

# Kollmorgen Brushless Motor Amplifier EB-60X Series Motors Installation and Service Manual

**Edition: September 2020, Revision B**  
**Part Number: EB-9207**  
Original Document



For safe and proper use, follow these instructions. Keep for future use.

**KOLLMORGEN**<sup>®</sup>

*Because Motion Matters™*

## Record of Document Revisions

Revision	Date	Remarks
1		Initial Release
2	11/2004	Update corporate identity, contact information
B	09/2020	Rebrand, CE and Declaration of Conformity removed

## IMPORTANT NOTICE

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### Technical changes which improve the performance of the device may be made without prior notice!

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### SAFETY – READ ALL INSTRUCTIONS BEFORE INSTALLING THIS MOTOR

#### **WARNING**

Dangerous voltages exist in this equipment. Do not attempt connecting or probing this equipment with power on.

The fold back feature must limit the over current to no more that 300% of rated current for a maximum period of 8 seconds.

#### **CAUTION**

Do not install the amplifier in a hazardous (classified) location unless the amplifier is listed for such location. The motor is U.L. listed for class I, C, and D, but the amplifier might not be suitable for such locations.

Do not operate the motor outside the parameters shown on the respective performance curve.

Do not service unless area is known to be non-hazardous. Keep covers tight while circuits are live.

Connect internal thermostat to limit motor surface temperature.

Instructions are provided indicating that motor thermostat is an automatic resetting device.

#### **NOTE**

Upon receipt of the equipment, closely inspect the components to ensure that no damage has occurred in shipment. If damage has occurred, notify the appropriate carrier at once.

Save these instructions for future reference. Should any question arise regarding any step outlined in this manual, please call the factory.

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# 1 INTRODUCTION

This installation and service manual is a general document and is applicable to a typical amplifier needed to properly control the EB-60X motor series. However, since these motor amplifiers are interfaced with motors of varying sizes having different operating characteristics such as internal resistance, inductance, rotor inertia, etc., these amplifiers vary with the motors with which they are compatible. Consult the manufacturer of the amplifier for the installation and service manual pertaining to the specific amplifier used. After the typical amplifier and a motor are connected together, the motor must perform per the motor's nameplate data.

The customer data (CD) and performance curve (PC) are specified documents and are applicable only to individual motors. They contain such information as maximum operating speed, peak current limits, and values, which make the amplifier motor combination compatible. Do not operate the motor outside the parameters shown on the respective performance curves.

Typical amplifiers are of the 3-phase sine wave, pulse-width modulated type. They are full regenerative four-quadrant bi-directional velocity loop amplifiers designed to be used with Kollmorgen's high-performance permanent magnet brushless motors.

An unregulated 300 VDC bus, derived from full-wave rectification of a 3-phase 230 AC line by the power supply unit, is used to power the motor amplifier.

Kollmorgen brushless motors feature the latest in permanent magnet technology; utilizing high energy Samarium-Cobalt and Neodymium-Iron-Boron alloys. These brushless motors consist of permanent magnet rotors and 3-phase Y-stator windings. Being brushless motors, there are no commutators or associated brushes. These motors run as synchronous motors, meaning the rotor speed is the same as the speed (frequency) of the rotating stator magnetic field. A brushless resolver is utilized as the feedback device and is mounted internally as part of the overall motor construction.

Benefits of the typical amplifier and brushless motor construction are:

- Lower rotor inertia allows higher acceleration rates.
- The motor is thermally more efficient since all heat is generated in the stator windings, which are in the outside shell.
- Higher speed operation and high peak horsepower are achieved. There is no commutation limit.
- Smaller physical motor size for a given HP rating.
- Higher reliability and less motor maintenance. There is no commutator or brushes.
- Smooth output torque.

## 1.1 Amplifier and Power Supply Ratings

Ratings		
Input Power:	235 V <sub>RMS</sub> (L-L) 3-phase (±10%); isolation transformer not required – provided short circuit (inrush) current remains limited to less than 1000 amps. 115 VAC 1-phase control power.	
Output Power	Power Supply DC Bus	325 VDC nominal, no load
	Amplifier: at rated load	230 VRMS (L-L), Nominal ±10%
	Continuous Current (ARMS/Phase)	Intermittent Current (5 sec. max., 30% duty cycle) (ARMS/Phase)
	As required to produce motors rated current	200% of continuous
Ambient Operating Temperature:	0-55° C	
Switching Frequency	10 kHz	
Cooling	Fan, convection (cold plate)	

## 2 WIRING

**NOTE**

**Install this motor and typical amplifier per the national electrical code.**

To adhere to suitable engineering practices, connect the 115 VAC circuit so the 115 VAC is applied first in order to activate the control and fault circuits before applying the main bus voltage. Provide over-current protection, based on continuous rated current, per article 430 of the NEC. If possible, adjust the amplifier accordingly. Otherwise, provide external protection.

The method of connecting the motor is by way of flying leads; where the leads of the 3-phase motor stator are color coded and are available directly out of the motor.

Connect the motor with flying leads, where the leads of the 3-phase motor stator are color-coded and available directly out of the motor. See the wiring diagrams for the correct method of wiring the motor stator. Connect the BROWN, RED, and WHITE leads to the points identified as M<sub>a</sub>, M<sub>b</sub>, and M<sub>c</sub> on the power terminal block. Connect the green/yellow lead to the ground point of the ground point of the same terminal block.

Bring the 3-phase 230 input power should be brought through a customer supplied circuit breaker and connected to points identified as L<sub>a</sub>, L<sub>b</sub> and L<sub>c</sub> on the power terminal block mounted on the power supply. The system is not AC line phase sensitive. Connect the 325 VDC output, the 115 VAC, and the regeneration circuit from the power supply to the amplifier with the strapping bars and the small 115 VAC and regen cable. Check to ensure that the small cable is connected to the correct pins and that it is not offset to one side, and do the following:

1. Wire the typical amplifier control terminal strips per the diagram. Dress the wiring neatly so it does not to interfere with remounting the cover.
2. Unplug the C1, C2 and C3 point terminal strips from their connectors on the amplifier-motor control board. This will prevent over flexing the board when wiring up the connectors.
3. After unplugging the terminal strips from the motor control board, wire them per the appropriate diagram.
4. Neatly dress the wire cable so that it enters the amplifier chassis and does not interfere with the front cover. Dress signal cables separately and not with the AC or power wiring.
5. Leave sufficient length in the wiring to allow the motor control board to slide out enough to expose the small compensation board. Insert the wired terminal strips back onto their connectors.

The following precautions are also recommended:

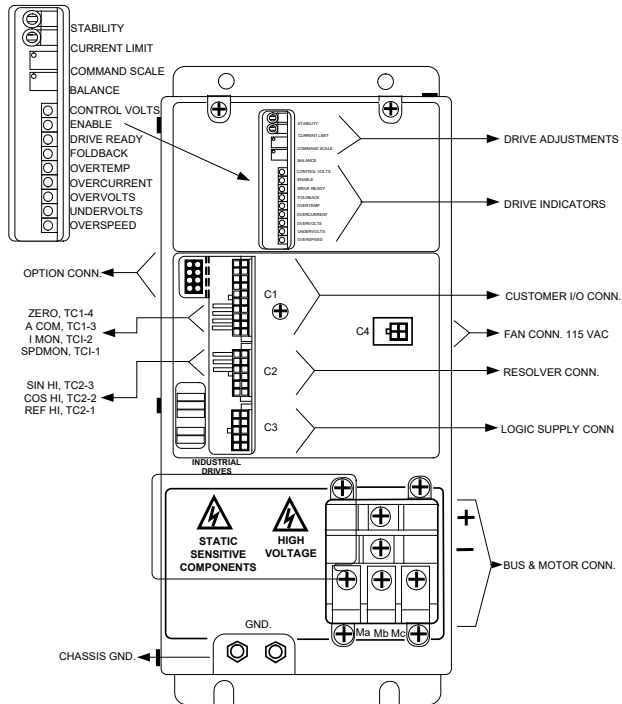
1. Twist all AC leads to minimize electromagnetic emissions and pick-up. Maintain shield over resolver leads.
2. Avoid running signal leads in close proximity to power leads, armature leads or other sources of electromagnetic noise.
3. Minimize lead lengths as much as practical.
4. Double-check all interface wiring. Carefully inspect all connections.
5. Do not use main contactor for control functions.

**⚠ CAUTION**

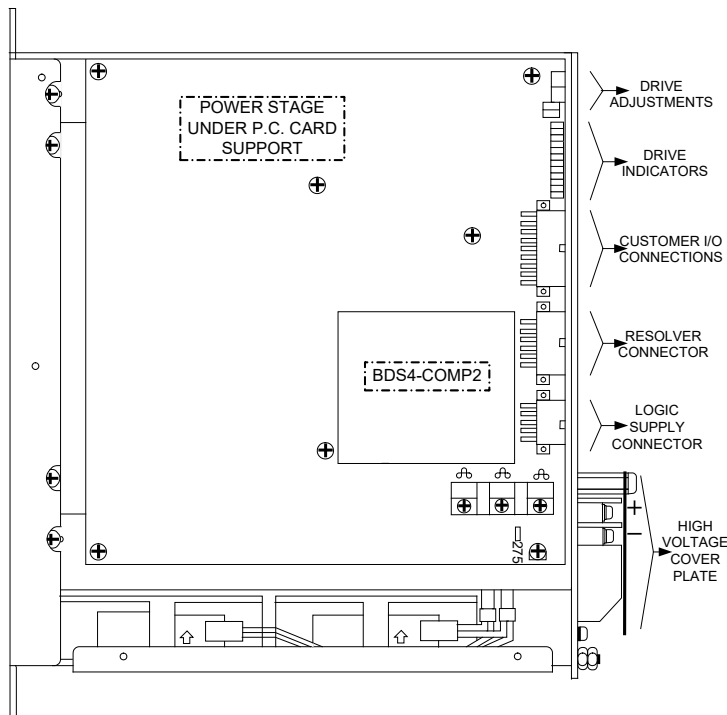
**Motor and resolver phasing are critical for proper operation.**

## 2.1 Typical Amplifier

### 2.1.1 Front View

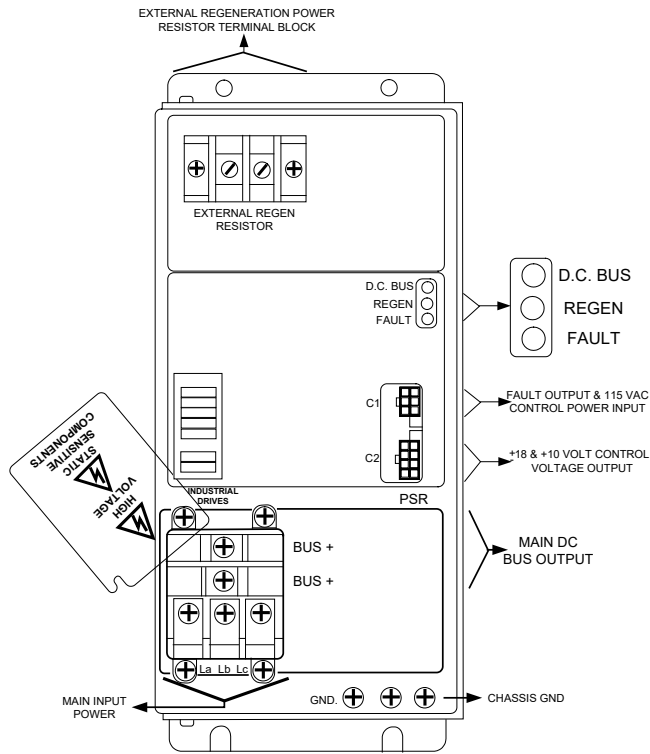


### 2.1.2 Side View

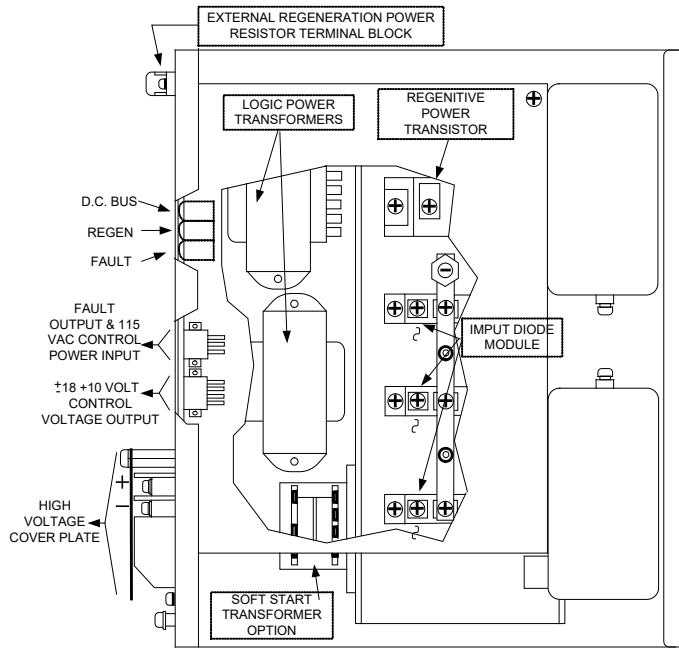


## 2.2 Typical Power Supply

### 2.2.1 Front View

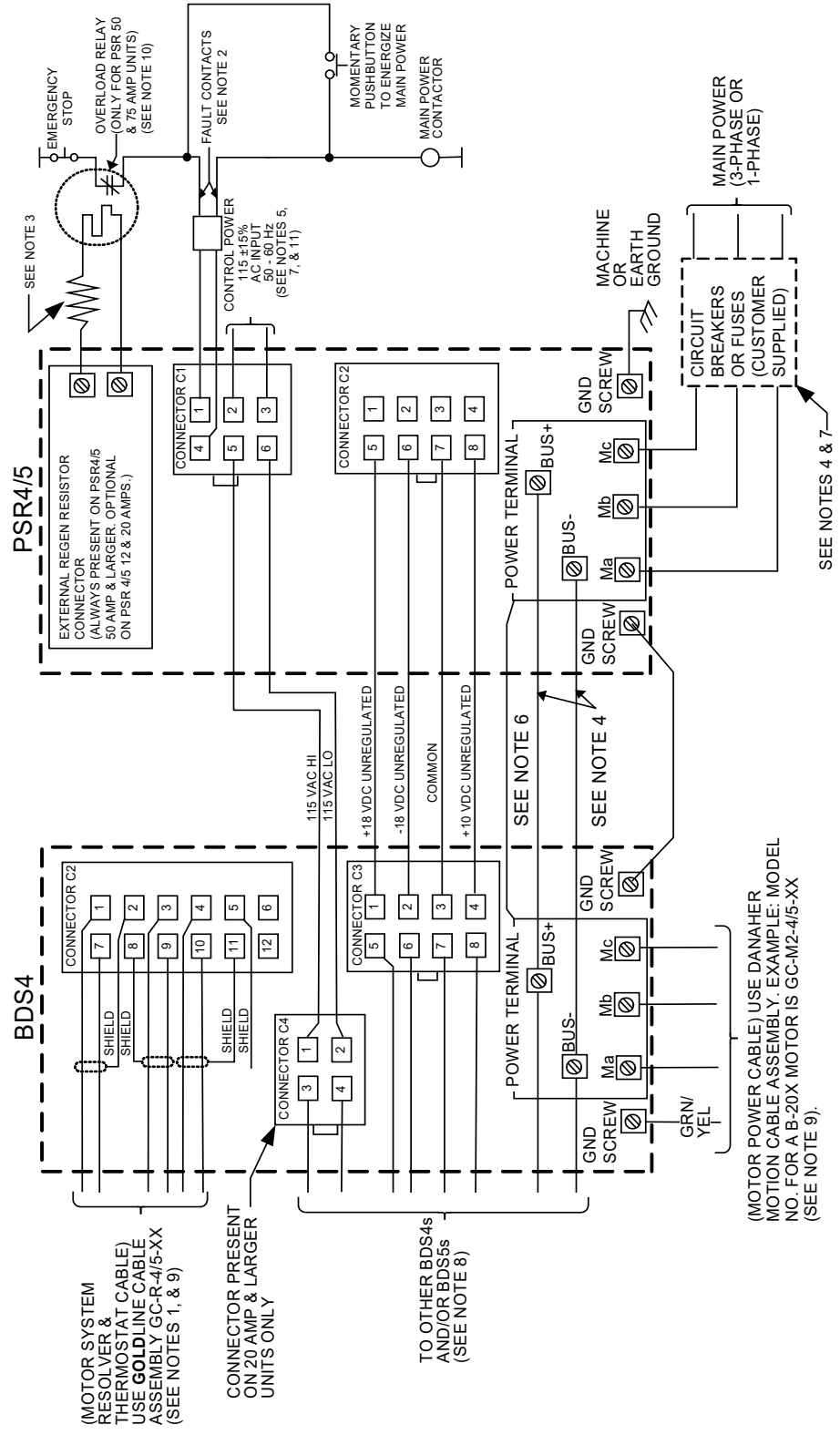


### 2.2.2 Side View





## 2.3 PSR4/5 & Motor Wiring



\*Notes are on the following pages.

