB022	D	7.5	5	23.3	8.3	25.3	27.8	37.9	30	50	30	100	100	30	140M-C2E-C25	140M-D8E-C25	140M-F8E-C25	140-CMN-2500
20AB028	D	10	7.5	29.8	10.7	32.2	37.9	50.6	40	70	40	125	125	50	–	–	140M-F8E-C32	140-CMN-4000
240 Volt AC Input																		
20AB2P2	A	0.5	0.33	2.5	1.1	2.2	2.4	3.3	3	4.5	3	8	15	3	140M-C2E-B25	140M-D8E-B25	–	–
20AB4P2	A	1	0.75	4.8	2	4.2	4.8	6.4	6	9	6	15	15	7	140M-C2E-B63	140M-D8E-B63	–	–
20AB6P8	B	2	1.5	8.7	3.6	6.8	9	12	15	15	15	25	25	15	140M-C2E-C10	140M-D8E-C10	140M-F8E-C10	–
20AB9P6	B	3	2	12.2	5.1	9.6	10.6	14.4	20	20	20	35	35	15	140M-C2E-C16	140M-D8E-C16	140M-F8E-C16	–
20AB015	C	5	3	13.9	5.8	15.3	17.4	23.2	20	30	20	60	60	30	140M-C2E-C16	140M-D8E-C16	140M-F8E-C16	–
20AB022	D	7.5	5	19.9	8.3	22	24.4	33	25	45	25	80	80	30	140M-C2E-C20	140M-D8E-C20	140M-F8E-C20	–
20AB028	D	10	7.5	25.7	10.7	28	33	44	35	60	35	110	110	50	–	–	140M-F8E-C32	140-CMN-4000

Table 2.N PF70 400/480 Volt AC Input Recommended Protection Devices

Drive Catalog Number	Frame(1)	kW *(400V)* HP *(480V)* Rating		Input Ratings		Output Amps			Dual Element Time Delay Fuse		Non-Time Delay Fuse		Circuit Breaker(4)	Motor Circuit Protector(6)	140M Motor Starter with Adjustable Current Range(7)(8)			
		ND	*HD*	*Amps*	*kVA*	*Cont.*	*1 Min.*	*3 Sec.*	*Min.*(2)	*Max.*(3)	*Min.*(2)	*Max.*(3)	*Max.*(5)	*Max.*(5)	*Available Catalog Numbers*(9)			
400 Volt AC Input																		
20AC1P3	A	0.37	0.25	1.6	1.1	1.3	1.4	1.9	3	3	3	5	15	3	140M-C2E-B16	–	–	–
20AC2P1	A	0.75	0.55	2.5	1.8	2.1	2.4	3.2	4	6	4	8	15	7	140M-C2E-B25	140M-D8E-B25	–	–
20AC3P5	A	1.5	1.1	4.3	3	3.5	4.5	6	6	6	6	12	15	7	140M-C2E-B40	140M-D8E-B40	–	–
20AC5P0	B	2.2	1.5	6.5	4.5	5	5.5	7.5	10	10	10	20	20	15	140M-C2E-C10	140M-D8E-C10	140M-F8E-C10	–
20AC8P7	B	4	3	11.3	7.8	8.7	9.9	13.2	15	17.5	15	30	30	15	140M-C2E-C16	140M-D8E-C16	140M-F8E-C16	–
20AC011	C	5.5	4	11	7.6	11.5	13	17.4	15	25	15	45	40	15	140M-C2E-C16	140M-D8E-C16	140M-F8E-C16	–
20AC015	C	7.5	5.5	15.1	10.4	15.4	17.2	23.1	20	30	20	60	60	20	140M-C2E-C16	140M-D8E-C16	140M-F8E-C16	–
20AC022	D	11	7.5	21.9	15.2	22	24.2	33	30	45	30	80	80	30	140M-C2E-C25	140M-D8E-C25	140M-F8E-C25	140-CMN-2500
20AC030	D	15	11	30.3	21	30	33	45	40	60	40	120	120	50	–	–	140M-F8E-C32	140-CMN-4000
20AC037	D	18.5	15	35	24.3	37	45	60	45	80	45	125	125	50	–	–	140M-F8E-C45	–
20AC043	D	22	18.5	40.7	28.2	43	56	74	60	90	60	150	150	60	–	–	–	–
480 Volt AC Input																		
20AD1P1	A	0.5	0.33	1.3	1.1	1.1	1.2	1.6	3	3	3	4	15	3	140M-C2E-B16	–	–	–
20AD2P1	A	1	0.75	2.4	2	2.1	2.4	3.2	3	6	3	8	15	3	140M-C2E-B25	140M-D8E-B25	–	–
20AD3P4	A	2	1.5	3.8	3.2	3.4	4.5	6	6	6	6	12	15	7	140M-C2E-B40	140M-D8E-B40	–	–
20AD5P0	B	3	2	5.6	4.7	5	5.5	7.5	10	10	10	20	20	15	140M-C2E-C63	140M-D8E-B63	–	–
20AD8P0	B	5	3	9.8	8.4	8	8.8	12	15	15	15	30	30	15	140M-C2E-C10	140M-D8E-C10	140M-F8E-C10	–
20AD011	C	7.5	5	9.5	7.9	11	12.1	16.5	15	20	15	40	40	15	140M-C2E-C16	140M-D8E-C16	140M-F8E-C16	–
20AD014	C	10	7.5	12.5	10.4	14	16.5	22	20	30	20	50	50	20	140M-C2E-C16	140M-D8E-C16	140M-F8E-C16	–
20AD022	D	15	10	19.9	16.6	22	24.2	33	25	45	25	80	80	30	140M-C2E-C20	140M-D8E-C20	140M-F8E-C20	–
20AD027	D	20	15	24.8	20.6	27	33	44	35	60	35	100	100	50	–	–	140M-F8E-C25	140-CMN-2500
20AD034	D	25	20	34	25.9	34	40.5	54	40	70	40	125	125	50	–	–	140M-F8E-C45	140-CMN-4000
20AD040	D	30	25	40	39.7	40	51	68	50	90	50	150	150	50	–	–	140M-F8E-C45	140-CMN-4000

See page 2-102 for Notes.

Table 2.O PF70 600 Volt AC Input Recommended Protection Devices

Drive Catalog Number	Frame(1)	HP Rating		Input Ratings		Output Amps			Dual Element Time Delay Fuse		Non-Time Delay Fuse		Circuit Breaker(4)	Motor Circuit Protector(6)	140M Motor Starter with Adjustable Current Range(7)(8)			
		ND	*HD*	*Amps*	*kVA*	*Cont.*	*1 Min.*	*3 Sec.*	*Min.(2)*	*Max.(3)*	*Min.(2)*	*Max.(3)*	*Max.(5)*	*Max.(5)*	*Available Catalog Numbers(9)*			
600 Volt AC Input																		
20AE0P9	A	0.5	0.33	1.3	1.3	0.9	1.1	1.4	3	3	3	3.5	15	3	140M-C2E-B16	–	–	–
20AE1P7	A	1	0.75	1.9	2	1.7	2	2.6	3	6	3	6	15	3	140M-C2E-B25	140M-D8E-B25	–	–
20AE2P7	A	2	1.5	3	3.1	2.7	3.6	4.8	4	6	4	10	15	7	140M-C2E-B40	140M-D8E-B40	–	–
20AE3P9	B	3	2	4.4	4.5	3.9	4.3	5.9	6	8	6	15	15	7	140M-C2E-C63	140M-D8E-B63	–	–
20AE6P1	B	5	3	7.5	7.8	6.1	6.7	9.2	10	12	10	20	20	15	140M-C2E-C10	140M-D8E-C10	140M-F8E-C10	–
20AE9P0	C	7.5	5	7.7	8	9	9.9	13.5	10	20	10	35	35	15	140M-C2E-C10	140M-D8E-C10	140M-F8E-C10	–
20AE011	C	10	7.5	9.8	10.1	11	13.5	18	15	20	15	40	40	15	140M-C2E-C16	140M-D8E-C16	140M-F8E-C16	–
20AE017	D	15	10	15.3	15.9	17	18.7	25.5	20	35	20	60	60	30	140M-C2E-C20	140M-D8E-C20	140M-F8E-C20	–
20AE022	D	20	15	20	20.8	22	25.5	34	25	45	25	80	80	30	140M-C2E-C25	140M-D8E-C25	140M-F8E-C25	140-CMN-2500

(1) For IP 66 (NEMA Type 4X/12) enclosures, drives listed as Frame A increase to Frame B and drives listed as Frame C increase to Frame D.
(2) Minimum protection device size is the lowest rated device that supplies maximum protection without nuisance tripping.
(3) Maximum protection device size is the highest rated device that supplies drive protection. For US NEC, minimum size is 125% of motor FLA. Ratings shown are maximum.
(4) Circuit Breaker - inverse time breaker. For US NEC, minimum size is 125% of motor FLA. Ratings shown are maximum.
(5) Maximum allowable rating by US NEC. Exact size must be chosen for each installation.
(6) Motor Circuit Protector - instantaneous trip circuit breaker. For US NEC, minimum size is 125% of motor FLA. Ratings shown are maximum.
(7) Bulletin 140M with adjustable current range should have the current trip set to the minimum range that the device will not trip.
(8) Manual Self-Protected (Type E) Combination Motor Controller, UL listed for 208 Wye or Delta, 240 Wye or Delta, 480Y/277 or 600Y/347. Not UL listed for use on 480V or 600V Delta/Delta systems.
(9) The AIC ratings of the Bulletin 140M Motor Protector may vary. See publication 140M-SG001B-EN-P.

Table 2.P PF700 208 Volt AC Input Protection Devices

Drive Catalog Number	Frame	HP Rating		PWM Freq.	Temp.	Input Ratings		Output Amps			Dual Element Time Delay Fuse		Non-Time Delay Fuse		Circuit Breaker (3)	Motor Circuit Protector (4)	140M Motor Starter with Adjustable Current Range (5)(6)			
		ND	*HD*	*kHz*	*°C*	*Amps*	*kVA*	*Cont.*	*1 Min.*	*3 Sec.*	*Min.* (1)	*Max.* (2)	*Min.* (1)	*Max.* (2)	*Max.* (8)	*Max.* (8)	*Available Catalog Numbers - 140 . . .* (7)			
208 Volt AC Input																				
20BB2P2	0	0.5	0.33	4	50	1.9	0.7	2.5	2.8	3.8	3	6	3	10	15	3	M-C2E-B25	M-D8E-B25	–	–
20BB4P2	0	1	0.75	4	50	3.7	1.3	4.8	5.6	7.0	6	10	6	17.5	15	7	M-C2E-B63	M-D8E-B63	–	–
20BB6P8	1	2	1.5	4	50	6.8	2.4	7.8	10.4	13.8	10	15	10	30	30	15	M-C2E-C10	M-D8E-C10	M-F8E-C10	–
20BB9P6	1	3	2	4	50	9.5	3.4	11	12.1	17	12	20	12	40	40	15	M-C2E-C16	M-D8E-C16	M-F8E-C16	–
20BB015	1	5	3	4	50	15.7	5.7	17.5	19.3	26.3	20	35	20	70	70	30	M-C2E-C20	M-D8E-C20	M-F8E-C20	–
20BB022	1	7.5	5	4	50	23.0	8.3	25.3	27.8	38	30	50	30	100	100	30	M-C2E-C25	M-D8E-C25	M-F8E-C25	-CMN-2500
20BB028	2	10	7.5	4	50	29.6	10.7	32.2	38	50.6	40	70	40	125	125	50	–	–	M-F8E-C32	-CMN-4000
20BB042	3	15	10	4	50	44.5	16.0	48.3	53.1	72.5	60	100	60	175	175	70	–	–	M-F8E-C45	-CMN-6300
20BB052	3	20	15	4	50	51.5	17.1	56	64	86	80	125	80	200	200	100	–	–	–	-CMN-6300
20BB070	4	25	20	4	50	72	25.9	78.2	93	124	90	175	90	300	300	100	–	–	–	-CMN-9000
20BB080	4	30	25	4	50	84.7	30.5	92	117	156	110	200	110	350	350	150	–	–	–	-CMN-9000
20BB104	5	40	–	4	50	113	40.7	120	132	175	150	250	150	475	350	150	–	–	–	–
		–	30	4	50	84.7	30.5	92	138	175	125	200	125	350	300	150	–	–	–	-CMN-9000
20BB130	5	50	–	4	50	122	44.1	130	143	175	175	275	175	500	375	250	–	–	–	–
		–	40	4	50	98	35.3	104	156	175	125	225	125	400	300	150	–	–	–	–
20BB154	6	60	–	4	50	167	60.1	177	195	266	225	350	225	500	500	250	–	–	–	–
		–	50	4	50	141	50.9	150	225	300	200	300	200	500	450	250	–	–	–	–
20BB192	6	75	–	4	50	208	75.0	221	243	308	300	450	300	600	600	400	–	–	–	–
		–	60	4	50	167	60.1	177	266	308	225	350	225	500	500	250	–	–	–	–

Table 2.Q PF700 240 Volt AC Input Protection Devices

Drive Catalog Number	Frame	HP Rating		PWM Freq.	Temp.	Input Ratings		Output Amps			Dual Element Time Delay Fuse		Non-Time Delay Fuse		Circuit Breaker (3)	Motor Circuit Protector (4)	140M Motor Starter with Adjustable Current Range (5)(6)			
		ND	*HD*	*kHz*	*°C*	*Amps*	*kVA*	*Cont.*	*1 Min.*	*3 Sec.*	*Min.* (1)	*Max.* (2)	*Min.* (1)	*Max.* (2)	*Max.* (8)	*Max.* (8)	*Available Catalog Numbers - 140 . . .* (7)			
240 Volt AC Input																				
20BB2P2	0	0.5	0.33	4	50	1.7	0.7	2.2	2.4	3.3	3	6	3	10	15	3	M-C2E-B25	M-D8E-B25	–	–
20BB4P2	0	1	0.75	4	50	3.3	1.4	4.2	4.8	6.4	5	8	5	15	15	7	M-C2E-B63	M-D8E-B63	–	–
20BB6P8	1	2	1.5	4	50	5.9	2.4	6.8	9	12	10	15	10	25	25	15	M-C2E-C10	M-D8E-C10	M-F8E-C10	–
20BB9P6	1	3	2	4	50	8.3	3.4	9.6	10.6	14.4	12	20	12	35	35	15	M-C2E-C10	M-D8E-C10	M-F8E-C10	–
20BB015	1	5	3	4	50	13.7	5.7	15.3	16.8	23	20	30	20	60	60	30	M-C2E-C16	M-D8E-C16	M-F8E-C16	–
20BB022	1	7.5	5	4	50	19.9	8.3	22	24.2	33	25	50	25	80	80	30	M-C2E-C25	M-D8E-C25	M-F8E-C25	-CMN-2500
20BB028	2	10	7.5	4	50	25.7	10.7	28	33	44	35	60	35	100	100	50	–	–	M-F8E-C32	-CMN-4000
20BB042	3	15	10	4	50	38.5	16.0	42	46.2	63	50	90	50	150	150	50	–	–	M-F8E-C45	-CMN-6300
20BB052	3	20	15	4	50	47.7	19.8	52	63	80	60	100	60	200	200	100	–	–	–	-CMN-6300
20BB070	4	25	20	4	50	64.2	26.7	70	78	105	90	150	90	275	275	100	–	–	–	-CMN-9000
20BB080	4	30	25	4	50	73.2	30.5	80	105	140	100	180	100	300	300	100	–	–	–	-CMN-9000
20BB104	5	40	–	4	50	98	40.6	104	115	175	125	225	125	400	300	150	–	–	–	–
		–	30	4	50	73	30.5	80	120	160	100	175	100	300	300	100	–	–	–	-CMN-9000
20BB130	5	50	–	4	50	122	50.7	130	143	175	175	275	175	500	375	250	–	–	–	–
		–	40	4	50	98	40.6	104	156	175	125	225	125	400	300	150	–	–	–	–
20BB154	6	60	–	4	50	145	60.1	154	169	231	200	300	200	600	450	250	–	–	–	–
		–	50	4	50	122	50.7	130	195	260	175	275	175	500	375	250	–	–	–	–
20BB192	6	75	–	4	50	180	74.9	192	211	288	225	400	225	600	575	250	–	–	–	–
		–	60	4	50	145	60.1	154	231	308	200	300	200	600	450	250	–	–	–	–

See page 2-105 for Notes.

Table 2.R PF700 400 Volt AC Input Protection Devices

Drive Catalog Number	Frame	kW Rating		PWM Freq.	Temp.	Input Ratings		Output Amps			Dual Element Time Delay Fuse		Non-Time Delay Fuse		Circuit Breaker (3)	Motor Circuit Protector (4)	140M Motor Starter with Adjustable Current Range (5)(6)			
		ND	HD	kHz	°C	Amps	kVA	Cont.	1 Min.	3 Sec.	Min. (1)	Max. (2)	Min. (1)	Max. (2)	Max. (8)	Max. (8)	Available Catalog Numbers - 140 . . . (7)			
400 Volt AC Input																				
20BC1P3	0	0.37	0.25	4	50	1.1	0.77	1.3	1.4	1.9	3	3	3	6	15	3	M-C2E-B16	–	–	–
20BC2P1	0	0.75	0.55	4	50	1.8	1.3	2.1	2.4	3.2	3	6	3	8	15	3	M-C2E-B25	M-D8E-B25	–	–
20BC3P5	0	1.5	0.75	4	50	3.2	2.2	3.5	4.5	6.0	6	7	6	12	15	7	M-C2E-B40	M-D8E-B40	–	–
20BC5P0	0	2.2	1.5	4	50	4.6	3.2	5.0	5.5	7.5	6	10	6	20	20	7	M-C2E-B63	M-D8E-B63	–	–
20BC8P7	0	4	2.2	4	50	7.9	5.5	8.7	9.9	13.2	15	17.5	15	30	30	15	M-C2E-C10	M-D8E-C10	M-F8E-C10	–
20BC011	0	5.5	4	4	50	10.8	7.5	11.5	13	17.4	15	25	15	45	45	15	M-C2E-C16	M-D8E-C16	M-F8E-C16	–
20BC015	1	7.5	5.5	4	50	14.4	10.0	15.4	17.2	23.1	20	30	20	60	60	20	M-C2E-C20	M-D8E-C20	M-F8E-C20	–
20BC022	1	11	7.5	4	50	20.6	14.3	22	24.2	33	30	45	30	80	80	30	M-C2E-C25	M-D8E-C25	M-F8E-C25	–
20BC030	2	15	11	4	50	28.4	19.7	30	33	45	35	60	35	120	120	50	–	–	M-F8E-C32	–
20BC037	2	18.5	15	4	50	35.0	24.3	37	45	60	45	80	45	125	125	50	–	–	M-F8E-C45	–
20BC043	3	22	18.5	4	50	40.7	28.2	43	56	74	60	90	60	150	150	60	–	–	–	–
20BC056	3	30	22	4	50	53	36.7	56	64	86	70	125	70	200	200	100	–	–	–	–
20BC072	3	37	30	4	50	68.9	47.8	72	84	112	90	150	90	250	250	100	–	–	–	–
20BC085	4	45	–	4	45	81.4	56.4	85	94	128	110	200	110	300	300	150	–	–	–	–
		–	37	4	45	68.9	47.8	72	108	144	90	175	90	275	300	100	–	–	–	–
20BC105	5	55	–	4	50	100.5	69.6	105	116	158	125	225	125	400	300	150	–	–	–	–
		–	45	4	50	81.4	56.4	85	128	170	110	175	110	300	300	150	–	–	–	–
20BC125	5	55	–	4	50	121.1	83.9	125	138	163	150	275	150	500	375	250	–	–	–	–
		–	45	4	50	91.9	63.7	96	144	168	125	200	125	375	375	150	–	–	–	–
20BC140	5	75	–	4	40	136	93.9	140	154	190	200	300	200	400	400	250	–	–	–	–
		–	55	4	40	101	69.6	105	157	190	150	225	150	300	300	150	–	–	–	–
20BC170	6	90	–	4	50	164	126	170	187	255	250	375	250	600	500	250	–	–	–	–
		–	75	4	50	136	103	140	210	280	200	300	200	550	400	250	–	–	–	–
20BC205	6	110	–	4	40	199	148	205	220	289	250	450	250	600	600	400	–	–	–	–
		–	90	4	40	164	126	170	255	313	250	375	250	600	500	250	–	–	–	–
20BC260	6	132	–	2	40	255	177	260	286	390	350	550	350	750	750	400	–	–	–	–
		–	110	2	40	199	138	205	308	410	250	450	250	600	600	400	–	–	–	–

Table 2.S PF700 480 Volt AC Input Protection Devices

Drive Catalog Number	Frame	HP Rating		PWM Freq.	Temp.	Input Ratings		Output Amps			Dual Element Time Delay Fuse		Non-Time Delay Fuse		Circuit Breaker (3)	Motor Circuit Protector (4)	140M Motor Starter with Adjustable Current Range (5)(6)			
		ND	HD	kHz	°C	Amps	kVA	Cont.	1 Min.	3 Sec.	Min. (1)	Max. (2)	Min. (1)	Max. (2)	Max. (8)	Max. (8)	Available Catalog Numbers - 140 . . . (7)			
480 Volt AC Input																				
20BD1P1	0	0.5	0.33	4	50	0.9	0.7	1.1	1.2	1.6	3	3	3	6	15	3	M-C2E-B16	–	–	–
20BD2P1	0	1	0.75	4	50	1.6	1.4	2.1	2.4	3.2	3	6	3	8	15	3	M-C2E-B25	–	–	–
20BD3P4	0	2	1.5	4	50	2.6	2.2	3.4	4.5	6.0	4	8	4	12	15	7	M-C2E-B40	M-D8E-B40	–	–
20BD5P0	0	3	2	4	50	3.9	3.2	5.0	5.5	7.5	6	10	6	20	20	7	M-C2E-B63	M-D8E-B63	–	–
20BD8P0	0	5	3	4	50	6.9	5.7	8.0	8.8	12	10	15	10	30	30	15	M-C2E-C10	M-D8E-C10	M-F8E-C10	–
20BD011	0	7.5	5	4	50	9.5	7.9	11	12.1	16.5	15	20	15	40	40	15	M-C2E-C16	M-D8E-C16	M-F8E-C16	–
20BD014	1	10	7.5	4	50	12.5	10.4	14	16.5	22	17.5	30	17.5	50	50	20	M-C2E-C16	M-D8E-C16	M-F8E-C16	–
20BD022	1	15	10	4	50	19.9	16.6	22	24.2	33	25	50	25	80	80	30	M-C2E-C25	M-D8E-C25	M-F8E-C25	-CMN-2500
20BD027	2	20	15	4	50	24.8	20.6	27	33	44	35	60	35	100	100	50	–	–	M-F8E-C32	-CMN-4000
20BD034	2	25	20	4	50	31.2	25.9	34	40.5	54	40	70	40	125	125	50	–	–	M-F8E-C45	-CMN-4000
20BD040	3	30	25	4	50	36.7	30.5	40	51	68	50	90	50	150	150	50	–	–	M-F8E-C45	-CMN-4000
20BD052	3	40	30	4	50	47.7	39.7	52	60	80	60	110	60	200	200	70	–	–	–	-CMN-6300
20BD065	3	50	40	4	50	59.6	49.6	65	78	104	80	125	80	250	250	100	–	–	–	-CMN-9000
20BD077	4	60	–	4	50	72.3	60.1	77	85	116	100	170	100	300	300	100	–	–	–	-CMN-9000
		–	50	4	50	59.6	49.6	65	98	130	80	125	80	250	250	100	–	–	–	-CMN-9000
20BD096	5	75	–	4	50	90.1	74.9	96	106	144	125	200	125	350	350	125	–	–	–	–
		–	60	4	50	72.3	60.1	77	116	154	100	170	100	300	300	100	–	–	–	-CMN-9000
20BD125	5	100	–	4	50	117	97.6	125	138	163	150	250	150	500	375	150	–	–	–	–
		–	75	4	50	90.1	74.9	96	144	168	125	200	125	350	350	125	–	–	–	–
20BD156	6	125	–	4	50	147	122	156	172	234	200	350	200	600	450	250	–	–	–	–
		–	100	4	50	131	109	125	188	250	175	250	175	500	375	250	–	–	–	–
20BD180	6	150	–	4	50	169	141	180	198	270	225	400	225	600	500	250	–	–	–	–
		–	125	4	50	147	122	156	234	312	200	350	200	600	450	250	–	–	–	–
20BD248	6	200	–	2	40	233	194	248	273	372	300	550	300	700	700	400	–	–	–	–
		–	150	2	40	169	141	180	270	360	225	400	225	600	500	250	–	–	–	–

See page 2-105 for Notes.

Table 2.T PF700 600 Volt AC Input Protection Devices

Drive Catalog Number	Frame	HP Rating ND	HP Rating HD	PWM Freq. kHz	Temp. °C	Input Ratings Amps	Input Ratings kVA	Output Amps Cont.	Output Amps 1 Min.	Output Amps 3 Sec.	Dual Element Time Delay Fuse Min.(1)	Dual Element Time Delay Fuse Max.(2)	Non-Time Delay Fuse Min.(1)	Non-Time Delay Fuse Max.(2)	Circuit Breaker (3) Max.(8)	Motor Circuit Protector (4) Max.(8)	140M Motor Starter with Adjustable Current Range (5)(6) Available Catalog Numbers - 140 . . .(7)			
600 Volt AC Input																				
20BE1P7	0	1	0.5	4	50	1.3	1.4	1.7	2	2.6	2	4	2	6	15	3	M-C2E-B16	–	–	–
20BE2P7	0	2	1	4	50	2.1	2.1	2.7	3.6	4.8	3	6	3	10	15	3	M-C2E-B25	–	–	–
20BE3P9	0	3	2	4	50	3.0	3.1	3.9	4.3	5.9	6	9	6	15	15	7	M-C2E-B40	M-D8E-B40	–	–
20BE6P1	0	5	3	4	50	5.3	5.5	6.1	6.7	9.2	9	12	9	20	20	15	M-C2E-B63	M-D8E-B63	–	–
20BE9P0	0	7.5	5	4	50	7.8	8.1	9	9.9	13.5	10	20	10	35	30	15	M-C2E-C10	M-D8E-C10	M-F8E-C10	–
20BE011	1	10	7.5	4	50	9.9	10.2	11	13.5	18	15	25	15	40	40	15	M-C2E-C10	M-D8E-C10	M-F8E-C10	–
20BE017	1	15	10	4	50	15.4	16.0	17	18.7	25.5	20	40	20	60	50	20	M-C2E-C16	M-D8E-C16	M-F8E-C16	–
20BE022	2	20	15	4	50	20.2	21.0	22	25.5	34	30	50	30	80	80	30	M-C2E-C25	M-D8E-C25	M-F8E-C25	-CMN-2500
20BE027	2	25	20	4	50	24.8	25.7	27	33	44	35	60	35	100	100	50	–	–	M-F8E-C25	-CMN-2500
20BE032	3	30	25	4	50	29.4	30.5	32	40.5	54	40	70	40	125	125	50	–	–	M-F8E-C32	-CMN-4000
20BE041	3	40	30	4	50	37.6	39.1	41	48	64	50	90	50	150	150	100	–	–	M-F8E-C45	-CMN-4000
20BE052	3	50	40	4	50	47.7	49.6	52	61.5	82	60	110	60	200	200	100	–	–	–	-CMN-6300
20BE062	4	60	50	2	50	58.2	60.5	62	78	104	80	125	80	225	225	100	–	–	–	-CMN-6300
20BE077	5	75	–	2	50	72.3	75.1	77	85	116	90	150	90	300	300	100	–	–	–	-CMN-9000
		–	60	2	50	58.2	60.5	63	94	126	90	125	90	250	250	100	–	–	–	-CMN-6300
20BE099	5	100	–	2	40	92.9	96.6	99	109	126	125	200	125	375	375	150	–	–	–	–
		–	75	2	40	72.3	75.1	77	116	138	100	175	100	300	300	100	–	–	–	-CMN-9000
20BE125	6	125	–	2	50	117	122	125	138	188	150	250	150	375	375	250	–	–	–	–
		–	100	2	50	93	96.6	99	149	198	125	200	125	375	375	150	–	–	–	–
20BE144	6	150	–	2	50	135	141	144	158	216	175	300	175	400	400	250	–	–	–	–
		–	125	2	50	117	122	125	188	250	150	275	150	375	375	250	–	–	–	–

Table 2.U PF700 690 Volt AC Input Protection Devices

Drive Catalog Number	Frame	kW Rating ND	kW Rating HD	PWM Freq. kHz	Temp. °C	Input Ratings Amps	Input Ratings kVA	Output Amps Cont.	Output Amps 1 Min.	Output Amps 3 Sec.	Dual Element Time Delay Fuse Min.(1)	Dual Element Time Delay Fuse Max.(2)	Non-Time Delay Fuse Min.(1)	Non-Time Delay Fuse Max.(2)	Circuit Breaker (3) Max.(8)	Motor Circuit Protector (4) Max.(8)
690 Volt AC Input																
20BF052	5	45	–	4	50	46.9	56.1	52	57	78	60	110	60	175	175	–
		–	37.5	4	50	40.1	48.0	46	69	92	50	90	50	150	150	–
20BF060	5	55	–	4	50	57.7	68.9	60	66	90	80	125	80	225	225	–
		–	45	4	50	46.9	56.1	52	78	104	60	110	60	175	175	–
20BF082	5	75	–	2	50	79.0	94.4	82	90	123	100	200	100	375	375	–
		–	55	2	50	57.7	68.9	60	90	120	80	125	80	225	225	–
20BF098	5	90	–	2	40	94.7	113	98	108	127	125	200	125	375	375	–
		–	75	2	40	79.0	94.4	82	123	140	100	200	100	375	375	–
20BF119	6	110	–	2	50	115	137	119	131	179	150	250	150	400	–	–
		–	90	2	50	94.7	113	98	147	196	125	200	125	375	–	–
20BF142	6	132	–	2	50	138	165	142	156	213	175	300	175	450	–	–
		–	110	2	50	115	137	119	179	238	150	250	150	400	–	–

Notes:

(1) Minimum protection device size is the lowest rated device that supplies maximum protection without nuisance tripping.
(2) Maximum protection device size is the highest rated device that supplies drive protection. For US NEC, minimum size is 125% of motor FLA. Ratings shown are maximum.
(3) Circuit Breaker - inverse time breaker. For US NEC, minimum size is 125% of motor FLA. Ratings shown are maximum.
(4) Motor Circuit Protector - instantaneous trip circuit breaker. For US NEC minimum size is 125% of motor FLA. Ratings shown are maximum.
(5) Bulletin 140M with adjustable current range should have the current trip set to the minimum range that the device will not trip.
(6) Manual Self-Protected (Type E) Combination Motor Controller, UL listed for 208 Wye or Delta, 240 Wye or Delta, 480Y/277 or 600Y/ 347. Not UL listed for use on 480V or 600V Delta/Delta systems.
(7) The AIC ratings of the Bulletin 140M Motor Protector may vary. See publication 140M-SG001B-EN-P.
(8) Maximum allowable rating by US NEC. Exact size must be chosen for each installation.

Table 2.V PF700 540 Volt DC Input Protection Devices

Drive Catalog Number	Frame	kW Rating		DC Input Ratings		Output Amps			Fuse	Bussmann Style Fuse
		ND	*HD*	*Amps*	*kW*	*Cont.*	*1 Min.*	*3 Sec.*		
540 Volt DC Input										
20BC1P3	1	0.37	0.25	1.3	0.7	1.3	1.4	1.9	3	BUSSMANN_JKS-3
20BC2P1	1	0.75	0.55	2.1	1.1	2.1	2.4	3.2	6	BUSSMANN_JKS-6
20BC3P5	1	1.5	0.75	3.7	2.0	3.5	4.5	6.0	8	BUSSMANN_JKS-8
20BC5P0	1	2.2	1.5	5.3	2.9	5.0	5.5	7.5	10	BUSSMANN_JKS-10
20BC8P7	1	4	3.0	9.3	5.0	8.7	9.9	13.2	20	BUSSMANN_JKS-20
20BC011	1	5.5	4	12.6	6.8	11.5	13	17.4	25	BUSSMANN_JKS-25
20BC015	1	7.5	5.5	16.8	9.1	15.4	17.2	23.1	30	BUSSMANN_JKS-30
20BC022	1	11	7.5	24	13	22	24.2	33	45	BUSSMANN_JKS-45
20BC030	2	15	11	33.2	17.9	30	33	45	60	BUSSMANN_JKS-60
20BC037	2	18.5	15	40.9	22.1	37	45	60	80	BUSSMANN_JKS-80
20BC043	3	22	18.5	47.5	25.7	43	56	74	90	BUSSMANN_JKS-90
20BC056	3	30	22	61.9	33.4	56	64	86	110	BUSSMANN_JKS-110
20BC072	3	37	30	80.5	43.5	72	84	112	150	BUSSMANN_JKS-150
20BC085	4	–	37	80.5	43.5	72	108	144	150	BUSSMANN_JKS-150
		45	–	95.1	51.3	85	94	128	200	BUSSMANN_JKS-200
20BH105 (1)	5	–	45	95.1	51.3	85	128	170	200	BUSSMANN_JKS-200
		55	–	117.4	63.4	105	116	158	200	BUSSMANN_JKS-200
20BH125 (1)	5	–	45	91.9	63.7	96	144	168	150	
		55	–	139.8	75.5	125	138	163	225	BUSSMANN_JKS-225
20BH140 (1)	6	–	55	117.4	63.4	105	158	210	200	BUSSMANN_JKS-200
		75	–	158.4	85.6	140	154	210	300	BUSSMANN_JKS-300
20DH170 (1)	6	–	75	158.4	85.6	140	210	280	300	BUSSMANN_JKS-300
		90	–	192.4	103.9	170	187	255	350	BUSSMANN_JKS-350
20DH205 (1)	6	–	90	192.4	103.9	170	255	313	350	BUSSMANN_JKS-350
		110	–	232	125.3	205	220	289	400	BUSSMANN_JKS-400

(1) Also applies to “P” voltage class.

Table 2.W PF700 650 Volt DC Input Protection Devices

Drive Catalog Number	Frame	kW Rating		DC Input Ratings		Output Amps			Fuse	Bussmann Style Fuse
		ND	*HD*	*Amps*	*kW*	*Cont.*	*1 Min.*	*3 Sec.*		
650 Volt DC Input										
20BD1P1	0	0.5	0.33	1.0	0.6	1.1	1.2	1.6	6	BUSSMANN_JKS-6
20BD2P1	0	1	0.75	1.9	1.2	2.1	2.4	3.2	6	BUSSMANN_JKS-6
20BD3P4	0	2	1.5	3.0	2.0	3.4	4.5	6.0	6	BUSSMANN_JKS-6
20BD5P0	0	3	2	4.5	2.9	5.0	5.5	7.5	10	BUSSMANN_JKS-10
20BD8P0	0	5	3	8.1	5.2	8.0	8.8	12	15	BUSSMANN_JKS-15
20BD011	0	7.5	5	11.1	7.2	11	12.1	16.5	20	BUSSMANN_JKS-20
20BD014	1	10	7.5	14.7	9.5	14	16.5	22	30	BUSSMANN_JKS-30
20BD022	1	15	10	23.3	15.1	22	24.2	33	45	BUSSMANN_JKS-45
20BD027	2	20	15	28.9	18.8	27	33	44	60	BUSSMANN_JKS-60
20BD034	2	25	20	36.4	23.6	34	40.5	54	70	BUSSMANN_JKS-70
20BD040	3	30	25	42.9	27.8	40	51	68	80	BUSSMANN_JKS-80
20BD052	3	40	30	55.7	36.1	52	60	80	100	BUSSMANN_JKS-100
20BD065	3	50	40	69.7	45.4	65	78	104	150	BUSSMANN_JKS-150
20BR077 (1)	4	–	50	67.9	45.4	65	98	130	150	BUSSMANN_JKS-150
	4	60	–	84.5	54.7	77	85	116	150	BUSSMANN_JKS-150
20BR096 (1)	5	–	60	84.5	54.7	77	116	154	150	BUSSMANN_JKS-150
		75	–	105.3	68.3	96	106	144	200	BUSSMANN_JKS-200
20BR125 (1)	5	–	75	105.3	68.3	96	144	168	200	BUSSMANN_JKS-200
		100	–	137.1	88.9	125	138	163	250	BUSSMANN_JKS-250
20BR156 (1)	6	–	100	137.1	88.9	125	188	250	250	BUSSMANN_JKS-250
		125	–	171.2	110.9	156	172	234	300	BUSSMANN_JKS-300
20BR180 (1)	6	–	125	171.2	110.9	156	234	312	300	BUSSMANN_JKS-300
		150	–	204.1	132.2	180	198	270	400	BUSSMANN_JKS-400

(1) Also applies to “J” voltage class.

Grounding, General

Refer to "*Wiring and Grounding Guidelines for PWM AC Drives,*" publication DRIVES-IN001.

HIM Memory

See Copy Cat on page 2-55.

HIM Operations

Selecting a Language

See also Language on page 2-111. PowerFlex 700 drives support multiple languages. When you first apply drive power, a language screen appears on the HIM. Use the Up or Down Arrow to scroll through the available languages. Press Enter to select the desired language. To switch to an alternate language, follow the steps below.

Step	Key(s)	Example Displays
1. Press ALT and then the Up Arrow (Lang). The Language screen will appear.	ALT + ▲	Speak English? Parlez Francais? Spechen Duetsch? Plare Italiano?
2. Press the Up Arrow or Down Arrow to scroll through the languages.	▲ ▼	
3. Press Enter to select a language.	↵	

Using Passwords

By default the password is set to 00000 (password protection disabled).

Logging in to the Drive

Step	Key(s)	Example Displays
1. Press the Up or Down Arrow to enter your password. Press Sel to move from digit to digit.	▲ ▼	Login: Enter Password 9999
2. Press Enter to log in.	↵	

Logging Out

Step	Key(s)	Example Displays
You are automatically logged out when the User Display appears. If you want to log out before that, select "log out" from the Main Menu.		

To change a password

Step	Key(s)	Example Displays
1. Use the Up Arrow or Down Arrow to scroll to Operator Intrfc. Press Enter.	▲ ▼	Operator Intrfc: Change Password User Display Parameters
2. Select "Change Password" and press Enter.	↵	
3. Enter the old password. If a password has not been set, type "0." Press Enter.	▲ ▼	Password: Old Code: 0 New Code: 9999 Verify: 9999
4. Enter a new password (1- 65535). Press Enter and verify the new password. Press Enter to save the new password.	↵	

The User Display

The User Display is shown when module keys have been inactive for a predetermined amount of time. The display can be programmed to show pertinent information.

Setting the User Display

Step	Key(s)	Example Displays
1. Press the Up Arrow or Down Arrow to scroll to Operator Intrfc. Press Enter.	▲ ▼	Operator Intrfc: Change Password User Display Parameters
2. Press the Up Arrow or Down Arrow to scroll to User Display. Press Enter.	↵	
3. Select the desired user display. Press Enter. Scroll to the parameter that the user display will be based on.	Sel	
4. Press Enter. Set a scale factor.		
5. Press Enter to save the scale factor and move to the last line.		
6. Press the Up Arrow or Down Arrow to change the text.		
7. Press Enter to save the new user display.		

Setting the Properties of the User Display

The following HIM parameters can be set as desired:

- User Display - Enables or disables the user display.
- User Display 1 - Selects which user display parameter appears on the top line of the user display.
- User Display 2 - Selects which user display parameter appears on the bottom line of the user display.
- User Display Time - Sets how many seconds will elapse after the last programming key is touched before the HIM displays the user display.

Input Devices

Contactors

See Motor Start/Stop Precautions on page 2-121

Circuit Breakers / Fuses

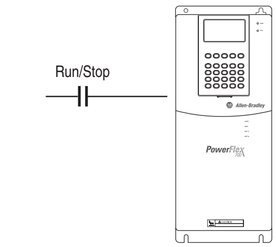
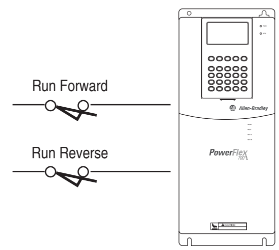
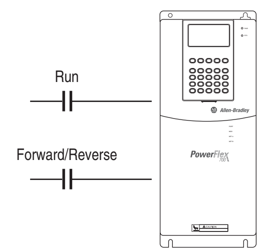
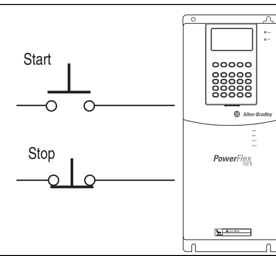
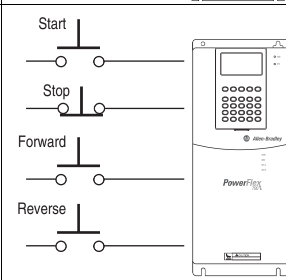
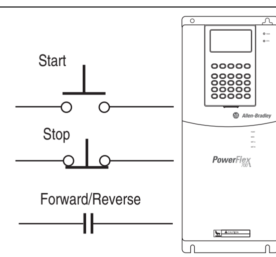
See Fuses and Circuit Breakers on page 2-100

Filters, EMC

Refer to CE Conformity on page 2-53.

Input Modes

The PowerFlex family of drives does not use a direct choice of 2-wire or 3-wire input modes, but allows full configuration of the digital I/O. As a means of defining the modes used, consider the following:

2-Wire Control This input mode is so named because it only utilizes one device and 2 wires to control both the Start (normally referred to as "RUN" in 2-wire) and Stop functions in an application.	• A maintained contact device, such as a thermostat, for example, closes its contact to Run the drive and opens to Stop the drive	
	• In other applications, the maintained device (such as a limit switch), can directly control both Run/Stop and direction control . . .	
	• Or, a combination of the two may be desirable.	
3-Wire Control This input mode utilizes 2 devices requiring 3 wires to control the Start (proper term for 3-wire) and Stop functions in an application. In this case, momentary contact devices, such as pushbuttons are used.	• A Start is issued when the Start button is closed, but unlike 2-wire circuits, the drive does not Stop when the Start button is released. Instead, 3-wire control requires a Stop input to Stop the drive	
	• Direction control is accomplished either with momentary inputs . . .	
	• Or, with a maintained input.	

Input Power Conditioning

Refer to Chapter 2 of “*Wiring and Grounding Guidelines for PWM AC Drives*,” publication DRIVES-IN001A-EN-P.

Jog

Also refer to Jog on page 2-67.

When a JOG command is issued by any of the controlling devices (terminal block digital input, communications adapter or HIM), the drive ouputs voltage and frequency to the motor as long as the command is present. When the command is released, the drive output stops.

Whenever a jog command is present, the value programmed in parameter 100, [Jog Speed] becomes the active speed reference. Regardless of the [Speed Mode] or [Feedback Select] setting, no modifications (i.e. no PI adder, no slip adder, no trim adder, etc.) will be made to the reference.

For PowerFlex 70 and PowerFlex 700 with **Standard Control**, the jog reference will always be a positive number limited between Minimum Speed and Maximum Speed.

If [Direction Mode] = “Unipolar” the drive will jog using the Jog reference parameter value and will use the direction currently selected via the DPI commanded direction. When [Direction Mode] = “Bipolar” and a Jog command (with no direction) is asserted, the drive will jog using the Jog reference parameter (which is always positive or forward). To accommodate jogging with direction while in Bipolar mode (such as from a terminal block), the drive will allow Jog Fwd and Jog Rev to be configured as terminal block inputs. When these inputs are asserted, the drive will jog the requested direction. This still implies that a HIM can only jog in the forward direction when in Bipolar mode since they only transmit a Jog command with no direction via DPI.

For PowerFlex 700 drives with **Vector Control**, 2 independent Jog Speeds (1 and 2) are provided. The jog reference is signed and limited between Minimum Speed or Reverse Speed Limit (whichever is programmed)) and Maximum Speed. In this control, the jog reference controls both speed and direction of the jog operation. If the programmed Jog Speed is negative the drive will jog in the reverse direction: if the Jog Speed value is positive, the drive will jog in the forward direction.

When a jog command is issued, exclusive control of speed and direction is given to the Jog function. If the master speed reference is bipolar and commanding reverse direction but the programmed Jog Speed is a positive value, the drive will jog in the forward direction, overriding the direction control of a bipolar speed reference.

Language

PowerFlex drives are capable of communicating in 7 languages; English, Spanish, German, Italian, French, Portuguese and Dutch. All drive functions and information displayed on an LCD HIM are shown in the selected language. The desired language can be selected several different ways:

- On initial drive power-up, a language choice screen appears.
- The language choice screen can also be recalled at any time to change to a new language. This is accomplished by pressing the "Alt" key followed by the "Lang" key.
- The language can also be changed by selecting the [Language] parameter (201). Note that this parameter is not functional when using an LED HIM.

Linking Parameters

(Vector Control Option Only)

Most parameter values are entered directly by the user. However, certain parameters can be “linked,” so the value of one parameter becomes the value of another. For Example: the value of an analog input can be linked to [Accel Time 2]. Rather than entering an acceleration time directly (via HIM), the link allows the value to change by varying the analog signal. This can provide additional flexibility for advanced applications.

Each link has 2 components:

- Source parameter – sender of information.
- Destination parameter – receiver of information.

Most parameters can be a source of data for a link, except parameter values that contain an integer representing an ENUM (text choice). These are not allowed, since the integer is not actual data (it represents a value). Table 2.X lists the parameters that can be destinations. All links must be established between equal data types (parameter value formatted in floating point can only source data to a destination parameter value that is also floating point).

Establishing A Link

Step	Key(s)	Example Displays
1. Select a valid destination parameter (see Table 2.X) to be linked. The parameter value screen will appear.		FGP: Parameter Accel Time 1 Accel Time 2 Decel Time 1
2. Press Enter to edit the parameter. The cursor will move to the value line.	↵	Min: 0.1 Secs Max: 3600.0 Secs Dflt: 10.0 Secs Present Value
3. Press ALT and then View (Sel). Next, press the Up or Down Arrow to change “Present Value” to “Define Link.” Press Enter.	ALT + Sel ▲ or ▼ ↵	. . . Define Link
4. Enter the Source Parameter Number and press Enter. The linked parameter can now be viewed two different ways by repeating steps 1-4 and selecting “Present Value” or “Define Link.” If an attempt is made to edit the value of a linked parameter, “Parameter is Linked!” will be displayed, indicating that the value is coming from a source parameter and can not be edited.	↵	Parameter: #141 Accel Time 2 Link: 017 Analog In1 Value
5. To remove a link, repeat steps 1-5 and change the source parameter number to zero (0).		
6. Press Esc to return to the group list.	Esc	

Table 2.X Linkable Parameters

Number	Parameter	Number	Parameter
54	Maximum Voltage	160	Bus Reg Ki
56	Compensation	164	Bus Reg Kp
57	Flux Up Mode	165	Bus Reg Kd
58	Flux Up Time	170	Flying StartGain
59	SV Boost Filter	175	Auto Rstrt Delay
62	IR Voltage Drop	180	Wake Level
63	Flux Current Ref	181	Wake Time
69	Start/Acc Boost	182	Sleep Level
70	Run Boost	183	Sleep Time
71	Break Voltage	185	Power Loss Time
72	Break Frequency	186	Power Loss Level
84	Skip Frequency 1	321	Anlg In Sqr Root
85	Skip Frequency 2	322	Analog In1 Hi
86	Skip Frequency 3	323	Analog In1 Lo
87	Skip Freq Band	324	Analog In1 Loss
91	Speed Ref A Hi	325	Analog In2 Hi
92	Speed Ref A Lo	326	Analog In2 Lo
94	Speed Ref B Hi	327	Analog In2 Loss
95	Speed Ref B Lo	343	Analog Out1 Hi
97	TB Man Ref Hi	344	Analog Out1 Lo
98	TB Man Ref Lo	346	Analog Out2 Hi
100	Jog Speed	347	Analog Out2 Lo
101	Preset Speed 1	381	Dig Out1 Level
102	Preset Speed 2	382	Dig Out1 OnTime
103	Preset Speed 3	383	Dig Out1 OffTime
104	Preset Speed 4	385	Dig Out2 Level
105	Preset Speed 5	386	Dig Out2 OnTime
106	Preset Speed 6	387	Dig Out2 OffTime
107	Preset Speed 7	389	Dig Out3 Level
119	Trim Hi	390	Dig Out3 OnTime
120	Trim Lo	391	Dig Out3 OffTime
121	Slip RPM @ FLA	416	Fdbk Filter Sel
122	Slip Comp Gain	419	Notch Filter Freq
123	Slip RPM Meter	420	Notch Filter K
127	PI Setpoint	428	Torque Ref A Hi
129	PI Integral Time	429	Torque Ref A Lo
130	PI Prop Gain	430	Torq Ref A Div
131	PI Lower Limit	432	Torque Ref B Hi
132	PI Upper Limit	433	Torque Ref B Lo
133	PI Preload	434	Torq Ref B Mult
140	Accel Time 1	435	Torque Setpoint
141	Accel Time 2	436	Pos Torque Limit
142	Decel Time 1	437	Neg Torque Limit
143	Decel Time 2	445	Ki Speed Loop
146	S-Curve %	446	Kp Speed Loop
148	Current Lmt Val	447	Kf Speed Loop
149	Current Lmt Gain	449	Speed Desired BW
151	PWM Frequency	450	Total Inertia
152	Droop RPM @ FLA	454	Rev Speed Limit
153	Regen Power Limit	460	PI Reference Hi
154	Current Rate Limit	461	PI Reference Lo
158	DC Brake Level	462	PI Feedback Hi
159	DC Brake Time	463	PI Feedback Lo

Masks

A mask is a parameter that contains one bit for each of the possible Adapters. Each bit acts like a valve for issued commands. Closing the valve (setting a bit's value to 0) stops the command from reaching the drive logic. Opening the valve (setting a bit's value to 1) allows the command to pass through the mask into the drive logic.

