A·B QUALITY

Allen-Bradley

*Power*Flex™

Adjustable
Frequency AC Drive

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 Allen-Bradley 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 Allen-Bradley Company 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 Allen-Bradley Company cannot assume responsibility or liability for actual use based on the examples and diagrams.

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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

Appendix A

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Specifications & Dimensions

PowerFlex 70/700 Specifications

Category	Specification						
Protection	**PowerFlex 70 Drive**	**200-208V Drive**	**240V Drive**	**380/400V 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:	350VDC	405VDC	675VDC	810VDC	1013VDC	
	Bus Undervoltage Trip:	176VDC	204VDC	339VDC	407VDC	998VDC	
	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 Trip:	Adjustable					
	Nominal Bus Voltage:	See PowerFlex 70 above					
	All Drives						
	Heat Sink Thermistor:	Monitored by microprocessor overtemp trip					

	Drive Overcurrent Trip
	    Software Current Limit:
	    Hardware Current Limit:
	    Instantaneous Current Limit:
		20-160% of rated current
		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					
Agency Certification	The drive is 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. NEMA 250 - Enclosures for Electrical Equipment IEC 146 - International Electrical Code.					
	ᴄ⟨UL⟩ᴜs	UL and cUL Listed to UL508C and CAN/CSA-C2.2 No. 14-M91					

	C E	Marked for all applicable European Directives[1]
		EMC Directive (89/336/EEC)
		Emissions
		    EN 61800-3 Adjustable Speed electrical power drive systems Part 3
		Immunity
		    EN 61800-3 Second Environment, Restricted Distribution
		Low Voltage Directive (73/23/EEC)
		    EN 60204-1 Safety of Machinery –Electrical Equipment of Machines
		    EN 50178 Electronic Equipment for use in Power Installations					

Category	Specification	
Environment	Altitude:	1000 m (3300 ft) max. without derating

	Ambient Operating Temperature without derating:
	    Open Type:
	    IP20:
	    NEMA Type 1:
	    IP56, NEMA Type 4X
		
		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 40 degrees C (32 to 104 degrees F)

	Storage Temperature (all const.):	–40 to 70 degrees C (–40 to 158 degrees F)
	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:	–10% of minimum, +10% of maximum.
	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
	    PF70 - C & D Frame Drives:
	    PF70 - A & B Frame Drives:
	    PF700
		
		0.92 lagging (entire speed range)
		0.64 lagging
		TBD

	Efficiency:	97.5% at rated amps, nominal line volts.

	Max. Short Circuit Current Rating:
	    Using Recommended Fuse or
	    Circuit Breaker Type
		Maximum short circuit current rating to match specified fuse/circuit breaker capability.

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 - A-D Frame Drives:
	    PF700 - 0-3 Frames:
		
		2-10 kHz. Drive rating based on 4 kHz
		2-10 kHz. Drive rating based on 4 kHz

	Output Voltage Range:	0 to rated motor voltage
	Output Frequency Range:	0 to 400 Hz.

	Frequency Accuracy
	    Digital Input:
	    Analog Input:
		
		Within ±0.01% of set output frequency.
		Within ±0.4% of maximum output frequency.

	Speed Regulation - Open Loop with Slip Compensation:	±0.5% of base speed across a 40:1 speed range.
	Selectable Motor Control:	Sensorless Vector with full tuning. Standard V/Hz with full custom capability. PF700 adds flux vector.
	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.

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

Input/Output Ratings

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

Heat Dissipation

See Watts Loss on page 2-172.

Derating Guidelines

PowerFlex 70 Ambient Temperature/Load

PowerFlex70, A Frame 400V Class. Derating, Ambient Temperature and Load. Open, NEMA1, IP20.

PowerFlex70, B Frame 400V Class. Derating, Ambient Temperature and Load. Open, NEMA1, IP20

PowerFlex70, C Frame 400V Class, Derating, Ambient Temperature and Load. Open, NEMA1 and IP20

PowerFlex70, D Frame 400V Class. Derating, Ambient Temperature and Load. Open, NEMA1, IP20

Altitude

PowerFlex 70 Altitude Derating Factor - All Frames.

Efficiency

PowerFlex 70 Dimensions

Figure 1.1　PowerFlex 70 Frames A-D
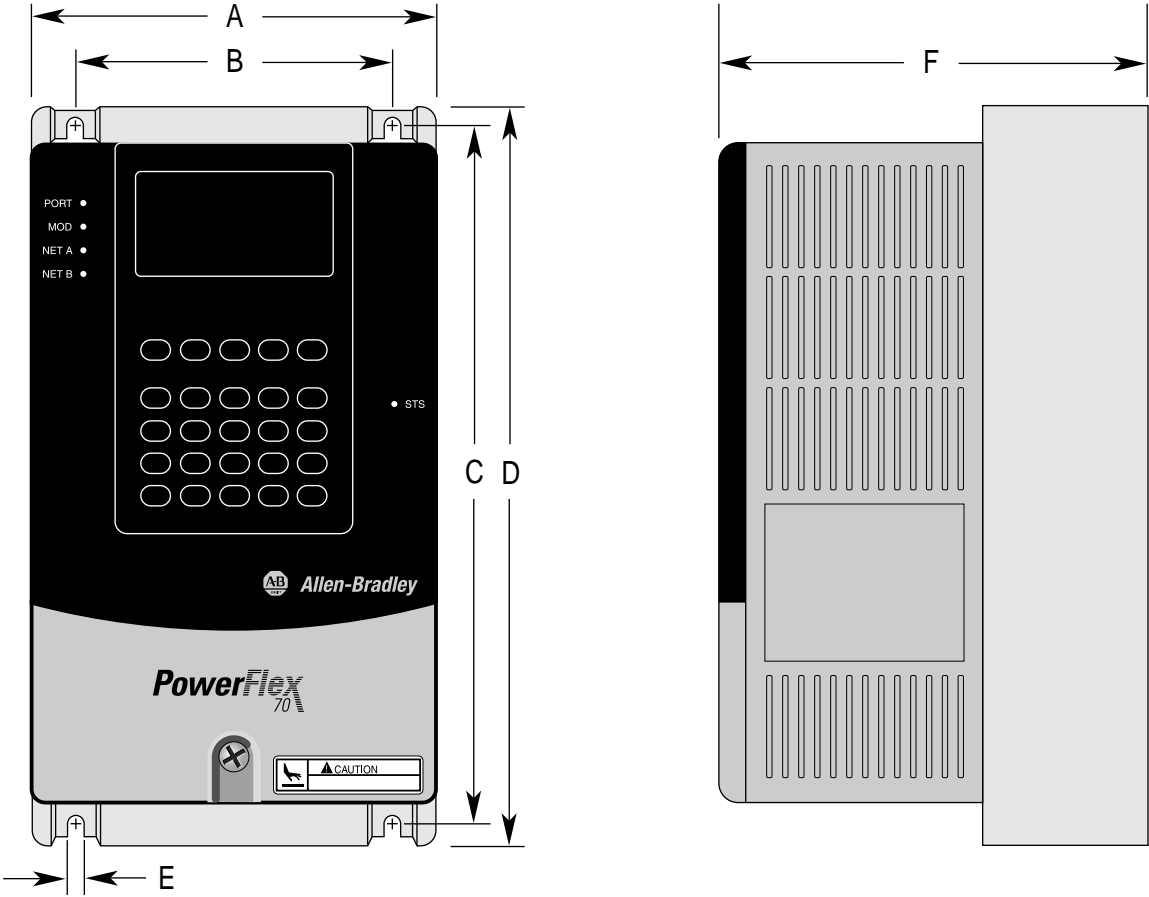
Dimensions are in millimeters and (inches)

Frame (see Table 1.A)	A	B	C	D	E	F	Weight
A	121.9 (4.80)	94.2 (3.71)	211.6 (8.33)	225.8 (8.89)	5.8 (0.23)	179.8 (7.08)	3.56 kg (7.85 lb)
B	171.2 (6.74)	122.7 (4.83)	220.2 (8.67)	234.6 (9.24)	5.8 (0.23)	179.8 (7.08)	4.49 kg (9.9 lb)
C	185.9 (7.32)	137.6 (5.42)	285.6 (11.25)	300.0 (11.81)	5.8 (0.23)	179.8 (7.08)	7.60 kg (16.75 lb)
D	220.4 (8.68)	169.0 (6.65)	335.7 (13.21)	350.0 (13.78)	5.8 (0.23)	180.4 (7.10)	9.75 kg (21.5 lb)

Table 1.A　PowerFlex 70 Frames

Frame	240/208V AC Input		400V AC Input		480V AC Input		600V AC Input	
	ND HP	HD HP	ND kW	HD kW	ND HP	HD HP	ND HP	HD HP
A	0.5	0.33	0.37	0.25	0.5	0.33	0.5	0.33
	1	0.75	0.75	0.55	1	0.75	1	0.75
	–	–	1.5	1.1	2	1.5	2	1.5
B	2	1.5	2.2	1.5	3	2	3	2
	–	–	4	3	5	3	5	3
C	3	2	5.5	4	7.5	5	7.5	5
	5	3	7.5	5.5	10	7.5	10	7.5
D	7.5	5	11	7.5	15	10	15	10
	10	7.5	15	11	20	15	20	15

Figure 1.2   PowerFlex 70 Bottom View Dimensions - Frame A
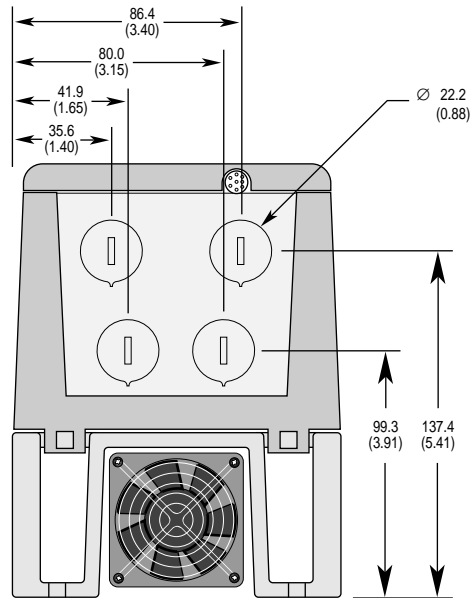
Dimensions are in millimeters and (inches)

Figure 1.3   PowerFlex 70 Bottom View Dimensions - Frame B
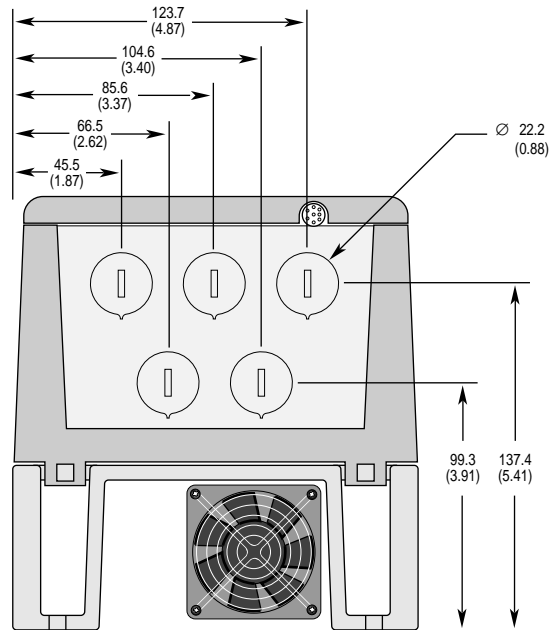
Dimensions are in millimeters and (inches)

Figure 1.4   PowerFlex 70 Bottom View Dimensions - Frame C

Number of fans will vary depending on drive size.

Dimensions are in millimeters and (inches)

Figure 1.5   PowerFlex 70 Bottom View Dimensions - Frame D

Dimensions are in millimeters and (inches)

PowerFlex 70 Flange Mount Dimensions

Drive Catalog Number	Figure	
	Knockout Dimensions	Cutout Dimensions
20AB2P2F 20AB4P2F 20AC1P3F / 20AD1P1F 20AC2P1F / 20AD2P1F 20AC3P5F / 20AD3P4F 20AE0P9F 20AE1P7F 20AE2P7F	Figure 1.7	Figure 1.11
20AB6P8F 20AC5P0F / 20AD5P0F 20AC8P7F / 20AD8P0F 20AE3P9F 20AE6P1F	Figure 1.8	Figure 1.12
20AB9P6F 20AB015F 20AC011F / 20AD011F 20AC015F / 20AD014F 20AE9P0F 20AE011F	Figure 1.9	Figure 1.13
20AB9P6F 20AB015F 20AC011F / 20AD011F 20AC015F / 20AD014F 20AE9P0F 20AE011F	Figure 1.10	Figure 1.14

Figure 1.6   Overall Dimensions
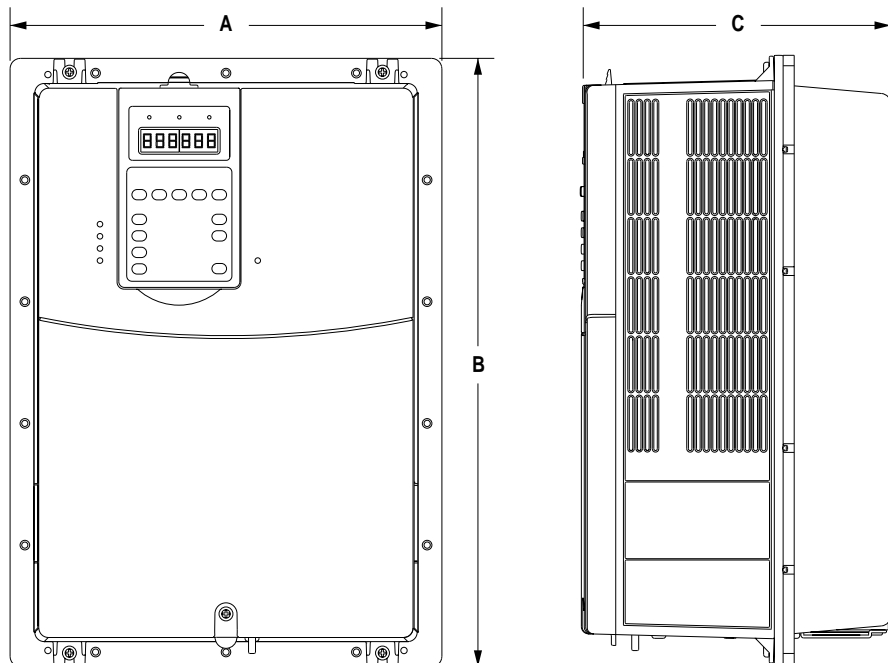
Dimensions are in millimeters and (inches)

Frame	A	B	C
A	156.0 (6.14)	225.8 (8.89)	178.6 (7.03)
B	205.2 (8.08)	234.6 (9.24)	178.6 (7.03)
C	219.0 (8.62)	300.0 (11.81)	178.6 (7.03)
D	248.4 (9.78)	350.0 (13.78)	178.6 (7.03)

Figure 1.7   A Frame Knockout Dimensions
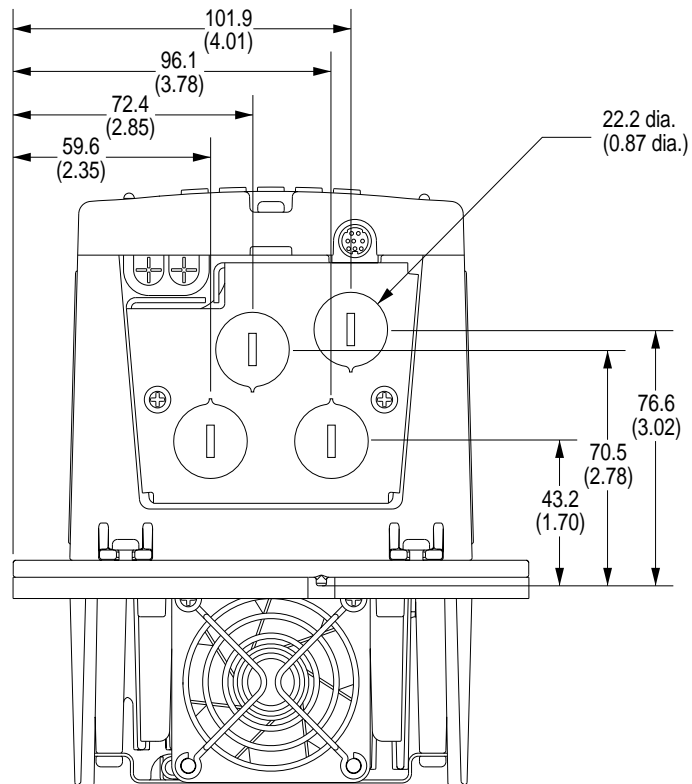
Dimensions are in millimeters and (inches)

Figure 1.8   B Frame Knockout Dimensions
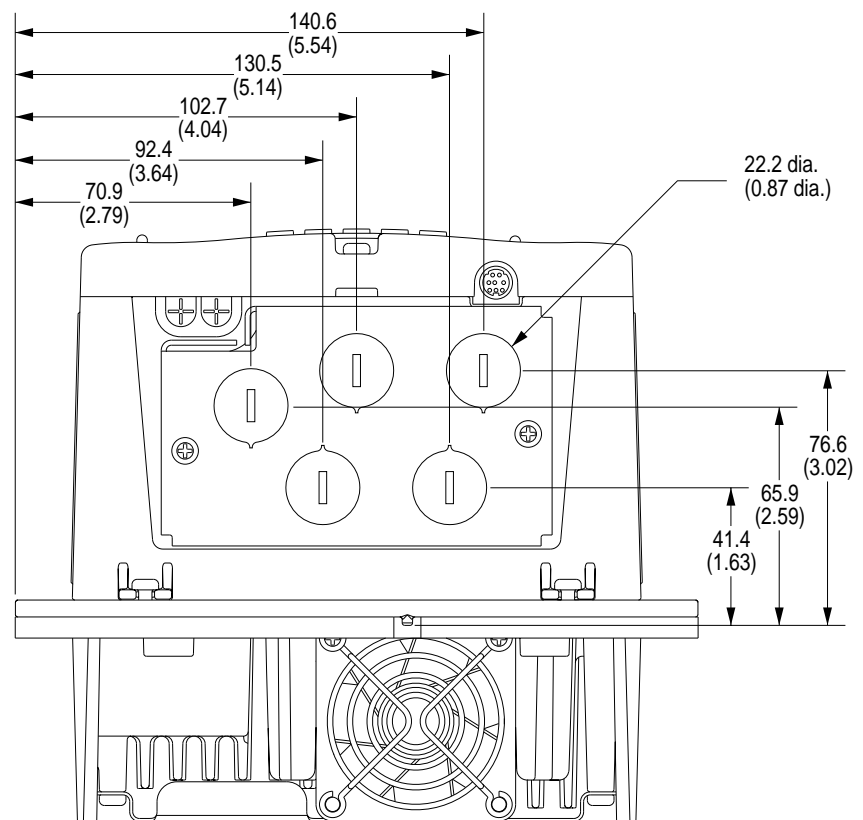
Dimensions are in millimeters and (inches)

Figure 1.9   C Frame Knockout Dimensions
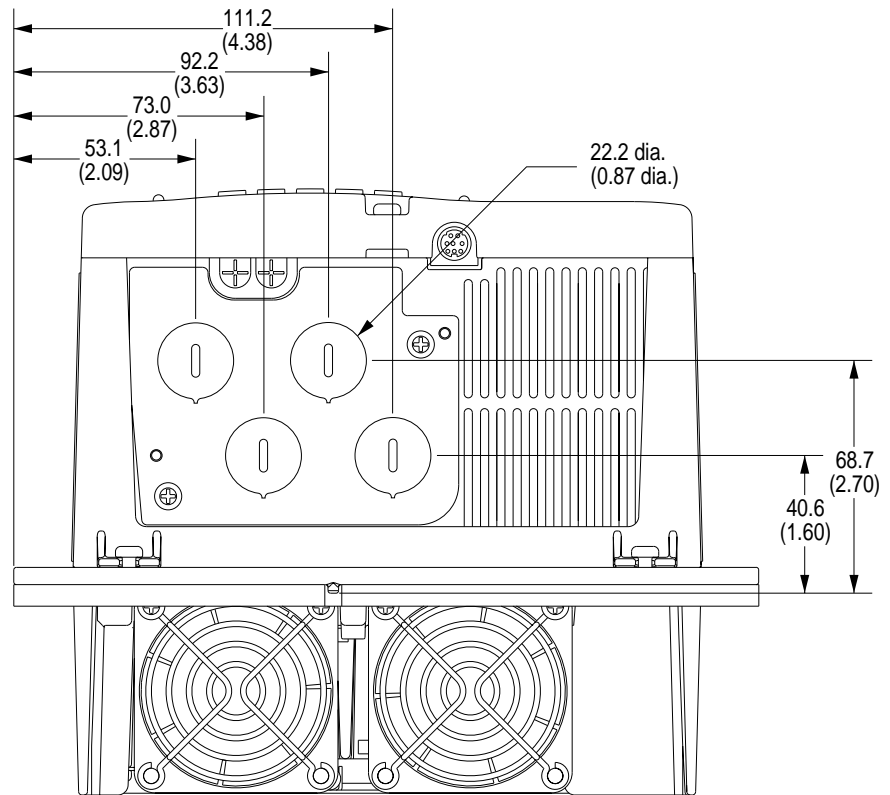
Dimensions are in millimeters and (inches)

Figure 1.10   D Frame Knockout Dimensions
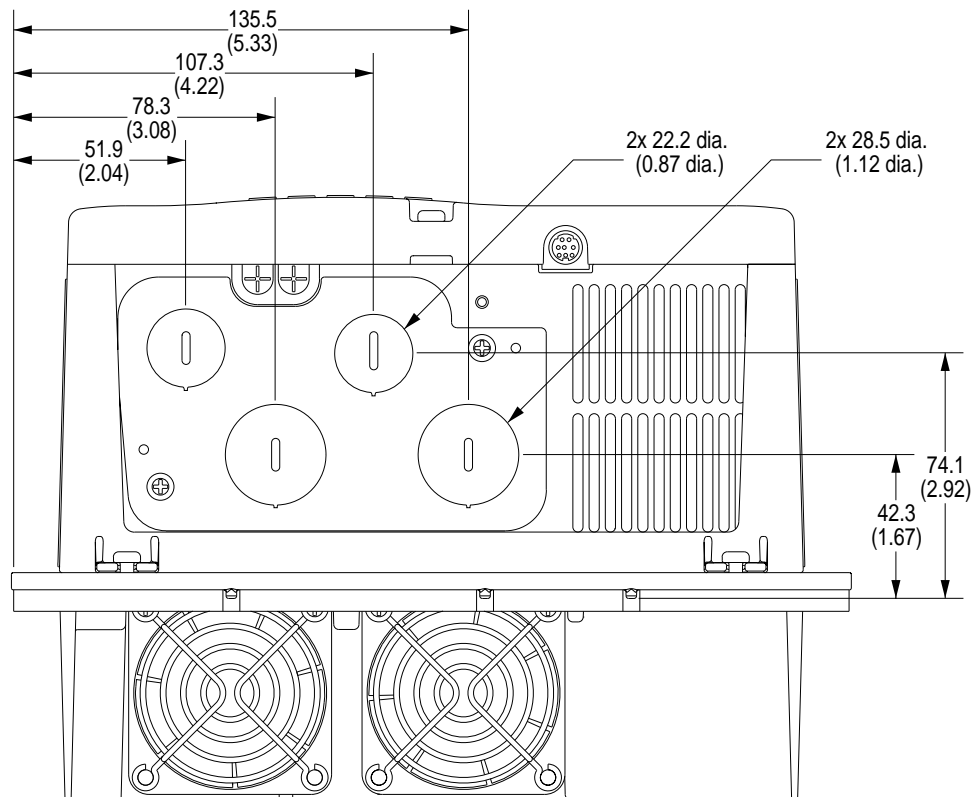
Dimensions are in millimeters and (inches)

Figure 1.11   A Frame Cutout Dimensions

156.0
(6.14)

140.7
(5.54)

70.4
(2.77)

6.9
(0.27)

127.0
(5.00)

195.1
(7.68)

225.8
(8.89)

210.6
(8.29)

105.3
(4.15)

8x 4.0 +0.13 -0.03 dia.
(0.16 +.005 -.001 dia.)

4x 3.0R
(0.12R)

7.7
(0.31)

58.8
(2.31)
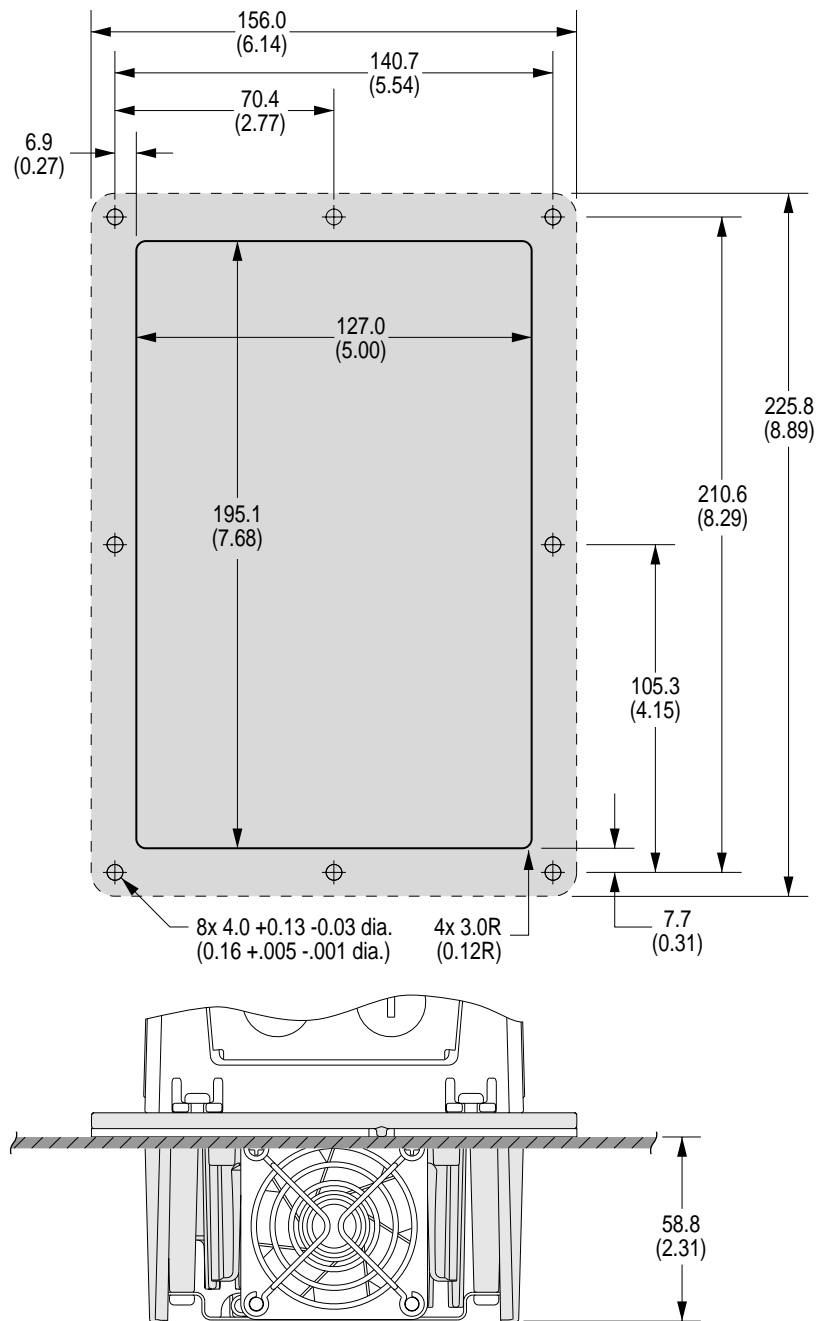
Dimensions are in millimeters and (inches)

Figure 1.12   B Frame Cutout Dimensions

205.2
(8.08)

190.0
(7.48)

95.0
(3.74)

6.9
(0.27)

176.3
(6.94)

205.5
(8.09)

234.6
(9.24)

219.3
(8.64)

109.7
(4.32)

8x 4.0 +0.13 -0.03 dia.
(0.16 +.005 -.001 dia.)

4x 3.0R
(0.12R)

6.9
(0.27)

58.8
(2.31)
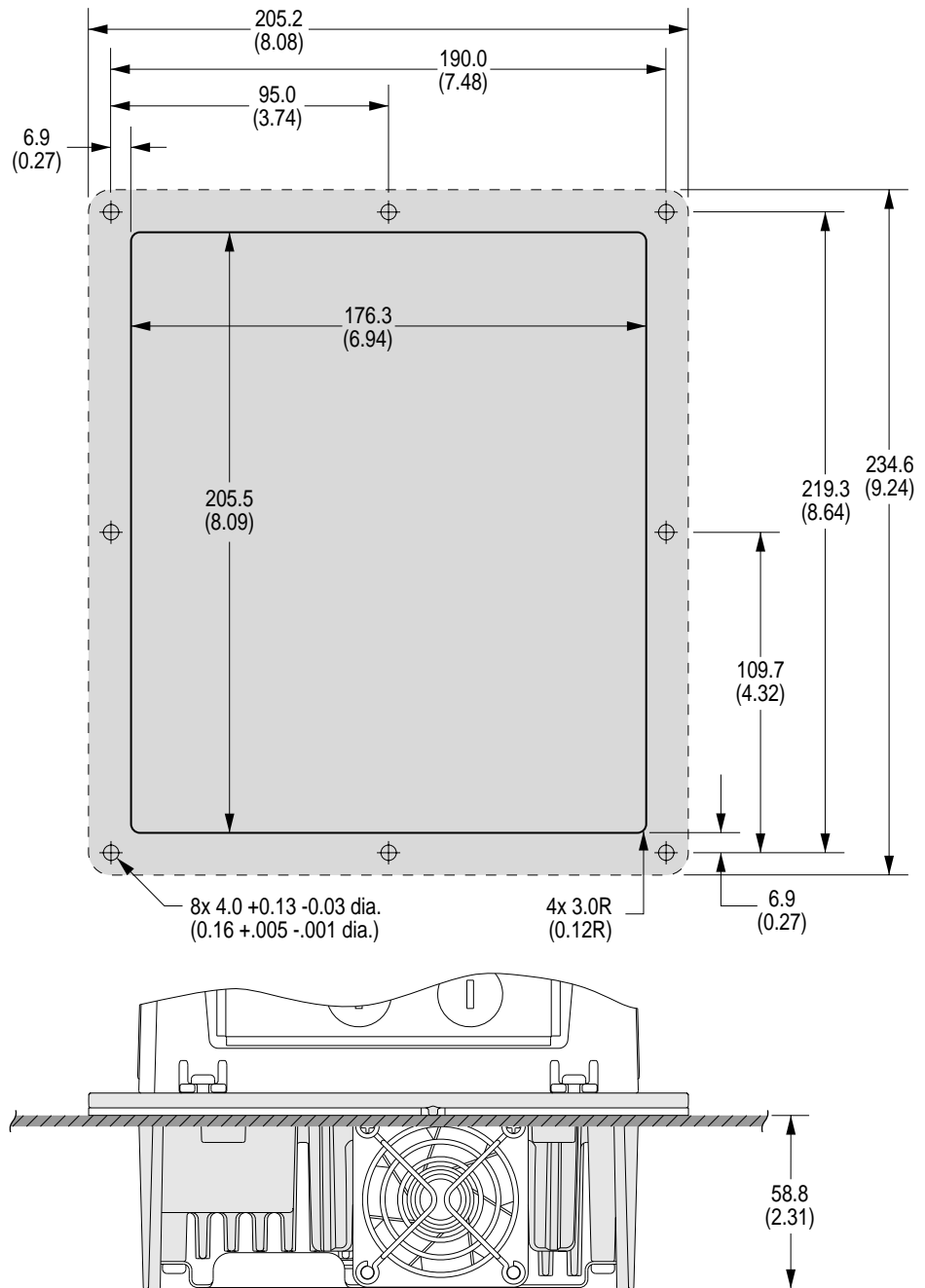
Dimensions are in millimeters and (inches)

Figure 1.13   C Frame Cutout Dimensions

219.0
(8.62)

202.0
(7.95)

101.0
(3.98)

6.3
(0.25)

189.4
(7.46)

271.8
(10.70)

300.0
(11.81)

283.0
(11.14)

241.5
(9.51)

141.5
(5.57)

41.5
(1.63)

12x 4.0 ±0.13 dia.
(0.16 ±.005 dia.)

4x   3.0R
(0.12R)

5.6
(0.22)

58.8
(2.31)

Dimensions are in millimeters and (inches)

Figure 1.14   D Frame Cutout Dimensions

248.4
(9.78)

231.4
(9.11)

190.7
(7.51)

115.7
(4.56)

40.7
(1.60)

4.5
(0.18)

222.4
(8.75)

319.8
(12.59)

350.0
(13.78)

333.0
(13.11)

271.5
(10.69)

201.5
(7.93)

131.5
(5.18)

61.5
(2.42)

14x 4.0 ±0.13 dia.
(0.16 ±.005 dia.)

4x: 3.0R
(0.12R)

6.0
(0.24)

58.8
(2.31)

Dimensions are in millimeters and (inches)

Figure 1.15   Flange Mounting
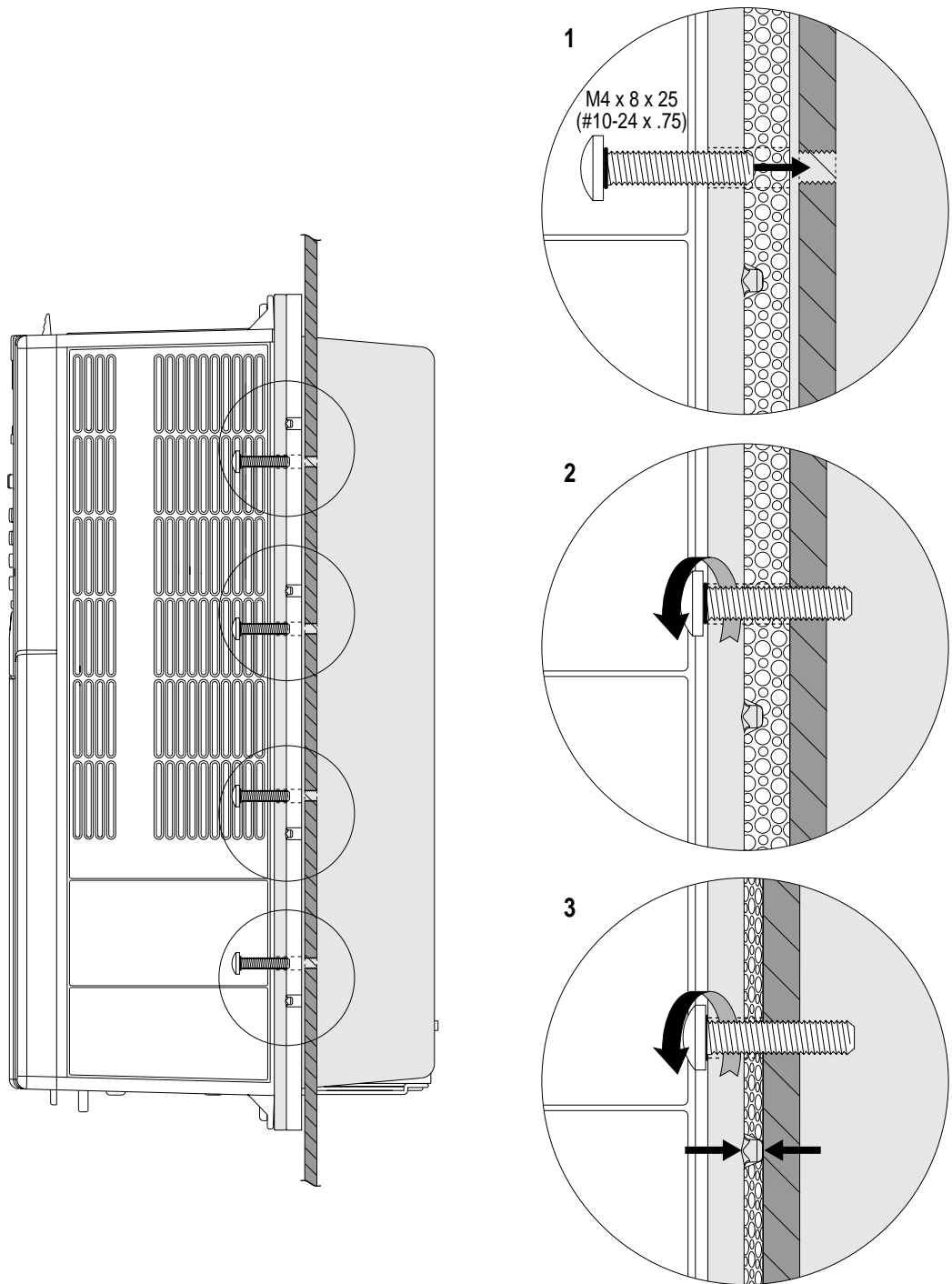
Dimensions are in millimeters and (inches)

PowerFlex 700 Dimensions

Figure 1.16   PowerFlex 700 Frames 0-3 *(0 Frame Shown)*
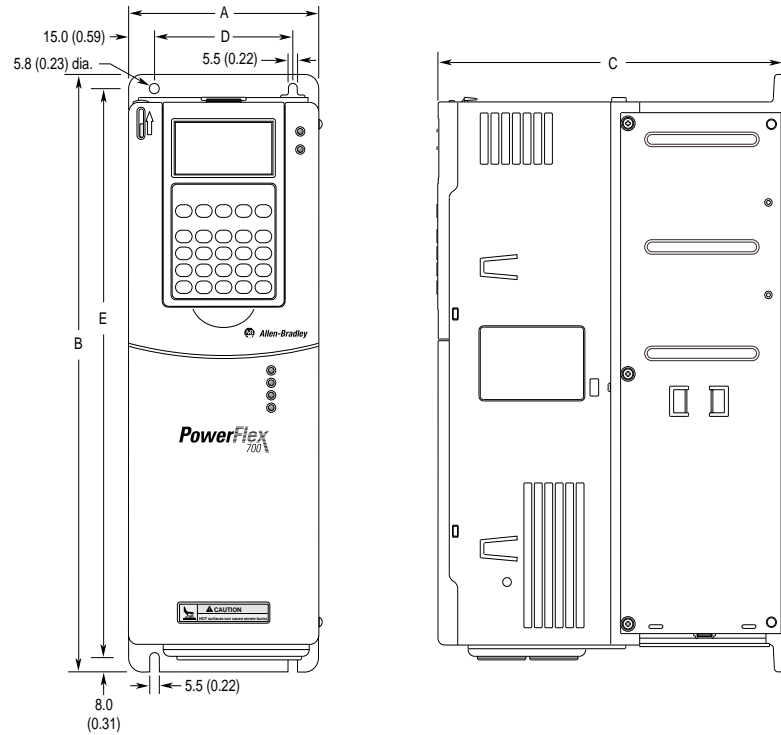
Dimensions are in millimeters and (inches).