**(ALL WIRES TO BE COPPER WITH MIN. TEMP. RATING OF 60° C)**

**⚠ WARNING**

The motor thermostat automatically resets when the motor cools. You are responsible for latching this signal to inhibit operation after a motor thermostat fault. Connect thermostat using twisted pair wire.

**⚠ CAUTION**

The PSR4/5 fault contacts (rated 115 VAC 1 amp) must be wired in series with the overload relay. On 12 & 20 amp PSR4/5s, this contact is normally open and closes within 250 ms after application of control and main power. This contact opens in fault conditions. On 50&75 amp PSR4/5s, this contact closes on application of control power and opens in fault conditions.

**⚠ WARNING**

Resistor is connected to high voltage. Ensure sufficient electrical clearance when mounting. Resistor may become very hot during operation. **Do not** mount near materials that are flammable or damaged by heat. Ventilation may be required. See wiring drawing for specific regen resistor kit. Each kit has different series/parallel resistor connections to obtain specific resistance and power rating.

**NOTE**

Wire sizes, breakers and fuses for PSR4/5:

- PSR4/5-X12 has a max main power input current of 12  $A_{RMS}$ .
- PSR4/5-X20 has a max main power input current of 20  $A_{RMS}$ .
- PSR4/5-X50 has a max main power input current of 50  $A_{RMS}$ .
- PSR4/5-X75 has a max main power input current of 75  $A_{RMS}$ .

The actual application may require less current. Use 600 VAC insulated wire and refer to local electrical codes for proper wire size for the currents listed above. Fuses for main power should be a U.L. rated time delay type, such as, buss FRN-R series.

The power BUS between a PSR4/5 and BOS4 should use the following wire gauge with 600 VAC insulation:

- PSR4/5-X12, 14 AWG (or larger) wire.
- PSR4/5-X20, 10 AWG wire.
- PSR4/5-X50, 8 AWG (or larger) wire.
- PSR4/5-X75, 8 AWG (or larger) wire.

**NOTE**

All signal and control wires must be 22-18 AWG wire. The crimp terminals for 22-18 AWG wire are supplied for use with BDS4 connectors C1, C2, C3, C4, option connector and PSR4/5 connectors C1 & C2, for 16 AWG wire use Molex #39-00-0078 terminals.

In the BDS4 3 amp thru 20 amp and the PSR4/5 12 amp and 20 amp, the screws in the power terminal blocks are captive. **DO NOT** attempt to remove them to use ring terminals. Use locking spring spade terminals such as Hollingsworth #XSS20954S or #SS20947SF for 16 AWG wire and #XSS20836 or #SS20832F for 12/10 AWG wire.

**NOTE**

All AC lines should be twisted cables.

**NOTE**

The total number of axes allowed, per PSR4/5, depends on the PSR4/5 model and the combination of BDS4s and/or BDS5s:

- PSR4/5-X12: a max of 4 BDS4's or 3 BDS5s.
- PSR4/5-X20: a max of 4 BDS4's or 3 BDS5s.
- PSR4/5-X50: a max of 6 BDS4's or 6 BDS5s.
- PSR4/5-X75: a max of 6 BDS4's or 6 BDS5s.

(If the BDS's are mixed, then the total number of axes that can be used would be the max given for the BDS5s.)

**NOTE**

XX in the cable number stands for cable length in meters. Cable length is available from 3 to 75 meters in increments of 3 meters.

**NOTE**

A thermal overload relay is supplied in the regen resistor kit for the 50 and 75 amp PSR4/5s. The thermal overload relay, included in the kit, was sized for your resistance and power rating. The output contacts of the relay must be wired to drop power to the main power contactor in a fault condition, as shown on sheet 1.

**NOTE**

Do not wire control power (PSR4/5 connector C1) through the main power contactor. This is so that control power will not be removed if PSR4/5 fault contacts open (this would turn **OFF** any fault LEDS).

**NOTE**

All shielded cables must have shield continuity for the full length of the cable.

**NOTE**

Resolver cable must be individually shielded pairs.

**NOTE**

Recommended torques for connection to terminal blocks and ground.

- BDS4/5-3 to 20 amp and PSR4/5-12 and 20 amp
  - Max torque per UL is 12 in/lb, external regen, main power and BUS connection.
  - Max torque 12 in/lb ground screw.
- BDS4/5-30 to 55 amp
  - Max torque 20 in/lb motor, BUS connection and ground stud
- PSR4/5-50 to 75 amp
  - Max torque 20 in/lb main power, BUS connection and ground stud
  - Max torque 12 in/lb external regen connection

For grounding to machine or earth ground. A screw lug should be attached to ground screw or stud. Recommended torque of 12 in/lb for ground screws and 20 in/lb for ground studs. May also refer to national electrical code (NEC) or UL standard 486B for recommended torques.

Thermal overload protection **DOES NOT** provide internal to amplifier and must be provided external. Refer to national electrical code for proper sizing of overload protection.

**NOTE**

Use a Corcom 5R1 single phase filter or equivalent (for CE requirements).

**NOTE**

Use a Shaffner three phase filter or equivalent

- Model No. 258-16/07 for PSR4/5A-112 & 212.
- Model No. 258-30/77 for PSR4/5A-120 & 220.
- Model No. 258-55/07 for PSR4/5A-250.
- Model No. 258-75/34 for PSR4/5A-275.
- For CE requirements.

**NOTE**

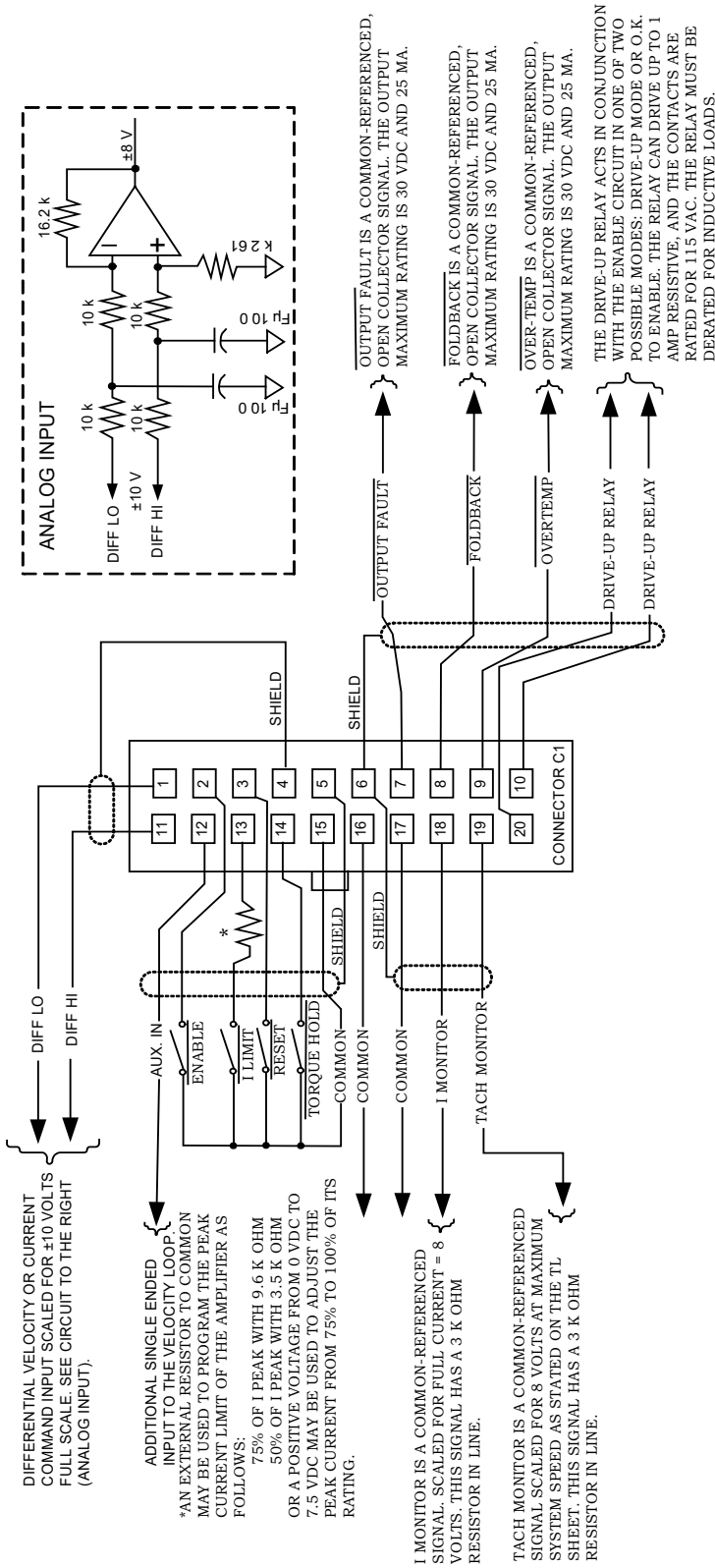
Use a Shaffner three phase choke or equivalent.

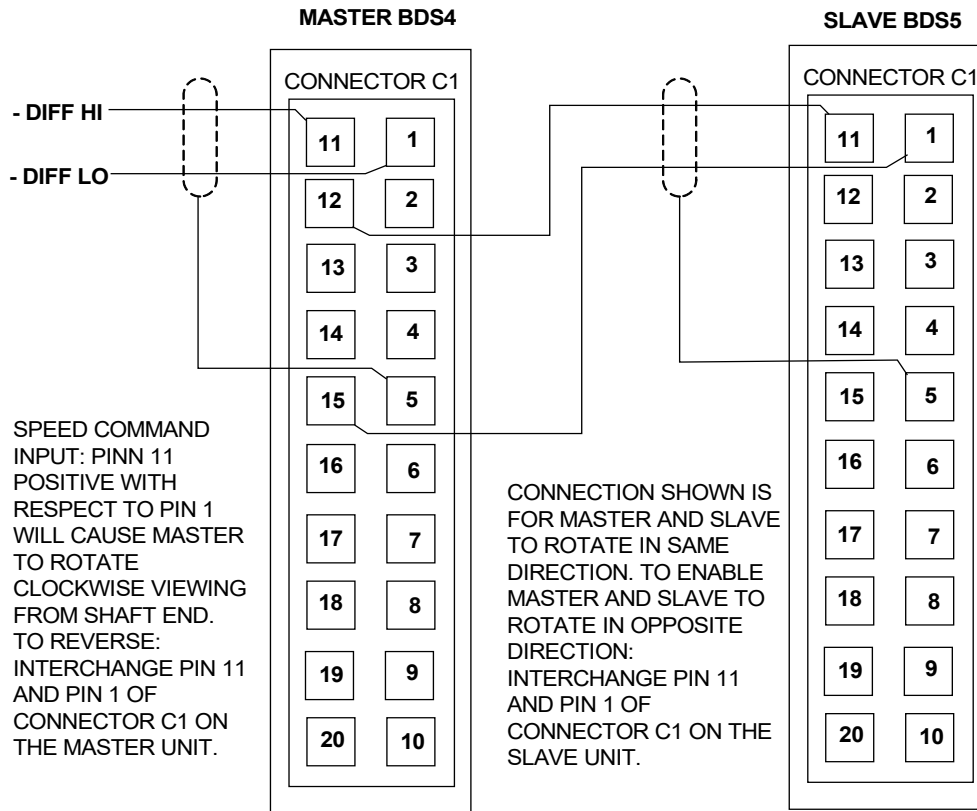
- Model No. RD 7137-6-12m0 or RD 7137-36-0m5 for BDS4A-103, 203, 106 & 206.
- Model No. RD 7137-10-6m6 or RD 7137-36-0m5 for BDS4A-110 & 210
- Model No. RD 7137-25-1m3 or RD 7137-36-0m5 for BDS4A-120 & 220
- Model No. RD 7137-36-12m0 for BDS4A-230.
- Model No. RD 7137-64-12m0 BDS4A-240 & 255.
- (For CE requirements)

**NOTE**

Suitable for use on circuit capable of delivering not more than 5000 symmetrical  $A_{RMS}$ , 240 volts max.

