ELECTRICAL PRODUCTS

AC & DC Adjustable Speed Controls and Motors

Boston Gear

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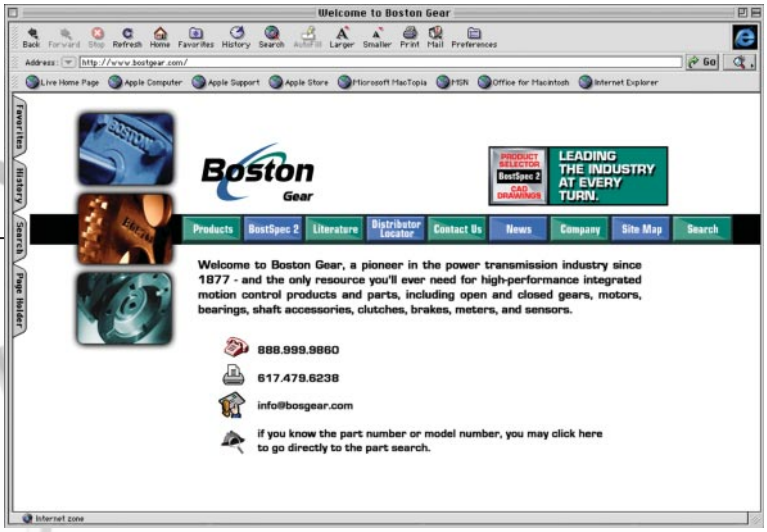

- Boston Gear
  - Enclosed Speed Reducers
    - Worm Gear Speed Reducers, 700 Series
      - Single Reduction Projecting O/P
      - Single Reduction Hollow O/P
      - Double Reduction
        - Right Angle (W/C) Projecting
        - Right Angle (W/C) Hollow
        - Parallel (W/A) Projecting
        - Parallel (W/A) Hollow
    - Helical Gear Drives
    - Bevel Gear Drives
    - Planetary Motor Multiplier
  - Open Gearing
  - Couplings
  - Universal Joints
  - Bearings
  - AC Motors

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WILL PROVIDE
ALL PRODUCTS AND SERVICES
AT A QUALITY LEVEL
THAT MEETS OR EXCEEDS
THE EXPECTATIONS
AND THE REQUIREMENTS
OF OUR CUSTOMERS

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Whether you're looking to design a worm gear speed reducer to fit your application, get information on Boston Gear's newest products, or receive the latest news about the company, www.bostgear.com is your answer.

The Second Century of Service

Started in 1877 as a machine shop making gear cutting machines, Boston Gear has led the growth of the power transmission industry for more than a century. In its early years, Boston Gear introduced the concepts of gear standardization and stock gears – innovations of enormous benefit to power transmission system designers, specifiers and users.

Boston Gear was the early pioneer in enclosed drives, a category it still dominates with dependable, high-performance products like Worm, Helical and Bevel Gear Drives.

Today, Boston Gear provides the widest range of integrated motion control products from one source. The convenience of this single-source capability is yours when you deal with Boston Gear.

Engineering Services

The Boston Gear Engineering Group can satisfy your technical needs through skillful application of standard products or development of custom designs. Creating specials is an important aspect of customer service. It is supported by R & D personnel who use microprocessor-controlled equipment to collect and monitor data on materials and product performance.

Computer-Aided-Design (CAD) systems help Boston Gear engineers create new approaches to broad industrial challenges or specific customer needs. Computer simulation and testing at critical stages ensure that their designs are practical

Manufacturing Excellence

Boston Gear manufactures more than 20,000 products in-house at facilities in Florence, Kentucky; York, Pennsylvania; and Louisburg and Charlotte, North Carolina. Production is efficiently organized into manufacturing cells under group technology. This approach encourages a sense of responsibility and pride of workmanship, to gain consistently high-quality output.

Computerized production control provides close supervision over scheduling and resource planning, coupled with the flexibility to fit your requirements smoothly into the master schedule. Other dedicated computer controls within the production department govern the ordering and delivery functions to keep operations lean and efficient.

AGMA
Power Transmission Distributors Association
Bearing Specialists Association

RATIOTROL SYSTEMS

RATIOTROL PRODUCTS ADD SOPHISTICATED CONTROL TO MOTION

Boston Gear, the reliable source for motion control products for over 100 years, has added electronic brains to its mechanical brawn. New Ratiotrol microprocessor-based AC and DC digital controllers bring operating intelligence to our high-performance speed reducers, gears, motors, bearings, shaft accessories, clutches and brakes. Your advantage is more capable and adaptable motion control systems when you utilize the coordinated components available from Boston Gear.

ELECTRONIC DRIVES AND CONTROLLERS

From fractional horsepower AC & DC controllers to powerful three-phase AC inverters, Boston Gear serves a broad spectrum of control needs for adjustable speed AC and DC drives. In manufacturing and assembly operations, Ratiotrol controllers adapt easily to new factory automation projects or system upgrades. For material handling systems and conveyors, food processing equipment, extruders and mixers, they give you a low-cost route to the infinitely adjustable speeds needed to match a production line or process flow. Many can be field or factory-modified for specialized performance and operating convenience.

CUSTOMER/FACTORY MODIFICATIONS

Many Boston Gear Ratiotrol series accept pre-engineered options to meet unusual environmental conditions or to offer specialized performance and operating convenience. Simple plug-in modules and Boston Gear Field Kits make it easy to accomplish many modifications in the field; other options are factory installed and tested before delivery. Modifications can range from simple product adaptations for OEM applications to complex integrated installations controlling multiple drives in automated process lines.

FIELD SUPPORT

The specialists at Boston Gear distributors are ready to help you meet all your motion control needs. For in-depth technical assistance, they can turn to the Boston Gear field application engineering force. Our field engineers have daily exposure to the specialized needs of many industries. They work cooperatively with our distributors to solve customer problems, design new systems and upgrade existing systems with added capabilities.

APPLICATION ASSISTANCE

Multi-level assistance is available from the network of Boston Gear full-line distributors, backed by Boston Gear's own dedicated field specialists, electrical product specialists and factory application engineers. All are available to analyze applications and help you specify the product combination that will perform your work with efficiency and economy.

TECHNICAL ASSISTANCE

Besides assisting with application review and product selection, all of the people in the Boston Gear distributor, field and factory organizations can help resolve problems by offering technical assistance. They are trained and prepared to troubleshoot unexpected process difficulties, or to provide functional analysis and repair of the controller/motor drive system.

AVAILABILITY

Boston Gear service has many facets and they all involve the coast-to-coast Boston Gear distributor organization. The distributors' own product knowledge is supplemented by our field and factory experts; their local product inventories are backed by national and regional warehouse stocks. On-line computer links give distributors instant access to Boston Gear headquarters for order entry, inventory checks, price information, etc.

Boston Gear customer support services include technical application assistance, complete electronic and mechanical repairs and skilled factory modifications of standard products.

TABLE OF CONTENTS

INTRODUCTION.....1-2

PRODUCT SELECTION/REFERENCE GUIDE 3-7

NONREGENERATIVE AND REGENERATIVE, DC CONTROLLERS.....9-52

OPTIONS AND MODIFICATIONS FOR DC CONTROLLERS.....53-71

SINGLE AND THREE PHASE AC CONTROLLERS.....73-107

ACCESSORIES 109-115

CLUTCHES AND BRAKES.....117-143

DC MOTORS 145-153

AC MOTORS 155-171

WASHDOWN PRODUCTS.....173-174

APPLICATION ENGINEERING.....175-189

TERMS AND CONDITIONS 190-191

PRODUCT SELECTION/REFERENCE GUIDE

DC Controllers, Single Phase, Nonregenerative — Section A

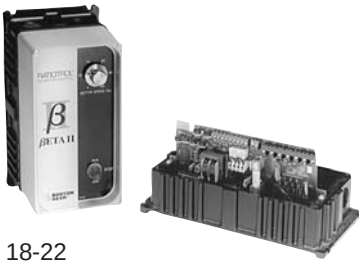
Ratiopax

Pages 11-12

DCX

Pages 13-17

BETA II



Pages 18-22

BETAplus

Pages 23-27

VEplus

Pages 28-32

VED

Pages 33-39

DC Controllers, Single-Phase, Regenerative — Section A

RBA/VEA-RG

Pages 43-47

VEL/H-RG

Pages 48-52

AC Controllers, Single and Three Phase — Section B

BCX

Pages 75-79

ACX

Pages 80-87

ADX

Pages 89-101

SSX

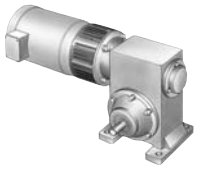
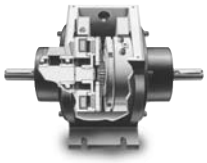
Pages 102-104

PRODUCT SELECTION/REFERENCE GUIDE

Accessories — Section C

Remote Stations	Tachometer Generator	Magnetic Pick-up	Analog Meter	Digital Meter
				
Pages 109-110	Pages 111-112	Page 113-114	Page 114	Page 115

Clutches and Brakes — Section D

DC C-Face	DC Foot Mounted	DC Shaft Mounted	AC C-Face	AC C-Face Washdown	AC Motor Brake Kit
					
Page 119-120	Page 121-124	Pages 125	Page 139	Pages 140-141	Page 142

DC Motors — Section E

Permanent Magnet	Permanent Magnet-Washdown	Shunt Wound
		
Pages 147-149	Page 150	Pages 151-153

AC Motors — Section F

Open Dripproof	Totally Enclosed	Washdown	Brake Motors	Rigid Base	Inverter Duty
					
Pages 157-158	Page 159-164	Page 165	Pages 166-167	Page 169	Pages 170-171

RATIOTROL SYSTEMS

System Selection

The proper selection of a Ratiotrol system is based on first determining the load torque, second, the horsepower of the motor and last, the type and configuration of the controller to power the selected motor. Sizing an adjustable speed drive generally is no different than selecting a motor and reducer for a constant speed application. Maximum RPM and maximum torque are used in all calculations involving constant torque applications, which are the most common. Our standard Ratiotrol systems are constant torque drives and therefore, selection is straight forward.

Constant horsepower applications, typically winders or machine tools, require the use of the maximum load torque (usually at the minimum speed) in selecting a suitable drive. If the required constant HP value is known, the required system HP is equal to the required speed range ratio multiplied by the constant HP figure.

NOTE: Auxiliary drives beyond the reducer output shaft can reduce the cost of a system significantly since a chain or gear drive multiplies the torque delivered by the reducer, thereby reducing the load required to be driven by the reducer. For instance, if a 3:1 ratio chain drive can be incorporated in a drive train, the driven load (torque) can be divided by 3 and the load speed multiplied by 3 before selecting a suitable motor and reducer combination.

SELECTION PROCEDURE:

1) Select a reducer as you would for a constant speed application and size the motor/controller package to provide the HP indicated by the reducer's input HP rating.

   Note: When using compound worm gear reducers with ratios greater than 200:1, use a motor with twice the HP shown for that reducer. This technique will provide sufficient starting torque at low motor speeds to overcome the near-static friction conditions present in the output bearings and gearing of the reducer.

2) The motor selected in Step 1 determines the "System HP" to use when you progress to the Ratiotrol System Selection Guides.

3) From the Selection Guide, proceed to the appropriate AC or DC Controller section to determine the complete motor and controller catalog numbers, options and any desired accessories.

SINGLE PHASE DC CONTROLLER SELECTION GUIDE

System HP	Line Voltage (VAC)	Nonregenerative						Regenerative			Motor Series*	
		Ratiopax	DCX	BETA II	BETAplus	VEplus	VED	RBA-RG	VEA-RG	VEL/H-RG	PM	Shunt
1/12	115	•	•								BPM/PM908T	—
1/6	115	•	•	•	•	•	•	•	•	•	PM916	V91600
1/4	115	•	•	•	•	•	•	•	•	•	PM925	V92500
1/3	115	•	•	•	•	•	•	•	•	•	PM933	V93300
1/2	115	•	•	•	•	•	•	•	•	•	PM950	V95000
	230	•	•	•	•	•	•	•	•		PM1850	—
3/4	115		•	•	•	•	•	•	•	•	PM975	V97500
	230	•	•	•	•	•	•	•	•		PM1875	V18750
1	115		•	•	•	•	•	•	•	•	PM9100	V91000
	230	•	•	•	•	•	•	•	•	•	PM18100	V18100
1 1/2	230		•	•	•	•	•	•	•	•	PM18150	V18150
2	230		•	•	•	•	•	•	•	•	PM18200	V18200
3	230		•	•	•	•	•	•	•	•	PM18300	18300
5	230					•			•	•	PM18500	18500

* Basic DC Motor Catalog number, refer to Section I for complete motor selection.

System Selection

AC CONTROLLER SELECTION GUIDE					
System HP	Line Voltage (VAC)	BCX	ACX	ADX	Motor* Series
1/6	115-1-60	•	•		CU
	230-1-60	•	•		
	230-3-60	•	•		
1/4	115-1-60	•	•		DU
	230-1-60	•	•		
	230-3-60	•	•		
1/3	115-1-60	•	•		EU
	230-1-60	•	•		
	230-3-60	•	•		
1/2	115-1-60	•	•		FU
	230-1-60	•	•		
	230-3-60	•	•		
3/4	115-1-60	•	•		GU
	230-1-60	•	•		
	230-3-60	•	•		
1	115-1-60	•	•		HU
	230-1-60	•	•		
	230-3-60	•	•	•	
	460-3-60	•	•	•	
1 1/2	230-1-60		•		JU
	230-3-60	•	•	•	
	460-3-60	•	•	•	
2	230-1-60		•		KU
	230-3-60	•	•	•	
	460-3-60	•	•	•	
3	230-3-60	•	•	•	LU
	460-3-60	•	•	•	
5	230-3-60	•	•	•	KU
	460-3-60	•	•	•	
7 1/2	230-3-60		•	•	NU
	460-3-60		•	•	
10	230-3-60		•	•	PU
	460-3-60		•	•	
15	230-3-60		•	•	RU
	460-3-60		•	•	
20	230-3-60		•	•	SU
	460-3-60		•	•	
25	230-3-60		•	•	TU
	460-3-60		•	•	
30	230-3-60		•	•	UU
	460-3-60		•	•	
40	230-3-60			•	VU
	460-3-60		•	•	
50	230-3-60				WU
	460-3-60		•	•	
60	460-3-60		•	•	XU
75	460-3-60		•	•	YU
100	460-3-60			•	ZU
125	460-3-60			•	
150	460-3-60			•	
200	460-3-60			•	
250	460-3-60			•	
300	460-3-60			•	
400	460-3-60			•	

*Basic AC Motor Catalog number, refer to Section J for complete motor selection.

NOTES

Single-Phase Adjustable Speed DC Motor Controllers, Nonregenerative

TABLE OF CONTENTS

SPECIFICATION CHART 10

RATIOPAX 11-12

DCX/DCXplus 13-17

BETA II 18-22

BETAplus 23-27

VEplus 28-32

VED 33-39

OPTIONS FOR DC CONTROLLERS 53-71

APPLICATION ENGINEERING 175-189

RATIOTROL SYSTEMS

Single-Phase Adjustable Speed DC Motor Controllers, Nonregenerative

Specification Chart

The purpose of this chart is to provide a general feature comparison of the Boston Gear controllers. When selecting, refer to the specific catalog selection for complete information.

SINGLE PHASE NONREGENERATIVE DC MOTOR CONTROLLER SPECIFICATIONS

Features		Ratiopax		DCX		DCXplus		BETA II		BETAplus		VEplus		VED	
AC Line	Voltage 50/60 Hz	115	230	115	230	115	230	115	230	115	230	115	230	115	230
Range	Maximum Horsepower	1/2	1	1	3	1/2	1	1	3	1	3	1	5	1	3
Output	Armature Voltage (0 to) Field Voltage	90 50	180 100	90 100	180 200	90 100	180 200	90 50/ 100	180 100/ 200	90 50/ 100	180 100/ 200	90 50/ 100	180 100/ 200	90 50	180 100
AC Line Protection	Fuse	S		O		S		S		S		S			
	Circuit Breaker											O		S	
Functions	Jog							S		S		S		S	
	Preset Speeds													O	
	Armature Contactor														
	Unidirectional W/ D.B.			O				S		S		S			
	Reversing W/DB			O				S		S		S		O	
	Reversing, Switch	S				S		S		S		S			
	Constant Torque Operation	S		S		S		S		S		S		S	
Enclosure	Angle Bracket Chassis			S				S		S					
	Open Chassis							S		S		S		S	
	NEMA 1	S				S								S	
	NEMA 3													O	
	NEMA 4							S		S		S		O	
	NEMA 12					S		S		S		S		O	
Adjustments	Acceleration (Seconds)			0.8-10		0.8-10		0.2-40		0.2-30		0.2-30		0.2-100	
	Deceleration (Seconds)			0.8-10		0.8-10		0.2-40		0.2-30		0.2-30		0.2-100	
	IR Compensation (%)			0-100		0-100		0-100		0-100		0-100		0-100	
	Maximum Speed (%)	75-100		60-100		60-100		50-100		50-100		50-100		0-100	
	Minimum Speed (%)			0-40		0-40		0-40		0-40		0-40		0-100	
	Current Limit (%)	150		0-150		0-150		0-150		0-150		0-150		0-150	
Horsepower/ Voltage Calibration	Trim Pot Adjustments			S		S									
	Resistance Wire	S						S						S	
	Reconnectable Jumpers									S		S			
	Dip Switches									S		S			
Isolated Regulator				O						S		S		S	
Load Monitor										S		S		S	
Speed Regulation	Standard IR Feedback														
	Percentage	5%		2%		2%		2%		2%		2%		2%	
	Speed Range	20:1		30:1		30:1		50:1		50:1		50:1		50:1	
	Tachometer Feedback														
	Percentage			1%		1%		0.5%		0.5%		0.5%		0.2%	
	Speed Range			100:1		100:1		200:1		200:1		200:1		200:1	
Input	Analog	S		S		S		S		S		S		S	
	Digital													S	
Tachometer Feedback	Unidirectional			S		S		S		S		S		S	
	Bidirectional							O		O		O		O	
Modifiable Features	DC Tachometer Feedback			S		S		S		S		S		S	
	AC Line Starting			S		S		S		S		S		S	
	Torque Regulator							S		S		S		S	
	External DC Signal Follower									S		S		O	
	Limit Switch Reversing							S		S		S			
Options	Field Installed			O				O		O		O		O	
	Factory Installed			O								O		O	
UL/cUL				S		S		S		S		S		S	
Pages		11-12		13-17		13-17		18-22		23-27		28-32		33-39	

S-Standard O-Optional

Single-Phase Adjustable Speed DC Motor Controllers, Nonregenerative

***RATIOPAX* Series**
***1/12-1* Horsepower**

Ratiopax Controllers are economical, **non-modifiable**, general purpose controllers featuring static conversion of AC line power to regulated DC for nonregenerative, adjustable speed armature control of shunt-wound and permanent-magnet DC motors. Their lightweight and compact design makes these units an ideal choice for a broad range of industrial applications.

Motors suitable for application with these controllers are listed in the DC motor section.

A

DESIGN FEATURES AND FUNCTIONS

1. **Enclosure** – All models are furnished in a rugged die cast enclosure. Complete control assembly is attached to the front cover which can be removed from the enclosure by removing four (4) screws.
2. **Operator Controls** – Mounted on the front cover. Included is a calibrated SPEED control potentiometer and a RUN-STOP toggle switch. A Forward-Stop-Reverse maintained switch is standard on the RPIR & RP2R. This switch includes a no pass through center detent which provides anti-plug protection.
3. **AC Line Protection** – AC line fuse provides instantaneous protection from peak loads and fault currents. The fuse is front panel mounted, and can be replaced without removing the cover.
4. **Voltage Transient Protection** – Suppression network to minimize the effect of high voltage or high frequency spikes.
5. **Full-Wave Power Conversion** – 2 SCRs 2 diodes and a free-wheeling diode provide optimum form factor for best motor performance and longevity. NEMA Code K Converter.
6. **Reference Circuit** – 24 VDC regulated to provide stable performance with changes in line voltage.
7. **Maximum Speed Adjustment** – Adjustable from 75 to 100% of motor base speed.
8. **Trigger Circuit** – Fast rise, hard firing type to minimize di/dt degradation of SCRs.
9. **Counter EMF Voltage Feedback with IR Compensation** – Non-adjustable, factory set.
10. **Quality Features** – FR4 glass printed circuit card • Rugged construction • Conservatively rated components selected for long service life.

RATINGS

1. **Service factor** 1.0
2. **Duty** ..... Continuous
3. **Overload Capacity**.....150% for 1 minute
4. **Run Speed Potentiometer** .....100K Ohms, 2W
5. **Reference Power Supply**..... 24 VDC
6. **AC Line Fuse, Interrupting Capacity** ..... 5000 Amps
7. **RP1, RP1R Controllers**.....115 VAC, 50 or 60 Hz, Single Phase
8. **RP2, RP2R Controllers**..... 230 VAC, 50 or 60 Hz, Single Phase

PERFORMANCE CHARACTERISTICS

1. **Controlled Speed Range** – Zero to motor base speed. Speed range with respect to specified regulation is shown below.
2. **Speed Regulation** – Regulation percentages listed are of motor base speed under steady-state conditions. Normal operation will result in performance equal to or better than specifications.

SPEED REGULATION CHARACTERISTICS

Regulation Method	Variables				Speed Range
	Load Change 95%	Line Voltage ±10%	Field Heating Cold/ Normal	Temp. ±10°C	
Standard Voltage Feedback with IR Compensation	5%	±1%	5–12%	±2%	20:1

3. **Efficiency** (rated speed/rated load)
   (a) Controller (SCR regulator).....98%
   (b) Complete drive (controller and motor, typical) 85%
4. **Current Limit** (factory set, nonadjustable) .....150% full-load torque (typical)

OPERATING CONDITIONS

1. **Line Voltage Variation**.....±10% of rated
2. **Line Frequency Variation** .....±2 Hz
3. **Ambient Temperature**.....0°C to 40°C (32°F to 104°F)
4. **Altitude (standard)** ....3300 feet (1000 meters) maximum

A

MODEL TYPES

Ratiopax controllers are offered as four standard models. Models RP1 and RP2, are unidirectional packaged controllers and Models RP1R and RP2R, are reversible controllers with Forward-Stop-Reverse switch. All are furnished in a totally-enclosed, non-ventilated, rugged, die-cast aluminum alloy enclosure with integral operator controls.

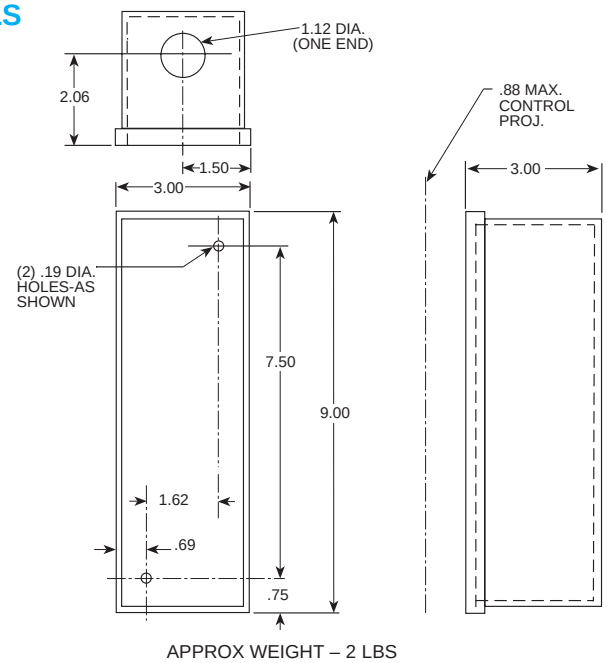
ORDER BY CATALOG NUMBER OR ITEM CODE

NEMA 1 ENCLOSED CONTROLLER WITH INTEGRAL OPERATOR CONTROLS				
Horsepower Range		Catalog Number	Item Code	Function
115 VAC	230 VAC			
1/6 – 1/2	—	RP1	63370	Run/Stop
		RP1R	63372	Armature Switch Reversing
—	1/2 – 1	RP2	63371	Run/Stop
		RP2R	63373	Armature Switch Reversing

TYPICAL APPLICATION DATA								
			Ratings					
Rated Horsepower (HP)			1/6	1/4	1/3	1/2	3/4	1
Rated Kilowatts (kW)			0.124	0.187	0.249	0.373	0.560	0.746
1-Phase AC Input (Full-Load)	Line Amps	115V Unit	3.9	5.0	6.0	8.7	—	—
		230V Unit	—	—	—	4.2	5.9	8.8
	KVA		.48	.58	.71	1.0	1.4	2.0
DC Output (Full-Load)	Motor Armature Amps	90V	2.0	2.8	3.5	5.4	—	—
		180V	—	—	—	2.6	3.8	5.5
	Motor(1) Field Amps	50V	2.0	2.0	2.0	2.0	—	—
		100V	—	—	—	2.0	2.0	2.0
Full-Load Torque (lb-ft) with 1750 RPM Base Speed Motors			0.5	0.75	1.0	1.5	2.2	3.0

(1) Does not apply to permanent magnet motors.

DIMENSIONS – ALL MODELS



APPROX WEIGHT – 2 LBS

Single-Phase Adjustable Speed DC Motor Controllers, Nonregenerative

DCX® Series
DCXplus® Series
1/12-3 Horsepower

Ratiotrol DCX® controllers statically convert single-phase AC line power to regulated DC for nonregenerative adjustable speed armature control of shunt-wound and permanent magnet DC motors. They are ideal for simple MRO modifications of existing drives or for installation in OEM equipment to provide variable speed motor operation with traditional Boston Gear reliability.

These controls feature a number of exclusive advantages. Their built-in adjustment trimpots, for example, offer immediate access to a broad range of horsepower settings.

They completely eliminate the need to stock a variety of components for every horsepower rating.

The dual voltage models can be connected to either 115 VAC or 230 VAC for operation without the use of jumpers or switches.

With a selection of four enclosed models, two panel-front models for installation in OEM control cabinets, and three chassis models with up to 3 horsepower capability and companion optional accessories, Boston Gear has a low-cost controller suitable for virtually any requirement.

Motors suitable for application with these controllers are listed in the DC motor section.

DESIGN FEATURES AND FUNCTIONS

1. **DCXplus® Enclosed Models** – These units are furnished in a compact, die cast aluminum, nonventilated NEMA 1 or NEMA 12 rated enclosure. The complete control assembly is mounted on the front panel which can be removed from the enclosure by removing four (4) screws. The unenclosed panel assembly can be mounted through a cut-out in the user's enclosure.
2. **DCX® Chassis Models** – The units are furnished as a very compact open chassis consisting of the regulator/power conversion circuit board mounted to a formed aluminum chassis. The DCX202C model may be furnished with a supplemental heatsink (DCX-HTSK or DCX-RHTSK) to improve heat dissipation and thereby extend the horsepower range. Chassis units are dimensionally interchangeable with many competitive units.
3. **Full-Wave Power Conversion** – NEMA Code K converter configuration formed of discrete devices rated 600 PIV. Converter consists of two (2) SCR's, two diodes and a free wheeling diode which provide optimum form factor for best motor performance and long service. Enclosed models use the control enclosure as an integral heatsink with the power control devices electrically isolated from the enclosure.
4. **Voltage Transient Protection** – Metal oxide suppressor across the AC line minimizes the effect of high voltage spikes from the AC power source.
5. **Tachometer Feedback** – All standard units except DCX102C accept a 35, 50 or 100 VDC/1000 RPM feedback signal from a motor mounted DC tachometer generator for improved speed regulation. (Unidirectional units only).
6. **Horsepower Selection** – Easily calibrated by built-in trimpots to suit individual motor horsepower ratings without special instruments, or plug-in shunts.
7. **Wiring Terminals** – Enclosed models are provided with barrier terminal strips for all external power and signal wires. Chassis models are provided with male tab wiring connectors. A terminal strip is offered as Options DCX-BTB2 or DCX-BTB3.
8. **AC Line Fuse** – Enclosed models include an AC line fuse mounted on the circuit board. Chassis units do not include a fuse as standard, but a fuse holder may be provided with Options DCX-BTB2, DCX-BTB3 or DCX-FBK.
9. **Operator Controls** – All enclosed models include integral operator controls consisting of a speed setting potentiometer and an ON-OFF AC line power switch. Switch is maintained in ON and OFF positions. Reversing models additionally include a 3-position FORWARD-STOP-REVERSE maintained switch. Switch includes a no pass through center detent which provides a delay when changing direction.

   Chassis units are controlled by external, customer furnished switches, pushbuttons, or control logic. These units include an inhibit circuit for automatic operation by switch, relay or PLC.

   Chassis units are furnished with a speed setting potentiometer and female wiring connectors supplied loose.
10. **Line Voltage Selection** – Line voltage selection is automatic without the use of jumpers or switches.
11. **Field Supply** – A full-wave, transient protected motor field supply is provided.
12. **UL Rating** – The DCX Series units are either UL listed or UL recognized.

RATINGS

1. **Horsepower. . . See selection chart page A7**
2. **Service Factor** 1.0
3. **Duty** ..... Continuous
4. **Operating Voltages**

OPERATING VOLTAGES		
Power Source (Single-Phase)	**Output VDC**	
	Armature	**Field**
115V, 50 or 60 Hz	0-90	100
230V, 50 or 60 Hz	0-180	200

5. **Overload Capacity** (armature).....150% for 1 minute
6. **Run Speed Potentiometer**..... 5K Ohms, 1/2 W
7. **Reference Power Supply**.....10VDC(1)
8. **Line Fuse**(2) ..... Provided by others

(1) Units are optionally adaptable for use with 4-20mA and 0-10 VDC reference voltages by the use of option DCX-25A

(2) Line fuse is standard on DCXplus models, optional on all others

PERFORMANCE CHARACTERISTICS

1. **Controlled Speed Range —** Zero to motor base speed. Speed range with respect to specified regulation is shown on right
2. **Speed Regulation** — Regulation percentages listed are of motor base speed under steady-state conditions. Normal operation will result in performance equal to or better than specifications.

SPEED REGULATION CHARACTERISTICS					
Regulation Method	**Variable**				**Speed Range**
	Load Change 95%	**Line Voltage ± 10%**	**Field Heating Cold/Normal**	**Temp. ±10°C**	
Standard Voltage Feedback with IR Compensation	2%	± 1%	5–12%	± 2%	30:1
Tachometer Feedback(1)	1%	± 1%	0.2%	±2%	100:1

(1) Unidirectional models only.

3. **Efficiency (Rated speed/rated load)**
   Controller..... 99%
   Controller and Motor (typical)..... 85%

ADJUSTMENTS

1. **Current Limit**..... 0-150% full-load torque (typical)
2. **Maximum Speed**..... 60-100% of motor base speed
3. **Minimum Speed** ..... 0-40% of motor base speed
4. **IR (load) Compensation** ..... 0-100% of rated load
5. **Acceleration/Deceleration**(1) ..... 0.8-10 seconds

NOTE: (1) DCX102C acceleration/deceleration is 1.0 second fixed rate.

OPERATING CONDITIONS

1. **Line Voltage Variation**..... ±10% of rated
2. **Line Frequency Variation**..... ±2 Hz
3. **Ambient Temperature**
   Chassis..... 0°C to 50°C (32°F to 122°F)
   Enclosed..... 0°C to 40°C (32°F to 104°F)
4. **Altitude** (Standard)... 3300 Feet (1000 meters) maximum
5. **Relative Humidity**..... 95% non-condensing

TYPICAL APPLICATION DATA											
			Ratings								
Rated Horsepower (HP)			**1/12**	**1/6**	**1/4**	**1/3**	**1/2**	**3/4**	**1**	**1-1/2**	**2**	**3**
Rated Kilowatts (kW)			**0.062**	**0.124**	**0.187**	**0.249**	**0.373**	**0.560**	**0.746**	**1.129**	**1.492**	**2.238**
1-Phase AC Input (Full-Load)	Line Amps	115V Unit	2.0	3.9	5.0	6.0	8.7	12.4	15.0	—	—	—
		230V Unit	—	—	—	—	4.8	5.9	8.8	12.6	15.8	24.0
	KVA		.30	.48	.58	.71	1.0	1.4	2.0	3.0	4.0	6.0
DC Output (Full-Load)	Motor Armature Amps	90V	0.9	2.0	2.8	3.5	5.4	8.1	10.5	—	—	—
		180V	—	—	—	—	2.5	3.8	5.5	8.2	11.6	16.0
	Motor(1) Field Amps	100V	1.0	1.0	1.0	1.0	1.0	1.0	1.0	—	—	—
		200V	—	—	—	—	1.0	1.0	1.0	1.0	1.0	1.0
Full-Load Torque (lb-ft) with 1750 RPM Base Speed Motors			.25	0.5	0.75	1.0	1.5	2.2	3.0	4.5	6.0	9.0

(1) Does not apply to permanent magnet motors.

Single-Phase Adjustable Speed DC Motor Controllers, Nonregenerative

DCX® Series
DCXplus® Series
1/12-3 Horsepower

MODEL TYPES

DCX and DCXplus Series controllers are offered as open chassis or enclosed configurations in nine (9) standard models in four (4) functional groups. The DCX® Series chassis units are ideal for the OEM or panel builder who may want to build a custom system by integrating the controller in an enclosure with special logic or auxiliary control devices. The DCXplus® Series enclosed units are offered as complete self-contained functional packages which include power conversion and regulator electronics, AC line protection and integral operator controls.

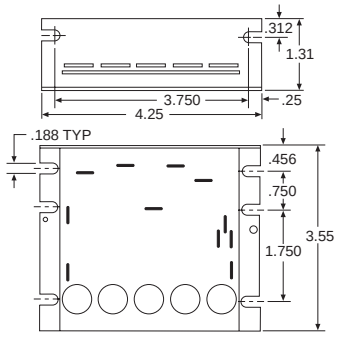
DCX® AND DCXplus® SERIES SELECTION CHART

ORDER BY CATALOG NUMBER OR ITEM CODE

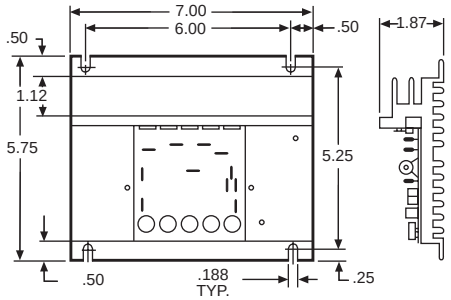
Horsepower Range(4)		Catalog	Item	
115 VAC	230 VAC	Number	Code	Function
DCX ANGLE BRACKET CHASSIS CONTROLLERS				
1/12 – 1/2	—	DCX102C	65984	Run/Stop(3)(2)
1/12 – 1/2 1/12 – 1(1)	1/2 – 1 1/2 – 2(1)	DCX202C	65985	Run/Stop(3)(2)
1/12 – 1	1/2 – 3	DCX302C	65986	Run/Stop(3)(2)
DCXplus FRONT PANEL ASSEMBLY WITH INTEGRAL OPERATOR CONTROLS				
1/12 – 1/2	1/2 – 1	DCX202EP	65987	Run/Stop
		DCX202ERP	65991	Run/Stop, Armature Switch Reversing
DCXplus NEMA 1 ENCLOSED CONTROLLER WITH INTEGRAL OPERATOR CONTROLS				
1/12 – 1/2	1/2 – 1	DCX202E	65988	Run/Stop
		DCX202ER	65992	Run/Stop, Armature Switch Reversing
DCXplus NEMA 12 ENCLOSED CONTROLLER WITH INTEGRAL OPERATOR CONTROLS				
1/12 – 1/2	1/2 – 1	DCX202EN12	65990	Run/Stop
		DCX202ERN12	65995	Run/Stop, Armature Switch Reversing

(1) Requires either Option DC-RHTSK for 1 HP on 115 VAC and 2 HP on 230 VAC or Option DCX-HTSK for 3/4 HP on 115 VAC and 1-1/2 HP on 230 VAC.
(2) DC units are furnished with a potentiometer rated 5K ohms, 1/2 watt for separate mounting.
(3) Armature contactor Run-Stop-DB, and contactor reversing and dynamic braking are provided by Options DCX-DA and DCX-RA
(4) Units may be easily recalibrated for any standard rating within the range of the product using trimpots.

DIMENSIONS - DCX CHASSIS



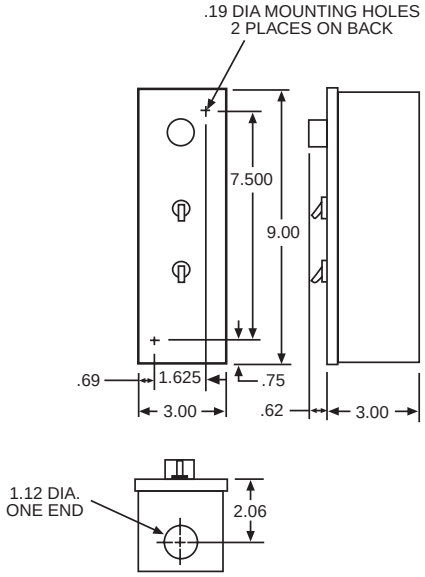
DCX102C, DCX202C



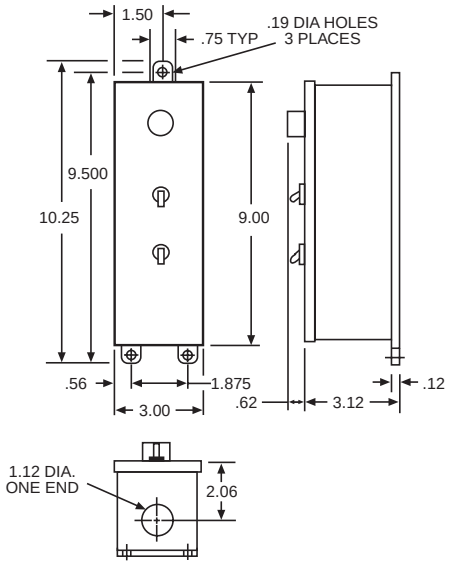
DCX302C

A

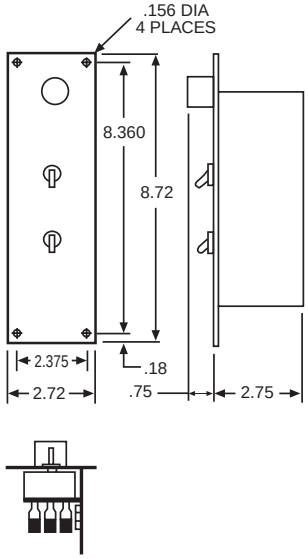
DIMENSIONS - DCXplus ENCLOSED



DCXplus NEMA 1

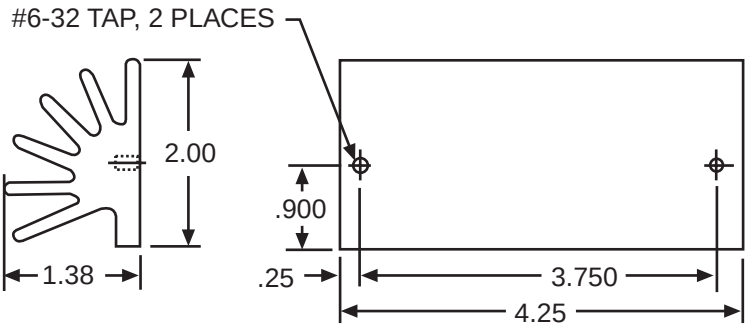


DCXplus NEMA12

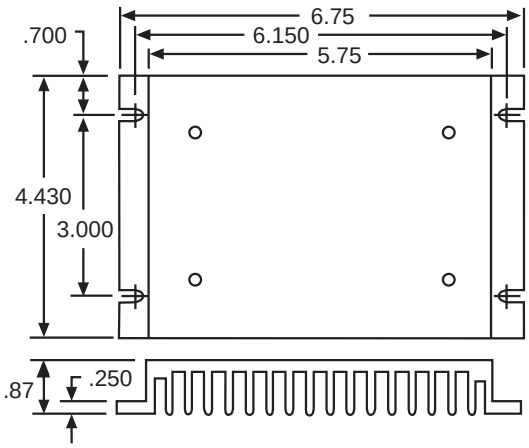


DCXplus Panel–Front

DIMENSIONS - HEATSINKS



DCX RHTSK



DCX HTSK

OPTIONS FOR DCX SERIES CHASSIS UNITS

ORDER BY CATALOG NUMBER OR ITEM CODE

Barrier Terminal Board DCX-BTB-2 (68249) DCX-BTB-3 (68254)

Kit includes screw terminals for all external wiring, one line fuse holder, and an LED power on indicator in an assembly that plugs piggy-back onto chassis model units. (fuse not included)
Total height when assembled to DCX102C or DCX202C is 2.12 inches

OPTION	INPUT VOLTAGE	HP RATING
DCXBTB-2	115 VAC	1
DCXBTB-3	115/230 VAC	3

Contactor, Two-Pole with Dynamic Braking DCX-DA (65996)

The basic DCX Series chassis controller is designed for Run-Stop unidirectional operation without an armature contactor. This option provides a two-pole armature contactor which is necessary whenever the application requires a positive disconnection of the rectified armature power source from the motor on a stop command. Action of the contactor is sequenced with the SCR regulator to ensure that the DC power circuit is "phased off" before the contactor is opened. This results in "dry switching" for improved contactor longevitiy. This option also includes dynamic braking which provides exponential rate braking of the DC motor armature. Included is a DB resistor with an anti-plug circuit to prevent restarting the controller until the braking cycle is complete, thereby preventing a potentially damaging electrical surge and mechanical stress.

DYNAMIC BRAKING RESISTOR RATINGS

COMPONENT	UNIT	RATED HORSEPOWER									
		1/12	1/6	1/4	1/3	1/2	3/4	1	1-1/2	2	3
Braking	115V	250	180	129	103	66	44	34	–	–	–
Torque %	230V	–	–	–	–	278	190	130	88	62	44
Stops Per	115V	18	15	12	11	8	6	2	–	–	–
Minute	230V	–	–	–	–	8	6	1	1	1	1

This option permits motor Start/Stop operation by pushbuttons or external logic in 115 or 230 VAC applications.

Dimensions 4.3” x 4.6” x 1.9”

Reversing, Armature with Dynamic Braking DCX-RA (65998)

This option is the same as DCX-DA except two double pole contactors are provided for reversing the DC motor armature rated 1 HP at 90 VDC armature or 3 HP at 180 VDC maximum. Anti-plug protection is provided to prevent armature reversal until a safe minimum speed is attained. The direction of motor rotation is controlled by external RUN/FORWARD-REVERSE pushbuttons, switches or logic. Braking times are same as DCX-DA above.
Dimensions 4.3” x 4.6” x 1.9”

Fuse Block Kit DCX-FBK (67114)

Kit includes a fuse block, lead wire with spade connectors, and mounting screw. This option provides external line fuse protection for DCX Series chassis controllers (fuse not included).

Heatsink Kit (Flat) DCX-HTSK (67106)

This option consists of an extruded aluminum heatsink and hardware to mount a Model DCX202C controller. This heatsink is intended for use only with Model DCX202C where its greater heat dissipation permits increasing the units original rated horsepower.
Dimensions: 4.44"x6.75"x.88"

Heatsink Kit (Radial) DCX-RHTSK (67098)

This option provides the same function as Option DCX-HTSK except it is a unique space saving radial design and offers a greater horsepower rating.
Dimensions: 2"x1.38"x4.25"

Dual Connector Terminal Adapter DCX-DP (67118)

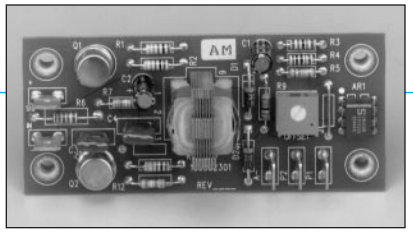
This option provides a two (male) into one (female) push-on terminal to facilitate connection of DCX Series units for tachometer feedback and/or inhibit.

Knob and Dial Plate Kit DCX-KDP (67109)

This option provides a knob and a dial face graduated 0-100% for use with the potentiometer provided with DCX Series units.

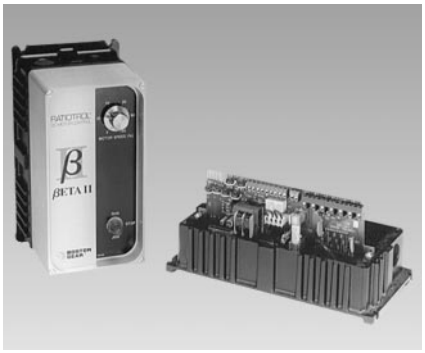
Follower, External Signal DCX-25A (68342)

This option is intended as a low cost alternative which offers greater accuracy and flexibility. The option is capable of operating from the following isolated or nonisolated signals: 4-20 DC ma, 0-10 VDC. *This option includes a scaling potentiometer for offset adjustment.*
Dimensions 1.5" x 3.38" x .75"



Single-Phase Adjustable Speed DC Motor Controllers, Nonregenerative

BETA II Series
1/6-3 Horsepower



BETA II series controllers are high quality, economically priced, general purpose controllers that feature static conversion of AC line power to regulated DC for nonregenerative adjustable speed armature control of shunt wound and permanent magnet DC motors. The combination of a rugged compact design, mechanical flexibility, with many standard and field modifiable features, make these units an ideal choice for a broad range of industrial applications.

The BETA II controllers are designed and manufactured to comply with applicable standards established by the National Electric Code and NEMA for industrial motor and control equipment. The units are UL and cUL Listed.

Motors suitable for Application with these controllers are listed in the DC motor section.

DESIGN FEATURES AND FUNCTIONS

1. **Construction**

   a) Angle Bracket Chassis – Circuit board and power devices are mounted to a formed metal bracket which allows a smaller footprint than the conventional basic chassis. The optional contactor assemblies may also be mounted on the same bracket.

   b) Basic Chassis – Open chassis constructed of a rugged die-cast aluminum alloy with provisions for conduit entry at the top and bottom by two (2) 3/4-14 NPSC tapped holes with knockout plugs. The optional contactor boards may also be mounted in the basic chassis.

   c) Enclosed – Basic chassis unit with an aluminum die-cast cover added. The cover has a recessed area to guard the local operator control from accidental operation. All units use an oil resistant synthetic gasket to meet the provisions for NEMA 4/12, making them suitable for a wide range of wet and dirty industrial environments. All models with integral operator controls include flexible boots to seal the operator control switches, and a seal for the motor speed potentiometer.

   d) Washdown Duty – Basic Chassis unit and aluminum die-cast cover painted with a durable white epoxy paint. All units are furnished with stainless steel hardware, oil resistant synthetic gasket and flexible boots for sealing the operator controls to meet the provisions of NEMA 4X.

2. **Full-Wave Conversion** – NEMA Code K converter configuration consisting of two (2) SCRs, two (2) diodes and a free wheeling diode provides optimum form factor for best motor performance and long service. The units have 600 PIV devices. The controller base or metal bracket forms an integral heatsink with the power control devices and is electrically isolated from the rest of the control.

3. **Voltage Transient Protection** – Metal oxide suppresser across the AC line minimizes the effect of high voltage spikes from the AC power source.

4. **AC Line Protection** – AC line fuse provides instantaneous protection from peak loads and fault currents. The AC line fuse and holder are located on the main circuit board of the controller.

5. **Motor Contactor** – Models with a M or U in the catalog number include DC magnetic armature contactors. This provides a positive, two-pole disconnection of the motor armature from the rectified power source. Action of the contactor is sequenced with the SCR regulator to ensure that the DC power circuit is "phased-off" before the contactor is opened. This results in "dry-switching" for improved contactor life. Anti-plug protection is provided to prevent armature reversal until a safe minimum speed is reached. Two types of contactor assemblies are available; Unidirectional (U suffix) which adds contactors to disconnect the motor armature when the control is stopped and Reversing (M suffix) which adds additional contactors to disconnect and reverse the motor armature when the unit is reversed.

6. **Dynamic Braking** – A standard feature of the controllers when supplied with the motor contactor. Dynamic braking provides exponential rate braking of the DC motor armature. Included is a DB resistor with an anti-plug circuit to prevent restarting the controller until the braking cycle is complete, thereby preventing a potentially damaging electrical surge and mechanical stress.

   The DB resistor is rated for stopping a typical load, when the external machine inertia does not exceed that of the motor armature, as shown in the chart below. The DB resistor may be disconnected when braking is not desired.

DB RESISTOR RATINGS

Model	Component	Voltage	Rated Horsepower								
			1/6	1/4	1/3	1/2	3/4	1	1-1/2	2	3
RBA2	Braking Torque (%)	115V	180	129	103	66	44	34	—	—	—
		230V	—	—	—	278	190	130	88	62	—
	Stops Per Minute	115V	15	12	11	8	6	2	—	—	—
		230V	—	—	—	8	6	1	1	1	—
RBA3	Braking Torque (%)	115V	300	215	170	110	75	60	—	—	—
		230V	—	—	—	400	320	220	145	105	85
	Stops Per Minute	115V	9	6	5	5	4	4	—	—	—
		230V	—	—	—	5	4	4	3	3	2

7. **Operator Controls** – All enclosed models with integral operator controls include a speed setting potentiometer and a multi-position switch providing RUN-STOP-JOG functions. The switch is maintained in RUN and STOP positions and a spring return to the center stop position from the momentary JOG position. Jog speed is set by the RUN speed potentiometer. The reversing models, when supplied without a contactor assembly, have an armature reversing power switch which is maintained in the FORWARD or REVERSE run positions. This switch

Single-Phase Adjustable Speed DC Motor Controllers, Nonregenerative

BETA II Series
1/6-3 Horsepower

DESIGN FEATURES AND FUNCTIONS *(Continued)*

includes a no pass through center detent which provides a delay when changing direction for anti-plug protection.

Reversing models with a contactor assembly include a momentary contact FORWARD-REVERSE run switch with a spring return to the center position. This switch controls only low control power since armature switching is accomplished by magnetic contactors. The unit is jogged forward or reverse by the momentary FORWARD-REVERSE switch after selecting the JOG position on the RUN-STOP-JOG switch (the JOG position is maintained on this unit).

8. **Control Transformer** – All models include a control transformer which provides internal reference and power supply voltages, and a low voltage source for the magnetic controls, control logic and operator controls.
9. **Counter EMF Voltage Feedback with IR Compensation** – Adjustable to suit individual motor characteristics.
10. **Trigger Circuit** – Fast rise, hard firing to ensure reliable conduction and minimize di/dt degradation of SCRs.
11. **Field Supply** – Transient protected. Selectable for either half-wave or full-wave output. See Table for operating voltages.
12. **Control Relay** – Enables remote control of all models and provides an interlock to prevent a restart after a power outage. This may be defeated when an external customer furnished AC line contactor is used to control the unit.
13. **Customer Use Run Relay Contact** – Form A normally open contact rated five (5) amps at 115 VAC or 30 VDC coordinating with a run command. May be used for external control and indicating devices. May also be applied as a pushbutton seal-in or a drive OK contact.
14. **Hybrid Circuitry** – Miniature components in custom surface mount assemblies improve reliability and make available more features in the smallest possible mechanical configuration.
15. **Selectable Capabilities –**

a) DC Tachometer Feedback – Provided is impedance matching, voltage scaling and terminals for accepting a signal from a DC tachometer generator directly coupled to the drive motor armature. The tachometer signal makes the controller directly sensitive to motor speed. This results in an expanded speed range, improved speed regulation with load changes, motor field heating and other operating variables. The controller will automatically transfer to counter EMF voltage feedback to prevent a runaway motor if the tachometer circuit is opened. (A broken tachometer drive coupling will cause the motor to run at maximum speed.) Tachometers producing 7 to 150 VDC at maximum motor speed may be used. *This feature is suitable for use only with unidirectional units using DC tachometers.*

b) AC Line Starting – A provision is included to defeat the no-restart-on-power-failure feature to permit run-stop control of unidirectional models by an external AC line contactor. Included is circuitry to assure smooth motor starting.

c) Torque Regulator – These units may be easily reconfigured to function as torque regulators. In this mode, the speed setting potentiometer is used to set and regulate the maximum motor armature current over a range of 0 to 150% of rated current. Accordingly motor speed is unregulated and will go to a level of 0 to 100% of rated speed, depending upon the application load torque.

16. **Mechanical Flexibility** – The same basic unit can be used as an open chassis or an enclosed package controller. Enclosed units may be mounted under or through a console surface as shown on page 20. The angle bracket chassis offers the same controller in a smaller footprint and is designed for use in the customer's own panel.
17. **Horsepower and Voltage Calibration** – Units are shipped calibrated for the maximum horsepower rating and 230V operation. They may be easily recalibrated for 115V operation by reconfigurable jumpers and any standard horsepower rating within the design range by clipping shunt wires.
18. **Safety Features** – UL, cUL listed, low voltage operator control. Requires mandatory restart after power interruption, NEMA 4/12.

RATINGS

1. **Horsepower Range:**
   Enclosed ..... 1/6 thru 1 HP @ 115 VAC
   1/2 thru 2 HP @ 230 VAC
   Chassis ..... 1/6 thru 1 HP @ 115 VAC
   1/2 thru 3 HP @ 230 VAC
2. **Operating Voltages**

OPERATING VOLTAGES

Power Source (Single-Phase)	Output VDC		Control Reference Voltage(2)	Magnetic Control Voltage
	Armature	Field(1)		
115V, 50 or 60 Hz	0–90	50/100	0-10 VDC	24 VDC
230V, 50 or 60 Hz	0–180	100/200		

(1) Selectable
(2) Where operation from an external, non-isolated 4-20 mA or 0-10 VDC signal is desired we suggest using either the BETAplus or VE plus Series

3. **Service Factor** 1.0
4. **Duty** ..... Continuous
5. **Overload Capacity** (Armature circuit). 150% for 1 minute
6. **Run Speed Potentiometer** ..... 5K ohms, 1/2 W
7. **Reference Power Supply** .....10 VDC
8. **AC Line Fuse, Interrupting Capacity** ..... 100,000 Amps

ADJUSTMENTS

Potentiometer adjustments are provided for:

1. **Acceleration Time** ..... 0.2–40 seconds
2. **Deceleration Time** ..... 0.2–40 seconds
3. **Minimum Speed** ..... 0–40% of base speed
4. **Maximum Speed** ..... 50–100% of base speed
5. **IR (Load) Compensation** .....0–100% of rated load
6. **Current Limit** .....0–150% of full load torque

RATIOTROL SYSTEMS

Single-Phase Adjustable Speed DC Motor Controllers, Nonregenerative

***BETA II* Series**
***1/6-3* Horsepower**

PERFORMANCE CHARACTERISTICS

1. **Controlled Speed Range** — Zero to motor base speed. Speed range with respect to specified regulation is shown below.
2. **Speed Regulation** — Regulation percentages listed are of motor base speed under steady-state conditions. Normal operation will result in performance equal to or better than specifications.

SPEED REGULATION CHARACTERISTICS					
Regulation Method	Variable				Speed Range
	Load Change 95%	Line Voltage ±10%	Field Heating Cold/ Normal	Temp. ±10°C	
Standard Voltage Feedback with IR Compensation	2%	±1%	5-12%	±2%	50:1
Optional Tachometer Feedback(1)	0.5%	±1%	0.2%	±2%	200:1

(1) Unidirectional Models Only

3. **Efficiency** — (rated speed/rated load)
   (a) Controller (SCR regulator) 99%
   (b) Complete drive (Controller and motor, typical) 85%

OPERATING CONDITIONS

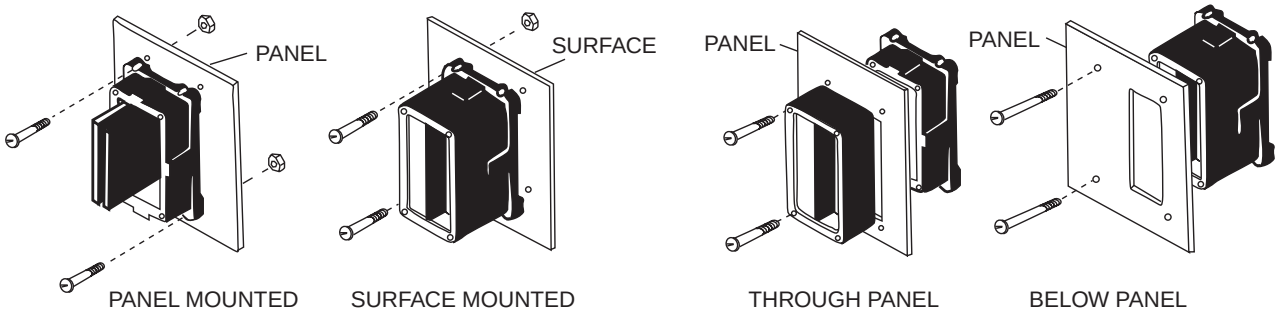
1. **Line Voltage**..... 115/230 VAC, 50/60 Hz, Single Phase
2. **Line Voltage Variation**..... ±10% of rated(1)
3. **Line Frequency Variation**..... ±2 Hz
4. **Ambient Temperature** .....Enclosed: 0° to 40° C (32° to 104° F)
   Chassis: 0° to 55° C (32° to 131° F)
5. **Altitude** ..... 3300 ft. (1000 meters) maximum
6. **Relative Humidity**..... 0–95%, noncondensing

(1) Unit will operate down to -15% of rated voltage although this may prevent rated speed with rated load.

TYPICAL APPLICATION DATA										
			Ratings								
Rated Horsepower (HP)			1/6	1/4	1/3	1/2	3/4	1	1-1/2	2	3
Rated Kilowatts (kW)			0.124	0.187	0.249	0.373	0.560	0.746	1.120	1.492	2.238
1-Phase AC Input (Full-Load)	Line Amps	115 VAC	3.9	5.0	6.0	8.7	12.4	15.8	—	—	—
		230 VAC	—	—	—	4.2	5.9	8.8	12.6	15.8	22.0
	KVA		0.48	0.58	0.71	1.00	1.40	2.00	3.00	4.00	5.00
DC Output (Full-Load)	Motor Armature Amps	90V	2.0	2.8	3.5	5.4	8.1	10.5	—	—	—
		180V	—	—	—	2.7	4.0	5.5	8.2	11.6	14.4
	Motor(1) Field Amps (Maximum)	50V	1.0	1.0	1.0	1.0	1.0	1.0	—	—	—
		100V	—	—	—	1.0	1.0	1.0	1.0	1.0	1.0
		200V	—	—	—	1.0	1.0	1.0	1.0	1.0	1.0
Full-Load Torque (lb-ft) with 1750 RPM Base Speed Motors			0.5	0.75	1.0	1.5	2.2	3.0	4.5	6.0	9.0
Minimum Transformer KVA for Voltage Matching or Isolation			0.5	0.75	0.75	1.0	1.5	2.0	3.0	5.0	7.5

(1) Does not apply to Permanent Magnet Motors

MOUNTING CONFIGURATIONS



PANEL MOUNTED OPEN CHASSIS

SURFACE MOUNTED ENCLOSED PACKAGE

THROUGH PANEL SURFACE MOUNTED

BELOW PANEL SURFACE MOUNTED

Single-Phase Adjustable Speed DC Motor Controllers, Nonregenerative

BETA II Series
1/6-3 Horsepower

MODEL TYPES

BETA II controllers are offered in twenty three (23) standard models in six functional groups. The basic chassis models are the nucleus of all the enclosed models; standard covers and contactor assemblies can be added to the basic chassis to make an enclosed controller or the enclosed unit may be ordered complete as shown below.

ORDER BY CATALOG NUMBER OR ITEM CODE

Horsepower Range(1)		Catalog Number	Item Code	Function
115 VAC	230 VAC			
ANGLE BRACKET CHASSIS CONTROLLERS WITHOUT OPERATOR CONTROLS*				
1/6 – 1	1/2 – 2	RBA2C	57854	Run/Stop(2)
		RBA2CU	57855	Armature Contactor Run/Stop and DB
		RBA2CM	57856	Armature Contactor Forward/Reverse and DB
BASIC CHASSIS CONTROLLERS WITHOUT OPERATOR CONTROLS*				
1/6 – 1	1/2 – 2	RBA2	64801	Run/Stop(2)
		RBA2U	57831	Armature Contactor Run/Stop and DB
		RBA2M	64821	Armature Contactor Forward/Reverse and DB
1/6 – 1	1/2 – 3	RBA3	64865	Run/Stop(2)
		RBA3U	57889	Armature Contactor Run/Stop and DB
		RBA3M	64873	Armature Contactor Forward/Reverse and DB
NEMA 4/12 ENCLOSED CONTROLLERS WITHOUT OPERATOR CONTROLS*				
1/6 – 1	1/2 – 2	RBA2B	64805	Run/Stop(2)
		RBA2UB	57852	Armature Contactor Run/Stop and DB
		RBA2MB	64855	Armature Contactor Forward/Reverse and DB
NEMA 4/12 ENCLOSED CONTROLLERS WITH INTEGRAL OPERATOR CONTROLS				
1/6 – 1	1/2 – 2	RBA2S	64814	Run/Stop/Jog(2) (4)
		RBA2R	64820	Run/Stop/Jog, Armature Switch Reversing(3) (4)
		RBA2US	57853	Run/Stop/Jog, Armature Contactor Run and DB(4)
		RBA2MR	64863	Run/Stop/Jog, Armature Contactor Forward/Reverse and DB(5)
WASHDOWN DUTY ENCLOSED CONTROLLERS WITHOUT OPERATOR CONTROLS*				
1/6 – 1	1/2 – 2	RBA2B-WD	13048	Run/Stop(2)
		RBA2UB-WD	13050	Armature Contactor Run/Stop and DB
		RBA2MB-WD	13100	Armature Contactor Forward/Reverse and DB
WASHDOWN DUTY ENCLOSED CONTROLLERS WITH INTEGRAL OPERATOR CONTROLS				
1/6 – 1	1/2 – 2	RBA2S-WD	13102	Run/Stop/Jog(2) (4)
		RBA2R-WD	13104	Run/Stop/Jog, Armature Switch Reversing(3) (4)
		RBA2US-WD	13106	Run/Stop/Jog, Armature Contactor Run and DB(4)
		RBA2MR-WD	13108	Run/Stop/Jog, Armature Contactor Forward/Reverse and DB(5)

*Refer to Remote Operator Control Stations on pages 109 and 110.
(1) Units are shipped calibrated for the maximum horsepower ratings shown. Units may be calibrated for other standard ratings by the removal of appropriate resistance wires. Units are connected for 230 VAC and are easily reconnected for 115 VAC input.
(2) Contactorless Run-Stop Operation
(3) Contactorless Reversing Operation
(4) Jog Speed is set by the Run Speed Potentiometer. Maintained in RUN position, JOG position is momentary with a spring return to STOP.
(5) Jog Speed is set by the Run Speed Potentiometer. Maintained JOG position, Forward/Reverse are momentary.

CONTROLLER WEIGHTS

Model	RBA2C	RBA2CU RBA2CM	RBA2 RBA3	RBA2U RBA2M RBA3U RBA3M	RBA2B, RBA2S RBA2R, RBA2BWD RBA2SWD RBA2RWD	RBA2UB, RBA2MB RBA2US, RBA2MR RBA2UB-WD RBA2MB-WD RBA2US-WD RBA2MR-WD
Weight (Lbs)	2.0	2.3	3.3	3.8	5.5	6.1

ORDER BY CATALOG NUMBER OR ITEM CODE

REMOTE OPERATOR CONTROL STATIONS BETA II					
Catalog Number	Item Code	Control Elements			Use With Controller Models
		Pushbuttons	Switches	Pots	
RCS1	69362	Run, Stop	—	Motor Speed	ALL
RCS3C	58098	Run, Stop	Run/Jog	Motor Speed Jog Speed	RBA2U, RBA3U, RBA2UB
RCS3D	58099	Run, Stop	Run/Jog	Motor Speed Jog Speed	RBA2, RBA3, RBA2B
RCS6	60239	Fwd, Rev, Stop	—	Motor Speed	RBA2M, RBA3M, RBA2MB
RCS16	58102	—	Run/Stop/Jog	Motor Speed	RBA2U, RBA3U, RBA2UB
RCS17	58103	—	Run/Stop/Jog, Fwd/Rev	Motor Speed	RBA2M, RBA3M, RBA2MB

Remote Operator Station dimensions shown on page 110.

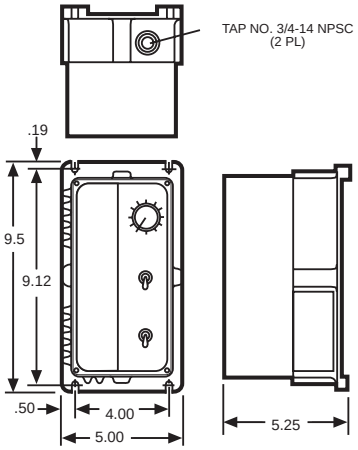
OPTIONS

Options and modifications are listed alpha-numerically within each group. Complete option descriptions are listed in the DC option section. To order a controller with the option installed or the modification made, add the option number or letter as a suffix to the controller catalog number, e.g. RBA2B-21. To order a kit for field installation, order by item code.

Group	Option	No.	Kit Item Code	Notes
Feedback	Torque (Current) Reference	18E	—	(1)
	DC Tachometer Feedback	24	—	(1)
External	Line Starting	LS	—	(1)
	Motor Speed Potentiometer, One Turn	21	—	(2)
	Motor Speed Potentiometer, Ten Turn (Analog)	21A	60168	(3)
	Motor Speed Potentiometer, Ten Turn (Digital)	21B	66103	(3)

Notes:
(1) Modifiable feature of controller
(2) Unit will not be rated NEMA 4/12 unless factory installed.
(3) Unit will not be rated NEMA 4/12

DIMENSIONS



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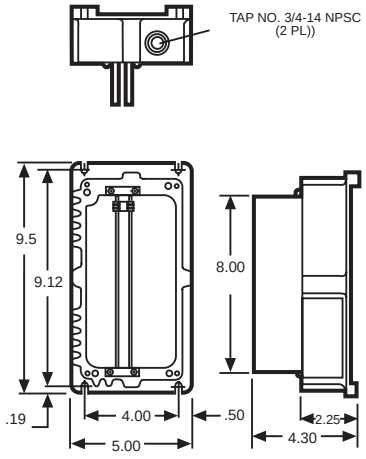
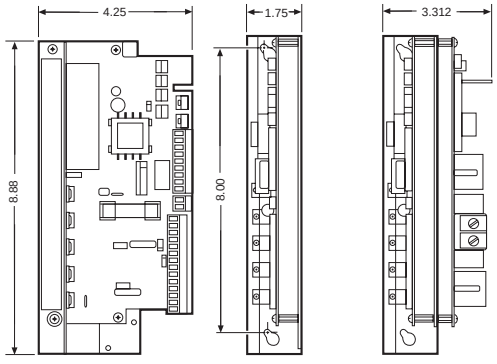


CHASSIS



RBA2C

RBA2CU
RBA2CM

ANGLE BRACKET CHASSIS

Single-Phase Adjustable Speed DC Motor Controllers, Nonregenerative

***BETAplus* Series**
***1/6-3* Horsepower**

BETAplus series controllers are high performance, high quality, general purpose units which feature static conversion of AC line power to regulated DC for nonregenerative, adjustable speed armature control of shunt-wound or permanent magnet DC motors. The BETAplus series features an *isolated speed reference circuit* and uses miniature component hybrid assemblies which provide many standard features in a compact package. This series incorporates the use of *DIP switches and reconnectable jumpers* to configure the voltage, horsepower and selectable features of the controller. The combination of a rugged compact design with standard features and field modifications make this controller an ideal choice for a broad range of industrial applications.

These controllers are designed and manufactured to comply with applicable standards established by the National Electric Code and NEMA pertaining to motor and industrial control equipment. The controllers are UL and cUL Listed.

Motors suitable for application with these controllers are listed in the DC motor section.

A

DESIGN FEATURES AND FUNCTIONS

1. **Construction**

   a) Angle Bracket Chassis – Circuit board and power devices are mounted to formed metal bracket which allows a smaller footprint than the conventional basic chassis. The optional contactor assemblies may also be mounted on the same bracket.

   b) Basic Chassis – Open chassis constructed of a rugged die-cast aluminum alloy with provisions for conduit entry at the top and bottom by two (2) 3/4-14 NPSC tapped holes with knockout plugs. The optional contactor assemblies may also be mounted in the basic chassis.

   c) Enclosed – Basic chassis unit with an aluminum die-cast cover added. The cover has a recessed area to guard the local operator control from accidental operation. All units use an oil resistant synthetic gasket to meet the provisions for NEMA 4/12, making them suitable for a wide range of wet and dirty environments. All models with integral operator controls include flexible boots to seal the operator control switches, and a seal for the motor speed potentiometer.

   d) Washdown Duty – Basic chassis unit and aluminum die-cast cover painted with a durable white epoxy paint. All units are furnished with stainless steel hardware, oil resistant synthetic gasket and flexible boots for sealing the operator controls to meet the provisions of NEMA 4X.

2. **Full-Wave Power Conversion** – Full-wave converter configuration consisting of four SCR's and a freewheeling diode provide benefits for optimum motor performance and long service. Power bridge is composed of 600PIV, discrete, encapsulated and electrically isolated devices. The alloy base forms an integral heatsink with the power control devices electrically isolated from the base.

   The "full-bridge" configuration offers important benefits over the conventional two SCR semiconverter commonly used. Smoother operation results since two SCR's in series must fire to enable conduction as opposed to one SCR in conventional single-phase converters. This provides broad band immunity to inadvertent SCR firing due to line noise, and contributes to operating safety since the failure of one SCR will not initiate undesired motor rotation when the armature is at rest.

   The freewheeling diode improves the form factor which lowers rms currents resulting in reduced motor temperatures by minimizing power dissipation at low speeds. This enhances both motor performance and life.

3. **Voltage Transient Protection** – Metal oxide suppressor across the AC line is combined with RC snubbers across the power bridge to limit potentially damaging high voltage spikes from the AC power source.
4. **AC Line Protection** – A high (100K amp) interrupting capacity AC line fuse provides instantaneous protection from peak loads and fault currents. This fuse holder is mounted on the main circuit board of the controller.
5. **Isolated Regulator** – Internal DC circuits are isolated from the AC power source for operator and equipment safety and for simplified application. The control reference input common may be grounded or connected without additional isolation to other drive units or grounded external signal sources. Isolation eliminates the common condition of line voltage to ground potentials being present on the speed control potentiometer.
6. **Feedback Isolation** –
   (a) Current Feedback – Isolation by optical coupler.
   (b) Voltage Feedback – High impedance circuit (two megohms).
7. **Feedback –** Two selectable modes of analog feedback are provided. See table for speed regulation characteristics.

   (a) Armature Feedback – Counter EMF voltage feedback with IR compensation. IR compensation is adjustable to suit individual motor characteristics and optimize speed regulation in this mode.

   (b) DC Tachometer Feedback – Provides impedance matching, voltage scaling and terminals for accepting a signal from a DC tachometer generator mechanically coupled to the drive motor armature. This results in expanded speed range, improved speed regulation with load changes and reduced sensitivity to operating conditions such as line voltage variations, ambient temperature changes, motor field heating and other operating variables. The controller will automatically transfer to counter EMF voltage feedback to prevent runaway if the tachometer circuit is open. (A broken tachometer drive coupling will cause the motor to run at maximum speed.) Tachometers producing 7 VDC to 150 VDC at maximum motor speed may be used.

This feature is suitable for use with unidirectional units using DC tachometers.

DESIGN FEATURES AND FUNCTIONS *(Continued)*

8. **Control Voltage –** A transformer coupled 24 VDC power supply isolates all magnetic pushbutton control and logic from the AC power source for operator protection.
9. **Field Supply –** Transient protected, half-wave or full-wave. See table for operating voltages.
10. **Contactorless Design –** Unit is designed for reliable solid state, run-stop operation without an armature contactor. Logic includes a provision to prevent an involuntary restart after a power failure. This feature may be defeated when an external customer furnished AC line contactor is used to control the unit.
11. **Motor Contactor –** Models with a M or U in the catalog number include DC magnetic armature contactors. This provides a positive, two-pole disconnection of the motor armature from the rectified power source. Action of the contactor is sequenced with the SCR regulator to ensure that the DC power circuit is "phased-off" before the contactor is opened. This results in "dry-switching" for improved contactor life. Anti-plug protection is provided to prevent armature reversal until a safe minimum speed is reached. Two types of contactor assemblies are available; Unidirectional (U suffix) which adds contactors to disconnect the motor armature when the control is stopped and Reversing (M suffix) which adds additional contactors to disconnect and reverse the motor armature when the unit is reversed.
12. **Dynamic Braking –** Standard feature of models with a motor contactor. Dynamic braking provides exponential rate braking of the DC motor armature. Included is a DB resistor with an anti-plug circuit to prevent restarting the controller until the braking cycle is complete, thereby preventing a potentially damaging electrical surge and mechanical stress. The DB resistor is rated for stopping a typical load, when the external machine inertia does not exceed that of the motor armature, as shown below.

DB RESISTOR RATINGS

Model	Component	Voltage	Rated Horsepower								
			1/6	1/4	1/3	1/2	3/4	1	1-1/2	2	3
RBS2	Braking Torque (%)	115V	180	129	103	66	44	34	—	—	—
		230V	—	—	—	278	190	130	88	62	—
	Stops Per Minute	115V	15	12	11	8	6	2	—	—	—
		230V	—	—	—	8	6	1	1	1	—
RBS3	Braking Torque (%)	115V	300	215	170	110	75	60	—	—	—
		230V	—	—	—	400	320	220	145	105	85
	Stops Per Minute	115V	9	6	5	5	4	4	—	—	—
		230V	—	—	—	5	4	4	3	3	2

13. **Motor Overload –** A nonadjustable electronic circuit continuously monitors motor armature current and shuts down the drive whenever the load exceeds 120% for 80 seconds.
14. **Operator Controls** – All enclosed models with integral operator controls include a speed setting potentiometer and a multi-position switch providing RUN-STOP-JOG functions. The switch is maintained in RUN and STOP positions and a spring return to the center stop position from the momentary JOG position. Jog speed is set by the RUN speed potentiometer. The reversing models, when supplied without a contactor assembly, have an armature reversing power switch which is maintained in the FORWARD or REVERSE run positions. This switch includes a no pass through center position detent which provides a delay when changing direction. Reversing models with a contactor assembly include a momentary contact FORWARD-REVERSE run switch with a spring return to the center position. This switch controls only low control power since armature switching is accomplished by magnetic contactors. The unit is jogged forward or reverse by the momentary FORWARD-REVERSE switch after selecting the JOG position on the RUN-STOP-JOG switch (the JOG position is maintained on this unit).
15. **Selectable Capabilities –**
    (a) DC Tachometer Feedback – See description under Feedback 7(b).
    (b) AC Line Starting – Provision is included to defeat the no-restart-after-power-failure feature to permit run-stop control of unidirectional models by an external AC line contactor. Included is circuitry to assure smooth starting.
    (c) Torque Regulator – BETAplus units may be easily reconfigured to function as a torque regulator. In this mode the speed setting potentiometer is used to set and regulate the motor maximum armature current over a range of 0–150% of rated. Accordingly, motor speed is unregulated and will go to a level of 0–100% of rated, depending upon the application load torque.
    (d) External DC Signal Follower – These units include isolation and impedance matching circuitry to interface an externally supplied grounded or ungrounded, isolated or non-isolated 0–5 VDC, 0–10 VDC or 4–20 mA DC signal source with the motor controller reference input. This provides a linear transfer of the external signal to motor speed. Typical applications include those where motor speed must be controlled as a function of a process variable such as temperature, weight, flow, pressure, etc. In many applications, the reference signal is obtained from a process instrument controller, or other commercially available transducers with a DC output.
16. **Mechanical Flexibility –** BETAplus units offer outstanding application flexibility. The same basic unit can be used as an open chassis or enclosed package controller.
17. **Horsepower and Voltage Calibration –** Units are shipped calibrated for the maximum horsepower rating and 230V operation. They may be easily recalibrated for any standard horsepower rating within the design range and 115V operation by reconfigurable jumpers.
18. **Customer Use Run Contact –** Form A normally open contact rated five amps at 115 VAC or 30 VDC coordinated with run command may be used for external control and indicating devices.
19. **Visual Status Indicator –** Bicolor LED glows green to show normal operation with the armature current at 100% of rated or less, glows red to show current limit operation.
20. **Control Relay –** Enables remote control of all models and provides an interlock to prevent a restart after a power outage.
21. **Hybrid Circuitry –** Extensive use of surface mount miniature components expands flexibility, enhances reliability, and results in a significant reduction in the size of the controller.
22. **Safety Features –** UL and cUL Listed. Low Voltage Operator Control. Requires reset for restart after power interruption. TENV enclosure. Isolated regulator. High Interrupting Capacity AC Line Fuse.

Single-Phase Adjustable Speed DC Motor Controllers, Nonregenerative

***BETAplus* Series**
***1/6-3* Horsepower**

RATINGS

1. **Horsepower:**
   Enclosed..... 1/6 thru 1 HP @ 115 VAC
   1/2 thru 2 HP @ 230 VAC
   Chassis..... 1/6 thru 1 HP @ 115 VAC
   1/2 thru 3 HP @ 230 VAC
2. **Service Factor** 1.0
3. **Duty**..... Continuous
4. **Operating Voltages**

OPERATING VOLTAGES				
Power Source (Single-Phase)	Output VDC		Control Reference Voltage(2)	Magnetic Control Voltage
	Armature	Field(1)		
115V, 50 or 60 Hz	0–90	50/100	0–5 VDC 0–10 VDC 4–20 mA	24 VDC
230V, 50 or 60 Hz	0–180	100/200		

(1) Selectable
(2) Grounded or Ungrounded. Choice of one reference voltage.

5. **Overload Capacity** (Armature circuit). 150% for 1 minute
6. **Run Speed Potentiometer**..... 5K ohms, 1/2 W
7. **Reference Power Supply**.....10 VDC
8. **AC Line Fuse, Interrupting Capacity**..... 100,000 Amps

ADJUSTMENTS

Potentiometer adjustments are provided for:

1. **Acceleration Time** ..... 0.2–30 seconds
2. **Deceleration Time** ..... 0.2–30 seconds
3. **Minimum Speed**..... 0–40% of Base Speed
4. **Maximum Speed**..... 50–100% of Base Speed
5. **IR (Load) Compensation**.....0–100% of Rated Load
6. **Torque (Current) Limit** .....0–150% of Full Load

OPERATING CONDITIONS

1. **Line Voltage**..... 115/230 VAC, 50/60 Hz, Single Phase
2. **Line Voltage Variation**..... ±10%(1)
3. **Line Frequency Variation** ..... ±2 Hz
4. **Ambient Temperature** .....Enclosed: 0° to 40°C (32° to 104°F)
   Chassis: 0° to 55°C (32° to 131°F)
5. **Altitude**..... 3300 ft. (1000 meters) maximum
6. **Relative Humidity**..... 0–95%, noncondensing

(1) Unit will operate down to -15% of rated voltage, although this may prevent rated speed with rated load.

PERFORMANCE CHARACTERISTICS

1. **Controlled Speed Range** — Zero to motor base speed. Speed range with respect to specified regulation is shown below.
2. **Speed Regulation** — Regulation percentages listed are of motor base speed under steady-state conditions. Normal operation will result in performance equal to or better than specifications.

SPEED REGULATION CHARACTERISTICS					
Regulation Method	Variable				Speed Range
	Load Change 95%	Line Voltage ±10%	Field Heating Cold/ Normal	Temp. ±10°C	
Standard Voltage Feedback with IR Compensation	2%	±1%	5–12%	±2%	50:1
Optional Tachometer Feedback(1)	0.5%	±1%	0.2%	±2%	200:1

(1) Unidirectional Models Only

3. **Efficiency** — (rated speed/rated load)
   (a) Controller (SCR regulator) 98%
   (b) Complete drive (Controller and motor, typical) 85%

ELECTRICAL DATA

TYPICAL APPLICATION DATA											
Component			Ratings								
Rated Horsepower (HP)			1/6	1/4	1/3	1/2	3/4	1	1-1/2	2	3
Rated Kilowatts (kW)			0.124	0.187	0.249	0.373	0.560	0.746	1.120	1.492	2.238
1-Phase AC Input (Full-Load)	Line Amps	115 VAC	3.9	5.0	6.0	8.7	12.4	15.8	—	—	—
		230 VAC	—	—	—	4.2	5.9	8.8	12.6	15.8	22.0
	KVA		0.48	0.58	0.71	1.00	1.40	2.00	3.00	4.00	5.00
DC Output (Full-Load)	Motor Armature Amps	90V	2.0	2.8	3.5	5.4	8.1	10.5	—	—	—
		180V	—	—	—	2.6	3.8	5.5	8.2	11.6	15.1
	Motor(1) Field Amps (Maximum)	50V	1.0	1.0	1.0	1.0	1.0	1.0	—	—	—
		100V	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5
		200V	—	—	—	1.0	1.0	1.0	1.0	1.0	1.5
Full-Load Torque (lb-ft) with 1750 RPM Base Speed Motors			0.5	0.75	1.0	1.5	2.2	3.0	4.5	6.0	9.0
Minimum Transformer KVA for Voltage Matching or Isolation			0.5	0.75	0.75	1.0	1.5	2.0	3.0	5.0	7.5

(1) Does not apply to Permanent Magnet Motors

A

MODEL TYPES

BETAplus controllers are offered in twenty-three (23) standard models in six functional groups. The basic chassis models are the nucleus of all the enclosed models; standard covers can be added to the basic chassis to make an enclosed controller or the enclosed unit may be ordered complete as shown below.

ORDER BY CATALOG NUMBER OR ITEM CODE

Horsepower Range(1)		Catalog Number	Item Code	Function
115 VAC	230 VAC			
ANGLE BRACKET CHASSIS CONTROLLERS WITHOUT OPERATOR CONTROLS*				
1/6–1	1/2–2	RBS2C	57898	Run/Stop(2)
		RBS2CU	57899	Armature Contactor Run/Stop and DB
		RBS2CM	57903	Armature Contactor Forward/Reverse and DB
BASIC CHASSIS CONTROLLERS WITHOUT OPERATOR CONTROLS*				
1/6–1	1/2–2	RBS2	64874	Run/Stop(2)
		RBS2U	57894	Armature Contactor Run/Stop and DB
		RBS2M	64878	Armature Contactor Forward/Reverse and DB
1/6–1	1/2–3	RBS3	64881	Run/Stop(2)
		RBS3U	57895	Armature Contactor Run/Stop and DB
		RBS3M	64882	Armature Contactor Forward/Reverse and DB
NEMA 4/12 ENCLOSED CONTROLLERS WITHOUT OPERATOR CONTROLS				
1/6–1	1/2–2	RBS2B	64875	Run/Stop(2)
		RBS2UB	57896	Armature Contactor Run/Stop and DB
		RBS2MB	64879	Armature Contactor Forward/Reverse and DB
NEMA 4/12 ENCLOSED CONTROLLERS WITH INTEGRAL OPERATOR CONTROLS				
1/6–1	1/2–2	RBS2S	64876	Run/Stop/Jog(2) (4)
		RBS2R	64877	Run/Stop/Jog, Armature Switch Reversing(3) (4)
		RBS2US	57897	Run/Stop/Jog, Armature Contactor Run and DB(4)
		RBS2MR	64880	Run/Stop/Jog, Armature Contactor Forward/Reverse and DB(5)
WASHDOWN DUTY ENCLOSED CONTROLLERS WITHOUT OPERATOR CONTROLS*				
1/6–1	1/2–2	RBS2B-WD	13184	Run/Stop(2)
		RBS2UB-WD	13280	Armature Contactor Run/Stop and DB
		RBS2MB-WD	13324	Armature Contactor Forward/Reverse and DB
WASHDOWN DUTY ENCLOSED CONTROLLERS WITH INTEGRAL OPERATOR CONTROLS				
1/6–1	1/2–2	RBS2S-WD	13350	Run/Stop/Jog(2) (4)
		RBS2R-WD	13362	Run/Stop/Jog, Armature Switch Reversing(3) (4)
		RBS2US-WD	13364	Run/Stop/Jog, Armature Contactor Run and DB(4)
		RBS2MR-WD	13378	Run/Stop/Jog, Armature Contactor Forward/Reverse and DB(5)

*Refer to Remote Operator Stations, pages 109 and 110.
(1) Units are shipped calibrated for the maximum horsepower ratings shown. Units may be calibrated for other standard ratings by the changing of a Jumper. Units are connected for 230 VAC and are easily reconnected for 115VAC input.
(2) Contactorless Run-Stop Operation
(3) Contactorless Reversing Operation
(4) Jog Speed is set by the Run Speed Potentiometer. Maintained in RUN position, JOG position is momentary with a spring return to STOP.
(5) Jog Speed is set by the Run Speed Potentiometer. Maintained JOG position, Forward/Reverse are momentary.

CONTROLLER WEIGHTS

Model	RBS2C	RBS2CU RBS2CM	RBS2 RBS3	RBS2U RBS2M RBS3U RBS3M	RBS2B, RBS2S RBS2R, RBS2BWD RBS2SWD RBS2RWD	RBS2UB, RBS2MB RBS2US, RBS2MR RBS2UB-WD RBS2MB-WD RBS2US-WD RBS2MR-WD
Weight (Lbs.)	2.0	2.3	3.3	3.8	5.5	6.1

Single-Phase Adjustable Speed DC Motor Controllers, Nonregenerative

***BETAplus* Series**
***1/6-3* Horsepower**

REMOTE STATIONS

ORDER BY CATALOG NUMBER OR ITEM CODE

REMOTE OPERATOR CONTROL STATIONS BETAplus					
Catalog Number	Item Code	Control Elements			Use With Controller Models
		Pushbuttons	Switches	Pots	
RCS1	69362	Run, Stop	—	Motor Speed	ALL
RCS3C	58098	Run, Stop	Run/Jog	Motor Speed Jog Speed	RBS2U, RBS3U, RBS2UB
RCS3D	58099	Run, Stop	Run/Jog	Motor Speed Jog Speed	RBS2, RBS3, RBS2B
RCS6	60239	Fwd, Rev, Stop	—	Motor Speed	RBS2M, RBS3M, RBS2MB
RCS16	58102	—	Run/Stop/Jog	Motor Speed	RBS2U, RBS3U, RBS2UB
RCS17	58103	—	Run/Stop/Jog, Fwd/Stop/Rev	Motor Speed	RBS2M, RBS3M, RBS2MB

Remote Operator Station dimensions shown on page110.

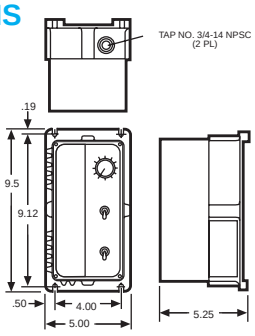
OPTIONS

Options are listed alpha-numerically within each group. Complete option descriptions are listed in the DC option section. To order a controller with the option installed or the modification made, add the option number or letter as a suffix to the controller catalog number e.g. RBS2B-21. To order a kit for field installation, order by item code.