File	Group	No.	Parameter Name & Description	Values	Related
COMMUNICATION	Masks & Owners	276	**[Logic Mask]** Determines which adapters can control the drive. If the bit for an adapter is set to "0," the adapter will have no control functions except for stop.		288 thru 297

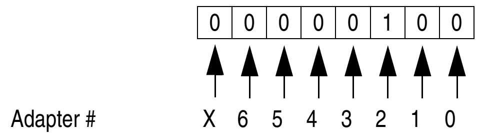
	x	x	x	x	x	x	x	x	x	x	Digital In... DPI Port 5	DPI Port 4	DPI Port 3	DPI Port 2	DPI Port 1	Digital In
Factory Default Bit Values	x	x	x	x	x	x	x	x	x	x	1	1	1	1	1	1
Bit #	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

1 =Control Permitted
0 =Control Masked
x =Reserved

File	Group	No.	Parameter Name & Description	Values	Related
COMMUNICATION	Masks & Owners	277	**[Start Mask]** Controls which adapters can issue start commands.	See [Logic Mask].	288 thru 297
		278	**[Jog Mask]** Controls which adapters can issue jog commands.	See [Logic Mask].	288 thru 297
		279	**[Direction Mask]** Controls which adapters can issue forward/reverse direction commands.	See [Logic Mask].	288 thru 297
		280	**[Reference Mask]** Controls which adapters can select an alternate reference; [Speed Ref A, B Sel] or [Preset Speed 1-7].	See [Logic Mask].	288 thru 297
		281	**[Accel Mask]** Controls which adapters can select [Accel Time 1, 2].	See [Logic Mask].	288 thru 297
		282	**[Decel Mask]** Controls which adapters can select [Decel Time 1, 2].	See [Logic Mask].	288 thru 297
		283	**[Fault Clr Mask]** Controls which adapters can clear a fault.	See [Logic Mask].	288 thru 297
		284	**[MOP Mask]** Controls which adapters can issue MOP commands to the drive.	See [Logic Mask].	288 thru 297
		285	**[Local Mask]** Controls which adapters are allowed to take exclusive control of drive logic commands (except stop). Exclusive "local" control can only be taken while the drive is stopped.	See [Logic Mask].	288 thru 297

Example: A customer's process is normally controlled by a remote PLC, but the drive is mounted on the machine. The customer does not want anyone to walk up to the drive and reverse the motor because it would damage the process. The local HIM (drive mounted Adapter 1) is configured with an operator's panel that includes a "REV" Button. To assure that only the PLC (connected to Adapter 2) has direction control, the [Direction Mask] can be set as follows:

Direction Mask



This "masks out" the reverse function from all adapters except Adapter 2, making the local HIM (Adapter 1) REV button inoperable. Also see Owners on page 2-127.

MOP

The Motor Operated Pot (MOP) function is one of the sources for the frequency reference. The MOP function uses digital inputs to increment or decrement the Speed reference at a programmed rate.

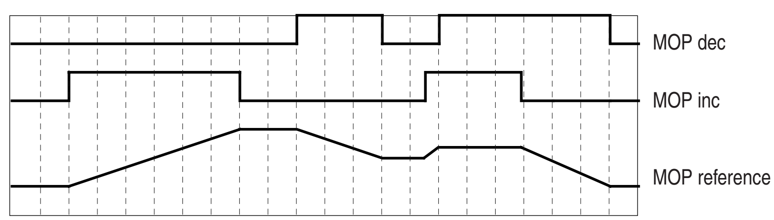
The MOP has three components:

- [MOP Rate] parameter
- [Save MOP Ref] parameter
- [MOP Frequency] parameter

MOP increment input

MOP decrement input

The MOP reference rate is defined in [MOP rate]. The MOP function is defined graphically below



MOP rate is defined in Hz/sec. The MOP reference will increase/decrease linearly at that rate as long as the MOP inc or dec is asserted via TB or DPI port (the MOP inputs are treated as level sensitive).

Both the MOP inc and dec will use the same rate (i.e. they can not be separately configured). The MOP rate is the rate of change of the MOP reference. The selected active MOP reference still feeds the ramp function to arrive at the present commanded speed/frequency (eg. is still based on the accel/decel rates). Asserting both MOP inc and dec inputs simultaneously will result in no change to the MOP reference.

[Save MOP Ref] is a packed boolean parameter with two bits used as follows:

Bit 0
0 = Don't save MOP reference on power-down (default)
1 = Save MOP reference on power-down

If the value is "SAVE MOP Ref" when the drive power returns, the MOP reference is reloaded with the value from the non-volatile memory. When the bit is set to 0, the MOP reference defaults to zero when power is restored. The MOP save reference parameter and the MOP rate parameter can be changed while the drive is running.

Bit 1
0 = Reset MOP reference when STOP edge is asserted
1 = Don't reset MOP reference when STOP is asserted (default)

Important: The MOP reset only occurs on the *stop* edge and is not continuously cleared because the *stop* is asserted (this is always processed when a *stop* edge is seen, even if the drive is stopped). The reset only applies to the stop edge and not when a fault is detected.

In order to change the MOP reference (increment or decrement) a given DPI port must have the MOP mask asserted (and the logic mask asserted). In the case of the terminal block, if the MOP increment or MOP decrement function is assigned to a digital input, then the act of asserting either of those inputs will cause the TB to try and gain ownership of the MOP inc/dec reference change.

Ownership of the MOP function can be obtained even if the MOP reference is not being used to control the drive. If ownership is granted, the owner has the right to inc/dec the MOP reference. Whether this reference is the active speed reference for the drive is separately selected via TB reference select, or Ref A/B select through DPI.

The MOP Frequency parameter is an output which shows the active value of the MOP reference in Hz x 10.

MOP handling with Direction Mode

If the Direction Mode is configured for "Unipolar," then the MOP decrement will clamp at zero not allowing the user to generate a negative MOP reference that is clamped off by the reference generation. When Direction Mode = "Bipolar" the MOP reference will permit the decrement function to produce negative values. If the drive is configured for Direction Mode = "Bipolar" and then is changed to "Unipolar", the MOP reference will also be clamped at zero if it was less than zero.

Motor Control

See Torque Performance Modes on page 2-205

Motor Nameplate

[Motor NP Volts]
The motor nameplate base voltage defines the output voltage, when operating at rated current, rated speed, and rated temperature.

[Motor NP FLA]
The motor nameplate defines the output amps, when operating at rated voltage, rated speed, and rated temperature. It is used in the motor thermal overload, and in the calculation of slip.

[Motor NP Hz]
The motor nameplate base frequency defines the output frequency, when operating at rated voltage, rated current, rated speed, and rated temperature.

[Motor NP RPM]
The motor nameplate RPM defines the rated speed, when operating at motor nameplate base frequency, rated current, base voltage, and rated temperature. This is used to calculate slip.

[Motor NP Power]
The motor nameplate power is used together with the other nameplate values to calculate default values for motor parameters to and facilitate the commissioning process. This may be entered in horsepower or in kilowatts as selected in the previous parameter or kW for certain catalog numbers and HP for others.

[Motor NP Pwr Units]
Determines the units for [Motor NP Power]. Possible setting are:
0 "Horsepower" - units are displayed in HP
1 "kilowatts" - units are displayed in kW
The following are only available with the PowerFlex 700 Vector option
2 "Convert HP" - converts units to HP (from kW) by dividing [Motor NP Power] by 0.746.
3 "Covert kW" - converts units to kW (from HP) by multiplying [Motor NP Power] by 0.746.

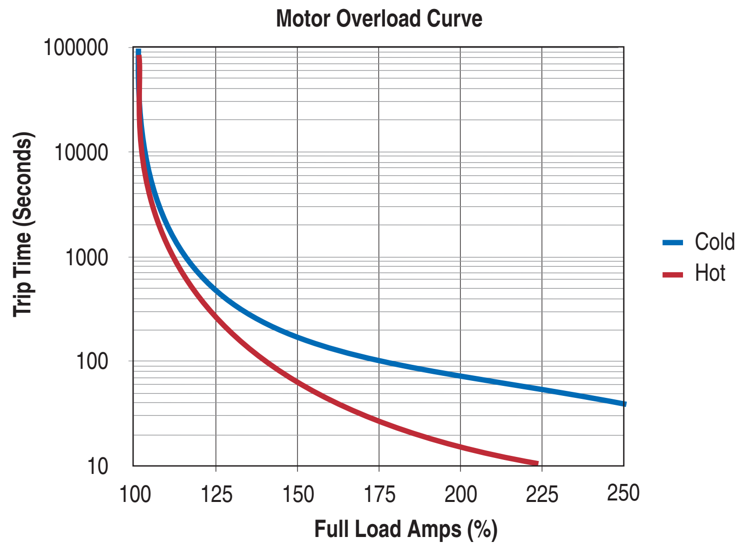
Vector [Motor Poles]
Defines the number of motor poles in the motor. [Motor Poles] is calculated automatically if the user enters the motor nameplate data through the Start-up menu of an LCD HIM. The number of motor poles is defined by:

$$P = \frac{120f}{N}$$

where:
P = motor poles
f = base motor frequency (Hz)
N = base motor speed (RPM)
P is rounded up to the nearest whole even number

Motor Overload

The motor thermal overload uses an IT algorithm to model the temperature of the motor. The curve is modeled after a Class 10 protection thermal overload relay that produces a theoretical trip at 600% motor current in ten (10) seconds and continuously operates at full motor current.

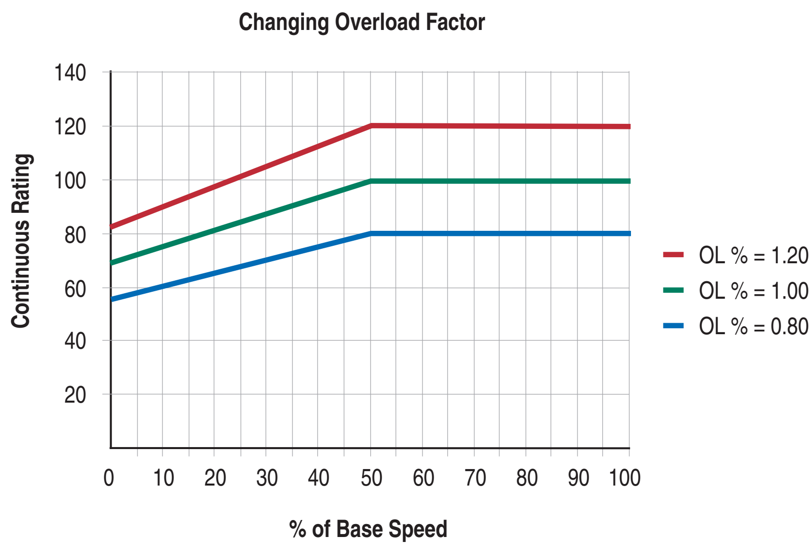


Motor nameplate FLA programming is used to set the overload feature. This parameter, which is set in the start up procedure, is adjustable from 0 - 200% of drive rating and should be set for the actual motor FLA rating.

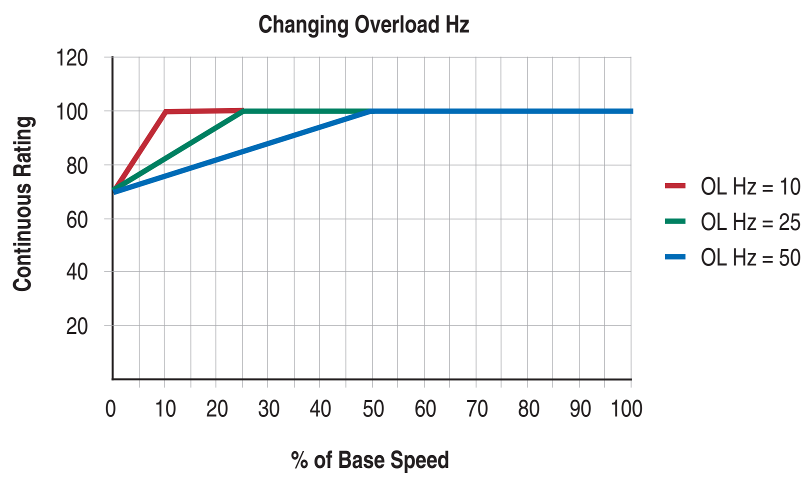
Setting the correct bit in [Fault Config x] to zero disables the motor thermal overload. Most multimotor applications (using one drive and more than one motor) will require the MTO to be disabled since the drive would be unable to distinguish each individual motor's current and provide protection.

Operation of the overload is based on three parameters; [Motor NP FLA], [Motor OL Factor] and [Motor OL Hertz].

1. [Motor NP FLA] is the base value for motor protection.
2. [Motor OL Factor] is used to adjust for the service factor of the motor. Within the drive, motor nameplate FLA is multiplied by motor overload factor to select the rated current for the motor thermal overload. This can be used to raise or lower the level of current that will cause the motor thermal overload to trip without the need to adjust the motor FLA. For example, if motor nameplate FLA is 10 Amps and motor overload factor is 1.2, then motor thermal overload will use 12 Amps as 100%.

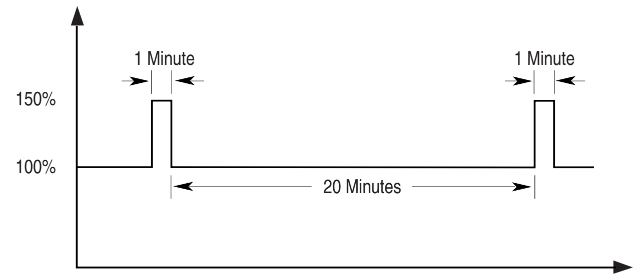


3. [Motor OL Hertz] is used to further protect motors with limited speed ranges. Since some motors may not have sufficient cooling ability at lower speeds, the Overload feature can be programmed to increase protection in the lower speed areas. This parameter defines the frequency where derating the motor overload capacity should begin. As shown here, the motor overload capacity is reduced when operating below the motor overload Hz. For all settings of overload Hz other than zero, the overload capacity is reduced to 70% when output frequency is zero. During DC injection the motor current may exceed 70% of FLA, but this will cause the Motor Thermal Overload to trip sooner than when operating at base speed. At low frequencies, the limiting factor may be the Drive Thermal Overload.



Duty Cycle for the Motor Thermal Overload

When the motor is cold motor thermal overload will allow 3 minutes at 150%. When the motor is hot motor thermal overload will allow 1 minute at 150%. A continuous load of 102% will not trip. The duty cycle of the motor thermal overload is defined as follows. If operating continuous at 100% FLA, and the load increases to 150% FLA for 59 seconds and then returns to 100%FLA, the load must remain at 100% FLA for 20 minutes to reach steady state.



The ratio of 1:20 is the same for all durations of 150%. When operating continuous at 100%, if the load increases to 150% for 1 second the load must then return to 100% for 20 seconds before another step to 150%

FLA%	Cold Trip Time	Hot Trip Time
105	6320	5995
110	1794	1500
115	934	667
120	619	375
125	456	240
130	357	167
135	291	122
140	244	94
145	209	74
150	180	60

FLA%	Cold Trip Time	Hot Trip Time
155	160	50
160	142	42
165	128	36
170	115	31
175	105	27
180	96	23
185	88	21
190	82	19
195	76	17
200	70	15

FLA%	Cold Trip Time	Hot Trip Time
205	66	14
210	62	12
215	58	11
220	54	10
225	51	10
230	48	9
235	46	8
240	44	8
245	41	7
250	39	7

Motor Start/Stop Precautions

Input Contactor Precautions

ATTENTION: A contactor or other device that routinely disconnects and reapplies the AC line to the drive to start and stop the motor can cause drive hardware damage. The drive is designed to use control input signals that will start and stop the motor. If an input device is used, operation must not exceed one cycle per minute or drive damage will occur.

ATTENTION: The drive start/stop/enable control circuitry includes solid state components. If hazards due to accidental contact with moving machinery or unintentional flow of liquid, gas or solids exist, an additional hardwired stop circuit may be required to remove the AC line to the drive. An auxiliary braking method may be required.

Output Contactor Precaution

ATTENTION: To guard against drive damage when using output contactors, the following information must be read and understood. One or more output contactors may be installed between the drive and motor(s) for the purpose of disconnecting or isolating certain motors/loads. If a contactor is opened while the drive is operating, power will be removed from the respective motor, but the drive will continue to produce voltage at the output terminals. In addition, reconnecting a motor to an active drive (by closing the contactor) could produce excessive current that may cause the drive to fault. If any of these conditions are determined to be undesirable or unsafe, an auxiliary contact on the output contactor should be wired to a drive digital input that is programmed as "Enable." This will cause the drive to execute a coast-to-stop (cease output) whenever an output contactor is opened.

Bypass Contactors

ATTENTION: An incorrectly applied or installed bypass system can result in component damage or reduction in product life. The most common causes are:

- Wiring AC line to drive output or control terminals.
- Improper bypass or output circuits not approved by Allen-Bradley.
- Output circuits which do not connect directly to the motor.

Contact Allen-Bradley for assistance with application or wiring.

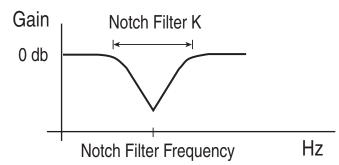
Mounting

Refer to the Chapter 1 of the correct drive User Manual for mounting instructions and limitations. As a general rule, drives should be mounted on a metallic flat surface in the vertical orientation. If other orientations are being considered, contact the factory for additional data.

Notch Filter

Vector FV The 700 Vector has a notch filter in the torque reference loop used to eliminate mechanical resonance created by a gear train. [Notch Filter Freq] sets the center frequency for the 2 pole notch filter, and [Notch Filter K] sets the gain.

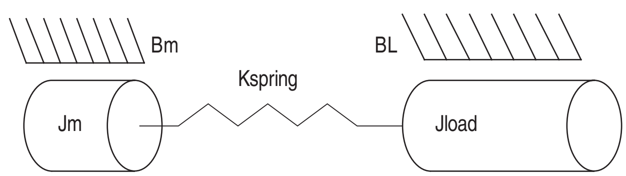
Figure 2.23 Notch Filter Frequency



Due to the fact that most mechanical frequencies are described in Hertz, [Notch Filter Freq] and [Notch Filter K] are in Hertz as well. The following is an example of a notch filter.

A mechanical gear train consists of two masses (the motor and the load) and spring (mechanical coupling between the two loads). See Figure 2.24.

Figure 2.24 Mechanical Gear Train



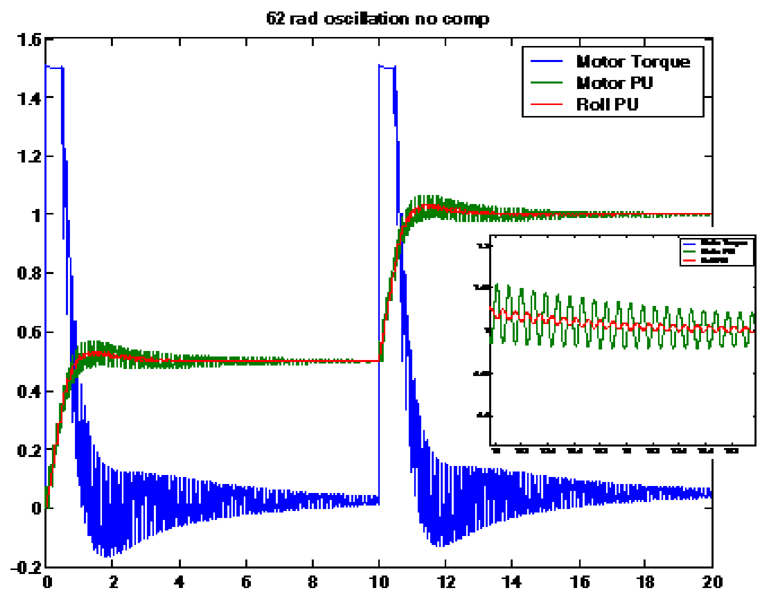
The resonant frequency is defined by the following equation:

$$resonance = \sqrt{Kspring\frac{(Jm + Jload)}{Jm \times Jload}}$$

Jm is the motor inertia (seconds)
Jload is the load inertia (seconds)
Kspring is the coupling spring constant (rad^2/sec)

Figure 2.25 shows a two mass system with a resonant frequency of 62 radians/second (9.87 Hz). One Hertz is equal to 2ðπ radians/second.

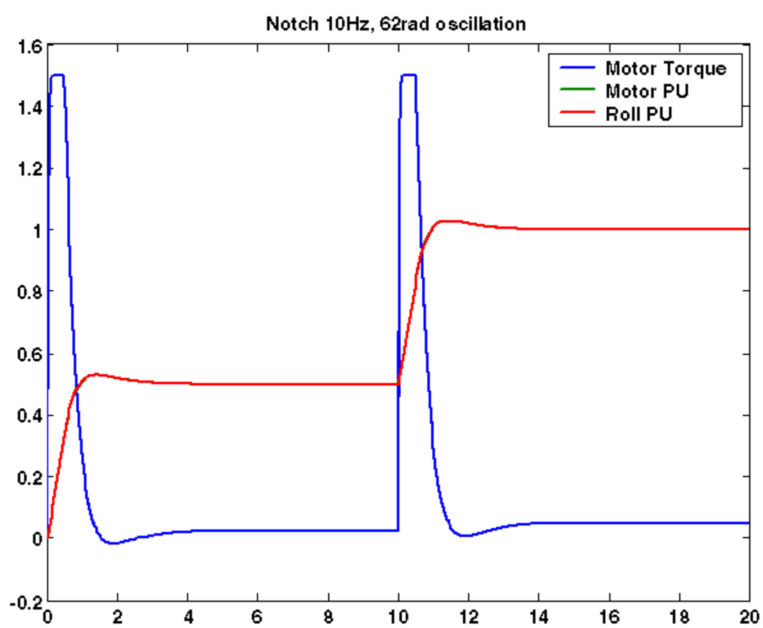
Figure 2.25 Resonance



The insert shows the resonant frequency in detail.

Figure 2.26 shows the same mechanical gear train as Figure 2.25. [Notch Filter Freq] is set to 10.

Figure 2.26 10 Hz Notch



Output Current

[Output Current]

This parameter displays the total output current of the drive. The current value displayed here is the vector sum of both torque producing and flux producing current components.

Output Devices

Drive Output Contactor

ATTENTION: To guard against drive damage when using output contactors, the following information must be read and understood. One or more output contactors may be installed between the drive and motor(s) for the purpose of disconnecting or isolating certain motors/loads. If a contactor is opened while the drive is operating, power will be removed from the respective motor, but the drive will continue to produce voltage at the output terminals. In addition, reconnecting a motor to an active drive (by closing the contactor) could produce excessive current that may cause the drive to fault. If any of these conditions are determined to be undesirable or unsafe, an auxiliary contact on the output contactor should be wired to a drive digital input that is programmed as "Enable." This will cause the drive to execute a coast-to-stop (cease output) whenever an output contactor is opened.

Also see Input Devices on page 2-108.

Cable Termination

Voltage doubling at motor terminals, known as reflected wave phenomenon, standing wave or transmission line effect, can occur when using drives with long motor cables.

Inverter duty motors with phase-to-phase insulation ratings of 1200 volts or higher should be used to minimize effects of reflected wave on motor insulation life.

Applications with non-inverter duty motors or any motor with exceptionally long leads may require an output filter or cable terminator. A filter or terminator will help limit reflection to the motor, to levels which are less than the motor insulation rating.

Cable length restrictions for unterminated cables are discussed on page 2-51. Remember that the voltage doubling phenomenon occurs at different lengths for different drive ratings. If your installation requires longer motor cable lengths, a reactor or cable terminator is recommended.

Optional Output Reactor

Bulletin 1321 Reactors can be used for drive input and output. These reactors are specifically constructed to accommodate IGBT inverter applications with switching frequencies up to 20 kHz. They have a UL approved dielectric strength of 4000 volts, opposed to a normal rating of 2500 volts. The first two and last two turns of each coil are triple insulated to guard against insulation breakdown resulting from high dv/dt. When using motor line reactors, it is recommended that the drive PWM frequency be set to its lowest value to minimize losses in the reactors.

By using an output reactor the effective motor voltage will be lower because of the voltage drop across the reactor - this may also mean a reduction of motor torque.

Output Frequency

[Output Frequency]

This parameter displays the actual output frequency of the drive. The output frequency is created by a summation of commanded frequency and any active speed regulator such as slip compensation, PI Loop, bus regulator. The actual output may be different than the commanded frequency.

Output Power

This parameter displays the output kW of the drive. The output power is a calculated value and tends to be inaccurate at lower speeds. It is not recommended for use as a process variable to control a process.

Output Voltage

[Output Voltage]

This parameter displays the actual output voltage at the drive output terminals. The actual output voltage may be different than that determined by the sensorless vector or V/Hz algorithms because it may be modified by features such as the Auto-Economizer.

Overspeed Limit

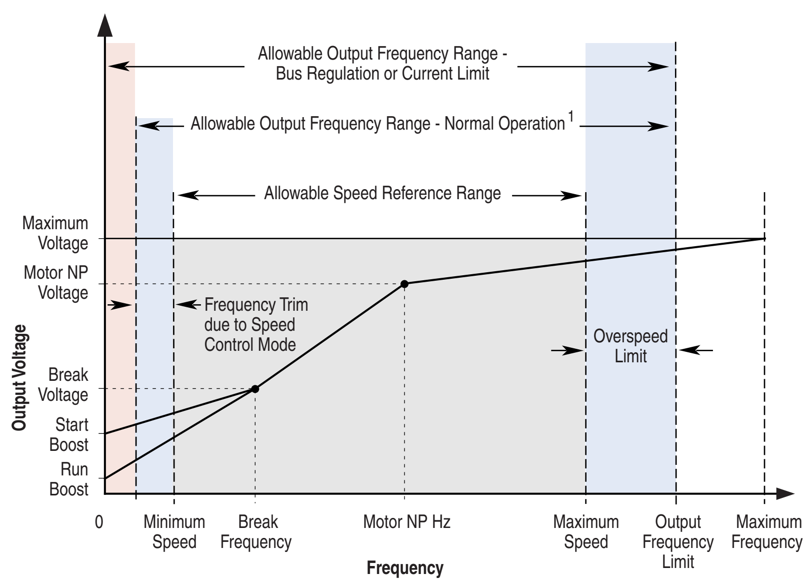
The Overspeed Limit is a user programmable value that allows operation at maximum speed but also provides an "overspeed band" that will allow a speed regulator such as encoder feedback or slip compensation to increase the output frequency above maximum Speed in order to maintain maximum Motor Speed.

Figure 2.27 illustrates a typical Custom V/Hz profile. Minimum Speed determines the lower speed reference limit during normal operation. Maximum Speed determines the upper speed reference limit. The two "Speed" parameters only limit the speed reference and not the output frequency.

The actual output at maximum speed reference is the sum of the speed reference plus "speed adder" components from functions such as slip compensation, encoder feedback or process trim.

The Overspeed Limit is added to Maximum Speed and the sum of the two (Speed Limit) limits is output. This sum (Speed Limit) is compared to Maximum Frequency and an alarm is initiated which prevents operation if the Speed Limit exceeds Maximum Frequency.

Figure 2.27 Typical V/Hz Curve for Full Custom (with Speed/Frequency Limits



Note 1: The lower limit on this range can be 0 depending on the value of Speed Adder

Owners

An owner is a parameter that contains one bit for each of the possible DPI or SCANport adapters. The bits are set high (value of 1) when its adapter is currently issuing that command, and set low when its adapter is not issuing that command. Ownership falls into two categories;

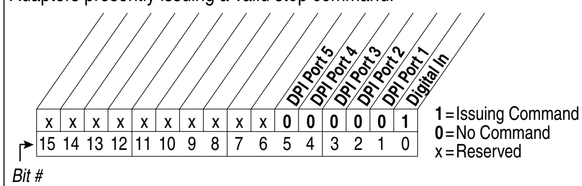
Exclusive

Only one adapter at a time can issue the command and only one bit in the parameter will be high.

For example, it is not allowable to have one Adapter command the drive to run in the forward direction while another Adapter is issuing a command to make the drive run in reverse. Direction Control, therefore, is exclusive ownership.

Non Exclusive

Multiple adapters can simultaneously issue the same command and multiple bits may be high.

File	Group	No.	Parameter Name & Description	Values	Related
COMMUNICATIONS	Masks & Owners	288	**[Stop Owner]** Adapters presently issuing a valid stop command. 	Read Only	276 thru 285
		289	**[Start Owner]** Adapters that are presently issuing a valid start command.	See [Stop Owner]	276 thru 285
		290	**[Jog Owner]** Adapters that are presently issuing a valid jog command.	See [Stop Owner]	276 thru 285
		291	**[Direction Owner]** Adapter that currently has exclusive control of direction changes.	See [Stop Owner]	276 thru 285
		292	**[Reference Owner]** Adapter that has the exclusive control of the command frequency source selection.	See [Stop Owner]	276 thru 285
		293	**[Accel Owner]** Adapter that has exclusive control of selecting [Accel Time 1, 2].	See [Stop Owner]	140 276 thru 285
		294	**[Decel Owner]** Adapter that has exclusive control of selecting [Decel Time 1, 2].	See [Stop Owner]	142 276 thru 285
		295	**[Fault Clr Owner]** Adapter that is presently clearing a fault.	See [Stop Owner]	276 thru 285
		296	**[MOP Owner]** Adapters that are currently issuing increases or decreases in MOP command frequency.	See [Stop Owner]	276 thru 285
		297	**[Local Owner]** Adapter that has requested exclusive control of all drive logic functions. If an adapter is in local lockout, all other functions (except stop) on all other adapters are locked out and non-functional. Local control can only be obtained when the drive is not running.	See [Stop Owner]	276 thru 285

Conversely, any number of adapters can simultaneously issue Stop Commands. Therefore, Stop Ownership is **not** exclusive.

Example:

The operator presses the Stop button on the Local HIM to stop the drive. When the operator attempts to restart the drive by pressing the HIM Start button, the drive does not restart. The operator needs to determine why the drive will not restart.

The operator first views the Start owner to be certain that the Start button on the HIM is issuing a command.

Start Owner

	0	0	0	0	0	0	0	0
Adapter #	X	6	5	4	3	2	1	0

When the local Start button is pressed, the display indicates that the command is coming from the HIM.

Start Owner

	0	0	0	0	0	0	1	0
Adapter #	X	6	5	4	3	2	1	0

The [Start Owner] indicates that there is not any maintained Start commands causing the drive to run.

Stop Owner

	0	0	0	0	0	0	0	1
Adapter #	X	6	5	4	3	2	1	0

The operator then checks the Stop Owner. Notice that bit 0 is a value of “1,” indicating that the Stop device wired to the Digital Input terminal block is open, issuing a Stop command to the drive.

Until this device is reclosed, a permanent Start Inhibit condition exists and the drive will not restart.

Also refer to Start Inhibits and Start Permissives.

Parameter Access Level

The PowerFlex 70 allows the user to restrict the number of parameters that are viewable on the LCD or LED HIM. By limiting the parameter view to the most commonly adjusted set, additional features that may make the drive seem more complicated are hidden.

If you are trying to gain access to a particular parameter and the HIM skips over it, you must change the parameter view from “Basic” to “Advanced.” This can be accomplished in two different ways:

- Press “Alt” and then “View” from the HIM and change the view.

or

- Reprogram Parameter 196 [Param Access Lvl] to “Advanced”.

PET

Pulse Elimination Technique – See Reflected Wave on page 2-152.

Power Loss

Some processes or applications cannot tolerate drive output interruptions caused by momentary power outages. When AC input line power is interrupted to the drive, user programming can determine the drive's reaction.

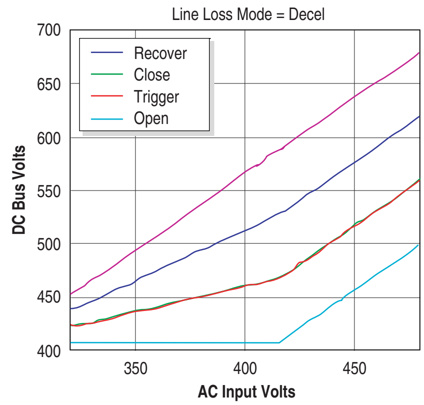
Terms

The following is a definition of terms. Some of these values are drive parameters and some are not. The description of how these operate is explained below

Term	Definition
Vbus	The instantaneous DC bus voltage.
Vmem	The average DC bus voltage. A measure of the "nominal" bus voltage determined by heavily filtering bus voltage. Just after the pre-charge relay is closed during the initial power-up bus pre-charge, bus memory is set equal to bus voltage. Thereafter it is updated by ramping at a very slow rate toward Vbus. The filtered value ramps at 2.4V DC per minute (for a 480VAC drive). An increase in Vmem is blocked during deceleration to prevent a false high value due to the bus being pumped up by regeneration. Any change to Vmem is blocked during inertia ride through.
Vslew	The rate of change of Vmem in volts per minute.
Vrecover	The threshold for recovery from power loss.
Vtrigger	The threshold to detect power loss. PowerFlex 700 The level is adjustable. The default is the value in the PF700 Bus Level table. If "Pwr Loss Lvl" is selected as an input function AND energized, Vtrigger is set to Vmem minus [Power Loss Level]. Vopen is normally 60V DC below Vtrigger (in a 480VAC drive). Both Vopen and Vtrigger are limited to a minimum of Vmin. This is only a factor if [Power Loss Level] is set to a large value. PowerFlex 70 This is a fixed value. **WARNING:** When using a value of Parameter #186 [Power Loss Level] larger than default, the customer must provide a minimum line impedance to limit inrush current when the power line recovers. The input impedance should be equal or greater than the equivalent of a 5% transformer with a VA rating 5 times the drive's input VA rating.
Vinertia	The software regulation reference for Vbus during inertia ride through.
Vclose	The threshold to close the pre-charge contactor.
Vopen	The threshold to open the pre-charge contactor.
Vmin	The minimum value of Vopen.
Voff	The bus voltage below which the switching power supply falls out of regulation.

Table 2.Y PF70 Bus Levels

Class	**200/240 VAC**	**400/480 VAC**	**600/690 VAC**
Vslew	1.2V DC	2.4V DC	3.0V DC
Vrecover	Vmem – 30V	Vmem – 60V	Vmem – 75V
Vclose	Vmem – 60V	Vmem – 120V	Vmem – 150V
Vtrigger1	Vmem – 60V	Vmem – 120V	Vmem – 150V
Vtrigger2	Vmem – 90V	Vmem – 180V	Vmem – 225V
Vopen	Vmem – 90V	Vmem – 180V	Vmem – 225V
Vmin	204V DC	407V DC	509V DC
Voff 3	?	300V DC	?



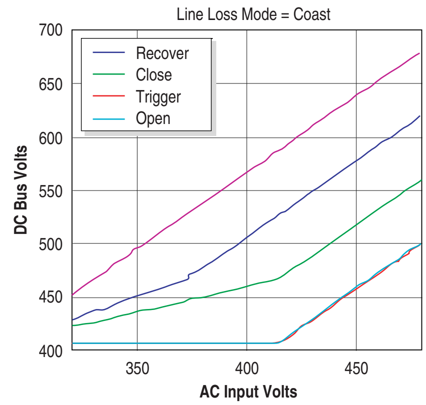
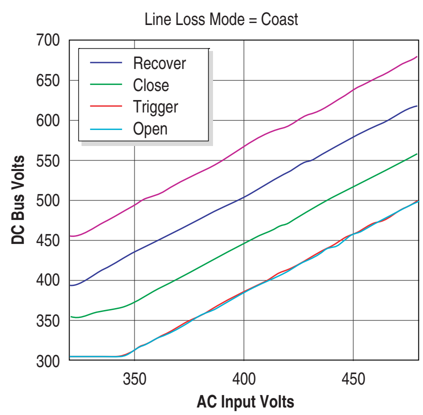
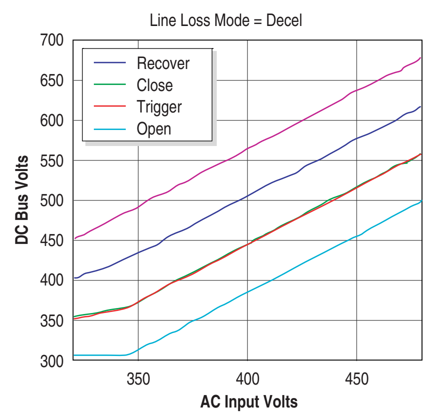


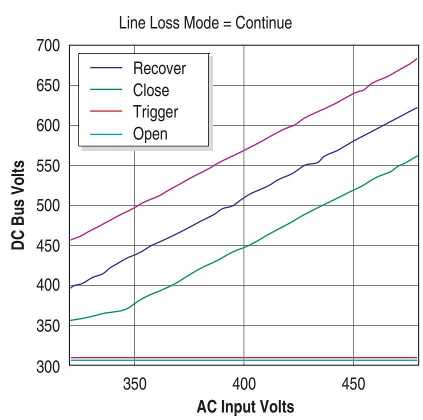
Table 2.Z PF700 Bus Levels

Class	200/240V AC	400/480V AC	600/690V AC
Vslew	1.2V DC	2.4V DC	3.0V DC
Vrecover	Vmem – 30V	Vmem – 60V	Vmem – 75V
Vclose	Vmem – 60V	Vmem – 120V	Vmem – 150V
Vtrigger1,2	Vmem – 60V	Vmem – 120V	Vmem – 150V
Vtrigger1,3	Vmem – 90V	Vmem – 180V	Vmem – 225V
Vopen	Vmem – 90V	Vmem – 180V	Vmem – 225V
Vopen4	153V DC	305V DC	382V DC
Vmin	153V DC	305V DC	382V DC
Voff 5	–	200V DC	–

Note 1:Vtrigger is adjustable, these are the standard values.







Restart after Power Restoration

If a power loss causes the drive to coast and power recovers the drive will return to powering the motor if it is in a “run permit” state. The drive is in a “run permit” state if:

3 wire mode – it is not faulted and if all Enable and Not Stop inputs are energized.

2 wire mode – it is not faulted and if all Enable, Not Stop, and Run inputs are energized.

Power Loss Actions

The drive is designed to operate at a nominal bus voltage. When Vbus falls below this nominal value by a significant amount, action can be taken to preserve the bus energy and keep the drive logic alive as long as possible. The drive will have three methods of dealing with low bus voltages:

- “Coast” – Disable the transistors and allow the motor to coast.
- “Decel” – Decelerate the motor at just the correct rate so that the energy absorbed from the mechanical load balances the losses.
- “Continue” – Allow the drive to power the motor down to half bus voltage.

Power Loss	184	**[Power Loss Mode]** Sets the reaction to a loss of input power. Power loss is recognized when: • DC bus voltage is ≤ 73% of [DC Bus Memory] and [Power Loss Mode] is set to “Coast”. • DC bus voltage is ≤ 82% of [DC Bus Memory] and [Power Loss Mode] is set to “Decel”.	Default: Options:	0 “Coast” 0 “Coast” 1 “Decel” 2 “Continue” 3 “Coast Input” 4 “Decel Input”	013 185

Coast

This is the default mode of operation.

The drive determines a power loss has occurred if the bus voltage drops below Vtrigger. If the drive is running the inverter output is disabled and the motor coasts.

The power loss alarm in [Drive Alarm 1] is set and the power loss timer starts.

The Alarm bit in [Drive Status 1] is set if the Power Loss bit in [Alarm Config 1] is set.

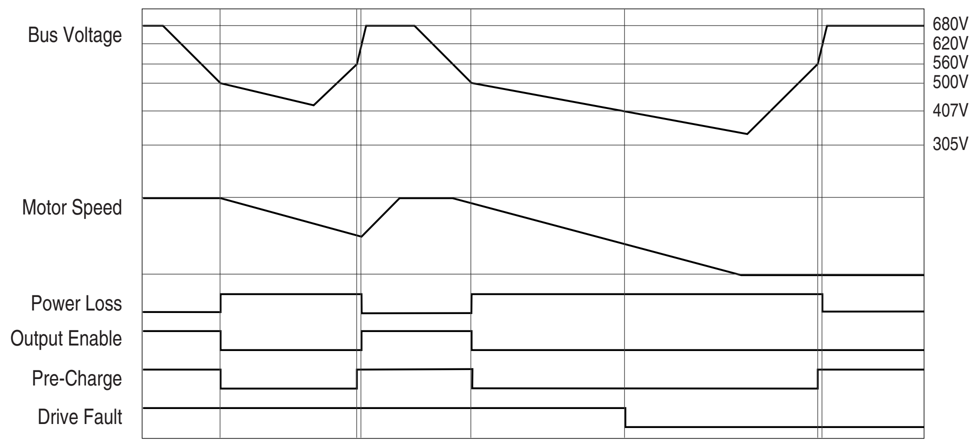
The drive faults with a F003 – Power Loss Fault if the power loss timer exceeds [Power Loss Time] and the Power Loss bit in [Fault Config 1] is set.

The drive faults with a F004 – UnderVoltage fault if the bus voltage falls below Vmin and the UnderVoltage bit in [Fault Config 1] is set.

The pre-charge relay opens if the bus voltage drops below Vopen and closes if the bus voltage rises above Vclose

If the bus voltage rises above Vrecover for 20mS, the drive determines the power loss is over. The power loss alarm is cleared.

If the drive is in a “run permit” state, the reconnect algorithm is run to match the speed of the motor. The drive then accelerates at the programmed rate to the set speed.



480V example shown, see Table 2.Z for further information.

Decel

This mode of operation is useful if the mechanical load is high inertia and low friction. By recapturing the mechanical energy, converting it to electrical energy and returning it to the drive, the bus voltage is maintained. As long as there is mechanical energy, the ride through time is extended and the motor remains fully fluxed up. If AC input power is restored, the drive can ramp the motor to the correct speed without the need for reconnecting.

The drive determines a power loss has occurred if the bus voltage drops below Vtrigger.

If the drive is running, the inertia ride through function is activated.

The load is decelerated at just the correct rate so that the energy absorbed from the mechanical load balances the losses and bus voltage is regulated to the value Vinertia.

The Power Loss alarm in [Drive Alarm 1] is set and the power loss timer starts.

The Alarm bit in [Drive Status 1] is set if the Power Loss bit in [Alarm Config 1] is set.

The drive faults with a F003 – Power Loss fault if the power loss timer exceeds [Power Loss Time] and the Power Loss bit in [Fault Config 1] is set.

The drive faults with a F004 – UnderVoltage fault if the bus voltage falls below Vmin and the UnderVoltage bit in [E238 Fault Config 1] is set.

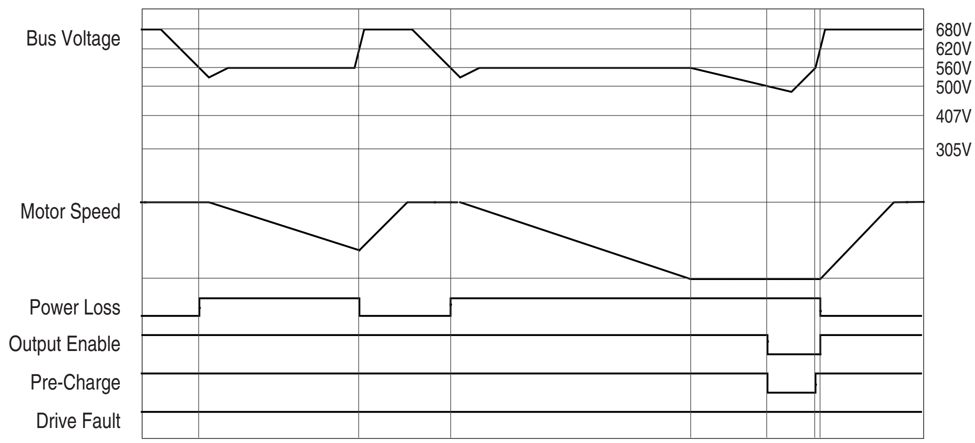
The inverter output is disabled and the motor coasts if the output frequency drops to zero or if the bus voltage drops below Vopen or if any of the “run permit” inputs are de-energized.

The pre-charge relay opens if the bus voltage drops below Vopen.

The pre-charge relay closes if the bus voltage rises above Vclose

If the bus voltage rises above Vrecover for 20mS, the drive determines the power loss is over. The power loss alarm is cleared.

If the drive is still in inertia ride through operation, the drive immediately accelerates at the programmed rate to the set speed. If the drive is coasting and it is in a “run permit” state, the reconnect algorithm is run to match the speed of the motor. The drive then accelerates at the programmed rate to the set speed.



480V example shown, see Table 2.Z for further information.

Half Voltage

This mode provides the maximum power ride through. In a typical application 230VAC motors are used with a 480VAC drive, the input voltage can then drop to half and the drive is still able to supply full power to the motor.

ATTENTION: To guard against drive damage, a minimum line impedance must be provided to limit inrush current when the power line recovers. The input impedance should be equal or greater than the equivalent of a 5% transformer with a VA rating 6 times the drive’s input VA rating.

The drive determines a power loss has occurred if the bus voltage drops below Vtrigger.

If the drive is running the inverter output is disabled and the motor coasts.

If the bus voltage drops below Vopen/Vmin (In this mode of operation Vopen and Vmin are the same value) or if the Enable input is de-energized, the inverter output is disabled and the motor coasts. If the Not Stop or Run inputs are de-energized, the drive stops in the programmed manner.

The pre-charge relay opens if the bus voltage drops below Vopen/Vmin and closes if the bus voltage rises above Vclose.

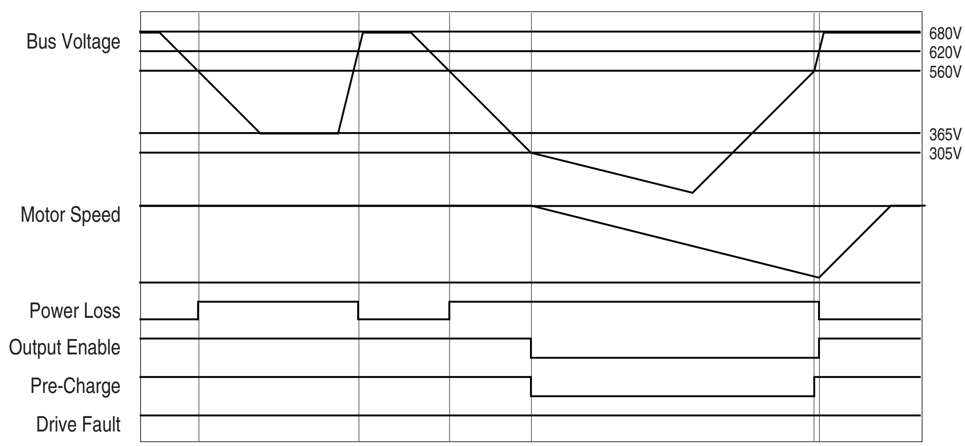
The power loss alarm in [Drive Alarm 1] is set and the power loss timer starts. The Alarm bit in [Drive Status 1] is set if the Power Loss bit in [Alarm Config 1] is set.

The drive faults with a F003 – Power Loss fault if the power loss timer exceeds [Power Loss Time] and the Power Loss bit in [Fault Config 1] is set.

The drive faults with a F004 – UnderVoltage fault if the bus voltage falls below Vmin and the UnderVoltage bit in [Fault Config 1] is set.

If the bus voltage rises above Vrecover for 20mS, the drive determines the power loss is over. The power loss alarm is cleared.

If the drive is coasting and if it is in a “run permit” state, the reconnect algorithm is run to match the speed of the motor. The drive then accelerates at the programmed rate to the set speed.



480V example shown, see Table 2.Z for further information.

Coast Input (PowerFlex700 Only)

This mode can provide additional ride through time by sensing the power loss via an external device that monitors the power line and provides a hardware power loss signal. This signal is then connected to the drive through the “pulse” input (because of its high-speed capability). Normally this hardware power loss input will provide a power loss signal before the bus drops to less than Vopen.

The drive determines a power loss has occurred if the “pulse” input is de-energized OR the bus voltage drops below Vopen. If the drive is running, the inverter output is disabled.

The Power Loss alarm in [Drive Alarm 1] is set and the power loss timer starts.

The Alarm bit in [Drive Status 1] is set if the Power Loss bit in [Alarm Config 1] is set.

The drive faults with a F003 – Power Loss fault if the power loss timer exceeds [Power Loss Time] and the Power Loss bit in [Fault Config 1] is set.

The drive faults with a F004 – UnderVoltage fault if the bus voltage falls below Vmin and the UnderVoltage bit in [Fault Config 1] is set.

The pre-charge relay opens if the bus voltage drops below Vopen and closes if the bus voltage rises above Vclose.

If the “pulse” input is re energized and the pre-charge relay is closed, the drive determines the power loss is over. The power loss alarm is cleared.

If the drive is in a “run permit” state, the reconnect algorithm is run to match the speed of the motor. The drive then accelerates at the programmed rate to the set speed.

Decel Input (PF700 only)

This mode can provide additional ride through time by sensing the power loss via an external device that monitors the power line and provides a hardware power loss signal. This signal is then connected to the drive through the “pulse” input (because of its high-speed capability). Normally this hardware power loss input will provide a power loss signal before the bus drops to less than Vopen.

The drive determine a power loss has occurred if the “pulse” input is de-energized or the bus voltage drops below Vopen.

If the drive is running, the inertia ride through function is activated. The load is decelerated at just the correct rate so that the energy absorbed from the mechanical load balances the losses and bus voltage is regulated to the value Vmem.

If the output frequency drops to zero or if the bus voltage drops below Vopen or if any of the “run permit” inputs are de-energized, the inverter output is disabled and the motor coasts.

The power loss alarm in [Drive Alarm 1] is set and the power loss timer starts. The Alarm bit in [Drive Status 1] is set if the Power Loss bit in [Alarm Config 1] is set.

The drive faults with a F003 – Power Loss fault if the power loss timer exceeds [Power Loss Time] and the Power Loss bit in [E238 Fault Config 1] is set.

The drive faults with a F004 – UnderVoltage fault if the bus voltage falls below Vmin and the UnderVoltage bit in [Fault Config 1] is set.

The pre-charge relay opens if the bus voltage drops below Vopen and closes if the bus voltage rises above Vclose.

If power recovers while the drive is still in inertia ride through the power loss alarm is cleared and it then accelerates at the programmed rate to the set speed. Otherwise, if power recovers before power supply shutdown, the power loss alarm is cleared.

If the drive is in a "run permit" state, the reconnect algorithm is run to match the speed of the motor. The drive then accelerates at the programmed rate to the set speed.

Preset Frequency

There are 7 Preset Frequency parameters that are used to store a discrete frequency value. This value can be used for a speed reference or PI Reference. When used as a speed reference, they are accessed via manipulation of the digital inputs or the DPI reference command. Preset frequencies have a range of plus/minus [Maximum Speed].

Process PI Loop

[PI Config]
[PI Control]
[PI Reference Sel]
[PI Setpoint]
[PI Feedback Sel]
[PI Integral Time]
[PI Prop Gain]
[PI Upper/Lower Limit]
[PI Preload]
[PI Status]
[PI Ref Meter]
[PI Feedback Meter]
[PI Error Meter]
[PI Output Meter]

The internal PI function provides closed loop process control with proportional and integral control action. The function is designed to be used in applications that require simple control of a process without external control devices. The PI function allows the microprocessor to follow a single process control loop.