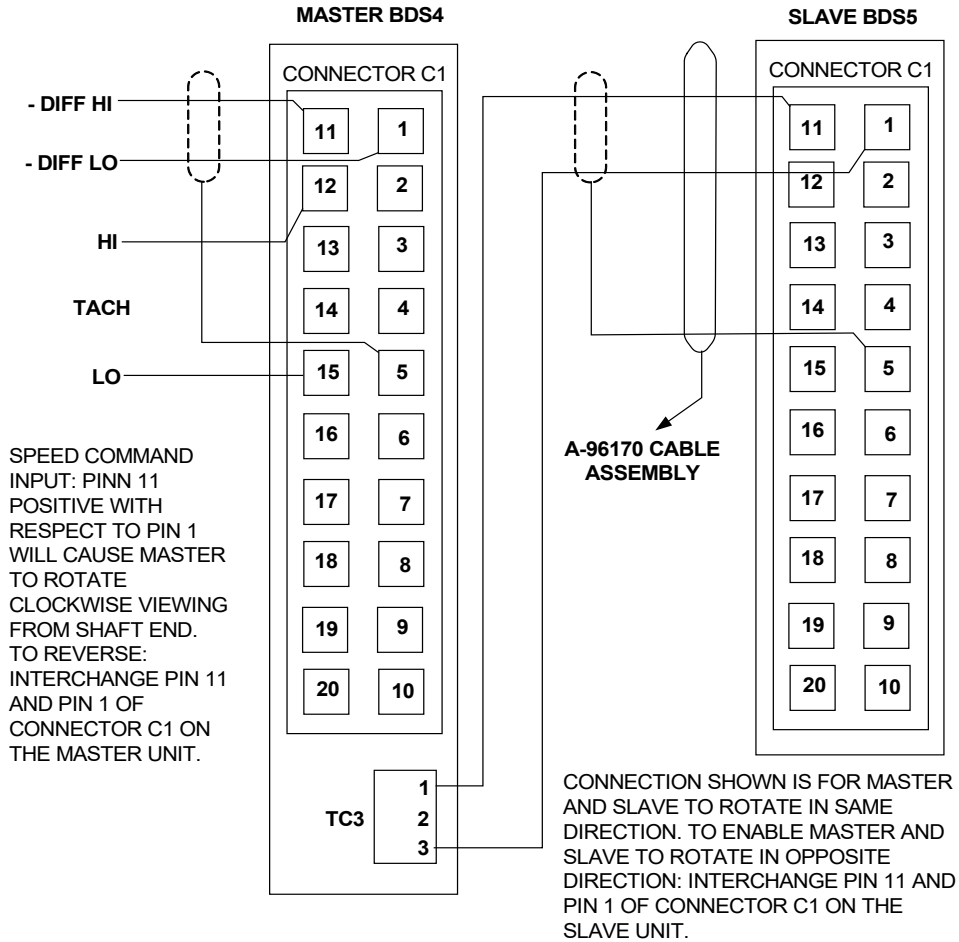
## 2.4 BDS4 Wiring





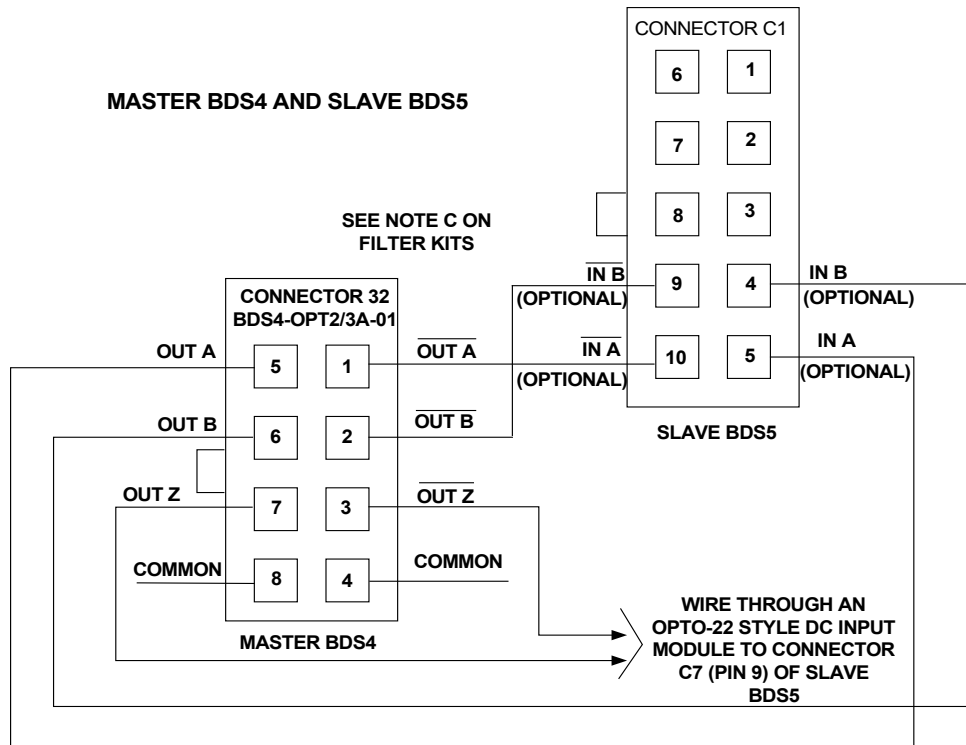
### System Setup

1. The master unit requires a master (M) type compensation card – designated (i.e., BDS4-230J/SOSA2M). The slave requires a slave (S) type compensation card designated (i.e., BDS4-230J/XOXA2S).
2. For proper load sharing between the master and slave units, the following adjustment must be made on the slave unit (the stability and command scale pots now function as torque gain adjustments):
  - Adjust the stability pot fully counter-clockwise.
  - Adjust the command scale pot fully clockwise.
  - Adjust the current limit pot fully clockwise.
  - Under load conditions, the load sharing may be improved slightly by comparing each unit's current monitor signal:
    - To increase load on the slave unit, adjust its stability pot clockwise
    - To decrease load on the slave unit, adjust its command scale pot counter-clockwise.
3. Master/slave operation is incompatible with brush tach systems.



### System Setup

1. The master unit requires a master (M) type compensation card – designated (i.e. BDS4-230J/X0XA2M). The slave requires a slave(s) type compensation card – designated (i.e. BDS4-230J/X0XA2S).
2. For proper load sharing between the master and slave units, the following adjustment must be made on the slave unit (the stability and command scale pots now function as torque gain adjustments):
  - Adjust the stability pot fully counter-clockwise.
  - Adjust the command scale pot fully clockwise
  - Adjust the current limit pot fully clockwise
  - Under load conditions, the load sharing may be improved slightly by comparing each unit's current monitor signal:
    - To increase load on the slave unit, adjust its stability pot clockwise
    - To decrease load on the slave unit, adjust its command scale pot counter-clockwise.



**NOTE**

The commons of master BDS4 and slave BDS5 must be connected. This is accomplished through connector C3 in the BDS4 and connector C4 in the BDS5 if they share one PSR4/5.

**NOTE**

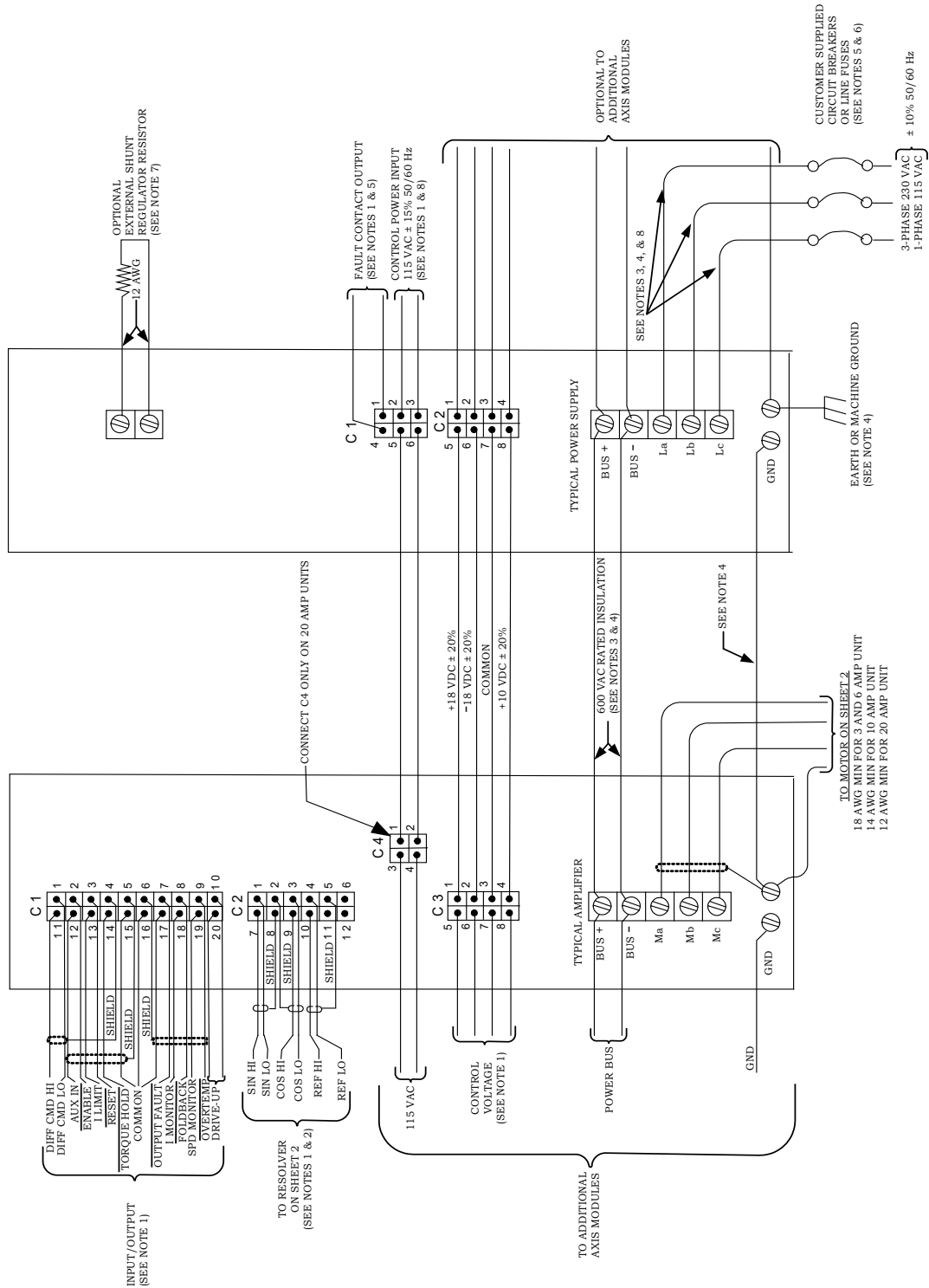
If the BDS5 uses the optional analog input card (BDS5-OPT1), the optional encoder inputs in connector C1 are not allowed.

**NOTE**

The filter kit uses a Ferrishield Sleeve snap model no. SS3382036 or equivalent



## 2.5 System Wiring

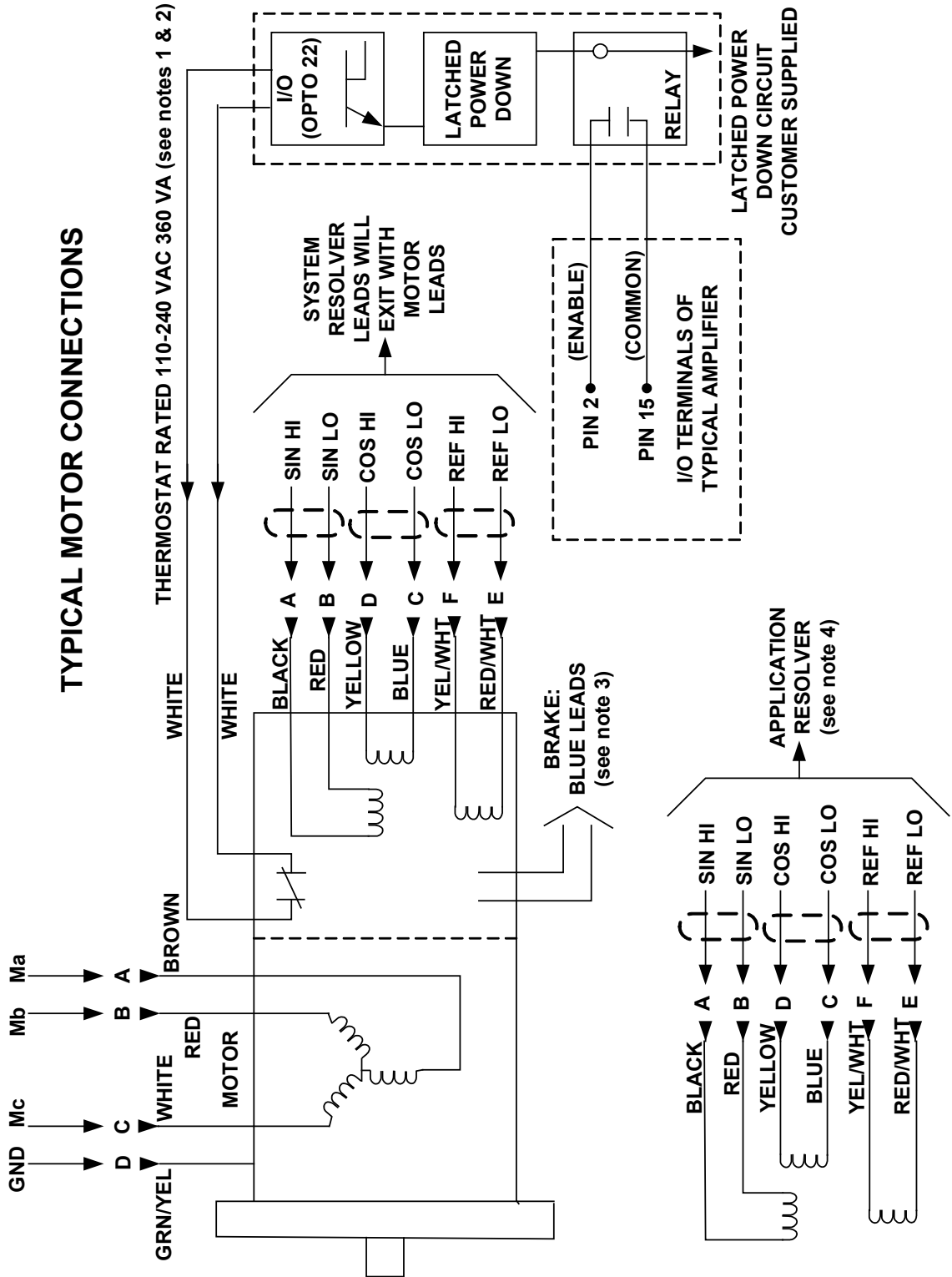


\*Notes are shown on the next page.

Notes for System Wiring:

1. All signal and control wire to be 22-18 AWG wire. If 16 AWG is desired, then use Molex #39-00-0078 crimp pins (not supplied) instead of the parts supplied.
2. Resolver must be wired with (3) sets of 2-conductor shielded pairs as shown. Thermostat wiring to be twisted pair.
3. The screws in the power terminal blocks are captive. Do not attempt to remove them for using ring terminals. Use locking type spring spade terminals such as Hollingsworth #XSS20954S or #SS20947SF for 16/14 AWG wire and #XSS20836 or #SS20832F for 12/10 AWG wire.
4. Wire gauge dependent on application: For total axis currents less than 9-amps: 16 AWG may be used. For total axis currents greater than 20-amps: 10 AWG must be used.
5. The power supply fault contact (rated 115 VAC 1 amp) should be wired to drop main 3-phase power (La, Lb, Lc) in fault conditions. (This contact is normally open, closed on power-up (approximately 0.250 ms) and opens in fault conditions.)
6. Fuse or circuit breaker sizing dependent on application.
  - PSR4 Recommended Fuse
  - 12 amp Buss #FAN-A-12 or equivalent
  - 20 amp Buss #FAN-A-20 or equivalent
7. Resistor must be mounted away from any flammable material. A 400 VDC potential is present (electrical isolation should be maintained for this voltage rating).
8. All AC lines should be twisted cables.

## 2.6 Typical Motor Connections



Notes are found on following page.

Notes for previous diagram:

1. The motor thermostat is an automatic resetting device and should be connected into a latched (lock-out) power down type circuit.
2. Thermostat to be wired with twisted pair.
3. The brake should be energized before switching the motor on and while it is in operation. For proper operation an electrical interlock circuit should be employed to ensure that the brake is not engaged while the motor is energized.

Model	Holding VDC	Holding ADC
EB-60X-X-XX-B2	90	0.33
EB-60X-X-XX-B3	24	1.20

4. Application resolver leads will exit at a different location than system resolver leads.

## 2.7 Grounding

Ground the motor at either the amplifier motor terminal block or at the main ground point. Connect shielded cables at one end only.

## 2.8 Inputs

The drive-up contact closure (internal) is provided at pins 10 and 20. When this internal contact is closed, it indicates to the outside world (software) that the typical amplifier is ready to operate. When open, it indicates it is in Inhibit mode. The contact is rated at 115 VAC at 2 amps.

### **⚠ CAUTION**

The motor is provided with two normally closed thermostat reset devices connected in series. They are auto-resetting devices intended to shut the power down from the amplifier to limit the surface temperature of the motor to prevent ignition in hazardous atmospheres.

The remote Inhibit allows the amplifier to be disabled without removing the main power. When a contact is closed between pins 2 and 15 (D-common) the amplifier is placed in ready to operate mode. These pins (2 & 15) are connected through the latched power down circuit to the motor thermostat. The motor thermostat is an automatic resetting device used to shut the power down from the controller should an over-temperature condition occur in the motor windings. Connect the thermostat to a latched (locked-out) power down type circuit that requires manual reset. This prevents inadvertent restarting of the motor when it cools down below the thermostat's set value.

## 2.9 Preliminary Checks

Once the typical amplifier system has been installed and wired in, follow the steps below to ensure proper **operation before the main power is applied**.

### 2.9.1 Checking AC Input Voltage

**Open the circuit breaker** or remove the fuses in the secondary of the large 3-phase isolation transformer.

**Apply power.** With an AC voltmeter, check the 3-phase secondary line-to-line voltage. The voltage should be approximately  $230 V_{RMS} \pm 10\%$ .