Frame *(see Table 1.B)*	A	B	C	D	E	Weight [1] 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)
5	300.0 (11.81)	583.0 (22.95)	270.3 (10.64)	225.0 (8.86)	625.0 (24.61)	[2]	[2]

[1]   Weights include HIM and Standard I/O.

[2]   Not available at time of publication

Table 1.B   PowerFlex 700 Frames

Frame	208/240V AC Input		400V AC Input		480V AC Input	
	ND HP	HD HP	ND kW	HD kW	ND HP	HD HP
0	0.5	0.33	0.37	0.25	0.5	0.33
	1	0.75	0.75	0.55	1	0.75
	2	1.5	1.5	0.75	2	1.5
	3	2	2.2	1.5	3	2
	–	–	4	2.2	5	3
	–	–	5.5	4	7.5	5
1	5	3	7.5	5.5	10	7.5
	7.5	5	11	7.5	15	10
2	10	7.5	15	11	20	15
	–	–	18.5	15	25	20
3	15	10	22	18.5	30	25
	20	15	30	22	40	30
5	–	–	–	45	–	60
	–	–	55	–	75	–

Figure 1.17   PowerFlex 700 Bottom View Dimensions – Frame 0
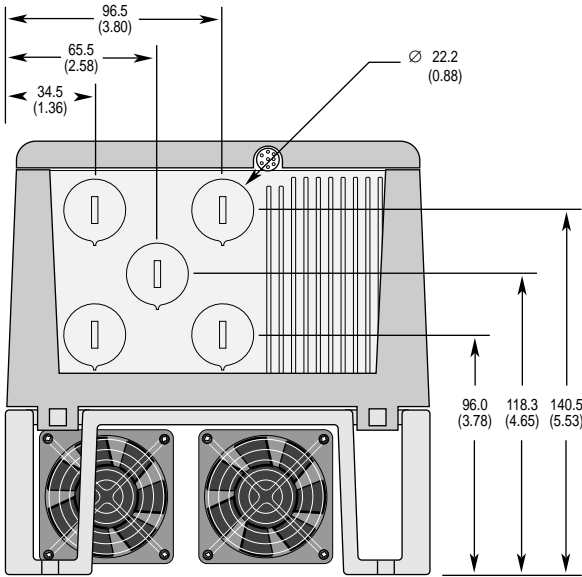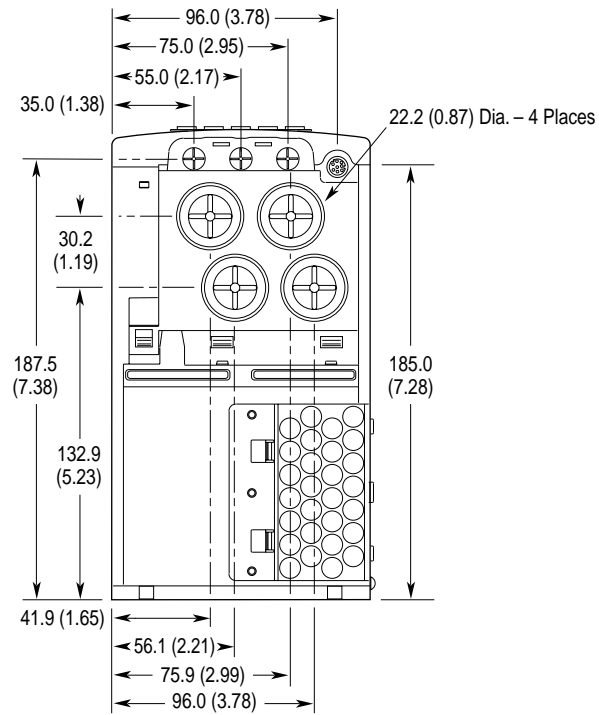

Dimensions are in millimeters and (inches)

Figure 1.18   PowerFlex 700 Bottom View Dimensions – Frame 1

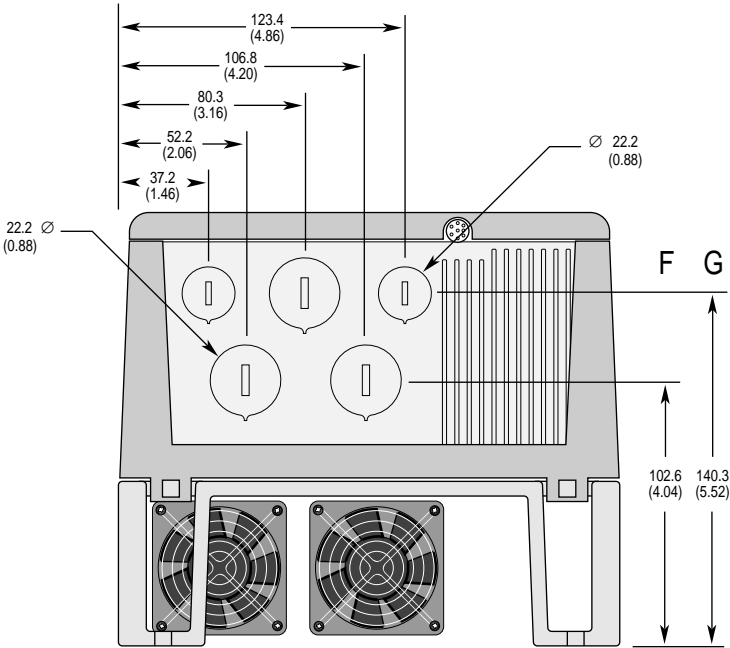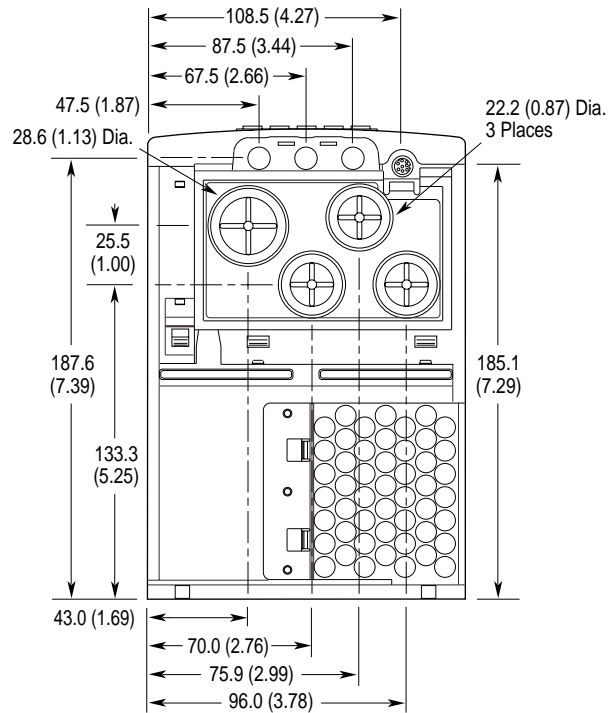*Dimensions are in millimeters and (inches)*

Figure 1.19   PowerFlex 700 Bottom View Dimensions – Frame 2
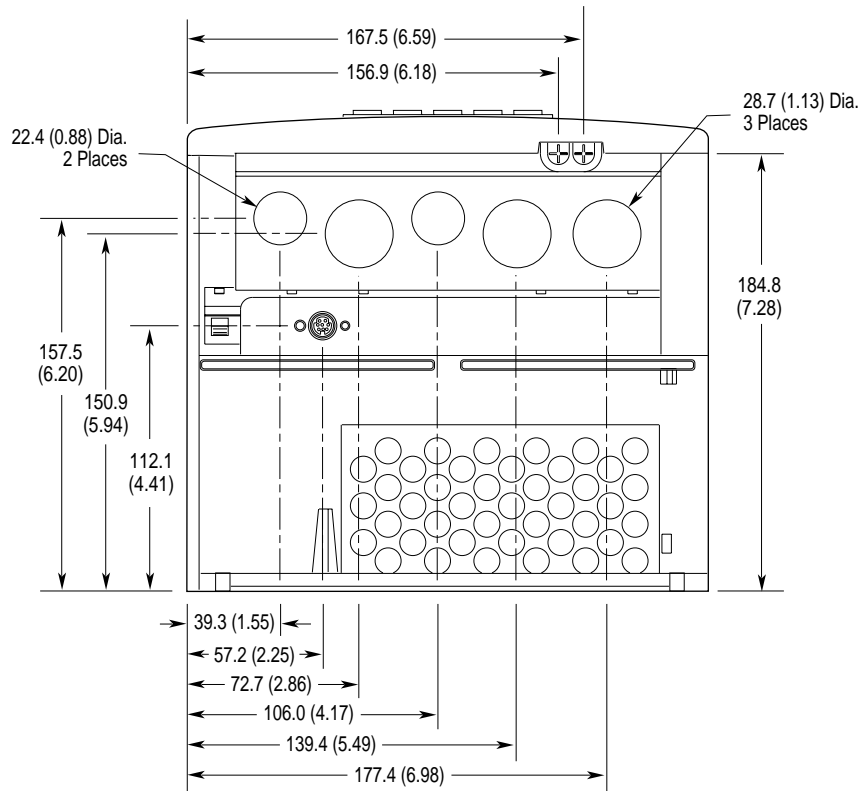
Dimensions are in millimeters and (inches)

Figure 1.20   PowerFlex 700 Bottom View Dimensions – Frame 3
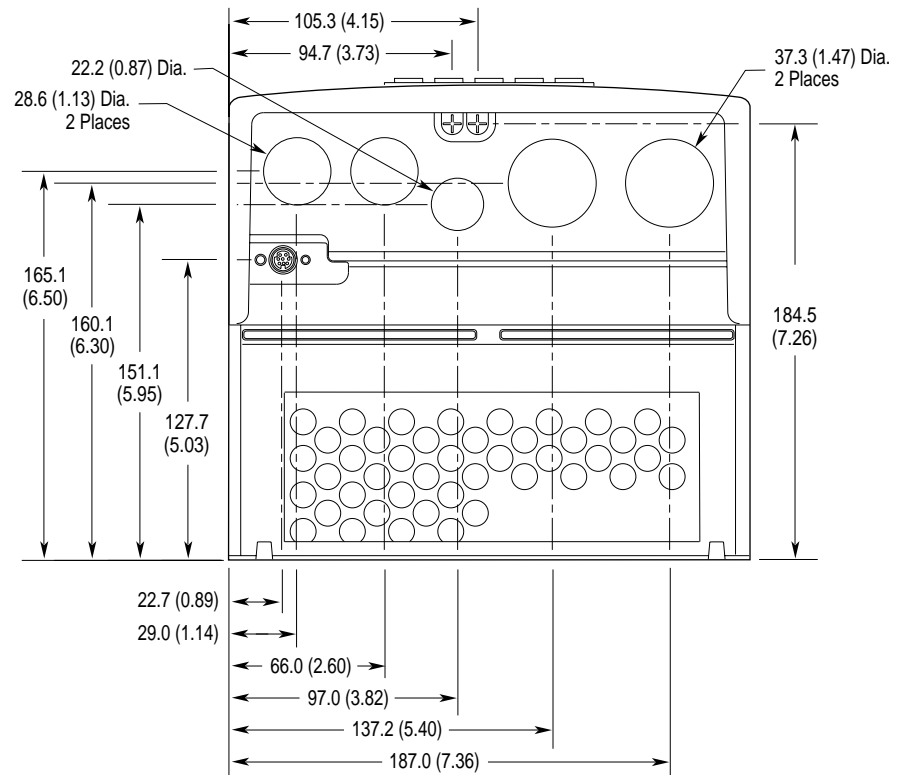
Dimensions are in millimeters and (inches)

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:

$$\frac{\text{Maximum Frequency} - \text{Minimum Frequency}}{\text{Accel Time}} = \text{Accel Rate}$$

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 using the 1st / 2nd Accel inputs shown below or a similar pattern of Accel Time select bits in the Logic Control word used via PLC communications.

Times are adjustable in .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.

AC Supply Source Considerations

PowerFlex 700 drives are suitable for use on a circuit capable of delivering up to a maximum of 200,000 rms symmetrical amperes, 600V.

> ⚠ **ATTENTION:** To guard against personal injury and/or equipment damage caused by improper fusing or circuit breaker selection, use only the recommended line fuses/circuit breakers specified in Tables 2.O through 2.S.

If a system ground fault monitor (RCD) is to be used, only Type B (adjustable) devices should be used to avoid nuisance tripping.

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.

Drive Alarm

												1	1	1

Alarm Config

												1	0	0

	↓	X	X
	Active Alarm	Inactive Alarm	Inactive 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"

Analog In Config

											0	1

Speed Ref A Sel

												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"

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
P325 4mA	P092 0 HZ

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

	324	**[Analog In 1 Loss]**	Default:	0	"Disabled"	091
	327	**[Analog In 2 Loss]**		0	"Disabled"	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
		Selects the drive status that will energize a (CRx) output relay. [1]Contacts shown on page 1-12 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.	Options:	1	"Fault"[1]	382
				2	"Alarm"[1]	386
				3	"Ready"	383
				4	"Run"	
				5	"Forward Run"	
				6	"Reverse Run"	
				7	"Auto Restart"	
				8	"Powerup Run"	
				9	"At Speed"	002
				10	"At Freq"	001
				11	"At Current"	003
				12	"At Torque"	004
				13	"At Temp"	218
				14	"At Bus Volts"	012
				15	"At PI Error"	137
				16	"DC Braking"	157
				17	"Curr Limit"	147
				18	"Economize"	053
				19	"Motor Overld"	048
				20	"Power Loss"	184
				21	"Input 1 Link"	
				22	"Input 2 Link"	
				23	"Input 3 Link"	
				24	"Input 4 Link"	
				25	"Input 5 Link"	
				26	"Input 6 Link"	

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	**[Alarm 1 Code]**	Default: Read Only	261
		263	**[Alarm 2 Code]**	Min/Max: 0/256	
		264	**[Alarm 3 Code]**	Display: 1	
		265	**[Alarm 4 Code]**		
		266	**[Alarm 5 Code]**		
		267	**[Alarm 6 Code]**		
		268	**[Alarm 7 Code]**		
		269	**[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.		

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 .
- Provide an external and adjustable value for the current limit and DC braking level
- Enter and exit sleep mode.

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 for details on this mode of operation.

Legend:
- 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 |

Speed Ref A Lo
Speed Ref A Hi

Speed Ref B Lo
Speed Ref B Hi

Ref A Scale/Limit

Ref B Scale/Limit

Trim Lo
Trim Hi

Brake Level Scale/Limit

Sleep Level
Wake Level

Trim Scale/Limit

TB Manual Scale/Limit

Sleep Level Compare

Hz

Trim Out Sel

+

PI Reference Scale/Limit

PI Feedback Scale/Limit

+

Current Limit Scale/Limit

+

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

Input/Output

Parameter

Processing

Selection/Control

Anlg In Config

Analog 1
Voltage

Analog 1
Current

ADC

0-10v

Unipolar
Cal 1

0-20mA

Current
Cal 1

Anlg In 1 Loss

Loss
Detect

Limit
0-10V

Loss
Detect

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.

Anlg In Config

Analog In 2 Lo

Analog In 2 Hi

Analog 2
Unipolar

Analog 2
Bipolar

Analog 2
Current

ADC

(voltage)

(current)

0-10v

Unipolar
Cal 2

-10v - +10v

Bipolar
Cal 2

0-20mA

Current
Cal 2

Anlg In 2 Loss

Loss
Detect

Limit
0-10V

Limit
-10V to
10V

Loss
Detect

Limit
4-20mA

Anlg In Sqr Root

Square
Root

Cal Analog 2
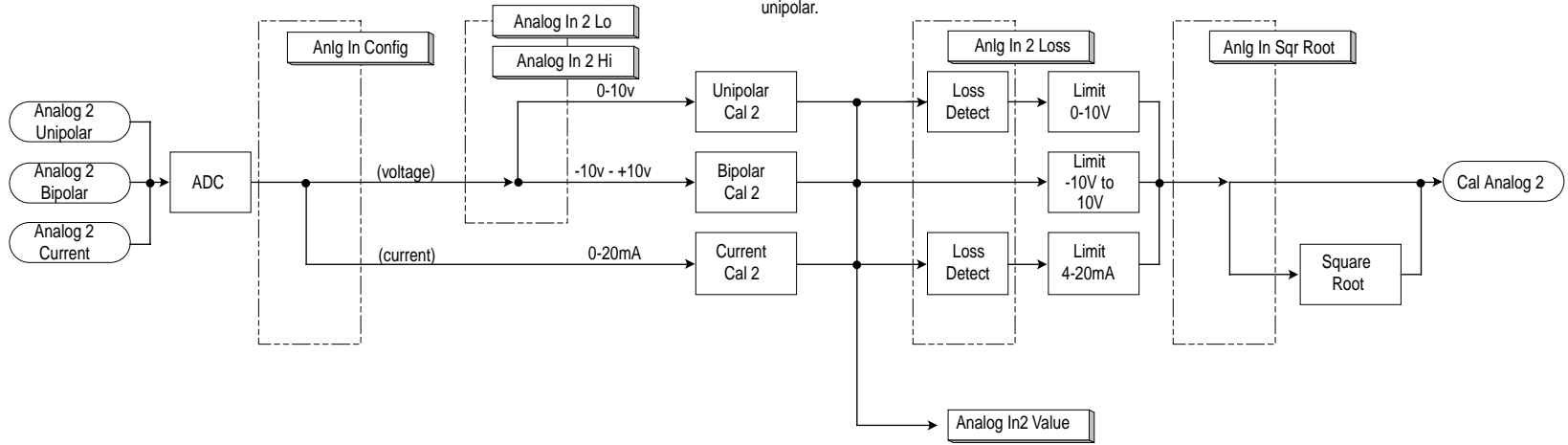
Analog In2 Value

Scaling Blocks

[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 or current limit. 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.
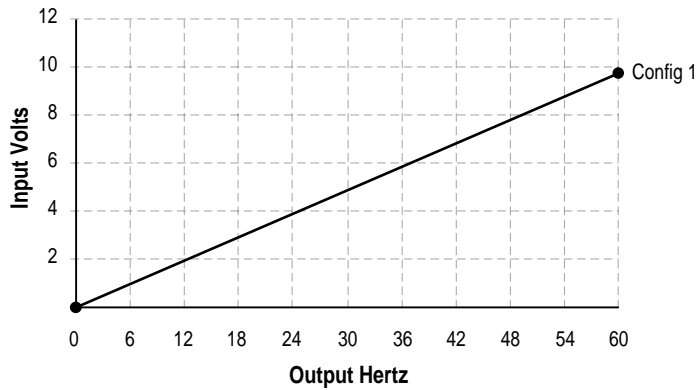
The 0-10 volt input scaling can be adjusted using the following parameters:

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

Configuration #1:

- [Speed Ref A Sel] = "Analog In 1"
- [Minimum Speed] = 0 Hz
- [Maximum Speed] = 60 Hz
- [Analog In 1 Lo] = 0%
- [Analog In 1 Hi] = 100%

This is the default setting, where minimum input (0 volts) represents [Minimum Speed] of 0 Hz and maximum input (10 volts) represents [Maximum Speed] of 60 Hz.

Scaling Block

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

Configuration #2:

- [Speed Ref A Sel] = "Analog In 1"
- [Minimum Speed] = 0 Hz
- [Maximum Speed] = 30 Hz
- [Analog In 1 Lo] = 0%
- [Analog In 1 Hi] = 100%

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).
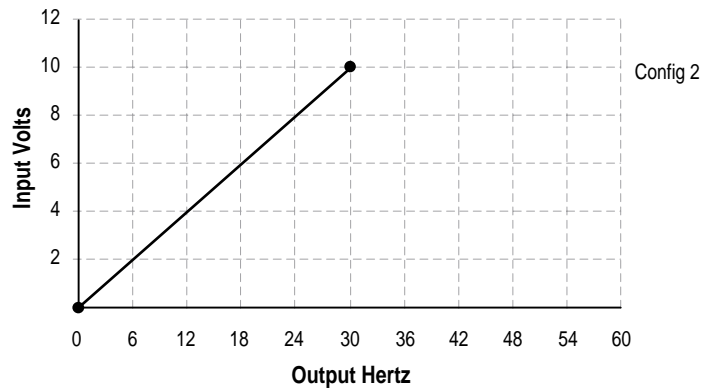
Scaling Block

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

Configuration #3:

- [Speed Ref A Sel] = "Ana In 1"
- [Minimum Speed] = 0 Hz.
- [Maximum Speed] = 60 Hz.
- [Analog In 1 Lo] = 20%
- [Analog In 1 Hi] = 100%

This configuration is referred to as offset. In this case, a 2-10 volt input signal provides 0-60 Hz output, providing a 2 volt offset in the speed command.
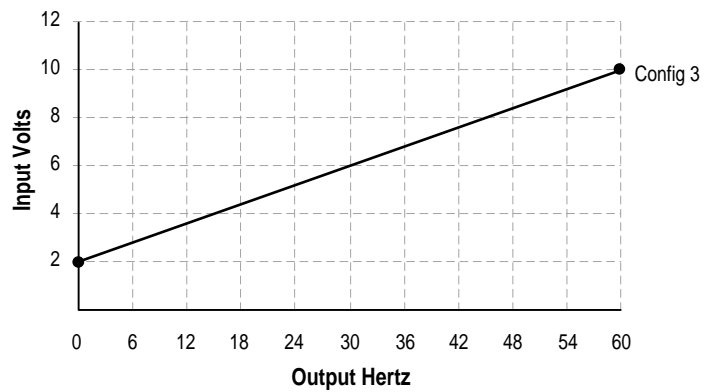
Scaling Block

[Speed Reference A Sel] = "Analog In 1"	
[Analog In 1 Lo] 2V	[Minimum Speed] 0 Hz
[Analog In 1 Hi] 10V	[Maximum Speed] 60Hz

Configuration #4:

- [Minimum Speed] = 0 Hz.
- [Maximum Speed] = 60 Hz.
- [Analog In 1 Lo] = 100%
- [Analog In 1 Hi] = 0%

This configuration is used to invert the operation of the input signal. Here, maximum input (100% of 10 Volts = 10 Volts) represents [Minimum Speed] of 0 Hz and minimum input (0% of 10 Volts = 0 Volts) represents [Maximum Speed] of 60 Hz.
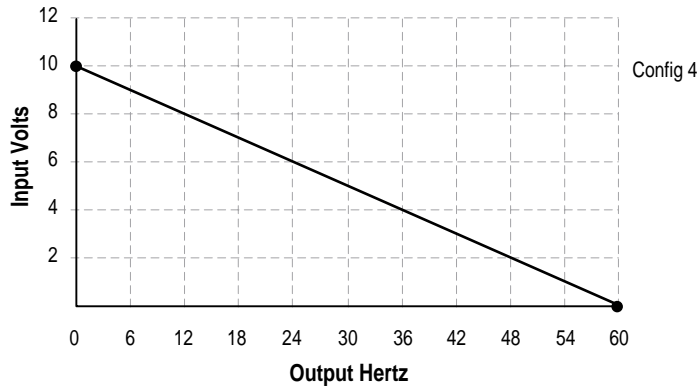
Scaling Block

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

Configuration #5:

- [Minimum Speed] = 0 Hz.
- [Maximum Speed] = 60 Hz.
- [Analog In 1 Lo] = 0%
- [Analog In 1 Hi] = 50%

This configuration is used when the input signal is 0-5 volts. Here, minimum input (0% of 10 Volts = 0 Volts) represents [Minimum Speed] of 0 Hz and maximum input (50% of 10 Volts = 5 Volts) represents [Maximum Speed] of 60 Hz. This allows full scale operation from a 0-5 volt source.
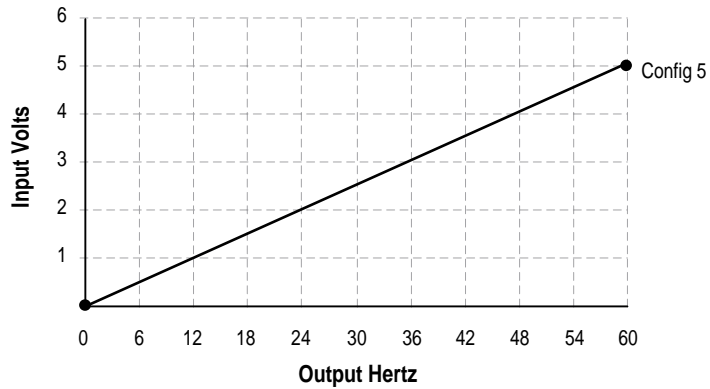
Scaling Block

[Speed Reference A Sel] = "Analog In 1"	
[Analog In 1 Lo] 0V	[Minimum Speed] 0 Hz
[Analog In 1 Hi] 5V	[Maximum Speed] 60Hz

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.
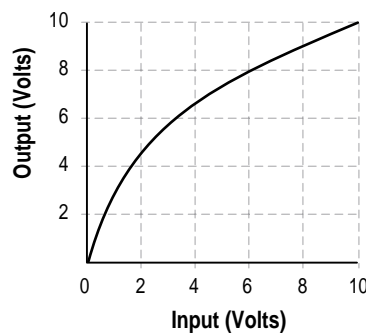
Signal Loss

[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
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 .

- [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 or 0.001 Volt

Cable Selection

Important points to remember:

- Always use copper wire.
- Wire with an insulation rating of 600V or greater is recommended.
- Control and signal wires should be separated from power wires by at least 0.3 meters (1 foot).

Important: I/O terminals labeled "–" or "Common" <u>are</u> <u>not</u> referenced to ground and are designed to greatly reduce common mode interference. Grounding these terminals can cause signal noise.

ATTENTION: Configuring an analog input for 0-20mA operation and driving it from a voltage source could cause component damage. Verify proper configuration prior to applying input signals.

ATTENTION: Hazard of personal injury or equipment damage exists when using bipolar input sources. Noise and drift in sensitive input circuits can cause unpredictable changes in motor speed and direction. Use speed command parameters to help reduce input source sensitivity.
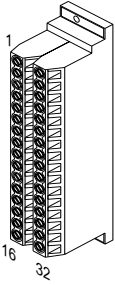
Table 2.A   Recommended Signal Wire

Signal Type	Wire Type(s)	Description	Minimum Insulation Rating
Standard Analog I/O	Belden 8760/9460 (or equiv.)	0.750 mm^2 (18 AWG), twisted pair, 100% shield with drain [1].	300V, 60 degrees C (140 degrees F)
	Belden 8770 (or equiv.)	0.750 mm^2 (18 AWG), 3 cond., shielded for remote pot only.	
Encoder/ Pulse I/O	Less than or equal to 30 m (98 ft.) – Belden 9730 (or equiv.)	0.196 mm^2 (24 AWG), individually shielded.	
	Greater than 30 m (98 ft.) – Belden 9773 (or equiv.)	0.750 mm^2 (18 AWG), twisted pair, shielded.	
EMC Compliance	Refer to <u>EMC Instructions on page 2-37</u> for details.		

[1] If the wires are short and contained within a cabinet which has no sensitive circuits, the use of shielded wire may not be necessary, but is always recommended.

Refer to [Table 2.J on page 2-46](#) for recommended digital I/O control wire.

Figure 2.1 PowerFlex 700 Standard I/O Terminal Designations

No.	Signal	Factory Default	Description	Related Param.
1	Anlg Volts In 1 (–)	(1)	Isolated [2], bipolar, differential, ±10V, 11 bit & sign, 100k ohm input impedance.	320 - 329
2	Anlg Volts In 1 (+)			
3	Anlg Volts In 2 (–)	(1)	Isolated [3], bipolar, differential, ±10V, 11 bit & sign, 100k ohm input impedance.	
4	Anlg Volts In 2 (+)			
5	Pot Common	–	For (+) and (–) 10V pot references.	
6	Anlg Volts Out 1 (–)	(1)	Bipolar, differential, ±10V, 11 bit & sign, 2k ohm minimum load.	338 - 346
7	Anlg Volts Out 1 (+)			
8	Anlg Current Out 1 (–)	(1)	4-20mA, 11 bit & sign, 500 ohm maximum load.	
9	Anlg Current Out 1 (+)			
10	Reserved for Future Use			
11	Digital Out 1 – N.C.	Fault	Resistive Load Rating: 8A at 250V AC/30V DC Min. Load: 10mA Inductive Load Rating: 2A at 250V AC/30V DC Min. Load: 10mA	380 - 387
12	Digital Out 1 Common			
13	Digital Out 1 – N.O.			
14	Digital Out 2 – N.C.	Alarm		
15	Digital Out 2 Common			
16	Digital Out 2 – N.O.			
17	Anlg Current In 1 (–)	(1)	Isolated [2], 4-20mA, 11 bit & sign, 100 ohm input impedance.	320 - 329
18	Anlg Current In 1 (+)			
19	Anlg Current In 2 (–)	(1)	Isolated [3], 4-20mA, 11 bit & sign, 100 ohm input impedance.	
20	Anlg Current In 2 (+)			
21	–10V Pot Reference	–	2k ohm minimum, 15mA maximum load.	
22	+10V Pot Reference	–		
23	Reserved for Future Use			
24	+24VDC	–	Drive supplied power for logic inputs. 150mA maximum Load.	
25	Digital In Common	–		
26	24V Common	–		
27	Digital In 1	Stop - CF	115V AC, 50/60 Hz Opto isolated (250V) Low State: less than 30V AC High State: greater than 100V AC	361 - 366
28	Digital In 2	Start		
29	Digital In 3	Jog		
30	Digital In 4	Speed Sel 1	24V AC/DC, 50/60 Hz	
31	Digital In 5	Speed Sel 2	Opto isolated (250V) Low State: less than 5V AC High State: greater than 20V AC	
32	Digital In 6	Speed Sel 3		

[1] These inputs/outputs are dependant on a number of parameters. See "Related Parameters."

[2] Differential Isolation - External source must be maintained at less than 160V with respect to PE. Input provides high common mode immunity.

[3] Differential Isolation - External source must be less than 10V with respect to PE.

Refer to the PowerFlex 70 User Manual for terminal designations and wiring examples.

I/O Wiring Examples (PowerFlex 700 shown)

Input/Output	Connection Example[3]		
Potentiometer[1] 10k Ohm Pot. Recommended (2k Ohm Minimum) **Joystick**[1] ±10V Input - 100k ohm input impedance.	Potentiometer 	Joystick 	
Analog Input ±10V Input - 100k ohm input impedance. 4-20 mA Input - 100 ohm input impedance	Voltage - Bipolar[1] 	Current - Unipolar 	
Analog/Digital Output ±10V Output - Can drive a 10k ohm load (25 mA short circuit current limit).	Voltage 	Current 	Logic
2 Wire Control[2] - **Non-Reversing** Requires 2-wire functions only ([Dig- ital In1 Sel]). Using 3-wire selections will cause a type 2 alarm.	24V DC Internal Supply[4] 	24V DC External Supply 	115V External Source
3 Wire Control Requires only 3-wire functions ([Digital In1 Sel]). Including 2-wire selections will cause a type 2 alarm.	24V DC Internal Supply[4] 	24V DC External Supply 	115V External Source

[1] Refer to the Attention statement on page 2-15 for important bipolar wiring information.

[2] **Important:** Programming inputs for 2 wire control deactivates all HIM Start buttons.

[3] Examples show hardware wiring only. Refer to page 2-16 for parameters that must be adjusted.

[4] If desired, a User Supplied 24V DC power source can be used. Refer to the "External" example.

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 source for the analog output by setting [Analog Out*x* Sel].

INPUTS & OUTPUTS / **Analog Outputs**	342	**[Analog Out1 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

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

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, as described in Table 2.B, and 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].

Table 2.B   Analog Output Scaling Ranges

Quantity	[Analog Outx Lo] Corresponds to: (Absolute Value Disabled)	[Analog Outx Lo] Corresponds to: (Absolute Value Enabled)	[Analog Outx Hi] Corresponds to:
Output Frequency	-[Maximum Freq]	0 Hz	[Maximum Freq]
Commanded Frequency	-[Maximum Freq]	0 Hz	[Maximum Freq]
Output Current	0 Amps	0 Amps	200% of drive rated current
Output Torque Current	-200% of drive rated current	0 Amps	200% of drive rated current
Output Flux Current	0 Amps	0 Amps	200% of drive rated current
Output Power	0 kW	0 kW	200% of drive rated power
Output Voltage	0 V	0 V	120% of drive rated voltage
Dc Bus Voltage	0 V	0 V	200% of drive rated voltage
PI Reference	-100%	0%	100%
PI Feedback	-100%	0%	100%
PI Error	-100%	0%	100%
PI Output	-100%	0%	100%

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
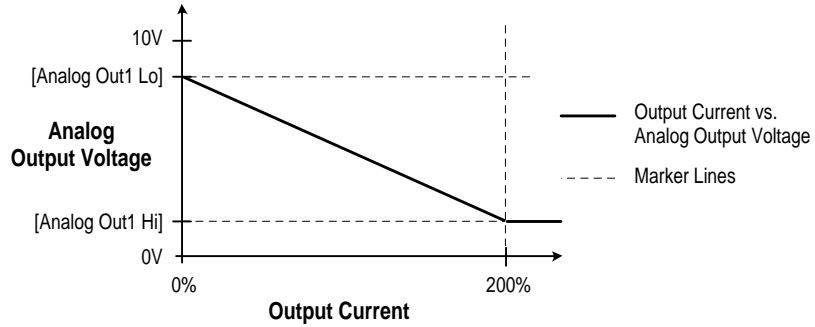- [Analog Out1 Hi] = 9 volts
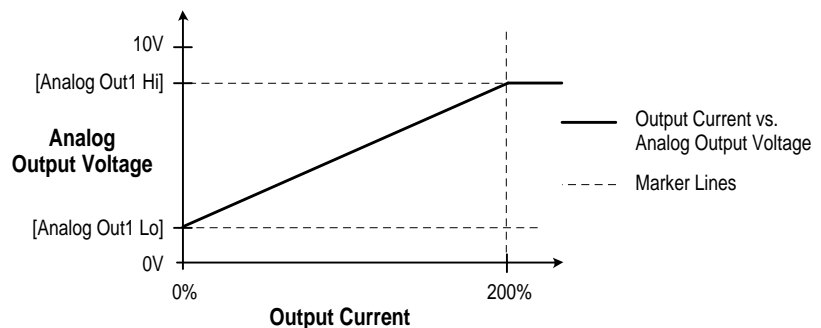
Note that analog output value never goes outside the range defined by [Analog Out1 Lo] and [Analog Out1 Hi], even if output current is beyond the range defined in Table 2.B. This is true in all cases, including all the following examples.