Group	Option	No.	Kit Item Code	Notes
Feedback	Torque (Current) Reference	18E	—	(1)
	DC Tachometer Feedback	24	—	(1)
External	Motor Speed Potentiometer, One Turn	21	—	(2)
	Motor Speed Potentiometer, TenTurn (Analog)	21A	60168	(3)
	Motor Speed Potentiometer, Ten Turn (Digital)	21B	66103	(3)
	Follower/Manual Mode Selector Switch	38	—	(2)
	Line Starting	LS	—	(1)

(1) Modifiable Feature of controller
(2) Unit will not be NEMA 4/12 unless factory installed.
(3) Unit will not be rated NEMA 4/12

DIMENSIONS



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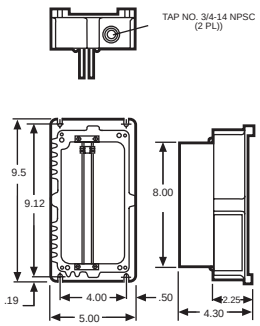
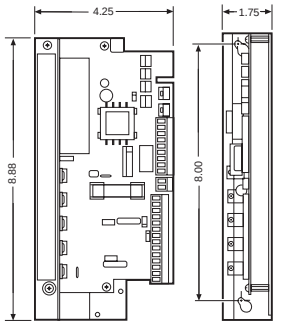
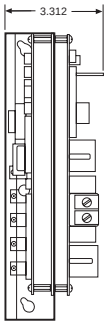


CHASSIS



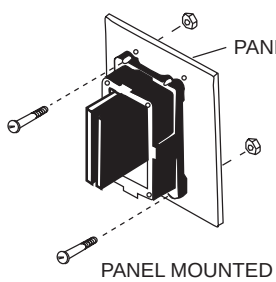
RBS2C



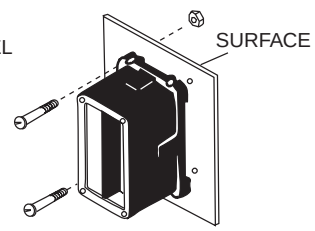
RBS2CU
RBS2CM

ANGLE BRACKET CHASSIS

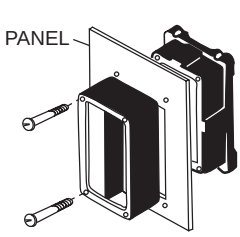
MOUNTING CONFIGURATIONS



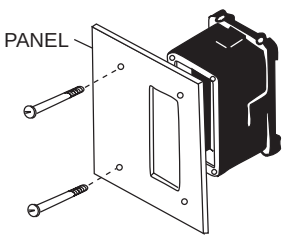
PANEL MOUNTED
OPEN CHASSIS



SURFACE MOUNTED
ENCLOSED PACKAGE



THROUGH PANEL
SURFACE MOUNTED



BELOW PANEL
SURFACE MOUNTED

BOSTON GEAR®

RATIOTROL SYSTEMS

Single-Phase Adjustable Speed DC Motor Controllers, Nonregenerative

VEplus Series
1/6-5 Horsepower

VEplus series of controllers are a high performance, high quality, general purpose unit which features static conversion of AC line power to regulated DC for nonregenerative, adjustable speed armature control of shunt-wound or permanent magnet DC motors. The VEplus series *features an isolated speed reference circuit* and use miniature component hybrid assemblies which provide an additional number of standard features and field modifications. This series also incorporates the *use of DIP switches* and *reconnectable jumpers* to configure the voltage, horsepower and selectable features of the controller. Supplied in a larger chassis to *allow the addition of pre-engineered options* and *extending the horsepower range to 5 HP* make this an ideal choice for your more demanding requirements.

These controllers are designed and manufactured to comply with applicable standards established by the National Electric Code and NEMA pertaining to motor and industrial control equipment. The controllers are UL and cUL Listed.

Motors suitable for application with these controllers are listed in the DC motor section.

DESIGN FEATURES AND FUNCTIONS

1. **Construction**

   a) Basic Chassis – Open chassis constructed of a rugged die-cast aluminum alloy which features a heatsink design consisting of a unique pin configuration with omnidirectional heat dissipation characteristics. This allows the unit to be wall mounted in either a vertical or horizontal position. Conduit entry is provided top and bottom by two (2) 3/4-14 NPSC tapped holes. All open chassis are cooled by natural convection. Additional space is provided in the base for the addition of the optional contactor assemblies and pre-engineered options.

   b) Enclosed – Basic chassis unit with the addition of a screw fixed cover which is gasketed with an oil resistant synthetic rubber gasket to meet the provisions for NEMA 4/12, making them suitable for a wide range of wet and dirty industrial environments. The covers are molded of high strength Noryl® engineering plastic. The cover is designed to accept either a blank panel or various local control panels. All models with integral operator controls include flexible boots to seal the operator control switches, and a seal for the motor speed potentiometer. 5 HP units require the use of a fan assembly mounted to the bottom of the heatsink.

2. **Full-Wave Power Conversion** – Full-wave converter configuration consisting of four SCR's and a freewheeling diode provide benefits for optimum motor performance and long service. Power bridge is composed of 600PIV, discrete, encapsulated and electrically isolated devices. The alloy base forms an integral heatsink with the power control devices electrically isolated from the base.

   The "full-bridge" configuration offers important benefits over the conventional two SCR semiconverter commonly used. Smoother operation results since two SCR's in series must fire to enable conduction as opposed to one SCR in conventional single-phase converters. This provides broad band immunity to inadvertent SCR firing due to line noise, and contributes to operating safety since the failure of one SCR will not initiate undesired motor rotation when the armature is at rest.

   The freewheeling diode improves the form factor which lowers rms currents resulting in reduced motor temperatures by minimizing power dissipation at low speeds. This enhances both motor performance and life.

3. **Voltage Transient Protection** – Metal oxide suppressors across the AC line is combined with RC snubbers across the power bridge to limit potentially damaging high voltage spikes from the AC power source.

4. **AC Line Protection** – A high (100K amp) interrupting capacity AC line fuse provides instantaneous protection from peak loads and fault currents. The fuse holder is mounted on the main circuit board of the controller. The optional circuit breaker (30) is a two-pole, molded case, magnetic trip circuit breaker which provides a means of manually disconnecting the AC power to the controller and motor and automatic, instantaneous trip protection from a peak load.

5. **Isolated Regulator** – Internal DC circuits are isolated from the AC power source for operator and equipment safety and for simplified application. The control reference input common may be grounded or connected without additional isolation to other drive units or grounded external signal sources. Isolation eliminates the common condition of line voltage to ground potentials being present on the speed control potentiometer.

6. **Feedback Isolation** –
   (a) Current Feedback – Isolation by optical coupler.
   (b) Voltage Feedback – High impedance circuit (two megohms).

7. **Feedback –** Two selectable modes of analog feedback are provided. See Table for speed regulation characteristics.
   (a) Armature Feedback – Counter EMF voltage feedback with IR compensation. IR compensation is adjustable to suit individual motor characteristics and optimize speed regulation in this mode.
   (b) DC Tachometer Feedback – Provides impedance matching, voltage scaling and terminals for accepting a signal from a DC tachometer generator mechanically coupled to the drive motor armature. This results in expanded speed range, improved speed regulation with load changes and reduced sensitivity to operating conditions such as line voltage variations, ambient temperature changes, motor field heating and other operating variables. The controller will automatically transfer to counter EMF voltage feedback to prevent run away if the tachometer circuit is open. (A broken Tachometer drive coupling will cause the motor to run at maximum speed). Tachometers producing 7 VDC to 150 VDC at maximum motor speed may be used.

   This feature is suitable for use with unidirectional units using DC tachometers.

8. **Control Voltage –** A transformer coupled 24 VDC power supply isolates all magnetic pushbutton control and logic from the AC power source for operator protection.

9. **Field Supply –** Transient protected, half-wave or full-wave. See Table for output voltages.

10. **Contactorless Design –** Unit is designed for reliable solid state, run-stop operation without an armature contactor. Logic includes a provision to prevent an involuntary restart after a power failure. This feature may be defeated when an external customer furnished AC line contactor is used to control the unit.

Single-Phase Adjustable Speed DC Motor Controllers, Nonregenerative

***VEplus* Series**
***1/6-5* Horsepower**

DESIGN FEATURES AND FUNCTIONS *(Continued)*

11. **Motor Contactor –** Models with M or U in the catalog number include DC magnetic armature contactors. This provides a positive, two-pole disconnection of the motor armature from the rectified power source. Action of the contactor is sequenced with the SCR regulator to ensure that the DC power circuit is "phased-off" before the contactor is opened. This results in "dry-switching" for improved contactor life. Anti-plug protection is provided to prevent armature reversal until a safe minimum speed is reached. Two types of contactor assemblies are available; Unidirectional (U suffix) which adds contactors to disconnect the motor armature when the control is stopped and Reversing (M suffix) which adds additional contactors to disconnect and reverse the motor armature when the unit is reversed.
12. **Dynamic Braking –** Standard feature of models with a motor contactor. Dynamic braking provides exponential rate braking of the DC motor armature. Included is a DB resistor with an anti-plug circuit to prevent restarting the controller until the braking cycle is complete, thereby preventing a potentially damaging electrical surge and mechanical stress. The DB resistor is rated for stopping a typical load, when the external machine inertia does not exceed that of the motor armature, as shown below.

DB RESISTOR RATINGS

Model	Component	Voltage	Rated Horsepower									
			1/6	1/4	1/3	1/2	3/4	1	1-1/2	2	3	5
VES3	Braking Torque (%)	115V	300	215	170	110	75	60	—	—	—	—
		230V	—	—	—	400	320	220	145	105	85	—
	Stops Per Minute	115V	9	6	5	5	4	4	—	—	—	—
		230V	—	—	—	5	4	4	3	3	2	—
VES5	Braking Torque (%)	115V	1000	960	660	460	320	220	150	100	—	—
		230V	—	—	—	920	640	440	300	200	160	100
	Stops Per Minute	115V	15	12	11	8	6	4	3	3	—	—
		230V	—	—	—	8	6	4	3	3	2	2

13. **Motor Overload –** A nonadjustable electronic circuit continuously monitors motor armature current and shuts down the drive whenever the load exceeds 120% for 80 seconds.
14. **Operator Controls –** All enclosed models with integral operator controls include a speed setting potentiometer and a multiposition switch providing RUN-STOP-JOG functions. The switch is maintained in RUN and STOP positions and a spring return to the center stop position from the momentary JOG position. Jog speed is set by the RUN speed potentiometer. Reversing models with a contactor assembly include a momentary contact FORWARD-REVERSE run switch with a spring return to the center position. This switch controls only low control power since armature switching is accomplished by magnetic contactors. The unit is jogged forward or reverse by the momentary FORWARD-REVERSE switch after selecting the JOG position on the RUN-STOP-JOG switch (the JOG position is maintained on this unit).
15. **Selectable Capabilities –**
    (a) DC Tachometer Feedback – See description under Feedback 7(b)
    (b) AC Line Starting – Provision is included to defeat the no-restart-after-power-failure feature to permit run-stop control of unidirectional models by an external AC line contactor. Included is circuitry to assure smooth starting.
    (c) Torque Regulator – VEplus units may be easily reconfigured to function as a torque regulator. In this mode the speed setting potentiometer is used to set and regulate the motor maximum armature current over a range of 0–150% of rated. Accordingly, motor speed is unregulated and will go to a level of 0–100% of rated, depending upon the application load torque.
    (d) External DC Signal Follower – These units include isolation and impedance matching circuitry to interface an externally supplied grounded or ungrounded, isolated or non-isolated 0–5 VDC, 0–10 VDC or 4–20 mA DC signal source with the motor controller reference input. This provides a linear transfer of the external signal to motor speed. Typical applications include those where motor speed must be controlled as a function of a process variable such as temperature, weight, flow, pressure, etc. In many applications, the reference signal is obtained from a process instrument controller, or other commercially available transducers with a DC output.
16. **Mechanical Flexibility –** VEplus series units offer outstanding application flexibility. The same basic unit can be used as an open chassis or enclosed package controller.
17. **Horsepower and Voltage Calibration –** Units are shipped calibrated for the maximum horsepower rating and 230V operation. They may be easily recalibrated for any standard horsepower rating within the design range and 115V operation by reconfigurable jumpers.
18. **Customer Use Run Contact –** Form A normally open contact rated five amps at 115 VAC or 30 VDC coordinated with run command may be used for external control and indicating devices.
19. **Visual Status Indicator –** Bicolor LED glows green to show normal operation with the armature current at 100% of rated or less, glows red to show current limit operation.
20. **Control Relay –** Enables remote control of all models and provides an interlock to prevent a restart after a power outage.
21. **Hybrid Circuitry –** Extensive use of surface mount miniature components expands flexibility, enhances reliability, and results in a significant reduction in the size of controllers over competitive models.
22. **Safety Features –** UL and cUL Listed. Low Voltage Operator Control. Requires reset for restart after power interruption. TENV enclosure. Isolated regulator. High Interrupting Capacity AC Line Fuse.
23. **Quality Features –** FR4 glass circuit cards. Rugged die-cast aluminum alloy chassis base. High strength Noryl® covers. Conservatively rated components selected for long service life.

RATIOTROL SYSTEMS

Single-Phase Adjustable Speed DC Motor Controllers, Nonregenerative

***VEplus* Series**

***1/6-5* Horsepower**

A

RATINGS

1. **Horsepower:**
   Enclosed or Chassis ..... 1/6 thru 1 HP @ 115 VAC
   .....1/2 thru 5 HP @ 230 VAC
2. **Service Factor** 1.0
3. **Duty** ..... Continuous
4. **Operating Voltages**

OPERATING VOLTAGES				
Power Source (single-phase)	Output VDC		Control Reference Voltage(2)	Magnetic Control Voltage
	Armature	Field(1)		
115V, 50 or 60 Hz	0–90	50/100	0–5 VDC 0–10 VDC 4–20 mA	24 VDC
230V, 50 or 60 Hz	0–180	100/200		

(1) Selectable
(2) Grounded or Ungrounded, choice of one Reference Voltage

5. **Overload Capacity** (Armature circuit). 150% for 1 minute
6. **Run Speed Potentiometer** ..... 5K ohms, 1/2 W
7. **Reference Power Supply** .....10 VDC
8. **AC Line Fuse, Interrupting Capacity** ..... 100,000 Amps

ADJUSTMENTS

Potentiometer adjustments are provided for:

1. **Acceleration Time** ..... 0.2–30 seconds
2. **Deceleration Time** ..... 0.2–30 seconds
3. **Minimum Speed** ..... 0–40% of base speed
4. **Maximum Speed** ..... 50–100% of base speed
5. **IR (Load) Compensation** .....0–100% of rated load
6. **Torque (Current) Limit** .....0–150% of full load

PERFORMANCE CHARACTERISTICS

1. **Controlled Speed Range —** Zero to motor base speed. Speed range with respect to specified regulation is shown below.
2. **Speed Regulation —** Regulation percentages listed are of motor base speed under steady-state conditions. Normal operation will result in performance equal to or better than specifications.

SPEED REGULATION CHARACTERISTICS					
Regulation Method	Variable				Speed Range
	Load Change 95%	Line Voltage ±10%	Field Heating Cold/ Normal	Temp. ±10°C	
Standard Voltage Feedback with IR Compensation	2%	±1%	5–12%	±2%	50:1
Optional Tachometer Feedback(1)	0.5%	±1%	0.2%	±2%	200:1

(1) Unidirectional Models Only

3. **Efficiency (rated speed/rated load)**
   (a) Controller (SCR regulator) 98%
   (b) Complete drive (Controller and motor, typical) 85%

OPERATING CONDITIONS

1. **Line Voltage**..... 115/230 VAC, 50/60 Hz, Single Phase
2. **Line Voltage Variation** ..... ±10%
3. **Line Frequency Variation**..... ±2 Hz
4. **Ambient Temperature**..... 0° to 40°C (32° to 104°F)
   ..... Chassis: 0° to 55°C (32° to 131°F)
5. **Altitude** ..... 3300 ft. (1000 meters) maximum
6. **Relative Humidity** ..... 0–95%, noncondensing

(1) Unit will operate down to -15% of rated voltage, although this may prevent rated speed with rated load.

TYPICAL APPLICATION DATA											
			Ratings								
Rated Horsepower (HP)			1/6	1/4	1/3	1/2	3/4	1	1-1/2	2	3	5
Rated Kilowatts (kW)			0.124	0.187	0.249	0.373	0.560	0.746	1.120	1.492	2.238	3.730
1-Phase AC Input (Full-Load)	Line Amps	115 VAC	3.9	5.0	6.0	8.7	12.4	15.8	—	—	—	—
		230 VAC	—	—	—	4.2	5.9	8.8	12.6	15.8	22.0	32.0
	KVA		0.48	0.58	0.71	1.00	1.40	2.00	3.00	4.00	5.00	8.00
DC Output (Full-Load)	Motor Armature Amps	90V	2.0	2.8	3.5	5.4	8.1	10.5	—	—	—	—
		180V	—	—	—	2.6	3.8	5.5	8.2	11.6	15.1	25.0
	Motor(1) Field Amps (Maximum)	50V	1.0	1.0	1.0	1.0	1.0	1.0	—	—	—	—
		100V	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	2,0
		200V	—	—	—	1.0	1.0	1.0	1.0	1.0	1.5	2.0
Full-Load Torque (lb-ft) with 1750 RPM Base Speed Motors			0.5	0.75	1.0	1.5	2.2	3.0	4.5	6.0	9.0	15.0
Minimum Transformer KVA for Voltage Matching or Isolation			0.5	0.75	0.75	1.0	1.5	2.0	3.0	5.0	7.5	10.0

(1) Does not apply to Permanent Magnet Motors

Single-Phase Adjustable Speed DC Motor Controllers, Nonregenerative

***VEplus* Series**
***1/6-5* Horsepower**

MODEL TYPES

VEplus controllers are offered in eighteen (18) standard models in three functional groups. The basic chassis models are the nucleus of all the enclosed models. Standard covers can be added to the basic chassis to make an enclosed controller (a fan assembly must also be added to the VES5 models) or the enclosed model may be ordered complete as shown below.

ORDER BY CATALOG NUMBER OR ITEM CODE

Horsepower Range(1)		Catalog Number	Item Code	Functions
115 VAC	230 VAC			
BASIC CHASSIS CONTROLLERS WITHOUT OPERATOR CONTROLS*				
1/6–1	1/2–3	VES3	64883	Run/Stop(2)
		VES3U	57904	Armature Contactor Run/Stop and DB
		VES3M	64884	Armature Contactor Forward/Reverse and DB
1/6–1	1/2–5	VES5	64890	Run/Stop(2)
		VES5U	57909	Armature Contactor Run/Stop and DB
		VES5M	64891	Armature Contactor Forward/Reverse and DB
NEMA 4/12 ENCLOSED CONTROLLERS WITHOUT OPERATOR CONTROLS*				
1/6–1	1/2–3	VES3B	64885	Run/Stop(2)
		VES3UB	57910	Armature Contactor Run/Stop and DB
		VES3MB	64887	Armature Contactor Forward/Reverse and DB
1/6–1	1/2–5	VES5B	64892	Run/Stop(2)
		VES5UB	57926	Armature Contactor Run/Stop and DB
		VES5MB	64894	Armature Contactor Forward/Reverse and DB
NEMA 4/12 CONTROLLERS WITH INTEGRAL OPERATOR CONTROLS				
1/6–1	1/2–3	VES3S	64886	Run/Stop/Jog(2) (3)
		VES3US	57930	Run/Stop/Jog, Armature Contactor Run and DB(3)
		VES3MR	64889	Run/Stop/Jog, Armature Contactor Forward/Reverse and DB(4)
1/6–1	1/2–5	VES5S	64893	Run/Stop/Jog(2) (3)
		VES5US	57935	Run/Stop/Jog, Armature Contactor Run/Stop and DB(3)
		VES5MR	64896	Run/Stop/Jog, Armature Contactor Forward/Reverse and DB(4)

(1) Units are shipped calibrated for the maximum HP ratings shown. Units may be calibrated for other standard HP ratings by changing the position of a jumper. Units are connected for 230VAC and are easily reconnected for 115VAC input.
(2) Contactorless Run-Stop operation.
(3) JOG speed is set by the RUN-SPEED potentiometer. Maintained in RUN position, JOG position is momentary with a spring return to STOP.
(4) JOG speed is set by the RUN SPEED potentiometer. Maintained in JOG position. FORWARD/REVERSE are momentary.

*Refer to Remote Operator Station, pages 109 and 110.

ORDER BY CATALOG NUMBER OR ITEM CODE

REMOTE OPERATOR CONTROL STATIONS VEplus					
Catalog Number	Item Code	Control Elements			Use With Controller Models
		Pushbuttons	Switches	Pots	
RCS1	69362	Run, Stop	—	Motor Speed	ALL
RCS3C	58098	Run, Stop	Run/Jog	Motor Speed Jog Speed	VES3UB VES5UB
RCS3D	58099	Run, Stop	Run/Jog	Motor Speed Jog Speed	VES3, VES5, VES3B, VES5B
RCS6	60239	Fwd, Rev, Stop	—	Motor Speed	VES3MB VES5MB
RCS16	58102	—	Run/Stop/Jog	Motor Speed	VES3UB VES5UB
RCS17	58103	—	Run/Stop/Jog, Fwd/Stop/Rev	Motor Speed	VES3MB VES5MB

Remote Operator Station dimensions shown on page 110.

A

OPTIONS

Options and modifications are listed alpha-numerically within each group. Complete option descriptions are listed in the DC option section.

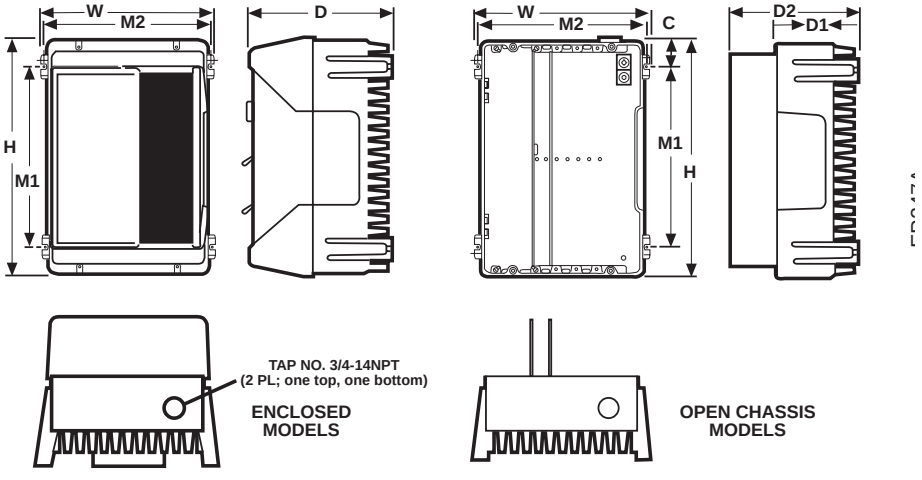
To order a controller with the options installed, add the option number or letter as a suffix to the controller catalog number, e.g. VES3MR-IAB-25A, VES5MB-21A, etc. To order a kit for field installation, order by item code.

A large number of options, or certain combinations of options may require a larger enclosure or an additional enclosure.

Group	Option	No.	Kit Item Code	Notes
Power	Circuit Breaker (Two-Pole)	30	58091	
Input Signal (plug in)(2)	Follower, Master Override	14	60170	(1, 2)
	Follower, AC or DC Tachometer Generator	22A	60163	(1, 2)
	Follower, Digital Pulse Generator	22B	60270	(1, 2)
	Follower, External DC Signal	25A	60165	(1, 2)
	Follower, AC Current Transducer	25C	—	(1, 2)
	Follower, MIRC	35	60173	(1, 2)
	Precision Reference	47	50390	(1, 2)
Feedback (plug-in)(2)	Torque Taper	18A	60164	(1, 2)
	Torque (Current) Limit Control	18B	60164	(1, 2)
	Torque (Current) Reference	18E	—	(6)
	DC Tachometer Feedback	24	—	(6)
	Feedback, AC or DC Tachometer Generator	24A	60162	(1, 2)
	Feedback, Digital Pulse Generator	24B	60269	(1, 2)
Input and Feedback	Centerwind Torque Control	36A	60175	(1, 2, 3)
	Constant Velocity Winder	36B	61285	(1, 2, 3)
Interfaces	Interface Adapter Board	IAB	64907	
External	Line Starting	LS	—	(6)
	Motor Speed Potentiometer, Ten Turn (Analog)	21A	60168	(5)
	Motor Speed Potentiometer, Ten Turn (Digital)	21B	66103	(5)
	Follower/Manual Mode Selector Switch	38	—	(4)
Enclosure	Hinge, Enclosure Cover	50	67539	

Notes: (1) Option IAB (64907) required to use these options
(2) Only one plug-in option in a group is possible
(3) Not to be combined with options from other groups
(4) Will not be NEMA 4/12 unless factory installed
(5) Unit will not be rated NEMA 4/12
(6) Modifiable feature of controller

DIMENSIONS



	H	W	D	D1	D2	M1	M2	C	Weight (lbs.) Chassis	Weight (lbs.) Enclosed
VES3	12.1	9.0	7.3	4.1	5.6	9.3	8.6	1.3	9.0	11.4
VES5	12.1	9.0	9.0	4.1	6.9	9.3	8.6	1.3	9.5	13.0

NOTE: VES5 enclosed models are supplied with a fan assembly.

Single-Phase Adjustable Speed Digital DC Motor Controllers, Nonregenerative

***VED** Series*

***1/6-3** Horsepower*

VED SERIES CONTROLLERS

VED Series digital controllers are high performance, microprocessor based, software-configured, packaged drive units representing a most significant advance in single-phase drive design. In their most basic form the units easily duplicate and expand upon the capabilities of their analog counterparts while more sophisticated optional versions offer advantages formerly not possible without complex and expensive external digital control loops. Features include pretuned control algorithms for speed and current regulators, digital set-up and troubleshooting, self diagnostics with optional capabilities for: remote interrogation, digital speed input and feedback, super accurate digital speed regulation and serial communication for direct control by programmable logic controllers and computers.

The units include conversion of AC line power to DC for the adjustable speed nonregenerative armature control of shunt wound or permanent magnet DC motors. VED Series controllers are offered with a wide range of options making them an ideal choice for a broad range of industrial applications.

The VED Series controllers are designed and manufactured to comply with applicable standards established by the National Electrical Code and NEMA pertaining to motor and industrial control equipment. The controllers are UL and cUL Listed.

Motors suitable for application with these controllers are listed in the DC motor section.

DESIGN FEATURES AND FUNCTIONS

1. **Microprocessor Based Design** – VED controllers are designed around a proprietary microcontroller. Up to two identical but individually software configured microcontrollers are used in each controller. One in the controller chassis provides all necessary digital drive regulator functions in accord with control algorithms for speed and current loops and ports for external communications. The other is located in the optional Model MB1 membrane operator control panel where it is dedicated to operator input commands, the various data displays, communications with the regulator microcontroller, and external control and monitoring devices.

   An important, integral part of the microcontroller architecture is the FINbus option port which is standard in all VED units. This unique bus structure is specifically configured to support a wide range of drive optional features dedicated to the VED Series units making them much more versatile than previous analog designs.

2. **Trigger Circuit** – Digitally generated, super-hard firing with repetitive 10 microsecond wide pulses at a 5kHz rate. High energy circuit ensures reliable conduction and minimizes di/dt degradation of SCR's. Gate isolation is standard.

3. **Overload Protection** – Processor continuously monitors output current. Sophisticated inverse time circuit integrates armature circuit overload level with time matching the shutdown to the motor's thermal time constant and capacity.

4. **Undervoltage/Overvoltage Protection** – Processor continuously monitors its internal power supplies and will shut down the unit on undervoltage or overvoltage.

5. **Isolated Regulator** – Internal DC circuits are optically isolated from the AC power source for operator and equipment safety and for simplified application. The control reference input common may be grounded or connected without additional isolation to other drive units or grounded external signal sources. Isolation eliminates the common condition of line voltage to ground potentials being present on the speed control potentiometer.

6. **Feedback Isolation**

   (a) Current Feedback – Isolation by optical coupler

   (b) Voltage Feedback – High impedance circuit (2 megohms).

7. **Feedback** – Two selectable modes of analog feedback are provided. See Table for speed regulation characteristics.

   (a) Armature Feedback – Counter EMF voltage feedback with IR compensation. IR compensation is adjustable to suit individual motor characteristics.

   (b) DC Tachometer Feedback – Provided is impedance matching, voltage scaling and terminals for accepting a signal from a DC tachometer generator mechanically coupled to the drive motor armature. The tachometer signal makes the unit directly sensitive to motor speed. This results in expanded speed range, improved speed regulation with load changes and reduced sensitivity to operating conditions such as line voltage variations, ambient temperature changes, motor field heating and other operating variables. The controller will automatically transfer to counter EMF voltage feedback to prevent run away if the tachometer signal is lost. Tachometers producing 7VDC to 150VDC at maximum motor speed may be used.

   This feature is suitable for use with unidirectional units using DC tachometers.

8. **Operator Control Panels** – A choice of two operator control panels are offered as an integral part of the enclosed standard units. They mount in a dedicated space in the cover. This mounting is dimensionally identical to the Remote Operator Control Station housing where the control panel may be optionally mounted for remote control applications.

DESIGN FEATURES AND FUNCTIONS *(Continued)*

(a) Membrane Operator Control Panel – Is a state of the art operator panel using membrane push switches for all control functions: RUN-JOG-STOP, MOTOR SPEED FASTER-SLOWER and MOTOR DIRECTION FORWARD-REVERSE (Optional). Each switch includes a raised perimeter which defines the operating area. Also included is tactile feedback providing confidence that the command has been accepted. The unbroken, smooth surface of the membrane panel is easy to keep clean since it has no openings or voids which will allow penetration by liquid or dust contaminants.

The integral LCD bar graph provides a visual indication of: the relative operating speed of the drive motor, the relative speed reference setting for the drive motor at rest, and FORWARD-REVERSE designators indicate the selected direction of motor rotation. Also the bar graph will flash on-off whenever the current limit is exceeded, warning the operator of this condition. The operator panel also includes space for mounting Option 44, Digital Meter, which provides important additional operational and troubleshooting data. See Option 44.

(b) Pushbutton Operator Control Panel – Utilizes conventional industrial control elements including RUN and STOP pushbuttons and a MOTOR SPEED potentiometer. Reversing models include a FORWARD-REVERSE selector switch. Space is also provided in the Operator Control Panel to add the optional RUN-JOG selector switch and JOG SPEED potentiometer or a MANUAL-AUTO selector switch.

9. **Nonvolatile Memory** – Basic drive regulator and application programs are permanently stored in memory. The membrane panel stores application parameters such as JOG and RUN speeds, direction of motor rotation, etc. in the microprocessor memory with a battery back-up. Lithium battery life is 7 years minimum.
10. **50 Hz Operation** – Controller automatically synchronizes to either 50 or 60 Hz line frequency.
11. **Power Up Check** – Each time AC line power is applied, the processor goes through a self-checking routine (approximately 250 ms.)
12. **Construction** – The basic open chassis includes a die-cast aluminum alloy base, the digital regulator electronics, AC line circuit breaker, power conversion and protective circuitry as a totally functional, self contained unit. The entire back surface of the base is a unique, pin configuration heatsink with omni-directional heat dissipation characteristics. This allows vertical or horizontal mounting as best suits the available space. All models are cooled by natural convection.

    Enclosed models consist of the basic chassis with the addition of a screw fixed cover of molded, high strength Noryl® engineering plastic. Cover includes an oil resistant synthetic rubber gasket which seals against the base to prevent the intrusion of contaminants. Basic unit is TENV, NEMA 1 which may be easily and inexpensively converted to NEMA 4, 12 by the addition of Option 27M, a transparent flexible boot for the circuit breaker and a gasket for the operator panel or blank panel used with remote control models. Option 50 provides a kit permitting field installation of cover hinges where the user may find this more desirable. Conduit entry is provided by two 3/4-14 NPSC tapped holes, one each on the top and bottom.
13. **Full-Wave Power Conversion** – Full-wave converter configuration consisting of four SCR's and a freewheeling diode provide benefits for optimum motor performance and long service. Power bridge is composed of 600PIV, descrete, encapsulated and electrically isolated devices. The alloy base forms an integral heatsink with the power control devices electrically isolated from the base.

    The "full bridge" configuration offers important benefits over the conventional 2 SCR semiconverter commonly used. Smoother operation results since two SCR's in series must fire to enable conduction as opposed to one SCR in conventional single-phase converters. This provides broad band immunity to inadvertent SCR firing due to line noise, and contributes to operating safety since the failure of one SCR will not result in undesired motor rotation when the armature is at rest.

    The freewheeling diode improves the form factor which lowers rms currents resulting in reduced motor temperatures by minimizing power dissipation at low speeds. This enhances both motor performance and life.
14. **Voltage Transient Protection** – Metal oxide suppressors across the AC line are combined with RC snubbers across the power bridge to limit potentially damaging high voltage spikes from the AC power source.
15. **Circuit Breaker** – A single-pole, molded case, magnetic trip circuit breaker is provided as a means of manually disconnecting the AC power to the controller and motor and as automatic instantaneous trip protection from a peak load. A two-pole circuit breaker, (Option 30) is optional.
16. **Control Voltage** – A transformer coupled 24 VDC power supply isolates all magnetic pushbutton control and logic from the AC power source for operator protection.
17. **Field Supply** – Transient protected, half-wave. See Table 1 for output voltages. A full-wave field providing 100VDC for 115VAC controllers and 200VDC for 230 VAC controllers is available as a factory installed option.
18. **Contactorless Design** – Unit is designed for safe, reliable solid state, run-stop operation without an armature contactor. Logic includes a provision to prevent an involuntary restart after a power failure. This feature may be defeated when an external customer furnished AC line contactor is used to control the unit.

    Unidirectional, Dynamic Braking models and Reversing models include a two-pole DC magnetic contactor which provides a positive disconnection of the motor armature from the rectified power source. Action of the contactor is sequenced with the SCR regulator to ensure that the power circuit DC is "phased-off" before the contactor is

Single-Phase Adjustable Speed Digital DC Motor Controllers, Nonregenerative

VED Series
1/6-3 Horsepower

DESIGN FEATURES AND FUNCTIONS *(Continued)*

opened. This ensures that only "dry-switching" occurs for improved contactor longevity. *See Option R for additional information.*

19. **Optional Capabilities**
    (a) Tachometer Feedback – The standard unidirectional units include terminals to accept a feedback signal from a motor mounted DC tachometer generator for improved speed regulation as shown in Table 2.
    (b) AC Line Starting – Provision is included to defeat the no-restart-on-power-failure feature to permit run-stop control of unidirectional models by an external AC line contactor.
    (c) Half Voltage Output – Permits using 90VDC armature motors on a controller connected for operation from a 230V power source. May eliminate expensive transformers where 180VDC motors are not available.
20. **Paint Finish** – Base casting is painted with a durable, baked power epoxy finish in Boston Gear "Thermo Black." Enclosure covers are molded of resins in this color.
21. **Mechanical Flexibility** – VED Series units offer outstanding application flexibility. The same basic unit can be used as an open chassis or enclosed package controller.
22. **Safety Features** – UL and cUL Listed • Low Voltage Operator Control • Requires mandatory restart after power interruption • TENV enclosure • Isolated regulator
23. **Quality Features** – FR4 glass circuit cards • Rugged die aluminum alloy chassis base • High strength Noryl® cover • Conservatively rated components selected for long service life.

RATINGS

1. **Service Factor** 1.0
2. **Duty** ..... Continuous
3. **Overload Capacity (armature circuit)**.....150% for 1 minute
4. **Operating Voltages** ..... See Table 1

TABLE 1. OPERATING VOLTAGES

Power Source (single-phase)	Output VDC		Control Reference Voltage	Magnetic Control Voltage
	Armature	Field		
115V, 50 or 60 Hz	0–90	50	5VDC	24VDC
230V, 50 or 60 Hz	0–180	100		

5. **Horsepower Range** .....1/6-1 HP, 115VAC
   1/2-3 HP, 230 VAC
6. **Circuit Breaker Interrupting Capacity** ..... 5000 Amps
7. **Analog Reference Power Supply** ..... 5 VDC
8. **Run Speed Potentiometer (Optional)**.... 5K ohms, 1/2W
9. **Current/Torque Reference Potentiometer (Optional)**..... 5K ohms, 1/2W

PERFORMANCE CHARACTERISTICS

1. **Controlled Speed Range** - Zero to motor base speed. Speed range with respect to specified regulation is listed in Table 2.
2. **Speed Regulation** - Regulation percentages shown in Table 2 are of motor base speed under steady-state conditions.
3. **Efficiency -** (rated speed/rated load)
   (a) Controller SCR regulator 98%
   (b) Complete drive with motor (Typical)..... 84%

TABLE 2. SPEED REGULATION CHARACTERISTICS

Regulation Method	Variable				
	Load Change 95%	Line Voltage ±10%	Field Heating Cold-Normal	Temp. ±10°C	Speed Range
Standard Voltage Feedback with IR Compensation	2%	±1%	5–12%	± 2%	50:1
(Tach) Feedback	0.2%	± 0.2%	0.2%	±0.5%	500:1

OPERATING CONDITIONS

1. **Line Voltage Variation**..... ±10% of rated
2. **Line Frequency Variation** ..... ±2 Hz
3. **Ambient Temperature**(1)
   Enclosed Models ..... 0° C to 40°C
   (32° F to 104° F)
4. **Altitude** (Standard) ..... 3300 feet
   (1000 meters) maximum
5. **Relative Humidity** ..... 95% noncondensing

NOTE: (1) 55°C (131°F) maximum in enclosed areas where open chassis units are mounted.

ADJUSTMENTS

Potentiometer adjustments are provided for:

1. **Torque (Current) Limit** ..... 0-150% full-load torque
2. **Minimum Speed** ..... 0-100% of motor base speed
3. **Maximum Speed**..... 0-100% of motor base speed
4. **Jog Speed**..... 0-100% of motor base speed
5. **IR (Load) Compensation** ..... 0-100% of rated load
6. **Acceleration/Deceleration**(1)
   (a) Time ..... 0.2–100 seconds,
   (b) Rate..... 500%–1% per second

NOTE: (1) Adjustments are logarithmic for fine adjustment of fast rates. Acceleration and deceleration are linear and independently adjustable.

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TYPICAL APPLICATION DATA											
			Ratings								
Rated Horsepower (HP)			1/6	1/4	1/3	1/2	3/4	1	1-1/2	2	3
Rated Kilowatts (kW)			0.124	0.187	0.249	0.373	0.560	0.746	1.120	1.492	2.238
1-Phase AC Input (Full-Load)	Line Amps	115 VAC	3.9	5.0	6.0	8.7	12.4	15.8	—	—	—
		230 VAC	—	—	—	4.2	5.9	8.8	12.6	17.0	22.0
	KVA		.48	.58	.71	1.0	1.4	2.0	3.0	4.0	5.0
DC Output (Full-Load)	Motor Armature Amps	90V	2.0	2.8	3.5	5.4	8.1	10.5	—	—	—
		180V	—	—	—	2.6	3.8	5.5	8.2	11.6	15.1
	Motor(1) Field Amps	50V	2.0	2.0	2.0	2.0	2.0	2.0	—	—	—
		100V	—	—	—	2.0	2.0	2.0	2.0	2.0	2.0
Full-Load Torque (lb-ft) with 1750 RPM Base Speed Motors			0.5	0.75	1.0	1.5	2.2	3.0	4.5	6.0	9.0

(1) Does not apply to Permanent Magnet Motors

MODEL TYPES

The VED controllers are offered in both open chassis and NEMA 1 enclosed configurations in twenty-four standard models. The basic, open chassis models are the nucleus of all other VED Series controllers. The other models listed are constructed from these basic chassis by adding appropriate option kits and covers either factory installed or field modified.

Local Control Operation – Local control, enclosed, package drives are provided with integral, cover mounted operator control panel. Units with an M Suffix (e.g., VED100M) include membrane push switches for all control functions and an LCD Display providing important operational data while P units (VED100P) feature conventional pushbuttons, switches and a speed control potentiometer.

Remote Control Operation – Enclosed, package remote control models have a blank cover mounted in the space reserved for the operator control panel. Since the blank cover and the operator control panel are dimensionally the same and interchangeable, the controller may easily be field converted from local to remote control.

ORDER BY CATALOG NUMBER OR ITEM CODE

Horsepower Range (1)		Catalog Number	Item Code	Function
115 VAC	230 VAC			
ENCLOSED – LOCAL CONTROL WITH PUSHBUTTON PANEL				
1/6–1	—	VED100P	67001	Run-Stop
—	1/2–3	VED300P	67003	Run-Stop
1/6–1	—	VED100PR	67004	Run-Stop, Forward/Reverse Switch, DB
—	1/2–3	VED300PR	67008	Run-Stop, Forward/Reverse Switch, DB
ENCLOSED – LOCAL CONTROL WITH MEMBRANE PANEL				
1/6–1	—	VED100M	65853	Run-Stop-Jog
—	1/2–3	VED300M	65854	Run-Stop-Jog
1/6–1	—	VED100MR	65856	Forward-Reverse-DB-Jog
—	1/2–3	VED300MR	65857	Forward-Reverse-DB-Jog
ENCLOSED – BLANK COVER – FOR USE WITH RCS PUSHBUTTON STATIONS*				
1/6–1	—	VED100BP	65865	Run-Stop
—	1/2–3	VED300BP	65866	Run-Stop
1/6–1	—	VED100BPR	65869	Run-Stop, Forward/Reverse Switch, DB
—	1/2–3	VED300BPR	65870	Run-Stop, Forward/Reverse Switch, DB
ENCLOSED – BLANK COVER – FOR USE WITH MCS1 REMOTE STATION*				
1/6–1	—	VED100B	65859	Run-Stop-Jog
—	1/2–3	VED300B	65860	Run-Stop-Jog
1/6–1	—	VED100BR	65862	Forward-Reverse-DB-Jog
—	1/2–3	VED300BR	65863	Forward-Reverse-DB-Jog

(Continued)

Single-Phase Adjustable Speed Digital DC Motor Controllers, Nonregenerative

***VED** Series*
***1/6-3** Horsepower*

MODEL TYPES *(Continued)*

ORDER BY CATALOG NUMBER OR ITEM CODE

Horsepower Range (1)		Catalog Number	Item Code	Function
115 VAC	230 VAC			
OPEN CHASSIS – FOR USE WITH RCS PUSHBUTTON STATIONS*				
1/6–1	—	VED100CP	65878	Run-Stop
—	1/2–3	VED300CP	65879	Run-Stop
1/6–1	—	VED100CPR	65881	Run-Stop, Forward/Reverse Switch, DB
—	1/2–3	VED300CPR	65882	Run-Stop, Forward/Reverse Switch, DB
OPEN CHASSIS – FOR USE WITH MCS1 REMOTE STATION*				
1/6–1	—	VED100C	65872	Run-Stop-Jog
—	1/2–3	VED300C	65873	Run-Stop-Jog
1/6–1	—	VED100CR	65875	Forward-Reverse-DB-Jog
—	1/2–3	VED300CR	65876	Forward-Reverse-DB-Jog

*Refer to Remote Operator Stations, pages 109 and 110.
(1) Units are shipped calibrated for the maximum design horsepower rating. They may be easily calibrated in the field for any standard rating within the design range.

REMOTE OPERATOR CONTROL STATIONS VED					
Catalog Number	Item Code	Control Elements			Use With Controller Models
		Pushbuttons	Switches	Pots	
RCS1	69362	Run, Stop	—	Motor Speed	'BP, CP'
RCS3	69366	Run, Stop	Run/Jog	Motor Speed Jog Speed	'BP, CP'
RCS6	60239	Fwd, Rev, Stop	—	Motor Speed	'BPR, CPR'
MCS1	66774	Microprocessor Based Membrane Control Panel with Push Switches for Run-Jog-Stop, Motor Speed Faster–Slower and Motor Direction Forward–Reverse			'B, BR, C, CR'

Remote Operator Station dimensions shown on page 110.

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OPTIONS

Options and modifications are listed alphanumerically within each group. Complete option descriptions are listed in the DC option section.

To order assembled (installed) options, add the option number or letter as a suffix to the controller catalog number, e.g., VED100M-44. To order a kit for field installation, order by item code.

Group	Description	Option No.	Item Code	Notes
Input	Follower, AC/DC Volts	14	66827	(1)
	Follower, AC or DC Tachometer	22A	66830	(1)
	Follower, Pulse	22D	66836	(1)
	Follower, Serial Link-RS422	22L	66868	(1, 4)
	Parallel (BCD) Multiplexer	22M	67075	(1, 4, 7)
	Parallel (BCD) Digital Input	22P	66874	(1)
	Follower, DC mA Signal	25B	66853	(1)
	Follower, AC Current Transducer	25C	—	(1, 5)
	Follower/Isolator, DC mA Signal	25S	66865	(1)
Feedback	Tachometer Feedback, AC or DC	24A	66830	(1)
	Digital Pulse Feedback	24D	66836	(1)
Winder	Torque-Taper	18	66880	(2)
Power	Reverse/DB Kit	R	65889	(3)
	Circuit Breaker, 2-Pole	30	67540	
	Full-Wave Field Supply	32	—	
	Power Supply, Auxiliary	52	67573	
Auxiliary Control	Auxiliary Contacts	12A	66864	
	Auxiliary Contacts, Programmable	12B	67564	
	Programmable Speed/Torque	15	67577	
Operator Control	MCS1 Remote Station	MCS1	66774	
	Forward/Reverse Switch Kit	RSW	—	
	Remote Kit, Membrane	6A	65890	
	JOG, Toggle Switch	9A	—	
	Speed Pot, 10-Turn, Analog	21A	—	
	Speed Pot, 10-Turn, Digital	21B	—	
	Digital Meter, LCD	44	67565	
	Digital Monitor, Local	44A	67015	
	Digital Monitor, Remote	44B	67018	
Miscellaneous	Signal Bus Support Guide	53	67574	
	Signal Bus Cable	54	67575	
	Computer Monitoring Software	55	67576	(8)
Enclosure	NEMA 3, 4, 12 Kit (for Membrane Operators)	27M	66915	(4)
	NEMA 3, 4, 12 Kit (for Pushbutton Operators)	27P	—	(6)
	Hinge Kit	50	67539	

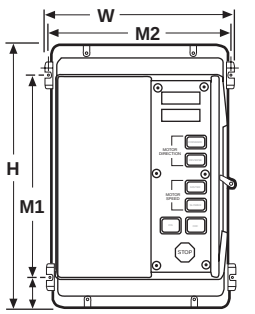
Notes:
(1) Only one may be Selected from this group.
(2) No input or Feedback Option may be used with this option.
(3) This option provides reversing and/or dynamic braking.
(4) For use Only with Membrane Controls (MP1 Panel and MCS1 Remote Station).
(5) Requires external current transducer; advise full-load current and voltage of AC motor to be followed.
(6) Cannot be used with Option 21A or 21B.
(7) Requires Option 22P.
(8) Specify 3½ or 5¼ floppy disk.

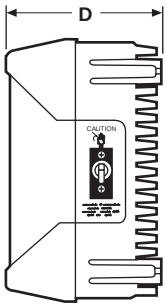
Single-Phase Adjustable Speed Digital DC Motor Controllers, Nonregenerative

***VED** Series*

***1/6-3** Horsepower*

DIMENSIONS





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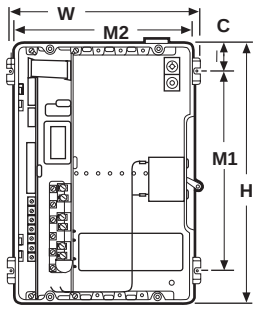
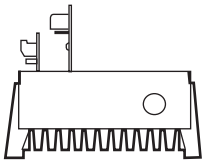
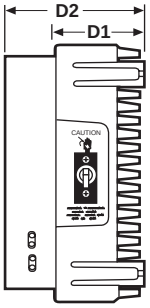
(2 PL; one top, one bottom)

ENCLOSED MODELS





OPEN CHASSIS MODELS



Model	Dimensions, inches								Weight – LB	
	H	W	D	D1	D2	M1	M2	C	Open Chassis Models	Enclosed Models
VED100 VED300	12.1	9.0	7.3	4.1	6.5	9.3	8.6	1.3	9.0	11.4

NOTES

A

Single-Phase Adjustable Speed Regenerative DC Motor Controllers

TABLE OF CONTENTS

SPECIFICATION CHART 42

RBA/VEA–RG.....43-47

VEL/VEH-RG 48-52

OPTIONS FOR DC CONTROLLERS.....53-71

APPLICATION ENGINEERING.....175-189

Single-Phase Adjustable Speed Regenerative DC Motor Controllers

Specification Chart

The purpose of this chart is to provide a general feature comparison of the Boston Gear controllers. When selecting refer to the specific catalog selection for complete information.

REGENERATIVE DC MOTOR CONTROLLER SPECIFICATIONS

Features		RBA-RG/VEA-RG		VEL/VEH-RG	
AC Line (50/60 Hz)	Single-Phase Voltage Three-Phase Voltage	115 —	230 —	115 —	230 —
Range	Maximum Horsepower	1	5	1	5
Output	Armature Voltage Field Voltage	90 50/100	180 100/200	90 100	180 200
AC Line Protection	Fuse Circuit Breaker	S	S O	S	
Enclosure	Open Chassis Angle Bracket Chassis NEMA 1 NEMA 4 NEMA 12	S S S S S	S S S S	S S	
Adjustments	Acceleration (Seconds) Deceleration (Seconds) IR Compensation (%) Maximum Speed (%) Current Limit (%) Gain Phase Shift	0.2–30 0.2–30 10 50–100 10–150		O O 0-100 60-100 50-150 S S	
Horsepower/ Voltage Calibration	Trim Pot Adjustments Resistance Wire Plug In Jumpers Switch	 S S		S	
Isolated Regulator		O		S	
Speed Regulation	Standard IR Feedback Percentage Speed Range Tachometer Feedback Percentage Speed Range	 2% 50:1 0.5% 200:1		 2% 50:1 0.5% 200:1	
Input	Analog Digital	S		S	
Tachometer Feedback	Bidirectional	S		O	
Options	Field Installed Factory Installed	O		S S	
UL/cUL		S		S	
Pages		43-47		48-52	

S-Standard O-Optional

Single-Phase Adjustable Speed Regenerative DC Motor Controllers

RBA-RG/VEA-RG Series
1/6-5 Horsepower

Boston Gear RBA-RG/VEA-RG regenerative controllers, are economical, general purpose units. The units feature static conversion of AC line power to regulated direct current adjustable speed, four-quadrant armature control of shunt-wound or permanent magnet DC motors. The compact dimensions and design features of the units make this series of controllers an ideal choice for numerous industrial applications which require controllable bidirectional speed and torque for overhauling loads, contactorless reversing and static braking.

RBA-RG & VEA-RG units are identical in standard features and functions and differ only in mechanical configuration and horsepower range. RBA-RG Series units are smaller, are limited to three horsepower maximum and will accept a limited number of options. VEA-RG Series units are physically larger permitting ratings through five horsepower and provide greater available space to facilitate mounting a wide range of optional features. Accordingly, RBA-RG Series units are preferred in space intensive applications where the standard features and functions are adequate for the application. The RBA-RG Series is available as standard in open and enclosed configurations along with the angle bracket chassis style. The VEA-RG Series is available as standard in the open and enclosed configuration.

RBA-RG/VEA-RG controllers are designed and manufactured to comply with applicable standards established by the National Electrical Code and NEMA for industrial motor and control equipment. The units are UL and cUL Listed.

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DESIGN FEATURES AND FUNCTIONS

1. **Construction** – The die-cast aluminum alloy base assembly forms the basic RBA-RG Series open chassis (excluding RBA2C-RG units) which includes regulator electronics, AC line fuse, power conversion and protective circuitry as a totally functional, self-contained unit. The entire back surface of the VEA-RG Series base is a unique, pin configuration heatsink with omni-directional heat dissipation characteristics. This allows vertical or horizontal wall mounting as best suits the available space. All open models are cooled by natural convection. Conduit entry is provided in the base by two 3/4-14 NPT tapped holes, one each on the top and bottom.

   Enclosed models consist of the basic chassis with the addition of a screw fixed cover which is gasketed with an oil resistant synthetic rubber gasket to exclude contaminants. Basic enclosed units are TENV, NEMA 4 and 12. All models with integral operator controls also include flexible boots to seal the operator control switches and a seal for the motor speed potentiometer.

   RBA3-RG Models, when rated three (3) horsepower as an enclosed unit, requires the use of a stand off kit (Option SK). This is included when an enclosed controller is ordered.

   VEA5-RG Models, when rated five (5) horsepower as an enclosed unit, requires the addition of Option VFKT cooling fan assembly. This is included when an enclosed controller is ordered.

   VEA-RG Series unit covers are molded of high strength Noryl® engineering plastic. An aperture in the cover permits mounting a blank panel for remote control models or various standard or optional local operator control panels. *Where a hinged cover is desired, Option 50 provides a kit permitting easy field installation.*

   RBA-RG Series unit covers are die-cast aluminum alloy. Various cover models are provided. Blank face models include no operator control elements, as they are intended for remote control operation. The local control model provides a motor speed potentiometer and Run/Stop Jog toggle switch.

   RBA2C-RG Models are offered only in a special space saving chassis configuration, formed of aluminum into a Right Angle chassis design, which requires only two (2) mounting screws.

2. **Full-Wave Power Conversion** – Dual full-wave converter configuration, consists of eight (8) SCRs connected in back to back bridges of four (4) SCRs each. The SCR's are rated 600 PIV minimum.
3. **Voltage Transient Protection** – Metal oxide suppressor with RC snubbers across the AC line input and a second RC snubber across the DC output.
4. **AC Line Protection** – A 100,000 ampere interrupting capacity AC line fuse provides instantaneous protection from peak loads and fault currents. This line fuse is located inside the controller. A molded-case magnetic-trip circuit breaker (Option 30) is available for VEA-RG Model controllers, which provides a manual disconnection to the controller, and also provides automatic instantaneous trip protection from a peak load.
5. **AC Line Power** – Controllers are reconnectable for 115 or 230 VAC, single-phase, 50 or 60 Hertz.
6. **Safety Features** – UL listed and cUL. Requires mandatory restart after power interruption.
7. **AC Line Starting** – Provision is included to defeat the mandatory restart after power interruption to permit run-stop control of the units by an external AC line contactor.
8. **Deadband Selection** – This will help to eliminate "creeping" motor speed with zero speed reference signal. It gives a non-adjustable ±2% deadband around zero speed.
9. **Field Supply** – Transient protected, full-wave and half-wave field supply.
10. **Operator Controls** – Units with a "S" suffix in the catalog number (example: RBA2S-RG) contain a motor speed potentiometer and a Run-Stop-Jog switch. The speed potentiometer is reconnectable for unidirectional or bidirectional operation.

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DESIGN FEATURES AND FUNCTIONS *(Continued)*

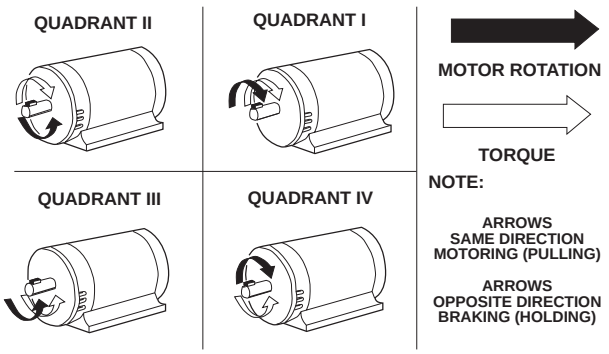
11. **Static Reversing** – Solid state, electronic reversal of the motor armature. No reversing contacts to burn, arc or wear.
12. **Static Braking** – Provides smooth regeneration braking of the DC drive motor. Braking is effective whenever the manual speed control potentiometer is reset to command a reduction in speed or change in the direction of motor rotation.
13. **DC Tachometer Feedback** – Unit includes terminals to accept a 5.5 to 100VDC/1000 RPM (1750 RPM maximum) signal from a motor mounted DC tachometer generator for improved speed regulation.
14. **External Current (Torque) Control** – Terminals are provided for external forward and reverse current limit (torque) control.
15. **Diagnostic LED** – A dual color LED, green for power on, red for current limit is provided.
16. **Customer Use Run Contacts** – Form A normally open contact rated five (5) amps at 115 VAC or 30 VDC coordinated with run command may be used for external control and indicating devices. May be applied as pushbutton seal-in or a drive "RUN" contact.
17. **Hybrid Circuitry** – Miniature components in a custom surface mount assembly, improve reliability and make possible more features in the smallest possible mechanical configuration.
18. **Option Connectors** – These connectors are provided for options that fit in a space provided inside the controller.
19. **Dynamic Braking** – Standard feature of model numbers with a "U" suffix. Dynamic braking provides exponential rate braking of the DC motor armature. Included is a Dynamic Braking resistor with an anti-plug circuit to prevent restarting the controller until the braking cycle is complete, thereby preventing a potentially damaging contact arcing. The Dynamic Braking resistor is rated for stopping a typical load, when the external machine inertia does not exceed that of the motor armature, as shown in table.
20. **Control Voltage** – A transformer coupled 24 VDC power supply provides non-isolated control power for all magnetic control logic and operator controls.
21. **DIP Switch Settings** – An 8-position DIP Switch is used to program the controller for various applications and operations.
22. **Motor Contactor** – Controller model numbers with a "U" suffix, e.g., RBA2U-RG, VEA5US-RG, have a DC magnetic armature contactor, which disconnects both motor armature leads from the controller. An antiplug circuit ensures that the contactor does not make or break DC from the SCR bridge.

DYNAMIC BRAKING CHARACTERISTICS (1) (2)

Component	Model	Rated Voltage	Rated Horsepower 1/6	1/4	1/3	1/2	3/4	1	1½	2	3	5
Braking Torque (%)	RBA2-RG	115V	180	129	103	66	44	34	N/A	N/A	N/A	N/A
		230V	N/A	N/A	400	278	200	138	93	66	N/A	N/A
	RBA3-RG	115V	300	214	171	111	74	57	N/A	N/A	N/A	N/A
		230V	N/A	N/A	N/A	462	316	218	146	103	79	N/A
	VEA5-RG	115V	600	429	343	222	148	114	N/A	N/A	N/A	N/A
		230V	N/A	N/A	N/A	923	632	436	293	207	159	96
Stops Per Minute	RBA2-RG	115V	15	12	11	8	6	2	N/A	N/A	N/A	N/A
		230V	N/A	N/A	12	8	6	2	1	1	N/A	N/A
	RBA3-RG	115V	9	6	5	5	4	4	N/A	N/A	N/A	N/A
		230V	N/A	N/A	N/A	5	4	4	3	3	2	N/A
	VEA5-RG	115V	15	12	10	10	7	7	N/A	N/A	N/A	N/A
		230V	N/A	N/A	N/A	10	7	7	5	5	3	2

Notes: (1) Ratings shown for units with contactor board (Model number contains "U" suffix, ex RBA3U-RG).

(2) High inertia loads may extend braking time and cause the wattage rating of the dynamic braking resistors to be exceeded.



PRINCIPLES OF OPERATION

Regenerative adjustable speed drives, also known as four-quadrant drives, are capable of controlling not only the speed and direction of motor rotation, but also the direction of motor torque. This is illustrated to the right.

The term regenerative describes the ability of the drive under braking conditions to convert the mechanical energy of the motor and connected load into electrical energy which is returned (or regenerated) to the AC power source.

When the drive is operating in Quadrants I and III, both motor rotation and torque are in the same direction and it functions as a conventional nonregenerative unit. The unique characteristics of a regenerative drive are apparent in Quadrants II and IV. In these quadrants the motor torque opposes the direction of motor rotation which provides a controlled braking or retarding force. A high performance regenerative drive, such as the RBA-RG/VEA-RG Series, is able to switch rapidly from motoring to braking modes while simultaneously controlling the direction of motor rotation.

RATINGS

1. **Horsepower Range** . . . . . 1/6-5 HP
2. **Power Source** . . . . . 115 or 230 VAC, ... Single-Phase, 50 or 60 Hz
3. **Operating Voltages**

OPERATING VOLTAGES

Power Source (Single-Phase)	Output VDC Armature	Output VDC Field	Control Reference Voltage	Magnetic Control Voltage
115V, 50 or 60 Hz	0-90	50/100	0 to ±10 VDC	24 VDC
230V, 50 or 60 Hz	0-180	100/200		

4. **Service Factor** 1.0
5. **Duty** . . . . . Continuous
6. **Overload Capacity (Armature Circuit)** . . . . . 150% for 1 Minute
7. **Line Fuse Interrupting Capacity (Non-Isolated)** . . . . . 100,000 Amps
8. **Reference Power Supply (Non-Isolated)** . . . . . ±10VDC
9. **Run Speed Potentiometer** . . . . 10K ohms, 1/2 W
10. **Current/Torque Reference Potentiometer** . . . . . 10K ohms, 1/2 W

Single-Phase Adjustable Speed Regenerative DC Motor Controllers

RBA-RG/VEA-RG Series
1/6-5 Horsepower

ADJUSTMENTS

Potentiometer adjustments are provided for:

1. **Current Limit**.....10-150% Full-Load Torque (Independent forward and reverse circuits)
2. **Maximum Speed**.....50-100% of Motor Base Speed
3. **IR (Load) Compensation**.....10% Boost
4. **Acceleration**.....0.2 to 30 Seconds
5. **Deceleration**.....0.2 to 30 Seconds
6. **Deadband (Yes or No Adjustment)**.....0 or ±2%
7. **Jog Speed**.....0 to 100% of Motor Base Speed

OPERATING CONDITIONS

1. **Line Voltage Variation**.....±10% of rated
2. **Line Frequency Variation**.....±2 Hz
3. **Ambient Temperature** (1).....0°C to 40°C (32°F to 104°F)
4. **Altitude (Standard)**.....1000 meters (3300 feet) Maximum
5. **Relative Humidity**.....95% Noncondensing

(1) 0°C to 55°C (32°F to 131°F) maximum in enclosed areas where chassis models are mounted.

PERFORMANCE CHARACTERISTICS

1. **Controlled Speed Range** – Zero to motor base speed. Speed range with respect to specified regulation is listed in Table. See page I2 for continuous duty application limitations of DC motors.
2. **Speed Regulation** – Regulation percentages shown in Table below are of motor base speed under steady-state conditions.
3. **Efficiency** (Rated speed/Rated load)
   (a) Controller SCR regulator.....98%
   (b) Complete drive with motor (typical).....85%
5. **Current Ripple Frequency**.....120 Hz (60 Hz line) 100 Hz (50 Hz line)
4. **Controller Bandwidth (Speed of Response)**.....5 Hz

SPEED REGULATION CHARACTERISTICS

Regulation Method	Variable				Speed Range
	Load Change 95%	Line Voltage ±10%	Field Heating Cold/ Normal	Temp. ±10°C	
Standard Voltage Feedback with IR Compensation	2%	±1%	5-12%	±2%	50:1
Tachometer Feedback with 5 PY DC Tach Feedback	0.5%	±1%	0.2%	±2%	200:1

TYPICAL APPLICATION DATA

Component			Ratings									
Rated Horsepower (HP)			1/6	1/4	1/3	1/2	3/4	1	1-1/2	2	3	5
Rated Kilowatts (kW)			0.124	0.187	0.249	0.373	0.560	0.746	1.120	1.492	2.238	3.730
1-Phase AC Input (Full-Load)	Line Amps	115V Unit	3.9	5.0	6.0	8.7	12.4	15.8	—	—	—	—
		230V Unit	—	—	—	4.2	5.9	8.8	12.6	15.8	22.0	32.0
	KVA		0.48	0.58	0.71	1.00	1.40	2.00	3.00	4.00	5.00	8.00
DC Output (Full-Load)	Motor Armature Amps	90V	2.0	2.8	3.5	5.4	8.1	10.5	—	—	—	—
		180V	—	—	—	2.6	3.8	5.5	8.2	11.6	15.1	25.0
	Motor Field Amps	RBA-RG	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	—
		VEA-RG	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Full Load Torque (lb-ft) with 1750 RPM Base Speed Motors			0.5	0.75	1.0	1.5	2.2	3.0	4.5	6.0	9.0	15.0
Minimum Transformer KVA for Voltage Matching or Isolation			0.5	0.75	0.75	1.0	1.5	2.0	3.0	5.0	7.5	10.0

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MODEL TYPES

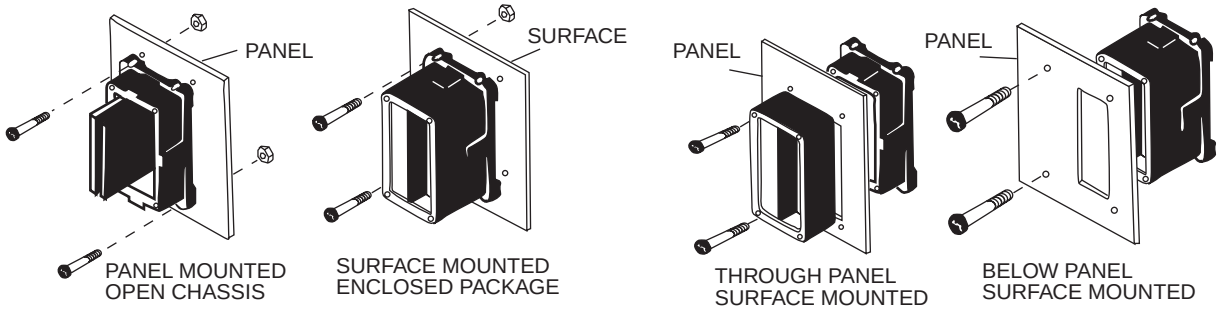
RBA-RG/VEA-RG controllers are offered in eighteen (18) standard models in four (4) functional groups. The basic chassis models are the nucleus of all the enclosed models; standard covers and contactor assemblies can be added to the basic chassis to make an enclosed controller or the enclosed unit may be ordered complete as shown below.

ORDER BY CATALOG NUMBER OR ITEM CODE

Horsepower Range (1)		Catalog Number	Item Code	Function
115 VAC	230 VAC			
ANGLE BRACKET CHASSIS UNITS WITHOUT OPERATOR CONTROLS*				
1/6-1	1/2-2	RBA2C-RG	68402	Run/Stop(4)
		RBA2CU-RG	68411	Bidirectional with Armature Contactor and DB
BASIC CHASSIS CONTROLLERS WITHOUT OPERATOR CONTROLS*				
1/6-1	1/2-2	RBA2-RG	68385	Run/Stop(4)
		RBA2U-RG	68388	Bidirectional with Armature Contactor and DB
1/6-1	1/2-3	RBA3-RG	68397	Run/Stop(4)
		RBA3U-RG	68400	Bidirectional with Armature Contactor and DB
1/6-1	1/2-5	VEA5-RG	68440	Run/Stop(4)
		VEA5U-RG	68441	Bidirectional with Armature Contactor and DB
NEMA 4/12 ENCLOSED CONTROLLERS WITHOUT OPERATOR CONTROLS*				
1/6-1	1/2-2	RBA2B-RG	68392	Run/Stop(4)
		RBA2UB-RG	68394	Bidirectional with Armature Contactor and DB
1/6-1	1/2-3	RBA3B-RG	68419	Run/Stop(2)(4)
1/6-1	1/2-5	VEA5B-RG	68442	Run/Stop(3)(4)
		VEA5UB-RG	68443	Bidirectional with Armature Contactor and DB(3)
NEMA 4/12 ENCLOSED CONTROLLERS WITH OPERATOR CONTROLS*				
1/6-1	1/2-2	RBA2S-RG	68395	Run/Stop/Jog(4)(5)
		RBA2US-RG	68396	Bidirectional with Armature Contactor and DB
1/6-1	1/2-3	RBA3S-RG	68424	Run/Stop/Jog(2)(4)(5)
1/6-1	1/2-5	VEA5S-RG	68444	Run/Stop/Jog(3)(4)(5)
		VEA5US-RG	68445	Bidirectional with Armature Contactor and DB

*Refer to Remote Operator Stations on pages 109 and 110

(1) Units are shipped calibrated for the maximum horsepower ratings shown. Units may be calibrated for other standard ratings by the removal of jumpers. Units are connected for 230 VAC and are easily reconnected for 115 VAC input.
(2) Includes option SK, Spacer Kit, as standard.
(3) Includes option VFKT, Cooling Fan, as standard.
(4) Contactorless Run-Stop Operation.
(5) Jog Speed is set by the Run Speed potentiometer, maintained in the Run position, Jog position is momentary with a spring return to Stop.

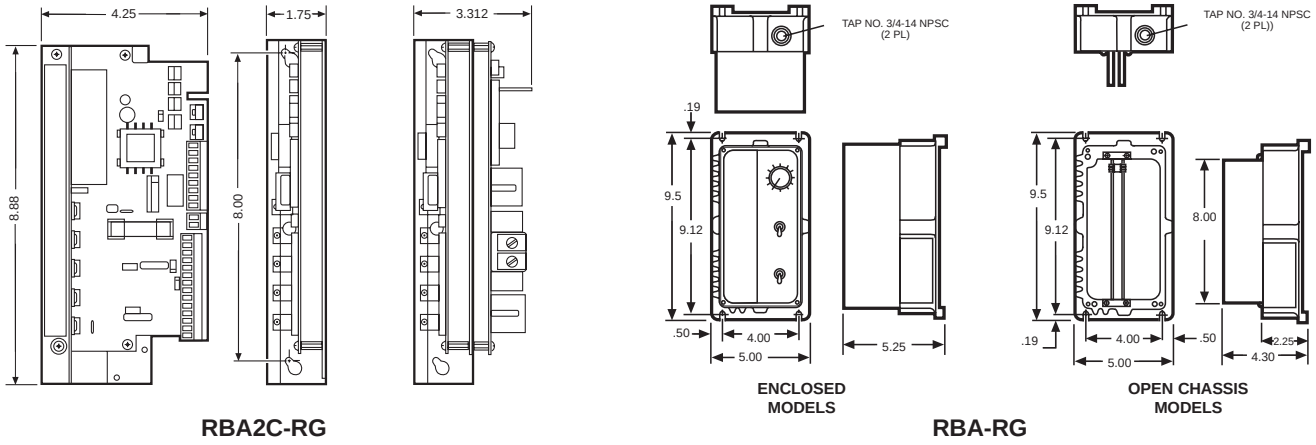


RBA-RG Series Mounting Configurations

Single-Phase Adjustable Speed Regenerative DC Motor Controllers

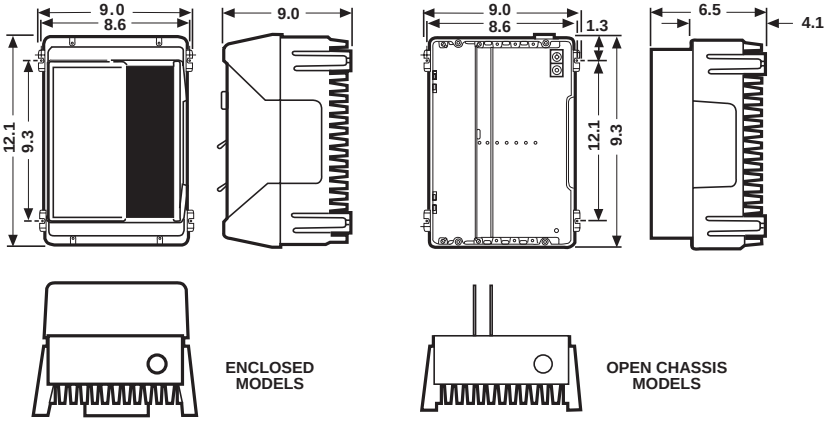
RBA-RG/VEA-RG Series
1/6-5 Horsepower

DIMENSIONS



RBA2C-RG

RBA-RG



VEA-RG

CONTROLLER WEIGHTS	
Unit	**Weight lbs.**
RABA2-RG, RBA3-RG	7.70
RBA2U-RG, RBA3U-RG	8.50
RBA2B-RG, RBA3B-RG RBA2S-RG, RBA3S-RG	11.60
RBA2UB-RG RBA2US-RG	12.40
RBA2C-RG	2.00
RBA2CU-RG	2.25
VEA5-RG	8.20
VEA5U-RG	8.90
VEA5B-RG VEA5S-RG	12.50
VEA5UB-RG VEA5US-RG	13.20

OPTIONS

The versatility of the RBA-RG/VEA-RG Series controllers for various applications can be extended by selecting one (1) or more of the listed options. Most can be easily added in the field via simplified instructions provided. The table below lists the options in functional groups along with information on allowable combinations and installation complexity.

Allowable Option Combinations

Remarks	Option	Catalog Number	Kit Number	Notes
Enclosure Options—Choice of any or all within this group. May be combined with options from any other group.	Hinge kit to allow the cover to swing open	50	67539	
	Spacer kit for RBA3B-RG, RBA3S-RG enclosed controllers	SK	68416	
Power Options	Circuit Breaker—Two Pole (VEA-RG only)	30	68456	
Accel/Decel Option	Four-Quadrant Acceleration/Deceleration	17	68457	
Circuit Board Options—Choice of one within this group	Torque Taper	18	68458	(1)
	Pulse Tachometer Feedback/Follower	24B	68462	(1)
	Isolated Input	25	68478	
	Limit Switch Reversing	RI	68461	(1)
External Options—Choice of any or all within this group	Motor Speed Potentiometer, One-Turn	21	—	(2)
	Motor Speed Potentiometer, Ten-Turn With Analog Dial	21A	66929	(2)
	Option Guide Card Kit	MK	68476	(1)
	Option/Contactor Mounting Kit for RBA2C-RG	SKO	64101	

(1) Option MK is a pre-requisite to enable the use of options in the VEA-RG Series.
(2) Will not be NEMA 4/12 unless factory installed.

RATIOTROL SYSTEMS

Single-Phase Adjustable Speed Regenerative DC Motor Controllers

VEL/VEH-RG Series

1/6-5 Horsepower

Boston Gear VEL/VEH-RG regenerative controllers are high performance, general-purpose units featuring static conversion of AC line power to regulated DC for adjustable speed, four-quadrant armature control of shunt-wound or permanent-magnet DC motors. Unique design features of the basic units and a wide range of standard and custom options make the VEL/VEH-RG controllers an ideal choice for numerous industrial applications which require controllable bidirectional torque for overhauling loads, contactorless reversing or precise position control. Motors for use with these controllers are listed in the DC motor section.

VEL/VEH-RG controllers are designed and manufactured to comply with applicable standards established by the National Electrical Code and NEMA for industrial motor and control equipment. The units are ***UL and cUL Listed.***

DESIGN FEATURES AND FUNCTIONS

1. **Construction** – VEL/VEH-RG models feature a totally enclosed, non-ventilated NEMA Type 12 enclosure, constructed of rugged, die-cast aluminum alloy. Hinged cover includes a draw latch that tightly compresses the gasket to exclude contaminants. Conduit entry is provided by four 3/4-14 NPSC tapped holes on three (3) sides. Back surface is deeply finned for maximum heat transfer.

   VEL/VEH-RG-CM models feature an open chassis with a dead back and front construction. Front access is provided to all components by a hinged, latched front cover which forms a mounting surface for the main control circuit board. The entire base is a finned alloy extrusion for maximum heat transfer.
2. **Full-Wave Power Conversion** – Dual full-wave converter configuration, consists of two (2) back-to-back bridges of four (4) SCRs each, which provides optimum form factor for best motor performance and long service. Power bridges are an integrated, encapsulated component.
3. **Voltage Transient Protection** – Metal oxide suppressor across the AC line and RC snubbers across the power bridge modules minimize the effect of high voltage spikes from the AC power source.
4. **AC Line Protection** – AC line fuse(s) provide instantaneous protection from peak loads and fault currents.
5. **Motor Contactor** – A two-pole DC magnetic contactor provides positive disconnection of the motor armature from the rectified power source. Action of the contactor is sequenced with the SCR regulator to ensure that the power circuit is “phased-off” before the contactor is opened. This ensures that only “dry switching” occurs for improved contactor longevity.
6. **Control Transformer** – A 24-volt secondary transformer isolates all magnetic control and logic from the AC power source for operator protection.
7. **Counter EMF Voltage Feedback with IR Compensation** – Adjustable for individual motor characteristics.
8. **Trigger Circuit** – Fast rise, hard firing with repetitive twenty-five (25) microseconds wide-shaped pulses at a 10 KHz rate to ensure reliable conduction and minimize di/dt degradation of the SCRs. Gate isolation is standard.
9. **Field Supply** – Transient protected, full-wave power supply.
10. **DC Loop Protection** – Fast acting, current limiting fuse provides protection from inverting faults.
11. **Undervoltage Protection** – By motor contactor.
12. **Isolated Regulator** – Internal DC circuits are isolated from the AC power circuitry for operator and equipment safety and for simplified application. The control reference input common may be grounded or connected without additional isolation to other drive units or grounded output process controllers. Isolation eliminates the common condition of line voltage to ground potentials being present on the MOTOR SPEED potentiometer.
13. **Feedback Isolation Networks** –
    (a) Current Feedback – Current transformer in the AC line.
    (b) Voltage Feedback – High impedance circuit: 115V units – two (2) megohms, 230V units – four (4) megohms.
14. **Static Reversing** – Electronic reversal of motor armature. No reversing contacts to burn, arc or wear.
15. **Static Braking** – Provides smooth regenerative braking of the DC drive motor. Braking is effective under the following conditions:
    (a) Overhauling Load – Whenever the speed of driven load attempts to exceed the speed set by the reference signal.
    (b) Speed Reference Change – Whenever the speed reference is reset to command a reduction in speed or change in the direction of motor rotation.
    (c) Stop Function – Motor will brake to minimum speed before the motor contactor opens. Stop command can originate from a pushbutton or compatible external logic.
16. **Safety Features** – Isolated regulator • Low voltage operator control • Mandatory restart after power interruption • High interrupting capacity AC line fuses • Two-pole armature contactor.
17. **General Features** – Rugged construction • Lightweight • Compact Dimensions • No heavy center-tap transformers or DC inductors required.
18. **Two Button Stop** – Normal STOP initiates Static Braking, EMERGENCY STOP provides Dynamic Braking.
19. **Sync Shift** – Ensures that regenerated energy from motor CEMF is properly synchronized with the AC line. In the regenerative mode, this unique circuit automatically shifts the SCR firing angle ±30°, regardless of other control commands to precisely transfer energy back to the power source. This provides smooth, controllable regenerative braking, minimum dead band, and super fast response.
20. **Dynamic Braking –** Provides exponential rate braking of the DC Motor Armature. Dynamic Braking is standard in the EMERGENCY STOP mode. The Dynamic Braking resistor is selected to provide initial braking torques as listed.

Component		Ratings									
Rated Horsepower (HP)		1/6	1/4	1/3	1/2	3/4	1	1-1/2	2	3	5
Rated Kilowatts (KW)		0.124	0.187	0.249	0.373	0.560	0.746	1.120	1.492	2.238	3.730
Braking Torque (%)	115V Unit	300	215	170	110	75	60	—	—	—	—
	230V Unit	—	—	—	—	—	220	145	105	85	96
Stops Per Minute	115V Unit	9	6	5	5	4	4	—	—	—	—
	230V Unit	—	—	—	—	—	4	3	3	2	2

Single-Phase Adjustable Speed Regenerative DC Motor Controllers

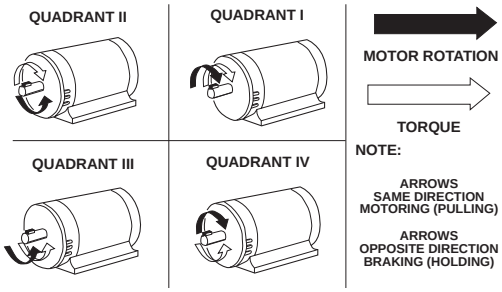
VEL/VEH-RG Series
1/6-5 Horsepower

PRINCIPLES OF OPERATION

Regenerative adjustable speed drives, also known as four-quadrant drives, are capable of controlling not only the speed and direction of motor rotation, but also the direction of motor torque. This is illustrated by the figure below.

The term regenerative describes the ability of the drive under braking conditions or overhauling loads (torque is in the opposite direction of speed) to convert the mechanical energy of the motor and connected load into electrical energy which is returned (or regenerated) to the AC power source. This is in contrast to nonregenerative drives where mechanical energy is dissipated as heat through the use of a dynamic braking resistor.

When the drive is operating in Quadrants I and III, both motor rotation and torque are in the same direction and it functions as a conventional nonregenerative unit. The unique characteristics of a regenerative drive are apparent in Quadrants II and IV. In these quadrants, the motor torque opposes the direction of motor rotation which provides a controlled braking or retarding force. A high performance regenerative drive, such as the VEL/VEH-RG, is able to switch rapidly from motoring to braking modes while simultaneously controlling the direction of motor rotation.



RATINGS

1. **Horsepower Range** .....1/6-5 HP
2. **Power Source** .....115 or 230V, single-phase, 50 or 60 Hz
3. **115V Unit Output (1/6-1 HP–VEL-RG)**
   (a) Armature .....0-90 VDC
   (b) Field .....100 VDC
4. **230V Unit Output (1-5 HP–VEH-RG)**
   (a) Armature .....0-180 VDC
   (b) Field .....200 VDC
5. **Service Factor** 1.0
6. **Duty** .....Continuous
7. **Overload Capacity** (Armature circuit)..150% for 1 minute
8. **Reference Power Supply** .....±10VDC
9. **Run Speed Potentiometer** .....10K ohms, 1/2 W

ADJUSTMENTS

1. **Current Limit** .....50-150% full-load torque (Common forward and reverse circuits)
2. **Maximum Speed** .....60-100% of motor base speed (Common forward and reverse circuits)
3. **IR (load) Compensation** .....0-100% of rated load
4. **Gain (motor stability, factory set)** .....Adjustable for individual motor characteristics.
5. **Phase Shift (factory set)** .....Adjustable for individual motor characteristics.

PERFORMANCE CHARACTERISTICS

1. **Controlled Speed Range** – Zero to motor base speed. Speed Range with respect to specified regulation is listed in Table below. For continuous duty application limitations of DC motors, see Section I.
2. **Speed Regulation** – Regulation percentages listed are of motor base speed under steady-state conditions. Normal operation will result in performance equal to or better than specified.

SPEED REGULATION CHARACTERISTICS

Regulation Method	Variable				
	Load Change 95%	Line Voltage ±10%	Field Heating Cold/ Normal	Temp. ±10°C	Speed Range
Standard Voltage Feedback with IR Compensation	2%	±1%	5-12%	±2%	50:1
Optional Speed (Tach) Feedback	0.5%	±1%	0.2%	±2%	200:1

3. **Efficiency** (rated speed, rated load)
   (a) Controller SCR regulator 99%
   (b) Complete drive with motor (typical) 85%
4. **Acceleration Control** (standard) .....By current limit
   Linear acceleration is optional
5. **Controller Bandwidth (responsiveness)** .....25 Hz (60 Hz line)
   21 Hz (50 Hz line)
6. **Current Ripple Frequency** .....120 Hz (60 Hz line)
   100 Hz (50 Hz line)

OPERATING CONDITIONS

1. **Line Voltage Variation** ..... ±10% of rated
2. **Line Frequency Variation** ..... ±2 Hz
3. **Ambient Temperature**(1) ..... 0°C to 40°C (32°F to 104°F)
4. **Altitude** (standard) .....3300 feet (1000 meters) maximum

(1) Chassis Models are designed for panel mounting where the internal temperature of the enclosure does not exceed 55°C (131°F).

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MODEL TYPES

VEL/VEH-RG controllers are offered in two (2) basic model types:

1. **VEL/VEH-RG-CM** – Basic unenclosed, chassis-mount controller offered in ratings 1/6 through 5 HP. The unit is a complete, self-contained, functional package which includes power conversion and regulator electronics, AC line and DC loop transient protection and a motor contactor. These models are ideal for the OEM or panel builder who may want to build his own custom system by integrating special logic or auxiliary control devices with the controller.
2. **VEL/VEH-RG** – Packaged controller furnished in a rugged die-cast aluminum NEMA Type 12 enclosure. This configuration is offered in ratings 1/6 through 5 HP and shares common circuitry and basic features of the chassis models.

ORDER BY CATALOG NUMBER OR ITEM CODE

Horsepower Range		Catalog Number	Item Code	Function
115 VAC	230 VAC			
BASIC CHASSIS CONTROLLERS WITHOUT OPERATOR CONTROLS*				
1/6	—	VELRG16-CM	66835	Armature Contactor Run/Stop (Rev By Speed Pot)
1/4	—	VELRG25-CM	66888	Armature Contactor Run/Stop (Rev By Speed Pot)
1/3	—	VELRG33-CM	66890	Armature Contactor Run/Stop (Rev By Speed Pot)
1/2	—	VELRG50-CM	66909	Armature Contactor Run/Stop (Rev By Speed Pot)
3/4	—	VELRG75-CM	66911	Armature Contactor Run/Stop (Rev By Speed Pot)
1	—	VELRG100-CM	66913	Armature Contactor Run/Stop (Rev By Speed Pot)
—	1	VEHRG100-CM	66914	Armature Contactor Run/Stop (Rev By Speed Pot)
—	1-1/2	VEHRG150-CM	66916	Armature Contactor Run/Stop (Rev By Speed Pot)
—	2	VEHRG200-CM	66917	Armature Contactor Run/Stop (Rev By Speed Pot)
—	3	VEHRG300-CM	66918	Armature Contactor Run/Stop (Rev By Speed Pot)
—	5	VEHRG500-CM	66919	Armature Contactor Run/Stop (Rev By Speed Pot)
NEMA 12 ENCLOSED CONTROLLERS WITHOUT OPERATOR CONTROLS*				
1/6	—	VELRG16	66809	Armature Contactor Run/Stop (Rev By Speed Pot)
1/4	—	VELRG25	66811	Armature Contactor Run/Stop (Rev By Speed Pot)
1/3	—	VELRG33	66814	Armature Contactor Run/Stop (Rev By Speed Pot)
1/2	—	VELRG50	66815	Armature Contactor Run/Stop (Rev By Speed Pot)
3/4	—	VELRG75	66816	Armature Contactor Run/Stop (Rev By Speed Pot)
1	—	VELRG100	66817	Armature Contactor Run/Stop (Rev By Speed Pot)
—	1	VEHRG100	66819	Armature Contactor Run/Stop (Rev By Speed Pot)
—	1-1/2	VEHRG150	66822	Armature Contactor Run/Stop (Rev By Speed Pot)
—	2	VEHRG200	66824	Armature Contactor Run/Stop (Rev By Speed Pot)
—	3	VEHRG300	*	Armature Contactor Run/Stop (Rev By Speed Pot)
—	5	VEHRG500	*	Armature Contactor Run/Stop (Rev By Speed Pot)

*Remote control stations are shown on pages 109 and 110.