The PI function reads a process variable input to the drive and compares it to a desired setpoint stored in the drive. The algorithm will then adjust the output of the PI regulator, changing drive output frequency to try and make the process variable equal the setpoint.

Proportional control (P) adjusts output based on size of the error (larger error = proportionally larger correction). If the error is doubled, then the output of the proportional control is doubled and, conversely, if the error is cut in half then the output of the proportional output will be cut in half. With proportional control there is always an error, so the feedback and the reference are never equal.

Integral control (I) adjusts the output based on the duration of the error. (The longer the error is present, the harder it tries to correct). The integral control by itself is a ramp output correction. This type of control gives a smoothing effect to the output and will continue to integrate until zero error is achieved. By itself, integral control is slower than many applications require and therefore is combined with proportional control (PI).

Derivative Control (D) adjusts the output based on the rate of change of the error and, by itself, tends to be unstable. The faster that the error is changing, the larger change to the output. Derivative control is generally not required and, when it is used, is almost always combined with proportional and integral control (PID).

The PI function can perform a combination of proportional and integral control. It does not perform derivative control, however, the accel / decel control of the drive can be considered as providing derivative control.

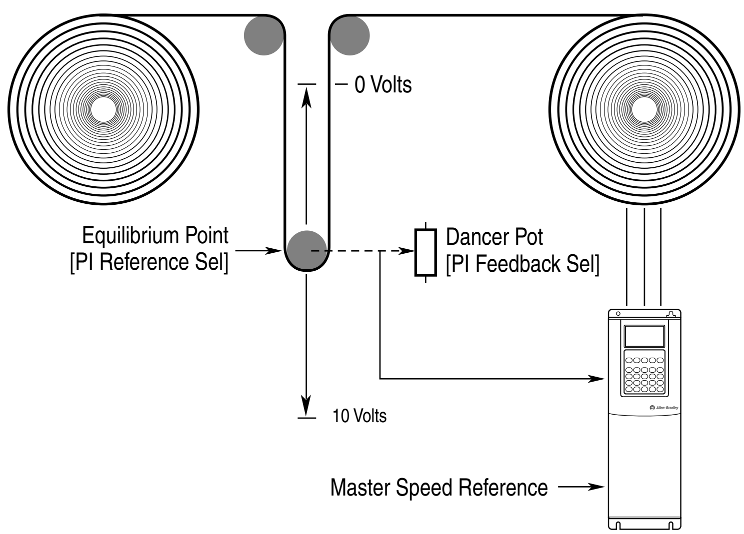
There are two ways the PI Controller can be configured to modify the commanded speed.

- Process Trim - The PI Output can be added to the master speed reference
- Process Control - PI can have exclusive control of the commanded speed.

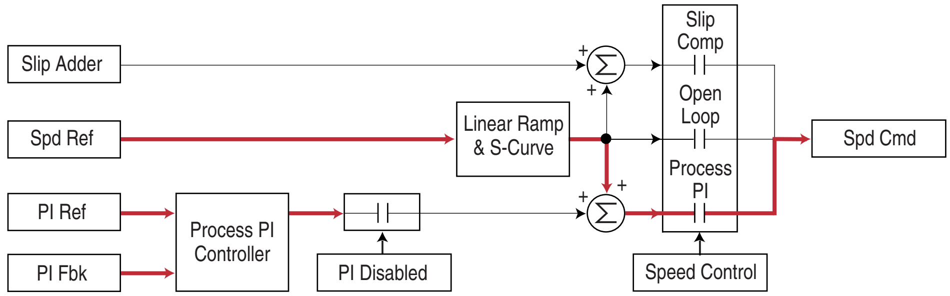
The selection between these two modes of operation is done in the [PI Configuration] parameter.

Process Trim

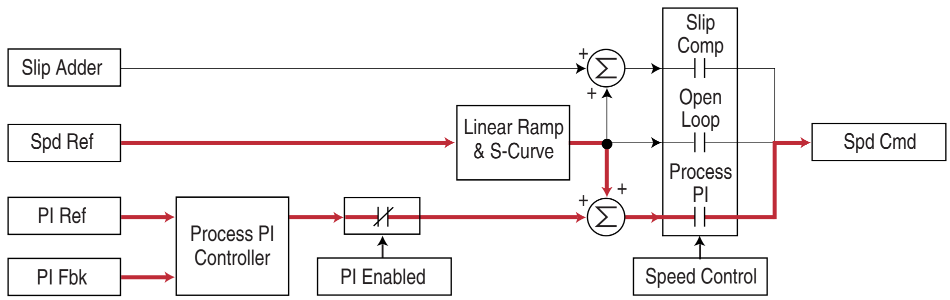
Process Trim takes the output of PI regulator and sums it with a master speed reference to control the process. In the following example, the master speed reference sets the wind/unwind speed and the dancer pot signal is used as a PI Feedback to control the tension in the system. An equilibrium point is programmed as PI Reference, and as the tension increases or decreases during winding, the master speed is trimmed to compensate and maintain tension near the equilibrium point.



When the PI is disabled the commanded speed is the ramped speed reference.



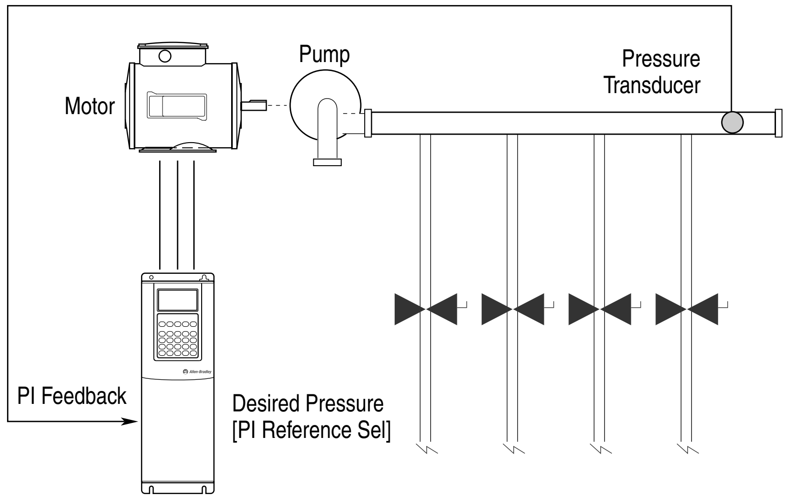
When the PI is enabled, the output of the PI Controller is added to the ramped speed reference.



Exclusive Control

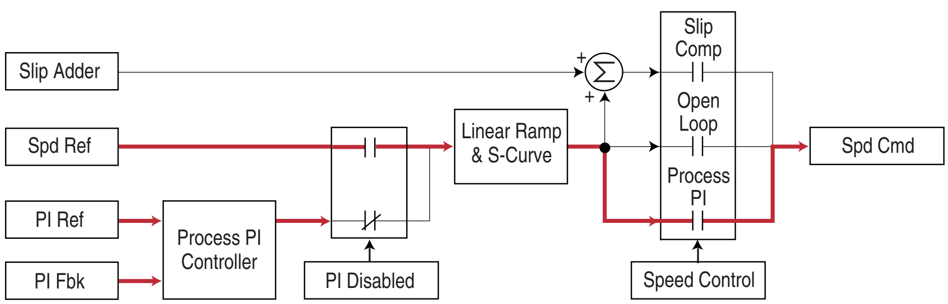
Process Control takes the output of PI regulator as the speed command. No master speed reference exists and the PI Output directly controls the drive output.

In the pumping application example below, the reference or setpoint is the required pressure in the system. The input from the transducer is the PI feedback and changes as the pressure changes. The drive output frequency is then increased or decreased as needed to maintain system pressure regardless of flow changes. With the drive turning the pump at the required speed, the pressure is maintained in the system.

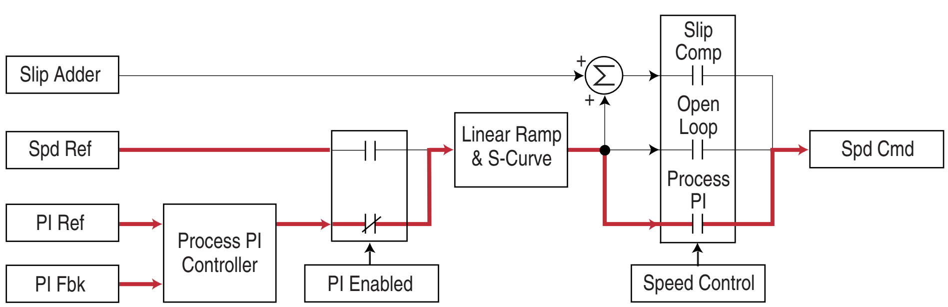


However, when additional valves in the system are opened and the pressure in the system drops, the PI error will alter its output frequency to bring the process back into control.

When the PI is disabled the commanded speed is the ramped speed reference.



When the PI is enabled, the speed reference is disconnected and PI Output has exclusive control of the commanded speed, passing through the linear ramp and s-curve.



Configuration

To operate the drive in PI Regulator Mode for the Standard Control option, change the mode by selecting "Process PI" through the [Speed Mode] parameter.

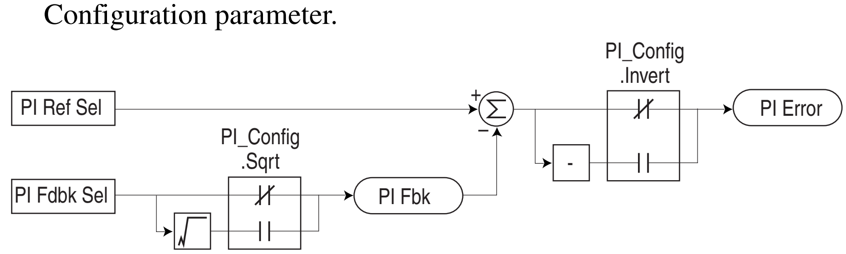
Three parameters are used to configure, control, and indicate the status of the logic associated with the Process PI controller; [PI Configuration], [PI Control], and [PI Status]. Together these three parameters define the operation of the PI logic.

1. **[PI Configuration]** is a set of bits that select various modes of operation. The value of this parameter can only be changed while the drive is stopped.

   - **Exclusive Mode** - see page 2-139.
   - **Invert Error** - This feature changes the "sign" of the error, creating a decrease in output for increasing error and an increase in output for decreasing error. An example of this might be an HVAC system with thermostat control. In Summer, a rising thermostat reading commands an increase in drive output because cold air is being blown. In Winter, a falling thermostat commands an increase in drive output because warm air is being blown.

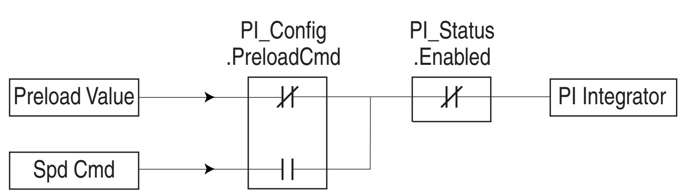
     The PI has the option to change the sign of PI Error. This is used when an increase in feedback should cause an increase in output.

     The option to invert the sign of PI Error is selected in the PI Configuration parameter.



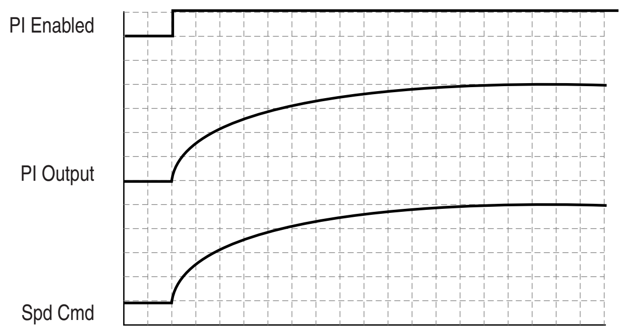
   - **Preload Integrator** - This feature allows the PI Output to be stepped to a preload value for better dynamic response when the PI Output is enabled. Refer to diagram 2 below.

     If PI is not enabled the PI Integrator may be initialized to the PI Pre-load Value or the current value of the commanded speed. The operation of Preload is selected in the PI Configuration parameter.

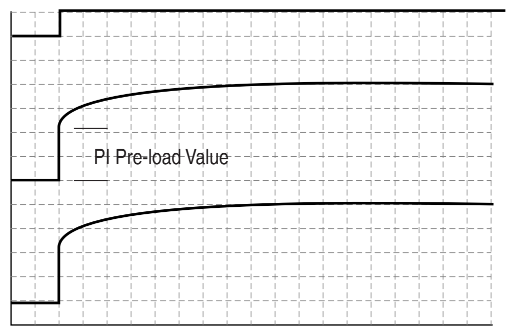


     By default, Pre-load Command is off and the PI Load Value is zero, causing a zero to be loaded into the integrator when the PI is disabled.

As below shown on the left, when the PI is enabled the PI output will start from zero and regulate to the required level. When PI is enabled with PI Load Value is set to a non-zero value the output begins with a step as shown below on the right. This may result in the PI reaching steady state sooner, however if the step is too large the drive may go into current limit which will extend the acceleration.

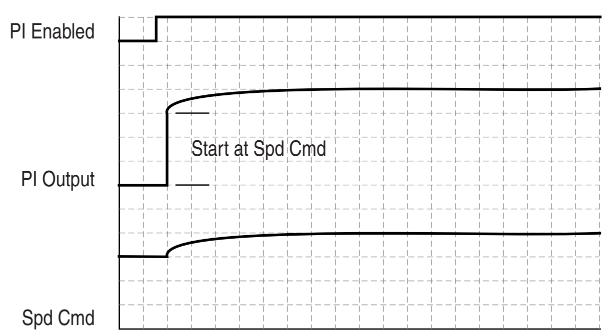


PI Pre-load Value = 0



PI Pre-load Value > 0

Pre-load command may be used when the PI has exclusive control of the commanded speed. With the integrator preset to the commanded speed there is no disturbance in commanded speed when PI is enabled. After PI is enabled the PI output is regulated to the required level.



Pre-load to Command Speed

When the PI is configured to have exclusive control of the commanded speed and the drive is in current limit or voltage limit the integrator is preset to the commanded speed so that it knows where to resume when no longer in limit.

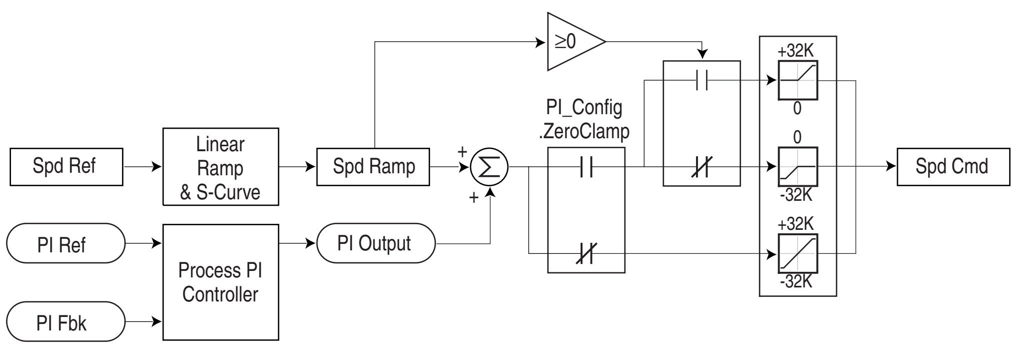
- **Ramp Ref** - The PI Ramp Reference feature is used to provide a smooth transition when the PI is enabled and the PI output is used as a speed trim (not exclusive control),.

When PI Ramp Reference is selected in the PI Configuration parameter, and PI is disabled, the value used for the PI reference will be the PI feedback. This will cause PI error to be zero. Then when the PI is enabled the value used for the PI reference will ramp to the selected value for PI reference at the selected acceleration or deceleration rate. After the PI reference reaches the selected value the ramp is bypassed until the PI is disabled and enabled again. S-curve is not available as part of the PI linear ramp.

- **Zero Clamp** - This feature limits the possible drive action to one direction only. Output from the drive will be from zero to maximum frequency forward or zero to maximum frequency reverse. This removes the chance of doing a “plugging” type operation as an attempt to bring the error to zero.

  The PI has the option to limit operation so that the output frequency will always have the same sign as the master speed reference. The zero clamp option is selected in the PI Configuration parameter. Zero clamp is disabled when PI has exclusive control of speed command.

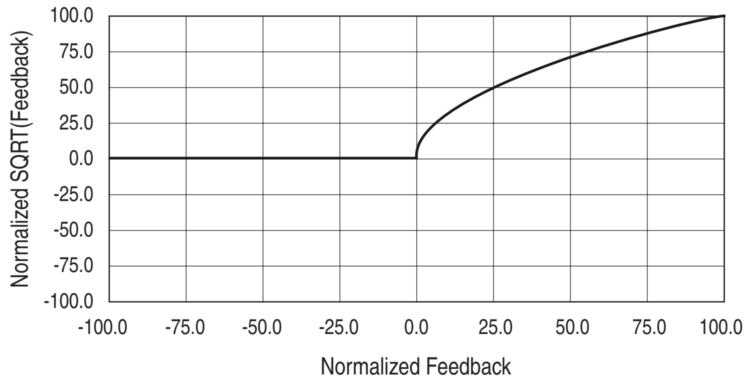
  For example, if master speed reference is +10 Hz and the output of the PI results in a speed adder of –15 Hz, zero clamp would limit the output frequency to not become less than zero. Likewise, if master speed reference is –10 Hz and the output of the PI results in a speed adder of +15 Hz, zero clamp would limit the output frequency to not become greater than zero.



- **Feedback Square Root** - This feature uses the square root of the feedback signal as the PI feedback. This is useful in processes that control pressure, since centrifugal fans and pumps vary pressure with the square of speed.

  The PI has the option to take the square root of the selected feedback signal. This is used to linearize the feedback when the transducer produces the process variable squared. The result of the square root is normalized back to full scale to provide a consistent range of operation. The option to take the square root is selected in the PI Configuration parameter.

- **Stop Mode (PowerFlex 700 Only).** When Stop Mode is set to “1” and a Stop command is issued to the drive, the PI loop will continue



to operate during the decel ramp until the PI output becomes more than the master reference. When set to “0,” the drive will disable PI and perform a normal stop. This bit is active in Trim mode only.

- **Anti-Wind Up (PowerFlex 700 Only).** When Anti-Windup is set to “1” the PI loop will automatically prevent the integrator from creating an excessive error that could cause loop instability. The integrator will be automatically controlled without the need for PI Reset or PI Hold inputs.
- Vector FV **Torque Trim.** When Torque Trim is set to “1” the output of the process PI loop will be added to Torque Reference A and B, instead of being added to the speed reference.

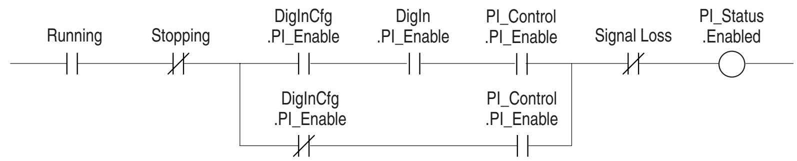
2. **[PI Control]** is a set of bits to dynamically enable and disable the operation of the process PI controller. When this parameter is interactively written to from a network it must be done through a data link so the values are not written to EEprom.

   - **PI Enable** - The PI loop can be enabled/disabled. The Enabled status of the PI loop determines when the PI regulator output is part or all of the commanded speed. The logic evaluated for the PI Enabled status is shown in the following ladder diagram.

     The drive must be in run before the PI Enabled status can turn on. The PI will remain disabled when the drive is jogged. The PI is disabled when the drive begins a ramp to stop, except in the PowerFlex 700 when it is in Trim mode and the Stop mode bit in [PI Configuration] is on.

     When a digital input is configured as “PI Enable,” the PI Enable bit of [PI Control] must be turned on for the PI loop to become enabled.

     If a digital input is not configured as “PI Enable” and the PI Enable bit in [PI Control] is turned on, then the PI loop may become enabled. If the PI Enable bit of [PI Control] is left continuously, then the PI may become enabled as soon as the drive goes into run. If analog input signal loss is detected, the PI loop is disabled.



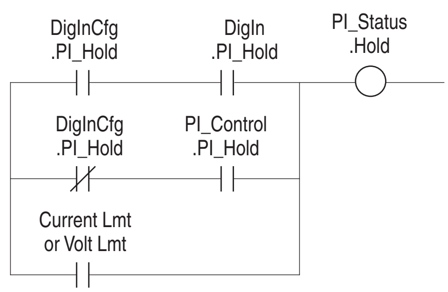
- **PI Hold** - The Process PI Controller has the option to hold the integrator at the current value so if some part of the process is in limit the integrator will maintain the present value to avoid windup in the integrator.

  The logic to hold the integrator at the current value is shown in the following ladder diagram. There are three conditions under which hold will turn on.

– If a digital input is configured to provide PI Hold and that digital input is turned on then the PI integrator will stop changing. Note that when a digital input is configured to provide PI Hold that takes precedence over the PI Control parameter.

– If a digital input is not configured to provide PI Hold and the PI Hold bit in the PI Control parameter is turned on then the PI integrator will stop changing.

– If the current limit or voltage limit is active then the PI is put into hold.



- **PI Reset –** This feature holds the output of the integral function at zero. The term “anti windup” is often applied to similar features. It may be used for integrator preloading during transfer and can be used to hold the integrator at zero during “manual mode”. Take the example of a process whose feedback signal is below the reference point, creating error. The drive will increase its output frequency in an attempt to bring the process into control. If, however, the increase in drive output does not zero the error, additional increases in output will be commanded. When the drive reaches programmed Maximum Frequency, it is possible that a significant amount of integral value has been “built up” (windup). This may cause undesirable and sudden operation if the system were switched to manual operation and back. Resetting the integrator eliminates this windup.

NOTE: In the PowerFlex 70, once the drive has reached the programmable positive and negative PI limits, the integrator stops integrating and no further “windup” is possible.

3. **[PI Status]** parameter is a set of bits that indicate the status of the process PI controller

    - **Enabled –** The loop is active and controlling the drive output.
    - **Hold –** A signal has been issued and the integrator is being held at its current value.
    - **Reset –** A signal has been issued and the integrator is being held at zero.
    - **In Limit –** The loop output is being clamped at the value set in [PI Upper/Lower Limit].

PI Reference and Feedback

The selection of the source for the reference signal is entered in the PI Reference Select parameter. The selection of the source for the feedback signal is selected in the PI Feedback Select parameter. The reference and feedback have the same limit of possible options.

PowerFlex 70 options include DPI adapter ports, MOP, preset speeds, analog inputs and PI setpoint parameter. In the PowerFlex 700, options are expanded to also include additional analog inputs, pulse input, and encoder input.

The value used for reference is displayed in PI Reference as a read only parameter. The value used for feedback is displayed in PI Feedback as a read only parameter. These displays are active independent of PI Enabled. Full scale is displayed as ±100.00.

Refer to Analog Input Configuration on page 2-9.

Vector PI Reference Scaling

The PI reference can be scaled by using [PI Reference Hi] and [PI Reference Lo]. [PI Refence Hi] determines the high value, in percent, for the PI reference. [PI Reference Lo] determines the low value, in percent, for the PI reference.

The PI feedback can be scaled by using [PI Feedback Hi] and [PI Feedback Lo]. [PI Feedback Hi] determines the high value, in percent, for the PI feedback. [PI Feedback Lo] determines the low value, in percent, for the PI feedback.

<u>Configuration Example:</u>

The PI reference meter and PI feedback meter should be displayed as positive and negative values. Feedback from our dancer comes into Analog Input 2 as a 0-10V DC signal.

- [PI Reference Sel] = 0 “PI Setpoint”
- [PI Setpoint] = 0 %
- [PI Feedback Sel] = 2 “Analog In 2”
- [PI Reference Hi] = 100 %
- [PI Reference Lo] = –100 %
- [PI Feedback Hi] = 100 %
- [PI Feedback Lo] = –100 %
- [Analog In 2 Hi] = 10V
- [Analog In 2 Lo] = 0V

PI Feedback Scaling

[Torque Ref A Sel] = “Analog In 1”	
[Analog In 2 Hi] 10 V	[PI Feedback Hi] 100 %
[Analog In 1 Lo] 0V	[PI Feedback Lo] -100 %

Now 5V corresponds to 0% on the PI Feedback, so we will try to maintain a PI setpoint of 0% (5V). Now [PI Ref Meter] and [PI Fdback Meter] are displayed as bipolar values.

PI Setpoint

This parameter can be used as an internal value for the setpoint or reference for the process. If [PI Reference Sel] points to this Parameter, the value entered here will become the equilibrium point for the process.

PI Output

The PI Error is then sent to the Proportional and Integral functions, which are summed together.

PI Gains

The PI Proportional Gain and the PI Integral Gain parameters determine the response of the PI.

The PI Proportional Gain is unitless and defaults to 1.00 for unit gain. With PI Proportional Gain set to 1.00 and PI Error at 1.00% the PI output will be 1.00% of maximum frequency.

The PI Integral Gain is entered in seconds. If the PI Integral Gain is set to 2.0 seconds and PI Error is 100.00% the PI output will integrate from 0 to 100.00% in 2.0 seconds.

Positive and Negative Limits

The PI has parameters to define the positive and negative limits of the output PI Positive Limit, and PI Negative Limit. The limits are used in two places; on the integrator and on the sum of the Kp + Ki terms.

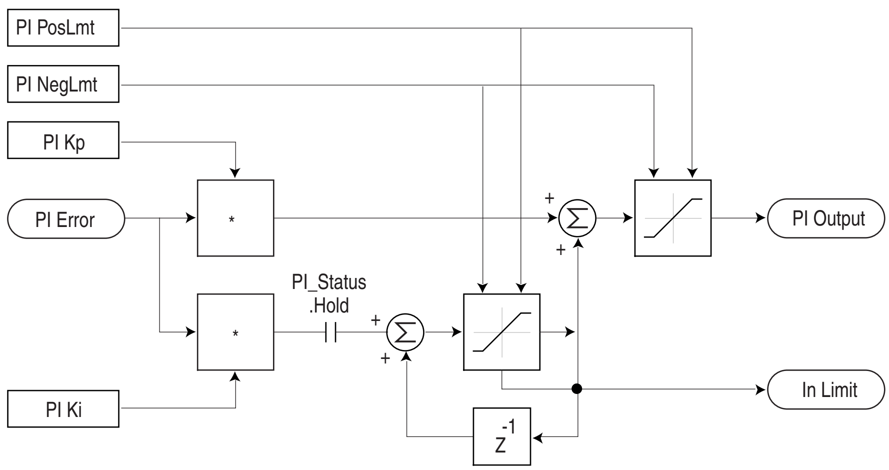
Providing an external source doesn't turn on Hold, the integrator is allowed to integrate all the way to Positive or Negative limit. If the integrator reaches the limit the value is clamped and the InLimit bit is set in the PI Status parameter to indicate this condition.

The limits are entered in the range of ±100.00.

PI Positive Limit must always be greater than PI Negative Limit.

If the application is Process Control, typically these limits would be set to the maximum allowable frequency setting. This allows the PI regulator to control over the entire required speed range.

If the application is Process Trim, large trim corrections may not be desirable and the limits would be programmed for smaller values.



Output Scaling

The output value produced by the PI is displayed as ±100.00. Internally this is represented by ±32767 which corresponds to ±maximum frequency.

Vector FV Output Scaling for Torque Trim

The output value from the Process PI loop, when in torque trim mode, is displayed as +/–100% which corresponds to +/–100% of rated motor torque.

Figure 2.28 Process PI Block Diagram

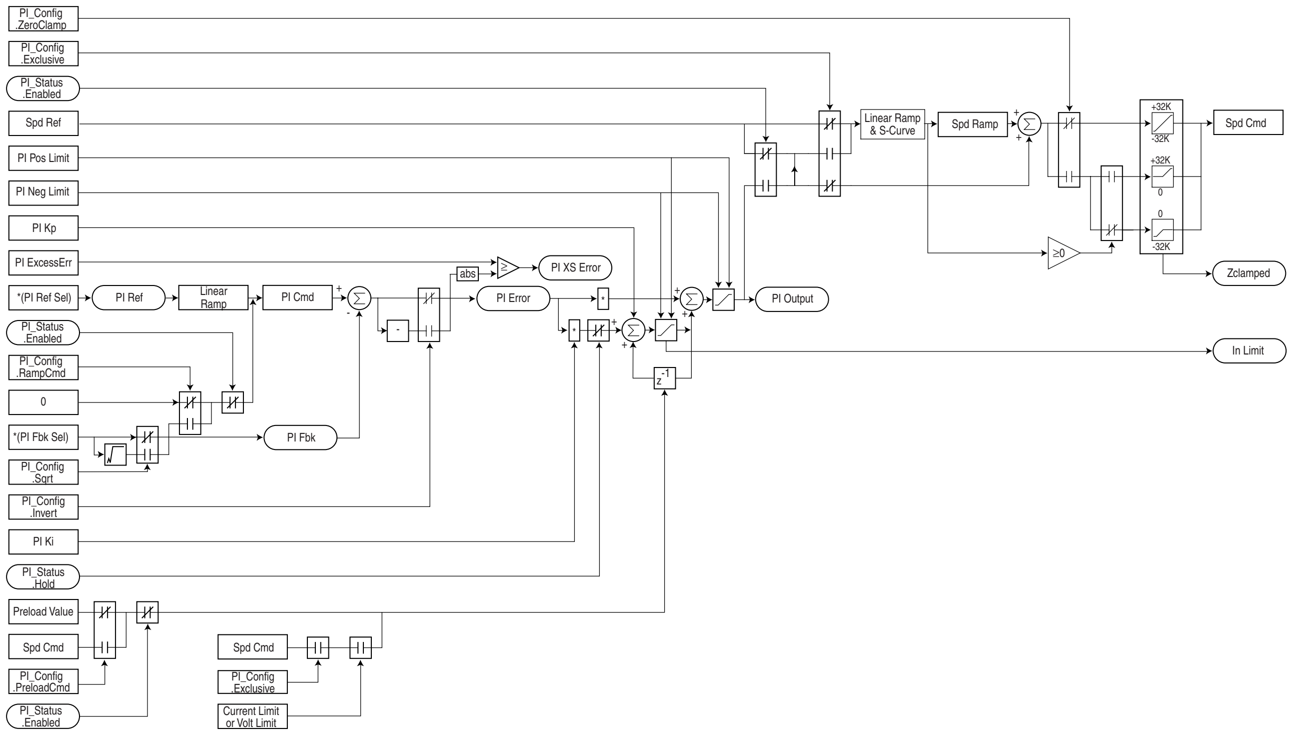
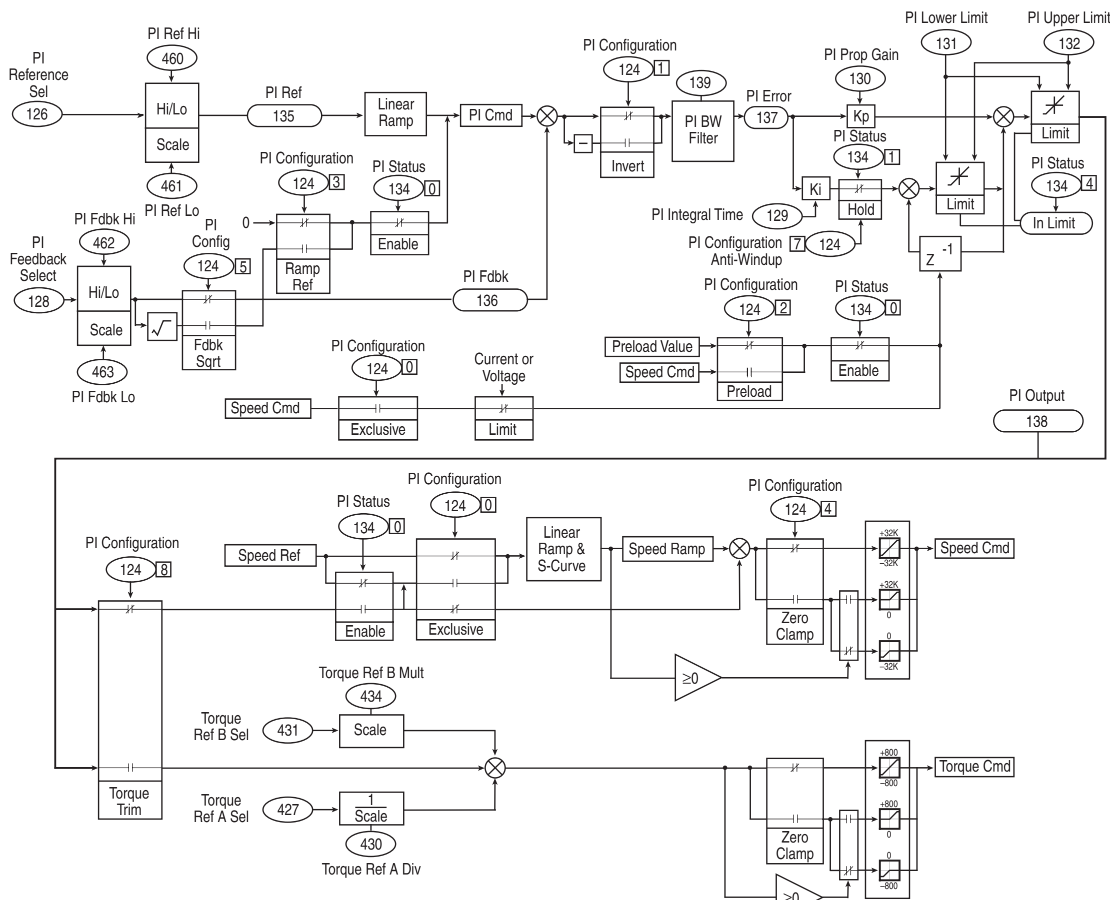


Figure 2.29 Vector Control Option Process PI Loop Overview



PowerFlex 700 Firmware 3.001 (& later) Enhancements

Process PID Control and Trim enhancements have been included in firmware version 3.001 (and later) for the PowerFlex 700 Vector Control drive, including:

- Derivative term added to Process PI controller to create PID
- Ability to scale output of PID to a percentage of Speed Reference
- Connect scale blocks to the Reference and Feedback selections on PID
- Ability to select % of Reference for the Speed Trim function

Derivative Term

The Derivative term has been added to the Process PI. This adds to the flexibility of the Process control.

459	**Vector v3** **[PI Deriv Time]** Refer to formula below: $\text{PI}_{\text{Out}} = \text{KD (Sec)} \times \dfrac{d\text{PI Error (\%)}}{d_t \text{ (Sec)}}$	Default: 0.00 Secs Min/Max: 0.00/100.00 Secs Units: 0.01 Secs

For example, winders using torque control rely on PD control not PI control. Also, [PI BW Filter] is useful in filtering out unwanted signal response in the PID loop. The filter is a Radians/Second low pass filter.

Percent of Reference

124 [PI Configuration]

Sets configuration of the PI regulator.

						% of Ref **	Torque Trim *	Anti-Wind Up	Stop Mode	Feedbak Sqrt	Zero Clamp	Ramp Ref	Preload Mode	Invert Error	Excl Mode
x	x	x	x	x	x	0	0	0	0	0	0	0	0	0	0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

1 = Enabled
0 = Disabled
x = Reserved

Bit #
Factory Default Bit Values
* *Vector Control Option Only*
** *Vector firmware 3.001 & later*

124 thru 138

When using Process PID control the output can be selected as percent of the Speed Reference. This works in Speed trim mode only, not in Torque Trim or Exclusive Mode.

Example

% of Ref selected, Speed Reference = 43 Hz, PID Output = 10%, Maximum Frequency = 130 Hz . 4.3 Hz will be added to the final speed reference.

% of Ref not selected, Speed Reference = 43 Hz, PID Output = 10%, Maximum Frequency = 130 Hz. 13.0 Hz will be added to the final speed reference.

Scale Blocks with PID

Scale Blocks are now included in the Reference and Feedback selections of the Process PID controller. This selects the output of the scale block for use as Reference or Feedback to the Process PID.

No.	Parameter	Values			Related
126	**[PI Reference Sel]** Selects the source of the PI reference. (1) Vector firmware 3.001 and later.	Default:	0	"PI Setpoint"	024 124 thru 138
		Options:	0	"PI Setpoint"	
			1	"Analog In 1"	
			2	"Analog In 2"	
			3-6	"Reserved"	
			7	"Pulse In"	
			8	"Encoder"	
			9	"MOP Level"	
			10	"Master Ref"	
			11-17	"Preset Spd1-7"	
			18-22	"DPI Port 1-5"	
			23-24	"Reserved"	
			25	"Scale Block 1" (1)	
			26	"Scale Block 2" (1)	
			27	"Scale Block 3" (1)	
			28	"Scale Block 4" (1)	

Trim % of Reference

The Trim function of the drive can be selected as % of Reference or % of Maximum Frequency.

118 [Trim Out Select]

Specifies which speed references are to be trimmed.

													Add or % *	Trim Ref B	Trim Ref A
x	x	x	x	x	x	x	x	x	x	x	x	x	0	0	0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

1 = Trimmed/%
0 = Not Trimmed/Add
x = Reserved

Bit #
Factory Default Bit Values
* *Vector firmware 3.001 & later.*

117 119 120

For example, % selected, Max Frequency = 130, Speed Reference = 22 Hz, Trim Reference = 20%. 4.4 Hz will be added to the Speed Reference.

% not selected, Max Frequency = 130, Speed Reference = 22 Hz, Trim Reference = 20%. 26 Hz will be added to the Speed Reference.

Reflected Wave

[Compensation]

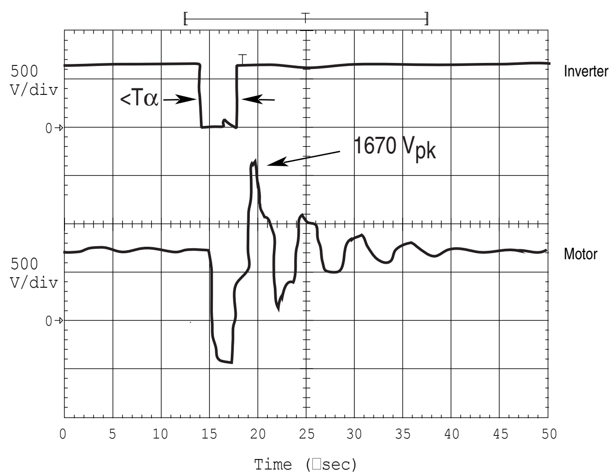
The pulses from a Pulse Width Modulation (PWM) inverter using IGBTs are very short in duration (50 nanoseconds to 1 millisecond). These short pulse times combined with the fast rise times (50 to 400 nanoseconds) of the IGBT, will result in excessive over-voltage transients at the motor.

Voltages in excess of twice the DC bus voltage (650V DC nominal at 480V input) will occur at the motor and can cause motor winding failure.

The patented reflected wave correction software in the PowerFlex 70/700 will reduce these over-voltage transients from a VFD to the motor. The correction software modifies the PWM modulator to prevent PWM pulses less than a minimum time from being applied to the motor. The minimum time between PWM pulses is 10 microseconds. The modifications to the PWM modulator limit the over-voltage transient to 2.25 per unit volts line-to-line peak at 600 feet of cable.

400 V Line = 540V DC bus x 2.25 = 1215V
480 V Line = 650V DC bus x 2.25 = 1463V
600 V Line = 810V DC bus x 2.25 = 1823 V

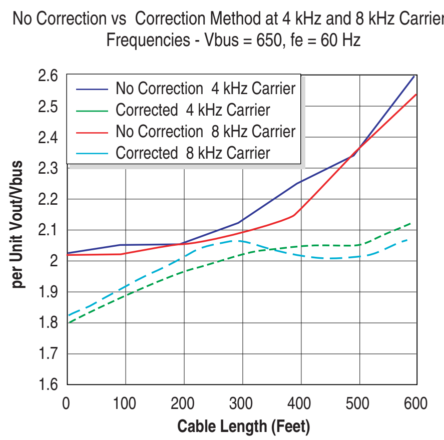
The software is standard and requires no special parameters or settings.



The above figure shows the inverter line-to-line output voltage (top trace) and the motor line-to-line voltage (bottom trace) for a 10 HP, 460V AC inverter, and an unloaded 10 HP AC induction motor at 60 Hz operation. 500 ft. of #12 AWG cable connects the drive to the motor.

Initially, the cable is in a fully charged condition. A transient disturbance occurs by discharging the cable for approximately 4ms. The propagation delay between the inverter terminals and motor terminals is approximately 1ms. The small time between pulses of 4ms does not provide sufficient time to allow the decay of the cable transient. Thus, the second pulse arrives at a point in the motor terminal voltage's natural response and excites a motor over-voltage transient greater than 2 pu. The amplitude of the double pulsed motor over-voltage is determined by a number of variables. These include the damping characteristics of the cable, bus voltage, and the time between pulses, the carrier frequency, modulation technique, and duty cycle.

The plot below shows the per unit motor overvoltage as a function of cable length. This is for no correction versus the modulation correction code for varied lengths of #12 AWG cable to 600 feet for 4 and 8 kHz carrier frequencies. The output line-to-line voltage was measured at the motor terminals in 100 feet increments.



Without the correction, the overvoltage increases to unsafe levels with increasing cable length for both carrier frequencies.

The patented modulation correction code reduces the overvoltage for both carrier frequencies and maintains a relatively flat overvoltage level for increasing cable lengths beyond 300 feet.

To determine the maximum recommended motor cable lengths for a particular drive refer to Cable, Motor Lengths on page 2-51.

Refer to: **www.ab.com/drives/techpapers/menu** for detailed technical papers.

Regen Power Limit

Vector FV The [Regen Power Lim] is programmed as a percentage of the rated power. The mechanical energy that is transformed into electrical power during a deceleration or overhauling load condition is clamped at this level. Without the proper limit, a bus overvoltage may occur.

When using the bus regulator [Regen Power Lim] can be left at factory default, –50%. When using dynamic braking or a regenerative supply, [Regen Power Lim] can be set to the most negative limit possible (–800%). When the user has dynamic braking or regenerative supply, but wishes to limit the power to the dynamic brake or regenerative supply, [Regen Power Lim] can be set to a level specified by the user.

Reset Meters

The Elapsed kW Hour meter and/or Elapsed Time meter parameters are reset when parameter 200 is set to a value not equal to zero. After the reset has occurred, this parameter automatically returns to a value of zero.

200	**[Reset Meters]**	Default:	0	"Ready"	
	Resets selected meters to zero.	Options:	0 1 2	"Ready" "MWh" "Elapsed Time"	

0 = Ready
1 = Reset kW Hour Meter
2 = Reset Elapsed Time Meter

Reset Run

Refer to Auto Restart (Reset/Run) on page 2-29.

RFI Filter Grounding

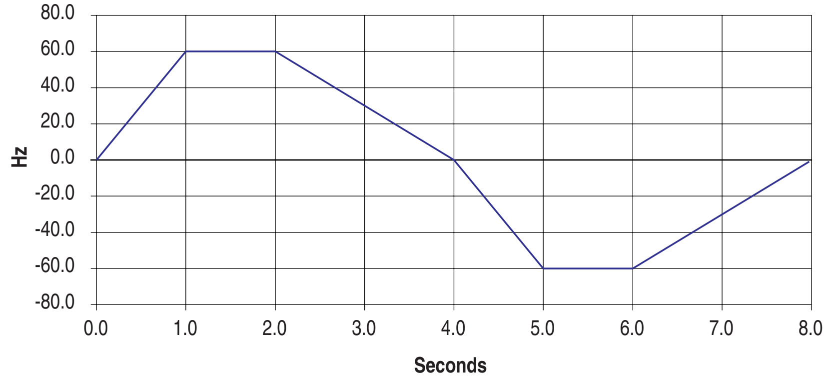
Refer to "*Wiring and Grounding Guidelines for PWM AC Drives,*" publication DRIVES-IN001.

S Curve

The S Curve function of the PowerFlex family of drives allows control of the "jerk" component of acceleration and deceleration through user adjustment of the S Curve parameter. Jerk is the rate of change of acceleration and controls the transition from steady state speed to acceleration or deceleration and vice versa. By adjusting the percentage of S Curve applied to the normal accel/decel ramps, the ramp takes the shape of an "S". This allows a smoother transition that produces less mechanical stress and smoother control for light loads.

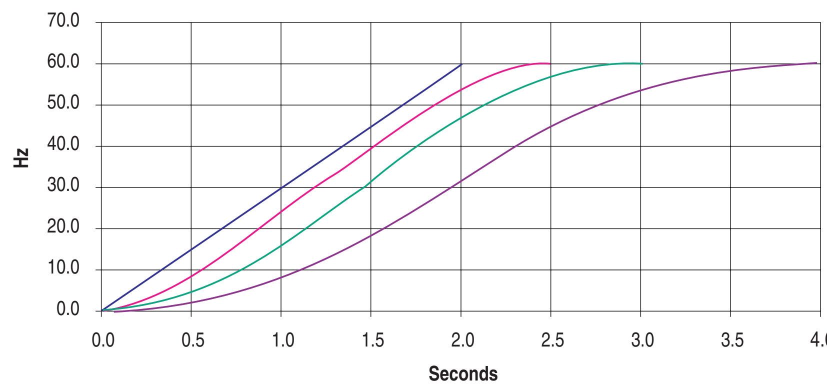
Linear Accel & Decel

Acceleration is defined as moving away from zero; deceleration is defined as moving toward zero. The linear acc / dec ramp is active when the S curve% is set to zero. The accel time and maximum frequency determine the ramp rate for speed increases while decel time and maximum frequency determine the ramp rate for speed decreases. Separate times can be set for accel and decel. In addition, a second set of accel and decel times is available. In this example Ta = 1.0 sec, Td = 2.0 sec and Maximum Frequency is set to 60.0 Hz.

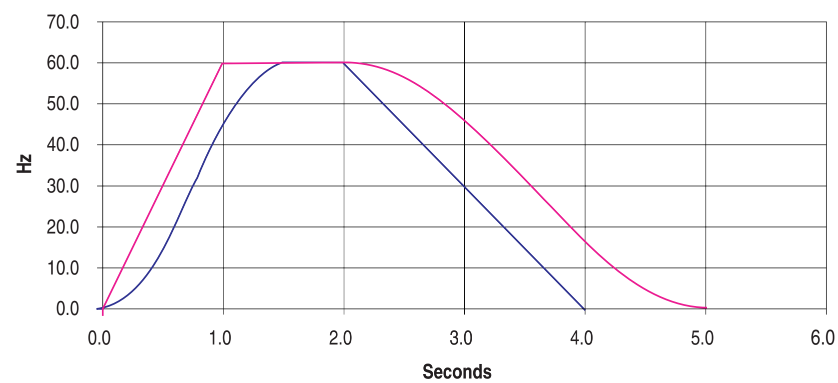


S-Curve Selection

S-curve is enabled by defining the time to extend the acceleration and deceleration. The time is entered as a percentage of acceleration and deceleration time. In this case acceleration time is 2.0 seconds. The line on the left has s-curve set to 0%. The other lines show 25%, 50%, and 100% S-curve. At 25% S-curve acceleration time is extended by 0.5 seconds (2.0 * 25%). Note that the linear portion of this line has the same slope as when s-curve is set to zero.

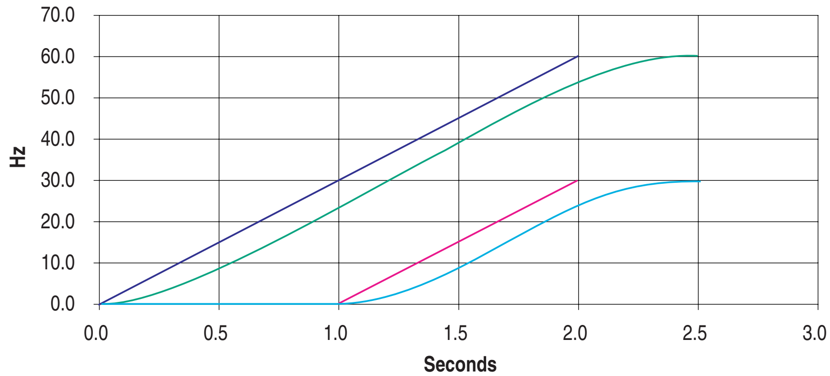


The acceleration and deceleration times are independent but the same S-curve percentage is applied to both of them. With S-curve set to 50%, acceleration time is extended by 0.5 seconds (1.0 * 50%), and deceleration time is extended by 1.0 seconds (2.0 * 50%).



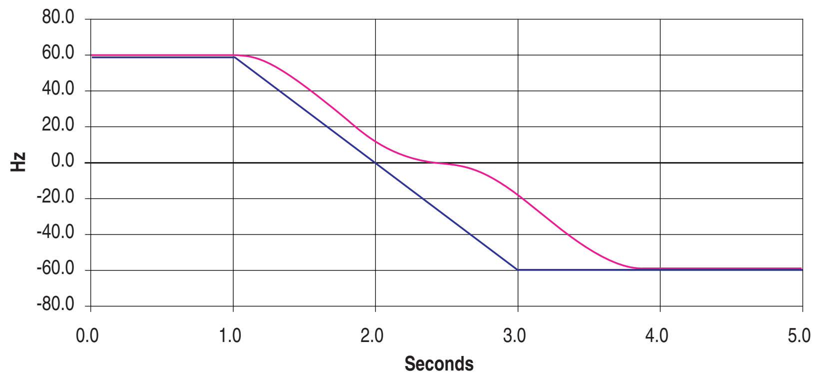
Time to Max Speed

Note that S-curve time is defined for accelerating from 0 to maximum speed. With maximum speed = 60 Hz, Ta = 2.0 sec, and S-curve = 25%, acceleration time is extended by 0.5 seconds (2.0 * 25%). When accelerating to only 30 Hz the acceleration time is still extended by the same amount of time.