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.
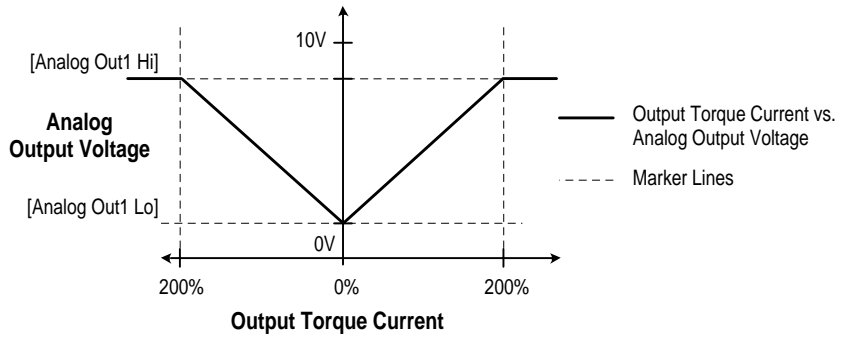
Example 4 – Signed Output Quantity, Absolute Value Disabled
- [Analog Out1 Sel] = "Output Torque Current"
- [Analog Out1 Lo] = 1 volt
- [Analog Out1 Hi] set to 9 volts
- [Anlg Out Absolut] set so that absolute value is disabled for output 1.
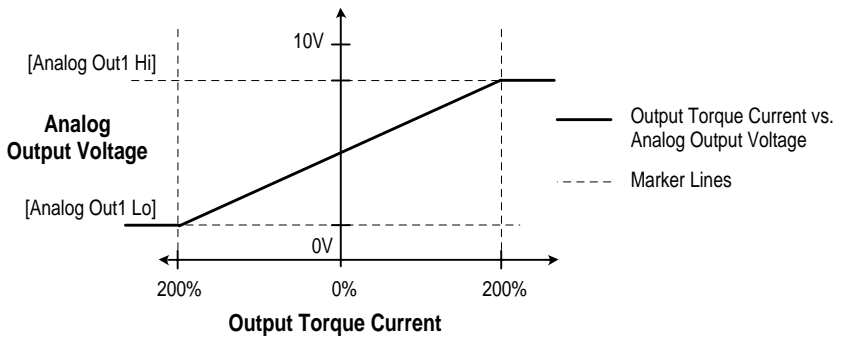
Filtering

Software filtering will be performed on the analog outputs for certain signal sources, as specified in Table 2.C. "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.C   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%.

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.
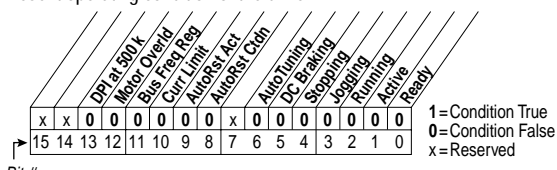
Configuration

This feature is configured through two user parameters

174	**[Auto Rstrt Tries]**	Default:	0	175
	Sets the maximum number of times the drive attempts to reset a fault and restart.	Min/Max:	0/9	
		Display:	1	
	⚠ **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]**	Default:	1.0 Secs	174
	Sets the time between restart attempts when [Auto Rstrt Tries] is set to a value other than zero.	Min/Max:	0.5/30.0 Secs	
		Display:	0.1 Secs	

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	210	**[Drive Status 2]**	Read Only	209

Present operating condition of the drive.

Bit labels: DPI at 500 K, Motor Overld, Bus Freq Reg, Curr Limit, AutoRst Act, AutoRst Ctdn, AutoTuning, DC Braking, Stopping, Jogging, Running, Active, Ready

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

1 = Condition True
0 = Condition False
x = Reserved

Bit #

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."
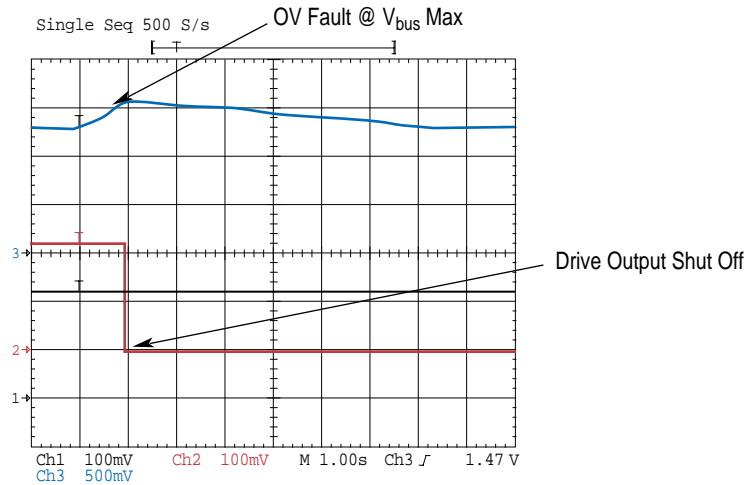
Bus Regulation

[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.

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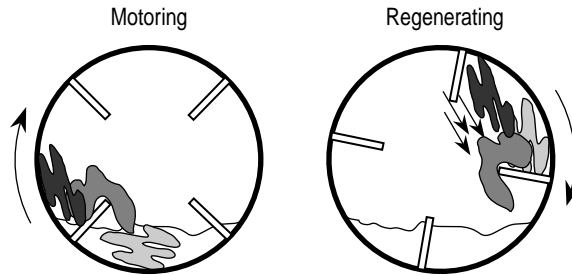
Without bus regulation, if the bus voltage exceeds the operating limit established by the power components of the drive, the drive will fault, shutting off the output devices to protect itself from excess voltage.

Single Seq 500 S/s   OV Fault @ V_{bus} Max

Drive Output Shut Off

Ch1 100mV   Ch2 100mV   M 1.00s Ch3 ∫ 1.47 V
Ch3 500mV

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 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.

```
Single Seq 2.50kS/s
```


Ch1 100mV   Ch2 100mV   M 200ms Ch3 ∫   1.49 V
Ch3 500mV
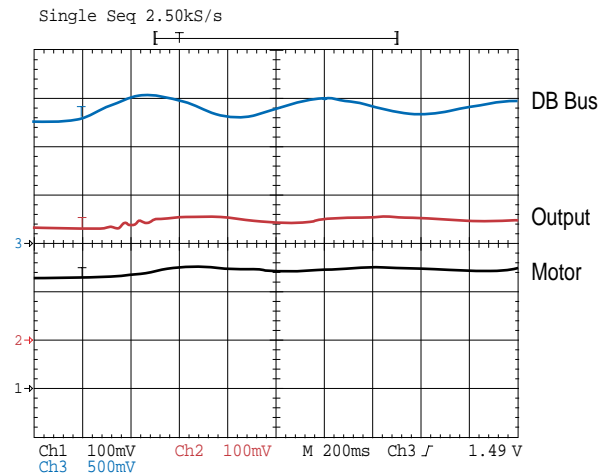
To avoid over-voltage faults, a bus voltage regulator is incorporated as part of the acceleration/deceleration control. As the bus voltage begins to approach the bus voltage regulation point (Vreg), the bus voltage regulator increases the magnitude of the output frequency and voltage to reduce the bus voltage. The bus voltage regulator function takes precedence over the other two functions. See Figure 2.2.

The bus voltage regulator is shown in the lower one-third of Figure 2.2. 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 2.2 move to the positions shown in Table 2.D.

Table 2.D   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 2.2   Bus Voltage Regulator, Current Limit and Frequency Ramp.
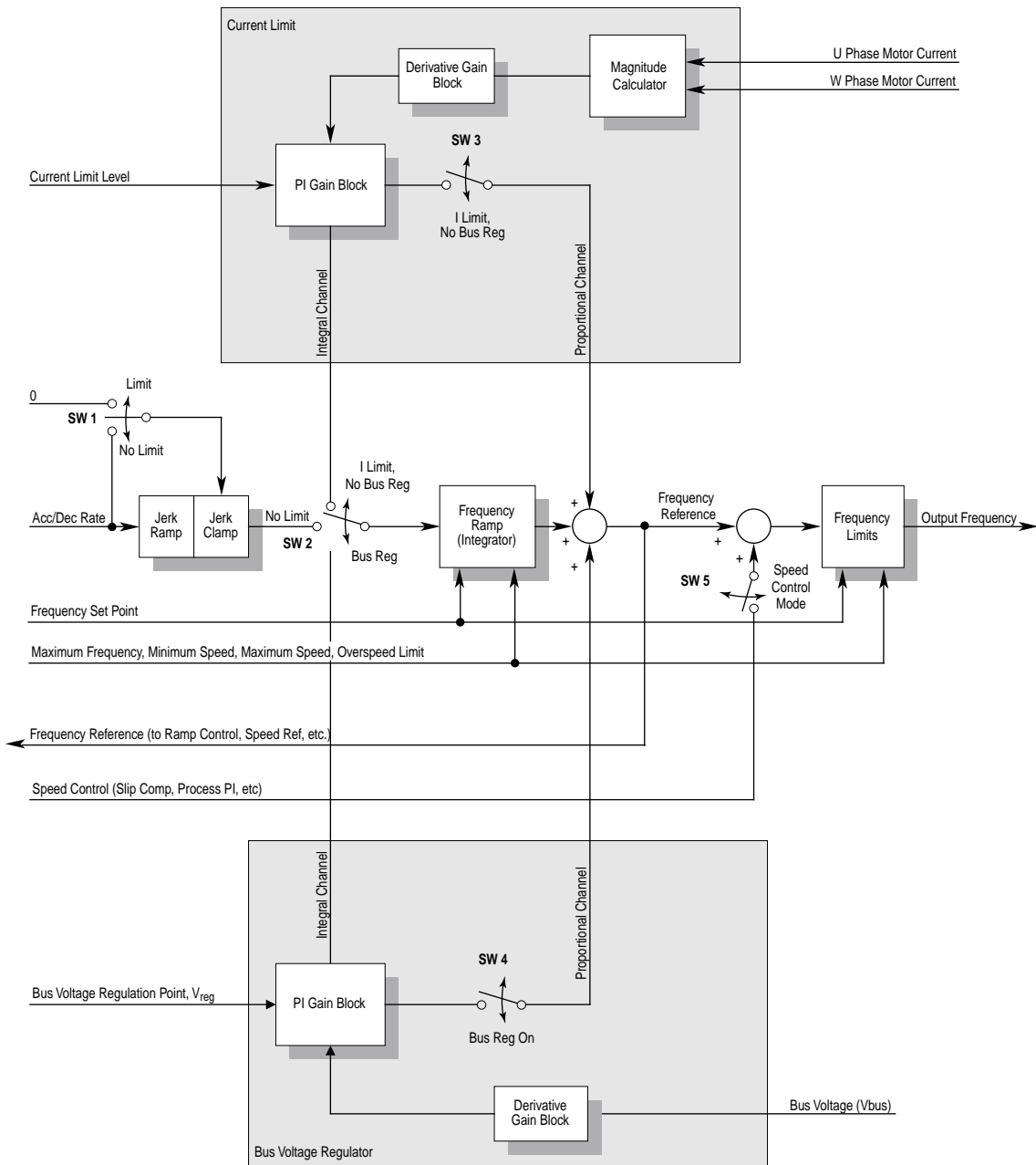
The derivative term senses a rapid rise in the bus voltage and activates the bus regulator prior to actually reaching the bus voltage regulation set point Vreg. The derivative term is important since it minimizes overshoot in the bus voltage when bus regulation begins thereby attempting to avoid an over-voltage 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

In PowerFlex 70, the user selects the bus voltage regulator using the [Bus Reg Mode A] and [Bus Reg Mode B] parameters. The available modes include "Disabled," "Adjust Freq," and "Dynamic brak." The bus voltage regulator is never active with the internal dynamic braking function.

The bus voltage regulation set point Vreg in PowerFlex 70 is fixed for each voltage class of drive. The bus voltage regulation set points are identical to the internal dynamic brake regulation set points $V_{DB's}$ and are shown in Table 2.E.

Table 2.E   PowerFlex 70 Bus Voltage Regulation Set Points (Vreg)

	200/240 V Class Drive	400 V Class Drive	480 V Class Drive	600 V Class
V_{reg}	377 VDC	750 VDC	750 VDC	–

The nature of this control is to increase the magnitude of the drive's output frequency to reduce or eliminate regeneration and avoid an over-voltage fault. The increase in output frequency may increase the operating voltage. The magnitude increase in frequency when bus regulation is active is limited to the sum of [Maximum Speed] and [Overspeed Limit]. When this frequency limit is met, the output frequency will be clamped and an over-voltage fault occurs if regeneration continues to increase the bus voltage.

PowerFlex 700

PowerFlex 700 allows the user to simultaneously enable both internal dynamic braking and the bus voltage regulator. There are two bus voltage regulation set point parameters, [Bus Reg Mode A] and [Bus Reg Mode B] in the PowerFlex 700 (See Table 2.F). The user can select which bus regulation set point is active by configuring one of the digital inputs as a selector.

Table 2.F   PowerFlex 700 Dynamic Braking and Bus Voltage Limit References

	200/240 V Class Drive	400 V Class Drive	480 V Class Drive	600 V Class
V_{db}	377 VDC	750 VDC	750 VDC	–
Bus Reg 1 Bus Reg 2	358 – 392 VDC	715 – 785 VDC	715 – 785 VDC	–

The nature of this control, like PowerFlex 70, is to increase the magnitude of the drive's output frequency to reduce or eliminate regeneration and avoid a bus over-voltage fault. The increase in the output frequency may increase the operating voltage. PowerFlex 700 internally limits the magnitude of output frequency to the sum of Maximum Speed and Overspeed Limit.

Cable, Control

See Cable Selection on page 2-15 and Cable Selection on page 2-46.

Cable Entry Plate Removal

If additional wiring access is needed, the Cable Entry Plate on 0-3 Frame drives can be removed. Simply loosen the screws securing the plate to the chassis. The slotted mounting holes assure easy removal.

Cable, Motor Lengths

The length of cable between the drive and motor may be limited by various application parameters. The 2 primary areas of concern are Reflected Wave and Cable charging.

The Reflected Wave phenomenon, also known as transmission line effect, produces very high peak voltages on the motor due to voltage reflection. While Allen-Bradley drives have patented software that limits the voltage peak to 2 times the DC bus voltage and reduce the number of occurrences, many motors have inadequate insulation systems to tolerate these peaks. See Reflected Wave on page 2-127 for more details.

Refer to Figure 2.3 for measuring cable lengths when concerned about Reflected Wave. Each individual motor must be considered based on the lead length for that motor only. Diagram A shows 2 motors, each 300 feet from the drive. Motor protection decisions are based on 300 feet cable length (not 600 ft). If the motors need protection at this distance, then both motors must be dealt with individually. Diagram B shows 1 motor at 50 feet and one at 550 feet. It is likely that the motor that is close to the drive (50 Ft) will not need protection, but the motor farther from the drive (550 Ft) may. Again, each motor must be considered individually based on its distance from the drive.

Cable charging occurs because of the capacitance, phase-to-phase or phase-to-ground, inherent in the length of cable. The current that is used to charge the cable capacitance detracts from the overall current capability of the drive and reduces the availability of torque producing current for the motor. This can result in poor motor performance, motor stalls under full load and nuisance drive overcurrent tripping.

Refer to Figure 2.3 for measuring cable lengths when concerned about cable charging. In this case, it is the total amount of cable connected to the drive that must be considered. Diagram A shows 2 motors, each 300 feet from the drive. The drive must be capable of supplying enough current to charge the total length (600 ft) plus the needed current to produce necessary torque in the motors. If the motors will not receive the desired current due to cable charging, then the drive size should be increased to supply needed current. Diagram B shows 1 motor at 50 feet and one at 550 feet. Again, the drive must be capable of supplying enough current to charge the total length (600 ft), plus the needed current to produce necessary torque in the motors. In fact, diagrams A, B, C and D will all require the same cable charging installation guidelines because they all have total cable lengths of 600 feet.

Figure 2.3   How to Measure Motor Cable Lengths Limited by Capacitance
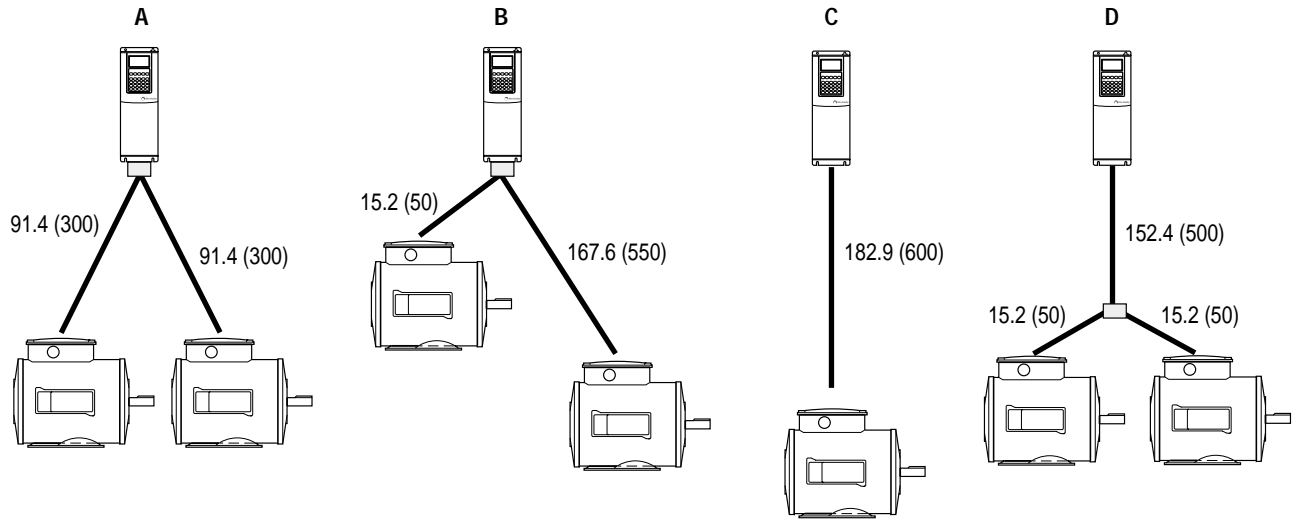
All examples represent motor cable length of 182.9 meters (600 feet).

Cable, Power

> ⚠ **ATTENTION:** National Codes and standards (NEC, VDE, BSI etc.) and local codes outline provisions for safely installing electrical equipment. Installation must comply with specifications regarding wire types, conductor sizes, branch circuit protection and disconnect devices. Failure to do so may result in personal injury and/or equipment damage.

A variety of cable types are acceptable for drive installations. For many installations, unshielded cable is adequate, provided it can be separated from sensitive circuits. As an approximate guide, allow a spacing of 0.3 meters (1 foot) for every 10 meters (32.8 feet) of length. In all cases, long parallel runs must be avoided. Do not use cable with an insulation thickness less than or equal to 15 mils (0.4 mm/0.015 in.).

Shielded/Armored

Shielded cable is recommended if sensitive circuits or devices are connected or mounted to the machinery driven by the motor.

Figure 2.4   Recommended Power Wire

Location	Rating/Type	Description
Standard (Option 1)	600V, 90°C (194°F) XHHW2/RHW-2 Anixter B209500-B209507, Belden 29501-29507, or equivalent	• Four tinned copper conductors with XLP insulation. • Copper braid/aluminum foil combination shield and tinned copper drain wire. • PVC jacket.
Standard (Option 2)	Tray rated 600V, 90° C (194° F) RHH/RHW-2 Anixter OLF-7xxxxx or equivalent	• Three tinned copper conductors with XLPE insulation. • 5 mil single helical copper tape (25% overlap min.) with three bare copper grounds in contact with shield. • PVC jacket.
Class I & II; Division I & II	Tray rated 600V, 90° C (194° F) RHH/RHW-2 Anixter 7V-7xxxx-3G or equivalent	• Three bare copper conductors with XLPE insulation and impervious corrugated continuously welded aluminum armor. • Black sunlight resistant PVC jacket overall. • Three copper grounds on #10 AWG and smaller.

Based on field and internal testing, Rockwell Automation/Allen-Bradley has determined conductors manufactured with Poly Vinyl Chloride (PVC) wire insulation are subject to a variety of manufacturing inconsistencies which can lead to premature insulation degradation when used with IGBT drives that produce the reflected wave phenomena. Flame-retardant heat-resistant thermoplastic insulation is the type of insulation listed in the NEC code for the THHN wire designation. This type of insulation is commonly referred to as PVC. In addition to manufacturing inconsistencies, the physical properties of the cable can change due to environment, installation and operation, which can also lead to premature insulation degradation. The following is a summary of our findings:

Manufacturing Inconsistencies and their Effects on Cable Life

Due to manufacturing inconsistencies, the following conditions can exist:

- PVC insulation material may have a dielectric constant ranging between 4 and 8 depending on the manufacturer. The higher the dielectric constant, the lower the dielectric strength (and voltage withstand to transients). A single IGBT drive output may have reflected wave transient voltage stresses of up to twice (2 per unit) the DC bus voltage between its own output wires. Multiple drive output wires in a single conduit or wire tray further increase output wire voltage stress between multi-drive output wires that are touching. Drive #1 may have a (+) 2 pu stress while drive #2 may simultaneously have a (–) 2 pu stress. Wires with dielectric constants (>4) cause the voltage stress to shift to the air gap between the wires that are barely touching. This electric field may be high enough to ionize the air surrounding the wire insulation and cause a partial discharge mechanism (corona) to occur. The electric field distribution between wires increases the possibility for corona which further produces ozone. This attacks the PVC insulation and produces carbon tracking, leading to the susceptibility of insulation breakdown.

- Due to inconsistencies in manufacturing processes or wire pulling, air voids can also occur in the THHN wire between the nylon jacket and PVC insulation. Because the dielectric constant of air is much lower than the dielectric constant of the insulating material, the transient reflected wave voltage may appear across the small air void capacitance. The Corona Inception Voltage (CIV) for the air void may be reached which further produces ozone, which attacks the PVC insulation and produces carbon tracking, leading to the susceptibility of insulation breakdown as in the above case.

- Asymmetrical construction of the insulation has also been observed for some manufacturers of PVC wire. A wire with a 15 mil specification was observed to have an insulation thickness of 10 mil at some points. The smaller the insulation thickness, the less voltage the wire can withstand.

### Installation, Operation and Environmental Considerations

- THHN jacket material has a relatively brittle nylon that lends itself to damage (i.e. nicks and cuts) when pulled through conduit on long wire runs. This issue is of even greater concern when the wire is being pulled through multiple 90 degree bends in the conduit. It is these nicks that may be a starting point for corona that leads to insulation degradation.

- During operation, the conductor heats up and a "coldflow" condition may occur with PVC insulation at points where the unsupported weight of the wire may stretch the insulation. This has been observed at right angle bends where wire is dropped down to equipment from an above wireway. This "coldflow" condition produces thin spots in the insulation which lowers the cable's voltage withstand capability.

- The NEC 1996 code defines "dry, damp and wet" locations (7-31) and permits the use of heat-resistant thermoplastic wire in both dry and damp applications (Table 310-13). However, PVC insulation material is more susceptible to absorbing moisture than XLPE (Cross Linked Polyethylene) insulation material (XHHN-2) identified for use in wet locations. Because the PVC insulating material absorbs moisture, the Corona Inception Voltage insulation capability of the "damp" or "wet" THHN was found to be less than 1/2 of the same wire when "dry". For this reason, certain industries where water is prevalent in the environment have refrained from using THHN wire with IGBT drives.

Cable Recommendations for New & Existing Installations of IGBT Drives in Wet Locations

- Belden YR41709 cable is a PVC jacketed, shielded type TC with XLPE conductor insulation designed to meet NEC code designation XHHW-2 (wet locations per NEC 1996, Table 310-13). Based on Rockwell Automation research, tests have determined the Belden YR41709 is notably superior to loose wires in dry, damp and wet applications and can significantly reduce capacitive coupling and common mode noise. Other cable types for wet locations include those in the table above

Figure 2.5 summarizes the previous considerations and explanations. Because applications can vary widely, the information in the flowchart is intended to be used only as a guideline in the decision-making process.

Figure 2.5   Wire Selection Flowchart

(1) The mimimum wire size for PVC cable with 20 mil or greater insulation is 10 gauge.
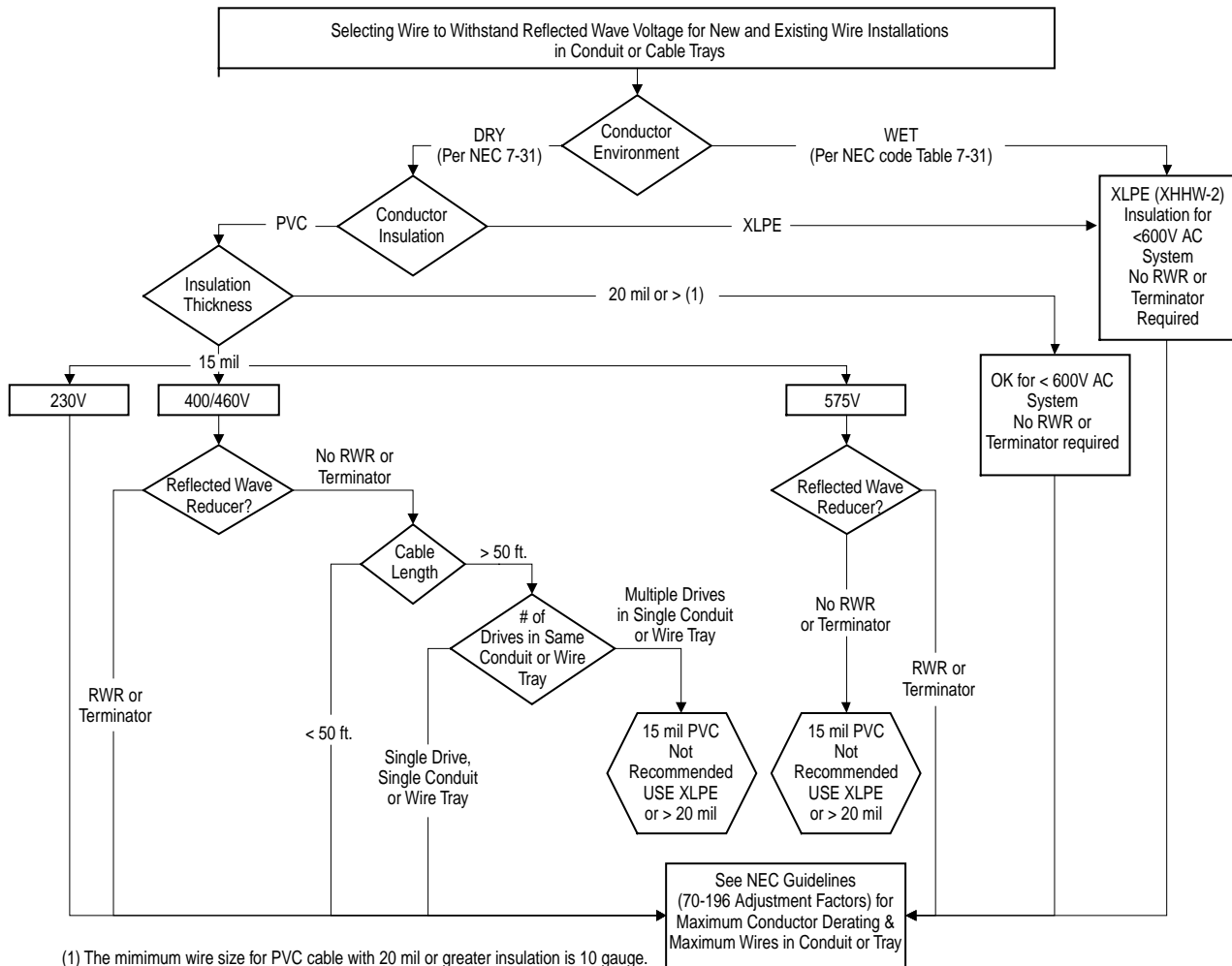
Cable, Standard I/O

Refer to <u>Cable Selection on page 2-15</u> and <u>Cable Selection on page 2-46</u>.

Cable Trays and Conduit

Important: Because of the nature of the drive PWM output and the reflected wave phenomenon, it is preferable to have each set of drive motor/power cables in an individual conduit. If this is not possible, it is important that the allowable fill rates specified in the applicable national or local codes NOT BE Exceeded.

⚠️ **ATTENTION:** To avoid a possible shock hazard caused by induced voltages, unused wires in the conduit must be grounded at both ends. For the same reason, if a drive sharing a conduit is being serviced or installed, all drives using this conduit should be disabled. This will help minimize the possible shock hazard from "cross coupled" motor leads.

Carrier (PWM) Frequency

This section is under construction. If further information is required, please contact factory.

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 Manual.

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.
- EN60204-1 Safety of machinery – Electrical equipment of machines.

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.

Essential Requirements for CE Compliance

Conditions 1-4 listed below **must be** satisfied for PowerFlex drives to meet the requirements of **EN61800-3**.

1. Standard PowerFlex CE compatible Drive.

2. Grounding as described on page 2-86.

3. 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.

4. Conditions in the appropriate table (2.G, 2.H or 2.I).

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

Frame	Drive Description	Restrict Motor Cable to 12 m (40 ft.)	Restrict Motor Cable to 40 m (131 ft.)	Internal Filter Option	External Filter	Comm Cable Ferrite [1]	Common Mode Core [2]
A	Drive Only	–	✔	–	✔	–	–
	Drive with DeviceNet	–	✔	–	✔	–	–
	Drive with Remote I/O	–	✔	–	✔	✔	–
B	Drive Only	✔	–	✔	–	–	–
	Drive with DeviceNet	✔	–	✔	–	–	–
	Drive with Remote I/O	✔	–	✔	–	✔	–
C	Drive Only	✔	–	–	–	–	✔
	Drive with DeviceNet	✔	–	–	–	–	✔
	Drive with Remote I/O	✔	–	–	–	✔	✔
D	Drive Only	✔	–	–	–	–	–
	Drive with DeviceNet	✔	–	–	–	–	–
	Drive with Remote I/O	✔	–	–	–	✔	–

[1]   Two turns of the blue comm option cable through a Ferrite Core (Fair-Rite #2643102002 or equivalent).

[2]   Refer to the 1321 Reactor and Isolation Transformer Technical Data publication, 1321-TD001x for 1321-Mxxx selection information.

Table 2.H   PowerFlex 70 – EN61800-3 Second Environment

Frame	Drive Description	Restrict Motor Cable to 12 m (40 ft.)	Restrict Motor Cable to 40 m (131 ft.)	Internal Filter Option	External Filter	Comm Cable Ferrite	Common Mode Core
A	Drive Only	–	✔	–	✔	–	–
	Drive with DeviceNet	–	✔	–	✔	–	–
	Drive with Remote I/O	–	✔	–	✔	–	–
B	Drive Only	–	✔	✔	–	–	–
	Drive with DeviceNet	–	✔	✔	–	–	–
	Drive with Remote I/O	–	✔	✔	–	–	–
C	Drive Only	–	✔	–	–	–	–
	Drive with DeviceNet	–	✔	–	–	–	–
	Drive with Remote I/O	–	✔	–	–	–	–
D	Drive Only	–	✔	–	–	–	–
	Drive with DeviceNet	–	✔	–	–	–	–
	Drive with Remote I/O	–	✔	–	–	–	–

Table 2.I   PowerFlex 700 EN61800-3 EMC Compatibility

Frame	Second Environment *Restrict Motor Cable to 30 m (98 ft.)* *Any Drive and Option*	First Environment Restricted Distribution *Restrict Motor Cable to 150 m (492 ft.)* *Any Drive and Option*	*External Filter Required [1]*
0	✔	✔	✔
1	✔	✔	✔
2	✔	✔	✔
3	✔	✔	✔

[1]   Select the Roxburgh filter (or equivalent) that meets your specifications from the list below. Refer to: **http://www.deltron-emcon.com** for detailed filter information.

Filter Part No.	Current	Filter Part No.	Current
MIF306	6A	MIF350	50A
MIF310	10A	MIF375	75A
MIF316	16A	MIF3100	100A
MIF323	23A	MIF3150	150A
MIF330	30A		

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

A. 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.

B. Software Instantaneous Trip - If it is determined that the hardware overcurrent levels are too high for certain drives (below certain output frequencies), an additional software overcurrent trip is invoked. When the drive is being operated below the given frequency (fixed and stored in drive memory) the software overcurrent trip level is set to a value less than the hardware overcurrent level. This offers additional protection to drives running at very low output frequencies, if needed. If the reduced current limit level is exceeded, an F36 "SW Overcurrent" fault is generated.

C. 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.

D. Overload Protection I2T - 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 I2T 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.

E. 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.

F. Thermal manager (see).

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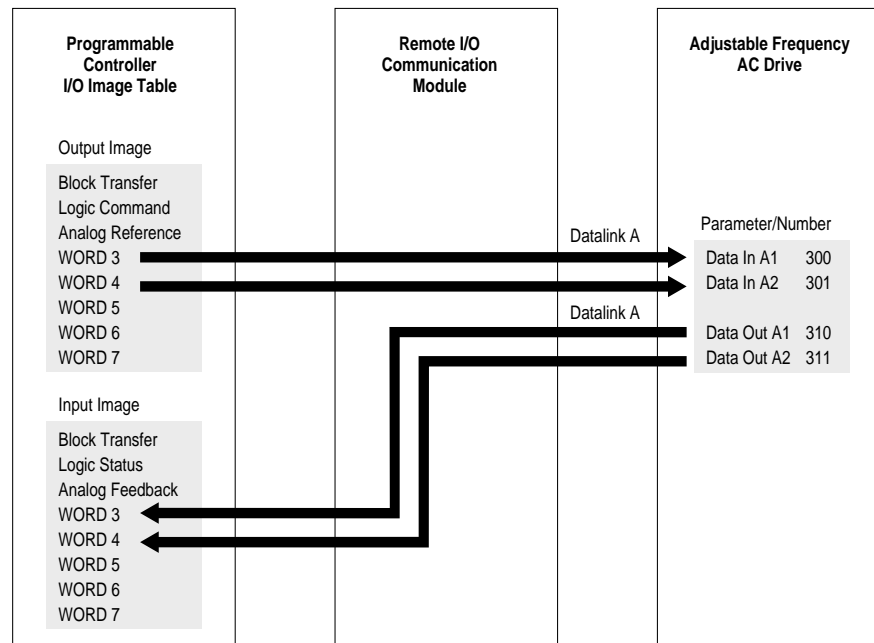
In the PLC data Table, the user enters Word 3 as a value of 100 (10.0 Secs) and word 4 as a value of 133 (13.3 seconds). On each I/O scan, the parameters in the PowerFlex drive are updated with the value from the data table:
Accel Time P140 = 10.0 seconds (value from output image table Word 3)
Decel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

A measure of the instantaneous value or "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 approximately 2.4V DC per minute (for a 480V AC drive). An increase in DC Bus memory is blocked during deceleration to prevent a false high value due to the bus being pumped up by regeneration. Any change to DC Bus memory is blocked during inertia ride through.

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:

$$\frac{\text{Maximum Frequency} - \text{Minimum Frequency}}{\text{Decel Time}} = \text{Decel Rate}$$

Two Decel times exist to allow the user to change rates "on the fly" via PLC command or Digital Input. The selection is made using the 1st/2nd Decel inputs shown below or a similar pattern of decel time select bits in the Logic Control word used via PLC communications.

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

Important points to remember about I/O wiring:

- Always use copper wire.
- Wire with an insulation rating of 600V or greater is recommended.
- Control and signal wires should be separated from power wires by at least 0.3 meters (1 foot).

Table 2.J   Recommended Control Wire for Digital I/O

Type	Wire Type(s)	Description	Minimum Insulation Rating
Unshielded	Per US NEC or applicable national or local code	–	300V, 60 degrees C (140 degrees F)
Shielded	Multi-conductor shielded cable such as Belden 8770 (or equiv.)	0.750 mm^2 (18 AWG), 3 conductor, shielded.	

Wiring Examples

There are 6 digital (discrete) inputs (numbered 1 through 6) available at the terminal block.

PowerFlex 70

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.

PowerFlex 700

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.

		361	**[Digital In1 Sel]**	Default:	4	"Stop – CF" (CF = Clear Fault)	
		362	**[Digital In2 Sel]**	Default:	5	"Start"	
		363	**[Digital In3 Sel]**	Default:	10	"Jog"	
		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"	
INPUTS & OUTPUTS	**Digital Inputs**	⭕	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.	Options:	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	"Not Used" "Enable" "Clear Faults"[1] "Aux Fault' "Stop – CF"[2] "Start"[2] "Fwd/ Reverse"[2] "Run"[3] "Run Forward"[3] "Run Reverse"[3] "Jog"[2] "Jog Forward" "Jog Reverse" "Stop Mode B" "Bus Reg Md B" "Speed Sel 1"[4] "Speed Sel 2"[4] "Speed Sel 3"[4] "Auto/ Manual"[5] "Local" "Acc2 & Dec2" "Accel 2" "Decel 2" "MOP Inc" "MOP Dec" "Excl Link" "PI Enable" "PI Hold" "PI Reset" "Pwr Loss Lvl" "Precharge En"	100 156 162 096 140 194 380 124

Speed select table:

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. For example, [Digital In1 Sel] set to 5 "Start" in 3-wire control and [Digital In2 Sel] set to 7 "Run" in 2-wire control.

Refer to Alarm Descriptions on page 4-8 for information on resolving this type of conflict.

[5] Auto/Manual - Refer to Figure 1.6 on page 1-13 for details.

The available functions are defined in Table 2.K.

Table 2.K   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.

- **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 2-104). 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 <u>Stop Modes on page 2-158</u>.

    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 <u>Bus Regulation</u>.

    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 <u>Process PI Loop on page 2-116</u>.

- **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 2-116.

- **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 2-116.

- **Auxiliary Fault**

  The "Auxiliary 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 Fault" fault code.

  If the "Auxiliary Fault" input function is assigned to a physical digital input, that input will be active irrespective 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 a parameter. 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.L** 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.L   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.M   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.