Single-Phase Adjustable Speed Regenerative DC Motor Controllers

VEL/VEH-RG Series
1/6-5 Horsepower

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TYPICAL APPLICATION DATA											
Component			Ratings									
Rated Horsepower (HP)			1/6	1/4	1/3	1/2	3/4	1	1-1/2	2	3	5
Rated Kilowatts (kW)			0.124	0.187	0.249	0.373	0.560	0.746	1.120	1.492	2.238	3.730
1-Phase AC Input (Full-Load)	Line Amps	115V Unit	3.9	5.0	6.0	8.7	12.4	15.8	—	—	—	—
		230V Unit	—	—	—	—	—	8.8	12.6	17.0	22.0	35.0
	KVA		.48	.58	.71	1.0	1.4	2.0	3.0	4.0	5.0	8.0
DC Output (Full-Load)	Motor Armature Amps	90V	2.0	2.8	3.5	5.4	8.1	10.5	—	—	—	—
		180V	—	—	—	—	—	5.5	8.2	11.6	15.1	24.0
	Motor Field Amps Max(1)	100V	1.0	1.0	1.0	1.0	1.0	1.0	—	—	—	—
		200V	—	—	—	—	—	1.0	1.0	1.0	1.0	1.0
Full-Load Torque (lb-ft) with 1750 RPM Base Speed Motors			0.5	0.75	1.0	1.5	2.2	3.0	4.5	6.0	9.0	15.0

(1) Does not apply to Permanent Magnet Motors.

ORDER BY CATALOG NUMBER OR ITEM CODE

REMOTE OPERATOR CONTROL STATIONS VEL/H-RG					
Use With Catalog Number	Item Code	Control Elements			Controller Models
		Pushbuttons	Switches	Pots	
RCS30-RG	66953	Run, Stop, Emer. Stop	—	Motor Speed 100 – 0 – 100	ALL
RCS31-RG	66954	Run, Stop, Emer. Stop	Run/Jog	Motor Speed 100 – 0 – 100	ALL
RCS32-RG	66955	Run, Stop, Emer. Stop	Fwd/Rev	Motor Speed 0 – 100	ALL

Remote Operator Station dimensions shown on page 110.

OPTIONS

Options and modifications are listed alphabetically within each group. Option numbers have been retained for the sake of continuity with previous control systems. Complete option descriptions are listed alpha/numerically in the DC option section.

To order assembled (installed) options, add the option number or letter as a suffix to the controller catalog number, e.g. VELRG50-17-24, etc., To order a kit for field installation, order by item code.

Group	Option	No.	Kit Item Code	Notes
Input (Plug-In)	Acceleration/Deceleration, Bidirectional Linear	17	66925	(1)
	Acceleration/Deceleration, "S" Curve	17S	66926	(1)
	Follower, DC Tachometer Generator	22	66930	(1)
	Follower, Process Instrument Controller	25	66935	(1)
	Follower, MIRC	35	—	
Feedback (Plug-In)	Feedback, Tachometer DC	24	66932	(1)
Input and Feedback (Plug-In)	Torque Taper	18	50448	(1, 2)
	Torque (Current) Limit Control	18B	—	(1, 2)
Interface	Input/Feedback Interface Board	IFA	—	(4)
	Input/Feedback Adapter (1-position)	IF1	—	(4)
	Input/Feedback Adapter (2-position)	IF2	—	(4)
External	Jog, Toggle Switch Selection	9A	60166	
	Motor Speed Potentiometer, One Turn	21		
	Motor Speed Potentiometer, Ten Turn (Analog)	21A	66929	(3)
	Follower/Manual Mode Selector Switch	38	67488	

NOTES:

(1) Only one (1) plug-in option per group is possible unless IFA option is selected.
(2) Can not be combined with options from other groups.
(3) Unidirectional operation only.
(4) Chassis controllers only.
A large number of options, or certain combinations of options may require a larger enclosure or an additional enclosure.

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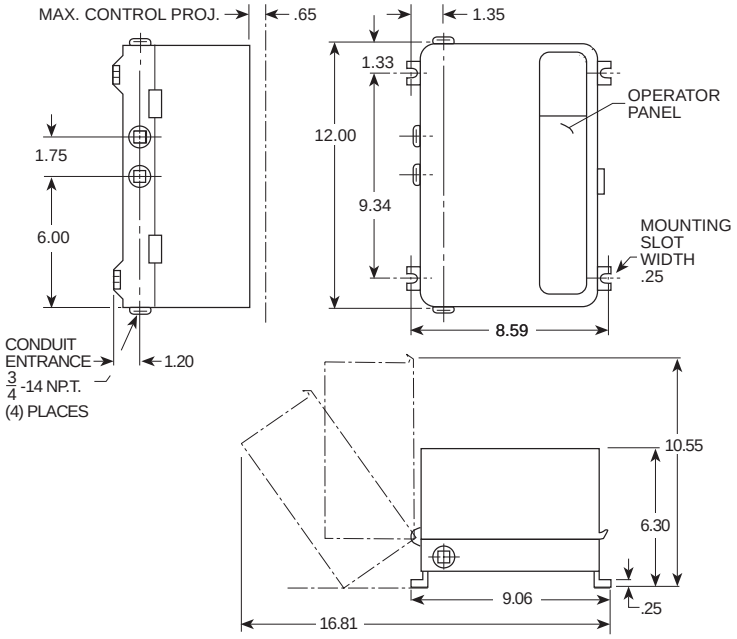
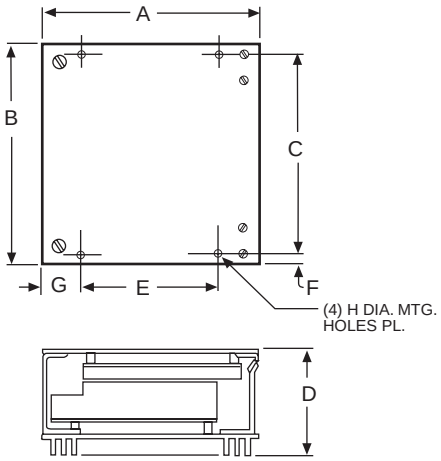
DIMENSIONS

VEL/VEH-RG – Enclosed Controller



Approximate Weight: 12 Lbs.

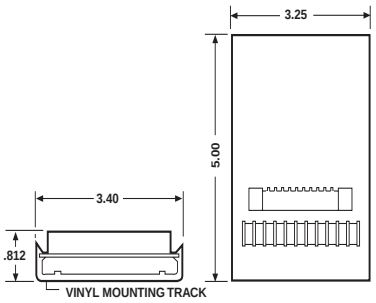
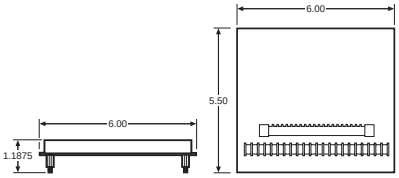
VEL/VEH-RG-CM-Chassis Controller



Model	HP	Mounting Dimensions								Controller Weight (lbs)
		A	B	C	D	E	F	G	Hole Dia.	
VEL/H-RG 16-200 CM	1/6-2	9.88	13.00	12.25	6.56	5.00	.38	2.44	.188	12.5
VEH-RG 300-500 CM	3-5	12.75	13.00	12.00	6.25	11.38	.50	.44	.281	17.0

All Dimensions in Inches

Options and Modifications for DC Controllers

Option No.	Description	For Use with Series
CL	**MAGNETIC CONTROL INTERFACE (115V)** The standard magnetic control run logic excitation is 24 VDC, obtained from a self-contained power supply in the VEplus controllers. This option provides a means of interfacing a controller with pushbuttons or external logic powered by a 115 or 230 VAC excitation source. The interface circuit includes three control relays with 115 VAC coils for use in both unidirectional and reversing applications.	VEplus
IAB	**INTERFACE, SIGNAL OPTIONS** Series VEplus units incorporate as standard many of the functions that were formerly offered as extra cost options on the products they replace. However, some special applications may still require the use of signal options. Option IAB enables the use of these options by providing a power supply, mounting area and an electrical connector to interface and mate with these options. This option mounts within the VEplus chassis. Space limitations prevent mounting this option within the BETA units and therefore it may be mounted externally with brackets provided in a kit.	BETA II BETAplus VEplus
IFA	**FEEDBACK/INPUT ADAPTER, INTERFACE BOARD** Signal input or feedback circuit boards plug directly into the control board of the controller. Some applications require multiple operating modes with the ability to selectively track two (2) or more external reference signals, i.e., a tachometer signal or an external DC signal. This option provides an extender circuit board with a terminal strip which replaces the standard input or feedback board. This brings the internal regulator circuits of the control board to screw terminal connection points. The input or feedback boards are mounted externally from the controller and wired through selection logic to the external input or feedback interface terminal board.	VELRG VEHRG
IF1	**FEEDBACK/INPUT ADAPTER, 1-POSITION** Provides an assembly capable of accepting either a standard input option board or a feedback option board. *Option IF1 consists of a vinyl mounting track with P.C. socket and terminal board.* 	VELRG VEHRG
IF2	**FEEDBACK/INPUT ADAPTER, 2-POSITION** Provides an assembly capable of accepting feedback and input boards or a double width board containing both the feedback and input function (i.e., Option 36A). *Option IF2 consists of a base with P.C. socket and terminal board.* 	VELRG VEHRG
LS	**LINE STARTING** A modification which will defeat the internal “anti-restart” feature of the controller. An external AC line contactor may then be used to start and stop the controller.	BETA II BETAplus VEplus
MK	**OPTION CARD GUIDE KIT** This option is required when mounting the option cards in the enclosure or if the option cards are mounted external.	VEA-RG

Options and Modifications for DC Controllers

R — ARMATURE CONTACTOR, REVERSING AND/OR DYNAMIC BRAKING

For Use with Series: VED

This option is required whenever unidirectional or bidirectional operation with or without dynamic braking is required. Included are double-pole armature reversing contactors and a DB resistor for rapid deceleration. The direction of motor rotation is controlled by a FWD-REV membrane push switches in the membrane operator control panel or a Fwd-Rev toggleswitch and Run pushbutton in the pushbutton operator control panel.

Reversing includes software configured antiplug protection. The drive must be stopped by the Stop pushbutton before a reverse command may be given. Drive motor is then restarted in the new direction of rotation by pushing the Run push switch.

Rated Horsepower (1750 RPM)										
		Ratings								
Component	Line Volt	1/6	1/4	1/3	1/2	3/4	1	1-1/2	2	3
Braking Torque (%)	115V Unit	300	215	170	110	75	60	—	—	—
	230V Unit	—	—	670	460	320	220	145	105	85
Stops per Minute	115V Unit	9	6	5	5	4	4	4	4	—
	230V Unit	—	—	—	5	4	4	3	3	2

Dynamic Braking provides exponential rate braking of the DC motor armature. Braking is initiated by disconnecting the armature from the rectified power source and reconnecting it to a DB resistor. This is accomplished by normally-closed contacts which are mechanically interlocked with the normal run contacts. The DC motor, thus connected, functions as a generator with the kinetic energy of the armature and machine load dissipated as heat by the resistor. The resistor is selected to provide initial braking torques as listed in the Table.

Included is software configured antiplug logic to prevent restarting the controller until the braking cycle is complete, preventing a potentially damaging electrical surge a mechanical stress.

The DB resistor is rated for stopping a typical load, a maximum number of stops per minute from top speed as shown in the table. A typical load is defined as:

1. Not exceeding rated-load torque
2. External load inertia (beyond the motor shaft) not exceeding that of the motor armature.

High inertia loads may extend braking times beyond the wattage rating of the DB resistor. Dynamic braking is not a holding brake; it will not prevent a motor at rest from rotating.

Option R consists of a circuit board containing two double pole armature contactors and a separate dynamic braking resistor. This option is a standard factory installed feature of all models with an "R" suffix in the model number, or it may be easily installed in the field.

RI — LIMIT SWITCH REVERSING

For Use with Series: VEA-RG, RBA-RG

This option board allows interfacing the controller with a variety of external devices, such as limit switches, push buttons and potentiometers. There are two (2) speed potentiometers on this board, one (1) for forward speed and one (1) for reverse speed. These internal potentiometers can be switched out if external potentiometers are required. In addition, this board will allow a controlled stop feature with an adjustable speed dropout.

RSW — REVERSING SWITCH

For Use with Series: VED

Option includes a forward/reverse toggle switch for use with a pushbutton operator station.

SK — SPACER KIT FOR 3 HP RBA-RG ENCLOSED CONTROLLER

For Use with Series: RBA-RG

This spacer kit is required for mounting controllers when they are to be used for their maximum 3 HP rating.

SKO — OPTION MOUNTING KIT

For Use with Series: RBA-RG

This kit contains standoffs for mounting an optional contactor or option board onto an Angle Bracket chassis.

6A — REMOTE CONTROL KIT, MEMBRANE

For Use with Series: VED

Remote control kit includes Remote Box, two (2) Buffer Amplifiers, and Blank Panel to remote the Membrane Panel included with the controllers.

9A — JOG, TOGGLE SWITCH SELECTION

For Use with Series: VED

Option includes a RUN-JOG selector switch and a JOG SPEED potentiometer for installation in the operator control panel.

The RUN-JOG toggle switch (maintained) contacts in the operator station open the contactor seal-in circuit. Controller then jogs when the RUN pushbutton is pressed and held at the JOG SPEED potentiometer setting.

Jog action is momentary, causing motor rotation only when the RUN pushbutton is depressed. This option is also suitable for reversing units where identical forward and reverse jog speeds are acceptable.

Options and Modifications for DC Controllers

Option No.	Description	For Use with Series
12A	**AUXILIARY CONTACTS** Provides two (2) form C relays with one normally-open and one (1) normally-closed contact rated 1 amp, 120 VAC or 28 VDC. One relay is energized with a Forward Run command and the other relay is energized with the Reverse contactor (reversing controllers only) or it can be reprogrammed so both relays pick up on either a Forward or Reverse command. Contacts may be used to signal external circuits. *Option 12A consists of a circuit board which mounts in the chassis and a ribbon cable which connects to the logic board.*	VED
12B	**PROGRAMMABLE AUXILIARY OUTPUT CONTACTS** This versatile option provides two (2) Form C relays each with one normally open and one normally closed contact rated 1 amp, 120 VAC or 28 VDC. The relays may be programmed to individually energize whenever: 1. A preset motor speed is attained, adjustable 0–100% of motor base speed. – or – 2. A preset torque (current) level is attained, adjustable 0 – 150% of rated current. Hysteresis is adjustable to establish pick-up and drop-out points. Terminals are provided for connection of the output contacts to external indicating and control devices. Each Option 12B will provide a choice of either motor current or motor speed sensing. Multiple Option 12B circuits will be required whenever both current and speed sensing are desired or whenever additional output contacts/set points are necessary. *Option 12B consists of a small circuit board which mounts in the chassis base and communicates with the controller*	VED
14	**FOLLOWER, EXTERNAL AC/DC SIGNAL** Provides necessary matching, isolation, signal conversion and filtering as required to adjust the speed of the drive (or drives) from an external signal source. Option 14 permits full range speed control from an external 0 to 115 VAC (or 0-105VDC) adjustable signal source manually controlled by a potentiometer, variable autotransformer (AC only) or some other suitable means. **This option is required for each controller which is to be controlled by the external AC signal.** When using this option the normal drive run speed setting device functions as a ratio setting when following the external signal. The maximum ratio is 150%. This option is useful for multiple section machines where a definite speed relationship must be maintained between sections, while the entire machine is varied over a specified speed range by a common manual speed control device. This option consists of a small plug-in circuit board which mounts in the chassis base and communicates with the controller via Finbus. This option does not include the external AC signal source,	VED
14	**MASTER OVERRIDE (FOLLOWER, EXTERNAL AC SIGNAL)** Provides necessary impedance matching, isolation, signal conversion and filtering as required to adjust the speed of the drive (or drives) from an external AC signal source. Option 14 permits full range speed control from an external 0 to 115 VAC adjustable signal source manually controlled by a potentiometer, variable autotransformer or some other suitable means. This option is required for each controller which is to be controlled by the external AC signal. Included in this option are minimum and maximum speed adjustments, with the normal drive run speed potentiometer functioning as a ratio setting when following the external AC signal. This option is useful for multiple section machines where a definite speed relationship must be maintained between sections, while the entire machine is varied over a specified speed range by a common manual speed control device. This option consists of a small plug-in circuit board which inserts into the input connector of the control board. *The option does not include the external AC signal source.* Master Override Station Cat. No. 62317 provides the required master signal and also includes master run-stop pushbuttons. (Option 14A) If the controls are to be started with individual pushbutton stations, Master Station Cat. No. 62311 may be used to provide master speed control only. (Option 14B)	VEplus
15	**PROGRAMMABLE PRESET SPEED/TORQUE PROGRAM CONTROL** This option offers exceptional application flexibility whenever it is necessary to select a combined total of up to five preset motor speeds, and/or preset motor armature current (torque) reference levels in either Forward or Reverse (with Option R) directions of rotation. Included are four independent circuits, each of which is programmable by individual DIP switches for selecting a choice of one of the functions listed: 1. Forward-Run Speed or Current 2. Reverse-Run Speed or Current 3. Forward-Jog Speed or Current 4. Reverse-Jog Speed or Current Four integral reference adjustment potentiometers permit setting the motor speed from zero to base speed, an zero to 150% current. If none of the four preset circuits are selected, control reverts to a default circuit which can provide a fifth programmable potentiometer adjustable speed or current. When desired, external potentiometers may be used to establish the operating preset reference levels. The programmed speed or current settings may be selected by external pushbuttons, relay contacts, programmable control, etc., operating from the internal 24VDC source or an external source of this level. Multiple Option 15 circuits may be used when greater than five (5) preset references are desired. *This option consists of a small printed circuit board which inserts into the chassis base and communicates with the controller.*	VED

Option No.	Description	For Use with Series
17	**ACCELERATION/DECELERATION BIDIRECTIONAL LINEAR (adjustable 1-9 sec)** Permits potentiometer adjustments of a desired time span to attain maximum speed from zero speed. The preset rate is effective any time there is a speed change command, not just from startup. Circuit includes four (4) totally independent 1 to 9 second adjustable timing circuits on a plug-in circuit board as follows: 1. FWD ACCEL 2. FWD DECEL 3. REV ACCEL 4. REV DECEL	VELRG VEHRG
17	**FOUR-QUADRANT ACCELERATION/DECELERATION** This option board has four (4) adjustment potentiometers consisting of a forward acceleration potentiometer, a forward deceleration potentiometer, a reverse acceleration potentiometer and a reverse deceleration potentiometer. The potentiometers have an adjustment range of .3 to 30 seconds. Also, the board has a bypass mode to disable the four (4) potentiometers on the option board and switch to the two (2) potentiometers (acceleration and deceleration) on the control board. This option board mounts on the control board and does not take up the option slot in the casting base.	VEA-RG RBA-RG
17S	**ACCELERATION/DECELERATION "S" CURVE** Provides a smooth take-off and soft final approach to minimize any overshoot. The acceleration profile approximates that of an "S" curve. The time span from 0 to base speed is adjustable from 1 to 9 seconds. This option provides one (1) potentiometer to adjust the time rate and two (2) potentiometers to adjust the "S" curve.	VELRG VEHRG
18	**TORQUE TAPER** Center driven winders ideally require a reciprocal speed torque relationship (constant horsepower) to maintain constant tension throughout the range of material build-up. Acceptable performance can be economically achieved for many applications with an inverse-linear speed-torque relationship provided by this option. Tension control accuracy of approximately 20% can normally be maintained from empty to full roll over a 2:1 build ratio at a fixed production machine speed. **Use caution in the selection of motors for center driven windup applications where torque loads increase in inverse proportion to motor speed. Web break or other process material detectors are recommended to prevent a dangerous overspeed should the process material break.** Option 18 normally provides acceptable performance in applications where the material being wound travels at a constant speed during winder roll buildup. *Option 18 can also be used for constant torque applications where conventional operation of the current limit is required and remote mounting of the torque (current) potentiometer is desired. When used in this manner, the Slope adjustment is set for a vertical cut-off of motor (maximum setting) torque (current).* *This option consists of a small circuit board which mounts in the chassis base and communicates with the controller.*	VED

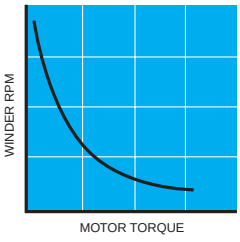


FIGURE A.
"Ideal" Constant HP curve for a winder application

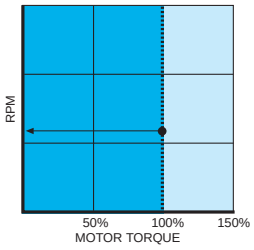


FIGURE B.
Torque Adjust with slope adjust at maximum

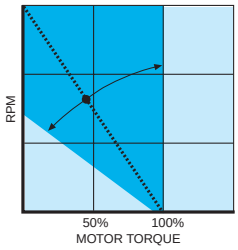
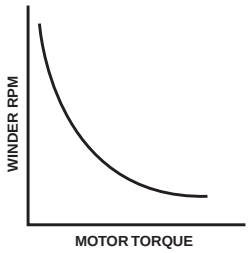
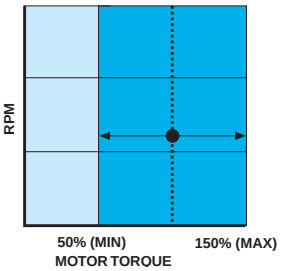
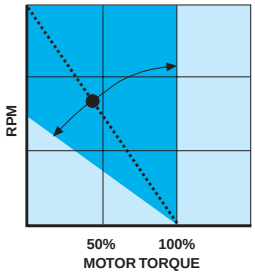


FIGURE C.
Slope Adjust with torque adjust at 100% torque setting

Options and Modifications for DC Controllers

Option No.	Description	For Use with Series
18	**TORQUE TAPER** Center-driven winders ideally require a reciprocal speed-torque relationship (constant horsepower) to maintain constant tension throughout the range of material build-up. Acceptable performance can be economically achieved for many applications with an inverse-linear speed-torque relationship provided by this option. Tension control accuracy of approximately 20% can normally be maintained from empty roll to full roll at a given production machine speed. This option consists of a plug-in circuit board which inserts into the FEEDBACK AND INPUT connector of the control circuit board and a TORQUE ADJUST potentiometer for installation in the operator control station. Independent potentiometers are provided. TORQUE ADJUST – Establishes maximum low speed torque. The TORQUE ADJUST in combination with the Taper adjustments, establishes the torque available at any point throughout the operating speed range. The TORQUE ADJUST potentiometer is mounted in the operator control station. *Option 18 can also be used for constant torque applications where conventional operation of the current limit is required and a remote mounted torque current potentiometer is desired. When used in this manner the TAPER adjustment is set for a vertical cut-off of motor torque (current.* REV/FWD TAPER – Establishes the slope or rate of linear torque increase with decreasing speed throughout the operating range. Adjustable from 0 to 100% torque at maximum motor speed with minimum effect on low speed torque. The FORWARD TAPER and REVERSE TAPER potentiometers are mounted within the controller on the option circuit board. **CAUTION – This option can only control torque in a single direction.** **Use caution in the selection of motors for center-driven windup applications where torque loads increase in inverse proportion to motor speed.** **Web break or other process material detectors are recommended to prevent a dangerous overspeed should a break in the process material occur.** *Option 18 normally provides acceptable performance in applications where the material being wound travels at a constant speed during winder roll buildup. This option can also be used to drive unwind stands.*	**VELRG** **VEHRG**
18	**TORQUE TAPER** This option consists of a plug-in circuit board. This board provides an inverse-linear speed-torque relationship when operating in the braking (regenerative) mode, and provides constant torque in the motoring mode of operation. Motoring torque and braking torque are individually adjustable as well as forward and reverse torque taper. Applications include the following: 1. Winders where the material being wound travels at a constant speed during winder roll buildup. 2. Unwinders, since this option provides relatively constant holdback tension (±20%) from full roll to empty roll.	**VEA-RG** **RBA-RG**
18A	**TORQUE TAPER** Center driven winders ideally require a reciprocal speed torque relationship (constant horsepower) to maintain constant tension throughout the range of material build-up. Acceptable performance can be economically achieved for many applications with an inverse-linear speed-torque relationship provided by this option. Tension control accuracy of approximately 20% can normally be maintained from empty to full roll at a given machine speed. *This option consists of a plug-in circuit board which replaces the FEEDBACK board in the control and a torque potentiometer for installation in the operator's panel. Independent potentiometers are provided for:* TORQUE ADJUST—Establishes maximum low speed torque. The TORQUE ADJUST in combination with the SLOPE ADJUST establishes the torque available at any point throughout the operating speed range SLOPE ADJUST–Establishes the rate of torque increase with decreasing speed, throughout the operating range. Adjustable from 0 to 100% torque at maximum motor speed with minimum effect on low speed torque. The SLOPE ADJUST potentiometer is mounted within the controller on the option circuit board. **Use caution in the selection of motors for center driven windup applications where torque loads increase in inverse proportion to motor speed. Web break or other process material detectors are recommended to prevent a dangerous overspeed should the process material break.** *Option 18A normally provides acceptable performance in applications where the material being wound travels at a constant speed during winder roll buildup. If the process is such that the speed of the material being wound varies during winder roll buildup or if more accurate tension control is desired, see Option 36A.* *This Option Kit is also used for constant torque applications where conventional operation of the current limit is required and remote mounting of the torque (current) potentiometer is desired. When used in this manner, the Slope adjustment is set for a vertical cutoff of motor (maximum setting) torque (current). See Option 18B.*	**VEplus**

Option No.	Description	For Use with Series
18A	**TORQUE TAPER *(Continued)***  ***FIGURE A.*** ***"Ideal" constant hp Curve for a winder application***  ***FIGURE B.*** ***Torque adjust with a slope adjust at maximum***  ***FIGURE C.*** ***Slope adjust with torque adjust at 100% torque setting***	VEplus
18B	**TORQUE (CURRENT) LIMIT CONTROL** Provides the ability to adjust the drive current limit setting and thus the motor torque over a range of 50-150% by a remote mounted TORQUE ADJUST potentiometer. (See Option 18A).	VEplus
18B	**FOLLOWER, CURRENT REGULATOR (LESS ADJUSTMENTS)** Provides a means of controlling motor armature current and torque by a manually adjusted potentiometer or an external 0 to 12 VDC signal. This option provides separate current reference inputs for forward and reverse torque, but operates in one (1) motor direction only. *This option is useful in applications where load sharing of two (2) or more drive units is required where one (1) unit can be designated as master. The master unit would generate a 0 to 12 VDC current reference to be used by the slave drives.*	VEL-RG VEH-RG
18C	**FOLLOWER, CURRENT REGULATOR** Provides a means of controlling motor armature current and torque by a manually adjusted potentiometer or an external DC voltage reference signal. The circuit includes internal isolation permitting direct connection to a grounded signal source. Since torque is directly controlled independent of motor speed, provision is included for limiting maximum motor speed. Multiple motor applications typically involve master speed regulated drive which establishes the speed of the system and one (1) or more current regulated follower drive units. The follower units obtain their current reference signal from the master controller. Typical applications include: a. Load sharing between two (2) or more drive units with their motors mechanically coupled. b. Load sharing between two (2) or more drive units coupled by the process material itself such as steel bar stock being pulled by multiple drive units through separately powered sections of a machine. c. Tension control of a web of process material being transferred between sections of a multiple section machine. **APPLICATION INFORMATION** **1. Current response time** Zero to full-load current.....150 Milliseconds **2. Output current control** Range .....10:1 **3. Signal input required for maximum current output** Range 1 .....3.35 to 36.5 VDC Range 2 .....0.34 to 3.7 VDC Range 3 .....0.04 to 0.44 VDC **4. Transfer linearity** Input signal to output current.....1% *This option consists of a plug-in circuit board which inserts into both input and feedback connectors of the control board. Included are separate adjustments for:* **Maximum Speed**.....0-Motor Base Speed **Maximum Current**.....0-150% of rated(1) **Input Scaling**.....Adjustable to match the input signal (0.04 to 36.5 VDC) for maximum current output. **Current offset**.....Adjustable for zero current output with minimum signal input. (1) 0-75% of rated achieved by adjustment of the unit current limit. *(Continued)*	VEplus

Options and Modifications for DC Controllers

Option No.	Description	For Use with Series
18E	**TORQUE (CURRENT) REFERENCE** A modification that will allow the controller to function as a torque regulator. This modification allows the use of an external potentiometer to set maximum motor torque (0-150% of rated).	BETA II BETAplus VEplus
21	**POTENTIOMETER, SINGLE TURN MOTOR SPEED** Provides a single turn, 2W potentiometer, knob and analog dial plate. Not intended for bidirectional operation via speed potentiometer.	ALL
21A	**POTENTIOMETER, TEN-TURN MOTOR SPEED (ANALOG)** Provides a Ten-Turn, 2W potentiometer, knob and analog dial. Not intended for bi-directional operation via speed potentiometer.	ALL
21B	**POTENTIOMETER, TEN-TURN MOTOR SPEED (DIGITAL)** Provides a Ten Turn, 1/2W Potentiometer with digital dial and knob. Not intended for bi-directional operation via speed potentiometer.	ALL
22	**FOLLOWER, DC TACHOMETER GENERATOR** Intended for single or multi-drive control systems where it is necessary for the drive(s) to follow the speed of a preceding drive unit or rotating machine coupled to a DC tachometer generator. The tach signal provides the speed reference for the "follower" drive. This option provides bidirectional operation. Option 22 includes impedance matching circuitry and a RATIO adjustment potentiometer connected across the output of the DC tachometer generator to interface with the reference input of the drive controller(s). Controllers include internal isolation permitting the reference common to be connected directly with other drive(s) without utilizing line isolation transformers. *Option 22 does not include the tachometer generator which must provide a minimum of 30 VDC at base speed and not exceed 180 VDC at maximum speed.*	VELRG VEHRG
22A	**FOLLOWER, AC OR DC TACHOMETER** Intended for automatic control systems where it is necessary for the drive to follow the speed of a preceding drive unit or rotating machine coupled to an AC single-phase or 2-phase or DC tachometer generator with either output polarity. The tachometer voltage signal provides the speed reference for the "follower" drive. Adjustments are provided to adapt the unit to a wide range of system requirements. Included are independent adjustments for: TACH SCALING – Adjustable to interface the tachometer generated voltage with the required controller reference voltage. FOLLOWER RATIO (Optional) – Adjustable to permit tracking the tachometer signal voltage at a plus or minus ratio. See Figure A. The FOLLOWER RATIO potentiometer is mounted in the operator control panel. OFFSET – Adjustable to permit tracking the tachometer signal at a fixed (+ or –) offset. The offset potentiometer is mounted on the option circuit board. See Figure B. MINIMUM SPEED (Override) – Adjustable by an optional potentiometer which is used to establish a minimum drive speed independent of tachometer signal voltage. The MOTOR SPEED control may also be used as a manual speed setting control when no tachometer signal is present. See Figure C. A MANUAL/FOLLOWER selector switch input is provided in order to select the membrane operator panel when in manual mode. VED Series controllers include internal isolation permitting the reference common to be directly connected with other drive(s) without utilizing line isolation transformers. *This option requires a tachometer generator which provides 7 to 150V, AC or DC, at motor maximum and/or base speed. This option does not include the tachometer generator.*	VED

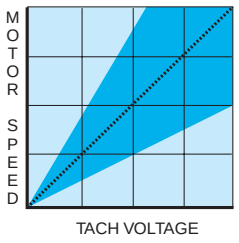


FIGURE A. TACH SCALING AND FOLLOWER RATIO

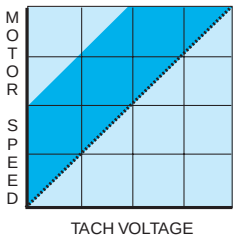


FIGURE B. MINIMUM SPEED ADDITIVE

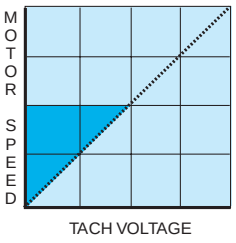
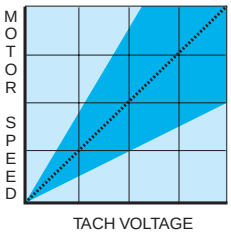
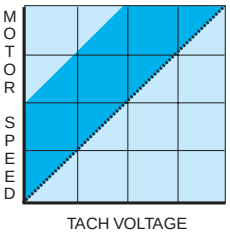
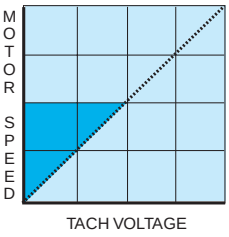


FIGURE C. MINIMUM SPEED OVERRIDE

Option No.	Description	For Use with Series
22A	**FOLLOWER, AC OR DC TACHOMETER GENERATOR** Intended for automatic control systems where it is necessary for the drive to follow the speed of a preceding drive unit or rotating machine coupled to an AC or DC tachometer generator. The tachometer voltage signal provides the speed reference for the "follower" drive. Option 22A is not recommended for use where multiple drive controllers are required to operate from a common signal source, unless the controllers are isolated. A more economical approach if the controllers are not isolated would be the use of the MIRC master isolated reference controller which is intended for use with multiple drive controllers. See Option 35. Adjustments are provided to adapt the unit to a wide range of system requirements. Included are independent adjustments for: TACH SCALING – Adjustable to interface the tachometer generated voltage with the required controller reference voltage when the FOLLOWER RATIO potentiometer is set on maximum. If a plus ratio is required (i.e.: the follower drive is at full speed when the master drive is at half speed) set the FOLLOWER RATIO potentiometer at its midpoint and adjust TACH SCALING for the required controller reference voltage and then adjust the FOLLOWER RATIO potentiometer toward 100. FOLLOWER RATIO – Adjustable to permit tracking the tachometer signal voltage at a plus or minus ratio. The FOLLOWER RATIO potentiometer is mounted in the operator control panel. MINIMUM SPEED (Additive)–Adjustable to permit tracking the tachometer signal at a fixed offset voltage. MINIMUM SPEED ADDITIVE potentiometer is mounted on the Option 22A circuit board. MINIMUM SPEED (Override)–Adjustable by the MOTOR SPEED potentiometer to establish a minimum drive speed independent of tachometer signal voltage. The MOTOR SPEED potentiometer is also used as a manual speed setting control when no tachometer signal is present. The MOTOR SPEED potentiometer is mounted in the operator control station. A MANUAL/FOLLOWER selector switch is therefore unnecessary for most applications and is not included with this option. See Option 38 when a switch is desired. The MOTOR SPEED potentiometer is mounted in the operator control station. *Option 22A consists of a small plug-in circuit board which inserts into the input connector of the Control Circuit Board and a FOLLOWER RATIO potentiometer for separate mounting.* *This option does not include the tachometer generator which must provide 30 volts at base speed and not to exceed 180 volts at maximum speed.*  **FIGURE A. TACH SCALING AND FOLLOWER RATIO**  **FIGURE B. MINIMUM SPEED ADDITIVE**  **FIGURE C. MINIMUM SPEED OVERRIDE**	VEplus
22B	**FOLLOWER, DIGITAL PULSE GENERATOR** This option provides signal conditioning and isolation for accepting a signal from a magnetic pulse pick-up mechanically coupled to a preceding drive motor, rotating machinery or various static pulse generators permitting the drive to follow at an adjustable ratio. *This option consists of:* *a. Digital to analog conversion circuit board which inserts into the INPUT connector of the control circuit board.* *b. A signal conditioning circuit board which is mounted in the base of the controller or remotely mounted.* *c. MANUAL/FOLLOWER selector switch for separate mounting.* *d. Interconnection wire harness.* Two (2) modes of operation are provided: Manual and Follower, as selected by the MANUAL/FOLLOWER switch. In the Manual mode, the MOTOR SPEED potentiometer controls motor speed. In the Follower mode, the motor follows the digital pulse signal, and the MOTOR SPEED potentiometer functions as the follower ratio adjust potentiometer. The signal conditioner circuit board accepts the output of any one of the following devices: 1. Magnetic pulse pick-up capable of providing 450 pulses/second at motor base speed and not exceeding a maximum of 2500 pulses/second at motor base speed. Recommended input: 100 tooth gear on a 1150 RPM motor. 60 tooth gear on a 1750 RPM motor. 30 tooth gear on a 2400 RPM motor. 2. Pulse generator (TTL) with a 0 to +5V output, capable of providing a minimum of 450 pulses/second at motor base speed and not exceeding a maximum of 2500 pulses/second at motor base speed. 3. Pulse generator with an open collector output, capable of conducting 2 milliamperes at 24 VDC. *This option does not include the magnetic pick-up assembly, pulse gear or other signal source, or the motor speed potentiometer.*	VEplus

Options and Modifications for DC Controllers

Option No.	Description	For Use with Series
22D	**DIGITAL PULSE FOLLOWER** This option provides signal conditioning for accepting a signal from a magnetic pulse pick-up mechanically coupled to a preceding drive motor, rotating machinery or various static pulse generators permitting the drive to follow at an adjustable ratio. Two modes of operation are provided: Manual and Follower, as selected by the MANUAL/FOLLOWER switch. In the Manual mode, the Membrane Panel 1 MOTOR SPEED Faster-Slower switches control motor speed. In the Follower mode, the motor follows the digital pulse signal, and the optional MOTOR SPEED potentiometer functions as the follower ratio adjust potentiometer. The signal conditioner circuit board accepts the output of any one (1) of the following devices: Magnetic pulse pick-up capable of providing 1000-2500 pulses/second at motor base speed. A 60 tooth gear on a 1750 RPM motor generates 1750 PPS. *This option consists of a small printed circuit board which mounts in the base chassis and communicates with the controller. This option does not include the magnetic pulse pick-up or other signal source.*	VED
22L	**SERIAL LINK (COMPUTER CONTROL)** Option provides the capability of two way communication and direct control by computer via an RS422 link. This bypasses all on board potentiometer adjustments and permits computer control of all operating parameters: Speed, Torque, Direction of Rotation, Current Limit, Acceleration/Deceleration Rate, Run-Stop-Jog-Reversing commands, Min-Max speeds while permitting remote interrogation by the computer of these and other operational data such as the First Fault Annunciator described in Option 44. Provision is included for manual operator safety stop circuit bypassing the computer and a watch-dog circuit which will automatically stop the drive in the event of failure of the micro-processor or communication link. The serial link is expandable for the individual or simultaneous control of up to thirty-two (32) drive units in a system. *The option consists of a small printed circuit board which mounts in the chassis base and communicates with the controller. This option must be used in conjunction with Option 52, Power Supply, Auxiliary. Host computer software to suit individual system requirements is not included with this option.*	VED
22M	**PARALLEL (BCD) MULTIPLEXER** This option provides means of connecting up to three (3) BCD thumbwheel switches to the same parallel (BCD) digital input Option 22P with which it must be used. It is the digital equivalent of the programmable speed/torque control Option 15. Ordinarily when Option 22P is used, e.g. as a speed reference, only one BCD switch assembly may be connected. This is very inconvenient when multiple speeds such as jog, reverse, or preset speed settings are required. Each of the three (3) BCD inputs is selected by an external enable and a switch settable operating mode. The operating modes are: forward, reverse, forward jog, and reverse jog. More than one (1) operating mode may be assigned to one (1) BCD switch assembly. For example: Forward jog and reverse jog may be set by a common BCD switch assembly. *Option consists of a small printed circuit board which mounts within the controller base and communicates with Option 22P BCD input, and other options.*	VED
22P	**PARALLEL (BCD) DIGITAL INPUT** Allows precise selection of motor speed, motor armature current (torque) or other adjustable operating parameters by a 4 digit BCD thumbwheel switch or other external, parallel digital reference. Since this option is totally digital it provides a higher degree of accuracy than that available with analog inputs, and accuracy is now limited only by the quality of feedback. Motor speed may be selected 0-100% and current 0-150% by tenths. Other switch selectable parameters include individual parameters such as Current Limit, Current Reference, IR compensation, Ratio and parameter pairs such as min/max speed and accel/decel. An optional “Data Enter” feature may be implemented with a N.O. pushbutton so thumbwheel changes are not read until the pushbutton is depressed. Inputs are buffered for reliable operation in industrial environments. One (1) option 22P and one (1) thumbwheel switch is required for each individual parameter to be selected. However, parameter pairs such as min/max speed and accel/decel require two (2) thumbwheels for each Option 22P. See also Option 22M Parallel (BCD) Multiplexer where multiple presets (BCD switches) may be selected for the same parameter. *Option consists of a small printed circuit board which mounts within the chassis base and communicates with the controller. Option does not include the thumbwheel switch(s) enter pushbutton, or other digital reference.*	VED
24	**FEEDBACK. DC TACHOMETER** Provides impedance matching and terminals for accepting a signal from a DC tachometer generator which is directly coupled to the motor armature. This option replaces the standard Counter EMF feedback mode in the controller and improves speed regulation with respect to changes in load, line voltage variations, ambient temperatures and motor field heating as well as other operating variables. The tachometer generator must provide 30 to 180 VDC at maximum speed. The tachometer generator is not included as part of this option.	VELRG VEHRG

Options and Modifications for DC Controllers

Option No.	Description	For Use with Series
24	**TACHOMETER FEEDBACK** An internal modification which provides impedance matching from a DC tachometer generator which is directly coupled to the motor armature. This option improves speed regulation with respect to changes in load, line voltage, ambient temperature and motor field heating. The tachometer generator must be capable of providing 5 to 120 VDC/1000 RPM. The tachometer generator is not part of this option.	**BETA II** **BETAplus** **VEplus**
24A	**FEEDBACK TACHOMETER AC OR DC** VED units include as standard the capability to accept a signal from a feedback tachometer if it is; (a) a unidirectional application and/or (b) the tachometer signal is DC. All other applications will require this option which provides voltage scaling and terminals for accepting a signal from an AC (2 phase only) or DC tachometer generator (either polarity), mechanically coupled to the drive motor armature. The tachometer signal defeats the IR compensation circuitry in the drive controller making the unit directly sensitive to motor speed. This results in expanded speed range, improved speed regulation with load changes, and reduced sensitivity to operating conditions such as line voltage variations, ambient temperature changes, motor field heating and other operating variables. This option requires a tach generator which provides 7 to 150V AC or DC at motor maximum and/or base speed. The option does not include the tachometer generator.	**VED**
24A	**FEEDBACK, TACHOMETER AC OR DC** Provides impedance matching and terminals for accepting a signal from a 2-phase AC or DC tachometer generator, mechanically coupled to the drive motor armature. The tachometer signal defeats the IR compensation circuitry in the drive controller making the unit directly sensitive to motor speed. This results in expanded speed range, improved speed regulation with load changes and reduced sensitivity to operating conditions such as line voltage variations, ambient temperature changes, motor field heating and other operating variables. The controller will automatically switch to armature feedback if the tachometer signal is lost. Tachometer generator must provide 30 to 180 volts at maximum motor speed. A MAXIMUM SPEED TACHOMETER potentiometer is provided to scale the tachometer signal. *Option 24A consists of a small plug-in circuit board which inserts into the FEEDBACK connector on the control circuit board, replacing the armature feedback circuit board. Option 24A does not include the tachometer generator.* *Caution: Do not use a single-phase AC Tachometer.*	**VEplus**
24B	**FEEDBACK, DIGITAL PULSE GENERATOR** Provides signal conditioning and isolation for accepting a signal from a magnetic pulse pick-up mechanically coupled to the drive motor armature. The magnetic pulse pickup must provide a minimum of 450 pulses per second at motor speed (60 tooth gear on a 1750 RPM motor). The pulse pick-up signal defeats the IR compensation circuitry in the drive controller, making the unit directly sensitive to motor speed. Speed range is limited to 35:1. The option results in improved speed regulation with load changes (equal to DC tachometer feedback) and reduced sensitivity to operating conditions such as line voltage variations, ambient temperature changes, motor field heating and other variables. *Option 24B consists of:* *a. Digital to analog conversion circuit board which inserts into the FEEDBACK connector of the control circuit board.* *b. A signal conditioner circuit board which is mounted on the base of the controller or remotely mounted.* *This option does not include the pulse pick-up assembly.*	**VEplus**
24B	**PULSE TACHOMETER FEEDBACK/FOLLOWER** This option is interfaces the controller to a pulse train for speed reference or as a feedback signal. It allows the use of a 60 tooth gear for either speed reference or feedback. It is capable of providing digital pulse tach reference an/or feedback functions. The sensor can be a magnetic pickup (2 wire), proximity sensor (3 wire), AC tachometer generator (18 cycles/revolution), two-phase AC tachometer generator, or digital tachometer generator or encoder (240 pulses/revolution) Note: two-phase AC tachometer generator can be used for follower or feedback applications, but not both.	**VEA-RG** **RBA-RG**
24D	**DIGITAL PULSE FEEDBACK** Provides signal conditioning for accepting a signal from a magnetic pulse pick-up mechanically coupled to the drive motor armature. The magnetic pulse pick-up must provide a minimum of 1750 pulses per second at motor speed (60 tooth gear on a 1750 RPM motor). The pulse pick-up signal defeats the IR compensation circuitry in the drive controller, making the unit directly sensitive to motor speed. Speed range is limited to 35:1 with a 1750 RPM motor, 20:1 with a 1150 RPM motor and 45:1 with a 2400 RPM motor. The option results in improved speed regulation with load changes (equal to DC tachometer feedback) and reduced sensitivity to operating conditions such as line voltage variations, ambient temperature changes, motor field heating and other variables. *This option consists of a small printed circuit board which mounts in the chassis base and communicates with the controller. This option does not include the magnetic pulse pick-up or other signal source.*	**VED**

Options and Modifications for DC Controllers

Option No.	Description	For Use with Series
25	**FOLLOWER, DC PROCESS INSTRUMENT** Provides necessary impedance matching circuitry to interface a customer supplied DC signal source with the controller reference input. Typical applications are those where motor speed must be controlled as a function of a process variable, such as temperature, weight, fluid flow, pressure, etc. *In many applications, the reference signal is obtained from a process instrument controller or other commercially available transducer with a DC milliampere output. Devices of this type normally provide signal levels within the ranges listed in the Table.* This option provides bidirectional operation. **Option provides suitable adjustments for linear transfer of instrument output current to motor speed. These adjustments are normally set so minimum transducer signal results in minimum or zero motor speed and maximum signal produces maximum motor speed. Also provided are adjustments to extend or compress the transducer signal output, so a 5:1 transducer output signal range, for example, could provide a 10:1 or 20:1 drive speed range.** *The controllers include internal DC isolation permitting the reference common to be directly connected to a process controller with a grounded output signal without the requirement for a signal isolator or AC line power isolation transformers. Multiple controllers may also be connected directly to a common process controller without further isolation.*	VELRG VEHRG
25	**ISOLATED INPUT AND FOLLOWER** This option board isolates the motor speed potentiometer from the non-isolated controller for operator and equipment safely. Also, it will allow the controller to follow a 4-20 DCMA current signal and a wide range of DC voltage signals (±.05 to ±500 VDC). This makes the option ideal for following signal transducers, motor shunts, DC tachometer generators and the armature voltage from DC motors.	VEA-RG RBA-RG
25A	**FOLLOWER, DC PROCESS** Provides necessary impedance matching circuitry to interface a customer supplied DC signal source with the drive controller reference input. Typical applications are those where motor speed must be controlled as a function of a process variable such as temperature, weight, flow, pressure, etc. In many applications, the reference signal is obtained from a process instrument controller or other commercially available transducer with a DC milliampere output. Devices of this type normally provide signal levels compatible with requirements listed in the table: Included are suitable adjustments for linear transfer or instrument output current to motor speed. The adjustments will normally be set so minimum transducer signal results in minimum or zero motor speed and maximum signal produces maximum motor speed. Also provided is an adjustment to extend or compress the transducer signal output so a 5:1 transducer output signal range, for example, could provide a 10:1 or 20:1 drive speed range. Included are individual potentiometer adjustments for: MINIMUM SPEED (Override)–Adjustable by the MOTOR SPEED potentiometer to establish a minimum drive speed independent of the external reference signal. The MOTOR SPEED potentiometer is also used as a manual speed setting control when no external reference signal is present. A MANUAL/FOLLOWER selector switch is therefore unnecessary for most applications and is not included with this option. See Option 38 when a switch is required. The MOTOR SPEED potentiometer is mounted in the operator control station. IMPEDANCE MATCH–Provides a means of matching the impedance of the signal source and also functions as a GAIN adjustment. OFFSET–Trims minimum input signal. IMPEDANCE MATCH and OFFSET potentiometers are mounted on the Option Circuit Board.	VEplus

Follower Input Requirements

Current Signal Range (mA) DC	Follower Input Impedance (Ohms)	Voltage Signal Required (Volts) DC
0-5	80	0.4 VDC
0-10	40	
0-25	16	
0-50	8	
1-5	80	
2-10	40	
4-20	20	
10-50	8	

DC Input Signal Range (ma)	Option Input Impedance (Ohms)
0-5	80
0-10	40
0-25	16
0-50	8
1-5	80
2-10	40
4-20	16
10-50	8

Option No.	Description	For Use with Series
25A	**FOLLOWER, DC PROCESS INSTRUMENT *(Continued)***	VEplus

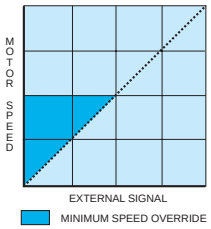


FIGURE A

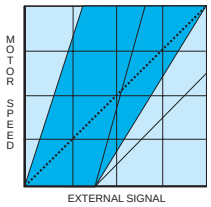


FIGURE B

Option consists of a small plug-in circuit board which inserts into the INPUT connector of the control circuit board.

Option does not include the external signal source, Motor Speed potentiometer or optional Manual Follower selector switch.

25B — **FOLLOWER, PROCESS CONTROL SIGNAL** — **VED**

Provides a necessary impedance matching circuitry to interface a customer supplied DC (current mode) signal source with the drive controller reference input. Typical applications are those where motor speed or current (torque) must be controlled as a function of a process variable such as temperature, weight, flow, pressure, etc.

In many applications, the reference signal is obtained from a process instrument controller or other commercially available transducer with a DC milliampere output. Devices of this type normally provide signal levels compatible with requirements listed in the table:

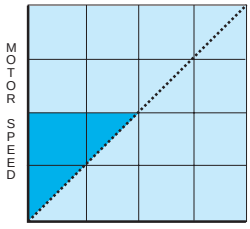
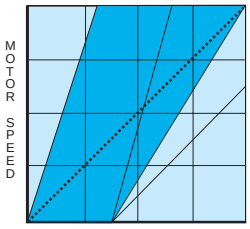
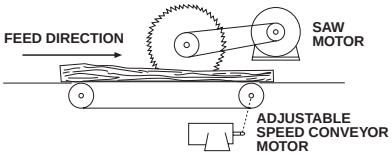
Follower Input Requirement		
Current Signal Range (ma) DC	**Follower Input Impedance (Ohms)**	**Voltage Signal Required (Volts) DC**
0-5	1K	5.0 VDC
0-20	300	
0-50	150	
1-5	1K	
4-20	300	
10-50	150	

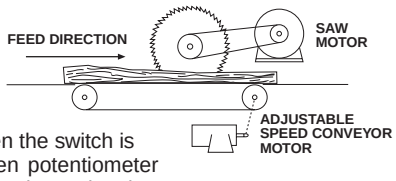
Included are suitable adjustments for linear transfer of instrument output current to motor speed. The adjustments will normally be set so minimum transducer signal results in minimum or zero motor speed and maximum signal produces maximum motor speed. Also provided is an adjustment to extend or compress the transducer signal output so a 5:1 transducer output signal range, for example, could provide a 10:1 or 20:1 drive speed range. Included are individual potentiometer adjustments for:

MINIMUM SPEED (Override) – Used to establish a minimum drive speed independent of the external reference signal. The operator panel is also used as a manual speed setting control when no external reference signal is present. See Figure A. A MANUAL/FOLLOWER selector switch is necessary to select between automatic and manual control operation when membrane is used.

GAIN – See Figure B for adjustment range.

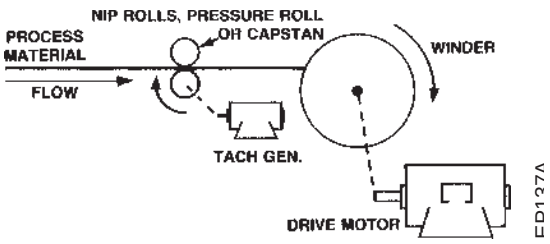
THRESHOLD – See Figure B for adjustment range.

Option No.	Description	For Use with Series
25B	**FOLLOWER, PROCESS CONTROL SIGNAL *(Continued)***	VED
	VED Series controllers include internal DC isolation permitting the reference common to be directly connected to a process controller with a grounded output signal without the requirement for a signal isolator or AC line power isolation transformers. Multiple controllers (up to 3) may also be connected directly to a common process controller without further isolation. *This option consists of a small circuit board which mounts in the chassis base and communicates with the controller.* *Option 25B does not include the external signal source.*  ***FIGURE A.***  ***FIGURE B.***	
25C	**FOLLOWER, AC CURRENT TRANSDUCER**	VEplus
	Intended for automatic control systems where it is necessary for the drive to follow an AC signal proportional to the load current of a constant speed, AC induction motor. Typical examples are conveying systems where the material feed rate has a direct influence over the loading of the AC motor, i.e.: the carriage or conveyor feeding logs to a saw powered by an AC motor. Since the thickness and density of the wood is not uniform this option permits automatic adjustment of conveyor speed to the highest feed rate which will not overload the saw motor. **In order that a proper current transformer may be supplied it is necessary that nameplate data such as horsepower, voltage, load current, etc. be provided from the AC motor.** AUTO/MANUAL SELECTOR SWITCH (1)–Selects the operation function. When the switch is in AUTO position, the drive functions as an AC current follower unit. When the switch is in MANUAL position the drive functions as an adjustable speed unit. When the AUTO function is selected, the separately furnished Motor Speed potentiometer provides speed adjustment of the DC motor at a ratio from 0 to 100% of the AC input signal. When the MANUAL function is selected, the Motor Speed potentiometer provides normal manual speed adjustment of the DC motor. DIRECT/INVERT SLIDE SWITCH (2)–Selects the operation mode. When the switch is in DIR position, the speed of the DC drive motor varies directly proportional to the load current drawn by the AC motor. When the switch is in INVT position the speed of the DC drive motor varies inversely proportional to the AC motor load current, i.e., when the load of the AC motor increases causing it to draw more current, the DC motor speed decreases. BIAS (2)–Set the maximum DC motor speed for the INVERT mode of operation. CURRENT SCALING (2)–Matches the range of the AC input signal to the input signal range requirements of the controller. INTEGRATION RATE (2)–Sets the response rate of the system when the AUTO function is selected. MINIMUM SPEED (2)–Sets minimum speed independently of the input control signal. PROPORTIONAL GAIN (2)–Sets the gain of Circuit Board when the AUTO function is selected. *This option consists of:* *a. Toroidal current transformer for separate mounting by the user for sensing AC motor load current.* *b. A small plug-in circuit board which inserts into the input connector of the control circuit board.* *c. AUTO/MANUAL selector switch for mounting remotely.* *NOTES: (1) Mounted in operator control station.* *(2) Located on circuit board.* *This illustration shows an application which requires an inverse relationship between AC motor load current and the follower drive motor speed. This option may also be programmed for a direct relationship where the follower drive would increase in speed with increasing AC motor load current.* 	
25C	**FOLLOWER, AC CURRENT TRANSDUCER**	VED
	Intended for automatic control systems where it is necessary for the drive speed to follow an AC signal proportional to the load current of an AC constant speed, induction motor. Typical examples are conveying systems where the material feed rate has a direct influence over the loading of the AC motor, I.e.: the carriage or conveyor feeding logs to a saw powered by an AC motor.	

Option No.	Description	For Use with Series
25C	**FOLLOWER, AC CURRENT TRANSDUCER *(Continued)*** Since the thickness and density of the wood is not uniform this option permits automatic adjustment of conveyor speed to the highest feed rate which will not overload the saw motor. In order that a proper current transformer may be supplied it is necessary that nameplate data such as horsepower, voltage, load current, etc. be provided from the AC motor. This illustration shows an application which requires an inverse relationship between AC motor load current and the follower drive motor speed. This option may also be programmed for a direct relationship where the follower drive would increase in speed with increasing AC motor load current. Included are independent controls and adjustments for:  AUTO/MANUAL SELECTOR SWITCH—Selects the operation function. When the switch is in AUTO position, the drive functions as an AC current follower unit. When potentiometer provides speed adjustment of the DC motor at a ratio from 0 to 100% of the AC input signal. NORMAL/INVERT SLIDE SWITCH—Selects the operation mode. When the switch is in NORMAL position, the speed of the DC drive motor varies directly proportional to the load current drawn by the AC motor. When the switch is in INVERT position the current, i.e., when the load of the AC motor increases causing it to draw more current, the DC motor speed decreases. THRESHOLD— Since AC motors draw significant current even when unloaded, a threshold adjustment is provided to enable minimizing drive response below this point. An LED is provided to signal the threshold has been exceeded and the drive begins to track proportionately. OFFSET—Sets an additive minimum speed in the normal mode and sets the maximum motor speed for the INVERT mode of operation. CURRENT SCALING—Matches the range of the AC input signal to the input signal range requirements of the controller. INTEGRATION RATE—Sets the response rate of the system when the AUTO function is selected. PROPORTIONAL GAIN— Sets the Gain to enhance stability when the AUTO function is selected. RATIO— Controls speed as a ratio of reference in the auto mode or may be wired as a manual speed control. MIN SPEED CLAMP—Sets independent manual or min speed control without affecting ratio. *This option consists of:* *a. Toroidal current transformer for separate mounting by the user for sensing AC motor load current.* *b. A small circuit board which mounts in the chassis base and communicates with the controller via FINbus.*	VED
25S	**FOLLOWER, EXTERNAL REFERENCE (ISOLATOR)** Provides a means of controlling motor speed or current (torque) by an external DC voltage reference signal. The circuit includes internal isolation permitting direct connection to a hot signal source riding upon a floating voltage such as a shunt or speed potentiometer (500 VDC maximum) in the armature circuit of another DC drive controller. Multiple motor applications typically involve a master speed regulated drive which establishes the speed of the system and one (1) or more current regulated follower drive units which may follow at adjustable ratios up to 150%. The follower units obtain their current reference signal from the master controller. Typical applications include: a. Load sharing between two (2) or more drive units with their motors mechanically coupled. b. Load sharing between two (2) or more drive units coupled by the process material itself such as steel bar stock being pulled by multiple drive units through separately powered sections of a machine. c. Tension control of a web of process material being transferred between sections of a multiple section machine. *This option consists of a small circuit board which mounts in the chassis base and communicates with the controller via FINbus.*	VED
27P	**NEMA 3/4/12 KIT** Provides protective covers over the control elements in the cover to covert the enclosure to NEMA 3/4/12.	VED
27M	**ENCLOSURE MODIFICATION, NEMA TYPE 3/4/12** Provides necessary gaskets for the operator panel (in local and remote control models) and a protective cover on the circuit breaker to convert the standard VED enclosure to NEMA Type 3, 4 and 12. **The modified unit is suitable for operation in nonhazardous applications where it may be subjected to splashing water, seepage water, hose directed water, severe condensation and dust.**	VED
30	**CIRCUIT BREAKER, 2-POLE** This option provides two-pole interrupting capabilities enabling both incoming lines to be disconnected. The VED Series has a single pole circuit breader as standard.	VED
30	**AC LINE CIRCUIT BREAKER, TWO POLE** Provides a two-pole, magnetic only, fast trip circuit breaker as a means of manually disconnecting controller from the AC line. The high interrupting capacity fuse in the basic unit is retained as primary short circuit protection.	VEA-RG

Options and Modifications for DC Controllers

Option No.	Description	For Use with Series
31	**TORQUE (CURRENT) MONITOR** Provides an adjustable, static circuit that monitors motor armature current and provides a programmed shutdown of the drive under sustained overload conditions to prevent motor damage. The circuit provides greater versatility than the standard, nonadjustable overload circuit calibrated to trip whenever armature current exceeds 120% for 80 seconds. The static overload circuit supplements the protective benefits of the controller current limit and motor thermostat. It is especially effective in preventing motor damage when: a. The motor is subjected to high torque loads at low speeds. b. The current limit allows adjustment to 150% of rated armature current. Standard 1.0 service factor motors are rated for 1 minute of operation at this load. Damage or reduced motor life may result if sustained for longer periods since the current limit functions independent of time. c. The motor is forced cooled and must run at speeds below 50% base speed for any sustained period of time. Circuit includes one set of Form C, 2 amp, 120 VAC or 28 VDC rated relay contacts that may be used to signal audible or visual alarms or auxiliary control devices such as lubrication pumps, fans or valves. The circuit includes two adjustments: 1. "THRESHOLD" (trip current level).....10-180% Rated Armature Amps 2. "DELAY" (time at trip current level).....1-90 seconds The threshold adjustment establishes the amount of armature current necessary to initiate the timing period set by the delay circuit. When the current remains above the threshold level for a period equal to the delay time setting, the relay energizes. **The accuracy of the current monitor is not affected by ambient temperature changes within the design operating limits of the drive controller.**	**VEplus**
32	**FIELD SUPPLY, FULL-WAVE** Provides a full-wave excitation source for the field of a shunt-wound DC motor. Enables the use of 100 VDC field motors with 115 VAC controller or 200 VDC field motors with a 230 VAC controller.	**VED**
34	**MASTER ISOLATED REFERENCE CONTROLLER** This is a master system housed in a VEL/H size cabinet including a circuit breaker for use as an on-off switch, a run-stop control relay, operator's controls consisting of run and stop pushbuttons and a master speed pot. Input voltage may be 115 or 230 VAC, 60/50 Hz. The control provides an adjustable frequency signal for each control in the system with a suitable follower board (see below). The master control also accepts input options and thus can provide system acceleration-deceleration, external signal, etc. Order Cat. No. 60174.	**VEHRG** **VELRG** **VEplus**
35	**FOLLOWER, MASTER ISOLATED REFERENCE CONTROLLER (MIRC)** Provides an input circuit board to interface a controller with speed reference signals transmitted by the Model MIRC master controller. The receiver circuit board includes necessary isolation, impedance matching and frequency to analog conversion. This option is required for each controller whenever one or more is to be controlled by the MIRC. Option 35 includes adjustments for maximum ratio, minimum speed and offset as well as the separately furnished MOTOR SPEED potentiometer. The MIRC is a versatile master controller suggested for use whenever isolation is required between a controller and a grounded external signal source and/or signal isolation is required between multiple controllers which must track a common speed reference signal. All adjustments excepting the MOTOR SPEED potentiometer are mounted on the option circuit board. The MOTOR SPEED potentiometer functions as a manual speed setting device with the MASTER/LOCAL selector switch in the LOCAL position. In the MASTER position the potentiometer provides a ratio or draw adjustment. See Option 34 for additional information on the MIRC Master Controller. *Option 35 consists of a small plug-in circuit board which inserts into a prewired connector provided for this purpose and a MASTER/LOCAL selector switch.* *The MIRC follower option will control motor speed for unidirectional operation only.* *This option does not include the MIRC Master Controller or the MOTOR SPEED potentiometer. See Option 34.*	**VEHRG** **VELRG** **VEplus**
36A	**CENTERWIND TORQUE CONTROL** This option offers a more sophisticated solution to controlling the tension of center driven winders than Torque Taper Options 18 & 18A. Tension control is more accurate since this option produces a reciprocal speed-torque relationship which closely matches the ideal constant horsepower curve required to maintain constant tension. Option 36A has provisions to accept a signal proportional to web speed from either a tachometer generator driven from the production machine feeding the winder or a potentiometer ganged to the production machine speed control. Tension control accuracy of better than 20% can normally be maintained from empty to full roll, and the control automatically compensates for changes in production machine speed.	**VEplus**

Option No.	Description	For Use with Series
36A	**CENTERWIND TORQUE CONTROL *(Continued)***	VEplus
	This option consists of a plug-in circuit board which inserts into both the INPUT and the FEEDBACK connectors of the control board, and a TORQUE ADJUST potentiometer pre-wired for installation in the operator control panel. Included are independent potentiometer adjustments for: TORQUE ADJUST – Sets the desired tension in the material being wound. This potentiometer is mounted in the operator control panel. TACH SCALING (1) – Scales the production machine tachometer signal voltage to the control requirements. MAX TORQUE EMPTY ROLL (1) – Establishes the torque required to maintain proper tension at high winder speed. MAX TORQUE FULL ROLL (1) – Establishes the torque required to maintain proper tension at low winder speed. TORQUE BOOST TIME (1) – Establishes the time that additional torque is supplied to accelerate the winder when the production machine speed is increased. **Use caution in the selection of motors for center driven windup applications where torque loads increase in inverse proportion to motor speed. Also, web break or other process material detectors are suggested to prevent a dangerous overspeed should the process material break.** An AC or DC tachometer generator with a minimum output of 30 volts at base speed and not exceeding 180 volts at maximum production machine speed or a 5K ohm potentiometer ganged to the production machine speed control is required, but not furnished as part of this option. (1) These potentiometers are mounted on the option circuit board.	
36B	**CONSTANT VELOCITY WINDER** This option provides an economical but accurate method of automatically controlling the tension of process material in strip, web, wire or cable form as wound by a center driven winder. The option requires the use of a DC tachometer generator coupled to the process material by nip rolls, a pressure roller or capstan in a manner that will provide a continuous feedback of the velocity of the process material. A manually set MOTOR SPEED potentiometer establishes the desired line speed of the process material. As material builds up on the winder core, the diameter increases which would tend to increase the line speed of the material. This will produce a higher voltage output from the tachometer generator which will cause the drive motor and winder to slow down to maintain a constant velocity and uniform winder tension. Should a break occur in the process material, this option will automatically transfer to an adjustable minimum take up speed to minimize damage to the product and winder machinery. **RATINGS** 1. Regulation Accuracy .....2% of motor base speed 2. Maximum Line Speed Range..... $\frac{30}{\text{Build Ratio}}$ Example: a 3:1 build ratio (3 ft. dia. full roll, 1 ft. dia. empty roll) = 10:1 line speed range. 3. MOTOR SPEED potentiometer.....5,000 ohms *This option consists of a plug-in circuit board which inserts into both the INPUT and the FEEDBACK connectors of the control board. Included are independent potentiometer adjustments for:* **ADJUSTMENTS** 1. Take-Up Speed .....0 to 50% of maximum speed 2. Maximum Speed .....Sets maximum range of MOTOR SPEED potentiometer 3. Acceleration (Response Time) .....1-60 sec. **Use caution in the selection of motors for center driven windup applications where torque loads increase in inverse proportion to motor speed.** A DC Tachometer Generator with a minimum output of 1.0 volt at base speed and not to exceed 120 volts at maximum production machine speed and a 5K MOTOR SPEED potentiometer are required but not furnished as part of this option.  	VEplus

Option No.	Description	For Use with Series
38	**MANUAL/FOLLOWER MODE SELECT (TOGGLE SWITCH)** This option is intended as a companion to Option 22, Option 25A and Option 25B. Option 22, 25A and 25B do not include a selector switch and rely upon a zero speed setting of the MOTOR SPEED potentiometer to transfer to full automatic control by the external signal. Option 38 when used with these options, allows manual switch selection of either the MOTOR SPEED potentiometer or automatic control by the external signal. *Option 38 includes a switch with a MANUAL/FOLLOWER legend plate for installation in the operator control panel.*	ALL
44	**DIGITAL METER** Option provides a 3 1/2 digit LCD meter for mounting and plug-in interconnection within a dedicated space in the membrane operator control panel. Meter greatly expands the operational versatility of any VED Series unit by monitoring important operating parameters and by annunciating faults. **1. Operating parameters displayed:** a. Power – percent of rated b. Armature current – percent of rated c. Armature voltage – percent of rated d. Motor speed – percent of rated e. Motor RPM – direct reading in RPM for 1750 RPM motors only. A DIP switch permits programming the meter for continuous display of any one (1) of the parameters listed. Alternately, any two or more parameters may be selected for sequential display at 12 second intervals. See Figure A.  FIGURE A.  FIGURE B. **2. Fault Annunciator** In the event the drive shuts down due to a fault, it is displayed in the form of an error code. Error codes include: a. ARMATURE FEEDBACK LOSS (E1) Indicates the correct armature feedback signal has not been received by the microprocessor. b. CURRENT FEEDBACK LOSS (E2) Indicates that the correct current feedback signal has not been received by the microprocessor. c. HALF WAVE FIRING (E3) d. OVERVOLTAGE (E4) 120% or greater Line Voltage e. UNDERVOLTAGE (E5) 85% or less Line Voltage f. CONTROLLER OVERLOAD (E6) Armature Current 120% for 90 seconds. g. COMMUNICATION ERROR (E7) Determines that a connected option fails to respond with expected data. h. MEMBRANE OPERATOR PANEL COMMUNICATION ERROR (E8) Operator panel serial link determines that a MB1 MEMBRANE OPERATOR PANEL is connected but fails to respond with expected data. i. CONTROLLER OVERCURRENT (E9) Armature current exceeds 200% j. MOTOR OVERTEMPERATURE (E10) k. MOTOR ROTOR LOCKED (E11) Overload trip l. MOTOR OVERSPEED (E12) Shutdown whenever counter EMF is 120% of nominal base speed armature voltage m. TACH LOSS (E13) When speed (voltage) from a feedback tachometer differs from armature feedback voltage by 20% or more the controller will switch to armature voltage feedback. When speed from the tach is restored to within 10% of armature feedback the tach signal is again used. A STOP is *not* initiated. n. CONTROLLER TO PANEL COMMUNICATION ERROR (E33) o. BATTERY FAILURE (E34) Lithium battery is exhausted. Only operator preset adjustments in membrane panel such as Run Forward or Reverse speeds, Jog speeds, etc. will be lost under this condition. See Figure B.	VED

Options and Modifications for DC Controllers

Option No.	Description	For Use with Series
44A	**DIGITAL MONITOR (LOCAL)** Provided is a 3 1/2 digit, microprocessor based, programmable, LCD meter intended for use as a monitor only of VED controller operating parameters and fault annunciation error codes. It is identical in function to the Option 44 digital meter in the membrane operator panel, except it has no control capability. It may be used as a complementary meter either in conjunction with the Option 44 meter, or it may be used as a separate, stand alone monitor. It is perhaps most useful when the VED unit is controlled by conventional pushbuttons and speed setting potentiometer in the pushbutton operator control panel, or a remote operator control station. Option 44A is furnished as an unenclosed component, complete with a 12 in. (0.3M) ribbon interconnection cable for mounting in the space reserved for the membrane operator control panel in the cover of the unit or adjacent to it. The digital monitor includes membrane pushswitches for selecting the operating parameter to be monitored: Motor RPM (1750 RPM only), Motor Speed %, Motor Volts %, Motor Amps %, Frequency Hz., and Watts %, plus a Reset Pushbutton. When the digital monitor must be mounted remote from the enclosure, Option 44B is suggested.	VED
44B	**DIGITAL MONITOR (REMOTE)** This option is identical to Option 44A except it is furnished for remote mounting in the same die cast aluminum housing as provided for remote operator stations. Additionally, it includes one (1) buffer amplifier to enable remote mounting up to 100 feet (30M) away from the VED controller. The buffer amplifier also permits interconnection wiring with conventional stranded wire as opposed to the ribbon cable required for Option 6A.	VED
47	**REFERENCE, PRECISION** This option provides a high stability, precision reference circuit that replaces the function of the standard internal reference circuit in the drive controller. This circuit offers important benefits for critical applications where sensitivity to operating variables such as load changes, temperature, line voltage variations, etc. must be held to an absolute minimum. This option may be used in combination with Option 24A, Feedback, Tachometer AC or DC. *This option consists of a small plug-in circuit board which replaces the standard input board.*	VEplus
50	**HINGE, ENCLOSURE COVER** Enclosed models include a screw fixed, gasketed cover which is removable for increased accessibility during installation, troubleshooting or repair. When desired the cover may also be provided with optional hinges making servicing more convenient. *This option may be provided factory installed or a kit is offered for simple field installation.*	VEplus VED VEA-RG
52	**POWER SUPPLY, AUXILIARY** Provides a supplemental power supply with +5VDC, and ±24VDC outputs for multiple options selected that may require more power than available from the basic controller. *This option consists of a small printed circuit board which mounts in the chassis base.*	VED
53	**SIGNAL BUS SUPPORT GUIDE** This option consists of an insulating circuit board edge guide/support plus necessary attachment hardware. While one guide is supplied with each FINbus option installed in a VED chassis, two are required whenever the option is installed on a baseplate adjacent to the controller. See also Option 54 for the necessary extender cable required for this purpose.	VED
54	**SIGNAL BUS EXTENDER CABLE** Provides a 12 inch long, extender ribbon cable to enable mounting the FINbus option outside of the VED chassis.	VED
55	**COMPUTER MONITOR** Provides a very useful means of obtaining operation data from a VED controller using any IBM compatible computer for continuous monitoring, test, and diagnostic purposes. Enables monitoring (with plain language designations) over 25 essential controller parameters: 1. **Preset Adjustments** (displayed in percent) a. Maximum Motor Speed b. Minimum Motor Speed c. Acceleration Rate d. Deceleration Rate e. I.R. Compensation f. Current Limit 2. **Reference Input** (displayed in percent) a. Speed Reference b. Current Reference	VED

Option No.	Description	For Use with Series
55	**COMPUTER MONITOR *(Continued)***	VED

3. Membrane Operator Control Panel
- a. Direction of Operation Selected
- b. Speed Presets (displayed in percent)
- c. Run Forward
- d. Run Reverse
- e. Jog Forward
- f. Jog Reverse

4. Measured Dynamic Parameters (displayed in percent except as noted)
- a. Armature Voltage
- b. Armature Current
- c. Counter EMF
- d. Tachometer (Optional) Input
- e. Speed Feedback
- f. Current Offset
- g. Line Frequency (displayed in Hz)
- h. Error Bus Data
- i. Tachometer Offset
- j. Input Status (Bit Parameters)
- k. Motor Status (Bit Parameters)
- l. Error Flags–First Fault Annunciator

See option 44 for parameters monitored

5. Fault Description – See Option 44 for Error Code and parameters monitored.

Output is an optically coupled and isolated RS232/RS422 link limited to a maximum distance of 50 feet (RS232) or 4000 feet (RS422). Operation is at 2.4K baud which provides an update approximately every two (2) seconds.

The option includes an option circuit board and either a 3 1/2" or 5 1/4" floppy disk containing the required software. The option board mounts in a slot located within the VED Series chassis which is connected to the controller via a dedicated serial port connector provided for this purpose.

This is a read only monitor. See Option 22L when the ability to also control the unit from a computer is desired.

NOTES

Adjustable Frequency AC Motor Controllers

B

TABLE OF CONTENTS

SPECIFICATION CHART 74

BCX, AC INVERTER 75-79

ACX, AC INVERTER 80-87

ADX, AC INVERTER 89-101

SSX, SOFT-START CONTROLLERS 102-104

OPTIONS FOR AC CONTROLLERS 105-107

APPLICATION ENGINEERING 175-189

RATIOTROL SYSTEMS

Adjustable Frequency AC Motor Controllers

Specification Chart

The purpose of this chart is to provide a general feature comparison of the Boston Gear controllers. When selecting refer to the specific catalog section for complete information.

Features		BCX	ACX	ADX
Maximum HP @ AC Line	115 Single Phase 230 Single Phase 230 Three Phase 460 Three Phase	1 2 5 5	1 5 30 75	 30 75
Controller Type	V/F (Volts/Frequency) Encodorless Flux Vector	S	S	S S S
Input	Phase (Hz)	50/60	50/60	50/60
Output Frequency	Range (Hz)	0-120	0-400	0-400
Input Speed Resolution	Resolution (Hz) Analog Digital	0.2	.03 .01	.015 .006
V/F Ratios		3	21	22
Braking	Regenerative (%) Electronic (%) Ramp-To-Stop Coast-To-Stop	20 O S S	20 O S S	20 O S S
Functions	Jump Frequencies Current Limit (%) Acceleration (Sec) Deceleration (Sec) Jog Frequency (Hz)	 75-150 0.1-100 0.1-100	3 50-200 0.1-999 0.1-999	3 20-250% 0-1900 0-1900 0-400
Isolated Regulator			S	S
Microprocessor Based		S	S	S
Keypad	Buttons (#) Display		6 3-LEDS	10 2 X 16 LCD
Remote Keypad Cable				
Protection	Trip Stall Instantaneous Power Failure Phase-To-Phase Ground Fault	S S S S	S S S S S	S S S S S
Programmable Functions			46	403
Enclosure	NEMA 1 NEMA 4 NEMA 12	S	S S	S
Error Messages		6	13	24
Output Speed Display			S	S
Serial Ports	RS485		15	S
Pages		75-79	80-87	89-101

S - Standard
O - Optional

Single and Three Phase Adjustable Frequency AC Motor Controller

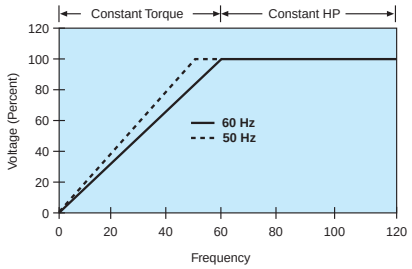
BCX Series
1/6 – 5 Horsepower
230 and 460 VAC

The BCX Series micro-controllers are OEM designed microprocessor based units providing the ultimate combination of inverter technology, simplicity and affordability. The BCX utilizes surface mount and IGBT technologies to provide a compact low cost AC controller. The BCX offers an unbeatable package of size, price and flexibility to suit your application: whether converting fixed speed to adjustable speed, replacing an existing AC inverter, or as an alternative to a motor starter.

B

DESIGN FEATURES AND FUNCTIONS

1. **Construction** – Furnished in a rugged NEMA 1 (UL Type 1) ventilated enclosure. The unit consists of four primary components: (1) an aluminum heatsink, (2) a power cube assembly, (3) an integrated logic/power board and (4) the non-metallic housing. The three phase BCX is self-cooling at 2 HP, 230 VAC and 5 HP, 460 VAC and below. Units above these ratings are fan cooled.
2. **Microprocessor Design** – The BCX utilizes a powerful 16-bit microprocessor for logic and regulator functions.
3. **Power Devices** – The BCX incorporates state-of-the-art insulated gate bi-polar transistor (IGBT) output power switches. IGBTs require less gate drive power which reduces the internal temperature of the drive. Fast turn off prevents damage in the event of an output short circuit.
4. **PWM Modulation Technique** – The BCX controllers utilize a modified voltage vector modulation for smooth motor operation. Asynchronous modulation eliminates the "gear shifting" sound made by AC drives using older technology.
5. **Acceleration/Deceleration Adjustment** – A common accel/decel adjustment potentiometer is provided for acceleration and deceleration time adjustment.
6. **Status LEDs** – Two LEDs are provided for drive status indication. The yellow LED lights when power is applied to the unit. The red LED lights in the event of a pending overload or flashes in the event of a fault.
7. **Speed Potentiometer** – A 5K ohm speed control potentiometer is supplied loose for customer mounting on the cover of the BCX control.
8. **Control Power Supply** – A +5VDC non-isolated power supply is provided for pushbuttons and external Run-Stop logic.
9. **Power Loss Ride-Through** – The BCX can maintain motor control during periods of input power loss for a minimum of 0.1 seconds.
10. **Line Starting Capability** – Causes the motor to start upon application of power to the drive.
11. **AC Line Voltage Compensation** – Holds output voltage constant with rated line voltage variations when output voltage is less than line voltage (10% line voltage variation causes 1% output voltage variation).
12. **Multiple Motor Operation** – The BCX is capable of operating multiple motors at a common frequency. Total amp draw of the motors cannot exceed the controller's rating.
13. **Volts/Hertz Patterns** – The chart at right shows the Volts per Hertz Patterns available when the FC (Frequency Calibration) Potentiometer is adjusted for 50 to 120 Hz operation. The drive will operate in the Constant Torque mode when the FC Potentiometer is set for a maximum frequency less than 60 Hz. When the FC Potentiometer is adjusted for a frequency greater than 60 Hz, the drive will operate in the Constant Torque mode from 0 to 60 Hz and will operate in the Constant HP mode at frequencies above 60 Hz.



VOLTS PER HERTZ PATTERNS

14. **Electronic Inverse Time Motor Overload Protection** – The threshold for overload protection is 83% of the current limit setting. The overload time is fixed at 60 seconds in current limit.
15. **Protective Features –**
    - A. **Inverter Trip**: Due to overvoltage, overcurrent, undervoltage, overload or a logic fault.
    - B. **Output Fault Protection:** The unit is protected from line-to-line output short circuits.
    - C. **Instantaneous Power Failure:** The unit will shut down safely after a power loss greater than approximately 0.1 second. If power is restored within 1 second, the drive will restart.
    - D. **Overvoltage and Undervoltage Protection:** Electronic shutdown when the bus voltage is outside normal operating conditions.
16. **Fault Trip Reset** – Faults are cleared on the BCX by (a) removing and then reapplying AC power, (b) pressing the stop button (if used), or (c) opening and closing a maintained run contact (if used).
17. **Fuse Protection** – An external AC line fused disconnect or circuit breaker must be provided by the user in accordance with electrical codes.

DESIGN FEATURES AND FUNCTIONS *(Continued)*

18. **Regeneration Limit** – Designed to eliminate drive trips when excessive braking energy is transferred from the motor to the control. Regeneration limit will perform in the following fashion:
    (a) Will extend decel time to prevent bus overvoltage trip with high inertia loads.
    (b) Will increase output frequency to user programmed maximum frequency range during overhauling loads.
19. **Analog Signal Inputs** – One analog signal input is provided. The associated external signals may not be grounded or connected to other equipment because the drive common is not isolated from the AC line.
20. **Digital Control Inputs** – Two digital inputs are provided for the following functions.
    (a) Forward
    (b) Reverse/Stop (Programmable via jumper)

    All inputs are designed to be used with the +5VDC (non-isolated) control voltage supplied by the BCX. The BCX can be started and stopped by maintained dry circuit contacts.
21. **Current Limit** – Limits the motor output current to prevent overcurrent trips during acceleration. The current limit is adjustable from 75% to 150% of the rated motor full load current.
22. **Drive OK Relay Contact**– The BCX includes a drive OK relay contact which is closed whenever power is applied to the control and the drive is not faulted. The contact opens when power is removed and the DC bus voltage drops below the minimum bus voltage for drive operation. The contact also will open if the controller should fault.

RATINGS

1. **Horsepower Range:**
   115 VAC Single Phase . . . . . .1/6-1 HP(1)
   208/230 VAC Single Phase . . . . . .1/6-2 HP
   208/230 VAC Three Phase . . . . . .1/6-5 HP
   460 VAC Three Phase . . . . . .1-5 HP
2. **Power Source:**
   . . . . . .115 VAC, 1 Phase 50/60 Hz(1)
   . . . . . .208/230 VAC, 1 or 3 Phase 50/60 Hz
   . . . . . .460 VAC, 3 Phase 50/60 Hz
3. **Output Power:**
   (a) Voltage . . . . . .0 – 208/230 or 0 – 460, Three Phase
   (b) Frequency . . . . . .0-60 Hz Constant Torque
   60-120 Hz Constant Horsepower
4. **Service Factor** 1.0
5. **Duty** . . . . . .Industrial, Continuous
6. **Overload Capacity** . . . . . .150% for 1 Minute
7. **Linearity** . . . . . .±1.0% Maximum
8. **Analog Reference** . . . . . .+5 VDC (for 5K ohm pot, non-isolated)
9. **External Analog Reference Source**(2) . . . . .0 – 5 VDC
10. **Magnetic (Pushbutton) Control Voltage** . . . . . .5 VDC (non-isolated)
11. **Storage Temperature** . . . . . .32° – 168°F (0° – 70°C)

Notes: (1) Optional voltage doubler (2XV) required for 115 VAC operation

(2) External control signals must be ungrounded and not connected to other equipment (drive common is not isolated from the AC line input).

PERFORMANCE CHARACTERISTICS

1. **Controlled Speed Range** – Zero to motor base speed, constant or variable torque with NEMA design B AC induction motors.
2. **Speed Regulation** – Regulation percentages listed in Table are of motor rated (base) speed under steady-state operating conditions.

SPEED REGULATION CHARACTERISTICS(1)

Regulation Method	Load Change 95%	Line Voltage ±10%	Motor Heating Cold to Normal	Temperature ±10°C
Normal	3.0%	±0.5%	1.0%	±0.5%

(1) Average expected values are dependent upon individual motor characteristics.

3. **Frequency Resolution** . . . . . .0.2% of Maximum Frequency
4. **Frequency Stability** . . . . . ±1% of Maximum Frequency (or better)
5. **Efficiency (at rated speed, rated load)**:
   Control 95%
   Control and Motor
   (assumes 89% motor efficiency) 85%
   (assumes 93% motor efficiency) 88%
6. **Displacement Power Factor** . . . . . .Greater than 96%
7. **Torque** . . . . . .Minimum developed torque under any operating condition will not be less than 150%

Single and Three Phase Adjustable Frequency AC Motor Controller

BCX Series
1/6 – 5 Horsepower
230 and 460 VAC

ADJUSTMENTS

All adjustments are performed utilizing potentiometers.

1. **Acceleration/Deceleration (linear)** . . .0.1 – 100 Seconds
2. **Maximum Frequency** . . . . . .50 – 120 Hz(1)
3. **Current (Torque) Limit** . . . . . .75 – 150% of Rated

(1) 50 – 60 Hz Constant Torque, 60 – 120 Hz Constant Horsepower.