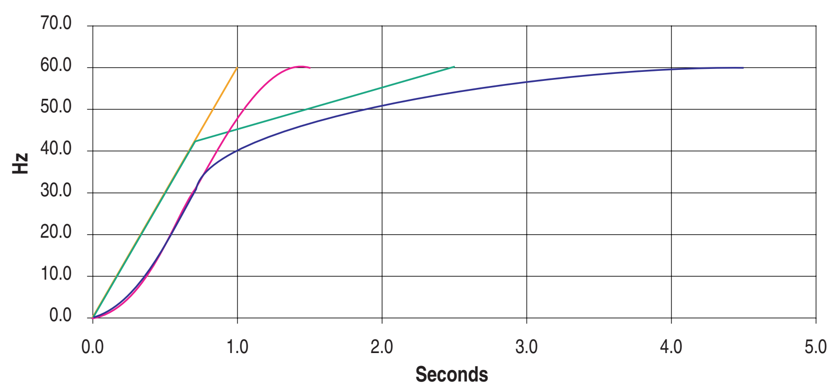


Crossing Zero Speed

When the commanded frequency passes through zero the frequency will S-curve to zero and then S-curve to the commanded frequency.



The following graph shows an acceleration time of 1.0 second. After 0.75 seconds, the acceleration time is changed to 6.0 seconds. When the acceleration rate is changed, the commanded rate is reduced to match the requested rate based on the initial S-curve calculation. After reaching the new acceleration rate, the S-curve is then changed to be a function of the new acceleration rate.



Scale Blocks

See also Analog Scaling on page 2-12 and page 2-22.

Vector Scale blocks are used to scale a parameter value. [Scalex In Value] is linked to the parameter that you wish to scale. [Scalex In Hi] determines the high value for the input to the scale block. [Scalex Out Hi] determines the corresponding high value for the output of the scale block. [Scalex In Lo] determines the low value for the input to the scale block. [Scalex Out Lo] determines the corresponding low value for the output of the scale block. [Scalex Out Value] is the resulting output of the scale block.

There are (3) ways to use the output of the scale block:

1. A linkable destination parameter can be linked to [Scalex Out Value]. See Example Configuration #1.

2. [Analog Outx Sel] can be set to:
   – 20, “Scale Block1”
   – 21, “Scale Block2”
   – 22, “Scale Block3”
   – 23, “Scale Block4”

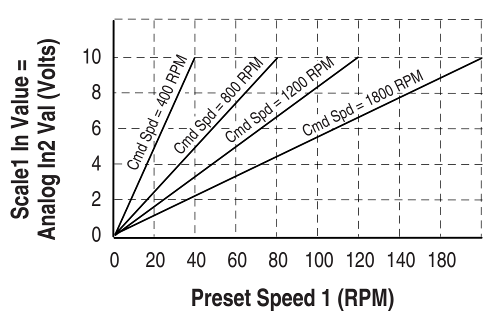
   Note that when the Analog Outputs are set to use the scale blocks, the [Scale x Out Hi] and [Scale x Out Lo] parameters are not active. Instead, [Analog Outx Hi] and [Analog Outx Lo] determine the scaling for the output of the scale block. See Example Configuration #2.

3. [PI Reference Sel] and [PI Feedback Sel] can also use the output of the scale block by setting them to:
   – 25, “Scale Block1 Out”
   – 26, “Scale Block2 Out”

   Note that when [PI Reference Sel] and [PI Feedback Sel] are set to use the scale blocks, the [Scale x Out Hi] and [Scale x Out Lo] parameters are not active. Instead, [PI Reference Hi] and [PI Reference Lo], or [PI Feedback Hi] and [PI Feedback Lo], determine the scaling for the output of the scale block. See Example Configuration #3.

Example Configuration #1

Use the scale blocks to add a speed trim as a percentage of the speed reference instead of as a percent of full speed. Analog In 2 will be used to provide a 0-10V DC trim signal. For example, when the commanded speed is 800 RPM, the maximum trim with 10V DC at Analog In 2 will be 80 RPM. If the commanded speed is 1800 RPM the maximum trim will be 180 RPM.

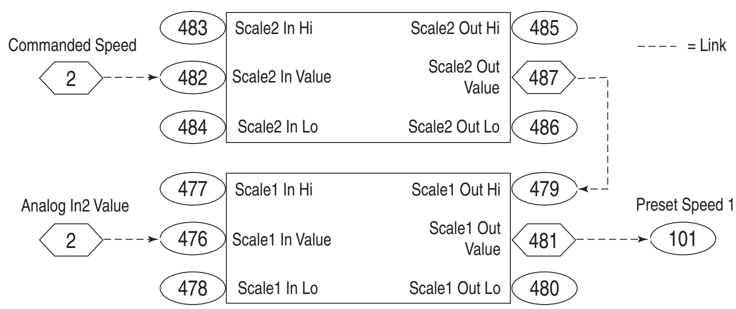


Parameter Settings

Parameter	Value	Description
[Trim In Select]	11, Preset 1	Preset 1 becomes the trim speed
[Scale1 In Hi]	10.0 V	Hi value of Analog In 2
[Scale1 In Lo]	0 V	Lo value of Analog In 2
[Scale1 Out Lo]	0 RPM	Lo value of desired Trim
[Scale2 In Hi]	1800 RPM	Hi value of Commanded Speed (Max Speed)
[Scale2 In Lo]	0 RPM	Lo value of Commanded Speed
[Scale2 Out Hi]	180 RPM	10% of Max Speed
[Scale2 Out Lo]	0 RPM	Corresponds to lo value of Commanded Speed

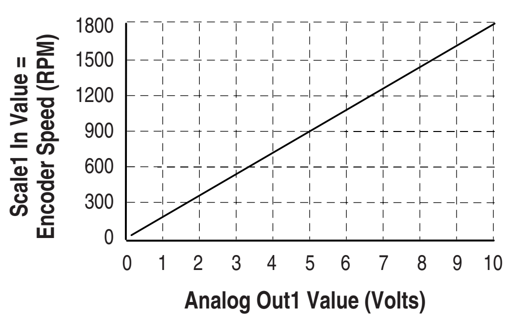
Parameter Links

Destination Parameter	Source Parameter	Description
[Scale1 In Value]	[Analog In2 Value]	We are scaling Analog In 2 for our trim
[Scale2 In Value]	[Commanded Speed]	Use Commanded Speed as Input to Scale Block 2
[Scale1 Out Hi]	[Scale2 Out Value]	Use the output of Scale Block 2 to set the upper limit of Scale Block 1 output
[Preset Speed 1]	[Scale 1 Out Value]	Use the scaled analog input as the trim reference into Preset Speed 1



Example Configuration #2

Setup a scale block to send parameter 415, [Encoder Speed] to Analog Output 1 as a 0-10V signal.

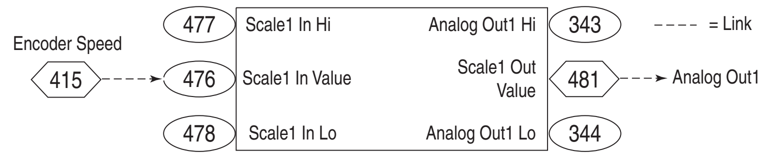


Parameter Settings

Parameter	Value	Description
[Analog Out1 Sel]	Scale Block1 Out	Scale Block1 Output goes to Analog Out1
[Analog Out1 Hi]	10 V	Hi value of Analog Output 1 corresponding to Hi value of encoder speed
[Analog Out1 Lo]	0 V	Lo value of Analog Output 1 corresponding to Lo value of encoder speed
[Scale1 In Hi]	1800 RPM	Hi value of the encoder speed
[Scale1 In Lo]	0 RPM	Lo value of the encoder speed

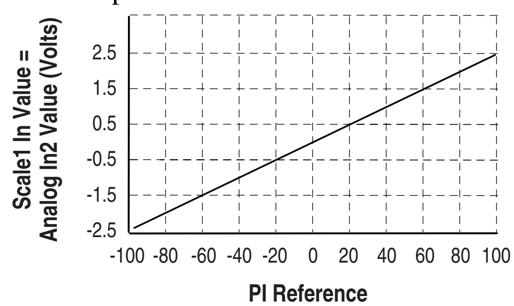
Parameter Links

Destination Parameter	Source Parameter	Description
[Scale1 In Value]	[Encoder Speed]	We are scaling Encoder Speed



Example Configuration #3

In this configuration Analog In 2 is a –10V to +10V signal which corresponds to –800% to +800% motor torque from another drive. We want to use the –200% to +200% range (–2.5V to +2.5V) of that motor torque and correspond it to –100% to +100% of the PI Reference.

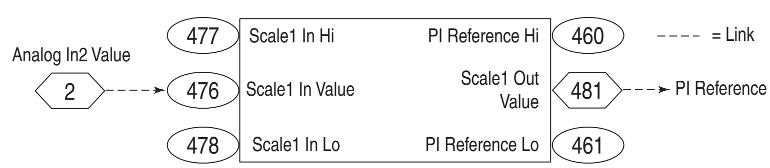


Parameter Settings

Parameter	Value	Description
[Scale 1 In Hi]	2.5 V	2.5 V = 200% torque from other drive
[Scale 1 In Lo]	–2.5V	–2.5 V = –200% torque from other drive
[PI Reference Sel]	25, Scale Block1 Out	The PI Reference becomes the output of the scale block
[PI Reference Hi]	100 %	100% PI Reference corresponds to 200% torque from other drive
[PI Reference Lo]	–100 %	–100% PI Reference corresponds to –200% torque from other drive

Parameter Links

Destination Parameter	Source Parameter	Description
[Scale1 In Value]	[Analog In2 Value]	We are scaling Analog In 2 value



Shear Pin Fault

This feature allows the user to select programming that will fault the drive if the drive output current exceeds the programmed current limit. As a default, exceeding the set current limit is not a fault condition. However, if the user wants to stop the process in the event of excess current, the Shear Pin feature can be activated. By programming the drive current limit value and enabling the electronic shear pin, current to the motor is limited, and if excess current is demanded by the motor, the drive will fault.

Configuration

The Shear Pin Fault is activated by setting Bit 4 of [Fault Config 1] to "1."

238 **[Fault Config 1]**

Enables/disables annunciation of the listed faults.

Bit #	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Fault				Out PhaseLoss *	ShearPNo Acc *		Load Loss *	In PhaseLoss *	Motor Therm *	Decel Inhibt	AutRstTries	Shear Pin	Motor OverLd		UnderVoltage	Power Loss
Factory Default Bit Values	x	x	x	0	0	x	0	0	0	1	0	0	1	x	1	0

1 = Enabled
0 = Disabled
x = Reserved

* Vector firmware 3.001 & later

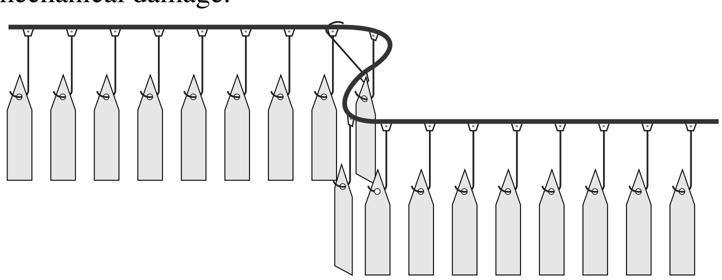
The programmable current limit [Current Lmt Sel] should also set to identify the source of the current limit value. If "Cur Lim Val" is selected, then [Current Lmt Val] should be set to the required limit value.

DYNAMIC CONTROL	No.	Parameter	Values			Related
	147	**[Current Lmt Sel]** Selects the source for the adjustment of current limit (i.e. parameter, analog input, etc.).	Default:	0	"Cur Lim Val"	146 149
			Options:	0 1 2	"Cur Lim Val" "Analog In 1" "Analog In 2"	

A separate fault (**Shear Pin Fault, F63**) dedicated to the Shear Pin feature, will be generated if the function is activated.

Application Example

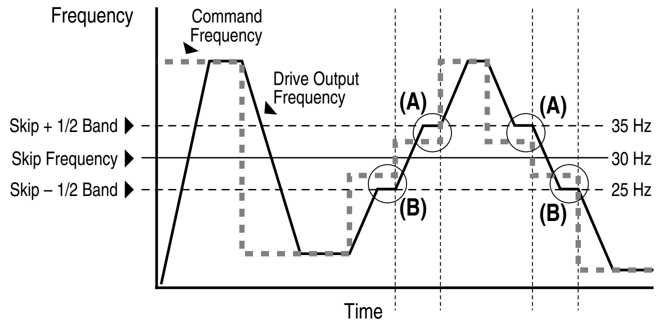
In some applications, mechanical hardware can be damaged if the motor is allowed to develop excess torque. If a mechanical jam should occur, shutting down the system may be the only way to prevent damage. For example, a chain conveyor may be able to "hook" itself, causing a jam on the conveyor. Excess torque from the motor could cause chain or other mechanical damage.



By programming the Shear Pin feature, the user can cause the drive to fault, stopping the excess torque before mechanical damage occurs.

Skip Frequency

Figure 2.30 Skip Frequency



Some machinery may have a resonant operating frequency that must be avoided to minimize the risk of equipment damage. To assure that the motor cannot continuously operate at one or more of the points, skip frequencies are used. Parameters 084-086, ([Skip Frequency 1-3]) are available to set the frequencies to be avoided.

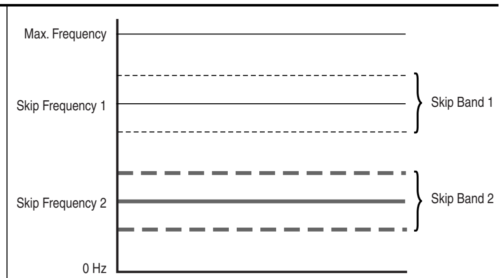
The value programmed into the skip frequency parameters sets the center point for an entire "skip band" of frequencies. The width of the band (range of frequency around the center point) is determined by parameter 87, [Skip Freq Band]. The range is split, half above and half below the skip frequency parameter.

If the commanded frequency of the drive is greater than or equal to the skip (center) frequency and less than or equal to the high value of the band (skip plus 1/2 band), the drive will set the output frequency to the high value of the band. See (A) in Figure 2.30.

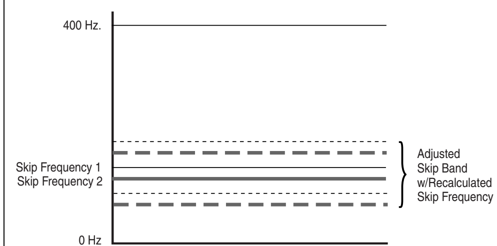
If the commanded frequency is less than the skip (center) frequency and greater than or equal to the low value of the band (skip minus 1/2 band), the drive will set the output frequency to the low value of the band. See (C) in Figure 2.30.

Skip Frequency Examples

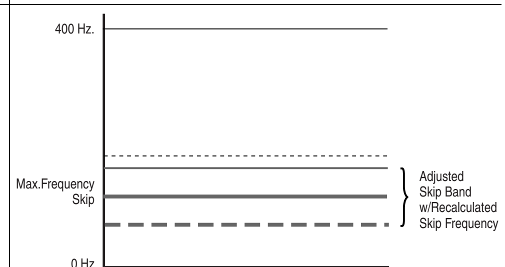
The skip frequency will have hysteresis so the output does not toggle between high and low values. Three distinct bands can be programmed. If none of the skip bands touch or overlap, each band has its own high/low limit.



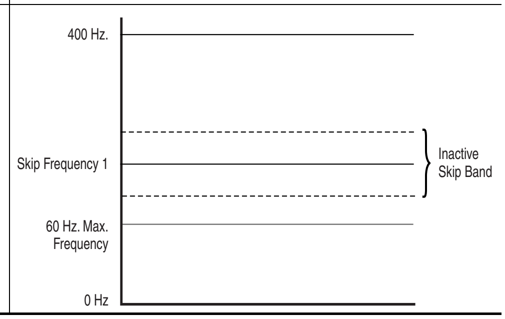
If skip bands overlap or touch, the center frequency is recalculated based on the highest and lowest band values.



If a skip band(s) extend beyond the max frequency limits, the highest band value will be clamped at the max frequency limit. The center frequency is recalculated based on the highest and lowest band values.



If the band is outside the limits, the skip band is inactive.



Acceleration and deceleration are not affected by the skip frequencies. Normal accel/decel will proceed through the band once the commanded frequency is greater than the skip frequency. See (A) & (B) in Figure 2.30. This function affects only continuous operation within the band.

Sleep Mode

Operation

The basic operation of the Sleep-Wake function is to **Start** (wake) the drive when an analog signal is greater than or equal to the user specified [Wake Level], and **Stop** (sleep) the drive when an analog signal is less than or equal to the user specified [Sleep Level]. Setting [Sleep-Wake Mode] to “Direct” enables the sleep wake function.

Requirements

In addition to enabling the sleep function with [Sleep-Wake Mode], at least one of the following assignments **must** be made to a digital input: Enable, Stop-CF, Run, Run Fwd or Run Rev, and the input must be closed. All normal Start Permissives must also be satisfied (Not Stop, Enable, Not Fault, Not Alarm, etc.).

Conditions to Start/Restart

ATTENTION: Enabling the Sleep-Wake function can cause unexpected machine operation during the Wake mode. Equipment damage and/or personal injury can result if this parameter is used in an inappropriate application. Do Not use this function without considering the table below and applicable local, national & international codes, standards, regulations or industry guidelines.

Table 2.AA Conditions Required to Start Drive[1][2][3]

Input	After Power-Up	After a Drive Fault		After a Stop Command
		Reset by Stop-CF, HIM or TB	*Reset by Clear Faults (TB)*	*HIM or TB*
Stop	Stop Closed Wake Signal	Stop Closed Wake Signal New Start or Run Cmd.[4]	Stop Closed Wake Signal	Stop Closed Analog Sig. > Sleep Level[6] New Start or Run Cmd.[4]
Enable	Enable Closed Wake Signal[4]	Enable Closed Wake Signal New Start or Run Cmd.[4]	Enable Closed Wake Signal	Enable Closed Analog Sig. > Sleep Level[6] New Start or Run Cmd.[4]
Run Run For. Run Rev.	Run Closed Wake Signal	New Run Cmd.[5] Wake Signal	Run Closed Wake Signal	New Run Cmd.[5] Wake Signal

(1) When power is cycled, if all conditions are present after power is restored, restart will occur.
(2) If all conditions are present when [Sleep-Wake Mode] is “enabled,” the drive will start.
(3) The active speed reference is determined as explained in the User Manual. The Sleep/Wake function and the speed reference may be assigned to the same input.
(4) Command must be issued from HIM, TB or network.
(5) Run Command must be cycled.
(6) Signal does not need to be greater than wake level.

Timers

Timers will determine the length of time required for Sleep/Wake levels to produce true functions. These timers will start counting when the Sleep/Wake levels are satisfied and will count in the opposite direction whenever the respective level is dissatisfied. If the timer counts all the way to the user specified time, it creates an edge to toggle the Sleep/Wake function to the respective condition (sleep or wake). On power up, timers are initialized to the state that does not permit a start condition. When the analog signal satisfies the level requirement, the timers start counting.

Interactive functions

Separate start commands are also honored (including a digital input “start”), but only when the sleep timer is not satisfied. Once the sleep timer times out, the sleep function acts as a continuous stop. There are two exceptions to this, which will ignore the Sleep/Wake function:

1. When a device is commanding “local” control
2. When a jog command is being issued.

When a device is commanding “local” control, the port that is commanding it has exclusive start control (in addition to ref select), essentially overriding the Sleep/Wake function, and allowing the drive to run in the presence of a sleep situation. This holds true even for the case of Port 0, where a digital input start or run will be able to override a sleep situation.

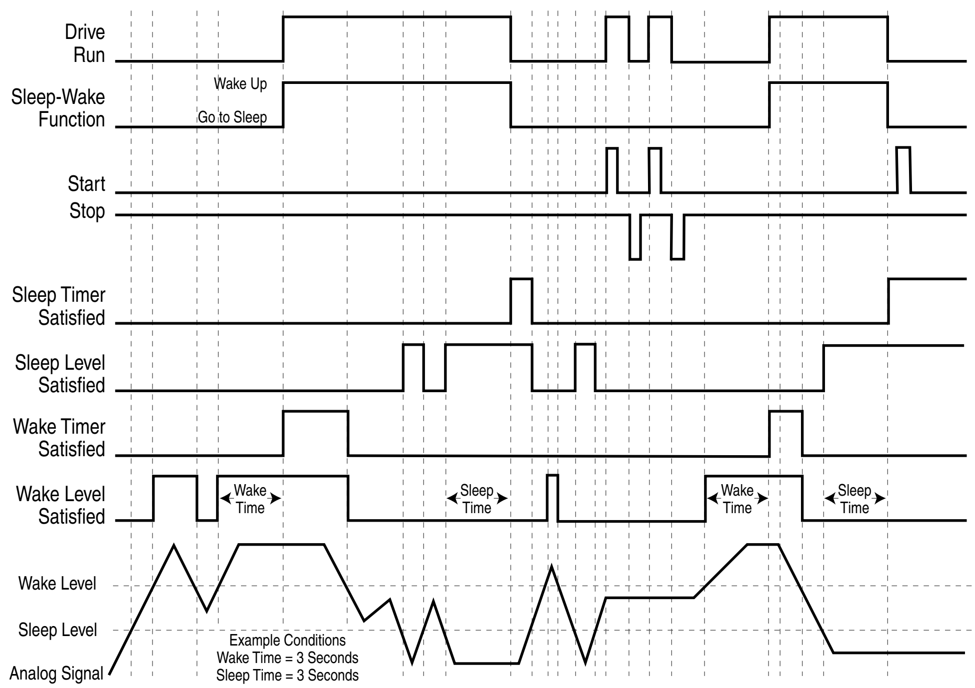
Sleep/Wake Levels

Normal operation will require that [Wake Level] be set greater than or equal to [Sleep Level]. However, there are no limits that prevent the parameter settings from crossing, but the drive will not start until such settings are corrected. These levels are programmable while the drive is running. If [Sleep Level] is made greater than [Wake Level] while the drive is running, the drive will continue to run as long as the analog input remains at a level that doesn’t trigger the sleep condition. Once the drive goes to sleep in this situation, it will not be allowed to restart until the level settings are corrected (increase wake, or decrease sleep). If however, the levels are corrected prior to the drive going to sleep, normal Sleep/Wake operation will continue.

Sleep/Wake Sources

All defined analog inputs for a product shall be considered as valid Sleep/Wake sources. The Sleep/Wake function is completely independent of any other functions that are also using the assigned analog input. Thus, using the same analog input for both speed reference and wake control is permitted. Also, [Analog In x Hi] and [Analog In x Lo] parameters have no affect on the function. However, the factory calibrated result will be used. In addition, the absolute value of the calibrated result will be used, thus making the function useful for bipolar direction applications. The analog in loss function is unaffected and therefore operational with the Sleep/Wake function, but not tied to the sleep or wake levels.

Figure 2.31 Sleep/Wake Function



Speed Control, Mode, Regulation & Vector Speed Feedback

The purpose of speed regulation is to allow the drive to adjust certain operating conditions, such as output frequency, to compensate for actual motor speed losses in an attempt to maintain motor shaft speed within the specified regulation percentage.

The [Speed Mode] parameter selects the speed regulation method for the drive, and can be set to one of 3 choices on the PowerFlex 70/700. The PowerFlex 700 Vector option has 5 choices. In addition, [Feedback Select] in the Vector option, chooses the feedback used for the speed regulator.

- Open Loop - No speed control is offered
- Slip Comp - Slip Compensation is active – approximately 5% regulation
- Process PI - The PI Loop sets the actual speed based on process variables

080	**Standard** **[Speed Mode]** Sets the method of speed regulation.	Default: Options:	0 "Open Loop" 0 "Open Loop" 1 "Slip Comp" 2 "Process PI"
	Vector **[Feedback Select]** Selects the source for motor speed feedback. Note that all selections are available when using Process PI. "Open Loop" (0) - no encoder is present, and slip compensation is not needed. "Slip Comp" (1) - tight speed control is needed, and encoder is not present. "Encoder" (3) - an encoder is present. "Simulator" (5) - Simulates a motor for testing drive operation & interface check.	Default: Options:	0 "Open Loop" 0 "Open Loop" 1 "Slip Comp" 2 "Reserved" 3 "Encoder" 4 "Reserved" 5 "Simulator"

Open Loop

As the load on an induction motor increases, the rotor speed or shaft speed of the motor decreases, creating additional slip (and therefore torque) to drive the larger load. This decrease in motor speed may have adverse effects on the process. If the [Speed Mode] parameter is set to "Open Loop," no speed control will be exercised. Motor speed will be dependent on load changes and the drive will make no attempt to correct for increasing or decreasing output frequency due to load.

Slip Compensation

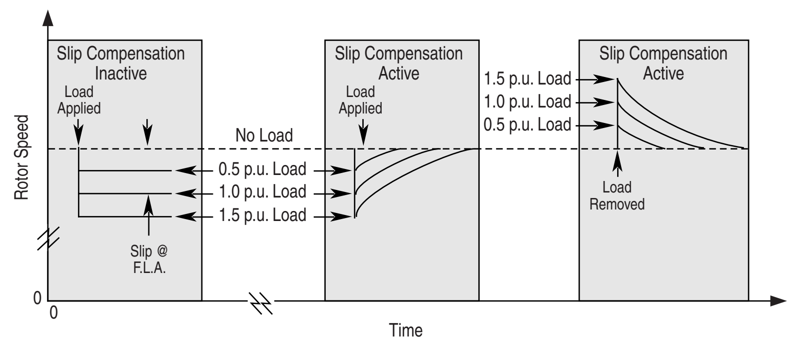
As the load on an induction motor increases, the rotor speed or shaft speed of the motor decreases, creating additional slip (and therefore torque) to drive the larger load. This decrease in motor speed may have adverse effects on the process. If speed control is required to maintain proper process control, the slip compensation feature of the PowerFlex drives can be enabled by the user to more accurately regulate the speed of the motor without additional speed transducers.

When the slip compensation mode is selected, the drive calculates an amount to increase the output frequency to maintain a consistent motor speed independent of load. The amount of slip compensation to provide is selected in [Slip RPM @ FLA]. During drive commissioning this parameter is set to the RPM that the motor will slip when operating with Full Load Amps. The user may adjust this parameter to provide more or less slip.

As mentioned above, induction motors exhibit slip which is the difference between the stator electrical frequency, or output frequency of the drive, and the induced rotor frequency.

The slip frequency translates into a slip speed resulting in a reduction in rotor speed as the load increases on the motor. This can be easily seen by examining Figure 2.32.

Figure 2.32 Rotor Speed with/without Slip Compensation



Without slip compensation active, as the load increases from no load to 150% of the motor rating, the rotor speed decreases approximately proportional to the load.

With slip compensation, the correct amount of slip compensation is added to the drive output frequency based on motor load. Thus, the rotor speed returns to the original speed. Conversely, when the load is removed, the rotor speed increases momentarily until the slip compensation decays to zero.

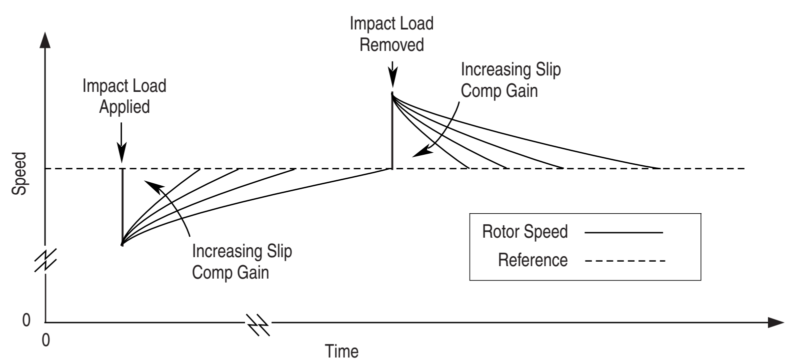
Motor nameplate data must be entered by the user in order for the drive to correctly calculate the proper amount of slip compensation. The motor nameplate reflects slip in the rated speed value at rated load. The user can enter the Motor Nameplate RPM, Motor Nameplate Frequency, the Motor Nameplate Current, Motor Nameplate Voltage, and Motor Nameplate HP/kW and during commissioning the drive calculates the motor rated slip frequency and displays it in [Slip RPM @ FLA]. The user can adjust the slip compensation for more accurate speed regulation, by increasing or decreasing [Slip RPM @ FLA] value.

Internally, the drive converts the rated slip in RPM to rated slip in frequency. To more accurately determine the rated slip frequency in hertz, an estimate of flux current is necessary. This parameter is either a default value based on motor nameplate data or the auto tune value. The drive scales the amount of slip compensation to the motor rated current. The amount of slip frequency added to the frequency command is then scaled by the sensed torque current (indirect measurement of the load) and displayed.

Slip compensation also affects the dynamic speed accuracy (ability to maintain speed during “shock” loading). The effect of slip compensation during transient operation is illustrated in Figure 2.33. Initially, the motor is operating at some speed and no load. At some time later, an impact load is applied to the motor and the rotor speed decreases as a function of load and inertia. And finally, the impact load is removed and the rotor speed increases momentarily until the slip compensation is reduced based on the applied load.

When slip compensation is enabled the dynamic speed accuracy is dependent on the filtering applied to the torque current. The filtering delays the speed response of the motor/drive to the impact load and reduces the dynamic speed accuracy. Reducing the amount of filtering applied to the torque current can increase the dynamic speed accuracy of the system. However, minimizing the amount of filtering can result in an unstable motor/drive. The user can adjust the Slip Comp Gain parameter to decrease or increase the filtering applied to the torque current and improve the system performance.

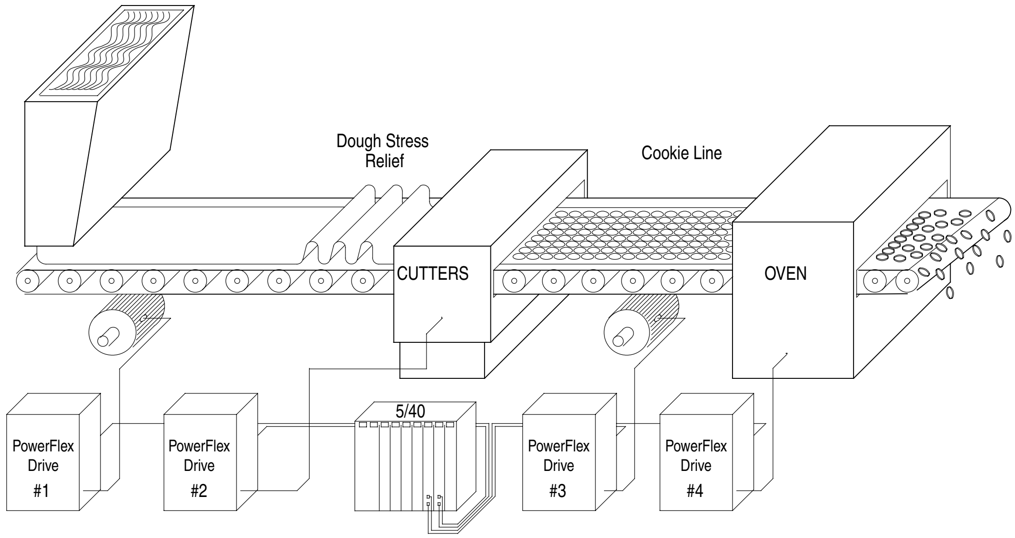
Figure 2.33 Rotor Speed Response Due to Impact Load and Slip Com Gain



Application Example - Baking Line

The diagram below shows a typical application for the Slip Compensation feature. The PLC controls the frequency reference for all four of the drives. Drive #1 and Drive #3 control the speed of the belt conveyor. Slip compensation will be used to maintain the RPM independent of load changes caused by the cutter or dough feed. By maintaining the required RPM, the baking time remains constant and therefore the end product is consistent.

With the Slip Compensation feature, the process will only require a new speed reference when the product is changed. The user will not have to tune the drive due to a different load characteristic.



Process PI – *See* *Process PI Loop on page 2-137*

Vector

Encoder

There is (1) encoder input on the I/O board of the PowerFlex 700VC. The encoder input must be line driver type, quadrature (dual channel) or pulse (single channel). The encoder input accepts 8 or 12V DC encoder signals. There is a 12V DC supply on the drive that can be used to supply power for the encoders.

An encoder offers the best performance for both speed and torque regulation applications. Encoder feedback is required for applications with high bandwidth response, tight speed regulation, torque regulation of (+/-2%) or when the motor is required to operate at less than 1/120th its' base speed.

[Motor Fdbk Type] selects the type of encoder:

- "Quadrature" – dual channel.
- "Quad Check" – dual channel and detects loss of encoder signal when using differential inputs.
- "Single Chan" – pulse type, single channel.
- "Single Check" – pulse type, single channel and detects loss of encoder signal when using differential inputs.

[Encoder PPR] sets the number of encoder pulses per revolution.

[Enc Position Fdbk] displays the raw encoder count. For single channel encoders, this count will increase (per rev.) by the amount in [Encoder PPR]. For quadrature encoders this count will increase by 4 times the amount defined in [Encoder PPR].

Vector Encoderless/Deadband

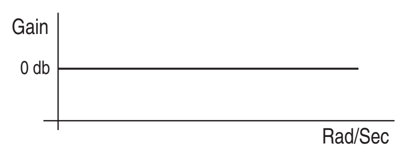
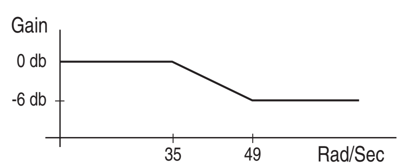
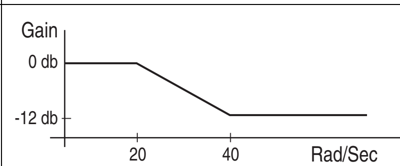
Encoderless/Deadband is recommended when more than a 120:1 speed range of operation is not required and the user will set the speed reference below 0.5Hz/15 RPM. The deadband will help prevent cogging and unstable motor operation below a reference of 0.5Hz/15RPM by clamping the speed and torque regulators to zero.

Vector Simulator

The simulator mode allows the drive to be operated without a motor connected and is meant for demo purposes only. If a motor is connected with this mode selected very erratic and unpredictable operation will occur.

Speed Feedback Filter

Vector [Fdbk Filter Select] determines the type of filter to use for the speed feedback. The filter is used to filter out high frequency signals (noise) by reducing the gain at high frequencies. The selections for the filter are:

Description	To select this type of filter . . .	Select this value . . .
No filter		0
A light 35/49 radian feedback filter		1
A heavy 20/40 radian feedback filter		2

Speed Reference

Operation

The output frequency of the drive is controlled, in part, by the speed command or speed reference given to it. This reference can come from a variety of sources including:

- HIM (local or remote)
- Analog Input
- Preset Speed Parameter
- Jog Speed Parameter
- Communications Adapter
- Process PI Loop
- Digital Input MOP

Selection

Binary Logic

Some references can be selected by binary logic, through digital inputs to the terminal block or bit manipulation of the Logic Command Word in a communications adapter. These sources are used when the drive is in "Auto" mode. The default reference is from the source selected in [Speed Ref A Sel], parameter 90. This parameter can be set to any one of the 22 choices. If the binary logic selection is zero, this will be the active speed reference.

Auto/Manual

Many applications require a "manual mode" where adjustments can be made and setup can be done by taking local control of the drive speed. Typically, these adjustments would be made via a "local" HIM mounted on the drive. When all setup is complete, control of the drive frequency command is turned over to automatic control from a remote source such as a PLC, analog input etc.

The source of the speed reference is switched to one of two "manual" sources when the drive is put into manual mode:

1. Local HIM
2. Analog Input to terminal block

If the selection is the HIM, then the digital or analog speed control on the HIM provides the reference.

If the switch to manual mode was made via a digital input, (parameters 361-366 set to "18, Auto/Manual") then the source for the reference is defined in [TB Man Ref Sel], parameter 96. This can be either of the 2 analog inputs or the digital MOP.

When the drive is returned to automatic mode, the speed reference returns to the source selected by the binary logic. Also see Auto/Manual on page 2-27.

DPI

See the DPI on page 2-83 for a description of DPI. One of the DPI ports can be selected as the source of the speed reference.

In the PowerFlex 70, 700, and 700VC the speed reference from DPI is scaled so that [Maximum Freq] = 32767. [Maximum Freq] is the largest **output** frequency that the drive will deliver to the motor.

Additionally, the PowerFlex 70 and 700 drives have a parameter called [Maximum Speed]. [Maximum Speed] limits the drive speed **reference**, such as from a communication network or analog input.

PowerFlex drives contain the following necessary rule:

[Maximum Speed] + [Overspeed Limit] = [Maximum Freq]

[Overspeed Limit] allows the drive to operate above [Maximum Speed] for certain functions such as bus regulation, current limit (during regeneration), PI control, and slip compensation. It is important that [Overspeed Limit] is set to allow enough headroom for the application. For example, let's assume we have an application where [Speed Mode] = "Slip Comp". Slip compensation adds some frequency to the commanded speed in order to compensate for slip in a loaded motor. In this case, [Overspeed Limit] should not be set to 0. Otherwise, if the drive is running with a commanded frequency of 60 Hz and the motor is loaded at all, slip compensation will add some frequency and we would get a nuisance "Overspeed" fault.

Defaults are as follows:

- [Maximum Speed] = 60 Hz
- [Overspeed Limit] = 10 Hz
- [Maximum Freq] = 130 Hz (this is default so that users who want to go twice base speed don't have to change it).

To send out a speed reference to the drive from a controller over RIO, you can perform the following calculation:

$$\text{SpeedRef} = \frac{\text{CommandFreq}}{\text{[Maximum Freq]}} \times 32767$$

For example, to send out a command frequency of 60 Hz on a PowerFlex 70 or 700 with default settings we would calculate the following:

$$\text{SpeedRef} = \frac{60\ \text{Hz}}{130\ \text{Hz}} \times 32767 = 15123$$

The following example illustrates how a change in P55 [Maximum Freq] in the PowerFlex 70 or 700 affects the speed reference scaling:

[Overspeed Limit] = 10 Hz (this is factory default)
[Maximum Speed] = 60 Hz (this is factory default).
[Maximum Freq] = [Maximum Speed] + [Overspeed Limit] = 60 Hz + 10 Hz = 70 Hz.

Using the above formula, calculate the Speed Reference sent from a network using a DPI adapter.

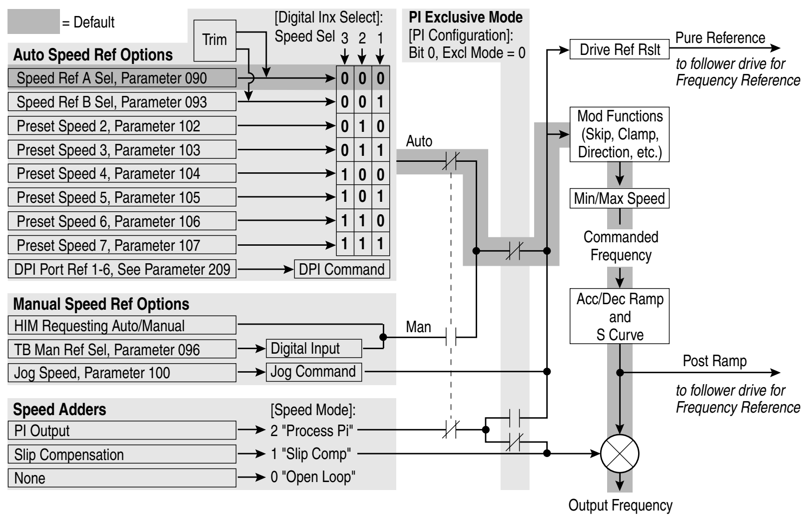
For example, to send out a command frequency of 60 Hz with [Maximum Freq] = 70 Hz, we would calculate the following:

$$\text{SpeedRef} = \frac{60\text{ Hz}}{70\text{ Hz}} \times 32767 = 28086$$

Jog

When the drive is not running, pressing the HIM Jog button or a programmed Jog digital input will cause the drive to jog at a separately programmed jog reference. This speed reference value is entered in [Jog Speed], parameter 100.

Figure 2.34 Speed Reference Selection



Scaling

Scaling applies only to references from analog inputs and reference sources selected in [Speed Ref x Sel], parameters 90/93.

Each analog input has its own set of scale parameters:

- [Analog In x Hi] sets the maximum level on input to be seen (i.e. 10 Volts).
- [Analog In x Lo] sets the minimum level on input to be seen (i.e. 0 Volts).

Each [Speed Ref x Sel] parameter has an additional set of scale parameters:

- [Speed Ref x Hi] selects the reference value for the maximum input specified in [Analog In x Hi].
- [Speed Ref x Lo] selects the reference value for the minimum input specified in [Analog In x Lo].

For example, if the following parameters are set:

[Analog In x Hi] = 10 V
[Analog In x Lo] = 0 V
[Speed Ref A Hi] = 45 Hz
[Speed Ref x Lo] = 5 Hz

then the speed command for the drive will be linearly scaled between 45 Hz at maximum analog signal and 5 Hz at minimum analog signal. See additional examples under Analog Inputs on page 2-12.

Polarity

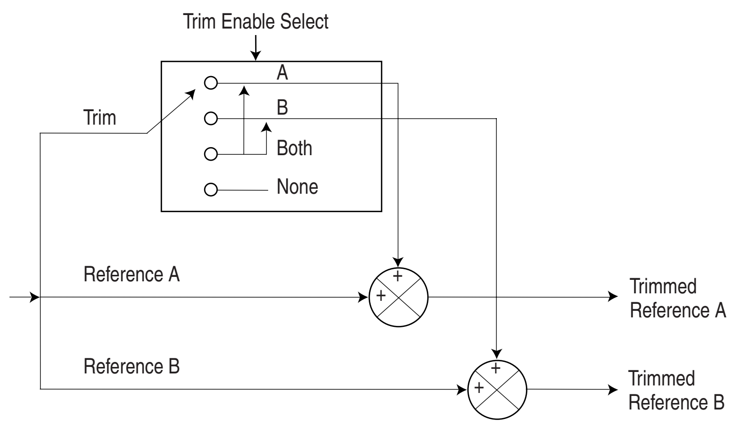
The reference can be selected as either unipolar or bipolar. Unipolar is limited to positive values and supplies only the speed reference. Bipolar supplies both the speed reference AND the direction command: + signals = forward direction and – signals = reverse direction.

Trim

If the speed reference is coming from the source specified in [Speed Ref A Sel] or [Speed Ref B Sel], the a trim signal can be applied to adjust the speed reference by a programmable amount. The source of the trim signal is made via [Trim In Sel], parameter 117 and can be any of the sources that are also used as references. [Trim Out Select], parameter 118 selects which of the references, A/B will be trimmed.

If the trim source is an analog input, two additional scale parameters are provide to scale the trim signal.

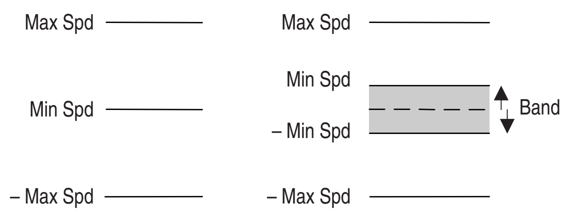
Figure 2.35 Trim



Min/Max Speed

[Max Speed]

Maximum and minimum speed limits are applied to the reference. These limits apply to the positive and negative references. The minimum speed limits will create a band that the drive will not run continuously within, but will ramp through. This is due to the positive and negative minimum speeds. If the reference is positive and less than the positive minimum, it is set to the positive minimum. If the reference is negative and greater than negative minimum, it is set to the negative minimum. If the minimum is not 0, hysteresis is applied at 0 to prevent bouncing between positive and negative minimums. See below.



Maximum frequency

The maximum frequency defines the maximum reference frequency. The actual output frequency may be greater as a result of slip compensation and other types of regulation. This parameter also defines scaling for frequency reference. This is the frequency that corresponds to 32767 counts when the frequency reference is provided by a network.

Speed Regulator

Vector FV The drive takes the speed reference that is specified by the speed reference control loop and compares it to the speed feedback. The speed regulator uses proportional and integral gains to adjust the torque reference that is sent to the motor. This torque reference attempts to operate the motor at the specified speed. This regulator also produces a high bandwidth response to speed command and load changes.

Vector FV Integral Gain

The integral gain block outputs a torque command relative to the error integrated over a period of time.

[Ki Speed Loop] sets the integral gain of the speed regulator. Its value is automatically calculated based on the bandwidth setting in [Speed Desired BW]. Integral gain may be manually adjusted by setting [Speed Desired BW] to a value of zero. Units are (per unit torque/sec) / (per unit speed). For example, when [Ki Speed Loop] is 50 and the speed error is 1%, the integral output will integrate from 0 to 50% motor rated torque in 1 second.

Vector FV Proportional Gain

The proportional gain determines how much of a speed error occurs during a load transient.

[Kp Speed Loop] sets the proportional gain of the speed regulator. Its value is automatically calculated based on the bandwidth setting in [Speed Desired BW]. Proportional gain may be manually adjusted by setting [Speed Desired BW] to a value of zero. Units are (per unit torque) / (per unit speed). For example, when [Kp Speed Loop] is 20, the proportional gain block will output 20% motor rated torque for every 1% error of motor rated speed.

Vector FV Feed Forward Gain

The first section of the PI regulator is the feed forward block. [Kf Speed Loop] allows the speed regulator to be dampened during speed changes. To reduce speed overshoot, reduce the value of [Kf Speed Loop]. During auto-tune, the feed forward is left open (no dampening).

Vector FV Speed Desired BW

[Speed Desired BW] sets the speed loop bandwidth and determines the dynamic behavior of the speed loop. As bandwidth increases, the speed loop becomes more responsive and can track a faster changing speed reference. Adjusting this parameter will cause the drive to calculate and change [Ki Speed Loop] and [Kp Speed Loop] gains.

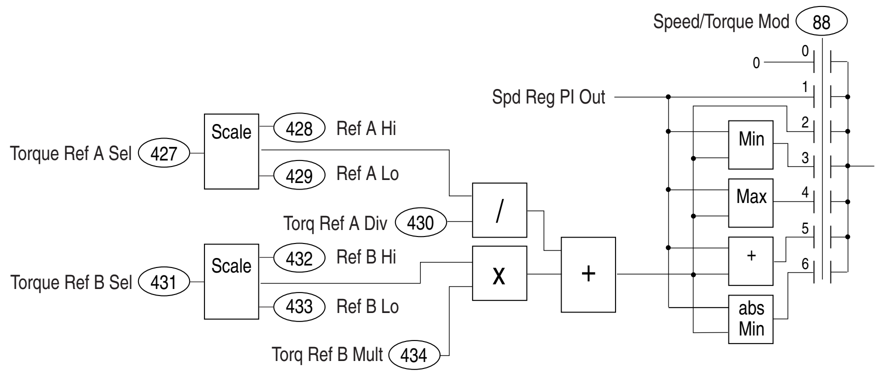
Vector FV Total Inertia

[Total Inertia] represents the time in seconds, for a motor coupled to a load to accelerate from zero to base speed, at rated motor torque. The drive calculates Total Inertia during the autotune inertia procedure. Adjusting this parameter will cause the drive to calculate and change [Ki Speed Loop] and [Kp Speed Loop] gains.

Speed/Torque Select

Vector FV [Speed/Torque Mod] is used to choose the operating mode for the drive. The drive can be programmed to operate as a velocity regulator, a torque regulator, or a combination of the two. Refer to 2.36.

Figure 2.36



As shown, [Speed/Torque Mod] (parameter 88) is used to select the mode of operation. Zero torque current is allowed when set to "0."

When set to a "1," the drive/motor is operated in speed mode. The torque command changes as needed to maintain the desired speed.

A value of "2" selects torque mode. In torque regulation mode, the drive controls the desired motor torque. The motor speed will be a result of the torque command and load present at the motor shaft.

Min and Max mode are selected by values 3 and 4, respectively. These two modes offer a combination of speed and torque operation. The algebraic minimum or maximum of speed/torque will be the operating point for the Min and Max modes. The drive will automatically switch from speed to torque mode (or from torque to speed) based on the dynamics of the motor/ load.

The Min mode is typically used with positive torque and forward speed operation, the minimum of the two being closest to zero. The Max mode is opposite, typically used with reverse speed and negative torque, the maximum being the least negative (closest to zero).

Sum mode is selected when set to "5." This mode allows an external torque command to be added to the speed regulator output when desired.

Speed Regulation Mode

Operating as a speed regulator is the most common and therefore simplest mode to setup. Examples of speed regulated applications are blowers, conveyors, feeders, pumps, saws, and tools.

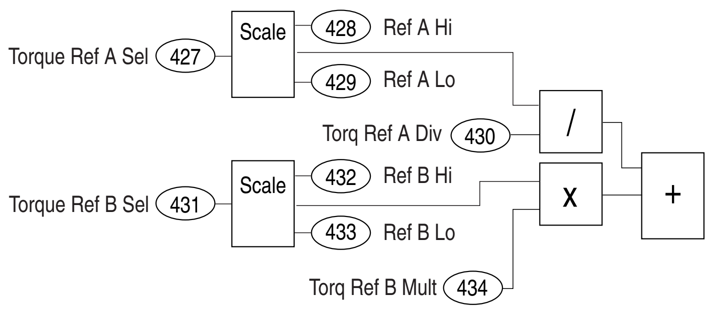
In a speed regulated application, the torque reference is generated by the speed regulator output. Note that under steady state conditions the speed feedback is steady while the torque reference is a constantly adjusting signal. This is required to maintain the desired speed. At transient state, the torque reference will change dramatically to compensate for a speed change. A short duration change in speed is the result of increasing or decreasing the load very rapidly.

Torque Regulation Mode

A torque regulated application can be described as any process that requires some tension control. An example of this is a winder or unwind where material is being “drawn” or pulled with a specific tension required. The process requires another element setting the speed. Configuring the drive for torque regulation requires [Speed/Torque Mod] to be set to “2.” In addition, a reference signal must be selected (Torque Ref A or Torque Ref B). If an analog signal is used for the reference, select that from the Torque Ref A or Torque Ref B selections.

When operating in a torque mode, the motor current will be adjusted to achieve the desired torque. If the material being wound/unwound breaks, the load will decrease dramatically and the motor can potentially go into a “runaway” condition.

Figure 2.37



Torque Reference:

[Torque Ref A Sel], parameter 427 is scaled by [Torque Ref A Hi] and [Torque Ref A Lo]. Then divided by [Torq Ref A Div].

[Torque Ref B Sel], parameter 431 is scaled by [Torque Ref B Hi] and [Torque Ref B Lo]. Then multiplied by [Torq Ref B Mult].