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.

 "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

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.

Examples

PowerFlex 70

Below is a typical digital input configuration that includes "3-wire" start. The digital input configuration parameters should be set up as follows:

- [Digital In1 Sel] set to "Start"
- [Digital In2 Sel] set to "Stop - Clear Faults"
- [Digital In3 Sel] set to "Forward/Reverse"
- [Digital In4 Sel] set to "Jog"
- [Digital In5 Sel] set to "Speed Select 1"
- [Digital In6 Sel] set to "Enable"

Figure 2.6 Typical digital input configuration with "3-wire" start

Digital In1	Start
Digital In2	Stop - CF
Digital In3	Forward/Reverse
Digital In4	Jog
Digital In5	Speed Select 2
Digital In6	Enable
Common	
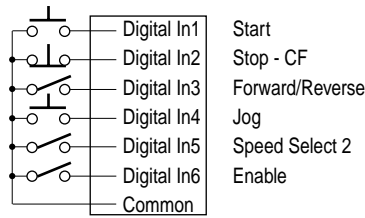
Figure 2.7 represents a typical digital input configuration that includes "Run Fwd/Rev" start. The digital input configuration parameters should be set up as follows:

- [Digital In1 Sel] = "Run Forward".
- [Digital In2 Sel] = "Run Reverse".
- [Digital In3 Sel] = "Jog Forward".
- [Digital In4 Sel] = "Jog Reverse"
- [Digital In5 Sel] = "Accel 2 & Decel 2".
- [Digital In6 Sel] = "Speed Select 1".

Figure 2.7 Typical digital input configuration with "Run Fwd/Rev" start

Digital In1	Run Forward
Digital In2	Run Reverse
Digital In3	Jog Forward
Digital In4	Jog Reverse
Digital In5	Accel 2/Decel 2
Digital In6	Speed Select 1
Common	
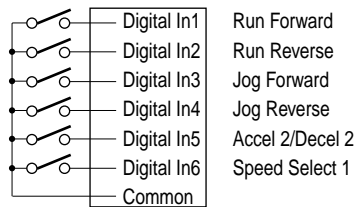
Digital Outputs

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 250 VAC or 220 VDC. The table below shows specifications and limits for each relay / contact.

	PowerFlex 70		PowerFlex 700	
	Resistive Load	Inductive Load		
Rated Voltage	250 VAC	250 VAC	250 VAC	250 VAC
	220 VDC	220 VDC	220 VDC	220 VDC
Maximum Current	3 A	1.5 A	8 A	4 A
Maximum Power	AC - 50 VA	AC - 25 VA		
	DC - 60 W	DC - 30 W		
Minimum DC Current	10 µA			
Minimum DC Voltage	10 mV			
Switching Time	8ms		8ms	
Initial State	De-energized		De-energized	
Number of relays (Standard I/O)	2		2	

Configuration

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

<table>
<tr><td rowspan="2" style="writing-mode: vertical-rl">INPUTS & OUTPUTS</td><td rowspan="2" style="writing-mode: vertical-rl">Digital Outputs</td><td>380</td><td>**[Digital Out1 Sel]**</td><td>Default:</td><td>1</td><td>"Fault"</td><td>381</td></tr>
<tr><td>384</td><td>**[Digital Out2 Sel]**</td><td></td><td>4</td><td>"Run"</td><td>385</td></tr>
</table>

Default:	1	"Fault"	381
	4	"Run"	385
Options:	1	"Fault"[1]	382
	2	"Alarm"[1]	386
	3	"Ready"	383
	4	"Run"	
	5	"Forward Run"	
	6	"Reverse Run"	
	7	"Auto Restart"	
	8	"Powerup Run"	
	9	"At Speed"	002
	10	"At Freq"	001
	11	"At Current"	003
	12	"At Torque"	004
	13	"At Temp"	218
	14	"At Bus Volts"	012
	15	"At PI Error"	137
	16	"DC Braking"	157
	17	"Curr Limit"	147
	18	"Economize"	053
	19	"Motor Overld"	048
	20	"Power Loss"	184
	21	"Input 1 Link"	
	22	"Input 2 Link"	
	23	"Input 3 Link"	
	24	"Input 4 Link"	
	25	"Input 5 Link"	
	26	"Input 6 Link"	

380 [Digital Out1 Sel]
384 [Digital Out2 Sel]

Selects the drive status that will energize a (CRx) output relay.

[1]Contacts shown on page 1-12 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.

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	**[Dig Out1 Level]**	Default:	0.0	380
	385	**[Dig Out2 Level]**		0.0	
		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).	Min/Max:	0.0/819.2	
			Display:	0.1	

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.

The user can disable either timer by setting the corresponding delay time to 0.

Important: Note that whether a particular type of transition (FALSE to TRUE or TRUE TO 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.

382	**[Dig Out1 OnTime]**	Default:	0.0 Secs	380
386	**[Dig Out2 OnTime]**		0.0 Secs	
	Sets the "ON Delay" time for the digital outputs. This is the time between the occurrence of a condition and activation of the relay.	Min/Max:	0.0/600.0 Secs	
		Display:	0.1 Secs	
383	**[Dig Out1 OffTime]**	Default:	0.0 Secs	380
387	**[Dig Out2 OffTime]**		0.0 Secs	
	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.	Min/Max:	0.0/600.0 Secs	
		Display:	0.1 Secs	

Relay Activates
CR1 On Delay = 2 Seconds
Current Limit Occurs
0   5   10

Relay Does Not Activate
CR1 On Delay = 2 Seconds
Cyclic Current Limit (every other second)
0   5   10
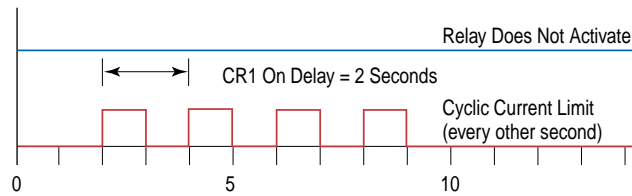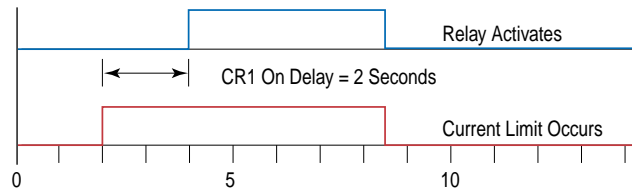
Direction Control

Direction control of the drive is an exclusive ownership function. This means that 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, of the **drive output**, not he motor. Motor wiring and phasing determines its CW or CCW rotation The direction of the drive, is controlled in one of three ways:

1. 2-Wire digital input selection such as Run Forward or Run Reverse

2. 3-Wire digital input selection such as Forward/Reverse, Forward or Reverse

3. Control Word bit manipulation from a DPI device such as a communications interface.

4. The sign (+ / -) of a bipolar analog input

Refer to and for more detail on the configuration and operating rules for direction control.

DPI

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 drives support the existing SCANport and Drive Peripheral Interface (DPI) communication protocols. Multiple devices of each type (SCANport or DPI) can be attached to and communicate with the drive at the same time. This communication interface is the primary way to interact with, and control the drive.

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.N   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 2.8 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 2.8   Normal Duty Boundary of Operation
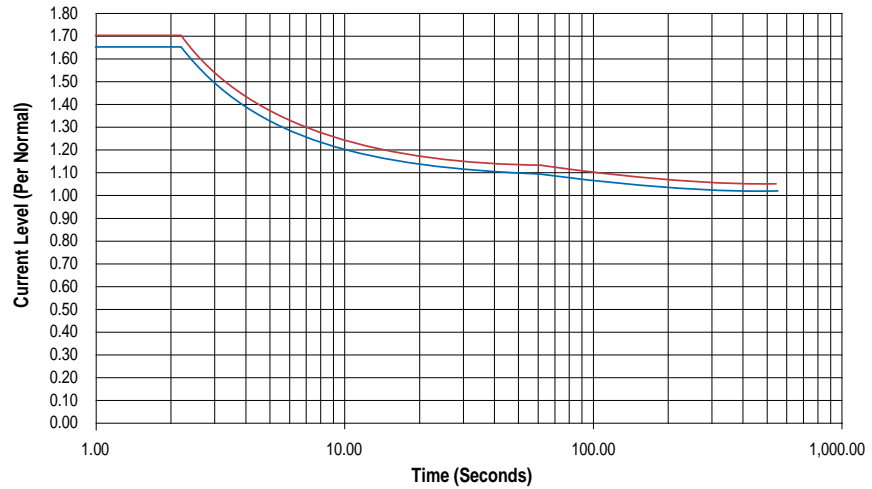
The lower curve in Figure 2.9 shows the boundary of heavy duty operation. In heavy duty, the drive is rated to produce 150% of rated current for 60 seconds, 200% of rated current for three seconds, and 220% of rated current for 100 milliseconds. The maximum value for current limit is 200% so the limit 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 2.9   Heavy Duty Boundary of Operation
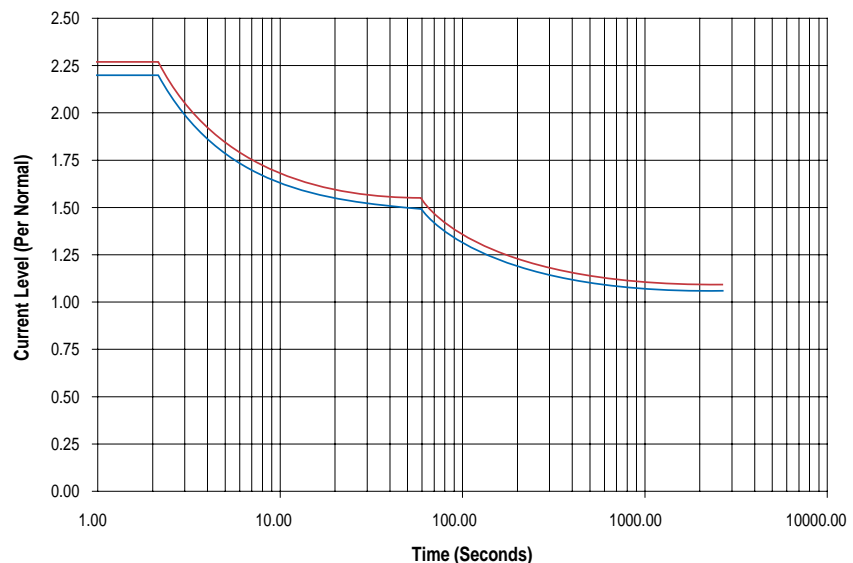
Thermal Manager Protection

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 2.10   Thermal Manager Inputs/Outputs
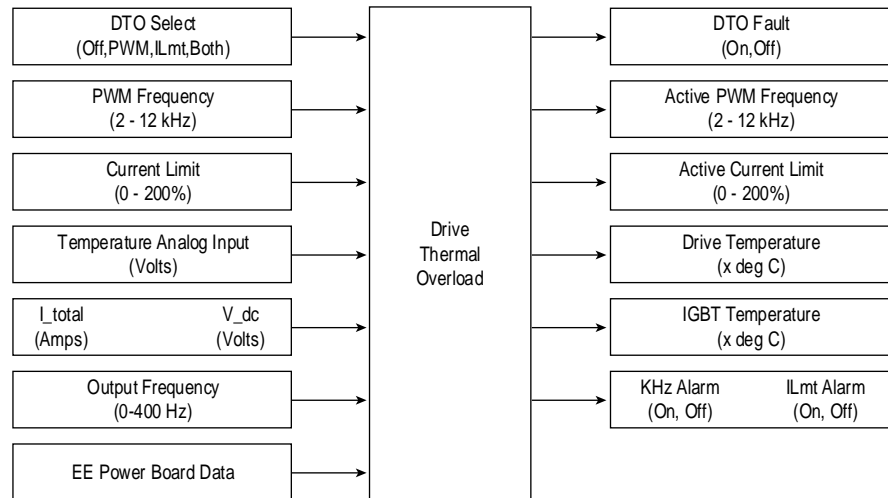
The following is a generalization of the calculations done by the thermal manager. The IGBT junction temperature T_J is calculated based on the measured drive temperature T_{Drive}, and a temperature rise that is a function of operating conditions. When the temperature device is inside the power module T_{Drive} is the same as T_{Case}. On larger size drives the temperature device will be mounted on the heat sink rather than inside the power module, and the thermal model becomes more complex.

P_J as defined in the second equation is the power dissipated in one generalized IGBT.

R_{J-Case} is the worst case thermal resistance from the junction to the case.

Boost[freq] is a term that increases the modeled temperature at low output frequencies.

*kHz * SwitchLosses* is a term that increases losses at higher PWM carrier frequencies.

$$T_J = T_{Case} + P_J\, R_{J-Case}\, Boost\{Freq\}$$

$$P_J = I_{Peak}^2\, R_0 + I_{Peak}V_0 + I_{Peak}\, V_{DC}\, kHz * SwitchLosses$$

Without a temperature device on each IGBT the calculation of T_J must take into account the worst case conditions for heat transfer. A model that adds the heat dissipated in the rectifier is also under consideration. More detail will be included in the design specification.

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 *kHz 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 ILmt 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 measured Drive temperature is displayed as a standard parameter. The calculated IGBT temperature may be displayed as a test point parameter. Analysis of the possible source or error shows that the drive temperature should be within $+/- 3$ °C of the actual temperature, over the full range of operation.

Low Speed Operation

When operation is below 4 Hz, the rating of the drive is reduced. At low output frequencies 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 .

Economizer

Auto-Economizer (also see Torque Performance Modes on page 2-162)

Economize mode consists of the sensorless vector control voltage with an energy saving function (E-SVC).

The output voltage is automatically adjusted, in steady state frequency operation only, as the load is increased or decreased such that minimum current is supplied to the motor and its efficiency is optimized. Adjusting the flux producing current facilitates reduction of the output voltage. The flux current is reduced as long as the total drive output current does not exceed 75% of motor rated current.   The flux current is not allowed to be less than 50% of the selected flux current parameter value.
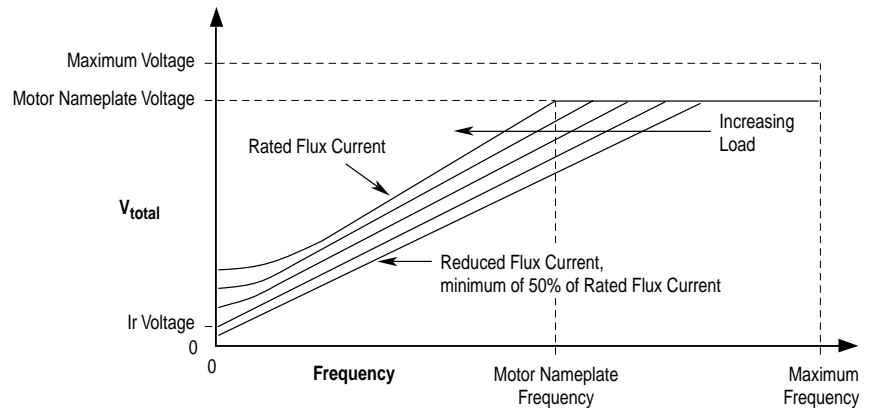
Efficiency

The following chart is typical of the efficiency calculations for variable frequency drives. Efficiency generally decreases with increasing load on decreasing speed.
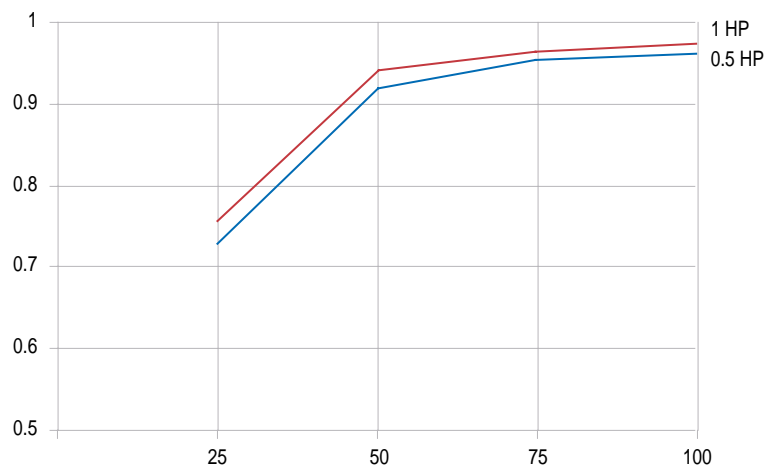
Fan Curve

When torque performance is set to Fan Curve the relation ship between frequency and voltage is as shown in the following figure. The fan curve provides the option to generate 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 is offset by the run boost parameter to provide necessary starting torque. No extra parameters are needed for fan curve.
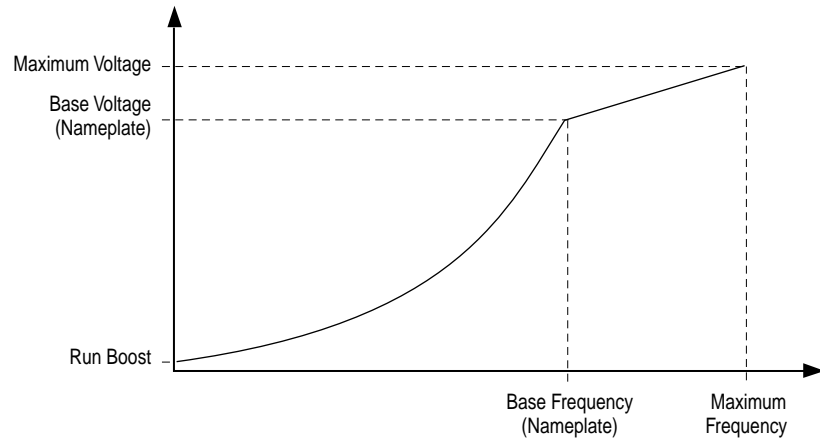
Fan

See Fan Curve above.

Faults

Faults are events or conditions within the drive which constitute user notification and may warrant various responses. Some conditions are user configurable as to whether the drive will consider them a fault. Faults are indicated to the user via HIM fault codes and/or popup dialogs or status indications as well as a group of output parameters. Faults are latched, requiring the user or application to perform a fault reset action to clear the latched condition. If the fault condition still exists it will be latched again.

When a Fault Occurs

1. The faulted status is set causing a coast stop sequence to occur turning off output power to the motor.

2. If this is the first fault latched:

– An entry is made in the fault queue.

– The following fault context data will be recorded/updated. Note there is only a single copy of this information which is always related to the most recent fault queue entry (#1).

– Status 1 @ Fault and Status 2 @ Fault

State of Drive Status 1 and Drive Status 2.

– Alarm 1 @Fault and Alarm 2 @Fault

State of Alarm Status 1 and Alarm Status 2

– Fault Frequency: drive speed at time of fault (output frequency if in v/hz or SVC operation).

– Fault Motor Amps: motor amps at time of fault.

– Fault Bus Volts: unfiltered DC Bus volts at time of fault.

A faulted status indicates whether one or more fault conditions have occurred. The state of the fault queue (empty or full) has no affect on the faulted status.

Fault Queue

Faults are also logged Into a fault queue such that a history of the most recent fault events Is retained.

A fault queue will record the occurrence of the first fault event - i.e. the 1st fault which occurs while no other fault is latched. A new fault event will not be logged to the fault queue if a previous fault is already latched (has occurred but not yet reset/cleared). This results in fault queue entry #1 always indicating the fault which last tripped the drive.

Each fault queue entry will include a fault code and a time stamp value. The fault queue will be a first-in first-out (FIFO) queue. This results in the most recent 'n' faults being retained in the fault queue. Entry 1 will always be the most-recent entry (newest). Entry 'n' will always be the oldest entry, where 'n' is the maximum number of queue entries supported by the drive. As a

new fault is logged into the queue 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

The fault code for each entry can be read via a corresponding output (read-only) parameter. Viewed in this manner (i.e. as a parameter) a numeric fault code is presented - i.e. no text string. This was decided to provide consistent fault indication between the LED and LCD HIM peripherals.

A text string of up to 16 characters is presented when accessing the fault queue via a DPI peripheral, which can present the fault queue to the user rather than through parameters.

Time

[Fault 1-8 Time]

Time Stamp Value

The time stamp value recorded in the fault queue is the value of an internal drive-under-power-timer at the time of the fault. At drive power-up, this internal value is copied to [PowerUp Marker]. The fault queue time stamp can then be compared to determine when the fault occurred relative to the last drive power-up. The user has no control over the value of the internal drive under power timer, which will increment in value over the life of the power structure (saved in nonvolatile storage on the power structure, not the Control Board).

The time stamp for each fault queue entry can be read via a corresponding parameter. The time stamp value will be presented in xxx.yyyy hours (4 decimal places). Each increment of 1 will represent 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. 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 be latched and another entry made in the fault queue.

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

Configuration

[Fault Config 1]

Bit-mapped 16 bit word enabling certain fault conditions. Disabling a fault removes the affect 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.

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

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

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

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
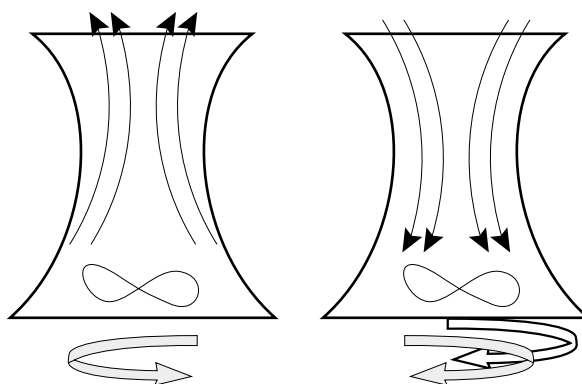
Fuses and Circuit Breakers

Tables 2.O through 2.S 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.

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(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.O   PF70 208/240 Volt AC Input Recommended Protection Devices

Drive Catalog Number	Frame	HP Rating ND	HD	Input Ratings Amps	kVA	Output Amps Cont.	1 Min.	3 Sec.	Dual Element Time Delay Fuse Min. [1]	Max. [2]	Non-Time Delay Fuse Min. [1]	Max. [2]	Circuit Breaker [3] Amps	Motor Circuit Protector [4] Amps	140M Motor Starter with Adjustable Current Range [5][6] Available Catalog Numbers [7]			
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	10.0	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	14.0	5.1	11.0	12.1	16.5	20	25	20	40	40	30	140M-C2E-C16	140M-D8E-C16	140M-F8E-C16	–
20AB015	C	5	3	16.0	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	25	50	25	100	100	30	140M-C2E-C25	140M-D8E-C25	140M-F8E-C25	140M-CMN-2500
20AB028	D	10	7.5	29.8	10.7	32.2	37.9	50.6	35	70	35	125	125	50	–	–	140M-F8E-C32	140M-CMN-4000
240 Volt AC Input																		
20AB2P2	A	0.5	0.33	2.5	1.1	2.2	2.4	3.3	6	4.5	6	8	15	3	140M-C2E-B25	140M-D8E-B25	–	–
20AB4P2	A	1	0.75	4.8	2	4.2	4.8	6.4	10	9	10	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	C	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	24.2	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	140M-CMN-4000

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

Drive Catalog Number	Frame	HP Rating ND	HD	Input Ratings Amps	kVA	Output Amps Cont.	1 Min.	3 Sec.	Dual Element Time Delay Fuse Min. [1]	Max. [2]	Non-Time Delay Fuse Min. [1]	Max. [2]	Circuit Breaker [3] Amps	Motor Circuit Protector [4] Amps	140M Motor Starter with Adjustable Current Range [5][6] Available Catalog Numbers [7]			
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	6	4	6	8	15	7	140M-C2E-B25	140M-D8E-B25	–	–
20AC3P5	A	1.5	1.1	4.3	3	3.5	4.5	6	10	6	10	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	25	45	25	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	35	60	35	120	120	50	–	–	140M-F8E-C32	140M-CMN-4000
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	6	6	6	8	15	3	140M-C2E-B25	140M-D8E-B25	–	–
20AD3P4	A	2	1.5	3.8	3.2	3.4	4.5	6	10	10	10	12	15	7	140M-C2E-B40	140M-D8E-B40	–	–
20AC5P0	B	3	2	5.6	4.7	5	5.5	7.5	10	10	10	20	20	15	140M-C2E-C63	140M-D8E-C63	–	–
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-C10	140M-D8E-C10	140M-F8E-C10	–
20AD015	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	140M-CMN-2500

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

Drive Catalog Number	Frame	HP Rating ND	HD	Input Ratings Amps	kVA	Output Amps Cont.	1 Min.	3 Sec.	Dual Element Time Delay Fuse Min. [1]	Max. [2]	Non-Time Delay Fuse Min. [1]	Max. [2]	Circuit Breaker [3] Amps	Motor Circuit Protector [4] Amps	140M Motor Starter with Adjustable Current Range [5][6] Available Catalog Numbers [7]
600 Volt AC Input															
20AE0P3	A	0.5	0.33	1.3	1.3	0.9	1.1	1.4	3	3	3	3.5	15	3	
20AE1P7	A	1	0.75	1.9	2.0	1.7	2.0	2.6	3	3.5	3	6	15	3	
20AE2P7	A	2	1.5	3.0	3.1	2.7	3.6	4.8	4	6	4	10	15	7	
20AE3P9	B	3	2	4.4	4.5	3.9	4.3	5.9	6	8	6	15	15	7	Not Applicable
20AE6P1	B	5	3	7.5	7.8	6.1	6.7	9.2	10	12	10	20	20	15	
20AE9P0	C	7.5	5	7.7	8.0	9.0	9.9	13.5	10	20	10	35	35	15	
20AE011	C	10	7.5	9.8	10.1	11.0	13.5	18.0	15	20	15	40	40	15	
20AE017	D	15	10	15.3	15.9	17.0	18.7	25.5	20	35	20	60	60	30	
20AE022	D	20	15	20.0	20.8	22.0	25.5	34.0	25	45	25	80	80	30	

Table 2.R PF700 208/240 Volt AC Input Recommended Protection Devices

Drive Catalog Number	Frame	HP Rating ND	HD	Input Ratings Amps	kVA	Output Amps Cont.	1 Min.	3 Sec.	Dual Element Time Delay Fuse Min.[1]	Max.[2]	Non-Time Delay Fuse Min.[1]	Max.[2]	Circuit Breaker[3] Amps	Motor Circuit Protector[4] Amps	140M Motor Starter with Adjustable Current Range[5][6] Available Catalog Numbers[7]			
208 Volt AC Input																		
20BB2P2	0	0.5	0.33	1.9	0.7	2.5	2.7	3.7	3	6	3	10	15	3	140M-C2E-B25	140M-D8E-B25	–	–
20BB4P2	0	1	0.75	3.7	1.3	4.8	5.5	7.4	6	10	6	17.5	15	7	140M-C2E-B63	140M-D8E-B63	–	–
20BB6P8	0	2	1.5	6.8	2.4	7.8	10.3	13.8	10	15	10	30	30	15	140M-C2E-C10	140M-D8E-C10	140M-F8E-C10	–
20BB9P6	0	3	2	9.5	3.4	11	12.1	16.5	12	20	12	40	40	15	140M-C2E-C16	140M-D8E-C16	140M-F8E-C16	–
20BB015	1	5	3	15.7	5.7	17.5	19.2	26.2	20	35	20	70	70	30	140M-C2E-C20	140M-D8E-C20	140M-F8E-C20	–
20BB022	1	7.5	5	23.0	8.3	25.3	27.8	37.9	30	50	30	100	100	30	140M-C2E-C25	140M-D8E-C25	140M-F8E-C25	140M-CMN-2500
20BB028	2	10	7.5	29.6	10.7	32.2	37.9	50.6	40	70	40	125	125	50	–	–	140M-F8E-C32	140M-CMN-4000
20BB042	3	15	10	44.5	16.0	48.3	53	72.5	60	100	60	175	175	70	–	–	140M-F8E-C45	140M-CMN-6300
20BB054	3	20	15	57.2	20.6	62.1	72.5	97	80	125	80	225	225	100	–	–	–	140M-CMN-6300
240 Volt AC Input																		
20BB2P2	0	0.5	0.33	1.7	0.7	2.2	2.4	3.3	3	6	3	10	15	15	140M-C2E-B25	140M-D8E-B25	–	–
20BB4P2	0	1	0.75	3.3	1.4	4.2	4.8	6.4	5	8	5	15	15	15	140M-C2E-B63	140M-D8E-B63	–	–
20AB6P8	0	2	1.5	5.9	2.4	6.8	9	12	10	15	10	25	25	25	140M-C2E-C10	140M-D8E-C10	140M-F8E-C10	–
20BB9P6	0	3	2	8.3	3.4	9.6	10.6	14.4	12	20	12	35	35	35	140M-C2E-C10	140M-D8E-C10	140M-F8E-C10	–
20BB015	1	5	3	13.7	5.7	15.3	17.4	23.2	20	30	20	60	60	60	140M-C2E-C16	140M-D8E-C16	140M-F8E-C16	–
20BB022	1	7.5	5	19.9	8.3	22	24.2	33	25	50	25	80	80	80	140M-C2E-C25	140M-D8E-C25	140M-F8E-C25	140M-CMN-2500
20BB028	2	10	7.5	25.7	10.7	28	33	44	35	60	35	100	100	100	–	–	140M-F8E-C32	140M-CMN-4000
20BB042	3	15	10	38.5	16.0	42	46.2	63	50	90	50	150	150	150	–	–	140M-F8E-C45	140M-CMN-6300
20BB054	3	20	15	49.5	20.6	54	63	84	70	100	70	200	200	200	–	–	–	140M-CMN-6300

Table 2.S PF700 400/480 Volt AC Input Recommended Protection Devices

Drive Catalog Number	Frame	kW/HP Rating ND	HD	Input Ratings Amps	kVA	Output Amps Cont.	1 Min.	3 Sec.	Dual Element Time Delay Fuse Min.[1]	Max.[2]	Non-Time Delay Fuse Min.[1]	Max.[2]	Circuit Breaker[3] Amps	Motor Circuit Protector[4] Amps	140M Motor Starter with Adjustable Current Range[5][6] Available Catalog Numbers[7]			
400 Volt AC Input																		
20BC1P1	0	0.37	0.25	1.08	0.75	1.3	1.4	1.9	3	3	3	5	15	3	140M-C2E-B16	–	–	–
20BC2P1	0	0.75	0.55	1.7	1.2	2.1	2.4	3.2	3	6	3	8	15	3	140M-C2E-B25	140M-D8E-B25	–	–
20BC3P5	0	1.5	0.75	3.1	2.1	3.5	4.5	6.0	6	8	6	12	15	7	140M-C2E-B40	140M-D8E-B40	–	–
20BC5P0	0	2.2	1.5	4.5	3.2	5.0	5.5	7.5	6	10	6	20	20	7	140M-C2E-B63	140M-D8E-B63	–	–
20BC8P7	0	4	2.2	8.2	5.7	8.7	9.9	13.2	15	17.5	15	30	30	15	140M-C2E-C10	140M-D8E-C10	140M-F8E-C10	–
20BC011	0	5.5	4	11.0	7.6	11.5	13	17.4	15	25	15	45	45	15	140M-C2E-C16	140M-D8E-C16	140M-F8E-C16	–
20BC015	1	7.5	5.5	15.1	10.4	15.4	17.2	23.1	20	30	20	60	60	20	140M-C2E-C20	140M-D8E-C20	140M-F8E-C20	–
20BC022	1	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	–
20BC030	2	15	11	30.3	21.0	30	33	45	40	60	40	120	120	50	–	–	140M-F8E-C32	–
20BC037	2	18.5	15	37.7	26.1	37	45	60	50	80	50	125	125	50	–	–	140M-F8E-C45	–
20BC043	3	22	18.5	44.1	30.6	43	56	74	60	90	60	150	150	80	–	–	–	–
20BC056	3	30	22	57.9	40.1	56	64	86	75	120	75	200	200	80	–	–	–	–
480 Volt AC Input																		
20BD1P1	0	0.5	0.33	0.9	0.7	1.1	1.2	1.6	3	3	3	4	15	3	140M-C2E-B16	–	–	–
20BD2P1	0	1	0.75	1.6	1.4	2.1	2.4	3.2	3	6	3	8	15	3	140M-C2E-B25	–	–	–
20BD3P4	0	2	1.5	2.6	2.2	3.4	4.5	6.0	4	8	4	12	15	7	140M-C2E-B40	140M-D8E-B40	–	–
20BD5P0	0	3	2	3.9	3.2	5.0	5.5	7.5	6	10	6	20	20	7	140M-C2E-C63	140M-D8E-C63	–	–
20BD8P0	0	5	3	6.9	5.7	8.0	8.8	12	10	15	10	30	30	15	140M-C2E-C10	140M-D8E-C10	140M-F8E-C10	–
20BD011	0	7.5	5	9.5	7.9	11	12.1	16.5	15	20	15	40	40	15	140M-C2E-C10	140M-D8E-C10	140M-F8E-C10	–
20BD014	1	10	7.5	12.5	10.4	14	16.5	22	17.5	30	17.5	50	50	20	140M-C2E-C16	140M-D8E-C16	140M-F8E-C16	–
20BD022	1	15	10	19.9	16.6	22	24.2	33	25	50	25	80	80	30	140M-C2E-C25	140M-D8E-C20	140M-F8E-C25	140M-CMN-2500
20BD027	2	20	15	24.8	20.6	27	33	44	35	60	35	100	100	50	–	–	140M-F8E-C32	140M-CMN-4000
20BD034	2	25	20	31.2	25.9	34	40.5	54	40	70	40	125	125	50	–	–	140M-F8E-C45	140M-CMN-4000
20BD040	3	30	25	36.7	30.5	40	51	68	50	90	50	150	150	50	–	–	140M-F8E-C45	140M-CMN-4000
20BD052	3	40	30	47.7	39.7	52	60	80	60	110	60	200	200	70	–	–	–	140M-CMN-6300

[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.

[3] Circuit Breaker - inverse time breaker.

[4] Motor Circuit Protector - instantaneous trip circuit breaker.

[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.

Grounding, General

The drive Safety Ground - PE must be connected to system ground. Ground impedance must conform to the requirements of national and local industrial safety regulations and/or electrical codes. The integrity of all ground connections should be periodically checked.

Figure 2.11   Typical Grounding
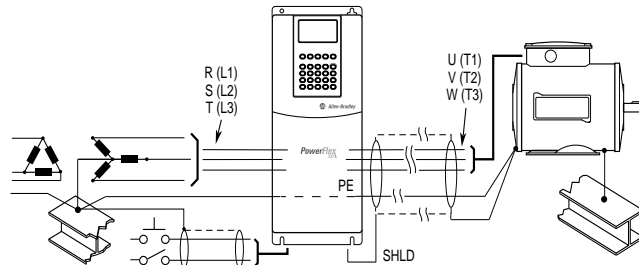
For installations within a cabinet, a single safety ground point or ground bus bar connected directly to building steel should be used. All circuits including the AC input ground conductor should be grounded independently and directly to this point/bar.

Figure 2.12   Single-Point Grounding/Panel Layout

Refer to for an explanation of numbered items.
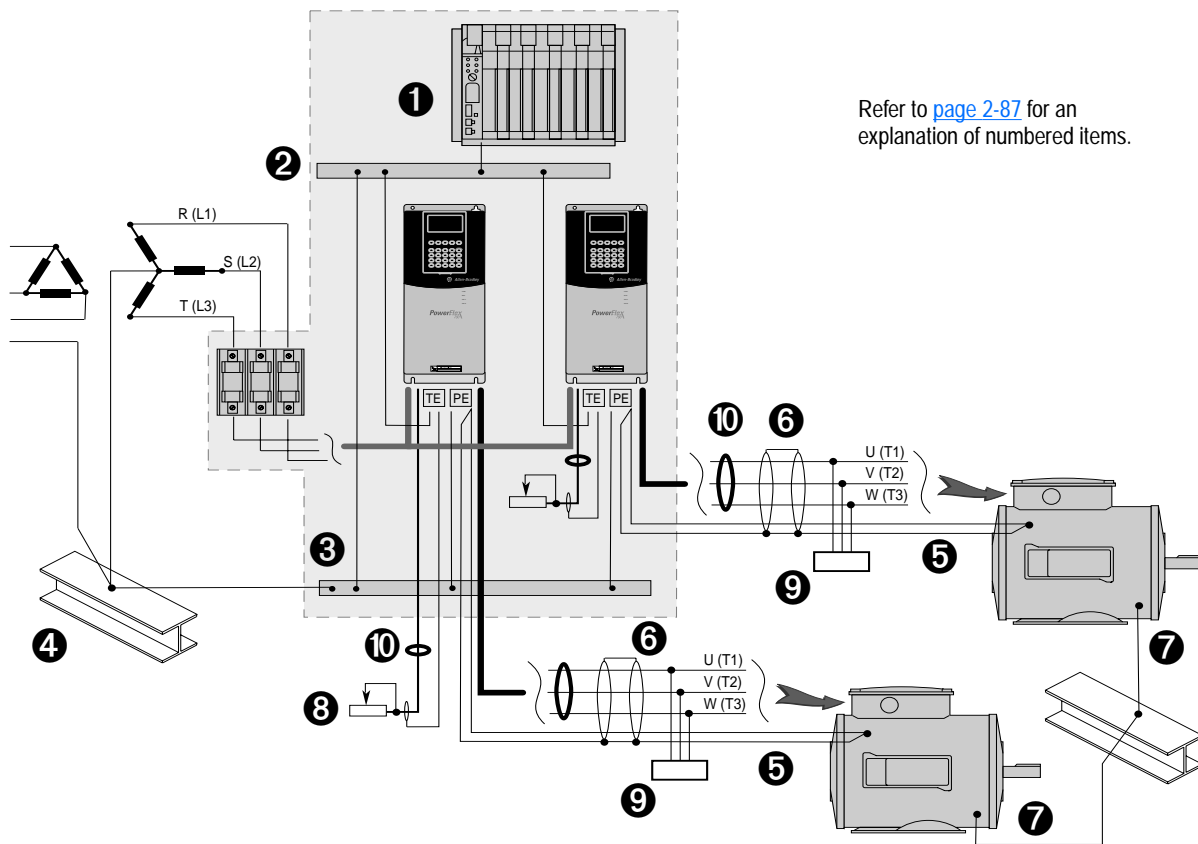
No.	Description	Install as Needed	Notes
1	Programmable Controller		Refer to publication 1770-4.1 for Programmable Controller Grounding Recommendations
2	PE ⏚		Motor ground
3	PE (Safety) - ground bus		PE to bus to building steel
4	Nearest building structure steel		
5	Shield		
6	Additional shield (if required)	✔	
7	Attach to motor frame		Ground per local or national codes
8	Analog signal		
9	Motor Terminator	✔	
10	Common mode core	✔	

Safety Ground - PE

This is the safety ground for the drive that is required by code. This point must be connected to adjacent building steel (girder, joist), a floor ground rod or bus bar (see above). Grounding points must comply with national and local industrial safety regulations and/or electrical codes. A second terminal is provided for the motor ground connection.