OPERATING CONDITIONS

1. **Line Voltage Variation** . . . . . .±10% Rated
2. **Line Frequency Variation** . . . . . .± 2 Hz
3. **Ambient Temperature** . . . . . .32° to 104°F (0° – 40°C)
4. **Ambient Humidity** . . . . . .95% Non-condensing
5. **Altitude (Standard)** . .3300 Feet (1000 meters) Maximum

TYPICAL APPLICATION DATA

SINGLE PHASE 115/208/230 VAC INPUT

Motor		Controller								
		115 VAC		208 VAC			230 VAC			Catalog Number
HP	KW	KVA	Input Amps	KVA	Input Amps	Output Amps*	KVA	Input Amps	Output Amps*	
1/6	0.12	BCX2003 AND 2XV-03		0.42	2.0	0.94	0.44	1.9	0.85	BCX2003
1/4	0.19			0.52	2.5	1.5	0.55	2.4	1.4	
1/3	0.25			0.71	3.4	2.0	0.76	3.3	1.8	
1/2	0.37	BCX2010 AND 2XV-10		0.99	4.8	2.2	1.10	4.8	2.0	BCX2010
3/4	0.56			1.54	7.4	3.1	1.54	6.7	2.8	BCX2015
1	0.75			2.00	9.6	3.9	2.00	8.7	3.6	BCX2020
1 1/2	1.12	—		2.91	14.0	5.7	2.92	12.7	5.2	BCX2030
2	1.50	—		3.58	17.2	7.5	3.57	15.5	6.8	BCX2050

*3-Phase output

THREE PHASE 208/230 VAC INPUT

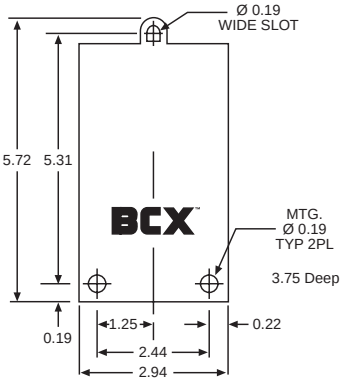
Motor		Controller						
		208 VAC			230 VAC			Catalog Number
HP	KW	KVA	Input Amps	Output Amps	KVA	Input Amps	Output Amps	
1/6	0.12	0.50	1.4	0.94	0.56	1.4	0.85	BCX2003
1/4	0.19	0.58	1.6	1.5	0.64	1.6	1.4	
1/3	0.25	0.79	2.2	2.0	0.88	2.2	1.8	
1/2	0.37	1.01	2.8	2.2	1.12	2.8	2.0	BCX2010
3/4	0.56	1.44	4.0	3.1	1.59	4.0	2.8	
1	0.75	1.73	4.8	3.9	1.83	4.6	3.6	
1 1/2	1.12	2.77	7.7	5.7	2.79	7.0	5.2	BCX2015
2	1.50	3.39	9.4	7.5	3.39	8.5	6.8	BCX2020
3	2.24	5.12	14.2	10.6	5.10	12.8	9.6	BCX2030
5	3.73	8.50	23.6	16.7	8.49	21.3	15.2	BCX2050

THREE PHASE 460 VAC INPUT

Motor		Controller			
		460 VAC			Catalog Number
HP	KW	KVA	Input Amps	Output Amps	
1	0.75	1.91	2.4	1.8	BCX4010
1 1/2	1.12	2.79	3.5	2.6	BCX4015
2	1.50	3.43	4.3	3.4	BCX4020
3	2.24	5.10	6.4	4.8	BCX4030
5	3.73	8.53	10.7	7.6	BCX4050

DIMENSIONS

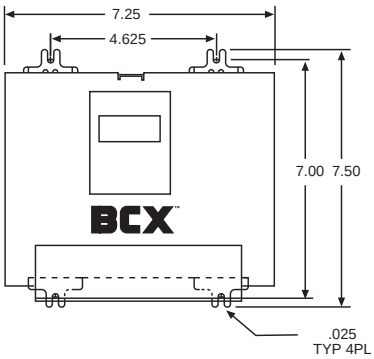
1/6 -1 HP, 230 VAC

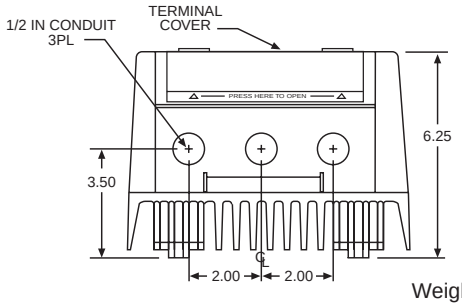


Weight 1.5 lbs

1 1/2-5 HP, 230 VAC

1 - 5 HP, 460 VAC





Weight 5.6 lbs

MODEL TYPES

The BCX Series of controllers are offered as a NEMA 1 enclosed controller. These units are available in either 115 VAC (with voltage doubler), 208/230 VAC or 460 VAC input voltages covering a range of 1/6 to 5 HP as shown below.

ORDER BY CATALOG NUMBER OR ITEM CODE

Input Voltage	Motor HP	Motor Max. KW	Rated Output Amps (2) 208 VAC	Rated Output Amps (2) 230 VAC	Catalog Number	Item Code
115 VAC Single Phase 50/60 Hz	1/6-1/3(1)	0.25	2.0	1.8	BCX2003 and 2XV-03	08106 and 58575
	1/2-1(1)	0.75	3.9	3.6	BCX2010 and 2XV-10	08108 and 58576
208/230 VAC Single Phase 50/60 Hz	1/6-1/3	0.25	2.0	1.8	BCX2003	08106
	1/2	0.37	2.2	2.0	BCX2010	08108
	3/4	0.56	3.1	2.8	BCX2015	07152
	1	0.75	3.9	3.6	BCX2020	07154
	1 1/2	1.12	5.7	5.2	BCX2030	07156
	2	1.50	7.5	6.8	BCX2050	07170
208/230 VAC Three Phase 50/60 Hz	1/6-1/3	0.25	2.0	1.8	BCX2003	08106
	1/2-1	0.75	3.9	3.6	BCX2010	08108
	1 1/2	1.12	5.7	5.2	BCX2015	07152
	2	1.50	7.5	6.8	BCX2020	07154
	3	2.24	10.6	9.6	BCX2030	07156
	5	3.73	16.7	15.2	BCX2050	07170
460 VAC Three Phase 50/60 Hz			460 VAC			
	1	0.75	1.8		BCX4010	07176
	1 1/2	1.12	2.6		BCX4015	85459
	2	1.50	3.4		BCX4020	07193
	3	2.24	4.8		BCX4030	07203
	5	3.73	7.6		BCX4050	07206

(1) For HP/Voltage rating shown, both the controller and option are required.
(2) At maximum horsepower rating

Single and Three Phase Adjustable Frequency AC Motor Controller

BCX Series
1/6 – 5 Horsepower
230 and 460 VAC

OPTIONS

Complete option descriptions are listed in the AC option section. To order a kit for field installation order by the item code.

Option	Voltage and Horsepower		Option Number	Field Kit Item Code
Din Rail Mounting Kit	230 VAC	1/6 -1	DIN	58572
Conduit Box	230 VAC	1/6 -1	WBX-B	84255
Voltage Doubler	230 VAC	1/6 - 1/3	2XV-03(1)	58575
		1/2 - 1	2XV-10(1)	57576
Magnetic Bypass	230 VAC	1 1/2	MB(1)	18392
		2		18393
		3		18394
		5		18395
	460 VAC	1		18398
		1 1/2		18399
		2		18400
		3		18401
		5		18402
AC Line Circuit Breaker with Handle	230 VAC	1 - 2	CBH(1)	18405
		3 - 5		18406
	460 VAC	1 - 5		18405
AC Line Contactor	230 VAC	1 1/2 - 2	LC(1)	18407
		3 - 5		18408
	460 VAC	1 - 5		18407
Motor Contactor	230 VAC	1 1/2 - 2	MC(1)	18409
		3 - 5		18410
	460 VAC	1 - 5		18409
Overload Relay	230 VAC	1 1/2	OR(1)	18414
		2		18416
		3		18417
		5		18418
	460 VAC	1		18413
		1 1/2		18415
		2		18414
		3 - 5		18416
HAND-OFF-AUTO Switch	230 VAC	1 1/2 - 5	HOA	18421
	460 VAC	1 - 5		
Input Line Chokes (Open)	230 VAC	1 - 2	LCO(1)	18422
		3		18423
		5		18424
	460 VAC	1 - 1 1/2		18427
		2 - 3		18428
		5		18429
Input Line Chokes (Enclosed)	230 VAC	1 - 2	LCE(1)	18432
		3		18433
		5		18434
	460 VAC	1 - 1 1/2		18437
		2 - 3		18438
		5		18439
Output Line Filter (Open)	460 VAC	1 - 2	LFO(1)	18442
		3 - 5		18443
Output Line Filter (Enclosed)	460 VAC	1 - 2	LFE(1)	18445
		3 - 5		18446
Electronic Braking	230 VAC	1 1/2	EB(1)	18449
		2		18450
		3		18451
		5		18452
	460 VAC	1		18455
		1 1/2		18456
		2		18457
		3		18458
		5		18459
RUN/STOP Switch	ALL	ALL	RSS	58578
Washdown Duty - Integral Operator Controls	ALL	ALL	WD	CF
Washdown Duty - without Operator Controls	ALL	ALL	WDB	CF

(1) Provided as a separate assembly for customer mounting and connections.

Single and Three Phase Adjustable Frequency AC Motor Controller

ACX Series
1/6 – 75 Horsepower
230 and 460 VAC

The ACX Series micro-controllers are OEM designed, microprocessor based software controlled units representing the latest advances in AC drive technology. The ACX couples state of the art inverter technology with simple easy-to-use features, providing a compact affordable AC drive. With the capabilities of drives costing hundreds of dollars more, the ACX is suitable for any OEM budget. These controllers are UL and cUL certified. Also, they include the CE mark through 10 horsepower.

DESIGN FEATURES AND FUNCTIONS

1. **Construction** – Furnished in a rugged NEMA 1 ventilated enclosure or a NEMA 4 washdown enclosure. The unit consists of five primary components: (1) an aluminum heatsink, (2) a power cube assembly, (3) a power board, (4) an integrated logic board and (5) the non-metallic housing which contains a membrane keypad. Power connections are easily accessible via a removable panel located at the bottom of the unit. The three phase ACX units are self-cooling at 2HP, 230 VAC and 5HP, 460 VAC and below. Units above these ratings are fan cooled.
2. **Microprocessor Design** – The ACX utilizes a powerful 16-bit microprocessor for logic, communications and regulator functions.
3. **Power Devices** – The ACX incorporates state-of-the-art insulated gate bi-polar transistor (IGBT) output power switches. IGBTs require less gate drive power which reduces the internal temperature of the drive. Fast turn off prevents damage in the event of an output short circuit.
4. **PWM Modulation Technique** – The ACX controllers utilize a modified voltage vector modulation for smooth motor operation. Asynchronous modulation eliminates the "gear shifting" sound made by AC drives using older technology.
5. **Operator Panel** – ACX units include a versatile digital control panel mounted on the front cover of the controller. The panel includes a membrane keypad and an LED display for set-up and monitoring of all controller functions, operating parameters, and self diagnostics. The panel is also used as a local operator control station.

   A. Display: 3-digit, 7-segment alphanumeric LED panel displays motor speed and indicates all programmable functions and faults.

B. Keypad: 6 tactile feedback buttons are provided for programming and local operator control.

1. **FWD** – Provides forward run function.
2. **REV** – When enabled, will provide reverse run function (may be enabled or disabled by programming the Reverse Enable Parameter).
3. **STOP (controlled)** – Local stop.
4. **MODE** – Monitor (displays parameter value), Parameter Selection (selects a parameter to edit), Data Entry (edits a parameter value).
5. **Up Arrow** – Increments upward to desired data to be set; allows parameter values to be changed; increases motor speed in the run mode; moves within display and trip modes.
6. **Down Arrow** – Increments downward to desired data to be set; allows parameter values to be changed; decreases motor speed in the run mode; moves within display and trip modes.

ACX KEYPAD

C. Security Code: All ACX adjustments may be protected by a password access scheme at the owner's discretion. Once the password has been entered, the user may adjust any drive parameter. The user may adjust certain parameters (such as run speed) without entering a password. If desired, the user may program password protection for all drive parameters.

Single and Three Phase Adjustable Frequency AC Motor Controller

ACX Series
1/6 – 75 Horsepower
230 and 460 VAC

DESIGN FEATURES AND FUNCTIONS (Continued)

6. **Operating Modes** – The ACX provides three basic operating modes selectable via the operator panel.
   - **A. Monitor Mode:** Will display but not change parameters. Allows the user to monitor all of the drive parameters and conditions. The up/down arrow keys will function as a digital speed pot if enabled. The rate at which the run speed command is changed in this mode is controlled by the acceleration and deceleration time parameters.
   - **B. Parameter Selection Mode:** Entered from the Monitor Mode by pressing the Mode key once. The LED panel will display a "P" followed by a two digit number. The up and down arrows allow the parameter number to be changed.
   - **C. Data Entry Mode:** Allows parameter values to be changed by the up/down keys. If the parameter is editable, the decimal point will flash at a 1 second rate. Editing data is always terminated by pressing the Mode key. Data may not be edited when: (1) the data is read only, (2) operating conditions are such that it is not safe or technically impossible, (3) during a fault condition, or (4) when password protection has been activated.
7. **Non-Volatile Parameter Storage** – User parameter settings are stored permanently in memory (EEPROM). The user must save the parameters for these settings to be maintained when power is removed from the ACX.
8. **Control Power Supply** – A +24VDC isolated power supply is provided for pushbuttons and external Run-Stop logic.
9. **Power Loss Ride-Through** – The ACX can maintain motor control during periods of input power loss for a minimum of 0.1 seconds.
10. **Automatic Restart** – The ACX can be programmed to automatically restart after any drive fault. This feature allows the user to program the number of restart tries as well as the elapsed time between these tries. The ACX must be configured for Line Starting for automatic restart to function properly.
11. **Line Starting Capability** – Causes the motor to start upon application of power to the drive.
12. **Start Into a Rotating Motor** – When programmed for this mode of operation, the ACX can start while the motor is still spinning. The drive will not trip and the motor will not necessarily be brought to zero speed. The connected inertia may not exceed 5 times the rotor inertia for this feature to operate correctly.
13. **Resonant Frequency Avoidance** – The ACX can be programmed to accelerate or decelerate through, but not continuously run at certain frequencies that may cause mechanical and or acoustic resonance. The avoidance point may be programmed by setting a center point and band width. Up to three points may be programmed.
14. **AC Line Voltage Compensation** – Holds output voltage constant with rated line voltage variations when output voltage is less than line voltage (10% line voltage variation causes 1% output voltage variation).
15. **Multiple Motor Operation** – The ACX is capable of operating multiple motors at a common frequency. Total Amp draw of the motors cannot exceed the controller's rating.
16. **Torque Boost** – Improves torque capacity at lower speeds. ACX torque boost provides a programmable boost level for optimal starting performance.

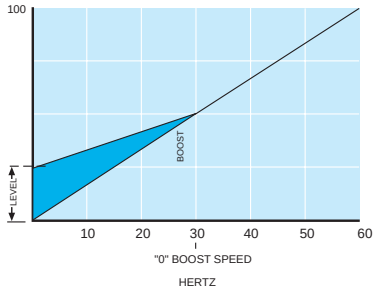


FIGURE 3. TORQUE BOOST

17. **DC Injection Braking** – This feature is adjustable for activation on start, stop, or start and stop and is programmed by setting a braking level and time period.
18. **Volts/Hertz Adjustment** – Volts/Hertz may be trimmed to ±20% of nominal.
19. **Volts/Hertz Patterns** – 21 pre-programmed patterns are provided as shown in the tables below. They provide constant horsepower and/or constant torque patterns for a wide range of applications.

Pattern Number	0	1*	2	3	4	5	6	7	8	9	10
Frequency At Full Output Voltage	50	60	90	120	180	240	400	50	60	60	60
Maximum Frequency	50	60	90	120	180	240	400	55	66	90	120

*Factory Default

Pattern Number	11	12	13	14	15	16	17	18	19	20
Frequency At Full Output Voltage	60	60	60	90	90	90	90	120	120	120
Maximum Frequency	180	240	400	120	180	240	400	180	240	400

20. **Slip Compensation** – Programmable slip compensation is provided to correct for induction motor speed droop or slip and thereby improve speed regulation.
21. **Electronic Inverse Time Motor Overload Protection** – Provides a programmable threshold and time to trip to reduce the potential of costly motor damage.
22. **Static Reversing Control** – Contactorless reversing is a standard capability and is enabled via parameter selection. Direction may also be selected by external control contacts.

DESIGN FEATURES AND FUNCTIONS (Continued)

23. Protective Features –

A. Inverter Trip: Due to overvoltage, overcurrent, undervoltage, overload and CPU error.

B. Output Fault Protection: The unit is protected from line-to-line output short circuits. Also, models with a "WD" suffix have line to ground output protection as well.

C. Instantaneous Power Failure: The unit will shut down safely after a power loss greater than approximately 0.1 second. The ACX will automatically restart if power is restored within one second.

D. Overvoltage and Undervoltage Protection: Electronic shutdown when the bus voltage is outside normal operating limits.

24. Fault Trip Reset – Faults are cleared on the ACX by (a) pressing the stop button, (b) opening and closing a maintained run contact, or (c) removing and then reapplying AC power.

25. Fuse Protection – An external AC line fused disconnect or circuit breaker must be provided by the user in accordance with electrical codes.

26. Regeneration Limit – Designed to eliminate drive trips when excessive braking energy is transferred from the motor to the control. Regeneration limit will perform in the following fashion:

(a) Will extend decel time to prevent bus overvoltage trip with high inertia loads.
(b) Will increase output frequency to user programmed maximum frequency range during overhauling loads.

27. Analog Signal Inputs – One analog signal input is provided. The associated external signals may be grounded or ungrounded. This input is programmable for the following functions:

(a) Run Speed Command (b) Current Limit
(c) None (input is unused)

28. Digital Control Inputs – Two digital inputs are provided, programmable for the following functions.

(a) Forward (b) Reverse
(c) Stop (d) Preset Speed Selection

All inputs are designed to be used with the +24 VDC control voltage supplied by the ACX. The ACX can be started and stopped by either maintained contacts or momentary pushbuttons.

29. Current Limit – Limits the motor output current to prevent overcurrent trips during acceleration. The current limit is adjustable from 50% to 200% of the rated motor full load current.

30. Programmable Stopping Modes – The ACX can be programmed for controlled stop (using deceleration time control) or coast-to-stop operation.

31. Preset Speeds – The ACX can be programmed to operate in the forward direction at up to three preset speeds selected by two programmable digital inputs.

32. Drive OK Relay Contact – The ACX includes a drive OK relay contact which is closed whenever power is applied to the control and the drive is not faulted. The contact opens when power is removed and the DC bus voltage drops below the minimum bus voltage for drive operation. The contact also will open if the controller should fault.

33. Electronic Braking – The ACX has an option to add an external braking resistor and circuitry for increased motor braking torque. (Units sized 1-1/2 HP, 230 VAC and 1HP, 460 VAC and greater)

RATINGS

1. Horsepower Range:
115 VAC Single Phase . . . . . .(input) 1/6-1 HP(1)
208/230 VAC Single Phase . . . . . .(input) 1/6-5 HP
208/230 VAC Three Phase . . . . . .(input) 1/6-30 HP
460 VAC Three Phase . . . . . .1-75 HP

2. Power Source:
. . . . . 115 VAC, 1 Phase 50/60 Hz(1)
. . . . . 208/230 VAC, 1 or 3 Phase 50/60 Hz
. . . . . 460 VAC, 3 Phase 50/60 Hz

3. Output Power
(a) Voltage . . . . . .0 - 208/230 or 0 - 460, Three Phase
(b) Frequency . . .0 - 400 Hz Constant Torque/Constant Horsepower

4. Service Factor 1.0

5. Duty . . . . . .Industrial, Continuous

6. Overload Capacity . . . . . .150% for 1 Minute

7. Linearity
(a) Digital Input . . . . . .±0.1% Maximum
(b) Analog Input . . . . . .±1.0% Maximum

8. Analog Reference(2) . . . . . .+10 VDC (for 5K ohm load)

9. External Analog Reference Source . . . . .0 – 10 VDC, 4 - 20 mA (requires external 500 ohm resistor)

10. Magnetic (Pushbutton) Control Voltage . . .+24 VDC

11. Storage Temperature . . . . . .32° – 168° F (0° – 70°C)

(1) Optional voltage doubler (2XV) required for 115 VAC operation.

(2) An isolated reference. External control signals may be grounded or ungrounded. Offset and scaling are programmable.

ADJUSTMENTS

All adjustments are programmed using the standard, integral operator keypad.

1. Acceleration (linear or S-curve)
(a) Linear . . . . . .0.1 to 999 Seconds
(b) S-curve . . . . . .6.0 to 150 Seconds

2. Deceleration (linear or S-curve)
(a) Linear . . . . . .0.1 to 999 Seconds
(b) S-curve . . . . . .6.0 to 150 Seconds

3. Minimum Speed . . . . . .0 – 75% of Maximum Speed

4. Maximum Speed . . . .50 –100% of Motor Base Speed

5. Current (Torque) Limit . . . . . .50 – 200% of Rated

6. Low Frequency Voltage Boost . . . . . .0 – 30%

7. Slip Compensation . . . . . .0 – 100%

8. Volts/Hertz Trim . . . . . .±20% of Nominal

9. Preset Speeds, 3 Provided . . . . . .0 – 100% Speed

Single and Three Phase Adjustable Frequency AC Motor Controller

ACX Series
1/6 – 75 Horsepower
230 and 460 VAC

PERFORMANCE CHARACTERISTICS

1. **Controlled Speed Range** – Zero to motor base speed, constant or variable torque with NEMA design B AC induction motors. Constant horsepower is also programmable.
2. **Speed Regulation** – Regulation percentages listed in Table are of motor rated (base) speed under steady-state operating conditions.

SPEED REGULATION CHARACTERISTICS (1)

Regulation Method	Motor Type		Change 95%	Load Voltage ±10%	Line Cold to Normal	Motor Heating Temperature ±10°C
	NEMA B	SYNCHRONOUS				
Normal	X		3.0%	±0.5%	1.0%	±0.5%
		X	0.0%	±0.0%	0.0%	±0.5%
Slip Comp.	X		1.0%	±0.5%	1.0%	±0.5%

(1) Average expected values are dependent upon individual motor characteristics.

3. **Frequency Resolution:**
   Digital Input . . . . . .0.01% of Maximum Frequency
   Analog Input . . . . . .0.03% of Maximum Frequency
4. **Frequency Stability:**
   Digital . . . . . .±0.5% of Set Point (or better)
   Analog . . . . .±1% of Maximum Frequency (or better)
5. **Efficiency (at rated speed, rated load):**
   Control 95%
   Control and Motor (assumes 89% motor efficiency)85%
   (assumes 93% motor efficiency)88%
6. **Displacement Power Factor** . . . . . .Greater than 96%
7. **Torque** . . . . . .Minimum developed torque under any operating condition will not be less than 150%

OPERATING CONDITIONS

1. **Line Voltage Variation** . . . . . .±10% Rated
2. **Line Frequency Variation** . . . . . .±2 Hz
3. **Ambient Temperature** . . . . . .32° to 104°F (0° – 40°C)
4. **Ambient Humidity** . . . . . .95% Non-condensing
5. **Altitude (Standard)** 3300 Feet (1000 meters) Maximum

TYPICAL APPLICATION DATA

SINGLE-PHASE 115/208/230 VAC INPUT

Motor		Controller									
		115 VAC		208 VAC			230 VAC			Catalog Number (NEMA 1)	Catalog Number (NEMA 4)
HP	KW	KVA	Input Amps	KVA	Input Amps	Output Amps*	KVA	Input Amps	Output Amps*		
1/6	0.12	ACX2003 and 2XV-03		0.42	2.0	0.94	0.44	1.9	0.85	ACX2003	ACX2005-WD
1/4	0.19			0.52	2.5	1.5	0.55	2.4	1.4		
1/3	0.25			0.71	3.4	2.0	0.76	3.3	1.8		ACX2010-WD
1/2	0.37	ACX2010 and 2XV-10		0.99	4.8	2.2	1.10	4.8	2.0	ACX2010	
3/4	0.56			1.54	7.4	3.1	1.54	6.7	2.8	ACX2015	ACX2015-WD
1	0.75			2.00	9.6	3.9	2.00	8.7	3.6	ACX2020	ACX2020-WD
1 1/2	1.12	—		2.91	14.0	5.7	2.92	12.7	5.2	ACX2030	ACX2030-WD
2	1.50	—		3.58	17.2	7.5	3.57	15.5	6.8	ACX2050	ACX2050-WD
3	2.24	—		5.35	25.7	10.6	5.36	23.3	9.6	ACX2075	ACX2075-WD
5	3.73	—		8.92	42.9	16.7	8.92	38.8	15.2	ACX2100	ACX2100-WD

*3-phase output

THREE-PHASE 208/230 VAC INPUT

Motor		Controller							
		208 VAC			230 VAC			Catalog Number (NEMA 1)	Catalog Number (NEMA 4)
HP	KW	KVA	Input Amps	Output Amps	KVA	Input Amps	Output Amps		
1/6	0.12	0.50	1.4	0.94	0.56	1.4	0.85	ACX2003	ACX2005-WD
1/4	0.19	0.58	1.6	1.5	0.64	1.6	1.4		
1/3	0.25	0.79	2.2	2.0	0.88	2.2	1.8		
1/2	0.37	1.01	2.8	2.2	1.12	2.8	2.0	ACX2010	ACX2010-WD
3/4	0.56	1.44	4.0	3.1	1.59	4.0	2.8		
1	0.75	1.73	4.8	3.9	1.83	4.6	3.6		
1 1/2	1.12	2.77	7.7	5.7	2.79	7.0	5.2	ACX2015	ACX2015-WD
2	1.50	3.39	9.4	7.5	3.39	8.5	6.8	ACX2020	ACX2020-WD
3	2.24	5.12	14.2	10.6	5.10	12.8	9.6	ACX2030	ACX2030-WD
5	3.73	8.50	23.6	16.7	8.49	21.3	15.2	ACX2050	ACX2050-WD
7 1/2	5.60	12.6	35.0	24.2	12.6	31.6	22.0	ACX2075	ACX2075-WD
10	7.46	16.6	46.1	30.8	16.6	41.7	28.0	ACX2100	ACX2100-WD
15	11.2	24.1	67.2	46.2	24.2	60.8	42.0	ACX2150	ACX2150-WD
20	14.9	32.3	89.6	59.4	32.3	81.1	54.0	ACX2200	ACX2200-WD
25	18.6	39.9	111.0	74.8	39.9	100.0	68.0	ACX2250	–
30	22.4	47.9	133.0	88.0	47.9	120.0	80.0	ACX2300	–

THREE-PHASE 460 VAC INPUT

Motor		Controller				
		460 VAC			Catalog Number (NEMA 1)	Catalog Number (NEMA 4)
HP	KW	KVA	Input Amps	Output Amps		
1	0.75	1.91	2.4	1.8	ACX4010	ACX4010-WD
1 1/2	1.12	2.79	3.5	2.6	ACX4015	ACX4015-WD
2	1.50	3.43	4.3	3.4	ACX4020	ACX4020-WD
3	2.24	5.10	6.4	4.8	ACX4030	ACX4030-WD
5	3.73	8.53	10.7	7.6	ACX4050	ACX4050-WD
7 1/2	5.60	12.7	16.0	11.0	ACX4075	ACX4075-WD
10	7.46	16.6	20.9	14.0	ACX4100	ACX4100-WD
15	11.2	24.9	31.3	21	ACX4150	ACX4150-WD
20	14.9	31.6	39.7	27	ACX4200	ACX4200-WD
25	18.6	39.7	49.8	34	ACX4250	ACX4250-WD
30	22.4	47.6	59.7	40	ACX4300	ACX4300-WD
40	29.8	63.5	79.6	52	ACX4400	–
50	37.3	79.0	99.1	65	ACX4500	–
60	44.8	94.8	119	77	ACX4600	–
75	56.0	118.0	149	96	ACX4750	–

PARAMETERS

PROGRAMMABLE

P00	Password Entry
P01	Run Speed Command
P02	Minimum Speed
P03	Maximum Speed
P04	Acceleration Time
P05	Deceleration Time
P06	Motor Full Load Amps
P07	Nominal Line Voltage
P08	Save Parameters
P09	Current Limit
P10	Boost Level
P11	Slip Compensation
P12	Ramp Type
P13	Analog Input Mode
P14	Analog Input Invert
P15	Run Speed Source
P16	Current Limit Source
P17	DC Injection Braking on Start
P18	DC Injection Braking on Stop
P19	DC Injection Braking Level
P20	DC Injection Braking Time
P21	Speed Avoidance Band #1
P22	Speed Avoid Band #1 Width
P23	Speed Avoidance Band #2
P24	Speed Avoid Band #2 Width
P25	Speed Avoidance Band #3
P26	Speed Avoid Band #3 Width
P27	Forward Enable
P28	Reverse Enable
P29	Remote Stop
P30	Remote Maintained Run
P31	Keypad Speed Adjust
P32	Stopping Mode
P33	Line Starting
P34	Rotating Motor Starting
P35	Overload Threshold
P36	Overload Time
P37	Restart Tries
P38	Restart Window
P39	Restart Delay
P40	V/F Profile List
P41	Volts Hertz
P42	Preset Speed Enable
P43	Preset Speed #1
P44	Preset Speed #2
P45	Preset Speed #3
P46	Electronic Braking Enable
P47	Analog Input Offset
P48	Analog Input Trim
P49	Keypad Run Enable
P94	Start Delay
P95	Monitor Parameter
P96	Factory Preset
P97	Reset Drive
P98	Global Password
P99	User Password

READ ONLY

P50	Frequency
P51	Analog Input
P52	Speed Command
P53	Speed Operator Control
P54	Final Speed Reference
P55	Speed Accel/Decel
P56	Speed Current Limit Input
P57	Speed Correction
P58	Final Speed Output
P59	Voltage Volts Hertz Profile
P60	Current Error
P61	Motor Voltage
P62	Bus Voltage
P63	Bus Voltage
P64	Bus Voltage Integrator
P65	Motor Amps
P66	Motor Amps
P67	Current Setpoint
P68	Current Limit Integrator
P69	Slip Compensation Torque
P70	Overload Integrator
P71	Overload Trip
P72	DC Injection Braking Timer
P73	Disable Timer
P74	Frequency Scale
P75	PWM Frequency
P76	PWM Voltage
P77	Speed Search Volts/Hertz
P78	Speed Search Timer
P79	Match Speed
P80	Fault Code
P81	Start Again Timer
P82	Digital Inputs
P83	Last Digital Inputs
P84	Logic State
P85	Status
P86	Status 2
P87	Flags

MODEL TYPES

The ACX Series of controllers are offered as a NEMA 1 or NEMA 4 enclosed controllers. These units are available in either 115 VAC (with voltage doubler), 208/230 VAC or 460 VAC input voltages covering a range of 1/6 to 75 HP as shown.

ORDER BY CATALOG NUMBER OR ITEM CODE

Input Voltage	Motor HP	Motor Max. KW	Rated Output Amps (2) 208 VAC	Rated Output Amps (2) 230 VAC	Catalog Number (NEMA 1)	Item Code	Catalog Number (NEMA 4)	Item Code
115 VAC Single Phase 50/60 Hz	1/6-1/3(1)	0.25	2.0	1.8	ACX2003 and 2XV-03	08100 and 58575	–	–
	1/2-1(1)	0.75	3.9	3.6	ACX2010 and 2XV-10	08102 and 58576		
208/230 VAC Single Phase 50/60 Hz	1/6-1/4	0.19	1.5	1.4	ACX2003	08100	ACX2005-WD	63134
	1/3	0.25	2.0	1.8			ACX2010-WD	63135
	1/2	0.37	2.2	2.0	ACX2010	08102		
	3/4	0.56	3.1	2.8	ACX2015	07085	ACX2015-WD	63136
	1	0.75	3.9	3.6	ACX2020	07086	ACX2020-WD	63137
	1 1/2	1.12	5.7	5.2	ACX2030	07087	ACX2030-WD	63138
	2	1.50	7.5	6.8	ACX2050	07097	ACX2050-WD	63139
	3	2.24	10.6	9.6	ACX2075	07108	ACX2075-WD	63140
	5	3.73	16.7	15.2	ACX2100	85455	ACX2100-WD	63141
208/230 VAC Three Phase 50/60 Hz	1/6-1/3	0.25	2.0	1.8	ACX2003	08100	ACX2005-WD	63134
	1/2	0.37	2.2	2.0	ACX2010	08102		
	3/4-1	0.75	3.9	3.6			ACX2010-WD	63135
	1 1/2	1.12	5.7	5.2	ACX2015	07085	ACX2015-WD	63136
	2	1.50	7.5	6.8	ACX2020	07086	ACX2020-WD	63137
	3	2.24	10.6	9.6	ACX2030	07087	ACX2030-WD	63138
	5	3.73	16.7	15.2	ACX2050	07097	ACX2050-WD	63139
	7 1/2	5.60	24.2	22.0	ACX2075	07108	ACX2075-WD	63140
	10	7.46	30.8	28.0	ACX2100	85455	ACX2100-WD	63141
	15	11.2	46.2	42	ACX2150	60537	ACX2150-WD	63142
	20	14.9	59.4	54	ACX2200	60538	ACX2200-WD	63143
	25	18.6	74.8	68	ACX2250	60539	–	–
	30	22.4	88	80	ACX2300	60540	–	–
460 VAC Three Phase 50/60 Hz			460 VAC					
	1	0.75	1.8		ACX4010	07111	ACX4010-WD	63144
	1 1/2	1.12	2.6		ACX4015	85456	ACX4015-WD	63154
	2	1.50	3.4		ACX4020	07117	ACX4020-WD	63145
	3	2.24	4.8		ACX4030	07121	ACX4030-WD	63146
	5	3.73	7.6		ACX4050	07122	ACX4050-WD	63147
	7 1/2	5.60	11.0		ACX4075	07124	ACX4075-WD	63148
	10	7.46	14.0		ACX4100	85457	ACX4100-WD	63149
	15	11.2	21.0		ACX4150	60541	ACX4150-WD	63150
	20	14.9	27		ACX4200	60542	ACX4200-WD	63151
	25	18.6	34		ACX4250	60543	ACX4250-WD	63152
	30	22.4	40		ACX4300	60544	ACX4300-WD	63153
	40	29.8	52		ACX4400	60545	–	–
	50	37.3	65		ACX4500	60546	–	–
	60	44.8	77		ACX4600	50647	–	–
	75	56.0	96		ACX4750	60548	–	–

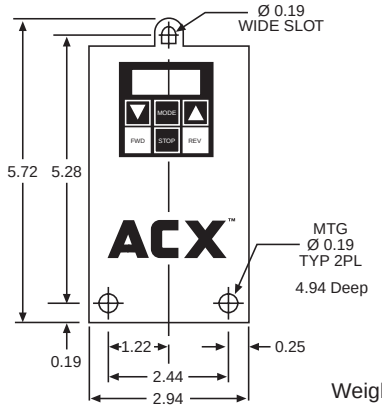
(1) For HP/Voltage rating shown, both the controller and option are required.
(2) At maximum horsepower rating.

Single and Three Phase Adjustable Frequency AC Motor Controller

ACX Series
1/6 – 75 Horsepower
230 and 460 VAC

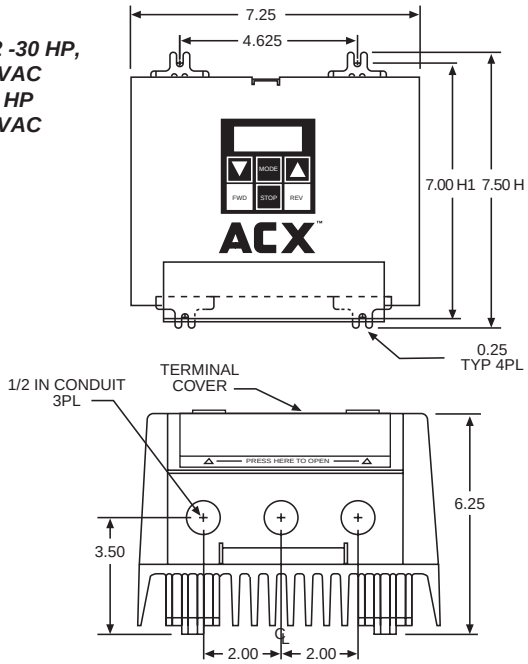
DIMENSIONS FOR NEMA 1 CONTROLLERS

1/6 -1 HP, 230 VAC



Weight 1.8 lbs

1 1/2 -30 HP, 230 VAC 1-75 HP 460 VAC



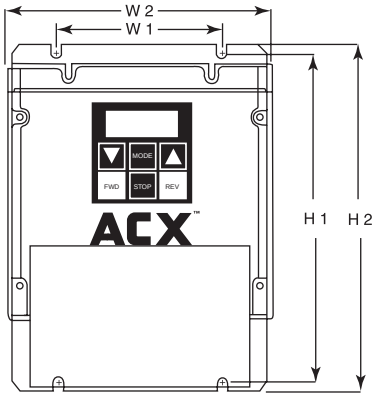
HP	Voltage	H	W	D	Mounting		Weight (lbs.)
					H1	W1	
1.5-5	230	7.50	7.25	6.25	7.00	4.63	5.6
1-10	460	7.50	7.25	6.25	7.00	4.63	5.6
7.5-10	230	12.0	7.25	6.25	11.5	4.63	7.2
15	460	12.0	7.25	6.25	11.5	4.63	12.7
15-20	230	15.94	7.25	9.13	13.63	4.63	25
20-30	460	15.94	7.25	9.13	13.63	4.63	27
25-30	230	25.25	7.25	9.13	21.88	4.63	37
40	460	22.13	7.25	9.13	19.63	4.63	30
50	460	25.13	7.25	9.13	22.63	4.63	30
60-75*	460	27.00	14.38	9.13	26.25	11.75	55

*Dimensions and weight of 60-75HP are preliminary and subject to change.

DIMENSIONS FOR NEMA 4 CONTROLLERS

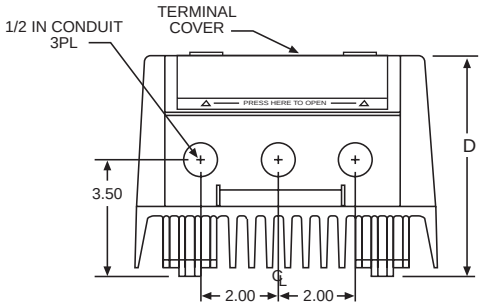
DIMENSIONS-THREE PHASE UNITS

1/2 -20 HP 230 VAC 1-30 HP 460 VAC



HP	Voltage	H 2	W 2	D	Mounting		Weight (lbs.)
					H1	W1	
1/2-2	230	8.75	7.438	9.38	8.25	4.625	5.6
1-3	460						
3-5	230	8.75	7.438	10.50	8.25	4.625	7.6
5-10	460						
7.5-10	230	12.75	7.438	10.75	12.25	4.625	12.7
15	460						
15-20	230	15.75	7.438	10.75	15.25	4.625	27.0
25-30	460						

DIMENSIONS-SINGLE PHASE UNITS



HP	Voltage	H 2	W 2	D	Mounting		Weight (lbs.)
					H1	W1	
1/4-2	230	8.75	7.438	9.38	8.25	4.625	5.6
1 1/2-2	230	8.75	7.438	10.50	8.25	4.625	7.6
3-5	230	12.75	7.438	10.75	12.25	4.625	12.7

B

OPTIONS

Complete option descriptions are listed in the AC option section. To order a kit for field installation order by the item code if shown.

Option	Voltage and Horsepower		Option Number	Field Kit Item Code
Din Rail Mounting Kit	230 VAC	1/6 - 1	DIN	58572[2]
Conduit Box	230 VAC	1/6 - 1	WBX	58573[2]
Local Speed Potentiometer	ALL	ALL	LSP	58574[2]
Door Mounting Kit	230 VAC	1/6 - 1	DMK	58579[2]
Voltage Doubler	230 VAC	1/6 - 1/3	2XV-03[1]	58575[2]
		1/2 - 1	2XV-10[1]	58576[2]
Magnetic Bypass	230 VAC	1 1/2	MB[1]	18392[2]
		2		18393[2]
		3		18394[2]
		5		18395[2]
		7 1/2		18396[2]
		10		18397[2]
		15-30		CF
	460 VAC	1		18398[2]
		1 1/2		18399[2]
		2		18400[2]
		3		18401[2]
		5		18402[2]
		7 1/2		18403[2]
		10		18404[2]
		15-75		CF
AC Line Circuit Breaker with Handle	230 VAC	1 - 2	CBH[1]	18405
		3 - 5		18406
		7 1/2 - 10		82926
		15-30		CF
	460 VAC	1 - 5		18407[2]
		7 1/2 - 10		18408[2]
		15 - 75		CF
AC Line Contactor	230 VAC	1 1/2 - 2	LC [1]	18407[2]
		3 - 5		18408[2]
		7 1/2 - 10		83460[2]
		15-30		CF
	460 VAC	1 - 5		18407[2]
		7 1/2 - 10		18408[2]
		15-75		CF
Motor Contactor	230 VAC	1 1/2 - 2	MC [1]	18409[2]
		3 - 5		18410[2]
		7 1/2 - 10		18411[2]
		15-30		CF
	460 VAC	1 - 5		18409[2]
		7 1/2 - 10		18410[2]
		15-75		CF
Overload Relay	230 VAC	1 1/2	OR [1]	18414[2]
		2		18416[2]
		3		18417[2]
		5		18418[2]
		7 1/2		18419[2]
		10		18420[2]
		15-30		CF
	460 VAC	1		18413[2]
		1 1/2		18414[2]
		2		18415[2]
		3 - 5		18416[2]
		7 1/2		18417[2]
		10		18418[2]
		15-75		CF
HAND-OFF-AUTO Switch	230 VAC	1 1/2 - 30	HOA	18421[2]
	460 VAC	1 - 75		
HAND-OFF-AUTO Switch with pot	230 VAC	1 1/2 - 30	HP	CF
	460 VAC	1 - 75		

(Continued)

Single and Three Phase Adjustable Frequency AC Motor Controller

ACX Series
1/6 – 75 Horsepower
230 and 460 VAC

OPTIONS *(Continued)*

Option	Voltage and Horsepower		Option Number	Field Kit Item Code
Input Line Chokes (Open)	230 VAC	1 - 2	LCO (1)	18422(2)
		3		18423(2)
		5		18424(2)
		7 1/2		18425(2)
		10		18426(2)
		15-30		CF
	460 VAC	1 - 1 1/2		18427(2)
		2 - 3		18428(2)
		5		18429(2)
		7 1/2		18430(2)
		10		18431(2)
		15-75		CF
Input Line Chokes (Enclosed)	230 VAC	1 - 2	LCE (1)	18432(2)
		3		18433(2)
		5		18434(2)
		7 1/2		18435(2)
		10		18436(2)
		15-30		CF
	460 VAC	1 - 1 1/2		18437(2)
		2 - 3		18438(2)
		5		18439(2)
		7 1/2		18440(2)
		10		18441(2)
		15-75		CF
Output Line Filter (Open)	460 VAC	1 - 2	LFO (1)	18442(2)
		3 - 5		18443(2)
		7 1/2 - 10		18444(2)
		15-75		CF
Output Line Filter (Enclosed)	460 VAC	1 - 2	LFE (1)	18445(2)
		3 - 5		18446(2)
		7 1/2 - 10		18447(2)
		15-75		CF
Electronic Braking Control Module	ALL	ALL	EB (1)	CF
Electronic Braking Resistor Assembly	ALL	ALL	EBR (1)	CF

(1) Provided as a separate assembly for customer mounting and connections.
(2) This field kit is only for NEMA 1 controllers. Consult factory for part number when used on NEMA 4 controllers.

NOTES

Three Phase Adjustable Frequency AC Motor Controller

ADX Series
1 – 75 Horsepower
230 and 460 VAC

The ADX Series controllers provide wide range adjustable speed control of conventional AC induction motors in applications exhibiting a variety of load characteristics. The unit converts the fixed frequency and voltage of the AC line power source to a sine coded pulse width modulated (PWM) adjustable voltage and frequency output that will control induction motors over a wide speed range.

B

DESIGN FEATURES AND FUNCTIONS

1. **Construction -** Compact, high density, dead back configuration. Standard Series ADX units are furnished in a ventilated NEMA type 1 (IP 20) enclosure. Most units include an external fan to force cooling air over fins on the back of the enclosure to aid dissipation of internal heat.
2. **Microprocessor Design -** Series ADX units use a powerful 16-bit microprocessor for logic, communications, regulator functions, and generation of the PWM waveform to control the motor.
3. **Power Devices -** Series ADX controllers use state of the art Insulated Gate Bipolar Transistor (IGBT) power switches. IGBT's require less gate drive power, which reduces internal controller temperatures. Their extremely high speed switching capability provides a superior waveform for greater starting torque, cooler and virtually inaudible motor operation. Fast turn-off prevents damage in the event of an output short circuit.
4. **PWM Modulation Technique -** Series ADX controllers use modified voltage vector modulation for smooth, quiet motor operation. Asynchronous modulation eliminates undesirable "Gear Shifting" sounds produced by earlier designs. Sensorless Torque Control is selectable and Closed Loop Flux Vector control is available with the addition of option 24E.

OPERATOR PANEL FOR SERIES ADX CONTROLLERS

5. **Operator Panel -** Series ADX units include a versatile, digital operator control panel mounted on the front cover of the unit. The panel includes a membrane keypad, and an LCD display that enables its use for set-up and monitoring of all controller functions, operating parameters, self-diagnostics, and also as a local operator control station. The operator panel is a smooth, unbroken surface, which is easy to keep clean and is sealed to prevent the penetration of liquids and dust.

A. Display - LCD super twist type provides two lines of 16 alphanumeric characters each. Display is backlighted, enabling viewing in extremes of lighting conditions including total darkness and is temperature compensated for reliable viewing. Displays motor speed, motor load, and power, and indicates all programmable functions and faults in English language word messages, no cryptic fault codes are used.

B. Visual Indicators - LED's are provided to indicate power on, direction, run/jog, manual/auto, and "at speed".

C. Keypad - 10 buttons are provided for local operator control and programming. The buttons include a raised perimeter, which defines the operating area, and tactile feedback, which provides confidence that the command has been entered. The keypad is logically designed with two operating areas, one for local operator control, and the other for programming:

1. Local Operator Control - Buttons and their functions:
   a. Stop (controlled) - Oversized button, easy to locate.
   b. Forward (FWD) - Provides forward run/jog function. Includes an LED indicator.
   c. Reverse (REV) - When enabled (at start-up) will provide reverse run function. Includes an LED indicator.
   d. Jog - Alternate presses activate and deactivate the Jog mode. An LED indicator is illuminated when Jog mode is selected. Jog mode makes the operation of the Forward and Reverse buttons momentary.
   e. Alternate presses activate and deactivate the Auto mode. An LED indicator is illuminated when Auto mode is selected. Auto mode allows speed and/or torque control commands to be accepted from alternate or external sources.
   f. Faster - When the "Faster" indicator is illuminated, pressing the up arrow key will increase the local run speed command.

DESIGN FEATURES AND FUNCTIONS

g. Slower - When the “Slower” indicator is illuminated, pressing the down arrow key will decrease the local run speed command.

h. Optional Potentiometer - Space is provided to mount an optional speed setting potentiometer.Option LSP provides a single turn speed setting potentiometer and the dial face for mounting in a dedicated area on the operator panel. The potentiometer is used instead of the faster-slower buttons to set motor speed.

2. Programming Buttons and their functions:

a Menu - Selects adjustable drive parameters, which can then be set with the arrow buttons.

b. Arrow Buttons - Arrow up, arrow down, arrow right, and arrow left buttons are provided to select, program, and monitor all operating parameters.

Optionally, Series ADX units may be provided without the standard, integral, digital operator panel. The ADX in this configuration is then programmed and monitored by a personal computer via the standard serial port.

D. Programming - The ADX controller provides three levels of user programmability.

Level One - Without entering a password or entering the menu operating system, the user may change the motor speed and the display configuration for monitoring purposes.

Level Two - Upon entering the menu system by pressing the Menu button, the user may adjust any of the most commonly adjusted parameters without entering a password. These parameters are listed as adjustments under ADJUSTMENTS - Page 94 (excludes preset speeds and field trim).

Level Three - Upon entering the menu system and entering a password, the operator has access to all programmable features of the ADX. This level is intended for complex or nonstandard control applications. A partial list of available functions includes:

a. Line Starting
b. Operating Patterns
c. Volts/Hertz
d. Resonant Frequency Avoidance
e. Carrier Frequency Select
f. Static Braking
g. DC Injection Braking
h. Start into Rotating Motor
i. Inverse Time Overload
j. Torque Boost
k. Regeneration Limit
l. Dwell
m. Torque Taper
n. Auto Restart
o. PID Control
p. Digital Input Selection
q. Digital Signal Output
r. Analog Signal Input Selection
s. Analog Output
t. Operating Mode Selection

E. Security Code - All ADX adjustments may be protected by a “password” access scheme. Once the password has been entered, the user may remove password protection from commonly adjusted parameters that need not be restricted.

6. Keypad Operator Disable - The Operator control functions described above can be disabled if desired by changing a parameter in the ADX Drive.

7. Operating Modes - Series ADX controllers provide three basic operating modes selectable via the operator panel.

A. Control Mode - Permits Run-Stop-Jog-Reverse-Manual/Auto functions and speed control from the integral operator panel, a remote control station, or an external signal source such as a process controller.

B. Monitor Mode - In monitor mode the operating state of the ADX may be observed. English language messages and/or a parameter number inform the operator of the parameter being displayed. The unit may be programmed so any two of the following parameters may be displayed simultaneously.

1. Drive Legend (Assigned Name)
2. Custom Parameter
3. Speed Reference
4. Motor Speed
5. Output Power
6. Torque Limit Set-point
7. Motor Load
8. Output Frequency
9. Output Voltage
10. Ratio
11. Status
12. Operating Hours
13. None (Display Not Used)
14. Motor Current
15. Extended Monitor
16. Date and Time

C. Programming Mode - Allows monitoring and adjustment of all ADX parameters. Parameters are grouped logically into menus using descriptive English names and a companion identification number for ease of location. Parameters are grouped indescending order from those most general to those more specific for operational simplicity and quick selection.

8. Control Power Supply - A 24 VDC power supply isolates all magnetic control for pushbuttons and external Run-Stop logic from the AC power source for operator protection and equipment reliability.

9. Over voltage and Under voltage Protection - Electronic shutdown when line voltage exceeds approximately +10 % or -30% of rated line voltage.

10. Power Loss Ride Through - The controller has sufficient energy storage to maintain control of the motor for at least 1 second whenever the AC power source is interrupted. Upon reapplication of AC line power within 1 second, the motor will resume its set speed with a minimum of disturbance. The amount of speed droop during the power outage will be determined by the actual motor loading and other mechanical time constants.

11. Power Loss Shutdown - During power interruption, if power is lost for longer than 1 second, a power loss fault is registered. If a phase of the AC Input is missing for more than 1 second, a phase loss fault will be issued if the drive is running.

Three Phase Adjustable Frequency AC Motor Controller

ADX Series
1 – 75 Horsepower
230 and 460 VAC

DESIGN FEATURES AND FUNCTIONS

12. **Automatic Restart -** Series ADX units may be programmed for automatic restart after any or all of the faults listed under STANDARD DIAGNOSTIC FEATURES, item 3, Faults (Page 95). This feature allows the user to program the number of tries as well as the retry time. Units in the restart mode will display "Restarting".
13. **Start into Rotating Motor -** The unit can be programmed to start into a spinning motor. When programmed for this mode of operation, the ADX can start while the motor is still spinning. The drive will not trip and the motor will not necessarily be brought to zero speed.
14. **Line Starting Capability -** The unit can be programmed to start when the main AC power is applied to its input terminals.
15. **Visual Indicators -** LED indicators are provided to monitor circuit operation and aid in troubleshooting. Included are individual red LED's showing FWD, REV, JOG, AUTO, POWER, and AT SPEED status.
16. **Multiple PWM Carrier Frequencies -** The user can program carrier frequencies of 2, 3, 4, 5, 6, 7, 8, 9, and 10 KHZ. The most efficient operation is produced at the lower carrier frequencies. Series ADX units through 75 HP are shipped programmed for 5 KHz.
17. **AC Line Voltage Calibration -** Holds output voltage constant with rated line variations when output voltage is less than line voltage (10% line voltage variation causes 1% output voltage variation).
18. **Volts/Hertz, Sensorless Torque, or Closed Loop Flux Vector Control Operation -** In the Volts/Hertz mode the Volts/Hertz ratio may be trimmed ±20% of nominal. In the Sensorless Torque Control or Closed Loop Flux Vector mode the Motor Torque may be adjusted from 50 to 200% of nominal.
19. **Run/Stop Control -** Series ADX controllers can be remotely started and stopped by:
    1. 2 wire control (maintained dry contact)
    2. 3 wire control
    3. Application of AC Line power
20. **Jog Control -** The ADX features a separate jog function with unique directional acceleration/deceleration rates. This feature allows hard or ramp acceleration on jog without affecting run operation.
21. **Isolated Regulator -** Internal logic and control circuits are isolated from the AC power source and internal DC power circuitry for operator and equipment safety and for simplified application. Isolation eliminates the common condition of line voltage to ground potentials being present on the speed control potentiometer.
22. **PID Control -** A built in Proportional Integral Derivative type control is standard in the ADX. Provides outer loop control of speed, flow, pressure, fluid level, or other process variables. The PID loop may be programmed to accept set-point/feedback input or error input. A flexible configuration scheme allows PID inputs to be either analog or digital with PID gains being separately adjustable.
23. **Dwell Feature -** The Standard Series ADX units incorporate this feature providing an adjustable Dwell time and Dwell Speed. This feature is commonly used in pumping HVAC applications. The dwell feature halts acceleration for a period of time at a programmed Dwell Speed.
24. **Resonant Frequency Avoidance -**The ADX controller can be programmed to accelerate or decelerate through, but not continuously run at certain frequencies that may cause mechanical and or acoustic resonance. These frequencies are determined by setting a center point and width. Three programmable frequency bands are offered.
25. **Multiple Motor Operation -** All motors will track the common output frequency of the Series ADX controller. Synchronous motors are ideal for this purpose since they will provide identical motor-to-motor shaft speeds. For multiple motor operation, only Volts/Hertz operation is recommended.
26. **Torque Boost -** Provides improved torque capacity at lower speeds to produce up to 200% starting torque with most standard motors. ADX Torque Boost provides programmable boost level as well as a programmable frequency where maximum boost is obtained. This feature is disabled in sensorless torque or flux vector mode of operation.
27. **DC Injection Braking -** Provides effective low speed braking by injecting DC current into two motor windings. The braking time period programmable to 25.5 seconds and is engaged under programmable control at start, stop, or both.
28. **Volts/Hertz Patterns -** 21 preprogrammed and one user programmable pattern is included as standard as shown in the following table. They provide constant horsepower and/or constant torque patterns for a wide range of applications. Additionally, the unit may be programmed for any desired pattern within the frequency and voltage range of the unit as shown by Table 3.

Table 3

Pattern Number	1	2	3	4	5	6	7	8	9	10	11
Frequency at Full Output Voltage	50	60	90	120	180	240	400	50	60	60	60
Maximum Frequency	50	60	90	120	180	240	400	55	66	90	120

Pattern Number	12	13	14	15	16	17	18	19	20	21
Frequency at Full Output Voltage	60	60	60	90	90	90	90	120	120	120
Maximum Frequency	180	240	400	120	180	240	400	180	240	400

The unit is shipped programmed for pattern number 2. Patterns, which permit operation above 60 Hz, may require a special high speed motor. Patterns 3 through 7 produce constant torque from special motors wound for the design operating voltage at the pattern frequency, e.g.: when Pattern 7 is selected for a 460V unit the motor must be wound for 460V at 400Hz.

B

DESIGN FEATURES AND FUNCTIONS

Pattern 22 shows the range over which the ADX units may be individually programmed for constant torque or constant HP. Patterns 8 and 9 are for variable torque applications where it may be desirable to trim the pump or fan speed by ±10%.

Both Linear and Non-Linear Volts per Hertz curves can be selected. The Non-Linear Volts per Hertz curve offers additional power savings for variable torque loads.

29. **Output Protection -** Line-to-Line and Line-to-Ground output fault protection is provided. Also programmable is output phase loss protection to protect the motor from single-phase operation.

30. **Phase Loss Protection -** The controller detects phase loss and inhibits normal operation as necessary to prevent drive malfunction. If the phase loss is of short duration (less than 1 second), the drive will continue to operate normally until the phase is missing for more than 1 second. When the phase is missing for longer than 1 second a phase loss fault will be generated if the motor is running.

31. **Over Temperature Protection -** A thermal switch on the controller heatsink will shut down the controller in the event of a cooling fan failure or other causes for overheating.

32. **Analog Output -** One Analog Output rated 0 - 10 VDC @ 2mA is provided as standard. Two additional analog outputs are available as an option and may be programmed to one of the following parameters:

a) Actual Speed
b) Analog Input #1
c) Analog Input #3
d) Motor Load
e) None
f) PID Error
g) PID Output
h) Power
i) Speed Command
j) Speed Trim
k) Acceleration Ramp
l) Analog Input #2
m) Motor Current
n) Motor Voltage
o) Output Frequency
p) PID Feedback
q) PID Reference
r) Remote Digital
s) Speed Ratio
t) Torque Reference

This output may be programmed for offset, scaling, and inversion. The output could be used for external meters or as a speed reference for other drive units in a system.

33. **Output Contacts -** One set of form C output contacts rated 30 VDC @ 2.0 Amps or 115 VAC @ 0.5 Amps for fault annunciation.

34. **Digital Control Outputs -** Four buffered open collector outputs, rated 24 VDC @ 50 mA, are available for external alarms or monitoring. One of these outputs is dedicated for a pulse train at the drive output frequency. The three remaining outputs are user programmable to be any of the following parameters:

a) Acceleration
b) Alarm
c) Auto
d) At Speed
e) Bus Voltage Limit
f) Bypass
g) DC Braking
h) Deceleration
i) Drive Enabled
j) Dwelling
k) Forward Direction
l) Jog
m) Motor Overload
n) None
o) Regeneration Limit
p) Reverse Direction
q) Run
r) Speed Avoidance
s) Speed Search
t) Taper #1 Speed
u) Taper #2 Speed
v) Torque Limit
w) Zero Speed
x) Proof of Torque

35. **Slip Compensation -** Programmable slip compensation is provided to correct for induction motor speed droop or slip and thereby improve speed regulation in the Volts/Hertz operating mode (see Table 2, Page 95).

36. **Electronic Inverse Time Motor Overload Protection -** Inverse time motor overload protection provides a programmable threshold and time to trip to reduce the potential of costly motor damage. NOTE: To insure motor protection, a motor thermal switch is suggested.

37. **Static Reversing Control -** Contactorless reversing is a standard capability. Requires only the selection of an operator station with reversing controls or direction may be selected by external control contacts. NOTE: The drive must also be programmed to enable reverse operation by changing a parameter.

38. **Protective Features -**
    a. Inverter Trip - Due to over voltage, over current, under voltage, controller over temperature, ground fault, motor overload, and CPU error. The unit will annunciate the fault with an English language word.
    b. Trip Avoidance - Series ADX units include sophisticated torque control circuitry to minimize nuisance tripping under conditions of rapid deceleration and/or overhauling loads, or when encountering high peak torque loads. Under these abnormal torque conditions, the circuits function much like the current limiter in a DC drive extending the programmed acceleration or deceleration times to hold motor currents within set limits without tripping.
    c. Output Fault Protection - Unit is protected from phase-to-phase and phase-to-ground output short circuits and can be programmed for output phase loss.

39. **Regeneration Limit -** Designed to eliminate trips when excessive braking energy is transferred from the motor to the control, regeneration limit will perform in the following fashion:
    a. Will extend the deceleration time to prevent bus over voltage trip with high inertia loads.
    b. Will increase output frequency to user programmed maximum frequency range during overhauling loads.

Three Phase Adjustable Frequency AC Motor Controller

ADX Series
1 – 75 Horsepower
230 and 460 VAC

DESIGN FEATURES AND FUNCTIONS

40. Fault Trip Reset - Should a fault trip occur, the ADX offers two reset modes.
a. Disconnect and reapply power.
b. Reset by STOP pushbutton command by operator.

41. Static Braking Control - Provides adjustable linear rate electronic braking for the three-phase AC induction motor. The braking rate is determined by the setting of the deceleration control, which is adjustable.

Braking is effective under the following conditions:

a. Speed Reference Change - Whenever the speed reference is changed to command a reduction in speed. The speed reference change can originate from a manually adjusted speed setting potentiometer, an external DC analog signal or a change in the digital speed reference. This permits the drive to rapidly follow a reduced speed command otherwise impossible except with a heavy friction loads.

b. Stop Function - When selected, the motor will brake following the deceleration ramp to zero speed. The stop command can originate from a pushbutton or external logic. A selectable alternate method of operation allows un-powered coast to stop.

The standard unit provides a typical braking torque of 20% (dependent on motor efficiency) of rated motor torque. This is the limit of the standard drive to dissipate the regenerative energy produced by the kinetic energy of the motor and connected machine load.

Where the inertia of the load is such that the desired minimum braking time cannot be achieved with the standard unit, an optional high torque braking circuit is also offered. See Electronic Braking Option ER and EBR.

42. Analog Signal Inputs - Three analog signal inputs are provided. The Analog to Digital conversion resolution is 12 bit plus sign. The associated external signals may be grounded or ungrounded. However all three analog inputs share the same common connection. These inputs are programmable for the following functions:

a) Run Speed Command
b) Jog Speed Command
c) Torque Reference
d) Auto Speed Command
e) Auto Torque Limit
f) PID Reference
g) PID Error
h) PID Feedback
i) Speed Ratio
j) Speed Trim
k) Speed Feedback
l) None (input is unused)

The Analog Input may be programmed for Scaling, Offset, Inversion. Signal Filtering are available for all Analog Inputs.

43. Digital Control Inputs - A total of 5 predefined and 3 programmable digital inputs are provided, these provide the following functions.

Predefined Digital Inputs:
Forward Run
Reverse Run
Forward Jog
Stop
Emergency Stop

Programmable Digital Inputs:
Faster
Jog Reverse
Slower
Preset Speed

All inputs are designed for use with the 24V control voltage supplied by the ADX controller. The predefined Digital Inputs can be disabled if desired.

44. Torque Limit - State of the art electronics allow the ADX to provide good torque control over a programmable range of 20-200% of rated torque.

45. Torque Taper - Torque Limit slope and threshold are adjustable providing a programmable torque taper range of 0.1:1 to 3:1

46. Adjustments - The adjustments listed in ADJUSTMENTS on page 94 and most other adjustments can be changed while the drive is in operation. This feature simplifies fine-tuning since the drive does not need to be stopped, then restarted after each adjustment. See Series ADX Equipment Manual for a complete list of adjustable parameters.

47. Standard Serial Port - An RS-485 compatible serial port is standard on the ADX. This port provides read/write access to all parameters available in the ADX. Up to 31 ADX drives can be connected to a host computer with an RS-485 Serial Port.
The ADX has the capability of communicating serially with a host computer or PLC. Any parameter may be read or written via the serial port. Full communication is allowed during motor operation as well as at stop. The only exceptions to this are, configuration parameters that may not be adjusted from the keypad during operation, cannot be adjusted through the serial port during operation. When the drive is faulted, no parameters may be changed through the serial port. All parameters may be read under any condition.
Transmission rates up to 9600 baud and an optimized machine to machine protocol, make the ADX suitable for low to moderate performance real time communication tasks by providing a single parameter communications bandwidth of better than 5 Hertz.

Three Phase Adjustable Frequency AC Motor Controller

ADX Series
1 – 75 Horsepower
230 and 460 VAC

DESIGN FEATURES AND FUNCTIONS

48. Speed Regulator -The ADX AC Drive controls motor speed via a Proportional Integral Derivative (PID) Speed Regulator. Speed Feedback to this PID Speed Regulator can be selected from one of the following sources:

1. Sensorless (Motor Speed is determined from Applied Stator Voltage and measured stator currents).
2. DC Tachometer Feedback (Requires external scaling resistor if Tachometer voltage exceeds ±10VDC).
3. Encoder or Pulse Tachometer Feedback (Option 24E).

49. Analog Input Loss - This feature detects the loss of a 4-20 mA analog input by determining if the input current drops below a user programmable level. The user has the option of generating a fault, replacing the analog input with a fixed reference, or turning on a programmable digital alarm output when the input is lost.

50. CE Marking
- 1-5HP 208/230V units are available with CE
- 2-5HP 208/230V units are CE
- 1-10HP 460V units are CE
- others pending certification

RATINGS

1. Horsepower Range 3 - 75 HP (see Table 1)
2. Power Source (1) 208/230 or 460V, 3-Phase, 50 or 60 Hz
3. Output Power (Three-Phase)
(a) Voltage . . . . . .0 - 208/230, 0 - 460 V
(b) Frequency (3) . . . .0 to 400 Hz. Constant Torque
. . . . . .(Constant V/Hz)
. . . . . .50 to 400 Hz Constant HP
. . . . . .(Constant V, Variable Hz)
4. Service Factor 1.0
5. Duty . . . . . Industrial, Continuous
6. Overload Capacity . . . . . 150% for 1 minute
7. Linearity (Output to Input) . . . . . ± 0.1% maximum.
8. Reference Power Supply . . . . . 10 VDC @ 5 mA
9. External Reference Source (2) . . . . . 0 - 10 VDC
. . . . . .2 -10, 4 - 20, or 10 - 50 mA (4)
10. Magnetic (Pushbutton) Control Voltage . . 24 VDC
11. Storage Temperature . . . . . .0 - 70 ° C.
12. Relative Humidity . . . . . 95% Non-condensing.

NOTES: (1) 190V, 380V, and 415V models are available.
(2) Isolated reference, external control signal may be grounded or ungrounded.
(3) Standard frequency ranges 0 - 400 Hz, (See Figure 2).
(4) 2 - 10 mA and 10 - 50 mA input require an external load resistor.

ADJUSTMENTS

All adjustments are programmed digitally via the standard integral operator panel or the standard serial port. Basic adjustments include:

1. Acceleration (Linear).....0.1 - 1900.0 Seconds
(S Curve) .....3.0 - 120.0 Seconds
2. Deceleration (Linear).....0.1 - 1900.0 Seconds
(S Curve) .....3.0 - 120.0 Seconds
3. Minimum Speed (6).....0 - 75.00 %
4. Maximum Speed (6).....50.00 - 100.00 %
5. Torque Limit (7).....20.00 - 200.00 %
6. Jog Speed (6) .....0 - 100.00 %
7. Torque Boost (8).....0 - 200.00 %
8. Slip Compensation .....0 - 100.00 %
9. Volts/Hz Trim.....±20.00 % of Nominal Setting
10. Preset Speeds, 7 Provided (6) .0 - 100.00 %
11. Field Trim (9) .....50.00 - 200.00 %

NOTES: (6) % of Maximum Frequency.
(7) Motor design typically limits available torque to 200%.
(8) % of Rated Torque. Applicable only in Volts/Hz mode.
(9) % of Rated Current. Applicable only in Vector Control mode.

TABLE 1: SERIES ADX MODEL MATRIX

208/230V Units							
Motor		Rated Output Amps		Catalog	Dimensions (inches)		
HP	Max KW	208 VAC	230 VAC	Number	Height	Width	Depth
1	.75	3.9	3.6	ADX20010	7.48	7.25	7.51
1 1/2	1.12	5.7	5.2	ADX20015	7.48	7.25	7.51
2	1.5	7.5	6.8	ADX20020	7.48	7.25	7.51
3	2.24	10.6	9.6	ADX20030	7.48	7.25	7.51
5	3.73	16.7	15.2	ADX20050	7.48	7.25	7.51
7.5	5.60	24.2	22	ADX20075	11.88	7.25	8.12
10	7.46	30.8	28	ADX20100	11.88	7.25	7.50
15	11.19	46.2	42	ADX20150	19.13	7.25	10.38
20	14.92	59.4	54	ADX20200	19.13	7.25	10.38
25	18.65	74.8	68	ADX20250	28.31	7.25	10.38
30	22.38	88	80	ADX20300	28.31	7.25	10.38
460V Units							
Motor		Rated Output Amps		Catalog	Dimensions (inches)		
HP	Max KW	460 VAC		Number	Height	Width	Depth
1	.75	1.8		ADX40010	7.48	7.25	7.51
1 1/2	1.12	2.6		ADX40015	7.48	7.25	7.51
2	1.5	3.4		ADX40020	7.48	7.25	7.51
3	2.24	4.8		ADX40030	7.48	7.25	7.51
5	3.73	7.6		ADX40050	7.48	7.25	7.50
7.5	5.6	11.0		ADX40075	11.88	7.25	8.12
10	7.46	14.0		ADX40100	11.88	7.25	7.50
15	11.19	21.0		ADX40150	19.13	7.25	10.38
20	14.92	27.0		ADX40200	19.13	7.25	10.38
25	18.65	34.0		ADX40250	22.13	7.25	10.38
30	22.38	40.0		ADX40300	22.13	7.25	10.38
40	29.84	52.0		ADX40400	27.00	14.28	10.38
50	37.30	65.0		ADX40500	27.00	14.38	10.38
60	44.76	77.0		ADX40600	27.00	14.38	10.38
75	55.95	96.0		ADX40750	27.00	14.38	10.38

Three Phase Adjustable Frequency AC Motor Controller

ADX Series
1 – 75 Horsepower
230 and 460 VAC

MODEL TYPES

Series ADX controllers are offered in 14 basic power frame configurations comprising 27 models covering the range of 3 to 400 HP as shown in TABLE 1. See TABLE 5 for dimensions and weights.

PERFORMANCE CHARACTERISTICS

1. **Controlled Speed Range:** Minimum speed to motor base speed, constant or variable torque with NEMA B AC induction motors (see Table 2). Selectable constant HP operation is a standard capability.

2. **Speed Regulation (See Table 2):** Regulation percentages listed are of motor rated (base) speed under steady-state operating conditions.

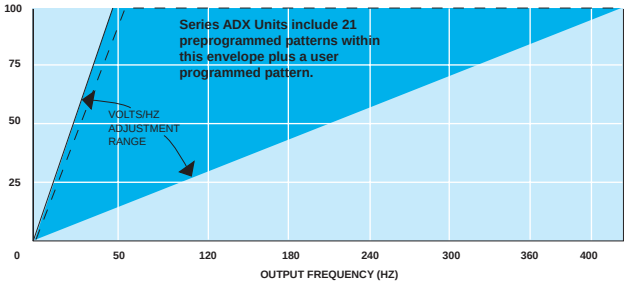
TABLE 2: SPEED REGULATION

Regulation Method	Motor Type		Load Change 95%	Line Voltage +/- 10% (1)	Motor Heating Cold to Normal	Temperature +/-10 C (Controller and Motor)	Speed Range
	Induction	Synchronous					
Normal Volts per Hertz (2)	X	-----	3.00%	0.50%	1.00%	0.25%	30:1
	-----	X	0.00%	0.00%	0.00%	0.25%	60:1
Slip Comp Volts per Hertz (2)	X	-----	1.00%	0.50%	0.50%	0.25%	30:1
	-----	X	0.00%	0.00%	0.00%	0.00%	60:1
Normal Sensorless Torque Control (2)	X	-----	0.50%	0.50%	0.50%	0.25%	50:1
	-----	N/A	-----	-----	-----	-----	-----
Option 24E Encoder Feedback (3)	X	-----	0.02%	0.02%	0.02%	0.25%	100:1
	-----	N/A	-----	-----	-----	-----	-----

NOTES: (1) Shown at full load, full speed.
(2) Listed are average, expected values when using a wide range of standard motors. Results may vary with some models.
(3) 1000 PPR (Minimum) encoder.

3. **Frequency Resolution** (at 60 Hz)
   (a) Analog Input . . . . . .0.0146 Hz
   (b) Digital Input . . . . . .0.0060 Hz
4. **Frequency Stability** 0.005%
5. **Modulation Frequency** (Selectable)2,3,4,5,6,7,8,9, or 10 KHZ
6. **Efficiency** (at rated speed, rated load @the specified carrier frequency)
7. **Displacement Power Factor** . . . . . .95% or better

Carrier Frequency (KHz)	2	3	4	5	6	7	8	9	10
Controller	97.0%	96.8%	96.6%	96.4%	96.2%	96.0%	95.8%	95.6%	95.4%
Controller with 93% Efficient Motor	90.2%	90.0%	89.8%	89.7%	89.5%	89.3%	89.1%	88.9%	88.7%



——— ADJUSTMENT RANGE FOR CONSTANT TORQUE APPLICATIONS

- - - - - ADJUSTMENTS RANGE FOR CONSTANT HP APPLICATIONS

------ ADJUSTMENT RANGE FOR 60 HZ CONSTANT TORQUE APPLICATIONS. BOSTON SERIES ADX UNITS ARE ADJUSTED FOR THIS PATTERN AS SHIPPED.

FIGURE 2: VOLTS/HERTZ ADJUSTMENT RANGE

OPERATING CONDITIONS

1. **Line Voltage Variation**.....±10% of rated
2. **Line Frequency Variation**.....50 or 60 Hz ±5 %
3. **Ambient Temperature**.....0 - 40 °C (32 - 104 °F)
4. **Altitude** (Standard).....3300 feet (1000 meters) maximum
5. **Relative Humidity**..... 95% Non-condensing

STANDARD DIAGNOSTIC FEATURES:

1. Over current
   Current Limit
   Overload
   Short Circuit
   Ground Fault

2. **Test Mode select -** Normal self-test on power-up is always performed.

3. **Fault Parameter Values -** All operating parameters are frozen on fault, providing extensive information on the conditions present at the time of fault. One of the following English language 15 character fault codes will be displayed.

4. **Fault Clearing**
   Faults are cleared on the ADX AC drive by the following actions:
   - Stop button press
   - Remote Stop Button Press
   - Removing and Re-applying power

Three Phase Adjustable Frequency AC Motor Controller

ADX Series
1 – 75 Horsepower
230 and 460 VAC

Fault Code Number	Fault Description
0	None
1	External Fault
2	Over Temperature Fault
3	Rating Mismatch Fault
4	Bus Over Voltage Fault
5	Bus Over Current Fault
6	No Encoder Option Fault
7	Ground Fault
8	Power Loss Fault
9	Frequency Range Fault
10	Voltage Knee Fault
11	Precharge Fault
12	Motor Configuration Fault
13	Motor Overload Fault
14	EEPROM Write Fault
15	EEPROM Read Fault
16	EEPROM Missing Fault
17	EEPROM Acknowledge Fault
18	User Memory Fault
19	Unknown Fault
20	Phase Loss Fault
21	Carrier Frequency Fault
22	Analog / Digital Converter Fault
23	Feedback Loss Fault
24	Analog Input #1 Fault
25	Analog Input #2 Fault
26	Analog Input #3 Fault
27	Output Phase Loss
28	10 VDC Power Supply Loss
29	24 VDC Power Supply Loss
30	Motor Current Fault
31	Phase Imbalance Fault

Three Phase Adjustable Frequency AC Motor Controller

***ADX* Series**
***1 – 75* Horsepower**
230 and 460 VAC

TABLE 4. TYPICAL APPLICATION DATA STANDARD SERIES ADX MODELS

Component			Ratings										
Rated Horsepower (HP)			1	1.5	2	3	5	7.5	10	15	20	25	30
Rated Kilowatts (KW)			0.746	1.12	1.49	2.24	3.73	5.60	7.46	11.2	14.9	18.7	22.4
3-Phase AC Output (Full Load)	Amps 460V		2.1	3.0	3.4	4.8	7.6	11.0	14.0	21.0	27.0	34.0	40.0
	Amps 230V		4.2	6.0	6.8	9.6	15.2	22.0	28.0	42.0	54.0	68.0	80.0
	Amps 208V		4.6	6.6	7.5	10.6	16.7	24.2	30.8	46.2	59.4	74.8	88.0
	KVA		1.7	2.4	2.7	3.8	6.0	8.7	11.1	16.6	21.4	26.9	31.7
Motor Torque (lb-ft)	Motor Speed RPM	3500	1.5	2.2	3	4.50	7.50	11.3	15.0	22.5	30.0	37.5	45.0
		1750	3	4.5	6	9.00	15.0	22.5	30.0	45.0	60.0	75.0	90.0
		1150	4.5	6.9	9	13.7	22.8	34.3	45.7	68.5	91.3	114	137
Minimum Transformer KVA for Voltage Matching or Isolation			2	3	3	5	7.5	11	15	20	27	27	34

Component			Ratings			
Rated Horsepower (HP)			40	50	60	75
Rated Kilowatts (KW)			29.8	37.3	44.8	56.0
3-Phase AC Output (Full Load)	Amps 460V		52.0	65.0	77.0	96.0
	KVA		41.2	51.5	61.0	76.1
Motor Torque (lb-ft)	Motor Speed RPM	3500	60.0	75.0	90.0	113
		1750	120	150	180	225
		1150	183	228	274	343
Minimum Transformer KVA for Voltage Matching or Isolation			40	51	63	75

TABLE 5. DIMENSIONS AND WEIGHTS*

HP RANGE		DIMENSIONS Inches (mm)					WEIGHT lbs
		ENCLOSURE			MOUNTING		
208/230V	460V	H	W	D	H	W	
1 - 5	1 - 5	7.48 (190)	7.25 (184)	7.51 (191)	7.00 (178)	4.63 (118)	6.5
7.5 - 10	7.5 - 10	11.88 (302)	7.25 (184)	8.12 (206)	11.31 (287)	4.63 (118)	14.6
15 - 20	15 - 20	19.13 (486)	7.25 (184)	10.38 (264)	16.63 (422)	4.63 (118)	29
25 - 30	--	28.31 (719)	7.25 (184)	10.38 (264)	24.88 (632)	4.63 (118)	42.5
--	25 - 30	22.13 (562)	7.25 (184)	10.38 (264)	19.63 (499)	4.63 (118)	34.5
--	40 - 75	27.00 (686)	14.38 (365)	10.38 (264)	25.25 (667)	11.75 (298)	63.3

*Contact Factory for dimensions above 75 HP.

FIGURE 4-1. ADX CONTROLLER MOUNTING DIMENSIONS, 1 - 5HP, 230/460V

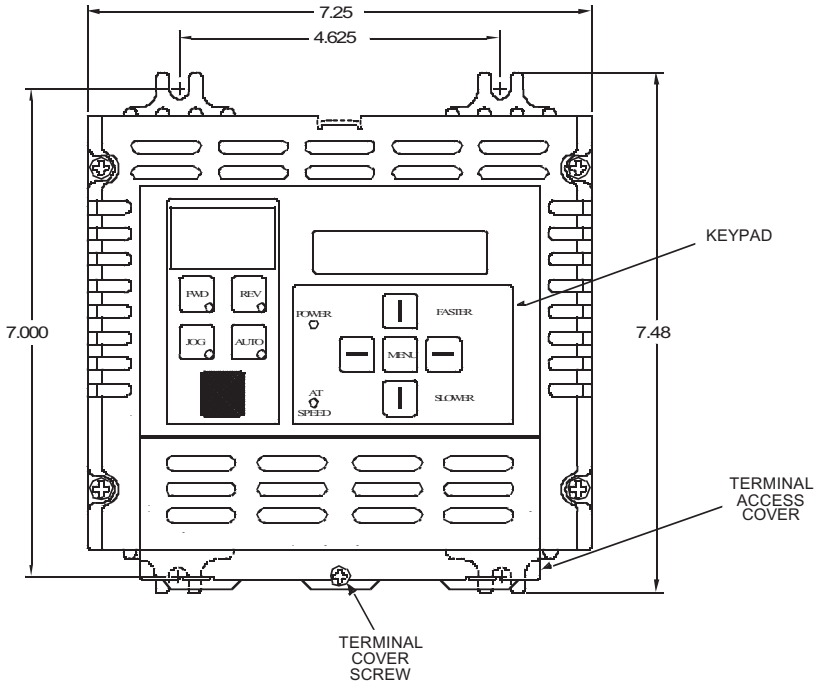
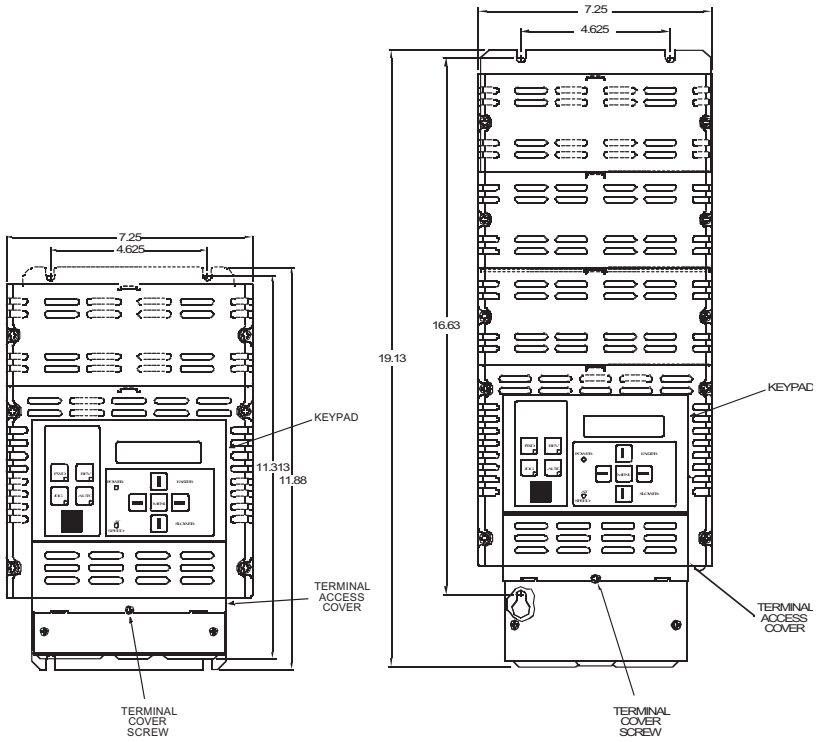


FIGURE 4-2. ADX CONTROLLER MOUNTING DIMENSIONS, 7-1/2 - 20HP, 230/460V

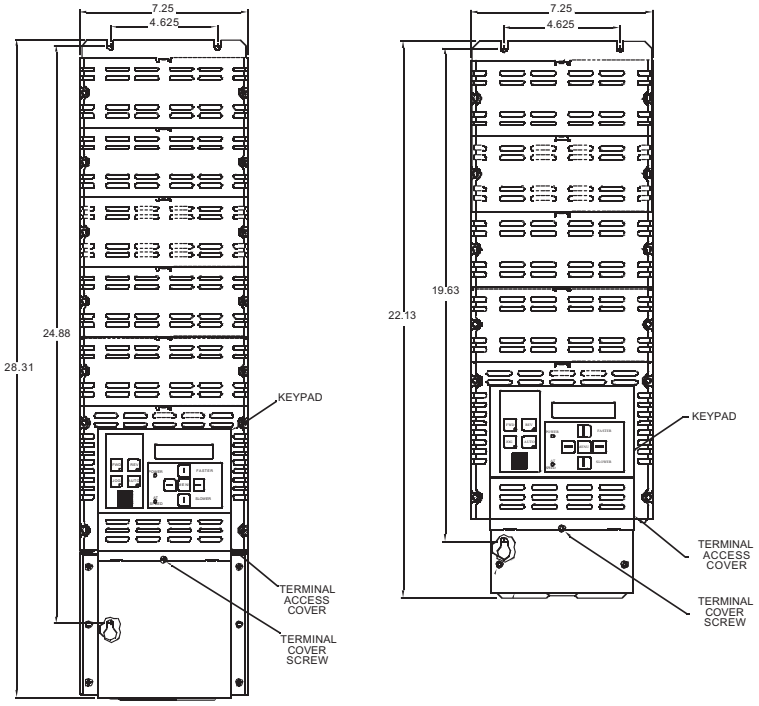


7-1/2 - 10 HP

15 - 20 HP

B

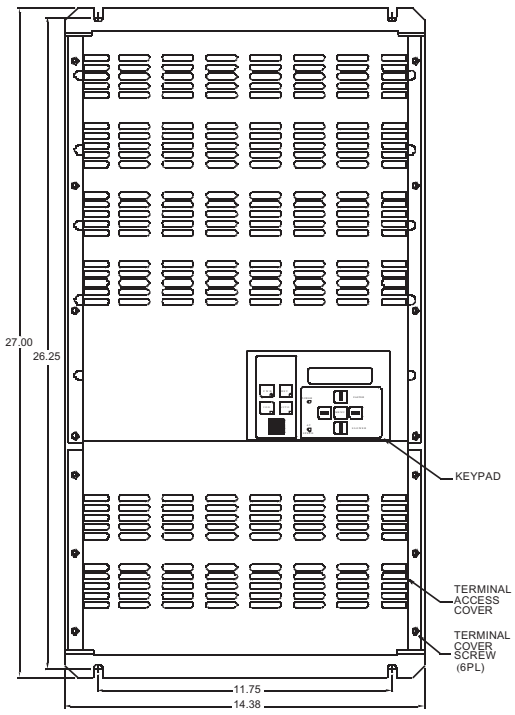
FIGURE 4-3. ADX CONTROLLER MOUNTING DIMENSIONS, 25 - 30HP, 230/460V



25 - 30 HP, 230V

25 - 30 HP, 460V

FIGURE 4-4. ADX CONTROLLER MOUNTING DIMENSIONS, 40 - 75HP, 460V



OPTIONS

Complete option descriptions are listed in the AC option section. To order a kit for field installation order by the item code if shown.

Option	Voltage and Horsepower		Option Number	Field Kit Item Code
Local Speed Potentiometer	ALL	ALL	LSP	CF
Magnetic Bypass	230 VAC	1 1/2	MB[1]	18392
		2		18393
		3		18394
		5		18395
		7 1/2		18396
		10		18397
		15-30		CF
	460 VAC	1		18398
		1 1/2		18399
		2		18400
		3		18401
		5		18402
		7 1/2		18403
		10		18404
		15-75		CF
AC Line Circuit Breaker with Handle	230 VAC	1-30	CBH[1]	CF
	460 VAC	1 - 75		CF
Motor Contactor	230 VAC	1 1/2 - 2	MC [1]	18409
		3 - 5		18410
		7 1/2 - 10		18411
	460 VAC	15-30		CF
		1 - 5		18409
		7 1/2 - 10		18410
		15-75		CF
Overload Relay	230 VAC	1-30	OR [1]	CF
	460 VAC	1-75		CF
HAND-OFF-AUTO Switch	230 VAC	1 1/2 - 30	HOA	18421
	460 VAC	1 - 75		

Three Phase Adjustable Frequency AC Motor Controller

ADX Series
1/6 – 75 Horsepower
230 and 460 VAC

OPTIONS *(Continued)*

Option	Voltage and Horsepower		Option Number	Field Kit Item Code
Input Line Chokes (Open)	230 VAC	1 - 2	LCO (1)	18422
		3		18423
		5		18424
		7 1/2		18425
		10		18426
		15-30		CF
	460 VAC	1 - 1 1/2		18427
		2 - 3		18428
		5		18429
		7 1/2		18430
		10		18431
		15-75		CF
Input Line Chokes (Enclosed)	230 VAC	1 - 2	LCE (1)	18432
		3		18433
		5		18434
		7 1/2		18435
		10		18436
		15-30		CF
	460 VAC	1 - 1 1/2		18437
		2 - 3		18438
		5		18439
		7 1/2		18440
		10		18441
		15-75		CF
Output Line Filter (Open)	460 VAC	1 - 2	LFO (1)	18442
		3 - 5		18443
		7 1/2 - 10		18444
		15-75		CF
Output Line Filter (Enclosed)	460 VAC	1 - 2	LFE (1)	18445
		3 - 5		18446
		7 1/2 - 10		18447
		15-75		CF
Electronic Braking Control Module	ALL	ALL	EB (1)	CF
Electronic Braking Resistor Assembly	ALL	ALL	EBR (1)	CF
Magnetic Control Interface (115V)	ALL	ALL	MCI	CF
Fuses, Current Limiting	230VAC	1-30	FCL (1)	CF
	460VAC	1-75		CF
Crane Control Interface	ALL	ALL	CCI	CF
Hand-Off -Auto Switch with pot	ALL	ALL	HP	CF
Blower Motor Control	ALL	ALL	45A	CF
Blower Motor Fuses	ALL	ALL	45B	CF
Relay Output Option	ALL	ALL	RO	CF
Auxiliary Enclosure	ALL	ALL	AH	CF
Digital Operator Panel and Cable	ALL	ALL	OPC	CF
Lonworks Network Interface	ALL	ALL	LON	CF
Encoder Feedback	ALL	ALL	24E	CF
Analog Outputs	ALL	ALL	AO	CF

(1) Provided as a separate assembly for customer mounting and connections.
(2) This field kit is only for NEMA 1 controllers.