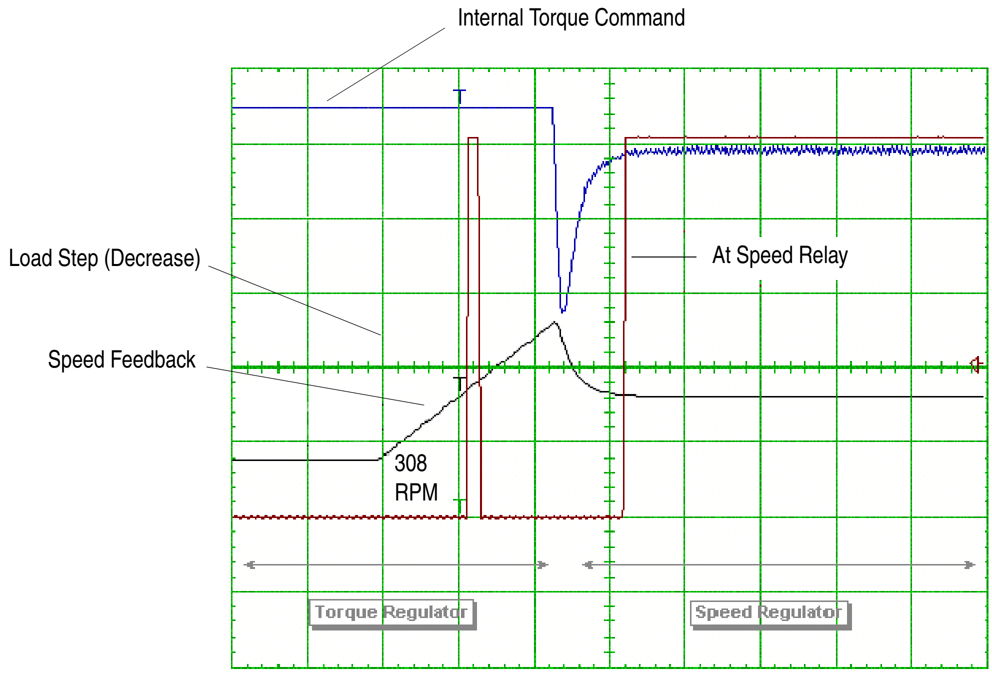
The final torque reference, in the Torque Mode, is the sum of scaled Torque Ref A and scaled Torque Ref B.

Min Mode/Max Mode

This operating mode compares the speed and torque commands. The algebraically minimum value is used. This mode can be thought of as a Speed Limited Adjustable Torque operation. Instead of operating the drive as a pure torque regulator, the “runaway” condition can be avoided by limiting the speed. A winder is a good example for the application of the Min Spd/Trq operating mode. Max mode would be used if both speed and torque are negative.

Figure 2.38 illustrates how min mode operates. The drive starts out operating as a torque regulator. The torque reference causes the motor to operate at 308rpm. The speed reference is 468rpm, so the minimum is to operate as a torque regulator. While operating in torque regulation, the load decreases and the motor speeds up. Notice the torque command has not changed. When the speed regulator comes out of saturation, it clamps the speed and now the drive operates as a speed regulator. The At Speed Relay then closes.

Figure 2.38



Sum Mode

Configuring the drive in this mode allows an external torque input to be summed with the torque command generated by the speed regulator. The drive requires both a speed reference and a torque reference to be linked. This mode can be used for applications that have precise speed changes with critical time constraints. If the torque requirement and timing is known for a given speed change, then the external torque input can be used to preload the integrator. The timing of the speed change and the application of an external torque command change must be coordinated for this mode to be useful. The sum mode will then work as a feed forward to the torque regulator.

Zero Torque Mode

Operation in zero torque mode allows the motor to be fully fluxed and ready to rotate when a speed command or torque command is given. For a cyclical application where through put is a high priority this mode can be used. The control logic can select zero torque during the "rest" portion of a machine cycle instead of stopping the drive. When the cycle start occurs, instead of issuing a start to the drive, a speed regulate mode can be selected. The drive will then immediately accelerate the motor without the need for "flux up" time.

Important: Zero Torque may excessively heat the motor if operated in this mode for extended periods of time. No load or flux current is still present when the drive is operating in zero torque mode. A motor with an extended speed range or separate cooling methods (blower) may be required.

Speed Units

Vector [Speed Units] selects the units to be used for all speed related parameters. The options for [Speed Units] are:

- "Hz" – converts status parameters only to Hz.
- "RPM" – converts status parameters only to RPM.
- "Convert Hz" - converts all speed based parameters to Hz, and changes the value proportionately (i.e. 1800 RPM = 60 Hz).
- "Convert RPM" - converts all speed based parameters to RPM, and changes the value proportionately.

Start Inhibits

The [Start Inhibits] parameter indicates the inverted state of all start permissive conditions. If the bit is on (HI or 1), the corresponding permissive requirement has not been met and the drive is inhibited from starting. It will be updated continually, not only when a start attempt is made. See also Start Permissives on page 2-180.

Start Permissives

Start permissives are conditions required to permit the drive to start in any mode – run, jog, auto-tune, etc. When all permissive conditions are met the drive is considered *ready* to start. The ready condition is available as the *drive ready* status.

Permissive Conditions

1. No faults can be active.
2. No type2 alarms can be active.
3. The TB Enable input (if configured) must be closed.
4. The DC bus precharge logic must indicate it is a start permissive.
5. All Stop inputs must be negated (See special Digital Inputs Stops Configuration issues below).
6. No configuration changes (parameters being modified) can be in-progress.

If all permissive conditions are met, a valid start, run or jog command will start the drive. The status of all inhibit conditions, except for item 6 above, are reflected in the output parameter Start Inhibits. The configuration change condition is a transient (short-term) condition and not directly user controlled. It is therefore not reflected in the Start Inhibits parameter.

Note that the Start Inhibits conditions do not include any of the functionality imposed by the DPI logic such as owners, masks, local control, etc.

Start-Up

Start-Up Routines

PowerFlex drives offer a variety of Start Up routines to help the user commission the drive in the easiest manner and the quickest possible time. PowerFlex 70 Drives have the S.M.A.R.T Start routine and a Basic assisted routine for more complex setups. PowerFlex 700 drives have both of the above plus an advanced startup routine.

S.M.A.R.T. Start

During a Start Up, the majority of applications require changes to only a few parameters. The LCD HIM on a PowerFlex 70 drive offers S.M.A.R.T. start, which displays the most commonly changed parameters. With these parameters, you can set the following functions:

S - Start Mode and Stop Mode
M - Minimum and Maximum Speed
A - Accel Time 1 and Decel Time 1
R - Reference Source
T - Thermal Motor Overload

To run a S.M.A.R.T. start routine:

Step	Key(s)	Example LCD Displays
1. Press ALT and then Esc (S.M.A.R.T). The S.M.A.R.T. start screen appears.	ALT Esc	S.M.A.R.T. List Start Mode Stop Mode Minimum Speed
2. View and change parameter values as desired. For HIM information, see Appendix B.		
3. Press ALT and then Sel (Exit) to exit the S.M.A.R.T. start.	ALT Sel	

Basic Start Up

The Basic Start Up routine leads the user through the necessary information in a simple question and answer format. The user can make the choice to execute or skip any section of the routine. Below is a complete flow chart of the routine.

Figure 2.39 PowerFlex 70 & 700 Standard Control Option Startup

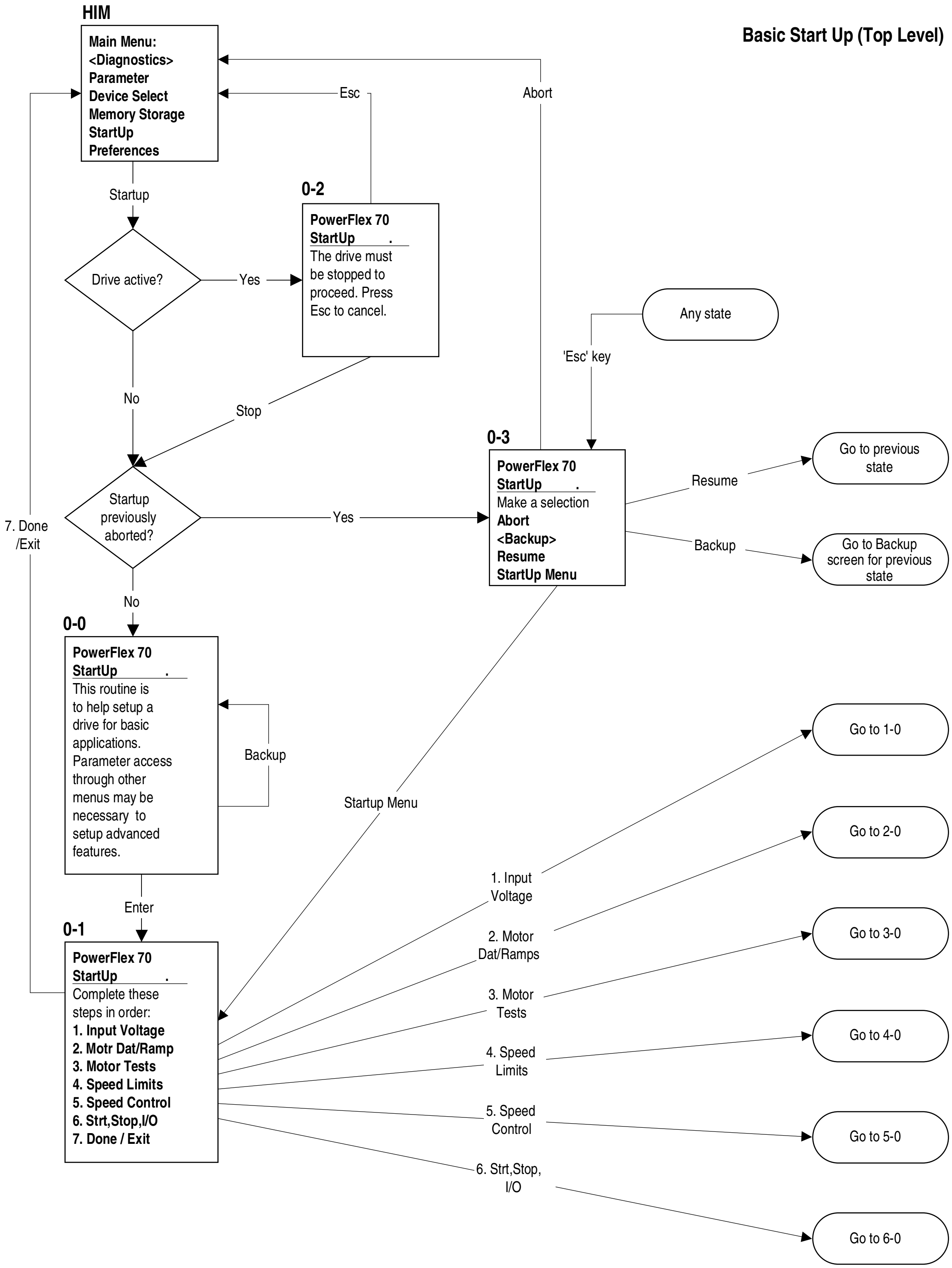


Figure 2.39 PowerFlex 70 & 700 Standard Control Option Startup (1)

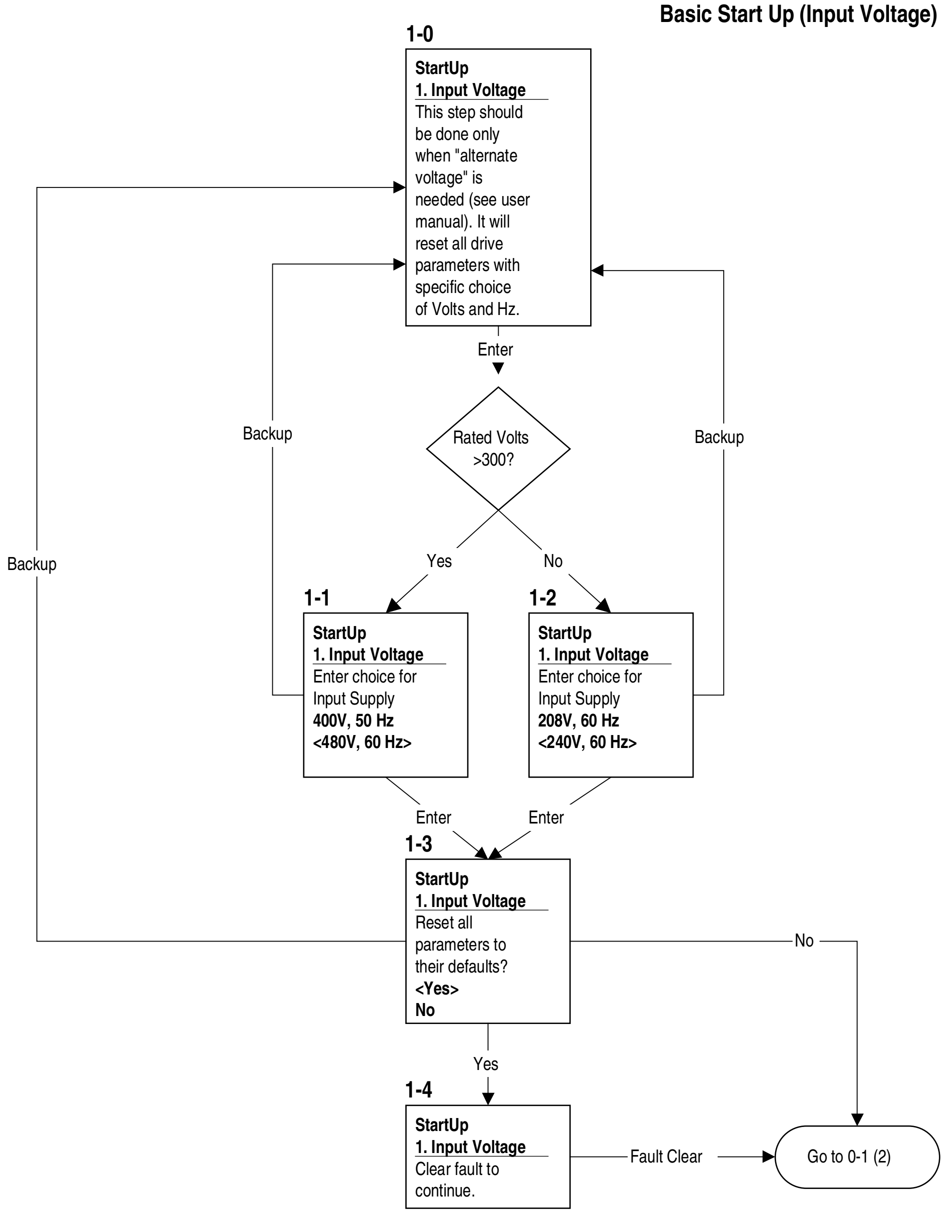


Figure 2.39 PowerFlex 70 & 700 Standard Control Option Startup (2)

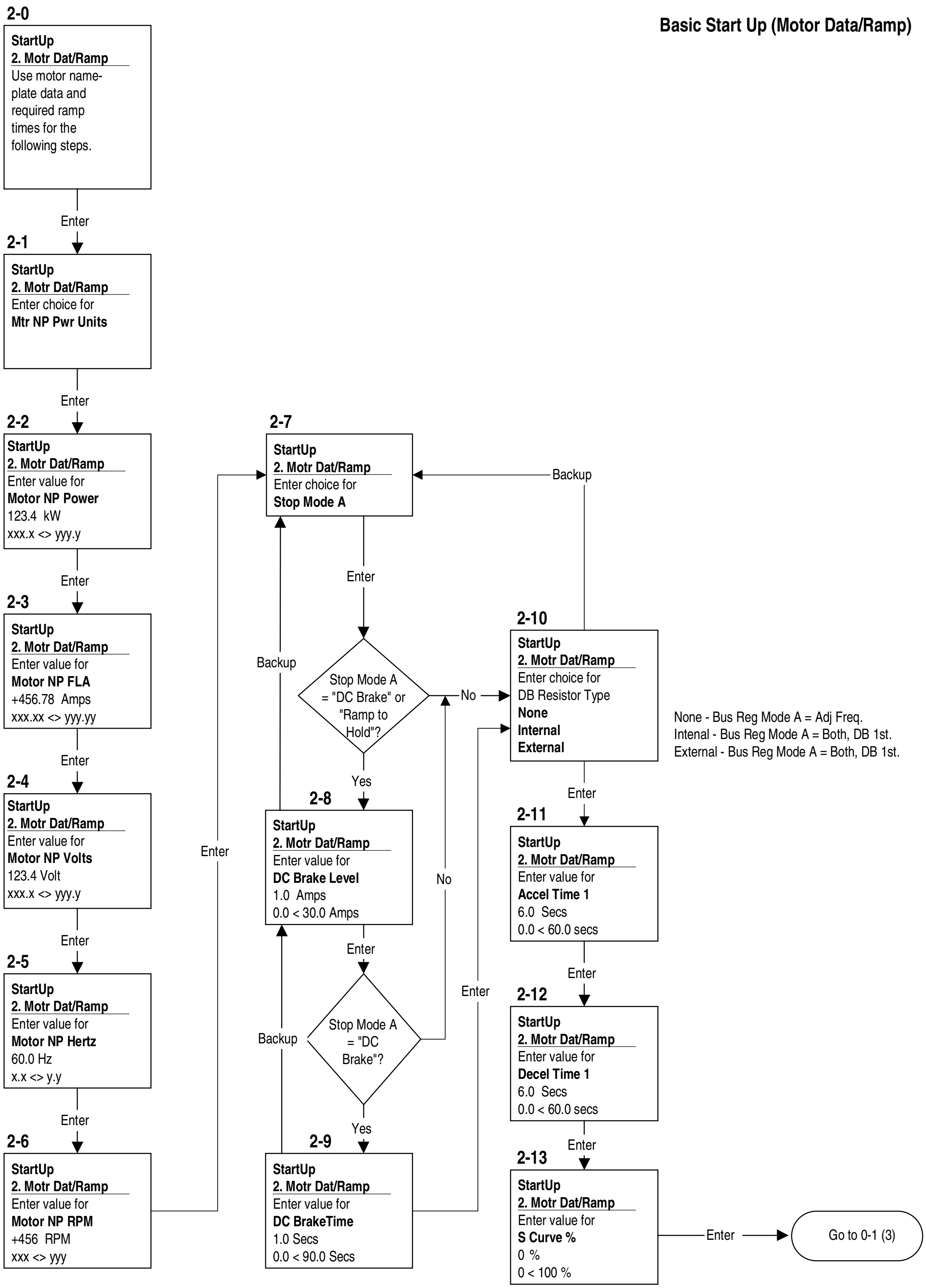


Figure 2.39 PowerFlex 70 & 700 Standard Control Option Startup (3)

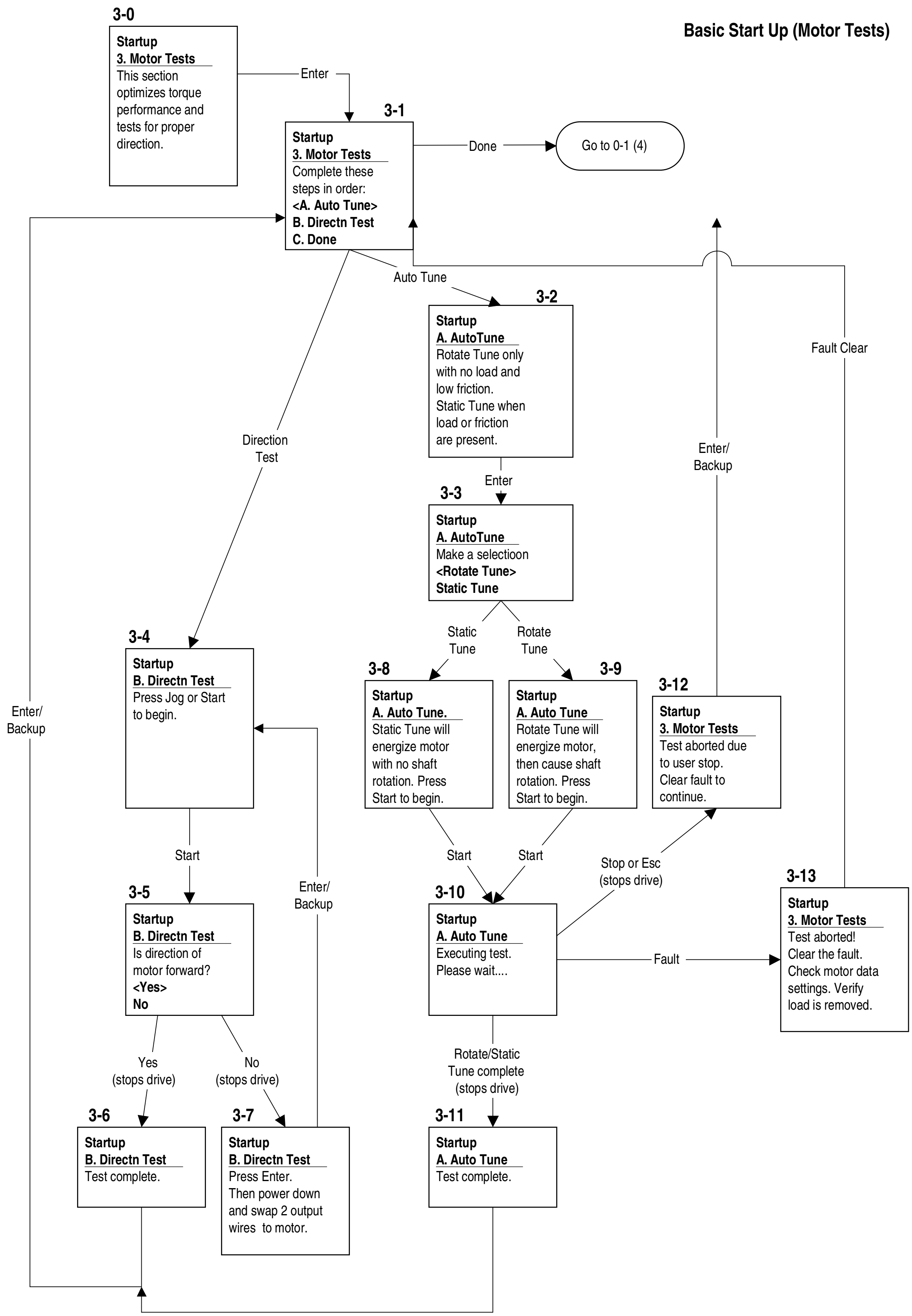


Figure 2.39 PowerFlex 70 & 700 Standard Control Option Startup (4)

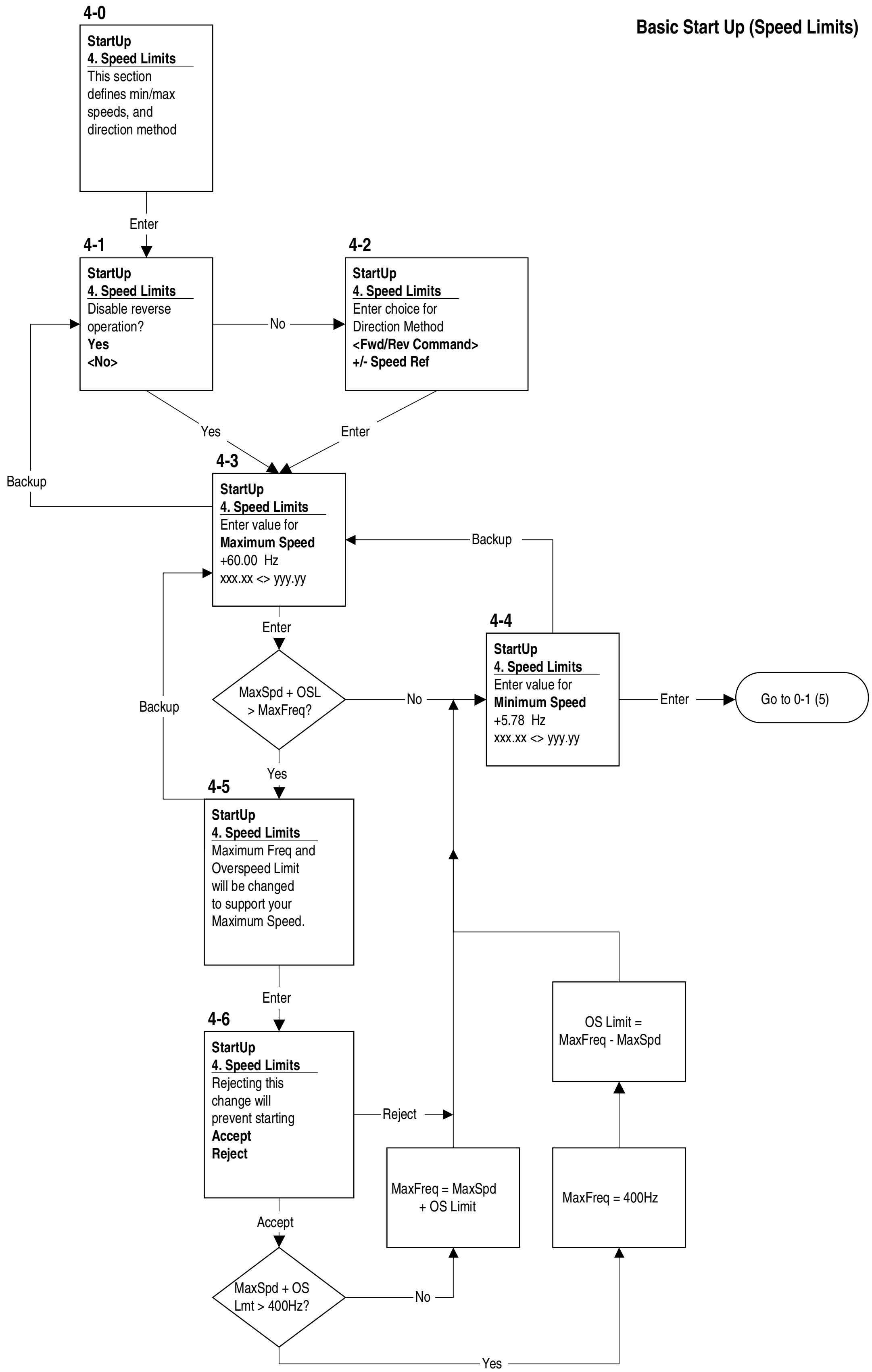


Figure 2.39 PowerFlex 70 & 700 Standard Control Option Startup (5)

Basic Start Up (Speed Control)

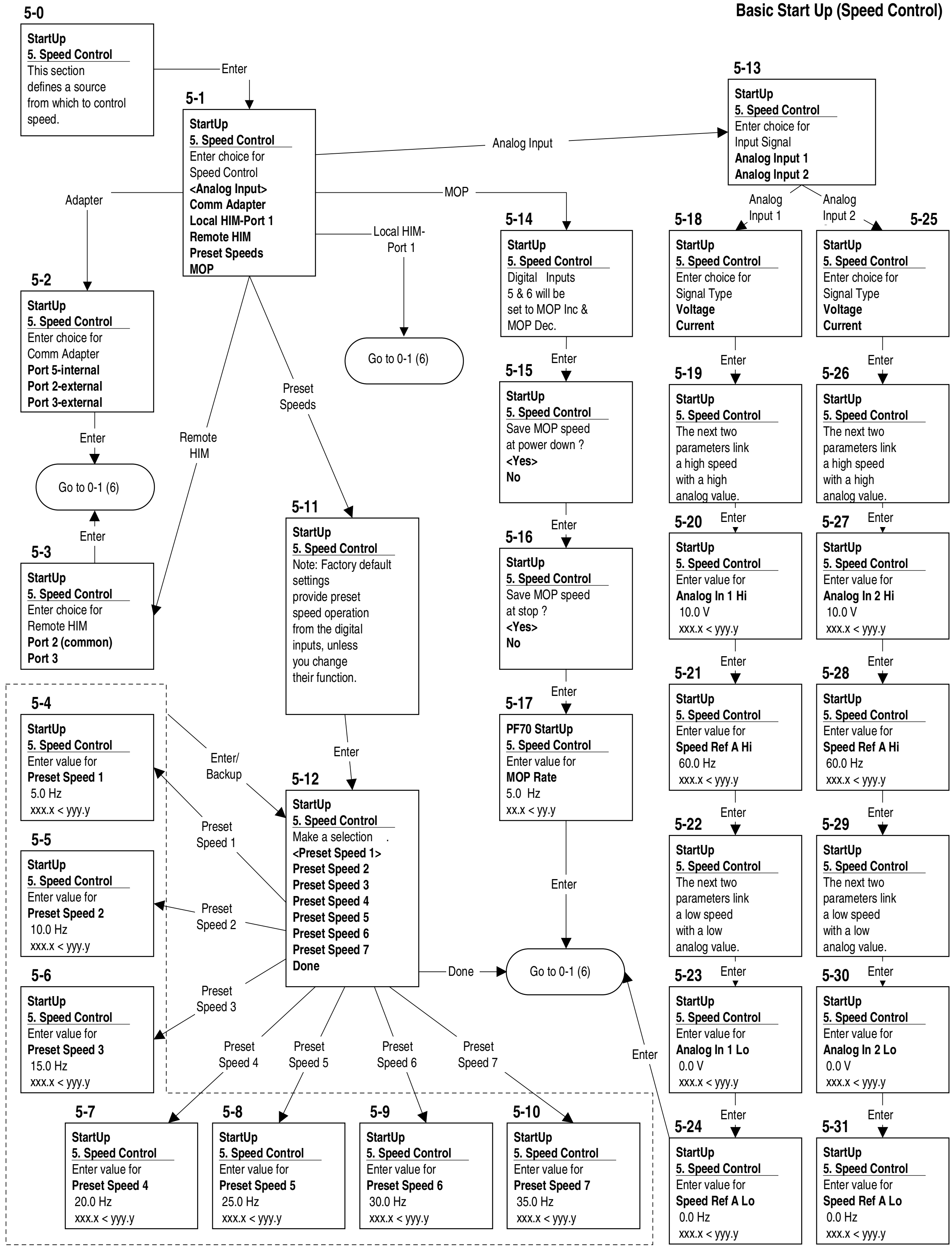


Figure 2.39 PowerFlex 70 & 700 Standard Control Option Startup (6)

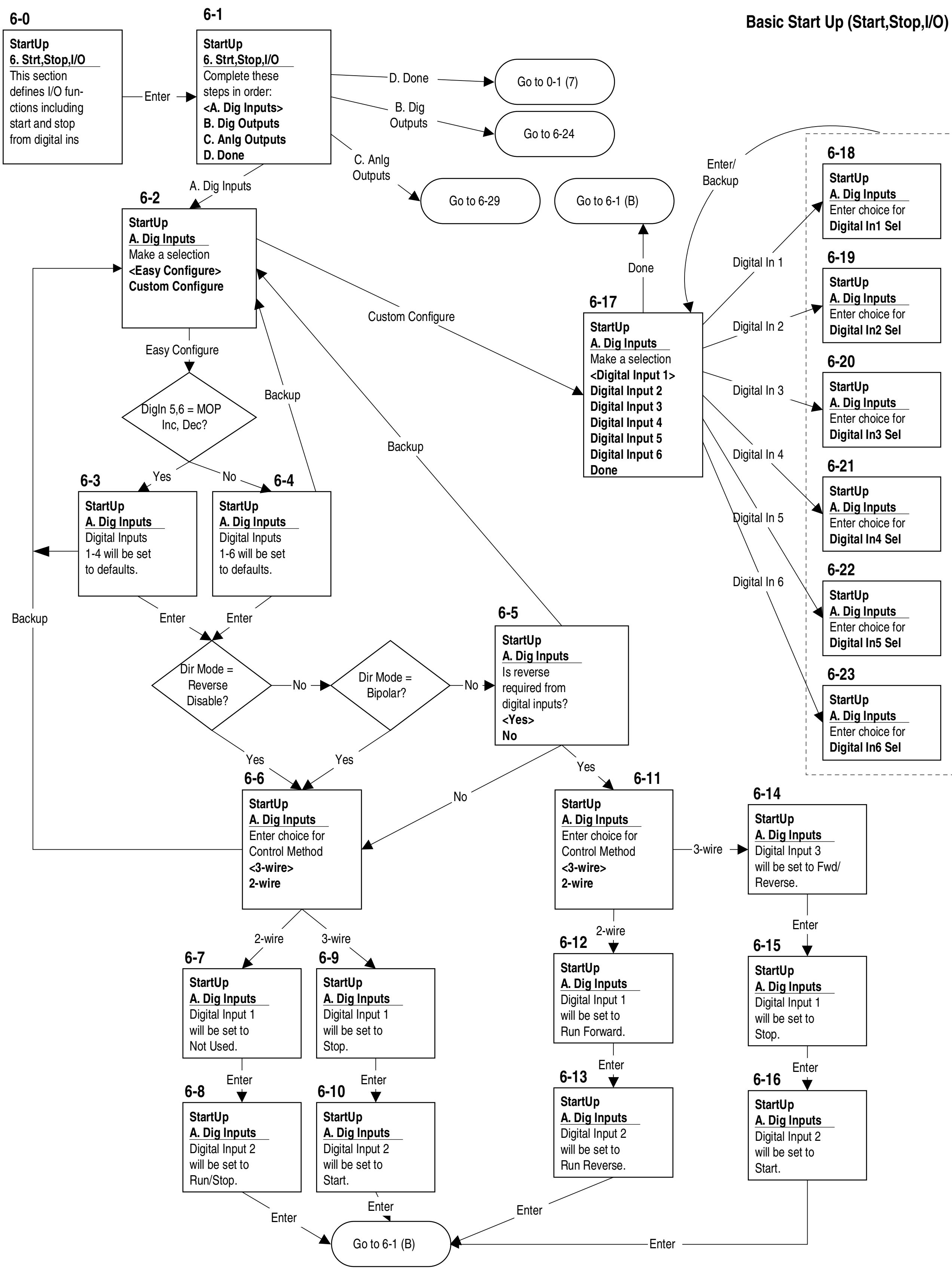


Figure 2.39 PowerFlex 70 & 700 Standard Control Option Startup (7)

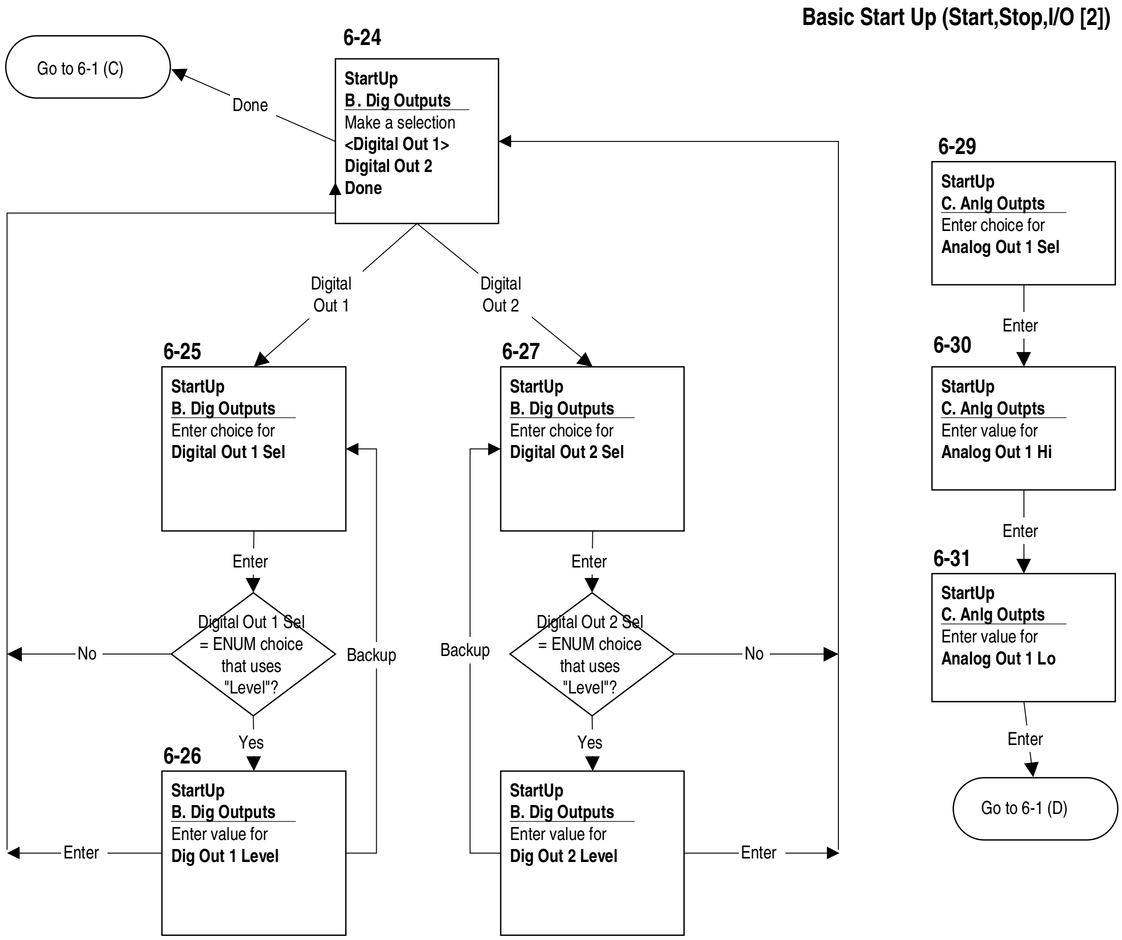


Figure 2.40 PowerFlex 700 Vector Control Option Startup

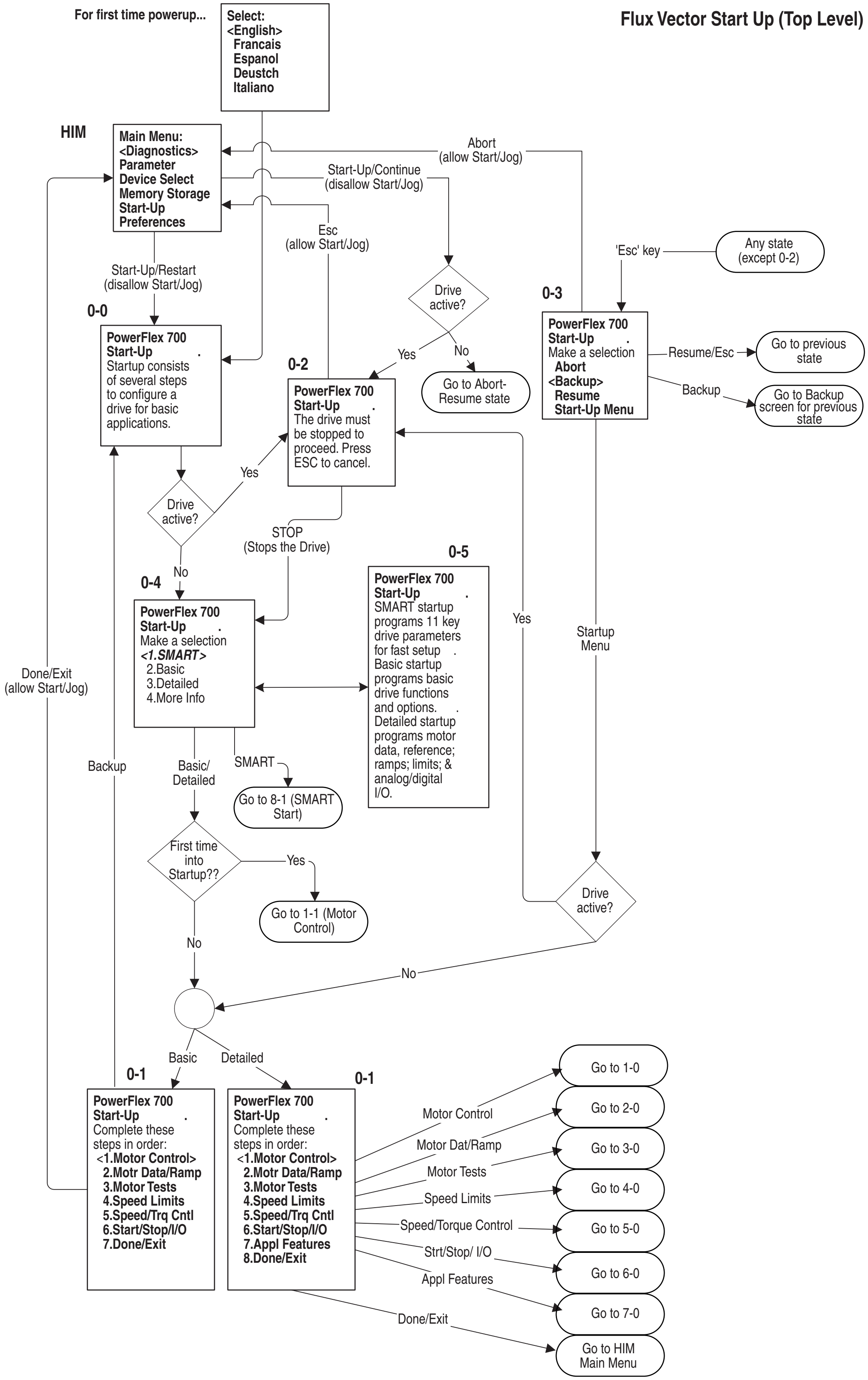


Figure 2.40 PowerFlex 700 Vector Control Option Startup (1)

Flux Vector Start Up (Motor Control Select)

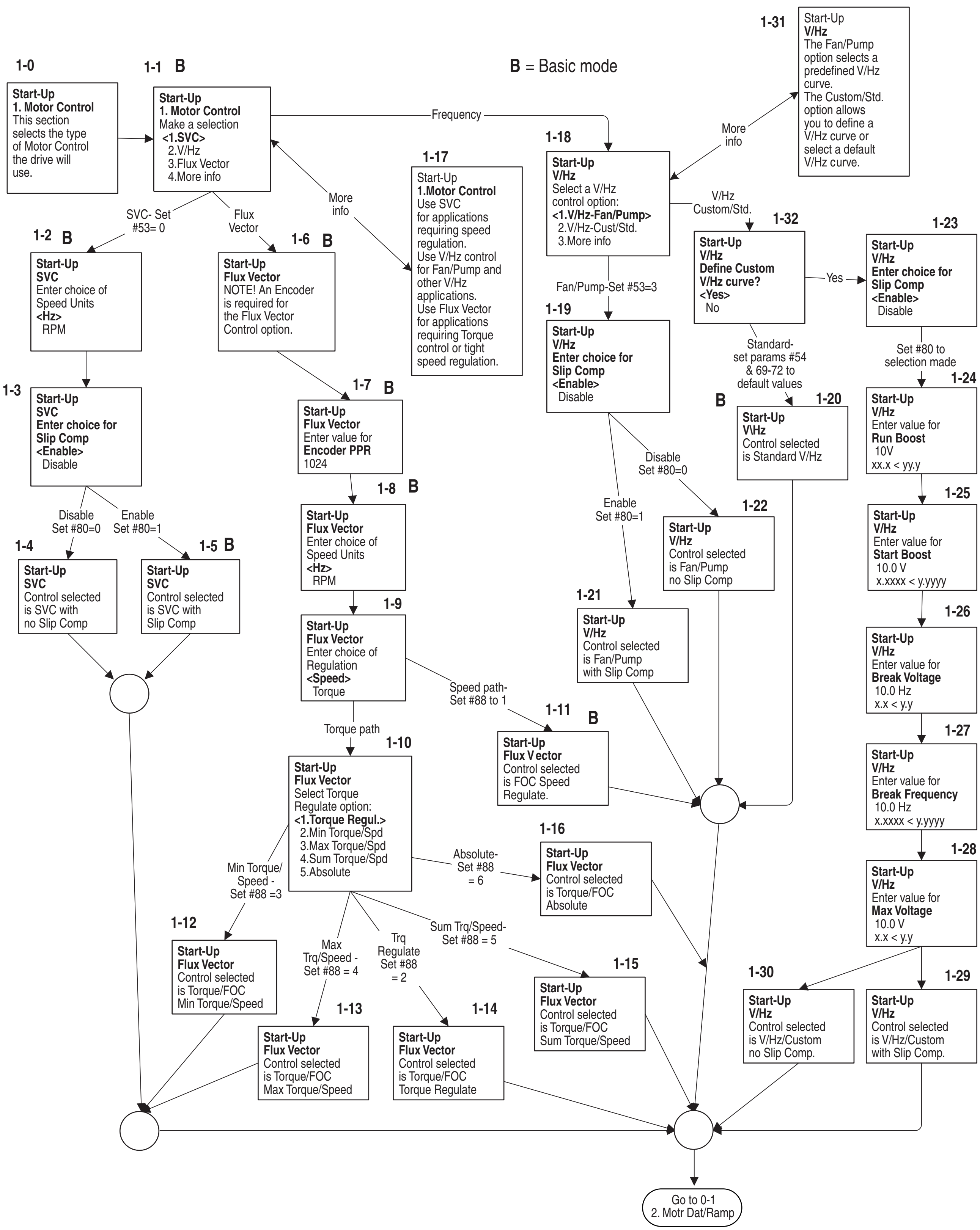
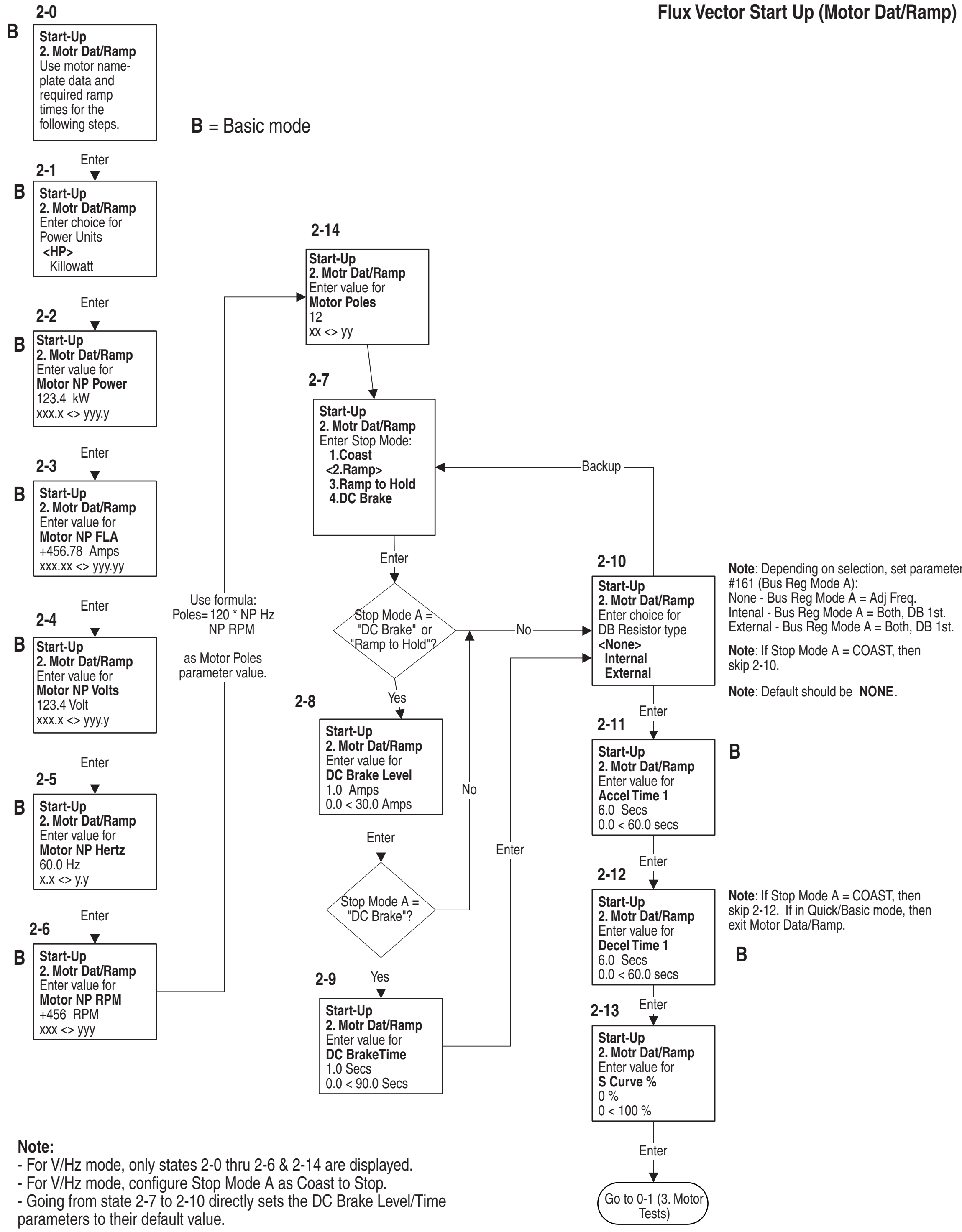


Figure 2.40 PowerFlex 700 Vector Control Option Startup (2)



Note:
- For V/Hz mode, only states 2-0 thru 2-6 & 2-14 are displayed.
- For V/Hz mode, configure Stop Mode A as Coast to Stop.
- Going from state 2-7 to 2-10 directly sets the DC Brake Level/Time parameters to their default value.