Shield Termination - SHLD

The SHLD terminal (located on the Cable Entry Plate) provides a grounding point for the motor cable shield. It must be connected to an earth ground by a separate continuous lead. The **motor cable** shield should be grounded to both the drive Cable Entry Plate (drive end) and the motor frame (motor end).

When shielded cable is used for remote **control and signal wiring**, the shield should be grounded at the source end only, not at the drive.

RFI Filter Grounding

Using an optional RFI filter may result in relatively high ground leakage currents. Therefore, the filter must only be used in installations with grounded AC supply systems and be permanently installed and solidly grounded (bonded) to the building power distribution ground.

Ensure that the incoming supply neutral is solidly connected (bonded) to the same building power distribution ground. Grounding must not rely on flexible cables and should not include any form of plug or socket that would permit inadvertent disconnection. Some local codes may require redundant ground connections. The integrity of all connections should be periodically checked. Refer to the instructions supplied with the filter

HIM Memory

See .
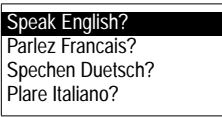
HIM Operations

Selecting a Language

See also . 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).
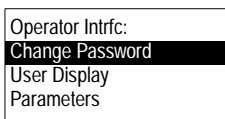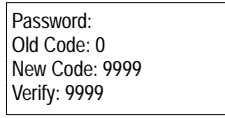
Logging in to the Drive

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.		
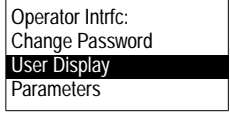
To change a password

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 2-100

Circuit Breakers / Fuses

See Fuses and Circuit Breakers on page 2-83

Filters
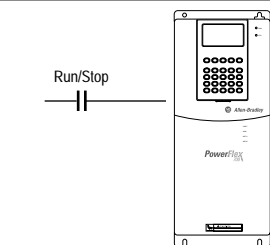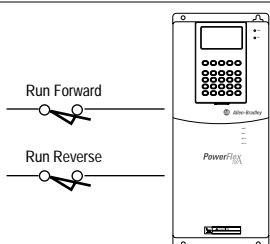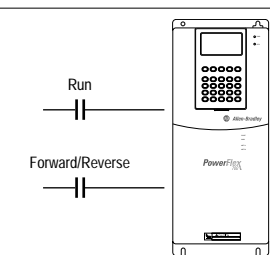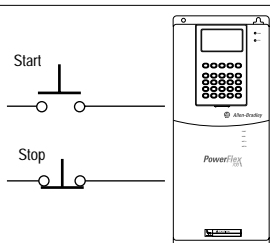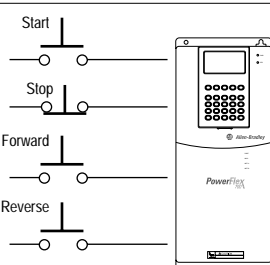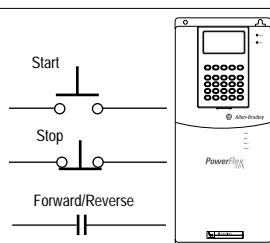
Internal EMC
Refer to CE Conformity on page 2-37.

External EMC
This section is under construction. If further information is required, please contact factory.

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	Run/Stop
	• In other applications, the maintained device (such as a limit switch), can directly control both Run/Stop and direction control . . .	Run Forward Run Reverse
	• Or, a combination of the two may be desirable.	Run Forward/Reverse
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	Start Stop
	• Direction control is accomplished either with momentary inputs . . .	Start Stop Forward Reverse
	• Or, with a maintained input.	Start Stop Forward/Reverse

Input Power Conditioning

In general, the drive is suitable for direct connection to an AC line of the correct voltage. Certain conditions can exist, however, that prompt consideration of a line reactor or isolation transformer ahead of the drive.

The basic rules to aid in determining whether a line reactor or isolation transformer should be considered are as follows:

1. If the source is greater than 6 times the drive kVA then use a reactor or transformer.

2. If the AC source for the drive does not have a ground reference (neutral or phase ground), an isolation transformer with the neutral of the secondary grounded is highly recommended. These products contain PE referenced capacitors for EMC compliance and PE referenced MOV devices for input transient voltage limiting. If the drive must be operated on an ungrounded voltage source, these devices should be disconnected from PE by removing the appropriate jumpers (Refer to *Disconnecting MOVs and Common Mode Capacitors* in the User Manual). Transients occurring on a non-ground referenced voltage source may generate excessive line to ground voltages which could exceed the limits of the insulation system of the drive. Under these conditions, it is highly recommended that a system level transient voltage suppression device be employed in order to limit the potential line to ground voltage.

Figure 2.13   Phase to Ground MOV Removal (PF70)
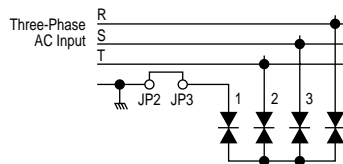
3. Power factor capacitor switching will cause line voltage transients. Characteristics of how the capacitors are switched and the impedance of the distribution system will determine the nature of the voltage transients. If the transients are severe enough and the source impedance as seen by the drive is low enough, nuisance fuse blowing, overvoltage faults or drive power structure damage may occur. Historically if there have been voltage transient issues at the facility where the drive is being applied, the use of a 5% 3 phase reactor or appropriately sized isolation transformer for the drive 3 phase power is recommended.

Jog

Refer to .
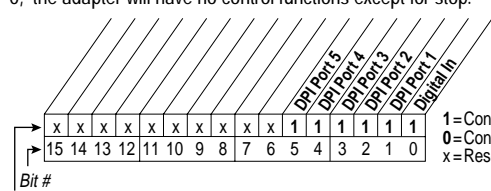
Language

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.

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.

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
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

COMMUNICATION — Masks & Owners

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

0	0	0	0	0	1	0	0

Adapter #   X 6 5 4 3 2 1 0

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 2-104.

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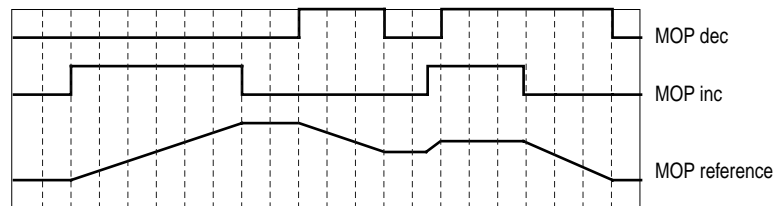
MOP rate is defined in Hz/sec. The MOP reference will increase/decrease linearly at that rate as long as the MOP inc or dec is asserted via TB or DPI port (the MOP inputs are treated as level sensitive).

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:

<u>Bit 0</u>
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.

<u>Bit 1</u>
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 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]

The rated power of the motor may be entered in horsepower or in kilowatts. This parameter determines the units on the following parameter.

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, 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 the Fault Config parameter to zero disables the motor thermal overload. Since the MTO cannot distinguish individual currents in a multimotor application, it is suggested that the MTO be disabled.

The operation of the overload is actually based on three parameters, Motor Nameplate Full Load Amps, Motor Overload Factor, and Motor Overload Hz. Motor nameplate full load amps is multiplied by the motor overload factor to allow the user to move the motor overload protection into the drive overload area (simulating a higher motor service factor) by defining the continuous level of current allowed by the MTO.

Motor Overload Hz is used to allow the user to adjust the response of the MTO to lower motor speeds (lower output frequencies) where a higher degree of protection may be required due to decreased motor cooling.

Motor Overload Curve
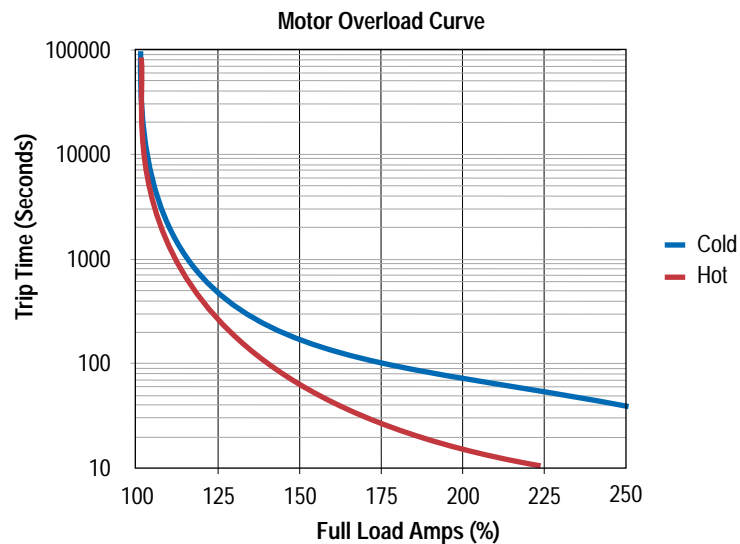
[Motor OL Hz]

[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.

Changing Overload Hz
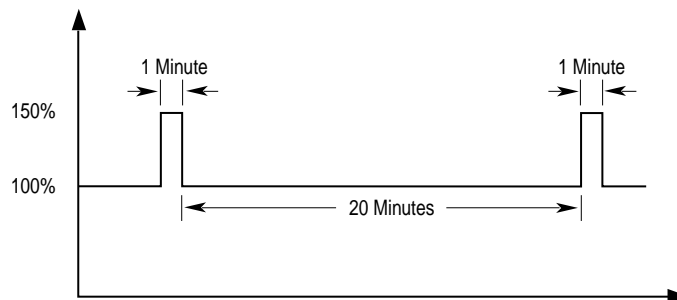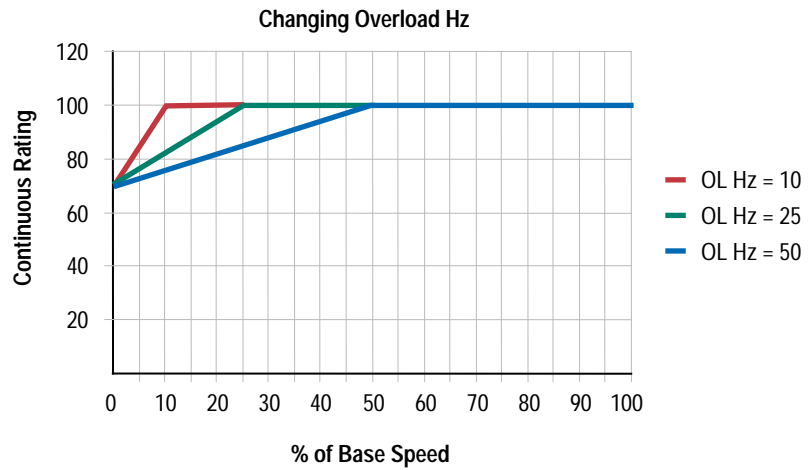
{Motor OL Factor]

[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%.

The effective overload factor is a combination of overload Hz and overload factor.

Changing Overload Factor
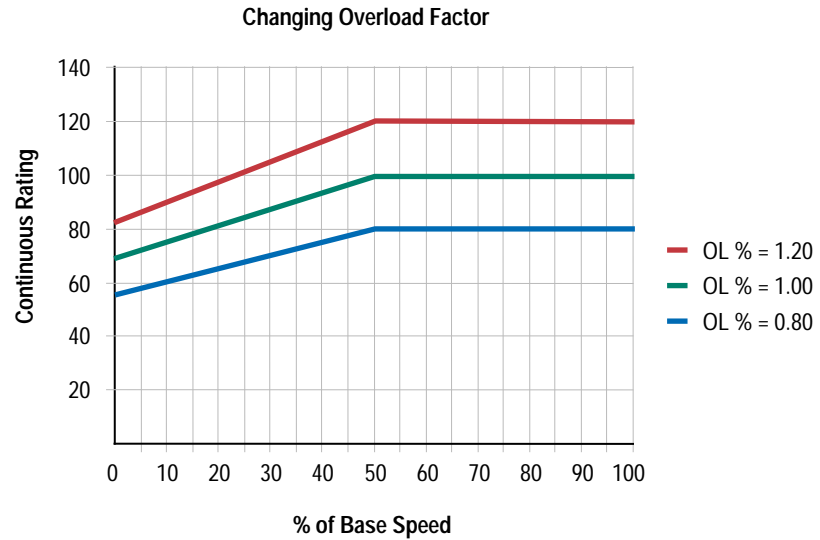
Duty Cycle for the Motor Thermal Overload

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	FLA%	Cold Trip Time	Hot Trip Time	FLA%	Cold Trip Time	Hot Trip Time
105	6320	5995	155	160	50	205	66	14
110	1794	1500	160	142	42	210	62	12
115	934	667	165	128	36	215	58	11
120	619	375	170	115	31	220	54	10
125	456	240	175	105	27	225	51	10
130	357	167	180	96	23	230	48	9
135	291	122	185	88	21	235	46	8
140	244	94	190	82	19	240	44	8
145	209	74	195	76	17	245	41	7
150	180	60	200	70	15	250	39	7

Motor Start/Stop 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 occasionally, an auxiliary contact on that device should also be wired to a digital input programmed as a "Stop" function.

⚠️ **ATTENTION:** The drive start/stop control circuitry includes solidstate 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. When the AC line is removed, there will be a loss of any inherent regenerative braking effect that might be present - the motor will coast to a stop. An auxiliary braking method may be required.

Mounting

Refer to the User Manual for Mounting Clearances. Drive mounting dimensions are presented in .

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 Disconnection

⚠️ **ATTENTION:** Any disconnecting means wired to the drive output terminals U, V and W must be capable of disabling the drive if opened during drive operation. If opened during drive operation, the drive will continue to produce output voltage between U, V, W. An auxiliary contact must be used to simultaneously disable the drive.

Allen-Bradley Drives can be used with an output contactor between the drive and motor. This contactor can be opened under load without damage to the drive. It is recommended, however, that the drive have a programmed "Enable" input and that this input be opened at the same time as the output contactor.

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 . 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 ouput 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 2.14 illustrates a typical Custom V/Hz profile. Minimum Speed is entered in Hertz and determines the lower speed reference limit during normal operation. Maximum Speed is entered in Hertz and determines the upper speed reference limit. The two "Speed" parameters only limit the speed reference and not the output frequency.

The actual output frequency at maximum speed reference is the sum of the speed reference plus "speed adder" components from functions such as slip compensation.

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

Figure 2.14   Typical V/Hz Curve for Full Custom (with Speed/Frequency Limits
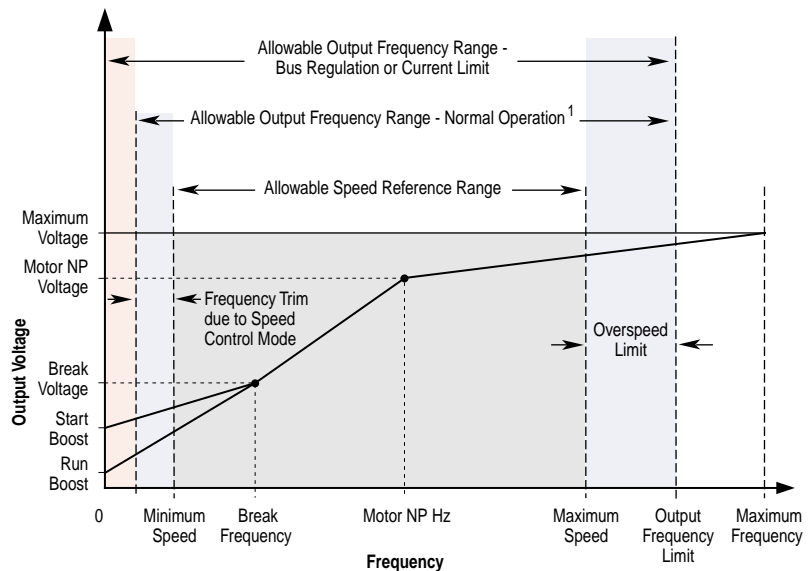
Note 1: The lower limit on this range can be 0 depending on the value of Speed Adder

Owners

An owner is a parameter that contains one bit for each of the possible 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.

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

COMMUNICATIONS	**Masks & Owners**	288	**[Stop Owner]** Adapters that are presently issuing a valid stop command. Bit # 1 = Issuing Command 0 = No Command x = Reserved	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

Some ownership must be **exclusive**; that is, only one Adapter at a time can issue certain commands and claim ownership of that function. 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**.

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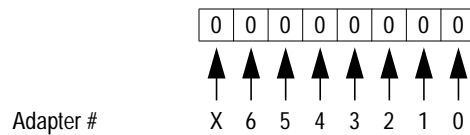
When the local Start button is pressed, the display indicates that the command is coming from the HIM.

Start Owner

0	0	0	0	0	0	1	0

Adapter #   X   6   5   4   3   2   1   0
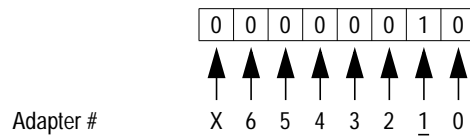
The [Start Owner] indicates that there is not any maintained Start commands causing the drive to run.

Stop Owner

0	0	0	0	0	0	0	1

Adapter #   X   6   5   4   3   2   1   0
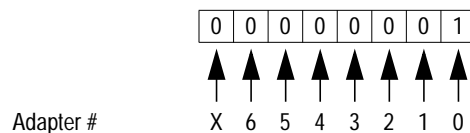
The operator then checks the Stop Owner. Notice that bit 0 is a value of "1," indicating that the Stop device wired to the Digital Input terminal block is open, issuing a Stop command to the drive.

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 <u>Reflected Wave on page 2-127</u>.

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 2.4VDC 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 60VDC 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.T   PF70 Bus Levels

Class	200/240 VAC	400/480 VAC	600/690 VAC
Vslew	1.2 VDC	2.4 VDC	3.0 VDC
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	204 VDC	407 VDC	509 VDC
Voff 3	?	300 VDC	?
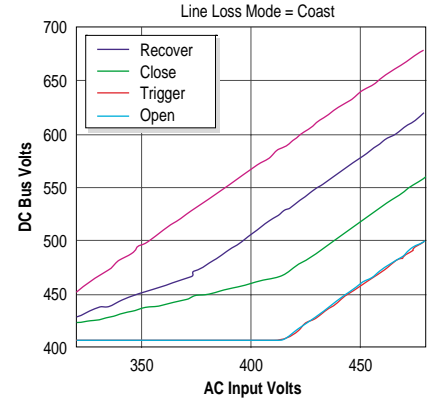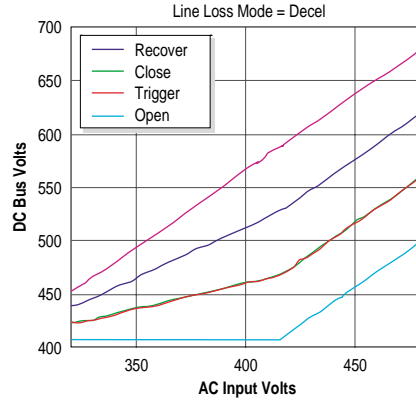
Table 2.U   PF700 Bus Levels

Class	200/240 VAC	400/480 VAC	600/690 VAC
Vslew	1.2 VDC	2.4 VDC	3.0 VDC
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	153 VDC	305 VDC	382 VDC
Vmin	153 VDC	305 VDC	382 VDC
Voff 5	–	200 VDC	–

Note 1:Vtrigger is adjustable, these are the standard values.
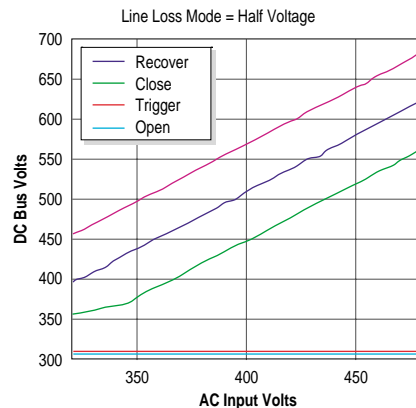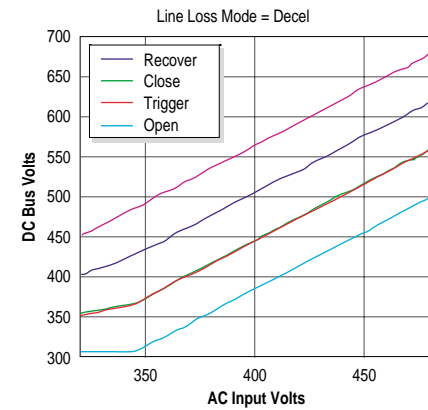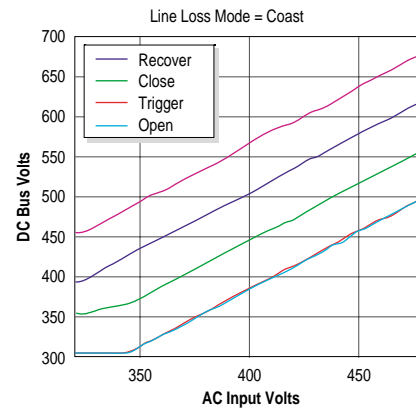
Restart after Power Restoration

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.
- "Inertia" – Decelerate the motor at just the correct rate so that the energy absorbed from the mechanical load balances the losses.
- "Half Voltage" – Allow the drive to power the motor down to half bus voltage.If Parameter #184 [Power Loss Mode] = "Coast"

	184	**[Power Loss Mode]**	Default:	0	"Coast"	013
Power Loss		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".	Options:	0 1 2 3 4	"Coast" "Decel" "Continue" "Coast Input" "Decel Input"	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.

	680V
Bus Voltage	620V
	560V
	500V
	407V
	305V

Motor Speed

Power Loss
Output Enable
Pre-Charge
Drive Fault

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.
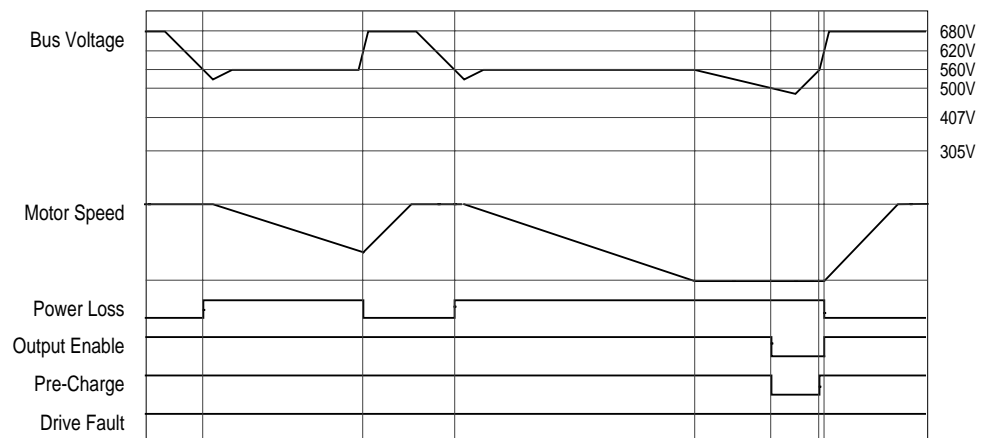
Half Voltage

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.
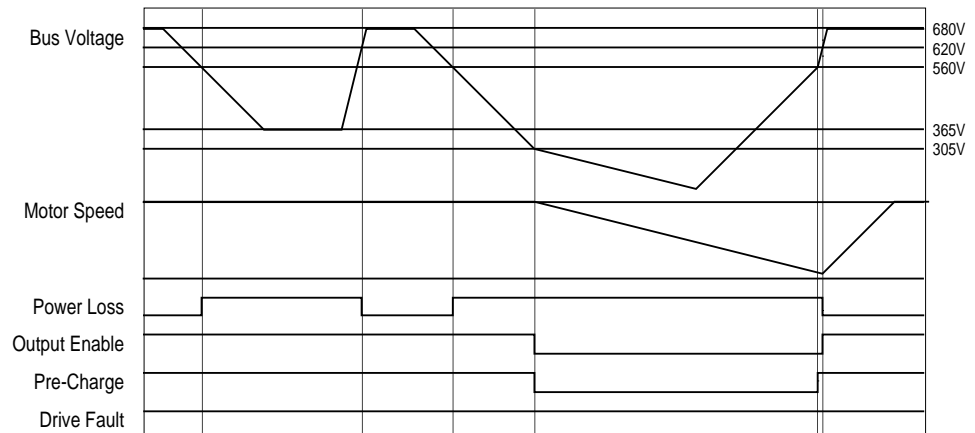
Coast Input   (PowerFlex700 Only)

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 operate.

- 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.
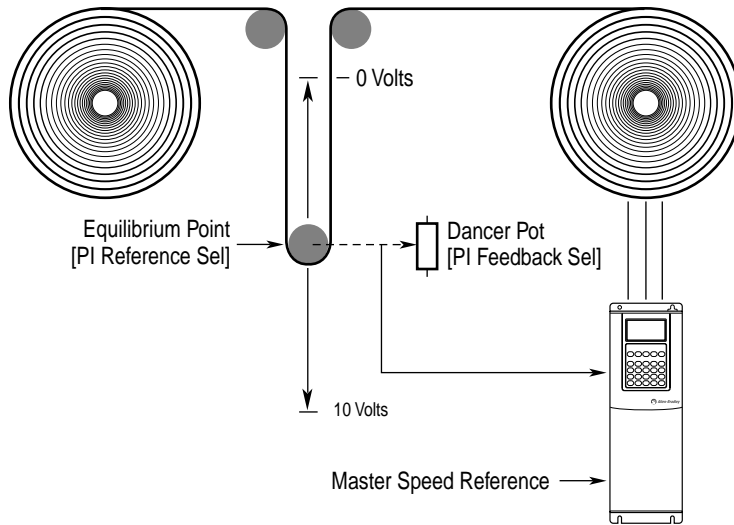
When the PI is disabled the commanded speed is the ramped speed reference.
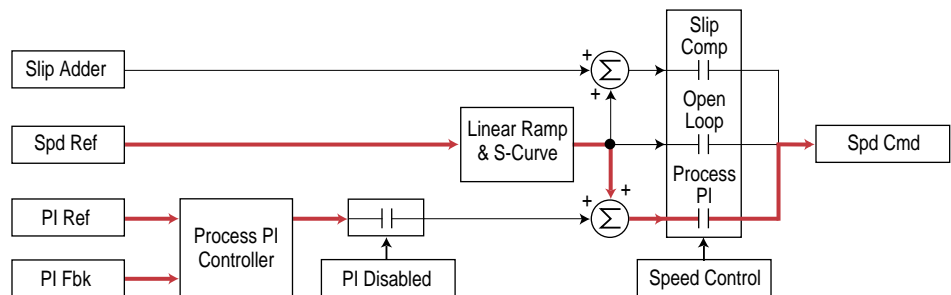
When the PI is enabled, the output of the PI Controller is added to the ramped speed reference.
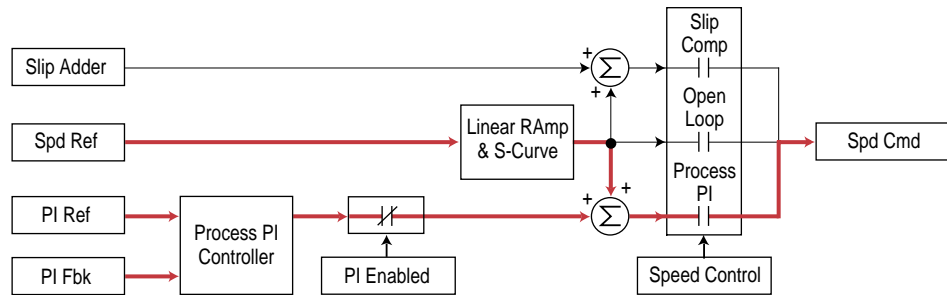
Exclusive Control

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.
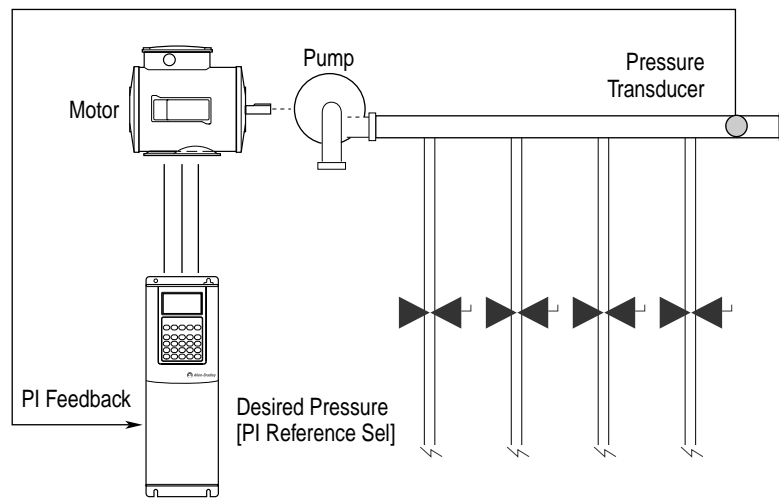
However, when additional valves in the system are opened and the pressure in the system drops, the PI error will alter its output frequency to bring the process back into control.

When the PI is disabled the commanded speed is the ramped speed reference.
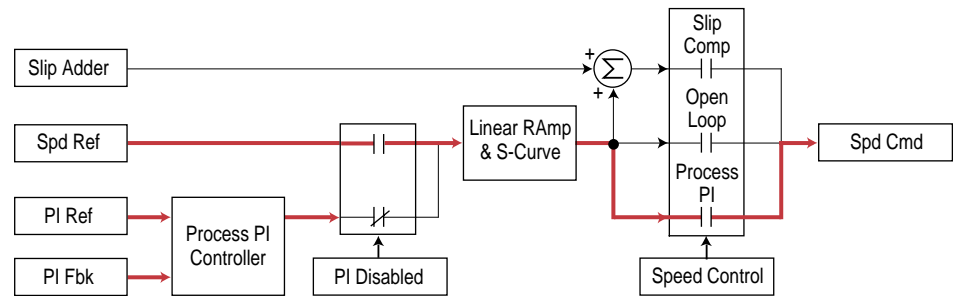
When the PI is enabled, the speed reference is disconnected and PI Output has exclusive control of the commanded speed, passing through the linear ramp and s-curve.
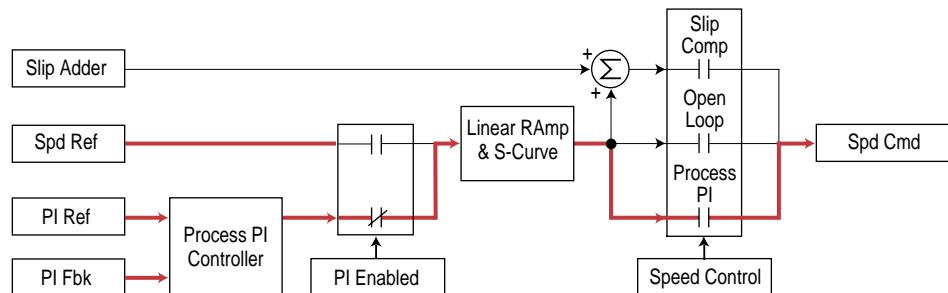
Configuration

To operate the drive in PI regulator Mode, the speed regulation mode must be changed by selecting "Process PI" through the [Speed Control] 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 .

- **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.
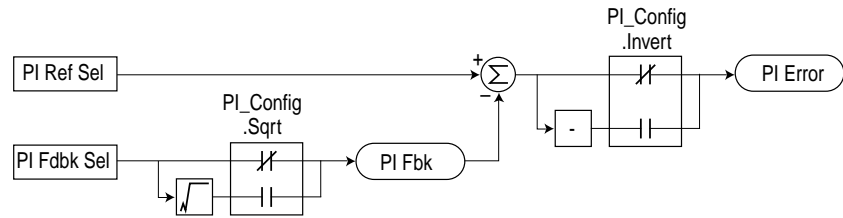
- **Preload Integrator** - This feature allows the PI Output to be stepped to a preload value for better dynamic response when the PI Output is enabled. Refer to diagram 2 below.

  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.
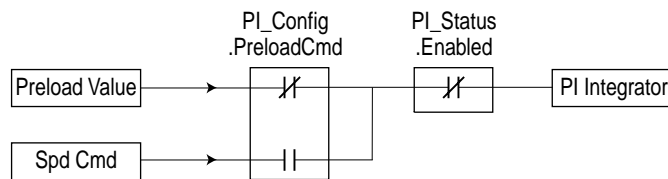
  By default, Pre-load Command is off and the PI Load Value is zero, causing a zero to be loaded into the integrator when the PI is disabled. As below shown on the left, when the PI is enabled the PI output will start from zero and regulate to the required level. When PI is enabled with PI Load Value is 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
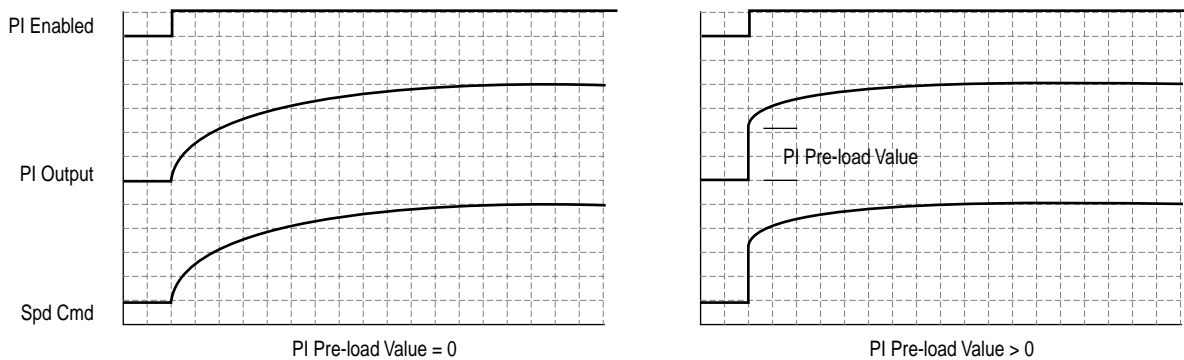
Pre-load command may be used when the PI has exclusive control of the commanded speed. With the integrator preset to the commanded speed there is no disturbance in commanded speed when PI is enabled. After PI is enabled the PI output is regulated to the required level.
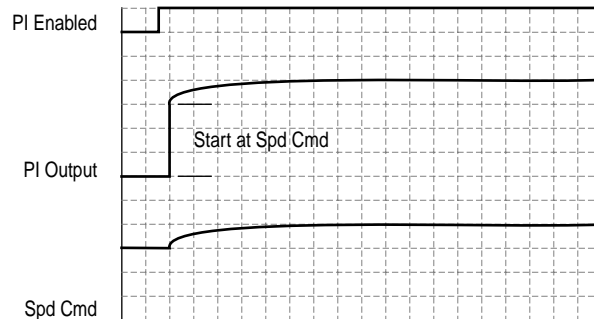
Pre-load to Command Speed

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.