RATIOTROL SYSTEMS

Soft Start Acceleration Controllers

SSX Series

1/2-20 Horsepower, 230 VAC
1-40 Horsepower, 460 VAC
1-50 Horsepower, 575 VAC

SSX SERIES

SSX Series controllers provide an economical, efficient means of controlling the acceleration of conventional three-phase AC induction motors. The units feature convenient, simple controls for adjusting the starting torque developed by the motor and its acceleration time to rated speed. Acceleration is smooth and stepless under all load conditions. The SSX0310DTC and SSX0520DTC units have torque control and a deceleration ramp time and can be utilized as a motor overload device making it an ideal replacement for single speed motor starters.

DESIGN FEATURES AND FUNCTIONS

1. **Construction** – Furnished in a rugged NEMA 1 ventilated enclosure. The SSX consists of only four primary components: (1) a die cast aluminum heatsink, (2) a Thyristor bridge, (3) an integrated regulator/power board, and (4) a non-metallic housing. The SSX0076, SSX0310 and SSX0310DTC units are self-cooling. The SSX0520DTC includes a fan on the heatsink to aid in heat dissipation.
2. **Power Circuit Configuration** – Full control utilizing 6 SCR's.
3. **SCR Protective Networks** –
   a. Voltage transient protection - RC snubber across each SCR.
   b. Current surge protection - Inherent in motor inductance.
4. **Phase Insensitive** – Simplifies application. Unit may be started with any phase rotation.
5. **Phase Loss Protection** – A lost phase produces a shut-down and prevents restarting until the lost phase is restored. This feature requires the use of either an SSX0310DTC or SSX0510DTC unit.
6. **External Control Input** – External control contacts are provided for SSX units.
7. **Stepless Acceleration** – No discrete speed transition points during acceleration.
8. **Solid-State Construction** – No electromechanical parts or contacts to bounce, arc or burn and generate transients. Noiseless, maintenance free operation.
9. **Life Expectancy** – Unlimited when operated within design parameters.
10. **Compact** – One tenth the size and weight of electromechanical reduced voltage acceleration controls of equivalent power handling capacity.
11. **Line Protection** – Fuses or circuit breaker, provided by the user.
12. **Power Connections** – Terminal board with screw terminals.
13. **Rugged Construction** – Designed for mounting "on board" traveling components in material handling systems.

    NOTE: Where severe shock loads and/or vibration are encountered, suitable diaphragm type (or equivalent) flexible isolators are suggested for mounting.

14. **Electrical Codes**– SSX Series controllers are designed and manufactured to comply with standards established by the National Electrical Code and NEMA, as applied to motor and industrial control equipment.
15. **Restart** – A 250 millisecond delay is required between starts. Restarting the motor in less time can damage the controller.
16. **SSX0310DTC and SSX0510DTC** – Units contain torque control and a deceleration ramp time.

Soft Start Acceleration Controllers

SSX Series
1/2-20 Horsepower, 230 VAC
1-40 Horsepower, 460 VAC
1-50 Horsepower, 575 VAC

PRINCIPLES OF OPERATION

When commanded to start, these units provide a precisely regulated minimum voltage necessary to develop starting torque adequate to initiate motor rotation. They then initiate a programmed increase in voltage (timed ramp) until the motor reaches rated voltage and speed within the desired time span. Typical acceleration time and deceleration adjustment ranges are illustrated by Figures 1 and 2.

FIGURE 1: ACCELERATION TIME

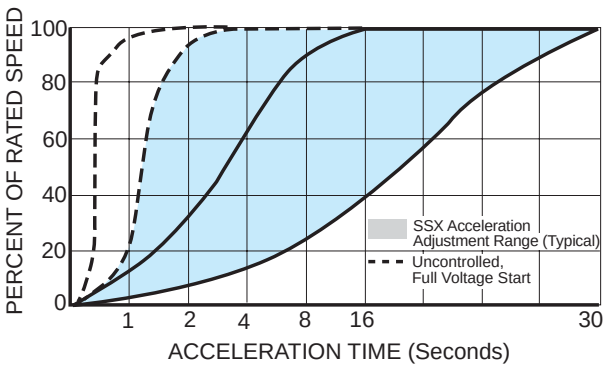
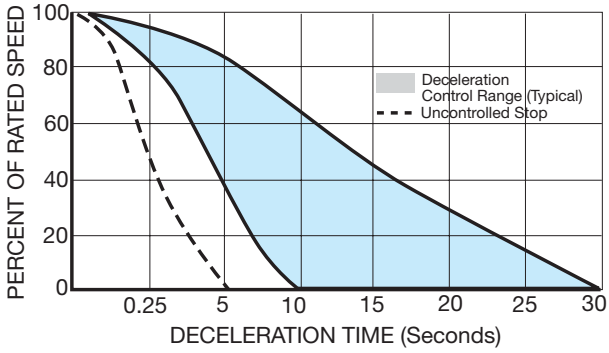


FIGURE 2: DECELERATION TIME



OPERATING CONDITIONS

1. **Line Voltage Variation** . . . . . .±10% of Rated
2. **Line Frequency Variation** . . . . . .48 to 62 Hz
3. **Ambient Temperature Range** . .30° -104°F (0° - 40°C)
4. **Altitude (standard)** . .3300 Feet (1000 Meters) Maximum
5. **Load Type** . . .3-phase ungrounded AC induction motor

ADJUSTMENTS

1. **Starting Torque** . . . . . .0 – 100% of rated voltage
   The starting voltage is adjustable to provide adequate breakaway torque for instant reaction to operator start commands.
2. **Ramp Time (typical)** . . . . . .0-30 Seconds
   AC Motor design (NEMA A, B, C, D) and load characteristics (inertia and work load) can vary the adjustment range.
3. **Dwell Time** – 0-6 seconds. Time that starting torque is held (for slack take-up etc.).
4. **Torque Control (models with "DTC" suffix)** – Provides a torque limit adjustment as well as a motor overload threshold. It adds a motor current monitoring circuit which in turn allows torque limit and overload functions. With this feature, the SSX may be utilized and rated as an overload device.
5. **Deceleration Ramp Time (models with "DTC" suffix)**
   0-30 seconds AC motor design (NEMA Type A, B, C, D) and the load characteristics (inertia and work load) can vary the adjustment range.

RATINGS

1. **Horsepower Range**
   230 VAC Three Phase . . . . . .1/2 – 20 HP
   460 VAC Three Phase . . . . . .1 – 40 HP
   575 VAC Three Phase . . . . . .1 – 50 HP
2. **Power Source** . . . . . .208/230V,460V,or 575V, 3 Phase, 50/60 Hz
3. **Output Voltage Range** . . . . . .0-100% of Line Voltage
4. **Service Factor** 1.15
5. **Duty** . . . . . .Continuous
6. **Overload Capacity** . . . . . .115% Continuous
   500% for 30 Seconds
7. **Efficiency (Rated Speed/Rated Load)**
   Controller SCR regulator 99%
   Complete drive with 93% efficient motor 92%

RATIOTROL SYSTEMS

Soft Start Acceleration Controllers

SSX Series

1/2-20 Horsepower, 230 VAC
1-40 Horsepower, 460 VAC
1-50 Horsepower, 575 VAC

MODEL TYPES

The SSX Series of Soft Start Acceleration Controllers are offered as a NEMA 1 enclosed controller. These units are available in either 208/230 VAC, 460 VAC or 575 VAC input voltages covering a range of 1/2 to 50 HP as shown below.

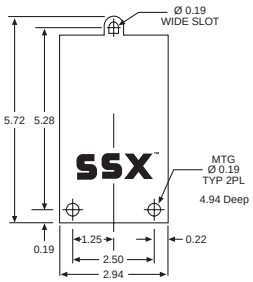
ORDER BY CATALOG NUMBER OR ITEM CODE

Input Voltage	Motor HP[1]	Motor KW	Rated Output Amps	Catalog Number	Item Code
208/230 VAC Three Phase 50/60 H	2	1.5	7.6	SSX0076	18499
	10	7.5	31	SSX0310	19267
	10	7.5	31	SSX0310DTC	72302
	20[2]	15[2]	52	SSX0520DTC	19297
460 VAC Three Phase 50/60 H	5	3.7	7.6	SSX0076	18499
	20	15	31	SSX0310	19267
	20	15	31	SSX0310DTC	72302
	40	30	52	SSX0520DTC	19297
575 VAC Three Phase 50/60 HZ	5	3.7	7.6	SSX0076	18499
	25	19	31	SSX0310	19267
	25	19	31	SSX0310DTC	72302
	50	38	52	SSX0520DTC	19297

(1) Higher horsepower ratings are available. Please contact the factory for ratings up to 4,000 HP.
(2) 230 VAC Only

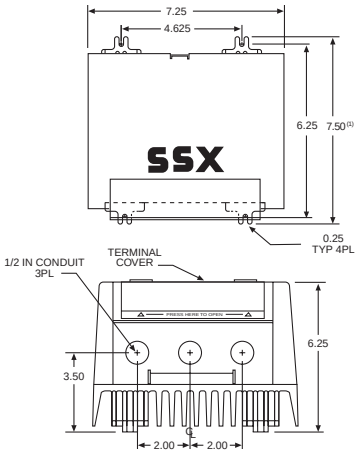
DIMENSIONS

SSX0076



Weight 1.5 LBS.

SSX0310 / SSX0520



Weight 5.6 LBS.
(1) SSX0540 overall height = 7.625

Option	Description	Applicable Drive	Installed Option Number
Conduit Box	This option provides 0-30 second stepless deceleration control upon activation of a remote switch. Three adjustments are provided: Stop Response, Deceleration Time, and Drop Out.	SSX0076	WBX

Options AC Motor Controllers

Option No.	Description	For Use with Series
AH	**ENCLOSURE, AUXILIARY** This option consists of a separate sheet metal NEMA 1 enclosure. It has ample space to allow for mounting various options.	ADX
AO	**ANALOG OUTPUTS** The standard controller has one 0-10 VDC analog output rated 2mA which may be programmed to follow any one of the listed parameters: a. Speed Command b. Motor Voltage c. Motor Current d. Frequency e. RPM f. Output Power g. Remote Digital (a parameter set through the serial port) h. P.I.D. Output i. Actual Speed j. Accel/Decel Ramp k. Motor Load l. P.I.D. Error m. P.I.D. Feedback n. P.I.D. Reference Option AO provides the capability to follow two additional parameters of those listed. This option may be useful for external analog monitoring devices or as a speed or torque reference for other drives in a system.	ADX
CBH [1]	**AC LINE CIRCUIT BREAKER WITH HANDLE** This option provides a three-pole magnetic trip circuit breaker as a means of manually disconnecting the drive from the AC line. The handle for the option is cover mounted.	ACX ADX BCX
CCI [2]	**CRANE CONTROL INTERFACE (JOYSTICK CONTROL)** This option facilitates the application of standard controllers to new or existing material handling systems where individual preset motor speeds, and the direction of rotation are commonly determined by 115 VAC input signals selected by external control contacts such as pushbuttons, joysticks or drum switches. The option accepts up to six (6) 115 VAC inputs from external contact closures as follows: 1. Two (2) inputs provide directional commands: Forward, Reverse, or Up, Down and Preset Speed step number 1 2. Four (4) inputs provide Preset Speed step numbers 2 through 5 in either forward or reverse directions. The speed steps can be adjusted to produce motor speeds anywhere between zero and maximum as required by the application. Additionally, Option CCI can also be used where forward and reverse run commands are selected as previously described, and the speed command is infinitely adjustable by a speed setting potentiometer or external signal. The option also coordinates the operation of a failsafe holding brake. To enable this capability Analog Output (Option AO) must be added to the drive. Included is a provision to assure the brake will not energize until sufficient torque is produced by the motor (typically 10-30% torque). This is factory set for 20% but can be reset in the field to optimize performance. The brake will not de-energize until a stop command is given, and the controller senses the preset low speed setpoint. The low speed setpoint is separately adjustable for both forward and reverse directions. A fault condition (External or Drive Internal) will de-energize and set the brake immediately.	ADX
DIN	**DIN RAIL MOUNTING KIT** This option enable the control to be mounted on a standard 35mm DIN rail, simplifying installation and maximizing available panel real estate. Applies to 1/3 + 1HP, 230 VAC (NEMA 1) models only.	ACX BCX
DMK [1]	**DOOR MOUNTING KIT** Bracket and gasket to mount ACX2003 and ACX2010 to door of an enclosure.	ACX
EB	**ELECTRONIC BRAKING** The braking capability of the standard AC controller is approximately 15-20% of rated torque. This is the limit of a typical drive to dissipate the energy regenerated from the motor and connected machine while braking. This option consists of an electronic braking transistor module. This module must be used with option EBR to increase braking capability to 100% of rated torque at motor base speed. Option EB is in a NEMA 1 enclosure.	ACX ADX BCX
EBR	**BRAKING RESISTOR ASSEMBLY (furnished in a NEMA 1 enclosure)** This option must be used with option EB to allow 100% braking torque. The braking circuit is rated for stopping a typical load a maximum of two stops per minute from motor base speed. A typical load is defined as: 1. Not exceeding rated-load torque 2. External load inertia (beyond the motor shaft) not exceeding that of the motor's rotor. High inertia loads may extend braking times beyond the wattage rating of the power dissipation resistor. The braking circuit is not rated for continuous regeneration and should be used only where intermittent control of overhauling loads is required. The braking circuit is not a holding brake; it will not prevent a motor a rest from rotating.	ACX ADX BCX

Options AC Motor Controllers

Option No.	Description	For Use with Series
FCL [1]	**FUSES, CURRENT LIMITING** Provides 3-pole current limiting, Class J fuses with a clearing capacity of at least 100,000 symmetrical amperes for protection of the plant power bus from fault conditions.	ADX
HOA	**HAND-OFF-AUTO SWITCH** Provides a 3-position switch and legend plate to select between user supplied manual speed pot and an automatic speed reference. Option MB is also required for option HOA.	ACX ADX BCX
HP	**SELECTOR SWITCH HAND-OFF-AUTO WITH MANUAL POT** Provided is a 3-position switch, manual (HAND mode) pot and legend plate with associated circuitry to select between user supplied external (AUTO mode) signal and manual pot.	ACX ADX
LC	**AC LINE CONTACTOR** Provides an AC line disconnect for the controller.	ACX BCX
LCE [1]	**INPUT LINE CHOKES – ENCLOSED** Same as LCO but furnished in a NEMA 1 enclosure. This option should not normally be used in combination with Option LFO/LFE Output Line Filter.	ACX ADX BCX
LCO [1]	**INPUT LINE CHOKES – OPEN** Includes an assembly with three (3) AC line reactors (chokes rated 3% impedance) connected in series with the AC supply lines. They are furnished loose for customer mounting. These reactors oppose rapid line current changes and surges and help protect the unit from transients. This option is not normally needed when a controller is connected to the AC supply through an isolation transformer. However, option LCE is suggested whenever: 1. The KVA of the AC power supply is greater than three (3) times the horsepower rating of the controller. 2. Additional transient voltage surge protection is desirable. 3. It is desirable to isolate inverter ripple currents from the AC line. 4. Harmonic distortion must be reduced. *This option should not be used in combination with Options LFO or LFE.*	ACX ADX BCX
LFE [1]	**OUTPUT FILTER (ENCLOSED)** Same as LFO but furnished in a NEMA 1 enclosure, *Since this option represents a 3% output impedance, it may not be acceptable in applications characterized by low line voltage, heavy loading, and high speeds, or in combination with Input Line Chokes.*	ACX ADX BCX
LFO [1]	**OUTPUT LINE FILTER – OPEN** This is furnished loose for customer mounting and filters the AC output to provide the following benefits: a. Quiet motor operation at low carrier frequencies. b. Elimination of ground fault due to DV/DT. c. Reduced DV/DT stress on motor windings at higher carrier frequencies. d. Reduced electrical interference. *Since this option represents a 3% output impedance, it may not be acceptable in applications characterized by low line voltage, heavy loading, and high speeds, or in combination with Input Line Chokes.*	ACX ADX BCX
LON [2]	**LONWORKS NETWORK INTERFACE** This circuit board provides a LonWorks port, which conforms to the LonMark Profile for Variable Speed Motor Drives. An external LonMark compliant device can then control the ADX. Additional access, beyond the LonMark profile, is provided to all ADX parameters.	ADX
LSP	**LOCAL SPEED POTENTIOMETER** This option provides local analog motor speed control (1/2 watt, 5K ohm, single turn). For the ACX2003 and ACX2010, option WBX is also required.	ACX ADX BCX
MB [1]	**MAGNETIC BYPASS** With this option, the ACX is bypassed and the motor is directly connected to the AC line. Three contactors, motor overload, and AC line disconnect fuses are included in the enclosure. The drive is isolated in the bypass mode. Option MB can be ordered in a NEMA 1 or a NEMA 4 enclosure.	ACX ADX BCX
MC [1]	**MOTOR CONTACTOR** Provides an AC output contactor that is coordinated with the controller's electronics to ensure a safe, reliable shutdown and a positive disconnection of the motor from the control. Option MB can be ordered in a NEMA 1 or a NEMA 4 enclosure.	ACX ADX BCX

Options AC Motor Controllers

Option No.	Description	For Use with Series
MCI [2]	**MAGNETIC CONTROL INTERFACE (115V)** This option provides a means of interfacing the controller with pushbuttons or external logic powered by a 115 VAC excitation source. The interface circuit includes five (5) control relays with 115 VAC coils for use in both unidirectional and reversing applications, and three (3) or more preset speeds, or other functions.	ADX
OPC	**DIGITAL OPERATOR PANEL (UNENCLOSED, SEPARATE MOUNTING)** This option provides the standard operator panel furnished with an 18" (.46m) cable and connector for plug-in connection to the controller. The operator panel would normally be mounted in the door of a larger enclosure within which the enclosure is mounted.	ADX
OR [1]	**OVERLOAD RELAY** This option includes a standard NEMA rated 3-pole overload relay. Motor full-load current must match listed adjustment range.	ACX ADX BCX
RO [2]	**RELAY OUTPUT** This option provides four (4) relays with Form C contacts rated 2 amps @ 250 VAC for customer use to annunciate the digital control outputs provided by the standard open connector transistors. This option allows these outputs to be used with warning devices such as bells, buzzers and indicator lights or other monitoring devices. This option mounts within a dedicated area in the controller.	ADX
RSS	**RUN STOP SWITCH** This option consists of a single-pole, single-throw slide switch which mounts on the front of the controller	BCX
WBX	**CONDUIT BOX** This option connects to the bottom of the controller allowing for termination of standard conduit connections. This option is only for controllers ACX2003, ACX2010, BCX2003, and BCX2010.	ACX BCX
2XV-03 2XV-10	**VOLTAGE DOUBLER** This option permits the use of 115VAC single-phase power to the controller. Two (2) models are available, 2XV-03 for up to 1/3 HP and 2XV-10 for up to 1 HP.	ACX BCX
24E	**CLOSED LOOP FLUX VECTOR (ENCODER FEEDBACK)** Provides terminals and circuitry for accepting a digital feedback signal from a photo optical encoder mechanically coupled to the drive motor rotor. The feedback signal replaces the slip compensation circuitry in the controller, making the unity directly sensitive to motor speed. This option results in improved speed regulation with load changes and reduced sensitivity to operating conditions such as line voltage variations, ambient temperature changes, motor heating, and other variables. **ENCODER SPECIFICATIONS** 1. Electrical: LED/Optical type 2. Supply Voltage: +5 VDC power supply 3. Channel Arrangement: Quadrature, Differential, Bidirectional. 4. Line drivers (TTL) are needed for applications where greater than fifty (50) feet of wiring distance separate the motor and controller. 5. Marker Pulse: Not required. 6. Number of Lines, Pulses Per Revolution (PPR): 1000 or 1024 is standard. A performance reduction will result when lower frequency encoders are applied. *This option does not include the encoder.*	ADX
45A	**BLOWER MOTOR CONTROL** Includes a 3-pole AC motor starter with 3-leg overload protection and an integral circuit breaker to control and protect an AC force-ventilation blower mounted on the main drive motor. The blower is energized whenever power is applied to the controller and the optional AC line switch or circuit breaker is closed. **Motor blower is not included with this option.**	ADX
45B	**BLOWER MOTOR FUSES** Includes 3-pole line fuses to protect an AC force ventilation blower, mounted on the main drive motor. The blower is energized whenever power is applied to the controller and the optional AC line switch or circuit breaker is closed. **Motor Blower is not included with this option.**	ADX

NOTES

Boston Gear offers a complete range of accessories for use with our AC and DC Ratiotrol controllers. All components have been selected for their compatibility to the systems.

TABLE OF CONTENTS

REMOTE CONTROL STATIONS.....109-110

DC TACHOMETER GENERATORS.....111

AC TACHOMETER GENERATOR DOUBLE C-FACE 112

DC TACHOMETER GENERATOR DOUBLE C-FACE 112

MAGNETIC PICKUP ASSEMBLIES.....113

DIGITAL PULSE TACHOMETER.....114

ANALOG METER.....114

DIGITAL METER 115

C

REMOTE CONTROL STATIONS

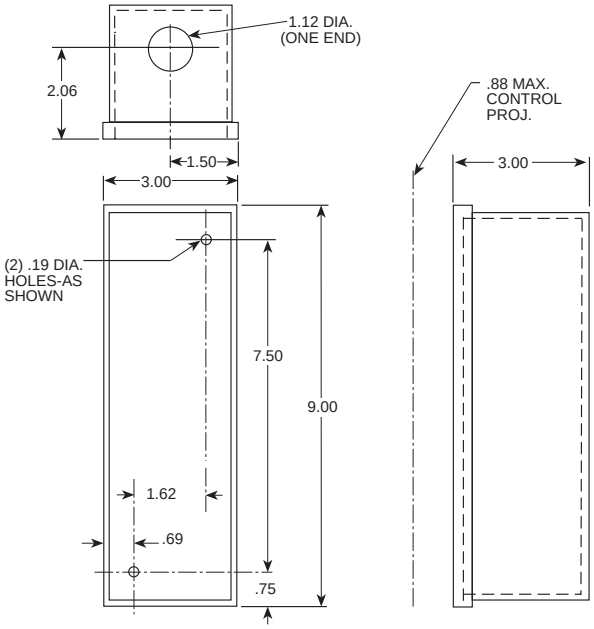
The remote control stations shown on these pages may be used with one or more controller. The listings indicate control functions, components and the controllers with which each remote control station may be used. Dimensions are shown for NEMA 1 enclosures. Consult factory for dimensions on other NEMA enclosures. NEMA definitions are on page 189.

ORDER BY CATALOG NUMBER OR ITEM CODE

Control Elements			Use With Controller Models	Remote Station	
Pushbuttons	Switches	Pots		Catalog Number	Item Code
Run, Stop	—	Motor Speed	ACX, BCX, ADX RBA, RBS, VES, VED(BP, CP)	RCS1	69362
Run, Stop	Run/Jog	Motor Speed Jog Speed	VED(BP, CP)	RCS3	69366
Run, Stop	Run/Jog	Motor Speed	RBA(U,UB), RBS(U,UB), VES(U,UB)	RCS3C	58098
Run, Stop	Run/Jog	Motor Speed Jog Speed	RBA, RBS, VES	RCS3D	58099
Fwd, Rev, Stop	—	Motor Speed	RBA(M,MB), RBS(M,MB), VED(BPR,CPR), VES(M,MB)	RCS6	60239

(CONTINUED)

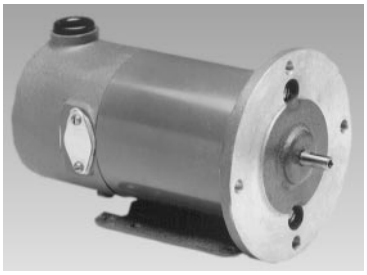
REMOTE CONTROL STATIONS *(Continued)*



ORDER BY CATALOG NUMBER OR ITEM CODE

Control Elements			Use With Controller Models	Remote Station	
Pushbuttons	Switches	Pots		Catalog Number	Item Code
—	Run/Stop/Jog	Motor Speed	RBA(U,UB), RBS(U,UB), VES(U,UB)	RCS16	58102
—	Run/Stop/Jog, Fwd/Stop/Rev	Motor Speed	RBA(M,MB), RBS(M,MB), VES(M,MB)	RCS17	58103
Run, Stop, Emer. Stop	—	Motor Speed 100-0-100	VEL/H-RG	RCS30-RG	66953
Run, Stop, Emer. Stop	Run/Jog	Motor Speed 100-0-100	VEL/H-RG	RCS31-RG	66954
Run, Stop, Emer. Stop	Fwd/Rev	Motor Speed 0-100	VEL/H-RG	RCS32-RG	66955
Microprocessor Based Membrane Control Panel with Push Switches for Run-Jog-Stop, Motor Speed Faster-Slower and Motor Direction Forward-Reverse			VED (B, BR, C, CR)	MCS1	66774

DC Tachometer Generator



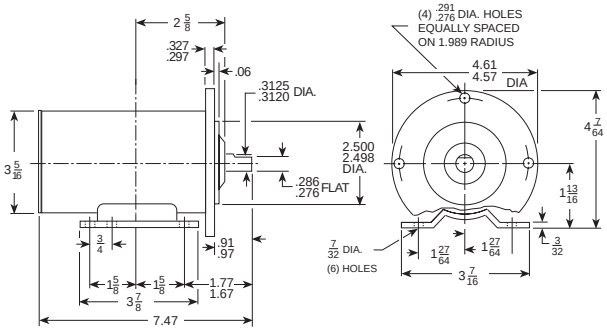
Tachometer Generators are used to sense (monitor) motor shaft speed and to supply a voltage signal to a meter for speed indication, to another control to set its speed (follower or “Slave”) or to signal speed changes to the control associated with the motor (tachometer feedback).

Boston Gear offers three models to allow a variety of applications, flange mounted to adapt to rear of motors (with adapters), foot mounted for belt driven applications and one unit which can be both foot or flange mounted.

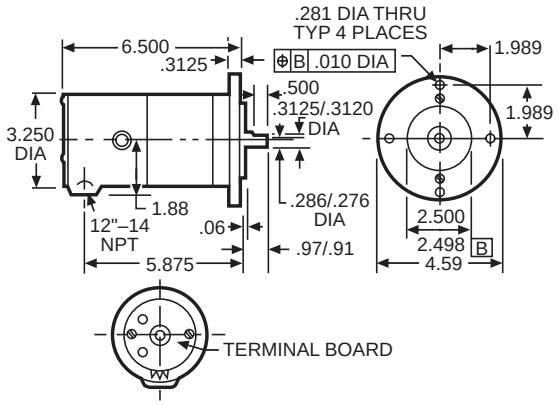
ORDER BY CATALOG NUMBER OR ITEM CODE

Output per 1000 RPM	Mounting	Catalog Number	Item Code	Driving Torque (oz. in.)	Max RPM	Inertia (lb. in^2)	Ripple %
50 VDC	Foot/flange	TG-3	38614	1.5	5000	1.4	1.5
50 VDC	Flange	TG3C-P	19170	1.5	5000	1.4	.5
50 VDC	Foot	TG3F-P	19171	1.5	5000	1.4	.5

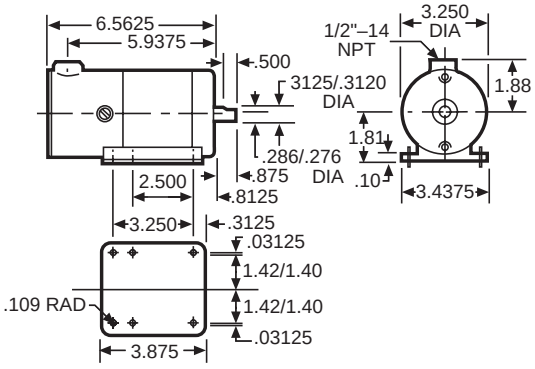
DIMENSIONS



TG3



TG3C-P



TG3F-P

ADAPTERS

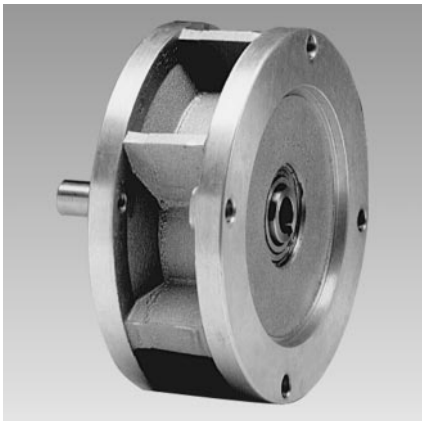
Flange mounted generator can be mounted on certain motors capable of supporting its size and weight as shown below:

ORDER BY CATALOG NUMBER OR ITEM CODE

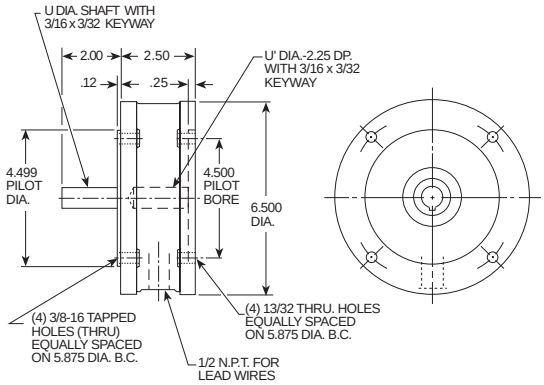
For Use With Motors	Adapter Required	
	Catalog Number	Item Code
18300ATF-B	TGAB3*	66795

*Requires coupling BG11-3-5-5 Coupling

AC Tachometer Generator, Double C-Face — TG50A Series



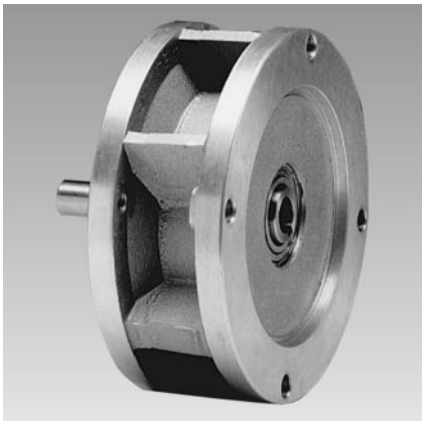
These self-contained AC voltage generators produce a 2 phase linear output voltage proportional to speed. There are two gray leads (1st phase) and two black leads (2nd phase) in each generator. The generator output voltage, of 50 VAC/1000 RPM, can be used with a meter for speed indication or in a Tachometer follower or Tachometer feedback system. These generators will fit any standard NEMA 56C, 180C or 140TC frame motor. To prevent excessive loading, external connections to the generator should not total less than 25K ohms. This unit is designed for use between a C-Face motor and a flanged reducer, it is not intended for overhung loads on output shaft.



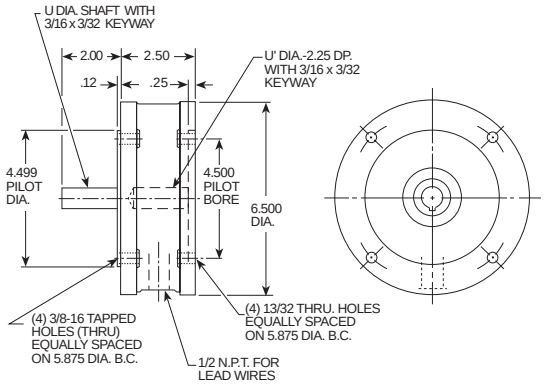
ORDER BY CATALOG NUMBER OR ITEM CODE

Voltage Output/ 1000 RPM	Max. Speed RPM	Catalog Number	Item Code	NEMA C-Face	Bore Code	Temperature Constant (Per Degree F)	U Output Dia.	U′ Input Dia.	Approx. Weight (Lbs.)
50 VAC	6000	TG50A56C	60153	56C	B5	.04 Volt	.6245/.6250	.6257/.6252	7
50 VAC	6000	TG50A140TC	60154	180C-140TC	B7	.04 Volt	.8745/.8750	.8757/.8752	7

DC Tachometer Generator, Double C-Face — TG35D Series



These self-contained DC voltage generators produce a linear output voltage proportional to speed. The generator output voltage of 35 VDC/1000 RPM can be used with a meter for speed indication or in a Tachometer follower or Tachometer feedback system. These generators will fit any standard NEMA 56C, 180C or 140TC frame motor. To prevent excessive loading, external connections to the generator should not total less than 50K ohms. Not for use with regenerative controllers. This unit is designed for use between a C-Face motor and a flanged reducer, it is not intended for overhung loads on output shaft.



ORDER BY CATALOG NUMBER OR ITEM CODE

Voltage Output/ 1000 RPM	Max. Speed RPM	Catalog Number	Item Code	NEMA C-Face	Bore Code	Temperature Constant (Per Degree F)	U Output Dia.	U′ Input Dia.	Approx. Weight (Lbs.)
35 VDC	2000	TG35D56C	50477	56C	B5	.04 Volt	.6245/.6250	.6257/.6252	7
35 VDC	2000	TG35D140TC	50478	180C-140TC	B7	.04 Volt	.8745/.8750	.8757/.8752	7

Magnetic Pick-up Assemblies

Magnetic pickup assemblies are used to deliver a 60 pulse per revolution signal for use with a tachometer to display the accurate speed of a motor.

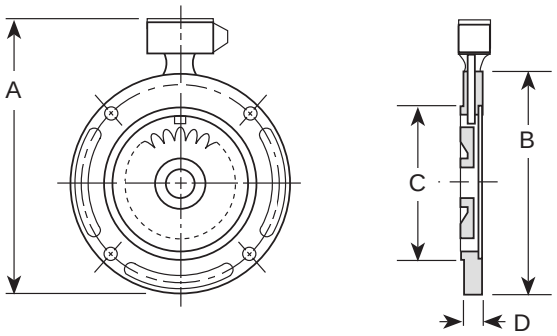
The assemblies contain a 60 tooth gear, C-face adapter with conduit box and sensor.

ORDER BY CATALOG NUMBER OR ITEM CODE

Catalog Number	Item Code	NEMA C-FACE	Bore Code
MPA56C	60254	56C	B5
MPA140TC	60255	140TC	B7
MPA180TC	60256	180TC	B9
MPA210TC	60257	210TC	B11
MPA250TC	60258	250TC	B13

DIMENSIONS

ALL DIMENSIONS IN INCHES				
NEMA C-FACE	A	B	C	D
56C, 140TC	9.32	6.50	4.500	.750
180TC, 210TC, 250TC	12.63	9.62	8.500	.875



Inline Amplifier and Pulse Shaper for Magnetic Pick-ups

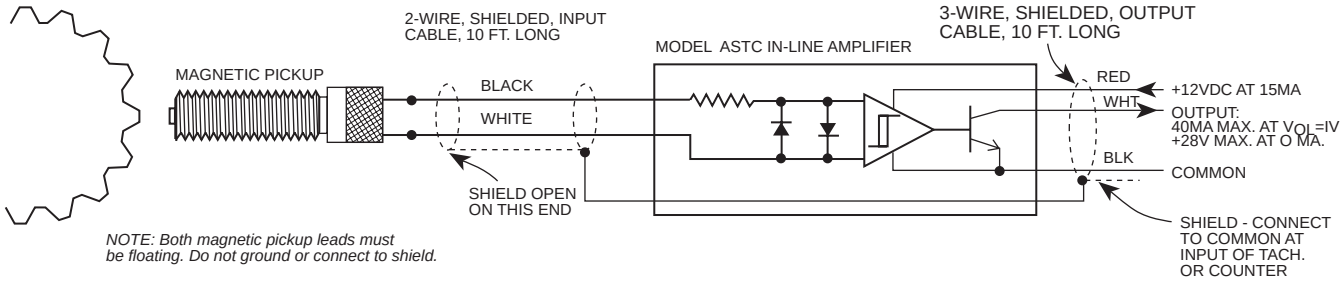
ASTC Series

The ASTC boosts magnetic pickup signals by a factor of more than 100, and provides an NPN Open-Collector pulse output which is compatible with the DPT-1A and DPT-2A meters. The ASTC can be used at pulse rates to 10KHz. The NPN O.C. output is current limited to 40mA. The unit is epoxy encapsulated in a 3/4" Dia. stainless steel shell, with overall dimensions of 0.9"D × 4.5"L including Neoprene strain-reliefs on each end. In installations where long signal runs are to be made it is advisable to keep the ASTC close to the pickup and let its output cable make the long run. Input and output cables should not be run in conduit, cable troughs, or bundles with power or control voltage lines. Operating temperature is –18° to +60°C.

ORDER BY CATALOG NUMBER OR ITEM CODE

Catalog Number	Item Code
ASTC	19132

NOTE: This amplifier is recommended when using two or more meters (DPT series) from one magnetic pulse pick-up signal. Also when the meter is more than ten feet from the signal source.



C

5 Digit Digital Pulse Tachometers

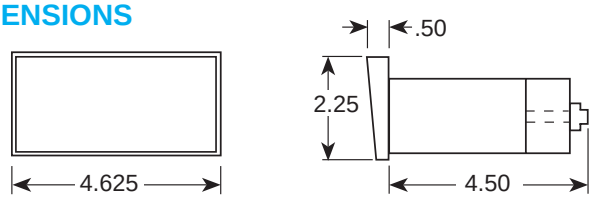
DPT Series

The DPT Series of digital tachometers are completely field programmable. The display updates to a new reading at the conclusion of each time base. The time base is set with switches, giving a choice of time bases from .001 seconds to 32.76 seconds in minimum increments of .001 seconds. In addition these tachometers have programmable decimal points and frequency doubling at the flip of a switch. This feature provides a count pulse at both the leading and trailing edges of the input pulse, which doubles the input information rate and allows the time base to be reduced by half.

Frequency doubling allows shorter update times for the readout for those applications where a longer rate is objectionable and otherwise unavoidable. For example, frequency doubling permits a 30 second time base to be used where a 60 second time base would normally be required.

When using two or more generators on the same magnetic pick-up signal or for distances over ten feet, it is recommended to use the ASTC amplifier shown on page 113.

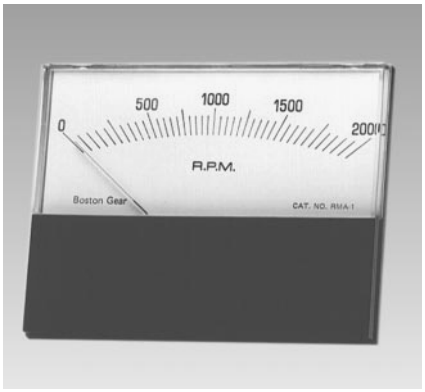
DIMENSIONS



ORDER BY CATALOG NUMBER OR ITEM CODE

A.C. Line	Catalog Number	Item Code
115V	DPT-1A	48862
230V	DPT-2A	48863

Analog Meter

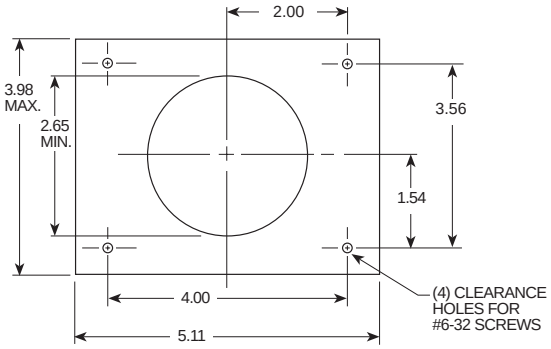


The RMA-1 meter is a 4-1/2" rectangular meter with additional printed circuitry and adjustment pot to permit the indication of RPM when connected to the various AC and DC voltages present on motor armatures and tachometer generators. Five voltage ranges are provided to permit inputs of 50 VAC or 50 VDC to 500 VDC.

The meter face is readily removed to enable you to substitute a face with special calibration, such as 0-100%, reducer RPM, FPM, etc.

Accuracy ±2% full scale
Tracking ±2%
Repeatability 2%
Balance (Horizontal to vertical) ±1%
Temperature Effect (15°-35°C) 1%
Damping Factor 2.5 min.
Response Time 1.5 sec. max.

DIMENSIONS



ORDER BY CATALOG NUMBER OR ITEM CODE

Catalog Number	Item Code	Approx. Weight
RMA-1	60879	1 Lb.

Digital Meter

The RMD-1 digital meter is low cost, reliable, accurate and physically interchangeable with existing 4-1/2 inch rectangular analog meters. Four input ranges accept minimum signals from 50 mV to 500 VDC, to read full scale (1999). The 20 turn calibration pot allows the output to be scaled to the indication required.

DISPLAY: 4 active digits (0 to 1999). 0.5 inch LED non-blinking with a 0.25 second update period. Optional decimal point before last digit.

INPUT SIGNAL FREQUENCY: Minimum fixed frequency input is 40 Hz. Minimum variable frequency input to produce maximum readout is 200 Hz. Maximum variable frequency input is 2000 Hz.

INPUT SIGNAL VOLTAGE: Minimum input to produce full reading is 50 millivolts dc, 100 millivolts ac. Maximum input voltage is 500 VDC, 460 VAC.

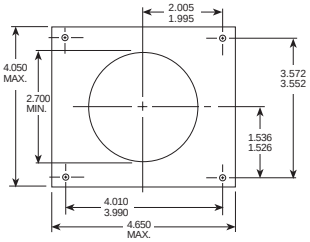
INPUT SIGNAL DEVICE: Any AC or DC shunt providing a 50 mV. or larger signal. An AC or DC signal source. A fixed pulse area digital tachometer.

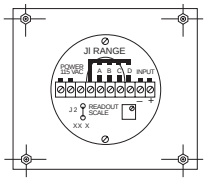
READOUT LINEARITY: 0.5% F.S. ±1 count.

POWER REQUIREMENTS: 115 VAC ±10V, 2 watts. Meter circuit is entirely isolated from line and case.

OVERRANGE: Indication by “EEE”. 500% signal input over-voltage protection on all scales except high voltage scale.

DIMENSIONS





ORDER BY CATALOG NUMBER OR ITEM CODE

Catalog Number	Item Code	Approx. Weight
RMD-1	60880	1 Lb.

C

NOTES

A natural addition to constant speed motor/reductor drives and adjustable speed Ratiotrol systems, these products fill a need where high inertial loads exist or frequent starts and stops exceed the capabilities of standard motors.

These products are comprised of four groups; C-face clutch/brakes, C-face clutches, foot-mounted clutch-brakes and shaft-mounted clutches, brakes and combination clutch-brakes.

Boston Clutch and Brake products are a result of many years of manufacturing and application experience resulting in a reliable, rugged and sound design providing maximum performance and life.

TABLE OF CONTENTS

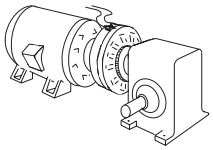
GENERAL INFORMATION 118
DOUBLE C-FACE DC CLUTCH/BRAKES 119-120
FOOT MOUNTED DC CLUTCH/BRAKES 121-124
DC SHAFT MOUNTED SELECTION 125
DC SHAFT MOUNTED CLUTCHES 126-129
DC SHAFT MOUNTED BRAKES 130-133
DC SHAFT MOUNTED CLUTCH/BRAKES 134-137
DC CLUTCH/BRAKE POWER SUPPLIES 138
DOUBLE C-FACE AC BRAKES 139
DOUBLE C-FACE WASHDOWN AC BRAKES 140-141
AC MOTOR BRAKE KIT 142
APPLICATION ENGINEERING 176-189

General Information

These are a few common applications. Clutches and Brakes may be used wherever control of linear or rotary motion starts and stops are required.

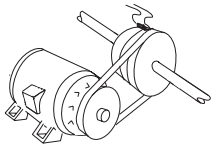
Electric clutches and brakes perform controlled start and stop functions between a constantly-running prime mover and a load. Electrical commands are generated manually (pushbutton) or automatically (switch, photocell, tape, sequence programmer, etc.)

CLUTCH – *Acceleration*



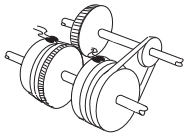
NO SHOCK

In this split-shaft application, the field and rotor are mounted to a motor and the armature to a reducer input shaft. A low setting of the potentiometer on the control allows the clutch to engage the reducer worm gears smoothly, eliminating shock to the machine system.



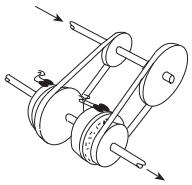
HIGH RESPONSE

In this thru-shaft application, the potentiometer is set to full current. Engaging the clutch produces millisecond power transmission from motor to driven shaft.



REVERSING

In this application, the rotational direction of the driven shaft is determined by engaging different clutches.



SPEED CHANGING

The speed of the driven shaft is determined by engaging the appropriate clutch.

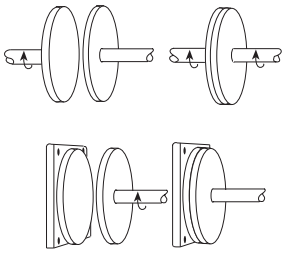
CLUTCH & BRAKE BASICS

DC clutches and brakes are magnetically-activated mechanical power transmission members normally installed between a motor shaft and driven shaft – either a speed reducer or the final driven shafts.

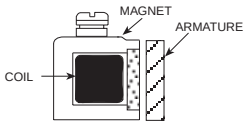
Both a clutch and brake transmit torque mechanically in response to an electrical signal.

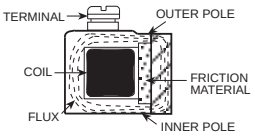
In a clutch, a disc on a revolving shaft is connected by magnetic attraction to a disc on a stationary shaft thus starting the drive.

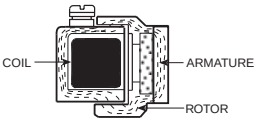
In a brake, one disc is fixed and magnetic attraction stops the revolving disc.



THE DISCS ARE CONNECTED BY MEANS OF ELECTRO-MAGNETIC ATTRACTION





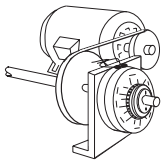


In a brake, one disc (the magnet) contains a coil embedded in a circular horseshoe shaped cavity. The other disc (the armature) consists of segments of iron attached to backing plate.

A friction face is embedded in the magnet of the brake between the inner pole and the outer pole. When direct current is applied to the coil, magnetic force attracts the armature to the magnet.

In the clutch, the magnet is stationary and the magnetic flux passes across an airgap and through a rotating rotor into the armature.

BRAKE – *Deceleration*



NO SHOCK

Potentiometer low: controlled stop.

HIGH RESPONSE

Potentiometer full: fast precise stop.

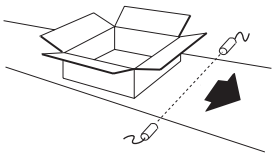
EMERGENCY STOP

Signal to brake brings malfunctioning system to a fast stop.

HOLDING

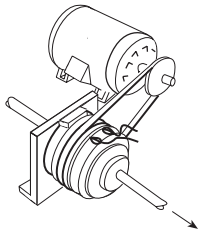
Fully engaged brake holds machine in stopped position.

CLUTCH/BRAKE



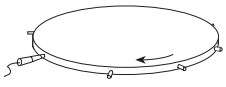
LINEAR POSITIONING

Carton breaks the beam, disengaging the clutch, engaging the brake. Carton (counter timer, pressure switch, etc.) disengages the brake, engages the clutch.



JOGGING

Pushbutton IN, clutch is ON; button OUT, clutch is disengaged and brake is ON. Common in machine setup and registration controls.



ROTARY INDEXING

Proximity switch disengages the clutch, engages the brake for precise positioning.

CYCLING

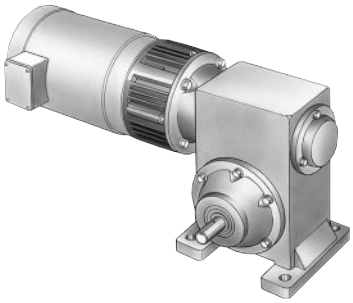
Programmed sequencer alternately engages the clutch and brake, producing programmed start-stop sequence.

C-Face Mounted
90 VDC

Clutches - CC Series
Clutch Brakes - CBC Series

"CC" clutch and "CBC" clutch/brake modules may be mounted directly to NEMA C-face motors and reducers. (Modules have 90VDC coils)

NEMA C-Face Mounting

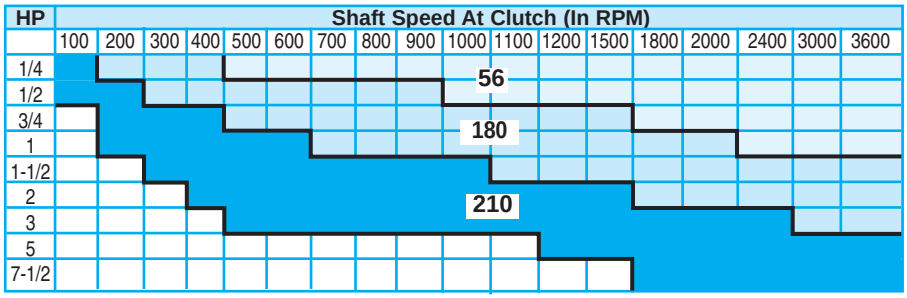


An optional conduit box is available. It has two conduit connection holes for 1/2" standard conduit connectors.

To select the correct module package:

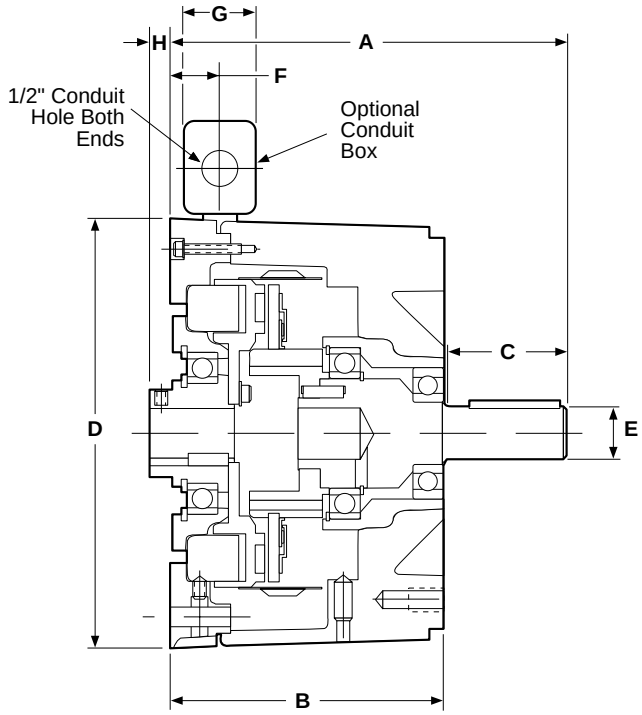
1. Determine the frame size, horsepower and output rpm of your motor.
2. Choose the right size module from the horsepower versus shaft speed chart and the NEMA mounting flange.

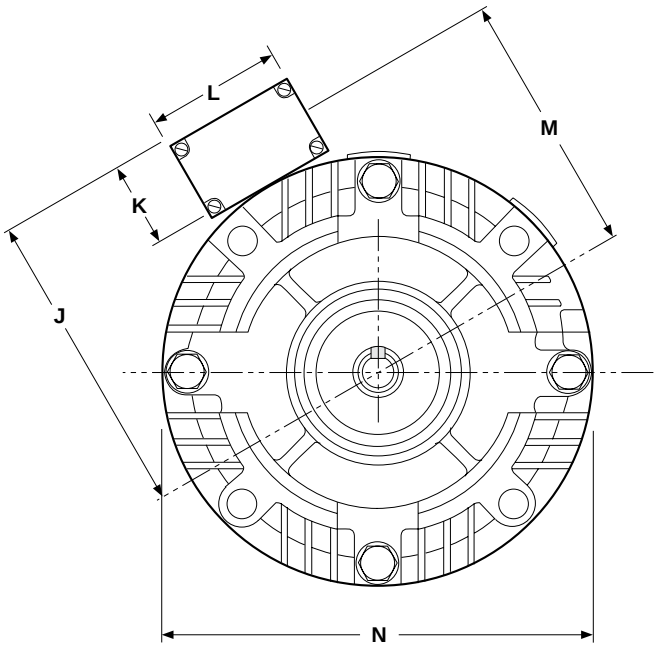
Horsepower vs. Shaft Speed



ORDER BY CATALOG NUMBER OR ITEM CODE

Static Torque (Lb. Ft.)	Maximum Motor HP 3600 RPM	NEMA-C Frame	Reducer Bore Code	Approx. Weight (lbs)		CC Series Clutches		CBC Series Clutch Brakes	
				CC Series	CBC Series	Catalog Number	Item Code	Catalog Number	Item Code
16	1	56	B5	8.3	10.0	CC56-16A	82904	CBC56-16A	82907
30	3	143TC, 145TC 182C, 184C	B7	10.3	13.2	CC180-30A	82905	CBC180-30A	82908
95	7.5	182TC, 184TC 213C, 215C	B9	24.3	30.6	CC210-95A	82906	CBC210-95A	82909





All dimensions are nominal, unless otherwise noted.

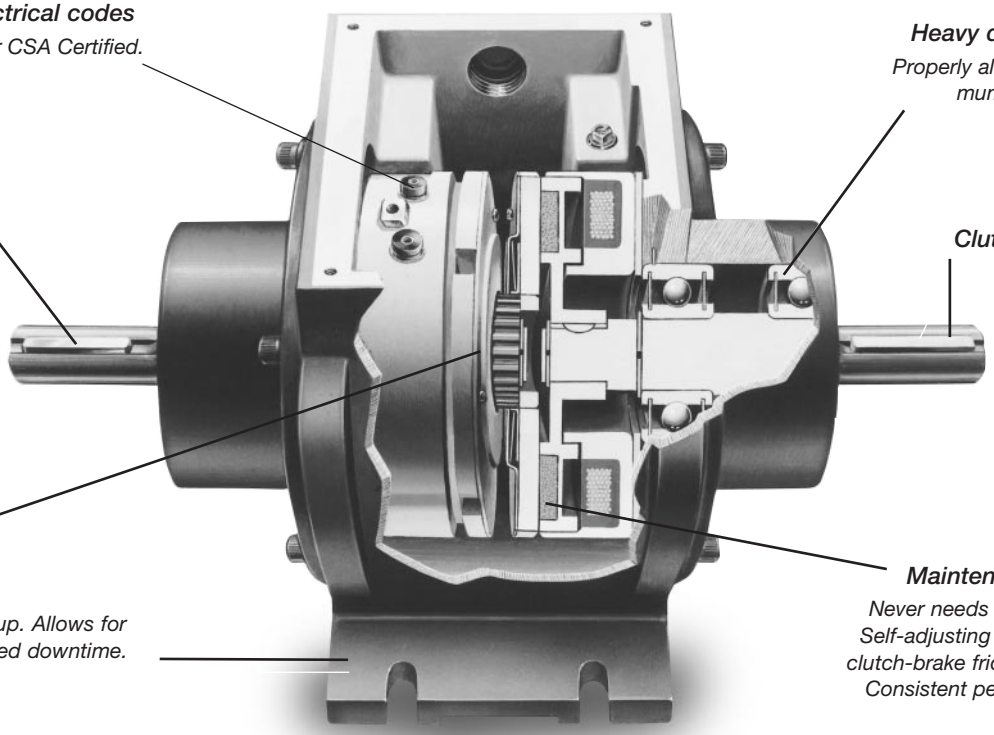
SIZE*	A	B	C	D	E	F	G	H
56 - 16A	6.750	4.844	1.813	6.750	.625	.937	2.203	----
180 - 30A	6.828	4.844	1.812	6.750	.875	.937	2.203	----
210 - 95A	8.891	5.922	2.500	9.250	1.125	.500	2.203	.500

SIZE*	J	K	L	M	N
56 - 16A	5.531	2.188	3.250	4.438	6.688
180 - 30A	5.531	2.188	3.250	4.438	6.688
210 - 95A	6.859	2.188	3.250	5.766	9.688

* Dimensions are the same for “CC” and “CBC” Series

Foot Mounted

Clutch Brakes - CBF Series
90 VDC



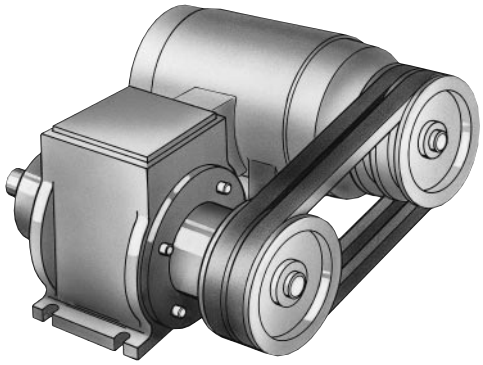
CBF Modules are rugged, pre-assembled clutch and brake combinations in an enclosed, foot mounted housing.

They are factory aligned and pre-assembled and have been designed to mate easily with industry standard motors and reducers with v-belts, pulleys, chain and sprockets, in line couplings and timing belt drives.

FEATURES

- Bolt-it-down and wire-it-up . . . it's ready to go!
- Maintenance free
- Torque range from 22.5 lb. ft. to 50 lb. ft.

TYPICAL APPLICATION



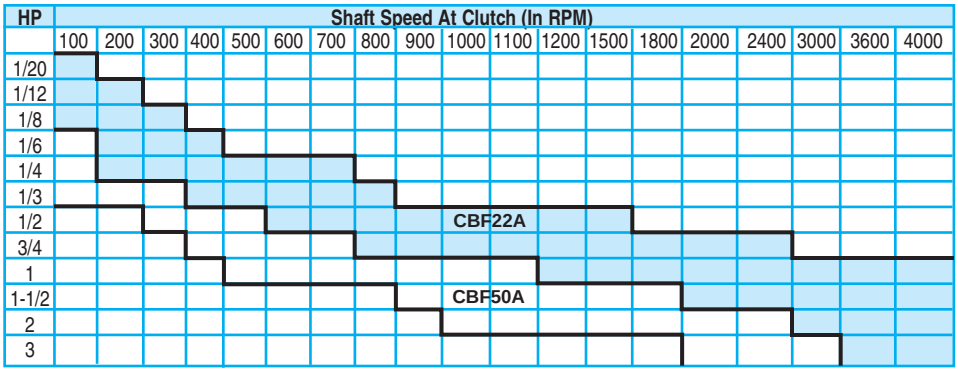
A foot mounted module combines with a motor in a parallel shaft drive application.

D

SELECTION PROCEDURE

Determine the shaft speed at the clutch/brake module. The number listed at the intersection of horsepower and speed is the size clutch/brake module you require.

Horsepower vs. Shaft Speed



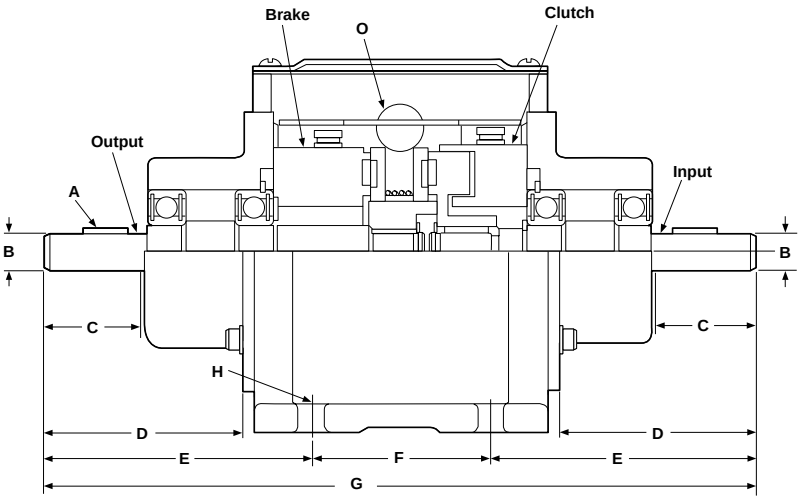
ORDER BY CATALOG NUMBER OR ITEM CODE

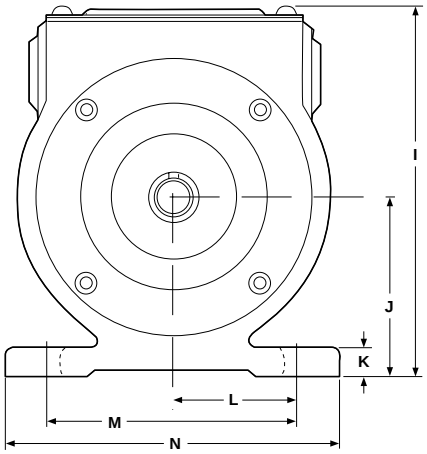
Static Torque (Lb. Ft.)	Max. RPM	Approx. Weight (Lbs.)	Totally Enclosed	
			Catalog Number	Item Code
22.5	4500	19.7	CBF22A	82902
50*	4000	56	CBF50A	82903

*Clutch is rated 40 Lb. Ft., brake is rated 50 Lb. Ft.

Foot Mounted

Clutch Brakes - CBF Series
90 VDC





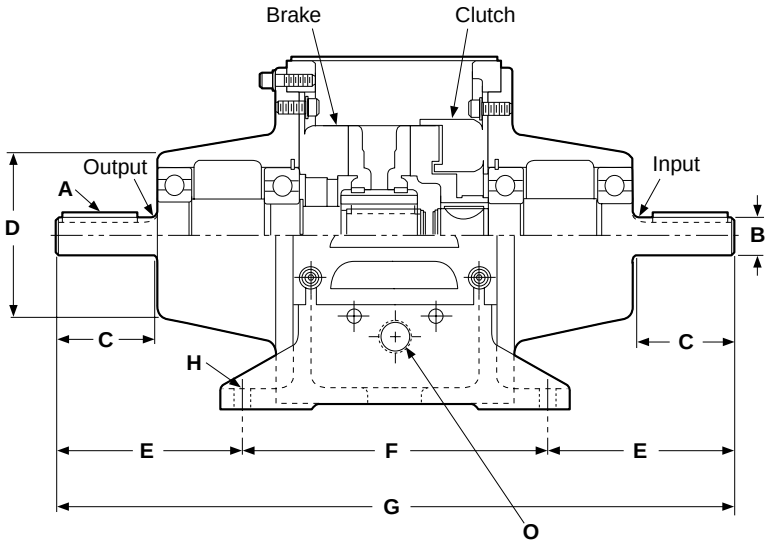
Size	A	B	C Min.	D	E	F	G Max.	H
CBF22A	3/16 x 3/16 x 1-1/2	.7495 / .7485	1.875	3.515	4.593	2.500	11.781	.312 Wide (4 slots)

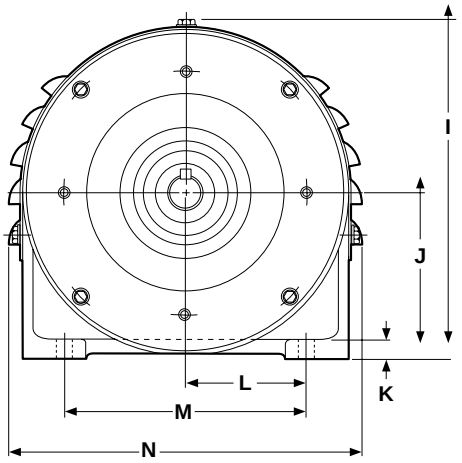
Size	I	J	K	L	M	N	O
CBF22A	6.937	.3474 / .3464	.500	2.578	5.156	6.000	1/2 conduit x 2

SPECIFICATIONS

Size	Static Torque (lb. ft.)	Inertia*-WR² (lb-in²)		Max. RPM	Weight lbs.
		Output	Input		
CBF22A	270	2.566	2.222	4500	19.7

D





Size	A	B Dia.	C Min.	D Max. Dia.	E	F	G Max.
CBF50A	3/16 X 3/16 1-3/4	.8750 .8745	2.218	3.796	4.234	7.000	15.515

Size	H Dia.	I	J	K	L	M	N Max.	O
CBF50A	.406 (4 holes)	8.218	4.004 3.992	5.00	2.937	5.875	8.734	1/2 conduit x 2

SPECIFICATIONS

Size	Unit	Static Torque (lb. ft.)	Inertia*-WR² (lb-ft²)		Max. RPM	Weight lbs.
CBF50A	Clutch Brake	50 40	2.222		4000	56
			Output	Input		
			.063	.039		

DC Shaft Mounted Selection

Clutch and brake components for shaft-mounting provide flexible arrangements to satisfy almost any mechanical arrangement where power transmission capabilities are required.

The most common arrangement is the bearing-mounted ***split-shaft*** application used to couple two in-line shafts.

Clutches for ***through-mounting*** utilize bearing mounted sprockets or pulleys to drive ***parallel*** shafts.

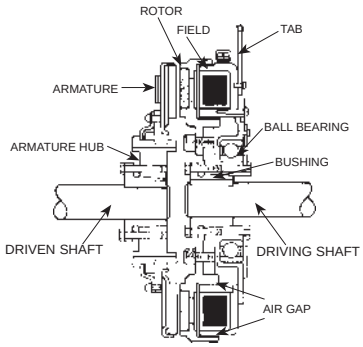
Brakes are ***flanged mounted*** with the field held stationary on a machine member.

Clutch brakes are bearing-mounted for split-shaft coupling.

For application engineering see pages 175-189.

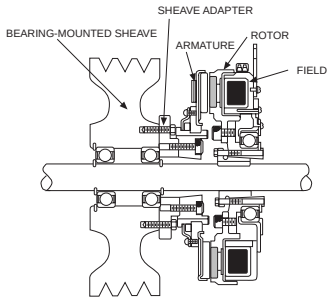
CLUTCH, BEARING-MOUNTED, SPLIT SHAFT (TYPE S)

Clutches consist of a field, rotor, armature and its hub. The field is mounted on sealed ball bearings and remains stationary while the rotor revolves. The rotor extends through the field assembly and is attached to the drive shaft by a bushing, in many sizes. A small tab holds the field stationary. The armature is mounted on a splined hub held on the shaft by standard tapered bushings.



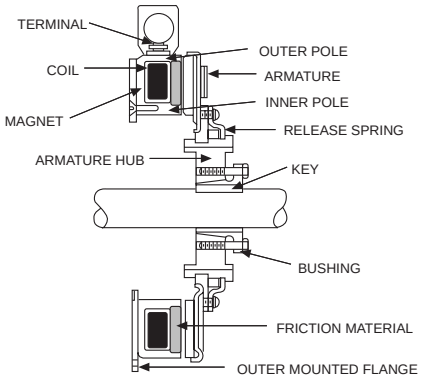
CLUTCH, BEARING MOUNTED, THROUGH SHAFT (TYPE T)

The through-shaft mounting of the field and rotor is as described for the split-shaft version. The armature in this application is mounted to a bearing mounted sheave, sprocket or gear. A special sheave adapter is necessary to assist in the mounting of the armature sheave. (Typical C50 and larger)



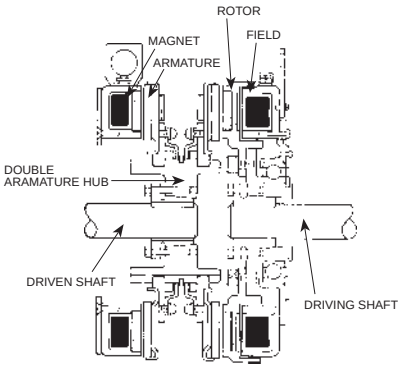
BRAKE, FLANGE MOUNTED

The magnet is mounted to a machine member, or a stationary mounting plate by inner or outer mounted flanges. The space available determines which flange to use. Terminals are wired directly to the brake control terminals. The armature rides on a splined drive hub. Standard tapered bushings secure the hub to the rotating shaft, in most units.



CLUTCH BRAKE

When the clutch field is energized and the brake coil is de-energized, the clutch and brake armatures rotate with the drive shaft. When the clutch coil is de-energized and the brake coil energized, the two armatures are stopped. The rotor continues to turn. Operation is the same whether the clutch is bearing or flange mounted.



D

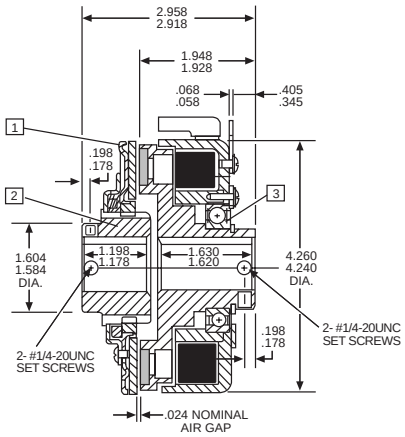
RATINGS

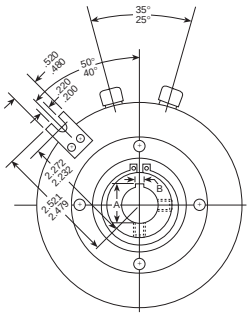
Static Torque: 20 Lb. Ft.
Maximum Speed: 4500 RPM
Voltage: 90 VDC
Resistance at 20°C: 1087 ±5% ohms
Maximum Current: .087 Amps
Maximum Watts: 7.83
Coil Build-up: 95 ms
Coil Decay: 23 ms

INSTALLATION REQUIREMENTS — C20S

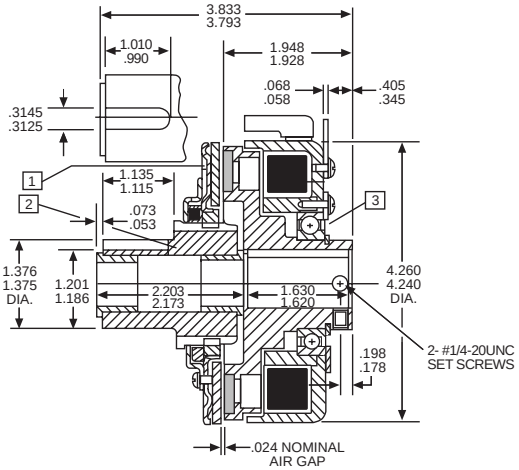
Angular alignment of shafts within .006" TIR at 5" diameter
Armature mounting shaft concentric with rotor mounting shaft within .003" TIR

SPLIT SHAFT MODELS — C20S





THROUGH SHAFT MODELS — C20T



AVERAGE WEIGHTS AND INERTIAS		
Part	**Wt. (lbs.)**	**Inertia (lb ft²)**
Field and Rotor	3.890	—
Field	2.343	—
Rotor 3/4 bore	1.547	.0159
Armature	.815	.0151
Armature hub (C20S)	.604	.0023
Armature hub (C20T)	.802	.0023
Total C20S	5.309	
Total C20T	5.507	

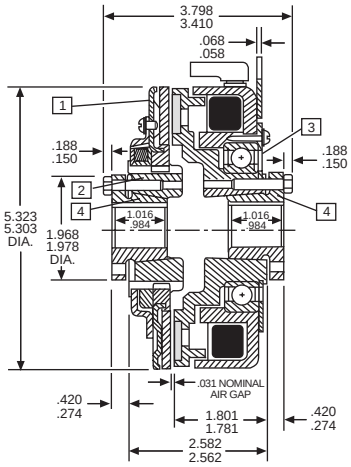
ALL DIMENSIONS IN INCHES					ORDER BY ITEM CODE			
STANDARD BORES		KEYWAY DIMENSIONS*			No. 1 Armature	No. 2 Armature Hub		No. 3 Field and Rotor Assembly
Nominal	Actual	Keyway	A	B	C20S/C20T	C20S	C20T	C20S/C20T
1/2	.5005/.5015	1/8 × 1/16	.560/.565	.126/.128		45062	45067	45070
5/8	.6255/.6270	3/16 × 3/32	.709/.715	.188/.190		45063	45068	45071
3/4	.7505/.7520	3/16 × 3/32	.837/.845	.188/.190	45061	45064	45069	45072
7/8†	.8755/.8770	3/16 × 3/32	.964/.970	.188/.190		45065	—	45073†
1 †	1.0005/1.0020	1/4 × 1/8	1.114/1.122	.251/.253		45066	—	45074†

*Armature Hub Data not applicable to C20T.
†Not applicable to C20T.
HOW TO ORDER: Specify Item Codes for Armature, Armature Hub (desired bore) and Field and Rotor Assembly (desired bore) for desired Type, C20S or C20T.

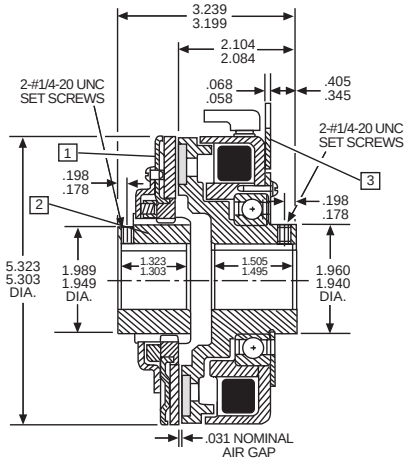
Clutches

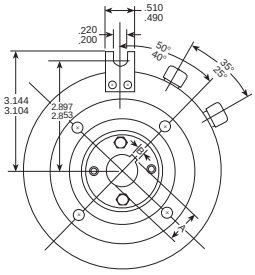
C50 Series
90 VDC

SPLIT SHAFT MODELS — C50S



1/2-1" BORES





1-1/8" & 1-1/4" BORES

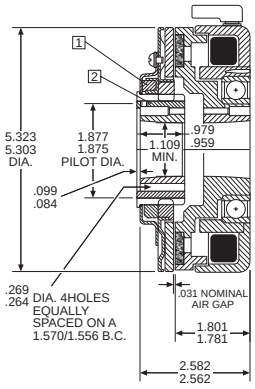
RATINGS

Static Torque: 50 Lb. Ft.
Maximum Speed: 4000 RPM
Voltage: 90 VDC
Resistance at 20°C: 237 ±5% ohms
Maximum Current: 400 Amps
Coil Build-up: 70 ms
Coil Decay: 15 ms

INSTALLATION REQUIREMENTS — C50S

Rotor shaft concentric with armature shaft within .004" TIR Angular misalignment of shafts within .008" TIR at 5" diameter.

THROUGH SHAFT MODELS — C50T



AVERAGE WEIGHTS AND INERTIAS		
Part	**Wt. (lbs.)**	**Inertia (lb ft²)**
Field and Rotor Assy	6.074	—
Field	3.408	—
Rotor 3/4" bore	2.666	.053
Armature	1.516	.044
Armature hub & 3/4" bushing	.958	.005
Total	8.548	—

ALL DIMENSIONS IN INCHES					ORDER BY ITEM CODE				
STANDARD BORES		KEYWAY DIMENSIONS			No. 1 Armature	No. 2 Armature Hub		No. 3 Field and Rotor Assembly		No. 4 Bushing*
Nominal	Actual	Keyway	A	B	C50S/C50T	C50S	C50T	C50S	C50T	C50S/C50T
1/2	.5000/.5015	—	.555/.565	.124/.126	45091	45092	45092	45095	45095	45163
5/8	.6250/.6265	—	.704/.714	.1865/.1885						45164
3/4	.7500/.7515	—	.832/.842	.1865/.1885						45165
7/8	.8750/.8765	—	.959/.969	.1865/.1885						45166
1	1.0000/1.0015	—	1.110/1.120	.250/.252						45167
1-1/8†	1.1255/1.1270	1/4 × 1/8	1.241/1.251	.251/.253		45093	—	45096	—	—
1-1/4†	1.2505/1.2520	1/4 × 1/8	1.367/1.377	.251/.253		45094	—	45097	—	—

*Two required for C50S Models, one for C50T Models.
†Not applicable to C50T Models.
HOW TO ORDER: Specify Item Codes for Armature, Armature Hub (desired bore), Field and Rotor Assembly and Bushing (desired bore and quantity required) for desired Type, C50S or C50T.

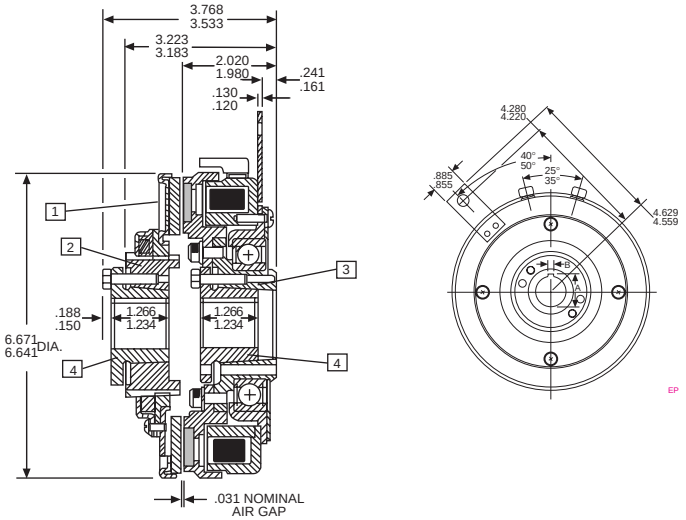
RATINGS

Static Torque: 100 Lb. Ft.
Maximum Speed: 3600 RPM
Voltage: 90 VDC
Resistance at 20°C: 202 ±5% ohms
Maximum Current: .469 Amps
Maximum Watts: 42.3
Coil Build-up: 65 ms
Coil Decay: 15 ms

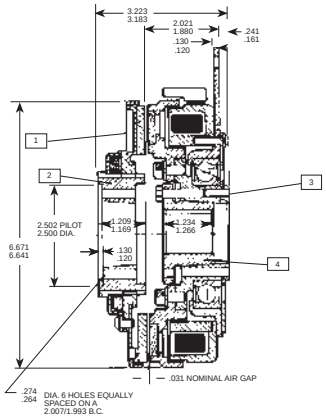
INSTALLATION REQUIREMENTS

Rotor shaft concentric with armature shaft within .004" TIR
Angular misalignment of shafts within .008" TIR at 5" diameter

SPLIT SHAFT MODELS — C100S



THROUGH SHAFT MODELS — C100T



AVERAGE WEIGHTS AND INERTIAS		
Part	**Wt. (lbs.)**	**Inertia (lb ft²)**
Field and Rotor Assy	10.90	—
Field	6.25	—
Rotor 3/4" bore	4.65	.123
Armature	2.43	.115
Armature hub & 3/4" bushings	1.79	.015
Total	15.12	

ALL DIMENSIONS IN INCHES				ORDER BY ITEM CODE			
STANDARD BORES		KEYWAY DIMENSIONS					
Nominal	Actual	A	B	No. 1 Armature C100S/C100T	No. 2 Hub C100S/C100T	No. 3 Field and Rotor Assembly C100S/C100T	No. 4 Bushing* C100S/C100T
1/2	.5000/.5015	.555/.565	.124/.126	45119	45120	45121	45168
5/8	.6250/.6265	.704/.714	.1865/.1885				45169
3/4	.7500/.7515	.832/.842	.1865/.1885				45170
7/8	.8750/.8765	.959/.969	.1865/.1885				45171
1	1.0000/1.0015	1.110/1.120	.249/.251				45172
1-1/8	1.125/1.127	1.236/1.246	.249/.251				45173
1-1/4	1.250/1.252	1.300/1.310	.249/.251				45174
1-3/8	1.375/1.377	1.419/1.429	.3115/.3135				45175
1-1/2	1.500/1.502	1.540/1.570	.375/.377				45176

*Two required for C100S Models, one for C100T Models.
HOW TO ORDER: Specify Item Codes for Armature, Armature Hub, Field and Rotor Assembly and Bushing (desired bore and quantity required) for desired type, C100S or C100T.

Clutches

C150 Series
90 VDC

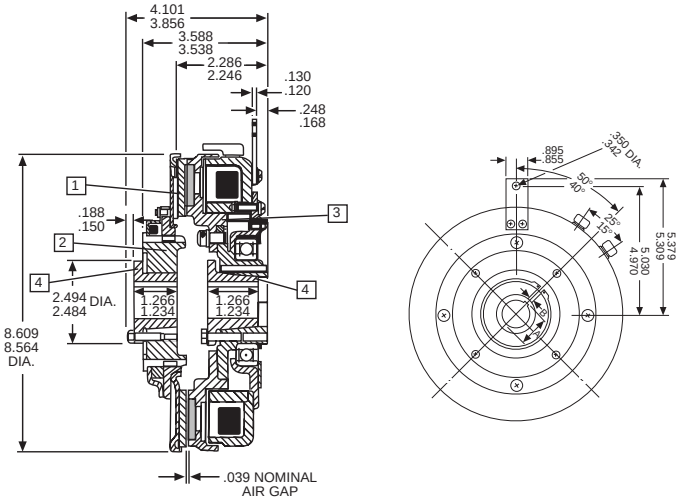
RATINGS

Static Torque: 150 Lb. Ft.
Maximum Speed: 3600 RPM
Voltage: 90 VDC
Resistance at 20°C: 219 ±5% ohms
Maximum Current: .433 Amps
Maximum Watts: 39
Coil Build-up: 155 ms
Coil Decay: 36 ms

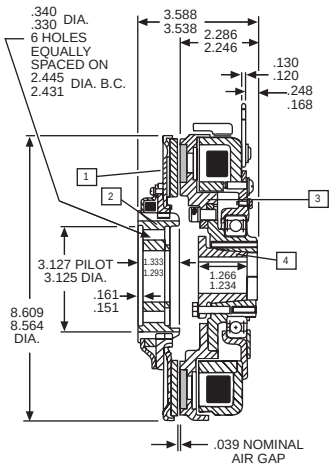
INSTALLATION REQUIREMENTS

Rotor shaft concentric with armature shaft within .006" TIR
Angular misalignment of shafts within .010" TIR at 8" diameter

SPLIT SHAFT MODELS — C150S



THROUGH SHAFT MODELS — C150T



AVERAGE WEIGHTS AND INERTIAS		
Part	**Wt. (lbs.)**	**Inertia (lb ft²)**
Field and Rotor Assy	18.33	—
Field	10.85	—
Rotor 3/4" bore	7.48	.354
Armature	4.85	.326
Armature hub & 3/4" bushings	2.74	.033
Total	25.92	

ALL DIMENSIONS IN INCHES				ORDER BY ITEM CODE			
STANDARD BORES		KEYWAY DIMENSIONS					
Nominal	Actual	A	B	No. 1 Armature	No. 2 Hub	No. 3 Field and Rotor Assembly	No. 4 Bushing*
				C150S/C150T	C150S/C150T	C150S/C150T	C150S/C150T
1/2	.5000/.5015	.555/.565	.124/.126	45136	45137	45138	45168
5/8	.6250/.6265	.704/.714	.1865/.1885				45169
3/4	.7500/.7515	.832/.842	.1865/.1885				45170
7/8	.8750/.8765	.959/.969	.1865/.1885				45171
1	1.0000/1.0015	1.110/1.120	.249/.251				45172
1-1/8	1.125/1.127	1.236/1.246	.249/.251				45173
1-1/4	1.250/1.252	1.300/1.310	.249/.251				45174
1-3/8	1.375/1.377	1.419/1.429	.3115/.3135				45175
1-1/2	1.500/1.502	1.540/1.570	.375/.377				45176

*Two required for C150S Models, one for C150T Models.
HOW TO ORDER: Specify Item Codes for Armature, Armature Hub, Field and Rotor Assembly and Bushing (desired bore and quantity required) for desired type C150S or C150T.

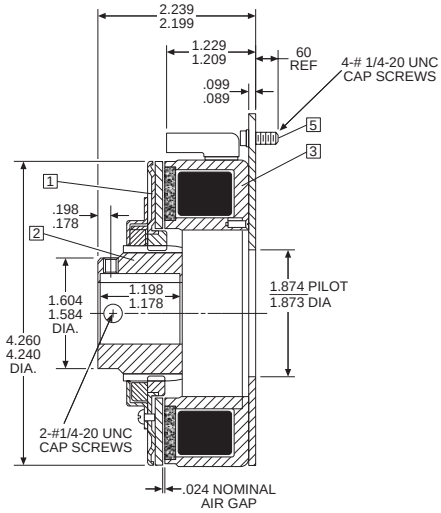
D

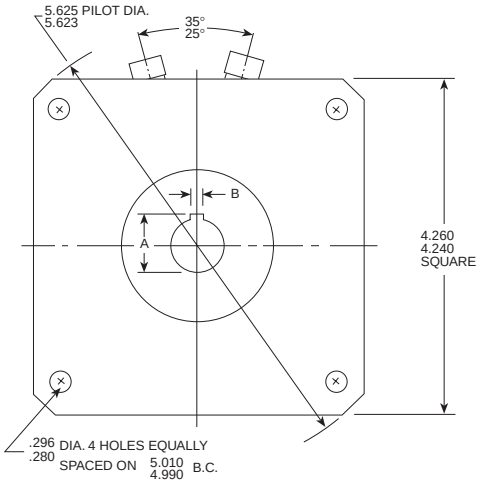
RATINGS

Static Torque: 20 Lb. Ft.
Maximum Speed: 4500 RPM
Voltage: 90 VDC
Resistance at 20°C: 1087 ±5% ohms
Maximum Current: .087 Amps
Maximum Watts: 7.83
Coil Build-up: 100 ms
Coil Decay: 22 ms

INSTALLATION REQUIREMENTS

Squareness of brake mounting surface with armature shaft within .006" TIR at 5" diameter.
Concentricity of brake mounting pilot diameter with armature shaft within .006" TIR.





AVERAGE WEIGHTS AND INERTIAS		
Part	**Wt. (lbs.)**	**Inertia (lb ft²)**
Field	2.586	—
Armature	.815	.0151
Armature hub	.604	.0023
Total	4.005	.0174

ALL DIMENSIONS IN INCHES					ORDER BY ITEM CODE			
STANDARD BORES		KEYWAY DIMENSIONS						
Nominal	Actual	Keyway	A	B	No. 1 Armature	No. 2 Armature Hub	No. 3 Field Assembly Outside Mounted	No. 5 Field Mounting Hardware Outside Mounting
1/2	.5005/.5015	1/8 × 1/16	.560/.565	.126/.128		45062		
5/8	.6255/.6270	3/16 × 3/32	.709/.715	.188/.190		45063		
3/4	.7505/.7520	3/16 × 3/32	.837/.845	.188/.190	45061	45064	45075	45081
7/8	.8755/.8770	3/16 × 3/32	.964/.970	.188/.190		45065		
1	1.0005/1.0020	1/4 × 1/8	1.114/1.122	.251/.253		45066		

HOW TO ORDER: Specify Item Codes for Armature, Armature Hub (desired bore), Field Assembly, and Field Mounting Hardware.