**Remove power.** Close the circuit breaker or replace the fuses in the secondary of the large 3-phase isolation transformer.

### 2.9.2 Checking the Typical Power Supply DC Output Voltage

Do not apply the 115 VAC. Apply power to the large 3-phase transformer only. With a DC voltmeter, monitor the 325 VDC bus bars of the power supply and amplifier units. The voltage from the power supply should be approximately  $\pm 325 VDC \pm 10\%$ . Remove power.

### 2.9.3 Zero System Resolver

To Adjust the System Resolver to zero:

**⚠ CAUTION** Do not remove the cover while the motor is in a hazardous location.

1. Remove power.
2. Remove the motor end cover.
3. Loosen, but do not remove the resolver servo clamp screws.
4. Rotate the outer member of the resolver as needed for adjustment.
5. Replace and cover. All bolts must be tightened securely before applying power to the motor or resolver.

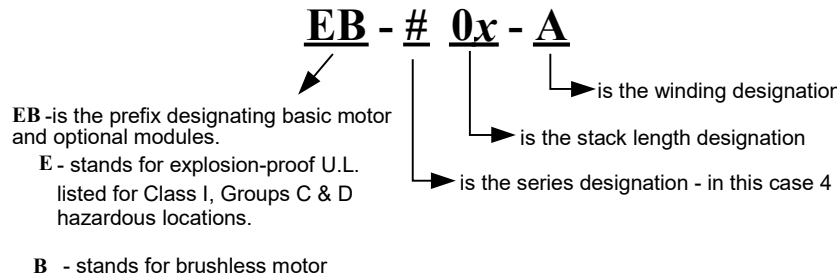
### 3. MOTOR DATA PACKAGE

This product's features and benefits are:

- UL-listed explosion-proof for Class I, Groups C & D hazardous locations
- Neodymium-Iron-Boron magnets
- Aluminum end bells
- Frameless, shaft-mounted resolver
- Rugged Construction

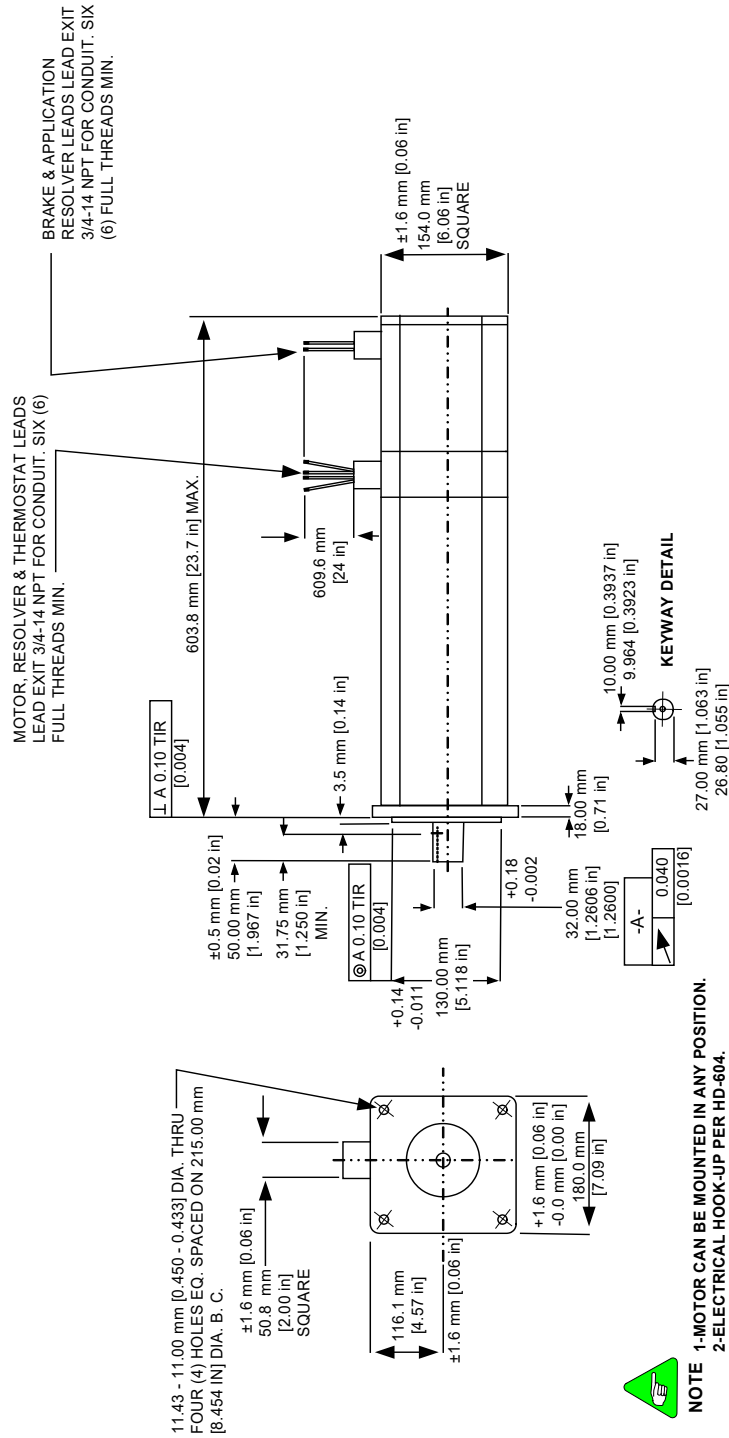
#### 3.1 EB-60X

##### 3.1.1 Model Number System



### 3.2 Outline Drawing

#### 3.2.1 EB-606-11-BXR102



A-62908

**3.3 EB-602**

**3.3.1 Specifications CD-27026**

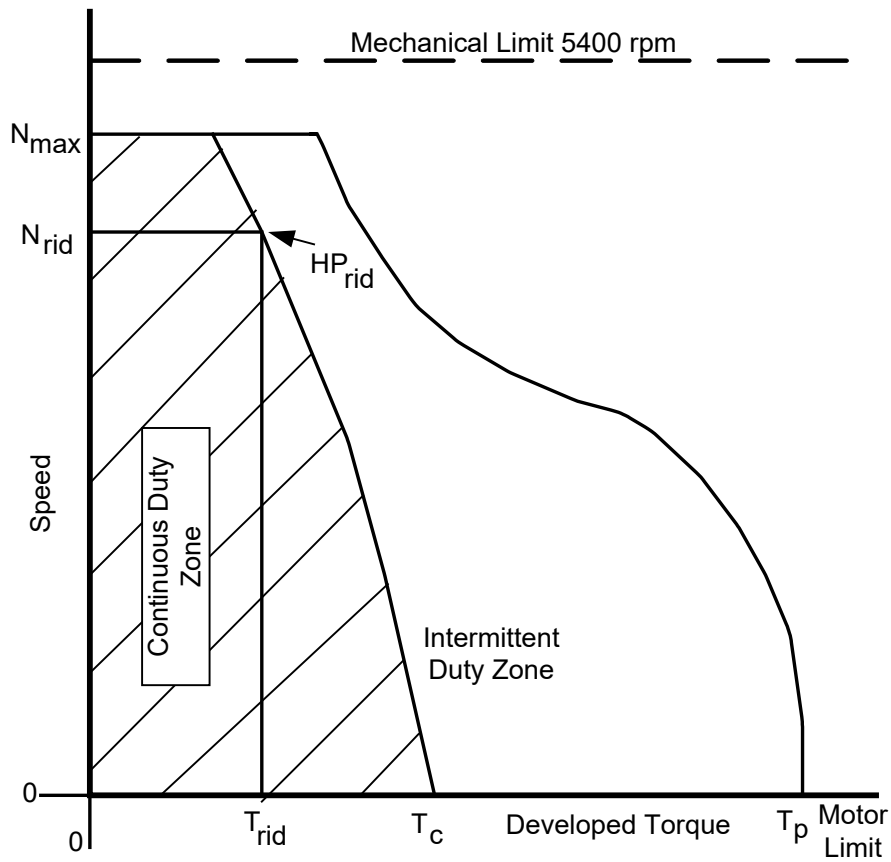
Specification	Tol	Symbol	Units	A	B	C	
*Continuous Torque (stall) at 40° C Ambient	Nom.	T <sub>C</sub>	lb-ft	13.0	12.8	12.8	
			N-m	17.63	17.36	17.36	
Cont. Line Current	Nom.	I <sub>C</sub>	A <sub>RMS</sub>	10.0	20.0	15.0	
†Max. Speed	Nom.	N max.	rpm	2000	4000	3000	
*Peak Torque	Nom.	T <sub>P</sub>	lb-ft	37.7	36.7	36.5	
			N-m	51.2	49.8	49.5	
Peak Line Current	Nom.	I <sub>P</sub>	A <sub>RMS</sub>	30.5	61.4	45	
129.2†Theoretical Acceleration	Nom.	α <sub>m</sub>	rad/sec <sup>2</sup>	48681	48417	48945	
†Horsepower	Rated	H <sub>P</sub> rtd	H <sub>P</sub>	4.4	7.7	6.1	
†Speed	Rated	N rtd	rpm	2000	4000	3000	
†Torque	Rated	T rtd	lb-ft	11.6	10.1	10.7	
			N-m	15.7	13.7	14.5	
Volts (line to line)	Rated	V rtd	V <sub>RMS</sub>	230	230	230	
*Torque Sensitivity	± 10%	K <sub>T</sub>	lb-ft / A <sub>RMS</sub>	1.302	0.629	0.854	
			N-m / A <sub>RMS</sub>	1.765	0.853	1.158	
Back EMF (line-to-line)	± 10%	K <sub>B</sub>	V/krpm	106.8	51.6	70.0	
Max. line-to-line volts	Max.	V max	V <sub>RMS</sub>	250	250	250	
DC Res at 25° C (line-to-line)	± 10%	R <sub>M</sub>	ohms	1.548	0.382	0.674	
Inductance (line-to-line)	± 30%	L <sub>M</sub>	mH	32	9.0	14.0	
Time Constant at 25° C	Mech.	Nom.	T <sub>M</sub>	ms	0.77	0.81	0.77
	Elec.	Nom.	T <sub>E</sub>	ms	20.7	23.6	20.8
System Performance Curve				26614	26615	26804	

\*At ultimate winding temperature for ambient data multiply by 1.06



†	Symbol	Units	Value
Rotor Inertia	$J_M$	lb ft sec <sup>2</sup>	0.000758
		kg m <sup>2</sup>	0.001028
Weight	Wt	lb	37
		kg (f)	16.8
Static Friction	$T_F$	lb-ft	0.360
		N-m	0.490
Thermal Time Constant Peak	TCTP	Minutes	12
Viscous Damping ∞Z Source	$F_1$	lb-ft/krpm	0.053
		N-m/krpm	0.072

† If brush type tach is used, these parameters may be affected. Consult the factory.



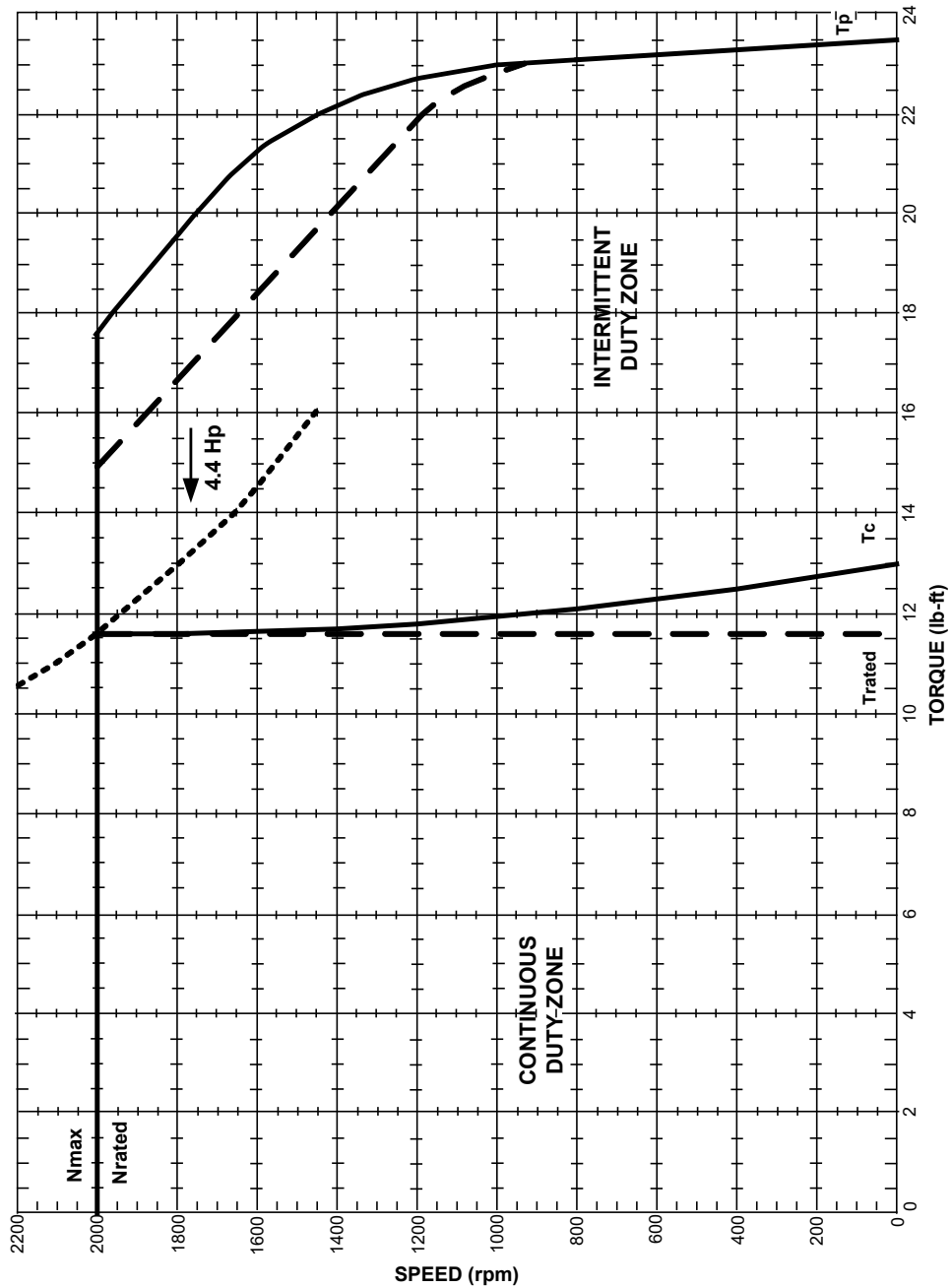
### 3.3.2 Performance Curves

#### 3.3.2.1 EB-602-A PC-26614

**NOTE**

Do not operate this motor outside the parameters shown on this performance curve.

