OUR QUALITY POLICY

DRIVEN BY THE VOICE OF THE CUSTOMER AND TOTAL ASSOCIATE INVOLVEMENT, BOSTON GEAR WILL STRIVE, THROUGH CONTINUOUS IMPROVEMENT, TO PROVIDE PRODUCTS AND SERVICES THAT MEET OR EXCEED CUSTOMER EXPECTATIONS.

www.bostongear.com

Boston Gear's new, easy to navigate web site offers a variety of tools designed to simplify the selection and ordering process. Powered by advanced Internet XML technology, www.bostongear.com offers 24 hour access to the industry's premier source for power transmission information:

- **BostSpec2 – Boston Gear's award winning open and enclosed gearing configurator. Based upon your applications requirements, select from over 84,000 parts, view specifications, even download CAD drawings**
- **Products – get the most current product information, features, benefits, or application data**
- **Literature – all of Boston Gear's catalogs, brochures, specification sheets, and installation manuals are available for immediate down loading**
- **Distributor Locator – find your local stocking Boston Gear distributor**

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.bostongear.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 50,000 products in-house at our facility in Charlotte, North Carolina. Production is efficiently organized into manufacturing cells under group technology.For example, turning and grinding are combined under the control of a single operator in each cell. 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 PTDA IAFIS BEARING SPECIALISTS ASSOCIATION YOUR INDUSTRY CONNECTION MHEDA Material Handling Equipment Distributors Association

BOSTON GEAR®

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 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.

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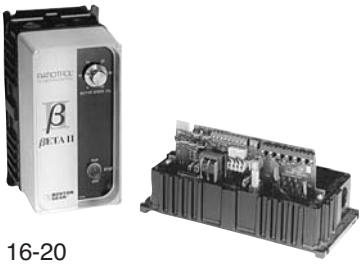

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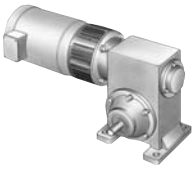					
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		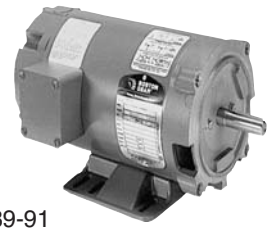
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System Selection

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	RBA-RG	VEA-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 Pages 86-87 for complete motor selection.

Single-Phase Adjustable Speed DC Motor Controllers, Nonregenerative

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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	
AC Line	Voltage 50/60 Hz	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
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
AC Line Protection	Fuse Circuit Breaker	S		O		S		S		S		S O	
Functions	Jog Preset Speeds Armature Contactor Unidirectional W/ D.B. Reversing W/DB Reversing, Switch Constant Torque Operation	 S S		 O O S		 S S		S S S S S		S S S S S		S S S S S	
Enclosure	Angle Bracket Chassis Open Chassis NEMA 1 NEMA 3 NEMA 4 NEMA 12	 S 		S 		 S S		S S S S		S S S S		 S S S	
Adjustments	Acceleration (Seconds) Deceleration (Seconds) IR Compensation (%) Maximum Speed (%) Minimum Speed (%) Current Limit (%)	 75-100 150		0.8-10 0.8-10 0-100 60-100 0-40 0-150		0.8-10 0.8-10 0-100 60-100 0-40 0-150		0.2-40 0.2-40 0-100 50-100 0-40 0-150		0.2-30 0.2-30 0-100 50-100 0-40 0-150		0.2-30 0.2-30 0-100 50-100 0-40 0-150	
Horsepower/ Voltage Calibration	Trim Pot Adjustments Resistance Wire Reconnectable Jumpers Dip Switches	 S 		S 		S 		 S S		 S S		 S S	
Isolated Regulator				O				S		S		S	
Load Monitor										S		S	
Speed Regulation	Standard IR Feedback Percentage Speed Range Tachometer Feedback Percentage Speed Range	 5% 20:1 		 2% 30:1 1% 100:1		 2% 30:1 1% 100:1		 2% 50:1 0.5% 200:1		 2% 50:1 0.5% 200:1		 2% 50:1 0.5% 200:1	
Input	Analog	S		S		S		S		S		S	
Tachometer Feedback	Unidirectional Bidirectional			S		S		S O		S O		S O	
Modifiable Features	DC Tachometer Feedback AC Line Starting Torque Regulator External DC Signal Follower Limit Switch Reversing			S S		S S		S S S S S		S S S S S		S S S S S	
Options	Field Installed Factory Installed			O O				O		O		O O	
UL/cUL				S		S		S		S		S	
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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.

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 RP1R & 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

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.

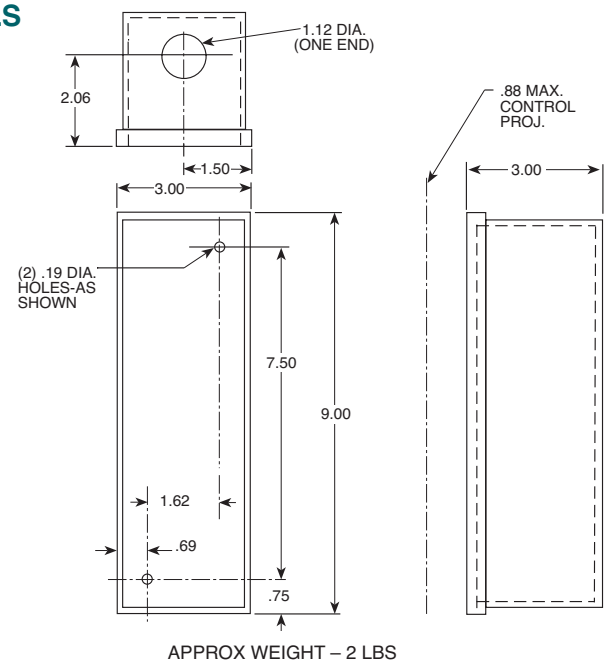
ORDER BY CATALOG NUMBER OR ITEM CODE

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, non-ventilated 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 6**
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.

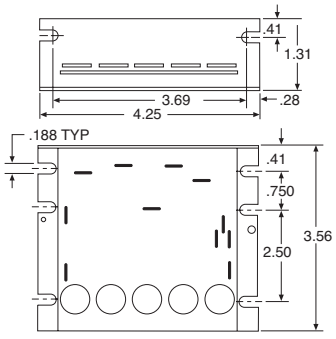
DCX® AND DCXplus® SERIES SELECTION CHART

ORDER BY CATALOG NUMBER OR ITEM CODE

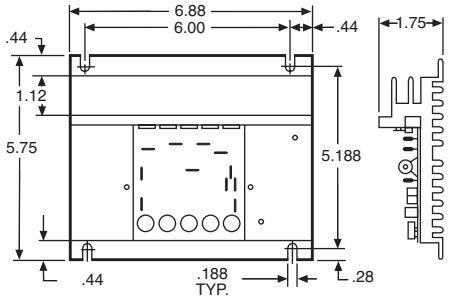
Horsepower Range(4)		Catalog	Item	
115 VAC	230 VAC	Number	Code	Function
DCX ANGLE BRACKET CHASSIS CONTROLLERS				
1/12 – 1/2	—	DCX102C	65984	Run/Stop(3)(2)
1/12 – 1/2 1/12 – 1(1)	1/2 – 1 1/2 – 2(1)	DCX202C	65985	Run/Stop(3)(2)
1/12 – 1	1/2 – 3	DCX302C	65986	Run/Stop(3)(2)
DCXplus FRONT PANEL ASSEMBLY 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

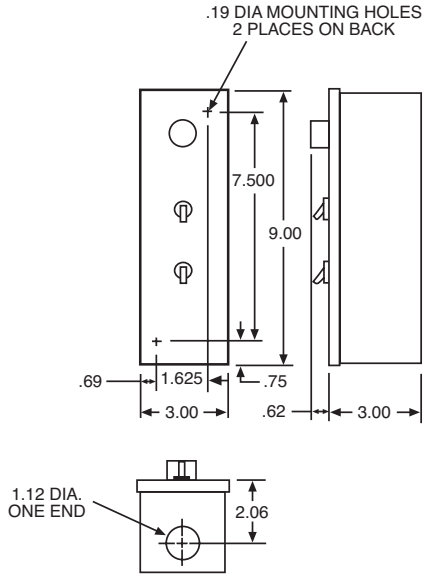


DCX102C, DCX202C

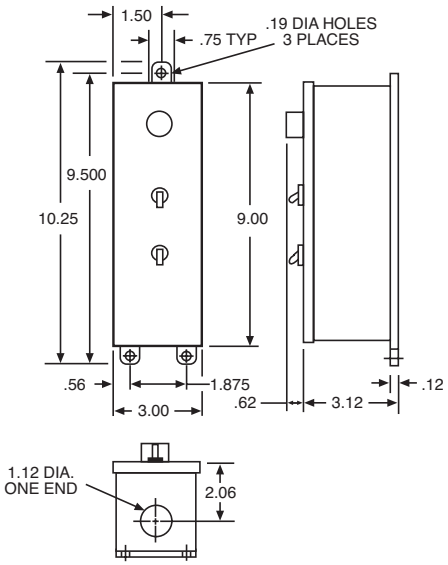


DCX302C

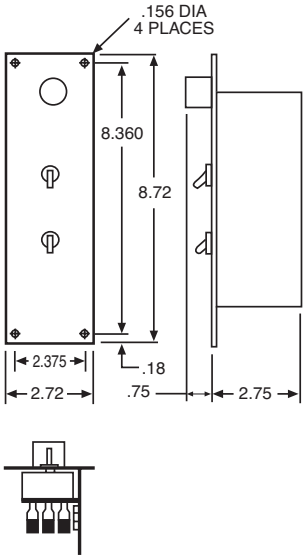
DIMENSIONS - DCXplus ENCLOSED



DCXplus NEMA 1

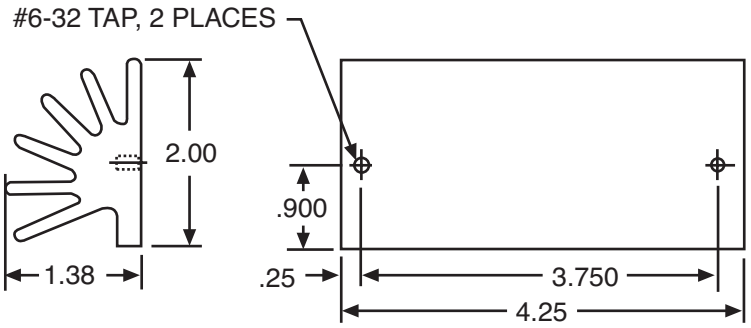


DCXplus NEMA12

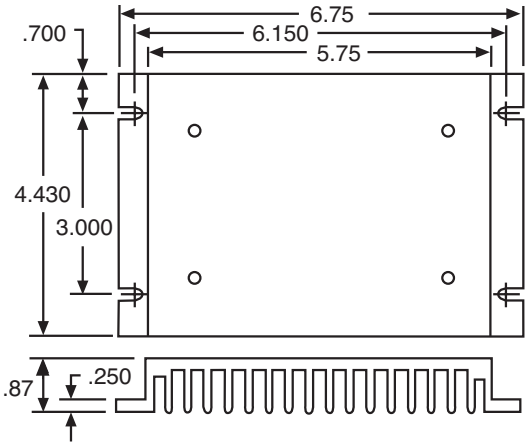


DCXplus Panel–Front

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)

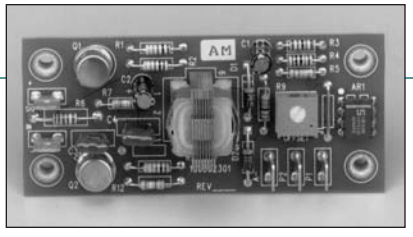
This option provides the same function as Option DCX-HTSK except it is a unique space saving radial design and offers a greater horsepower rating.
Dimensions: 2"x1.38"x4.25"

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.

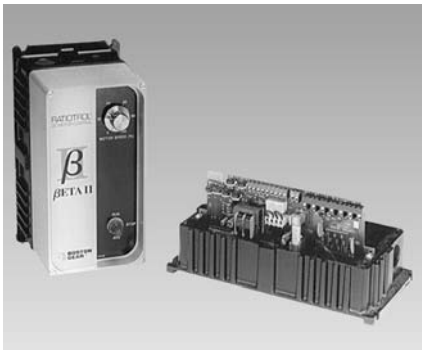


Follower, External Signal DCX-25A (68342)

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 (%) Stops Per Minute	115V	180	129	103	66	44	34	—	—	—
		230V	—	—	—	278	190	130	88	62	—
		115V	15	12	11	8	6	2	—	—	—
		230V	—	—	—	8	6	1	1	1	—
RBA3	Braking Torque (%) Stops Per Minute	115V	300	215	170	110	75	60	—	—	—
		230V	—	—	—	400	320	220	145	105	85
		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	Magnetic Control Voltage
	Armature	Field(1)		
115V, 50 or 60 Hz	0–90	50/100	0-10 VDC 4-20 MA	24 VDC
230V, 50 or 60 Hz	0–180	100/200		

(1) Selectable

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

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

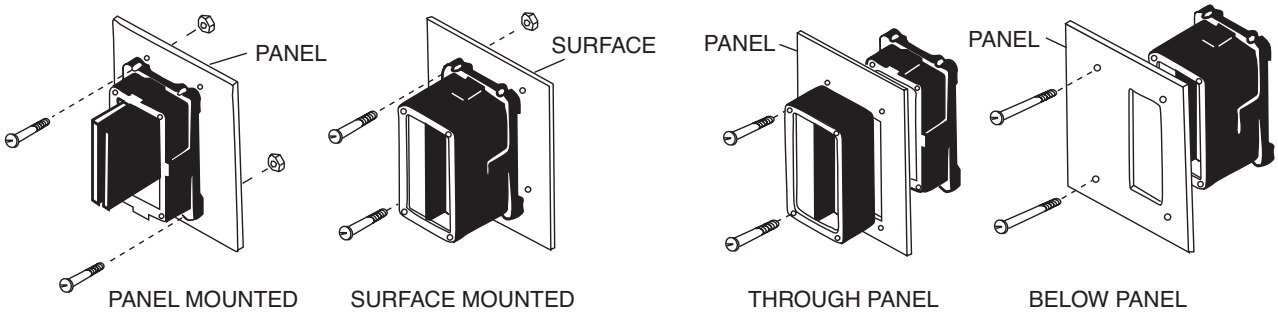
1. **Line Voltage**..... 115/230 VAC, 50/60 Hz, Single Phase
2. **Line Voltage Variation**..... ±10% of rated(1)
3. **Line Frequency Variation**..... ±2 Hz
4. **Ambient Temperature**.....Enclosed: 0° to 40° C (32° to 104° F)
   Chassis: 0° to 55° C (32° to 131° F)
5. **Altitude**..... 3300 ft. (1000 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 47 and 48.
(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 48.

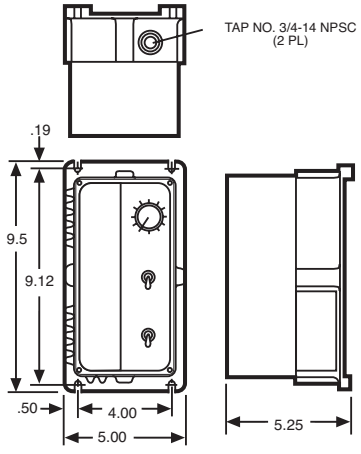
OPTIONS

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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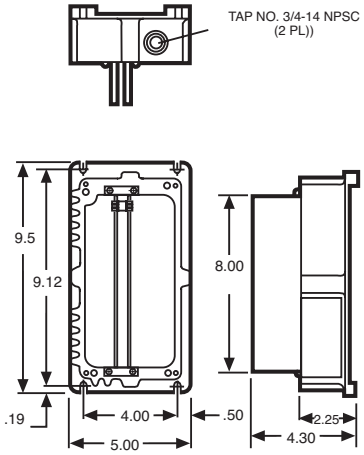
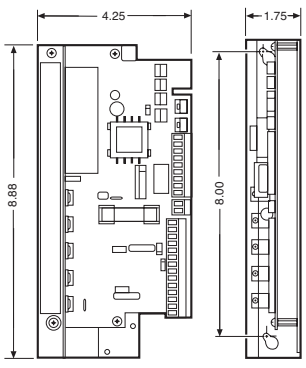
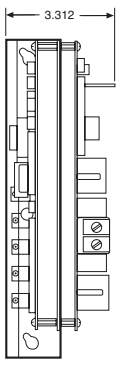


CHASSIS



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.

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) Unidirectional Models Only
(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

ELECTRICAL DATA

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%

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

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 47 and 48.
(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 Page 48.

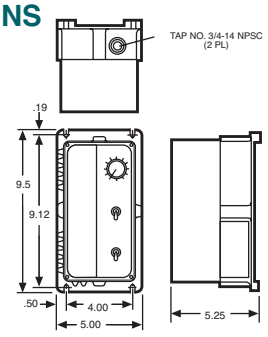
OPTIONS

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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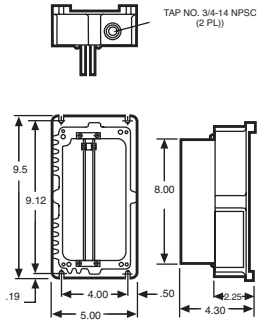
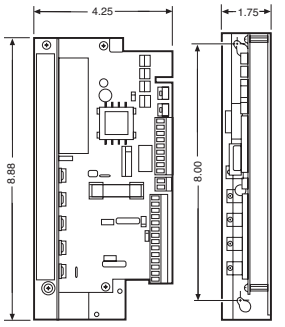
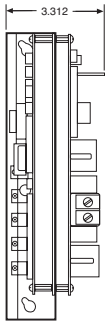


CHASSIS



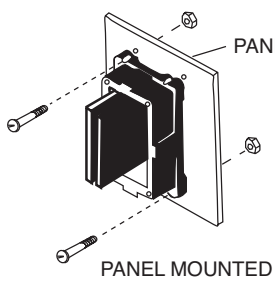
RBS2C



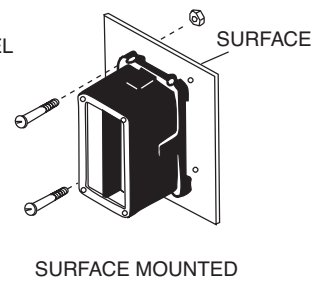
RBS2CU
RBS2CM

ANGLE BRACKET CHASSIS

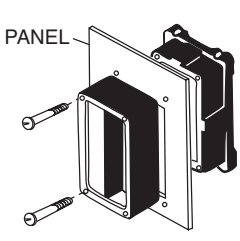
MOUNTING CONFIGURATIONS



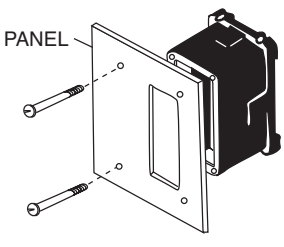
PANEL MOUNTED
OPEN CHASSIS



SURFACE MOUNTED
ENCLOSED PACKAGE



THROUGH PANEL
SURFACE MOUNTED



BELOW PANEL
SURFACE MOUNTED

BOSTON GEAR®

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.

Single-Phase Adjustable Speed DC Motor Controllers, Nonregenerative

VEplus Series
1/6-5 Horsepower

DESIGN FEATURES AND FUNCTIONS *(Continued)*

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 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 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. 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.

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**(1) ..... 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 47 and 48.

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 48.

OPTIONS

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

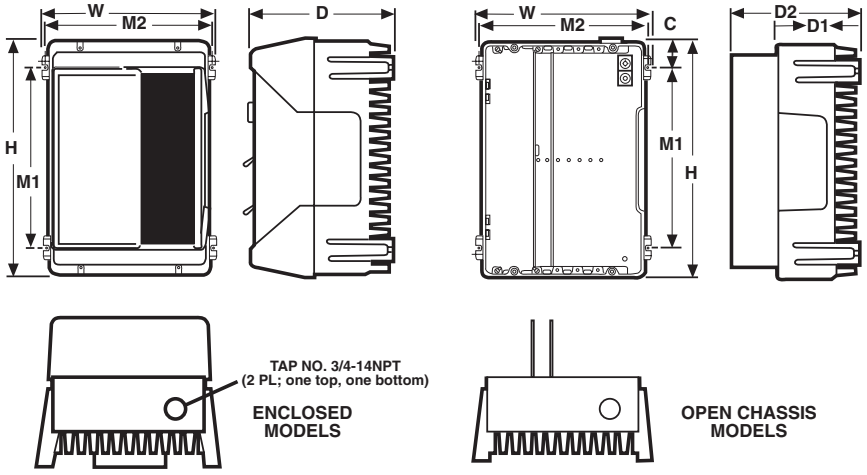
To order a controller with the options installed, add the option number or letter as a suffix to the controller catalog number, e.g. VES3MR-IAB-25A, VES5MB-21A, etc. To order a kit for field installation, order by item code.

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	

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

Single-Phase Adjustable Speed Regenerative DC Motor Controllers

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

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.

DESIGN FEATURES AND FUNCTIONS *(Continued)*

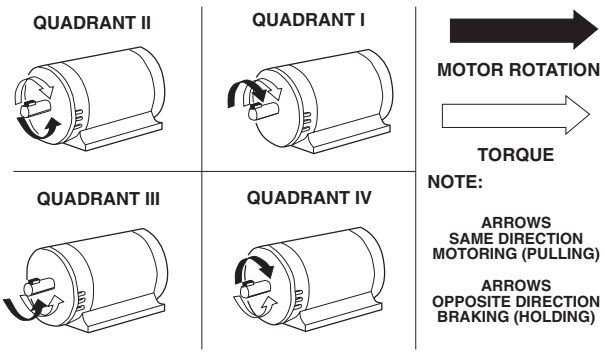
11. **Static Reversing** – Solid state, electronic reversal of the motor armature. No reversing contacts to burn, arc or wear.
12. **Static Braking** – Provides smooth regeneration braking of the DC drive motor. Braking is effective whenever the manual speed control potentiometer is reset to command 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)

Rated Component	Rated Model	Horsepower Voltage	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	400	278	200	138	93	66	N/A	N/A		
	RBA3-RG 115V	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	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	12	8	6	2	1	1	N/A	N/A		
	RBA3-RG 115V	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	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		Control Reference Voltage	Magnetic Control Voltage
	Armature	Field		
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

MODEL TYPES

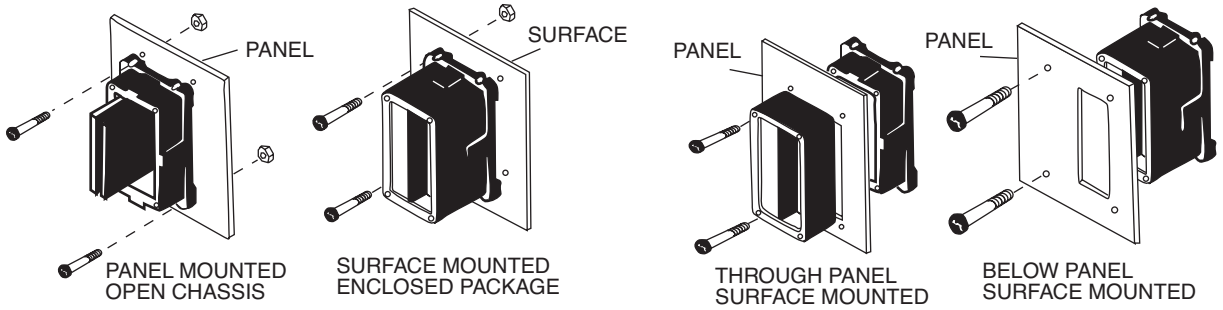
RBA-RG/VEA-RG controllers are offered in eighteen (18) standard models in four (4) functional groups. The basic chassis models are the nucleus of all the enclosed models; standard covers and contactor assemblies can be added to the basic chassis to make an enclosed controller or the enclosed unit may 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 47 and 48

(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.