Brakes

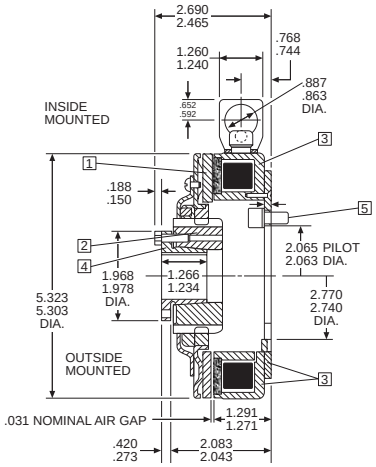
B50 Series
90 VDC

RATINGS

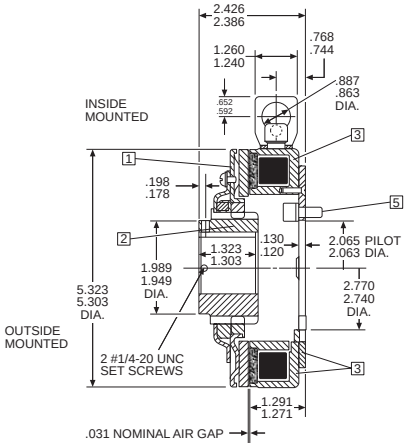
Static Torque: 50 Lb. Ft.
Maximum Speed: 4000 RPM
Voltage: 90 VDC
Resistance at 20°C: 237 ±5% ohms
Maximum Current: .400 Amps
Maximum Watts: 36
Coil Build-up: 65 ms
Coil Decay: 13 ms

INSTALLATION REQUIREMENTS

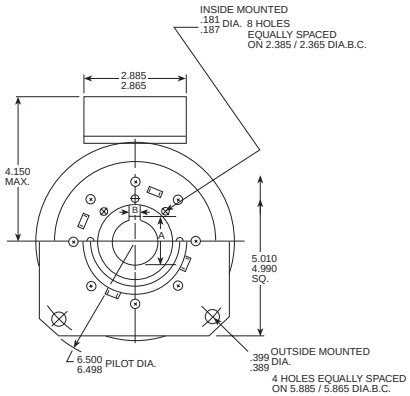
Squareness of brake mounting surface with armature shaft within .006" TIR at 4" diameter.
Concentricity of brake mounting pilot diameter with armature shaft within .010" TIR.



1/2" To 1" MODELS



1-1/8" AND 1-1/4" MODELS



AVERAGE WEIGHTS AND INERTIAS		
Part	**Wt. (lbs.)**	**Inertia (lb ft²)**
Field	3.763	—
Armature	1.516	.044
Armature hub	.958	.005
Total	6.237	.049

ALL DIMENSIONS IN INCHES					ORDER BY ITEM CODE						
STANDARD BORE			KEYWAY DIMENSIONS		No. 1	No. 2	No. 3 Field Assembly		No. 4	No. 5 Field Mounting Hardware	
Nominal	Actual	Keyway	A	B	Armature	Armature Hub	Inside Mounted	Outside Mounted	Bushing	Inside Mounting	Outside Mounting
1/2	.5000/.5015	—	.555/.565	.124/.126	45091	45092	45098	45099	45163	45107	45108
5/8	.6250/.6265	—	.704/.714	.1865/.1885					45164		
3/4	.7500/.7515	—	.832/.842	.1865/.1885					45165		
7/8	.8750/.8765	—	.959/.969	.1865/.1885					45166		
1	1.0000/1.0015	—	1.110/1.120	.250/.252					45167		
1-1/8	1.1255/1.1270	1/4 × 1/8	1.241/1.251	.251/.253		45093			—		
1-1/4	1.2505/1.2520	1/4 × 1/8	1.367/1.377	.251/.253		45094			—		

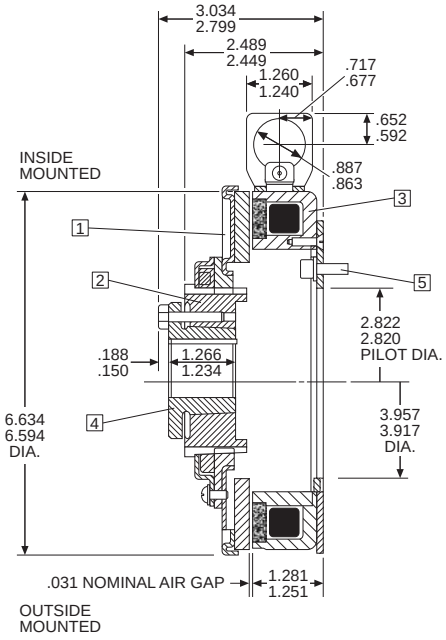
HOW TO ORDER: Specify Item Codes for Armature, Armature Hub (desired bore), Field Assembly, (inside or outside mounting) Bushing (desired bore) and Field Mounting Hardware.

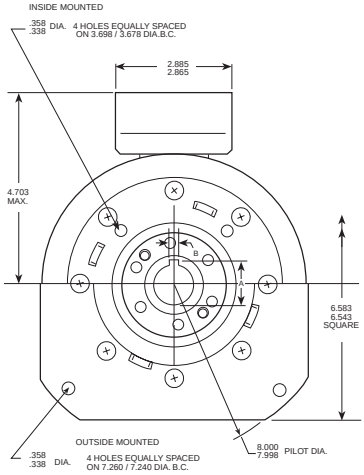
RATINGS

Static Torque: 100 Lb. Ft.
Maximum Speed: 3600 RPM
Voltage: 90 VDC
Resistance at 20°C: 202 ±5% ohms
Maximum Current: .469 Amps
Maximum Watts: 42.3
Coil Build-up: 76 ms
Coil Decay: 12 ms

INSTALLATION REQUIREMENTS

Squareness of brake mounting surface with armature shaft within .006" TIR at 5" diameter.
Concentricity of brake mounting pilot diameter with armature shaft within .010" TIR.





AVERAGE WEIGHTS AND INERTIAS		
Part	**Wt. (lbs.)**	**Inertia (lb ft²)**
Field	4.85	—
Armature	2.43	.115
Armature hub	1.79	.015
Total	9.07	.130

ALL DIMENSIONS IN INCHES				ORDER BY ITEM CODE						
STANDARD BORE		KEYWAY DIMENSIONS		ITEM CODES						
				No. 1	No. 2	No. 3 Field Assembly		No. 4	No. 5 Field Mounting Hardware	
Nominal	Actual	A	B	Armature	Armature Hub	Inside Mounted	Outside Mounted	Bushing	Inside Mounting	Outside Mounting
1/2	.5000/.5015	.555/.565	.124/.126					45168		
5/8	.6250/.6265	.704/.714	.1865/.1885					45169		
3/4	.7500/.7515	.832/.842	.1865/.1885					45170		
7/8	.8750/.8765	.959/.969	.1865/.1885					45171		
1	1.0000/1.0015	1.110/1.120	.249/.251	45119	45120	45122	45123	45172	45124	45124
1-1/8	1.125/1.127	1.236/1.246	.249/.251					45173		
1-1/4	1.250/1.252	1.300/1.310	.249/.251					45174		
1-3/8	1.375/1.377	1.419/1.429	.3115/.3135					45175		
1-1/2	1.500/1.502	1.540/1.570	.375/.377					45176		

HOW TO ORDER: Specify Item Codes for Armature, Armature Hub, Field Assembly (inside or outside mounting), Bushing (desired bore) and Field Mounting Hardware.

Brakes

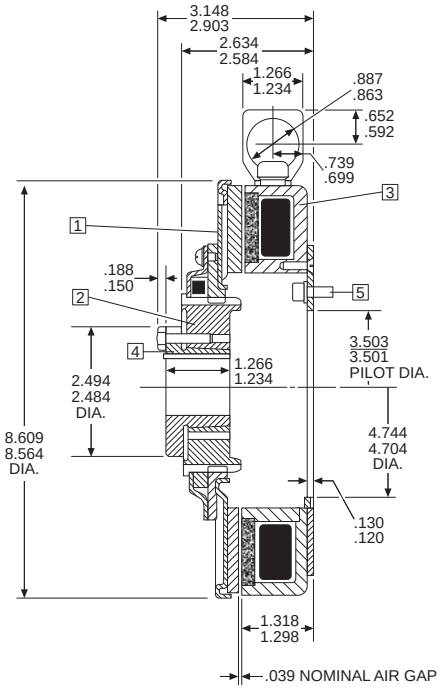
B150 Series
90 VDC

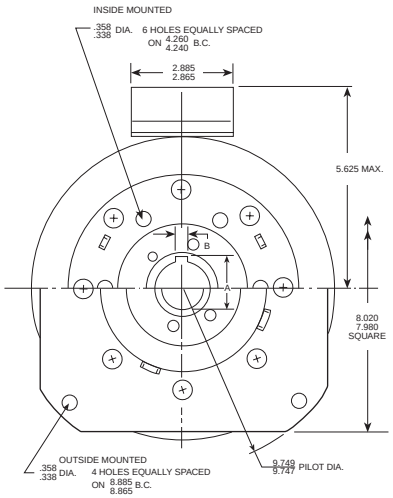
RATINGS

Static Torque: 150 Lb. Ft.
Maximum Speed: 3600 RPM
Voltage: 90 VDC
Resistance at 20°C: 219 ±5% ohms
Maximum Current: .433 Amps
Maximum Watts: 39
Coil Build-up: 110 ms
Coil Decay: 20 ms

INSTALLATION REQUIREMENTS

Squareness of brake mounting surface with armature shaft within .006" TIR at 6" diameter.
Concentricity of brake mounting pilot diameter with armature shaft within .010" TIR.





AVERAGE WEIGHTS AND INERTIAS		
Part	**Wt. (lbs.)**	**Inertia (lb ft²)**
Field	8.46	—
Armature	4.85	.326
Armature hub	2.74	.033
Total	16.05	.359

ALL DIMENSIONS IN INCHES				ORDER BY ITEM CODE						
STANDARD BORE		KEYWAY DIMENSIONS		ITEM CODES						
				No. 1	No. 2	No. 3 Field Assembly		No. 4	No. 5 Field Mounting Hardware	
Nom-inal	Actual	A	B	Armature	Armature Hub	Inside Mounted	Outside Mounted	Bushing	Inside Mounting	Outside Mounting
1/2	.5000/.5015	.555/.565	.124/.126					45168		
5/8	.6250/.6265	.704/.714	.1865/.1885					45169		
3/4	.7500/.7515	.832/.842	.1865/.1885					45170		
7/8	.8750/.8765	.959/.969	.1865/.1885					45171		
1	1.0000/1.0015	1.110/1.120	.249/.251	45136	45137	45139	45140	45172	45141	45124
1-1/8	1.125/1.127	1.236/1.246	.249/.251					45173		
1-1/4	1.250/1.252	1.300/1.310	.249/.251					45174		
1-3/8	1.375/1.377	1.419/1.429	.3115/.3135					45175		
1-1/2	1.500/1.502	1.540/1.570	.375/.377					45176		

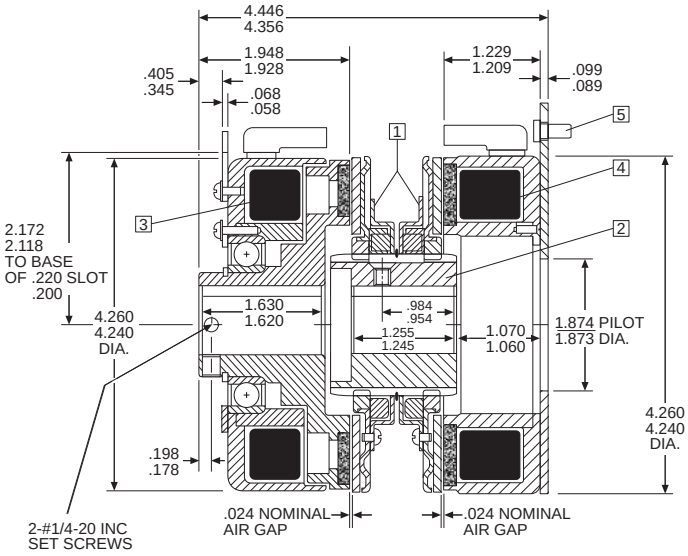
HOW TO ORDER: Specify Item Codes for Armature, Armature Hub (desired bore), Field Assembly (inside or outside mounting), Bushing (desired bore) and Field Mounting Hardware.

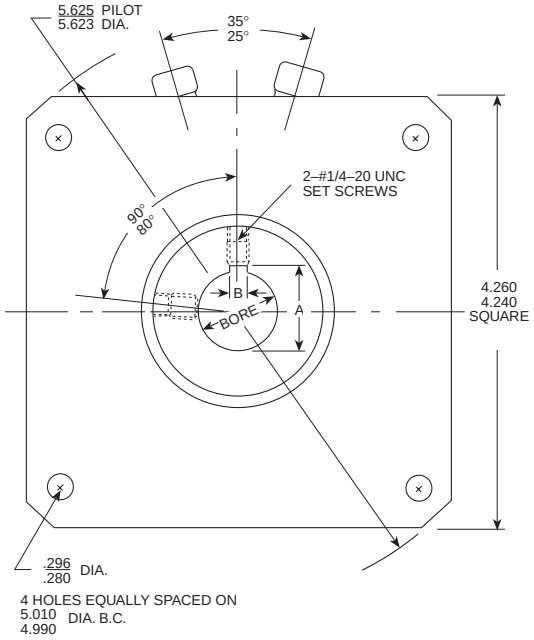
RATINGS

Static Torque: 20 Lb. Ft.
Maximum Speed: 4500 RPM
Average Weight: 9.01 Lbs.
Output Inertia: .0336 Lb. Ft.^{2}
Coil Build-up: (Clutch): 95 ms, (Brake): 100 ms
Coil Decay: (Clutch): 23 ms, (Brake): 22 ms
Voltage: 90 VDC
Maximum Watts: 7.83
Maximum Current: .087 Amps
Resistance at 20°C: 1087 ±5% ohms

INSTALLATION REQUIREMENTS

Angular alignment of shafts within .006" TIR at 5" diameter.
Shafts to be concentric within .003" TIR
Armature shaft square to brake mounting surface within .006" TIR at 5" diameter
Brake pilot diameter to be concentric with shaft within .006" TIR





ALL DIMENSIONS IN INCHES					ORDER BY ITEM CODE				
STANDARD BORES		KEYWAY DIMENSIONS							
Nom-inal	Actual	Keyway	A	B	No. 1 Armature (2 req'd.)	No. 2 Armature Hub	No. 3 Field Rotor Assembly	No. 4 Brake Field	No. 5 Brake Field Mounting Assy.
1/2	.5005/.5015	1/8 × 1/16	.560/.565	.126/.128		45076	45070		
5/8	.6255/.6270	3/16 × 3/32	.709/.715	.188/.190		45077	45071		
3/4	.7505/.7520	3/16 × 3/32	.837/.845	.188/.190	45061	45078	45072	45075	45081
7/8	.8755/.8790	3/16 × 3/32	.964/.970	.188/.190		45079	45073		
1	1.0005/1.0020	1/4 × 1/8	1.114/1.122	.251/.253		45080	45074		

HOW TO ORDER: Specify Item Codes for Armatures, Armature Hub (desired bore), Field Rotor Assembly (desired bore), Brake Field and Brake Field Mounting Assembly.

Clutch/Brakes

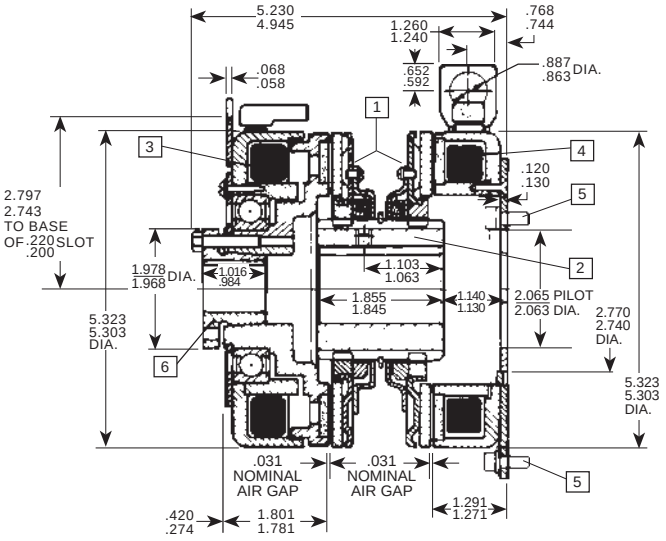
CB-50S Series
90 VDC

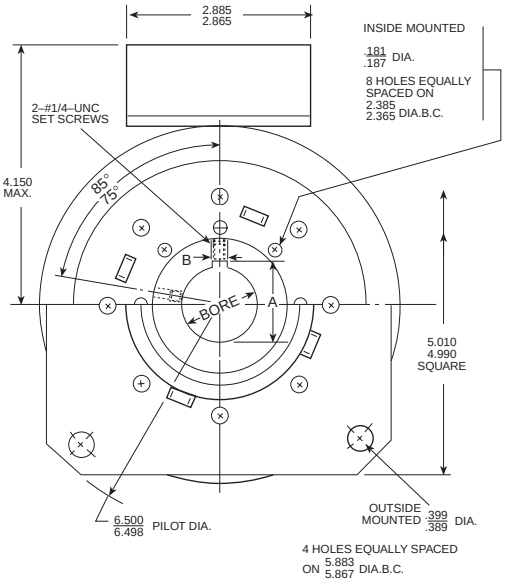
RATINGS

Static Torque: 50 Lb. Ft.
Maximum Speed: 4000 RPM
Average Weight: 14.31 Lbs.
Output Inertia: .0955 Lb. Ft.^{2}
Coil Build-up: (Clutch): 70 ms, (Brake): 65 ms
Coil Decay: (Clutch): 15 ms, (Brake): 12 ms
Voltage: 90 VDC
Maximum Watts: 34
Maximum Current: .38 Amps
Resistance at 20°C: 237 ±5% ohms

INSTALLATION REQUIREMENTS

Angular alignment of shafts within .008" TIR at 5" diameter.
Shafts to be concentric within .004" TIR
Armature shaft square to brake mounting surface within .006" TIR at 5" diameter
Brake pilot diameter to be concentric with shaft within .010" TIR





ALL DIMENSIONS IN INCHES				ORDER BY ITEM CODE						
STANDARD BORES		KEYWAY DIMENSIONS		No. 1	No. 2	No. 3	No. 4 Brake Field		No. 5 Brake Field Mounting Hardware		No. 6
Nom-inal	Actual	A	B	Armature (2 Req'd.)	Armature Hub	Field Rotor Assembly	Inside Mounted	Outside Mounted	Inside Mounting	Outside Mounting	Bushing
1/2	.5000/.5015	.555/.565	.124/.126	45091	45100	45095	45098	45099	45107	45108	45163
5/8	.6250/.6265	.704/.714	.1865/.1885		45101						45164
3/4	.7500/.7515	.832/.842	.1865/.1885		45102						45165
7/8	.8750/.8765	.959/.969	.1865/.1885		45103						45166
1	1.0000/1.0015	1.110/1.120	.250/.252		45104						45167
1-1/8	1.1255/1.1270	1.241/1.251	.251/.253		45105	45096					—
1-1/4	1.2505/1.2520	1.367/1.377	.251/.253		45106	45097					—

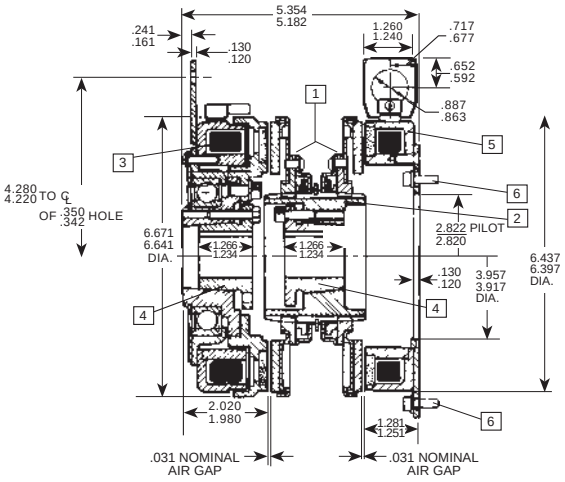
HOW TO ORDER: Specify Item Codes for Armatures, Armature Hub (desired bore), Field Rotor Assembly (desired bore), Brake Field (inside or outside mounting), Brake Field Mounting Hardware and Bushing (desired bore).

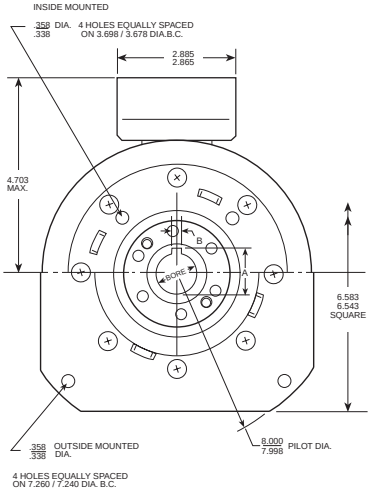
RATINGS

Static Torque: 100 Lb. Ft.
Maximum Speed: 3600 RPM
Average Weight: 23.30 Lbs.
Output Inertia: .2525 Lb. Ft.^{2}
Coil Build-up: (Clutch): 65 ms, (Brake): 76 ms
Coil Decay: (Clutch): 15 ms, (Brake): 12 ms
Voltage: 90 VDC
Maximum Watts: 42.3
Maximum Current: .469 Amps
Resistance at 20°C: 202 ±5% ohms

INSTALLATION REQUIREMENTS

Angular alignment of shafts within .008" TIR at 5" diameter.
Shafts to be concentric within .004" TIR
Armature shaft square to brake mounting surface within .006" TIR at 5" diameter
Brake pilot diameter to be concentric with shaft within .010" TIR





ALL DIMENSIONS IN INCHES				ORDER BY ITEM CODE							
STANDARD BORES		KEYWAY DIMENSIONS		No. 1	No. 2	No. 3	No. 4	No. 5 Brake Field		No. 6 Brake Field Mounting Hardware	
Nominal	Actual	A	B	Armature (2 Req'd.)	Armature Hub	Field Rotor Assembly	Bushing	Inside Mounted	Outside Mounted	Inside Mounting	Outside Mounting
1/2	.5000/.5015	.555/.565	.124/.126				45168				
5/8	.6250/.6265	.704/.714	.1865/.1885				45169				
3/4	.7500/.7515	.832/.842	.1865/.1885				45170				
7/8	.8750/.8765	.959/.969	.1865/.1885	45119	45125	45121	45171	45122	45123	45124	45124
1	1.0000/1.0015	1.072/1.102	.249/.251				45172				
1-1/8	1.125/1.127	1.236/1.246	.249/.251				45173				
1-1/4	1.250/1.252	1.300/1.310	.249/.251				45174				
1-3/8	1.375/1.377	1.419/1.429	.3115/.3135				45175				
1-1/2	1.500/1.502	1.540/1.570	.375/.377				45176				

HOW TO ORDER: Specify Item Codes for Armatures, Armature Hub Field Rotor Assembly, Bushing (desired bore), Brake Field (inside or outside mounting) and Brake Field Mounting Hardware.

Clutch/Brakes

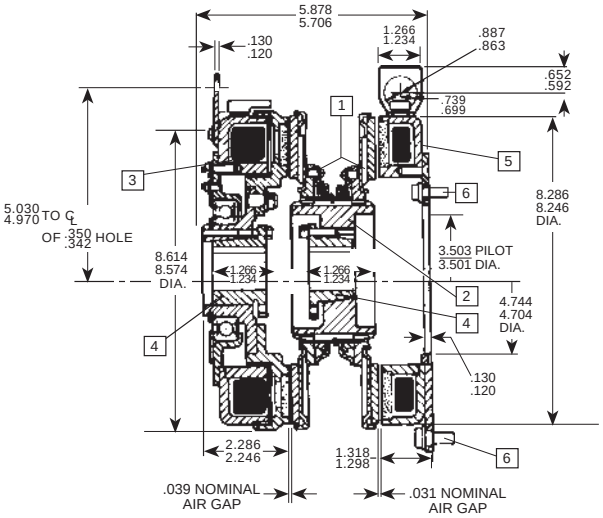
CB-150S Series
90 VDC

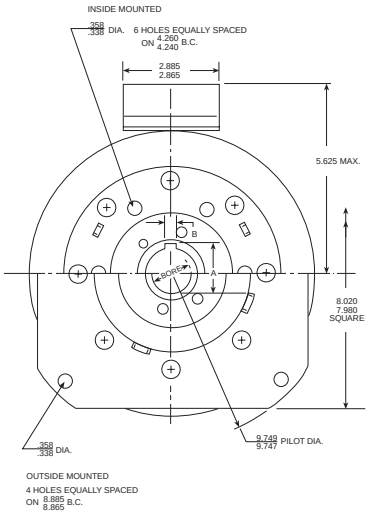
RATINGS

Static Torque: 150 Lb. Ft.
Maximum Speed: 3600 RPM
Average Weight: 40.60 Lbs.
Output Inertia: .7015 Lb. Ft.^{2}
Coil Build-up (Clutch): 155 ms (Brake): 110 ms
Coil Decay (Clutch): 36 ms (Brake): 20 ms
Voltage: 90 VDC
Maximum Watts: 39
Maximum Current: .433 Amps
Resistance at 20°C: 219 ±5% ohms

INSTALLATION REQUIREMENTS

Angular alignment of shafts within .010" TIR at 5" diameter.
Shafts to be concentric within .006" TIR
Armature shaft square to brake mounting surface within .006" TIR at 5" diameter
Brake pilot diameter to be concentric with shaft within .010" TIR





ALL DIMENSIONS IN INCHES				ORDER BY ITEM CODE							
STANDARD BORES		KEYWAY DIMENSIONS		No. 1	No. 2	No. 3	No. 4	No. 5 Brake Field		No. 6 Brake Field Mounting Hardware	
Nominal	Actual	A	B	Armature (2 Req'd.)	Armature Hub	Field Rotor Assembly	Bushing	Inside Mounted	Outside Mounted	Inside Mounting	Outside Mounting
1/2	.5000/.5015	.555/.565	.124/.126				45168				
5/8	.6250/.6265	.704/.714	.1865/.1885				45169				
3/4	.7500/.7515	.832/.842	.1865/.1885				45170				
7/8	.8750/.8765	.959/.969	.1865/.1885	45136	45142	45138	45171	45139	45140	45141	45124
1	1.0000/1.0015	1.110/1.120	.249/.251				45172				
1-1/8	1.125/1.127	1.236/1.246	.249/.251				45173				
1-1/4	1.250/1.252	1.300/1.310	.249/.251				45174				
1-3/8	1.375/1.377	1.419/1.429	.3115/.3135				45175				
1-1/2	1.500/1.502	1.540/1.570	.375/.377				45176				

HOW TO ORDER: Specify Item Codes for Armatures, Armature Hub, Field Rotor Assembly, Bushing (desired bore), Brake Field (inside or outside mounting) and Brake Field Mounting Hardware.

D

DC Power Supplies/Controls

The following standard controls provide 90 VDC from 115 VAC lines and fulfill most clutch and brake power supply requirements.

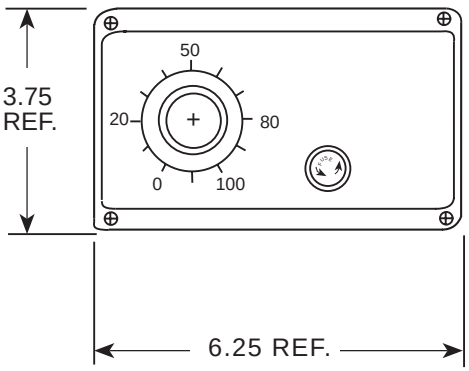
Other versions, modified or special, are available.

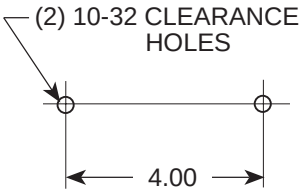
All controls operate one or two units – one unit at a time – through the use of SPDT switch, 15 Amp rated. (Customer supplied)

ORDER BY CATALOG NUMBER OR ITEM CODE

Description	Catalog Number	Item Code
Basic Power Supply – Plug in Fixed output	PS90B	45153
As above, fused	PS90F	45154
Octal socket for PS90B, F	Octal Socket	67530
Dual output, one fixed and one adjustable 0-90VDC	PS90-1	45156
Dual output, both adjustable	PS90-2	45157
Dual; relay output	PS90-2R	45158

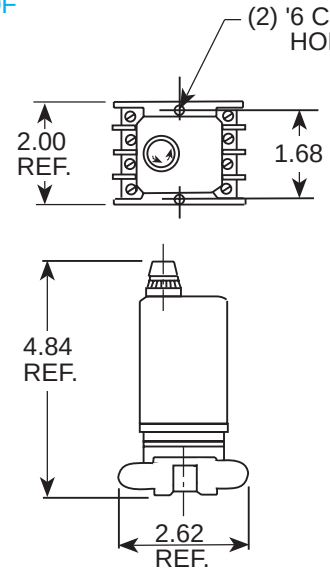
PS90 (-1, -2, -2R)



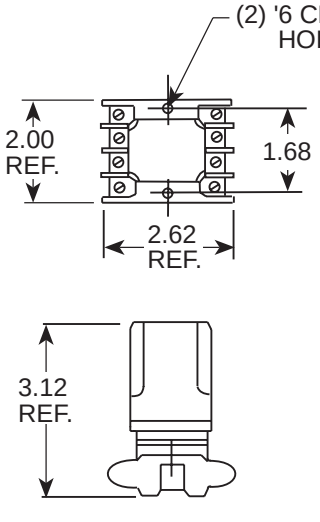


WALL MOUNTING HOLE PATTERN

PS90F



PS90B

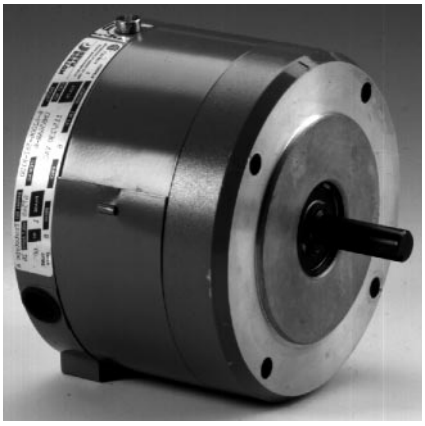


All Dimensions in Inches.
Dimensions subject to change.

AC BRAKES

Double C-Face AC Brakes

CMBA Series



These double C-Face Brakes are direct acting with only one moving part. They are spring set and electro-magnetically released. Movement is limited to a spring loaded pressure plate. Release is instantaneous. If power fails, the brake will immediately set and hold.

FEATURES

- *Automatic Reset*
- *Compact*
- *Continuous Duty*
- *Dependable*
- *Full Torque Stop*
- *Horizontal/Vertical Mount*
- *Instant Magnetic Release*
- *One Moving Part*
- *Ready to Mount*
- *Shock Mounted Magnet*
- *Direct Acting*
- *Flange/Foot Mounting*
- *Splined Hub*
- *Standard NEMA Voltages/Frequencies*
- *Superior Disc Life*
- *Superior Thermal Capacity*
- *Double C-Face*

OPERATION

Friction discs rotate with the motor shaft and are free to move axially on the hub. When the magnet coil is de-energized, a spring loaded pressure plate (magnet armature) presses against the rotating discs. Friction force stops and holds the motor shaft.

The pressure plate retracts against torque springs by magnetic force when the magnet is energized. Friction discs are then released and free to rotate with the hub and motor shaft. A manual release is also provided.

Brake coil leads connect directly to motor leads so that power is simultaneously supplied to both brake and motor. No control equipment is required. An instruction bulletin on mounting and hookup are included with each brake.

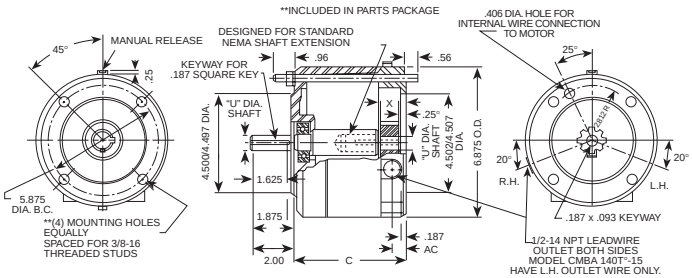
SPLINED HUB

These C-Face brakes use splined hubs and internally splined friction discs as standard equipment. The spline design virtually eliminates backlash which is a delayed action effect caused by excessive clearances between hub and discs. Splines increase disc life because the many contact points between hub and discs reduce the concentration of stresses encountered with non-splined hubs having only a few contact points.

ORDER BY CATALOG NUMBER OR ITEM CODE

Torque (Lb. Ft.)	NEMA Frame	Bore Code	Mounting	Coil Voltage: 115/230 VAC, 60 Hz Catalog Number	115/230 VAC, 60 Hz Item Code	208-230/460 VAC, 60 Hz 190/380 VAC, 50 Hz Catalog Number	208-230/460 VAC, 60 Hz 190/380 VAC, 50 Hz Item Code	575 VAC, 60 Hz Catalog Number	575 VAC, 60 Hz Item Code
3	56C	B5	Horizontal/Vertical	CMBA56R-3	67545	CMBA56U-3	67546	CMBA56Y-3	67547
		B5	Horizontal	CMBA56R-6	67548	CMBA56U-6	67549	CMBA56Y-6	67550
6	140TC	B7	Horizontal	CMBA140TR-6	67551	CMBA140TU-6	67552	CMBA140TY-6	67553
		B7	Vertical Shaft Up	CMBA140TR-6U	67554	CMBA140TU-6U	67556	—	—
		B7	Vertical Shaft Down	CMBA140TR-6D	67555	CMBA140TU-6D	67557	—	—

DIMENSIONS



ALL DIMENSIONS IN INCHES							
Size	AC	C	G	X	U	Housing O.D.	Approx. Weight
56-3 56-6 140T-6	9/16	4-15/16	1-3/16	7/8	5/8 5/8 7/8	6-7/8	12 Lbs.

PARTS

ORDER BY ITEM CODE	
Description	Item Code
Base Kit	67561
Coil–115/230 VAC 60 Hz	67558
Coil–208-200-380-440 VAC	67559
Coil–575 VAC 60 Hz	67560
Disc–Stationary	67562
Disc–Rotating	67563

D

Double C-Face AC Brakes Washdown (BISSC)

CMBWB Series

Double C-Face brakes provide the simplest solution for adding a brake between a C-Face motor and a flanged gear reducer. These brakes offer the added feature of meeting BISSC standards, AAA standards and other food industry washdown requirements. The CMB-WB double C-Face brakes are a perfect compliment to our AC washdown motors.

OPERATION

The brake hub is attached to the motor shaft. The friction disk fits around the hub and is free to move axially along the hub. When the motor and the brake solenoid coil are de-energized, the brake is in a set condition. In a set condition, the pressure spring applies a force against the pressure plate to clamp the friction disc against the stationary disc and endplate to retard motion. The clamped friction disc prevents the hub and motor shaft from rotating.

The brake is released electrically when voltage is applied to the solenoid coil of the brake. This produces an electromagnetic force which pulls the lever arm away from the pressure plate, releasing the clamping force on the friction disc. This allows the brake hub and motor shaft to turn freely. An important feature of this spring set brake is it's power failure characteristic. If a loss of electric power to the motor and brake occurs, the brake will automatically engage and hold the load provided that it has been properly applied and maintained.

The brake coil is connected directly to the motor leads so that power is simultaneously supplied to the brake and the motor. No additional control equipment is required.

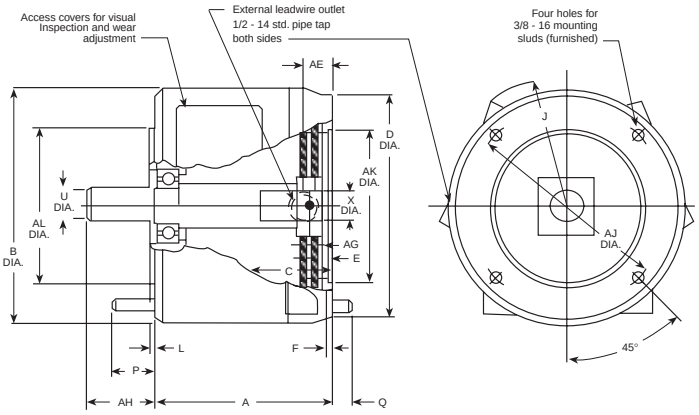
FEATURES

- *BISSC Certified*
- *CSA Certified*
- *Meets National AAA Dairy Standards*
- *Complies with Wisconsin Food and Dairy Regulations*
- *White FDA Approved Epoxy Paint*
- *Stainless Steel Hardware*
- *Neoprene Gasketing*
- *Splined Hub for Increased Disc Life*
- *Sizes for NEMA 56C to 184TC Frame Motors*
- *Standard Torque Ranges from 3 to 10 lb-ft*
- *Maximum RPM: 5000 (56C and 140TC) and 4000 (180TC)*
- *Manual Adjust for Lining Wear (56C and 140TC)*
- *Self-Adjusting for Lining Wear (180TC only)*
- *Automatic Reset, Manual Brake Release*
- *Rated for Continuous Duty*
- *Available in AC or DC Voltages*

ORDER BY CATALOG NUMBER OR ITEM CODE

Nominal Static Torque (Lb. Ft.)	Bore Code	NEMA Frame	Mounting	Coil Voltage					
				115/208-230 VAC, 60 Hz		208-230/460 VAC, 60 Hz 190/380 VAC, 50 Hz		575 VAC, 60 Hz	
				Catalog Number	Item Code	Catalog Number	Item Code	Catalog Number	Item Code
3	B5	56C	Horizontal/ Vertical	CMBWB-3-R-B5	58106	CMBWB-3-U-B5	58107	CMBWB-3-Y-B5	58108
6	B5	56C	Horizontal/ Vertical	CMBWB-6-R-B5	58110	CMBWB-6-U-B5	58111	CMBWB-6-Y-B5	58112
6	B7	143/145TC	Horizontal/ Vertical	CMBWB-6-R-B7	58114	CMBWB-6-U-B7	58115	CMBWB-6-Y-B7	58116
10	B9	182/184TC	Horizontal/ Vertical Down	CMBWB-10-R-B9	58125	CMBWB-10-U-B9	58126	CMBWB-10-Y-B9	58127
			Vertical Up	CMBWB-10U-R-B9	58128	CMBWB-10U-U-B9	58130	CMBWB-10U-Y-B9	58131

DIMENSIONS



DIMENSIONS											
Unit*	**A**	**AE**	**AG**	**AJ**	**AK**	**AL**	**B**	**C**	**D**	**E**	**F**
CMBWB-3-*-B5 CMBWB-6-*-B5	5.22	.88	.41	5.88	4.502/4.507	4.500/4.497	7.00	2.19	6.50	.25	.19
CMBWB-6-*-B7	5.22	.88	.41	5.88	4.502/4.507	4.500/4.497	7.00	2.19	6.50	.25	.19
CMBWB-10-*-B9	8.38	2.12	.18	7.25	8.500/8.502	8.500/8.498	10.38	2.81	9.00	1.00	.19

					Input Shaft		Output Shaft		
Unit*	**J**	**L**	**P**	**Q**	**X**	**Keyway**	**U**	**Keyway**	**AH**
CMBWB-3-*-B5 CMBWB-6-*-B5	3.88	.12	1.25	.56	.626/.627	.19 X .09	.625/.624	.19 X .09	2.00
CMBWB-6-*-B7	3.88	.12	1.25	.56	.876/.877	.19 X .09	.875/.874	.19 X .09	2.00
CMBWB-10-*-B9	12.12	.25	——	——	1.125/1/126	.25 X .12	1.125/1.124	.25 X .12	2.62

Dimensions for estimating only. For installation purposes, request certified prints.
* Voltage

SPECIFICATIONS								
Unit*	**Nominal Static Torque (lb-ft)**	**No. of Friction Discs**	**Maximum Solenoid Cycle Rate[1] (cycles/min)**	**Max. RPM[2]**	**Thermal Capacity[3] (hp-sec/min)**	**Inertia (Wk^2) ($lb\text{-}ft^2$)**	**Kinetic Energy Absorption[4] (ft-lb)**	**Net Weight (lb)**
CMBWB-3-*-B5	3	1	40	5,000	5	.008	9,750	11
CMBWB-6-*-B5 CMBWB-6-*-B7	6	1	40	5,000	5	.008	9,750	11
CMBWB-10-*-B9	10	1	30	4,000	20	.078	34,000	57

1 Maximum solenoid cycle rate is based on ambient temperature of 72° F (22°C) with 50% duty cycle. Does not relate to brake cycle rate (see Thermal Capacity).
2 Maximum RPM rating based on horizontal operation. Contact factory for maximum RPM on vertical applications.
3 Thermal capacity rating is based on ambient temperature of 72°F (22°C), stop time of one second or less, with no heat absorbed from motor and brake mounted horizontally.
4 Total kinetic energy absorption is based on ambient temperatures at 100°F (38°C) or less, including motor heat, with brake mounted horizontally. At the given rating, a 1 1/2 hour cool-down interval between stops is required. (3 hours for 10 lb ft unit.)
* Voltage

AC Motor Brake Kit

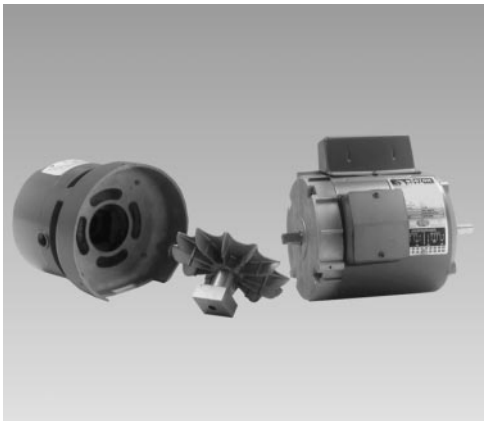
BRAKE KITS

These brakes are for quick field conversion of stock Boston Gear brand motors to brakemotors* using only hand tools.

All brakes are totally enclosed, fail-safe, spring set and electrically released for positive stop and hold operation. A manual release is provided for power off operation. The manual release automatically resets when power is restored.

The brake torque rating should equal 100% to 150% or more of the full load torque of the motor. The brake coils are AC single phase for use with single or three phase motors.

*1/3 to 2 HP TEFC Motors Shown Below.



Kit includes all of the components needed for conversion of a 56C or 143-5TC frame totally enclosed fan cooled motor* to a brakemotor. (Totally enclosed Stearns brake, replacement cast fan cover, shaft extension and fan/hub.) Mounts on fan end of motor. May be used on single or three phase motors.

Two 1/2" NPT holes with 18" leads are provided for connections. The BRAKE KIT adds 5-1/8" to the overall length of TEFC motors.

FOR MOTOR VOLTAGES—

230/460 VOLTS THREE PHASE OR 230 VOLTS SINGLE PHASE				
Catalog Number	Item Code	Brake Rating (lb-ft)	Max HP @ 1725 RPM	Mounts to NEMA Frame
MBRK3	60000	3	1	56C/143-5TC
MBRK6	60002	6	2	56C/143-5TC
MBRK10	60003	10	3	56C/143-5TC

FOR MOTOR VOLTAGES—

575 VOLTS THREE PHASE				
Catalog Number	Item Code	Brake Rating (lb-ft)	Max HP @ 1725 RPM	Mounts to NEMA Frame
MBR5K3	69765	3	1	56C/143-5TC
MBR5K6	69766	6	2	56C/143-5TC
MBR5K10	69767	10	3	56C/143-5TC

FOR USE WITH THESE MOTORS					
HP	NEMA Mtg.	Bore Code	Voltage Phase-Hz	Catalog Number	Item Code
1/3	56C	B5	115/230-1-60	ERTF	63750
1/3	56C	B5	230/460-3-60	EUTF	63958
1/3	56C	B5	575-3-60	EYTF	64944
1/2	56C	B5	115/230-1-60	FRTF	63754
1/2	56C	B5	230/460-3-60	FUTF	63961
1/2	56C	B5	575-3-60	FYTF	64945
3/4	56C	B5	115/230-1-60	GRTF	63755
3/4	56C	B5	230/460-3-60	GUTF	63979
3/4	56C	B5	575-3-60	GYTF	64946
1	56C	B5	115/230-1-60	HRTF-5/8	63795
1	143TC	B7	115/230-1-60	HRTF	63797
1	56C	B5	230/460-3-60	HUTF-5/8	63980
1	143TC	B7	230/460-3-60	HUTF	63981
1	143TC	B7	575-3-60	HYTF	64948
1-1/2	145TC	B7	115/230-1-60	JRTF	63800
1-1/2	56C	B5	230/460-3-60	JUTF-5/8	63988
1-1/2	145TC	B7	230/460-3-60	JUTF	64281
1-1/2	145TC	B7	575-3-60	JYTF	64949
2	56C	B5	230/460-3-60	KUTF-5/8	64769
2	145TC	B7	230/460-3-60	KUTF	64770
2	145TC	B7	575-3-60	KYTF	64950

Motor Enclosures

ENCLOSURES — Most applications can utilize open drip-proof motors; other enclosures are listed. For information purposes, the various enclosures are defined below.

OPEN, DRIPPROOF — Same as open, except the construction of motor prevents the entrance of drops of liquid or particles falling on the motor at any angle not greater than 15 degrees from vertical.

TOTALLY-ENCLOSED — A motor so constructed as to prevent free exchange of air between the inside and outside of the motor case, but not air-tight.

TOTALLY-ENCLOSED, NON-VENTILATED (TENV) — A totally-enclosed motor of sufficient size and mass to permit the necessary heat dissipation to eliminate the need for external cooling.

TOTALLY-ENCLOSED FAN-COOLED (TEFC) — Basically a TENV motor which has an external fan to blow cooling air over the motor. The additional cooling eliminates the necessity of a more costly oversized TENV motor. NOTE: TENV and TEFC construction are equal in all respects regarding application, temperature capabilities and performance.

TOTALLY ENCLOSED, BLOWER COOLED (TEBC) — A totally enclosed motor constructed with a fan on the opposite end of motor shaft designed to blow cooling air over the motor. The fan is powered separately from the motor to provide constant air flow whether the motor is running or stopped.

EXPLOSION-PROOF — A totally-enclosed motor designed and built to withstand an explosion within it and/or to prevent ignition of the atmosphere surrounding it. These motors may be either TENV or TEFC as determined by the design and the manufacturer. All are U.L. listed and bear a U.L. label indicating the class of hazardous atmospheres in which the motor may be operated. All Boston Gear explosion-proof motors are nameplated Class I Group D and Class II Groups F&G.

WASHDOWN — Totally enclosed motors, either TENV or TEFC; that are constructed to withstand washdown requirements.

BISSC — Motors that have the Baking Industry Sanitation Standards Committee certification.

NOTES

TABLE OF CONTENTS

GENERAL INFORMATION 146

NEMA BOLT CIRCLE DIMENSIONS 147

PERMANENT MAGNET 1/12 HP TENV 147

PERMANENT MAGNET 1/6-5 HP TENV AND TEFC 148-149

PERMANENT MAGNET (WASHDOWN) 150

SHUNT WOUND OPEN DRIPPROOF 1/6-5 HP 151

SHUNT WOUND TEFC 1/6-5 HP 152

SHUNT WOUND EXPLOSION PROOF 1/2-1 HP 153

E

DC MOTORS

Ratiotrol DC motors have specific characteristics to match the controls with which they operate. Thus, it is not necessary that a motor and control be mated; any stock motor will operate with a stock control of suitable rating within a series.

Standard motors have a base speed of 1750 RPM and are stocked in ratings from 1/6 through 5 HP. Operating characteristics, reliability and durability are similar; PM motors do offer advantages such as smaller size, lower weight and the absence of field hum on critical applications. In addition, installation is simplified since only two armatures leads need be connected.

Service factor for PM and V series motors is 1.0.

SPEED RANGE

All listed Ratiotrol 90 VDC and 180 VDC motors for Boston controllers have been designed to operate continuously at full rated torque throughout the specified speed range of the control. All shunt wound motors can operate continuously at 20:1 speed range and permanent magnet at 50:1 speed range.

Full torque operation is possible at even lower speeds if duty is intermittent. In many cases, reduced loads will permit continuous operation at speeds as low as 100:1 speed range.

MOUNTING

Separate listings are shown for NEMA C-face mounted motors for use with flange reductors and rigid base mounted motors for coupled loads.

AMBIENT TEMPERATURES

All standard motors are rated for continuous full load operation at ambient temperatures not exceeding 40°C (104°F). The insulation used varies with motor design; therefore, when higher temperatures than normal are expected, please contact the factory with complete details i.e., maximum temperature, HP, enclosure, mounting, etc.

CATALOG NUMBERING SYSTEM

With few exceptions, noted below, motor catalog numbers indicate voltage HP and enclosure.

V9 SERIES – 1/6 – 1 HP, 90 VDC armature, 50/100 VDC field.

V9	16	0	0	— –	B
A	B	C	D	E	F

A – Series designation

B –
- 16 - 1/6 HP
- 25 - 1/4 HP
- 33 - 1/3 HP
- 50 - 1/2 HP
- 75 - 3/4 HP
- 100 - 1 HP

C – 0 - 1750 RPM (Standard)
- 1 - 1150 RPM
- 2 - 2500 RPM
- 3 - 3450 RPM

D – Mounting
- 0 – NEMA C-Face
- 1 – Rigid Base

E – Enclosure*
- No letter – Open dripproof
- T – TENV
- TF – TEFC
- X – Explosion-proof

F – Manufacturer
- B – Baldor

V18 SERIES – 3/4-5 HP, 180VDC armature, 100/200VDC field.

V18	10	0	TF	–B
A	B	C	D	E

A – Series designation

B – HP
- 10 - 1 HP
- 15 - 1-1/2 HP
- 20 - 2 HP
- 30 - 3 HP
- 50 - 5 HP

C – Mounting
- 0 – NEMA C-Face
- 1 – Rigid Base

D – Enclosure*
- No letter – Open dripproof
- T – TENV
- TF – TEFC
- X – Explosion-proof

E – Manufacturer
- B – Baldor

PM MOTORS

PM	9	16	AT –	B
A	B	C	D	E

A – PM Series designation

B – Voltage, armature
- 9-90VDC
- 18-180VDC

C – HP

16 - 1/6 HP	100 - 1 HP
25 - 1/4 HP	150 - 1-1/2 HP
33 - 1/3 HP	200 - 2 HP
50 - 1/2 HP	300 - 3 HP
75 - 3/4 HP	

PM	18	100	AT –	I
A	B	C	D	E

D – Enclosure*
- No letter – Open dripproof
- AT, T – TENV
- ATF, TF – TEFC
- WB – Washdown (BISSC)

E – Manufacturer
- B – Baldor
- I – Indiana General

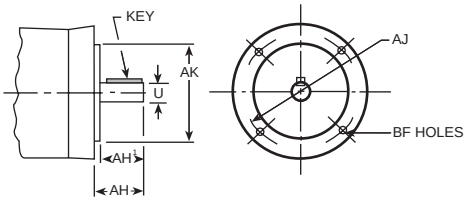
OPTIONS AND MODIFICATIONS

From an economic and delivery standpoint, it is, of course, preferable that standard stock motors be specified for an application. However, many other types of motors and optional features are available on a special order basis. Some modifications are more readily available on fractional HP motors than integral HP and vice versa. Among the many options are:

Base-Speeds other than 1750 RPM such as 3450, 2500 and 1150 RPM.
Severe Duty and corrosion-proof enclosures.
Explosion-Proof enclosures–specify Class and Group of hazardous atmosphere.
Brakemotors–brakes are AC.
Double Shafts, extended shafts, etc.
Motor-Mounted Tachometer Generators–for those motors not adaptable to standard tachometer packages. See page 111 and 112 for stock tachometer generators.

***Motor Enclosures described on page 143.**

NEMA Motor Bolt Circle Dimensions

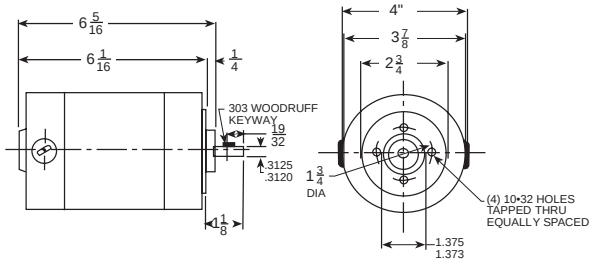


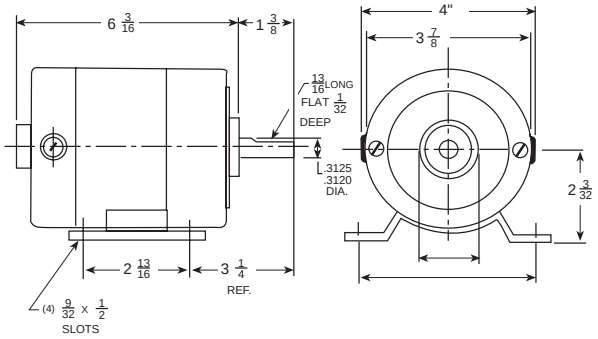
Boston Gear Bore Code	NEMA Frame No.	U	AK	Max. AH	Max. AH'	Key SQ.	Key LG.	AJ	BF
B4	42CZ	.5000 .4995	3.000 2.997	1-5/16	—	1/8	3/4	3.750	1/4–20
B5	56C	.6250 .6245	4.500 4.497	2-5/32	—	3/16	1-3/8	5.875	3/8-16
B7	56CZ 182C 184C	.8750 .8745	4.500 4.497	2-5/32	—	3/16	1-3/8	5.875	3/8–16
	143TC 145TC								
B9	213C 215C	1.1250 1.1245	8.500 8.497	—	2-25/32	1/4	1-3/4	7.250	1/2–13
	182TC 184TC								
B11	254UC 256UC	1.3750 1.3745	8.500 8.497	—	3-17/32	5/16	2-3/8	7.250	1/2–13
	213TC 215TC								
B13	254TC 256TC	1.6250 1.6240	8.500 8.497	—	3-13/16	3/8	2-7/8	7.250	1/2–13

Flanged Reductors are designed for use with motors having NEMA "C" face and shaft dimensions as shown. AH and AH' must not be exceeded.

Permanent Magnet TENV

1/12 Horsepower



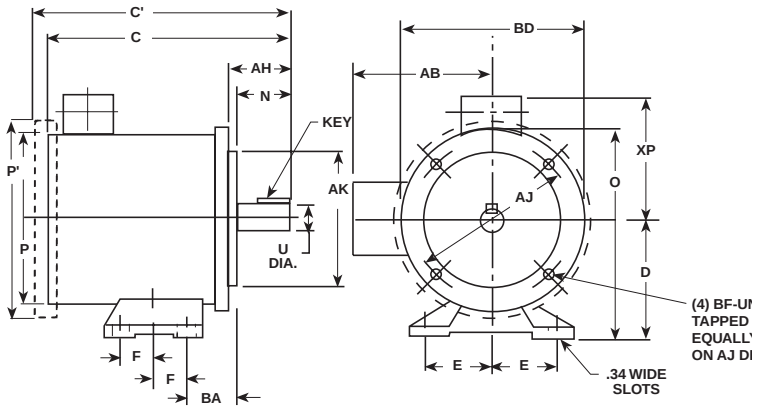


ORDER BY CATALOG NUMBER OR ITEM CODE

HP	Volts Armature	Catalog Number	Item Code	NEMA Mounting	Approximate Weight (Lbs.)
C-FACE MOUNTED					
1/12	90	PM908T-B	69825	Special	4
BASE MOUNTED					
1/12	90	BPM908T-B	64803	Special	4

NEMA C-Face w/Removable Bases

Permanent Magnet TENV & TEFC 1/6-5 HP 1750 RPM



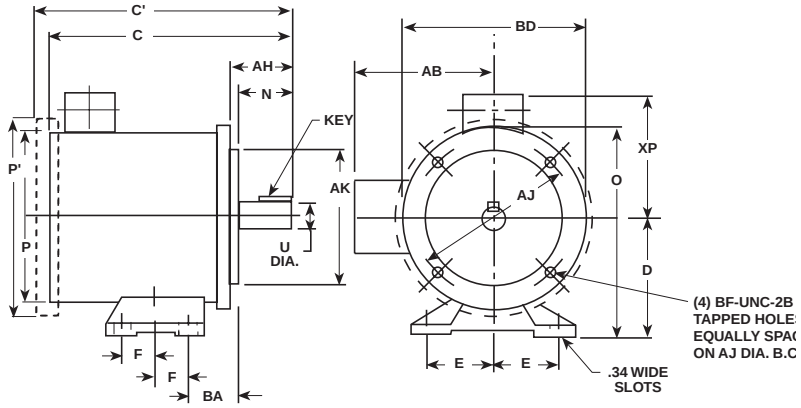
ORDER BY CATALOG NUMBER OR ITEM CODE

HP	Volts Arma-ture	Catalog Number	Item Code	Bore Code	NEMA MTG	Encl.	C	C'	D	E	F	N	O	P	P'
1/6	90	APM916AT-B	19117	B4	42CYZ	TENV	9.50	—	3.50	2.44	1.50	1.13	5.88	4.68	—
		APM916T	59475	B4	42CYZ	TENV	8.47	—	3.50	2.44	1.50	1.17	5.75	4.87	—
		PM916AT-B	19120	B5	56C	TENV	10.31	—	3.50	2.44	1.50	1.94	5.88	4.68	—
		PM916T	59476	B5	56C	TENV	9.19	—	3.50	2.44	1.50	1.90	6.75	4.87	—
1/4	90	APM925AT-B	19118	B4	42CYZ	TENV	10.44	—	3.50	2.44	1.50	1.13	5.88	4.68	—
		APM925T	59477	B4	42CYZ	TENV	8.97	—	3.50	2.44	1.50	1.17	5.75	4.87	—
		PM925AT-B	19121	B5	56C	TENV	11.25	—	3.50	2.44	1.50	1.94	5.88	4.68	—
		PM925T	59478	B5	56C	TENV	9.72	—	3.50	2.44	1.50	1.90	6.75	4.87	—
1/3	90	APM933AT-B	19119	B4	42CYZ	TENV	11.38	—	3.50	2.44	1.50	1.13	5.88	4.68	—
		APM933T	59479	B4	42CYZ	TENV	9.47	—	3.50	2.44	1.50	1.17	5.75	4.87	—
		PM933AT-B	19122	B5	56C	TENV	12.18	—	3.50	2.44	1.50	1.94	5.88	4.68	—
		PM933T	59480	B5	56C	TENV	10.19	—	3.50	2.44	1.50	1.90	6.75	4.87	—
1/2	90	PM950AT-B	19123	B5	56C	TENV	13.94	—	3.50	2.44	1.50	1.94	5.88	4.68	—
		PM950TF	59481	B5	56C	TEFC	—	11.81	3.50	2.44	1.50	1.90	6.75	4.87	5.16
	180	PM1850TF-B	19186	B5	56C	TEFC	—	13.75	3.50	2.44	1.50	1.94	6.38	5.81	6.13
		PM1850TF	59482	B5	56C	TEFC	—	11.81	3.50	2.44	1.50	1.90	6.75	4.87	5.16
3/4	90	PM975TF-B	69853	B5	56C	TEFC	—	13.75	3.50	2.44	1.50	1.94	6.38	5.81	6.13
		PM975TF	59483	B5	56C	TEFC	—	14.31	3.50	2.44	1.50	1.90	6.75	4.87	5.16
	180	PM1875TF-B	69866	B5	56C	TEFC	—	13.75	3.50	2.44	1.50	1.94	6.38	5.81	6.13
		PM1875TF	59484	B5	56C	TEFC	—	13.81	3.50	2.44	1.50	1.90	6.75	4.87	5.16
1	90	PM9100TF-B	69867	B7	56CZ	TEFC	—	14.68	3.50	2.44	1.50	2.00	6.38	5.81	6.13
		PM9100TF	59485	B7	56CZ	TEFC	—	16.31	3.50	2.44	1.50	1.90	6.38	5.61	5.88
		PM9100TF-5/8-B	50421	B5	56C	TEFC	—	14.63	3.50	2.44	1.50	1.94	6.38	5.81	6.13
		PM9100TF-5/8	59486	B5	56C	TEFC	—	15.81	3.50	2.44	1.50	1.90	6.75	5.61	5.88
	180	PM18100TF-B	69869	B7	56CZ	TEFC	—	14.68	3.50	2.44	1.50	2.00	6.38	5.81	6.13
		PM18100TF	59487	B7	56CZ	TEFC	—	15.31	3.50	2.44	1.50	1.90	6.75	5.61	5.88
		PM18100TF-5/8-B	50424	B5	56C	TEFC	—	14.63	3.50	2.44	1.50	1.94	6.38	5.81	6.13
		PM18100TF-5/8	59488	B5	56C	TEFC	—	14.81	3.50	2.44	1.50	1.90	6.75	5.61	5.88
1-1/2	180	PM18150TF-B	69870	B7	56CZ	TEFC	—	17.19	3.50	2.44	1.50	2.00	6.88	6.50	7.19
		PM18150TF	59489	B7	143/145TC	TEFC	—	18.34	3.50	2.75	2.00†	1.96	6.75	6.55	7.16
2	180	PM18200TF-B	68783	B7	56CZ	TEFC	—	18.19	3.50	2.44	1.50	2.00	6.88	6.50	7.19
		PM18200TF	59490	B7	143/145TC	TEFC	—	19.34	3.50	2.75	2.00†	1.96	6.75	6.55	7.16
3	180	PM18300TF-B	69411	B9	184TC	TEFC	—	24.09	4.50	3.75	2.75	2.50	10.00	7.88	8.88
5	180	PM18500TF-B	69412	B9	1810ATC	TEFC	—	27.59	4.50	3.75	2.75	2.00	10.00	7.88	8.88

†Includes 6 mounting holes
All dimensions in inches. Dimensional information for estimating purposes only.

NEMA C-Face w/Removable Bases

Permanent Magnet TENV & TEFC 1/6-5 HP 1750 RPM (Continued)

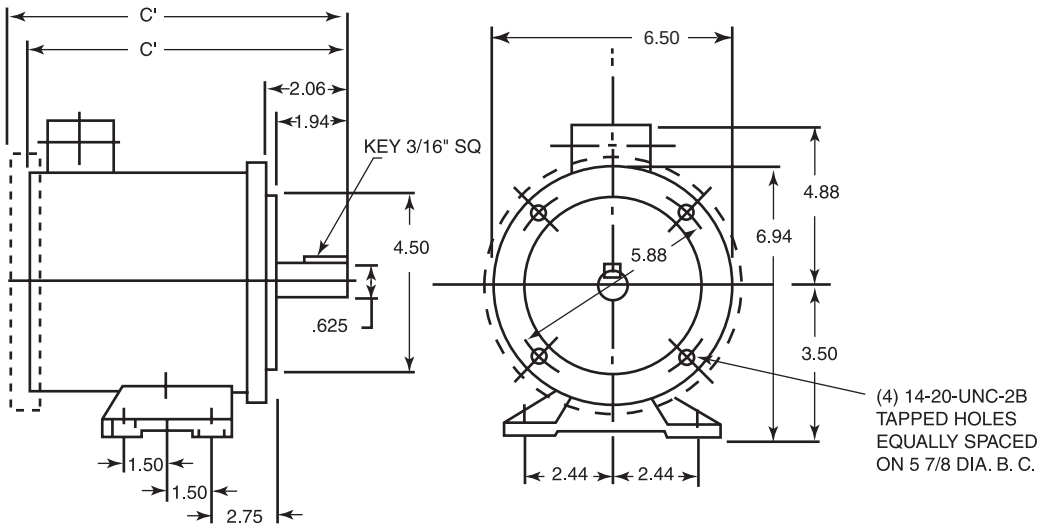


ORDER BY CATALOG NUMBER OR ITEM CODE

HP	Volts Armature	Catalog Number	Bore Code	NEMA MTG	U +.0000 -.0005	Key SQ.	Key Long	AH	AJ	AK	BA	BD	BF	XP	Approx. Weight (Lbs.)	AB
1/6	90	APM916AT-B	B4	42CYZ	.5000	1/8	.75	1.28	3.75	3.00	2.75	4.63	1/4-20	4.56	21	–
		APM916T	B4	42CYZ	.5000	1/8	.88	1.31	3.75	3.00	2.69	–	1/4-20	–	19	4.47
		PM916AT-B	B5	56C	.6250	3/16	1.38	2.06	5.88	4.50	2.75	6.50	3/8-16	4.56	21	–
		PM916T	B5	56C	.6250	3/16	1.38	2.06	5.88	4.50	2.69	6.50	3/8-16	–	19	4.47
1/4	90	APM925AT-B	B4	42CYZ	.5000	1/8	.75	1.28	3.75	3.00	2.75	4.63	1/4-20	4.56	22	–
		APM925T	B4	42CYZ	.5000	1/8	.88	1.31	3.75	3.00	2.69	–	1/4-20	–	21	4.47
		PM925AT-B	B5	56C	.6250	3/16	1.38	2.06	5.88	4.50	2.75	6.50	3/8-16	4.56	22	–
		PM925T	B5	56C	.6250	3/16	1.38	2.06	5.88	4.50	2.69	6.50	3/8-16	–	23	4.47
1/3	90	APM933AT-B	B4	42CYZ	.5000	1/8	.75	1.28	3.75	3.00	2.75	4.63	1/4-20	4.56	26	–
		APM933T	B4	42CYZ	.5000	1/8	.88	1.31	3.75	3.00	2.69	–	1/4-20	–	24	4.47
		PM933AT-B	B5	56C	.6250	3/16	1.38	2.06	5.88	4.50	2.75	6.50	3/8-16	4.56	26	–
		PM933T	B5	56C	.6250	3/16	1.38	2.06	5.88	4.50	2.69	6.50	3/8-16	–	23	4.47
1/2	90	PM950AT-B	B5	56C	.6250	3/16	1.38	2.06	5.88	4.50	2.75	6.50	3/8-16	4.56	32	–
		PM950TF	B5	56C	.6250	3/16	1.38	2.06	5.88	4.50	2.69	6.50	3/8-16	–	26	4.47
	180	PM1850TF-B	B5	56C	.6250	3/16	1.38	2.06	5.88	4.50	2.69	6.63	3/8-16	4.00	32	–
		PM1850TF	B5	56C	.6250	3/16	1.38	2.06	5.88	4.50	2.69	6.50	3/8-16	–	26	4.47
3/4	90	PM975TF-B	B5	56C	.6250	3/16	1.38	2.06	5.88	4.50	2.69	6.63	3/8-16	4.00	39	–
		PM975TF	B5	56C	.6250	3/16	1.38	2.06	5.88	4.50	2.69	6.50	3/8-16	–	37	4.47
	180	PM1875TF-B	B5	56C	.6250	3/16	1.38	2.06	5.88	4.50	2.69	6.63	3/8-16	4.00	39	–
		PM1875TF	B5	56C	.6250	3/16	1.38	2.06	5.88	4.50	2.69	6.50	3/8-16	–	37	4.47
1	90	PM9100TF-B	B7	56CZ	.8750	3/16	1.38	2.06	5.88	4.50	2.69	6.63	3/8-16	4.00	44	–
		PM9100TF	B7	56CZ	.8750	3/16	1.38	2.06	5.88	4.50	2.69	6.50	3/8-16	–	47	4.87
		PM9100TF-5/8-B	B5	56C	.6250	3/16	1.38	2.06	5.88	4.50	2.69	6.63	3/8-16	4.00	44	–
		PM9100TF-5/8	B5	56C	.6250	3/16	1.38	2.06	5.88	4.50	2.69	6.50	3/8-16	–	47	4.87
	180	PM18100TF-B	B7	56CZ	.8750	3/16	1.38	2.06	5.88	4.50	2.69	6.63	3/8-16	4.00	44	–
		PM18100TF	B7	56CZ	.8750	3/16	1.38	2.06	5.88	4.50	2.69	6.50	3/8-16	–	43	4.87
		PM18100TF-5/8-B	B5	56C	.6250	3/16	1.38	2.06	5.88	4.50	2.69	6.63	3/8-16	4.00	44	–
		PM18100TF-5/8	B5	56C	.6250	3/16	1.38	2.06	5.88	4.50	2.69	6.50	3/8-16	–	42	4.87
1 1/2	180	PM18150TF-B	B7	56CZ	.8750	3/16	1.38	2.13	5.88	4.50	2.88	6.63	3/8-16	4.25	73	–
		PM18150TF	B7	143/145TC	.8750	3/16	1.38	2.13	5.88	4.50	3.00	–	3/8-16	–	76	5.31
2	180	PM18200TF-B	B7	56CZ	.8750	3/16	1.38	2.13	5.88	4.50	2.88	6.63	3/8-16	4.25	75	–
		PM18200TF	B7	143/145TC	.8750	3/16	1.38	2.13	5.88	4.50	3.00	–	3/8-16	–	83	5.31
3	180	PM18300TF-B	B9	184TC	1.1250	1/4	1.75	2.63	7.25	8.50	2.88	9.00	1/2-13	6.06**	116	–
5	180	PM18500TF-B	B9	1810ATC	1.1250	1/4	2.00	2.13	7.25	8.50	2.88	9.00	1/2-13	6.06**	157	–

** The conduit box is located 90 degrees to the base
*** .41 wide slots on 3 & 5 HP motors
All dimensions in inches. Dimensional information for estimating purposes only.

Boston's Permanent Magnet Washdown Motors are specifically designed for use where dust, dirt and moisture are present in industrial and washdown environments. These motors retard the entrance of water during cleaning operations and release any water that does enter the motor. Extra protection for the motor's interior prevents rust and corrosion build-up and drains release trapped moisture to insure a longer life than possible with a standard motor. The motors are constructed using stainless steel shafts, hardware and nameplates, sealed ball bearings and forsheda seals to prevent water leakage into the motor.



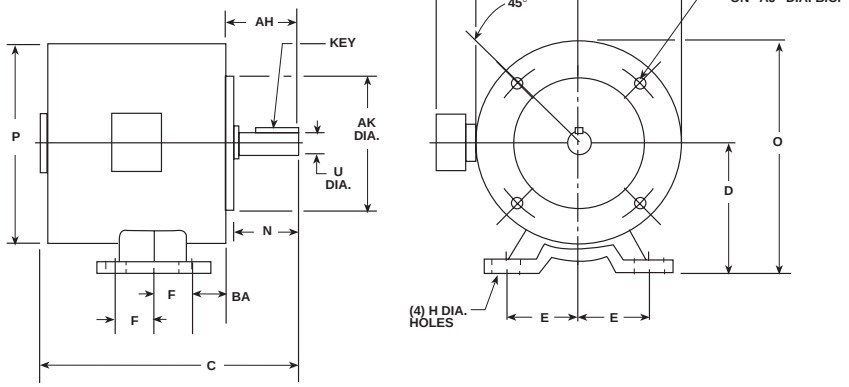
ORDER BY CATALOG NUMBER OR ITEM CODE

HP	Volts Armature	Catalog Number	Item Code	Bore Code	NEMA Mtg.	Encl.	C	C'
1/4	90	PM925T-WD	59354	B5	56C	TENV	10.69	–
1/3	90	PM933T-WD	59355	B5	56C	TENV	11.69	–
1/2	90	PM950T-WD	59356	B5	56C	TENV	13.69	–
	180	PM1850T-WD	59357	B5	56C	TENV	13.69	–
3/4	90	PM975T-WD	59364	B5	56C	TENV	15.69	–
	180	PM1875T-WD	59365	B5	56C	TENV	15.69	–
1	90	PM9100TF-5/8-WD	59366	B5	56C	TEFC	–	15.81
	180	PM18100TF-5/8-WD	59367	B5	56C	TEFC	–	14.81
1 1/2	180	PM18150TF-5/8-WD	59368	B5	56C	TEFC	–	16.81

All dimensions in inches. Dimensional information for estimating purposes only.

NEMA C-FACE
With Removable Bases

Shunt Wound
Open Drip Proof
1/6-5 HP
1750 RPM



ORDER BY CATALOG NUMBER OR ITEM CODE

HP	Volts Arma-ture	Volts Field	Catalog Number	Item Code	Bore Code	NEMA Mtg	C	D	E	F	H*	N	O	P
1/6	90	50/100	V91600-B	66666	B5	56C	11.94	3.50	2.44	1.50	.34(S)	1.94	6.38	5.68
1/4	90	50/100	V92500-B	66669	B5	56C	11.94	3.50	2.44	1.50	.34(S)	1.94	6.38	5.68
1/3	90	50/100	V93300-B	66672	B5	56C	11.94	3.50	2.44	1.50	.34(S)	1.94	6.38	5.68
1/2	90	50/100	V95000-B	66675	B5	56C	12.94	3.50	2.44	1.50	.34(S)	1.94	6.38	5.68
3/4	90	50/100	V97500-B	66678	B5	56C	13.56	3.50	2.44	1.50	.34(S)	1.94	6.38	5.68
	180	100/200	V18750-B	66681	B5	56C	13.56	3.50	2.44	1.50	.34(S)	1.94	6.38	5.68
1	90	50/100	V9100-B	66897	B5	56CZ	15.06	3.50	2.44	1.50	.34(S)	2.00	6.88	6.50
	180	100/200	V18100A-B	66684	B7	56CZ	15.06	3.50	2.44	1.50	.34(S)	2.00	6.88	6.50
1 1/2	180	100/200	V18150A-B	66690	B7	184C	15.06	4.50	3.75	2.75	.41	2.00	8.44	7.88
2	180	100/200	V18200A-B	66696	B7	184C	18.38	4.50	3.75	2.75	.41	2.00	8.44	7.88
3	180	100/200	18300-B	66702	B9	215C	20.94	5.25	4.25	3.50	.41	2.75	9.94	9.38
5	180	100/200	18500A-B	66790	B11	256UC	23.38	6.25	5.00	5.00	.53	3.25	11.94	11.38

HP	Catalog Number	Item Code	U +.0000 -.0005	Key		AB	AH	AJ	AK	BA	BD	BF	Approx. Weight (lbs.)
				Sq.	Long								
1/6	V91600-B	66666	.6250	3/16	1.38	4.50	2.06	5.88	4.500	2.69	6.63	3/8-16	22
1/4	V92500-B	66669	.6250	3/16	1.38	4.50	2.06	5.88	4.500	2.69	6.63	3/8-16	22
1/3	V93300-B	66672	.6250	3/16	1.38	4.50	2.06	5.88	4.500	2.69	6.63	3/8-16	23
1/2	V95000-B	66675	.6250	3/16	1.38	4.50	2.06	5.88	4.500	2.69	6.63	3/8-16	28
3/4	V97500-B	66678	.6250	3/16	1.38	4.50	2.06	5.88	4.500	2.69	6.63	3/8-16	34
	V18750-B	66681	.6250	3/16	1.38	4.50	2.06	5.88	4.500	2.69	6.63	3/8-16	34
1	V9100-B	66897	.8750	3/16	1.38	5.25	2.13	5.88	4.500	2.69	6.63	3/8-16	61
	V18100-B	66684	.8750	3/16	1.38	5.25	2.13	5.88	4.500	2.69	6.63	3/8-16	61
1 1/2	V18150A-B	66690	.8750	3/16	1.38	5.88	2.13	5.88	4.500	2.88	7.88	3/8-16	87
2	V18200A-B	66696	.8750	3/16	1.38	5.88	2.13	5.88	4.500	2.88	7.88	3/8-16	105
3	18300-B	66702	1.1250	1/4	1.75	7.38	3.00	7.25	8.500	3.50	9.00	1/2-13	155
5	18500A-B	66790	1.3750	5/16	2.38	8.88	3.50	7.25	8.500	4.50	9.63	1/2-13	290

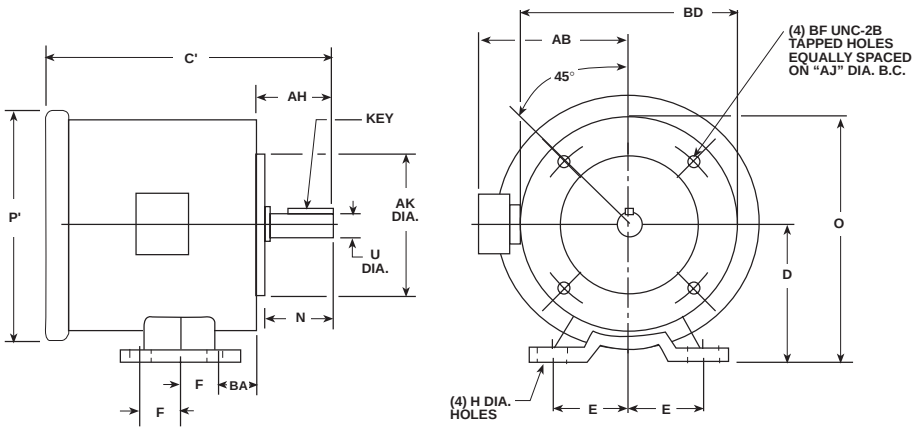
*(S) Slotted (Dim is Width)
All dimensions in inches. Dimensional information for estimating purposes only.

E

DC MOTORS

NEMA C-FACE
With Removable Bases

Shunt Wound
TEFC
1/6-5 HP
1750 RPM



ORDER BY CATALOG NUMBER OR ITEM CODE

HP	Volts Armature	Volts Field	Catalog Number	Item Code	Bore Code	NEMA Mtg	C'	D	E	F	H*	N	O	P'
1/6	90	50/100	V91600TF-B	66741	B5	56C	12.56	3.50	2.44	1.50	.34(S)	1.94	6.38	6.13
1/4	90	50/100	V92500TF-B	66744	B5	56C	13.25	3.50	2.44	1.50	.34(S)	1.94	6.38	6.13
1/3	90	50/100	V93300TF-B	66747	B5	56C	13.25	3.50	2.44	1.50	.34(S)	1.94	6.38	6.13
1/2	90	50/100	V95000TF-B	66750	B5	56C	14.25	3.50	2.44	1.50	.34(S)	1.94	6.38	6.13
3/4	90	50/100	V97500TF-B	66752	B5	56C	14.75	3.50	2.44	1.50	.34(S)	1.94	6.38	6.13
	180	100/200	V18750TF-B	66755	B5	56C	14.75	3.50	2.44	1.50	.34(S)	1.94	6.38	6.13
1	90	50/100	V9100BTF-B	66901	B7	56CZ	15.50	3.50	2.44	1.50	.34(S)	2.00	6.88	7.18
	180	100/200	V18100BTF-B V18100ATF-B	66757 66761	B7 B7	56CZ 182C	16.24 15.56	3.50 4.50	2.44 3.75	1.50 2.75	.34(S) .41	2.00 2.00	6.88 8.44	7.18 8.50
1 1/2	180	100/200	V18150ATF-B	66767	B7	184C	17.31	4.50	3.75	2.75	.41	2.00	8.44	8.50
2	180	100/200	V18200ATF-B	66773	B7	184C	18.56	4.50	3.75	2.75	.41	2.00	8.44	8.50
3	180	100/200	18300ATF-B	66778	B9	215C	21.18	5.25	4.25	3.50	.41	2.75	9.94	10.18
5	180	100/200	18500ATF-B	66791	B11	256UC	24.38	6.25	5.00	5.00	.53	3.50	11.94	12.38

HP	Catalog Number	Item Code	U +.0000 -.0005	Key		AB	AH	AJ	AK	BA	BD	BF	XP	Approx. Weight (lbs.)
				Sq.	Long									
1/6	V91600TF-B	66741	.6250	3/16	1.38	—	2.06	5.88	4.500	2.69	6.63	3/8-16	4.00	22
1/4	V92500TF-B	66744	.6250	3/16	1.38	—	2.06	5.88	4.500	2.69	6.63	3/8-16	4.00	22
1/3	V93300TF-B	66747	.6250	3/16	1.38	—	2.06	5.88	4.500	2.69	6.63	3/8-16	4.00	23
1/2	V95000TF-B	66750	.6250	3/16	1.38	—	2.06	5.88	4.500	2.69	6.63	3/8-16	4.00	28
3/4	V97500TF-B	66752	.6250	3/16	1.38	—	2.06	5.88	4.500	2.69	6.63	3/8-16	4.00	36
	V18750TF-B	66755	.6250	3/16	1.38	—	2.06	5.88	4.500	2.69	6.63	3/8-16	4.00	34
1	V9100BTF-B	66901	.8750	3/16	1.38	—	2.13	5.88	4.500	2.69	6.63	3/8-16	4.25	61
	V18100BTF-B V18100ATF-B	66757 66761	.8750 .8750	3/16 3/16	1.38 1.38	5.25 6.00	2.13 2.13	5.88 5.88	4.500 4.500	2.75 3.00	6.63 6.50	3/8-16 3/8-16	— —	61 81
1 1/2	V18150ATF-B	66767	.8750	3/16	1.38	6.00`	2.13	5.88	4.500	3.00	6.50	3/8-16	—	90
2	V18200ATF-B	66773	.8750	3/16	1.38	6.00	2.13	5.88	4.500	3.00	6.50	3/8-16	—	105
3	18300ATF-B	66778	1.1250	1/4	2.00	7.38	3.00	7.25	8.500	3.50	9.00	1/2- 13	—	167
5	18500ATF-B	66791	1.3750	5/16	2.38	9.06	3.75	7.25	8.500	4.50	9.63	1/2-13	—	306

*(S) Slotted (Dim is Width)
All dimensions in inches. Dimensional information for estimating purposes only.

E

NEMA C-FACE
With Removable Base

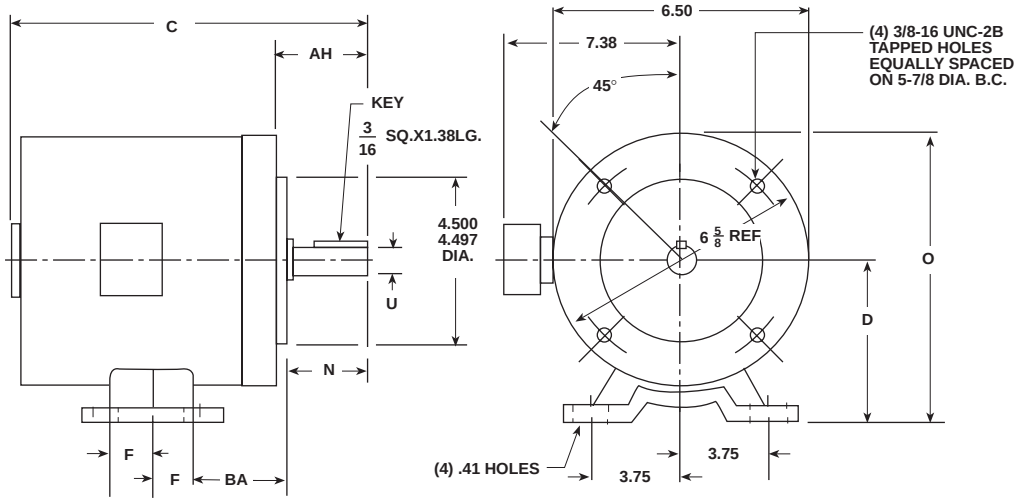
Shunt Wound
Explosion Proof
1/2-1 HP
1750 RPM

CONTINUOUS DUTY

1.0 SERVICE FACTOR

CLASS I, GROUP D

CLASS II, GROUP F & G



ORDER BY CATALOG NUMBER OR ITEM CODE

HP	Volts Armature	Volts Field	Catalog Number	Item Code	Bore Code	NEMA Mtg*	F	BA	D	N	U +.0000 -.0005	AH	O	C	Approximate Weight (lbs.)
1/2	90	50/100	V95000X-B	69871	B5	182CZ	2.25	2.75	4.50	1.94	.6250	2.06	8.44	18.62	103
3/4	90	50/100	V97500X-B	69872	B5	66CZ	2.50	3.06	4.13	1.94	.6250	2.06	7.94	15.56	105
1	180	100/200	V18100X-B	69873	B7	182C	2.75	2.75	4.50	2.00	.8750	2.13	8.44	18.68	103

All dimensions in inches. Dimensional information for estimating purposes only.
*56C Shaft and face mounting only, base mounting and shaft height differs from standard NEMA dimensions.

E

NOTES

TABLE OF CONTENTS

GENERAL INFORMATION 156
NEMA C-FACE DIMENSIONS 156
OPEN DRIP PROOF 157-158
TENV 159
TEFC 160-164
WASHDOWN/BISSC 165
BRAKE MOTORS 166-167
EXPLOSION PROOF 168
RIGID BASE 169
INVERTER DUTY 170-171

AC MOTORS

Boston Gear AC motors are general purpose motors selected for use with Boston Gear Reductors and Flanged Reductors and are suitable for all common industrial applications.

HORSEPOWER — Motor's listed range from 1/20 to 75 HP. Larger HP motors can be supplied.

VOLTAGES — All motors listed are for 60 Hz (cycle) power; fractional HP motors are also stocked in 50 Hz single phase ratings.

SINGLE-PHASE motors are split phase 1/20 HP through 1/6 HP. Some 1/6 HP motors and all 1/4 HP motors and larger are capacitor start. Standard 60 Hz voltages are 115V, 230V or 115/230V. 50 Hz voltages are 110/220. NOTE: 50 Hz motors have a speed of 1425 RPM, nominal. Single phase 60 Hz motors cannot be used on 50 Hz power.

POLYPHASE motors are all NEMA design B induction motors. Standard 60 Hz voltages are 208-230/460 and 575V. 50 Hz Voltage are 220/380/440 . NOTE 50Hz motors have a speed of 1425 RPM nominal.

MOUNTING — Separate listings are shown for NEMA C-face mounted motors for use with flange reductors and rigid base mounted motors for coupled loads.

SERVICE FACTORS indicate the allowable overload on a motor. The service factors vary from motor to motor. Please consult factory for the service factor on any particular motor.

ALLOWABLE STARTS AND STOPS—based on no external inertia and each start from a standstill:

Three phase motors .....up to 20 times per min.
Single phase–split phase motors.....up to 20 times per hour
Single phase–capacitor motors .....up to 30 times per hour

NOTE: Motor enclosures description on page 143.

BOSTON GEAR MOTOR CATALOG NUMBERS consists generally of two or more letters denoting horsepower, voltage, enclosure and mounting for motors 1/6 HP and larger.

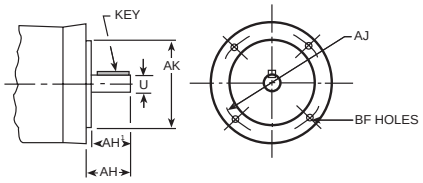
Prefix	H.P.	Voltage	Enclosure	Suffix	Manufacturer
A-Small Frame	A - 1/20	R 115/230-1-60	No letter-Dripproof	B-Brake	Blank-Boston Gear
B-Rigid Base	AA - 1/12	S 115-1-60	T-TENV	35-3450 RPM	B-Baldor
	B - 1/8	T 230-1-60	TF-TEFC	11-1150 RPM	G-General Electric
	C - 1/6	U 230/460-3-60	X-Explosion Proof		
	D - 1/4	Y 575-3-60	WB-Washdown BISSC		
	E - 1/3	R5 110/220-1-50	BC-TEBC		
	F - 1/2	S5 110-1-50			
	G - 3/4	T5 230-1-50			
	H - 1	U5 220/380/440-3-50			
	J - 1-1/2				
	K - 2				
	L - 3				
	M - 5				
	N - 7-1/2				
	P - 10				
	R - 15				
	S - 20				
	T - 25				
	U - 30				
	V - 40				
	W - 50				
	X - 60				
	Y - 75				
	Z - 100				

NOTE: A dash followed by a letter indicates the motor manufacturer eg -"-B" - Baldor "-G- -General Electric or "Blank" Boston Gear. Example - FUTF-B 1/2 HP, 230/460-3 -60, TEFC, Baldor.

REVERSING—All listed motors are reversible with standard motor reversing switches or suitable manual or magnetic reversing starters. Single phase motors must stop before reversing; polyphase may be instantly reversed by reversing any two of the three incoming power leads with a suitable starter.