Motor B-602-A  
 Drive BDS4-210  
 Test T3-1443

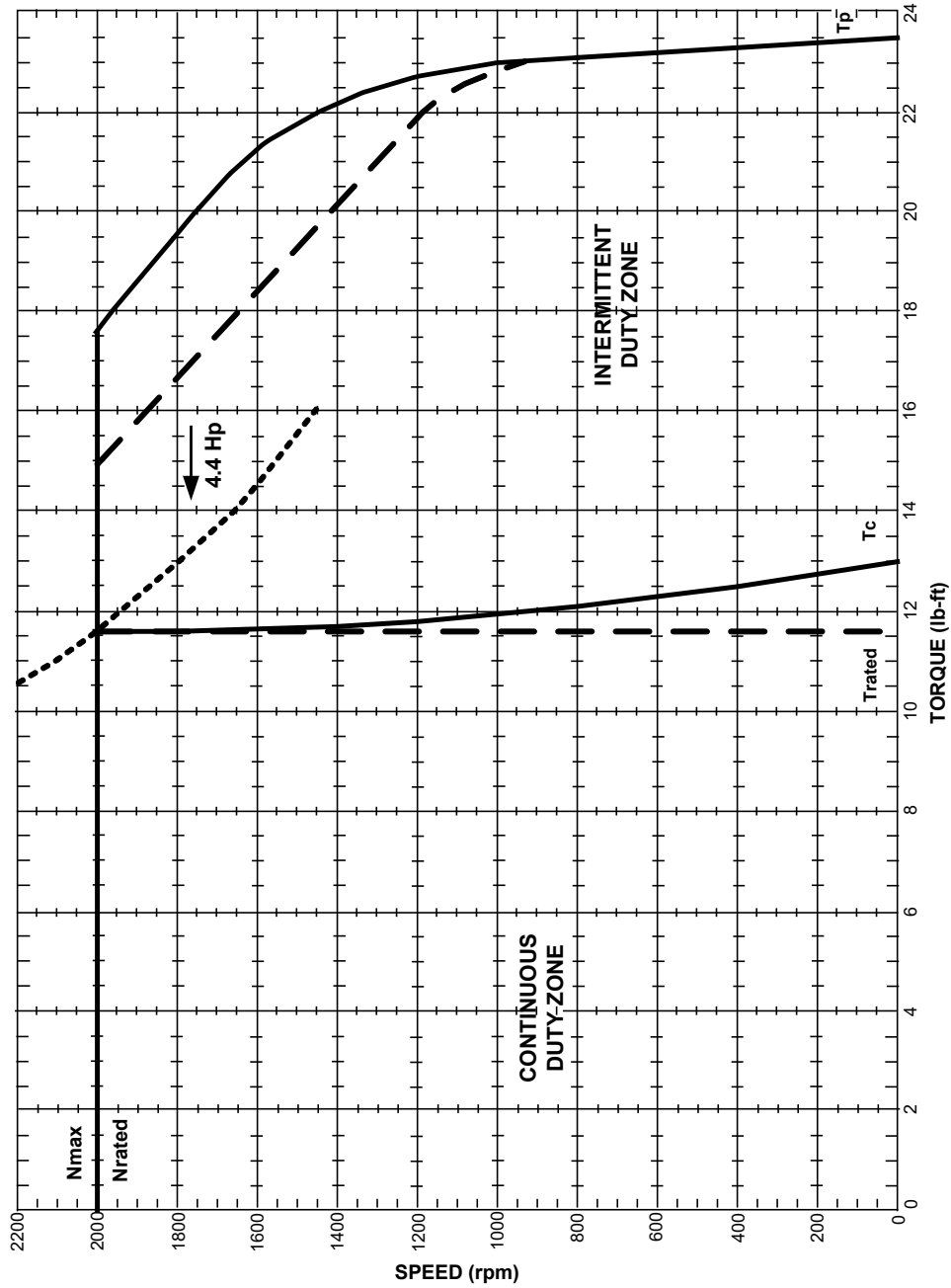


3.3.2.2 EB-602-A PC-26614

**NOTE**

Do not operate this motor outside the parameters shown on this performance curve.

Motor EB-602-A  
 Drive BDS4-210  
 Test T3-1443

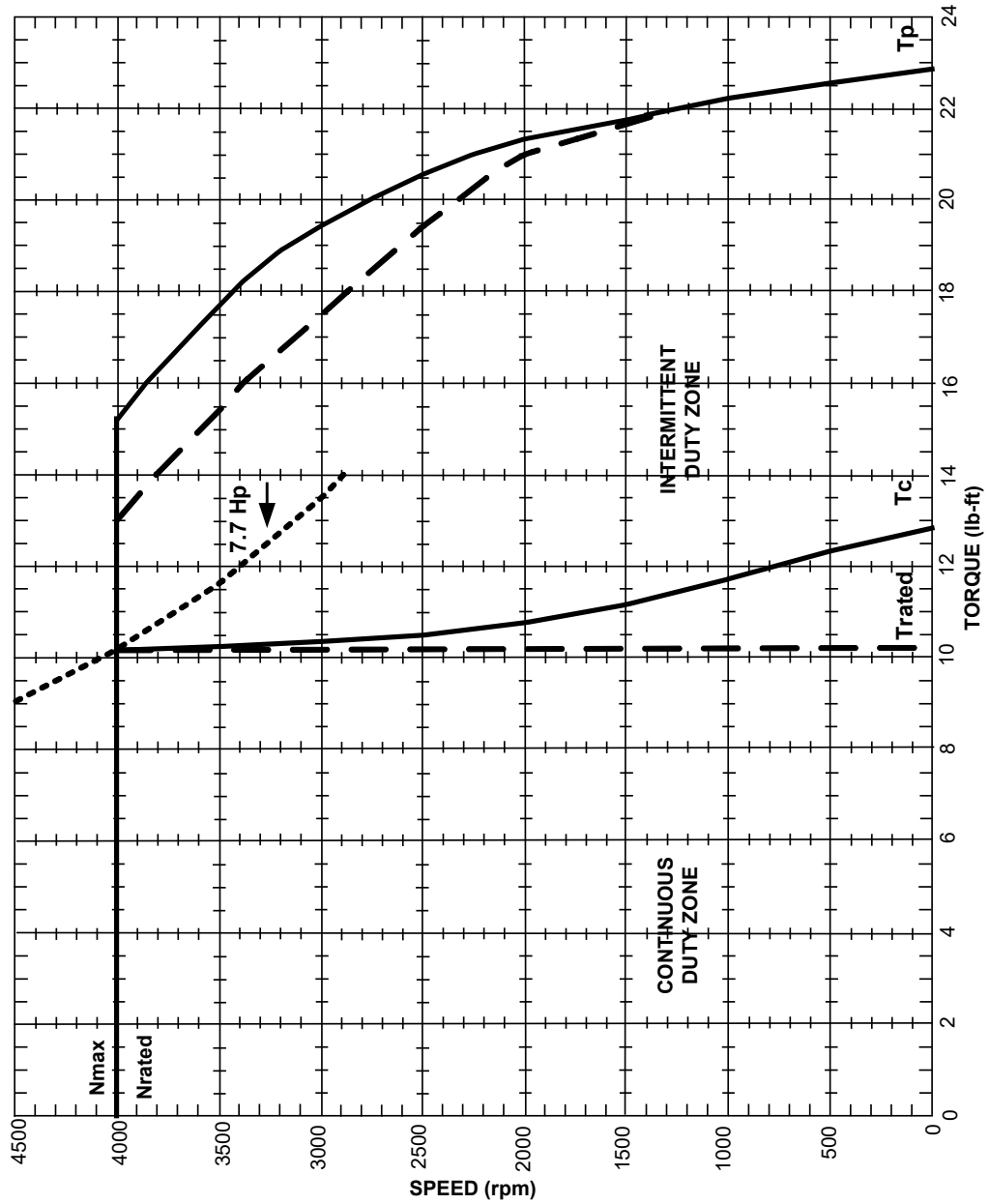


3.3.2.3 EB-602-B PC-26615



Do not operate this motor outside the parameters shown on this performance curve.

Motor EB-602-B  
 Drive BDS4-220  
 Test T3-1441

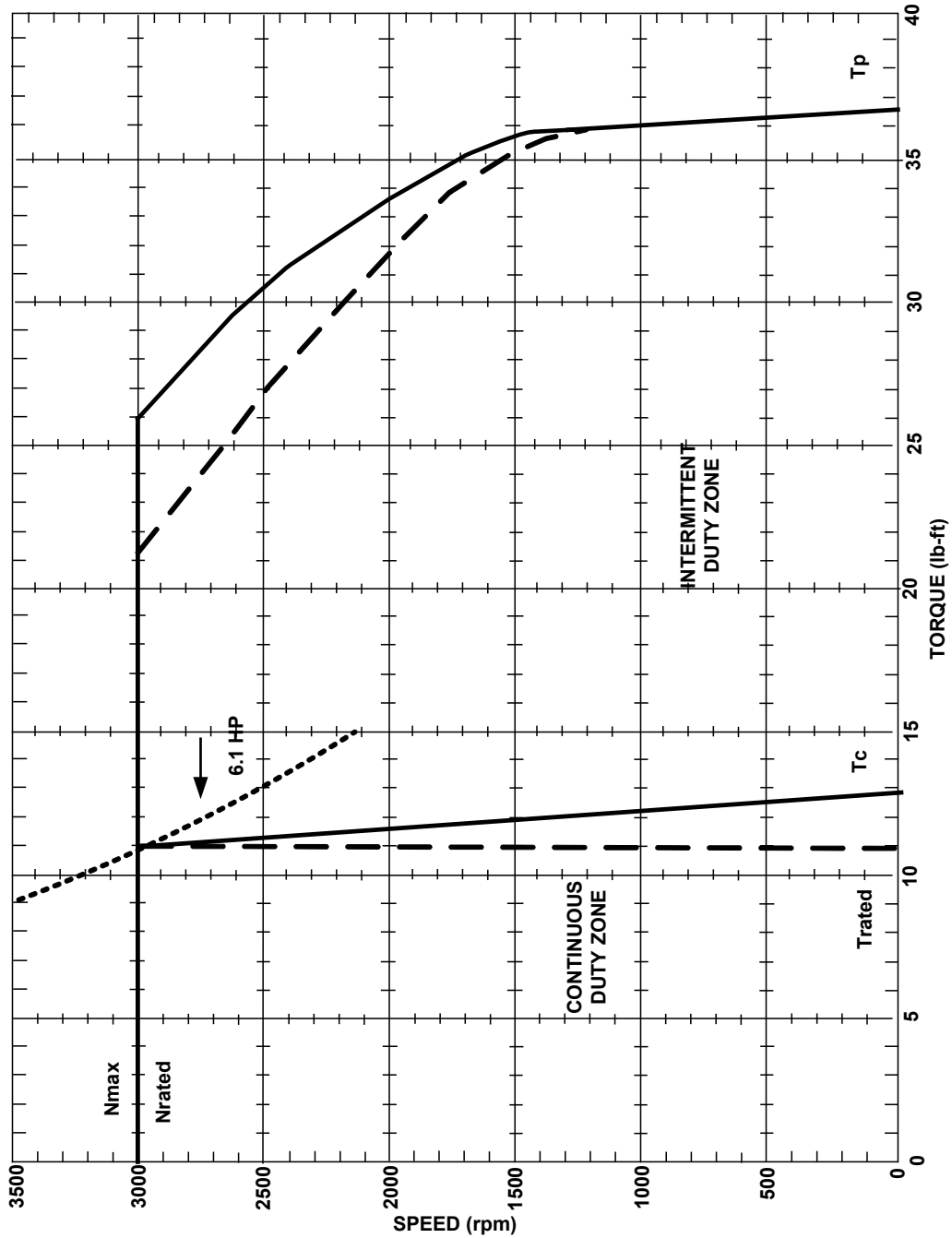


3.3.2.3 EB-602-C PC-26804 (Q)



Do not operate this motor outside the parameters shown on this performance curve.

Motor EB-602-C  
 Drive 15-amp continuous/45 amp peak  
 Test Calculated



### 3.4 EB-604

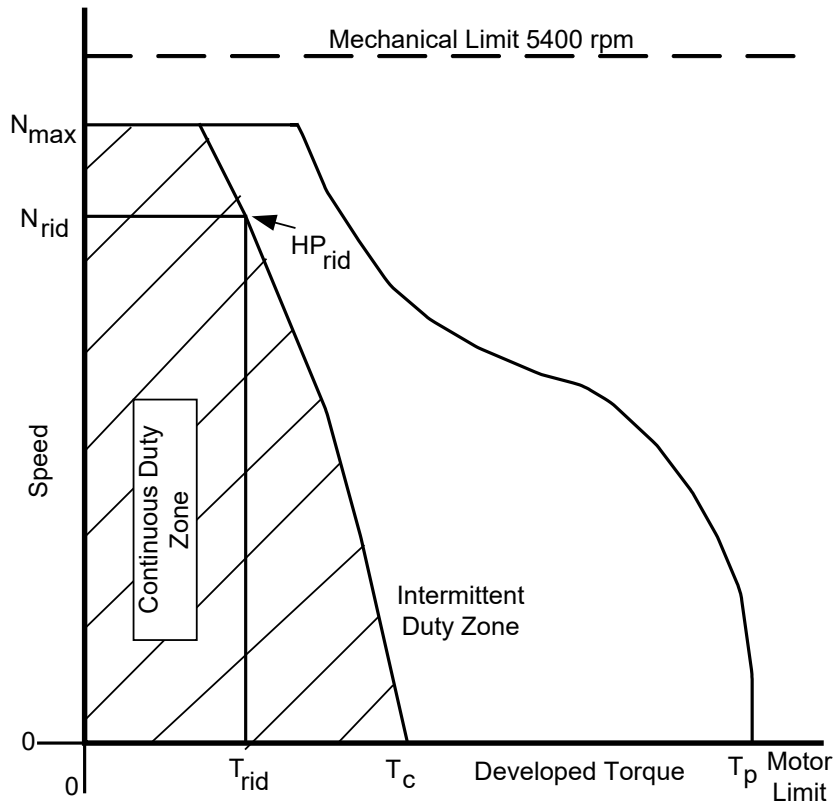
#### 3.4.1 Specifications CD-27027

Specification	Tol	Symbol	Units	A	B	C	D
*Continuous Torque (stall) at 40° C Ambient	Nom.	T <sub>C</sub>	lb-ft	22.2	22.2	23.0	22.8
			N-m	30.1	30.1	31.2	30.9
Cont. Line Current	Nom.	I <sub>C</sub>	A <sub>RMS</sub>	19	27.7	39.4	15
†Max. Speed	Nom.	N max.	rpm	2150	3150	4300	1600
*Peak Torque	Nom.	T <sub>P</sub>	lb-ft	63.7	64.7	63.7	64.9
			N-m	86.4	87.7	86.4	88
Peak Line Current	Nom.	I <sub>P</sub>	A <sub>RMS</sub>	57.4	84.8	114.8	45
129.2†Theoretical Acceleration	Nom.	∞m	rad/sec <sup>2</sup>	42467	43133	42467	43267
†Horsepower	Rated	H <sub>P</sub> rtd	H <sub>P</sub>	8	12	13	6.3
†Speed	Rated	N rtd	rpm	2150	3150	4300	1600
†Torque	Rated	T rtd	lb-ft	19.5	20	15.9	20.6
			N-m	26.5	27.1	21.6	27.9
Volts (line to line)	Rated	V rtd	V <sub>RMS</sub>	230	230	230	230
*Torque Sensitivity	± 10%	K <sub>T</sub>	lb-ft / A <sub>RMS</sub>	1.168	0.803	0.584	1.518
			N-m / A <sub>RMS</sub>	1.584	1.089	0.792	2.058
Back EMF (line-to-line)	± 10%	K <sub>B</sub>	V/krpm	95.78	66.85	47.89	124.5
Max. line-to-line volts	Max.	V max	V <sub>RMS</sub>	250	250	250	250
DC Res at 25° C (line-to-line)	± 10%	R <sub>M</sub>	ohms	0.508	0.234	0.126	0.838
Inductance (line-to-line)	± 30%	L <sub>M</sub>	mH	13.3	6.3	3.3	22
Time Constant at 25° C	Mech.	Nom.	T <sub>M</sub>	ms	0.62	0.60	0.60
	Elec.	Nom.	T <sub>E</sub>	ms	26.2	26.9	26.2
System Performance Curve				26616	26951	26952	26805

\*At ultimate winding temperature for ambient data multiply by 1.06

†	Symbol	Units	Value
Rotor Inertia	$J_M$	lb ft sec <sup>2</sup>	0.001500
		kg m <sup>2</sup>	0.002034
Weight	Wt	lb	51
		kg (f)	23.1
Static Friction	$T_F$	lb-ft	0.38
		N-m	0.52
Thermal Time Constant Peak	TCTP	Minutes	14
Viscous Damping $\infty Z$ Source	$F_1$	lb-ft/krpm	0.080
		N-m/krpm	0.109

† If brush type tach is used, these parameters may be affected. Consult the factory.