PI_Config
.ZeroClamp

Spd Ref → Linear Ramp & S-Curve → Spd Ramp

PI Ref → Process PI Controller → PI Output

PI Fbk

≥0

+32K / 0 / -32K

Spd Cmd
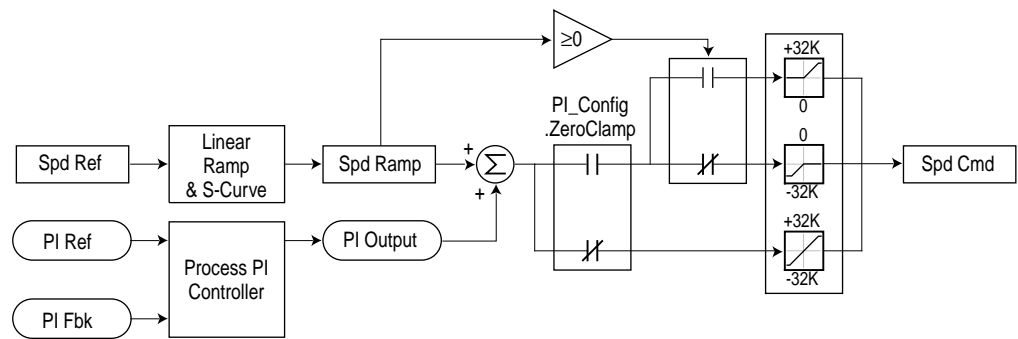
- **Feedback Square Root** - This feature uses the square root of the feedback signal as the PI feedback. This is useful in processes that control pressure, since centrifugal fans and pumps vary pressure with the square of speed.

  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.

Normalized SQRT(Feedback) vs Normalized Feedback
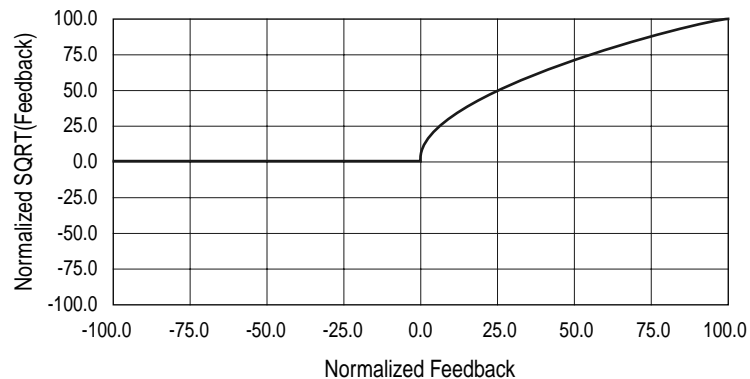
- **Stop Mode (PF700 Only).** When Stop Mode is set to "1" and a Stop command is issued to the drive, the PI loop will continue to operate during the decel ramp. When set to "0" the drive will perform a normal stop.

- **Anti-Wind Up (PF700 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.

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 regulator output can be turned on/off. PI Enabled determines when PI Output is part, or all of the commanded speed. The logic evaluated for PI Enabled is shown in the following ladder diagram.

  The drive must be in run before PI Enabled can turn on. PI Enabled will stay off when the drive is jogged. The PI is disabled when the drive begins a ramp to stop.

  If a digital input is configured to provide PI Enable and that digital input is turned on then PI Enabled may turn on. Note that when a digital input is configured to provide PI Enable that input takes precedence over the PI Control parameter.

  If a digital input is not configured to provide PI Enable and the PI Enable bit in the PI Control parameter is turned on then PI Enabled may turn on. If PI_Control.PI_Enable is left on all the time then the PI may become enabled as soon as the drive goes into run. If analog input signal loss is detected PI Enabled is turned off.
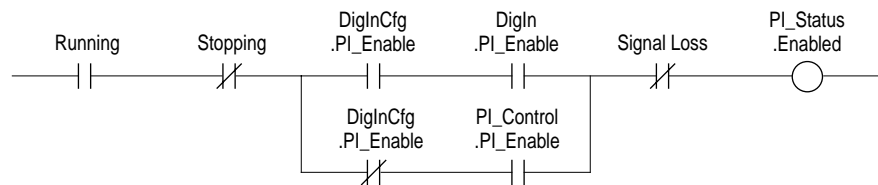
- **PI Hold** - The Process PI Controller has the option to hold the integrator at the current value so if some part of the process is in limit the integrator will maintain the present value to avoid windup in the integrator.

  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.
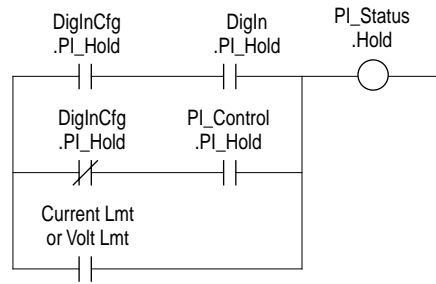
- **PI Reset** – This feature holds the output of the integral function at zero. The term "anti windup" is often applied to similar features. It may be used for integrator preloading during transfer and can be used to hold the integrator at zero during "manual mode". Take the example of a process whose 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.

PF70 options include DPI adapter ports, MOP, preset speeds, analog inputs and PI setpoint parameter. In the PF700, 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 .

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.
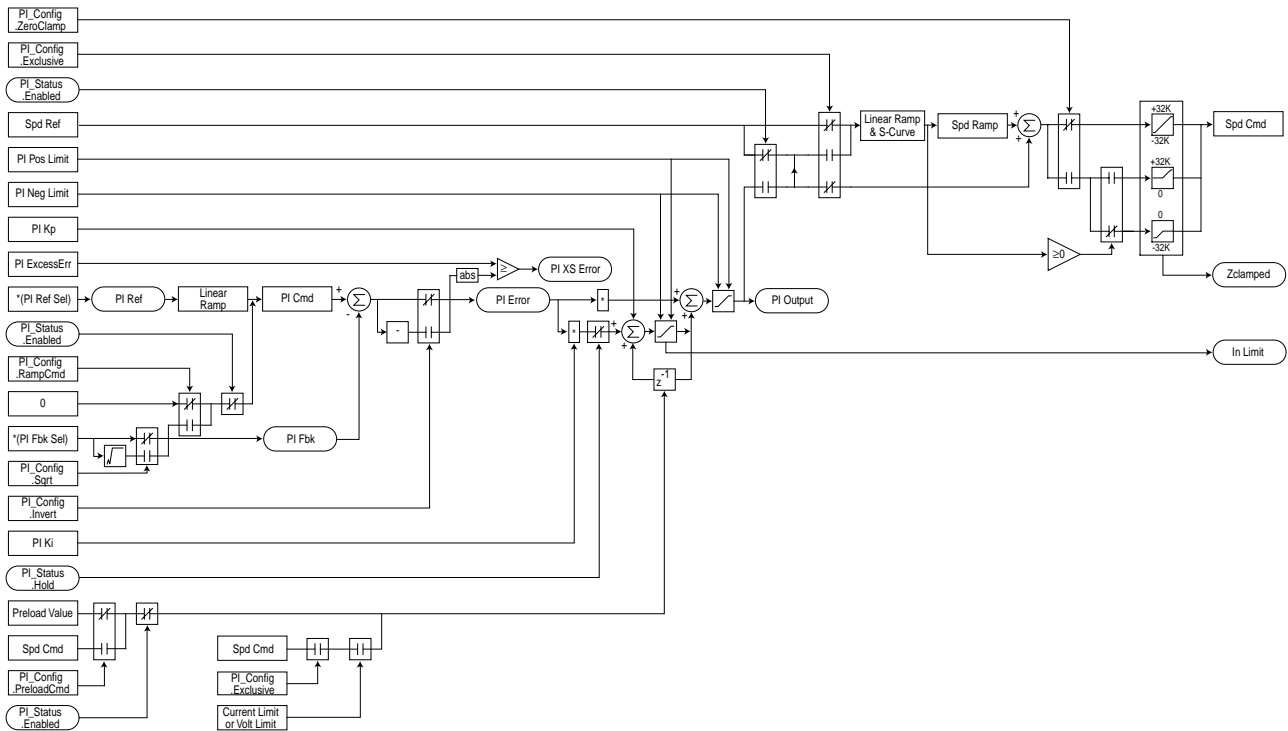
If the application is Process Trim, large trim corrections may not be desirable and the limits would be programmed for smaller values.
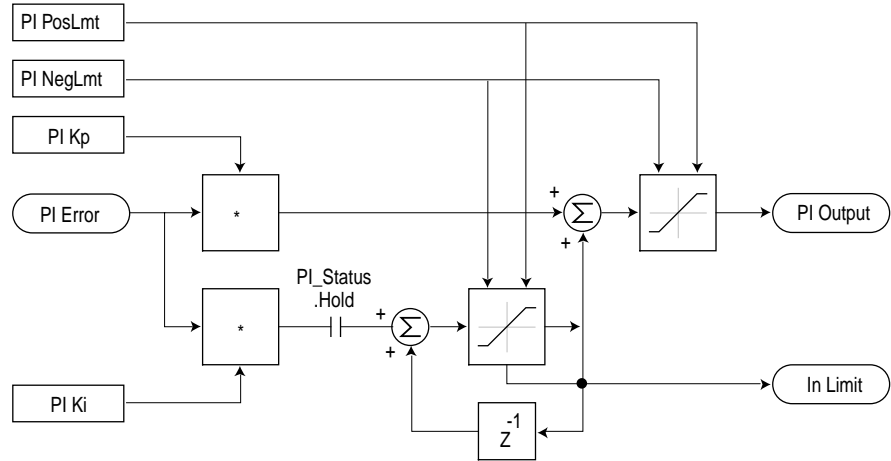
Output Scaling

The output value produced by the PI is displayed as ±100.00. Internally this is represented by ±32767 which corresponds to maximum frequency.

Figure 2.15   Process PI Block Diagram

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 @ 480 V input) result at the motor and can cause motor winding failure.

The patented reflected wave correction software in the PowerFlex 70 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 + 10% High Line = 540V DC bus X 2.25 = 1200 V

480 V Line + 10% High Line = 715V DC bus X 2.25 = 1600 V

600 V Line + 10% High Line = 891V DC bus X 2.25 = 2000 V

(inverter duty grade motor insulation)

The software is standard and requires no special parameters or settings.
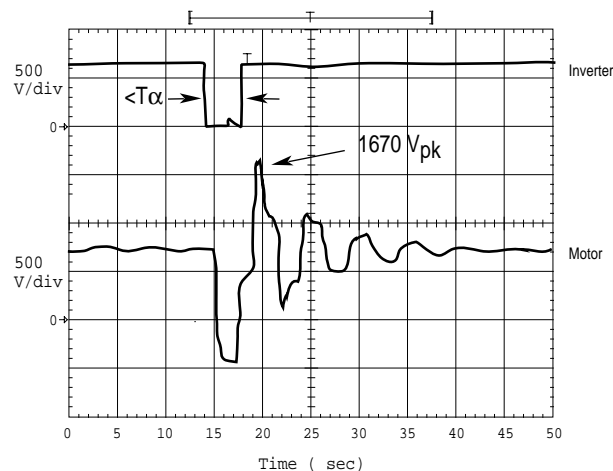
The above figure shows the inverter line-to-line output voltage (top trace) and the motor line-to-line voltage (bottom trace) for a 10 HP, 460V AC inverter, and an unloaded 10 HP AC induction motor at 60 Hz operation. 500 ft. of #12 AWG PVC cable connects the drive to the motor.

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 over-voltage as a function of cable length. This is for no correction versus the modulation correction code for varied lengths of #12 AWG PVC cable to 600 feet for a 4 kHz and 8 kHz carrier frequencies. The output line-to-line voltage was measured at the motor terminals in 100 feet increments.

No Correction vs Correction Method at 4 kHz and 8 kHz Carrier
Frequencies - Vbus = 650, fe = 60 Hz
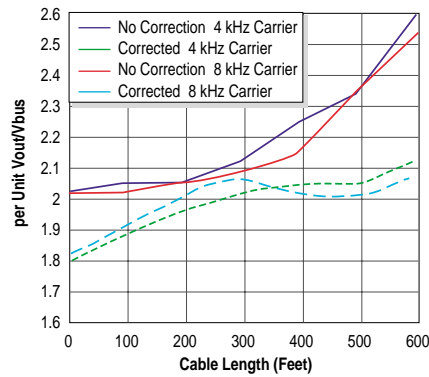
Without the correction, the over-voltage increases to unsafe levels with increasing cable length for both carrier frequencies.

The patented modulation correction code reduces the over-voltage for both carrier frequencies and maintains a relatively flat over-voltage level for increasing cable lengths beyond 300 feet.

Reset Meters

This section is under construction. If further information is required, please contact factory.

Reset Run

Refer to Auto Restart (Reset/Run) on page 2-24.

RFI Filter Grounding

See RFI Filter Grounding on page 2-87

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.
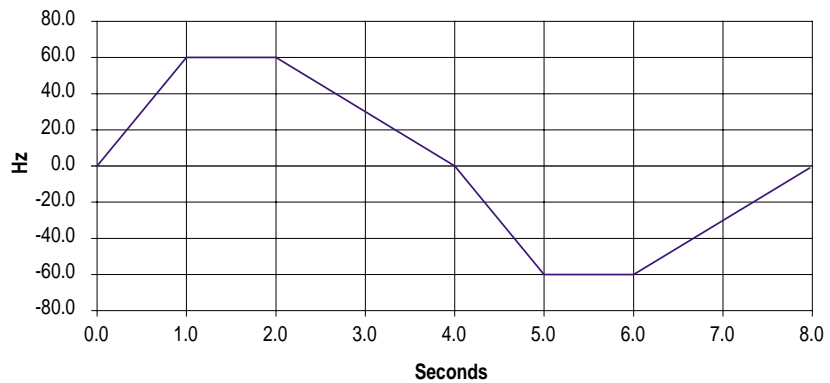

S-Curve Selection

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.
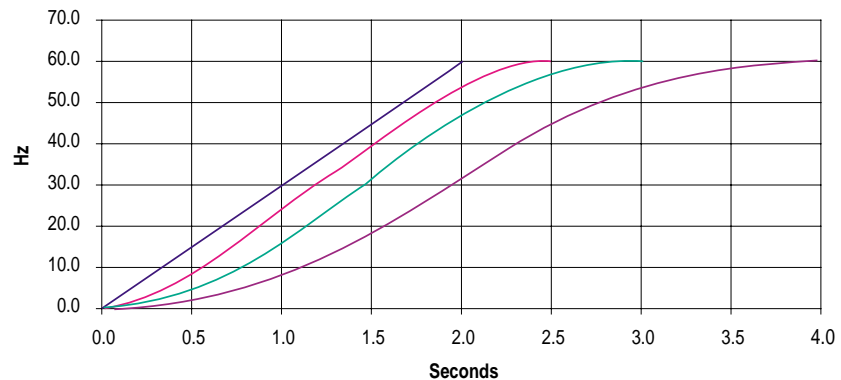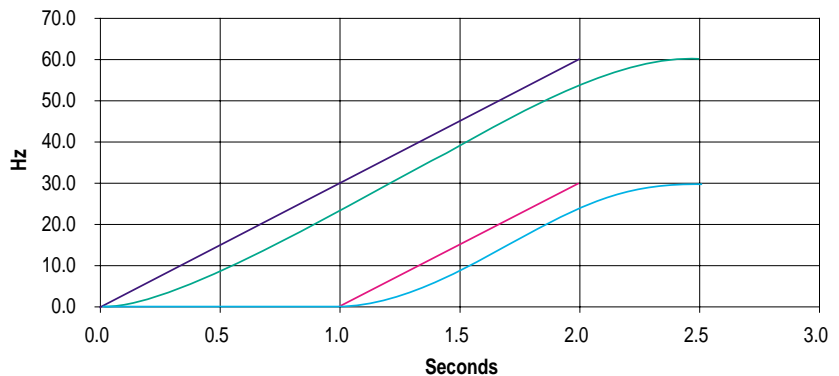
The acceleration and deceleration times are independent but the same S-curve percentage is applied to both of them. With S-curve set to 50%, acceleration time is extended by 0.5 seconds (1.0 * 50%), and deceleration time is extended by 1.0 seconds (2.0 * 50%).
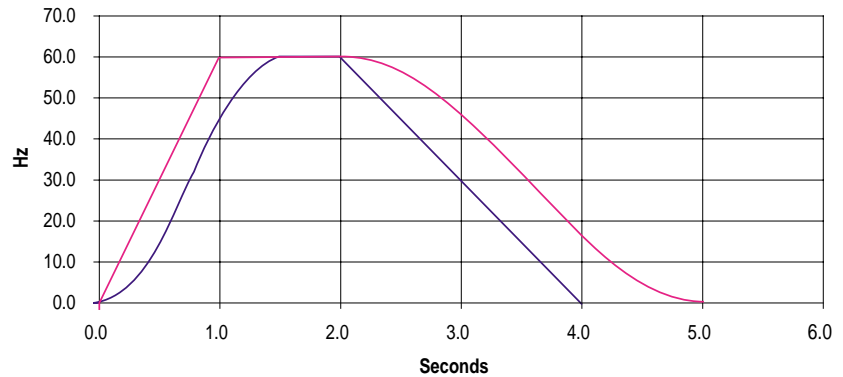

Time to Max Speed

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.
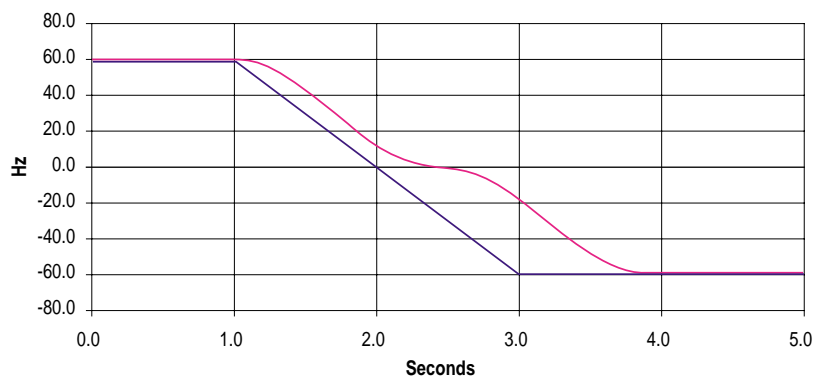
The following graph shows an acceleration time of 1.0 second. After 0.75 seconds, the acceleration time is changed to 6.0 seconds. When the acceleration rate is changed, the commanded rate is reduced to match the requested rate based on the initial S-curve calculation. After reaching the new acceleration rate, the S-curve is then changed to be a function of the new acceleration rate.
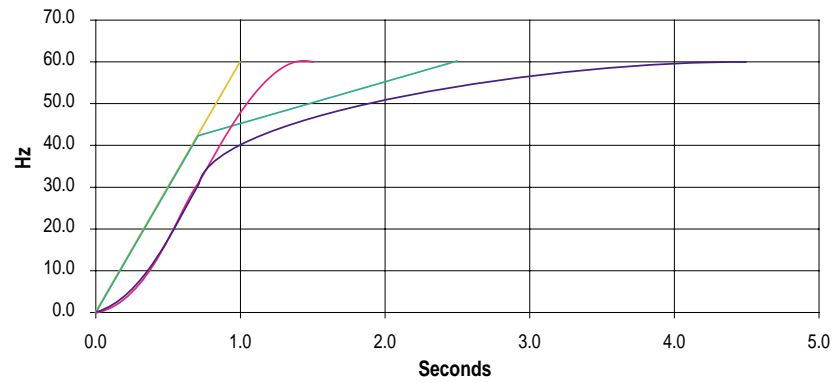
Scaling Blocks

This section is under construction. If further information is required, please contact factory.

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.

									Decel Inhibit	AutRst Tries	Shear Pin	Motor OverLd		UnderVoltage	Power Loss	
x	x	x	x	x	x	x	x	x	1	0	0	1	x	1	0	**1** = Enabled
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	**0** = Disabled

x = Reserved

Bit #
Factory Default Bit Values

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.

	147	**[Current Lmt Sel]**	Default:	0	"Cur Lim Val"	146
⬤		Selects the source for the adjustment of current limit (i.e. parameter, analog input, etc.).	Options:	0 1 2	"Cur Lim Val" "Analog In 1" "Analog In 2"	149

DYNAMIC CONTROL

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.
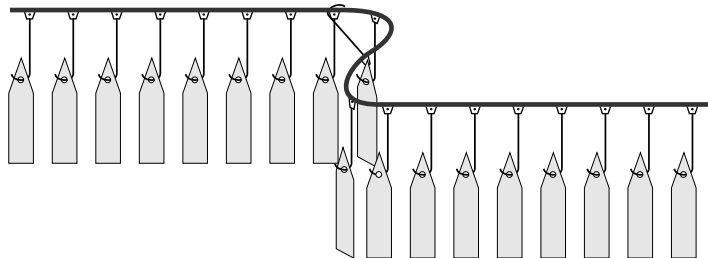
By programming the Shear Pin feature, the user can cause the drive to fault, stopping the excess torque before mechanical damage occurs.
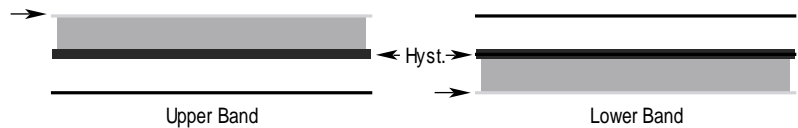
Skip Bands

[Skip Freq 1-3]

The skip band function provides three skip bands that the drive will ramp through but will not continuously run within. The user will be able to set the skip frequency (center frequency) for each band and the skip band centered on the skip frequency. The skip band applies to all three skip frequencies.

The skip band function operates as follows.

1. Greater than or equal to the center frequency and less than or equal to the high value of the band sets the output to the high value of the band. See grayed area of 'Upper Band' below.

2. Less than the center frequency and greater than or equal to the low value of the band, sets the output to the low value of the band. See grayed area of 'Lower Band' below.

3. The skip frequency will have hysteresis so the output does not toggle between high and low values.
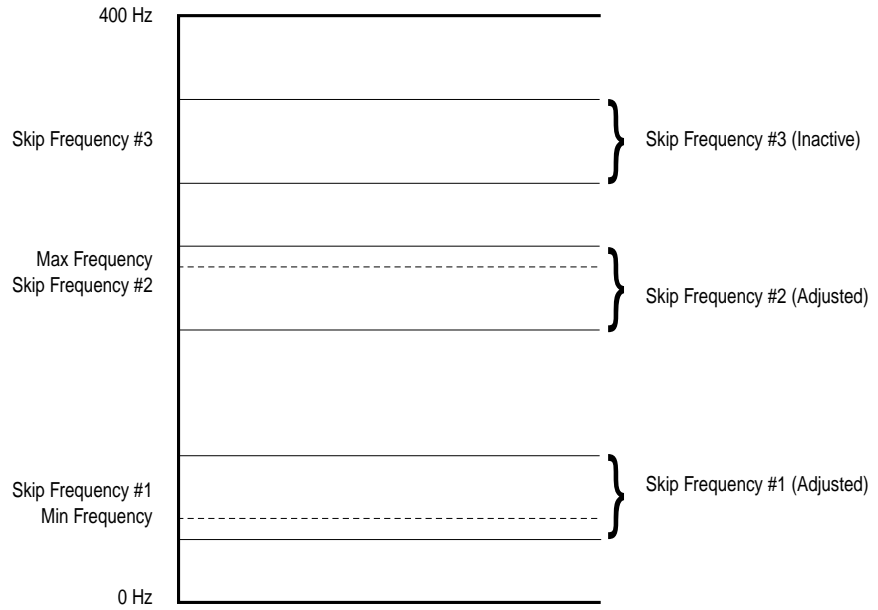

Upper Band   Lower Band

Conditions

If none of the skip bands touch or overlap, each band has its own high/low limit. See example #1 below.

If skip bands overlap or touch, the center frequency is recalculated based on the highest and lowest band values. See example #2 below.
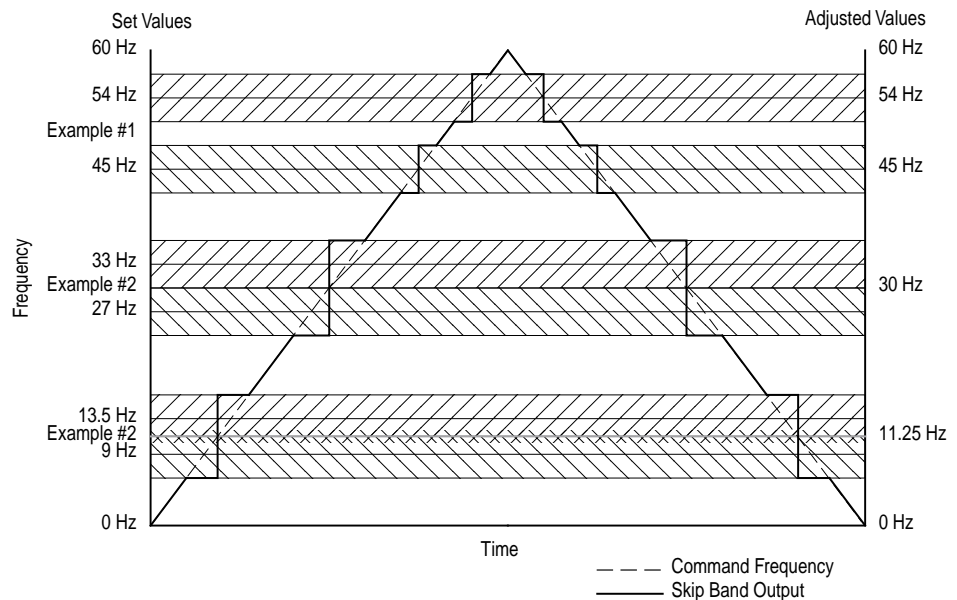
If a skip band(s) extend beyond the max or min limits, the highest or lowest band values, respectively, will be clamped at the limit. The center frequency is recalculated based on the highest and lowest band values. If the band is outside the limits, the skip band is inactive.

```
400 Hz

Skip Frequency #3                                    } Skip Frequency #3 (Inactive)


Max Frequency
Skip Frequency #2                                    } Skip Frequency #2 (Adjusted)



Skip Frequency #1                                    } Skip Frequency #1 (Adjusted)
Min Frequency


0 Hz
```

Disabling
If a skip band is not required, its skip frequency value is set to zero.

Range
The skip bands apply to both forward and reverse directions.

Sleep Mode

The basic operation of this function is to start (wake) the drive when an analog signal is greater than or equal to the user specified [Wake Level], and stop the drive when an analog signal is less than or equal to the user specified [Sleep Level].

Enabling the sleep wake function is accomplished by setting the [Sleep-Wake Mode] parameter to "Direct".

All previously defined permissives (stop, enable, faults, type 2 alarms, etc.) are honored. In addition to the sleep function, at least one of the following assignments must be made to a digital input, and the input must be closed: (Enable, Stop-CF, Run, Run Fwd, Run Rev).

Restarting following a fault condition will be possible by either a rising edge of the timed wake signal or a separate start signal. A wake signal condition will not interfere with the resetting of a fault or restarting of the drive with another signal.

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). Upon power up, timers should be initialized to the state that does not permit a start condition, and then start counting if the analog signal satisfies the level requirement.

Separate start commands are also honored (including a digital input "start"), but only when the sleep timer is not satisfied, essentially acting 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, and

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.

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. 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.
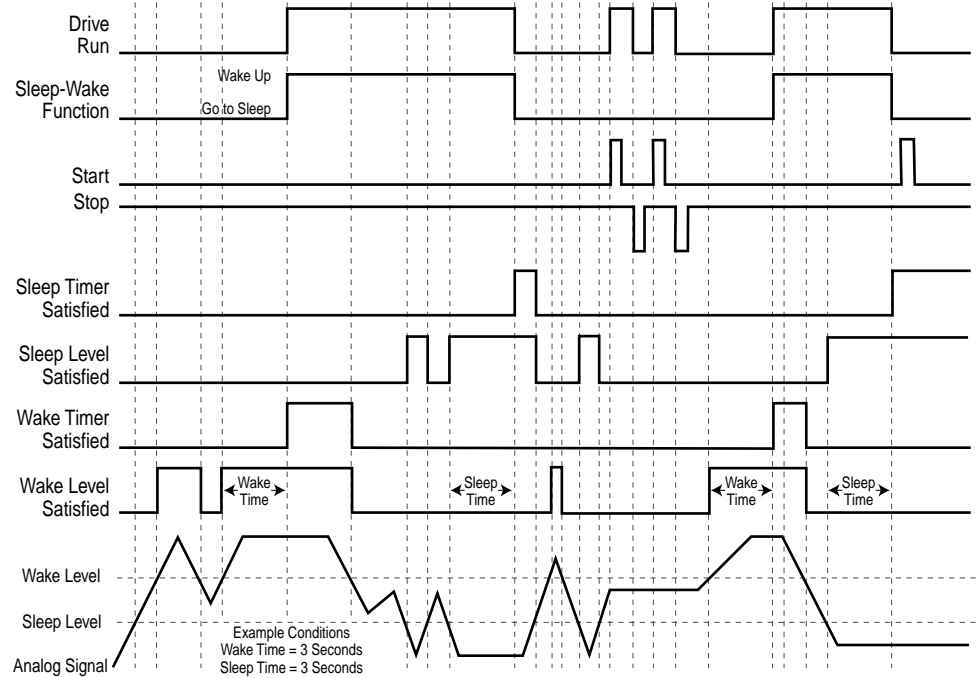
Speed Control Speed Mode Speed Regulation

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. Additional choices are available on the PowerFlex 700 (see):

- 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	**[Speed Mode]**	Default:	0	"Open Loop"	121
	⭘	Sets the method of speed regulation.	Options:	0	"Open Loop"	thru
				1	"Slip Comp"	138
				2	"Process PI"	

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.
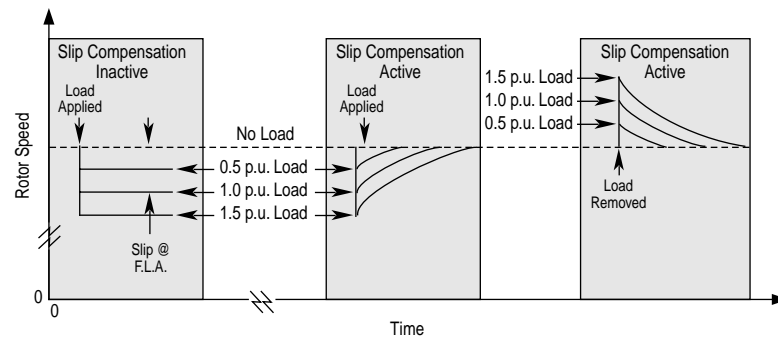
Slip Compensation

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 2.16.

Figure 2.16   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 2.17. 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 2.17   Rotor Speed Response Due to Impact Load and Slip Com Gain
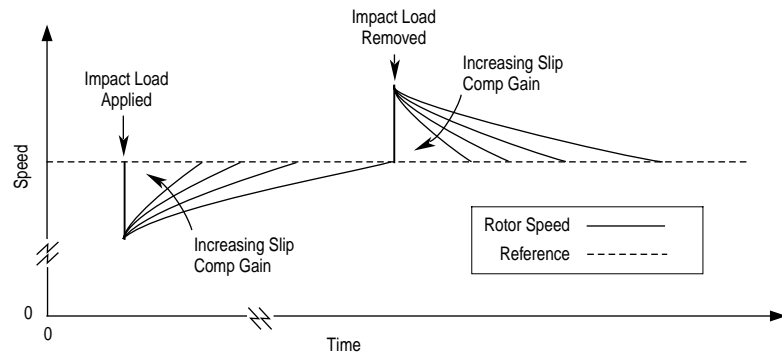
Application Example - Baking Line

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.
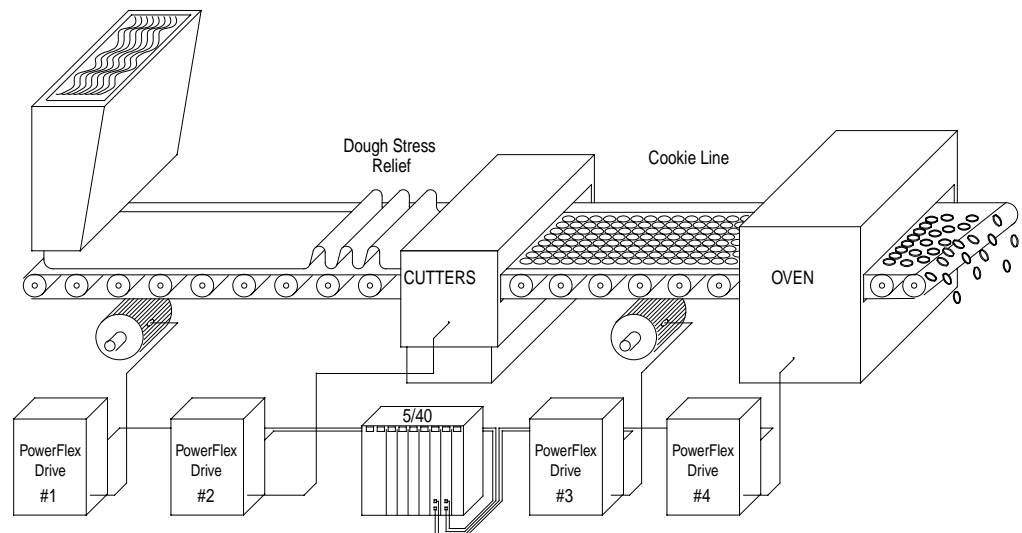
Process PI – *See *

Encoder Feedback *(PowerFlex 700 Only)*

This section is under construction. If further information is required, please contact factory.

Droop *(PowerFlex 700 Only)*

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 increase in motor torque could cause undesirable operation in some process. Typically, if two or more motors are mechanically linked to the same load, this increased torque will cause one motor to assume more of the load and it may set up an unstable "struggle" between motors. In this case, the droop function will decrease the output frequency to maintain a consistent torque level, allowing multiple motors to "share" the work.

Without droop active, as the load increases, the rotor speed decreases creating uneven loading on the motors.

With droop, the correct amount of compensation is deducted from the drive output frequency based on motor load. Thus, the torque level decreases and other motors can share the load. Conversely, when the load is reduced, the rotor speed decreases momentarily until the droop decays to zero.

Application Considerations

The Droop function is enabled by selecting "Droop" as the speed control method in [Speed Control]. The amount of Droop that will be subtracted from the output frequency at full load is determined by the setting of the [Slip @ F.L.A.]. The response of the droop circuit can be adjusted by setting [Slip Comp Gain], 1 being the slowest and 40 the fastest.

The droop feature is used in applications that have two or more motors that are mechanically connected via the load. Each drive must control only one motor for the function to work properly. The control source should supply all of the drives with an identical speed reference. This setup will allow the system load to be shared by each motor.

Application Example - Automotive Chain Conveyor

The above diagram shows a typical example for the Speed Droop feature. The chain conveyor is used to transfer car bodies through the final assembly area. This application is usually a 5-15 HP motor with a 250:1 (typical) gear reduction. Since the motors are mechanically interlocked, they will need to load share. The "take-up" adjusts the tension of the chain but does not directly affect the load of an individual motor. Therefore, the drive must adjust the output frequency based on load changes.
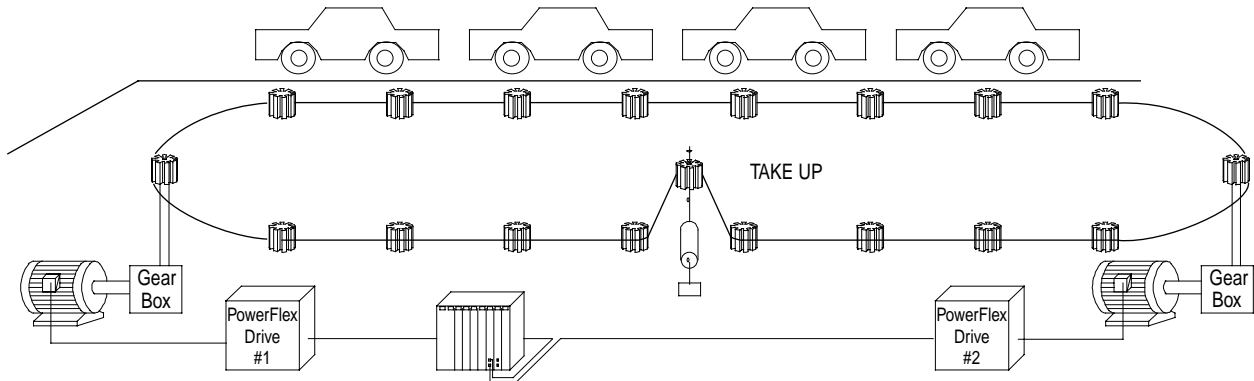
To accomplish this, the PLC or other controller, will control the speed command being sent to the drives. Both drives can be programmed for droop operation. Or the lead drive may be used as the "speed regulator" with the second drive used as a "torque helper" to share the load. The speed regulator will be used to shed the load of an individual motor as the system cycles through the process.When a car is finished and removed from the line, the load on drive #1 will decrease. At this time, another vehicle is added to the conveyor causing drive #2 to see an increase in load. Drive/motor #2 will decrease its output frequency causing more of the load to be taken by drive/motor #1.

Speed Reference

Speed Reference Scaling

[Speed Ref A, B Sel]
[TB Man Ref Sel]

The reference generation function is to provide a reference to the drive. Its purpose is to determine which reference source should be used based on parameters and logic command. Seven references can be selected by logic command. The first two references (A & B) have selectable sources. References A & B can be trimmed by a trim that has selectable sources. The other five are fixed at preset frequencies three to seven. The user will be able to select if the reference is unipolar, which is limited to a positive value and enables the direction bit or bipolar which disables the direction bit allowing the reference sign to command direction. The min and max speed limit the final reference going to the skip band module.