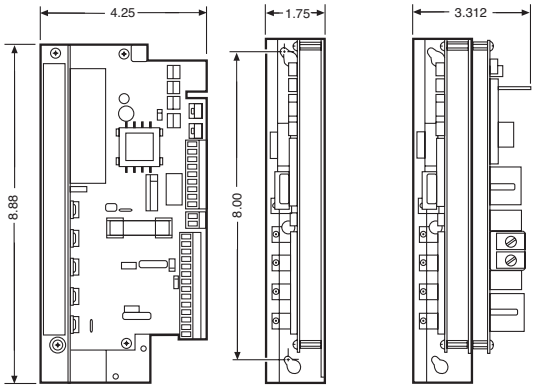


RBA-RG Series Mounting Configurations

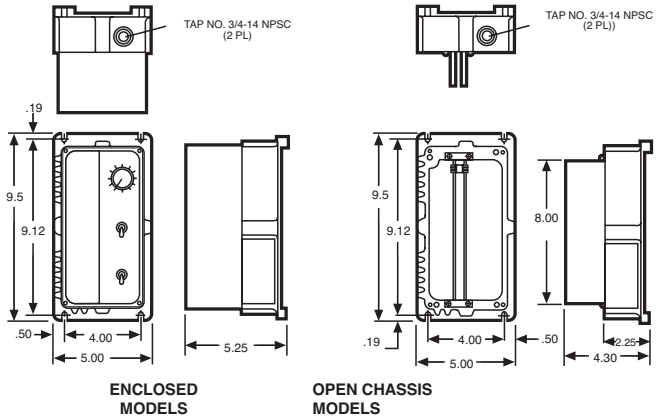
Single-Phase Adjustable Speed Regenerative DC Motor Controllers

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

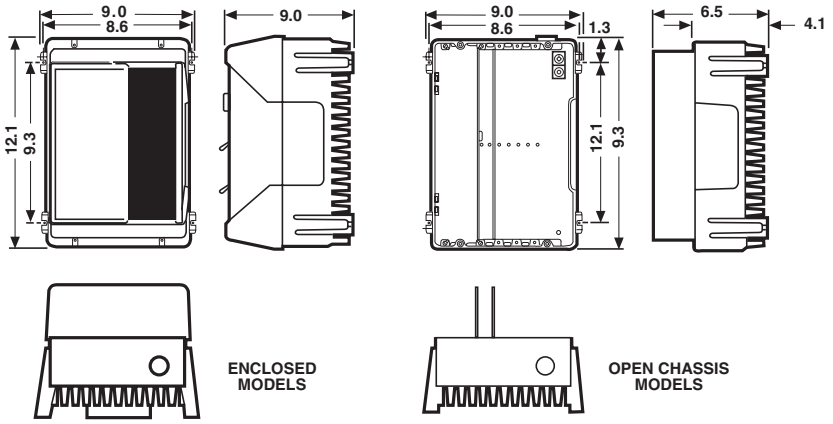
DIMENSIONS



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.

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
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 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
RI	**LIMIT SWITCH REVERSING** 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.	VEA-RG RBA-RG
SK	**SPACER KIT FOR 3 HP RBA-RG ENCLOSED CONTROLLER** This spacer kit is required for mounting controllers when they are to be used for their maximum 3 HP rating.	RBA-RG
SKO	**OPTION MOUNTING KIT** This kit contains standoffs for mounting an optional contactor or option board onto an Angle Bracket chassis.	RBA-RG
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
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

Options and Modifications for DC Controllers

Option No.	Description	For Use with Series
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
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
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.	VEplus
18C	**FOLLOWER, CURRENT REGULATOR (LESS ADJUSTMENTS)** ***(Continued)***	

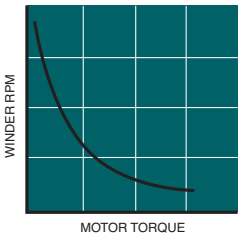


FIGURE A. "Ideal" Constant HP curve for a winder application

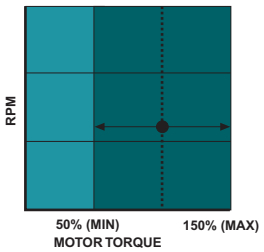


FIGURE B. Torque Adjust with slope adjust at maximum

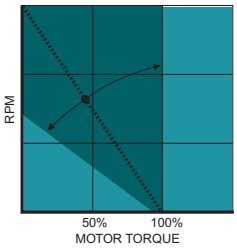
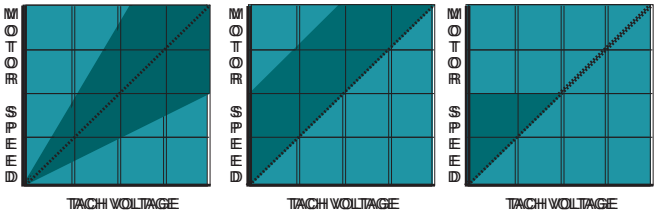


FIGURE C. Slope Adjust with torque adjust at 100% torque setting

Options and Modifications for DC Controllers

Option No.	Description	For Use with Series
	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.	**VEplus**
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**
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.	**VEplus**

Option No.	Description	For Use with Series
22A	**FOLLOWER, AC OR DC TACHOMETER GENERATOR *(Continued)*** 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
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** 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	VEplus

Options and Modifications for DC Controllers

<table>
<tr><th>Option No.</th><th>Description</th><th>For Use with Series</th></tr>
<tr><td>24A</td><td>FEEDBACK, TACHOMETER AC OR DC (Continued)
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.</td><td>VEplus</td></tr>
<tr><td>24B</td><td>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.</td><td>VEplus</td></tr>
<tr><td>24B</td><td>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.</td><td>VEA-RG
RBA-RG</td></tr>
<tr><td>25</td><td>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.</td><td>VEA-RG
RBA-RG</td></tr>
<tr><td>25A</td><td>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:
<table><tr><th>DC Input Signal Range (ma)</th><th>Option Input Impedance (Ohms)</th></tr><tr><td>0-5</td><td>80</td></tr><tr><td>0-10</td><td>40</td></tr><tr><td>0-25</td><td>16</td></tr><tr><td>0-50</td><td>8</td></tr><tr><td>1-5</td><td>80</td></tr><tr><td>2-10</td><td>40</td></tr><tr><td>4-20</td><td>16</td></tr><tr><td>10-50</td><td>8</td></tr></table>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) – 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.</td><td>VEplus</td></tr>
</table>

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

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 GAIN adjustment.

OFFSET - Trims minimum input signal.

IMPEDANCE MATCH and OFFSET potentiometers are mounted on the Option Circuit Board

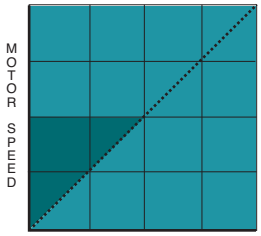


FIGURE A

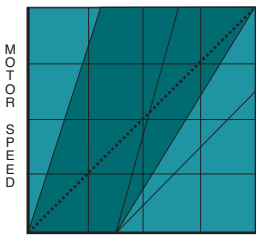


FIGURE B

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.

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.

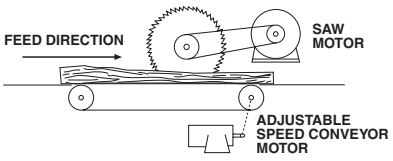
BIAS (2)–Set the maximum DC motor speed for the INVERT mode of operation.

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.

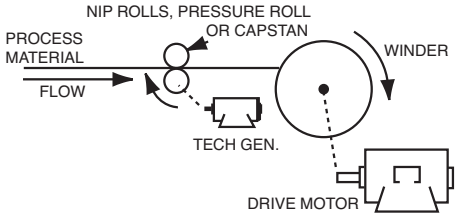


This option consists of:

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.

Option No.	Description	For Use with Series
25C	**FOLLOWER, AC CURRENT TRANSDUCER *(Continued)*** *NOTES:* *(1) Mounted in operator control station.* *(2) Located on circuit board.* *This illustration shows an application which requires an inverse elationship 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.*	VEplus
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
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.	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.*	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. *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.	VEplus

Options and Modifications for DC Controllers

Option No.	Description	For Use with Series
36A	**CENTERWIND TORQUE CONTROL *(Continued)***	VEplus
	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**	VEplus
	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.	
		
38	**MANUAL/FOLLOWER MODE SELECT (TOGGLE SWITCH)**	ALL
	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.	

Options and Modifications for DC Controllers

Option No.	Description	For Use with Series
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 VEA-RG

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.

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REMOTE CONTROL STATIONS

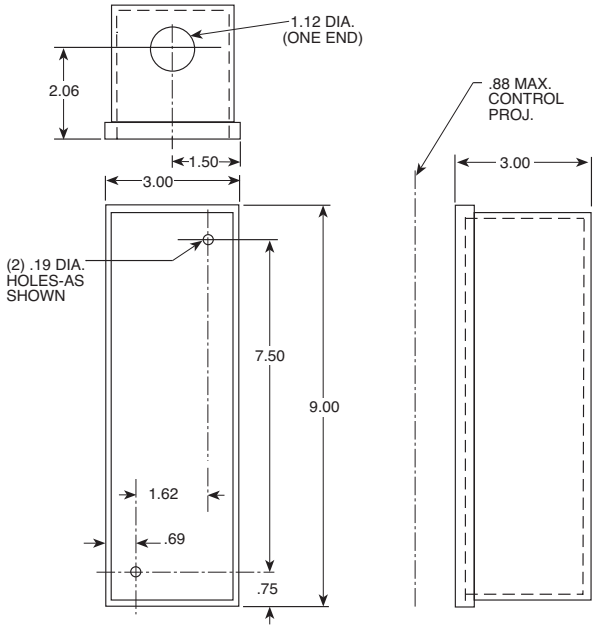
The remote control stations shown on these pages may be used with one or more controller. The listings indicate control functions, components and the controllers with which each remote control station may be used. Dimensions are shown for NEMA 1 enclosures. Consult factory for dimensions on other NEMA enclosures. NEMA definitions are on Page 127.

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 Jog Speed	RBA, RBS, VES	RCS1	69362
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),	RCS6	60239

(CONTINUED)

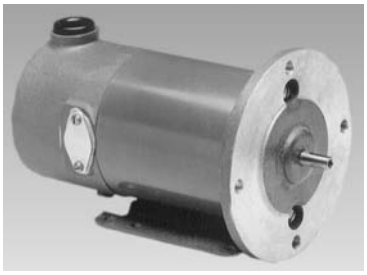
REMOTE CONTROL STATIONS *(Continued)*



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,	Motor Speed	RBA(M,MB),	RCS17	58103

DC Tachometer Generator



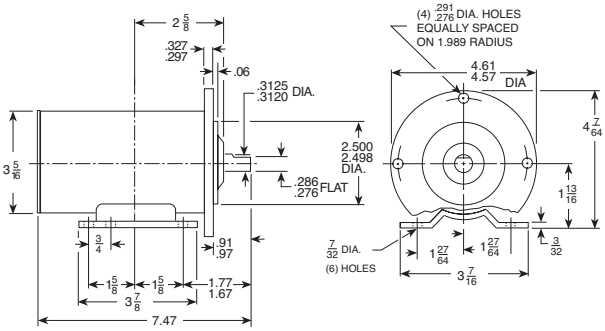
Tachometer Generators are used to sense (monitor) motor shaft speed and to supply a voltage signal to a meter for speed indication, to another control to set its speed (follower or "Slave") or to signal speed changes to the control associated with the motor (tachometer feedback).

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.

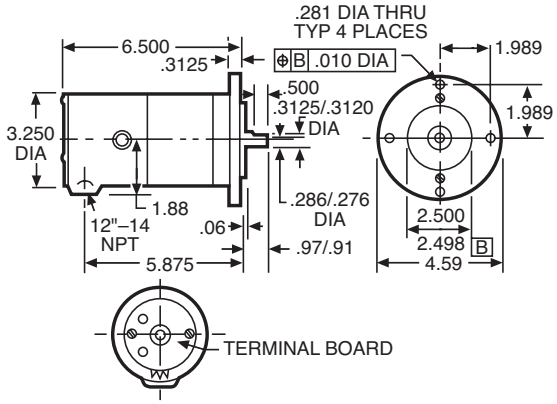
ORDER BY CATALOG NUMBER OR ITEM CODE

Output per 1000 RPM	Mounting	Catalog Number	Item Code	Driving Torque (oz. in.)	Max RPM	Inertia (lb. in²)	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

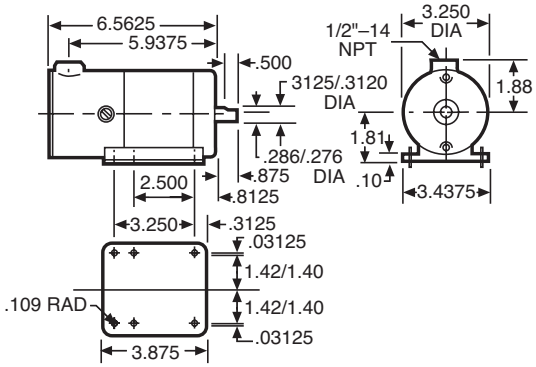
DIMENSIONS



TG3



TG3C-P



TG3F-P

ADAPTERS

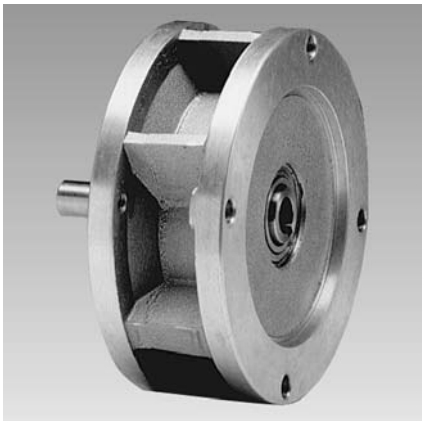
Flange mounted generator can be mounted on certain motors capable of supporting its size and weight as shown below:

ORDER BY CATALOG NUMBER OR ITEM CODE

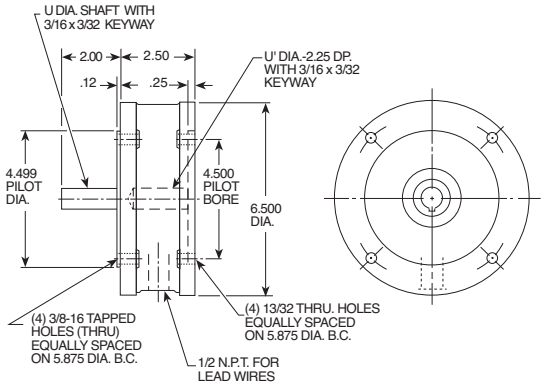
For Use With Motors	Adapter Required	
	Catalog Number	Item Code
18300ATF-B	TGAB3*	66795

*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.

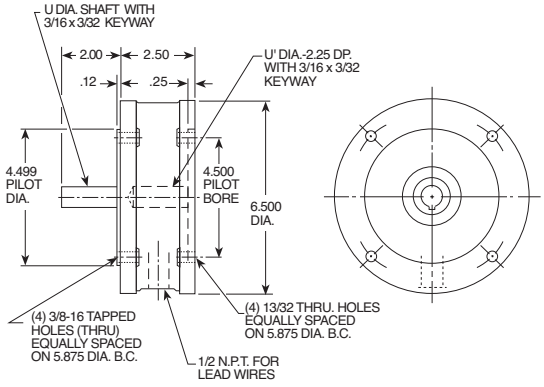


ORDER BY CATALOG NUMBER OR ITEM CODE

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

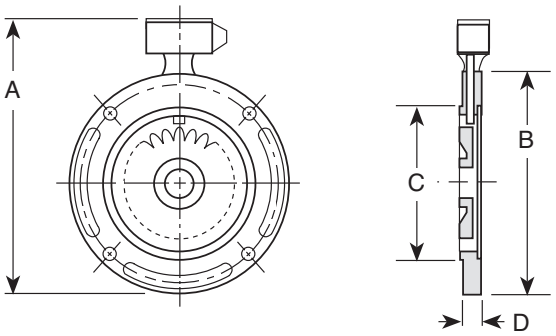
Magnetic pickup assemblies are used to deliver a 60 pulse per revolution signal for use with a tachometer to display the accurate speed of a motor.

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

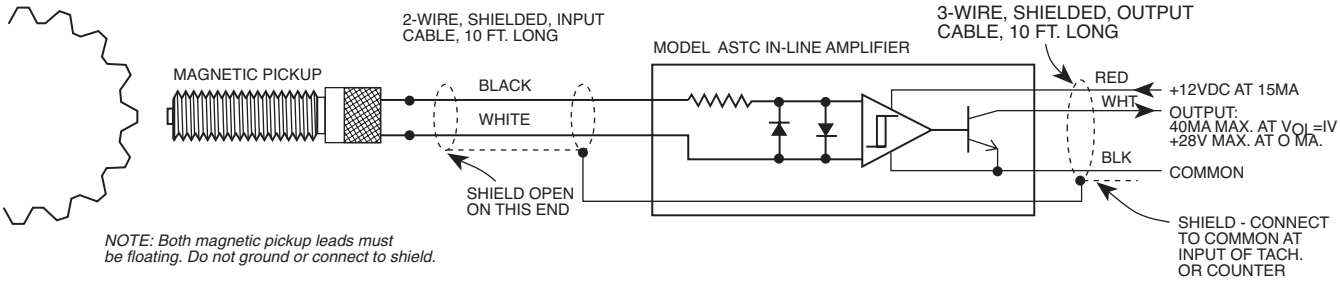
Inline Amplifier and Pulse Shaper for Magnetic Pick-ups — ASTC Series

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.



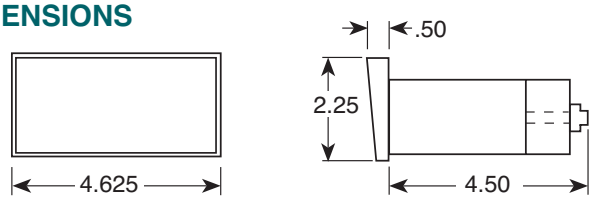
5 Digit Digital Pulse Tachometers — DPT Series

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 51.

DIMENSIONS



ORDER BY CATALOG NUMBER OR ITEM CODE

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

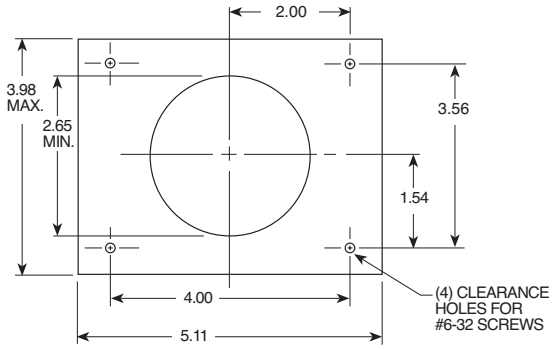
Analog Meter

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.

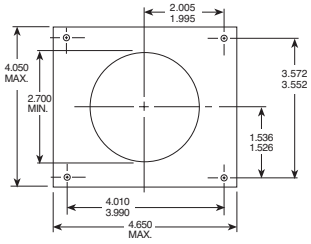
INPUT SIGNAL DEVICE: Any AC or DC shunt providing a 50 mV. or larger signal. An AC or DC signal source. A fixed pulse area digital tachometer.

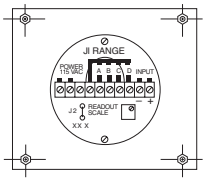
READOUT LINEARITY: 0.5% F.S. ±1 count.

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.

NOTES

CLUTCHES AND BRAKES

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.

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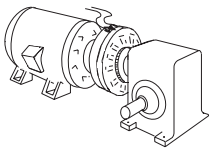
General Information

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

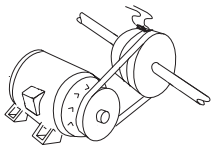
Electric clutches and brakes perform controlled start and stop functions between a constantly-running prime mover and a load. Electrical commands are generated manually (pushbutton) or automatically (switch, photocell, tape, sequence programmer, etc.)

CLUTCH – *Acceleration*



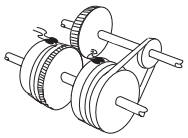
NO SHOCK

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.



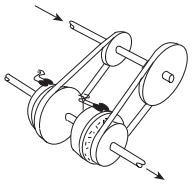
HIGH RESPONSE

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.

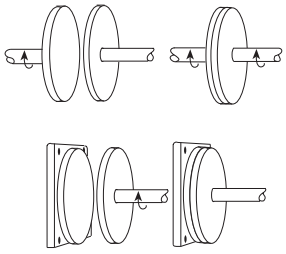
CLUTCH & BRAKE BASICS

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.

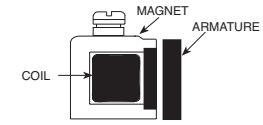
Both a clutch and brake transmit torque mechanically in response to an electrical signal.

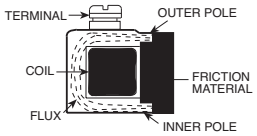
In a clutch, a disc on a revolving shaft is connected by magnetic attraction to a disc on a stationary shaft thus starting the drive.

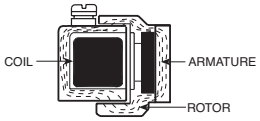
In a brake, one disc is fixed and magnetic attraction stops the revolving disc.



THE DISCS ARE CONNECTED BY MEANS OF ELECTRO-MAGNETIC ATTRACTION





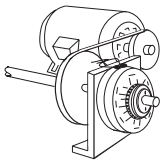


In a brake, one disc (the magnet) contains a coil embedded in a circular horseshoe shaped cavity. The other disc (the armature) consists of segments of iron attached to backing plate.

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.

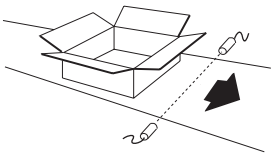
EMERGENCY STOP

Signal to brake brings malfunctioning system to a fast stop.

HOLDING

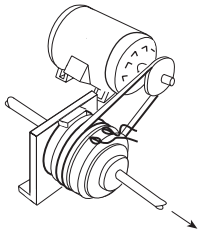
Fully engaged brake holds machine in stopped position.

CLUTCH/BRAKE



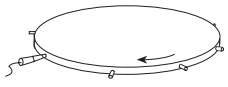
LINEAR POSITIONING

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

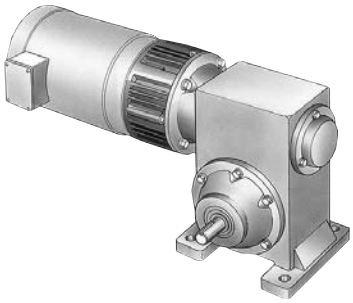
Programmed sequencer alternately engages the clutch and brake, producing programmed start-stop sequence.

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

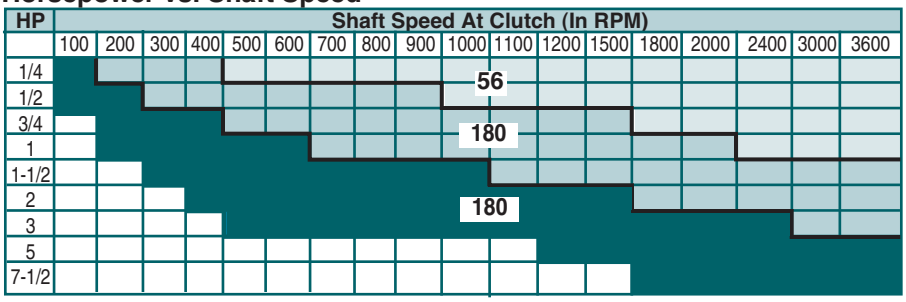


An optional conduit box is available. It has two conduit connection holes for 1/2" standard conduit connectors.

To select the correct module package:

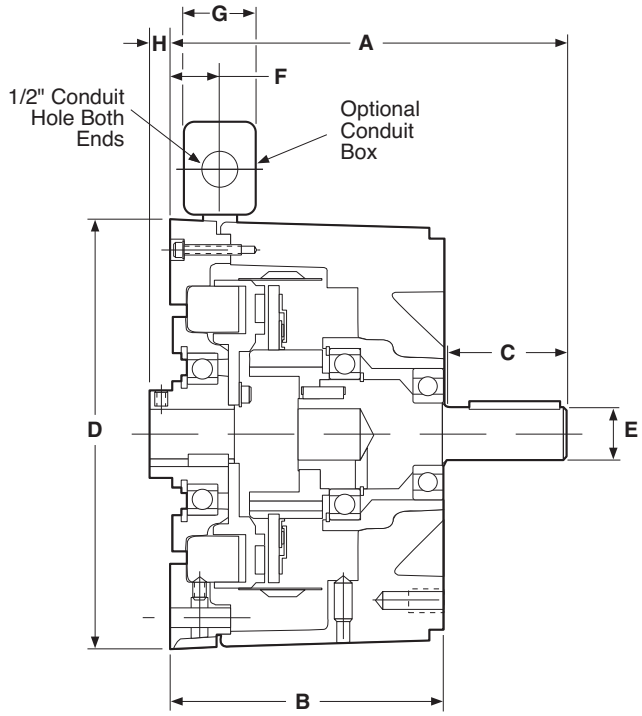
1. Determine the frame size, horsepower and output rpm of your motor.
2. Choose the right size module from the horsepower versus shaft speed chart and the NEMA mounting flange.