Figure 2.40 PowerFlex 700 Vector Control Option Startup (3)

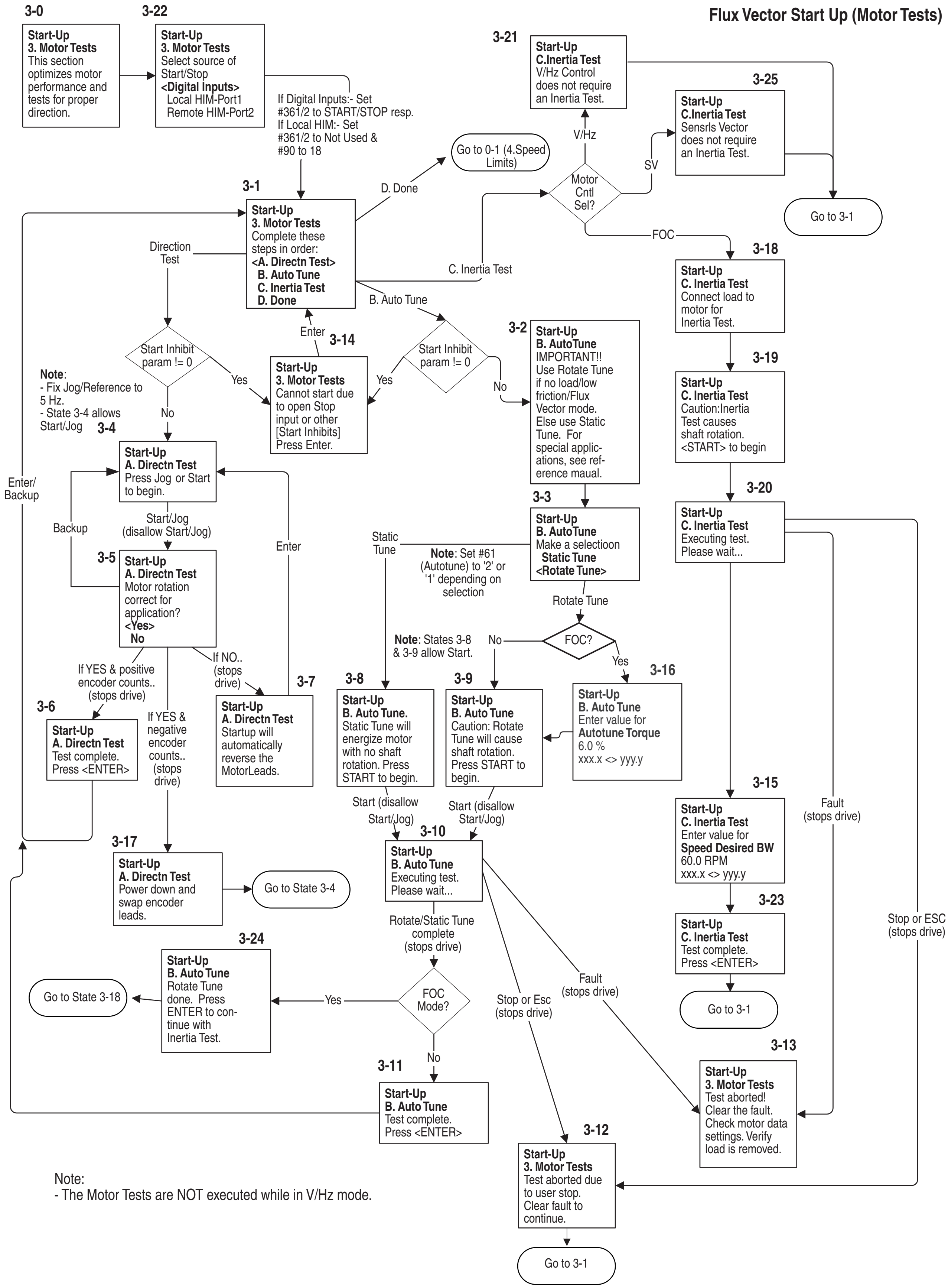


Figure 2.40 PowerFlex 700 Vector Control Option Startup (4)

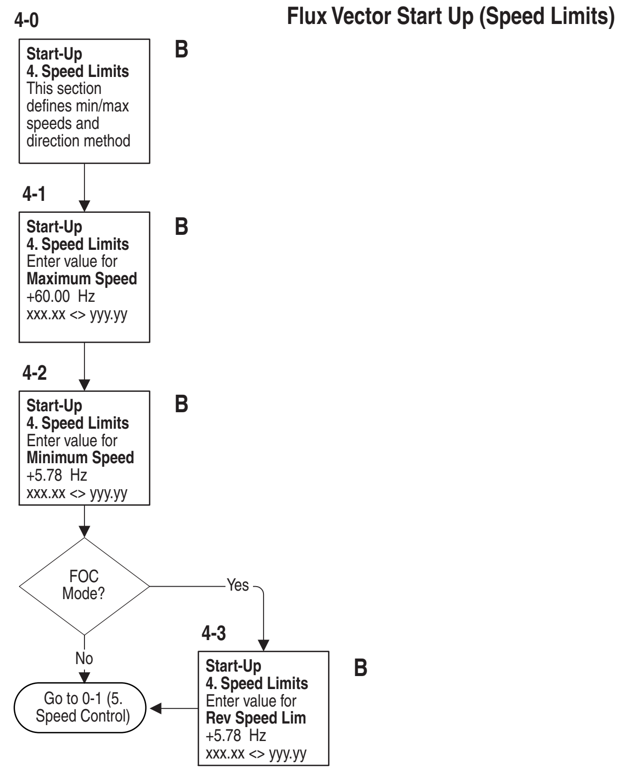


Figure 2.40 PowerFlex 700 Vector Control Option Startup (5)

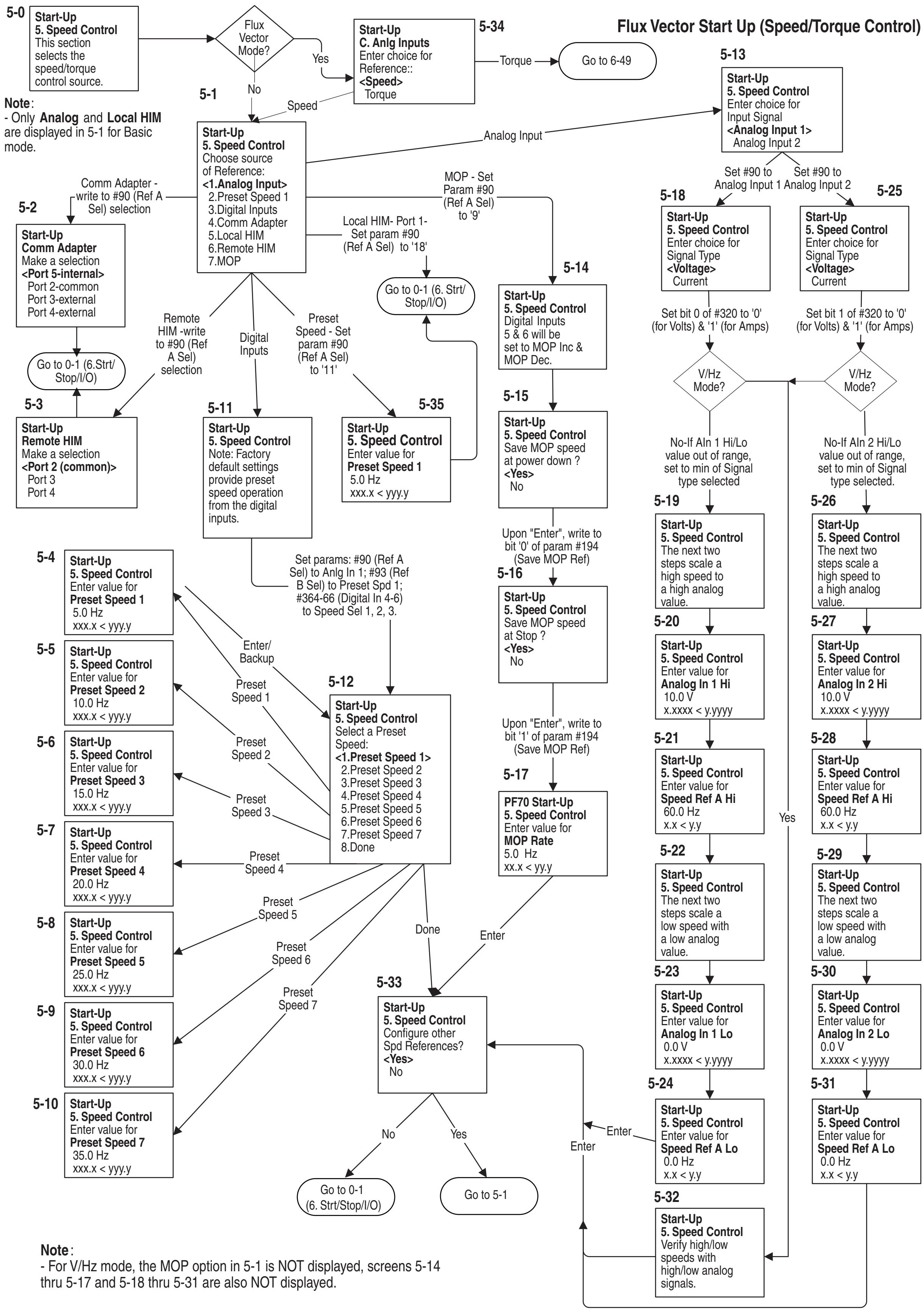
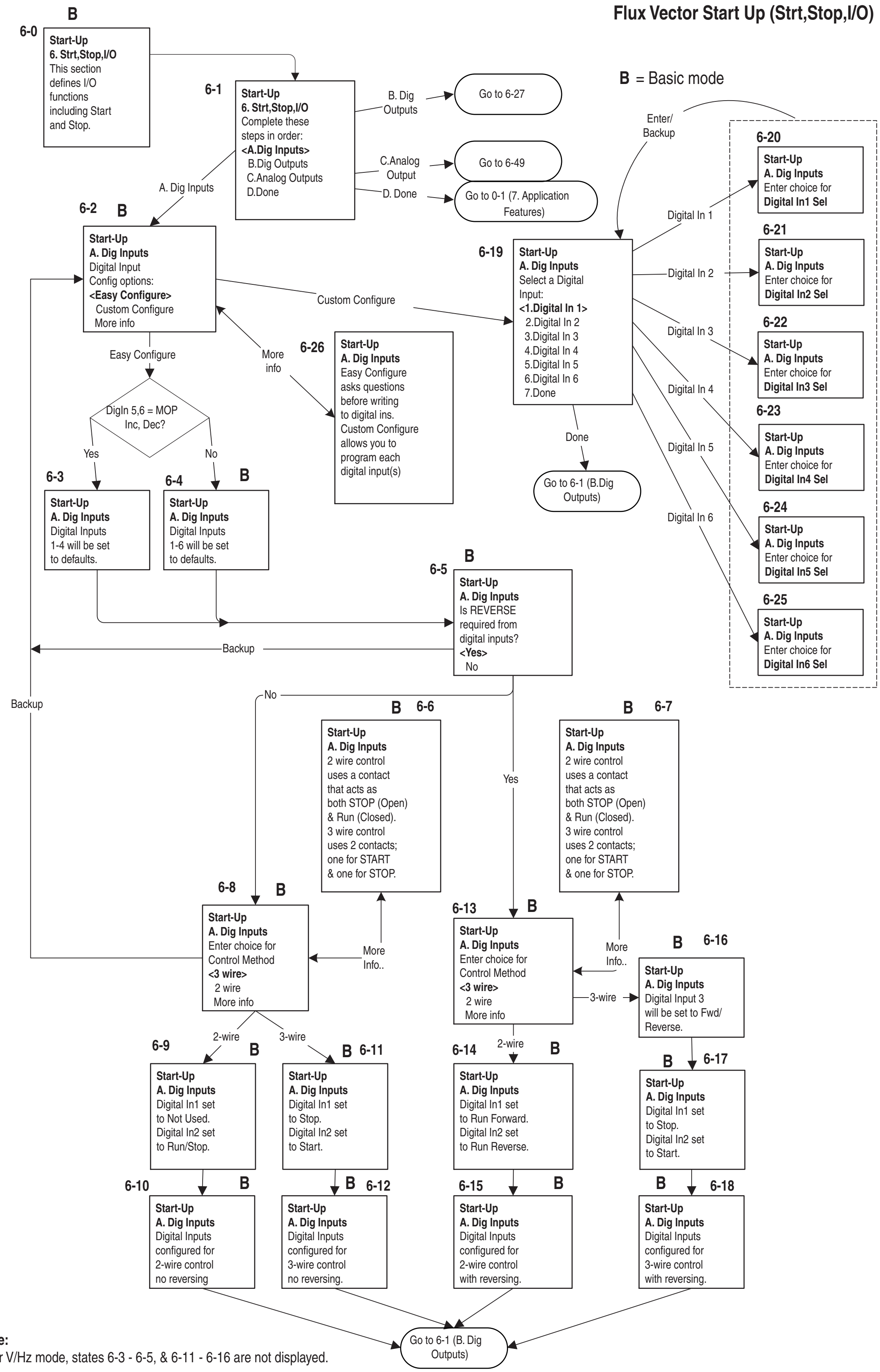


Figure 2.40 PowerFlex 700 Vector Control Option Startup (6)



Note:
- For V/Hz mode, states 6-3 - 6-5, & 6-11 - 6-16 are not displayed.

Figure 2.40 PowerFlex 700 Vector Control Option Startup (7)

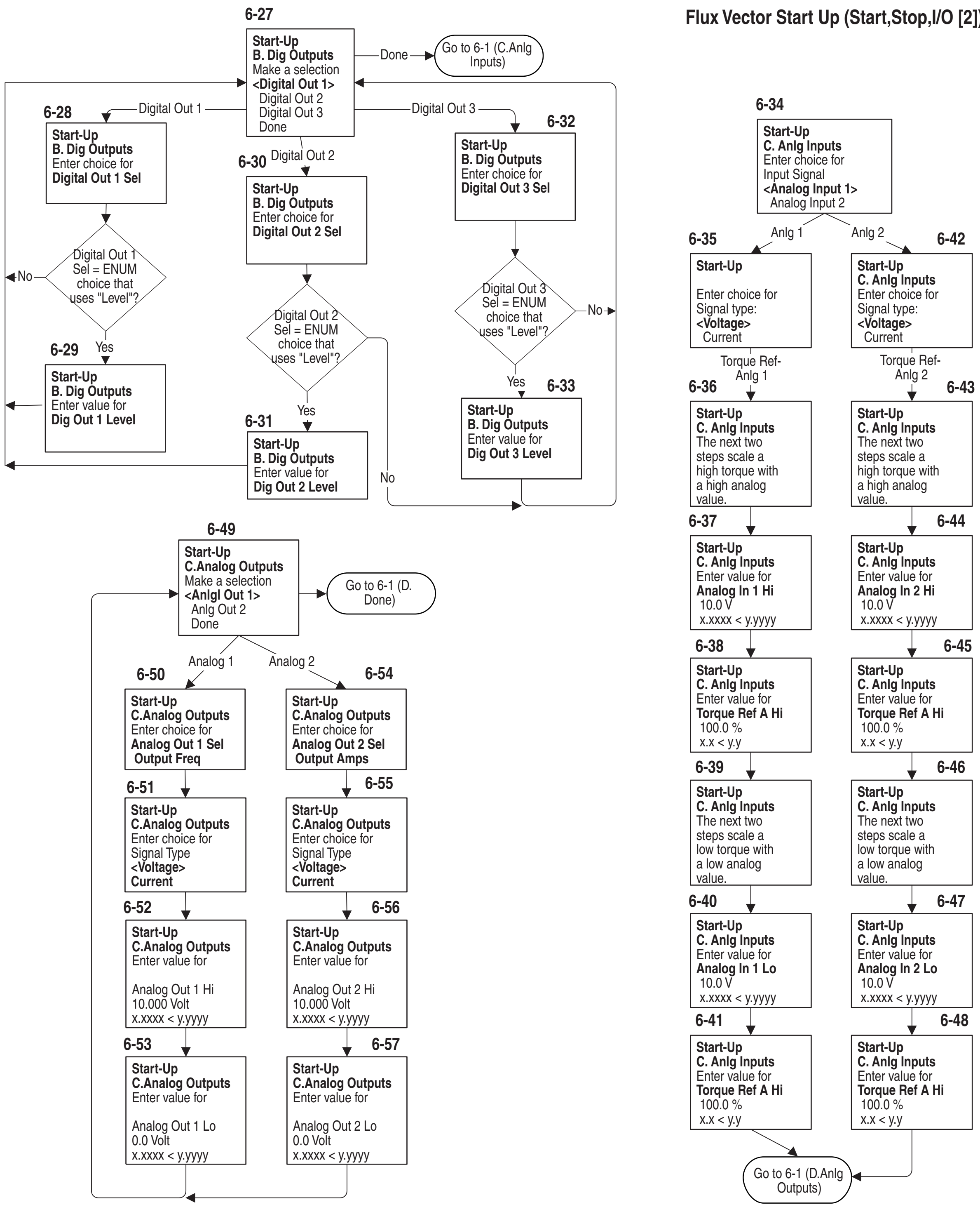


Figure 2.40 PowerFlex 700 Vector Control Option Startup (8)

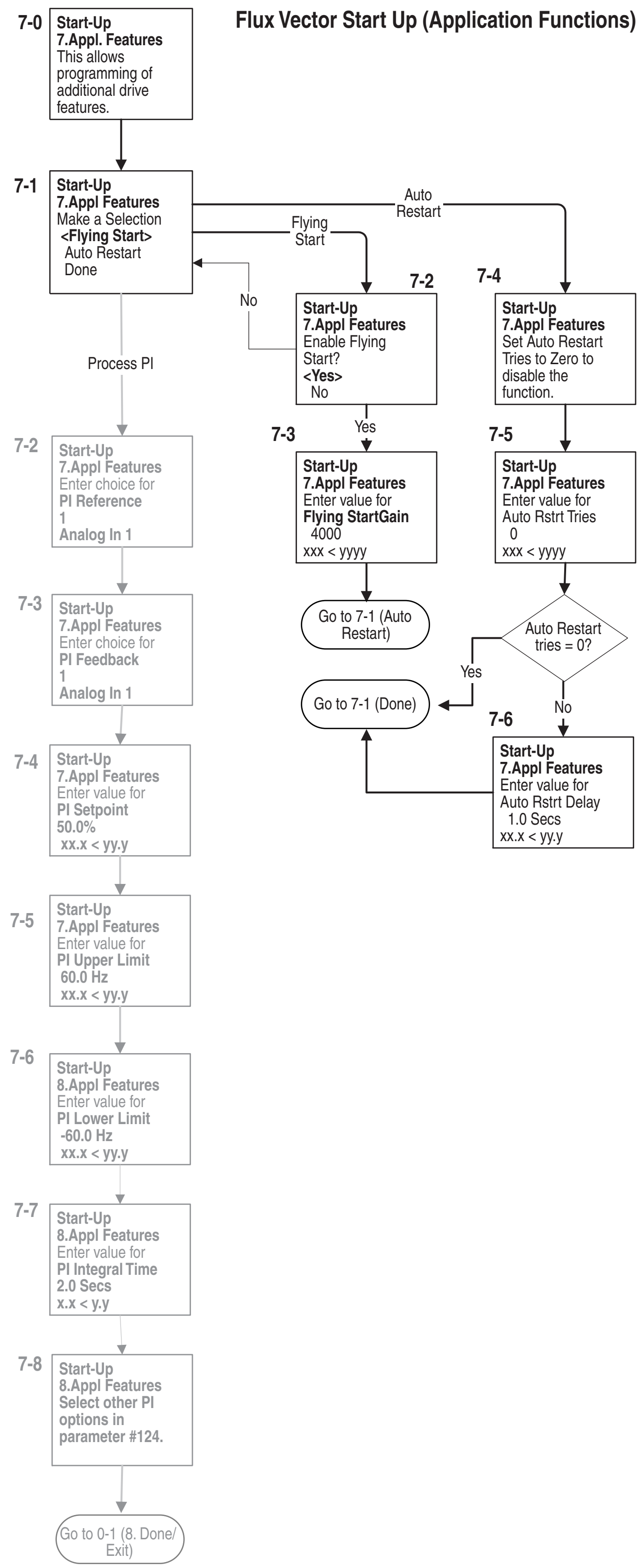


Figure 2.40 PowerFlex 700 Vector Control Option Startup (9)

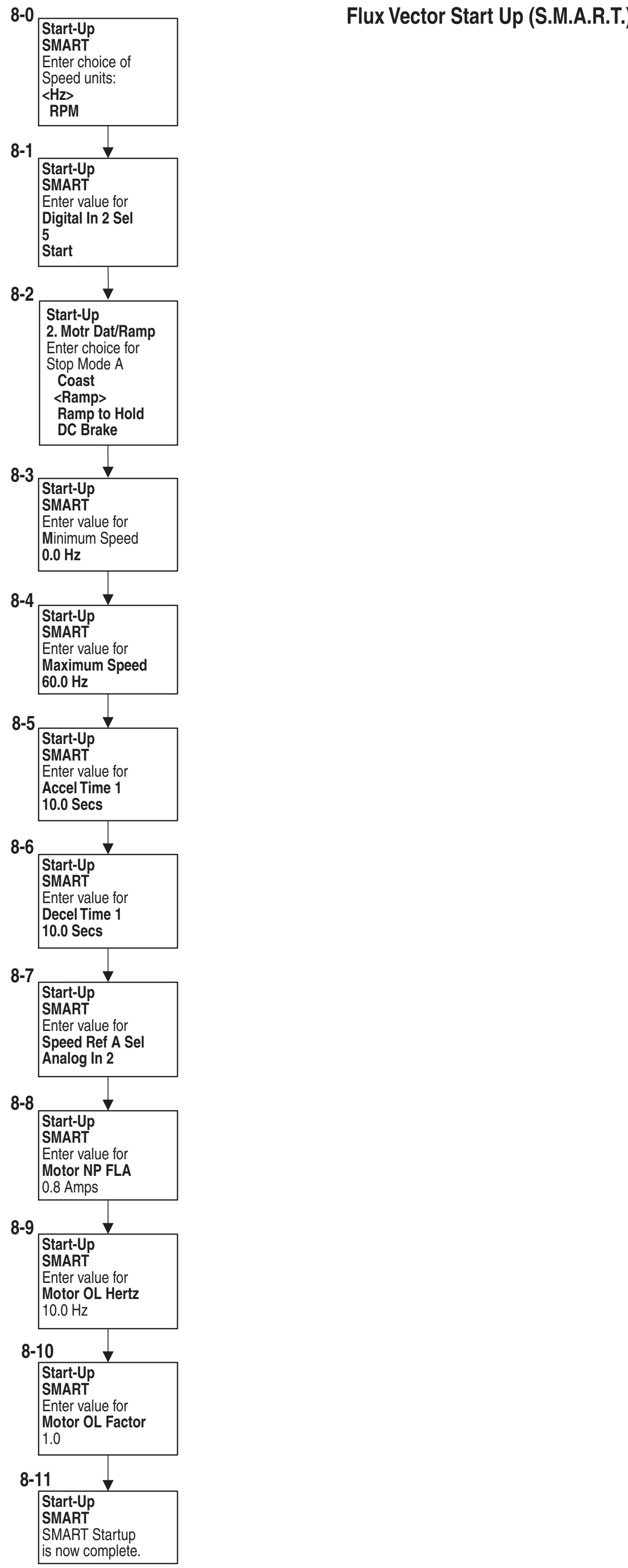
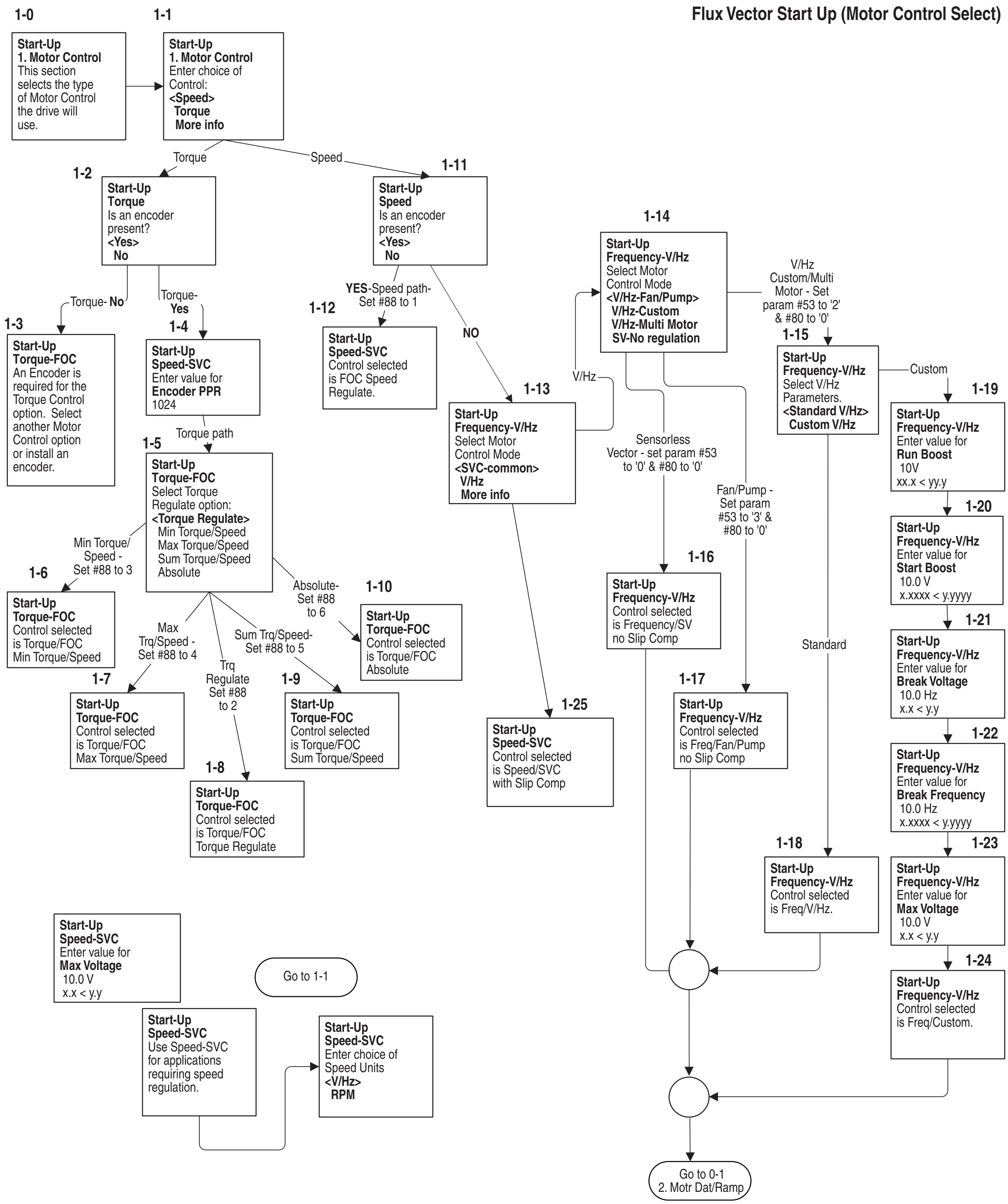


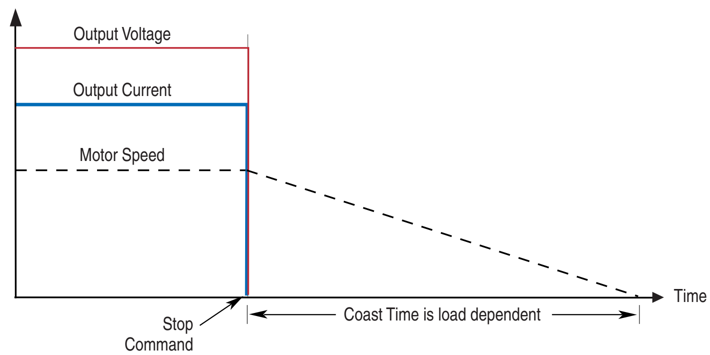
Figure 2.40 PowerFlex 700 Vector Control Option Startup (10)



Stop Modes

[Stop Mode A, B]
[DC Brake Lvl Sel]
[DC Brake Level]
[DC Brake Time]

1. **Coast to Stop** - When in Coast to Stop, the drive acknowledges the Stop command by shutting off the output transistors and releasing control of the motor. The load/motor will coast or free spin until the mechanical energy is dissipated.

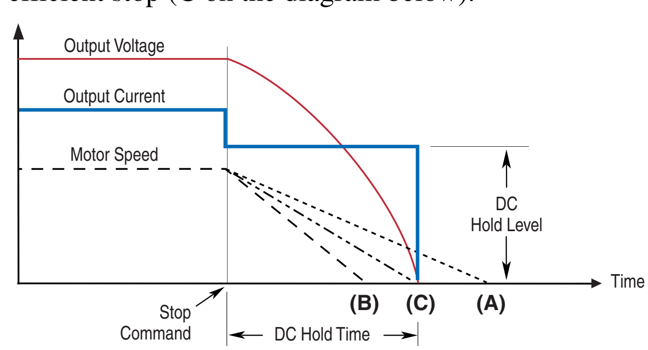


2. **Dynamic Braking** is explained in detail in the PowerFlex Dynamic Braking Selection Guide, presented in Appendix A.

3. **DC Brake** is selected by setting [Stop Mode A] to a value of "3." The user can also select the amount of time the braking will be applied and the magnitude of the current used for braking with [DC Brake Time] and [DC Brake Level]. This mode of braking will generate up to 40% of rated motor torque for braking and is typically used for low inertia loads.

   When in Brake to Stop, the drive acknowledges the Stop command by immediately stopping the output and then applying a programmable DC voltage [DC Brake Level] to 1 phase of the motor.

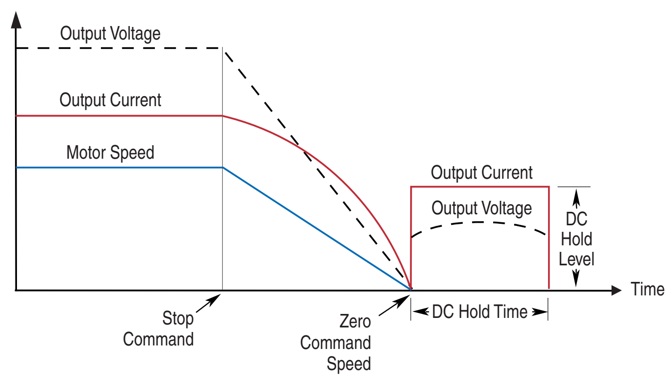
   The voltage is applied for the time programmed in [DC Brake Time]. After this time has expired, all output ceases. If the load is not stopped, it will continue to coast until all energy is depleted (A on the diagram below). If the time programmed exceeds the needed time to stop, the drive will continue to apply the DC hold voltage to the non-rotating motor (B on the diagram below). Excess motor current could cause motor damage. The user is also cautioned that motor voltage can exist long after the Stop command is issued. The right combination of Brake Level and Brake Time must be determined to provide the safest, most efficient stop (C on the diagram below).



4. **Ramp To Stop** is selected by setting [Stop Mode x]. The drive will ramp the frequency to zero based on the deceleration time programmed into [Decel Time 1/2]. The “normal” mode of machine operation can utilize [Decel Time 1]. If the “Machine Stop” mode requires a faster deceleration than desired for normal mode, the “Machine Stop” can activate [Decel Time 2] with a faster rate selected. When in Ramp to Stop, the drive acknowledges the Stop command by decreasing or “ramping” the output voltage and frequency to zero in a programmed period (Decel Time), maintaining control of the motor until the drive output reaches zero. The output transistors are then shut off.

   The load/motor should follow the decel ramp. Other factors such as bus regulation and current limit can alter the decel time and modify the ramp function.

   Ramp mode can also include a “timed” hold brake. Once the drive has reached zero output hertz on a Ramp-to-Stop and both parameters [DC Hold Time] and [DC Hold Level] are not zero, the drive applies DC to the motor producing current at the DC Hold Level for the DC Hold Time.



   Motor speed during and after the application of DC depends upon the combination of the these two parameter settings, and the mechanical system. The drive output voltage will be zero when the hold time is finished.

   The level and uniformity of the DC braking offered at zero speed may not be suitably smooth for many applications. If this is an application requirement, a vector control drive, motion control drive or mechanical brake should be used.

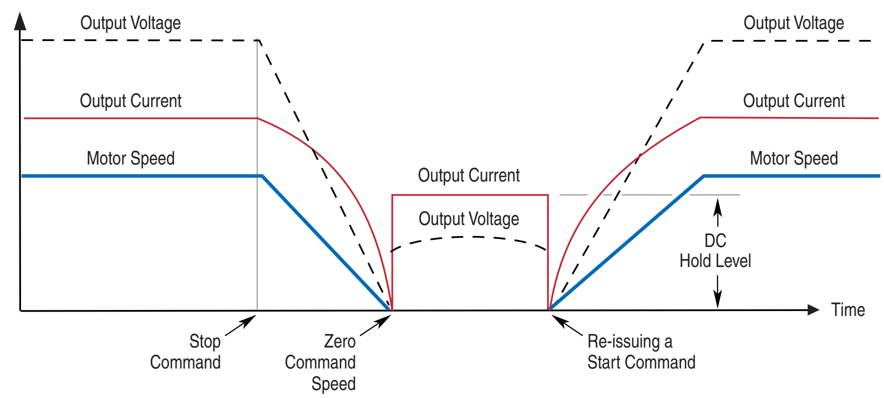
   The drive output voltage will be zero when the hold time is finished

5. **Ramp To Hold** is selected by setting [Stop Select x]. The drive will ramp the frequency to zero based on the deceleration time programmed into [Decel Time 1/2]. Once the drive reaches zero hertz, a DC Injection holding current is applied to the motor. The level of current is set in [DC Brake Level].

   In this mode, the braking is applied Continuously. [DC Hold Time] has no effect in this mode. Braking will continue until one of the following events occur:

   – The Enable Input is opened, or . . .
   – A Start command is re-issued.

   Again, caution must be exercised to not overheat the motor by applying excess voltage and/or for excess time, particularly if the motor is not rotating.



Test Points

UTILITY (File E)	Diagnostics	No.	Parameter Name & Description	Values	
		234 236	**[Testpoint 1 Sel]** **[Testpoint 2 Sel]** Selects the function whose value is displayed value in [Testpoint x Data]. These are internal values that are not accessible through parameters. See Testpoint Codes and Functions on page 4-10 for a listing of available codes and functions.	Default: 499 Min/Max: 0/999 Display: 1	
		235 237 32	**[Testpoint 1 Data]** **[Testpoint 2 Data]** The present value of the function selected in [Testpoint x Sel].	Default: Read Only Min/Max: 0/65535 Display: 1	

Table 2.AB Testpoint Codes and Functions

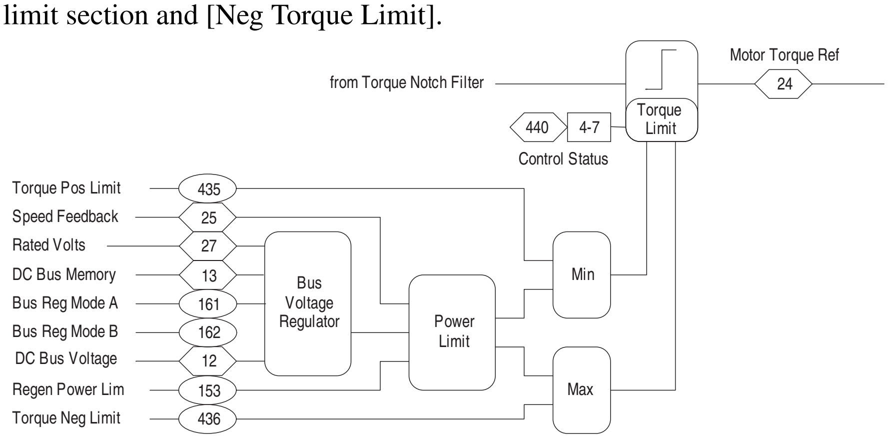
Code Selected in [Testpoint x Sel]	Function Whose Value is Displayed in [Testpoint x Data]
0	DPI Error Status
1	Heatsink Temperature
2	Active Current Limit
3	Active PWM Frequency
4	Lifetime MegaWatt Hours
5	Lifetime Run Time
6	Lifetime Powered Up Time
7	Lifetime Power Cycles
8-99	Reserved for Factory Use

Thermal Regulator

See Drive Overload on page 2-86.

Torque Limits

Vector FV The bus regulator, when enabled, generates a regenerative power limit to prevent the DC bus voltage from rising. The maximum (value closest to zero) of the bus regulator regen power limit and [Regen Power Limit] is converted into a positive and negative torque limit. The positive limit is used when the motor is regenerating in the reverse direction. The negative limit is used when the motor is motoring in the reverse direction. Finally, the drive's torque reference is limited by the minimum (value closest to zero) of the positive torque limit from the power limit section and [Pos Torque Limit]. The drive's torque reference is also limited by the maximum (value closest to zero) of the negative torque limit from the power limit section and [Neg Torque Limit].



Torque Performance Modes

[Torque Perf Mode] or [Motor Cntl Sel] (Vector) selects the output mode of the drive. The choices are:

- Custom Volts/Hertz
  Used in multi-motor or synchronous motor applications.
- Fan/Pump Volts/Hertz
  Used for centrifugal fan/pump (variable torque) installations for additional energy savings.
- Sensorless Vector
  Used for most general constant torque applications. Provides excellent starting, acceleration and running torque.
- Sensorless Vector w/Economizer
  Used in constant torque applications that have significant "idle" time (time spent at greatly reduced load) to offer additional energy conservation.

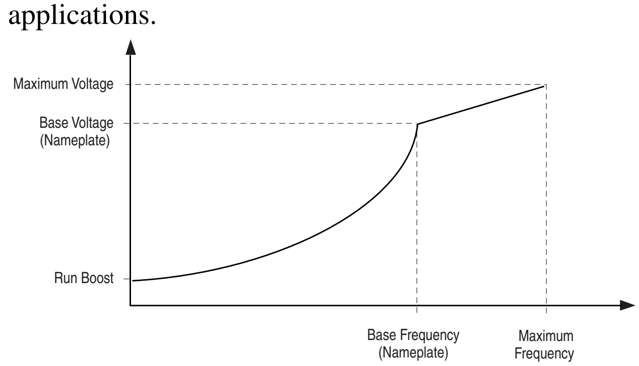
The following table shows the performance differences between V/Hz and Sensorless Vector.

Torque Mode	Fan/Pump and Custom V/Hz with Slip Comp	SVC with Slip Comp	SVC with Feedback	Flux Vector without Feedback	Flux Vector with Feedback
Speed Regulation (% of base speed)	0.5%	0.5%	0.1%	0.1%	0.001%
Operating Speed Range	40:1	80:1	80:1	120:1	1000:1
Speed Bandwidth	10 rad/sec	20 rad/sec	20 rad/sec	50 rad/sec	250 rad/sec

Volts/Hertz

Volts/Hertz operation creates a fixed relationship between output voltage and output frequency. The relationship can be defined in two ways.

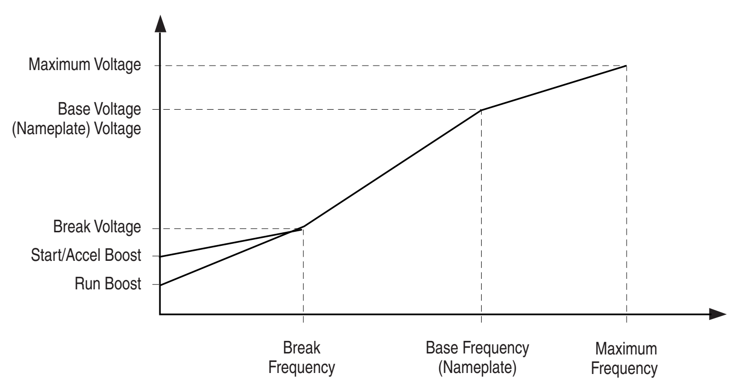
1. Fan/Pump
When this option is chosen, the relationship is $1/X^2$. Therefore; for full frequency, full voltage is supplied and for ½1/2 rated frequency, 1/4 voltage is applied, etc. This pattern closely matches the torque requirement of a variable torque load (centrifugal fan or pump – load increases as speed increases) and offers the best energy savings for these applications.



2. Custom
Custom Volts/Hertz allows a wide variety of patterns using linear segments. The default configuration is a straight line from zero to rated voltage and frequency. This is the same volts/hertz ratio that the motor

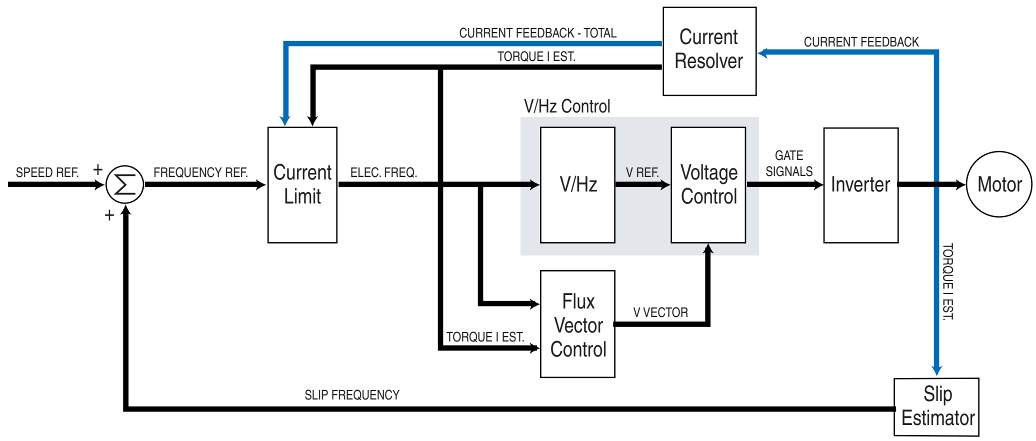
would see if it were started across the line. As seen in the diagram below, the volts/hertz ratio can be changed to provide increased torque performance when required. The shaping takes place by programming 5 distinct points on the curve:

– **Start Boost** - Used to create additional torque for breakaway from zero speed and acceleration of heavy loads at lower speeds
– **Run Boost** - Used to create additional running torque at low speeds. The value is typically less than the required acceleration torque. The drive will lower the boost voltage to this level when running at low speeds (not accelerating). This reduces excess motor heating that could be caused if the higher start / accel boost level were used.
– **Break Voltage/Frequency** - Used to increase the slope of the lower portion of the Volts / hertz curve, providing additional torque.
– **Motor Nameplate Voltage/Frequency** - sets the upper portion of the curve to match the motor design. Marks the beginning of the constant horsepower region
– **Maximum Voltage/Frequency** - Slopes that portion of the curve used above base speed.



Sensorless Vector

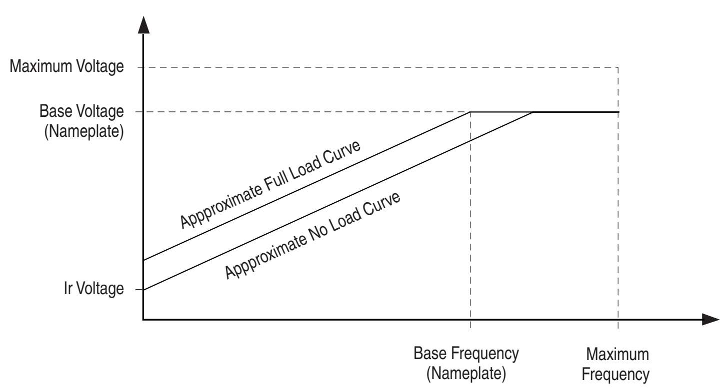
Sensorless Vector technology consists of a basic V/Hz core surrounded by excellent current resolution (the ability to differentiate flux producing current from torque producing current), a slip estimator, a high performance current limiter (or regulator) and the vector algorithms.



The algorithms operate on the knowledge that motor current is the vector sum of the torque and flux producing components. Values can be entered to identify the motor values or an autotune routine can be run to interrogate and identify the motor values (see Autotune on page 2-31). Early versions required feedback, but today, performance is sensorless. It offers high breakaway torque, exceptional running torque, a wider speed range than V/Hz, higher dynamic response and a fast accel "feed forward" selectable for low inertia loads (adaptive current limit).

Sensorless vector is not a torque regulating technology. It does NOT independently control the flux and torque producing currents. Therefore, it cannot be used to regulate torque (torque follower).

In sensorless vector control, the drive maintains a constant flux current up to base speed, allowing the balance of the drive available current to develop maximum motor torque. By manipulating output voltage as a function of load, excellent motor torque can be generated.

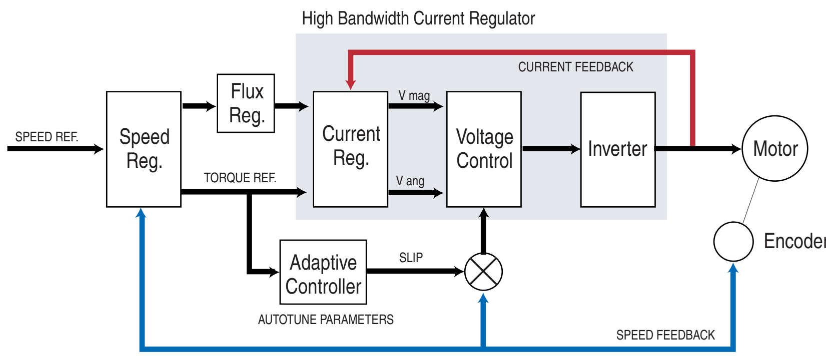


Vector FV Flux Vector Control

The drive takes the speed reference that is specified by the Speed Reference Selection Block and compares it to the speed feedback. The speed regulator uses Proportional and Integral gains to adjust the torque reference for the motor. This torque reference attempts to operate the motor at the specified speed. The torque reference is then converted to the torque producing component of the motor current. This type of speed regulator produces a high bandwidth response to speed command and load changes.

In flux vector control, the flux and torque producing currents are indepently controlled. Therefore, we can send a torque reference directly instead of a speed reference. The independent flux control also allows us to reduce the flux in order to run above base motor speed.

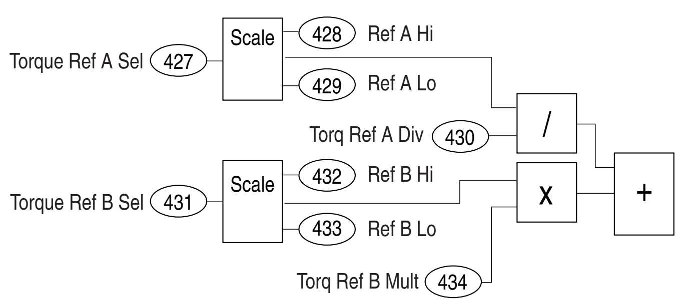
Figure 2.41 Flux Vector



Torque Reference

Vector FV When the PowerFlex 700 Vector Control drive is operated in Torque mode, an external signal is used for a Torque reference. Refer to Figure 2.42.

Figure 2.42



Torque Reference Input

[Torque Ref A], parameter 427 is used to supply an external reference for how much torque is desired. The scaling of this parameter is from –800 to +800, via [Torq Ref A Hi] and [Torq Ref A Lo].

Torque Ref 1 is then divided by [Torq Ref A Div], parameter 430. This defines the scaled Torque Ref A.

[Torque Ref B], parameter 431 is used to supply an external reference for how much torque is desired. The scaling of this parameter is from –800 to +800, via [Torq Ref B Hi] and [Torq Ref B Lo].

The Torque Ref B is then multiplied by [Torq Ref B Mul], parameter 434. This defines the scaled Torque Ref B.

Once the scaling is complete on both Torque Ref A and Torque Ref B, the output is summed to create the external torque reference

This can be utilized when a master/slave multi-drive system is configured. The torque reference into the "slave" can be scaled to create the proper torque output. Keep in mind that the motors may be different ratings and this function is used to help the "system" share the load.

PowerFlex 700 Firmware 3.001 (& later) Enhancements

Extra selections have been added to [Torque Ref A Sel] and [Torque Ref B Sel] in firmware version 3.001 (and later) for the PowerFlex 700 Vector Control drive:

- Scale Block Output available as a selection
- Torque Setpoint 2 is new and available as a selection

No.	Parameter Name & Description	Values			Related
427 431	**Vector** **[Torque Ref A Sel]** **Vector** **[Torque Ref B Sel]** FV Selects the source of the external torque reference to the drive. How this reference is used is dependent upon [Speed/ Torque Mod]. (1) See *User Manual* for DPI port locations. (2) Vector firmware 3.001 and later.	Default:	1 1	"Torque Setpt" "Disabled"	053
		Options:	0 1 2 3-17 18-22 23 24 25-28 29	"Torque Setpt" "Torque Stpt1"(2) "Analog In 1" "Analog In 2" "Reserved" "DPI Port 1-5"(1) "Reserved" "Disabled" "Scale Block1-4"(2) "Torque Stpt2"(2)	

No.	Parameter Name & Description	Values		Related
438	**Vector v3** **[Torque Setpoint2]** FV Provides an internal fixed value for Torque Setpoint when [Torque Ref Sel] is set to "Torque Setpt 2."	Default:	0.0%	
		Min/Max: Units:	–/+800.0% 0.1%	

Troubleshooting

See Faults on page 2-93 and Advanced Tuning on page 2-2.

Unbalanced or Ungrounded Distribution Systems

Refer to *"Wiring and Grounding Guidelines for Pulse Width Modulated (PWM) AC Drives*," publication DRIVES-IN001 for detailed information on Unbalanced or Ungrounded Distribution Systems.

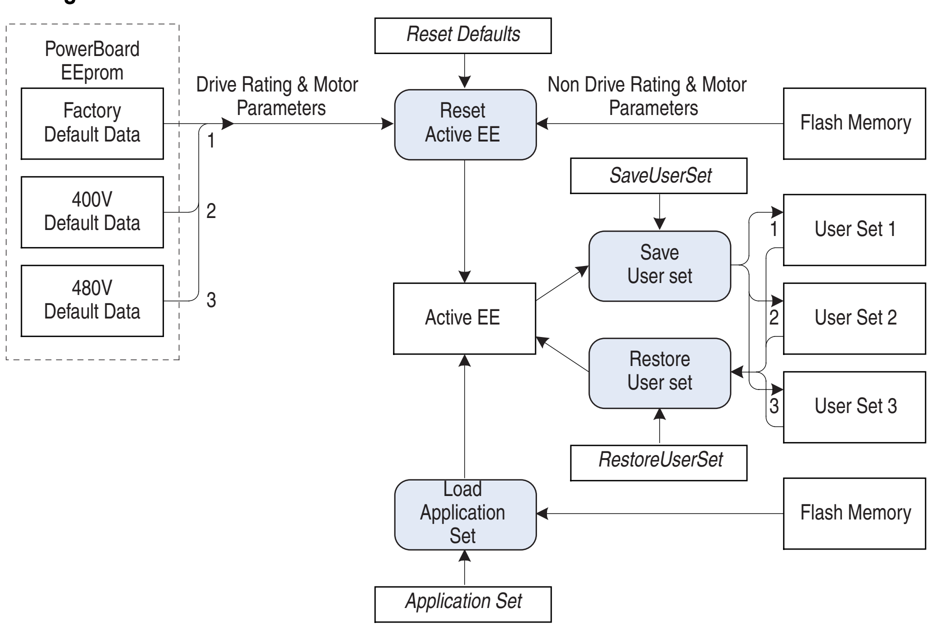
User Sets

After a drive has been configured for a given application the user can store a copy of all of the parameter settings in a specific EEPROM area known as a "User Set." Up to 3 User Sets can be stored in the drives memory to be used for backup, batch "switching" or other needs. All parameter information is stored. The user can then recall this data to the active drive operating memory as needed. Each User Set can also be identified with a programmable name, selected by the user for clarity.

Two operations are available to manage User Sets, "Save To User Set" and "Restore From User Set." The user selects 1, 2, or 3 as the area in which to store data. After data is successfully transferred, "Save User Set" returns to a value of 0. To copy a given area back into the active EEprom memory, the user selects Set 1, 2, or 3 for "Restore User Set." After data is successfully transferred, "Restore User Set" returns to a value of 0. When shipped from the factory all user sets have the same factory default values. Reset Defaults does not effect the contents of User Sets.