AMBIENT TEMPERATURES — All standard motors are rated for continuous full load operation at ambient temperatures not exceeding 40°C (104°F). The insulation used varies with motor design; therefore, when higher temperatures than normal are expected, please contact the factory with complete details i.e., maximum temperature, HP, enclosure, mounting, etc.

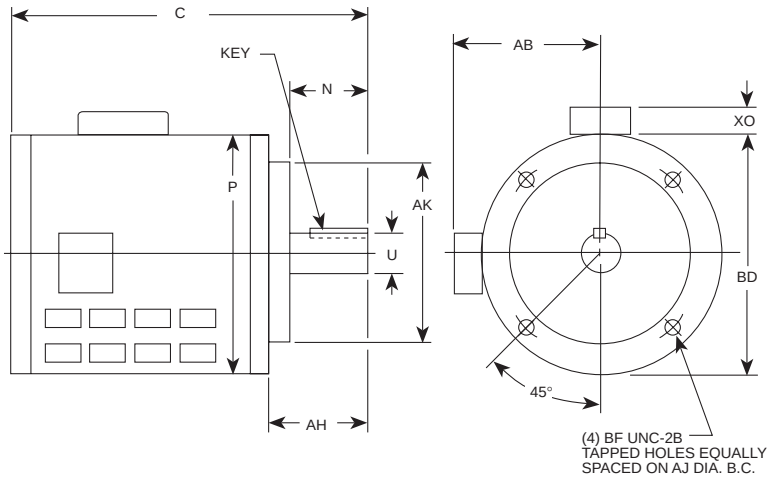
NEMA C-Face Bolt Circle Dimensions



Boston Gear Bore Code	NEMA Frame No.	U	AK	Max. AH	Max. AH'	Key		AJ	BF
						Sq.	Lg.		
B4	42CZ	.5000 .4995	3.000 2.997	1-5/16	—	1/8	3/4	3.75	1/4-20
B5	56C	.6250 .6245	4.500 4.497	2-5/32	—	3/16	1-3/8	5.88	3/8-16
B7	182C 184C 143TC 145T C	.8750 .8745	4.500 4.497	2-5/32	—	3/16	1-3/8	5.88	3/8-16
B9	213C 215C 182TC 184TC	1.1250 1.1245	8.500 8.497	—	2-25/32	1/4	1-3/4	7.25	1/2-13
B11	254UC 256UC 213TC 215TC	1.3750 1.3745	8.500 8.497	—	3-17/32	5/16	2-3/8	7.25	1/2-13
B13	254TC 256TC	1.6250 1.6240	8.500 8.497	—	3-13/16	3/8	2-7/8	7.25	1/2-13

110/220 VAC 1ø 50 Hz
115 VAC 1ø 60 Hz
115/230 VAC 1ø 60 Hz

Open Drip Proof
NEMA C-Face
Single Phase
1/4–1-1/2 Horsepower



ORDER BY CATALOG NUMBER OR ITEM CODE

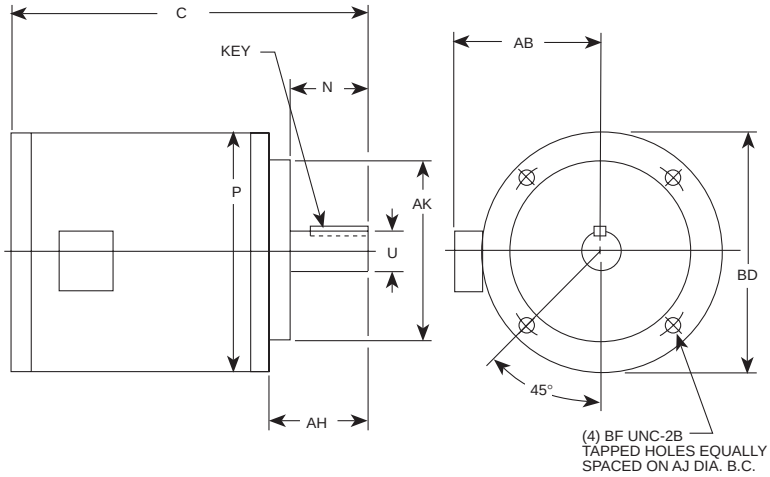
HP	RPM	F.L.A. @Max Volts	NEMA Mtg	Bore Code	Catalog Number	Item Code	C	N	P	U +.0000 -.0005	Key		AB	AH	AJ	AK	BD	BF	XO	Wt. Lbs
											Sq.	Long								
110/220 VAC 1ø 50 Hz																				
1/4	1425	2.8	56C	B5	DR5-B	66854	10.25	1.94	5.69	0.6250	3/16	1.38	4.75	2.06	5.875	4.500	5.87	3/8-16	1.54	22
1/3	1425	3.2	56C	B5	ER5-B	66866	10.69	1.94	5.69	0.6250	3/16	1.38	4.75	2.06	5.875	4.500	5.87	3/8-16	1.54	25
1/2	1425	4.4	56C	B5	FR5-B	66872	11.56	1.94	5.69	0.6250	3/16	1.38	4.75	2.06	5.875	4.500	5.87	3/8-16	1.54	27
3/4	1425	6.5	56C	B5	GR5-B	66878	11.06	1.94	6.63	0.6250	3/16	1.38	5.75	2.06	5.875	4.500	6.50	3/8-16	2.25	35
115 VAC 1ø 60 Hz																				
1/20	1725	1.35	SP	SPL	AST-B	65403	8.98	0.93	3.86	0.3125	See	Note	—	1.18	1.750	1.375	4.64	10/32	-	10
1/12	1725	2.0	SP	SPL	AAST-B	65402	8.98	0.93	3.86	0.3125	See	Note	—	1.18	1.750	1.375	4.64	10/32	-	10
1/4	1725	2.7	56C	B5	DS	63316	8.88	1.94	5.61	0.6250	3/16	1.38	—	2.06	5.875	4.500	5.61	3/8-16	1.94	16
1/4	1725	5.0	56C	B5	DS-B	66112	10.25	1.94	5.69	0.6250	3/16	1.38	4.50	2.06	5.875	4.500	5.81	3/8-16	1.54	22
115/230 VAC 1ø 60 Hz																				
1/6	1725	2.0	56C	B5	CR-G	49655	9.25	1.94	5.61	0.6250	3/16	1.38	—	2.06	5.875	4.500	6.52	3/8-16	-	12
1/4	1725	2.7	56C	B5	DR	63315	8.88	1.94	5.61	0.6250	3/16	1.38	—	2.06	5,875	4.500	5.61	3/8-16	1.94	16
1/4	1725	2.5	56C	B5	DR-B	66109	10.25	1.94	5.69	0.6250	3/16	1.38	4.88	2.06	5.875	4.500	5.81	3/8-16	1.54	22
1/3	1725	3.1	56C	B5	ER	63317	9.38	1.94	5.61	0.6250	3/16	1.38	—	2.06	5.875	4.500	5.61	3/8-16	1.94	19
1/3	1725	3.0	56C	B5	ER-B	66121	10.25	1.94	5.69	0.6250	3/16	1.38	4.88	2.06	5.875	4.500	5.81	3/8-16	1.54	25
1/2	1725	4.4	56C	B5	FR	63318	9.88	1.94	5.61	0.6250	3/16	1.38	—	2.06	5.875	4.500	5.81	3/8-16	1.94	19
1/2	1725	4.2	56C	B5	FR-B	66130	11.56	1.94	5.69	0.6250	3/16	1.38	4.75	2.06	5.875	4.500	5.87	3/8-16	1.54	27
3/4	1725	5.4	56C	B5	GR	63319	10.88	1.94	5.61	0.6250	3/16	1.38	—	2.06	5.875	4.500	6.50	3/8-16	1.94	26
3/4	1725	5.6	56C	B5	GR-B	66139	11.56	1.94	6.63	0.6250	3/16	1.38	5.88	2.06	5.875	4.500	6.50	3/8-16	2.25	34
1	1725	6.7	56C	B5	HR-5/8-B	19183	12.24	1.94	6.63	0.6250	3/16	1.38	5.75	2.06	5.875	4.500	6.50	3/8-16	2.18	35
1	1725	6.5	143TC	B7	HR-B	66145	12.13	1.94	6.63	0.8750	3/16	1.38	5.75	2.13	5.875	4.500	6.50	3/8-16	2.25	35
1-1/2	1725	9.0	145TC	B7	JR-B	66154	12.13	1.94	6.63	0.8750	3/16	1.38	5.75	2.13	5.875	4.500	6.50	3/8-16	2.25	41

All Dimensions in Inches. Dimensional Information for Estimating Purposes Only
NOTE: #302.5 Woodruff Key (3/32 wide)

AC MOTORS

208-230/460 VAC 3ø 60 Hz

Open Drip Proof
NEMA C-Face
Three Phase
1/6 – 20 Horsepower



ORDER BY CATALOG NUMBER OR ITEM CODE

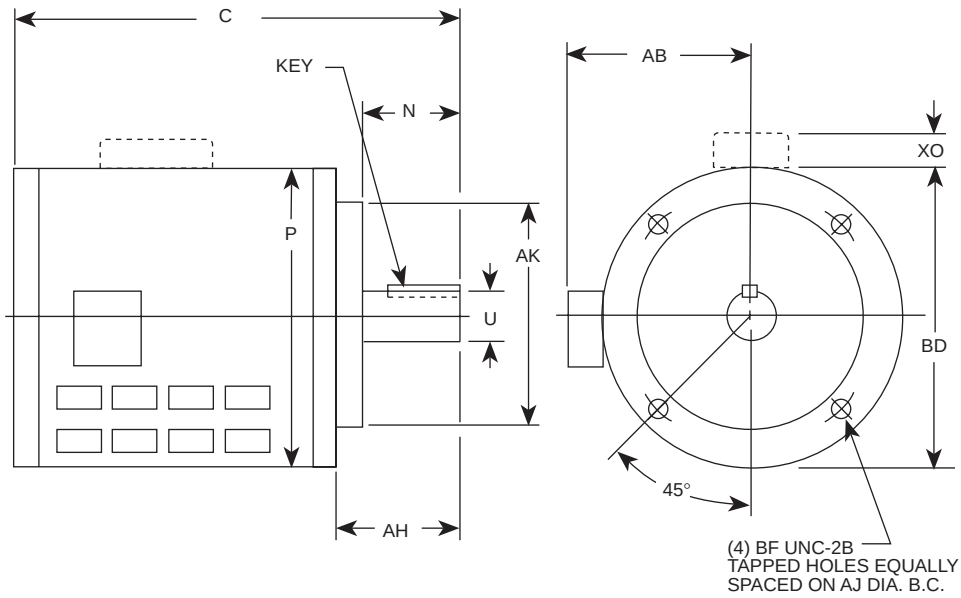
HP	RPM	F.L.A. @Max Volt	NEMA Mtg	Bore Code	Catalog Number	Item Code	C	N	P	U +.0000 -.0005	Key		AB	AH	AJ	AK	BD	BF	Wt. Lbs
											Sq.	Long							
208 – 230/460 VAC 3ø 60 Hz																			
1/6	1725	0.55	56C	B5	CU-G	66108	9.25	1.94	5.61	0.6250	3/16	1.38	—	2.06	5.88	4.500	6.52	3/8-16	14
1/4	1725	0.65	56C	B5	DU	63531	9.38	1.94	5.61	0.6250	3/16	1.38	—	2.06	5.88	4.500	5.61	3/8-16	16
1/4	1725	0.65	56C	B5	DU-B	66115`	10.25	1.94	5.69	0.6250	3/16	1.38	4.88	2.06	5.88	4.500	5.88	3/8-16	18
1/3	1725	0.8	56C	B5	EU	63532	9.38	1.94	5.61	0.6250	3/16	1.38	—	2.06	5.88	4.500	5.61	3/8-16	18
1/3	1725	0.8	56C	B5	EU-B	66124	10.25	1.94	5.69	0.6250	3/16	1.38	4.88	2.06	5.88	4.500	5.88	3/8-16	21
1/2	1725	1.0	56C	B5	FU	63533	9.88	1.94	5.61	0.6250	3/16	1.38	—	2.06	5.88	4.500	5.61	3/8-16	20
1/2	1725	1.0	56C	B5	FU-B	66133	10.31	1.94	5.69	0.6250	3/16	1.38	4.75	2.06	5.88	4.500	5.88	3/8-16	22
3/4	1725	1.4	56C	B5	GU	63536	10.88	1.94	5.61	0.6250	3/16	1.38	—	2.06	5.88	4.500	5.61	3/8-16	22
3/4	1725	1.5	56C	B5	GU-B	66142	11.56	1.94	5.69	0.6250	3/16	1.38	4.75	2.06	5.88	4.500	5.88	3/8-16	26
1	1725	1.7	56C	B5	HU-5/8	63537	10.88	1.94	6.53	0.6250	3/16	1.38	—	2.06	5.88	4.500	5.88	3/8-16	31
1	1725	1.7	56C	B5	HU-5/8-B	50427	11.06	1.94	6.63	0.6250	3/16	1.38	5.63	2.06	5.88	4.500	6.50	3/8-16	33
1	1725	1.7	143TC	B7	HU	63538	10.88	1.94	6.53	0.8750	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	31
1	1725	1.7	143TC	B7	HU-B	66148	11.13	2.00	6.63	0.8750	3/16	1.38	5.63	2.13	5.88	4.500	6.50	3/8-16	33
1-1/2	1725	2.3	145TC	B7	JU	63539	11.38	1.94	6.53	0.8750	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	35
1-1/2	1725	2.4	145TC	B7	JU-B	66157	11.13	2.00	6.63	0.8750	3/16	1.38	5.63	2.13	5.88	4.500	6.50	3/8-16	34
2	1725	3.1	145TC	B7	KU	63540	11.38	1.94	6.53	0.8750	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	37
2	1725	3.2	145TC	B7	KU-B	66163	12.13	2.00	6.63	0.8750	3/16	1.38	5.63	2.13	5.88	4.500	6.50	3/8-16	37
3	1725	4.4	182TC	B9	LU	63542	12.63	2.63	8.46	1.1250	1/4	1.75	6.30	2.89	7.25	8.500	8.88	1/2-13	65
3	1725	4.3	182TC	B9	LU-B	66166	13.63	2.63	7.88	1.1250	1/4	1.75	5.88	2.89	7.25	8.500	9.00	1/2-13	66
5	1725	7.2	184TC	B9	MU	63543	13.13	2.63	8.46	1.1250	1/4	1.75	6.30	2.89	7.25	8.500	8.88	1/2-13	62
5	1725	7.0	184TC	B9	MU-B	66170	15.00	2.63	7.88	1.1250	1/4	1.75	5.88	2.89	7.25	8.500	9.00	1/2-13	80
7-1/2	1725	11.0	213TC	B11	NU-B	66174	17.06	3.13	9.58	1.3750	5/16	2.38	7.38	3.38	7.25	8.500	9.00	1/2-13	114
10	1725	14.0	215TC	B11	PU-B	66176	17.06	3.13	9.96	1.3750	5/16	2.38	7.38	3.38	7.25	8.500	9.00	1/2-13	118
15	1760	19.9	254TC	B13	RU-B	66180	20.00	3.75	11.50	1.6250	3/8	2.88	8.94	4.00	7.25	8.500	9.13	1/2-13	220
20	1760	26.0	256TC	B13	SU-B	66184	21.50	3.75	11.50	1.6250	3/8	2.88	8.94	4.00	7.25	8.500	9.13	1/2-13	261

All dimensions in inches. Dimensional information for estimating purposes only.

115/230 1ø 60 Hz
208 – 230/460 3ø 60 Hz

TENV
NEMA C-Face
Single and Three Phase
1/6 – 1/2 Horsepower
1725 RPM

F



ORDER BY CATALOG NUMBER OR ITEM CODE

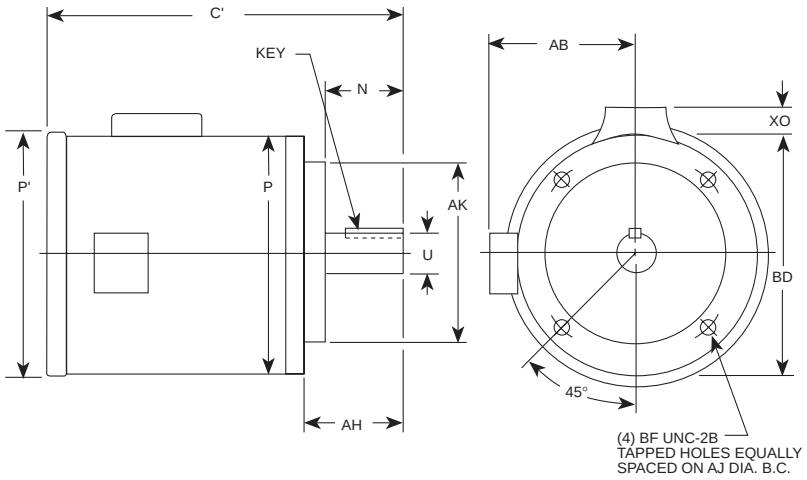
HP	RPM	F.L.A. @ Max Volt	NEMA Mtg.	Bore Code	Catalog Number	Item Code	C	N	P	U +.0000 -.0005	Key Sq.	Key Long	AB	AH	AJ	AK	BD	BF	XO	Wt. Lbs.
115/230 VAC 1ø 60 Hz																				
1/6	1725	1.6	56C	B5	CRT-G	66034	9.88	1.94	5.61	0.6250	3/16	1.38	—	2.06	5.88	4.500	6.52	3/8-16	—	18
1/4	1725	2.4	56C	B5	DRT	63544	9.94	1.94	6.53	0.6250	3/16	1.38	—	2.06	5.88	4.500	5.88	3/8-16	1.97	27
1/3	1725	2.9	56C	B5	ERT	63732	9.94	1.94	6.53	0.6250	3/16	1.38	—	2.06	5.88	4.500	5.88	3/8-16	1.97	29
208 – 230/460 VAC 3ø 60 Hz																				
1/6	1725	0.60	42CZ	B4	ACUT-B	69728	9.31	1.15	4.65	0.5000	1/8	0.75	4.03	1.28	3.75	3.000	4.63	1/4-20	—	19
1/6	1725	0.55	56C	B5	CUT-G	66037	9.00	1.94	5.61	0.6250	3/16	1.38	—	2.06	5.88	4.500	6.64	3/8-16	—	18
1/4	1725	0.60	56C	B5	DUT	63801	9.44	1.94	5.61	0.6250	3/16	1.38	—	2.06	5.88	4.500	5.61	3/8-16	—	16
1/4	1725	0.60	56C	B5	DUT-G	66038	9.98	1.94	6.42	0.6250	3/16	1.38	—	2.06	5.88	4.500	6.64	3/8-16	—	22
1/3	1725	0.65	56C	B5	EUT	63952	9.44	1.94	6.53	0.6250	3/16	1.38	—	2.06	5.88	4.500	5.88	3/8-16	—	20
1/2	1725	1.0	56C	B5	FUT	63959	10.44	1.94	6.53	0.6250	3/16	1.38	—	2.06	5.88	4.500	5.88	3/8-16	—	25

All dimensions in inches. Dimensional information for estimating purposes only.

AC MOTORS

115/230 VAC 1ø 60 Hz

TEFC
NEMA C-Face
Single Phase
1/6 – 1 1/2 Horsepower
1725 RPM



ORDER BY CATALOG NUMBER OR ITEM CODE

HP	RPM	F.L.A. @ Max. Volt	NEMA Mtg.	Bore Code	Catalog Number	Item Code	C′	N	P	P'	U +.0000 -.0005	Key Sq.	Key Lg.	AB	AH	AJ	AK	BD	BF	XO	Wt. Lbs.
115/230 VAC 1ø 60 Hz																					
1/6	1725	1.9	42CZ	B4	ACRTF-B	69725	9.31	1.15	4.69	5.19	0.5000	1/8	0.75	4.03	1.28	3.75	3.000	4.63	1/4-20	1.66	20
1/6	1725	2.0	56C	B5	CRTF-G	66190	10.30	1.94	5.61	6.78	0.6250	3/16	1.38	4.74	2.06	5.88	4.500	6.78	3/8-16	1.53	18
1/4	1725	2.3	42CZ	B4	ADRTF-B	69726	10.31	1.15	4.69	5.19	0.5000	1/8	0.75	4.03	1.28	3.75	3.000	4.63	1/4-20	1.66	21
1/4	1725	2.7	56C	B5	DRTF	63545	9.81	1.94	5.61	5.88	0.6250	3/16	1.38	4.87	2.06	5.88	4.500	5.61	3/8-16	2.00	20
1/4	1725	2.5	56C	B5	DRTF-B	66199	11.38	1.94	5.69	6.19	0.6250	3/16	1.38	4.89	2.06	5.88	4.500	5.81	3/8-16	1.54	23
1/4	1725	2.7	56C	B5	DRTF-G	66200	10.30	1.94	5.61	6.78	0.6250	3/16	1.38	4.74	2.06	5.88	4.500	5.66	3/8-16	1.53	20
1/4	1725	5.0	56C	B5	DSTF-B*	66202	11.38	1.94	5.69	6.19	0.6250	3/16	1.38	4.89	2.06	5.88	4.500	5.81	3/8-16	1.54	23
1/3	1725	3.1	42CZ	B4	AERTF-B	69727	10.31	1.15	4.69	5.19	0.5000	1/8	0.75	4.03	1.28	3.75	3.000	4.63	1/4-20	1.66	23
1/3	1725	3.2	56C	B5	ERTF	63750	10.94	1.94	6.53	7.16	0.6250	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	1.97	26
1/3	1725	3.0	56C	B5	ERTF-B	66211	11.38	1.94	5.69	6.19	0.6250	3/16	1.38	4.89	2.06	5.88	4.500	5.81	3/8-16	1.54	26
1/2	1725	4.4	56C	B5	FRTF	63754	10.94	1.94	6.53	7.16	0.6250	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	1.97	29
1/2	1725	3.7	56C	B5	FRTF-B	66219	12.00	1.94	5.69	6.19	0.6250	3/16	1.38	4.89	2.06	5.88	4.500	5.81	3/8-16	1.54	30
3/4	1725	5.8	56C	B5	GRTF	63755	11.44	1.94	6.53	7.16	0.6250	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	1.97	30
3/4	1725	5.5	56C	B5	GRTF-B	66228	13.31	1.94	6.63	7.19	0.6250	3/16	1.38	5.63	2.06	5.88	4.500	6.50	3/8-16	2.25	42
1	1725	6.4	56C	B5	HRTF-5/8	63795	11.94	1.94	6.53	7.19	0.6250	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	1.97	34
1	1725	6.2	56C	B5	HRTF-5/8-B	19178	13.31	1.94	6.63	7.19	0.6250	3/16	1.38	5.75	2.06	5.88	4.500	6.50	3/8-16	2.25	34
1	1740	6.4	143TC	B7	HRTF	63797	11.94	1.94	6.53	7.16	0.8750	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	1.97	34
1	1725	6.2	143TC	B7	HRTF-B	66234	13.38	2.00	6.63	7.19	0.8750	3/16	1.38	5.75	2.13	5.88	4.500	6.50	3/8-16	2.25	47
1-1/2	1740	8.6	145TC	B7	JRTF	63800	12.44	1.94	6.53	7.16	0.8750	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	1.78**	47
1-1/2	1725	8.0	145TC	B7	JRTF-B	66243	14.25	2.00	6.63	7.19	0.8750	3/16	1.38	5.75	2.13	5.88	4.500	6.50	3/8-16	2.25	58

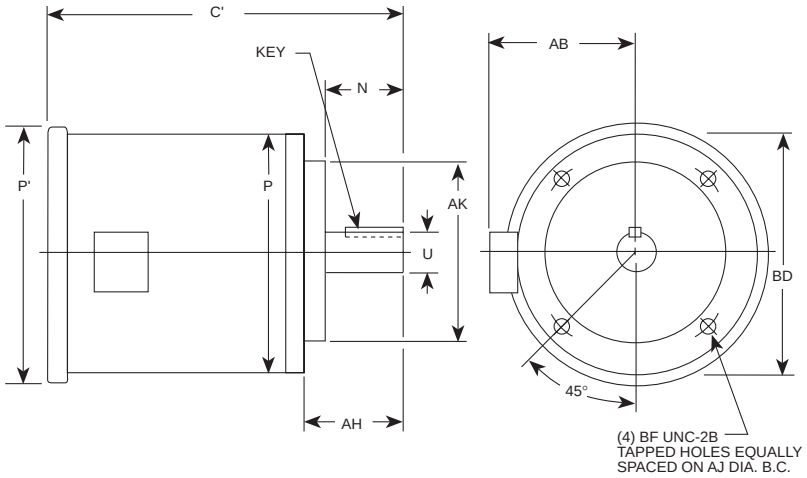
*115 VAC Single Phase 60 Hz only
All dimensions in inches. Dimensional information for estimating purposes only.

**Two capacitors

208-230/460 VAC 3ø 60 Hz

TEFC
NEMA C-Face
Three Phase
1/6 – 1 Horsepower
1725 RPM

F



ORDER BY CATALOG NUMBER OR ITEM CODE

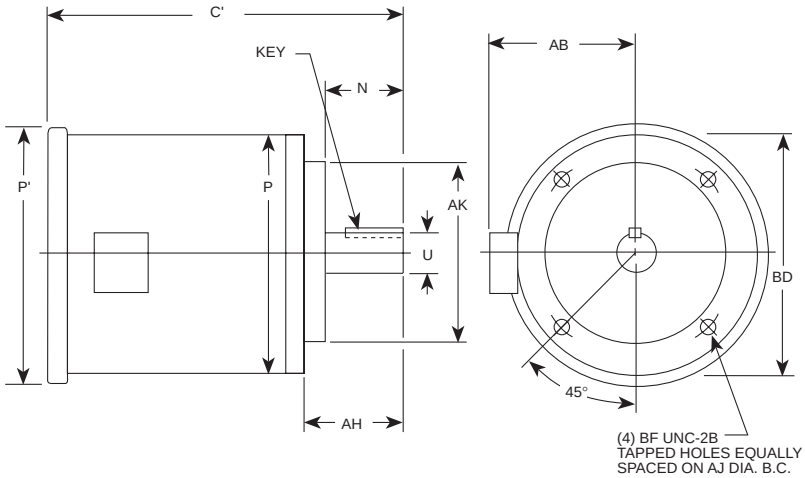
HP	RPM	F.L.A. @ Max. Volt	NEMA Mtg.	Bore Code	Catalog Number	Item Code	C′	N	P	P'	U +.0000 -.0005	Key Sq.	Key Long	AB	AH	AJ	AK	BD	BF	Wt. Lbs.
208-230/460 VAC 3ø 60 Hz																				
1/6	1725	0.55	56C	B5	CUTF-G	66197	10.30	1.94	5.61	6.78	0.6250	3/16	1.38	4.74	2.06	5.88	4.500	6.78	3/8-16	18
1/4	1725	0.60	42CZ	B4	ADUTF-B	69729	10.31	1.15	4.69	5.19	0.5000	1/8	0.75	4.03	1.28	3.75	3.000	4.63	1/4-20	21
1/4	1725	0.65	56C	B5	DUTF	63949	9.81	1.94	5.61	5.88	0.6250	3/16	1.38	4.87	2.06	5.88	4.500	5.61	3/8-16	18
1/4	1725	0.65	56C	B5	DUTF-B	66205	11.38	1.94	5.69	6.19	0.6250	3/16	1.38	4.89	2.06	5.88	4.500	5.81	3/8-16	19
1/4	1725	0.70	56C	B5	DUTF-G	66206	10.30	1.94	5.61	6.78	0.6250	3/16	1.38	4.74	2.06	5.88	4.500	5.66	3/8-16	20
1/3	1725	0.70	42CZ	B4	AEUTF-B	69730	10.31	1.15	4.69	5.19	0.5000	1/8	0.75	4.03	1.28	3.75	3.000	4.63	1/4-20	21
1/3	1725	0.65	56C	B5	EUTF	63958	10.94	1.94	6.53	7.16	0.6250	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	20
1/3	1725	0.80	56C	B5	EUTF-B	66214	11.38	1.94	5.69	6.19	0.6250	3/16	1.38	4.89	2.06	5.88	4.500	5.81	3/8-16	19
1/2	1725	1.0	56C	B5	FUTF	63961	10.94	1.94	6.53	7.16	0.6250	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	25
1/2	1725	1.0	56C	B5	FUTF-B	66223	11.38	1.94	5.69	6.19	0.6250	3/16	1.38	4.89	2.06	5.88	4.500	5.81	3/8-16	22
1/2	1725	1.0	56C	B5	FUTF-G	66224	10.93	1.94	5.61	6.78	0.6250	3/16	1.38	4.74	2.06	5.88	4.500	5.66	3/8-16	26
3/4	1725	1.4	56C	B5	GUTF	63979	11.44	1.94	6.53	7.16	0.6250	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	26
3/4	1725	1.5	56C	B5	GUTF-B	66231	11.38	1.94	5.69	6.19	0.6250	3/16	1.38	4.89	2.06	5.88	4.500	5.81	3/8-16	32
3/4	1725	1.4	56C	B5	GUTF-G	66233	11.36	1.94	5.61	6.78	0.6250	3/16	1.38	4.74	2.06	5.88	4.500	5.66	3/8-16	32
1	1725	1.7	56C	B5	HUTF-5/8	63980	11.94	1.94	6.53	7.19	0.6250	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	33
1	1725	1.7	56C	B5	HUTF-5/8-B	50428	12.31	1.94	6.63	7.19	0.6250	3/16	1.38	5.75	2.06	5.88	4.500	6.50	3/8-16	35
1	1740	1.7	143TC	B7	HUTF	63981	11.63	1.94	6.53	7.16	0.8750	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	33
1	1725	1.7	143TC	B7	HUTF-B	66237	12.38	2.00	6.63	7.19	0.8750	3/16	1.38	5.75	2.13	5.88	4.500	6.50	3/8-16	35
1	1725	1.8	143TC	B7	HUTF-G	66239	11.72	1.94	6.42	7.10	0.8750	3/16	1.38	5.94	2.13	5.88	4.500	6.52	3/8-16	26

All dimensions in inches. Dimensional information for estimating purposes only.

AC MOTORS

208-230/460 VAC 3ø 60 Hz

TEFC
NEMA C-Face
Three Phase
1-1/2 – 20 Horsepower
1725 RPM



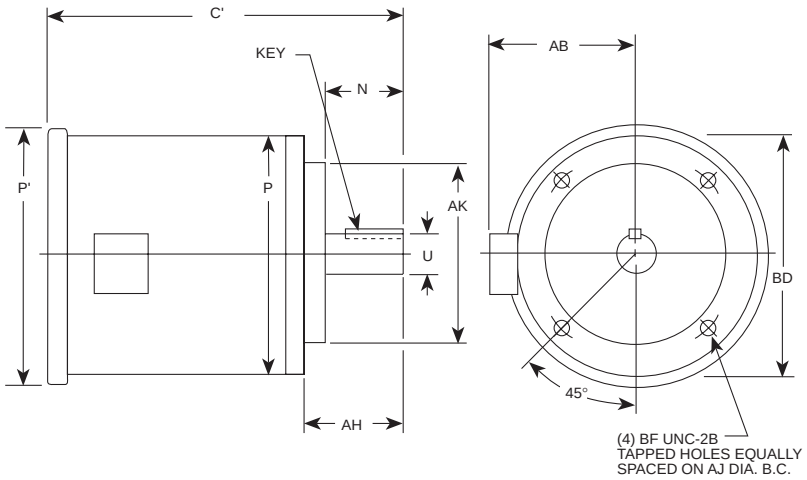
ORDER BY CATALOG NUMBER OR ITEM CODE

HP	RPM	F.L.A. @ Max. Volt	NEMA Mtg.	Bore Code	Catalog Number	Item Code	C	N	P	P'	U +.0000 -.0005	Key Sq.	Key Long	AB	AH	AJ	AK	BD	BF	Wt. Lbs.
208-230/460 VAC 3ø 60 Hz																				
1-1/2	1725	2.3	56C	B5	JUTF-5/8	63988	12.44	1.94	6.53	7.16	0.6250	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	37
1-1/2	1725	2.5	56C	B5	JUTF-5/8-B	19784	12.31	1.94	6.63	7.19	0.6250	3/16	1.38	5.75	2.06	5.88	4.500	6.50	3/8-16	37
1-1/2	1740	2.3	145TC	B7	JUTF	64281	12.44	1.94	6.53	7.16	0.8750	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	37
1-1/2	1725	2.0	145TC	B7	JUTF-B	66246	12.38	2.00	6.63	7.19	0.8750	3/16	1.38	5.75	2.13	5.88	4.500	6.50	3/8-16	37
1-1/2	1725	2.4	145TC	B7	JUTF-G	66248	12.72	1.94	6.42	7.10	0.8750	3/16	1.38	5.94	2.13	5.88	4.500	6.52	3/8-16	35
2	1725	3.1	56C	B5	KUTF-5/8	64769	12.44	1.94	6.53	7.16	0.6250	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	42
2	1725	3.1	56C	B5	KUTF-5/8-B	19785	13.31	1.94	6.63	7.19	0.6250	3/16	1.38	5.75	2.06	5.88	4.500	6.50	3/8-16	42
2	1740	3.1	145TC	B7	KUTF	64770	12.44	1.94	6.53	7.16	0.8750	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	42
2	1725	3.1	145TC	B7	KUTF-B	66252	13.38	2.00	6.63	7.19	0.8750	3/16	1.38	5.75	2.13	5.88	4.500	6.50	3/8-16	45
2	1725	3.1	145TC	B7	KUTF-G	66254	14.10	1.94	6.42	7.10	0.8750	3/16	1.38	5.25	2.13	5.88	4.500	6.52	3/8-16	39
3	1740	4.4	182TC	B9	LUTF	64771	13.91	2.63	8.46	9.09	1.1250	1/4	1.75	6.36	2.89	7.25	8.500	8.58	1/2-13	65
3	1725	4.3	182TC	B9	LUTF-B	66258	15.18	2.63	7.88	8.50	1.1250	1/4	1.75	5.88	2.89	7.25	8.500	9.00	1/2-13	94
5	1740	6.7	184TC	B9	MUTF	64772	14.91	2.63	8.46	9.09	1.1250	1/4	1.75	6.36	2.89	7.25	8.500	8.58	1/2-13	84
5	1725	6.6	184TC	B9	MUTF-B	66262	16.56	2.63	7.88	8.50	1.1250	1/4	1.75	5.88	2.89	7.25	8.500	9.00	1/2-13	102
7-1/2	1725	10.0	213TC	B11	NUTF-B	66266	18.69	3.13	9.56	10.19	1.3750	5/16	2.38	7.38	3.38	7.25	8.500	9.00	1/2-13	113
10	1725	13.0	215TC	B11	PUTF-B	66270	19.44	3.13	9.56	10.19	1.3750	5/16	2.38	7.38	3.38	7.25	8.500	9.00	1/2-13	146
15	1725	19.6	254TC	B13	RUTF-B	66274	22.00	3.75	12.94	13.25	1.6250	3/8	2.38	9.63	4.00	7.25	8.500	9.13	1/2-13	312
20	1725	26.0	256TC	B13	SUTF-B	66278	22.00	3.75	12.94	13.25	1.6250	3/8	2.38	9.63	4.00	7.25	8.500	9.13	1/2-13	312

All dimensions in inches. Dimensional information for estimating purposes only.

575 VAC 3ø 60 Hz

TEFC
NEMA C-Face
Three Phase
1/4 – 5 Horsepower
1725 RPM



ORDER BY CATALOG NUMBER OR ITEM CODE

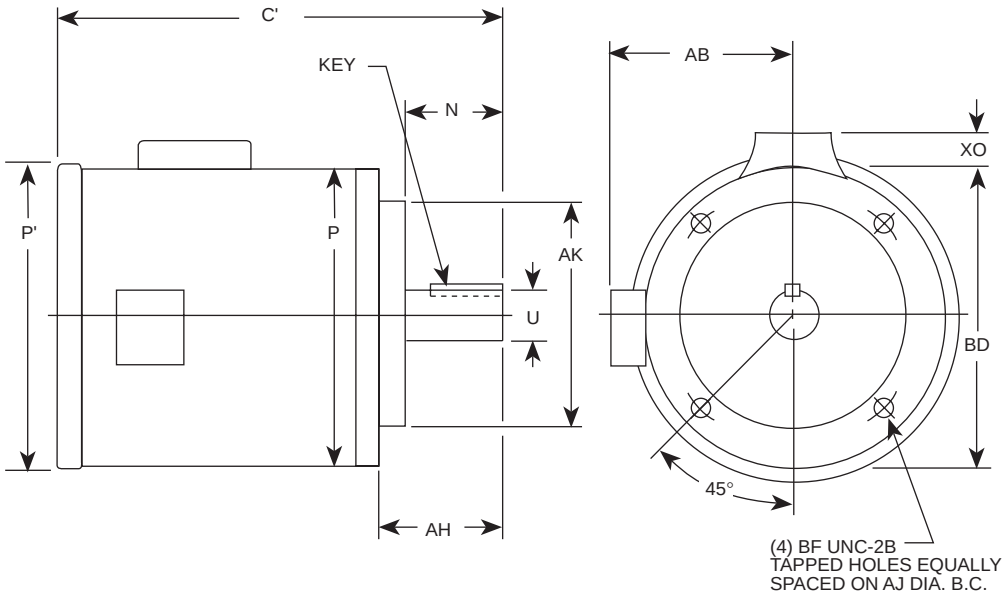
HP	RPM	F.L.A. @ Max. Volt	NEMA Mtg.	Bore Code	Catalog Number	Item Code	C′	N	P	P'	U +.0000 -.0005	Key Sq.	Key Long	AB	AH	AJ	AK	BD	BF	Wt. Lbs.
575 VAC 3ø 60 Hz																				
1/4	1725	0.56	56C	B5	DYTF	64963	9.81	1.94	5.61	5.88	0.6250	3/16	1.38	4.87	2.06	5.88	4.500	5.61	3/8-16	18
1/4	1725	0.48	56C	B5	DYTF-B	66208	11.38	1.94	5.69	6.13	0.6250	3/16	1.38	4.89	2.06	5.88	4.500	5.81	3/8-16	19
1/3	1725	0.52	56C	B5	EYTF	64944	10.94	1.94	6.53	7.16	0.6250	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	26
1/3	1725	0.64	56C	B5	ETYF-B	66217	11.38	1.94	5.69	6.19	0.6250	3/16	1.38	4.89	2.06	5.88	4.500	5.81	3/8-16	19
1/2	1725	0.80	56C	B5	FYTF	64945	10.94	1.94	6.53	7.16	0.6250	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	26
1/2	1725	0.80	56C	B5	FYTF-B	66226	11.38	1.94	5.69	6.19	0.6250	3/16	1.38	4.89	2.06	5.88	4.500	5.81	3/8-16	22
3/4	1725	1.1	56C	B5	GYTF	64946	11.44	1.94	6.53	7.16	0.6250	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	26
3/4	1725	1.2	56C	B5	GYTF-B	66831	12.31	1.94	6.63	7.19	0.6250	3/16	1.38	5.75	2.06	5.88	4.500	6.50	3/8-16	32
1	1725	1.4	56C	B5	HYTF-5/8-B	19179	12.31	1.94	6.63	7.19	0.6250	3/16	1.38	5.75	2.06	5.88	4.500	6.50	3/8-16	35
1	1740	1.4	143TC	B7	HYTF	64948	11.94	1.94	6.53	7.16	0.8750	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	32
1	1725	1.4	143TC	B7	HYTF-B	66240	12.38	2.00	6.63	7.19	0.8750	3/16	1.38	5.75	2.13	5.88	4.500	6.50	3/8-16	35
1-1/2	1740	1.9	145TC	B7	JYTF	64949	12.44	1.94	6.53	7.16	0.8750	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	35
1-1/2	1725	1.9	145TC	B7	JYTF-B	66249	12.38	2.00	6.63	7.19	0.8750	3/16	1.38	5.75	2.13	5.88	4.500	6.50	3/8-16	37
2	1740	2.5	145TC	B7	KYTF	64950	12.44	1.94	6.53	7.16	0.8750	3/16	1.38	5.09	2.06	5.88	4.500	5.88	3/8-16	37
2	1725	2.5	145TC	B7	KYTF-B	66255	13.38	2.00	6.63	7.19	0.8750	3/16	1.38	5.75	2.13	5.88	4.500	6.50	3/8-16	45
3	1740	3.5	182TC	B9	LYTF	64954	13.91	2.63	8.46	9.09	1.1250	1/4	1.75	6.36	2.88	7.25	8.500	8.58	1/2-13	60
3	1725	3.6	182TC	B9	LYTF-B	66260	15.18	2.63	7.88	8.50	1.1250	1/4	1.75	5.88	2.88	7.25	8.500	9.00	1/2-13	94
5	1740	5.4	184TC	B9	MYTF	64955	14.91	2.63	8.46	9.09	1.1250	1/4	1.75	6.36	2.88	7.25	8.500	8.58	1/2-13	77
5	1725	5.3	184TC	B9	MYTF-B	66264	16.56	2.63	7.88	8.50	1.1250	1/4	1.75	5.88	2.88	7.25	8.500	9.00	1/2-13	102

All dimensions in inches. Dimensional information for estimating purposes only.

AC MOTORS

110/220 1ø 50 Hz
220/380/440 3ø 50 Hz

TEFC
NEMA C-Face
Single and Three Phase, 50 Hz
1/6 – 1-1/2 Horsepower
1425 RPM



ORDER BY CATALOG NUMBER OR ITEM CODE

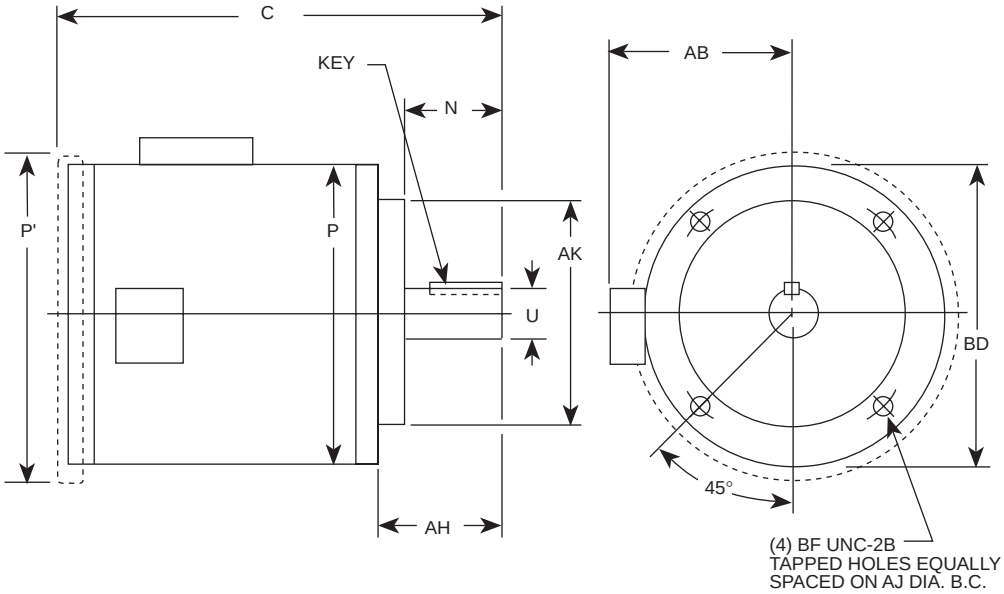
HP	RPM	F.L.A. @ Max. Volt	NEMA Mtg.	Bore Code	Catalog Number	Item Code	C	N	P	P'	U +.0000 -.0005	Key Sq.	Key Long	AB	AH	AJ	AK	BD	BF	XO	Wt. Lbs.
110/220 VAC 1ø 50 Hz																					
1/6	1425	2.1	42CZ	B4	ACR5TF-B	50480	9.31	1.15	4.69	5.19	0.5000	1/8	0.75	4.03	1.28	3.75	3.000	4.63	1/4-20	1.66	20
1/4	1425	2.3	42CZ	B4	ADR5TF-B	66970	9.31	1.15	4.69	5.19	0.5000	1/8	0.75	4.03	1.28	3.75	3.000	4.63	1/4-20	1.66	21
1/4	1425	2.8	56C	B5	DR5TF-B	66858	11.38	1.94	5.69	6.19	0.6250	3/16	1.38	4.51	2.06	5.88	4.500	5.81	3/8-16	1.56	23
1/3	1425	3.1	56C	B5	ER5TF-B	66869	12.38	1.94	5.69	6.19	0.6250	3/16	1.38	4.51	2.06	5.88	4.500	5.81	3/8-16	1.56	26
1/2	1425	4.0	56C	B5	FR5TF-B	66875	12.88	1.94	5.69	6.19	0.6250	3/16	1.38	4.51	2.06	5.88	4.500	5.81	3/8-16	1.56	30
3/4	1425	6.4	56C	B5	GR5TF-B	66881	13.31	1.94	6.63	7.19	0.6250	3/16	1.38	5.25	2.06	5.88	4.500	6.50	3/8-16	2.25	42
220/380/415-440 VAC 3ø 50 Hz																					
1/2	1425	1.0	56C	B5	FU5TF-B	50337	11.38	1.94	5.69	6.19	0.6250	3/16	1.38	4.51	2.06	5.88	4.500	5.81	3/8-16	—	22
3/4	1425	1.3	56C	B5	GU5TF-B	50338	12.00	1.94	5.69	6.19	0.6250	3/16	1.38	4.51	2.06	5.88	4.500	5.81	3/8-16	—	32
1	1425	1.5	143TC	B7	HU5TF-B	50339	12.38	2.00	6.63	7.19	0.8750	3/16	1.38	5.25	2.13	5.88	4.500	6.50	3/8-16	—	35
1-1/2	1425	2.1	145TC	B7	JU5TF-B	50340	13.38	2.00	6.63	7.19	0.8750	3/16	1.38	5.25	2.13	5.88	4.500	6.50	3/8-16	—	37

All dimensions in inches. Dimensional information for estimating purposes only.

208-230/460 VAC 3ø 60 Hz
575 VAC 3ø 60 Hz

BISSC Approved Washdown & Stainless Steel
NEMA C-Face
Three Phase
TENV-TEFC
1/2 – 5 Horsepower
1725 RPM

F



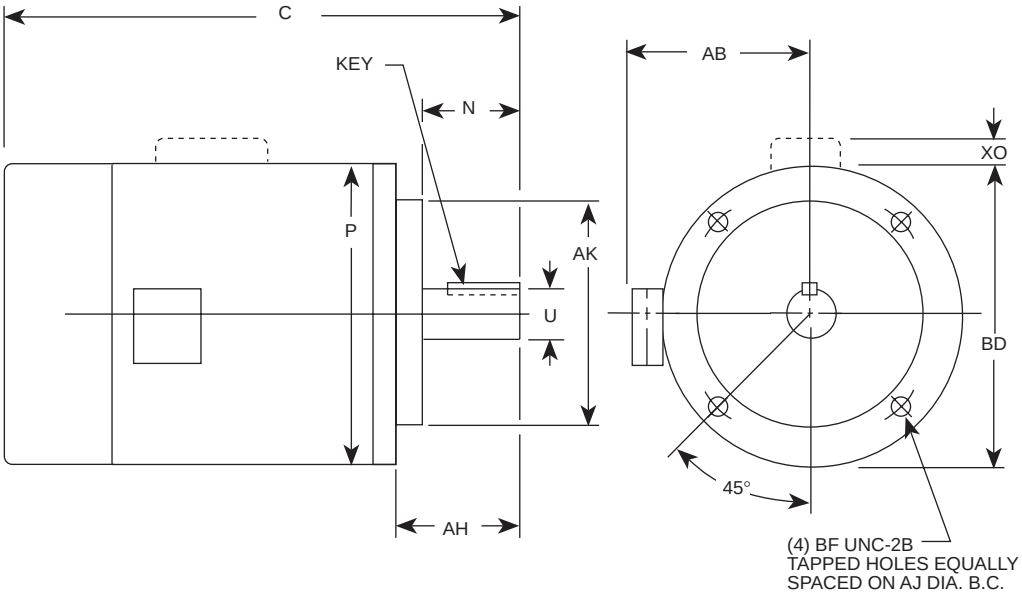
ORDER BY CATALOG NUMBER OR ITEM CODE

HP	F.L.A. @ Max. Volt	NEMA Mtg.	Bore Code	Catalog Number	Item Code	C	N	P	P'	U +.0000 -.0005	Key Sq.	Key Lg.	AB	AH	AJ	AK	BD	BF	Wt. Lbs.
208-230/460 VAC 3ø 60 Hz BISCC Approved																			
1/2	0.80	56C	B5	FUT-WB-B	69105	11.06	1.94	6.63	—	0.6250	3/16	1.38	5.25	2.06	5.88	4.500	6.62	3/8-16	30
3/4	1.1	56C	B5	GUT-WB-B	69106	11.06	1.94	6.63	—	0.6250	3/16	1.38	5.25	2.06	5.88	4.500	6.62	3/8-16	34
1	1.5	56C	B5	HUT-WB-5/8-B	69123	12.13	1.94	6.63	—	0.6250	3/16	1.38	5.25	2.06	5.88	4.500	6.62	3/8-16	38
1	1.7	143TC	B7	HUT-WB-B	69107	12.13	2.00	6.63	—	0.8750	3/16	1.38	5.25	2.13	5.88	4.500	6.62	3/8-16	39
1 1/2	2.5	145TC	B7	JUTF-WB-B *	69110	12.38	2.00	6.63	7.19	0.8750	3/16	1.38	5.25	2.13	5.88	4.500	6.62	3/8-16	40
2	3.1	145TC	B7	KUTF-WB-B *	69111	13.38	2.00	6.63	7.19	0.8750	3/16	1.38	5.25	2.13	5.88	4.500	6.62	3/8-16	44
3	4.3	182TC	B9	LUTF-WB-B *	69112	15.19	2.62	7.88	8.50	1.1250	1/4	1.75	5.88	2.88	7.25	8.500	9.00	1/2-13	61
5	6.6	184TC	B9	MUTF-WB-B *	69113	16.56	2.62	7.88	8.50	1.1250	1/4	1.75	5.88	2.88	7.25	8.500	9.00	1/2-13	76
208-230/460 VAC 3ø 60 Hz Stainless Steel																			
1/2	1.4	56C	B5	FUT-SS	46488	11.56	1.94	6.53	—	0.6250	3/16	1.38	5.44	2.06	5.88	4.500	6.53	3/8-16	34
3/4	2.2	56C	B5	GUT-SS	46630	12.06	1.94	6.53	—	0.6250	3/16	1.38	5.44	2.06	5.88	4.500	6.53	3/8-16	38
1	2.9	56C	B5	HUT-5/8-SS	46634	12.06	1.94	6.53	—	0.6250	3/16	1.38	5.44	2.06	5.88	4.500	6.53	3/8-16	39
1	2.9	143TC	B7	HUT-SS	46635	12.13	2.00	6.53	—	0.8750	3/16	1.38	5.44	2.13	5.88	4.500	6.53	3/8-16	39
1 1/2	4.4	145TC	B7	JUTF-SS	46636	14.25	2.00	6.53	—	0.8750	3/16	1.38	5.44	2.13	5.88	4.500	6.53	3/8-16	46
2	6.0	145TC	B7	KUTF-SS	46639	14.25	2.00	6.53	—	0.8750	3/16	1.38	5.44	2.13	5.88	4.500	6.53	3/8-16	49
575 VAC 3ø 60 Hz Stainless Steel																			
1/2	1.4	56C	B5	FYT-SS	59000	11.56	1.94	6.53	—	0.6250	3/16	1.38	5.44	2.06	5.88	4.500	6.53	3/8-16	34
3/4	2.2	56C	B5	GYT-SS	59001	12.06	1.94	6.53	—	0.6250	3/16	1.38	5.44	2.06	5.88	4.500	6.53	3/8-16	38
1	2.9	56C	B5	HYT-5/8-SS	59003	12.06	1.94	6.53	—	0.6250	3/16	1.38	5.44	2.06	5.88	4.500	6.53	3/8-16	39
1	2.9	143TC	B7	HYT-SS	59002	12.13	2.00	6.53	—	0.8750	3/16	1.38	5.44	2.13	5.88	4.500	6.53	3/8-16	39
1 1/2	4.4	145TC	B7	JYTF-SS	59004	14.25	2.00	6.53	—	0.8750	3/16	1.38	5.44	2.13	5.88	4.500	6.53	3/8-16	46
2	6.0	145TC	B7	KYTF-SS	59005	14.25	2.00	6.53	—	0.8750	3/16	1.38	5.44	2.13	5.88	4.500	6.53	3/8-16	49

All dimensions in inches. Dimensional information for estimating purposes only.
*TEFC, All other TENV

115/230 1ø 60 Hz
208-230/460 3ø 60 Hz

Brake Motors, Open Drip Proof
NEMA C-Face
Single and Three Phase
1/4 – 5 Horsepower
1725 RPM



ORDER BY CATALOG NUMBER OR ITEM CODE

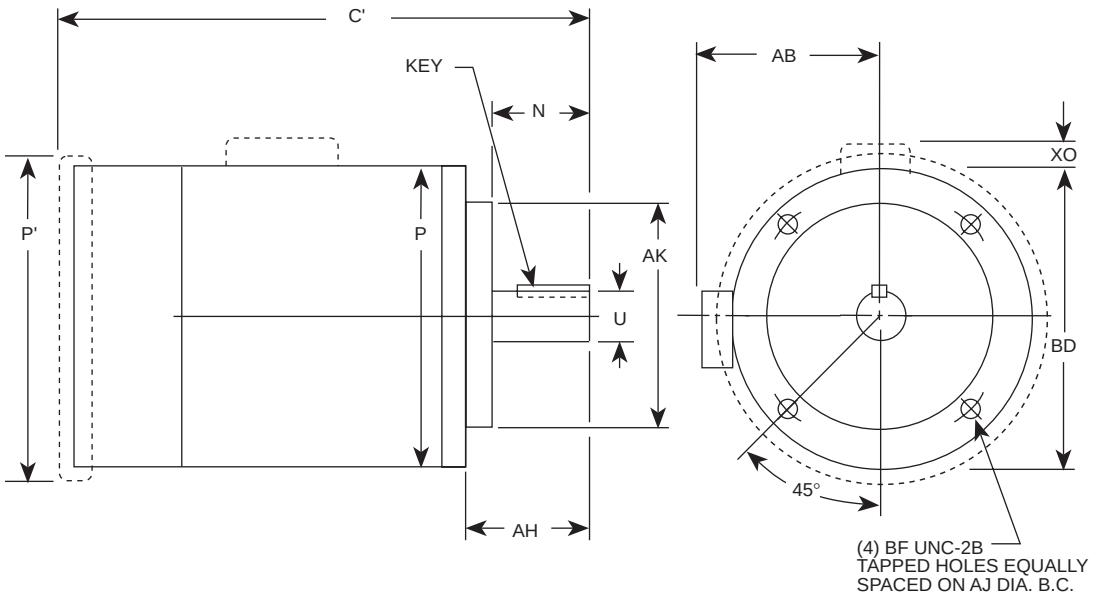
HP	Brake Rating (Lb. Ft.)	F.L.A. @ Max. VOLT	NEMA MTG.	Bore CODE	Catalog Number	Item Code	C	N	P	U +.0000 -.0005	Key Sq.	Key Lg.	AB	AH	AJ	AK	BD	BF	XO	Wt. Lbs.
115/230 VAC 1ø 60 Hz																				
1/4	3	2.5	56C	B5	DRB-B	66361	14.19	1.88	5.69	.6250	3/16	1.38	4.88	2.06	5.88	4.500	5.81	3/8-16	2.20	34
1/3	3	3.0	56C	B5	ERB-B	66370	15.19	1.88	5.69	.6250	3/16	1.38	4.88	2.06	5.88	4.500	5.81	3/8-16	2.20	34
1/2	3	4.2	56C	B5	FRB-B	66379	16.19	1.88	5.69	.6250	3/16	1.38	4.88	2.06	5.88	4.500	5.81	3/8-16	2.20	38
3/4	3	5.4	56C	B5	GRB-B	66388	15.25	1.88	6.63	.6250	3/16	1.38	5.63	2.06	5.88	4.500	6.50	3/8-16	2.28	45
208-230/460 VAC 3ø 60 Hz																				
1/4	3	0.65	56C	B5	DUB-B	66364	14.19	1.88	5.69	.6250	3/16	1.38	4.88	2.06	5.88	4.500	5.81	3/8-16	—	26
1/3	3	0.80	56C	B5	EUB-B	66373	14.19	1.88	5.69	.6250	3/16	1.38	4.88	2.06	5.88	4.500	5.81	3/8-16	—	28
1/2	3	1.0	56C	B5	FUB-B	66382	14.19	1.88	5.69	.6250	3/16	1.38	4.88	2.06	5.88	4.500	5.81	3/8-16	—	31
3/4	3	1.5	56C	B5	GUB-B	66391	15.25	1.88	6.63	.6250	3/16	1.38	5.63	2.06	5.88	4.500	6.50	3/8-16	—	41
1	3	1.7	56C	B5	HUB-5/8-B	19181	15.25	1.88	6.63	.6250	3/16	1.38	5.47	2.06	5.88	4.500	6.50	3/8-16	—	31
1	3	1.7	143TC	B7	HUB-B	66397	15.31	2.00	6.63	.8750	3/16	1.38	5.25	2.13	5.88	4.500	6.50	3/8-16	—	40
1 1/2	6	2.4	145TC	B7	JUB-B	66403	15.31	2.00	6.63	.8750	3/16	1.38	5.25	2.13	5.88	4.500	6.50	3/8-16	—	43
2	6	3.2	145TC	B7	KUB-B	66409	16.31	2.00	6.63	.8750	3/16	1.38	5.25	2.13	5.88	4.500	6.50	3/8-16	—	53
3	10	4.3	182TC	B9	LUB-B	66415	18.19	2.63	7.88	1.1250	1/4	1.75	5.88	2.89	7.25	8.500	9.00	1/2-13	—	73
5	10	7.0	184TC	B9	MUB-B	66834	19.56	2.63	7.88	1.1250	1/4	1.75	5.88	2.89	7.25	8.500	9.00	1/2-13	—	84

All dimensions in inches. Dimensional information for estimating purposes only.

115/230 VAC 1ø 60 Hz
208-230/460 VAC 3ø 60 Hz
575 VAC 3ø 60 Hz

Brake Motors
TEFC & TENV
NEMA C-Face
Single and Three Phase
1/4 – 5 Horsepower
1725 RPM

F



ORDER BY CATALOG NUMBER OR ITEM CODE

HP	Brake Rating (lb ft)	F.L.A. @ Max. Volt	NEMA Mtg.	Bore Code	Catalog Number	Item Code	C	N	P	P'	U +.0000 -.0005	Key Sq.	Key Lg.	AB	AH	AJ	AK	BD	BF	XO	Approx. Wght. (lb)
115/230 VAC 1ø 60 Hz																					
1/4	3	2.5	56C	B5	DRTB-B	66419	15.19	1.88	5.68	—	.6250	3/16	1.38	4.88	2.06	5.88	4.500	5.81	3/8-16	1.54	34
1/3	3	2.4	56C	B5	ERTB-B	66431	16.19	1.88	5.68	—	.6250	3/16	1.38	4.88	2.06	5.88	4.500	5.81	3/8-16	1.54	38
1/2	3	3.4	56C	B5	FRTB-B	66440	16.25	1.88	6.63	—	.6250	3/16	1.38	5.75	2.06	5.88	4.500	6.50	3/8-16	2.30	39
3/4	3	5.6	56C	B5	GRTFB-B*	66449	17.88	1.88	6.63	7.18	.6250	3/16	1.38	5.75	2.06	5.88	4.500	6.50	3/8-16	2.30	48
208-230/460 VAC 3ø 60 Hz																					
1/4	3	0.60	56C	B5	DUTB-B	66425	14.19	1.88	5.68	—	.6250	3/16	1.38	4.88	2.06	5.88	4.500	5.81	3/8-16	—	25
1/3	3	0.70	56C	B5	EUTB-B	66434	14.19	1.88	5.68	—	.6250	3/16	1.38	4.88	2.06	5.88	4.500	5.81	3/8-16	—	27
1/2	3	0.90	56C	B5	FUTB-B	66443	14.81	1.88	5.69	—	.6250	3/16	1.38	4.89	2.06	5.88	4.500	5.81	3/8-16	—	30
3/4	3	1.1	56C	B5	GUTB-B	66452	15.25	1.88	6.63	—	.6250	3/16	1.38	5.75	2.06	5.88	4.500	6.50	3/8-16	—	40
1	3	1.5	56C	B5	HUTB-5/8-B	19182	16.25	1.88	6.63	—	.6250	3/16	1.38	5.75	2.06	5.88	4.500	6.50	3/8-16	—	41
1	3	1.5	145TC	B7	HUTB-B	66458	16.31	2.00	6.63	—	.8750	3/16	1.38	5.75	2.3	5.88	4.500	6.50	3/8-16	—	41
1 1/2	6	2 5	145TC	B7	JUTFB-B*	66464	16.94	2.00	6.63	7.18	.8750	3/16	1.38	5.75	2.13	5.88	4.500	6.50	3/8-16	—	43
2	6	3.1	145TC	B7	KUTFB-B*	66470	17.94	2.00	6.63	7.18	.8750	3/16	1.38	5.75	2.13	5.88	4.500	6.50	3/8-16	—	51
3	10	4.3	182TC	B9	LUTFB-B*	66474	19.81	2.63	8.50	7.18	1.1250	1/4	1.75	5.88	2.88	7.85	8.500	9.00	1/2-13	—	76
5	25	6.6	184TC	B9	MUTFB-B*	66838	21.18	2.63	7.89	10.18	1.1250	1/4	1.75	5.97	2.88	7.25	8.500	8.86	1/2-13	—	118
575 VAC 3ø 60 Hz																					
1/4	3	.40	56C	B5	DYTB-B	66428	15.25	1.88	6.63	—	.6250	3/16	1.38	5.63	2.06	5.08	4.500	5.81	3/8-16	—	30
1/2	3	.72	56C	B5	FYTB-B	66446	15.19	1.88	5.81	—	.6250	3/16	1.38	4.88	2.06	5.88	4.500	5.81	3/8-16	—	30
3/4	3	1.2	56C	B5	GYTB-B	66455	15.19	1.88	5.81	—	.6250	3/16	1.38	4.88	2.06	5.88	4.500	5.81	3/9-16	—	40
1	3	1.2	145TC	B7	HYTB-B	66461	16.31	2.00	6.63	—	.8750	3/16	1.38	5.75	2.13	5.88	4.500	6.50	3/8-16	—	51
1 1/2	6	2.0	145TC	B7	JYTFB-B*	66467	16.94	2.00	6.63	7.18	.8750	3/16	1.38	5.75	2.13	5.88	4.500	6.50	3/8-16	—	43
2	6	2.5	145TC	B7	KYTFB-B*	66472	17.94	2.00	6.63	7.18	.8750	3/16	1.38	5.75	2.13	5.88	4.500	6.50	3/8-16	—	51
3	10	3.6	182TC	B9	LYTFB-B*	66476	19.81	2.63	8.50	7.18	1.1250	1/4	1.75	5.88	2.88	7.25	8.500	9.00	1/2-13	—	76
5	10	5.3	184TC	B9	MYTFB-B*	66840	21.18	2.63	8.50	7.18	1.1250	1/4	1.75	5.88	2.88	7.25	8.500	9.00	1/2-13	—	112

*TEFC, All others TENV.
All dimensions in inches. Dimensional information for estimating purposes only.

AC MOTORS

115/230 VAC 1ø 60 Hz
208-230/460 VAC 3ø 60 Hz

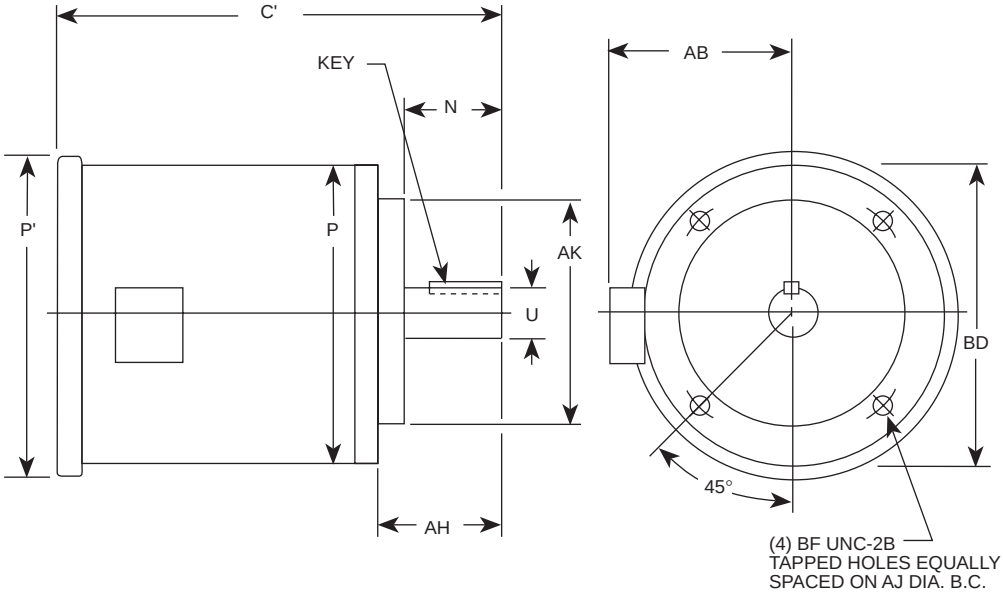
Explosion Proof
NEMA C-Face
Single and Three Phase
1/4-5 Horsepower
1725 RPM

CONTINUOUS DUTY

1.0 SERVICE FACTOR

CLASS I GROUP D

CLASS II GROUPS F & G



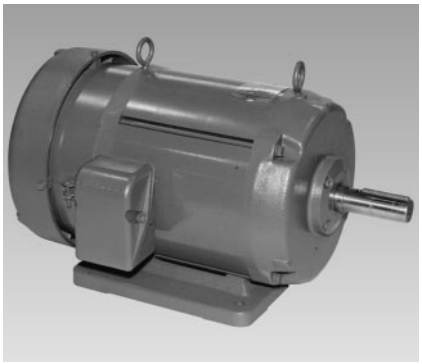
ORDER BY CATALOG NUMBER OR ITEM CODE

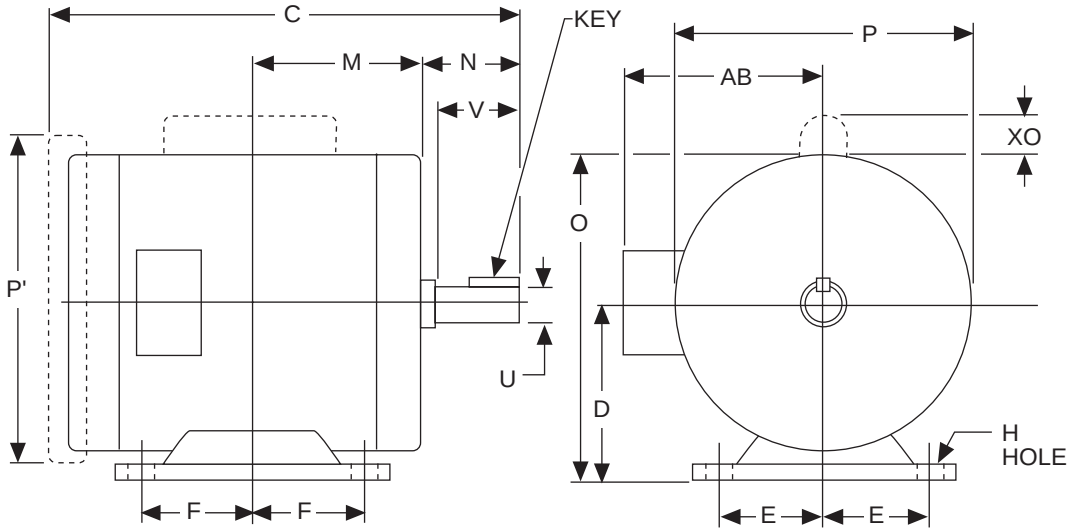
HP	F.L.A. @ Max. Volt	NEMA Mtg.	Bore Code	Catalog Number	Item Code	C'	N	P	P'	U +.0000 -.0005	KEY Sq.	KEY Lg.	AB	AH	AJ	AK	BD	BF	Wt. Lbs.
115/230 VAC 1ø 60 Hz																			
1/4	2.5	56C	B5	DRX-B	66292	14.38	1.94	6.68	7.19	0.6250	3/16	1.38	6.75	2.06	5.88	4.500	6.50	3/8-16	42
1/3	3.0	56C	B5	ERX-B	66304	14.38	1.94	6.68	7.19	0.6250	3/16	1.38	6.75	2.06	5.88	4.500	6.50	3/8-16	42
1/2	3.8	56C	B5	FRX-B	66313	14.38	1.94	6.75	7.19	0.6250	3/16	1.38	6.75	2.06	5.88	4.500	6.50	3/8-16	49
3/4	5.3	56C	B5	GRX-B	66322	15.25	1.94	6.75	7.19	0.6250	3/16	1.38	6.75	2.06	5.88	4.500	6.50	3/8-16	54
208-230/460 VAC 3ø 60 Hz																			
1/4	0.65	56C	B5	DUX-B	66298	14.38	1.94	6.68	7.19	0.6250	3/16	1.38	6.75	2.06	5.88	4.500	6.50	3/8-16	42
1/3	0.80	56C	B5	EUX-B	66307	13.22	1.94	6.68	6.20	0.6250	3/16	1.38	6.50	2.06	5.88	4.500	6.50	3/8-16	28
1/2	1.0	56C	B5	FUX-B	66316	14.38	1.94	6.68	7.19	0.6250	3/16	1.38	6.75	2.06	5.88	4.500	6.50	3/8-16	42
3/4	1.5	56C	B5	GUX-B	66325	14.38	1.94	6.68	7.19	0.6250	3/16	1.38	6.75	2.06	5.88	4.500	6.50	3/8-16	43
1	1.8	56C	B5	HUX-5/8-B	19180		1.94	6.68	6.20	0.6250	3/16	1.38	6.50	2.06	5.88	4.500	6.50	3/8-16	44
1	1.7	143TC	B7	HUX-B	66334		2.00	6.68	7.19	0.8750	3/16	1.38	6.92	2.13	5.88	4.500	6.50	3/8-16	39
1-1/2	2.5	145TC	B7	JUX-B	66343		2.00	6.88	7.19	0.8750	3/16	1.38	6.92	2.13	5.88	4.500	6.50	3/8-16	43
2	3.1	145TC	B7	KUX-B	66349		2.00	6.75	7.19	0.8750	3/16	1.38	6.92	2.13	5.88	4.500	6.50	3/8-16	50
3	4.3	182TC	B9	LUX-B	66353	17.50	2.63	7.88	8.49	1.1250	1/4	1.75	7.52	2.88	7.25	8.500	8.98	1/2-13	81
5	6.5	184TC	B9	MUX-B	66357		2.63	7.88	8.82	1.1250	1/4	1.75	7.52	2.88	7.25	8.500	8.98	1/2-13	111

All dimensions in inches. Dimensional information for estimating purposes only.

115/230 VAC 1ø 60 Hz
208-230/460 VAC 3ø 60 Hz

TEFC
Rigid Base
Single and Three Phase
1/2 – 50 Horsepower
1725 RPM





ORDER BY CATALOG NUMBER OR ITEM CODE

HP	RPM	F.L.A. @ Max. Volt	NEMA MTG	Catalog Number	Item Code	C	D	E	F	H*	M	N	O	P	P′	U +.0000 -.0005	Key SQ	Key Long	V	AB	XO	Wt. (Lbs.)
115/230 VAC 1ø 60 Hz																						
1/2	1725	3.7	56	BFRTF-B	66530	11.95	3.50	2.44	1.50	.34(S)	3.63	2.50	6.34	5.68	6.13	.6250	3/16	1.38	1.88	4.88	1.50	27
3/4	1725	5.6	56	BGRTF-B	66536	13.31	3.50	2.44	1.50	.34(S)	3.69	2.50	6.88	6.63	7.18	.6250	3/16	1.38	1.88	5.75	2.25	35
1	1725	6.2	143T	BHRTF-B	66542	13.31	3.50	2.75	2.00	.34(S)	4.00	2.50	6.81	6.63	7.18	.8750	3/16	1.38	2.25	5.75	2.25	39
1 1/2	1725	8.0	145T	BJRTF-B	66548	14.19	3.50	2.75	2.00	.34(S)	4.00	2.50	6.81	6.63	7.18	.8750	3/16	1.38	2.25	5.75	2.25	48
208-230/460 VAC 3ø 60 Hz																						
1/2	1725	1.0	56	BFUTF-B	66533	11.38	3.60	2.44	1.50	.34(S)	3.63	2.50	6.38	5.68	6.13	.6250	3/16	1.38	1.88	4.88	—	23
3/4	1725	1.5	56	BGUTF-B	66538	12.38	3.50	2.44	1.50	.34(S)	3.63	2.50	6.38	5.68	6.13	.6250	3/16	1.38	1.88	4.88	—	26
1	1725	1.7	143T	BHUTF-B	66544	12.38	3.50	2.75	2.00	.34(S)	4.00	2.50	6.88	6.63	7.18	.8750	3/16	1.38	2.25	5.75	—	32
1 1/2	1725	2.5	145T	BJUTF-B	66550	13.31	3.50	2.75	2.00	.34(S)	4.00	2.50	6.81	6.63	7.18	.8750	3/16	1.38	2.25	5.75	—	41
2	1725	3.1	145T	BKUTF-B	66554	13.38	3.50	2.75	2.00	.34(S)	4.00	2.50	6.88	6.63	7.18	.8750	3/16	1.38	2.25	5.75	—	42
3	1750	4.3	182T	BLUTF-B	61314	15.18	4.50	3.75	2.25	.41	4.19	3.56	8.44	7.88	8.50	1.1250	1/4	1.75	2.75	5.88	—	55
5	1750	6.6	184T	BMUTF-B	61316	16.56	4.50	3.75	2.25	.41	4.19	3.56	8.44	7.88	8.50	1.1250	1/4	1.75	2.75	5.88	—	75
7 1/2	1750	10.0	213T	BNUTF-B	61318	17.94	5.25	4.25	2.75	.41	5.75	3.88	10.06	9.56	10.18	1.3750	5/16	2.38	3.38	7.38	—	99
10	1750	13.0	215T	BPUTF-B	61320	19.06	5.25	4.25	2.75	.41	5.75	3.88	10.06`	9.56	10.18	1.3750	5/16	2.38	3.38	7.38	—	127
15	1760	19.6	254T	BRUTF-B	66886	21.09	6.25	5.00	4.13	.53	8.06	4.31	12.18	12.94	10.62	1.6250	3/8	3.00	4.00	8.86	—	244
20	1760	26.0	256T	BSUTF-B	61341	23.18	6.25	5.00	5.00	.53	8.94	4.31	12.88	12.94	13.25	1.6250	3/8	3.00	4.00	9.50	—	269
25	1760	30.0	284T	BTUTF-B	61343	27.28	7.00	5.50	4.75	.53	9.44	4.75	15.56	14.63	15.00	1.8750	1/2	3.63	4.63	12.63	—	359
30	1760	37.0	286T	BUUTF-B	61345	27.76	7.00	5.50	5.50	.53	10.29	4.75	14.44	14.63	15.00	1.8750	1/2	3.63	4.63	13.12	—	433
40	1760	46.5	324T	BVUTF-B	61347	30.25	8.00	6.25	5.25	.66	10.31	5.44	16.25	17.38	16.94	2.1250	1/2	4.25	5.25	14.62	—	583
50	1760	62.0	326T	BWUTF-B	61349	30.25	8.00	6.25	6.00	.66	11.06	5.44	16.50	17.38	16.94	2.1250	1/2	4.25	5.25	14.13	—	526

All dimensions in inches. Dimensional information for estimating purposes only.
*(S) Slotted (Dimension is Width)

AC MOTORS

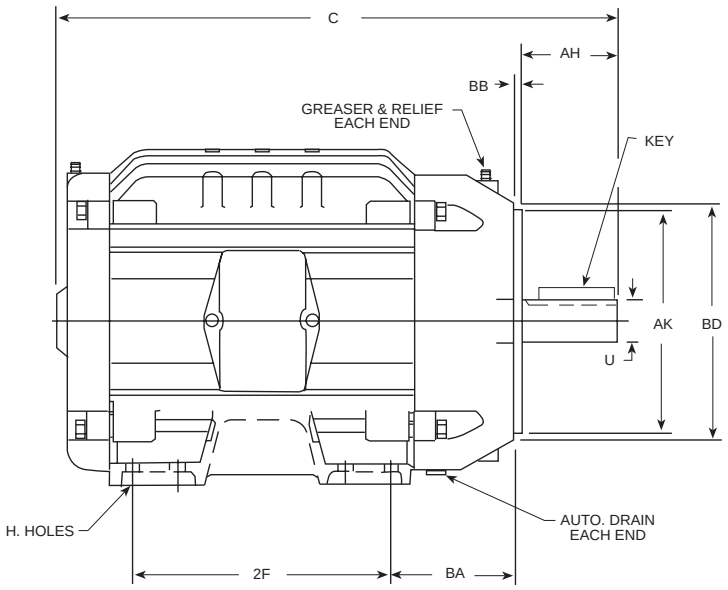
Totally Enclosed Nonventilated

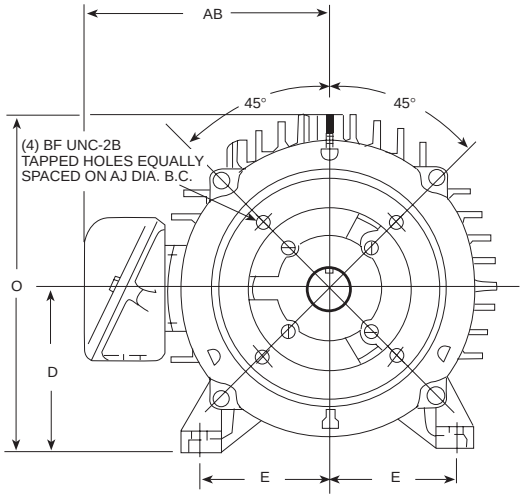
Inverter Duty

1/3–10 Horsepower

Boston Gear's Inverter Drive motors are specifically designed for today's tough adjustable speed applications. The design uses a rugged ribbed (for cooling) cast iron frame*, endplates and connection box. The motors feature a cast iron base and C-face mounting. Locked bearings allow for vertical wall and horizontal mountings without modifications. These motors are fully insulated (Class H) for protection against voltage spikes which could cause phase to phase or turn to turn shorts. Also included are normally closed thermal protectors for overheating protection. These motors are offered at 1800 RPM base speed in a TENV or TEBC enclosure. Also available 1150 RPM Base Speed in a TEBC Enclosure.

*1 HP and above





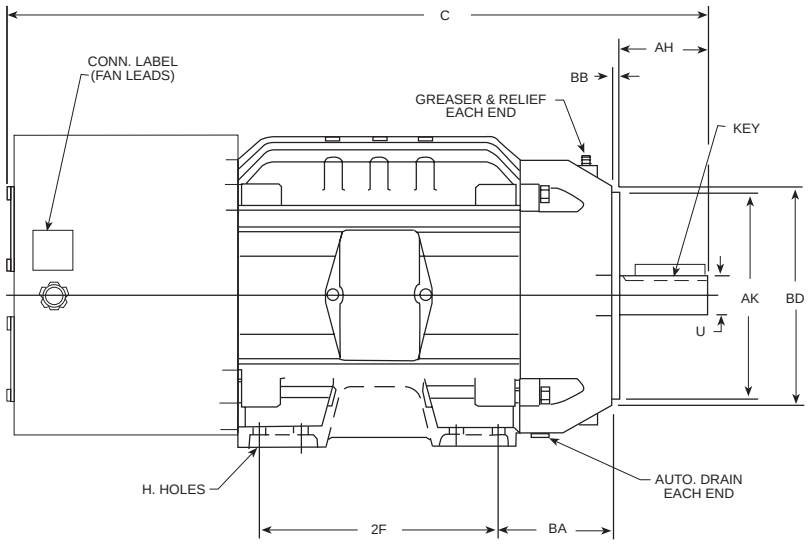
ORDER BY CATALOG NUMBER

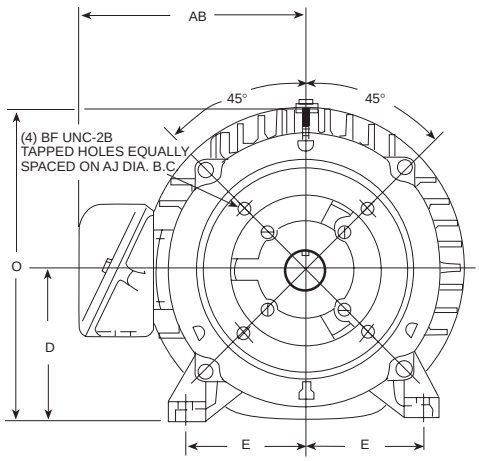
HP	RPM @ 60 Hz	F.L.A. @ Max. Volt	NEMA Mtg.	Bore Code	Catalog Number	C	D	E	2F	H	O	U +.0000 −.0005	Key Sq	Key Long	AB	AH	AJ	AK	BA	BB	BD	BF	Wt. Lbs.
Totally Enclosed, Non-Ventilated					230/460-3-60 VAC																			
1/3	1725	0.50	56C	B5	EUT-ID-B	10.25	3.50	2.44	3.00	.34(S)	6.34	.6250	3/16	1.38	4.51	1.94	5.88	4.500	2.69	.12	5.81	3/8-16	24
1/2	1725	0.65	56C	B5	FUT-ID-B	10.88	3.50	2.44	3.00	.34(S)	6.34	.6250	3/16	1.38	4.51	1.94	5.88	4.500	2.69	.12	5.81	3/8-16	26
3/4	1725	0.65	56C	B5	GUT-ID-B	11.50	3.50	2.44	3.00	.34(S)	6.88	.6250	3/16	1.38	5.25	1.94	5.88	4.500	2.69	.12	6.50	3/8-16	42
1	1725	1.6	143TC	B7	HUT-ID-B	11.82	3.50	2.75	4.00	.38	7.59	.8750	3/16	1.38	6.33	2.00	5.88	4.500	2.38	.12	6.50	3/8-16	54
1-1/2	1725	2.1	143TC	B7	JUT-ID-B	11.82	3.50	2.75	4.00	.38	7.59	.8750	3/16	1.38	6.33	2.00	5.88	4.500	2.38	.12	6.50	3/8-16	63
2	1725	2.9	182TC	B9	KUT-ID-B	14.86	4.50	3.75	4.50	.41	9.23	1.1250	1/4	1.75	7.08	2.62	7.25	8.500	3.38	.25	9.00	1/2-13	105
3	1750	4.0	184TC	B9	LUT-ID-B	14.86	4.50	3.75	5.50	.41	9.23	1.1250	1/4	1.75	7.08	2.62	7.25	8.500	3.38	.25	9.00	1/2-13	124
5	1760	6.7	213TC	B11	MUT-ID-B	18.07	5.25	4.25	5.50	.41	10.99	1.3750	5/16	2.38	8.61	3.12	7.25	8.500	4.25	.25	9.06	1/2-13	170
7-1/2	1760	10.0	254TC	B13	NUT-ID-B	21.67	6.25	5.00	8.25	.53	12.87	1.6250	3/8	2.88	9.42	3.75	7.25	8.500	4.75	.25	9.09	1/2-13	204
10	1760	12.8	256TC	B13	PUT-ID-B	21.67	6.25	5.00	10.00	.53	12.87	1.6250	3/8	2.88	9.42	3.75	7.25	8.500	4.75	.25	9.09	1/2-13	265

All dimensions in inches. (S) Slotted (Dimension is width).
Dimensional information for estimating purposes only.