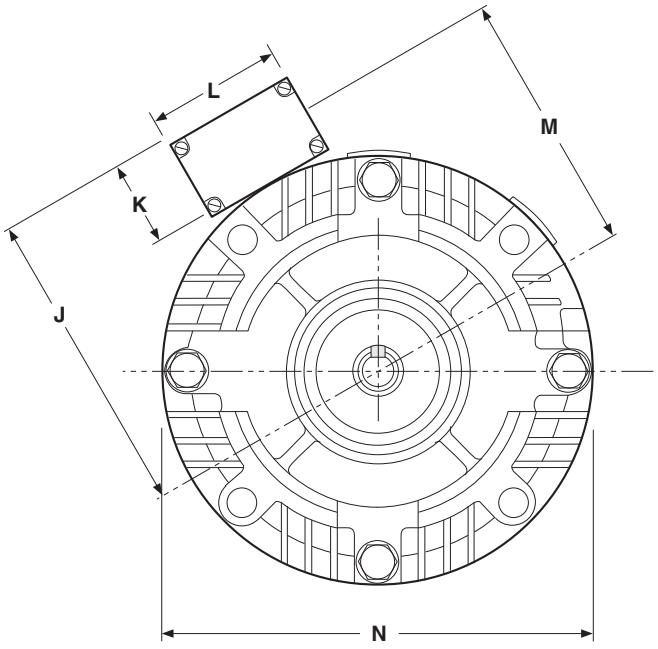
Horsepower vs. Shaft Speed



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	56C/48Y	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.

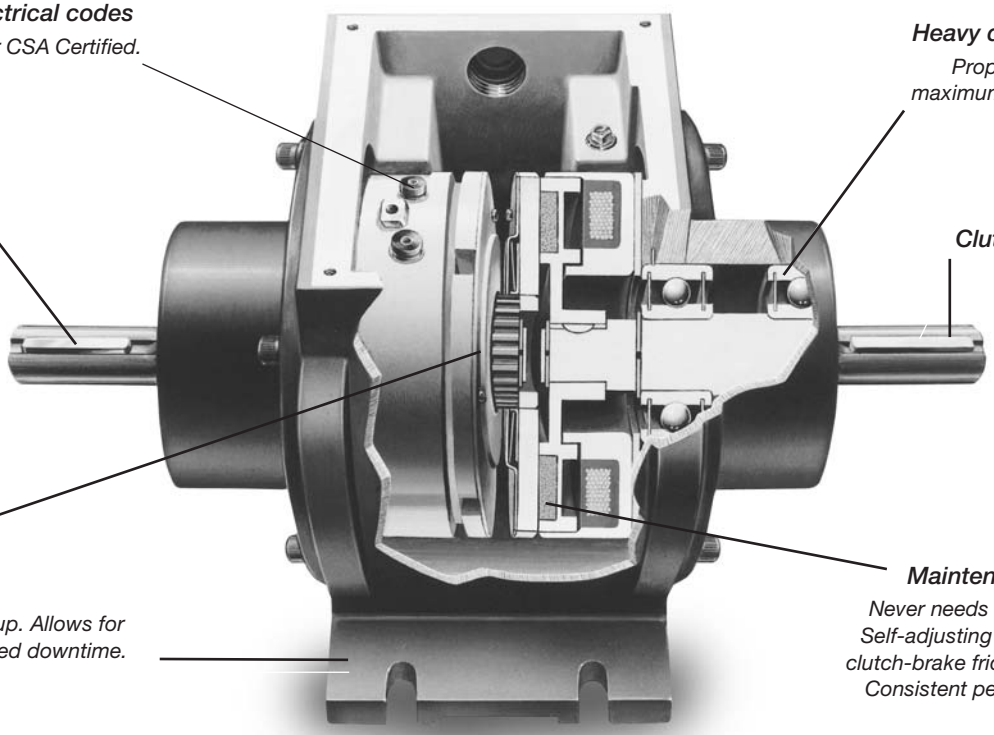
SIZE*	A	B	C	D	E	F	G	H
56 - 16A	6.750	4.844	1.813	6.750	.625	.937	2.203	----
180 - 30A	6.828	4.844	1.891	6.750	.875	.937	2.203	----
210 - 95A	8.891	5.922	2.500	9.250	1.125	.500	2.203	.500

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



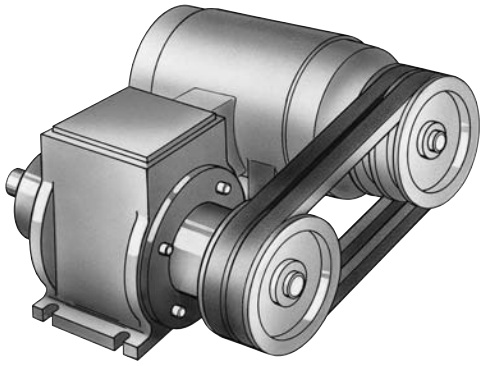
CBF Modules are rugged, pre-assembled clutch and brake combinations in an enclosed, foot mounted housing.

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

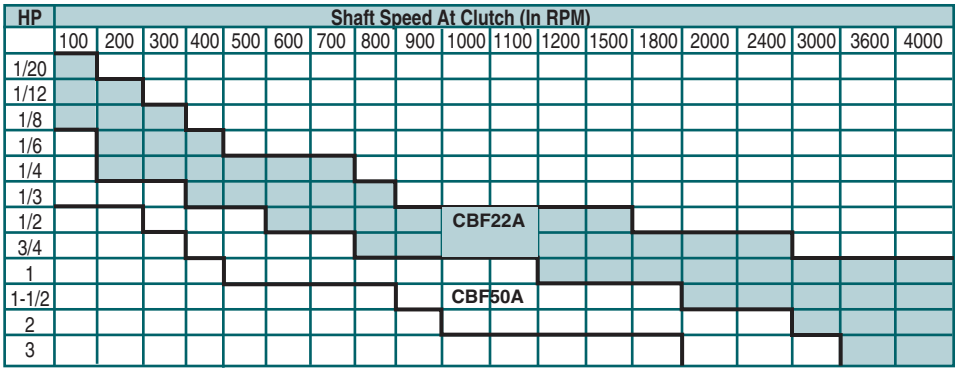


A foot mounted module combines with a motor in a parallel shaft drive application.

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



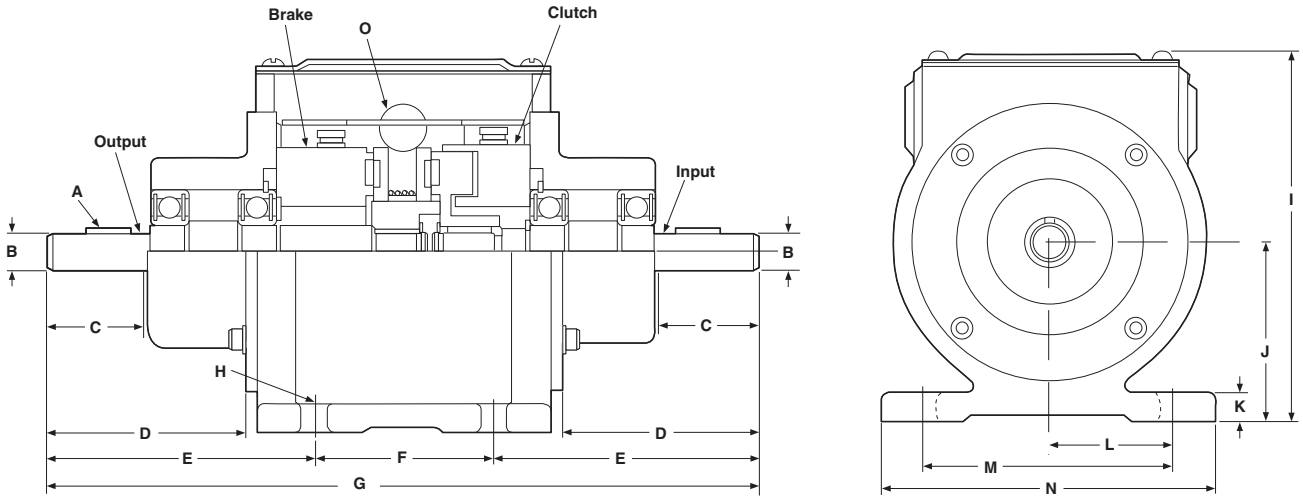
ORDER BY CATALOG NUMBER OR ITEM CODE

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

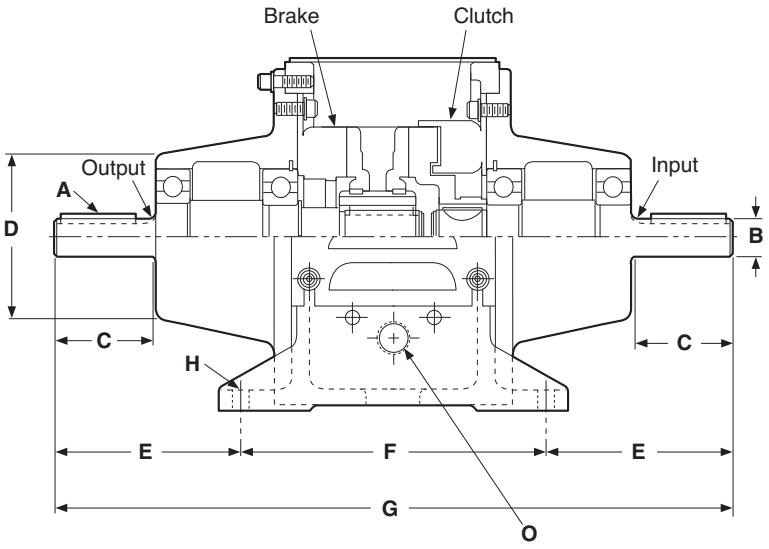


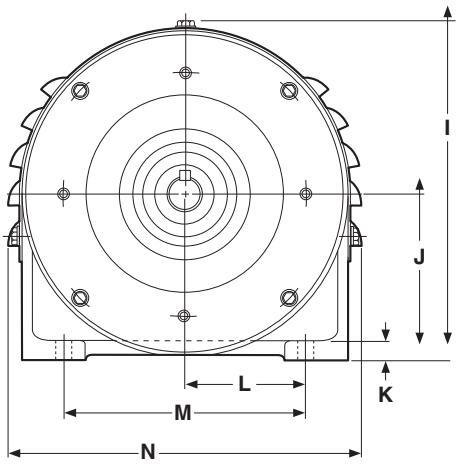
Size	A	B	C Min.	D	E	F	G Max.	H
CBF22A	3/16 x 3/16 x 1-1/2	.7495 / .7485	1.875	3.515	4.593	2.500	11.781	.312 Wide (4 slots)

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-WR (lb-in²)			Max. RPM	Weight lbs.
		Output		Input		
CBF22A	270	2.566	2.222	19.7	4500	





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 40	50	2.222		4000	56
Brake			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.

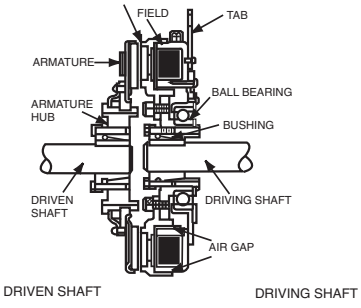
Brakes are ***flanged mounted*** with the field held stationary on a machine member.

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

For application engineering see Pages 113-127.

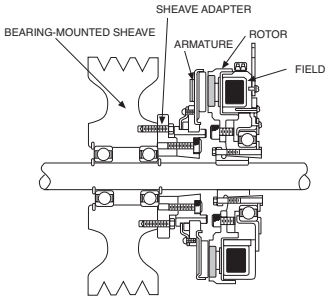
CLUTCH, BEARING-MOUNTED, SPLIT SHAFT (TYPE S)

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.



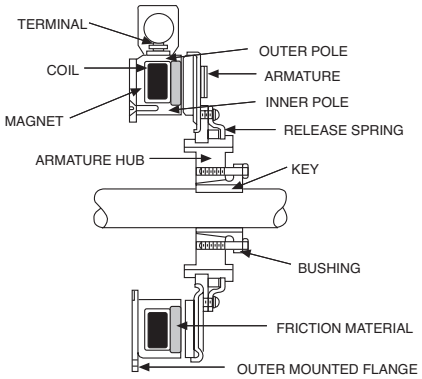
CLUTCH, BEARING MOUNTED, THROUGH SHAFT (TYPE T)

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)



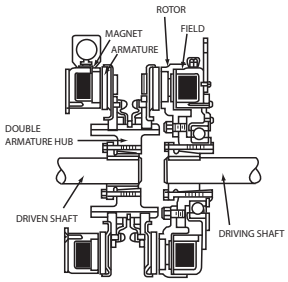
BRAKE, FLANGE MOUNTED

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.



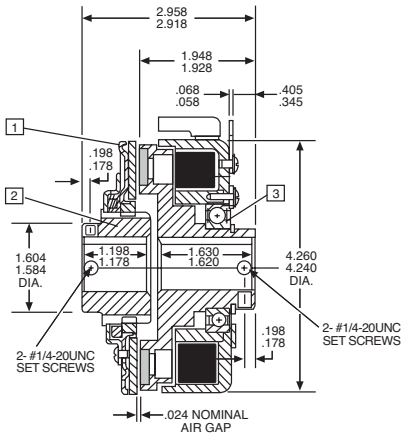
RATINGS

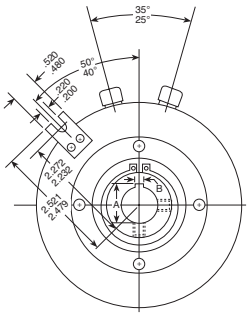
Static Torque: 20 Lb. Ft.
Maximum Speed: 4500 RPM
Voltage: 90 VDC
Resistance at 20°C: 1087 ±5% ohms
Maximum Current: .087 Amps
Maximum Watts: 7.83
Coil Build-up: 95 ms
Coil Decay: 23 ms

INSTALLATION REQUIREMENTS — C20S

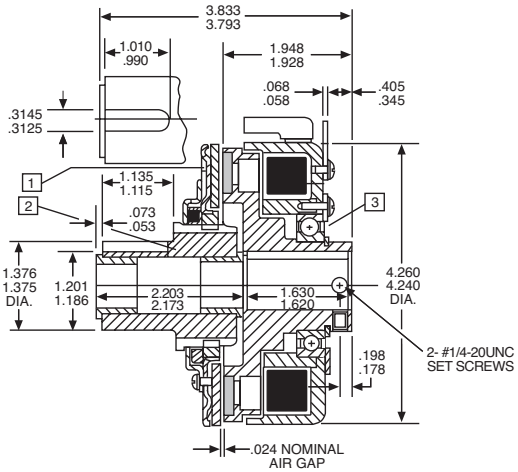
Angular alignment of shafts within .006" TIR at 5" diameter
Armature mounting shaft concentric with rotor mounting shaft within .003" TIR

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	

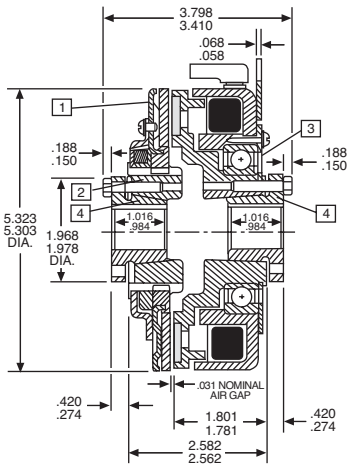
ALL DIMENSIONS IN INCHES					ORDER BY ITEM CODE			
STANDARD BORES		KEYWAY DIMENSIONS*			ITEM CODES			
					No. 1 Armature	No. 2 Armature Hub		No. 3 Field and Rotor Assembly
Nominal	Actual	Keyway	A	B	C20S/C20T	C20S	C20T	C20S/C20T
1/2	.5005/.5015	1/8 × 1/16	.560/.565	.126/.128		45062	45067	45070
5/8	.6255/.6270	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.

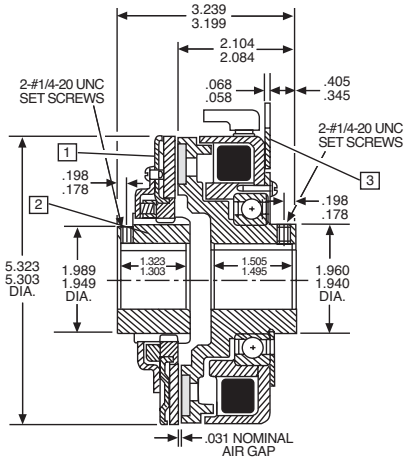
Clutches

C50 Series
90 VDC

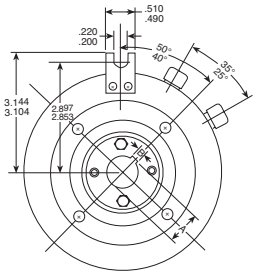
SPLIT SHAFT MODELS — C50S



1/2-1" BORES



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



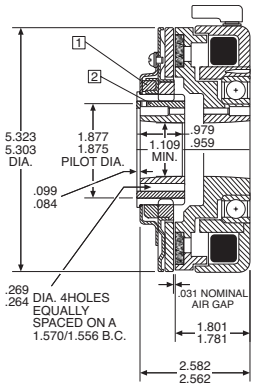
RATINGS

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			ITEM CODES					
					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.

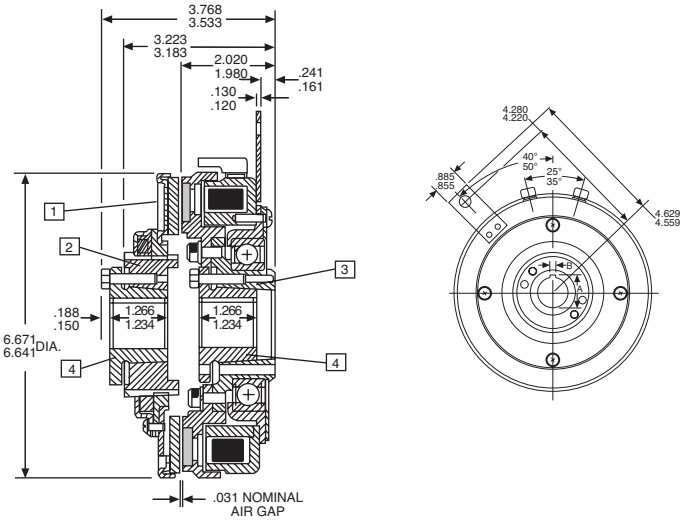
RATINGS

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

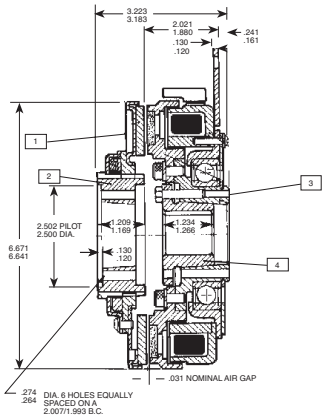
INSTALLATION REQUIREMENTS

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		ITEM CODES			
Nominal	Actual	A	B	No. 1 Armature C100S/C100T	No. 2 Armature 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

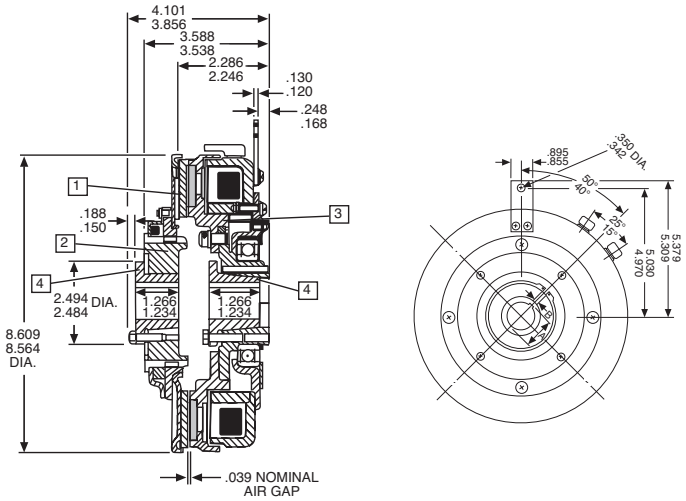
RATINGS

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

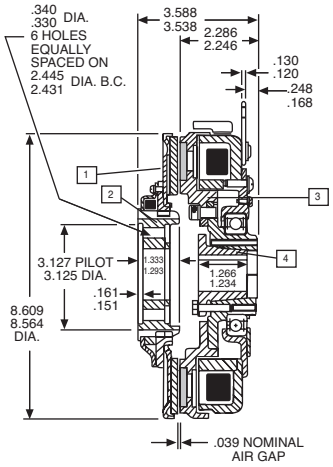
INSTALLATION REQUIREMENTS

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		ITEM CODES			
Nominal	Actual	A	B	No. 1 Armature C150S/C150T	No. 2 Armature Hub C150S/C150T	No. 3 Field and Rotor Assembly C150S/C150T	No. 4 Bushing* 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

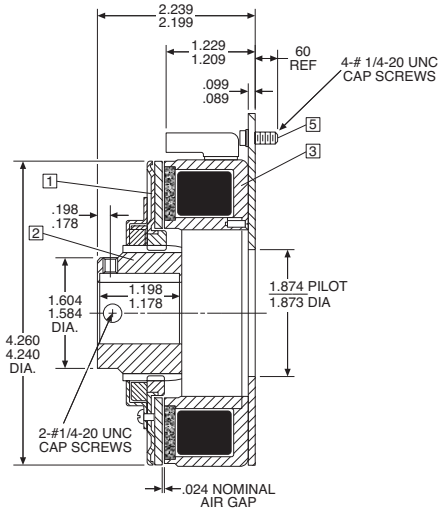
*Two required for C150S Models, one for C150T Models.
HOW TO ORDER: Specify Item Codes for Armature, Armature Hub, Field and Rotor Assembly and Bushing (desired bore and quantity required) for desired type C150S or C150T.

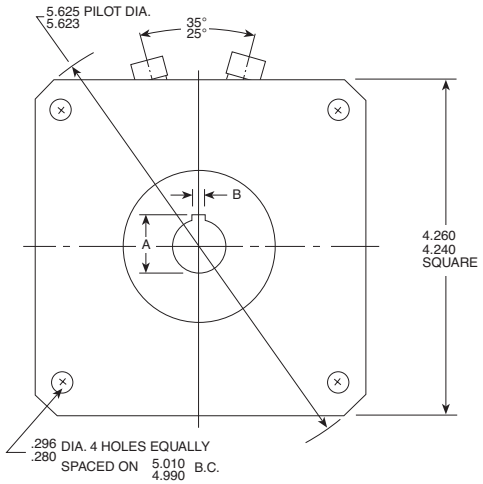
RATINGS

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			ITEM CODES			
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	45061	45062	45075	45081
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		45064		
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

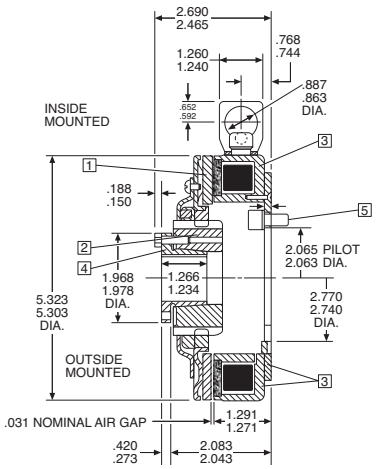
B50 Series
90 VDC

RATINGS

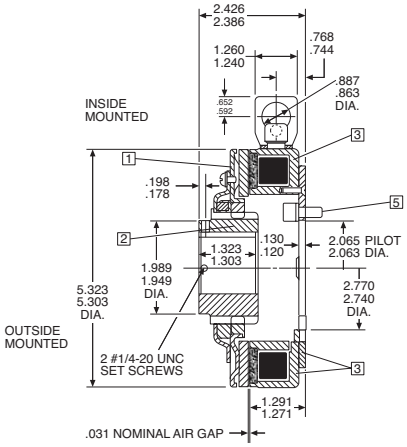
Static Torque: 50 Lb. Ft.
Maximum Speed: 4000 RPM
Voltage: 90 VDC
Resistance at 20°C: 237 ±5% ohms
Maximum Current: .400 Amps
Maximum Watts: 36
Coil Build-up: 65 ms
Coil Decay: 13 ms

INSTALLATION REQUIREMENTS

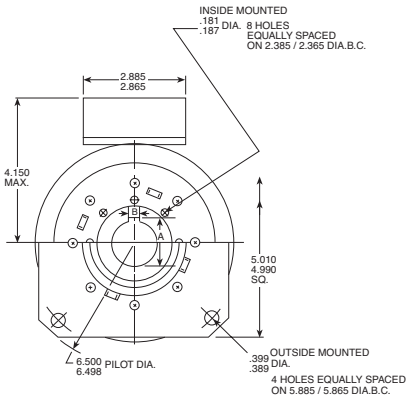
Squareness of brake mounting surface with armature shaft within .006" TIR at 4" diameter.
Concentricity of brake mounting pilot diameter with armature shaft within .010" TIR.