Important: User Sets can only be transferred via the HIM. No provisions exist for control via digital I/O or communications module.

Figure 2.43 User Sets



Voltage Class

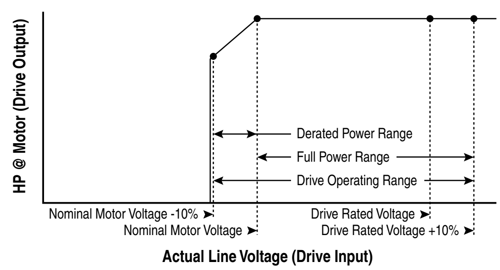
PowerFlex drives are sometimes referred to by voltage "class." This class identifies the general input voltage to the drive. This general voltage includes a range of actual voltages. For example, a 400 Volt Class drive will have an input voltage range of 380-480VAC. While the hardware remains the same for each class, other variables, such as factory defaults, catalog number and power unit ratings will change. In most cases, all drives within a voltage class can be reprogrammed to another drive in the class by resetting the defaults to something other than "factory" settings. The [Voltage Class] parameter can be used to reset a drive to a different setup within the voltage class.

As an example, consider a 480 volt drive. This drive comes with factory default values for 480V, 60 Hz with motor data defaulted for U.S. motors (HP rated, 1750 RPM, etc.) By setting the [Voltage Class] parameter to "low Voltage" (this represents 400V in this case) the defaults are changed to 400V, 50 Hz settings with motor data for European motors (kW rated, 1500 RPM, etc.). Refer to Figure 2.43.

Voltage Tolerance

Drive Rating	Nominal Line Voltage	Nominal Motor Voltage	Drive Full Power Range	Drive Operating Range
200-240	200	200*	200-264	180-264
	208	208	208-264	
	240	230	230-264	
380-400	380	380*	380-528	342-528
	400	400	400-528	
	480	460	460-528	
500-600 *(Frames 0-4 Only)*	600	575*	575-660	432-660
500-690 *(Frames 5-6 Only)*	600	575*	575-660	475-759
	690	690	690-759	475-759

Drive Full Power Range =	Nominal Motor Voltage to Drive Rated Voltage +10%. Rated power is available across the entire Drive Full Power Range.
Drive Operating Range =	Lowest (*) Nominal Motor Voltage –10% to Drive Rated Voltage +10%. Drive Output is linearly derated when Actual Line Voltage is less than the Nominal Motor Voltage.

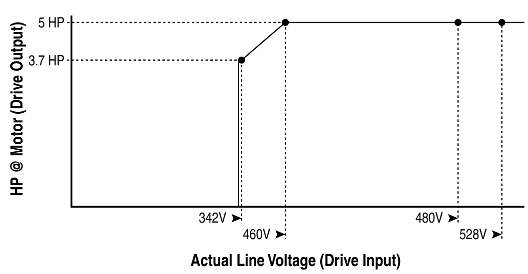


Example:

Calculate the maximum power of a 5 HP, 460V motor connected to a 480V rated drive supplied with 342V Actual Line Voltage input.

- Actual Line Voltage / Nominal Motor Voltage = 74.3%
- 74.3% × 5 HP = 3.7 HP
- 74.3% × 60 Hz = 44.6 Hz

At 342V Actual Line Voltage, the maximum power the 5 HP, 460V motor can produce is 3.7 HP at 44.6 Hz.



Watts Loss

The following table lists watts loss data for PowerFlex drives running at full load, full speed and a factory default PWM Frequency of 4 kHz.

PowerFlex 70

For PowerFlex 70 drives, Internal Watts are those dissipated by the control structure of the drive and will be dissipated into the cabinet regardless of mounting style. External Watts are those dissipated directly through the heatsink and will be outside the cabinet for flange mount and inside the cabinet for panel mount.

Table 2.AC PowerFlex 70 Watts Loss at Full Load/Speed, 4kHz[1]

Voltage	ND HP	External Watts	Internal Watts	Total Watts Loss
480	0.5	11.5	17.9	29.4
	1	27.8	19.5	47.3
	2	43.6	21.6	65.2
	3	64.6	24.0	88.6
	5	99.5	28.2	127.7
	7.5	140.0	27.8	167.8
	10	193.3	32.0	225.3
	15	305.4	34.2	339.6
	20	432.9	42.9	475.8
240V	0.5	12.2	19.2	31.4
	1	30.7	20.5	51.2
	2	44.6	22.6	67.2
	3	67.3	25.4	92.7
	5	141.3	33.2	174.5
	7.5	205.7	34.2	239.9
	10	270.4	48.1	318.5

(1) Includes HIM.

PowerFlex 700

PowerFlex 700 drives are offered in panel mount versions only. At this time, no method exists for venting outside of a secondary enclosure. This requires enclosure sizing for total watts. see Table 2.AD.

Table 2.AD PowerFlex 700 Watts Loss (Rated Load, Speed & PWM)[2]

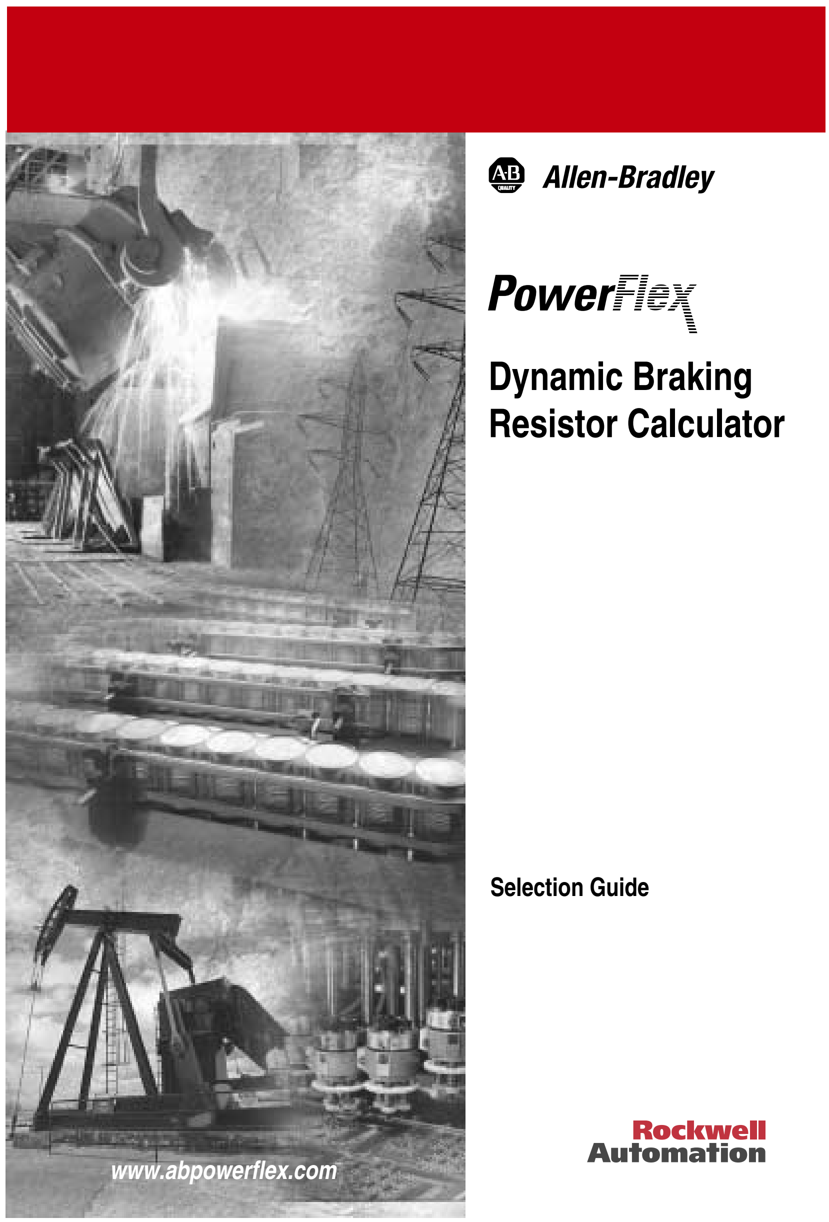
Voltage	ND HP	External Watts	Internal Watts	Total Watts Loss
240V	0.5	9	37	46
	1	22	39	61
	2	38	39	77
	3	57	41	98
	5	97	82	179
	7.5	134	74	208
	10	192	77	269
	15	276	92	368
	20	354	82	436
	25	602	96	698
	30	780	96	876
	40	860	107	967
	50	1132	138	1270
	60	1296	200	1496
	75	1716	277	1993
	100	1837	418	2255

Voltage	ND HP	External Watts	Internal Watts	Total Watts Loss
480V	0.5	11	42	53
	1	19	44	63
	2	31	45	76
	3	46	46	93
	5	78	87	164
	7.5	115	79	194
	10	134	84	218
	15	226	99	326
	20	303	91	394
	25	339	102	441
	30	357	103	459
	40	492	117	610
	50	568	148	717
	60	722	207	930
	75	821	286	1107
	100	1130	397	1479
	125	1402	443	1845
	150	1711	493	2204
	200	1930	583	2512
600V	0.5	9	37	46
	1	14	40	54
	2	25	40	65
	3	41	42	83
	5	59	83	142
	7.5	83	75	157
	10	109	77	186
	15	177	93	270
	20	260	83	343
	25	291	95	385
	30	324	95	419
	40	459	109	569
	50	569	141	710
	60	630	195	825
	75	1053	308	1361
	100	1467	407	1874
	125	1400	500	1900
	150	1668	612	2280

(2) Worst case condition including Vector Control board, HIM and Communication Module

Dynamic Brake Selection Guide

The Dynamic Braking Selection Guide provided on the following pages contains detailed information on selecting and using dynamic brakes.


Allen-Bradley

PowerFlex

Dynamic Braking Resistor Calculator

Selection Guide

Rockwell Automation

www.abpowerflex.com

Allen-Bradley

PowerFlex®

Dynamic Braking Resistor Calculator

Rockwell Automation

Important User Information

Solid state equipment has operational characteristics differing from those of electromechanical equipment. "*Safety Guidelines for the Application, Installation and Maintenance of Solid State Controls*" (Publication SGI-1.1 available from your local Rockwell Automation Sales Office or online at **http://www.ab.com/manuals/gi**) describes some important differences between solid state equipment and hard-wired electromechanical devices. Because of this difference, and also because of the wide variety of uses for solid state equipment, all persons responsible for applying this equipment must satisfy themselves that each intended application of this equipment is acceptable.

In no event will the 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, the 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 we use notes to make you aware of safety considerations.

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 the hazard
- recognize the consequences

Important: Identifies information that is especially important for successful application and understanding of the product.

Shock Hazard labels may be located on or inside the drive to alert people that dangerous voltage may be present.

Table of Contents

Section 1 **Understanding How Dynamic Braking Works**

This section provides an overview of the components required to do Dynamic Braking and their functionality.

Section 2 **Determining Dynamic Brake Requirements**

This section steps you through the calculations necessary to determine the amount of Dynamic Braking required for your application.

Section 3 **Evaluating the Internal Resistor**

This section steps you through the process to determine whether or not the available PowerFlex internal resistors are adequate for your application.

Section 4 **Selecting An External Resistor**

This section steps you through the process of selecting an external resistor when the internal resistors prove to be insufficient for your application.

Appendix A

Understanding How Dynamic Braking Works

How Dynamic Braking Works

When an induction motor's rotor is turning slower than the synchronous speed set by the drive's output power, the motor is transforming electrical energy obtained from the drive into mechanical energy available at the drive shaft of the motor. This process is referred to as *motoring*. When the rotor is turning faster than the synchronous speed set by the drive's output power, the motor is transforming mechanical energy available at the drive shaft of the motor into electrical energy that can be transferred back to the drive. This process is referred to as *regeneration*.

Most AC PWM drives convert AC power from the fixed frequency utility grid into DC power by means of a diode rectifier bridge or controlled SCR bridge before it is inverted into variable frequency AC power. Diode and SCR bridges are cost effective, but can only handle power in the motoring direction. Therefore, if the motor is regenerating, the bridge cannot conduct the necessary negative DC current, the DC bus voltage will increase and cause an overvoltage fault at the drive. More complex bridge configurations use SCRs or transistors that can transform DC regenerative electrical power into fixed frequency utility electrical energy. This process is known as *line regeneration*.

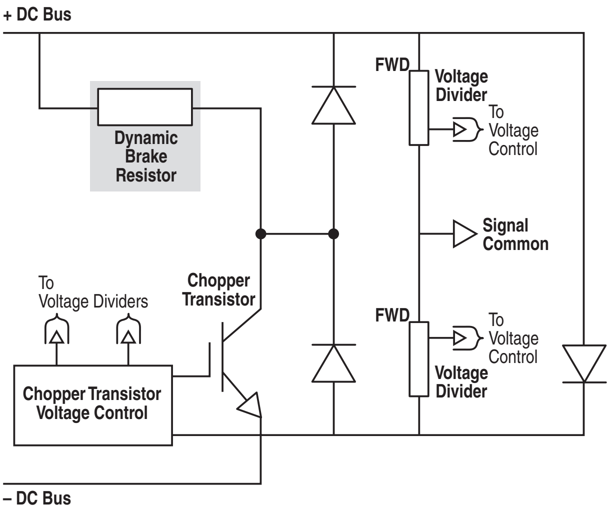
A more cost effective solution can be provided by allowing the drive to feed the regenerated electrical power to a resistor which transforms it into thermal energy. This process is referred to as *dynamic braking*.

Dynamic Brake Components

A Dynamic Brake consists of a Chopper (the chopper transistor and related control components are built into PowerFlex drives) and a Dynamic Brake Resistor.

Figure 1.1 shows a simplified Dynamic Braking schematic.

Figure 1.1 Simplified Dynamic Brake Schematic



Chopper

The **Chopper** is the Dynamic Braking circuitry that senses rising DC bus voltage and shunts the excess energy to the Dynamic Brake Resistor. A Chopper contains three significant power components:

The **Chopper Transistor** is an Isolated Gate Bipolar Transistor (IGBT). The Chopper Transistor is either ON or OFF, connecting the Dynamic Brake Resistor to the DC bus and dissipating power, or isolating the resistor from the DC bus. The most important rating is the collector current rating of the Chopper Transistor that helps to determine the minimum resistance value used for the Dynamic Brake Resistor.

Chopper Transistor Voltage Control regulates the voltage of the DC bus during regeneration. The average values of DC bus voltages are:

Drive Input Voltage	Transistor Turn-On Voltage	Maximum Power Calculation Voltage
208	375V DC	395V DC
240	375V DC	395V DC
400	750V DC	790V DC
480	750V DC	790V DC
575	937.5V DC	987V DC
600	937.5V DC	987V DC
600 (Frame 5 & 6)	1076V DC	1135V DC
690	1076V DC	1135V DC

Voltage dividers reduce the DC bus voltage to a value that is usable in signal circuit isolation and control. The DC bus feedback voltage from the voltage dividers is compared to a reference voltage to actuate the Chopper Transistor.

The **Freewheel Diode** (FWD), in parallel with the Dynamic Brake Resistor, allows any magnetic energy stored in the parasitic inductance of that circuit to be safely dissipated during turn off of the Chopper Transistor.

Resistor

The **Resistor** dissipates the regenerated energy in the form of heat. The PowerFlex Family of Drives can use either the internal dynamic brake resistor option or an externally mounted dynamic brake resistor wired to the drive.

Wiring

<u>Frames 0-4</u>
Wire to the DB resistor should be no longer than 10 feet from the drive terminals. Wire should be twisted to minimize inductance.

<u>Frames 5-6</u>
Wire to the DB resistor should be no longer than 100 feet from the drive terminals.

Notes:

Determining Dynamic Brake Requirements

How to Determine Dynamic Brake Requirements

When a drive is consistently operating in the regenerative mode of operation, serious consideration should be given to equipment that will transform the electrical energy back to the fixed frequency utility grid.

As a general rule, Dynamic Braking can be used when the need to dissipate regenerative energy is on an occasional or periodic basis. In general, the motor power rating, speed, torque, and details regarding the regenerative mode of operation will be needed in order to estimate what Dynamic Brake Resistor value is needed.

The **Peak Regenerative Power** and **Average Regenerative Power** required for the application must be calculated in order to determine the resistor needed for the application. Once these values are determined, the resistors can be chosen. If an internal resistor is chosen, the resistor must be capable of handling the regenerated power or the drive will trip. If an external resistor is chosen, in addition to the power capabilities, the resistance must also be less than the application maximum and greater than the drive minimum or the drive will trip.

The power rating of the Dynamic Brake Resistor is estimated by applying what is known about the drive's motoring and regenerating modes of operation. The **Average Power Dissipation** must be estimated and the power rating of the Dynamic Brake Resistor chosen to be greater than that average. If the Dynamic Brake Resistor has a large thermodynamic heat capacity, then the resistor element will be able to absorb a large amount of energy without the temperature of the resistor element exceeding the operational temperature rating. Thermal time constants in the order of 50 seconds and higher satisfy the criteria of large heat capacities for these applications. If a resistor has a small heat capacity (defined as thermal time constants less than 5 seconds) the temperature of the resistor element could exceed its maximum.

Peak Regenerative Power can be calculated as:

- Horsepower (English units)
- Watts (The International System of Units, SI)
- Per Unit System (pu) which is relative to a value

The final number must be in watts of power to estimate the resistance value of the Dynamic Brake Resistor. The following calculations are demonstrated in SI units.

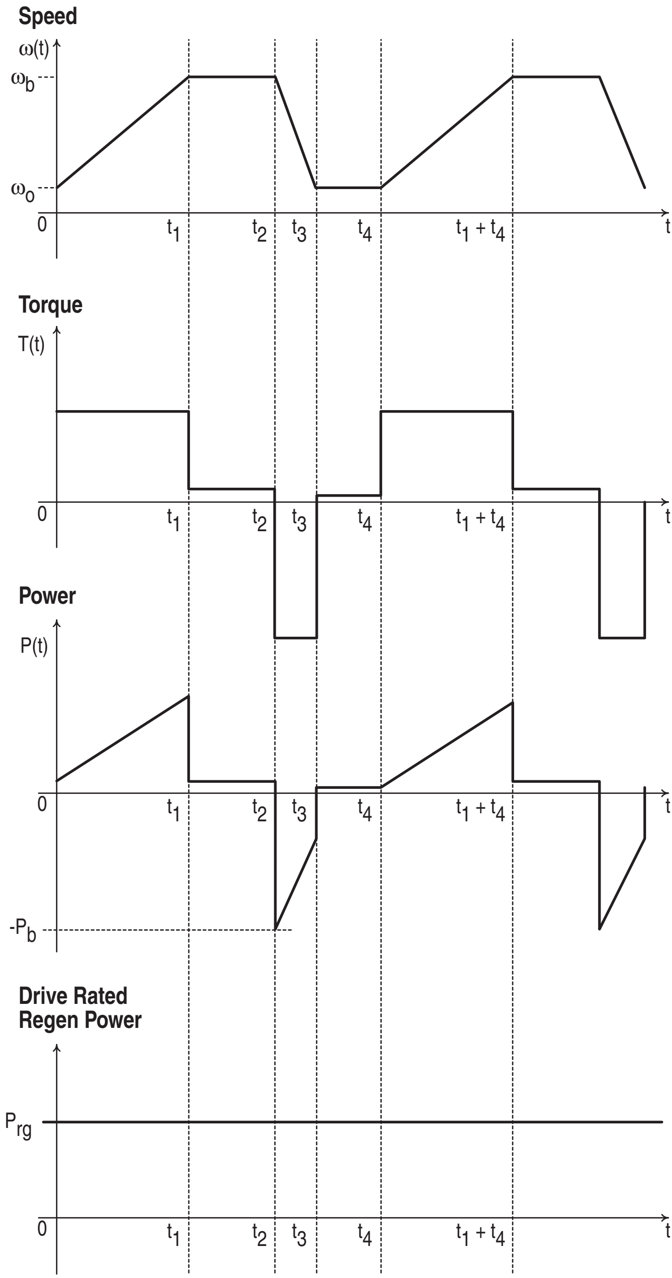
Gather the Following Information

- Power rating from motor nameplate in watts, kilowatts, or horsepower
- Speed rating from motor nameplate in rpm or rps (radians per second)
- Required decel time (per Figure 2.1, $t_3 - t_2$). This time is a process requirement and must be within the capabilities of the drive programming.
- Motor inertia and load inertia in kg-m^2 or WK^2 in lb.-ft.^{2}
- Gear ratio (GR) if a gear is present between the motor and load
- Motor shaft speed, torque, and power profile of the drive application

Figure 2.1 shows typical application profiles for speed, torque and power. The examples are for cyclical application that is periodic over t_4 seconds. The following variables are defined for Figure 2.1:

$\omega(t)$	=	Motor shaft speed in radians per second (rps) $\omega = \frac{2\pi N}{60}$
N	=	Motor shaft speed in Revolutions Per Minute (RPM)
T(t)	=	Motor shaft torque in Newton-meters 1.0 lb.-ft. = 1.355818 N-m
P(t)	=	Motor shaft power in watts 1.0 HP = 746 watts
ω_b	=	Rated angular rotational speed $\frac{Rad}{s}$
ω_o	=	Angular rotational speed less than ω_b (can equal 0) $\frac{Rad}{s}$
$-P_b$	=	Motor shaft peak regenerative power in watts

Figure 2.1 Application Speed, Torque and Power Profiles



Determine Values of Equation Variables

Step 2 Total Inertia

$$J_T = J_m + (GR^2 \times J_L)$$

J_T = Total inertia reflected to the motor shaft ($kg\text{-}m^2$ or WK^2 in $lb.\text{-}ft.^2$)

J_m = Motor inertia ($kg\text{-}m^2$ or WK^2 in $lb.\text{-}ft.^2$)

GR = Gear ratio for any gear between motor and load (dimensionless)

$$GR = \frac{\text{Load Speed}}{\text{Motor Speed}}$$

If the gear ratio is 2:1 then $GR = \frac{1}{2} = 0.5$

J_L = Load inertia ($kg\text{-}m^2$ or WK^2 in $lb.\text{-}ft.^2$)
$1.0\ lb.\text{-}ft.^2 = 0.04214011\ kg\text{-}m^2$

Calculate Total Inertia:

$$J_T = [\qquad\qquad\qquad] + (\qquad\qquad\qquad \times \qquad\qquad\qquad)$$

Record Total Inertia:

J_T	=

Step 3 Peak Braking Power

$$P_b = \frac{J_T[\omega_b(\omega_b - \omega_o)]}{(t_3 - t_2)}$$

P_b = Peak braking power (watts)
1.0 HP = 746 watts

J_T = Total inertia reflected to the motor shaft (kg-m^2)

ω_b = Rated angular rotational speed $\frac{Rad}{s} = \frac{2\pi N_b}{60}$

ω_o = Angular rotational speed, less than rated speed down to zero $\frac{Rad}{s}$

N_b = Rated motor speed (RPM)

$t_3 - t_2$ = Deceleration time from ω_b to ω_o (seconds)

Calculate Peak Braking Power:

$$P_b = \frac{[\qquad\qquad] \times [\qquad\qquad] \times (\qquad\qquad - \qquad\qquad)}{(\qquad\qquad - \qquad\qquad)}$$

Record Peak Braking Power:

P_b =

Compare the peak braking power (P_b) to the drive rated regenerative power (P_{rg}). If the peak braking power is greater than the drive rated regenerative power, the decel time will have to be increased so that the drive does not enter current limit. Drive rated regenerative power (P_{rg}) is determined by:

$$P_{rg} = \frac{V^2}{R}$$

P_{rg} = Drive rated regenerative power

V = DC bus regulation voltage from Table A.A

R = Minimum brake resistance from Table A.A

$$P_{rg} = \frac{[\qquad\qquad]^2}{(\qquad\qquad)}$$

Record Rated Regenerative Power:

P_{rg} =

For the purposes of this document, it is assumed that the motor used in the application is capable of producing the required regenerative torque and power.

Step 4 Minimum Power Requirements for the Dynamic Brake Resistors

It is assumed that the application exhibits a periodic function of acceleration and deceleration. If $(t_3 - t_2)$ equals the time in seconds necessary for deceleration from rated speed to ω_o speed, and t_4 is the time in seconds before the process repeats itself, then the average duty cycle is $(t_3 - t_2)/t_4$. The power as a function of time is a linearly decreasing function from a value equal to the peak regenerative power to some lesser value after $(t_3 - t_2)$ seconds have elapsed. The average power regenerated over the interval of $(t_3 - t_2)$ seconds is: $\frac{P_b}{2} \times \frac{(\omega_b + \omega_o)}{\omega_b}$

P_{av} = Average dynamic brake resister dissipation (watts)

$t_3 - t_2$ = Deceleration time from ω_b to ω_o (seconds)

t_4 = Total cycle time or period of process (seconds)

P_b = Peak braking power (watts)

ω_b = Rated angular rotational speed $\frac{Rad}{s}$

ω_o = Angular rotational speed, less than rated speed down to zero $\frac{Rad}{s}$

The Average Power in watts regenerated over the period t_4 is:

$$P_{av} = \left[\frac{(t_3 - t_2)}{t_4}\right]\frac{P_b}{2}\left[\frac{(\omega_b + \omega_o)}{\omega_b}\right]$$

Calculate Average Power in watts regenerated over the period t_4:

$$P_{av} = \left[\frac{(\qquad - \qquad)}{[\qquad]}\right] \times \frac{[\qquad]}{2} \times \left[\frac{(\qquad + \qquad)}{[\qquad]}\right]$$

Record Average Power in watts regenerated over the period t_4:

P_{av} =

Step 5 Percent Average Load of the Internal Dynamic Brake Resistor

Skip this calculation if an external dynamic brake resistor will be used.

$$AL = \frac{P_{av}}{P_{db}} \times 100$$

AL = Average load in percent of dynamic brake resistor.
Important: The value of AL should not exceed 100%.

P_{av} = Average dynamic brake resistor dissipation calculated in Step 4 (watts)

P_{db} = Steady state power dissipation capacity of dynamic brake resistors obtained from Table A.A (watts)

Calculate Percent Average Load of the dynamic brake resistor:

$$AL = \frac{[\qquad\qquad]}{[\qquad\qquad]} \times 100$$

Record Percent Average Load of the dynamic brake resistor:

AL	=

The calculation of AL is the Dynamic Brake Resistor load expressed as a percent. P_{db} is the sum of the Dynamic Brake dissipation capacity and is obtained from Table A.A. This will give a data point for a line to be drawn on one the curves provided in Section 3.

Step 6 Percent Peak Load of the Internal Dynamic Brake Resistor

Skip this calculation if an external dynamic brake resistor will be used.

$$PL = \frac{P_b}{P_{db}} \times 100$$

PL = Peak load in percent of dynamic brake resistor

P_{av} = Peak braking power calculated in Step 2 (watts)

P_{db} = Steady state power dissipation capacity of dynamic brake resistors obtained from Table A.A (watts)

Calculate Percent Peak Load of the dynamic brake resistor:

$$PL = \frac{[\qquad\qquad]}{[\qquad\qquad]} \times 100$$

Record Percent Average Load of the dynamic brake resistor:

PL	=

The calculation of PL in percent gives the percentage of the instantaneous power dissipated by the Dynamic Brake Resistors relative to the steady state power dissipation capacity of the resistors. This will give a data point to be drawn on one of the curves provided in Section 3.

Example Calculation

A 10 HP, 4 Pole, 480 Volt motor and drive is accelerating and decelerating as depicted in Figure 2.1.

- Cycle period t_4 is 40 seconds
- Rated speed is 1785 RPM and is to be decelerated to 0 speed in 15.0 seconds
- Motor load can be considered purely as inertia, and all power expended or absorbed by the motor is absorbed by the motor and load inertia
- Load inertia is 4.0 lb.-ft.^{2} and is directly coupled to the motor
- Motor rotor inertia is 2.2 lb.-ft.^{2}
- A PowerFlex 70, 10 HP 480V Normal Duty rating is chosen.

Calculate the necessary values to choose an acceptable Dynamic Brake.

$$\text{Rated Power} = 10\text{ HP} \times 746\text{ watts} = 7.46\text{ kW}$$

This information was given and must be known before the calculation process begins. This can be given in HP, but must be converted to watts before it can be used in the equations.

$$\text{Rated Speed} = \omega_b = 1785\text{ RPM} = 2\pi \times \frac{1785}{60} = \frac{186.98\text{ Rad}}{\text{s}}$$

$$\text{Lower Speed} = \omega_o = 0\text{ RPM} = 2\pi \times \frac{0}{60} = \frac{0\text{ Rad}}{\text{s}}$$

This information was given and must be known before the calculation process begins. This can be given in RPM, but must be converted to radians per second before it can be used in the equations.

$$\text{Total Inertia} = J_T = 6.2\text{ lb.-ft.}^2 = 0.261\text{ kg-m}^2$$

This value can be in lb.-ft.^{2} or Wk^2, but must be converted into kg-m^2 before it can be used in the equations.

$$\text{Deceleration Time} = (t_3 - t_2) = 15\text{ seconds}$$

$$\text{Period of Cycle} = t_4 = 40\text{ seconds}$$

$$V_d = 790 \text{ Volts}$$

This was known because the drive is rated at 480 Volts rms. If the drive were rated 230 Volts rms, then $V_d = 395$ Volts.

All of the preceding data and calculations were made from knowledge of the application under consideration. The total inertia was given and did not need further calculations as outlined in Step 2.

$$\text{Peak Braking Power} = P_b = \frac{J_T[\omega_b(\omega_b - \omega_o)]}{(t_3 - t_2)}$$

$$P_b = \frac{0.261[186.92(186.92 - 0)]}{15} = 608.6 \text{ watts}$$

Note that this is 8.1% of rated power and is less than the maximum drive limit of 150% current limit. This calculation is the result of Step 3 and determines the peak power that must be dissipated by the Dynamic Brake Resistor.

$$\text{Average Braking Power} = P_{av} = \left[\frac{(t_3 - t_2)}{t_4}\right]\frac{P_b}{2}\left[\frac{(\omega_b + \omega_o)}{\omega_b}\right]$$

$$P_{av} = \left(\frac{15}{40}\right)\left(\frac{608.6}{2}\right)\left(\frac{186.92 + 0}{186.92}\right) = 114.1 \text{ watts}$$

This is the result of calculating the average power dissipation as outlined in Step 5. Verify that the sum of the power ratings of the Dynamic Brake Resistors chosen in Step 4 is greater than the value calculated in Step 5.

For an internal resistor, refer to Table A.A to determine the continuous power rating of the resistor in the given drive you are using. Skip this calculation if an external dynamic brake resistor will be used.

In this case, a 10 HP PowerFlex 70 drive has an internal resistor rated for 40 continuous watts. Because $P_{av} = 114.1$ watts, and is greater than the resistor's continuous watts rating, the drive will eventually trip on a Resistor Over Heated fault. Calculate the minimum cycle time (in seconds) using the formula in Section 3, number 2 B.

$$\frac{\left(\frac{608.6}{2} \times 15\right)}{40} = 114.1 \text{ seconds}$$

Recalculate the average power dissipation.

$$P_{av} = \left(\frac{15}{114.1}\right)\left(\frac{608.6}{2}\right)\left(\frac{186.92 + 0}{186.92}\right) = 40 \text{ watts}$$

If the cycle cannot be adjusted, the decel time must be extended or the system inertia lowered to reduce the average load on the resistor. Another option is to use an external resistor.

Calculate the Percent Average Load. You will need this number to calculate the Percent Peak Load.

$$\text{Percent Average Load} = AL = 100 \times \frac{P_{av}}{P_{db}}$$

$$AL = 100 \times \frac{40}{40} = 100\%$$

Important: The value of AL should not exceed 100%.

This is the result of the calculation outlined in Step 6. Record this value on page 3-1.

$$\text{Percent Peak Load} = PL = 100 \times \frac{P_b}{P_{db}}$$

$$PL = 100 \times \frac{608.6}{40} = 1521\%$$

This is the result of the calculation outlined in Step 6. Record this value on page 3-1.

Now that the values of AL and PL have been calculated, they can be used to determine whether an internal or external resistor can be used. Since the internal resistor package offers significant cost and space advantages, it will be evaluated first.

Notes:

Evaluating the Internal Resistor

Evaluating the Capability of the Internal Dynamic Brake Resistor

To investigate the capabilities of the internal resistor package, the values of AL (Average Percent Load) and PL (Peak Percent Load) are plotted onto a graph of the Dynamic Brake Resistor's constant temperature power curve and connected with a straight line. If any portion of this line lies to the right of the constant temperature power curve, the resistor element temperature will exceed the operating temperature limit.

Important: The drive will protect the resistor and shut down the Chopper transistor. The drive will then likely trip on an overvoltage fault.

1. Record the values calculated in Section 2.

AL =

PL =

$t_3 - t_2 =$

$P_{ave} =$

2. **A.** Compare the calculated average power to the continuous rating of the dynamic brake resistor in the frame drive you have selected. See Table A.A.
Record the resistor's continuous rating.

$R_{cont.} =$

B. If P_{ave} is greater than $R_{cont.}$ you will need to extend the cycle time (in seconds) by the result of the following equation.

$$\frac{\left(\frac{P_b}{2} \times \text{Decel}\right)}{R_{cont}} = \text{seconds}$$

3. Find the correct constant temperature Power Curve for your drive type, voltage and frame.

Power Curves for PowerFlex 70 Internal DB Resistors

Drive Voltage	Drive Frame(s)	Figure Number
240	A and B	3.1
240	C	3.3
240	D	3.4
400/480	A and B	3.5
400/480	C	3.6
400/480	D	3.7

OR

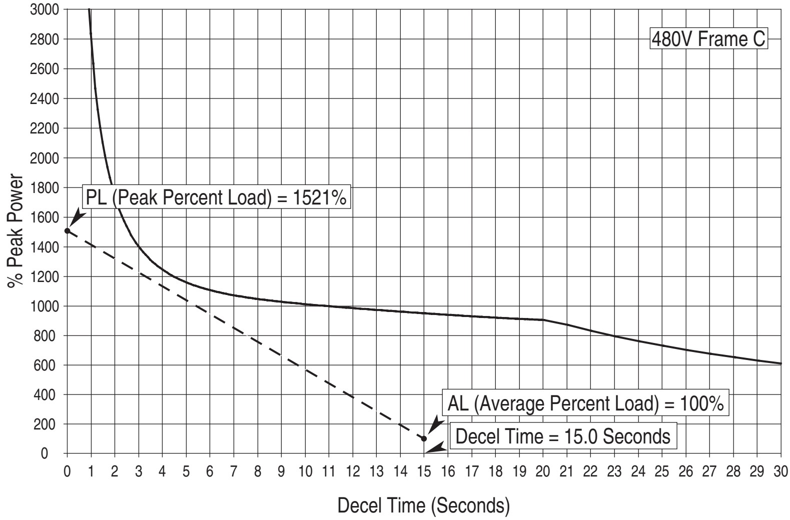
Power Curves for PowerFlex 700 Internal DB Resistors

Drive Voltage	Drive Frame	Figure Number
400/480	0	3.13
400/480	1	3.14
400/480	2	3.15
400/480	3	Uses external DB resistors only. Refer to Section 4

4. Plot the point where the value of AL, calculated in Step 5 of Section 2, and the desired deceleration time $(t_3 - t_2)$ intersect.
5. Plot the value of PL, calculated in Step 6 of Section 2, on the vertical axis (0 seconds).
6. Connect AL at $(t_3 - t_2)$ and PL at 0 seconds with a straight line. This line is the power curve described by the motor as it decelerates to minimum speed.

If the line connecting AL and PL lies entirely to the left of the Power Curve, then the capability of the internal resistor is **sufficient** for the proposed application.

Figure 3.1 Example of an Acceptable Resistor Power Curve



If any portion of the line connecting AL and PL lies to the right of the Power Curve, then the capability of the internal resistor is **insufficient** for the proposed application.

- Increase deceleration time ($t_3 - t_2$) until the line connecting AL and PL lies entirely to the left of the Power Curve

  or

- Go to Section 4 and select an external resistor from the tables

PowerFlex 70 Power Curves

Figure 3.2 PowerFlex 70 – 240 Volt, Frames A and B

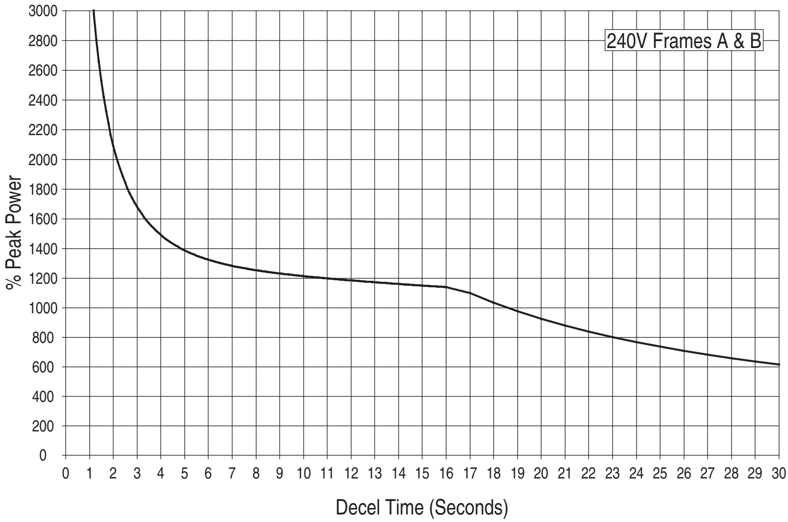


Figure 3.3 PowerFlex 70 – 240 Volt, Frame C

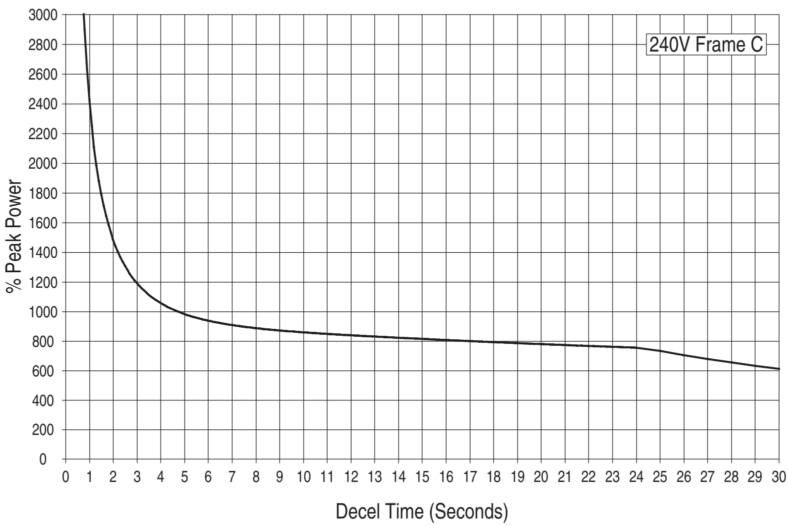


Figure 3.4 PowerFlex 70 – 240 Volt, Frame D

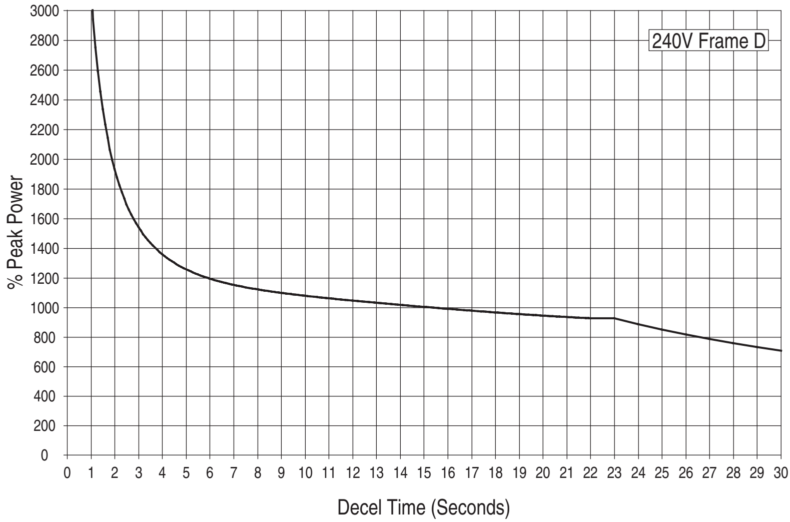


Figure 3.5 PowerFlex 70 – 480 Volt, Frames A and B

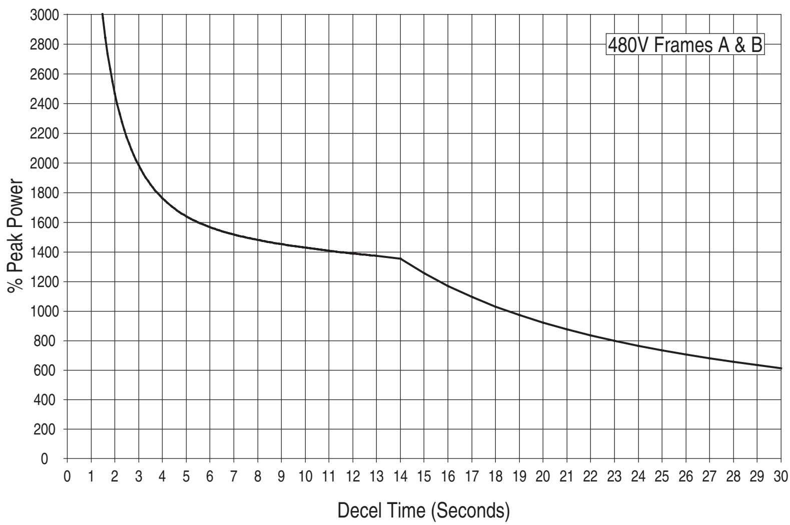


Figure 3.6 PowerFlex 70 – 480 Volt, Frame C

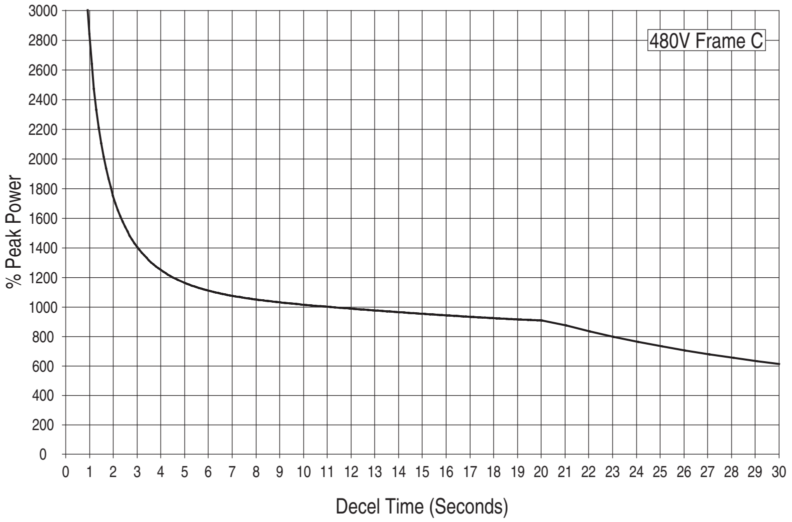


Figure 3.7 PowerFlex 70 – 480 Volt, Frame D

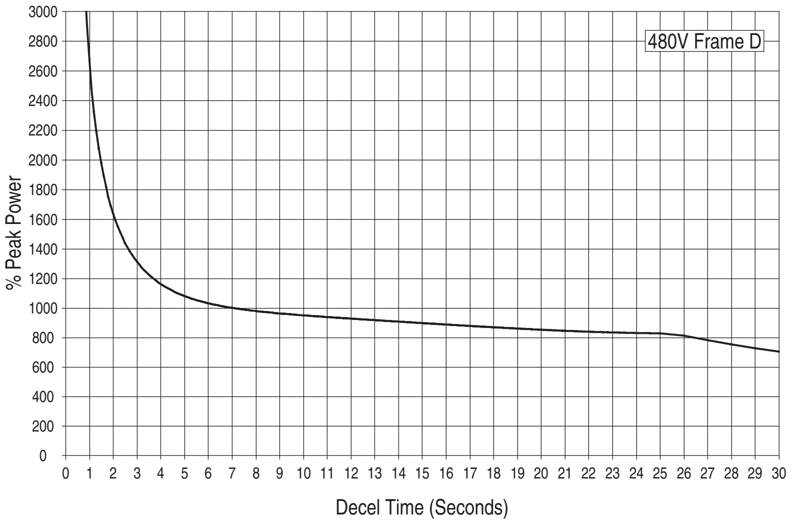


Figure 3.8 PowerFlex 70 – 600 Volt, Frames A and B

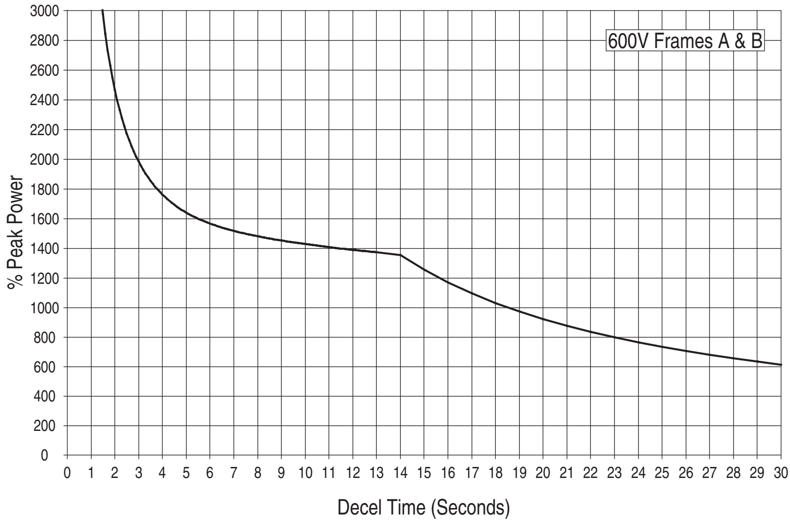
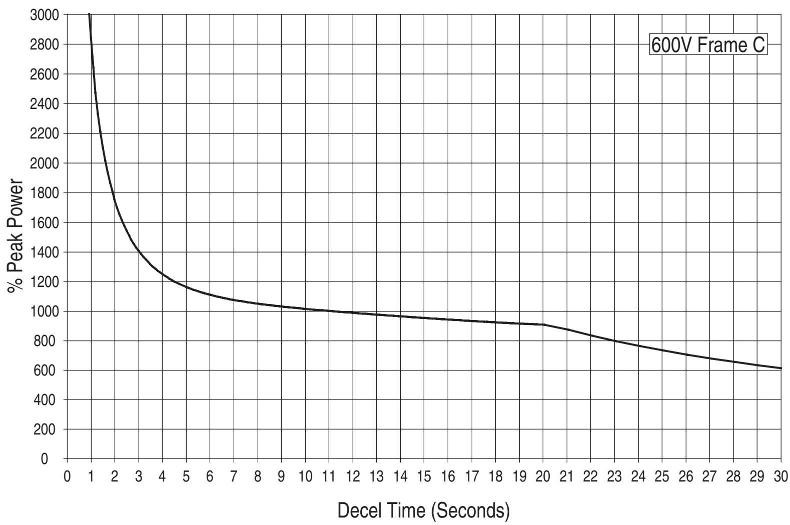


Figure 3.9 PowerFlex 70 – 600 Volt, Frame C



PowerFlex 700 Power Curves

Figure 3.10 PowerFlex 700 – 240 Volt, Frame 1 to 5 HP

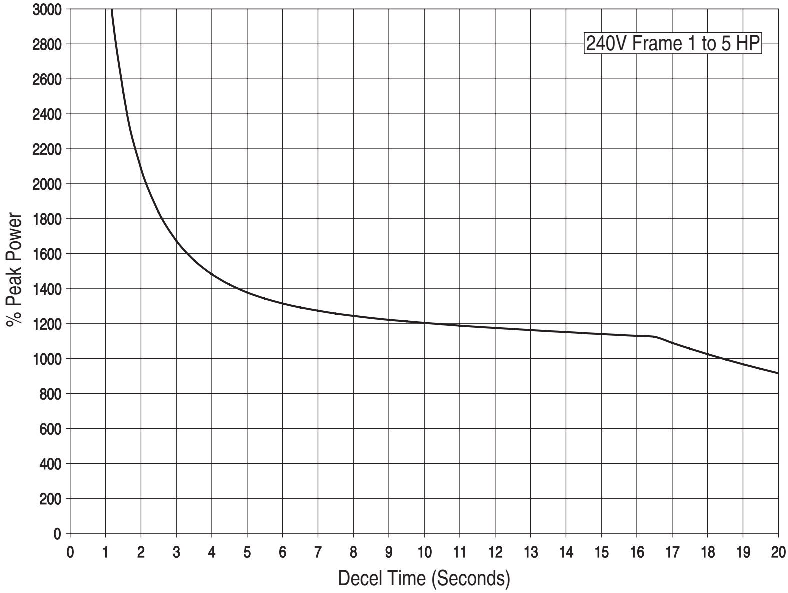


Figure 3.11 PowerFlex 700 – 240 Volt, Frame 1 - 7.5 HP

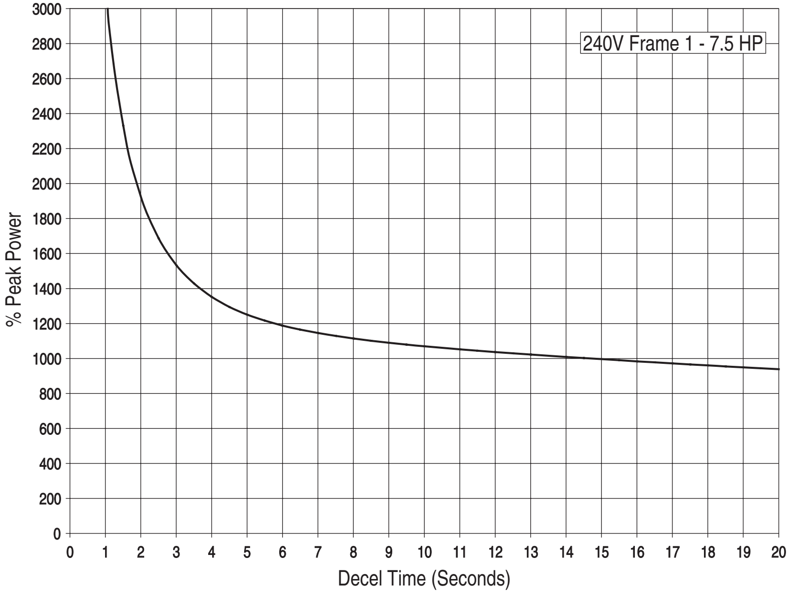


Figure 3.12 PowerFlex 700 – 240 Volt, Frame 2

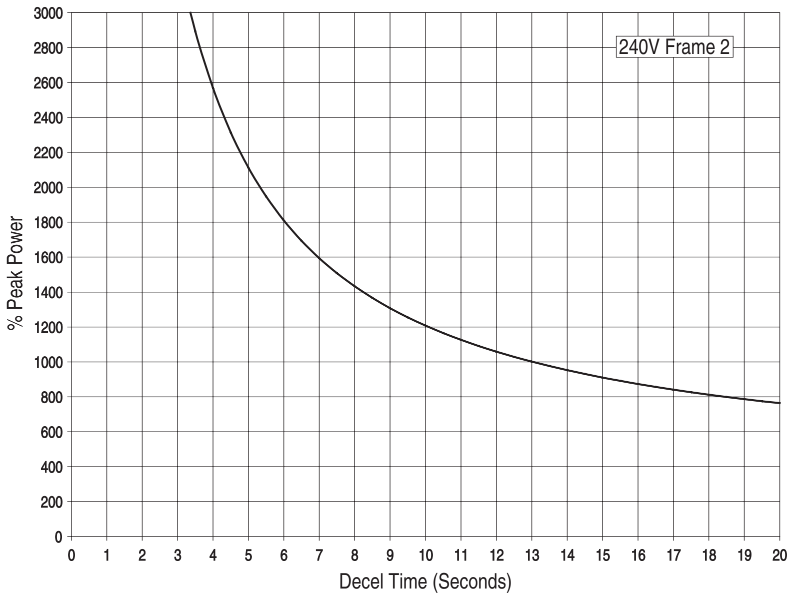


Figure 3.13 PowerFlex 700 – 480 Volt, Frame 0

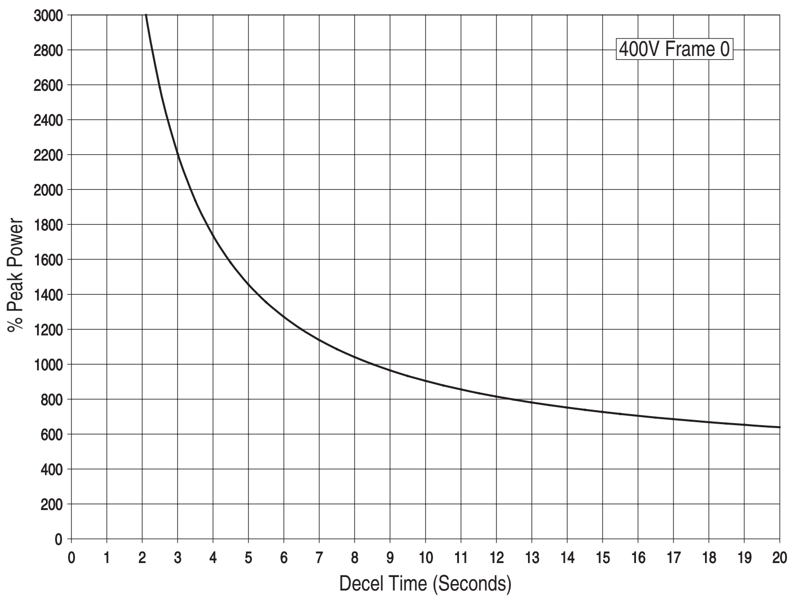


Figure 3.14 PowerFlex 700 – 480 Volt, Frame 1

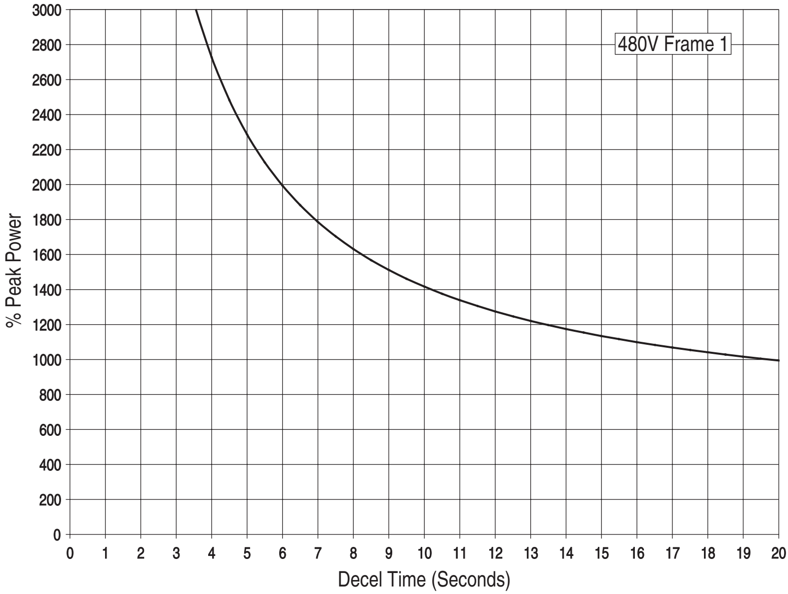
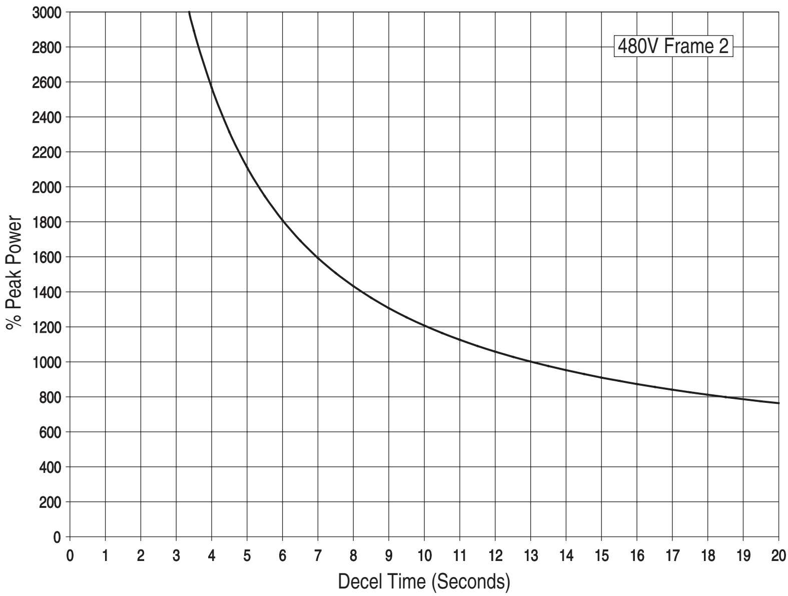


Figure 3.15 PowerFlex 700 – 480 Volt, Frame 2



Selecting An External Resistor

How to Select an External Dynamic Brake Resistor

In order to select the appropriate External Dynamic Brake Resistor for your application, the following data must be calculated.