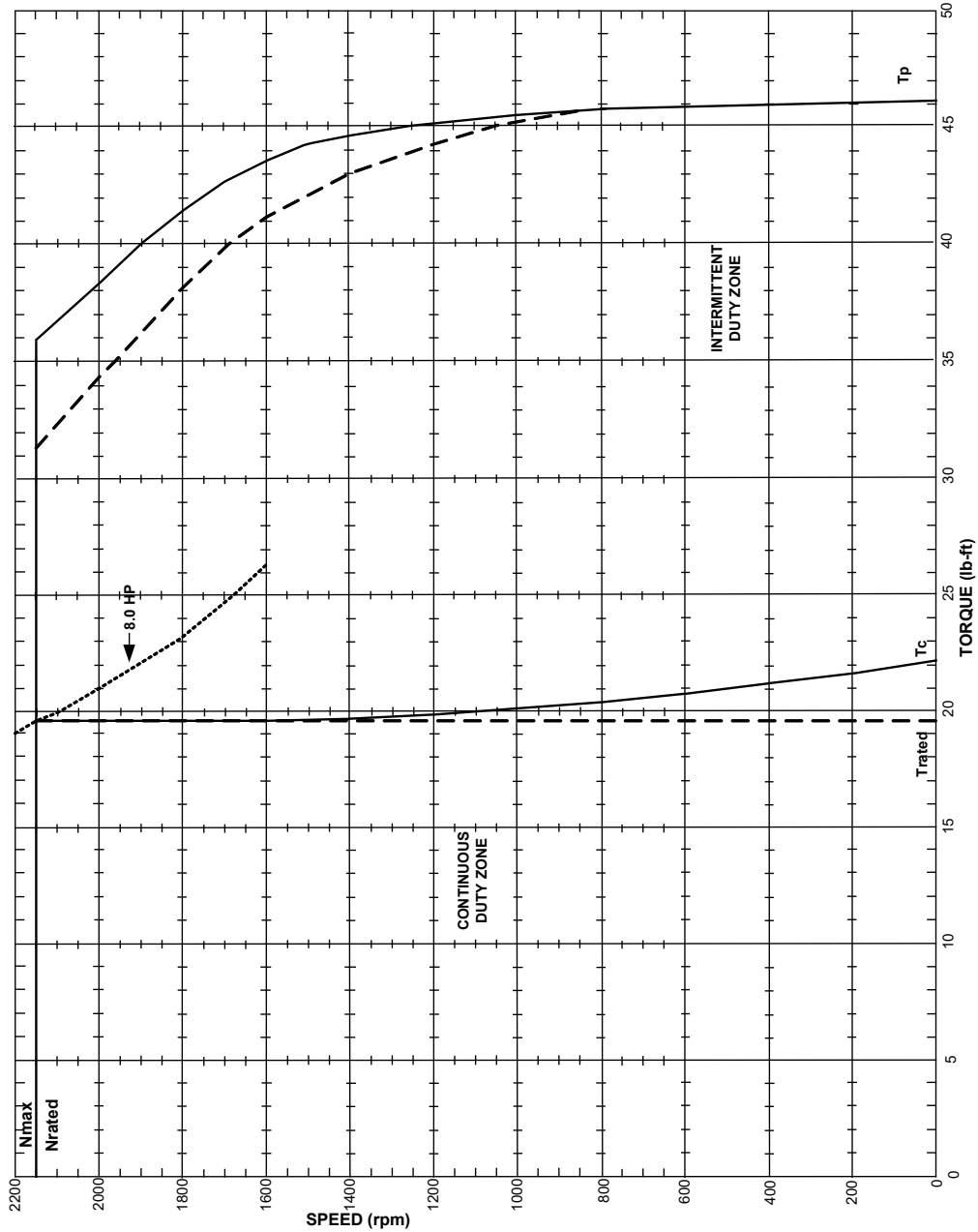
### 3.4.2 Performance Curves

#### 3.4.2.1 EB-604-A PC-26616

**NOTE**

Do not operate this motor outside the parameters shown on this performance curve.

Motor EB-604-A  
 Drive BDS4-230/20  
 Test T3-1433



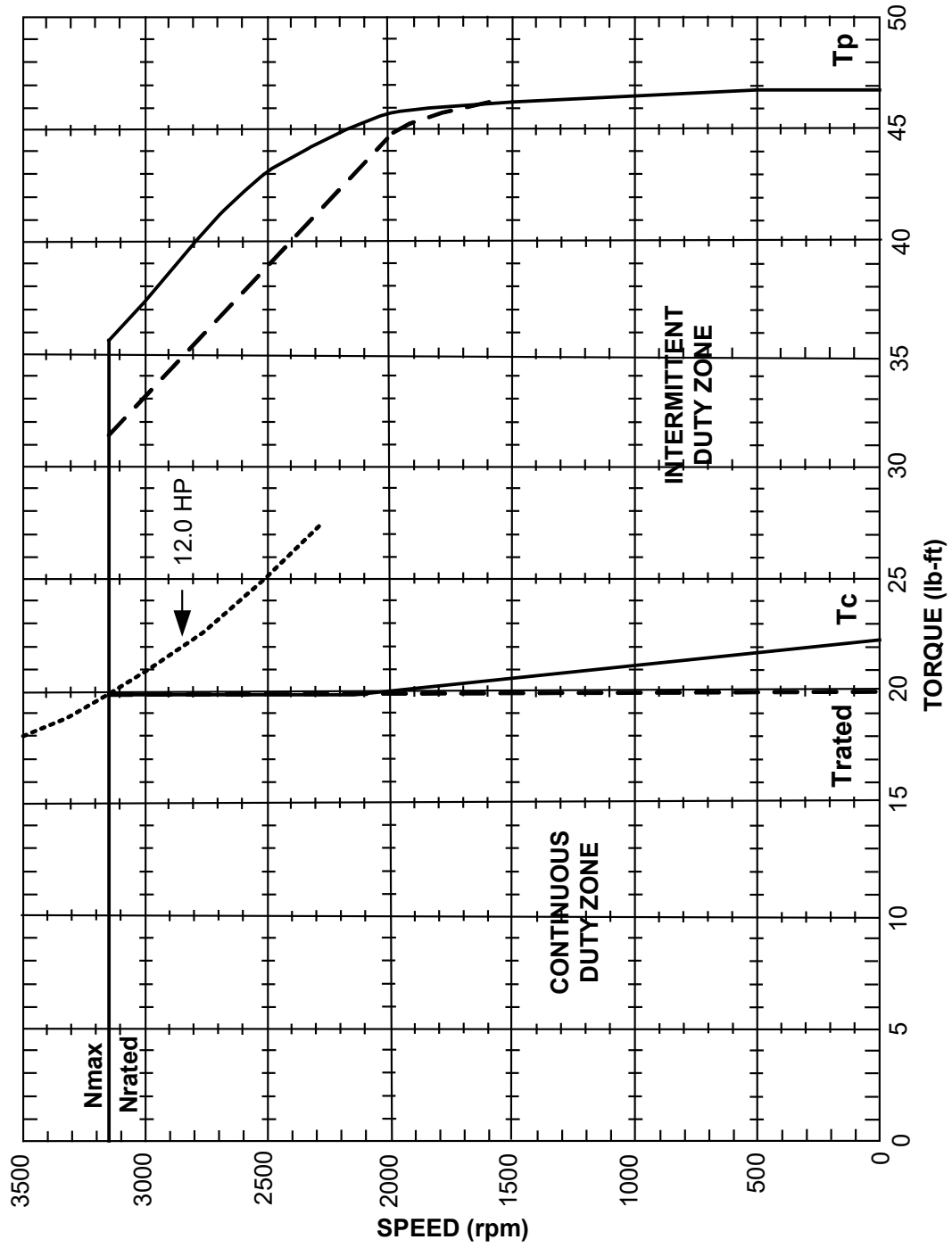


3.4.2.2 EB-604-B PC-26951

**NOTE**

Do not operate this motor outside the parameters shown on this performance curve.

Motor EB-604-B  
 Drive BDS4-230  
 Test T3-1633

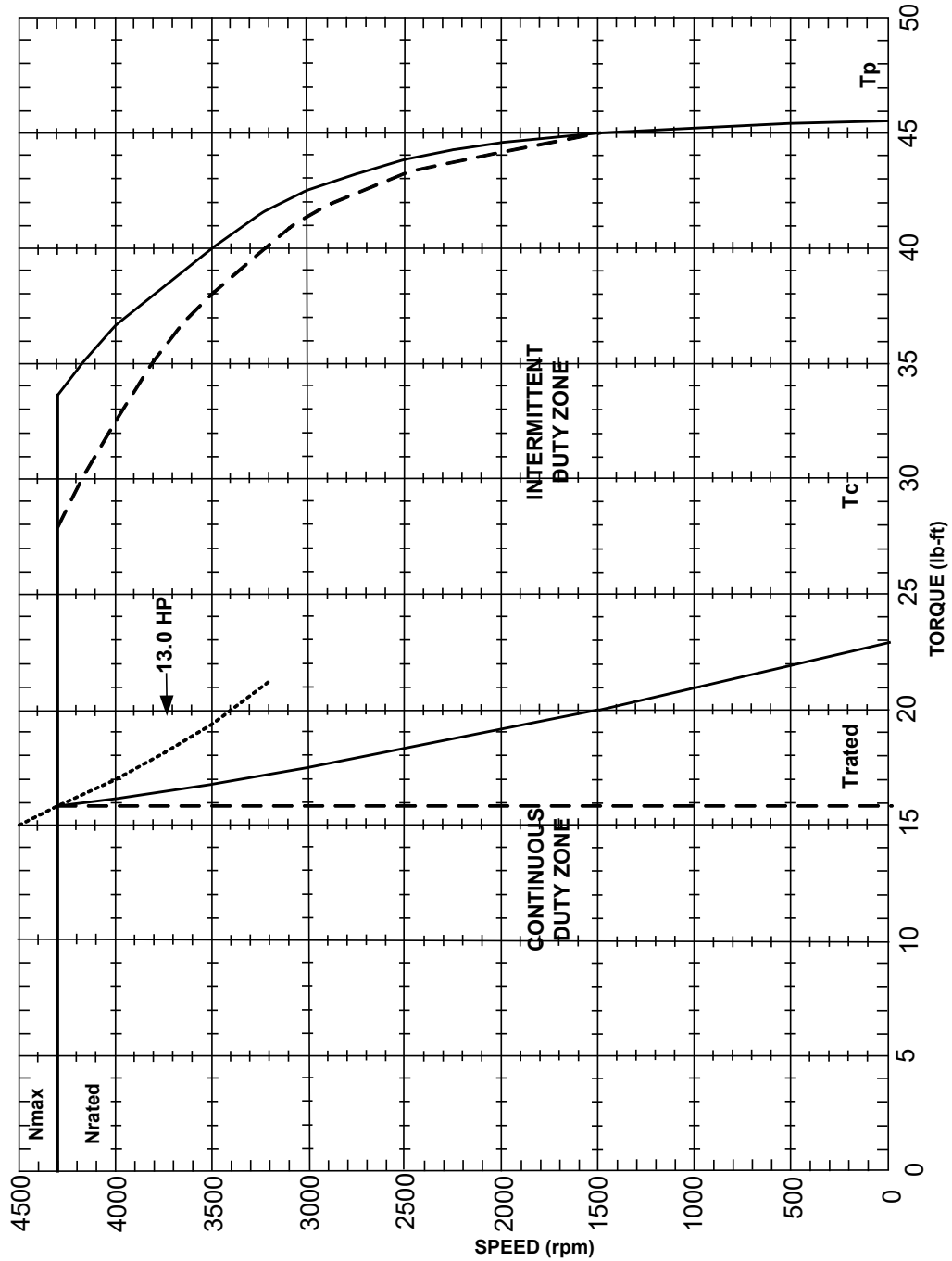


3.4.2.3 EB-604-C PC-26952

**NOTE**

Do not operate this motor outside the parameters shown on this performance curve.

Motor EB-604-C  
 Drive BDS4-240  
 Test T3-1635

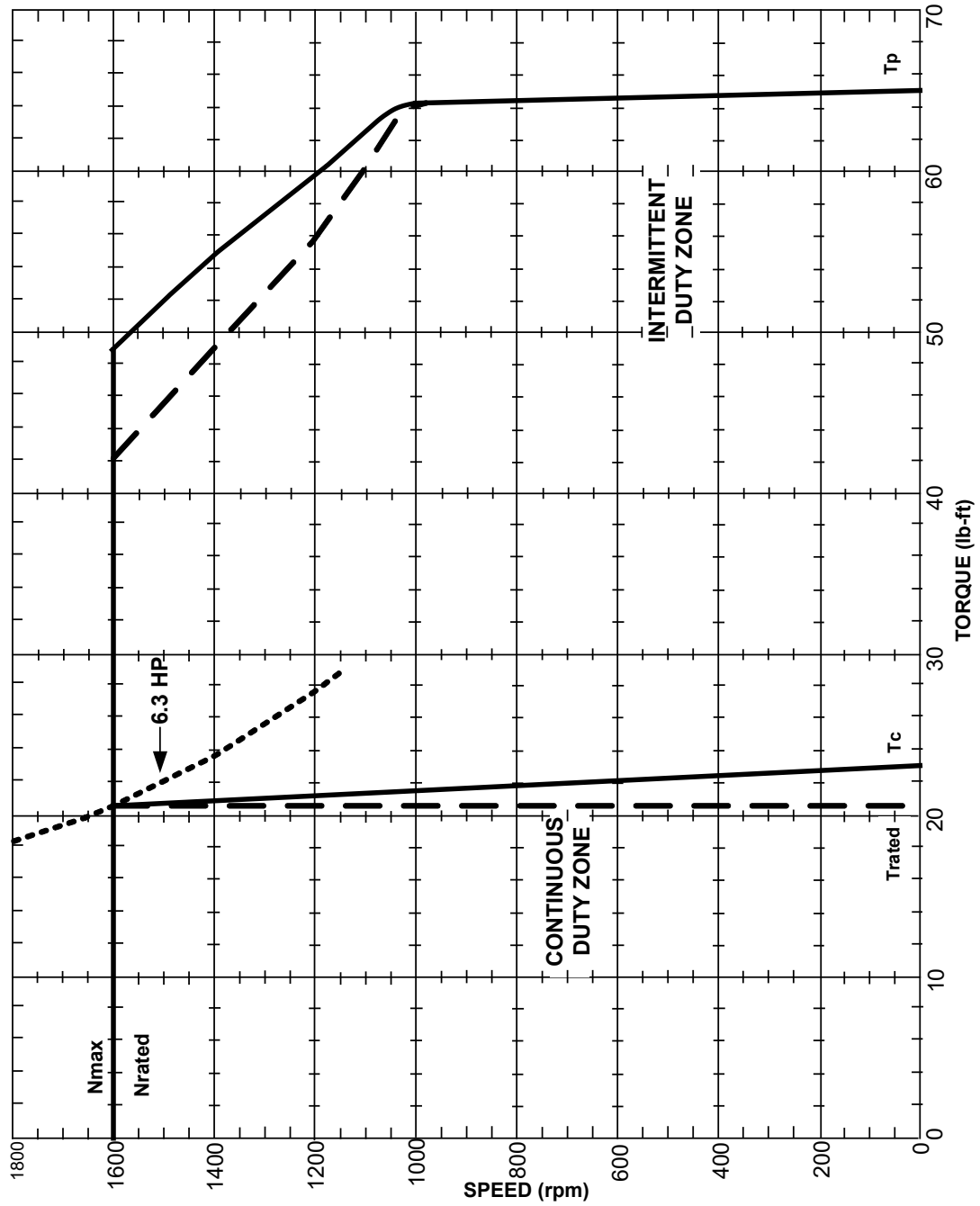


3.4.2.4 EB-604-D PC-26805 (Q)

**NOTE**

This motor is not to be operated outside the parameters shown on the respective performance curve.