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		ITEM CODES						
							No. 3 Field Assembly			No. 5 Field Mounting Hardware	
Nominal	Actual	Keyway	A	B	No. 1 Armature	No. 2 Armature Hub	Inside	Outside	No. 4 Bushing	Inside Mounting	Outside Mounting
1/2	.5000/.5015	—	.555/.565	.124/.126	45091	45092	45098	45163	45166	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				45099			
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		—			

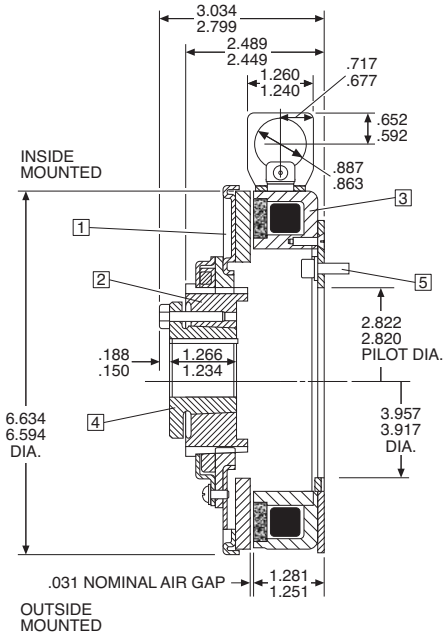
HOW TO ORDER: Specify Item Codes for Armature, Armature Hub (desired bore), Field Assembly, (inside or outside mounting) Bushing (desired bore) and Field Mounting Hardware.

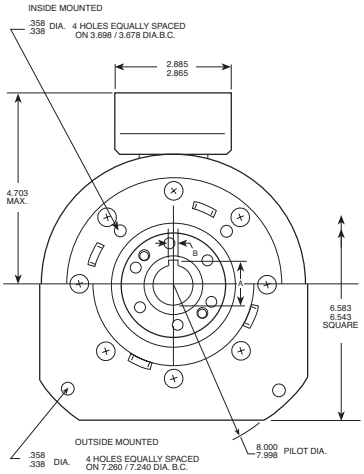
RATINGS

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. 3 Field Assembly			No. 5 Field Mounting Hardware	
Nominal	Actual	A	B	No. 1 Armature	No. 2 Armature Hub	Inside Mounted	Outside Mounted	No. 4 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

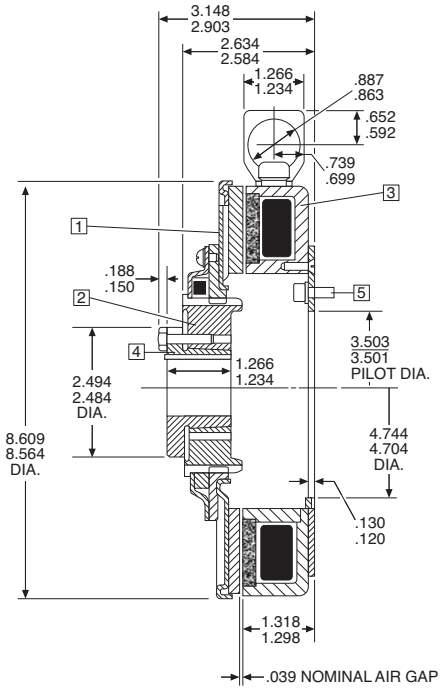
B150 Series
90 VDC

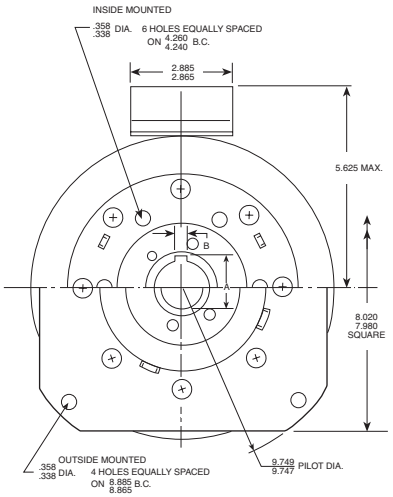
RATINGS

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. 3 Field Assembly			No. 5 Field Mounting Bushing Hardware	
Nominal	Actual	A	B	No. 1 Armature	No. 2 Armature Hub	Inside Mounted	Outside Mounted	No. 4 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		

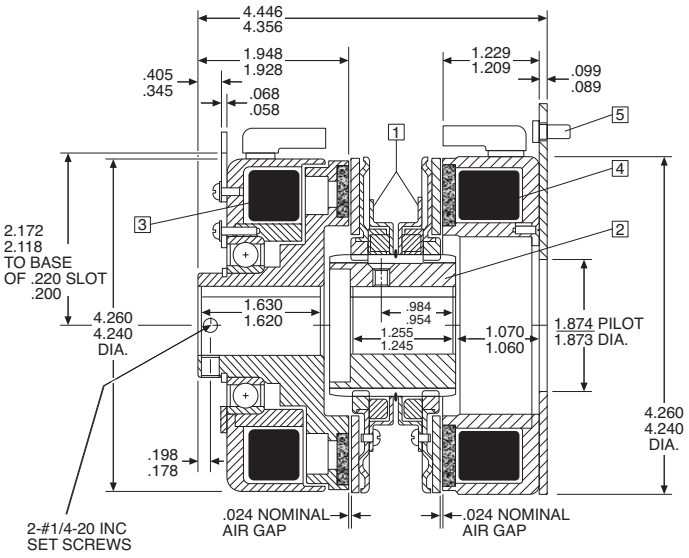
HOW TO ORDER: Specify Item Codes for Armature, Armature Hub (desired bore), Field Assembly (inside or outside mounting), Bushing (desired bore) and Field Mounting Hardware.

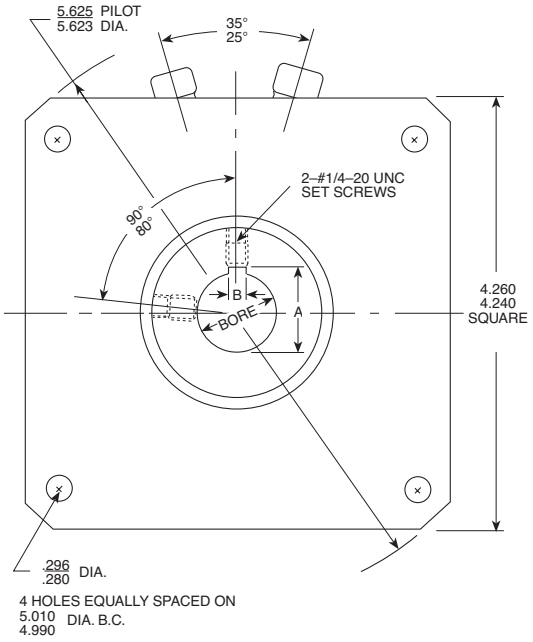
RATINGS

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			ITEM CODES				
Nominal	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

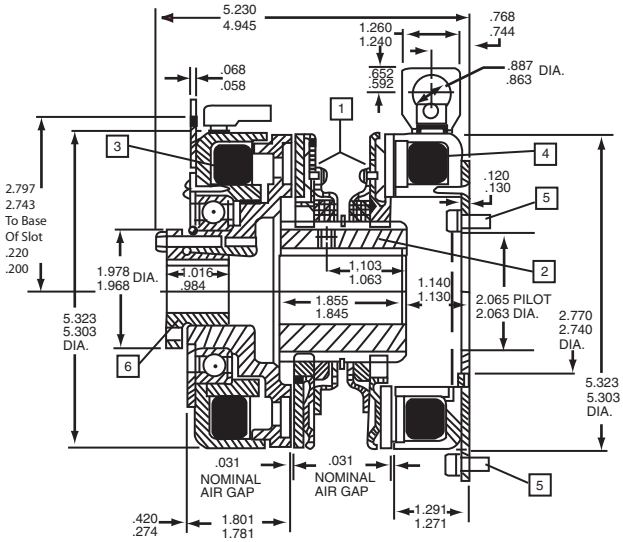
CB-50S Series
90 VDC

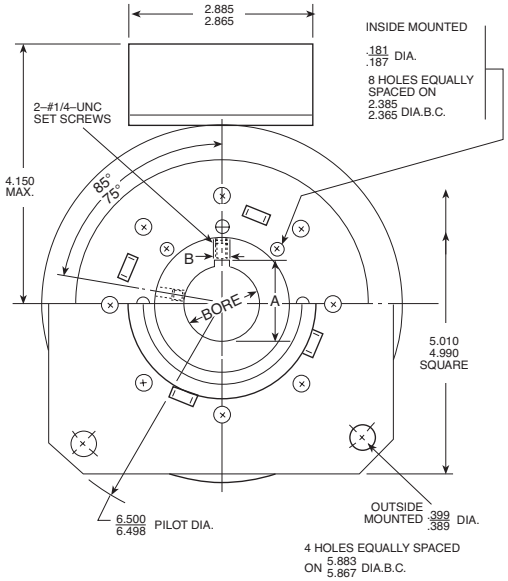
RATINGS

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		ITEM CODES							
Nominal	Actual	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 Hardware		No. 6 Bushing
							Inside Mounted	Outside Mounted	Inside Mounting	Outside Mounting	
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					—

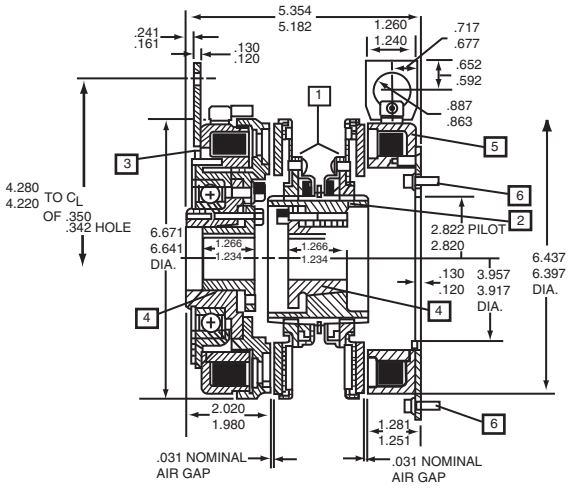
HOW TO ORDER: Specify Item Codes for Armatures, Armature Hub (desired bore), Field Rotor Assembly (desired bore), Brake Field (inside or outside mounting), Brake Field Mounting Hardware and Bushing (desired bore).

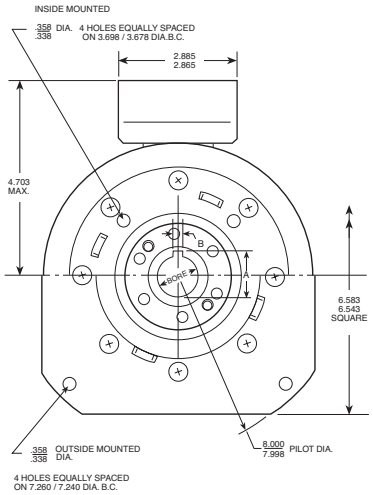
RATINGS

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		ITEM CODES							
								No. 5 Brake Field		No. 6 Brake Field Mtg. Hardware	
Nominal	Actual	A	B	No. 1 Armature (2 Req'd.)	No. 2 Armature Hub	No. 3 Field Rotor Assembly	No. 4 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

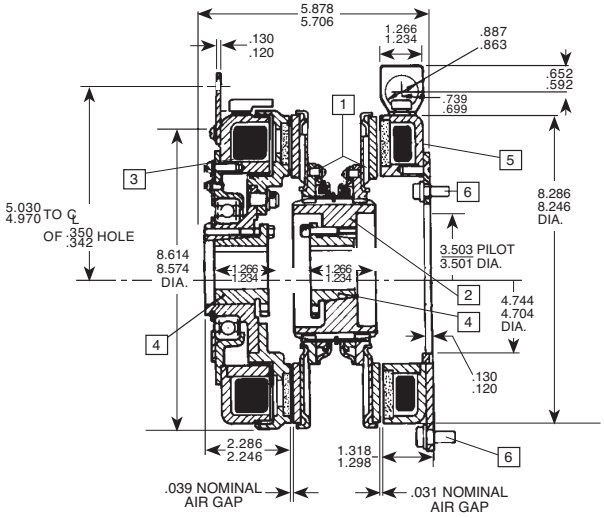
CB-150S Series
90 VDC

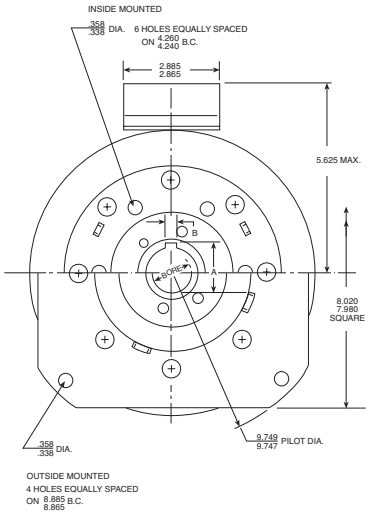
RATINGS

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		ITEM CODES							
								No. 5 Brake Field		No. 6 Brake Field Mounting Hardware	
Nominal	Actual	A	B	No. 1 Armature (2 Req'd.)	No. 2 Armature Rotor	No. 3 Field Assembly Hub	No. 4 Inside 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.

DC Power Supplies/Controls

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

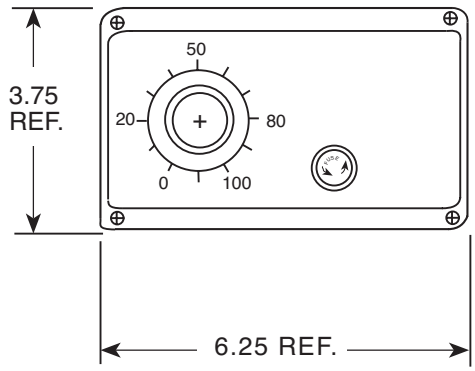
Other versions, modified or special, are available.

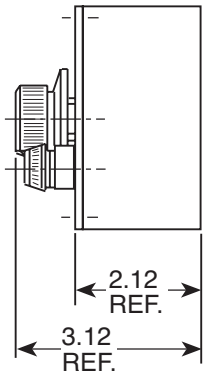
All controls operate one or two units – one unit at a time – through the use of SPDT switch, 15 Amp rated. (Customer supplied)

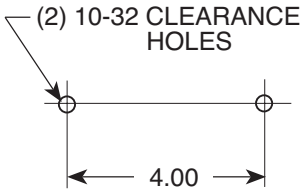
ORDER BY CATALOG NUMBER OR ITEM CODE

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)

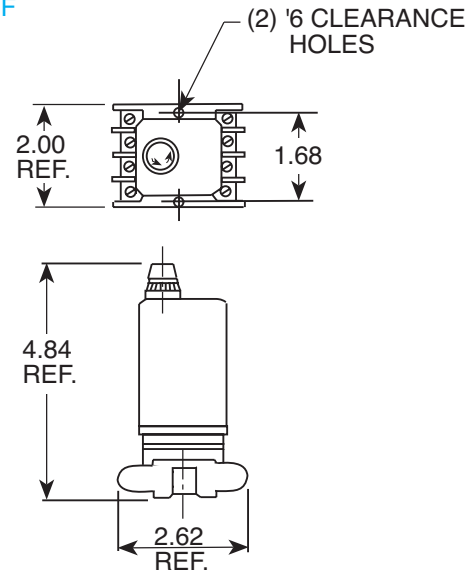




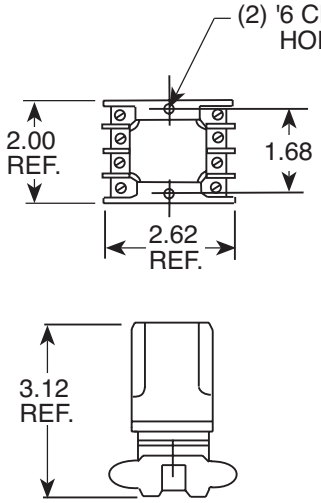


WALL MOUNTING HOLE PATTERN

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.

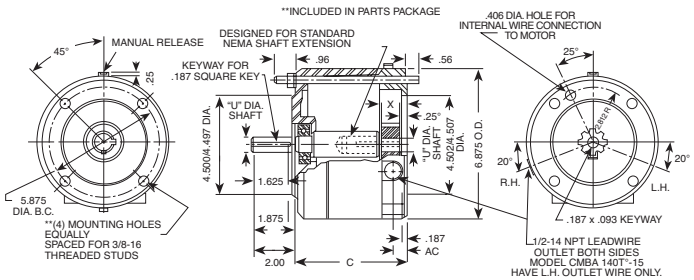
SPLINED HUB

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

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*

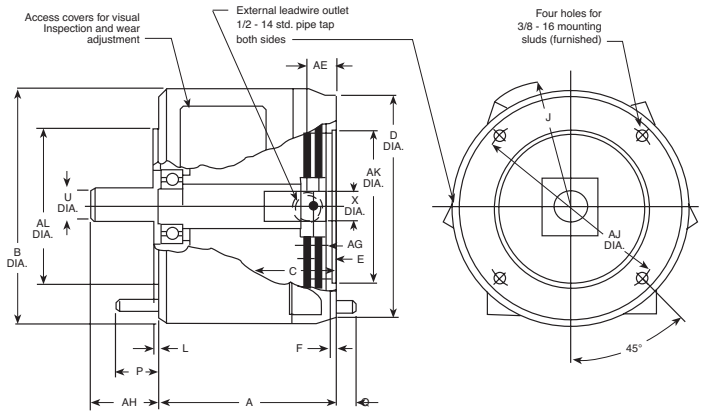
ORDER BY CATALOG NUMBER OR ITEM CODE

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

Double C-Face Brakes Washdown (BISSC)

CMB-WB Series

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

MBRK Series

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-W	65348
1/3	56C	B5	230/460-3-60	EUTF-W	65383
1/3	56C	B5	575-3-60	EYTF-W	65454
1/2	56C	B5	115/230-1-60	FRTF-W	65350
1/2	56C	B5	230/460-3-60	FUTF-W	65404
1/2	56C	B5	575-3-60	FYTF-W	65455
3/4	56C	B5	115/230-1-60	GRTF-W	65351
3/4	56C	B5	230/460-3-60	GUTF-W	65405
3/4	56C	B5	575-3-60	GYTF-W	65457
1	56C	B5	115/230-1-60	HRTF-5/8-W	65354
1	143TC	B7	115/230-1-60	HRTF-W	66234
1	56C	B5	230/460-3-60	HUTF-5/8-W	65406
1	143TC	B7	230/460-3-60	HUTF-W	65412
1	143TC	B7	575-3-60	HYTF-W	65460
1-1/2	145TC	B7	115/230-1-60	JRTF	63800
1-1/2	56C	B5	230/460-3-60	JUTF-5/8-W	65407
1-1/2	145TC	B7	230/460-3-60	JUTF-W	65437
1-1/2	145TC	B7	575-3-60	JYTF-W	65475
2	56C	B5	230/460-3-60	KUTF-5/8-W	65440
2	145TC	B7	230/460-3-60	KUTF-W	65445
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.

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SHUNT WOUND OPEN DRIPPROOF 1/6-5 HP 89

SHUNT WOUND TEFC 1/6-5 HP 90

SHUNT WOUND EXPLOSION PROOF 1/2-1 HP 91

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
25 - 1/4 HP
33 - 1/3 HP
50 - 1/2 HP
75 - 3/4 HP
100 - 1 HP
150 - 1-1/2 HP
200 - 2 HP
300 - 3 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

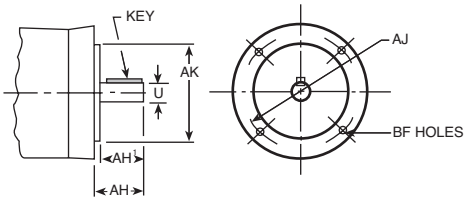
OPTIONS AND MODIFICATIONS

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 Pages 49 and 50 for stock tachometer generators.

***Motor Enclosures described on Page 81.**

NEMA C-Face Motor Bolt Circle Dimensions

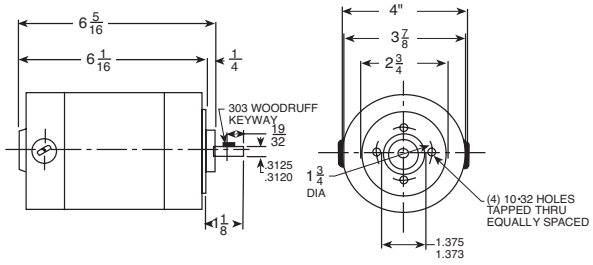


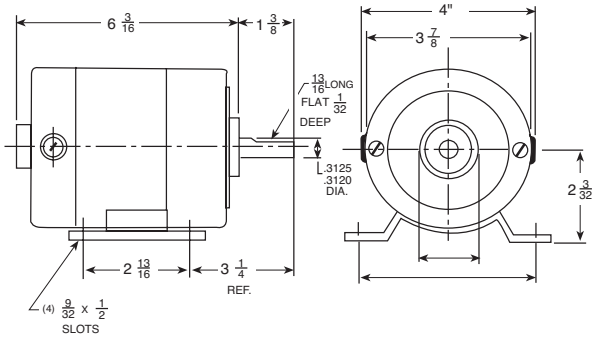
Boston Gear Bore Code	NEMA Frame No.	U	AK	Max. AH	Max. AH[1]	Key SQ.	Key LG.	AJ	BF
B4	42CZ	.5000 .4995	3.000 2.997	1-5/16	—	1/8	3/4	3.750	1/4–20
B5	56C	.6250 .6245	4.500 4.497	2-5/32	—	3/16	1-3/8	5.875	3/8-16
B7	56CZ 182C 184C	.8750 .8745	4.500 4.497	2-5/32	—	3/16	1-3/8	5.875	3/8–16
	143TC 145TC								
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[1] must not be exceeded.

Permanent Magnet TENV

1/12 Horsepower





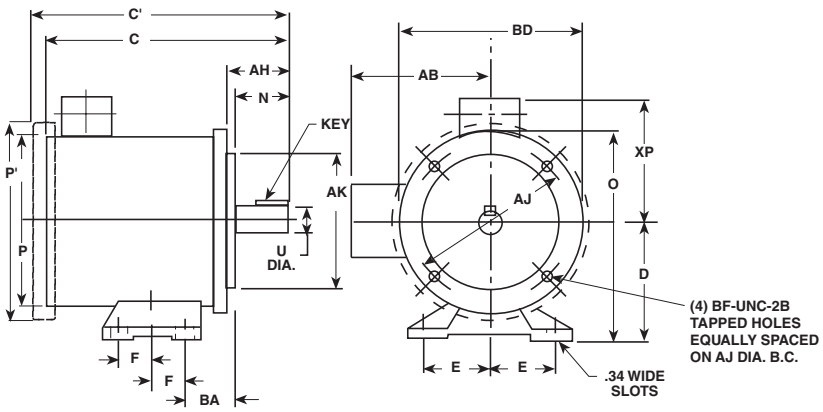
ORDER BY CATALOG NUMBER OR ITEM CODE

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

DC MOTORS

NEMA C-Face w/Removable Bases

Permanent Magnet TENV & TEFC 1/6-5 HP 1750 RPM



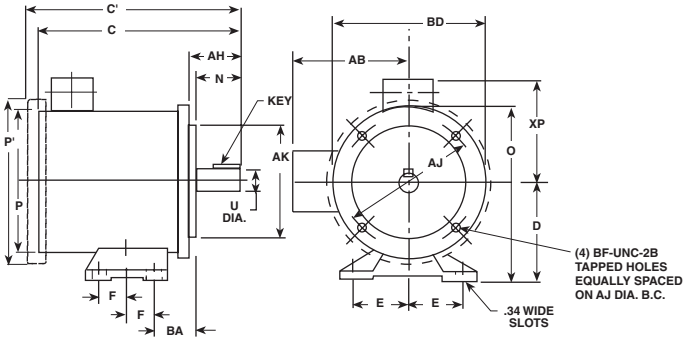
ORDER BY CATALOG NUMBER OR ITEM CODE

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 Arma-ture	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	–

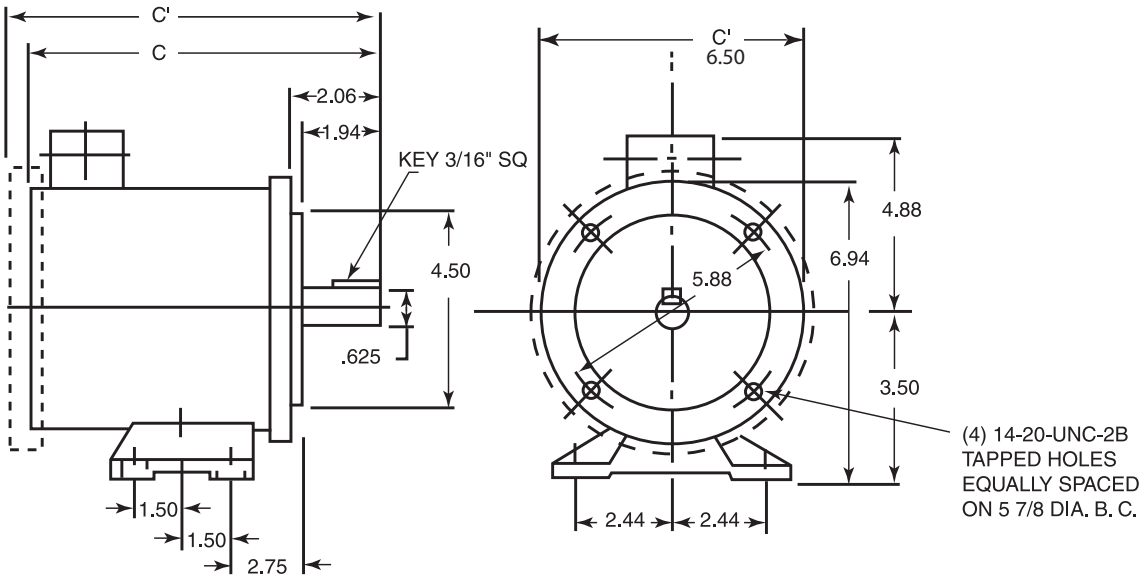
** The conduit box is located 90 degrees to the base
*** .41 wide slots on 3 & 5 HP motors
All dimensions in inches. Dimensional information for estimating purposes only.