Peak Regenerative Power

(Expressed in watts)

This value is used to determine the maximum resistance value of the Dynamic Brake Resistor. If this value is greater than the maximum imposed by the peak regenerative power of the drive, the drive can trip off due to transient DC bus overvoltage problems.

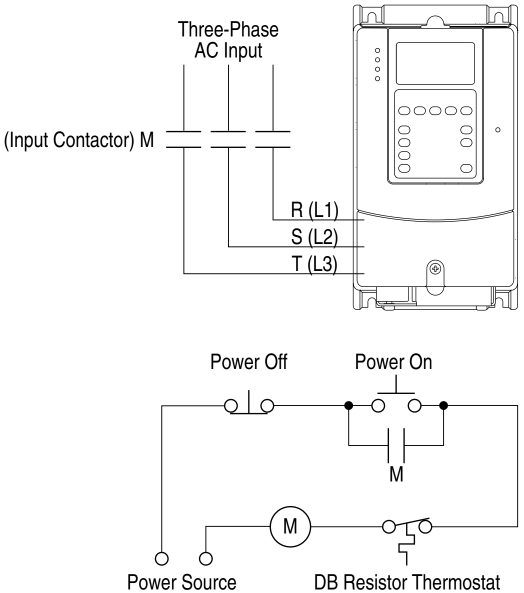
Power Rating of the Dynamic Brake Resistor

The average power dissipation of the regenerative mode must be estimated and the power rating of the Dynamic Brake Resistor chosen to be greater than the average regenerative power dissipation of the drive.

Protecting External Resistor Packages

ATTENTION: PowerFlex drives do not offer protection for externally mounted brake resistors. A risk of fire exists if external braking resistors are not protected. External resistor packages must be self-protected from over temperature or the protective circuit show below, or equivalent, must be supplied.

Figure 4.1 External Brake Resistor Circuitry



Record the Values Calculated in Section 2

P_b =

P_{av} =

Calculate Maximum Dynamic Brake Resistance Value

When using an internal Dynamic Brake Resistor, the value is fixed. However, when choosing an external resistor, the maximum allowable Dynamic Brake resistance value (R_{db1}) must be calculated.

$$R_{db1} = \frac{(V_d)^2}{P_b}$$

R_{db1} = Maximum allowable value for the dynamic brake resistor (ohms)

V_d = DC bus voltage used for calculating maximum power. (395V DC, 790V DC, 987V DC, or 1135V DC)

P_b = Peak breaking power calculated in Section 2: Step 3 (watts)

Calculate Maximum Dynamic Brake Resistance:

$$R_{db1} = \frac{(\qquad\qquad)^2}{[\qquad\qquad]}$$

Record Maximum Dynamic Brake Resistance:

R_{db1} =

The choice of the Dynamic Brake resistance value should be less than the value calculated in this step. If the value is greater, the drive can trip on DC bus overvoltage.

Calculate required joule rating (joules = watt-seconds):

$$\left(\frac{P_b}{2}\right) \times (t_3 - t_2) = \text{watt-seconds}$$

$$\text{watt-second losses} = \left[\frac{P_b}{2} \times (t_3 - t_2)\right] \times [1 - (\text{motor efficiency} \times \text{drive efficiency})]$$

Drive Efficiency = 0.975

$$\text{Total watt-seconds} = \text{watt-seconds} - \text{watt-second losses}$$

Select Resistor

Select a resistor bank from the following tables or from your resistor supplier that has **all** of the following:

- a resistance value that is less than the value calculated (R_{db1} in ohms)
- a resistance value that is greater than the minimum resistance listed in Table A.A
- a power value that is greater than the value calculated in Step 4 (P_{av} in watts)
- a watt-second value greater than the value calculated.

ATTENTION: The internal dynamic brake IGBT will be damaged if the resistance value of the resistor bank is less than the minimum resistance value of the drive. Use Table A.A to verify that the resistance value of the selected resistor bank is greater than the minimum resistance of the drive.

If no resistor appears in the following tables that is greater than the minimum allowable resistance **and** is less than the calculated maximum resistance:

- Adjust the deceleration time of the application to fit an available resistor package.

  or

- Use the calculated data to purchase resistors locally.

  or

- Consult the factory for other possible resistor packages.

Table 4.A Resistor Selection – 240V AC Drives

Ohms	Watts	Watt Seconds	Catalog Number
154	913	16431	220-1
154	610	16431	220-1A
154	604	16431	225-1
154	408	6416	225-1A
154	242	6416	222-1
154	182	6416	222-1A
117	3000	20800	T117R3K0
117	2700	14300	T117R2K7
117	2100	18600	T117R2K1
117	1500	15800	T117R1K5
117	1200	12500	T117R1K2
117	900	10600	T117R900W
117	600	10100	T117R600W
117	300	7950	T117R300W
110	1278	46947	220-2
110	850	18779	220-2A
110	845	18779	225-2
110	570	18779	225-2A
110	338	7511	222-2
110	255	7511	222-2A
97	4200	19100	T97R4K2
97	3600	22400	T97R3K6
97	3000	16800	T97R3K0
97	2700	19100	T97R2K7
97	2100	15400	T97R2K1
97	1500	20800	T97R1K5
97	1200	16500	T97R1K2
97	900	13800	T97R900W
97	600	13400	T97R600W
97	300	10300	T97R300W
91	86	17000	AKR2091P500
85	1654	57901	220-3
85	1094	36384	225-3
85	1089	36384	220-3A
85	730	23004	225-3A
85	438	9076	222-3
85	326	9076	222-3A
80	9300	230000	T80R9K3
80	9000	209000	T80R9K0
80	5700	29400	T80R5K7
80	4500	23300	T80R4K5
80	4200	25100	T80R4K2
80	3600	18500	T80R3K6
80	3000	22100	T80R3K0
80	2700	24600	T80R2K7
80	2100	19100	T80R2K1
80	1500	17500	T80R1K5
80	1200	13700	T80R1K2
80	900	18500	T80R900W
80	600	10900	T80R600W
80	300	8530	T80R300W
77	9300	230000	T77R9K3
77	9000	209000	T77R9K0
77	5700	28700	T77R5K7
77	4500	22400	T77R4K5
77	4200	24200	T77R4K2
77	3600	28100	T77R3K6
77	3000	21300	T77R3K0
77	2700	23800	T77R2K7
77	2100	19100	T77R2K1
77	1500	16400	T77R1K5
77	1200	20800	T77R1K2
77	900	17900	T77R900W
77	600	10600	T77R600W
77	300	8210	T77R300W
60	11000	448000	T60R11K0
60	6900	164000	T60R6K9
60	4500	28000	T60R4K5
60	3600	22000	T60R3K6
60	2700	18500	T60R2K7
60	1500	20800	T60R1K5
60	1200	16400	T60R1K2
60	900	13700	T60R900W
60	600	13000	T60R600W
60	300	10300	T60R300W
59	2384	99762	220-4
59	1577	64161	220-4A
59	1576	64161	225-4
59	1056	39201	225-4A
59	631	25038	222-4
59	473	10094	222-4A
48	20400	716000	T48R20K4
48	19100	656000	T48R19K1
48	12600	359000	T48R12K6
48	6600	131000	T48R6K6
48	5670	131000	T48R5K67
48	4200	23800	T48R4K2
48	3600	28000	T48R3K6
48	3000	21100	T48R3K0

240V AC Drives Continued

Ohms	Watts	Watt Seconds	Catalog Number
48	2700	23300	T48R2K7
48	1500	16600	T48R1K5
48	1200	20800	T48R1K2
48	900	17500	T48R900W
48	600	16500	T48R600W
48	300	13100	T48R300W
47	166	33000	AKR2047P500
45	19100	656000	T45R19K1
45	12600	359000	T45R12K6
45	6000	125000	T45R6K0
45	3600	26600	T45R3K6
45	3125	197177	220-5
45	3000	19800	T45R3K0
45	2700	22000	T45R2K7
45	2100	28100	T45R2K1
45	2066	124800	225-5
45	2056	124800	220-5A
45	1500	24900	T45R1K5
45	1378	49529	225-5A
45	1200	19100	T45R1K2
45	827	30828	222-5
45	617	30828	222-5A
45	600	15800	T45R600W
45	300	12300	T45R300W
40	22000	1202000	T40R22K0
40	19000	568000	T40R19K0
40	17000	574000	T40R17K0
40	16000	521000	T40R16K0
40	11000	333000	T40R11K0
40	10000	309000	T40R10K0
40	4000	105000	T40R4K0
40	1800	18500	T40R1K8
40	1200	17300	T40R1K2
40	900	14300	T40R900W
40	300	10900	T40R300W
34	26000	1591000	T34R26K0
34	19000	1048000	T34R19K0
34	18000	1017000	T34R18K0
34	17000	990000	T34R17K0
34	15000	456000	T34R15K0
34	13000	456000	T34R13K0
34	9000	285000	T34R9K0
34	8000	262000	T34R8K0
34	4000	98600	T34R4K0
34	3600	93000	T34R3K6

Ohms	Watts	Watt Seconds	Catalog Number
34	2400	30100	T34R2K4
34	1800	25100	T34R1K8
34	900	19100	T34R900W
34	300	14700	T34R300W
32	28000	2304000	T32R28K0
32	26000	1591000	T32R26K0
32	18000	1017000	T32R18K0
32	17100	931000	T32R17K1
32	12700	410000	T32R12K7
32	8420	246000	T32R8K42
32	4500	105000	T32R4K5
32	4395	222215	220-6
32	4000	83300	T32R4K0
32	2918	82626	220-6A
32	2906	82626	225-6
32	2700	25200	T32R2K7
32	2100	20200	T32R2K1
32	1955	88573	225-6A
32	1500	28100	T32R1K5
32	1162	55162	222-6
32	900	19100	T32R900W
32	875	35054	222-6A
32	600	17500	T32R600W
32	300	13800	T32R300W
30	260	52000	AKR2030P1K2
27	27400	2075000	T27R27K4
27	21600	1346000	T27R21K6
27	15000	931000	T27R15K0
27	11500	391000	T27R11K5
27	8420	358000	T27R8K42
27	3300	73900	T27R3K3
27	2100	27300	T27R2K1
27	1500	23700	T27R1K5
27	1200	18800	T27R1K2
27	900	24900	T27R900W
27	600	15400	T27R600W
27	300	18500	T27R300W
25	8420	328000	T25R8K42
25	3900	190000	T25R3K9
25	3300	73900	T25R3K3
25	1500	22000	T25R1K5
25	1200	27700	T25R1K2
25	900	23000	T25R900W
25	600	14300	T25R600W
25	300	17200	T25R300W

240V AC Drives Continued

Ohms	Watts	Watt Seconds	Catalog Number
23	10200	310000	T23R10K2
23	7490	328000	T23R7K49
23	6310	179000	T23R6K31
23	2100	23100	T23R2K1
23	1500	20200	T23R1K5
23	900	21300	T23R900W
23	600	20800	T23R600W
23	300	15800	T23R300W
20	34600	1148000	T20R34K6
20	28400	1066000	T20R28K4
20	20600	1602000	T20R20K6
20	15200	924000	T20R15K2
20	10700	582000	T20R10K7
20	8920	267000	T20R8K92
20	7031	169227	220-7
20	5940	260000	T20R5K94
20	4650	221432	225-7
20	4572	222215	220-7A
20	3063	138493	225-7A
20	1860	55084	222-7
20	1500	28000	T20R1K5
20	1372	87086	222-7A
20	900	18500	T20R900W
20	600	17300	T20R600W
20	300	13700	T20R300W
15	11400	734000	T15R11K4
15	8570	466000	T15R8K57
15	6160	232000	T15R6K16
15	4210	143000	T15R4K21
15	1500	38800	T15R1K5
15	900	22000	T15R900W
15	600	20800	T15R600W
15	520	104000	(2) AKR2030P1K2
15	300	16400	T15R300W
14	12700	1038000	T14R12K7
14	11400	734000	T14R11K4
14	10045	523728	220-8
14	6708	172138	220-8A
14	6642	172138	225-8
14	6160	232000	T14R6K16
14	4495	117367	225-8A
14	2657	154455	222-8
14	2012	61344	222-8A
14	1800	27800	T14R1K8
14	1200	24500	T14R1K2

Ohms	Watts	Watt Seconds	Catalog Number
14	900	20700	T14R900W
14	600	19400	T14R600W
14	300	15400	T14R300W
11	12784	890985	220-9
11	8537	407344	220-9A
11	8454	407344	225-9
11	5720	237243	225-9A
11	3381	100080	222-9
11	2561	121123	222-9A
10.4	72300	4620000	T10F4R72K3
10.4	43900	1367000	T10F4R43K9
10.4	35600	1230000	T10F4R35K6
10.4	26000	2002000	T10F4R26K0
10.4	18900	1991000	T10F4R18K9
10.4	15500	1742000	T10F4R15K5
10.4	11000	359000	T10F4R11K0
10.4	8890	801000	T10F4R8K89
10.4	6040	489000	T10F4R6K4
10.4	5360	329000	T10F4R5K36
10.4	2970	95100	T10F4R2K97
10.4	1500	25400	T10F4R1K5
10.4	900	24500	T10F4R900W
10.4	600	22900	T10F4R600W
10.4	300	17300	T10F4R300W
7.3	19264	656981	220-10
7.3	12754	359925	220-10A
7.3	12738	359925	225-10
7.3	8545	566990	225-10A
7.3	5095	267369	222-10
7.3	3826	164245	222-10A
5.7	24694	1781970	220-11
5.7	16461	880744	220-11A
5.7	16314	880744	225-11
5.7	11029	905640	225-11A
5.7	6525	421193	222-11
5.7	4938	260816	222-11A
5.4	104000	3444000	T5F4R104K0
5.4	51900	1953000	T5F4R51K9
5.4	48100	1845000	T5F4R48K1
5.4	37700	2310000	T5F4R37K7
5.4	22000	717000	T5F4R22K0
5.4	20300	738000	T5F4R20K3
5.4	12000	699000	T5F4R12K0
5.4	7280	328000	T5F4R7K28
5.4	5780	169000	T5F4R5K78

240V AC Drives Continued

Ohms	Watts	Watt Seconds	Catalog Number
5.4	5080	401000	T5F4R5K8
5.4	2680	185000	T5F4R2K68
5.4	1670	55700	T5F4R1K67
4.8	132000	8077000	T4F8R132K0
4.8	99300	6159000	T4F8R99K3
4.8	61000	3916000	T4F8R61K0
4.8	58200	3696000	T4F8R58K2
4.8	34600	2310000	T4F8R34K6
4.8	25800	984000	T4F8R25K8
4.8	19200	586000	T4F8R19K2
4.8	10900	359000	T4F8R10K9
4.8	8880	260000	T4F8R8K88
4.8	5490	169000	T4F8R5K49
4.8	4590	401000	T4F8R4K59
4.8	2580	185000	T4F8R2K58
4.5	30918	1486256	220-12
4.5	20715	1425576	225-12
4.5	20612	1425576	220-12A
4.5	13810	660558	225-12A
4.5	8266	239950	222-12
4.5	6184	152850	222-12A
3.8	36138	2672955	220-13
3.8	24212	1321116	225-13
3.8	24089	751149	220-13A
3.8	16139	430346	225-13A
3.8	9788	328491	222-13
3.8	7227	182571	222-13A
2.7	35178	2187360	225-14
2.7	35003	2164091	220-14A
2.7	23452	1173670	225-14A
2.7	15750	520110	222-14
2.7	10500	521631	222-14A
2.2	44785	1724576	225-15
2.2	29860	1685270	225-15A
2.2	20053	1603773	222-15
2.2	13370	316618	222-15A
1.8	34281	2138364	225-16A
1.8	23026	1570711	222-16
1.8	15350	782447	222-16A
1.5	19884	1308926	222-17A

Table 4.B Resistor Selection – 480V AC Drives

Ohms	Watts	Watt Seconds	Catalog Number
615	915	13302	440-1
615	605	13615	445-1
615	602	13302	440-1A
615	404	4225	445-1A
615	242	4225	442-1
615	180	4225	442-1A
439	1281	24647	440-2
439	848	9389	440-2A
439	847	11267	445-2
439	568	2973	445-2A
439	339	2973	442-2
439	254	2973	442-2A
360	86	17000	AKR2360P500
342	1645	36306	440-3
342	1096	22534	440-3A
342	1088	23473	445-3
342	734	14397	445-3A
342	435	3677	442-3
342	329	3677	442-3A
237	2373	61422	440-4
237	1577	39748	440-4A
237	1570	38496	445-4
237	1057	25351	445-4A
237	628	15649	442-4
237	473	5321	442-4A
181	3108	77775	440-5
181	2068	77853	440-5A
181	2055	77853	445-5
181	1385	30985	445-5A
181	822	19248	442-5
181	620	19248	442-5A
128	4395	138024	440-6
128	2912	82626	440-6A
128	2906	86382	445-6
128	1951	55397	445-6A
128	1162	32863	442-6
128	874	22065	442-6A
120	260	52000	AKR2120P1K2
117	3000	20800	T117R3K0
117	2700	14300	T117R2K7
117	2100	18600	T117R2K1
117	1500	15800	T117R1K5
117	1200	12500	T117R1K2

Ohms	Watts	Watt Seconds	Catalog Number
117	900	10600	T117R900W
117	600	10100	T117R600W
117	300	7950	T117R300W
97	4200	19100	T97R4K2
97	3600	22400	T97R3K6
97	3000	16800	T97R3K0
97	2700	19100	T97R2K7
97	2100	15400	T97R2K1
97	1500	20800	T97R1K5
97	1200	16500	T97R1K2
97	900	13800	T97R900W
97	600	13400	T97R600W
97	300	10300	T97R300W
81	6944	221276	440-7
81	4629	221432	440-7A
81	4592	224640	445-7
81	3102	55319	445-7A
81	1837	55084	442-7
81	1389	34975	442-7A
80	9300	230000	T80R9K3
80	9000	209000	T80R9K0
80	5700	29400	T80R5K7
80	4500	23300	T80R4K5
80	4200	25100	T80R4K2
80	3600	18500	T80R3K6
80	3000	22100	T80R3K0
80	2700	24600	T80R2K7
80	2100	19100	T80R2K1
80	1500	17500	T80R1K5
80	1200	13700	T80R1K2
80	900	18500	T80R900W
80	600	10900	T80R600W
80	300	8530	T80R300W
77	9300	230000	T77R9K3
77	9000	209000	T77R9K0
77	5700	28700	T77R5K7
77	4500	22400	T77R4K5
77	4200	24200	T77R4K2
77	3600	28100	T77R3K6
77	3000	21300	T77R3K0
77	2700	23800	T77R2K7
77	2100	19100	T77R2K1
77	1500	16400	T77R1K5
77	1200	20800	T77R1K2
77	900	17900	T77R900W

480V AC Drives Continued

Ohms	Watts	Watt Seconds	Catalog Number
77	600	10600	T77R600W
77	300	8210	T77R300W
60	11000	448000	T60R11K0
60	6900	164000	T60R6K9
60	4500	28000	T60R4K5
60	3600	22000	T60R3K6
60	2700	18500	T60R2K7
60	1500	20800	T60R1K5
60	1200	16400	T60R1K2
60	900	13700	T60R900W
60	600	13000	T60R600W
60	520	104000	(2) AKR2120P1K2
60	300	10300	T60R300W
56	10045	388094	440-8
56	6702	245375	440-8A
56	6642	245375	445-8
56	4490	245062	445-8A
56	2657	154455	442-8
56	2010	61344	442-8A
48	20400	716000	T48R20K4
48	19100	656000	T48R19K1
48	12600	359000	T48R12K6
48	6600	131000	T48R6K6
48	5670	131000	T48R5K67
48	4200	23800	T48R4K2
48	3600	28000	T48R3K6
48	3000	21100	T48R3K0
48	2700	23300	T48R2K7
48	1500	16600	T48R1K5
48	1200	20800	T48R1K2
48	900	17500	T48R900W
48	600	16500	T48R600W
48	300	13100	T48R300W
45	19100	656000	T45R19K1
45	12600	359000	T45R12K6
45	6000	125000	T45R6K0
45	3600	26600	T45R3K6
45	3000	19800	T45R3K0
45	2700	22000	T45R2K7
45	2100	28100	T45R2K1
45	1500	24900	T45R1K5
45	1200	19100	T45R1K2
45	600	15800	T45R600W
45	300	12300	T45R300W

Ohms	Watts	Watt Seconds	Catalog Number
44	12784	369388	440-9
44	8537	302807	440-9A
44	8454	305624	445-9
44	5720	184031	445-9A
44	3381	190604	442-9
44	2561	121670	442-9A
40	22000	1202000	T40R22K0
40	19000	568000	T40R19K0
40	17000	574000	T40R17K0
40	16000	521000	T40R16K0
40	11000	333000	T40R11K0
40	10000	309000	T40R10K0
40	4000	105000	T40R4K0
40	1800	18500	T40R1K8
40	1200	17300	T40R1K2
40	900	14300	T40R900W
40	300	10900	T40R300W
34	26000	1591000	T34R26K0
34	19000	1048000	T34R19K0
34	18000	1017000	T34R18K0
34	17000	990000	T34R17K0
34	15000	456000	T34R15K0
34	13000	456000	T34R13K0
34	9000	285000	T34R9K0
34	8000	262000	T34R8K0
34	4000	98600	T34R4K0
34	3600	93000	T34R3K6
34	2400	30100	T34R2K4
34	1800	25100	T34R1K8
34	900	19100	T34R900W
34	300	14700	T34R300W
32	28000	2304000	T32R28K0
32	26000	1591000	T32R26K0
32	18000	1017000	T32R18K0
32	17100	931000	T32R17K1
32	12700	410000	T32R12K7
32	8420	246000	T32R8K42
32	4500	105000	T32R4K5
32	4000	83300	T32R4K0
32	2700	25200	T32R2K7
32	2100	20200	T32R2K1
32	1500	28100	T32R1K5
32	900	19100	T32R900W
32	600	17500	T32R600W
32	300	13800	T32R300W

480V AC Drives Continued

Ohms	Watts	Watt Seconds	Catalog Number
29	19396	615920	440-10
29	12826	359925	445-10
29	12667	359925	440-10A
29	8487	253840	445-10A
29	5130	199993	442-10
29	3800	127069	442-10A
27	27400	2075000	T27R27K4
27	21600	1346000	T27R21K6
27	15000	931000	T27R15K0
27	11500	391000	T27R11K5
27	8420	358000	T27R8K42
27	3300	73900	T27R3K3
27	2100	27300	T27R2K1
27	1500	23700	T27R1K5
27	1200	18800	T27R1K2
27	900	24900	T27R900W
27	600	15400	T27R600W
27	300	18500	T27R300W
25	8420	328000	T25R8K42
25	3900	190000	T25R3K9
25	3300	73900	T25R3K3
25	1500	22000	T25R1K5
25	1200	27700	T25R1K2
25	900	23000	T25R900W
25	600	14300	T25R600W
25	300	17200	T25R300W
23	16172	825698	445-11
23	11125	492736	445-11A
23	10200	310000	T23R10K2
23	7490	328000	T23R7K49
23	6469	399830	442-11
23	6310	179000	T23R6K31
23	4982	254295	442-11A
23	2100	23100	T23R2K1
23	1500	20200	T23R1K5
23	900	21300	T23R900W
23	600	20800	T23R600W
23	300	15800	T23R300W
20	34600	1148000	T20R34K6
20	28400	1066000	T20R28K4
20	24910	1781970	440-11
20	20600	1602000	T20R20K6
20	16605	825698	440-11A
20	15200	924000	T20R15K2
20	10700	582000	T20R10K7

Ohms	Watts	Watt Seconds	Catalog Number
20	8920	267000	T20R8K92
20	5940	260000	T20R5K94
20	1500	28000	T20R1K5
20	900	18500	T20R900W
20	600	17300	T20R600W
20	300	13700	T20R300W
18	30910	899814	440-12
18	20664	1336477	445-12
18	20612	1336477	440-12A
18	13810	660558	445-12A
18	8266	234734	442-12
18	6184	152850	442-12A
15	35663	1313963	440-13
15	23894	719851	445-13
15	23772	719851	440-13A
15	15927	1158280	445-13A
15	11400	734000	T15R11K4
15	9919	328491	442-13
15	8570	466000	T15R8K57
15	7132	179963	442-13A
15	6160	232000	T15R6K16
15	4210	143000	T15R4K21
15	1500	38800	T15R1K5
15	900	22000	T15R900W
15	600	20800	T15R600W
15	300	16400	T15R300W
14	12700	1038000	T14R12K7
14	11400	734000	T14R11K4
14	6160	232000	T14R6K16
14	1800	27800	T14R1K8
14	1200	24500	T14R1K2
14	900	20700	T14R900W
14	600	19400	T14R600W
14	300	15400	T14R300W
12	48204	1314510	440-14
12	32297	1040221	445-14
12	32136	1040221	440-14A
12	21531	1924486	445-14A
12	12398	890985	442-14
12	9641	440372	442-14A
10.4	72300	4620000	T10F4R72K3
10.4	43900	1367000	T10F4R43K9
10.4	35600	1230000	T10F4R35K6
10.4	26000	2002000	T10F4R26K0
10.4	18900	1991000	T10F4R18K9

480V AC Drives Continued

Ohms	Watts	Watt Seconds	Catalog Number
10.4	15500	1742000	T10F4R15K5
10.4	11000	359000	T10F4R11K0
10.4	8890	801000	T10F4R8K89
10.4	6040	489000	T10F4R6K4
10.4	5360	329000	T10F4R5K36
10.4	2970	95100	T10F4R2K97
10.4	1500	25400	T10F4R1K5
10.4	900	24500	T10F4R900W
10.4	600	22900	T10F4R600W
10.4	300	17300	T10F4R300W
9.5	59635	1820386	440-15
9.5	39955	1079776	445-15
9.5	39755	2851152	440-15A
9.5	26636	3000513	445-15A
9.5	17890	479901	442-15
9.5	11926	316618	442-15A
8	70477	3325398	440-16
8	47219	1560331	445-16
8	46977	2966898	440-16A
8	31474	1564893	445-16A
8	21143	693480	442-16
8	14093	401656	442-16A
6.4	58718	4929414	445-17
6.4	58430	4818224	440-17A
6.4	39148	1231840	445-17A
6.4	26292	719851	442-17
6.4	17529	574859	442-17A
5.4	104000	3444000	T5F4R104K0
5.4	51900	1953000	T5F4R51K9
5.4	48100	1845000	T5F4R48K1
5.4	37700	2310000	T5F4R37K7
5.4	22000	717000	T5F4R22K0
5.4	20300	738000	T5F4R20K3
5.4	12000	699000	T5F4R12K0
5.4	7280	328000	T5F4R7K28
5.4	5780	169000	T5F4R5K78
5.4	5080	401000	T5F4R5K8
5.4	2680	185000	T5F4R2K68
5.4	1670	55700	T5F4R1K67
5	76534	3651418	445-18
5	51028	1733701	445-18A
5	34269	959801	442-18
5	22848	1603773	442-18A

Ohms	Watts	Watt Seconds	Catalog Number
4.8	132000	8077000	T4F8R132K0
4.8	99300	6159000	T4F8R99K3
4.8	61000	3916000	T4F8R61K0
4.8	58200	3696000	T4F8R58K2
4.8	34600	2310000	T4F8R34K6
4.8	25800	984000	T4F8R25K8
4.8	19200	586000	T4F8R19K2
4.8	10900	359000	T4F8R10K9
4.8	8880	260000	T4F8R8K88
4.8	5490	169000	T4F8R5K49
4.8	4590	401000	T4F8R4K59
4.8	2580	185000	T4F8R2K58
4	42308	1386961	442-19
4	28207	1321116	442-19A
3.9	62996	8013142	445-19A
3.9	49108	3246136	442-20
3.9	32736	2405659	442-20A
2.6	44505	1126723	442-21A

Table 4.C Resistor Selection – 600V AC Drives

Ohms	Watts	Watt Seconds	Catalog Number
956	915	6260	550-1
956	605	6260	555-1
956	597	6260	550-1A
956	400	6260	555-1A
956	242	4225	552-1
956	179	4225	552-1A
695	1258	15258	550-2
695	832	7981	555-2
695	825	7981	550-2A
695	553	7981	555-2A
695	333	4929	552-2
695	248	4929	552-2A
546	1601	36619	550-3
546	1059	23004	555-3
546	1055	23004	550-3A
546	707	12050	555-3A
546	424	12050	552-3
546	316	5634	552-3A
364	2402	39514	550-4
364	1590	38496	550-4A
364	1588	38496	555-4
364	1065	24412	555-4A
364	635	15336	552-4
364	477	3990	552-4A
360	86	17000	AKR2360P500
283	3089	76680	550-5
283	2048	47338	550-5A
283	2043	48120	555-5
283	1372	30046	555-5A
283	817	19092	552-5
283	614	19092	552-5A
196	4460	130669	550-6
196	2965	83096	550-6A
196	2950	83096	555-6
196	1987	53519	555-6A
196	1180	33567	552-6
196	890	20970	552-6A
125	6994	212513	550-7
125	4625	208131	555-7
125	4620	208131	550-7A
125	3095	130903	555-7A
125	1850	51954	552-7
125	1386	32863	552-7A
120	260	52000	AKR2120P1K2
117	3000	20800	T117R3K0
117	2700	14300	T117R2K7
117	2100	18600	T117R2K1
117	1500	15800	T117R1K5
117	1200	12500	T117R1K2
117	900	10600	T117R900W
117	600	10100	T117R600W
117	300	7950	T117R300W
97	4200	19100	T97R4K2
97	3600	22400	T97R3K6
97	3000	16800	T97R3K0
97	2700	19100	T97R2K7
97	2100	15400	T97R2K1
97	1500	20800	T97R1K5
97	1200	16500	T97R1K2
97	900	13800	T97R900W
97	600	13400	T97R600W
97	300	10300	T97R300W
85	10285	361490	550-8
85	6854	231135	550-8A
85	6801	231135	555-8
85	4592	233795	555-8A
85	2720	92016	552-8
85	2056	57588	552-8A
80	9300	230000	T80R9K3
80	9000	209000	T80R9K0
80	5700	29400	T80R5K7
80	4500	23300	T80R4K5
80	4200	25100	T80R4K2
80	3600	18500	T80R3K6
80	3000	22100	T80R3K0
80	2700	24600	T80R2K7
80	2100	19100	T80R2K1
80	1500	17500	T80R1K5
80	1200	13700	T80R1K2
80	900	18500	T80R900W
80	600	10900	T80R600W
80	300	8530	T80R300W
77	9300	230000	T77R9K3
77	9000	209000	T77R9K0
77	5700	28700	T77R5K7
77	4500	22400	T77R4K5
77	4200	24200	T77R4K2
77	3600	28100	T77R3K6

600V AC Drives Continued

Ohms	Watts	Watt Seconds	Catalog Number
77	3000	21300	T77R3K0
77	2700	23800	T77R2K7
77	2100	19100	T77R2K1
77	1500	16400	T77R1K5
77	1200	20800	T77R1K2
77	900	17900	T77R900W
77	600	10600	T77R600W
77	300	8210	T77R300W
70	12489	482144	550-9
70	8424	295765	550-9A
70	8258	297173	555-9
70	5643	189665	555-9A
70	3303	144048	552-9
70	2527	76680	552-9A
60	11000	448000	T60R11K0
60	6900	164000	T60R6K9
60	4500	28000	T60R4K5
60	3600	22000	T60R3K6
60	2700	18500	T60R2K7
60	1500	20800	T60R1K5
60	1200	16400	T60R1K2
60	900	13700	T60R900W
60	600	13000	T60R600W
60	520	104000	(2) AKR2120P1K2
60	300	10300	T60R300W
48	20400	716000	T48R20K4
48	19100	656000	T48R19K1
48	12600	359000	T48R12K6
48	6600	131000	T48R6K6
48	5670	131000	T48R5K67
48	4200	23800	T48R4K2
48	3600	28000	T48R3K6
48	3000	21100	T48R3K0
48	2700	23300	T48R2K7
48	1500	16600	T48R1K5
48	1200	20800	T48R1K2
48	900	17500	T48R900W
48	600	16500	T48R600W
48	300	13100	T48R300W
45	19427	563362	550-10
45	19100	656000	T45R19K1
45	12943	409420	550-10A
45	12846	409420	555-10
45	12600	359000	T45R12K6

Ohms	Watts	Watt Seconds	Catalog Number
45	8672	370410	555-10A
45	6000	125000	T45R6K0
45	5138	308128	552-10
45	3883	120810	552-10A
45	3600	26600	T45R3K6
45	3000	19800	T45R3K0
45	2700	22000	T45R2K7
45	2100	28100	T45R2K1
45	1500	24900	T45R1K5
45	1200	19100	T45R1K2
45	600	15800	T45R600W
45	300	12300	T45R300W
40	22000	1202000	T40R22K0
40	19000	568000	T40R19K0
40	17000	574000	T40R17K0
40	16000	521000	T40R16K0
40	11000	333000	T40R11K0
40	10000	309000	T40R10K0
40	4000	105000	T40R4K0
40	1800	18500	T40R1K8
40	1200	17300	T40R1K2
40	900	14300	T40R900W
40	300	10900	T40R300W
36	24978	1321116	550-11
36	16863	449907	550-11A
36	16517	449907	555-11
36	11298	316618	555-11A
35	6423	249757	552-11
35	5058	157272	552-11A
34	26000	1591000	T34R26K0
34	19000	1048000	T34R19K0
34	18000	1017000	T34R18K0
34	17000	990000	T34R17K0
34	15000	456000	T34R15K0
34	13000	456000	T34R13K0
34	9000	285000	T34R9K0
34	8000	262000	T34R8K0
34	4000	98600	T34R4K0
34	3600	93000	T34R3K6
34	2400	30100	T34R2K4
34	1800	25100	T34R1K8
34	900	19100	T34R900W
34	300	14700	T34R300W
32	28000	2304000	T32R28K0
32	26000	1591000	T32R26K0

600V AC Drives Continued

Ohms	Watts	Watt Seconds	Catalog Number
32	18000	1017000	T32R18K0
32	17100	931000	T32R17K1
32	12700	410000	T32R12K7
32	8420	246000	T32R8K42
32	4500	105000	T32R4K5
32	4000	83300	T32R4K0
32	2700	25200	T32R2K7
32	2100	20200	T32R2K1
32	1500	28100	T32R1K5
32	900	19100	T32R900W
32	600	17500	T32R600W
32	300	13800	T32R300W
28	30492	2138364	550-12
28	20646	1033301	555-12
28	20321	1100930	550-12A
28	13615	359925	555-12A
28	8258	237463	552-12
28	6096	299521	552-12A
27	27400	2075000	T27R27K4
27	21600	1346000	T27R21K6
27	15000	931000	T27R15K0
27	11500	391000	T27R11K5
27	8420	358000	T27R8K42
27	3300	73900	T27R3K3
27	2100	27300	T27R2K1
27	1500	23700	T27R1K5
27	1200	18800	T27R1K2
27	900	24900	T27R900W
27	600	15400	T27R600W
27	300	18500	T27R300W
25	8420	328000	T25R8K42
25	3900	190000	T25R3K9
25	3300	73900	T25R3K3
25	1500	22000	T25R1K5
25	1200	27700	T25R1K2
25	900	23000	T25R900W
25	600	14300	T25R600W
25	300	17200	T25R300W
24	36710	844315	550-13
24	24468	1871068	550-13A
24	24086	1173670	555-13
24	16393	533797	555-13A
24	9635	299938	552-13
24	7340	211079	552-13A
23	10200	310000	T23R10K2

Ohms	Watts	Watt Seconds	Catalog Number
23	7490	328000	T23R7K49
23	6310	179000	T23R6K31
23	2100	23100	T23R2K1
23	1500	20200	T23R1K5
23	900	21300	T23R900W
23	600	20800	T23R600W
23	300	15800	T23R300W
20	34600	1148000	T20R34K6
20	28400	1066000	T20R28K4
20	20600	1602000	T20R20K6
20	15200	924000	T20R15K2
20	10700	582000	T20R10K7
20	8920	267000	T20R8K92
20	5940	260000	T20R5K94
20	1500	28000	T20R1K5
20	900	18500	T20R900W
20	600	17300	T20R600W
20	300	13700	T20R300W
19	47709	5953399	550-14
19	31965	2913365	555-14
19	31798	3029900	550-14A
19	21305	1514674	555-14A
19	12170	410613	552-14
19	9540	410613	552-14A
15	60579	7591398	550-15
15	40587	1313963	555-15
15	40388	1300276	550-15A
15	27060	719851	555-15A
15	18173	1158280	552-15
15	12112	550465	552-15A
15	11400	734000	T15R11K4
15	8570	466000	T15R8K57
15	6160	232000	T15R6K16
15	4210	143000	T15R4K21
15	1500	38800	T15R1K5
15	900	22000	T15R900W
15	600	20800	T15R600W
15	300	16400	T15R300W
14	12700	1038000	T14R12K7
14	11400	734000	T14R11K4
14	6160	232000	T14R6K16
14	1800	27800	T14R1K8
14	1200	24500	T14R1K2
14	900	20700	T14R900W
14	600	19400	T14R600W

600V AC Drives Continued

Ohms	Watts	Watt Seconds	Catalog Number
14	300	15400	T14R300W
12	68911	10015318	550-16
12	46170	2247026	555-16
12	45934	2387466	550-16A
12	30776	1040221	555-16A
12	20673	599876	552-16
12	13780	890985	552-16A
10.4	72300	4620000	T10F4R72K3
10.4	43900	1367000	T10F4R43K9
10.4	35600	1230000	T10F4R35K6
10.4	26000	2002000	T10F4R26K0
10.4	18900	1991000	T10F4R18K9
10.4	15500	1742000	T10F4R15K5
10.4	11000	359000	T10F4R11K0
10.4	8890	801000	T10F4R8K89
10.4	6040	489000	T10F4R6K4
10.4	5360	329000	T10F4R5K36
10.4	2970	95100	T10F4R2K97
10.4	1500	25400	T10F4R1K5
10.4	900	24500	T10F4R900W
10.4	600	22900	T10F4R600W
10.4	300	17300	T10F4R300W
10	59339	1950414	555-17
10	59043	1950414	550-17A
10	39559	1956117	555-17A
10	26569	903350	552-17
10	17713	479901	552-17A
8	78475	5345909	555-18
8	52321	1559677	555-18A
8	35138	2494758	552-18
8	23427	1211023	552-18A
6	62551	2135190	555-19A
6	42015	1981674	552-19
6	28008	1960167	552-19A
5.4	104000	3444000	T5F4R104K0
5.4	51900	1953000	T5F4R51K9
5.4	48100	1845000	T5F4R48K1
5.4	37700	2310000	T5F4R37K7
5.4	22000	717000	T5F4R22K0
5.4	20300	738000	T5F4R20K3
5.4	12000	699000	T5F4R12K0
5.4	7280	328000	T5F4R7K28
5.4	5780	169000	T5F4R5K78
5.4	5080	401000	T5F4R5K8

Ohms	Watts	Watt Seconds	Catalog Number
5.4	2680	185000	T5F4R2K68
5.4	1670	55700	T5F4R1K67
5	46464	3891643	552-20
5	30978	1651395	552-20A
4.8	132000	8077000	T4F8R132K0
4.8	99300	6159000	T4F8R99K3
4.8	61000	3916000	T4F8R61K0
4.8	58200	3696000	T4F8R58K2
4.8	34600	2310000	T4F8R34K6
4.8	25800	984000	T4F8R25K8
4.8	19200	586000	T4F8R19K2
4.8	10900	359000	T4F8R10K9
4.8	8880	260000	T4F8R8K88
4.8	5490	169000	T4F8R5K49
4.8	4590	401000	T4F8R4K59
4.8	2580	185000	T4F8R2K58
4	66084	1799627	552-21
4	44057	3441020	552-21A

Table A.A Minimum Dynamic Brake Resistance

Drive Normal Duty Rating	Regen DC Bus Voltage (V_d)	Rated Continuous Power, Internal Resistors (P_{db})				Minimum Ohms (±10%), External Resistors[1]		
		PowerFlex 70		PowerFlex 700		PowerFlex Product		
		Frame	Watts	Frame	Watts	4	70	700
240V, 0.5 HP	395	A	48	0	50		30.4	35.8
240V, 1 HP		A	48	0	50	60	30.4	35.8
240V, 2 HP		B	28	1	50	60	30.4	35.8
240V, 3 HP		B	40	1	50	48	30.4	35.8
240V, 5 HP		C	40	1	50	32	27.4	29.5
240V, 7.5 HP		D	36	1	50		20.9	22.7
240V, 10 HP		D	36	2	50		20.9	21
240V, 15 HP								11.2
240V, 20 HP								9
240V, 25 HP								9
240V, 30 HP								7
240V, 40 HP								4.6
240V, 50 HP								4.6
240V, 60 HP								2.1
240V, 70 HP								2.1
400V, 0.37 kW 480V, 0.5 HP	790 for 400V and 480V Drives	A	48	0	50		61.7	63.1
400V, 0.75 kW 480V, 1 HP		A	48	0	50	121	61.7	63.1
400V, 1.5 kW 480V, 2 HP		A	48	0	50	121	61.7	63.1
400V, 2.2 kW 480V, 3 HP		B	28	0	50	97	61.7	63.1
400V, 4 kW 480V, 5 HP		B	28	0	50	97	61.7	63.1
400V, 5.5 kW 480V, 7.5 HP		C	40	0	50		66.9	63.1
400V, 7.5 kW 480V, 10 HP		C	40	1	50		66.9	63.1
400V, 11 kW 480V, 15 HP		D	36	1	50		39.9	43.3
400V, 15 kW 480V, 20 HP		D	36	2	50		27.8	40.2
400V, 18.5 kW 480V, 25 HP		D		2	50		24.6	28.2
400V, 22 kW 480V, 30 HP		D					25.1	21.7
400V, 30 kW 480V, 40 HP								18.7

(1) Does not include a resistor tolerance.

Drive Normal Duty Rating	Regen DC Bus Voltage (V_d)	Rated Continuous Power, Internal Resistors (P_{db})				Minimum Ohms (±10%), External Resistors[1]		
		PowerFlex 70		PowerFlex 700		PowerFlex Product		
		Frame	Watts	Frame	Watts	4	70	700
400V, 37 kW 480V, 50 HP	790 for 400V and 480V Drives							18.7
400V, 45 kW 480V, 60 HP								15.4
400V, 55 kW 480V, 75 HP								9.2
400V, 75 kW 480V, 100 HP								9.2
400V, 90 kW 480V, 125 HP								4.4
400V, 110 kW 480V, 150 HP								4.4
400V, 132 kW 480V, 200 HP								3.3
600V, 0.5 HP	987.5	A	48	0	50		117	84
600V, 1 HP		A	48	0	50		117	84
600V, 2 HP		A	48	0	50		117	84
600V, 3 HP		B	28	0	50		117	84
600V, 5 HP		B	28	0	50		80	84
600V, 7.5 HP		C	40	0	50		80	75.5
600V, 10 HP		C	40	1	50		80	75.5
600V, 15 HP		D					48	52
600V, 20 HP		D					48	41.8
600V, 25 HP								36.1
600V, 30 HP								28.9
600V, 40 HP								24.3
600V, 50 HP								24.3
600V, 60 HP								17.7
600V, 75 HP	1135							18.1
600V, 100 HP								18.1
600V, 125 HP								6.3
600V, 150 HP								6.3
690V, 45 kW	1135							NA
690V, 55 kW								18.1
690V, 75 kW								18.1
690V, 90 kW								18.1
690V, 110 kW								6.3
690V, 132 kW								6.3

(1) Does not include a resistor tolerance.

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