Motor EB-604-D  
 Drive 15-amp continuous/45-amp peak  
 Test Calculated



### 3.5 EB-606

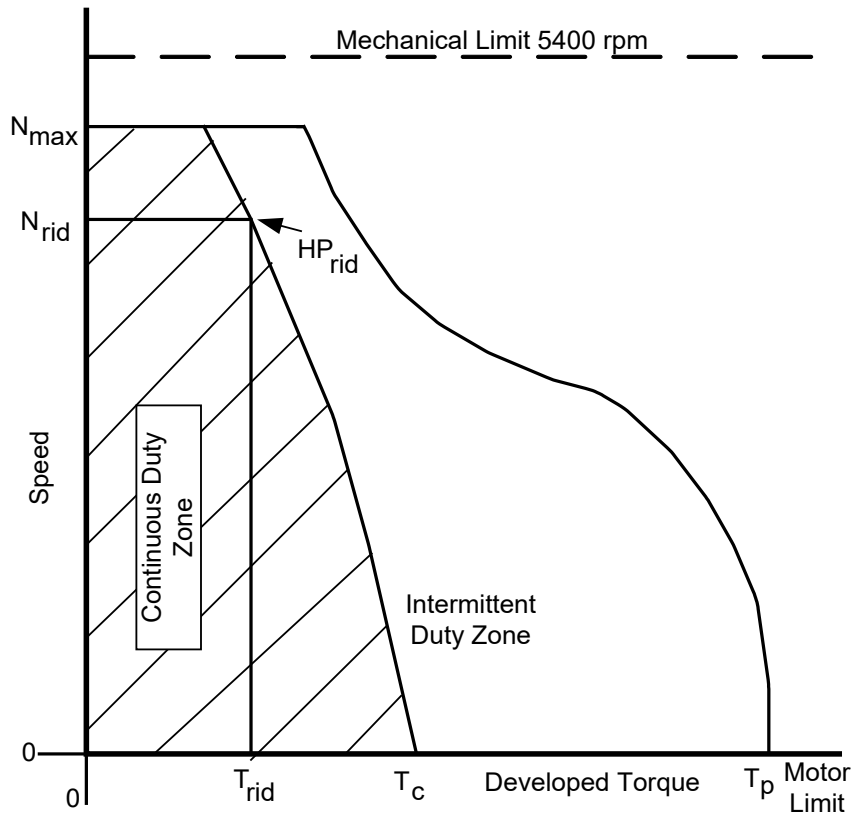
#### 3.5.1 Specifications CD-27028

Specification	Tol	Symbol	Units	A	B	C	D
*Continuous Torque (stall) at 40° C Ambient	Nom.	T <sub>C</sub>	lb-ft	33	33	33	31
			N-m	44.8	44.8	44.8	42
Cont. Line Current	Nom.	I <sub>C</sub>	A <sub>RMS</sub>	20	40	54.8	28
†Max. Speed	Nom.	N max.	rpm	1550	3050	4150	2300
*Peak Torque	Nom.	T <sub>P</sub>	lb-ft	97.2	93	91.6	90.4
			N-m	131.9	126.1	124.3	122.6
Peak Line Current	Nom.	I <sub>P</sub>	A <sub>RMS</sub>	62	118.6	160	86.2
129.2†Theoretical Acceleration	Nom.	∞m	rad/sec <sup>2</sup>	43393	41518	40893	40357
†Horsepower	Rated	H <sub>P</sub> rtd	HP	8.8	13.7	14.2	11
†Speed	Rated	N rtd	rpm	1550	3050	4150	2300
†Torque	Rated	T rtd	lb-ft	29.7	23.6	18	25.03
			N-m	40.3	32	24.4	33.9
Volts (line to line)	Rated	V rtd	V <sub>RMS</sub>	230	230	230	230
*Torque Sensitivity	± 10%	K <sub>T</sub>	lb-ft / A <sub>RMS</sub>	1.651	0.826	0.603	1.104
			N-m / A <sub>RMS</sub>	2.239	1.120	0.818	1.497
Back EMF (line-to-line)	± 10%	K <sub>B</sub>	V/krpm	135.4	67.7	49.5	90.5
Max. line-to-line volts	Max.	V max	V <sub>RMS</sub>	250	250	250	250
DC Res at 25° C (line-to-line)	± 10%	R <sub>M</sub>	ohms	0.500	0.140	0.076	0.26
Inductance (line-to-line)	± 30%	L <sub>M</sub>	mH	15.6	3.8	2.1	7.0
Time Constant at 25° C	Mech.	Nom.	T <sub>M</sub>	ms	0.45	0.51	0.53
	Elec.	Nom.	T <sub>E</sub>	ms	31.2	27.1	27.6
System Performance Curve				26618	26619	26954	26955

*\*At ultimate winding temperature for ambient data multiply by 1.06*

†	Symbol	Units	Value
Rotor Inertia	$J_M$	lb ft sec <sup>2</sup>	0.00224
		kg m <sup>2</sup>	0.00304
Weight	Wt	lb	66
		kg (f)	29.9
Static Friction	$T_F$	lb-ft	0.694
		N-m	0.941
Thermal Time Constant Peak	TCTP	Minutes	16
Viscous Damping $\infty Z$ Source	$F_1$	lb-ft/krpm	0.108
		N-m/krpm	0.147

† If brush type tach is used, these parameters may be affected. Consult the factory.



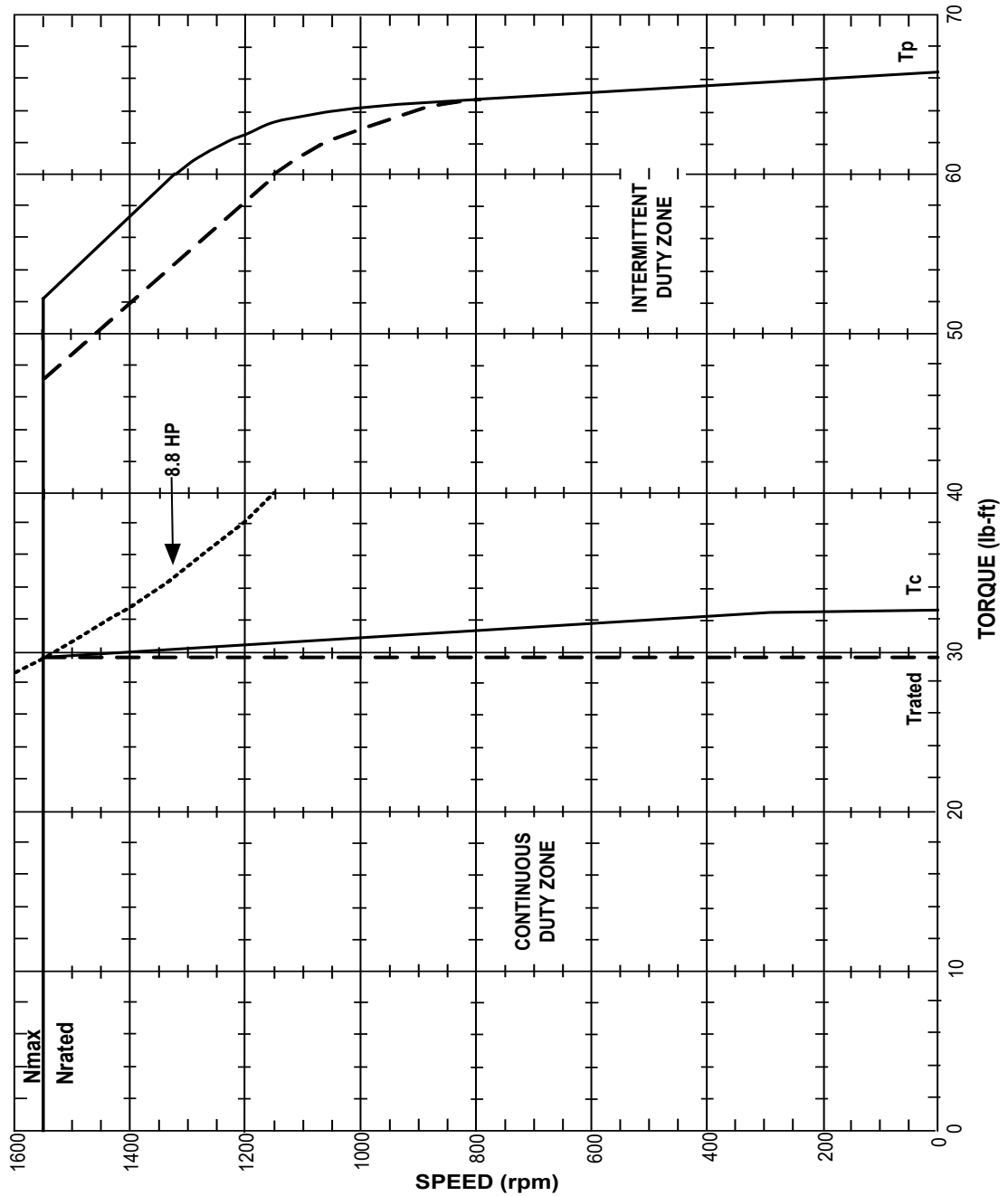
### 3.5.2 Performance Curves

#### 3.5.2.1 EB-606-A PC-26618

**NOTE**

This motor is not to be operated outside the parameters shown on the respective performance curve.

Motor EB-606-A  
 Drive BDS4-230/20  
 Test T3-1432

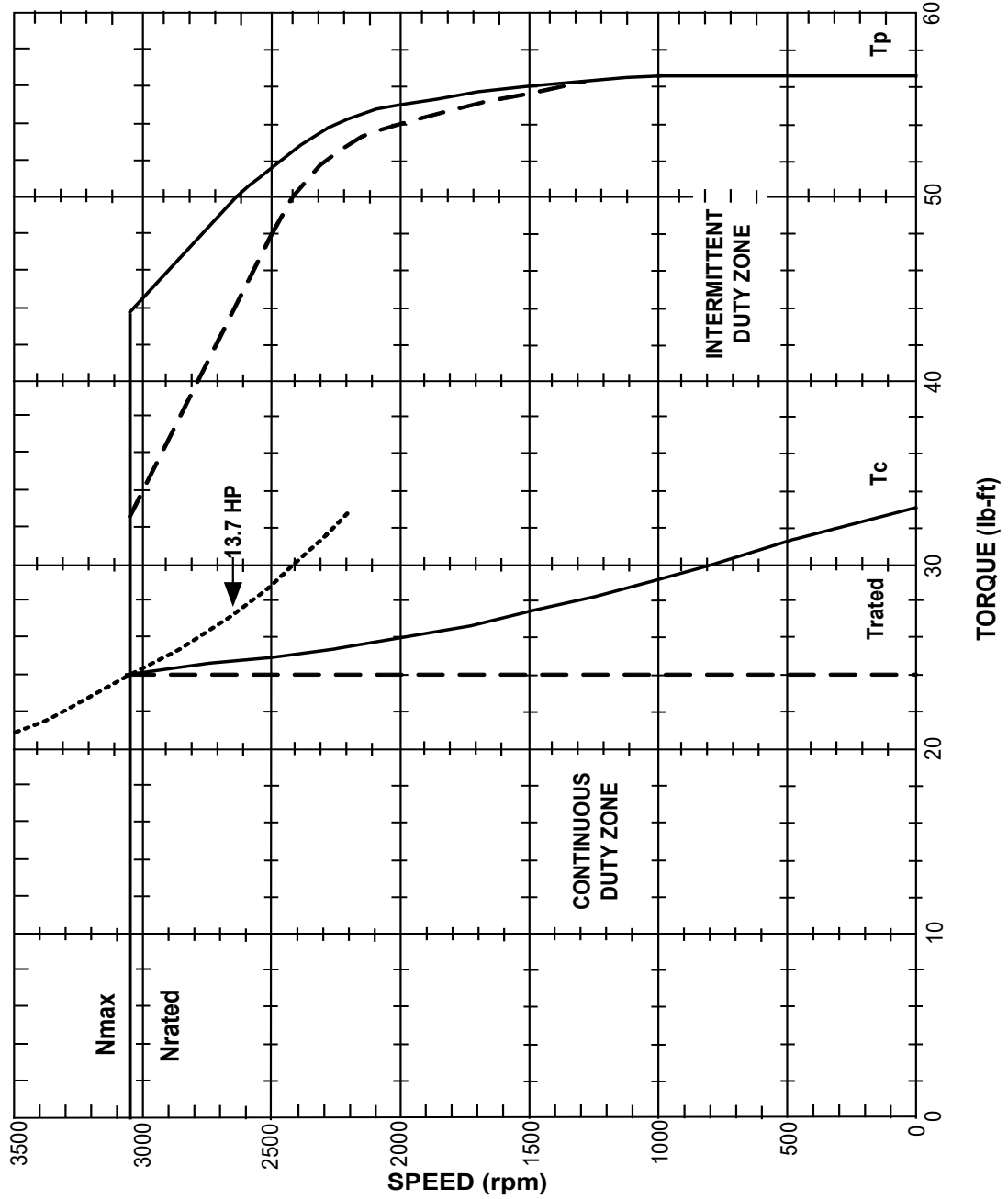


3.5.2.2 EB-606-B PC- 26619



This motor is not to be operated outside the parameters shown on the respective performance curve.

Motor EB-606-B  
 Drive BDS4-230/40  
 Test T3-1422

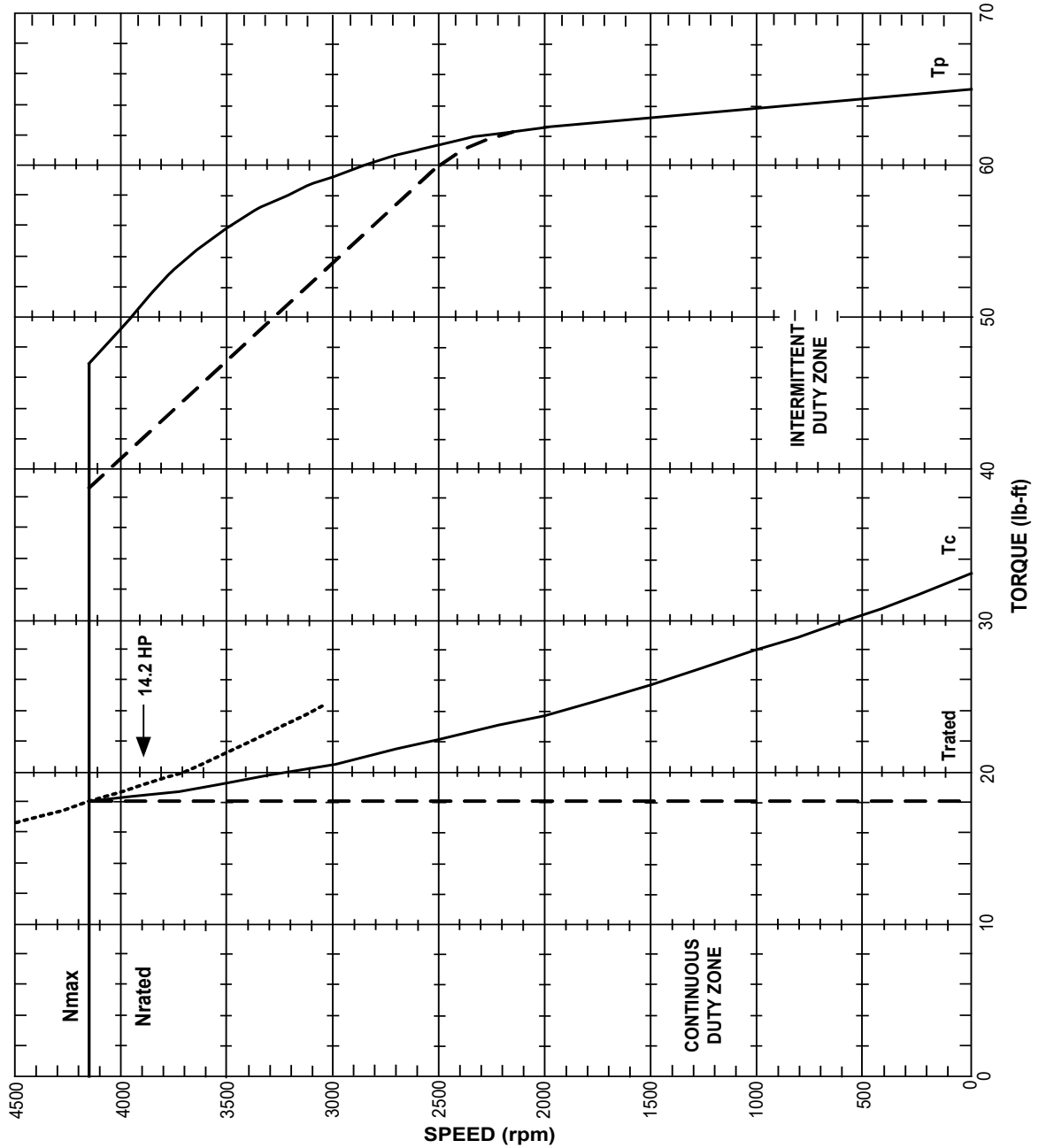


3.5.2.3 EB-606-C PC- 26954



This motor is not to be operated outside the parameters shown on the respective performance curve.