Permanent Magnet TENV/TEFC

1/4-1 1/2 Horsepower

1750 RPM

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.



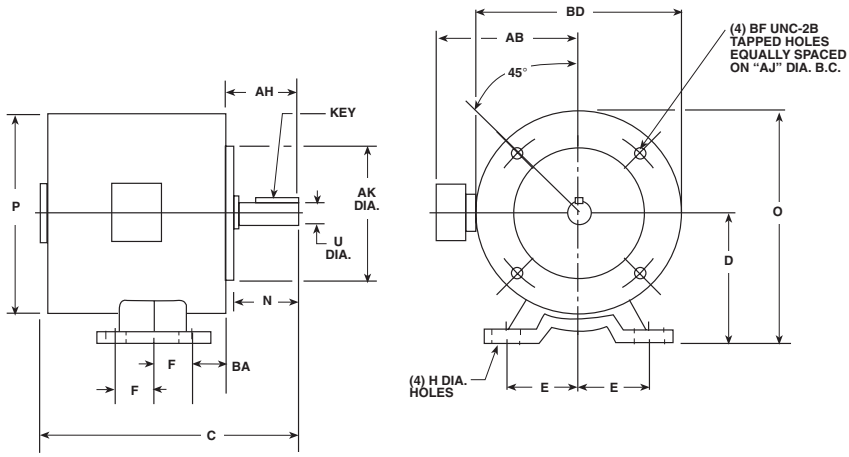
ORDER BY CATALOG NUMBER OR ITEM CODE

HP	Volts Arma-ture	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 Dripproof
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	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

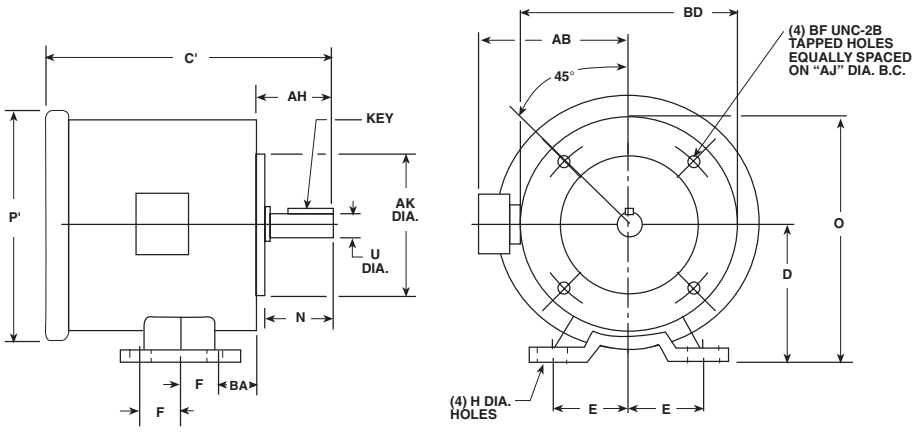
HP	Catalog Number	Item Code	U +.0000 -.0005	Key		AB	AH	AJ	AK	BA	BD	BF	Approx. Weight (lbs.)
				Sq.	Long								
1/6	V91600-B	66666	.6250	3/16	1.38	4.50	2.06	5.88	4.500	2.69	6.63	3/8-16	22
1/4	V92500-B	66669	.6250	3/16	1.38	4.50	2.06	5.88	4.500	2.69	6.63	3/8-16	22
1/3	V93300-B	66672	.6250	3/16	1.38	4.50	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.

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.

NEMA C-FACE
With Removable Base

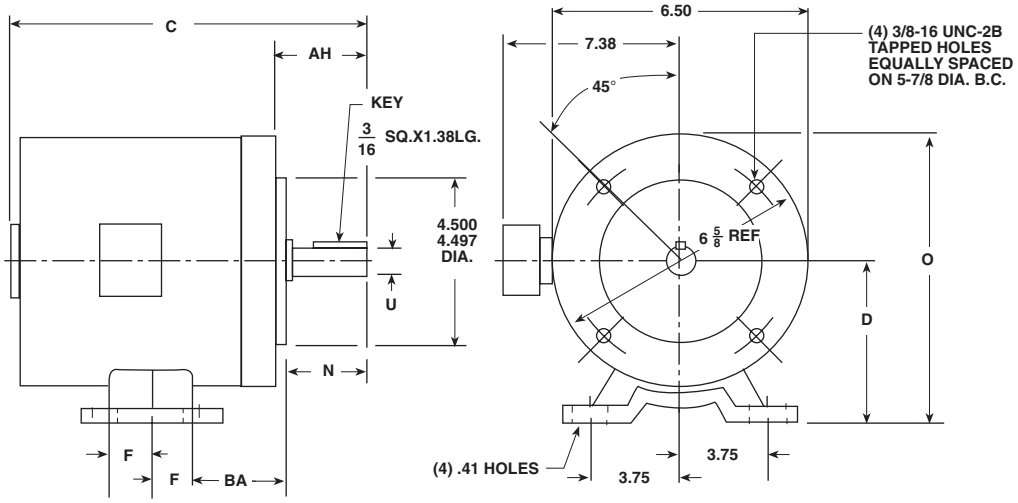
Shunt Wound
Explosion Proof
1/2-1 HP
1750 RPM

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.

NOTES

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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 81.

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.

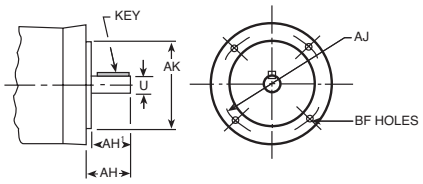
Prefix	H.P.	Voltage	Enclosure	Suffix	Manufacturer
A-Small Frame	A - 1/20	R 115/230-1-60	No letter-Dripproof	B-Brake	B-Balder
B-Rigid Base	AA - 1/12	S 115-1-60	T-TENV	35-3450 RPM	W-WEG
	B - 1/8	T 230-1-60	TF-TEFC	11-1150 RPM	
	C - 1/6	U 230/460-3-60	X-Explosion Proof		
	D - 1/4	Y 575-3-60	WB-Washdown 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 or "W"- -WEG
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.

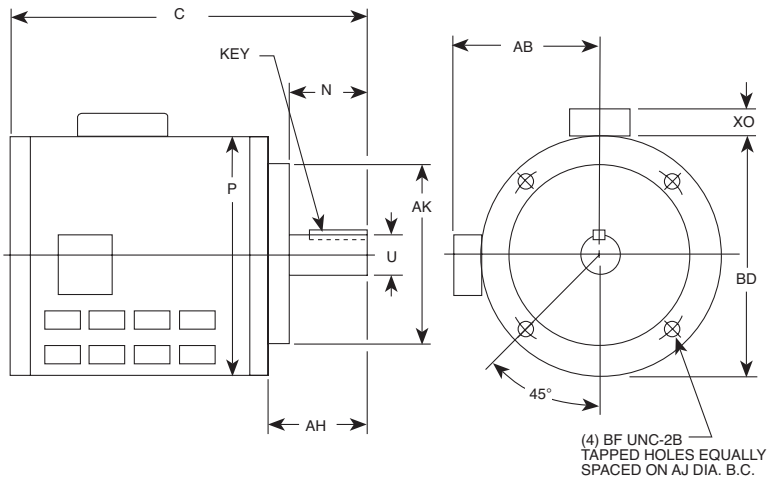
NEMA C-Face Bolt Circle Dimensions



Boston Gear Bore Code	NEMA Frame No.	U	AK	Max. AH	Max. AH'	Key Sq.	Key Lg.	AJ	BF
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	.8750 .8745	4.500 4.497	2-5/32	—	3/16	1-3/8	5.88	3/8-16
	143TC 145T C								
B9	213C 215C	1.1250 1.1245	8.500 8.497	—	2-25/32	1/4	1-3/4	7.25	1/2-13
	182TC 184TC								
B11	254UC 256UC	1.3750 1.3745	8.500 8.497	—	3-17/32	5/16	2-3/8	7.25	1/2-13
	213TC 215TC								
B13	254TC 256TC	1.6250 1.6240	8.500 8.497	—	3-13/16	3/8	2-7/8	7.25	1/2-13

110/220 VAC 1ø 50 Hz
115 VAC 1ø 60 Hz
115/230 VAC 1ø 60 Hz

Open Dripproof
NEMA C-Face
Single Phase
1/4–1-1/2 Horsepower



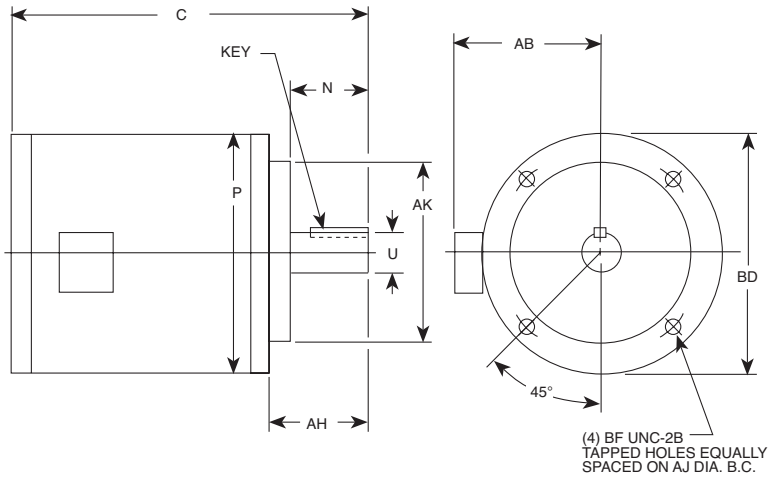
ORDER BY CATALOG NUMBER OR ITEM CODE

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	0.625	3/16	1.38	4.75	2.06	5.88	4.50	5.87	3/8-16	1.54	22
1/3	1425	3.2	56C	B5	ER5-B	66866	10.69	1.94	5.69	0.625	3/16	1.38	4.75	2.06	5.88	4.50	5.87	3/8-16	1.54	25
1/2	1425	4.4	56C	B5	FR5-B	66872	11.56	1.94	5.69	0.625	3/16	1.38	4.75	2.06	5.88	4.50	5.87	3/8-16	1.54	27
3/4	1425	6.5	56C	B5	GR5-B	66878	11.06	1.94	6.63	0.625	3/16	1.38	5.75	2.06	5.88	4.50	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	0.313	See	Note	—	1.18	1.75	1.38	4.64	10/32	—	10
1/12	1725	2.0	SP	SPL	AAST-B	65402	8.98	0.93	3.86	0.313	See	Note	—	1.18	1.75	1.38	4.64	10/32	—	10
1/4	1725	2.7	56C	B5	DS	63316	8.88	1.94	5.61	0.625	3/16	1.38	—	2.06	5.88	4.50	5.61	3/8-16	1.94	16
1/4	1725	5.0	56C	B5	DS-B	66112	10.25	1.94	5.69	0.625	3/16	1.38	4.50	2.06	5.88	4.50	5.81	3/8-16	1.54	22
1/4	1725	5.3	56C	B5	DS-W	65220	9.65	1.91	5.71	0.625	3/16	1.10	—	2.06	5.88	4.50	5.75	3/8-16	—	19
115/230 VAC 1ø 60 Hz																				
1/6	1725	2.0	56C	B5	CR-W	65221	9.65	1.91	5.71	0.625	3/16	1.10	—	2.06	5.88	4.50	5.75	3/8-16	—	18
1/6	1725	1.9	56C	B5	CR-B	85773	10.09	1.93	—	0.625	3/16	1.38	4.41	2.06	5.88	4.50	5.87	3/8-16	1.41	18
1/4	1725	2.7	56C	B5	DR	63315	8.88	1.94	5.61	0.625	3/16	1.38	—	2.06	5.88	4.50	5.61	3/8-20	1.94	16
1/4	1725	2.7	56C	B5	DR-W	65222	9.65	1.91	5.71	0.625	3/16	1.10	—	2.06	5.88	4.50	5.75	3/8-16	—	19
1/4	1725	2.5	56C	B5	DR-B	66109	10.25	1.94	5.69	0.625	3/16	1.38	4.88	2.06	5.88	4.50	5.81	3/8-16	1.54	22
1/3	1725	3.1	56C	B5	ER	63317	9.38	1.94	5.61	0.625	3/16	1.38	—	2.06	5.88	4.50	5.61	3/8-20	1.94	19
1/3	1725	3.1	56C	B5	ER-W	65223	10.55	1.91	5.71	0.625	3/16	1.10	—	2.06	5.88	4.50	5.45	3/8-16	—	22
1/3	1725	3.0	56C	B5	ER-B	66121	10.25	1.94	5.69	0.625	3/16	1.38	4.88	2.06	5.88	4.50	5.81	3/8-16	1.54	25
1/2	1725	4.4	56C	B5	FR	63318	9.88	1.94	5,61	0.625	3/16	1.38	—	2.06	5.88	4.50	5.81	3/8-20	1.94	19
1/2	1725	4.4	56C	B5	FR-W	65224	10.55	1.91	5.71	0.625	3/16	1.10	—	2.06	5.88	4.50	5.75	3/8-16	—	24
1/2	1725	4.2	56C	B5	FR-B	66130	11.56	1.94	5.69	0.625	3/16	1.38	4.75	2.06	5.88	4.50	5.87	3/8-16	1.54	27
3/4	1725	5.4	56C	B5	GR	63319	10.88	1.94	5.61	0.625	3/16	1.38	—	2.06	5.88	4.50	6.50	3/8-16	1.94	26
3/4	1725	5.6	56C	B5	GR-B	66139	11.56	1.94	6.63	0.625	3/16	1.38	5.88	2.06	5.88	4.50	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	0.625	3/16	1.38	5.75	2.06	5.88	4.50	6.50	3/8-16	2.18	35
1	1725	6.5	143TC	B7	HR-B	66145	12.13	1.94	6.63	0.875	3/16	1.38	5.75	2.13	5.88	4.50	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	0.875	3/16	1.38	5.75	2.13	5.88	4.50	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)

208-230/460 VAC 3ø 60 Hz

Open Dripproof
NEMA C-Face
Three Phase
1/6 – 20 Horsepower



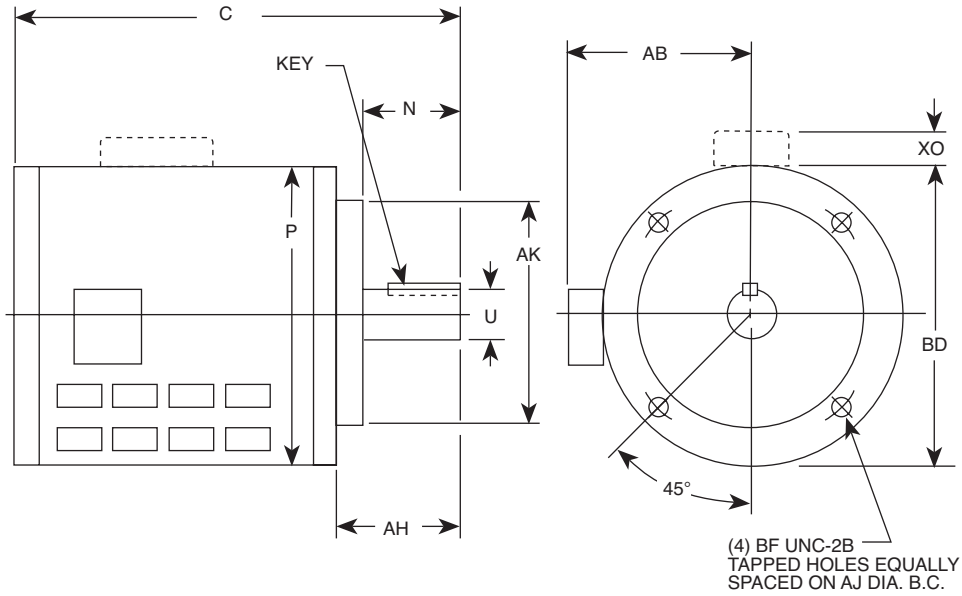
ORDER BY CATALOG NUMBER OR ITEM CODE

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	0.45	56C	B5	CU-B	85774	10.10	1.93	—	0.625	3/16	1.38	4.41	2.06	5.88	4.50	5.87	3/8-16	19
1/6	1725	0.55	56C	B5	CU-W	65237	10.32	1.91	6.50	0.625	3/16	1.10	—	2.06	5.88	4.50	6.54	3/8-16	19
1/4	1725	0.65	56C	B5	DU	63531	9.38	1.94	5.61	0.625	3/16	1.38	—	2.06	5.88	4.50	5.61	3/8-16	16
1/4	1725	0.65	56C	B5	DU-W	65238	10.32	1.91	9.50	0.625	3/16	1.10	—	2.06	5.88	4.50	6.54	3/8-16	19
1/4	1725	0.65	56C	B5	DU-B	66115	10.25	1.94	5.69	0.625	3/16	1.38	4.88	2.06	5.88	4.50	5.88	3/8-16	18
1/3	1725	0.8	56C	B5	EU	63532	9.38	1.94	5.61	0.625	3/16	1.38	—	2.06	5.88	4.50	5.61	3/8-16	18
1/3	1725	0.8	56C	B5	EU-W	65239	10.32	1.91	6.50	0.625	3/16	1.10	—	2.06	5.88	4.50	6.54	3/8-16	19
1/3	1725	0.8	56C	B5	EU-B	66124	10.25	1.94	5.69	0.625	3/16	1.38	4.88	2.06	5.88	4.50	5.88	3/8-16	21
1/2	1725	1.0	56C	B5	FU	63533	9.88	1.94	5.61	0.625	3/16	1.38	—	2.06	5.88	4.50	5.61	3/8-16	20
1/2	1725	1.0	56C	B5	FU-W	65241	10.32	1.91	6.50	0.625	3/16	1.10	—	2.06	5.88	4.50	6.54	3/8-16	20
1/2	1725	1.0	56C	B5	FU-B	66133	10.31	1.94	5.69	0.625	3/16	1.38	4.75	2.06	5.88	4.50	5.88	3/8-16	22
3/4	1725	1.4	56C	B5	GU	63536	10.88	1.94	5.61	0.625	3/16	1.38	—	2.06	5.88	4.50	5.61	3/8-16	22
3/4	1725	1.4	56C	B5	GU-W	65243	11.10	1.91	6.50	0.625	3/16	1.10	—	2.06	5.88	4.50	6.54	3/8-16	24
3/4	1725	1.5	56C	B5	GU-B	66142	11.56	1.94	5.69	0.625	3/16	1.38	4.75	2.06	5.88	4.50	5.88	3/8-16	26
1	1725	1.7	56C	B5	HU-5/8	63537	10.88	1.94	6.53	0.625	3/16	1.38	—	2.06	5.88	4.50	5.88	3/8-16	31
1	1725	1.7	56C	B5	HU-5/8-W	65246	11.10	1.91	6.50	0.625	3/16	1.10	—	2.06	5.88	4.50	6.54	3/8-16	26
1	1725	1.7	56C	B5	HU-5/8-B	50427	11.06	1.94	6.63	0.625	3/16	1.38	5.63	2.06	5.88	4.50	6.50	3/8-16	33
1	1725	1.7	56C	B5	HU	63538	10.88	1.94	6.53	0.875	3/16	1.38	5.09	2.06	5.88	4.50	5.88	3/8-16	31
1	1725	1.7	143TC	B7	HU-B	66148	11.13	2.00	6.63	0.875	3/16	1.38	5.63	2.13	5.88	4.50	6.50	3/8-16	33
1-1/2	1725	2.3	145TC	B7	JU	63539	11.38	1.94	6.53	0.875	3/16	1.38	5.09	2.06	5.88	4.50	5.88	3/8-16	35
1-1/2	1725	2.4	145TC	B7	JU-B	66157	11.13	2.00	6.63	0.875	3/16	1.38	5.63	2.13	5.88	4.50	6.50	3/8-16	34
2	1725	3.1	145TC	B7	KU	63540	11.38	1.94	6.53	0.875	3/16	1.38	5.09	2.06	5.88	4.50	5.88	3/8-16	37
2	1725	3.2	145TC	B7	KU-B	66163	12.13	2.00	6.63	0.875	3/16	1.38	5.63	2.13	5.88	4.50	6.50	3/8-16	37
3	1725	4.4	182TC	B9	LU	63542	12.63	2.63	8.46	1.125	1/4	1.75	6.30	2.89	7.25	8.50	8.88	1/2-13	65
3	1725	4.3	182TC	B9	LU-B	66166	13.63	2.63	7.88	1.125	1/4	1.75	5.88	2.89	7.25	8.50	9.00	1/2-13	66
5	1725	7.2	182TC	B9	MU	63543	13.13	2.63	8.46	1.125	1/4	1.75	6.30	2.89	7.25	8.50	8.88	1/2-13	62
5	1725	7.0	184TC	B9	MU-B	66170	15.00	2.63	7.88	1.125	1/4	1.75	5.88	2.89	7.25	8.50	9.00	1/2-13	80
7-1/2	1725	11.0	213TC	B11	NU-B	66174	17.06	3.13	9.58	1.375	5/16	2.38	7.38	3.38	7.25	8.50	9.00	1/2-13	114
10	1725	14.0	215TC	B11	PU-B	66176	17.06	3.13	9.96	1.375	5/16	2.38	7.38	3.38	7.25	8.50	9.00	1/2-13	118
15	1760	19.9	254TC	B13	RU-B	66180	20.00	3.75	11.50	1.625	3/8	2.88	8.94	4.00	7.25	8.50	9.13	1/2-13	220
20	1760	26.0	256TC	B13	SU-B	66184	21.50	3.75	11.50	1.625	3/8	2.88	8.94	4.00	7.25	8.50	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