208-230/460 VAC 3ø 60 Hz

Inverter Duty
Blower Cooled
NEMA C-Face
1–75 Horsepower
1150 & 1725 RPM





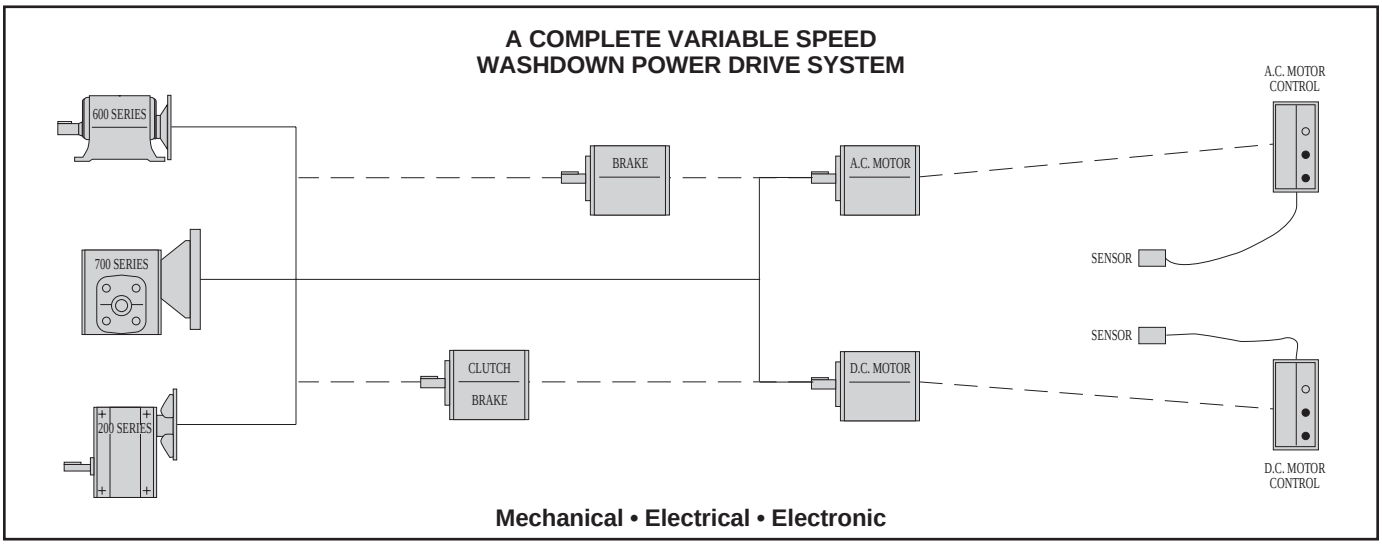
ORDER BY CATALOG NUMBER OR ITEM CODE

HP	RPM @ 60 Hz	F.L.A. @Max. Volt	NEMA Mtg.	Bore Code	Catalog Number	C	D	E	2F	H	O	U +.0000 −.0005	Key Sq	Key Long	AB	AH	AJ	AK	BA	BB	BD	BF	Wt. Lbs.
Totally Enclosed, Blower Cooled					230/460-3-60 VAC																		
1	1725	1.7	143TC	B7	HUBC-ID-B	18.65	3.50	2.75	4.00	.38	7.59	.8750	3/16	1.38	6.33	2.00	5.88	4.50	2.38	.12	6.50	3/8-16	58
1	1150	1.5	145TC	B7	HUBC-11-ID-B	18.65	3.50	2.75	5.00	.38	7.59	.8750	3/16	1.38	6.33	2.00	5.88	4.50	2.38	.12	6.50	3/8-16	60
1 1/2	1725	2.5	145TC	B7	JUBC-ID-B	18.65	3.50	2.75	5.00	.38	7.59	.8750	3/16	1.38	6.33	2.00	5.88	4.50	2.38	.12	6.50	3/8-16	61
1 1/2	1140	2.6	182TC	B9	JUBC-11-ID-B	21.73	4.50	3.75	4.50	.41	9.23	1.1250	1/4	1.75	7.08	2.63	7.25	8.50	3.38	.25	9.00	1/2-13	96
2	1750	3.1	145TC	B7	KUBC-ID-B	18.65	3.50	2.75	5.00	.38	7.59	.8750	3/16	1.38	6.33	2.00	5.88	4.50	2.25	.12	6.50	3/8-16	67
2	1160	2.8	184TC	B9	KUBC-11-ID-B	21.73	4.50	3.75	5.50	.41	9.23	1.1250	1/4	1.75	7.08	2.63	7.25	8.50	3.38	.25	9.00	1/2-13	100
3	1760	4.5	184TC	B9	LUBC-ID-B	21.73	4.50	3.75	5.50	.41	9.23	1.1250	1/4	1.75	7.08	2.63	7.25	8.50	3.38	.25	9.00	1/2-13	113
3	1160	5.0	213TC	B11	LUBC-11-ID-B	25.39	5.25	4.25	5.50	.41	10.99	1.3750	5/16	2.38	8.61	3.12	7.25	8.50	4.25	.25	9.06	1/2-13	157
5	1760	6.8	184TC	B9	MUBC-ID-B	21.73	4.50	3.75	5.50	.41	9.23	1.1250	1/4	1.75	7.08	2.63	7.25	8.50	3.38	.25	9.00	1/2-13	132
5	1160	7.7	215TC	B11	MUBC-11-ID-B	25.39	5.25	4.25	7.00	.41	10.99	1.3750	5/16	2.38	8.61	3.12	7.25	8.50	4.25	.25	9.06	1/2-13	182
7 1/2	1760	9.8	213TC	B11	NUBC-ID-B	25.39	5.25	4.25	5.50	.41	10.99	1.3750	5/16	2.38	8.61	3.12	7.25	8.50	4.25	.25	9.06	1/2-13	180
7 1/2	1170	10.2	254TC	B13	NUBC-11-ID-B	29.29	6.25	5.00	8.25	.53	12.87	1.6250	3/8	2.88	9.42	3.75	7.25	8.50	4.75	.25	9.09	1/2-13	235
10	1760	12.7	215TC	B11	PUBC-ID-B	25.39	5.25	4.25	7.00	.41	10.99	1.3750	5/16	2.38	8.61	3.12	7.25	8.50	4.25	.25	9.06	1/2-13	210
10	1170	14.0	256TC	B13	PUBC-11-ID-B	29.29	6.25	5.00	10.00	.53	12.87	1.6250	3/8	2.88	9.42	3.75	7.25	8.50	4.75	.25	9.09	1/2-13	300
15	1760	18.0	256TC	B13	RUBC-ID-B	29.29	6.25	5.00	10.00	.53	12.87	1.6250	3/8	2.88	9.42	3.75	7.25	8.50	4.75	.25	9.09	1/2-13	275
15	1170	19.5	284TC	*	RUBC-11-ID-B	32.82	7.00	5.50	9.50	.56	14.44	1.8750	1/2	3.25	12.96	4.38	9.00	10.50	4.75	.25	11.21	1/2-13	450
20	1780	24.0	256TC	B13	SUBC-ID-B	29.29	6.25	5.00	10.00	.53	12.87	1.6250	3/8	2.88	9.42	3.75	7.25	8.50	4.75	.25	9.09	1/2-13	311
20	1170	26.0	286TC	*	SUBC-11-ID-B	32.82	7.00	5.50	11.00	.56	14.44	1.8750	1/2	3.25	12.96	4.38	9.00	10.50	4.75	.25	11.21	1/2-13	459
25	1780	30.4	284TC	*	TUBC-ID-B	32.82	7.00	5.50	9.50	.56	14.44	1.8750	1/2	3.25	12.96	4.38	9.00	10.50	4.75	.25	11.21	1/2-13	408
25	1180	29.8	324TC	*	TUBC-11-ID-B	35.23	8.00	6.25	10.50	.65	16.23	2.1250	1/2	3.88	14.46	5.00	11.00	12.50	5.25	.25	13.40	5/8-11	571
30	1780	35.5	286TC	*	UUBC-ID-B	32.82	7.00	5.50	11.00	.56	14.44	1.8750	1/2	3.25	12.96	4.38	9.00	10.50	4.75	.25	11.21	1/2-13	470
30	1180	36.0	326TC	*	UUBC-11-ID-B	35.23	8.00	6.25	12.00	.65	16.23	2.1230	1/2	3.88	14.46	5.00	11.00	12.50	5.25	.25	13.40	5/8-11	612
40	1780	46.5	324TC	*	VUBC-ID-B	35.23	8.00	6.25	10.50	.65	16.23	2.1250	1/2	3.88	14.46	5.00	11.00	12.50	5.25	.25	13.40	5/8-11	547
40	1180	47.0	364TC	*	VUBC-11-ID-B	37.13	9.00	7.00	11.25	.66	18.38	2.3750	5/8	4.25	14.80	5.62	11.00	12.50	5.88	.25	12.89	5/8-11	747
50	1780	57.5	326TC	*	WUBC-ID-B	35.23	8.00	6.25	12.00	.65	16.23	2.1250	1/2	3.88	14.46	5.00	11.00	12.50	5.25	.25	13.40	5/8-11	670
50	1180	59.0	365TC	*	WUBC-11-ID-B	37.13	9.00	7.00	12.25	.66	18.38	2.3750	5/8	4.25	14.80	5.62	11.00	12.50	5.88	.25	12.89	5/8-11	835
60	1780	71.0	364TC	*	XUBC-ID-B	37.13	9.00	7.00	11.25	.66	18.38	2.3750	5/8	4.25	14.80	5.62	11.00	12.50	5.88	.25	12.89	5/8-11	797
75	1780	86.0	365TC	*	YUBC-ID-B	37.13	9.00	7.00	12.25	.66	18.38	2.3750	5/8	4.25	14.80	5.62	11.00	12.50	5.88	.25	12.89	5/8-11	869

All dimensions in inches. Dimensional information for estimating purposes only.
*Not standard BG mounting.

NOTES

Boston Gear has developed a wide range of power transmission products specifically for the food and beverage industry. Working with design and maintenance personnel we have designed certain mechanical, electrical and electronic products to meet their harsh washdown applications.



SPEED REDUCERS

700 Series — Stainless *Bost-Kleen™*

- Durable stainless steel epoxy coating system utilizes a unique stainless steel leafing pigment
- USDA Approved for use in food processing and handling industry where incidental food contact may occur
- BISSC Certified
- Washable and scrubbable
- Corrosion resistant
- Prelubricated with USDA Approved Mobil SHC634 synthetic oil
- Double lipped oil seals
- Excluder seal on output shaft
- Limited lifetime warranty
- Available up to 25 HP in 1” to 6” Center distances

DC CONTROLLERS

BETA II/Beta Plus DC Controllers

- NEMA 4 washdown enclosure
- 1/12 to 2 horsepower range
- Reconnectable 115/230 VAC input
- Run/Stop/Job & Forward/Reverse operation
- Rugged, compact design
- Durable non-absorbent, non-toxic white epoxy finish, USDA approved
- NEMA 4 washdown duty AC inverters also available

AC BRAKE

Double C-Face AC Brakes *BISSC Certified*

- Standard torque ranges from 3 to 10 lb-ft
- Available with DC voltage coils
- Automatic reset, manual brake release
- Rated for continuous duty
- Available from stock

WASHDOWN PRODUCTS

AC/DC MOTORS

AC Motors (pg. 165)
- 1/2 – 5 Horsepower
- 230/460-3-60 VAC
- BISSC Certified
- Durable White Epoxy Finish
- Totally Enclosed Design
- NEMA C-Face Mounting
- Weep Holes

DC Motors (pg. 150)
- 1/4 – 3/4 Horsepower
- 90 & 180 VAC
- BISSC Certified
- Durable White Epoxy
- TENV
- NEMA C-Face Mounting
- Permanent Magnet

800 SERIES

800 Series Bost-Kleen™*
- Durable non-absorbent, non-toxic white (BK) or stainless epoxy finish (SBK)
- Washable & scrubbable
- Includes all the standard 800 features
- Single, double and triple reduction ratios from 1:5:1 to 250:1
- Helical gearing
- Standard NEMA C-face or projecting input shaft configurations

700 SERIES

Bost-Kleen™*
- Boston Gear's proven 700 Series quality
- Limited lifetime warranty
- Pressure relief valves standard
- Double lipped oil seals
- Available from stock up to 25 hp in 1" to 6" center distances
- Single Reduction Ratios 5:1 to 60:1
- Double Reduction Ratios 100:1 to 1800:1

BISSC Certified
- All single reduction 700 series Quill type & nonflanged unit
- Cast iron horizontal base standard
- Pre-lubricated standard with SHC634 synthetic oil, USDA approved
- Smooth flat machined surfaces to resist dirt build-up. Bolt heads and nuts are exposed so contaminants can easily be removed to simplify washdown
- Durable, non-absorbent, non-toxic white epoxy finish, USDA approved
- Single Reduction Ratios 5:1 to 60:1

AC MOTORS

Stainless Steel AC Motors
- AC Motors 1/2-2 horsepower range
- All surfaces of the end bells and conduit box are hard anodized and processed with a USDA approved resin-bound Fluorocarbon Duplex Coating Process to enhance chemical and corrosion resistance
- Shaft seals, slingers and one-way stainless steel drains to retard entrance of contaminants and water into the motor
- Bearings are double sealed and prelubricated with moisture resistant Shell Dolium R lubricant
- Construction is CSA Certified for safety and energy efficiency verification programs
- NEMA C-face mounting

200 SERIES

200 Series – Bost-Kleen™**
- Washable & Scrubbable
- Durable, non-absorbent, non-toxic white epoxy finish, USDA approved
- Corrosion resistant
- 1/4 to 20 horsepower range
- Single and double reduction ratios – 4:1 to 24:1
- Standard NEMA C-face and projecting input shaft configurations
- Horizontal and vertical mounting kits
- Projecting and hollow output shafts

600A SERIES

600A Series – Bost-Kleen™**
- Washable & Scrubbable
- Durable non-absorbent, non-toxic white epoxy finish
- Single, double and triple reductions 1.6:1 to 160:1 ratios
- Helical gearing
- Output flange available

*Located in Worm Gear Drives Catalog
**Located in Helical and Bevel Gear Drives Catalog

ADJUSTABLE SPEED DRIVES – WHAT THEY ARE, HOW THEY WORK

The primary function of any adjustable speed drive is to control the speed, torque, acceleration, deceleration and direction of rotation of a machine. Unlike constant speed systems, the adjustable speed drive permits the selection of an infinite number of speeds within its operating range.

Most multi-purpose production machines benefit from adjustable speed control, since frequently their speeds must change to optimize the machine process or adapt it to various tasks for improved product quality, production speed or safety. Lathes and other machine tools run small diameter work pieces at high speed and large diameter pieces at low speeds to optimize the feed rate into the cutting tool. A printing press is operated at the speed that produces the best quality product, which may vary greatly with the weight and coating of paper, and the characteristics of the inks used. Also, the controlled acceleration provided by an adjustable speed drive allows the press to accelerate smoothly to prevent breaking the web of paper. A pump supplying water in a high rise building may run at very slow speeds at 3 o'clock AM to maintain system pressure, but be called upon at 3 o'clock PM to run at high speeds to provide high flow rates necessitated by water usage by the inhabitants.

While early types of adjustable speed drives based upon mechanical and hydraulic principles still remain in limited usage, the overwhelming choice today for industrial applications is the electrical adjustable speed drive. No other type offers the combined benefits of high performance, high efficiency, low maintenance, versatility and moderate initial cost. Electrical adjustable speed drives are offered in a number of basic types, but the two most versatile for general purpose applications and therefore the most common, are direct current (DC drives) and adjustable frequency (AC drives) as manufactured by Boston Gear. Electrical adjustable speed drives typically consist of three principle elements, as shown by the system block diagram in Figure 1.

1.OPERATOR CONTROL STATION – THE BOSS

Allows the operator to start and stop the drive controller by push buttons or switches, and set the motor speed by turning a potentiometer to the desired dial setting. Operator controls may be integrated into the controller or mounted remotely from the drive controller.

2. DRIVE CONTROLLER – THE BRAINS

Converts the fixed voltage and frequency of the alternating current (AC) plant power source into an adjustable power output to control the drive motor over a wide speed range. The output is established by the speed control potentiometer. The controller includes sensing circuits to hold or regulate the motor at the desired speed with variations in the source voltage and changes in motor load. The controller also includes protective circuitry and devices to prevent damage from overloads, power source transients and output power faults.

3. DRIVE MOTOR – THE MUSCLE

Translates electrical energy into mechanical motion. The output is a shaft rotation (RPM), which varies in proportion to the power applied by the drive controller. The motor shaft is normally coupled to a gear reducer or other mechanical power transmission device to further reduce the motor speed to a level useable by the driven machine.

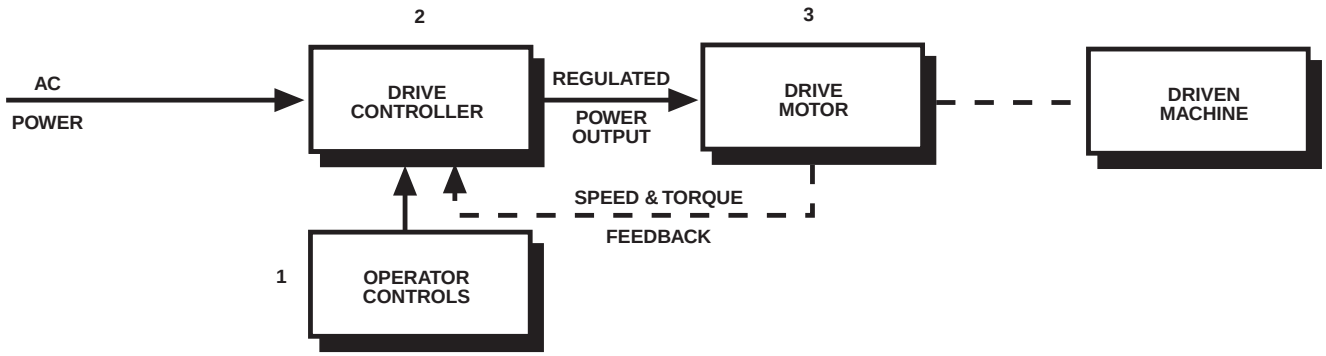


FIGURE 1.

DC DRIVES – PRINCIPLES OF OPERATION

DC drives, because of their simplicity, ease of application, reliability and favorable cost remain the backbone of industrial applications. A typical adjustable speed drive using a silicon controller rectifier (SCR) power conversion section, common for this type unit, is shown in Figure 2. The SCR, (also termed a thyristor) power converter converts the fixed voltage alternating current (AC) of the power source to an adjustable voltage, controlled direct current (DC) output which is applied to the armature of a DC motor.

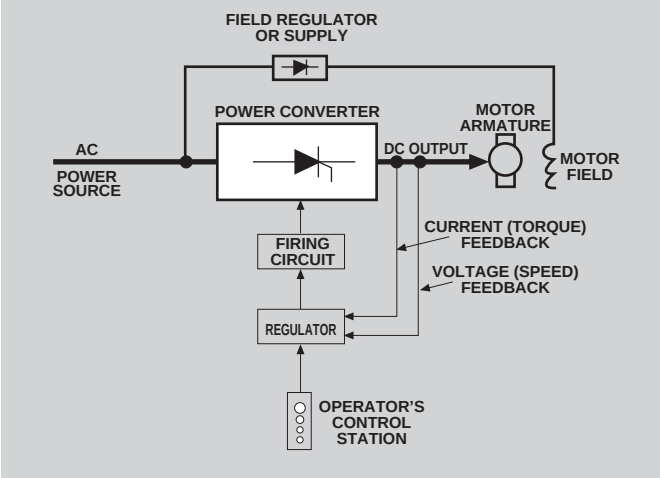


FIGURE 2. TYPICAL DC DRIVE

SCR's provide a controllable power output by "phase angle control", so called because the firing angle (a point in time where the SCR is triggered into conduction) is synchronized with the phase rotation of the AC power source. If the device is triggered early in half cycle, maximum power is delivered to the motor; late triggering in the half cycle provides minimum power, as illustrated by Figure 3. The effect is similar to a very high speed switch, capable of being turned on and "conducted" off at an infinite number of points within each half cycle. This occurs at a rate of 60 times a second on a 60 Hz line, to deliver a precise amount of power to the motor. The efficiency of this form of power control is extremely high since a very small amount of triggering energy can enable the SCR to control a great deal of output power.

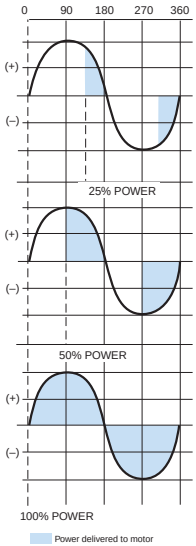


FIGURE 3. TRIGGERING POINTS FOR VARIOUS POWER OUTPUTS

DC DRIVE TYPES

Nonregenerative DC Drives–Nonregenerative DC drives are the most conventional type in common usage. In their most basic form they are able to control motor speed and torque in one direction only as shown by Quadrant I in Figure 4. The addition of an electromechanical (magnetic) armature reversing contactor or manual switch permits reversing the controller output polarity and therefore the direction of rotation of the motor armature as illustrated in Quadrant III. In both cases torque and rotational direction are the same.

Regenerative DC Drives–Regenerative adjustable speed drives, also known as four-quadrant drives, are capable of controlling not only the speed and direction of motor rotation, but also the direction of motor torque. This is illustrated by Figure 4.

The term regenerative describes the ability of the drive under braking conditions to convert the mechanical energy of the motor and connected load into electrical energy which is returned (or regenerated) to the AC power source.

When the drive is operating in Quadrants I and III, both motor rotation and torque are in the same direction and it functions as a conventional nonregenerative unit. The unique characteristics of a regenerative drive are apparent only in Quadrants II and IV. In these quadrants, the motor torque opposes the direction of motor rotation which provides a controlled braking or retarding force. A high performance regenerative drive, is able to switch rapidly from motoring to braking modes while simultaneously controlling the direction of motor rotation.

A regenerative DC drive is essentially two coordinated DC drives integrated within a common package. One drive operates in Quadrants I and IV, the other operates in Quadrants II and III. Sophisticated electronic control circuits provide interlocking between the two opposing drive sections for reliable control of the direction of motor torque and/or direction of rotation.

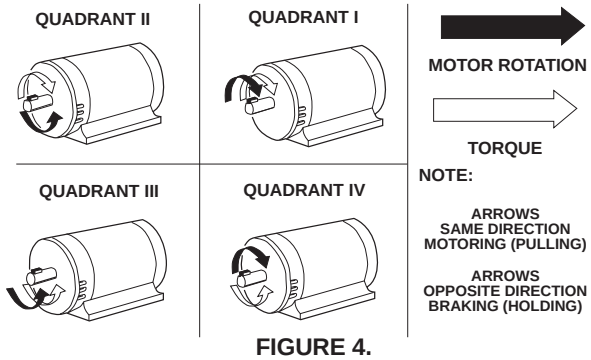


FIGURE 4.

TABLE 1. COMPARISON OF NONREGENERATIVE VS. REGENERATIVE DC DRIVE CAPABILITIES

	Nonregenerative	Regenerative
Braking	No inherent braking capability. Requires the addition of a dynamic braking circuit which dissipates the braking energy as heat in a resistor. Braking effort is exponential with initial high torque which reduces to zero at zero speed. Braking circuits are rated for stopping only, not continuous hold back, or as a holding brake.	Inherent electronically by regeneration whereby the kinetic energy of the motor and driven machine is restored to the AC power source. Can be regulated to control the braking torque down to, and at zero speed. Typically capable of continuous braking torque for hold back applications.
Reversing	No inherent reversing capability. Requires the addition of reversing contactors or a switch to reverse the polarity of DC voltage applied to the motor. Normally rated for occasional reversing.	An inherent capability. Motor polarity is reversed electronically with no contacts to arc, burn or wear. Desirable for applications requiring frequent reversals.
Simplicity	The least complex and least expensive form of electronic adjustable speed motor control.	More complex since it includes double the nonregenerative circuitry.
Efficiency and Speed Range	Controller efficiency up to 99%, complete drive with motor 87%. Speed range up to 50:1 without a feedback tachometer, 200:1 and greater with a tachometer.	

Converter Types – The power conversion or rectified power section of a DC drive is commonly called the converter. The individual characteristics of the various converter types used in standard industrial applications have had a definite influence in the design of compatible DC motors as shown in Table 2.

TABLE 2.

	Rectified Power Source				Motor Ratings			
Series	Converter Type	NEMA Code	Form(2) Factor	Ripple(2) Hz	Source VAC	HP Range	Armature VDC	Field VDC
P40 P60 DP60 DP60RG	Full Converter 6 SCR Nonregenerative 12 SCR Regenerative	C	1.01	360	230	5-125	240	150
					460	5-1000	500	300
P25	Semiconverter 3 SCR, 4 Diode	D	1.05	180	230	5-10	240	150
					460	5-20	500	300
Ratiopax BETA II DCX	Semiconverter 2 SCR, 3 Diode(1)	K	1.35	120	115,230	1-3	90, 180	50,100 100,200 100,200
BETAplus VEplus VED VERG	Full Converter 4 SCR Nonregenerative 8 SCR Regenerative(1)	–	–	120	115,230	1-5	90,180	100,200

NOTES: (1) Single-phase: others are three-phase
(2) Ripple frequency quoted for 60 Hz power source. 50 Hz power sources result in ripple currents 20%, higher than those for a 60 Hz source under the same operating conditions. The higher ripple produces additional heating which may be compensated by reducing the continuous load capability below base speed by approximately 5%. Form factor is at base speed, full load. Form factor of the current is the ratio of the rms current to the average current. For pure DC, such as a battery, the form factor is 1.0. For motors operated on rectified power the AC ripple content of the rectified current causes additional heating which increases as the square of the form factor. A motor is suitable for continuous operation of the form factor stamped on the data plate at rated load and rated speed. Actual motor heating when run from a half-wave converter should be determined by test, and is the responsibility of the purchaser.

DC MOTOR CONTROL CHARACTERISTICS

A shunt-wound motor is a direct-current motor in which the field windings and the armature may be connected in parallel across a constant-voltage supply. In adjustable speed applications, the field is connected across a constant-voltage supply and the armature is connected across an independent adjustable-voltage supply. Permanent magnet motors have similar control characteristics but differ primarily by their integral permanent magnet field excitation.

The speed (N) of a DC motor is proportional to its armature voltage; the torque (T) is proportional to armature current, and the two quantities are independent, as illustrated in Figure 5.

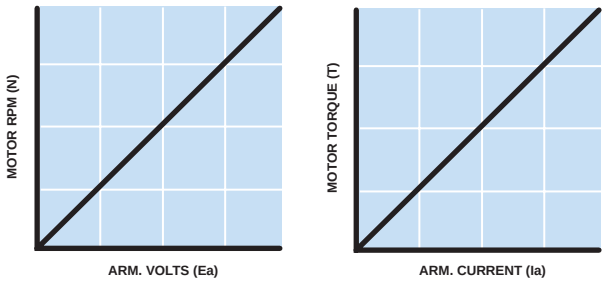


FIGURE 5. DC MOTOR CHARACTERISTICS

CONSTANT TORQUE APPLICATIONS

Armature voltage controlled DC drives are constant torque drives. They are capable of providing rated torque at any speed between zero and the base (rated) speed of the motor as shown by Figure 6. Horsepower varies in direct proportion to speed, and 100% rated horsepower is developed only at 100% rated motor speed with rated torque.

CONSTANT HORSEPOWER APPLICATIONS

Armature Controlled DC Drives – Certain applications require constant horsepower over a specified speed range. The screened area, under the horsepower curve in Figure 6, illustrates the limits of constant horsepower operation for armature controlled DC drives. As an example, the motor could provide constant horsepower between 50% speed and 100% speed, or a 2:1 range. However, the 50% speed point coincides with the 50% horsepower point. Any constant horsepower application may be easily calculated by multiplying the desired horsepower by the ratio of the speed range over which horsepower must remain constant. If 5 HP is required over a 2:1 range, an armature only controlled drive rated for 10 (5 x 2) horsepower would be required.

Table 3 provides a convenient listing of horsepower output at various operating speeds for constant torque drives.

Field Controlled DC Drives – Another characteristic of a shunt-wound DC motor is that a reduction in field voltage to less than the design rating will result in an increase in speed for a given armature voltage. It is important to note, however, that this results in a higher armature current for a given motor load. A simple method of accomplishing this is by inserting a resistor in series with the field voltage source. This may be useful for trimming to an ideal motor speed for the application. An optional, more sophisticated method uses a variable voltage field source as shown by Figure 6. This provides coordinated automatic armature and field voltage control for extended speed range and constant HP applications. The motor is armature voltage controlled for constant torque-variable HP operation to base speed where it is transferred to field control for constant HP-variable torque operation to motor maximum speed.

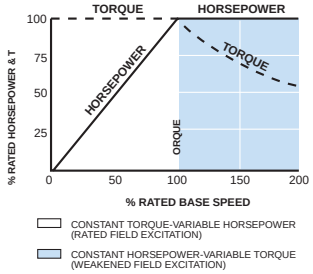


FIGURE 6.

AC DRIVES – PRINCIPLES OF OPERATION

Adjustable frequency AC motor drive controllers frequently termed inverters are typically more complex than DC controllers since they must perform two power section functions, that of conversion of the AC line power source to DC and finally an inverter changes the DC to a coordinated adjustable frequency and voltage output to the AC motor. The appeal of the adjustable frequency drive is based upon the simplicity and reliability of the AC drive motor, which has no brushes, commutator or other parts that require routine

(Continued)

TABLE 3. HORSEPOWER OUTPUT AT VARIOUS MOTOR SPEEDS WITH 1750 RPM BASE SPEED CONSTANT TORQUE DRIVES

Rated HP At 1750 RPM Base Speed	Rated Torque At All Speeds Lb. -Ft. (1)	HP Ratings at Various Motor RPM										
		1575	1400	1225	1050	875	700	525	350	175	87.5	35
1/6	0.50	.150	.133	.117	.100	.083	.067	.050	.033	.017	.008	.003
1/4	0.75	.225	.200	.175	.150	.125	.100	.075	.050	.025	.013	.005
1/3	1.00	.300	.267	.233	.200	.167	.133	.100	.067	.033	.017	.007
1/2	1.50	.450	.400	.350	.300	.250	.200	.150	.100	.050	.025	.010
3/4	2.25	.675	.600	.525	.450	.375	.300	.225	.150	.075	.038	.015
1	3.00	.900	.800	.700	.600	.500	.400	.300	.200	.100	.050	.020
1-1/2	4.50	1.350	1.200	1.050	.900	.750	.600	.450	.300	.150	.075	.030
2	6.00	1.800	1.600	1.400	1.200	1.000	.800	.600	.400	.200	.100	.040
3	9.00	2.700	2.400	2.100	1.800	1.500	1.200	.900	.600	.300	.150	.060
5	15.00	4.500	4.000	3.500	3.000	2.500	2.000	1.500	1.000	.500	.250	.100
7-1/2	22.50	6.750	6.000	5.250	4.500	3.750	3.000	2.250	1.500	.750	.375	.150
10	30.00	9.000	8.000	7.000	6.000	5.000	4.000	3.000	2.000	1.000	.500	.200
15	45.00	13.500	12.000	10.500	9.000	7.500	6.000	4.500	3.000	1.500	.750	.300
20	60.00	18.000	16.000	14.000	12.000	10.000	8.000	6.000	4.000	2.000	1.000	.400
25	75.00	22.500	20.000	17.500	15.000	12.500	10.000	7.500	5.000	2.500	1.250	.500
30	90.00	27.000	24.000	21.000	18.000	15.000	12.000	9.000	6.000	3.000	1.500	.600
40	120.00	36.000	32.000	28.000	24.000	20.000	16.000	12.000	8.000	4.000	2.000	.800
50	150.00	45.000	40.000	35.000	30.000	25.000	20.000	15.000	10.000	5.000	2.500	1.000
60	180.00	54.000	48.000	42.000	36.000	30.000	24.000	18.000	12.000	6.000	3.000	1.200
75	225.00	67.500	60,000	52.500	45.000	37.000	30.000	22.500	15.000	7.500	3.750	1.500
100	300.00	90.000	80.000	70.000	60.000	50.000	40.000	30.000	20.000	10.000	5.000	2.00
125	375.00	112.500	100.000	87.500	75.000	62.500	50.000	37.500	25.000	12.500	6.250	2.50
Percent of Base Speed		90	80	70	60	50	40	30	20	10	5	2

Motors may require supplemental cooling when operated continuously at rated load at reduced speeds. See Motor Specifications.
NOTE: (1) lb-in = lb - ft × 12

(1) Torque ratings for other base speed motors:
2500 RPM Motor = 1750 RPM Torque x .7 Approx.
1150 RPM Motor = 1750 RPM Torque x 1.52 Approx.
850 RPM Motor = 1750 RPM Torque x 2.06 Approx.

maintenance, which more than compensates for the complexity of the AC controller. The robust construction, and low cost of the AC motor makes it very desirable for a wide range of uses. Also, the ability to make an existing standard constant speed AC motor an adjustable speed device simply by the addition of an adjustable frequency controller creates a very strong incentive for this type of drive.

AC CONTROLLER TYPES

A number of different types of AC motor controllers are currently in common use as general purpose drives: Six-Step or Variable Voltage Input (VVI), Pulse Width Modulated (PWM), Current Source Input (CSI), and the Load Commutated Inverter (LCI). Each type offers specific benefits and characteristics but the Six-Step and PWM types have been selected by Boston Gear as offering the best combination of simplicity, performance and economy for general purpose applications. Table 4 shows comparative advantages and disadvantages.

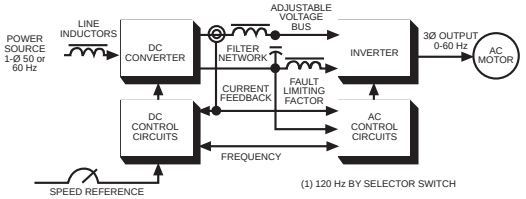


FIGURE 7.

Six Step Controllers – Six-Step controllers, so called due to their output voltage waveform, utilize an adjustable voltage, linkcoupled inverter system as shown in Figure 7.

The controller converts the AC power source to an adjustable DC voltage proportional to the speed reference command. The DC voltage is smoothed by a filter network and directed to a six-step inverter. The inverter changes the DC to AC at a frequency proportional to the speed reference. Output voltage and frequency are simultaneously coordinated and regulated to maintain a specific relationship of voltage and frequency (volts/Hz ratio) throughout the normal speed range. The voltage waveform applied to the motor is a stepped wave approximation of a true sinusoidal waveform as shown by Figure 8. The low harmonic content of this waveform has little adverse effect on the motor.

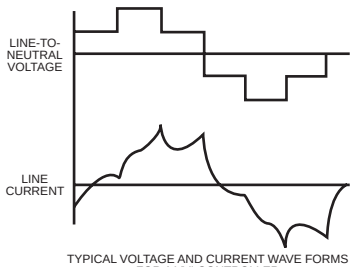


FIGURE 8.

TABLE 4. COMPARISON OF PWM VERSUS SIX-STEP ADJUSTABLE FREQUENCY AC CONTROLLER CAPABILITIES

Type	Advantages	Disadvantages
PWM	• Microprocessor based PWM units are typically less expensive than six-step units which commonly use SCR phase converters and analog techniques. • 30:1 and greater, constant torque speed range with smooth, noncogging low speed operation. • High Power Factor–Displacement power factor is 96% or better over entire speed range at rated load. • High Efficiency – Controller only 96%. Complete drive powered by a 3-phase source 83%, 70-80% when powered from a single-phase source, dependent upon motor efficiency. • Power section with simple diode bridge AC to DC front end converter. • Diode converter causes no line notching. • Complex microprocessor circuitry easily serviced by substitution.	• Audible motor noise may be objectionable for some applications. This can be minimized/eliminated with higher carrier frequencies, but this reduces controller efficiency (IGBT units allow higher switching frequencies, therefore less audible motor noise). • Microprocessor control common to PWM inverters and high frequency power output tends to produce radiated, radio frequency interference (RFI) which may be objectionable in sensitive environments such as hospitals, communications centers, etc. • Up to 2.5 times greater distortion of the AC voltage source than phase control input six step drives.
Six-Step	• Quiet motor operation with minimal audible noise. • Radiated RFI well within F.C.C. guidelines (non-microprocessor designs) making them desirable for sensitive applications such as hospitals. • Minimal distortion of the AC voltage source with phase control input designs. • Power factor 95% or less, variable with speed and load.	• Speed range limited to 10:1 constant torque. Rated torque operation produces motor cogging at and below this speed. • Phase controlled converter may produce notches in the AC line power source. • Power factor reduces with speed and load. • SCR phase converters and analog circuitry common to these units usually make them more expensive than PWM designs.

PWM Controllers–The PWM controller converts the AC power source to a fixed DC voltage by a full-wave rectifier. The resultant DC voltage is smoothed by a filter network and applied to a pulse width modulated inverter using high power transistors. These transistors are normally Darlington, MOSFET (Metal Oxide Semiconductor Field Effect Transistor) or IGBT (Insulated Gate Bipolar Transistor) types. The MOSFET and IGBT types allow higher switching frequencies and therefore, less audible motor noise. The speed reference command is directed to the microprocessor which simultaneously optimizes the carrier (chopping) frequency and inverter output frequency to maintain a proper volts/Hz ratio and high efficiency throughout the normal speed range. See Block Diagram, Figure 9.

The voltage applied to the motor is a pulsed approximation of a true sinusoidal waveform as shown in Figure 10. This is commonly called a PWM waveform because both the carrier frequency and pulse-width is changed (modulated) to change the effective voltage amplitude and frequency. The current waveform very closely follows the shape of a sine wave and therefore provides improved low speed motor performance, efficiency, and minimizes motor heating.

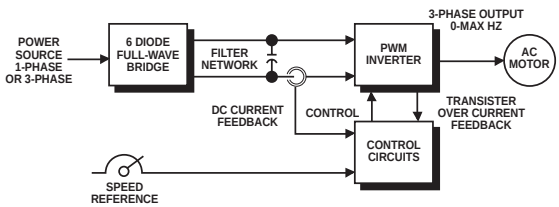


FIGURE 9.

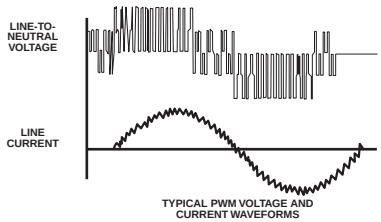


FIGURE 10.

AC MOTOR CONTROL CHARACTERISTICS

The synchronous speed of an AC induction motor is directly proportional to the applied frequency.

$$\text{Speed} = \frac{120 \times \text{Frequency}}{\text{No. of Motor Poles}}$$

The synchronous speed is the speed of the rotating electrical field, not the actual motor rotor speed. The difference between the synchronous speed and the full-load motor speed is called slip, which is normally expressed in percent. The percentage of slip is determined by the design of the motor, primarily the rotor resistance. NEMA has assigned code letters (A, B, C, D, etc.) to standardize motor characteristics including slip. The type most commonly used is NEMA Design B with 3% slip at rated operating conditions. Figure 11 shows typical speed/torque curves for NEMA Design B and D motors.

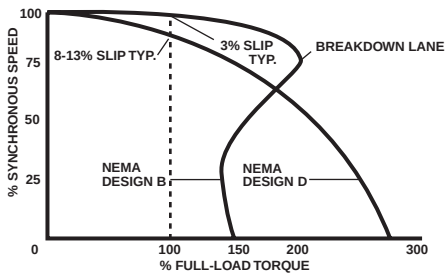


FIGURE 11.

As the applied frequency is changed, the motor will run faster or slower as shown by Figure 12. The actual full-load motor slip (as a percent of the motor synchronous speed) varies in inverse proportion to the frequency, where a 3% slip motor 60 Hz would have a 6% slip at 30 Hz or 1 1/2 % slip at 120 Hz. Motor speed is limited only by the maximum inverter output frequency, load torque requirements, and the mechanical integrity of the motor.

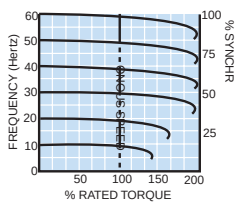


FIGURE 12. TYPICAL SPEED TORQUE CURVES FOR 60 HZ NEMA DESIGN B MOTOR (WITHOUT VOLTAGE BOOST)

MOTOR SELECTION

Constant Torque Applications–About 90% of all general industrial machines, other than fans and pumps, are constant torque systems where the machine's torque requirement is independent of its speed. If the machine speed is doubled, its horsepower requirement doubles. Conversely a reduction in machine speed by 50% will result in an equal reduction in horsepower, but no reduction in torque.

1. Standard three-phase AC motors, designed for fixed speed operation at standard line frequency, may be easily adapted for use with the AC controller by considering the following:
   a. A slight increase in motor losses occurs with inverter power.
   b. The motor thermal capacity must typically be derated as a function of the minimum, continuous operating speed in accord with Figure 13, due to the reduced ventilation provided by the integral motor fan. Where the application requires 100% rated torque at speeds below 50% of synchronous speed, a separately powered ventilation blower, a nonventilated motor with greater reserve thermal capacity or, a motor with higher rated capacity should be used. When a separately powered ventilation blower is used, a thermostat should be built into the motor to prevent damage which may result from a failure in the ventilation system.

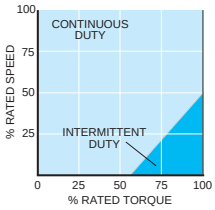


FIGURE 13. TYPICAL STANDARD AC MOTORS ADJUSTABLE SPEED OPERATION

2. Any three-phase synchronous or induction AC motor designed expressly for adjustable speed service by inverter control may normally be used over its design speed range with the AC controller.

Variable Torque Applications–The application of standard AC motors to adjustable speed variable torque applications such as centrifugal fans or pumps is ideal from a motor cooling standpoint. The torque characteristics of a variable torque (cubed exponential horsepower) load are such that the load falls off rapidly as the motor speed is reduced. The variable torque load eliminates the necessity to derate the motor due to excessive heat resulting from diminished motor cooling at reduced speeds. Figure 14 illustrates the relationship between speed and torque in variable torque applications.

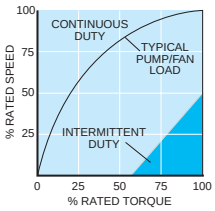


FIGURE 14. TYPICAL STANDARD AC MOTOR APPLICATION WITH VARIABLE TORQUE LOADS

Potential Power Savings–Most fan and pump applications require the system to run for sustained periods at reduced outputs by either reducing the speed of the motor or by mechanically altering the flow. Figure 15 illustrates typical energy savings, in percent of rated power, which can be realized when using an adjustable frequency controller to reduce motor speed and thereby system flow as opposed to a constant speed motor which has its system flow varied by an outlet damper.

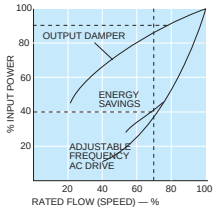


FIGURE. 15. ENERGY SAVINGS

Constant Torque Operation–The ability of the AC controller to maintain a constant volts/Hz relationship is ideal from a motor standpoint. This permits operation of the motor at rated torque from near standstill to rated speed.

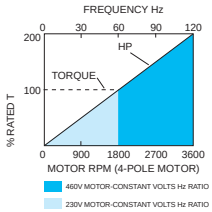


FIGURE 16. CONSTANT TORQUE OPERATION

Figure 16 represents the relationship between torque, horsepower and motor speed with a maintained volts/Hz ratio using a 60 Hz controller for illustration. A standard 4-pole 460V motor can be controlled by this method to its synchronous speed of 1800 RPM. If the same motor were wound for 50% of the input voltage (230V), it could be controlled with constant torque to double the normal rated speed and horsepower. The motor would not be "overvoltaged" because the volts/Hz ratio could be maintained e.g.: a motor wound for 230 VAC can supply constant torque to twice the AC line frequency when used on a 460V power source without overvoltaging the motor because the volts/Hz ratio of 230V/60 Hz is the same as 460V/120 Hz. The horsepower would also double since the same torque would be developed at twice the normal rated speed.

Caution must be observed when applying standard motors for continuous low speed, rated torque operation. The motor's self-cooling capability is dependent upon self-ventilation schemes with efficiency that is considerably reduced at lower operating speeds.

Constant Horsepower Operation – AC motor controllers are also adaptable to constant horsepower operation as shown by Figure 17. With this mode of operation, the volts/Hz ratio is maintained to a specific frequency, normally 50 or 60 Hz. At this point, the voltage is "clamped" at a constant level while the frequency is adjusted further to achieve the desired maximum speed. Since the controller maximum output voltage is limited to the voltage of the AC power source, the volts/Hz ratio must decrease beyond this point as the frequency increases. The motor becomes "voltage starved" above the clamping point and torque decreases as speed increases, resulting in constant horsepower output.

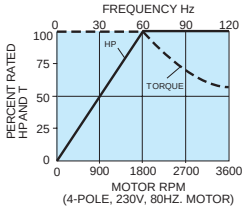


FIGURE 17. TYPICAL CONSTANT HP OPERATION

As shown in Figure 17 the drive provides conventional constant torque/variable horsepower operation up to 60 Hz which is equivalent to the 1800 RPM base speed of the 60 Hz motor. Between 1800 and 3600 RPM, the drive provides constant horsepower/variable torque operation. If constant horsepower is required between 900 and 3600 RPM (a 4:1 speed range) – using the same 1800 RPM base speed motor, the drive rated horsepower must be increased since 900 RPM intersects the curve at a point which is 50% of rated horsepower.

Constant HP operation (above synchronous speed) is limited to induction motors only. In addition, at some point, typically around three times base speed for a four-pole induction motor, the breakdown torque of the motor prevents further constant horsepower operation. Synchronous reluctance motor characteristics prevent operation in this mode.

Multiple Motor Operation (From a Common Controller) – An adjustable frequency AC motor controller is ideally suited for simultaneous control of multiple motors in process line applications. All motors are operated at a common frequency and are therefore synchronized at a common speed. Tracking accuracy between the individual motors varies only the difference in their loads, typically 0.5% to 3% with standard NEMA Design B motors and 0.0% with synchronous reluctance types.

Where tracking ratios other than 1:1 are desirable, gear boxes, fixed or adjustable sheaves may be used to attain the desired individual speeds. Two-pole, four-pole and six-pole motors may also be mixed to obtain various individual motor operating speeds when operated from a common adjustable frequency controller. Selection of a properly rated controller should be made with consideration for the total KVA required by all the motors which are normally started and stopped simultaneously. Some process line applications require the ability to selectively start and stop one or more of the motors while the others are operated at the desired speed. A standard motor started under this condition instantaneously draws locked-rotor current of 600-800%. Unless this factor is considered in the selection of an adequately rated controller, the additional load may exceed the capacity of the power unit, reducing the voltage to the entire system which could cause the line to stall or trip off.

AC VS. DC DRIVE COMPARISON

AC and DC drives both continue to offer unique benefits and features that may make one type or other better suited for certain applications.

AC drives may be better because . . .

- They use conventional, low cost, 3-phase AC induction motors for most applications.
- AC motors require virtually no maintenance and are preferred for applications where the motor is mounted in an area not easily reached for servicing or replacement.
- AC motors are smaller, lighter, more commonly available, and less expensive than DC motors.
- AC motors are better suited for high speed operation (over 2500 rpm) since there are no brushes, and commutation is not a problem.
- Whenever the operating environment is wet, corrosive or explosive and special motor enclosures are required. Special AC motor enclosure types are more readily available at lower prices.
- When multiple motors in a system must operate simultaneously at a common frequency/speed.
- When it is desirable to use an existing constant speed AC motor already mounted and wired on a machine.
- When the application load varies greatly and light loads may be encountered for prolonged periods. DC motor commutators and brushes may wear rapidly under this condition.
- When low cost electronic motor reversing is required.
- Whenever it is important to have a back up (constant speed) if the controller should fail.

DC drives may be better because . . .

- DC drives are less complex with a single power conversion from AC to DC.
- DC drives are normally less expensive for most horsepower ratings.
- DC motors have a long tradition of use as adjustable speed machines and a wide range of options have evolved for this purpose:
- Cooling blowers and inlet air flanges provide cooling air for a wide speed range at constant torque.
- Accessory mounting flanges and kits for mounting feedback tachometers and encoders.
- DC regenerative drives are available for applications requiring continuous regeneration for overhauling loads. AC drives with this capability would be more complex and expensive.
- When properly applied brush and commutator maintenance is minimal.
- DC motors are capable of providing starting and accelerating torques in excess of 400% of rated.
- Some AC drives may produce audible motor noise which is undesirable in some applications.
- DC SCR drives have been the first choice of industry for over 25 years. Their maintenance, technology, serviceability and reliability are well understood by plant maintenance personnel.

BASIC MECHANICS

The curve in Figure 6 shows a distinct relationship between speed, torque and horsepower. Torque is constant at any speed while there is a direct proportional relationship between horsepower and speed; horsepower varies directly with the speed. Therefore, horsepower is motion dependent, torque is not.

TORQUE

A force applied in a manner that tends to produce rotation, such as a pipe wrench on a shaft. Torque (force) without rotation is termed static torque, since no motion is produced.

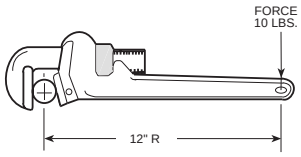


FIGURE 19

Torque is measured in lb-in or lb-ft which is the product of the force in pounds (lb) x the distance in inches (in) or feet (ft) from the center of the point of apparent rotation. Figure 19 shows 120 lb-in (12 inches x 10 lbs) or 10 lb-ft torque.

Because most power transmission is based upon rotating elements, torque is important as a measurement of the effort required to produce work (horsepower).

POWER (Horsepower)

A force applied in a manner that produces motion and, therefore, work over a specified time period. A common unit of power is horsepower. **One horsepower (HP) is defined as the force required to lift 33,000 lbs, one foot in one minute.**

THREE BASIC FACTORS ARE INVOLVED:	
Factor	**Unit**
Distance (Radius)	Foot (or inches)
Force (Push or Pull)	Pounds
Time	One (1) Minute

$$HP = \frac{F \text{ (Load in Pounds)} \times \text{Feet per Minute}}{33{,}000}$$

HORSEPOWER-TORQUE, GETTING IT TOGETHER

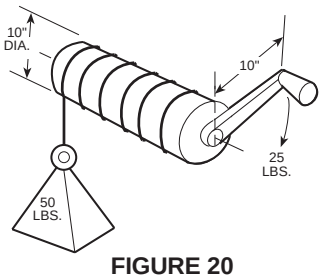


FIGURE 20

As shown in Figure 20, the 50 lb load is acting on the 5 inch radius (distance) of the winch, producing a load torque of 250 lb-in (50 lbs × 5 inches) that must be overcome to lift the load. Since the hand crank arm has a 10 inch radius (distance), a minimum force of 25 lbs must be exerted to overcome the load torque (25 lbs × 10" = 250 lb-in). If no motion is involved, the system is in balance. Although torque is being exerted, no work is accomplished and no horsepower is developed.

The winch diameter is 10 inches. Therefore, each revolution of the hand crank will lift the weight 10 inches x π = 31.416 inches (2.618 feet).

If the crank is turned at 10 RPM, 50 lbs will be lifted a distance of 26.18 feet in one minute:

$$HP = \frac{\text{Load in Pounds} \times \text{Feet per Minute}}{33{,}000}$$

$$HP = \frac{50 \times 26.18}{33{,}000} = .03966 \text{ HP}$$

Turning the crank twice as fast (20 RPM) will develop twice the horsepower.

$$HP = \frac{50 \times 52.36}{33{,}000} = .07933 \text{ HP}$$

Thus, the horsepower of rotating elements can be calculated from the following formula:

$$HP = \frac{F \times 2\pi \times R \times RPM}{33{,}000} = \frac{T \times RPM}{5252}$$

Where,
F = force in pounds
R = radius (lever length in feet)
RPM or N = revolutions per minute
T = torque in lb-ft (F x R)

SELECTING A DRIVE FOR A MACHINE

The application of an adjustable speed drive to power a machine is a mechanical, rather than an electrical problem. When applying the drive, the speed – torque – horsepower characteristics developed at the drive motor shaft must be considered, and how well these characteristics suit the machine.

Four essential parameters are

1. Breakaway Torque
2. Process Torque
3. Accelerating Torque
4. Running Torque

BREAKAWAY TORQUE –

The torque required to start the machine in motion.

It is most always greater than the torque required to maintain motion (running torque). Breakaway torque combined with process torque frequently determines drive selection. Table 5 lists typical breakaway torques for various machine types.

TABLE 5. TYPICAL BREAKAWAY TORQUES FOR VARIOUS MACHINE TYPES

Machine Types	Breakaway Torque*	Drive Selection
Machines with ball or roller bearings	110 to 125%	Standard drive rating
Machines with sleeve bearings	130 to 150%	Standard drive rating
Conveyors and machines with excessive sliding friction	160 to 250%	Oversize drive
Machines that have "high" load spots in their cycle, e.g., printing and punch presses, and machines with cam or crank operated mechanisms	250% to 600%	Oversize drive
High Inertia – Machines with fly-wheels or other heavy rotating masses. Also, some machines that move large masses by cranks, centrifuges, etc.	Nominal rating of drive will depend on the breakaway torque requirement	Drive rating depen-dent upon desired acceleration time and drive torque

*Typical percentages of running torque

PROCESS TORQUE –

The torque required to pull, push, compress, stretch or otherwise process or act upon the material being transported by or through the machine.

On some machines, process torque may be so significant as to determine the drive power rating. On other machines, this load may be insignificant. The process torque load is superimposed on all other static and dynamic torque requirements of the machine.

ACCELERATING TORQUE –

The torque required to bring the machine to an operating speed within a given time.

With most machines, the load is largely friction and a standard drive rating may have adequate torque for satisfactory acceleration. However, certain machines classified as "high inertia" with flywheels, bull gears or other large rotating masses may require drive selection based upon the power required to accelerate the load within a given time.

RUNNING TORQUE –

The torque required to maintain machine motion after it accelerates to the desired operating speed.

The characteristics of the speed-torque curves of various machines are very important to proper adjustable speed drive selection. Most machines fall into four basic categories:

1. Constant Torque (Figure 21)
2. Constant Horsepower (Figure 22)
3. Squared Exponential Horsepower (Figure 23)
4. Cubed Exponential Horsepower (Figure 24)

Some machines may have operating characteristics which are a composite of the basic types.

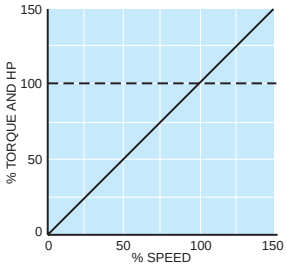


Figure 21. Constant Torque

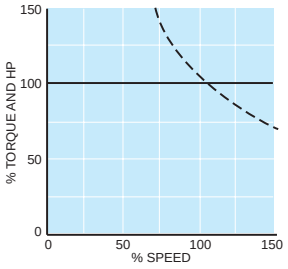


Figure 22. Constant Horsepower

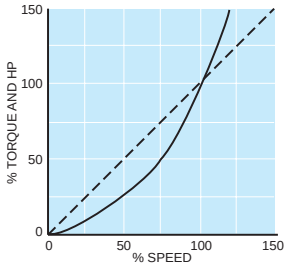


Figure 23. Squared Exponential Horsepower

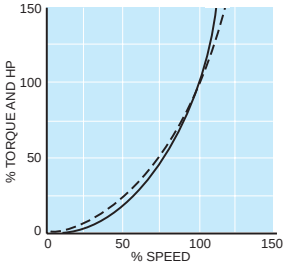


Figure 24. Cubed Exponential Horsepower

– – – – Torque _____ HP

CONSTANT TORQUE –

Most industrial machine applications, other than pumps, are constant torque systems.

The machine's torque requirement is independent of its speed. If the machine speed is doubled, its horsepower requirement doubles. This fact must be kept in mind when replacing a constant speed drive with an adjustable speed drive and the machine operating speed is increased.

CONSTANT HORSEPOWER –

For machines with constant horsepower loads, the power demand is independent of speed, and torque varies inversely with speed.

This type is most often found in the machine-tool industry and with center driven winders. When drilling, shaping, milling, or turning metal, the loads all tend toward constant horsepower. At low speed there is high torque; at high speed, light torque. A drive must be selected for its highest torque condition which is at the lowest speed of the range. With most machines, the "constant horsepower range" seldom exceeds a 3:1 range.

SQUARED-EXPONENTIAL LOADS –

With machines of this type, torque varies directly as the speed, and power as the square of speed.

Such relationships are frequently found in positive-displacement pumps and mixer applications.

CUBED-EXPONENTIAL LOADS –

It is characteristic of these machines that torque varies as the square of speed, and power as the cube of speed.

This type of load is imposed on centrifugal pump drives and most fan or blower drives. In some uses, fan or blower horsepower varies as the fifth power of speed. The exponential relationship is characteristic of these machines. This fact must be considered when sizing motors for adjustable speed drives. If the speed of a centrifugal pump is doubled, its power requirement increases by a factor of eight.

OTHER APPLICATION FACTORS

CONSTANT TORQUE SPEED RANGE –

On large motors, minimum operating speed limitations may be necessary for self-ventilated motors, since their cooling is entirely dependent upon motor speed and, therefore, diminishes as speed is reduced. Where rated torque operation is required continuously at lower speeds, either a higher rated drive motor or supplemental motor ventilation, such as a motor mounted cooling blower or external air duct, is required.

TORQUE LIMITATIONS –

Most adjustable speed drives feature a torque limiter to protect the drive and the machine from torque overloads. The torque limiter (current limit) is normally adjusted to 150% of rated torque to allow extra momentary torque for breakaway, acceleration or cyclic overloads. Most drive systems are capable of sustaining the 150% torque overload for one minute or less.

DUTY CYCLE –

Certain applications may require continuous reversals, long acceleration times at high torque due to inertia loads, frequent high rate acceleration, or cyclic overloads which may result in severe motor heating if not considered in the selection of the drive. Most drives with 150% overload capability will operate successfully if there are compensating periods of operation where motor temperatures can be normalized.

MEASURING MACHINE TORQUE

To measure the torque required to drive a machine, fasten a pulley securely to the shaft which the motor is to drive. Fasten one end of a cord to the outer surface of the pulley and wrap a few turns of the cord around the pulley. Tie the other end of the cord to a spring scale. See Figure 25.

TORQUE = F X R

Figure 25.

Pull on scale until the shaft turns. The force in pounds or ounces, indicated on the scale, multiplied by the radius of the pulley (measured from the centerline of the machine shaft) in inches gives the torque value in lb-inches or oz-inches. On some machines, this torque may vary as the shaft rotates. The highest value of torque must be used when selecting a motor.

The running torque required by a machine will be approximately equal to the starting torque if the load is composed almost entirely of friction. If the load is primarily inertia or windage, the characteristics of the inertia or windage producing elements must be determined.

The running torque of a machine can be accurately determined by making a test run with an armature controlled DC drive (with a shunt wound or permanent magnet DC motor) of known horsepower rating. The DC drive should have an ammeter in the armature circuit so significant current readings can be observed and recorded throughout the speed range of the machine. Since armature current and torque are directly proportional within very close limits, the current readings will provide accurate information for selecting the drive rating required by the machine.

Most machines require a higher torque value for breakaway, but once running, the torque requirement will decrease. Many drives have 150% load capability for one minute, which may allow the required additional breakaway torque to be obtained without increasing the drive horsepower rating.

If the running torque is equal to or less than the breakaway torque divided by 1.5, use the breakaway torque divided by 1.5 as the full-load torque required to determine the motor horsepower.

If the running torque is greater than the breakaway torque divided by 1.5, but less than the breakaway torque, use the running torque as the full load rated torque required to determine the motor horsepower.

MECHANICAL FORMULAS

HOW TO CALCULATE TORQUE

If the horsepower and base speed of a motor are known, the full-load torque of the motor is determined by:

$$T = \frac{(5250)\,(HP)}{N}$$

Where, T = Torque (lb-ft)
HP = Horsepower
N = Base speed of motor (RPM)

HOW TO CALCULATE HORSEPOWER

For Rotating Objects:

$$HP = \frac{TN}{63{,}025}$$ Where, T = Torque (lb-in), N = Speed (RPM)

or:

$$HP = \frac{TN}{5250}$$ Where, T = Torque (lb-ft), N = Speed (RPM)

For Objects in Linear Motion:

$$HP = \frac{FV}{396{,}000}$$ Where, F = Force (lb), V = Velocity (IPM)

or:

$$HP = \frac{FV}{33{,}000}$$ Where, F = Force (lb), V = Velocity (FPM)

For Pumps:

$$HP = \frac{(GPM) \times (\text{Head in Feet}) \times (\text{Specific Gravity})}{3950 \times (\text{Efficiency of Pump})}$$

For Fans and Blowers:

$$HP = \frac{CFM \times (\text{Pressure in Pounds/Sq ft})}{33{,}000 \times \text{Efficiency}}$$

When calculated horsepower falls between standard motor ratings, select the next higher rating.

CALCULATING ACCELERATING FORCE FOR LINEAR MOTION.

The following formula can be used to calculate the approximate accelerating force required for linear motion. However, before sizing the drive, add the torque required to accelerate the motor armature, gears, pulleys, etc. to the linear-motion accelerating force converting to torque.

$$\text{Acceleration Force (F)} = \frac{W\,(\Delta V)}{1933t}$$

Where, W = Weight (lb)
ΔV = Change in velocity (FPM)
t = Time (seconds) to accelerate weight

CALCULATING ACCELERATING TORQUE FOR ROTARY MOTION

When, in addition to the selection of a motor with proper torque capacity to start and maintain machine motion, a desired time for acceleration is involved and the required torque value may be affected, an additional formula must be considered. This formula makes it possible to calculate the average torque required over the complete range of speed change to accelerate a known inertia (WK^2).

On high inertia loads, accelerating torque may be the major factor in the drive selection.

The formula to calculate acceleration torque (torque required above load torque) or a rotating member:

$$T = \frac{(WK^2)(\Delta N)}{308t}$$

Where,
- T = Acceleration torque (lb-ft)
- WK^2 = Total system inertia (lb-ft^2) that the motor must accelerate. This value includes motor armature, reducer and load.
- ΔN = Change in speed required (RPM)
- t = Time to accelerate total system load (seconds)

The same formula can also be used to determine the minimum acceleration time of a given drive, or if it can accomplish the desired change in speed within the required time period.

$$t = \frac{(WK^2)(\Delta N)}{308T}$$

INERTIA (WK^2)

The factor WK^2 is the weight (lbs) of an object multiplied by the square of the radius of gyration (K). The unit measurement of the radius of gyration is expressed in feet.

For solid or hollow cylinders, inertia may be calculated by the equations shown in Figure 26.

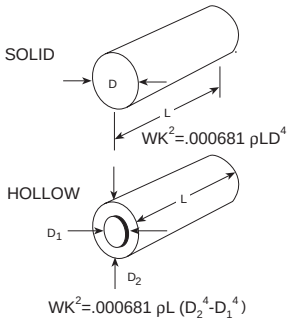


FIGURE 26.

WK^2 = lb-ft^2

D, D_1, D_2 and L = in.

ρ = lb./in.^{3}

ρ (aluminum) = .0924

ρ (bronze) = .320

ρ (cast iron) = .260

ρ (steel) = .282

The inertia of solid steel shafting per inch of shaft length is given in Table 6. To calculate for hollow shafts, take the difference between the inertia values for the O.D. and I.D. as the value per inch. For shafts of materials other than steel, multiply the value for steel by the factors in Table 7.

FORMULAS TO APPROXIMATE WK^2

For a solid cylinder or disc = $W \times \frac{r^2}{2}$

where r = radius in feet and W is weight in pounds.

For a hollow cylinder: $W\ K^2 = W \times \frac{r_1^2 + r_2^2}{2}$

where r_1, is $\frac{ID}{2}$ and r_2 is $\frac{OD}{2}$.

TABLE 6. INERTIA OF STEEL SHAFTING (PER INCH OF LENGTH)

Diam. (IN.)	WK^2 (lb Ft^2)	Diam. (IN.)	WK^2 (lb Ft^2)
3/4	0.00006	10-1/2	2.35
1	0.0002	10-3/4	2.58
1-1/4	0.0005	11	2.83
1-1/2	0.001	11-1/4	3.09
1-3/4	0.002	11-1/2	3.38
2	0.003	11-3/4	3.68
2-1/4	0.005	12	4.00
2-1/2	0.008	12-1/4	4.35
2-3/4	0.011	12-1/2	4.72
3	0.016	12-3/4	5.11
3-1/2	0.029	13	5.58
3-3/4	0.038	13-1/4	5.96
4	0.049	13-1/2	6.42
4-1/4	0.063	13-3/4	6.91
4-1/2	0.079	14	7.42
5	0.120	14-1/4	7.97
5-1/2	0.177	14-1/2	8.54
6	0.250	14-3/4	9.15
6-1/4	0.296	15	9.75
6-1/2	0.345	16	12.59
6-3/4	0.402	17	16.04
7	0.464	18	20.16
7-1/4	0.535	19	25.03
7-1/2	0.611	20	30.72
7-3/4	0.699	21	37.35
8	0.791	22	44.99
8-1/4	0.895	23	53.74
8-1/2	1.00	24	63.71
8-3/4	1.13	25	75.02
9	1.27	26	87.76
9-1/4	1.41	27	102.06
9-1/2	1.55	28	118.04
9-3/4	1.75	29	135.83
10	1.93	30	155.55
10-1/4	2.13	—	—

TABLE 7.

SHAFT MATERIAL	FACTOR
Rubber	.121
Nylon	.181
Aluminum	.348
Bronze	1.135
Cast Iron	.922

The inertia of complex concentric rotating parts is calculated by breaking the part up into simple rotating cylinders, calculating their inertia and summing their values, as shown in Figure 27.

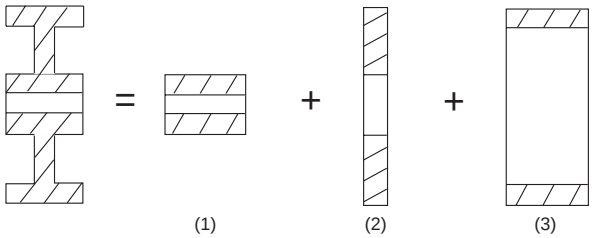


FIGURE 27.

H

WK² OF ROTATING ELEMENTS

In practical mechanical systems, all the rotating parts do not operate at the same speed. The WK^2 of all moving parts operating at each speed must be reduced to an equivalent WK^2 at the motor shaft, so that they can all be added together and treated as a unit, as follows:

$$\text{Equivalent } WK^2 = WK^2 \left[\frac{N}{N_M}\right]^2$$

Where, WK^2 = Inertia of the moving part
N = Speed of the moving part (RPM)
N_M = Speed of the driving motor (RPM)

When using speed reducers, and the machine inertia is reflected back to the motor shaft, the equivalent inertia is equal to the machine inertia divided by the square of the drive reduction ratio.

$$\text{Equivalent } WK^2 = \frac{WK^2}{(DR)^2}$$

$$\text{Where, DR = drive reduction ratio} = \frac{N_M}{N}$$

WK² OF LINEAR MOTION

Not all driven systems involve rotating motion. The equivalent WK^2 of linearly moving parts can also be reduced to the motor shaft speed as follows:

$$\text{Equivalent } WK^2 = \frac{W(V)^2}{39.5(N_M)^2}$$

Where, W = Weight of load (lbs)
V = Linear velocity of rack and load or conveyor and load (FPM)
N_M = Speed of the driving motor (RPM)

NOTE: This equation can only be used where the linear speed bears a continuous fixed relationship to the motor speed, such as a conveyor.

ELECTRICAL FORMULAS
OHMS Law:

$$\text{Amperes} = \frac{\text{Volts}}{\text{Ohms}}$$

$$\text{Ohms} = \frac{\text{Volts}}{\text{Amperes}}$$

$$\text{Volts} = \text{Amperes} \times \text{Ohms}$$

POWER IN DC CIRCUITS:

$$\text{Watts} = \text{Volts} \times \text{Amperes}$$

$$\text{Horsepower} = \frac{\text{Volts} \times \text{Amperes}}{746}$$

$$\text{Kilowatts} = \frac{\text{Volts} \times \text{Amperes}}{1000}$$

$$\text{Kilowatt-Hours} = \frac{\text{Volts} \times \text{Amperes} \times \text{Hours}}{1000}$$

POWER IN AC CIRCUITS:

Kilovolt - Amperes (KVA)

$$\text{KVA (Single-Phase)} = \frac{\text{Volts} \times \text{Amperes}}{1000}$$

$$\text{KVA (Three-Phase)} = \frac{\text{Volts} \times \text{Amperes} \times 1.73}{1000}$$

Kilowatt (Kw)

$$\text{Kw (Single-Phase)} = \frac{\text{Volts} \times \text{Amperes} \times \text{Power Factor}}{1000}$$

$$\text{Kw (Two-Phase)} = \frac{\text{Volts} \times \text{Amperes} \times \text{Power Factor} \times 1.42}{1000}$$

$$\text{Kw (Three-Phase)} = \frac{\text{Volts} \times \text{Amperes} \times \text{Power Factor} \times 1.73}{1000}$$

$$\text{Power Factor} = \frac{\text{Kilowatts}}{\text{Kilovolts} \times \text{Amperes}}$$

CONVERSION FACTORS

	MULTIPLY	BY	TO OBTAIN
Length	Meters	3.281	Feet
	Meters	39.37	Inches
	Inches	.0254	Meters
	Feet	.3048	Meters
	Millimeters	.0394	Inches
Torque	Newton-Meters	.7376	Lb-Ft
	Lb-Ft	1.3558	Newton-Meter
	Lb-In	.0833	Lb-Ft
	Lb-Ft	12.00	Lb-In
Rotation	RPM	6.00	Degrees/Sec.
	RPM	.1047	Rad./Sec.
	Degrees/Sec.	.1667	RPM
	Rad./Sec.	9.549	RPM
Moment of Inertia	Newton-Meters^2	2.42	Lb-Ft^2
	Oz-In^2	.000434	Lb-Ft^2
	Lb-In^2	.00694	Lb-Ft^2
	Slug-Ft^2	32.17	Lb-Ft^2
	Oz-In-Sec^2	.1675	Lb-Ft^2
	Lb-In-Sec^2	2.68	Lb-Ft^2
Power	Watts	.00134	HP
	Lb-Ft/Min	.0000303	HP
Temperature	Degree C = (Degree F -32) × 5/9 Degree F = (Degree C × 9/5) + 32		

CURRENT RATINGS OF INSULATED COPPER CONDUCTORS

TABLE 8. ALLOWABLE CURRENT CARRYING CAPACITIES
(Amperes) of Insulated Copper Conductors. Not more than three conductors in raceway or direct burial, based on 30°C (86°F) ambient (Condensed from National Electrical Code)

Type of Insulation	Maximum Operating Temperature	Wire Size AWG or MCM												*Correction Factors	
		14	12	10	8	6	4	3	2	1	0	00	000		
		Allowable Line Amperes												31–40°C	41–50°C
T-TW	60°C	15	20	30	40	55	70	80	95	110	125	145	165	.82	.58
RH,RHW, THW,THWN, XHHW	75°C	15	20	30	45	65	85	100	115	130	150	175	200	.88	.75
V-C(V) V-C(AVB) THHN,RHH, XHHW	85-90°C	25	30	40	50	70	90	105	120	140	155	185	210	.90	.80

Type of Insulation	Maximum Operating Temperature	Wire Size AWG or MCM												*Correction Factors	
		0000	250	300	350	400	500	600	700	750	800	900	1000		
		Allowable Line Amperes												31–40°C	41–50°C
T-TW	60°C	195	215	240	260	280	320	355	385	400	410	435	455	.82	.58
RH,RHW, THW,THWN, XHHW	75°C	230	255	285	310	335	380	420	460	475	490	520	545	.88	.75
V-C(V) V-C(AVB) THHN,RHH, XHHW	85-90°C	235	270	300	325	360	405	455	490	500	515	555	585	.90	.80

*For room temperatures above 30°C ( ).

DEFINITIONS

Performance specifications listed for the basic Boston Gear adjustable-speed drives in the standard specification sheets and those provided with companion functional options are based upon the following conditions:

DRIVE SPEED REGULATION

The motor speed change between minimum load and full-load torque, expressed as a percentage of the full-load motor speed. This change is measured after all transient disturbances, due to load change, have terminated.

(1)

$$\% \text{ Regulation} = \frac{(\text{Min-Load Speed}) - (\text{Full-Load Speed})}{(\text{Motor Rated Speed})} \times 100$$

Minimum-load is normally expressed as 5% of rated full load.

For drives with armature controlled DC motors, the rated speed is the motor operating speed when developing full-load torque with 100% rated armature voltage and field power applied. This is normally termed base speed.

For drives operated in the field weakened range, regulation is specified as a percentage of top speed.

Speed regulation for standard drives is expressed as a percentage of base speed. Set speed regulation is expressed as a percentage change in speed from an operating point (set speed) due to load changes. If a drive had 1% regulation of base speed, a 2% change of set speed could result at 1/2 motor speed.

Formula (1) is more realistic than Formula (2), since the friction in the driven machine normally loads the motor appreciably, and the changing work load on the machine subjects the motor to a smaller speed change than from absolute no-load to full-load torque.

(2)

$$\% \text{ Regulation} = \frac{(\text{No-Load Speed}) - (\text{Full-Load Speed})}{(\text{Motor Rated Speed})} \times 100$$

DRIVE SPEED RANGE

Any motor speed between minimum and maximum that can be obtained in a stable manner. For most static, electronic drives it is normally specified that the minimum speed is zero and the maximum speed is the motor base speed.

“Controlled Speed Range” specifies the operating range with respect to the quoted drive speed regulation. This is typically expressed as a ratio of the minimum to maximum speeds such as 20:1, 50:1, etc. Typically, high performance drives will offer close speed regulation along with wide speed range capability.

DRIVE SERVICE FACTOR

A multiplier, which when applied to the drive rated horsepower, indicates a permissible maximum loading at which the drive can be operated continuously. To determine the horsepower required for greater than standard service factor, multiply the rated horsepower by the service factor. If the rating thus calculated is not standard, select a drive (same base speed motor) with the next higher rating. Boston Gear’s standard drives have a 1.0 service factor.

STEADY-STATE REGULATION

The regulated value due to the following variation in operating parameters occurring independently or simultaneously. (Load remaining constant for speed and voltage regulators.

VARIABLE	VARIATION	RANGE
AC Supply Voltage	10% with rate of change not to exceed 2.5% per second	±10% of nominal voltage
AC Supply Frequency	2 Hz variation with rate of change not to exceed 2.5% per second	58-62 Hz (60 nominal) 48.5-51.5 Hz (50 nominal)
Ambient Temperature Random Drift	15°C 8 hour period after 1 hour warmup	0 to 40°C

TEMPERATURE

A change in ambient temperature produces a change in the control variable expressed as a percentage change for a specified temperature change of ±10°C. All standard units are designed to operate with a maximum enclosure interior temperature of 55°C surrounding the regulator power conversion module.

TRANSIENT DEVIATION

A momentary speed change from a speed set point, occurring at the result of a specified rate of load change. Performance is dependent on load inertia, motor inertia, load friction, etc.

TRANSIENT RESPONSE TIME

Time required to recover and maintain speed within the specified regulation tolerance after a specified change in load. Performance is dependent on load inertia, motor inertia, load friction, etc.

RANDOM DRIFT

A change from initial set speed during an unchanging load condition over specified time period with constant reference input, constant temperature, constant line voltage, and constant line frequency. Equipment must be operating at a specified ambient condition for a warm-up of one hour before the drift specification is applicable. Drift is specified as a percentage change (may be plus or minus) of base speed, unless otherwise stated. Drift is caused by random changes in operating characteristics of drive components.

DISPLACEMENT POWER FACTOR

The ratio of the active power of the fundamental wave to the apparent power of the fundamental wave in rms voltamperes. Displacement power factor is the power factor for which electric power utility companies charge penalties for low power factor.

CALCULATED POWER FACTOR

Expressed by the formula: Watts = 3 × E Line (rms) × I Line (rms) × Cos θ (Power-Factor), represents the ratio of total watts input to total rms voltamperes input. This considers the harmonic content of line input, as well as the fundamental wave of the line, and is always lower than the displacement power factor.

NEMA DEFINITIONS

Extracted from NEMA Standard (ICS-110)

ENCLOSURES	DESCRIPTION
NEMA 1	**General Purpose — Indoor.** Intended for use indoors, primarily to prevent accidental contact of personnel with the enclosed equipment. In addition, they provide protection against falling dirt.
NEMA 3	**Dusttight, Raintight and Sleet (Ice) Resistant – Outdoor.** Intended for use outdoors to protect the enclosed equipment against windblown dust and water. They are not sleet (ice) proof.
NEMA 3R	**Rainproof and Sleet (Ice) Resistant – Outdoor.** Intended for use outdoors to protect the enclosed equipment against rain. They are not dust, snow, nor sleet (ice) proof.
NEMA 3S	**Dusttight, Raintight and Sleet (Ice) Proof – Outdoor.** Intended for use outdoors to protect the enclosed equipment against windblown dust and water and to provide for its operation when the enclosure is covered by external ice or sleet. Does not protect the enclosed equipment against malfunction resulting from internal icing.
NEMA 4	**Watertight and Dusttight – Indoor.** Intended for use indoors to protect the enclosed equipment against splashing water, seepage of water, falling or hose-directed water, and severe external condensation.
NEMA 4X	**Watertight and Dusttight – Indoor.** Same provisions as NEMA 4 enclosures and, in addition, are corrosion resistant.
NEMA 5	**Superseded by NEMA 12.**
NEMA 6	**Submersible, Watertight, Dusttight and Sleet (Ice) Resistant – Indoor and Outdoor.** Intended for use indoors or outdoors where occasional submersion is encountered.
NEMA 12	**Industrial Use – Dusttight and Driptight – Indoor.** Intended for use indoors to protect the enclosed equipment against fibers, flyings, lint, dust and dirt, and light splashing, seepage, drippings and external condensation of non-corrosive liquids.
NEMA 13	**Oiltight and Dusttight – Indoor.** Intended for use indoors primarily to house pilot devices such as limit switches, foot switches, pushbuttons, selector switches, pilot lights, etc., and to protect these devices against lint and dust, seepage, external condensation, and spraying of water, oil or coolant.

ENCLOSURES FOR HAZARDOUS LOCATIONS	DESCRIPTION
	The term “explosion-proof” has been so loosely applied that NEMA deprecates its use. As defined by the National Electrical Code, the term “explosion-proof” applies only to NEMA 7 and 10 enclosures which, when properly installed and maintained, are designed to contain an internal explosion without causing external hazard.
NEMA 7, Class I Group A,B,C, or D	Intended for use indoors, in the atmospheres and locations defined as Class I and Group A, B, C or D in the National Electrical Code. The letters indicate the gas or vapor in the hazardous location.
NEMA 9, Class II Group E,F, or G	Intended for use indoors in the atmospheres defined as Class II and Group E, F or G in the National Electrical Code. The letters E, F or G indicate the dust in the hazardous location.
NEMA 10	Designed to meet the requirements of the U.S. Bureau of Mines which relate to atmospheres containing mixtures of methane and air, with or without coal dust.

TERMS AND CONDITIONS

ALL QUOTATIONS AND SALES BY BOSTON GEAR. THE CONTRACTING PARTY HERETO, A DIVISION OF IMO INDUSTRIES INC. HEREAFTER CALLED "COMPANY" ARE MADE ON THE FOLLOWING TERMS AND CONDITIONS

1- QUOTATIONS and THEIR ACCEPTANCE

Unless otherwise specified, quotations on stock products are for immediate acceptance, subject to prior sales. Quotations on special products are made subject to acceptance within thirty (30) days from date thereof, but in making such quotations, the Company reserves the right to change or cancel them at any time prior to the receipt of the customer's written acceptance. All quotations for special products are based upon supplying up to plus or minus 5% of quantity ordered unless otherwise stated in the quotation. All quotations are made F.O.B. shipping point.

2- PRICES

Prices are in accordance with current Company price lists, are based on quantity specified and are subject to minimum order requirements of the Company. In the event the Company consents to the cancellation or suspension of orders, it shall be entitled to charge for work done and material ordered or used up to the time of giving its written consent to such cancellation or suspension. When work is to be done on material furnished by the customer, prices are based on the quantity specified being delivered by the customer at one time within a reasonable time after acceptance of order. Quotations will be made on special products of all types or on cutting only. Prices, specifications, and terms and conditions, as well as all statements appearing in the Company's catalogs and advertisements, and made elsewhere by the Company are subject to change without notice. Changes by the customer in specifications or delivery requirements will be subject to change in price. Whenever the net price of an order amounts to less than $25.00, a minimum charge of $25.00 will be made.

3- CREDIT TERMS

To those customers and prospective customers whose credit is satisfactory to the Company, terms are net thirty (30) days, from date of invoice, with the option of paying semi-monthly. The Company may at any time when, in its opinion, the financial condition of the customer or prospective customer warrants it, either alter or suspend credit, or discontinue deliveries, and render a charge covering the value of any partially finished special products which are then being manufactured for the customer. In those instances where credit is not established, and in cases where satisfactory references are not given, the terms are cash with order. For special products in those instances where credit is not established to the satisfaction of the Company, a deposit of at least 50% of total value of the order is required. Remittances should be made by check or money order, payable to the Boston Gear, Quincy, Massachusetts. 02171, U.S.A. Delays in transportation shall not extend the terms of payment.

4- MATERIAL FURNISHED BY THE CUSTOMER

Unless otherwise specified, quotations are based on material furnished by the customer being of ordinary hardness, normal allowance for finish, uniform specification, and machine work being of ordinary commercial accuracy. If material furnished by the customer involves the Company in expense not contemplated by the contract, the customer will be charged for all such additional expense. If serious defects are found in the material furnished by the customer, the customer will be charged for the actual work done. The Company assumes no responsibility for, and will not be liable for loss of or damage to samples, blueprints, diagrams, and other material of any nature submitted or furnished by the customer or prospective customer, provided the Company has exercised reasonable care in the handling of the same. The Company does not assume transportation and insurance costs on any of the foregoing items. In all cases where the customer or prospective customer makes no statement in writing, concerning the disposition of any of the foregoing material when submitted, the Company reserves the right to dispose of such material according to its best judgment.

5- DIMENSIONS

When dimensions of rims, bores, and hubs are not clearly specified, quotations are based on ordinary dimensions. Before the customer's blanks are accepted by the Company for cutting, the diameter, holes, rims and ends of holes must be finished; for bevel gears, hubs, must be of uniform length. There should also be an allowance of extra blanks to cover possible spoilage. Unless otherwise specified, dimensions are in inches.

6- SAMPLES

In no case are samples furnished free. If agreed to by the Company, a few products in advance of a regular quantity order will be furnished but only at an agreed upon price over the regular quantity price.

7- TAXES

If any tax is at any time levied or imposed by the federal or any state or local government, or any other taxing authority, upon the products covered hereby, or in respect of the production, processing, manufacture, storage, sale, use, or consumption thereof, or, in the case of goods delivered at the Company's expense, upon the transportation thereof, including freight charges thereon, the amount of such tax shall be added to the purchase price above specified and shall be borne by the customer. The Company will accept a valid exemption certificate from the customer if applicable; however, if any exemption certificate previously accepted is not recognized by the taxing authority involved and the Company is required to pay the tax covered by such exemption certificate, the customer shall be required to promptly reimburse the Company for the taxes so paid.

8- SHIPMENTS

All shipments are made F.O.B. shipping point (subject to freight allowance under conditions stated in separate price schedules). When ordering, the customer's desired method of shipment must be clearly stated. Where instructions for shipping do not appear on the order, shipment will be made according to the Company's best judgment. Fully risk of loss (including transportation delays and losses) shall pass to the customer upon delivery of the products to F.O.B. point. Unless otherwise instructed, all Parcel Post shipments are insured at the customer's expense. Parcel Post shipments without insurance are at the customer's risk. Deliveries by Messenger Service to a terminal are made at the customer's risk and expense. Partial shipments shall be permitted and the Company may invoice each shipment separately.

TERMS AND CONDITIONS

ALL QUOTATIONS AND SALES BY BOSTON GEAR. THE CONTRACTING PARTY HERETO, A DIVISION OF IMO INDUSTRIES INC. HEREAFTER CALLED "COMPANY" ARE MADE ON THE FOLLOWING TERMS AND CONDITIONS

9- REFUSAL of SHIPMENT

In case of the refusal or inability of the customer to accept any shipment in accordance with the terms of the order, the customer shall be liable for freight, express, storage, extra cost of handling and all other expenses incurred by the Company as a result of such refusal or inability.

10- DELAY or NONPERFORMANCE

The Company shall not be liable for any delay or loss of any nature or failure in performance due to or caused by fire, flood, strike, or other differences with workmen, accidents, labor or material or transportation shortages, war (declared or undeclared), insurrection, riot, or by any governmental orders or regulations, legal interferences or prohibitions, defaults on the part of suppliers or other causes beyond the Company's reasonable control.

11- CLAIMS and REJECTED MATERIAL

Any products which have been altered or damaged are not returnable except with the Company's written consent. To reject products on inspection as defective, customer must notify the Company in writing within ten (10) days from receipt of the products. Before allowing or rejecting claim, the Company shall then have the option of reinspection at the customer's plant or its own. Defects that do not impair service shall not be a cause for rejection. The Company shall have the right to replace within a reasonable time any product or products which in its opinion do not conform to the order. No claim will be allowed for any products damaged by the customer or damaged in transit. Expenses incurred in connection with claims for which the Company is not liable, will be charged to the customer. The Company will not be responsible for any work done to correct errors unless such work is authorized by the written consent of the Company. The Company assumes no liability for any claim for infringement of any foreign or domestic patent.

12- LIMITED WARRANTY

The Company warrants that products manufactured or sold by it shall be free from defects in material and workmanship. Any products which shall within two (2) years of delivery, be proved to the Company's satisfaction to have been defective at the time of delivery in these respects will be replaced or repaired by the Company at its option. Freight is the responsibility of the customer. The Company's liability under this limited warranty is limited to such replacement or repair and it shall not be held liable in any form of action for direct or consequential damages to property or person. THE FOREGOING LIMITED WARRANTY IS EXPRESSLY MADE IN LIEU OF ALL OTHER WARRANTIES WHATSOEVER. EXPRESS, IMPLIED AND STATUTORY AND INCLUDING WITHOUT LIMITATION THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS.

No employee, agent, distributor, or other person is authorized to give additional warranties on behalf of Boston Gear, nor to assume for Boston Gear any other liability in connection with any of its products, except an officer of Boston Gear by a signed writing.

13- WAIVER OF BREACH

No waiver by the Company of any breach of these provisions shall constitute a waiver of any other breach.

14- CONSEQUENTIAL DAMAGES

The Company shall not be liable to the customer or others claiming through the customer for special or consequential charges for any reason whatsoever.

15- LAWS

To the best of the Company's knowledge and belief it is in compliance with all local, state and federal laws. All orders are subject to the condition that the Company's obligation under such local, state and federal laws and Executive Orders. Rules and Regulations issued thereunder, whether now in force or hereafter made effective, shall be no greater as a result of this agreement and no greater than required by such laws and the Company expressly disclaims assumptions of any of the customer's obligations under such laws.

16- GENERAL

Any terms and conditions of a customer's order which are inconsistent with or additional to the terms and conditions hereof shall not be binding on the Company and shall not be considered applicable to any sale or shipment of the Company's products. All such terms and conditions are hereby expressly rejected. No waiver, alteration or modification of any of the Company's terms and conditions shall be binding on the Company unless made in writing and agreed to by a duly authorized official of the Company.

17- PRINTERS, STENOGRAPHIC, and CLERICAL ERRORS

The Company is not responsible for printers' errors made in any of its publications and other forms of printed matter, or for any stenographic and clerical errors. All such errors are subject to correction.

Other products available from Boston Gear

Gears and Shaft Accessories

Boston Gear has been a leader and pioneer in manufacturing gearing products since 1877, when we introduced the concept of gear standardization and stock gears -innovations of enormous benefit to power transmission system designers, specifiers, and users. Today, Boston Gear manufactures open gearing at our state-of-the-art facility in Charlotte, NC, where we continue to improve product quality and manufacturing efficiencies with programs like gear cell manufacturing, CAD/CAM design and manufacturing and CNC/DNC programming.

Enclosed Gear Drives

Boston Gear's comprehensive line of enclosed gear drives, including worm, in-line and parallel-shaft helical, miter, and bevel, provides you with the product variety you need to get the job done. Factor in our Guaranteed Same Day Shipment Program, which ensures rapid delivery, or our innovative Reducer Express™, which ensures overnight delivery, and you'll see why Boston Gear's speed reducers are preferred by manufacturers worldwide. In fact, every time you specify a Boston Gear product, you incorporate quality, responsiveness, and Boston Gear's 123-year reputation into your design.

Centric Clutches

Boston Gear offers the industry's most diversified line of clutches, with mechanical and pneumatic clutches to suit most any application. Our complete selection of torque overload devices, along with our Model H clutch and our entire line of centrifugal clutches, comes with Boston Gear's 120 years of mechanical power transmission expertise - so ask for Centric™ clutches by name. Because we apply the same quality standards to all of our products, you'll find our electrical and clutches offer exceptional performance, as well.

Bearing Products

When you want the freedom to select from the widest range of the highest quality bearings, come to the power transmission specialists at Boston Gear, because we offer the most comprehensive selection of bearing products from one single source in the power transmission industry. Everything from plain sleeve bearings, ball bearings, rod ends, and spherical bearings to linear bearings, pillow blocks and flanged units are in stock.

Electrical Products

From fractional horsepower AC and DC motor controllers to a complete offering of complementary motors -including Ratiotrol®, the industry's first stock single phase DC drive, Boston Gear is prepared to meet the broad spectrum of your adjustable speed needs. And with a complete line of complementary clutches, brakes, and other accessories available from Boston Gear, we are prepared to serve your motion control product needs.

COLFAX PT GROUP

Colfax Power Transmission Group

Colfax Power Transmission Group
Quincy, MA 02171
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Boston Gear

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50115 12/01

Printed in USA