Motor EB-606-C  
 Drive BDS4-255  
 Test T3-1637



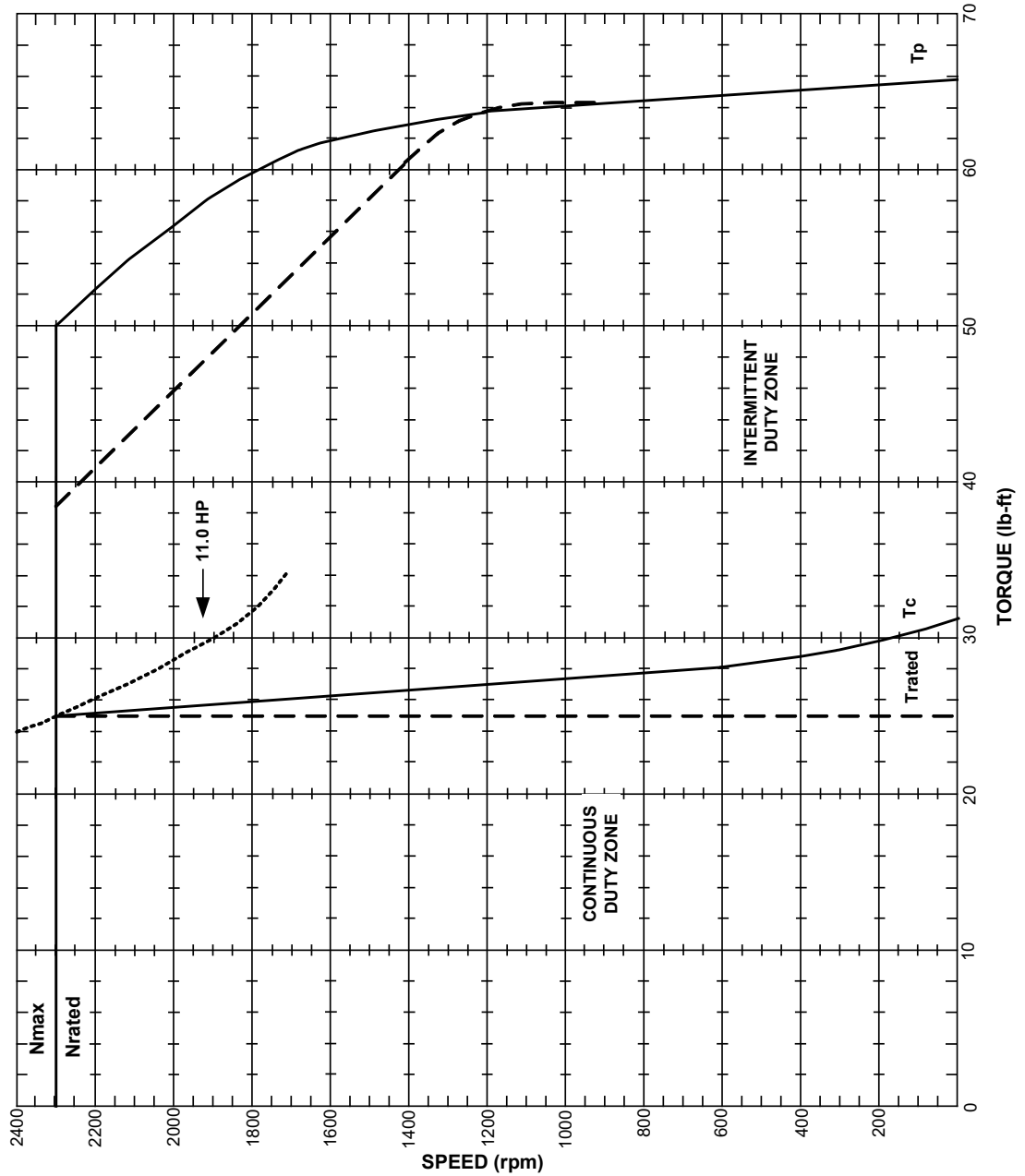


3.5.2.4 EB-606-D PC- 26955



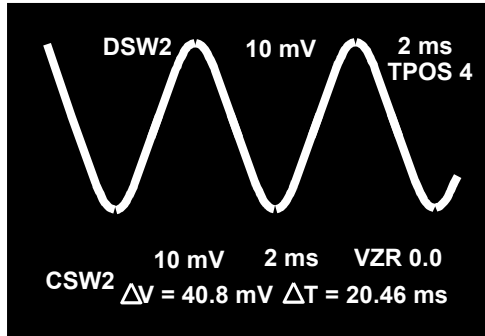
This motor is not to be operated outside the parameters shown on the respective performance curve.

Motor EB-606-D  
 Drive BDS3-230  
 Test T3-1634



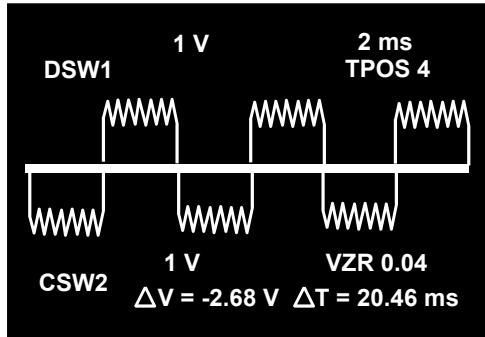
### 3.6 EB-60x Typical Current and Voltage (Wave forms at Motor)

#### 3.6.1 Current Phase C



EB-606-C– BDS4-255J is illustrated at 20 amps/div., 2500 rpm, 22.2 lb-ft

#### 3.6.2 Voltage line A-C



EB-606-C– BDS4-255J is illustrated at 100 volts/div., 2500 rpm, 22.2 lb-ft

### 3.7 EB-60x Intermittent Duty Operation

If a motor operates intermittently, it is not necessary that the peak load torque fall within the motor's continuous torque capabilities. However, it is important that the RMS (root mean square) load torque be inside the continuous duty zone. The key here is that a sufficient OFF time follows each On time of the motor. Equation 1 (EQ-1) gives the RMS torque:

$$(EQ-1) \quad T_{RMS} = \sqrt{\frac{T_1^2 t_1 + T_2^2 t_2 + \dots + T_i^2 t_i}{t_1 + t_2 + \dots + t_i}}$$

$T_i$  = Torque at Time  $i$   
 $t_i$  = Duration of time  $i$

This equation assumes  $t_i$  is small compared to the thermal time constant for peak power of motor (TCTP) for torque values significantly larger than the continuous torque ( $T_c$ ). This is not always a good assumption. For cases where torque values significantly exceed  $T_c$ , the following equation is used:

$$\frac{T_{OUT}}{T_c} = \sqrt{\frac{1 - e^{-ton / \text{Duty cycle} \times TCTP}}{1 - e^{-ton / TCTP}}}$$

where, duty cycle =  $\frac{ton}{ton + toff}$   
 $T_{OUT}$  = output torque  
 $T_c$  = continuous torque at operating speed  
 $t_{ON}$  = time on  
 $TCTP$  = thermal time constant for peak power of motor

This equation expresses operating torque as a function of ON time. It also breaks the operating cycle down into individual periods of ON time and OFF time. Substituting for duty cycle and solving for  $t_{OFF}$ , the above equation yields Equation 2 (EQ-2):

$$(EQ-2) \quad toff = -TCTP \ln \left[ 1 - \frac{1 - e^{-ton / TCTP}}{T_c^2} * T_{OUT}^2 \right] - ton$$

For a specific output torque and a given ON time, the required OFF time is known. This OFF time is required so the motor cools sufficiently and does not exceed its thermal limits. The calculated OFF time should proceed the initial ON time to ensure that the ultimate temperature is not surpassed on the first cycle.

It may also be useful to calculate a time to ultimate experience temperature based on a one-time excursion from ambient temperature. Consider the following pair of equations:

$$(EQ-3) \quad T_{R \text{ Actual Above Ambient}} = T_{R \text{ Rated Above Ambient}} \left[ \frac{T_{OUT}}{T_c} \right]^2$$

$$(EQ-4) \quad T_{R \text{ Rated}} = T_{R \text{ Ulitimate}} (1 - e^{-})$$

where = time / TCTP  
 substitute (3) into (4) and obtain

$$T_{R \text{ actual}} \left[ \frac{T_c}{T_{OUT}} \right]^2 = T_{R \text{ Ulitimate}} (1 - e^{-t/TCTP})$$

To find the time to ultimate temperature, set  $T_{R \text{ actual}} = T_{R \text{ ultimate}}$  and solve for t. This yields the following equation:

$$(EQ-5) \quad t_{\max} - TCTP \ln \left[ 1 - \left[ \frac{T_c}{T_{OUT}} \right]^2 \right]$$

where: t = max on time  
 TCTP = thermal time constant of motor  
 T<sub>c</sub> = continuous torque of the motor at the particular operating speed  
 T<sub>OUT</sub> = operating torque

This gives the maximum ON time for a given operating torque beginning at ambient temperature. Examination of this equation reveals that as T<sub>OUT</sub> approaches T<sub>c</sub>, t approaches infinity. This is expected since we can theoretically operate the motor indefinitely at continuous torque without exceeding its thermal limits. EQ-5, with EQ-2, define the motor's operating time limits.

**Example #1**

An EB-606-B has torque vs. speed performance characteristics described in the performance curve, EB-606-B PC- 26619. The motor is operating intermittently at 4150 rpm with a torque of 47.1 lb-ft.

FIND:

- a) maximum ON time without exceeding ultimate temperature
- b) the required OFF time for an ON time of 4 seconds

GIVEN: T<sub>OUT</sub> = 47.1 lb-ft

From performance curve, EB-606-B PC- 26619 the continuous torque at 4150 rpm is obtained.

$$T_c = 18.0 \text{ lb. ft.}$$

From the Specifications CD-27028:

$$TCTP = 16 \text{ min.}$$

- a) The maximum ON time is found from EQ-5:

$$t_{\max} - TCTP \ln \left[ 1 - \left[ \frac{T_c}{T_{OUT}} \right]^2 \right]$$

TCTP = 16 min.  
 T<sub>c</sub> = 18.0 lb-ft  
 T<sub>OUT</sub> = 47.1 lb-ft

$$t_{\max} = 16 \text{ min} \ln \left[ 1 - \left[ \frac{18.0}{47.1} \right]^2 \right]$$

t<sub>MAX</sub> = 16 min. ln [0.8540]  
 t<sub>MAX</sub> = 16 min (0.158)  
 t<sub>MAX</sub> = 2.52 min.

If the motor has an ON time greater than 2.52 minutes, it exceeds the thermal limits.

b) The required OFF time for a given ON time is found from (EQ-2).

$$t_{\text{off}} = -TCTP \ln \left[ 1 - \frac{1 - e^{-t_{\text{on}} / TCTP} * T_{\text{OUT}}^2}{T_c^2} \right] - t_{\text{on}}$$

$$\begin{aligned} t_{\text{ON}} &= 4 \text{ sec} \\ TCTP &= 16 \text{ min. } 60 \text{ sec/min} = 960 \text{ sec} \\ t_{\text{OUT}} &= 47.1 \text{ lb-ft} \\ T_c &= 18.0 \text{ lb-ft} \end{aligned}$$

$$t_{\text{off}} = -960 \text{ sec} \ln \left[ 1 - \frac{(1 - e^{-4/960}) (47.1)^2}{18.0^2} \right] - 4 \text{ sec}$$

$$\begin{aligned} t_{\text{OFF}} &= -960 \text{ sec} \ln 0.9383 - 4 \text{ sec} \\ t_{\text{OFF}} &= 23.7 \text{ sec} \end{aligned}$$

For the EB-606-C motor operating at the load point in this example, an ON time of 4 sec must be followed by an OFF time of 23.7 sec. so as not to exceed its thermal limits.

### Example #2

The motor of Example #1 is running at 2500 rpm with an intermittent operating torque of 61.2 lb-ft.

FIND:

- a) max. ON time
- b) required OFF time for an ON time of 4 sec.

(a) Given  $T_{\text{OUT}} = 61.2 \text{ lb-ft}$

From performance curve EB-606-B PC- 26619  
 $T_c$  at 2500 rpm = 22.2 lb- ft.

From Specifications CD-27028:  
 TCTP = 16 min.

Using EQ-5 and above values:  
 $t_{\text{MAX}} = 2.3 \text{ min.}$

- (b) Using (EQ-2) and an ON time of 4 sec, an OFF time is:  
 $t_{\text{OFF}} = 27.1 \text{ sec.}$

### Example #3

The motor of Example 1 is running at 500 rpm with an intermittent operating torque of 64.5 lb-ft.

FIND:

- a) max. ON time
- b) required OFF time for an ON time of 4 seconds

(a) Given  $t_{out} = 64.5$  lb-ft.

From performance curve EB-606-C PC- 26954:

$T_C = 30.6$  lb-ft. at 500 rpm

From Specifications CD-27028:

TCTP = 16 min.

Using EQ-5 and above values:

$t_{MAX} = 4.078$  min.

$t_{ON} = 4$  seconds

Using EQ-2 and known values:

$t_{OFF} = 14.1$  seconds

#### **NOTE**

The applications engineers at Kollmorgen can assist in the proper sizing of the motor and amplifier based on the applications' duty cycle. Contact them if any questions arise in the derivation of  $t_{MAX}$  or  $t_{OFF}$  with a specific duty cycle.

## 4. TYPICAL AMPLIFIER DATA PACKAGE

### 4.1 Typical Amplifier Specifications

Ratings		
Input Power:	235 V <sub>RMS</sub> (L-L) 3-phase (±10%); isolation transformer not required – provided short circuit (inrush) current remains limited to less than 1000 amps. 115 VAC 1-phase control power.	
Output Power	Power Supply DC Bus	325 VDC nominal, no load
	Amplifier: at rated load	230 VRMS (L-L), Nominal ±10%
	Continuous Current (ARMS/Phase)	Intermittent Current (5 sec. max., 30% duty cycle) (ARMS/Phase)
	As required to produce motors rated current	200% of continuous
Ambient Operating Temperature:	0-55° C	
Switching Frequency	10 kHz	
Cooling	Fan, convection (cold plate)	

Save these instructions for future reference.

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## About Kollmorgen

Kollmorgen is a leading provider of motion systems and components for machine builders. Through world-class knowledge in motion, industry-leading quality and deep expertise in linking and integrating standard and custom products, Kollmorgen delivers breakthrough solutions that are unmatched in performance, reliability and ease-of-use, giving machine builders an irrefutable marketplace advantage.



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