ORDER BY CATALOG NUMBER OR ITEM CODE

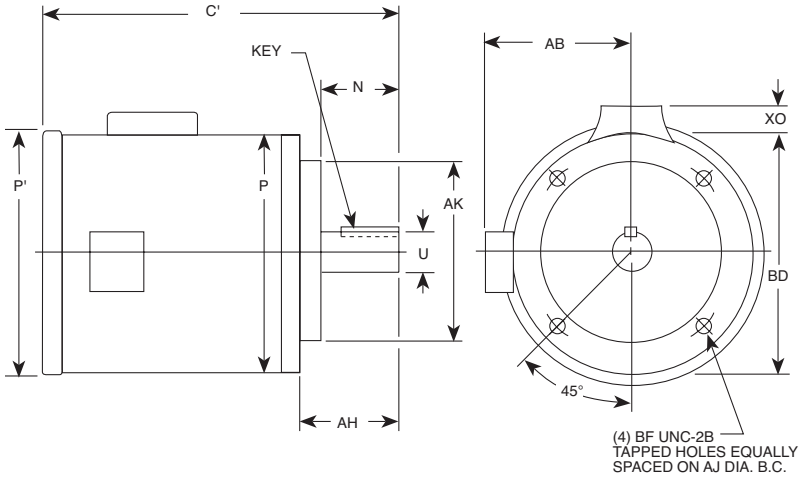
HP	RPM	F.L.A. @ Max Volt	NEMA Mtg.	Bore Code	Catalog Number	Item Code	C	N	P	U +.0000 -.0005	Key Sq.	Key Long	AB	AH	AJ	AK	BD	BF	XO	Wt. Lbs.
115/230 VAC 1ø 60 Hz																				
1/6	1725	2.1	56C	B5	CRT-B	85775	10.25	1.94	—	0.625	3/16	1.38	4.90	2.06	5.88	4.50	5.81	3/8-16	1.50	23
1/6	1725	1.7	42CZ	B4	ACRT-W	65320	8.29	1.10	—	0.500	1/8	0.98	4.23	1.26	3.75	3.00	4.80	1/4-20	—	14.1
1/4	1725	2.4	56C	B5	DRT	63544	9.94	1.94	6.53	0.625	3/16	1.38	—	2.06	5.88	4.50	5.88	3/8-16	1.97	27
1/4	1725	2.7	42CZ	B4	ADRT-W	65325	9.67	1.10	—	0.500	1/8	0.98	4.23	1.26	3.75	3.00	4.80	1/4-20	—	18.3
1/3	1725	2.9	56C	B5	ERT	63732	9.94	1.94	6.53	0.625	3/16	1.38	—	2.06	5.88	4.50	5.88	3/8-16	1.97	29
1/3	1725	3.8	42CZ	B4	AERT-W	65346	9.43	1.10	—	0.500	1/8	0.98	4.704	1.26	3.75	3.00	5.75	1/4-20	—	18.3
208 – 230/460 VAC 3ø 60 Hz																				
1/6	1725	0.6	42CZ	B4	ACUT-B	69728	8.52	1.14	—	0.500	1/8	0.88	4.03	1.26	3.75	3.00	4.62	1/4-20	—	17
1/6	1725	0.4	56C	B5	CUT-B	85776	10.25	1.94	5.68	0.625	3/16	1.38	4.51	2.06	5.88	4.50	5.81	3/8-16	—	19
1/6	1725	0.5	42CZ	B4	ACUT-W	65368	7.89	1.10	—	0.500	1/8	0.98	4.65	1.26	3.75	3.00	4.80	1/4-20	—	17
1/4	1725	0.6	56C	B5	DUT	63801	9.44	1.94	5.61	0.625	3/16	1.38	—	2.06	5.88	4.50	5.61	3/8-16	—	16
1/4	1725	0.6	42CZ	B4	ADUT-W	65374	8.65	1.10	—	0.500	1/8	0.98	4.65	1.26	3.75	3.00	4.80	1/4-20	—	17
1/3	1725	0.65	56C	B5	EUT	63952	9.44	1.94	6.53	0.625	3/16	1.38	—	2.06	5.88	4.50	5.88	3/8-16	—	20
1/3	1725	0.7	42CZ	B4	AEUT-W	65381	8.65	1.10	—	0.500	1/8	0.98	4.65	1.26	3.75	3.00	4.80	1/4-20	—	18
1/2	1725	1.0	56C	B5	FUT	63959	10.44	1.94	6.53	0.625	3/16	1.38	—	2.06	5.88	4.50	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



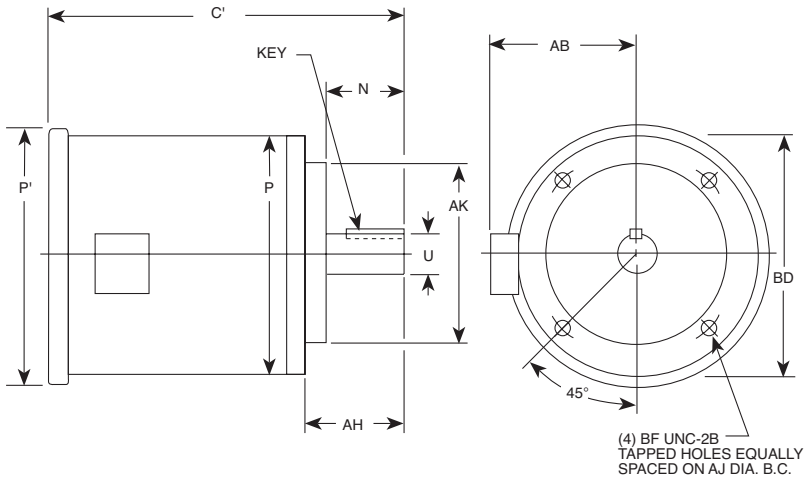
ORDER BY CATALOG NUMBER OR ITEM CODE

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	0.500	1/8	0.75	4.03	1.28	3.75	3.00	4.63	1/4-20	1.66	20
1/6	1725	1.9	56C	B5	CRTF-B	85777	11.35	1.93	6.19	—	0.625	3/16	1.38	4.90	2.06	5.88	4.50	5.81	3/8-16	1.56	19
1/6	1725	2.0	56C	B5	CRTF-W	65315	11.10	1.91	—	7.32	0.625	3/16	1.10	5.43	2.06	5.87	4.50	6.54	3/8-16	—	20
1/4	1725	2.3	42CZ	B4	ADRTF-B	69726	10.31	1.15	4.69	5.19	0.500	1/8	0.75	4.03	1.28	3.75	3.00	4.63	1/4-20	1.66	21
1/4	1725	2.7	56C	B5	DRTF-W	65326	11.10	1.91	—	7.32	0.625	3/16	1.10	5.43	2.06	5.87	4.50	6.54	3/8-16	—	20
1/4	1725	2.5	56C	B5	DRTF-B	66199	11.38	1.94	5.69	6.19	0.625	3/16	1.38	4.89	2.06	5.88	4.50	5.88	3/8-16	1.97	34
1/4	1725	2.2	56C	B5	DR5TF-W	65346	11.10	1.91	—	—	0.625	3/16	1.10	5.43	2.06	5.87	4.50	6.54	3/8-16	—	23
1/4	1725	2.7	56C	B5	DRTF	63545	9.81	1.94	5.61	5.88	0.625	3/16	1.38	4.87	2.06	5.88	4.50	5.61	3/8-16	2.00	20
1/4	1725	5.0	56C	B5	DSTF-B*	66202	11.38	1.94	5.69	6.19	0.625	3/16	1.38	4.89	2.06	5.88	4.50	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	0.500	1/8	0.75	4.03	1.28	3.75	3.00	4.63	1/4-20	1.66	23
1/3	1725	3.2	56C	B5	ERTF-W	65348	11.10	1.91	—	7.32	0.625	3/16	1.10	5.43	2.06	5.87	4.50	6.54	3/8-16	—	22
1/3	1725	3.0	56C	B5	ERTF-B	66211	11.38	1.94	5.69	6.19	0.625	3/16	1.38	4.89	2.06	5.88	4.50	5.81	3/8-16	1.54	26
1/3	1725	3.2	56C	B5	ERTF	63750	10.94	1.94	6.53	7.16	0.625	3/16	1.38	5.09	2.06	5.88	4.50	5.88	3/8-16	1.97	26
1/2	1725	4.4	56C	B5	FRTF	65350	10.94	1.94	6.53	7.16	0.625	3/16	1.38	5.09	2.06	5.88	4.50	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	0.625	3/16	1.38	4.89	2.06	5.88	4.50	5.81	3/8-16	1.54	30
3/4	1725	5.8	56C	B5	GRTF-W	65351	11.102	1.91	—	7.32	0.625	3/16	1.10	5.43	2.06	5.87	4.50	6.54	3/8-16	—	28
3/4	1725	5.5	56C	B5	GRTF-B	66228	13.31	1.94	6.63	7.19	0.625	3/16	1.38	5.63	2.06	5.88	4.50	6.50	3/8-16	2.25	42
3/4	1725	5.8	56C	B5	GRTF	63755	11.44	1.94	6.53	7.16	0.625	3/16	1.38	5.09	2.06	5.88	4.50	5.88	3/8-16	1.97	30
1	1725	6.4	56C	B5	HRTF-5/8-W	65354	12.28	1.91	—	7.32	0.625	3/16	1.10	5.43	2.06	5.87	4.50	6.54	3/8-16	—	34
1	1725	6.2	56C	B5	HRTF-5/8-B	19178	13.31	1.94	6.63	7.19	0.625	3/16	1.38	5.75	2.06	5.88	4.50	5.88	3/8-16	1.97	34
1	1725	6.4	56C	B5	HRTF-5/8	63795	11.94	1.94	6.53	7.19	0.625	3/16	1.38	5.09	2.06	5.88	4.50	5.88	3/8-16	1.97	34
1	1740	6.4	143TC	B7	HRTF	63797	11.94	1.94	6.53	7.16	0.875	3/16	1.38	5.09	2.06	5.88	4.50	6.50	3/8-16	2.25	47
1	1725	6.2	143TC	B7	HRTF-B	66234	13.38	2.00	6.63	7.19	0.875	3/16	1.38	5.75	2.13	5.88	4.50	5.88	3/8-16	1.78**	47
1-1/2	1740	8.6	145TC	B7	JRTF	63800	12.44	1.94	6.53	7.16	0.875	3/16	1.38	5.09	2.06	5.88	4.50	6.50	3/8-16	2.25	58
1-1/2	1725	8.0	145TC	B7	JRTF-B	66243	14.25	2.00	6.63	7.19	0.875	3/16	1.38	5.75	2.13	5.88	4.50	5.88	3/8-16	1.97	34

*115 VAC Single Phase 60 Hz only
**Two capacitors
All dimensions in inches. Dimensional information for estimating purposes only.

208-230/460 VAC 3ø 60 Hz

TEFC
NEMA C-Face
Three Phase
1/6 – 1 Horsepower
1725 RPM



ORDER BY CATALOG NUMBER OR ITEM CODE

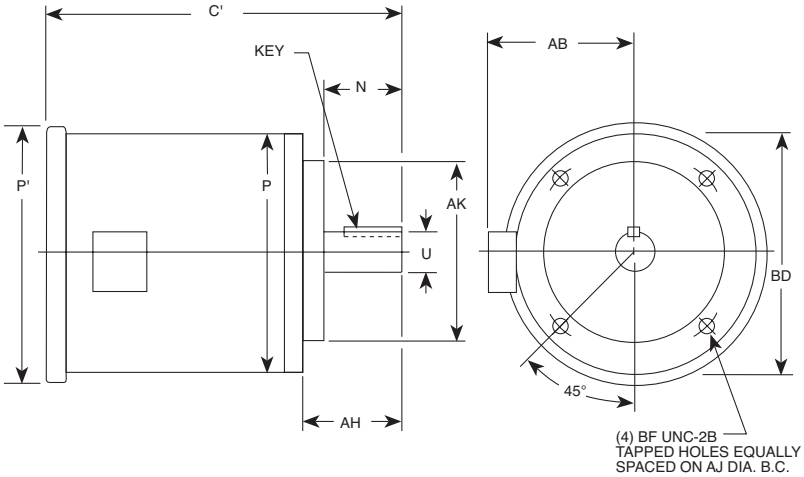
HP	RPM	F.L.A. @ Max. Volt	NEMA Mtg.	Bore Code	Catalog Number	Item Code	C′	N	P	P'	U +.0000 -.0005	Key Sq.	Key Long	AB	AH	AJ	AK	BD	BF	Wt. Lbs.
208-230/460 VAC 3ø 60 Hz																				
1/6	1725	0.55	56C	B5	CUTF-W	65371	11.10	1.91	—	7.32	0.625	3/16	1.10	5.43	2.06	5.87	4.50	6.54	3/8-16	19
1/6	1725	0.45	56C	B5	CUTF-B	85778	11.35	1.93	—	6.19	0.625	3/16	1.38	4.90	2.06	5.88	4.50	5.81	3/8-16	19
1/4	1725	0.60	42CZ	B4	ADUTF-B	69729	10.31	1.15	4.69	5.19	0.500	1/8	0.75	4.03	1.28	3.75	3.00	4.63	1/4-20	21
1/4	1725	0.65	56C	B5	DUTF-W	65380	11.10	1.91	—	7.32	0.625	3/16	1.10	5.43	2.06	5.87	4.50	6.54	3/8-16	20
1/4	1725	0.65	56C	B5	DUTF-B	66205	11.38	1.94	5.69	6.19	0.625	3/16	1.38	4.89	2.06	5.88	4.50	5.81	3/8-16	19
1/4	1725	0.70	56C	B5	DUTF	63949	9.81	1.94	5.61	5.88	0.625	3/16	1.38	4.87	2.06	5.88	4.50	5.61	3/8-16	18
1/3	1725	0.70	42CZ	B4	AEUTF-B	69730	10.31	1.15	4.69	5.19	0.500	1/8	0.75	4.03	1.28	3.75	3.00	4.63	1/4-20	21
1/3	1725	0.65	56C	B5	EUTF-W	65383	11.10	1.91	—	7.32	0.625	3/16	1.10	5.43	2.06	5.87	4.50	6.54	3/8-16	22
1/3	1725	0.65	56C	B5	EUTF	63958	10.94	1.94	6.53	7.16	0.625	3/16	1.38	5.09	2.06	5.88	4.50	5.88	3/8-16	20
1/3	1725	0.80	56C	B5	EUTF-B	66214	11.38	1.94	5.69	6.19	0.625	3/16	1.38	4.89	2.06	5.88	4.50	5.81	3/8-16	19
1/2	1725	1.0	56C	B5	FUTF-W	65404	11.10	1.91	—	7.32	0.625	3/16	1.10	5.43	2.06	5.87	4.50	6.54	3/8-16	24
1/2	1725	1.0	56C	B5	FUTF-B	66223	11.38	1.94	5.69	6.19	0.625	3/16	1.38	4.89	2.06	5.88	4.50	5.81	3/8-16	22
1/2	1725	1.0	56C	B5	FUTF	63961	10.94	1.94	6.53	7.16	0.625	3/16	1.38	5.09	2.06	5.88	4.50	5.88	3/8-16	25
3/4	1725	1.4	56C	B5	GUTF-W	65405	11.10	1.91	—	7.32	0.625	3/16	1.10	5.43	2.06	5.87	4.50	6.54	3/8-16	27
3/4	1725	1.5	56C	B5	GUTF-B	66231	11.38	1.94	5.69	6.19	0.625	3/16	1.38	4.89	2.06	5.88	4.50	5.81	3/8-16	32
3/4	1725	1.4	56C	B5	GUTF	63979	11.44	1.94	6.53	7.16	0.625	3/16	1.38	5.09	2.06	5.88	4.50	5.88	3/8-16	26
1	1725	1.7	56C	B5	HUTF-5/8-W	65406	12.28	1.91	—	7.32	0.625	3/16	1.42	5.43	2.06	5.87	4.50	6.54	3/8-16	31
1	1725	1.7	56C	B5	HUTF-5/8-B	50428	12.31	1.94	6.63	7.19	0.625	3/16	1.38	5.75	2.06	5.88	4.50	6.50	3/8-16	35
1	1725			B5	HUTF-5/8	63980	11.94	1.94	6.63	7.19	0.625	3/16	1.38	5.09	2.06	5.88	4.50	5.88	3/8-16	33
1	1740	1.7	143TC	B7	HUTF-W	65412	13.07	1.97	—	7.32	0.875	3/16	1.42	5.433	2.13	5.87	4.50	6.54	3/8-16	31
1	1725	1.7	143TC	B7	HUTF-B	66237	12.38	2.00	6.63	7.19	0.875	3/16	1.38	5.75	2.13	5.88	4.50	6.50	3/8-16	35
1	1725	1.8	143TC	B7	HUTF	63981	11.63	1.94	6.53	7.16	0.875	3/16	1.38	5.09	2.06	5.88	4.50	5.88	3/8-16	33

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



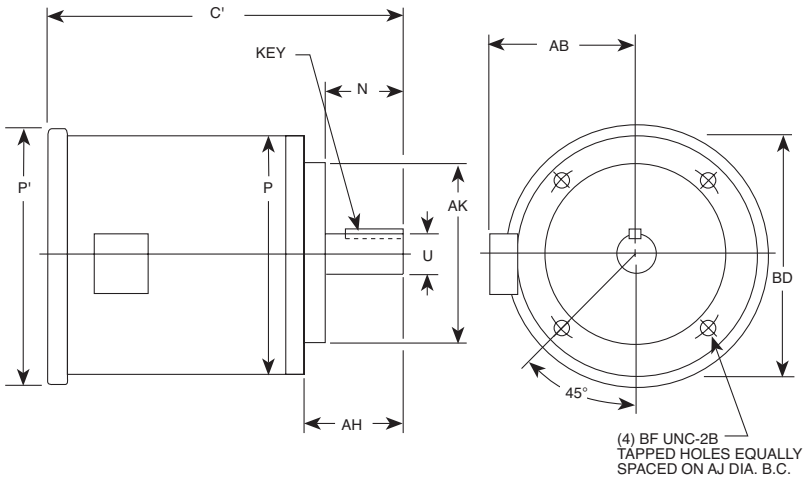
ORDER BY CATALOG NUMBER OR ITEM CODE

HP	RPM	F.L.A. @ Max. Volt	NEMA Mtg.	Bore Code	Catalog Number	Item Code	C'	N	P	P'	U +.0000 -.0005	Key		AB	AH	AJ	AK	BD	BF	Wt. Lbs.
												Sq.	Long							
208-230/460 VAC 3ø 60 Hz																				
1-1/2	1725	2.3	56C	B5	JUTF-5/8-W	65407	12.28	1.91	—	7.32	0.625	3/16	1.10	5.43	2.06	5.87	4.50	6.54	3/8-16	35
1-1/2	1725	2.5	56C	B5	JUTF-5/8-B	19784	12.31	1.94	6.63	7.19	0.625	3/16	1.38	5.75	2.06	5.88	4.50	6.50	3/8-16	37
1-1/2	1725	2.3	56C	B5	JUTF-5/8	63988	12.44	1.94	6.53	7.16	0.625	3/16	1.38	5.09	2.06	5.88	4.50	5.88	3/8-16	37
1-1/2	1740	2.3	145TC	B7	JUTF-W	65437	13.07	1.97	—	7.32	0.875	3/16	1.42	5.43	2.13	5.87	4.50	6.54	3/8-16	35
1-1/2	1725	2.0	145TC	B7	JUTF-B	66246	12.38	2.00	6.63	7.19	0.875	3/16	1.38	5.75	2.13	5.88	4.50	6.50	3/8-16	37
1-1/2	1725	2.4	145TC	B7	JUTF	64281	12.44	1.94	6.53	7.16	0.875	3/16	1.38	5.09	2.06	5.88	4.50	5.88	3/8-16	37
2	1725	3.1	56C	B5	KUTF-5/8	64769	12.44	1.94	6.53	7.16	0.625	3/16	1.38	5.09	2.06	5.88	4.50	5.88	3/8-16	42
2	1725	3.1	56C	B5	KUTF-5/8-W	65440	13.46	1.91	—	7.32	0.625	3/16	1.10	5.43	2.06	5.87	4.50	6.54	3/8-16	43
2	1725	3.1	56C	B5	KUTF-5/8-B	19785	13.31	1.94	6.63	7.19	0.625	3/16	1.38	5.75	2.06	5.88	4.50	6.50	3/8-16	42
2	1740	3.1	145TC	B7	KUTF-W	65445	14.25	1.97	—	7.32	0.875	3/16	1.42	5.43	2.13	5.87	4.50	6.54	3/8-16	43
2	1725	3.1	145TC	B7	KUTF-B	66252	13.38	2.00	6.63	7.19	0.875	3/16	1.38	5.75	2.13	5.88	4.50	6.50	3/8-16	45
2	1725	3.1	145TC	B7	KUTF	64770	12.44	1.94	6.53	7.16	0.875	3/16	1.38	5.09	2.06	5.88	4.50	5.88	3/8-16	42
3	1740	3.9	182TC	B9	LUTF-W	65446	15.86	2.38	—	—	1.125	1/4	1.97	6.61	2.63	7.25	8.50	8.88	1/2-13	73
3	1725	4.3	182TC	B9	LUTF-B	66258	15.18	2.63	7.88	8.50	1.125	1/4	1.75	5.88	2.89	7.25	8.50	9.00	1/2-13	94
3	1725	4.4	182TC	B9	LUTF	64771	13.91	2.63	8.46	9.09	1.125	1/4	1.75	6.36	2.89	7.25	8.50	8.58	1/2-13	65
5	1740	6.7	184TC	B9	MUTF-W	65448	15.86	2.38	—	—	1.125	1/4	1.97	6.61	2.63	7.25	8.50	8.88	1/2-13	80
5	1725	6.6	184TC	B9	MUTF-B	66262	16.56	2.63	7.88	8.50	1.125	1/4	1.75	5.88	2.89	7.25	8.50	8.88	1/2-13	84
5	1725	6.7	184TC	B9	MUTF	64772	14.91	2.63	8.46	9.09	1.125	1/4	1.75	6.36	2.89	7.25	8.50	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	1.375	5/16	2.38	7.38	3.38	7.25	8.50	9.00	1/2-13	113
10	1725	13.0	215TC	B11	PUTF-B	66270	19.44	3.13	9.56	10.19	1.375	5/16	2.38	7.38	3.38	7.25	8.50	9.00	1/2-13	146
15	1725	19.6	254TC	B13	RUTF-B	66274	22.00	3.75	12.94	13.25	1.625	3/8	2.38	9.63	4.00	7.25	8.50	9.13	1/2-13	312
20	1725	26.0	256TC	B13	SUTF-B	66278	22.00	3.75	12.94	13.25	1.625	3/8	2.38	9.63	4.00	7.25	8.50	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