Seven references can be selected through logic command.

Logic command (drive control command) is a bit enumerated parameter, which contains the final command after it has been funneled through a command evaluation module of masks, owners, and transitions. Logic commands come from the terminal block, DPI peripherals, and HIM all at the same time. Logic command could consists of stop, start, jog, accel , decel ,MOP inc/dec, direction, etc. The command evaluation module is not within the scope of this document and will be covered in another document.

The first two references are programmable. The user can select which source they would like for each reference. If an analog input reference or pulse input reference (PowerFlex 700 Only) is chosen, two scale parameters are provide to scale the reference. The scale min/max are based on other parameter (uni/bipolar, analog in config, etc.). See also Analog Inputs for more information.

The last five are fixed references, preset frequencies 3-7.

Reference A & B can be trimmed with a selectable source trim. If an analog input reference or pulse input reference (PowerFlex 700 Only) is chosen, two scale parameters are provide to scale the reference. The trim is a +/– reference which can be set to trim none, A, B, or Both.

Auto / Manual

Many applications require a "manual mode" where adjustments can be made and setup can be done by offering local control of the drive speed. Typically, these adjustments could 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. Also see Auto / Manual on page 2-22.

Trim

[Trim In Sel]

Reference A and Reference B can be trimmed with a selectable source. The trim is an input signal value (+/-) which ia added to the reference. If an analog input is chosen as the trim source, two scale parameters are provide to scale the trim signal.

The choices for Trim source select are:

- LED HIM
- DPI Peripheral 1 (LCD HIM)
- DPI Peripheral 2 - 5
- MOP
- Preset Speed 1 - 7
- Analog Input 1 - 2
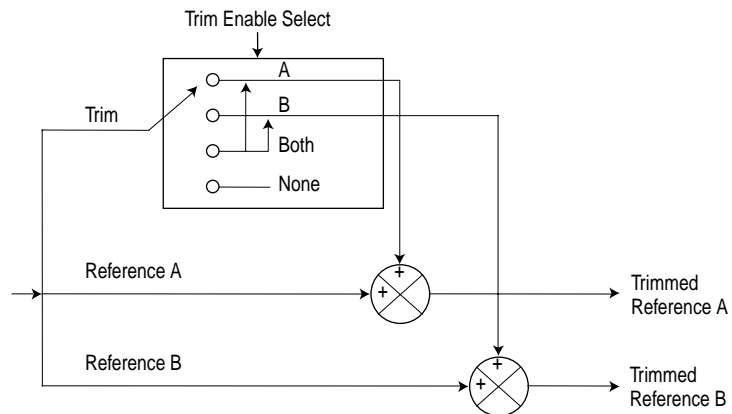
Min / Max Speed

[Max Speed]

Max and min speed limits are applied to the reference. These limits apply to the positive and negative references. The min 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 min speeds. If the reference is positive and less than the positive min, it is set to the positive min. If the reference is negative and greater than negative min, it is set to the negative min. If min is not 0, hysteresis is applied at 0 to prevent bouncing between positive and negative mins. See below.
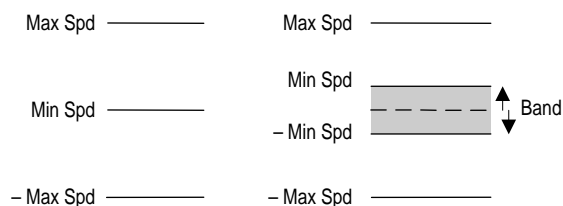
Follower/Leader

This section is under construction. If further information is required, please contact factory.

HIM Speed Reference

This section is under construction. If further information is required, please contact factory.

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.

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 2-148.

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.

Basic Start Up (Top Level)

HIM

Main Menu:
<Diagnostics>
Parameter
Device Select
Memory Storage
StartUp
Preferences

Startup

Drive active? — Yes →

0-2

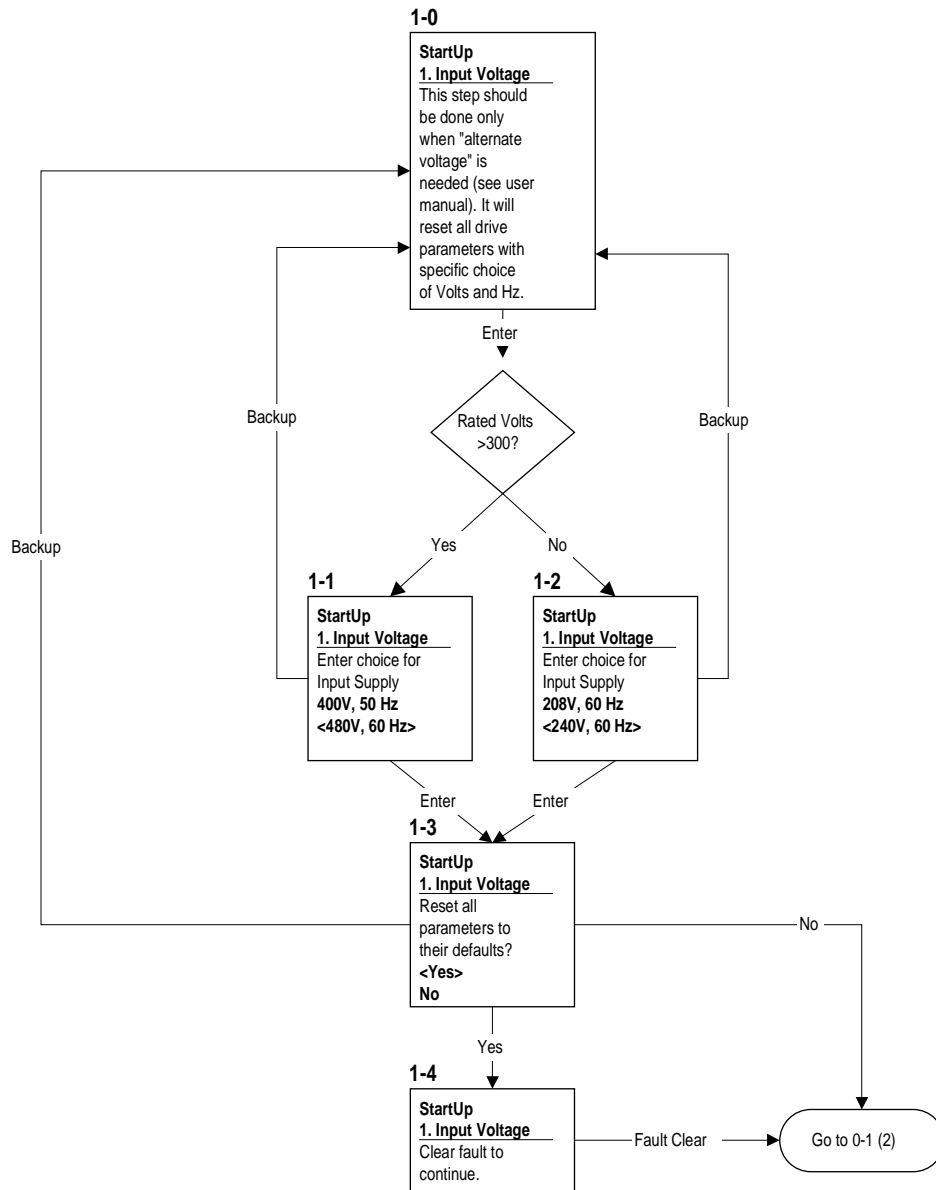PowerFlex 70
StartUp .
The drive must
be stopped to
proceed. Press
Esc to cancel.

Esc

Abort

Any state

'Esc' key

No

Stop

Startup
previously
aborted? — Yes →

0-3

PowerFlex 70
StartUp .
Make a selection
Abort
<Backup>
Resume
StartUp Menu

Resume → Go to previous state

Backup → Go to Backup screen for previous state

7. Done
/Exit

No

0-0

PowerFlex 70
StartUp .
This routine is
to help setup a
drive for basic
applications.
Parameter access
through other
menus may be
necessary to
setup advanced
features.

Backup

Enter

0-1

PowerFlex 70
StartUp .
Complete these
steps in order:
1. Input Voltage
2. Motr Dat/Ramp
3. Motor Tests
4. Speed Limits
5. Speed Control
6. Strt,Stop,I/O
7. Done / Exit

Startup Menu

1. Input Voltage → Go to 1-0

2. Motor Dat/Ramps → Go to 2-0

3. Motor Tests → Go to 3-0

4. Speed Limits → Go to 4-0

5. Speed Control → Go to 5-0

6. Strt,Stop, I/O → Go to 6-0

Basic Start Up (Input Voltage)

1-0

StartUp
1. Input Voltage
This step should be done only when "alternate voltage" is needed (see user manual). It will reset all drive parameters with specific choice of Volts and Hz.

Enter

Rated Volts >300?

Backup   Backup

Backup

Yes   No

1-1

StartUp
1. Input Voltage
Enter choice for Input Supply
400V, 50 Hz
<480V, 60 Hz>

1-2

StartUp
1. Input Voltage
Enter choice for Input Supply
208V, 60 Hz
<240V, 60 Hz>

Enter   Enter

1-3

StartUp
1. Input Voltage
Reset all parameters to their defaults?
<Yes>
No

No

Yes

1-4

StartUp
1. Input Voltage
Clear fault to continue.

Fault Clear   Go to 0-1 (2)

Basic Start Up (Motor Data/Ramp)

2-0

StartUp
2. Motr Dat/Ramp
Use motor name-
plate data and
required ramp
times for the
following steps.

Enter

2-1

StartUp
2. Motr Dat/Ramp
Enter choice for
Mtr NP Pwr Units

Enter

2-2

StartUp
2. Motr Dat/Ramp
Enter value for
Motor NP Power
123.4 kW
xxx.x <> yyy.y

Enter

2-3

StartUp
2. Motr Dat/Ramp
Enter value for
Motor NP FLA
+456.78 Amps
xxx.xx <> yyy.yy

Enter

2-4

StartUp
2. Motr Dat/Ramp
Enter value for
Motor NP Volts
123.4 Volt
xxx.x <> yyy.y

Enter

2-5

StartUp
2. Motr Dat/Ramp
Enter value for
Motor NP Hertz
60.0 Hz
x.x <> y.y

Enter

2-6

StartUp
2. Motr Dat/Ramp
Enter value for
Motor NP RPM
+456 RPM
xxx <> yyy

2-7

StartUp
2. Motr Dat/Ramp
Enter choice for
Stop Mode A

Backup

Enter

Stop Mode A
= "DC Brake" or
"Ramp to
Hold"?

Backup

No →

Yes

2-8

StartUp
2. Motr Dat/Ramp
Enter value for
DC Brake Level
1.0 Amps
0.0 < 30.0 Amps

Backup

Enter

Stop Mode A
= "DC
Brake"?

No

Yes

2-9

StartUp
2. Motr Dat/Ramp
Enter value for
DC BrakeTime
1.0 Secs
0.0 < 90.0 Secs

Enter

Enter

2-10

StartUp
2. Motr Dat/Ramp
Enter choice for
DB Resistor Type
None
Internal
External

None - Bus Reg Mode A = Adj Freq.
Intenal - Bus Reg Mode A = Both, DB 1st.
External - Bus Reg Mode A = Both, DB 1st.

Enter

2-11

StartUp
2. Motr Dat/Ramp
Enter value for
Accel Time 1
6.0 Secs
0.0 < 60.0 secs

Enter

2-12

StartUp
2. Motr Dat/Ramp
Enter value for
Decel Time 1
6.0 Secs
0.0 < 60.0 secs

Enter

2-13

StartUp
2. Motr Dat/Ramp
Enter value for
S Curve %
0 %
0 < 100 %

Enter → Go to 0-1 (3)

Backup

Basic Start Up (Motor Tests)

3-0

Startup
3. Motor Tests
This section optimizes torque performance and tests for proper direction.

— Enter →

3-1

Startup
3. Motor Tests
Complete these steps in order:
<A. Auto Tune>
B. Directn Test
C. Done

— Done → (Go to 0-1 (4))

Auto Tune

3-2

Startup
A. AutoTune
Rotate Tune only with no load and low friction. Static Tune when load or friction are present.

Enter

3-3

Startup
A. AutoTune
Make a selectioon
<Rotate Tune>
Static Tune

Static Tune   Rotate Tune

3-8

Startup
A. Auto Tune.
Static Tune will energize motor with no shaft rotation. Press Start to begin.

3-9

Startup
A. Auto Tune
Rotate Tune will energize motor, then cause shaft rotation. Press Start to begin.

3-12

Startup
3. Motor Tests
Test aborted due to user stop. Clear fault to continue.

Enter/Backup

Fault Clear

Direction Test

3-4

Startup
B. Directn Test
Press Jog or Start to begin.

Start

3-5

Startup
B. Directn Test
Is direction of motor forward?
<Yes>
No

Yes (stops drive)   No (stops drive)

Enter/Backup

3-6

Startup
B. Directn Test
Test complete.

3-7

Startup
B. Directn Test
Press Enter. Then power down and swap 2 output wires to motor.

Start   Start

3-10

Startup
A. Auto Tune
Executing test. Please wait....

Stop or Esc (stops drive)

— Fault →

Rotate/Static Tune complete (stops drive)

3-11

Startup
A. Auto Tune
Test complete.

3-13

Startup
3. Motor Tests
Test aborted! Clear the fault. Check motor data settings. Verify load is removed.

Enter/Backup

Basic Start Up (Speed Limits)

4-0

StartUp
4. Speed Limits
This section
defines min/max
speeds, and
direction method

Enter

4-1

StartUp
4. Speed Limits
Disable reverse
operation?
Yes
<No>

4-2

StartUp
4. Speed Limits
Enter choice for
Direction Method
<Fwd/Rev Command>
+/- Speed Ref

No

Yes

Enter

4-3

StartUp
4. Speed Limits
Enter value for
Maximum Speed
+60.00 Hz
xxx.xx <> yyy.yy

Backup

Enter

MaxSpd + OSL
> MaxFreq?

No

Backup

Yes

4-4

StartUp
4. Speed Limits
Enter value for
Minimum Speed
+5.78 Hz
xxx.xx <> yyy.yy

Enter

Go to 0-1 (5)

4-5

StartUp
4. Speed Limits
Maximum Freq and
Overspeed Limit
will be changed
to support your
Maximum Speed.

Enter

OS Limit =
MaxFreq - MaxSpd

4-6

StartUp
4. Speed Limits
Rejecting this
change will
prevent starting
Accept
Reject

Reject

MaxFreq = MaxSpd
+ OS Limit

MaxFreq = 400Hz

Accept

MaxSpd + OS
Lmt > 400Hz?

No

Yes

Basic Start Up (Speed Control)

5-0

StartUp
5. Speed Control
This section
defines a source
from which to control
speed.

— Enter →

5-1

StartUp
5. Speed Control
Enter choice for
Speed Control
<Analog Input>
Comm Adapter
Local HIM-Port 1
Remote HIM
Preset Speeds
MOP

Adapter →

MOP →

Analog Input →

Local HIM-Port 1

5-13

StartUp
5. Speed Control
Enter choice for
Input Signal
Analog Input 1
Analog Input 2

5-2

StartUp
5. Speed Control
Enter choice for
Comm Adapter
Port 5-internal
Port 2-external
Port 3-external

Enter ↓

Go to 0-1 (6)

Enter ↓

5-3

StartUp
5. Speed Control
Enter choice for
Remote HIM
Port 2 (common)
Port 3

Remote
HIM

Preset
Speeds

Local HIM-
Port 1

Go to 0-1 (6)

5-14

StartUp
5. Speed Control
Digital   Inputs
5 & 6 will be
set to MOP Inc &
MOP Dec.

Enter ↓

5-15

StartUp
5. Speed Control
Save MOP speed
at power down ?
<Yes>
No

Enter ↓

5-16

StartUp
5. Speed Control
Save MOP speed
at stop ?
<Yes>
No

Enter ↓

5-17

PF70 StartUp
5. Speed Control
Enter value for
MOP Rate
5.0 Hz
xx.x < yy.y

Enter →

Go to 0-1 (6)

Analog Input 1

Analog Input 2

5-18

StartUp
5. Speed Control
Enter choice for
Signal Type
Voltage
Current

Enter ↓

5-19

StartUp
5. Speed Control
The next two
parameters link
a high speed
with a high
analog value.

Enter ↓

5-20

StartUp
5. Speed Control
Enter value for
Analog In 1 Hi
10.0 V
xxx.x < yyy.y

Enter ↓

5-21

StartUp
5. Speed Control
Enter value for
Speed Ref A Hi
60.0 Hz
xxx.x < yyy.y

Enter ↓

5-22

StartUp
5. Speed Control
The next two
parameters link
a low speed
with a low
analog value.

Enter ↓

5-23

StartUp
5. Speed Control
Enter value for
Analog In 1 Lo
0.0 V
xxx.x < yyy.y

Enter ↓

5-24

StartUp
5. Speed Control
Enter value for
Speed Ref A Lo
0.0 Hz
xxx.x < yyy.y

5-25

StartUp
5. Speed Control
Enter choice for
Signal Type
Voltage
Current

Enter ↓

5-26

StartUp
5. Speed Control
The next two
parameters link
a high speed
with a high
analog value.

Enter ↓

5-27

StartUp
5. Speed Control
Enter value for
Analog In 2 Hi
10.0 V
xxx.x < yyy.y

Enter ↓

5-28

StartUp
5. Speed Control
Enter value for
Speed Ref A Hi
60.0 Hz
xxx.x < yyy.y

Enter ↓

5-29

StartUp
5. Speed Control
The next two
parameters link
a low speed
with a low
analog value.

Enter ↓

5-30

StartUp
5. Speed Control
Enter value for
Analog In 2 Lo
0.0 V
xxx.x < yyy.y

Enter ↓

5-31

StartUp
5. Speed Control
Enter value for
Speed Ref A Lo
0.0 Hz
xxx.x < yyy.y

Enter →

5-11

StartUp
5. Speed Control
Note: Factory default
settings
provide preset
speed operation
from the digital
inputs, unless
you change
their function.

Enter ↓

5-12

StartUp
5. Speed Control
Make a selection   .
<Preset Speed 1>
Preset Speed 2
Preset Speed 3
Preset Speed 4
Preset Speed 5
Preset Speed 6
Preset Speed 7
Done

Done →

Enter →

Enter/
Backup

Preset
Speed 1

Preset
Speed 2

Preset
Speed 3

Preset
Speed 4

Preset
Speed 5

Preset
Speed 6

Preset
Speed 7

5-4

StartUp
5. Speed Control
Enter value for
Preset Speed 1
5.0 Hz
xxx.x < yyy.y

5-5

StartUp
5. Speed Control
Enter value for
Preset Speed 2
10.0 Hz
xxx.x < yyy.y

5-6

StartUp
5. Speed Control
Enter value for
Preset Speed 3
15.0 Hz
xxx.x < yyy.y

5-7

StartUp
5. Speed Control
Enter value for
Preset Speed 4
20.0 Hz
xxx.x < yyy.y

5-8

StartUp
5. Speed Control
Enter value for
Preset Speed 5
25.0 Hz
xxx.x < yyy.y

5-9

StartUp
5. Speed Control
Enter value for
Preset Speed 6
30.0 Hz
xxx.x < yyy.y

5-10

StartUp
5. Speed Control
Enter value for
Preset Speed 7
35.0 Hz
xxx.x < yyy.y

Basic Start Up (Start,Stop,I/O)

6-0
StartUp
6. Strt,Stop,I/O
This section defines I/O functions including start and stop from digital ins

Enter →

6-1
StartUp
6. Strt,Stop,I/O
Complete these steps in order:
<A. Dig Inputs>
B. Dig Outputs
C. Anlg Outputs
D. Done

D. Done → Go to 0-1 (7)

B. Dig Outputs → Go to 6-24

C. Anlg Outputs → Go to 6-29

Go to 6-1 (B)

A. Dig Inputs

6-2
StartUp
A. Dig Inputs
Make a selection
<Easy Configure>
Custom Configure

Easy Configure

DigIn 5,6 = MOP Inc, Dec?

Yes → **6-3**
StartUp
A. Dig Inputs
Digital Inputs 1-4 will be set to defaults.

No → **6-4**
StartUp
A. Dig Inputs
Digital Inputs 1-6 will be set to defaults.

Backup

Enter / Enter

Dir Mode = Reverse Disable?

No → Dir Mode = Bipolar?

No → **6-5**
StartUp
A. Dig Inputs
Is reverse required from digital inputs?
<Yes>
No

Yes / Yes

6-6
StartUp
A. Dig Inputs
Enter choice for Control Method
<3-wire>
2-wire

No

Yes → **6-11**
StartUp
A. Dig Inputs
Enter choice for Control Method
<3-wire>
2-wire

3-wire → **6-14**
StartUp
A. Dig Inputs
Digital Input 3 will be set to Fwd/Reverse.

Enter

6-15
StartUp
A. Dig Inputs
Digital Input 1 will be set to Stop.

Enter

6-16
StartUp
A. Dig Inputs
Digital Input 2 will be set to Start.

2-wire → **6-12**
StartUp
A. Dig Inputs
Digital Input 1 will be set to Run Forward.

Enter

6-13
StartUp
A. Dig Inputs
Digital Input 2 will be set to Run Reverse.

Enter

2-wire → **6-7**
StartUp
A. Dig Inputs
Digital Input 1 will be set to Not Used.

Enter

6-8
StartUp
A. Dig Inputs
Digital Input 2 will be set to Run/Stop.

3-wire → **6-9**
StartUp
A. Dig Inputs
Digital Input 1 will be set to Stop.

Enter

6-10
StartUp
A. Dig Inputs
Digital Input 2 will be set to Start.

Enter

Go to 6-1 (B)

Custom Configure

Backup

6-17
StartUp
A. Dig Inputs
Make a selection
<Digital Input 1>
Digital Input 2
Digital Input 3
Digital Input 4
Digital Input 5
Digital Input 6
Done

Enter/Backup

Done → Go to 6-1 (B)

Digital In 1 → **6-18**
StartUp
A. Dig Inputs
Enter choice for **Digital In1 Sel**

Digital In 2 → **6-19**
StartUp
A. Dig Inputs
Enter choice for **Digital In2 Sel**

Digital In 3 → **6-20**
StartUp
A. Dig Inputs
Enter choice for **Digital In3 Sel**

Digital In 4 → **6-21**
StartUp
A. Dig Inputs
Enter choice for **Digital In4 Sel**

Digital In 5 → **6-22**
StartUp
A. Dig Inputs
Enter choice for **Digital In5 Sel**

Digital In 6 → **6-23**
StartUp
A. Dig Inputs
Enter choice for **Digital In6 Sel**

Backup

Basic Start Up (Start,Stop,I/O [2])

Go to 6-1 (C)

Done

6-24

StartUp
B. Dig Outputs
Make a selection
<Digital Out 1>
Digital Out 2
▲ **Done**

Digital Out 1

Digital Out 2

6-25

StartUp
B. Dig Outputs
Enter choice for
Digital Out 1 Sel

Enter

Digital Out 1 Sel = ENUM choice that uses "Level"?

No

Backup

6-26

StartUp
B. Dig Outputs
Enter value for
Dig Out 1 Level

Yes

Enter

6-27

StartUp
B. Dig Outputs
Enter choice for
Digital Out 2 Sel

Enter

Backup

Digital Out 2 Sel = ENUM choice that uses "Level"?

No

Yes

StartUp
B. Dig Outputs
Enter value for
Dig Out 2 Level

Enter

6-29

StartUp
C. Anlg Outpts
Enter choice for
Analog Out 1 Sel

Enter

6-30

StartUp
C. Anlg Outpts
Enter value for
Analog Out 1 Hi

Enter

6-31

StartUp
C. Anlg Outpts
Enter value for
Analog Out 1 Lo

Enter

Go to 6-1 (D)

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 coats or free spin until the mechanical energy is dissipated.
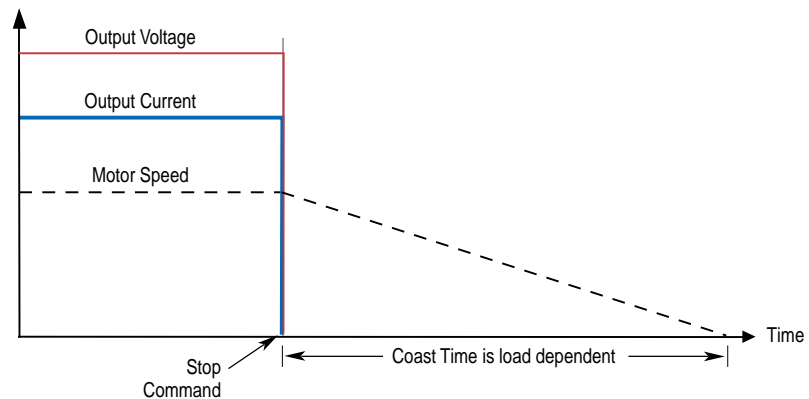
2. **Dynamic Braking** is explained in detail in the PowerFlex Dynamic Braking Selection Guide, presented in Appendix A.

3. **Brake to Stop** 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. This voltage is only removed by one of two events;
  – Opening an Enable digital input
  – Reissuing the Start command

Caution must be used when setting [DC Brake Level]. Excess motor current could damage the motor.

Caution must also be observed, since motor voltage will exist even though a Stop command was issued.
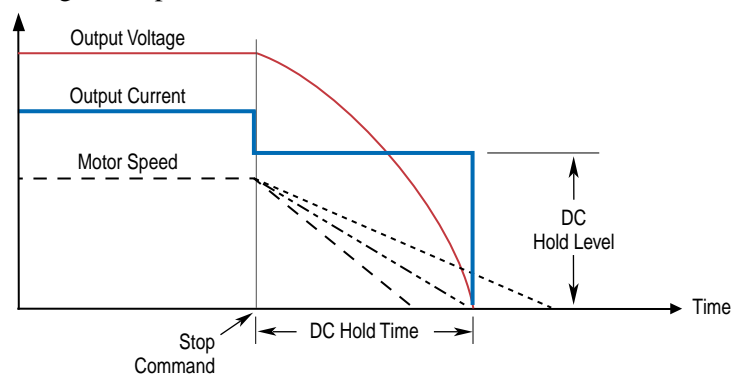
4. **Ramp To Stop** is selected by setting [Stop Mode x]. The drive will ramp the frequency to zero based on the deceleration time programmed into [Decel Time 1/2]. The "normal" mode of machine operation can utilize [Decel Time 1]. If the "Machine Stop" mode requires a faster deceleration than desired 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.
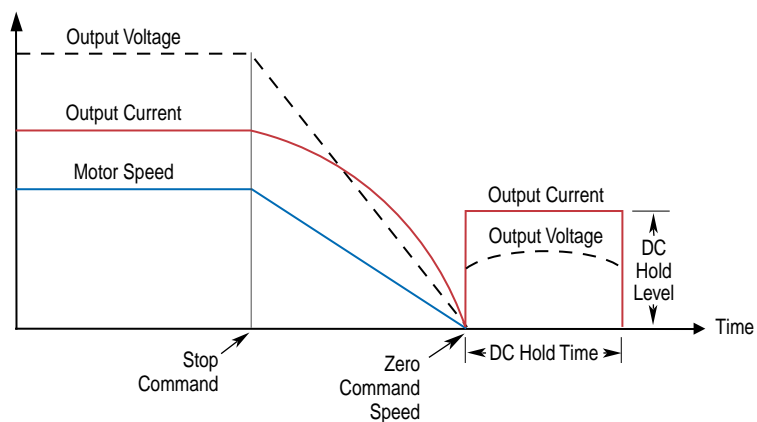
The drive output voltage will be zero when the hold time is finished

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]. The DC hold is removed only by removing the "Enable" input or by a valid start input.

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.

Test Points

UTILITY (File E)	Diagnostics	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.V   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 .

Torque Performance Modes

[Torque Perf Mode]
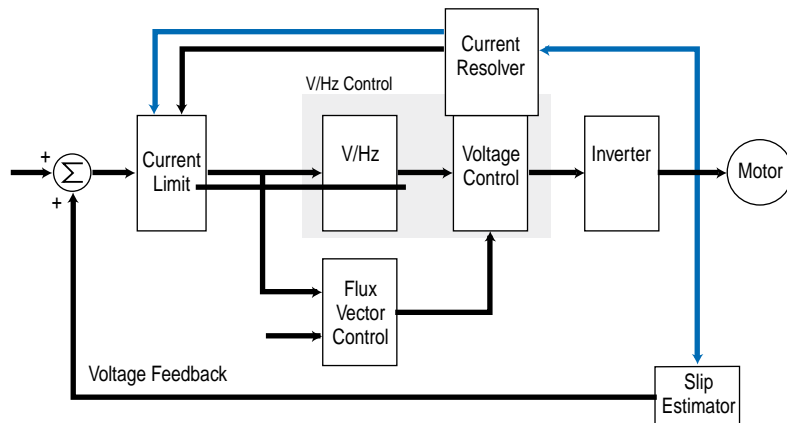
V/Hz

When torque performance is set to Custom V/Hz the following parameters are used to define the relationship between frequency and voltage. The following examples are for a 480v class drive.
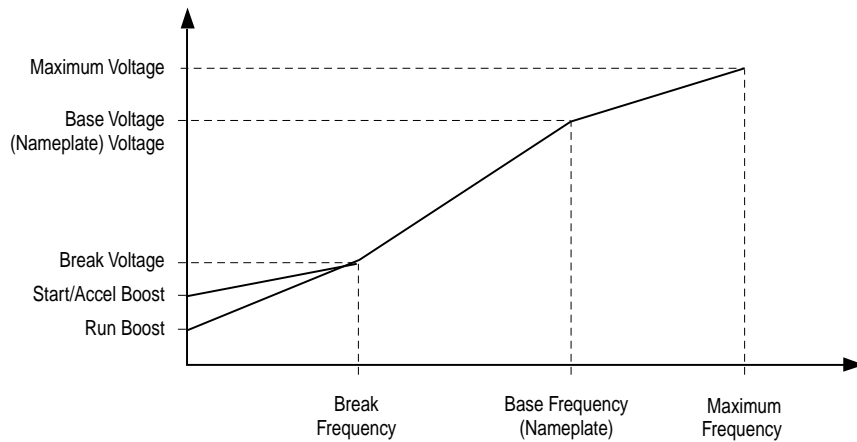
The performance of the V/Hz modes and SVC mode are outlined below. These specifications do not apply to Economize mode due to weakened field conditions. Slip compensation incorporates the effects of field weakening so as to minimize the speed regulation error due to either economize mode or operation above base frequency. The specifications below are applicable over the constant torque speed range.

Specification	Normal Duty		Heavy Duty	
	Fan/Pump and Custom V/Hz	SVC	Fan/Pump and Custom V/Hz	SVC
Speed Regulation/accuracy (w/ slip compensation)	0.5% (40:1 speed range)	0.1% (60:1 speed range)	0.5% (40:1 speed range)	0.1% (60:1 speed range)
Operating Speed Range (w/slip compensation)	40:1	120:1	40:1	120:1
Dynamic Speed Accuracy (speed response to a 95% step load change)	0.5% base speed	0.1% base speed	0.5% base speed	0.1% base speed
Velocity Bandwidth (w/slip compensation and no encoder)	10 rad/s	20 rad/s (50 rad/s desired)	10 rad/s	20 rad/s (50 rad/s desired)
Minimum settability of velocity bandwidth/slip compensation	0.1 rad/s	0.1 rad/s	0.1 rad/s	01 rad/s

This curve is intended for applications such as fans and pumps where the load increases as the speed increases. This mode is intended to have a V/Hz profile that more closely matches the developed torque to the load torque.

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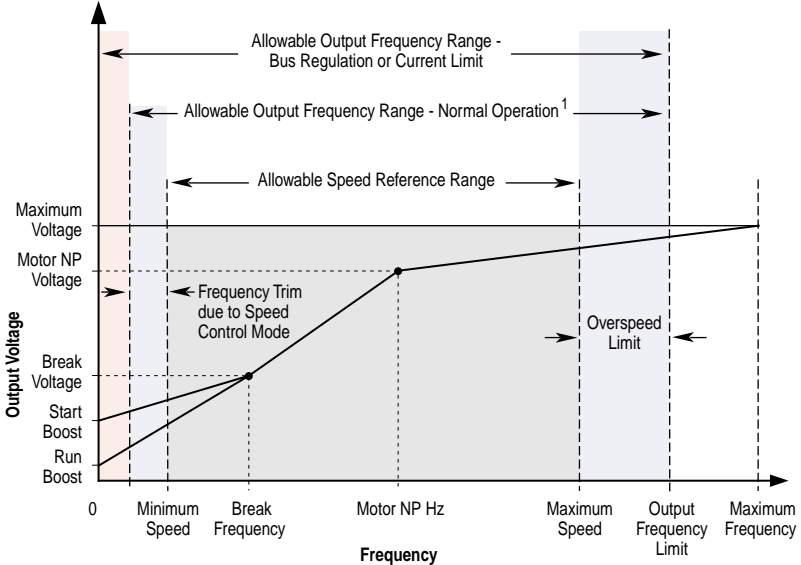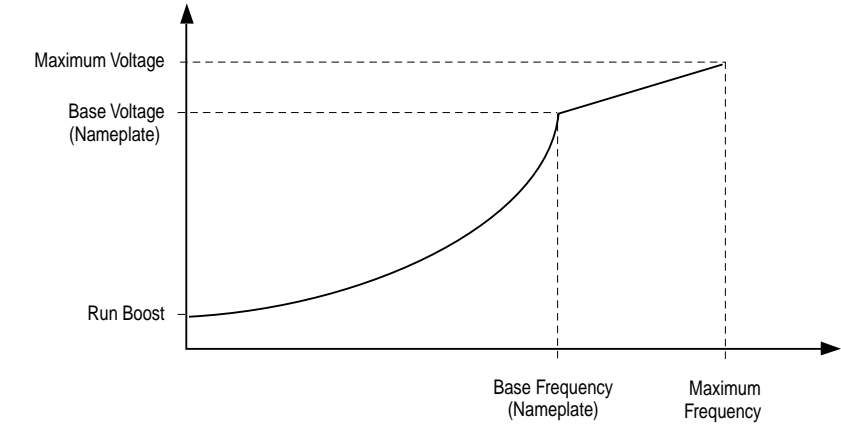
Sensorless Vector

In sensorless vector control the drive maintains a consistent magnetizing current up to base speed, the output voltage increases as a function of load.
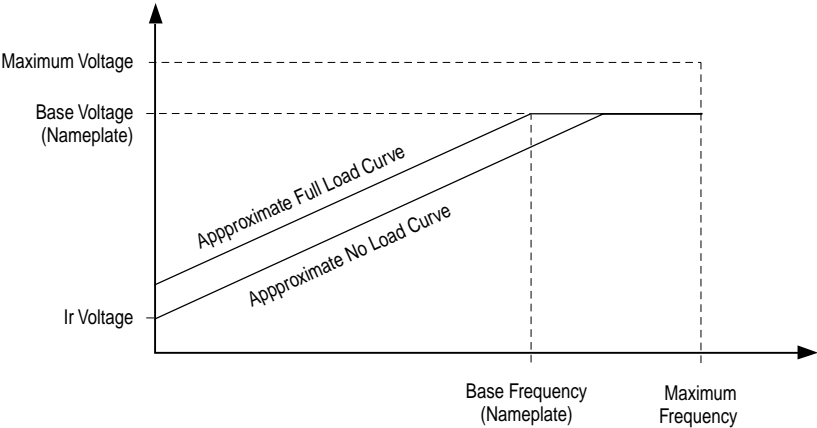
Autotune

[Autotune]

The purpose of Autotune is to identify the motor flux current and stator resistance for use in Sensorless Vector Control and Economizer modes. The result of the flux current test procedure is stored in the parameter [Flux Current]. The product of [Flux Current] and the result of the stator resistance test procedure will be stored in the parameter [IR Voltage Drop]. There are two options for autotuning:

• Static - the motor shaft will not rotate during this test.

• Dynamic - the motor shaft will rotate during this test.

The static test determines only stator resistance, while the dynamic Autotune procedure determines both the stator resistance and motor flux current.

[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.

If it is not possible or desirable to run the Autotune tests, there are two other methods for the drive to determine the [IR Voltage Drop] and [Flux Current] parameters. One method retrieves the default parameters stored in the power EEprom, and the other method calculates them from the user-entered motor nameplate data parameters.

If the stator resistance and flux current of the motor are known, the user can calculate the voltage drop across the stator resistance and directly enter these values into the [Flux Current] and [IR Voltage Drop] parameters.

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]

In addition to the motor nameplate parameters, the user must also enter a value in the [Autotune] parameter to determine which Autotune tests to perform.

The following options for the [Autotune] parameter are as follows:

0 = Ready
1 = Static Tune
2 = Rotate Tune
3 = Calculate

The procedure to identify the motor flux current, stator resistance, and IR voltage drop is started with the [Autotune] parameter. The tests are initiated

after a value is entered (1 for static or 2 for dynamic) into this parameter and the start button is pressed. When the tests are finished, the [Autotune] parameter is set to 0 (ready), the drive is stopped, and the Autotune procedure is complete.