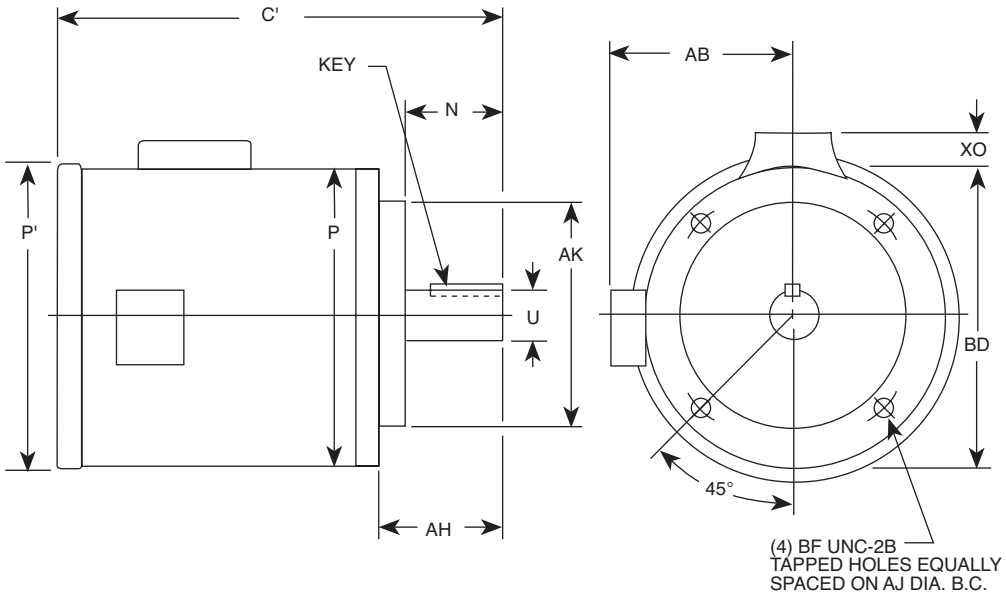
HP	RPM	F.L.A. @ Max. Volt	NEMA Mtg.	Bore Code	Catalog Number	Item Code	C'	N	P	P'	U +.0000 -.0005	Key Sq.	Key Long	AB	AH	AJ	AK	BD	BF	Wt. Lbs.
575 VAC 3ø 60 Hz																				
1/4	1725	0.56	56C	B5	DYTF	64963	9.81	1.94	5.61	5.88	0.625	3/16	1.38	4.87	2.06	5.88	4.50	5.61	3/8-16	18
1/4	1725	0.48	56C	B5	DYTF-B	66208	11.38	1.94	5.69	6.13	0.625	3/16	1.38	4.89	2.06	5.88	4.50	5.81	3/8-16	19
1/3	1725	0.52	56C	B5	EYTF-W	65454	11.10	1.91	—	7.32	0.625	3/16	1.10	5.43	2.06	5.87	4.50	6.54	3/8-16	22
1/3	1725	0.64	56C	B5	ETYF-B	66217	11.38	1.94	5.69	6.19	0.625	3/16	1.38	4.89	2.06	5.88	4.50	5.81	3/8-16	19
1/2	1725	0.80	56C	B5	FYTF-W	65455	11.10	1.91	—	7.32	0.625	3/16	1.10	5.43	2.06	5.87	4.50	6.54	3/8-16	24
1/2	1725	0.80	56C	B5	FYTF-B	66226	11.38	1.94	5.69	6.19	0.625	3/16	1.38	4.89	2.06	5.88	4.50	5.81	3/8-16	22
3/4	1725	1.1	56C	B5	GYTF-W	65457	11.10	1.91	—	7.32	0.625	3/16	1.10	5.43	2.06	5.87	4.50	6.54	3/8-16	27
3/4	1725	1.2	56C	B5	GYTF-B	66831	12.31	1.94	6.63	7.19	0.625	3/16	1.38	5.75	2.06	5.88	4.50	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	0.625	3/16	1.38	5.75	2.06	5.88	4.50	6.50	3/8-16	35
1	1740	1.4	143TC	B7	HYTF-W	65460	13.07	1.97	—	7.32	0.875	3/16	1.42	5.43	2.13	5.87	4.50	6.54	3/8-16	31
1	1725	1.4	143TC	B7	HYTF-B	66240	12.38	2.00	6.63	7.19	0.875	3/16	1.38	5.75	2.13	5.88	4.50	6.50	3/8-16	35
1-1/2	1740	1.9	145TC	B7	JYTF-W	65475	13.07	1.97	—	7.32	0.875	3/16	1.42	5.43	2.13	5.84	4.50	6.54	3/8-16	35
1-1/2	1725	1.9	145TC	B7	JYTF-B	66249	12.38	2.00	6.63	7.19	0.875	3/16	1.38	5.75	2.13	5.88	4.50	6.50	3/8-16	37
2	1740	2.5	145TC	B7	KYTF	64950	12.44	1.94	6.53	7.16	0.875	3/16	1.38	5.09	2.06	5.88	4.50	5.88	3/8-16	37
2	1725	2.5	145TC	B7	KYTF-B	66255	13.38	2.00	6.63	7.19	0.875	3/16	1.38	5.75	2.13	5.88	4.50	6.50	3/8-16	45
3	1740	3.5	182TC	B9	LYTF	64954	13.91	2.63	8.46	9.09	1.125	1/4	1.75	6.36	2.88	7.25	8.50	8.58	1/2-13	60
3	1725	3.6	182TC	B9	LYTF-B	66260	15.18	2.63	7.88	8.50	1.125	1/4	1.75	5.88	2.88	7.25	8.50	9.00	1/2-13	94
5	1740	5.4	184TC	B9	MYTF	64955	14.91	2.63	8.46	9.09	1.125	1/4	1.75	6.36	2.88	7.25	8.50	8.58	1/2-13	77
5	1725	5.3	184TC	B9	MYTF-B	66264	16.56	2.63	7.88	8.50	1.125	1/4	1.75	5.88	2.88	7.25	8.50	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



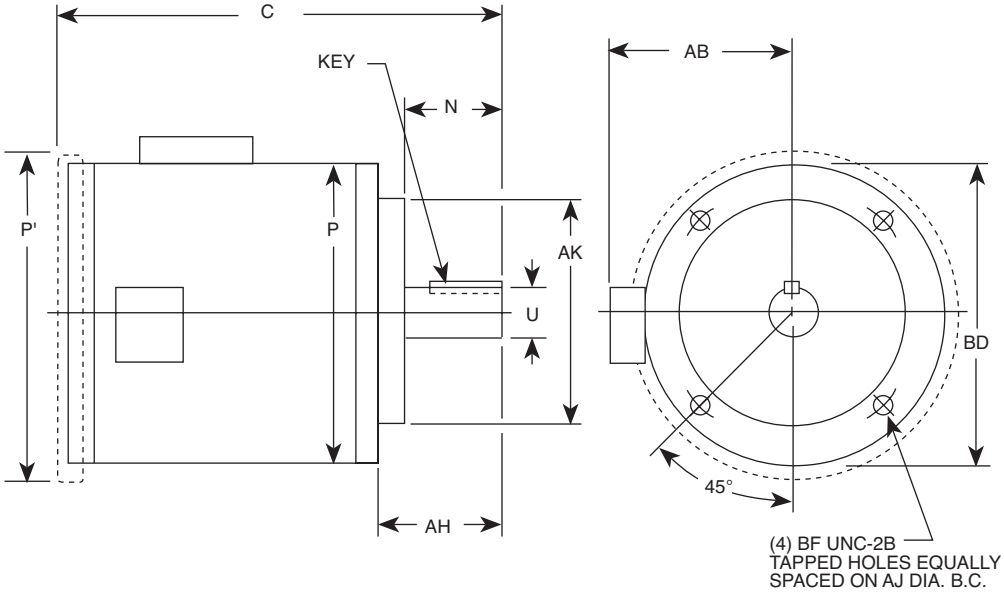
ORDER BY CATALOG NUMBER OR ITEM CODE

HP	RPM	F.L.A. @ Max. Volt	NEMA Mtg.	Bore Code	Catalog Number	Item Code	C'	N	P	P'	U +.0000 -.0005	Key		AB	AH	AJ	AK	BD	BF	XO	Wt. Lbs.
												Sq.	Long								
110/220 VAC 1ø 50 Hz																					
1/6	1425	2.1	42CZ	B4	ACR5TF-B	50480	9.31	1.15	4.69	5.19	0.500	1/8	0.75	4.03	1.28	3.75	3.00	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	0.500	1/8	0.75	4.03	1.28	3.75	3.00	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	0.625	3/16	1.38	4.51	2.06	5.88	4.50	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	0.625	3/16	1.38	4.51	2.06	5.88	4.50	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	0.625	3/16	1.38	4.51	2.06	5.88	4.50	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	0.625	3/16	1.38	5.25	2.06	5.88	4.50	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	0.625	3/16	1.38	4.51	2.06	5.88	4.50	5.81	3/8-16	—	22
3/4	1425	1.3	56C	B5	GU5TF-B	50338	12.00	1.94	5.69	6.19	0.625	3/16	1.38	4.51	2.06	5.88	4.50	5.81	3/8-16	—	32
1	1425	1.5	143TC	B7	HU5TF-B	50339	12.38	2.00	6.63	7.19	0.875	3/16	1.38	5.25	2.13	5.88	4.50	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	0.875	3/16	1.38	5.25	2.13	5.88	4.50	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



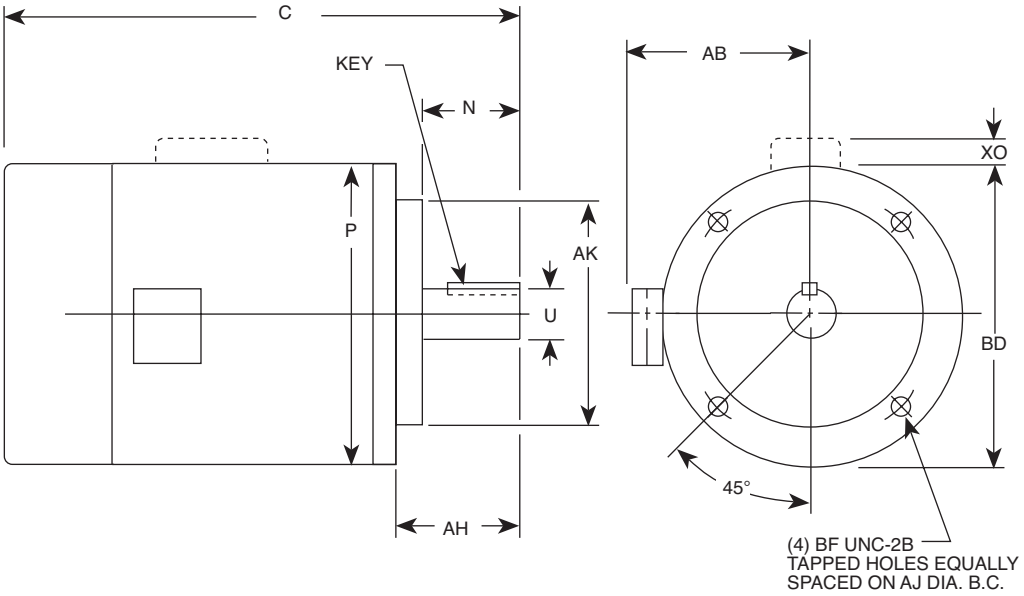
ORDER BY CATALOG NUMBER OR ITEM CODE

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	—	0.625	3/16	1.38	5.25	2.06	5.88	4.50	6.62	3/8-16	30
3/4	1.1	56C	B5	GUT-WB-B	69106	11.06	1.94	6.63	—	0.625	3/16	1.38	5.25	2.06	5.88	4.50	6.62	3/8-16	34
1	1.5	56C	B5	HUT-WB-5/8-B	69123	12.13	1.94	6.63	—	0.625	3/16	1.38	5.25	2.06	5.88	4.50	6.62	3/8-16	38
1	1.7	143TC	B7	HUT-WB-B	69107	12.13	2.00	6.63	—	0.875	3/16	1.38	5.25	2.13	5.88	4.50	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	0.875	3/16	1.38	5.25	2.13	5.88	4.50	6.62	3/8-16	40
2	3.1	145TC	B7	KUTF-WB-B *	69111	13.38	2.00	6.63	7.19	0.875	3/16	1.38	5.25	2.13	5.88	4.50	6.62	3/8-16	44
3	4.3	182TC	B9	LUTF-WB-B *	69112	15.19	2.62	7.88	8.50	1.125	1/4	1.75	5.88	2.88	7.25	8.50	9.00	1/2-13	61
5	6.6	184TC	B9	MUTF-WB-B *	69113	16.56	2.62	7.88	8.50	1.125	1/4	1.75	5.88	2.88	7.25	8.50	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	—	0.625	3/16	1.38	5.44	2.06	5.88	4.50	6.53	3/8-16	34
3/4	2.2	56C	B5	GUT-SS	46630	12.06	1.94	6.53	—	0.625	3/16	1.38	5.44	2.06	5.88	4.50	6.53	3/8-16	38
1	2.9	56C	B5	HUT-5/8-SS	46634	12.06	1.94	6.53	—	0.625	3/16	1.38	5.44	2.06	5.88	4.50	6.53	3/8-16	39
1	2.9	143TC	B7	HUT-SS	46635	12.13	2.00	6.53	—	0.875	3/16	1.38	5.44	2.13	5.88	4.50	6.53	3/8-16	39
1-1/2	4.4	145TC	B7	JUTF-SS	46636	14.25	2.00	6.53	—	0.875	3/16	1.38	5.44	2.13	5.88	4.50	6.53	3/8-16	46
2	6.0	145TC	B7	KUTF-SS	46639	14.25	2.00	6.53	—	0.875	3/16	1.38	5.44	2.13	5.88	4.50	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	—	0.625	3/16	1.38	5.44	2.06	5.88	4.50	6.53	3/8-16	34
3/4	2.2	56C	B5	GYT-SS	59001	12.06	1.94	6.53	—	0.625	3/16	1.38	5.44	2.06	5.88	4.50	6.53	3/8-16	38
1	2.9	56C	B5	HYT-5/8-SS	59003	12.06	1.94	6.53	—	0.625	3/16	1.38	5.44	2.06	5.88	4.50	6.53	3/8-16	39
1	2.9	143TC	B7	HYT-SS	59002	12.13	2.00	6.53	—	0.875	3/16	1.38	5.44	2.13	5.88	4.50	6.53	3/8-16	39
1-1/2	4.4	145TC	B7	JYTF-SS	59004	14.25	2.00	6.53	—	0.875	3/16	1.38	5.44	2.13	5.88	4.50	6.53	3/8-16	46
2	6.0	145TC	B7	KYTF-SS	59005	14.25	2.00	6.53	—	0.875	3/16	1.38	5.44	2.13	5.88	4.50	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 Dripproof
NEMA C-Face
Single and Three Phase
1/4 – 5 Horsepower
1725 RPM



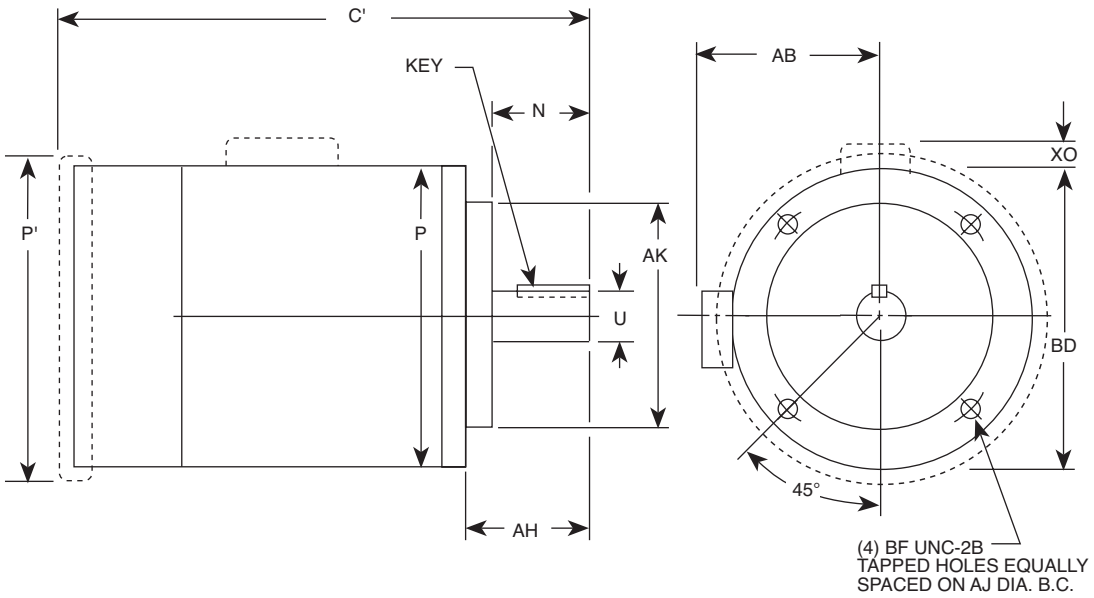
ORDER BY CATALOG NUMBER OR ITEM CODE

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	.625	3/16	1.38	4.88	2.06	5.88	4.50	5.81	3/8-16	2.20	34
1/3	3	3.0	56C	B5	ERB-B	66370	15.19	1.88	5.69	.625	3/16	1.38	4.88	2.06	5.88	4.50	5.81	3/8-16	2.20	34
1/2	3	4.2	56C	B5	FRB-B	66379	16.19	1.88	5.69	.625	3/16	1.38	4.88	2.06	5.88	4.50	5.81	3/8-16	2.20	38
3/4	3	5.4	56C	B5	GRB-B	66388	15.25	1.88	6.63	.625	3/16	1.38	5.63	2.06	5.88	4.50	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	.625	3/16	1.38	4.88	2.06	5.88	4.50	5.81	3/8-16	—	26
1/3	3	0.80	56C	B5	EUB-B	66373	14.19	1.88	5.69	.625	3/16	1.38	4.88	2.06	5.88	4.50	5.81	3/8-16	—	28
1/2	3	1.0	56C	B5	FUB-B	66382	14.19	1.88	5.69	.625	3/16	1.38	4.88	2.06	5.88	4.50	5.81	3/8-16	—	31
3/4	3	1.5	56C	B5	GUB-B	66391	15.25	1.88	6.63	.625	3/16	1.38	5.63	2.06	5.88	4.50	6.50	3/8-16	—	41
1	3	1.7	56C	B5	HUB-5/8-B	19181	15.25	1.88	6.63	.625	3/16	1.38	5.47	2.06	5.88	4.50	6.50	3/8-16	—	31
1	3	1.7	143TC	B7	HUB-B	66397	15.31	2.00	6.63	.875	3/16	1.38	5.25	2.13	5.88	4.50	6.50	3/8-16	—	40
1-1/2	6	2.4	145TC	B7	JUB-B	66403	15.31	2.00	6.63	.875	3/16	1.38	5.25	2.13	5.88	4.50	6.50	3/8-16	—	43
2	6	3.2	145TC	B7	KUB-B	66409	16.31	2.00	6.63	.875	3/16	1.38	5.25	2.13	5.88	4.50	6.50	3/8-16	—	53
3	10	4.3	182TC	B9	LUB-B	66415	18.19	2.63	7.88	1.125	1/4	1.75	5.88	2.89	7.25	8.50	9.00	1/2-13	—	73
5	10	7.0	184TC	B9	MUB-B	66834	19.56	2.63	7.88	1.125	1/4	1.75	5.88	2.89	7.25	8.50	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



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	—	.625	3/16	1.38	4.88	2.06	5.88	4.50	5.81	3/8-16	1.54	34
1/3	3	2.4	56C	B5	ERTB-B	66431	16.19	1.88	5.68	—	.625	3/16	1.38	4.88	2.06	5.88	4.50	5.81	3/8-16	1.54	38
1/2	3	3.4	56C	B5	FRTB-B	66440	16.25	1.88	6.63	—	.625	3/16	1.38	5.75	2.06	5.88	4.50	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	.625	3/16	1.38	5.75	2.06	5.88	4.50	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	—	.625	3/16	1.38	4.88	2.06	5.88	4.50	5.81	3/8-16	—	25
1/3	3	0.70	56C	B5	EUTB-B	66434	14.19	1.88	5.68	—	.625	3/16	1.38	4.88	2.06	5.88	4.50	5.81	3/8-16	—	27
1/2	3	0.90	56C	B5	FUTB-B	66443	14.81	1.88	5.69	—	.625	3/16	1.38	4.89	2.06	5.88	4.50	5.81	3/8-16	—	30
3/4	3	1.1	56C	B5	GUTB-B	66452	15.25	1.88	6.63	—	.625	3/16	1.38	5.75	2.06	5.88	4.50	6.50	3/8-16	—	40
1	3	1.5	56C	B5	HUTB-5/8-B	19182	16.25	1.88	6.63	—	.625	3/16	1.38	5.75	2.06	5.88	4.50	6.50	3/8-16	—	41
1	3	1.5	145TC	B7	HUTB-B	66458	16.31	2.00	6.63	—	.875	3/16	1.38	5.75	2.3	5.88	4.50	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	.875	3/16	1.38	5.75	2.13	5.88	4.50	6.50	3/8-16	—	43
2	6	3.1	145TC	B7	KUTFB-B*	66470	17.94	2.00	6.63	7.18	.875	3/16	1.38	5.75	2.13	5.88	4.50	6.50	3/8-16	—	51
3	10	4.3	182TC	B9	LUTFB-B*	66474	19.81	2.63	8.50	7.18	1.125	1/4	1.75	5.88	2.88	7.85	8.50	9.00	1/2-13	—	76
5	25	6.6	184TC	B9	MUTFB-B*	66838	21.18	2.63	7.89	10.18	1.125	1/4	1.75	5.97	2.88	7.25	8.50	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	—	.625	3/16	1.38	5.63	2.06	5.08	4.50	5.81	3/8-16	—	30
1/2	3	.72	56C	B5	FYTB-B	66446	15.19	1.88	5.81	—	.625	3/16	1.38	4.88	2.06	5.88	4.50	5.81	3/8-16	—	30
3/4	3	1.2	56C	B5	GYTB-B	66455	15.19	1.88	5.81	—	.625	3/16	1.38	4.88	2.06	5.88	4.50	5.81	3/9-16	—	40
1	3	1.2	145TC	B7	HYTB-B	66461	16.31	2.00	6.63	—	.875	3/16	1.38	5.75	2.13	5.88	4.50	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	.875	3/16	1.38	5.75	2.13	5.88	4.50	6.50	3/8-16	—	43
2	6	2.5	145TC	B7	KYTFB-B*	66472	17.94	2.00	6.63	7.18	.875	3/16	1.38	5.75	2.13	5.88	4.50	6.50	3/8-16	—	51
3	10	3.6	182TC	B9	LYTFB-B*	66476	19.81	2.63	8.50	7.18	1.125	1/4	1.75	5.88	2.88	7.25	8.50	9.00	1/2-13	—	76
5	10	5.3	184TC	B9	MYTFB-B*	66840	21.18	2.63	8.50	7.18	1.125	1/4	1.75	5.88	2.88	7.25	8.50	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

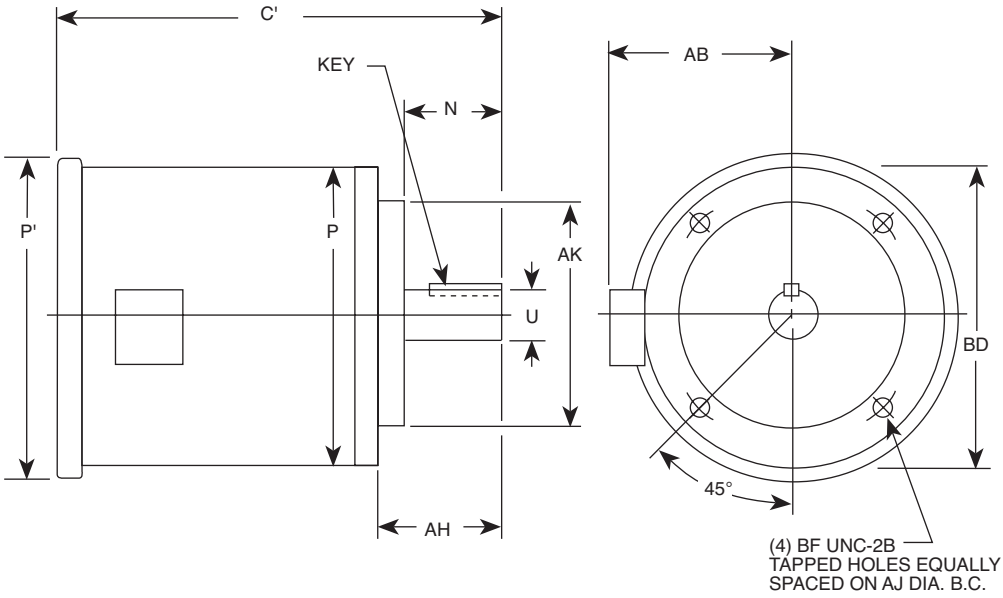
Explosion Proof
NEMA C-Face
Single and Three Phase
1/4-5 Horsepower
1725 RPM

CONTINUOUS DUTY

1.0 SERVICE FACTOR

CLASS I GROUP D

CLASS II GROUPS F & G



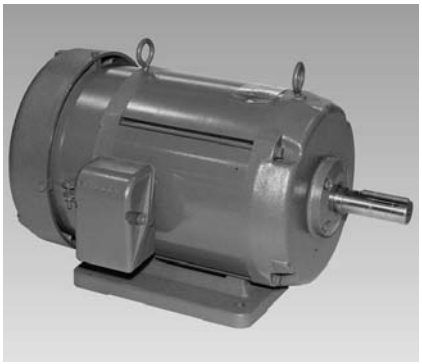
ORDER BY CATALOG NUMBER OR ITEM CODE

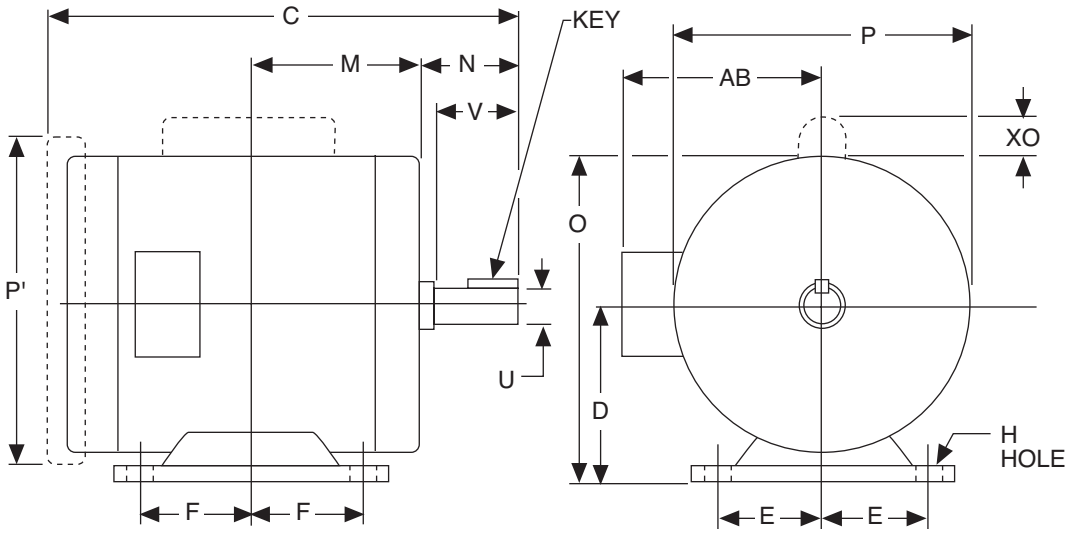
HP	F.L.A. @ Max. Volt	NEMA Mtg.	Bore Code	Catalog Number	Item Code	C'	N	P	P'	U +.0000 -.0005	KEY Sq.	KEY Lg.	AB	AH	AJ	AK	BD	BF	Wt. Lbs.
115/230 VAC 1ø 60 Hz																			
1/4	2.5	56C	B5	DRX-B	66292	14.38	1.94	6.68	7.19	0.625	3/16	1.38	6.75	2.06	5.88	4.50	6.50	3/8-16	42
1/3	3.0	56C	B5	ERX-B	66304	14.38	1.94	6.68	7.19	0.625	3/16	1.38	6.75	2.06	5.88	4.50	6.50	3/8-16	42
1/2	3.8	56C	B5	FRX-B	66313	14.38	1.94	6.75	7.19	0.625	3/16	1.38	6.75	2.06	5.88	4.50	6.50	3/8-16	49
3/4	5.3	56C	B5	GRX-B	66322	15.25	1.94	6.75	7.19	0.625	3/16	1.38	6.75	2.06	5.88	4.50	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	0.625	3/16	1.38	6.75	2.06	5.88	4.50	6.50	3/8-16	42
1/3	0.80	56C	B5	EUX-B	66307	13.22	1.94	6.68	6.20	0.625	3/16	1.38	6.50	2.06	5.88	4.50	6.50	3/8-16	28
1/2	1.0	56C	B5	FUX-B	66316	14.38	1.94	6.68	7.19	0.625	3/16	1.38	6.75	2.06	5.88	4.50	6.50	3/8-16	42
3/4	1.5	56C	B5	GUX-B	66325	14.38	1.94	6.68	7.19	0.625	3/16	1.38	6.75	2.06	5.88	4.50	6.50	3/8-16	43
1	1.8	56C	B5	HUX-5/8-B	19180	—	1.94	6.68	6.20	0.625	3/16	1.38	6.50	2.06	5.88	4.50	6.50	3/8-16	44
1	1.7	143TC	B7	HUX-B	66334	—	2.00	6.68	7.19	0.875	3/16	1.38	6.92	2.13	5.88	4.50	6.50	3/8-16	39
1-1/2	2.5	145TC	B7	JUX-B	66343	—	2.00	6.88	7.19	0.875	3/16	1.38	6.92	2.13	5.88	4.50	6.50	3/8-16	43
2	3.1	145TC	B7	KUX-B	66349	—	2.00	6.75	7.19	0.875	3/16	1.38	6.92	2.13	5.88	4.50	6.50	3/8-16	50
3	4.3	182TC	B9	LUX-B	66353	17.50	2.63	7.88	8.49	1.125	1/4	1.75	7.52	2.88	7.25	8.50	8.98	1/2-13	81
5	6.5	184TC	B9	MUX-B	66357	—	2.63	7.88	8.82	1.125	1/4	1.75	7.52	2.88	7.25	8.50	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	.625	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	.625	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	.875	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	.875	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	.625	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	.625	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	.875	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	.875	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	.875	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	1.125	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	1.125	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	1.375	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	1.375	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	1.625	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	1.625	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	1.875	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	1.875	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	2.125	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	2.125	1/2	4.25	5.25	14.13	—	526

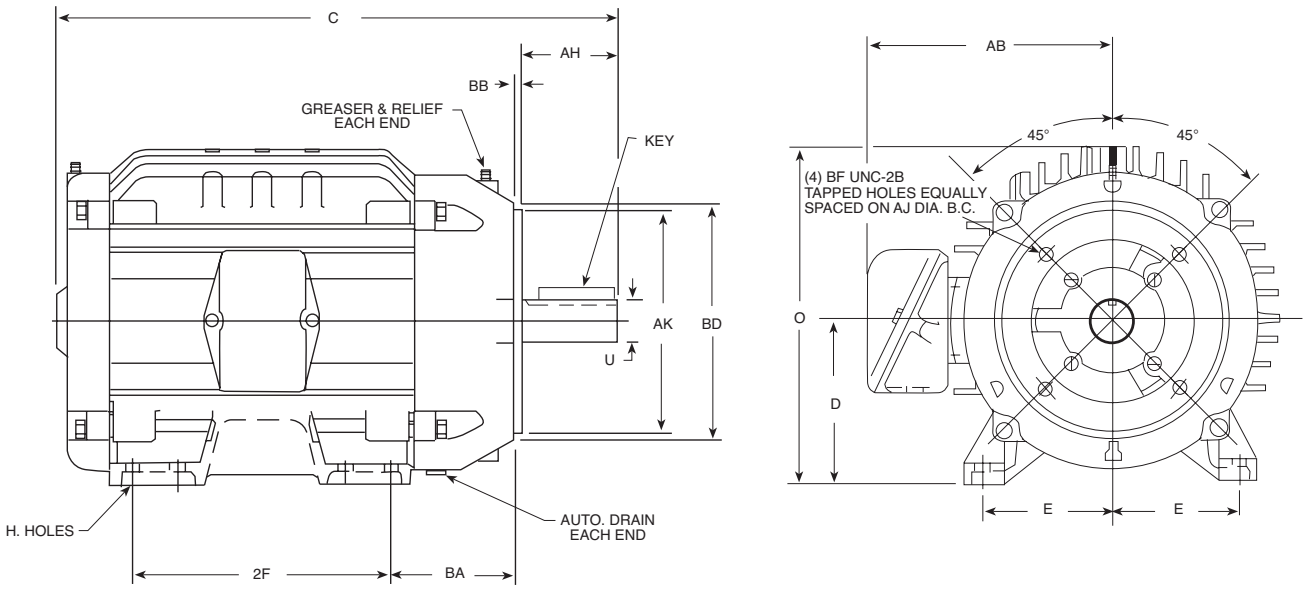
All dimensions in inches. Dimensional information for estimating purposes only.
*(S) Slotted (Dimension is Width)

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



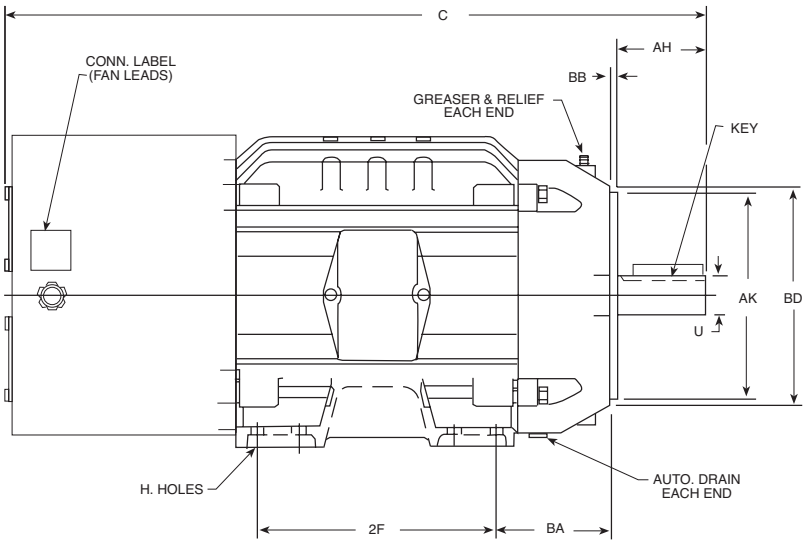
ORDER BY CATALOG NUMBER

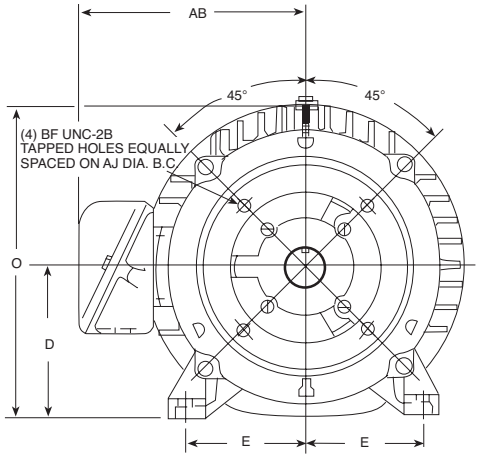
HP	RPM @ 60 Hz	F.L.A. @ Max. Volt	NEMA Mtg.	Bore Code	Catalog Number	C	D	E	2F	H	O	U +.0000 −.0005	Key Sq	Key Long	AB	AH	AJ	AK	BA	BB	BD	BF	Wt. Lbs.
Totally Enclosed, Non-Ventilated												**230/460-3-60 VAC**											
1/3	1725	0.50	56C	B5	EUT-ID-B	10.25	3.50	2.44	3.00	.34(S)	6.34	.625	3/16	1.38	4.51	1.94	5.88	4.50	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	.625	3/16	1.38	4.51	1.94	5.88	4.50	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	.625	3/16	1.38	5.25	1.94	5.88	4.50	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	.875	3/16	1.38	6.33	2.00	5.88	4.50	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	.875	3/16	1.38	6.33	2.00	5.88	4.50	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	1.125	1/4	1.75	7.08	2.62	7.25	8.50	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	1.125	1/4	1.75	7.08	2.62	7.25	8.50	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	1.375	5/16	2.38	8.61	3.12	7.25	8.50	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	1.625	3/8	2.88	9.42	3.75	7.25	8.50	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	1.625	3/8	2.88	9.42	3.75	7.25	8.50	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																								
1	1725	1.7	143TC	B7	HUBC-ID-B	18.65	3.50	2.75	4.00	.38	7.59	.875	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	.875	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	.875	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	1.125	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	.875	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	1.125	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	1.125	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	1.375	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	1.125	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	1.375	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	1.375	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	1.625	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	1.375	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	1.625	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	1.625	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	1.875	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	1.625	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	1.875	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	1.875	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	2.125	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	1.875	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	2.123	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	2.125	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	2.375	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	2.125	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	2.375	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	2.375	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	2.375	5/8	4.25	14.80	5.62	11.00	12.50	5.88	.25	12.89	5/8-11	869

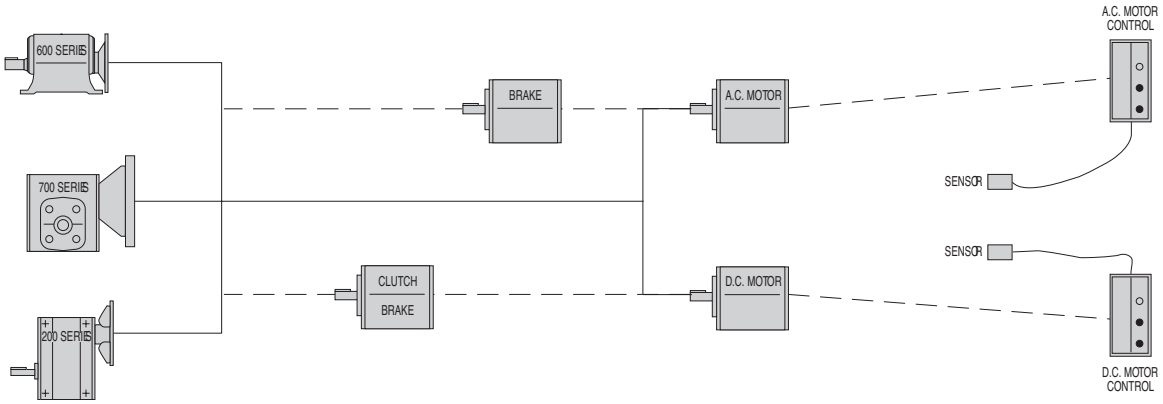
All dimensions in inches. Dimensional information for estimating purposes only.
*Not standard BG mounting.

NOTES

WASHDOWN PRODUCTS

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.

A COMPLETE VARIABLE SPEED WASHDOWN POWER DRIVE SYSTEM



Mechanical · Electrical · Electronic

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. 103)
- 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. 88)
- 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

600 SERIES

600 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 the Enclosed 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.

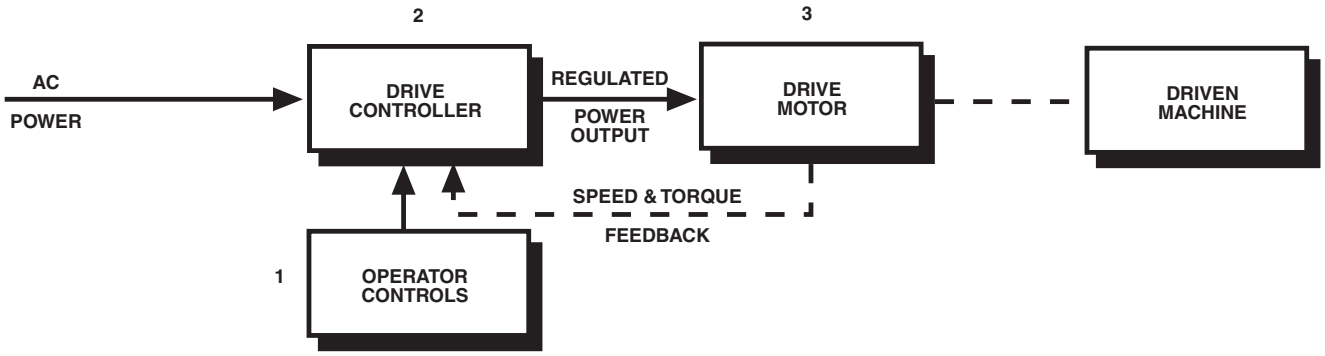


FIGURE 1.

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.

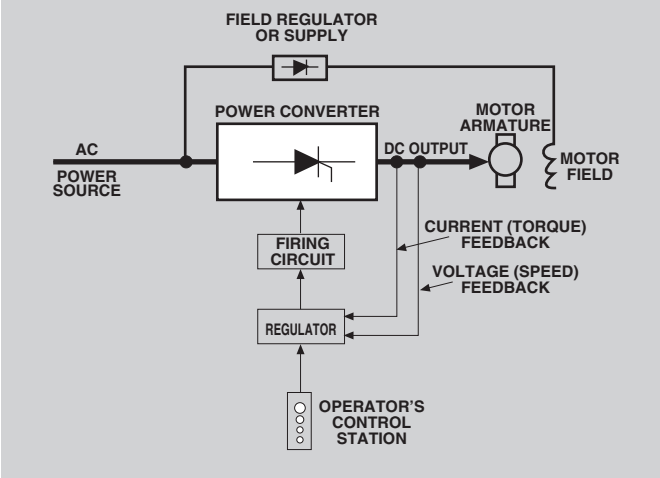


FIGURE 2. TYPICAL DC DRIVE

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.

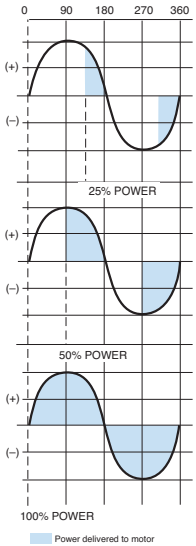


FIGURE 3. TRIGGERING POINTS FOR VARIOUS POWER OUTPUTS

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.

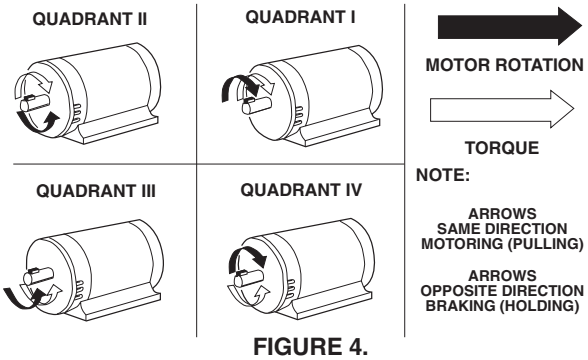


FIGURE 4.

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.

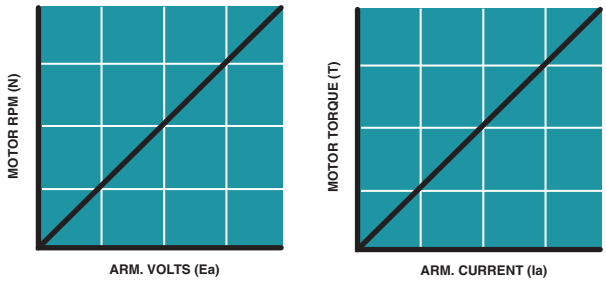


FIGURE 5. DC MOTOR CHARACTERISTICS

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.

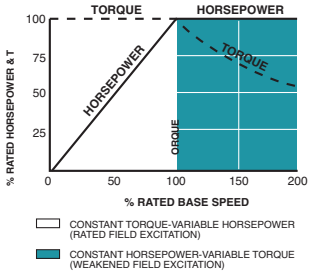


FIGURE 6.

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.

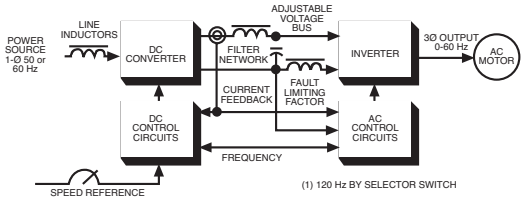


FIGURE 7.

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.

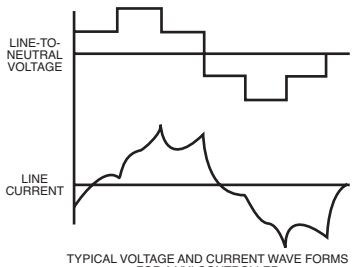


FIGURE 8.

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.

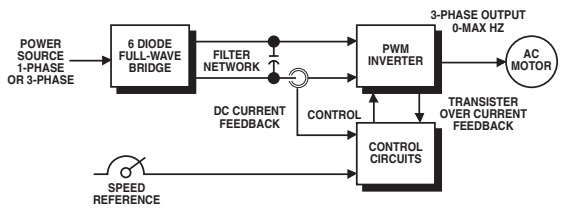


FIGURE 9.

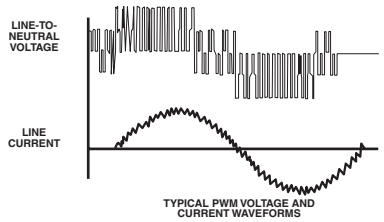


FIGURE 10.

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.

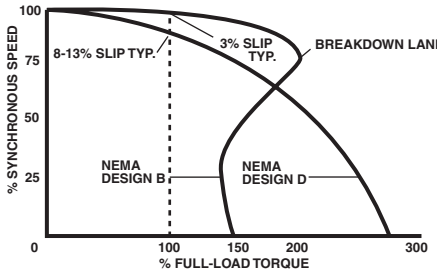


FIGURE 11.

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.

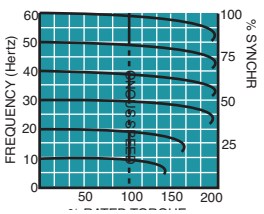


FIGURE 12. TYPICAL SPEED TORQUE CURVES FOR 60 HZ NEMA DESIGN B MOTOR (WITHOUT VOLTAGE BOOST)

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.

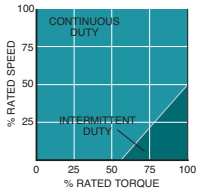


FIGURE 13. TYPICAL STANDARD AC MOTORS ADJUSTABLE SPEED OPERATION

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.

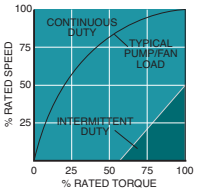


FIGURE 14. TYPICAL STANDARD AC MOTOR APPLICATION WITH VARIABLE TORQUE LOADS

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.

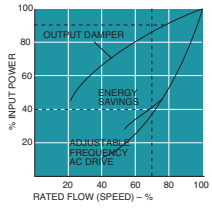


FIGURE. 15. ENERGY SAVINGS

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.

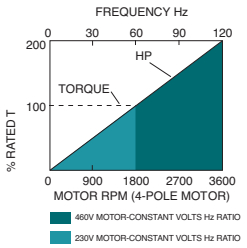


FIGURE 16. CONSTANT TORQUE OPERATION

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.

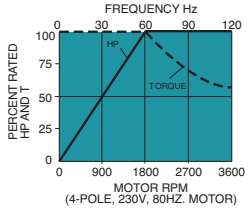


FIGURE 17. TYPICAL CONSTANT HP OPERATION

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.

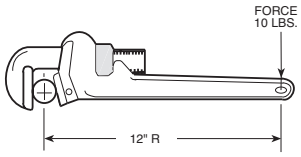


FIGURE 18

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 18 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

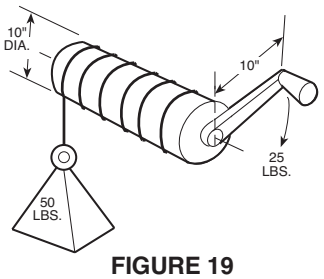


FIGURE 19

As shown in Figure 19, 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 dependent 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 20)
2. Constant Horsepower (Figure 21)
3. Squared Exponential Horsepower (Figure 22)
4. Cubed Exponential Horsepower (Figure 23)

Some machines may have operating characteristics which are a composite of the basic types.

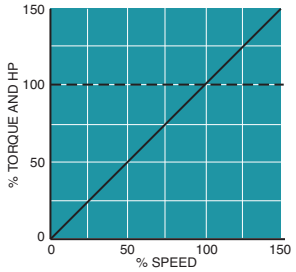


Figure 20. Constant Torque Horsepower

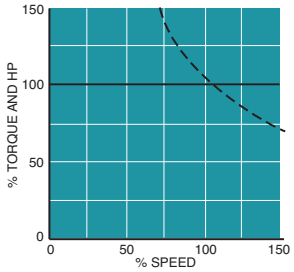


Figure 21. Constant

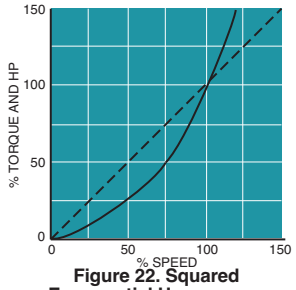


Figure 22. Squared Exponential Horsepower

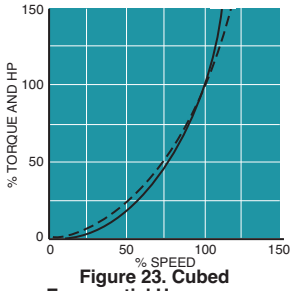


Figure 23. Cubed Exponential Horsepower

– – – – 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 24.

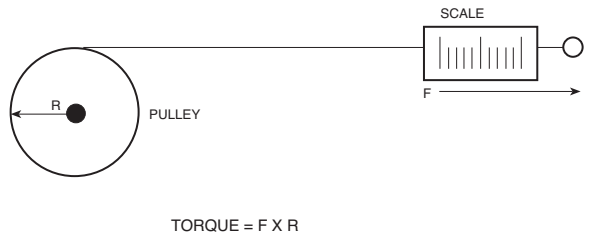


Figure 24.

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:

$$HP = \frac{(GPM) \times (Head\ in\ Feet) \times (Specific\ Gravity)}{3950 \times (Efficiency\ of\ Pump)}$$

For Fans and Blowers:

$$HP = \frac{CFM \times (Pressure\ in\ Pounds/Sq\ ft)}{33{,}000 \times Efficiency}$$

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 25.

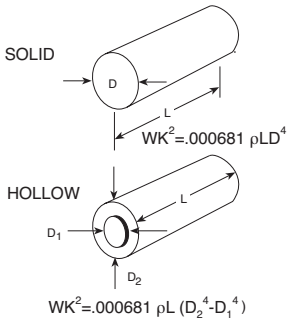


FIGURE 25.

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: $W K^2 = W \times \frac{r^2 + r_2^2}{2}$

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 26.

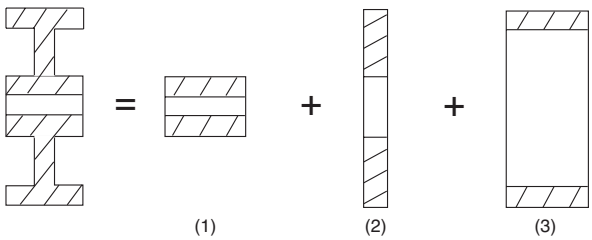


FIGURE 26.

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.

ALL QUOTATIONS AND SALES BY BOSTON GEAR. THE CONTRACTING PARTY HERETO, A DIVISION OF ALTRA INDUSTRIAL MOTION. 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

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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.