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

When the drive is initially powered up, the [Autotune] parameter is defaulted to a value of 3(calculate). With this setting, any changes made by the user to motor nameplate HP, Voltage, Frequency, or Power activates a new calculation, which will update the [IR Voltage Drop] and [Flux Current] parameters. This calculation is based on a typical motor with those nameplate values. The Autotune parameter will not be reset to zero after this calculation is performed; calculations will continue to be performed every time motor nameplate values are changed.

Flux Current

This parameter displays only the flux producing component of output current. It displays the amount of current that is out of phase with the output voltage. This current is reactive current and is used to produce flux in the motor.

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 2.18   Accel Profile during Normal Start - No Flux Up
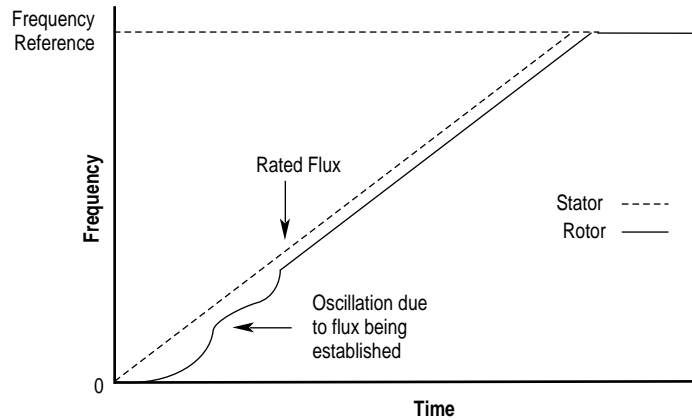
The second method is Flux Up Mode. In this mode, DC current is applied to the motor at a level equal to the lesser of the current limit setting, drive rated current, and drive DC current rating. The flux up time period is based on the level of flux up current and the rotor time constant of the motor.

The flux up current is not user adjustable.

Figure 2.19   Flux Up Current versus Flux Up Time
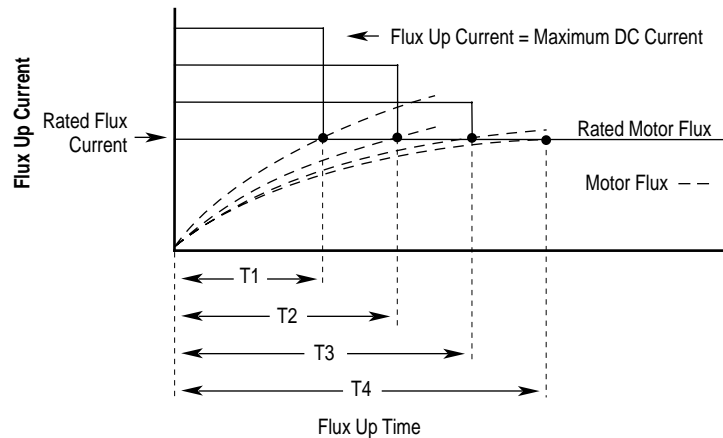
[Flux Up Time]

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

Figure 2.20   Rated Flux Reached
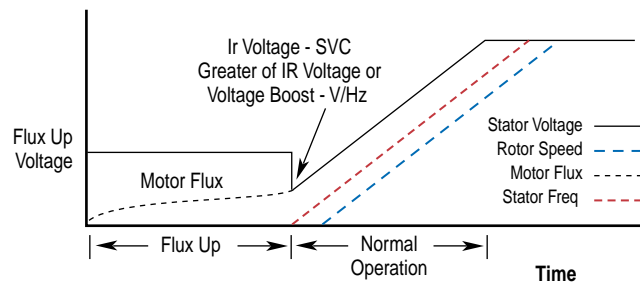
Torque Current

This parameter displays only the torque producing component of output current. It displays the amount of current that is in phase with the output voltage. This current is real current and is used to produce torque in the motor.

IR Drop Volts

[IR Voltage Drop]

The test to identify the IR drop of the drive and motor does not require the load to be uncoupled from the motor and should be run even if the flux current identification procedure is skipped.

Flux Current

[Flux Current Ref]

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 and the no load current is know then the value can be entered into the flux current parameter and this step in the drive commissioning can be skipped. If it is not possible to uncouple the load and the no load current is not known, then a value of zero is entered into flux and this step in the drive commissioning can be skipped.

Troubleshooting

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).

Unbalanced or Ungrounded Distribution Systems

Unbalanced Distribution Systems

This drive is designed to operate on three-phase supply systems whose line voltages are symmetrical. Surge suppression devices are included to protect the drive from lightning induced overvoltages between line and ground. Where the potential exists for abnormally high phase-to-ground voltages (in excess of 125% of nominal), or where the supply ground is tied to another system or equipment that could cause the ground potential to vary with operation, suitable isolation is required for the drive. Where this potential exists, an isolation transformer is strongly recommended.

Ungrounded Distribution Systems

All drives are equipped with an MOV (Metal Oxide Varistor) that provides voltage surge protection and phase-to-phase plus phase-to-ground protection which is designed to meet IEEE 587. The MOV circuit is designed for surge suppression only (transient line protection), not continuous operation.

With ungrounded distribution systems, the phase-to-ground MOV connection could become a continuous current path to ground. Energy ratings are listed below. Exceeding the published phase-to-phase or phase-to-ground energy ratings may cause physical damage to the MOV.
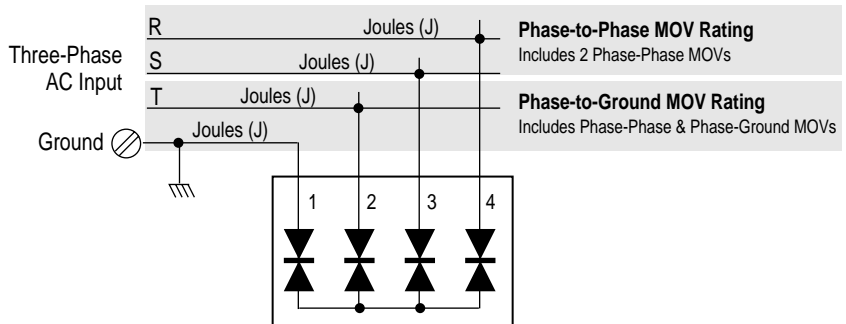
Device Rating (V AC)	240	480/600	240/480	600	240/480	600
Phase-Phase Total	160J	320J	280J	320J	280J	300J
Phase-Ground Total	220J	380J	360J	410J	360J	370J

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.

There are two operations to manage the operation of 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.

Figure 2.21   User Sets
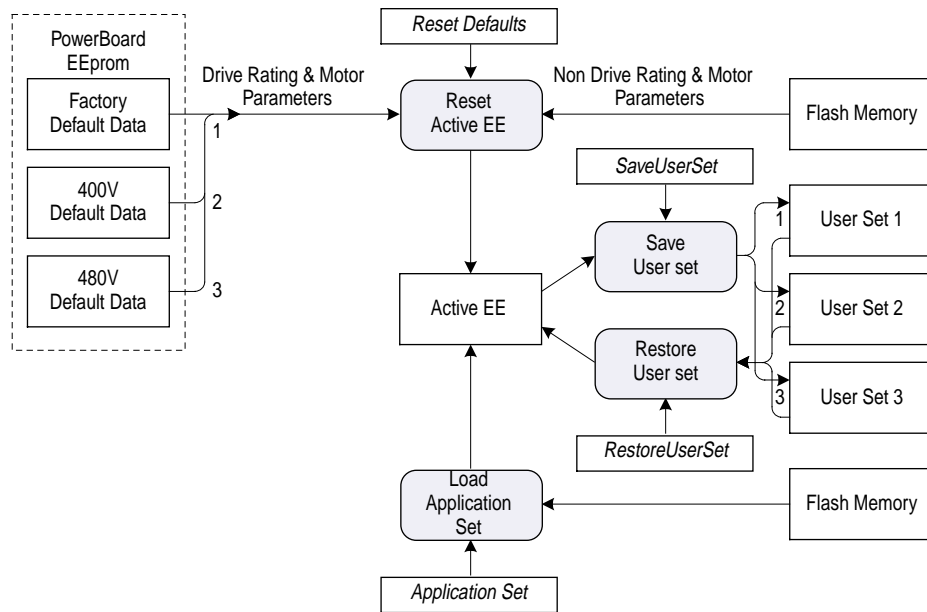
Voltage class

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 2.21.

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. Data for other load/speed/PWM combinations can be determined using the calculator on the PowerFlex e-Library.

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.W   480V Watts Loss at Full Load/Speed, 4kHz[1]

Normal Duty HP	Internal	External	Total
0.5	17.9	11.5	29.4
1	19.5	27.8	47.3
2	21.6	43.6	65.2
3	24.0	64.6	88.6
5	28.2	99.5	127.7
7.5	27.8	140.0	167.8
10	32.0	193.3	225.3
15	34.2	305.4	339.6
20	42.9	432.9	475.8

Table 2.X   240V Watts Loss at Full Load/Speed, 4kHz[1]

Normal Duty HP	Internal	External	Total
0.5	19.2	12.2	31.4
1	20.5	30.7	51.2
2	22.6	44.6	67.2
3	25.4	67.3	92.7
5	33.2	141.3	174.5
7.5	34.2	205.7	239.9
10	48.1	270.4	318.5

PowerFlex 700

For PowerFlex 700 drives, a flange mount version is not offered - only total watts are shown (see Table 2.Y).

---

(1) Includes HIM.

Table 2.Y   480V Watts Loss at Full Load/Speed, 4kHz[1]

Normal Duty HP	Total
0.5	43.9
1	54.2
2	66.4
3	84.8
5	157.2
7.5	187.6
10	213.1
15	326.3
20	397.9
25	445.8
30	464.3
40	619.7

(1) Includes HIM and Standard I/O Board.

Dynamic Brake Selection Guide

The Dynamic Braking Selection Guide provided on the following pages contains detailed information on selecting and using dynamic brakes.

A·B *Allen-Bradley*

*Power**Flex***

Dynamic Braking

Selection Guide

Rockwell
Automation

www.abpowerflex.com

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 Allen-Bradley 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 Allen-Bradley Company 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 Allen-Bradley Company cannot assume responsibility or liability for actual use based on the examples and diagrams.

No patent liability is assumed by Allen-Bradley Company 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.

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.

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

Table of Contents

Notes:

What This Guide Contains

This Selection Guide contains the information necessary to determine whether or not dynamic braking is required for your drive application and select the correct resistor rating.

- Section 1 provides an overview of dynamic braking principles.

- Section 2 steps you through the calculations used to determine if dynamic braking is required for your drive application.

- Section 3 steps you through the calculations used to determine if the internal dynamic brake option is adequate for your drive application.

- Section 4 steps you through the calculations needed to select an externally mounted dynamic brake resistor for your drive application.

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
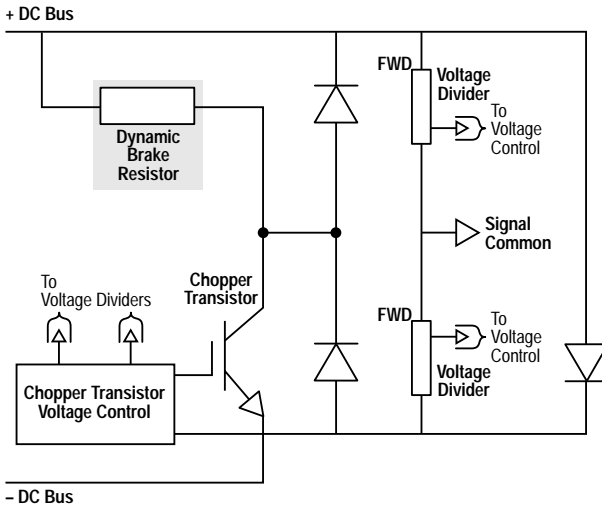
Chopper

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:

- 375V DC (for 240V AC input)
- 750V DC (for 480V AC input)

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.

The internal resistor kit for the drive may be used for the application if the required energy, deceleration time, and duty, all are small enough to be within the capabilities of the resistor.

The internal resistor is protected by drive software so that its duty cycle capability is not exceeded. The duty cycle is attenuated by the magnitude of the 'DB Suppress' signal coming from the Thermal Model algorithm. The Thermal Model algorithm uses resistor thermal property constants to compute DB resistor temperature from applied resistor power that is computed from knowing the DB transistor duty cycle (DutyDB). When the Thermal Model computes that the DB resistor temperature is nearing the maximum rise allowed, the 'DB Suppress' signal begins to rise reaching full value when maximum temperature rise is reached..

When the internal resistor cannot provide the required braking capability an external resistor may be supplied by the user that has more capability A DB Resistance Auto-Detect algorithm is used. This algorithm is executed as part of the 'power-up' diagnostics and is only re-enabled until the drive is fully powered down again. This algorithm checks that the resistance measured across the DB terminals of the power board is within limits that are stored in the power board EEPROM.

The algorithm runs as follows:

- Opens the precharge relay if not already open.
- Pulses the DB transistor on in a series of increasing width pulses.
- Measures the resulting capacitor bank voltage drop during each pulse.
- Verifies the drop is within allowed limits (stored in the power board EEPROM).

If the resistance measured is out of limits and the DB regulator is enabled then the 'DB Resistance Out of Range' fault is set. If the DB Regulator is not enabled with this out of limits condition, no fault is set. But, if some time after power-up the [Bus Reg Mode] parameter is set to enable the DB Regulator, the fault is set at that time.

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** of the drive must be calculated in order to determine the maximum resistance value of the Dynamic Brake Resistor. Once the maximum resistance value of the Dynamic Brake Resistor current rating is known, the required rating and number of Dynamic Brake Resistors can be determined. If a Dynamic Brake Resistance value greater than the minimum imposed by the choice of the peak regenerative power is made and applied, the drive can trip off due to transient DC bus overvoltage problems. Once the approximate resistance value of the Dynamic Brake Resistor is determined, the necessary power rating of the Dynamic Brake Resistor can be calculated.

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)

- Motor inertia and load inertia in kg-m^2 or 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 the speed, torque, and power profiles of the drive as a function of time for a particular cyclic application that is periodic over t_4 seconds. The desired time to decelerate is known or calculable and is within the drive performance limits. In Figure 2.1, the following variables are defined:

$\omega(t)$ = Motor shaft speed in radians per second (rps) $\omega = \dfrac{2\pi N}{60}$

$N(t)$ = 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 $\dfrac{Rad}{s}$

ω_0 = Angular rotational speed less than ω_b (can equal 0) $\dfrac{Rad}{s}$

$-P_b$ = Motor shaft peak regenerative power in watts

Figure 2.1 Application Speed, Torque and Power Profiles
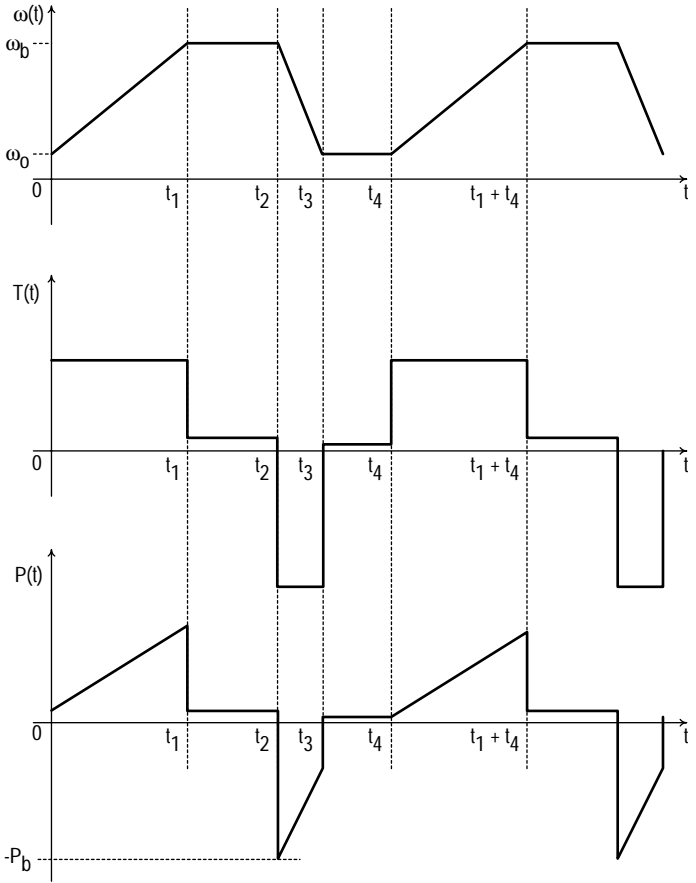
Determine Values of Equation Variables

Step 2   Total Inertia

$$J_T = J_m + (GR^2 \times J_L)$$

J_T = Total inertia reflected to the motor shaft (kg-m^2 or lb.-ft.^{2})

J_m = Motor inertia (kg-m^2 or lb.-ft.^{2})

GR = Gear ratio for any gear between motor and load (dimensionless)

J_L = Load inertia (kg-m^2 or lb.-ft.^{2})
   1.0 lb.-ft.^{2} = 0.04214011 kg-m^2

Calculate Total Inertia:

$$J_T = [\qquad\qquad] + (\qquad\qquad \times \qquad\qquad)$$

Record Total Inertia:

J_T =

Step 3   Peak Braking Power

$$P_b = \frac{J_T[\omega_b(\omega_b - \omega_0)]}{(t_3 - t_2)}$$

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_0 = 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_0 (seconds)

Calculate Peak Braking Power:

$$P_b = \frac{[\qquad] \times [\qquad] \times (\qquad - \qquad)}{(\qquad - \qquad)}$$

Record Peak Braking Power:

P_b =

Compare the peak braking power to that of the rated motor power. If the peak braking power is greater that 1.5 times that of the motor, then the deceleration time $(t_3 - t_2)$ needs to be increased so that the drive does not go into current limit.

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_0 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: $\dfrac{P_b}{2} \times \dfrac{(\omega_b + \omega_0)}{\omega_b}$

P_{av} =   Average dynamic brake resister dissipation (watts)

$t_3 - t_2$ =   Deceleration time from ω_b to ω_0 (seconds)

t_4 =   Total cycle time or period of process (seconds)

P_b =   Peak braking power (watts)

ω_b =   Rated angular rotational speed $\dfrac{Rad}{s}$

ω_0 =   Angular rotational speed, less than rated speed down to zero $\dfrac{Rad}{s}$

The Average Power in watts regenerated over the period t_4 is:

$$P_{av} = \left[\frac{(t_3 - t_2)}{t_4}\right]\frac{P_b}{2}\left[\frac{(\omega_b + \omega_0)}{\omega_b}\right]$$

Calculate Average Power in watts regenerated over the period t_4:

$$P_{av} = \left[\frac{(\underline{\hspace{1cm}} - \underline{\hspace{1cm}})}{[\quad\quad]}\right] \times \frac{[\quad\quad]}{2} \times \left[\frac{(\underline{\hspace{1cm}} + \underline{\hspace{1cm}})}{[\quad\quad]}\right]$$

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

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 2.A (watts)

Calculate Percent Average Load of the dynamic brake resistor:

$$AL = \frac{[\underline{\hspace{2cm}}]}{[\hspace{2cm}]} \times 100$$

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 2.A. This will give a data point for a line to be drawn on one the curves provided in Section 3.

Table 2.A Rated Continuous Power for Internal DB Kits

Drive Voltage	Frame	P_{db} Internal Resistor Continuous Power (watts)
230	A	48
230	B	28
230	C	40
230	D	36
460	A	48
460	B	28
460	C	40
460 (15HP)	D	36
460 (20HP)	D	36

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 2.A (watts)

Calculate Percent Peak Load of the dynamic brake resistor:

$$PL = \frac{[\underline{\hspace{3cm}}]}{[\hspace{3cm}]} \times 100$$

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 .

- 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}

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.

$$\text{Rated Speed} = \omega_b = 1785 \text{ RPM} = 2\pi \times \frac{1785}{60} = \frac{186.98 \text{ Rad}}{s}$$

$$\text{Lower Speed} = \omega_o = 0 \text{ RPM} = 2\pi \times \frac{0}{60} = \frac{0 \text{ Rad}}{s}$$

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.

$$\text{Deceleration Time} = (t_3 - t_2) = 15 \text{ seconds}$$

$$\text{Period of Cycle} = t_4 = 40 \text{ seconds}$$

$$V_d = 750 \text{ Volts}$$

This was known because the drive is rated at 480 Volts rms. If the drive were rated 230 Volts rms, then $V_d = 375$ 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.

$$\text{Peak Braking Power} = P_b = \frac{J_T[\omega_b(\omega_b - \omega_0)]}{(t_3 - t_2)}$$

$$P_b = \frac{0.261[186.92(186.92 - 0)]}{15} = 608.6 \text{ watts}$$

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.

$$\text{Average Braking Power} = P_{av} = \left[\frac{(t_3 - t_2)}{t_4}\right]\frac{P_b}{2}\left[\frac{(\omega_b + \omega_0)}{\omega_b}\right]$$

$$P_{av} = \left(\frac{15}{40}\right)\left(\frac{608.6}{2}\right)\left(\frac{186.92 + 0}{186.92}\right) = 114.1 \text{ watts}$$

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.

Refer to Table 2.A to determine the continuous power rating of the resistor in the given drive frame you are using. You will need this number to determine the Percent Average Load and the Percent Peak Load.

$$\text{Percent Average Load} = AL = 100 \times \frac{P_{av}}{P_{db}}$$

$$AL = 100 \times \frac{114.1}{40} = 285\%$$

This is the result of the calculation outlined in Step 6. This point is plotted at the decel time of the application moving up vertically to this percentage.

$$\text{Percent Peak Load} \; = \; PL \; = \; 100 \times \frac{P_b}{P_{db}}$$

$$PL \; = \; 100 \times \frac{608.6}{40} \; = \; 1521\%$$

This is the result of the calculation outlined in <u>Step 6</u>. This point is plotted at zero seconds moving up vertically to this percentage.

Figure 2.2 Resistor Power Curve
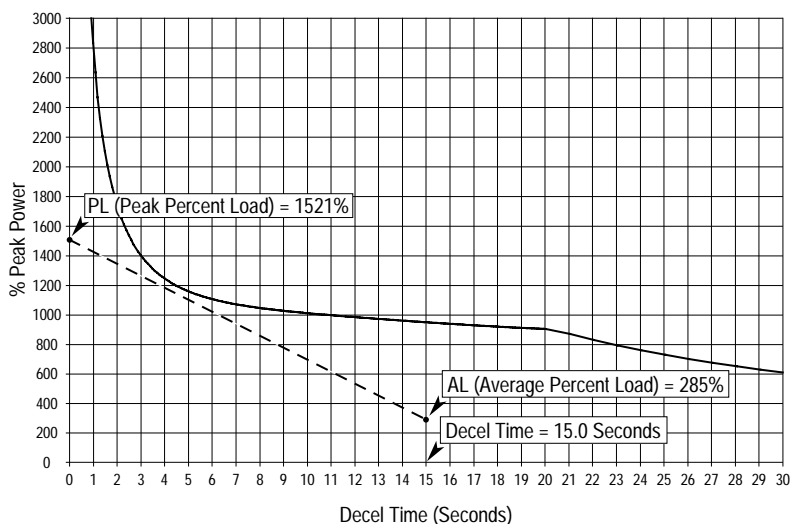
AL and PL are plotted and connected with a dotted line. This is the Motor Power Curve. If any portion of this curve lies to the right of the constant temperature power curve of the Dynamic Brake Resistor, the resistor element temperature will exceed the operating temperature limit. The drive will protect the resistor and shut down the Chopper transistor. The drive will then likely trip on an overvoltage fault.

Notes:

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Evaluating the Capability of the Internal Dynamic Brake Resistor

Record the values calculated in Section 2.

AL   =

PL   =

$t_3 - t_2 =$

PowerFlex 70 Drives

Find the correct Figure for your PowerFlex 70 drive rating.

Drive Voltage	Frame(s)	Figure Number
240	A and B	3.1
240	C	3.2
240	D	3.3
480	A and B	3.4
480	C	3.5
480	D	3.6

1. Plot the point where the value of AL (Average Load), calculated in Step 5, and the desired deceleration time $(t_3 - t_2)$ intersect.

2. Plot the value of PL (Peak Load), calculated in Step 6, on the vertical axis (0 seconds).

3. Connect PL at 0 seconds and AL at $(t_3 - t_2)$ with a straight line. This line is the power curve described by the motor as it decelerates to minimum speed.

If the power curve lies to the left of the constant temperature power curve of the Dynamic Brake Resistor, then there is no problem with the intended application. If any portion of the power curve lies to the right of the constant temperature power curve of the Dynamic Brake Resistor, then there is an application problem. The Internal Dynamic Brake Resistor will exceed its rated temperature during the interval that the transient power curve is to the right of the resistor power curve capacity.

Figure 3.1   PowerFlex 70 – 240 Volt, A and B Frames
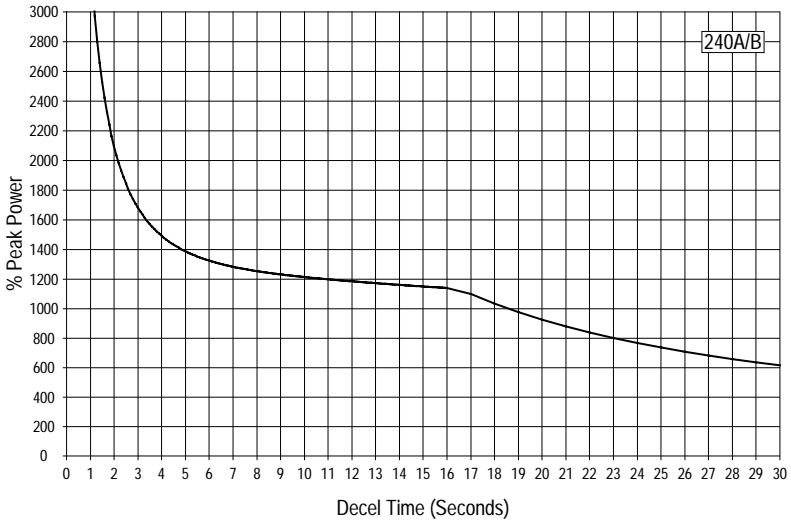
Figure 3.2   PowerFlex 70 – 240 Volt, C Frame
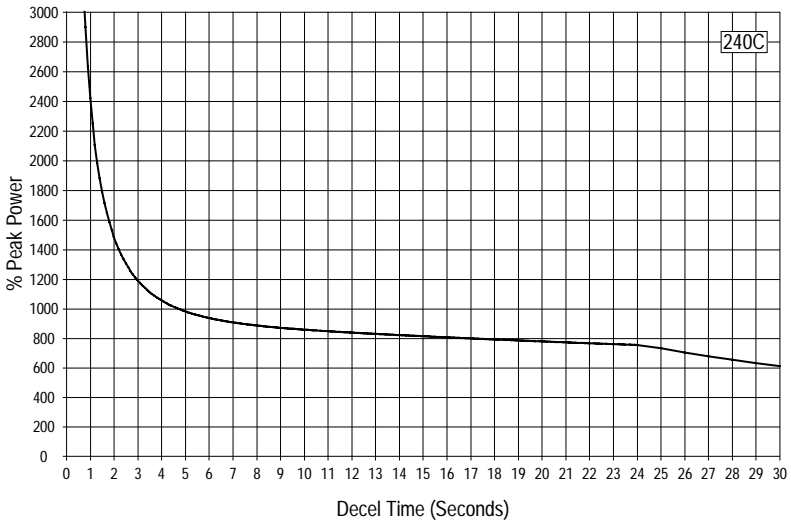
Figure 3.3   PowerFlex 70 – 240 Volt, D Frame
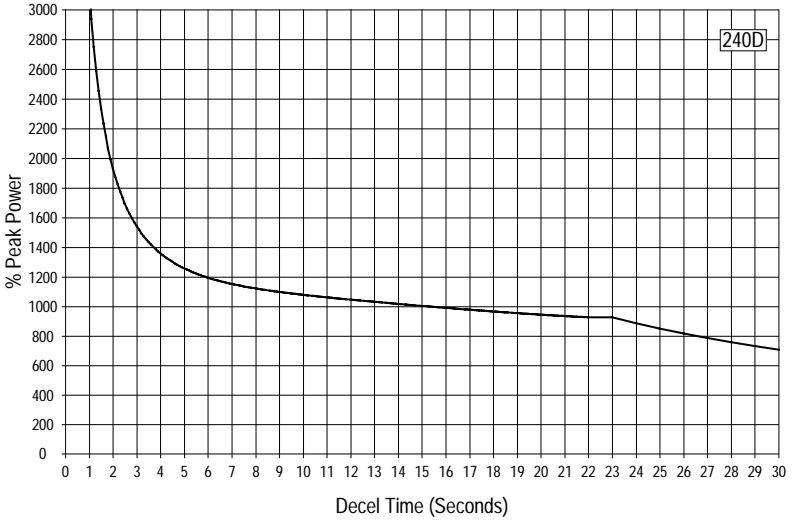
Figure 3.4   PowerFlex 70 – 480 Volt, A and B Frames
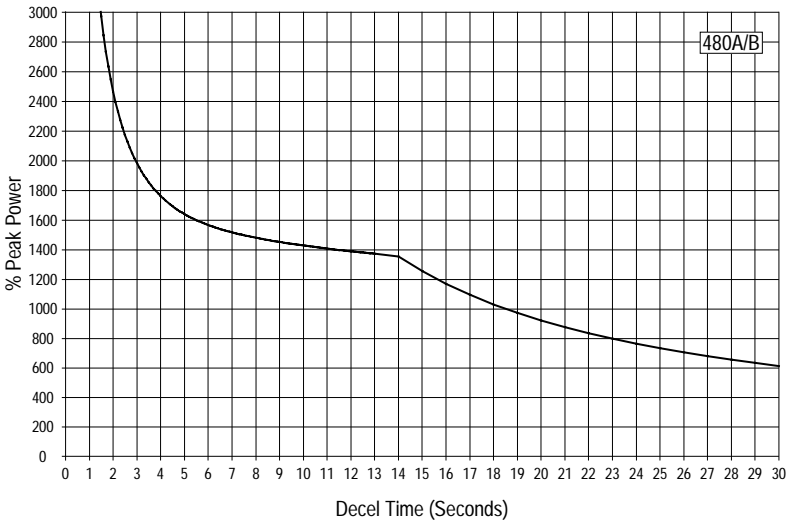
Figure 3.5   PowerFlex 70 – 480 Volt, C Frame
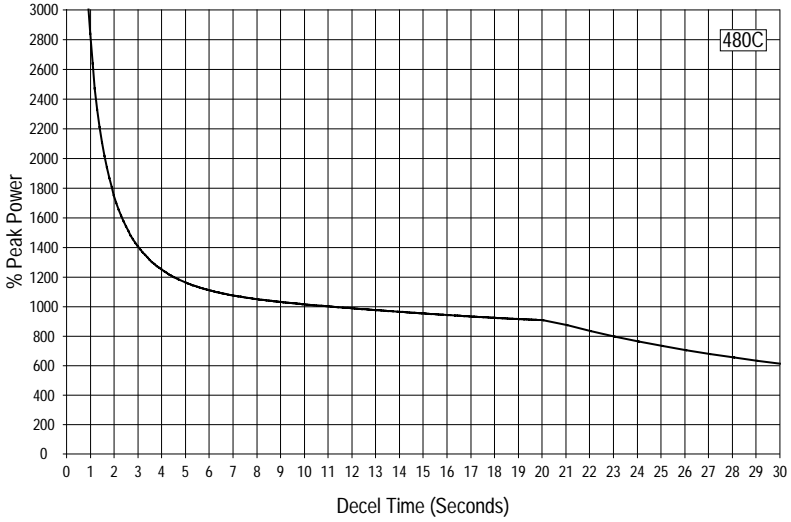
Figure 3.6   PowerFlex 70 – 480 Volt, D Frame
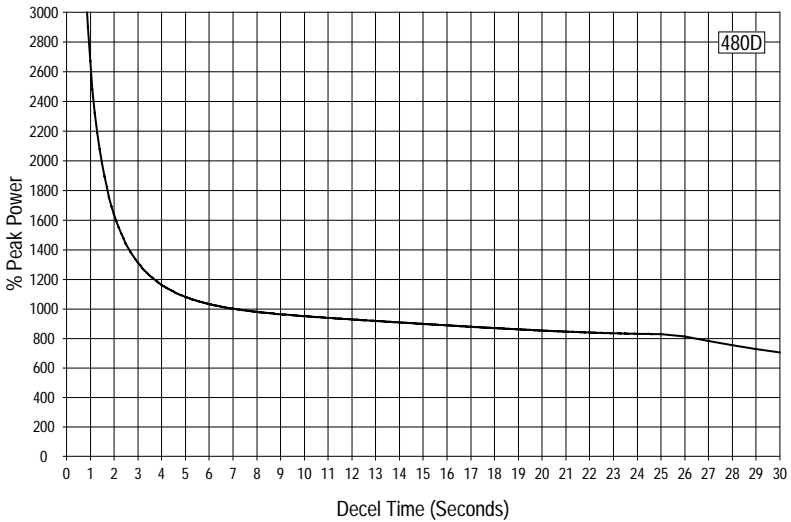
How to Select an External Dynamic Brake Resistor

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 of power.)

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.

Table 4.A Minimum Dynamic Brake Resistance for PowerFlex 70 Drives

Drive Voltage	Frame	Minimum External Resistance (Ohms 10%)
230	A	32.9
230	B	32.9
230	C	28.7
230	D	21.7
460	A	63.4
460	B	63.4
460	C	71.1
460 (15HP)	D	42.3
460 (20HP)	D	29.1

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.

Record the Values Calculated in Section 2

P_b =

P_{av} =

Calculate Maximum Dynamic Brake Resistance Value

$$R_{db1} = \frac{0.9 \times (V_d)^2}{P_b}$$

R_{db1} = Maximum allowable value for the dynamic brake resistor (ohms)

V_d = DC bus voltage the chopper module regulates to (375V DC or 750V DC)

P_b = Peak breaking power calculated in Section 2: (watts)

Calculate Maximum Dynamic Brake Resistance:

$$R_{db1} = \frac{0.9 \times (\underline{\hspace{2cm}})^2}{[\underline{\hspace{2cm}}]}$$

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. Do not reduce P_b by any ratio because of estimated losses in the motor and inverter. This has been accounted for by an offsetting increase in the manufacturing tolerance of the resistance value and the increase in resistance value due to the temperature coefficient of resistor element.

Select Resistor

Select a resistor bank from Table 4.B or 4.C or your resistor supplier that has:

- 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 4.A

- a power value that is greater than the value calculated in Step 4 (P_{av} in watts)

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 4.A to verify that the resistance value of the selected resistor bank is greater than the minimum resistance of the drive.

Table 4.B Resistor Selection for 240V AC Drives

Ohms	Watts	Catalog Number	Ohms	Watts	Catalog Number
154	182	222-1A	45	617	222-5A
154	242	222-1	45	827	222-5
154	408	225-1A	45	1378	225-5A
154	604	225-1	45	2056	220-5A
154	610	220-1A	45	2066	225-5
154	913	220-1	45	3125	220-5
110	255	222-2A	32	875	222-6A
110	338	222-2	32	1162	222-6
110	570	225-2A	32	1955	225-6A
110	845	225-2	32	2906	225-6
110	850	220-2A	32	2918	220-6A
110	1278	220-2	32	4395	220-6
85	326	222-3A	20	1372	222-7A
85	438	222-3	20	1860	222-7
85	730	225-3A	20	3063	225-7A
85	1089	220-3A	20	4572	220-7A
85	1094	225-3	20	4650	225-7
85	1954	220-3	20	7031	220-7
59	473	222-4A			
59	631	222-4			
59	1056	225-4A			
59	1576	225-4			
59	1577	220-4A			
59	2384	220-4			

Table 4.C   Resistor Selection for 480V AC Drives

Ohms	Watts	Catalog Number	Ohms	Watts	Catalog Number
615	242	442-1	128	874	442-6A
615	404	445-1A	128	1162	442-6
615	602	440-1A	128	1951	445-6A
615	605	445-1	128	2906	445-6
615	915	440-1	128	2912	440-6A
615	180	442-1A	128	4395	440-6
439	254	442-2A	81	4629	440-7A
439	339	442-2	81	6944	440-7
439	568	445-2A	81	4592	445-7
439	847	445-2	81	1837	442-7
439	848	440-2A	81	1389	442-7A
439	1281	440-2	81	3102	445-7A
342	329	442-3A	56	6702	440-8A
342	1645	440-3	56	2010	442-8A
342	1096	440-3A	56	10045	440-8
342	1088	445-3	56	6642	445-8
342	435	442-3	56	4490	445-8A
342	734	445-3A	56	2657	442-8
237	473	442-4A	44	3381	442-9
237	628	442-4	44	5720	445-9A
237	1057	445-4A	44	8454	445-9
237	1570	445-4	44	8537	440-9A
237	1577	440-4A	44	12784	440-9
237	2373	440-4	44	2561	442-9A
181	2068	440-5A	29	5130	442-10
181	2055	445-5	29	8487	445-10A
181	620	442-5A	29	12667	440-10A
181	822	442-5	29	12826	445-10
181	3108	440-5	29	19396	440-10
181	1385	445-5A	29	3800	442-10A

Notes:

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